GEOLOGY AND GEOCHEMISTRY OF AN ALKALI VOLCANIC SUITE (SKINNER COVE FORMATION) IN THE HUMBER ARM ALLOCHTHON, NEWFOUNDLAND

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by

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WHEN BINDING, PLEASE ENSURE THAT TABLE 6., p. 105, IS PLACED AS FAR TO THE LEFT AS POSSIBLE.

Donald Baker

ABSTRACT

The Skinner Cove Formation, an igneous/metamorphic assemblage, comprises one of a number of transported slices in the Humber Arm Allochthon of western Newfoundland. The allochthon was assembled in an Ordovician ocean basin and at a continental margin, and then emplaced upon platform carbonates of the continental shelf during the lower Middle Ordovician. The Skinner Cove Formation, presently recognized only in the northern part of the allochthon, consists of two structural slices (Trout River and Chimney Cove). Two other slices, containing rocks previously included in the Skinner Cove, are herein named the Western Head and Beverley Head slices; rocks of the former slice are assigned to the Little Port Complex, and those of the latter to a miscellaneous structural unit. These four slices are everywhere structurally separate, one from another. Additionally, each of the four newly named slices is overlain structurally by other slices of either the Little Port Complex or the Bay of Islands (ophiolite) Complex, and is underlain structurally by sedimentary slices of the Humber Arm Supergroup. Locally, Skinner Cove rocks are enveloped in mélange and structurally associated with sediments of the Humber Arm Supergroup.

The Skinner Cove Formation is typified by the stratigraphy and lithologies in the Trout River slice. Rocks of the Trout River slice are herein subdivided into the Main Sea Stack, Wallace Brook and Red Fire Brook Members, which consist of a distinctive, undeformed lithic assemblage including mafic and intermediate lavas, trachyte, subvolcanic rocks and volcaniclastics. These have all been altered to a metamorphic mineral assemblage, zeolite/analcime-quartz, which is diagnostic of zeolite facies metamorphism. The Chimney Cove slice is composed mainly

of epiclastic breccia and fossiliferous limestone, with brecciated mafic lavas similar to those in the Trout River slice. Rocks of the Beverley Head slice are internally imbricated, with rocks of the Little Port Complex, Humber Arm Supergroup and Skinner Cove Formation all represented.

Mineralogical, petrochemical and petrographic studies show that the Skinner Cove is a differentiated, mildly alkaline igneous suite (presently metamorphosed to zeolite facies) that underwent olivine and clinopyroxene fractionation. In contrast, the mafic rocks of the Little Port are texturally, mineralogically and petrochemically distinct from the Skinner Cove suite. There is no apparent direct genetic relationship between the rocks of the Skinner Cove Formation and the rocks in any other allochthonous assemblage (*e.g.* Little Port Complex).

Prior to its incorporation into the allochthon, the Skinner Cove Formation is interpreted to have been a mature oceanic volcano that erupted alkaline magma. The Little Port Complex, which has subalkaline magmatic affinities, is interpreted to include both ocean floor volcanics and volcanic arc rocks.

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CHAPTER 1

INTRODUCTION

The Humber Arm Allochthon of western Newfoundland constitutes a Cambro-Ordovician sedimentary and igneous/metamorphic terrane that was emplaced upon a contemporaneous autochthonous carbonate platform and older Grenvillian continental basement during the culmination of the Taconic Orogeny.

The Skinner Cove Formation, Old Man Cove Formation, Little Port and Bay of Islands Complexes and the Humber Arm Supergroup are the five major structural units within the Humber Arm Allochthon.

The Skinner Cove Formation is unique to all of the allochthonous rocks in that it has no known equivalents elsewhere in Newfoundland or in the mainland Appalachians or Caledonides. The Skinner Cove rocks consist predominantly of mafic to felsic lavas, subvolcanic lithologies and volcaniclastics all of which are distinctive in their zeolite facies metamorphism, preservation of relict minerals and lack of penetrative deformation.

The outcrop area of the Skinner Cove Formation is limited compared to that of the igneous/metamorphic Little Port and Bay of Islands Complexes, but it possibly contains a more diverse extrusive rock suite than either of the aforementioned complexes.

1.1 Purpose and Scope

The good rock exposures and spectrum of rock types in the Humber Arm Allochthon affords an excellent opportunity to study some of the problematical and controversial relationships between a variety of separated structural rock units. Two of the highest structural units;

the Skinner Cove Formation, and Little Port Complex are of primary concern here. Rocks of the Old Man Cove Formation and Bay of Islands (ophiolite) Complex are described, but they are of secondary interest. Each of these rock units will be clearly defined and described in later chapters.

To date, the emphasis of geological studies in transported terranes of western Newfoundland has been on mafic/ultramafic rocks of the ophiolite suite. Ophiolite suites, though petrologically important, and impressive in outcrop, remain the most intensively studied and therefore the best understood lithic sequences in this and most other transported terranes. In contrast, mélange and other important lithic sequences (*e.g.* Skinner Cove Formation, Little Port Complex) in allochthonous zones are only poorly understood because of their relative neglect as compared to rocks of the ophiolite.

The purpose of this work is to outline in detail the geology and geochemistry of the Skinner Cove Formation, which is a lithic unit containing a unique and decidedly non-ophiolitic suite of volcanic rocks. The geology, petrochemistry and mineral chemistry of the Skinner Cove suite is compared and contrasted with that of the problematical Little Port Complex, the Bay of Islands Complex, and various other rocks in the Humber Arm Allochthon. The purpose of the comparative study is to outline any possible genetic relationship between the Skinner Cove Formation and the other rock units within the allochthon. The presence or absence of such a genetic relationship may bear on the Early Paleozoic evolution of the Humber Arm Allochthon.

A final synthesis of laboratory, field data and published information allows the interpretation of a magmatic affinity and a possible tectonic setting for the Skinner Cove Formation and Little Port Complex. The close association between alkaline volcanic suites and ophiolites in transported terranes is noted.

It is hoped that this work will focus attention on the little-known assemblages that constitute an integral part of the Humber Arm Allochthon.

1.2 Acknowledgements

I am indebted to my advisor, Dr. H. Williams, who has greatly improved my style of writing and enhanced my knowledge of Appalachian geology. In addition, Dr. B. Doolan (University of Vermont) gave much support and guidance during his sabbatical stay at Memorial University. I also thank Dr. D. Strong for his criticism of the geochemistry chapter of this work. Dr. D. Skevington provided dates on the graptolites found during the course of the study, and Dr. N. James scrutinized several rocks for evidence of fossils. D. Hunter processed many limestone samples from the writer's field-area, with the hope of finding microfossils.

G. Langdon proved an excellent field assistant and without him I am certain that our dory would have swamped on (more) numerous occasions.

I thank G. Andrews, D. Press, Dr. A. Thompson, F. Thornhill, W. Marsh, G. Sommerton, and others who provided indispensable technical support during the period in which I collected and processed analytical data. J. Berkland, G. Einarson, and Drs. W. Church, R. Coish, D. Strong, E. Nisbet, J. Pearce and A. Hynes all provided published or unpublished data that have immeasurably improved parts of this thesis.

A familiar face was most welcome during the field season and I therefore thank Dr. R.K. Stevens and A. Poynter, Dr. H. Williams, D. Hunter and S. Stouge, R. Jamieson, and Drs. E. Appleyard and J. Malpas

for visits, or attempted visits, in the field.

This entire work would have been impossible were it not for the generous financial assistance provided by Dr. H. Williams. In addition to the funding through Dr. Williams' National Research Council and Canada Council grants, the writer also received, and herein acknowledges, support from a Memorial University Graduate Fellowship.

1.3 Location and Access

The rocks investigated are located in western Newfoundland (Fig. 1a.), north of the Bay of Islands and adjacent to the Gulf of St. Lawrence (Fig. 1b.). The main exposures of the Skinner Cove Formation (using the terminology of Williams, 1973) are situated in the vicinity of the following localities (Fig. 1b.; Fig. 2. for detail):

(a) Skinner Cove

(b) Western Head

(c) Chimney Cove

(d) Beverley Head

Area (a) is the type of area of the Skinner Cove Formation and both areas (a) and (b) are within Gros Morne National Park. Additionally, mapping included possible Skinner Cove Formation rocks 2 and 5 km southeast of Trout River Village, near Trout River Pond (Fig. 1b.).

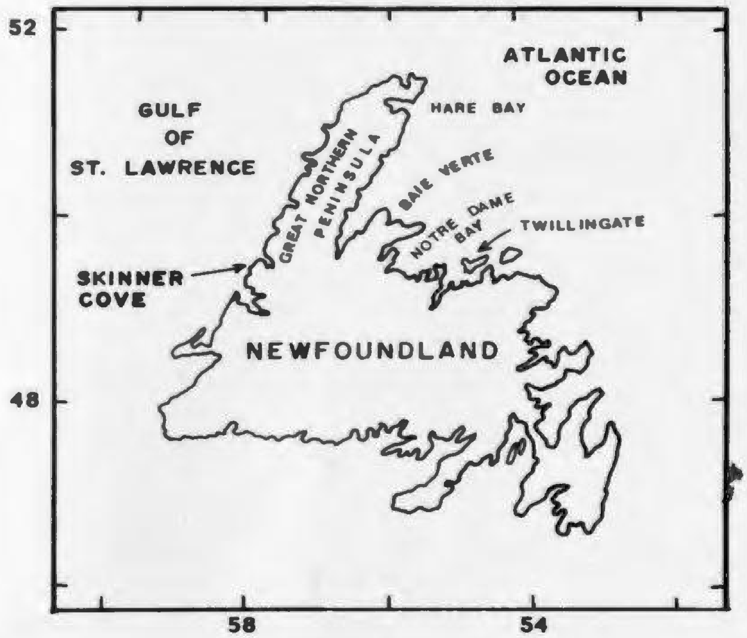
Little Port Complex volcanic rocks were sampled south of the Bay of Islands in the vicinity of Little Port (Fig. 1b.) and on Gregory Island, the northernmost island in the Bay of Islands.

Most rock exposures are accessible only by motor-dory, although access to rocks at Skinner Cove may be gained by foot from Trout River Village. Base camps were situated at Skinner Cove, Trout River Village,

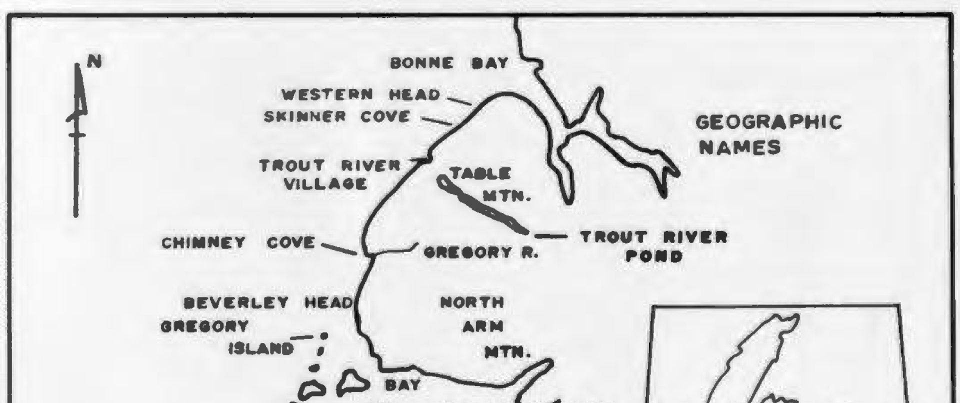
Figure 1. Location Maps

a. Location of the island of Newfoundland

b. Detailed map of western Newfoundland and some local geographic names


52
48
58
54
ATLANTIC OCEAN
GULF OF ST. LAWRENCE
HARE BAY
GREAT NORTHERN PENINSULA
BAIE VERTE
NOTRE DAME BAY
TWILLINGATE
SKINNER COVE
NEWFOUNDLAND

a.


N
BONNE BAY
WESTERN HEAD
SKINNER COVE
GEOGRAPHIC NAMES
TROUT RIVER VILLAGE
TABLE MTN.
CHIMNEY COVE
GREGORY R.
TROUT RIVER POND
BEVERLEY HEAD
GREGORY ISLAND
NORTH ARM MTN.
BAY OF ISLANDS
LITTLE PORT
10 KM
BLOW-ME-DOWN MTN.
HUMBER ARM

b.

Chimney Cove and Beverley Head, and rocks at Western Head and Gregory Island were approached from the closest base camp. Exposures near Little Port are readily accessible by short traverses or dory.

1.4 Physiography and Climate

The Bay of Islands area forms a distinctive physiographic subprovince of the Long Range Peneplane (Twenhofel and McClintock, 1940). To the south, the highlands near Lewis Hills (Fig. 3.) attain elevations in excess of 800 m. North of the Bay of Islands, North Arm Mountain and Table Mountain form relatively flat, barren and dissected highlands (in the order of 700 m) locally referred to as the 'Tableland'. The region extending from Bonne Bay to Chimney Cove (Fig. 1b.), is dominated by a coastal scarp, which in places (*e.g.* east of Chimney Cove) reaches 300 m within 1 km of the Gulf of St. Lawrence (Fig. 2.).

Undoubtedly, the most important physiographic controls on the Bay of Islands region are the variable nature of the bedrock geology, and the related bedrock structures (Twenhofel, 1912; Cooper, 1936). Recent geological surveys in west Newfoundland (*e.g.* Williams, 1973) indicate that within this unique transported terrane, resistant igneous and metamorphic rocks everywhere structurally overlie less competent and easily eroded sedimentary rocks. Therefore, regions containing sedimentary rocks are relatively low-lying and poorly exposed.

The area near Skinner Cove consists of a northeast trending ridge composed of volcanic rocks (Fig. 2.). A pronounced topographic depression to the south is probably the surface expression of the major geologic contact between the Skinner Cove Formation and Little Port Complex (Fig. 2.). Similarly, the contacts between nearly all of the major structural units consist of an easily eroded shale and/or serpentinite

Figure 2. Detailed maps of field-areas

topographic contour intervals

20 feet (6.1 m)

100 feet (30.5 m)

1 Trout River slice

2 Western Head slice

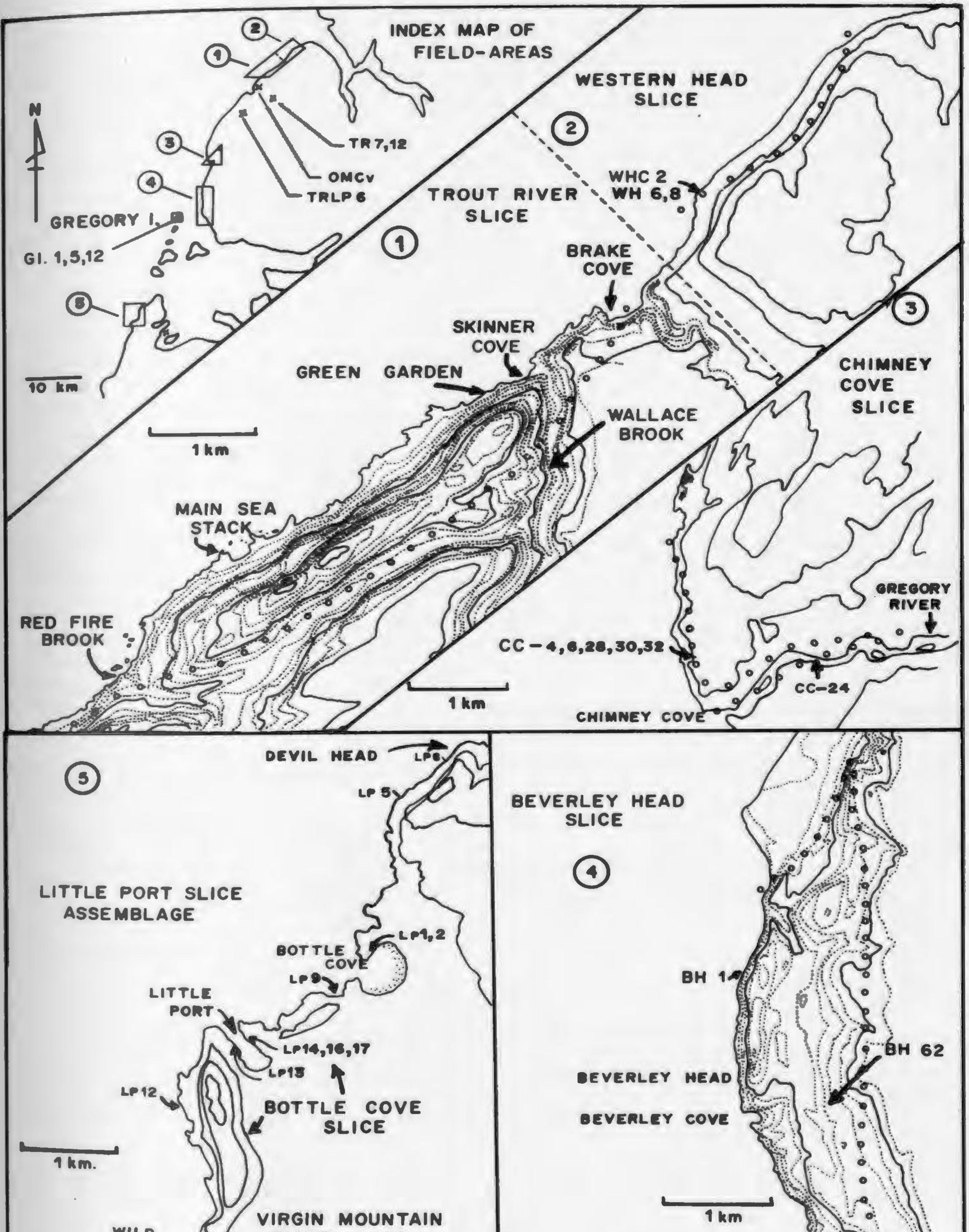
3 Chimney Cove slice

4 Beverley Head slice

5 Little Port slice assemblage

For each of areas 2 through 5, sample locations and numbers are given in the figure. The samples are for petrography, petrochemistry ± mineral chemistry. Sample locations and numbers for area 1 are given in Plate 1.

Small circles, °°°°, in areas 1, 2, 3, and 4, outline the approximate structural boundaries of the rock units of interest to this study.


INDEX MAP OF
FIELD-AREAS
N
TR 7,12
OMCv
TRLP 6
GREGORY I.
GI. 1,5,12
10 km
WESTERN HEAD
SLICE
WHC 2
WH 6,8
TROUT RIVER
SLICE
BRAKE
COVE
SKINNER
COVE
GREEN GARDEN
WALLACE
BROOK
1 km
MAIN SEA
STACK
RED FIRE
BROOK
CHIMNEY
COVE
SLICE
GREGORY
RIVER
CC – 4,6,28,30,32
CC–24
1 km
CHIMNEY COVE
DEVIL HEAD
LP 5
LITTLE PORT SLICE
ASSEMBLAGE
BOTTLE
COVE
LP1,2
LP9
LITTLE
PORT
LP14,16,17
LP13
LP12
BOTTLE COVE
SLICE
1 km.
VIRGIN MOUNTAIN
SLICE
WILD
COVE
LP 10, 11
BEVERLEY HEAD
SLICE
BH 1
BH 62
BEVERLEY HEAD
BEVERLEY COVE
1 km

mélange. At Beverley Head a ridge of volcanic and plutonic rocks parallels the coastline (Fig. 2.). East of this ridge, there is a gradual incline to the highlands of North Arm Mountain.

Most glacial processes have merely emphasized local bedrock distributions and structural trends.

Pleistocene wave-cut terraces and sea stacks are elevated about 15 to 20 m above present sea level, thus providing excellent coastal exposures, particularly northeast of Trout River Village and at Beverley Head (Twenhofel, 1912).

The field-area has a maritime climate with moderate to strong prevailing southwesterly winds and frequent rainfall. Average temperatures during the Newfoundland field season are approximately 10°C (night) and 20°C (day).

1.5 Survey Control

Topographic maps (at 1:50,000) published by the Surveys and Mapping Branch, Department of Energy, Mines and Resources, provided a base for locating the pertinent rock units. Aerial photographs (1:15,840) were enlarged twofold to an adequate scale for detailed mapping. The resultant mapping scale, and the scale of Plate 1. is 1:7,920 (1 inch = 1/8 mile, or 2.5 cm = 200 m).

1.6 The Geological Evolution of Western Newfoundland

The Skinner Cove Formation and Little Port Complex igneous/metamorphic rocks occur in western Newfoundland at the northeastern termination of the North American Appalachian structural province.

The geology of the Newfoundland Appalachians was interpreted by Williams (1964) as a two-sided symmetrical system consisting of a mobile belt in an axial position between stable platforms to the east and west. Numerous revisions and refinements have since occurred in the zonal subdivision (*i.e.* Church and Stevens, 1971; Williams *et al.*, 1972*a*, 1974; Williams, 1978) and the scheme of Williams (1978) is adopted here. From west to east, the zones are the Humber, Dunnage, Gander and Avalon. The geological evolution of the Humber and Dunnage Zones is intimately related to the genesis of the Skinner Cove Formation and the other transported rocks in western Newfoundland. Therefore the geological evolution of these two zones is briefly reviewed here.

The Humber Zone encompasses the Great Northern Peninsula (Figs. 1a., 3.) and those areas west of the Baie Verte Lineament (Fig. 3.).

In the Proterozoic (Hadrynian), rupturing of Grenvillian metamorphosed continental basement (Fig. 3.) signaled the imminent break-up of the 'stable' North American craton and the formation of the Iapetus Ocean (Williams and Stevens, 1974). The intial stage of continental break-up was dominated by crustal warping and vertical tectonics, which played vital roles in the development of horst-and-graben basement topography. Thick sequences of coarse immature clastic sediments (*e.g.* Fleur de Lys Supergroup, Fig. 3.), accumulated in the newly formed basins, especially at the eastern part of the Humber Zone. The Precambrian to Lower Cambrian sediments exhibit increasing maturity from stratigraphic base to top and east to west, indicating a Cambrian marine transgression onto the crystalline basement to the west. This sedimentary sequence is thought to represent a continental rise prism (Stevens, 1970; Williams and Stevens, 1974).

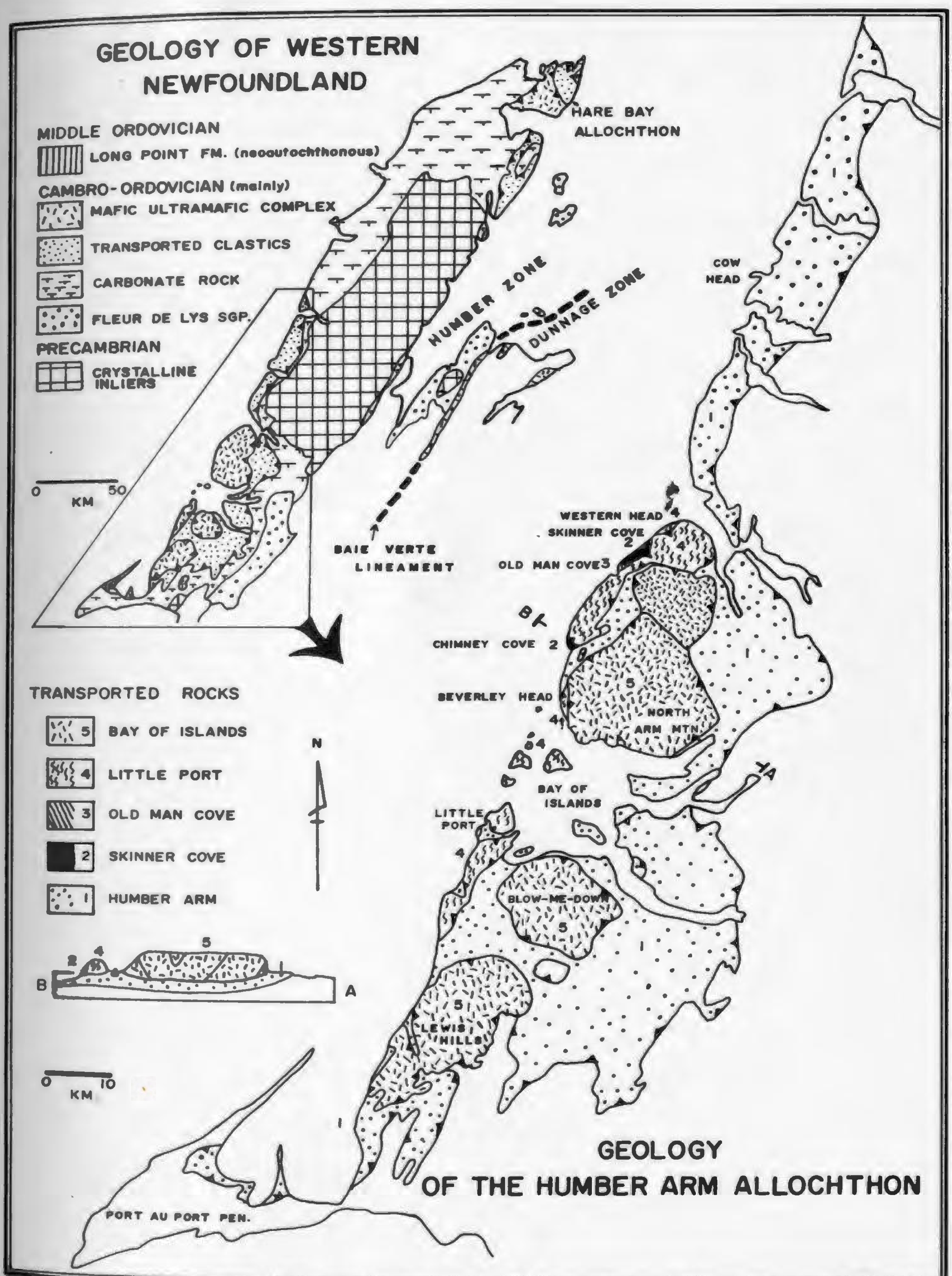
Rift facies tholeiitic dykes and coeval mafic flows (Lighthouse Cove Formation) are closely associated with the gneissic crystalline basement and mature clastic sediments (*e.g.* Bradore and Bateau

Figure 3. Geologic maps of west-central and western Newfoundland

upper left: Geology of western Newfoundland

lower right: Geology of the Humber Arm Allochthon

maps are adapted from Williams (1975)


GEOLOGY OF WESTERN NEWFOUNDLAND
MIDDLE ORDOVICIAN
LONG POINT FM. (neoautochthonous)
CAMBRO-ORDOVICIAN (mainly)
MAFIC ULTRAMAFIC COMPLEX
TRANSPORTED CLASTICS
CARBONATE ROCK
FLEUR DE LYS SGP.
PRECAMBRIAN
CRYSTALLINE INLIERS
0 KM 50
HARE BAY ALLOCHTHON
HUMBER ZONE
DUNNAGE ZONE
BAIE VERTE LINEAMENT
TRANSPORTED ROCKS
5 BAY OF ISLANDS
4 LITTLE PORT
3 OLD MAN COVE
2 SKINNER COVE
1 HUMBER ARM
N
B A
0 KM 10
COW HEAD
WESTERN HEAD
SKINNER COVE
OLD MAN COVE
CHIMNEY COVE
BEVERLEY HEAD
NORTH ARM MTN.
BAY OF ISLANDS
LITTLE PORT
BLOW-ME-DOWN
LEWIS HILLS
PORT AU PORT PEN.
GEOLOGY OF THE HUMBER ARM ALLOCHTHON

Formations) of Late Precambrian and Cambrian age (Williams and Stevens, 1969; Strong and Williams, 1972). It may therefore be that the Skinner Cove Formation is an alkaline volcanic suite related to early continental rifting and is analagous to the present-day Afar volcanism. The various environments for the other different rock suites will be outlined in later chapters.

Middle Ordovician and older carbonate rocks (*e.g.* Forteau, St. George, Table Head Formations) that conformably overlie the Cambrian clastic sediments are interpreted as a carbonate platform constructed at the continental margin. These carbonates grade upward and eastward into shales.

The Dunnage Zone (Fig. 3.) has a different geological setting from that of the Humber Zone to the west. However, the two zones were interrelated during their evolutionary stages. To be more precise, the Cambrian to Lower Ordovician history of the Humber Zone is interpreted as the constructional phase of a continental margin, whereas the Early Paleozoic rocks of the Dunnage Zone record the evolution of an ocean basin and the construction of subduction-related volcanic islands (Kean and Strong, 1975).

The continental margin was progressively destroyed in the Lower and Middle Ordovician as a direct result of the closing of the Iapetus Ocean basin. The ensuing events and interactions between the Humber and Dunnage Zones are those attributed to the Taconic Orogeny.

At the end of the Lower Ordovician, widespread instability at the continental margin is recognized by uplift and development of karst topography across the platform carbonates, followed by deep subsidence. The subsidence coincided with the deposition of westerly transgressing immature sediments. Locally, these sediments contain ophiolite detritus, thus suggesting the subaerial exposure of ophiolite to the east (Stevens, 1970).

Williams (1975) has suggested that the Skinner Cove Formation formed at the juncture between the continental margin and oceanic crust (*i.e.* essentially the Humber and Dunnage Zones) during or just before the obduction of ophiolite onto the continental margin.

Two large allochthons of the Humber Zone are known as the Humber Arm and Hare Bay Allochthons (Fig. 3.). The allochthons structurally overlie autochthonous easterly derived flysch and continental margin platform carbonates. Both allochthons consist of a series of contrasting lithologies, which occur in separate structural units. The Late Precambrian to Middle Ordovician clastic sequences that comprise the lowest and most areally extensive structural units in each allochthon consist of continental margin sediments. Each successively higher structural unit is interpreted as having travelled farther from the east. The obducted ophiolite (interpreted as oceanic lithosphere) and accompanying structural rock units, including the Skinner Cove Formation, were assembled at or immediately basinward of the continental margin prior to their emplacement upon lower sedimentary units.

Williams *et al.* (1977) and Williams (1977) report the occurrence of 'ophiolite mélange' in the Birchy Complex of the Fleur de Lys Supergroup. The Birchy and Fleur de Lys rocks are interpreted to have been undeformed continental margin sediments prior to the formation of mélange. The polyphase deformation of the Fleur de Lys and the incorporation of ophiolite blocks into Birchy Complex sediments (*i.e.* mélange development) probably represents the westerly movement of ophiolite and possibly volcanic arc suites structurally above continental margin sediments. Therefore, the ophiolites of west Newfoundland probably originated east of the Fleur de Lys terrane and Baie Verte Lineament (*i.e.* they were generated in the Dunnage Zone) (Fig. 3.).

The sediments of the neoautochthonous Long Point Formation of Middle Ordovician age unconformably overlie transported sediments at Port au Port Peninsula (Fig. 3.) and their age thus provides a lower limit for the time of final emplacement of the Humber Arm Allochthon.

1.7 History of Geological Investigation

Johannes Troelsen (1947) worked on the stratigraphic, paleontologic and structural relationships in the Bonne Bay and Bay of Islands areas. He introduced the name 'Skinner Cove Volcanics' for a distinctive suite of volcanic rocks represented only in narrow fault blocks east of the Gulf of St. Lawrence. The formation was considered to be distributed as follows:

> "A small block found north of Brake Cove,...between Brake Cove and Trout River (Village). .... and a vertical block of tuffs and lavas forms the coast for a few hundred feet north of Chimney Cove Head." (Troelsen, 1947, p. 106)

According to Troelsen, the Skinner Cove Volcanics consist of tuff, pillowed and massive lavas, lava breccias, porphyritic andesite tuff, dolomite and minor shale. The total thickness of the Skinner Cove Volcanics in the fault block between Brake Cove and Trout River Village was estimated at about 3,500 feet (1.06 km) with an average dip of 66 degrees to the southeast.

Before Troelsen's studies, numerous workers including Richardson (1862), Howley (1907), Schuchert and Dunbar (1934), Ingerson (1935), and Cooper (1936), all noted the presence of trachyte, agglomerate, lavas, etc., between Trout River Village and Bonne Bay (Fig. 1b.).

The geologists mentioned above (also Weitz, 1953) believed that the large mafic and ultramafic plutons in the Bay of Islands area (defined as the Bay of Islands Complex by Cooper, 1936) intruded the regional sedimentary terrane and fed nearby volcanic units.

In his regional mapping study, Smith (1958) delineated the plutonic rocks and assigned them to the Bay of Islands Igneous Complex. This complex included the plutons of the Bay of Islands Complex as defined by Cooper (1936), but it also encompassed the gabbros and other plutonic rocks that crop out along the Gulf of St. Lawrence. However, instead of feeding volcanic groups like the Skinner Cove, the Bay of Islands Igneous Complex was interpreted to have intruded them and likewise the surrounding sedimentary terrane (Smith, 1958, p. 9).

Johnson (1941) and Kay (1945) first suggested that the clastic sedimentary rocks in the Bay of Islands area represented a stratigraphic sequence that was initially transported, then intruded by the Bay of Islands plutons. Troelsen (1947, p. 114) suggested the following (parentheses contain minor clarifications of Troelsen's nomenclature):

> "In view of the fact that the post-Ordovician thrust faulting must have greatly shortened the original width of the belt occupied by the Humber Arm Group (*i.e.* rocks of the Humber Arm Supergroup) it is conceivable that the two formations were laid down simultaneously in different parts of the same sea and that later faulting has brought strata of the typical South Arm formation (*i.e.* a sedimentary formation of Troelsen's Humber Arm group) into contact with volcanics of the Skinner Cove formation."

Although Troelsen's "post-Ordovician" timing of thrusting is now known to be incorrect for the emplacement of the transported terrane, our present-day interpretation is remarkably similar to his.

Rodgers and Neale (1963) argued that the entire sedimentary/igneous/metamorphic terrane in the Humber Arm area might represent a transported sequence similar to the classic Taconic region of the New England Appalachians. The intrusion of the mafic/ultramafic plutons into the regional terrane was considered by them to have predated transport.

Advances in plate tectonic theory during the late 1960's allowed Church and Stevens (1968, 1971) and Stevens (1970) to interpret the rocks in the Bay of Islands area as Taconic klippen presently distributed in composite thrust sheets. The Bay of Islands Igneous Complex was interpreted as ophiolite (possibly oceanic lithosphere) positioned structurally above transported clastic sediments. This entire succession, termed the Humber Arm Allochthon (Stevens, 1970), was interpreted to structurally overlie an autochthon consisting of flysch, carbonates and basement gneiss.

Williams (1973, 1975) recognized the systematic stacking order of the transported structural units (see also Chapter 2) and was able to isolate and name five separate structural units. Williams (1973) re-named the Skinner Cove Volcanics of Troelsen (1947) the 'Skinner Cove Formation' to conform to his revised nomenclature. The nomenclature of Williams (1973) is followed throughout this work with only minor revisions.

Comeau (1972) outlined the distribution of the rocks in the vicinity of Little Port (Fig. 1b.) and called them the Coastal Complex; a name recently revised to the Little Port Complex (Williams, 1973). The newly defined Little Port Complex was previously included as part of the Bay of Islands Igneous Complex of Smith (1958). Williams (1973) and Williams and Malpas (1972) suggested that the rocks of the Little

Port Complex are different from those of the Bay of Islands mafic/ultramafic massifs, so they divided the Bay of Islands Igneous Complex of Smith (1958) into the Bay of Islands Complex and the Little Port Complex.

Strong (1974) presented petrochemical and petrographic data on the rocks of the Skinner Cove Formation (northeast of Trout River Village) and attributed their origin to 'off-axis' alkalic volcanism (*i.e.* volcanism removed from the spreading axis of the Cambro-Ordovician ocean basin of which the Bay of Islands Complex is a relic).

As part of a study of the petrogenesis of the Bay of Islands Complex, Malpas (1976) briefly reviewed some of the rock types in the Skinner Cove Formation, but he essentially re-stated the views of Strong (1974) regarding their genesis.

Karson and Dewey (1978) did two 'geotraverses' in the Bay of Islands area. The one of special concern to this study is called the Trout River Section. Within this section, field descriptions of the rock types of the Skinner Cove Formation at its type area are briefly reviewed.

CHAPTER 2

REGIONAL GEOLOGICAL SETTING OF THE SKINNER COVE FORMATION

The Skinner Cove Formation forms an integral part of the Humber Arm Allochthon and lies in a constant structural position with respect to all other transported rock groups.

The Humber Arm Allochthon is a composite unit composed of five contrasting rock groups (Fig. 3.) as outlined in Chapter 1. Each rock group is defined and separated from all other rock groups by differences in lithology, stratigraphy, metamorphism, deformation and structural position within the transported sequence. The five groups have each been given the formal stratigraphic status of either formation, complex or supergroup (Stevens, 1965, 1970; Williams, 1973). Each group of lithologies forms one or more separate structural 'slices' and has a constant structural position with respect to underlying and overlying rock groups within the allochthon (Williams, 1973, 1975).

The lower structural slices consist of clastic sedimentary rocks with some limestone and volcanic rocks. These are overlain structurally by a varied sequence of igneous/metamorphic lithologies.

A structural stacking order of the lithic units within the Humber Arm Allochthon has been interpreted as the result of westward compressive telescoping with the lowest structural slices derived from a continental slope and successively higher structural slices representing a sampling of more oceanward terranes (see also section 1.6).

The sediments of the lower structural slices are known as the Humber Arm Supergroup (Stevens, 1970) and its stratigraphic succession has been worked out at Humber Arm (Fig. 1a.). The Skinner Cove Formation, Old Man Cove Formation, Little Port Complex and the Bay of Islands Complex are the structurally high slices composed of igneous/metamorphic rocks (Williams, 1973) (Fig. 3.).

The Humber Arm Supergroup is characterized by three stratigraphic lithofacies. The lowest unit (Summerside Formation) is a thick sequence of quartzofeldspathic flysch containing westerly derived Precambrian continental detritus. The middle unit is a condensed sequence of shale, dolomite, and carbonate breccia (Cooks Brook Formation). These latter rocks are interpreted as distal equivalents of the coarse Cow Head Group carbonate breccias deposited at the foot of the Cambro-Ordovician carbonate bank (Stevens, 1970). The uppermost unit (Blow-Me-Down Brook Formation) comprises easterly derived quartzofeldspathic flysch with massive arkose, graywacke and shale beds. The Blow-Me-Down Brook Formation contains sparse ophiolite detritus (chromite and serpentinite), which is interpreted as indicating the subaerial exposure of oceanic crust to the east.

The Skinner Cove Formation is the lowest igneous/metamorphic structural unit in the Humber Arm Allochthon and is represented in at least three separate slices in the thesis area. It consists of undeformed mafic to felsic lavas, dykes and volcaniclastic strata, which are metamorphosed to the zeolite facies. The geology of Skinner Cove Formation is the primary subject of this work and will be described in detail in later chapters.

The Old Man Cove Formation (Fig. 3.) is a small slice of polydeformed greenschists with minor calcareous lenses. The slice is cut by brecciated, but otherwise undeformed mafic dykes. The rocks may represent schists similar to those of the Birchy Complex of the Fleur de Lys Supergroup (Williams *et al.*, 1977; Williams, 1977). The Old Man

Cove Formation may well be a dynamothermal aureole to the Little Port Complex, in which case it should be considered an integral part of that complex (Malpas, 1976).

Detached slices of igneous/metamorphic rocks near Little Port (Figs. 1b., 3.) were known previously as the 'Coastal Complex' (Comeau, 1972). Williams (1973) re-named these igneous/metamorphic rocks at Little Port and similar but more continuous rock slices north of the Bay of Islands, as the Little Port Complex (Fig. 3.). The Little Port Complex is a polygenetic rock sequence comprising deformed and undeformed mafic plutonic rocks, amphibolites, minor ultramafic rocks, plagiogranites, and undeformed but brecciated mafic dykes and extrusive rocks. Slices of the Humber Arm Supergroup, Skinner Cove and Old Man Cove Formations are everywhere structurally overlain by slices of the Little Port Complex. The origin of the Little Port Complex is problematical and portions of this thesis bear on its possible significance. The Little Port Complex is variously interpreted as a rift facies igneous suite (Comeau, 1972), a volcanic arc terrane (Williams and Payne, 1975), an accretionary mélange (Stevens, pers. communication with Malpas, in Malpas, 1976), or possibly oceanic lithosphere affected by transform faulting (Karson and Dewey, 1978).

The most thoroughly studied rocks of the Humber Arm Allochthon are those of the Bay of Islands Complex (Fig. 3.) (Malpas, 1976). This group of rocks consists of a complete ophiolite suite with attached dynamothermal metamorphic aureole (Williams and Smyth, 1973). All of the mafic and ultramafic massifs (*i.e.* slices) of the Bay of Islands Complex are interpreted as obducted oceanic lithosphere (Church and Stevens, 1971).

The massifs of the Bay of Islands Complex (Table Mountain, North Arm Mountain, Blow-Me-Down Mountain, and Lewis Hills) are clearly superposed above slices of the Humber Arm Supergroup, and the first three massifs mentioned would presumably have overridden slices of Skinner Cove Formation, Old Man Cove Formation and/or the Little Port Complex had they travelled slightly farther west (Fig. 3.).

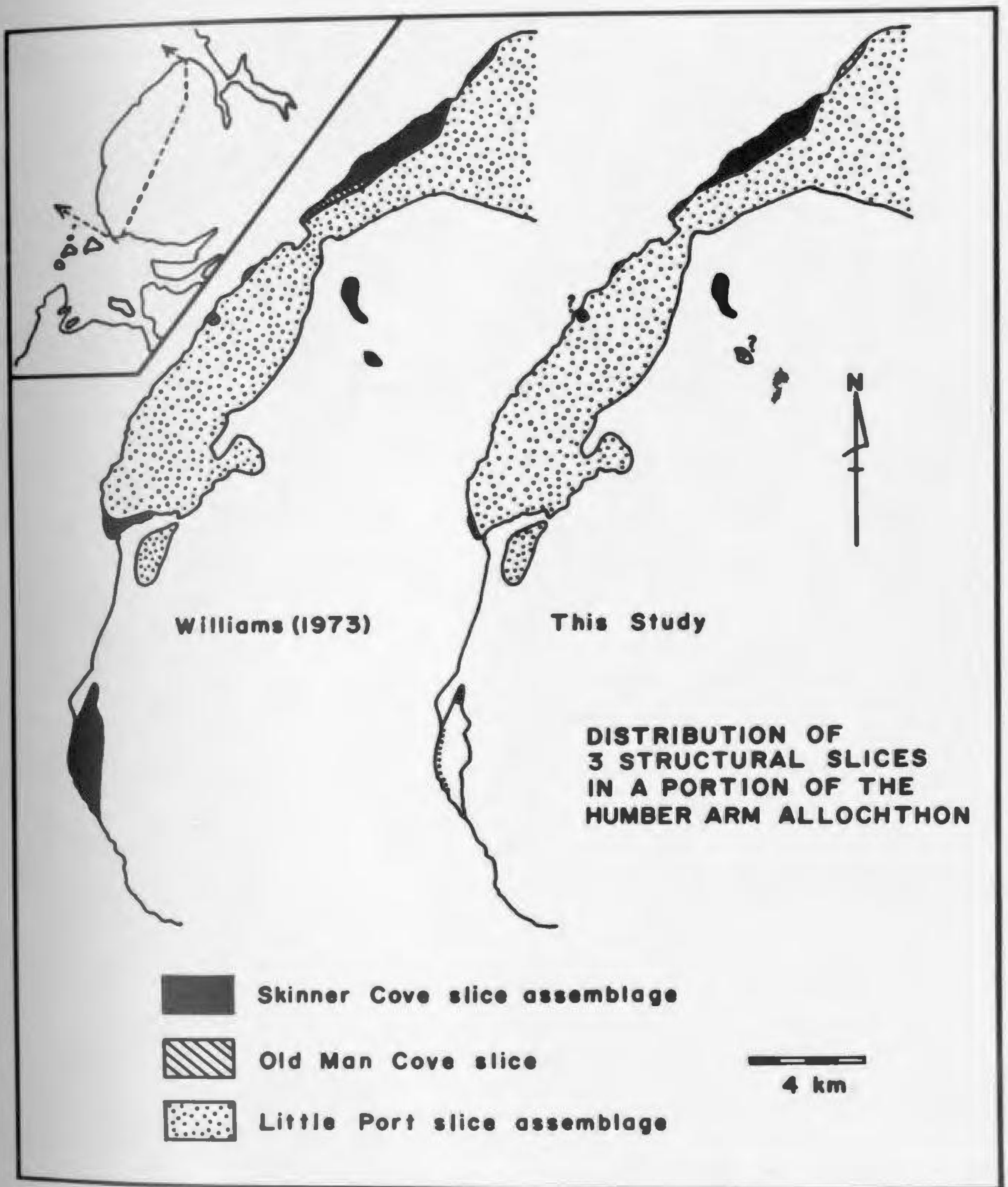
2.1 Definition of Slice Assemblage and a Revised Nomenclature for the Skinner Cove Slice Assemblage

The term 'structural slice' is intuitively simple to grasp and is explained at the beginning of Chapter 2.

Williams (1973) has introduced a scheme of classification and nomenclature for the contrasting lithic groups and structural slices that comprise the Humber Arm Allochthon. Slices composed of the same rock group (or formation, complex, supergroup) are referred to as a 'slice assemblage'. Thus the five lithic groups recognized in the Humber Arm Allochthon define four slice assemblages and one slice (the Old Man Cove Formation is represented in only a single slice). Each slice assemblage bears the name of its comprising rock group (*e.g.* Skinner Cove slice assemblage).

According to Williams (1973), rocks of the Skinner Cove Formation are represented in five separate structural slices (and as knockers in mélange), collectively known as the Skinner Cove slice assemblage (Fig. 4.). The detailed field observations and laboratory work of this study indicate that the Skinner Cove slice assemblage is not as extensive as suggested by the reconnaissance work of Williams (1973) (Fig. 4.). The major slices of the Skinner Cove slice assemblage have now been mapped and their boundaries and contact relationships with nearby slices are

Figure 4. Maps showing the older (Williams, 1973) and revised (this work) interpretations of the distribution of three structural slices in a portion of the Humber Arm Allochthon.


N
Williams (1973)
This Study
DISTRIBUTION OF
3 STRUCTURAL SLICES
IN A PORTION OF THE
HUMBER ARM ALLOCHTHON
Skinner Cove slice assemblage
Old Man Cove slice
Little Port slice assemblage
4 km

all sharply defined. The writer therefore proposes a set of slice names for the slices previously referred to as the Skinner Cove slice assemblage (Williams, 1973). The proposed names are outlined in Figure 2. and listed in Table 1. Two of these slices (Western Head and Beverley Head) have chemical and lithic characteristics more akin to rocks of the Little Port than to rocks of the Skinner Cove Formation in its type area. Only the 'coastal' rocks north of Chimney Cove are defined as part of the Skinner Cove slice assemblage. The newly proposed slice names (Table 1.) are used throughout this thesis, but it must be realized that assignment of some rocks from the Skinner Cove Formation to the Little Port Complex is based on data to follow. The structural stacking scheme of Williams (1973, 1975) is not significantly changed by the above revisions.

Table 1.

Proposed structural slice names

slice number in Fig. 2.	slice name	affinity to igneous rocks of the Humber Arm Allochthon
1	Trout River	Skinner Cove Formation
2	Western Head	Little Port Complex
3	Chimney Cove	Skinner Cove Formation
4	Beverley Head	undefined (*i.e.* contains definite components of the Little Port Complex and Humber Arm Supergroup. Possible Skinner Cove Formation is present)

2.2 Age of the Skinner Cove Formation

Williams (1973) recognized that the Skinner Cove slice assemblage is separated by mélange from higher and lower slices (*i.e.* Little Port, Bay of Islands, and Humber Arm slice assemblages, respectively), thus indicating that the Skinner Cove Formation is an integral part of the

Humber Arm Allochthon. He therefore assigned the Skinner Cove Formation a Lower Ordovician age (Williams, 1973 map 1355A).

Blocks of sedimentary rocks from a chaotic zone located at Brake Cove (Plate 1.) have yielded a Late Cambrian to Lower Ordovician brachiopod fauna (*Acrothretaceans ced.*, H. Williams, pers. communication with A. Berger, 1973). Unfortunately, the displaced nature of the rocks was not recognized when the fossils were discovered by A. Berger. Clarification of the precise fossil locality (A. Berger, pers. communication, 1976) and further field work by the writer and H. Williams indicate that the fossils are actually located in a mélange zone between juxtaposed structural slices of the Skinner Cove Formation and Little Port Complex. The mélange contains bedded carbonates, sandstone, shale, chert and volcanic rocks of known and unknown slice assemblage affinity, all chaotically suspended in a foliated black shale matrix. Therefore, the brachiopods cannot be assumed to date the Skinner Cove Formation (*i.e.* the Trout River slice).

Without this prior knowledge of the precise setting of the fossil locality, Strong (1974), Williams and Stevens (1974), Williams (1975), Malpas (1976), and Karson and Dewey (1978) all quoted or referred to the brachiopod date as the age of the Skinner Cove Formation. Strong (1974) made reference to the Late Cambrian to Lower Ordovician brachiopod date and also presented a Middle Silurian (432 ± 6 m.y.) K/Ar date on an altered scoriaceous basalt from the Trout River slice. The apparent age discrepancy was attributed to K/Ar updating "...by some later event the effects of which are not otherwise evident." (Strong, 1974, p. 303).

A new graptolite locality was found by G. Langdon, H. Williams and the writer during the initial stages of field work. The locality is within black shale and chert slabs in the mélange at Brake Cove (Plate 1.). A faunal list follows (Table 2.) (fossil identifications by D. Skevington; written communication to H. Williams, 1976):

Table 2.

Graptolite fauna located in shale/chert beds in a mélange at Brake Cove

fauna	relative frequency of occurrence
? Bryograptus sp.	rare
Tetragraptus approximatus (Nicholson)	rare
Tetragraptus sp., pendent form	rare
Didymograptus ? extensus (J. Hall) stipe fragments only	few
Didymograptus ? nitidus (J. Hall) stipe fragments only	few
Didymograptus nitidus/patulus, transients	common
Didymograptus patulus (J. Hall)	very common

The graptolite fauna indicate a lower Arenig (Lower Ordovician) age for the shale blocks. As is the case with the brachiopods, the graptolites do not date the Skinner Cove Formation, but they provide a lower age limit (Lower Arenig) for the emplacement of the Trout River slice, assuming there has been no major structural disturbance since the initial Ordovician transport.

Massive, stylolitized and recrystallized limestone from the Chimney Cove slice contains fossil debris evident in thin section. The fossils are tentatively identified as bivalves (N. James, pers. communication, 1977) with the additional possibility of some trilobite fragments. The presence of these fossils in limestone from a predominantly igneous/

metamorphic slice may warrant more detailed sampling at the same locality. A sample of the limestone failed to yield conodonts.

There are no reliable radiometric or fossil dates on competent rocks of the Skinner Cove Formation, thus the formation must be dated using indirect geological evidence. The present study indicates that volcanic knockers in a mélange near Trout River Village (sample locality of TR-7, 12 and marked by an 'X' on the index map in Fig. 2.) have alkaline affinities, implying they are detached slabs of Skinner Cove Formation. Since the knockers are contained in mélange, in turn interpreted as the result of Middle Ordovician structural transport, then the Skinner Cove Formation must be pre-Middle Ordovician in age. This reasoning is the same as that of Williams (1973) and mentioned in the first paragraph of this section.

CHAPTER 3

GEOLOGY OF THE SKINNER COVE FORMATION AND POSSIBLE RELATED ROCKS

The internal structure, contact relations, field descriptions of the lithologies, petrography and the geological significance of each newly defined structural slice is presented here. These features are outlined in particular detail for the Trout River slice because it is the type area and contains the best stratigraphic section of the Skinner Cove Formation.

There are several geological features common to every structural slice investigated. Firstly, the main portion of each slice consists of competent rocks arranged in strata, which acted as a unit during its transport and emplacement.

Secondly, between juxtaposed structural slices there is a mélange (*i.e.* a mixed or chaotic zone) of variable width, which consists of blocks suspended in a matrix. The blocks or 'knockers' are rocks contributed from the juxtaposed slices, clastic sedimentary rocks from the Humber Arm Supergroup, and exotic blocks. Mélange matrices are mainly shales of the Humber Arm Supergroup and sheared and finely comminuted lithologies from the juxtaposed slices. The structural slices moved on these mélange surfaces during emplacement. Presumably then, the mélange was under very high hydrostatic pressures during movement.

Thirdly, each slice contains a 'disrupted' zone near the mélange contact, where the competent strata of the slice are structurally re-arranged or rotated without the aid of a lubricating matrix. In most places this disrupted zone is gradational into mélange.

3.1 Geology of the Trout River Structural Slice

The Trout River slice (Fig. 2., Plate 1.) is the type area of the Skinner Cove Formation. It contains the best stratigraphic sections and the widest variety of lithologies of all the structural slices investigated.

The internal structure of the Trout River slice is relatively simple. Approximately 0.8 km thickness of well-bedded volcaniclastic rocks and lava flows strike northeast and face and dip (70 degrees average) southeast. Williams (1973) interpreted the section as overturned (*i.e.* dipping southeast and facing northwest), but most facing criteria support the re-interpretation given above.

The Trout River slice is devoid of penetrative deformation. Primary flattening resulting from compaction of tuff and lapilli fragments in volcaniclastic beds is not unusual and at first glance give the false impression of a planar tectonic fabric. Sedimentary slumping of a thick tuffaceous unit (Plate 1., stratigraphic section (D-D')) reveals complex irregular folding, brecciation and pervasive hematization and carbonatization. This deformation, however, is restricted to the single tuff unit.

Deformation is evident within the Trout River slice only at the major contact between the overlying structural slice of Little Port/Old Man Cove to the southeast (Plate 1.). A discussion of these contact relationships follows.

3.1.1 Contact relationships

The southwestern contact of the Trout River slice is a high-angle, northeast striking, east dipping (at 70 degrees) fault (Plate 1., lower left hand inset). This fault juxtaposes the Trout River slice against the higher slices of Little Port/Old Man Cove (Plate 2.) and is interpreted as a mélange zone (or, in Karson and Dewey's 1978 terminology: "zone of high strain"), which formed at the time of assembly and during the emplacement of the transported slices.

The mélange is about 60 m wide and may be divided into two mutually gradational segments. The first extends about 30 m north from the contact into the Trout River slice (Plate 1., inset). This zone consists of fine-grained buff limestone beds, blue-gray chert, and volcanic knockers suspended in a foliated black, green and red shale matrix. Trachyte and pyroxene-phyric basalt (the latter contains lineated pyroxenes) native to the Trout River slice are brecciated and enveloped by the foliated shale matrix.

Shales near the contact have two main deformations; the first is represented as a strong foliation which trends parallel to the strike and dip of the main contact. The long axes of competent knockers are rotated parallel to this same foliation. A second deformation produces irregular folds that effect foliation in the matrix shales (Plate 3.). Amplitudes of 2 to 3 cm are noted in small scale chevron folds of this second deformation.

Mélange at the northeastern contact is best exposed at Brake Cove (Plates 1. and 4.). It is about 150 m wide and consists of a mixture of the following rock types all suspended in a folded and foliated black shale matrix:

(1) 40 to 50 m knockers of mafic volcanic rocks

(2) 2 m knockers of fine-grained, reddish-brown, thinly bedded limestone

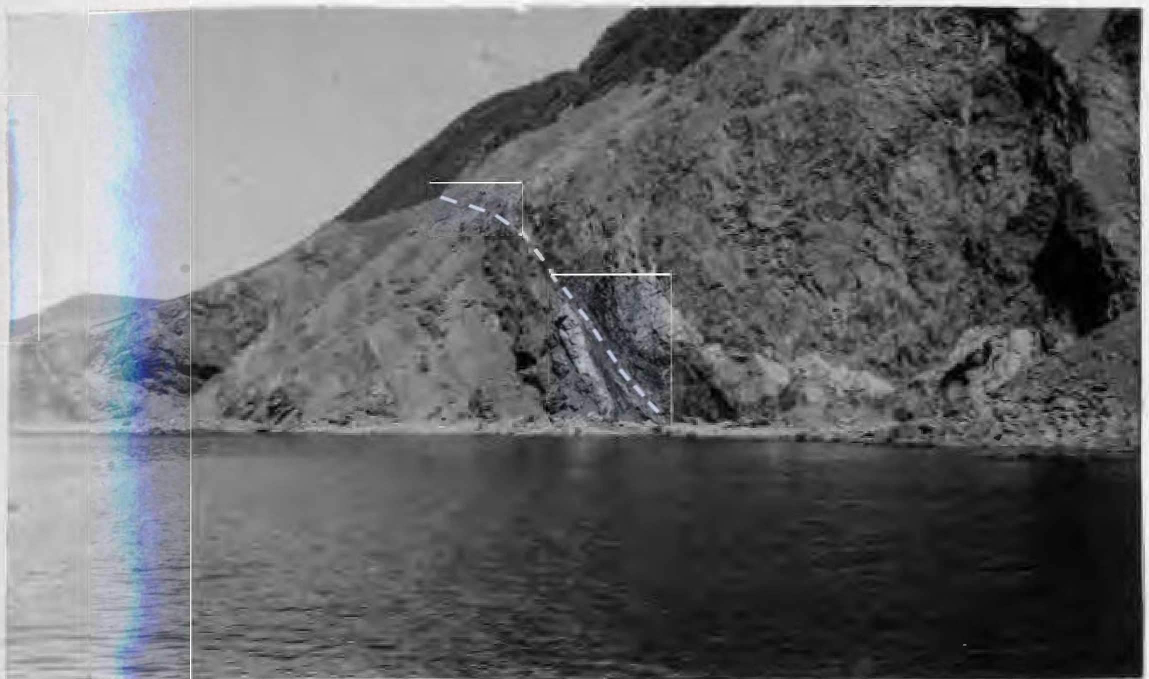


Plate 2. The high-angle structural contact between the Trout River slice (left of dashed line)and the structurally overlying Old Man Cove/Little Port rocks (right of the line) is shown. (see also Plate 1. for geology).

Plate 3. Irregular folding in the shales of the mélange, located at the southwest contact of the Trout River slice (precise location is along the dashed line in Plate 2.).

(3) 10 m knockers of coarsely crystalline, medium-bedded limestone (*i.e.* marble) rich in volcaniclastic detritus. The margins of these knockers are broken. The black shale 'matrix' is squeezed into fractures in the carbonate, thereby isolating marble clasts and giving the overall false appearance of a primary breccia (Plate 4.). This carbonate unit failed to yield conodont microfossils.

(4) graptolitic black shales interbedded with chert form small slabs suspended in the shale matrix

(5) 2 m knockers of red, laminated, fine-grained sandstone adjacent to the structural contact have the appearance of the Devonian Clam Bank Formation (R. K. Stevens, pers. communication, 1976).

The mélange terminates abruptly in a vertical fault, which juxtaposes foliated Little Port gabbros against shales of the mélange (the shales within 3 or 4 m of this contact are rich in serpentine).

South of Skinner Cove along Wallace Brook the contact is ill-defined. Poor exposures of foliated Humber Arm Supergroup shale and Little Port actinolite/zoisite-bearing gabbros intervene between breccias of the Trout River slice to the north and south (Plate 1.), suggesting mélange and/or local imbrication.

Monzonitic intrusive rocks (Plate 1., '2b' along Wallace Brook) are interpreted as knockers. They consist of equidimensional, interlocking albitized plagioclase, primary apatite and clinopyroxene, and an abundant alteration assemblage of low albite, chlorite, sphene, pumpellyite, and opaque minerals. The clinopyroxenes of this rock have strong chemical affinities with those in the mafic rocks of the Trout River slice (see Chapter 6). This monzonite is precisely similar to a lithology at

Plate 4. Limestone knockers and brecciated limestone in the mélange at Brake Cove. The smaller knockers to the left are about 1 metre across. Graptolite and brachiopod localities are in this area.

Plate 5. Mafic pillow lava and coeval dykes. The more massive unit in the centre of the photo is likely a coeval sill. The scale is at the lower right of the sill. Unit a, Main Sea Stack Member.

the northern extremity of the Beverley Head slice (section 3.4, Plate 30.). The entire zone is considered an extension of the mélange best exposed at Brake Cove, even though a shale matrix is not seen and the boundaries of the knockers are poorly defined. The structural contact from Wallace Brook west-southwest to Red Fire Brook (Plate 1.) is nowhere exposed, but its position is interpreted on the basis of a pronounced topographic depression between adjacent highlands (Fig. 2.).

3.1.2 Volcanic stratigraphy

Many of the lithologies of the Trout River slice are spectacular from a volcanological point of view. To the knowledge of the writer, ankaramite, trachyte, and 'peperite' breccias (Carozzi, 1960) of Ordovician age have never been described elsewhere in the Appalachian Orogen. Therefore it seems reasonable to present a detailed account of the stratigraphy. In this summary, the rock nomenclature of Fisher (1966) and Parsons (1969) is adopted.

The interpretation of lithic sequences is hindered by rapid lateral facies changes, as are common in recent volcanic terranes. Subaqueous paleotopographic depressions and ridges probably had a great influence on the rate and thickness of volcaniclastic accumulations. Penecontemporaneous deposition and erosion of unstable volcanic debris resulted from localized tectonic disturbances. Minor vertical faulting is restricted to several beds and probably indicates re-adjustment to local post-depositional instability.

Rocks of the Trout River slice are divided into three members: (1) the Main Sea Stack Member has the lowest exposed strata, although its base and top are nowhere exposed, (2) the Wallace Brook Member overlies the Main Sea Stack Member; its top is probably structurally omitted and its base is assumed to conformably overlie the Main Sea Stack Member, (3) the Red Fire Brook Member is composed of a single lithology; trachyte (or perhaps more precisely 'metatrachyte' or 'keratophyre'). It is the felsic end member of the Skinner Cove Formation (Trout River slice) igneous/metamorphic suite and occurs at the southwest portion of the slice. Trachyte is in a problematical stratigraphic position as it is not exactly known if it is an intrusive or partly extrusive body.

These rocks are defined as members for a variety of reasons:

(1) Beds or rock strata in each of the respective members form the type lithologies that define the Skinner Cove Formation. The recognition of these type lithologies in the field (and subsequent elucidation of mineralogical and geochemical compositions) may permit the identification of rocks of the Skinner Cove Formation elsewhere in the allochthon (*e.g.* in the more poorly understood Lewis Hills area).

(2) The strata comprising the members are the most continuous along strike, although they may show severe lateral facies changes (*e.g.* lateral coarsening, stratigraphic thinning, lateral change (*e.g.* massive pillow lava changing to pillow breccia), etc.).

(3) Grouping of the rocks into members facilitates the overall geological description of the Trout River slice.

The reader is referred to Plate 1. during the descriptions that follow.

3.1.2.1 Main Sea Stack Member

The Main Sea Stack Member is defined at section (B-B'). It is approximately 120 m in stratigraphic thickness and consists of ten beds at the type section. Components of the Main Sea Stack Member are continuously exposed from the Main Sea Stack (near section (C-C')), for 0.8 km southwest along strike. The stratigraphic base is nowhere exposed; the top consists of poorly exposed tuff, which is in assumed conformable contact with the overlying Wallace Brook Member. The following is a brief description of each bed of the member. Various interpretations for the members are given in section 3.1.2.5.

Section (B-B'), Plate 1.

Unit	thickness (m)
a	66^+

The base of a is unexposed. a consists of black to dark-brown mafic pillowed flows and coeval dyke intrusions (Plate 5.). Facing directions may be determined by three methods: 1) well developed cusps are located at the base of most pillows, 2) quenched pillow selvage detritus has spalled and collected at the stratigraphic base of interpillow regions, 3) truncation of interpillow graded bedding by stratigraphically higher volcaniclastic detritus. All methods indicate southeasterly directed tops. Fine-grained, sparsely plagioclase-phyric pillow lavas are generally round, have radial and concentric joint patterns, and are usually less than 1.5 m in maximum dimension. Pillow selvages consist of a 2 or 3 cm wide, light-green, fine-grained chloritic devitrification product which grades into darker cores.

a correlates with a' of section (C-C').

b	1

b is composed of alternating thin-bedded to finely laminated, reworked tuff and minor lapilli-tuff and is in sharp but conformable contact with the underlying unit a pillows (Plate 6.). Numerous sedimentary structures are evident (*i.e.* graded bedding, cross-lamination and scour structures, 'sandstone'

Unit thickness (m)

(*i.e.* tuff and lapilli) dykes and flame structures) and again indicate tops to the southeast. Coarser tuff (1 to 2 mm) and lapilli consist of flattened fragments of altered plagioclase- and clinopyroxene-phyric basalt and trachybasalt.

b correlates with b' of section (C-C').

c 9

c comprises medium- to thick-bedded, poorly sorted, light-green limy lithic lapilli-tuff to lapillistone (Plate 6.). It has a sharp conformable basal contact with limy lithic tuff (unit b). and is distributed from the headlands (Plate 5.) 250 m southwest of section (B-B'), northeast 700 m to the Main Sea Stack (Plate 7.) where it pinches out. Bedding is distinct but upper and lower bed contacts are in places diffuse and are usually denoted by zones of decreased frequency of lapilli and increased frequency of ash.

The least altered lapilli are aphyric, sparsely amygdaloidal basaltic fragments with much chlorite/opaque mineral mesostasis. Groundmass clinopyroxene is present. Calcite cements all lithic fragments.

c correlates with c' of section (C-C').

d 14

d is formed of dark-brown, hematized, amygdaloidal, tightly packed, pillowed trachybasalt flow. This sequence is conformable on underlying volcaniclastics; the upper contact is assumed to be conformable against another sequence of pillows at section (B-B'). In (C-C'), the pillow lava thins and eventually terminates in the Main Sea Stack (Plate 7.). Pillow breccia and aquagene tuff are lateral facies equivalents.

d correlates with d' of section (C-C').

e 5

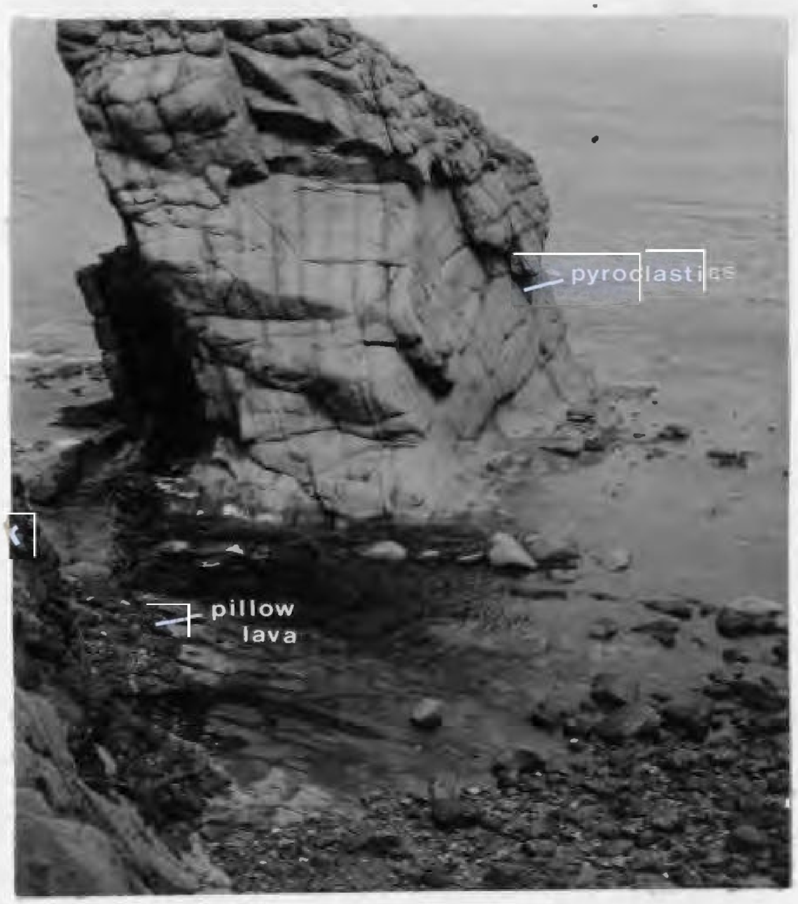
e consists of fine-grained, sparsely pyroxene-phyric pillowed trachybasalt. The pillowed flows are generally hematized and rubbly in outcrop. e is assumed conformable above d, and is itself conformably overlain by f. Unit e is laterally discontinuous.

Plate 6.

Pillow lavas (a), draped by reworked tuff (b), which is overlain by tuff and lapilli-tuff (c). The letters also designate the units in the Main Sea Stack Member

Plate 7.

The 'Main Sea Stack', containing bedded pyroclastics and pillow lava. Each bed is about 1 metre thick.



Unit	thickness (m)
f	9

f consists of mafic pillow breccia and a mixture of tuff, reworked tuff, and aquagene tuff. Pillow fragments are in places broken and isolated, and are similar to the breccias described by Carlisle (1963).

f is correlative with f' of section (C-C').

g	5

g is composed of indistinctly pillowed, densely pyroxene-phyric, amygdaloidal, coarse-grained, mafic lava. g is assumed to be conformable on pillow breccias of f and is conformably overlain by pillow breccia and/or heterolithic breccia. In places the mafic flow appears to have intrusive margins with the pillow breccia while in other areas rounded ankaramitic pillow shapes are evident.

Large (about 2 cm), black, fresh augite phenocrysts are suspended in a greenish-grey, fine-grained matrix.

g has no correlatives in (C-C'). Ankaramite lavas are found in the vicinity of section (B-B'), northeast of the mouth of Red Fire Brook, near the Trout River slice/Old Man Cove slice contact, and at the northeastern termination of the slice near Brake Cove. Ankaramitic to densely clinopyroxene-phyric breccia fragments are abundant in the stratigraphically higher beds of the Wallace Brook Member (see section 3.1.2.2).

h	4

h forms rubbly outcrops of pillow breccia and varying proportions of aquagene tuff and heterolithic volcanic breccia. h conformably overlies pillowed ankaramite and is conformably overlain by ankaramite southwest of section (B-B') and mafic pillowed flows in (C-C'). Clasts are mafic to intermediate in composition, aphyric, aphanitic, with a high density of calcite-filled amygdales. Rounded and subrounded clasts indicate pillow forms, whereas broken clasts likely represent the fracturing and reworking of pillows. Besides clast rounding, the heterolithic nature of the fragments (*i.e.* basalt to trachybasalt) suggests some reworking.

Unit thickness (m)

Similar rocks are best exposed in intertidal shelves 0.2 km west of section (B-B').

i 7

i is a hematized, amygdaloidal, mafic pillowed flow. Southwest of (B-B'), i pinches out and is replaced by ankaramitc lava similar to unit g. i conformably overlies heterolithic breccia, pillow breccia and ankaramite. Interpillow zones are everywhere calcite cemented.

i correlates with i' of section (C-C') where it attains a thickness of 48 m.

j 2

j is a green, friable, calcite-cemented mafic tuff and lapilli-tuff which conformably overlies mafic lavas of i and is assumed to conformably underlie unit a of the Wallace Brook Member. j correlates with j' of section (C-C') where it attains an approximate thickness of 12 m. Possible lateral correlations may be made with c and d of section (D-D').

cumulative exposed thickness 122 m

3.1.2.2 Wallace Brook Member

The Wallace Brook Member, defined along Wallace Brook near Skinner Cove (Plate 1., section (E-E')), consists of a thick (260+ m) series of fine- to very coarse-grained polygenetic fragmental volcanic rocks. Southeasterly dipping (at 70 degrees) and southeasterly facing beds outcrop in a coastal ridge that extends from Brake Cove 4.4 km southwest along strike to Red Fire Brook. Neither the base nor the top of the Wallace Brook Member is exposed and the stratigraphically highest breccias are probably juxtaposed against mélange and the structurally higher Little Port slice.

The Wallace Brook Member contains bedded and nonbedded, epiclastic and monolithic breccias with much interstitial calcite cement. In places, lime mud forms a matrix to a variety of volcanic fragments. The following is a description of the member and as for the previously described member, possible paleoenvironmental interpretations are given in section 3.1.2.5.

Section (E-E'), Plate 1.

Unit	thickness (m)
a	20^+

The base of a is unexposed; the top is gradational into unit b. a forms a sequence of monolithic, poorly sorted, medium- to thick-bedded volcanic breccia. Bedding is defined by an alternation of greenish chloritic-lithic bands. The volcanic clasts are predominantly aphyric to sparsely pyroxene-phyric. Disrupted but linear mafic bodies 2 to 3 m long and 0.5 m wide are probably dismembered dykes. Rounded to elliptical shapes and accompanying angular spalled chips may represent pillows and pillow breccia, respectively. 0.1 to 0.2 km southwest along the coast from Brake Cove, brown lime mud and volcaniclastic debris cements the mafic volcanic clasts (Plate 8.). This matrix limestone is bedded and consists of 10 to 20 per cent mafic lithic fragments and white calcite fragments, both set in lime mud. In thin section, the degree of recrystallization varies, but in places, regular rod-like shapes might represent 'ghosts' of organic material, perhaps sponge spicules (N. James, pers. communication, 1977). The (possible) organic-bearing reddish lime mud locally grades into recrystallized sparry calcite.

b	19.6

b grades upward from unit a and has a sharp upper contact with c. b is a poorly sorted, heterolithic, epiclastic volcanic breccia. Reddish, mafic, plagioclase-phyric clasts occur with mafic amygdaloidal, sparsely olivine-phyric clasts.
Mafic scoriaceous fragments have calcite-rich amygdales with lesser amounts of chlorite. Clasts are everywhere set in a

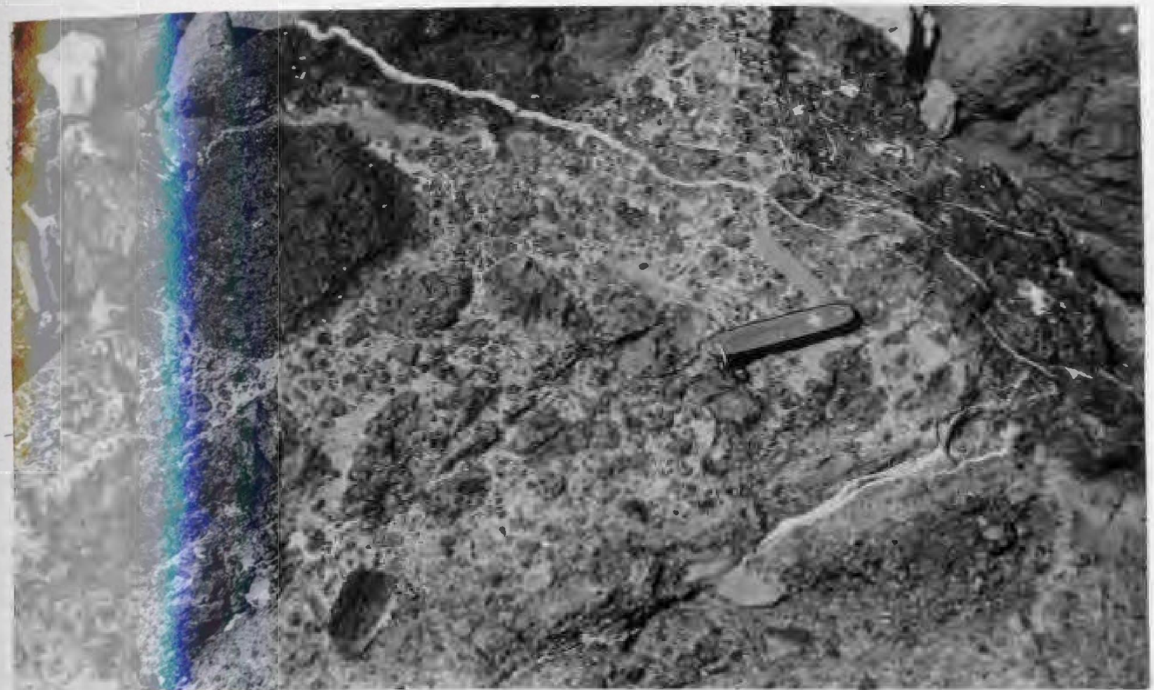


Plate 8. Pink lime mud comprises the matrix to pyroxene-phyric mafic clasts. Unit a, Wallace Brook Member.

Plate 9.

Poorly sorted epiclastic breccia at Wallace Brook. Crude graded bedding indicates tops to the right (SE). Unit c, Wallace Brook Member.

Unit thickness (m)

white calcite cement.

c 12.8

c is a poorly sorted epiclastic breccia composed of aphyric volcanic clasts set in a fine, greenish-brown matrix (Plate 9.). Clast distributions may represent a crude graded bedding, indicating tops to the southeast. Fragments are either well rounded or angular. The upper contact of c is gradational into basal portion of unit d.

d 35.6

d is split into two separate portions by a later mafic dyke or sill. d is a thick sequence of epiclastic, heterolithic volcanic breccia and is dominated by two lithologies: 1) an aphyric purplish and amygdaloidal mafic volcanic and 2) aphyric gray-green to red intermediate volcanic with greenish alteration rims (Plate 10.). Clasts are set in a fine, chlorite-pumpellyite green matrix, locally accompanied by lime mud. Most clasts are angular to subrounded.

e . . . . a later dyke or sill that is not directly associated with the stratigraphy.

f 32.3

f has a gradational basal contact with the stratigraphically lower unit g. f is a poorly sorted, monolithic, carbonate-cemented breccia with aphyric, aphanitic, dark-gray mafic fragments. Four or five thinner (0.6 m), sandy, volcanic arenite interbeds (f') are better sorted than f. Multi-generation, white, coarsely crystalline, zoned calcite cement surrounds many clasts (Plate 11.).

The upper contact of f with unit g is gradational, although units g and f are similar in many respects.

g 25

g contains scoriaceous aphyric amygdaloidal clasts and massive, aphanitic aphyric (glassy?) clasts. Locally, the clasts are elongate as if quenched from a plastic or semi-molten state. Larger clasts are set in a matrix of smaller clasts which are in turn cemented by white, zoned calcite. Crude bedding is

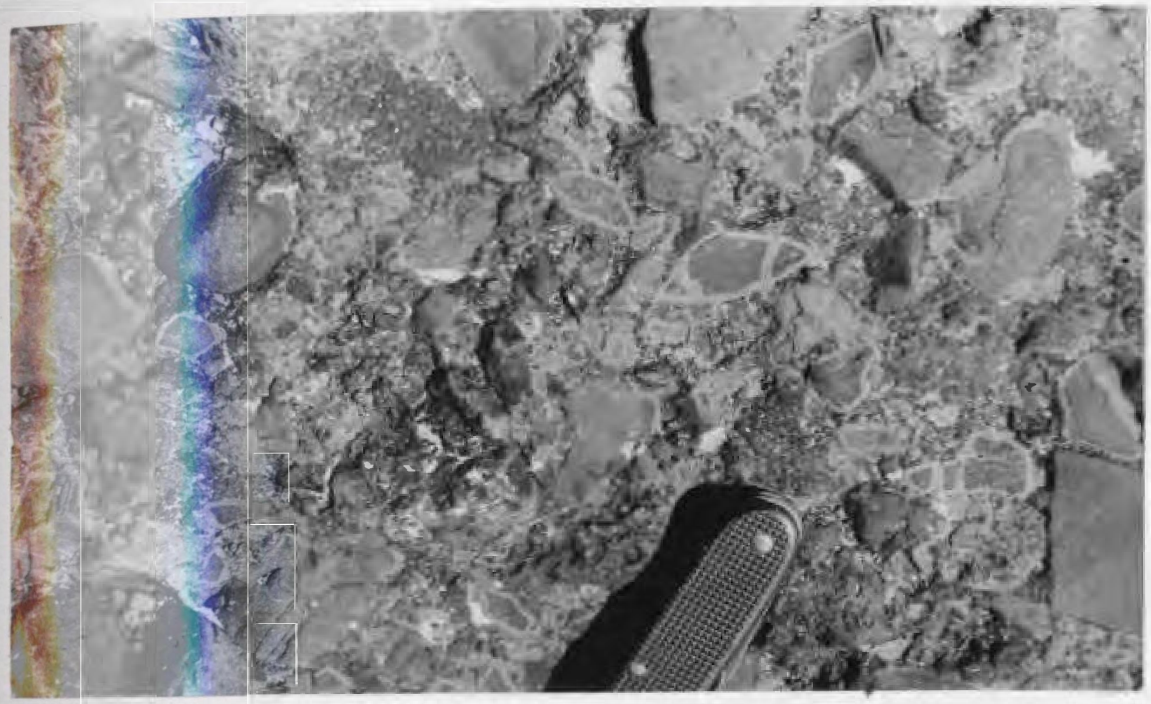


Plate 10. Heterolithic epiclastic breccia with some subrounded and subangular clasts. Unit d, Wallace Brook Member.

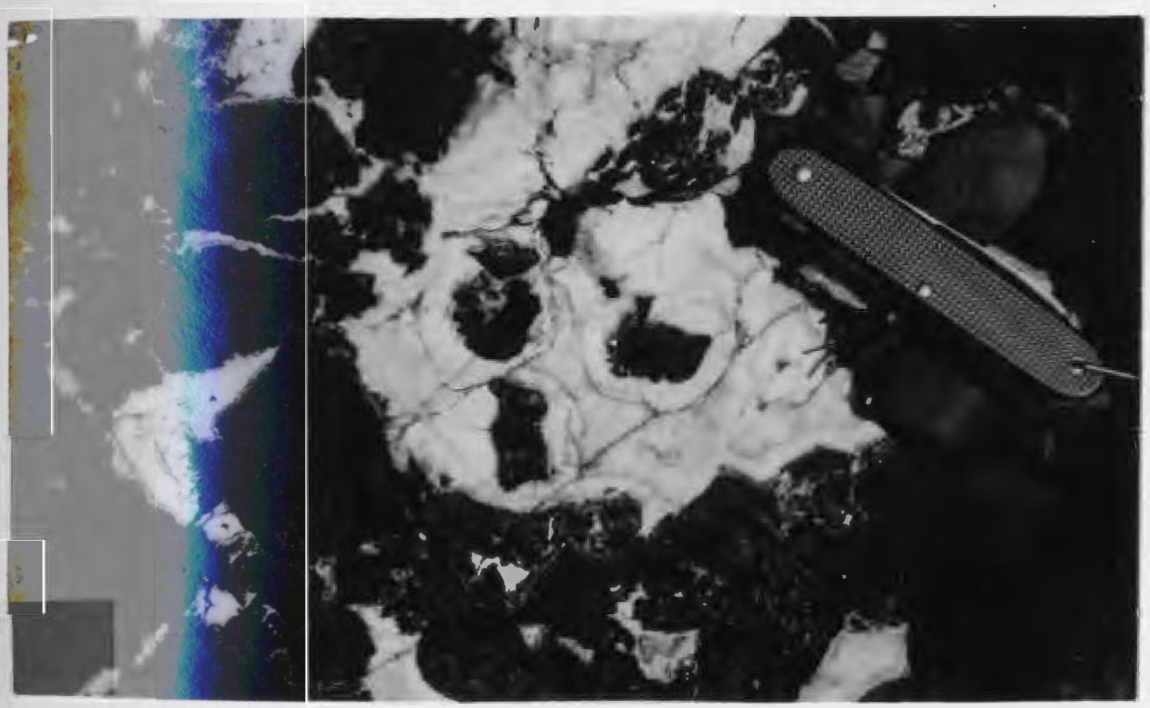


Plate 11. Mafic volcanic clasts cemented by multi-generation calcite. Unit f, Wallace Brook Member.

Unit thickness (m)

preserved; no other sedimentary structures are represented. Minor buff recrystallized limy matrix between mafic lithic fragments grades into white, coarsely crystalline calcite cement.

h & i . . . . 9.3 & 5.6

h has a sharp basal boundary with unit g and a gradational upper contact with i. h is a bedded, monolithic, volcanic breccia composed of aphyric, dark-brown mafic clasts. Locally the clasts are about 1 m in maximum dimension, however the distinguishing features of this unit are the sandy beds and finer breccia beds. Unit h is poorly sorted but well-packed with small quantities of calcite cement. Crude graded bedding reveals tops to the southeast. i is a peculiar breccia in that it consists of mafic, heterolithic (?), scoriaceous aphanitic (*i.e.* aphantic groundmass, yet moderately porphyritic) and non-scoriaceous aphyric fragments. The scoriaceous clasts contain up to 70 per cent calcite amygdales.

j & k . . . . 70.2 & 31+

Unit j is a spectacularly coarse-grained, monolithic, nonbedded mafic breccia composed of densely clinopyroxene-phyric clasts. Large (up to 2 cm), fresh clinopyroxene euhedra comprise 40 to 50 per cent of the mafic clasts in places. The pyroxenes are 'suspended' in a gray-brown lithic matrix mixed with lesser amounts of serpentine-chlorite pseudomorphs after olivine phenocrysts. The dark breccia fragments are in sharp contrast to the 20 to 30 per cent white calcite cement. Calcite occurs in two modes; it forms two generations of open space filling and as massive unzoned cement.

The basal contact with unit i is sharp: the upper contact with k is gradational over several metres and is recognized by the onset of more calcite cement and a notable decrease in the abundance of porphyritic fragments. The uppermost contact of unit k is unexposed. k is a crudely bedded mafic monolithic (?), volcanic breccia with a matrix : fragment ratio of about 0.1.

cumulative exposed thickness
261.4 m

3.1.2.3 Red Fire Brook Member

The Red Fire Brook Member, unlike the other two members is a geographically separated lithic unit consisting of trachyte. The Red Fire Brook Member is continuously exposed from the mouth of Red Fire Brook (Plate 1.) to 0.4 km northeast of Red Fire Brook, where the trachytes are in assumed fault contact with the Main Sea Stack Member. Excellent examples of trachyte are exposed at Red Fire Brook (Plate 1., section (A-A')). 0.4 km southeast of Red Fire Brook, the trachyte outcropping along the coast is highly altered, presumably the result of its proximity to the structural slice contact.

Knockers of trachyte and brecciated trachyte are located in the disrupted zone at the southeastern slice contact (Plate 1. lower left inset) where the distinction between knockers and *in situ* trachyte becomes increasingly difficult.

Outcrops of trachyte are hexagonally columnar jointed (Plate 12.) and a brilliant reddish-orange to brick-red colour owing to the oxidation of iron ores. Fresh surfaces reveal sparsely feldspar-phyric textures.

At the mouth of Red Fire Brook, two islands have been affected by strike-slip faulting. Northeast of the smaller island, the trachyte contact deviates from its normal strike and in doing so, becomes discordant to the strike of the tuffaceous rocks (*i.e.* the exposed base of section (A-A')), thereby forming intrusive relationships. 0.3 km southeast of Red Fire Brook, trachyte crops out along the coast and appears in conformable contact with the stratigraphically underlying breccias. Contact brecciation, veining, baking, or satellite intrusions are nowhere seen in occurrences of the type Red Fire Brook Member. It is thus concluded that the Red Fire Brook Member is a thick flow

Plate 12.

Columnar jointing in the trachyte of the Red Fire Brook Member. The photo was taken at the mouth of Red Fire Brook. The scale is located at the juncture between the outcrop and scree slope.

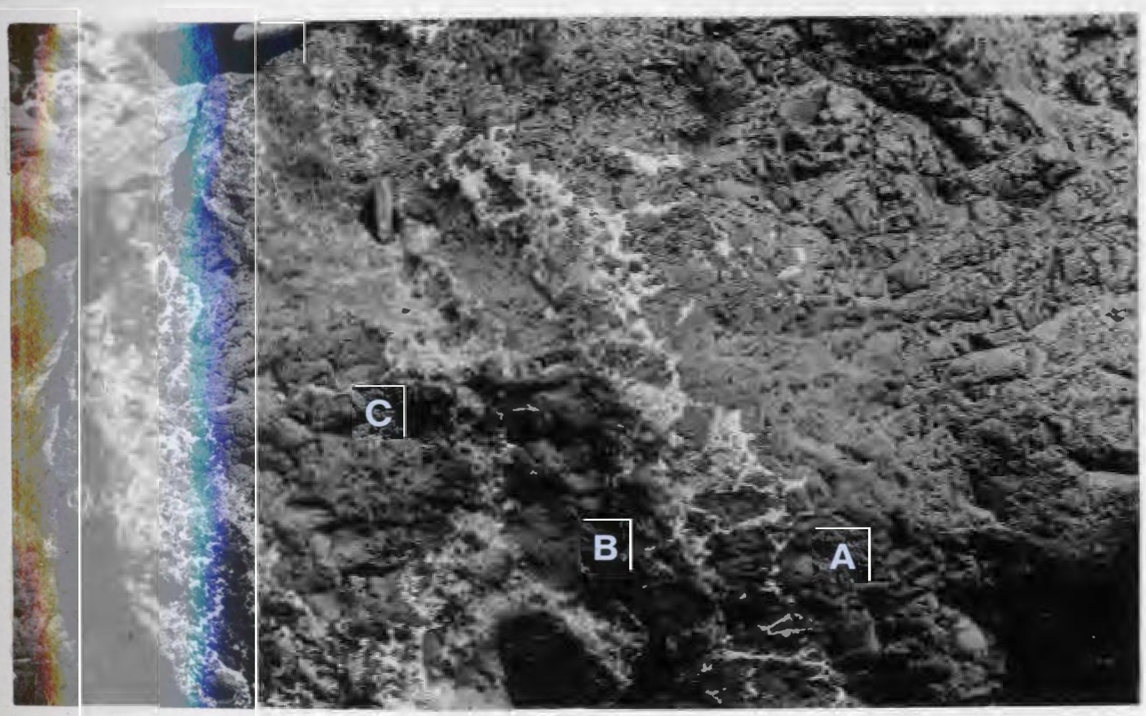


Plate 13. Autobrecciated mafic lava (A) with spalled units (B) and (C). White calcite is the cementing agent.

southeast of Red Fire Brook and a shallow subvolcanic to extrusive at the mouth of the brook. All of the other felsic rocks of the Trout River slice can be considered correlatives of the Red Fire Brook Member.

3.1.2.4 Description and formation of miscellaneous fragmental volcanic rocks

In conjunction with the separation of the Trout River slice into members, the description of several occurrences of other breccias allows the total coverage of the rocks in the 'type' Skinner Cove Formation. Brief descriptions of these different fragmental rocks follow.

3.1.2.4.1 Epiclastic volcanic breccia

Epiclastic volcanic breccias are defined as mechanically deposited volcanic sediments of pre-existant volcanic rock (Fisher, 1966). The epiclastic deposit consists of weathered, rounded or broken heterolithic or monolithic clasts. In this work, fine-, medium- and coarse-grained epiclastic rocks are termed lutite, arenite and rudite, respectively. Good examples are found in the lower beds of the Wallace Brook Member (see also section 3.1.2.2). Two examples of epiclastic breccia will be described here. The first and most spectacular occurs in section (A-A') and consists of nine distinct clast types as follows:

(1) interbedded sandy-limy clasts

(2) non-amygdaloidal ankaramite

(3) oceanite or picrite (olivine phenocrysts are pseudomorphed by calcite, chlorite, or serpentine)

(4) massive, aphyric, aphanitic, non-amygdaloidal clasts

(5) scoriaceous aphyric clasts with calcite-filled amygdales

(6) brecciated, honeycomb-veined ankaramite

(7) broken pillow (mafic volcanic) clasts

(8) clasts of medium-grained (1 to 2 mm) epiclastic (?) breccia (*i.e.* a breccia within an epiclastic breccia)

(9) reddish-pink, bedded limestone clasts.

The breccia is a poorly sorted, nonbedded, structureless aggregate of volcanic and limy fragments. Angular to subangular clasts are less than 25 cm in maximum dimension with a median grain size of 2 to 3 cm. The breccia is welded by minor (5 to 10 per cent) calcite cement. The attitude of the bed does not allow precise thickness determination, but it is likely about 4 or 5 m thick.

About one half kilometre southeast of section (D-D'), a heterolithic epiclastic breccia contains several unusual fragment types. The breccia consists of about 75 m thickness (the base and top are unexposed) of thin- to thick-bedded reworked monolithic lapilli and ash. The breccia also contains 1 or 2 per cent coarse-grained, well rounded, undeformed, leucocratic plutonic pebbles. Most pebbles are 1 cm in dimension although two larger 5 cm clasts were sampled. In thin section, one clast is a coarse-grained plagioclase (An 40; optical determination) cumulate with much intergranular accessory apatite and minor zircon euhedra. The rock is most properly termed an anorthosite.

3.1.2.4.2. Pyroclastic lithologies

Pyroclastic rocks are those rocks that are the direct products of volcanism (Wentworth and Williams, 1932). The Trout River slice pyroclastic rocks were probably produced by subaqueous volcanic activity. Pyroclastic deposits consist primarily of mixtures of ash and lapilli; only rarely are blocks or bombs present.

In the Trout River slice, medium-bedded, thick sequences (*e.g.* 0.4 to 0.6 km E-NE of the Main Sea Stack; section (D-D')) of monolithic lapillistone, lapilli-tuff, grading upward into tuff, are interpreted as subaqueous pyroclastic flow. Microvesicular, chlorite and analcime-bearing lapilli and lapilli-tuff are ubiquitous. The flattening of clasts parallel to bedding attests to clast softness resulting from submarine weathering and accompanying mineralogical changes. These pyroclastic rocks are now loosely cemented by small amounts of calcite.

3.1.2.4.3 Autoclastic volcanic breccia (syn. autobreccia, flow breccia)

Autoclastic breccias form by variable degrees of internal brecciation of lava flows. A number of mechanisms have been cited for the origin of autoclastic breccias. Most authors attribute autobrecciation to lava movement, but Curtis (1954) described the shattering of extrusive and shallow subvolcanic lithologies where there has been only minor movement.

Two types of breccias in the Trout River slice are interpreted as autobreccias: (1) In one example (section (A-A')), a dark gray mafic lava flow or dyke is shattered along its margin. At least two successive phases of spalling or separation of elongated slabs from the massive, unbrecciated internal portion of the flow has occurred (Plate 13.). The peripheries of the successive separated slabs are quenched. Shattered and spalled detritus is encased by white to greenish-brown calcite. (2) The second type of autoclastic breccia occurs in unit a of the Wallace Brook Member. Mafic, monolithic, poorly sorted clasts have become brecciated during downslope movement. The components of the whole may be visually re-assembled to form a single irregular form (Plate IIIb. in Malpas, 1976). The distinction between autobrecciated flow and hyaloclastic or pillow breccia becomes increasingly difficult when the breccia fragments are small, rounded and widely separated.

3.1.2.4.4 Pillow breccia

Carlisle (1963) called the breccias on Quadra Island, British Columbia 'pillow breccia' and the intimately associated matrix tuff to lapilli-tuff was termed 'aquagene tuff' because it is not of pyroclastic origin. Carlisle's scheme applies well to similar breccias in the Trout River slice.

Isolated pillow breccia occurs in great quantities in coastal outcrops northwest of the Green Garden (Plate 1.). To the southeast, isolated pillow breccia is overlain by stratified tuff that is similar to the matrix of the isolated pillow breccia. Large pillow fragments are absent, but 2 to 3 cm mafic clasts similar in appearance to the pillow lithologies are dispersed throughout the 10 m-thick unit. The upper contact of this tuff is in sharp contact with a 0.1 km-thick pillow breccia. Within the thick pillow breccia unit, the matrix : pillow fragment ratio increases stratigraphically upward for several metres and is then overlain by a 3 to 4 m-thick sequence of tightly packed pillows which indicate tops directed to the southeast. These pillows are overlain by aquagene tuff and isolated pillow breccia for another 4 m.

3.1.2.5 Interpretation of the stratigraphy

It is clear that the strata of the Main Sea Stack Member were deposited subaqueously with subsequent reworking of pyroclastic and pillow breccia units. For example, it is possible that the lavas of unit f (section (B-B')) erupted onto/into unconsolidated pyroclastics.

Subsequent sloughing, off the volcanic flanks, developed pillow forms and pillow breccia. The classification of unit h of this member is ambiguous. It might represent reworked pyroclastics, pillow breccia and lava that became intermixed and stratified during downslope movement.

Lavas alternating with volcaniclastics suggests passive lava extrusion followed by explosive-phreatic eruption. Detritus of tuffaceous unit b (section (B-B')) varies from mafic to intermediate in composition (*i.e.* basalt through trachybasalt) and shows that evolved (differentiated) lava compositions were previously erupted, subaerially exposed, eroded and reworked. Thus, whatever the initial tectonic setting of the Skinner Cove Formation may have been, the main volcanic pile was well developed by the time the Main Sea Stack Member formed. This same feature is also seen in the Chimney Cove slice, where clasts of evolved rocks (*e.g.* trachybasalt) are rounded, and found in epiclastic deposits.

One of the outstanding features of the Wallace Brook Member is the abundance of carbonate cement, which binds autoclastic breccias, and to a lesser extent, epiclastic breccias.

There are a number of possibilities for the generation of this calcite cement and/or limy matrix:

(1) The mafic fragments were once lava that erupted into a primary organic lime mud (Plate 8.). Subsequent recrystallization of the mud obliterated most primary textures. In this instance, the lime mud was a matrix to the breccia.

(2) The subaqueous volcanic environment of deposition provided the physiochemical conditions suitable for the precipitation of calcite in open spaces to form a cement (*e.g.* Plate 11.).

(3) The upward percolation of fluids from the autochthonous carbonate bank influenced the precipitation of carbonate in open spaces (during or following the transport of the Skinner Cove slice assemblage).

(4) Derivation of lime from the primary mineralogy (*i.e.* calcic plagioclase, augite) of the mafic volcanic rocks by submarine alteration followed by the redeposition of carbonate as a cement.

(5) Solution of carbonate (*i.e.* cement or primary carbonate mud) and redeposition as a cement (Plate 11.).

(6) Any combination of possibilities (1) through (5).

The relationship between reddish-brown limestones gradationally recrystallizing to white sparry calcite would indicate that lime muds were at the site of eruption of the Skinner Cove volcanoes. Hypotheses (1), (2) and (3) explain the abundance of calcite cement, but only hypothesis (1) accounts for the existence of organics in the possible lime mud. Additional supporting evidence for hypothesis (1) is as follows: (see also section 3.1.2.4.3, example (1), and Plate 13.) this is an example of autobreccia that shows some interesting and unusual features. Two successive sequences of separation of mafic lava from a massive mafic lava core are seen in this example (Plate 13.). The plastic or quenched 'molten' appearance of the separated slabs, their elongate irregular form, their chilled margins and their sequential and parallel separation from the long axis of the competent flow, all suggest the slabs were suspended in a matrix. Presently the lava is cemented by coarsely crystalline calcite. If the slabs are indeed suspended, then the lava must have intruded (or extruded) and been cooled by previously deposited material; probably lime mud. The muds recrystallized into white calcite when they contacted the magma, or later after solution of the carbonate and redeposition as calcite.

The presence of this type of breccia reinforces the suggestion that much of the carbonate presently cementing many breccias, was initially a lime mud. Such an eruption of hot lava into lime mud has been described by Carozzi (1960, p. 86) and is termed "peperite." Peperite breccia is also present in the Chimney Cove slice (see also section 3.3).

The mafic volcanic breccias of the Wallace Brook Member are polygenetic and probably represent the periodic eruption of mafic lava into lime mud, followed by downslope movement to form bedding. Some units (*e.g.* a of this member) probably comprise a mixture of pillow breccia, autoclastic breccia and pyroclastic breccia. Epiclastic breccias in the member possibly represent subaerial and shallow submarine conditions of clast reworking with later density flow to derive crudely graded beds.

To summarize, the Trout River slice consists of three distinctive members; the Main Sea Stack, Wallace Brook, and Red Fire Brook Members (Plate 1.). All strata strike northeast (with the possible exception of the Red Fire Brook Member in some exposures), and are southeast dipping and southeast facing. The competent stratigraphy is devoid of penetrative deformation.

The Main Sea Stack Member comprises a 122^{+} m - thick series of mafic to intermediate massive and pillowed flows, volcaniclastics (pyroclastic, reworked pyroclastic, epiclastic, pillow breccia) and distinctive ankaramite (see also section 3.1.3.1).

The next highest stratigraphic unit is the Wallace Brook Member and is defined along Wallace Brook (Plate 1.). The member is composed of a spectacular, 260^{+} m - thick sequence of autoclastic, epiclastic and

and pillow breccias. Many of the mafic clasts are densely pyroxene- and olivine-phyric; others are aphyric. Heterolithic epiclastic breccias are interpreted as the result of weathering, erosion, transportation and deposition of pre-existing, subaerially exposed rocks of the Skinner Cove Formation. A most unique type of breccia, peperite (Carozzi, 1960), consists of mafic clasts set in a lime mud matrix, thus suggesting that mafic lavas erupted into/onto lime muds. In most places, the muds have been entirely recrystallized into white, sparry calcite.

The Red Fire Brook Member is a feldspar-phyric trachyte. It is best exposed along Red Fire Brook and in coastal exposures immediately northeast of Wallace Brook. This member is in some places interpreted as a shallow subvolcanic unit, whilst in other places it may well be extrusive.

Clearly then, the volcanic stratigraphy of the Trout River slice consists of an interesting succession of mafic, intermediate and felsic rocks that form a varied sequence of lava flows and fragmental rocks. Some rocks exposed along the coast at Chimney Cove are very similar to the peperites in the Wallace Brook Member. Other Chimney Cove lavas are densely clinopyroxene-phyric and are therefore reminiscent of the phyric lavas of the Trout River slice.

3.1.3 Petrography and classification of the extrusive and subvolcanic rocks

Classification schemes attempt to discriminate between different rock types such that the combined range of distinct types defines a rock suite. The paleogeographic location of these suites is dependent on the tectonic framework at the time of their formation. Thus, the classification of the Skinner Cove igneous/metamorphic rocks should contribute clues as to where the volcanism was initiated during the Early Paleozoic.

The classification of the rocks is somewhat arbitrary and simplified, but is entirely justifiable when one considers their Ordovician age, transport history, and low grade metamorphic mineral assemblage. Most of the rock names used are the same as those employed by Strong (1974).

All lithologies are mineralogically and chemically altered relative to their original pristine igneous condition, but primary igneous textures are well preserved in most examples.

Mafic to felsic rocks have been classified in many recent volcanic settings. Rock classification by modal composition, C.I.P.W. norms, normative plagioclase, modal plagioclase composition, differentiation index, solidification and crystallization indices are all in common usage. The scheme adopted for the rocks of the Skinner Cove Formation is one based on petrographic characteristics (*i.e.* minerals present (or once present), modal per cent minerals, preserved igneous textures) and broad chemical ranges. Fine-grained mafic rocks are cautiously classified according to their SiO_2, TiO_2 and P_2O_5 contents.

3.1.3.1 Mafic and intermediate rocks

The mafic to intermediate rocks of the Trout River slice are ankaramite basalt, pyroxene-phyric basalt, alkali basalt and trachybasalt. The ankaramites are probably enriched in cumulus augite and olivine. The lithologies have not been degraded to the extent that all primary minerals are obliterated, thus, in their present state of alteration, the rocks of the Trout River slice are best described as moderately degraded or spilitized rocks.

3.1.3.1.1 Ankaramite basalt

Ankaramite basalts are defined by Gary *et al.* (1972) as: "olivine-bearing basalt containing numerous pyroxene and olivine phenocrysts, the former being more abundant than the latter, in a fine-grained groundmass composed of augite and titanaugite microlites, labradorite, and accessory biotite."

Ankaramites are relatively common lavas in the carbonate-cemented breccias of the upper Wallace Brook Member and in the Main Sea Stack Member. By definition, outcrops of ankaramitic basalt are strongly porphyritic (25 to 30 per cent phenocrysts) with variable proportions (0 to 8 per cent) of irregular to spherical calcite-filled amygdales (see Appendix A. for mode). Phenocrysts consist of pyroxene, altered olivine, and some plagioclase, all set in a greenish-gray matrix. The pyroxenes are black, vitreous, euhedral to subhedral, stubby prisms and wedges that are usually less than 6 mm across. Exceptionally large pyroxenes (35 mm) are found in the upper Wallace Brook Member breccias. Altered olivine phenocrysts are now rusty-brown aggregates of carbonate, iddingsite and hematite. Other olivine crystals are totally replaced by serpentine-hematite-chlorite minerals and are barely distinguishable from the greenish matrix. In places, olivines are 15 mm across as indicated by pseudomorphs.

Thin sections reveal porphyritic-hiatal textures. Euhedral to subhedral titanaugite phenocrysts are zoned to strongly zoned (Plate 14.), weakly pleochroic, with some examples of twinning. In some crystals, the contact between zones is razor-sharp and marked by granular opaque minerals, minor chloritization and minute isolated fluid inclusions.

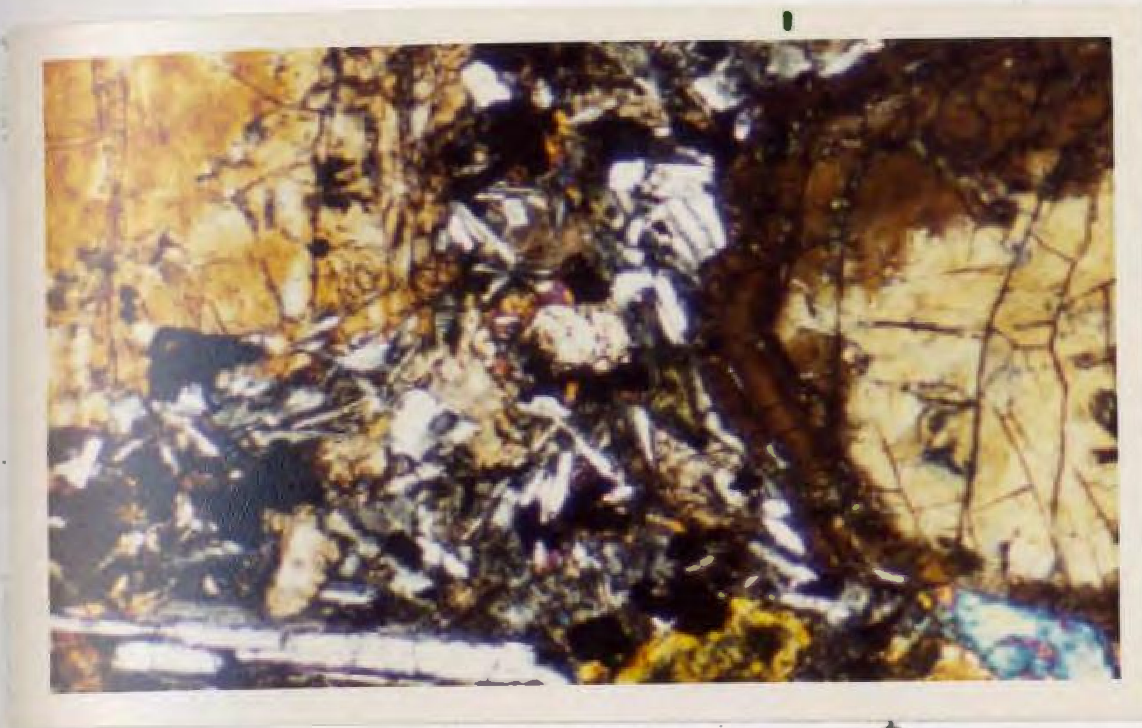


Plate 14. Large phenocrysts of zoned titanaugite are set in a holocrystalline, intergranular matrix consisting of plagioclase, augite, opaque oxides and alteration minerals. Ankaramite, SKC-41, x-nicols, (X 50).

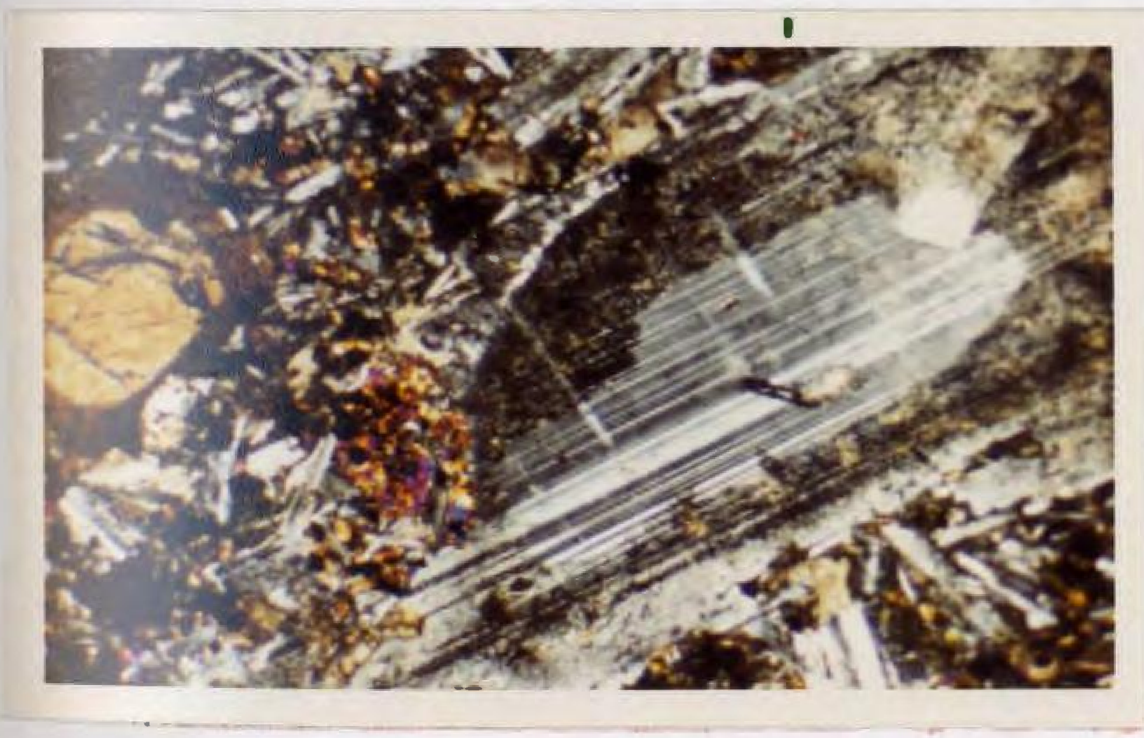


Plate 15. The large plagioclase phenocryst in ankaramite has a pristine labradorite core and thoroughly altered rim; suggesting normal zoning. SKC-41, x-nicols (X 125).

Serpentine, chlorite, iddingsite, carbonate, hematite and some opaque minerals are pseudomorphic after euhedral to subhedral olivine phenocrysts and microphenocrysts. Olivine is less than 1 mm across, and forms up to 4 per cent of the mode (*e.g.* SKC-41).

Plagioclase phenocrysts form laths and tablets less than 5 mm in length. Some ankaramites have only rare plagioclase while in others, more abundant plagioclase imparts a seriate texture. Zoned and twinned labradorite (optical and microprobe determinations) contains sieve textures with inclusions of brownish-pink augite prisms, opaque minerals, chlorite, carbonate lenses and mica (*e.g.* SKC-25A). The zoned plagioclase is characterized by either highly altered cores and fresh rims or vice versa. The reversal in preferred alteration location suggests reverse zoning.

The ankaramite groundmass is typically holocrystalline, but chlorite/skeletal plagioclase/finely comminutedopaque minerals may represent devitrified glassy mesostasis, in which case the texture is intersertal-holocrystalline. Some ankaramites contain gray, poorly twinned, pitted plagioclase (early albitization ?); others contain fresh calcic plagioclase. The remainder of the groundmass consists of anhedral, granular, brown titanaugite, resorbed primary Fe-Ti oxide, secondary Fe-oxide, alkali feldspar, apatite needles encased in chlorite, and minor serpentinized olivine pseudomorphs. Feathery and needle-like Fe-Ti oxide splinters are common groundmass minerals.

Amygdales are largely made up of coarse-grained calcite with and without chlorite, hematite, minor quartz or low albite rims. In some samples (SKC-25B), amygdales contain euhedral analcime crystals.

In contradiction to the reports of Strong (1974) and Malpas (1976),

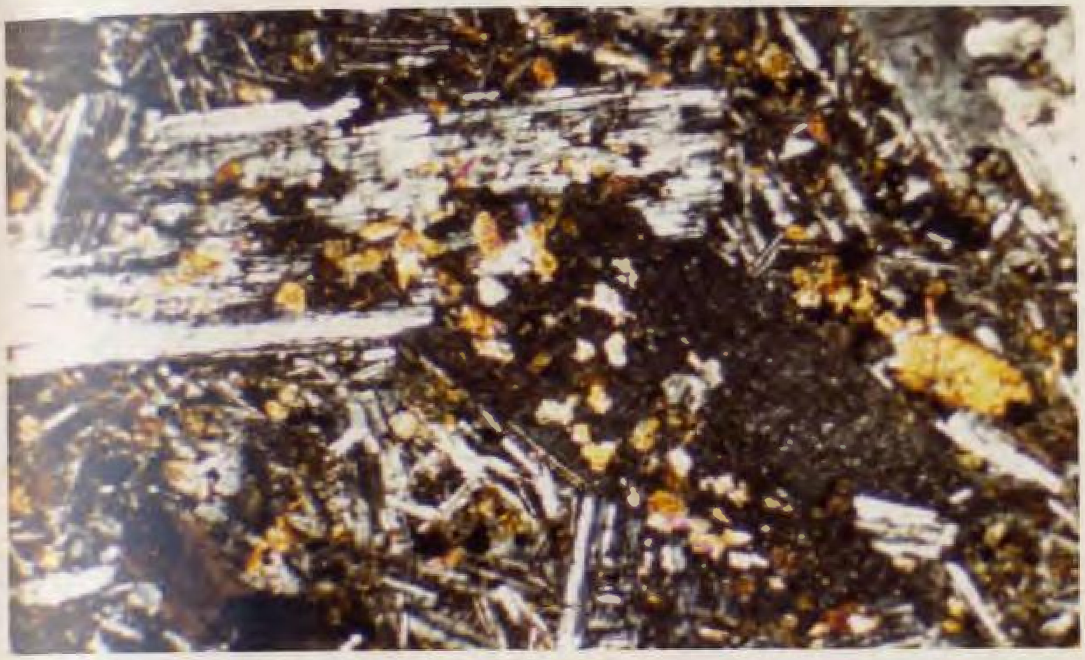


Plate 16. Ankaramite with zoned, poikilitic, intergrown plagioclase phenocrysts. The mineral included in plagioclase is titanaugite. SKC-24, x-nicols, (X 31).

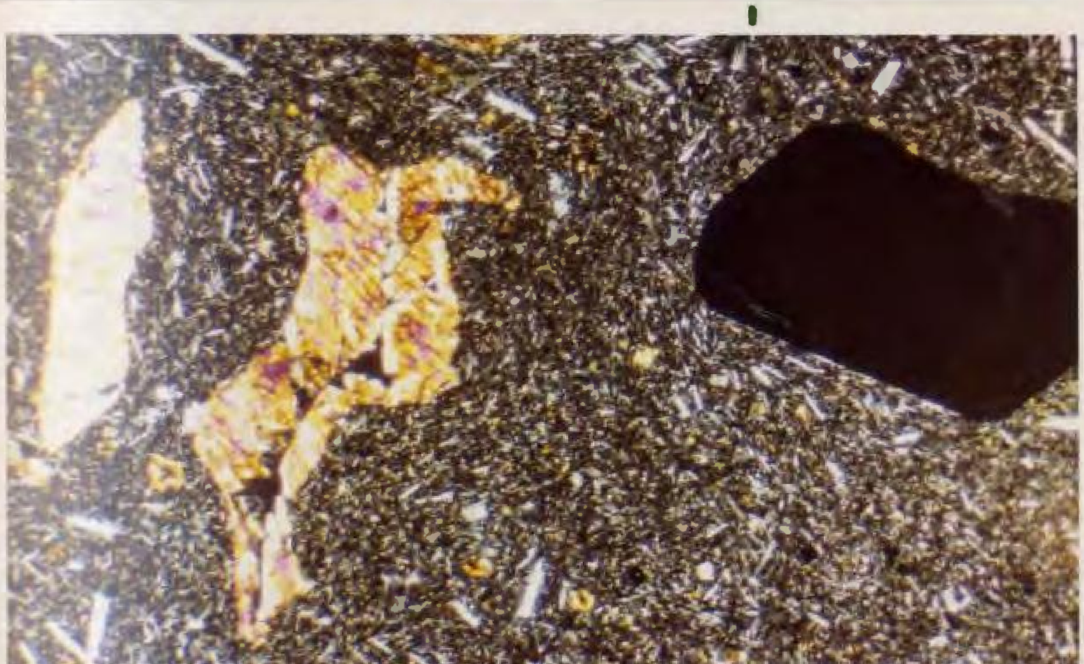


Plate 17. Pyroxene-phyric basalt with resorbed and embayed pyroxene and subrounded titanomagnetite phenocrysts. Groundmass consists of bytownite microlites, opaque oxide, altered olivine, chlorite mesostasis. SKC-39, x-nicols, (X 31).

there is no primary glass or olivine in the ankaramites. A (pseudo)-isotropic matrix suggests that Strong's thin sections were cut far too thick. Chromian diopside (microprobe determinations) within these same sections resembles the olivine described by Malpas (1976) and Strong (1974).

3.1.3.1.2 Pyroxene-phryic basalt

Pyroxene-phyric basaltic rocks are abundant in the Wallace Brook Member. They are gradational into ankaramites with increasing amounts of olivine and pyroxene phenocrysts. Outcrops contain black, euhedral to subhedral pyroxene phenocrysts set in a dark, fine-grained, sparsely amygdaloidal matrix. Where present, plagioclase phenocrysts have clear, dark cores with light-green altered rims.

Phyric, microphyric, and minor glomerophyric textures are visible in thin section (Plate 17.). Pyroxene phenocrysts are zoned, pale-brown titanaugite (optical and microprobe determinations). Phenocrysts have rounded, corroded, resorbed crystal margins; 'wormy' embayments are evident in some titanaugites (*e.g.* SKC-39, Plate 17.). In contrast to these resorption textures, most titanaugites are euhedral and show only minor disequilibrium features.

Minor amounts (less than 1 per cent) of zoned calcic plagioclase (sodic bytownite; optical and microprobe determinations) microphenocrysts are evident. Titanomagnetite (microprobe determinations) microphenocrysts are subhedral, subrounded (Plate 17.), and comprise about 1 per cent of the lithology. Possible microphyric olivine is represented by pseudomorphs of serpentine and chlorite.

The groundmass forms 90 per cent of the lithology (Appendix A.) and consists of aligned bytownite microlites, plagioclase crystallites, altered olivine, chloritic mesostasis, granular sphene, abundant disseminated Fe-Ti oxide and some carbonate. Groundmass textures are pilotaxitic to hyalopilitic. The plagioclase crystallites probably formed as devitrification products of basalt glass; the same is true of chlorite and secondary opaque minerals.

Amygdales are rare, but where present, consist of radiating sheaves of green chlorite, or white calcite.

3.1.3.1.3 Alkali basalt and trachybasalt

Aphanitic to sparsely phyric and microphyric lavas and dyke rocks are broadly termed 'alkali basalt' and 'trachybasalt'. The two rock types are mutually gradational. The alkali basalts of this slice contain essential calcic plagioclase, titanaugite, plus or minus altered groundmass olivine and phyric olivine, opaque minerals and accessory apatite. Thus, these fine-grained rocks mineralogically satisfy the criteria for their classification as alkali basalts (Wilkinson, 1974). The preponderance of mineralogical and geochemical evidence (Chapters 6 and 7) further supports the primary alkali basaltic nature of these altered rocks. With increasing silica content, decreasing modal augite, and increasing alignment of groundmass feldspar microlites, the rocks are called trachybasalt (*e.g.* SKC-26, Plate 19.).

Extensive descriptions of rock mineralogy, individual textures, etc., would be futile, thus a brief description of the modes of occurrence of the primary minerals should suffice.

Feldspar: Calcic plagioclase (andesine to bytownite; optical and microprobe determinations) is the major constituent of the alkali basalts and trachybasalts, forming 60 to 70 per cent of the mode (see Appendix A.). Calcic plagioclase forms simply twinned laths, blocks, tablets and microlites. The grain size ranges from phyric (rarely),

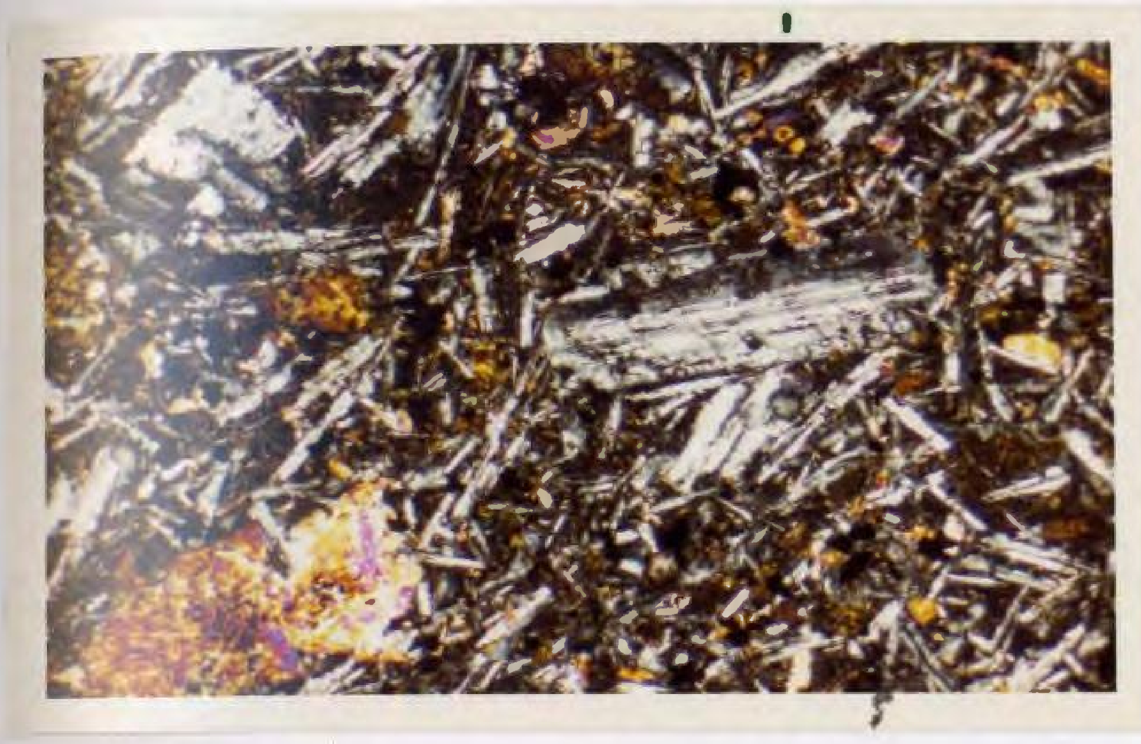


Plate 18. Typical alkali basalt. Titanaugite microcrysts and labradorite are set in an intergranular groundmass consisting of calcic plagioclase and brown, granular titanaugite. SKC-54, x-nicols, (X 31).

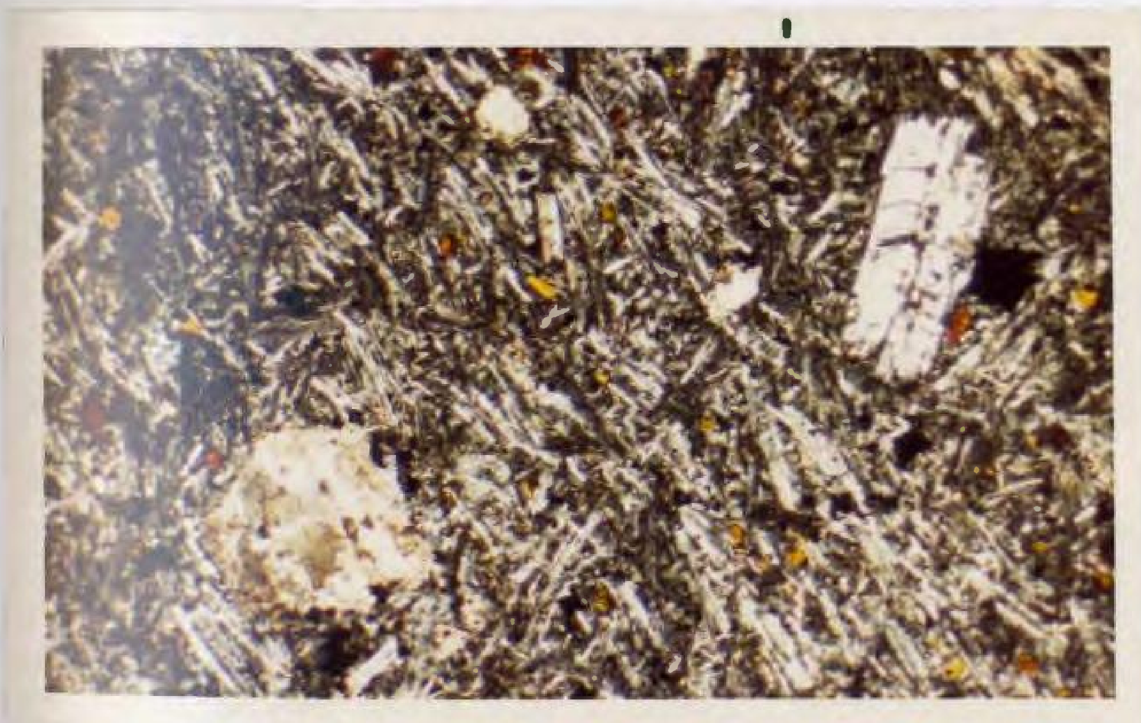


Plate 19. Microphyric trachybasalt. Pronounced fluidal/pilotaxitic texture is emparted by aligned feldspar. The clinopyroxene microcryst (lower left) is partly replaced by calcite. Red/yellow flecks in the groundmass are iddingsite after olivine. SKC-26 x-nicols, (X 31).

microphyric to microlitic. Plagioclase is usually a fraction of a millimetre in grain size, although sparse (much less than 1 per cent), 15 mm tablets are dispersed throughout unit a of the Main Sea Stack Member.

Zoning is common and is denoted by concentrations of alteration products, mineral inclusions, or by oscillatory zoning. Poikilitic calcic plagioclase has inclusions of earlier-formed plagioclase, mauve titanaugite and opaque minerals (Plate 18.).

As in the ankaramites, the plagioclase is not invariably calcic. Plagioclase has in places recrystallized to albite and mica, or in the more severely altered cases to sodium hydrous silicates (*e.g.* analcime SKC-53; optical, x-ray diffraction and microprobe determinations).

Alkali feldspar of anorthoclase composition may or may not be of primary origin. Alkali feldspar microlites may have crystallized from the devitrification of alkali glass which is common in alkaline suites (Keil *et al.*, 1972). In some samples, adularia is found, suggesting the anorthoclase feldspar is secondary.

Pyroxene: All pyroxene is monoclinic, calcic and titaniferous (optical and microprobe determinations). Titanaugite occurs as pinkish-brown euhedral microphenocrysts, subhedral tablets or granules, anhedral wedges interstitial to plagioclase laths, or as branching skeletal laths. Common twinning and hourglass structure are rare, colour zoning is ubiquitous. Granular, anhedral opaque minerals are in places associated with or occur as inclusions in titanaugite. Densely clustered opaque minerals form core inclusions of some titanaugite microphenocrysts.

Olivine: Where once present, olivine is entirely altered to brown-green serpentine, iddingsite, chlorite and carbonate, with blood-red to black hematite and opaque mineral skeletons. The form of the pseudomorphic material is generally euhedral, although subhedral forms are also evident. Olivine forms up to 4 per cent of the mode (Appendix A.).

Opaque oxides: Primary opaque minerals are volumetrically insignificant although they were doubtless important minerals in the evolving magma. Microphyric opaque minerals are euhedral to anhedral; finer opaques have the entire spectrum of grain shapes. Optical inspection of polished thin sections shows discontinuous Fe-Ti oxide zoning. Ilmenite-magnetite exsolution lamellae are extremely fine and form good trellis patterns. Other opaque minerals have ilmenite exsolution 'patches' rather than lamellae. Granular opaque oxides that form interstitially to plagioclase and pyroxene are very difficult to assign to either a primary or secondary origin.

Apatite: Apatite is an accessory mineral in most alkali basalts and trachybasalts. It commonly forms euhedral groundmass prisms and fibres; in some samples (*e.g.* SKC-26, Plate 20.) apatite microphenocrysts are quite abundant. This mineral typically occurs interstitially to plagioclase and clinopyroxene and is associated (in cores or embayments) with Fe-Ti oxides.

Many primary igneous textures are well preserved. Grain size/textures range from aphanitic to sparsely phyric/microphyric. Devitrified glass is seen as a chlorite/fine opaque mineral/plagioclase crystallite mesostasis between plagioclase crystals. Intergranular to intersertal textures are common, while diabasic textures are seen in some examples. Trachybasaltic rocks usually have holocrystalline

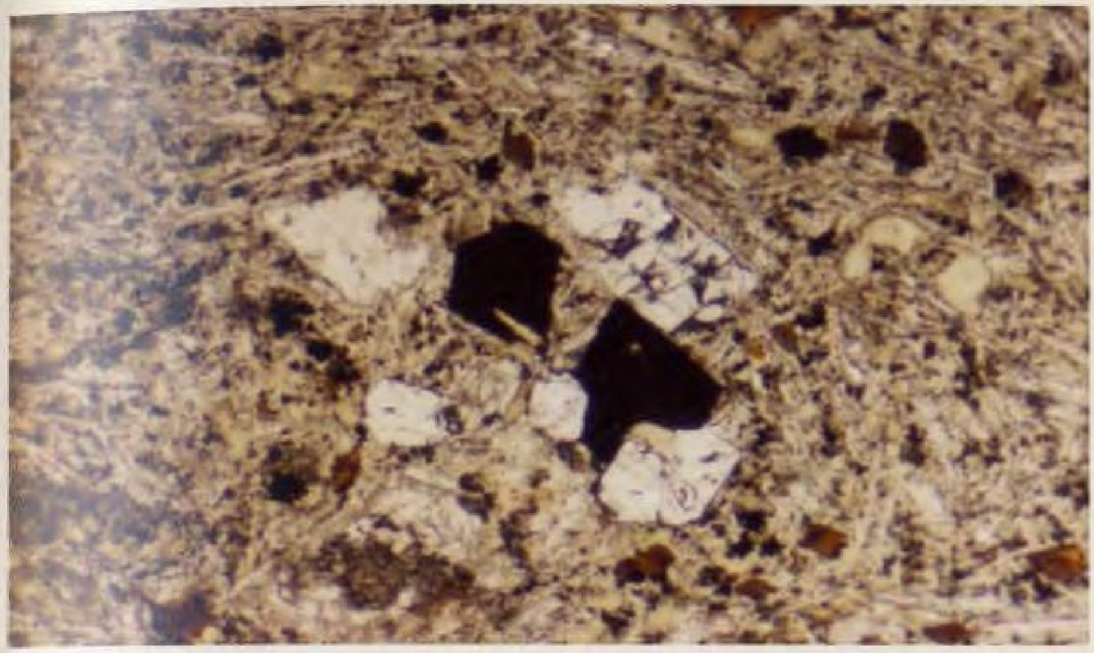


Plate 20. Euhedral and subhedral apatite microcrysts and opaque oxides in trachybasalt. SKC-26, plane light, (X 50).

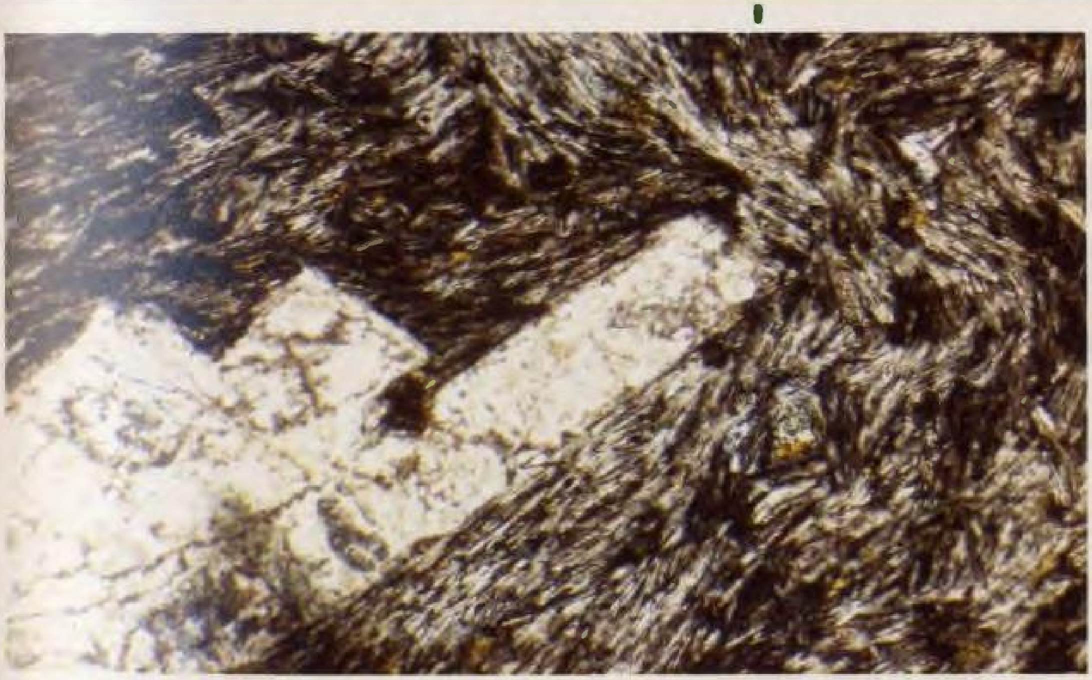


Plate 21. Trachytic texture emparted by subparallel alignment of groundmass feldspars. Amygdales contain quartz ± pumpellyite ± albite ± calcite ± epidote. Chlorite, opaque minerals and epidote are present in the groundmass. Trachyte, SKC-20, x-nicols, (X 31).

matrices with pronounced fluidal texture in the plagioclase microlites.

Calcite and chlorite-filled amygdales are common to both rock types (Plate 19.).

3.1.3.2 Felsic rocks

The felsic rocks of this slice are contained mainly in the Red Fire Brook Member and its possible correlatives (section 3.1.2.3). Siliceous dykes (probably feeders to trachyte flows) do not have trachytic textures, but are mineralogically and chemically identical to the trachytes.

3.1.3.2.1. Trachyte

As defined by Gary *et al.* (1973), trachytes are: "a group of fine-grained, generally porphyritic, extrusive rocks, having alkali feldspar, minor mafic minerals as the main components and possibly a small amount of acid plagioclase. Trachyte grades into latite as the alkali feldspar content decreases."

In thin sections of trachyte (Red Fire Brook Member samples from the mouth of Red Fire Brook, Plate 1.) the subparallel 'sheaf' arrangement of feldspar (anorthoclase and albite) microlites forms distinctive trachytic textures (Plate 21.). Twinned and untwinned, flow-aligned euhedral tablets of zoned anorthoclase (or its altered equivalent) form phenocrysts up to 1 cm in dimension and comprise 3 to 10 per cent of the mode (Appendix A.). In places, feldspar forms aggregates or glomerophyric splays suspended in a trachytic groundmass. Altered feldspar phenocrysts are a brownish, clouded mixture of carbonate, mica, quartz, opaque oxide, chlorite and minute fluid inclusions. Where such pervasive alteration has occurred, the potassium

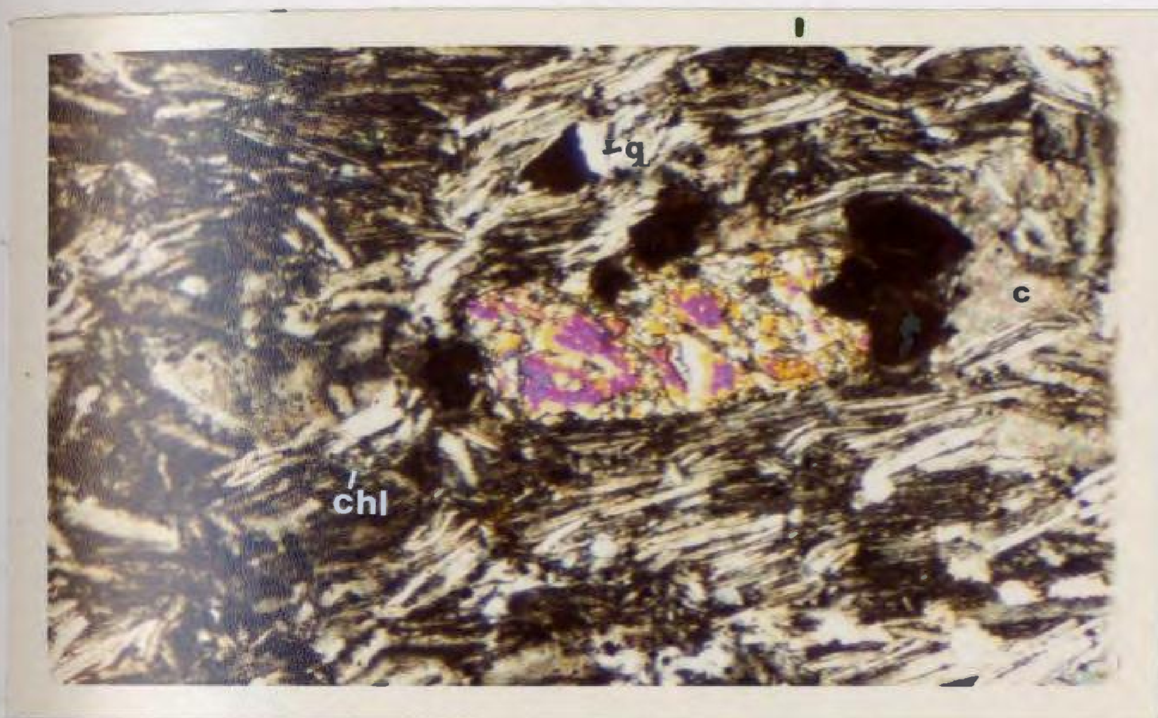


Plate 22. Relict ferrosalite euhedra in trachyte. The pyroxene is being replaced by calcite. calcite (c), chlorite (chl), quartz (q). Trachyte, SKC-65, x-nicols, (X 31).

feldspar is albitized (*e.g.* in SKC-18, anorthoclase has recrystallized to Ab_{99}; microprobe determination).

Relict microphyric ferrosalite euhedra (from a trachyte exposure between Skinner Cove and Brake Cove, Plate 1., sample SKC-63; pyroxene composition determined by microprobe analysis) are light-green, apparently unzoned, highly fractured, carbonatized, and associated with primary and secondary opaque minerals (Plate 22.). Most trachytes contain no primary mafic silicates, but the regular outlines of opaque and carbonate minerals suggest the replacement of former clinopyroxene.

Trachyte groundmass consists of primary anorthoclase and sanidine (?) (or albite pseudomorphs). Hematization, carbonatization, silicification and chloritization have given most trachyte samples a patchy, brownish, altered appearance. Secondary granular disseminated opaque minerals and minor epidote are distributed throughout most samples. Carbonate, chlorite, quartz, low albite and pumpellyite have crystallized in amygdales (Plate 23.).

3.1.3.3 Metamorphic mineral assemblages and facies

This section outlines the non-primary (metamorphic/spilitic) mineral assemblages and lists the primary minerals from which the alteration mineralogy most likely formed. Progressive metamorphic zones are not found in the rocks of the Trout River slice and it is therefore impossible to calculate precisely the pressures and temperatures at which metamorphism occurred.

Metamorphic minerals occur in 1) open spaces (Plate 23.), fractures (*i.e.* low pressure areas), 2) as replacement minerals of

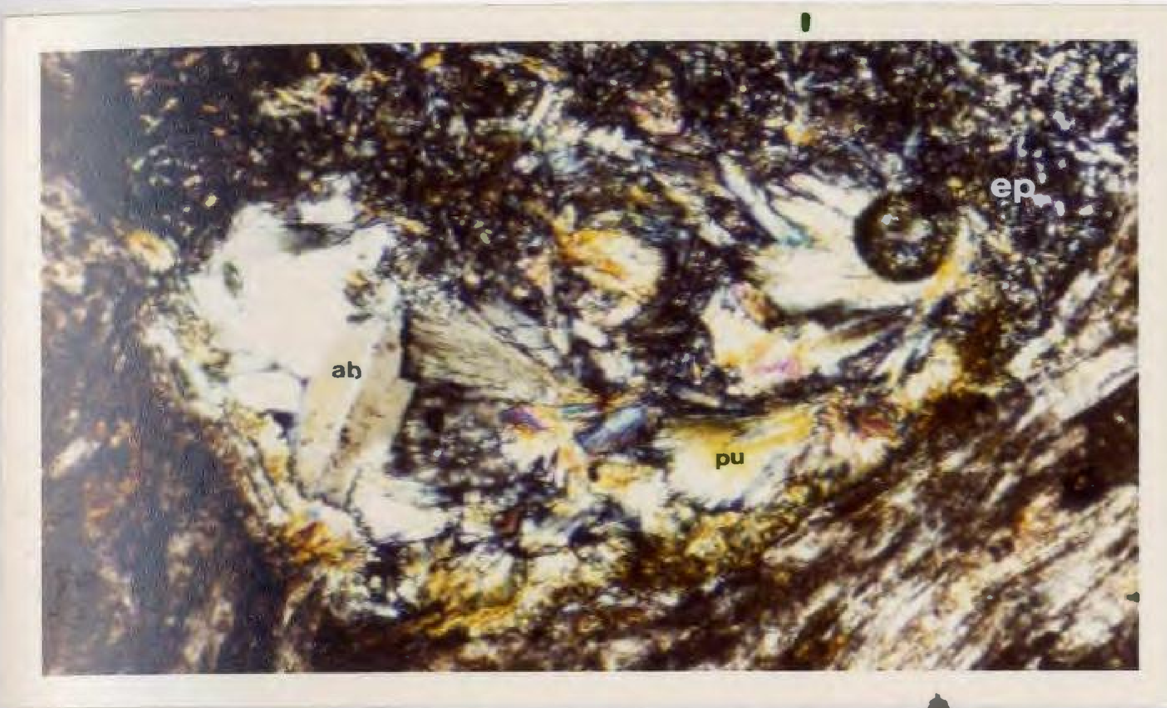


Plate 23. The mineral assemblage of an amygdale in trachyte. Epidote (ep), pumpellyite (pu), low albite (ab). Trachyte, SKC-20, x-nicols, (X 200).

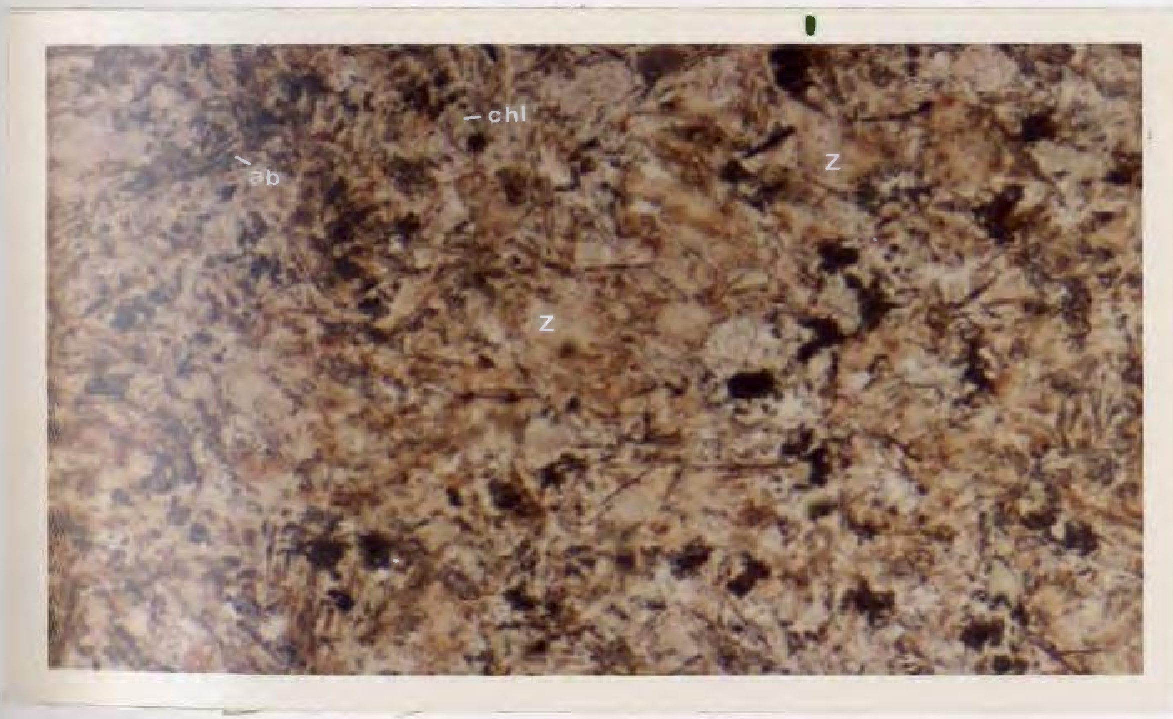


Plate 24. Zeolitized alkali basalt. Brown, fibrous zeolite (z), has replaced much groundmass. The important mineral assemblage is zeolite (z), albite (ab), chlorite (chl). SK-29, plane light, (X 50).

glass or groundmass minerals (Plate 24.) and coarser grained minerals. Table 3. is a list of the mineral assemblages for the different rock types as found in the amygdales and groundmass of the rocks of the Trout River slice.

Table 3.

Metamorphic mineral assemblages in the rocks of the Trout River slice

rock type	amygdales	groundmass
ankaramite	cc-chl-hem-qz-(clay ?)	cc-chl
	cc-hem	cc-chl-Fe.ox.-serp
	anal-cc	cc-chl-sph-Fe.ox.
	chl-cc	mica in pl
	chl-qz	cc-chl-Fe.ox.-idd
	chl-hem	chl-qz-sph
plagioclase-phyric basalt,	chl-anal-amp (?)	zeo-chl-ab
alkali basalt, trachy-	chl-cc-anal	chl-Fe.ox.-ab (mica)
basalt	cc-hem	serp-chl-ab
	cc-anal-amp-sph	cc-ab-mica-sph
	anal-qz	anal-chl-sph
	zeo-cc-anal-ab (chl ?)	hem-idd-Fe.ox.
		adularia-chl-ab
		anal-qz
trachyte	ab-pu-Fe.ox.-ep	ab-chl-cc-hem-(sph)
	chl-pu-ep	ep-ab-Fe.ox.
	cc-Fe.ox.	

primary minerals	alteration assemblage
calcic plagioclase, K-feldspar	cc-ab-mica-Fe.ox-anal-zeo-adularia-(ep-in trachyte)
augite	Fe. ox.-chl-sph (amp ?)
glass	ab-pl crystallites-Fe.ox.-chl-sph-amp-clay?-qz
olivine	chl-serp-qz-cc-idd-hem-Fe.ox.
opaque minerals	minor leucoxene-hem-sph
apatite	inert in most samples

Table 3. (continued)

Abbreviations: cc (calcite); chl (chlorite); hem (hematite); Fe.ox. (opaque iron oxide); qz (quartz); anal (analcime); ab (albite); serp (serpentine); sph (sphene); idd (iddingsite); zeo (fibrous zeolite of unidentified composition); pu (pumpellyite); amp (amphibole); pl (plagioclase); ep (epidote).

Fyfe *et al.* (1958) suggested that analcime and heulandite-bearing assemblages are diagenetic (autometasomatic ?) rather than metamorphic in origin. Coombs *et al.* (1959) and Coombs (1961) defined the zeolite facies to include those assemblages produced under physical conditions during which quartz-analcime, quartz-heulandite, and quartz-laumontite assemblages are commonly formed (N.B. analcime alone does not necessarily diagnose zeolite facies rocks).

The mafic rocks of this slice contain mineral assemblages that correspond to the very low grade metamorphic facies; namely the zeolite facies of Coombs (1961, 1971) or the heulandite-laumontite facies of Seki (1969). The presence of fibrous zeolite (type unknown) and the assemblage analcime-quartz (according to Reaction A, below) in the mafic rocks of the Trout River slice is diagnostic of zeolite facies metamorphism.

Reaction A analcime + quartz = albite + fluid

Physical conditions influencing the presence of mineral assemblages include μH_2O, μCO_2, P_{fluid}, T, and the bulk compositions of various lithologies. Zen (1961) suggested that under isobaric - isothermal conditions, the progression in metamorphic grade from zeolite $\rightarrow$ prehnite -pumpellyite $\rightarrow$ greenschist can be accounted for by the decreasing μH_2O at low values of μCO_2. Qualitatively, the presence of zeolite and analcime-quartz in the Trout River slice may indicate a relatively high μH_2O which facilitated the degradation of the primary mineralogy.

Liou (1971*a*) placed the maximum temperature of analcime crystallization (*i.e.* Reaction A) in an H_2O-rich siliceous environment at 183°C at 5 kb P_{fluid}, 196°C at 3 kb P_{fluid}, 200°C at 2 kb P_{fluid}. Campbell and Fyfe (1965) calculated the equilibration temperature for Reaction A in pure water at 196°C. Furthermore, this temperature may be displaced to 100°C in saturated NaCl solutions. Therefore it is very likely that temperatures were less than 200°C during the metamorphism of the Skinner Cove Formation. Pressures were probably low to medium (approximately 2 to 3 kb) based on literature surveys by Seki (1969) and Liou (1971*b*).

The presence of pumpellyite-albite and epidote-albite-iron oxide in the Red Fire Brook Member trachyte may be the result of bulk composition. Pumpellyite-albite is not diagnostic of the prehnite-pumpellyite facies especially since these low grade metamorphic facies are best defined in mafic rocks and not trachytic bulk compositions.

This structural slice contains the first fibrous zeolite and abundant groundmass analcime described in the higher igneous slices of the Humber Arm Allochthon. Volcanic rocks of similar metamorphic grade in the Bay of Islands Complex contain clay minerals instead of zeolite/analcime (G. Einarson, pers. communication, 1978).

3.1.4 Significance

The Trout River slice is subdivided into the Main Sea Stack, Wallace Brook and Red Fire Brook Members. The lithologies comprising the members are ankaramite, pyroxene-phyric basalt, alkali basalt, trachybasalt and trachyte, thereby forming a unique petrographic suite. Many different types of breccias are evident in the slice suggesting explosive volcanic eruptions (lapilli, tuff), brecciation of lava during downslope movement (pillow breccia and 'peperite' autobreccia), or subaerially eroded and later reworked breccia (epiclastic breccia).

The competent lithologies are separated from juxtaposed structural slices by a mélange, which is interpreted as the surface upon which the Trout River slice was transported.

With the exception of mélange, the rocks are undeformed. The presence of fibrous zeolite and analcime-quartz indicates the low-grade zeolite facies metamorphism of the slice. Relict titanaugite and serpentine-chlorite-calcite pseudomorphs of olivine phenocrysts suggest the rocks have alkaline affinities.

3.2 Geology of the Western Head Structural Slice

This structural slice is located at Western Head (Fig. 1b., 2.) and about 2 km northeast of the Trout River slice (Fig. 2.).

The slice consists of a northeast striking (range of 35 to 55 degrees), southeast dipping (range of 40 to 55 degrees), discontinuous sequence of mafic extrusive and dyke rocks. Pillow forms give southeasterly facing directions and indicate that the rocks are upright. The strata are considered too discontinuous along strike to be depicted as mappable units. On the basis of petrography and geochemistry, the rocks of the Western Head slice are re-assigned from the Skinner Cove Formation (Williams, 1973) to the Little Port Complex (Fig. 4.).

3.2.1 Contact relationships

The northeastern contact is a sharp, high-angle, southeasterly dipping (about 65 degrees) fault, which places foliated and banded gabbros and amphibolites of the Little Port slice assemblage structurally above mafic volcanic rocks of the competent Western Head slice (Plate 25.). The southwestern contact is an inferred reverse fault that juxtaposes Western Head rocks structurally above Little Port gabbro, however, these relationships are obscured by scree slopes.

Where visible, the contact is marked by a mélange (about 50 m wide) containing 10 m knockers of gabbro (Plate 26.), ultramafic rocks and sandstone beds. The sandstones are coarse-grained and contain much quartz and feldspar (they probably belong to the Humber Arm Supergroup). All of the mélange knockers are suspended in a shale/serpentinite matrix.

3.2.2 Lithologies

The lithologies of the competent slice consist of about 75 m thickness of mafic pillowed and massive lava flows, pillow breccia, aquagene tuff, and mafic sills. Mafic dykes that transect portions of the sequence are assumed to be coeval with the pillow lavas and breccias.

Pillow forms are well preserved and display excellent radial and concentric joint patterns. The pillow shapes vary from spherical, to branching, budding and bulbous. Numerous, thin (15 cm), rapidly cooled sills or flows interdigitate with the pillow lavas. In places, dark, massive lavas show primary undulating flow structures on their upper surfaces; other lavas are autobrecciated. Pillow breccias consist of brownish pillow fragments set in 60 per cent fine-grained green auquagene tuff.

Two distinct types of dykes are evident: 1)thick (1 to 3 m), medium-grained diabase with about 5 per cent pyrite, 2) gray to brown aphanitic dykes that intermingle with pillow lavas and are assumed to

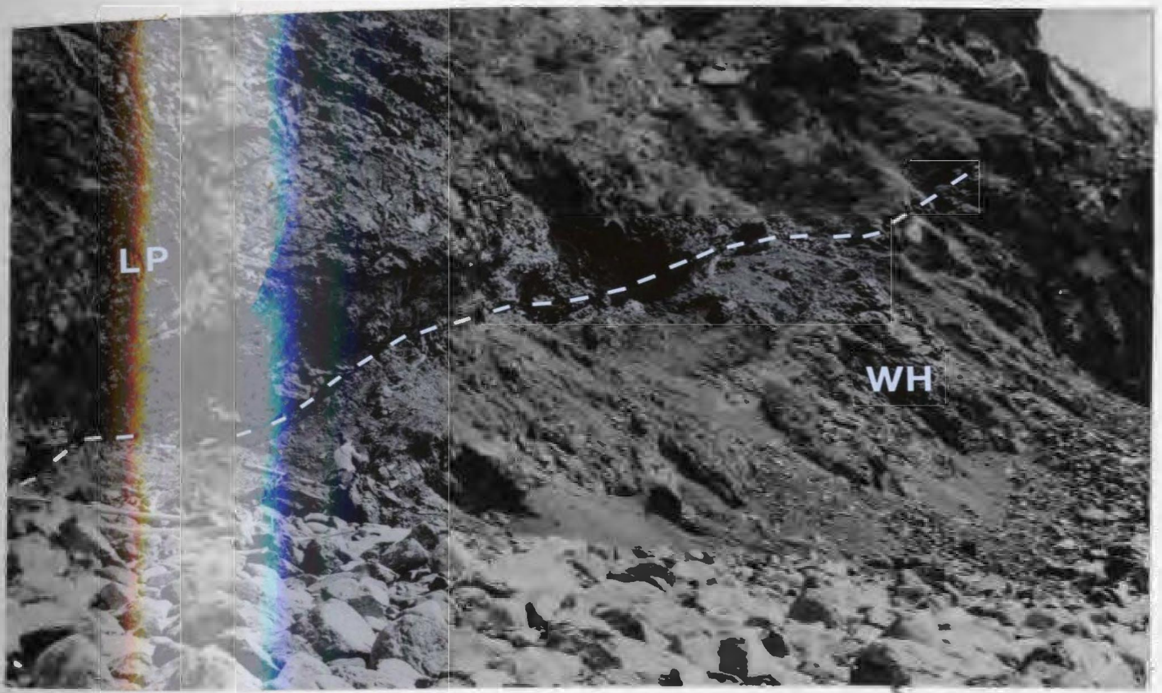


Plate 25. The NE contact of the Western Head slice is a high-angle, SE dipping thrust (dashed line), which places Little Port gabbro (LP) structurally above Western Head rocks (WH). Scale is left of centre below the fault.

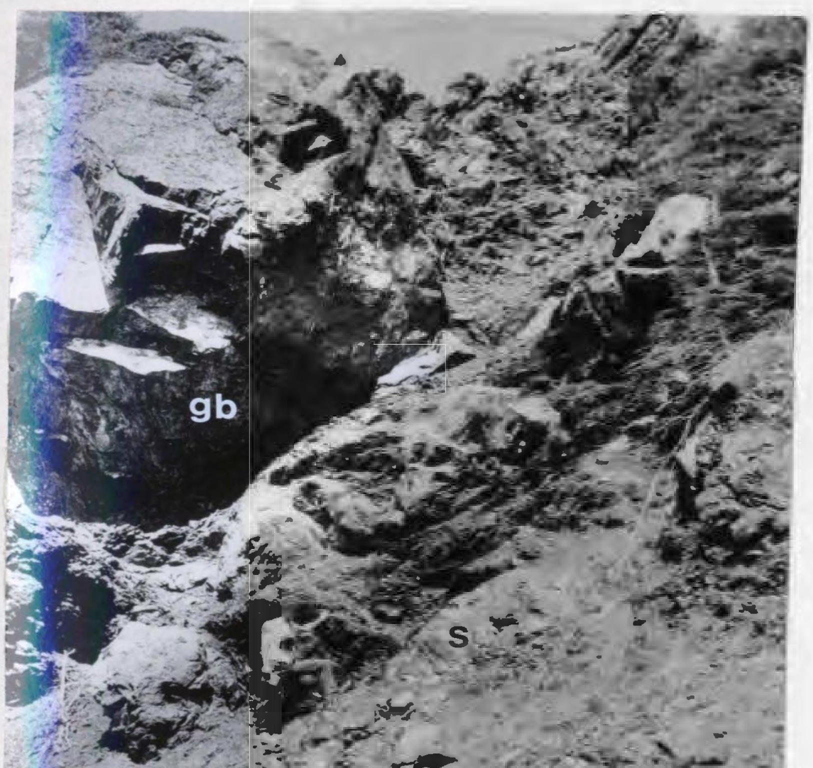


Plate 26. Mélange between the Western Head slice and another slice of the Little Port Complex. Rubbly sedimentary beds (S) are located in the foreground. Large gabbro knockers(gb), are evident.

be the feeders of those lavas.

3.2.3 Petrography and metamorphism

Thin sections of rocks from the southwestern portion of the Western Head slice (*e.g.* WH-6, WH-2, see Appendix A.) are aphyric, aphanitic to medium grained, and only sparsely amygdaloidal. Diabasic and subdiabasic primary textures are superbly preserved in most examples (Plate 27. and 28.). Texturally and mineralogically, these rocks are all basalts and diabases, consisting of slightly varying proportions of plagioclase, clinopyroxene, opaque minerals and alteration minerals (Appendix A.).

Relict clinopyroxene occurs between brownish, cloudy, pitted plagioclase laths. Plagioclase is usually altered to albite (plus calcite and mica), but in some examples, oligoclase and labradorite are preserved (optical and microprobe determinations, WH-6). Very fine-grained subhedral to anhedral and skeletal magnetite grains are located interstitially to albite laths. The clinopyroxenes are relics of basaltic augites, which locally have chloritized rims and fractures. In more rapidly cooled rocks, the augites tend to be elongate in habit and 'feathery' in texture. Chlorite, granular sphene, minor calcite and hematite are ubiquitous in the basalts. Pyrite is most abundant in the medium-grained diabase dykes.

The mineral assemblage albite-chlorite-sphene-calcite-Fe oxide is not diagnostic of any particular metamorphic facies. As in the Trout River slice (section 3.1), primary structures and textures are not obliterated, and penetrative deformation is nowhere observed. Thus the possibilities for metamorphic facies are low greenschist to zeolite. The preservation of some calcic plagioclase suggests sub-greenschist

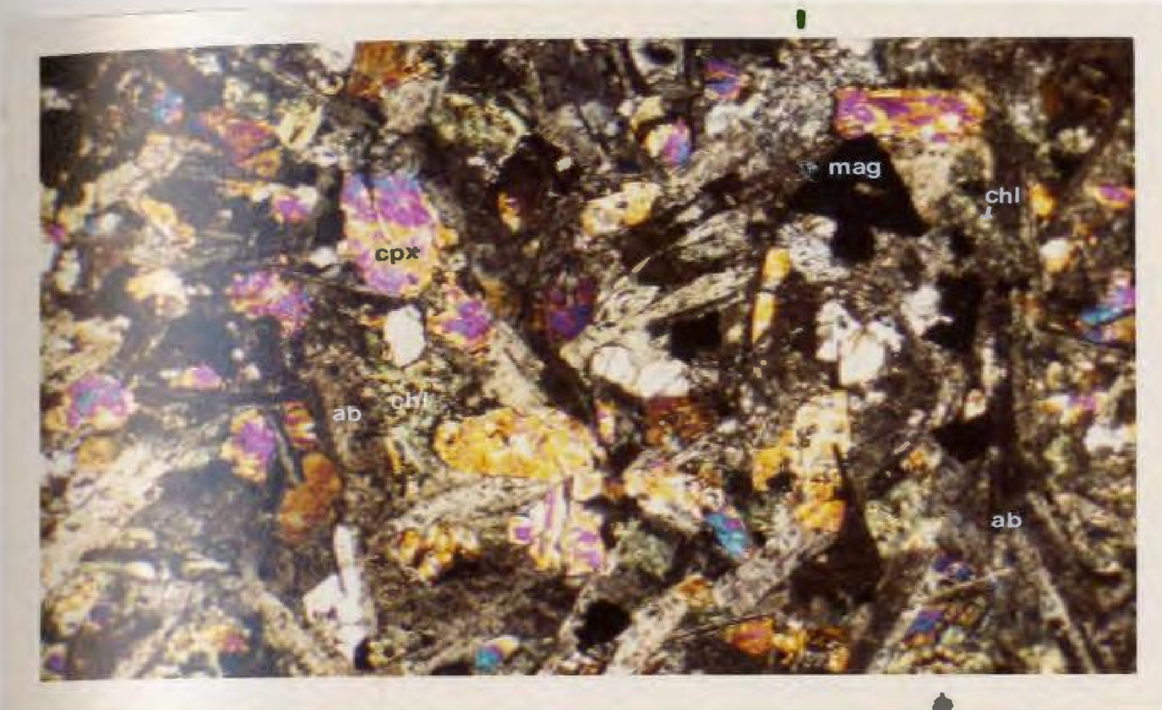


Plate 27. Diabasic/subdiabasic texture in a mafic lava at Western Head. Clinopyroxene (cpx), skeletal magnetite (mag), dusty albite (ab), chlorite (chl). Basalt, WH-8, x-nicols, (X 31).

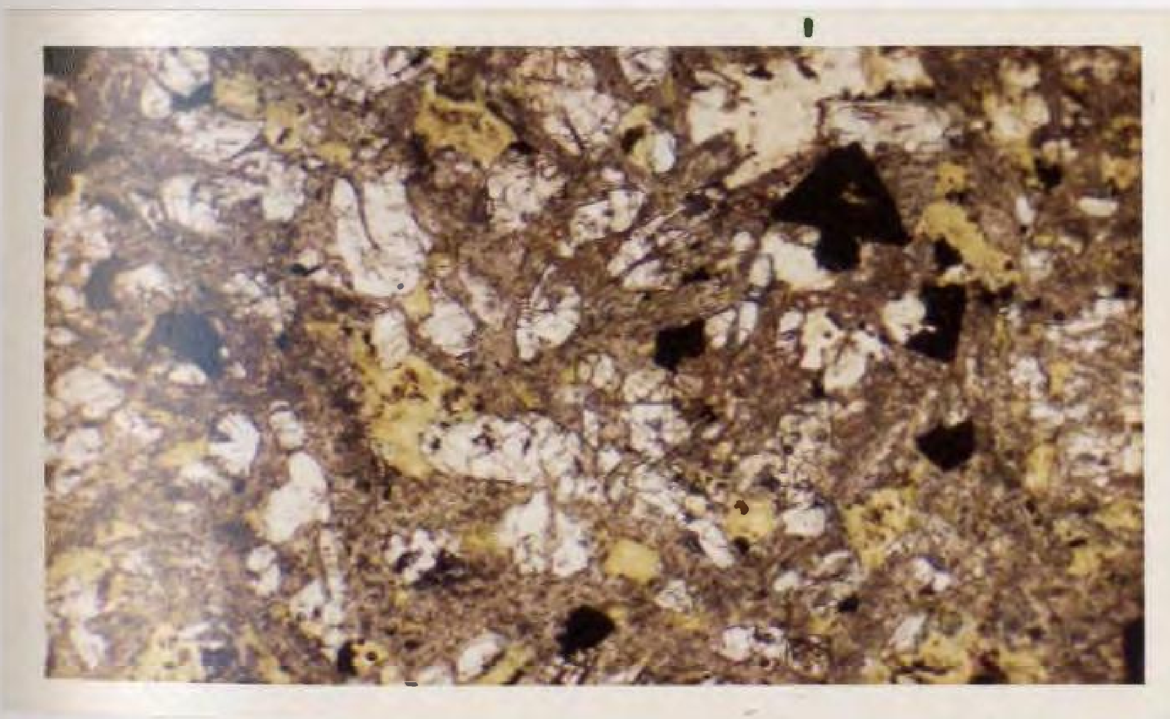


Plate 28. Same example as in Plate 27. Note particularly dusty brown albite and yellow-green chlorite. Plane light, (X 31).

facies; possibly prehnite-pumpellyite facies.

3.2.4 Significance

Macroscopically, the appearance of the pillow lavas and medium-grained diabase dykes is not similar to the mafic rocks of the Trout River slice. Microscopically, the textures and mineralogies are nearly identical to some of the mafic rocks studied from the vicinity of the 'type' Little Port Complex (*i.e.* at Little Port, Figs. 1b. and 2.), (*cf.* Plate 27. to Plate 33.).

Based on the available field and petrographic observations, it is concluded that the Western Head and Trout River structural slices are not in stratigraphic continuity and that the rocks of the Western Head slice have primary magmatic affinities, like those of the volcanic rocks of the Little Port Complex in its type area. Accordingly, the rocks of the Western Head slice are re-assigned from the Skinner Cove Formation to the Little Port Complex (see also Chapter 6 for more decisive evidence).

3.3 Geology of the Chimney Cove Structural Slice

The Chimney Cove slice is exposed along the coastline 100 m north of Chimney Cove and the Gregory River (Fig. 2.). The form of the slice (in plan section) is that of a north-northeast trending wedge, approximately 0.8 km in strike length. The exposed width of the slice is about 75 m. As outlined in Chapter 2, and shown in Figure 4., just the coastal lithologies of the Chimney Cove slice are assigned to the Skinner Cove Formation. The affinity of the inland rocks is unknown.

3.3.1 Contact relationships

The contact relations near Chimney Cove are unique in that one sees faulted contacts between three major structural slices (*i.e.*

Skinner Cove, Little Port, Humber Arm slice assemblages).

Along the shoreline, volcanic and sedimentary rocks of probable Skinner Cove Formation parentage are juxtaposed against Little Port anorthositic gabbros to the east, and Humber Arm sediments to the south (Fig. 3.). The eastern contact of the coastal slice with the Little Port is a high-angle, easterly dipping (80 degees) fault, with an intervening mélange. The contact is about 5 to 10 m wide and consists of sheared Humber Arm sedimentary rocks.

The southern contact places rocks of the Chimney Cove slice structurally above disrupted red and green shales and bedded sandstone of the Humber Arm slice assemblage.

3.3.2 Coastal lithologies

Considerable variation is noted in lithic type, including heterolithic volcaniclastics, monolithic mafic breccia, massive mafic flows and limestones.

The volcaniclastic unit forms thick (about 38 m), bedded strata that dip vertically and strike east. Beds are variable in thickness and have poorly defined upper and lower contacts, making top determinations difficult. Clasts are intermediate to felsic, rounded, aphyric to slightly porphyritic.

Mafic autobreccias are carbonate-cemented and are reminiscent of beds of the Wallace Brook Member (section 3.1.2.2). These breccias consist of coarse- (2 to 3 m) and fine- (ash size) grained phyric mafic clasts. The larger clasts are typically irregularly shaped and show all degrees of autobrecciation. In places, primary limy muds or sandy limestones form the matrix to the mafic clasts. Usually, however, most muds are partly or totally recrystallized to coarsely crystalline calcite.

Breccia clasts and most massive lava flows consist of ankaramite, pyroxene-phyric basalt, plagioclase-phyric basalt and aphyric basalt. These lithologies are very similar to those described in the Trout River slice to the north. Plagioclase-phyric basalts are probably the most abundant local rock type.

Thick (minimum of 7 m), massive, fossiliferous limestone rests (assumed conformably) upon massive and brecciated lavas. The limestone is buff to brownish-gray and has flakey, hummocky, 0.5 cm rounded pockets on the weathered surface. The unit appears very impure and contains much volcanic detritus. Several limestone samples failed to yield conodonts (see also section 2.2).

Three or 4 m of black and green shales (volcanic lutite) strike north-south and have an overprinted foliation with the same trend. Immediately to the west, brecciated, buff, fossiliferous limestone forms undulating lenses for a strike distance of 30 to 40 m. This limestone/shale relationship is found intermittantly along the strike-length of the slice. The limestone/shale contact is a tectonic breccia consisting of limestone clasts suspended in shale.

3.3.3 Inland lithologies

The 'inland' lithologies are situated in a faulted sliver east of the shoreline and north of Gregory River (Fig. 2.). The lithologies are essentially altered mafic lavas, breccias and interbedded black and green shales.

Volcanic rocks are everywhere hematized, calcite-veined and sparsely plagioclase-phyric. Carbonate-cemented volcanic breccias are highly altered and it is not discernable whether or not they are similar to the breccias along the coast. Within 200 m of the contact with the Little Port gabbros to the north, sediments and volcanic lithologies become intensely veined and slickensided. Closer to the same contact (within 30 m) volcanic knockers are engulfed in foliated black shale.

3.3.4 Petrography and metamorphism

Ankaramites from the coastal exposures of the Chimney Cove slice (*e.g.* CC-ANK, Fig. 2.) consist of large (8 mm) euhedral to anhedral clinopyroxene (titanaugite) phenocrysts. The clinopyroxenes comprise about 20 per cent of the lithology (Appendix A.). Serpentine-chlorite-calcite assemblages always pseudomorph 0.5 to 2 mm olivine euhedra. The groundmass is flecked by opaque minerals, calcic plagioclase laths, much granular sphene and chlorite. Titanaugite is prismatic and abundant in the groundmass.

In the plagioclase- and pyroxene-phyric basalts (*e.g.* CC-30), plagioclase crystals include phenocrysts (4 mm tablets), microphenocrysts and groundmass microlites, thus emparting seriate textures. Plagioclase is altered to an albite-mica $\pm$ calcite assemblage. Titanaugites form euhedral phenocrysts, microcrysts and glomerocrysts. Groundmass textures are hypocrystalline and pilotaxitic. The single most spectacular thin section from Chimney Cove contains hourglass structure, zoned and twinned titanaugite phenocrysts and glomerocrysts (Plate 29.). Resorbed euhedral and anhedral titanomagnetite microcrysts are invariably associated with augite glomerocrysts. Matrix titanaugite laths are hourglass zoned and twinned; groundmass plagioclase crystals are dusty, and contain numerous mica and opaque mineral inclusions. Granular sphene is exceedingly abundant as an alteration product of Fe-Ti oxide.

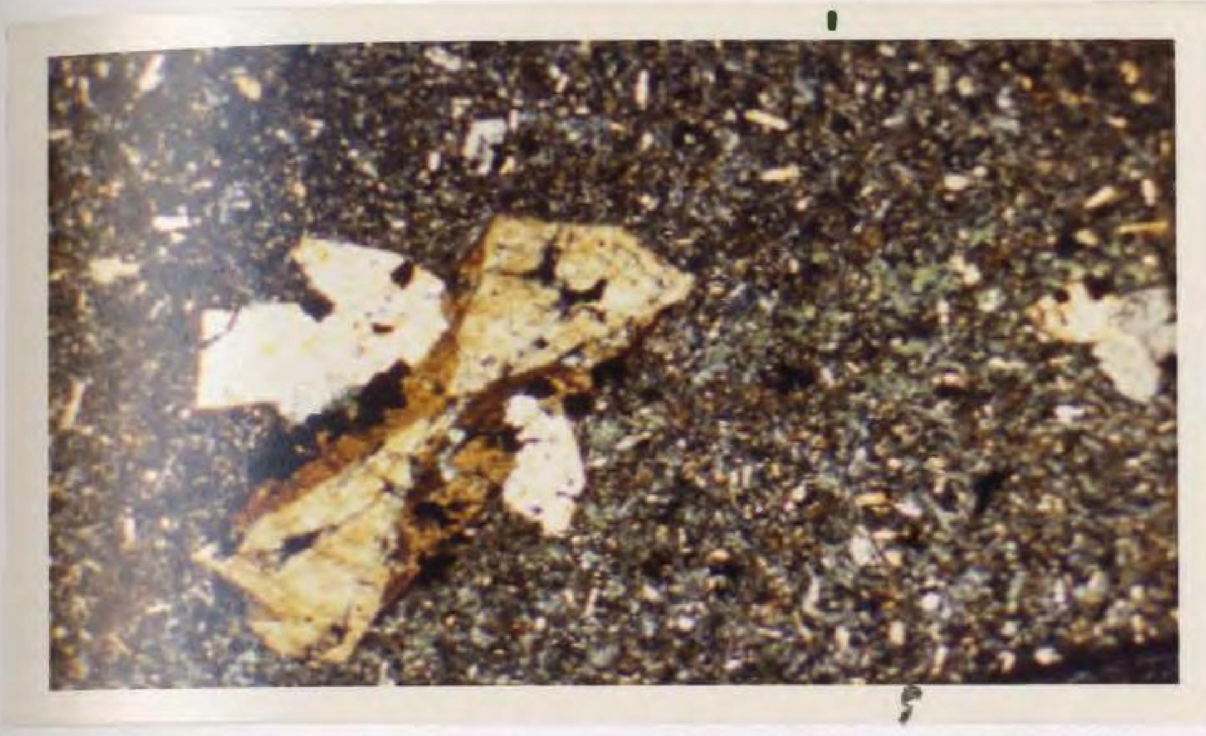


Plate 29. Glomerophyric, zoned Ti-augite with hourglass structure. Groundmass consists partly of devitrified glass, microlitic plagioclase and tabular/granular titanaugite. Pyroxene-phyric basalt, CC-32, x-nicols, (X 31).

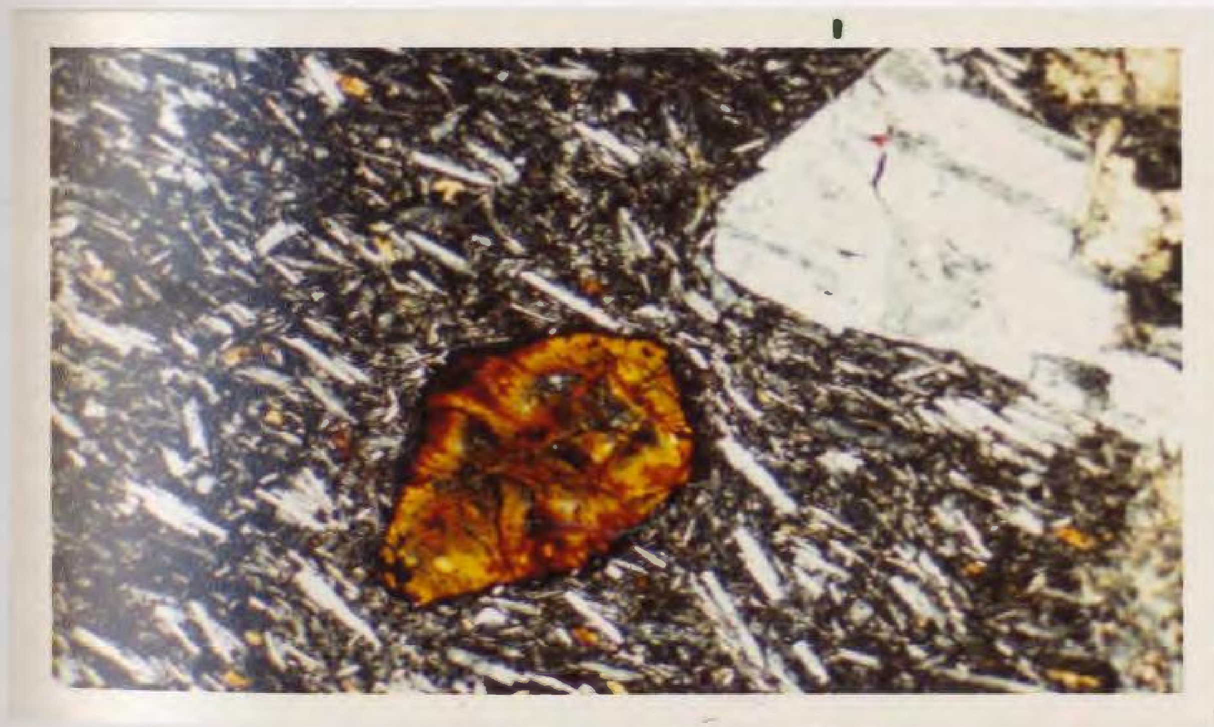


Plate 31. Iddingsitized microphyric olivine euhedra in trachybasalt. Note also pilotaxitic groundmass. Knocker from mélange near Trout River Village. TR-7, x-nicols, (X 31).

Chemically, some of the augites are the most titanian ever described (*i.e.* for terrestrial augite, CC-28 contains 6.5 per cent TiO_2, Appendix B.).

Metamorphic mineral assemblages are presented in Table 4.

Table 4.

Metamorphic mineral assemblage in the volcanic rocks of the Chimney Cove slice (see Table 3. the legend to abbreviations)

primary minerals	alteration minerals
calcic plagioclase	ab-mica-cc
clinopyroxene	Fe.ox.-cc-chl (rarely)
olivine	serp-cc-chl-sph
glass	Fe.ox.-cc-chl-sph-ab
Fe-Ti oxide	sph
	secondary chl and cc veining is common

As in the Western Head slice, the metamorphic mineral assemblage (Table 4.,above) is not diagnostic of one metamorphic facies; but considering the lack of metamorphic fabrics coupled with the preservation of primary textures in most samples, the metamorphic grade can be interpreted as low to very low (*i.e.* prehnite-pumpellyite to zeolite facies).

The heterolithic volcaniclastic unit contains mafic, and intermediate to felsic lithic clasts, all weakly cemented by calcite. These lithologies correspond precisely to the alkali basalt, trachybasalt, trachyte suite of the Trout River slice.

3.3.5 Significance

Chimney Cove coastal rocks are faulted to the east against Little Port Complex gabbros, and to the south against Humber Arm sediments. Therefore, the coastal rocks form a structural slice that is distinct and separated from the mafic volcanic and sedimentary rocks north of Gregory River (Fig. 2.).

The mafic rocks of the coastal structural slice are alkaline, as they contain (1) a single monoclinic titaniferous pyroxene, and (2) serpentinized olivine phenocrysts and groundmass crystals. The suite (*i.e.* ankaramite to trachyte) is differentiated and similar in all respects to the volcanic suite of the Trout River slice (section 3.1.3). Additionally, the carbonate-cemented mafic autoclastic breccias are similar in appearance to the Wallace Brook Member of the Trout River slice (see Plate 8.). The Chimney Cove slice contains low grade metamorphic rocks devoid of penetrative deformation (N.B. foliations in the volcanic lutite (black shales) and brecciation of nearby marble are interpreted to have formed during the emplacement of the slice. Under high hydrostatic pressure, the lutites would fail against competent limestone and become the locus of glide).

Pre-transport paleoenvironmental and depositional implications are as follows:

(1) The mafic volcanic breccia probably formed as lava erupted onto/into lime mud (*i.e.* a peperite). Subsequent downslope movement autobrecciated the lava.

(2) Analysis of the thick heterolithic volcanic lutite to rudite suggests:

(i) The constituent lithologies of the unit are basalt, trachybasalt and trachyte. These latter two rock types are typically late stage differentiates of mature alkaline volcanic piles, thus their accumulation in a conglomerate suggests subaerial exposure, weathering and erosion of a nearby volcanic terrane.

(ii) The rounding of felsic pebbles and boulders must have occurred in a high energy, shallow water environment (beach or shallow alluvial). The available data are insufficient to construct a depositional facies model for the clastic unit.

(3) Thick, volcaniclastic-rich, fossiliferous limestones suggest carbonate sedimentation in shallow, warm marine waters, proximal to a subaerial volcano.

In summary, the coastal slice near Chimney Cove has lithic, petrographic, structural and metamorphic characteristics similar to those of the Trout River slice. Therefore there is a high probability that the structural slice is part of the Skinner Cove slice assemblage, as suggested by Williams (1973). This study could not define the slice affinities of the mafic and sedimentary rocks north of Gregory River (*i.e.* the 'inland' lithologies above). These inland rocks may belong with the Little Port Complex, or the Humber Arm Supergroup (*i.e.* Wood's Island Member (Stevens, 1965, 1970)).

3.4 <u>Geology of the Beverley Head Structural Slice</u>

The slice is located at Beverley Head, north of the Bay of Islands (Figs. 1b., 2.). The rocks form a structural sliver that is poorly exposed (except along the coast) for a distance of 5 km along its northerly strike.

Stratigraphic sections cannot be measured or thicknesses approximated owing to the probable imbrication of the rocks and the discontinuous nature of the exposures. Pillow lavas along the coast strike southeast, dip moderately (45 degrees) east, and are east facing. Tops are determined by pillow forms and graded bedding in limy sediments. The slice contains foliated gabbro of probable Little Port Complex affinities.

3.4.1 Contact relationships

The Beverley Head slice is bounded on the west by a slice of Humber Arm clastic sediments (Fig. 3.) and the Gulf of St. Lawrence. Ultramafic rocks of the Bay of Islands slice assemblage form all eastern contacts. All northern contacts with the Humber Arm sediments are unexposed (Plate 30.).

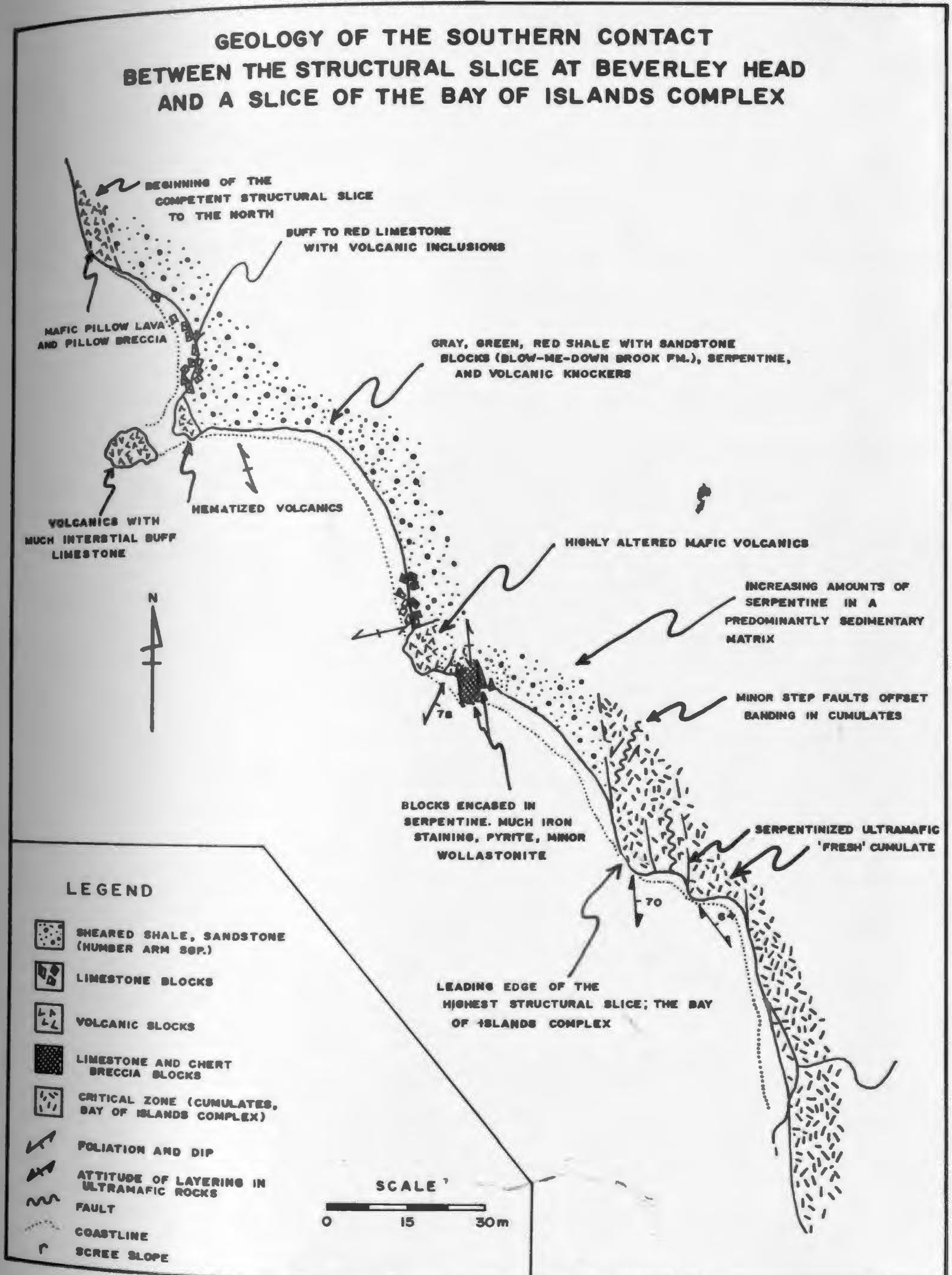
A geological map showing the southern contact relationships with the Bay of Islands slice is illustrated in Figure 5. Fractures in mafic volcanic knockers locally contain wollastonite (visual and x-ray diffraction determinations) and other calc-silicate minerals are evident near limestone blocks within the mélange (possibly xonotolite ?). Talcose and serpentinized ultramafic knockers become increasingly abundant near the contact with mafic and ultramafic cumulates of the Bay of Islands slice.

The eastern contact of the structural slice juxtaposes serpentinized ultramafic rocks of the Bay of Islands slice against hematized (thermally altered ?) volcanic rocks. These volcanic lithologies are in places interbedded with foliated shales and sandstones (a mélange ?). Two parallel faults along the east contact offset the leading edge of the ultramafic rocks, imparting a ragged, or 'sawtooth' contact (Plate 30.).

The attitudes of all inland contacts are unknown.

Figure 5. Geology of the southern contact between the structural slice at Beverley Head and a slice of the Bay of Islands Complex.

This map can be located at the southern contact of the slice and is denoted by a circled area in Plate 30.


GEOLOGY OF THE SOUTHERN CONTACT
BETWEEN THE STRUCTURAL SLICE AT BEVERLEY HEAD
AND A SLICE OF THE BAY OF ISLANDS COMPLEX
BEGINNING OF THE COMPETENT STRUCTURAL SLICE TO THE NORTH
BUFF TO RED LIMESTONE WITH VOLCANIC INCLUSIONS
MAFIC PILLOW LAVA AND PILLOW BRECCIA
GRAY, GREEN, RED SHALE WITH SANDSTONE BLOCKS (BLOW-ME-DOWN BROOK FM.), SERPENTINE, AND VOLCANIC KNOCKERS
HEMATIZED VOLCANICS
VOLCANICS WITH MUCH INTERSTIAL BUFF LIMESTONE
HIGHLY ALTERED MAFIC VOLCANICS
N
INCREASING AMOUNTS OF SERPENTINE IN A PREDOMINANTLY SEDIMENTARY MATRIX
MINOR STEP FAULTS OFFSET BANDING IN CUMULATES
78
BLOCKS ENCASED IN SERPENTINE. MUCH IRON STAINING, PYRITE, MINOR WOLLASTONITE
SERPENTINIZED ULTRAMAFIC
'FRESH' CUMULATE
70
64
LEADING EDGE OF THE HIGHEST STRUCTURAL SLICE; THE BAY OF ISLANDS COMPLEX
LEGEND
SHEARED SHALE, SANDSTONE (HUMBER ARM SGP.)
LIMESTONE BLOCKS
VOLCANIC BLOCKS
LIMESTONE AND CHERT BRECCIA BLOCKS
CRITICAL ZONE (CUMULATES, BAY OF ISLANDS COMPLEX)
FOLIATION AND DIP
ATTITUDE OF LAYERING IN ULTRAMAFIC ROCKS
FAULT
COASTLINE
SCREE SLOPE
SCALE
0
15
30m

3.4.2 Lithologies

The distribution of the lithologies can be seen best in Plate 30.

The slice consists of mafic volcanic lavas, pillow lavas, pillow breccia, minor dykes, monzonite and foliated gabbro. Limestones are common in inter- and intrapillow regions, as matrices and breccias, and in monolithic rubbly (faulted) outcrops. Arkose, graywacke, and red and green shales are structurally intermixed with volcanics near the eastern slice contact. Clastic sediments occur in zones of imbrication within the main body of the slice. Foliated gabbro and serpentinized ultramafic pods are situated in Gabbro Brook (Plate 30.). The northernmost outcrop forms a poorly delineated body of subvolcanic rocks. The same type of lithology is present more than 27 km northeast near the Trout River slice (see Plate 1., rock type '2b' in Wallace Brook).

Mafic volcanic rocks are everywhere strongly hematized, and veined by calcite. Weathered lava surfaces have a tendency to be crumbly and friable and therefore considered unsuitable for geochemical analysis. Dyke rocks are aphanitic, aphyric, non-amygdaloidal and have good hexagonal columnar joints.

Interpillow limestones are massive, very fine-grained and irregularly distributed. In contrast, intrapillow limestones occur as regularly shaped, consistantly convex upward pods. The limestones in the pods show bedding, graded bedding or they are simply massive. Intrapillow limestones consist of re-sedimented mud and sand that accumulated in voids of pillow cores and are similar to the rocks described by Garrison (1972). Faults exposed along the coast formed preferentially near less competent limestone beds, resulting in scree slopes consisting of limy blocks. Open warping of laminations in non-fossiliferous, brecciated lime muds suggests that the brecciation process occurred when the muds were not totally lithified.

Thin- to medium-bedded, medium-grained arkose, graywacke and shales are found along Waterfall Stream (Plate 30.), and are assumed to belong to the Blow-Me-Down Brook Formation (Stevens, 1965) of the Humber Arm Supergroup. Shales are cleaved; coarser clastics show no deformation. Between the coastal volcanics and foliated gabbro in Gabbro Brook, shales are foliated and folded.

3.4.3 Petrography and metamorphism

Volcanic rocks retain most primary igneous textures, although relict minerals are relatively rare. The volcanics are simply termed basalts or spilitized basalts. Aphanitic basalts with rare plagioclase-phyric varieties comprise the main types of volcanic rocks. Calcite, clay (?)-celadonite and chlorite are present in amygdales. In places, clinopyroxene microcrysts have escaped alteration and are found in association with albite (pseudomorphs of calcic plagioclase) microcrysts. The pyroxenes are clear, non-pleochroic and are not noticeably zoned. Alteration products of pyroxene are calcite, hematite, and chlorite. The groundmass consists of chlorite, iron oxide, carbonate, albite, and in some samples, celadonite.

Foliated, medium-grained gabbro consists of granular, anhedral clinopyroxene and olivine set in a serpentinized-chloritic matrix and dusty-brown mesostasis. Plagioclase is totally replaced by radiating sheaves of prehnite. Hydrogarnet is identified tentatively.

The shallow subvolcanic rock at the northern limit of the slice is composed of about 80 per cent equidimensional, dusty-brown, albitized and carbonatized plagioclase. Interstitial to the albite laths and tablets, chlorite, calcite, opaque minerals and secondary albite have formed. The rock is called a monzonite.

Laminated limestones contain very fine-grained carbonate grains that are partly surrounded by hematite. Limestones dissolved for conodonts failed to yield any specimens.

Alteration mineral assemblages in mafic volcanics indicate low grades of metamorphism. It is obvious that if the structural slice is internally imbricated, an overall metamorphic facies cannot be assigned. Rocks that were metamorphosed to different grades in different tectonic settings prior to transport could easily be juxtaposed during emplacement.

3.4.4 Significance

The salient features of the geology of the Beverley Head slice are as follows:

(1) An easterly facing, undeformed, mafic volcanic sequence is exposed along the coast. Immediately east of the coast, volcanics, folded sediments and deformed, serpentinized gabbro and ultramafic rocks abut one another. The presence of folded clastic sediments associated with foliated plutonic rocks, and the existance of deformed (older ?) plutonic rocks above undeformed extrusive volcanics suggests severe faulting; but it is not known whether the faults represent imbricate structures or merely vertical faults. Field evidence does not provide the age of formation of the faults, although intuitively, an age corresponding to that of the emplacement of the allochthon is favoured.

(2) Siliciclastic sedimentary rocks of the Humber Arm slice

assemblage occur within the main body of the structural slice.

(3) All lithologies (with the possible exception of the northernmost monzonite) are atypical of the 'type' Skinner Cove Formation as defined in the Trout River structural slice (section 3.1).

(4) Foliated gabbros, like those of Gabbro Brook, are characteristic and abundant lithologies in the Little Port Complex (Williams, 1973).

(5) The attitude and age of the faults that juxtapose different lithologies could not be determined.

The Beverley Head slice cannot be interpreted as a slice of any one of the major transported formations or complexes. Instead, it is a structural assemblage of juxtaposed volcanic, plutonic and sedimentary rocks from at least three slice assemblages (*i.e.* Little Port, Humber Arm, Skinner Cove).

3.5 Other Volcanic Rocks of Possible Skinner Cove Formation Affinities

Williams (1973) mapped several knockers of volcanic rock in the sedimentary terrane immediately east of the coastal igneous/metamorphic complex north of the Bay of Islands (Fig. 3.). As is explained in section 2.2 on age relationships, it is essential to know the slice affinity of some of these knockers; as such knowledge support a pre-Middle Ordovician age for otherwise undated rocks (*e.g.* Skinner Cove Formation).

3.5.1 Geology and petrography of volcanic rocks surrounded by sediment, near Trout River Village

A large isolated exposure containing volcanic rocks occurs 2 km southeast of Trout River Village, west of Table Mountain and at the northwest end of Trout River Pond (Figs. 1b., 4.). The outcrop area is elongated north-south and is 1.5 km long and 0.4 km wide. The rocks are best exposed in a local stream (Feeder Brook) and along ridges.

The volcanics consist of lavas and volcaniclastic rocks, which are petrographically similar to the alkali basalt/trachybasalts of the Trout River slice. These mafic and intermediate rocks are composed of microphyric and groundmass calcic and albitized plagioclase, minor groundmass augite, microphyric iddingsitized olivine (Plate 31., p.81) and abundant alteration minerals. Trachybasalts contain microphyric apatite (see Plate 20.), which is often correlated with alkaline volcanic suites. Alignment of groundmass plagioclase laths and microlites imparts a strong felted texture (Plate 31.). Volcaniclastic rocks consist of angular, monolithic clasts less than 2 cm in size. Clasts are cemented by carbonate and secondary opaque oxides. Alteration minerals are as follows: calcite, hematite, other Fe oxides, chlorite, epidote and sphene.

The presence of abundant primary apatite, olivine microcrysts and sphene indicates that the rocks are rich in phosphorus and titanium, and contain alkaline mineralogy. Trace element data strongly support the suggestion that the rocks are alkalic (section 6.2).

A small (50 m) outcropping of mafic volcanic rocks is located along the south shore of Trout River Pond near Trout River Village. Exposures contain massive brown limestone irregularly distributed amongst the volcanic rocks. The rocks of this knocker are tentatively assigned to the Little Port Complex (Fig. 4.).

3.5.2 Significance

Contact relationships between volcanic/plutonic rocks and the host sediments are obscure in places, but locally, and in the Feeder Brook example, a faulted contact between the volcanics and the surrounding sediments is clearly exposed (Feeder Brook passes through Trout River Village. The brook is too narrow to be located in Figures 1. and 2.). It is reasonable to assume that if the structural slices (*e.g.* Skinner Cove slice assemblage) moved on a lubricating surface consisting of continental margin sediments, then detachment of blocks from competent or 'brittle' slices might occur. The blocks would then be engulfed in the lubricating sediments. The present level of erosion has simply exposed the fault-bounded volcanic/plutonic blocks.

Alternatively, the volcanic rocks may represent extrusive products of the intrusion of mafic magmas into host sediments before or after slice assembly or final emplacement. It would appear fortuitous to follow this line of thinking for the following reasons: 1) the volcanic rocks are lithologically varied; locally with limestones. In order to reconcile the variation and present distribution of the rock-types, one must evoke many aerially isolated and diverse eruptive environments, 2) plagiogranite and gabbro west of Chimney Cove (Fig. 3.) form detached units and are defined on the basis of lithology as Little Port (Williams, 1973). The Little Port slice assemblage everywhere has structural contacts rather than intrusive contacts with the regional sedimentary terrane; it is therefore unlikely that the extrusive equivalents of the plutonic rocks would have intrusive contacts with the same host sediments.

The volcanic block along Feeder Brook and of interest to the present study, is interpreted as having alkaline affinities, and probably represents a detached block of Skinner Cove Formation. This again suggests that the Skinner Cove Formation must have developed in the Early Paleozoic before the emplacement of the allochthon.

CHAPTER 4

GEOLOGY OF THE LITTLE PORT COMPLEX AND SLICE ASSEMBLAGE

Geological descriptions of the Little Port Complex, and its relationships to the surrounding transported terrane are best summarized by Williams (1973, 1975). Descriptions of brecciated dykes and volcanic rocks are given by Williams and Malpas (1972). The brief summary that follows is taken from these publications, personal observations, and Comeau (1972).

The outcrop distribution of the Little Port Complex is seen in Figure 3. and in more detail in Williams (1973) and Williams and Malpas (1972).

The Little Port Complex comprises the Little Port slice assemblage. It is structurally underlain by the Skinner Cove and Humber Arm slice assemblages and possibly the Old Man Cove slice (*i.e.* if one does not consider the Old Man Cove an aureole to the Little Port Complex).

The most voluminous rock types are as follows: 1) foliated gabbro, anorthositic gabbro, amphibolite, 2) basaltic and andesitic (*i.e.* plagioclase-phyric basalt) flows and associated dyke rocks, 3) plagiogranite. The gabbroic and amphibolitic rocks contain a planar tectonic fabric (which is folded in places) that developed prior to the Lower Ordovician structural stacking process. Metamorphic grades are zeolite (?) (Zen, 1974), prehnite-pumpellyite to amphibolite facies. Plagiogranite forms elongate bodies that parallel the fabric and northeast trending outcrop pattern of the gabbros. Locally, plagiogranite cuts and includes foliated amphibolite. The gabbro and plagiogranite are cut by single dykes and locally by sheeted, internally brecciated mafic dykes. The dykes are considered unrelated to the foliated gabbro and coeval with mafic extrusive rocks (Church, 1976 does not agree; see sections 6.1 and 6.2 for details). Porphyritic rhyolite is quantitatively insignificant, but its mere presence with mafic volcanic rocks amplifies its importance. Ultramafic pods, primary igneous scouring and cross bedding in cumulate gabbros, and tectonite fabrics in olivine gabbros, are all evident northeast of Trout River Village.

4.1 Rationale Behind the Sampling of the Dykes and Volcanic Rocks of the Little Port Slice Assemblage

The structural relationships between the Skinner Cove and Little Port slice assemblages are now partly understood, but the hypothesis of a possible genetic relationship between the two slice assemblages (Malpas, 1976) and also the rocks of the Bay of Islands massifs, has not been thoroughly tested. The geochemical relationships between the Little Port lavas and dykes and those of the Bay of Islands Complex should also be more thoroughly investigated. Considering the above, dyke rocks and volcanics of the Little Port Complex were sampled from slices in the vicinity of Little Port (Fig. 2.), where there is geological control.

4.2 Geology of the Little Port Slice Assemblage in the Vicinity of Little Port

Comeau (1972) divided the Little Port transported igneous/metamorphic rocks into six separate slices. The slices structurally overlie sediments of the Humber Arm slice assemblage, but locally, they overlie one another. Sedimentary and/or serpentinite mélange zones are always located between the various slices. Mafic lavas and dyke rocks were sampled from the Bottle Cove and Virgin Mountain slices

(Fig. 2.). The Bottle Cove slice comprises five smaller slices that separated and rotated during the final stages of emplacement. These smaller slices are found from Caplin Cove in the south, to Devil Head in the north (Fig. 2.).

Rocks of the Bottle Cove slice include deformed gabbro, basalt and andesite. The extrusive rock types are massive lavas, pillowed lavas and breccia, and assorted pyroclastic rocks. Comeau (1972) and Williams (1973) note that where deformed coastal gabbros abut undeformed volcanic rocks, prehnitization and penetrative brecciation occur in the volcanics. The juncture between the two rock types is interpreted as a steep unconformity along which subsequent brecciation was facilitated. The writer found tops directed to the west in Little Port (based on graded bedding in fine volcaniclastic rocks), which would place the deformed (older ?) gabbros to the west in a younger geological position. This then implies the presence of an intervening fault.

4.2.1 Petrography and metamorphism

Mafic rocks of the Bottle Cove slice are basalts that have been altered to varying degrees, and are considered here as spilites. The only penetrative post-consolidation structure is brecciation in some flows and dykes (*e.g.* LP-10, Plate 32.), or 'fluidization' as described by Reynolds (1954). Most volcanic rocks contain normal, undisturbed basaltic textures. Where dykes are not brecciated, excellent fine-grained diabasic textures are seen (*e.g.* LP-12, Plate 33.). Flow rocks are massive to pillowed, with and without amygdales. Plagioclase-phyric mafic rocks are probably andesites and basaltic andesites

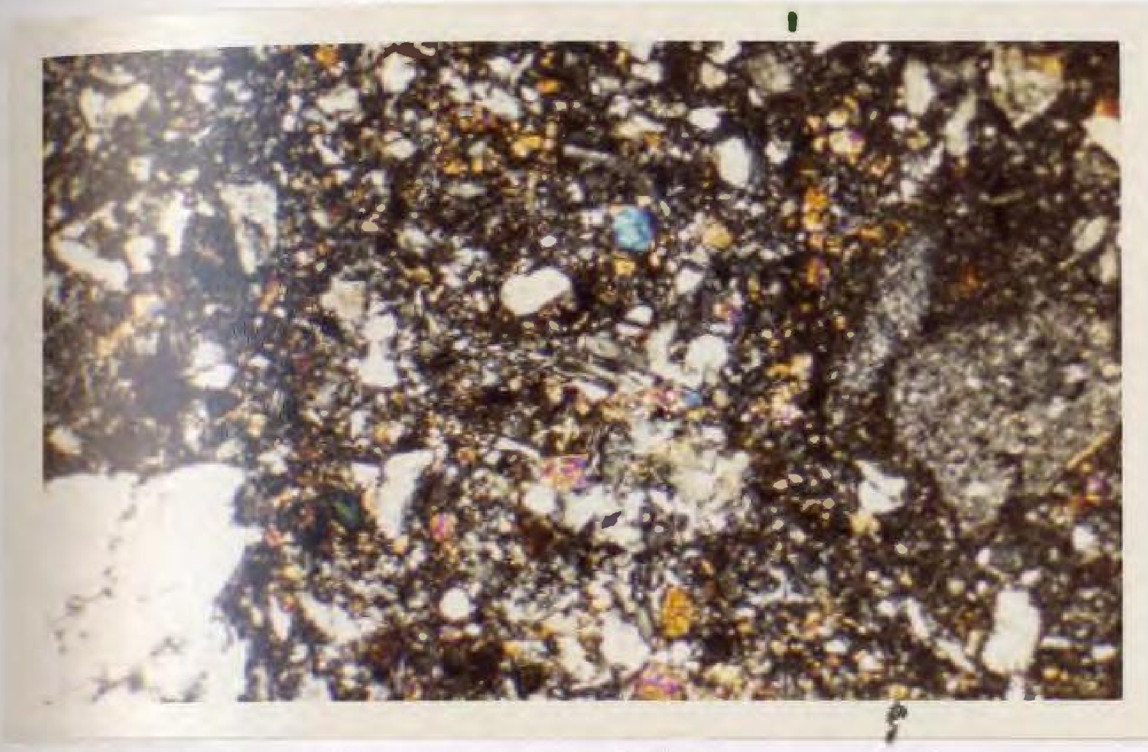


Plate 32. Fluidized mafic dyke at Little Port. LP-10, x-nicols, (X 31).

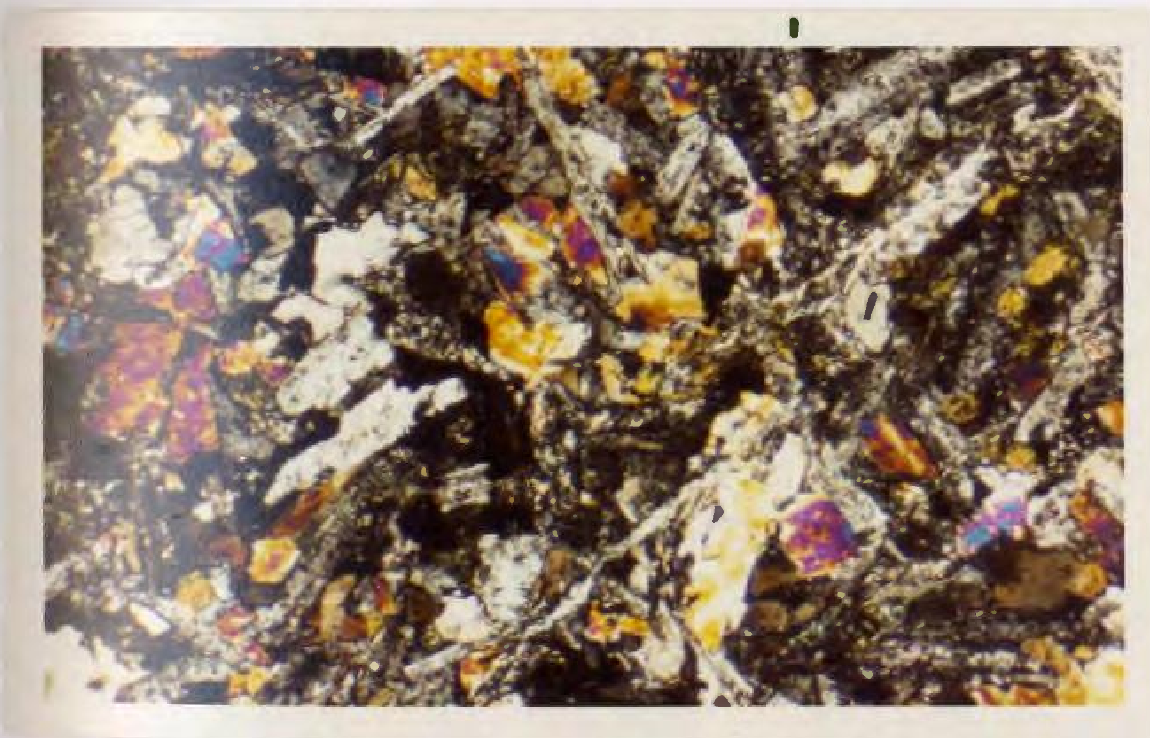


Plate 33. Diabasic/subdiabasic textures are well preserved in some unbrecciated dykes near Little Port. The dyke cuts a foliated gabbro of the Bottle Cove slice (see Fig. 2.), Mafic dyke, LP-12, x-nicols, (X 40).

(Comeau, 1972), but Little Port rocks with "trachytic textures" (trachyte ? of Comeau, 1972, p. 46) were not found during the present study or by Malpas (1976, p. 73). All mafic rocks contain variable proportions of primary and alteration minerals (Appendix A.).

Plagioclase at Little Port is invariably albitized (optical and microprobe determinations), dusty grayish-brown with micaceous, and in a few samples, epidote overgrowths. An isotropic mineral of low relief (analcime ?) replaces plagioclase in one specimen. Pillows contain splinter-like, quenched groundmass plagioclase laths (albite) that are recrystallizing to epidote and calcite. Much opaque, epidote-sphene-chlorite-calcite mesostasis is evident.

Clinopyroxene is the only widely preserved primary ferromagnesian mineral. Dykes and some flows contain clear, unaltered, anhedral to subhedral clinopyroxene. Marginal to substantial alteration of pyroxene to chlorite, carbonate and possible actinolite is common. Within brecciated mafic dykes and flows, fresh clinopyroxene is granular, anhedral (rounded) and bears no primary relationship to the 'fluidized' albite-chlorite-opaque oxide groundmass (Plate 32.). Intact clasts in these rocks contain the usual diabasic-ophitic or plagioclase-phyric textures.

Euhedral to anhedral primary opaque oxides are ubiquitous and in most places have the skeletal triangular habit of magnetite. Overgrowths of sphene partly or totally replace some magnetite, indicating that the opaque oxides are rich in titanium.

The alteration mineral assemblage is presented in Table 5.

Table 5.

Metamorphic mineral assemblage in the mafic volcanic and dyke rocks in the vicinity of Little Port

amygdales	groundmass
qz-cc	pl-mica-ep-pu-cc
chl-cc	ep-Fe.ox.-cc-sph
	ab-chl-pu-cc-ep
	pl-anal (?)
	chl-stilp (rare)

Abbreviations: pl (albitized Ca-plagioclase); ab (clear, low temperature albite); cc (calcite); qz (quartz); ep (epidote); sph (sphene); pu (pumpellyite); chl (chlorite); anal (?) (possible analcime); Fe.ox. (opaque iron/titanium oxide); stilp (stilpnomelane)

The same mineral assemblage as in Table 5. above, was also determined by Zen (1974, Table 5., p. 220) in samples collected at Little Port. Following the discovery of analcime in a vein, Zen (1974) posed the question of the possibility of zeolite facies in the western Appalachian metamorphic rocks. Analcime is never present in significant quantities and never in association with true, fibrous zeolite or quartz. The abundance of albite-calcite-chlorite-epidote-pumpellyite would suggest prehnite-pumpellyite facies metamorphism; but the metamorphic grade could well be transitional from zeolite to prehnite-pumpellyite facies.

4.3 Geology of Gregory Island, Bay of Islands

Gregory Island is located 3.6 km west of Beverley Head (Fig. 2.), and is the northernmost island in the Bay of Islands (Fig. 1b). The island is small (0.5 by 0.3 km), and attains elevations in the order of 60 m.

Lithologies that comprise the island are mineralogically peculiar, and similar rocks have not been reported from the higher igneous/ metamorphic slices.

4.3.1 Lithologies and petrography

Gregory Island consists of two lithologic types; mafic pillow lava and porphyritic pyroclastics (agglomerate and crystal tuff), which correspond compositionally and petrographically to basalt, and plagioclase-two pyroxene basaltic andesite (*e.g.* GI-12). The porphyritic agglomerate is of primary concern here.

Subrounded blocks (up to 0.5 m) of porphyritic agglomerate (basaltic andesite) are set in a tuffaceous matrix of similar texture and composition. Thin sections reveal densely phyric textures (50 per cent phenocrysts; Appendix A.) (Plate 34.). Phenocrysts include calcic plagioclase, augite, hypersthene, and a possible xenocryst that contains spinel.

Idiomorphic calcic plagioclase is the most abundant phyric phase. The largest plagioclase is greater than 2 mm in length and consists of an aggregate of 23 individual crystals (Plate 35.). Plagioclase-plagioclase resorption is very common as are plagioclase growth twins. Oscillatory zoning is observed along with normal zoning, with some fluctuations resulting from oscillations. Plagioclase occurs as follows:

(1) as individual phenocrysts, or growth twins

(2) as inclusions in large plagioclase phenocrysts

(3) as rounded inclusions within poikilitic hypersthene phenocrysts

(4) rounded inclusions within poikilitic clinopyroxene phenocrysts

(5) associated with hypersthene (reaction relationship)

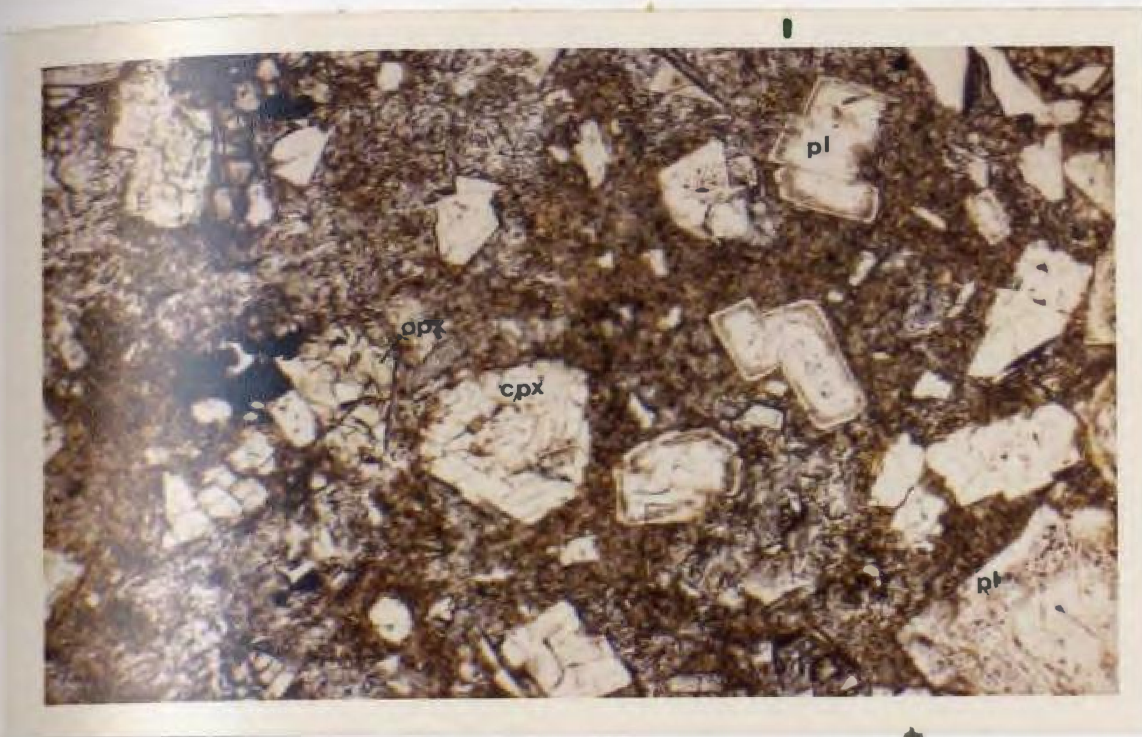


Plate 34. Porphyritic texture in a basaltic andesite on Gregory Island. Phenocrysts consist of zoned labradorite (pl), augite (cpx), and hypersthene (opx). GI-12, plane light, (X 50).

Plate 35. Normally zoned Ca-plagioclase (bytownite-labradorite) phenocryst with inclusion trains. This phenocryst consists of 23 individual crystals that have intergrown. Groundmass is pseudo-isotropic and was glassy. Basaltic andesite, GI-12, x-nicols, (X 31).

Plagioclase abounds with rod-shaped inclusion trains consisting of amber solids (possible glass ?) and possible fluid inclusions (Plate 35.).

Hypersthene shows varying states of alteration. Where fresh, it forms euhedral, poikilitic (plagioclase, opaque oxide, and apatite inclusions, Plate 34.) stubby prisms. Clinopyroxene forms a thin mantle around some hypersthene crystals, thus segregating them from the melt (perhaps this is why they are preserved). It is possible that two generations of orthopyroxene phenocrysts are present, because some crystals are entirely bastitized, while others are fresh.

Clinopyroxene (augite) is the last important mineral phase. It occurs as follows:

(1) as large (3 mm), euhedral, poikilitic, unzoned crystals

(2) as inclusions within poikilitic calcic plagioclase

(3) as euhedral microcrysts

(4) groundmass crystals

(5) clinopyroxene phenocrysts are in reaction relationship with plagioclase and orthopyroxene. Clinopyroxene mantles orthopyroxene.

The groundmass was probably glassy, but now it consists of hematite, opaque iron oxide, chlorite, celadonite, calcite, and plagioclase microlites. GI-5 (Appendix A.) contains much free silica, calcite and some celadonite (microprobe determination).

CHAPTER 5

GEOCHEMISTRY

The mineral chemistry and petrochemistry of dykes and volcanic rocks in the Skinner Cove Formation bear directly on the problem of its origin and place of formation. Since the Skinner Cove volcanic rocks are represented only in transported slices, it is significant to establish whether or not the rocks in the separate slices are linked by a similar chemical affinity.

It was found that the most effective way to describe the mineral and whole rock chemistry of a given suite is to compare it to other similarly altered rocks within a restricted area (*i.e.* within the Humber Arm Allochthon). One thereby gains an impression of the relative chemical differences between the various structural slices. Presumably then, the relative differences in petrochemistry may be proportional to the absolute chemical differences in the once-fresh rocks. This however, is a somewhat questionable assumption at least for the mobile elements in the whole rock analyses (see also Chapter 6). In the rocks with mafic petrochemistry, relict mineral compositions are directly compared both within and between the different structural slices and to more recent igneous provinces.

This chapter is divided into two parts; mineral chemistry and petrochemistry. Considerable emphasis is placed on the mineral chemistry and petrochemistry of the Trout River slice mainly because it is the type area of the Skinner Cove Formation and also because it contains a mafic to felsic suite. In combination with the stratigraphy and petrochemistry, other rocks of Skinner Cove affinity may be identified elsewhere in the transported sequence.

Therefore, the main purposes of this section are as follows:

(1) to gain an overview of the mineralogy, mineral chemistry and petrochemistry of all the various structural slices (with emphasis on the Trout River slice).

(2) to present the data for use in the subsequent chapters on magmatic affinity, etc.

(3) to state any similarities or differences in the mineral and whole rock chemistry of the different structural slices

The compositions of a total of six hundred and thirty clinopyroxene groundmass crystals, microphenocrysts and phenocrysts were determined using the electron microprobe. Electron microprobe analytical procedures are given in Appendix A. The sampling program for clinopyroxene microprobe analyses included mafic dykes and lavas from the following slices: (a) Trout River, (b) Chimney Cove, (c) Little Port (including Gregory Island), (d) Western Head, (e) Beverley Head, (f) Old Man Cove, (g) one sample from the Pomo Beds, Franciscan terrane, California. With the exception of '(g)' above, the sample numbers and corresponding analytical summary are shown in Table 6. The samples in Table 6. correspond to the whole rock analyses and individual microprobe analyses as listed in Appendix B. Sample locations are shown in Plate 1. (for the Trout River slice only) and Figure 2. Eight wet chemical analyses of clinopyroxene phenocrysts and eleven microprobe determinations on orthopyroxene phenocrysts (the latter are from Gregory Island) are presented in Table 6. Additionally, one hundred and twenty-five feldspar compositions were determined using the electron microprobe

SUMMARY OF PYROXENE COMPOSITIONS AS DETERMINED BY WET CHEMISTRY AND THE ELECTRON MICROPROBE

Sample Locations#	SKC-23**	SKC-24**	SKC-25A†	SKC-25B†	SKC-27**	SKC-31A			
	ph.	ph.	ph.	ph.	ph.	mph. S	mph.c. S	mph.r. S	gm. S
SiO_2	46.6	48.4	48.8	48.2	47.6	46.84 (1.34)	48.52 (1.14)	45.90 (1.65)	47.61 (1.69)
TiO_2	1.62	1.50	1.46	1.80	1.64	2.11 (0.28)	1.45 (0.06)	2.49 (0.59)	2.54 (0.71)
Al_2O_3	5.87	5.25	5.14	5.31	5.47	5.52 (0.72)	4.02 (0.18)	6.25 (0.71)	4.81 (1.41)
Cr_2O_3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
FeO	5.13	4.31	4.17	4.26	4.23	8.37 (0.33)	7.89 (0.31)	8.86 (0.73)	9.57 (0.68)
MnO	0.27	0.23	0.11	0.11	0.11	0.22 (0.04)	0.21 (0.04)	0.22 (0.04)	0.26 (0.06)
MgO	16.70	16.50	16.83	16.28	16.45	13.03 (0.50)	14.10 (0.18)	12.56 (1.01)	12.20 (1.07)
CaO	19.20	21.00	21.50	21.00	21.18	22.70 (0.19)	22.66 (0.23)	22.67 (0.25)	22.49 (0.27)
Na_2O	0.45	0.42	0.42	0.43	0.44	0.52 (0.07)	0.43 (0.05)	0.59 (0.10)	0.60 (0.13)
K_2O	0.02	0.02	0.01	<0.01	0.02	*	*	*	*
Ign.	1.42	0.86	1.02	0.94	1.16				
TOTAL	99.24	100.50	101.42	100.47	100.54	99.31	99.28	99.54	99.89
n	1(A.A.)	1(A.A.)	1(A.A.)	1(A.A.)	1(A.A.)	24	10	10	16
Recalculated FeO	0.48	0.73	0.10	1.27	0.00	3.02	3.00	2.81	5.63
Recalculated Fe_2O_3	7.13	5.99	6.46	5.46	6.93	5.94	5.44	6.72	4.37
Si	1.741	1.777	1.779	1.774	1.753	1.753	1.810	1.718	1.782
Al^{IV}	0.259	0.223	0.220	0.226	0.237	0.244	0.177	0.276	0.212
Fe^{IV}	0.001	0.000	0.004	0.000	0.010	0.003	0.014	0.006	0.006
Al^{VI}	0.000	0.004	0.000	0.006	0.000	0.000	0.000	0.000	0.000
Ti	0.046	0.041	0.040	0.050	0.046	0.059	0.041	0.070	0.072
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fe^{3+}	0.200	0.166	0.173	0.151	0.182	0.164	0.139	0.183	0.118
Fe^{2+}	0.015	0.022	0.003	0.039	0.000	0.095	0.093	0.088	0.176
Mn	0.009	0.007	0.003	0.003	0.003	0.007	0.007	0.007	0.008
Mg	0.930	0.903	0.913	0.893	0.903	0.727	0.784	0.701	0.681
Ca	0.769	0.826	0.838	0.828	0.836	0.911	0.906	0.909	0.902
Na	0.033	0.030	0.030	0.031	0.031	0.038	0.031	0.043	0.044
Sum to 4 cations	4.001	4.001	4.001	4.001	4.003	4.001	4.001	4.001	4.000
w	0.034	0.031	0.030	0.031	0.032	0.038	0.031	0.043	0.044
z	0.259	0.223	0.225	0.226	0.247	0.247	0.190	0.282	0.218
y	0.291	0.253	0.253	0.256	0.274	0.263	0.220	0.323	0.261
Formula to 6 (O)	4.049	4.037	4.042	4.031	4.046	4.057	4.052	4.065	4.042
Ca	39.98	42.94	43.32	43.25	43.21	47.76	46.63	48.00	47.72
Mg	48.43	46.92	47.17	46.63	46.68	38.13	40.36	38.99	36.00
Fe	11.65	10.14	9.17	10.12	10.11	14.11	13.01	15.01	16.28

Sample Locations#	SKC-32				SKC-38	SKC-39†
	ph. S	ph.c. S	ph.r. S	gm. S	gm. S	ph.
SiO_2	46.99 (1.47)	46.51 (1.78)	46.62 (2.08)	47.38 (1.89)	47.30 (1.64)	47.8
TiO_2	2.23 (0.90)	2.01 (0.88)	3.17 (1.08)	2.86 (0.94)	2.80 (0.63)	1.74
Al_2O_3	5.26 (1.75)	5.44 (2.30)	5.89 (1.24)	5.02 (1.46)	5.13 (1.49)	5.56
Cr_2O_3	n.d.	n.d.	n.d.	n.d.	*	*
FeO	10.46 (3.36)	10.47 (4.17)	9.66 (1.25)	9.45 (0.72)	8.98 (0.46)	4.17
MnO	0.31 (0.17)	0.29 (0.19)	0.24 (0.05)	0.25 (0.03)	0.16 (0.04)	0.12
MgO	11.68 (1.72)	11.84 (2.15)	11.77 (1.15)	12.26 (1.23)	13.51 (0.70)	16.10
CaO	22.14 (0.37)	22.12 (0.50)	22.23 (0.36)	22.23 (0.28)	22.10 (0.29)	21.18
Na_2O	0.52 (0.06)	0.52 (0.06)	0.61 (0.16)	0.57 (0.12)	0.40 (0.04)	0.50
K_2O	*	*	*	*	*	*
Ign.						1.12
TOTAL	99.62	99.20	100.19	100.01	100.38	100.76
n	17	5	4	25	25	1(A.A.)
Recalculated FeO	6.18	5.33	6.08	6.00	4.69	0.52
Recalculated Fe_2O_3	4.76	5.72	3.79	3.83	4.77	6.93
Si	1.772	1.759	1.746	1.776	1.757	1.758
Al^{IV}	0.228	0.241	0.254	0.222	0.225	0.241
Fe^{IV}	0.000	0.000	0.000	0.003	0.019	0.001
Al^{VI}	0.006	0.001	0.007	0.000	0.000	0.000
Ti	0.063	0.057	0.089	0.080	0.078	0.048
Cr	0.000	0.000	0.000	0.000	0.000	0.000
Fe^{3+}	0.135	0.163	0.112	0.105	0.115	0.180
Fe^{2+}	0.195	0.168	0.191	0.188	0.146	0.016
Mn	0.010	0.009	0.008	0.008	0.005	0.004
Mg	0.657	0.667	0.657	0.685	0.748	0.883
Ca	0.895	0.896	0.892	0.893	0.880	0.835
Na	0.040	0.038	0.044	0.041	0.029	0.036
Sum to 4 cations	4.000	4.001	4.000	4.000	4.000	4.001
w	0.040	0.038	0.044	0.041	0.029	0.036
z	0.228	0.241	0.254	0.225	0.243	0.242
y	0.267	0.278	0.297	0.266	[illegible]	0.276
Formula to 6 (O)	4.046	4.056	4.038	4.037	4.045	4.036
Ca	47.31	47.07	47.98	47.44	46.01	43.53
Mg	34.72	35.05	35.33	36.39	39.14	46.02
Fe	17.97	17.88	16.68	16.16	14.86	10.45

Sample Locations#							SKC-41†
	ph. S	mph. S	ph.c. S	mph.c. S	ph.r. S	mph.r. S	ph.
SiO_2	47.68 (1.97)	45.84 (2.10)	48.16 (2.79)	46.25 (2.17)	44.78 (0.67)	45.59 (0.75)	47.7
TiO_2	2.20 (1.48)	2.72 (0.65)	1.84 (1.36)	2.40 (0.87)	3.62 (0.57)	3.20 (0.28)	1.56
Al_2O_3	6.43 (1.96)	6.91 (1.01)	5.64 (1.99)	6.76 (1.36)	7.33 (1.70)	6.74 (0.87)	5.71
Cr_2O_3	0.09 (0.01)	0.05 (0.08)	0.15 (0.15)	*	0.03 (0.03)	0.05 (0.07)	n.d
FeO	6.03 (0.85)	6.73 (0.67)	5.29 (1.28)	6.57 (0.91)	7.78 (0.52)	7.74 (0.05)	4.42
MnO	0.09 (0.01)	0.09 (0.01)	0.12 (0.04)	0.13 (0.02)	0.11 (0.00)	0.09 (0.02)	0.25
MgO	14.21 (1.27)	13.37 (1.15)	14.61 (1.57)	13.88 (1.43)	12.41 (0.30)	12.92 (0.67)	16.40
CaO	22.24 (0.15)	22.18 (0.20)	22.55 (0.11)	22.20 (0.13)	21.87 (0.93)	22.06 (0.73)	20.20
Na_2O	0.44 (0.06)	0.48 (0.05)	0.43 (0.08)	0.49 (0.04)	0.47 (0.01)	0.42 (0.04)	0.46
K_2O	*	*	*	*	*	*	0.02
Ign.							0.88
TOTAL	99.41	98.32	96.79	98.68	98.40	98.13	99.66
n	18	11	3	3	3	3	1(A.A.)
Recalculated FeO	3.05	2.72	2.01	1.92	4.39	4.08	0.94
Recalculated Fe_2O_3	3.31	4.54	3.43	5.17	3.77	4.06	5.93
Si	1.766	1.724	1.790	1.728	1.696	1.717	1.766
Al^{IV}	0.234	0.276	0.210	0.272	0.304	0.283	0.234
Fe^{IV}	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Al^{VI}	0.047	0.030	0.037	0.026	0.023	0.016	0.015
Ti	0.061	0.070	0.051	0.067	0.103	0.091	0.043
Cr	0.003	0.000	0.004	0.000	0.001	0.000	0.000
Fe^{3+}	0.092	0.126	0.096	0.145	0.107	0.115	0.166
Fe^{2+}	0.094	0.086	0.069	0.060	0.139	0.129	0.029
Mn	0.003	0.003	0.004	0.004	0.004	0.003	0.008
Mg	0.785	0.749	0.809	0.773	0.701	0.725	0.905
Ca	0.883	0.894	0.898	0.889	0.888	0.890	0.801
Na	0.032	0.035	0.031	0.036	0.035	0.031	0.033
Sum to 4 cations	4.000	4.000	4.000	4.000	4.000	4.000	4.001
w	0.032	0.035	0.031	0.036	0.035	0.031	0.034
z	0.234	0.276	0.210	0.272	0.304	0.283	0.234
y	0.265	0.310	0.241	0.306	0.338	0.313	0.267
Formula to 6 (O)	4.031	4.043	4.031	4.050	4.036	4.039	4.036
Ca	47.54	48.11	47.88	47.50	48.29	47.81	41.99
Mg	42.25	40.34	43.15	41.31	38.11	38.94	47.42
Fe	10.21	11.55	8.97	11.19	13.60	13.25	10.59

Sample Locations#	Bx.A.*†	SK-6A	CC-5	CC-27				CC-28			
	ph.	gm. S	gm. S	ph. S	ph.c. S	ph.r. S	gm. S	ph. S	ph.c.	ph.r.	gm. S
SiO_2	44.1	49.23 (1.06)	47.11 (1.89)	47.67 (1.56)	48.34 (2.26)	47.44 (1.91)	46.46 (1.93)	44.04 (1.57)	46.42	42.20	44.70 (2.24)
TiO_2	1.46	1.60 (0.41)	2.57 (0.58)	2.10 (0.57)	1.75 (0.86)	2.20 (0.57)	2.75 (0.85)	4.24 (1.00)	2.82	5.45	3.89 (0.96)
Al_2O_3	6.50	2.54 (0.77)	6.06 (1.84)	5.93 (1.47)	5.23 (2.30)	5.88 (1.61)	6.90 (1.91)	8.91 (1.62)	6.35	10.27	7.59 (1.66)
Cr_2O_3	n.d.	0.02 (0.02)	0.02 (0.02)	0.18 (0.27)	0.20 (0.35)	0.19 (0.34)	0.04 (0.06)	*	*	*	0.01 (0.02)
FeO	4.64	12.62 (0.61)	8.43 (0.62)	7.68 (1.08)	8.06 (2.01)	7.50 (1.10)	8.33 (0.61)	8.47 (0.68)	7.72	9.02	8.55 (0.83)
MnO	0.23	0.42 (0.05)	0.19 (0.05)	0.17 (0.06)	0.21 (0.16)	0.18 (0.03)	0.17 (0.05)	0.12 (0.03)	0.16	0.12	0.13 (0.04)
MgO	15.70	11.20 (0.49)	13.26 (0.90)	13.63 (0.89)	13.62 (0.91)	13.74 (1.03)	13.02 (1.01)	12.20 (1.09)	13.87	11.16	12.55 (1.27)
CaO	19.20	21.66 (0.30)	21.74 (0.40)	21.74 (0.41)	21.80 (0.30)	22.04 (0.57)	21.56 (0.61)	22.88 (0.24)	22.62	22.77	22.22 (0.57)
Na_2O	0.59	0.50 (0.06)	0.43 (0.07)	0.43 (0.06)	0.43 (0.09)	0.40 (0.09)	0.45 (0.07)	0.54 (0.06)	0.48	0.51	0.44 (0.07)
K_2O	0.05	*	*	*	*	*	*	*	*	*	*
Ign.	3.24										
TOTAL	98.72	99.79	99.81	99.53	99.64	99.57	99.79	99.16	100.44	101.50	100.08
n	1(A.A.)	27	27	19	5	5	25	9	2	2	20
Recalculated FeO	0.00	9.84	4.99	4.59	4.98	3.96	4.94	2.85	2.02	3.88	3.98
Recalculated Fe_2O_3	8.19	3.09	3.83	3.84	3.43	3.94	3.77	6.24	6.34	5.73	5.08
Si	1.677	1.871	1.756	1.776	1.800	1.768	1.734	1.621	1.712	1.562	1.668
Al^{IV}	0.296	0.114	0.244	0.244	0.200	0.234	0.266	0.379	0.276	0.438	0.332
Fe^{IV}	0.008	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000
Al^{VI}	0.000	0.000	0.022	0.036	0.030	0.024	0.037	0.008	0.000	0.010	0.008
Ti	0.042	0.046	0.072	0.059	0.049	0.062	0.077	0.117	0.078	0.152	0.109
Cr	0.000	0.001	0.001	0.005	0.006	0.006	0.001	0.000	0.000	0.000	0.000
Fe^{3+}	0.229	0.073	0.107	0.096	0.096	0.110	0.106	0.173	0.164	0.160	0.143
Fe^{2+}	0.000	0.313	0.156	0.143	0.155	0.123	0.164	0.088	0.062	0.120	0.124
Mn	0.007	0.014	0.006	0.005	0.007	0.006	0.005	0.004	0.005	0.004	0.004
Mg	0.901	0.634	0.737	0.757	0.756	0.762	0.724	0.669	0.763	0.616	0.124
Ca	0.792	0.882	0.868	0.868	0.870	0.879	0.862	0.903	0.894	0.903	0.888
Na	0.044	0.037	0.031	0.031	0.031	0.029	0.033	0.039	0.034	0.030	0.032
Sum to 4 cations	4.017	4.000	4.000	4.000	4.000	4.000	4.000	4.001	4.001	4.001	4.000
w	0.45	0.037	0.031	0.031	0.031	0.029	0.033	0.039	0.034	0.037	0.032
z	0.303	0.129	0.244	0.224	0.200	0.234	0.266	0.379	0.288	0.438	0.332
y	0.314	0.166	0.275	0.255	0.230	0.263	0.299	0.416	0.321	0.473	0.363
Formula to 6 (O)	4.071	4.030	4.036	4.033	4.032	4.037	4.036	4.059	4.060	4.055	4.049
Ca	40.88	45.66	46.34	46.43	46.19	46.75	46.55	49.15	47.06	50.12	47.83
Mg	46.49	32.87	39.31	40.48	40.13	40.53	39.13	36.45	40.14	34.17	37.58
Fe	12.63	21.47	14.35	13.09	13.68	12.72	14.33	14.40	12.80	15.71	14.59

Sample Locations#	LP-3	LP-9	LP-12	LP-14	LP-16	LP-17	WH-6	WH-8	BH-1	OMCv
	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	gm.
SiO_2	50.39 (1.19)	50.36 (0.91)	51.21 (1.59)	49.59 (1.50)	49.30 (1.68)	50.26 (1.07)	49.02 (0.85)	50.80 (0.81)	50.23 (0.62)	49.02
TiO_2	1.21 (0.32)	1.21 (0.35)	1.06 (0.36)	1.43 (0.44)	1.49 (0.79)	0.97 (0.22)	1.53 (0.31)	0.93 (0.22)	0.72 (0.15)	1.36
Al_2O_3	3.76 (0.97)	3.77 (0.96)	3.16 (1.13)	3.52 (1.13)	4.14 (1.11)	4.01 (0.99)	3.99 (1.10)	2.60 (0.78)	2.81 (0.58)	4.75
Cr_2O_3	0.12 (0.07)	0.14 (0.22)	*	0.05 (0.07)	0.09 (0.09)	0.27 (0.13)	0.15 (0.11)	0.03 (0.04)	0.13 (0.07)	*
FeO	7.64 (0.74)	8.02 (2.89)	8.86 (1.93)	9.45 (2.07)	9.31 (1.76)	7.04 (0.69)	11.14 (1.86)	9.57 (2.95)	12.52 (1.25)	10.88
MnO	0.19 (0.04)	0.21 (0.09)	0.22 (0.06)	0.24 (0.06)	0.21 (0.07)	0.15 (0.04)	0.24 (0.05)	0.24 (0.10)	0.27 (0.08)	0.25
MgO	15.19 (0.86)	14.66 (1.27)	15.69 (1.33)	14.44 (1.44)	14.69 (1.28)	15.99 (0.79)	13.43 (0.78)	14.93 (1.53)	15.78 (0.68)	13.79
CaO	20.56 (0.84)	21.02 (0.75)	19.82 (0.83)	20.41 (0.58)	20.25 (0.99)	20.87 (0.67)	20.40 (0.91)	20.43 (1.01)	16.55 (0.93)	19.32
Na_2O	0.34 (0.05)	0.32 (0.07)	0.33 (0.09)	0.36 (0.08)	0.35 (0.09)	0.32 (0.06)	0.38 (0.10)	0.33 (0.06)	0.28 (0.16)	0.56
K_2O	*	*	*	*	*	*	*	*	*	*
Ign.										
TOTAL	99.40	99.41	100.35	99.49	100.23	99.88	100.28	99.76	99.34	99.93
n	26	22	26	22	25	25	21	24	15	24
Recalculated FeO	6.15	6.65	7.07	6.79	6.81	4.11	7.93	7.03	9.77	7.67
Recalculated Fe_2O_3	1.65	1.64	1.98	2.96	2.79	3.26	3.57	2.83	3.06	3.57
Si	1.871	1.870	1.886	1.863	1.841	1.848	1.830	1.891	1.883	1.827
Al^{IV}	0.129	0.130	0.114	0.147	0.159	0.152	0.170	0.109	0.117	0.173
Fe^{IV}	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Al^{VI}	0.036	0.035	0.024	0.008	0.021	0.022	0.006	0.001	0.007	0.036
Ti	0.034	0.034	0.029	0.040	0.042	0.027	0.043	0.026	0.020	0.038
Cr	0.004	0.004	0.000	0.001	0.003	0.008	0.004	0.001	0.004	0.000
Fe^{3+}	0.046	0.046	0.055	0.083	0.077	0.090	0.100	0.079	0.086	0.100
Fe^{2+}	0.191	0.203	0.218	0.212	0.211	0.126	0.248	0.219	0.306	0.239
Mn	0.006	0.007	0.007	0.008	0.007	0.005	0.008	0.008	0.009	0.008
Mg	0.841	0.811	0.861	0.804	0.811	0.877	0.747	0.828	0.882	0.766
Ca	0.818	0.837	0.782	0.817	0.804	0.823	0.816	0.815	0.665	0.772
Na	0.024	0.023	0.024	0.026	0.025	0.023	0.028	0.024	0.020	0.040
Sum to 4 cations	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000
w	0.024	0.023	0.024	0.026	0.025	0.023	0.028	0.024	0.020	0.040
z	0.129	0.130	0.114	0.147	0.159	0.152	0.170	0.109	0.117	0.173
y	0.153	0.153	0.137	0.173	0.184	0.174	0.197	0.133	0.138	0.213
Formula to 6 (O)	4.015	4.016	4.018	4.028	4.026	4.030	4.034	4.027	4.029	4.034
Ca	43.01	43.94	40.67	42.47	42.09	42.83	42.53	41.82	34.11	40.94
Mg	44.20	42.63	44.78	41.79	42.47	45.65	38.94	42.50	45.31	40.64
Fe	12.79	13.43	14.55	15.74	15.45	11.52	18.52	15.68	20.58	18.41

+ - 0.001 K in the structural formula

† - Fe_2O_3 (wet chemistry)

SKC-23	1.96	SKC-27	2.23
SKC-24	2.01	SKC-39	2.47
SKC-25A	1.96	SKC-41	2.06
SKC-25B	2.14	Bx.A.	2.81

* - Element concentrations below detection level of the electron microprobe

** - Element concentrations below detection level of the X-ray fluorescence

- Slice or slice assemblage affinity for the pyroxenes
SKC, SK, Bx.A - Trout River
CC - Chimney Cove
BH - Beverley Head
WH - Western Head
LP, GI - Little Port
OMCv - Old Man Cove

n - number of analyses per sample
S - standard deviation
ph. - phenocryst
mph. - microphenocryst
gm. - groundmass
r. - rim
c. - core
(A.A.) - analysis of phenocryst separates by atomic absorption spectrometry
n.d. - not determined
Ign. - Loss on ignition (on A.A. samples only)

	Zr	Sr	Rb	Zn	Ba	Nb	Ga	Pb	Ni	La	Cr	V	Y	Ce
SKC-41	54	82	0**	58	42	5	8	6	212	14	1020	228	13	18
SKC-23	67	81	0**	58	24	3	12	6	211	18	1006	237	14	22

Analyses by X-ray fluorescence in parts per million (ppm.)

SUMMARY OF PYROXENE COMPOSITIONS AS DETERMINED BY WET CHEMISTRY AND THE ELECTRON MICROPROBE

			SKC-38	SKC-39†							SKC-41†					SKC-58	SKC-63	SKC-65	
ph.c. S	ph.r. S	gm. S	gm. S	ph.	ph. S	mph. S	ph.c. S	mph.c. S	ph.r. S	mph.r. S	ph.	ph. S	ph.c. S	ph.r. S	gm. S	gm. S	gm. S	mph. S	
46.51 (1.78)	46.62 (2.08)	47.38 (1.89)	47.30 (1.64)	47.8	47.68 (1.97)	45.84 (2.10)	48.16 (2.79)	46.25 (2.17)	44.78 (0.67)	45.59 (0.75)	47.7	46.93 (1.36)	50.08 (2.30)	48.47 (1.96)	48.39 (1.73)	48.86 (1.54)	44.32 (1.39)	48.41 (1.46)	SiO_2
2.01 (0.88)	3.17 (1.09)	2.85 (0.94)	2.80 (0.63)	1.74	2.20 (1.46)	2.72 (0.65)	1.84 (1.36)	2.40 (0.87)	3.62 (0.57)	3.20 (0.28)	1.56	1.55 (0.41)	1.03 (0.26)	2.67 (0.85)	2.48 (0.70)	2.22 (0.61)	5.09 (0.73)	0.54 (0.26)	TiO_2
5.44 (2.30)	5.89 (1.24)	5.02 (1.45)	5.13 (1.49)	5.56	6.43 (1.96)	6.91 (1.01)	5.64 (1.99)	6.76 (1.36)	7.33 (1.70)	6.74 (0.87)	5.71	5.34 (0.98)	4.76 (1.28)	5.15 (1.89)	4.76 (1.64)	4.22 (1.40)	6.68 (0.73)	1.61 (0.52)	Al_2O_3
n.d.	n.d.	n.d.	*	*	0.09 (0.01)	0.06 (0.06)	0.15 (0.15)	*	0.03 (0.03)	0.05 (0.07)	n.d	n.d.	n.d.	n.d.	n.d.	n.d.	0.01 (0.02)	n.d.	Cr_2O_3
10.47 (4.17)	9.66 (1.25)	9.45 (0.72)	8.98 (0.46)	4.17	6.03 (0.85)	6.73 (0.67)	5.29 (1.28)	6.57 (0.91)	7.78 (0.52)	7.74 (0.05)	4.42	5.93 (0.50)	5.03 (0.52)	7.60 (0.32)	7.93 (0.44)	7.78 (0.52)	10.12 (0.41)	19.42 (0.79)	FeO
0.29 (0.19)	0.24 (0.06)	0.25 (0.09)	0.16 (0.04)	0.12	0.09 (0.01)	0.09 (0.01)	0.12 (0.04)	0.13 (0.02)	0.11 (0.00)	0.09 (0.02)	0.25	0.10 (0.02)	0.08 (0.02)	0.13 (0.04)	0.18 (0.03)	0.18 (0.06)	0.18 (0.03)	0.19 (0.10)	MnO
11.84 (2.15)	11.77 (1.16)	12.26 (1.23)	13.61 (0.70)	16.10	14.21 (1.27)	13.37 (1.15)	14.61 (1.67)	13.68 (1.43)	12.41 (0.30)	12.92 (0.67)	16.40	15.51 (0.79)	16.44 (0.92)	13.88 (1.08)	13.85 (0.89)	13.92 (0.76)	11.54 (0.68)	6.69 (0.57)	MgO
22.12 (0.50)	22.23 (0.36)	22.23 (0.28)	22.10 (0.29)	21.18	22.24 (0.15)	22.18 (0.20)	22.95 (0.11)	22.20 (0.13)	21.87 (0.93)	22.06 (0.73)	20.20	22.83 (0.16)	22.81 (0.20)	23.19 (0.23)	22.65 (0.35)	22.68 (0.33)	21.62 (0.31)	21.16 (0.60)	CaO
0.52 (0.05)	0.61 (0.16)	0.57 (0.12)	0.40 (0.04)	0.50	0.44 (0.06)	0.48 (0.05)	0.43 (0.08)	0.49 (0.04)	0.47 (0.01)	0.42 (0.04)	0.46	0.38 (0.06)	0.32 (0.04)	0.41 (0.08)	0.39 (0.06)	0.36 (0.06)	0.56 (0.07)	0.57 (0.05)	Na_2O
*	*	*	*	*	*	*	*	*	*	*	0.02	*	*	*	*	*	*	*	K_2O
				1.12							0.88								Ign.
99.20	100.19	100.01	100.38	100.76	99.41	98.32	98.79	98.66	98.40	98.13	99.66	100.57	100.55	101.50	100.59	100.29	100.16	99.32	TOTAL
5	4	25	25	1(A.A.)	18	11	3	3	3	3	1(A.A.)	20	3	3	27	34	15	4	n
5.33	6.08	6.00	4.69	0.52	3.05	2.72	2.01	1.92	4.39	4.08	0.94	1.89	0.75	3.90	4.37	4.62	6.51	13.78	FeO Recalculation
5.72	3.79	3.83	4.77	6.53	3.31	4.54	3.43	5.17	3.77	4.06	5.93	5.27	4.76	4.12	3.96	3.51	4.02	5.84	Fe_2O_3 Recalculation
1.759	1.746	1.775	1.757	1.758	1.766	1.724	1.790	1.728	1.696	1.717	1.766	1.783	1.816	1.779	1.788	1.810	1.670	1.880	Si
0.241	0.254	0.222	0.225	0.241	0.234	0.276	0.210	0.272	0.304	0.283	0.234	0.217	0.184	0.222	0.207	0.184	0.297	0.074	Al^{IV}
0.000	0.000	0.003	0.019	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.005	0.033	0.046	Fe^{IV}
0.001	0.007	0.000	0.000	0.000	0.047	0.030	0.037	0.026	0.023	0.016	0.015	0.013	0.020	0.000	0.000	0.000	0.000	0.000	Al^{VI}
0.057	0.089	0.080	0.078	0.048	0.061	0.070	0.051	0.067	0.103	0.091	0.043	0.042	0.028	0.073	0.068	0.062	0.144	0.016	Ti
0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Cr
0.163	0.112	0.105	0.115	0.180	0.092	0.126	0.096	0.145	0.107	0.115	0.165	0.145	0.130	0.109	0.105	0.093	0.081	0.128	Fe^{3+}
0.166	0.191	0.188	0.146	0.016	0.094	0.086	0.069	0.060	0.139	0.129	0.029	0.036	0.023	0.119	0.135	0.143	0.205	0.454	Fe^{2+}
0.009	0.008	0.008	0.005	0.004	0.003	0.003	0.004	0.004	0.004	0.003	0.008	0.003	0.002	0.004	0.006	0.006	0.006	0.031	Mn
0.667	0.657	0.685	0.748	0.883	0.785	0.749	0.809	0.773	0.701	0.725	0.906	0.843	0.889	0.757	0.763	0.769	0.648	0.411	Mg
0.896	0.892	0.893	0.880	0.835	0.883	0.894	0.898	0.889	0.888	0.890	0.801	0.892	0.023	0.909	0.897	0.901	0.873	0.919	Ca
0.038	0.044	0.041	0.029	0.036	0.032	0.035	0.031	0.036	0.035	0.031	0.033	0.027	0.886	0.029	0.028	0.027	0.041	0.042	Na
4.001	4.000	4.000	4.000	4.001	4.000	4.000	4.000	4.000	4.000	4.000	4.001	4.000	4.000	4.000	4.000	4.000	4.000	4.001	Sum to 4 cations
0.038	0.044	0.041	0.029	0.036	0.032	0.035	0.031	0.036	0.036	0.031	0.034	0.029	0.023	0.029	0.028	0.027	0.041	0.042	w
0.241	0.254	0.225	0.243	0.242	0.234	0.276	0.210	0.272	0.304	0.283	0.234	0.217	0.184	0.227	0.212	0.190	0.330	0.120	z
0.278	0.297	0.266	0.271	0.276	0.255	0.310	0.241	0.306	0.338	0.313	0.257	0.243	0.206	0.255	0.240	0.216	0.370	0.160	y
4.056	4.038	4.037	4.045	4.036	4.031	4.043	4.031	4.050	4.036	4.039	4.036	4.049	4.044	4.038	4.037	4.033	4.053	4.056	Formula to 6 (O)
47.07	47.98	47.44	46.01	43.53	47.54	48.11	47.86	47.50	48.29	47.81	41.99	46.49	45.93	47.78	46.95	47.00	47.27	46.20	Ca
35.05	35.33	36.39	39.14	46.02	42.25	40.34	43.15	41.31	38.11	38.94	47.42	43.93	46.04	39.78	39.93	40.12	35.16	20.65	Mg
17.88	16.68	16.16	14.86	10.45	10.21	11.55	8.97	11.19	13.60	13.25	10.59	9.59	8.03	12.43	13.12	12.88	17.58	33.16	Fe

			LP-3	LP-9	LP-12	LP-14	LP-16	LP-17	WH-6	WH-8	BH-1	OMCv	GI-6				GI-12			GI-12	
ph.c.	ph.r.	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	gm. S	ph. S	ph.c. S	ph.r. S	gm.† S	ph. S	ph.c.	ph.r.	ph. S	
46.42	42.20	44.70 (2.24)	50.39 (1.19)	50.36 (0.91)	51.21 (1.59)	49.59 (1.50)	49.30 (1.58)	50.26 (1.07)	49.02 (0.85)	50.60 (0.81)	50.23 (0.62)	49.02 (1.38)	51.61 (0.21)	51.29 (0.66)	51.29 (0.63)	51.54 (0.76)	51.03 (0.85)	49.99	51.36	51.16 (0.35)	SiO_2
2.82	5.45	3.89 (0.96)	1.21 (0.32)	1.21 (0.38)	1.06 (0.36)	1.43 (0.44)	1.49 (0.79)	0.97 (0.22)	1.53 (0.31)	0.93 (0.22)	0.72 (0.15)	1.36 (0.37)	0.42 (0.08)	0.38 (0.13)	0.52 (0.05)	0.31 (0.06)	0.50 (0.07)	0.55	0.46	0.29 (0.05)	TiO_2
6.36	10.27	7.59 (1.66)	3.76 (0.97)	3.77 (0.96)	3.16 (1.13)	3.52 (1.13)	4.14 (1.11)	4.01 (0.99)	3.99 (1.10)	2.50 (0.78)	2.81 (0.58)	4.75 (0.88)	2.16 (0.26)	2.24 (0.43)	2.26 (0.37)	3.08 (1.17)	1.71 (0.24)	1.90	1.73	1.05 (0.19)	Al_2O_3
*	*	0.01 (0.02)	0.12 (0.07)	0.14 (0.22)	*	0.05 (0.07)	0.09 (0.09)	0.27 (0.13)	0.15 (0.11)	0.03 (0.04)	0.13 (0.07)	*	0.11 (0.07)	0.13 (0.18)	0.07 (0.04)	0.41 (0.31)	*	*	*	0.02 (0.01)	Cr_2O_3
7.72	9.02	8.55 (0.83)	7.64 (0.74)	8.02 (2.89)	8.86 (1.93)	9.45 (2.07)	9.31 (1.75)	7.04 (0.69)	11.14 (1.86)	9.57 (2.95)	12.52 (1.25)	10.88 (1.71)	8.67 (1.26)	8.32 (1.77)	9.88 (0.59)	6.51 (1.55)	10.44 (0.28)	10.22	10.47	21.46 (0.37)	FeO
0.16	0.12	0.13 (0.04)	0.19 (0.04)	0.21 (0.09)	0.22 (0.06)	0.24 (0.06)	0.21 (0.07)	0.15 (0.04)	0.24 (0.05)	0.24 (0.10)	0.27 (0.08)	0.25 (0.07)	0.21 (0.03)	0.21 (0.08)	0.24 (0.05)	0.17 (0.04)	0.32 (0.06)	0.29	0.34	0.59 (0.06)	MnO
13.87	11.16	12.55 (1.02)	15.19 (0.86)	14.66 (1.27)	15.69 (1.33)	14.44 (1.44)	14.69 (1.28)	15.99 (0.79)	13.43 (0.76)	14.93 (1.53)	15.78 (0.88)	13.79 (0.93)	16.21 (0.63)	16.18 (1.05)	15.83 (0.28)	17.07 (0.71)	14.90 (0.45)	15.25	14.42	23.32 (0.36)	MgO
22.62	22.77	22.22 (0.57)	20.56 (0.84)	21.02 (0.75)	19.82 (0.83)	20.41 (0.58)	20.25 (0.59)	20.87 (0.67)	20.40 (0.91)	20.43 (1.01)	16.55 (0.93)	19.32 (1.41)	19.81 (0.68)	19.90 (0.74)	19.32 (0.41)	20.27 (0.84)	20.14 (0.15)	20.01	20.16	1.48 (0.05)	CaO
0.48	0.57	0.44 (0.07)	0.34 (0.05)	0.32 (0.07)	0.33 (0.0[illegible])	0.36 (0.08)	0.35 (0.09)	0.32 (0.05)	0.38 (0.10)	0.33 (0.06)	0.28 (0.16)	0.56 (0.12)	0.28 (0.05)	0.28 (0.06)	0.31 (0.03)	0.25 (0.03)	0.25 (0.04)	0.22	0.27	0.02 (0.01)	Na_2O
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	K_2O
																					Ign.
100.44	101.50	100.08	99.40	99.41	100.35	99.49	100.23	99.88	100.28	99.76	99.34	99.93	99.42	98.93	99.71	99.64	99.29	98.44	99.21	100.39	TOTAL
2	2	20	26	22	26	22	25	25	21	24	15	24	17	5	5	9	9	2	2	11	n
2.02	3.86	3.98	6.15	6.55	7.07	6.79	6.81	4.11	7.93	7.03	9.77	7.67	6.31	5.83	7.14	4.09	7.63	6.15	8.70	18.49	FeO Recalculated
6.34	5.73	6.08	1.66	1.64	1.98	2.96	2.79	3.26	3.57	2.83	3.06	3.57	2.56	2.77	3.04	2.69	3.12	4.52	1.97	3.30	Fe_2O_3 Recalculated
1.712	1.562	1.668	1.871	1.870	1.886	1.853	1.841	1.848	1.830	1.891	1.883	1.827	1.914	1.910	1.904	1.891	1.913	1.886	1.931	1.924	Si
0.276	0.438	0.332	0.129	0.130	0.114	0.147	0.159	0.152	0.170	0.109	0.117	0.173	0.086	0.090	0.096	0.109	0.076	0.085	0.069	0.046	Al^{IV}
0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.030	0.000	0.031	Fe^{IV}
0.000	0.010	0.002	0.036	0.035	0.024	0.008	0.021	0.022	0.006	0.001	0.007	0.036	0.008	0.008	0.002	0.025	0.000	0.000	0.007	0.000	Al^{VI}
0.078	0.152	0.109	0.034	0.034	0.029	0.040	0.042	0.027	0.043	0.026	0.020	0.038	0.012	0.011	0.015	0.009	0.014	0.016	0.013	0.008	Ti
0.000	0.000	0.000	0.004	0.004	0.000	0.001	0.003	0.008	0.004	0.001	0.004	0.000	0.003	0.004	0.002	0.012	0.000	0.000	0.000	0.001	Cr
0.164	0.160	0.143	0.046	0.046	0.055	0.083	0.077	0.090	0.100	0.079	0.086	0.100	0.071	0.078	0.085	0.074	0.077	0.099	0.056	0.061	Fe^{3+}
0.062	0.120	0.124	0.191	0.203	0.218	0.212	0.211	0.126	0.248	0.219	0.306	0.239	0.196	0.182	0.222	0.126	0.239	0.194	0.273	0.570	Fe^{2+}
0.005	0.004	0.004	0.006	0.007	0.007	0.008	0.007	0.006	0.008	0.008	0.009	0.008	0.007	0.007	0.008	0.006	0.010	0.009	0.011	0.018	Mn
0.763	0.616	0.124	0.841	0.811	0.861	0.804	0.811	0.877	0.747	0.828	0.882	0.766	0.896	0.898	0.876	0.934	0.833	0.858	0.808	1.282	Mg
0.894	0.903	0.888	0.818	0.837	0.782	0.817	0.804	0.823	0.816	0.815	0.665	0.772	0.787	0.794	0.769	0.797	0.809	0.809	0.812	0.058	Ca
0.034	0.030	0.032	0.024	0.023	0.024	0.026	0.025	0.023	0.028	0.024	0.020	0.040	0.020	0.020	0.022	0.018	0.018	0.016	0.020	0.001	Na
4.001	4.001	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	Sum to 4 cations
0.034	0.037	0.032	0.024	0.023	0.024	0.026	0.025	0.023	0.028	0.024	0.020	0.040	0.020	0.020	0.022	0.019	0.018	0.016	0.020	0.001	w
0.288	0.438	0.332	0.129	0.130	0.114	0.147	0.159	0.152	0.170	0.109	0.117	0.173	0.086	0.090	0.096	0.109	0.087	0.114	0.069	0.076	z
0.321	0.473	0.363	0.153	0.153	0.137	0.173	0.184	0.174	0.197	0.133	0.138	0.213	0.106	0.110	0.119	0.128	0.105	0.130	0.089	0.078	y
4.060	4.065	4.049	4.015	4.015	4.018	4.028	4.026	4.030	4.034	4.027	4.029	4.034	4.024	4.026	4.029	4.024	4.031	4.062	4.019	4.046	Formula to 6 (O)
47.06	50.12	47.83	43.01	43.94	40.67	42.47	42.09	42.83	42.53	41.82	34.11	40.94	40.23	40.56	39.24	41.18	40.88	40.47	41.43	2.89	Ca
40.14	34.17	37.58	44.20	42.63	44.78	41.79	42.47	45.65	38.94	42.50	45.31	40.64	45.79	45.87	44.72	48.23	42.09	42.93	41.22	63.43	Mg
12.80	15.71	14.59	12.79	13.43	14.55	15.74	15.45	11.52	18.52	15.68	20.58	18.41	13.96	13.57	16.05	10.59	17.05	16.60	17.35	33.67	Fe

	Zr	Sr	Rb	Zn	Ba	Nb	Ga	Pb	Ni	La	Cr	V	Y	Ce
SKC-41	54	82	0**	58	42	5	8	6	212	14	1020	228	13	18
SKC-23	67	81	0**	58	24	3	12	6	211	18	1006	237	14	22

Analyses by X-ray fluorescence in parts per million (ppm.)

(Appendix B.). Quantitative electron microprobe analyses of analcime, celadonite and amphibole are discussed in the text to follow. The compositions of some opaque oxides were determined semi-quantitatively using the electron microprobe.

Eighty-seven rocks were analysed for eleven major and minor elements by atomic absorption spectrometry and eighty-nine rocks were analysed for fourteen trace elements by X-ray fluorescence spectrometry. Sample preparation, analytical procedures, precision and accuracy are all outlined in Appendix A. Rock analyses are listed with their corresponding lithologic name in Appendix B.

The slice distribution of rocks analysed is given in Plate 1. (for the Trout River slice only) and Figure 2.

Table 7.

Structural slice distribution of whole rock analyses

slice name	number of samples analysed
Trout River	51
Chimney Cove	10
Little Port	15
Western Head	3
Beverley Head	2
Gregory Island (probable Little Port)	3
Old Man Cove	1
miscellaneous (mafic monzonite, see Plate 1 along Wallace Brook)	2
knockers near Trout River Village	2
	89 total

In addition to the above analyses, many unpublished rock analyses were kindly provided by W.R. Church, R. Coish and G. Einarson. These analyses are listed in Appendix B., and are used extensively in

Chapters 6 and 7. The accuracy and precision of these analyses are unknown to the writer.

5.1 Mineral Chemistry

5.1.1 Pyroxene

The compositions of clinopyroxenes (from mafic rocks) are very important because they may be directly compared to one-another and to pristine pyroxenes from rocks of known magmatic/tectonic settings (see also section 6.3). The above comparisons are not true for most whole rock analyses since depositional and post-depositional conditions may strongly, and to a considerable extent unpredictably, affect the initial elemental concentrations (see also Chapters 6 and 7 for further discussions).

Variable amounts of relict clinopyroxene are found in the mafic to felsic rocks of the Trout River slice and in the mafic rocks of the Western Head, Chimney Cove and Beverley Head slices. Little Port mafic lavas (at Little Port, Fig. 2.) contain 10 to 30 per cent clinopyroxene (see Appendix A. for modes). Gregory Island lavas contain both clinopyroxene and orthopyroxene phenocrysts. Orthopyroxene is rarely found in extrusive rocks of the Humber Arm Allochthon, therefore its mere presence is noteworthy.

5.1.1.1 Clinopyroxene

Clinopyroxenes from the mafic/intermediate rocks of the Trout River and Chimney Cove slices are mainly salites. The mafic rocks of the Western Head slice and Little Port slice assemblage contain mostly augite with minor diopside and endiopside.

The histograms in Figure 6. illustrate the frequency distributions of SiO_2, Al_2O_3, TiO_2, MgO, CaO, FeO (total), MnO, and Na_2O in the groundmass clinopyroxenes of four structural slices. The pyroxenes were analysed at random in a given polished thin section, with one analysis per crystal at a randomly selected area in that crystal.

The important features of these histograms are as follows:

(1) For the Trout River and Chimney Cove slices (Figs. 6a. and b., respectively), SiO_2, Al_2O_3, TiO_2, MgO and Na_2O are generally bimodally distributed. Such a distribution undoubtedly represents a change in the magma composition with time and/or a change in cooling rate. The writer emphasizes that none of the analysed minerals shows typical quench textures. The ranges of the various oxides in the above two slices are virtually identical with only minor differences in contents of Al_2O_3 and Na_2O. The frequency distributions of CaO, MnO and FeO (total) in the Trout River and Chimney Cove slices best fit bell-shaped normal curves.

(2) Clinopyroxenes of the Little Port slice assemblage contain bimodal distributions of MgO, Al_2O_3 and MnO. Similarly, the clinopyroxenes from the Western Head slice contain bimodal distributions of MgO, SiO_2, Al_2O_3, TiO_2 and MnO. The histograms clearly illustrate that the ranges in oxide contents of the Little Port slice assemblage and Western Head slice are precisely similar.

(3) Although there is some overlap in oxide ranges, it is clear from Figure 6. that the compositions of the groundmass clinopyroxenes of the Trout River and Chimney Cove slices are relatively enriched in CaO, Al_2O_3, TiO_2, Na_2O and depleted in SiO_2 and MgO compared to the Western Head and Little Port clinopyroxenes.

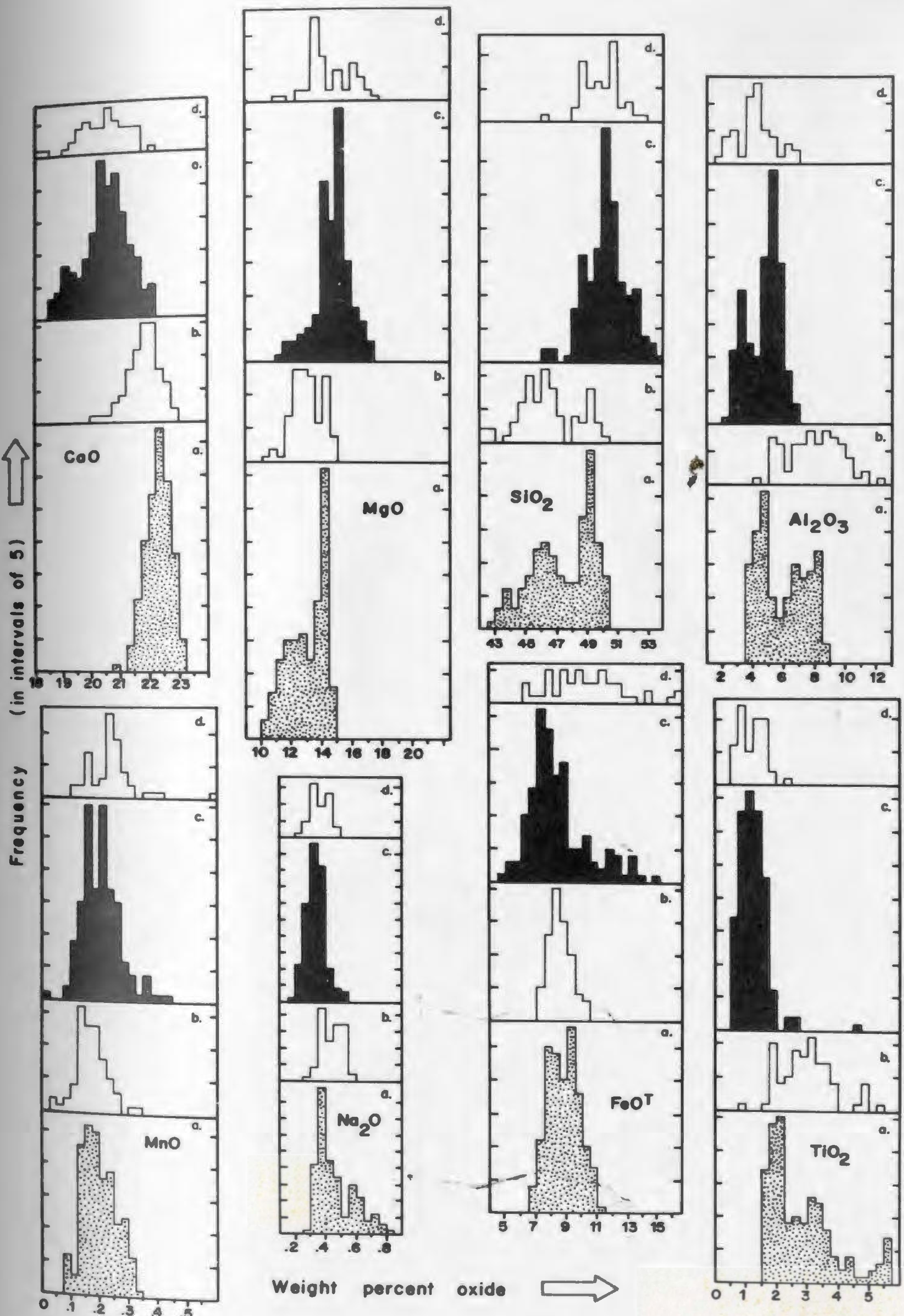
Figure 6. Histograms of frequency versus weight per cent oxides in the groundmass clinopyroxenes from four structural slices

a. Trout River (stippled)

b. Chimney Cove

c. Little Port (black)

d. Western Head


CaO
MgO
SiO2
Al2O3
MnO
Na2O
FeO^T
TiO2
a.
b.
c.
d.
Frequency (in intervals of 5)
Weight percent oxide
18 19 20 21 22 23
10 12 14 16 18 20
43 45 47 49 51 53
2 4 6 8 10 12
0 .1 .2 .3 .4 .5
.2 .4 .6 .8
5 7 9 11 13 15
0 1 2 3 4 5

The histograms in Figure 6. do not illustrate the relationships between any two oxides in a given clinopyroxene. For instance if a clinopyroxene of the Trout River slice (Fig. 6a.) contains 2 per cent TiO_2, does it also tend to contain 5 or 8 per cent Al_2O_3, and 44 or 49 per cent SiO_2, and so on. One may review the raw data in Appendix B. to gain such knowledge, or simply inspect Table 8.

Table 8. contains four Pearson correlation coefficient matrices of groundmass clinopyroxene compositions. One matrix corresponds to all the clinopyroxene analyses from each of (a) Trout River, (b) Chimney Cove, (c) Little Port and (d) Western Head slices. The same data are used as in Figure 6. This type of correlation coefficient depicts statistically the degree of linearity between two variables; those variables (*i.e.* oxides) with moderate correlations may contain complex curvilinear correlations not investigated in this study. The correlation coefficient is used in lieu of numerous X-Y scatter plots.

If we arbitrarily assign those correlations greater than or equal to +0.600 or less than or equal to -0.600 as being 'strong' correlations; then of the 72 separate correlations between each of FeO (total), CaO, MnO and all the other oxides from all the slices, 9 correlations (*i.e.* 12.5 per cent) are 'strong'. If we now consider all the remaining 40 correlation coefficients between SiO_2, TiO_2, Al_2O_3, MgO and Na_2O, only 7 correlations (*i.e.* 17.5 per cent) are 'weak'; conversely, 82.5 per cent are 'strong'. (N.B..this all assumes linear correlations only).

Considering the above, and the distributions illustrated in Figure 6., FeO (total), CaO and MnO vary most independently of the other oxides in all the analysed groundmass clinopyroxene crystals. This fact becomes useful in attaining the statistical assumptions

Table 8 . Pearson Correlation Coefficient Matrix of Major oxides from Groundmass Clinopyroxenes* taken from Four Structural Slices.

	TiO_2	Al_2O_3	$FeO^{\dagger}$	MnO	MgO	CaO	Na_2O
	-0.925[a]	-0.895	-0.598	0.157	0.844	0.462	-0.658
	-0.922[b]	-0.931	-0.215	0.483	0.917	-0.433	-0.648
SiO_2	-0.809[c]	-0.688	-0.388	-0.029	0.758	-0.196	-0.678
	-0.893[d]	-0.814	-0.243	0.262	0.620	-0.152	-0.605
		0.844	0.592	-0.204	-0.809	-0.489	0.613
TiO_2		0.872	0.268	-0.497	-0.876	0.474	0.578
		0.569	0.471	0.133	-0.807	0.091	0.690
		0.766	0.348	-0.111	-0.716	0.077	0.769
			0.353	-0.300	-0.749	-0.237	0.570
Al_2O_3			0.062	-0.523	-0.9[illegible]0	0.415	0.754
			-0.175	-0.405	-0.363	0.388	0.573
			-0.220	-0.542	-0.298	0.575	0.443
				0.364	-0.770	-0.667	0.769
$FeO^{\dagger}$				0.082	-0.247	-0.319	0.066
				0.671	-0.686	-0.536	0.405
				0.736	-0.826	-0.782	0.460
					-0.197	-0.127	0.358
MnO					0.414	-0.534	-0.272
					-0.384	-0.472	0.105
					-0.467	-0.736	0.077
						0.404	-0.916
MgO						-0.371	-0.768
						-0.078	-0.748
						0.388	-0.669
							-0.306
CaO							0.236
							0.110
							-0.221

Structural slice names	Number of analyses	correlation coefficient at .01 level of significance
a Trout River	150	0.208
b Chimney Cove	78	0.302
c Little Port	150	0.208
d Western Head	48	0.314

*all analyses are by electron microprobe

†total iron as FeO

validating the discriminant functions used in section 6.4.

The phenocrysts separated from the porphyritic basaltic rocks of the Trout River and Chimney Cove slices are slightly enriched in CaO and MgO and depleted in TiO_2 compared to microprobe analyses of phenocrysts from the same rock. For example, in Table 8., the mean phenocryst composition for SCK-41 by microprobe is $Ca_{46.5}\ Mg_{43.9}\ Fe_{9.6}$, while the separated phenocrysts have a mean composition of $Ca_{42.0}\ Mg_{47.4}\ Fe_{10.6}$. The difference appears real (*i.e.* it probably is not a result of the analytical technique or random variation) and probably represents a preferred sampling of the cores of phenocrysts during mechanical separation.

Phenocryst rims (*e.g.* SKC-31A, 32, 39, 41 and CC-28, in Table 6.) are titaniferous and contain about 3 per cent TiO_2, and are therefore best termed zoned titanaugites. Groundmass clinopyroxenes are everywhere more titaniferous than the mean or core of the coexisting phenocrysts and microphenocrysts, however the compositions of phenocryst rims and coexisting groundmass crystals are similar, thus suggesting similar conditions of crystallization.

In SKC-39 resorbed phenocrysts and microphenocrysts (Plate 17.) coexist with euhedral phenocrysts and granular groundmass crystals. This suggests two generations of phenocrysts and also disequilibrium conditions during magma evolution and cooling.

Both SKC-63 and CC-28 (Table 6., and Appendix B.) are Ti-rich with in excess of 6 per cent TiO_2. Tracy and Robinson (1977) found that some Tahitian titanaugites contain up to 8.8 per cent TiO_2, making them the most titanian-rich augites yet documented from earth. They also suggest that magmatic conditions which favoured the crystallization of Tahitian Ti-rich augites included low pressure, high TiO_2, low SiO_2, high Ca/Al and Mg/Fe ratios and low fO_2. Since the magmatic conditions favouring titanaugite may differ (Tracy and Robinson, 1977), one cannot extend the Tahitian analogy to the present study, however low pressure, high TiO_2, low SiO_2 and late crystallization of plagioclase in the Trout River and Chimney Cove magmas may have favoured the formation of the titanaugite.

Relict clinopyroxene microcrysts and groundmass crystals can be found in one trachyte; SKC-65 (Plate 22.). These pyroxenes are ferrosalite ($Ca_{46.1}\ Mg_{19.9}\ Fe_{34.0}$) and are apparently unzoned. In thin section the ferrosalites are euhedral, highly fractured, light-green, variably altered to calcite and completely surrounded by feldspar laths.

Crystallization trends for pyroxenes of the Trout River slice are illustrated in Figure 7. (trends 1a. and 1b.). 1c. in Figure 7. represents the crystallization trend of groundmass pyroxene in the Chimney Cove slice. Accompanying the trends determined in this study are those from several well known igneous provinces. The range in clinopyroxene phenocryst compositions for the rocks in the Trout River slice are as follows:

atomic percent Ca-Mg-Fe	rock type
$Ca_{43}\ Mg_{47}\ Fe_{10}$	ankaramite
$Ca_{48}\ Mg_{40}\ Fe_{12}$	pyroxene-phyric basalt
$Ca_{47}\ Mg_{35}\ Fe_{18}$	alkali basalt
$Ca_{46}\ Mg_{20}\ Fe_{34}$	trachyte

Compared with trends from other suites, the Trout River and Chimney Cove slices crystallization trends all follow an alkaline

Figure 7. Crystallization trends of clinopyroxenes from the Trout River and Chimney Cove slices and comparisons with some other known suites

1a. Phenocryst crystallization trend in the rocks of the Trout River slice*
b. Trout River slice (groundmass clinopyroxene)**
c. Chimney Cove slice (groundmass clinopyroxene)**

2a. Hawaiian alkaline trend (Fodor *et al.*, 1975)
b. Hawaiian nephelinitic trend (Fodor *et al.*, 1975)

3. Gough Island alkaline trend (Le Maitre, 1962)

4. Japanese alkaline trend (Aoki, 1964)

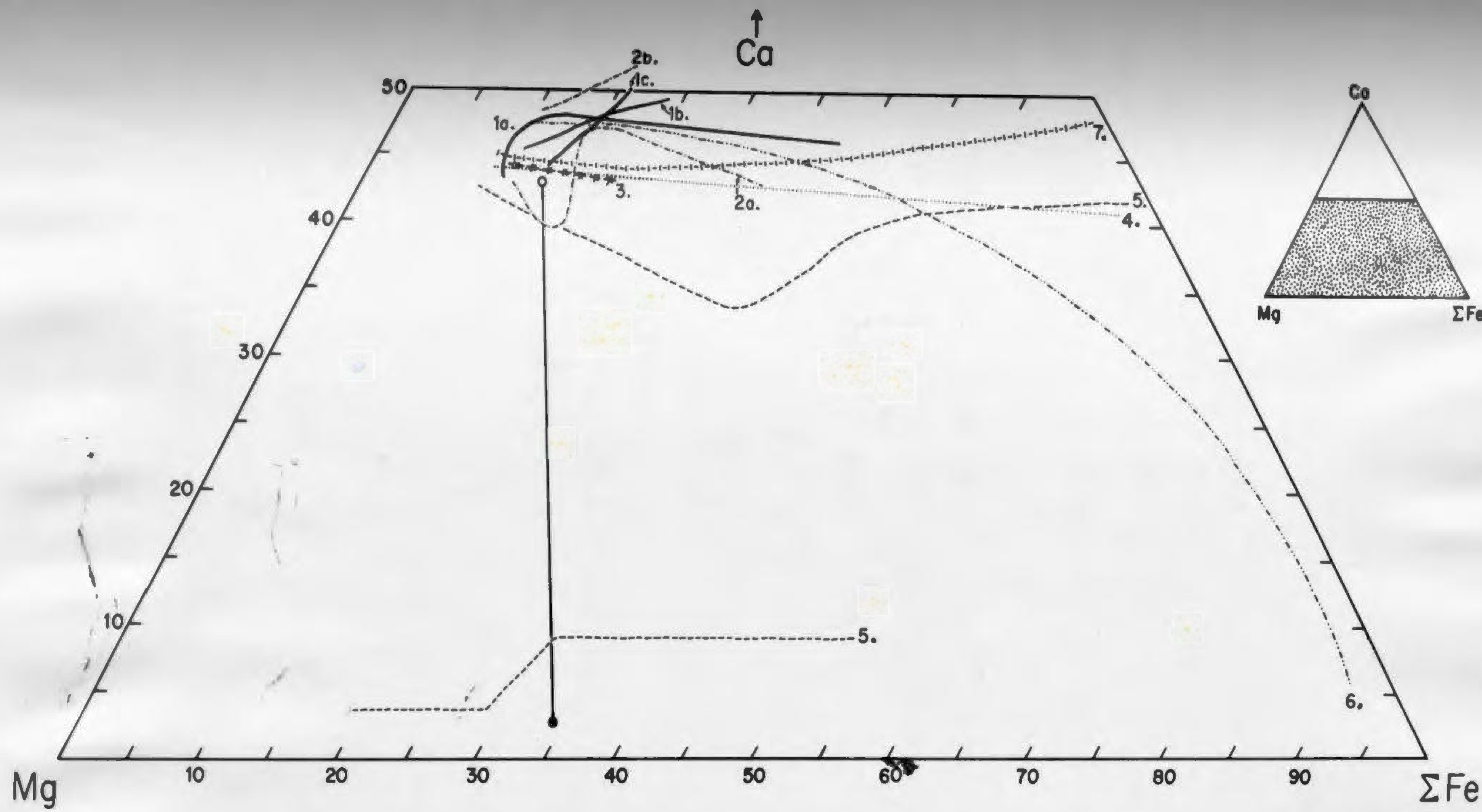
5. Skaergaard tholeiitic trend (Brown and Vincent, 1963)

6. Shonkin Sag Laccolith (Nash and Wilkinson, 1970)

7. Shiant Isles Sill (Gibb, 1973)

o—● augite - hypersthene couple, Gregory Island

* The reader is referred to Table 6. (p. 105) for data
** The reader is referred to Figure 14. (p. 147) for data points and also data points for the Little Port and Western Head, if so desired.


Ca
50
40
30
20
10
Mg
10
20
30
40
50
60
70
80
90
ΣFe
1a.
1b.
1c.
2a.
2b.
3.
4.
5.
5.
6.
7.
Ca
Mg
ΣFe

trend (Wilkinson, 1956; Aoki, 1964). The crystallization trend of phenocrysts (1a. in Fig. 7.) is very similar to the diopsidic augite/augite/ferroaugite/hedenbergite series of Aoki (1964). Aoki (1964) mentions that such a crystallization trend is illustrated by the alkali basalt-trachyte series of Japan (trend 4. in Fig. 7.), the Garbh Eilean picrite-crinanite series (Murray, 1954) and the alkali basalt-trachybasalt-trachyte series of Gough Island (Le Maitre, 1962) (trend 3. in Fig. 7.). The crystallization trends of groundmass clinopyroxenes (*i.e.* 1b. and 1c. in Fig. 7.) are similar to the Hawaiian nephelinitic trend (trend 2b. in Fig. 7.).

The above trends suggest the Trout River and Chimney Cove clinopyroxenes are similar in composition, moderately alkaline, and that with time the clinopyroxenes become increasingly alkalic (*i.e.* groundmass as compared to phenocryst trends).

5.1.1.2 Orthopyroxene

Fresh, euhedral hypersthene phenocrysts ($Ca_{2.9}$ $Mg_{64.4}$ $Fe_{33.7}$) are found in the basaltic andesites on Gregory Island (see Fig. 2. index map for location and sample numbers). Many hypersthene phenocrysts are poikilitic with calcic plagioclase (*i.e.* sodic bytownite, An_{70}, microprobe determinations) and apatite inclusions. Clinopyroxene, Ca_{41} Mg_{41} Fe_{18}, mantles some hypersthene and outlines the form of bastitized hypersthene.

A coexisting hypersthene/augite couple is shown in Fig. 7. Unfortunately more hypersthene / augite-bearing rocks are not present.

Orthopyroxene is not found elsewhere in the structural slices under investigation. The present study failed to find orthopyroxene in the

Little Port lavas although Comeau (1972, p. 76) mentions the rare occurrence of orthopyroxene in some altered Little Port gabbros. Malpas (1976, p. 245) has identified rare pigeonite phenocrysts in the lower sequences of the Bay of Islands (ophiolite) volcanics.

5.1.2 Feldspar

The compositions of sixty-eight groundmass feldspars have been determined from thirteen of the fourteen rock specimens shown in Table 9. The compositions of eight feldspar phenocrysts were determined to detect the presence of zoning. Plagioclase phenocrysts in the basaltic andesites from Gregory Island display excellent oscillatory zoning.

All feldspar compositions were determined by use of the electron microprobe. Individual analyses are tabulated in Appendix B., the sample numbers correspond to the whole rock analyses (also listed in Appendix B.). Sample locations are given in Plate 1. and Figure 2. In the text to follow, feldspar analyses are summarized in terms of molecular per cent Ab - Or - An.

Table 9.

Structural slice distribution, sample numbers and corresponding rock types analysed for feldspar compositions

structural slice	sample numbers	rock type	number of analyses (groundmass and phenocrysts
Trout River	SKC-24, SKC-41	ankaramite	15
Trout River	SKC-39	pyroxene-phyric basalt	5
Trout River	SKC-32, SKC-49	alkali basalt	16
Trout River	SKC-26, SKC-42	trachybasalt	22

Table 9. (continued)

structural slice	sample numbers	rock type	number of analyses (groundmass and phenocrysts)
Trout River	SKC-47, SKC-65	trachyte	13
Western Head	WH-6	basalt	3
Little Port	LP-3, LP-12, LP-14	basalt dyke, basalt	14
Little Port (Gregory Island)	GI-12	basaltic andesite	58

The groundmass feldspar of ankaramites is consistantly calcic labradorite ($Ab_{32.0}$ $Or_{1.5}$ $An_{66.2}$) to labradorite ($Ab_{41.1}$ $Or_{2.8}$ $An_{56.1}$). The single analysed phenocryst (from ankaramite SKC-24) has reverse zoning indicated by a sodic andesine core ($Ab_{54.2}$ $Or_{1.5}$ $An_{44.3}$) and labradorite rim ($Ab_{40.1}$ $Or_{2.7}$ $An_{57.2}$). Thin sections show most of the feldspar from ankaramite to be exceptionally clear, and free of alteration products. The groundmass feldspar of the pyroxene-phyric basalt is sodic bytownite ($Ab_{27.5}$ $Or_{1.5}$ $An_{71.1}$).

Feldspar from two alkali basalts consists of calcic plagioclase, a transitional feldspar and secondary sodic feldspar. Five variable compositions are noted for the groundmass feldspar of SKC-32 as follows: calcic andesine ($Ab_{47.9}$ $Or_{3.2}$ $An_{48.9}$), andesine, sodic andesine, transitional sodic-potassic feldspar ($Ab_{37.4}$ $Or_{43.5}$ $An_{19.1}$) and albite ($Ab_{96.6}$). These results suggest an intermediate stage of basalt degradation.

As in the alkali basalts, trachybasalts contain feldspar of variable composition. The groundmass feldspar of SKC-42 is consistently labradorite. Table 10. shows the compositional variability of groundmass feldspar in trachybasalt SKC-26.

Table 10.

Compositional variability of groundmass feldspar in trachybasalt (SKC-26)

feldspar name	molecular per cent Ab - Or - An		
	Ab	Or	An
sodic andesine	62.1	7.5	30.4
andesine	60.7	3.5	35.8
albite	99.0	0.0	1.0
sodic/potassic/calcic feldspar . . . . ('metastable plagioclase')	53.6	21.0	25.4
anorthoclase (in its present metastable condition) . .	75.5	23.2	1.3
alkali feldspar (adularia)	1.3	98.7	0.1

It is clear from Table 10. that the groundmass feldspar in SKC-26 has been affected by potassium and sodium mobilization, possibly due to the redistribution of groundmass potassium and the presence of sodium brine (?) during the zeolite facies metamorphism. Although groundmass feldspar has been affected by alkali mobility, the single analysed phenocryst in SKC-26 is labradorite, which has apparently been unaffected by the elemental mobility.

Trachytes consist of a metastable groundmass feldspar assemblage. For example, the groundmass feldspar in SKC-47 ranges in composition from anorthoclase through albite with precisely similar compositions as listed in Table 10. Feldspar phenocrysts are anorthoclase (in SKC-47) and secondary albite (in SKC-65).

One sample of basalt from the Western Head slice (WH-6) contains groundmass feldspar ranging in composition from albite (Ab_{92}) to labradorite ($Ab_{37.7}\ Or_{0.2}\ An_{62.2}$). Only the labradorite is considered to represent the primary plagioclase composition.

Feldspar from the Little Port slice assemblage (in the vicinity of Little Port, Fig. 2.) is generally albite, although a dyke (LP-12) contains some oligoclase ($Ab_{75.5}$ $Or_{0.2}$ $An_{24.2}$). The andesitic rocks on Gregory Island consist of plagioclase, augite and hypersthene phenocrysts all set in a chloritic, devitrified groundmass. The plagioclase phenocrysts have calcic bytownite cores ($Ab_{22.8}$ $Or_{0.5}$ $An_{76.7}$) and relatively sodic rims ($Ab_{35.6}$ $Or_{0.8}$ $An_{62.7}$).

In summary, the feldspar from the Trout River slice is pristine calcic plagioclase, metastable plagioclase and secondary alkali feldspar (adularia and albite). The most calcic feldspar composition probably indicates the pristine feldspar. Adularization and albitization both suggest alkali mobility during basalt degradation. Plagioclase from Western Head and Little Port is mostly albite with some labradorite and oligoclase. The original feldspar of both suites is probably labradorite. The best preserved plagioclase is from the andesites on Gregory Island, which consists predominantly of zoned labradorite.

5.1.3 Other minerals

5.1.3.1 Amphibole

Primary amphibole is not found in lavas of the Trout River slice (although some secondary amphibole is seen) or the Little Port slice assemblage. Brecciated but undeformed dykes post-date the deformations in the greenschists of the Old Man Cove slice (Fig. 3.). The amphiboles from the dykes are pale green/brown, euhedral to subhedral prisms and wedges that show typical amphibole cleavage. They comprise 1 per cent of the mode, and are located interstitial to clinopyroxene, titano-magnetite and plagioclase (Plate 36.). Means of microprobe analyses

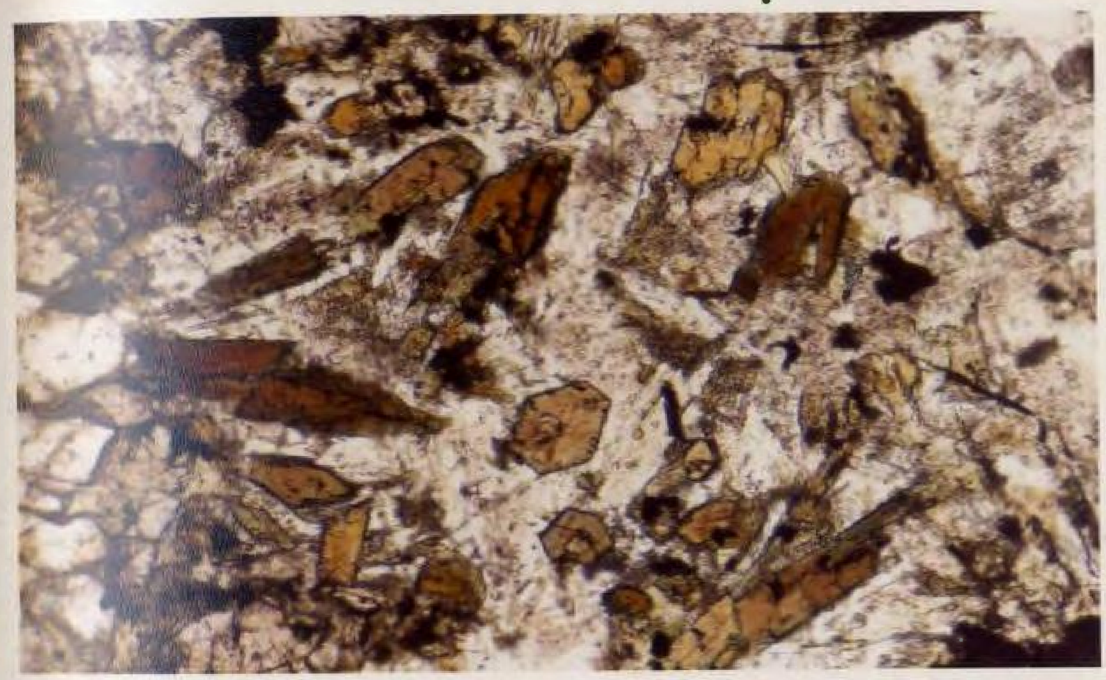


Plate 36. Euhedral and subhedral amphibole (subcalcic, titaniferous, hastingsitic) from a post-deformation, brecciated dyke that cuts greenschists of the Old Man Cove Formation. Basalt, OMCv, plane light (X 125).

are presented in Table 11. below.

Table 11.

Primary amphibole compositions from dykes that cut the Old Man Cove Formation&

Oxide	Grain 1 (5 analyses)	Grain 2 (3 analyses)	Grain 3 (3 analyses)
SiO_2	40.50	39.38	40.53
Al_2O_3	10.80	10.80	10.81
TiO_2	3.48	1.74	3.29
FeO_{total}	25.70	33.38	25.31
MgO	6.39	3.32	6.63
MnO	0.37	0.61	0.39
CaO	9.16	7.37	8.68
Na_2O	3.09	2.98	3.15
K_2O	0.19	0.15	0.16
Cr_2O_3	0.01	*	0.02
NiO	*	*	0.01
total	99.27	99.74	98.98
Amphibole structural formula recalculated based on 23(O)			
Si	6.260	6.257	6.257
Al	1.740	1.743	1.743
Al	0.147	0.280	0.223
Fe	2.980	3.732	2.875
Ti	0.403	0.205	0.380
Mg	1.470	0.783	1.522
Mn	-	-	-
Mn	0.045	0.079	0.050
Fe	0.340	0.702	0.392
Ca	1.515	1.219	1.432
Na	0.100	-	-
Na	0.025	0.918	0.816
K	0.036	0.218	0.027
Ca	-	0.035	-
total	15.862	15.981	15.843
X	0.862	0.981	0.843
W	0.100	-0.035	0.126
Y	0.953	0.690	0.983
Z	1.740	1.743	1.743
Minimum Fe_2O_3 #	0.0%	0.9%	0.0%
Maximum Fe_2O_3 #	7.0%	12.2%	10.6%

& B. Doolan, analyst
* below the level of detection of electron microprobe
\- 0.00
\# if there is no Ti in the tetrahedral site

Note particularly the variation of TiO_2, FeO, MgO, MnO and CaO. Based on the above mean values, the differences in the oxides appear real and therefore possibly reflect changes in the residual liquid compositions immediately before crystallization. The amphibole is a subcalcic titaniferous hastingsitic amphibole and does not particularly indicate alkalic or peralkalic mineralogy or magmatic affinity.

5.1.3.2 Opaque minerals

The opaque oxide mineralogy was not investigated in detail. Microprobe energy scans (Ti K-alpha) suggest high titanium contents in the opaque oxides of the Trout River slice. Semi-quantitative microprobe analyses indicate the presence of the ilmenite-hematite series (*i.e.* about 50 per cent TiO_2). Other opaque oxides are titanium-rich (mean of 3 microprobe analyses from SKC-63 yield 20 per cent TiO_2) and are called titanomagnetites.

5.1.3.3 Analcime and celadonite

Analcime is pseudomorphic after plagioclase, and is also found as patches (pseudomorphic after zeolite ?) surrounded by chlorite (*e.g.* SKC-53). All analcime is definitely secondary in origin. Boles (1971) found that Si/Al ratio of analcime is linearly related to the Si/Al ratio of its 'zeolite' precursor. Based on 96 oxygens, the range of formulas for four analcime minerals is $Na_{15-17}\,Al_{17-18}\,Si_{31-14}\,O_{96}$. Unfortunately it is not known if calcic plagioclase $\rightarrow$ albite $\rightarrow$ zeolite $\rightarrow$ analcime, or whether sodic plagioclase was reduced directly to analcime (based on Boles (1971), albite and some zeolites have similar Si/Al ratios, therefore the Si/Al in the Skinner

Cove analcime supports either mineral precursor). The structural formula complies with "Group C" of Coombs and Whetten (1967) within which silica-poor analcimes are inferred to have formed by direct precipitation or by reaction of highly alkaline water with sediment (in this instance the presence of alkalis derived from volcanics in stagnant sea water could produce alkaline waters).

Microprobe analyses of a chrome-green mineral from the lavas of Gregory Island produced the composition of potassic celadonite. Experiments by Velde (1972) indicate that this type of celadonite has a high thermal stability (*i.e.* 420^{o} C at 2 kb) and does not signify changing 'diagenetic' conditions. Wise and Eugster (1964) suggest that celadonite is stable through zeolite to prehnite - pumpellyite facies metamorphism, but that special bulk rock compositions restrict its occurrence at higher metamorphic grades.

5.2 Petrochemistry

The structural slice distribution of whole rock analyses is shown in Table 7. at the beginning of Chapter 5. The aerial distribution of the samples is illustrated in Plate 1. and Figure 2. Analytical methods, precision and accuracy are given in Appendix A.; tables showing individual rock analyses are listed in Appendix B. according to structural slice and rock type.

Analyses of the volcanic rocks of the Skinner Cove Formation in its type area (*i.e.* Trout River slice) are discussed in some detail. Tedious discussion of miscellaneous analyses of nearby rocks is avoided here, but general remarks are incorporated in later sections.

The major, minor and trace element petrochemistry of the Trout

River suite is summarized in Figures 8. and 9. and in Table 12. Table 12. is a correlation coefficient matrix (coefficients are always designated by 'r') of the entire mafic to felsic suite and is meant to show the degree of linearity between any two elements/oxides. This analysis is necessarily somewhat qualitative since the trends of Al_2O_3, CaO, Na_2O, MgO in Figure 8., and Rb, Zr, V, etc., in Figure 9. are clearly curvilinear with SiO_2.

This suite, like most other rock suites shows a continuous variation from mafic to felsic end members (*i.e.* ankaramite through trachyte). Since the chemical relationships are all well illustrated, only the salient features need be noted. The reader is referred to Figures 8. and 9. and Table 12.

The different rock types of the Trout River slice have already been defined on the basis of petrography in section 3.1.3, and in order from mafic to felsic members, they are: ankaramite, pyroxene-phyric basalt, alkali basalt, trachybasalt and trachyte. To simplify nomenclature of these zeolite facies rocks, the prefix 'meta-' has been dropped. In most cases, the naming of the rocks is further supported by the separate clustering of the five rock types based on their chemical compositions.

Most of the variations are as one might expect in an altered rock suite. The alkali basalts, trachybasalts and trachytes are enriched in Na_2O and K_2O. The ratio of K_2O/Na_2O fluctuates from 0.28 to 2.7 in the trachytes (as a group) signifying substantial alkali mobility. The trend of Rb in Fig. 9. follows closely that of K_2O (*i.e.* r = +0.91).

The average MgO content is rather low for the suite, with a mean of about 4 per cent. Magnesia is highest in the ankaramites, but

Figure 8. Harker variation diagrams for the rocks of the Trout River slice (all values are in weight per cent oxide)

■ .... ankaramite

▼ .... pyroxene-phyric basalt

○ .... alkali basalt

□ .... trachybasalt

● .... trachyte

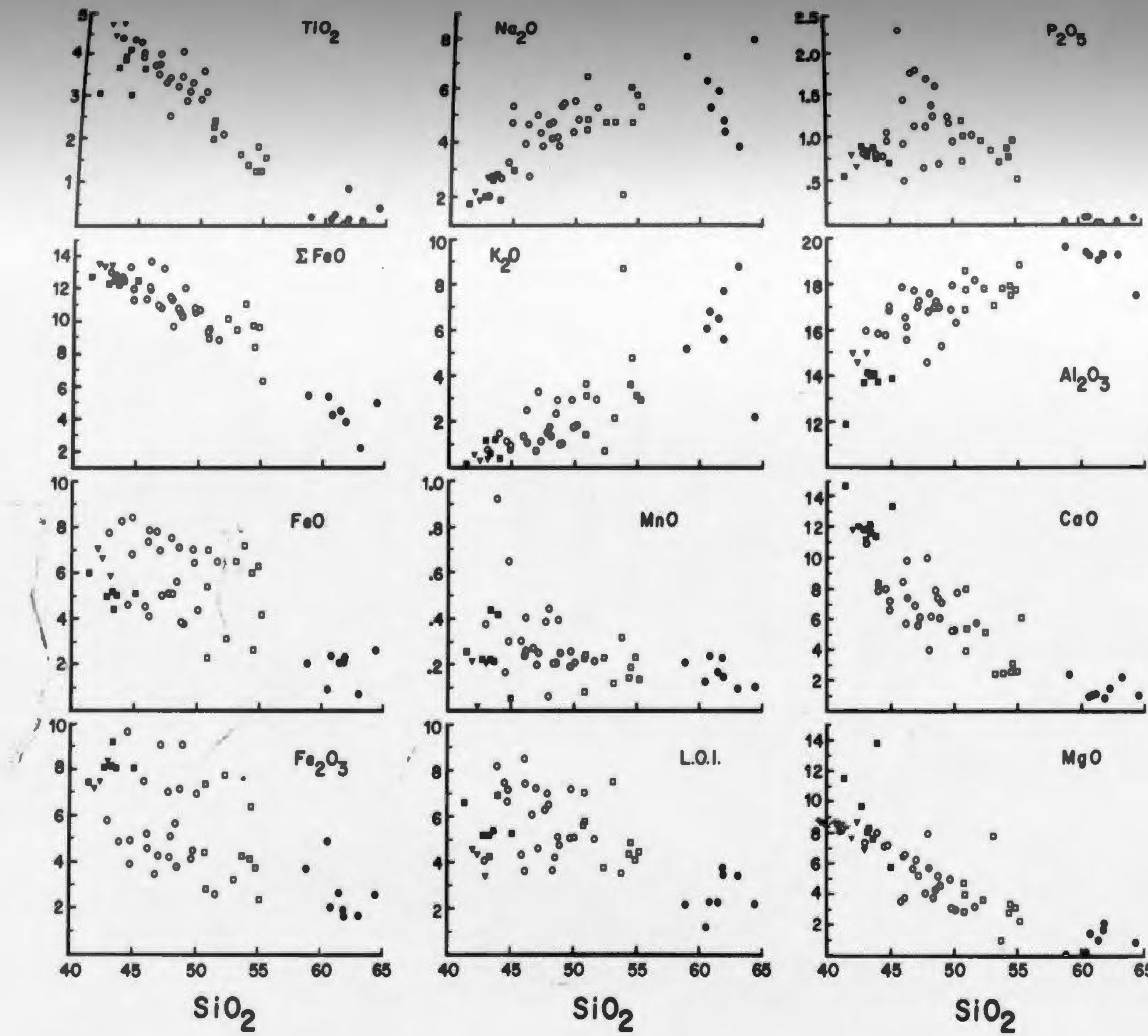

TiO2
Na2O
P2O5
ΣFeO
K2O
Al2O3
FeO
MnO
CaO
Fe2O3
L.O.I.
MgO
SiO2
SiO2
SiO2

Figure 9. Harker-type variation diagrams of trace elements versus SiO_2 for the rocks of the Trout River slice (trace elements are in ppm, SiO_2 is in weight per cent)

■....... ankaramite

▼....... pyroxene-phyric basalt

○....... alkali basalt

□....... trachybasalt

●....... trachyte

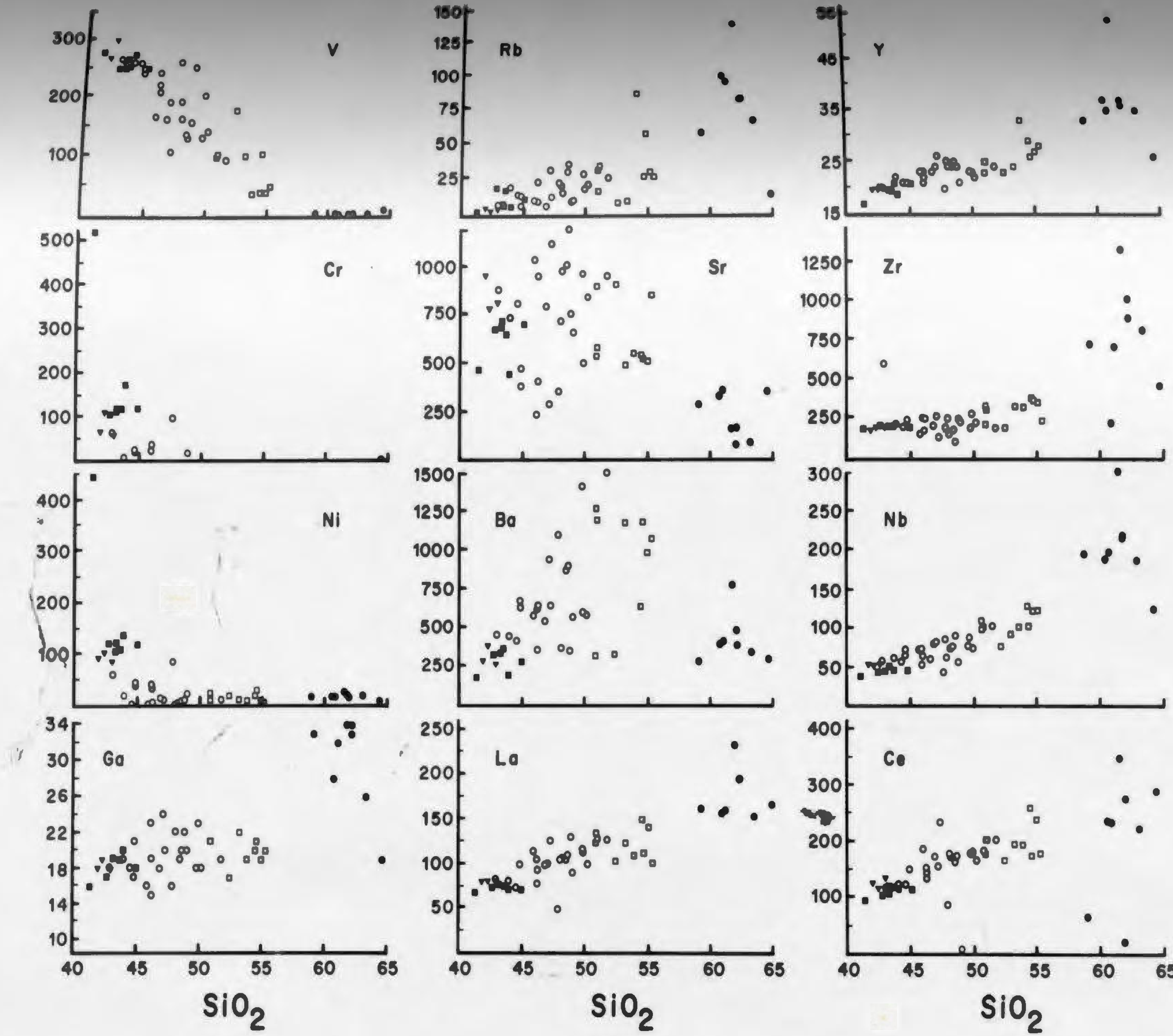

V
Rb
Y
Cr
Sr
Zr
Ni
Ba
Nb
Ga
La
Ce
40 45 50 55 60 65
SiO_2
SiO_2
SiO_2

Table 12.

DIFFERENTIATION-ALTERATION MATRIX FOR THE ROCK CHEMISTRY OF THE TROUT RIVER STRUCTURAL SLICE

VARIABLE MEANS AND STANDARD DEVIATIONS FOR 51 SETS OF DATA

	FE2O3	TIO2	P2O5	SIO2	CAO	K2O	MGO	AL2O3	FEO	NA2O	LOI	MNO	ZR	SR	RB	ZN	BA	NB	GA	PB	NI	LA	R	V	Y	CE
X	5.20	2.58	0.81	47.55	6.62	2.42	4.82	15.91	4.97	4.08	4.80	0.24	326.	630.	29.	124.	792.	93.	21.	7.	40.	111.	36.	153.	25.	180.
SD	2.23	1.30	0.46	6.51	3.70	2.14	2.75	1.81	1.89	1.40	1.53	0.14	236.0	276.5	29.8	18.9	1007.0	55.4	4.7	1.5	68.1	36.7	82.5	94.9	6.4	88.7

CORRELATION MATRIX CALCULATION FOR 51 SETS OF DATA

	FE2O3	TIO2	P2O5	SIO2	CAO	K2O	MGO	AL2O3	FEO	NA2O	LOI	MNO	ZR	SR	RB	ZN	BA	NB	GA	PB	NI	LA	CR	V	Y	CE
VBL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
1	0	637	365	-625	719	-623	424	-661	10	-473	111	139	-535	471	-534	-396	-221	-635	-569	-488	346	-652	354	665	-574	-450
2	0	0	548	-938	811	-823	734	-747	642	-629	554	343	-666	544	-774	-571	-116	-864	-698	-807	257	-841	272	930	-811	-678
3	0	0	0	-554	312	-516	274	-192	463	-200	349	236	-639	725	-552	-273	69	-573	-576	-527	-161	-393	-117	341	-493	-341
4	0	0	0	0	-852	819	-842	835	-703	681	-661	-365	704	-495	779	569	99	887	709	817	-417	872	-438	-927	833	671
5	0	0	0	0	0	-760	706	-871	400	-702	327	223	-569	460	-696	-558	-276	-790	-678	-716	630	-841	639	859	-758	-626
6	0	0	0	0	0	0	-720	741	-500	327	-519	-265	683	-520	907	504	377	827	719	712	-335	735	-364	-814	843	538
7	0	0	0	0	0	0	0	-847	630	-704	603	277	-491	248	-659	-486	-183	-713	-497	-657	586	-707	605	832	-698	-610
8	0	0	0	0	0	0	0	0	-470	691	-514	-233	552	-235	688	664	168	807	656	677	-690	836	-707	-882	770	685
9	0	0	0	0	0	0	0	0	0	-456	600	305	-519	352	-545	-403	269	-631	-549	-643	125	-555	156	565	-566	-443
10	0	0	0	0	0	0	0	0	0	0	-260	-207	324	-332	349	386	-98	566	448	620	-531	658	-542	-670	471	632
11	0	0	0	0	0	0	0	0	0	0	0	318	-448	46	-555	-378	12	-571	-379	-552	133	-527	162	572	-576	-487
12	0	0	0	0	0	0	0	0	0	0	0	0	-177	93	-206	-228	-63	-290	-197	-285	56	-304	62	352	-260	-212
13	0	0	0	0	0	0	0	0	0	0	0	0	0	-649	758	626	-41	868	813	751	-152	786	-194	-596	823	572
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-526	-184	29	-566	-630	-545	-87	-463	-44	335	-496	-340
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	642	260	892	802	811	-271	770	-307	-742	937	520
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-19	774	640	639	-328	713	-348	-608	756	500
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	-57	-9	-214	25	-197	-217	180	19
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	882	889	-338	939	-375	-845	960	706
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	742	-261	807	-297	-647	823	668
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-289	851	-327	-740	873	651
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-425	991	486	-354	-331
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-454	-677	865	712
23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	497	-389	-349
24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-811	-696
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	630

r = 0.354 at .01 level of significance

x = mean value

SD = standard deviation

example: r between variable 1 and 2 (i.e. Fe_2O_3 and TiO_2) is 0.637

r between variable 10 and 17 (i.e. (Na_2O and Ba)) is -0.098

there remains much scatter in the mafic rocks, which probably reflects varying degrees of pyroxene and olivine fractionation. Pyroxene-phyric basalts have comparable major and minor element contents to the more densely-phyric ankaramites, suggesting that the groundmass composition of the pyroxene-phyric basalts may be similar to the whole rock ankaramite composition.

TiO_2 and V both show good linear relationships with SiO_2 and also many other elements. The pyroxene-phyric basalts are rich in TiO_2 (4.6 per cent TiO_2) and V (about 300 ppm). This apparent enrichment in TiO_2 and V can be attributed to the presence of titanomagnetite microphenocrysts in some pyroxene-phyric basalts (Plate 17.), granular titanomagnetite in the ankaramites, plus the contribution of TiO_2 from titanaugite.

Alkali basalts are enriched in P_2O_5 (a mean of 1 per cent P_2O_5) and the pyroxene-phyric basalts contain about 0.75 per cent P_2O_5. The high P_2O_5 contents are the result of abundant apatite microphenocrysts.

La, Ce, Nb, Zr, Y and V all show excellent linear trends in the ankaramites to the trachybasalts, but there is much scatter of some elements in the felsic members (trachyte). Barium shows a high degree of scatter, especially in the alkali basalts where it varies from 355 ppm to more than 3600 ppm. The pyroxene-phyric basalts and ankaramites show a tighter clustering of 280 to 400 ppm; a range which overlaps with the trachytes. Barium has the weakest linear correlations of all the analysed elements (*i.e.* r is less than 0.38 and greater than -0.28).

Strontium, like barium, is weakly correlated and shows much scatter at the mafic end of the suite. The alkali basalts have a range in Sr contents from 200 to 1200 ppm. Sr tends to enter the plagioclase structure and would therefore be concentrated in mafic rocks. Taylor (1965) suggests that Sr preferentially enters the potassium feldspar of a coexisting potassium feldspar/plagioclase couple, thus Sr is still fairly abundant in the trachytes.

Nickel and chromium have exactly similar trends in Figure 9., but Cr seems depleted in many basalts, all trachybasalts and trachytes (generally below the level of detection in x-ray fluorescence analysis). One ankaramite contains both high Cr (525 ppm) and Ni (439 ppm). Between 125 and 439 ppm Ni, there is a gap, likewise for Cr between 180 and 525 ppm. Ni decreases drastically from 100 ppm in the porphyritic basalts to 10 to 20 ppm in most alkali basalts, trachybasalts and trachytes. Undoubtedly, clinopyroxene and olivine fractionation have been important in the depletion of Ni and Cr, and likewise the overall low MgO contents in the mafic to intermediate portion of the suite.

The histograms in Figure 10. depict the contents of the major and minor oxides in the rocks of the following structural slices: (a) Trout River, (b) Chimney Cove, (c) Little Port, and (d) Western Head. The oxide data (and loss of ignition, L.O.I.) are taken from Appendix B., recalculated anhydrous and plotted as oxide frequencies.

The present distribution of the oxides in the histograms is not intended to represent the original distributions of the oxides since it is highly probable that much stratigraphy has been structurally omitted during tectonic movement and that elemental mobility has affected the rocks somewhat. However, for the Trout River, Chimney Cove and Western Head slices, the distributions are valid for the amount of stratigraphy exposed. Little Port volcanics outcrop over

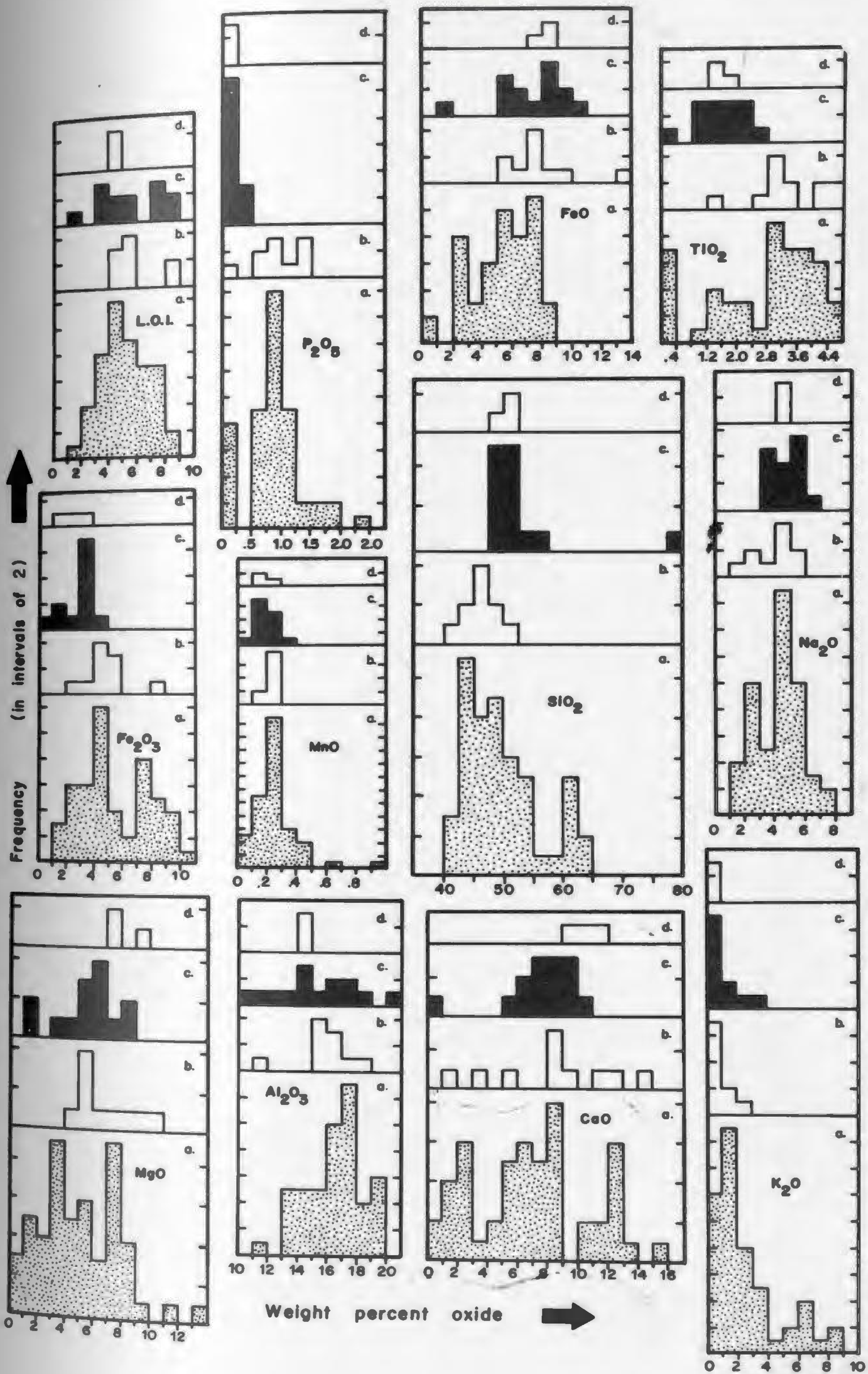
Figure 10. Histograms of frequency versus weight per cent oxides for the rock compositions from four structural slices

a. Trout River (stippled)

b. Chimney Cove

c. Little Port (black)

d. Western Head


L.O.I.
P_2O_5
FeO
TiO_2
Fe_2O_3
MnO
SiO_2
Na_2O
MgO
Al_2O_3
CaO
K_2O
a.
b.
c.
d.
Frequency (in intervals of 2)
Weight percent oxide

large areas and statistical sampling procedures could not be followed.

It is immediately apparent from Figure 10. that SiO_2 is the major contributor to the total variance of the Trout River slice rocks. The only other silica-rich rock noted is in the Little Port (index map of Fig. 2., see sample TRLP-6) and consists of a light-gray, brecciated, silicified rhyolite. SiO_2 is bimodally distributed in the rocks of the Trout River slice. Such a distribution is strikingly similar to the bimodal SiO_2 distribution in the world-wide oceanic island basalt-trachyte association compiled by Chayes (1963, 1977).

The Trout River and Chimney Cove rocks have higher concentrations of TiO_2, P_2O_5 and Fe_2O_3 than do the Little Port or Western Head basalts. The Trout River rocks are enriched in K_2O as compared to all other slices, but this is due to the presence of trachybasaltic and trachytic compositions.

The ranges in loss on ignition, MgO, Al_2O_3, CaO, Na_2O, MnO and FeO in the slices studied all overlap to a considerable extent.

In summary, the rocks of the Trout River and Chimney Cove slices are broadly similar in their enriched contents of P_2O_5, TiO_2 and Fe_2O_3 compared to the other slices. Most other oxide ranges appear similar although further sampling of the Little Port rocks may yet change the observed frequency distributions.

CHAPTER 6

RECOGNITION OF THE PRIMARY MAGMATIC AFFINITIES OF THE SKINNER COVE FORMATION AND RELATED ROCK SUITES

One of the purposes of this work is to outline the possible magmatic and tectonic settings of the Skinner Cove Formation and volcanic rocks of the Little Port Complex prior to their Ordovician transport (see section 1.1). It is clear that the simplified usage of total alkalis versus silica diagrams and uncorrected normative compositions (*e.g.* Strong, 1974) is probably not an indicator of primary magmatic affinity (*i.e.* alkalic versus subalkalic) of the rocks of the Skinner Cove Formation. However, such usage adequately shows the present alkalinity and alteration resulting from hydration, oxidation and elemental mobility.

This section proposes to look through the 'haze' of secondary alteration to the primary magmatic affinties of the rock suites.

6.1 Elemental Mobility During Zeolite Facies Metamorphism

The lithologies of the Trout River slice of the Skinner Cove Formation have been affected by zeolite facies metamorphism (see also section 3.1.3.3) and there is no doubt that this slight degree of metamorphism has affected the mobility of some elements (see also section 5.1.2). Hart *et al.* (1974) found that during initial submarine alteration of ocean floor basalt, SiO_2, Al_2O_3, CaO, S, and Ga are lost; Fe_2O_3, total Fe, MnO, K_2O, H_2O, Rb, Cl, B and Cs all increase. MgO, Na_2O, P_2O_5, Ba, Ni and Cu show significant but inconsistent changes. Wood *et al.* (1976) determined that MgO, SiO_2, K_2O, Rb, Sr, La and Ce are all mobile during zeolite facies metamorphism of recent Icelandic tholeiites.

Analysis of the mineralogy confirms that there has been substantial mobilization of K_2O, Na_2O and CaO in the formation of alkali feldspar from basaltic plagioclase, but it cannot be implied from this that there has been profound potassium metasomatism since the K_2O may be derived from an original alkali-rich mesostasis (Keil *et al.*, 1972). All original glass is devitrified (*cf.* Strong, 1974 and Malpas, 1976; they both describe fresh basaltic glass) with the subsequent mobility of Fe, MgO, SiO_2, and H_2O. Amygdales are filled with chlorite, albite, analcime, calcite, iron oxide and zeolite, attesting to the mobility of Mg, Fe, Ca, Na, Si, Al and H oxides.

The mafic rocks are hydrated and generally contain 3 to 4 per cent loss on ignition (Fig. 9.). Analcime pseudomorphs plagioclase, signifying Na_2O, CaO, Ba, Sr and Rb mobility plus the addition of about 10 per cent H_2O to complete the analcime crystal structure.

In Figures 9. and 10., the scatter of points (*i.e.* deviation about a regression line), and not the variation trends, is attributed to secondary alteration effects. In Figure 9., FeO and Fe_2O_3 plot as broadly linear 'corridors' from ankaramite through trachyte compositions. However, total Fe shows a tigher linear clustering, indicating that total iron has stayed approximately constant even though the oxidization ratio Fe_2O_3/FeO (0.5 to 2) has increased relative to the primary ratio (probably less than 0.5).

Unlike multiple metamorphic facies stratigraphic and chemical studies in thick flows (*e.g.* Vallance, 1974*a*) and ophiolite igneous/metamorphic rocks (*e.g.* Coish, 1977), the rocks of the Trout River slice are restricted to a single metamorphic facies (*i.e.* zeolite). Therefore, it is impossible to determine a metamorphic/chemical stratigraphy. Furthermore, if a metamorphic stratigraphy were present, the probability of sampling a constant lithic type in such a varied petrographic suite, would be very remote indeed.

Studies of variation diagrams (Figs. 9. and 10.), correlation matrices of mafic rocks and the entire lithic suite (Table 12.), and petrographic and mineral/chemical analyses all suggest that Nb, La, Ce, V, Y, Ti, Zr, P and Si were the least mobile elements during the alteration of the Trout River slice mafic rocks.

P_2O_5 versus SiO_2 appears to show much scatter (Fig. 9.). The increased weight percentage of P_2O_5 in the range of 45 to 50 per cent SiO_2 is deemed a primary effect resulting from the relative abundance of primary apatite microphenocrysts and groundmass crystals in the basalts.

The least mobile elements in this study include those determined for the basalts of several studies (*e.g.* Cann, 1970; Pearce and Cann, 1971, 1973; Pearce, 1975; Smith and Smith, 1976; Wood *et al.*, 1976). These elements include Ti, Zr, Nb and Y. Additionally, P_2O_5 is considered immobile by Floyd and Winchester (1975) and Ce, Ga are considered immobile by Winchester and Floyd (1977).

The salient features noted for elemental mobility are as follows:

(1) Zr, Nb, V, La, Ce, Y, Ti, P and Si are relatively immobile. Ba, Sr, Rb, Zn, K, Na, are relatively mobile. Barium is the most highly mobile element.

(2) Variation <u>trends</u> in scatter diagrams (Figs. 9. and 10.) are considered primary and the scatter of points about these trends is probably the result of secondary alteration. It might be argued that the observed variation trends are strictly the result of secondary

alteration. However, the abundance of primary mineralogy and the consistant clustering of analyses of separate rock groups (*i.e.* especially ankaramite through trachybasalt) on variation diagrams point to igneous differentiation as the main contributor to the chemical variations. There is no evidence of massive metasomatism (*e.g.* silification, carbonatization, etc.) and even if the suite were metasomatized, it would be fortuitous to believe; (i) that the resultant chemical trends would coincide with variations that could equally as well be attributed to igneous processes, (ii) that abundant primary mineralogy would be preserved.

(3) The writer readily concedes that all the rocks are altered to varying degrees, but it is highly probable that conclusions drawn from considerations of immobile major/minor oxides, trace elements, mineral chemistry, petrography and field geology, are very reliable.

(4) Nb, Y, Ti, Zr, V, P are considered relatively stable during the alteration of the Western Head, Beverley Head, Chimney Cove slices mafic volcanic rocks, Little Port and Bay of Islands slice assemblages mafic lavas and coeval mafic dykes.

Table 13. (unpublished data of W.R. Church, written communication, 1978) lists chemical analyses on the core and margin of a mafic pillow from the Little Port Complex.

Table 13.

Chemical analyses on the core and margin of a pillow lava from the Little Port Complex

oxide/element	pillow core	pillow margin
SiO_2	47.7	45.8
TiO_2	2.2	2.25
Al_2O_3	13.1	16.4
Fe_{total}	13.5	15.1
MnO	0.22	0.24
MgO	5.82	6.7
CaO	8.0	7.73
Na_2O	4.1	1.72
K_2O	0.02	2.34
P_2O_5	0.13	0.14
SO_3	0.22	0.26
Cr	19	34
Ni	10	5
Zr	141	148
Sr	182	140
Ba	1115	206
Rb	19	3
Y	29	31
Cu	36	60
Nb	tr.	2

Relative to the pillow margin, the core contains more Na_2O, Ni, Sr, Ba, Rb, and less Al_2O_3, total Fe, MgO, K_2O, Cr, Cu. Assuming that due care was taken in sampling and analysis, and considering the analytical error, SiO_2, TiO_2, MnO, P_2O_5, Zr, Y and Nb are relatively stable. As for the Trout River and Chimney Cove slices mafic rocks, possibly the least mobile elements in the Little Port rocks are Si, Ti, P, Nb, Zr, Y.

6.2 Immobile Element Plots

Unbiased fourth degree polynomial regression curves in Figure 11., depict the chemical variation trends of the least mobile elements of rocks in the Trout River slice. All elements are plotted against anhydrous SiO_2. With the exception of zirconium, which is anomalously below the level of detection in some Chimney Cove samples (x-ray fluorescence determinations), all other Chimney Cove samples plot close to the Trout River slice trend. It is equally obvious that specimens from Western Head, Old Man Cove, Little Port, Beverley Head, Gregory Island and the Bay of Islands plot away from the differentiation trends of the Trout River slice.

Figure (12a., b., c.) employ percentage TiO_2, ppm Zr, Y, Nb and P_2O_5 in order to separate mafic rocks of alkaline affinity from those of tholeiitic (*i.e.* subalkaline) magmatic affinity (Winchester and Floyd, 1976).

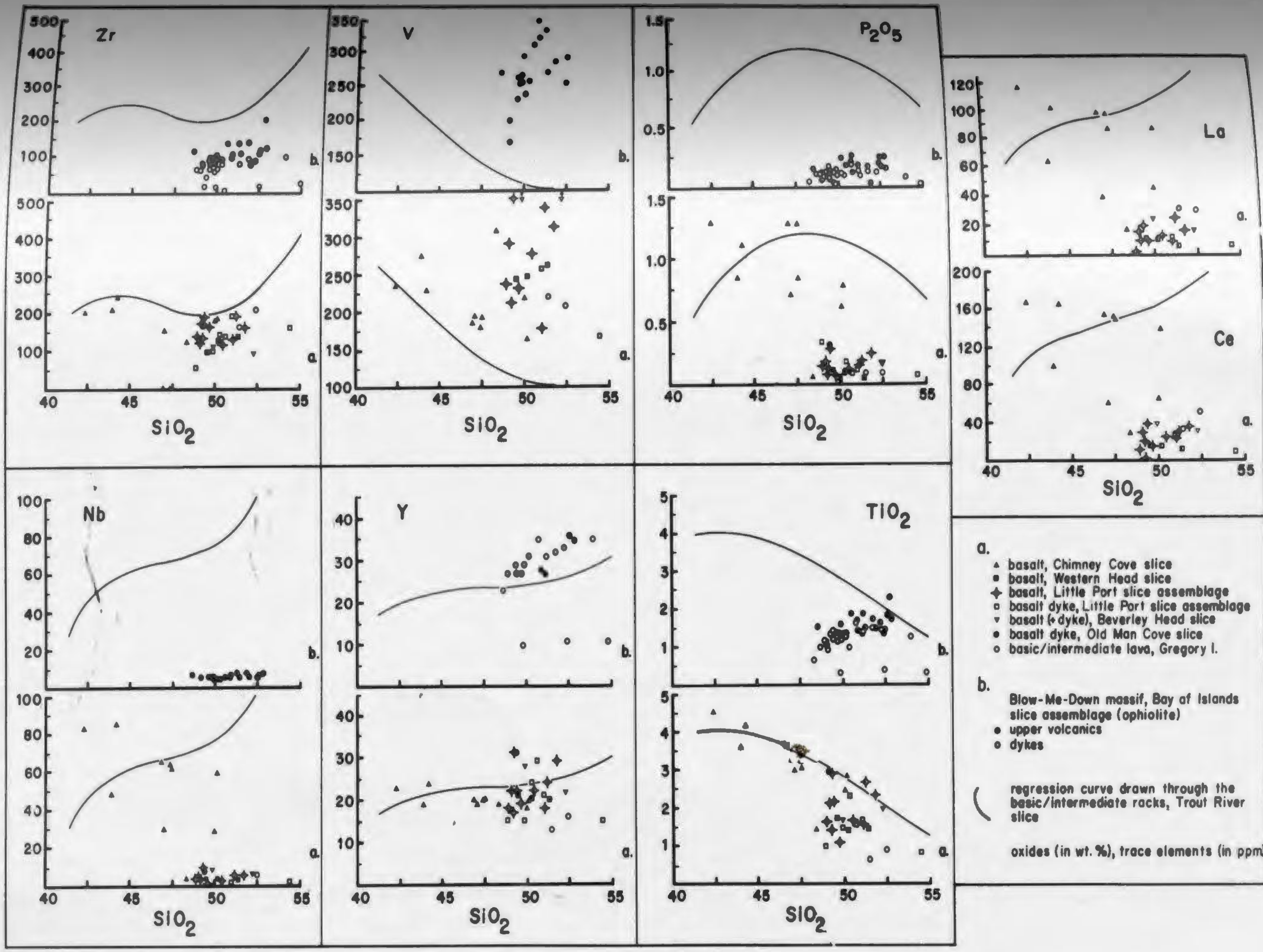
P_2O_5 versus Zr (Fig. 12a.)

The diagram shows that the Trout River and Chimney Cove slices are alkalic. Only one Chimney Cove basalt plots in the subalkalic field (and this sample is from the 'inland' lithologies, section 3.3). The dyke from the Old Man Cove slice is located on the alkalic/tholeiitic boundary line. Note the clustering of the least altered upper volcanic rocks of the Bay of Islands Complex (Blow-Me-Down massif, Fig. 3.) in the tholeiitic field.

Nb/Y versus Zr/P_2O_5 (Fig. 12 b.)

As in Figure 12a., Skinner Cove and Chimney Cove slice basalts are restricted to the alkaline field. The monzonitic intrusive and related mafic phase from the mélange in Wallace Brook (Plate 1.) (*i.e.* SK-6A

Figure 11. Plots of least mobile elements (*i.e.* Zr, Nb, V, Y, P_2O_5, TiO_2, La, Ce) versus SiO_2. The plot is used for comparisons between the rocks of the Trout River slice and those in some of the other transported units


Zr
V
P_2O_5
La
Ce
Nb
Y
TiO_2
SiO_2
a.
▲ basalt, Chimney Cove slice
■ basalt, Western Head slice
✦ basalt, Little Port slice assemblage
□ basalt dyke, Little Port slice assemblage
▼ basalt (+dyke), Beverley Head slice
● basalt dyke, Old Man Cove slice
○ basic/intermediate lava, Gregory I.
b.
Blow-Me-Down massif, Bay of Islands slice assemblage (ophiolite)
● upper volcanics
○ dykes
regression curve drawn through the basic/intermediate rocks, Trout River slice
oxides (in wt. %), trace elements (in ppm)

and SK-7A) lie distinctly in the alkaline field. Trace elements from the mafic rocks of a knocker east of Trout River Village (Fig. 2., index map, samples denoted by an 'X' for samples TR-7, 12) are listed in Table 14. below.

Table 14.

Trace element analyses of altered mafic rocks east of Trout River Village (knockers enveloped in Humber Arm Supergroup sediments) and the mean alkali basalt and trachybasalt from the Trout River slice

trace element (ppm)	sample TR-7	TR-12	1.	2.
Nb	72	83	70	105
Zr	420	496	233	310
Y	34	29	23	26
Sr	660	726	740	638
Rb	33	12	18	34
Pb	5	2	7	7
Ga	23	24	19	20
Zn	159	128	119	138
Cu	16	13	n.d.	n.d.
Ba	537	513	823	638
V	130	62	189	84
Nb/Y	2.1	2.9	3.0	4.0

1. mean alkali basalt, Trout River slice n = 23
2. mean trachybasalt, Trout River slice n = 10
n.d. not determined

The high zirconium contents alone suggest an alkaline affinity for the TR (Trout River) knocker (Table 14.). Most of the elements are in a comparable range to the mean Trout River slice alkali basalts and trachybasalts. The Nb/Y ratios are similar to those of the ankaramites and alkali basalts of the Trout River slice (Fig. 12b.). The available

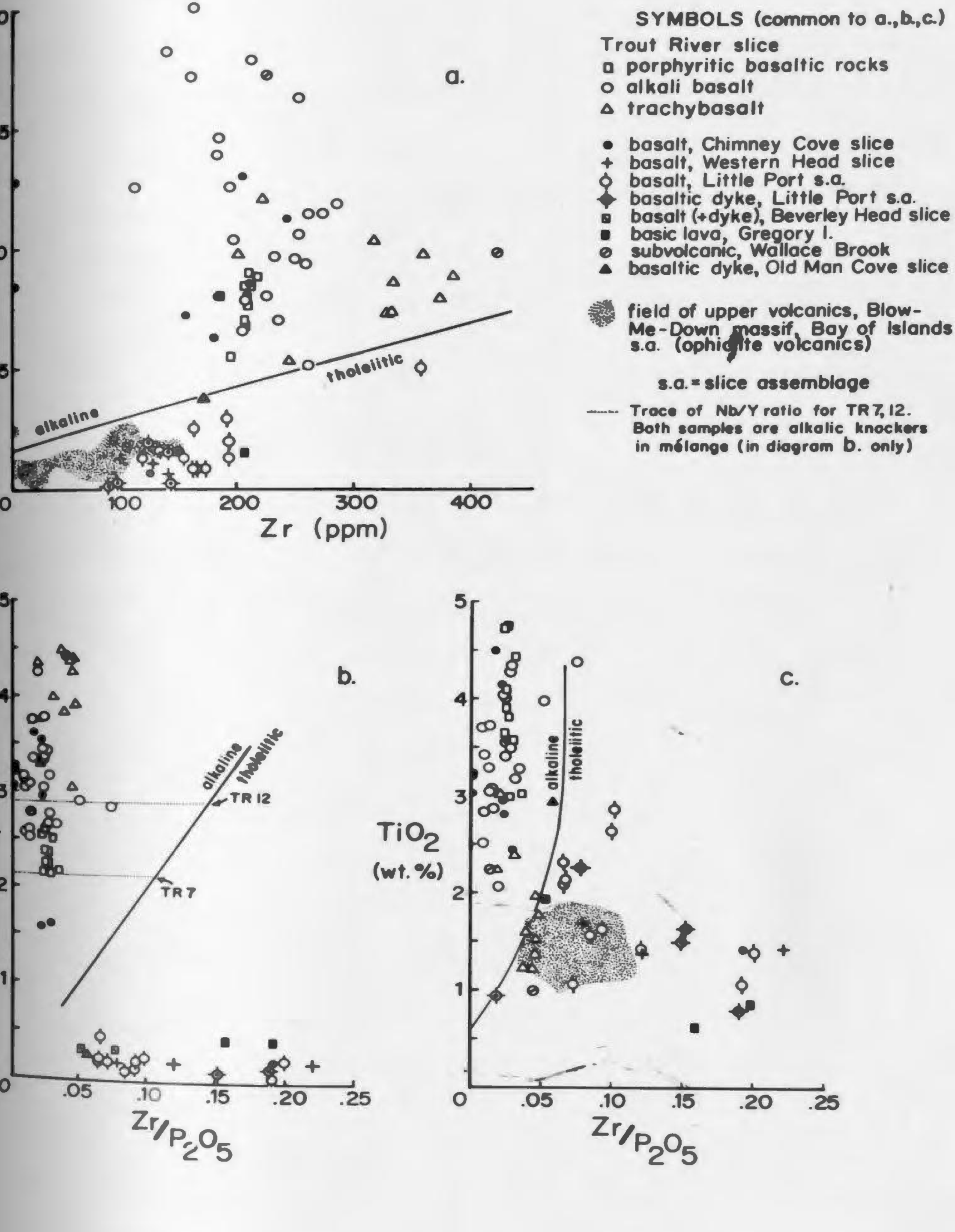
Figure 12. Immobile element plots for the comparison and determination of magmatic affinities of a variety of rock groups

a. P_2O_5 versus Zr

b. $Nb/_{Y}$ versus $Zr/_{P_2O_5}$

c. TiO_2 versus $Zr/_{P_2O_5}$

(after Winchester and Floyd, 1976)


SYMBOLS (common to a.,b.,c.)
Trout River slice
porphyritic basaltic rocks
alkali basalt
trachybasalt
basalt, Chimney Cove slice
basalt, Western Head slice
basalt, Little Port s.a.
basaltic dyke, Little Port s.a.
basalt (+dyke), Beverley Head slice
basic lava, Gregory I.
subvolcanic, Wallace Brook
basaltic dyke, Old Man Cove slice
field of upper volcanics, Blow-Me-Down massif, Bay of Islands s.a. (ophiolite volcanics)
s.a. = slice assemblage
Trace of Nb/Y ratio for TR 7, 12. Both samples are alkalic knockers in mélange (in diagram b. only)
a.
P2O5 (wt. %)
Zr (ppm)
alkaline
tholeiitic
b.
Nb/Y
Zr/P2O5
TR 12
TR 7
c.
TiO2 (wt. %)
Zr/P2O5

chemical and petrographic evidence clearly suggest that the volcanic knockers are of alkaline affinity. Therefore there is a high probability that the knockers are Skinner Cove Formation.

TiO_2 versus Zr/P_2O_5 (Fig. 12c.)

Alkaline rocks tend to have lower Zr/P_2O_5 ratios and higher TiO_2 than do tholeiitic rocks. However, four or five trachybasalts of the Trout River slice plot in the tholeiitic field close to the tholeiitic/alkaline boundary. The mafic and monzonitic intrusive rocks of Wallace Brook (Plate 1.) plot near the trachybasalts and in the tholeiitic field. The Old Man Cove dyke has high TiO_2 (controlled by opaque minerals and therefore the fO_2 of the magma) and is shifted from the tholeiitic field of the Nb/Y versus Zr/P_2O_5, and the P_2O_5 versus Zr diagrams to the alkaline field in Figure 12c.

The V versus Ti diagram (Fig. 13.) after Langmuir *et al.* (1977) shows the rocks of the Trout River and Chimney Cove slices are related and of alkaline affinity, whereas the Little Port and ocean floor volcanics of the Bay of Islands Complex fall in the same field. This may signify similar origins for the rocks of the Little Port and Bay of Islands Complexes.

All of the above diagrams strongly suggest:

(1) The mafic rocks of the Trout River and Chimney Cove slices are chemically similar (*i.e.* Chimney Cove slice follows the chemical variation trends evident in the Trout River slice).

(2) The Western Head, Gregory Island, Little Port and Bay of Islands mafic lavas are chemically similar (*i.e.* they cluster away from the Trout River slice variation trends, (Fig. 11.)).

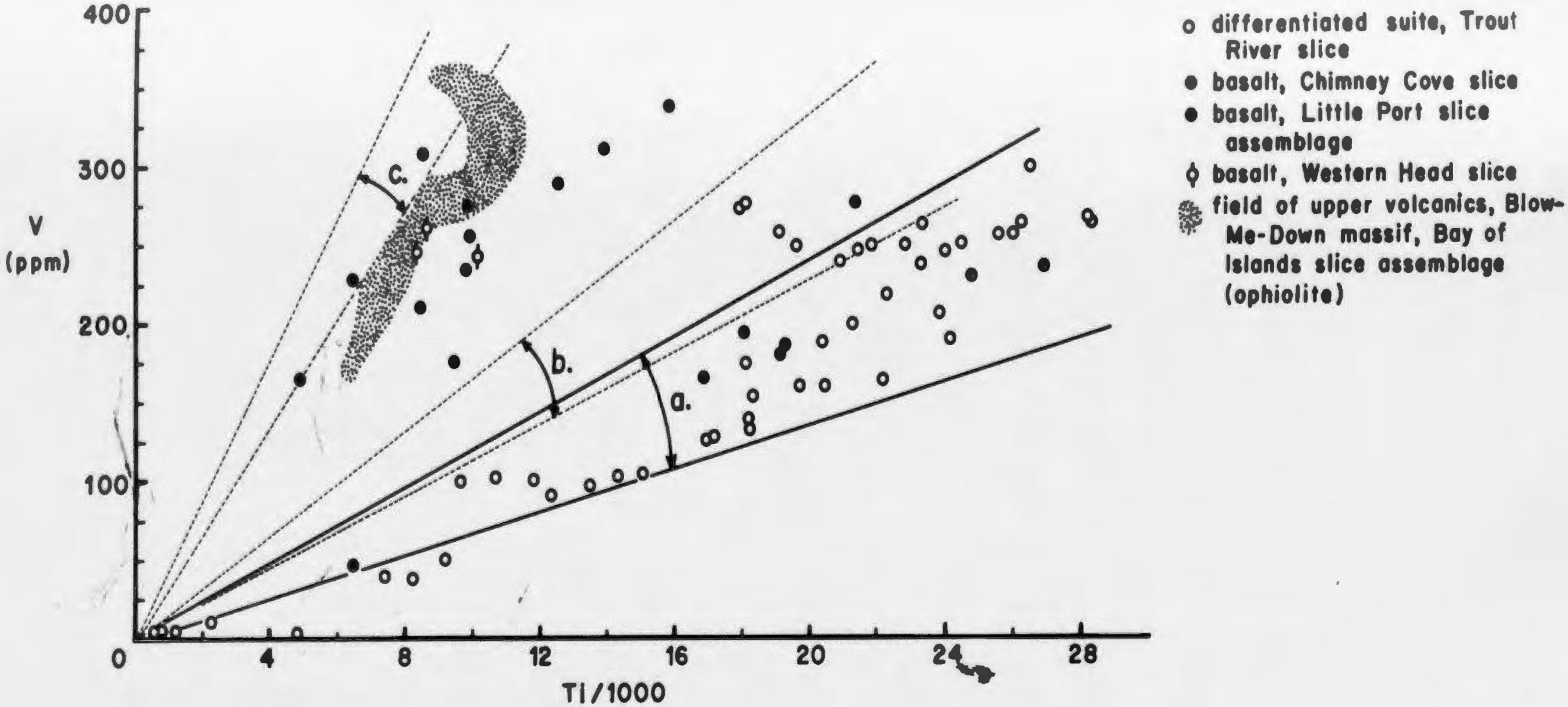
(3) The rocks in the Trout River and Chimney Cove slices are alkaline; all other rock groups are tholeiitic (possibly better

Figure 13. V versus Ti (after Langmuir *et al.*, 1977)

a. Field of the Trout River differentiated suite and Chimney Cove basalts

b. Field of alkali basalts (*i.e.* Ross Island basinitoids; Goldrich *et al.*, 1975)

c. Field of ocean floor basalts (Langmuir *et al.*, 1977; Muir *et al.*, 1964; Frey *et al.*, 1974)


400
300
200
100
0
V
(ppm)
4
8
12
16
20
24
28
Ti/1000
c.
b.
a.
o differentiated suite, Trout River slice
● basalt, Chimney Cove slice
● basalt, Little Port slice assemblage
ϕ basalt, Western Head slice
field of upper volcanics, Blow-Me-Down massif, Bay of Islands slice assemblage (ophiolite)

termed 'subalkaline').

(4) Tholeiitic dykes that cut the Little Port gabbros probably feed the Little Port lavas. This interpretation differs from the opinion of Church (1976). Church (1976) found that Little Port lavas are relatively enriched in iron (FeO = 15 per cent) and titanium (TiO_2 = 2.2 per cent at FeO_{total}/MgO = 2.3) with all SiO_2 contents less than 52 per cent. Church also found that Little Port dykes are less differentiated with lower FeO_{total}/MgO and TiO_2 contents and relative enrichment in Cr and Ni compared to the lavas. The ranges of oxides and available trace elements in Little Port lavas and dykes are presented in Table 15. below.

Table 15.

Elemental ranges in Little Port mafic lavas and dykes (oxides and trace elements)

oxide/trace	dykes (n = 4)	lavas (n = 14)
SiO_2	49.13 - 50.92	46.38 - 54.28
TiO_2	0.96 - 1.64	0.81 - 2.86
Al_2O_3	14.97 - 19.92	14.00 - 20.18
FeO_{total}	7.44 - 10.95	7.11 - 15.41
MnO	0.15 - 0.24	0.14 - 0.37
MgO	6.43 - 8.14	4.96 - 8.41
CaO	8.59 - 10.52	5.26 - 10.85
Na_2O	2.06 - 3.93	1.74 - 6.15
K_2O	0.63 - 1.89	0.02 - 2.37
P_2O_5	0.02 - 0.13	0.09 - 0.25
FeO_{total}/MgO	0.91 - 1.70	1.03 - 3.09
Cr	82 - 217	19 - 238
Ni	28 - 88	5 - 144

Table 15. (continued)

Zr	99 - 198	118 - 192
Rb	6 - 36	1 - 19
Sr	270 - 639	118 - 875

The transition elements and most major elements are mobile, as shown in Table 15. With the possible exception of Ti, Zr, P, all of the elements presented in Table 15. above, are of dubious value in distinguishing the consanguinity of the dykes and lavas. Nonetheless, all major and minor oxide whole rock compositions and Cr, Ni, Sr in the Little Port dykes generally fall within the chemical range of the Little Port extrusive rocks. The FeO_{total}/MgO ratio must be used with caution in interpreting the degree of differentiation since both oxides have been mobile (Table 15.). Petrographically and geochemically (including considerations of clinopyroxene compositions), the dykes must be considered coeval with the lavas.

Malpas (1976, p. 53) states that ... "the relatively fresh dykes and pillow lavas that cut older foliated rocks of the Little Port Complex are remarkably similar in mineralogy and petrography to the Skinner Cove rocks ..." Based on his interpretation of a total alkalis versus SiO_2 plot, Malpas (1976, p. 73) states that ... "The young dykes and volcanics (of the Little Port Complex) ... appear to be chemically similar to members of the Skinner Cove series." The present study has used the least mobile elements available in the interpretation of magmatic affinity of the rock suites. Na_2O and K_2O are highly mobile during post-consolidation alteration(s) and diagrams that employ them are considered irrelevant to the present discussion of magmatic affinity. Contrary to Malpas (1976, p. 73), the present study strongly suggests that the petrography, mineral compositions and whole rock chemistry of the Little Port and Skinner Cove suites differ tremendously.

6.3 The Status of Clinopyroxene Compositions and the Recognition of Primary Magmatic Affinity

Kushiro (1960) suggested that clinopyroxene crystallizing from a SiO_2 saturated melt would have higher proportions of Si and less Al in the tetrahedral position of the clinopyroxene structure, whereas clinopyroxene crystallizing from a SiO_2 undersaturated melt would have higher proportions of tetrahedral Al and relatively lower proportions of tetrahedral Si. Increases in Al_z are compensated by additional Ti, Al, and Fe^{3+} in the y site of the pyroxene structure to maintain the charge balance. Thus Si varies antipathetically with Al_z and Ti, and clearly, Ti and Al_z vary sympathetically. This feature is evident from Table 8. where strong correlations are seen between SiO_2, TiO_2 and Al_2O_3 for all of the suites investigated.

Le Bas (1962) applied Kushiro's Si-Al relations by directly correlating the percentage of Al in the z position with Si and Ti to define the alkalinity in some recent igneous suites. Le Bas (1962) showed that the atomic proportions of Ca, Mg, and Fe in clinopyroxene change systematically depending on the magma type and fractionation stage. Three separate fields were constructed in the pyroxene quadrilateral and rectangular plots; (1) non-alkaline field, (2) normal alkaline field, (3) peralkaline (meaning 'very alkaline') field. Figures 14. and 15. indicate that the groundmass clinopyroxene compositions of the Trout River slice are normal alkaline to peralkaline, those of the Little Port are non-alkaline to normal alkaline; likewise Figures 14. and 15. suggest that Chimney Cove clinopyroxenes are normal alkaline to highly peralkalic, while those of the Western Head slice are non-alkaline to normal alkaline.

Coombs (1963) approached the magmatic affinity problem by suggesting that clinopyroxenes crystallizing from a melt undersaturated in SiO_2 should be slightly nepheline normative. C.I.P.W. norms for alkaline clinopyroxenes indicate that alumina generally forms normative feldspar or nepheline. Highly undersaturated melts produce nepheline or leucite normative clinopyroxenes.

Vallance (1969) suggested that chemical analyses of relict clinopyroxenes from spilites could provide clearer recognition of the magmatic parentage. The hypothesis was later substantiated when the clinopyroxene chemistry of a single flow (varying from fresh tholeiite to spilite) was found to remain stable throughout (Vallance, 1974*b*). Vallance's work indicates that clinopyroxenes of spilites are relict metastable igneous phases and not pseudomorphs of pyroxene as suggested by Yoder (1967).

More recently, Hynes (1974, 1976), Garcia (1975) and Barron (1976) have employed the above clinopyroxene compositional schemes to interpret different geological settings where whole rock compositions and trace elements are unavailable or unreliable.

Barberi *et al.* (1971) cast doubts on the validity of using clinopyroxene compositions as indicators of parental affinity, since the physical conditions in the magma and the order of plagioclase and clinopyroxene crystallization, affect Al, Ti, and Ca concentrations in the clinopyroxene. Under the optimum physio-chemical conditions (*i.e.* initial clinopyroxene crystallization, low and falling fO_2, low

Figure 14. Groundmass clinopyroxene compositions in the "pyroxene quadrilateral"; with the fields of magmatic affinity as suggested by Le Bas (1962)

a. ● Trout River

b. ⊙ Chimney Cove

c. ■ Little Port

d. ▼ Western Head

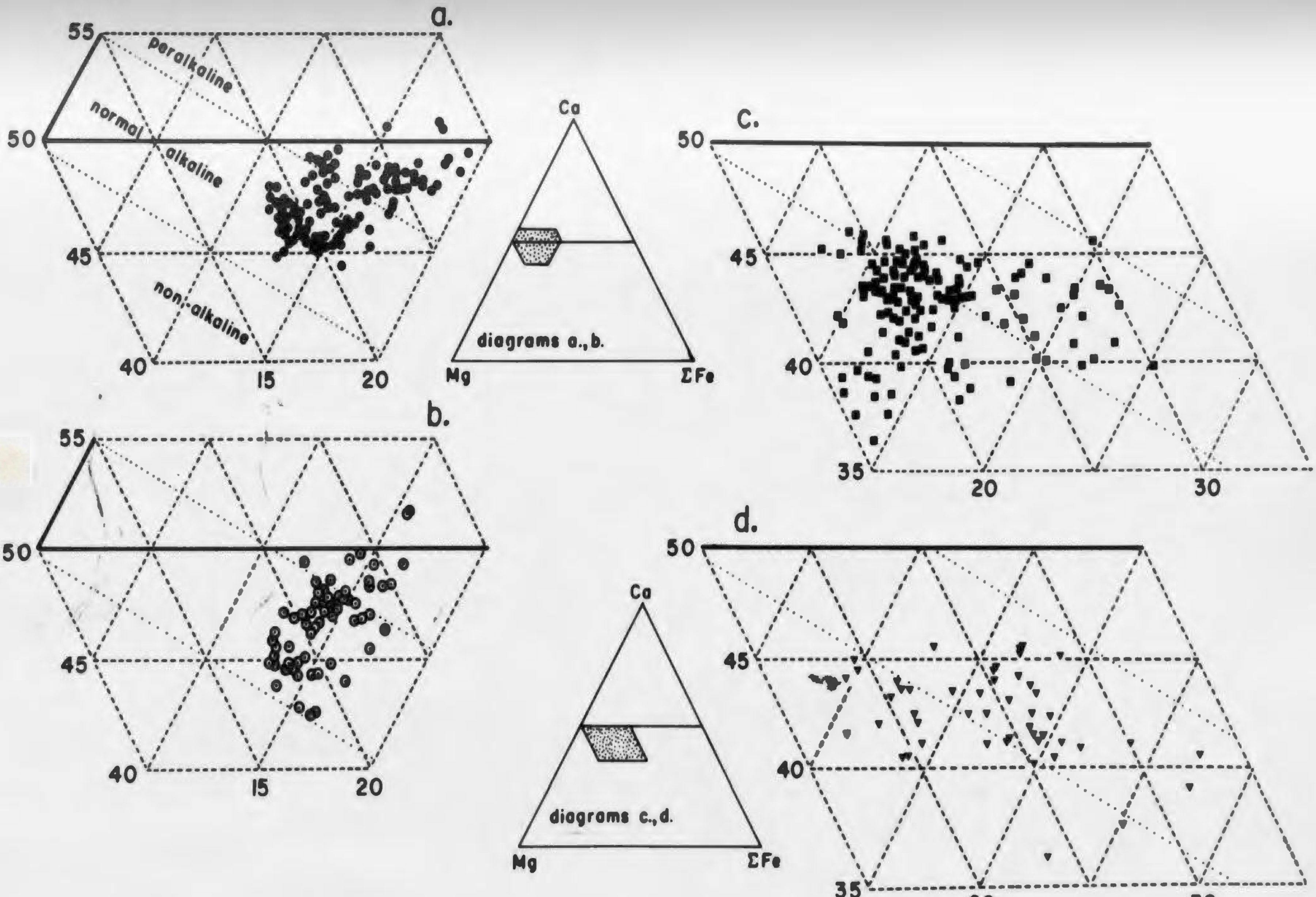

a.
peralkaline
normal
alkaline
non-alkaline
55
50
45
40
15
20
b.
55
50
45
40
15
20
Ca
Mg
ΣFe
diagrams a., b.
Ca
Mg
ΣFe
diagrams c., d.
c.
50
45
40
35
20
30
d.
50
45
40
35
20
30

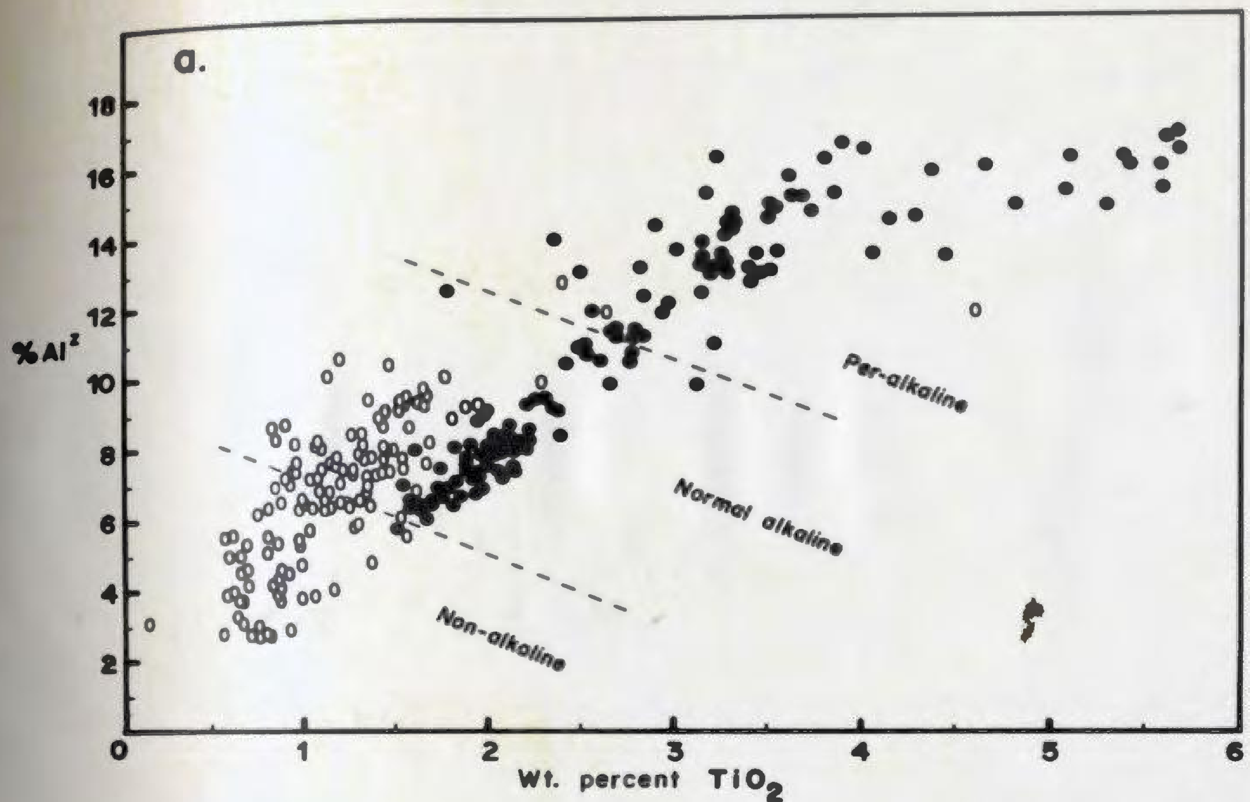
Figure 15. Per cent Al_z versus TiO_2 for the groundmass clinopyroxenes from four structural slices (fields of magmatic affinity were suggested by Le Bas, 1962)

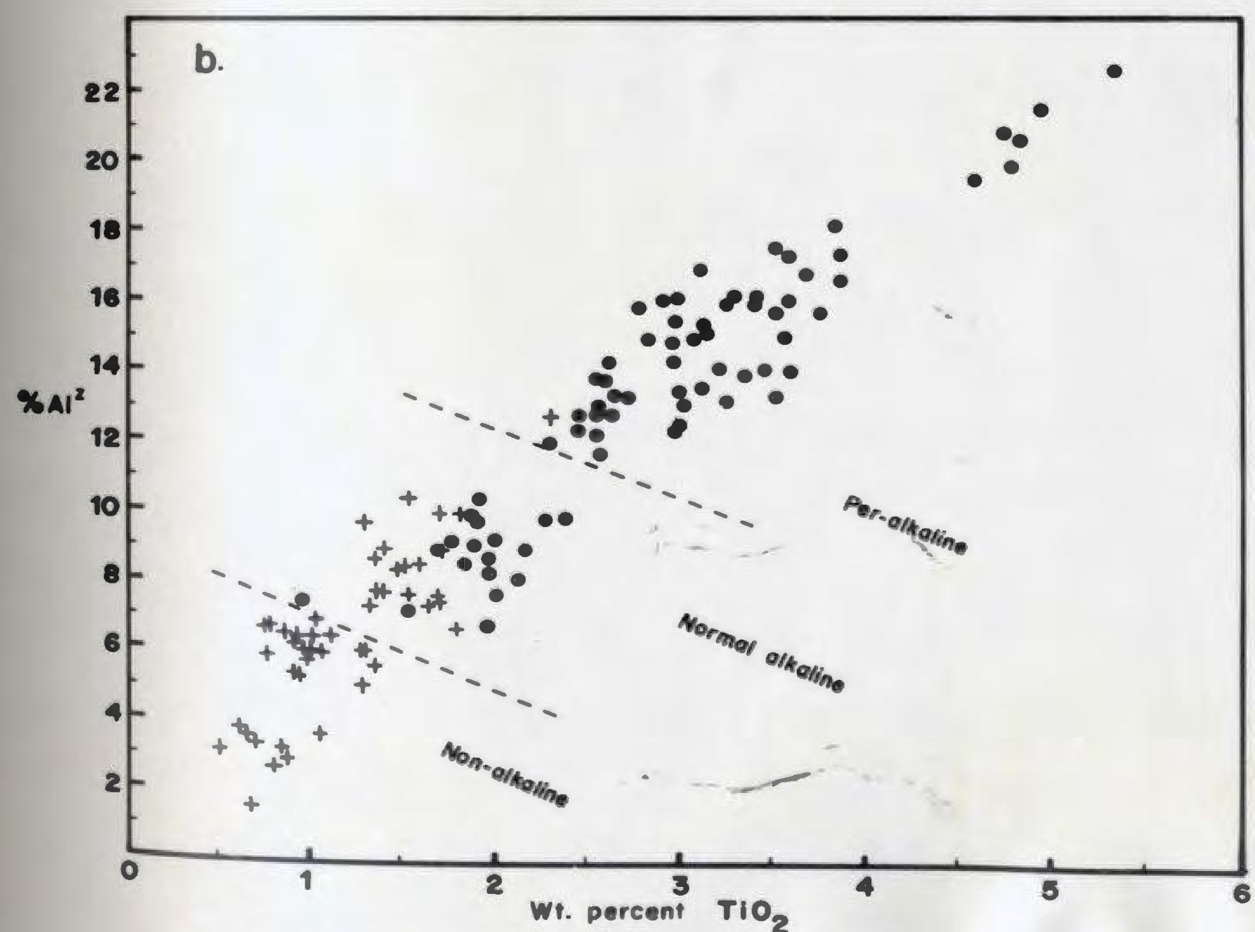
a. ● Trout River

O Little Port

b. ⊙ Chimney Cove

\+ Western Head


a.
%Al[z]
Per-alkaline
Normal alkaline
Non-alkaline
Wt. percent TiO_2


b.
%Al[z]
Per-alkaline
Normal alkaline
Non-alkaline
Wt. percent TiO_2

pH_2O) Barberi *et al.* (1971) point out that tholeiitic magmatic trends and tholeiitic clinopyroxenes (lower Ca, Ti, Al, high Mg, Si compared to alkali pyroxene) could evolve from a parental alkaline magma. Gibb (1973) concurred with Barberi *et al.* (1971) in that the fields designated by Le Bas (1962) (*e.g.* Figs. 14 and 15.) are of dubious use in depicting the nature of parental magma. However, Gibb (1973) emphasized that the salite-aegerine trend is typical of strongly alkaline mafic magmas (*e.g.* Shonkin Sag Laccolith, Fig. 7.) and that the trend is markedly different from the augite-ferroaugite trend (*e.g.* the Skaergaard thoeiitic trend, Fig. 7.). The trends observed by Barberi *et al.* (1971) may therefore be anomalous.

Groundmass clinopyroxene compositions from spilites of known tholeiitic or transitional affinity give Ti and Al proportions typical of those for alkali basalt magmas (Mevel and Velde, 1976). This phenomenon is attributed to differential cooling rates (and therefore rates of clinopyroxene crystallization) between pillow cores and rims. For this reason, only non-quench textured groundmass clinopyroxene compositions are included in this study.

Consideration of the above and the present results all suggest:

(1) All conclusions derived from clinopyroxene chemistry must be further supported by field constraints and whole rock immobile element petrochemistry.

(2) Clinopyroxenes constitute the only pristine igneous phase common to all of the rock suites under investigation. Studies of the minerals based on statistically valid numbers of analyses will shed light on the differences and similarities between the volcanic rocks from the various structural slices.

(3) Figure 7., trend 1a., suggests that the Trout River slice phenocrysts crystallized from a mildly alkaline magma. The Trout River and Chimney Cove slice groundmass clinopyroxene trends (Fig. 7. trends 1b., c.) indicate the increasingly alkaline nature of the magma with time. The Chimney Cove groundmass clinopyroxene crystallization trend, Figure 7., trend 1c., parallels the Hawaiian nephelinitic trend.

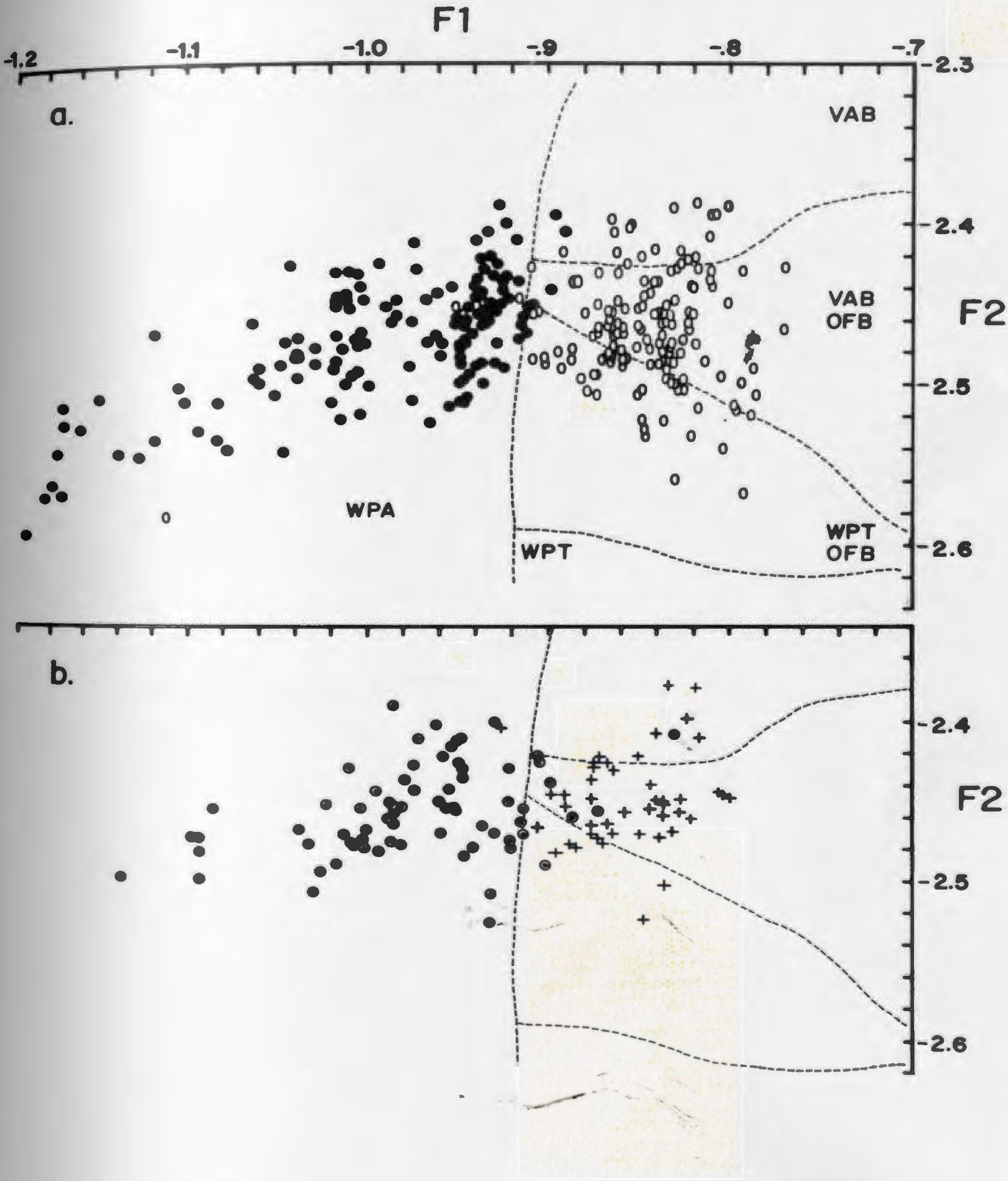
6.4 Statistical Treatment of the Groundmass Clinopyroxene Data and the Derivation of Some Magmatic-tectonic Settings

The discriminant function is a powerful tool of multivariate statistical analysis (see Appendix C.). Pearce and Cann (1971), and Pearce (1975, 1976) used the discriminant function extensively in distinguishing tectonic settings of fresh and altered basalts. Nisbet and Pearce (1977) applied the same technique of analysis to clinopyroxenes of different known tectonic settings in order to clearly separate them. Figure 16a., b. are rectangular plots with discriminant functions 'F1' and 'F2' derived from clinopyroxene major and minor elements (Nisbet and Pearce, 1977). The equations of the two discriminant functions, F1 and F2, are as follows:

$$F1 = -0.012SiO_2 - 0.0807TiO_2 + 0.0026Al_2O_3 - 0.0012FeO_{total} - 0.026MnO + 0.0087MgO - 0.0128CaO - 0.0419Na_2O$$

$$F2 = -0.0469SiO_2 - 0.0818TiO_2 - 0.0212Al_2O_3 - 0.0041FeO_{total} - 0.1435MnO - 0.0029MgO + 0.0085CaO + 0.0160Na_2O$$

In both F1 and F2, the absolute value of the coefficients indicates that TiO_2 is the strongest discriminator since it has the largest coefficient. Note the clear separation between the alkaline Trout River slice and tholeiitic Little Port (Fig. 16a.) and a similar


F1
-1.2
-1.1
-1.0
-.9
-.8
-.7
-2.3
a.
VAB
-2.4
VAB
OFB
F2
-2.5
WPA
WPT
WPT
OFB
-2.6
b.
-2.4
F2
-2.5
-2.6

configuration in Figure 16b., between the alkaline Chimney Cove and tholeiitic Western Head slice groundmass clinopyroxenes.

Two types of discriminant functions follow. First, if the Trout River and Little Port groundmass clinopyroxene analyses are treated as 'known' samples of much larger populations, then the clinopyroxenes from the other rock groups (*i.e.* Chimney Cove, Western Head, Old Man Cove, Beverley Head, Wallace Brook, and Gregory Island), may be 'classified' on the basis of a function that best separates the two known samples. The samples to be classified, are termed 'unknowns' and it is assumed that each unknown has an equal probability of belonging to one or the other 'known' groups.

Details of the discriminant function method and the statistical assumptions involved are given in Appendix C.

Figure 17. shows the relationship between the Trout River and Little Port clinopyroxenes (*i.e.* the knowns) and the various unknown suites which were classified according to a discriminant function using approximately normally distributed major oxides (CaO, FeO_{total}, and MnO, see also histograms; Fig. 6., and correlation matrix, Table 8.). Excellent separation is obtained on the known suites (Table 16.).

Table 16.

Summary of group membership of clinopyroxenes of known samples (see also Fig. 17.)

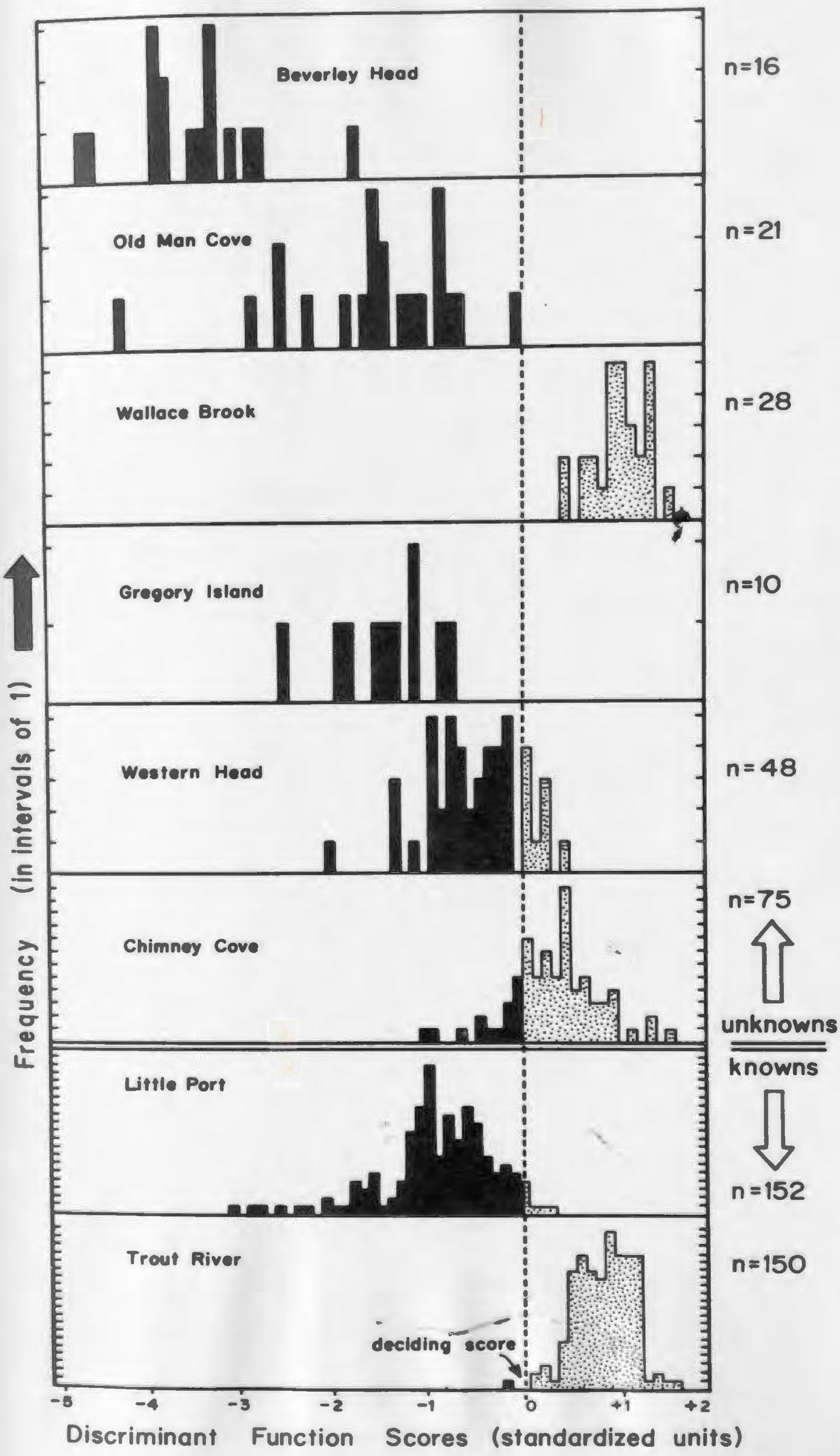
actual group	n of cases (*i.e.* analyses)	predicted group 1.	predicted group 2.	centroid (standardized)
1. Trout River	150	149 = 99.3%	1 = 0.7%	+ 0.879
2. Little Port	152	6 = 3.9%	146 = 96.1%	- 0.867

per cent of 'known' cases correctly classified = 97.7%

Figure 17. Histograms of discriminant function scores, using the groundmass clinopyroxene compositions (CaO, FeO_{total}, MnO) of this study

Trout River affinity (stipple)

Little Port affinity (black)


Beverley Head
n=16
Old Man Cove
n=21
Wallace Brook
n=28
Gregory Island
n=10
Western Head
n=48
Chimney Cove
n=75
unknowns
knowns
Little Port
n=152
Trout River
n=150
deciding score
Frequency (in intervals of 1)
-5
-4
-3
-2
-1
0
+1
+2
Discriminant Function Scores (standardized units)

Consider the histogram of discriminant scores for Trout River slice (Fig. 17.). The standarized centroid (mean) discriminant score is + 0.88. All those Trout River slice analyses whose discriminant score is between 0 and + 0.88, are assigned a probability of belonging to the Little Port slice assemblage. Those Trout River slice analyses with discriminant scores greater than + 0.88 are assigned probabilities of 1 (*i.e.* there is 0% probability that a given analysis has Little Port affinities, or conversely 100% probability that it does belong to the Trout River slice). The single Trout River slice analysis falling on the Little Port side of deciding score has only 18.6 per cent probability of having Trout River slice affinity based on CaO and FeO_{total} contents (N.B. all probabilities are approximate, depending on how closely the statistical assumptions outlined in Appendix C. are approached).

Chimney Cove and Wallace Brook clinopyroxenes have strong Trout River slice affinities, while all other 'unknown' groups can be assigned to the Little Port.

Significance of the discriminant function:

Dykes that cut the Old Man Cove and Beverley Head structural slices contain clinopyroxenes that are probably of Little Port and not Trout River slice affinity. This implies that the magmatism that occurred following the deformation of the Old Man Cove protolith was not alkaline or at least unrelated to the Skinner Cove Formation magmatism. Clinopyroxenes from dyke rocks of structural slices other than the Trout River and Chimney Cove slices are not alkaline, supporting the hypothesis that the Beverley Head slice and the dykes that cut the older Little Port gabbros are genetically unrelated to the Trout River and Chimney Cove slices. This conclusion is also supported by immobile trace elements from bulk rock studies.

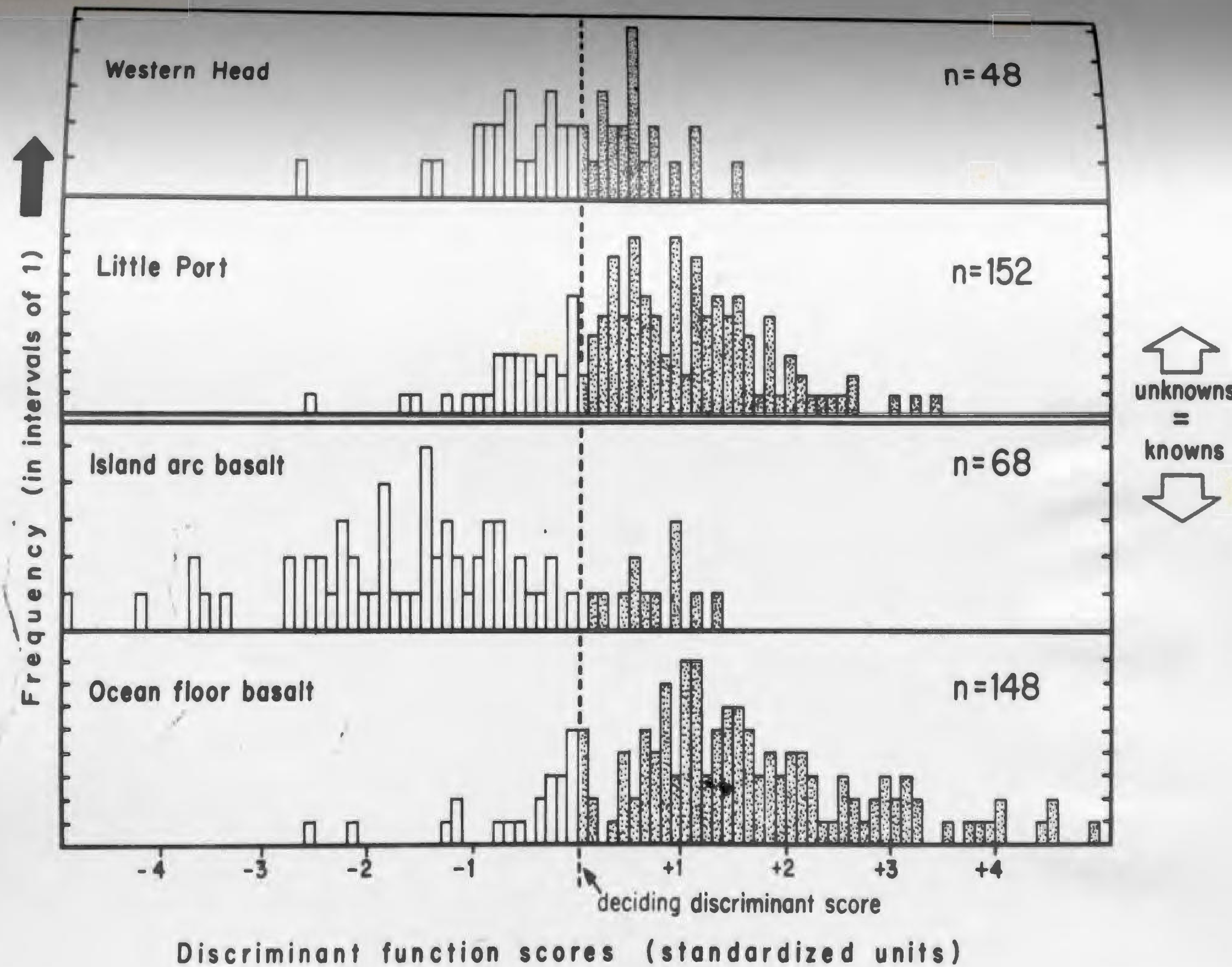
Clinopyroxenes from the Wallace Brook monzonitic intrusion (Plate 1.) have Trout River slice affinities. The discrimination also indicates that Skinner Cove Formation rocks are present in the internally imbricated Beverley Head structural slice (Plate 30.).

To digress for a moment, Figure 16a., b. shows a clustering of the Little Port and Western Head clinopyroxenes in the volcanic arc and ocean floor basalt field of Nisbet and Pearce (1977). The plot is less powerful than a single discriminant function between 2 unknowns since it attempts to separate four magmatic-tectonic settings (three of which show strong chemical similarities) using 2 functions.

Lithologies and relationships of the Little Port Complex to nearby rock groups suggests that it most likely evolved in an oceanic regime as (1) a volcanic arc (Williams, 1975) or (2) as oceanic crust (Karson and Dewey, 1978). The major, minor and trace element data (Chapter 6) and clinopyroxene data (Fig. 16.) define the Little Port dykes and lavas as possessing subalkaline magmatic affinities. There is no evidence to suggest that the Little Port and Western Head volcanic rocks erupted within continental plates, oceanic volcanoes (*i.e.* non-subduction related islands), or continental rifts. Therefore it is assumed that the volcanic rocks are either of ocean floor basalt or volcanic arc affinity. With this understanding, the second discriminant function is applied with volcanic arc and ocean floor basalt clinopyroxenes as 'knowns' and the Little Port and Western Head basalt clinopyroxenes as 'unknowns' (Fig. 18.). The Gregory Island clinopyroxenes were run through the same discriminant function, but a histogram is not shown. Table 17. shows the good

Figure 18. Histograms of discriminant function scores using the groundmass clinopyroxene compositions of this study and the data provided by Nisbet and Pearce (1977) (the function uses all oxides)

stipple indicates ocean floor basalt affinity of clinopyroxenes, as separated by the discriminant function


Western Head
n=48
Little Port
n=152
Island arc basalt
n=68
Ocean floor basalt
n=148
Frequency (in intervals of 1)
unknowns
=
knowns
-4
-3
-2
-1
+1
+2
+3
+4
deciding discriminant score
Discriminant function scores (standardized units)

separation between the known groups using SiO_2, TiO_2, Al_2O_3, FeO_{total}, MnO, MgO, CaO, and Na_2O as the variables. A summary of the group membership is presented in Table 17.

Table 17.

Summary of group membership of clinopyroxenes from known tectonic settings (see also Fig. 18.)

actual group	n of cases (*i.e.* analyses)	predicted group 1.	predicted group 2.	centroid (standardized)
1. ocean floor	147	126 = 85.7%	21 = 14.3%	+ 0.448
2. volcanic arc	68	12 = 17.6%	56 = 82.4%	- 0.967

per cent of 'known' cases correctly classified = 84.7%

The following features are seen in Figure 18.:

(1) The Little Port clinopyroxenes show strong ocean floor basalt affinities.

(2) Western Head clinopyroxene tectonic affinites are inconclusive and they may be derived from either tectonic setting based on the discriminant function alone.

(3) Although not shown in Figure 18., 9 of 10 electron microprobe analyses on Gregory Island groundmass clinopyroxenes have strong volcanic arc affinities based on the same discriminant function as above.

6.5 Summary of Magmatic-tectonic Affinities Based on Geochemistry

The Chimney Cove slice mafic volcanic rocks are closely related to those of the Trout River slice (*i.e.* the type area of the Skinner Cove Formation). Both slices show moderately alkaline trace element trends. The groundmass clinopyroxenes of the slices are similar in chemistry and plot in the alkaline fields of Le Bas (1962) and Nisbet and Pearce (1977).

The Western Head lavas, Little Port Complex dykes and lavas, Old Man Cove and Beverley Head dykes, and the Gregory Island lavas are non-alkaline in magmatic affinity (*i.e.* low Nb/Y, TiO_2, P_2O_5 as compared to the Skinner Cove Formation). Evidence from comparisons with the Bay of Islands Complex dykes and upper volcanic rocks, coupled with clinopyroxene chemistry supports a subalkaline, probably tholeiitic (*i.e.* ocean floor) affinity for the sampled Little Port lavas and dykes and possibly the Western Head lavas.

CHAPTER 7

DISCUSSION OF TECTONIC SETTINGS FOR THE SKINNER COVE FORMATION AND THE LITTLE PORT COMPLEX

7.1 Introduction

If the geology of the Skinner Cove Formation and Little Port Complex is to be of more than just local significance, it is essential that it be compared and contrasted with both recent and ancient occurrences of similar rock types. The following is a list of all known possible occurrences of alkaline rocks which could be compared to the Skinner Cove Formation (*i.e.* Trout River and Chimney Cove slices).

(1) Oceanic alkaline (*e.g.* Tahiti, McBirney and Aoki, 1968; Gough Island, Le Maitre, 1962), seamount alkaline (*e.g.* Newfoundland Seamounts, Sullivan and Keen, 1977).

(2) Continental rift or graben (*e.g.* Rhine Graben, East African rift, Midland Valley of Scotland)

(3) Continental alkaline (*e.g.* Yellowstone Park shoshonites of Joplin, 1968), volcanic arc alkaline (*e.g.* Papua, New Guinea; again the shoshonite association of Joplin, 1968), volcanic arc alkaline (*e.g.* Japanese alkaline series, Yagi, 1959... shoshonite ?).

(4) Oceanic island alkaline situated above an hypothesized mantle hot spot (*e.g.* Hawaii, MacDonald, 1968)

The possible tectonic settings for the formation of the Little Port Complex (including the Western Head structural slice) are:

(1) oceanic crust

(2) volcanic arc terrane

(3) a combination of (1) and (2)

(4) subalkaline pedestal to an oceanic island situated above an hypothesized mantle hot spot (*e.g.* Hawaii)

7.2 A Review of the Geology of Recent and Ancient Oceanic Islands and Seamounts

Oceanic islands and seamounts occur in chains, individually on normal oceanic crust, or along extensions of transform faults (*i.e.* fracture zones). Fracture zones probably enable the extraction of alkaline magmas along zones of relatively low pressure. Volcanoes and volcanic chains on normal oceanic crust are attributed by some to hot mantle plumes (*e.g.* the Emperor Seamount chain, Hawaii) or possible combinations of plumes and tectonic control (*e.g.* Rio Grande Rise, Fodor *et al.*, 1977).

McBirney and Gass (1967) demonstrated that there are systematic chemical variations in ocean island lavas of the same age, with distance from the spreading ridge. They also showed that extreme differentiation products of islands tend to be siliceous (peralkaline in some places, *e.g.* Bouvetøya, Imsland *et al.*, 1977) near the crests of active spreading ridges. Schminke (1973) suggests that igneous processes (*e.g.* differentiation) and biased sampling, rather than distance from the spreading ridge account for the observed trends of McBirney and Gass (1967). It is evident, however, that some oceanic islands and presumably seamounts that erupt on or adjacent to a spreading ridge, are of tholeiitic affinity (*e.g.* Bouvetøya, Imsland *et al.*, 1977 ; Easter Island, Baker *et al.*, 1974). It is equally apparent that many oceanic islands with tholeiitic pedestals may be the result of mantle plume activity (Imsland *et al.*, 1977). Galapagos and Iceland tholeiitic volcanism may also be related to mantle plume activity (Schilling *et al.*, 1976). It must also be noted that Iceland contains some alkaline basalts in close association with the more voluminous tholeiites (Jakobsson, 1972).

If the Skinner Cove Formation is the result of oceanic island volcanism, Gough Island (Le Maitre, 1962) would appear most analogous to local lithologies and mineral compositions. The lavas of Gough Island are notably potassic (in fact, K_2O/Na_2O ratios and total alkalis are equal to, if not greater than those of the supposedly highly potassic shoshonite association; see section 7.3.2), and only mildly undersaturated. Strong (1974) mentioned that most of the Skinner Cove lavas are mildly undersaturated (slightly nepheline normative) and therefore, in conjunction with alkaline trends on standard variation diagrams, of alkaline magmatic affinity. Strong's norms are uncorrected and therefore the nepheline normative contents directly reflect ~~the~~ alteration chemistry. The original Skinner Cove igneous rocks may or may not have been nepheline normative. Therefore the writer is unable to compare the slightly undersaturated nature of the Gough Island basalts (Le Maitre, 1962) to the unrecalculated norms of the Skinner Cove altered suite (Strong, 1974, Table 2.). An extensive literature survey did not reveal occurrences of ocean island rocks incorporated in ancient or recent obduction/subduction related events (seamounts have been recognized). Some oceanic islands have been beveled by sea action, others have fringing coral reefs (atolls). Similarly, the Skinner Cove rocks must have been in a relatively shallow marine environment because of the presence of limestone (deposition was at least above the carbonate compensation depth).

Seamounts are known to contain alkalic basic volcanic rocks (*e.g.*

Engel and Chase, 1965; Engle and Engel, 1966 for the Pacific Ocean, and Aumento, 1968 for the Atlantic Ocean). Rocks with definite tholeiitic affinities are located on the crest of the Mid-Atlantic ridge (Minia seamount; Hekinian and Aumento, 1973) and near the crest of the Juan de Fuca ridge (Heck and Heckle seamount chains; Barr, 1974). In a study of seamount volume, composition and age, Batiza (1977) suggests that individual seamounts sequentially erupt tholeiitic, alkali basalt and alkaline differentiated lavas with increasing distance from a spreading ridge. He also states that volcanism on isolated seamounts at relatively large distances from the ridge crest is alkaline, regardless of where the seamount originated. Thus, if the Skinner Cove Formation originated as a seamount near the main spreading ridge, the differentiated rocks (*e.g.* Red Fire Brook Member trachyte) may have formed about 10 m.y. after initial tholeiitic eruption at the ridge (assuming present-day sea floor spreading rates during the Ordovician). However, mafic lavas with tholeiitic affinities are not found within the Skinner Cove slice assemblage; but this could be the result of structural omission.

Dredge hauls containing differentiated alkaline rocks are not uncommon, yet the presence of mafic alkaline rocks is much more common and may be a function of the relative proportions of the lavas present. Some known occurrences of trachyte-bearing seamounts that are invariably associated with alkali and transitional basalts are listed in Table 18. below. The occurrence of trachyte and alkali basalt outlined by Forbes and Hoskin (1969) is of particular interest since the seamount is located in the active Aleutian trench.

Table 18.

Occurrences of trachyte-bearing seamounts

lithology	associated lithologies	tectonic setting	reference
sparsely biotite, plagioclase-phyric trachyte	alkali basalt tholeiite	located on volcanoes set on a major lineament (fracture) which strikes through the Hawaiian chain	Engel and Engel (1966), S.E of Hawaii
aegerine-augite trachyte	alkali basalt	located in the Aleutian trench; the northernmost seamount of Kodiak-Bowie seamount chain	Forbes and Hoskin (1969), Kodiak seamount, Pacific Ocean
trachyte/mugearite	alkali basalt	southern seamount of the Kodiak-Bowie seamount chain	Herzer (1971) Bowie seamount, Pacific Ocean
plag-pyroxene - titanomagnetite-phyric sodic trachyte	alkali basalt	possible seamount chain related to a leaky transform? fracture zone? hot spot?	Sullivan and Keen (1977), near Newfoundland, Atlantic Ocean

Ancient examples of seamounts associated with allochthonous terranes:

A. The Pomo Beds seamount, Northwestern California

J.O. Berkland (1972*a*) has interpreted the rocks of Pomo Beds as representing the stratigraphy of an ancient seamount. The seamount began its early development near the present Hawaiian Islands, migrated eastward, and was eventually caught in the Franciscan paleotrench about 60 to 65 m.y. ago.

West of the Great Valley Sequence (about 30 km) and isolated within the Franciscan terrane is the Middle Mountain sequence which is a fault-bounded outlier of distinctly non-Franciscan rocks

(Berkland , 1972*a*, *b*). The Middle Mountain sequence is interpreted as continental terrace sediments deposited throughout the Cretaceous.

The Pomo beds sedimentary and volcanic rocks dip homoclinally to the east beneath the western margin of the Middle Mountain sequence for a strike length of 32 km. The base and top of the 1.2 km-thick Pomo Beds is not seen. The lowest exposed rocks consist of mafic pillow lavas and feeder dykes which are in fault contact with rocks of the Franciscan mélange (J. O. Berkland, written communication, 1976). Rocks of the Pomo beds form exotic lithologies within the Franciscan mélange. K/Ar dates on the Pomo beds give a date of 120 m.y.

A basalt sample was kindly provided by Berkland. The clinopyroxenes are relic $Ca_{44.4}$ $Mg_{37.1}$ $Fe_{18.5}$. Most plagioclase is cloudy and pitted albite(optical determinations). Accessory opaque minerals are granular and anhedral. A rock analysis (Berkland, 1972*b*) and the mean of eight clinopyroxenes analyses (electron microprobe determinations, Appendix B. for raw data) from the same rock are presented in Table 19. below.

Table 19.

Basalt and mean clinopyroxene compositions from the Pomo Beds (Seamount), California

	whole rock (wt. per cent)	clinopyroxene (standard deviations in brackets, n = 8)	
SiO_2	48.2	46.91	(2.15)
TiO_2	2.8	2.62	(1.18)
Al_2O_3	17.4	5.22	(1.61)
FeO_{total}	12.0	10.48	(0.87)
MnO	0.2	0.23	(0.07)
MgO	6.2	12.05	(0.53)
CaO	6.1	20.07	(0.61)
Na_2O	4.3	0.56	(0.02)

Table 19. (continued)

P_2O_5	0.5	n.d
Rb-13, Sr-210, Y-35, Zr-217		$\bar{x}$ $Ca_{44.5}$ $Mg_{34.1}$ $Fe_{18.5}$
Nb-31 (trace elements in ppm)		
n.d. not determined		

Optical observations suggest and microprobe determinations confirm the calcic and titaniferous nature of the Pomo basaltic clinopyroxenes.

Trace element data indicate that the rocks are transitional in character with alkaline tendencies. The basalts are probably representative of a seamount, or a continental volcano erupting away from plate boundaries (J. R. Cann, written communication to J. O. Berkland, 1972).

The stratigraphy consists of pillow lavas, radiolarian chert (dated at 140 to 125 m.y.), more pillow lavas (120 m.y.) followed upward by an unconformity which indicates subaerial exposure and erosion of the basalts. Later submergence provided a basal unconformable contact between the lower basalts and a basal basalt pebble conglomerate accompanied by Maestrichtian neritic sandstones (65 to 68 m.y.) (J. O. Berkland, written communication, 1976).

B. The Oman Mountains

The Oman Mountains constitute an Upper Paleozoic to Mesozoic allochthonous sequence, which has a similar structural style and contains similar lithologies as the Humber Arm Allochthon. A summary of the events leading to the emplacement of the Oman allochthon and the evolution of rocks that may be analagous to the Skinner Cove Formation will be described.

Before the Mid-Permain (Glennie *et al.*, 1973) or in the Triassic

(Stöcklin, 1974), that region of Iran southeast of the present-day Main Zagros Thrust was a continental platform on the Arabian plate. Rifting of the continental crust (and possible formation of alkaline rocks) and creation of Neo-Tethys spreading ridge was followed by the northeastward growth of the Arabian-Zagros continental margin, comprising a carbonate shelf, slope, rise and distal facies equivalents. Mafic and felsic volcanic lithologies are interbedded with pelagic chert, limestone, etc. of the Halfa, Haliw and Al Aridh Formations of the Hawasina Allochthon. Sheared volcanic rocks are associated with the shallow water limestones of the Oman Exotics; the structurally highest and farthest travelled rocks of the allochthon. These volcanic lithologies are tentatively interpreted as mid-ocean (fracture zone ?) seamounts (Glennie *et al.*, 1973).

The Afro-Arabian plate motion changed in the Late Cretaceous and the Neo-Tethys was progressively destroyed. The Arabian continental margin was driven toward and eventually into the Iran plate. Emplacement of the Hawasina allochthonous slices and the structurally overlying Semail Nappe (ophiolite) onto the Oman autochthon occurred in the Campanian-Maestrichtian time.

The alkaline lavas (seamounts or rift facies) include coarse labradorite porphyrite dykes and lavas, augite-hornblende porphyrite, titanaugite picrite (with clinopyroxene containing 4.5 per cent TiO_2), spilite and trachyte. These lithologies form an evolved alkaline suite comparable to the Skinner Cove Formation. Reinhardt (1974) attributes the spilitic alteration features to a primary spilite magma generated from the Semail Nappe ultramafic rocks. In contrast, alteration in the Skinner Cove Formation (*i.e.* Trout River slice) is accounted for by low-grade (burial ?) metamorphic effects.

C. Cape Onion Formation, Hare Bay Allochthon, Newfoundland

The stratigraphic and structural relationships of the Cambro-Ordovician Hare Bay Allochthon (Fig. 3.) are given by Williams (1975). Generally, the structural relationships and overall sequence of lithologies bears strong similarities to the Humber Arm Allochthon to the south. Smyth (1973) suggests that rocks of a lower allochthonous structural slice, the Maiden Point Formation, were deposited at the ancient continental margin. The White Hills Peridotite of the St. Anthony Complex is directly analagous to the Bay of Islands Complex.

The Cape Onion Formation is a predominantly igneous structural slice, which may be genetically related to the structurally higher St. Anthony Complex (DeLong, 1976). The Cape Onion Formation consists of altered, variolitic mafic pillow lavas, mafic feeder dykes, and minor gabbro, which are alkaline in magmatic affinity. Jamieson (1977) presents evidence suggesting that alkalic gabbros (*i.e.* the Partridge Point gabbro), which occur as intrusions in the upper Maiden Point Formation, the Cape Onion Formation, and the Ireland Point Volcanics (a lower formation of the St. Anthony Complex), are genetically linked. Presently these rock units are structurally separated. The alkalic Partridge Point gabbro and the volcanics of the Cape Onion slice are presumably coeval, having formed close to the continental margin. The gabbros intruded continental margin sediments before the Ordovician structural stacking took place, thereby implying the construction of seamounts near the continental margin.

The Cape Onion Formation volcanics are similar to the Skinner

Cove Formation in the following respects:

(1) the two formations occur as slices in approximately the same structural positions (*i.e.* structurally above continental margin sediments and beneath an ophiolite sequence).

(2) Both rock units are moderately alkaline in affinity (some Hare Bay lavas contain feldspathoid (nepheline), R. Jamieson, pers. communication, 1977).

(3) Skinner Cove and Cape Onion Formation lavas are distinct from layers 2 and 3 of the typical ophiolite suite.

The two formations differ in the following respects:

(1) The Skinner Cove Formation is a differentiated mafic to felsic suite, whereas the Cape Onion rocks are less differentiated with lower FeO_{total}/MgO ratios (Jamieson, 1977, Fig. 4., p. 351). Mafic rocks of the Skinner Cove Formation are richer in TiO_2 and P_2O_5.

(2) Unlike the Cape Onion rocks, this study has not found igneous/metamorphic rocks in other structural slices that are chemically similar to the Skinner Cove Formation.

(3) The Skinner Cove Formation does not contain primary hydrous minerals (*i.e.* biotite, hornblende) as does the Cape Onion Formation.

(4) Pyroclastic, epiclastic and carbonate rocks are prevalent in the Skinner Cove Formation, while the Cape Onion consists of deeper water pillow lava, pillow breccia and graptolitic black shales.

D. Upper Pillow Lavas of the Troodos ophiolite Complex, Cyprus

The Troodos massif of Cyprus is perhaps the first described group of rocks defined as ophiolite (with the interpretation of oceanic lithosphere) (Moores and Vine, 1971). It contains the typical ophiolite stratigraphy, however, the normal pillow lava and sheeted dyke sequence is unconformably overlain by one other succession of pillow lavas; the Upper Pillow Lavas.

The Lower Pillow Lavas are associated with the spreading ridge activity and are the extrusive equivalent of the sheeted dyke series. The origin of the Upper Pillow Lavas is problematical.

The Upper Pillows consist of mildly undersaturated, olivine and pyroxene-phyric basalts (limburgite and picrite) (Gass and Smewing, 1973). Some basalts contain hypersthene phenocrysts that are normally considered atypical of alkaline basalts (Pearce, 1975). The rocks are metamorphosed to the zeolite facies.

Gass and Smewing (1973) suggest the Upper Pillows formed in an 'off-axis' environment (yet close to the ridge crest) in a setting similar to seamounts, or possibly along a transform fault (Moores and Vine, 1971). Pearce (1975) suggests on the basis of immobile trace elements that the Upper Pillows represent primitive low potassium volcanic arc tholeiites. Smewing *et al.* (1975) and Smewing and Potts (1976) support their contention that the Upper Lavas developed in an off-axis environment.

The Upper Pillow Lavas differ from the Skinner Cove Formation in that they are entirely basaltic (*i.e.* mafic) and primitive in composition. The Upper Pillows occur unconformably above the ophiolite lavas, whereas the Skinner Cove Formation differentiated sequence occurs as a discrete structural slice beneath the Bay of Islands Complex (ophiolite). Strong (1974) has drawn an analogy between the formation of the Skinner Cove Formation and the 'off-axis' (?) Upper Pillow Lavas.

Such a direct analogy must be considered with caution because transitional or alkaline basic lavas are nowhere found structurally or stratigraphically above the Bay of Islands Complex.

E. Other volcanic rocks interpreted as seamounts

Thick sequences (10 to 15 km) of tholeiitic and minor alkaline lavas of the Olympic Peninsula (Washington) are tentatively interpreted as seamounts above oceanic floor (Cady, 1975).

DeRoever (1942) has described a varied suite of alkaline rocks in the Permian allochthonous sequence of Timor. The suite includes alkaline basalt, trachybasalt and alkali trachyte.

The dormant Yap arc-trench system of the southwestern Pacific Ocean is a link between the active Mariana and Philippine volcanic arcs. The Yap Island system contains mostly deformed mafic and ultramafic rocks (greenschists) with minor marble and limestone-silicate rocks (Shiraki, 1971). The trench wall east of Yap contains amphibolite facies metabasites and metasediments, which are overlain by penetratively deformed Yap ultramafic schists. Hawkins and Batiza (1977) suggest that Yap Island comprises ophiolitic rocks which have been obducted above a volcanic arc. They further propose that the P_2O_5 and TiO_2 rich basalts of the Yap trench are alkaline in affinity and probably represent seamount volcanism. Westerly subduction of the Pacific plate during the Tertiary led to the formation of volcanic arc rocks. Subsequently, subduction ceased when 'un-subductable' seamounts or volcanic islands on the Pacific plate blocked the trench (a similar situation exists today with the Kodiak-Bowie seamounts being subducted beneath the Aleutian arc). Oceanic crust was then thrust above the volcanic arc from a spreading ridge to the west (Hawkins and Batiza, 1977). It is important to note that there is no evidence of an accretionary prism or mélange in the Yap trench.

Malpas *et al.* (1973) and Malpas (1976) state that the amphibolitic rocks of their Little Port 'island arc' are analgous to the Yap amphibolites. However, island arc volcanic rocks are nowhere exposed *in situ* on Yap (*i.e.* they are present only in breccias). Therefore the Little Port island arc analogy with Yap is suspect.

7.3 A Review of Continental Rift Magmatism and Volcanic Arc Alkaline Magmatism

Continental magmatism can be separated into two tectonic groups. The most widely distributed setting is that of continental rifting (*e.g.* East African Rift system, the Rhine-Oslo Rift system). Joplin (1968) considers the high potassium alkaline rift valley volcanic rocks to belong with her "shoshonite association." The present writer uses the term shoshonite (although he feels it should be abandoned) to describe subduction-related magmatism associated with volcanic arcs and stable continental crust; but not associated with continental rifting or oceanic islands.

7.3.1 Continental rift magmatism

Continental rifts are broken crests of crustal arches (Bailey, 1974). If the resultant rift successfully fractures a continent, an oceanic spreading ridge will be created. Furthermore, if oceanic crust is newly created, it must elsewhere be destroyed and ultimately result in subduction-related processes.

Scrutton (1973) proposes the following scheme for the timing of continental break-up:

(1) arching of a continental area with precursory igneous activity

(2) rifting and onset of more continuous igneous activity; first marine incursions

(3) igneous activity reaches a peak

(4) at or soon after this peak, break-up occurs

(5) fully marine conditions are established

(6) igneous activity on the continents decreases as an active mid-ocean ridge develops

The type of magmatism in the region of the Afro-Arabian Dome is related in space and time to the evolutionary stage of the dome. Immediately preceeding and during regional vertical uplift, alkali basalt eruption is aerially extensive. With further crustal attenuation, transalkaline basic lavas and peralkaline silicic differentiates erupt along the downfaulted axial crest of the dome; alkali basalts erupt symmetrically off the crest axis. Igneous activity reaches a peak and finally, low potassium tholeiites (of oceanic type) develop (*e.g.* Red Sea).

If the Skinner Cove Formation is considered to have erupted during Late Precambrian to Cambrian rifting of Grenvillian crystalline basement, one might expect evidence of subaerial eruption, peralkaline igneous activity, and siliciclastic sedimentation. Church suggests (W. R. Church, written communication with D. F. Strong: in Malpas, 1976, p. 51) that peralkaline rocks in the Skinner Cove Formation may indicate that the magmatism occurred during the Early Paleozoic continental rifting. However, since the alkalis have been redistributed in the Skinner Cove rocks (see section 6.1) and peralkaline mineralogy is not observed, it would be difficult to determine whether the rocks are peralkalic. Furthermore, peralkaline rocks are not only restricted to rift systems; Bouvetøya Island, which is located on ocean floor rocks, also contains rocks of peralkaline affinity (Imsland *et al.*, 1977).

7.3.1.1 Ancient examples of continental rift magmatism

Abortive and/or dormant rift systems are preserved in the geologic record (*e.g.* Midland Valley of Scotland, etc.), as are the failed arms of triple junctions. Dormant and abortive rifts contain alkaline and highly undersaturated alkaline igneous rocks.

A. Evidence of continental rifting in Brazil

Campos *et al.* (1974) give a tectono-stratigraphic summary of the break-up of South America and Africa and the evolution of the Brazilian continental margin. Campos *et al.* (1974, Fig. 5.) illustrate that at the peak of rifting igneous activity, thick (1500 m plus) aerially extensive tholeiitic flood basalts were the predominant rock type. It is important that old alkaline rocks associated with the rifting are not evident. Minor alkaline volcanism was consanguinous with the flood basalts, but most of the alkaline activity followed the continental break-up. It would appear then, that voluminous tholeiitic lavas herald the successful break-up of continents.

B. Late Precambrian continental rifting of eastern North America

Late Precambrian rift facies tholeiitic dykes (Long Range dykes) and coeval plateau lavas (Lighthouse Cove Formation) are described by Strong and Williams (1972) and Strong (1975). The dykes cut the deformed Grenvillian crystalline basement of west Newfoundland.

Figure 19. Pyroxene quadrilateral showing the crystallization trends from this study compared to the trend of the Lighthouse Cove Formation (rift facies tholeiites) (after Strong, 1975)

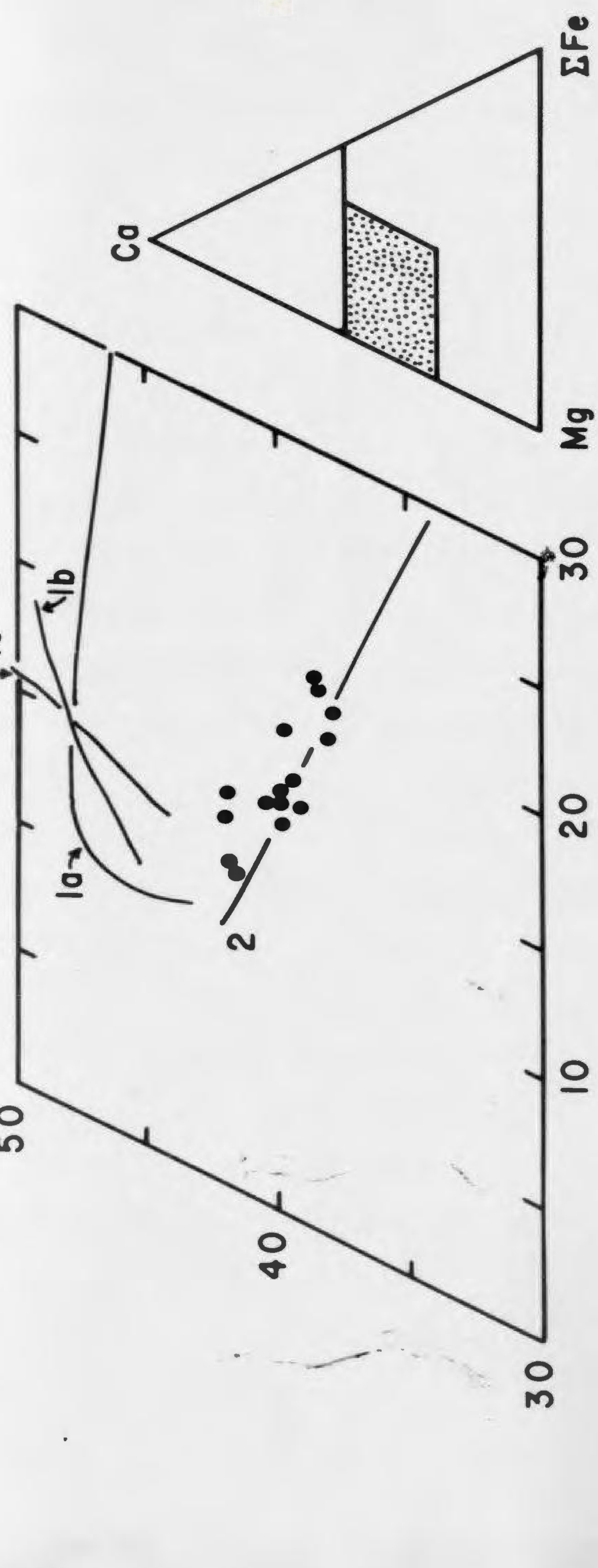
- ● Groundmass clinopyroxene compositions from the Lighthouse Cove Formation (electron microprobe analyses from Strong, 1975)

1a. Clinopyroxene phenocryst trend (Trout River slice)

b. Groundmass clinopyroxene trend (Trout River slice)

c. Groundmass clinopyroxene trend (Chimney Cove slice)

2. trend of the clinopyroxenes from the Skaergaard Intrusion


Ca
Mg
ΣFe
Ia
Ib
Ic
2
50
40
30
10
20
30

They are correlated with the Catoctin bimodal igneous suite of the Southern Appalachians. The dykes are believed to indicate the final stages of continental rifting and break-up and the incipient development of the Iapetus Ocean (Strong and Williams, 1972; Williams and Stevens, 1974). Obviously, the opening and closing of the Iapetus Ocean bears directly on the problem of the genesis of the Skinner Cove Formation and the Little Port Complex.

Several generations of tholeiitic dykes have been found (Strong, 1975), possibly attesting to the periodicity of magma generation along the rift. Clinopyroxene compositions and trace element studies show that the dykes and lavas are decidedly tholeiitic in magmatic affinity. In Figure 19. the alkaline clinopyroxenes of the Trout River and Chimney Cove slices are compared with those analysed from the rift facies dykes and lavas. None of the generations of dykes has been found to be alkalic in magmatic affinity, thus suggesting that the Skinner Cove rocks could not be the extrusive transported equivalent of the dykes presently exposed cutting the Grenvillian inliers. (The writer suggests that it would be most interesting to study the variation in chemistry of the various dyke generations across their strike in the Great Northern Peninsula (Fig. 1a.). Does their chemistry (or mineral chemistry) become increasingly alkaline toward the west? Are there generations of tholeiitic, transitional or alkaline dykes ?). As for A. above, voluminous outpouring of tholeiitic lava points to the successful break-up of a continent.

C. Alkaline volcanism associated with the allochthonous terrane of the Alpine Mountain chain

(1) The Agrilia Formation and Sperkhios Complex, Greece

Stratigraphic, chemical and tectonic relationships of the Othris Mountains have recent been clarified by Hynes (1972), Hynes *et al.* (1972), Smith *et al.* (1975) and Hynes (1974).

The Othris Group consists of deformed Permian basement, undeformed continental margin coarse conglomerates, sandstones, carbonates and a distinctive differentiated volcanic sequence (the Agrilia Formation and Sperkhios Complex). The Minia Group is an ophiolite suite. These rocks are now assembled as structural slices in much the same manner as the Oman allochthon and the Humber Arm Allochthon (*i.e.* continental margin clastics at the structural base, an ophiolite suite at the structural top).

The Agrilla Formation is a Lower Mesozoic igneous suite containing cumulo-phyric picrites (70 per cent modal olivine in some samples), ophitic dolerites, mafic pillow lava and interbedded siliceous sediments. The Sperkhios Complex (used by Hynes, 1972, but not formally defined by Smith *et al.*, 1974) contains altered, amygdaloidal porphyritic basalt (rich in titanaugite), and alkali feldspar-phyric trachyte. Hynes (1972, pp. 110, 111) states: "the abundance of olivine, the presence of titaniferous augite, the existance of trachytes all suggest that the (Sperkhios) complex is undersaturated with silica."

Unpublished data of A. Hynes and E. Nisbet suggest a calc-alkaline to oceanic affinity for the Agrilia Formation igneous rocks (in Smith *et al.*, 1974). E. Nisbet suggests that the crustal splitting could have been caused by the initiation of a marginal ocean basin behind a nearby subducting plate. In contrast, Hynes (1972, 1974) suggests the data indicate major continental splitting precisely analagous to the events that led to the formation of the present-day Red Sea.

(2) The Mamonia Complex, southwest Cyprus

The transported structural slices of Cyprus are comparable in rock types and age to the rocks in Greece (*i.e.* in (1), above). The Mamonia Nappes that constitute the Mamonia Complex are transitional between competent structural slices and tectonic mélange (Robertson and Hudson, 1974). Lapierre and Rocci (1976) recognize three main volcanic sequences from the base to the top of the Mamonia Complex. First, fine- to coarse-grained clastic sediments probably represent formation of grabens and the erosion of adjacent siliceous basement horsts. This activity is followed by the extrusion of basalts and andesite lava flows interbedded first with Halobia limestone, then siliceous and calcareous pelagic sediments. The top of the sequence contains columnar jointed trachyte flows.

The Mamonia Nappes contain coarse quartzites, interbedded plant fossils and polydeformed amphibolitic gneisses; thus providing and undisputed continental origin for the detritus (Robertson and Hudson, 1974).

Lapierre and Rocci (1976) make a direct analogy between the present Afar rift facies volcanism and the nature of the Mamonia Nappes prior to their transport.

(3) Other similar mafic and differentiated alkaline suites associated with ophiolite, continental sediments, and platform carbonates are listed in Table 20., below.

Table 20.

Location, lithology and origin of some alkaline rocks in transported sequences and associated with continental sediments

location	name	alkaline rocks	origin	source
Turkey	Antalya Nappes Calbai Dag massif	high TiO_2, K_2O ankaramite, picrite, porphyritic basalt	rift	Juteau (1974)
Syria	Baër-Bassit Nappes, Hatay	ankaramite, high TiO_2 alkali basalt, trachyte, trachybasalt	rift	Parrot (1977)
Oman	Hawasina Allochthon	high TiO_2 alkali basalt, titan-augite picrite, trachyte	seamount ? rift ?	Glennie *et al.* (1974)

Significance of the rift facies alkaline rocks of the Alpine Mountain Chain:

In none of the above regions is there a tholeiitic basalt rift facies sequence recognized, which is peculiar because voluminous tholeiitic basalts generally preceed successful continental rifting (*e.g.* Brazil, eastern North America; see section 7.3.1.1). The alkalinity and mildly undersaturated nature of the rocks (based on corrected bulk rock and clinopyroxene norms), combined with coarse-grained continental sediments, and fossils, allows the various authors to directly interpret their rocks as alkalic continental rift facies. Perhaps the most important influence on this common 'rift facies' interpretation is that rocks of similar age and lithology crop out along the entire length of the thrust belt from the Italian Alps to Oman (about 4,000 km). Hynes, Nisbet, Lapierre, Rocci and Parrot do not mention the possible occurrence of volcanic arc alkaline or oceanic island rocks. However, some 'oceanic' islands are sited on continental margin silicic sediments and possibly deformed crystalline basement (*e.g.* Comores Archipelago; Strong, 1972). If, for some reason the Comores were thrust onto a continental margin and good sections were later exposed, one would undoubtedly see alkalic dykes, flows and sills cutting the silicic continental basement. The volcanics could easily be misinterpreted as comprising a 'rift facies' sequence associated with clastic continental sediments.

The above discussion shows that rock suites of similar character to the Skinner Cove Formation occur as allochthonous slices associated with, and always structurally beneath the ophiolite suite.

7.3.2 Volcanic arc alkaline magmatism (shoshonite)

Potassic alkaline magmas associated with high potassium calc-alkaline rocks are described in Papua New Guinea (Mackenzie and Chappell, 1972; Jaques, 1976) and the Mediterranean region (Ninkovitch and Hayes, 1972). Cenozoic high potassium alkaline rocks of Japan (Yagi, 1953, 1959) may be related to subduction, or to Miocene continental rifting. These volcanoes are located in volcanic arcs built upon sialic continental crust above a deep, partially melted subducting plate. Jakeš and Gill (1970), and Jakeš (1973) suggest that island arcs are characterized by gradational, lateral and vertical magma types; proceeding away from the trench, one recognizes volcanic arc tholeiite, calc-alkaline rocks and finally shoshonites in the most mature arcs. Ancient occurrences of shoshonite in transported terranes or elsewhere, have not been recognized.

If the Little Port Complex is interpreted as a volcanic arc suite, then the Skinner Cove Formation could conceivably be interpreted as a shoshonite suite. K_2O and Na_2O values for the Skinner Cove Formation are high (*e.g.* 8.4 per cent alkalis at 53.2 per cent SiO_2), but the mobilization of the alkalis precludes their usefulness in genetic discussions. Shoshonites generally occur only in mature volcanic arcs; the Little Port Complex, if interpreted as a volcanic arc, does not hint of maturity. The following is a list of miscellaneous alkaline and undersaturated magma occurrences in recent volcanic arcs. DeLong *et al.* (1975) note that the present-day occurrence of alkaline rocks in volcanic arcs built on oceanic crust are of two types;

(1) those that occur along or near lateral edges of subduction zones where hinge faulting is occurring (*e.g.* Sigurdsson *et al.*, 1973 (Grenada); Arculus, 1976 (Bering, Hispanolia); Gill, 1976 (Fiji)).

(2) those that occur where fracture zones or other linear features are approximately perpendicular to the trench being subducted (*e.g.* Arculus *et al.*, 1977, and DeLong *et al.*, 1975 (Kanaga in the Aleutian Islands; Aoba and Ambry, adjacent to the New Hebrides Trench; Iwo-Zima)). These settings may be difficult, if not impossible to identify in the ancient geological record.

7.4 On the Interpretation of Tectonic Settings of Ancient Alkaline Rocks

In the above discussion it is evident that alkaline mafic rocks, plus or minus felsic differentiates, are synonymous with oceanic islands, seamounts, and early rifting of continental lithosphere. Alkaline olivine basalts are the most common rocks associated with these different environments. Schwarzer and Rogers (1974) determined that alkali basalt differentiation trends show no differences between environments when plotted on total alkalis versus silica, and A.F.M. diagrams. The Skinner Cove probably belongs to one of the environments listed above, therefore there is little hope of discriminating the tectonic setting using Na_2O, K_2O, SiO_2, MgO, or total Fe especially since most of these oxides have been mobilized during metamorphism. There is little trace element data on recent alkaline rocks since the recent rocks may be easily classified using normative and modal schemes. The situation for chemical comparisons is frustrating to say the least.

Menzies (1976) mentions that rare earth element patterns could be used to distinguish between basalts from oceanic islands, seamounts, and oceanic margins (alkaline rift ?), but he was unable to convincingly classify Hynes' (1972, 1974) 'rift facies' rocks using just R.E.E. Surely isotope (*e.g.* Sr) chemistry would enable distinction between alkaline magmas which have passed through continental crust and those of oceanic islands which have moved through oceanic crust. Still, Sr isotopes would be of restricted use in spilites where elemental mobility is the rule.

Clearly then, the geochemistry of altered basalts can only hint at tectonic settings, whereas stratigraphic and regional relationships are more useful for environmental and tectonic interpretation. For example, if Hynes (1974) or Lapierre and Rocci ~~(1976)~~ had found transitional or tholeiitic rocks interbedded with metamorphic detritus, the setting could equally as well be interpreted as a continental rift. Their interpretation of the alkaline rocks as representing a rift facies sequence is enhanced by a similar geological setting for a minimum of 4,000 km along the system, especially since it would be unlikely that any other alkaline setting would be so continuous in outcrop.

7.5 The Tectonic Setting and Environment of Deposition of the Skinner Cove Formation and the Little Port Complex

7.5.1 Previous interpretations of the Skinner Cove Formation

According to Strong (1974) the Skinner Cove Formation formed in an 'off-axis' position (*i.e.* off the mid-ocean ridge where the Bay of Islands Complex was generated) in a precisely similar fashion as the Upper Pillow Lavas of the Troodos Complex, Cyprus. He also compared the Skinner Cove Formation to the 'off-axis' ankaramites of the Crozet Archipelago (Gunn *et al.*, 1970). However, the origin of the Upper Pillow Lavas of Troodos remains controversial, and the Crozet rocks do not form a differentiated suite like that of the Skinner Cove Formation.

Possible alternate interpretations for the origin of the Skinner Cove Formation were pointed out and then rejected by Strong (1974, p. 308). He suggested that the rocks "might have been taken (*i.e.* might have been interpreted as...) as an autochthonous sequence prior to the obduction of the ophiolites, possibly related to the Late Precambrian lavas of the Lighthouse Cove Formation...", or in Strong's opinion, the Skinner Cove rocks could possibly be directly correlated with the Carboniferous lavas of the Midland Valley of Scotland.

Malpas (1976) agreed with Strong's 'off-axis' interpretation, and he also introduced a petrogenetic scheme whereby alkaline melts could be generated by partial melting of the undepleted ultramafic rocks of the Bay of Islands Complex. This suggests that the mafic alkalic rocks in the Skinner Cove Formation may be derived from the Bay of Islands ultramafic rocks.

To alleviate some problems in the palinspastic restoration of the Humber Arm Allochthon, Williams (1975) suggested the Skinner Cove

Formation formed in a back arc rift during the Ordovician closing of the Iapetus Ocean. The rift was placed by Williams at the continental margin/oceanic crust interface.

7.5.2 Interpretations of the Skinner Cove Formation based on the present study

(1) The sedimentary rocks of the Skinner Cove Formation (Trout River and Chimney Cove slices) do not contain sialic or metamorphic detritus which would signify the uplift and erosion of a continental source, as is the case in Cyprus (Lapierre and Rocci, 1976). Neither ophiolitic, nor gabbroic or amphibolitic detritus that would be derived from the Bay of Islands or Little Port Complexes, is found in the Skinner Cove rocks. Therefore, there is no sedimentary/detrital link between the Skinner Cove Formation and the other structural slices.

(2) Epiclastic reworking of Skinner Cove evolved volcanic rocks (*i.e.* trachybasalt, trachyte) indicates that the volcanoes were sufficiently mature as to produce differentiated lava compositions.

(3) The presence of autoclastic breccias that erupted onto or into lime muds and subsequently sloughed off paleoslopes, attests to the local instability of the marine depositional environment.

(4) Thick, fossiliferous limestone at Chimney Cove suggests relatively shallow, warm, marine conditions of sedimentation.

(5) Zeolite facies metamorphism suggests relatively high-level, - low pressure and temperature metamorphic conditions. Strong (1974) points out that the low grade metamorphism represented in the Skinner Cove rocks signifies that its formation is younger than the Bay of Islands and Little Port Complexes. In contrast, it is the writer's opinion that no matter what the interpretation of the Skinner Cove Formation, the

metamorphism may be entirely unrelated to that of the Bay of Islands or Little Port Complexes. The zeolite metamorphism of the Skinner Cove rocks could have been imprinted before the structural stacking process (*i.e.* by an isolated thermal system), or perhaps even during structural assembly.

(6) Fault-bounded Skinner Cove knockers are located in mélange comprised of sediments of the Humber Arm Supergroup. These knockers provide conclusive evidence that the Skinner Cove Formation is intimately related with the Ordovician assembly of the Humber Arm Allochthon, and thus is of Ordovician or earlier age. Stevens and Williams (1973) have shown that the transported structural units were emplaced as pre-assembled allochthons. This implies that the Skinner Cove Formation, the lowest igneous slice, was initially located between the ocean basin and the continental margin clastic wedge, probably lying on ocean floor.

An alternate interpretation is that the alkaline volcanic rocks formed during the Late Precambrian/Cambrian continental rifting event. The following all suggest that this alternate interpretation is unlikely:

(1) The Skinner Cove rocks have undergone low-grade metamorphism; they are devoid of deformation and nowhere do they contain continental or metamorphic detritus. One would not relegate such a sequence to an early rift environment that was later buried by a thick pile of continental siliciclastics (*e.g.* Fleur de Lys Supergroup) and overlain in turn by a thick carbonate platform.

(2) Since the Skinner Cove Formation is located structurally above continental sediments but does not itself contain interbeds of such sediments, one must assume that the Skinner Cove rocks formed basinward of continental sedimentation, probably on the Ordovician ocean floor.

(3) The Late Precambrian rift facies Long Range dykes and thick coeval plateau lavas are tholeiitic (Strong, 1974, and Fig. 19.). Likewise in the Southern Appalachians, another thick sequence of mafic and felsic lavas are thought to represent tholeiitic rift facies volcanics (Blackburn, 1976; Rankin, 1976). Some slightly alkaline mafic lavas are interpreted as tensional continental rift facies volcanics (*e.g.* Rankin, 1976; Pieratti, 1976*a,b* *i.e.* Tibbet Hill metavolcanics). It is clear that nowhere in the Appalachian system is there known an *in situ*, or transported sequence of Ordovician age that rivals the Skinner Cove Formation in its alkalinity and degree of differentiation. Therefore it seems unlikely that such a distinctive and seemingly isolated suite would represent the preserved remnants of a widespread alkaline rift facies sequence that occurred along a continental rift thousands of kilometres in length (*i.e.* the entire Appalachian and Caledonian Systems). Furthermore, since rift facies rocks of tholeiitic affinity are clearly defined and evident in thick *in situ* deposits, it is therefore reasonable to assume that tholeiites would also be preserved in allochthonous sequences. All this suggests that the Skinner Cove Formations represents a relict oceanic volcano and not an alkaline rift facies suite.

It is probable that the Skinner Cove Formation was likely a Cambro-Ordovician seamount, atoll and subaerially exposed volcano, which possibly formed along a fracture zone, or isolated on normal oceanic crust. Since present-day oceanic volcanoes are relatively restricted in aerial extent, the probability of locating alkaline feeder dykes cutting the Bay of Islands or Little Port Complexes is exceedingly remote.

The Skinner Cove oceanic volcano later became involved in the Late Cambrian to Lower Ordovician slice assembly and emplacement episode, pushed in front of the advancing Bay of Islands (ophiolite) slices.

7.5.3 Previous interpretations of the Little Port Complex

The variably deformed nature of the Little Port Complex led Comeau (1972) and Williams *et al.*(1972*b*) to interpret the Little Port as a raft of an already deformed terrane. Further considerations of the origin of the Humber Arm Allochthon, and preliminary work on the Twillingate Granite led Williams and Malpas (1972) to 1) reject the possibility that the Little Port is a typical ophiolite, and 2) conclude that the geological setting of the Little Port and Twillingate Granite is similar.

Based on the similarities between granites (*i.e.* plagiogranite) of the Little Port Complex and Twillingate (see Fig. 1a.), Williams (1973) suggested that the Bay of Islands and Little Port Complexes were a sampling of the volcanic arc/ophiolite terrane of north-central Newfoundland (*i.e.* the Dunnage Zone, Fig. 3.). Payne (1974) and Williams and Payne (1975) maintained that the Little Port represents a sampling of the Twillingate terrane, but they re-interpreted the Little Port as a volcanic arc. Strong and Payne (1973), Malpas *et al.* (1973), Williams (1975) all interpreted the Twillingate Granite as an ancient volcanic arc terrane; the latter two authors also called the Little Port a volcanic arc.

Mattinson (1976) and Malpas (1976) first suggested the Little Port could comprise both oceanic lithosphere and volcanic arc lithologies. Church (1976) found a volcanic arc interpretation untenable, but he failed to present any ideas regarding the genesis of the suite.

Dewey and Karson (1976) and Karson and Dewey (1978) suggest a model that might account for the local deformation in the Little Port Complex, the undeformed nature of the Skinner Cove Formation, and local intrusive relationships between the southernmost Bay of Islands massif (the Lewis Hills, Fig. 3.) and the Little Port Complex. Simply stated, they interpret the Little Port and Bay of Islands Complexes as ocean floor formed along the same spreading ridge. The Little Port Complex was affected by a local transform fault. Shearing from ocean floor spreading resulted in the deformation of the subvolcanic rocks of the Little Port Complex. The deformation continued along the transform fault until the Little Port reached its parallel spreading ridge, where it was reintruded by newly formed dykes (*i.e.* the site of the formation of the relatively younger Bay of Islands Complex).

Stevens (R. K. Stevens, pers. communication with Malpas, in Malpas, 1976) suggests the Little Port Complex may represent an accretionary mélange formed in a trench environment.

7.5.4 Interpretation of the Little Port Complex based on the present study

The writer favours an interpretation that combines the elements of ancient sea floor deformed along a transform fault, and a primitive volcanic arc terrane built on the ocean floor.

The coeval dykes and volcanics of the Little Port are chemically similar to the upper volcanic rocks of the Bay of Islands Complex. Both the Bay of Islands and Little Port extrusive rocks and dykes are petrographically distinct form those of the Skinner Cove Formation (Figs. 6. and 10. to 18.). The discriminant function (Fig. 18.) indicates the similarity between the clinopyroxenes of the Little Port and those from ocean floor lavas. Therefore, in the vicinity of Little Port (Figs. 1b. and 2.) the dykes and lavas are possibly ophiolitic in nature.

During field mapping and sampling, the writer was impressed by the abundance of mafic and intermediate pyroclastic lithologies, and the presence of about fifty metres thickness of blue-gray rhyolite (see analysis TRLP-6 in Appendix B.) in the Little Port Complex. These lithologies are not typical of recent dredge hauls taken from the deep ocean floor (along the ridge or in fracture zones). The most atypical ocean floor lithology is that of the porphyritic andesitic agglomerates and lavas located on Gregory Island. Classic volcanic arcs commonly contain such pyroclastic rocks, porphyritic andesite and rhyolite. Therefore the best explanation to account for these features is to interpret the Little Port Complex as containing an ophiolitic basement (mainly deformed gabbro with local ultramafic rocks) locally overlain by volcanic arc basalt, andesite (lava and pyroclastic rocks) and rhyolite flows.

CHAPTER 8

SUMMARY AND CONCLUSIONS

The writer has given a detailed account of the geology of the Skinner Cove Formation and its relationships to the other major transported slices in the Humber Arm Allochthon. The following is a brief summary of the findings of this study.

(1) Age

Since the Skinner Cove Formation is an integral part of the Humber Arm Allochthon, it is therefore assigned a Cambro-Ordovician age. Knockers of volcanic rock suspended in mélange strongly suggest that blocks became detached and engulfed in sediments during the assembly of the allochthon. Some of these knockers are alkaline, which suggests they belong to the Skinner Cove Formation. Fossil dates quoted by some writers only date the blocks of the mélange (at Brake Cove) within which they were found. They do not date the Skinner Cove Formation.

(2) Distribution

North of the Bay of Islands, Skinner Cove rocks are distributed in two newly named slices; the Trout River and Chimney Cove slices. Locally, knockers or blocks of Skinner Cove rocks (also mentioned in '(1)', above) are enveloped in mélange consisting of sediments of the Humber Arm Supergroup. The Beverley Head slice, previously interpreted as Skinner Cove, is given a 'miscellaneous' status because it is internally imbricated and contains components of several major transported slices. The Western Head slice, also previously interpreted as Skinner Cove Formation, is re-assigned to the Little Port Complex.

(3) Contact relationships

All the slices investigated are separated from structurally underlying and overlying slices by a mélange, which contains finely comminuted lithologies and blocks from the juxtaposed slices, and exotic blocks, all suspended in a foliated shaley matrix. The mélanges represent the surfaces upon which the slices last moved, and were undoubtedly under high hydrostatic pressure during transport. Shales in the mélange have been affected by ductile deformation and several periods of recrystallization; they are not mylonites. The Old Man Cove slice, which was interpreted by Williams (1973) to structurally overlie the Trout River slice, is in this work interpreted only to (structurally ?) underlie the Little Port, with unknown relationship toward the Trout River slice.

(4) Stratigraphy and lithology

The Skinner Cove Formation is defined on the basis of stratigraphy and lithology (and also structural position within the allochthon), which are best seen in the Trout River slice. The strata strike northeast, dip at about 70 degrees to the southeast, and are also southeasterly facing. The section, though not continuously exposed, is about 0.8 km thick. The base and top of the section are not seen. The Main Sea Stack, Wallace Brook and Red Fire Brook Members are three stratigraphic units defined in the Trout River slice. The Main Sea Stack and Wallace Brook Members are in assumed continuity even though the base of the Wallace Brook Member is nowhere seen in contact with the top of the Main Sea Stack Member. The Main Sea Stack Member consists of pillowed alkali basalt and trachybasalt, ankáramite, pyroclastics and heterolithic breccia. The Wallace Brook Member consists of a unique series containing mafic breccias welded by lime mud (the mud is usually recrystallized to calcite) and known as 'peperite' breccia. Epiclastic breccia, monolithic breccia and heterolithic breccia all exist in well defined beds. The Red Fire Brook Member is a brick-red, feldspar-phyric trachyte, which locally contains both conformable or unconformable relationships to the adjacent strata.

The Chimney Cove slice is subdivided into 'coastal' and 'inland' lithologies. Only the coastal lithologies represent rocks of the Skinner Cove Formation. The coastal lithologies consist mainly of epiclastic breccia and fossiliferous limestone, with mafic autoclastic breccias similar to the peperites in the Trout River slice.

The stratigraphy of the Western Head slice is not thick or continuous enough to be illustrated in this work. This slice is composed of mafic pillow lavas and coeval dykes. In outcrop the pillows are different in character from those of the Trout River slice. Petrography and geochemistry support the contention that the rocks of the Western Head and Trout River slices are different in origin.

The Beverley Head slice contains pillow breccia and pillow lava along a coastal ridge. Inland, there is sparse exposure, except in streams. Locally, foliated gabbro containing serpentinized ultramafic pods is in faulted contact with folded Humber Arm sediments and undeformed mafic rocks on the coast. A monzonitic subvolcanic lithology is similar to that located near Trout River slice. Therefore, this slice contains components of the Skinner Cove Formation, Humber Arm Supergroup and the Little Port Complex.

Gregory Island, probably a part of the Little Port Complex, contains andesite tuff, mafic pillow lavas and a very distinctive lithology interpreted as a plagioclase- two pyroxene-phyric basaltic andesite.

(5) Petrology and geochemistry

The rocks of the Skinner Cove Formation in the Trout River slice, are classified as ankaramite, pyroxene-phyric basalt, alkali basalt, trachybasalt and trachyte (some of the nomenclature is after Strong, 1974). Trachybasalt/trachyte and pyroxene-phyric basalts are also found in the Chimney Cove slice. The Western Head slice contains mafic lavas similar in petrography and geochemistry to those of the Little Port. Mafic rocks at Beverley Head are exceedingly altered and were not sampled extensively for petrography or geochemistry.

The zeolite facies of metamorphism is defined in the Trout River slice by the presence of a fibrous zeolite and quartz-analcime. Diagnostic mineral assemblages are not evident in the other slices, but they probably range from zeolite to prehnite-pumpellyite facies. With the possible exception of the Beverley Head slice, relict igneous textures are well preserved in the mafic rocks of all slices. Clinopyroxene is the most widely preserved mineral, although there is abundant calcic plagioclase in the mafic rocks of the Trout River slice and the lavas on Gregory Island. The zeolite metamorphism suggests conditions of less than 200^{o} C, and 2 to 3 kb in an alkaline fluid environment.

Although some primary mineralogy is preserved, the rocks are everywhere variably hydrated and oxidized, and contain a mineral assemblage and bulk rock composition that is far from being primary. Therefore, to avoid the confusion introduced when comparing such altered rocks to the 'Hawaiian trend' or the 'Skaergaard trend', or by projecting the compositions into experimental phase systems (*e.g.* C.M.A.S., O'Hara, 1968), the writer has used relict mineral compositions and immobile elements to determine affinities.

Ti, P, Si, Nb, Zr, Y, La, Ce and V are probably the least mobile elements in the rocks of this study. In conjunction with petrography, the above elements and clinopyroxene compositions, the rocks of the Skinner Cove Formation are of alkaline affinity (this was also suggested by Strong (1974) and Malpas (1976), but their approach to determining magmatic affinity and tectonic setting never considered elemental mobility). The mafic dykes and lavas of the Western Head slice and at Little Port are coeval (in each respective area) and of subalkaline affinity.

Texturally, mineralogically and geochemically, the mafic rocks of the Skinner Cove Formation are different from those of the Little Port or the Bay of Islands Complexes. This work is entirely opposed to Malpas'(1976) suggestions that the Skinner Cove Formation and the Little Port Complex are genetically linked by a common alkaline magmatic affinity.

(6) Origin of the rocks, and some speculation

The Skinner Cove Formation is interpreted to have been a mature oceanic volcano that was an island for part of its Ordovician history. It formed either on normal oceanic crust, or along a transform fault (Karson and Dewey, 1978). Since both areas of development are located off the axis of spreading ridge, Strong's (1974) "off-axis" interpretation for the place of origin of the Skinner Cove Formation is accepted in this work.

The Little Port Complex comprises an ocean floor and volcanic arc terrane. This is based mainly on several factors: 1) the presence of the basalt-andesite-rhyolite association commonly found in recent volcanic arcs, 2) the clinopyroxene compositions of the sampled mafic rocks of the Little Port Complex are similar to clinopyroxene compositions in present-day ocean floor basalts, 3) the clinopyroxene compositions of the rocks on Gregory Island (part of the Little Port Complex) are of volcanic arc affinity, 4) the upper ophiolite pillow lavas and dykes (Blow-Me-Down slice, Bay of Islands Complex) and the sampled Little Port dykes and lavas have very comparable major, minor, and trace element contents, and similar clinopyroxene compositions.

Rocks of alkaline affinity are known to occur in many other transported terranes (*e.g.* Hare Bay Allochthon, Newfoundland; the Alpine Mountain chain; the Franciscan terrane, etc.) and are invariably associated with transported ophiolite suites. This then implies a genetic connection between the ophiolite and alkaline rocks, which in turn suggests that alkaline magma formed contemporaneously (or nearly so) with ocean floor (rift facies or oceanic volcano alkaline magma), or that the process of obduction of oceanic floor induces alkalic magmatism during emplacement.

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APPENDICES

APPENDIX A.

ANALYTICAL AND DETERMINATIVE METHODS AND MODAL ANALYSES

A.1 Sampling Procedure

Samples of rock were taken with the following purposes:

(1) to collect a representative suite of rocks in the relative abundance of their occurrence in a given structural slice (*e.g.* in the Trout River slice, it is clear that the most abundant type of rock is alkali basalt (called 'mafic volcanic' in the field). Therefore, more alkali basalts were sampled than felsic volcanics, etc.).

(2) since parts of this work bear on the identification of possible genetic relationships between the rocks in different structural slices, it was necessary to sample some dykes that intrude parts of the Old Man Cove Formation and the Little Port Complex. In addition some mafic volcanics of the Little Port Complex were collected for comparative purposes. Therefore, this type of sampling is more specific than that outlined in (1), above.

Wherever possible, a single bulk sample (of about 1 to 2 kg) was taken. Where outcrop surfaces were smooth, chip samples were taken. Samples were logged, and then isolated, one from another, to minimize contamination.

A.2 Preparation of Rock Powders

Thin sections were cut from prospective geochemical samples before deciding on the samples to be powdered. F. Thornhill and co-workers made nearly two hundred thin sections during the course of my stay at Memorial University.

Procedure for the preparation of rock powders:

(1) each sample was cut into a number of 1 to 2 cm - thick slabs
(2) individual slabs were scrubbed with a bristle brush, using hot water to remove cutting lubricants

(3) weathered zones and obvious veining were trimmed from all samples (cutting out veining introduces some bias, since the vein material may be derived from the same rock. Therefore, veined rocks were avoided wherever possible).

(4) saw marks were ground off the samples using a coarse carborundum grit.

(5) samples were again scrubbed thoroughly under hot water, then cleaned in an ultrasonic bath for one minute, and finally air-dried.

(6) a hardened steel hammer was used to chip the slabs to a suitable size for pulverizing (since the rocks were in thin slabs, only light taps were required to fracture most samples, thus avoiding excess iron contamination).

(7) the rock chips were shaken to ensure homogeneity, then the chips were coned, and split-and-quartered. One quarter was then pulverized for about 1 minute in a tungsten-carbide swing mill (to about -100 mesh). After grinding each sample, the tungsten-carbide bowl and rings were scrubbed in hot water with an abrasive silica cleanser. After grinding every third sample, silica sand was pulverized to further ensure clean grinding conditions.

(8) the newly formed powder was homogenized, coned, and split in half. One half was taken and stored in an appropriately marked glass jar.

A.3 X-ray Fluorescence Analyses

Trace element abundances were determined using a Philips 1450 fully automatic x-ray fluorescence spectrometer. The unit is equipped with spectrometer/detector, x-ray generator, PDP mini computer, teletype input/output, and a self-feeding sample tray. Molybdenum and silver tubes were used with matrix corrections by the Compton peak method. U.S.G.S. prepared rock powders were used as standards for calibrations. D. Press of Memorial University wrote various computer programs and did the calibrations for X.R.F. spectrometry.

Preparation of hardened discs (composed mainly of rock powder) for

X.R.F. spectrometry:

(1) rock powders (prepared as in A.2) were again shaken to ensure homogeneity.

(2) appoximately 10 g of rock powder was weighed out and placed in a clean glass jar. This was shaken for 10 minutes together with about 1.1 g of binder (binder material is low density Union Carbide Phenolic Resin, material TR-16933).

(3) the homogenized mixture was then formed into a disc in a Herzog hydraulic press at a pressure of 30 tons p.s.i., for 1 minute.

(4) after each pressing, the powder container on the hydraulic press was thoroughly cleaned with acetone.

(5) the disc was baked at 200° C for 10 minutes, then allowed to cool before labelling.

(6) the hardened disc was then stored in a dessicating apparatus to await analysis.

During analyses, an internal standard and basalt standard (BCR-1) were analysed with every run on the X.R.F. (if not more often), for the determination of precision and accuracy. Precision and accuracy of X.R.F. analyses are presented in Tables A.3.i and A.3.ii, respectively.

symbols in Tables A.3.i & ii.....

$\bar{x}$ = mean value
s = standard deviation
c = coefficient of variation $\quad c = \frac{s}{\bar{x}}$
C = per cent variation

(after Shaw, 1969)

Table A.3.i Precision of x-ray fluorescence trace element determinations

element	number of determinations	$\bar{x}$ (ppm)	s	c	C
Zr	10	209	3.9	.019	1.9
Sr	26	686	4.2	.006	0.6
Rb	26	7.8	0.4	.051	5.1
Zn	26	104	2.0	.019	1.9
Ba	26	204	2.2	.011	1.1
Nb	26	46	1.9	.014	4.1
Ga	26	18.7	1.1	.059	5.9
Pb	26	6.3	0.5	.079	7.9
Ni	10	107	8.4	.079	7.9
La	26	73	5.0	.068	6.8
Cr	26	175	3.8	.022	2.2
V	26	271	2.5	.009	0.9
Y	26	19.9	0.3	.015	1.5
Ce	26	112	4.0	.036	3.6

Table A.3.ii Accuracy of x-ray fluorescence trace element determinations

element	number of determinations	proposed value* (Flanagan, 1973)	$\bar{x}$ (ppm)	s
Zr	10	190	186	4.2
Sr	16	330	332	2.4
Rb	16	46.6	44	0.6
Zn	16	120	133	2.8
Ba	18	675	695	6.3
Nb	18	13.5	14	1.6
Ga	16	20	21	1.0
Pb	16	17.6	13	1.0
Ni	10	15.8	16	3.5
La	18	26	37	4.0
Cr	18	17.6	24	6.2
V	18	399	369	4.1
Y	18	37.1	42	0.8
Ce	18	53.9	72	5.7

* basalt standard BCR-1

A.4 Atomic Absorption Analyses (and phosphorus, ferrous iron and loss on ignition)

Major and minor elements were determined on Perkin Elmer models 303 and 404 atomic absorption spectrophotometers. Samples were prepared according to the method outlined by Langmhyr and Paus (1968).

(1) exactly 0.1000 g of rock powder were weighed out and placed placed in a clear, labelled, 'Nalgene' polycarbonate digestion bottle.

(2) using an automatic pipette, 5 ml of HF (stock solution) was added to the digestion bottle to effect dissolution of the powder. The solution was steam-heated for about ½ hour.

(3) after cooling of the solution, 50 ml of saturated H_3BO_4 solution was added to complex undissolved fluorides. This was then followed by the addition of 145 ml of distilled H_2O.

(4) the solution was shaken and then stored in a clean polyethylene bottle.

Standards were prepared by G. Andrews in a similar manner to that described by Abbey (1968).

Phosphorus was determined on a Bausch and Lomb Spectronic 20 colourimeter according to a method somewhat modified after Shapiro and Brannock (1962).

Loss on ignition (L.O.I.) was determined by weighing an amount of sample in a porcelain crucible, heating at 1050° C for two hours, cooling in a dessicator, and weighing to determine the per cent weight loss of volatiles (mainly CO_2, H_2O, SO_2).

Percentage ferrous iron was determined by a variation of the titrimetric method of Wilson (1955).

Precision was determined by the analysis of replicate samples of a representative basalt (SKC-25A). The precision sample was analysed after every fourth regular sample. Precision is shown in Table A.4.i.

Accuracy of major/minor element analyses was determined by the analysis of U.S.G.S. basalt standard BCR-1. Accuracy of analyses is shown in Table A.4.ii.

Table A.4.i Precision of major/minor element analyses

oxide	number of determinations	$\bar{x}$ (wt. %)	s	c	C
SiO_2	16	40.7	0.70	.017	1.72
TiO_2	16	3.52	0.17	.049	4.90
Al_2O_3	16	13.3	0.25	.018	1.80
FeO	14	4.79	0.16	.033	3.28
Fe_2O_3	14	7.40	0.23	.031	3.12
Fe_{total}	16	12.71	0.14	.011	1.13
MnO	16	0.21	0.01	.034	3.42
MgO	16	6.42	0.09	.014	1.40
CaO	16	11.93	0.08	.006	0.65
Na_2O	16	2.54	0.05	.021	2.10
K_2O	16	1.18	0.02	.019	1.88
P_2O_5	8	0.83	0.03	.039	3.90
L.O.I.	16	4.48	0.10	.023	2.31

Table A.4.ii Accuracy of major/minor element analyses (BCR-1)

oxide	number of determinations	proposed value (Flanagan, 1973)	$\bar{x}$ (wt. %)	s
SiO_2	6	54.50	53.3	1.6
TiO_2	6	2.20	2.26	0.03
Al_2O_3	6	13.61	13.46	0.23
FeO_{total}	6	13.40	13.12	0.12
MnO	6	0.15	0.18	0.00
MgO	6	3.46	3.56	0.07
CaO	6	6.44	6.89	0.08
Na_2O	6	3.27	3.24	0.02
K_2O	6	1.70	1.70	0.02

$\bar{x}$ = mean
s = standard deviation
c = coefficient of variation $c = \frac{s}{\bar{x}}$
C = per cent variation

A.5 Electron Microprobe Analyses

Electron microprobe analyses of all minerals were done on an automated microprobe; the JEOL JXA - 50A electron probe microanalyser with Krisel Control through a PDP-11 computer. Operating conditions included an acceleration potential of 15 kV and a beam current of about 0.3 microamps. On pyroxenes, hornblendes and opaque oxides, the spot size was about 1 to 2 microns, a count rate of 30,000 and default time of 30 seconds. More diffuse scanning beams, and shorter count times were used during the analysis of feldspar, analcime and celadonite. Correction for absorption is by Philbert (1963) as modified by Heinrich (1967). Reed (1965) describes the fluorescence correction, and the atomic number effects are calculated using the method described by Philibert and Tixier (1968).

A selection of well known mineral standards and pure standards, was used during the microanalyses.

Most polished thin sections were prepared by the writer. The final polish was done with a 0.3 micron aluminum oxide abrasive powder, which was applied in the form of a slurry. The final thin section was bathed in the ultrasonic cleaner. The sections were then given a thin coating of carbon in a Varian VE10 vacuum evaporator.

A.6 Modal Analyses and Mineral Assemblages

Tables of per cent mineralogy, primary and alteration mineral assemblages are given in the following three pages.

MODAL ANALYSES OF SOME REPRESENTATIVE SPECIMENS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	SKC-24	SKC-41	SKC-39	SKC-38	SKC-53	SKC-54	SKC-60	SKC-63	SKC-26	SKC-42	SKC-65	CC-ANK	CC-6	WH-8	WHC-2	LP-2	LP-12	LP-14	GI-5**	GI-12	SK-6A
Phenocrysts																					
clinopyroxene	16.86	24.75	9.42	---	---	---	---	0.89	---	---	---	25.53	2.94	---	---	---	---	---	5.66	4.38	---
orthopyroxene	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7.85	---
plagioclase	9.90	7.32	---	---	---	4.14	16.65	---	.5	---	11.21	---	18.02	---	---	1.00	---	---	19.14	35.05	---
olivine (pseudomorphs)	3.72	1.47	---	---	---	---	---	1.67	---	---	---	6.94	3.05	---	---	---	---	---		---	---
Microphenocrysts																					
clinopyroxene	---	---	1.39	---	---	---	---	---	---	---	.47	---	---	---	---	---	---	---	---	---	---
plagioclase	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
opaque	---	---	1.20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Groundmass																					
clinopyroxene	4.97	7.09	---	21.25	7.77	12.51	---	18.69	---	---	---	3.70	1.24	26.61	34.87	10.04	29.26	14.76	.66	---	3.41
plagioclase	30.18	31.27	13.06	2.29	4.64	48.12	26.98	53.02	66.58	54.28	64.97	---	---	46.70	43.13	55.18	45.82	31.18	---	---	49.62
chlorite	14.41	13.54	10.74	55.69	30.08	24.95	32.35	---	20.68	5.69	12.36	---	---	21.25	6.93	19.56	19.16	---	---	---	37.69
calcite	1.55	5.82	---	.66	.52	---	---	.77	4.03	1.20	1.86	---	---	---	1.24	3.31	1	1.63	10.24	---	---
opaque	6.92	8.71	---	8.48	3.40	7.74	7.77	7.24	5.41	14.57	4.05	3.68	1.37	4.95	2.98	9.07	5.39	2.89	---	.72	6.66
analcime	---	---	---	8.60	53.01	---	3.19	---	---	---	---	---	---	---	---	---	---	---	---	---	---
pumpellyite	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
sphene	11.49	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
devitrified glass	---	---	---	---	---	---	---	---	---	7.14	---	---	---	---	---	---	---	---	---	---	---
iddingsite	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
other*	---	---	64.70	3.03	.57	2.26	---	2.74	2.81	17.51	5.07	60.15	73.36	49	10.84	1.87	.36	49.54	59.15	51.99	2.62
Amygdales	1.6	<1	<<1	---	---	---	---	---	1.79	---	---	---	---	---	---	1.35	---	---	---	---	---
Vol. % phenocrysts and microphenocrysts	30.5	33.54	9.42	---	---	4.14	16.65	2.56	.5	---	11.21	32.47	24.01	---	---	1.00	---	---	29.95	47.28	---
Vol. % groundmass	68.0	66.43	88.49	100.00	100.00	95.86	83.35	97.36	99.51	100.00	88.27	67.53	75.99	100.00	100.00	100.00	100.00	100.00	70.05	52.71	100.00
Phenocrysts/groundmass	.45	.5	.14	---	---	.04	.2	.03	---	---	.13	.48	.3	---	---	---	---	---	.43	.9	---
# of points counted	5030	5095	5986	5186	4026	4420	4389	5040	4233	4412	4022	4023	4594	5130	4428	4233	5194	4423	4561	6003	4696

*apatite, sphene, poorly crystallized or unidentified mineral, quartz.
**4.45 - chlorite, serpentine, celadonite

Analysis Number	Trout River slice
1, 2	ankaramite
3	clinopyroxene-phyric basalt
4-8	alkali basalt
9, 10	trachybasalt
11	trachyte
12, 13	porphyritic basalts, Chimney Cove slice
14, 15	basalt, Western Head slice
16-18	basalt, Little Port slice assemblage
19, 20	porphyritic andesite, Gregory Island, Little Port slice assemblage
21	mafic subvolcanic associated with monzonite phase, Wallace Brook, Trout River slice

		alteration assemblage															amygdale assemblage								primary mineral assemblage								
	Trout River slice	iddingsite after ol.	serpentine after ol.	hematite after ol.	chlorite	pumpellyite	analcime	calcite	opaque	quartz	natrolite(?)	white mica		sphene	hornblende	albitized plagioclase	calcite	opaque	pumpellyite	chlorite	quartz	adularia	analcime	sphene	clinopyroxene ph.	clinopyroxene mph.	clinopyroxene gm.	plagioclase ph.	plagioclase mph.	plagioclase gm.	olivine-ph. mph.	orthopyroxene	opaque mph. or gm.
1*	SKC-23				●			●	●					●		○				●				●	●	●	●	●	●	●			●
2	SKC-24	●		●	●			●	●	●				●			●	●							●						●		
3	SKC-25A		●		●		●	●	●			●		●		○	●	●							●	●	●	●	●	●	●		●
4	SKC-25B	●	●	●	●			●	●			●					●			●					●		●	●	●	●	●		●
5	SKC-27		●		●			●	●	●							●	●		●	●				●		●	●	●	●			●
6	SKC-41	●	●	●	●			●	●																●	●	●	●		●	●		●
7	SKC-66		●	●	●			●	●	●										●					●	●	●			●			
8	SKC-36				●	○		●	●					●											●	●	●			●			●
9	SKC-37				●			●	●					●		○									●	●	●			●			
10	SKC-39		●		●			●	●																●	●			●	●	●		●
11	SKC-21	●	●	●	●			●	●					●		○	●	●		●										●			
12	SKC-30				●		●	●	●		●	●			○	●										●	●		●	●			●
13	SKC-31A		●		●			●	●			●			●	○									●	●	●	●		●	●		●
14	SKC-32		●		●				●			●			●										●	●	●	●		●	●		●
15	SKC-33				●				●			●				●	●	●		●										●			
16	SKC-34				●		●		●			●				●				●										●			
17	SKC-38				●		●	●	●					●	●	●	●	●	●	●			●			●	●			●			●
18	SKC-40	●	●	●	●			●	●							○									●		●	●	●	●	●		●
19	SKC-46							●	●	●						●													●	●			
20	SKC-48				●				●																				●	●	●		●
21	SKC-49				●			●	●			●		●		○	●	●										●	●				●
22	SKC-50				●		●		●		●	●		●		●	●			●			●				●			●			
23	SKC-51				●		●	●	●		●									●			●										●
24	SKC-53				●		●	●	●	●	●			●							●						●			●			●
25	SKC-54		●		●		●	●	●		●	●		●												●	●		●	●			●
26	SKC-56				●		●	●	●					●		●	●						●		●	●	●			●			●
27	SKC-57				●		●	●	●	●	●					●							●				●			●			●
28	SKC-58				●		●	●	●		●				○								●				●			●			●
29	SKC-60				●		●		●	●				●		●				●			●					●		●			
30	SKC-63	●			●			●	●	●		●		●											●		●			●	●		●
31	SKC-64				●		●	●				●				●														●			●
32	SKC-71				●		●	●	●						○	●	●	●		●							●			●			●
33	SK-66	●	●	●	●			●	●					●											●	●	●			●			●
34	SKC-14				●		●	●	●							●	●			●										●			
35	SKC-17				●		●	●	●							●	●													●			
36	SKC-26	●	●		●		●	●	●	●	●						●			●			●		●			●		●			●
37	SKC-28		●		●			●	●					●			●			●							●			●			●
38	SKC-29		●	●	●			●	●					●		●	●	●							●			●	●	●			
39	SK-29				●		●	●			●			●		●	●			●													
40	SKC-42	●	●		●			●	●			●																		●			●
41	SKC-43		●		●			●	●			●															●			●			●
42	KC-59				●			●	●		●			●		●	●			●			●	○						●			●
43	KC-68				●			●	●							○											●			●			●
44	SKC-148				●	●			●							●												●		●			
45	SKC-18				●	●			●	●		●		●		●	●		●	●	●	●						●		●			
46	SKC-19				●	●		●	●							●	●	●	●			●						●		●			
47	SKC-20				●			●	●	●																		●		●			
48	SKC-44				●			●	●							●	●				●							●		●			
49	SKC-45							●	●	●						○														●			
50	SKC-47							●	●	●																				●			
51	SKC-6?				●			●	●	●						●												●		●			

*1-7 ankaramite
8-10 clinopyroxene-phyric basalt
11-33 alkali basalt
34-43 trachybasalt
44-51 trachyte

	alteration assemblage															amygdale assemblage								primary mineral assemblage								
	iddingsite after ol	serpentine after ol.	hematite after ol.	chlorite	pumpellyite	analcime	calcite	opaque	quartz	natrolite(?)	white mica		sphene	hornblende	albitized plagioclase	calcite	opaque	pumpellyite	chlorite	quartz	adularia	analcime	sphene	clinopyroxene ph.	clinopyroxene mph.	clinopyroxene gm.	plagioclase ph.	plagioclase mph.	plagioclase gm.	olivine-ph. mph.	orthopyroxene	opaque mph. or gm.
Chimney Cove slice																																
CC-ANK		●		●			●	●																●		●			●	●		●
CC-4				●			●	●							●											●			●			●
CC-5				●			●	●			●				●									●	●	●	●	●	●	●		
CC-6				●			●	●			●		●		●									●		●	●	●	●			●
CC-24				●			●	●			●		●		●												●		●			
CC-25				●			●	●							●																	
CC-27				●			●	●			●		●		●									●	●	●	●		●			●
CC-28				●			●	●			●		●		●									●	●	●			●			●
CC-30				●			●	●			●		●		●									●	●	●	●		●			●
CC-32				●			●	●			●		●		●									●	●	●			●			●
Western Head slice																																
WH-6				●			●	●			●															●			●			●
WH-8				●			●	●			●		●		●											●			●			●
WHC-2				●			●	●			●		●		●	●			●							●			●			●
Beverley Head slice																																
BH-1				●				●					●		●																	
BH-62				●			●	●			●				●																	
Little Port slice assemblage																																
LP-1				●			●	●			●		●		●											●	●		●			
LP-2				●			●	●			●		●		●				●							●	●		●			
LP-5				●			●	●			●		●		●											●		●	●			
LP-6				●				●	●		●		●		●	●			●	●								●	●			●
LP-9				●		●	●	●			●		●		●	●			●							●	●		●			
LP-10				●		●	●	●	●		●		●		●											●	●	●	●			●
LP-11				●			●	●			●		●		●	●	●		●							●			●			●
LP-12				●			●	●			●		●		●	●	●		●				●			●			●			
LP-13				●			●	●			●				●	●	●		●										●			●
LP-14				●			●	●			●		●		●											●			●			
LP-16				●			●	●			●		●		●	●			●							●		●	●			
LP-17				●			●	●			●				●											●			●			
YK.HBR.				●			●	●			●				●											●			●			
TRLP-6				●							●				●													●	●			
GI-1				●			●	●																●	●	●	●	●	●		●	●
GI-5				●			●	●	●															●	●	●	●		●		●	●
GI-12				●				●																●	●	●	●	●	●		●	●
Miscellaneous																																
SK-6A				●	●		●	●							●											●			●			●
SK-7A				●	●		●	●							●											●			●			●
OMCV				●				●			●														●	●	●		●			●

APPENDIX B.

LISTINGS OF CHEMICAL DATA

In the tabulation of trace elements, the integer zero indicates that the elemental concentration is below the level of detection of the x-ray fluourescence.

Major elements and Nb and Y were not determined for samples TR-7 and TR-12.

In the analyses of mafic dykes and lavas of the Little Port Complex supplied by Dr. W. R. Church, Fe_2O_3 and L.O.I. were not determined. Total iron is listed as FeO.

Code for groundmass clinopyroxene compositions as determined on the electron microprobe:

e.g. SKC-31-1,n (this corresponds to the composition of groundmass clinopyroxenes in crystals 1,2,3,...n of specimen SKC-31. The last analysis, n, is not a true microprobe analysis; it is the mean of the preceding n-1 analyses. The n'th analysis (in this example SKC-31-19) is also listed in Table 6. in the text with the standard deviations for each oxide. (Only the specimen supplied by J. O. Berkland, BK-198, is not listed in Table 6. since it is outside the writer's field-area.))

Code for the compositions of clinopyroxene, orthopyroxene and plagioclase phenocrysts and microphenocrysts, as determined on the electron microprobe:

Phenocryst and microphenocryst are abbreviated to PH, and MPH, respectively.

e.g. SKC-31-MPH-1-1 indicates the composition of microphenocryst number 1, analysis 1. SKC-31-MPH-99 is the mean composition of all the analysed microphenocrysts in specimen SKC-31. Likewise, SKC-31-MPH-0 and SKC-31-MPH-00 represents the mean composition of the cores and rims, respectively, of all the analysed microphenocrysts in specimen SKC-31. This last sentence is only true for pyroxene analyses.

Code for groudmass plagioclase compositions as determined on the electron microprobe:

This is similar to the code for groundmass clinopyroxenes, except that the n'th analysis is omitted. Thus the final analysis in a series of analyses of groundmass plagioclase is not a mean value, but a true analysis.

B.1 Listings of Whole Rock Analyses

** ANKARAMITE **   (SKINNER COVE FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	SKC 23	SKC 24	SKC 25A	SKC 25B	SKC 27	SKC 41	SKC 66
SIO2	41.40	41.10	41.20	41.10	40.10	43.00	38.30
TIO2	2.82	3.62	3.86	3.70	3.42	3.42	2.80
AL2O3	12.90	13.30	13.20	13.20	12.80	13.20	11.00
FE2O3	4.59	8.73	7.64	7.73	7.57	7.76	6.90
FEO	7.69	4.21	4.78	4.94	4.70	4.93	5.58
MNO	0.40	0.21	0.21	0.42	0.21	0.06	0.24
MGO	13.05	7.78	7.28	7.87	9.17	5.54	10.67
CAO	8.28	12.02	11.52	11.83	11.83	13.30	14.71
NA2O	1.81	2.51	2.61	2.58	1.87	2.81	1.61
K2O	0.43	0.64	1.20	0.64	1.18	0.72	0.15
P2O5	0.71	0.75	0.82	0.79	0.83	0.66	0.50
LOI	6.55	4.96	5.06	4.06	4.86	5.03	6.12
TOTAL	100.63	99.83	99.38	98.86	98.54	100.43	98.58
ZR	210	209	218	208	211	207	195
SR	448	686	648	715	672	700	465
RB	7	8	17	9	19	11	1
ZN	104	104	105	107	100	101	108
BA	204	336	362	337	335	287	181
NB	45	45	50	45	43	45	37
GA	20	19	19	19	17	18	16
PB	6	6	6	6	7	6	6
NI	131	100	106	118	116	118	439
LA	70	75	74	75	73	69	67
CR	174	116	121	121	109	121	525
V	271	248	249	261	248	245	275
Y	19	20	21	20	20	21	17
CE	112	108	117	116	102	111	94

** PYROX-PHYRIC BASALT ** (SKINNER CV. FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	SKC 36	SKC 37	SKC 39
SIO2	41.10	39.90	40.20
TIO2	4.52	4.48	4.20
AL2O3	14.30	14.20	13.80
FE2O3	8.00	6.86	7.09
FEO	5.63	6.75	6.36
MNO	0.20	0.21	0.02
MGO	6.69	7.35	8.34
CAO	11.30	11.91	12.05
NA2O	2.55	2.06	1.77
K2O	0.45	0.60	0.38
P2O5	0.79	0.75	0.63
LOI	3.26	4.33	4.14
TOTAL	98.79	99.40	98.98
ZR	208	185	208
SR	810	949	784
RB	4	5	3
ZN	123	115	117
BA	258	285	377
NB	52	51	50
GA	18	18	19
PB	6	6	6
NI	79	88	98
LA	80	79	79
CR	63	66	109
V	262	265	297
Y	20	20	20
CE	131	124	114

** ALKALI BASALT ** (SKINNER COVE FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	SKC 21	SKC 30	SKC 31A	SKC 32	SKC 33	SKC 34	SKC 38
SIO2	45.90	46.80	46.70	46.40	47.50	44.50	41.40
TIO2	2.88	2.70	2.72	2.92	2.88	3.74	3.70
AL2O3	15.90	15.80	16.50	16.20	15.40	15.50	15.50
FE2O3	6.71	3.88	3.64	5.42	6.56	3.89	3.59
FEO	3.63	6.58	6.85	5.40	4.17	6.97	7.79
MNO	0.37	0.18	0.20	0.20	0.20	0.06	0.28
MGO	4.95	4.71	4.24	3.68	2.93	7.39	6.67
CAO	6.12	5.28	7.40	7.91	7.74	4.04	7.21
NA2O	5.02	4.11	3.72	4.01	4.58	3.85	4.36
K2O	0.98	2.78	2.85	2.27	1.77	1.66	0.76
P2O5	1.50	1.16	1.19	1.31	0.90	1.04	0.96
LOI	4.79	4.71	4.03	3.50	4.80	6.47	6.12
TOTAL	98.75	98.69	100.04	99.22	99.43	99.11	98.34
ZR	254	195	113	184	233	260	253
SR	754	961	1193	1010	843	718	472
RB	10	29	36	31	22	21	7
ZN	124	116	124	113	113	120	120
BA	355	1411	903	872	589	3652	635
NB	90	77	76	74	74	86	64
GA	22	18	20	19	18	22	17
PB	7	7	7	7	7	7	7
NI	9	0	5	3	0	3	36
LA	129	115	109	104	99	104	98
CR	0	0	0	0	0	0	22
V	153	127	125	132	138	188	244
Y	24	23	25	24	22	25	21
CE	179	176	171	161	163	175	147

** ALKALI BASALT ** (SKINNER COVE FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	SKC 40	SKC 46	SKC 48	SKC 49	SKC 50	SKC 51	SKC 53
SIO2	46.90	42.20	45.10	45.60	46.30	44.80	42.30
TIO2	3.14	4.04	2.40	3.24	3.30	3.24	3.20
AL2O3	14.60	14.90	16.40	16.60	16.60	16.10	15.10
FE2O3	8.69	9.12	8.66	4.84	4.19	4.04	4.77
FEO	3.66	4.39	4.81	4.84	5.98	6.66	6.76
MNO	0.24	0.16	0.24	0.42	0.24	0.19	0.22
MGO	4.46	6.79	5.06	5.48	3.00	5.97	6.03
CAO	7.11	8.04	6.16	6.24	5.31	5.65	5.76
NA2O	5.22	3.10	3.65	4.50	5.13	4.15	4.28
K2O	1.01	1.14	1.13	1.35	1.65	3.16	2.33
P2O5	0.66	0.73	1.71	1.60	1.08	1.07	0.84
LOI	4.56	7.05	4.38	6.14	6.65	6.86	7.78
TOTAL	100.25	101.66	99.74	100.85	99.43	101.89	99.37
ZR	236	208	141	162	286	274	259
SR	659	811	1119	978	500	289	233
RB	11	15	13	16	19	32	24
ZN	111	127	141	113	115	113	115
BA	575	421	647	373	604	942	633
NB	56	56	82	62	87	80	73
GA	20	18	20	22	23	24	23
PB	8	6	7	7	7	7	6
NI	21	2	0	3	5	11	38
LA	89	72	125	106	113	99	104
CR	18	1	0	1	1	0	23
V	248	255	104	159	198	187	238
Y	21	21	26	24	23	24	23
CE	130	123	227	169	178	154	152

** ALKALI BASALT ** (SKINNER COVE FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	SKC 54	SKC 56	SKC 57	SKC 58	SKC 60	SKC 63	SKC 64
SIO2	48.60	44.40	42.30	41.50	44.40	44.40	43.60
TIO2	1.94	2.96	3.64	3.60	3.12	3.58	3.52
AL2O3	17.00	13.50	14.70	15.70	16.70	14.90	16.90
FE2O3	2.45	6.52	4.19	4.57	3.29	10.10	7.12
FEO	6.09	4.75	7.19	6.33	7.40	3.99	4.34
MNO	0.20	0.36	0.24	0.60	0.26	0.39	0.29
MGO	3.13	3.89	6.08	6.71	5.46	3.71	3.43
CAO	5.81	10.00	7.44	6.65	6.94	9.85	8.49
NA2O	4.98	4.33	4.16	4.94	4.77	2.68	3.76
K2O	2.79	1.44	1.04	0.94	0.71	1.07	1.33
P2O5	0.96	0.60	0.46	0.87	1.66	1.38	2.18
LOI	4.68	5.82	6.78	6.61	5.77	3.49	4.11
TOTAL	98.63	98.57	98.22	99.02	100.48	99.54	99.07
ZR	198	205	261	250	214	186	164
SR	950	352	406	380	789	950	1037
RB	27	23	10	14	7	10	11
ZN	140	109	116	108	123	128	120
BA	1500	1102	651	680	548	367	579
NB	102	43	64	72	60	53	72
GA	19	16	19	21	18	15	16
PB	8	7	7	7	6	6	7
NI	9	83	5	42	13	32	2
LA	126	49	92	98	98	77	113
CR	0	97	0	19	0	37	0
V	90	256	205	236	159	217	163
Y	24	20	22	21	23	21	23
CE	198	89	143	148	169	135	182

** ALKALI BASALT ** (SKINNER COVE FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	SKC 71	SK 66
SIO2	40.10	40.80
TIO2	3.96	4.16
AL2O3	14.40	15.10
FE2O3	4.44	5.48
FEO	7.53	7.38
MNO	0.84	0.36
MGO	7.34	7.05
CAO	7.90	10.95
NA2O	2.47	1.96
K2O	1.42	0.80
P2O5	0.72	0.76
LOI	7.44	3.88
TOTAL	98.56	98.68
ZR	226	601
SR	735	880
RB	20	8
ZN	116	123
BA	447	460
NB	61	57
GA	19	18
PB	6	6
NI	18	58
LA	80	82
CR	8	65
V	255	262
Y	22	20
CE	124	118

** TRACHYBASALT ** (SKINNER COVE FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	SKC 14	SKC 17	SKC 26	SKC 28	SKC 29	SK 29	SKC 42
SIO2	52.20	52.80	52.00	48.80	46.90	48.10	49.90
TIO2	1.18	1.20	1.70	1.48	1.82	2.26	2.88
AL2O3	16.80	17.30	16.60	15.60	15.50	16.70	16.90
FE2O3	3.52	3.99	6.06	2.97	6.80	2.65	7.38
FEO	5.96	5.83	2.56	6.01	2.14	6.62	3.01
MNO	0.22	0.14	0.18	0.11	0.21	0.23	0.22
MGO	3.06	2.81	3.24	7.16	2.73	3.84	3.53
CAO	2.65	2.60	3.12	2.47	8.00	5.42	5.18
NA2O	5.47	5.86	4.49	4.34	5.98	4.56	4.51
K2O	3.00	3.54	4.55	1.99	1.35	3.00	0.73
P2O5	0.92	0.85	0.74	0.78	0.67	0.96	0.92
LOI	3.93	4.24	4.64	6.92	6.50	5.48	3.62
TOTAL	98.91	101.16	99.88	98.63	98.60	99.82	98.78
ZR	360	385	373	334	333	318	202
SR	509	540	520	488	535	580	910
RB	31	28	58	11	18	35	10
ZN	130	132	120	141	132	132	142
BA	987	643	1187	1186	327	1197	335
NB	121	127	102	92	98	100	76
GA	19	20	21	22	21	21	17
PB	8	8	8	8	8	7	7
NI	6	18	25	7	20	2	15
LA	139	148	111	122	122	126	102
CR	0	0	0	0	6	0	0
V	39	39	101	99	100	102	174
Y	27	29	26	24	23	25	23
CE	232	252	172	191	174	198	164

** TRACHYBASALT ** (SKINNER COVE FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	SKC 43	SKC 59	SKC 68
SIO2	50.70	47.80	52.40
TIO2	1.30	2.12	1.46
AL2O3	16.70	17.40	17.80
FE2O3	4.00	4.14	2.25
FEO	6.77	5.10	4.00
MNO	0.30	0.08	0.13
MGO	1.00	4.49	2.22
CAO	2.51	4.00	6.14
NA2O	1.97	4.18	5.06
K2O	8.20	3.47	2.83
P2O5	0.68	1.12	0.50
LOI	3.36	5.30	4.25
TOTAL	97.49	99.20	99.04
ZR	330	223	245
SR	549	897	853
RB	87	33	28
ZN	111	137	157
BA	6816	1274	1079
NB	101	109	123
GA	19	21	20
PB	7	7	6
NI	9	7	2
LA	108	133	100
CR	0	0	0
V	37	96	49
Y	33	25	28
CE	191	199	176

** TRACHYTE ** (SKINNER COVE FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	SKC 14B	SKC 18	SKC 19	SKC 20	SKC 44	SKC 45	SKC 47
SIO2	59.70	59.00	56.70	59.70	60.90	60.60	60.40
TIO2	0.02	0.14	0.20	0.24	0.80	0.10	0.14
AL2O3	18.40	18.80	18.80	18.80	18.90	18.40	18.70
FE2O3	2.59	4.77	3.56	2.02	1.89	1.61	1.61
FEO	2.04	0.93	2.00	2.37	2.08	0.71	2.30
MNO	0.16	0.12	0.20	0.23	0.22	0.09	0.14
MGO	1.11	0.34	0.14	1.56	1.78	0.08	2.21
CAO	0.86	1.08	2.48	1.14	1.47	2.27	0.10
NA2O	5.73	6.14	7.00	5.18	4.72	3.66	4.26
K2O	6.31	5.90	4.98	6.67	5.50	8.40	7.50
P2O5	0.04	0.10	0.04	0.10	0.04	0.06	0.04
LOI	2.19	1.18	2.10	2.24	3.68	3.28	3.36
TOTAL	99.15	98.50	98.20	100.25	101.98	99.26	100.76
ZR	1310	227	716	700	997	803	881
SR	163	330	287	361	81	91	167
RB	142	101	59	97	84	68	84
ZN	201	146	142	143	150	116	169
BA	782	403	292	421	490	353	398
NB	305	188	195	197	215	186	218
GA	34	28	33	32	34	26	33
PB	14	11	10	9	8	10	10
NI	24	16	15	16	17	19	14
LA	233	156	162	160	194	153	195
CR	0	0	0	0	0	0	0
V	0	5	4	2	2	4	3
Y	54	37	33	35	37	35	36
CE	335	229	690	228	260	217	267

** TRACHYTE **   (SKINNER COVE FM. * TROUT RIVER SLICE * TYPE SECTION)

SAMPLE	*	SKC 65	*
SIO2	*	63.30	*
TIO2	*	0.38	*
AL2O3	*	17.10	*
FE2O3	*	2.53	*
FEO	*	2.61	*
MNO	*	0.10	*
MGO	*	0.99	*
CAO	*	1.11	*
NA2O	*	7.81	*
K2O	*	2.16	*
P2O5	*	0.10	*
LOI	*	2.14	*
TOTAL	*	100.33	*
ZR	*	456	*
SR	*	351	*
RB	*	16	*
ZN	*	92	*
BA	*	309	*
NB	*	123	*
GA	*	19	*
PB	*	9	*
NI	*	8	*
LA	*	167	*
CR	*	0	*
V	*	10	*
Y	*	26	*
CE	*	280	*

** C-PYROX / PLAGIO-PHYRIC MAFIC LAVA ** (SKINNER CV. FM. * CHIMNEY CV. SLICE)

SAMPLE	CC ANK	CC 4	CC 5	CC 6	CC 24	CC 25	CC 27
SIO2	41.90	44.60	45.00	44.00	45.10	42.30	44.50
TIO2	3.40	1.31	2.86	3.02	2.20	2.66	3.00
AL2O3	10.50	14.50	16.00	16.10	15.30	16.20	15.80
FE2O3	5.27	8.52	4.69	3.93	2.80	1.95	4.43
FEO	7.06	4.96	6.82	7.09	8.23	12.58	6.52
MNO	0.22	0.20	0.23	0.26	0.24	0.16	0.18
MGO	9.71	7.63	5.14	4.95	8.86	6.76	5.14
CAO	13.80	5.15	8.37	8.73	2.95	1.54	8.07
NA2O	1.70	4.92	4.13	3.83	3.59	4.44	4.16
K2O	1.03	0.43	0.73	0.71	0.40	0.68	0.88
P2O5	0.80	0.06	0.80	1.20	0.56	0.64	1.20
LOI	3.85	8.08	4.17	4.62	7.87	9.78	5.05
TOTAL	99.24	100.36	98.94	98.44	98.10	99.69	98.93
ZR	211	125	0	0	181	156	0
SR	689	250	1555	2231	206	93	1404
RB	11	8	6	2	5	7	7
ZN	102	100	119	126	132	153	114
BA	1930	125	1832	1067	296	1128	667
NB	48	4	61	65	29	30	64
GA	15	16	16	15	21	23	17
PB	6	0	6	6	6	7	7
NI	223	680	38	38	120	172	41
LA	63	17	86	98	45	39	97
CR	328	121	43	46	80	79	40
V	275	308	193	186	218	195	180
Y	19	19	20	20	18	19	20
CE	99	28	147	152	64	60	150

** C-PYROX / PLAGIO-PHYRIC MAFIC LAVA ** (SKINNER CV. FM. * CHIMNEY CV. SLICE)

SAMPLE	CC 28	CC 30	CC 32
SIO2	39.60	47.00	41.70
TIO2	4.20	2.64	3.90
AL2O3	14.50	14.90	15.00
FE2O3	4.72	4.69	5.19
FEO	7.64	5.14	6.92
MNO	0.20	0.23	0.20
MGO	6.15	4.38	5.38
CAO	11.39	8.00	10.46
NA2O	2.21	5.44	2.43
K2O	1.73	0.63	2.06
P2O5	1.20	0.74	1.04
LOI	4.68	4.71	5.33
TOTAL	98.22	98.50	99.61
ZR	206	183	243
SR	998	934	813
RB	19	6	29
ZN	118	112	122
BA	2100	1307	1591
NB	83	59	85
GA	20	15	21
PB	6	6	8
NI	37	21	35
LA	116	86	101
CR	10	31	7
V	235	165	229
Y	23	20	24
CE	166	137	163

** MAFIC LAVAS/DYKES ** (LITTLE PORT COMPLEX * BOTTLE CV., VIRGIN MTN. SLICES)

SAMPLE	LP 1	LP 2	LP 5	LP 6	LP 9	LP 10	LP 11
SIO2	46.20	47.30	49.50	53.30	45.40	51.00	47.30
TIO2	1.00	2.44	2.22	1.00	1.30	0.76	1.54
AL2O3	16.50	13.30	13.20	11.90	16.90	16.40	14.60
FE2O3	1.30	3.42	2.92	4.22	2.52	1.36	2.82
FEO	7.21	7.94	9.26	10.18	5.15	5.47	7.59
MNO	0.21	0.28	0.24	0.24	0.13	0.14	0.18
MGO	7.86	4.82	5.24	1.40	5.58	6.48	7.90
CAO	8.70	7.57	7.55	6.32	10.04	4.94	7.38
NA2O	3.19	5.01	5.20	3.56	4.09	5.02	4.32
K2O	0.88	0.19	0.14	0.41	1.15	2.06	0.08
P2O5	0.08	0.18	0.24	0.46	0.08	0.08	0.12
LOI	5.37	6.77	2.97	7.60	6.74	4.64	5.55
TOTAL	98.50	99.22	98.68	100.59	99.08	98.35	99.38
ZR	164	193	163	357	173	162	118
SR	675	425	132	82	760	347	138
RB	19	3	1	5	10	19	2
ZN	93	109	120	162	84	75	103
BA	1516	592	37	57	221	1468	122
NB	1	6	6	11	4	2	3
GA	18	16	17	21	17	14	18
PB	7	6	7	6	7	6	6
NI	144	30	52	39	56	31	87
LA	9	24	16	31	9	7	12
CR	238	47	82	0	123	88	180
V	229	337	311	46	210	164	275
Y	19	24	29	56	17	15	22
CE	14	29	34	90	19	8	23

** MAFIC LAVAS/DYKES ** (LITTLE PORT COMPLEX * BOTTLE CV., VIRGIN MTN. SLICES)

SAMPLE	LP 12	LP 13	LP 14	LP 16	LP 17	YK HBR
SIO2	48.30	45.40	46.90	48.90	45.20	44.60
TIO2	1.56	1.40	2.00	2.02	1.51	1.94
AL2O3	14.20	15.10	14.20	14.40	18.70	14.70
FE2O3	3.06	3.06	3.54	2.93	2.20	2.79
FEO	7.64	5.53	8.65	7.60	5.59	7.48
MNO	0.17	0.25	0.16	0.16	0.14	0.25
MGO	6.10	4.42	6.33	5.33	5.07	6.46
CAO	9.26	7.86	9.47	8.66	8.14	6.81
NA2O	3.72	5.48	4.14	5.34	4.79	4.76
K2O	0.60	0.39	0.04	0.23	1.02	0.35
P2O5	0.12	0.14	0.18	0.18	0.14	0.26
LOI	3.40	9.04	4.57	4.68	6.48	7.85
TOTAL	98.13	98.07	100.18	100.43	98.98	98.25
ZR	193	133	123	154	140	191
SR	639	163	118	203	875	318
RB	6	5	1	3	11	5
ZN	98	107	94	105	90	118
BA	67	323	39	60	325	399
NB	2	2	5	5	4	10
GA	16	18	17	16	16	17
PB	6	9	7	7	6	7
NI	53	46	38	39	31	45
LA	12	9	15	18	2	19
CR	82	177	49	52	66	36
V	255	176	289	311	235	350
Y	21	18	22	23	18	22
CE	25	22	28	34	10	37

** APHYRIC MAFIC LAVA ** LITTLE PORT COMPLEX * WESTERN HEAD SLICE

SAMPLE	* WH 6	* WH 8	* WHC 2	*
SIO2	47.70	47.70	48.60	
TIO2	1.32	1.63	1.36	
AL2O3	14.10	13.60	14.10	
FE2O3	1.83	3.18	2.22	
FEO	8.29	8.31	6.92	
MNO	0.18	0.23	0.17	
MGO	8.60	7.32	7.00	
CAO	9.36	10.77	10.32	
NA2O	3.17	3.44	3.71	
K2O	0.45	0.06	0.20	
P2O5	0.10	0.12	0.06	
LOI	3.84	4.08	4.09	
TOTAL	98.94	100.44	98.75	
ZR	127	98	140	
SR	218	118	352	
RB	5	1	2	
ZN	103	102	100	
BA	34	23	35	
NB	4	4	4	
GA	15	17	14	
PB	6	6	6	
NI	64	31	54	
LA	10	11	6	
CR	242	77	257	
V	245	242	261	
Y	20	21	20	
CE	14	15	11	

** MAFIC DYKE/LAVA ** (BEVERLEY HEAD SLICE (COMPLEX IMBRICATED SLICE))

SAMPLE	BH 1	BH 62
SIO2	48.60	47.40
TIO2	1.60	1.76
AL2O3	13.20	12.70
FE2O3	6.17	5.56
FEO	9.50	7.90
MNO	0.31	0.12
MGO	6.12	12.00
CAO	8.02	1.20
NA2O	3.48	1.31
K2O	0.29	0.64
P2O5	0.14	0.16
LOI	2.57	7.93
TOTAL	100.00	98.68
ZR	112	93
SR	139	42
RB	2	7
ZN	123	101
BA	172	56
NB	9	7
GA	18	18
PB	6	7
NI	63	75
LA	24	17
CR	67	82
V	444	440
Y	28	22
CE	37	30

** PLAG-2 PYROXENE BASALTIC ANDESITE (GREGORY I.) LITTLE PORT COMPLEX **

SAMPLE	GI 1	GI 5	GI 12
SIO2	49.70	59.90	49.50
TIO2	0.60	0.44	0.82
AL2O3	18.50	15.40	19.70
FE2O3	3.19	1.54	3.30
FEO	4.86	2.38	4.10
MNO	0.22	0.15	0.17
MGO	6.54	3.06	4.94
CAO	9.44	8.26	8.50
NA2O	3.29	3.82	2.95
K2O	0.23	1.53	0.41
P2O5	0.10	0.10	0.10
LOI	2.89	3.81	4.01
TOTAL	99.56	100.39	98.50
ZR	165	154	210
SR	395	253	321
RB	2	27	5
ZN	97	87	106
BA	92	188	126
NB	5	1	7
GA	17	17	21
PB	7	8	9
NI	30	28	12
LA	31	0	30
CR	95	127	29
V	218	159	206
Y	13	13	16
CE	32	9	50

** MAFIC TO INTERMEDIATE(MONZONITE) PLUTONIC ** MELANGE, WALLACE BROOK

SAMPLE	*	SK 6A	*	SK 7A	*
SIO2	*	46.40	*	53.70	*
TIO2	*	2.10	*	0.96	*
AL2O3	*	15.80	*	17.30	*
FE2O3	*	4.67	*	3.35	*
FEO	*	7.35	*	4.26	*
MNO	*	0.24	*	0.18	*
MGO	*	4.98	*	2.48	*
CAO	*	3.75	*	2.89	*
NA2O	*	4.00	*	5.55	*
K2O	*	2.67	*	3.74	*
P2O5	*	1.58	*	0.92	*
LOI	*	5.03	*	3.57	*
TOTAL	*	98.57	*	98.90	*
ZR	*	227	*	423	*
SR	*	839	*	518	*
RB	*	29	*	38	*
ZN	*	126	*	115	*
BA	*	1203	*	1222	*
NB	*	75	*	127	*
GA	*	20	*	20	*
PB	*	7	*	8	*
NI	*	0	*	8	*
LA	*	122	*	149	*
CR	*	0	*	0	*
V	*	78	*	43	*
Y	*	27	*	29	*
CE	*	214	*	226	*

* MISCELLANEOUS * ((TRLP-6-RHYOLITE,TRLP-10-BASALT)LITTLE PORT CPLX) OMCV-DYKE

SAMPLE	TRLP-6	TRLP-10	OMCV	TR-7	TR-12
SIO2	76.80	47.10	47.80	0.0	0.0
TIO2	0.18	1.71	2.80	0.0	0.0
AL2O3	10.80	14.50	13.10	0.0	0.0
FE2O3	0.0	5.79	2.52	0.0	0.0
FEO	1.22	5.79	12.58	0.0	0.0
MNO	0.03	0.17	0.27	0.0	0.0
MGO	1.08	3.29	4.80	0.0	0.0
CAO	0.54	9.43	8.83	0.0	0.0
NA2O	3.02	6.20	3.34	0.0	0.0
K2O	3.89	0.12	0.58	0.0	0.0
P2O5	0.05	0.05	0.31	0.0	0.0
LOI	1.46	10.08	2.93	0.0	0.0
TOTAL	99.07	104.23	99.86	0.0	0.0
ZR	92	61	169	420	496
SR	52	46	185	660	726
RB	30	1	9	33	12
ZN	65	89	125	159	128
CU	18	29	66	16	13
BA	420	32	106	537	513
NB	7	6	8	0	0
GA	8	21	22	23	24
PB	17	0	0	5	2
NI	3	80	16	15	6
CR	10	210	26	12	6
V	3	4190	466	130	62
Y	27	190	31	0	0

* MAFIC DYKES AND LAVAS * LITTLE PORT COMPLEX (DATA OF W.R. CHURCH)

SAMPLE	LP-DYKE	LP-DYKE	LP-DYKE	LP-LAVA	LP-LAVA	LP-LAVA
SIO2	47.80	48.10	48.50	45.80	47.70	45.80
TIO2	0.93	1.39	1.45	2.07	2.20	2.25
AL2O3	19.40	16.10	16.70	17.30	13.30	16.40
FE2O3	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.24	9.50	9.81	9.06	13.50	15.10
MNO	0.15	0.20	0.23	0.27	0.22	0.24
MGO	7.94	7.55	7.07	5.25	5.82	6.70
CAO	10.02	10.15	8.23	6.30	8.00	7.70
NA2O	2.20	2.25	2.23	3.89	4.10	1.72
K2O	1.84	1.24	1.51	1.01	0.02	2.34
P2O5	0.33	0.02	0.09	0.17	0.13	0.14
LOI	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	97.85	96.50	95.82	91.12	94.99	98.39
ZR	58	99	140	145	141	148
SR	302	292	270	216	182	140
RB	36	22	26	8	19	3
BA	229	149	213	1384	1115	2[illegible]6
NI	88	28	62	15	10	5
CR	217	196	170	35	19	34
Y	15	15	29	24	29	31

* UPPER LAVAS * BLOW-ME-DOWN MASSIF, BAY OF ISLANDS COMPLEX (DATA OF EINARSON)

SAMPLE	4 8	4 23	4 25	4 28	4 66	4 68	4 70
SIO2	59.46	45.37	54.36	46.49	47.86	47.45	54.57
TIO2	1.16	0.97	1.66	1.51	1.57	1.31	1.41
AL2O3	15.14	17.37	13.67	14.84	14.83	15.01	14.47
FE2O3	2.32	3.05	5.62	3.40	4.71	4.27	1.64
FEO	5.26	4.87	4.37	5.83	6.82	5.65	6.39
MNO	0.08	0.14	0.10	0.14	0.17	0.15	0.11
MGO	1.26	9.08	5.34	6.77	7.05	7.88	4.15
CAO	3.54	8.93	4.41	11.52	7.30	11.07	5.72
NA2O	6.74	2.42	4.10	2.47	3.62	2.31	4.92
K2O	0.40	0.12	0.60	0.11	0.10	0.02	0.40
P2O5	0.18	0.12	0.14	0.14	0.20	0.14	0.14
LOI	4.10	7.38	5.05	8.50	5.65	4.69	6.58
TOTAL	99.64	99.82	99.42	101.72	99.88	99.95	100.50
ZR	161	79	153	105	97	95	82
SR	103	132	126	159	168	112	212
RB	10	4	15	3	3	2	3
ZN	81	68	100	86	102	92	80
CU	15	69	58	69	74	97	50
BA	23	55	56	19	23	20	19
NB	8	6	7	7	6	6	5
GA	18	16	18	19	21	18	14
PB	2	2	0	0	0	8	0
NI	9	171	38	49	68	43	95
CR	79	290	120	71	134	101	169
V	205	167	351	291	347	263	282

* UPPER LAVAS * BLOW-ME-DOWN MASSIF, BAY OF ISLANDS COMPLEX (DATA OF EINARSON)

SAMPLE	A 73	A 76	A 79	A 82	A 91	A 95	A 101
SIO2	49.41	49.57	49.27	47.08	45.82	48.77	48.45
TIO2	1.56	1.37	2.17	1.20	1.53	1.44	1.78
AL2O3	15.12	16.96	16.17	15.73	14.80	15.60	15.07
FE2O3	3.39	4.25	2.16	1.46	5.64	3.21	2.73
FEO	8.20	4.72	8.92	7.11	5.54	6.22	7.32
MNO	0.17	0.11	0.11	0.17	0.08	0.15	0.16
MGO	6.67	5.07	4.28	7.09	6.82	6.26	6.00
CAO	4.86	6.05	4.20	10.61	5.70	8.31	8.36
NA2O	4.37	5.41	5.67	3.67	3.32	4.55	4.49
K2O	0.74	0.68	0.21	0.38	0.65	0.40	0.06
P2O5	0.14	0.24	0.24	0.04	0.24	0.10	0.18
LOI	5.53	5.88	4.30	5.16	9.75	4.70	4.10
TOTAL	100.16	100.31	97.70	99.70	99.89	99.71	98.70
ZR	88	117	202	84	106	110	137
SR	217	83	98	284	149	274	226
RB	2	9	4	5	5	5	3
ZN	94	65	117	83	113	82	136
CU	44	55	59	97	34	96	92
BA	85	15	36	44	50	45	32
NB	7	7	8	5	7	6	8
GA	19	21	20	15	20	15	21
PB	0	0	4	0	22	0	2
NI	84	42	24	72	13	64	30
CR	156	129	44	271	14	221	42
V	359	289	408	252	320	267	332

* UPPER LAVAS * BLOW-ME-DOWN MASSIF, BAY OF ISLANDS COMPLEX (DATA OF EINARSON)

SAMPLE	4 106	4 131	4 134	4 138	5 96	5 258-3	5 574
SIO2	48.45	48.33	51.19	48.45	50.21	45.38	47.24
TIO2	1.39	1.31	1.32	1.80	1.64	1.43	1.32
AL2O3	16.73	15.78	14.60	14.13	14.46	14.81	14.88
FE2O3	1.77	4.12	1.83	3.36	5.44	3.98	4.20
FEO	6.48	4.90	7.40	7.52	4.44	5.25	5.63
MNO	0.14	0.15	0.16	0.15	0.15	0.22	0.16
MGO	6.00	7.96	7.64	6.69	5.80	5.14	7.21
CAO	6.65	10.87	8.87	9.26	10.97	13.22	12.03
NA2O	5.39	2.52	4.16	4.28	3.32	3.81	2.39
K2O	0.27	0.05	0.29	0.10	0.09	0.09	0.09
P2O5	0.04	0.24	0.20	0.18	0.18	0.15	0.13
LOI	7.30	4.35	3.54	4.70	4.07	6.75	4.87
TOTAL	100.61	100.58	101.20	100.62	100.77	100.23	100.15
ZR	77	94	106	137	121	116	97
SR	223	146	369	129	134	104	127
RB	3	2	5	3	1	3	4
ZN	85	78	77	108	73	85	80
CU	56	99	93	82	73	83	97
BA	23	4	52	18	29	7	0
NB	6	5	6	6	5	7	6
GA	18	20	15	20	17	20	21
PB	0	0	0	1	0	0	6
NI	246	68	45	40	30	50	57
CR	283	225	237	43	62	184	238
V	359	254	251	309	317	267	260

* JPPER LAVAS * BLOW-ME-DOWN MASSIF. BAY OF ISLANDS COMPLEX (DATA OF EINARSON)

SAMPLE	5 575	5 576	5 578-1	5 579	5 580
SIO2	47.91	49.12	47.61	47.24	46.75
TIO2	1.27	1.65	1.25	1.10	1.09
AL2O3	15.41	14.52	15.72	17.51	17.26
FE2O3	4.51	3.75	3.64	3.71	3.51
FEO	5.[illegible]1	5.51	4.73	4.54	4.81
MNO	0.15	0.16	0.15	0.14	0.15
MGO	7.15	7.28	7.22	5.86	7.22
CAO	12.32	8.24	12.08	12.58	12.06
NA2O	2.43	4.24	2.61	2.56	2.26
K2O	0.06	0.23	0.07	0.07	0.11
P2O5	0.11	0.17	0.12	0.07	0.07
LCI	4.22	[illegible].72	3.96	4.31	4.40
TOTAL	100.55	99.59	99.16	99.69	99.69
ZR	96	140	95	81	82
SR	128	340	148	148	147
RB	1	2	1	2	4
ZN	80	85	81	66	65
CU	93	84	102	96	92
BA	34	9	12	11	21
NB	5	8	5	6	6
GA	17	17	23	18	16
PB	0	0	0	0	0
NI	60	45	88	92	109
CR	222	206	235	238	211
V	251	283	235	228	198

DYKES, BLOW-ME-DOWN MASSIF, BAY OF ISLANDS COMPLEX (DATA OF R. COISH)

SAMPLE	RC-76	RC-77	RC-78	RC-79	RC-80	RC-81	RC-82
SIO2	40.70	41.40	46.80	48.40	50.10	49.40	47.20
TIO2	1.17	1.29	1.24	1.68	1.64	1.35	1.19
AL2O3	12.50	17.30	13.80	14.10	15.50	14.80	16.50
FE2O3	5.95	8.20	9.12	10.64	9.46	3.25	3.04
FEO	4.39	2.82	0.0	0.0	0.0	6.58	4.78
MNO	0.25	0.20	0.20	0.20	0.17	0.0	0.22
MGO	9.40	6.51	6.70	5.55	6.78	7.90	7.04
CAO	12.00	9.03	9.59	6.82	5.15	8.94	9.35
NA2O	2.41	3.46	3.92	4.33	5.95	3.73	3.54
K2O	0.42	1.21	0.03	0.17	0.01	0.04	1.05
P2O5	0.08	0.10	0.11	0.16	0.15	0.12	0.11
LOI	10.82	8.57	9.78	4.73	5.15	5.70	6.72
TOTAL	99.99	100.09	101.29	96.78	99.96	100.81	100.73
ZR	70	76	88	122	124	97	82
SR	470	195	138	222	126	340	535
RB	8	17	0	3	[illegible]	1	13
CU	99	50	38	31	111	108	11
BA	517	560	68	411	108	262	69
NI	645	275	74	60	64	101	127
CR	776	836	211	292	287	276	216
Y	25	27	27	36	35	28	31

DYKES, BLOW-ME-DOWN MASSIF, BAY OF ISLANDS COMPLEX (DATA OF E. COISH)

SAMPLE	EC-83	EC-84	EC-85	EC-86	EC-87	EC-88	EC-89
SIO2	48.60	49.80	47.80	49.60	49.90	47.40	48.80
TIO2	1.31	1.37	1.15	1.42	1.16	1.12	1.12
AL2O3	14.80	14.40	17.10	13.90	15.40	17.30	15.40
FE2O3	2.97	2.66	1.53	10.75	3.96	2.56	2.74
FEO	6.99	7.91	7.61	0.0	5.02	6.82	6.39
MNO	0.24	0.24	0.22	0.0	0.19	0.19	0.19
MGO	6.91	7.15	8.25	7.87	5.66	8.55	8.19
CAO	10.06	8.45	9.71	8.37	6.00	9.98	11.32
NA2O	2.76	3.34	2.11	3.51	4.18	2.42	2.94
K2O	0.16	0.07	1.09	0.30	0.03	0.39	0.40
P2O5	0.13	0.12	0.08	0.13	0.08	0.11	0.12
LOI	4.12	3.34	3.44	3.88	5.73	3.56	2.05
TOTAL	99.05	98.85	100.09	99.73	98.21	100.39	100.16
ZR	81	85	69	96	100	66	62
SR	116	184	527	292	137	445	271
RB	3	2	10	6	0	4	4
CU	6	4	18	53	15	23	113
BA	28	29	94	25	16	54	24
NI	46	30	98	55	24	140	87
CR	235	124	252	256	68	252	293
Y	31	33	27	32	35	27	27

DYKES, BLOW-ME-DOWN MASSIF, BAY OF ISLANDS COMPLEX (DATA OF R. COISH)

SAMPLE	RC-90	RC-91	RC-92	RC-93	RC-94	RC-95	RC-96
SIO2	47.70	48.30	47.30	47.60	46.80	47.60	47.70
TIO2	1.13	1.54	0.96	1.37	0.62	0.89	1.28
AL2O3	15.30	13.50	18.50	15.90	18.60	19.50	14.70
FE2O3	2.79	10.75	1.77	2.46	1.33	1.46	2.44
FEO	6.65	0.0	5.93	7.59	6.14	5.83	7.91
MNO	0.17	0.19	0.16	0.18	0.15	0.15	0.18
MGO	7.81	7.35	8.18	7.99	10.40	7.76	10.01
CAO	9.06	8.42	11.35	9.62	11.07	9.56	9.48
NA2O	3.98	4.88	2.57	2.84	1.74	2.52	2.62
K2O	0.25	0.02	0.29	0.77	0.18	1.47	0.32
P2O5	0.10	0.18	0.11	0.17	0.05	0.09	0.13
LOI	4.17	4.35	2.21	3.41	2.92	3.50	3.51
TOTAL	99.71	100.08	99.33	99.70	99.80	100.34	100.28
ZR	69	113	69	89	0	21	46
SR	191	117	297	529	248	374	218
RB	6	1	3	4	0	10	1
CU	71	0	0	0	152	159	174
BA	25	99	13	56	17	141	29
NI	83	43	143	92	34	151	165
CR	132	86	267	221	495	271	278
Y	29	35	23	20	0	0	0

DYKES, BLOW-ME-DOWN MASSIF, BAY OF ISLANDS COMPLEX (DATA OF E. CRISH)

SAMPLE	RC-97	RC-98	RC-99	RC-100
SIO2	48.10	51.90	51.60	50.70
TIO2	0.94	0.30	0.39	0.32
AL2O3	14.90	13.60	16.00	15.30
FE2O3	1.45	8.26	1.49	0.72
FEO	7.73	0.0	7.18	6.34
MNO	0.19	0.0	0.17	0.17
MGO	9.85	11.04	7.40	12.45
CAO	10.10	6.65	10.32	10.30
NA2O	2.00	2.74	2.74	1.69
K2O	0.13	0.11	0.22	0.05
P2O5	0.10	0.03	0.07	0.03
LOI	3.76	3.91	1.90	2.35
TOTAL	99.24	98.54	100.33	104.02
ZR	10	28	21	18
SR	130	342	158	127
RB	1	2	2	0
CU	78	7	0	0
BA	25	39	25	13
NI	230	264	24	327
CR	510	764	38	331
Y	0	11	11	10

B.2 Electron Microprobe Analyses of Minerals

B.2.1 Groundmass Clinopyroxene Analyses

** G*MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./TROUT R. SLICE

SAMPLE	SKC-31-1	SKC-31-2	SKC-31-3	SKC-31-4	SKC-31-5	SKC-31-6	SKC-31-7
SIO2	50.70	47.43	46.51	45.96	46.53	46.16	46.46
TIO2	1.65	2.70	2.83	3.47	3.41	3.31	2.58
AL2O3	2.94	5.02	6.05	5.94	6.02	7.18	5.29
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	8.78	10.75	9.09	10.01	9.75	8.96	9.87
MNO	0.27	0.31	0.32	0.22	0.25	0.20	0.23
MGO	13.54	11.40	12.29	10.38	11.04	11.81	11.84
CAO	22.80	22.32	22.26	22.79	22.94	22.52	22.12
NA2O	0.46	0.73	0.59	0.75	0.72	0.64	0.68
TOTAL	101.14	100.66	99.94	99.52	100.66	100.78	99.07

SAMPLE	SKC-31-8	SKC-31-9	SKC-31-10	SKC-31-11	SKC-31-12	SKC-31-13	SKC-31-14
SIO2	50.22	49.48	48.02	47.08	48.75	48.82	48.61
TIO2	1.64	1.75	1.95	2.85	1.77	1.55	1.89
AL2O3	2.91	3.36	3.84	5.66	2.94	3.10	3.42
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	9.30	9.05	8.83	9.05	9.63	8.99	9.55
MNO	0.30	0.29	0.32	0.11	0.25	0.21	0.23
MGO	13.45	13.65	12.57	12.24	12.81	13.86	13.27
CAO	22.39	22.55	22.77	22.70	22.77	22.22	22.43
NA2O	0.43	0.45	0.51	0.60	0.48	0.41	0.47
TOTAL	100.64	100.58	98.81	100.29	99.40	99.16	99.87

SAMPLE	SKC-31-15	SKC-31-16	SKC-31-17	SKC-31-18	SKC-31-19	SKC-32-1	SKC-32-2
SIO2	45.01	45.43	46.39	45.77	47.61	47.95	45.31
TIO2	3.42	3.31	2.70	3.02	2.54	2.80	4.16
AL2O3	5.52	6.35	5.04	6.08	4.81	5.27	7.02
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	10.99	9.30	10.77	9.52	9.57	10.28	10.33
MNO	0.30	0.26	0.31	0.26	0.26	0.23	0.27
MGO	10.55	11.91	11.34	11.64	12.20	11.85	10.39
CAO	22.09	22.33	22.17	22.61	22.49	22.15	21.75
NA2O	0.81	0.63	0.75	0.63	0.60	0.70	0.70
TOTAL	98.69	99.52	99.47	99.53	100.08	101.23	99.93

** G*MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./TROUT R. SLICE

SAMPLE	SKC-32-3	SKC-32-4	SKC-32-5	SKC-32-6	SKC-32-7	SKC-32-8	SKC-32-9
SIO2	50.79	46.25	44.81	48.84	47.92	46.86	47.45
TIO2	1.60	3.52	4.29	1.98	3.22	3.23	2.57
AL2O3	2.91	5.95	6.38	3.04	5.76	5.96	5.45
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	8.38	9.47	10.45	9.38	9.71	8.84	9.34
MNO	0.26	0.22	0.29	0.19	0.25	0.21	0.23
MGO	14.48	11.55	10.52	13.04	11.42	12.37	12.38
CAO	22.64	22.21	22.15	21.89	22.21	22.75	22.52
NA2O	0.42	0.64	0.73	0.43	0.66	0.59	0.65
TOTAL	101.48	99.81	99.62	98.79	101.15	100.81	100.59

SAMPLE	SKC-32-10	SKC-32-11	SKC-32-12	SKC-32-13	SKC-32-14	SKC-32-15	SKC-32-16
SIO2	49.59	45.87	47.79	50.04	44.70	49.66	47.82
TIO2	1.61	3.29	1.95	1.70	4.37	1.71	2.79
AL2O3	4.23	5.90	2.93	2.94	7.15	2.96	5.11
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.42	8.70	9.33	9.30	9.74	9.01	9.60
MNO	0.20	0.22	0.31	0.24	0.23	0.29	0.26
MGO	13.89	12.35	12.79	13.29	10.92	14.27	11.98
CAO	22.50	22.78	22.01	22.40	21.98	22.07	22.19
NA2O	0.39	0.47	0.47	0.49	0.72	0.40	0.62
TOTAL	99.83	99.58	97.58	100.40	99.81	100.37	100.37

SAMPLE	SKC-32-17	SKC-32-18	SKC-32-19	SKC-32-20	SKC-32-21	SKC-32-22	SKC-32-23
SIO2	48.18	46.41	46.09	49.17	46.87	47.46	49.66
TIO2	2.62	3.56	3.45	1.79	2.98	2.50	1.71
AL2O3	5.37	6.36	6.06	3.09	5.45	4.88	2.96
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	9.34	9.34	10.30	9.28	9.34	9.28	9.01
MNO	0.29	0.22	0.23	0.29	0.29	0.25	0.29
MGO	11.88	11.75	11.43	13.49	12.16	12.86	14.27
CAO	22.59	22.40	21.98	22.12	22.08	22.40	22.07
NA2O	0.58	0.60	0.65	0.47	0.61	0.50	0.40
TOTAL	100.85	100.64	100.19	99.70	99.78	100.13	100.37

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./TROUT R. SLICE

SAMPLE	SKC-32-24	SKC-32-25	SKC-32-26	SKC-38-1	SKC-38-2	SKC-38-3	SKC-38-4
SIO2	43.24	45.70	47.38	49.11	45.69	48.26	45.96
TIO2	4.66	3.16	2.85	2.39	3.69	2.26	3.16
AL2O3	6.86	5.47	5.02	4.15	6.85	4.24	6.21
CR2O3	0.0	0.0	0.0	0.0	0.0	0.01	0.0
FEO	10.72	10.41	9.45	8.30	9.22	8.21	8.34
MNO	0.28	0.25	0.25	0.10	0.11	0.14	0.14
MGO	10.02	11.25	12.26	14.28	12.39	13.70	12.93
CAO	21.90	22.05	22.23	22.23	22.11	22.05	21.71
NA2O	0.78	0.70	0.57	0.38	0.50	0.38	0.38
TOTAL	98.46	98.99	100.01	100.94	100.56	99.25	98.83

SAMPLE	SKC-38-5	SKC-38-6	SKC-38-7	SKC-38-8	SKC-38-9	SKC-38-10	SKC-38-11
SIO2	49.10	46.41	45.13	48.73	47.89	48.57	48.62
TIO2	2.22	3.51	3.81	2.40	2.77	2.67	2.32
AL2O3	3.62	6.63	7.36	3.78	4.71	4.89	4.29
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	8.70	9.27	8.88	8.80	9.23	8.18	9.08
MNO	0.20	0.16	0.08	0.20	0.21	0.20	0.10
MGO	14.24	13.11	12.39	13.78	13.68	13.55	14.08
CAO	22.05	21.77	22.41	21.96	21.85	21.85	22.22
NA2O	0.38	0.46	0.41	0.39	0.40	0.37	0.40
TOTAL	100.51	101.32	100.47	100.04	100.74	100.28	101.11

SAMPLE	SKC-38-12	SKC-38-13	SKC-38-14	SKC-38-15	SKC-38-16	SKC-38-17	SKC-38-18
SIO2	50.13	45.92	48.48	48.47	46.46	44.74	48.89
TIO2	2.15	3.30	2.23	2.18	3.29	3.55	2.09
AL2O3	3.36	5.76	3.84	3.68	5.96	6.53	3.21
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	8.70	9.17	8.69	8.93	9.21	9.03	9.99
MNO	0.23	0.16	0.13	0.19	0.14	0.16	0.23
MGO	14.22	12.80	14.37	14.27	13.00	12.57	14.05
CAO	22.17	22.72	22.46	22.18	22.86	21.97	21.89
NA2O	0.37	0.41	0.41	0.41	0.41	0.44	0.34
TOTAL	101.33	100.24	100.61	100.31	101.33	98.99	100.69

** G*MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./TROUT R. SLICE

SAMPLE	SKC-38-19	SKC-38-20	SKC-38-21	SKC-38-22	SKC-38-23	SKC-38-24	SKC-38-25
SIO2	44.64	45.22	46.93	48.72	45.25	48.27	47.00
TIO2	3.90	3.24	2.51	2.14	3.53	1.96	2.67
AL2O3	7.45	7.67	5.91	3.36	6.64	3.20	5.05
CR2O3	0.0	0.0	0.0	0.0	0.05	0.0	0.02
FEO	9.39	8.83	8.76	9.25	9.94	9.19	9.17
MNO	0.16	0.18	0.13	0.21	0.10	0.23	0.16
MGO	12.74	12.69	13.85	14.34	12.69	14.06	13.99
CAO	21.86	22.17	21.94	22.30	21.62	22.13	21.95
NA2O	0.38	0.48	0.39	0.38	0.45	0.36	0.35
TOTAL	100.52	100.48	100.42	100.70	100.27	99.40	100.36

SAMPLE	SKC-38-26	SKC-41-1	SKC-41-2	SKC-41-3	SKC-41-4	SKC-41-5	SKC-41-6
SIO2	47.30	45.92	49.01	50.57	49.42	46.03	50.09
TIO2	2.80	3.62	2.07	1.93	2.13	3.74	2.01
AL2O3	5.13	7.66	3.57	3.31	3.32	7.02	3.74
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	8.98	7.69	8.49	8.18	8.33	8.33	8.09
MNO	0.16	0.13	0.24	0.21	0.21	0.14	0.22
MGO	13.51	12.69	14.29	14.26	14.27	12.03	14.12
CAO	22.10	23.11	22.63	22.53	22.28	22.85	22.72
NA2O	0.40	0.44	0.36	0.36	0.40	0.57	0.38
TOTAL	100.38	101.26	100.66	101.35	100.36	100.71	101.37

SAMPLE	SKC-41-7	SKC-41-8	SKC-41-9	SKC-41-10	SKC-41-11	SKC-41-12	SKC-41-13
SIO2	48.66	44.96	49.11	49.75	49.37	48.87	48.50
TIO2	1.91	3.86	2.07	2.01	2.08	2.12	2.10
AL2O3	3.65	7.28	3.66	3.64	3.83	3.91	3.62
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.82	8.25	7.96	7.79	8.02	8.23	8.13
MNO	0.27	0.16	0.20	0.13	0.16	0.13	0.20
MGO	13.90	11.86	14.30	14.61	14.34	14.46	14.25
CAO	22.01	22.20	23.02	22.81	22.93	22.18	22.22
NA2O	0.35	0.48	0.38	0.37	0.37	0.36	0.37
TOTAL	98.57	99.05	100.70	101.11	101.10	100.26	99.39

** G.MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./TROUT R. SLICE

SAMPLE	SKC-41-14	SKC-41-15	SKC-41-16	SKC-41-17	SKC-41-18	SKC-41-19	SKC-41-20
SIO2	47.22	48.25	45.10	48.80	48.51	49.85	45.68
TIO2	2.37	1.79	4.02	2.36	2.10	2.02	3.64
AL2O3	7.47	6.73	7.68	4.15	3.74	3.87	6.86
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.30	6.71	8.06	8.24	7.46	7.61	8.53
MNO	0.17	0.14	0.16	0.22	0.17	0.16	0.17
MGO	13.79	14.46	12.23	14.01	14.39	14.55	12.43
CAO	22.57	23.02	22.88	23.06	23.09	22.35	22.59
NA2O	0.43	0.34	0.45	0.39	0.34	0.35	0.50
TOTAL	101.32	101.44	100.58	101.23	99.80	100.76	100.40

SAMPLE	SKC-41-21	SKC-41-22	SKC-41-23	SKC-41-24	SKC-41-25	SKC-41-26	SKC-41-27
SIO2	49.46	49.79	49.65	45.61	50.27	47.89	50.27
TIO2	2.13	2.05	2.15	3.18	1.96	2.09	2.23
AL2O3	3.77	3.60	3.63	7.02	4.10	3.79	3.89
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.59	8.16	8.22	8.36	7.05	7.61	8.02
MNO	0.20	0.16	0.16	0.16	0.14	0.18	0.17
MGO	14.35	14.39	14.37	12.42	14.95	14.12	14.29
CAO	22.96	22.85	22.53	22.90	23.29	22.43	22.54
NA2O	0.32	0.38	0.32	0.50	0.35	0.34	0.39
TOTAL	100.78	101.38	101.03	100.15	102.11	98.45	101.80

SAMPLE	SKC-41-28	SKC-58-1	SKC-58-2	SKC-58-3	SKC-58-4	SKC-58-5	SKC-58-6
SIO2	48.39	49.25	50.19	50.33	49.35	49.21	49.25
TIO2	2.43	1.89	1.65	2.00	1.96	1.89	1.97
AL2O3	4.76	3.42	2.85	3.89	3.33	3.32	3.54
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.93	7.45	8.63	7.03	8.10	7.36	7.38
MNO	0.18	0.14	0.23	0.13	0.21	0.14	0.17
MGO	13.85	14.38	14.11	14.30	14.27	14.50	14.19
CAO	22.65	22.48	21.87	22.86	22.11	23.04	22.95
NA2O	0.39	0.37	0.34	0.30	0.36	0.34	0.36
TOTAL	100.58	99.38	99.87	100.84	99.69	99.80	99.81

** G*MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./TROUT R. SLICE

SAMPLE	SKC-58-7	SKC-58-8	SKC-58-9	SKC-58-10	SKC-58-11	SKC-58-12	SKC-58-13
SIO2	50.16	50.04	51.00	50.58	49.40	48.58	50.04
TIO2	1.83	2.01	1.82	1.52	1.68	2.04	1.59
AL2O3	3.72	3.45	2.99	2.61	2.69	3.71	2.88
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.81	7.75	7.97	8.38	9.20	7.43	7.81
MNO	0.20	0.20	0.23	0.29	0.28	0.34	0.25
MGO	14.79	14.24	14.16	14.19	13.56	14.12	14.32
CAO	22.64	22.74	22.82	22.59	21.92	22.33	22.36
NA2O	0.39	0.38	0.34	0.37	0.44	0.34	0.41
TOTAL	101.54	100.81	101.33	100.53	99.17	98.89	99.66

SAMPLE	SKC-58-14	SKC-58-15	SKC-58-16	SKC-58-17	SKC-58-18	SKC-58-19	SKC-58-20
SIO2	49.27	50.91	49.91	49.35	49.92	49.22	51.07
TIO2	2.04	1.71	1.71	1.84	1.74	1.59	1.86
AL2O3	3.82	2.92	2.89	3.18	3.13	2.93	3.09
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.21	8.40	8.16	7.90	7.89	8.23	7.63
MNO	0.16	0.23	0.28	0.20	0.14	0.14	0.18
MGO	14.69	14.18	14.77	14.54	14.72	14.76	14.54
CAO	22.96	22.79	22.40	22.96	22.82	22.12	23.04
NA2O	0.32	0.33	0.36	0.34	0.36	0.31	0.34
TOTAL	100.47	101.47	100.48	100.31	100.72	99.30	101.75

SAMPLE	SKC-58-21	SKC-58-22	SKC-58-23	SKC-58-24	SKC-58-25	SKC-58-26	SKC-58-27
SIO2	46.16	45.87	48.09	49.47	49.18	50.14	49.28
TIO2	2.91	3.32	2.95	1.99	2.14	2.06	2.00
AL2O3	6.63	7.04	6.35	4.11	3.64	3.50	4.20
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.50	7.80	7.91	6.85	7.55	7.18	7.05
MNO	0.10	0.10	0.17	0.13	0.19	0.22	0.10
MGO	13.38	12.40	12.71	14.78	14.48	14.30	14.20
CAO	22.76	23.07	22.95	22.86	22.81	22.70	23.18
NA2O	0.38	0.45	0.50	0.37	0.35	0.31	0.34
TOTAL	99.82	100.05	101.63	100.56	100.34	100.41	100.35

** G*MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./TROUT R. SLICE

SAMPLE	SKC-58-28	SKC-58-29	SKC-58-30	SKC-58-31	SKC-58-32	SKC-58-33	SKC-58-34
SIO2	46.38	46.52	46.91	45.96	46.80	46.80	47.59
TIO2	3.33	3.15	3.20	3.28	3.16	3.26	2.54
AL2O3	7.10	6.71	5.89	6.44	6.53	6.15	4.94
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	7.63	7.13	7.64	7.85	8.87	8.24	8.02
MNO	0.14	0.14	0.16	0.13	0.20	0.19	0.17
MGO	12.85	12.79	13.26	12.65	12.46	13.30	13.76
CAO	22.89	22.72	22.96	22.65	22.79	22.41	22.64
NA2O	0.43	0.44	0.43	0.48	0.55	0.41	0.40
TOTAL	100.75	99.60	100.45	99.44	101.36	100.76	100.06

SAMPLE	SKC-58-35	SKC-63-1	SKC-63-2	SKC-63-3	SKC-63-4	SKC-63-5	SKC-63-6
SIO2	48.86	43.61	44.21	42.55	43.28	47.98	42.96
TIO2	2.22	5.61	5.43	5.67	5.63	3.13	5.39
AL2O3	4.22	7.32	7.03	7.22	7.30	4.40	6.94
CR2O3	0.0	0.0	0.0	0.05	0.04	0.02	0.0
FEO	7.78	10.15	10.00	10.12	10.42	9.31	9.91
MNO	0.18	0.18	0.19	0.17	0.13	0.21	0.19
MGO	13.92	10.99	11.63	11.28	11.11	13.25	11.35
CAO	22.68	21.72	22.04	21.93	21.72	21.41	21.70
NA2O	0.38	0.59	0.64	0.59	0.59	0.36	0.58
TOTAL	100.24	100.17	101.17	99.58	100.22	100.07	99.02

SAMPLE	SKC-63-7	SKC-63-8	SKC-63-9	SKC-63-10	SKC-63-11	SKC-63-12	SKC-63-13
SIO2	44.50	46.24	44.64	44.04	45.52	43.70	44.07
TIO2	4.38	4.07	4.82	5.59	4.45	5.30	5.11
AL2O3	7.28	6.06	6.50	6.67	5.94	6.37	7.13
CR2O3	0.0	0.0	0.0	0.0	0.04	0.0	0.03
FEO	9.37	10.09	9.87	10.98	9.97	10.61	9.91
MNO	0.23	0.20	0.19	0.16	0.13	0.21	0.17
MGO	11.30	12.07	11.84	10.79	12.55	10.91	11.91
CAO	21.51	21.89	21.63	21.32	20.85	21.73	21.28
NA2O	0.57	0.48	0.53	0.62	0.51	0.65	0.52
TOTAL	99.14	101.10	100.02	100.17	99.96	99.48	100.13

** G*MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./TROUT R. SLICE

SAMPLE	SKC-63-14	SKC-63-15	SKC-63-16
SIO2	43.13	44.30	44.32
TIO2	5.58	5.68	5.09
AL2O3	6.93	7.27	6.68
CR2O3	0.0	0.03	0.01
FEO	10.72	9.93	10.12
MNO	0.14	0.16	0.18
MGO	10.96	11.14	11.54
CAO	21.63	22.00	21.62
NA2O	0.58	0.61	0.56
TOTAL	99.57	101.12	100.12

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./CHIMNEY CV. SLICE

SAMPLE	CC-5 -1	CC-5 -2	CC-5 -3	CC-5 -4	CC-5 -5	CC-5 -6	CC-5 -7
SIO2	50.15	46.80	49.41	45.46	43.50	44.90	48.27
TIO2	1.98	2.46	2.14	3.32	3.86	3.27	1.93
AL2O3	3.27	5.57	3.71	8.30	9.27	8.68	4.69
CR2O3	0.0	0.07	0.0	0.05	0.0	0.01	0.03
FEO	8.59	8.83	8.88	8.75	8.70	7.43	7.69
MNO	0.26	0.14	0.17	0.10	0.18	0.20	0.14
MGO	14.20	12.98	14.23	12.46	11.57	12.38	14.15
CAO	21.33	22.32	21.96	22.11	21.70	21.84	21.78
NA2O	0.37	0.39	0.36	0.50	0.54	0.50	0.38
TOTAL	100.15	99.56	100.86	101.05	99.32	99.21	99.06

SAMPLE	CC-5 -8	CC-5 -9	CC-5 -10	CC-5 -11	CC-5 -12	CC-5 -13	CC-5 -14
SIO2	46.17	46.61	45.13	47.74	45.50	45.21	47.48
TIO2	2.63	2.66	3.43	2.29	2.98	3.10	2.59
AL2O3	6.97	6.91	8.55	4.53	7.32	7.73	5.84
CR2O3	0.0	0.05	0.04	0.04	0.04	0.03	0.04
FEO	8.98	7.84	8.38	8.89	8.01	7.91	9.35
MNO	0.13	0.19	0.14	0.25	0.16	0.19	0.22
MGO	12.95	12.88	12.19	13.59	12.69	12.30	13.35
CAO	21.87	21.68	21.68	20.77	22.21	22.07	21.09
NA2O	0.49	0.45	0.52	0.36	0.47	0.45	0.36
TOTAL	100.19	99.27	100.06	98.46	99.38	98.99	100.32

SAMPLE	CC-5 -15	CC- 5-16	CC-5 -17	CC-5 -18	CC-5 -19	CC-5 -20	CC-5 -21
SIO2	46.56	48.62	44.66	45.33	47.93	50.29	47.02
TIO2	2.48	2.18	3.01	2.85	2.39	2.02	2.57
AL2O3	6.79	4.51	8.04	7.84	4.45	4.11	6.77
CR2O3	0.02	0.0	0.05	0.03	0.0	0.01	0.0
FEO	8.71	7.95	7.82	7.59	9.11	8.37	8.15
MNO	0.16	0.23	0.13	0.18	0.26	0.20	0.14
MGO	12.41	13.84	12.63	12.57	13.80	14.42	12.82
CAO	21.91	21.49	21.97	22.16	21.09	21.50	22.44
NA2O	0.50	0.35	0.50	0.44	0.38	0.32	0.44
TOTAL	99.54	99.17	98.81	98.99	99.41	101.24	100.35

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./CHIMNEY CV. SLICE

SAMPLE	CC-5 -22	CC-5 -23	CC-5 -24	CC-5 -25	CC-5 -26	CC-5 -27	CC-5 -28
SIO2	49.19	49.67	44.88	48.74	48.62	48.04	47.11
TIO2	1.91	1.85	3.54	1.99	2.01	1.93	2.57
AL2O3	4.18	4.44	7.97	3.96	4.21	5.01	6.06
CR2O3	0.05	0.02	0.02	0.01	0.02	0.02	0.02
FEO	8.01	7.54	9.23	8.45	8.93	7.69	8.43
MNO	0.25	0.16	0.22	0.31	0.23	0.20	0.19
MGO	14.57	14.32	11.91	14.05	14.45	14.19	13.26
CAO	21.75	22.21	21.28	21.47	21.59	21.66	21.74
NA2O	0.38	0.37	0.54	0.34	0.34	0.45	0.43
TOTAL	100.29	100.58	99.59	99.32	100.40	99.19	99.81

SAMPLE	CC-27-1	CC-27-2	CC-27-3	CC-27-4	CC-27-5	CC-27-6	CC-27-7
SIO2	45.40	42.66	47.00	45.46	45.51	46.61	49.03
TIO2	2.93	4.79	2.66	3.00	3.15	2.59	1.99
AL2O3	8.84	10.11	6.84	7.80	8.24	6.68	4.35
CR2O3	0.09	0.04	0.04	0.04	0.05	0.02	0.02
FEO	7.76	9.29	8.29	8.26	7.97	8.06	9.47
MNO	0.07	0.13	0.19	0.19	0.10	0.14	0.23
MGO	13.02	10.77	13.28	12.67	12.45	13.12	14.06
CAO	21.47	21.70	22.04	22.02	22.04	21.98	19.98
NA2O	0.56	0.54	0.46	0.52	0.48	0.40	0.39
TOTAL	100.14	100.03	100.80	99.96	99.99	99.60	99.52

SAMPLE	CC-27-8	CC-27-9	CC-27-10	CC-27-11	CC-27-12	CC-27-13	CC-27-14
SIO2	46.00	44.58	45.07	48.36	47.77	49.08	46.29
TIO2	2.63	3.43	2.81	1.90	3.54	1.72	2.57
AL2O3	6.96	8.95	8.82	4.78	8.67	4.63	6.30
CR2O3	0.05	0.10	0.30	0.0	0.03	0.03	0.10
FEO	8.16	7.80	7.00	7.54	8.63	8.31	8.34
MNO	0.16	0.13	0.10	0.13	0.13	0.20	0.19
MGO	12.64	12.26	12.42	14.26	12.18	14.55	14.20
CAO	22.07	21.20	22.41	22.02	21.41	20.95	21.41
NA2O	0.52	0.47	0.37	0.36	0.56	0.39	0.29
TOTAL	99.19	98.92	99.30	99.35	102.92	99.86	99.69

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./CHIMNEY CV. SLICE

SAMPLE	CC-27-15	CC-27-16	CC-27-17	CC-27-18	CC-27-19	CC-27-20	CC-27-21
SIO2	45.41	44.07	46.71	45.07	49.16	44.44	49.47
TIO2	3.16	3.89	2.32	3.58	1.55	3.70	0.98
AL2O3	7.78	8.82	5.40	7.82	3.57	8.39	3.85
CR2O3	0.0	0.0	0.01	0.0	0.0	0.03	0.03
FEO	8.40	8.85	8.41	8.32	9.43	8.85	9.20
MNO	0.24	0.21	0.19	0.18	0.33	0.19	0.20
MGO	12.26	11.65	13.32	12.27	14.02	12.16	14.44
CAO	21.97	21.73	21.84	21.25	20.13	21.65	20.52
NA2O	0.50	0.52	0.47	0.47	0.40	0.43	0.41
TOTAL	99.72	99.74	98.67	98.96	98.59	99.84	99.10

SAMPLE	CC-27-22	CC-27-23	CC-27-24	CC-27-25	CC-27-26	CC-28-1	CC-28-2
SIO2	49.20	48.87	45.88	44.32	46.46	45.73	45.11
TIO2	1.98	1.79	2.99	3.14	2.75	3.47	3.77
AL2O3	4.76	4.39	7.46	8.21	6.90	6.37	7.11
CR2O3	0.03	0.0	0.01	0.04	0.04	0.02	0.0
FEO	7.48	7.88	8.30	8.45	8.33	10.08	9.42
MNO	0.20	0.17	0.18	0.19	0.17	0.16	0.14
MGO	14.13	14.46	12.40	12.43	13.02	13.45	12.56
CAO	21.66	21.69	21.92	21.95	21.56	20.91	21.82
NA2O	0.39	0.37	0.54	0.51	0.45	0.37	0.43
TOTAL	99.83	99.62	99.68	99.24	99.68	100.56	100.36

SAMPLE	CC-28-3	CC-28-4	CC-28-5	CC-28-6	CC-28- 7	CC-28-8	CC-28-9
SIO2	39.41	41.99	46.68	47.02	46.67	47.06	45.56
TIO2	6.54	4.96	3.14	3.02	3.37	2.99	3.22
AL2O3	10.95	9.87	6.53	5.98	6.41	5.63	6.36
CR2O3	0.04	0.0	0.01	0.0	0.02	0.0	0.0
FEO	8.83	8.32	8.05	8.24	8.61	7.91	9.68
MNO	0.03	0.16	0.16	0.13	0.10	0.13	0.16
MGO	10.29	11.65	13.09	13.45	13.24	13.73	12.08
CAO	22.69	22.59	22.30	21.91	22.50	22.34	22.86
NA2O	0.51	0.45	0.49	0.31	0.37	0.37	0.44
TOTAL	99.29	99.99	100.45	100.06	101.29	100.16	100.36

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA SKINNER CV. FM./CHIMNEY CV. SLICE

SAMPLE	CC-28-10	CC-28-11	CC-28-12	CC-28-13	CC-28-14	CC-28-15	CC-28-16
SIO2	42.54	46.87	46.61	46.46	46.17	45.58	41.68
TIO2	4.83	3.02	3.04	3.27	3.61	3.61	5.34
AL2O3	9.52	6.18	5.94	5.99	7.23	7.54	10.34
CR2O3	0.0	0.05	0.04	0.0	0.04	0.02	0.0
FEO	9.60	7.54	7.91	8.77	7.93	9.55	9.20
MNO	0.11	0.20	0.13	0.03	0.14	0.16	0.17
MGO	11.45	14.02	13.85	13.57	12.63	12.56	11.00
CAO	22.05	22.75	22.58	22.47	21.87	22.04	22.75
NA2O	0.49	0.37	0.42	0.36	0.50	0.47	0.56
TOTAL	100.59	101.00	100.52	100.92	100.12	101.53	101.04

SAMPLE	CC-28-17	CC-28-18	CC-28-19	CC-28-20	CC-28-21
SIO2	42.18	43.35	43.18	44.13	44.70
TIO2	4.76	3.53	4.60	3.61	3.89
AL2O3	9.41	7.83	8.86	7.83	7.59
CR2O3	0.0	0.0	0.0	0.0	0.01
FEO	8.14	10.11	9.03	10.14	8.55
MNO	0.16	0.11	0.13	0.17	0.13
MGO	11.88	11.95	11.83	12.63	12.55
CAO	22.54	21.18	22.89	21.34	22.22
NA2O	0.53	0.46	0.55	0.40	0.44
TOTAL	99.60	98.52	101.07	100.25	100.08

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA LITTLE PORT CPLX AT LITTLE PORT

SAMPLE	LP-3 -1	LP-3 -2	LP-3-3	LP-3-4	LP-3-5	LP-3-6	LP-3-7
SIO2	50.44	50.42	51.36	49.92	49.67	50.10	51.88
TIO2	1.16	1.25	0.70	1.41	1.28	1.43	0.85
AL2O3	4.39	4.59	2.13	4.69	4.59	4.00	2.82
CR2O3	0.17	0.16	0.22	0.18	0.20	0.06	0.13
FEO	7.16	7.43	8.02	7.23	6.79	7.33	5.63
MNO	0.23	0.18	0.20	0.14	0.22	0.13	0.20
MGO	14.88	14.55	17.53	14.73	14.89	14.75	15.82
CAO	20.97	20.54	18.35	20.69	20.79	21.70	21.73
NA2O	0.36	0.38	0.25	0.37	0.39	0.34	0.30
TOTAL	99.76	99.50	98.76	99.36	98.82	99.84	99.36

SAMPLE	LP-3-8	LP-3-9	LP-3-10	LP-3-11	LP-3-12	LP-3-13	LP-3-14
SIO2	48.98	50.58	48.94	49.13	48.60	51.86	52.45
TIO2	1.66	1.35	1.45	1.59	1.45	0.92	0.68
AL2O3	5.46	3.82	4.46	4.64	4.49	2.89	2.14
CR2O3	0.16	0.05	0.17	0.16	0.20	0.05	0.13
FEO	8.33	7.63	7.66	7.92	7.54	6.50	7.63
MNO	0.22	0.20	0.16	0.17	0.13	0.16	0.27
MGO	14.52	15.05	14.86	14.57	14.78	15.55	16.90
CAO	20.12	21.00	20.74	20.80	21.07	20.43	19.06
NA2O	0.37	0.36	0.39	0.40	0.36	0.33	0.23
TOTAL	99.82	100.04	98.83	99.38	98.62	98.69	99.49

SAMPLE	LP-3-15	LP-3-16	LP-3-17	LP-3-18	LP-3-19	LP-3-20	LP-3-21
SIO2	52.31	49.45	50.12	52.49	49.63	51.79	49.70
TIO2	0.70	1.69	1.15	0.70	1.45	1.00	1.31
AL2O3	2.25	4.33	3.58	2.11	4.01	2.66	4.39
CR2O3	0.05	0.10	0.08	0.10	0.0	0.02	0.20
FEO	7.19	8.68	6.84	7.83	8.78	7.66	8.07
MNO	0.19	0.22	0.19	0.21	0.24	0.20	0.19
MGO	16.52	14.37	15.32	16.53	14.55	14.91	14.66
CAO	19.39	20.63	21.36	18.71	20.75	21.10	20.78
NA2O	0.30	0.41	0.32	0.25	0.33	0.30	0.41
TOTAL	98.90	99.88	98.96	98.93	99.74	99.64	99.71

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA LITTLE PORT CPLX/AT LITTLE PORT

SAMPLE	LP-3-22	LP-3-23	LP-3-24	LP-3-25	LP-3-26	LP-3 -27	LP-9 -1
SIO2	49.36	48.78	51.05	50.19	50.83	50.39	51.02
TIO2	1.34	1.67	0.88	1.32	1.16	1.21	0.77
AL2O3	4.55	4.53	2.74	3.66	3.74	3.76	3.75
CR2O3	0.14	0.16	0.04	0.0	0.25	0.12	0.54
FEO	8.29	9.07	7.70	8.27	7.36	7.64	5.13
MNO	0.17	0.16	0.25	0.20	0.11	0.19	0.11
MGO	14.76	14.10	15.93	14.86	15.03	15.19	15.86
CAO	20.36	21.30	20.38	20.48	21.33	20.56	22.05
NA2O	0.36	0.39	0.34	0.34	0.37	0.34	0.30
TOTAL	99.33	100.16	99.31	99.32	100.18	99.40	99.53

SAMPLE	LP-9 -2	LP-9 -3	LP-9 -4	LP-9 -5	LP-9 -6	LP-9 -7	LP-9 -8
SIO2	50.05	51.10	50.46	50.20	48.36	51.86	50.62
TIO2	1.22	0.63	0.99	1.59	1.87	0.87	1.17
AL2O3	4.19	2.89	3.23	4.30	2.99	2.63	1.81
CR2O3	0.07	0.65	0.01	0.01	0.0	0.0	0.0
FEO	6.57	4.63	7.20	7.46	11.86	7.13	11.57
MNO	0.20	0.14	0.21	0.19	0.25	0.20	0.30
MGO	15.69	16.58	14.88	14.58	12.62	15.88	13.88
CAO	21.03	21.87	21.17	20.61	20.39	20.65	19.97
NA2O	0.29	0.29	0.30	0.36	0.45	0.20	0.29
TOTAL	99.31	98.78	98.45	99.30	98.79	99.42	99.61

SAMPLE	LP-9 -9	LP-9 -10	LP-9 -11	LP-9 -12	LP-9 -13	LP-9 -14	LP-9 -15
SIO2	50.71	51.04	50.93	50.11	50.29	48.56	50.30
TIO2	0.83	0.81	1.05	1.48	1.63	1.52	0.93
AL2O3	1.20	4.00	3.73	4.63	4.00	4.12	1.91
CR2O3	0.0	0.66	0.11	0.33	0.0	0.0	0.0
FEO	15.55	5.04	5.44	6.11	7.63	7.14	9.60
MNO	0.44	0.20	0.12	0.12	0.17	0.16	0.25
MGO	12.41	16.11	15.66	15.03	14.32	14.98	15.17
CAO	19.64	21.53	21.78	21.41	21.66	21.72	20.07
NA2O	0.35	0.31	0.26	0.34	0.32	0.30	0.28
TOTAL	101.13	99.70	99.08	99.56	100.02	98.50	98.51

** G*MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA LITTLE PORT CPLX/AT LITTLE PORT

SAMPLE	LP-9 -16	LP-9 -17	LP-9 -18	LP-9 -19	LP-9 -20	LP-9 -21	LP-9 -22
SIO2	49.60	49.74	49.79	50.85	49.69	50.40	52.31
TIO2	1.54	1.27	1.22	1.36	1.68	1.29	0.81
AL2O3	2.38	3.90	4.11	4.35	3.88	3.69	1.95
CR2O3	0.0	0.0	0.36	0.23	0.0	0.02	0.0
FEO	13.00	6.94	5.45	6.23	11.01	7.80	7.60
MNO	0.40	0.11	0.13	0.16	0.23	0.16	0.26
MGO	11.93	14.79	15.50	15.33	13.01	14.67	15.86
CAO	20.07	21.79	21.71	21.75	20.81	20.51	20.25
NA2O	0.47	0.32	0.30	0.30	0.46	0.34	0.27
TOTAL	99.89	98.86	98.57	100.56	100.77	98.88	99.31

SAMPLE	LP-9 -23	LP-14-1	LP-14-2	LP-14-3	LP-14-4	LP-14-5	LP-14-6
SIO2	50.36	48.66	50.38	49.83	50.40	52.06	52.76
TIO2	1.21	1.42	1.45	1.57	1.12	0.88	0.88
AL2O3	3.77	4.14	3.88	2.46	3.17	2.02	2.10
CR2O3	0.14	0.03	0.05	0.01	0.09	0.01	0.0
FEO	8.02	8.44	8.84	13.63	8.13	8.30	8.20
MNO	0.21	0.20	0.20	0.35	0.23	0.26	0.17
MGO	14.66	14.28	14.64	12.43	15.41	16.41	16.41
CAO	21.02	21.37	21.18	19.60	20.38	20.37	20.27
NA2O	0.32	0.37	0.48	0.32	0.36	0.27	0.25
TOTAL	99.71	98.91	101.10	100.20	99.29	100.58	101.04

SAMPLE	LP-14-7	LP-14-8	LP-14-9	LP-14-10	LP-14-11	LP-14-12	LP-14-13
SIO2	48.46	47.56	49.29	48.60	48.27	50.88	52.12
TIO2	1.38	2.30	1.57	1.62	1.66	1.01	0.71
AL2O3	2.04	4.41	5.46	5.32	5.31	2.14	2.03
CR2O3	0.04	0.0	0.21	0.14	0.02	0.0	0.09
FEO	12.84	11.84	7.79	7.53	8.54	9.97	7.61
MNO	0.36	0.22	0.17	0.20	0.17	0.29	0.25
MGO	13.35	12.45	15.12	14.61	13.91	15.89	16.60
CAO	19.81	20.43	20.34	20.55	20.78	19.85	20.41
NA2O	0.32	0.52	0.40	0.37	0.39	0.25	0.22
TOTAL	98.60	99.73	100.35	98.94	99.05	100.28	100.04

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA LITTLE PORT CPLX/AT LITTLE PORT

SAMPLE	LP-14-14	LP-14-15	LP-14-16	LP-14-17	LP-14-18	LP-14-19	LP-14-20
SIO2	48.88	48.95	50.42	48.81	50.32	48.46	46.81
TIO2	1.30	1.56	0.89	1.55	1.10	1.81	2.53
AL2O3	2.57	3.52	3.17	3.46	4.35	4.20	4.67
CR2O3	0.0	0.0	0.09	0.0	0.27	0.02	0.01
FEO	12.21	10.04	8.16	10.37	6.25	10.11	11.96
MNO	0.28	0.27	0.23	0.23	0.20	0.25	0.35
MGO	13.79	13.30	16.30	13.29	15.51	13.24	11.75
CAO	19.28	20.77	19.60	21.24	20.86	20.83	20.06
NA2O	0.33	0.39	0.31	0.46	0.32	0.42	0.52
TOTAL	98.64	98.80	99.17	99.41	99.18	99.34	98.66

SAMPLE	LP-14-21	LP-14-22	LP-14-23	LP-16-1	LP-16-2	LP-16-3	LP-16-4
SIO2	48.75	50.24	49.59	50.10	51.09	52.54	50.62
TIO2	1.45	1.07	1.43	1.14	0.99	0.76	1.00
AL2O3	3.29	3.79	3.52	4.28	3.73	2.25	4.32
CR2O3	0.0	0.12	0.05	0.25	0.11	0.06	0.17
FEO	10.86	6.42	9.45	7.85	7.15	7.46	7.45
MNO	0.32	0.17	0.24	0.21	0.20	0.20	0.22
MGO	13.59	15.35	14.44	15.30	15.82	15.96	15.20
CAO	19.87	21.12	20.41	20.50	20.90	20.33	20.48
NA2O	0.41	0.33	0.36	0.37	0.30	0.27	0.35
TOTAL	98.54	98.61	99.49	100.00	100.29	99.83	99.81

SAMPLE	LP-16-5	LP-16-6	LP-16-7	LP-16-8	LP-16-9	LP-16-10	LP-16-11
SIO2	50.82	49.84	50.99	49.28	49.04	49.04	50.87
TIO2	1.07	1.47	0.90	1.45	1.56	1.89	1.21
AL2O3	3.47	4.64	2.06	4.39	4.91	4.48	4.60
CR2O3	0.14	0.04	0.04	0.0	0.12	0.21	0.14
FEO	7.48	8.73	8.27	9.79	8.92	10.57	7.75
MNO	0.13	0.16	0.17	0.20	0.18	0.01	0.18
MGO	15.34	14.90	15.93	13.86	14.61	13.67	15.32
CAO	21.39	20.05	20.09	20.44	20.16	20.55	20.44
NA2O	0.31	0.36	0.29	0.37	0.50	0.42	0.38
TOTAL	100.15	100.19	98.73	99.78	100.00	100.84	100.89

** G*MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA LITTLE PORT CPLX/AT LITTLE PORT

SAMPLE	LP-16-12	LP-16-13	LP-16-14	LP-16-15	LP-16-16	LP-16-17	LP-16-18
SIO2	50.23	49.95	49.72	49.40	46.13	49.99	48.80
TIO2	1.35	1.27	1.59	1.38	4.60	1.08	1.48
AL2O3	3.91	4.54	4.56	2.87	5.21	3.89	5.68
CR2O3	0.02	0.09	0.02	0.02	0.0	0.21	0.27
FEO	9.00	10.18	9.00	13.52	11.25	7.96	8.76
MNO	0.26	0.21	0.31	0.36	0.26	0.24	0.23
MGO	14.90	15.14	14.27	13.04	11.48	15.64	15.39
CAO	20.87	19.23	20.30	19.37	20.86	20.95	19.54
NA2O	0.34	0.40	0.40	0.30	0.43	0.26	0.31
TOTAL	100.88	101.01	100.17	100.26	100.22	100.22	100.46

SAMPLE	LP-16-19	LP-16-20	LP-16-21	LP-16-22	LP-16-23	LP-16-24	LP-16-25
SIO2	50.30	51.96	48.36	46.68	46.46	49.18	51.16
TIO2	1.04	0.82	1.77	2.41	2.65	1.53	0.94
AL2O3	3.90	2.34	4.95	5.96	5.28	5.15	2.04
CR2O3	0.19	0.04	0.0	0.0	0.02	0.13	0.03
FEO	7.12	8.87	10.50	11.73	12.60	9.71	11.07
MNO	0.22	0.29	0.25	0.16	0.25	0.14	0.22
MGO	15.18	16.37	14.05	12.84	11.88	15.25	15.98
CAO	20.89	20.23	19.87	20.06	20.28	18.97	19.52
NA2O	0.30	0.29	0.37	0.39	0.49	0.33	0.20
TOTAL	99.14	101.21	100.12	100.23	99.91	100.39	101.16

SAMPLE	LP-16-26	LP-17-1	LP-17-2	LP-17-3	LP-17-4	LP-17-5	LP-17-6
SIO2	49.70	50.27	50.57	48.09	50.56	49.77	52.13
TIO2	1.49	1.11	0.70	1.21	1.01	0.96	0.60
AL2O3	4.14	4.45	2.41	5.54	4.81	4.24	2.62
CR2O3	0.09	0.35	0.20	0.29	0.35	0.22	0.05
FEO	9.31	6.87	6.67	8.65	6.49	6.89	7.34
MNO	0.21	0.16	0.18	0.10	0.09	0.23	0.20
MGO	14.69	15.98	16.58	15.13	15.47	15.58	17.50
CAO	20.25	20.91	21.73	19.71	20.16	21.19	19.71
NA2O	0.35	0.32	0.24	0.37	0.33	0.42	0.23
TOTAL	100.23	100.42	99.28	99.09	99.27	99.50	100.38

** G!MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA LITTLE PORT CPLX/AT LITTLE PORT

SAMPLE	LP-17-7	LP-17-8	LP-17-9	LP-17-10	LP-17-11	LP-17-12	LP-17-13
SIO2	49.43	50.98	50.66	50.43	50.55	49.43	50.73
TIO2	0.86	0.86	1.15	1.18	1.05	1.09	0.98
AL2O3	4.20	3.29	4.66	4.29	4.79	5.09	4.23
CR2O3	0.23	0.19	0.57	0.22	0.47	0.50	0.23
FEO	7.10	7.55	6.48	7.43	6.01	6.66	6.67
MNO	0.11	0.19	0.13	0.17	0.17	0.18	0.16
MGO	15.88	16.38	15.80	15.77	15.49	14.78	16.00
CAO	20.74	20.88	20.90	20.66	21.00	21.05	21.23
NA2O	0.33	0.32	0.37	0.29	0.38	0.33	0.32
TOTAL	98.88	100.64	100.72	100.44	99.91	99.11	100.55

SAMPLE	LP-17-14	LP-17-15	LP-17-16	LP-17-17	LP-17-18	LP-17-19	LP-17-20
SIO2	50.03	51.43	48.66	50.15	50.86	50.18	51.01
TIO2	0.91	0.58	1.36	1.34	0.93	1.13	1.09
AL2O3	4.24	2.54	4.53	5.04	4.02	4.82	4.33
CR2O3	0.26	0.23	0.16	0.48	0.14	0.26	0.36
FEO	7.41	6.24	8.12	6.55	7.38	5.55	8.02
MNO	0.16	0.14	0.16	0.21	0.13	0.17	0.11
MGO	16.09	17.32	15.54	15.10	15.71	15.57	15.50
CAO	21.23	20.93	20.18	21.55	21.14	21.35	20.60
NA2O	0.30	0.25	0.26	0.38	0.36	0.33	0.37
TOTAL	100.63	99.66	98.97	100.80	100.67	99.36	101.39

SAMPLE	LP-17-21	LP-17-22	LP-17-23	LP-17-24	LP-17-25	LP-17-26
SIO2	51.67	48.71	50.22	50.93	51.15	50.26
TIO2	0.62	1.14	0.84	0.66	0.91	0.97
AL2O3	1.82	4.69	4.05	2.27	3.34	4.01
CR2O3	0.09	0.29	0.23	0.21	0.21	0.27
FEO	6.53	7.21	7.39	7.49	7.22	7.04
MNO	0.16	0.11	0.14	0.13	0.09	0.15
MGO	16.50	15.90	16.15	17.74	16.17	15.99
CAO	21.13	20.95	21.49	19.14	22.15	20.87
NA2O	0.22	0.35	0.36	0.26	0.30	0.32
TOTAL	98.74	99.35	100.87	98.83	101.54	99.88

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC DYKE LITTLE PORT CPLX/NEAR LITTLE PORT

SAMPLE	LP-12-1	LP-12-2	LP-12-3	LP-12-4	LP-12-5	LP-12-6	LP-12-7
SIO2	51.80	52.23	50.57	48.98	51.62	52.49	49.39
TIO2	0.89	1.00	1.11	1.19	1.07	0.59	1.09
AL2O3	2.00	4.07	4.65	3.50	1.89	1.83	4.91
CR2O3	0.0	0.18	0.48	0.0	0.0	0.03	0.33
FEO	10.13	6.28	6.29	8.60	11.57	8.35	7.02
MNO	0.22	0.13	0.17	0.14	0.40	0.26	0.16
MGO	15.66	16.10	15.98	15.37	14.59	17.43	15.65
CAO	19.18	20.83	20.65	20.62	18.90	19.12	19.79
NA2O	0.34	0.36	0.32	0.33	0.36	0.22	0.40
TOTAL	100.22	101.18	100.22	98.73	100.40	100.32	98.74

SAMPLE	LP-12-8	LP-12-9	LP-12-10	LP-12-11	LP-12-12	LP-12-13	LP-12-14
SIO2	48.47	50.95	50.64	51.65	50.71	48.96	48.08
TIO2	1.96	1.28	1.35	0.82	1.12	1.66	1.96
AL2O3	4.10	4.13	3.95	3.62	3.99	4.43	4.16
CR2O3	0.0	0.04	0.0	0.09	0.03	0.0	0.0
FEO	13.21	8.61	9.17	6.59	7.68	9.96	12.47
MNO	0.23	0.23	0.26	0.16	0.23	0.24	0.28
MGO	13.11	15.84	14.51	16.03	15.56	14.43	12.72
CAO	18.95	20.05	20.52	21.14	20.29	20.20	20.02
NA2O	0.47	0.33	0.42	0.26	0.37	0.36	0.51
TOTAL	100.50	101.46	100.82	100.36	99.98	100.24	100.20

SAMPLE	LP-12-15	LP-12-16	LP-12-17	LP-12-18	LP-12-19	LP-12-20	LP-12-21
SIO2	52.25	52.52	52.56	53.39	51.78	53.19	52.16
TIO2	0.86	0.76	0.66	0.64	0.94	0.74	0.67
AL2O3	2.04	1.91	1.96	1.99	1.59	2.02	2.09
CR2O3	0.0	0.0	0.0	0.04	0.0	0.0	0.0
FEO	10.74	8.14	8.96	7.18	11.95	8.83	8.92
MNO	0.29	0.26	0.22	0.20	0.29	0.26	0.23
MGO	15.89	16.29	17.29	17.76	13.96	17.46	17.25
CAO	18.92	19.57	18.61	19.54	19.23	17.82	19.34
NA2O	0.29	0.25	0.24	0.27	0.34	0.26	0.25
TOTAL	101.28	99.70	100.50	101.01	100.08	100.58	100.91

** G' MASS CLINOPYROXENE ANALYSES ** MAFIC DYKE LITTLE PORT CPLX/NEAR LITTLE PORT

SAMPLE	LP-12-22	LP-12-23	LP-12-24	LP-12-25	LP-12-26	LP-12-27
SIO2	50.06	53.34	50.02	50.55	53.52	51.21
TIO2	1.38	0.68	0.95	1.36	0.77	1.06
AL2O3	4.16	2.63	4.21	4.17	2.07	3.16
CR2O3	0.0	0.07	0.05	0.0	0.0	0.0
FEO	8.71	6.47	6.64	9.37	8.61	8.86
MNO	0.16	0.14	0.20	0.16	0.20	0.22
MGO	14.91	17.16	16.07	14.44	16.48	15.69
CAO	20.71	20.59	20.52	20.69	19.52	19.82
NA2O	0.35	0.26	0.28	0.40	0.31	0.33
TOTAL	100.44	101.34	98.94	101.14	101.48	100.35

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA LITTLE PORT CPLX/WESTERN HD SLICE

SAMPLE	WH-6 -1	WH-6 -2	WH-6 -3	WH-6 -4	WH-6 -5	WH-6 -6	WH-6 - 7
SIO2	49.46	49.51	49.45	50.02	48.70	48.64	46.38
TIO2	1.71	1.34	1.66	0.89	1.49	1.61	2.33
AL2O3	3.90	3.50	3.33	1.33	4.22	4.15	5.77
CR2O3	0.05	0.18	0.07	0.04	0.38	0.07	0.31
FEO	11.09	10.88	11.42	13.91	9.38	10.27	11.04
MNO	0.23	0.29	0.28	0.38	0.25	0.23	0.15
MGO	13.32	13.91	13.55	14.61	13.79	13.53	12.29
CAO	20.07	19.71	19.82	17.64	20.37	20.38	21.11
NA2O	0.45	0.46	0.42	0.29	0.40	0.40	0.44
TOTAL	100.28	99.78	100.00	99.11	98.98	99.28	99.82

SAMPLE	WH-6 -8	WH-6 -9	WH-6 -10	WH-6 -11	WH-6 -12	WH-6 -13	WH-6 -14
SIO2	48.96	48.48	48.59	48.52	49.62	48.96	48.88
TIO2	1.37	1.72	1.83	1.73	1.55	1.81	1.42
AL2O3	3.96	5.18	5.35	4.31	3.51	2.99	4.52
CR2O3	0.16	0.26	0.31	0.24	0.11	0.0	0.29
FEO	11.19	9.90	9.94	10.63	12.06	16.38	9.62
MNO	0.22	0.22	0.23	0.26	0.28	0.32	0.17
MGO	13.35	13.00	12.95	13.06	13.66	11.12	13.60
CAO	20.89	21.56	21.37	20.61	20.24	19.41	21.17
NA2O	0.35	0.35	0.36	0.41	0.41	0.45	0.39
TOTAL	100.45	100.67	100.93	99.77	101.44	101.44	100.06

SAMPLE	WH-6 -15	WH-6 -16	WH-6 -17	WH-6 -18	WH-6 -19	WH-6 -20	WH-6 -21
SIO2	48.74	50.17	49.73	50.43	49.02	48.27	48.80
TIO2	1.31	1.29	1.38	0.98	1.42	1.55	1.72
AL2O3	5.68	2.82	4.31	2.79	3.51	5.40	3.34
CR2O3	0.23	0.0	0.17	0.14	0.06	0.13	0.03
FEO	7.55	12.54	9.66	10.69	12.17	10.36	13.36
MNO	0.16	0.23	0.23	0.27	0.23	0.17	0.25
MGO	14.27	13.47	13.68	14.92	13.59	13.27	13.19
CAO	21.49	19.40	20.92	20.39	20.82	21.00	19.95
NA2O	[illegible].34	0.44	0.41	0.33	0.39	0.42	0.42
TOTAL	99.77	100.36	100.49	100.94	101.21	100.57	101.06

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA LITTLE PORT CPLX/WESTERN HD SLICE

SAMPLE	WH-6 -22	WH-8 -1	WH-8 -2	WH-8 -3	WH-8 -4	WH-8 -5	WH-8 -6
SIO2	49.02	50.58	50.16	49.57	51.29	52.19	49.15
TIO2	1.53	1.07	1.37	1.13	0.96	0.52	1.05
AL2O3	3.99	1.66	2.67	3.02	2.68	1.48	3.13
CR2O3	0.15	0.0	0.05	0.0	0.02	0.07	0.0
FEO	11.14	14.48	11.48	10.30	8.96	7.00	9.15
MNO	0.24	0.42	0.27	0.14	0.23	0.20	0.17
MGO	13.43	12.13	13.44	14.14	14.99	17.40	14.82
CAO	20.40	19.73	19.78	20.22	21.05	20.93	21.14
NA2O	0.38	0.36	0.46	0.31	0.31	0.25	0.33
TOTAL	100.28	100.43	99.68	98.83	100.49	100.04	98.94

SAMPLE	WH-8 -7	WH-8 -8	WH-8 -9	WH-8 -10	WH-8 -11	WH-8 -12	WH-8 -13
SIO2	50.77	50.57	50.61	51.68	50.80	50.63	50.52
TIO2	1.08	0.80	0.82	0.63	0.95	0.93	0.77
AL2O3	3.07	3.13	1.23	1.76	3.37	2.97	3.61
CR2O3	0.0	0.08	0.0	0.05	0.0	0.04	0.15
FEO	8.52	6.13	15.59	7.55	7.39	8.55	6.19
MNO	0.25	0.10	0.35	0.22	0.20	0.24	0.12
MGO	15.47	16.28	13.00	16.79	15.59	15.59	16.06
CAO	20.38	22.11	18.04	20.64	21.34	20.46	21.54
NA2O	0.32	0.25	0.30	0.27	0.36	0.36	0.31
TOTAL	99.86	99.45	99.94	99.59	100.00	99.77	99.27

SAMPLE	WH-8 -14	WH-8 -15	WH-8 -16	WH-8 -17	WH-8 -18	WH-8 -19	WH-8 -20
SIO2	52.59	50.32	50.64	50.86	51.39	51.39	49.94
TIO2	0.72	1.30	1.02	1.03	0.67	0.67	1.32
AL2O3	1.85	2.38	3.20	3.25	1.66	1.66	2.93
CR2O3	0.0	0.0	0.0	0.0	0.05	0.05	0.0
FEO	8.38	12.54	7.57	9.05	8.70	8.70	11.87
MNO	0.27	0.28	0.16	0.16	0.25	0.25	0.26
MGO	15.79	13.09	15.31	15.77	16.16	16.16	13.41
CAO	20.85	19.52	21.26	19.99	19.81	19.81	19.51
NA2O	0.27	0.43	0.30	0.37	0.30	0.30	0.49
TOTAL	100.72	99.86	99.46	100.48	98.99	98.99	99.73

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC LAVA LITTLF PORT CPLX/WESTERN HO SLICE

SAMPLE	WH-8 -21	WH-8 -22	WH-8 -23	WH-8 -24	WH-8 -25	WH-8 -25
SIO2	51.75	50.98	50.88	49.72	51.51	50.80
TIO2	0.69	0.86	1.00	0.88	0.78	0.93
AL2O3	0.90	1.48	2.81	2.98	2.87	2.50
CR2O3	0.0	0.0	0.01	0.01	0.13	0.03
FEO	16.46	12.27	7.87	7.70	6.02	9.57
MNO	0.58	0.32	0.24	0.14	0.23	0.24
MGO	11.49	13.88	15.46	15.62	16.63	14.93
CAO	18.61	19.34	21.09	21.21	21.79	20.43
NA2O	0.30	0.38	0.33	0.30	0.29	0.33
TOTAL	100.78	99.51	99.69	98.56	100.25	99.76

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC DYKE IN THE BEVERLEY HEAD SLICE

SAMPLE	BH-1 -1	BH-1 -2	BH-1 -3	BH-1 -4	BH-1 -5	BH-1 -6	BH-1 -7
SIO2	50.06	51.07	50.25	50.00	49.91	49.01	50.59
TIO2	0.71	0.65	0.60	0.50	0.64	0.96	0.73
AL2O3	2.94	2.52	1.84	2.80	2.70	3.89	3.30
CR2O3	0.14	0.20	0.02	0.16	0.15	0.10	0.18
FEO	12.72	10.87	15.02	13.86	12.35	12.02	11.83
MNO	0.32	0.31	0.37	0.23	0.28	0.18	0.38
MGO	16.89	16.30	14.34	16.04	15.45	16.15	16.52
CAO	15.11	17.21	16.11	14.91	17.42	16.20	16.32
NA2O	0.21	0.25	0.25	0.24	0.23	0.23	0.21
TOTAL	99.10	99.38	98.80	98.74	99.13	98.74	100.06

SAMPLE	BH-1 -8	BH-1 -9	BH-1 -10	BH-1 -11	BH-1 -12	BH-1 -13	BH-1 -14
SIO2	50.20	50.39	50.27	50.88	51.25	50.63	49.54
TIO2	0.66	0.65	0.74	0.60	0.71	0.70	0.90
AL2O3	2.80	1.80	2.21	2.59	2.81	3.52	3.28
CR2O3	0.15	0.0	0.0	0.21	0.24	0.16	0.17
FEO	11.67	14.52	13.39	11.42	11.74	11.02	12.06
MNO	0.23	0.44	0.23	0.21	0.25	0.25	0.18
MGO	16.84	14.82	13.83	16.08	16.34	15.58	15.74
CAO	16.34	15.64	18.25	17.29	16.41	17.66	16.86
NA2O	0.25	0.28	0.24	0.20	0.22	0.83	0.22
TOTAL	99.14	98.54	99.16	99.48	99.97	100.35	98.95

SAMPLE	BH-1 -15	BH-1 -16
SIO2	49.41	50.23
TIO2	1.08	0.72
AL2O3	3.11	2.81
CR2O3	0.11	0.13
FEO	13.27	12.52
MNO	0.25	0.27
MGO	15.76	15.78
CAO	16.51	16.55
NA2O	0.28	0.28
TOTAL	99.78	99.29

** G*MASS CLINOPYROXENE ANALYSES ** LAVA LITTLE PORT CPLX(?)/GREGORY ISLAND

SAMPLE	GI-5 -1	GI-5 -2	GI-5 -3	GI-5 -4	GI-5 -5	GI-5 -6	GI-5 -7
SIO2	50.90	52.48	50.72	50.99	52.91	51.20	51.39
TIO2	0.29	0.28	0.29	0.36	0.21	0.28	0.39
AL2O3	3.79	3.33	3.38	2.95	1.96	3.54	2.99
CR2O3	0.75	0.82	0.54	0.19	0.12	0.61	0.09
FEO	5.54	5.15	5.91	7.42	6.63	5.45	6.86
MNO	0.16	0.15	0.13	0.25	0.14	0.16	0.16
MGO	16.96	16.67	17.46	17.33	18.31	17.41	16.43
CAO	20.89	21.44	20.37	19.58	18.95	19.95	20.52
NA2O	0.27	0.24	0.27	0.26	0.21	0.23	0.26
TOTAL	99.45	100.56	99.07	99.33	99.44	98.83	99.09

SAMPLE	GI-5 -8	GI-5 -9	GI-5 -10
SIO2	52.00	51.41	51.54
TIO2	0.41	0.30	0.31
AL2O3	2.20	1.62	3.08
CR2O3	0.01	0.29	0.41
FEO	10.12	5.52	6.51
MNO	0.23	0.12	0.17
MGO	15.81	17.22	17.07
CAO	19.48	21.23	20.27
NA2O	0.32	0.22	0.25
TOTAL	100.58	97.93	99.61

** G'MASS CLINOPYROXENE ANALYSES ** PLUTONIC PROBABLE SKINNER CV.FM./WALLACE BK.

SAMPLE	SK-6 -1	SK-6 -2	SK-6 -3	SK-6 -4	SK-6 -5	SK-6 -6	SK-6 -7
SIO2	48.46	49.85	49.65	47.80	51.06	49.89	48.77
TIO2	2.20	1.41	1.38	2.25	0.86	1.24	1.37
AL2O3	3.25	1.54	2.18	4.08	1.15	1.98	2.07
CR2O3	0.0	0.02	0.01	0.01	0.0	0.06	0.02
FEO	12.23	12.71	12.86	10.76	13.36	12.36	13.06
MNO	0.41	0.39	0.41	0.43	0.54	0.38	0.42
MGO	10.56	11.74	11.40	12.44	11.97	11.27	11.00
CAO	21.44	21.60	22.01	21.51	22.03	21.74	21.95
NA2O	0.58	0.38	0.48	0.54	0.37	0.43	0.51
TOTAL	99.13	99.64	100.38	99.82	101.34	99.35	99.17

SAMPLE	SK-6 -8	SK-6 -9	SK-6 -10	SK-6 -11	SK-6 -12	SK-6 -13	SK-6 -14
SIO2	49.51	50.92	49.21	50.80	49.17	51.06	48.62
TIO2	1.67	1.20	1.43	1.28	1.71	0.85	1.68
AL2O3	2.69	1.59	2.26	1.79	2.55	1.44	3.14
CR2O3	0.05	0.0	0.06	0.02	0.0	0.0	0.0
FEO	12.64	12.05	13.08	13.69	12.73	12.27	12.58
MNO	0.36	0.41	0.45	0.45	0.36	0.46	0.38
MGO	11.25	12.05	10.74	11.00	11.13	11.68	11.29
CAO	22.05	21.35	21.62	21.27	21.45	22.12	21.38
NA2O	0.54	0.38	0.55	0.62	0.54	0.44	0.55
TOTAL	100.76	99.95	99.40	100.92	99.64	100.32	99.62

SAMPLE	SK-6 -15	SK-6 -16	SK-6 -17	SK-6 -18	SK-6 -19	SK-6 -20	SK-6 -21
SIO2	48.71	48.69	49.64	50.02	49.05	49.80	48.36
TIO2	1.51	1.49	1.61	1.32	2.03	1.34	1.63
AL2O3	2.53	2.37	2.61	2.34	3.57	1.91	2.77
CR2O3	0.04	0.0	0.0	0.02	0.04	0.01	0.0
FEO	12.23	12.68	13.05	13.39	12.23	13.36	11.87
MNO	0.48	0.43	0.34	0.52	0.32	0.46	0.40
MGO	11.38	11.05	11.62	10.94	11.08	10.33	11.00
CAO	21.36	21.51	21.86	20.81	21.72	21.60	22.08
NA2O	0.50	0.49	0.46	0.59	0.51	0.50	0.49
TOTAL	98.74	98.71	101.19	99.95	100.55	99.31	98.60

** G'MASS CLINOPYROXENE ANALYSES ** PLUTONIC PROBABLE SKINNER CV.FM./WALLACE BK.

SAMPLE	SK-6 -22	SK-6 -23	SK-6 -24	SK-6 -25	SK-6 -26	SK-6 -27	SK-6 -28
SIO2	47.96	47.29	49.94	47.96	47.65	49.50	49.23
TIO2	2.32	2.42	1.49	1.66	2.23	1.67	1.60
AL2O3	3.92	3.64	2.56	2.63	3.52	2.50	2.54
CR2O3	0.03	0.0	0.0	0.02	0.01	0.0	0.02
FEO	12.90	12.38	12.00	12.96	12.15	13.24	12.62
MNO	0.39	0.39	0.39	0.35	0.46	0.44	0.42
MGO	10.45	10.66	11.32	11.00	10.89	11.05	11.20
CAO	21.53	21.57	21.93	21.62	22.02	21.64	21.66
NA2O	0.56	0.56	0.49	0.50	0.51	0.47	0.50
TOTAL	100.06	98.91	100.02	98.70	99.44	100.51	99.79

** G'MASS CLINOPYROXENE ANALYSES ** MAFIC DYKE, OLD MAN COVE FORMATION

SAMPLE	OMCV- 1	OMCV- 2	OMCV- 3	OMCV- 4	OMCV- 5	OMCV- 6	OMCV- 7
SIO2	48.69	48.87	48.93	49.18	47.46	48.57	51.18
TIO2	1.22	1.37	1.50	1.41	1.34	1.72	1.10
AL2O3	4.91	4.73	5.58	5.05	4.91	5.69	5.00
CR2O3	0.07	0.02	0.12	0.05	0.02	0.10	0.09
FEO	9.93	14.39	9.64	12.45	12.00	9.86	8.43
MNO	0.28	0.37	0.16	0.28	0.29	0.27	0.14
MGO	13.60	12.91	12.79	13.74	13.55	13.16	13.60
CAO	20.18	17.13	20.54	18.64	19.82	21.08	19.92
NA2O	0.47	0.56	0.51	0.51	0.57	0.44	0.43
TOTAL	99.35	100.35	99.77	101.31	99.96	100.89	99.89

SAMPLE	OMCV- 8	OMCV- 9	OMCV-10	OMCV-11	OMCV-12	OMCV-13	OMCV-14
SIO2	50.17	49.08	49.42	50.36	51.57	49.79	48.17
TIO2	1.15	1.29	2.43	1.07	0.90	1.01	1.65
AL2O3	5.01	4.99	5.34	3.54	2.53	3.87	5.33
CR2O3	0.04	0.08	0.0	0.0	0.0	0.0	0.0
FEO	10.29	12.75	12.33	11.14	13.56	9.39	10.18
MNO	0.23	0.29	0.39	0.20	0.34	0.16	0.23
MGO	13.46	15.45	12.02	12.44	15.48	15.05	14.01
CAO	19.83	17.20	17.68	18.30	15.41	19.23	19.37
NA2O	0.53	0.41	0.66	0.69	0.48	0.66	0.55
TOTAL	100.71	101.54	100.27	97.74	100.27	99.16	99.49

SAMPLE	OMCV-15	OMCV-16	OMCV-17	OMCV-18	OMCV-19	OMCV-20	OMCV-MEA
SIO2	48.59	47.63	49.03	47.98	49.61	48.39	49.02
TIO2	1.39	1.93	1.60	1.55	1.37	1.64	1.36
AL2O3	4.92	5.53	5.30	5.07	5.00	5.06	4.75
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	10.19	10.77	9.96	10.11	9.80	9.82	10.88
MNO	0.20	0.22	0.22	0.19	0.22	0.22	0.25
MGO	13.29	13.80	13.69	13.78	14.36	13.88	13.79
CAO	20.13	19.50	20.24	19.41	19.46	19.89	19.32
NA2O	0.69	0.71	0.66	0.77	0.68	0.62	0.56
TOTAL	99.39	100.09	100.70	98.86	100.50	99.52	99.93

** G'MASS CLINOPYROXENE ANALYSES ** ALKALI BASALT, POMO BEDS (SEAMOUNT), CALIF.

SAMPLE	BK-198-1	BK-198-2	BK-198-3	BK-198-4	BK-198-5	BK-198-6	BK-198-7
SIO2	47.13	45.99	45.48	45.12	47.43	51.39	45.92
TIO2	2.79	3.02	3.38	3.82	2.79	0.72	3.07
AL2O3	5.23	6.05	5.91	6.13	5.22	1.34	5.72
CR2O3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FEO	9.84	10.76	10.76	10.26	9.12	11.64	9.61
MNO	0.20	0.28	0.20	0.18	0.20	0.36	0.14
MGO	12.12	11.98	11.67	11.71	12.13	13.28	12.16
CAO	21.44	21.28	21.23	21.83	21.42	19.74	21.20
NA2O	0.51	0.63	0.61	0.62	0.61	0.34	0.59
TOTAL	99.26	99.99	99.24	99.67	98.92	98.81	98.41

SAMPLE	BK-198-8	BK-198-9	BK-198-
SIO2	44.70	49.04	46.91
TIO2	3.89	2.14	2.62
AL2O3	6.92	4.42	5.22
CR2O3	0.0	0.0	0.0
FEO	10.63	11.71	10.48
MNO	0.22	0.28	0.23
MGO	11.37	12.07	12.05
CAO	20.87	20.60	20.07
NA2O	0.61	0.54	0.56
TOTAL	99.21	100.80	98.14

B.2.2 Phenocryst and Microphenocryst Clinopyroxene (1 Orthopyroxene) Analyses

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST SKINNER CV.FM./TROUT R. SLICE

SAMPLE		SKC-31-MPH-1 -1		SKC-31-MPH-1 -2		SKC-31-MPH-1 -3		SKC-31-MPH-1 -4		SKC-31-MPH-2 -1	
SIO2	*	49.64	*	47.47	*	47.39	*	48.17	*	47.02	*
TIO2	*	1.45	*	2.16	*	2.25	*	1.95	*	2.24	*
AL2O3	*	3.90	*	5.98	*	3.14	*	5.34	*	6.21	*
CR2O3	*	0.0	*	0.0	*	0.0	*	0.0	*	0.0	*
FEO	*	8.23	*	8.71	*	8.52	*	8.49	*	8.34	*
MNO	*	0.22	*	0.24	*	0.25	*	0.24	*	0.18	*
MGO	*	14.21	*	13.02	*	12.71	*	13.31	*	12.96	*
CAO	*	22.39	*	22.30	*	22.91	*	22.53	*	23.07	*
NA2O	*	0.42	*	0.42	*	0.55	*	0.46	*	0.55	*
TOTAL	*	100.46	*	100.30	*	97.72	*	100.49	*	100.57	*

SAMPLE		SKC-31-MPH-2 -2		SKC-31-MPH-2 -3		SKC-31-MPH-2 -4		SKC-31-MPH-3 -1		SKC-31-MPH-3 -2	
SIO2	*	50.29	*	49.34	*	48.88	*	47.32	*	46.32	*
TIO2	*	1.48	*	1.46	*	1.73	*	1.56	*	2.07	*
AL2O3	*	3.03	*	4.00	*	4.41	*	4.27	*	4.68	*
CR2O3	*	0.0	*	0.0	*	0.0	*	0.0	*	0.0	*
FEO	*	7.93	*	8.13	*	8.13	*	7.27	*	8.14	*
MNO	*	0.26	*	0.23	*	0.22	*	0.25	*	0.24	*
MGO	*	14.33	*	14.24	*	13.84	*	13.99	*	13.47	*
CAO	*	22.95	*	22.66	*	22.89	*	22.80	*	23.29	*
NA2O	*	0.41	*	0.37	*	0.44	*	0.49	*	0.51	*
TOTAL	*	100.68	*	100.43	*	100.54	*	97.95	*	98.72	*

SAMPLE		SKC-31-MPH-3 -3		SKC-31-MPH-3 -4		SKC-31-MPH-3 -5		SKC-31-MPH-4 -1		SKC-31-MPH-4 -2	
SIO2	*	47.50	*	46.77	*	46.98	*	49.65	*	45.39	*
TIO2	*	2.11	*	1.80	*	1.89	*	1.39	*	2.67	*
AL2O3	*	6.15	*	5.37	*	5.11	*	3.89	*	7.13	*
CR2O3	*	0.0	*	0.0	*	0.0	*	0.0	*	0.0	*
FEO	*	8.30	*	9.19	*	8.22	*	7.83	*	8.71	*
MNO	*	0.23	*	0.28	*	0.28	*	0.22	*	0.27	*
MGO	*	12.93	*	12.70	*	13.27	*	14.03	*	11.95	*
CAO	*	23.13	*	22.62	*	22.96	*	22.77	*	22.44	*
NA2O	*	0.53	*	0.58	*	0.53	*	0.37	*	0.56	*
TOTAL	*	100.88	*	99.26	*	99.24	*	100.15	*	99.12	*

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST SKINNER CV.,EM./TROUT F. SLICE

SAMPLE	SKC-31-MPH-4 -3	SKC-31-MPH-5 -1	SKC-31-MPH-5 -2	SKC-31-MPH-5 -3	SKC-31-MPH-6 -1
SIO2	47.52	45.05	44.77	44.91	45.77
TIO2	2.03	2.61	2.43	2.52	2.42
AL2O3	5.51	6.57	6.91	6.74	6.44
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	8.27	8.68	8.76	8.72	7.96
MNO	0.25	0.19	0.27	0.23	0.20
MGO	12.99	12.86	12.49	12.67	12.62
CAO	22.61	22.67	22.66	22.67	22.46
NA2O	0.47	0.61	0.59	0.60	0.49
TOTAL	99.65	99.24	98.97	99.06	98.26

SAMPLE	SKC-31-MPH-6 -2	SKC-31-MPH-6 -3	SKC-31-MPH-7 -1	SKC-31-MPH-7 -2	SKC-31-MPH-7 -3
SIO2	46.50	46.14	47.75	45.15	46.45
TIO2	2.10	2.26	1.44	2.47	1.96
AL2O3	5.84	6.14	4.30	5.38	4.84
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	8.07	7.97	7.35	8.72	8.29
MNO	0.23	0.22	0.14	0.17	0.16
MGO	12.30	12.46	13.85	12.66	13.26
CAO	23.52	22.99	23.02	22.43	22.73
NA2O	0.46	0.48	0.51	0.55	0.53
TOTAL	99.02	98.66	98.96	97.53	98.22

SAMPLE	SKC-31-MPH-8 -1	SKC-31-MPH-8 -2	SKC-31-MPH-8 -3	SKC-31-MPH-9 -1	SKC-31-MPH-9 -2
SIO2	46.97	42.69	44.33	48.99	46.92
TIO2	1.39	3.69	2.54	1.44	2.34
AL2O3	3.88	7.00	5.44	3.93	6.53
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	7.86	10.36	9.11	8.06	8.20
MNO	0.23	0.20	0.22	0.16	0.21
MGO	14.01	10.89	12.45	14.37	12.75
CAO	22.53	22.48	22.51	22.43	22.75
NA2O	0.45	0.82	0.64	0.43	0.53
TOTAL	97.32	98.13	97.74	99.81	100.23

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST SKINNER CV.FM./TROUT R. SLICE

SAMPLE		SKC-31-MPH-9 -3		SKC-31-MPH-10-1		SKC-31-MPH-10-2		SKC-31-MPH-10-3		SKC-31-MPH-99-	
SIO2	*	47.96	*	47.05	*	45.99	*	46.52	*	46.84	*
TIO2	*	1.99	*	2.41	*	2.16	*	2.29	*	2.11	*
AL2O3	*	5.23	*	6.59	*	6.29	*	6.44	*	5.52	*
CR2O3	*	0.0	*	0.0	*	0.0	*	0.0	*	0.0	*
FEO	*	8.13	*	8.28	*	8.48	*	8.38	*	8.37	*
MNO	*	0.19	*	0.20	*	0.14	*	0.17	*	0.22	*
MGO	*	13.56	*	12.60	*	12.37	*	12.49	*	13.03	*
CAO	*	22.59	*	22.39	*	22.60	*	22.50	*	22.70	*
NA2O	*	0.48	*	0.53	*	0.58	*	0.56	*	0.52	*
TOTAL	*	100.03	*	100.05	*	98.61	*	99.35	*	99.31	*

SAMPLE		SKC-31-MPH- 0-		SKC-31-MPH-00-		SKC-32-PH -1 -1		SKC-32-PH -1 -2		SKC-32-PH -1 -3	
SIO2	*	48.52	*	45.90	*	46.66	*	47.39	*	46.38	*
TIO2	*	1.45	*	2.49	*	2.17	*	2.52	*	2.86	*
AL2O3	*	4.02	*	6.25	*	5.98	*	5.59	*	5.45	*
CR2O3	*	0.0	*	0.0	*	0.0	*	0.0	*	0.0	*
FEO	*	7.89	*	8.86	*	8.06	*	7.69	*	9.55	*
MNO	*	0.21	*	0.22	*	0.19	*	0.23	*	0.20	*
MGO	*	14.10	*	12.56	*	13.01	*	13.05	*	12.07	*
CAO	*	22.66	*	22.67	*	22.28	*	22.58	*	22.46	*
NA2O	*	0.43	*	0.59	*	0.47	*	0.52	*	0.59	*
TOTAL	*	99.28	*	99.54	*	98.82	*	99.57	*	100.06	*

SAMPLE		SKC-32-PH -1 -4		SKC-32-PH -2 -1		SKC-32-PH -2 -2		SKC-32-PH -2 -3		SKC-32-PH -2 -4	
SIO2	*	46.98	*	49.20	*	49.55	*	49.54	*	49.99	*
TIO2	*	2.52	*	0.51	*	0.58	*	0.57	*	0.48	*
AL2O3	*	5.67	*	1.45	*	1.81	*	1.89	*	1.81	*
CR2O3	*	0.0	*	0.0	*	0.0	*	0.0	*	0.0	*
FEO	*	8.43	*	17.85	*	17.59	*	17.57	*	16.12	*
MNO	*	0.21	*	0.63	*	0.66	*	0.71	*	0.66	*
MGO	*	12.71	*	8.03	*	8.11	*	8.30	*	9.13	*
CAO	*	22.44	*	21.56	*	21.57	*	20.98	*	21.61	*
NA2O	*	0.53	*	0.53	*	0.56	*	0.41	*	0.54	*
TOTAL	*	99.49	*	99.76	*	100.43	*	99.97	*	100.34	*

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST SKINNER CV.FM./TROUT R. SLICE

SAMPLE	SKC-32-PH -2 -5	SKC-32-PH -2 -6	SKC-32-PH -3 -1	SKC-32-PH -3 -2	SKC-32-PH -3 -3
SIO2	46.79	49.01	45.76	46.18	46.27
TIO2	2.50	0.93	2.12	2.23	3.00
AL2O3	6.59	2.71	5.87	6.18	7.64
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	8.12	15.45	9.59	8.29	8.66
MNO	0.20	0.57	0.26	0.19	0.26
MGO	12.23	9.16	12.30	13.06	12.62
CAO	22.36	21.62	21.81	22.75	22.31
NA2O	0.49	0.51	0.60	0.53	0.56
TOTAL	99.28	99.96	98.31	99.41	101.32

SAMPLE	SKC-32-PH -3 -4	SKC-32-PH -3 -5	SKC-32-PH -4 -	SKC-32-PH -5 -1	SKC-32-PH -5 -2
SIO2	43.97	45.52	46.64	44.30	45.69
TIO2	4.77	3.03	2.76	2.49	2.25
AL2O3	7.15	6.71	7.18	6.73	6.26
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	11.17	9.43	8.16	8.69	7.77
MNO	0.30	0.25	0.21	0.16	0.25
MGO	10.09	12.02	12.99	12.86	12.57
CAO	21.69	22.14	22.86	22.08	21.98
NA2O	0.85	0.64	0.50	0.49	0.49
TOTAL	99.89	99.74	101.30	97.80	97.25

SAMPLE	SKC-32-PH -5 -3	SKC-32-PH -5 -4	SKC-32-PH -5 -5	SKC-32-PH -99-	SKC-32-PH - 0-
SIO2	46.94	48.92	46.46	46.99	46.51
TIO2	2.45	2.53	2.43	2.23	2.01
AL2O3	6.38	4.37	5.94	5.26	5.44
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	7.85	9.78	8.52	10.46	10.47
MNO	0.22	0.24	0.22	0.31	0.29
MGO	13.16	12.68	12.82	11.68	11.84
CAO	22.90	22.40	22.34	22.14	22.12
NA2O	0.53	0.52	0.51	0.55	0.52
TOTAL	100.43	101.44	99.24	99.62	99.20

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST SKINNER CV.FM./TROUT R. SLICE

SAMPLE	SKC-32-PH -00-	SKC-39-PH -1 -1	SKC-39-PH -1 -2	SKC-39-PH -1 -3	SKC-39-PH -1 -4
SIO2	46.62	50.00	50.21	49.95	49.51
TIO2	3.17	1.24	1.26	1.45	1.42
AL2O3	5.99	4.88	4.55	5.48	5.08
CR2O3	0.0	0.31	0.26	0.02	0.08
FEO	9.66	4.12	4.85	5.68	5.50
MNO	0.24	0.07	0.04	0.07	0.12
MGO	11.77	15.53	15.76	15.39	15.22
CAO	22.23	22.68	22.44	22.41	22.38
NA2O	0.61	0.42	0.42	0.45	0.39
TOTAL	100.19	99.25	99.79	100.90	99.70

SAMPLE	SKC-39-PH -1 -5	SKC-39-PH -1 -6	SKC-39-PH -1 -7	SKC-39-PH -2 -1	SKC-39-PH -2 -2
SIO2	49.82	45.54	49.17	44.95	45.42
TIO2	1.46	4.13	1.83	3.09	2.98
AL2O3	5.13	7.20	5.39	7.90	9.47
CR2O3	0.10	0.04	0.14	0.02	0.0
FEO	5.17	8.28	5.60	6.66	7.16
MNO	0.08	0.11	0.09	0.14	0.09
MGO	15.50	12.38	14.96	12.30	12.75
CAO	21.80	20.89	22.10	22.49	22.19
NA2O	0.39	0.47	0.42	0.51	0.52
TOTAL	99.45	99.04	99.69	98.56	100.58

SAMPLE	SKC-39-PH -2 -3	SKC-39-PH -2 -4	SKC-39-PH -2 -5	SKC-39-PH -2 -6	SKC-39-PH -2 -7
SIO2	45.74	44.64	46.52	46.40	44.49
TIO2	3.01	3.20	3.04	3.02	3.00
AL2O3	9.47	9.30	8.39	8.23	8.05
CR2O3	0.02	0.0	0.0	0.0	0.0
FEO	6.89	6.95	6.71	7.41	7.25
MNO	0.10	0.0[illegible]	0.07	0.13	0.11
MGO	12.58	12.56	12.85	12.94	12.73
CAO	22.25	22.10	22.47	22.51	22.75
NA2O	0.55	0.59	0.46	0.46	0.46
TOTAL	100.61	99.41	100.50	101.10	98.84

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST SKINNER CV.FM./TROUT C. SLICT

SAMPLE		SKC-39-PH -2 -8		SKC-39-PH -3 -1		SKC-39-PH -3 -2		SKC-39-PH -3 -3		SKC-39-PH -3 -4	
SIO2	*	45.45	*	49.54	*	49.57	*	48.73	*	50.00	*
TIO2	*	3.05	*	1.20	*	1.11	*	1.30	*	1.20	*
AL2O3	*	8.69	*	4.15	*	4.12	*	4.79	*	4.48	*
CR2O3	*	0.0	*	0.13	*	0.13	*	0.11	*	0.23	*
FEO	*	7.00	*	5.09	*	5.24	*	4.63	*	4.61	*
MNO	*	0.10	*	0.14	*	0.10	*	0.05	*	0.11	*
MGO	*	12.74	*	15.50	*	15.45	*	15.66	*	15.85	*
CAO	*	22.39	*	22.48	*	21.58	*	22.54	*	22.54	*
NA2O	*	0.51	*	0.36	*	0.33	*	0.42	*	0.39	*
TOTAL	*	99.93	*	98.59	*	97.63	*	98.23	*	99.41	*

SAMPLE		SKC-39-PH -3 -5		KC-39-PH -3 -6		SKC-39-PH -99-		SKC-39-PH - 0-		SKC-39-PH -00-	
SIO2	*	44.30	*	48.43	*	47.68	*	48.16	*	44.78	*
TIO2	*	3.72	*	1.71	*	2.20	*	1.84	*	3.62	*
AL2O3	*	8.54	*	5.22	*	6.43	*	5.64	*	7.33	*
CR2O3	*	0.05	*	0.13	*	0.09	*	0.15	*	0.03	*
FEO	*	7.81	*	5.48	*	6.03	*	5.29	*	7.78	*
MNO	*	0.11	*	0.10	*	0.09	*	0.12	*	0.11	*
MGO	*	12.13	*	14.92	*	14.21	*	14.61	*	12.41	*
CAO	*	21.98	*	22.22	*	22.24	*	22.55	*	21.87	*
NA2O	*	0.47	*	0.39	*	0.44	*	0.43	*	0.47	*
TOTAL	*	99.11	*	98.60	*	99.41	*	98.79	*	98.40	*

SAMPLE		SKC-39-MPH-1 -1		SKC-39-MPH-1 -2		SKC-39-MPH-1 -3		SKC-39-MPH-1 -4		SKC-39-MPH-2 -1	
SIO2	*	46.72	*	45.71	*	45.24	*	45.89	*	48.15	*
TIO2	*	2.52	*	2.93	*	2.94	*	2.80	*	1.48	*
AL2O3	*	6.22	*	7.12	*	7.00	*	6.78	*	5.75	*
CR2O3	*	0.02	*	0.0	*	0.0	*	0.0	*	0.25	*
FEO	*	7.26	*	7.33	*	7.73	*	7.11	*	5.54	*
MNO	*	0.11	*	0.07	*	0.07	*	0.08	*	0.14	*
MGO	*	13.60	*	12.70	*	12.55	*	12.95	*	15.43	*
CAO	*	22.29	*	22.34	*	21.50	*	22.04	*	22.05	*
NA2O	*	0.49	*	0.52	*	0.47	*	0.49	*	0.45	*
TOTAL	*	99.23	*	98.72	*	97.50	*	98.14	*	99.24	*

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST SKINNER CV.FM./TROUT R. SLICE

SAMPLE	SKC-39-MPH-2 -2	SKC-39-MPH-2 -3	SKC-39-MPH-2 -4	SKC-39-MPH-2 -5	SKC-39-MPH-3 -1
SIO2	49.32	49.02	46.45	48.24	43.85
TIO2	1.72	1.73	3.17	2.03	3.21
AL2O3	6.24	6.11	5.77	5.97	[illegible]
CR2O3	0.07	0.12	0.0	0.11	0.0
FEO	5.27	5.25	7.79	5.96	6.92
MNO	0.05	0.04	0.11	0.09	0.13
MGO	14.69	14.86	13.70	14.67	12.61
CAO	21.93	22.57	21.80	22.09	22.25
NA2O	0.42	0.45	0.39	0.43	0.52
TOTAL	99.71	100.15	99.18	99.59	97.83

SAMPLE	SKC-39-MPH-3 -2	SKC-39-MPH-3 -3	SKC-39-MPH-3 -4	SKC-39-MPH-3 -5	SKC-39-MPH-99-
SIO2	44.07	44.47	45.09	44.38	45.84
TIO2	3.31	3.25	3.50	3.32	2.72
AL2O3	8.39	7.75	7.45	7.97	6.91
CR2O3	0.0	0.04	0.02	0.0	0.0
FEO	6.66	7.19	7.69	7.12	6.73
MNO	0.10	0.09	0.09	0.10	0.09
MGO	12.59	12.23	12.52	12.49	13.37
CAO	22.28	22.23	22.88	22.41	22.18
NA2O	0.57	0.58	0.40	0.52	0.48
TOTAL	97.97	97.83	99.64	98.31	98.32

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SAMPLE	SKC-39-MPH- 0-	SKC-39-MPH-00-	SKC-41-PH -1 -1	SKC-41-PH -1 -2	SKC-41-PH -1 -3
SIO2	46.25	45.59	49.29	47.38	51.27
TIO2	2.40	3.20	2.15	2.25	0.69
AL2O3	6.76	6.74	3.91	6.53	3.87
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	6.57	7.74	7.29	7.69	4.57
MNO	0.13	0.09	0.17	0.09	0.10
MGO	13.98	12.92	14.51	14.25	16.96
CAO	22.20	22.06	22.93	22.57	22.41
NA2O	0.49	0.42	0.39	0.46	0.38
TOTAL	98.68	98.76	100.64	101.22	100.25

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST SKINNER CV.FM./TECUT F. SLICE

SAMPLE	SKC-41-PH -1 -4	SKC-41-PH -1 -5	SKC-41-PH -1 -6	SKC-41-PH -2 -1	SKC-41-PH -2 -2
SIO2	50.96	51.43	50.07	46.23	43.37
TIO2	0.79	0.80	1.34	3.65	3.17
AL2O3	3.97	3.71	4.40	7.33	9.89
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	4.63	4.66	5.76	7.90	7.72
MNO	0.09	0.08	0.12	0.10	0.11
MGO	17.02	17.27	16.00	12.64	12.46
CAO	22.55	22.64	22.62	23.36	22.33
NA2O	0.36	0.30	0.33	0.50	0.54
TOTAL	100.37	100.89	100.69	101.71	99.59

SAMPLE	SKC-41-PH -2 -3	SKC-41-PH -2 -4	SKC-41-PH -2 -5	SKC-41-PH -2 -6	SKC-41-PH -2 -7
SIO2	48.23	50.16	48.63	47.43	47.32
TIO2	1.18	1.22	1.30	1.31	1.97
AL2O3	5.31	5.48	5.95	6.19	6.69
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	5.49	5.23	5.82	5.63	6.29
MNO	0.10	0.11	0.10	0.07	0.10
MGO	16.04	15.74	15.50	15.45	14.63
CAO	22.79	22.75	23.30	23.03	22.93
NA2O	0.39	0.34	0.33	0.36	0.41
TOTAL	99.53	101.03	100.93	99.47	100.34

SAMPLE	SKC-41-PH -3 -1	SKC-41-PH -3 -2	SKC-41-PH -3 -3	SKC-41-PH -3 -4	SKC-41-PH -3 -5
SIO2	49.98	47.13	46.12	46.92	51.39
TIO2	2.20	2.35	2.55	0.99	0.99
AL2O3	4.22	4.66	8.81	4.53	4.38
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	7.64	7.20	7.11	5.01	4.82
MNO	0.13	0.13	0.08	0.08	0.10
MGO	14.50	14.45	13.08	16.79	16.60
CAO	23.28	23.28	22.86	22.72	22.77
NA2O	0.35	0.38	0.39	0.34	0.29
TOTAL	102.20	99.57	101.00	97.38	101.32

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST SKINNER CV.FM./TROUT R. SLICE

SAMPLE	SKC-41-PH -3 -6	SKC-41-PH -4 -1	SKC-41-PH -4 -2	SKC-41-PH -4 -3	SKC-41-PH -4 -4
SIO2	48.29	49.41	49.52	50.07	51.17
TIO2	1.80	1.00	0.99	1.26	1.07
AL2O3	5.32	4.72	4.57	5.53	4.93
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	6.37	5.07	5.13	5.58	5.45
MNO	0.10	0.07	0.11	0.09	0.04
MGO	15.08	16.73	16.65	15.84	16.13
CAO	22.98	22.55	23.13	22.68	22.84
NA2O	0.35	0.37	0.33	0.42	0.35
TOTAL	100.29	99.92	100.43	101.47	101.98

SAMPLE	SKC-41-PH -4 -5	SKC-41-PH -99-	SKC-41-PH -00-	SKC-41-PH - 0-	SKC-65-MPH-1 -1
SIO2	50.04	48.93	50.08	48.47	49.65
TIO2	1.08	1.55	1.03	2.67	0.42
AL2O3	4.94	5.34	4.76	5.15	1.35
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	5.31	5.93	5.03	7.60	19.86
MNO	0.08	0.10	0.08	0.13	1.01
MGO	16.34	15.51	16.44	13.98	6.32
CAO	22.30	22.83	22.81	23.19	21.27
NA2O	0.37	0.38	0.32	0.41	0.54
TOTAL	100.96	100.57	100.55	101.50	100.42

SAMPLE	SKC-65-MPH-1 -2	SKC-65-MPH-1 -3	SKC-65-MPH-1 -4	SKC-65-MPH-2 -	SKC-65-MPH-99-
SIO2	46.56	48.91	48.41	47.01	47.71
TIO2	0.37	0.84	0.54	0.56	0.55
AL2O3	1.27	2.20	1.51	1.57	1.59
CR2O3	0.0	0.0	0.0	0.0	0.0
FEO	19.90	18.51	19.42	18.67	19.05
MNO	0.82	0.95	0.93	0.93	0.93
MGO	6.40	7.34	6.69	7.28	6.99
CAO	21.70	20.51	21.61	22.34	21.75
NA2O	0.54	0.63	0.57	0.53	0.55
TOTAL	97.66	99.89	99.79	98.89	99.12

* C-P-X ANALYSES * MPH=MICROPHENO PH=PHENOCRYST SKINNER CV.FM./CHIMNEY CV. SLICE

SAMPLE	CC-27-PH -1 -1	CC-27-PH -1 -2	CC-27-PH -1 -3	CC-27-PH -1 -4	CC-27-PH -2 -1
SIO2	46.66	48.96	46.95	47.52	45.40
TIO2	2.43	1.92	1.91	2.09	2.92
AL2O3	6.51	5.39	5.77	5.89	8.54
CR2O3	0.11	0.0	0.02	0.04	0.01
FEO	7.61	8.34	8.20	8.05	7.32
MNO	0.05	0.27	0.19	0.17	0.14
MGO	13.53	13.81	13.95	13.76	12.87
CAO	21.91	21.46	21.73	21.70	21.69
NA2O	0.37	0.51	0.40	0.43	0.52
TOTAL	99.18	100.65	99.12	99.65	99.41

SAMPLE	CC-27-PH -2 -2	CC-27-PH -2 -3	CC-27-PH -2 -4	CC-27-PH - 2-5	CC-27-PH -3 -1
SIO2	44.15	45.61	46.05	45.30	48.77
TIO2	3.29	2.64	2.38	2.93	1.16
AL2O3	9.23	8.57	7.30	8.41	4.69
CR2O3	0.04	0.37	0.08	0.13	0.82
FEO	7.57	6.88	8.44	7.55	5.31
MNO	0.07	0.07	0.20	0.12	0.09
MGO	12.63	13.07	12.73	12.83	15.12
CAO	21.08	22.30	21.20	21.57	22.15
NA2O	0.50	0.41	0.47	0.48	0.32
TOTAL	98.56	99.92	99.35	99.32	98.42

SAMPLE	CC-27-PH -3 -2	CC-27-PH -3 -3	CC-27-PH -3 -4	CC-27-PH -4 -1	CC-27-PH -4 -2
SIO2	47.96	49.33	48.69	50.40	48.83
TIO2	1.57	1.54	1.42	1.21	1.91
AL2O3	5.71	4.96	5.12	3.27	5.46
CR2O3	0.36	0.80	0.66	0.05	0.04
FEO	6.71	5.71	5.91	10.09	8.36
MNO	0.09	0.12	0.10	0.41	0.20
MGO	14.49	15.06	14.89	13.67	13.20
CAO	22.20	22.51	22.29	21.35	21.81
NA2O	0.30	0.27	0.30	0.49	0.52
TOTAL	99.39	100.30	99.38	100.94	100.33

* C-P-X ANALYSES * MPH=MICROPHENO PH=PHENOCRYST SKINNER CV.FM./CHIMNEY CV. SLICE

SAMPLE		CC-27-PH -4 -3		CC-27-PH -4 -4		CC-27-PH -4 -5		CC-27-PH -4 -6		CC-27-PH -5 -1	
SIO2	*	48.65	*	49.52	*	49.54	*	49.39	*	50.46	*
TIO2	*	1.99	*	1.71	*	1.98	*	1.76	*	1.04	*
AL2O3	*	5.44	*	4.20	*	4.58	*	4.59	*	3.14	*
CR2O3	*	0.05	*	0.04	*	0.02	*	0.04	*	0.0	*
FEO	*	7.27	*	7.61	*	7.20	*	8.11	*	9.99	*
MNO	*	0.16	*	0.16	*	0.19	*	0.22	*	0.34	*
MGO	*	14.11	*	14.50	*	14.29	*	13.95	*	12.91	*
CAO	*	22.54	*	21.77	*	22.25	*	21.94	*	21.92	*
NA2O	*	0.44	*	0.38	*	0.36	*	0.44	*	0.47	*
TOTAL	*	100.65	*	99.89	*	100.41	*	100.44	*	100.27	*

SAMPLE		CC-27-PH -5 -2		CC-27-PH -5 -3		CC-27-PH -5 -4		CC-27-PH -5 -5		CC-27-PH -99-	
SIO2	*	48.46	*	45.62	*	45.32	*	47.47	*	47.67	*
TIO2	*	2.03	*	3.39	*	2.71	*	2.29	*	2.10	*
AL2O3	*	4.99	*	7.70	*	6.79	*	5.66	*	5.93	*
CR2O3	*	0.0	*	0.03	*	0.05	*	0.02	*	0.18	*
FEO	*	8.93	*	8.27	*	7.96	*	8.79	*	7.69	*
MNO	*	0.28	*	0.16	*	0.20	*	0.25	*	0.17	*
MGO	*	13.09	*	12.18	*	12.68	*	12.72	*	13.63	*
CAO	*	21.67	*	22.59	*	22.53	*	21.18	*	21.74	*
NA2O	*	0.57	*	0.48	*	0.49	*	0.50	*	0.43	*
TOTAL	*	100.02	*	100.42	*	98.73	*	98.88	*	99.53	*

SAMPLE		CC-27-PH - 0-		CC-27-PH -00-		CC-28-PH -1 -1		CC-28-PH -1 -2		CC-28-PH -1 -3	
SIO2	*	48.34	*	47.44	*	46.53	*	43.65	*	43.68	*
TIO2	*	1.75	*	2.20	*	2.72	*	4.19	*	4.21	*
AL2O3	*	5.23	*	5.88	*	5.93	*	9.34	*	9.20	*
CR2O3	*	0.20	*	0.19	*	0.0	*	0.0	*	0.01	*
FEO	*	8.06	*	7.50	*	7.14	*	8.30	*	7.97	*
MNO	*	0.21	*	0.18	*	0.17	*	0.08	*	0.10	*
MGO	*	13.62	*	13.74	*	14.07	*	11.98	*	12.08	*
CAO	*	21.80	*	22.04	*	22.35	*	22.96	*	23.16	*
NA2O	*	0.43	*	0.40	*	0.48	*	0.60	*	0.62	*
TOTAL	*	99.64	*	99.57	*	99.39	*	101.10	*	101.03	*

* C-P-X ANALYSES * MPH=MICROPHENO PH=PHENOCRYST SKINNER CV.FM./CHIMNEY CV. SLICE

SAMPLE	CC-28-PH -1 -4	CC-28-PH -1 -5	CC-28-PH -1 -6	CC-28-PH -1 -7	CC-28-PH -2 -1
SIO2	44.08	44.77	41.98	44.12	46.30
TIO2	4.81	3.77	5.91	4.27	2.92
AL2O3	9.62	8.61	10.96	8.94	6.76
CR2O3	0.0	0.0	0.04	0.0	0.0
FEO	9.15	9.17	9.10	8.47	8.30
MNO	0.13	0.13	0.13	0.12	0.14
MGO	11.87	12.56	10.77	12.22	13.66
CAO	23.03	22.82	22.80	22.85	22.88
NA2O	0.51	0.48	0.47	0.53	0.47
TOTAL	103.20	102.31	102.16	101.52	101.43

SAMPLE	CC-28-PH -2 -2	CC-28-PH -2 -3	CC-28-PH -2 -4	CC-28-MPH-1 -1	CC-28-MPH-1 -2
SIO2	43.15	42.42	43.96	47.82	49.21
TIO2	4.70	4.98	4.20	2.99	2.79
AL2O3	10.29	9.58	8.88	5.78	5.01
CR2O3	0.09	0.0	0.0	0.0	0.06
FEO	8.18	8.93	8.47	9.94	8.87
MNO	0.08	0.10	0.11	0.20	0.16
MGO	11.34	11.55	12.18	13.91	14.43
CAO	23.13	22.74	22.92	22.35	23.07
NA2O	0.59	0.55	0.55	0.37	0.35
TOTAL	101.55	100.85	101.27	103.36	103.95

SAMPLE	CC-28-MPH-1 -3	CC-28-MPH-2 -1	CC-28-MPH-2 -2	CC-28-MPH-2 -3	CC-28-PH -99-
SIO2	48.52	44.48	45.64	45.06	44.04
TIO2	2.89	6.88	3.58	3.73	4.24
AL2O3	5.40	8.86	6.67	7.67	8.91
CR2O3	0.03	0.0	0.0	0.0	0.0
FEO	9.41	8.63	9.24	8.94	8.47
MNO	0.18	0.18	0.11	0.15	0.12
MGO	14.17	12.26	13.51	12.89	12.20
CAO	22.71	22.05	22.29	22.17	22.88
NA2O	0.36	0.54	0.40	0.47	0.54
TOTAL	103.67	103.88	101.44	101.08	101.40

* C-PX ANALYSES * MPH=MICROPHENO PH=PHENOCRYST SKINNER CV.FM./CHIMNEY CV. SLICE

SAMPLE		CC-28-PH - 0-		CC-28-PH -00-	
SIO2	*	46.42	*	42.20	*
TIO2	*	2.92	*	5.45	*
AL2O3	*	6.35	*	10.27	*
CR2O3	*	0.0	*	0.0	*
FEO	*	7.72	*	9.02	*
MNO	*	0.16	*	0.12	*
MGO	*	13.97	*	11.16	*
CAO	*	22.62	*	22.77	*
NA2O	*	0.48	*	0.51	*
TOTAL	*	100.44	*	101.50	*

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST LITTLE PORT CMPX/GREGORY I.

SAMPLE	GI-5 -PH -1 -1	GI-5 -PH -1 -2	GI-5 -PH -1 -3	GI-5 -PH -1 -4	GI-5 -PH -1 -5
SIO2	50.44	51.91	51.66	52.47	51.07
TIO2	0.47	0.30	0.32	0.23	0.55
AL2O3	2.32	2.49	2.55	1.94	2.61
CR2O3	0.0	0.17	0.0	0.25	0.12
FEO	9.71	6.08	5.98	4.92	9.22
MNO	0.30	0.11	0.10	0.15	0.23
MGO	15.35	16.69	16.70	17.19	16.26
CAO	19.95	21.49	21.65	21.91	19.40
NA2O	0.30	0.18	0.21	0.20	0.25
TOTAL	98.84	99.32	99.24	99.26	99.71

SAMPLE	GI-5 -PH -1 -6	GI-5 -PH -2 -1	GI-5 -PH -2 -2	GI-5 -PH -2 -3	GI-5 -PH -2 -4
SIO2	51.49	51.47	51.27	51.20	51.30
TIO2	0.39	0.44	0.54	0.57	0.52
AL2O3	2.38	2.05	2.55	2.63	2.41
CR2O3	0.11	0.08	0.07	0.11	0.09
FEO	7.18	9.04	9.86	9.33	9.41
MNO	0.18	0.28	0.20	0.22	0.23
MGO	16.44	15.83	15.33	15.62	15.59
CAO	20.88	19.14	19.56	19.38	19.36
NA2O	0.23	0.31	0.35	0.32	0.33
TOTAL	99.28	98.60	99.73	99.38	99.24

SAMPLE	GI-5 -PH -3 -1	GI-5 -PH -3 -2	GI-5 -PH -3 -3	GI-5 -PH -3 -4	GI-5 -PH -4 -1
SIO2	50.98	52.02	51.80	51.60	51.36
TIO2	0.32	0.42	0.47	0.40	0.49
AL2O3	2.94	1.90	1.89	2.24	2.13
CR2O3	0.44	0.09	0.02	0.18	0.0
FEO	7.97	9.47	10.18	9.21	9.47
MNO	0.14	0.26	0.17	0.19	0.19
MGO	15.82	16.29	15.67	15.93	15.89
CAO	20.09	18.63	19.39	19.37	19.33
NA2O	0.34	0.29	0.32	0.32	0.27
TOTAL	99.04	99.37	99.91	99.44	99.13

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PENOCRYST LITTLE PORT CMPX/GREGORY I.

SAMPLE	GI-5 -PH -4 -2	GI-5 -PH -4 -3	GI-5 -PH -4 -4	GI-5 -PH -5 -1	GI-5 -PH -5 -2
SIO2	51.72	51.94	51.67	52.25	53.41
TIO2	0.43	0.47	0.46	0.19	0.18
AL2O3	1.85	1.86	1.95	1.78	1.63
CR2O3	0.02	0.05	0.02	0.15	0.31
FEO	10.35	9.91	9.91	5.39	5.91
MNO	0.29	0.31	0.26	0.14	0.16
MGO	16.11	15.64	15.83	18.01	17.61
CAO	18.93	19.77	19.34	21.01	20.64
NA2O	0.27	0.33	0.29	0.19	0.21
TOTAL	99.97	100.29	99.78	99.11	100.06

SAMPLE	GI-5 -PH -5 -3	GI-5 -PH -5 -4	GI-5 -PH -99-	GI-5 -PH - 0-	GI-5 -PH -00-
SIO2	50.37	52.01	51.61	51.29	51.28
TIO2	0.55	0.31	0.42	0.38	0.52
AL2O3	2.29	1.93	2.16	2.24	2.26
CR2O3	0.05	0.17	0.11	0.13	0.07
FEO	10.69	7.33	8.61	8.32	9.38
MNO	0.28	0.19	0.21	0.21	0.24
MGO	15.98	17.20	16.21	16.19	15.83
CAO	18.65	20.10	19.81	19.90	19.32
NA2O	0.32	0.24	0.29	0.28	0.31
TOTAL	99.18	99.45	99.42	98.93	99.71

SAMPLE	GI-12-PH -2 -1	GI-12-PH -2 -2	GI-12-PH -2 -3	GI-12-PH -2 -4	GI-12-PH -2 -5
SIO2	49.14	51.58	50.43	50.65	50.76
TIO2	0.65	0.55	0.54	0.55	0.54
AL2O3	1.89	1.38	1.93	1.91	1.82
CR2O3	0.23	0.02	0.0	0.04	0.04
FEO	9.98	10.24	10.50	10.85	10.87
MNO	0.23	0.31	0.24	0.37	0.26
MGO	15.36	15.58	15.35	14.58	14.70
CAO	19.84	20.33	19.96	20.11	20.29
NA2O	0.19	0.17	0.25	0.30	0.26
TOTAL	97.51	100.16	99.20	99.36	99.54

* CLINOPYROX ANALYSES * MPH=MICROPH PH=PHENOCRYST LITTLE PORT (MPX) GREGORY I.

SAMPLE		GI-12-PH -2 -6		GI-12-PH -2 -7		GI-12-PH -4 -1		GI-12-PH -4 -2		GI-12-PH -4 -3	
SIO2	*	51.53	*	50.68	*	50.84	*	52.09	*	51.18	*
TIO2	*	0.50	*	0.56	*	0.45	*	0.46	*	0.41	*
AL2O3	*	1.74	*	1.78	*	1.91	*	1.29	*	1.71	*
CR2O3	*	0.02	*	0.06	*	0.0	*	0.0	*	0.0	*
FEO	*	10.57	*	10.50	*	10.46	*	10.33	*	10.36	*
MNO	*	0.38	*	0.30	*	0.34	*	0.39	*	0.29	*
MGO	*	14.79	*	15.06	*	15.15	*	14.99	*	14.05	*
CAO	*	20.21	*	20.12	*	20.18	*	20.20	*	20.10	*
NA2O	*	0.24	*	0.24	*	0.25	*	0.24	*	0.30	*
TOTAL	*	99.98	*	99.30	*	99.58	*	99.99	*	98.40	*

SAMPLE		GI-12-PH -4 -4		GI-12-PH -99-		GI-12-PH - 0-		GI-12-PH -00-	
SIO2	*	51.37	*	51.03	*	49.90	*	51.36	*
TIO2	*	0.44	*	0.50	*	0.55	*	0.46	*
AL2O3	*	1.64	*	1.71	*	1.99	*	1.73	*
CR2O3	*	0.0	*	0.0	*	0.0	*	0.0	*
FEO	*	10.38	*	10.44	*	10.22	*	10.47	*
MNO	*	0.34	*	0.32	*	0.29	*	0.34	*
MGO	*	14.73	*	14.90	*	15.26	*	14.42	*
CAO	*	20.16	*	20.14	*	20.01	*	20.16	*
NA2O	*	0.26	*	0.25	*	0.22	*	0.27	*
TOTAL	*	99.32	*	99.29	*	98.44	*	99.21	*

* ORTHOPYROX ANALYSES * PH=PHENOCRYST LITTLE PORT CMPLX/GREGORY 8.

SAMPLE	GI-12-PH -1 -1	GI-12-PH -1 -2	GI-12-PH -1 -3	GI-12-PH -1 -4	GI-12-PH -3 -1
SIO2	51.57	52.32	51.91	51.93	52.61
TIO2	0.29	0.24	0.26	0.26	0.24
AL2O3	0.93	0.95	0.93	0.90	0.97
CR2O3	0.04	0.04	0.0	0.03	0.0
FEO	21.94	21.77	21.25	21.65	21.93
MNO	0.61	0.58	0.63	0.61	0.57
MGO	23.18	22.91	22.37	22.99	23.15
CAO	1.49	1.39	1.40	1.43	1.49
NA2O	0.02	0.04	0.02	0.03	0.01
TOTAL	99.97	100.24	99.27	99.83	100.97

SAMPLE	GI-12-PH -3 -2	GI-12-PH -3 -3	GI-12-PH -3 -4	GI-12-PH -3 -5	GI-12-PH -5 -1
SIO2	53.38	52.34	51.90	52.56	52.50
TIO2	0.23	0.29	0.31	0.27	0.32
AL2O3	0.96	1.14	1.00	0.99	1.21
CR2O3	0.01	0.0	0.05	0.02	0.0
FEO	21.91	20.82	22.14	21.70	20.57
MNO	0.53	0.57	0.64	0.58	0.46
MGO	23.54	23.09	23.25	23.26	24.00
CAO	1.48	1.45	1.59	1.50	1.55
NA2O	0.0	0.02	0.0	0.01	0.02
TOTAL	101.94	99.72	100.88	100.89	100.63

SAMPLE	GI-12-PH -5 -2	GI-12-PH -5 -3	GI-12-PH -5 -4	GI-12-PH -5 -5	GI-12-PH - 0-
SIO2	52.06	52.65	50.80	52.00	52.23
TIO2	0.40	0.36	0.31	0.35	0.28
AL2O3	1.25	1.19	1.44	1.27	1.00
CR2O3	0.01	0.02	0.0	0.01	0.0
FEO	20.75	20.49	22.29	21.03	21.48
MNO	0.48	0.53	0.59	0.52	0.55
MGO	24.15	23.43	23.25	23.71	23.44
CAO	1.52	1.55	1.44	1.52	1.51
NA2O	0.04	0.01	0.01	0.02	0.02
TOTAL	100.66	100.23	100.13	100.43	100.51

* ORTHOPYROX ANALYSES * PH=PHENOCRYST LITTLE PORT CMPLX/GREGORY I.

SAMPLE		GI-12-PH -00-		GI-12-PH -09-	
SIO2	*	51.54	*	52.16	*
TIO2	*	0.29	*	0.29	*
AL2O3	*	1.12	*	1.05	*
CR2O3	*	0.0	*	0.02	*
FEO	*	21.89	*	21.46	*
MNO	*	0.62	*	0.59	*
MGO	*	23.12	*	23.32	*
CAO	*	1.48	*	1.48	*
NA2O	*	0.0	*	0.02	*
TOTAL	*	100.06	*	100.39	*

B.2.3 Feldspar Analyses

* [illegible]MASS PLAGIOCLASE ANALYSES * SKINNER COVE FM. - TROUT RIVER SLICE

SAMPLE	SKC-24--1	SKC-24--2	SKC-24--3	SKC-24--4	SKC-26--1	SKC-26--2	SKC-26--3
SIO2	5?.64	50.38	5?.34	5?.59	62.30	66.70	58.40
TIO2	0.11	0.13	0.18	0.14	0.03	0.05	0.12
AL2O3	30.41	30.64	29.55	30.37	19.29	19.92	25.52
FEO	0.64	0.96	0.91	0.84	0.23	0.16	0.47
MNO	[illegible]	0.02	0.04	0.02	0.01	0.03	0.0
MGO	0.06	0.08	[illegible]	0.08	0.02	0.0	0.04
CAO	13.52	13.26	13.25	13.34	0.48	0.22	6.29
NA2O	3.56	3.53	3.50	3.56	0.76	11.78	7.11
K2O	0.26	0.36	0.34	0.32	15.02	0.0	1.31
TOTAL	99.6?	99.36	98.79	99.26	98.14	98.86	99.26

SAMPLE	SKC-26--4	SKC-26--5	SKC-26--6	SKC-26--7	SKC-26--8	SKC-26--9	SKC-26--1
SIO2	63.?0	62.71	65.19	65.35	63.14	58.65	63.10
TIO2	0.04	0.35	0.17	0.08	0.0	0.07	0.0
AL2O3	19.28	18.88	20.01	21.76	19.16	26.46	18.75
FEO	0.21	0.11	0.44	0.38	0.13	0.50	0.16
MNO	0.0	0.0	0.01	0.0	0.0	0.0	0.04
MGO	0.0	0.03	0.0	0.01	0.0	0.03	0.0
CAO	0.02	0.01	0.27	1.81	0.0	7.77	0.0
NA2O	0.13	0.28	8.63	10.50	0.16	7.28	0.17
K2O	15.61	15.63	4.03	1.21	15.75	0.64	16.29
TOTAL	98.?9	98.[illegible]	98.77	101.10	98.34	101.45	98.53

SAMPLE	SKC-26--1	SKC-26--1	SKC-32--1	SKC-32--2	SKC-32--3	SKC-32--4	SKC-32--5
SIO2	59.[illegible]	62.85	67.91	53.43	60.41	53.32	54.89
TIO2	0.13	0.08	0.14	0.14	0.10	0.15	0.14
AL2O3	24.45	19.07	20.[illegible]	28.29	22.38	28.59	27.63
FEO	0.56	0.17	1.1?	1.26	0.66	0.88	1.08
MNO	0.04	[illegible]	0.0	0.0	0.0	0.04	0.01
MGO	0.03	0.0	0.19	0.15	0.07	0.08	0.14
CAO	5.41	0.1?	6.68	0.95	3.80	10.87	9.17
NA2O	6.32	0.30	6.79	5.39	4.12	4.91	5.70
K2O	3.76	15.66	1.17	0.54	7.29	0.57	0.76
TOTAL	100.35	98.23	99.98	99.15	98.83	99.41	99.52

* G*MASS PLAGIOCLASE ANALYSES * SKINNER COVE FM. - TROUT RIVER SLICE

SAMPLE	SKC-39--1	SKC-39--2	SKC-39--3	SKC-39--4	SKC-39--5	SKC-39--6	SKC-41--1
SIO2	49.02	49.57	48.91	48.86	48.42	47.56	53.30
TIO2	0.15	0.17	0.19	0.21	0.17	0.19	0.20
AL2O3	31.35	31.39	31.51	31.71	31.94	31.58	28.24
FEO	1.24	1.02	1.28	1.04	1.15	1.15	0.73
MNO	0.0	0.01	0.0	0.0	0.0	0.0	0.01
MGO	0.12	0.09	0.13	0.11	0.13	0.12	0.07
CAO	14.55	14.31	14.12	14.51	15.04	14.51	10.54
NA2O	3.11	3.28	3.08	3.01	3.02	3.10	5.09
K2O	0.26	0.27	0.24	0.27	0.20	0.25	0.57
TOTAL	99.80	100.11	99.46	99.72	100.07	98.46	98.75

SAMPLE	SKC-41--2	SKC-41--3	SKC-41--4	SKC-41--5	SKC-42--1	SKC-42--2	SKC-42--3
SIO2	50.95	53.70	51.52	52.37	53.89	52.69	51.59
TIO2	0.12	0.14	0.13	0.15	0.16	0.14	0.14
AL2O3	29.54	28.64	29.92	28.93	29.99	30.48	30.30
FEO	0.61	0.48	0.81	0.66	0.61	0.72	0.73
MNO	0.02	0.01	0.02	0.02	0.01	0.01	0.03
MGO	0.06	0.05	0.05	0.06	0.05	0.07	0.04
CAO	12.27	10.89	12.36	11.52	11.75	12.23	12.14
NA2O	4.11	5.17	4.30	4.67	4.25	4.18	4.08
K2O	0.35	0.55	0.43	0.48	0.47	0.43	0.46
TOTAL	98.03	99.63	99.54	98.86	101.18	100.95	99.51

SAMPLE	SKC-42--4	SKC-42--5	SKC-42--6	SKC-42--7	SKC-42--8	SKC-42--9	SKC-42--1
SIO2	[illegible]	52.29	51.47	52.06	51.97	52.90	52.32
TIO2	0.16	0.16	0.13	0.08	0.14	0.17	0.14
AL2O3	29.42	28.87	30.31	30.65	30.38	29.09	29.94
FEO	0.34	0.78	0.63	0.56	0.87	0.69	0.71
MNO	0.01	0.0	0.04	0.0	0.04	0.03	0.02
MGO	0.07	0.08	0.08	0.08	0.09	0.09	0.07
CAO	11.63	11.18	12.29	12.61	12.23	10.99	11.89
NA2O	4.71	5.11	4.07	4.18	4.23	4.69	4.39
K2O	0.51	0.61	0.39	0.33	0.48	0.59	0.49
TOTAL	99.48	99.08	99.41	100.55	100.43	99.24	99.97

* G*MASS PLAGIOCLASE ANALYSES * - SKINNER COVE FM. - TROUT RIVER SLICE

SAMPLE	SKC-47--1	SKC-47--2	SKC-47--3	SKC-47--4	SKC-47--5	SKC-47--6	SKC-49--1
SIO2	67.04	67.91	68.35	64.63	66.94	66.98	66.71
TIO2	0.21	0.0	0.0	0.03	0.01	0.01	0.17
AL2O3	19.72	20.33	20.01	19.04	20.35	19.89	20.57
FEO	0.32	0.32	0.11	0.14	0.12	0.20	0.19
MNO	0.02	0.0	0.23	0.05	0.01	0.02	0.0
MGO	0.0	0.01	0.02	0.0	0.02	0.01	0.0
CAO	0.01	0.07	0.12	0.05	0.04	0.06	0.80
NA2O	6.01	11.14	9.32	5.82	11.90	8.94	11.36
K2O	7.91	1.32	3.82	6.95	0.16	4.43	0.14
TOTAL	101.64	101.10	101.98	98.76	99.55	100.54	99.94

SAMPLE	SKC-49--2	SKC-49--3	SKC-49--4	SKC-65--1	SKC-65--2	SKC-65--3	SKC-65--
SIO2	66.95	66.49	66.72	69.23	65.90	67.91	66.85
TIO2	0.03	0.08	0.09	0.0	0.01	0.03	0.16
AL2O3	20.35	20.89	20.50	19.97	20.36	19.40	19.39
FEO	0.32	0.26	0.16	0.25	0.18	0.80	0.11
MNO	0.04	0.04	0.03	0.0	0.01	0.04	0.04
MGO	0.0	0.02	0.0	0.01	0.0	0.04	0.01
CAO	0.25	0.62	0.56	0.20	0.26	0.19	0.28
NA2O	11.84	11.36	11.52	11.84	12.10	11.21	10.86
K2O	0.01	0.30	0.15	0.11	0.12	1.02	1.24
TOTAL	99.50	100.05	99.83	101.61	98.94	100.64	98.94

SAMPLE	SKC-65--5	SKC-65--6
SIO2	65.31	67.34
TIO2	0.0	0.04
AL2O3	19.79	19.77
FEO	0.21	0.31
MNO	0.07	0.02
MGO	0.0	0.01
CAO	0.12	0.21
NA2O	10.17	11.24
K2O	2.52	1.00
TOTAL	99.55	99.94

* G?MASS PLAGIOCLASE ANALYSES * LITTLE PORT CMPLX - AT LITTLE PORT

SAMPLE	LP-3 -1-	LP-3 -2-	LP-3 -3-	LP-3 -4-	LP-3 -5-	LP-12-1-	LP-12-2-
SIO2	67.03	55.62	66.05	67.56	66.62	64.29	65.21
TIO2	0.01	0.01	0.02	0.01	0.01	0.0	0.0
AL2O3	19.66	20.85	20.27	20.60	20.35	21.53	21.33
FEO	0.0	0.04	0.16	0.12	0.08	0.14	0.28
MNO	0.01	0.0	0.05	0.02	0.02	0.04	0.02
MGO	0.0	0.0	0.0	0.0	0.0	0.01	0.0
CAO	0.15	0.31	0.32	0.29	0.27	1.50	1.28
NA2O	11.31	11.38	11.36	11.91	11.74	11.15	11.24
K2O	0.12	0.04	0.06	0.05	0.06	0.02	0.01
TOTAL	98.77	98.45	98.79	100.56	99.15	98.68	99.37

SAMPLE	LP-12-3-	LP-12-4-	LP-12-5-	LP-12-6-	LP-14-1-	LP-14-2-	LP-14-3-
SIO2	66.45	63.91	60.75	64.12	66.95	66.92	68.23
TIO2	0.0	0.03	0.03	0.0	0.15	0.0	0.0
AL2O3	20.22	21.83	23.30	21.60	20.16	20.06	20.08
FEO	0.11	0.34	0.45	0.26	0.17	0.02	0.12
MNO	0.0	0.04	0.01	0.02	0.05	0.0	0.0
MGO	0.0	0.0	0.04	0.0	0.03	0.0	0.0
CAO	0.44	1.36	5.35	1.99	0.59	0.30	0.20
NA2O	11.68	10.95	9.18	10.84	11.59	11.60	11.94
K2O	0.02	0.29	0.03	0.07	0.06	0.01	0.01
TOTAL	98.92	98.75	99.14	98.90	99.75	98.91	100.58

SAMPLE	LP-14-4-	LP-14-5-	LP-14-6-	LP-99-9-
SIO2	67.15	66.59	67.17	65.97
TIO2	0.04	0.03	0.04	0.02
AL2O3	20.68	20.40	20.28	20.74
FEO	0.29	0.20	0.12	0.15
MNO	0.0	0.0	0.0	0.01
MGO	0.0	0.04	0.0	0.0
CAO	0.24	0.39	0.34	0.87
NA2O	11.30	11.64	11.71	11.43
K2O	0.04	0.02	0.03	0.05
TOTAL	100.04	99.31	99.67	99.24

* SIMAS PLAGIOCLASE ANALYSES * LITTLE PORT CMPX - WESTERN HEAD SLICE

SAMPLE	WH-6 --1	WH-6 --2	WH-6 --3	WH-6 --4
SIO2	67.53	64.30	52.80	61.58
TIO2	0.01	0.01	0.27	0.10
AL2O3	20.73	22.37	28.58	23.89
FEO	0.16	0.38	1.11	0.55
MNO	0.0	0.05	0.01	0.02
MGO	0.0	0.01	0.32	0.11
CAO	1.75	2.68	12.88	5.77
NA2O	11.45	9.91	4.31	8.56
K2O	0.01	0.24	0.01	0.09
TOTAL	101.74	99.95	100.29	100.67

* PLAGIOCLASE PHENOCRYST ANALYSES * SKINNER COVE FM. - TROUT RIVER SLICE

SAMPLE	SKC-24-PH -1 -1	SKC-24-PH -1 -2	SKC-24-PH -1 -3	SKC-24-PH -1 -4	SKC-24-PH -1 -5
SIO2	52.74	51.15	50.00	50.43	51.08
TIO2	0.11	0.12	0.24	0.17	0.11
AL2O3	29.40	30.32	30.80	30.54	30.27
FEO	0.45	0.63	0.54	0.75	0.59
MNO	0.0	0.0	0.05	0.09	0.04
MGO	0.08	0.05	0.08	0.08	0.07
CAO	11.46	12.79	13.61	13.34	12.80
NA2O	4.74	3.79	3.32	3.11	3.74
K2O	0.38	0.32	0.24	0.29	0.31
TOTAL	99.36	99.15	98.68	98.80	99.01

SAMPLE	SKC-26-PH -1 -1	SKC-26-PH -1 -2	SKC-26-PH -1 -3	SKC-32-PH -1 -1	SKC-32-PH -2 -1
SIO2	53.74	53.13	53.44	51.79	55.27
TIO2	0.11	0.11	0.11	0.05	0.08
AL2O3	[illegible]	29.19	29.60	28.77	28.94
FEO	0.56	0.69	0.63	0.66	0.54
MNO	0.04	0.01	0.03	0.0	0.0
MGO	0.03	0.06	0.05	0.03	0.05
CAO	11.55	11.09	11.34	11.75	10.34
NA2O	4.61	4.63	4.62	4.59	5.41
K2O	0.35	0.40	0.37	0.40	0.35
TOTAL	101.22	99.31	100.19	98.04	100.98

SAMPLE	SKC-32-PH -2 -2	SKC-32-PH -2 -3	SKC-32-PH -2 -4	SKC-32-PH -3 -1	SKC-32-PH -3 -2
SIO2	52.92	52.85	53.70	51.90	51.75
TIO2	0.11	0.12	0.29	0.09	0.11
AL2O3	30.37	29.02	29.44	29.70	29.93
FEO	0.66	0.82	0.57	0.70	0.59
MNO	0.0	0.0	0.0	0.02	0.01
MGO	0.04	0.08	0.06	0.05	0.07
CAO	11.32	11.02	11.06	11.96	12.51
NA2O	4.19	4.73	4.74	4.32	4.37
K2O	0.37	0.48	0.40	0.38	0.34
TOTAL	100.49	99.17	100.16	99.12	99.68

* PLAGIOCLASE PHENOCRYST ANALYSES * SKINNER COVE FM. - TROUT RIVER SLICE

SAMPLE	SKC-32-PH -3 -3	SKC-32-PH -3 -4	SKC-32-PH -20-	SKC-41-PH -1 -1	SKC-41-PH -1 -2
SIO2	52.63	52.09	52.90	56.23	55.44
TIO2	[illegible]	0.12	0.10	0.09	0.08
AL2O3	29.67	29.33	29.64	27.38	27.52
FEO	0.51	0.50	0.64	0.42	0.39
MNO	0.01	0.01	0.0	0.03	0.01
MGO	0.04	0.06	0.05	0.02	0.02
CAO	12.57	12.35	11.71	9.18	8.90
NA2O	4.24	4.31	4.53	5.95	5.64
K2O	0.37	0.35	0.38	0.66	0.67
TOTAL	100.33	99.70	99.95	99.96	98.67

SAMPLE	SKC-41-PH -1 -3	SKC-41-PH -1 -4	SKC-41-PH -1 -5	SKC-41-PH -1 -6	SKC-47-PH -1 -1
SIO2	55.45	53.29	50.48	54.17	64.89
TIO2	0.07	0.09	0.15	0.10	0.04
AL2O3	27.17	29.50	31.18	28.55	19.95
FEO	0.55	0.31	0.36	0.65	0.18
MNO	0.0	0.04	0.0	0.02	0.02
MGO	0.04	0.08	0.09	0.05	0.0
CAO	9.62	11.97	13.31	10.40	0.40
NA2O	6.02	4.64	3.49	5.15	5.44
K2O	0.71	0.47	0.23	0.56	8.57
TOTAL	99.62	100.39	99.35	99.65	99.49

SAMPLE	SKC-47-PH -1 -2	SKC-47-PH -1 -3	SKC-65-PH -1 -1
SIO2	68.25	66.57	68.08
TIO2	0.03	0.04	0.02
AL2O3	19.39	19.91	20.12
FEO	0.13	0.15	0.11
MNO	0.0	0.01	0.0
MGO	0.0	0.0	0.0
CAO	0.01	0.20	0.19
NA2O	10.74	8.09	11.70
K2O	1.35	5.22	0.04
TOTAL	100.93	100.19	100.26

* PLAGIOCLASE PHENOCRYST PROBE TRAVERSE * LITTLE PORT CMPX. - GREGORY I.

SAMPLE	GI-12-PH -1 -1	GI-12-PH -1 -2	GI-12-PH -1 -3	GI-12-PH - 1- 4	GI-12-PH - 1- 5
SIO2	49.63	[illegible]	51.03	50.11	51.73
TIO2	[illegible]	0.04	[illegible]	0.04	0.0
AL2O3	32.12	[illegible]	31.72	30.95	30.36
FEO	0.71	0.69	0.71	0.79	0.62
MNO	0.03	0.04	0.0	0.0	0.0
MGO	0.03	[illegible]	0.16	0.05	0.08
CAO	14.07	15.49	14.27	14.21	13.77
NA2O	3.25	[illegible]	3.52	3.31	3.71
K2O	0.11	[illegible]	0.18	0.17	0.11
TOTAL	[illegible]	99.71	101.66	99.63	100.28

SAMPLE	GI-12-PH -1 -6	GI-12-PH -1 -7	GI-12-PH - 1- 8	GI-12-PH -1 -9	GI-12-PH -1 -10
SIO2	[illegible]	50.68	51.10	50.03	49.51
TIO2	0.03	0.04	0.04	0.03	0.03
AL2O3	30.84	30.21	31.17	31.01	30.21
FEO	[illegible]	0.60	0.59	0.69	0.64
MNO	[illegible]	0.04	0.0	0.04	0.0
MGO	[illegible]	[illegible]	0.03	0.05	0.05
CAO	[illegible]	13.15	13.88	13.39	13.66
NA2O	[illegible]	3.37	3.51	3.69	3.86
K2O	0.17	0.14	0.11	0.18	0.14
TOTAL	98.56	[illegible]	100.53	99.11	98.10

SAMPLE	GI-12-PH -1 -11	GI-12-PH -1 -12	GI-12-PH -1 -13	GI-12-PH -1 -14	GI-12-PH -1 -15
SIO2	[illegible]	53.18	52.55	50.38	50.20
TIO2	[illegible]	0.04	0.04	0.03	0.02
AL2O3	[illegible]	[illegible]	30.11	29.88	31.14
FEO	[illegible]	[illegible]	0.39	0.63	0.70
MNO	0.0	[illegible]	0.01	0.02	0.04
MGO	[illegible]	[illegible]	0.11	0.08	0.08
CAO	13.18	12.16	[illegible]	13.64	13.22
NA2O	4.15	3.95	4.39	3.50	3.69
K2O	0.24	0.47	0.35	0.69	0.26
TOTAL	[illegible]	99.94	100.74	98.85	99.35

* PLAGIOCLASE PHENOCRYST PROBE TRAVERSE * LITTLE PORT CMPX. - GREGORY I.

SAMPLE	GI-12-PH -1 -16	GI-12-PH -1 -17	GI-12-PH -1 -18	GI-12-PH -1 -19	GI-12-PH -1 -20
SIO2	51.79	50.48	49.40	51.65	52.24
TIO2	0.04	0.05	0.03	0.05	0.03
AL2O3	30.37	31.46	30.97	31.47	30.74
FEO	0.52	0.60	0.54	0.66	0.56
MNO	0.0	0.04	0.0	0.01	0.0
MGO	0.03	0.05	0.06	0.05	0.05
CAO	13.40	14.28	13.38	13.07	13.20
NA2O	3.91	3.16	3.66	4.12	3.80
K2O	0.21	0.11	0.17	0.16	0.18
TOTAL	100.25	100.23	98.61	101.24	100.80

SAMPLE	GI-12-PH -1 -21	GI-12-PH -1 -22	GI-12-PH -1 -23	GI-12-PH -1 -24	GI-12-PH -1 -25
SIO2	52.11	52.01	50.64	50.77	50.90
TIO2	0.03	0.05	0.04	0.03	0.04
AL2O3	30.23	29.52	30.26	27.81	30.60
FEO	0.54	0.73	0.45	0.73	0.64
MNO	0.01	0.0	0.0	0.01	0.01
MGO	0.07	0.07	0.06	0.46	0.08
CAO	13.32	12.55	13.09	13.07	13.46
NA2O	3.95	4.25	4.21	4.18	3.74
K2O	0.11	0.14	0.14	0.14	0.20
TOTAL	100.47	99.33	98.89	97.20	99.67

SAMPLE	GI-12-PH -2 -1	GI-12-PH -2 -2	GI-12-PH -2 -3	GI-12-PH -2 -4	GI-12-PH -2 -5
SIO2	49.13	50.47	50.14	50.57	51.13
TIO2	0.04	0.04	0.04	0.01	0.03
AL2O3	31.77	31.77	30.47	31.46	30.54
FEO	0.33	0.54	0.77	0.66	1.06
MNO	0.04	0.05	0.04	0.0	0.0
MGO	0.03	0.04	0.07	0.07	0.26
CAO	14.61	14.52	13.78	14.16	13.84
NA2O	3.60	3.40	3.29	3.45	3.53
K2O	0.11	0.14	0.13	0.09	0.32
TOTAL	99.22	100.97	98.73	100.47	100.71

* PLAGIOCLASE PHENOCRYST PROBE TRAVERSE * LITTLE PORT CMPX. - GREGORY I.

SAMPLE		GI-12-PH -2 -6		GI-12-PH -2 -7		GI-12-PH -2 -8		GI-12-PH -2 -9		GI-12-PH -2 -10	
SIO2	*	51.31	*	52.43	*	50.28	*	51.66	*	51.67	*
TIO2	*	0.04	*	0.02	*	0.04	*	0.03	*	0.04	*
AL2O3	*	30.93	*	30.59	*	30.25	*	29.23	*	30.83	*
FEO	*	1.10	*	1.22	*	1.25	*	0.73	*	0.50	*
MNO	*	0.04	*	0.01	*	0.0	*	0.05	*	0.0	*
MGO	*	0.25	*	0.27	*	0.18	*	0.21	*	0.06	*
CAO	*	12.69	*	12.45	*	12.52	*	12.82	*	12.30	*
NA2O	*	3.63	*	3.58	*	3.64	*	3.82	*	3.95	*
K2O	*	0.25	*	0.32	*	0.33	*	0.26	*	0.24	*
TOTAL	*	100.23	*	100.89	*	98.49	*	98.81	*	99.59	*

SAMPLE		GI-12-PH -2 -11		GI-12-PH -2 -12		GI-12-PH -2 -13		GI-12-PH -2 -14		GI-12-PH -2 -15	
SIO2	*	51.33	*	49.64	*	53.43	*	51.59	*	53.03	*
TIO2	*	0.03	*	0.03	*	0.03	*	0.04	*	0.04	*
AL2O3	*	30.15	*	31.00	*	29.73	*	29.88	*	29.39	*
FEO	*	0.69	*	0.81	*	0.99	*	0.65	*	0.72	*
MNO	*	0.04	*	0.0	*	0.05	*	0.0	*	0.03	*
MGO	*	0.03	*	0.09	*	0.30	*	0.07	*	0.05	*
CAO	*	13.26	*	14.63	*	14.38	*	12.71	*	12.69	*
NA2O	*	3.95	*	2.67	*	2.72	*	4.34	*	4.36	*
K2O	*	0.19	*	0.52	*	0.21	*	0.21	*	0.16	*
TOTAL	*	99.73	*	99.39	*	101.84	*	99.49	*	100.47	*

SAMPLE		GI-12-PH -2 -16		GI-12-PH -2 -17		GI-12-PH -2 -18		GI-12-PH -2 -19		GI-12-PH -2 -20	
SIO2	*	52.13	*	51.32	*	49.44	*	50.82	*	53.12	*
TIO2	*	0.03	*	0.04	*	0.05	*	0.04	*	0.05	*
AL2O3	*	29.80	*	29.42	*	30.41	*	30.40	*	27.76	*
FEO	*	0.64	*	0.69	*	0.85	*	0.82	*	0.80	*
MNO	*	0.04	*	0.0	*	0.04	*	0.09	*	0.01	*
MGO	*	0.07	*	0.04	*	0.05	*	0.21	*	0.86	*
CAO	*	12.83	*	12.73	*	13.21	*	13.93	*	13.69	*
NA2O	*	3.92	*	3.92	*	3.67	*	3.53	*	3.26	*
K2O	*	0.13	*	0.21	*	0.17	*	0.16	*	0.83	*
TOTAL	*	99.59	*	98.37	*	97.89	*	100.00	*	100.38	*

* PLAGIOCLASE PHENOCRYST PROBE TRAVERSE * LITTLE PORT CMPX. - GREGORY I.

SAMPLE	GI-12-PH -2 -21	GI-12-PH -2 -22	GI-12-PH -2 -23	GI-12-PH -2 -24	GI-12-PH -2 -25
SIO2	[illegible]	52.44	52.71	49.44	52.01
TIO2	0.04	0.03	0.04	0.03	0.05
AL2O3	[illegible]	29.82	29.61	30.23	30.02
FEO	1.29	0.55	0.75	0.63	0.57
MNO	0.0	0.02	0.0	0.0	0.0
MGO	0.33	0.09	0.06	0.06	0.06
CAO	11.39	12.54	13.37	13.59	12.39
NA2O	4.42	4.11	3.93	3.68	4.16
K2O	0.84	0.21	0.18	0.19	0.20
TOTAL	99.93	99.85	98.65	97.85	99.46

SAMPLE	GI-12-PH -2 -25	GI-12-PH -2 -27	GI-12-PH -2 -28	GI-12-PH -2 -29	GI-12-PH -2 -30
SIO2	52.41	53.27	52.11	48.73	50.18
TIO2	0.05	0.04	0.04	0.04	0.04
AL2O3	[illegible]	29.13	29.84	30.90	29.61
FEO	0.74	0.76	0.47	0.98	1.00
MNO	0.0	0.02	0.01	0.03	0.04
MGO	0.05	0.05	0.05	0.10	0.36
CAO	11.77	11.88	12.64	13.91	13.12
NA2O	4.59	4.60	4.29	3.18	3.59
K2O	0.25	0.21	0.22	0.18	0.33
TOTAL	99.76	100.01	99.58	98.05	98.18

SAMPLE	GI-12-PH -2 -31	GI-12-PH -2 -32	GI-12-PH -2 -33	GI-12-PH -2 -34
SIO2	52.27	51.65	51.22	51.33
TIO2	0.03	0.05	0.04	0.04
AL2O3	29.57	28.86	29.91	30.03
FEO	1.21	1.30	1.25	3.83
MNO	0.01	0.0	0.04	0.02
MGO	0.31	0.27	0.85	0.20
CAO	11.78	11.56	11.94	13.00
NA2O	3.79	3.96	4.42	3.77
K2O	0.60	0.61	0.42	0.29
TOTAL	99.37	98.27	99.99	99.51

APPENDIX C.

STATISTICAL ANALYSES AND THE REDUCTION OF DATA

The reader is referred to Anderson (1958) or Nie *et al.* (1975) for statistical and descriptive treatment of the discriminant function method. Pearce (1976) has also outlined the method with some petrological applications.

During discriminant function analysis of multivariate data, as is the case in this thesis, there are several basic assumptions about the data:

(1) the observations in each group should be randomly chosen
(2) the probability of an unknown observation belonging to either group, is equal
(3) variables are normally distributed within each group
(4) the variance-covariance matrices of the groups are equal in size
(5) none of the observations used to calculate the function were misclassified

The validity of the discriminant function is not severely affected by limited departures from normality, slight inequality of variances, or the misclassification of observations. Chi-squared tests on the clinopyroxene data suggest that CaO, FeO_{total} and MnO most closely approximate normal distributions, thus the discriminant function analyses were run on these three variables (see Table 16. in the text). The approximate normal frequency distribution of these three variables may also be seen in Figure 6. in the text.

The main discriminant function used is that of Nie *et al.* (1975) in the S.P.S.S. computer handbook. The function is derived using a 'stepwise' method with Rao's V as criterion for the entry of variables into the function. The Rao V is a generalized distance measure whereby the variable selected is the one which contributes the largest V (*i.e.* V is a statistical parameter) when added to the previous variables. This technique amounts to the greatest overall separation of the groups.

The coefficents for the variables in the discriminant function are available from the writer on request.

Computer programs for Pearson correlation coefficents, are taken from Davis (1973) and re-written by the writer. Programs from Nie *et al.* (1975), were also used.

Data Reduction

All analytical data, once collected, were coded, and then key-punched on I.B.M. computer cards, according to a pre-determined format. This enabled the writing of computer programs for the manipulation and presentation of data (*e.g.* Appendix B.). Possibly the most useful pieces of equipment in the geochemistry lab at M.U.N. are the Hewlett Packard 9820A calculator, 9869A card reader and 2862A flat-bed plotter. Without these machines, the treatment of the analytical data would have been exceedingly tedious.

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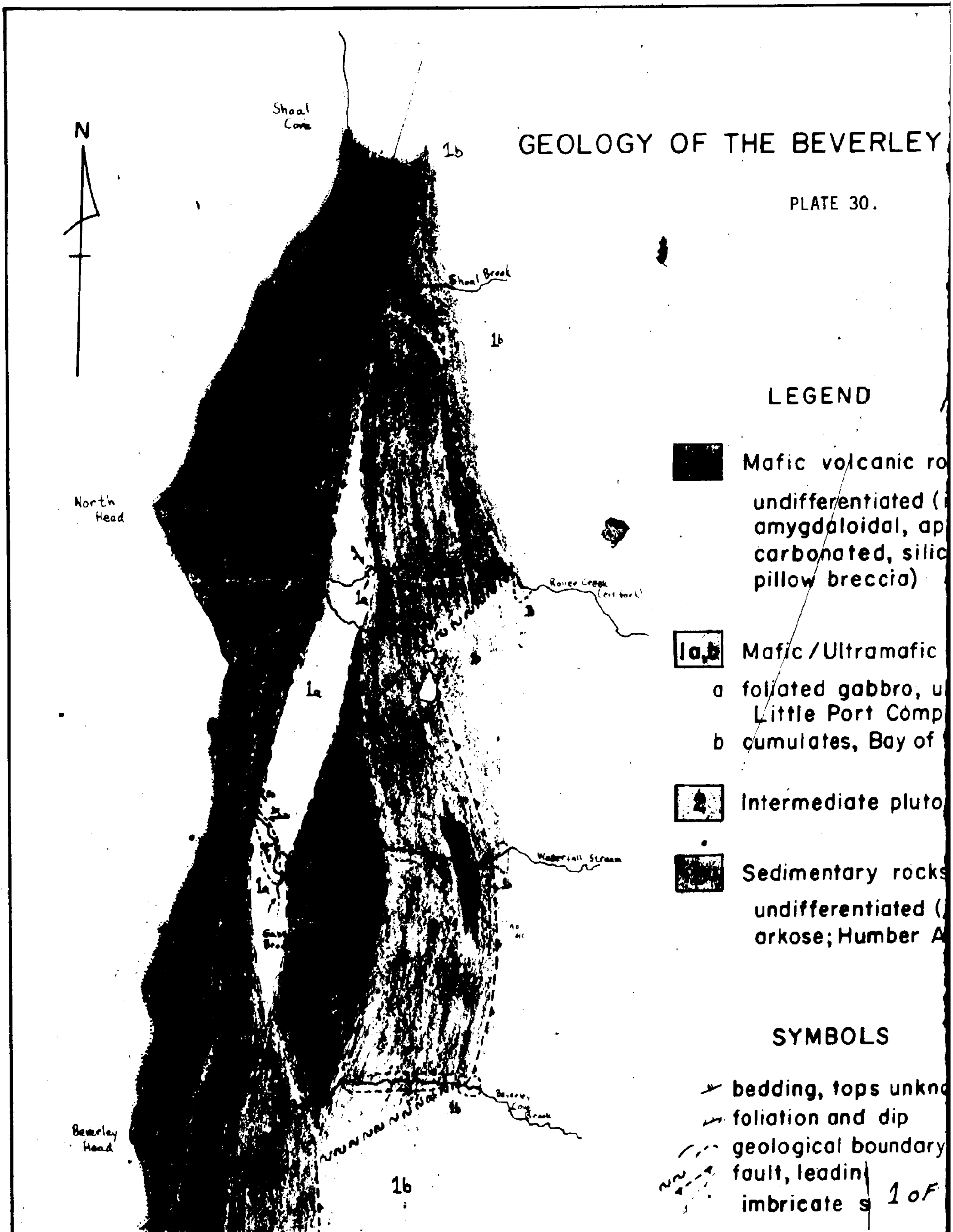

GEOLOGY OF THE BEVERLEY
PLATE 30.
N
Shoal Cove
1b
Shoal Brook
1b
North Head
1a
1a
1a
Waterfall Stream
Beverley Head
1b
1b
LEGEND
Mafic volcanic ro
undifferentiated (
amygdaloidal, ap
carbonated, silic
pillow breccia)
1a,b Mafic / Ultramafic
a foliated gabbro, u
Little Port Comp
b cumulates, Bay of
2 Intermediate pluto
Sedimentary rocks
undifferentiated (
arkose; Humber A
SYMBOLS
bedding, tops unkn
foliation and dip
geological boundary
fault, leadin
imbricate s
1 oF

GEOLOGY OF THE BEVERLEY HEAD SLICE

PLATE 30.

LEGEND

Mafic volcanic rocks

undifferentiated (includes mafic amygdaloidal, aphyric, hematized, carbonated, silicified; flows, dykes, pillow breccia)

1a,b Mafic/Ultramafic plutonic rocks

a foliated gabbro, ultramafic pods, Little Port Complex

b cumulates, Bay of Islands Complex

Intermediate plutonic; monzonite

Sedimentary rocks

undifferentiated (includes shale, arkose; Humber Arm Supergroup)

SYMBOLS

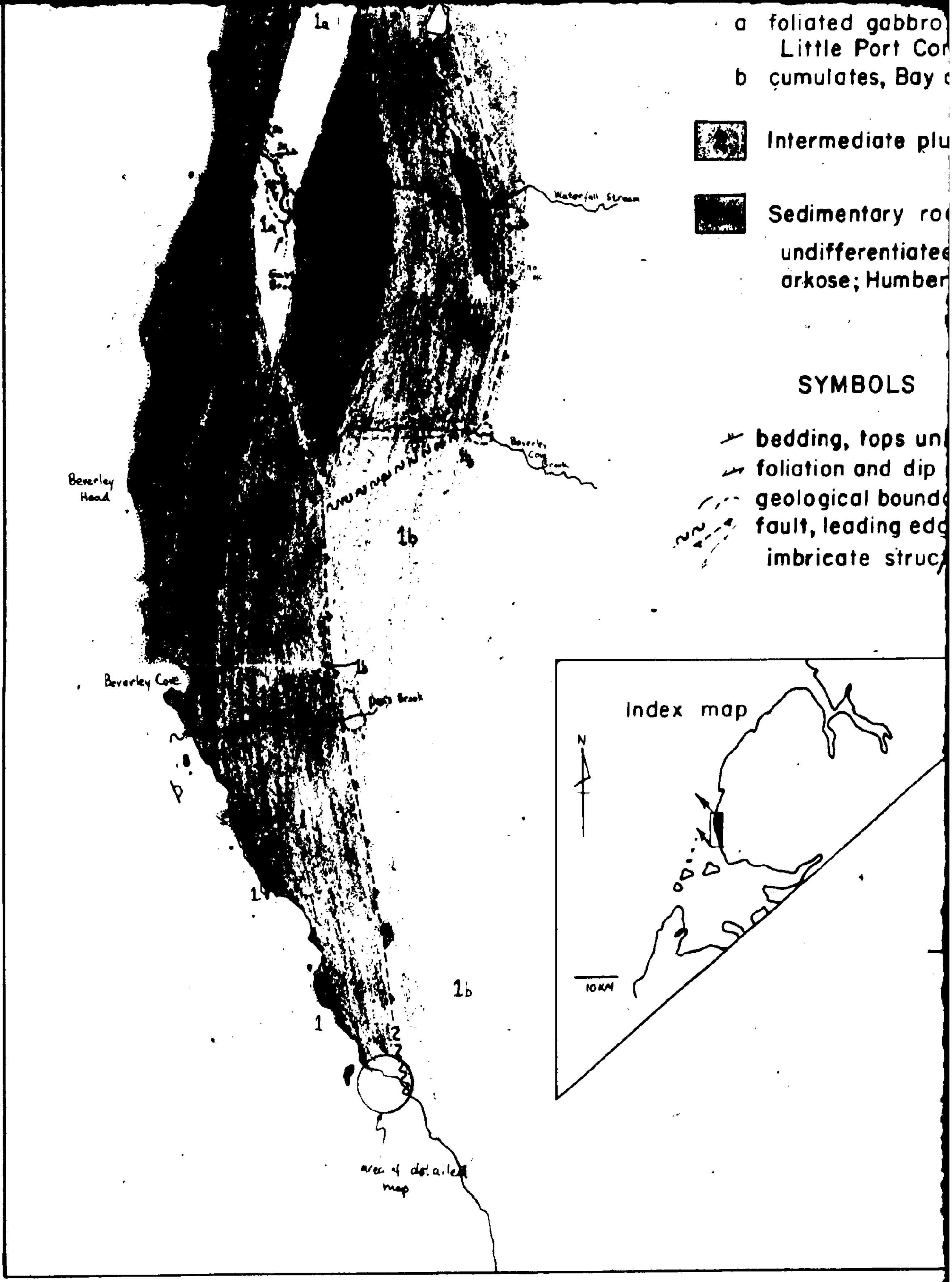
bedding, tops unknown

foliation and dip

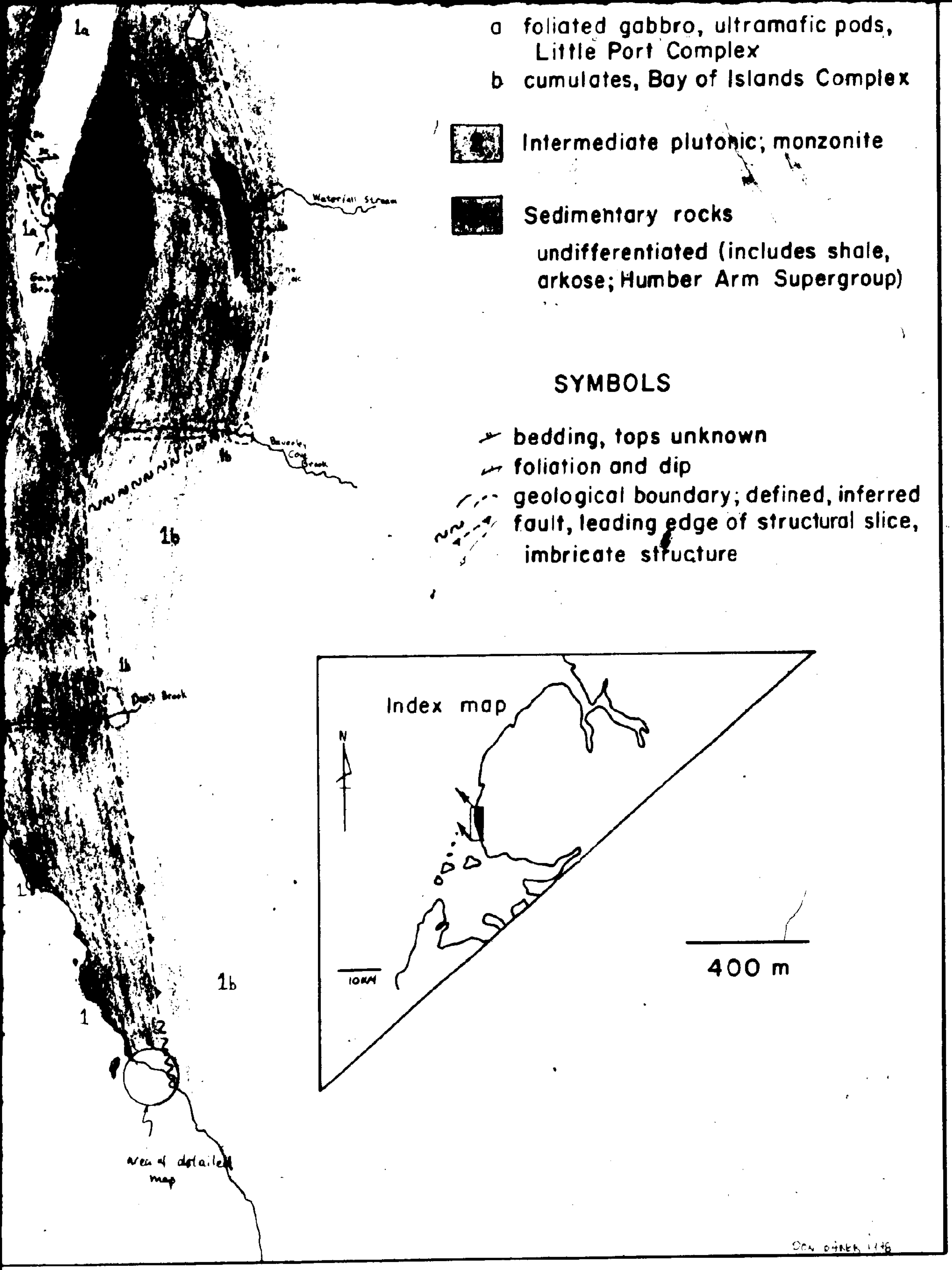
geological boundary; defined, inferred

fault, leading edge of structural slice, imbricate structure

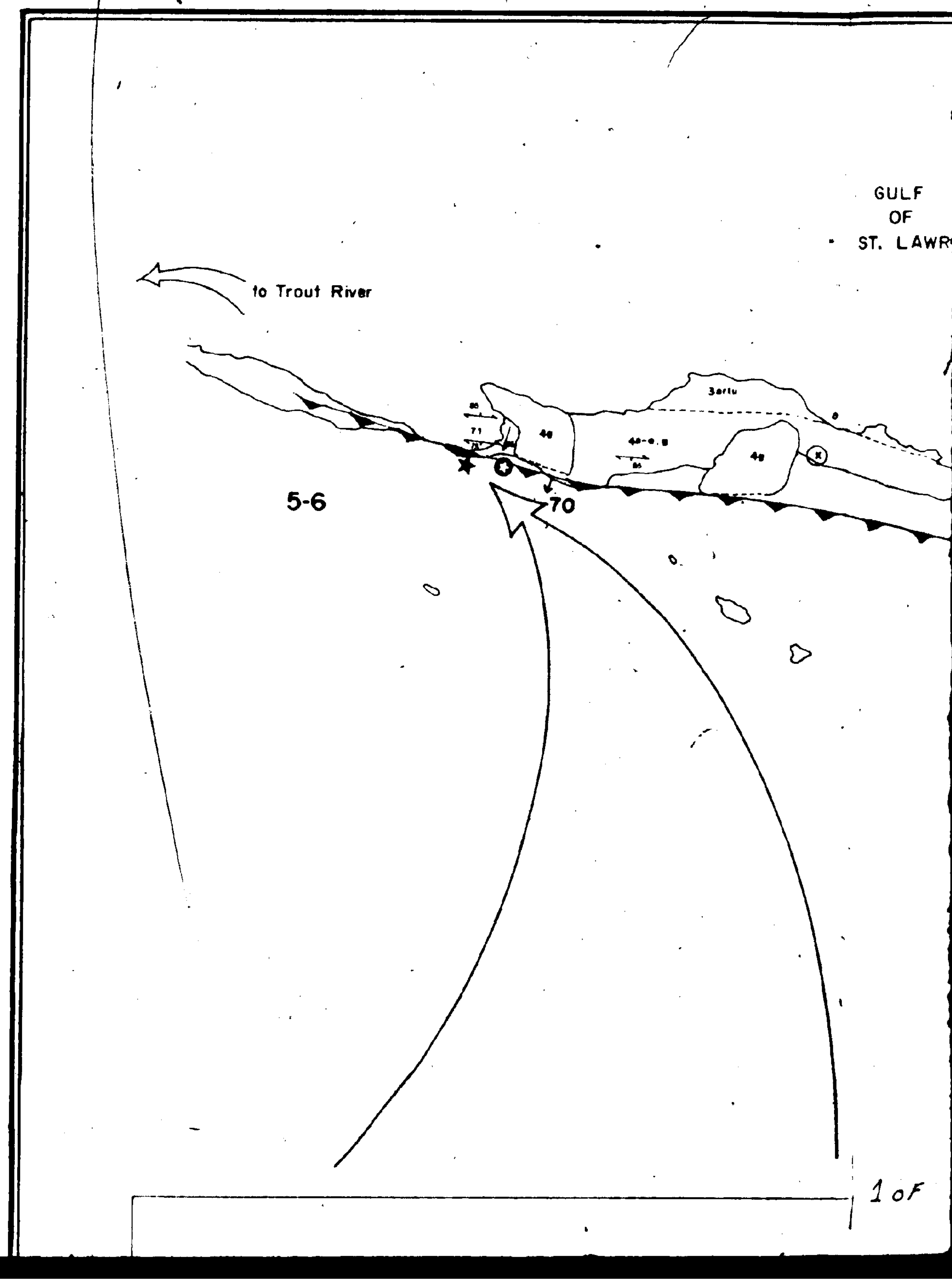
2 of


a foliated gabbro
Little Port Co
b cumulates, Bay
Intermediate plu
Sedimentary ro
undifferentiate
arkose; Humber
SYMBOLS
bedding, tops un
foliation and dip
geological bound
fault, leading ed
imbricate struc
Index map
N
10KM
Waterfall Stream
Beverley Head
Beverley Cove Brook
Beverley Cove
1a
1b
1
2
area of detailed map

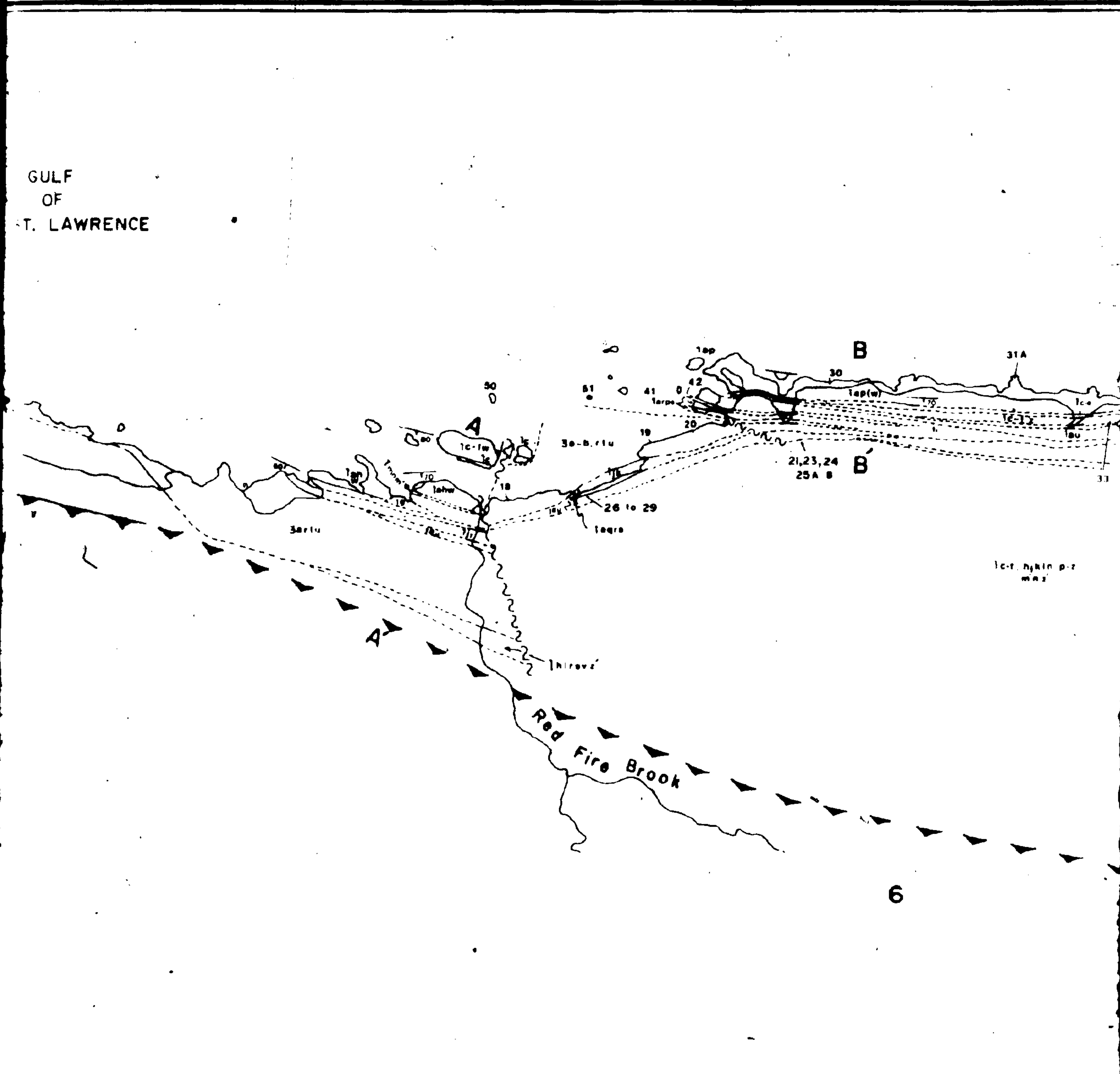
3 of


a foliated gabbro, ultramafic pods, Little Port Complex
b cumulates, Bay of Islands Complex
Intermediate plutonic; monzonite
Sedimentary rocks
undifferentiated (includes shale, arkose; Humber Arm Supergroup)
SYMBOLS
bedding, tops unknown
foliation and dip
geological boundary; defined, inferred
fault, leading edge of structural slice, imbricate structure
Index map
N
10KM
400 m
1a
1b
1
2
Waterfall Stream
Area of detailed map

4of4



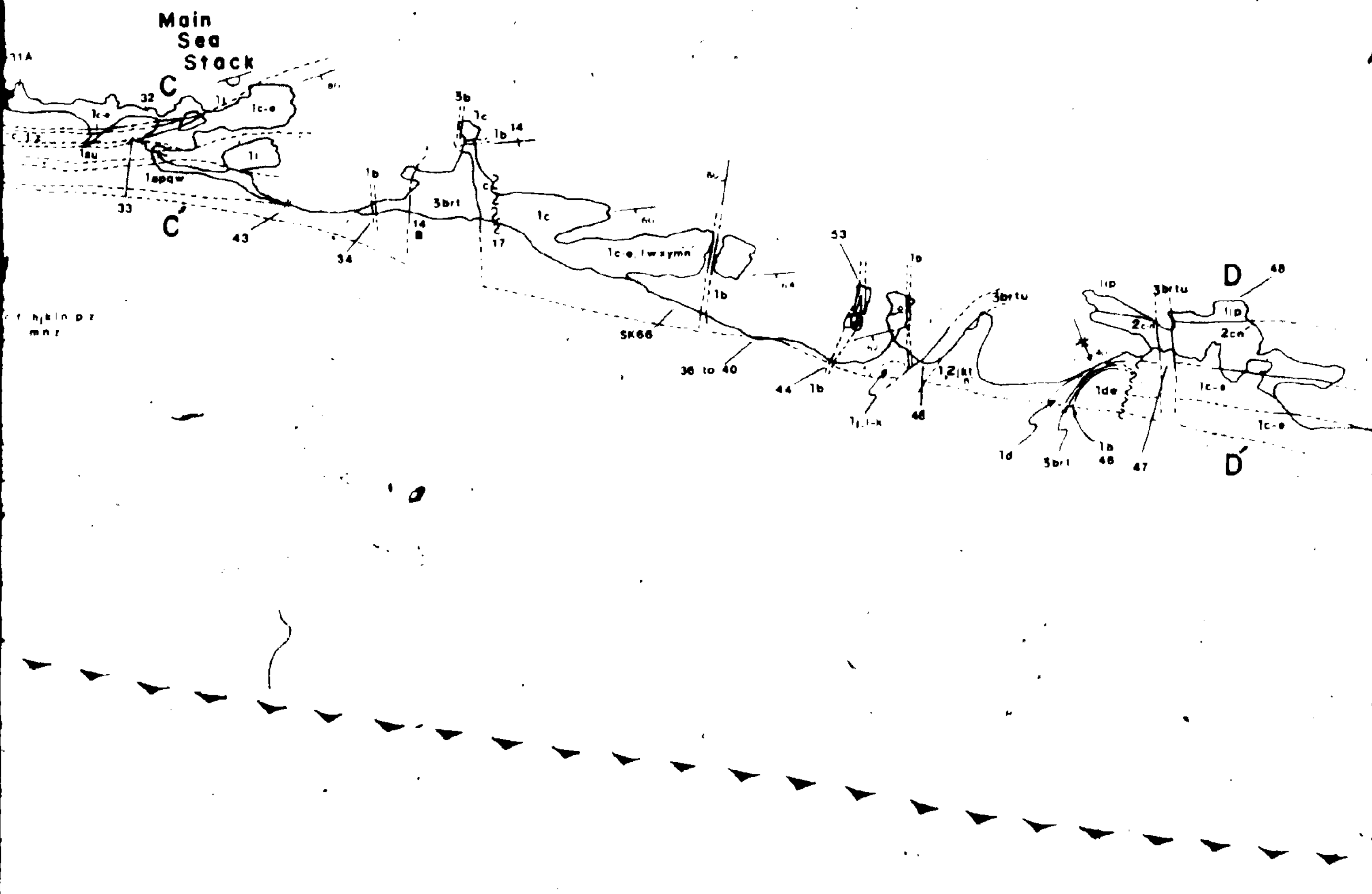
1 oF



STRATIGRAPHIC SECTIONS ACR

LINES OF TRAVERSE EXTEN

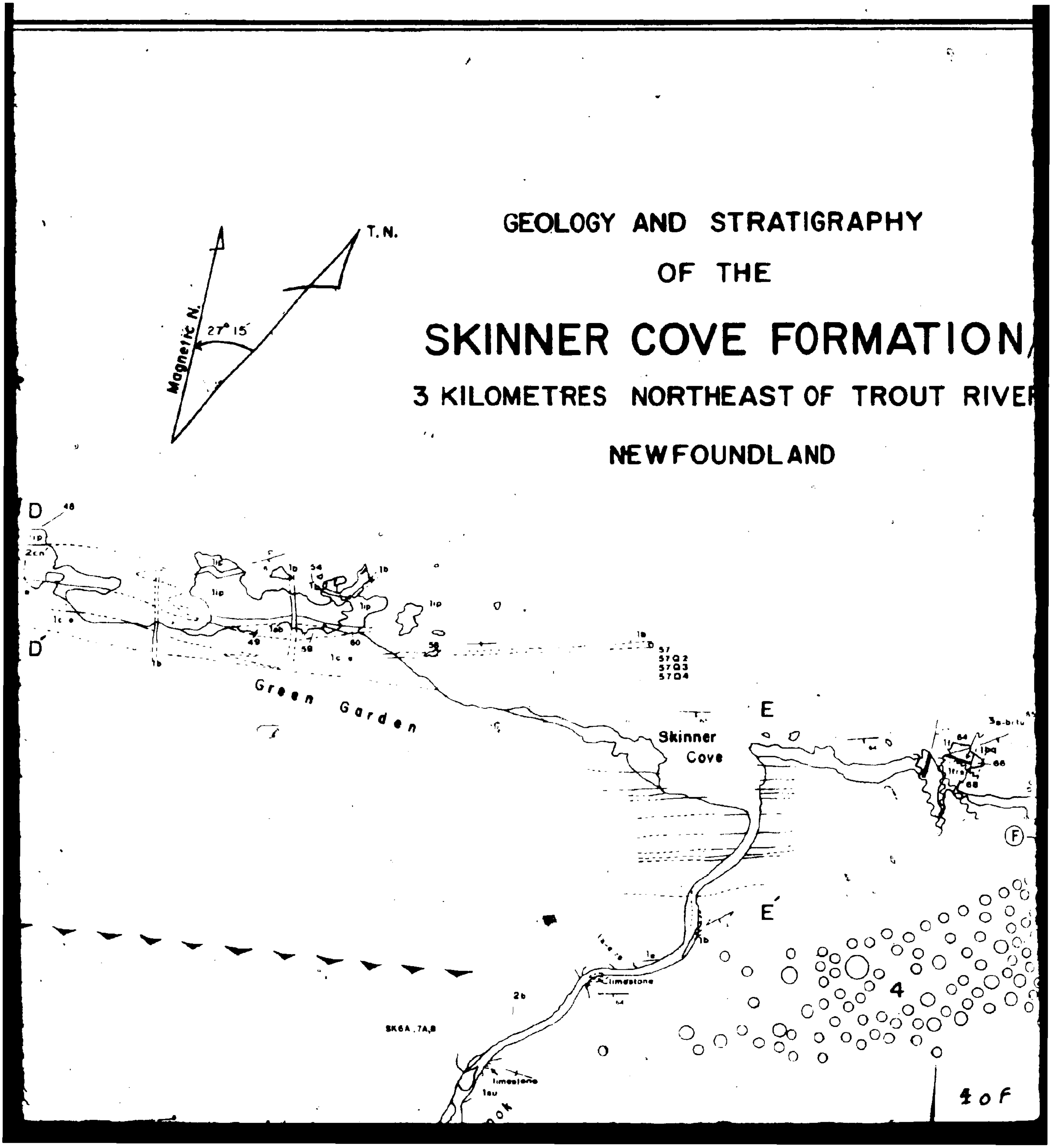
2 of



TIONS ACROSS THE SKINNER COVE FORMATION

WSE EXTEND FROM POINTS A-A', B-B', C-C', D-D', E-E

3 of


GEOLOGY AND STRATIGRAPHY
OF THE
SKINNER COVE FORMATION
3 KILOMETRES NORTHEAST OF TROUT RIVER
NEWFOUNDLAND
T.N.
Magnetic N.
27° 15′
D
D′
E
E′
F
Green Garden
Skinner
Cove
Limestone
limestone
SK6A, 7A,B
4
2b
4 of F

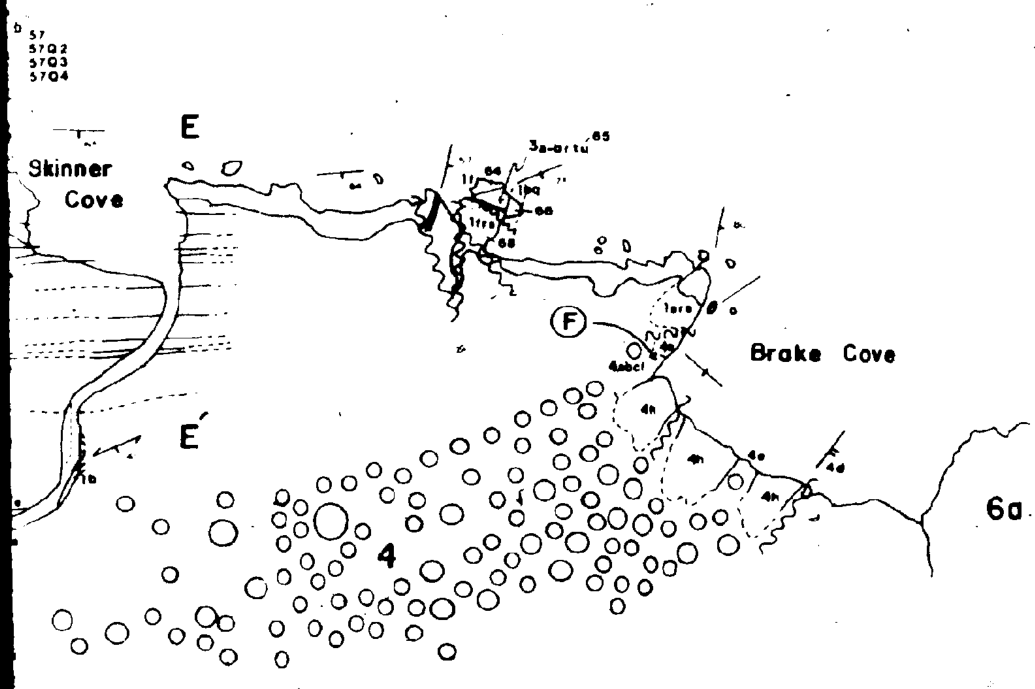
AND STRATIGRAPHY

OF THE

COVE FORMATION

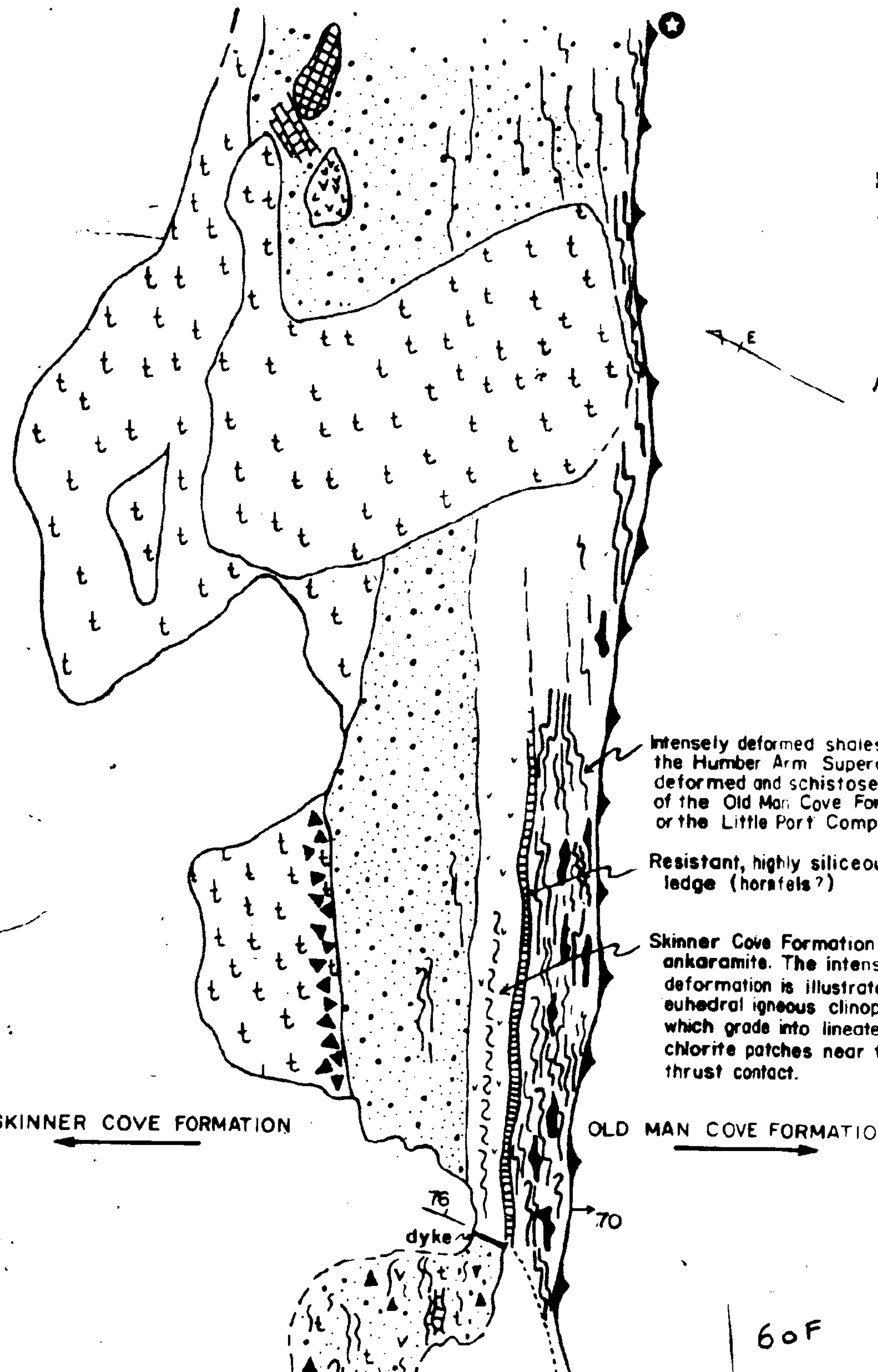
ORTHEAST OF TROUT RIVER

WFOUNDLAND



5oF

GEOLOGY OF A PORTION OF THE
SKINNER COVE FORMATION - OLD MAN COVE FORMATIO
CONTACT



60F

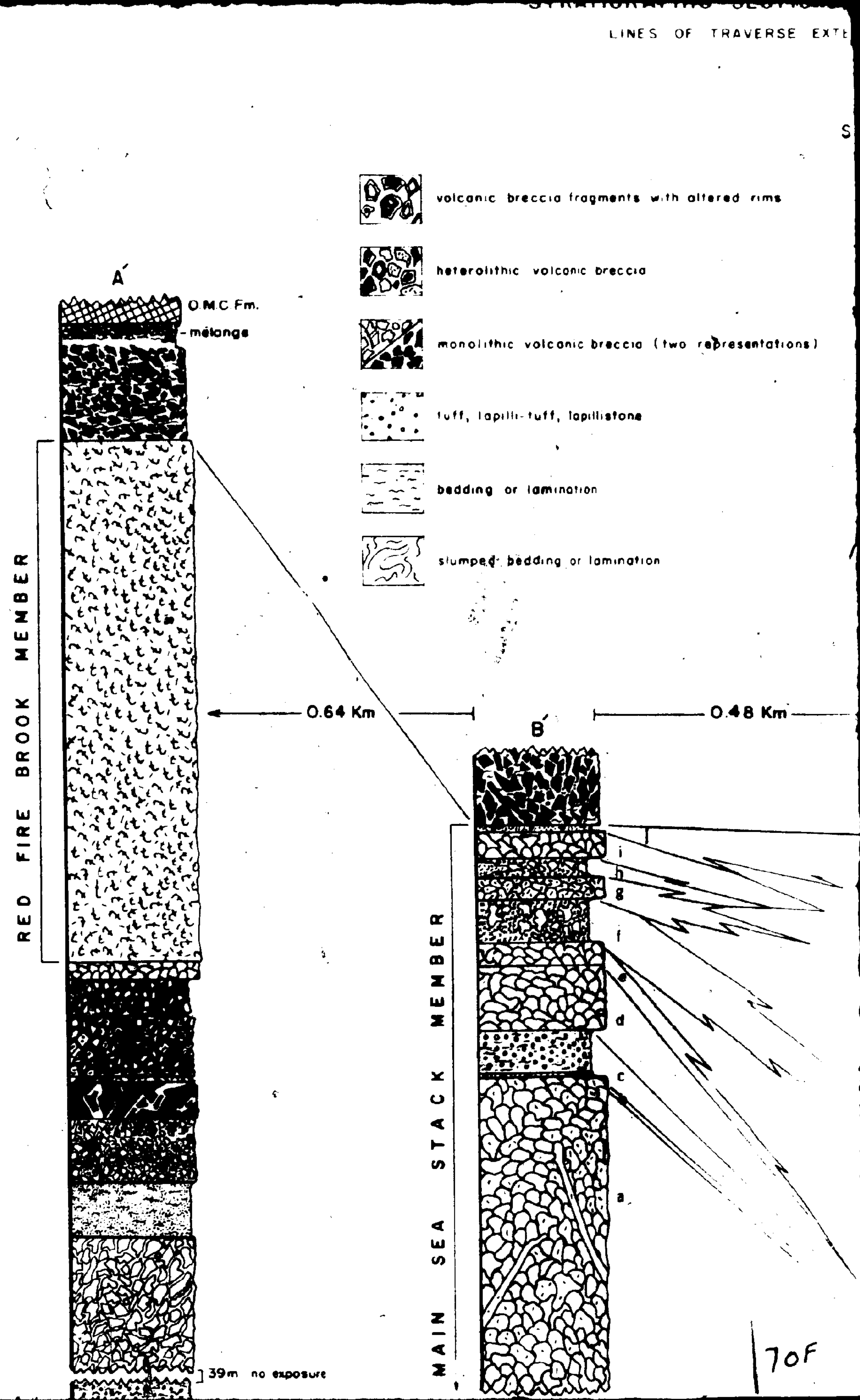
THE
E FORMATION

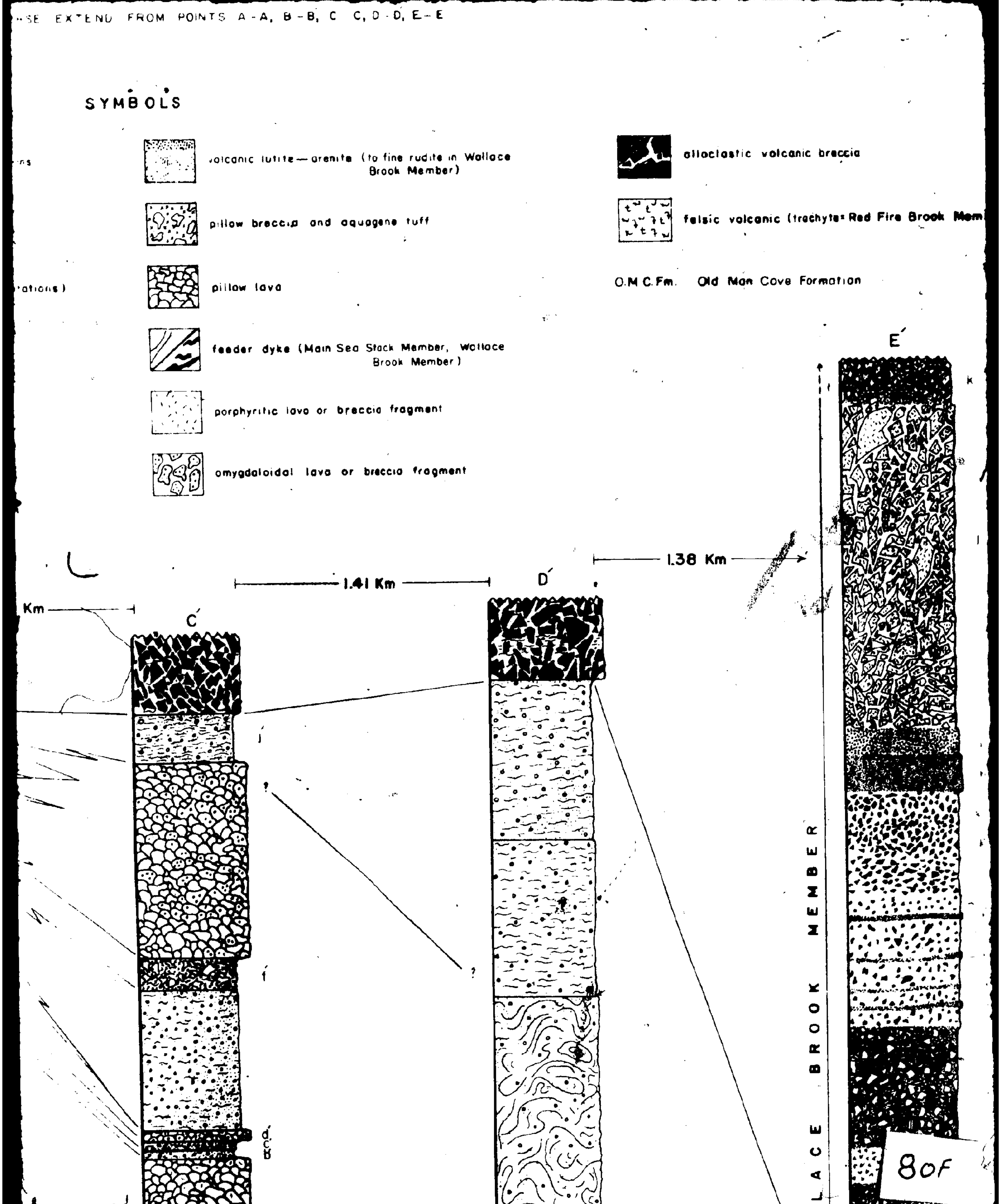
deformed shales of
ber Arm Supergroup,
d and schistose rocks
Old Man Cove Formation
ittle Port Complex

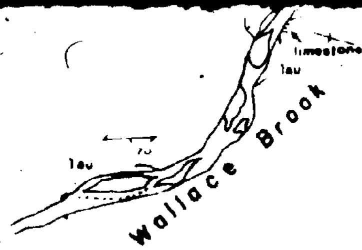
t, highly siliceous
(hornfels?)

Cove Formation
mite. The intensity of
ation is illustrated by
al igneous clinopyroxenes
grade into lineated
e patches near the
contact.

OVE FORMATION

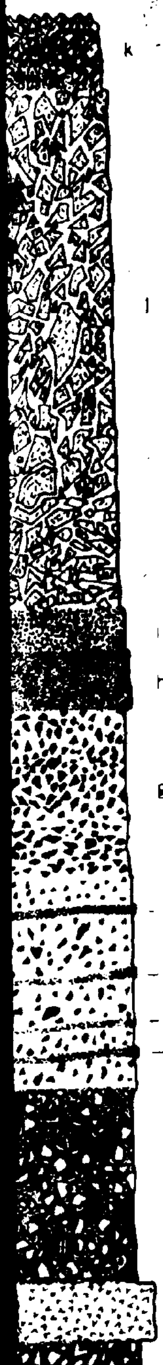



SE EXTEND FROM POINTS A-A, B-B, C C, D-D, E-E
SYMBOLS
volcanic lutite — arenite (to fine rudite in Wallace Brook Member)
pillow breccia and aquagene tuff
pillow lava
feeder dyke (Main Sea Stack Member, Wallace Brook Member)
porphyritic lava or breccia fragment
amygdaloidal lava or breccia fragment
alloclastic volcanic breccia
felsic volcanic (trachyte: Red Fire Brook Mem
O.M.C.Fm. Old Man Cove Formation
Km
1.41 Km
1.38 Km
C′
D′
E′
LACE BROOK MEMBER
8OF



e Brook Member)

LEGEND



SKINNER COVE FORMATION

LOWER ORDOVICIAN (?)

1 Mafic
2 Intermediate
3 Felsic
- a flow
- b subvolcanic
- c tuff } pyroclastic
- d lapilli-tuff } pyroclastic
- e lapillistone } pyroclastic
- f agglomerate } pyroclastic
- g alloclastic breccia
- h autoclastic breccia
- i pillow breccia + aquagene tuff
- j epiclastic breccia
- k heterolithic clasts
- l monolithic clasts
- m volcanic lutite
- n volcanic arenite
- o volcanic rudite
- p pillowed
- q amygdaloidal (calcite)
- r porphyritic
- s clinopyroxene
- t plagioclase
- u hematized
- v serpentine-calcite after olivine
- w carbonate cement
- x laminated to thin bedded < 3cm.
- y medium bedded 3-15cm.
- z thick bedded > 15 cm.
- z′ massive
- m′ graded bedding
- n′ reworked

Syn- or Post- LOWER ORDOVICIAN

4 Mélange Zone ○
- a shale matrix
- b shale block
- c chert block
- d sandstone block
- e limestone block
- f fossiliferous
- g felsic volcanic block
- h mafic volcanic block

OLD MAN COVE FORMATION

CAMBRO-ORDOVICIAN (?)

5 polydeformed greenschists, undeformed but slightly brecciated mafic dykes, minor calcareous lenses

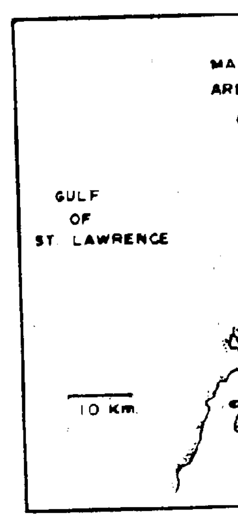
LITTLE PORT COMPLEX

...BRO-...VICIAN

6 unseparated
- a banded and foliated gabbro, leucogabbro

GEOLOG

Geological boundary (d
Bedding, tops known (
Bedding, tops unknown
Foliation, schistosity (i
Lineation (inclined wit
Minor syncline (inclined
Fault (defined with dip,
inferred)
Leading edge of stru
of dip (defi
Fossil locality
Mineral occurrence (
Geochemistry sample



9oF

N D

ON

stic

ne tuff

er olivine

ed < 3cm.
3-15cm.
> 15 cm.

ION

hists, undeformed
ed mafic dykes,
ses

X

bro, leucogabbro

GEOLOGICAL SYMBOLS

Geological boundary (defined, approximate, assumed) . . . . . .
Bedding, tops known (inclined, vertical, dip unknown) . . . . . .
Bedding, tops unknown (inclined, vertical, dip unknown) . . . . . .
Foliation, schistosity (inclined, vertical, dip unknown) . . . . . .
Lineation (inclined with amount of plunge) . . . . . .
Minor syncline (inclined with amount of plunge) . . . . . .
Fault (defined with dip, defined with sense of strike-slip, inferred) . . . . . .
Leading edge of structural slice with direction and amount of dip (defined, approximate) . . . . . .
Fossil locality . . . . . . (F)
Mineral occurrence (massive pyrite) . . . . . . (X)
Geochemistry sample no. and location (SKC) . . . . . .

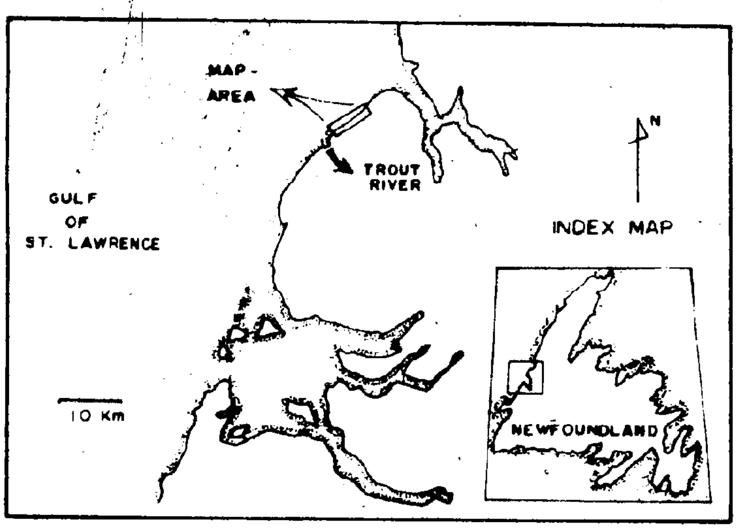
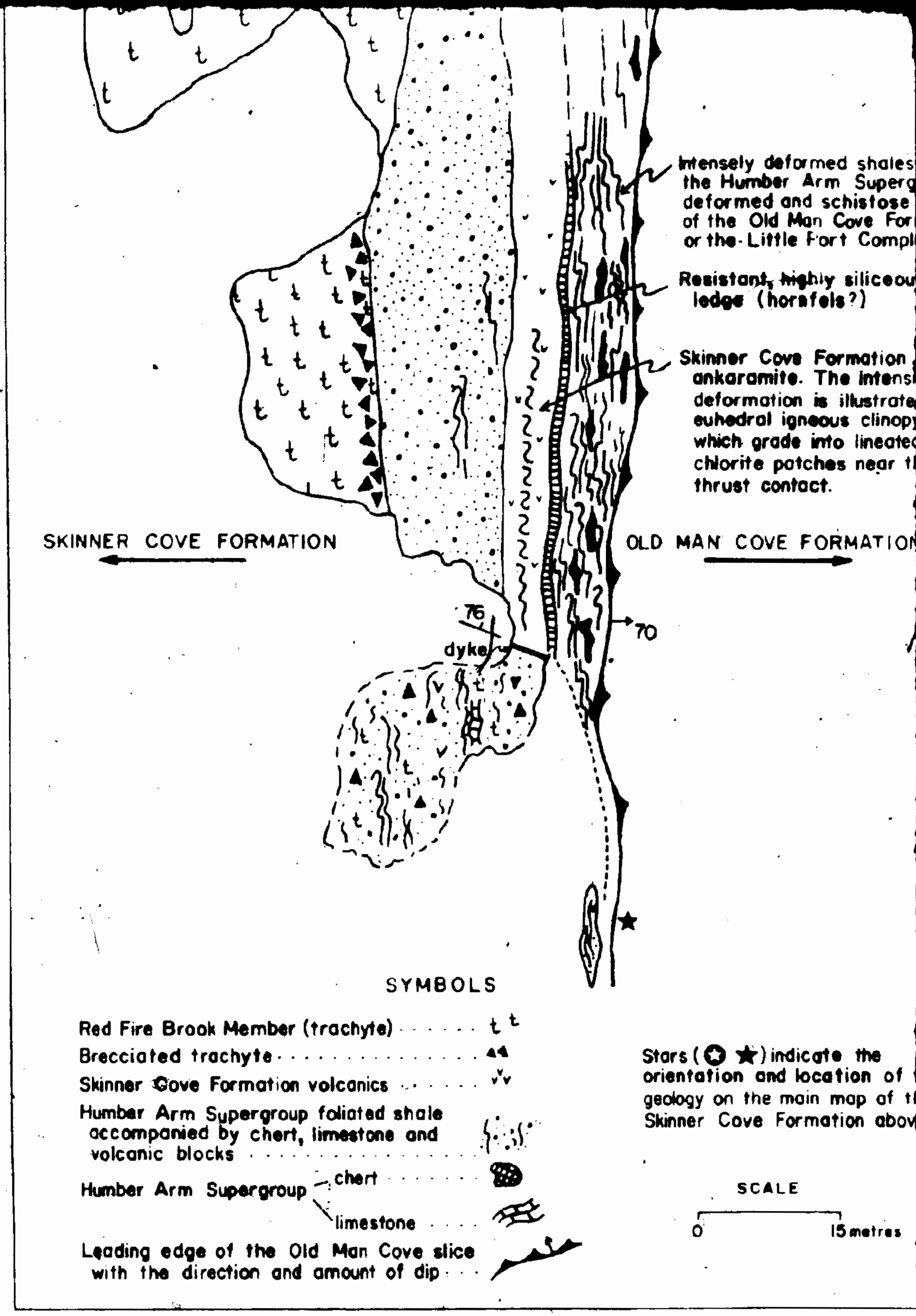


PLATE no. 1.

10 oF



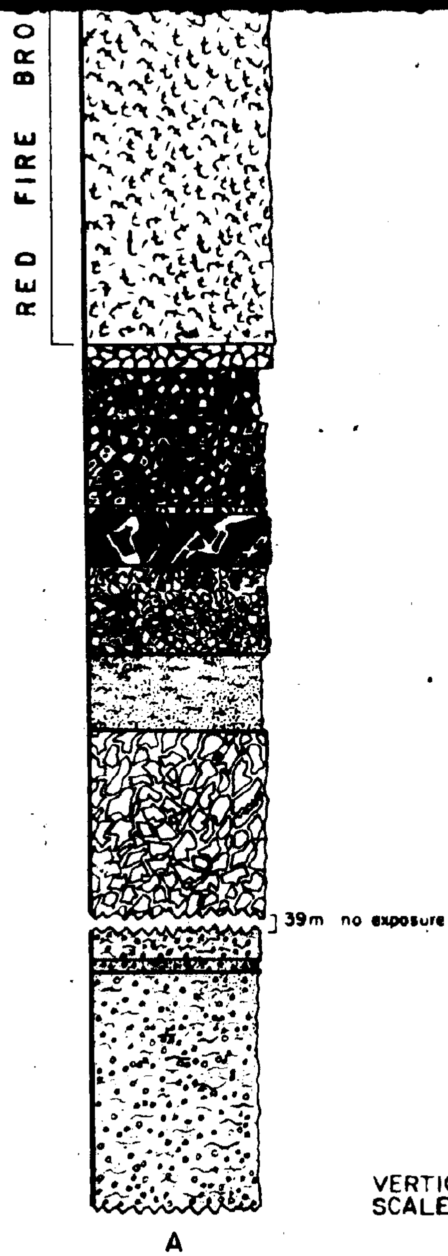
Intensely deformed shales
the Humber Arm Superg
deformed and schistose
of the Old Man Cove For
or the Little Fort Compl
Resistant, highly siliceou
ledge (hornfels?)
Skinner Cove Formation
ankaramite. The intens
deformation is illustrate
euhedral igneous clinop
which grade into lineate
chlorite patches near t
thrust contact.
SKINNER COVE FORMATION
OLD MAN COVE FORMATIO
76
dyke
70
SYMBOLS
Red Fire Brook Member (trachyte)
Brecciated trachyte
Skinner Cove Formation volcanics
Humber Arm Supergroup foliated shale accompanied by chert, limestone and volcanic blocks
Humber Arm Supergroup
chert
limestone
Leading edge of the Old Man Cove slice with the direction and amount of dip
Stars indicate the orientation and location of
geology on the main map of t
Skinner Cove Formation abov
SCALE
0
15 metres

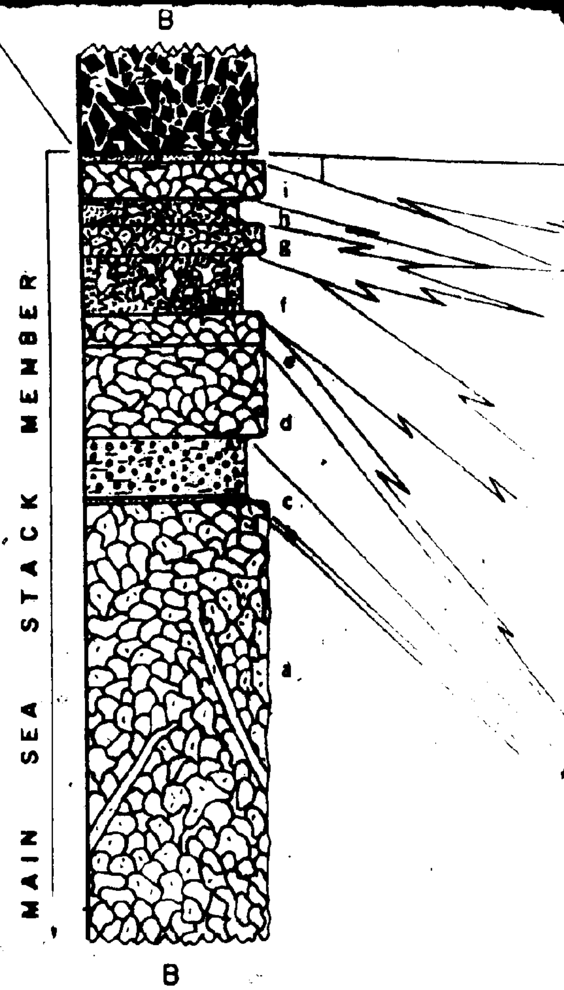
nsely deformed shales of
Humber Arm Supergroup,
ormed and schistose rocks,
he Old Man Cove Formation
he Little Port Complex

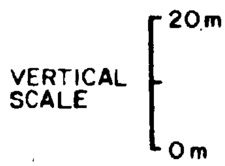
istant, highly siliceous
dge (hornfels?)

ner Cove Formation
karamite. The intensity of
formation is illustrated by
hedral igneous clinopyroxenes
ich grade into lineated
lorite patches near the
rust contact.

N COVE FORMATION







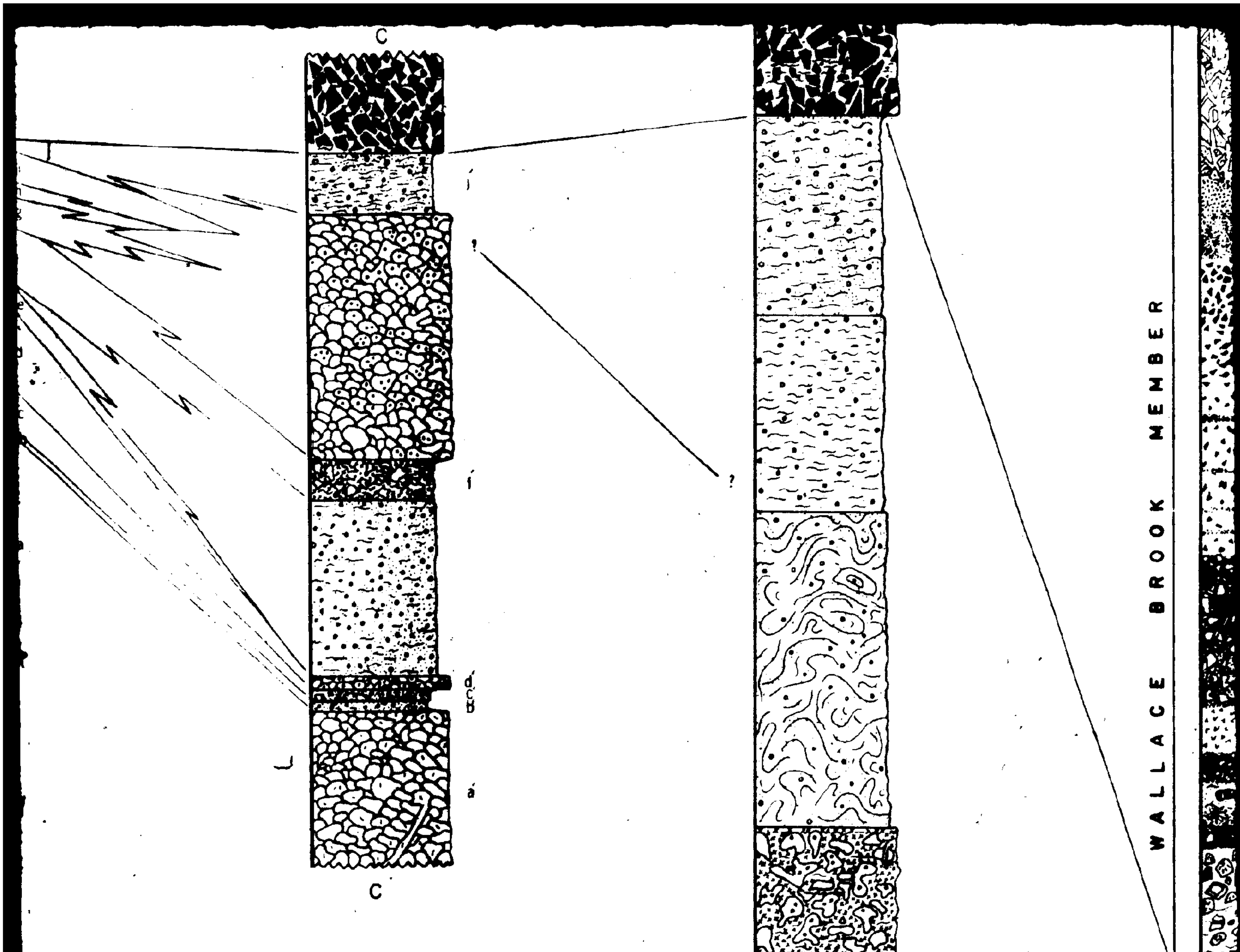
The top and base of each stratigrap

In section E-E, the abundance of white
of carbonate cement to volcan

★) indicate the
on and location of this
n the main map of the
Cove Formation above.

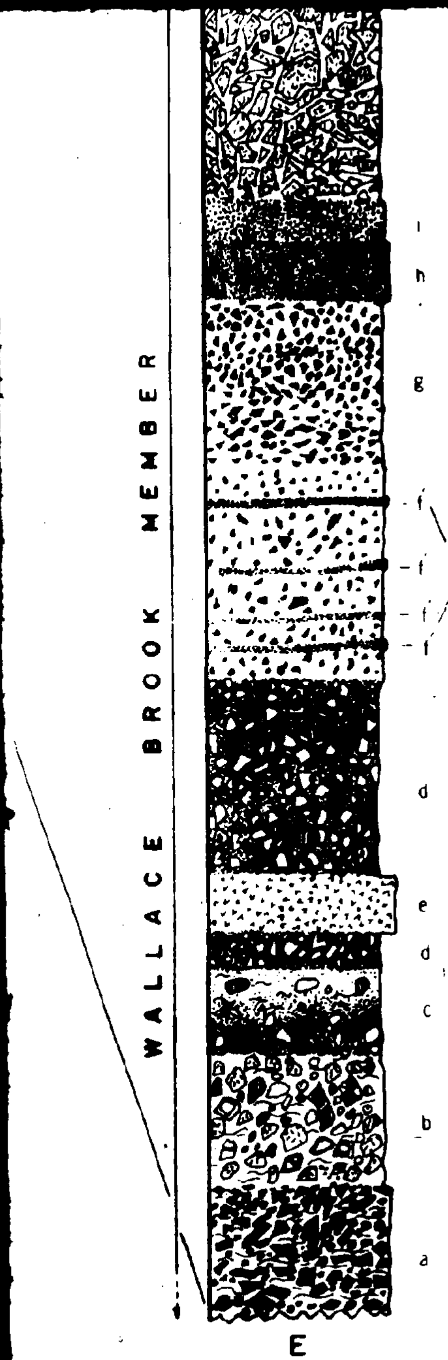
SCALE
15 metres

12of



and base of each stratigraphic section is not exposed.

n E-E', the abundance of white background represents the relative proportion
f carbonate cement to volcanic fragments.



LOWER ORDOVICIAN

p pillowed
q amygdaloidal (calcite)
r porphyritic
s clinopyroxene
t plagioclase
u hematized
v serpentine-calcite after olivine
w carbonate cement
x laminated to thin bedded < 3cm.
y medium bedded 3-15cm.
z thick bedded > 15 cm.
z′ massive
m′ graded bedding
n′ reworked

Syn- or Post- LOWER ORDOVICIAN

4 Mélange Zone ○
a shale matrix
b shale block
c chert block
d sandstone block
e limestone block
f fossiliferous
g felsic volcanic block
h mafic volcanic block

CAMBRO-ORDOVICIAN (?)

OLD MAN COVE FORMATION

5 polydeformed greenschists, undeformed but slightly brecciated mafic dykes, minor calcareous lenses

CAMBRO-ORDOVICIAN

LITTLE PORT COMPLEX

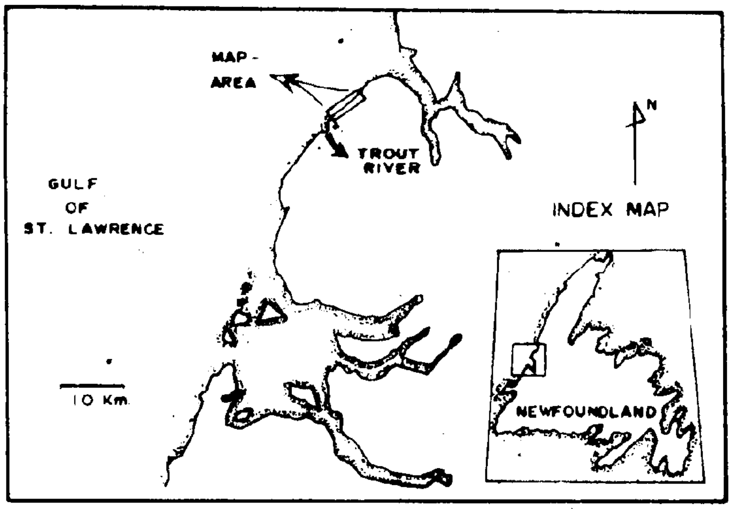
6 unseparated
a banded and foliated gabbro, leucogabbro

SCALE

0 .1 .5

er olivine

ed < 3cm.
3-15cm.
> 15 cm.



TION

chists, undeformed
ted mafic dykes,
ises

X

bbro, leucogabbro

PLATE no. 1.

SCALE

.5 1 kilometre

D. F. BAKER 1978