GEOLOGICAL SURVEY OF CANADA

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THE JEFFERS GROUP, WESTERN COBEQUID HILLS, NOVA SCOTIA

Georgia Pe-Piper and Denise Turner
Department of Geology, St. Mary's University,
Halifax, N.S., B3H 3C3

Final report under DSS contract 20ST.23233-6-0051, title "Map and carry out petrological studies of the Jeffers Formation, Cobequid Highlands, Nova Scotia, as an aid in assessement of resource potential"

Scientific Authority: Dr. F.W. Chandler, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

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Contribution to the Canada-Nova Scotia Mineral Development Agreement 1984-89.
Project carried by the Geological Survey of Canada.

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Abstract

This report consists of maps at a scale of 1:10 000 of the Jeffers Group, and a descriptive text detailing field and laboratory observations (particularly petrography and geochemistry) of the Jeffers Group rocks. The text also presents a synthesis of the volcanic and sedimentary history of the Jeffers Group, and an account of subsequent structural deformation, igneous intrusion and mineralisation.

The detailed mapping of the Late Hadrynian Jeffers Group (Avalon Zone) has permitted its subdivision into three formations: the Gilbert Hills, the Humming Brook and the Cranberry Lake. The volcanic Gilbert Hills Formation underlies and interfingers with deeper water argillite of the Humming Brook Formation and turbidite wacke and siltstone of the Cranberry Lake Formation. The Jeffers Group has a spatially inhomogeneous flat- lying cleavage, probably associated with thrust faults of Late Hadrynian age that were reactivated during the Acadian orogeny. This thrusting, together with major strike slip faulting, has resulted in a complex distribution pattern for rocks of the Jeffers Group.

The oldest rocks of the Gilbert Hills Formation are assigned to the Lakelands facies. The basal rocks are a geochemically distinctive suite of mafic lavas and minor interbedded pyroclastic rocks that pass up into a thick felsic pyroclastic sequence with minor rhyolite. These are overlain by volcaniclastic sandstone, locally with interbedded marble, which pass up into the Humming Brook Formation in the south of the map area and into the West Brook facies of the Cranberry Lake Formation in the north of the map area. Some of the mafic lavas in the Lakelands facies resemble ocean island tholeiites; others are calc-alkali in character.

The upper part of the Gilbert Hills Formation is assigned to the Harrington River facies. In most places, this facies is thrust over silty argillites at the top of the Lakelands facies. In the south of the map area, the Harrington River facies consists of a thick sequence of mafic lavas with minor rhyodacites and mafic tuffs. In the north of the map area, probably correlative rocks consist principally of mafic tuffs, with minor felsic tuffs and abundant hypabyssal intrusions. The mafic lavas of the Harrington River facies are calc-alkali in character.

The Humming Brook Formation is restricted to the southern part of the map area and occurs at the deepest structural levels. It consists of silty argillites, in many places poorly sorted and locally with interbedded fine grained turbidites. It is interpreted as a basin slope deposit.

The Cranberry Lake Formation is divided into two facies. The Pike Fire Brook facies consists of thick bedded fine to coarse lithic arkoses of proximal turbidite character. The West Brook facies consists of thin bedded very fine sandstone and siltstone turbidites, of arkosic composition and with a more distal turbidite character. Very limited paleocurrent data suggest transport directions to the northwest.

The Jeffers Group is interpreted as representing sedimentation in a deep water basin, within which volcanic islands grew and then subsided along the southern margin of the basin. The complex variety of rock successions can be most simply modelled as having accumulated in a series of east-west trending facies belts. The more northerly facies belts were then thrust over those to the south; the stratigraphically older rocks tending to be exposed in the south where they have been elevated by forceful Carboniferous granite intrusion. The southernmost belt consists of mafic-felsic volcanic complexes of the Lakelands facies, possibly built up on basin slope muds of the Humming Brook facies. As volcanism ceased, silty argillites and fine grained turbidites of the Cranberry Lake Formation accumulated on the flanks of the volcanoes. These incompetent rocks mark the zone over which thick mafic volcanics from the north (the Harrington River facies) have been thrust. These mafic rocks are also overlain by Cranberry Lake Formation, over which is thrust a facies belt principally of mafic pyroclastic rocks (Harrington River facies). Thrust over these are thick bedded proximal turbidites (Pike Fire Brook facies), perhaps representing a base of slope or deep sea fan environment. Thinner bedded West Brook facies turbidites overlie these deposits, and extend further to the north and west.

Two widespread types of hypabyssal mafic intrusions are associated with the Gilbert Hills Formation and appear to have been cleaved along with the Jeffers Group prior to the intrusion of the late Hadrynian Jeffers Brook pluton. They are (1) a feldspathic mafic lithology geochemically and petrographically similar to the calc-alkali Harrington River mafic lavas; and (2) a high-Ti tholeiitic lithology, geochemically similar to ocean island tholeiite.

Later mafic and microgranite dykes and sills appear to be associated with the intrusion of Carboniferous plutons; the extrusion of the Carboniferous Fountain Lake Group rhyolites and basalts; and Late Paleozoic strike slip motion on the Cobequid Fault.

Most mineralisation appears to be associated with these Late Paleozoic events. Hematite and barite mineralisation are associated with the Cobequid Fault zone. Sulphide mineralisation occurs in fracture zones associated with the Carboniferous plutons. There is minor mineralisation associated with basal Silurian rhyolites and with the margins of Hadrynian diorite plutons.

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1 - 3. Late Hadrynian Jeffers Group.
1 - Gilbert Hills Formation, 1a: Lakelands facies; 1b: Harrington River facies.
2 - Humming Brook Formation
3 - Cranberry Lake Formation, 3a: Lynn Road facies; 3b: Pike Fire Brook facies; 3c: West Brook facies.
4 - Late Hadrynian plutons
5 - Wilson Brook Formation (Silurian)
6 - Fountain Lake Group (Devono-Carboniferous)
7 - Carboniferous plutons
8 - undivided Carboniferous sedimentary rocks
FZ - fault zone with a wide range of lithologies
G.M.F. - Gilbert Mountain Fault

A to E are sections illustrated in Figure 4.

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INTRODUCTION

Purpose

The Cobequid Hills are one of the potentially mineral-rich areas of Precambrian and Palaeozoic rocks of the Avalon zone in Nova Scotia (Fig. 1). From reconnaisance mapping, Donohoe and Wallace (1980, 1982) defined an extensive sequence of Late PreCambrian volcanic rocks and associated sediments - the Jeffers Formation - in the western Cobequid Hills. Subsequently, Pe-Piper carried out further field investigations of the Jeffers Formation in support of a geochemical study of the volcanic rocks (Pe-Piper and Piper, in press), and supervised several B.Sc. honours thesis studies in the area (Blank, 1985; Boner, 1985; MacDonald, 1984; Clerk, 1987).

The present contract under the Canada - Nova Scotia Mineral Development Agreement, had the folowing objectives:
1. To prepare to modern scientific standards geological maps of the Hadrynian Jeffers Formation (as shown by Donohoe and Wallace, NSDME Report 80-7, p.211 et seq) at a scale of 1:10,000.
2. To prepare a report on the geology of the above formation, detailing its stratigraphy, correlation, chemical petrology, geological history, tectonic interpretation and mineral potential.

The maps and this report in fulfilment of the contract objectives draw heavily on work carried out using NSERC funding in the three years prior to the present contract. In particular, most thin sections, all geochemical work and all field work prior to 1986 was supported entirely by NSERC.

A preliminary report on the present contract (Pe-Piper, 1987) proposed three new formations within the original Jeffers Formation, which was redefined as the Jeffers Group.

Organisation of this report

The first part of this report is a summary of the regional geology based on field work largely summarised in previous publications (Pe-Piper, 1987; Pe-Piper and Piper, 1987): the information presented by Pe-Piper (1987) arises from this contract.

The second part of this report describes the petrography of the Jeffers Group and related rocks in all the well-exposed areas that have been mapped. Particular detail is presented for the lower Jeffers Brook and Harrington River sections, which illustrate most of the rock types within the Jeffers Group and associated intrusions.

The third part of the report examines such topics as the geochemistry, mineralisation, sedimentological and structural history of the area, based on the field observations and petrography described in the second part of the report.

Throughout this report, individual rock samples are referenced in order to document observations. Samples have numbers between 001 and 4149 and are shown in (parentheses). Those samples for which geochemical analyses are available (Table 2) are indicated with an * asterisk. Mineral localities are numbered from 1 to 40 and are shown in [square brackets].

The following nomenclature is used for volcanic and pyroclastic rocks. For lavas and fine grained hypabyssal intrusions, rhyolite refers to rocks with more than about 65% silica, rhyodacite to rocks with between about 60% and 65% silica, and mafic to rocks with less than about 60% silica (where further discrimination is necessary, mafics with >56% are andesites, others are basalts). Pyroclastic rocks with more than about 60% silica are felsic, with less than about 60% silica are mafic.

Physiography and access

The Cobequid Hills (Fig. 2) are a range of flat-topped hills some 250 to 300 m high. The summit plateau is swampy in places and outcrop is sparse. The southern margin of the Cobequid Hills is marked by the Cobequid Fault, which has produced a fault line scarp locally over 100 m high. A prominent gap in the Cobequid Hills north of Parrsboro (informally termed the "Parrsboro Gap") is occupied by the Parrsboro River draining south, the River Hebert draining north, and a series of glacial lakes. Southward- draining rivers and brooks are deeply incised, with steep valley sides up to 100 m high and spectacular waterfalls at faults. There is little till south of the drainage divide, but extensive periglacial deltas were deposited south of the Cobequid Fault. Northward-draining rivers occupy broad valleys, and there are thick till deposits north of the drainage divide (Stea et al., 1985), so that bedrock outcrops in this region are less common.

The contrast between the northern and southern slopes of the Cobequid Hills reflects their different glacial history. During Late Wisconsinan glacial retreat, ice stagnated on the north side of the Cobequid Hills and in the "Parrsboro Gap" (Wightman, 1979). The south side of the Cobequid Hiils appear to have been ice free much longer, but the south-flowing rivers could have carried much of the meltwater discharge from ice to the north. The deep valleys may be continuous with the steepsided subglacial meltwater channels in the Minas Basin (Piper et al., in press), developed when ice was more extensive in the Early Wisconsinan and earlier glaciations.

Within the study area, roads cross the Cobequid Hills in only two places - highway 2 in the "Parrsboro Gap" and the Lynn Road just east of the Harrington River. Highways 2 and 209 run along the southern margin of the Cobequid Hills, and there are a series of roads, largely unpaved, along the blueberry farming areas at the northern edge of the Hills. There are recent logging roads in the West Moose River area. There are older woods roads providing access to 4-wheel drive vehicles in the Kirkhill area, from Browns Brook to Cranberry Lake, north of Jeffers Brook, east of Lynn Road, east of North River and east of Bass River of Five Islands. However, significant areas are several kilometers from the nearest drivable road: these include the upper parts of West Brook, the southern headwaters of Jeffers Brook, the upper parts of the Moose River system, west Harrington River, and the upper parts of the Bass River and East River of Five Islands. Mapping the area thus required a large amount of unproductive time in gaining access to the rocks.

Geological Setting

A series of Late Proterozoic and Paleozoic rocks outcrop north of the Cobequid Fault in the western Cobequid Hills of northern Nova Scotia (Fig. 1). The Cobequid Fault forms part of the Minas Geofracture (Keppie, 1982), marking the southern boundary of the Avalon zone. The principal rock units of the western part of the Cobequid Hills, in the area centred north of the town of Parrsboro (Fig. 3), are volcanic and sedimentary rocks of the Jeffers Group (Pe-Piper, 1987), Late Hadrynian intrusions, shales of the Silurian Wilson Brook Formation, basalts and rhyolites of the Devono-Carboniferous Fountain Lake Group, and a series of Carboniferous plutons. Sedimentary rocks of the Cumberland Group (Carboniferous) onlap unconformably onto the northern margin of the Cobequid Hills (Fig. 1). South of the Cobequid Fault is a lowland region of Carboniferous and Triassic rocks.

The Jeffers Group was originally mapped as the Jeffers Formation by Donohoe and Wallace (1980, 1982) and defined in a type section in Jeffers Brook, north of Parrsboro, as a series of quartz metawackes and volcanic metawackes, metasiltstones, mafic volcanic rocks and minor marbles. Preliminary mapping of parts of the Jeffers Group by Pe-Piper and Piper (1986), to support a geochemical study of the volcanic rocks, suggested that it was considerably more extensive and lithologically more variable than indicated by Donohoe and Wallace (1980, 1982) and that systematic remapping was required. This new work has shown that several mappable units can be distinguished within the Jeffers Formation as defined by Donohoe and Wallace. These mappable units (Fig. 3) were defined by Pe-Piper (1987) as new formations, necessitating the elevation of the Jeffers Formation to Group status. These new formations are described in detail below.

Several major east-west trending faults (Fig. 3) cut the pre-Carboniferous rocks of the western Cobequid Hills (Pe-Piper and Piper, in press). The timing and sense of movement on these faults is poorly known and probably complex. The Cobequid Fault has a cataclastic zone several hundred metres wide and cuts large plutons of Carboniferous age, apparently with principally strike slip motion. Our mapping suggests that the Kirkhill Fault was a strike slip fault at some time in its history, but the Carboniferous motion was probably mostly vertical. The Gilbert Mountain Fault (G.M.F., Fig. 3), separating the Jeffers Group from the Wilson Brook Formation, also shows predominantly vertical motion.

Between the Cobequid and Kirkhill Faults, most of the exposed rocks are of Devono-Carboniferous age, and Jeffers Group rocks are rare. Most of the area between the Kirkhill and Gilbert Mountain Faults consists of Jeffers Group and younger intrusions, with minor inliers of Fountain Lake Group. The Jeffers Group in this area includes thick quartz wackes previously mapped as Wilson Brook Formation by Donohoe and Wallace (1982); their identification as Jeffers Group is discussed by Pe-Piper and Piper (in press).

Structure

Donohoe and Wallace (1982, 1985) recognised that the Jeffers Group has a distinctive shallow to moderately dipping foliation (S1), deformed by upright to inclined folds (F2), with both the S1 foliation and F2 folds cut by the Jeffers Brook pluton, which was radiometrically dated as latest Hadrynian. The new mapping has shown that the S1 foliation is spatially very variable; in places it is associated with intense flattening and stretching, with growth of chlorite-grade metamorphic minerals, whereas other parts of the Group have only very weak, flat-lying penetrative cleavage and in places, no cleavage can be distinguished. Areas that are intensely cleaved are most common in the southern part of the study area, are typically a few tens to a few hundred metres thick and generally separate different stratigraphic units (Fig 4). The variability in intensity of cleavage probably indicates a thrust style of deformation.

The age of the flat-lying cleavage is only locally defined.
At the eastern margin of the late Hadrynian Jeffers Brook pluton, Jeffers Group rocks with a very weak cleavage are cut by undeformed veins of coarse diorite. At the western margin of the pluton, highly cleaved Jeffers Group rocks are in fault contact with undeformed diorite. In the West River area, generally uncleaved Wilson Brook Formation (Silurian) shales are in fault contact with Jeffers Group that has a flat-lying cleavage. In the West Moose River area, undeformed Fountain Lake Group rhyolite (Devono-Carboniferous) unconformably overlies intensely cleaved Jeffers Group. These observations all suggest a pre-Devonian and probably Late Hadrynian age for much of the flat-lying cleavage, as suggested by Donohoe and Wallace (1982, 1985).

West of Parrsboro, however, there is widespread evidence for a strong flat-lying foliation of Carboniferous age. The Cape Chignecto - Apple River plutonic complex (CC - AR in Fig. 1) is lithologically similar to other Carboniferous granites, and has yielded Carboniferous radiometric dates (Table 1). The pluton and the nearby Fountain Lake Group and Rapid Brook Formation have been intensely deformed with the development of a strong, flat-lying stretching lineation and flat-lying sheared contacts between diorite and granite bodies. This deformation is probably related to Carboniferous thrusting in southwestern New Brunswick (Nance and Warner, 1986). Similar deformation of Carboniferous plutons can be recognised as far east as the Hanna Farm pluton northwest of Parrsboro; there is also local deformation within a kilometre of the Cobequid Fault farther east. It is therefore likely that some of the flat-lying deformation observed in the Jeffers Group is of Late Paleozoic age.

STRATIGRAPHY OF THE JEFFERS GROUP

Introduction

The Jeffers Group comprises mafic, intermediate and felsic volcanic rocks and interbedded volcaniclastic sediment (Pe-Piper, 1987). The volcanic rocks and immediately associated sediments are mapped as the Gilbert Hills Formation. The Humming Brook Formation comprises argillite and is developed in the southern part of the Cobequid Hills. The Cranberry Lake Formation is a thick sequence of greywacke and quartz wacke interbedded with and overlying the volcanic rocks. These formations are described below in approximate ascending order of age.

Gilbert Hills Formation

The Gilbert Hills Formation comprises lavas and pyroclastic rocks within the Jeffers Group. It is named for the Gilbert Hills, located within one of the areas in which volcanic rocks are best developed. The type section is located in Jeffers Brook (Fig. 4), immediately west of the contact with the Jeffers Brook pluton (map reference 972354). Two facies are recognised within the Formation, with different types of volcanic rocks and different stratigraphic position.

<u>Lakelands facies</u>

In the maps accompanying this report, four mappable divisions of the Lakelands facies are recognised. From top to base these are:

HG3 Sandstone and rare tuffs

HG2 Felsic pyroclastics, minor rhyolite and mafic lavas, and in some places sandstone and marble

HG1 Mafic lavas, minor pyroclastics

The Lakelands facies consists predominantly of felsic volcanic rocks, and is defined in the type section of the Gilbert Hills Formation. This section consists of a thin sequence of mafic lavas and possible pyroclastic rocks (which are highly sheared in the type section), overlain by several tens of metres of felsic pyroclastic rocks. The sequence passes up into silty argillite. Facing directions are determined from frequent graded beds, some with erosional bases.

Farther downstream in Jeffers Brook, the probable equivalent of the felsic pyroclastic sequence includes a felsic agglomerate several metres thick and rare rhyolite flows. An apparently correlative sequence of agglomerate and tuffs, local rhyolite flows and indistinctly bedded massive quartz sandstones (apparently derived from reworking of the the pyroclastic rocks) occurs to the west and north in Hanna Brook and southern Henry Brook.

Highly deformed felsic rocks in Fowler Brook, in an inlier of Jeffers Group rocks 30 km west of Parrsboro (FB in Fig. 1), are assigned to this facies. Three other felsic pyroclastic sequences - in Davidson Brook, near the West Moose River, and in North River - are also assigned to this facies. The rocks in Davidson Brook are felsic tuffs. They are in fault contact with mafic volcanic rocks of the Harrington River facies. They are cut by numerous hypabyssal intrusions and in fault contact with all other stratigraphic units. In the

West Moose River area, felsic tuffs several tens of metres thick are overlain by mafic rocks of the Harrington River facies.

In North River, there is a sequence underlying the Humming Brook Formation that consists of felsic tuffs and less common basalt, together with sandstones (apparently derived from reworking of the tuffs) and minor carbonates. The structural and mineralogical evolution of the carbonates is described by Boner (1985). The sandstone appears to pass up abruptly into silty argillite of the Hummming Brook Formation. Carbonates are not known elsewhere in the stratigraphic section in the western Cobequid Hills, except for the Carboniferous Windsor Group south of the Cobequid Fault, so that highly deformed carbonate bodies in fault zones in the Bass River of Five Islands and south of Hanna Brook may also be part of the Lakelands facies.

Harrington River facies

In the maps accompanying this report, three divisions of the Harrington River facies are recognised. They have no stratigraphic significance. They are, in order of importance from the south to the north of the mapped area:

HG4 predominantly mafic flows

HG5 mafic flows and mafic pyroclastics

The type section for the Harrington River facies is located in the Harrington River (Fig. 4), north of the junction with the West Harrington River (map reference 125350). It consists of massive intermediate and mafic lavas and minor interbedded pyroclastics. In the type section, the Harrington River facies differs from the Lakelands facies in the virtual absence of felsic volcanic rocks and the development of thick massive sequences of mafic lavas. In addition to the type section, the Harrington River facies is well exposed in the upper part of Harrington River, in Jeffers Brook (Fig. 4), and on the southern part of Lynn Road. The contacts of this facies of the Gilbert Hills Formation with other parts of the Jeffers Group are generally thrust faults, which bring Harrington River facies in contact with highly deformed silty argillites. The Harrington River facies is generally overlain by the Cranberry Lake Formation, whereas the Lakelands facies is overlain by the Humming Brook Formation.

In Jeffers Brook (Fig. 4), the base of the Harrington River facies is marked by a thrust fault, and the upper boundary is not exposed. The facies here consists of massive mafic and intermediate lavas, which locally overlie green lithic sandstones.

Mafic rocks geochemically similar to the Harrington River facies are also found in Davidson Brook and the West Moose River area. Those in the latter area appear to conformably overlie Lakelands facies pyroclastics.

In the upper and west Harrington River, Hanna Brook and probably McCarthy Gulch there are thick sequences of mafic pyroclastics, with some interbedded felsic pyroclastics and mafic and rhyodacitic lavas. These lithologies are similar to those in the main Harrington River facies which outcrop in areas further south. These sequences are tentatively assigned to the Harrington River facies: they are interpreted as the northern equivalents of the thick mafic lava sequences. They differ from the Lakelands facies in the high proportion of mafic lithologies; they also show geochemical differences.

Humming Brook Formation

The type section for this Formation is located in Humming Brook, a tributary of the West Moose River (map reference 074319). It consists of a thick sequence of isoclinally folded monotonous argillites with very fine silty laminae. There are also rare thin (< 2 cm) beds of very fine sandstone or siltstone. The spacing of siltstone laminae generally appears random, but in a few localities graded laminated beds are visible, suggesting a turbidite origin. Total thickness of the Formation is difficult to determine because of structural complexity, but is at least 100 m.

The Humming Brook Formation is well exposed in the Moose River area, in the lower Harrington River (where it is highly cleaved) and in North River and its tributaries south of the North River pluton. It is generally in fault contact with other formations within the Jeffers Group, but locally appears to overlie the Lakelands facies of the Gilbert Hills Formation, for example in North River and in Jeffers Brook.

A single unit, HH, is mapped for the Humming Brook Formation on the maps accompanying this report.

Cranberry Lake Formation

This Formation is the most extensive lithotype within the Jeffers Group, comprising a sequence of lithic arkosic wackes mostly or entirely of turbidite origin. The Formation is best developed around Cranberry Lake, for which it is named. The total stratigraphic thickness is difficult to determine because of the likelihood of structural repetition of strata. The type section is defined on the Lynn Road (map reference 131345), where it consists principally of thin to thick bedded lithic and arkosic fine to coarse wackes, with interbedded argillite, with a thickness of at least 40 m. Two facies are distinguished within the Cranberry Lake Formation, and are recognised as mapping units on the accompanying maps. They are, approximately in stratigraphic sequence:

HC2 West Brook facies
HC1 Pike Fire Brook facies

Pike Fire Brook facies
The type section of this facies is in the lower part of Big Pike Fire Brook (map reference 181363), consisting of thick bedded lithic arkosic wackes with a "proximal turbidite" character, and minor interbedded argillite (Fig. 4). Similar thick bedded wackes are exposed in nearby parts of the Bass River of Five Islands.

In the type section, the sequence maintains consistent dips over a stratigraphic thickness of at least 60 m. At the base, massive medium to fine wackes up to 1.5 m thick interbedded with thin beds of argillite pass up into sequences of massive fine wacke beds generally a few tens of centimetres thick. The wackes show Bouma A or AB sequences, and amalgamated beds are present in places. Exceptionally, convolute bedding, sole marks and cross lamination are present.

Rocks described as the Lynn Road facies by Pe-Piper (1987) are now assigned to the Pike Fire Brook facies.

West Brook facies
This facies, with a type section in West Brook (map reference 028383), consists principally of thin bedded fine grained greywacke turbidites interbedded with thin siltstone and argillite, with a sand/argillite ratio typically between 2:1 to 1:2. The predominance of thin bedded greywackes and the abundance of siltstone and argillite allow it to be distingusihed from the Pike Fire Brook facies. In the West Brook area, the facies is at least 40 m and more probably several hundreds of metres thick; thick sequences also occur in the upper parts of the Bass River of Five Islands, North River, Moose River, Jeffers Brook and Henry Brook. In the Henry Brook - Jeffers Brook area, the facies appears particularly siliceous. This facies is also well developed in fault slices in southern North River and southern Harrington River. In places, rhyolitic tuffs may interbed with the West Brook facies.

In general, the West Brook facies appears to occur stratigraphically higher and to be geographically more extensive than the Pike Fire Brook facies, which appears to be of more limited extent lower in the section. Facing directions in both facies are indicated by grading, rare erosional bases to beds, ripple cross laminated and truncated convolute lamination. The West Brook facies shows more evidence for folding; the Pike Fire Brook facies generally occur in consistently upward facing, gently dipping sequences.

HYPABYSSAL INTRUSIONS: FIELD OBSERVATIONS

Hypabyssal intrusions are widespread within the Jeffers Group. They are particularly common within and near the volcanic sequences of the Harrington River facies, suggesting that many of the hypabyssal intrusions may be genetically related to the Jeffers Group. Pe-Piper and Piper (in press) used the presence of a penetrative cleavage to attempt to distinguish between hypabyssal intrusions genetically related to the Jeffers Group volcanism and younger post-Hadrynian intrusions.

We now recognise that some of the flat-lying cleavage may be of "Acadian" age, so that the presence of a flat-lying cleavage is not necessarily evidence of a Hadrynian age. Only those hypabyssal intrusions with distinctive petrography and geochemistry that are regionally cleaved and always spatially associated with Jeffers Group volcanic sequences are identified as genetically part of the Jeffers Group and thus Hadrynian in age. On this basis, Pe-Piper (1987) suggested the classification of hypabyssal intrusions listed below. Our new work has modified this classification in detail, but it is retained as a basis for description of field sections.

Probable Jeffers Group hypabyssal intrusions

1. Alkaline basalt sills and rare dykes (geochemically high-Ti tholeiites). These are most abundant in the Harrington River area, but also occur in North River, Jeffers Brook and Lynn Road. Coarse grained equivalents form mafic porphyry with coarse plagioclase, occurring in thick sills south of Jeffers Brook and in the upper Harrington River.

2. Feldspathic basaltic andesite sills, seen in the Lynn Road, upper Harrington River and Jeffers Brook sections.

3. Some cleaved mafic dykes may also be of Late Hadrynian age.

4. Felsic dykes with prominent plagioclase phenocrysts which intrude rocks of the Lakelands facies in Davidson Brook.

Post-Jeffers hypabyssal intrusions

1. A series of mafic dykes striking NE - SW, many of which pass into sills and are associated with microgranite sills and dykes. These intrusions post-date the main thrusting in the Jeffers Brook and Harrington River sections; cleavage developed in some intrusions is thus probably of "Acadian" age. Similar composite dykes of microgranite and diabase cut the Jeffers Brook pluton and are common in many other areas. The geochemical character of these rocks suggests that they were probably represent feeders tothe Fountain Lake Group.

2. A series of wide, north-south striking mafic dykes, with ophitic texture and fresh clinopyroxenes, are particularly common east of the Jeffers Brook pluton. They cut cleaved Jeffers Group rocks.

3. Mafic dykes and sills cut many of the Carboniferous plutons; some of the diabase dykes cutting the Jeffers Group are probably related.

4. Various rhyolitic dykes occur; they are particularly common in the Henry Brook area, but also seen in the Lynn Road section. Some may be related to Carboniferous microgranites: others lithologically resemble rhyolite flows at the base of the Wilson Brook Formation in the Simpson Lake region (east of the study area).

PLUTONS

Late Hadrynian plutons

The main Late Hadrynian pluton is the Jeffers Brook Pluton, dated by K-Ar on hornblende at about 620 Ma (Donohoe and Wallace, 1980, 1982: see also Table 1), and provides a minumum age for the Jeffers Group and its flat-lying deformation (Pe-Piper and Piper, in press). The pluton is an appinitic complex consisting of small gabbro and diorite bodies within the main granodiorite pluton. It has an abrupt, steeply dipping, possibly faulted western margin. In contrast, the eastern margin has many marginal sills and dykes cutting country rock, including some hornblende pegmatites. On this eastern margin there is a 1 km wide thermal aureole. In the finer lithologies of the country rock, biotite or spots now replaced by muscovite and quartz are developed. At the southeastern edge of the pluton there is a leucocratic granite which appears to be a marginal phase of the pluton. It forms a dyke-like body beyond the main pluton. Similar dyke-like bodies outcrop beyond the northeastern and northwestern margins of the pluton (Fig. 3).

The granodiorite consists predominantly of plagioclase, with subordinate anhedral quartz and hornblende, and minor actinolite and biotite (generally partly altered to chlorite). The gabbro is subophitic, with plagioclase and clinopyroxene, which is usually largely replaced by hornblende. Chlorite is also common. The diorite phase consists predominantly of plagioclase and hornblende, with minor interstitial quartz and some actinolite and biotite.

Igneous bodies petrographically similar to the Jeffers Brook Pluton occur in a number of other areas, and are thus correlated with the Jeffers Brook Pluton. Hornblende diorite occurs within a cataclastic zone along the Kirkhill Fault northwest of Parrsboro. The Davidson Brook Pluton, outcropping within and just south of the Kirkhill Fault zone southwest of the Jeffers Brook Pluton, is probably also of similar age on the basis of its petrographic difference from all the Carboniferous plutons. Much of the Gilbert Mountain and Wyvern plutons, which we interpret as a single complex pluton, also petrographically resemble the Jeffers Brook pluton.

Carboniferous plutons

A series of granitic plutons (Fig. 1) of probable Carboniferous age are spatially associated with the Cobequid and Kirkhill Faults. They consist principally of biotite granites with minor dioritic bodies. Their age assignment is based on radiometric dates (Table 1) from the Cape Chignecto Pluton and the aureole of the Hanna Farm Pluton, and the petrographic and geochemical similarity of the West Moose River and North River Plutons to the two dated plutons.

The plutons are all represented by a graphic granite phase and a minor dioritic phase. The granite is generally K-feldspar rich granite on the IUGS classification. It is granophyric to varying degrees. The only mafic mineral is biotite. The diorites are medium grained with a subophitic texture typical of hypabyssal intrusions. The plagioclase is labradorite and the mafic phase is green hornblende. Brown magmatic biotite is also present in the Soldier Brook diorite. The rocks classify as diorite and gabbro in the IUGS classification. Mixed phases with the granites comprise monzonite and granodiorite.

Much of the Cape Chignecto pluton is foliated and the southern part close to the Cobequid Fault is highly deformed. A series of thick diorite bodies (the "Soldier Brook Pluton" of Donohoe and Wallace, 1982) intrude the southern half of the pluton, although most observed contacts with the granite are tectonic. Similar diorites occur in the small Fire Tower, and New Yarmouth and larger Apple River plutons, all of which are petrographically and structurally similar to the Cape Chignecto pluton, and appear to be continuations of it. Later diabase and microgranite dykes cut both the granite and diorite, but are deformed along the Cobequid Fault.

The Hanna Farm Pluton has minor diorite bodies at its margin. It is cut by the Kirkhill Fault, but our mapping suggests there was little strike slip movement on the fault after emplacement of the pluton.

The West Moose River Pluton lies between the Cobequid and Kirkhill Faults. Diabase or gabbro sills are common in the southern part of the pluton; dykes are less common. Small diorite bodies occur at some margins of the pluton. Roof pendants of Jeffers Formation are common within the pluton. The southern margin of the pluton is deformed along the Cobequid Fault zone. Slithers of granite and diorite occur for up to 10 km east of the pluton along the Cobequid Fault.

The North River Pluton lies immediately north of the Kirkhill Fault, which is marked by a complex zone of porphyritic rhyolite and diabase dykes some 350 m wide. The North River Pluton has some marginal bodies of diorite, and is cut by many diabase dykes.

The Carboniferous granites appear to be high level granites, on the basis of the presence of granophyric textures and the occurrence of roof pendants. Their intrusion appears spatially related to the Kirkhill and Cobequid Faults, and the abundance of mafic sills and dykes in the plutons (Fig. 1) may reflect continuing motion on the Cobequid Fault during emplacement and cooling of the plutons. The Variscan (mid-Carboniferous) tectonic event, which resulted in major thrusting in southern New Brunswick (Nance and Warner, 1986), deformed sedimentary rocks of Namurian age in the Cobequid Hills (Donohoe and Wallace, 1980) and is of approximately the same age as the radiometric dates for the Cape Chignecto Pluton. These dates may thus represent the development of the strong foliation, which by analogy with southern New Brunswick is interpreted as Variscan. The petrographic character of this pluton, however, is similar to that of the other Devono-Carboniferous plutons in the Cobequid Hills. The date for the Hanna Farm Pluton aureole is younger than this Variscan tectonic event.

Grouprocks are rare. Most of the area between the Kirkhill and GilbertMountain Faults consists of Jeffers Group and you

DESCRIPTION OF GEOLOGY AND PETROGRAPHY OF KEY SECTIONS

1. LOWER JEFFERS BROOK

Introduction

The lower Jeffers Brook section, west of the Jeffers diorite Pluton, was the type section of the Jeffers Formation as defined by Donohoe and Wallace (1980, 1982); and is the type section of the Gilbert Hills Formation defined by Pe-Piper (1987). The Jeffers Pluton has been radiometrically dated as latest Hadrynian and cross-cuts the flat lying cleavage of the Jeffers Group, thus providing a younger limit for the age of the group.

The structure of the Jeffers Brook section is illustrated in Figure 5. The stratigraphically lowest rocks in lower Jeffers Brook are probably a sequence of highly cleaved mafic rocks exposed immediately west of the pluton. These pass up into less deformed felsic pyroclastic rocks, including agglomerate, which in turn appear to be overlain by a thin and highly deformed sequence of silty argillite and interbedded tuff. This entire sequence, which is assigned to the Lakelands facies, is overthrust by a thick sequence of mafic volcanic rocks of the Harrington River facies. In the lowest reaches of the brook, Lakeland Facies rocks are again exposed and consist of interbedded mafic lavas and felsic pyroclastics which pass up into a thick felsic pyroclastic sequence with rare rhyolite flows. The pyroclastics include a spectacular agglomerate at the falls at the western end of Jeffers Brook.

Microgranite and mafic dykes, trending 060, cut the thrust zones and have only been slightly deformed subsequently.

Lakelands facies lavas

<u>Mafic rocks near base of the section (HG1)</u>

Variably cleaved mafic rocks, some highly deformed and some little cleaved, outcrop in lower Jeffers Brook immediately downstream from the Jeffers Brook pluton (729, 730*, 732, 734, 745, 746, 751, 929, 931, 942*, 945*). They appear to underlie a sequence of felsic tuffs of the Lakelands facies, although the degree of deformation means that stratigraphic continuity is not certain.

Geochemically similar mafic rocks (452*) are found in the thrust zone with phyllites and tuffs immediately below the Harrington River facies; similar rocks (447, 448*) also occur interbedded with Lakelands facies felsic pyroclastics in the lower part of Jeffers Brook.

All these mafic lithologies are cleaved, dusty rocks with a variable feldspar to ferromagnesian minerals ratio. The more feldspathic resemble distinctive feldspathic mafic sills sampled in Lynn Road (see below). Some mafic rocks are vesicular, with the vesicles filled with chlorite with or without actinolite and epidote. All contain an appreciable amount of iron-titanium oxides.

The feldspars are generally completely altered, and only crystal outlines are left from the other primary minerals. The secondary minerals include epidote, actinolite, chlorite, biotite, dusty opaque minerals, quartz and occasional calcite. The cleavage is defined by dusty opaques minerals and by fibrous actinolite, when present. Quartz crystals with corona rims of actinolite are common in sample 942.

Sample 732 is typical of this lithology. It is porphyritic, with a hyalopilitic groundmass showing foliation apparently due to flow. Subhedral to anhedral feldspar phenocrysts are twinned. Very fine grained opaque minerals are dispersed unevenly throughout the groundmass. The feldspar microlites in the groundmass are fairly fresh, showing slight alteration to chlorite and epidote. The glass has altered completely to chlorite and dusty opaque minerals.

Some samples are extremely fine grained and contain abundant opaque oxide minerals (945*), whereas other contain mostly feldspar phenocrysts in a fine grained matrix (448*)

<u>Mafic clast within the main agglomerate</u>
(1173*)

This is a fine grained metabasic rock consisting of plagioclase, secondary biotite and opaque minerals. Geochemically, it is extremely alkaline.

<u>Rhyolite clasts in the main agglomerate</u>

This type of rhyolite (1160*, 1178*, 1182*) has been found only as clasts (or possibly as flows) within the main Jeffers agglomerate. The rocks are glassy-looking and porphyritic in hand specimen. In thin section, the aphanitic matrix is very glassy, contains a high proportion of opaque grains, and shows flow texture. The phenocrysts and microphenocrysts consist of plagioclase, which is altered to albite and sericite, quartz, rare K-feldspar, and opaque minerals. Other secondary minerals present include epidote and rare chlorite and biotite. Sphene and scattered apatite crystals are also common. Some of the rocks contain holocrystalline clots of similar mineralogy to the host rock.

<u>Rhyolite flows within the Lakelands facies</u>

These rocks (449*) are porphyritic, grey to pinkish rocks in hand specimen, consisting of phenocrysts (~20%) of feldspar and subhedral quartz, opaque minerals and devitrified micro- crystalline groundmass.

Feldspar phenocrysts include both plagioclase and K- feldspar. Plagioclase phenocrysts usually exhibit polysynthetic twinning and are altered to sericite. Other secondary minerals present are dusty opaque oxides and rare chlorite.

The groundmass is composed of a microcrystalline mixture of quartz, feldspar, sericite and opaque minerals (hematite and magnetite). No tectonic foliation is present.

Pyroclastic rocks of the facies (HG2)

<u>The main agglomerate</u>

A prominent agglomerate outcrops in a gorge and falls at the lower end of Jeffers Brook. The main outcrop on the north side of the stream appears to be essentially a bedding plane outcrop. This outcrop contains clasts up to 0.5 m in length of a variety of igneous lithologies. Its thickness is uncertain because of structural complexities, but is probably only a few metres. Finer agglomerate outcrops in the stream section above the falls and in the gorge section on the south side of the brook below the falls, to a total thickness of perhaps 20 m.

The agglomerate includes large clasts 0.1 to 0.5 m in size, large numbers of clasts in the 2 to 20 mm size range, and a fine grained felsic matrix of cryptocrystalline quartz and plagioclase. Rhyolite (1160*, 1178*, 1182*) is the most common lithology of the large clasts, but felsic tuff (1179*), rhyodacite (1176*), and mafic (1173*) clasts are also present.

<u>Felsic tuffs</u>
(439*, 701*; 708* in thrust zone; 776* ignimbrite; 923*, 1179* clast in agglomerate)

These pyroclastic rocks include fine agglomerate, lithic, crystal-lithic and crystal tuffs and ignimbrite. In the field, the coarser lithologies occur in graded beds, in some cases with slightly irregular bases, which can be used as indicators of younging direction. The cleavage has obscured fine structures in many outcrops.

The ignimbrites (776*) form massive outcrops. They show a eutaxitic texture and a variable ratio of glass shards to lithic clasts. The clasts are of rhyolite, dacite and ash, with rare granite and masses of epidote. Crystals include plagioclase, quartz, K-feldspar and opaque oxides.

The clasts in the fine agglomerate are entirely felsic volcanic rocks: in places it is difficult to distinguish clast outlines.

The clasts in both the lithic and lithic-crystal tuffs (439*, 923*, 708* in thrust zone) appear to all be of felsic rocks (rhyolite and dacite) with a variable texture: fine grained, coarse grained or even holocrystalline. Rare clasts of vein quartz (some with epidote), chert and recrystallised ash have been found. The crystals in the tuffs consist of plagioclase, K-feldspar, quartz and opaque oxides. Clasts and crystals are set in a fine-grained matrix, which is usually recrystallised with a variable amount of muscovite.

The secondary minerals in all these rocks include biotite, muscovite, epidote, chlorite and dusty opaque minerals. They all also show a variable degree of foliation, which is defined mostly by the dusty opaques and the micas. Many are cut by quartz veins, which may include secondary biotite; and there are also rare epidote veins.

Similar tuff occurs as a clast in the main agglomerate (1179*).

Sedimentary rocks of the Lakelands facies (451*, 701*)

Silty argillite occurs stratigraphically above the thick tuff section of the Lakelands facies. It occurs immediately below the thrust zone at the base of the Harrington River facies, and is folded into complex isoclinal folds. It locally appears overlain by tuff: it is not known whether this reflects original stratigraphic position, inversion of the stratigraphic section, or whether the tuffs and silty argillite are in tectonic contact. The total stratigraphic thickness is probably only a few tens of metres. The silty argillite is similar to that in the Humming Brook Formation. Similar silty argillite, which is probably correlative, is found in the extreme lowest part of Henry Brook. The silty argillite in the upper part of the Middle Harrington River section, just south of the thrust fault, is also similar. In thin section, the silty laminae are seen to consist mostly of quartz and to show grading.

Harrington River facies (HG4)

<u>Mafic lavas</u> (717, 727, 758, 765*, 1107*, 3201*, 3209, 3208)

These rocks form massive, rather tectonised outcrops that are thrust over silty argillite at the top of the Lakelands facies in Jeffers Brook. Isolated outcrops of mafic rocks along the woods road north of Jeffers Brook are probably also from the Harrington River facies. Diagnostic primary features have not been seen in any of these rocks in the field.

Samples 3201*, 713* and 765* are highly altered and tectonised, but appear to have a bimodal grain size and to be rich in feldspars. These rocks appear petrographically and geochemically similar to the feldspar-rich mafic rocks of the type section of the Harrington River facies (described below), with which they are therefore correlated.

Sample 1107* from the woods road north of Jeffers Brook is probably part of the Harrington River facies. It is an altered, equigranular or slightly porphyritic vesicular rock. Fresh crystals include both clinopyroxene (20%) and plagiocalse feldspar (20%) set in an altered groundmass (55%). Vesicles are filled with chlorite.

<u>Rhyodacites</u>

Four analytical samples are available from this group: 1176* is a clast in the main agglomerate; 450*, 1956* and 3207* are stratigraphically interpreted as part of the Harrington River facies.

In hand specimen, these are grey to greenish rocks. In thin section, they are porphyritic and exhibit a trachytic to subtrachytic texture, with plagioclase laths preferentially oriented in a fluidal groundmass.

The phenocrysts and microphenocrysts make up about 50% of the rock and consist of feldspars (50-70%), quartz (10-20%), and secondary minerals such as chlorite (10-20%), epidote (5-10%, or occasionally more), biotite (<5%), opaques (<5%) and calcite in some samples. Sphene, apatite and zircon may also be present. The groundmass is a dusty intergrowth of quartz (~60%) and feldspar (~40%). Spherulitic textures and rhyolitic inclusions have been found. Both plagioclase and K-feldspar are present. Plagioclase is usually altered to albite, sericite, calcite or epidote. The biotite and chlorite are intermixed in most samples. Quartz may occur in the form of small clots. Many of the rocks are cut by complex vein systems: minerals in these veins include quartz, calcite, chlorite, epidote and opaque minerals. Other samples, found only as clasts in the main agglomerate, are cut by mafic stringers made up of epidote, chlorite and biotite.

Sample 1956 may be either a lava or a hypabyssal intrusion. The rock has a porphyritic texture, with phenocrysts of plagioclase, K-feldspar and quartz (with feldspar to quartz in a proportion of 2:1). Some of the phenocrysts of K-feldspar have inclusions of plagioclase. The feldspar phenocrysts are equant laths up to 2.5 mm in length, whereas the quartz are commonly anhedral and round. Feldspar phenocrysts are altered to sericite and possibly calcite. The groundmass is altered to chlorite and dusty opaques, and contain about 2% evenly distributed primary opaque oxides.

Probable Hadrynian hypabyssal intrusions

Feldspathic mafic dykes (230, ?737, 1163*)

These dykes are best seen at the main agglomerate outcrop. The rocks are very feldspathic (45-80% feldspar) and show a variable degree of foliation. Some are porphyritic, some are holocrystalline and others are very fine grained. In some the groundmass shows a trachytic to subtrachytic texture: in others it is fine grained and dusty. Opaque minerals and rare quartz are the only other primary minerals present. The secondary minerals consist of chlorite, actinolite, quartz, sericite, epidote and dusty opaque minerals.

Geochemically similar, but petrographically distinct, rocks outcrop in the Lakelands facies sequence of felsic tuffs and interbedded mafic rocks in lower Jeffers Brook (444*, 446*). They are cleaved and show a sub-ophitic texture. They are identified as intrusions on petrographic rather than field character. The phenocrysts and microphenocrysts consist of feldspars, fresh clinopyroxene and opaque iron oxides. Relics of a brownish, pleochroic biotite are also present. The secondary minerals consist of epidote, actinolite, chlorite, quartz and dusty opaque minerals.

High-Ti mafic dykes

These dykes are identified tentatively on the basis of their petrography and geochemistry. Dykes of this composition are represented by 1162* and 1165* from near the main agglomerate outcrop in lower Jeffers Brook. These are altered fine grained rocks. Feldspars are almost completely epidotized and ferromagnesian minerals have altered completely to chlorite, actinolite and opaque oxides. Sample 713* may also be an equivalent intrusion: it is geochemically anomalous, perhaps as a result of alteration. Original textures in this rock are almost completely obscured by alteration products.

Dykes of rather lamprophyric character (1159*, 1169*) cut the main agglomerate outcrop in lower Jeffers brook. They show a slight cleavage. They have a high proportion of secondary biotite, some K-feldspar and secondary sphene.

Probable Carboniferous hypabyssal intrusions

Microgranite (164*, 176*, 436*, 437*)

Microgranite occurs in large dyke-like bodies having sharp contacts with the country rock. They have porphyritic texture with subhedral to anhedral phenocrysts of quartz, alkali feldspar and plagioclase. The groundmass (~70%) is microcrystalline with local development of myrmekite and/or spherulitic texture. These intergrowth textures are commonly seen on the rim of phenocrysts.

Quartz (10%) occurs in rounded or oblong grains which are commonly strained and may show the beginning of the development of mortar texture. Plagioclase phenocrysts (5-10%) are commonly euhedral and twinned. Alkali feldspar(10%) occurs as subhedral phenocrysts or perthitic intergrowths with plagioclase. Accessory minerals are opaque oxides, biotite and apatite. Alteration is to chlorite, muscovite (sericite) and epidote. Deformation is exhibited by bent plagioclase twins, strain in quartz and mortar texture.

060 dykes associated with microgranites (442*, 704*, 706*, 764*, 1162*, 1165*)

These mafic intrusives consist mostly of dykes, some of which lead into sills; they trend about 060 degrees and appear associated with the microgranites. Some appear cleaved, whereas others are not cleaved. The cleavage, where present, is defined by dusty opaque minerals, fibrous actinolite and/or secondary biotite. In less altered samples, a subophitic texture is present. Some samples are vesicular, with vesicles filled by chlorite +- epidote +- actinolite.

The feldspars are generally completely altered and albitized, although fresh K-feldspar has been identified. Pseudomorphs after clinopyroxene are very common, with occasional fresh clinopyroxene relics. Fe-Ti oxides are very common in all samples. Rare relics of kaersutite (sample 442*) and biotite (298) have been found. Apatite and zircon are common accesory minerals.

Secondary minerals consist of actinolite, chlorite, epidote, quartz, dusty opaque minerals and very variable amounts of biotite. Veinlets are common and minerals found in such veins include quartz, chlorite, epidote and secondary biotite.

2. HARRINGTON RIVER

Introduction

The Harrington River exposes one of the most varied and continuous sections through the Jeffers Group. Geographically, it can be divided into five areas: Lower Harrington River, McCarthy Gulch, Middle Harrington River, Upper Harrington River and West Harrington River.

The Lower Harrington River section is faulted and cut by numerous intrusions. The southern part of the section comprises argillite (or possibly ash) of the Humming Brook Formation, which is in fault contact with a felsic pyroclastic or proximal turbidite sequence assigned to the Cranberry Lake Formation. The intrusions include microgranite that also cuts Carboniferous sediments; and complex mafic-microgranite intrusions. Several of these intrusions are cleaved, but the cleavage does not appear continuous with that in the Jeffers Group. Other mafic intrusions appear to have a cleavage continuous with that in the Jeffers Group, and are thus most probably of Late Hadrynian age.

The Middle Harrington River section exposes, from south to north:
1. Argillite of the West Brook facies of the Cranberry Lake Formation.
2. In thrust fault contact with the underlying argillite, a lava- tuff succession of the Gilbert Hills Formation.
3. This is stratigraphically overlain by green tuffs and rare interbedded mafic flows.
4. Stratigraphically overlying the tuffs is a sequence of green lavas, which are then overlain by
5. a sequence of mafic lavas. This and the underlying lava and tuff sequences are all part of the Gilbert Hills Formation.
6. A normal fault separates the mafic lavas from a greywacke- argillite sequence of the Cranberry Lake Formation.

In the southern part of the section, both the Cranberry Lake and Gilbert Hills Formations appear to be cut by microgranite sills that truncate the thrust fault between the two formations, but are offset by small reverse faults. The microgranites are thus probably of Carboniferous age. The northern outcrops of the Cranberry Lake Formation are intruded by cleaved mafic sills of probable Late Hadrynian age.

The Upper Harrington River section is in thrust fault contact with the Middle Harrington River section. It consists of a sequence of tuffs and possible volcaniclastic sediments cut by a very large number of intrusions. Some more mafic lithologies geochemically resemble Late Hadrynian intrusions elsewhere. The sequence is also cut by microgranite sills and dykes, some of which are highly cleaved. These are geochemically similar to the Carboniferous microgranites in the Middle Harrington River.

The McCarthy Gulch section consists of a sequence of tuffs, locally mylonitised, followed to the north by a sequence of rhyodacitic lavas and interbedded tuffs. They are similar to the tuffs and rhyodacitic lavas in the Middle and West Harrington Rivers. These are in fault contact with the Fountain Lake Group. The lower part of McCarthy Brook, just above the confluence of the Harrington River, crosses a complex fault zone with a variety of rocks, principally Carboniferous granite and diorite.

The West Harrington River section appears similar to the McCarthy Gulch and Upper Harrington River sections. It consists of a series of tuffs and interbedded rhyodacitic lavas. It is intruded by mafic dykes and microgranites.

Jeffers Group in the Lower Harrington River

Humming Brook Formation

The Jeffers Group rocks in the southern part of the Lower Harrington River are finely laminated, fine-grained rocks, which have suffered considerable tectonic deformation. Some consist of silty argillites with interbedded fine sandstones, whereas in parts of the section the rocks appear more rhyolitic than argillitic and may be fine grained pyroclastic or volcaniclastic sediments. This section may thus represent a stratigraphic transition between the Humming Brook Formation and the Lakelands facies of the Gilbert Hills Formation. The younging direction and the exact style of this transition are obscured by the deformation.

The silty argillites (1649*, 1651*) in thin sections are typically 95% clay minerals (largely altered to muscovite) and 5% silt, although siltier beds with up to 40% silt occur. The matrix may show a complex spotting pattern observed from branching and contorted mica-rich lenses, or the mica may have a random patchy appearance. The secondary minerals consist of muscovite, biotite, chlorite and iron oxides.

The more rhyolitic lithologies are represented by sample 1653*, which is a cleaved fine sandstone (Plate 1), cut by cleaved veins of quartz and actinolite parallel to the regional cleavage. The larger crystals in the rock consist of quartz (with pressure shadows and often partly recrystallised; plagioclase exhibiting multiple twinning, and with many grains completely sericitised; and opaque minerals. The groundmass is a partly dusty and partly recrystallised intergrowth of quartz, feldspar and opaque minerals. Secondary minerals consist of opaque oxide minerals, chlorite, actinolite and probable biotite.

Samples 1649* and 1651* have a higher Al2O3 and K2O content than 1653*, consistent with a more argillaceous composition.

Volcaniclastic rocks of the Cranberry Lake Formation

The northern part of the Lower Harrington River section consists of well stratified tuffs or sandstones, mostly thin bedded, of felsic composition. This section is much less cleaved than the Humming Brook Formation to the south, with which it is in fault contact. Very shallow cut and fill structures indicate that the sequence youngs to the south. Graded beds are commonly visible in outcrop. Thin sections of silty argillite samples (2162, 2163) show graded beds of siltstone passing up into argillite.

Thin sections of sandy siltstones (2170, 2174, 2175) contain 10 - 40% sand sized grains in a siltstone matrix. The sediment is poorly sorted. The grains typically have moderate to low sphericity and are subangular to rounded. Compositionally, they consist of quartz, twinned and untwinned feldspar, and rock fragments (generally siltstones or porphyritic igneous rocks). the quartz to feldspar ratio ranges from 1:1 to 3:1. Quartz grains show undulose extinction and mortar texture is poorly developed in places. Where this occurs, the silty matrix also appears recrystallised. Opaque oxides and detrital epidote grains are minor constituents. The matrix is altered to secondary biotite, chlorite and dusty opaque oxides. Rarely, bands of epidote in the rock indicate more feldspar rich beds within the sequence (2174).

These rocks have been mapped as West Brook facies (HC2), although they are much less well sorted than typical developments of this facies.

Post-Hadrynian sediments in lower Harrington River

Sedimentary rocks that are less deformed than the Jeffers Group occur in fault slices in the lower Harrington River, and probably correlative rocks outcrop in Lynn Road. All were mapped as undivided Siluro-Devonian by Donohoe and Wallace (1982). We recognise two lithologically different groups of rocks - predominantly grey sediments tentatively identified as proximal equivalents of the Carboniferous Parrsboro Formation; and reddish sediments which resemble the Early Devonian Knoydart Formation of the Arisaig area (Boucot et al., 1974) and the Portapique River Formation of the central Cobequid Highlands (Donohoe and Wallace, 1980, 1982).

?Early Devonian sediments

Well bedded purple sandstones, locally grey in colour, occur in the lower Harrington River immediately downstream from the confluence with McCarthy Gulch. The beds are sharp based, typically 5 to 20 cm thick, and grade up into siltstone which locally appears bioturbated. Thin silty shales interbed with the sandstones.

Similar, more deformed rocks occur in apparent fault slices in the lower part of McCarthy Brook and in the lower Harrington River near the southern end of the Jeffers Group exposures.

Sample 1210 is a purple argillite from the fault zone in the southern end of the Lower Harrington River, and its stratigraphic assignment is uncertain. It is an argillite with a low percentage of silt-sized material in thin section. It is finely laminated, with 1 to 5 mm thick laminae, some of which appear graded with a higher proportion of opaque oxide minerals near the base of the lamina. The sample is cut by quartz and chlorite veins and acicular needles of hematite.

Carboniferous sediments

These sediments, where exposed in the Lower Harrington River, consist of alternating fine grey sandstones and shales. The sandstones are locally massive, and contain carbonate concretions. They are quartz rich and contain macroscopic detrital mica. Locally, interbedded purplish mudstone outcrops. Most of the interbedded shales are grey, and many contain silty laminae. Bioturbation is visible in some samples. This sequence is cut by several irregular hypabyssal intrusions of microgranite.

A sequence of bedded fine sandstones and silty shales, with barite mineralised veins, outcrops on the Lynn Road and may be correlative. Samples of shale were processed for palynomorphs, but the sample was barren.

The shale samples from the lower Harrington River have a 10- 15% silt content, with a 3:1 quartz to feldspar ratio. Secondary minerals include muscovite, chlorite and iron oxides. The argillaceous matrix shows a complex spotting pattern in thin section of muscovite and chlorite rich lenses which have a branching and contorted pattern.

The type section of the Harrington River facies of the Gilbert Hills Formation in the Middle Harrington River

Introduction

The stratigraphic section through the Gilbert Hills Formation in the Middle Harrington River is bounded at base and top by faults and consists from base to top of:
a) a basal sequence of mafic lavas (805*, 807*, 812*, 815*) and minor tuffs and rhyodacitic lavas. [800-816, 2773-2776, 2795-2797]
b) mafic tuffs and interbedded rare mafic (576*) flows. . .[575-580, 2781-2783, 2786-2788]
c) predominantly andesitic lavas (2797, 2798, 2799, 2902, 2905, 2906), with minor rhyodacite lavas (2793) and minor tuffs. ..[563-575, 2789-2799, 2900-2906]
d) predominantly mafic lavas, with minor tuffs (2553*, 562*, 2554*)....are these all the numbers for the mafics at the top

Mafic lavas

Thick mafic sequences are developed at the base and at the top of the stratigraphic sequence in the middle Harrington River. Analytic samples from the base of the section include 807* and 815*; and from the top of the section 2546*, 2542*, 2553*, 562*, and 2554* (Plates 2-5). Samples 805* and 576* are interbedded with mafic tuffs in the middle part of the section.

The mafic lavas in the basal part of the section have a glomeroporphyritic texture with twinned plagioclase phenocrysts set in a trachytic groundmass of feldspar. These rocks are almost devoid of primary opaque oxides. Alteration is to chlorite, epidote, dusty opaque oxides and calcite. Deformation in the form of ductile shearing is noted from the growth of micas around phenocrysts forming augen structures and the formation of boudins from quartz veins.

The mafic flows in the middle and upper part of the section are similar to those in the lower part. They consist mainly of altered plagioclase, opaque minerals, and low grade metamorphic minerals such as chlorite, sericite, epidote, actinolite and quartz. The relative amounts of actinolite, epidote and groundmass are variable. Porphyritic or amygdaloidal textures are common, and pilotaxitic texture occurs locally. Amygdules either show a concentric arrangement of quartz, epidote and chlorite, or are filled with radial crystals of epidote together with some quartz and apatite crystals.

Plagioclase generally comprises more than 50% of the rock and occurs as large subhedral phenocrysts (in places up to 4.5 x 1.3 mm2) and as small euhedral laths (0.15 to 0.5 mm in length). Crystals are often altered to a mixture of sericite, epidote and some chlorite, but the degree of alteration varies from minor sericitisation to complete replacement of the original mineral.

The groundmass contains abundant opaque material, and some sericite and chlorite. Most primary textures are obliterated by the low grade metamorphic minerals,which may show no preferred orientation.

Some samples are highly epidotised, with moderate amounts of actinolite (553, 555); others contain a lot of dusty opaque minerals which follow a pronounced cleavage (580).

Some rocks in this group (805*) are very fine grained and are made up of microcrystals of feldspar, quartz and opaque minerals set in an extremely fine grained dusty groundmass (80- 90%). These rocks are cut by veins of quartz, epidote and chlorite, and the secondary minerals in these rocks include chlorite, opaque oxides and epidote. The chlorite and the dusty iron oxide define a lepidoblastic texture.

These rocks appear petrographically and geochemically similar to feldspathic mafic sills in Lynn Road, described below.

Rhyodacites

Rare rhyodacites (812*) interbed with both the mafic lava succession at the base of the Middle Harrington River section. They are porphyritic rocks , hyalopilitic to pilotaxitic in texture, with a glassy groundmass (up to 80%) and phenocrysts of feldspar (some partly recrystallised) and quartz. The rocks are variably cleaved. Those that are highly cleaved are transected by a net of veinlets made up of a greenish-brown biotite, chlorite, calcite and quartz. The glassy groundmass is a dusty intergrowth of feldspars, quartz, glass and opaque minerals, often metamorphosed to muscovite, which follows the primary flow texture. Secondary minerals consist of chlorite, sericite, muscovite, epidote, carbonate, opaque oxides and biotite. The feldspar phenocrysts are often dusty with inclusions of apatite and magnetite. In the more altered specimens, the feldspar phenocrysts are partly altered to sericite, muscovite, opaque oxide minerals, chlorite and, in some samples, calcite. Quartz is often partly recrystallised.

Rhyodacite lava (2793) also occurs interbedded with the mafic tuffs. This rock has a glomeroporphyritic texture of twinned plagioclase crystals and quartz phenocryst in a microcrystalline groundmass. Accessory minerals are opaque oxides. Alteration is to muscovite, calcite, chlorite and dusty opaque rocks. The muscovite shows an apparently tectonic fabric.

Mafic tuffs

In the field, the tuffs show a rather indistinct bedding on a scale of a few centimetres. This bedding is deformed around distinctive epidotised nodules (2700). Locally, fine agglomerate is seen.

In thin section (2787, 2788) the rocks appear to be crystal tuffs of various grain sizes. The principal crystals are of plagioclase. There is widespread alteration to epidote. Large areas of polygonal quartz and feldspar may represent highly recrystallised tuff, or devitrified pumice fragments.

Andesitic lavas interbedded with the mafic tuffs (2797- 2799, 2902-2906, ??575-578, 2786)

Andesitic lavas 0.4 to 2 m thick interbed with the intermediate tuffs. They have a porphyritic texture, with plagioclase phenocrysts set in a trachytic groundmass of feldpar microlites or altered glass. The groundmass is altered to chlorite, dusty opaque minerals, epidote, calcite and ?actinolite. Some samples contain epidote pseudomorphs, possibly after olivine, and phenocrysts of opaque oxides.

Andesitic lavas in the mafic lava sequence at the top of the section

These andesites (557*, 558*) interbed with the more common basaltic mafic lavas described above. They are highly porphyritic with a hyalopilitic to pilotaxitic or even very fine crystalline groundmass (5 to 15%). Apparent flow orientation of crystals has been observed (Plate).

Euhedral to subhedral plagioclase is the most common phenocryst (up to 2.4mm in length), but subhedral to euhedral K-feldspar, quartz and opaque oxide minerals are also present. Plagioclase phenocrysts usually exhibit polysynthetic twinning. Anhedral to subhedral plagioclase microlites (0.1 - 0.8 mm) are interstitial to the phenocrysts and may comprise up to 25% of the rock. Feldspars are altered to albite, epidote, chlorite and sericite, and locally appear strained.

The groundmass is either a dusty intergrowth of feldspar, quartz, chlorite and opaque oxide minerals, or a microcrystalline mixture of feldspar, quartz and opaque oxide minerals. Lepidoblastic textures are common, and are very well developed in those specimens with a large amount of very fine grained dusty clay-rich groundmass. These textures are defined by sericite, chlorite and dusty opaque oxide minerals.

Secondary minerals include epidote, chlorite, sericite, muscovite, opaque oxide minerals, and rare biotite and fibrous actinolite. Many of the rocks are cut by veins of quartz, calcite and chlorite, and some are highly epidotised.

Rhyodacite lavas in the West Harrington River

Rhyodacite lavas in West Harrington River (3770, 3771, 3780) are interbedded with tuffs. They are similar to those in Middle Harrington River, described above, but appear more abundant.

In McCarthy Gulch, many of these rocks are difficult to identify with confidence because of the high degree of deformation. Probable rhyodacitic lavas (2119, 2122, 2130, 2134, 2137, 2141) appear porphyritic; some contain secondary muscovite.

Pyroclastic rocks in the Upper and West Harrington Rivers

Country rock in the West and Upper Harrington River sections is principally pyroclastic. Exposure is poor in the West Harrington River; in the Upper Harrington River there are large numbers of hypabyssal intrusions. As a result, the detailed stratigraphy of both sections is unclear. In the upper Harrington River, this pyroclastic sequence has a thrust contact with the underlying Cranberry Lake Formation.

Mafic tuffs, Upper Harrington River

The mafic clastic rocks (325, 331, 338, 2540, 2541) range from crystal to lithic tuffs. They are composed of a dusty cryptocrystalline, commonly lepidoblastic matrix (20-75%); elongate and partly recrystallised fragments (0-65%); broken and partly to totally recrystallised crystals of quartz (0-11%); and feldspar, mostly plagioclase (2-20%). The foliation, wherever present, is defined by sericite and chlorite. The fragments are both accessory (mafic) and accidental (quartzite, greywacke and other mafic rocks). The latter mafic clasts are variable in their texture and proportions of phenocrysts and microphenocrysts. Some clasts are completely pseudomorphed and difficult to distinguish from the matrix. Secondary minerals consist of chlorite, epidote, sericite, muscovite, biotite, carbonate and opaque oxide minerals.

Felsic tuffs, Upper Harrington River

The rhyolitic clastic rocks (304, 317, 826, 302, 210, 2549*) range from crystal to lithic tuffs, and show extreme variation in grain size. The rocks are composed of a microcrystalline to cryptocrystalline, commonly lepidoblastic matrix (25-55%); elongated and partly recrystallised lithic fragments (30-60%); broken and partly to totally recrystallised crystals of quartz; and feldspar, mostly plagioclase (4-10%). The foliation, whenever present, is defined by sericite, dusty opaque stringers, and granulated quartz. All lithic fragments appear to be felsic, of variable texture, and some are completely pseudomorphed and difficult to distinguish from matrix. Secondary minerals consist of chlorite, sericite, muscovite, biotite, carbonate and opaque oxide minerals. Some samples show graded bedding, whereas a eutaxitic foliation in others may suggest an ignimbritic origin. They are often cut by quartz and chlorite veins. Some of the crystal tuffs are transected by stringers made up of secondary biotite with very small amounts of quartz.

Mafic tuff, West Harrington River

The mafic tuffs in West Harrington River are represented by samples 433, 435 and 3794. They consist of small crystals of quartz and feldspar (5-10%), crystals of opaque minerals (5-10%), chloritised glass (~10%) and a small proportion of lithic clasts, all embedded in an indistinguishable dusty matrix. The lithic clasts are highly digested, almost beyond recognition. Grains of epidote are visible in the matrix.

Felsic tuffs, West Harrington River

Felsic crystal tuffs (421, 422) occur in the tuff sequence in the West Harrington River. The commonest crystals are euhedral to subhedral plagioclase; subhedral to euhedral K-feldspar, quartz and opaque iron oxide minerals are also present. Plagioclase crystals usually exhibit polysynthetic twinning. The matrix is a microcrystalline to cryptocrystallne assemblage of quartz, feldspar, muscovite, epidote and opaque oxide minerals. Lepidoblastic textures are usually well developed and they are defined by muscovite and dusty iron oxides. In a stained thin section, K-feldspar has been identified in very small fine grained patches in the matrix. Secondary minerals include epidote, muscovite, opaque oxides, chlorite and biotite. Some samples (422) are cut by veinlets of green-brown biotite, chlorite and quartz.

Rhyolite or felsic tuff, West Harrington River

This rock (428*) appears to be country rock adjacent to a complex microgranite - mafic dyke and may be either hornfelsed felsic tuff or rhyolite. It is weakly porphyritic, with a fine- grained, often recrystallised matrix (60%) and scattered phenocrysts (40%) of quartz and feldspar. All feldspar phenocrysts have been albitised. Veinlets of fine grained dusty opaques (often accompanied by epidote and chlorite) transect the entire rock. Magnetite, pyrite, hematite and very little primary biotite are also present.

Probable Hadrynian intrusions

High-Ti tholeiite intrusions

Highly cleaved mafic rocks (1650*, 1211*, 2177*) occur as sills in the Lower Harrington River, with cleavage continuous with that in the Jeffers Group country rock. They are made of plagioclase laths, many of which are completely altered; dusty, altered crystals, some with brown-red relicts that appear to have originally been amphibole, and others with colourless relicts that appear to have originally been clinopyroxene; and opaque minerals (Plate 6). These crystals are set in a microcrystalline, dusty groundmass. The foliation is defined by sericite and chlorite. Other secondary minerals include actinolite, opaque oxide minerals, biotite and sphene. Biotite overgrowths on actinolite are present in sample 1650*. Quartz and calcite veins are present.

Similar sills occur in the greywacke-argillite sequence in the Middle Harrington River (548, 2550*, 2551*). These rocks are porphyritic (Plates 7-8), with a high proportion (~85%) of a holocrystalline to cryptocrystalline groundmass and very elongate, inequant feldspar phenocrysts (~15%). Many of these phenocrysts have completely altered to muscovite. Other secondary minerals include chlorite and dusty opaque oxide minerals.

A probably related group of sills (322) occur in the Upper Harrington River. They consist of cleaved mafic rocks with a sub-ophitic texture (Plate 9). They consist of partly or completely sericitised feldspar (~60%), Ti-rich pinkish augite (20-30%), opaque oxide minerals (5-10%) and chloritic patches (~10%).

Sills with a feldspathic groundmass and phenocrysts of clinopyroxene (2537*, 2538*, 2556) occur in the Upper Harrington River section. These rocks have a weakly porphyritic sub-ophitic texture. The ferromagnesian mineral is pinkish clinopyroxene in fresh samples (2556): in more alterated samples actinolite pseudomorphs the clinopyroxene. Most of the feldspar is completely altered to sericite and epidote. Accessory opaque oxide minerals have a cubic form. The finer areas of groundmass consist of chlorite, opaque oxides and epidote, perhaps indicating a ferromagnesian content. These rocks are petrographically similar to 2550 (Middle Harrington River) and 3796 (West Harrington River).

Feldspathic mafic intrusions

Distinctive feldspathic mafic rocks also occur in upper Harrington River, apparently as sills, although a flow origin cannot be ruled out for some samples. They include the following samples: 311, 313*, 2546*, 2555, and 2542*. These are petrographically distinct from the high-Ti tholeiite sills, having a fresh looking pilotaxitic groundmass with plagioclase phenocrysts (Plates 10-11).

Calc-alkaline mafic sill, Lower Harrington River

A 1m thick cleaved sill (1657*) in the lower Harrington River is of uncertain age. Geochemically, it is unlike other analysed samples in being very calcalkaline: this may suggest that it is of late Hadrynian age.

Mafic hypabyssal rocks of unknown age in West Harrington River

There are several different mafic rocks in the West Harrington River; their field relationships do not provide clear indication of their affinity or age, although they appear to be hypabyssal intrusions.

Sample 3796 is a cleaved mafic rock with an original ophitic to sub-ophitic texture. The original clinopyroxene phenocrysts are now almost completely altered to actinolite. Other primary minerals are plagioclase and opaque oxide minerals. The secondary minerals include actinolite, chlorite, dusty iron oxide epidote and quartz. It is probable a high-Ti tholeiite intrusion. ..does not seem to resemble 2734, 3001, 3002

Sample 417 is an altered diabase dyke with a porphyritic texture that is made up of altered crystals, some of which have higher relief than others, opaque minerals, and cavities filled with chlorite, biotite, epidote and actinolite. They are often cut by veins of calcite and the low-grade metamorphic minerals include epidote, chlorite, biotite, actinolite, quartz, opaque oxides and sphene.

Probable Carboniferous microgranites and associated mafic intrusions

Microgranite, Lower Harrington River

There are two types of microgranite: those with a granophyric texture (1201, 1646*) and those with a very porphyritic texture (1204). The granophyric microgranite consists of K-feldspar, quartz and plagiocalse, whereas plagioclase is the dominant mineral in the porphyritic microgranite. Muscovite is the only common secondary mineral. In the granophyric microgranite, there are crystals with rapakivi texture with clear albite rims and K-feldspar cores with perthitic textures. They appear to result from the deuteric alteration of primary plagioclase.

Although 1646* appears to be unusually Na rich, it is definitely intruded into post Jeffers and probably Carboniferous rocks. It is close to a major fault and hematite mineralisation and is therefore probably metasomatised. Similar albitic granites have been sampled in the West Moose River pluton. Sample 1880 appears also to be a Carboniferous intrusion: it is a granophyre.

A gabbro inclusion (2808) is found in the large microgranite that intrudes probable Carboniferous sediments in the Lower Harrington River. It has an intergranular ophitic texture with long, thin plagioclase crystals interlocking with more equant altered pyroxene.

Microgranite, Middle and Upper Harrington River

As in the Lower Harrington River, there are two types of microgranite: both are porphyritic, but one has a glassy matrix and the other a granophyric matrix. The microgranites with a glassy matrix (318, 342, 342, 343) have phenocrysts and microphenocrysts of quartz, K-feldspar and plagioclase in a dusty, devitrified glassy groundmass. The quartz crystals are usually embayed and display good graphic textures. Most of the feldspar crystals are euhedral, untwinned, often completely or partly altered to sericite and with zircon, chlorite and magnetite inclusions. Very small amounts of opaque oxides are present in some samples. Large amounts of sericite and muscovite are present in the groundmass and it is these minerals that define the good cleavage in some samples. They are usually cut by cleaved pegmatitic veins. Sample 318 contains granitic inclusions with graphic texture.

The microgranites with a granophyric matrix (332, 333, 813) have the same types of phenocryst set in a crystalline groundmass with radial intergrowths of quartz and feldspar. The K-feldspar crystals are untwinned, zoned and many contain zircon inclusions and chlorite patches. The plagioclase crystals display multiple zoning and the quartz crystals are sometimes embayed. Small amounts of opaque oxide minerals are present, and the only secondary mineral is chlorite.In some samples, lenses of mafic rock have been observed.

Microgranite (2540, 2541, 2543*) in upper Harrington River has a granophyric texture with radial intergrowths in the matrix. The degree of deformation in these rocks is very variable. In 2541, the cryptocrystalline groundmass has undergone a very ductile shearing which has produced a strong schistosity whereas the phenocrysts are more idioblastic, but show straining of quartz and minor fracturing of feldspar grains. The fabric in the groundmass is bent weakly around the phenocrysts producing augen. These observations suggest that the deformation may have taken place while the groundmass was still hot and ductile. In sample 2540, which has a microcrystalline groundmass, the deformation is more brittle. The groundmass contains small ragged chlorite crystals which show a weak fabric. There are also fractures in the groundmass with small equant grains of chlorite. Quartz grains are commonly broken and displaced, in places leaving a trail of recrystallised quartz between broken fragments. Many feldspars show substantial slippage along cleavage planes. There is no good evidence of deformation in 2543 except for a weak strain in the quartz phenocrysts, and parallel growth of secondary muscovite.

Microgranite, West Harrington River

Microgranite dykes and sills within the West Harrington River (425, 426) are porphyritic rocks with a granophyric texture. Phenocrysts of K-feldspar, quartz and plagioclase are set in a medium grained crystalline groundmass with radial intergrowths of quartz and K-feldspar. The K-feldspar crystals are untwinned, zoned and often with perthitic textures, completely sericitised and with epidote and chlorite patches. The plagioclase crystals display multiple zoning and some of the quartz crystals are embayed. Small amounts of opaque iron oxides and sphene are also present. The secondary minerals present are chlorite, dusty opaque oxides and epidote.

Probable Carboniferous mafic dykes, Lower Harrington River

These dykes occur in the middle of microgranite dykes (1658*), or cut Carboniferous rocks (1207, 1208). They are highly cleaved porphyritic rocks, with completely altered plagioclase phenocrysts and microphenocrysts and a very fine grained ground mass. Secondary minerals consist of actinolite, biotite, quartz, dusty opaque oxide minerals, and rare epidote. Calcite and quartz veins are common.

Although 1658* geochemically resembles 1211* and other high Ti tholeiites, it is also similar to some demonstrable Carboniferous or younger dykes such as 1869* and 1874*. It has a younger cleavage than the Jeffers rocks that it intrudes.

A dyke that cuts Carboniferous sediments in the Lower Harrington River has also been studied (1202). It is coarse to medium grained with an intergranular texture. Feldspars (55-60%) are elongated and in random orientation. Ferromagnesian minerals (probably original hornblende) are almost completely altered to secondary biotite, possible actinolite and chlorite. Opaque oxides (3%) are acicular and randomly oriented. The rock is cut by veins both of calcite and of quartz, opaque minerals and ?actinolite.

Mafic dykes, Middle and Upper Harrington River

The mafic rock type represented by sample 819* occurs at the margin of a clearly Carboniferous microgranite sill in the Middle Harrington River. It is a fine grained rock made up of microcrystals of feldspar, quartz and opaque oxide minerals set in an extremely fine grained dusty groundmass (75-80%). These rocks are cut by veins of quartz, epidote and chlorite and the secondary minerals in them include chlorite, iron oxides and epidote. The chlorite and the dusty iron oxides define a lepidoblastic texture. Geochemically, it is very alkaline and thus resembles the dyke rock 1140* from the lower part of Jeffers
Brook described above.

There is also a mafic rock [334*, 2539*] associated with cleaved microgranite of probable Carboniferous age in Upper Harrington River. It is a porphyritic (Plate 12) rock consisting mainly of dusty altered ferromagnesian mineral crystals (45-65%), altered plagioclase (25-30%), opaques (15-20%) and low-grade metamorphic minerals such as chlorite, sericite, epidote, quartz and biotite.

Some basalt (2127, 2139, 2140) occurs within the McCarthy Gulch section, but is much less deformed than the rhyodacite and is therefore probably later hypabyssal intrusions, perhaps associated with the microgranite.

Mafic dykes, West Harrington River

Dykes (426) within complex microgranite dykes are porphyritic and consist mainly of dusty, altered crystals (probably of ferromagnesian minerals) (25-30%), altered plagioclase (45-65%), opaque minerals (15-20%) and low grade metamorphic minerals such as chlorite, epidote, sericite and biotite. The differences from the dykes described below might be due to partial assimilation of microgranite.

Other dykes (427*) apparently associated with the microgranite have a subophitic texture (Plate), and consist of dusty altered crystals (probably ferromagnesian minerals) (~40%), dusty plagioclase laths (~40%) and opaque minerals (~20%). The secondary minerals include mainly actinolite, but also chlorite, epidote, quartz and iron oxides.

Gilbert Hills Formation in McCarthy Gulch

Rocks in the southern part of the Hadrynian McCarthy Gulch section are difficult to identify because of mylonitisation. Some rocks identified as tuffs (2C2115, 2117, 2118) may be felsic lavas, although in other cases (2131, 2135) the presence of lithic clasts confirms the presence of tuff.

In the northern part of the section, rhyodacite lavas similar to those described above from the Harrington River section interbed with the tuffs.

The presence of pyroclastic rocks and rhyodacites suggests that this section is similar to that in the West and Upper Harrington Rivers.

Fountain Lake Group

Basalt (207, 209)

These are very amygdaloidal basalts, with 10 to 40% amygdales filled with quartz, calcite, chlorite, epidote and actinolite. The rest of the rock is medium crystalline, with intergranular texture, and consists of feldspar, clinopyroxene, olivine and opaque oxide minerals. The plagioclase laths (40-50%) are in some cases completely sericitised. the clinopyroxene is a brown titaniferous augite that occurs in subhedral crystals. The olivine occurs in granules or subhedral crystals and is often completely altered with a thick opaque rim. The relative abundances of olivine and augite are variable and are difficult to estimate because of the varibale degree of alteration. Opaque oxide minerals make up 5 to 10% of the rock. The secondary minerals include epidote, chlorite, calcite, actinolite and in some samples (209) a mineral with an inhomogenous greenish-blue colour which may be pumpellyite.

Rhyolite

The Fountain Lake rhyolite in the Harrington River area has not been examined in detail. In the field, it consists of pinkish rhyolites and felsic pyroclastics, similar to those seen in the Davidson Brook and West Moose River sections.

3. LYNN ROAD

Introduction

The Lynn road section has been examined in detail on account of its accessibility. From north to south, four main rock units are exposed

1. A northward-younging sequence of turbidites of the Cranberry Lake Formation, with West Brook facies overlying more proximal Pike Fire Brook facies. These are cut by various hypabyssal rocks, including cleaved mafic dykes, cleaved basaltic andesite dykes and sills, a rhyolite dyke, and microgranite dykes and sills.

2. A complex sequence of volcanic rocks apparently associated with a thrust fault zone.

3. Mostly volcanic rocks (the "southern volcanic sequence", with some interbedded or tectonically interlayered greywackes of the West Brook facies.

4. A complex sequence of faulted and cataclastic rocks immediately north of the Cobequid Fault.

Turbidites of the Cranberry Lake Formation in the northern section

Most of the samples from the West Brook facies consist of coarse siltstone, whereas the Pike Fire Brook facies includes well sorted fine sandstones. Both occur interbedded with finer siltstones and argillites.

The coarse siltstones have maximum grain sizes of about 100 microns and typically range between 10 and 50 microns. They show size-sorted laminae in thin section. Grains are moderately to well sorted; they have low sphericity and are subangular to angular. Compositionally, the rocks are arkosic, with feldspar to quartz ratios of 1:1 to 4:1. The feldspars are mostly untwineed and slightly altered, although zoned and twinned feldspars are also present. Quartz is commonly strained, fresh-looking, and commonly has higher sphericity than the feldspar. Opaque minerals (20 microns in size) are common throughout the siltstones and sandstones. Other minerals observed include zircon, epidote, biotite, tourmaline, secondary biotite and calcite.

The coarse siltstones have their fine grained matrix altered to muscovite and chlorite. Many grains have been altered to dusty opaques, which make identification of the original mineralogy very difficult. Limonite and reddish iron oxide staining around fractures are seen in some rocks. Most samples show a weak deformational fabric producing a preferred orientation of secondary micas and a weak cleavage.

The fine sandstones (2834, 2647*) have most grains in the 50 to 200 micron range, with a minor silty or argillaceous matrix. The rocks are well sorted arkoses with a high feldspar to quartz ratio. Most are well laminated in hand specimen, apparently representing Bouma B division turbidites. Individual beds are 40 - 120 cm thick. Most beds are Bouma B sequences; AB and BC sequences are rare. No sole structures have been seen, but cross lamination provides occasional paleocurrent indicators (Table 4).

Argillite and silty argillite interbedded with the siltstones and sandstones show alternating anastomosing flattened lenses of mica-rich and mica-poor sediment, apparently reflecting deformation.

Hypabyssal intrusions in the Cranberry Lake Formation

Feldspathic mafic intrusions (188*, 867*, 2845, 2645*)

Feldspathic mafic rocks are widespread in the Lynn Road section. They mostly occur as hypabyssal intrusions, but in the southern volcanic section the occurence of flow textures pre- dating the cleavage suggests that some may be lavas [2845]. The description that follows is based on both hypabyssal intrusions and possible lavas.

The rocks show a variety of textures (Plates 13-15), intergranular to intersertal, or hyalopilitic to pilotaxitic. Some are amygdaloidal. They are distinctively feldspathic, with 40-70% feldspar, mostly plagioclase, now represented by albite. Sanidine is rare. Plagioclase crystals range in size from 1.5 mm to microlites; phenocrysts may be zoned. They alter to sericite and epidote. Actinolite occurs as blades or fibres, with fibres appearing to develop from blades as a result of deformation (Plate 188). Epidote is common, either as well formed crystals (colourless to lemon yellow) or dusty birefringent aggregates. Chlorite abundance varies from 5 to 20%. Brown green and bluish biotite are found either in the cleavage or cross cutting all other minerals, suggesting that it was the last secondary mineral to form. Quartz is ubiquitous but in small amounts as recrysallised interlocking aggregates showing a preferred orientation. Muscovite occurs in some samples as lenses or veinlets (Plate 14). In a few samples, relics of clinopyroxene and pseudomorphs of hornblende (made up of plagioclase, epidote, quartz and opaque minerals) are observed.

The interstitial material, which makes up to 60% of the rock, is micro- to cryptocrystalline, with plaioclase, epidote, dusty iron oxide, chlorite, actinolite and biotite.

The foliation is usually defined by fibrous actinolite, dusty iron oxides, chlorite and rare muscovite. Amygdales, where present, are filled with chlorite and quartz. The rocks are locally cut by calcite veins.

Mafic dykes (388, 860*, 855, 881*, 2830, 2825, 2833*)

These mafic dykes originally had a fairly coarse texture. They contain plagioclase, opaque minerals and common relics of Ti-rich augite (Plate 16). Secondary minerals consist of actinolite, epidote, chlorite, and quartz. Blue-greenish biotite cross cuts all other metamorphic minerals.

Where present, the foliation is defined by dusty iron oxide minerals and fibrous actinolite.

There may be several generations of dykes within this general petrographic description. 881* geochemically is a high-Ti tholeiite. 2833* has a chilled margin against microgranite, which it therefore probaly post-dates.

Rhyolite dyke

This is a 2m wide dyke (2646*, 2827) striking 140 degrees. It is a porphyritic rock with a high proportion (~98%) of microcrystalline groundmass. The phenocrysts consist of feldspar and quartz in a 2:1 ratio. The plagioclase shows irregular twins and the quartz is strained. The groundmass also consists of feldspar and quartz, with irregular anhedral grains which may be weakly recrystallised. Spinel occurs as an accessory mineral. The rhyolite is injected by numerous contorted microcrystalline quartz veinlets. The secondary minerals include very fine grained chlorite and dusty opaque oxide minerals.

Microgranite (395*, 856*, 857*, 873*, 1089*)

These rocks are porphyritic, show a weak cleavage, and many are cut by mafic stringers consisting of metabiotite, chlorite and minor opaques. They comprise phenocrysts of quartz, K- feldspar, plagioclase and minor opaque minerals, all set in a fine grained groundmass of quartz and feldspar. In some samples the feldspar shows kinking (Plate 17) and in many samples the groundmass quartz is partly recrystallised. The secondary minerals, concentrated in the mafic stringers, are scattered grains of epidote, biotite and chlorite.

Rocks of the complex thrust zone

Rocks present in this zone include mafic rocks (308, 388*) (Plate 18), andesites (379*, 380*) (Plate 19), and feldspathic mafic (368*, 373*, 1081*, 1082*) (Plate 20) lavas or intrusions similar to the hypabyssal rocks cutting the Cranberry Lake Formation to the north. In addition, pyroclastic rocks and rhyodacite are present. Similar rhyodacites and tuffs occur within the Cobequid Fault zone. The assemblage of lithologies is characteristic of both the lava and pyroclastic dominated sequences within the Harrington River facies of the Gilbert Hills Formation.

Rhyodacites

These rocks (033) consist of phenocrysts and microphenocrysts of feldspar, quartz and some opaque minerals set in a very glassy groundmass with primary flow texture (Plate 21). Many of the rocks are highly deformed or mylonitised, with lens-shaped and partly recrystallised quartz and rounded feldspars. Foliation is defined by muscovite. Secondary minerals include muscovite, biotite, quartz, chlorite and occasional actinolite, often as corona rims on quartz crystals with undulose extinction.
Pyrite with reaction rims is also present.

The biotite is either bluish or greenish in colour, with colour related to TiO2 content; the variation probably reflects local equilibrium conditions. Most biotite plates follow small fractures which cross-cut the general fabric of the rock, although rounded crystals following the cleavage are also present.

Partly recrystallised quartz veins cut the rock parallel to the cleavage. Veins of biotite, chlorite, quartz, actinolite and calcite cross cut the cleavage.

Pyroclastic rocks

The pyroclastic rocks (034, 037, 199, 2838, 2841, 2844 and 2851) (Plates 22-24) consist predominantly of tuffs and lapillistones. These rocks are composed of crystals and feldspathic lithic fragments enclosed in a fine-grained, sometimes intensely altered, matrix. Some pyroclastic rocks consist entirely of very angular fragments with a minor amount of very fine grained altered matrix between the clasts. Laminae (~3- 5 mm) of finer grained feldspar fragments have been observed. These commonly show sharp lithological boundaries.

The clasts are either sub-rounded or elliptical in shape, or partly digested, in which case it is difficult to distinguish them from the matrix. The most common type of clast that occurs is that of finely crystallised feldspathic mafic rocks with a strong flow texture, recrystallised ash, and fragments of vein quartz. the crystal fragments consist of plagioclase and quartz. The matrix is micro- to cryptocrystalline. Minerals identified in the matrix include quartz, feldspar, epidote, and opaque iron oxide minerals. It is probable that some of these clasts are hyaloclastites. The secondary minerals consist of muscovite, dusty iron oxides, epidote, calcite, chlorite, biotite and very little actinolite (e.g. 034, 381, 2841, 2844, 2851).

Bedding and graded bedding have been seen in some localities and all samples are cleaved. The foliation is defined usually by muscovite and iron oxides, although the biotite and chlorite often, but not always, follow the cleavage. Quartz, clacite and chlorite veins are common. A spaced pressure solution cleavage is sometimes present in the clast supported feldspathic tuffs.

Some pyroclastic rocks (2838, 037, 199) consist entirely of very angular plagioclase crystals. These are most commonly clast supported with a minor amount of very fine grained altered matrix between the clasts. Thin beds (~3 - 5 mm) of finer grained feldspar fragments have been observed. These commonly show sharp lithological boundaries.

Highly altered probable tuff is represented by sample 192, which is a schist in which the matrix is altered completely to chlorite and muscovite. There are a few porphyroclasts which are principally feldspar. Epidote is abundant. Chlorite occurs as large elongate crystals lying in the foliation: these crystals may have developed from the alteration of glass shards.

Cranberry Lake Formation below the thrust zone

Somewhat tectonised greywackes and argillite outcrop immediately below the thrust zone on the Lynn Road. They have ben mapped as West Brook facies, but are less well sorted than typical developments of this facies and most resemble the West Brook facies in lower Harrington River.

Probable lavas in the southern volcanic sequence

Mafic vesicular flows (45*, 1087*, 1088*)

These are vesicular somewhat foliated basalts (Plate 26) in the southern volcanic sequence which interlayer with much more highly cleaved metabasalts. These rocks are vesicular basalts, with altered plagioclase laths (45%), epidote crystals (25%), actinolite fibres and blades and biotite (together 15-20%), chlorite (5-10%) and dusty patches of indeterminate mineralogy. Some K-feldspar with Carlsbad twinning occurs. The biotite is pleochroic (colourless to brown-green) and seems to develop from actinolite. The vesicles make up 20-30% of the rock and are filled with epidote, actinolite, quartz, chlorite and occasional calcite and biotite. There is a strong foliation defined by fibrous actinolite and dusty iron oxides. The rocks are cut by kinked quartz veins (some including actinolite) parallel to cleavage; and by post cleavage granitic and calcite veins.

Foliated metabasalts (1083*, 1085*, 1086*)
These rocks are similar to the vesicular basalts, but lack vesicles and are more highly cleaved. Mineral assemblages are similar to those in the vesicular basalts, but muscovite is also present. Actinolite is usually as fibres following the foliation, but basal sections cross-cutting the foliation are also seen. The biotite in these samples is also pleochroic (colourless to brown- green) and it occurs either as fibres which both coss cut or parallel the cleavage, or as plates which usually form clots which cross-cut the cleavage.

Sample 1083* is similar, but has more prominent muscovite. Geochemically, it is a little different, and may be a cleaved volcaniclastic. It shows isoclinal folds (Plate 26) defined by muscovite and dusty iron oxides.

Mafic rocks of uncertain affinity
These are basalts (1084*) with a higher amount of opaques, epidote and actinolite-biotite than the vesicular basalts and cleaved metabasalts. Minerals present include plagioclase, quartz, chlorite, actinolite, epidote and biotite.The samples examined are highly cleaved, with quartz and feldspars partly recrystallised (Plate 27). These rocks are probably hypabyssal intrusions.

4. UPPER JEFFERS BROOK - HENRY BROOK AREA

Introduction

The area described in this section is bounded to the north by the onlap of the Cumberland Group and to the south by the Kirkhill Fault. The headwaters of Jeffers Brook, east of the Jeffers Brook pluton, expose rocks of the West Brook facies of the Cranberry Lake Formation. Similar rocks are exposed in the northern part of Henry Brook and in the northern part of the powerlines clearing that crosses the Gilbert Hills. Lower down Henry Brook is a section of felsic pyroclastics, rare rhyolites and felsic volcaniclastic sandstones, which appears to underlie the Cranberry Lake formation and is correlated with the Lakelands facies of the Gilbert Hills Formation exposed in lower Jeffers Brook. Felsic pyroclastics of the Lakelands facies are also exposed in the powerlines clearing south of Jeffers Brook.

Gilbert Hills Formation

Felsic tuffs of the Lakelands facies
Felsic tuffs outcrop along the powerlines clearing from Jeffers Brook south to the Kirkhill Fault. They appear to be a continuation of the felsic tuffs in the lowest part of Jeffers Brook. Sample 1381* is a crystal tuff or a rhyolite from this section. Larger crystals (phenocrysts?) consist of plagioclase, K-feldspar and quartz. The cryptocrystalline groundmass is altered to muscovite with a strong fabric. Clots of green secondary biotite are developed.

Rhyolite at margin of Jeffers Pluton (2085*)
A massive, fractured, slightly porphyritic pink rhyolite outcrops over a ten metre square area at the southeastern margin of the Jeffers Brook pluton. It is believed to be a hornfelsed rhyolite of the Lakelands facies.

Rhyolites, tuffs and sandstones, Henry Brook

Rhyolites and felsic pyroclastics (1051*): Massive felsic rocks in the central part of Henry Brook appear to consist of felsic pyroclastics and possible rhyolites. ..needs more work when thin section of 1051 is found.

Felsic volcaniclastic sandstones: A sequence of rather deformed medium to fine sandstones (352*, 1070*) outcrops in both the northern and southern parts of Henry Brook. Bedding is only rarely clearly visible in the field; the rocks appear rather deformed, and are difficult to distinguish conclusively from tuffs. In the upper part of Henry Brook, these rocks give way to thinner bedded greywackes of the West Brook facies (1078*).

In thin section, the sandstones consist of anhedral grains of quartz and feldspar, some of which are rounded. Feldspar is more abundant than quartz, and in some samples predominates. Mean grain size is between 0.01 and 0.5 mm. Rare lithic fragments consist of siltstone and feldspathic igneous rock. The matrix is poorly sorted with dusty opaques, muscovite and silt-sized quartz. The rounding of the grains suggests that this sample is a sandstone, not a tuff.

Cranberry Lake Formation

West Brook facies (1078*, 2281*, 2501*)

The Cranberry Lake Formation in the headwaters of Jeffers Brook consists of thin bedded fine sandstones and siltstones and interbedded argillite. Some of the sandstones and siltstones appear graded.

Sample 2501* has a microcrystalline texture of feldspar and quartz, forming small equant grains. There is a strong fabric produced by the alignment of long thin stringers of biotite. There are also parallel alignments of aggregates of fine grained hornblende crystals. Opaque minerals also show elongated crystal aggregates parallel to this fabric. All minerals appear very fresh.

Spotted rocks of the Cranberry Lake Formation in the thermal aureole of the Jeffers Pluton (641*, 659, 2292, 1122, 1123, 1124, 1125, 1127, 1130)

These spotted rocks include lithologies which are clearly sedimentary siltstones and sandstones to samples which might have been rhyolitic tuffs. Graded bedding is present in some samples. The rocks are variably cleaved: some are uncleaved, whereas the finer grained lithologies invariably show a good cleavage. All are quartz rich, with grain size in the fine to coarse silt range. In cleaved samples, quartz shows a strong preferred orientation. Some contain many small grains of brown biotite aligned in the direction of the cleavage (Plates 28-29). The spots are best developed in the finer grained, less quartz rich rocks. They are made up mainly of quartz and muscovite and in many samples these minerals lie in the cleavage plane of the host rock. In one sample in which the cleavage macroscopically appears to have ben kinked, many of the spots appear to have been rotated into the cleavage (Plates 30-31). Muscovite in some specimens with well developed spots appears to cross cut the cleavage and to pseudomorph an earlier mineral (?andalusite).

The inferred sequence of events in the development of these rocks is:

1. development of cleavage in the rocks to produce the quartz- biotite fabric and approximatley synchronous development of a thermal aureole with andalusite spots.
2. further alteration or metamorphism to replace andalusite with muscovite. This might be almost synchronous with event 1.
3. development of late stage kink folds and resulting rotation of spots

Hypabyssal intrusions

..1140* DYKE IN ne jEFFERS. djwp SORT OUTWHERE IT BELONGS Check Andy notes

Marginal mafic intrusions of the Jeffers Brook Pluton East of the Jeffers Brook pluton, dyke-like granodiorite bodies cut the Cranberry Lake Formation, in places with irregular vein-like margins. Uncleaved granodiorite cuts variably cleaved thin bedded siltstones.

In the Northeast Branch Jeffers Brook, a 6 m sill of diorite (2295*, 2299*) is intruded in the Cranberry Lake Formation. It has finer grained diabase margins, and locally includes coarse hornblendite.

Dyke-like bodies of diorite similar to the Jeffers Brook pluton outcrop in the Southeast Branch Jeffers Brook (668*).

Feldspathic mafic intrusion

A thick sill of feldspathic mafic rock (1931*) outcrops just north of the Kirkhill Fault to the west of the power-lines clearing. It appears to intrude Gilbert Hills Formation. Mafic dykes (1934*), similar to the 060 dykes of Jeffers Brook, cut this felspathic mafic intrusion.

The sill rock is primarily made up of large feldspar phenocrysts in a fine grained mafic groundmass. The feldspar phenocrysts are very altered and fractured. They are partly replaced by sericite and occasionally by actinolite. The groundmass contains small feldspar laths, abundant secondary minerals (such as actinolite, epidote and chlorite), opaque minerals and minor biotite. The rock is cut by numerous veins of chlorite, actinolite, epidote and quartz.

A dyke in upper Jeffers Brook (645*) geochemically resembles the feldspathic mafic intrusions. Petrographically, it is unusual, with small anhedral feldspar crystals and aggregates of brownish hornblende and acicular greenish actinolite (Plate 32).

Microgranites

a) north west of Davidson Brook

Microgranite sills intrude the Jeffers Group north of the Kirkhill Fault zone and also occur in isolated outcrops within the fault zone. They contain pink feldspars and quartz within a sugary groundmass. They appear undeformed, except where they occur within the Kirkhill Fault zone.

In thin section, the microgranites contain feldspar and quartz phenocrysts in a crystalline groundmass with secondary ferromagnesian minerals. They have subporphyritic textures intermediate between those of a granite and a rhyolite. They differ from the Fountain Lake rhyolites only in having a holocrystalline fine grained matrix rather than glass.

The feldspars display well preserved perthitic textures. The quartz generally shows some signs of deformation and corrosion. The secondary ferromagnesian minerals actinolite, epidote and chlorite occur in small patches throughout the rock.

b) margin of the Jeffers Brook pluton

A north-south trending microgranite dyke (2535*) cuts the Jeffers Brook pluton near its eastern margin. A similar wide microgranite (2527) dyke, trending 150 in the Southeast Branch Jeffers Brook, has narrow diabase dykes within it. A similar composite dyke, trending 130, cuts the middle of the Jeffers Brook pluton. The microgranite (1969*) is at least 3 m wide and has a central diabase dyke (1968*) about 80 cm wide. A north- south rhyolitic intrusion (2079*) outcrops in the south branch Jeffers Brook.

c) upper Henry Brook (1061*)

A 20 m wide dyke of reddish microgranite cuts the Gilbert Hills Formation in a tributary of Henry Brook.

d) powerlines clearing north of Henry Brook (1844*, 1846*)

Several north-south trending porphyritic microgranite dykes, a few metres to a few tens of metres wide, cut the Cranberry Lake Formation in the powerlines clearing northwest of Henry Brook. They are less reddened than some microgranites, but petrographically resemble those described above from the margin of the Jeffers Brook pluton.

060 mafic dyke (1847*)

Occasional mafic dykes trending 060 cut the Cranberry Lake Formation in the powerlines clearing northwest of Henry Brook. They are correlated with the dykes with a similar trend in lower Jeffers Brook.

North-south mafic dykes

(2084*, 1963, 647, 657*, 2074*, 2075, 2076, 2078)

These dykes are broad and tend to trend north-south. They have basaltic or andesitic composition. Some cut the thermal aureole of the Jeffers Diorite, and one in the South Branch Jeffers Brook appears to cut the Jeffers Diorite. They are parallel or subparallel to the microgranite dykes near the southeast margin of the Jeffers Brook pluton.

These rocks have an ophitic texture and they are not cleaved. Some of the rocks have a spotted appearance: the spots appear to be vesicles with chlorite or calcite + epidote + quartz. Corroded quartz crystals with corona rims of chlorite have been seen in one sample (657*) (Plate 33). The primary phenocrysts and microphenocrysts which are still preserved consist of feldspars, clinopyroxene and Fe-Ti oxides. The secondary minerals include actinolite, chlorite, quartz, dusty opaques, epidote and some calcite.

A massive rhyolite (2079*) from the South branch, Jeffers brook, may be an associated rhyolite intrusion or may be hornfelsed rhyolitic country rock.

5. HANNA BROOK

Introduction

In the lower part of Hanna Brook there is a well exposed section in rather tectonised mafic pyroclastic and volcaniclastic rocks and rare rhyolites. Some hypabyssal mafic rocks of uncertain affinity and several thick microgranite sills intrude this sequence. The pyroclastic sequence is similar petro- graphically to that in the upper and West Harrington River sections, which petrographically and geochemically are probably facies equivalents of the Harrington River facies lavas.

Gilbert Hills Formation

Rhyolites (242)

These are porphyritic rocks with a trachytic texture. The phenocrysts consist of plagioclase (15%), K-feldspar (10%), quartz (3%) and opaque minerals (<1%). All of these minerals are set in a trachytic groundmass (80%) of feldspars, quartz, opaque minerals and muscovite. The secondary minerals consist of chlorite (mostly along veinlets), muscovite and biotite (generally associated with opaque minerals). The rock is cut by veins either of monomineralic quartz, or of quartz, biotite, opaques and chlorite. Clasts similar to the groundmass of this rhyolite have been seen in some lithic tuffs from Hanna Brook (1030). A weak foliation (crenulation) is present.

Pyroclastics and associated volcaniclastic sediments

The finest grained rocks are ash tuffs (252, 1027), consisting of minor quantities of quartz and albite set in a very fine grained groundmass. Coarser pyroclastics are composed of crystal and lithic fragments enclosed in a fine grained matrix that shows variable degrees of recrystallisation.

Many of these rocks (251, 1028, 1032, 1040, 1042, 1043, 1044, 1045, 1047, 1050) are lithic-crystal tuffs with a very variable proportion of crystals to clasts. Crystal fragments consisting of quartz, sodic plagioclase and rare K-feldspar vary from 7 to 45 %. The quartz crystals (0-5%) are subangular to subrounded and show undulose extinction. In some samples, some of these crystals have recrystallised into smaller interlocking grains. The plagioclase (10-25%) ranges from andesine to albite in composition, and has been altered to epidote to a varying degree. Opaque minerals (1-12%) and epidote (2-15%), often in clots, are also common constituents of these tuffs. The epidote clots appear to have replaced plagioclase.

The lithic fragments are mainly mafic in composition, and include ash and lava. The ash fragments consist of minute unaltered crystallites of quartz and plagioclase, some of which is altered to sericite. The lava fragments consist of laths of sodic plagioclase enclosed in an aphanitic groundmass showing some similarities to the feldspathic mafic lava flows of the Harrington River section and to the lava clasts in the lithic tuffs in the same area. Some prismatic laths show good flow alignment at a random orientation to the regional foliation. The lithic fragments are subrounded to subangular and are somewhat sorted. Many appear partly digested or diagenetically altered and their margins are difficult to define.

The matrix consists of fine grained ash and is generally partly recrystallised. Secondary minerals consist of epidote, chlorite, muscovite, opaque oxides and rarely biotite. Foliation, whenever present, is defined by muscovite, dusty iron oxides and chlorite.

Two other minor types of lithic crystal tuffs are found within the main tuff sequence. Type A, represented by sample 1039, is more mafic than the main sequence. It contains felsic clasts similar to those of the main sequence, but also contains large proportions of epidote, in individual crystals or clots. Plagioclase and a ferromagnesian mineral such as hornblende are assumed to be the primary minerals that have been been altered to epidote. The clasts in type B (represented by sample 1033) are much finer and consist of fresh looking rhyolites, compared with the more mafic lavas in the main tuff sequence. These lavas compare with the rhyolite flows in lower Jeffers Brook and in the main agglomerate there.

Some felsic clastic rocks (1030, 1036, 1037*) may be volcaniclastic sediments. They contain a slightly different mineral assemblage, which in 1030 includes rather more rounded quartz grains. They resemble probable volcaniclastics from Browns
Brook (615), Harrington River (826) and Henry Brook (210). They are composed of a poorly recrystallised, commonly lepidoblastic matrix (62-64%), mainly of quartz and lesser feldspar; broken crystals of quartz (10-27%); broken crystals of feldspar, mostly plagioclase (10%); and anhedral dusty opaque aggregates (2-13%). The secondary minerals consist of chlorite, epidote and dusty iron oxides. The rocks are often cut by calcite and quartz veins. Exposure is unsuitable for sedimentological discrimination between tuffs and volcaniclastic sandstones.

Microgranites

At least three microgranite sills 1 to 4 m thick intrude the Gilbert Hills Formation in lower Hanna Brook (1026, 693, 1029, 1033). Granitic veins cut the country rock between the sills.

Hypabyssal mafic rocks

Three groups of mafic rocks have been found in the Hanna Brook section. Their texture and similarity with rocks elsewhere sugests that all are hypabyssal intrusives.

<u>Mafic type A</u> (236). This is a porphyritic basalt with an uncertain relationship to the Gilbert Hills Formation. It has a hyalopilitic to pilotaxitic texture. Large crystals of zoned augite, completely altered plagioclase, and opaque minerals are set in a groundmass which is a dusty intergrowth of clinopyroxene, feldspar and opaque minerals. Secondary minerals consist of chlorite in patches or clots, together with clinopyroxene crystals, iron oxides, quartz, epidote, calcite and a small amount of a bluish to colourless biotite. The rock is often cut by quartz veins with or without biotite and it shows a weak foliation.

<u>Mafic type B</u> (1017*). This is a vesicular mafic rock at the top of a thick microgranite sill. The only primary minerals left are plagioclase, now albite, and abundant opaques. the vesicles are filed with musocivte, biotite, actinolite and a very little feldspar. Other secondary minerals include epidote, chlorite, and quartz. The rock shows foliation which is defined by the elongated vesicles and opaque minerals.

<u>Mafic type C</u> (1020*). These are porphyritic, very feldspathic rocks of basaltic andesite composition with a hyalopilitic texture. The phenocrysts and microphenocrysts consist of feldspar, quartz and opaques. the secondary minerals include chlorite (some in veinlets), calcite (in patches and veinlets), quartz and dusty iron oxides.

6. DAVIDSON BROOK AREA

Introduction

The lower part of Davidson Brook, as well as the powerlines section to the west and Gavin Brook to the east, expose thick sequences of Fountain Lake rhyolite. Higher up Davidson Brook is an inlier of mafic and felsic volcanic rocks which are correlated with the Gilbert Hills Formation. In the upper part of the brook, they are again overlain by Fountain Lake rhyolite. The Gilbert Hills Formation is cut by a thick granodiorite sill. Similar granodiorite outcrops on the flanks of the Parrsboro valley west of Davidson Brook, where it was mapped as the Davidson Brook Pluton by Donohoe and Wallace (1982). The northern margin of this pluton is marked by the Kirkhill Fault zone. The fault zone is several hundred metres wide and includes mylonitised plutonic rocks, felsic pyroclastics of the Gilbert Hills Formation, and Fountain Lake rhyolite.

Gilbert Hills Formation

Mafic lavas (1326*)

The mafic rocks exposed in Davidson Brook appear somewhat tectonised and epidotised in outcrop. Clear weathering surfaces or regular joint patterns are absent. They are cut by veins, and locally have more felsic-looking alteration patterns. These rocks were mapped by Donohoe and Wallace (1982) as part of the Davidson Brook Pluton; it does not appear to be a plutonic sequence, and is unlike the rocks of the pluton petrographically and geochemically.

The basalts are locally amygdaloidal, with actinolite and minor quartz in the amygdales. The principal minerals in the basalts are feldspar phenocrysts, opaque minerals, small amounts of quartz, and secondary minerals such as actinolite, dusty iron oxides and minor chlorite and epidote. The feldspars are highly altered, and their crystal outlines are largely obliterated. Actinolite is the most abundant secondary mineral. It occurs both as large individual prismatic crystals and as radiating aggregates. The epidote occurs as crystals scattered through the rocks and as cross-cutting veins. The other secondary minerals occur within the fine groundmass.

Intermediate rocks (2194*)

Sample 2194* was collected from within the mafic sequence. Although there was no obvious field evidence that it was an intrusion, this possibility cannot be excluded. It is a porphyritic rock made up of plagioclase phenocrysts set in a fine grained crystalline groundmass of plagioclase, epidote and opaque oxide minerals. The rock is highly fractured.

Felsic cataclastic rocks in Davidson Brook (1504, 2193, 2184, 2195-2197)

In the field, these felsic rocks appear grey in colour and rather featureless in outcrop. Locally they appear fractured. Occasional fine agglomerates are seen in outcrop. Samples from near the contact with the mafic section, which the rhyolites appear to overlie, may consist of deformed microgranite (1505, 2182).

The felsic rocks (1504, 2183, 2184, 2193, 2195, 2197) are made up primarily of quartz and feldspar phenocrysts and secondary minerals such as epidote and chlorite. Secondary minerals also include apatite and rare sphene. There is a highly crystalline groundmass. The feldspars have a variable size range from 1.5 to 4 mm. They lack original crystal outlines because of severe sericitisation. The rocks are tectonised, with intense flattening and alteration to opaque minerals. Most of the rocks appear to have a clastic texture and are probably polymict felsic pyroclastics.

The possible microgranite near the contact with the mafic section is a reddened aphanitic rock with small K-feldspar phenocrysts.

The felsic rocks resemble some felsic cataclastites from Kirkhill Mountain and felsic pyroclastics from the West Harrington River.

Hypabyssal rocks

Diorite sill (2189*, 2190*)

A 20m-thick sill of granodiorite intrudes the Gilbert Hills rhyolite in Davidson Brook, and is truncated by a subvertical fault along which the stream runs. This granodiorite is similar to rocks in the main Davidson Brook Pluton to the northwest.

Feldspathic rhyolitic dyke (1394, 2262)

This is a highly porphyritic rock that occurs in a 1m wide dyke trending 060 in Davidson Brook. It contains large phenocrysts of highly sericitised and partly epidotised plagioclase. This plagioclase and some opaque crystals are set in a crystalline fine groundmass of quartz, feldspar and opaque minerals, together with secondary minerals such as chlorite, dusty iron oxide, epidote and sphene. The opaque minerals seem to alter to an anisotropic, dusty, extremely fine grained mineral mixture. The rock is dissected by epidote, quartz and chlorite veinlets.

Fountain Lake Group (1582*, 2264*)

Fountain Lake Group rhyolites are well exposed in Davidson and Gavin Brooks and consist of pink and greenish rhyolite flows and pink felsic pyroclastics.

The flows (2264*, 1582*) are porphyritic, with subhedral to euhedral phenocrysts of quartz, plagioclase and alkali feldspar set in a microcrystalline to cryptocrystalline matrix. The phenocrysts comprise about 10% of the rock and are fresh and undeformed. Quartz makes up about 80% of the phenocrysts. Feldspar occurs as perthitic intergrowths. There are a few large hexagonal opaque oxides. Most opaque oxides occur as very fine crystals dispersed throughout the groundmass. Irregular patches of sericite may represent original glass.

ls (Plate 6). These crystals are set in a microcrystalline,

8. THE WEST MOOSE RIVER AREA

Introduction

Jeffers Group rocks outcrop on the north side of the West Moose River pluton, and as roof pendants within the pluton. The West Moose River pluton is a Carboniferous pluton that is truncated on its southern side by the Cobequid Fault zone. Jeffers Group rocks also occur in fault slices along the fault zone. Major north - south and northwest - southeast trending faults cut the Jeffers Group north of the pluton, so that it is difficult to establish any continuous stratigraphic sections.

Humming Brook Formation argillites outcrop over large areas on the northeast side of the pluton, and also occur as hornfelsed roof pendants. They appear to be in fault contact with the Fountain Lake Group to the north.

Gilbert Hills Formation outcrops north of the pluton, where there appears to be a sequence of predominantly felsic tuffs that pass up into mafic flows. The lower part of the tuff sequence is cut by a thrust fault. The mafic flows are bounded to the northeast by a major NW - SE trending fault zone, with complex hypabyssal intrusions and mineralisation. North of this fault zone is a highly cleaved section of mafic Gilbert Hills Formation, resembling the rocks seen elsewhere in inferred thrust zones. These rocks are in close proximity to undeformed Fountain Lake rhyolites: the contact is probably unconformable; the lack of deformation in the Fountain Lake rhyolite renders a fault contact unlikely, but this interpretaion cannot be ruled out.

Cranberry Lake Formation rocks occur locally within the Cobequid Fault zone.

Humming Brook Formation

The Humming Brook Formation is best exposed in logging roads immediately west of Humming Brook. Here it consists of grey argillite with thin fine silty laminae and rare fine greywacke beds. The sequence appears to be folded into open folds.

In Humming Brook, there is a similar sequence, but it may also contains poorly sorted beds of fine greywacke. Silt laminae are 1 to 10 mm thick. Many of the rocks in Humming Brook are highly deformed.

Similar argillite with silty laminae occur in the upper part of McCallum Brook (3738, 2918-2925). Humming Brook Formation argillites are also exposed in the logging road immediately east of the upper West Moose River (2676). They locally include thin graded beds of silt 1 to 20 cm thick that young to the east. Roof pendants of the Humming Brook Formation, exposed on the West Moose River road (2440*), consist of hornfelsed argillite with thin silty laminae, rare thin fine greywacke beds, and a penetrative cleavage that predates granite intrusion. They were mapped by Donohoe and Wallace (1982) as undivided Siluro-Devonian sediments. We reject this correlation because of the presence of the cleavage and the lithologic similarity to the Humming Brook Formation, which is the immediate country rock wherever the margin of the pluton is not faulted.

Gilbert Hills formation

<u>Mafic flows</u> (1871*, 2027-8, 2203-11, 2666, 2670, 2671)

In hand specimen, these rocks are massive and amygdaloidal in places, and on weathered surfaces feldspars can be seen to be aligned in the regional foliation.

In thin section, the rocks are highly altered, consisting largely of chlorite, dusty opaque oxide minerals and some epidote. The rock appears to have originally comprised medium grained feldspar laths, showing a weak fabric. Vesicles are filled with polycrystalline quartz and actinolite.

In lower McCallum Brook, the West Moose River pluton intrudes mafic rocks apparently of the Harrington River facies of the Gilbert hills Formation (2556*, 2558, 2559)

<u>Felsic tuffs or greywacke-siltstones</u>
..@look at some of 2692, 2693, 2694 proabably tuff,2695, 2696
..@coarse 2697, 2698 coarse, 2702 coarse, 2703, ?2705, 2707, 2708,
..@2709, 2710, 2712.

In the West Moose River, north of the pluton, there is a long section in bedded felsic tuffs of very variable grain size. Locally, fine ash contains siliceous nodules similar to those seen in the Middle Harrington river section. Rare lenticular bedding in fine tuff has also been seen.

Where this tuff section continues in the logging road to the east of the river, there are large outcrops with unequivocal graded bedding indicating a younging direction to the east. Immediately below the overlying mafic flows, there is a fine agglomerate with clasts up to 8 mm in size. ..@2667, 2668, 2669 are from this area: brief description please

Similar tuffs also outcrop north of the mafic-felsic intrusive complex (described below) and below the thrust zone.

Mafic-felsic intrusive mineralised complex

In the logging road east of the West moose River, there is a 200 m wide fault zone in which the rocks are highly altered, with sulphide mineralisation and silicification. The county rock appears to be felsic tuff, but it is intruded by a complex of microgranite and mafic hypabyssal intrusions, all of which appear considerably fractured, and some of which show ductile shear.

..@microgranite 2678; dark rocks 2680, 2679, 2684.

..@check 2810 thin section for ignimbrite when available

The mineralisation is recognised by brownish sulphide weathering on fracture surfaces (2681, 2682, 2684).

Thrust zone rocks

The thrust zone at the northern end of the logging road east of the West Moose River consists mostly of cleaved mafic rocks, with some cleaved felsic tuffs.

Mafic dykes

Mafic dykes (2497*) cut the Jeffers Formation in the lower Moose River. They are slightly porphyritic, sometimes vesicular rocks, consisting of feldspar microphenocrysts in a medium grained matrix with a weak trachytic texture. The phenocrysts consist of plagioclase and are gnerally more equant than those in the matrix. The matrix consists of plagioclase, chlorite, and minor opaque minerals (which have a patchy distribution). stribution). ists of plagioclase, chlorite, and minor opaq

6. NORTH RIVER

Introduction

The North River south of the North River Pluton exposes a long section in Jeffers Group rocks , providing one of the best sections south of the Kirkhill Fault. The northern part of the river section is in folded Humming Brook Formation. This is separated by an east-west fault from a section assigned to the Gilbert Hills Formation, comprising rhyolite and reworked volcaniclastic sandstone, rare mafic lava, and metacarbonates, which appear to pass up into silty argillites of the Humming Brook Formation. Close to the Cobequid fault there are several fault slices which bring in other lithologies including fine grained turbidites of the Cranberry Lake Formation. Near the North River pluton, the Humming Brook Formation is cut by numerous rhyolitic and mafic dykes, with complex dykes extending for several hundred metres just south of the edge of the pluton.

Humming Brook Formation

Silty argillite of the Humming Brook Formation is the dominant lithology in the North River and its tributaries. The silty argillite is dark grey in colour, and generally consists of about 10% silty laminae. The silty laminae are genrally 1-2 mm thick, but thin silt beds up to 3 cm thick are seen. Some laminae and thin beds show distinct grading. In a few places, the argillite appears rather siliceous (as was also noted in the lower Harrington River).

The silty argillite has variable dips and appears to be isoclinally folded. Minimum thickness is estimated at 100m, and the true thickness is probably many times greater. Detailed structural analysis (Boner, 1985) suggests that it has suffered polyphase deformation.

Volcanic rocks of the Gilbert Hills Formation

In the lower part of the North River section, the valley is cut through a subhorizontal sequence of Gilbert Hills Formation (Fig. 8). Outcrop is rather discontinuous. On the valley floor are rhyolites and rare mafic rocks (probably flows), overlain by volcaniclastic sandstones, metacarbonates, chert and shale.

Rhyolite

(2877*, 2879*)

In hand specimen, these rocks have a greyish-white to greenish-white colour and appear highly brecciated. The rocks are generally featureless and aphanitic.

These are porphyritic rocks with phenocrysts of quartz and feldspar set in a microcrystalline to cryptocrystalline groundmass. The phenocrysts are fresh and show myrmekite and graphic intergrowths, which commonly grade out into the matrix. Some feldspar phenocrysts are zoned.

..check geochem to confirm that these look like Hadrynian rather ..than Carboniferous - ggp

Mafic ?flow (270*)

In hand specimen, this is a medium grey fine grained amygdaloidal basalt. Flattened dark spots 0.5 to 1.5 mm in length are evenly distributed throughout the sample.

In thin section, outlines of original phenocrystal plagioclase can be seen. The metamorphic mineral assemblage consists of chlorite, epidote, sericite and albite. The dark spots contain aggregates of chlorite and sericite, and appear to be vesicles rather than porphyroblasts.

Felsic ash

One prominent outcrop in the river exposes fine grained felsic ash (1010*) and some tuffs, with substanital bedding irregularities that appear to represent a pre-cleavage slump (Fig. 9).

Metacarbonate and associated rocks

Field observations

A variety of lithologies are associated with the metacarbonates. Almost pure white marbles alternate with yellow and green calc-silicate rocks, white quartzite (?or chert) and thin silty shale. A strong penetrative cleavage is associated with flat-lying isoclinal folds. This cleavage has been refolded into open, upright folds with an associated crenulation cleavage (Fig 10).

The white marbles contain rare quartz and opaque minerals that include pyrite and malachite. No clear relationship between mineralogy and structure were seen. There are two main types of calc-silicate rock. The green lithology consists of calcite and chlorite, with the chlorite developed along the pentrative cleavage and displaying the later crenulation cleavage well. The yellow lithologies appear banded in hand specimen, with bands picked out by the alternation of minerals including quartz, calcite, garnet, epidote, and actinolite. Minor clinopyroxene (hedenbergite or diopside) and opaque minerals including sphalerite and magnetite are also present. The garnets show interesting zoning and cleavage relationships that are described in detail below. A similar mineral assemblage, but with quartz predominant, occurs in the quartzites.

The silty shales contain chlorite and biotite (with minor quartz and epidote) that appear folded and fractured, and may have developed synchronously with the axial planar cleavage. Large mica flakes lie in the cleavage, but are not in any way folded.

Garnet mineralogy in the calc-silicate rocks

Garnets in the yellow calc-silicate rock have formed in massive bands, and have a strong fracture cleavage (Fig. 11) that is folded into upright open folds and is approximately parallel to the regional flat-lying penetrative cleavage. The massive garnets show optical zoning. In places, they are overgrown by uncleaved euhedral garnets. The uncleaved garnets appear associated with sphalerite and magnetite bands, which likewise appear undeformed.

Electron microprobe analyses show that grossular garnet occurs in the more siliceous lithologies (along with diopside) whereas andradite occurs in the more calcareous lithologies. (along with hedenbergite). The optically zoned fractured garnets show little chemical change corresponding to the optical zones. Andradite locally contains irregular patches of more grossular composition, presumably representing a failure to achieve equilibrium. The uncleaved rims contain a high proportion of the spessartine molecule.

The garnets that are present are those typically developed during thermal metamorphism (Deer et al., 1967; Einaudi et al., 1981). These garnets appear to have suffered a subsequent fracture cleavage when their host rock was isoclinally folded and cleaved. These cleavages are coincident with the regioal flat- lying cleavage of the Jeffers Group. The oldest thermal metamorphism thus appear to predate the main folding of the Jeffers Group. The uncleaved garnet represents a second thermal metamorphic event. This event most probably corresponds to the intrusion of the North River Pluton and associated dyke swarms.

Probable Hadrynian mafic dyke (2880*)

This mafic rock apparent intrudes a massive rhyolite unit and is cleaved with the rhyolite. In thin section, it appears highly altered. It has a prophyritic texture with large elongate feldspar phenocrysts set in a fine grained matrix. This matrix is completely altered to dusty opaque oxides, chlorite, actinolite and epidote. There are large rounded pseudomorphs of actinolite and chlorite after ferromagnesian mineral phenocrysts, some of which are rimmed by dusty opaque oxides

Cranberry Lake Formation (1002*, 1003*)

These rocks are exposed in a fault slice immediately north inal glass. of the

Cobequid Fault zone. They consist of well bedded fine grained greywackes and siltstones in beds typically 0.5 to 5 cm thick. This lithology is assigned to the West Brook facies of the Cranberry Lake Formation.

Cleaved mafic hypabyssal intrusions

High -Ti tholeiite intrusions (283, 981, 983, 989, 1006*, 1215, 1220)

These rocks occur as dykes showing varying degrees of deformation, and near the Cobequid Fault as thick sills that intrude the Cranberry Lake Formation.

In thin section, little remains of the primary mineralogy, which has been extensively metamorphosed. Primary minerals include Ti-rich augite, sphene, plagiocalse, K-feldspar, opaque minerals and minor quartz. Relict plagiocalse crystals lie within highly altered augite crystals, suggesting an original sub- ophitic texture. Metamorphic minerals include abundant actinolite, epidote, chlorite, sericite and minor biotite and albite.

These rocks show mineralogical and chemical affinities to the Harrington River facies mafic flows above the upper thrust zone in lower Jeffers Brook (3201, 3207); to rare dykes (881) on the Lynn Road; and to the high-Ti tholeiite intrusions of the Lower Harrington River.

Feldspathic mafic hypabyssal rocks (261, 263, 271, 1009, 1013*)

These rocks occur as dykes with slight or no cleavage; near the Cobequid fault zone, some show cataclastic texture. In thin section, they show an original porphyritic texture of large plagioclase and alkali feldspars set in a finer matrix of quartz, plagiocalse, K-feldspar and secondary biotite. Minor epidote, sericite and albite may also be present.

These intrusions appear similar to the feldspathic mafic sills of the Lynn Road (567).

Slightly cleaved intermediatee - mafic dykes (267, 1218)

These dykes show only slight cleavage, and are probably post-Hadrynian in age. They show distinctive large, well formed muscovite crystals. Coarser samples preserve a subophitic texture, with primary clinopyroxene, orthopyroxene, plagioclase, K-feldspar, opaque minerals and quartz. Secondary minerals include actinolite, chlorite and sericite, with minor epidote, albite and biotite. The rocks show closely spaced fractures along which alteration to dusty opaques has taken place.

Probable Carboniferous intrusive rocks

The dyke complex

This complex is made up of a series of mafic dykes (1627*) and microgranites (1639*) which border the North River Pluton. The mafic dykes contain primary plagioclase, K-feldspar and opaque minerals. Metamorphic minerals include sericite, biotite, chlorite and minor amounts of fine epidote.

Mafic dykes within the North River pluton (1643*, also 1676* sill in Bass River Five Islands section)

In thin section, rocks from these dykes have an original sub-porphyritic texture. All primary minerals are highly altered. Relic clinopyroxene and small alkali feldspar phenocrysts are surrounded by an interlocking matrix of minute plagioclase laths, chlorite, albite, epidote, sericite and minor biotite.

A foliation is well defined by the alignment of metamorphic minerals and opaques. Since these dykes intrude the pluton, they would act as weak points within the pluton. Stress in the pluton would be represented by strain in the dykes.

Pink microgranite

These rocks have a holocrystalline groundmass of alkali feldspar and plagioclase. Coarse rocks have a greater difference in grain size between groundmass and phenocrysts. Vermicular intergrowths of quartz and sodic feldspar form smaller phenocrysts. The finer grained rocks contain fewer myrmekite intergrowths and have phenocrysts of embayed quartz, microcline and orthoclase.

Deformation ranges from undulose extinction in quartz to parallel alignment of chlorite in finer rocks. Metamorphic minerals include biotite, chlorite, epidote, sericite and calcite in small aggregate patches.

Cleaved granophyre

In the field, these rocks are a very light pink to almost white colour. In thin section, primary minerals include quartz, orthoclase and other feldspars, minor biotite, plagioclase and opaque minerals. The primary texture is granophyric. A foliation was produced by the alignment of muscovite and stretching out of feldspars. All quartz grains show undulose extinction.

Tholeiitic mafic intrusion

A mafic dyke (1000*) is petrographically somehat similar to the high-Ti tholeiite intrusions of the Harrington River occurs within the Cranberry Lake Formation near the Cobequid Fault. It consists of acicular feldspars and clinopyroxene that is partly altered to brownis hornblende and chlorite.

Geochemically, this dyke is quite unlike the high-Ti tholeiites: it more resembles the composite tholeiitic dykes cutting the Jeffers Brook pluton and the Wilson Brook Formation basalt. zone

9. UPPER BASS RIVER FIVE ISLANDS AND AREAS TO THE EAST

Introduction

A thick sequence of sandstones and argillites of the Cranberry Lake Formation outcrops in the Bass River Five Islands and its tributaries north of the North River Pluton. The sequence is complicated by thrust faulting, at least in the area just north of the pluton. No distinctive marker horizons have been recognised, so it is not possible to correlate in detail from the sections in the tributaries to the section in the main stream. The boundary between the West Brook facies and the Pike Fire Brook facies is based on the first appearance of common thick beds of sandstone, and may be diachronous.

The rocks were mapped as unfossiliferous Wilson Brook Formation (Silurian) by Donahoe and Wallace (1982). This assignment was apparently based on an apparent strike continuation from fossiliferous sandstones and mudstones in the West Economy River. Some reconnaisance mapping was therefore carried out in this area. The degree of lithification and deformation of the fossiliferous Silurian mudstones is much less than in the argillites in the Bass River of Five Islands, and the sedimentological facies is quite different. The turbidite sandstones of the Bass River of Five Islands much more closely resemble the Cranberry Lake Formation exposed on Lynn Road, which is cut by feldspathic basaltic andesite intrusions of probable Hadrynian age.

Cranberry Lake Formation

Thin bedded fine sandstones and siltstones

These rocks are assigned to the West Brook facies. The fine sandstones and siltstones occur in beds typically a few centimetres thick and interbed with argillite. Locally beds are up to 40 cm thick. The argillite contains silty laminae. The only structures seen in the sandstones is poor grading and in some beds parallel lamination.

Similar rocks outcrop in the East River of Five Islands, with thin fine sandstone beds up to 3 cm thick, which locally show Bouma BC sequences.

Thick bedded fine to medium sandstones (3069,)

These rocks are assigned to the Pike Fire Brook facies. Beds of sandstone vary in thickness from a few tens to a few hundreds of centimetres. They interbed with argillites. Most of the beds appear massive. A few structures commonly found in turbidite sequences have been observed: these include load balls, erosive bases to beds, convolute laminae (truncated by parallel laminae - 3070). Many of the beds appear poorly graded, and would be termed AE beds in the Bouma classification of turbidites. Elsewhere, AB beds are seen, with the B division 30-50% of the thickness of the A division. Some such beds have groove marks on their soles. Rare beds show the Bouma ABC sequence, with well developed ripple drift at the tops of beds.

The petrographic composition of the sandstones is dependant on their grain size. Sample 3073, with a median grain size of 0.5 mm, is from a 1.3m thick massive coarse to medium sandstone bed, and is of arkosic composition, with 39% feldspar. Lithic fragments (23%) are predominantly felspathic lavas and granophyric granite. The low quartz content (2%) is a reflection of the coarse grain size. Sample 3725, with a median grain size of 0.3 mm, is from a 40 cm bed of medium sandstone in East River of Five Islands. It is a lithic arkose, with 42% igneous rock fragments and 23% feldspar. Quartz makes up 19% of the sandstone. Sample 3069, with a median grain size of 0.15 mm, is also a lithic arkose, with 35% lithic fragments, 25% feldspar and 20% quartz. Siltstones (e.g. 3070) with median grain size in the range of 0.05 mm have subequal abundances of quartz and feldspar.

Occasional samples (e.g. 2586 with a median grain size of 0.3 mm) have much higher quartz contents, with only minor feldspar and chlorite. The quartz ranges from sub-rounded to rounded.

Intraclast conglomerate with a very coarse sandstone matrix (3080, 3081)

An intraclast conglomerate with a very coarse sandstone matrix has been found only in one small area on the upper part of the Bass River of Five Islands, within an area of West Brook facies. The rock contains about 65% intraclasts, mostly of silty argillite 1-3 cm in size. The very coarse sandstone matrix has a wide variety of well rounded lithic clasts, including fine and coarse mafic trachytic lava, graphic textured granite, medium sandstone and spherulitic rhyolite; intraclasts of very fine sandstone with argillaceous matrix, silty argillite, and argillite; and abundant grains of quartz and a few rounded plagioclase crystals. There is a silt sized matrix between the sandstone grains. The rock overall is clast supported.

Sedimentological interpretation of the Cranberry Lake Formation

The upper Bass River of Five Islands area provides the most continuous sections through the Cranberry Lake Formation. Although the structure is complicated by thrusting, there is an overall upward fining sequence from Pike Fire Brook facies to West Brook facies.

There is a lack of conglomeratic beds within the Pike Fire Brook facies, and even coarse sandstone beds are rare. Most beds are of fine to medium sandstone. These beds are generally massive, showing a Bouma AE structural sequence. AB beds are rare, and ABC beds have been seen only in one outcrop. Thus the beds overall have a very proximal character. This is also indicated by the presence of groove casts, but no flute casts, on soles. Thick massive beds (up to 1.5 m thick) generally occur at the base of small fining and thinning up sequences of beds. The coarse grain size and bed thickness of the thickest beds in the Pike Fire Brook facies in this region is greater than in any other mapped areas of the Cranberry Lake Formation.

The West Brook facies also has rather proximal characteristics: the thin beds generally appear to be AE Bouma sequences, and there is an absence of well developed structures. The intraclast conglomerate with a coarse sandy matrix may represent an unusual transport of more proximal sediment downslope, perhaps as a result of slumping.

Hypabyssal intrusions

Rare sills (3066) of feldspathic mafic rock with a feldspathic trachytic groundmass occur within the Cranberry Lake Formation.

A dyke (3062) of similar composition trends 160 in the Cranberry Lake Formation. It has a subophitic texture with long thin plagioclase laths partially enclosed in subhedral clinopyroxene crystals. The feldspars are mostly twinned and some are zoned. Opaque minerals are anhedral and account for about 3% of the rock. Large rounded clsots of chlorite and secondary biotite may be amygdules. Chlorite is the dominant secondary
mineral; epidote and biotite also occur.

Wilson Brook Formation in the West Economy River

The base of the Wilson Brook Formation is exposed along the Simpson Lake road. A massive rhyolite (3737*) is overlain by a very coarse sandstone with clasts up to 1 cm (3735). This is then overlain by a sequence of bioturbated silty mudstones and interbedded sandstones. These sediments are well exposed in a tributary of the West Economy River. Sandstone beds are mostly 2 - 10 cm thick, with sharp bases and bioturbated tops. The sandstones tend to be lenticular and have low angle planar cross bedding. They closely resemble the storm-graded sandstone beds described from the Arisaig section by Cant (1980). In the West Economy River, cleaved grey shales outcrop. ..check the Cant reference

The basal rhyolite (3737*) has a seriate prophyritic texture with a cryptocrystalline groundmass and subhedral to anhedral phenocrysts (30%) of quartz, K-feldspar and plagioclase. Many of the quartz and K-feldspar phenocrysts are embayed and some have irregular boundaries as if reacting with the groundmass. Many of the K-feldspar crystals have a core of the groundmass material, of a lath-shaped feldspar crystal that appears to have crystallised under different crystallographic orientation. Most plagioclase phenocrysts have irregular discontinuous twins and are altered to sericite and minor chlorite and epidote. They contain inclusions of zircon. Many of the quartz phenocrysts show a conchoidal fracture. Cubic opaque minerals (pyrite) make up about 1% of the rock. There are clots of fine-grained (?)quartz which is slightly coarser than the groundmass. A few crystals show a radial structure. A possible pseudomorph after pyroxene was seen, altered to sericite, chlorite, opaques and zircon.

Petrographically, the medium to fine sandstones of the Wilson Brook Formation (3717) are arkosic whereas the very fine sandstones (3721) are quartzose (Table 3).

10. BROWN BROOK - WEST BROOK AREA

Introduction

West and Brown Brooks provide a long section across the strike of the rocks north of the Cobequid drainage divide. The area has a thick till cover (reflected in numerous blueberry fields) and bedrock outcrop is limited. Cumberland Group sedimentary rocks onlap at the northern edge of the area. Outliers of Fountain Lake rhyloite occur in several places. The fossiliferous Silurian Wilson Brook Formation is much less extensive than mapped by Donohoe and Wallace (1982). Its contact with the Cranberry Lake Formation to the south appears to be faulted.

Cranberry Lake Formation: West Brook facies sandstones and siltstones (615*, 616, 617)

The Cranberry Lake Formation in West Brook consists of quartzose sandstones, laminated siltstones and mudstones and felsic crystal tuffs. The siltstones and mudstones are well cleaved and show isoclinal folding. Cleavage dips about 40 W generally. In Brown Brook, the Formation consists of siltstones and mudstones with interbedded felsic tuffs and rare spherulitic rhyolites (which may be either of intrusive or extrusive origin). All the rocks have a pronounced cleavage dipping some 40 SW.

The sandstones and siltstones are very variable in grain size: some might be tuffs. They generally have a high proportion of matrix (33-79%) dominated by muscovite, fine grained quartz and feldspar; crystals or grains of quartz (6-10%) and feldspar (11-17%), often broken; and variable amounts (0-57%) of felsic rock fragments, including vein quartz, siltstone intraclasts, and various rhyolites. The foliation, where present, is defined by muscovite and dusty opaque minerals. Secondary minerals consist of muscovite, chlorite, opaque oxides and some epidote. .. [note similar to 826 Harrington and 1060 Hanna]

Rhyolites that might be either Jeffers Group or intrusive

Rhyolite sample 610 occurs within the Cranberry Lake Formation: whether it is part of the sequence or an intrusion is unclear. In thin section, this rock is seen to have an almost spherulitic texture (Plate 34). They consist of plagioclase phenocrysts (32%) and some opaque minerals (~1%) set in a groundmass (67%) that is rich in K-feldspar. Cognate clots of early crystals of quartz (Plate) are common. Some pyrite is also present. Secondary minerals consist of iron oxides and chlorite.

Rhyolite sample 1848 may also be part of the sequence or intrusive. In thin section this has an almost spherulitic texture. Principal minerals are plagioclase, K-feldspar and quartz, with secondary iron oxide, chlorite, muscovite and rare actinolite.

Silurian Wilson Brook Formation

Much of the Wilson Brook Formation consists of uncleaved bioturbated mudstone, thin graded siltstone and thicker sandstone beds. Some sandstones contain coquinas. Dips are typically about 40 N, but are in places almost vertical, perhaps indicating the presence of large faults. One 3 cm thick bed of oolitic hematite (2151) has been found. A rhyolite sill (2149) cuts the sediments.

At the base of the Wilson Brook Formation, basalt (1299*) is interbedded with steeply dipping red siltstones, sandstones and conglomerates (which contain basalt clasts). The finer sediments have an almost vertical cleavage and their degree of induration is similar to that in mudstones in the Wilson Brook Formation. These beds probably correlate with the basal Silurian red beds and volcanics in the Antigonish Highlands (Murphy, 1984). The basalt is amygdaloidal with an equigranular sub-ophitic texture. The feldspar laths are long, needle-shaped, and very ragged in appearance. They are partly enclosed by small equant clinopyroxene grains. Apparently primary opaque oxide minerals make up 15-20% of the rock. They are generally cubic: there are local patches where they are acicular. Alteration is to chlorite, possibly hornblende and dusty opaque oxides. The amygdales consist of chlorite, calcite and possibly natrolite.

Hypabyssal intrusive rhyolite (619*)

This is a porphyritic intrusive rhyolite that occurs in an igneous body several tens of metres across. Euhedral to subhedral phenocrysts of quartz (9%), plagioclase (1%) and some opaques are set in a crystalline groundmass (~90%) of K-feldspar, quartz and plagioclase (Plate 34). Some of the plagioclase phenocrysts show a fragmentary texture. Most of the groundmass feldspars appear completely altered to sericite, although rare fresh plagioclase laths do occur. Micromyrmekitic textures (Plate) have been seen in the groundmass. Secondary minerals consist of muscovite, chlorite and iron oxides. Xenoliths of siltstone are common.

Carboniferous microgranite in West Brook (2607*)

This microgranite occurs as a dyke some 50 m wide and over 500 m long. No evidence has been seen for the granitic pluton mapped by Donohoe and Wallace (1982). It has a prophyritic texture with ragged phenocrysts of plagioclase, quartz and alkali feldspar in a microcrystalline groundmass of the same constituents. The groundmass contains equant grains which are reddish in colour and includes scattered anhedral to cubic opaque oxide minerals. Alkali feldspar phenocrysts show perthitic intergrowths. Accessory minerals include minor zircon and green ?hornblende. Alteration is to chlorite, calcite and dusty opaque oxides.

Gabbro of unknown age (1851*)

In the upper part of Brown Brook there is a small area of gabbro outcrop with the Cranberry Lake Formation. It is not associated with any marked magnetic anomaly. It may represent either a Hadrynian or a Carboniferous intrusion.

11. KIRKHILL MOUNTAIN

Introduction

The Kirkhill Fault cuts Hadrynian and other rocks between Glasgow Mountain and the Hanna Farm Pluton. The rocks are highly cataclastically deformed. Several lithologies are present in this cataclastic zone: diorite of probable Hadrynian age; granite of both probable Carboniferous and probable Hadrynian age; sediments of probable Hadrynian age; and a variety of Jeffers Group volcanic rocks (mafic and rhyodacite lavas and felsic to intermediate cataclastic rocks). Contacts betwen these lithologies are everywhere tectonic.

Hadrynian plutonic rocks

Hornblende diorite (021*, 503*, 504*, 506*, 3880-3883)

This diorite has a sub-ophitic texture produced by stubby- shaped plagioclase crystals partially enclosed in equant crystals that were probably originally clinopyroxene. These clinopyroxene crystals have altered almost entirely to brown and greenish fibrous amphibole. Rarely, actinolite needles are observed within the plagioclase. An accessory anhedral silvery-grey opaque mineral also occurs as veins and as small needle-like grains within the hornblende. This diorite closely resembles the Jeffers Brook diorite.

Porphyritic diorite (018)

This diorite consists of plagioclase phenocrysts up to 1 cm long set in a fine-grained feldspar and hornblende matrix. Hornblende has altered to actinolite and chlorite. Accessory cubic opaque oxides are scattered throughout the matrix.

Quartz diorite (001, 020*)

This quartz diorite consists of large randomly oriented feldspar laths with interstitial quartz (which appears to be in optical continuity over large areas). The accessory minerals are biotite and opaque oxides. Most of the original texture has been lost to the brittle deformation, which has produced small angular grains of quartz and plagioclase in a highly altered fine grained matrix, consisting principally of angular grains of feldspar and epidote, with some sericite, chlorite, and dusty opaques.

Inequigranular leucogranites (3600, 3601)

This granite occurs only in a small section south of the Kirkhill Fire Tower, probably as a discrete fault slice. In hand specimen, it is inequigranular, white to greyish in colour, with large plagioclase, K-feldspar and quartz crystals set in a finer matrix.

In thin section, the granite is glomeroporphyritic, with large quartz, plagioclase and K-feldspar crystals set in a microcrystalline matrix of the same minerals. The cluster of phenocrysts commonly show granitic texture and in some some places there are graphic, perthitic and myrmeketic intergrowths. The matrix locally shows a fabric and is in places altered to greensih secondary biotite. Brittle deformation is evident in fractured grains, strained quartz, bent feldspar twins and the development of mortar texture. There are inclusions of a fine grained, probably mafic, rock consisting of fledspar and chlorite with a pilotaxitic texture. It is unclear whether these are xenoliths or clasts produced during deformation.

This composition and porphyritic nature of this granite is similar to the Hadrynian leucocratic granite in Henry Brook.

Jeffers Group rocks

Porphyritic white rhyolite (3616)

This rhyolite in hand specimen consists of spherules of quartz and plagioclase set in an aphanitic white matrix. Although the sample is iron stained, no mineralisation is observed.

In thin section, it has a cataclastic texture with angular and rounded grains of quartz and plagioclase enclosed in a finer grained matrix. The large grains are strained and in places show the development of mortar texture. There are some large angular fragments which show a granitic texture. The fine grained matrix shows no alteration. There are a few isolated small fragments of hornblende and chlorite.

This sample does not closely resemble either Fountain lake or Gilbert Hills rhyolites sampled elsewhere.

Mafic lava (3824, 3801, 3822)

Some lavas are porphyritic, others equigranular; some are vesicular, others lack amygdules. The prophyritic lavas have plagioclase phenocrysts set in a pilotaxitic groundmass, which in some samples shows trachytic texture. Opaque oxides are abundant as small cubes in the groundmass. Alteration is to chlorite, epidote, dusty opaque minerals and ?calcite. The vesicles are infilled with quartz and have been stretched out and recrystallized. Deformation has partially destroyed original textures, but is not so intense as to obliterate them completely.

Rhyodacite (3821)
This is a deformed recrystallised rock. A few porphyroclasts of plagioclase are set in a fine grained matrix with abundant muscovite (probably secondary) in addition to quartz and feldspar. The muscovite shows an augen-type structure around the phenocrysts, but elsewhere shows a strong foliation. Accessory opaques shown parallel alignment to this fabric. Alteration is to chlorite and muscovite. Some coarse recrystallised bands show tight little folds. Later veins of quartz, fledspar, chlorite and ?sphene cut the rock.

Felsic cataclastites (499*, 500, 502*, 507*, 3804, 3810, 3816, 3817, 3827)
In hand specimen, these samples are cataclastic with a greenish matrix and pink alkali feldspar clasts. In thin section, these rocks have a strong cataclastic texture, consisting of angular fragments of quartz and feldspar in a finely recrystallised matrix with mylonitic bands. Alteration is to chlorite, epidote, dusty opaques and muscovite. Strain shadows produced during the deformation are filled with calcite.

Pink granites (006, 3802, 3803, 3805, 3820, 3854)

In hand specimen, these granites are equigranular and pink in colour, resembling granite from the nearby Carboniferous Hanna Farm pluton.

In thin section, they consist of fragmented and recrystallised crystals of quartz, plagioclase, orthoclase and rarely microcline. Rare undeformed patches show medium-grained granitic textures. Accessory minerals include opaque minerals in irregular patches, muscovite, and biotite (probably primary). Alteration is to chlorite, epidote and dusty opaque minerals, but alteration is minor because the protolith is not rich in ferromagnesian minerals. Mortar texture is common. Some samples (e.g. 006) show more than one phase of deformation: a ductile shearing, which has produced mylonitized bands, and a later brittle deformation which has re-oriented these bands.

12. FOWLER BROOK

Introduction

In the Fowler Brook area, between Fraserville and Spencers Island, Donohoe and Wallace (1982) mapped an area of Jeffers Formation between the Cobequid Fault to the south and the Apple River pluton to the north. In the northern part of the area, the presence of Jeffers Group rhyolites has been confirmed, bit in the southern part of the area originally mapped as Jeffers Formation consists of orthoquartzites of the Devono-Carboniferous Greville Formation. the whole area shows strong cataclastic deformation and polymict cataclastites occur.

Gilbert Hills Formation

The Jeffers Group rocks consist principally of mylonitised rhyolitic lavas or felsic tuffs, assigned tentaively to the Lakelands facies. They are pink, white or grey in colour, locally appear banded, and in many places are fractured, cleaved or brecciated. The maximum observed thickness of rhyolite exceeds 60 m. Some mafic lithologies interbedded with the rhyolites may be either lavas or hypabyssal intrusions.

Rhyolite
The least deformed samples (480) have a seriate prophyritic texture with rounded or subhedral phenocrysts of feldspar and quartz in a cryptocrystalline groundmass. Many feldspars show intergrowth textures. The groundmass shows a weak fabric, with minor alteration to chlorite. Microfaults are common.

Sheared and brecciated cataclastites (134, 458, 473, 486, 488)
These samples probably have a rhyolite protolith. They show a strong foliation fabric in the matrix, picked out by stretched out grains of quartz and feldspar. Microphenocrysts of quartz and feldspar are generally anhedral and some show bands of recrystallised material extending out from either side. Some more epidotised domains are observed in the rock. Brecciation has occurred in the rock after the development of the foliation.

Brecciated cataclastites (140, 535)
These rocks have a felsic composition similar to the sheared and brecciated cataclastites described above, but have not undergone ductile shearing. The have undergone simply a brittle -type deformation, which has fragmented crystals and larger pieces of the rock.

Mylonite

These rocks show a reduced grain size and a strong fabric. Silicic and ferromagnesian-rich bands occur throughout the rock, which may be locally tightly folded. Quartz crystals and recrystallised bands are commonly very elongated. Some coarser grained bands, surrounded by finer-grained matrix, are clearly boudinaged.

Mafic ?flows

Rocks of mafic composition (594*, 595*) have been sampled within the main Gilbert Hills Formation section in the east branch of Fowler Brook. They have a weakly porphyritic texture, with feldspar phenocrysts in a highly altered groundmass. Some feldspars are twinned and most show minor alteration to sericite. The groundmass is highly altered to epidote, chlorite and opaque oxides. The samples are cut by sheared quartz grains, but quartz is absent in the groundmass. Geochemically, these rocks resemble the Harrington River facies mafic flows.

Probable mafic hypabyssal intrusions in the Gilbert Hills Formation

Mafic rocks occur within the cataclastic fault zones (460, 465, 470) and within the Gilbert Hills Formation (517). It is unclear whether these porphyritic rocks are lavas or dykes. The phenocrysts of feldspar and clinopyroxene are dusty and set in a highly altered and deformed matrix of chlorite, epidote, actinolite, opaque minerals and sericite. Recrystallised veins of quartz that cut the rock have been folded, faulted and boudinaged. The matrix shows a strong foliation.

Greville Formation

The Greville Formation includes both silty shales and sandstones. The sandstones (135, 137, 138, 483, 484) are fine to medium grained greywackes, with a median grain size of about 0.15 mm. The grains are sub-rounded, and include subequal amounts of quartz and feldspar (both plagioclase and K-feldspar).

Microgranite

Porphyritic microgranite cuts the Gilbert Hills Formation (147). Phenocrysts include plagioclase, microcline, quartz and amphibole. The groundmass has a weak foliation, but is reasonably fresh, with minor alteration to muscovite.

Microgranite also occurs within the cataclastic fault zone (463). Phenocrysts consist of rounded quartz and feldspar. The matrix shows a strong fabric due to deformation. Accessory minerals include cubic opaque minerals, rutile, allanite and euhedral sphene. Alteration is slight to chlorite, epidote and dusty opaque minerals.

Cataclastic fault zone

A variety of cataclastic lithologies occur within the cataclastic fault zone in lower Fowler Brook and at the fault contact with the Apple River Pluton. These include granite, highly schistose intermediate igneous rocks and rhyolite.

GEOCHEMISTRY

Introduction

In previous sections of this report, rocks have been grouped according to their geological occurrence and petrographic characteristics. In this section, the geochemical features of these various groups of rocks are synthesised. Because of the degree of metamorphism of the rocks studied, it is likely that many major and trace element compositions have been modified as a result of alteration of primary mineralogy. This geochemical interpretation is therefore based principally on the distribution of such relatively immobile elements as Ti, P, Zr and Y. The abundances of such elements are shown in Figures 12 - 16, using various discrimination diagrams.

Gilbert Hills Formation

Basal Lakelands facies mafic rocks

These are found in the Jeffers Brook section (448*, 730*, 942*, 945*); and in North River (270*). In the Jeffers Brook section, they are highly cleaved, and some of the analysed samples might be intrusions. Two geochemically distinct types of mafic rocks are present. One is similar to the mafic rocks of the Harrington River facies; it has the geochemical characteristics of calc-alkaline mafic rocks. The other group has rather higher Ti and lower Zr, and resembles some ocean island tholeiites. This latter group is not seen elsewhere in the western Cobequid Hills.

Lakelands facies rhyolites and felsic tuffs

Rhyolites are found in North River (2877*, 2879*); Jeffers Brook (449*); Henry Brook; Hanna Brook and possibly Fowler Brook. Felsic tuffs have been analysed from Jeffers Brook (439*, 923*, 776* ignimbrite, 708*), Henry Brook

(1051*), and North River (1010*). Rhyolitic clasts are also found within the main agglomerate outcrop in Jeffers Brook (1160*, 1178*, 1179*, 1182*). Felsic volcaniclastic sandstones associated with the pyroclastics have been analysed from Hanna Brook (1037*) and Henry Brook (352*).

Mafic clast in the Lakeland facies agglomerate

One mafic clast (1173*) has been analysed from the coarse agglomerate in lower Jeffers Group. It is an extremely alkaline rock, quite unlike any other Hadrynian rocks that have been sampled.

Harrington River facies: mafic flows

Basalt flows are abundant near the top of the type section in the Middle Harrington River (2546*, 2555*, 2542*, 2553*, 562*, 576* and 2554*). Mafic flows lower in the succession are represented by 805*, 807*, and 815*. Andesite flows have been identified only in the Middle Harrington River (557*, 558*). Harrington River facies have also been identified in the Jeffers Brook section above a major thrust zone (765*, 3201*).

Geochemically, these rocks are similar to the calc-alkaline mafic group of samples from the Lakelands facies: they have low Ti and P and relatively high Zr/Y. Geochemically similar rocks overlie thick felsic successions in the West Moose River area (1871*) and in the Davidson Brook section (1326*, 2194*). Geochemically similar mafic rocks are also found in the southern volcanic section in Lynn Road. They include 45*, 1087*, and 1088*. 1085* and 1086* are more cleaved, but have a similar chemical composition. Geochemically similar rocks (594*, 595*) also occur in the highly deformed Gilbert Hills Formation sequence in Fowler Brook.

Harrington River facies: rhyodacite

Rhyodacite flows occur in the Harrington River (812*) and Jeffers Brook (450*, 1956*, 3207*) sections, and rhyodacite occurs as a clast in the main Jeffers agglomerate (1176*).

Harrington River facies: pyroclastics

Thick mafic and felsic pyroclastics outcrop in the northern part of the study area, in Hanna Brook (1037*), Upper Harrington River and West Harrington River (428*).

Humming Brook Formation

Hornfelsed argillite (2440*) from a roof pendant in the West Moose River pluton and cleaved argillite from Lower Harrington River (1649*, 1651*, 1653*) have been analysed.

Cranberry Lake Formation

A few sedimentary rocks have been analysed from the Cranberry Lake Formation. These include fine greywacke from the West Brook facies (615*, 1002*, 2281*, 2647*) and spotted greywacke from the aureole of the Jeffers Brook pluton (641*).

Probable Jeffers Group hypabyssal intrusions

High-Ti tholeiitic basalt

These occur as sills and rare dykes. These are most abundant in the Harrington River area (1211*, 1650*, 2177*, 2550*, 2551*, 2537*, 2538*) but also occur in North River (1006*), and Lynn Road (881* dyke and 1084*). The coarse grained equivalent is a mafic porphyry with coarse plagioclase, occurring in thick sills south of Jeffers Brook (1931*) and in the upper Harrington River 2556*).

Mafic dykes cutting both the main Jeffers agglomerate (1162*, 1165*), including some with a more lamprophyric character (1159*, 1169*), are geochemically similar to these sills. So too is a mafic dyke (1934*) that cuts the mafic porphyry sill south of Jeffers Brook.

These rocks geochemically resemble ocean island tholeiites: they have relatively high P and Ti (higher than in any of the lavas in the Lakelands facies).

Feldspathic mafic sills

These are seen in the Lynn Road (188*, 867*, 2645*), upper Harrington River (313*, 2546*) and Jeffers Brook (1163*) sections.

These rocks are geochemically very similar to the Harrington River facies mafic lavas, except that some samples (1163*) have high P.

Calc-alkaline sill

A cleaved sill (1657*) in the Lower Harrington River has pronounced calc-alkaline characteristics. The rock, however, is highly altered, so that this character may be an artefact. If it is calc-alkaline in character, it is probably of Hadrynian age.

..Mafic dykes that appear to be cut by younger intrusions, or to be cleaved along with the Jeffers Group may also ..be of Hadrynian age. These need comparison with the groups already established. Examples include 2880* from North River, ?some from Lynn road

Palaeozoic volcanic rocks

Basal Silurian volcanics

Basalt has been found only in West Brook (1299*); rhyolite occurs in the Simpson Lake area (3737*).

Fountain Lake Group

A few selected samples of basalt (3917*, 3918*, 3919*, 4015*) and rhyolite (1582*, 2264*) have been analysed.

Post-Jeffers hypabyssal intrusions

Alkaline mafics in the 060 dyke

These are a series of cleaved mafic dykes striking NE - SW, many of which pass into sills and are associated with micro-granite sills and dykes, are common in the Jeffers Brook section and were previously regarded as Late Hadrynian in age (Pe-Piper and Piper, in press). New mapping has shown clearly that these intrusions post-date the main thrusting in the Jeffers Brook section; their deformation is probably of "Acadian" age. In Jeffers Brook, the dykes include 442*, 704*,706*, 764*, and 1140*. 1162*, 1165*, and corresponding micro-granites include 164*, 176* and 437*. Another microgranite (2535*) that cuts the Jeffers Brook pluton may be correlative, or may be associated with the Hadrynian plutonism. Geochemically similar composite microgranite - mafic dykes also occur in Harrington River (mafics - 427*, 819*; microgranite - 1646* intrudes Carboniferous sediment). Locally, the microgranites (2543*) and associated mafic dykes (334*, 2539*) are extremely sheared, perhaps indicating that they were still warm and ductile when deformation occurred. A prominent microgranite dyke (2607*) occurs in West Brook. These rocks probably represent feeders to the Fountain Lake Group.

Tholeiitic composite dykes

A few composite dykes of mafic rock and microgranite have tholeiitic or MORB-like geochemical characteristics. These include composite dykes in the lower Harrington River (1658* mafic) and the Jeffers brook pluton (1968* mafic, 1969* micro-granite); and a dyke (1847*) trending 060 in the powerlines clearing north of Henry Brook. The basalt from the base of the Silurian Wilson Brook Formation is geochemically very similar. ..Compare with published Fountain Lake and Arisaig mafics.

North-south dykes

A series of wide, north-south striking mafic dykes, with ophitic texture and fresh clinopyroxenes, are particularly common east of the Jeffers Brook pluton (657*, 2074*, 2084*). These rocks are geochemically rather variable.

Wide north-south microgranite dykes occur in the powerlines clearing north of Henry Brook (1844*, 1846*).

Rhyolite dyke

A distinctive rhyolitic dyke occurs in the Lynn Road section (2646*). This is lithologically similar to rhyolite flows at the base of the Wilson Brook Formation in the Simpson Lake region (east of the study area), but lacks the high Zr characteristic of
Silurian rhyolites in the Arisaig section (Keppie et al., 1979).

Other microgranites

A prominent wide microgranite dyke occurs west of West Brook
(2607*).

A distinctive rhyolite or microgranite, of unknown affinity, occurs in Browns Brook (619*).

..Mafic dykes cutting Silurian sediments .. These have been sampled at Wentworth Station 1248* and the ..Portapique River 1816*. The Wentworth Station sample is ocean ..island tholeiite character.

Late dykes and sills cutting microgranites or Carboniferous plutons

There are few observations of late dykes cutting microgranites: one has been seen in Lynn road (2833*). Dykes and sills are, however, common in the plutons (1643*, 1676*, 1869*, 1874*, 1876*, 1879*, 2012*, 2018*, 2455*, 2891*, 3002*, 3921*, 3925*, 3929*). Some are cleaved, suggesting that deformation took place while they were still a little warm.

Many of the dykes within the Carboniferous plutons are high-Ti tholeiites, similar to the probable Hadrynian intrusions.

MINERALISATION

Distribution of mineralisation

All mineralised samples collected in the field have been numbered and are shown on the 1:10 000 maps that accompany this report. Because systematic attention was paid to mineralisation only in the 1986 field season, the information on the map is not comprehensive, particularly for areas not in the Jeffers Group.

Hematite mineralisation

Mineralisation resulting in specular hematite is widespread throughout the region, and appears spatially related to the Cobequid Fault. There is intense purple hematitic staining in fault gouge shales in the Lower Harrington River [1], Lynn Road [2], and the logging road between Lynn road and North River [3]. Specular hematite also occurs in Fountain Lake Group [4] and Jeffers Group rocks [5 - 9] near these fault gouge occurrences. Hematite has also been observed associated with the Kirkhill Fault zone west of Kirkhill Mountain [28, 29].

Hematite mineralisation is also widespread in the Cape Chignecto granite. On the coast north of Baldrock Brook, it appears associated with vugs (2895, 2897, 2899) containing secondary quartz, feldspar and hematite, perhaps developed replacing ferromagnesian mineral clots. Vug formation appears to post-date the development of the strong foliation in these granites. Hematite and quartz also occur in breccia zones in the granite (2896). Elsewhere in the Cape Chignecto and Apple River plutons, the granite has a strong red colour but distinct hematite concentrations have not been seen.

Barite

Barite mineralisation also appears associated with the Cobequid Fault. It occurs in fault zones and sandstones (of unknown age) in the lower Bass River of Five Islands [10-12]; in fractures in probable Carboniferous sandstones on the Lynn Road [13]; and associated with hematite in the Lower Harrington River [1]. It also occurs in the Kirkhill Fault zone near Kirkhill Mountain [30, 31].

Mineralisation in the Fountain Lake Group

No new observations have been made on mineralisation associated with the Fountain Lake Group. ..[refer to assessment reports and to Donohoeand Wallace maps]

Sulphide mineralisation associated with frature zones near Carboniferous plutons

Sulphide mineralisation is common in fault zones close to Carboniferous plutons. The major NW - SE fault zone north of the West Moose River pluton is an example. The fault post-dates intrusion of the pluton, since it cuts the pluton and juxtaposes granite with Fountain Lake rhyolite. The fault is associated with much fracturing of apparently Carboniferous microgranite and mafic hypabyssal intrusions, and silicification of country rock. Sulphide mineralisation occurs both within the fracture zone [16- 18] and in Gilbert Hills Formation within 200 m of the fracture zone [19-21].

Sulphide mineralisation is also common in the Cobequid Fault zone immediately to the east of the West Moose River pluton [22- 24]. Sulphides occur in a fracture zone in Humming Brook formation near the southwest margin of the North River Pluton [6], and also occur in Cranberry Lake Formation rocks near the contact with the pluton at the western margin of the North River Pluton [25].

Sulphide mineralisation is also found in the Kirkhill Fault zone immediately southwest of the Hanna Farm Pluton [32, 33] and near the granite where this fault zone cuts the southern margin of the pluton [34, 35]. Azurite and malachite occur in the main thrust zone in the Lynn Road section [38].

Skarn mineralisation in North River

Sphalerite and magnetite found in skarn [14] in metacarbonates of the Gilbert Hills Formation in North River (Boner, 1985) have been described above. They are associated with late stage garnet overgrowths and are probably associated with the North River pluton.

Mineral occurrences within Carboniferous plutons

Other than the hematite mineralisation noted above, there are rare mineral occurrences within the Carboniferous plutons. Sulphides occur in the West Moose River within the West Moose River Pluton [26]. Copper minerals occur within microgranite sills close to the Hanna Farm Pluton [27].

Mineralisation in basal Silurian rhyolites

Pyrite and possibly other sulphide mineralisation appears common in the basal Silurian rhyolite in the Simpson Lake area. Pyrite and probably other sulphides also occur in rhyolite dykes on Lynn road [15] that may be correlative.

Sulphide mineralisation associated with Hadrynian plutons

Sulphide mineralisation occurs in a fault breccia in Cranberry Lake formation in NE Jeffers Brook, just beyond the margin of the Jeffers Brook pluton [36]. Similar mineralisation occurs in a rhyolite [37] in the thermal aureole at the southeast margin of the Jeffers Brook pluton.

Origin of mineralisation

Most mineralisation seen in the Western Cobequid Hills appears associated with the Carboniferous plutons and associated hypabyssal intrusions and Fountain Lake extrusives. Hematite mineralisation postdates Carboniferous granite deformation. Mineralisation might in part be related to the event that led to the development of secondary biotite in many rocks in the study area; this mica yielded a K/Ar date of 303 +- 11 Ma.

SYNTHESIS

Structural evolution

This study has not involved a systematic structural analysis of the Jeffers Group. Nevertheless, structural observations made in the course of the mapping provide a basis for some general conclusions on the tectonic history of the western Cobequid Hills.

The degree of deformation of the Jeffers Group is highly variable. In the southern part of the outcrop area, a prominent flat-lying cleavage is developed. The intensity of this deformation is spatially very variable. There are demonstrable thrust relationships between major units of the Jeffers Group. The Jeffers Brook pluton is seen in the field to cross-cut the flat-lying cleavage in the Jeffers Group. The mapped distribution of units within the Jeffers Brook section suggests that the major thrusts within this section also predate the intrusion of the Jeffers Brook Pluton. CS structures associated with these thrusts suggest tectonic transport to the southwest. However, most other major thrust zones, such as in the Lynn Road, Harrington River, West Moose River and Davidson Brook sections might be of either Hadrynian or "Acadian - Carboniferous" age. Rare CS structures in these sections suggest tectonic transport to the southeast or southwest.

There is widespread evidence for the development of flat- lying structures in the Devono-Carboniferous (referred to loosely as the "Acadian - Carboniferous" deformation). These are best developed in the Cape Chignecto - Apple River pluton and adjacent rocks (including the Jeffers Group in Fowler Brook and the Rapid Brook Formation of Donohoe and Wallace, 1985). Flat-lying structures are also seen in the more easterly Carboniferous plutons near the Cobequid Fault. Deformation of micrograinites in the Harrington River probably also dates from this time. Series of reverse faults in the Harrington River section cutting microgranites indicate a southward tectonic transport. In general, except within the Cobequid and Kirkhill Fault zones, the Fountain Lake Group appears undeformed.

From our mapping, we have a wealth of information on features such as dyke orientations, thrust fault movement, and defromation of plutons which presumably relate to Devono- Carboniferous strike-slip motion on the Cobequid Fault. A small amount of further fieldwork in critical areas will be required to adequately understand this complex history: no attempt at a comprehensive synthesis is made here.

The structural style of the "Acadian - Carboniferous" deformation is similar to that of inferred Hadrynian age: local development of a flat lying cleavage and local thrusting. This may indicate that the Hadrynian deformation took place in a strike-slip tectonic environment. Some of the geochemical data from both volcanic rocks and plutons, however, suggests that subduction might have played a role in the genesis of late Hadrynian magmatism.

Petrography of the sedimentary rocks

The sedimentary rocks of the Cranberry Lake Formation are mostly lithic arkoses, representing their derivation from a primary volcanic source. Quartz is of subequal importance to feldspar in silstones, but in sandstones the feldspar predominates. The abundance of lithic clasts is variable and, except in very fine sandstones where lithic clasts are rare, their abundance appears independant of grain size.

Hypabyssal intrusions

The classification of hypabyssal intrusions that cut the Jeffers Group is based both on field observations of cross-cutting relationships and on geochemistry. The geochemical interpretations suggest that the presence of a flat-lying cleavage is not a diagnostic feature for the identification of Hadrynian hypabyssal intrusions; a similar cleavage occurs in some intrusions that in every other respect resemble Paleozoic rocks.

<u>Hadrynian intrusions</u>

Hypabyssal intrusions are widespread within the Jeffers Group. They are particularly common within and near the volcanic sequences of the Harrington River facies, suggesting that many of the hypabyssal intrusions may be genetically related to the Jeffers Group.

a) Feldspathic mafic sills. These are geochemically calcalkaline tholeiites. They are almost identical in geochemistry and petrography to the lavas of the Harrington River facies of the Gilbert Hills Formation. They intrude Cranberry Lake Formation turbidite sequences, and have been cleaved with these sequences. It is uncertain whether this means that these parts of the Cranberry Lake Formation are older than the harrington River facies, or whether Harrington River facies magma persisted and intruded younger turbidites.

b) High-Ti tholeiite intrusions. These subalkaline intrusions occur principally as sills, and are widespread throughout the southern outcrop areas of the Jeffers Group. Geochemically, they are distinct from any of the known Jeffers Group lavas, but most closely resemble some lavas of the basal Lakelands facies. They are cleaved with the Jeffers Group, but their age relationship to the feldspathic mafic sills is not known.

c) Leucocratic marginal phases of the Jeffers Brook pluton show geochemical characteristics of subduction zone granites; so do many of the Gilbert Hills Formation felsic rocks. All analysed microgranites show "within-plate" geochemical characteristics. It is therefore unlikely that any of the microgranites are of Hadrynian age.

Post Hadrynian intrusions

Many post-Hadrynian hypabyssal intrusions appear to be geochemically similar to the Fountain Lake Group and the Carboniferous plutons. Many mafic intrusions cut the plutons and are deformed by motion on the Cobequid Fault zone. The main phase of post-Hadrynian hypabyssal intrusion is thus probably associated with this Carboniferous magmatic phase. It is difficult, however, to rule out the possibility that some of the intrusions are older. Sedimentary and volcanic rocks of Cambrian and Ordovician age are not known in the western Cobequid Hills, although Cambrian rocks are known from the Antigonish Highlands. Only minor outcrops of Silurian basalts and rhyolites have been mapped, and Silurian sediments are of limited extent. Thus there are few opportunities to use cross-cutting relationships or geochemical comparisons to identify Lower Paleozoic hypabyssal intrusions.

a) 060 mafic dykes and associated microgranites. These intrusions include both sills and dykes. The mafic rocks are alkalic. In upper Harrington River, one microgranite sill is highly foliated, probably while still warm. These intrusions are approximately synchronous with one of the phases of "Acadian - Carboniferous" deformation.

b) Wide north-south mafic dykes and microgranites. The unusual width of the dykes and their similar orientations suggests that the mafic dykes and microgranites are related.

c) Composite tholeiitic dykes. Composite dykes of mafic tholeiite and microgranite occur in several areas, in places paralleling the 060 dykes.

d) High-Ti tholeiite dykes locally cut the Carboniferous plutons. They are in places deformed. Geochemically, they closely resemble the Hadrynian high-Ti intrusions.

e) Unusual rhyolites of unknown age have been identified on the Lynn Road and Browns Brook.

The relationship of the late hypabyssal intrusions to movement on the Cobequid Fault zone

Mafic dykes and sills are abundant in the Carboniferous granites from the Cape Chignecto pluton in the west to the North River pluton in the east. The Cape Chignecto pluton is highly deformed: it contains apparently primary sill-like bodies and some late dykes. Almost no mafic hypabyssal intrusions have been seen in the Hanna Farm pluton.

In the West Moose River pluton, sills of mafic rock are common. Many are deformed along with the granite. The make up about 2% of the pluton near the Cobequid Fault in the south and as little as 0.1% at the northern edge of the pluton.

Dykes are more common than sills in the North River pluton, and are of approximately equal abundance throughout the pluton. In the southern part of the pluton, most trend east-west. In the northern part of the pluton, most trend north-south.

The major dyke complexes of the North River, West Moose River and upper McCarthy Gulch sections, in which hundreds of metres of section consist of Carboniferous microgranite and mafic dykes, are probably the result of pull apart associated with movement on the Cobequid Fault zone. The sense of motion required to produce the North River dyke complex is uncertain; the West Moose River complex would result from dextral movement on an east-west fault zone.

The abundance of slivers of plutonic rocks along the Cobequid Fault zone may in part be due to tectonic transport from plutons such as the Cape Chignecto and West Moose River that are cut by the Cobequid Fault zone. Some plutonic rocks, notably the diorites and granites in lower McCarthy Gulch, may also be the result of pull-apart during intrusion.

Further data interpretation is required to make a full analysis of the relationship between motion on the Cobequid Fault zone and the style of intrusion in the area immediately north of the fault.

The relationship between the Carboniferous granite plutons and the Fountain Lake Group

Donohoe and Wallace (1980, 1982) mapped West Moose River pluton as Carboniferous in age because it appeared to intrude the Devono-Carboniferous Fountain Lake Group. Our new mapping shows that nowhere can an intrusive relationship between the West Moose River pluton and the Fountain Lake Group; where the two are in contact, the contact is always a major fault. There is similarly no igneous contact demonstrable between the Fountain Lake Group and any of the other plutons mapped as Carboniferous by Donohoe and Wallace (1982).

All of the demonstrable igneous contacts of the West Moose River pluton with the Jeffers Group are with the Humming Brook Formation, although there are also probable igneous contacts with the Gilbert Hills Formation in the West Moose River area. Likewise, the southern margin of the North River pluton is everywhere in igneous contact with the Humming Brook Formation. Indeed, the Humming Brook Formation is restricted in its distribution to the margins of these two plutons. This distribution may be fortuitous, but it may also indicate that the Humming Brook Formation represents the deeper part of the Jeffers Group section near the Cobequid Fault Zone, brought to the surface by the forceful emplacement of the granites.

The observed relationship between the Fountain Lake Group and the Carboniferous plutons makes it possible that the Fountain Lake Group is the extrusive equivalent of the Carboniferous granites. The radiometric and geochemical evidence for such a relationship will be reported in a future paper (Pe-Piper and Cormier, in prep.).

Stratigraphic synthesis and paleogeographic setting

No basement rocks to the Jeffers Group are seen in the western Cobequid Hills. The stratigraphically oldest rocks, part of the Lakelands facies of the Gilbert Hills Formation, outcrop close to the Cobequid Fault and near the Jeffers Brook pluton. They consist of mafic lavas overlain by a felsic volcanic sequence with variable numbers of mafic flows, together with sandstones derived from reworking of the volcanic rocks and minor carbonates. The volcanic rocks include both calc-alkali basalts and basalts that resemble ocean island tholeiites.

These volcanic rocks are overlain by thick silty argillite of the Humming Brook Formation, which is interpreted as a basin slope deposit. This silty argillite may interfinger laterally and distally with coarse proximal turbidites of the Pike Fire Brook facies of the Cranberry Lake Formation, which are the only parts of the Cranberry Lake Formation to be intruded by sills of similar composition to the Harrington River facies of the Gilbert Hills formation. The more northerly developments of the Lakelands facies of the Gilbert Hills Formation pass up into fine grained volcaniclastic turbidites of the West Brook facies of the Cranberry Lake Formation.

The intermediate and mafic volcanic rocks of the Harrington River facies of the Gilbert Hills Formation in most places have a thrust relationship with underlying felsic tuffs of the Lakelands facies or fine-grained turbidites of the Cranberry Lake Formation. These thrusts are developed along zones of weak silty argilite. In the West Moose River section, they appear to conformably overlie felsic tuffs of the Lakelands facies. There is no evidence for the preservation of submarine extrusive rocks: the lavas are interpreted as subaerial flows.

The thick mafic and felsic pyroclastics, with abundant hypabyssal intrusions, seen in the northern areas of Hanna Brook, upper Harrington River and West Harrington River, appear to be a distal equivalent of the mafic lavas of the Harrington River facies. They are also thrust over rocks to the south along weak zones of silty argillite.

The Cranberry Lake Formation consists of turbidites. These generally have a proximal character, with the coarsest lithologies occurring in the east of the map area. Paleocurrent data are so sparse as to be almost useless: they may indicate transport to the northwest (Table 4). Petrographically, the sandstones are lithic arkoses and appear to be derived from a felsic volcanic source. The more proximal Pike Fire Brook facies is best developed in the east central part of the map area.

The Jeffers Group thus represents sedimentation in a deep water basin, within which volcanic islands grew and then subsided along the southern margin of the basin (Figure 17). The complex variety of rock successions can be most simply modelled as having accumulated in a series of east-west trending facies belts. The more northerly facies belts were then thrust over those to the south; the stratigraphically older rocks tending to be exposed in the south where they have been elevated by forceful Carboniferous granite intrusion. The southernmost belt consists of mafic-felsic volcanic complexes of the Lakelands facies, possibly built up on basin slope muds of the Humming Brook facies. As volcanism ceased, silty argillites and fine grained turbidites of the Cranberry Lake Formation accumulated on the flanks of the volcanoes. These incompetent rocks mark the zone over which thick mafic volcanics from the north (the Harrington River facies) have been thrust. These mafic rocks are also overlain by Cranberry Lake Formation, over which is thrust a facies belt principally of mafic pyroclastic rocks (Harrington River facies). Thrust over these are thick bedded proximal turbidites (Pike Fire Brook facies), perhaps representing a base of slope or deep sea fan environment. Thinner bedded West Brook facies turbidites overlie these deposits, and extend further to the north and west.

Acknowledgements

We thank F.W. Chandler for support and for visiting the field area; J.B. Murphy and J.W.F. Waldron for discussions in the field; and D.J.W. Piper and G. Chinn for assistance in the field. D.J.W. Piper assisted in the preparation of this report. Field work from 1983 to 1985 inclusive, all laboratory work prior to 1986, most thin sections and all geochemical work was supported by NSERC. Funding for this study through the Geological Survey of Canada is gratefully acknowledged. This manuscript was reviewed by F.W. Chandler and D.J.W. Piper.

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Table 1. PLUTONS OF THE WESTERN COBEQUID HILLS (from Pe-Piper and Piper, 1987)

Pluton name (1) (2)	lithology	Radiometric dates and other age data
Jeffers Brook	Granodiorite, with lesser diorite, gabbro and granite.	544+-22(b), 564+-22(b), 585+-23(b), 616+-28(h), 628+-28(h) (Donohoe and Wallace, 1982).
Davidson Brook	Biotite-bearing granodiorite, biotite-rich mafic diorite, minor gabbro (Blank, 1985)	Hadrynian from geo-chemical character
Cape Chignecto	Biotite-bearing granite (K-feldspar rich), with minor diorite	339+-22(Rw) (Donohoe and Wallace, 1982)
includes	Soldier Brook diorite	327+-11(b) (Pe-Piper and Piper, 1987)
Apple River	Leucocratic K-feldspar rich granite, with minor diorite, strongly foliated	Continuation of Cape Chignecto pluton (structural and pet-rographic similarity)
Hanna Farm	Biotite-bearing granite (K-feldspar rich) with minor diorite	aureole 303+-11(b) (Pe-Piper and Piper, 1987)
West Moose River	Biotite-bearing granite (K-feldspar rich), with minor diorite (Clerk, 1986)	Carboniferous by pet--rographic similarity
North River	Biotite-bearing granite (K-feldspar rich), with minor diorite (Boner, 1985)	Carboniferous by pet--rographic similarity

Notes

1. Pluton names from Donohoe and Wallace (1982). Their Soldier Brook, New Yarmouth, and Fire Tower plutons are regarded as part of the Cape Chignecto pluton. Gilbert Mountain and Wyvern plutons have not been re-investigated in detail, but the former appears to be similar to Carboniferous plutons whereas the latter is probably Late Hadrynian. The "West Brook Pluton" of Donohoe and Wallace (1982) is a large dyke which may be a marginal phase of the Gilbert Mountain Pluton.
2. Radiometric dates by potassium-argon on biotite(b) or hornblende (h) except (Rw), whole-rock rubidium/strontium dating.

Table 2. CATALOGUE OF ALL GEOCHEMICAL ANALYSED SAMPLES FROM THE WESTERN COBEQUID HILLS

Sample	file	lithology	locality	reliability	stratigraphic unit	notes
20	88	mafic	Kirkhill	uncertain		
21	177	hb diorite	Kirkhill	probable	Hadrynian pluton	
45	198	mafic	Lynn Road	probable	Harrington R. facies	:1087
164	111	granophyre	Lower Jeffers	probable	060 rhyolite dyke, probable Carboniferous	
176	286	microgranite	Lower Jeffers	probable	rhyolite dyke, probably Carboniferous	
188	183	feld. mafic	Lynn Road	definite	feld. mafic sill, Hadrynian	
270	170	mafic	lower North R	probable	Lakelands facies	:1249
313	171	mafic	U Harrington	probable	feld. mafic sill, Hadrynian	
334	185	mafic	U.Harrington	probable	Carboniferous rhyolite/mafic intrusions	:2539
352	186	sandstone	Henry BK	definite	Lakelands facies.	Sandstone associated with reworking of rhyolite
368	187	feld. mafic	L Lynn Rd	possible	?intrusion. From a highly cleaved thrust zone	
373	188	feld. mafic	L Lynn Rd	possible	?intrusion. From a highly cleaved thrust zone	
379	189	mafic	Lynn Road	uncertain	complex thrust zone	
380	190	mafic	Lynn Road	uncertain	complex thrust zone	
388	191	cleaved mafic	Lynn Road	uncertain	complex thrust zone	
395	192	granite	Lynn Road	probable	Carboniferous microgranite intrusion	
427	193	diabase dyke	W Harrington R	probable	Carboniferous rhyolite/diabase intrusions	
428	194	rhyolite or felsic	W Harrington R	probable	Lakelands facies tuff	
436	112	rhyolite	Lower Jeffers	uncertain	060 microgranite <u>or</u> rhyolite in Lakelands facies	
437	113	microgranite	Lower Jeffers	definite	060 microgranite	
439	114	tuff	Lower Jeffers	definite	lower Lakelands facies	
442	115	diabase	Lower Jeffers	definite	060 diabase dyke	
444	116	mafic	Lower Jeffers	probable	High Ti hypabyssal intrusion	

446 195	mafic	Lower Jeffers	probable	High Ti hypabyssal intrusion
448 196	mafic	Lower Jeffers	probable	basal Lakelands facies
449 117	rhyolite	Lower Jeffers	probable	Lakelands facies
450 168	rhyodacite	Lower Jeffers	uncertain	in thrust zone at top of Lakelands facies, might be base of Harrington River facies
451 118	phyllite	Lower Jeffers	definite	in thrust zone at top of Lakelands facies
452 197	cleaved mafic	Lower Jeffers	uncertain	in thrust zone at top of Lakelands facies, might be base of Harrington River facies
499 199	felsic cataclastite	Kirkhill	probable	Jeffers Group
502 902	felsic cataclastite	Kirkhill	probable	Jeffers Group
503 200	hbl. diorite	Kirkhill	probable	Hadrynian pluton
504 201	hbl. diorite	Kirkhill	probable	Hadrynian pluton
506 119	hbl. diorite	Kirkhill	probable	Hadrynian pluton
507 120	felsic cataclastite	Kirkhill	probable	Jeffers Group
557 172	andesite	Harrington R	definite	Harrington River facies, near base of upper mafic unit
558 173	andesite	Harrington R	definite	Harrington River facies, near base of upper mafic unit
562 203	mafic	Harrington R	definite	Harrington River facies, near base of upper mafic unit
576 174	mafic	Harrington R	definite	Harrington River facies, intermediate volcanic unit.
594 204	mafic	Fowler Brook	probable	Harrington River facies, within main Fowler Brook felsic sequence
595 205	mafic	Fowler Brook	probable	Harrington River facies, within main Fowler Brook felsic sequence
615 175	greywacke	Brown Brook	definite	West Brook facies
619 176	rhyolite	Brown Brook	uncertain	intrusion, possibly Silurian
641 121	spotted gw	Upper Jeffers	definite	West Brook facies
645 206	andesite	Upper Jeffers	possible	change to feldspathic mafic dyke
657 122 123	mafic	Upper Jeffers	definite	N-S dykes
668 125	mafic	Upper Jeffers	probable	marginal dyke of Hadrynian pluton
701 126	phyllite	Lower Jeffers	probable	top of Lakelands facies
704 208	mafic	Lower Jeffers	definite	060 dykes
706 127	mafic	Lower Jeffers	definite	060 dykes

708	128	felsic tuff	Lower Jeffers	probable	thrust zone between Lakelands and Harrington River facies
713	209	mafic	Lower Jeffers	possible	basal Harrington River facies, or high Ti hypabyssal intrusion
730	129	mafic	Lower Jeffers	probable	Lakelands facies mafics
764	130	mafic	Lower Jeffers	definite	060 dyke
765	131	mafic	Lower Jeffers	uncertain	Harrington River facies
776	132	ignimbrite	Lower Jeffers	probable	Lakelands facies
805	89	mafic	Harrington R.	probable	Harrington River facies, near base
807	905 906	mafic	Harrington R.	probable	Harrington river facies, near base
812	90	rhyodacite	Harrington R.	probable	Harrington River facies, within tuff sequence CHECK
815	907	mafic	Harrington R.	probable	Harrington River facies, near base.
819	210	mafic	Harrington R.	uncertain	margin of "Acadian" microgranite sill
856	134	microgranite	Lynn Road	probable	"Acadian" microgranite
857	135	microgranite	Lynn Road	probable	"Acadian" microgranite
860	91	mafic	Lynn Road	probable	mafic hypabyssal intrusion
867	92	feld. mafic	Lynn Road	probable	feld. mafic hypabyssal intrusion
873	136	microgranite	Lynn Road	probable	"Acadian" microgranite
881	93	mafic	Lynn Road	uncertain	mafic hypabyssal intrusion
923	288	felsic tuff	Lower Jeffers	probable	Lakelands facies
942	289	andesite	Lower Jeffers	probable	mafics at base of lakelands facies
945	137	mafic	Lower Jeffers	probable	mafics at base of Lakelands facies
1000	903	mafic	North River	sill	
1002	95 96	greywacke	North River	probable	West Brook facies
1003	97	mafic	North River	sill	
1006	98	mafic	North River	probable	sill, high Ti tholeiite
1010	139	felsic tuff	North River	probable	Lakelands facies
1013	99	mafic	North River	probable	sill, feldspathic basaltic andesite
1017	100	mafic	Hanna Brook	uncertain	sill or flow. Vesicular. If sill, associated with "Acadian" microgranite

1020	101	mafic	Hanna Brook	uncertain	sill or flow. Vesicular. If sill, associated with "Acadian" microgranite
1037	102	volcaniclastic sst	Hanna Brook	probable	Lakelands facies
1051	140	felsic tuff	Henry Brook	probable	Lakelands facies
1061	141	microgranite	Henry Brook	probable	"Acadian" microgranite
1070	142	volcaniclastic sst	Henry Brook	probable	Lakelands facies
1078	212	greywacke	Powerlines	probable	West Brook facies
1081	103	greywacke	Lynn Road	probable	West Brook facies
1082	104	feld. mafic	Lynn Road	probable	feld. mafic sill
1083	105	mafic	Lynn Road	probable	lava in southern volcanic zone
1084	213	mafic	Lynn Road	probable	High Ti hypabyssal intrusion
1085	904	mafic	Lynn Road	probable	Harrington River facies lava
1086	106	mafic	Lynn Road	probable	Harrington river facies lava
1087	214	vesicular mafic	Lynn Road	probable	Harrington River facies lava
1088	215	vesicular mafic	Lynn Road	probable	Harrington River facies lava
1089	107	granite	Lynn Road	probable	presumably Carboniferous granite
1107	143	mafic	Jeffers Rd	probable	Harrington River facies lava
1140	217	diabase dyke	NE Jeffers	probable	major dyke trending 060
1159	108	mafic dyke	Jeffers falls	probable	lamprophyric high Ti intrusion
1160	144	rhyolite (clast)	Jeffers falls	probable	Lakelands facies
1162	109	mafic dyke	Jeffers falls	probable	060 dykes
1163	145	feld. mafic	Jeffers falls	probable	feldspathic mafic dyke
1165	146	mafic dyke	Jeffers falls	probable	060 dykes
1169	110 147	mafic dyke	Jeffers falls	probable	lamprophyric high Ti tholeiite intrusion
1173	148	mafic (clast)	Jeffers falls	definite	Lakelands facies
1176	149	rhyodacite (clast)	Jeffers falls	definite	Lakelands facies
1178	150	rhyolite (clast)	Jeffers falls	definite	Lakelands facies
1179	151	felsic tuff (clast)	Jeffers falls	definite	Lakelands facies

1182 166	rhyolite (clast)	Jeffers falls	definite	Lakelands facies
1211 167	mafic sill	L. Harrington	probable	Hadrynian high Ti intrusion
1299 908	mafic	West Brook	probable	basal Silurian lava
1326 258	feldspathic mafic	Davidson Bk	probable	Harrington River facies lava
1381 261	tuff	Davidson area	uncertain	In Kirkhill Fault zone
1582 263	rhyolite	Davidson area	definite	Fountain Lake rhyolite
1627 244	mafic dyke	North River	probable	Carboniferous microgranite/mafic dykes, trends 060
1639 218	rhyolite dyke	North River	probable	Carboniferous rhyolite/mafic dykes
1643 247	mafic dyke	North River	probable	post-Carboniferous-pluton dyke
1646 290	microgranite	L. Harrington	probable	Carboniferous rhyolite/mafic dyke
1649 291	cleaved argillite	L. Harrington	probable	Humming Brook Fm
1650 292	mafic sill	L. Harrington	probable	Hadrynian intrusion, high Ti tholeiite
1651 293	cleaved argillite	L. Harrington	probable	Humming Brook Fm
1653 294	cleaved argillite or rhyolitic ash	L. Harrington	probable	Humming Brook Fm
1657 295	mafic sill	L. Harrington	uncertain	calc-alkaline intrusion
1658 296	mafic dyke	L. Harrington	probable	Carboniferous rhyolite/mafic dykes
1676 224	mafic sill	Bass River Fl	probable	post-Carboniferous-pluton sill
1844 236	porph. rhyolite	Henry Bk area	possible	rhyolite dyke (powerlines)
1846 306	porph. rhyolite	Henry Bk area	possible	rhyolite dyke (powerlines)
1847 307	mafic dyke	Henry Bk area	probable	060 mafic dyke
1851 156	gabbro	Cranberry Lk.	uncertain	mafic intrusion
1869 719	mafic	W. Moose R. rd	probable	mafic intrusion in Carboniferous pluton
1874 237	mafic dyke	W. Moose R. rd	probable	mafic intrusion in Carboniferous pluton
1931 265	mafic feldspathic sill	Davidson area	probable	Hadrynian high Ti tholeiite sill
1934 266	mafic dyke	Davidson area	probable	High Ti tholeiite dyke (cuts porphyritic feldspathic sill)
1956 252	rhyodacite	Jeffers Road	probable	Harrington River facies

1968 160	mafic dyke	Jeffers Bk	definite	Carboniferous rhyolite/mafic dykes (NW-SE)
1969 241	microgranite dyke	Jeffers Bk	definite	Carboniferous rhyolite/mafic dykes (NW-SE)
2074 315	mafic dyke	S.Jeffers	probable	N-S dykes
2079 321	rhyolite dyke	S.Jeffers	probable	N-S dykes
2084 317	diabase dyke	SE Jeffers	definite	N-S dykes
2085 318	rhyolite	SE Jeffers	possible	Lakelands facies, hornfelsed; may be intrusion
2177 911	mafic sill	L.Harrington	probable	Hadrynian intrusion, high Ti tholeiite
2189 912	diorite	Davidson Bk	possible	Hadrynian pluton/ intrusion part of thick sill
2190 913	mafic diorite	Davidson Bk	possible	Hadrynian pluton/ intrusion part of thick sill
2264 917	green rhyolite	Davidson area	definite	Fountain Lake rhyolite
2281 918	rhyolite or gw	NE Jeffers Bk	probable	West Brook facies
2295 919	diabase margin of sill	NE Jeffers Bk	possible	Hadrynian pluton/intrusion
2299 920	diorite sill	NE Jeffers Bk	possible	Hadrynian pluton/intrusion
2440 733	hornfelsed argill.	W.Moose R. Rd	probable	Humming Brook Fm.
2497 738	mafic dyke	Lower Moose R.	uncertain	dyke cutting Jeffers Gp, probably late
2535 922	rhyolite	Upper Jeffers	uncertain	?late microgranite, cuts Hadrynian pluton CHECK GEOCHEM
2537 923	mafic sill	U. Harrington	probable	High Ti intrusion
2538 924	mafic	U. Harrington	probable	High Ti intrusion
2539 921	mafic dyke	U. Harrington	probable	Carboniferous rhyolite/mafic intrusion. Highly cleaved
2542 925	mafic	U. Harrington	probable	feld. mafic intrusion or flow
2543 926	microgranite dyke	U. Harrington	probable	Carboniferous rhyolite/mafic intrusions Highly cleaved.
2546 927	mafic	U. Harrington	probable	feldspathic mafic sill
2549 928	mafic tuff or gw	Harrington	probable	Cranberry Lake Fm
2550 929	mafic sill	Harrington	probable	Hadrynian intrusion, high Ti tholeiite
2551 930	mafic sill	Harrington	probable	Hadrynian intrusion, high Ti tholeiite
2553 931	mafic	Harrington	definite	Harrington River facies upper mafic lavas
2554 932	mafic lava	Harrington	probable	Harrington River facies mafic lavas

2555 933	mafic	Harrington	probable	Hadrynian intrusion, might be flow	=2784
2556 934	feldspathic mafic	U. Harrington	probable	Hadrynian feldspathic mafic intrusion	
2607 948	microgranite dyke	West Brook	probable	Carboniferous microgranite intrusion	
2645 944	basaltic andesite	Lynn Road	probable	Hadrynian intrusion basaltic andesite	
2646 945	rhyolite dyke	Lynn Road	probable	intrusion of unknown age	

Table 3. MODAL COMPOSITIONS OF ROCKS

Modal compositions of rocks from the complex thrust zone, Lynn Road (recalculated to 100%).

Sample No	34	381	199	2838	202	29	869
No of grains	507	480	542	500	612	536	526
Matrix	79	62	86	10	91	32	23
Clasts	8	3	2	-	-	50	49
Crystals	13	29	12	90	8	10	15
quartz	-	1	-	-	2	0.5	-
feldspar	11	5	4	83	5	9	11
epidote	-	-	7	-	-	-	2
opaques	2	23	1	7	1	0.5	2
Veins	-	6	-	-	1	8	13
Lithology	tuff	tuff	tuff	tuff	rhd.	sst.	sst

Modal compositions of pyroclastic rocks from the Harrington River sections (recalculated to 100%).

Sample No	421	433 fine	433 crs	416
No of grains	516	816	651	647
Matrix	59	67	57	81
Clasts	-	2	1	-
Crystals	41	25	41	13
quartz	-	1	1	10
plagioclase	35	-	-	-
K-feldspar	5.5	11	25	1
epidote	0.4	12	14	-
opaques	0.1	1	1	2
Veins	-	6	1	6
quartz		6	1	2
calcite				4
Lithology	fel. tuff	maf. tuff	maf. tuff	schist

Modal compositions of pyroclastic rocks from Middle and Upper Harrington River sections (recalculated to 100%).

Sample No	299	303	325	330	331	335	336	337	338
No of grains	751	582	533	500	531	590	536	498	539
Matrix	64	37	64	40	24	75	19	18	25
Clasts	-	15	13	10	57	1	64	58	40
Crystals	35	43	16	50	14	20	11	12	35
quartz	-	3	-	3	-	11	-	-	-
feldspar	8	22	2	17	11	8	9	11	20
epidote	-	11	7	<1	-	-	0.5	-	14
opaques	27	7	7	30	3	1	1.5	1	1
Veins	1	4	7	-	5	4	6	12	0.2
quartz	1	4	7	-	5	4	6	12	0.2
calcite	-	-	-	-	-	-	-	-	-
Lithology	maf. tuff	maf. tuff	maf. tuff	maf. tuff	maf. tuff	maf. tuff	maf. tuff	maf. tuff	maf. tuff

Modal compositions of pyroclastic rocks from Middle and Upper Harrington River sections (recalculated to 100%). [CONTINUED]

Sample No	345	801	319	811	820	304	317	826	305
No of grains	506	500	509	632	667	500	500	500	500
Matrix	42	67	81	82	83	55	30	25	60
Clasts	27	-	-	-	-	30	40	59	15
Crystals	21	33	19	17	10	15	20	16	23
quartz	1	10	1	-	1	4	9	10	8
feldspar	10	20	6	4	5.5	10	4	5	10
epidote	7	-	4	-	0.5	-	4	-	-
opaques	3	3	8	13	3	1	3	1	5
Veins	8	-	-	1	7	-	10	-	2
quartz	7	-	-	-					
calcite	1	-	-	1					
Lithology	maf. tuff	maf. tuff	rhd. lava	rhd. lava	rhd. lava	fel. tuff	fel. tuff	fel. tuff	gw

Modal compositions of rocks from the Cranberry Lake Formation, SE Branch Jeffers Brook (recalculated to 100%).

Sample No	625	627	630	632
No of grains	586	500	500	500
Matrix	61	60	65	82
Clasts	5	10	11	5
Crystals	33	28	23	8
quartz	-	-	2	<1
feldspar	21	15	10	1
epidote	2	3	1	5
opaques	10	10	10	2
Veins	1	2	1	-
Lithology	sandstones and siltstones			

Modal compositions of rocks from the main agglomerate area of the Lakelands facies, Lower Jeffers Brook (recalculated to 100%).

Sample No	110	111	115	116	120	121	123	124	128
No of grains	500	500	510	500	591	500	500	500	500
Matrix	13	50*	53	77	61*	70*	88*	60	58
Clasts	71	45	11	10	19	10	5	25	30
Crystals	16	5	35	13	20	19	7	5	12
quartz	0.2	1	1	<1	1	1.5	1	1	2
feldspar	4	2	23	10	15	15	3	-	5
epidote	9	-	8	1	2	1	2	2	-
opaques	3	2	3	2	2	2	1	2	5
Veins	-	-	-	-	0.5	-	-	-	-
Lithology	tuff	ign.	tuff	tuff	ign.	ign.	ign.	tuff	tuff

*note: glass shards in ignimbrites included in matrix because their outlines are difficult to distinguish when point counting.

Modal compositions of rocks from the main agglomerate area of the Lakelands facies, Lower Jeffers Brook (recalculated to 100%). [CONTINUED]

Sample No	129	226	231	233	1179
No of grains	500	488	500	533	607
Matrix	55*	48	46	56*	57
Clasts	35	31	35	18	21
Crystals	10	20	19	26	21
quartz	2	3	2	6	-
feldspar	5	7	10	11	12
epidote	-	1	5	1	6
opaques	3	9	2	8	3
Veins	-	1	-	-	<1
Lithology	ign.	tuff	tuff	ign.	tuff

*note: glass shards in ignimbrites included in matrix beacuse their outlines are difficult to distinguish when point counting.

Modal compositions of rocks from the Lakelands facies, Lower Jeffers Brook (recalculated to 100%).

Sample No	163	168	172	174	286	289	597	697	699	708
No of grains	500	588	532	500	500	540	500	500	500	500
Matrix	73	59*	51	84	56*	70*	85*	49	89	52
Clasts	20	12	25	7	21	5	2	35	5	20
Crystals	7	23	20	9	23	25	8	16	4	23
quartz	2	-	1	1	<1	0.6	-	1	-	5
feldspar	2	11	7	5	2	4	3	10	1	15
epidote	1	-	-	-	12	3	-	-	-	2
opaques	2	12	9	3	9	17	5	5	3	1
calcite	-	-	3	-	-	-	-	-	-	-
Veins	-	6	4	-	-	0.2	5	-	2	-
Lithology	ign.	tuff	tuff	tuff	ign.	ign.	tuff	tuff	tuff	tuff

*note: glass shards in ignimbrites included in matrix because their outlines are difficult to distinguish when point counting.

Modal compositions of rocks from the Lakelands facies, Lower Jeffers Brook (recalculated to 100%) [CONTINUED]

Sample No	719	720	735	740	741	742	744	754	760	923
No of grains	500	500	500	421	500	500	482	500	524	537
Matrix	43	42*	69	42	68	48	26	67	33	53
Clasts	25	25	10	27	20	30	46	25	50	26
Crystals	32	33	21	31	12	19	28	8	17	22
quartz	2	1	<1	2	<1	3	<1	1	3	1
feldspar	20	10	20	19	10	10	5	5	7	12
epidote	-	7	<1	7	1	5	<1	3	5	5
opaques	10	15	<1	-	1	-	19	-	2	1
calcite	-	-	-	3	-	1	2	-	<1	3
Veins	-	-	-	-	-	3	-	-	-	-
Lithology	tuff	ign.	tuff	tuff	tuff	tuff	tuff	tuff	tuff	tuff

*note: glass shards in ignimbrites included in matrix beacuse their outlines are difficult to distinguish when point counting.

Modal compositions of rocks from Browns Brook (recalculated to 100%).

Sample No	615	616	617
No of grains	573	476	470
Matrix	79	71	33
Clasts	-	-	57
Crystals	21	27	10
quartz	7	9	10
plagioclase	11	17	-
K-feldspar	0.5	0.5	-
epidote	2	0.5	-
opaques	0.3	-	-
Veins	0.2	2	-
Lithology	all either v. fn sst or tuff		

Modal compositions of rocks from Hanna Brook (recalculated to 100%).

Sample No	248	251	1028	1032	1033	1036	1037	1039	1040
No of grains	533	641	500	500	500	581	532	684	503
Matrix	58	49	30	59	28	62	64	30	24
Clasts	7	25	45	-	35	-	-	24	42
Crystals	33	24	15	41	37	38	31	46	34
quartz	2	-	-	10	15	27	10	-	2
feldspar	15	14	10	25	20	8	8	18	17
epidote	4	6	2	5	-	1	-	15	6
opaques	12	4	3	1	2	2	13	13	9
Veins	2	2	-	-	-	-	-	-	-
Lithology	maf. ?lava	maf. tuff	maf. tuff	maf. tuff	fel. tuff	fel. tuff	fel. tuff	maf. tuff	maf. tuff

Modal compositions of rocks from Hanna Brook (recalculated to 100%). [CONTINUED]

Sample No	1042	1043	1044	1045	1047	1050
No of grains	500	536	500	642	440	796
Matrix	40	32	40	48	41	44
Clasts	35	30	35	21	26	17
Crystals	25	38	23	32	33	38
quartz	3	1	-	2	3	5
feldspar	15	19	16	18	21	20
epidote	2	15	-	9	2	8
opaques	5	3	6	3	7	5
Veins	-	-	2	-	-	1
Lithology	maf. tuff	maf. tuff	maf. tuff	maf. tuff	maf. tuff	maf. tuff

Modal compositions of rocks from Henry Brook (recalculated to 100%).

Sample No	210	217	357	363	1053	1064	1078
No of grains	500	573	426	555	500	500	500
Matrix	65	72	19	76	71	72	59
Clasts	-	-	22	3	2	5	10
Crystals	32	28	58	20	22	23	31
quartz	5	-	7	-	-	3	-
feldspar	24	18	4	-	21	15	25
epidote	-	2	39	-	0.5	1	5
opaques	3	3	3	-	0.5	1	1
chlorite + biotite	-	5	5	18	-	3	-
Veins	3	-	1	1	-	-	-

Lithology

Modal compositions of microgranite from the West Harrington River section (recalculated to 100%).

Sample No	425
No of grains	522
K-feldspar	24
Plagioclase	23
Quartz	6
Q/KF intergrowths	34
Dusty opaques	2
Opaques	6
Chlorite	4
Veins/ alteration	1
Lithology	mg

Modal composition of sandstones from the Cranberry Lake and Wilson Brook Formations

Sample No	3073	3725	3717	3721
No of grains	527	531	532	592
Mineral grains				
feldspar	39	23	28	21
quartz	2	19	15	62
opaques	0.3	6	3	6
chlorite*	8	9	43*	10
Rock fragments				
igneous	23	42	3	3
sedimentary	0.5	1	5	-
metamorphic	-	-	2	-
Matrix*	27	-	1	-

*chlorite is at least in part recrystallised matrix. In 3721, siliceous cement is included in quartz.

Table 4. PALEOCURRENT DIRECTIONS MEASURED IN THE CRANBERRY LAKE FORMATION.

1. Bass River	?cross lamination	?E
2. Bass River	ripple drift	320
3. Big Pike Fire B.	grooves	135, 140
4. Big Pike Fire B.	?cross lamination	?S
5. Upper Lynn Road	grooves	090
6. Middle Lynn Road	ripple drift	NW

Table 5. Geochemical analyses of Jeffers Group and hypabyssal intrusions. All analyses by x-ray fluorescence analysis. All samples are listed in Table 2.

COBEQUIDS

file #	88	177	198	111	286	183	170	171	185	186
sample	C20	C21	C45B	C164	C176	C188	C270	C313	C334	C352
SiO2	54.50	54.10	49.00	74.50	71.60	51.50	44.30	50.60	45.30	74.10
TiO2	2.09	2.17	1.18	0.23	0.38	0.89	1.88	1.26	3.64	0.38
Al2O3	15.60	15.80	17.10	12.60	13.90	16.00	16.40	17.60	13.00	13.10
Fe2O3	9.32	10.10	9.77	1.46	2.43	8.91	12.40	9.58	17.30	2.32
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.11	0.11	0.19	0.02	0.02	0.16	0.31	0.17	0.41	0.04
MgO	2.67	2.92	7.03	0.25	0.80	7.31	7.51	5.25	5.15	1.13
CaO	5.55	6.59	5.27	0.42	0.81	5.39	10.20	3.56	5.89	1.29
Na2O	4.60	4.08	3.27	3.45	3.82	4.60	1.78	5.46	1.66	3.98
K2O	1.81	2.26	3.96	5.70	4.74	1.28	1.57	1.25	2.55	7.16
P2O5	0.58	0.52	0.32	0.04	0.07	0.24	0.30	0.28	0.63	0.10
H2O+	1.62	1.23	2.31	0.85	1.16	3.08	2.77	3.77	3.00	1.39
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	353	499	790	398	651	529	325	539	525	372
Rb	62	80	148	172	115	32	109	17	197	76
Sr	462	543	314	37	85	303	296	294	311	167
Y	55	47	27	53	34	24	28	26	48	18
Zr	370	351	146	210	215	124	142	146	233	145
Nb	57	44	10	28	21	9	11	9	18	11
Th	0	2	5	23	25	3	0	7	4	7
Pb	7	10	13	17	7	10	13	91	11	7
Ga	27	30	16	19	13	20	21	19	25	12
Zn	42	45	125	17	19	88	182	236	143	25
Cu	81	19	43	4	0	22	52	84	33	3
Ni	17	12	78	12	13	109	82	39	32	9
V	163	198	239	9	40	213	269	263	494	43
Cr	0	9	173	7	13	307	114	137	0	20
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

cobequids

file #	187	188	189	190	191	192	193	194	112	113
sample	C368	C373	C379	C380	C388	C395	C427	C428	C436	C437
SiO2	51.90	51.90	53.10	53.10	44.00	73.20	47.40	65.80	77.70	75.10
TiO2	0.93	1.15	1.25	1.22	1.87	0.23	2.98	0.64	0.08	0.23
Al2O3	18.30	16.50	17.20	17.20	15.30	13.10	13.30	15.70	12.80	12.70
Fe2O3	8.30	9.68	8.56	9.32	12.60	2.37	15.40	4.16	0.53	1.56
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.06	0.16	0.13	0.08	0.18	0.03	0.26	0.07	0.02	0.01
MgO	3.88	4.24	4.32	4.42	8.70	0.75	4.95	1.57	0.14	0.26
CaO	5.52	7.75	5.56	6.59	9.97	0.65	6.87	2.73	0.24	0.25
Na2O	5.60	3.82	4.88	2.62	1.70	4.09	3.23	6.51	7.11	3.43
K2O	1.70	0.36	1.96	2.50	0.95	4.32	1.85	1.09	1.38	5.77
P2O5	0.26	0.19	0.48	0.49	0.25	0.03	0.51	0.16	0.02	0.04
H2O+	2.77	4.08	2.08	2.70	3.54	0.93	1.85	1.77	0.31	0.47
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	373	97	890	856	359	498	314	308	177	430
Rb	56	9	44	62	33	86	97	18	25	159
Sr	600	434	438	447	299	82	364	348	70	40
Y	25	23	28	29	28	64	44	23	45	42
Zr	125	108	147	150	97	226	210	188	111	195
Nb	7	7	10	9	5	31	15	11	40	27
Th	3	0	5	3	0	22	4	5	31	24
Pb	10	10	12	12	21	8	9	16	11	16
Ga	19	17	19	18	17	17	26	18	12	21
Zn	34	120	85	58	100	18	95	39	9	14
Cu	8	0	13	9	48	0	64	4	0	0
Ni	18	27	23	21	130	9	30	11	6	9
V	219	249	199	180	275	7	424	76	6	9
Cr	61	86	53	57	256	6	65	25	4	2
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

C1002B

file #	114	115	116	195	196	117	168	118	197	179
sample	C439	C442	C444	C446	C448	C449	C450	C451	C452	C499
SiO2	57.46	44.40	46.07	51.40	49.80	73.24	61.98	68.20	44.20	71.72
TiO2	1.05	2.91	1.43	1.25	1.22	0.30	0.99	0.65	3.04	0.98
Al2O3	16.59	15.33	16.89	16.30	17.50	14.49	16.70	14.70	14.60	12.50
Fe2O3	8.60	16.11	11.90	10.30	10.90	1.52	5.36	4.44	13.20	3.98
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.09	0.24	0.18	0.18	0.17	0.04	0.13	0.07	0.22	0.04
MgO	4.80	5.98	7.95	6.14	4.40	0.51	2.22	1.61	11.00	2.36
CaO	2.19	6.92	8.84	7.59	8.82	0.50	1.86	1.61	6.27	1.14
Na2O	3.41	3.02	2.48	2.60	3.42	2.10	6.04	3.34	1.64	2.00
K2O	2.28	1.63	1.06	1.59	0.72	6.03	1.90	2.99	1.14	3.44
P2O5	0.17	0.44	0.26	0.16	0.24	0.08	0.49	0.19	0.25	0.03
H2O+	3.26	2.92	3.01	2.70	2.93	1.35	1.72	2.47	4.93	1.85
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	953	502	515	377	458	1381	0	473	434	1351
Rb	82	66	48	50	10	203	0	111	47	53
Sr	290	416	326	279	425	95	0	119	346	123
Y	29	33	24	35	26	32	0	34	23	38
Zr	174	200	108	276	97	242	0	213	119	334
Nb	10	23	8	14	5	15	0	14	19	17
Th	7	2	1	2	4	20	0	14	0	14
Pb	9	15	8	17	10	11	0	194	6	9
Ga	22	21	23	20	24	17	0	17	20	17
Zn	43	131	89	117	91	26	0	618	123	34
Cu	15	29	43	206	35	0	0	4	24	0
Ni	19	40	97	78	11	7	0	16	222	33
V	221	279	226	202	347	6	0	84	297	98
Cr	48	5	71	77	27	0	0	34	591	114
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

COBEQUIDS

file #	902	200	201	119	120	172	173	203	174	204
sample	C502	C503	C504	C506	C507	C557	C558	C562	C576	C594
SiO2	60.70	46.00	46.90	52.20	60.60	57.60	56.60	50.10	51.50	49.50
TiO2	0.95	1.46	1.88	4.24	1.14	0.96	1.07	0.77	1.10	1.21
Al2O3	18.20	16.70	15.60	13.50	13.20	16.80	17.10	18.20	17.50	17.90
Fe2O3	6.34	11.30	12.80	8.75	10.90	8.14	8.29	11.20	9.14	11.10
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.07	0.21	0.19	0.23	0.05	0.13	0.16	0.13	0.16	0.13
MgO	1.86	8.17	6.87	3.77	3.38	3.76	3.90	2.79	4.24	4.35
CaO	3.05	9.07	8.76	9.05	2.28	3.34	3.13	10.80	8.65	6.45
Na2O	2.21	2.39	2.59	5.21	2.93	6.36	5.84	3.33	2.82	3.08
K2O	4.15	1.02	1.04	0.23	1.30	0.45	1.38	0.13	1.39	2.15
P2O5	0.05	0.28	0.36	0.64	0.21	0.22	0.27	0.16	0.21	0.37
H2O+	2.47	2.85	2.47	1.00	3.47	2.62	2.54	2.47	3.47	3.62
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	1384	409	231	99	237	176	926	56	439	1445
Rb	164	46	54	2	72	11	25	1	34	42
Sr	209	382	353	283	113	221	229	956	403	560
Y	35	24	31	60	39	22	31	19	23	23
Zr	231	120	161	381	229	107	192	82	106	104
Nb	18	9	13	36	19	7	10	5	6	7
Th	11	0	1	3	6	2	5	0	2	0
Pb	3	15	11	10	6	13	16	14	12	5
Ga	23	20	20	19	17	17	19	23	18	21
Zn	26	99	79	60	37	98	125	50	95	40
Cu	3	14	7	59	0	9	10	5	68	426
Ni	50	139	91	37	44	22	21	20	15	13
V	125	213	257	334	144	209	213	252	260	260
Cr	113	208	174	11	117	80	60	64	78	6
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

cobequids

file #	205	175	176	121	206	123	125	126	208	127
sample	C595	C615	C619	C641	C645	C657	C668	C701	C704	C706
SiO2	54.90	73.60	78.50	63.00	54.61	52.31	43.58	66.20	44.90	45.99
TiO2	1.00	0.40	0.09	0.89	1.08	2.25	3.59	0.73	2.72	2.68
Al2O3	17.60	13.00	12.20	15.86	17.34	15.35	17.07	16.30	14.70	14.82
Fe2O3	8.41	2.85	1.07	7.89	9.96	10.75	13.47	4.68	15.10	14.39
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.11	0.06	0.01	0.12	0.24	0.17	0.26	0.07	0.28	0.35
MgO	3.85	0.94	0.33	3.52	3.38	4.17	6.08	1.74	6.44	6.69
CaO	6.45	1.52	0.04	0.70	6.47	4.53	6.55	1.11	9.29	8.63
Na2O	3.46	3.66	1.46	1.64	3.73	4.09	3.58	2.75	2.34	1.98
K2O	1.52	2.64	4.79	2.71	1.76	2.42	1.50	3.66	0.60	1.44
P2O5	0.28	0.08	0.02	0.13	0.31	0.58	0.41	0.11	0.46	0.46
H2O+	2.62	1.23	1.77	3.10	0.68	3.79	3.46	2.77	3.00	2.71
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	1221	501	79	347	399	706	271	586	150	257
Rb	28	98	297	91	64	56	71	146	25	110
Sr	644	178	16	97	503	606	526	129	318	296
Y	22	21	77	31	32	28	24	35	39	37
Zr	162	160	325	189	108	232	191	212	211	187
Nb	10	13	87	15	9	21	26	15	16	14
Th	2	9	23	11	1	6	0	10	1	5
Pb	8	18	29	17	10	4	6	6	8	18
Ga	21	13	32	22	21	21	25	19	23	21
Zn	37	49	87	89	95	85	135	48	138	113
Cu	10	13	3	75	3	15	29	5	45	32
Ni	23	10	27	38	2	18	44	19	82	72
V	178	53	0	145	171	194	300	83	311	299
Cr	36	64	24	73	1	2	7	28	59	77
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

C1002B

file #	128	209	129	130	131	132	89	905	90	907
sample	C708	C713	C730	C764	C765	C776	C805	807	C812	815B
SiO2	50.30	48.50	45.00	53.03	49.58	71.80	54.00	50.03	61.80	49.78
TiO2	0.85	1.03	1.66	2.96	1.21	0.52	1.20	1.19	1.01	1.10
Al2O3	17.60	17.00	15.90	13.29	18.52	14.40	16.90	17.94	17.70	19.99
Fe2O3	6.97	10.90	12.90	13.26	11.06	2.48	9.00	11.12	5.80	9.83
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.17	0.16	0.20	0.17	0.17	0.03	0.19	0.13	0.10	0.14
MgO	2.83	5.49	6.70	3.89	6.48	0.84	5.55	6.28	1.22	4.87
CaO	4.51	6.40	7.88	5.58	4.08	1.02	4.59	5.20	1.88	6.34
Na2O	6.09	3.93	1.77	3.57	3.56	3.64	4.29	3.82	5.25	5.41
K2O	0.37	2.14	2.19	2.33	1.05	3.69	0.89	0.74	3.34	0.27
P2O5	0.27	0.59	0.23	0.58	0.28	0.11	0.28	0.19	0.39	0.20
H2O+	2.31	2.70	5.00	1.21	3.85	1.62	3.39	3.60	2.16	3.70
H2O-	0.00	0.00	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	144	835	357	255	661	969	302	177	742	78
Rb	9	91	83	128	34	130	16	20	137	6
Sr	633	966	273	223	366	159	389	296	234	439
Y	32	27	28	57	24	40	29	19	33	18
Zr	194	193	121	306	114	275	190	93	260	78
Nb	11	18	9	21	8	13	10	6	14	4
Th	3	0	0	4	2	8	6	0	13	0
Pb	18	7	10	12	12	10	18	0	9	6
Ga	22	20	22	25	20	18	18	18	19	21
Zn	63	105	89	86	116	22	145	72	19	88
Cu	36	13	27	9	46	7	0	4	2	4
Ni	14	39	108	30	42	11	32	24	8	9
V	140	211	309	330	244	32	173	287	107	331
Cr	16	7	260	9	51	2	121	99	6	31
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

cobequids

file #	210	134	135	91	92	136	93	288	289	137
sample	C819	C856	C857	C860	C867	C873	C881	C923	C942	C945
SiO2	49.00	78.50	74.10	48.30	55.20	76.50	45.70	56.30	55.30	46.38
TiO2	3.59	0.20	0.20	3.10	0.84	0.17	2.39	0.97	1.03	1.79
Al2O3	13.60	10.90	12.60	13.50	14.00	12.20	15.20	14.90	15.50	15.34
Fe2O3	15.40	1.88	2.86	14.20	7.71	1.51	13.30	6.93	8.05	11.85
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.18	0.02	0.04	0.22	0.16	0.02	0.24	0.17	0.14	0.17
MgO	4.48	0.60	1.04	4.70	6.71	0.26	6.78	3.34	5.54	6.91
CaO	5.18	0.70	0.29	8.09	6.30	0.21	9.35	5.67	4.85	12.14
Na2O	3.96	4.24	4.61	2.37	3.71	3.99	2.38	5.12	3.76	1.91
K2O	0.63	2.40	3.03	2.16	3.07	4.53	1.16	1.48	3.09	0.77
P2O5	0.86	0.04	0.03	0.89	0.27	0.02	0.44	0.19	0.16	0.24
H2O+	2.62	0.77	1.00	2.00	1.85	0.77	2.31	5.08	2.23	4.15
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	721	341	479	504	1007	383	335	544	795	135
Rb	19	38	47	123	71	86	62	28	56	29
Sr	261	82	58	351	308	55	275	181	315	316
Y	55	56	49	50	23	30	42	26	25	26
Zr	320	182	208	245	130	248	187	194	147	114
Nb	22	25	25	18	10	32	14	11	13	9
Th	4	19	23	3	3	18	1	7	8	1
Pb	16	9	8	13	5	13	12	14	7	9
Ga	24	14	17	25	11	15	21	19	17	20
Zn	154	19	21	90	83	13	119	71	76	102
Cu	19	0	0	22	57	15	36	7	5	62
Ni	21	7	10	28	101	6	135	11	63	93
V	332	16	11	303	187	2	255	143	175	291
Cr	6	8	1	33	257	5	143	33	67	230
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

COBEQUIDS

file #	903	95	97	98	139	99	100	101	102	140
sample	1000	1002	1003	1006	1010	1013	1017	1020	1037	1051
SiO2	46.20	65.10	61.50	44.71	82.24	50.11	44.57	53.43	74.20	66.21
TiO2	1.65	0.58	0.84	2.38	0.35	1.58	3.39	0.99	0.30	0.69
Al2O3	17.00	16.90	18.20	16.17	9.17	18.04	15.87	17.27	12.80	16.91
Fe2O3	11.60	5.48	7.13	11.97	1.97	10.40	13.50	8.92	1.75	3.58
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.22	0.10	0.10	0.20	0.05	0.21	0.47	0.19	0.05	0.08
MgO	7.49	1.90	2.17	7.30	0.77	5.00	5.90	4.17	0.67	1.39
CaO	9.26	1.84	0.80	9.95	0.47	4.80	7.78	4.44	3.32	3.98
Na2O	2.31	1.91	0.57	1.89	3.49	2.69	1.92	4.34	3.84	0.65
K2O	1.16	4.25	5.84	1.39	0.65	4.18	1.73	1.90	2.57	4.78
P2O5	0.14	0.09	0.18	0.51	0.15	0.36	0.54	0.23	0.06	0.21
H2O+	2.70	2.00	2.85	3.00	0.46	2.23	3.31	5.46	2.39	2.08
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	279	383	460	236	146	999	373	417	3083	932
Rb	68	220	274	74	19	162	125	76	47	204
Sr	245	88	38	301	112	337	324	208	166	197
Y	28	32	35	36	16	20	42	42	23	38
Zr	98	230	196	213	176	117	218	141	138	306
Nb	6	17	19	17	9	21	15	8	11	20
Th	1	12	17	3	7	2	2	3	8	16
Pb	165	15	15	16	57	21	38	8	13	12
Ga	19	19	26	24	6	17	27	18	9	20
Zn	355	93	150	119	86	195	235	113	29	42
Cu	77	1	9	36	3	8	56	112	14	6
Ni	118	27	34	95	5	3	82	34	2	17
V	273	62	123	266	30	189	389	216	27	42
Cr	159	35	71	132	25	1	64	71	5	11
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

Cobequids

file #	141	142	212	103	104	105	213	904	106	214
sample	1061	1070	1078	1081	1082	1083	1084	1085	1086	1087
SiO2	75.41	65.22	67.60	52.30	52.99	48.60	43.70	48.80	49.40	49.50
TiO2	0.11	0.90	0.54	1.15	1.03	0.98	2.95	1.02	0.98	1.28
Al2O3	12.08	14.72	15.30	18.10	17.80	15.70	15.80	16.20	15.30	10.20
Fe2O3	1.59	4.57	3.85	1.10	8.00	9.71	14.50	9.25	9.29	9.02
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.02	0.12	0.09	0.17	0.17	0.18	0.22	0.14	0.15	0.14
MgO	0.31	1.85	1.34	4.52	7.10	9.93	5.95	8.64	9.02	4.55
CaO	0.00	4.58	3.21	5.46	4.59	5.78	9.27	5.89	8.72	8.11
Na2O	1.16	1.20	5.13	4.01	4.87	3.01	1.69	2.16	1.96	4.12
K2O	7.57	3.71	1.82	0.87	1.05	2.00	1.81	4.33	1.21	2.18
P2O5	0.07	0.31	0.11	0.22	0.34	0.45	0.35	0.33	0.33	0.33
H2O+	0.77	2.00	1.16	3.39	2.85	3.85	3.23	3.16	3.77	2.31
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	428	924	580	215	402	507	224	1469	478	375
Rb	254	138	39	30	23	51	81	158	28	79
Sr	102	289	307	408	329	301	654	328	211	297
Y	58	33	23	23	26	28	25	27	26	29
Zr	295	268	170	118	152	147	191	131	126	158
Nb	43	15	11	7	11	8	22	9	8	10
Th	26	9	5	1	4	12	1	11	8	4
Pb	51	15	17	15	8	32	14	11	12	14
Ga	18	19	18	21	15	15	21	15	16	18
Zn	19	85	50	142	96	104	108	89	75	90
Cu	0	15	7	127	18	76	45	14	73	14
Ni	15	10	11	14	118	158	43	134	144	58
V	8	70	72	253	216	261	305	249	211	228
Cr	0	27	59	41	337	551	20	365	382	194
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

COBEQUIDS

file #	215	109	143	216	108	144	109	145	146	110
sample	1088	1162	1107	1128	1159	1160	1162	1163	1165	1169
SiO2	47.40	44.00	44.50	43.10	42.29	74.59	44.00	59.37	45.41	48.92
TiO2	1.18	2.40	2.36	3.60	2.70	0.72	2.40	1.22	2.56	2.27
Al2O3	18.10	14.70	16.92	15.10	17.04	12.26	14.70	16.32	15.97	15.07
Fe2O3	10.40	15.80	12.39	14.70	13.62	4.03	15.80	9.55	12.49	15.11
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.13	0.19	0.24	0.22	0.10	0.06	0.19	0.34	0.22	0.09
MgO	5.29	8.92	7.24	5.90	7.99	0.27	8.92	1.96	6.40	6.06
CaO	8.63	6.16	9.31	8.51	4.78	0.97	6.16	1.56	8.62	2.39
Na2O	2.51	2.02	1.75	3.06	1.69	6.52	2.02	6.51	2.66	3.15
K2O	3.91	1.77	1.13	0.78	6.53	0.13	1.77	1.03	1.38	4.48
P2O5	0.33	0.31	0.31	0.40	0.34	0.21	0.31	0.53	0.62	0.37
H2O+	1.85	3.62	2.85	3.54	1.77	0.20	3.62	1.33	2.31	1.96
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	956	152	186	200	1170	32	152	342	230	232
Rb	147	117	75	25	328	3	117	31	65	318
Sr	491	289	324	423	186	181	289	177	257	83
Y	26	24	28	24	23	29	24	34	44	50
Zr	153	152	132	195	160	215	152	239	239	213
Nb	10	23	12	27	26	16	23	12	18	20
Th	1	0	2	0	4	6	0	4	2	6
Pb	14	20	16	4	16	14	20	10	21	11
Ga	19	21	23	20	27	13	21	19	25	26
Zn	59	87	121	119	46	51	87	31	91	51
Cu	19	17	26	42	7	7	17	22	28	4
Ni	67	246	96	34	128	5	246	10	61	55
V	222	228	288	275	291	53	228	96	261	266
Cr	160	265	70	19	215	5	265	2	74	104
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

cobequids

file #	148	149	150	151	166	167	908	258	261	263
sample	1173	1176	1178	1179	1182	1211	1299	1326	1381	1582
SiO2	47.11	64.04	73.67	60.36	66.72	45.64	46.49	52.53	68.32	73.80
TiO2	3.12	0.51	0.49	0.75	0.99	2.40	1.88	1.22	0.51	0.14
Al2O3	13.57	19.03	13.82	19.10	17.05	14.80	15.42	16.57	17.58	12.28
Fe2O3	18.41	2.57	3.30	4.79	5.40	13.93	11.08	9.01	3.30	2.17
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.07	0.06	0.06	0.08	0.06	0.27	0.48	0.15	0.05	0.03
MgO	4.83	0.39	0.12	1.20	0.66	7.47	8.75	5.78	1.28	0.76
CaO	3.95	3.20	0.92	4.19	1.46	8.84	7.89	4.36	0.41	0.04
Na2O	3.43	8.86	7.21	7.53	9.52	2.55	3.13	5.99	4.09	2.22
K2O	3.43	0.32	0.19	0.90	0.25	1.01	0.16	0.78	3.86	5.33
P2O5	0.78	0.42	0.18	0.17	0.34	0.31	0.21	0.25	0.12	0.02
H2O+	1.29	0.52	0.06	1.09	0.31	2.50	5.00	1.85	1.69	2.92
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	700	91	58	268	63	279	73	380	575	204
Rb	180	6	3	24	5	55	2	21	136	141
Sr	140	423	292	548	151	291	216	344	105	74
Y	51	26	23	40	36	33	26	24	29	70
Zr	280	221	218	222	213	148	131	106	237	354
Nb	20	11	12	11	12	12	10	8	17	36
Th	2	4	7	4	8	0	0	6	13	15
Pb	8	12	16	14	14	11	7	22	11	13
Ga	23	23	14	26	14	21	22	17	21	20
Zn	40	14	25	24	20	114	242	68	28	98
Cu	16	0	7	2	5	34	112	18	0	0
Ni	22	0	0	1	2	72	47	18	12	14
V	461	63	41	99	100	298	306	287	44	12
Cr	0	4	4	3	3	113	115	55	1	6
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

Cobequids

file #	244	218	247	290	291	292	293	294	295	296
sample	1627	1639	1643	1646	1649	1650	1651	1653	1657	1658
SiO_2	48.51	74.50	45.52	73.80	66.00	47.10	66.70	69.50	43.50	45.60
TiO_2	3.44	0.30	3.23	0.11	0.75	1.84	0.72	0.66	0.88	1.75
Al_2O_3	14.08	12.60	14.15	11.70	16.30	15.80	15.90	13.80	12.80	16.00
Fe_2O_3	17.55	2.57	0.00	0.60	4.22	12.90	4.40	4.85	17.90	12.50
FeO	0.00	0.00	14.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.02	0.02	0.21	0.03	0.03	0.18	0.03	0.06	0.45	0.20
MgO	3.80	0.82	6.58	1.00	1.75	7.42	2.05	1.26	8.41	7.21
CaO	3.18	0.60	9.82	2.63	1.58	7.68	1.28	2.53	11.30	9.71
Na_2O	3.26	4.95	2.33	7.19	5.18	1.99	4.23	5.30	0.95	2.14
K_2O	4.23	3.00	1.61	0.09	1.95	2.69	2.68	1.34	1.89	1.59
P_2O_5	0.89	0.04	1.79	0.02	0.15	0.22	0.28	0.12	0.13	0.22
H_2O^+	0.00	0.85	0.00	3.08	2.39	2.23	2.00	0.85	2.08	3.16
H_2O^-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	309	253	286	43	469	325	633	310	321	99
Rb	349	56	129	1	102	137	176	79	104	120
Sr	130	67	237	89	135	251	119	161	126	344
Y	57	63	74	30	27	27	37	22	18	27
Zr	240	375	404	160	205	124	199	180	50	123
Nb	17	40	27	27	15	9	18	12	8	10
Th	5	22	2	9	12	0	10	7	0	0
Pb	11	12	11	7	51	9	11	6	14	11
Ga	26	17	23	12	18	20	21	13	20	22
Zn	26	16	124	6	83	79	85	45	366	150
Cu	2	10	27	0	31	37	7	27	11	18
Ni	47	17	58	5	28	86	27	18	301	85
V	373	28	194	4	102	285	118	99	509	284
Cr	10	59	77	14	63	142	68	56	1186	135
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

COBEQUIDS

file #	224	236	306	307	156	719	237	265	266	252
sample	1676	1844	1846	1847	1851	1869	1874	1931	1934	1956
SiO2	44.60	78.70	77.30	45.80	47.41	46.24	46.80	49.97	46.73	64.28
TiO2	2.45	0.06	0.08	2.06	3.08	2.18	1.87	1.45	2.56	0.68
Al2O3	15.30	11.40	11.80	15.30	17.58	15.11	14.80	19.78	15.42	14.86
Fe2O3	14.00	1.44	1.27	13.90	10.59	12.29	12.90	9.28	0.00	4.39
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.11	0.00
MnO	0.26	0.01	0.02	0.35	0.22	0.27	0.32	0.09	0.00	0.09
MgO	7.52	0.28	0.27	6.92	3.98	7.42	7.17	3.30	7.19	2.12
CaO	7.16	0.02	0.13	6.79	8.83	9.63	9.38	9.22	8.66	3.21
Na2O	2.20	1.84	1.92	3.07	3.56	2.21	1.93	2.53	2.80	4.15
K2O	1.93	4.54	5.41	1.53	1.58	1.16	1.18	2.09	1.93	4.01
P2O5	0.46	0.02	0.02	0.23	0.71	0.36	0.27	0.37	0.29	0.12
H2O+	4.39	1.39	1.00	3.00	1.31	2.60	2.85	1.46	0.00	3.00
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	338	148	52	570	553	182	292	644	320	655
Rb	107	268	336	70	58	76	82	78	76	106
Sr	154	63	68	372	431	267	287	510	230	146
Y	39	77	86	29	43	30	30	31	34	33
Zr	182	281	280	119	248	147	138	153	182	196
Nb	15	79	71	9	21	12	9	9	13	18
Th	2	30	24	0	3	2	0	2	0	21
Pb	5	41	21	9	9	37	28	16	13	14
Ga	22	24	26	19	24	21	24	22	19	14
Zn	138	66	59	255	101	109	98	41	65	60
Cu	51	9	0	37	48	56	67	105	38	14
Ni	94	25	35	66	34	77	61	17	60	26
V	300	9	2	297	327	270	293	312	310	96
Cr	196	31	31	107	46	287	187	18	100	22
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

Cobequids

file #	160	241	315	321	317	318	911	-912	913	914
sample	1968	1969	2074	2079	2084	2085	2177	2189	2190	2194
SiO2	42.09	75.70	46.43	76.70	45.70	76.50	44.86	59.06	59.15	58.44
TiO2	1.60	0.15	1.54	0.13	3.01	0.24	1.98	1.03	0.98	0.99
Al2O3	17.03	12.00	16.34	12.50	14.60	10.30	14.96	16.15	14.20	16.44
Fe2O3	11.44	1.42	11.34	1.52	15.30	2.45	12.36	8.52	7.80	8.45
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.24	0.01	0.24	0.01	0.30	0.01	0.17	0.05	0.07	0.06
MgO	7.16	0.31	8.61	0.37	5.37	0.70	9.16	2.84	4.28	3.34
CaO	9.33	0.32	5.30	0.08	8.99	0.18	9.51	1.84	4.69	2.26
Na2O	1.43	2.32	2.15	2.37	2.30	1.67	1.78	4.56	4.08	7.12
K2O	1.52	6.08	3.60	4.72	1.24	5.85	1.66	3.85	2.26	0.29
P2O5	0.24	0.03	0.20	0.02	0.54	0.04	0.29	0.21	0.11	0.25
H2O+	8.23	0.85	4.60	1.39	2.00	1.31	3.20	2.10	1.60	2.20
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	488	324	385	249	394	556	117	422	149	52
Rb	81	194	74	158	66	160	102	178	111	8
Sr	261	77	352	32	354	62	197	146	130	128
Y	23	67	40	68	42	65	30	18	72	20
Zr	101	247	232	387	244	446	138	186	228	103
Nb	7	42	17	38	18	29	10	13	39	7
Th	0	20	0	19	0	14	0	2	12	1
Pb	9	18	6	15	10	55	8	5	5	5
Ga	24	20	21	20	21	11	19	16	24	18
Zn	113	30	110	38	108	58	91	33	34	38
Cu	7	5	51	6	61	8	47	6	9	0
Ni	90	21	62	21	54	25	95	23	61	11
V	254	6	318	6	330	15	251	161	165	201
Cr	84	35	55	18	63	39	330	11	111	51
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

Cobequids

file #	917	918	919	920	733	738	922	923	924	921
sample	2264	2281	2295	2299	2440	2497	2535	2537	2538	2539
SiO2	80.35	65.62	45.05	43.46	63.32	60.61	78.40	44.50	45.22	46.00
TiO2	0.10	0.72	2.96	3.63	0.73	0.93	0.13	2.33	2.34	3.94
Al2O3	10.32	16.77	14.49	15.31	16.71	15.95	12.00	16.04	15.66	13.28
Fe2O3	2.61	3.73	14.02	14.31	6.93	7.32	1.70	13.11	13.04	17.65
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.03	0.09	0.37	0.21	0.05	0.10	0.02	0.26	0.24	0.27
MgO	1.57	1.68	6.92	6.03	2.84	4.14	0.63	7.51	6.73	5.51
CaO	0.03	1.70	9.64	8.90	0.83	3.54	0.17	8.92	9.26	5.09
Na2O	0.89	5.02	2.16	3.06	3.92	2.71	1.21	2.20	1.54	2.23
K2O	2.99	2.90	0.92	1.35	4.05	2.80	4.99	1.58	2.25	2.14
P2O5	0.02	0.15	0.47	0.39	0.12	0.12	0.02	0.28	0.29	0.62
H2O+	1.60	1.60	3.20	3.80	1.30	1.80	1.20	3.40	3.00	3.20
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	81	908	336	275	672	456	298	720	681	396
Rb	114	93	33	37	209	115	223	45	88	158
Sr	17	205	294	438	121	146	68	299	381	196
Y	133	43	35	24	30	31	75	27	29	43
Zr	386	390	215	195	212	206	388	142	148	224
Nb	47	19	15	26	15	14	42	13	12	19
Th	10	7	0	0	13	10	22	0	0	0
Pb	6	7	6	0	10	12	10	6	11	4
Ga	22	19	21	25	29	20	21	20	20	26
Zn	40	41	187	116	40	55	35	175	150	123
Cu	0	1	45	53	16	100	0	27	34	15
Ni	63	27	45	27	36	44	44	60	62	38
V	11	50	312	290	116	145	15	304	296	562
Cr	0	18	63	5	60	137	0	109	105	5
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

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Cobequids

file #	925	926	927	928	929	930	931	932	933	948
sample	2542	2543	2546	2549	2550	2551	2553	2554	2555	2607
SiO2	51.99	74.70	50.47	76.17	44.12	44.95	54.43	51.67	52.57	79.51
TiO2	1.15	0.23	1.35	0.34	2.50	2.30	1.00	1.03	1.16	0.07
Al2O3	17.56	13.07	18.07	12.22	16.06	18.20	17.71	17.94	18.44	10.94
Fe2O3	9.92	2.17	10.39	2.12	14.89	15.72	9.60	9.54	10.01	1.64
FeO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MnO	0.20	0.03	0.17	0.04	0.15	0.16	0.16	0.16	0.19	0.02
MgO	6.12	0.82	5.80	1.13	6.49	6.39	4.14	4.89	4.56	0.50
CaO	2.32	0.20	3.36	0.43	7.60	2.56	4.19	5.56	2.79	0.33
Na2O	5.40	2.00	5.12	5.67	1.59	1.30	6.01	5.61	5.88	3.17
K2O	1.08	6.24	1.50	0.58	2.92	4.11	0.44	1.20	1.58	3.66
P2O5	0.23	0.03	0.28	0.07	0.31	0.26	0.18	0.18	0.22	0.02
H2O+	3.90	1.10	3.60	0.50	3.30	4.30	2.40	2.90	2.60	0.60
H2O-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ba	421	1018	783	176	199	1358	193	706	497	86
Rb	16	170	26	4	206	125	7	25	44	183
Sr	162	70	319	93	338	115	326	320	212	47
Y	22	48	24	18	32	29	20	18	27	131
Zr	127	260	147	142	158	140	112	95	172	229
Nb	10	33	11	11	14	11	7	6	9	55
Th	2	10	4	6	0	0	0	0	5	19
Pb	8	14	17	4	11	6	3	6	8	3
Ga	21	21	20	13	26	20	20	19	21	19
Zn	128	24	166	21	50	90	116	94	141	39
Cu	57	0	17	0	28	0	3	0	91	0
Ni	25	29	33	5	71	64	21	22	15	69
V	317	26	256	30	320	330	260	251	284	0
Cr	204	5	145	21	97	128	70	87	23	0
Co	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0

Cobequids

file #	944	945
sample	2645	2646
SiO2	52.19	73.37
TiO2	0.99	0.23
Al2O3	16.25	14.26
Fe2O3	9.35	2.12
FeO	0.00	0.00
MnO	0.17	0.04
MgO	6.54	1.08
CaO	4.35	0.73
Na2O	4.32	6.60
K2O	2.56	0.43
P2O5	0.30	0.09
H2O+	3.20	0.50
H2O-	0.00	0.00
CO2	0.00	0.00
Ba	1027	97
Rb	58	4
Sr	295	169
Y	21	22
Zr	128	104
Nb	9	16
Th	6	3
Pb	5	47
Ga	18	15
Zn	117	43
Cu	41	0
Ni	37	4
V	230	38
Cr	224	10
Co	0	0
	0	0

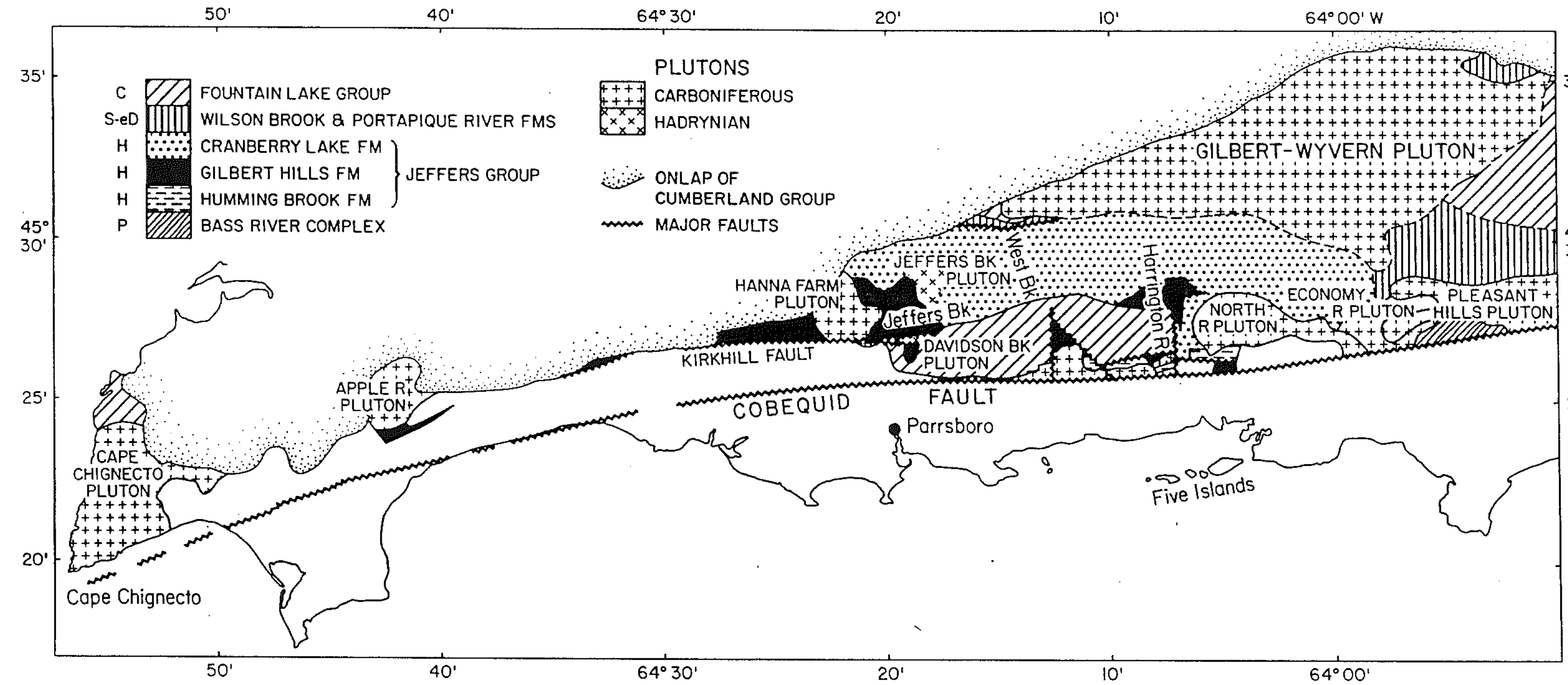


Figure 1. General map of the western Cobequid Hills showing location of the Jeffers Group and major plutons. Modified from Donohoe and Wallace (1982). (From Pe-Piper, 1987).

FOR ENLARGED 1:10,000 SCALE VERSION SEE 4 ENCLOSED MAPS

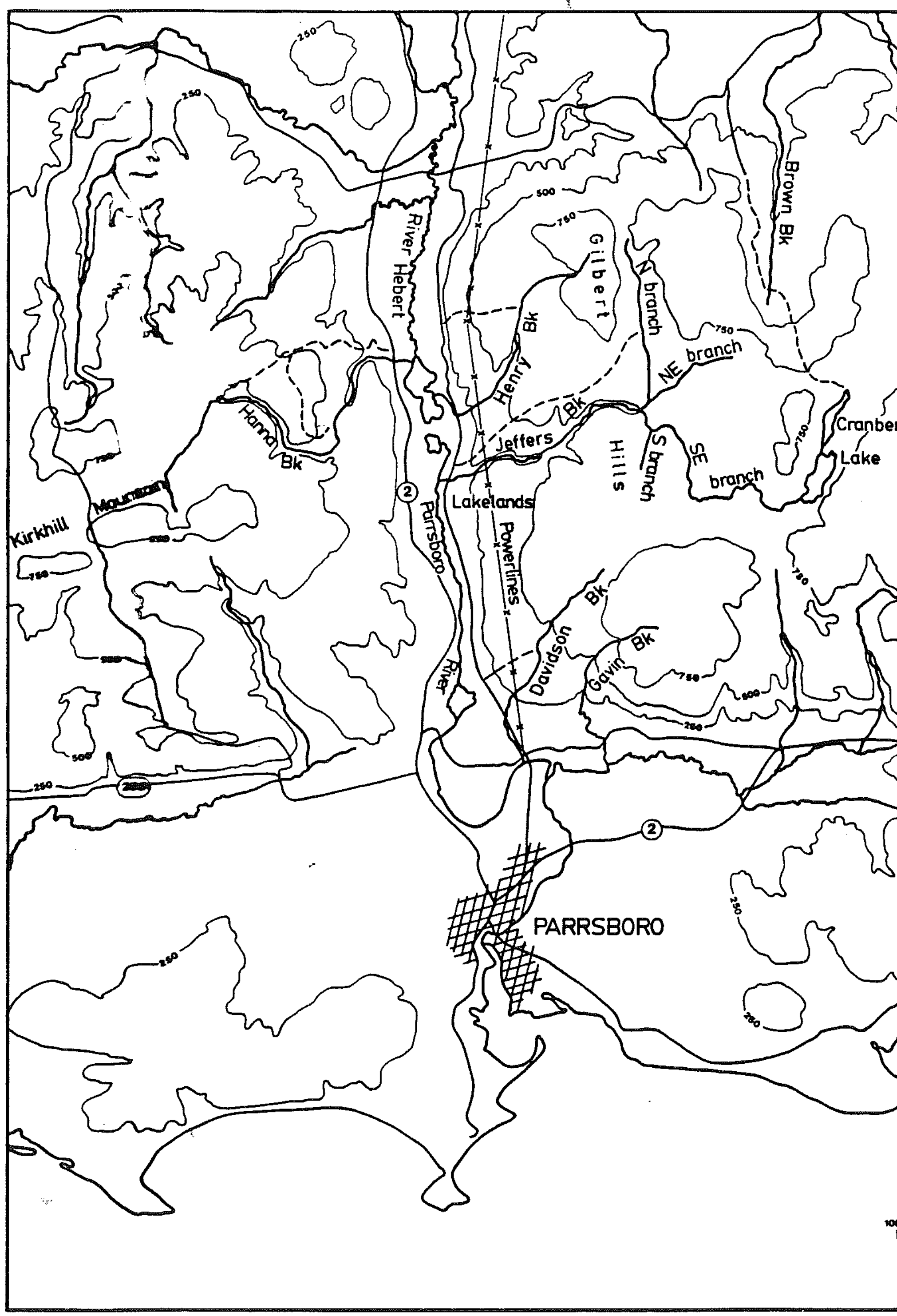
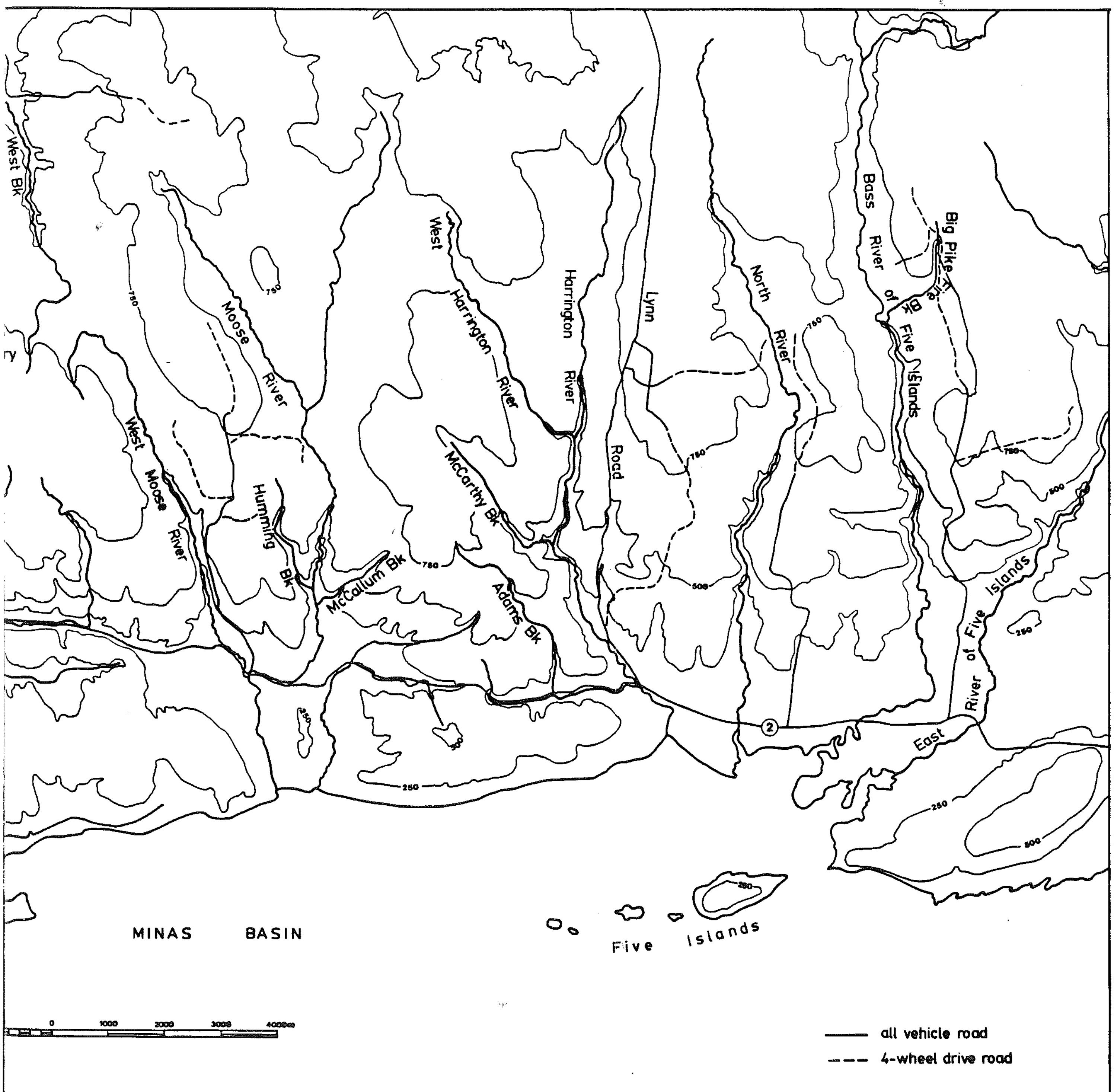


Figure 2. Physiographic map of the study area, showing the principal access roads.



West Bk
Moose River
West Moose River
Humming Bk
McCallum Bk
West Harrington River
Harrington River
McCarthy Bk
Adams Bk
Lynn Road
North River
Bass River of Five Islands
Big Pike Bk
East River of Five Islands
East
MINAS BASIN
Five Islands
750
500
250
2
0
1000
2000
3000
4000m
all vehicle road
4-wheel drive road

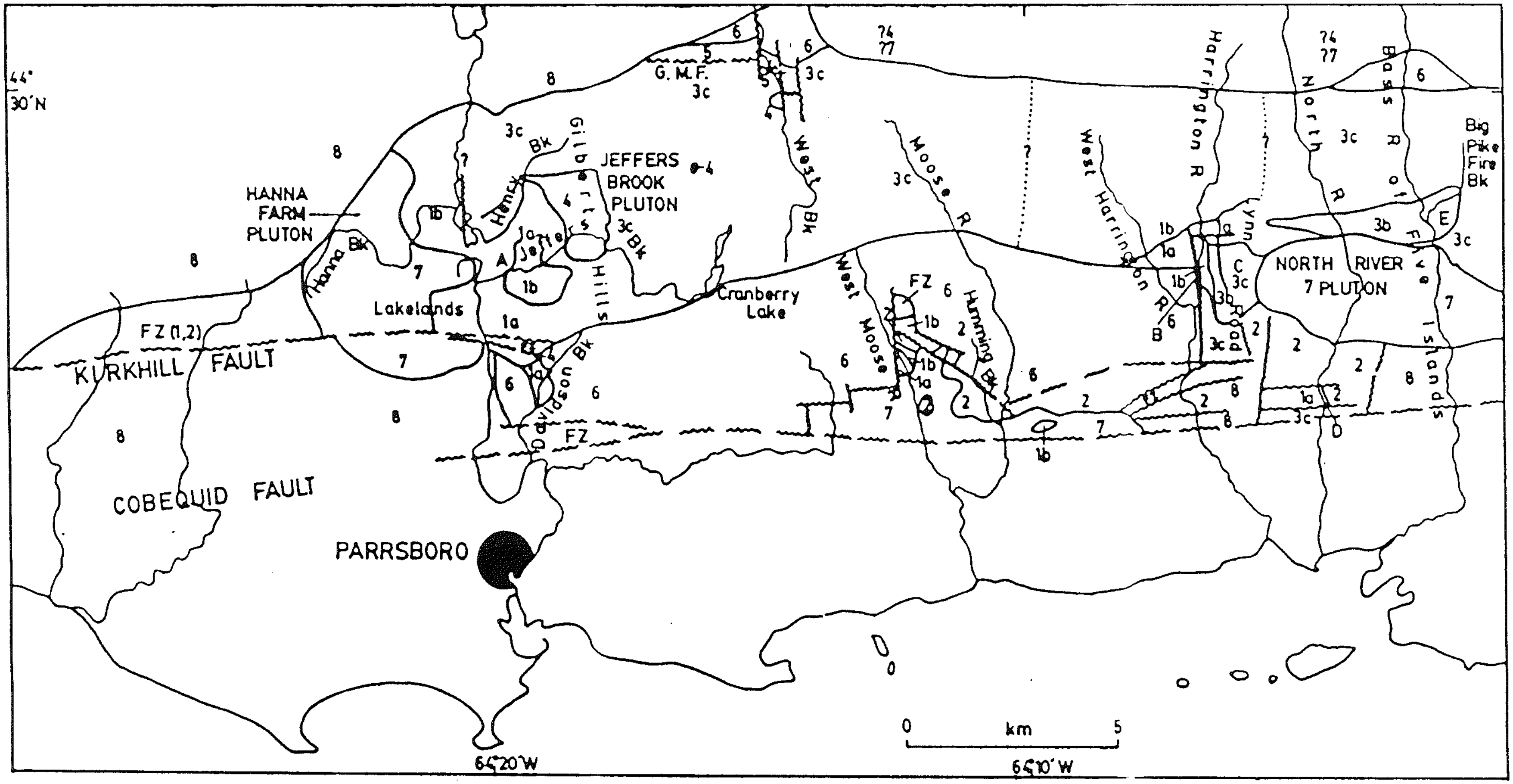


Figure 3. Preliminary geological map showing the Jeffers Group of the western Cobequid Hills (From Pe-Piper, 1987, with minor modifications).

1-3. Late Hadrynian Jeffers Group.

1 - Gilbert Hills Formation, 1a: Lakelands facies; 1b: Harrington River facies.

2 - Humming Brook Formation

3 - Cranberry Lake Formation, 3a: Lynn Road facies; 3b: Pike Fire Brook facies; 3c: West Brook facies.

4 - Late Hadrynian plutons

5 - Wilson Brook Formation (Silurian)

6 - Fountain Lake Group (Devono-Carboniferous)

7 - Carboniferous plutons

8 - undivided Carboniferous sedimentary rocks

FZ - fault zone with a wide range of lithologies

G.M.F. - Gilbert Mountain Fault

A to E are sections illustrated in Figure 4.

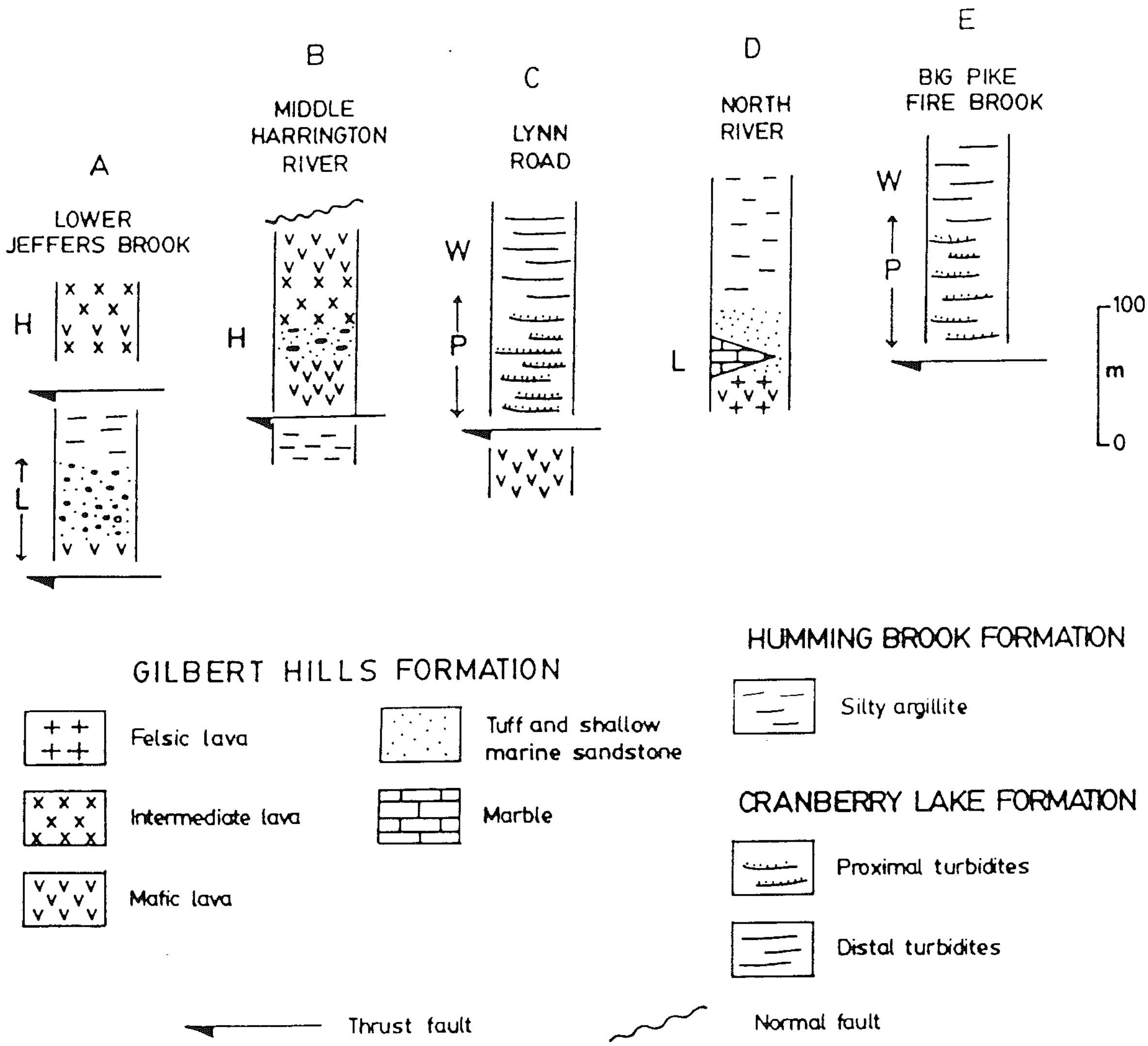


Figure 4. Schematic stratigraphic sections of the Jeffers Group. (From Pe-Piper, 1987).
A: Lower Jeffers Brook, showing type section of the Lakelands facies (L) of Gilbert Hills Formation, with overlying Harrington River facies (H) in thrust contact.
B: Middle Harrington River, showing type section of Harrington River facies (H) of Gilbert Hills Formation.
C: Lynn Road, showing Pike Fire Brook facies (P) of Cranberry Lake Formation overlying highly sheared mafic volcanic rocks.
D: North River, showing Lakelands facies (L) of Gilbert Hills Formation overlain by Humming Brook Formation.
E: Big Pike Fire Brook, showing type section of Pike Fire Brook facies (P) of the Cranberry Lake Formation overlain by the West Brook facies (W).

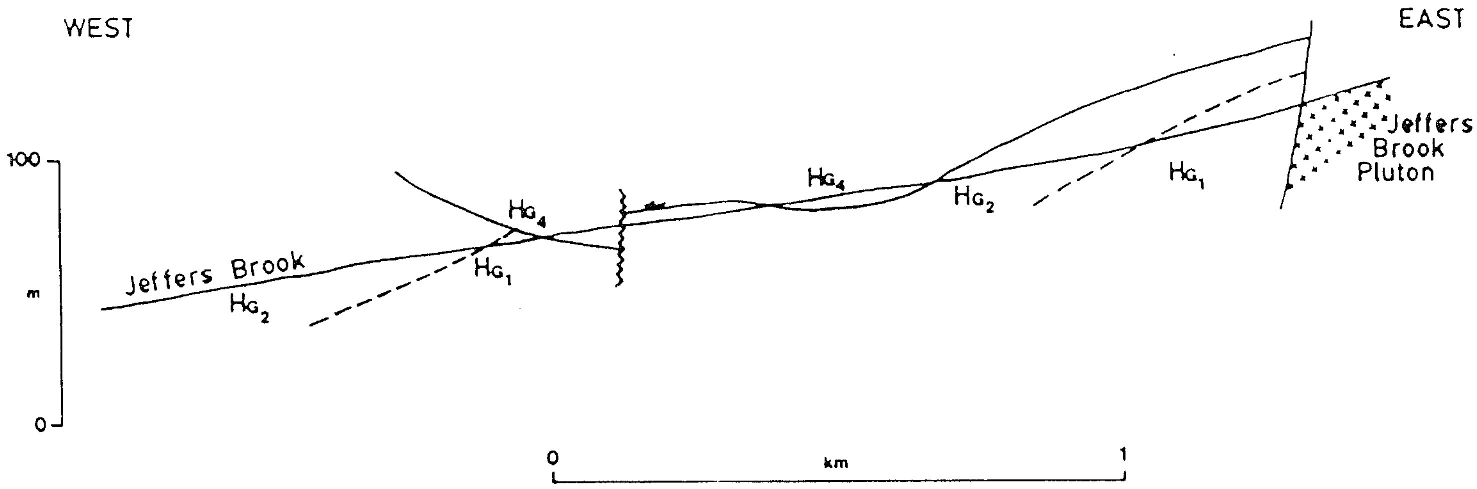


Figure 5. Cross section along lower Jeffers Brook, showing geological structure.

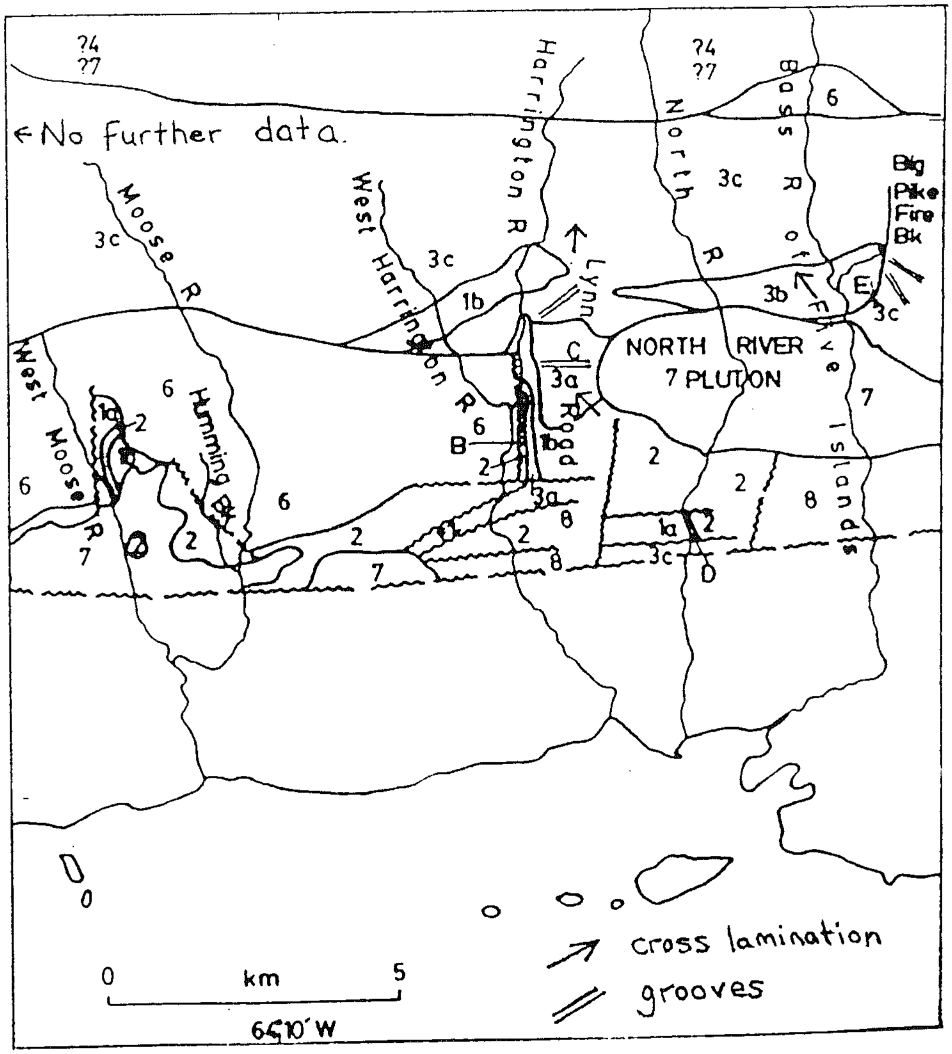


Figure 6. Map showing paleocurrent information from the Cranberry Lake Formation (for details see table 4).

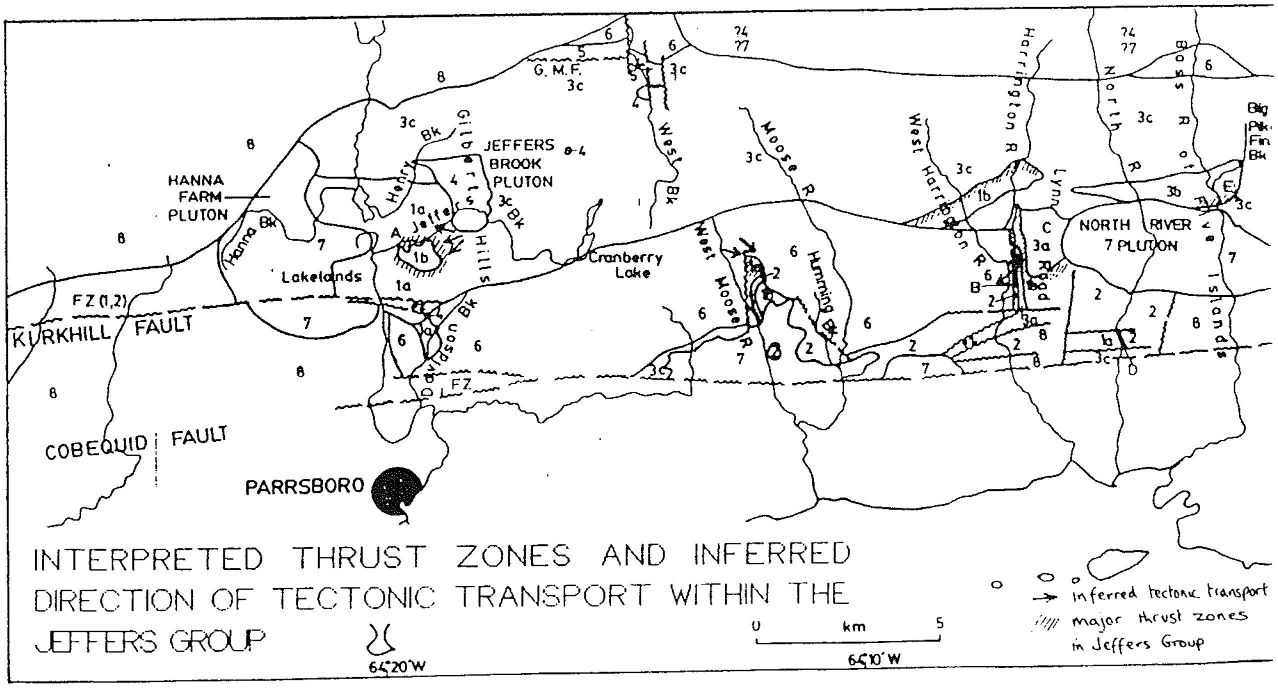


Figure 7. Map showing directional structural data from the Jeffers Group (based on CS structures and lineations) and the occurence of major thrust zones.

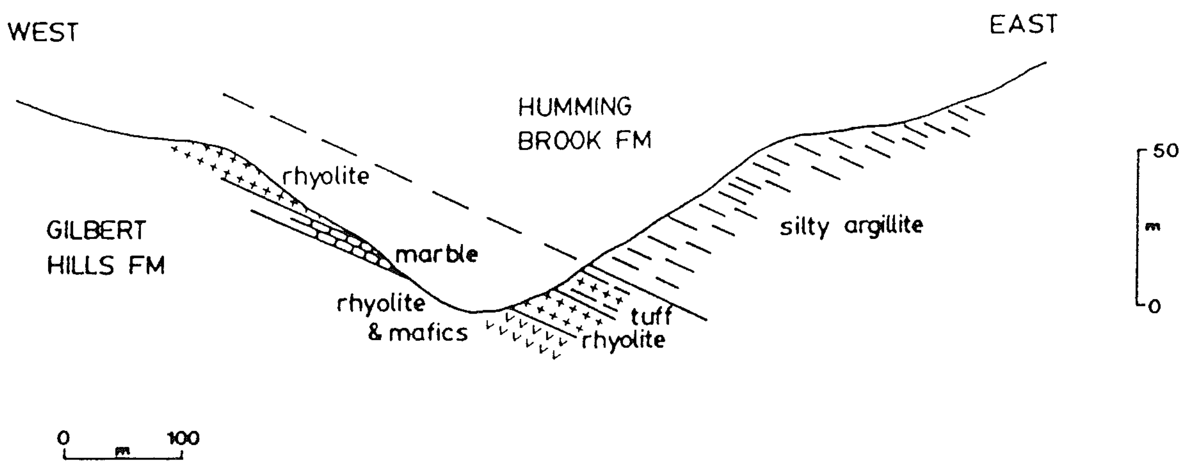


Figure 8. Schematic cross section of lower North River showing the section developed in the Gilbert Hills Formation.

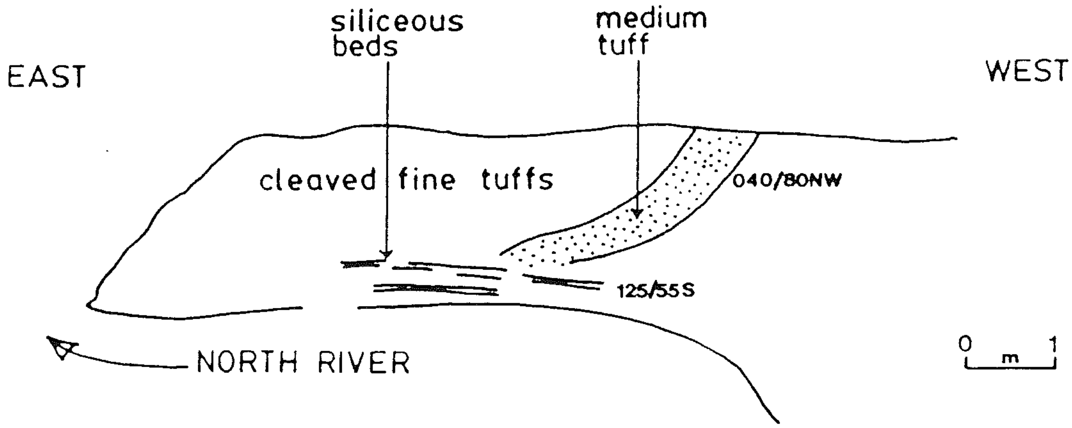


Figure 9. Field sketch of possible slump fold in felsic tuffs, Gilbert Hills Formation, lower North River

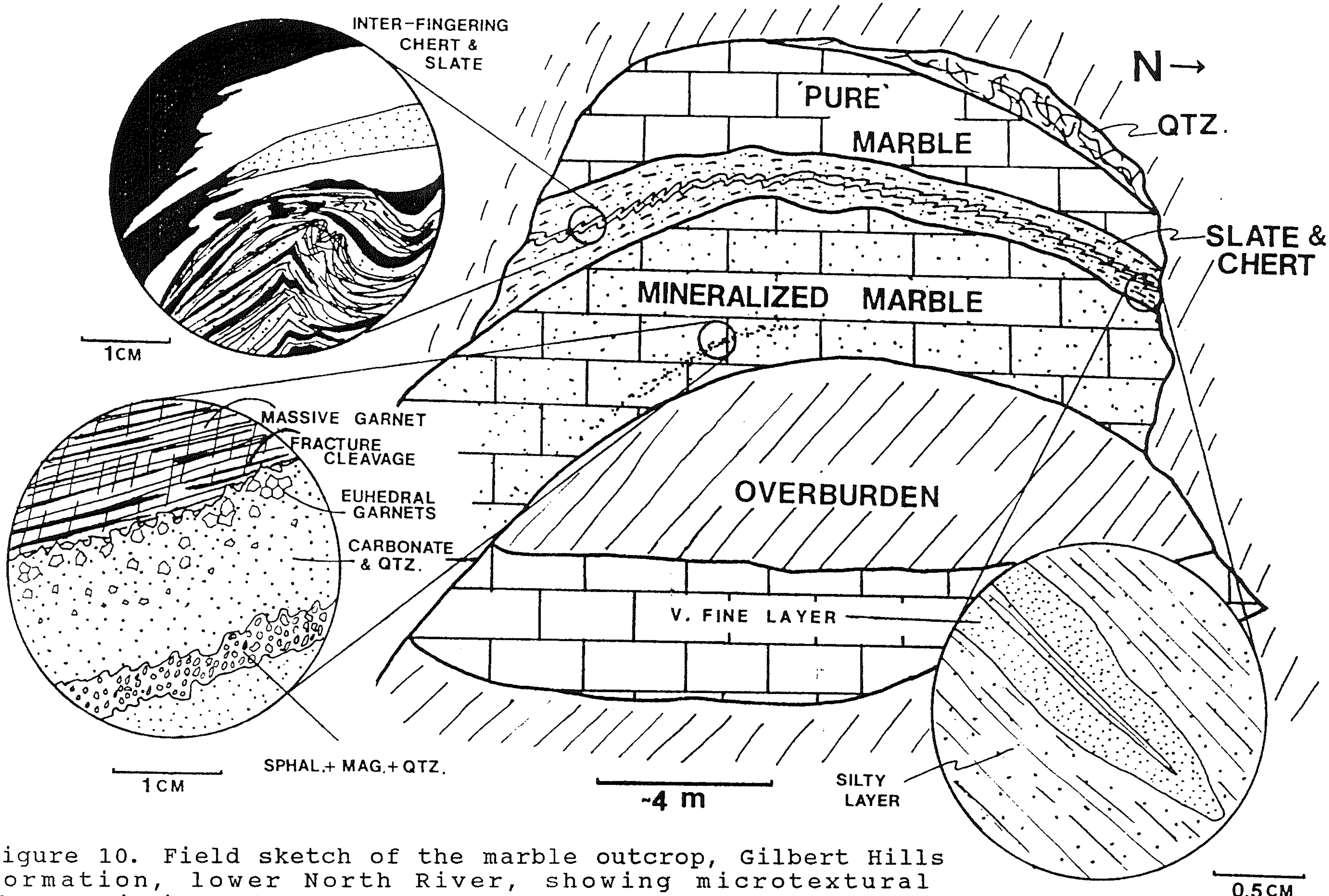


Figure 10. Field sketch of the marble outcrop, Gilbert Hills Formation, lower North River, showing microtextural characteristics (after Boner, 1985).

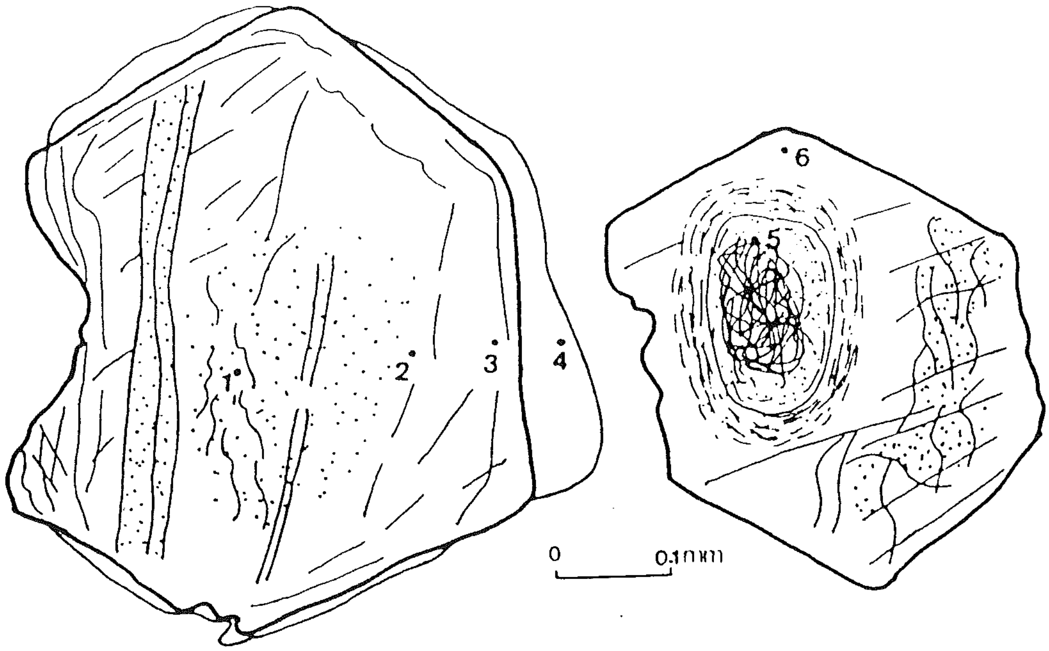


Figure 11. Textural features of garnet from the marbles, lower North River (after Boner, 1985).
a) sketches of euhedral garnet crystals showing optical zoning. Andradite cores (1-3, 5-6) show fracture cleavage; spessartine-rich rim (4) is uncleaved.
b) photomicrograph of 2.5 mm wide area of garnet showing sub-horizontal fracture cleavage.

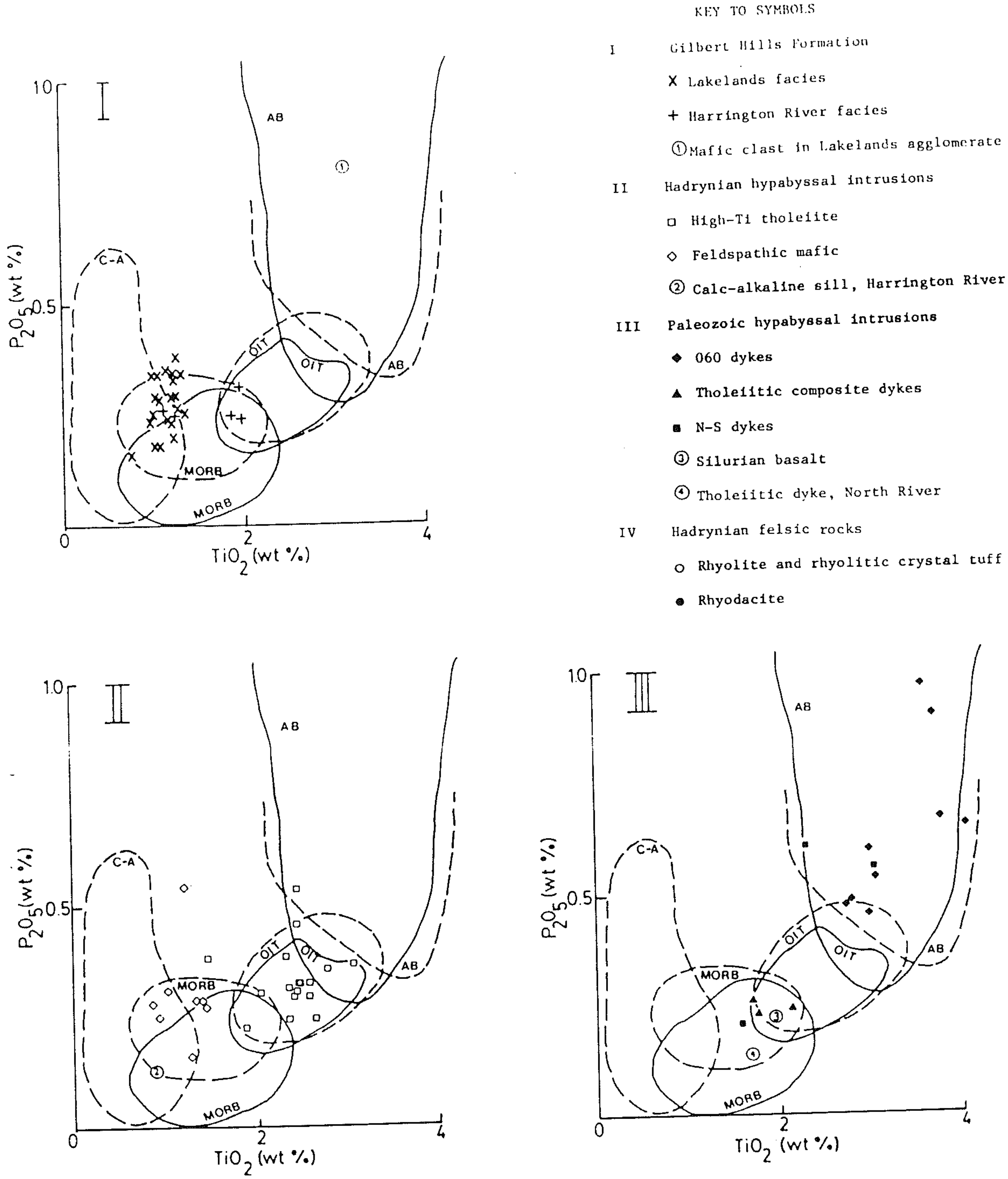


Figure 12. Geochemical discrimination of Jeffers Group mafic rocks.
(a) P205 v. TiO2. Solid fields after Ridley et al., 1974; dashed fields are modifications by Sarkar, 1978. AB- alkaline basalt, OIT- ocean island tholeiite, MORB- mid-ocean ridge basalt, CA- calcalkaline basalt.

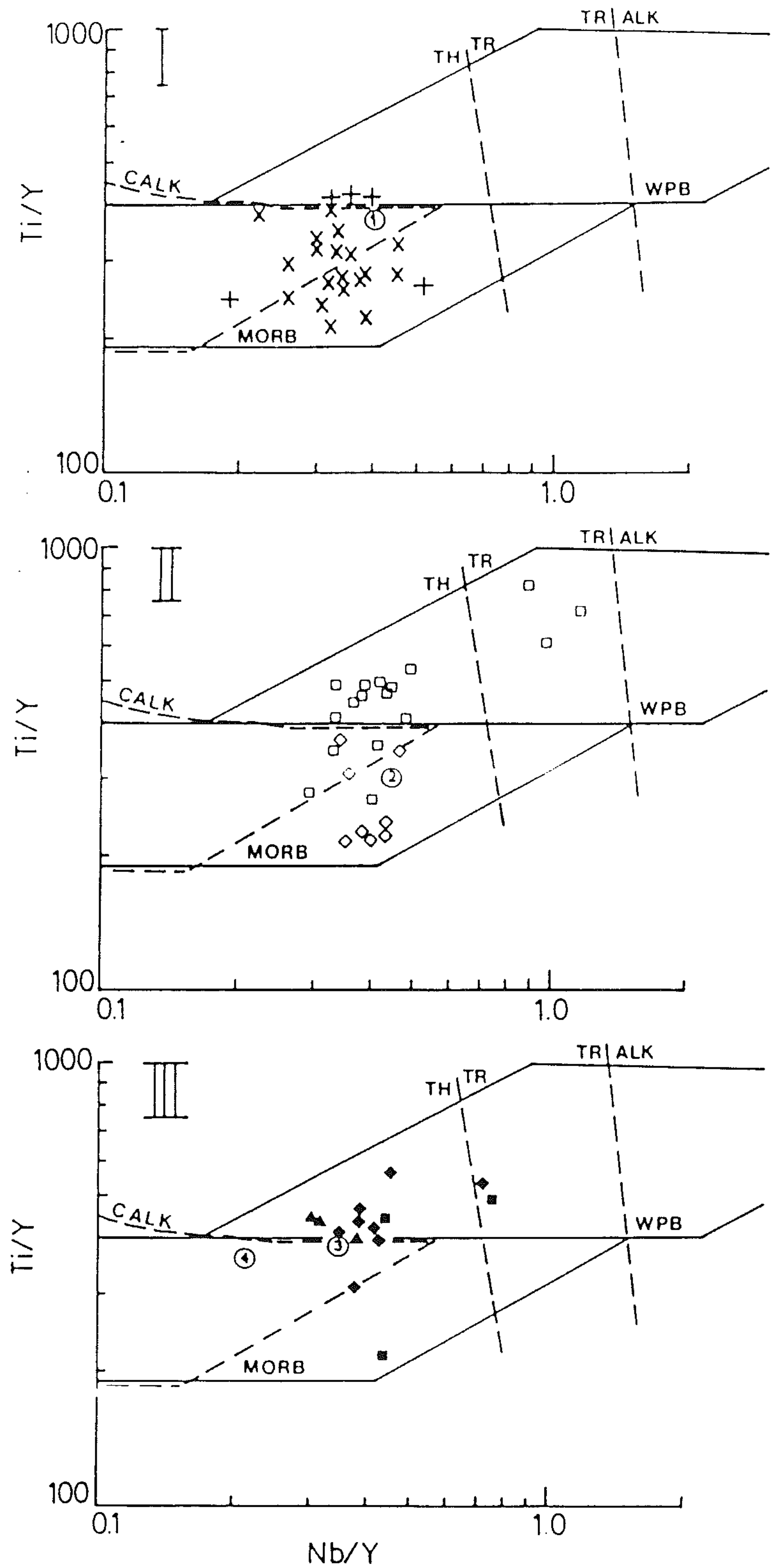


Figure 13. Geochemical discrimination of Jeffers Group mafic rocks. (b) Ti/Y v. Nb/Y. Fields from Pearce, 1982. Symbols and abbreviations as in Figure 12, except WPB- within plate basalt (ALK- alkaliine, TR- transitional, TH- tholeiitic).

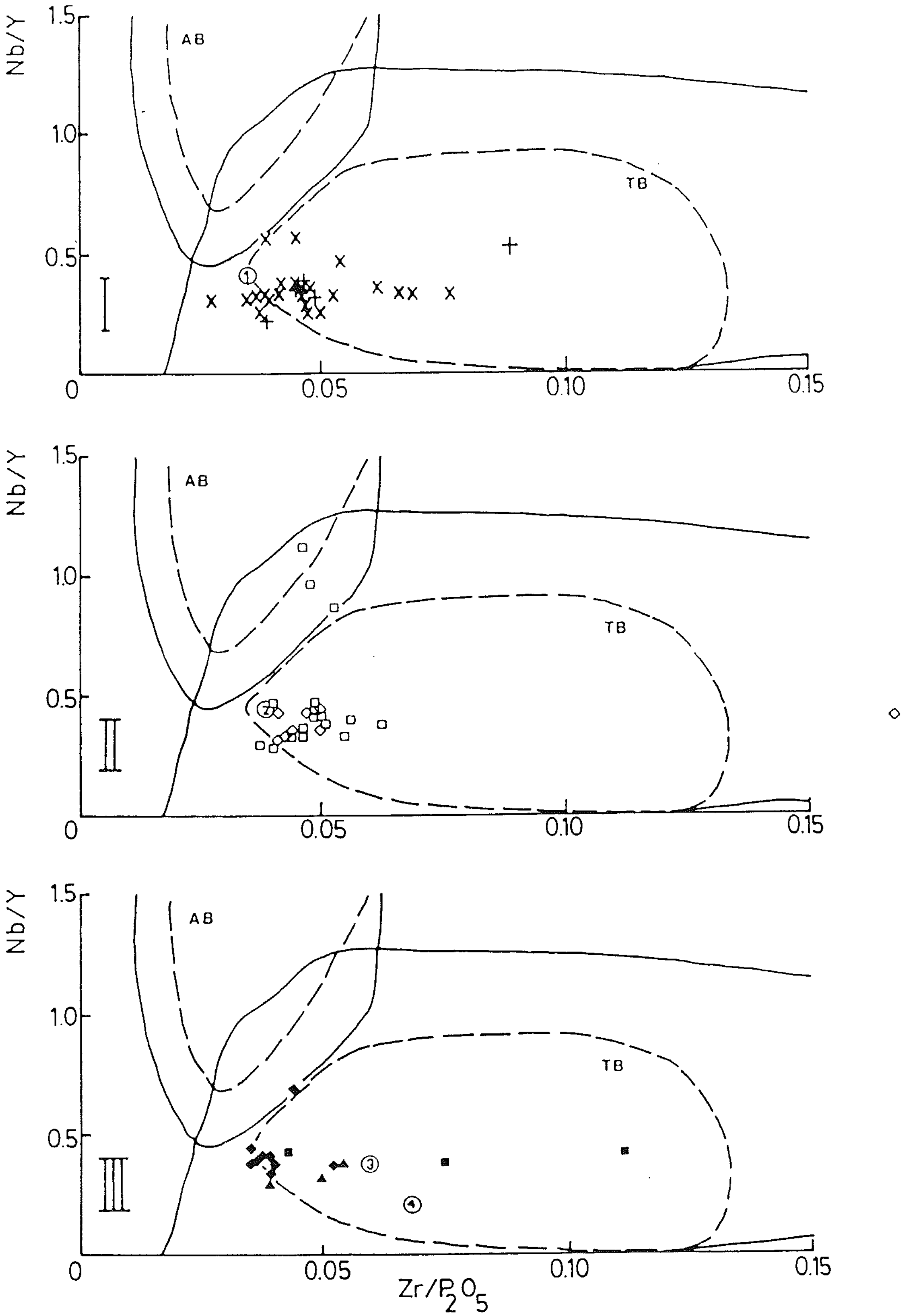


Figure 14. Geochemical discrimination of Jeffers Group mafic rocks. (c) Nb/Y v. Zr/P2O5. Fields from Floyd and Winchester, 1975; dashed- oceanic, solid- continental. Symbols and abbreviations as in Figure 12, except TB- tholeiitic basalt.

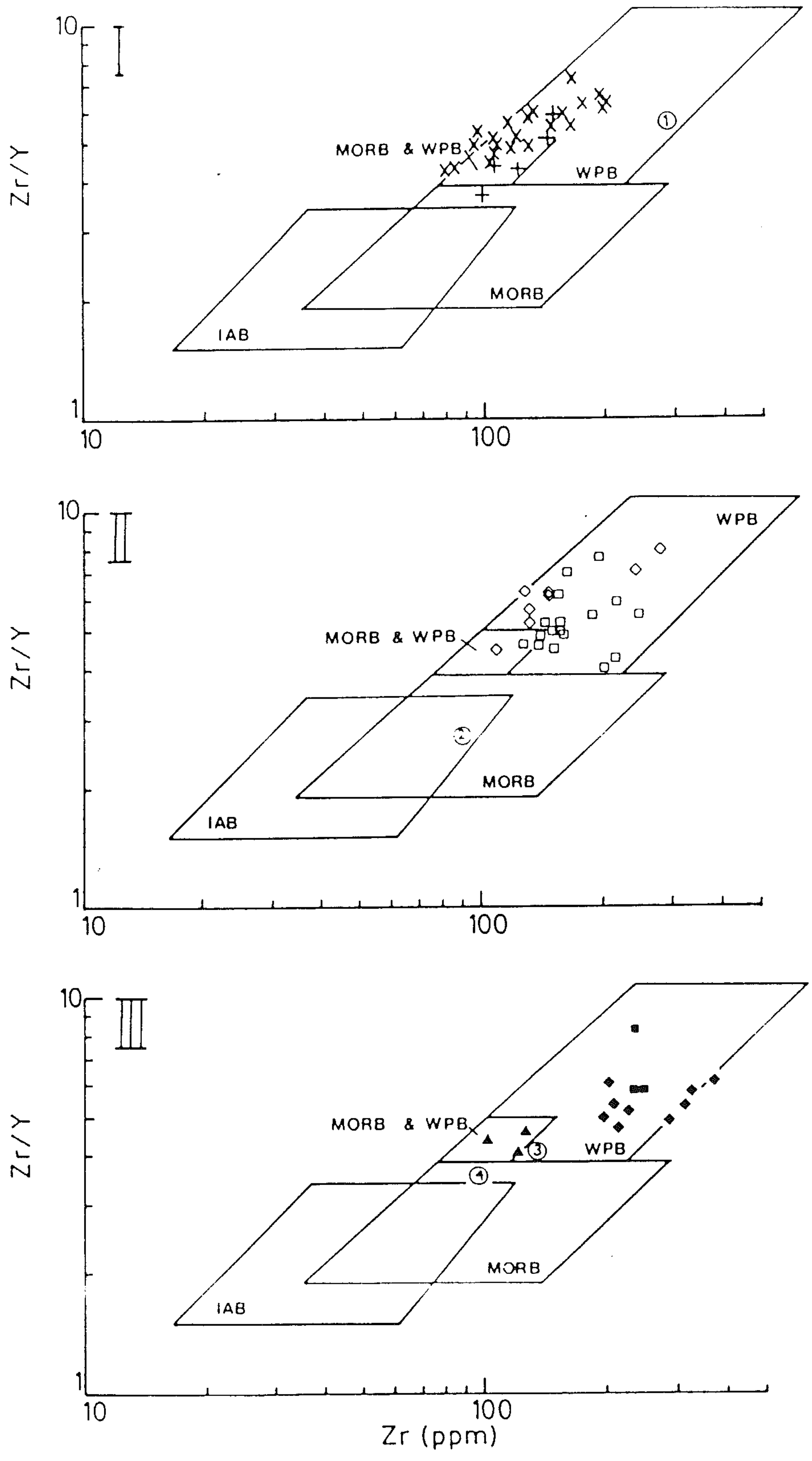


Figure 15. Geochemical discrimination of Jeffers Group mafic rocks. (d) Zr/Y v. Zr. Fields from Pearce and Norry, 1979. Symbols and abbreviations as in figure 12, except IAB- isalnd arc basalt, WPB- within plate basalt.

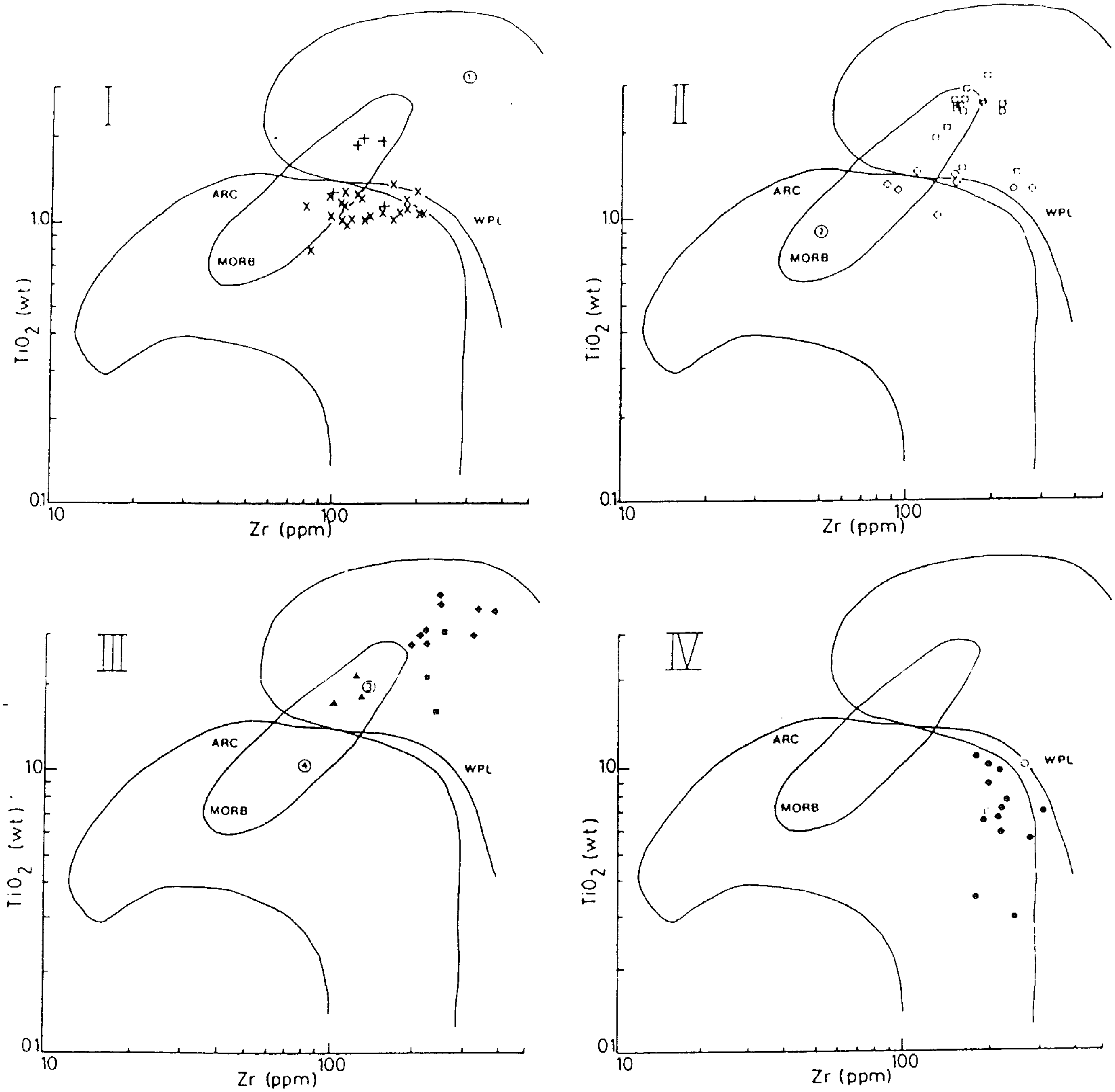


Figure 16. Geochemical discrimination of Jeffers Group rocks. (e) TiO2 v. Zr. Fields from Pearce, 1982. Key and abbreviations as in Figure 12, except that this plot includes Group IV - rhyolites. . - Hadrynian, + - Paleozoic. WPL- within plate lava; ARC- calcalkaline lavas.

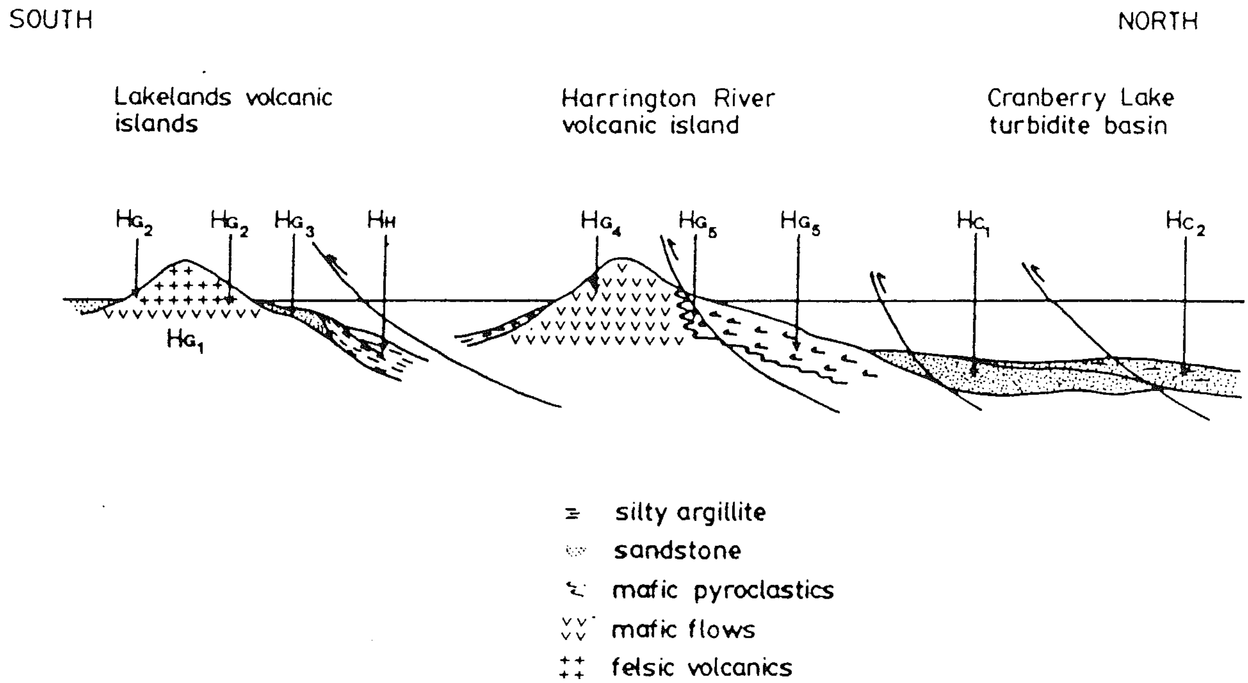


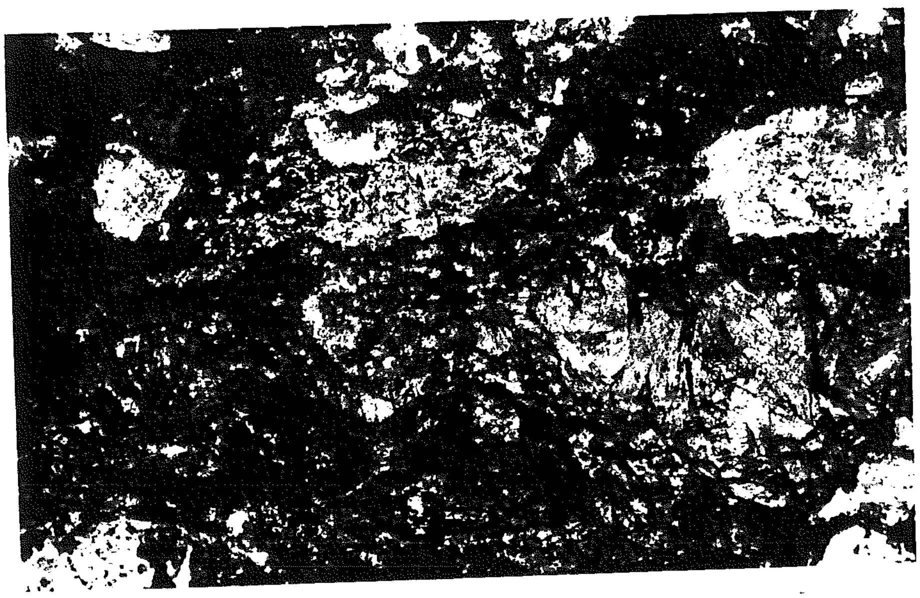
Figure 17. Schematic paleogeographic model of the Jeffers Group.

PLATES

Plate 1. Deformed sandstone, Humming Brook Formation, lower Harrington River. Shows elongated fragments of plagioclase and alkali feldspar, commonly with mortar textures. Band of recrystallisation observed at bottom of plate. 1653, crossed polars, x80.

Plate 2. Porphyritic mafic lava, Harrington River facies, middle Harrington River. Rock contains phenocrysts of large feldspars and a ferromagnesian mineral which has altered to epidote. The matrix consists of feldspar, opaque oxide minerals, dusty opaque minerals and chlorite. 562, plane polarized light, x80.

Plate 3. Mafic lava with hyalopilitic texture, Harrington River facies, middle Harrington River. There is a clot of coarser grained feldspars in lower right corner. Chlorite vein cuts rock at left edge of plate. 2452, crossed polars, x80.



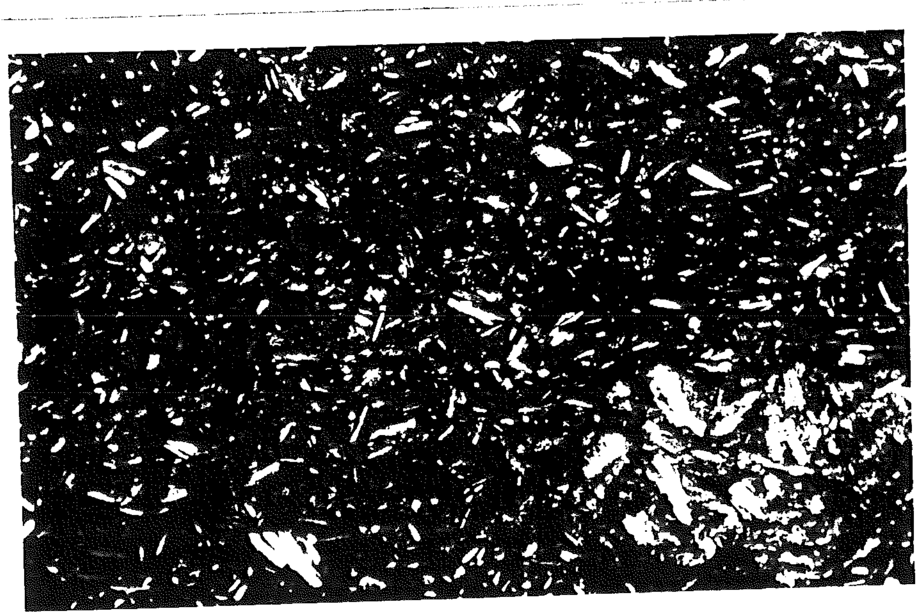
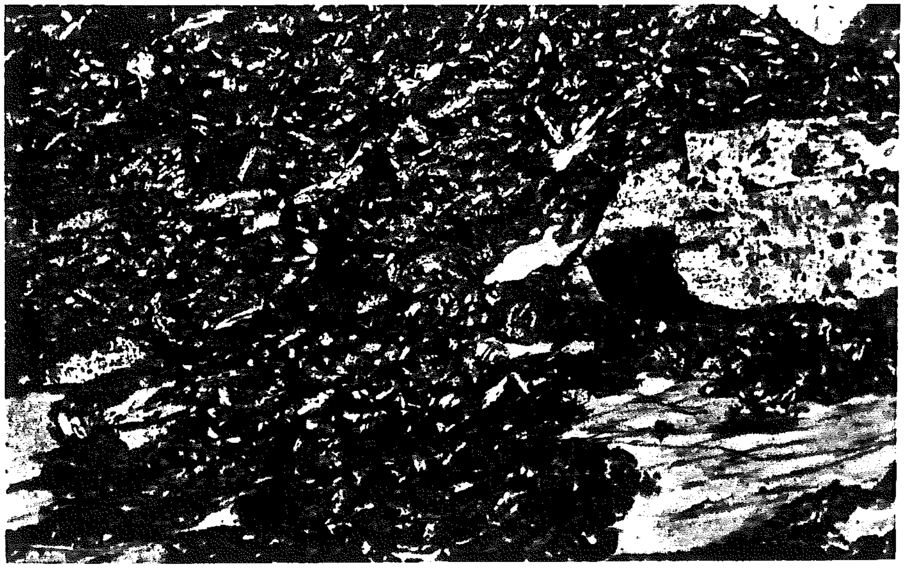


Plate 4. Porphyritic mafic lava, Harrington River facies, middle Harrington River. Groundmass is trachytic and altered. Note large crystals of plagioclase, chlorite and opaque minerals. Secondary minerals include epidote, chlorite and dusty opaque minerals. 2546, plane polarized light, x80.

Plate 5. Porphyritic feldspathic mafic lava, Harrington River facies, middle Harrington River. Rock with pilotaxitic groundmass and subhedral plagioclase phenocrysts. 2553, crossed polars, x80.

Plate 6. High- Ti tholeiite mafic sill, lower Harrington River. Rock shows large altered brown and green ferromagnesian minerals (probably clinopyroxene), anhedral feldspars, actinolite and stretched opaque minerals. 1211, plane polarized light, x80.



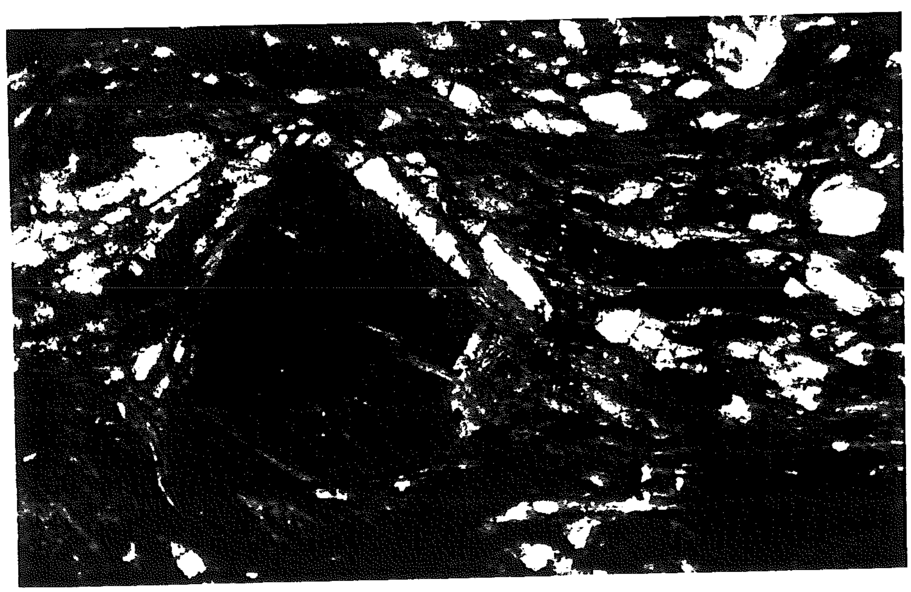


Plate 7. High- Ti tholeiitic mafic sill, middle Harrington River. Rock with large altered feldspar laths in a dusty isotropic (?originally glassy) groundmass. 2551, plane polarized light, x80.

Plate 8. High - Ti tholeiitic mafic sill, middle Harrington River. Rock shows subophitic texture exhibited by large altered ferromagnesian minerals and extremely altered feldspar. Alteration is to chlorite, epidote and biotite. The alignment of opaque minerals in bands suggests that deformation has occurred. 548, plane polarized light, x80.

Plate 9. High- Ti tholeiitic mafic sill, upper Harrington River. Rock with subophitic texture produced by partial inclusion of feldspar laths in a pinkish, subhedral pyroxene. Crystals of clinopyroxene (e.g. at bottom of plate) include rhombohedral epidote crystals. Opaque minerals are brownish, somewhat translucenet and anhedral. There is a weak fabric running horizontally in the plate. 322, plane polarized light, x80.

Plate 10. Feldspathic mafic sill with hiatal porphyritic texture, upper Harrington River. Subhedral to euhedral feldspar phenocrysts are set in an altered pilotaxitic matrix. The phenocrysts are commonly altered to epidote, and some have overgrowths of chlorite. Large chlorite crystals occur throughout the matrix. 311, plane polarized light, x80.

Plate 11. Feldspathic mafic sill, upper Harrington River. Plagioclase phenocrysts are set in a trachytic groundmass. Note the altered bands with muscovite. 2555, crossed polars, x80.

Plate 12. Mafic dyke rock, probably of Carboniferous age. Upper Harrington River. Rock consists mainly of dusty altered ferromagnesian mineral crystals, altered plagioclase, opaque minerals, and low-grade metamorphic minerals. 334, crossed polars, x80.

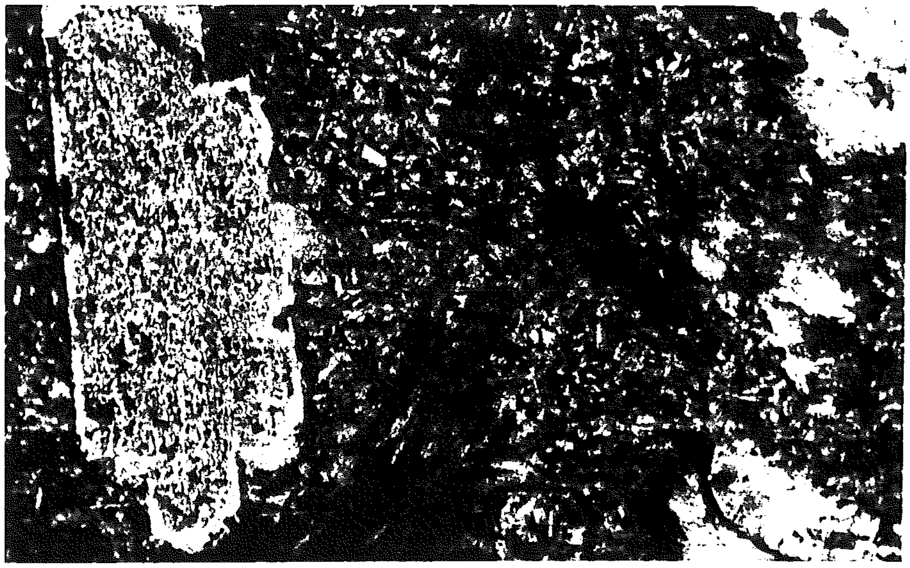
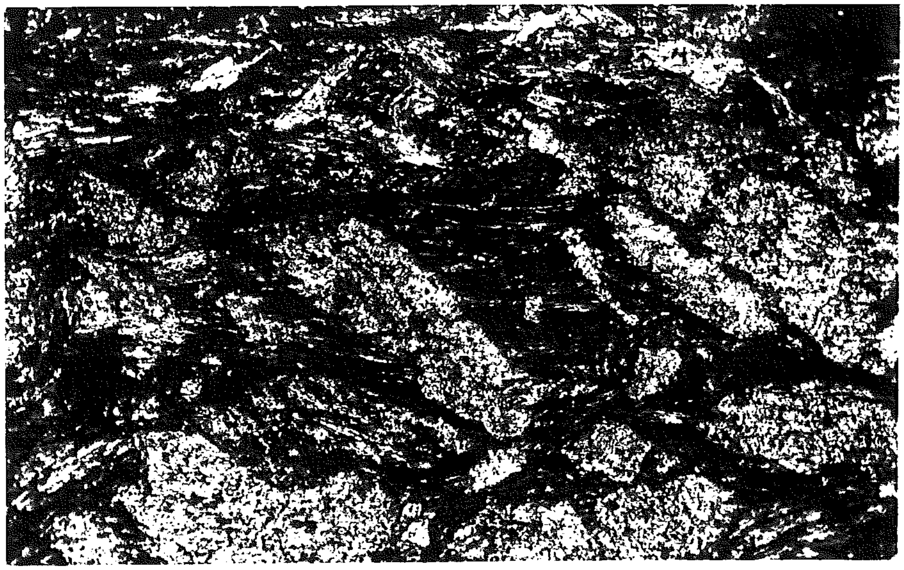


Plate 13. Feldspathic mafic intrusion, upper Lynn Road, showing growth of fibrous actinolite between the crystals. 188, plane polarized light, x200.

Plate 14. Feldspathic mafic intrusion, upper Lynn Road, showing porphyritic texture with a trachytic groundmass. The light coloured areas are thin muscovite lenses in the groundmass. 2845, crossed polars, x80.

Plate 15. Feldspathic mafic intrusion, upper Lynn Road. Texture is weakly porphyritic and trachytic. 2645, crossed polars, x80.



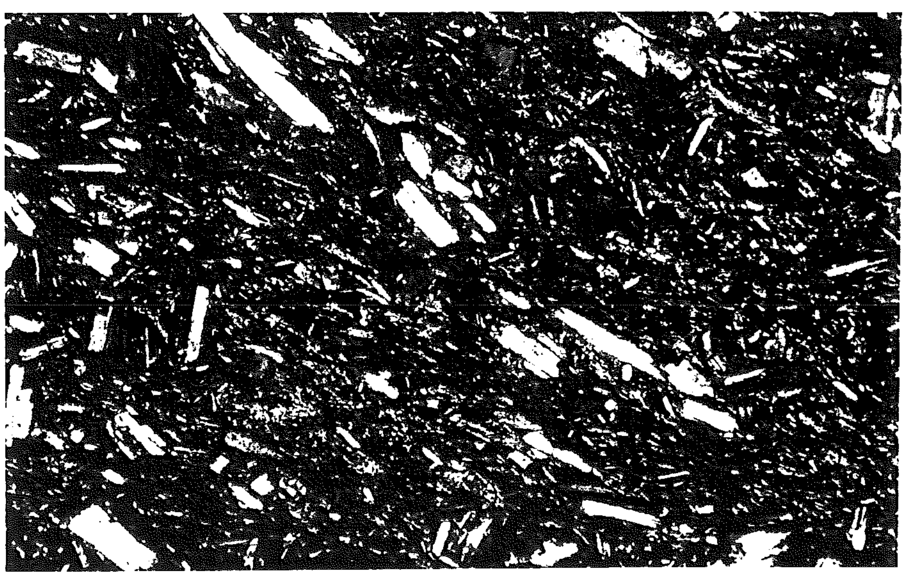


Plate 16. Cleaved mafic dyke, Lynn Road. Rock has medium-grained feldspar, chlorite and actinolite (?after ferromagnesian minerals). Opaque minerals occur in bands which bend around the feldspar as a result of deformation of the rock. 860, plane polarized light, x80.

Plate 17. Microgranite, upper Lynn Road, showing deformation effects. Albite twins in plagioclase are kinked and the groundmass in the top left corner of the plate is slightly recrystallised. 872, crossed polars, x200.

Plate 18. Sheared porphyritic mafic rock, complex thrust zone, Lynn Road. Note recrystallised nature of large phenocryst of plagioclase at bottom of plate. 2843, crossed polars, x80.

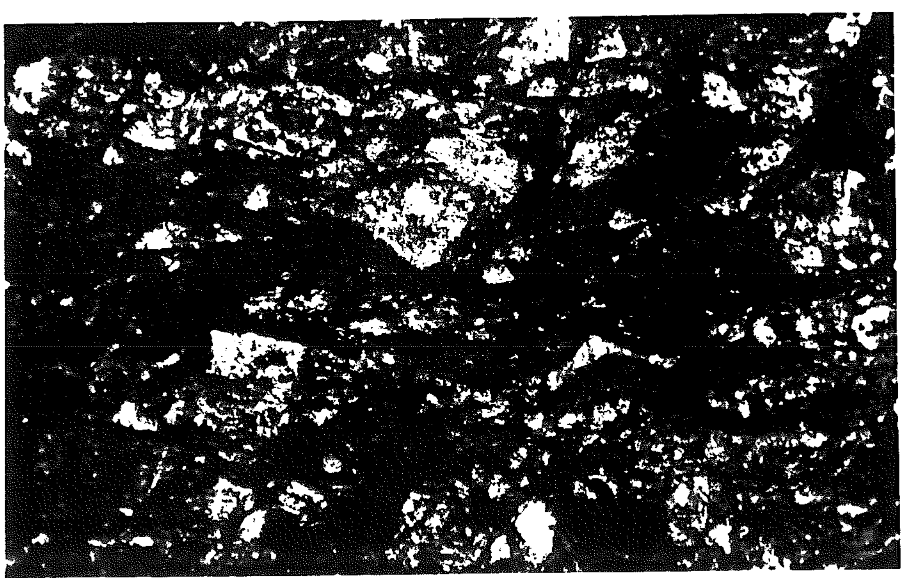
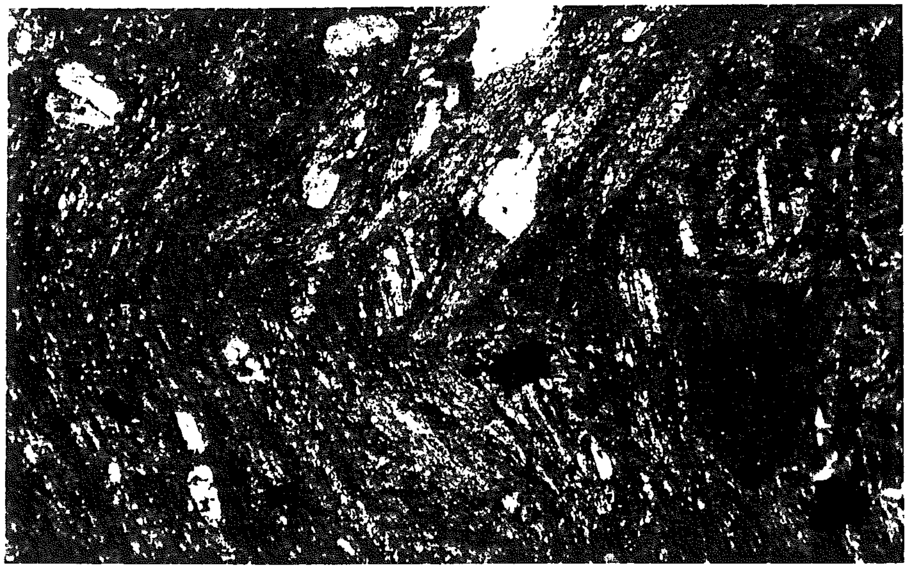
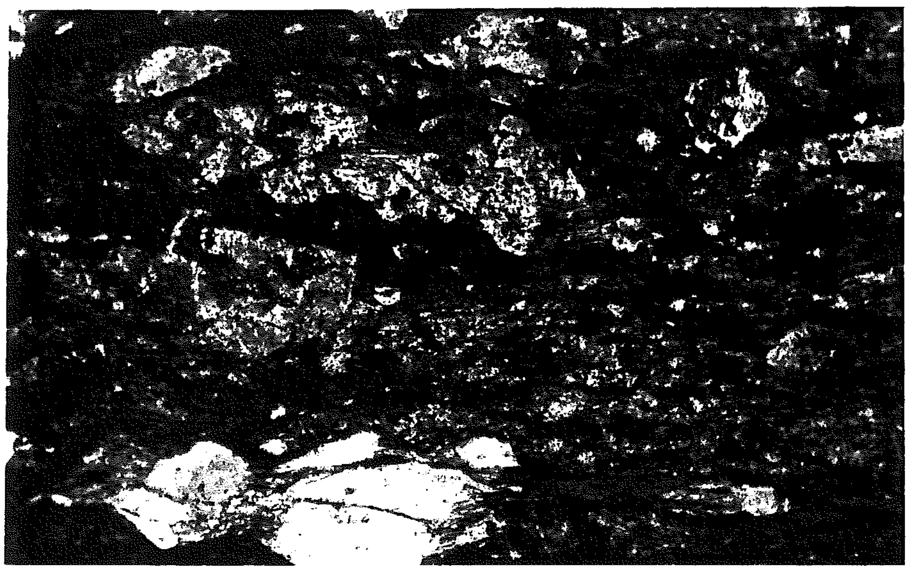


Plate 19. Sheared mafic rock (andesite), complex thrust zone, Lynn Road. The rock shows broken feldspar crystals, epidote, opaque minerals and chlorite (?pseudomorphing ferromagnesian mineral) between parallel cleavage traces. 379, plane polarized light, x80.

Plate 20. Mafic schist, probably originally Harrington River facies mafic lava, complex thrust zone, Lynn Road. The rock contains phenocrysts (?porphyroclasts) in a cryptocrystalline groundmass. Deformation is illustrated by the clear quartz crystal in the top right corner, which is broken and has chlorite and secondary biotite crystals and recrystallised quartz between the broken edges. There is also a thin lens of recrystallised material in the bottom right of the photograph. Alteration products include chlorite, epidote and dusty opaque minerals. 373, plane polarized light, x80.

Plate 21. Porphyritic rhyodacite, probable Harrington river facies, complex thrust zone, Lynn Road. The rock shows a fabric (?due to deformation or flow) folded into an open fold. Phenocrysts are plagioclase, alkali feldspar and cubic opaque minerals. The groundmass shows alternating fresh crypto-crystalline bands and bands of secondary biotite and muscovite. 033, crossed polars, x80.





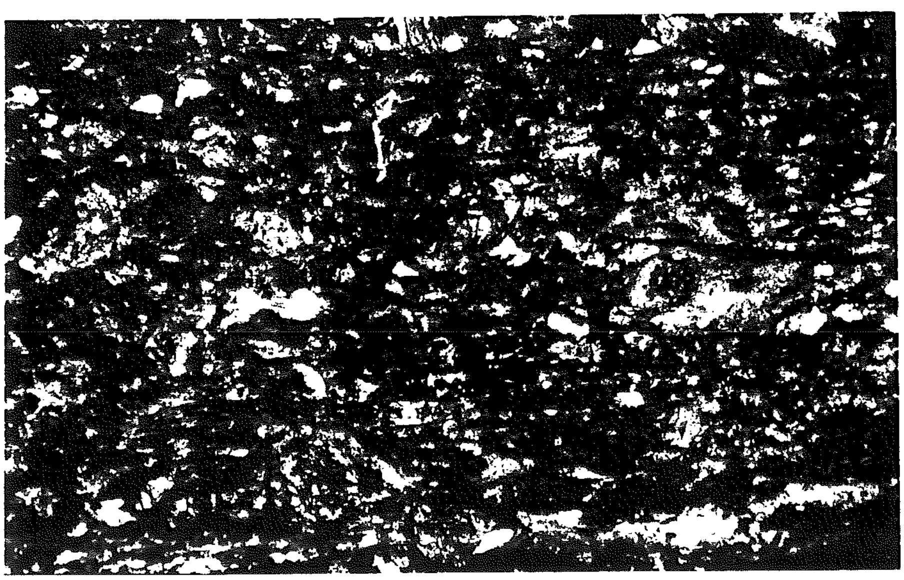
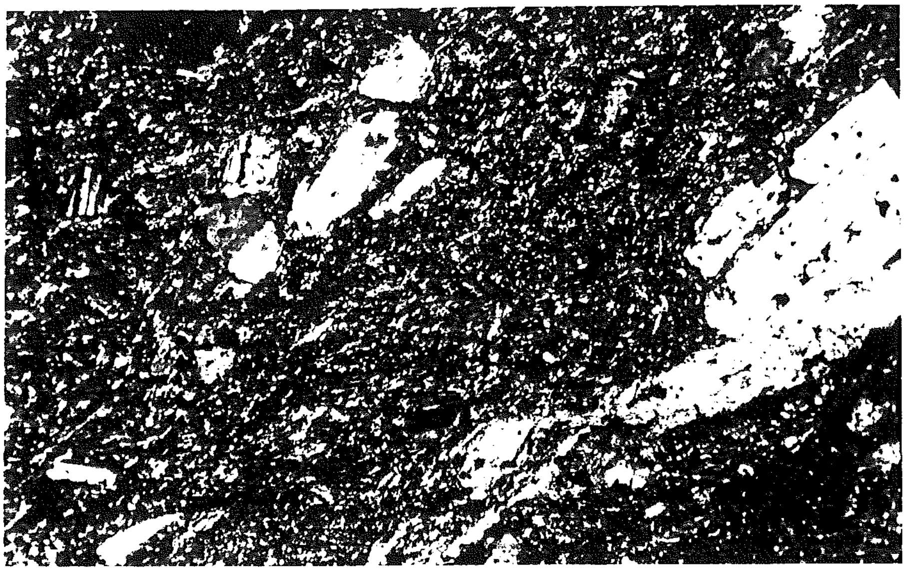


Plate 22. Matrix-supported tuff, complex thrust zone, Lynn Road. The rock shows sharp lithological boundaries: the dark layers are composed primarily of feldspar, chlorite and dusty opaque minerals, whereas the light layers consist of feldspar and minor chlorite. 199, plane polarized light, x80.

Plate 23. Coarse and fine grain-supported crystal tuff, complex thrust zone, Lynn Road. 2838, crossed polars, x80.

Plate 24. Mafic tuff with microcrystalline matrix and subhedral plagioclase crystals. Altereation to epidote is exhibited in the upper left corner of the plate. 2844, crossed polars, x80.



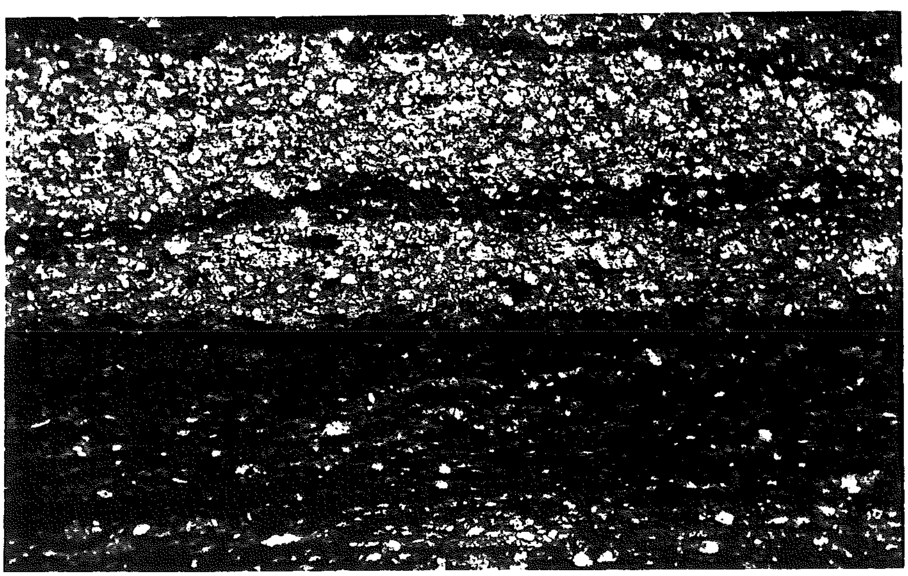
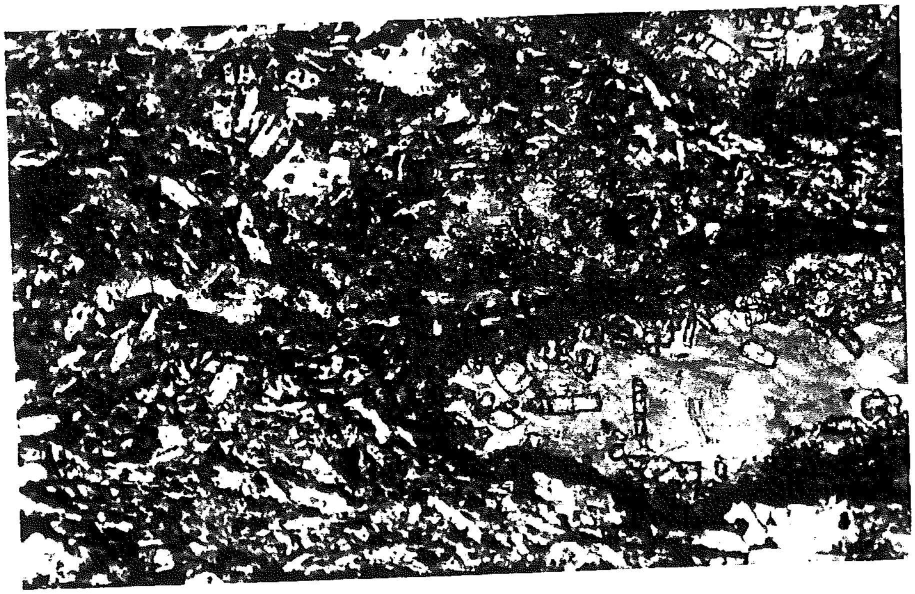


Plate 25. Porphyritic vesicular mafic flow, Harrington River facies, southern volcanic sequence, Lynn Road. The rock has a trachytic groundmass. Secondary minerals include chlorite, epidote and dusty opaque minerals. 1087, plane polarized light, x80.

Plate 26. Foliated mafic rock (tuff or flow), Harrington River facies, southern volcanic sequence, Lynn Road. Note the isoclinal nature of the kink folds in the groundmass. 1083, plane polarized light, x80.

Plate 27. Cleaved mafic rock, probably a hypabyssal intrusion, in the complex thrust zone, Lynn Road. The rock shows augen of feldspar phenocrysts at centre of plate. Feldspar has a growth of chlorite at the edges, which are slightly recrystallised. Opaques minerals are stretched out into thin bands. 1084, plane polarized light, x80.



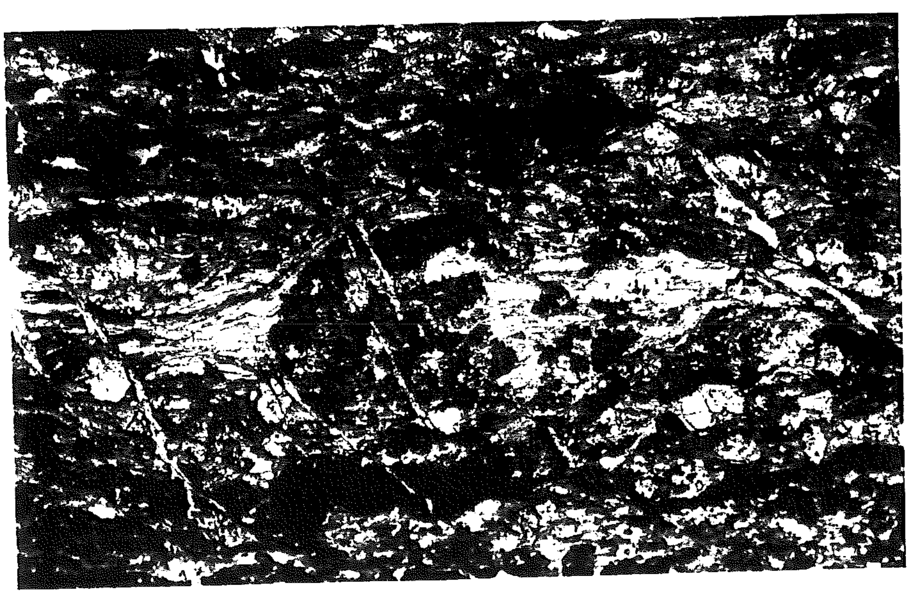
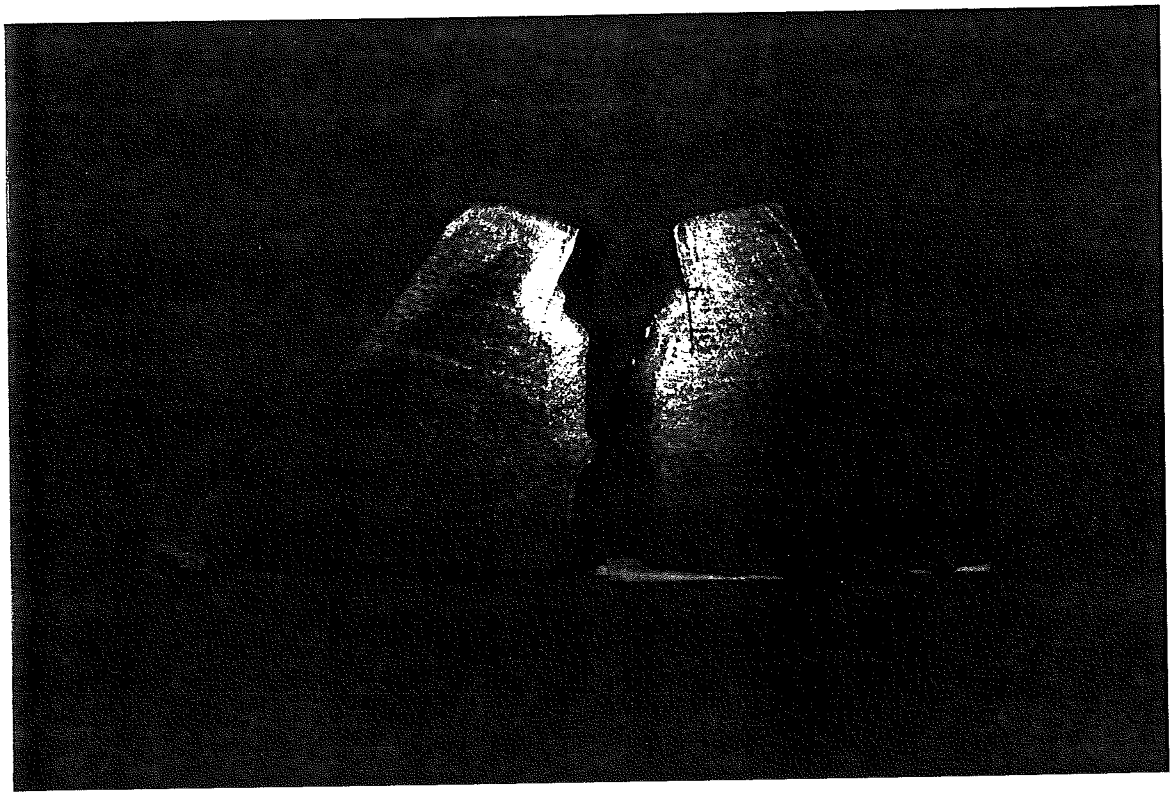


Plate 28. Hand specimen of spotted siltstone, West Brook facies, upper Jeffers Brook. 659.

Plate 29. Spotted siltstone, West Brook facies, upper Jeffers Brook. Shows area of development of brown biotite and spots of chlorite, quartz and muscovite. 659, plane polarized light, x80.



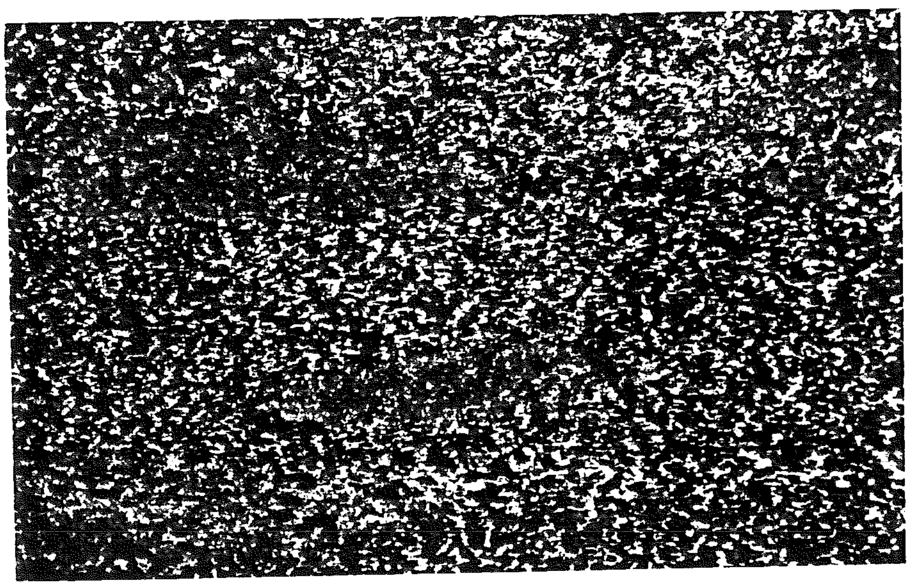
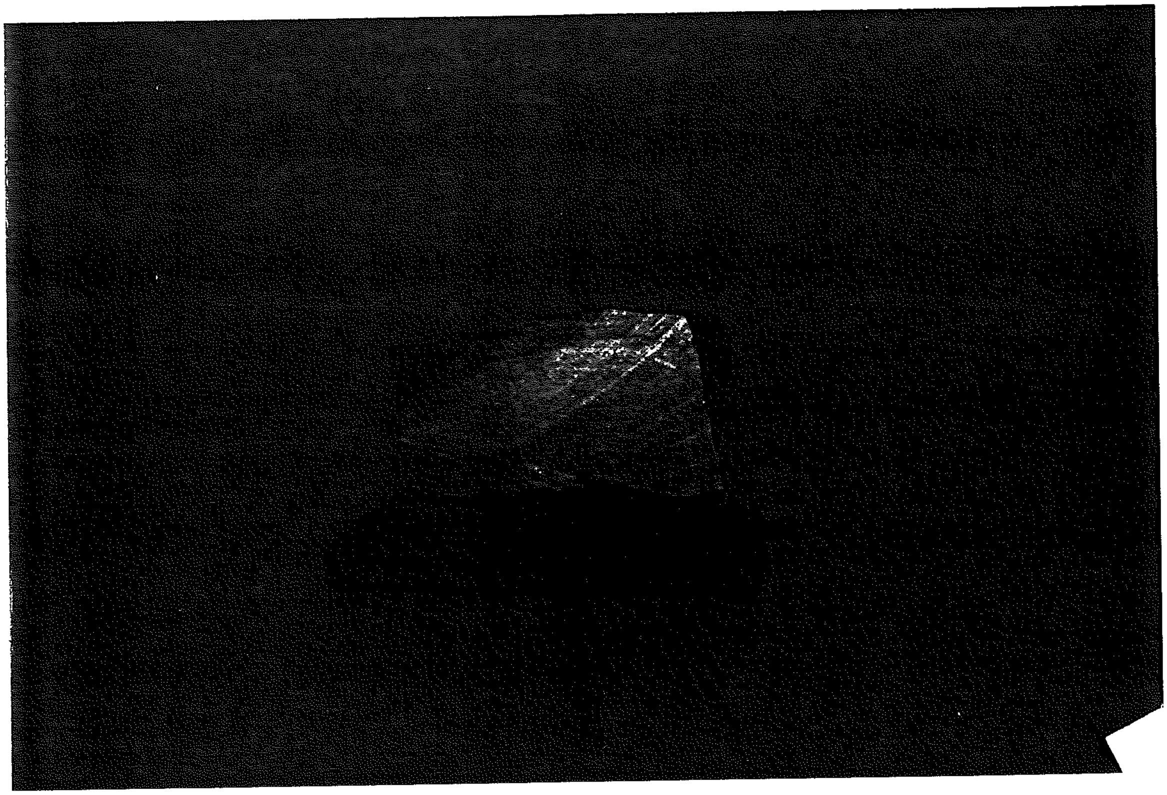


Plate 30. Hand specimen of deformed spotted siltstone, West Brook facies, upper Jeffers Brook. 641A.

Plate 31 Spotted siltstone, West Brook facies, upper Jeffers Brook. Shows apparent rotation of spots in the cleavage. 641A, plane polarized light, x80.



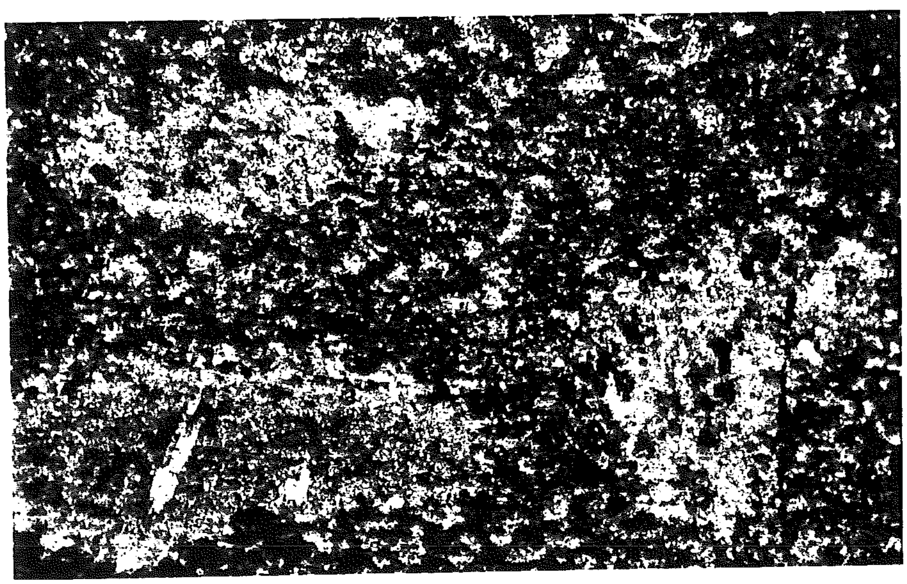
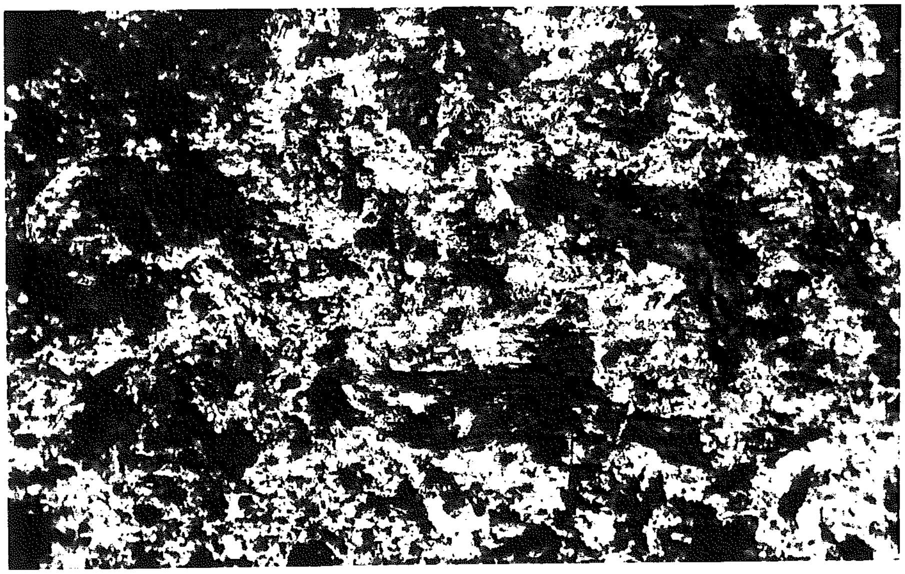


Plate 32. Mafic dyke, possibly a feldspathic mafic intrusion, upper Jeffers Brook. The rock shows an ophitic texture, consisting of altered feldspars, amphiboles and opaque oxides. Alteration is to actinolite, chlorite, epidote, and dusty opaques. 645, plane polarized light, x80.

Plate 33. Mafic dyke rock, N-S dykes, upper Jeffers Brook. The rock shows a subophitic texture, containing corroded quartz crystals with a rim of chlorite. 657, plane polarized light, x80.



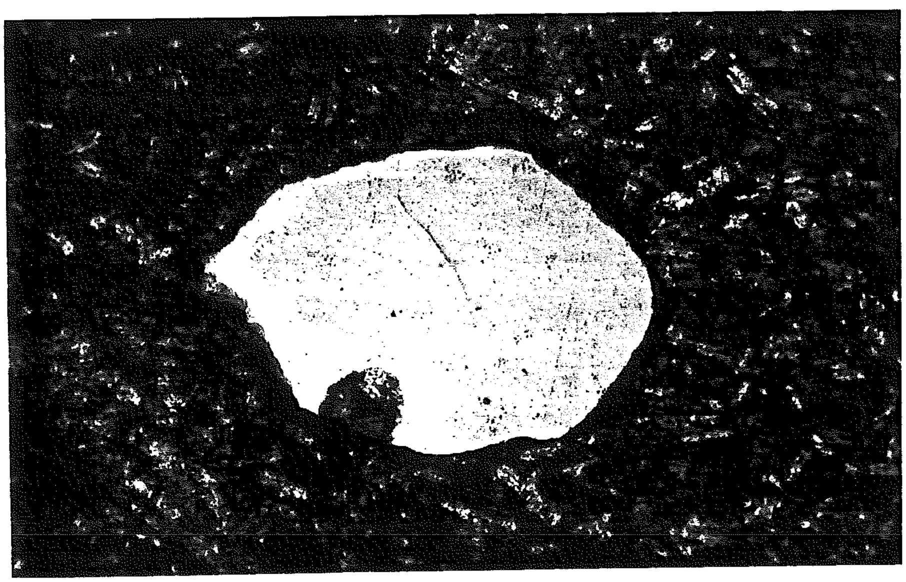


Plate 34. Rhyolite of uncertain affinity, Brown Brook. The rhyolite contains a clot of cognate quartz. 610, crossed polars, x80.

Plate 35. Porphyritic intrusive rhyolite, Brown Brook. Rock shows fine-grained matrix containing micromyrmekite. 619, crossed polars, x80.