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PRELIMINARY INVESTIGATION OF NEOPROTEROZOIC (AVALONIAN) ROCKS, NORTHEASTERN HOLYROOD (NTS 1N/6) MAP AREA: NOTES ON GEOLOGY, MINERALIZATION AND MINERAL EXPLORATION POTENTIAL

S.J. O'Brien and C.F. O'Driscoll[1]
Newfoundland Mapping Section

ABSTRACT

The early geological record in this part of the Newfoundland Avalonian belt reflects protracted and episodic volcanic activity near the end of the Proterozoic, the result of which was the accumulation of thick, and stratigraphically complex, successions of subaerial flows and pyroclastic rocks (Harbour Main Group). The deepest levels of this low-grade volcanic pile include felsic, intermediate and mafic rocks, dated between ca. 635 and 622 Ma. These have been intruded by high-level hornblende- and biotite-bearing calc-alkaline granites, granodiorites and related mafic and hybrid rocks that crystallized at about 620 Ma (Holyrood Intrusive Suite).

A thick sequence of argillite, sandstone and massive chert (Conception Group) was deposited unconformably above much or all of the Harbour Main Group. This marine siliciclastic succession also contains, near its base, glaciogenic debris flows and rare volcanic rocks. Basal contacts of the Conception Group, exposed in the eastern half of the study area, are erosive and are marked by boulder conglomerate units, rich in detritus derived from the underlying Harbour Main Group and Holyrood Intrusive Suite. Steeply dipping Harbour Main Group rocks locally strike perpendicularly into basal Conception Group conglomerates, implying that pre-Conception deformation of parts of the volcanic pile has occurred. In the westernmost part of the area, Conception strata overlie volcanic rocks that postdate the emplacement of the Holyrood Intrusive Suite. Although the Harbour Main–Conception boundary here is marked by boulder conglomerate, it appears to be regionally concordant.

Some of the youngest Neoproterozoic rocks are equigranular, diorite to quartz-monzonite intrusions that were emplaced into the Harbour Main Group and the overlying Conception Group, locally, across their boundary. These are considered to be younger than and unrelated to much of the Holyrood Intrusive Suite.

Hydrothermal alteration zones of varied scale are extensively developed within the Harbour Main Group. These consist of rocks displaying variable degrees of sericitization, pyrophyllitization, silicification and hydrothermal brecciation; most contain pyrite. In several cases, elevated gold values have been identified, and in these instances, copper mineralization is also present. A spatial association between mineralized outcrop and monzonitic to granodioritic intrusions is apparent locally. In a number of places, volcanic-hosted mineralization occurs at or near the boundary with overlying marine sedimentary rocks. The cherty appearance of parts of the Conception Group may also reflect hydrothermal alteration within the sedimentary pile. Intrusive rocks of all ages display variable alteration effects and are locally mineralized.

The most extensive documented mineralization in the study area occurs on the western flank of the Harbour Main Group, between Little Triangle Pond and Old Sea (Triangle Belt). There, gold occurs in float (up to 36g/t) and in till samples (500 to 2500 ppb) over a 5-km-long linear belt, underlain mainly by Harbour Main Group volcanic rocks and younger intrusions. Recent diamond drilling has identified gold mineralization along a strike length of approximately 1200 m.

[1] Mineral Deposits Section

INTRODUCTION

Subaerial volcanism, high-level calc-alkaline magmatism, and siliciclastic sedimentation in marine and terrestrial environments are geological processes long recognized as dominant in the Neoproterozoic record on the Avalon Peninsula of eastern Newfoundland (e.g., Rose, 1952; McCartney, 1967; Hughes and Bruckner, 1971; Nixon and Papezik, 1979; King, 1980). The resultant tripartite assemblage of low-grade volcanic, plutonic, and sedimentary rocks is equally representative of a large part of the encompassing Avalon Zone of the southeastern Newfoundland Appalachians (cf. Williams, 1979), to which the peninsula lends its name.

This larger tectonostratigraphic zone and the related Neoproterozoic rocks found farther west in the Appalachian Central Mobile Belt (Avalonian *sensu lato*; O'Brien *et al., in press*; Figure 1) together represent a composite pre-Iapetan terrane, characterized by four main pulses of tectonomagmatic activity between ca. 760 and ca. 550 Ma (O'Brien *et al.,* 1992). These events chronicle major tectonic stages in the evolution of parts of a larger peri-Gondwanan orogenic system, which was dispersed before, and reworked during subsequent Appalachian development (O'Brien *et al., in press*). Avalonian rocks sited east of the Central Mobile Belt have a unique lower Paleozoic record relative to the remainder of the Newfoundland Appalachians. In these areas, the composite Avalonian basement is overlain by a Cambrian to Early Ordovician shale-rich cover, containing distinctive peri-Gondwanan (Acado-Baltic) faunas (Hutchinson, 1962).

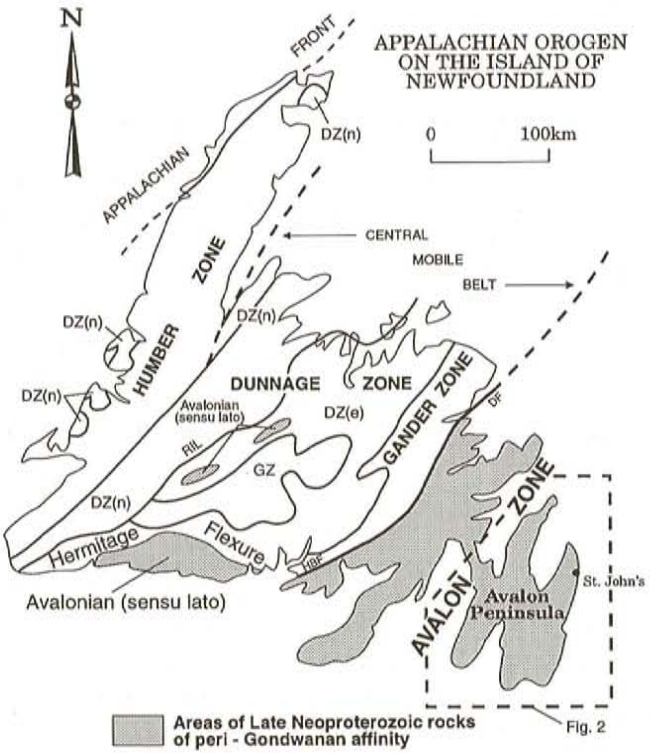


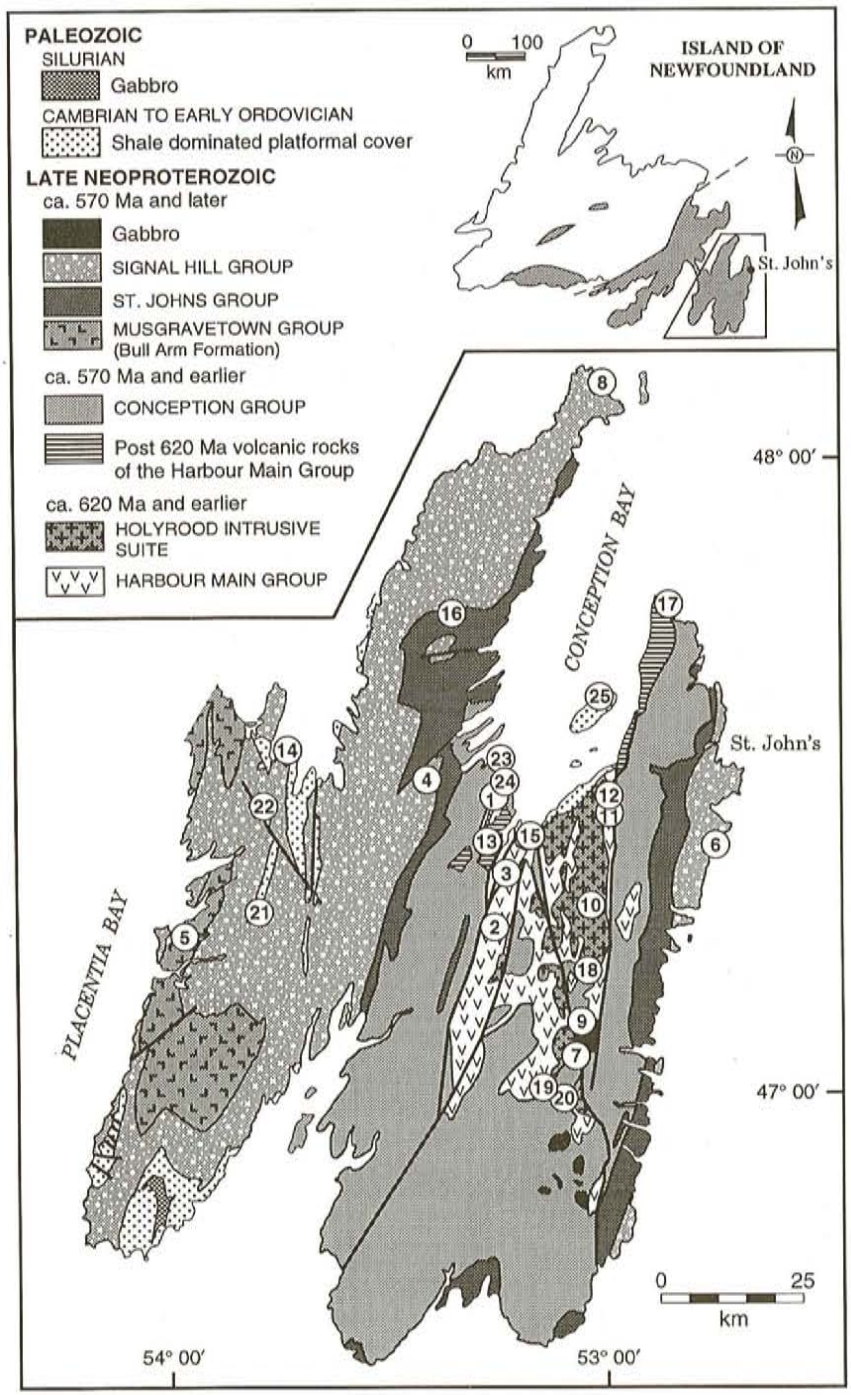
Figure 1. *Major geological divisions of the Newfoundland Appalachians, showing the distribution of Avalonian rocks (after O'Brien* et al., in press*); DZ(n) = Notre Dame Subzone, DZ(e) = Exploits Subzone, GZ = Gander Zone, RIL = Red Indian Line, DF = Dover Fault, HBF = Hermitage Bay Fault.*

AVALON PENINSULA: REGIONAL GEOLOGY AND MINERALIZATION

On the Avalon Peninsula, late Neoproterozoic (ca. 635 to 600 Ma) volcanic and plutonic units are disposed in an anticlinal dome (Holyrood horst), which extends southward from Conception Bay, flanked on a regional scale by successively younger, marine deltaic and fluvial siliclastic sedimentary rocks (e.g., King, 1988; Figure 2). Younger Neoproterozoic volcanic rocks (ca. 580 Ma and later) occur immediately below and within the fluvial sedimentary units, and appear to be most widely developed in the southwestern parts of the Avalon Peninsula. A less extensive suite of younger Proterozoic plutons has been locally emplaced into the volcanic and marine sedimentary assemblages.

Cambrian to earliest Ordovician shales and sandstones are preserved in outliers in several areas of the Avalon Peninsula, where they rest unconformably on different parts of the late Neoproterozoic stratified succession, and on the late Neoproterozoic plutonic rocks. Early Silurian mafic sills and related intrusions are emplaced into similar Cambrian cover in the southwestern part of the Avalon Peninsula, and represent the youngest exposed rocks in this portion of the Avalon Zone (Greenough *et al.*, 1993).

Late Neoproterozoic volcanic rocks along the eastern margin of the Holyrood horst are affected by widespread aluminous hydrothermal alteration (Hayes and O'Driscoll, 1990, 1994 and references therein). Several deposits of pyrophyllite occur in this zone (Figure 2), and the largest of these (Oval Pit Mine) is currently being mined by Armstrong World Industries Canada. The same alteration zone (Eastern Avalon High-Alumina Belt of Hayes and O'Driscoll, 1990) is locally associated with significantly elevated gold values (e.g., Dog Pond). Epithermal-style alteration is widely developed in Neoproterozoic rocks farther west in the Avalon horst and is, in places, associated with anomalously high concentrations of gold and copper (e.g., Triangle Belt; see section on Mineralization). Neoproterozoic plutons host hydrothermal alteration zones with anomalous concentrations of copper and gold. Elevated gold, arsenic and base-metal values in lake sediments are commonly associated with volcanic and plutonic rocks throughout the central Avalon Peninsula. Younger sedimentary successions elsewhere on the Avalon Peninsula also include sulphide-bearing shale-rich



REPRESENTATIVE MINERAL OCCURRENCES: AVALON PENINSULA

ORDOVICIAN HOST ROCKS

25 (B) Bell Island: Fe (hematite)

CAMBRIAN HOST ROCKS

24 (B) Brigus Point: Mn
23 (E) Brigus: Au
22 (C) Long Harbour: slate, SiO_2
21 (B) Villa Marie: SiO_2

LATE PRECAMBRIAN HOST ROCKS

20 (D) Aquaforte: Gn (Au)
19 (D) Bread and Cheese: Cu, Pb
18 (C) Butlers Pond: Cu, Au
17 (D) Cape St. Francis: Cu (Au)
16 (D) Carbonear: Cu, Fe (po)
15 (E) Chapel Cove: Fe, Py (Au)
14 (B) Collier Point: Ba
13 (C) Colliers River: Cu
12 (A) Foxtrap: pph
11 (C) Foxtrap TCH: Au
10 (E) Moly 1: Mo
9 (D) Oxley: Cu, Pb (Au)
8 (E) Red Head: Fe (qz veins)
7 (D) Rusty Zone: Pb
6 (E) Shoal Bay: Cu
5 (B) Silvercliff: Gn
4 (C) Snows Pond: Fe
3 (C) Triangle Pond N: Cu
2 (C) Triangle Pond S (Ace): Au, Cu
1 (B) Turks Gut

A = producer
B = past producer (dormant)
C = prospect
D = showing
E = indication

Figure 2. *Generalized geological map of the Avalon Peninsula, modified from King (1988), showing representative examples of mineralization.*

units (e.g., Carbonear), and these are highlighted in a number of areas by significant lake-sediment anomalies for base metals and gold.

The Paleozoic rocks of the Avalon Zone host a number of mineral occurrences, the largest, by far, being the Early Ordovician Clinton-type oolitic ironstone ores at Bell Island, Conception Bay (Hayes, 1915). These phosphate-rich iron deposits, which occur within gently dipping, shallow-marine strata, yielded more than 80 million tons (ca. 52 percent Fe) of ore, prior to mine closure in 1960. Enormous reserves remain undeveloped in the down-dip extension of the ore-bodies under Conception Bay. Nearby Cambrian rocks also contain significant reserves of manganese. Lower Cambrian

shales in eastern Newfoundland have long been quarried for use as roofing slate (e.g., Burgoynes Cove); extensive areas of such slate occur on the western Avalon Peninsula (e.g., Long Harbour).

Proterozoic and Paleozoic rocks host vein-type, base-metal, and/or gold mineralization in a number of areas. In some examples, such as on the west side of the Avalon Peninsula (Silver Cliff) and along the Isthmus of Avalon (La Manche), mineralization may be related to plutons exposed on nearby islands in Placentia Bay (Kerr *et al.*, 1993). In other cases (e.g., Brigus), no apparent link to plutonic rocks has been recognized.

SCOPE OF THE STUDY

The 1995 field work represents the resumption of a program of mapping and metallogenic investigations on the Avalon Peninsula, aimed specifically at late Neoproterozoic rocks (cf. Hayes and O'Driscoll, 1990, 1994). The focus of this current investigation is the late Neoproterozoic rocks in the north-central part of the Holyrood (NTS 1N/6) map area. To date, the study has concentrated on the nature of contacts of the three main Neoproterozoic units in the north half of that area, as well as the occurrence and nature of mineralization and alteration systems within these rocks. This report and the accompanying map are based, in part, on the authors' reconnaissance mapping, carried out over a 4-week-period in August and September, 1995, and in part, on subsequent compilation of existing published and unpublished data. The major sources of the compilation are McCartney (1954, 1967), O'Brien (1972), Nixon (1974), Ford (1977), Jacobs (1984), Rennie (1989) and Beischer (1991).

This study has dealt almost exclusively with Neoproterozoic rocks and the mineral occurrences therein, and for that reason, no discussion of the early Paleozoic outliers in the north of the area is presented. The geology of these rocks is described in a number of sources, including Hutchinson (1962), McCartney (1967), O'Brien (1972) and Boyce (1988). A comprehensive bibliography of paleontological studies of the Paleozoic rocks in and around Conception Bay is given in Boyce and Williams (1995).

DESCRIPTION OF THE LATE NEOPROTEROZOIC ROCKS

Most of the region considered here is underlain by low-grade rocks of late Neoproterozoic age, which belong to three regionally widespread geological units, *viz.* the Harbour Main Group (Rose, 1952), the Holyrood Intrusive Suite (McCartney, 1967), and the Conception Group (Rose, 1952; Figure 3). Less extensive Neoproterozoic units include a number of small plutonic bodies, most of which are younger than the Holyrood Intrusive Suite.

HARBOUR MAIN GROUP (UNITS 1 to 3)

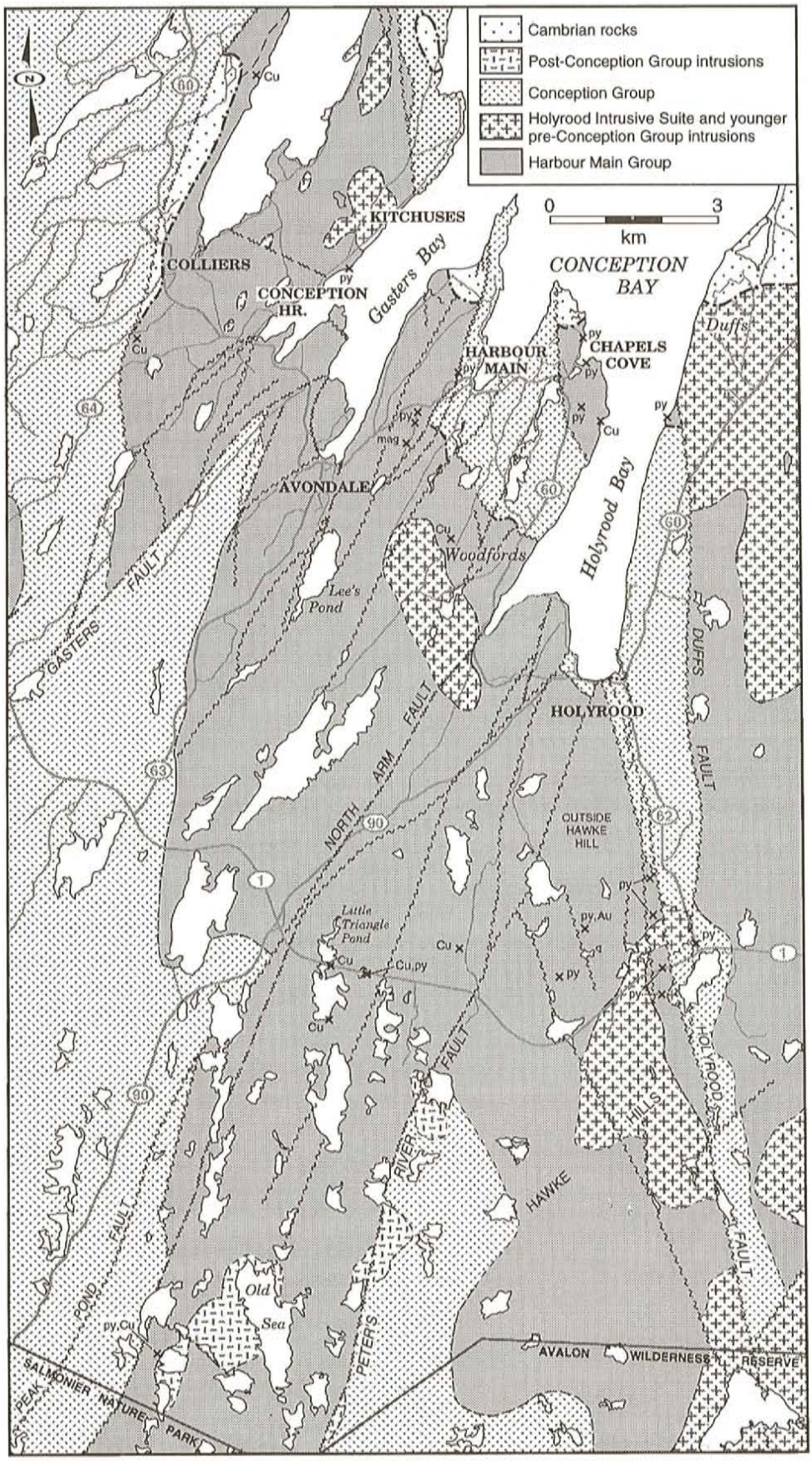
Introduction

Within the study area, rocks assigned to the Harbour Main Group record protracted and episodic volcanism over an interval of approximately 25 Ma in the late Neoproterozoic. Products of these eruptions form a thick and stratigraphically complex succession of subaerial flows and pyroclastic rocks of mafic to intermediate and felsic composition, interlayered on various scales with volcanogenic sedimentary strata. The presence of coarse-grained breccias, extensive rhyolite flows and thick ignimbrite sheets attest to the near-vent origin of much of the succession. The group consists primarily of prehnite – pumpellyite and low greenschist-facies rocks, disposed in broadly folded or steeply homoclinal sequences that, in most instances, are disrupted by brittle faults.

The oldest rocks in the Harbour Main Group occur east of the Peter's River Fault (King, 1988), where an unconformable relationship exists between the group and overlying siliciclastic rocks of the Conception Group. Rhyolite porphyries from this part of the Harbour Main Group have been dated at 631 ± 2 Ma (U – Pb zircon; Krogh *et al.*, 1988; see below) and are at least 25 Ma older than exposures encountered west of the Gasters Fault. Harbour Main Group strata outcropping in the area southeast of Gasters Bay are part of a succession of rocks that dip and appear to become progressively younger toward the east, up to the Holyrood Fault (King, 1988; Figure 4). This part of the group contains rhyolite flows dated at 622 ± 2 Ma (U – Pb zircon, Krogh *et al.*, 1988). The Harbour Main succession strikes at right angles into adjacent basal Conception Group rocks; their boundary has been interpreted as an unconformity (cf., McCartney, 1967).

In the western part of the study area, the Harbour Main Group forms an overall, northwest-dipping and northwest-younging, continuous succession that extends westward from the east shore of Gasters Bay, passing, through basal boulder conglomerate, into the Conception Group (west of Colliers Bay). This succession includes, in its medial stratigraphic levels, the youngest radiometrically dated rocks in the Harbour Main Group (606 ± 3 Ma; Krogh *et al.*, 1988).

The following summary of Harbour Main Group geology is presented within the framework of two main lithotectonic belts, separated by the Peter's River Fault. The western belt is further divisible into eastern and western blocks. A smaller and separate area of felsic volcanic rocks around Chapels Cove, on the west shore of Holyrood Bay, may represent the northwestward extension of Harbour Main Group exposed east of the Duffs Fault.

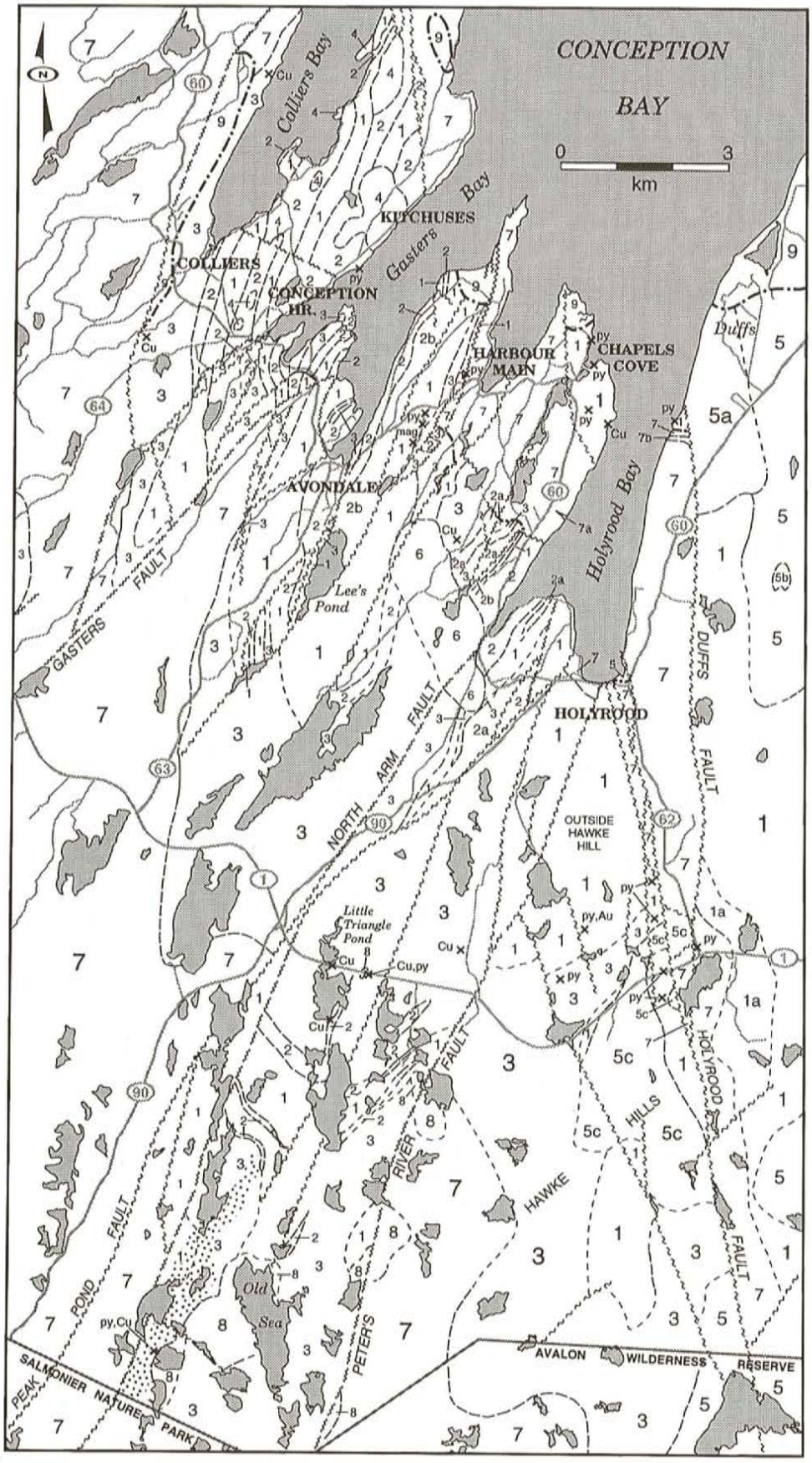


Harbour Main Group East of the Peter's River Fault

The oldest Harbour Main Group rocks in this part of the Avalon Peninsula occur in the area east of the Peter's River Fault (Figure 4). There, rhyolitic flows, ash flows, volcanic breccias and related rhyolite porphyry are exposed; all have been intruded by granite and granodiorite of the Holyrood Intrusive Suite. Fragmental rocks are variegated, in many instances coarse grained, and either monolithic (felsic) or polylithic (felsic and mafic) in character. Volcanogenic sedimentary rocks, widespread elsewhere in the Harbour Main Group, are not extensively developed east of the Peter's River Fault. It is unlikely that this difference reflects primary facies variations, given that the available U – Pb geochronology indicates that the volcanic-dominated stratigraphic succession encountered in the eastern portion of the study area predates that exposed west of the Peter's River Fault.

A narrow synclinal keel of Conception Group strata separates these volcanic rocks from a north-northeasterly to northeasterly trending sequence of unwelded lithic, crystal and lapilli tuffs, associated with welded ash flows. These are well-exposed on the

Figure 3. *Distribution of major stratigraphic and plutonic units in the study area.*



Outside Hawke Hill, where they form interlayered units with thicknesses in the order of hundreds of metres (Jacobs, 1984). The felsic units are bounded to the south and west by basalts, but the stratigraphic relationship between felsic and mafic rocks is unknown. Massive rhyolite flows in this belt are variably silicified, sericitized and, in several instances, heavily pyritized. The latter mineralization occurs around the north margin of a satellite body of the Holyrood Intrusive Suite at, and immediately west of, the Holyrood Fault (see section on Mineralization).

Harbour Main Group West of the Peter's River Fault

The widespread occurrence of epiclastic and volcanogenic sedimentary rocks is characteristic of the Harbour Main Group that is exposed west of the Peter's River Fault. Such facies occur at several different levels within two successions of contrasting stratigraphic character and age. Their boundary is locally defined by north-northeasterly trending faults near Lee's Pond.

Figure 4. *Geological compilation of parts of the Holyrood map area (NTS 1N/6), southeastern Newfoundland, incorporating the results of this study. Compilation sources given in accompanying report.*

LEGEND (for Figure 4)

EARLY AND MIDDLE CAMBRIAN

UNSEPARATED ADEYTON GROUP

9 *red, green, grey and black shale, minor limestone, basal conglomerate*

NEOPROTEROZOIC

8 *fine- to medium-grained monzonite, diorite and quartz monzonite*

CONCEPTION GROUP (Unit 7)

7 *unseparated thin- and medium-bedded, mainly grey and green, fine-grained marine siliciclastic rocks, including chert and siltstone; contains tillite and associated carbonate rocks in its lower parts, and locally, pebble- to boulder-conglomerate at and near its base; minor red chert and argillite;* **7a:** *pillowed basalt;* **7b:** *rhyolite flows and related breccia*

6 *fine- to medium-grained, equigranular, grey chloritized monzonite and quartz monzonite; minor diabase and granitic veins (Woodford's monzonite)*

HOLYROOD INTRUSIVE SUITE (Unit 5)

5 *mainly medium-grained, equigranular, pink, hornblende-biotite granite; minor unseparated dioritic and hybrid phases;* **5a:** *unseparated granodiorite, diorite, monzonite and quartz monzonite (may in part be equivalent to Unit 6); locally developed granophyre;* **5b:** *diorite;* **5c:** *granite porphyry, fine-grained granite and felsite; includes unseparated screens of rhyolite near its margins*

4 *equigranular, grey, plagioclase-rich hypabyssal intrusions of mainly intermediate composition; related intrusion breccia (Kitchuses porphyrites)*

HARBOUR MAIN GROUP (Units 1, 2 and 3)

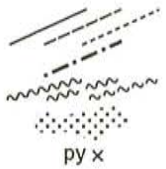
(stratigraphic order not implied)

3 *mainly subaerial flows and pyroclastic rocks of basaltic and andesitic composition; includes minor bedded epiclastic rocks*

2 *grey, green and red, coarse- to fine-grained epiclastic volcanic and sedimentary rocks; includes minor unseparated flows and massive pyroclastic rocks;* **2a:** *tuffaceous sandstone and bedded tuffs of mafic, intermediate and felsic composition;* **2b:** *thin-bedded, grey and green argillite*

1 *felsic lava flows and related fine- to coarse-grained pyroclastic rocks; includes minor epiclastic sedimentary rocks;* **1a:** *mainly coarse-grained fragmental rocks*

KEY



depositional or intrusive contact (defined, approximate, assumed)
unconformity
fault (defined, approximate, assumed)
zone of altered float and anomalous (Au) tills
mineral showing or alteration zone

ABBREVIATIONS

py.... pyrite
Cu.... copper mineralization, mainly chalcocite and malachite, minor bornite and chalcopyrite
Au.... gold
mag.. magnetite

Eastern Block. A continuous succession of Harbour Main Group strata, approaching 3 km in thickness, is exposed between the southeast shore of Gasters Bay and the Peter's River Fault. The sequence strikes northeastward, dips steeply to the southeast, and contains a series of massive rhyolite flows dated at 622 ± 2 Ma (Krogh *et al.*, 1988). The stratigraphically lowest of several thick rhyolite flow units is faulted against a parallel band of thinly laminated siliceous argillite, here assigned to the Harbour Main Group, following King (1988). Rhyolites are interlayered with basalt and basaltic breccia in the lower parts of the felsic succession. The rhyolites give way upward to interlayered felsic and mafic flows and pyroclastic rocks. Mafic rocks include vesicular basalt and andesite flows and distinctive, coarse-grained, green and red breccias. This mixed sequence passes up-section into a 1- to 2-km-thick succession of variegated volcanogenic sediment interstratified with crudely layered tuff units.

Mafic volcanic rocks also occur at several stratigraphic levels farther south within this belt, in an area where exposure is generally lacking. These units consist of massive flows and fine- to coarse-grained breccias of basaltic and andesitic composition. South of Little Triangle Pond, these rocks pass upward through tuffaceous sandstone, into rhyolite containing thin, discontinuous, volcanogenic sediment units. These pass southward, and supposedly up-section, into basaltic and andesitic flows (e.g., Rennie, 1989; Beischer, 1991). The exact relationship of this part of the Harbour Main Group with the well-exposed sequences in the north of the study area is uncertain.

Western Block. The Harbour Main Group exposed on the peninsula between Colliers Bay and Gasters Bay consists of red and maroon epiclastic sediments, regularly interbedded, on a scale of hundreds of metres, with thick units of ash-flow tuff (Nixon and Papezik, 1979). One of three major ash-flow units from this level of the Harbour Main Group (Weavers Hill sequence of Nixon, 1974) has yielded a U – Pb zircon age of 606 ± 3 Ma (Krogh *et al.*, 1988). The ash flows and sediments are intruded by high-level, cogenetic porphyritic plutons (see section on Kitchuses Porphyrites).

Between 300 and 600 m of basaltic flows and associated flow breccias overlie the interbedded ash flow–sediment succession (McCartney, 1967; Cameron, 1986). Compositionally, these basalts vary from subalkaline to mildly alkaline (Cameron, 1986), consistent with the view that the uppermost part of the Harbour Main Group, formed in an overall extensional regime (Nixon, 1974). It is suspected that these may represent the youngest flows within the Harbour Main Group, but their relation to thick and areally extensive mafic flows elsewhere in the area is unclear. Thus, it is not known whether the composition of the flows in the Colliers' area is representative of the Harbour Main Group as a whole (cf. Papezik, 1972; Nixon and Papezik, 1979). Similar flows reappear in an anticlinal dome exposed in the westernmost part of the study area.

Chapels Cove Area. Fine-grained, grey rhyolite lava flows, which are associated with breccias of both pyroclastic and hydrothermal origin, are exposed on the northwest shore of Holyrood Bay in the vicinity of Chapels Cove. These rocks are faulted with the Conception Group, and lie unconformably below fossiliferous Cambrian strata (O'Brien, 1972). The lavas and breccias are associated with intrusive rhyolite porphyry and granite porphyry, and host several pyritiferous alteration zones (see section on Mineralization). The rocks lie immediately northeast of, and up-dip from, a several-kilometre-thick, northeastward-younging succession of Conception Group rocks. The lavas are interpreted by O'Brien (1972) as being of post-Conception age. However, similar rocks are exposed due east of this section, on the east shore of Holyrood Bay, where they lie unconformably beneath the Conception Group. The absolute age of the Chapels Cove section is unknown and its relationship to volcanic rocks elsewhere is unclear.

KITCHUSES PORPHYRITES (UNIT 4)

Several small plugs and two larger bodies of grey, mainly fine-grained, plagiophyric intrusive rocks have been emplaced into volcanic and sedimentary units of the Harbour Main Group on the peninsula between Colliers and Gasters bays. The intrusions, referred to as porphyrites by Nixon (1974), are variably xenolithic and in many places exhibit autoclastic brecciation (Nixon, *op. cit.*). These intrusions are interpreted to be coeval with local Harbour Main volcanism, which is dated at 606 ± 3 Ma (Krough *et al.*, 1988), and are viewed to have been passively emplaced into non-lithified sediments (Nixon, *op. cit.*; Nixon and Papezik, 1979).

The porpyrites are significantly younger than the Holyrood Intrusive Suite, dated at 620 ± 2 Ma (Krogh *et al.*, 1988). The intrusions are intermediate in composition, and chemically distinct from the Harbour Main Group extrusive rocks, which in the immediate area of the porphyrites, comprise a distinctly bimodal (rhyolite-basalt) suite (Nixon and Papezik, 1979).

HOLYROOD INTRUSIVE SUITE (UNIT 5)

Hornblende- and biotite-bearing calc-alkaline plutons, which have been assigned collectively to the Holyrood Intrusive Suite, have been emplaced into the Harbour Main Group throughout the central Avalon Peninsula (King, 1988). With the exception of a small area of felsic intrusions in and around the Hawke Hills (Figure 3), only those plutonic rocks

occurring east of Duffs Fault are here assigned to this suite. Exposures in the study area represent the western edge of a much larger, continuous massif of granitic intrusions, having a total area of approximately 400 km^2 (McCartney, 1967; Rose, 1952). A sample of the Holyrood Intrusive Suite collected immediately east of this area has yielded a U – Pb zircon age of 620 ± 2 Ma (Krogh *et al.*, 1988).

The most extensive phases of the Holyrood Intrusive Suite encountered in the northern part of the study area are medium-grained, biotite – hornblende-bearing granite and granodiorite. These contain variably disaggregated dioritic enclaves, which occur on widely varying scales. Mixing and hybridization of the granitic rock with other less extensive, more melanocratic phases is common. Dark-grey, equigranular monzonitic to granodioritic rocks predate the leucocratic granite, and some of these rocks form discrete plutons (see McCartney, 1954). The more melanocratic phases host large rafts and rounded blocks of fine-grained diorite and aphyric mafic rocks, similar to that seen as inclusions in the granite. Fine- to very fine-grained granite and granite porphyry are also exposed locally, and are most extensive in the vicinity of the Hawke Hills. Chloritic and sericitic alteration of the Holyrood Intrusive Suite is prevalent in a number of areas. Exposures of the suite immediately east of the study area, near the entrance to Butterpot Park, include silicified, chloritized and vuggy granodiorite with quartz veins, locally containing heavily disseminated pyrite. Granodiorite in nearby exposures display various effects of hydrothermal alteration and contain distinctive, hydrothermal, diatreme breccias that resemble pebble dykes (cf. Sillitoe, 1985).

On the east shore of Holyrood Bay, near Duffs (Figure 3), spectacular coarse-grained, pink and white granophyre is spatially associated with xenolithic granite. The latter displays intrusive, gradational and tectonic contacts with diorite and monzonite. The granophyre forms round, blind bodies, and is associated with orbicular-textured microgranite. Large quartz crystals form stockschieder textures; individual quartz crystals up to 60 cm in width are preserved. The granites are crosscut by breccia veins, most of which are considered to be of tuffisitic origin (Hughes, 1971). Fluorite and tourmaline are spatially associated with the pegmatites and the breccias.

Rocks assigned to the Holyrood Intrusive Suite in the Hawke Hills area are typically fine-grained hornblende- and biotite-bearing, quartz-phyric granites and felsites. Granophyric textures are locally preserved on a macroscopic scale, and have been recognized more extensively in thin section (Jacobs, 1984). The Hawke Hills intrusions have been emplaced into variously altered rhyolites (see section on Mineralization), and may be linked at depth with the larger body of granite that occurs in the southeast corner of the study area.

External contacts of the Holyrood Intrusive Suite with the Harbour Main Group are either intrusive or tectonic. Complex intrusive intermingling of granite and the host volcanic rocks is observed locally (e.g., Holyrood Bay), whereas in other instances, their intrusive contact is sharp and discordant. The widespread presence of miarolitic cavities, tuffisite veins and granophyre is evidence that much of the suite crystallized at high crustal levels.

WOODFORD'S MONZONITE (UNIT 6)

Dark-grey and green intrusive rocks of chiefly monzonitic composition have been emplaced into the Harbour Main Group in the area west and southwest of Holyrood Bay. These rocks comprise a northwesterly oriented pluton (approximate dimensions of 3 km length and 1 km width) that McCartney (1959) denoted "Woodford's quartz monzonite", nomenclature based on exposures mapped in the vicinity of Woodford's. Their relationship to mafic to intermediate phases of the Holyrood Intrusive suite exposed farther to the east are unknown. McCartney's usage is here informally modified to 'Woodfords monzonite' in order to conform to the nature of the pluton's prominent lithology.

The most widely exposed rock type in the pluton is a medium-grained, green or green-brown to grey, altered pyroxene-bearing monzonite (Pelley, 1968). Minor quartz monzonite and granodiorite variants within the intrusion have also been described (O'Brien, 1972), and small-scale mixing of diorite and mafic monzonite with a pink, fine-grained granite phase is locally developed. The pluton is characterized by pervasive chloritic alteration. Chlorite may be related to regional metamorphism, but its presence could instead reflect regional (e.g., propylitic) hydrothermal alteration.

An intrusive contact with steeply dipping red sandstone and tuffaceous sedimentary rocks of the Harbour Main Group is exposed along the shore of the North Arm River, approximately 500 m south of Holyrood Bay. The Woodford's monzonite is not in contact with the Conception Group, and the relationship between these units is unknown. O'Brien (1972) noted that thermal affects of the granite observed in the Harbour Main Group are not seen in the Conception Group, and suggested that this may be evidence of a pre-Conception age for the Woodford's intrusion. The nearest outcrops of Conception Group are situated more than 1 km from the monzonite, and thus the presence or absence of thermal effects in these rocks may have little bearing on relative age.

CONCEPTION GROUP (UNIT 7)

Rocks assigned to the Conception Group within the study area are disposed in three separate belts. Broadly similar facies are found in each but the nature of the Conception Group's basal relationships with the Harbour Main Group in at least two of the belts are different (see section on Basal Relationships of the Conception Group). Most of our work has been restricted to the eastern belt of the Conception Group, which trends north-northwestward through Holyrood Bay. Unless otherwise noted, commentary is restricted to these exposures.

Basal conglomerates of the Conception Group are rich in well-rounded to angular detritus representing a wide variety of rocks found in both the Harbour Main Group and the Holyrood Intrusive Suite. The conglomerates are clast-supported and contain blocks locally up to 1 m in diameter. The detrital assemblage also includes vein quartz, jasper and silicified and veined volcanic rocks, in addition to clastic rocks of probable intrabasinal origin. Conglomerates contain thin, discontinuous, bedding-parallel layers of red sandstone and siltstone. Silty and shaly interbeds are more continuous and common up-section in the same area. Several, metre-thick flows of pink rhyolite overlie the conglomerate and are themselves overlain directly by volcaniclastic sediments and mixed mafic – felsic volcanic breccia; these, in turn, pass up into more conglomerates. The latter are overlain by green, thinly laminated argillite, locally containing dropstone-like granitic and volcanic clasts. The thin-bedded argillite passes up into red to purple boulder conglomerate, succeeded by green argillite associated with slumped, red, chert beds. Green sandstone overlies the cherts and gives way upward to a 30-m-thick, granite-rich, boulder conglomerate. The latter is capped by red and green chert and argillite.

Much of the Conception Group above this part of the succession consists of alternating units of thinly laminated, grey to green mudstone, argillite and more massive, cherty siltstone. Red chert laminae are conspicuous within the green strata in many areas, and locally, red, cherty exhalative-like rocks comprise separate, thicker beds. Green chert beds up to 20 cm thickness are locally interbedded with siltstone near the lower parts of the succession, in exposures south of Holyrood.

Tillites or mixtite-facies rocks (cf. King, 1990) are exposed close to the base of the Conception Group near Harbour Main. The glaciogenic succession is green in its lower half and red elsewhere. The mixtite contains numerous rounded dropstones of felsic and mafic volcanic rocks as well as high-level plutonic clasts suspended in a silty to sandy matrix. These rocks pass up into red siltstone containing thin, calcareous interbeds, which are overlain by a distinctive, ca. 50-cm-thick, grey-green to mottled pink-grey carbonate bed. The limy rocks are overlain by green siltstone. Finer grained clast-bearing rocks of similar glaciogenic appearance occur south of Holyrood Bay. Well-developed tillite is apparently absent in the section above the basal conglomerate on the east shore of Holyrood Bay. The presence of dropstones in one exposure may, nevertheless, suggest that at least some of the sediments near the base of the Conception Group in that section have a glaciogenic origin.

Between Holyrood Bay and Harbour Main, the basal exposures of the Conception Group, in a number of areas, are grey and green, well-rounded boulder conglomerates. These conglomerates are discontinuous along strike and vary in thickness from a few metres to almost 100 m (O'Brien, 1972); their local absence may be due in part to faulting. The conglomerate is rich in white vein quartz, black chert or quartzite, and red jasper; several examples of clasts with pre-incorporation foliations were noted. O'Brien (1972) has subdivided the overlying Conception Group in this area into alternating units of finely laminated and thin-bedded, dark-grey siltstone and massive, green cherty siltstone, regularly interbedded on the scale of tens to hundreds of metres. A mappable subunit of mafic volcanic rocks within the Conception Group occurs on the west shore of Holyrood Bay (McCartney, 1967; O'Brien, 1972). This thin unit of pillowed basalt flows occurs several hundred metres above the base of the group.

BASAL RELATIONSHIPS OF THE CONCEPTION GROUP

The Conception Group unconformably overlies Harbour Main Group felsic volcanic rocks on the east shore of Holyrood Bay. Erosional relief in the order of 1 m occurs at the contact. Basal conglomerate and overlying sedimentary rocks contain volcanic detritus derived from the underlying Harbour Main Group, in addition to a variety of granitoid clasts indistinguishable in lithology from phases of the Holyrood Intrusive Suite.

A similar unconformable relationship between the Harbour Main and Conception groups is reported in the area west of Holyrood (McCartney, 1967), in an area where Harbour Main rocks strike perpendicularly into the Conception Group. There, a basal conglomerate is locally preserved, although the original depositional relationships are variously obscured by late faulting. West of Avondale, the boundary of the Conception Group with the Harbour Main Group appears to be concordant. There is no interbedding of volcanic and sedimentary facies at the contact, and in several areas, coarse-grained conglomerate occurs at or near the boundary. The basal contact west of the Gasters Fault is unique within the study area in that it juxtaposes Conception Group strata (without mixtite-facies rocks) with Harbour

Main volcanic rocks that postdate the crystallization of the Holyrood Intrusive Suite.

UNNAMED MAFIC TO INTERMEDIATE PLUTONS (UNIT 8)

Within the exception of the aforementioned intrusions around the Hawke Hills, those plutonic rocks exposed west of the Duffs Fault are typically mafic to intermediate and equigranular. Several such plutons, composed of monzonite, quartz monzonite and quartz diorite of presumed late Neoproterozoic age, occur in the south central part of the study area. These rocks have intruded both the Harbour Main and Conception groups, and have been locally emplaced across the boundary of these units (McCartney, 1954; Rennie, 1989; Beischer, 1991). They are variously light-green to grey-green, or mottled pink and grey, fine- to medium- and locally coarse-grained, chlorite-rich and magnetic. Minor pink granite and felsite veins crosscut the predominant intermediate phases. One of these monzonitic intrusions is spatially associated with mineralization and alteration in the Triangle Belt.

Their intrusive relationship with the Conception Group requires that these intermediate plutons postdate those intrusions assigned to the Holyrood Intrusive Suite that lie unconformably below the Conception Group, or have shed detritus into it (including the dated 620 Ma plutons and co-genetic phases).

MINERALIZATION

INTRODUCTION

A brief description of some of the areas of hydrothermally altered and mineralized outcrops studied during the course of the 1995 field investigation is given below. The descriptions of mineralization in the Triangle Belt south of Route 1 are drawn solely from non-confidential assessment reports of Inco and Cominco (Rennie, 1989; Beischer, 1991). Brief descriptions of mineralized granite outcrops outside the study area have been presented elsewhere (see section on Holyrood Intrusive Suite).

Triangle Belt

Small chalcocite occurrences in Harbour Main Group basalt were discovered at Little Triangle Pond in the mid-1960s, and subsequently investigated by Texas Gulf Sulfur Company, in agreement with Commodore Mining. Prospecting south of Big Triangle Pond in the late-1980s, Vinland Resources discovered a major zone of mineralized and altered float and gold-bearing till along the southwestern side of the Harbour Main belt. The ground was subsequently optioned by Cominco in 1989 and by Inco in 1990. The property is presently being evaluated by Ace Developments Limited in agreement with Vinland Resources.

In the area from Little Triangle Pond, at least as far south as the Salmonier Nature Park (Triangle Belt), felsic to intermediate rocks displaying argillic and propylitic alteration, silicification and brecciation are found as angular boulders and, more rarely, as outcrop (Rennie, 1989; Beischer, 1991; Figure 4). Mineralized float and gold-bearing till occurs over a linear belt approximately 4 km in length. Elevated gold values have been obtained from till samples (500 to 2500 ppb) and float (up to 36g/t Au) (Beischer, 1991). Recent diamond drilling has identified gold mineralization along a strike length of approximately 1.2 km (Ace Developments Limited news release, June 16, 1995). Drilling on the property has intersected gold values up to 10.2 g/t, over 0.6 m (Ace Developments Limited, *op. cit.*). Other drillholes encountered extensive "quartz-breccias" with gold values of 1.2 g/t over 10 m and 0.5 g/t over 10 m (Ace Developments Limited, *op.cit.*). Elevated gold values associated with hydrothermal breccias in monzonite and host volcanic and volcanogenic sediments along strike of this zone have been discovered as far north as Route 1.

Holyrood Access Road and Environs

Silicified, pyritized and sericitized rocks of the Harbour Main Group and the Holyrood Intrusive Suite occur in outcrop and float in an extensive area between Outside Hawke Hill and Hawke Hills (Figure 4). A variety of rocks occur in the alteration zones in this area, including rhyolite, quartz-rich breccia, fine- and medium-grained granite and granite porphyry. Alteration occurs near the boundary of the Harbour Main and Conception groups, and bears additional spatial relationships with the Holyrood Fault and the Holyrood Intrusive Suite. A prominent, 200-m-long, north – south-trending rusty zone is exposed in roadside outcrops on Route 62, immediately north of Route 1. Heavily to lightly disseminated pyrite is associated with silicified and sericitized rhyolite, fine-grained hydrothermal breccia, and related clast-bearing rocks. The pyritic rock is fractured and locally traversed by reddish brown hematitic shear zones, and in a number of instances, is cut by narrow quartz veins and stringers. On the east side of the road, a narrow brittle fault separates pyritiferous rock from unaltered, coarse-grained boulder conglomerate of the Conception Group. Outcrops on the west side of the road record the gradation from felsic breccia and tuff with pyrite – silica – sericite alteration, southward through a 1-m-wide zone of pyrite – sericite alteration, into hematitized rhyolites containing quartz-chlorite veins; the latter rhyolites are juxtaposed with unaltered Conception Group rocks.

Approximately 2 km west of the Route 62 rusty zone, gold has been reported in outcrops of heavily pyritized rhyolite breccia (Mann, 1969). Anomalous gold values were described from seven localities over an area of approximately 1 km^2. Most were reported as containing only traces of gold, but values of ca. 270 and 2700 ppb were obtained from this zone (Mann, 1969; Figure 4).

In an area several hundred metres to the southwest of the Holyrood access road rusty zone (in roadcuts on Route 1), disseminated pyrite occurs in silicified rhyolite that is crosscut by discrete zones of aluminous alteration. Similarly sericitized, silicified and locally pyritized rhyolite and breccia occur sporadically within an outcrop area extending several hundred metres north and south from Route 1. Exposures of altered rhyolite near the eastern contact of the intrusion at the Hawke Hills (south of Route 1, near the power-line) contain narrow veinlets of hydrothermal magnetite, and are marked by elevated values of W, Mo and Zn.

Two smaller hydrothermal alteration zones outcrop approximately 1 km north of the rusty zone, in the Newfoundland Aggregate pit, west of Route 62. Veinlets and narrow stringers of red hematite, jasper and quartz are associated with hydrothermal breccia, within an intensely silicified, pyrite-rich felsic tuff. The latter is associated with red and green vitric tuff, silicified crystal tuff and welded ash-flows. The larger of the two alteration zones has an exposed width of 3 m and can be traced in the floor of the pit over approximately 30 m. It consists of rusty, highly silicified felsic volcanic rock, containing network fractures. Grab samples from the alteration zones contained only slightly elevated Au, As, and Sb (Table 1). A sample from a vein of granular-textured, light-grey quartz found as float within this pit contains visible gold. Granite is exposed in a nearby roadcut along Route 62, near the entrance to the pit.

Colliers River and Related Cu Occurrences

Basaltic and andesitic flows host copper mineralization associated with hydrothermal alteration and related fracturing in a number of other areas. At Colliers, a shaft and several prospect pits were sunk in mineralized basalt, presumably in the early part of this century. There, hydrothermally altered basalt contain narrow veinlets of bornite, chalcocite and chacopyrite. A 115-m-long adit driven in altered basalt on the east shore of the harbour at Avondale may date back to a similar era of exploration.

Minor chalcocite – malachite occurrences in quartz – carbonate veins are hosted by the Harbour Main Group mafic flows near Woodford's Station. Mineralization has a broad spatial relationship with the Woodford's monzonite. A grab sample from one of the veins revealed a slightly elevated Au value (68 ppb). A 5-m-deep shaft has been dug several hundred metres farther to the north in weakly silicified and sericitized mafic to intermediate rocks; no mineralization was seen in the exploration pit or in the surrounding dump. Large blocks of vuggy, monzonitic to granitic float, with fine chloritic network fractures and a hydrothermally leached appearance occur near the southern margin of the Woodford's monzonite; these have slightly elevated Au and As values.

At Little Triangle Pond, fractured and extensively epidotized intermediate fragmental rocks and andesitic flows host chalcocite and malachite in quartz – calcite veins and along fractures. Grab samples of chalcocite-bearing quartz – calcite veinlets contain slightly elevated gold values (18 ppb), and like the case noted above, mineralization has a broad spatial relationship with monzonite. Several hundred metres farther east, the same mafic sequence, with associated tuffaceous sediments, has been intruded by monzonite and pink granite. Both the intrusion and the country rocks are hydrothermally altered (chlorite – hematite – silica) and brecciated, and contain malachite, chalcocite and minor chalcopyrite; grab samples from this alteration zone returned assays between 11 ppb and 66 ppb Au.

Chapels Cove Area

On the southeast shore of Chapels Cove, Harbour Main Group felsic lavas host sericite–pyrite–silica alteration zones. Rhyolite flows and breccias (including hydrothermal varieties) contain discontinuous, 2- to 3-cm-wide zones in which massive to heavily disseminated pyrite forms a matrix of angular silicified breccia. The immediately adjacent volcanic rocks contain 1 to 2 percent disseminated pyrite. The autoclastic and hydrothermal breccias locally have a pebbly appearance and occur with quartz-phyric rhyolite porphyry and small, irregularly shaped zones of granite. A sample of pyrite-rich breccia assayed 70 ppb Au.

On the north shore of Chapels Cove, grey, slightly chloritized, sericitic rhyolite is host to several, metre-wide silicified zones, containing moderately to heavily disseminated pyrite. Several small adits have been blasted in altered rhyolite containing pyrite and chalcopyrite; these occur on a headland approximately 1 km south of Chapels Cove (O'Brien, 1972). Several rusty exposures of fragmental, sericitic volcanic rocks occur due east of this headland, on the east shore of Holyrood Bay. The largest of these extends for approximately 50 m along the shore. Pretectonic mafic dykes exposed in this area are unaffected by alteration.

Harbour Main Area

Silicified and variously pyritized and sericitized felsic volcanic rocks occur in outcrop and in float in the area

Table 1. Location of assayed samples, including alteration zones referred to in text (Au in ppb, As and Sb in ppm, INAA[1] results from Bequerel Laboratories Inc.); all samples collected from NTS 1N/6 (Zone 22)

Sample	Easting	Northing	Au	As	Sb	Rock Type
95-02	340100	5244900	2	7.7	0.4	rhyolite with sericite/silica alteration
95-06	334850	5244850	3	2.6	1.0	rhyolite with disseminate pyrite
95-07	334800	5244860	66	3.6	1.5	quartz-calcite-black chlorite breccia
95-08	334750	5244880	4	2.5	1.1	breccia
95-09	334700	5244900	11	7.8	4.8	quartz-calcite-malachite breccia vein
95-10	334710	5244900	9	4.0	1.9	silicified hydrothermal breccia with malachite
95-12	334700	5245010	18	7.8	0.8	mafic porphyry with chalcocite and malachite
95-13	335990	5248150	0	5.7	0.5	brecciated rhyolite
95-14	335050	5250710	14	28.0	2.0	leached, vuggy granite (float)
95-15	336495	5252551	14	1.3	0.3	quartz-calcite-chalcocite vein in basalt
95-16	336500	5252550	0	6.7	0.5	quartz vein
95-17	339150	5255750	16	3.4	0.6	rhyolite breccia with pyrite
95-18	337250	5253050	0	0.0	0.0	detrital vein quartz
95-19	336500	5252700	0	1.1	0.1	quartz-red hematite veins in basalt
95-20	340100	5244800	6	10.0	0.1	silicified zone in rhyolite
95-21	336400	5252920	0	1.5	0.3	sericitized intermediate tuff
95-22	344050	5245550	0	1.7	0.5	rhyolite with chlorite and disseminated pyrite
95-23	339908	5246482	6	8.1	1.8	hematite, quartz veinlets in hydrothermal breccia
95-24	339909	5246481	0	32.0	14.5	silicified, red hematite-pyrite bearing tuff
95-25	339910	5246480	7	25.0	2.3	silicified rusty rhyolite with hematite in fractures
95-26	339910	5246480	3	8.8	1.3	silicified rusty rhyolite with hematite in fractures
95-27	340580	5254710	0	0.6	0.0	sericitic alteration zone
95-28	340580	5254711	3	3.0	0.6	rusty sericite-rich alteration zone
95-29	345080	5254709	0	5.5	0.5	rusty sericite-rich alteration zone
95-30	345850	5249290	3	1.5	0.4	pyritic granitic
95-31	345710	5249050	2	0.9	0.8	altered granite
95-33	338390	5251600	0	1.4	0.5	rusty rhyolite
95-34	336900	5255600	0	29.0	3.9	clay-rich, rusty sericitic rhyolite
95-35	336900	5255601	0	14.0	3.3	sericitic flaggy rhyolite
95-36	336400	5255010	0	12.0	2.2	silicified rhyolite (float)
95-37	336300	5255050	3	48.0	3.1	sericite-silica-pyrite altered rhyolite
95-38	339100	5256200	2	17.0	0.6	chloritized pyritic rhyolite
95-39	339100	5257210	2	2.3	0.5	silicified pyritic rhyolite
95-40	340010	5244400	5	12.0	0.1	silicified rhyolite
95-41	340010	5244400	0	1.8	0.2	rhyolite with disseminated pyrite and magnetite veinlets
95-42	340010	5244401	0	9.4	0.0	rhyolite with disseminated pyrite
95-43	339150	5255750	70	7.3	0.8	pyrite-rich felsic breccia
95-44	340690	5245360	3	14.0	0.8	pyrite-rich rhyolite
95-45	340690	5245350	0	1.1	0.9	quartz-chlorite vein in silicified zone
95-46	340700	5245360	2	7.2	0.6	rusty, pyritiferous silica-sericite alteration zone
95-47	340690	5245390	3	7.4	1.1	rusty, pyritiferous silica-sericite alteration zone
95-48	340685	5245400	2	8.1	1.1	rusty, pyritiferous silica-sericite alteration zone
95-49	340670	5245430	0	14.0	1.5	rusty, pyritiferous silica-sericite alteration zone
95-50	340660	5245460	0	17.0	0.8	rusty, pyritiferous silica-sericite alteration zone
95-51	340650	5245490	4	19.0	0.9	rusty, pyritiferous silica-sericite alteration zone
95-53	340630	5245535	2	14.0	0.4	rusty zone with quartz veins
95-54	340620	5245550	0	2.5	0.6	rusty silica-sericitic alteration (zone)
95-55	339050	5255050	11	31.0	1.2	rhyolite with disseminated pyrite
95-56	336020	5254880	0	34.0	1.0	pyritic, silicified rhyolite
95-57	336000	5254800	3	6.6	1.0	vuggy, pyritic rhyolite
95-58	336000	5254810	2	11.0	1.1	vuggy, pyritic rhyolite

[1] Instrumental Neutron Activation Analysis

between Harbour Main and Holdens Road (approximately 1 km southwest of Harbour Main). The host rocks are interlayered with a thin mafic unit and occur at or within a few hundred metres of the contact of the Harbour Main and Conception groups, which in this area is tectonic. Near Holdens Road, alteration occurs in vuggy rhyolite with quartz lithophysae, and in rusty, variable brecciated, silicified rhyolite. A magnetite occurrence near the same area was noted by Mann (1969). Rusty, silicified felsic volcanic float, locally with malachite staining, occurs farther northeast, in building lots adjacent to Route 60. Nearby outcrops contain zones of sericite – epidote – silica – pyrite alteration. Farther northeast, at the Harbour Main fire hall, a zone of rusty alteration with sericite and clay minerals occurs in vuggy, lithophysae-bearing rhyolite at the fault contact with the Conception Group.

MINERAL EXPLORATION POTENTIAL

The volcanic rocks in this part of the Holyrood map area (NTS 1N/6) occur almost exclusively within the Harbour Main Group, and are host to a large number of silicified, sericite-rich hydrothermal alteration zones. Most are pyritiferous, and some contain copper mineralization and in some cases anomalous concentrations of gold. These vary from a few metres to kilometres in length and display variable degrees of silicification and sericitization, hydrothermal brecciation and hematization, and, locally, pyrophyllitization. The most extensive area of high-alumina alteration and anomalous gold occurs in the southwestern corner of the area (Ace Developments Limited "Triangle Pond properties"). Alteration affects the Harbour Main Group near the boundary with the Conception Group, and in many cases, is spatially associated with monzonitic intrusions.

The volcanic rocks of the Harbour Main Group, particularly in the vicinity of the Late Neoproterozoic intrusions, represent a favourable exploration target for epithermal gold mineralization. Preliminary assay results indicate that, in almost all cases, elevated gold values in volcanic-hosted alteration zones were encountered only where copper mineralization is present. There also appears to be a strong spatial association between mineralized outcrop and granitic and monzonitic intrusions, as in the Triangle Belt.

Felsic to intermediate intrusions within and proximate to the study area display chloritic and sericitic alteration and are locally mineralized, mainly with pyrite. Some are also associated with minor occurrences of molybdenite, magnetite, chalcopyrite, gold, tourmaline and fluorite. Some of these granites and related intrusions represent potential exploration targets for porphyry Cu – Au style mineralization, which may be related genetically to epithermal alteration occurring at higher crustal levels in the same volcano-plutonic complex.

Correlation with other Avalonian rocks in the Appalachians outside of Newfoundland, particularly those of the late Neoproterozoic Carolina Slate Belt (southeastern USA), further highlight the exploration potential of the Proterozoic rocks of eastern Newfoundland, particularly for gold. The Carolina Slate Belt is host to widespread epithermal and exhalative-style gold mineralization (Worthington and Kiff, 1970; Feiss *et al.*, 1993), and contains four mines that have been brought into production since the mid-1980's. Gold mineralization in some cases, such as the late Neoproterozoic high-sulphidation-type deposits of the Brewer Mine (Brewer Gold Company), is hosted exclusively by volcanic rocks. In the ca. 60-million-ton Ridgeway Mine (Kennecott Minerals Company), gold mineralization occurs within both sedimentary and volcanic rocks. Gold mineralization at Ridgeway and at the Piedmont-Amax Haile Mine is interpreted by a number of authors as submarine epithermal-exhalative in origin (Spence *et al.*, 1980; Kiff and Spence, 1987). Like most other mineralization in the Carolina Slate Belt, these deposits bear a strong spatial relationship to the boundary between volcanic and overlying marine sedimentary units of late Proterozoic age. Such correlations are important in identifying not only the volcanic rocks, but also the turbidites and related cherts, such as those in the lower part of the Conception Group and in other Avalonian marine sedimentary units, as potential targets for gold mineralization in eastern Newfoundland.

A number of recent studies have demonstrated that coeval Neoproterozoic rocks in the Hermitage Flexure region of the Newfoundland Appalachians formed together with those in eastern Newfoundland in a broadly similar tectonic environment (e.g., Dunning and O'Brien, 1989; O'Brien *et al.*, 1991, 1993). The presence of gold-bearing Neoproterozoic successions of Avalonian character in the Hermitage Flexure in southern Newfoundland (eg. Royal Oak's Hope Brook Mine; Dubé *et al.*, 1994) again underscores the Avalon Zone as an important area for gold exploration.

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Note: Geological Survey file numbers are included in square brackets.