Current Research (1990) Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 90-1, pages 145-155

REGIONAL GEOLOGICAL SETTING AND ALTERATION WITHIN THE EASTERN AVALON HIGH-ALUMINA BELT, AVALON PENINSULA, NEWFOUNDLAND

John P. Hayes[1] and Cyril F. O'Driscoll
Mineral Deposits Section

ABSTRACT

The eastern Avalon high-alumina belt is defined as a 14-km-long, north-striking zone of pyrophyllitic, sericitic and silicified, locally pyritic, felsic volcanic rocks. The high-alumina belt occurs within a shear-zone system in the Precambrian Harbour Main Group, near the eastern margin of the Holyrood Intrusive Suite. The presence of clasts of the altered rocks within the basal Cambrian conglomerates indicates that the alteration is Precambrian, and the apparent structural controls on the alteration provide conclusive evidence for a period of Precambrian deformation.

Results of a bedrock sampling program show that the silicified pyritized felsic volcanic rocks within the alteration system, locally contain anomalous concentrations of gold having a high value of 1060 ppb.

INTRODUCTION

Highly altered felsic volcanic and epiclastic rocks of the Harbour Main Group outcrop in a 14-km belt along the eastern margin of the Holyrood Intrusive Suite. Alteration is characterized by pyrophyllitization, silicification and sericitization. The Oval Pit Mine, owned and operated by Armstrong World Industries Canada Limited, Newfoundland Minerals Division (formerly Newfoundland Minerals Limited), is Canada's only producing pyrophyllite mine and is located in the northern part of the belt (Figure 1). Zones of intense pyrophyllitization also occur at Mine Hill, Trout Pond, Dog Pond and Jakes Gully. The name 'eastern Avalon high-alumina belt' is a name proposed as a collective term for the pyrophyllite occurrences and related alteration.

High-alumina-type alteration is widespread within the Avalon tectonostratigraphic zone and is locally associated with gold mineralization. The Hickey's Pond belt on the Burin Peninsula (Huard and O'Driscoll, 1985, 1986; Huard, 1989) is an example of high-alumina mineralization, associated with gold in the Newfoundland Avalon Zone. In North and South Carolina, U.S.A., gold is currently mined in areas characterized by the presence of high-alumina zones, in rocks equivalent to those of the Avalon Zone (Schmidt, 1985).

Previous Work

Previous geological studies in the area have concentrated on regional geology (Rose, 1952; Dawson, 1963; McCartney, 1967) and the geological setting and genesis of the pyrophyllite deposits (Vhay, 1937; Lee, 1958; Keats, 1970 and Papezik *et al.* 1978). Exploration for pyrophyllite has been done primarily by Newfoundland Minerals Limited. Drilling and assessment work has concentrated on all major pyrophyllite occurrences along the belt. Recent exploration in the area by APEX Geological Consultants (Saunders, 1986) and Esso Minerals (Lenters, 1986) has been directed toward gold.

Present Study

The objectives of this project are to determine the geographical extent and the precious mineral potential of the alteration system. It forms the basis for a M.Sc. thesis at Memorial University of Newfoundland by the first author. The thesis is a study on the genesis and regional geological setting of the alteration system.

During the present study, the alteration associated with the eastern Avalon high-alumina belt was mapped and sampled for gold. Mapping was conducted at a scale of 1:12,500 and in some areas at 1:2,500, to resolve regional geological relationships and delineate the distribution of secondary minerals within the alteration system. The mapping shows that the mineral zonation associated with the alteration system can be recognized at a mappable scale (see Hayes and O'Driscoll, 1989). Detailed mapping has led to revision of the existing geological maps for the area between Black Mountain to the Thousand Acre Marsh (Figure 2; Hayes and O'Driscoll, 1989).

[1] On temporary assignment from Newfoundland Mapping Section, June to December, 1989

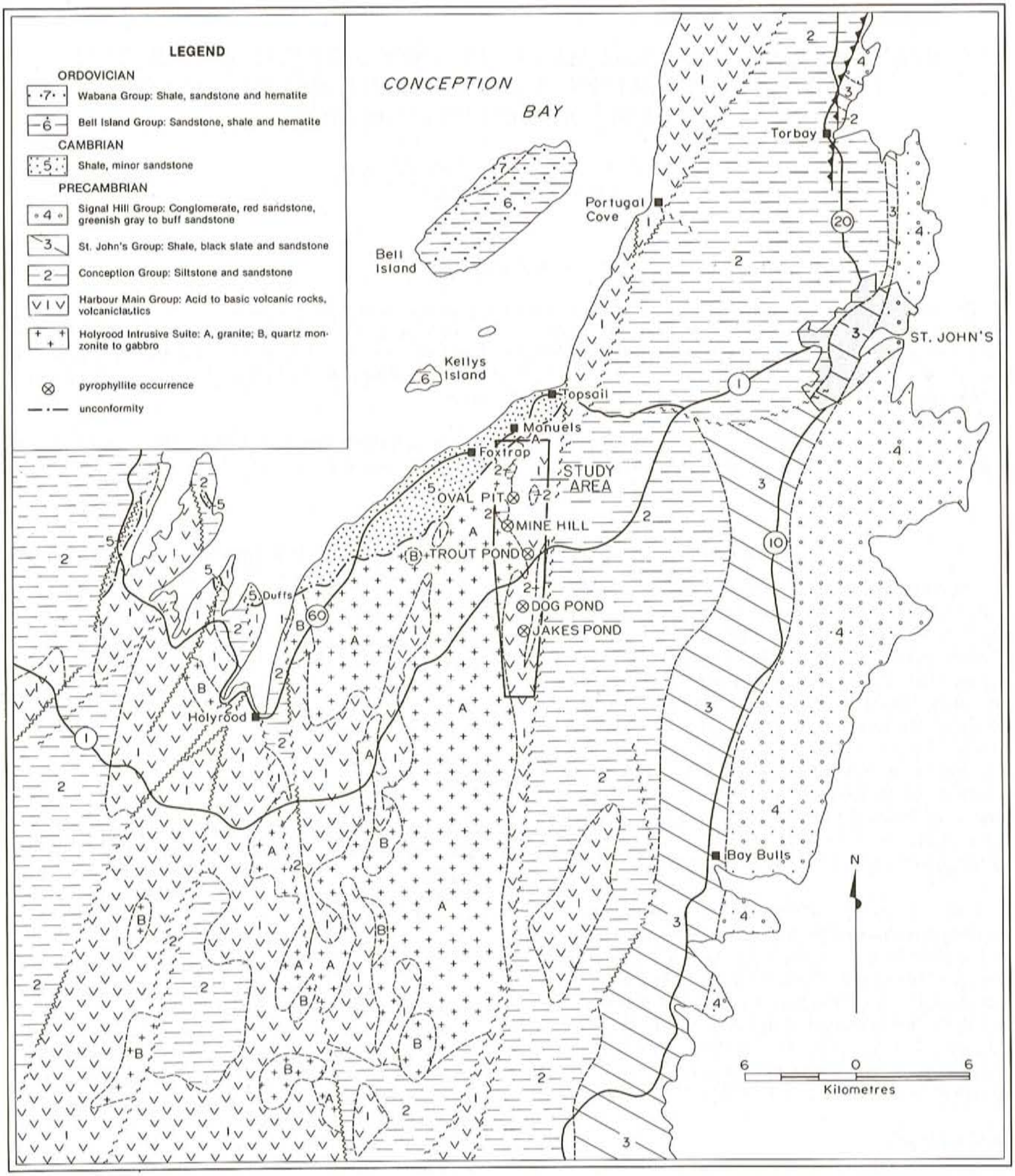
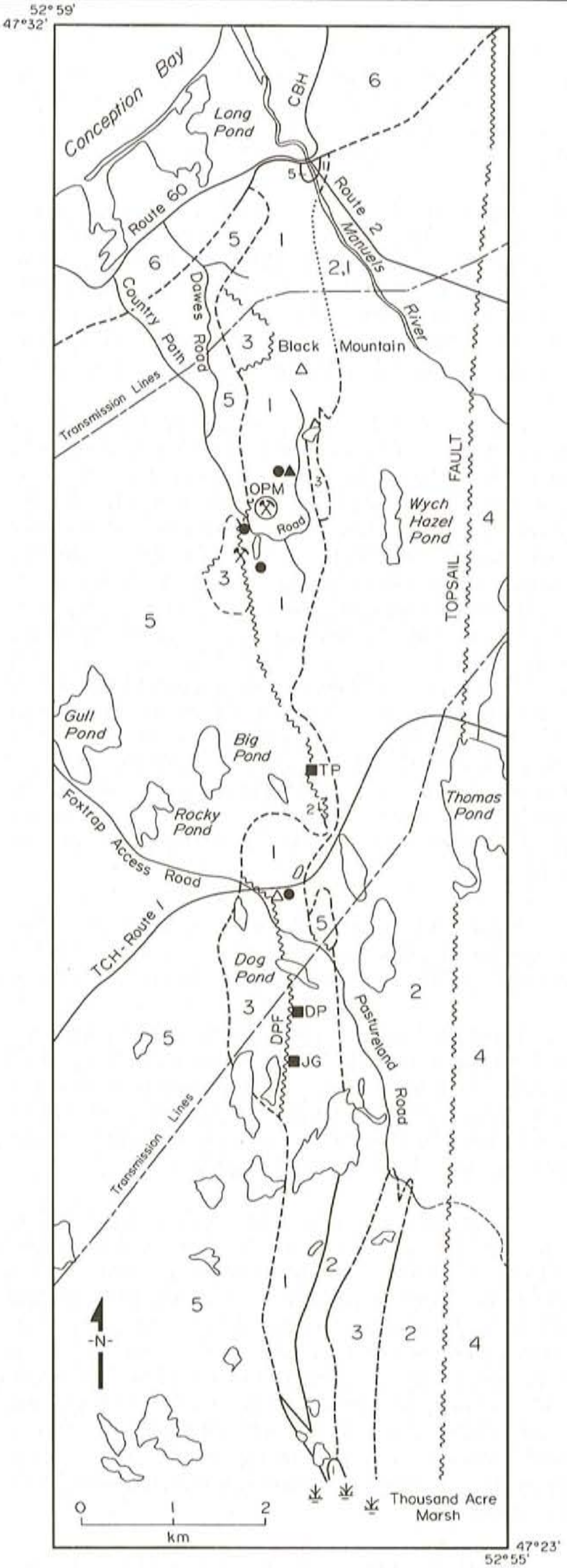


Figure 1. *Regional geology of the eastern Avalon Peninsula showing the location of the study area (after O'Driscoll* et al., *1988).*



LEGEND

CAMBRIAN

ADEYTON AND HARCOURT GROUPS

6 *Shale, siltstone and sandstone with conglomerate at base*

PRECAMBRIAN

HOLYROOD INTRUSIVE SUITE

5 *Granodiorite, granite and minor feldspar porphyry and gabbro*

CONCEPTION GROUP

4 *Siltstone and sandstone (may be equivalent to Unit 3)*

HARBOUR MAIN GROUP

3 *Siltstone, sandstone and minor conglomerate*

2 *Basalt flows, ash and lapilli tuff, minor interbedded debris flows and greywackes*

1 *Rhyolite ash-flow tuff, lithic and crystal tuffs; minor epiclastic rocks*

SYMBOLS

Fault (defined, approximate)

Geological boundary (defined, approximate, assumed)

Main Pyrophyllite Occurrences

⨂ *–Oval Pit Mine, active*

⚒ *–Mine Hill Quarry, dormant*

■ *–Prospects:*

TP –Trout Pond Prospect

DP –Dog Pond Prospect

JG –Jakes Gully Prospect

Anomalous Gold Values and Occurrences

▲ *–1060 ppb*

△ *–210–327 ppb*

• *–50–80 ppb*

Abbreviations

DPF –Dog Pond Fault

CBH –Conception Bay Highway

TCH –Trans-Canada Highway

Figure 2. *Geology and mineral occurrences of the eastern Avalon high-alumina belt (after Hayes and O'Driscoll, 1989).*

Regional Geology

The eastern Avalon Peninsula is underlain by a succession of Precambrian and Cambrian volcanic, intrusive and siliciclastic sedimentary rocks (Figure 1). Bimodal volcanic rocks of the Harbour Main Group form the base of the succession and are intruded by the Holyrood Intrusive Suite. These are overlain by marine turbiditic sandstones and siltstones of the Conception Group. The Conception Group is overlain by shale and deltaic sandstone of the St. John's Group, which is itself conformably overlain by molasse-type coarse sandstone and conglomerates of the Signal Hill Group (McCartney, 1967; King, 1988). Gently dipping Cambrian sedimentary rocks (Adeyton and Harcourt groups) unconformably overlie the folded Precambrian strata and the Holyrood Intrusive Suite throughout the Avalon Peninsula.

GEOLOGY OF THE MAP AREA

The study area is underlain by the Harbour Main Group (Units 1, 2 and 3) and the Holyrood Intrusive Suite (Unit 5). The Conception Group (Unit 4) outcrops at the eastern margin of the study area and was not examined in detail. To the north of the study area, the Harbour Main Group and the Holyrood Intrusive Suite are overlain unconformably by Cambrian sedimentary rocks (Unit 6). Figure 2 illustrates the geographic distribution of the geological units in the study area.

Description of Map Units

The Harbour Main Group has been divided into three units. The oldest stratigraphic unit within the map area is Unit 1, which hosts the alteration system. It is composed of felsic ash-flow tuffs and lesser coarse grained volcaniclastic and sedimentary rocks. The ash-flow tuffs are generally massive, very fine grained to aphanitic and buff to light purple. Locally, the tuffs contain, distinct 3 to 10 percent, 1- to 3-mm long feldspar crystals, set in a very fine grained to aphanitic matrix. Extensive welding and postdepositional recrystallization masks most primary features. Flow-banding is common and, in the less extensively welded rocks, alternating 1- to 2-cm-thick buff and purple bands are present, which probably define the ash-flow layering. These rocks are recognized as ash-flow tuffs by the presence of distinct lithophysal zones, rare shards and scattered millimetre-scale, lithic fragments. Lithophysal zones are developed in intensely welded, flow-banded rocks indicating that these rocks are not flow domes. The field appearance of the lithophysal zones ranges from compact masses of 5- to 10-mm lithophysae, to scattered 2- to 10-cm-sized individual lithophysae that locally form up to 25 percent of the rock volume. Most lithophysae are filled with white, fine grained quartz, locally with relict chalcedonic banding, indicating that the infillings are recrystallized amorphous quartz. Rare vuggy lithophysae are lined with clear euhedral quartz crystals.

The lithic tuffs are generally poorly sorted and contain millimetre- to centimetre-sized fragments of the ash-flow tuffs in a fine grained matrix. They are locally interbedded with welded and recrystallized ash-flow tuffs, and are well-indurated by matrix recrystallization. Some of the finer grained lithic tuffs interbedded within the ash-flow sequences, may represent base surge deposits to adjacent flows. Coarse lithic tuffs probably represent discrete pyroclastic flows. These are locally interbedded with conglomerates.

Coarse cobble–pebble conglomerates and minor sandstone, are locally interbedded with the lithic tuffs. The conglomerates contain well rounded clasts of moderate to high sphericity and appear to have been deposited in a fluvial setting. Discrete alteration zones locally affect both the clasts and the matrix of these horizons and differentiate these sedimentary rocks from the conglomerates of Unit 3.

Unit 2 consists of mafic volcanic and volcaniclastic rocks having interbedded immature sedimentary rocks. These rocks outcrop in isolated exposures along the eastern margin of Unit 1 and contact relationships are difficult to discern. The presence of felsic volcanic detritus in the mafic volcaniclastic rocks indicates that Unit 2 is younger than Unit 1. A complex interlayered sequence of felsic and mafic rocks is exposed in the bed of Manuels River. No clear stratigraphic relationship could be determined, possibly indicating that some parts of the mafic and felsic sequences are contemporaneous. Further detailed mapping is required to determine the nature of the contact in this area. Most rocks display a low-grade metamorphic mineral assemblage characterized by chlorite $\pm$ epidote. Identifiable facies within this unit include vesicular basalt flows, lapilli tuff, breccia, debris flow-style deposits, greywacke and strongly deformed green, very fine to fine grained chloritized rocks of unknown affinity.

The basalt flows are dark green, having calcite-infilled amygdules and minor 0.1- to 1-cm-wide veinlets. These locally contain 5- to 20-cm blocks of exotic mafic volcanic material.

The lapilli tuffs are composed of 20 to 60 percent, 2- to 5-cm-long vesiculated basalt fragments in a fine grained chloritized matrix. These lapilli fragments are slightly flattened and agglutination of the fragments is apparent. In places, some fragments are bomb-sized and these rocks may be more aptly described as agglomerates.

Volcanogenic breccias consisting of 2- to 3-m blocks of felsic volcanic rocks, set in a dark-green, fine grained chloritized matrix associated with scattered smaller fragments, occur in exposures west of Wych Hazel Pond (Figure 2). Some felsic volcanic blocks contain quartz veins, which do not cut the surrounding matrix. A similar breccia unit, exposed on the western flank of Mine Hill, is in contact with extensively pyrophyllitized felsic ash-flow tuffs. This unit contains 0.2- to 3-m clasts of mainly unaltered ash-flow tuffs, however, some of the fragments appear silicified and are cut by quartz veins. Rare fragments of pure quartz are also present in the exposure.

These features suggest that at least part of the source area for the blocks was altered. The rocks were described at Mine

Hill by Vhay (1937) as a breccia, and later interpreted by Papezik (1974) as the infilling of a volcanic vent. Since these rocks are widespread, they may be of laharic origin and related to a period of mafic volcanism younger than the alteration event. Their juxtaposition with the alteration zone at Mine Hill may be due to later faulting. Similar rocks are in fault contact with the alteration system at Trout Pond (Hayes and O'Driscoll, 1989).

Fine- to medium-grained ash tuffs and greywackes are equally as abundant as the coarser grained mafic volcaniclastic rocks and flows in the Harbour Main Group. The ash tuffs are poorly sorted and commonly contain scattered 1- to 5-mm angular lithic fragments in a dark-green chloritized matrix. The greywackes are similar in field appearance to the tuffs, having a coarser, fine- to medium-grained matrix mottled with discernable plagioclase crystals and lithic fragments. Within the volcanic succession, the greywackes habitually contain 20- to 100-cm-sized, elongate blocks or disrupted lenses of green, fine grained siliceous siltstone. A complete textural gradation is evident in the field area from mafic volcanic flows and pyroclastic deposits to sedimentary rocks. Locally, these are interbedded in the same outcrop (Plate 1).

Plate 1. *Interbedded basalt, siltstone and lapilli tuff (Unit 2), Pastureland Road.*

Green, very fine grained rocks also occur in the field area. They are generally chloritized and locally contain intensely folded and disrupted quartz veins (Plate 2). Diagnostic primary features are not preserved. These rocks may have originally been basalts, fine tuffs or mud flows, which have subsequently been subjected to intense deformation.

Unit 3 consists of sedimentary rocks that are provisionally considered part of the Harbour Main Group,

Plate 2. *Intensely deformed fine grained chloritized mafic volcanic rocks containing disrupted and folded pretectonic quartz veins.*

because they are locally interbedded with mafic volcanic rocks (Unit 2) of the sequence. The sedimentary rocks are generally in fault contact with the altered felsic volcanic rocks. These rocks are composed dominantly of green, very fine grained siliceous siltstone but also include interbedded greywacke, conglomerate and well-sorted sandstone. The green siltstone is the most widely distributed facies outside of the felsic volcanic rocks and is generally interbedded with coarse volcaniclastic rocks and sandstones containing mafic volcanic detritus (Unit 2).

At Black Mountain (Figure 2), the siltstone is interbedded with green and grey, fine- to medium-grained, poorly to moderately sorted sandstone and, near its base, mafic volcaniclastic rocks of Unit 2.

Unit 3 forms the west wall of the Oval Pit Mine. White and purple, pebble to boulder matrix and clast supported conglomerate, containing fragments of pure pyrophyllite, sericite and extensively silicified felsic volcanic rocks, unconformably overlie pyrophyllitized felsic volcanic rocks. The conglomerate contains a thin (0.75 to 1 m) fault-bounded slice of green mafic tuffaceous sandstone, which may have been originally interbedded with the sequence. The basal conglomerates are overlain by green, grey and red, fine- to medium-grained sandstones, which show evidence of decimetre synsedimentary faulting, and contain a 0.5-m interbed of white pebbly sandstone and conglomerate. The clasts in the conglomerate are dominantly silicified felsic volcanic rocks. The sandstones are overlain by green, fine grained siltstone, containing thin centimetre-scale sandstone lenses.

The hills west of Dog Pond are primarily composed of green siltstone that is interbedded with grey-green, fine- to coarse-grained sandstone and greywacke. The medium grained sandstone beds locally contain scour channels, filled with angular clasts of siltstone and mafic volcanic detritus. Loose blocks of sandstone having slump folds occur locally in scree slopes.

The stratigraphic relationship between these strata and the Harbour Main and Conception groups is a longstanding problem. Most of the rocks included in Unit 3 were informally called the 'Black Hill sequence' by Dawson (1963), and were considered to be distinct from other nearby sedimentary rocks as they unconformably overlie the Harbour Main Group. The similarity between the fine grained rocks within the sequence and the Conception Group was also noted, and Dawson (1963) suggested that the deposition of the Black Hill sequence was broadly contemporaneous and transitional to the deposition of the Conception Group. Near Holyrood, McCartney (1967) later showed that the Conception Group unconformably overlies the Harbour Main Group. Rose (1952) described similar relationships but considered the time break represented by the unconformity to be insignificant.

The present study indicates that the earlier observations are generally correct, but clarification is required. An unconformable relationship between the Harbour Main Group and Unit 3 is not always evident. The sedimentary rocks (Unit 3) unconformably overlie only the felsic volcanic rocks within the Harbour Main Group. Likewise, conformable relationships are evident only between the mafic volcanic and volcaniclastic rocks and Unit 3. These regional features indicate, along with relationships described in the foregoing section, that the unconformity is within the volcanic sequence in the study area and likely postdates the high-alumina alteration event. The regional extent of the unconformity remains to be demonstrated.

Unit 4 comprises the Drook Formation of the Conception Group (Figure 2). It outcrops outside the area studied in detail. The unit consists generally of turbiditic greenish-grey, siliceous sandstone containing local interbeds of waterlain tuff and volcanogenic mixtite (King, 1986, 1988). In the southern Avalon Peninsula, mafic volcanic rocks occur within the Drook Formation (Williams and King, 1979).

The Holyrood Intrusive Suite (Unit 5), within the field area, comprises granite, granodiorite and locally diorite. The suite generally consists of grey, massive, medium grained, equigranular to porphyritic biotite ± hornblende granite and granodiorite. Fine grained phases, locally cut by aplite dykes are most abundant near the margin of the intrusion. A porphyry is exposed on Country Path (Figure 2), which contains 1-cm long K-feldspar and plagioclase phenocrysts set in a grey, very fine grained to aphanitic matrix.

In this area, and also within the small plug exposed in Manuels River, the Holyrood granite is locally cut by tuffisite veins. The tuffisite veins contain 0.1- to 1-cm fragments of the host granite, within a dark-grey to black aphanitic matrix. These features also occur at Duffs, Conception Bay (Hughes, 1971) and extensive tuffisite veining is exposed in new roadcuts near Soldiers Pond on the Trans-Canada Highway and also in exposures on the Foxtrap access road near the Trans-Canada Highway. The wide distribution of tuffisite veins within various granitoid rock types indicates that the Holyrood Intrusive Suite is a series of high-level intrusions, possibly emplaced over a short interval. Clear evidence for an intrusive relationship between the Harbour Main Group is provided by xenoliths of felsic and mafic rocks. These relationships are best exposed on White Mountain, where large (>50 by 30 m) rafts of unaltered felsic volcanic rocks are included within the host granite. More commonly, the inclusions are 0.1- to 1-m xenoliths of mostly mafic rocks, which are most abundant near the contacts. These mafic xenoliths are massive black dense hornfels and may have originally been basalt flows.

On Country Path, near the Oval Pit Mine, altered granite contains inclusions of altered felsic volcanic rocks, including blocks of sheared, partly sericitized volcanic rocks and quartz–hematite breccia. At the south end of Mine Hill, the granite contains rafts and blocks of silicified felsic volcanic rock. The presence of xenoliths representing different types of alteration is difficult to reconcile with *in situ* alteration of both the host granite and xenoliths. The granite alteration may be unrelated to the alteration of the volcanic rocks. Later faulting has caused saussuritization and locally, intense quartz veining and pyritization elsewhere within the granite. The alteration event within the Harbour Main Group thus appears to predate the intrusion of the Holyrood Intrusive Suite in this locale.

Unit 6 consists of undivided Cambrian rocks of the Adeyton and Harcourt groups. The Cambrian strata nonconformably overlie a small plug of Holyrood Intrusive Suite beneath the Manuels River Bridge. The basal Cambrian conglomerate contains clasts of silicified and hematized felsic volcanic rocks. Rose (1952) reported that the basal Cambrian conglomerate also contained rare pyrophyllite clasts. These observations impose a Late Precambrian age on the pyrophyllitization and related alteration.

ALTERATION ZONES

High-alumina and related alteration zones in the eastern Avalon high-alumina belt are confined to the felsic volcanic sequence, where they are intimately related to the development of shear zones, within the host rhyolitic rocks. Many of the features of the alteration zones were described by previous workers. Vhay (1937) first noted that the pyrophyllite was confined to areas of intense shearing and that there was a mineralogical zonation within the alteration system. Lee (1958) produced a detailed structural map of Mine Hill in an effort to establish a reserve estimate for the Mine Hill deposit. Keats (1970) conducted a chemical–mineralogical study of the main deposits at the Oval Pit Mine and Dog Pond and showed the zonal distribution of the alteration minerals in transects through these bodies. He noted that at Dog Pond the alteration consisted of a single pyrophyllite-rich core surrounded by sericitized and silicified rocks and that the Oval Pit Mine area contained multiple pyrophyllite zones. Papezik *et al.* (1978) noted the distribution of the minerals and suggested that alkali metals, silica and iron were depleted in zones of pyrophyllitization.

Description of Alteration

The main types of alteration within the system are pyrophyllitization, silicification and sericitization. Zones characterized by these types of alteration are arranged concentrically. The innermost zone is represented by pyrophyllitization, surrounded by sericitization and a halo of silicification (Hayes and O'Driscoll, 1989). Alteration and deformation are intimately related throughout the field area. The following descriptions are based upon field observations of these zones.

Pyrophyllite Zone. This zone is developed locally along the belt and is characterized by intense brittle shearing of the host rock. The rocks range in mineralogy and texture from fine grained quartz–pyrophyllite ± sericite schist to massive pyrophyllite. Lenses of pure pyrophyllite locally contain diaspore nodules. These nodules also contain rutile and minor barite (Papezik *et al.* 1978) and only occur within intensely pyrophyllitized rocks.

Quartz–pyrophyllite schists are commonly intensely sheared felsic ash-flow tuffs; locally primary depositional features such as flow-banding and lithophysae are recognizable. The schists contain discontinuous 10- to 75-m scale enclaves of relatively unaltered felsic volcanic rocks, which show a complete gradation from relatively unaltered to pyrophyllitized rocks. The most abundant rock type is a blocky pyrophyllite schist, with 1- to 10-cm-scale blocks of white sericitized, and locally partly silicified rhyolite, enclosed in a pyrophyllite-rich sheared matrix. In several places, a gradation from slightly sheared rocks containing some pyrophyllite to nearly pure pyrophyllite having rare remnants of the host rock is seen. These relationships indicate that the pyrophyllitization is concomitant with comminution of the host rock. The partly sheared and altered rocks having pyrophyllite-rich matrices have been called ellipsoidal schists by earlier workers (Vhay, 1937) because of the shape of the blocks. This shape can be seen to have originated from a set of conjugate brittle shears that host the alteration and provided a focus for deformation (Plate 3). The shears intersect at an angle of about 45° from each other; this is best seen where the host rock is weakly pyrophyllitized and the shears are widely (>5 cm) spaced. Intersecting shears with this orientation produces diamond-shaped blocks. Alteration focused along the shears has modified the diamond so that they now form ellipses. The possibility that the ellipsoidal shape is partly due to stretching is difficult to demonstrate in outcrop, as suitable strain markers are absent. This brittle style of deformation is characteristic of most of the structural elements within and adjacent to alteration. With increasing alteration, greater plasticity is developed as the rhyolitic rocks become pyrophyllitic and schistose.

The main pyrophyllite occurrences within the belt are found at the Oval Pit Mine, Mine Hill, Trout Pond, Dog Pond and Jakes Gully (Figure 2). Mine Hill was the site of the earliest mining attempts along the belt. The Trout Pond, Dog Pond and Jakes Gully occurrences have undergone some assessment work including diamond drilling, which outlined a minor zone at Dog Pond.

The Oval Pit Mine is located on the widest pyrophyllite zone within the system. The size of the deposit has been attributed to the presence of multiple pyrophyllite and sericite

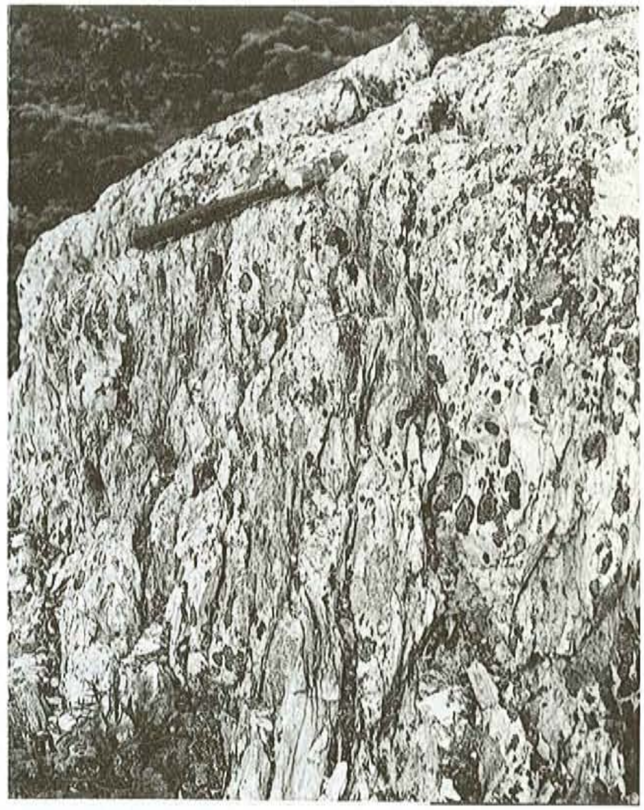


Plate 3. *Typical 'ellipsoidal schist'. Despite intense pyrophyllitization and development of schistosity some early diamond-shaped blocks are present.*

zones in this area (Keats, 1970). Where multiple pyrophyllite zones are developed as in the Oval Pit Mine, sericite zones are developed on the metre-scale within the pyrophyllite alteration.

Yearly production is about 50,000 short tons of pyrophyllite ore. At present, mining efforts are focused on a ca. 75-m-wide northeast-trending zone, which contains abundant high-grade pyrophyllite rock. Grade control within the mine is based on 25-ft-spaced boreholes drilled to the mine bench height of 20 feet. Chemical analysis of borehole cuttings is used as a basis for blast planning. Modifications are made during drilling in preparation for blasting to accommodate the highly irregular nature of the ore zones at this scale. The presence of abundant iron staining in blasthole cuttings is often the only indication of hematized, relatively unaltered rhyolite enclaves, and is thus avoided.

Sericite Zone. This is the most extensive alteration facies developed. Sericite is the common mineral in shear zones along the belt having moderate to intense alteration. The alteration has generally not destroyed primary volcanic textures and lithophysae are commonly seen in a matrix of relatively impure pale to pure dark-green sericite. Shear zones within the sericite zone are similar to those seen in the pyrophyllite zone except that the deformation is not as intense. Single sericite-rich shears <10 cm are common and metre-scale zones of sericite containing remnants of the host rock are rare. Rhyolitic ash-flow tuff on a ridge overlooking the Oval Pit Mine shows a similar pattern of alteration as a microstructure. Anastomosing veinlets of oriented sericite surround domains of relatively massive, very fine grained rhyolitic tuff.

In places, sericitization is accompanied by intense silicification. Unaltered rhyolitic ash-flow tuffs can be traced into a silicified and sericitized zone that contains a conjugate shear set. The transition between the unaltered and altered rocks is abrupt and is generally coincident with an increase in shearing of the host rock. A fracture cleavage within the unaltered host rock is most intense near the alteration. Introduction of silica into these rocks was possibly controlled by early fractures and subsequently by hydrothermal brecciation. Sericite-rich shears crosscut the silicified rock producing a diamond-shaped pattern similar to those described in the previous section (Plate 4). These relationships indicate that silicification preceded sericitization.

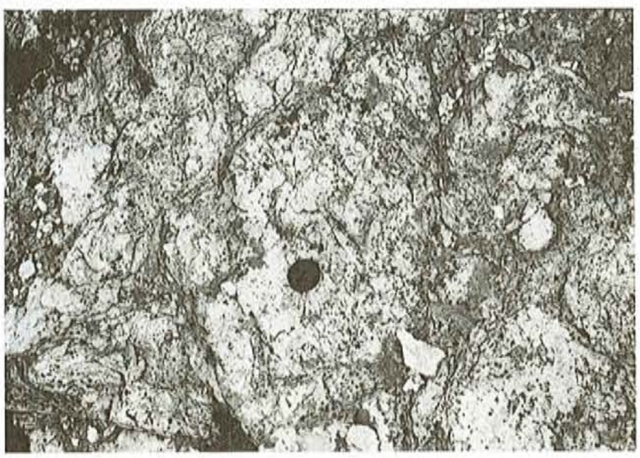


Plate 4. *Sericite-rich shears crosscutting silicified rhyolitic ash-flow tuff. Note orientation and pattern produced by intersecting shears; compare with Plate 3.*

Silicified Zone. Silicified zones are developed adjacent to, and within, the pyrophyllite and sericite zones. Primary textures are largely destroyed in the more intensely silicified rocks. Features of hydrothermal fluid activity such as brecciation and intense mm-scale quartz veining are widespread. Silicification of the felsic ash-flow tuffs, lithic tuffs and conglomerates occurs in zones ranging in size from less than 1 to 100 m^2. The most intensely silicified rocks are white weathering, white to grey and are very fine grained. The silicified rocks commonly contain 1 to 3 percent pyrite and in the most extensively mineralized areas contain 5 to 8 percent pyrite, as disseminated grains <0.1 mm to 5 mm. Silicified outcrops occur from north of the Oval Pit Mine to the Thousand Acre Marsh. These rocks are similar to descriptions of rocks marginal to pyrophyllite and sericite-rich rocks in the Carolinas where they have been called 'quartz granofels' (Schmidt, 1985).

Other Alteration

Other types of alteration associated with the alteration system reflect redistribution of minor constituents of the original rock. Remobilization of iron is widespread in areas adjacent to areas of intense pyrophyllitization. The most obvious indication of this is the conspicuous hematite staining on the faces of the Oval Pit Mine (Plate 5). Hematite occurs in abundant small veinlets (2 to 15 mm) within the stained areas. The wider veins are most evident along the margins of enclaves of unaltered rocks within the alteration zone. Veins gradually decrease in size and abundance toward pyrophyllite zones, indicating that the remobilization of iron is a result of pyrophyllitization. Hematite veins are rare toward the margins of the alteration system. Instead, the hematite occurs as fracture coatings and forms the matrix of some hydrothermal breccias. Quartz–hematite breccia veins up to 0.5-m wide are found near the Oval Pit Mine. These features indicate that iron deposition occurred late within the alteration system.

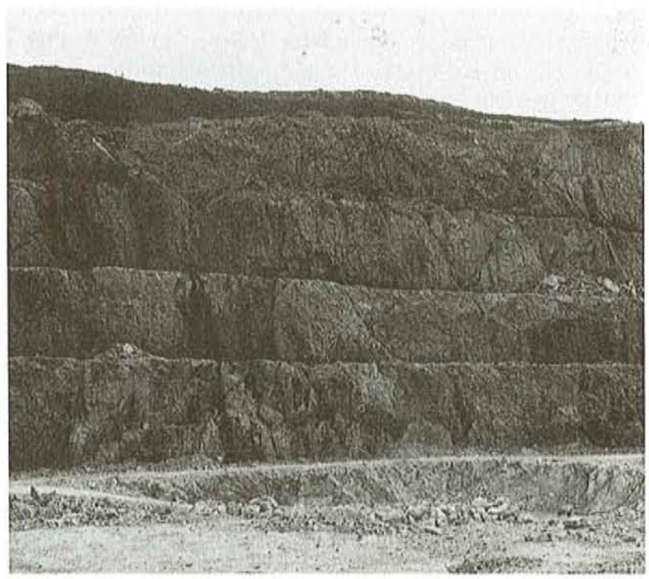


Plate 5. *Intense hematite staining on walls of Oval Pit Mine; staining is mainly in the unaltered rocks as iron migrates from zones of pyrophyllitization.*

Quartz veining is common throughout the field area. Few criteria exist to differentiate between veins directly related to the high-alumina alteration and later events. Rare, thin, steeply dipping, quartz–specularite veins cut relatively unaltered ash-flow tuffs exposed north and east of the Oval Pit Mine. These may be contemporaneous with the alteration system as are the quartz–hematite breccia veins.

Subhorizontal quartz–chlorite–epidote and quartz–chlorite veins are more common in the mafic and felsic volcanic rocks, respectively. The veins are locally vuggy and contain patches of dark-green chlorite up to 2 cm in width. These veins are likely related to a regional post-alteration event because they also crosscut different facies of the main alteration system.

A period of regional pyritic alteration younger than the high-alumina alteration is manifested by pyritization associated with faults, which cut the alteration system and the country rocks. The pyrite crystals are coarser than that associated with the silicified zones. Large pyrite cubes (1 to 2 cm) occur along the Dog Pond Fault in the vicinity of the transmission line. This period of alteration has also affected the Holyrood Intrusive Suite. The suite is commonly pyritic along faults. Sausseritization of feldspars and chloritization of the biotite often accompany pyritization.

Results of Gold Analysis

An effort was made to sample all parts of the alteration system for gold analysis, with some emphasis on localities containing sulphide mineralization. Prospective outcrops were usually chip sampled, composite grab samples were collected where this was not possible and single grab samples were collected from localized alteration. Sampling was not restricted to the felsic volcanic rocks. Mafic dykes and volcanics were sampled where these were veined or pyritized. The results from 150 samples analyzed, indicate that the silicified pyritized felsic volcanic rocks locally contain anomalous concentrations of gold. A silicified pyritized rhyolite ash-flow tuff, adjacent to a 0.5-m-wide quartz–hematite breccia vein returned 1060 mg/t Au, which is the highest value returned to date. The locations of the most interesting results are given in Figure 2. Figures 3a, b, and c show the variation of gold associated with arsenic and antimony, for the suite of felsic volcanic rocks. The suite includes analysis from the different alteration types and unaltered rocks with the majority of the samples being of silicified pyritized rocks.

The data presented provides an indication of the range of positive results obtained so far. A clear relationship between gold and the pathfinder elements is not immediately apparent. However, the absence of detectable gold in samples having low concentrations of Sb (Figure 3a) and As (Figure 3b) and a tendency for higher Au values to be accompanied by elevated Sb and As values, is suggestive of a positive correlation, although, high Sb and As concentrations are not necessarily accompanied by elevated Au values. Figure 3c shows the relationship between As and Sb. The data are less scattered and a positive correlation is readily apparent. The analytical results obtained thus far indicate that Au is positively correlated but also variable with respect to As and Sb. Analytical results for the 100 samples, mainly from south of the Trans-Canada Highway are not available at the time of writing. These results in conjunction with detailed examination of the geochemical data and petrographic–mineralogical studies are required to reach a precise conclusion, as to the behaviour of these elements, in the alteration system.

CONCLUSIONS

The following conclusions can be derived from the present study:

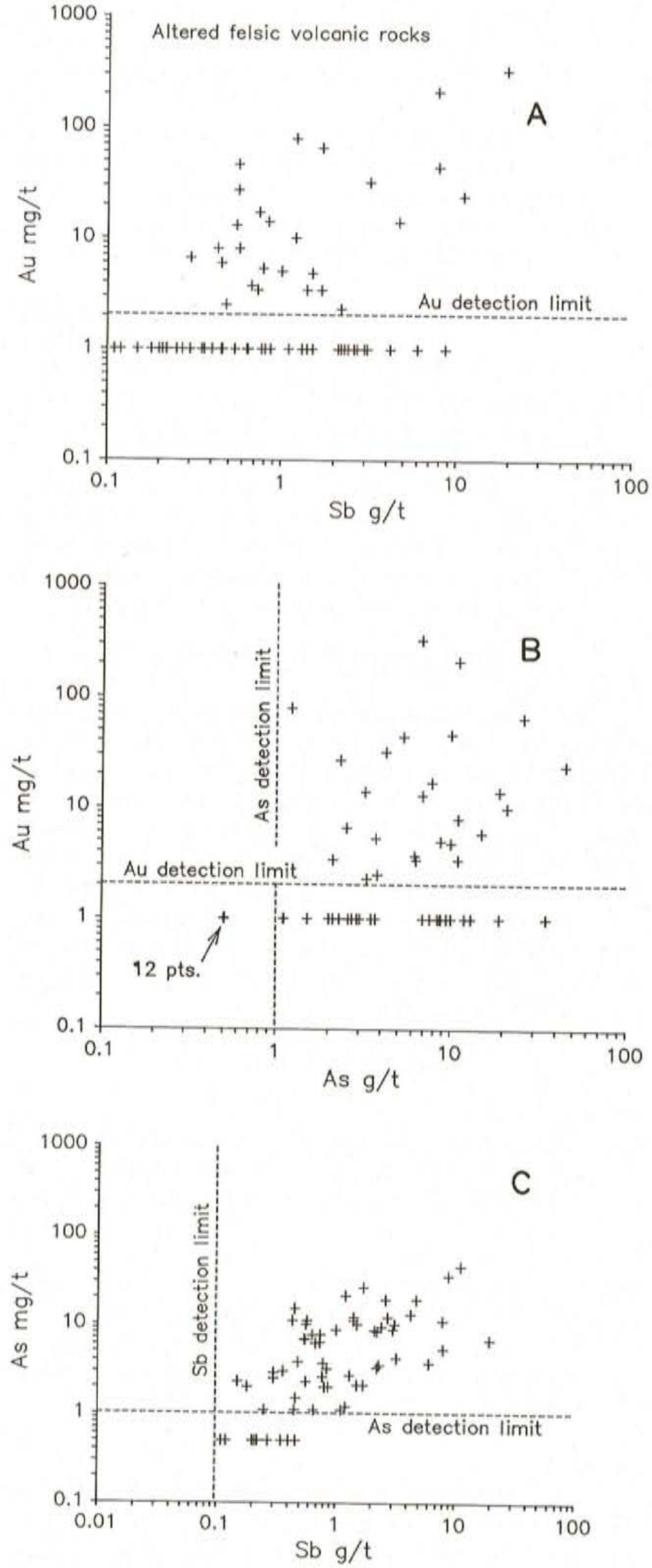


Figure 3. *Gold and pathfinder elements in altered felsic volcanic rocks of the Harbour Main Group; 3a, gold* vs *antimony; 3b, gold* vs *arsenic; and 3c, arsenic* vs *antimony. Refer to text for discussion.*

1. The eastern Avalon high-alumina belt is a Precambrian, structurally controlled alteration system. It appears to predate the Holyrood Intrusive Suite.
2. A second period of alteration is manifested by pyritization along major faults, which cut the host volcanic rocks and locally the alteration system. The faults also affect the Holyrood Intrusive Suite causing sausseritization and chloritization in addition to pyritization.
3. Contrasting stratigraphic relationships exist between the Harbour Main Group and rocks considered broadly equivalent to the Conception Group. The presence of altered felsic volcanic clasts within the mafic volcanic rocks demonstrate the presence of an unconformity within the volcanic sequence.
4. The best gold analyses are from silicified pyritized felsic volcanic rocks. These appear to be the prime exploration target. Pyritization and silicification within zones of intense hydrothermal brecciation may provide the best targets in these areas.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance provided by Duane Cole during the field season. Derek Wilton and Scott Swinden are thanked for lively outcrop discussions and their thought-provoking comments. Newfoundland Minerals Limited is acknowledged for access to the Oval Pit Mine. Stan Barnable, Max Dawe and Calvin Butler are thanked for sharing their knowledge of the pyrophyllite bodies and the operation. The manuscript owes much to critical reviews by Lawson Dickson, Scott Swinden and Derek Wilton. The quality of the geochemical plots reflects the skill of Lawson Dickson.

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NOTE: Geological Survey Branch file numbers are included in square brackets.