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GOLD METALLOGENY, EASTERN DUNNAGE ZONE CENTRAL NEWFOUNDLAND

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ABSTRACT

Rocks of the northeastern Dunnage Zone, particularly those belonging to the Botwood and Davidsville groups, are proving to be a significant exploration target for structurally controlled gold mineralization.

Preliminary results indicate that two broad classes or styles of gold mineralization are developed in the area: mesothermal, shear-zone related auriferous quartz veins, locally accompanied by intense Fe-carbonate alteration; and epithermal style, low-grade gold mineralization associated with spectacular hydrothermal brecciation, silicification and locally intense argillic alteration.

The gold occurrences appear to be spatially related to a complex network of northeast-, north-northeast- and northwest-trending linears. These linears may have acted as loci for the mineralizing fluids.

INTRODUCTION

A metallogeniç study of gold mineralization hosted by rocks of the eastern Dunnage Zone (i.e., south and east of the Red Indian Line) was initiated in the fall of 1989. The main thrust of this study is to document the styles and settings of the numerous gold occurrences recently found in the area. During 1990, fieldwork concentrated on gold mineralization located in the northeastern portion of the zone, particularly within the Middle Ordovician Davidsville Group and the Silurian Botwood Group. This work involved detailed grid and trench mapping, diamond-drill core logging and regional rock sampling for assaying.

Access to the area is provided by the Trans-Canada and the Gander Bay highways, and by an extensive network of forest access roads, which lead north and south from Glenwood and south from the Gander Bay and Horwood areas. The region is characterized by gently undulating topography that comprises heavily forested tracts, large cutover areas, long, narrow lakes and extensive bogs. The north to northeast trend of the numerous lakes and streams reflects the strong bedrock lithological and structural control on their orientation. Extensive glacial till covers the entire region resulting in limited bedrock exposure.

REGIONAL SETTING

The study area lies within the Dunnage Zone of Williams (1979) near its boundary with the Gander Zone (Figure 1). The Dunnage Zone records pre-accretionary and accretionary events related to the development and destruction of the early Paleozoic Iapetus ocean. The geological evolution of the region can be subdivided into two broad stages involving pre- and post-accretionary events (Swinden, 1990). The Dunnage Zone records both pre-accretion volcanism and pre- and syn-accretion sedimentation in a series of Cambrian to Middle Ordovician island arcs and back-arc basins. Cessation of volcanism coincided with the emplacement of the Taconic allochthons during the Middle Ordovician. During the late Ordovician and Early Silurian, the continued closure of the Iapetus Ocean resulted in the deposition of flyschoid sequences in fault-bound basins in the central and eastern Dunnage Zone.

The Davidsville Group is interpreted to have formed as a distal back-arc turbidite sequence derived from the volcanic arcs to the west, and deposited on an ophiolitic basement (Blackwood, 1982). Dismembered sections of the ophiolitic basement are represented by rocks of the Gander River Ultrabasic Belt (Jenness, 1958; Blackwood, 1982), referred to as the Gander River complex by O'Neill and Blackwood (1989).

In north-central Newfoundland, shelf facies rocks of the Gander Zone are interpreted to locally pass conformably westward into rocks of the Davidsville Group (Blackwood, 1982). Regionally, the Dunnage Zone is interpreted to be allochthonous upon rocks of the Gander Zone (Colman-Sadd and Swinden, 1984).

Post-accretion events, marked by the activation or re-activation of large strike-slip faults, the development of pull-apart basins (Szybinski *et al.*, 1990) and crustal melting resulting in epicontinental-style volcanism (Coyle and Strong, 1987), led to the deposition of Silurian fluviatile sedimentary and terrestrial volcanic rocks. In east-central Newfoundland this post-accretionary stage is represented by the Botwood and Indian Islands groups. The Botwood Group comprises grey and red, locally micaceous, sandstone, minor fossiliferous calcareous beds and conglomerate. Blackwood (1982) interpreted the Botwood Group to be conformable on the Davidsville Group, representing a transition from submarine fan to deltaic environments. The Indian Islands Group comprises phyllitic slates, quartzitic and calcareous sandstones, thin limestone lenses, conglomerate (Baird, 1958) and minor felsic volcanic rocks (Patrick, 1957).

Acadian deformation, metamorphism, plutonism and reactivation of the major fault systems during the early Devonian resulted in intense deformation and plutonism within the eastern Dunnage Zone. Rocks of both the Davidsville and Botwood groups exhibit a regional, northeast-trending, penetratative cleavage that is axial planar to isoclinal folds. Within the Davidsville Group, this cleavage is quite slaty. Second-phase deformation structures within the Davidsville Group comprise small conjugate kink bands and minor, open to moderately tight, gently southward-plunging folds that fold the F_1 cleavage (Blackwood, 1982). The rocks have been subjected to greenschist-facies metamorphism.

Abundant small, fine- to medium-grained gabbroic bodies intrude the Davidsville and Botwood groups, particularly near their contact. These intrusions are generally undeformed except were they have been affected by shearing along north- and north-east trending shear zones. The gabbros are interpreted to be of Devonian age (Blackwood, 1982) and probably related to the Mount Peyton batholith to the south.

PREVIOUS WORK

The first recorded geological investigation in the area was undertaken by Alexander Murray and J.P. Howley (Murray and Howley, 1881). These workers examined the geology along eastern Notre Dame Bay, the Gander River and Gander Lake. Murray and Howley (1881) also reported the first known occurrence of gold mineralization within the area. They stated that, 'Distinct traces of this precious metal were ascertained in a quartz vein cutting the silky, bluish slates on the S.W. Gander River in 1876.' They also reported that innumerable quartz veins, which looked promising for gold mineralization, were exposed along the railway line north of Gander Lake.

A number of significant regional studies have been undertaken within the study area. Chromite mineralization, associated with the ultrabasic rocks to the east of the Gander River, were examined by Snelgrove (1934) as part a study of the chromite deposits of Newfoundland. Twenhofel and Shrock (1937) examined the Silurian rocks exposed along Hamilton Sound, particularly within the Dog Bay (Horwood Bay) area. Patrick (1956) interpreted that these rocks extended southwestward into the Second Pond area. Baird (1958) referred to these and similar rocks exposed on islands in Hamilton Sound as the Indian Islands Group. Twenhofel (1947) proposed that the sequence of phyllites, slates, argillites and quartzites exposed on the shores of Gander Lake be designated the Gander Lake Series.

In 1951, the Photographic Survey Corporation Limited conducted geological reconnaissance mapping of east-central Newfoundland for the Newfoundland Government (Baird *et al.*, 1951). This work covered a belt extending south from Hamilton Sound to Baie d'Espoir. Baird *et al.* (1951) reported an occurrence of native gold reported by the Independent Mining Corporation. The gold, associated with sphalerite, molybdenite, fine-grained pyrite and vuggy quartz hosted by greywacke, was reported to be located three quarters of a mile south of Middle Ridge Pond.

Jenness (1954, 1958) defined the Gander River Ultrabasic Belt and the Gander Lake Group. The Gander Lake Group, which was proposed to replace the Gander Lake Series of Twenhofel (1947), was sub-divided into lower, middle and upper units (Jenness, 1963).

Regional 1:250,000-scale mapping of the area was undertaken by the Geological Survey of Canada (Williams, 1964; Anderson and Williams, 1970).

Kennedy and McGonigal (1972) redefined the Gander Lake Group to include only the pelitic, semipelitic and psammitic rocks (the lower unit of Jenness, 1963) located to the east of the Gander River Ultrabasic Belt. They defined the fossiliferous Middle Ordovician slates, siltstones and greywackes (the middle and upper units of Jenness, 1963), which are developed to the west of the Gander River Ultrabasic Belt, as belonging to the Davidsville Group. The contact between the Davidsville Group and the Gander River Ultrabasic Belt was described by Kennedy (1975) as an unconformity.

The Gander River Ultrabasic Belt and the Davidsville Group in the Carmanville area were mapped by Currie *et al.* (1980) at a scale of 1:50,000 for the Geological Survey of Canada.

Systematic 1:50,000-scale mapping of the Gander River area (2D/10, Blackwood, 1981, 1983; 2D/11, Blackwood, 1981; 2D/15 and 2E/2, Blackwood, 1982; 2E/1, O'Neill, 1987, O'Neill and Knight, 1988; and 2D/15, O'Neill, 1990) was carried out by the Newfoundland Department of Mines and Energy. Blackwood (1982) interpreted that rocks of the Gander River Ultrabasic Belt, to the north of Gander Lake, are in fault contact with rocks of the Gander Group. To the south of Gander Lake, where the Gander River Ultrabasic Belt is not continuously exposed, Blackwood (1982) interpreted the contact between the Davidsville and Gander groups to be conformable. The contact between the Davidsville and Botwood groups was described as probably conformable. Blackwood (1979, 1982) reported that arsenopyrite- and pyrite-bearing quartz veins, developed within intensely sheared gabbro northeast of Jonathans First Pond, assayed 6 g/t gold.

O'Neill (1987) reported that the basal part of the Davidsville Group, in the Weir's Pond area, is structurally interleaved with the Gander River Ultrabasic Belt. O'Neill (1987) also reported the presence of minor gold mineralization, within a small granite that intrudes the Davidsville Group, and mineralized quartz veins developed in psammitic and semipelitic rocks of the Gander Group. He also suggested that the talc–carbonate alteration associated with the rocks of the Gander River Ultrabasic Belt is similar to that associated with the listwaenite model of Buisson and LeBlanc (1985).

O'Neill and Blackwood (1989) proposed a revised stratigraphic nomenclature for the Gander and Davidsville groups and the Gander River Ultrabasic Belt. They proposed to subdivide the Gander Group into the Jonathans Pond and Indian Bay Big Pond formations and the Davidsville Group into the Weir's Pond, Hunt's Cove and The Outflow formations. The Gander River complex was proposed to replace the Gander River Ultrabasic Belt.

The area was included in a regional lake-sediment geochemical survey by the Newfoundland Department of Mines and Energy (2E, Davenport and Nolan, 1988; 2D, Davenport *et al.*, 1988). This survey showed the distribution of a wide range of elements including Au, Sb and As. This data has proved valuable to companies in defining exploration targets, particularly in previously unexplored areas.

Exploration within the northeastern Dunnage Zone has occurred in three phases. Prior to 1970, the emphasis was largely restricted to exploration for chromite and asbestos associated with ultramafic rocks of the Gander River complex. The Newfoundland and Labrador Corporation Limited (NALCO) held concession rights to much of the area from 1951 to 1980. The company conducted extensive prospecting of the Gander River complex (Dunlop, 1955).

Between 1970 and the early 1980's, the emphasis shifted to base-metal exploration as a number of companies concentrated on the volcanic rocks associated with the Gander River complex. International Mogul Mines Limited optioned a portion of the NALCO ground during the 1970's and discovered a number of small base-metal showings, which were subsequently drilled.

In the early 1980's, following the discovery of quartz vein-hosted gold mineralization near Jonathans Pond (Blackwood, 1979, 1982), the emphasis in exploration shifted once again, this time to gold. Since then a number of companies have been active in the area: Westfield Minerals, Duval International Limited, Esso Minerals Limited, Gander River Minerals, Esso Resources Canada, Falconbridge and Noranda Exploration Company Limited. Noranda has been active, particularly in the Botwood and Davidsville groups, having made a number of significant gold discoveries through a combination of regional prospecting and geochemical soil- and lake-sediment sampling.

GOLD MINERALIZATION

Known gold occurrences within north-central Newfoundland have gone from a single showing in the early 1980's to at least 15 significant showings or prospects, the majority of which were discovered since 1988 (Figure 1). The mineralization is epigenetic, structurally controlled and occurs in a wide variety of rocks of varying ages. Gold is not confined to particular stratigraphic belts and is found in rocks of the Gander Group, the Gander River complex, and the Davidsville and Botwood groups. However, mineralization appears to be concentrated in the Davidsville and Botwood groups, particularly near their contact.

Initial results from the 1990 field season suggest two broad classes of gold occurrences, with characteristics of mesothermal and epithermal styles of mineralization, respectively. At least four styles or variations of the former type have been documented within the study area:

1) gabbro-hosted gold-bearing quartz–carbonate veins accompanied by intense Fe-carbonate alteration (Clutha, Big Pond and Jonathons Pond);

2) sediment-hosted gold-bearing quartz–carbonate veins accompanied by silicification and carbonate alteration (Stinger);

3) shear-zone hosted gold-bearing quartz–carbonate veins accompanied by minor carbonate alteration developed in shales and greywackes (Bullet); and

4) dilational quartz veins developed within deformed graphitic greywacke and shale (Bowater).

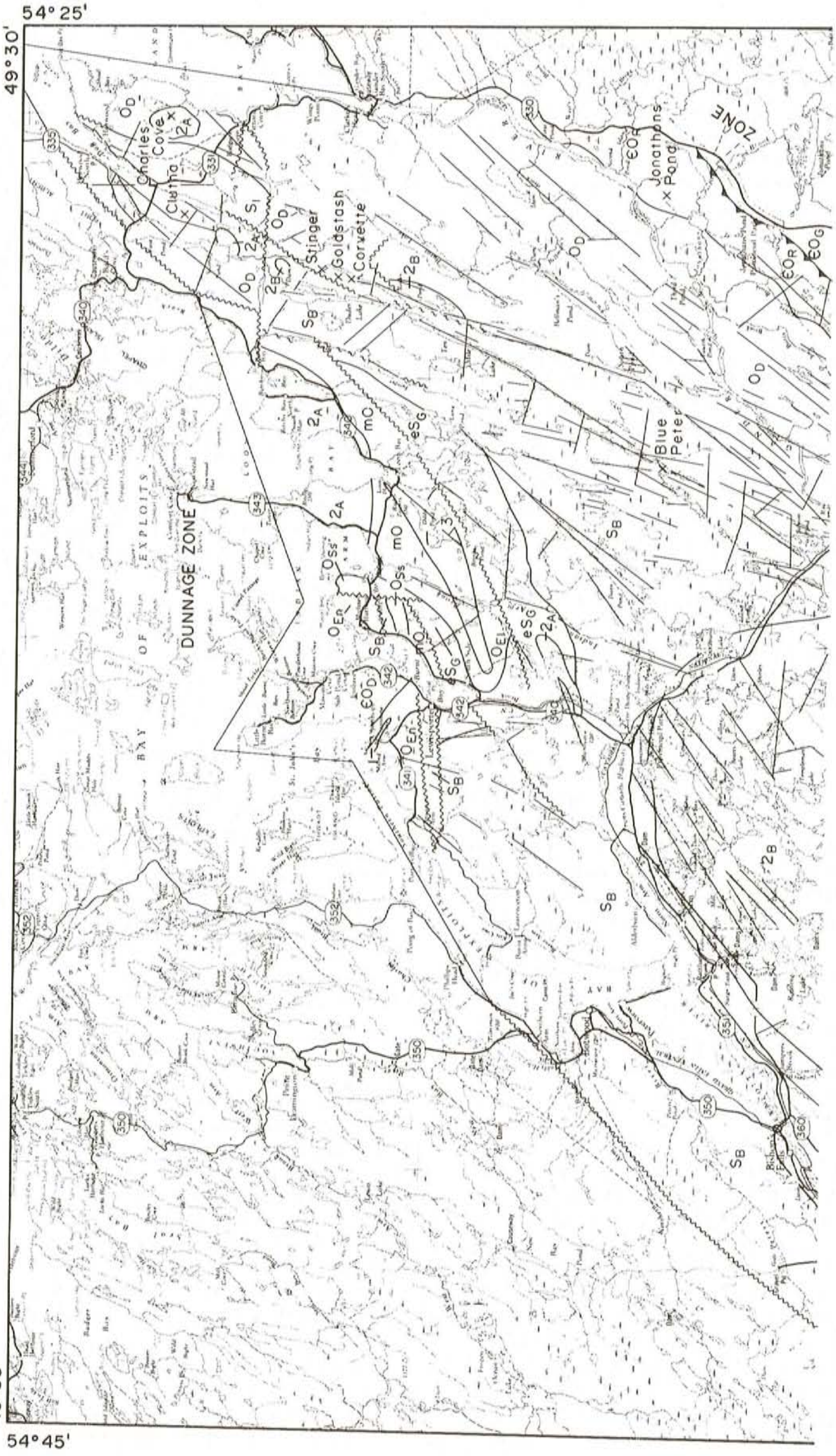
Epithermal-style mineralization typically contain low-grade gold accompanied by spectacular hydrothermal breccias, chalcedonic quartz and intense argillic alteration (Aztec and The Outflow).

MESOTHERMAL MINERALIZATION

Type 1

This style of gold mineralization is characterized by intense Fe-carbonate alteration haloes, which extend up to 2 m from the quartz veins; the quartz veins are discontinuous. They are, typically 2 to 10 cm thick (locally up to 50 cm), exhibit pinch- and swell-structures, and their orientation and distribution are controlled by the rheological properties of the gabbro bodies. The veins typically contain patches and disseminations of pyrite and crystals of arsenopyrite and, locally, spectacular free gold. Two variations of veining have been observed: shear-zone hosted veins and dilational veins.

The gabbro bodies are typically small, fine to medium grained, dark coloured, sill-like intrusions. They range from highly deformed to relatively undeformed, depending on the nature of the deformation in the surrounding rocks. The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DUNNAGE ZONE
BAY OF EXPLOITS
Charles Cove
Clutha
Stinger
Goldstash
Corvette
Jonathons Pond
Blue Peter
ZONE

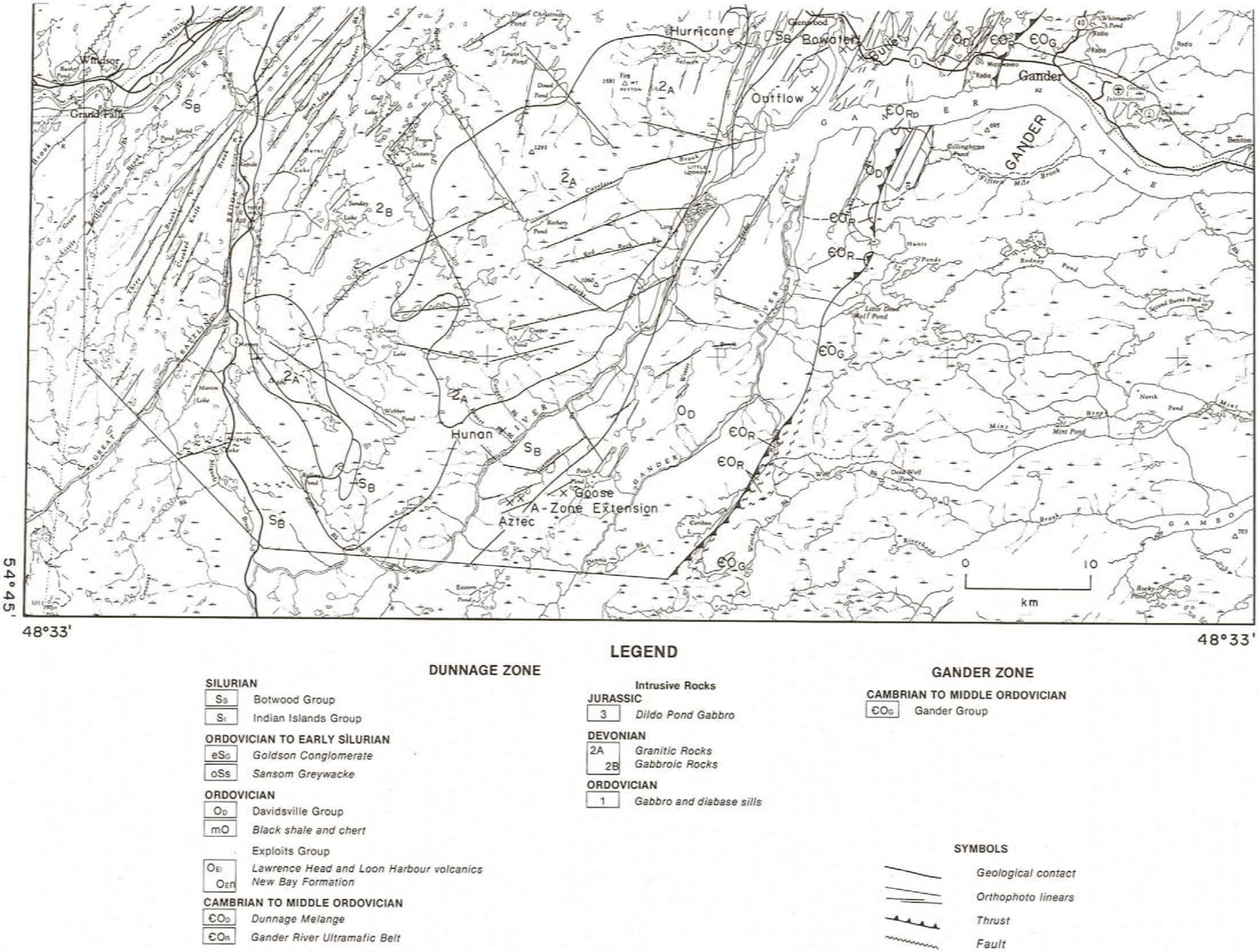


Figure 1. *Regional geology map showing orthophoto linears and gold prospects.*

gabbros are widespread throughout the Davidsville and Botwood groups. However, they appear to be concentrated along a linear belt that approximates the Botwood–Davidsville contact. This suggests a significant, regionally extensive, deep-seated structure, which governed the emplacement of these gabbro bodies, and may have provided a pathway for the later mineralizing fluids. Similar quartz veins, but with less intense Fe-carbonate alteration, are developed within deformed gabbros of the Gander River complex.

Clutha

Gold mineralization was discovered at Clutha (Figure 1) in 1988. At that time, the prospect was trenched and tested by fifteen diamond-drill holes. A channel sample from the prospect assayed 0.146 ounces/ton over 13.1 feet (Noront Resources Limited, 1990). The gold is hosted by pyrite- and arsenopyrite-bearing quartz–carbonate veins. These veins cut intensely Fe-carbonate altered and silicified, fine- to medium-grained gabbros, which are intruded into a monotonous sequence of black shale, siltstone and greywacke (Figure 2). The shales exhibit an intensely developed north-northeast trending, steeply east-dipping, slaty cleavage. Graded bedding in the greywacke units indicates that the rocks are overturned to the northwest.

These sedimentary rocks were mapped by Patrick (1956) and included in the Silurian Indian Islands Group by Baird (1958). However, the presence of intercalated, fine-grained, grey-green pillow lava along strike to the northeast as well as lithological similarity to the Davidsville Group, suggest that the belt of sedimentary rocks, which extend northward from Second Pond along the west side of Dog Bay, be included in the Davidsville Group.

The gabbro bodies range from approximately 2 to 20 m thick, have a strike length of up to 400 m and appear to be preferentially intruded along the belt described above as belonging to the Davidsville Group. However, the mineralization is confined to portions of the gabbros that underwent intense deformation. The gabbros appear to have been intruded during early regional deformation. Crosscutting relationships between the gabbros and the sedimentary rocks are preserved locally.

The quartz veins are typically 2 to 10 cm, but locally up to 50 cm thick, and discontinuous. Fine-grained, disseminated pyrite and arsenopyrite occur both in the veins and in the alteration haloes to the veins. Visible gold was observed in one quartz vein obtained from drill core. The Fe-carbonate-rich haloes extend up to 2 m from the veins. Abundant gold can be panned where the alteration and veining have been significantly weathered.

Two northeast-trending linear valleys are developed to the east and west of the prospect. Inferred sinistral movement on these structures would have resulted in clockwise rotation of the structural elements bounded by the two faults. This would result in the rotation of the gabbros into the plane of the regional foliation. This rotation produced conjugate

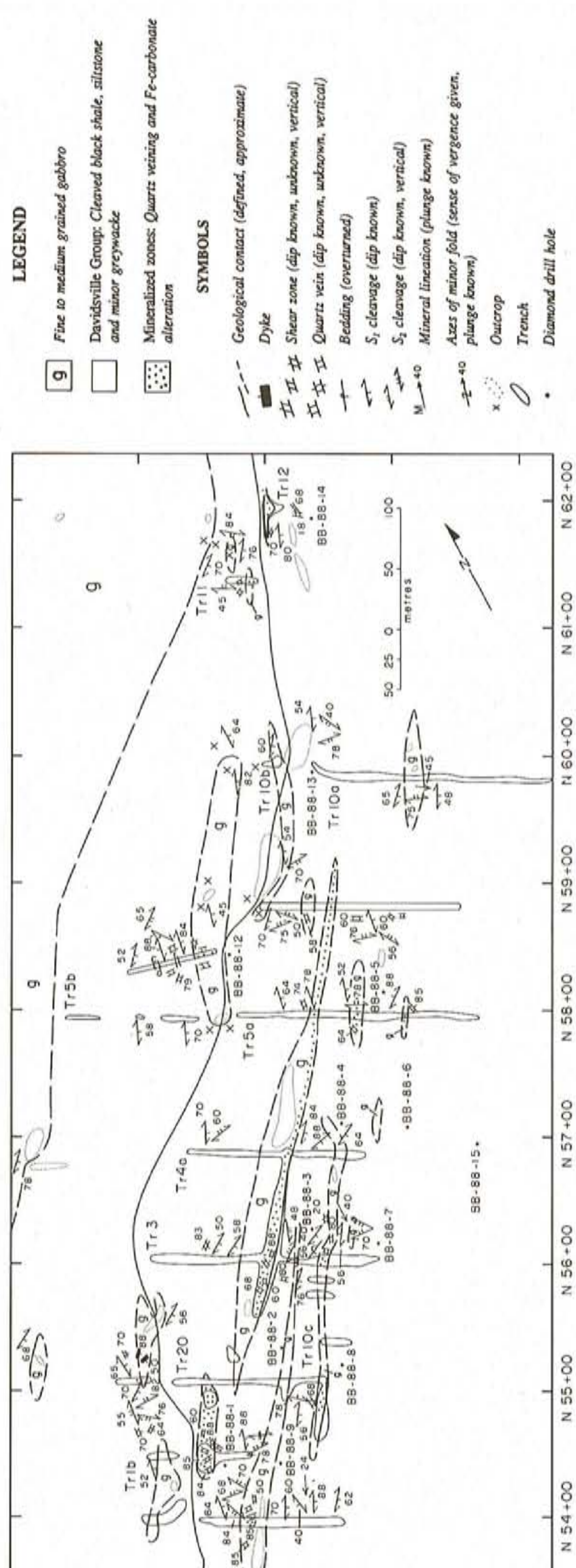


Figure 2. *Geology and trench map of the Clutha area.*

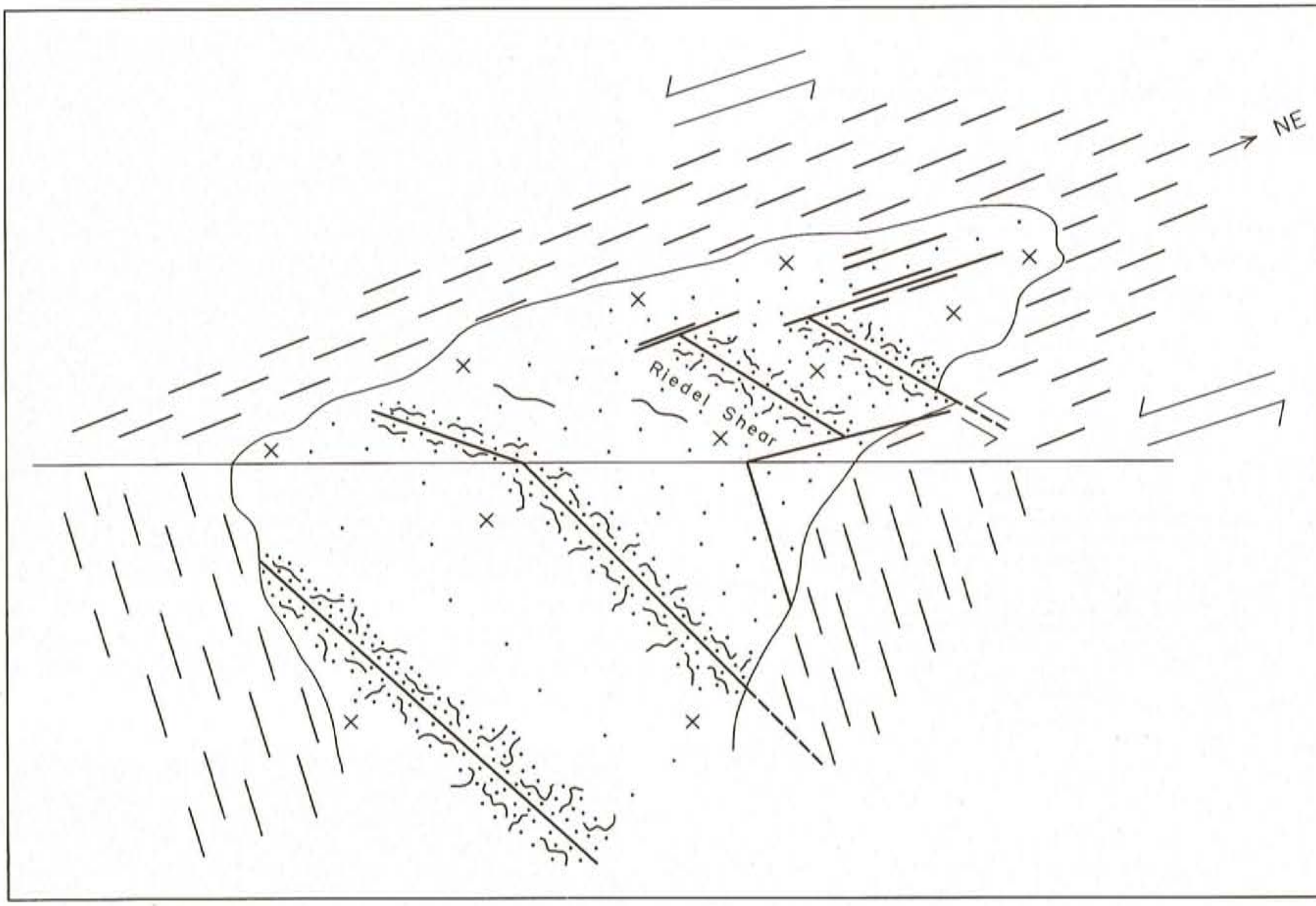


Figure 3. *Schematic diagram exhibiting the structures controlling gold mineralization at Clutha.*

jointing patterns as observed in the less deformed and altered gabbro bodies, and Riedel shears, conjugate Riedel shears and shears developed parallel to the regional foliation (Figure 3) in the deformed gabbros. Development of these structures can be related to rotational deformation (simple shear) of the strain ellipse (Figure 4).

These shears played a significant role in the localization of quartz veining and alteration with the most intense alteration appearing to have been developed along the conjugate Riedel shears (Plate 1). The veining and alteration mimicked the conjugate joints producing a blocky alteration pattern with remnent blocks of relatively unaltered gabbro being preserved (Plate 2). Mineralized zones within the gabbros are typically narrow, ranging from 2 to 10 m, and have a strike length that approximates that of the gabbro.

The conjugate Riedel shears intersect the gabbros at a relatively high angle, thereby limiting the strike potential of these shears to the width of the gabbro. When these shears intersect the surrounding shales they quickly die out, reflecting the competency difference between the gabbro and the shale. However, these shears are repeated regularly along the strike length of the gabbro, forming panels of shearing and alteration that dip variably to the northeast. Therefore, the economic potential of this style of mineralization is along the strike of the gabbro.

Big Pond (Blue Peter)

Spectacular gold mineralization was discovered at Big Pond (Blue Peter, Figure 1) in 1988 by Noranda. The prospect has been trenched and three diamond-drill holes have been completed. The gold is hosted by a shallow-dipping, northeast-striking, dilational quartz vein (main vein), which is developed within Fe-carbonate altered, sericitized and weakly silicified gabbro (Figure 5). The gabbro, which is fine to medium grained and black, intrudes maroon and green siltstone and sandstone of the Botwood Group. A number of these small gabbro bodies are developed along strike.

The main vein (Figure 6) appears to be part of a sheet-like set of quartz veins, three of which are exposed in the trench. The other two veins are much narrower, more discontinuous and to date have not yielded visible gold. The main vein is exposed for approximately 8 m and exhibits pinch-and-swell structures. It has a maximum thickness of 20 cm and appears to be slightly cupped shaped, plunging to the north-northwest. Abundant pyrite, fine-grained, semi-massive arsenopyrite and locally, coarse free gold are present along the length of the vein. The main vein contains abundant, locally rounded, wall rock and vein fragments, suggesting multiple injections of the mineralizing fluid.

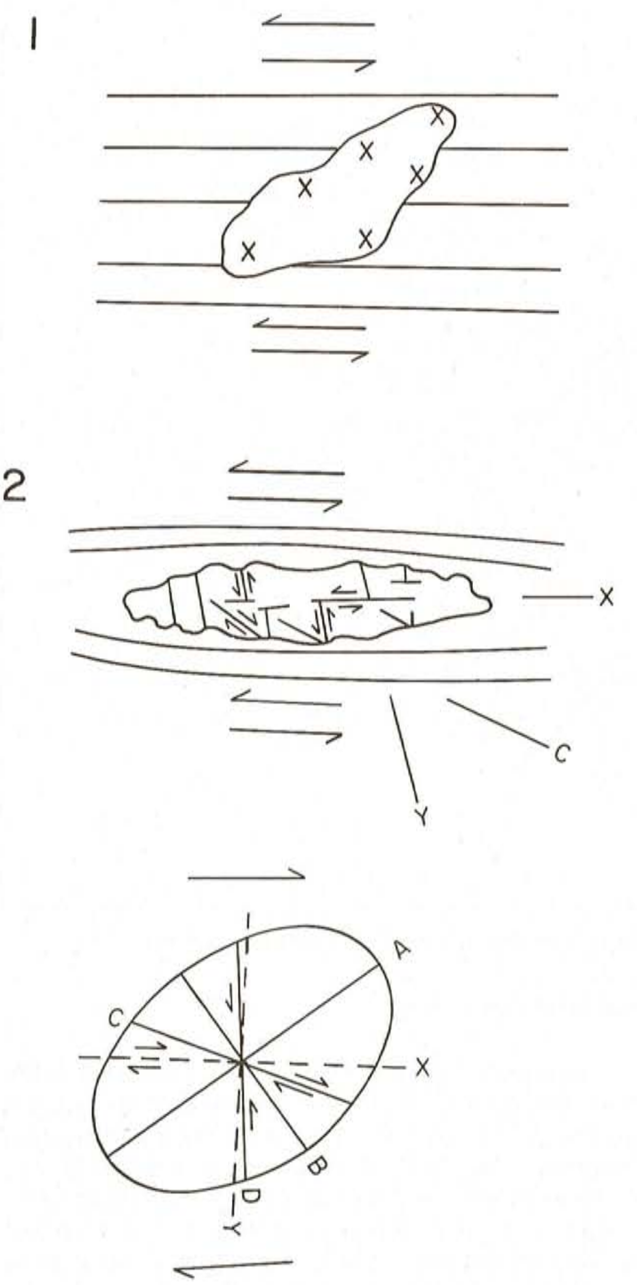


Figure 4. *Generalized model for the development of the structures hosting gold mineralization at Clutha.*

Later, north-northwest and west-northwest trending, small 1- to 2-cm-thick quartz veins transect the north-northeast trending veins. A conjugate set of narrow, brittle shears, which trend north-northwest and east-northeast, locally control quartz veining.

The host gabbro appears to have been intruded close to the intersection of two regionally extensive topographic linears, which are interpreted to be faults. The gabbro has a sigmoidal shape (as projected from drill core), which suggests it was rotated during movement along the fault system producing dilational zones that formed the loci for the mineralizing fluids.

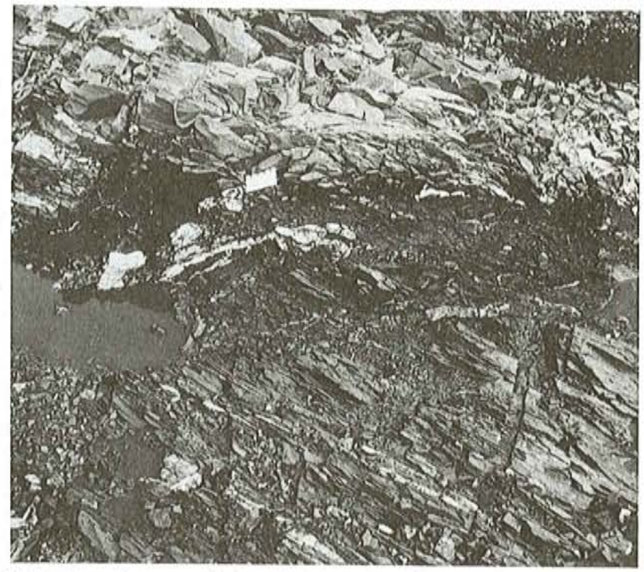


Plate 1. *Quartz veining developed within a conjugate Riedel shear; host rock is deformed and carbonate altered medium-grained gabbro. Note quartz veining developed parallel to the regional cleavage.*

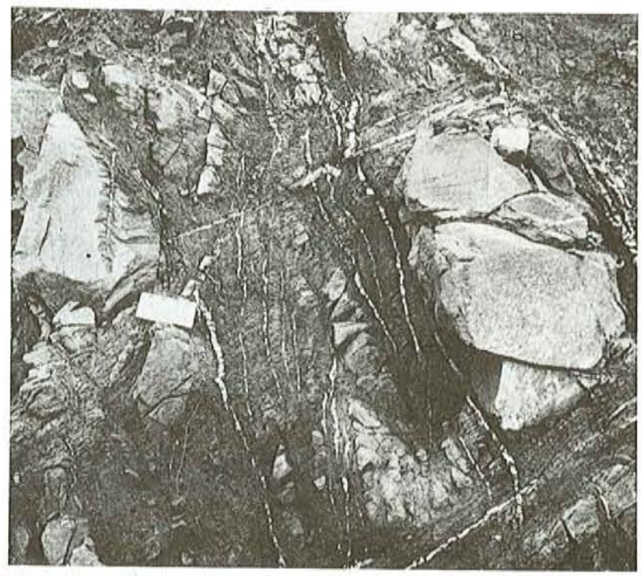


Plate 2. *Blocky alteration and quartz veining (Trench 12). Shearing, alteration and quartz veining follow jointing developed within the gabbro; blocks are remnants of less altered gabbro.*

Jonathans Pond

Gold mineralization was first discovered in the Jonathans Pond (Figure 1) area by the Newfoundland Department of Mines and Energy (Blackwood, 1979, 1982). The gold, which assayed 6 g/t, was described as being associated with pyrite- and arsenopyrite-bearing quartz veins developed within intensely sheared gabbro of the Gander River complex. The veins were described as containing local concentrations of massive pyrite, arsenopyrite and cubic pyrite, and rhombic arsenopyrite crystals 2 to 5 mm across.

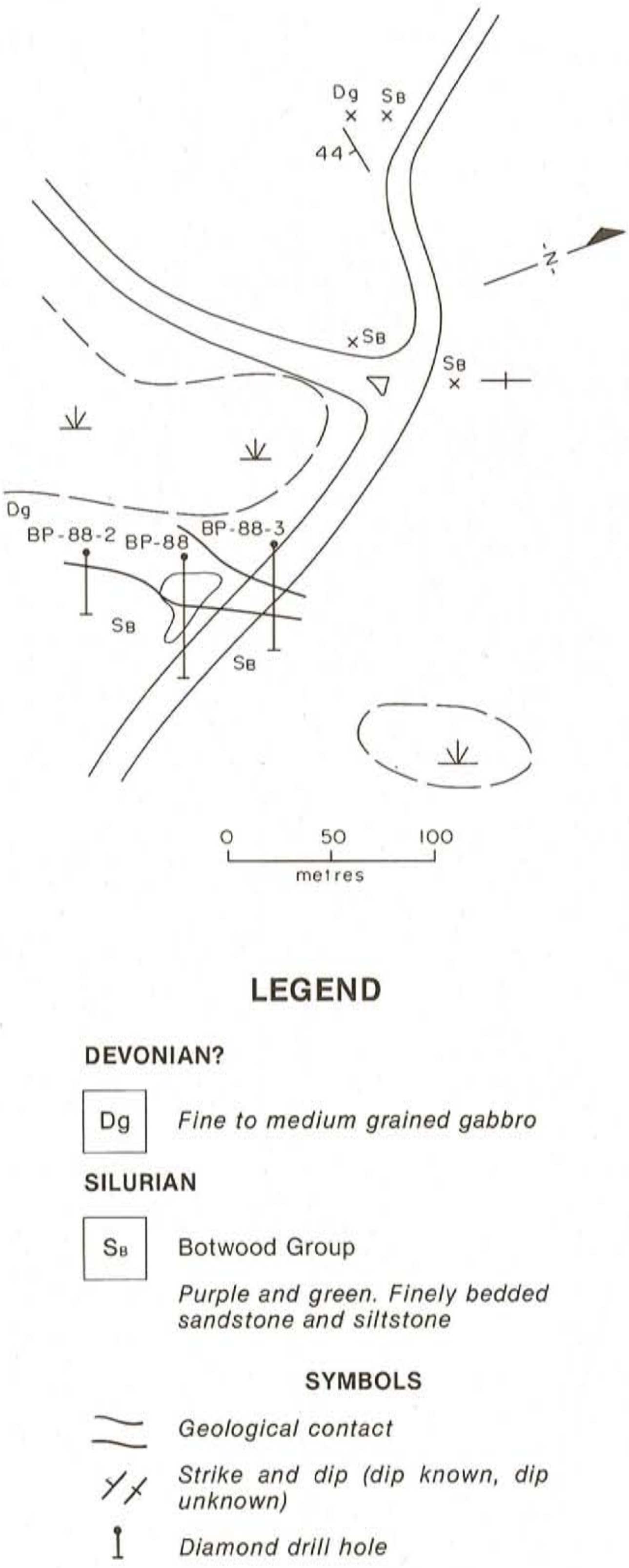


Figure 5. *Geology map of the Big Pond area.*

The area was staked by Westfield Minerals Limited in 1980 (Gagnon, 1981). The company conducted soil- and stream-sediment sampling, mapping, prospecting, trenching and carried out EM-16 surveys. The area was staked by Noranda in 1984 after a regional till-sampling program outlined anomalous gold values (MacKenzie, 1985). Noranda has conducted extensive work on the property but have been hindered by extensive, thick overburden and limited exposure.

The gold mineralization occurs in shear-zone controlled, pyrite- and arsenopyrite-bearing, milky white, locally vuggy quartz veins. The veins, up to 15 cm thick, form a stockwork-like network concentrated in a zone approximately 3 m wide. Pyrite and arsenopyrite within the quartz veins are generally fine grained and disseminated, but coarse sulphides are developed locally. Minor to intense silicification and minor carbonate alteration accompanies the quartz veining.

The gabbro is fine to medium grained and forms part of the Ordovician (?) Gander River complex. Rocks of the complex have been subjected to greenschist-facies metamorphism and as a result chlorite and epidote are common. A weak north-northeast penetrative fabric is developed in the gabbro. Serpentinized and talc–carbonate altered ultramafic rocks are exposed in a trench to the north, and are interpreted to be in fault contact with the gabbro. The setting of this mineralization maybe analogous to the listwaenite model of Buisson and LeBlanc (1985).

Type 2

Stinger

Sediment-hosted gold-bearing quartz–carbonate veins accompanied by intense silicification and carbonate alteration are developed at the Stinger prospect, Duder Lake (Figure 1). The prospect was discovered by Noranda and is part of an active exploration project in the Duder Lake area. The mineralization, as exposed on surface, comprises a 5- to 10-m-wide zone of fine-grained, highly deformed, silicified and Fe-carbonate altered, slightly graphitic sediments of the Davidsville Group. Dilational, pyrite- and arsenopyrite-bearing quartz–carbonate veins up to 40 cm thick are developed in the zone. Angular, wall-rock fragments are common in the quartz veins. The prospect appears to be a shear-controlled quartz vein system; however, further work is required.

Types 3 and 4

Extensive quartz veining is developed in the slates of the Davidsville Group, particularly to the east of the Gander River. Milky-white, barren quartz veins that developed parallel to the cleavage, and largely parallel to bedding, appear to be metamorphic in origin. Shear-zone hosted gold-bearing quartz–carbonate veins developed in the same rocks, generally, have anomalous gold values. These veins are typically accompanied by minor carbonate alteration that is restricted to the shear zone. The rocks that host the gold-bearing veins are typically graphitic shales and greywackes. Dilational quartz veins carrying gold are developed in deformed greywacke units. The veins developed as a result of rheological differences between the greywacke and surrounding shale.

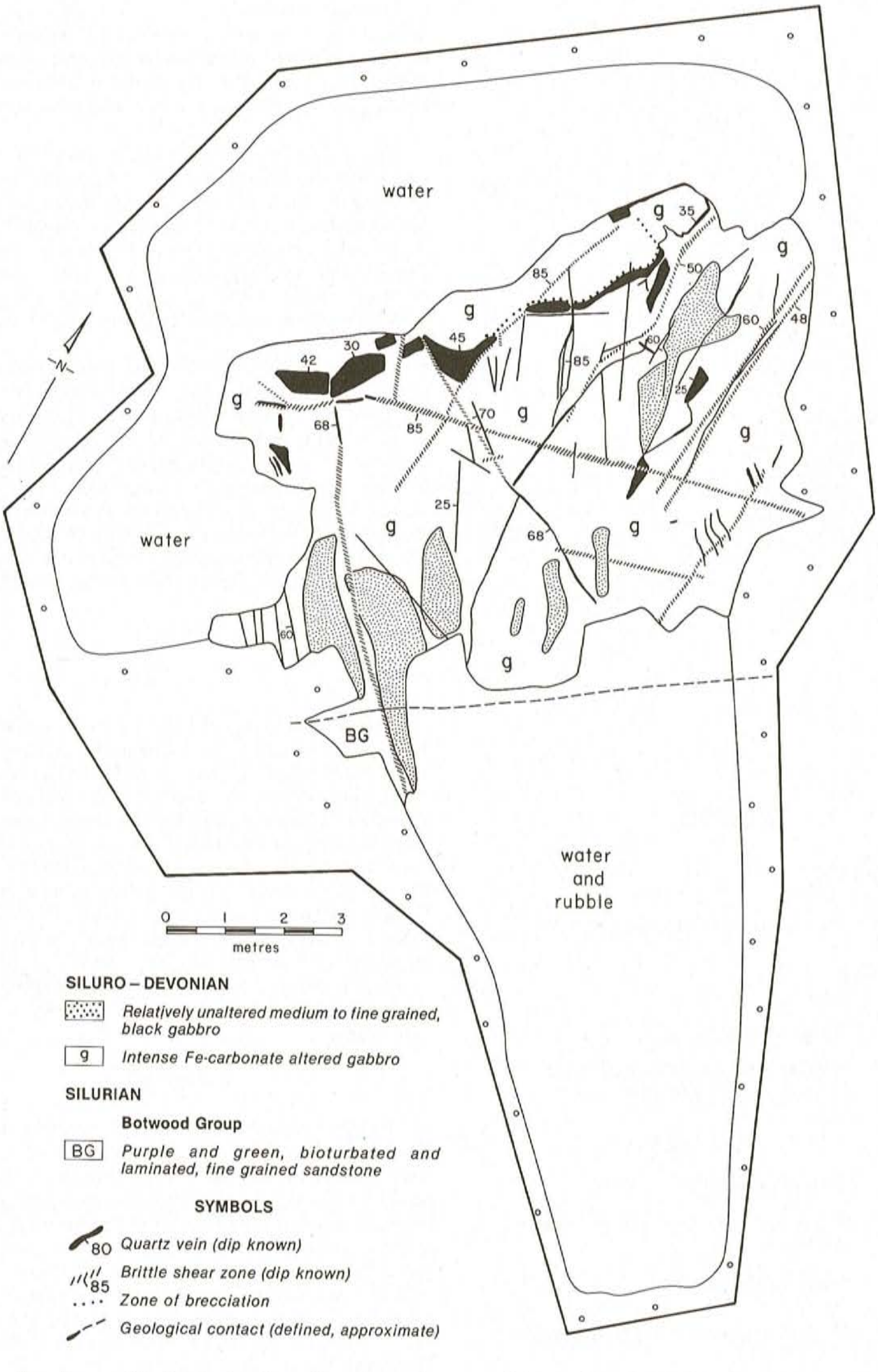


Figure 6. *Trench map, Big Pond, showing orientations of quartz veining and structures that locally control the veining. The main mineralized vein is located near the northwest edge of the outcrop.*

Bullet

Spectacular gold mineralization was discovered at the Bullet prospect (Figure 1) in 1987 by Noranda. The prospect has been trenched and three diamond-drill holes have been completed. The gold mineralization comprises a narrow, quartz–carbonate vein set (Figure 7) developed within a northeast-trending, steeply south-dipping, dextral shear zone. The quartz veins are generally less then 10 to 15 cm thick and comprise milky-white quartz containing disseminated pyrite, arsenopyrite and minor base metals (Plate 3). The gold occurs as specks and clusters of free gold.

The shear zone, which has a maximum width of 50 cm and an exposed strike length of 24 m, cuts highly cleaved, slightly graphitic shales and siltstone of the Davidsville Group (Figure 8). The shear zone dies out quickly toward the northeast. To the southwest, the shear and quartz veining is offset approximately 1 m by a sinistral shear zone. Movement along this zone appears to have been coincident with quartz-vein development as the vein cuts this shear, was offset by, and folded, into the plane of the shear. There appears to have been late movement on the shear, which hosts the main quartz veins, as these veins are broken and reoriented (Figure 8).

Bowater

The Bowater prospect (Figure 1), discovered by Noranda in 1987, comprises pyritiferous quartz veins and quartz breccia developed within graphitic, locally sericitic, black greywacke. The prospect has been trenched and drilled. Generally, gold assays from the conglomerate are less then 3 g/t (P. Tallman, personal communication, 1990). The greywacke, part of a sequence of graphitic siltstone, pyritiferous shales and greywacke belonging to the Davidsville Group, contains abundant broken feldspar crystals, small glassy quartz grains and sedimentary rock clasts. The sequence contains a slaty cleavage, co-planar to bedding, that trends north-northeast and dips shallowly to the east. Conjugate kink bands and open to moderately tight, southeast-plunging folds, which fold the cleavage, are locally developed (Woldeabzghi, 1988).

The quartz veining is dilational and not restricted to the greywacke. However, the intensity and width of the veining is greater in the greywacke, reflecting the rheological difference between the greywacke and the shales. The veins are typically milky white, locally rusty and vuggy and up to 10 cm in thickness. Minor, narrow, shear-related quartz are locally developed.

A northeast-trending, shallow, southeast-dipping shear zone is developed in the shales exposed in the pit wall approximately 50 m north of the prospect. Associated with this shear are sheeted, rusty quartz veins up to 5 cm thick. These veins appear to be largely restricted to the hanging wall. Samples from these veins will be assayed for gold.

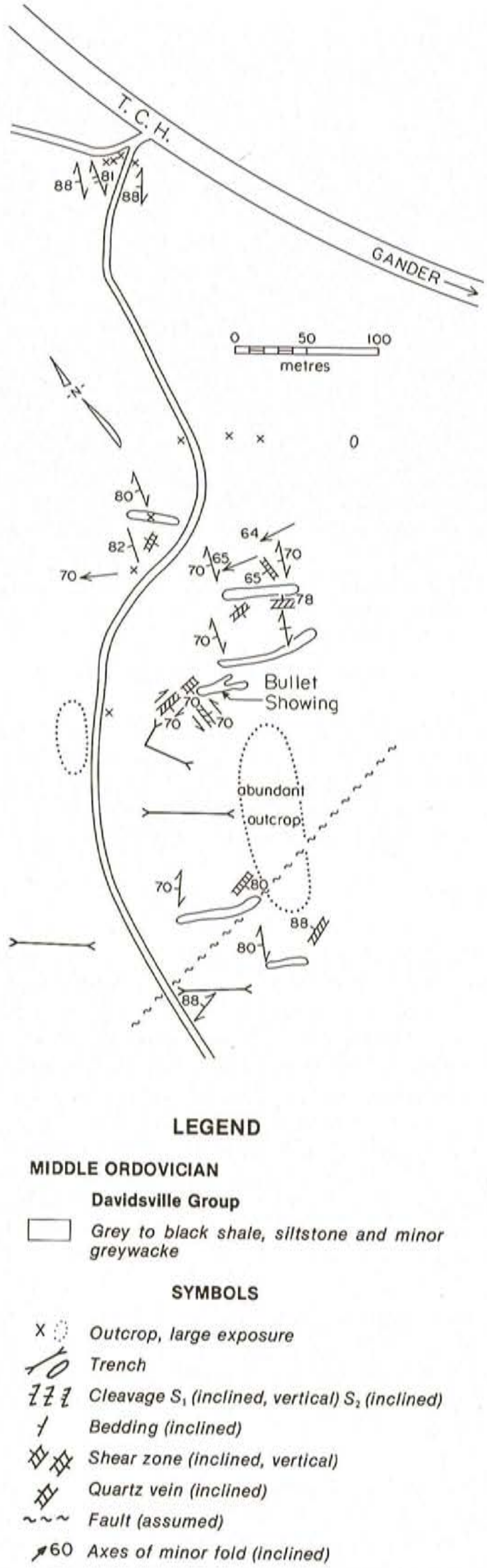


Figure 7. *Geology of the Bullet area.*

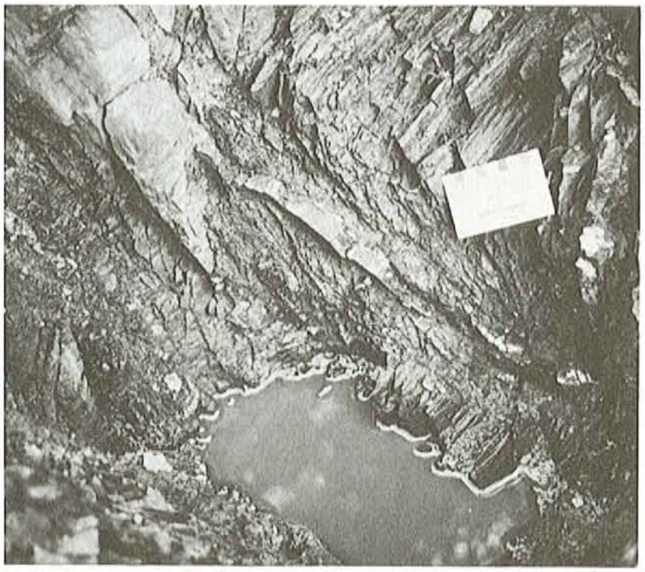


Plate 3. *Sheet-like, broken gold-bearing quartz-carbonate veins developed in a 30-cm-wide shear zone, which cuts highly cleaved Davidsville Group shale.*

Epithermal-Style Mineralization

Epithermal-style, low-grade gold mineralization developed within spectacular hydrothermal breccias occur in sedimentary rocks of both the Davidsville and Botwood groups. This style of mineralization and alteration has only been documented from the rocks south of Glenwood.

The Outflow

Gold mineralization was discovered at The Outflow (Figure 1) in 1987 by Noranda prospectors. Detailed mapping, trenching and diamond-drilling, by Noranda, has outlined anomalous mineralization over a strike length of 5 km. The mineralization is developed within greywacke lenses that are part of a sequence of shale, siltstone, sandstone, greywacke and minor conglomerate of the Davidsville Group (Figure 9). Gower and Tallman (1988) described the sequence as being isoclinally folded with an associated strongly developed penetrative cleavage, which has been deformed by upright to slightly inclined open folding. North-trending brittle faults cut the sequence.

Two mineralized zones, termed the Mustang and Piper zones having strike lengths of 1.8 km and 750 m, respectively, have been outlined (Gower and Tallman, 1988). The gold is associated with pyrite, arsenopyrite, stibnite and intense silicification.

Three styles of related silicification have been documented (Gower and Tallman, 1988): 1) spectacular hydrobreccia stockwork (Plate 4); 2) pervasive silicification; and 3) massive crystalline quartz and quartz–carbonate veins. They have shown that the Mustang Zone comprises all three styles of silicification and contains <1 to 3 percent stibnite

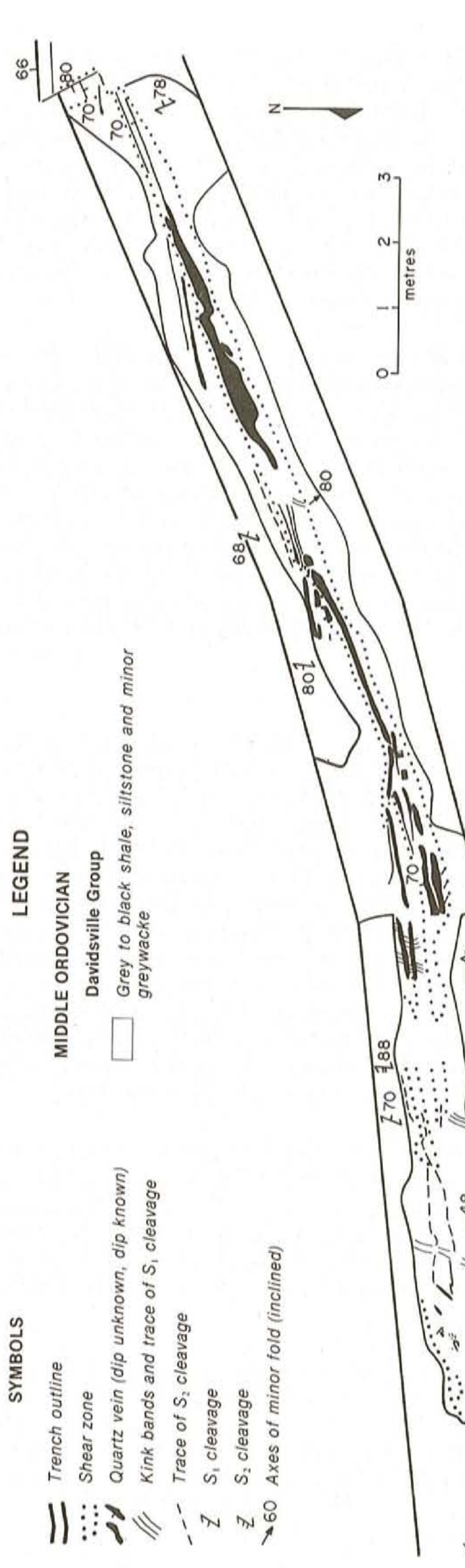
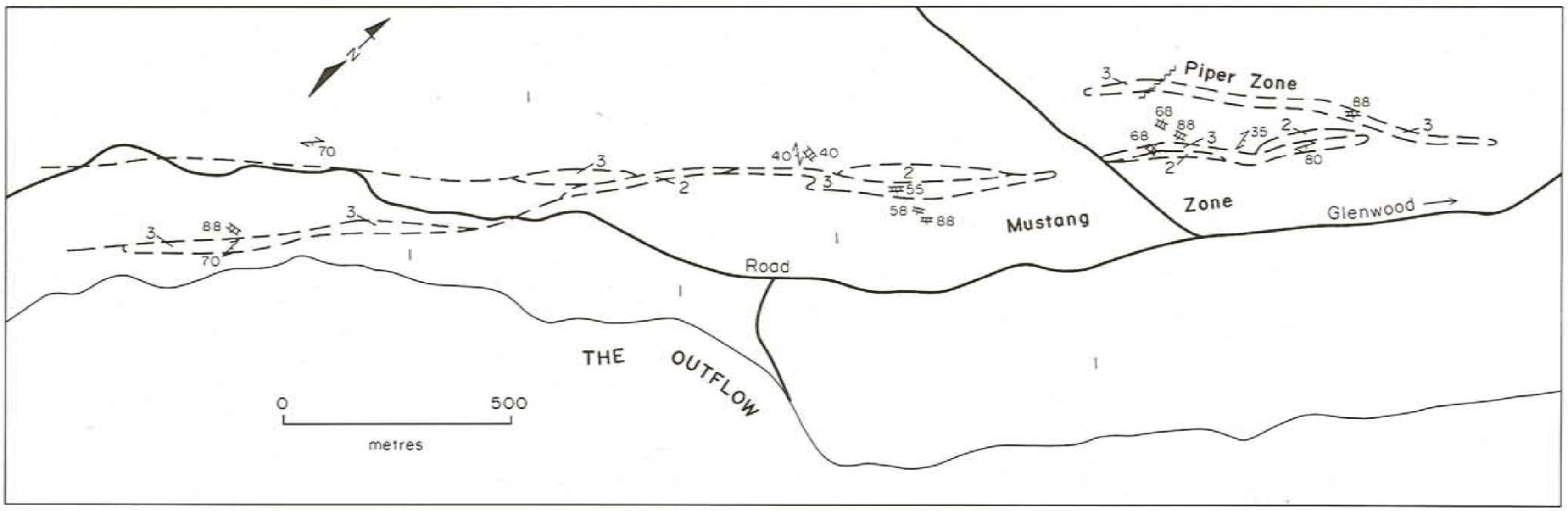


Figure 8. *Trench map of the Bullet prospect showing the brecciation of the quartz veins, the shear zone that hosts the veins and the sinistral shear that offsets the mineralized shear.*



LEGEND

Middle Ordovician
Davidsville Group

3	*Intense hydrothermal brecciation, silicification, quartz veining and localized stringer pyrite and disseminated pyrite, arsenopyrite and stibnite*
2	*Greywacke*
1	*Shale, siltstone and minor sandstone*

SYMBOLS

cleavage (dip known)

fault (defined)

quartz vein or stockwork (dip known)

---- *geological contact (approximate)*

Figure 9. *Geology of The Outflow area (modified after Gower and Tallman, 1988).*

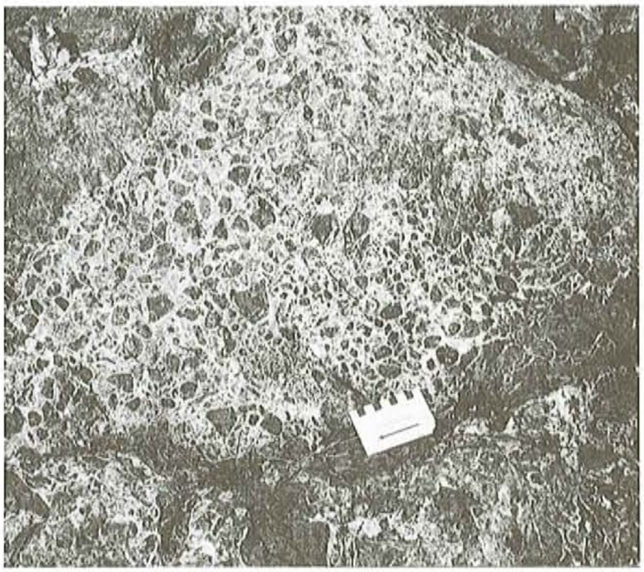


Plate 4. *Intense hydrothermal brecciation and silicification, The Outflow.*

and pyrite; further intense hydrobrecciation, quartz veining and local pervasive silicification characterize the Piper Zone.

Both zones trend northeast-southwest and dip to the northwest. However, the Mustang Zone appears to dip to the southeast at its southwest end (Gower and Tallman, 1988). A channel sample from the Mustang Zone assayed 12.23 g/t gold; gold values are typically <1 g/t (Gower and Tallman, 1988). Gold values for the Piper Zone are typically <1 g/t.

Textures such as the intense hydrobrecciation and vuggy quartz veining observed at The Outflow suggest high-level mineralizing processes more akin to epithermal systems. Tallman (1990) suggested that the relatively high concentrations of stibnite associated with The Outflow prospect may indicate that it formed in the higher levels of a hydrothermal system, which at deeper levels may have developed antimony mineralization similar to the Hunan and related prospects.

Aztec

Epithermal-style (Tallman, 1989a), low-grade gold mineralization was discovered by Noranda in the Paul's Pond area in 1988 (Aztec, Figure 1). The prospect has been trenched and six diamond-drill holes completed. The alteration system was described as being developed at or near the presumed fault contact between the Davidsville and Botwood groups (Figure 10). The fault is described by Tallman (1989b) as a brittle, low-angle thrust, defined by a 10-m-thick graphitic gouge zone, which dips shallowly to the northwest. This fault has been traced for approximately 15 km to the north.

The alteration associated with the Aztec prospect is developed in the structural footwall of this fault zone (Figure 11). The structural footwall to the fault consists of a locally silicified, pyritic conglomerate or breccia. The breccia overlies (but may also be developed adjacent to) the zone described as a silica sinter by Tallman (1989b). Fragments within the conglomerate are locally silicified, suggesting that the unit may have developed in part as talus breccia on the flanks of the sinter. The gold mineralization, typically <1 g/t, is associated with the conglomerate.

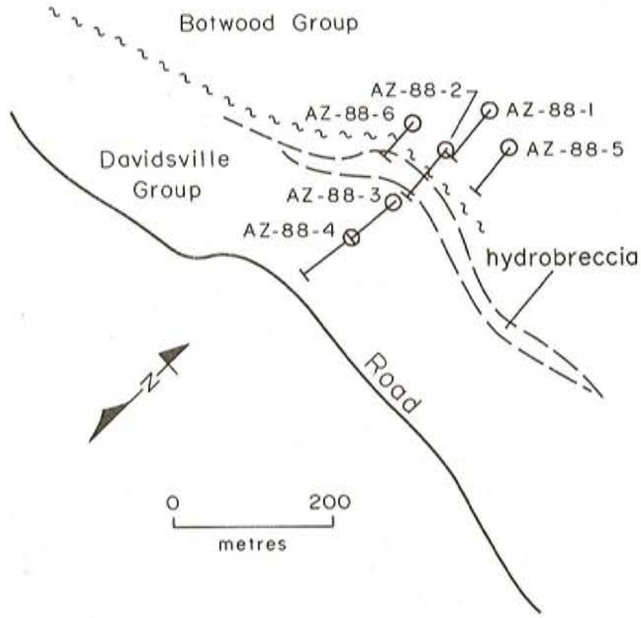


Figure 10. *Geology of the Aztec prospect, showing diamond-drill hole location. (modified after Tallman, 1989b).*

Spectacular hydrothermal breccias exhibiting multiple phases of brecciation and pervasive silicification comprise the silica sinter. Breccia fragments exhibit cockade textures comprising concentric rinds of chalcedony. Chalcedony also forms a large portion of the breccia matrix. This unit has a thickness of approximately 10 m and is well exposed on surface.

Structurally beneath this sinter is a 70-m-thick zone of variably developed argillic alteration, developed in fine-grained siltstone and sandstone. The intensity of the alteration appears to decrease downwards, but diamond-drilling did not extend into totally unaltered rocks. On the surface, the alteration has a strike length of 330 m, a width of 100 m and dips shallowly to the northwest (Tallman, 1989b).

The alteration and textures observed at the Aztec prospect fit an epithermal mineralization model related to movement along a regionally extensive structure.

DISCUSSION

Preliminary work indicates that the gold mineralization developed within rocks of the northeastern Dunnage Zone are structurally controlled and epigenetic. The prospects fall into two broad classes—epithermal and the deeper level mesothermal quartz vein systems. Mesothermal gold

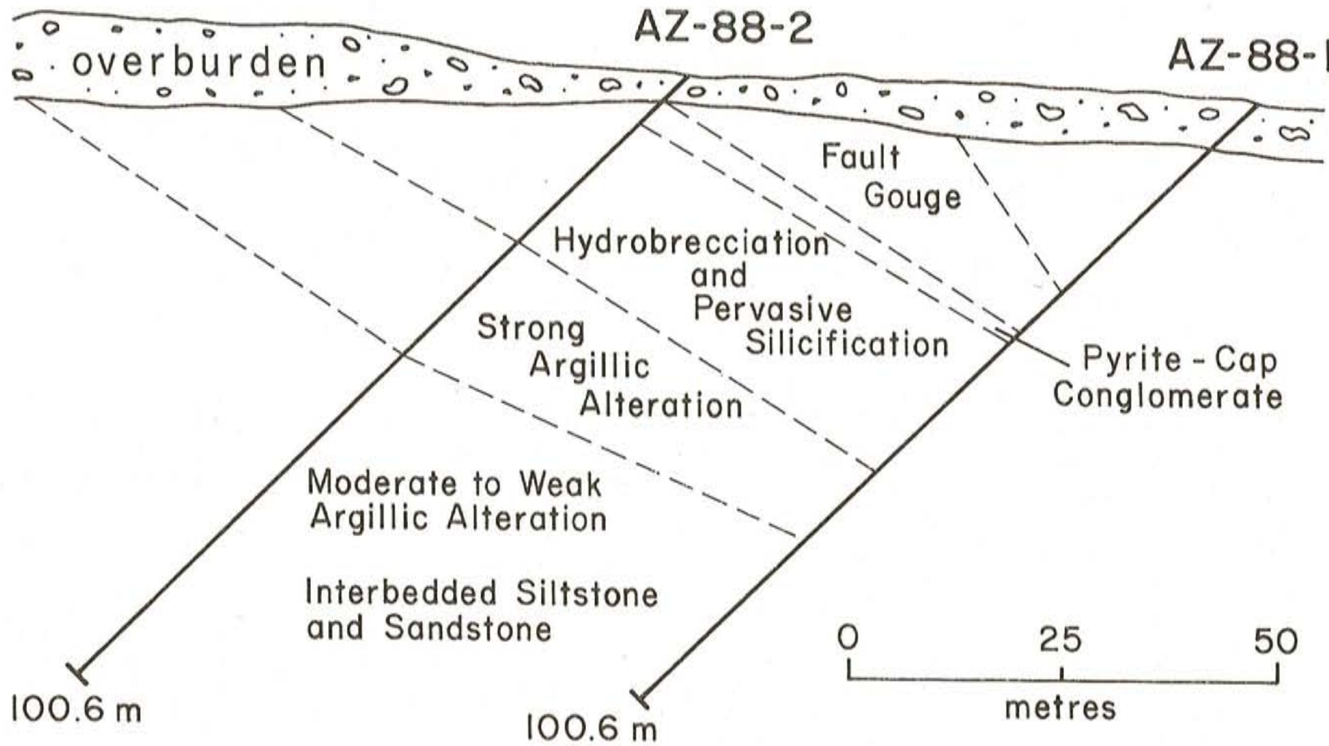


Figure 11. *Schematic cross-section through the Aztec prospect (modified after Tallman, 1989b).*

mineralization is tentatively subdivided into four types or styles based on variations in deposit style and host-rock characteristics.

Certain characteristics are shared by both the epithermal and mesothermal gold occurrences. They are all spatially associated with, and have been structurally modified by, fault systems of regional extent. The actual site and style of the gold mineralization is controlled largely by rheological differences between the host rock and the surrounding rocks.

Many of the variations or differences between the individual mesothermal prospects can be explained by the degree of disequilibrium between the host rocks and the ore fluids. Fe-rich rocks (those with a high Fe/(Fe+Mg) ratio; Barley and Groves, 1990) and graphitic sediments (Colvine *et al.*, 1984) appear to be selectively mineralized. Therefore, when a favourable, structurally prepared rock unit is subjected to mineralizing fluids, a gold-bearing quartz vein system may develop.

The gabbro bodies are Fe-rich and rheologically ideal for the formation of either shear-zone hosted or dilational, mesothermal quartz veins. Therefore, the numerous gabbro plugs may prove to be the best exploration targets as they exhibit the most favourable characteristics for the development of economic concentrations of gold mineralization. There appears to be a preponderance of small gabbroic bodies developed within the Middle Ordovician sedimentary sequences of the Exploits (B. O'Brien, personal communication, 1990), Victoria Lake and Davidsville groups. The regional geological significance of this phenomena is not clear. However, it has significant regional implications for mineral exploration as the sedimentary sequences of the Victoria Lake and Exploits groups are largely unexplored for gold.

Alteration and gold mineralization within the northeastern Dunnage Zone appears to be localized along second or higher order structures that form a complex network of northeast-, north-northeast- and northwest-trending linears. Figure 1 shows a regional, structural, linear map based on orthophoto interpretation. A similar regional model for gold mineralization has been suggested for the Victoria Lake Group (Kean and Evans, 1988; Evans *et al.*, 1990). These structures are related to a late accretionary transpressive regime active during the Late Silurian and early Devonian. Such regimes would be characterized by relatively high heat flow, a network of deep level structures, which would act as fluid pathways, and abundant high concentrations of H_2O- and C_2O-rich fluids (Kerrich, 1989; Kerrich and Wyman, 1990; Barley and Groves, 1990).

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