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GOLD MINERALIZATION IN NEWFOUNDLAND: A 1988 REVIEW

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Mineral Deposits Section

ABSTRACT

This paper reviews the geological environments of gold mineralization in Newfoundland. Gold has been recovered as a by-product from volcanogenic massive sulphide deposits. Island-arc and ophiolitic environments of massive sulphide formation are documented and the deposits are intimately related to volcanic stratigraphy. These deposits will continue to be of major importance.

The economic potential of epigenetic deposits that occur as individual or multiple veins, stockworks, or replacement zones, is now being recognized. These deposits are the focus of most recent exploration efforts that include the Hope Brook, Cape Ray, and Mings Bight areas. They occur in a variety of secondary structural environments associated with major fault zones and lineaments. Epithermal alteration assemblages, commonly deformed by later fault movements, are widely developed in volcanic and sedimentary rocks varying in age from Late Hadrynian to Late Silurian, and extensive carbonatization occurs in and adjacent to ophiolitic ultramafic rocks. A spatial, possibly genetic, association between granites and gold is evident at some prospects, but is not a universal feature. Major fault and thrust fault zones enhanced and focussed fluid, and possibly some magmatic systems, and were the fundamental control over epigenetic mineralization.

INTRODUCTION

Volcanogenic massive sulphide deposits have traditionally been an important source of gold in Newfoundland with an approximate total production of 3 tonnes. The deposits were mined primarily for their base metals, but in some mines, gold contributed to the viability of mining and locally attained ore grades irrespective of the base-metal content.

The largest gold producers were deposits associated with felsic volcanic rocks at Buchans and at Rambler (Figure 2); other similar deposits also contain gold. The recent Duck Pond–Tally Pond discovery (Figure 2), and the identification of gold in the Rambler tailings, should ensure continued production from those types of deposits. Minor production has been achieved from ophiolite-related deposits and several of these are being investigated for their gold potential.

A substantial increase in exploration for epigenetic gold deposits in Newfoundland has taken place since 1984. Hope Brook Mine (Figure 6) commenced production in 1987 and is the province's first significant gold-only mine. Underground exploration has been conducted at Cape Ray and at Deer Cove (Figure 6), and major surface exploration projects are underway at numerous localities. These epigenetic deposits include single and multiple veins, silicified and replacement zones, and stockwork vein systems. They are characterized by a relatively low sulphide content when compared to volcanogenic massive sulphides, and represent an important resource to the province.

The new prospects occur predominantly in Paleozoic rocks of the Appalachian Orogen, although some are hosted by late Precambrian rocks. An extremely diversified depositional, structural, plutonic and tectonic history of the province provides an abundance of mineralized environments that collectively exhibit features common to gold deposits worldwide.

The objectives of this paper are to update an earlier summary of gold-bearing environments in Newfoundland (Dean *et al.*, 1985) and to present our perspective on the controls of gold mineralization in the province. The descriptive emphasis of the paper is on the setting of newly recognized epigenetic vein-type deposits. A summary of environments of deposition of massive sulphides is also given and this topic will be reviewed in greater detail in a later publication.

GEOLOGY OF NEWFOUNDLAND

Newfoundland occupies a central position in the Appalachian–Caledonian Orogen and lies at the northeastern edge of the Appalachian Orogen in North America (Williams, 1978). Three major tectonic-stratigraphic subdivisions are recognized (Figure 1), and the rocks record the evolution and destruction of the Lower Paleozoic Iapetus Ocean (Bird and Dewey, 1970; Williams, 1978, 1979; Williams and Hatcher, 1982).

This project is a contribution to the Canada–Newfoundland Mineral Development Agreement, 1984–1989

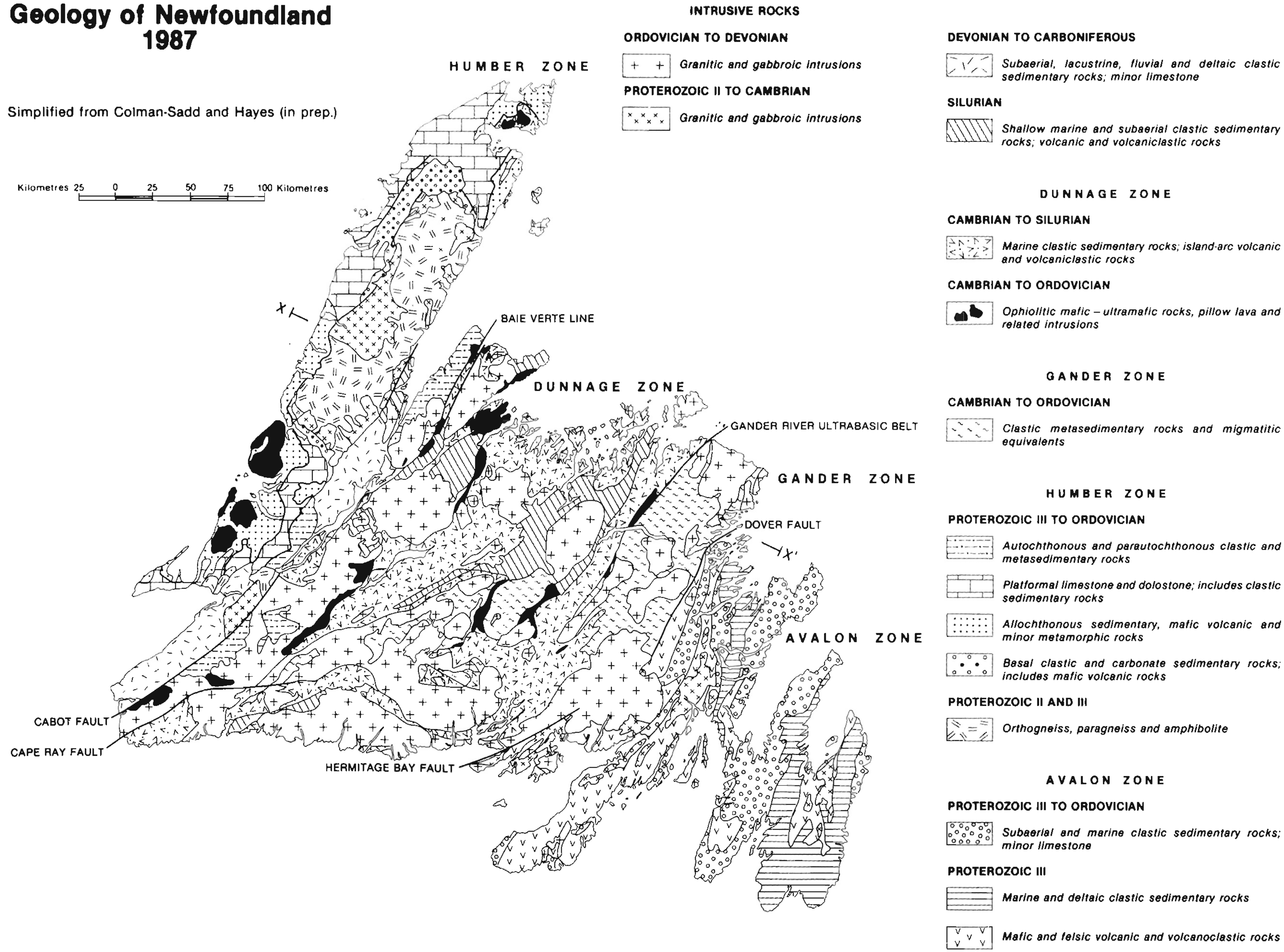


Figure 1. *Generalized geology of Newfoundland. Prepared by J. Hayes from a preliminary version of a revised geological map of Newfoundland by S.P. Colman-Sadd and J. Hayes. X-X' shows position of section in Figure 22.*

The Humber Zone (also known as the Western Platform) consists of a platformal (miogeoclinal) sequence of Eocambrian to Ordovician quartzite, carbonate and shale above a basement of Late Grenvillian (ca. 1240 Ma, Erdmer, 1986) gneisses and plutonic rocks. Mafic dykes in the Grenvillian rocks may be related to an episode of crustal rifting that led to development of the Iapetus Ocean (Strong and Williams, 1972). Allochthonous sedimentary and ophiolitic sequences are also present in the Humber Zone.

The Avalon Zone consists of a platformal sequence of Eocambrian to Ordovician clastic sediments and carbonates deposited on Late Hadrynian metavolcanic, metasedimentary and plutonic rocks. The Hadrynian basement has been correlated with Pan-African sequences (O'Brien *et al.*, 1983), and may have developed during rifting to form the Iapetus Ocean, or during a pre-Iapetus cycle of ocean closing (Williams, 1979).

The Central Mobile Belt includes the Dunnage and Gander zones. It consists of lower Paleozoic, ocean margin clastic wedge deposits, ophiolite sequences, and island-arc/back-arc basin volcanic and sedimentary sequences. These rocks record the evolution and destruction of the Iapetus Ocean (Williams, 1978). Middle to late Paleozoic continental clastic and volcanic sequences are also well developed and were deposited after accretion of oceanic sequences to the North American Craton.

Early Ordovician deformation and metamorphism (locally to amphibolite facies) in the western part of the Central Mobile Belt, and locally on the Western Platform, record westward obduction of oceanic sedimentary and ophiolite rocks during the Taconic Orogeny (Williams and Stevens, 1974). Silurian and later, upright to recumbent folding, thrusting, and metamorphism (locally to amphibolite facies) of rocks in the Central Mobile Belt occurred dominantly during the Acadian Orogeny and record final closure of the Iapetus Ocean (Strong *et al.*, 1974; Colman-Sadd, 1980, Stockmal *et al.*, 1987). In the Avalon Zone, areas of deformation record a Late Hadrynian orogeny; Acadian structures are evident in the west and become weaker to the east. Late Devonian to Carboniferous deformation resulted from strike slip and vertical fault movements, and local brittle thrust faults (cf. Hyde, 1979; Blackwood, 1985).

Late Precambrian plutonism occurred in basement rocks of the Western Platform and Avalon Zone, and plutonism occurred throughout the Paleozoic history of the orogen (Strong, 1980; Hayes *et al.*, 1987). Eocambrian to Cambrian plutons having alkaline to peralkaline affinities in the Western Platform and in the Avalon Zone may have formed during rifting to form the Iapetus Ocean. Isolated lower Paleozoic trondjhemitic plutons occur in the Central Mobile Belt and in allochthonous ophiolitic rocks on the Western Platform; these may have formed in oceanic crust or in the roots of oceanic island arcs. Large areas of Middle Ordovician granodiorite and tonalite occur along the western margin of the Central Mobile Belt. Major granitic plutonism occurred in the Middle Silurian to Early Devonian during the final stages of closure of the Iapetus Ocean. A variety of pluton types represent different tectonic environments; for example, calc-alkaline plutons with I-type affinities may be subduction related, whereas peraluminous granitoids with S-type affinities may be crustal melting during collision, and metaluminous to peralkaline plutons in the western part of the Central Mobile Belt may represent an anorogenic epicontinental setting (Coyle and Strong, 1987). Upper Devonian to Carboniferous metaluminous granites with A-type affinites occur throughout the eastern part of the Central Mobile Belt and in the Avalon Zone and cut many of the earlier structures.

MASSIVE SULPHIDE DEPOSITS

Gold has been produced from the base-metal mines developed in volcanogenic massive sulphide deposits in lower Paleozoic volcanic and volcaniclastic sequences (Figure 2; Table 1). Most of the production has been from exhalative, syngenetic massive sulphides although minor amounts have also been recovered from related stockwork zones.

Two main subdivisions of auriferous massive sulphide deposits are recognized in Newfoundland (cf. Swinden and Thorpe, 1984; Swinden and Kean, 1984, *in press*): 1) deposits associated with felsic volcanic rocks in mafic-felsic sequences and 2) deposits associated with pillow lavas of ophiolite sequences. A third type of massive sulphide deposit recognized by Swinden and Kean *(in press)* occurs in non-ophiolitic mafic volcanic rocks (the Fox Neck-type, which may also include the Great Burnt Lake deposit) but is not known to contain anomalous gold.

Deposits in Mafic–Felsic Sequences

The base- and precious-metal contents of massive sulphide deposits in mafic–felsic arc volcanic sequences in the Central Mobile Belt reflect regional variations in the compositions of the underlying volcanic rocks (Swinden and Thorpe, 1984; Swinden and Kean, 1984, *in press*). Three broad categories are recognized based on the relative amount of mafic and felsic rocks within the volcanic–volcaniclastic sequences (Figures 2, 3, 4).

Massive sulphide deposits in mafic-dominated sequences are copper- and/or zinc-rich (Figure 4a); those in the mixed sequences are polymetallic (Cu, Zn, Pb) and those in felsic-dominated sequences are zinc and lead rich. This is interpreted to reflect the availability of the metals to the hydrothermal cells during leaching, with Cu and Zn having been more abundant in the mafic volcanic rocks and Pb in felsic rocks. Similarly, the relative precious-metal contents of the various deposits is apparently a function of the composition of the host volcanic sequence (Figure 4b). Deposits hosted by mafic-dominated sequences generally have the highest gold/silver ratios and this ratio decreases with increasing proportions of felsic volcanic rocks in the underlying stratigraphic section. Irrespective of metal ratios, the absolute concentration of gold in any particular deposit is a function of the size of the hydrothermal system and the physicochemical conditions at the site of deposition.

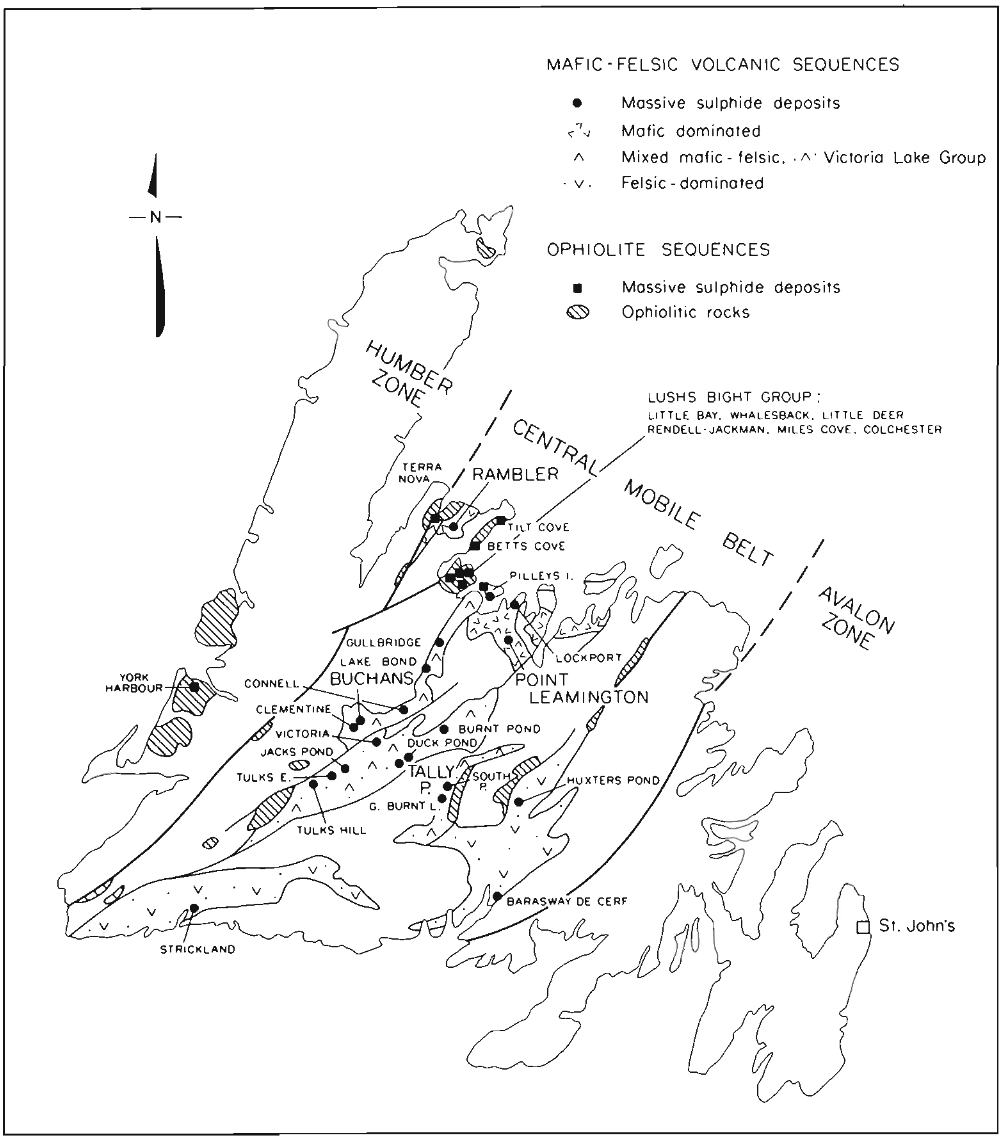


Figure 2. *Location of lower Paleozoic volcanogenic massive sulphide deposits and classification of the host sequences in Newfoundland.*

Economic concentrations of gold may accumulate in any environment where suitable source rocks are present.

The gold content of individual massive sulphide deposits may be relatively consistent between ore deposits in a deposit cluster as at Buchans (Thurlow and Swanson, 1981; Kirkham, 1987), or may vary between deposits as at Rambler (an average of 5.1 g/t gold was produced from the Main Mine; Table 1; Tuach and Kennedy, 1978). Significant variation can also occur within a single massive sulphide deposit as at Point Leamington (D. MacInnis, personal communication, 1987).

Deposits in Ophiolite Sequences

These are the most common type of volcanogenic sulphide deposits in Newfoundland (Table 1; Figure 2). They are copper- and zinc-rich and occur at all stratigraphic levels (Figure 5) within the ophiolitic pillow lava sequences (Duke and Hutchison, 1974; Kean, 1983; Kean, 1984). For example, the Betts Cove deposits occur at the base of the pillow lavas immediately above the sheeted-dike horizon (Uphadhyay and Strong, 1973), the York Harbour deposits occur in pillow lavas well above the sheeted dykes, and the Timber Pond deposit occurs at the top of the pillow lavas (Kean and Evans, *this volume).* It is also possible that deposits of the East Mine at Tilt Cove were formed at the top of the pillow lavas (although for an alternate viewpoint, see Strong, 1984). Several of the deposits occur in chlorite schist zones (e.g., Little Bay, Whalesback) related to shears preferentially developed along syngenetic alteration zones in mafic volcanic rocks and dykes (Kean, 1984).

Gold/silver ratios in these deposits are high (Figure 4), probably relecting the mafic (and potentially ultramafic) composition of the available source rocks. The gold content of the deposits has not been well documented, and production,

Table 1. Base- and precious-metal contents of selected volcanogenic massive sulphide deposits in Newfoundland

Deposit Name		Production/Reserves (Tonnes)		Grade Cu%	Pb%	Zn%	Ag(g/t)	Au(g/t)	Gold Production	Comments
FELSIC DOMINATED										
Strickland		260,000			5.25%		195	S		
Barasway de Cerf					-		-	-		
MAFIC/FELSIC										
Victoria Mine		200,000	R	7.5*	1.5	2.4	12	0.14		*Assay of grab sample from dump Tonnage is approximate
Tulks Hill		750,000	R	1.3	2	5-6	41	0.4		
Tulks East	A.	4,500,000	R	0.24	0.12	1.5	8.5	tr		
	B.	200,000	R	0.66	1.26	8.69	58.7	0.14		
	C.	900,000	R	<1% combined Cu + Pb + Zn						
Jacks Pond		200,000 to 900,000	R	Not reported but generally low						4 lenses
Boundary		500,000	R	3.5	1	4	34	S		
Duck Pond		3,600,000	R	3.71	1.36	7.58	72.3	1.2		
Burnt Pond		?		-	-	-	-	-		
Pilley's Island		1,051,436	P	1.23	-	-	-	S		
Lake Bond		1,096,699	R	0.31	-	2.12	-	S		
Gullbridge		3,466,000	P	1.02	-	-	-	-		
Southwest Shaft		<90,000	R	1-2	-	-	-	S		
Buchans		16,196,876	P	1.33	7.56	14.51	126	1.37	P 22,000 kg	
Connell Option		?		0.3	11.9	25.4	158	3.4		1 DDH
Clementine		363,000	R	0.3	2.6	4.9	10.3	S		
Great Burnt Lake		750,000	R	2.9	-	-	-	S		
South Pond		270,000	R	1.3	-	-	-	1.37		
MAFIC DOMINATED										
Rambler		399,000	P	1.3	-	2.16	29	5.1		
Ming		1,991,592	P	3.66	-	-	22	2.4	P 5,400 kg	
East		1,993,079	P	1.04	-	-	-	-		
Big Rambler Pond		45,000	P	1.2	-	-	-	-		Selected sample 1.4 g/t
Mine Tailings		2,000,000	R	?	?	?	?	1.6		Very approximate
Point Leamington		18,000,000	R	0.5	-	2	-	1.0		
Lockport		555,000	R	0.75	-	-	-	S		
OPHIOLITE-HOSTED(%)										
Skidder		900,000	R	2	-	2	-	-		
Tilt Cove		8,163,000	P	1-12	-	-	-	-	P <1,500 kg	
Betts Cove		118,528	P	2-10	-	-	-	-		
Terra Nova		226,750	P	2-2.5	-	-	-	1.6		dump sample; 16.8 g/t
Little Bay		3,083,800	P	.8-2	-	-	-	-	P 195 kg	
Whalesback		3,792,809	P	.85-1.1	-	-	-	?		
Little Deer		392,000	P & R	1.5	-	1.5	-	S		
Miles Cove		200,000	R	1.45	-	-	12	0.34		
Rendell-Jackman		10,000	R	1-5	-	-	-	1 g/t		
Colchester		1,000,000	R	1.3	-	-	-	S		
McNeily		-	R	.5-4	-	-	-	-		Grabs to 4 g/t
York Harbour		300,000	P & R	1.9	-	4.7	-	-	M 5 kg	

S—Sporadic (<0.4 g/t) P—Produced M—Mined R—Reserves (geological) tr—trace

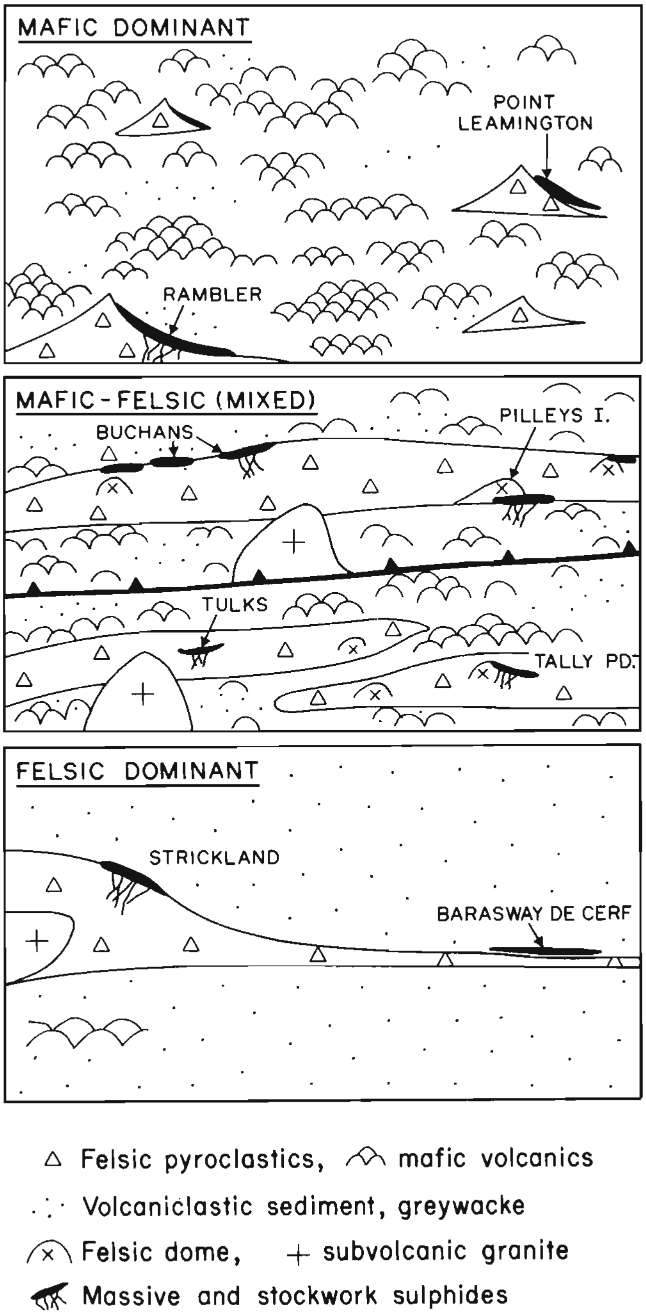


Figure 3. *Schematic diagram showing stratigraphic setting of massive sulphide deposits in mafic–felsic sequences in central Newfoundland.*

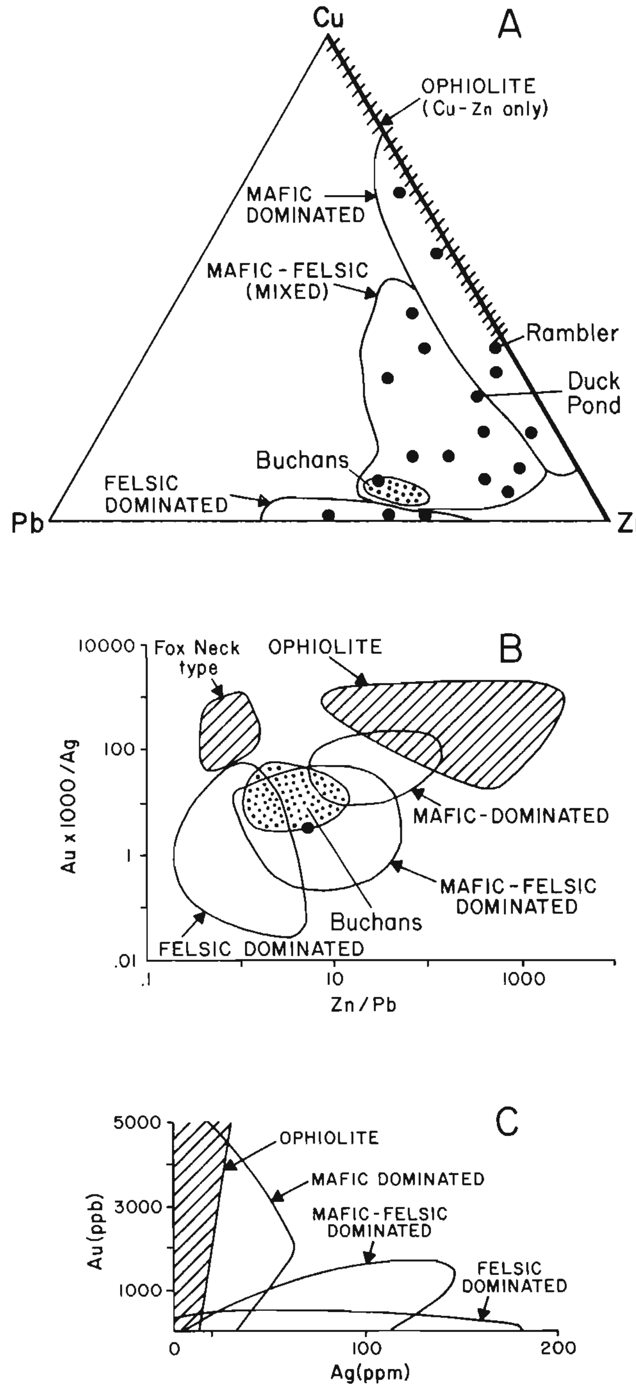


Figure 4. *(A) Cu-Pb-Zn, (B) Au/Ag-Zn/Pb and (C) Au-Ag ratios in massive volcanogenic sulphide deposits in Newfoundland. From unpublished analyses of dump samples and data compiled by S. Swinden and B.F. Kean.*

which mainly occurred prior to 1970, has been minor (Table 1). This may in part be a function of primitive analytical techniques and poor recovery. All the deposits were mined (or delineated) for copper; zinc from sphalerite, which is locally abundant, was not generally recovered. Recent data suggests that gold in these deposits is associated with sphalerite (Hurley and Crocket, 1985; Kean, unpublished data), and would have been therefore discarded during mining. Values in excess of 1 g/t gold were obtained from assays of dump material at Betts Cove (Saunders, 1985), York Harbour, Tilt Cove, and deposits throughout the Lushs Bight Group (Kean, unpublished data; Tuach, 1987a). In addition, ore-grade material is reported in outcrop at Tilt Cove (Kusmirski and Norman, 1982).

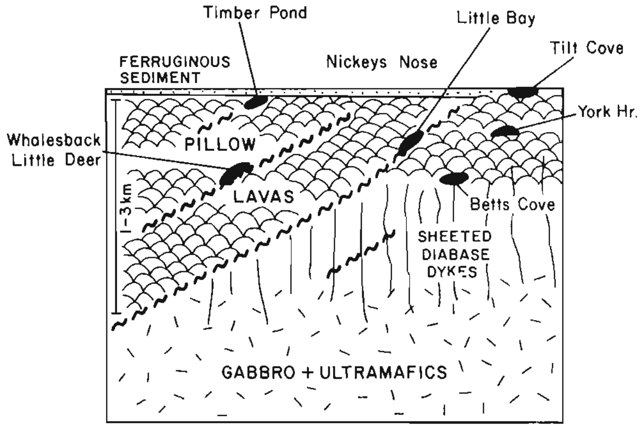


Figure 5. *Schematic diagram showing stratigraphic and structural setting of massive sulphide deposits in ophiolitic rocks in Newfoundland. These deposits occur in several different ophiolite sequences.*

Paleotectonic Environments of Massive Sulphide Formation

The thick mafic–felsic volcanic sequences in the Central Mobile Belt have been generally considered to record volcanism and mineralization in an island-arc environment (Mitchell and Garson, 1976; Swinden and Strong, 1976). Recent detailed geochemical studies in some sequences, for example, the Wild Bight Group (Swinden, 1987), the Victoria Lake Group, (Swinden and Kean, unpublished data), and the Buchans Group (Thurlow, 1973; Swinden, unpublished data) confirm these interpretations. In the Wild Bight Group, it has been suggested that mineralization occurred during rifting of an island arc prior to opening of a Middle Ordovician back-arc basin (Swinden, 1987).

The ophiolitic sequences are considered generally to record active rifting in back-arc environments (e.g., Dunning and Krogh, 1985), although some such as the Betts Cove Complex (Coish *et al.*, 1982) and the Lushs Bight Group (B.F. Kean and G.A. Jenner, unpublished data) contain geochemical evidence of the proximity of a subducting slab. In fact, the boundaries between the environments recorded by the two types of sequences may not be sharp. For example, the Rambler deposits (Figure 2) are associated with mafic and felsic volcanic rocks of the Pacquet Harbour Group which have been previously interpreted as representing an immature island-arc environment (e.g., Hutchinson, 1973; Tuach and Kennedy, 1978; Dean, 1978). Hibbard (1983), however, correlated magnesian volcanic rocks in the Pacquet Harbour Group with those in the Betts Cove complex, implying that the ore-bearing strata were actually part of a fragmented ophiolite (see also Gale, 1973). The latter interpretation is supported by recent unpublished geochemical data (G.A. Jenner, personal communication, 1987). The implication is that the ophiolites may have been generated in a suprasubduction zone environment. Clearly, there are ambiguities in the present classification that need to be resolved. In any event, the high heat flow associated with events in the island-arc or back-arc environments probably determine whether metal-rich hydrothermal systems develop.

The Fox Neck-type deposits apparently formed in back-arc settings not associated with active rifting (Swinden and Kean, *in press*). The deposits are generally metal-poor and it seems that although the hydrothermal systems were probably circulating in good Cu-, Zn- and Au-source rocks (i.e., oceanic crust), these metals were not transported to the ore-forming environment. It is suggested that these hydrothermal systems were generally small and short lived and not always capable of carrying significant quantities of most metals. They may have been the remnants of previously active systems which had drifted away from the main centers of tectonic activity and high heat flow, or they may have been associated with areas of low heat flow within the back arcs, such as along transform faults.

EPIGENETIC DEPOSITS

Geological descriptions of epigenetic gold mineralization (Figure 6) in the main areas of active exploration are presented below. They illustrate the variety of styles and environments of gold mineralization encountered in Newfoundland. The deposits include individual and multiple vein systems, stockworks, silicified zones, and replacement zones that are of epigentic origin. They are characterized by a relatively low to minor sulphide content when compared to syngenetic volcanogenic massive sulphide deposits. The mineralization and alteration in each area is described, and placed in the context of popular models of gold mineralization. The genetic inferences will no doubt expand and change as further information becomes available, particularly in central and southern Newfoundland where interpretation is difficult because of regional tectonic overprinting and multiple deformation along major fault zones.

Avalon

The Hickey's Pond Prospect (Table 2) is located on the Burin Peninsula in an 80-km-long zone of high-alumina and silica alteration that extends from Hickey's Pond to the Knee (Figure 7). The zone contains pyrophyllite, alunite, sericite, specularite, lazulite, chloritoid, apatite, rutile, and pyrite (Huard and O'Driscoll, 1985, 1986). The prospect is hosted by banded and hydrothermally brecciated hematite- and alunite-bearing rocks in a zone of advanced argillic alteration in Hadrynian volcanic rocks of the Love Cove Group (Figure 8). The deposit is separated from the Late Hadrynian Swift Current Granite by a fault. The alteration zone and the surrounding rocks exhibit a penetrative tectonic fabric and a low-greenschist-facies metamorphic assemblage.

The alteration assemblages and depositional features at Hickey's Pond led Huard and O'Driscoll (1986) to conclude that the deposit formed in an epithermal–fumarolic environment. Deposits throughout the belt vary from sinters and chemical precipitates with geyserite eggs to deeper-level hydrothermal stockworks and breccias. Pervasively altered volcanic rocks are ubiquitous.

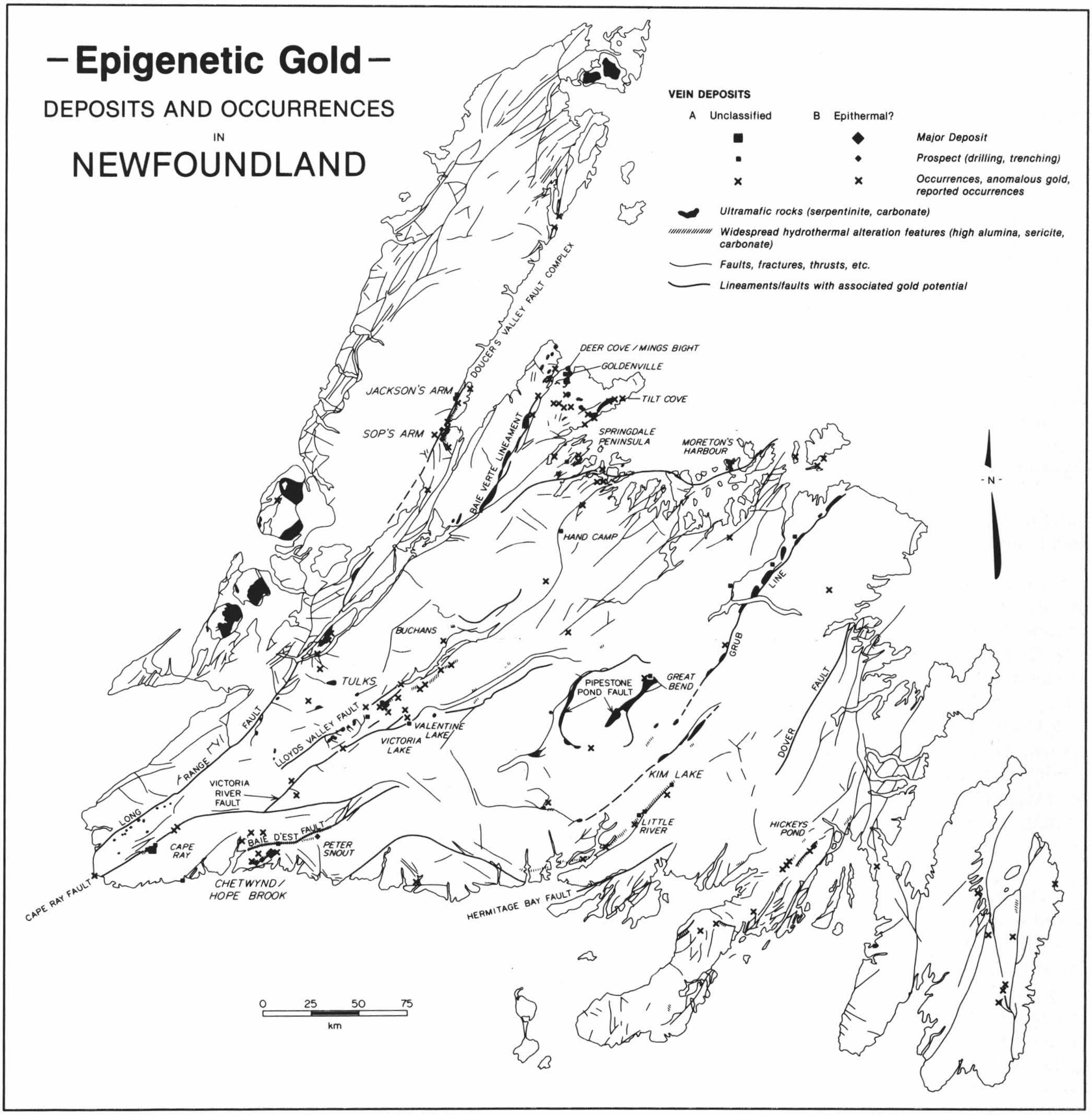


Figure 6. *Distribution of reported epigenetic gold deposits and occurrences in Newfoundland showing preliminary classification. Structures are shown, together with the location of ultramafic rocks and areas of extensive hydrothermal alteration. Structures with associated gold mineralization are highlighted. Simplified from Tuach (1987a).*

Minor gold occurrences in similar geological settings are found along the belt at Monkstown road (Figure 8) and at the Knee (Figure 7). Other areas of silica-sericite-pyrite alteration and anomalous gold content (i.e., > 0.4 g/t Au) have also been reported from other parts of the Avalon Zone (Figure 7; Tuach, 1987a; S. O'Brien 1987). A 7-km-long zone of high-alumina alteration (but no reported gold values) also occurs at and south of the Foxtrap Pyrophyllite Mine (Figure 7). The alteration is hosted by felsic volcanic rocks of the Late Hadrynian Harbour Main Group near the contact with the Late Hadrynian Holyrood Granite. The ore zone consists of massive and schistose pyrophyllite. Large areas of pervasive silica and sericite alteration are associated with the deposit and minor kaolinite, diaspore, specularite, pyrite, and rutile are present. Spectacular hydrothermal breccias are developed at and adjacent to the Foxtrap Mine. Conglomerate overlying

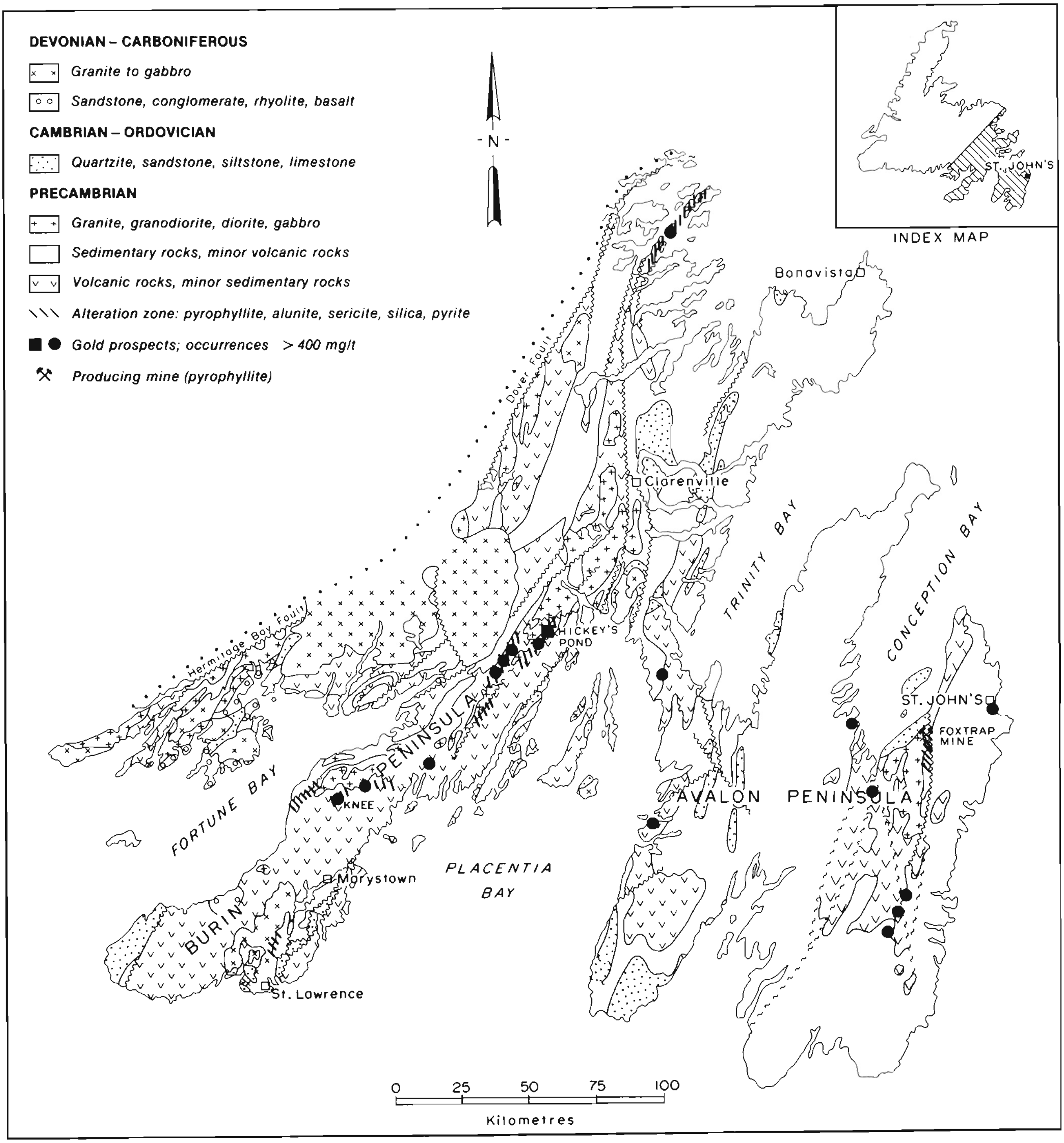


Figure 7. *Simplified geology and epigenetic gold occurrences in the Avalon Zone. Areas of extensive pyrophyllite-sericite-alunite-silica alteration are shown.*

the pyrophyllite zone contains both altered and unaltered volcanic fragments and is locally pervasively altered. The field relationships indicate that the alteration zone grew through a rapidly accumulating debris-fan adjacent to a fault scarp.

The rocks in the Foxtrap area are unconformably overlain by Lower Cambrian conglomerate, therefore, a Late Hadrynian age for development of the alteration is indicated. This alteration probably occurred in a high-level epithermal system (cf. Berger and Eimon, 1983; Figure 9) related to

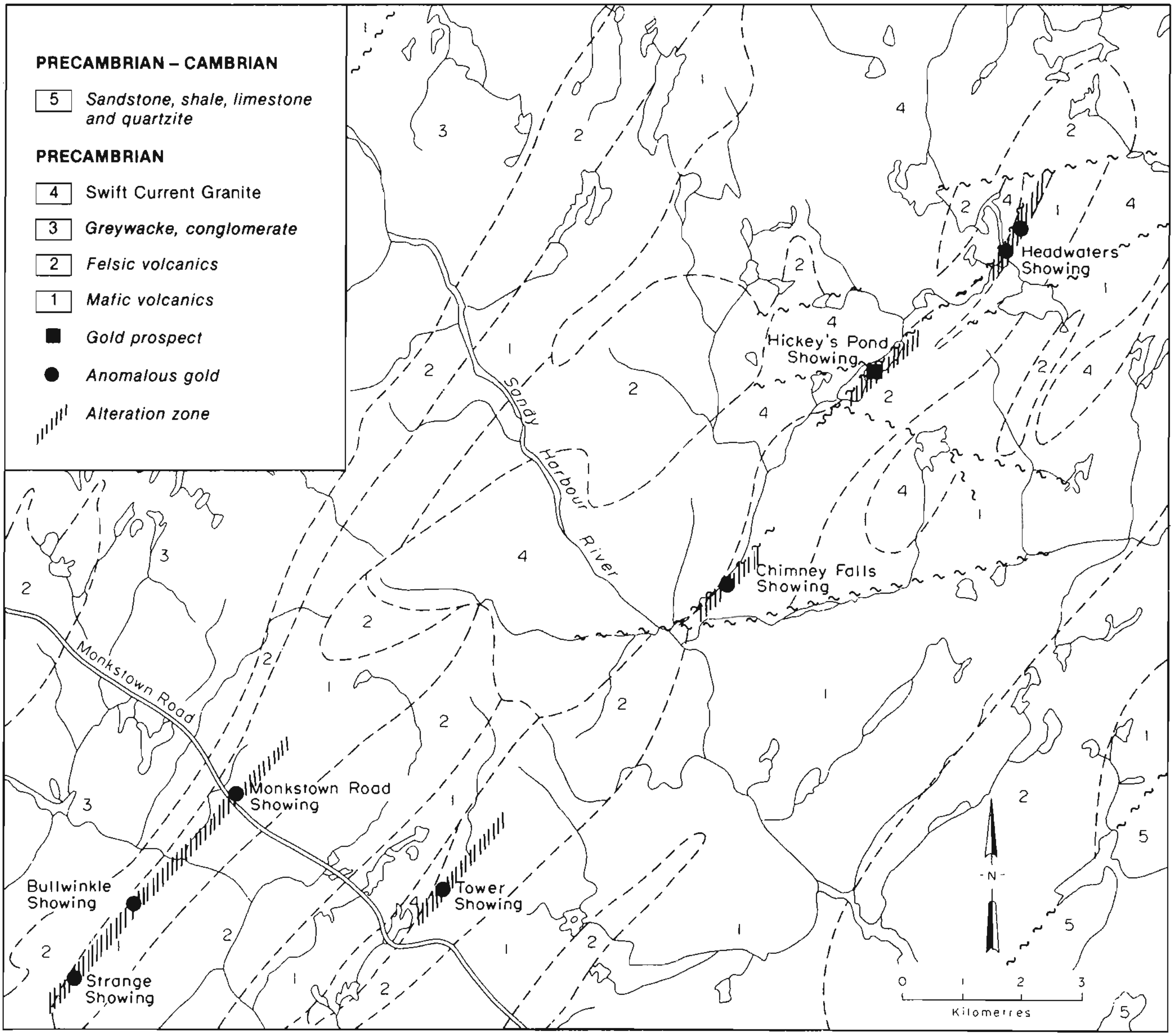


Figure 8. *Geology of the Hickey's Pond prospect; from Huard and O'Driscoll (1986).*

Table 2. Gold in epigenetic deposits in Newfoundland

Major Deposit	Million Tonnes	Grade g/t Au	Comments
Hope Brook	11.2	4.54	Minor Cu
Main Zone/Cape Ray	0.9	5.75	Zn, Pb, Cu, Ag

Prospects/Major Projects	Best Result g/t Au	Comments
Apsy Zone/Jackson's Arm	DDH: 2.27 g/t over 10 m	
Road Zone/Jackson's Arm	DDH: 1.23 g/t over 54.5 m	
Browning/Sops Arm		4.6 kg Au produced
Unknown Brook/Sops Arm	DDH: 8.4 g/t over 1.75 m	
Deer Cove/Mings Bight	ADIT: 16.1 g/t across 1.5 m over 30 m	
Bradley/Mings Bight	TRENCH: 6.3 g/t over 14 m	
Goldenville/Mings Bight		4.6 kg Au produced
Windowglass Hill/Cape Ray	DDH: 4.6 g/t over 12.5 m	
Mine Pond	DDH: 8.2 g/t over 1.5 m	
Hand Camp	DDH: 10.6 g/t over 3.0 m	
Midas Pond/Victoria	NA	
Valentine Lake/Victoria	NA	
Little River	DDH: 3.8 g/t over 4.0 m	
Hickeys Pond	DDH: 0.59 g/t over 1.5 m	Grab: 2.5 to 5.4 g/t

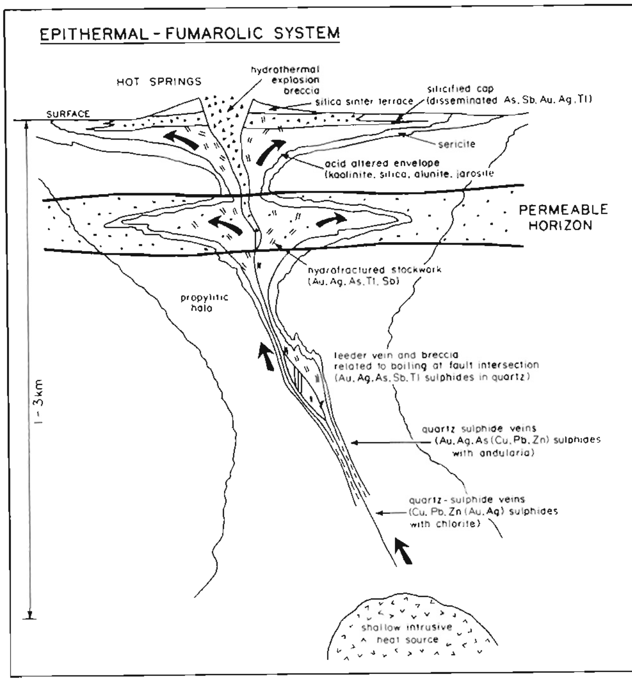


Figure 9. *Epithermal–fumarolic model for silver–gold mineralization; from Berger and Eimon (1983).*

intrusion of the Holyrood Granite (Papezik *et al.*, 1976; O'Driscoll and Tuach, 1987).

These Late Hadrynian epithermal–fumarolic systems correlate with similar, gold-bearing, Late Hadrynian environments in the Carolina Slate Belt of the southeastern United States (Spence *et al.*, 1980; Schmidt, 1983). The systems indicate extensive high-level alteration and local gold mineralization in the waning stages of volcanism during an early stage, or possibly prior to, development of the Appalachian Orogen.

Little River–Kim Lake

Gold is present in a variety of rocks of the Ordovician Baie d'Espoir Group (Figure 10). The gold is associated generally with fine grained, disseminated stibnite and arsenopyrite and locally with heavily mineralized stibnite-bearing veins and veinlets. Most of the prospects have been severely tectonized.

In the Kim Lake Prospect, historically regarded as a stibnite prospect (e.g., Swinden, 1981), gold occurs in thin, anastomosing quartz veins hosted by carbonatized rhyolite and/or porphyritic felsic intrusive rocks. At the Little River Prospect (McHale, 1985), gold is associated with a steeply dipping, silicified and mylonitized zone (up to 2 m wide and 4 km long) containing stockworks of quartz–carbonate veins and veinlets in silicic tuff. Gold in the Le Pouvoir horizon is associated with disseminated sulphides in fine grained chloritic schist. Other prospects in the area are hosted by laminated graphitic sediments, mafic tuffs, and carbonatized diabase and gabbro (McHale, 1985).

Carbonatization of the various rock types is the most distinctive alteration feature. Linear zones of silicification are also reported, and areas of sericite alteration are widespread. A band of quartz veining with minor pyrophyllite, specularite, and locally dumortierite and minor lazulite occurs along the Collins Brook Fault (Figure 10). Collectively, these alteration features indicate a variety of deep- to shallow-level mineralizing events. The linear and apparently conformable zones of alteration and mineralization at Little River and Le Pouvoir were interpreted to represent exhalative or syngenetic mineralization by McHale (1985) and McHale and McKillen (1986).

Recent mapping to the north of the Little River Prospect by Dickson *(this volume)* has identified a small outcrop of magnesite that probably represents a slice of carbonatized ultramafic rock. The outcrop is interpreted to mark the trace of a major fault called Le Pouvoir Fault (Figure 10) and the northward extension of the Day Cove Thrust lies approximately 2 km east of the Le Pouvoir Fault. These features suggest that the gold mineralization may be related to imbricate faulting and thrusting in the Little River area, an observation supported by the presence of mylonitic textures in the Little River Prospect.

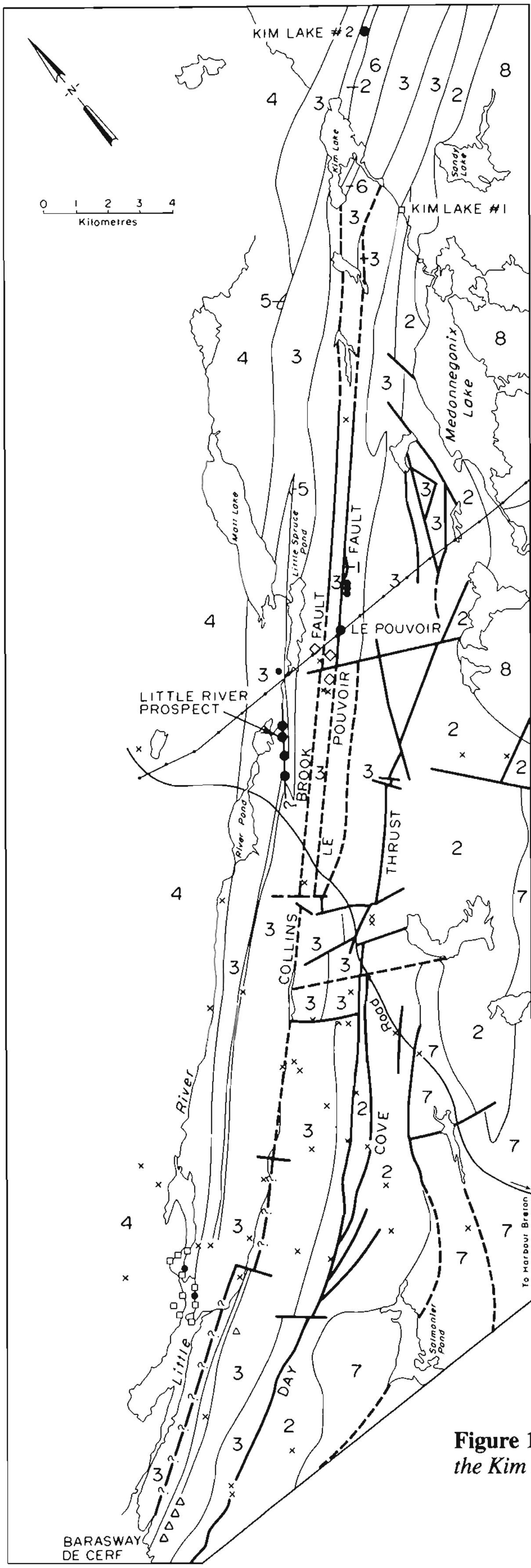
Hope Brook–Cinq Cerf

In southwest Newfoundland, the Hope Brook deposit (Figures 11 and 12) is a 400 by 60 m lens of fine grained silicified rock within the 5-km-long Chetwynd zone of pyrophyllite-sericite-silica alteration (McKenzie, 1986). Fine grained gold occurs with pyrite and minor chalcopyrite (generally less than 5 percent) disseminated throughout the deposit; elevated Sb and Ag values are present and minor tellurides, bismuthinite, cassiterite, native silver and tin have been noted. A pyrite-rich zone occurs immediately west of the ore deposit (Figure 12), and pyrophyllite–silica alteration occurs on the east. Significant gold intersections have also been obtained at the Chetwynd and Chetwynd South deposits within the Chetwynd alteration zone.

The host rocks and protolith to the altered zone are a sequence of felsic tuffs, volcaniclastic sediments and granitic intrusions of the La Poile Group (Chorlton, 1978, 1980; O'Brien, 1986). Post-alteration swarms of mafic dykes occur in the altered zone and in the host rocks to the east. The age of the rocks has not been determined, and could range from Early Cambrian to Silurian (B. O'Brien, 1987). The altered zone is intruded by the Devonian Chetwynd Granite at Hope Brook and may correlate with alteration at Peter Snout (Figure 6) northeast of the granite.

The alteration zone and the Hope Brook deposit have been deformed within the Cinq Cerf shear zone (Figure 11). Highly strained conglomerates and tuff are well exposed in Cinq Cerf Brook immediately west of the altered zone. Intrusion of the Chetwynd Granite postdated significant deformation on the Cinq Cerf shear zone.

The metallic mineral assemblages, and the spatial distribution of the alteration assemblages led McKenzie (1986)



LEGEND

DEVONIAN

8 *Porphyritic biotite granite (massive)*

SILURIAN

7 *Granite, granodiorite, gabbro (foliated)*

ORDOVICIAN?

6 *Kaegudeck diabase*

5 *Granodiorite (sheared)*

MIDDLE ORDOVICIAN

4 Riches Island Formation: *greywacke*

3 Isle Galet Formation: *felsic and mafic volcanic rocks*

2 Little Passage Gneiss *(psammite)*

ORDOVICIAN OR OLDER

1 *Carbonatized ultramafics*

● *Au prospects and occurrences (+ Py, Po, Asp, Sb)*

△ *Volcanogenic massive sulphides (Pb–Zn)*

◇ *Sb veins*

□ *Py-Po ± Sb veins*

× *Minor pyrite occurrence*

——— - - - *Faults (defined, inferred)*

Figure 10. *Simplified geology and mineral occurrences in the Kim Lake–Little River area; after Dickson* (this volume).

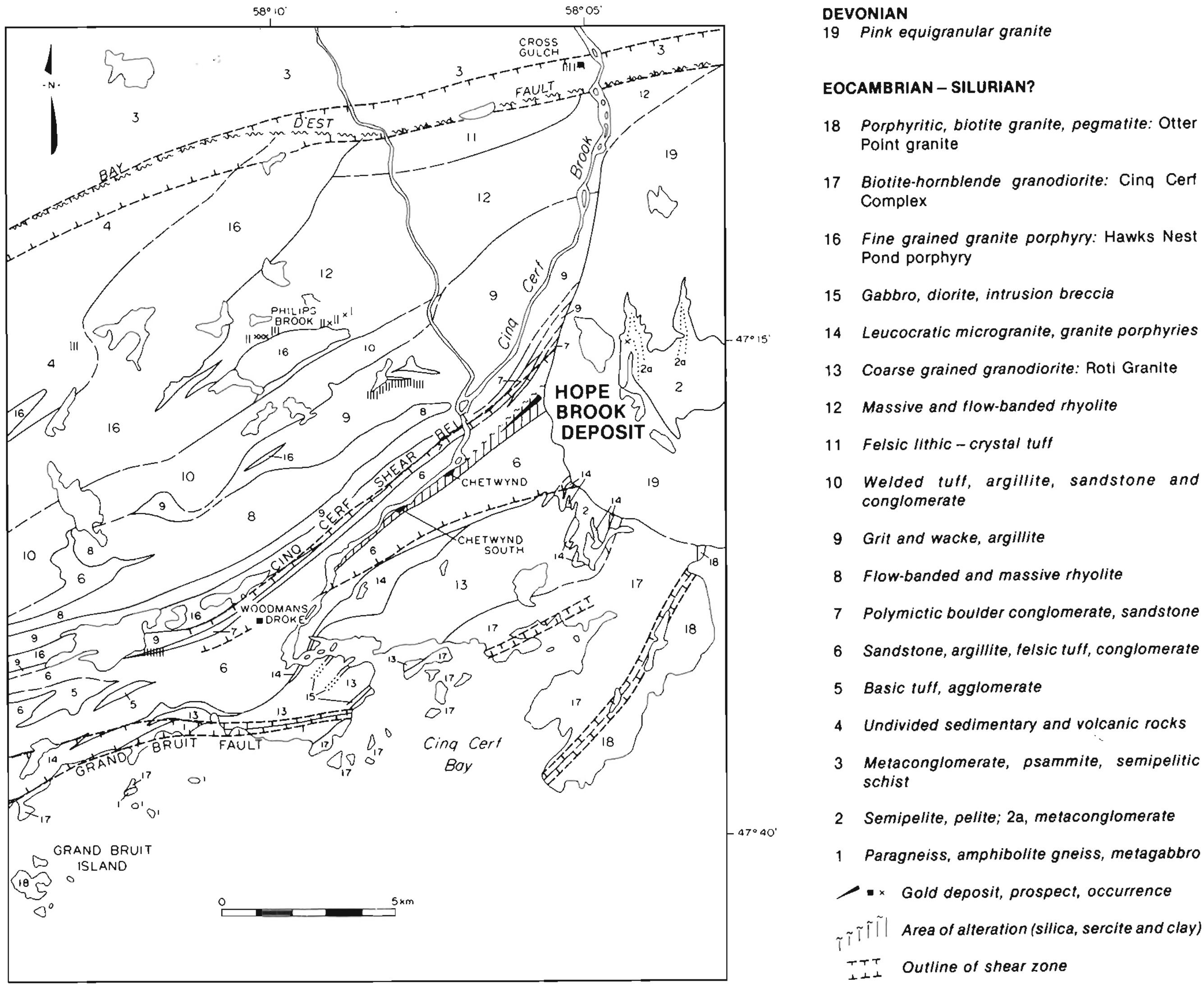


Figure 11. *Generalized geology in the Cinq Cerf area showing the location of the Hope Brook Mine and other gold occurrences, major structures, and areas of pervasive hydrothermal alteration; after Chorlton (1978, 1980), McKenzie (1986), and O'Brien (1987).*

to propose an epithermal origin for the deposit (also see Swinden, 1984). However, this interpretation is complicated by tectonic overprinting, indicated by flattening textures in the ore zone. A contact metamorphic halo and the presence of fluorite suggests the possibility of hydrothermal fluids emanating from the Chetwynd Granite. Other models, such as localization of the deposit in a shear zone with fluid and gold derived from metamorphic devolatilization are also possible (cf. Colvine *et al.*, 1984).

Several other prospects are reported from the Cinq Cerf area (Tuach, 1987a), however, information is limited. The Bay D'Est Fault is a brittle fault within a zone of ductile deformation (Figure 11) that locally contains large areas of sericitized and pyritized rock. The Cross Gulch Gold Prospect is a silicified zone in one such area of sericite alteration hosted by the Bay Du Nord Group (D. MacInnis, personal communication, 1986). Post-tectonic, undeformed, hydrothermally brecciated quartz veins occur in some alteration zones (B. O'Brien, personal communication, 1986). Anomalous gold is also reported in quartz veins hosted by relatively undeformed rocks at the Woodmans Droke Prospect, and in relatively undeformed hydrothermal alteration zones at the Philips Brook occurrence (Tuach, 1987a).

Cape Ray

The Main Zone and the Windowglass Hill deposits occur within a belt of mylonitized rocks that define the Cape Ray Fault Zone (Wilton, 1984; Wilton and Strong, 1986; Figure 13). The Main Zone consists of three separate lenses of mineralized quartz veins (Figure 13) that are hosted by deformed, bedded and laminated, graphitic and chloritic sediments. The graphitic sediments occur within a

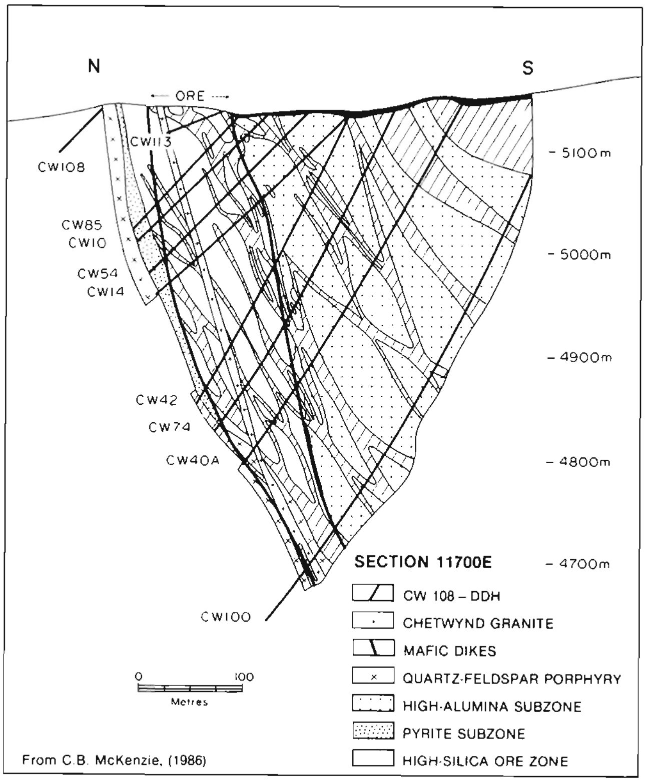


Figure 12. *Geological section across the Hope Brook deposit; from McKenzie (1986).*

penetratively deformed sequence of bedded to laminated mafic tuff and silicic pyroclastic rocks (Tuach, 1986). The Windowglass Hill deposit consists of sheeted quartz veins and stockwork quartz veins and veinlets hosted by albitized graphic granite. Hydrothermal breccia textures are locally well devleoped. In both deposits, gold occurs with silver as electrum and is associated with galena, sphalerite, chalcopyrite and pyrite in the quartz veins (Wilton and Strong, 1986).

The Main Zone veins are boudinaged and locally brecciated. Wilton (1984) interpreted the veins as occurring in chloritic and sericitic schist in a pre- to syntectonic 'Main Shear' separating the Devonian Windsor Point Group from the Ordovician or older Port Aux Basques Gneiss Complex. However, Tuach (1986) suggested that the mineralized lodes occur in a late brittle splay from the Cape Ray Fault in an undated sequence of volcanic and volcaniclastic rocks, and that brecciation and additional deformation occurred during late movement on the fault. Contrary to the description of Wilton and Strong (1986, page 292), the Windowglass Hill deposit has not been subject to intense deformation; intrusion and accompanying mineralization postdated the main movements on the fault zone. Therefore, it is likely that both deposits, with a comparable mineral and isotopic signature (Wilton and Strong, 1986), postdate the main deformation. The H and I Brook prospects adjacent to the Cape Ray mylonite are brecciated, probably by late movements.

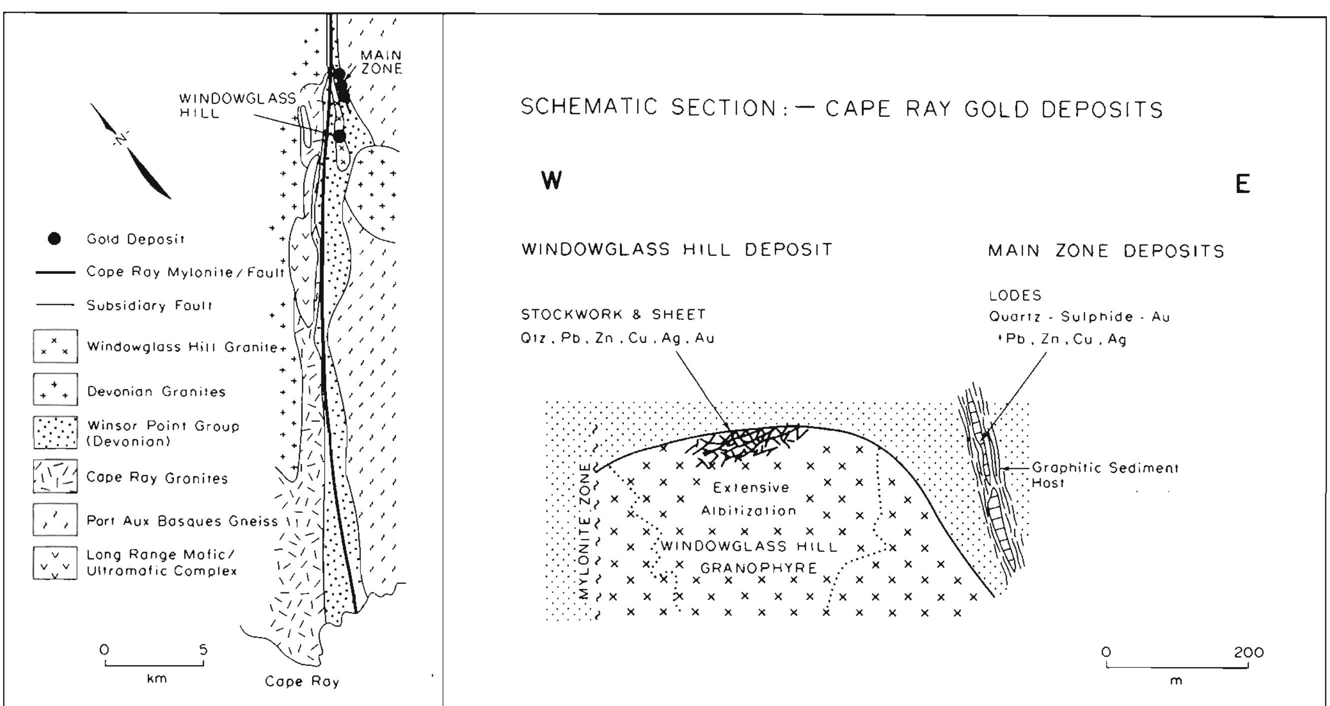
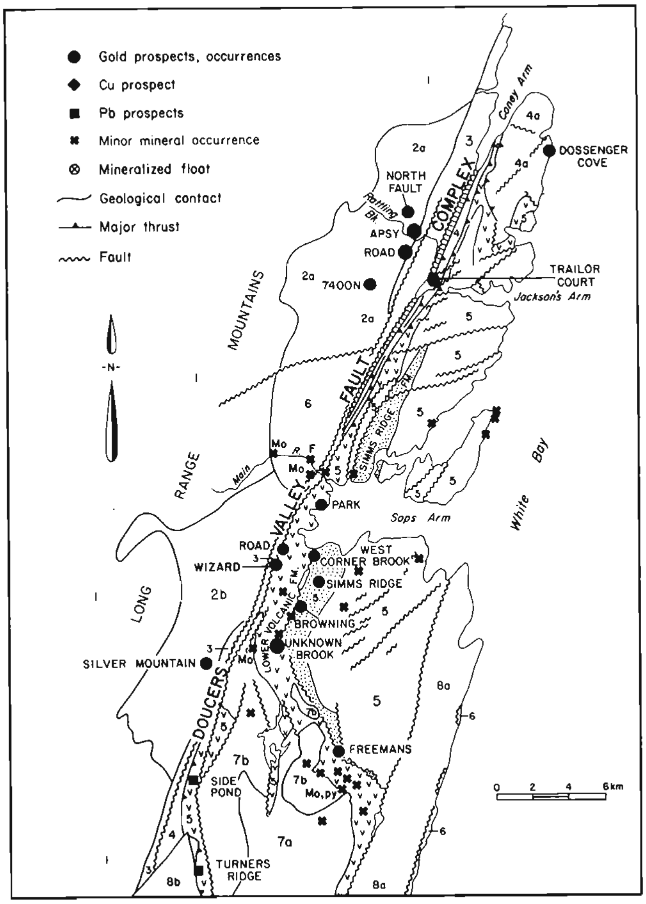


Figure 13. *(A) Generalized geology of the Cape Ray Fault Zone showing location of gold deposits and occurrences; (B) schematic section showing settings of mineralization; after Wilton (1984) and Tuach (1986).*



UPPER PALEOZOIC (Basin-fill sequences and intrusions)

CARBONIFEROUS

8 8a, Anguille Group (Tournaisian): *greywacke, shale, minor sandstone and conglomerate;* 8b, Deer Lake Group (Visean): *conglomerate, sandstone, siltstone:*

DEVONIAN (approximately 398 Ma)

7 Gull Lake intrusive suite: 7a, *granites;* 7b, *intermediate and mafic intrusive rocks*

6 Devils Room granite

SILURIAN

5 Sops Arm Group

LOWER PALEOZOIC ALLOCHTHON

CAMBRIAN – MIDDLE ORDOVICIAN

4 Southern White Bay Allochthon: *partially ophiolitic (mélange containing ultramafic blocks is cross-hatched)* 4a, Coney Head Complex

LOWER PALEOZOIC AUTOCHTHON (Platform)

3 Coney Arm Group: *carbonate, shale, quartzite*

PRECAMBRIAN (Grenvillian basement)

MIDDLE PROTEROZOIC AND EARLIER

2 *Massive to foliated, feldspar-megacrystic, granitoid plutons;* 2a, *Aspy pluton;* 2b, *Main River granite*

1 *Leucocratic gneiss, amphibolite, and gabbro*

Figure 14. *Simplified geology and mineral occurrences in Western White Bay from Tuach (1987b). The Lower Volcanic formation and the Simms Ridge Formation of the Sops Arm Group are patterned.*

Wilton (1984) and Wilton and Strong (1986) reported results of geochemical, isotopic and phase equilibra studies, and concluded that the gold deposits and prospects in the Cape Ray area were formed from magmatic-hydrothermal fluids exsolved as a vapour phase from the Windowglass Hill Granite. Temperatures of ore formation were estimated at 300°C. A schematic representation of the mineralization is presented in Figure 13.

Western White Bay

Gold mineralization of potential economic significance has been identified in western White Bay near Jackson's Arm and to the south of Sops Arm at Unknown Brook (Figure 14). Numerous other mineral occurrences are present, and a spatial relationship between mineralization and the Doucers Valley fault complex is evident (Tuach, 1987b).

The Jackson's Arm alteration system and associated gold mineralization overprint foliated, megacrystic granodiorite of Late Grenvillian age (Bruneau, 1984; Tuach and French, 1986; Saunders and Tuach, *this volume*). Mineralization and alteration has been recently reported in Eocambrian to Cambrian sedimentary rocks that unconformably overlie the Grenvillian granitoid rocks (McKenzie, 1987). In the granitoid rocks, K-feldspathization of original plagioclase occurred over large areas (up to 2 km) and is pervasively developed in the core of the alteration system. K-feldspar is also developed marginal to veins in the periphery of the alteration system. In the pervasively altered rocks, fracture stockworks and areas of hydrothermal breccia contain fine grained albite, Fe-carbonate, minor quartz, pyrite and arsenopyrite and locally contain gold associated with the sulphides. Shear zones and veins containing albite and sulphides are exposed in the periphery of the system.

Gold and base-metal-bearing quartz veins occur at a number of localities in Silurian silicic volcaniclastic and sedimentary rocks to the south of Sops Arm (Figure 14). West-directed thrust and folds occurred during the Late Silurian prior to intrusion of the Gull Lake intrusive suite.

The most significant deposit outlined to date is at Unknown Brook where quartz–carbonate–alkali feldspar–pyrite veins occur in a conglomerate bed above and parallel to a thrust plane. The thrust plane is defined by rodded quartz nodules in a sericite alteration zone (Figure 15). The Browning Mine overlies a thrust plane defined by a chlorite schist horizon; anomalous gold is present in both boudinaged and broken veins oriented parallel to foliation, and in crosscutting veins. Several showings occur as gash-veins in massive felsic tuffs (Park and West Corner Brook), and others

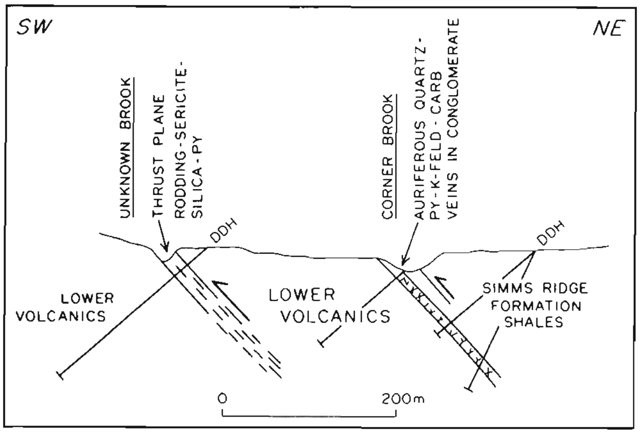


Figure 15. *Schematic section of the geology in the vicinity of the Unknown Brook deposit, Sops Arm area (Brad Mercer, personal communication, 1987). The altered zone in Unknown Brook is interpreted to represent a thrust plane. The mineralized zone represents tensional fractures in a more competent horizon.*

are located within the Doucers Valley fault complex as deformed and boudinaged veins (Wizard, Road) in areas of Carboniferous brittle movement. Siderite cubes are characteristic of the Simms Ridge Formation and increase in abundance toward the known mineralization at the Browning Mine and at Simms Ridge. These siderite cubes probably represent an outer (propylitic) alteration facies related to the hydrothermal systems. Therefore, the Simms Ridge Formation outlines the areal extent of the hydrothermal systems in the Silurian of White Bay.

The environment and age of gold deposition in western White Bay is equivocal. Tuach (1986) suggested that the Silurian alteration and associated mineral deposits were dominantly epithermal. However, the presence of ductile thrust zones in less competent rocks, and tensional mineralized veins in the more competent rocks, suggests a depth of vein formation in excess of 3 km and the possibility that detachment thrust models are applicable. The discovery of gold mineralization in Paleozoic rocks at Jackson's Arm negates the suggestion that the mineralizing system was Eocambrian (Tuach and French, 1986).

Baie Verte Peninsula

Vein-type mineralization in the Baie Verte Peninsula (Figure 16) is predominantly associated with Ordovician, ophiolitic, ultramafic and mafic rocks that occur as slivers within fault and thrust zones. The most prominent fault zones are in the Baie Verte Lineament and in the Tilt Cove–Betts Cove ophiolite belt (Hibbard, 1984). Minor gold-mineralized quartz veins have also been reported in the Rambler area in the vicinity of massive sulphide deposits (cf. Hibbard, 1984).

The recently discovered Deer Cove Prospect near Mings Bight is the best defined lode-gold prospect (Gower *et al.*, *in press*). It is a quartz and quartz-breccia vein in relatively unstrained pillow lavas and breccias overlying a moderately north-dipping thrust zone (the Deer Cove Thrust) that developed in sheared talc-carbonate rocks (Figure 17). The main zone has a northerly trend and has been traced for a distance of 500 m. It varies from 1 to 3 m wide and dips at aproximately 45 degrees to the west. Numerous other auriferous quartz veins are developed within mafic lavas, diabase, and gabbros throughout this area.

The Goldenville Mine produced approximately 4.6 kg Au in 1906; the surrounding area has been intermittently explored for gold since that time. The gold is located in quartz–pyrite veins and veinlets adjacent to and within a ferruginous iron formation that has been traced over a distance of 4 km. The Goldenville Mine appears to occur at the intersection of a north-trending structure and the iron formation.

Minor gold occurrences in quartz veins and shear zones have been reported throughout the ophiolitic Betts Cove Complex (Figure 16). The showings occur in talc-carbonate, gabbro, diabase, mafic pillow volcanics, mafic sediments and ferriginous chert horizons.

Several new prospects have recently been reported from the Baie Verte Lineament in the vicinity of Baie Verte (International Wildcat, 1987, International Impala, 1987). They occur as quartz veins and shear zones in a variety of deformed ophiolitic rocks. A showing at Marble Cove is hosted by clastic metasediments of the Fleur de Lys Supergroup (Unit 2 on Figure 16).

The spatial relationship of gold mineralization to fault zones with carbonatized ophiolitic ultramafic rocks suggests a direct comparison with the Mother Lode Belt in California (Landefeld and Silberman, 1987; Weir and Kerrick, 1987) and with similar deposits in British Columbia (Nesbitt *et al.*, 1986). Talc–carbonate–chrome-mica alteration of serpentinized ultramafic rocks is common, resulting in a bright green rock locally known as virginite (mariposite in California). The listwaenite alteration model (Buisson and LeBlanc, 1986; Figure 18) that invokes carbonitization of serpentinized ultramafic rocks and development of gold veins in and above thrusts and reverse and normal faults, has been a useful guide to exploration in the Baie Verte Peninsula (D. MacInnis, personal communication, 1987). Locally, the thrust zones associated with the ophiolites are defined by mélange.

Central Newfoundland–Victoria Lake

Most of the known prospects are hosted by rocks of the Tulks Hill volcanics of the Ordovician Victoria Lake Group (Figure 19; Kean and Jayasinghe, 1981). Epigenetic mineralization is associated with faults or shear zones, however, alteration assemblages characteristic of epithermal environments are locally well developed (Evans and Kean, 1987).

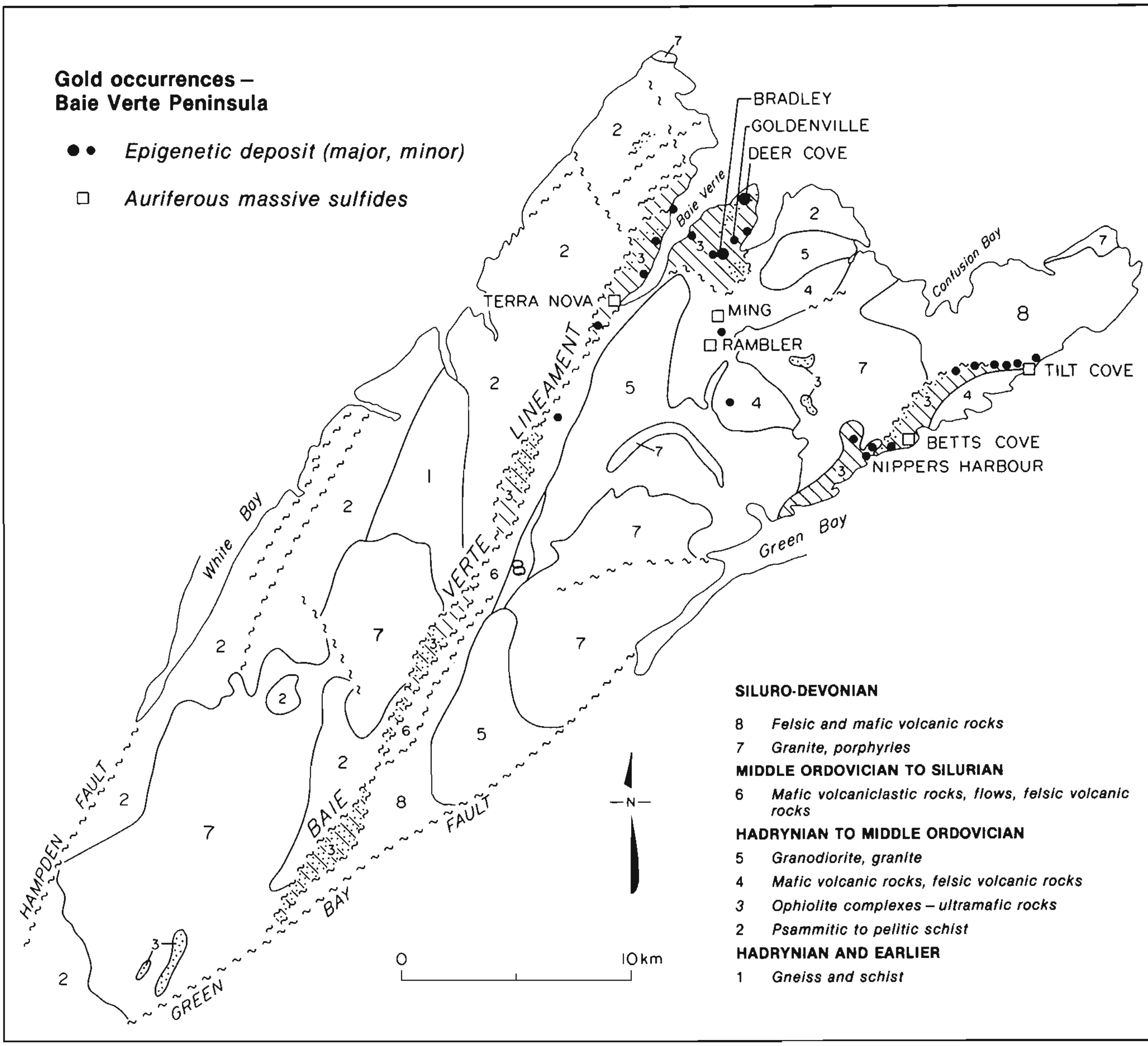


Figure 16. *Geology and location of gold occurrences on the Baie Verte Peninsula; after Hibbard (1984), Tuach (1987a), International Impala (1987), International Wildcat (1987). Ophiolitic rocks are lined, ultramafic rocks are lined and stippled. Unit 2 is the Fleur de Lys Supergroup, Unit 4 is the Pacquet Harbour Group.*

The Midas Pond Prospect (Figure 20) occurs to the east of the Tulks Valley Fault in sheared felsic and intermediate pyroclastic rocks of the Tulks Hill volcanics (Evans and Kean, 1987). It consists of a subvertical zone (maximum width of 12 m) of crosscutting quartz–carbonate–tourmaline–pyrite veins. Veins vary from foliation-parallel to crosscutting, with anomalous gold content present in both varieties. A 70 by 800 m area of pyrophyllite–kaolinite–sericite–silica alteration is present in the structural hanging wall of the mineralized zone. Banded, carbonate-rich mafic rocks with up to 5 percent pyrite occur in the vein zone and in the structural footwall; significant gold values occur in these pyrite-rich mafic rocks. The mineralization and alteration have been variably deformed in a 300 m wide shear zone (Figure 20).

Banded, massive, silicified, felsic volcanic rocks at Bobbys Pond contain an alteration assemblage of pyrophyllite, sericite, native sulphur and orpiment (Kean and Evans, *this volume).* Semimassive pyrite with pyrophyllite–sericite–silica alteration is developed in similar rocks at North Pond, 2.5 km to the northeast. The silicified zones appear to form boudins in less competent sericitized rocks in a shear zone. Minor anomalous gold is locally present within the enclosing sericite schist.

Evans and Kean (1987) noted the similarity in the alteration at Midas Pond to that of epithermal gold systems, but were uncertain as to the age and genetic significance of the enclosing shear zone, i.e., did the alteration provide a

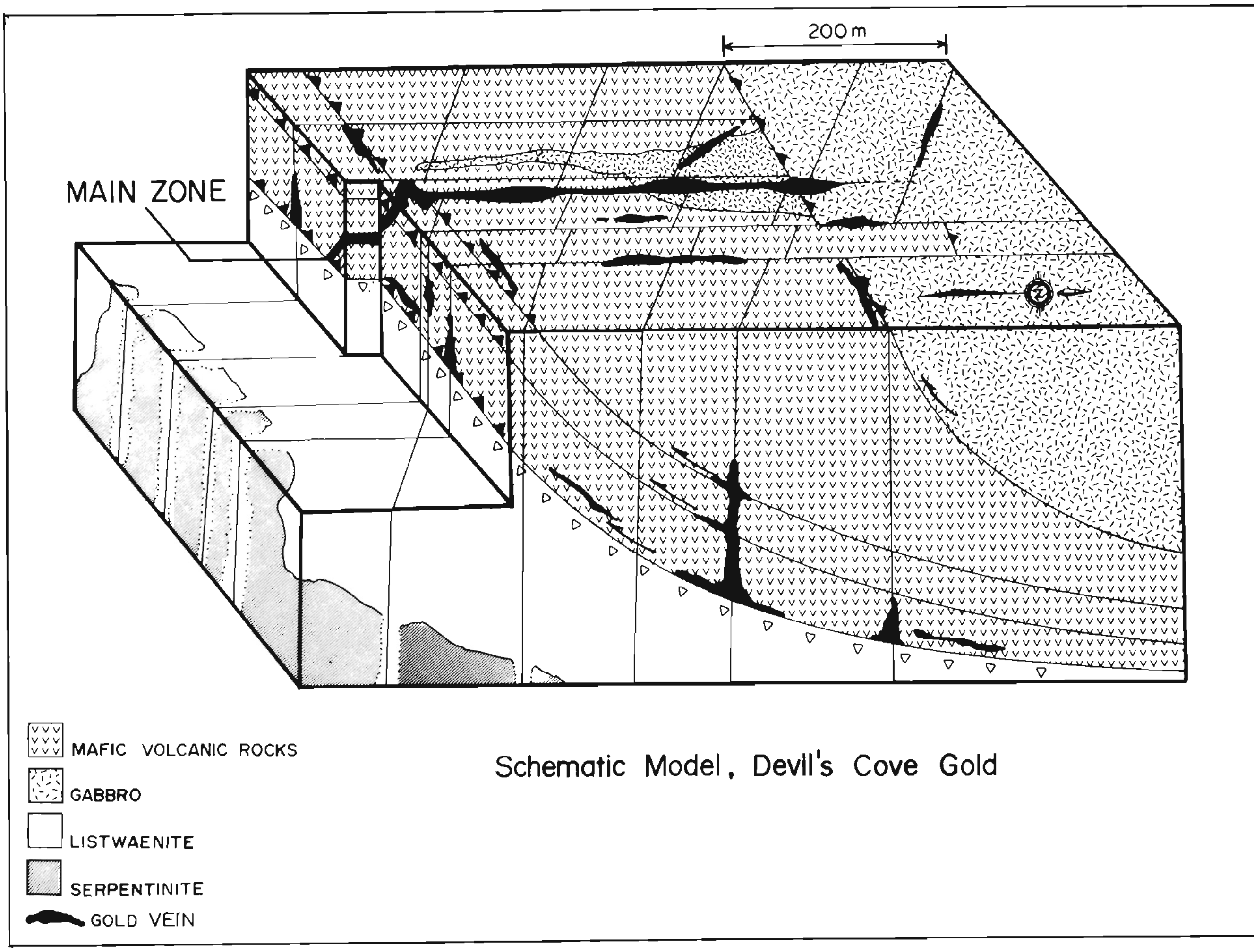


Figure 17. *Schematic section of the geology at the Deer Cove prospect; from Gower* et al. (in press).

favorable site for shearing or did the shear zone provide a conduit for epithermal fluids. Similar alteration and genetic ambiguities occur at Bobbys Pond.

An extensive zone of silicified, banded, and possibly mylonitized, chert or volcanic rocks occurs at West Tulks to the west of the Tulks Valley Fault (Figure 19). Gold occurs both in chert-like siliceous rocks and in galena–chalcopyrite-bearing quartz veins. Similar rocks occur along strike at Stag Pond. The Road or Camp Showing, located in the southern end of Tulks Valley, consists of narrow auriferous galena–sphalerite–pyrite-bearing quartz veins in sheared, sericitized and carbonatized felsic volcanic rocks. Both of these showings may have formed in shear zones related to the Tulks Valley lineament.

Visible gold, galena, sphalerite and specular hematite occur in 1 to 2 cm wide quartz–carbonate veins at the Second Exploits showing (Kean, 1984). The veins cut Ordovician (?) granite of the Lloyds River intrusive suite and are situated in a splay of the Cape Ray Fault (Kean, 1984). Devonian sedimentary rocks nonconformably overlie the granites.

At Valentine Lake (Figure 19), sheeted and stockwork quartz–tourmaline veins occur over an area of 20 km^2 in the Valentine Lake quartz monzonite. Numerous occurrences of free gold associated with minor pyrite and andradite are reported in the veins (Kean and Evans, *this volume).* The mineralization is adjacent to the Silurian(?) Rogerson Lake Conglomerate that contains boulders of the quartz monzonite. The outcrop pattern of the conglomerate is linear and probably defines a major fault in central Newfoundland (Kean, 1984). Veining is also reported in the conglomerate overlying the quartz monzonite, which suggests that the granite merely acted as a brittle host to later genetically unrelated mineralizing fluids.

On an island in Long Lake, auriferous, pyritic quartz veins occur in granite and aplite, which intruded into a narrow (3 m) shear zone in relatively undeformed pillow lavas. Tight, isoclinally folded and boudinaged quartz veins occur in the shear zone, although the aplite and granite are not penetratively deformed. The gold mineralization at this showing may be related to intrusion of the granitic host.

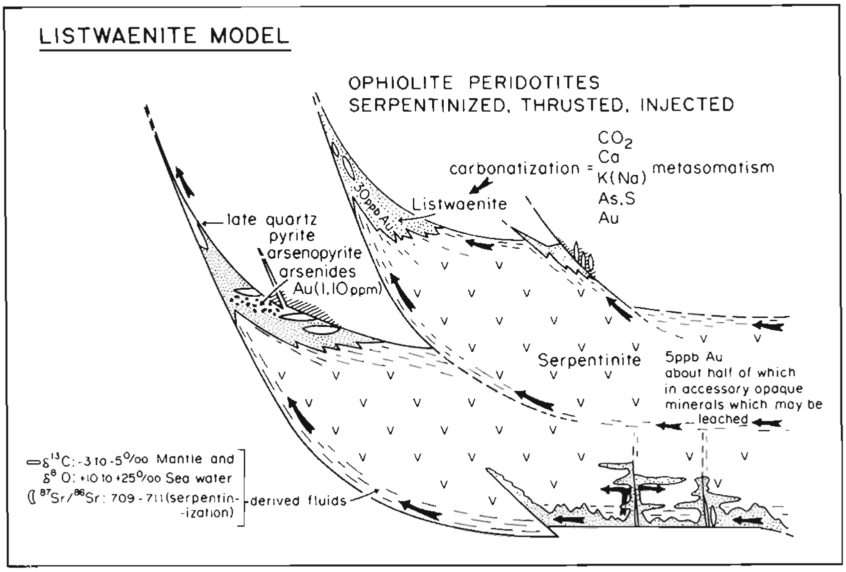


Figure 18. *The listwaenite model of gold mineralization, from Buisson and Leblanc (1986).*

In summary, many of the prospects and occurrences are adjacent to major faults or in shear zones. The structural controls of mineralization are further emphasized by the coincidence of mineralization with linears defined by regional analyses of topographic structures and magnetic gradiometer anomalies (Kean and Evans, *this volume).* In particular, mineralization with associated epithermal-style alteration in the Tulks Hill volcanics may occur in northeast-trending linears; these linears may have developed over earlier synvolcanic structures. However, considerable remobilization of gold probably occurred during progressive deformation. Alternatively, epithermal systems may have developed in the late Paleozoic at high crustal levels and were deformed in later shearing.

Other occurrences and prospects in diverse lithologies are associated with structures of various orientations. Formation of these deposits (cf. West Tulks, Valentine Lake) may be related to the development of shear zones at greater depths. The Long Lake Prospect suggests that plutonism may have been an important local control.

Other Areas

Several important showings and occurrences have not been described above. The Moretons Harbour prospects (Figure 6) consist of auriferous quartz veins with Sb, As and minor base metals hosted by Ordovician volcanics with local sericite alteration. The veins are considered as stratabound (Strong and Payne, 1973). Fluid inclusion studies (Kay and Strong, 1983) and lead isotope analyses (Swinden, unpublished data) indicate that the veins formed during growth of the volcanic pile, and may form part of a volcanogenic stockwork system. Similar environments may be present throughout central Newfoundland, particularly in the deeper levels of massive sulphide systems.

At the Handcamp Prospect (Figure 6), gold mineralization was discovered in 1928 in association with pyrite, chalcopyrite, sphalerite, and minor galena. It is hosted by altered mafic and felsic volcanics and volcaniclastic rocks and minor ferruginous chert beds of the Roberts Arm Group (Swinden and Sacks, 1986). Erratic high-grade gold values have been reported but a significant tonnage of ore has not been defined by drilling. Mineralization has been correlated with volcanogenic sulphide deposits at Gullbridge, Pilleys Island and Buchans (Figure 2). However, alternative genetic models involving later epigenetic fluids are possible.

Many occurrences throughout Newfoundland are associated with ophiolitic rocks and associated deformation zones (Figure 6). In the GRUB line (Figure 6), the Jonathon's Pond and Weir's Pond prospects north of Gander (O'Neill, 1987), and the recently discovered prospects at Great Bend (Figure 6), contain arsenopyrite as the dominant gangue sulphide. Numerous occurrences are reported from the ophiolite klippe in western Newfoundland (Figure 6). Carbonate alteration is widespread in ultramafic rocks to the east of Deer Lake and on Glover Island, and showings are reported on Glover Island. Further work is required to categorize these environments.

In addition to mineralization described above, gold has been discovered in numerous other geological environments. For example, auriferous quartz veins are reported at Wing Pond in the Gander Group (O'Neill, *this volume),* in quartz veins in the Ordovician Davidsville Group (D. MacInnis, personal communication) in the Silurian Indian Islands Group (McGillivray, 1985), and in carbonatized mafic dykes at Canada Bay (Knight (1987),

EPIGENETIC DEPOSITS AND MAJOR STRUCTURES

Most of the epigenetic deposits and occurrences described above are localized in secondary structural environments that are spatially (Figure 6) related to major north-northeast and northeast faults and lineaments of the Appalachian Orogen. These lineaments are defined by some combination of major shear zones and fault complexes separating areas of contrasting geology, carbonatized and serpentinized remnants of ophiolitic ultramafic rocks, unconformities and associated linear conglomerate sequences, geophysical contrasts, and/or topographic depressions.

Some of the lineaments may have originated as block faults during the Eocambrian rifting that formed the Iapetus Ocean followed by multiple reactivation of these lineaments

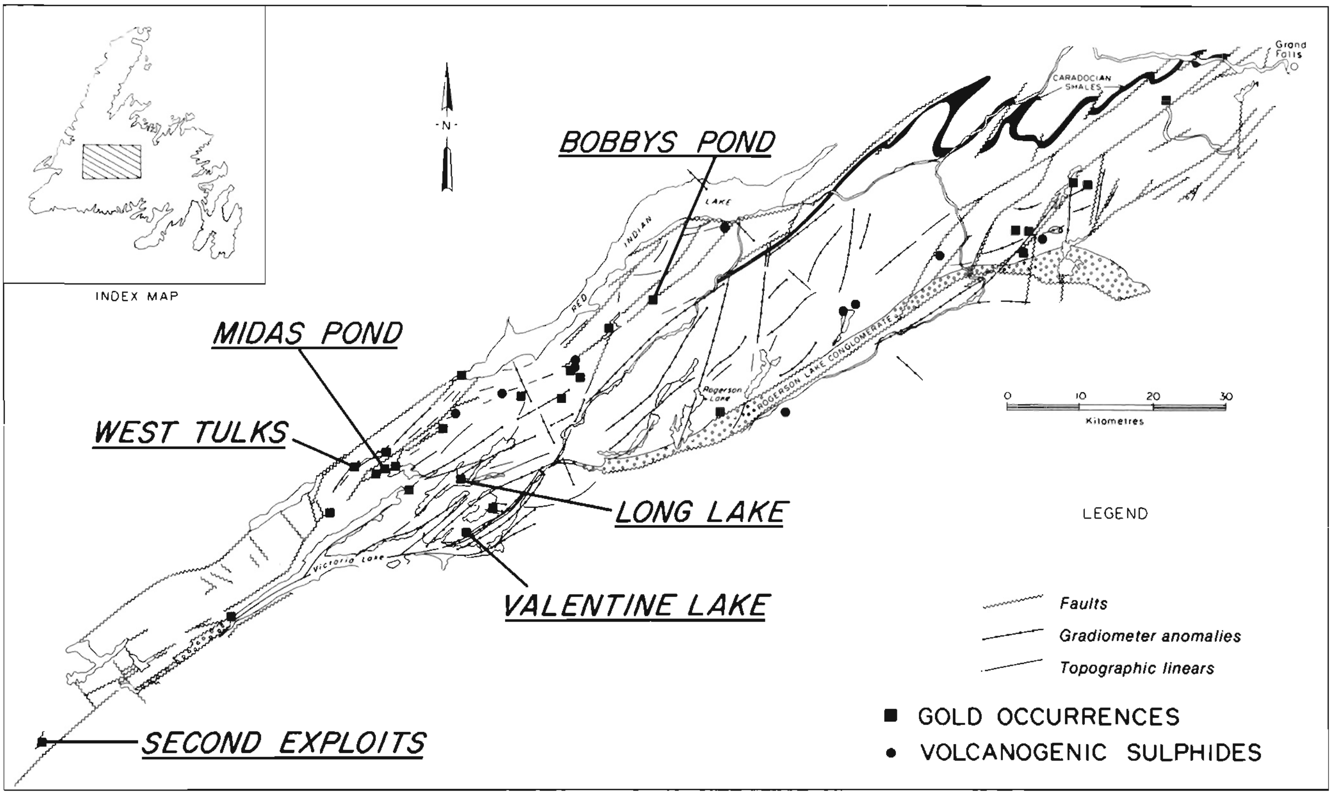


Figure 19. *Simplified geology, structure and location of epigenetic gold occurrences in the Buchans–Victoria Lake area, central Newfoundland; from Kean and Evans* (this volume).

and deformation (including thrusting and backthrusting) of overlying rocks during subsequent Paleozoic orogenic events (i.e., Baie Verte Lineament, Doucers Valley Fault Complex; Tuach, 1987b); other lineaments have been interpreted as accretionary terrane boundaries (Hermitage Bay–Dover Fault; Williams and Hatcher, 1982); others record major Ordovician–Silurian thrust planes (Pipestone Pond Fault, GRUB line; Colman-Sadd and Swinden, 1982; Stockmal *et al.*, 1987) or Acadian and Carboniferous transcurrent movements (Cape Ray Fault, Cabot Fault; Hyde, 1979).

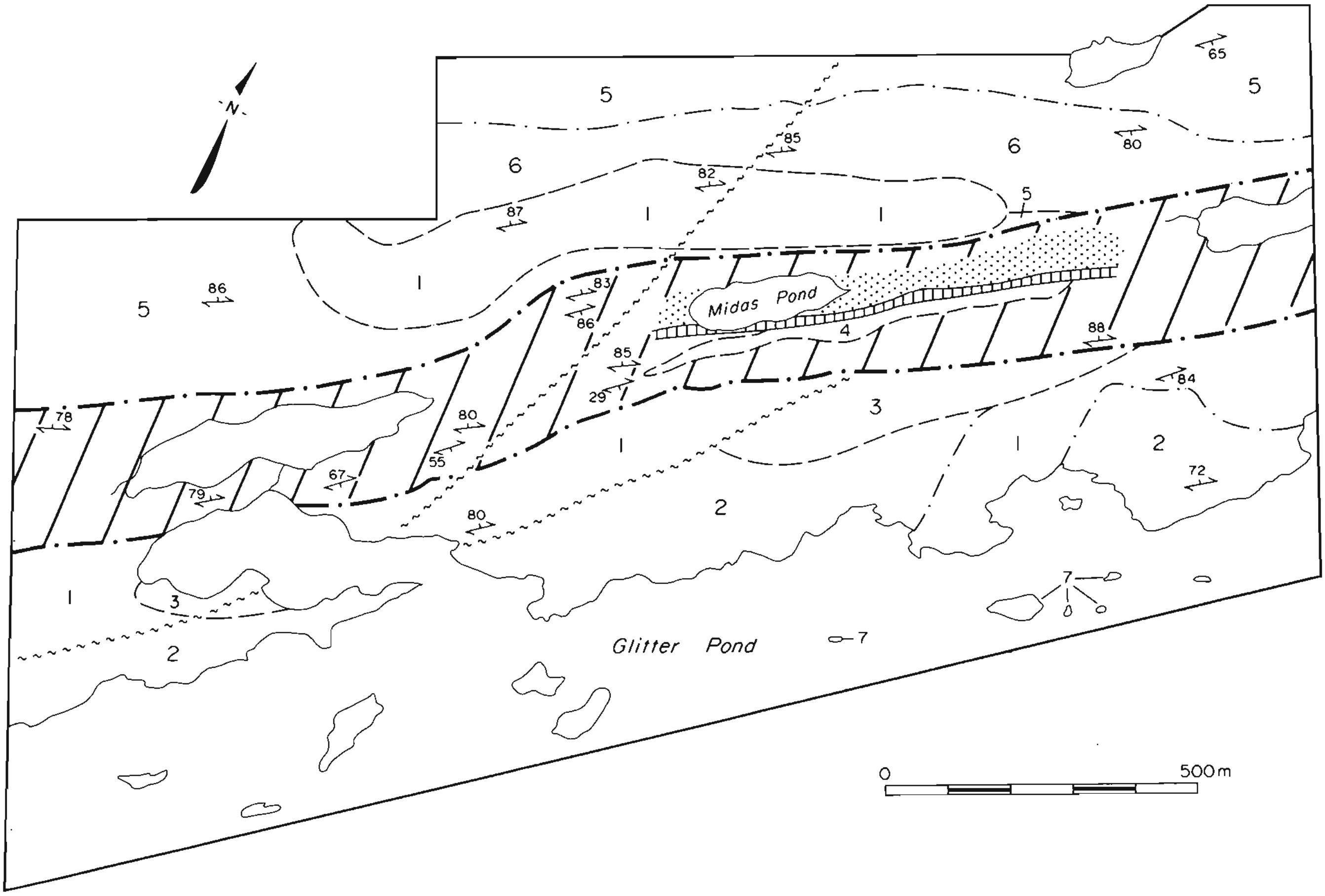
A genetic association between gold mineralization and major structures is implied. Movement on fault zones in the lineaments may have enhanced and focussed fluid systems and possibly magmatism, although a spatial and genetic association between plutonism and gold has not been generally well established. The genetic association between major faults and gold-bearing hydrothermal systems is emphasized by the presence of extensive lake sediment geochemical halos of a variety of gold-associated elements (As, Sb, W) around the major faults, i.e., Figure 21.

LATENT GOLD ENVIRONMENTS AND MODELS

Other geological environments with potential for gold mineralization are present in Newfoundland, although no gold has yet been reported.

Rocks of the Fleur de Lys Supergroup (Unit 2 on Figure 16) on the Baie Verte Peninsula have been correlated with the Dalradian of Ireland (Kennedy *et al.* 1972). These Dalradian rocks host the Gortin deposit in the Sperrin Mountains of Northern Ireland which contains 1.0 million tonnes grading 10.0 g/t Au. It occurs in quartz veins in a fault cutting polydeformed Dalradian metasediments (Clifford, 1986; Morris, 1987). Other important prospects are also located in crosscutting fault zones in Dalradian metasediments in Mayo and Donegal (Morris, 1987). Clearly, a similar potential exists in late faults throughout the Fleur de Lys Supergroup and in correlative rocks in Newfoundland.

Sulphide-bearing iron formations, termed Fox Neck (Nickeys Nose)-type deposits (Kean, 1983, 1984) are interbedded with argillite at the top of the ophiolitic pillow lava unit of the Lushs Bight Group (Figure 5). The rocks are also considered to form the stratigraphic base of the overlying island-arc sequences. The deposits are typically thin and discontinuous, but the stratigraphic units can be traced over a considerable distance. The iron formation is dominantly pyritic, but jasper and magnetite layers are common. A similar unit is present at the top of the pillow lavas in the Betts Cove ophiolite, and the Goldenville iron formation (Figure 16; Table 2) may be in a similar setting. Those iron formations described above from an ophiolite setting, and iron formations in the overlying island arc sequences, have potential for associated gold mineralization.



EARLY ORDOVICIAN

VICTORIA LAKE GROUP

7 *Gabbro*

6 *Silicified felsic tuff*

5 *Felsic crystal tuff, sericitic*

4 *Banded mafic rock, minor limonitic felsic bands*

3 *Felsic crystal tuff and minor breccia, sericitic, locally siliceous*

2 *Breccia; intermediate to mafic, minor tuff*

1 *Mafic, feldspar-crystal tuff and minor breccia*

~~~~~~ *Fault (assumed)*

———·— *Geological contact (approximate, gradational)*

Cleavage (inclined)

Anastomosing shear zone consisting of interbanded felsic crystal tuff, lapilli tuff and fine grained, mafic, crystal tuff variably pyrophyllitized and silicified

Extensively pyrophyllitized and locally silicified, felsic crystal tuff and lapilli tuff

Mineralized zone consisting of pyritiferous quartz veins cutting silicified felsic rocks and in part the banded mafic rocks of Unit 4

Figure 20. *Geology of the Midas Pond area; from Evans and Kean (1987).*
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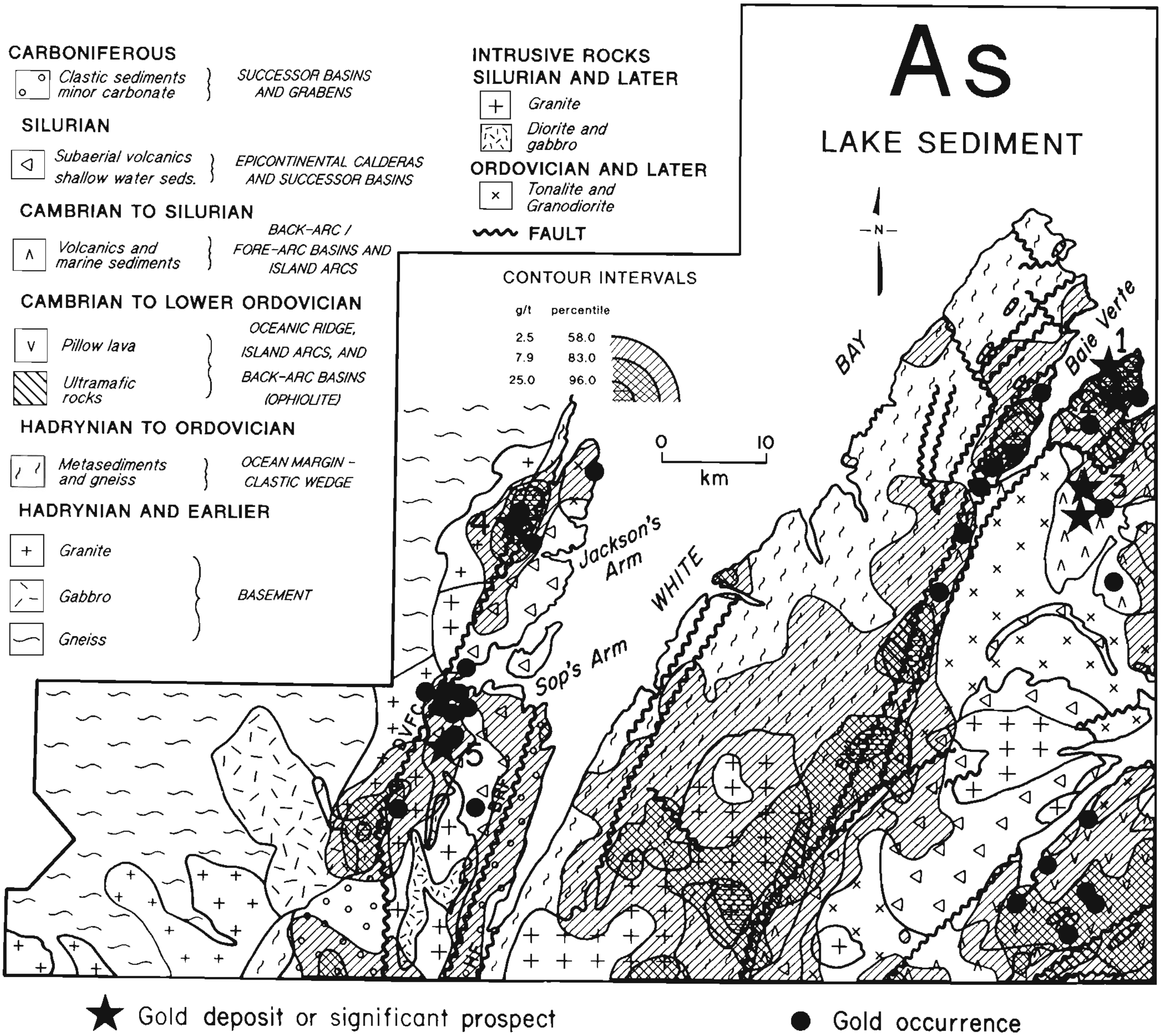

Figure 21. *Arsenic anomalies in lake sediments and major structures in the White Bay area; from Davenport and McConnell* (in press).

Thrusting and plutonism occur locally in the lower Paleozoic platformal clastic and carbonate sequences in the Western Platform and in the Avalon Zone. An analogy to the geological environment of the Carlin area in Nevada can be made.

Caldera environments are represented by Middle to Late Paleozoic volcanic and clastic sequences in central Newfoundland (Coyle and Strong, 1987), and may have associated epithermal deposits. The aluminous alteration and associated mineralization in the Avalon Zone may also be related to Late Hadrynian caldera development.

Lower to middle Paleozoic turbidite sequences in central Newfoundland may contain turbidite-hosted deposits and are similar in age and lithology to the Meguma Group of Nova Scotia. Therefore, the occurrences in the Davidsville Group may have a turbidite association.

DISCUSSION AND CONCLUSIONS

The continued importance and potential of gold-bearing massive sulphide deposits is emphasized by the recent discovery in the Duck Pond–Tally Pond area, and by the gold potential of the tailings pond at Rambler (Newfoundland

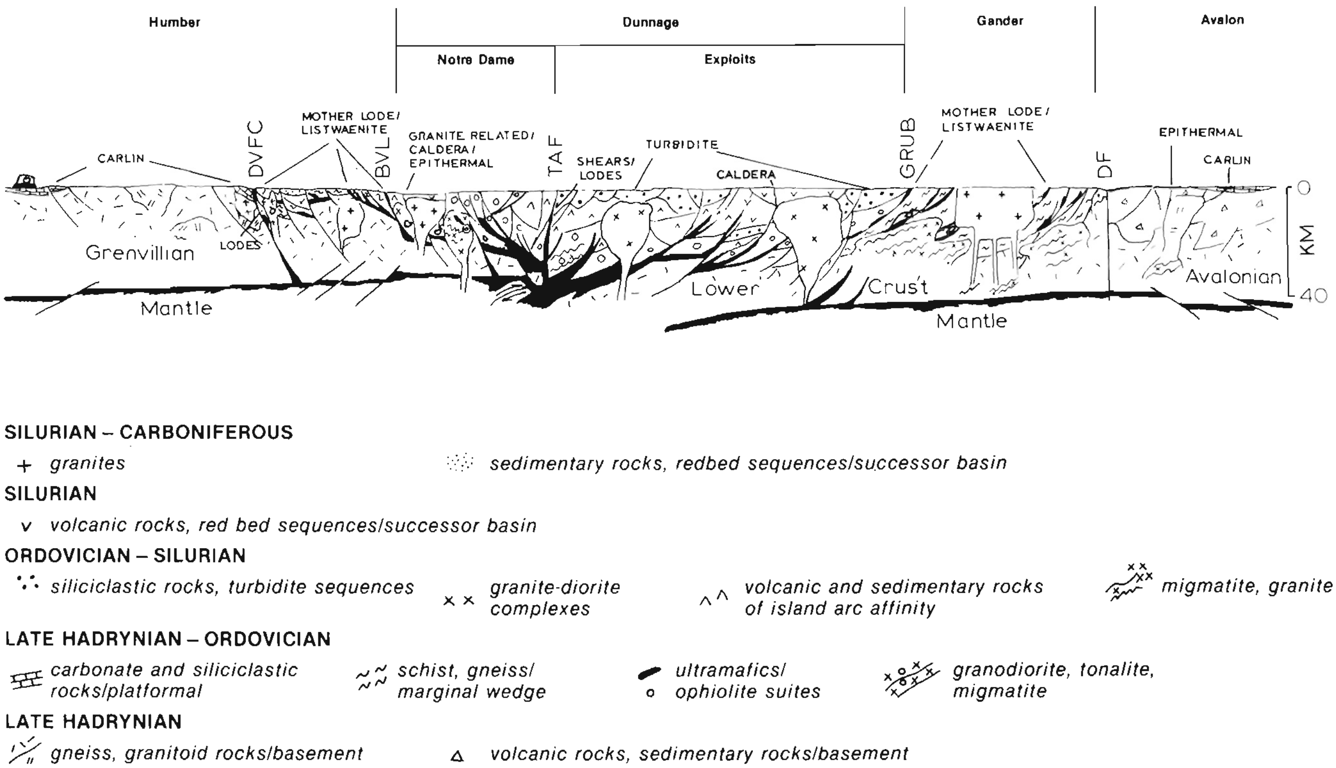

Figure 22. *Schematic geological section across Newfoundland showing environments of formation of epigenetic gold deposits. Approximate position shown on Figure 1. Section shows influence of basement faults and widespread low angle thrust zones. Note the extensive subsurface distribution of ultramafic rocks indicated by their presence along major thrust planes. Structural interpretations based on Keen* et al., *(1986), Stockmal* et al., *(1987) and S.P. Colman-Sadd (personal communication). DVFC, Doucers Valley Fault Complex; BVL, Baie Verte Line; TAF, Tommys Arm Fault; GRUB, Gander River Ultrabasic Belt; DF, Dover Fault.*

Department of Mines, 1987). Gold-bearing polymetallic deposits in mafic-felsic sequences and ophiolite-hosted massive sulphides provide an extremely attractive exploration target in Newfoundland. Variations in the relative metal contents of massive sulphide deposits mainly reflect the lithologies of the substrate from which the hydrothermal cells derived their metals.

Collectively, the new discoveries of epigentic gold mineralization in Newfoundland exhibit features common to gold deposits worldwide, and analogies to many of the major deposits can be made. The associations of gold, major faults and lineaments, sericite–carbonate–silica–clay-altered rocks, and carbonatized and serpentinized ultramafic rocks are proving to be effective exploration tools. However, the absence of one or all of these features does not preclude mineralization. Models involving epithermal alteration (Berger and Eimon, 1983) and listwaenite alteration (Buisson and LeBlanc, 1986) are locally applicable, and models involving metamorphic devolitatization (Colvine *et al.*, 1984) may also be relevant. Undoubtably other models will be developed and utilized as more information becomes available. A schematic section across Newfoundland that attempts to summarize the settings of known deposits and potential mineralized environments is presented in Figure 22.

The age of the gold systems has not been established in most cases. The epithermal systems in the Avalon Zone are probably Late Hadrynian. Systems that display deformed alteration assemblages characteristic of epithermal environments such as Hope Brook and Midas Pond may have developed during waning stages of volcanism (Cambrian to Silurian) prior to later deformation and have been extensively reworked by later fault movements (cf. Evans and Kean, 1987). Alternatively, they may have developed during late Paleozoic transcurrent faulting. The prospects associated with ultramafic rocks such as those in the Baie Verte Peninsula and the GRUB line developed during or after middle Ordovician and later faulting and deformation. Other systems directly associated with granitic rocks (i.e., Cape Ray) may be Devonian. It is possible that systems associated with Carboniferous and Mesozoic faulting may also be present. Characterization of the age of these gold systems could contribute significantly to our understanding of Appalachian tectonics.

It is evident that the gold rush in Newfoundland is just beginning, and that this summary may rapidly become obsolete. We hope it will prove useful in the near term as a guide to further prospecting.

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