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[1] Contribution to the Targeted Geoscience Initiative (TGI) 2000—2003

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Abstract

Gold-bearing mineralized zones in Ordovician turbidites of the Kendall Mountain Formation (St. Croix Terrane) in southwestern New Brunswick occur within shallowly dipping brittle high-strain zones. The gold zones, commonly several metres wide, are defined by stockwork, massive, and multiply brecciated quartz-sulphide veins containing arsenopyrite, pyrrhotite, pyrite and stibnite, and are enveloped by locally auriferous, weakly to intensely altered wall-rock. Vein paragenesis includes: 1) early (barren?) quartz-chlorite veins that are largely the product of migration of quartz from domains of cleavage-parallel pressure solution into extensional structures; 2) cross-cutting, multiphase, vuggy quartz-sulphide veins that contain most of the gold and are interpreted to be controlled by late-D_2 thrust faults; 3) late cross-cutting, non-gold-bearing veins containing various combinations of laumontite, chlorite, muscovite, quartz, fluorite and base-metal sulphides. These late veins constrain the upper time limit of gold mineralization to Late Devonian based on their widespread association with nearby plutons of that age. Alteration associated with gold is lithology-specific and notably carbonate-poor and appears to reflect overprinting of several events. Major elements removed during alteration include Si, Na, Mn, Mg; minor and trace elements include Co, Li, Sc and possibly Sr, Ni and Zn. Minor and trace elements added include Au, Ag, As, Sb, S, and possibly F, Cu, Pb and Zr. The gold-mineralized zones appear to be the product of a protracted structural history that culminated with late-D_2 thrust-faulting, and which facilitated gold mineralization. The gold deposits of Anomaly A are tentatively interpreted to be affiliated with intrusion-related gold deposits in the Clarence Stream Main Zone area.

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Introduction

The Clarence stream area of southwestern New Brunswick has recently been the focus of intensive gold exploration following the discovery of high grade gold in 1999. Since that time, a northeast-trending, gold-bearing belt at least 60km long has been defined (McLeod and Fyffe, 2002) and several medium- to high-grade deposits have been partially outlined by Freewest Resources Canada Inc. These new gold discoveries were studied as part of a regional, multi-disciplinary project of the Geological Survey of Canada's Targeted Geoscience Initiative (TGI), designed to characterize significant new gold occurrences in southwestern New Brunswick and to assess their relationship to the magmatic rocks with which they are spatially associated. Impetus for the project included the recognition that the setting of these gold occurrences is similar to that of a newly recognized class of economic gold deposits thought to be genetically related to granitic plutonic rocks. These "intrusion-related gold systems" (Lang and Baker, 2001; Thompson and Newberry, 2000) lie within extensive magmatic provinces, especially those in which Sn and W mineralization is prominent and lie further inboard than the better-known, granitic-associated Cu-Au systems that are related to volcanic arcs.

Two main areas of gold mineralization identified by drilling to date include the Clarence Stream "Main Zone" deposit (hereinafter referred to as the Main Zone) immediately adjacent to the Saint George batholith in the Silurian Mascarene Basin (Fig. 1, Thorne et al 2001, 2002) and the Anomaly "A" zones 3 km to the northwest, hosted by Ordovician turbidites of the St. Croix Terrane (Fig. 1).

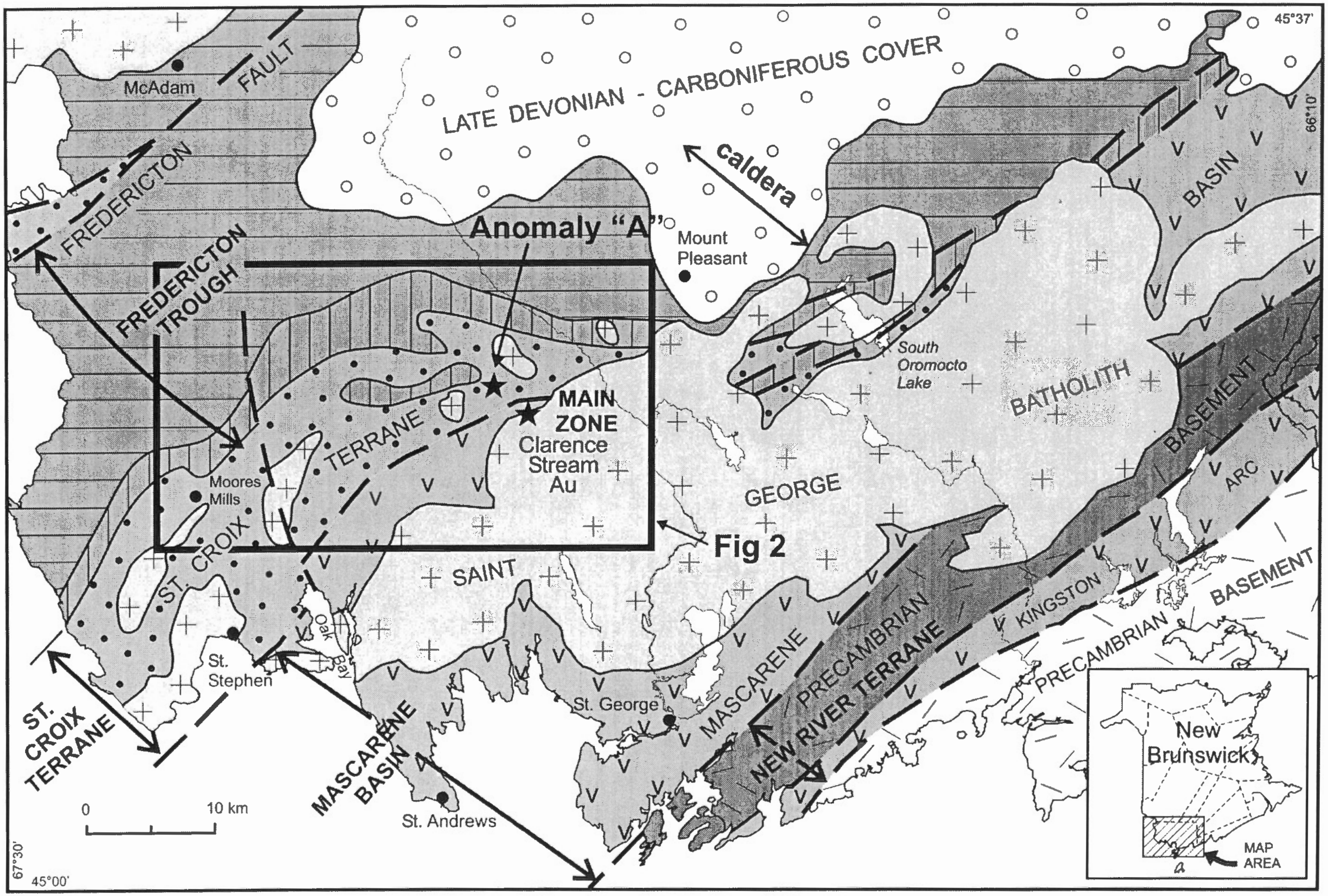

Figure 1. Geotectonic map of southern New Brunswick showing location of Anomaly "A" gold occurrences, Clarence Stream Main Zone, and location of Figure 2. Modified from Fyffe and Riva (2001).

The rocks hosting gold zones of “Anomaly A”, although polydeformed, are not as intensely sheared and mylonitized as those in the Main Zone deposit. Therefore, this area has better potential for determining the relationship of the local gold mineralizing event(s) to regional structure. The regional structural framework is the subject of a complementary study (Castonguay et al., 2003). Characterization of Anomaly A will also expand the presently very limited number of descriptions worldwide (Lang and Baker, 2001) of gold deposits which occur in a distal setting with respect to a potentially causative intrusion.

During the summer of 2002, surface exposures in outcrop and trenches were examined along with key drill core sections intersecting the three main gold zones of Anomaly A. The aim of the examination was to characterize the deposits, focusing on rock alteration, gold zone characterization, vein paragenesis and structural control.

Regional tectonic setting

The tectonostratigraphic units of southwestern New Brunswick can be described in terms of their relationship to two larger terranes, the Gander Terrane (Gander Zone of Williams, 1979) and the Avalon Composite Terrane both of which were outboard of the North American continental margin during early Paleozoic time. The St. Croix Terrane (Fig. 1) consists of Ordovician turbidites deposited on the passive southeast margin of the Gander Terrane (Fyffe et al., 1999) and younger, Silurian, turbidites occupying the belt immediately to the north (the Fredericton Trough). The New River Terrane consists mainly of Precambrian to Cambrian volcanosedimentary sequences and plutonic rocks characteristic of Peri-Gondwanan terranes (Johnson and McLeod, 1996). Originally interpreted as part of the Avalon Terrane (Johnson and McLeod 1996), Johnson (2001) has recently interpreted the portion of the New River Terrane in the study area to be part of the Gander Terrane. The Mascarene Basin contains a post-collision, Silurian volcano-sedimentary cover sequence (back arc basin; Fyffe et al., 1999) that spans the boundary between the St. Croix and New River (Gander-Avalon) Terranes. The large, Late Silurian to Late Devonian Saint George Batholith intrudes the St. Croix Terrane, the Mascarene Basin and the New River Terrane along the major suture zone separating the St. Croix and New River Terranes at depth (Fig. 1; Thomas and Willis, 1989; McLeod, 1990). Details of interpreted plate tectonic history are given in Fyffe et al (1999).

The Sawyer Brook Fault forms the boundary between this Silurian backarc basin and the southern limit of exposure of the Ordovician St. Croix Terrane (Fig. 1, 2). A splay of the Sawyer Brook Fault is interpreted to pass through the Main Zone gold deposits, which are hosted by meta-sedimentary and gabbroic intrusive rocks of the Mascarene Basin on the northwest flank of the Saint George Batholith (Thorne et al 2002). The gold deposits of Anomaly "A" (Fig. 1, 2, 3) lie 3 km northwest of the Main Zone deposits in the polydeformed Caradocian Kendall Mountain Formation at the top of the Cookson Group (Fyffe and Riva, 2001).

The regional structural geology of the area is characterized by four phases of deformation, which vary in style and intensity due to differences of rock competency and anisotropy, and occur in domains (Ruitenberg, 1967; Castonguay et al., 2003).

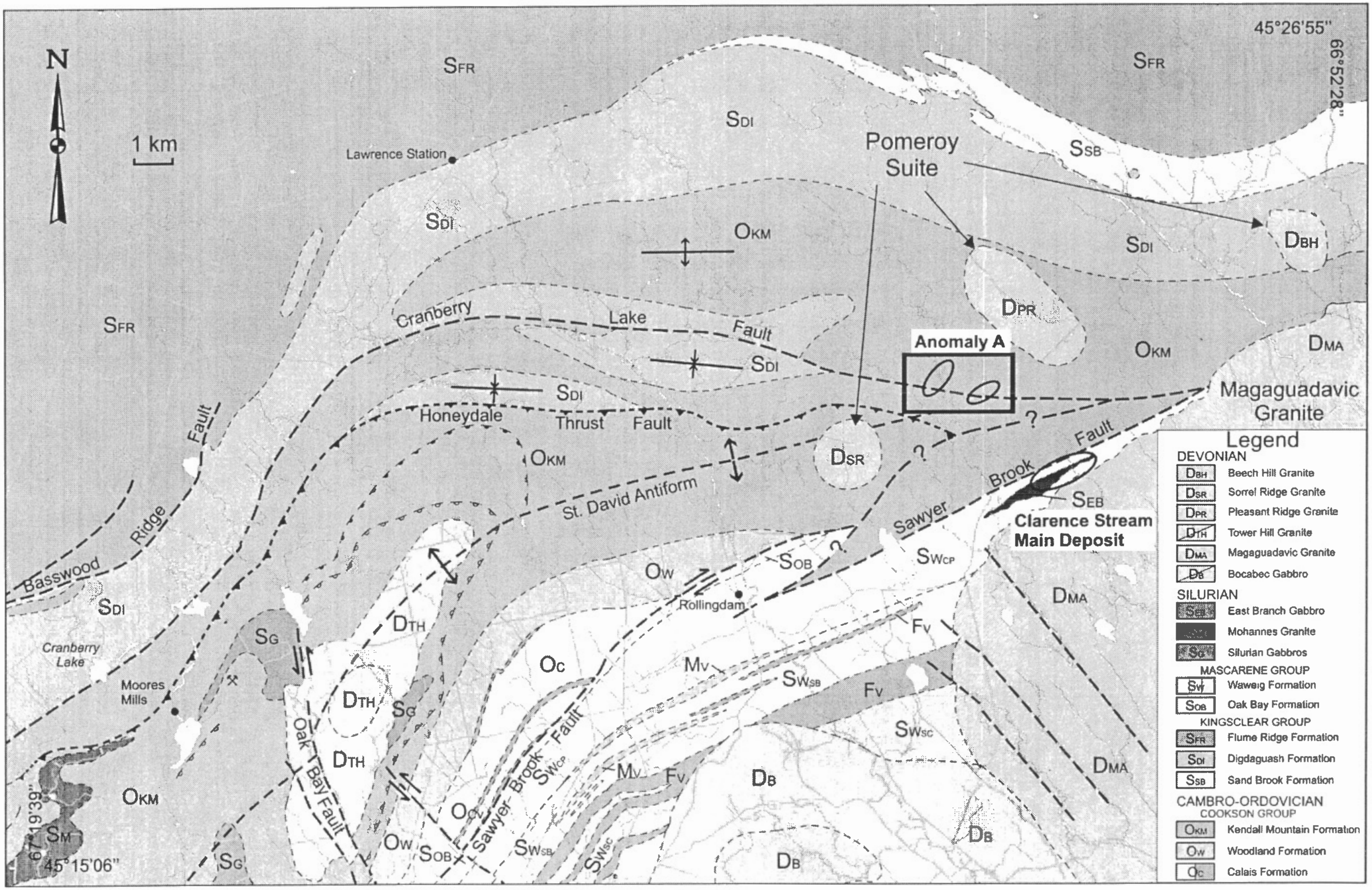

Figure 2. Regional geologic map of southwestern New Brunswick showing geological setting of Anomaly "A" gold occurrences and location of Figure 3. Modified from Fyffe 1997, McLeod et al. 1998 and Castonguay et al. 2003.

D_1 is dominantly recognized in the Cookson Group. S_1 is a bedding-parallel slaty cleavage, except when it is axial-planar to rarely observed isoclinal or intrafolial F_1 folds. When differentiated from D_1, D_2 is associated with close to isoclinal F_2 folds. S_2 varies from a dissolution cleavage to a crenulation. D_1 and D_2 may represent a composite phase, which evolved in continuum during an early thrusting event. (Ruitenberg and Ludman, 1978; Castonguay et al., 2003). Regional faults, such as the Honeydale Fault (Fig. 2), have been interpreted as D_2 structures (Ruitenberg, 1967; Castonguay et al., 2003). The D_3 phase, folds of which are mostly coaxial with those of D_2, has a profound influence on the regional structural map pattern (Fig. 2). The steeply-dipping S_3 cleavage is axial-planar to moderately northeast-plunging F_3 folds. The "St.-David Dome", previously recognized as an early structure (Ruitenberg, 1967), has been reinterpreted as the culmination of a megascopic F_3 antiform (Castonguay et al., 2003). D_3 structures are dominant southeast of the Sawyer Brook Fault, which is interpreted as an inherited late-D_3 dextral strike-slip fault cutting the southeastern limb of the St-David anticline (Fig. 2; Castonguay et al., 2003). The effect of D_4 is thought to mark local change of regional orientation and increase or decrease of dip (or plunge) of pre-existing structures. At the mesoscopic scale, F_4 are described as upright north-northwest-trending chevron folds, with gently plunging axes (Castonguay et al., 2003).

The main plutonic rocks in the region comprise the main body of the Saint George Batholith and satellite plutons (Fig. 1, 2) that consist of mafic to felsic (metaluminous and peraluminous) suites ranging in age from Late Silurian to Late Devonian. The granitic Magaguadavic phase of the batholith that is adjacent to the Main Zone gold deposit yields a Lower Devonian zircon age (396 Ma +/- 1; Bevier 1990) and is related to gold mineralization in that deposit (Thorne et al. 2002). The youngest, Late Devonian granites, which constitute most of the satellite plutons of the Pomeroy Suite, are highly evolved granites (including topaz granites). This suite generated the Mount Pleasant W-Mo-Sn-polymetallic deposits and other localized Sn-bearing greisen zones (Taylor 1985). Gravity data indicates that intrusions are present beneath much of the area at relatively shallow depths (Thomas and Willis 1989).

Lithologies Hosting Anomaly A Gold Zones

The Anomaly A gold zones are hosted by polydeformed turbidites of the Ordovician Kendall Mountain Formation, midway between the Pleasant Ridge and the Sorrel Ridge granites (Fig. 2). Interpretation of stratigraphy is hampered by a paucity of outcrop and lack of marker beds. However, one magnetic signature south of the Murphy Zone (Fig. 3) presents as an aeromagnetic high (Kiss et al., 2002). Although unexposed, float excavated from a trench over this zone indicates that the magnetic response may be due to a pyrrhotite-rich horizon of dark grey graphitic(?) laminated siltstone and argillite.

The following lithologic description of the Kendall Mountain Formation is based on bedrock exposures (which are limited to the vicinity of the Murphy Zone) and on drill core from the three main gold zones comprising Anomaly A: the Murphy, AD and MW Zones (Fig. 3). The formation consists of medium to dark grey, quartz-rich sandstones or greywackes interbedded with dark grey to black to slightly purplish grey argillites and lesser medium-grey siltstone.

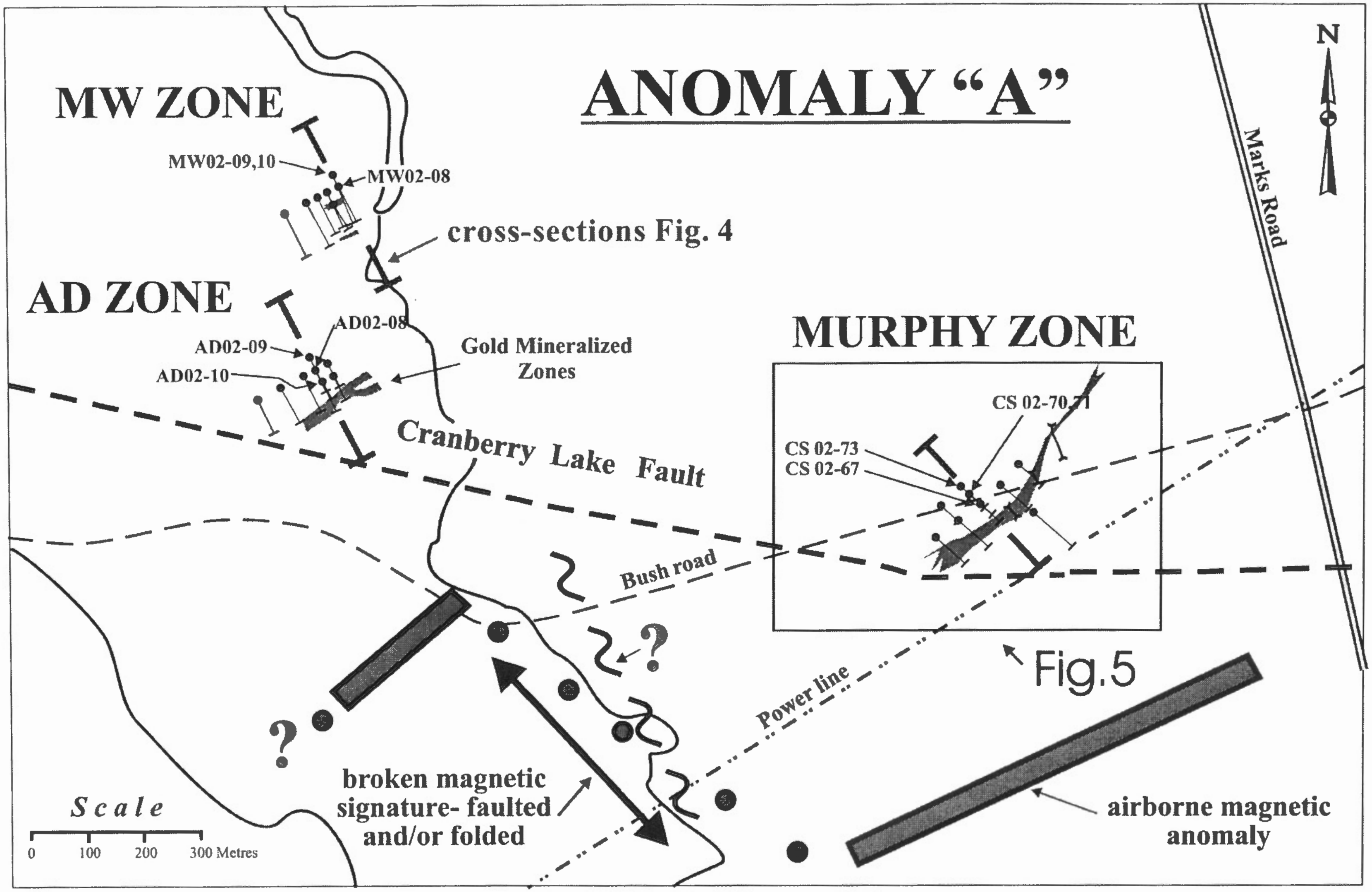

Figure 3. Property-scale geologic map showing drill hole locations on Murphy, AD, and MW Zones and showing cross-sections of Figure 4. Drill hole numbers are given where cores were examined during the present study. Location of magnetic marker horizon from unpublished ground magnetic map of Freewest Resources Canada Inc., and as discussed in text.

Greywacke beds range up to several metres thick, but are generally in the metre range and many are graded. Argillite beds vary in thickness from less than one centimetre to several decimetres. Cross-bedding is commonly present in narrow zones of siltstone and/or argillite laminae but deformation renders most of it ambiguous for stratigraphic tops indication.

The argillites examined microscopically, exhibit >95% fine-grained clay and/or mica plus 1-2% or less opaque minerals and up to a few % silt-size quartz class all aligned along the pervasive S_1 fabric. Although the intense foliation makes grain boundary distinction difficult, the grain size is estimated between 25 and 50 microns. Opaques have dark grey metallic colour in oblique reflected illumination and are locally concentrated along S_2 cleavage/fracture planes.

The greywackes are quartz-rich, containing up to 90% angular quartz class, plus fine-grained sedimentary and volcanic rock fragments, muscovite, minor plagioclase, and opaques, in a sericite-rich matrix. The opaques are mainly dark metallic grey in oblique illumination (ilmenite?) and the rest (<10%) are white to buff-coloured. Rare, 0.5 mm diagenetic(?) pyrite grains are present in some samples. Foliation is generally well developed and defined by all platy grains as well as by the long axis of locally elongate quartz grains.

Property Structure

Interpretation of property structure and correlation with the several phases of regional deformation is hampered by the small size and paucity of outcropping bedrock, and by the lack of stratigraphic marker beds. Another confounding factor, stated above, is that the imprint of structural phases apparently varies regionally (Castonguay et al. 2003) and the main folding phases (D_2 and D_3) are largely coaxial, thus restricting the usefulness of overprinting relationships and attitudes in distinguishing structures of the various phases.

At the property scale, lithologic layering appears to have an overall east-northeast strike, dipping moderately to steeply to the north, consistent with the orientation of the magnetic trend south of the Murphy Zone (Fig. 3). The most distinctive large scale structural feature involves reversals of younging direction, indicative of tight to isoclinal folding (Fig. 4). Panels of beds with internally consistent indicators of younging direction alternate with parallel panels in which the consistent younging direction is reversed, as originally observed in drill core by Glen Lutes (unpublished reports 2001, 2002) Further younging observations made in outcrop and trenches on the Murphy Zone were correlated with existing logs (Fig. 4; Lutes, unpublished reports 2001, 2002) to produce the interpreted first order structural pattern of panels 30 to 100 metres thick (Fig. 5). The drill section logged in the AD Zone shows 5 such panels of reversal, each roughly 20 to 35 metres thick in the plane of the section. The precise nature of the reversals is not yet confirmed. There is commonly a 5 to 15 metre interval of unknown younging direction between the reversed panels and there is no obvious lithologic symmetry across the

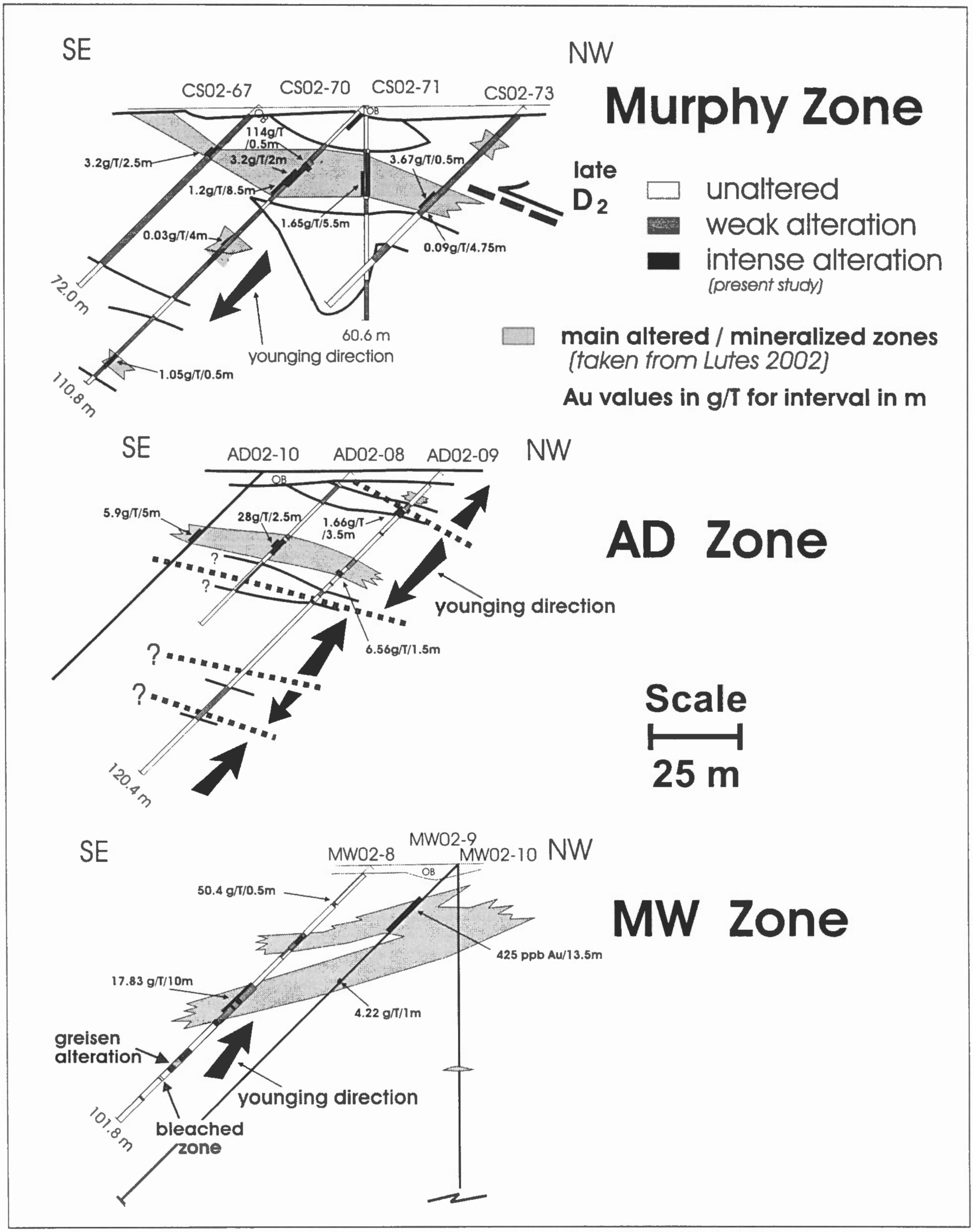

Figure 4. Cross-sections of the Murphy, AD and MW Zones showing main mineralized zones, associated alteration, and panels of reversed younging discussed in text. (Modified from Lutes, Unpublished reports, 2001, 2002).

reversals, probably indicative of faulting. Based on 1st order correlation with the regional structural framework (Ruitenberg, 1967; Castonguay et al., 2003), it is suggested that the reversals reflect the culmination of F_1 and F_2 folding, whereas the lack of symmetry might be explained by shearing along fold limbs.

The earliest recognizable microfabric in the rocks is a penetrative slaty cleavage (S_1) that is sub-parallel to bedding. This cleavage is pervasive in the argillites and siltstones (expressed mainly as mica grain foliation) but does not tend to be macroscopically obvious in the greywackes except as a locally developed, centimetre-spaced solution cleavage. S_1 also appears to be axial planar to a few small-scale isoclinal folds that were tentatively identified in drill core, and to rare millimetric intrafolial folds observed in outcrop. Metamorphic porphyroblasts (0.1mm) now completely altered to chlorite and quartz (microprobe analyses, Douglas Hall, personal communication) were observed in one sample of argillite (e.g., 25m core depth in DDH AD02-08; Fig. 3, 4). Opaque inclusions in the porphyroblasts vary from randomly oriented to aligned parallel with the earliest recognizable penetrative fabric, indicating an extended growth period, broadly contemporaneous with fabric development. Where folding is not observed, that fabric probably represents a composite S_{1-2} fabric.

Small-scale folds affecting the S_1 cleavage, which are inferred to be F_2 folds, were recognized locally, both in surface outcrops/trenches and in drill cores; some occur within and outside of zones of younging reversal. In outcrop, decimetre-scale F_2 folds plunge moderately to the southwest and northeast and possible F_2 folds observed in drill core in greywacke are locally accompanied by an axial planar solution cleavage (S_2) In the vertical hole CS-71 (Fig. 4, 5), a shallowly plunging fold nose of several metre wavelength, interpreted as an F_2, overlies the main mineralized deformation zone, which is inferred to be the product of the shearing off of its lower limb. The fold is shallowly plunging based on the near perpendicular relationship between the axial planar cleavage and the core axis. The relationship between the fold (the younging reversals) and the mineralized deformation zone (see below for description) indicates that they may be genetically related (Castonguay et al., 2003). The shallower dip of bedding measured both within Trench 1 and in outcrop (Fig. 5) could result from F_2/F_3 fold interaction.

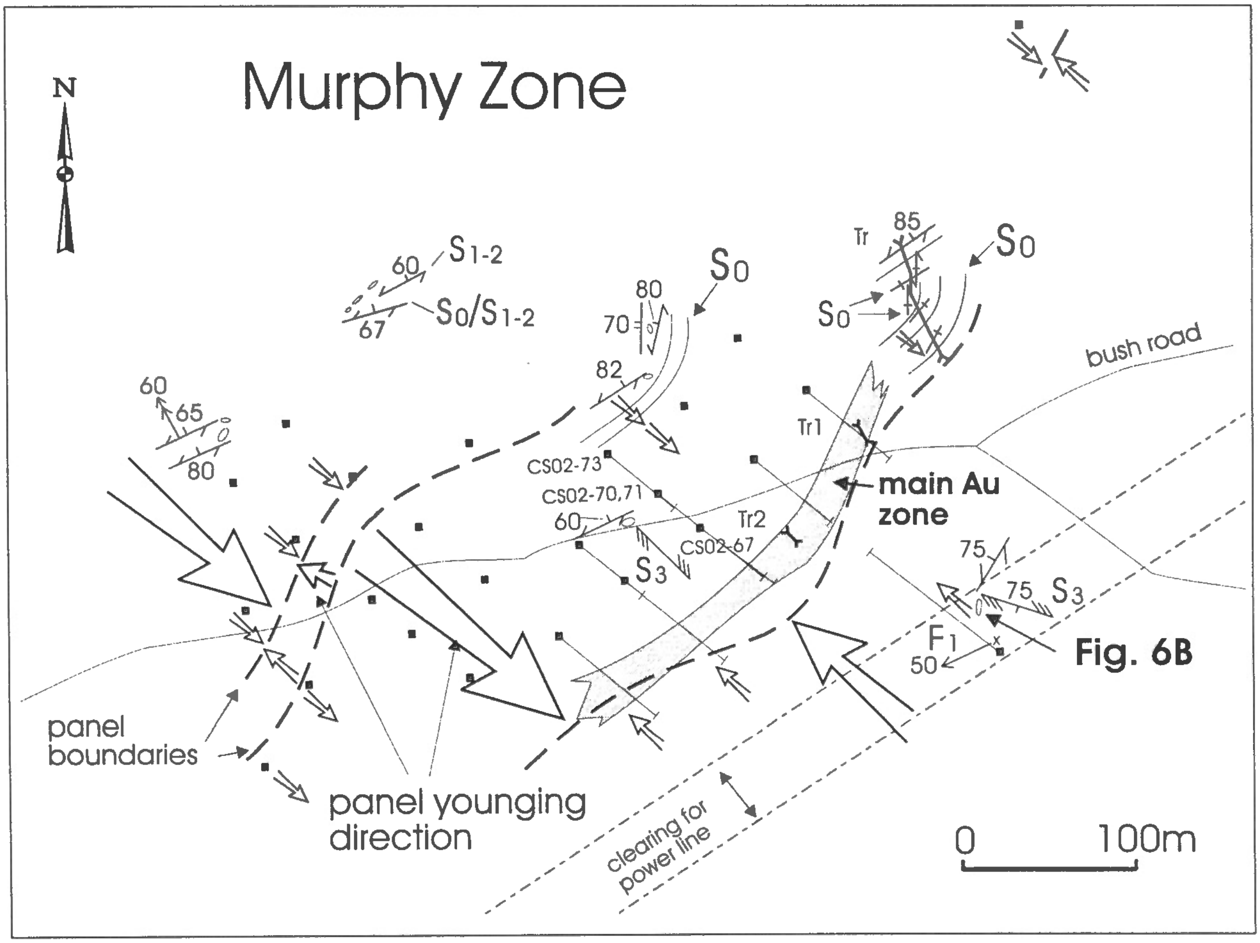

Figure 5. Plan map of Murphy Zone showing the main structures interpreted from surface outcrops plus the surface projections of main mineralized zone and of panels of younging reversals, interpreted using cross-sections Lutes (Unpublished reports, 2001, 2002).

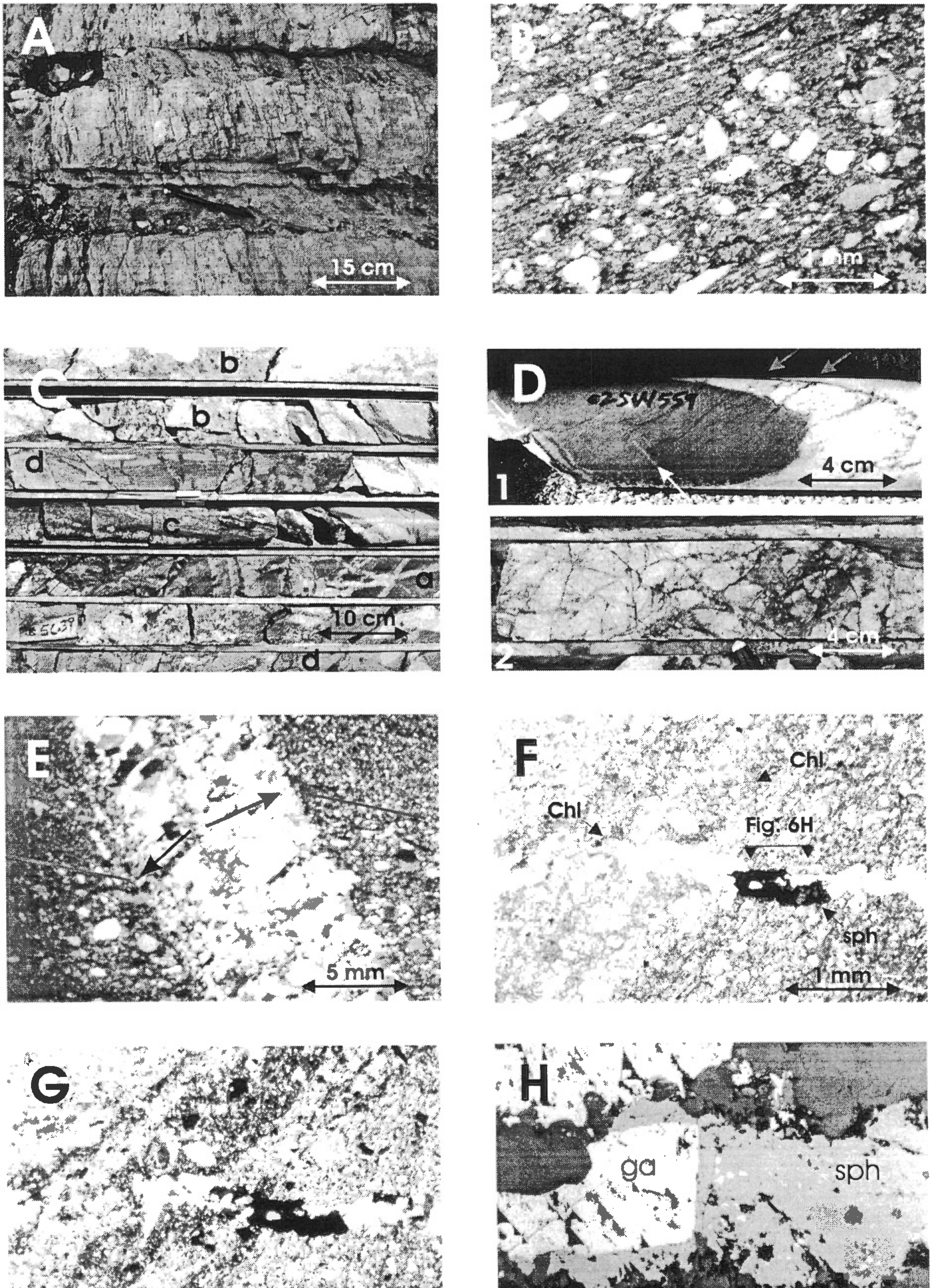
A
15 cm
B
1 mm
C
b
b
d
c
a
10 cm
d
D
1
4 cm
2
4 cm
E
5 mm
F
Chl
Chl
Fig. 6H
sph
1 mm
G
1 mm
H
ga
sph
0.2 mm

Figure 6. Photographs of representative structures and veins associated with gold-mineralized zones of Anomaly "A".
A. Horizontal view of steeply dipping, spaced (in greywacke beds), NW-trending cleavage (correlative to the regional S_3), Murphy Zone "power-line" outcrop. Pencil is parallel to refracted cleavage in argillite beds. See location in Fig. 5.
B. Photomicrograph of the main spaced solution cleavage in unaltered greywacke, AD Zone (transmitted plane light). See description in text.
C. Drill cores of the gold-mineralized zone in MW Zone showing: a. stockwork veins, b. vuggy massive quartz-sulphide vein, c. layered sulphides and quartz, d. intensely altered buff-coloured sedimentary wallrock..
D. NQ drill cores - MW Zone, showing:
1. Ghosts of sericitic S_1 solution planes in early quartz vein (white arrows). Black arrows point to late veinlets of laumontite, base-metal sulphides.
2. Multiphase gold-mineralized quartz-sulphide veins - clear quartz veinlet matrix to brecciated quartz veins
E. Photomicrograph of an early quartz vein showing extensional quartz fibres (polarized transmitted light). Black arrows show opening direction parallel to fibres at point of bedding contact (white lines) between greywacke and siltstone (unaltered), Murphy Zone. Vein is 7mm wide.
F, G, H. Photomicrographs of late base metal veinlet cutting chlorite veinlet in outer/weakly altered wallrock greywacke of Murphy gold Zone. Note characteristic pale green chlorite in altered host-rock vs. intense green of chlorite in late vein. F. plane transmitted light, G, polarized transmitted light, H. reflected light close-up of opaques in F and G. ga=galena, sph=sphalerite (with blebs of chalcopyrite).

Definite mesoscopic indication of F_3 folds were not observed at outcrop-scale or in drill core, but the near vertical, west-northwest striking cleavage observed in outcrop south of the Murphy Zone (Fig. 5, 6A) post-dates the main fabric and is compatible with regional F_3 folding (Castonguay et al., 2003).

Locally, as in Trench # 2 of the Murphy zone (Fig. 5), two sets of late irregular brittle slickensided planes apparently offset the mineralization. One set is steeply northeast dipping and has shallowly northwest-plunging slickenlines with indeterminate movement sense. The other set is shallowly north-northeast-dipping with coarse slickenlines plunging north-northwest and fine north-plunging slickenfibres, the latter indicating southward reverse movement. A similarly slickensided shallow north-northeast dipping surface was also observed in Trench # 1. The offset of mineralized zones on NW-trending structures is consistent with possible dextral offset of the mineralized trend between the Murphy and AD Zones. The broken signature of the magnetic anomaly in the south of the property (Fig. 3) as detailed by ground geophysical surveys conducted by Freewest Resources Canada Inc., potentially reflects the same NW-trending faulting. The apparent offset of the magnetic trend is in the same amount and sense as the postulated offset of the mineralized zone between the Murphy and AD Zones. This deformation may reflect the D4 structures of Castonguay et al. (2003).

General Description of Gold Mineralization

Observations from the present study indicate that most of the gold is contained within roughly tabular deformation zones commonly several metres thick that are variably dominated by stockwork veins, vein breccia or massive quartz-sulphide veining (Fig.6C). The mineralization is associated and often comprised within metric brittle high-strain zones (including breccias and cataclasites), which appear to have overall northeast to east-west strikes with variably sub-horizontal to moderate dips to the north and northwest in the AD and Murphy zones, and to the southeast in the MW Zone (Fig. 3, 4). Structures bounding the Murphy Zone are interpreted to be combinations of sub-horizontal fracture zones and steeper bedding-parallel shears (Lutes, unpublished reports 2001, 2002). A rough parallelism of the gold-mineralized zones with the panels of younging reversals can be seen in the interpreted surface expression of both features in the Murphy Zone (Fig. 5) and in the plane of the section examined on the AD Zone (Fig 4). Further, in some places mineralized zones are enclosed within the zone in which the reversal is constrained.

Gold grades in the drill sections examined include intersections of up to 17.83 g/t gold over 10 metres (Fig. 4) and individual multi-ounce assays (over 0.5 m core sample intervals) occur in many of the zone intersections that contain visible gold. The majority of the gold occurs within quartz-sulphide veins containing mainly pyrrhotite, arsenopyrite, pyrite and stibnite, though a few minimally veined samples of sulphide-bearing, intensely altered greywacke analysed for the present study yielded up to 1-2 g/t gold in both the Murphy and AD Zones.

Alteration Associated with Gold Mineralization

The gold mineralization is accompanied by discrete, visible, rock alteration (Fig 4) characterized macroscopically by sharp to gradational changes in colour, which appear to reflect intensity of alteration rather than separate episodes or style of alteration. Greenish-grey, weaker alteration occurs in the outermost parts of the main mineralized zones and is also associated with quartz veining in isolated, weakly anomalous gold-bearing zones. Intense, buff-coloured alteration, commonly containing up to about 5% arsenopyrite and pyrite, is much more restricted in extent and appears to be limited to the main gold-mineralized zones. Carbonate is notably absent as confirmed by analyses routinely yielding less than 0.01% CO_2 (Table 1).

Table 1 : Geochemical analyses

	Mineralization									Greisen overprint											Sericite alteration			Bleach.
	02-SW-523	02-SW-524	02-SW-517	02-SW-519	02-SW-532	02-SW-540	02-SW-541	02-SW-543	02-SW576	02-SW-530	02-SW-531	02-SW-551	02-SW-539	02-SW-544	649573	649574	649575	649618	649619	649620	02-SW-529	649672	649673	greyw. 649644
Major elements (weight %)																								
SiO_2[1]	34.30	78.34	69.72	53.42	88.26	77.82	65.86	80.26	79.21	80.63	61.39	76.85	50.41	85.81	66.39	77.30	72.42	60.21	49.33	62.16	58.41	66.21	59.67	79.44
Al_2O_3[1]	7.79	9.48	5.12	17.57	2.71	1.86	3.09	7.25	4.69	7.12	3.82	12.36	8.26	5.31	3.07	0.94	5.70	17.46	20.94	3.82	19.92	16.64	21.66	7.83
TiO_2[1]	0.39	0.57	0.32	0.97	0.12	0.13	0.08	0.58	0.34	0.45	0.23	0.78	0.39	0.26	0.16	0.04	0.33	0.79	0.84	0.22	1.27	0.83	1.05	0.44
CaO[1]	0.16	0.13	0.05	0.14	0.02	0.04	0.01	0.08	0.05	0.15	0.05	0.11	0.08	0.05	0.02	0.12	0.03	0.16	0.23	0.04	0.19	0.36	0.34	2.75
MgO[1]	1.43	1.08	0.34	2.01	0.13	0.14	1.37	0.50	0.80	0.47	0.62	0.72	0.17	0.32	0.50	0.44	0.53	1.09	1.11	0.39	1.62	1.65	1.76	0.75
Na_2O[1]	0.06	<0.01	0.02	0.10	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	0.01	0.02	<0.01	<0.01	<0.01	0.16	0.07	0.14	0.22	0.05	0.17	0.32	0.22	1.19
K_2O[1]	1.32	2.06	1.10	3.27	0.44	0.25	0.04	1.71	0.73	1.60	0.49	2.70	1.87	1.24	0.51	0.21	1.20	3.86	4.59	0.80	3.92	3.38	4.54	0.13
Fe_2O_3[1]	36.36	5.56	12.69	14.67	5.30	12.39	20.98	6.48	8.20	6.20	8.54	4.00	11.38	4.31	15.43	11.97	12.10	6.93	4.88	17.27	9.67	7.38	7.31	4.65
MnO[1]	0.15	0.05	0.01	0.10	0.02	0.02	0.06	0.02	0.04	0.04	0.14	0.04	0.02	0.01	0.03	0.02	0.02	0.08	0.06	0.03	0.41	0.10	0.09	0.07
LOI[1]	18.40	2.80	11.00	8.05	3.45	7.65	8.90	3.20	5.15	3.35	5.35	2.20	13.85	2.00	9.85	7.50	7.85	4.00	4.45	10.40	4.35	3.00	3.35	2.35
Sum	100.40	100.20	100.40	100.50	100.20	100.30	100.40	100.20	99.31	100.10	80.67	100.00	86.46	99.25	95.71	98.72	100.23	94.84	86.76	95.19	100.20	99.96	100.18	99.67
CO_2[5]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.39	0.13	0.11	0.04	0.05	<0.01	0.01	0.01	0.09
S[6]	26.00	1.81	5.83	5.36	1.34	5.97	11.10	2.47	3.88	3.49	7.32	0.32	10.70	2.07	9.80	7.55	7.84	2.20	3.40	8.00	0.25	0.21	0.10	0.96
Trace elements (ppm)																								
Au[4] (ppb)	13100.0	3060.0	>10000	8350.0	8300.0	7950.0	45200.0	>10000	6450.0	18800.0	1780.0	191.0	25100.0	5080.0	34800.0	49000.0	26700.0	39600.0	63500.0	103100.0	76.0	22.0	11.0	16.0
As[2,3]	7670.0	2930.0	>10000	>10000	>10000	>10000	>10000	>10000	>10000	358.0	348.0	1260.0	>10000	3800.0	>1000	>1000	>1000	680.0	326.0	>1000	370.0	120.0	50.2	3.0
Ag[2]	0.7	<0.2	0.2	<0.2	0.4	1.8	3.1	1.6	1.6	5.1	>10	1.7	7.6	0.7	2.1	1.7	2.7	4.5	>10	>10	1.3	<0.2	0.4	<0.2
Cu[2]	52.5	20.2	12.5	137.0	10.8	91.3	248.0	99.4	64.5	226.0	1860.0	43.1	80.6	90.0	328.0	199.0	202.0	195.0	168.0	915.0	20.1	35.0	12.2	77.4
Zn[2]	21.1	33.4	10.9	38.9	211.0	130.0	124.0	390.0	49.9	163.0	112300.0	33.4	731.0	1070.0	7530.0	425.0	319.0	1050.0	228.0	155.0	848.0	62.5	63.6	380.0
Pb[2]	38.0	22.0	10.0	73.0	49.0	1710.0	160.0	171.0	138.0	217.0	19200.0	227.0	764.0	55.0	875.0	419.0	532.0	483.0	1530.0	75.0	567.0	43.0	5.0	14.0
Sb[2,3]	181.0	203.0	>1000	4900.0	424.0	2770.0	1160.0	4690.0	438.0	113.0	37.3	2220.0	>10000	6120.0	>1000	>1000	>1000	>1000	>1000	>1000	54.8	71.5	48.6	7.9
Bi[2]	10.0	<5	<5	<5	<5	<5	6.0	<5	<5	205.0	20.0	<5	<5	<5	8.0	<5	7.0	56.0	31.0	12.0	<5	7.0	7.0	<5
Mo[2]	<1	<1	<1	<1	<1	<1	<1	<1	3.0	59.0	128.0	<1	<1	<1	4.0	3.0	2.0	1.0	<1	1.0	2.0	1.0	1.0	1.0
F[7]	265.0	305.0	190.0	494.0	95.0	87.0	112.0	220.0	162.0	359.0	213.0	351.0	238.0	141.0	100.0	10.0	162.0	945.0	1090.0	165.0	691.0	553.0	692.0	293.0
Co[2]	34.0	10.0	10.0	18.0	7.0	12.0	8.0	16.0	9.0	9.0	26.0	10.0	7.0	11.0	25.0	5.0	12.0	21.0	7.0	91.0	14.0	15.0	21.0	9.0
Cd[2]	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1320.0	<1	<1	6.0	59.0	9.0	7.0	13.0	4.0	10.0	3.0	3.0	3.0	4.0
Sn[2]	<10	<10	<10	<10	<10	<10	<10	<10	<10	23.0	14.0	14.0	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Li[2]	59.0	31.0	26.0	75.0	22.0	20.0	45.0	21.0	36.0	37.0	40.0	40.0	0.5	16.0	23.0	11.0	15.0	49.0	50.0	19.0	56.0	63.0	74.0	31.0
Sr[1]	9.0	19.0	11.0	37.0	5.0	8.0	2.0	8.0	14.0	14.0	1.0	40.0	15.0	9.0	12.0	19.0	22.0	40.0	43.0	7.0	70.0	63.0	72.0	258.0
Rb[1]	66.0	109.0	69.0	160.0	37.0	12.0	6.0	95.0	51.0	169.0	36.0	155.0	1.0	62.0	21.0	4.0	60.0	172.0	156.0	17.0	193.0	165.0	220.0	9.0
Sc[2]	3.9	6.9	2.9	12.1	1.3	0.9	4.1	6.5	3.8	6.8	2.4	10.3	5.8	4.4	2.4	2.8	5.5	13.6	18.6	2.6	15.1	15.7	20.6	5.0
Ni[2]	53.0	20.0	27.0	40.0	16.0	22.0	24.0	23.0	22.0	30.0	20.0	14.0	<1	15.0	28.0	20.0	22.0	22.0	3.0	57.0	37.0	33.0	46.0	17.0
Cr[2]	25.0	20.0	14.0	37.0	10.0	9.0	8.0	31.0	21.0	21.0	10.0	23.0	30.0	19.0	354.0	347.0	288.0	240.0	228.0	266.0	54.0	150.0	162.0	136.0
V[2]	48.0	48.0	29.0	91.0	16.0	14.0	16.0	57.0	25.0	49.0	27.0	68.0	36.0	36.0	29.0	15.0	53.0	98.0	86.0	36.0	123.0	115.0	148.0	37.0
Zr[1]	63.0	204.0	62.0	181.0	21.0	25.0	8.0	113.0	106.0	110.0	51.0	355.0	67.0	41.0	49.0	12.0	64.0	144.0	121.0	45.0	340.0	164.0	211.0	260.0

Analysis by XRAL Laboratories: 1=X-Ray Fluorescence Spectometry, 2=ICP-80, 3=Fusion/ICP/Hybride AA, 4=Fire Assay, 5=Coulometry, 6=Leco, 7=Lachat QuicChem

Petrography of Altered Rocks

Thin-sections of unaltered, weakly altered and intensely altered rocks were examined from the Murphy Zone and the AD Zone (12 greywackes and 9 argillites) in order to characterize mineralogical and textural changes that accompany the alteration related to gold mineralized zones, and to determine if the changes can be tied to one or more of the structural phases.

Microscopically, the most obvious change in altered greywackes is an increasingly dominant pressure solution cleavage S_{1-2}. Dissolution of quartz clasts resulted in elongate grains parallel to foliation (Fig. 6B). Domains that are subject to solution have higher argillic content due to removal of quartz. Solution domains in the unaltered greywackes are generally not as extensive or pervasive. The solution cleavage is unevenly expressed in the greywackes, ranging from domains 1-2mm wide, spaced centimetres apart, to a uniform, pervasive and intense solution fabric with local, lenticular remnants within which original quartz clasts remained intact. This solution cleavage is not evident in argillites that do not contain quartz clasts..

In the intensely altered argillites and greywackes, opaques are predominantly (commonly >90%) white to buff-coloured in reflected, oblique illumination (mainly leucoxene alteration of ilmenite?), which is largely responsible for the yellowish buff colour of the intensely altered rocks. The weakly altered greywackes and argillites contain intermediate amounts of dark grey metallic and altered light buff-coloured opaques. Other opaque minerals present in intensely altered host rocks and less abundant in weakly altered rocks, include highly variable amounts of regularly disseminated sulphide minerals up to about 2mm in size, including primarily pyrite, pyrrhotite, arsenopyrite and stibnite. In places, stibnite is present as films both along and perpendicular to cleavage planes. Chlorite is the main mineral that characterizes the weakly altered greywackes and argillites and is probably responsible for the greenish colour. Chlorite varies in occurrence from selective replacement of rock fragments in the host greywacke to veinlets in argillite with little or no chlorite in the intervening host. In some greywackes, chlorite occurs mainly as anastomosing veinlets parallel to the solution cleavage. Chlorite, both in veinlets and as replacement of host rock fragments, has the same pale yellowish green colour and is uniformly very fine-grained (commonly less than 0.03 mm and up to about 0.1-0.2 mm). The chlorite veinlets are both parallel and nearly perpendicular to the main foliation.

Other types of rock alteration not directly associated with the gold mineralization, and having more limited extent, were identified in drill cores. One type ("massive sericite" of Table 1) occurs in a few zones of apparent metre-scale thickness characterized by compact, medium to dark green sericite with highly folded and dismembered white quartz veins as noted by Lutes (unpublished report 2001). The protolith is not obvious macroscopically. Limited petrography from DDH 70 of the Murphy Zone shows that the greywacke portion of the host rock was subject to very intense pressure solution, in places highly concentrating opaques that exhibit the original dark grey metallic appearance in oblique illumination. Some pyrite grains are disseminated in the host and in the highly deformed and sheared off quartz-chlorite veins. About 10% chlorite occurs within the host rock both as veinlets and as apparent replacement of host rock sericite.

Two other alteration types are notable. One is a green, chlorite-rich, fluorite-bearing greisen-style alteration affecting a greywacke bed, and overprinting early quartz veins, about 10 metres below the gold zones in MW 08 (Fig. 4). The other is a unique, white, bleached(?) alteration zone about half a metre wide in greywacke below the greisen zone. In thin-section, the main alteration mineral in this zone is tentatively identified as laumontite. This zone has an abundance of mm-wide pyrrhotite veinlets, which in polished section, are observed to contain grains up to about 0.5mm of sphalerite enclosing exsolution-like blebs of chalcopyrite. (Table 1, sample 649644).

Vein Paragenesis

Several episodes/styles of veining are evident in drill cores and surface outcrops. These include: (1) early (barren?) veins that are syn- to post-D1; (2) cross-cutting, multiphase, quartz-sulphide veins that contain most of the gold and are interpreted as late D2; and (3) late cross-cutting, non-gold-bearing(?), sulphide- and fluorite-bearing veins.

Early Veins

The early veins are more prevalent in the greywackes and are composed mainly of white quartz with lesser chlorite. The great majority of these veins are 0.5 to 4 cm thick and typically display extensional textures including local quartz crystal-lined vugs. Some appear to be replacements of the host-rock while others have distinct quartz fibre growth perpendicular to the vein walls with one or more central, chlorite-rich seam(s) parallel to the walls. Macroscopically, many appear to overprint the widespread, S_{1-2}, spaced solution-cleavage in greywackes as evidenced by ghosts of the sericite-rich planes traversing the quartz veins (Fig. 6D) and the majority are nearly perpendicular to the cleavage. In general, these early veins probably represent end members of a continuum between wholesale replacement and open-space filling, in which the vein style is governed by such factors as opening rates, lithology and pre-existing fractures. Minor native gold may have been deposited during this stage of veining, since a few chlorite-rich, decimetre-scale white quartz-chlorite veins similar to these early veins, contain visible gold.

Petrographically, the early quartz veins are characteristically cloudy in plane light, have 0.5-1mm quartz grains with irregular inter-grain contacts and undulose extinction with variable amount of subgrain development. One of the larger veins examined has coarser quartz grains up to over half a centimetre in diameter with polysutured grain contacts and a high degree of subgrain development. Most veins examined consist of elongate quartz fibres with long dimension oriented roughly perpendicular to vein walls. These occur either as single crystals spanning the entire width of the vein or as one or more sets with a central vein-parallel region of more equant, smaller size quartz grains plus, commonly, chlorite. Locally, quartz crystals are in optical continuity with larger quartz class in the adjacent wallrock. Chlorite, commonly comprising less than 5% of the vein, is generally pale yellow-green in plane transmitted light, is mostly very fine-grained (0.03mm), and occurs in irregular patches about up to several mm across and locally along planes parallel to vein walls. Slivers of wallrock parallel to vein walls are locally enclosed within quartz veins.

Open-space filling by extensional quartz fibre growth is demonstrated in thin-section (Fig. 6E) where a vein cuts across a lithologic contact at about 60 degrees. The offset of the bedding contact on opposite sides of the vein can be exactly eliminated if the walls are joined by closing the space now occupied by the vein, along the direction of the quartz fibres. Elsewhere, wallrock replacement is evident on the basis of relict textures across some veins. Ghost textures consist of chlorite +/- sericite similar in grain-size and shape to that in the adjacent host, occurring along the projection of sericite-rich planes in the adjacent wallrock. Thin-sections show that the sericite-rich planes are domains of quartz dissolution in the host greywacke. Some of the dissolution planes in the wallrock extend into the quartz vein as stylolitic surfaces defined by insoluble chlorite. The foregoing textures are consistent with the interpretation that the quartz-chlorite veining is broadly synchronous with the solution cleavage development, in part overprinting and in part affected by it.

Gold-bearing quartz-sulphide veins

Multiple phases of veining characterize the deformation zones containing the majority of gold. These typically include irregular, locally folded sulphide-bearing stockwork-type veins, massive quartz-sulphide veins, some more than two metres wide and, locally, narrow veins that are completely disjointed especially in argillite-rich beds. All vein types are locally vuggy and all types locally display post-vein brittle deformation. Quartz with sulphides also commonly occurs as translucent veinlets filling fractures and forming the matrix to coarse breccias of the earlier quartz veins (Fig. 6D). Although the massive veining is commonly intersected in adjacent drill holes, the precise attitude and continuity of individual massive veins is unclear. These massive veins contain generally < 15% sulphides and typically have the highest gold grade-thickness. Trench exposures on the Murphy Zone show that stockwork-type veining is more abundant in the relatively competent greywacke beds as opposed to the argillites.

The coarse-grained (mm-scale) sulphide assemblage visible in the Murphy, AD and MW zones are quite similar overall consisting mainly of variable proportions of arsenopyrite, pyrite, pyrrhotite and stibnite. Textures and mineralogy of the sulphides vary abruptly in some zones, ranging in occurrence from very fine-grained veinlets and locally colloform-like masses to coarser-grained irregular masses of various sizes dispersed throughout quartz veins and, rarely, as massive layers up to several centimetres thick of mineralogically banded sulphide minerals. Stibnite, apparently lacking other sulphides, also occurs in highly vuggy centimetre-scale quartz veins within some gold-mineralized zones. In these veins, stibnite occurs enclosed by quartz, as crystals lining vugs, and commonly remobilized(?) as films on fractures and cleavages. Timing of these veins with respect to the more typical gold-bearing veins is ambiguous. Massive stibnite has also been discovered in the AD Zone with drill intersections exceeding two metres.

Crushed concentrates from five, half metre drill core samples from the AD and MW Zones, studied by Cabri (unpublished report 2002), indicate that the opaque mineralogy of the main gold-bearing intersections is quite complex. Native gold and numerous major ore mineral sulphides and sulphosalts composed of Fe, S, As, Sb and Pb, including pyrite, pyrrhotite, arsenopyrite, stibnite, berthierite ($FeSb_2S_4$) and jamesonite ($Pb_4FeSb_6S_{14}$) are present. Jamesonite occurs as a major mineral in only one sample, which also contains trace amounts of miargarite ($AgSbS_2$) and the only Ag-rich native gold. Cabri (unpublished report 2002) also identified minor opaque minerals including gudmundite (FeSbS) and kermesite (Sb_2S_2O) a secondary oxide, and a wide variety of trace to rare minerals (mainly sulphides, antimonides and sulphosalts) including native gold, native antimony, aurostibite ($AuSb_2$), nickel-bearing aurostibite, the rare mineral nisbite ($NiSb_2$), ullmannite (NiSbS), silver-rich and silver-poor tetrahedrite ($Cu_{12}Sb_4S_{13}$), chalcopyrite, sphalerite, Ni-bearing cobaltite ((Co, Fe, Ni)AsS), and rare magnetite, scheelite ($CaWO_4$), and zircon.

Cabri (unpublished report 2002) found that gold is present in significant quantities both as native gold and in aurostibite, but its possible presence in trace amounts ('invisible' gold) within the major minerals pyrite, arsenopyrite, and berthierite was not assessed. He further reported that the Ni-bearing minerals are consistently associated with the gold and suggested that this Ni (and Co) signature was possibly due to remobilization from a mafic or ultramafic source. He reports that gold is commonly intergrown with stibnite and is texturally associated with pyrrhotite, berthierite, ullmanite, gudmundite, arsenopyrite, chalcopyrite, sphalerite and with gangue minerals quartz and Fe-rich chlorite (chamosite) and other Ca-Al silicates. The association with generally only trace amounts of Cu, Zn and Pb minerals is consistent with the locally elevated but low concentrations of these elements in the analysed gold veins (Table 1).

Late Veins

The latest veins are typically up to several millimetres wide, planar, highly vuggy, and crosscut the gold-mineralized veins (Fig. 6D). They include various combinations of chlorite, quartz, muscovite, fluorite, chalcopyrite, galena and sphalerite plus abundant laumontite (Douglas Hall, written communication) and minor carbonate. They occur in each of the three zones of anomaly A and are widespread in altered and unaltered wallrocks with up to >3 veinlets per metre over more than 20 m (e.g. bottom of DDH AD-09, Fig. 4). The veins are inferred to be related to a separate greisen-style mineralization similar to that observed in the MW Zone (Fig. 4).

In thin-section, the late veinlets, in contrast to all earlier veins, typically have clear quartz in plane light and sharp extinction under crossed polars, and quartz crystals grow inward from the walls ending with good crystal terminations. Chlorite is more intensely green in plane light and has more anomalous interference colours (Fig. 6F, G). It occurs as massive, fine-grained segments and in vermicular intergrowth with quartz. Base-metal sulphides are commonly coarse-grained and sphalerite in the sections examined has blebs of chalcopyrite, probably as exsolution (Fig. 6H). Drill core observations and preliminary petrographic work indicates that most of the base metals present in the gold-mineralized zones are actually related to these late, overprinting veinlets associated with a greisen-style mineralizing event (see below).

Geochemistry

A whole rock geochemical study of the Murphy, AD and MW zones (Table 1) was undertaken in order to characterize the gold veins and the altered wallrock. The study also assessed greisen-style alteration and late base-metal-fluorite veins in an attempt to separate the effects of later mineralizing fluids on the gold system. Samples were analysed from a fluorite-bearing greisen-style alteration zone (inferred to be related to the late veinlets) occurring about 10 metres below the main gold zone in DDH MW02-08 (Fig. 4).

Analytical results from weakly and intensely altered wallrock are compared with unaltered equivalents on Isocon diagrams (Grant, 1986) presented in Figure 7A-D. Because of the low sample numbers, statistical analyses of confidence intervals for the plotted averages were calculated using Student's t distribution (see discussion in Fig. 7 caption). Separate diagrams were generated for greywackes and argillites. Results for the overprinting greisen alteration of greywacke are presented in Figure 7E and F. Some elements (Mo, Cd, Sn, W, Bi, CO2) commonly associated with greisen-style mineralization were not analysed at a low enough detection limit for consideration and are not plotted for gold-associated alteration. Interpretation of the diagrams for greisen alteration is not significantly affected by these high detection limits, since the altered samples generally contain amounts of these elements appreciably above the limits.

Immobility of Ti and Al during gold-related alteration of the greywackes is strongly supported by the plotted data since a line (the isocon) from the origin through the average for Ti from the intensely altered suite intersects the Al average from the same suite, and a similar line can also be drawn which lies within the confidence bar for both Ti and Al for the moderately altered greywackes. Also, the increasing steepness of slope (both >45 degrees) of these two lines from the moderate/outer to the intense/proximal alteration, respectively, is consistent with the interpretation that Ti and Al were immobile during rock alteration characterized by increasing intensity of bulk mass removal. Argillites likewise permit a straight line to be drawn from the origin through the confidence intervals of both Ti and Al. The limits of error associated with the isocon lines are arbitrarily taken as the steepest and the least steep lines that lie within both of the confidence intervals for Ti and Al.

It is difficult to identify immobile elements associated with the greisen alteration due to the fact that no single line from the origin joins more than one commonly immobile element. In order to increase confidence in the interpretation of elements added and removed, a very broad isocon error region was arbitrarily chosen by enclosing all the confidence intervals associated with Ti, P (also commonly immobile in these systems) and Al. Ti might, however, be mobile during greisen alteration, especially if F is volatile (Lentz and Gregoire 1995).

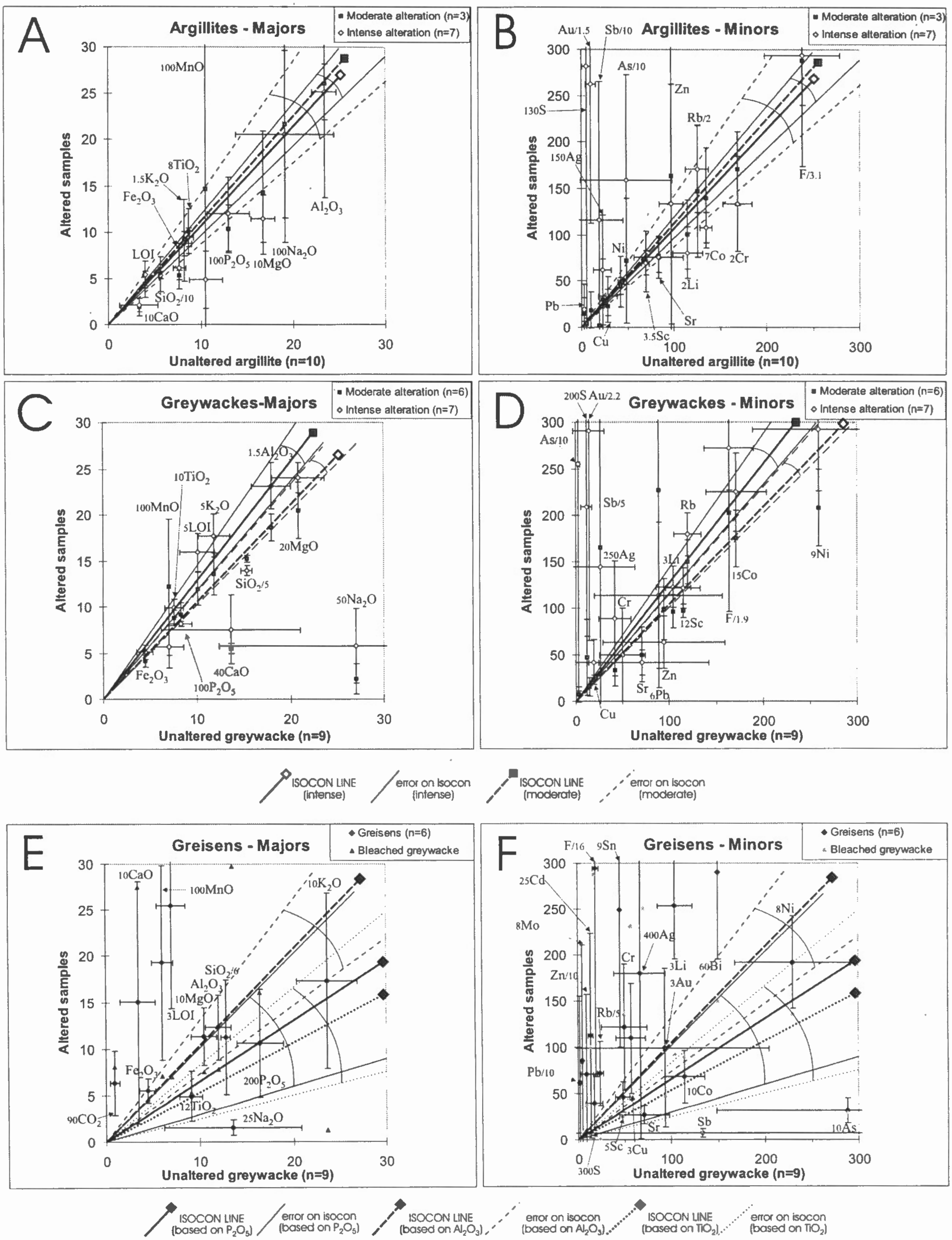

Figure 7. Isocon diagrams comparing the average weight concentrations of elements in unaltered greywackes and argillites with equivalents that are altered in association with gold mineralized zones (A to D) and in association with greisen zones (E and F). Bars attached to mean values show, at a 90% confidence level, the interval over which the true population mean would lie using Student's "t" for the low sample numbers (n) as indicated on each diagram (Hutchison 1974). A confidence interval thus plotted would enclose the true mean of the population, 9 sampling trials out of 10.

Geochemistry of Alteration Associated with Gold Mineralization

Chemical changes in the altered wallrocks of the gold mineralized zones (summarized in Table 2) are clearly lithology dependent and vary with intensity of alteration. The isocon diagrams indicate that the only major element removed from the wallrock of both the greywackes and argillites is Mn, during intense alteration. In addition to Mn, greywackes were subject to removal of Si, Na and Ca whereas argillites were subject to removal of Mg. Minor elements removed from greywackes include Ni and Sc, probably Sr (consistent with Ca removal) and possibly Zn. Argillites have indicated removal of two minor elements: Co and Li.

TABLE 2 Summary of elements added and removed during alteration

ALTERED WALLROCK ENCLOSING GOLD ZONES

( )elements in brackets are probably/possibly added or removed

lithology	elements removed			elements added	
	INTENSE & MODERATE	MODERATE ONLY	INTENSE ONLY	INTENSE & MODERATE	INTENSE ONLY
greywacke					
MAJORS	Na Si Ca		Mn		
MINORS	(Sr)	Sc (Ni)	(Zn)	Sb (F)	Au As S F (Ag Cu)
argillite					
MAJORS			Mg Mn		
MINORS			Co Li		Au As S Sb Ag Pb (Zr)

GREISEN ALTERATION

lithology	elements removed	elements added
greywacke		
MAJORS	Na	Ca Mn CO2
MINORS	As (Sb)	F Bi Li Sn Rb Cd (Ag Mo Cu Pb Zn S Cr)

Additions of minor elements to both greywackes and argillites are more consistent including S, Au, As, Sb and Ag during intense alteration. Also, F and possibly Cu were added to greywackes whereas Pb and possibly Zr were added to argillites.

As and Sb concentrations in unaltered argillites and greywackes (Table 1), when compared with the world averages for these elements reported for shales and for basalts, granodiorites, granite, shales and limestones, respectively (Levinson 1974) indicate that the 'unaltered' rocks contain greater than 100 times world averages. This indicates that the samples throughout the drilled sections are actually altered and that the rock alteration halo for these elements is quite extensive beyond the visually obvious alteration.

Geochemistry of gold-bearing quartz-sulphide veins

The veins are separated into two groups isolating those samples suspected of being overprinted by veining of the late base-metal-fluorite association (Table1). The veins with no suspected overprint clearly show strong correlations between Au and As, Sb and S with most of the high grade gold samples of both groups containing more than 1% As and commonly close to 0.5% Sb. A rare exception assayed >18 g/t gold with only 358ppm As, 113ppm Sb, and elevated but <250ppm Cu, Pb, and Zn.

Although Ni-bearing minerals are associated with gold (Cabri, unpublished report 2002), only very low concentrations were found in the presently analysed samples, including the highest combined Ni (57ppm) - Co (91ppm) concentrations in one sample adjacent to the sample in which Ni-bearing aurostibite was described. Geochemical results of the present study (Fig. 7B, D) indicate that the concentrations of Ni and Co in the analysed veins (Table 1) could have been derived from gold-related alteration of wallrock greywackes and argillites, respectively. Base metals Cu, Zn and Pb, although locally expressed mineralogically in textural association with gold (Cabri, unpublished report 2002), are generally less than 100ppm in the analysed high-grade gold vein samples except for those with suspected overprinting by late veins of the base metal-fluorite association. In sample 02-SW-531, these late veins overprint gold-mineralized rock and the analysed sample suggests an element association of Cu, Pb, Zn, Ag, Mo, Cd, Sn and Bi (Table 1). Greisen-style alteration in the MW Zone has elevated abundance of the same elements (Fig.4, Table 1, 2).

Discussion and Conclusions

Timing of Gold Mineralization

Constraints on the timing of gold mineralization are provided by crosscutting veins, relationship to structural phases at the local and regional scale, and by comparison with the Main Zone deposit. Crosscutting base-metal-fluorite veins give an upper time limit for gold mineralization, since similar greisen-style Sn-related mineralization is widely associated with the several late Devonian plutons in the area (Taylor et al. 1985). The $^{40}Ar/^{39}Ar$ cooling age of the Pleasant Ridge granite, ca. 361 Ma (Taylor 1992), is probably within a few million years of this upper limit. The lower age limit is indicated by structural considerations. The high-strain zone containing gold mineralization is interpreted to be genetically related to D_2 folding, at least locally cutting the limb of the

F_2 fold overlying the Murphy Gold Zone, thus indicating a late-D_2 timing of gold mineralization. Furthermore, gold-rich quartz-sulphide veins enclose wallrock fragments locally exhibiting at least two cleavages, which if correlative to regional fabrics, would provide a similar relative timing.

Ruitenberg (1967) observed that the 401±4 Ma Tower Hill granite (Rb-Sr; Taylor, 1992) encloses fragments with evidence of F_3 folding indicating that D_3 is no younger than 401 Ma and that gold mineralization is significantly older than the Late Devonian Pomeroy suite of intrusions. Since D_2 phase folding is interpreted to affect the Silurian Digdeguash Formation in the region (Ruitenberg 1967, Castonguay et al. 2003), the maximum age of the mineralizing event must be younger than the early Silurian, Landoverian age (ca 430 Ma) of graptolites in the Digdeguash (Fyffe and Riva 1990, 2001).

The age of mineralization at Anomaly A is likely to be close to that of the Main Zone gold deposits since they are nearby and are mineralogically similar (ore mineral study of Cabri, unpublished report 2002). Also, the time constraints would allow for them to be contemporaneous. At the Main Zone, monazites from within a pegmatite dyke that is inferred to grade into a mineralized quartz vein were dated at 390+/-8 Ma (electron microprobe age; Thorne et al., 2002) and 400+/- 5 Ma (maximum age; Davis et al., in preparation). The pegmatite is interpreted to be related to intrusion of the Magaguadavic phase of the Saint George Batholith (Thorne et al. 2002).

The zircon identified in Cabri's ore mineralogy study (unpublished report 2002) is noteworthy considering that it occurs as inclusions in arsenopyrite and that Zr is one of the elements interpreted to be introduced during alteration of argillites (Table 2). Therefore, it is potentially present as new growth during mineralization and may be suitable for radiometric dating, providing a direct age of the mineralizing event at Anomaly A.

Geological model for the deposit

A preliminary model proposed for the gold deposits of Anomaly A recognizes the interdependence of structure, alteration and veining over the protracted period recorded in the polydeformed host rocks of the Kendall Mountain Formation. The model mostly addresses controls that created structural porosity, permitting the focussed flow of hydrothermal fluids necessary for formation of a gold deposit. Evidence is presently too limited to interpret physical and/or chemical controls on the deposition of gold within these structures.

Late D_2 thrust faulting is proposed as the overall mechanism that generated the zones of dilatancy in which gold-bearing quartz-sulphide veins were deposited. The connection is uncertain between the proposed late D_2 thrust faulting and the Cranberry Lake Fault, which based on regional geological mapping, apparently runs through the property near the southern boundary of the Murphy and AD Zones (Fig. 2; Fyffe 1997). The gold-mineralized deformation zones might be associated with this structure. The competency contrast and anisotropy of the interbedded greywacke-argillite host rocks may also have played a role in localizing deformation and veining. The dilatant portions of the mineralized zones that are presently sub-horizontal occur where the fault surface steps across beds between adjacent steeper bedding-parallel portions. The locus of bedding-parallel portions could be the relatively incompetent argillite beds and/or reactivated, intensely foliated F_1 axial planes (zones of younging reversals?), especially where intense pressure solution produced structurally weakened layers. In this structural model, the sub-horizontal dilatant zones would be formed during reverse movement on steeper, bedding-parallel planes in an apparent "flat and ramp" style faulting. This geometry would provide paths for mineralizing fluids and dilatant zones for quartz vein precipitation of the typically vuggy gold-bearing veins. The multiple phases of quartz-sulphide veining, and fragmentation of the veins indicates that the gold mineralizing event occurred during significant movement on these structures.

Two types of competency contrast are probably responsible for localizing the portions of bedding-parallel fault movement and in creating structural porosity by brittle fracture in more competent zones. These are the lithologic contrast between argillites and greywackes and the competency contrast that was structurally induced during early D_{1-2} deformation (i.e. between early quartz-veined zones and zones of intense quartz pressure-solution). The early quartz veins, which commonly are more abundant in or near zones of pressure solution, may be interpreted as a product of the migration of quartz from zones of pressure solution to roughly perpendicular extensional planes. If these zones of S_{1-2} pressure solution were indeed major controls on the locus of the late D_2 faulting and quartz-sulphide veining, then the geochemistry of altered wall rocks could be a reflection of more than just the gold-related alteration, but also a product of D_{1-2} alteration.

The evidence for a possible magmatic connection to the gold-mineralizing fluids is mostly ambiguous; to this date, it is mostly based on comparison with the Main Zone gold deposits. The age constraints indicate that the older Magaguadavic granite or postulated coeval buried phases near Anomaly "A" are potential magmatic sources for gold mineralizing fluids. Late veins cutting gold mineralized zones contain base metals and fluorite that are likely to be associated with intrusions of the Pomeroy Suite. The Pomeroy intrusions are metaluminous to peraluminous and the entire Pomeroy suite is highly elevated in fluorine (Taylor 1985). Overprinting by the later veins/veinlets hamper interpretation of a magmatic connection using geochemical analyses of gold-bearing veins and their altered wall rocks. The interpreted introduction of F into the altered greywackes (Fig. 7D) enveloping the gold zones indicates magmatic-related alteration but could be due to a later vapour-phase fluorine permeating zones of structural porosity created during gold-related mineralization. Greisen alteration, with the accompanying F addition to greywackes at Anomaly A (Fig. 7F) is also accompanied by strong removal of the major gold-associated elements, As and Sb, consistent with the interpretation that Sn-related mineralization post-dated Au mineralization.

Ore mineralogy of the Anomaly A gold zones is quite similar to parts of the nearby Main Zone gold deposits (Cabri, unpublished report 2002), for which a magmatic connection has been interpreted (Thorne et al 2002). The timing constraints on mineralization at both locations would allow them to be contemporaneous. In contrast to the Main Zone, the lack of Bi minerals at Anomaly A could be due to its more distal position with respect to potentially causative intrusions. Indirect evidence, therefore, indicates that the Anomaly A gold zones are probable distal deposits of an intrusion-related gold system.

In summary, the gold-mineralized zones of Anomaly A appear to be the product of a protracted structural history that culminated with late-D_2 phase thrust-faulting, and which facilitated gold mineralization. The gold deposits are tentatively interpreted as distal deposits of an intrusion-related gold system, the more proximal deposits of which have been identified at the Main Zone. Later greisen alteration and fluorite-base metal veining associated with the Pomeroy intrusions overprinted the gold zones.

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