

THE MONTGOMERY LAKE PROSPECT, WESTERN LABRADOR: Cu(\pm Au?) MINERALIZATION RELATED TO THE WALSH LAKE THRUST

S. Swinden and F. Santaguida¹
Mineral Deposits Section

ABSTRACT

The Montgomery Lake copper prospect is located in the Howse Zone of western Labrador, approximately 80 km southeast of Schefferville. As part of a regional study of Labrador Trough metallogeny, the occurrence was mapped in detail and extensively sampled for petrography and geochemistry.

The mineralization, well exposed in a series of shallow trenches, comprises stringers and disseminations of chalcopyrite and pyrrhotite hosted by clastic sedimentary rocks of the Menihek Formation (including shale, sandstone and pebbly conglomerate) in a high-strain zone immediately west of the Walsh Lake Thrust. Gold values are generally low but locally range up to 424 ppb. The mineralized rocks are themselves highly strained and locally mylonitic and exhibit an extensive and intensely developed zoned-alteration system. A silica-sulphide alteration facies commonly occupies the internal parts of the alteration zone and carries most of the mineralization. Marginal to this is a carbonate-silica (\pm fuchsite) facies that is typically sulphide-poor. A silica-sericite facies of alteration is locally developed. There has been extensive metasomatism of the host rocks during alteration.

The Montgomery Lake prospect exhibits many features typical of mesothermal Au mineralization including the location of the mineralization in a high-strain zone marginal to a major structure, abundant carbonate alteration, local fuchsite, locally good grades of Cu, and locally anomalous Au. There would appear to be significant exploration potential for Au in the immediate area of the prospect. The preliminary interpretation of this prospect as possibly of mesothermal origin, suggests that there may be other similar occurrences elsewhere along the Walsh Lake and other major fault systems within the Labrador Trough.

INTRODUCTION

The Montgomery Lake copper prospect is located in the Howse Zone of western Labrador, approximately 80 km southeast of Schefferville (Figure 1). It consists of variably disseminated and stringer chalcopyrite hosted by strongly altered and intensely deformed clastic sedimentary rocks of the Menihek Formation.

In the context of Howse Zone metallogeny, this occurrence is unique in all aspects of its geological character and setting. Most mineral occurrences in the Howse Zone are either thin, conformable, pyritic, mildly cupriferous sulphide beds in black shale and carbonates (Swinden and Santaguida, 1993, 1994) or minor Cu-Ni sulphides associated with mafic intrusive rocks (Findlay *et al.*, 1990). None have been described as having any association with either alteration or deformation and none have, to date, yielded Cu values as high as those at Montgomery Lake.

The Montgomery Lake prospect was visited during 1992 and 1993 as part of a regional metallogenic study of the Howse Zone in western Labrador jointly funded by the Newfoundland Geological Survey and the Geological Survey of Canada under the Canada-Newfoundland Cooperation Agreement on Mineral Development. The trenches, which expose the mineralization, were mapped and extensively sampled. Here, the results of field observations, petrographic studies and major- and trace-element geochemical analyses are reported.

REGIONAL GEOLOGY

The Montgomery Lake area lies in the Howse Zone of the New Quebec Orogen (Labrador Trough) (Wardle *et al.*, 1990a) adjacent to the Quebec border (Figure 1). The regional stratigraphy of the Labrador Trough in western Labrador, the geological setting of mineralization in the Howse Zone, and the history of mineral exploration in the region were previously outlined by Swinden and Santaguida (1993).

¹ Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, K1A 0E8.

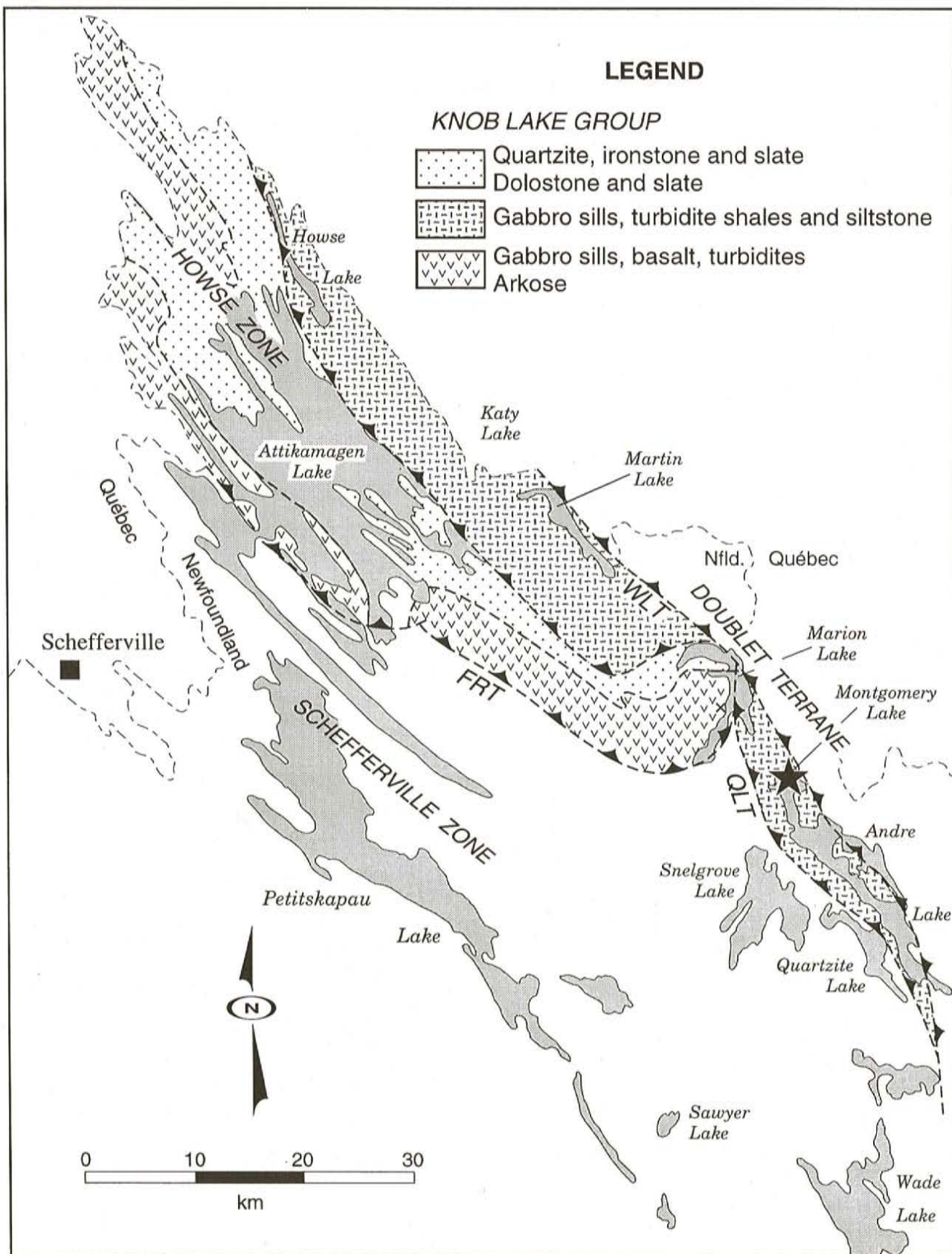


Figure 1. General geology of the Howse Zone, Labrador Trough (after Wardle et al., 1991) and location of the Montgomery Lake prospect. FRT—Ferrum River Thrust; QLT—Quartzite Lake Thrust; WLT—Walsh Lake Thrust.

The Howse Zone forms part of the western division of the New Quebec Orogen (Wardle *et al.*, 1990b). This comprises dominantly low-grade sedimentary and igneous rocks deposited during the Paleoproterozoic in a passive margin (Wardle and Bailey, 1981) to evolving foredeep (Hoffman, 1987) environment on or east of the eastern margin of the Superior Craton. The rocks are presently disposed in a west-facing fold-and-thrust belt, formed as a result of the Paleoproterozoic collision between the Rae Province to the east and the Superior Craton and overthrusting of the New Quebec Orogen rocks onto the Superior margin.

The stratigraphic succession of the Howse Zone consists of a basal continental arkose (Seward Subgroup) overlain by a thick deep-marine clastic succession comprising turbidites and carbonaceous argillite generally assigned to the Attikamagen Subgroup, and ultimately by quartzite, ironstone and slate of the Ferriman Subgroup. The sedimentary succession is extensively intruded by diabase and gabbro sills of oceanic tholeiite character, which are believed to be approximately coeval with the sediments (Baragar, 1967; Wardle *et al.*, 1990a,b).

The Howse Zone is bounded, and internally disrupted by, a series of northwest-trending thrust faults (Figure 1). Of particular interest to the present study is the Walsh Lake Thrust, which forms the eastern boundary of the Howse Zone,

separating dominantly sedimentary rocks of the Menihok Formation (Attikamagen Subgroup) to the west from dominantly volcanic rocks of the Doublet Group to the east. The fault was interpreted by Wardle *et al.* (1990a) to be part of a larger, west-directed imbricate system that includes the Ferrum River Thrust to the east. Both thrusts are interpreted to ramp upward from a deeper basal decollement (Wardle *et al.*, 1990a; Figure 2). Wardle *et al.* (1990a) have suggested that this fault may have an extended history of movement that includes a second, younger period of thrusting involving basement. However, to date, there are no published detailed studies of the structural history of the Walsh Lake Thrust.

HISTORY OF THE MONTGOMERY LAKE PROSPECT

Mineralization near Montgomery Lake was first discovered in 1942 by prospectors whose chip and grab samples are reported to have assayed up to 3.45 percent Cu and about 0.7 g/t Au (Love, 1966). Early work on the showing included some trenching and two packsack drillholes.

The property was subsequently explored by Labrador Mining and Exploration Company Limited. In the early 1960s, they carried out geological, geophysical (magnetic, electromagnetic, gravity, seismographic) and geochemical surveys over a 14 300 m grid, which included the old

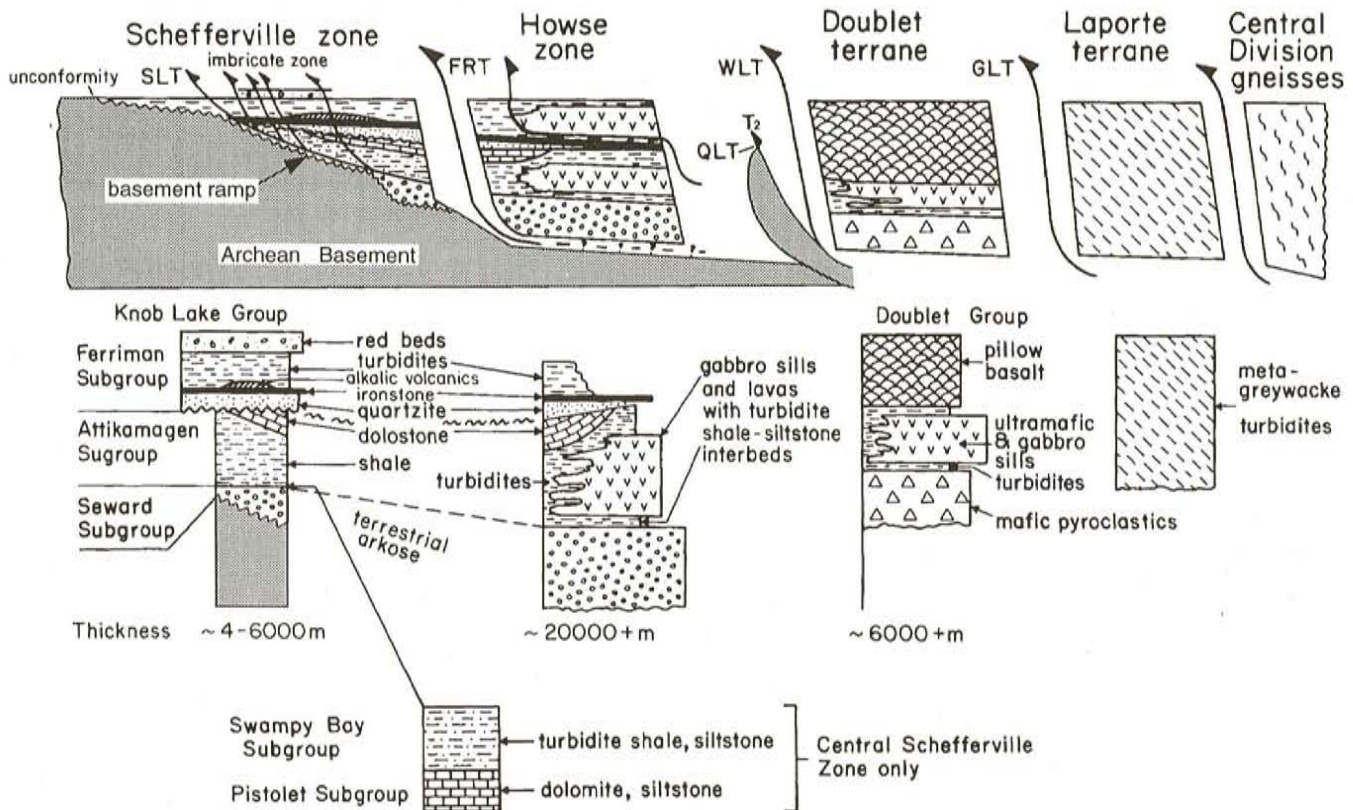


Figure 2. Schematic reconstruction of stratigraphic and structural relationships in the Labrador Trough (after Wardle *et al.*, 1991); GLT—Gill Lake Thrust; WLT—Walsh Lake Thrust; FRT—Ferrum River Thrust; SLT—Stakit Lake thrust; Wade Lake thrust zone; QLT—Quartzite Lake thrust.

showings and a considerable part of their along-strike extensions. These studies revealed geochemical, magnetic and electromagnetic anomalies over and to the north of the mineralized outcrops. In 1966, 12 holes totaling approximately 1255 m were drilled to test the mineralized zone and its attendant geophysical anomaly (Figure 3). The drilling intersected altered and mineralized rocks similar to those exposed in surface trenches. However, assays returned relatively low metal values (Love, 1966).

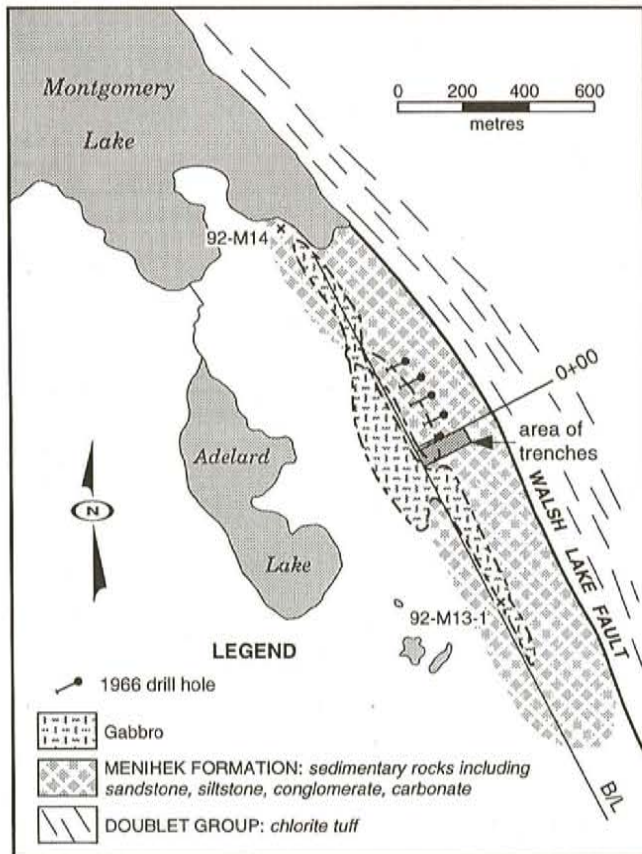


Figure 3. Simplified geological map of the Montgomery Lake area, showing the location of the trenches, the geophysical-geochemical anomalies (dashed line) and the 1966 diamond-drill holes.

GEOLOGY OF THE TRENCHES

The Montgomery Lake prospect occurs within clastic sedimentary rocks of the Menihek Formation immediately west of the Walsh Lake Thrust (Figure 3). The mineralization is exposed in a series of shallow trenches and adjacent outcrops across an area approximately 75 by 90 m (Figure 4 and Plate 1).

The general lithological succession in the trenches comprises fine- to coarse-grained clastic sedimentary rocks ranging from fine-grained carbonaceous slates to bedded sandstone and siltstone, and pebbly conglomerate. Carbonate is abundant in the area of the mineralization. Thin-section observations indicate that most rocks were originally

quartzofeldspathic in composition and that carbonate is dominantly if not entirely secondary. Medium- to coarse-grained gabbro intrusions comprise a significant component of the regional lithological succession (Figures 1 and 3). Gabbro outcrops do not appear to be appreciably altered or mineralized in the vicinity of the showings and no gabbro was recognized within the immediate area of the most intense alteration and mineralization.

The mineralization is associated with a complex alteration zone, characterized by silicification, carbonatization and sericitization. Variations in abundances of alteration minerals permit the identification of broad alteration facies in the field (Figure 4).

The most widespread alteration type comprises a silica-sulphide (\pm carbonate) facies. The rocks are highly bleached and silicified with up to 10 percent sulphide, composed predominantly of chalcopyrite and pyrrhotite with lesser pyrite (Plate 2a,b). Sulphides occur as disseminations, and as networks of anastomosing veinlets that are locally transposed into the plane of the principal foliation (Plate 2c,d). In thin section, these rocks are seen to consist mainly of quartz, which is commonly recrystallized. Carbonate is common, intergrown with the quartz. Chalcopyrite is by far the most abundant sulphide and is closely intergrown with pyrrhotite (Plate 2b).

Carbonate-rich alteration facies surround the silica-sulphide facies in plan. On the eastern margin of the trenches, the alteration comprises essentially silica-carbonate that differs from the adjacent mineralized silica-sulphide rocks mainly in the proportions of carbonate and silica (carbonate is relatively more abundant) and in the lack of sulphides. Elsewhere, the carbonate-rich alteration facies is characterized by significant amounts of a green mica, possibly fuchsite and is similarly poor in sulphides. In thin section, these rocks show abundant carbonate intergrown with silica and remnants of primary quartz and feldspar. Locally, carbonate forms discrete veinlets within the altered rocks (Plate 3a,b).

A third, locally developed alteration facies characterized by a silica-sericite assemblage (Plate 4) was observed only in two small outcrops located in the central part of the deposit.

As noted by Love (1966), the Montgomery Lake prospect occurs within a high-strain zone that is immediately west of, and apparently related to, the Walsh Lake Fault. Within this high-strain zone, the rocks are intensely foliated and locally mylonitic. In less-deformed outcrops, at least two periods of folding are evident; an early generation of recumbent folds with flat axial planes is folded by a later generation of upright, asymmetric, west-verging folds with steep western and shallow eastern limbs. Axial planes of the upright folds are similar in attitude to the plane of the Walsh Lake Thrust. Within the high-strain zones, the F2 folds are substantially tighter, generally upright and isoclinal, with a well-developed axial-planar foliation. (Plate 5). Rootless folds are common

LEGEND

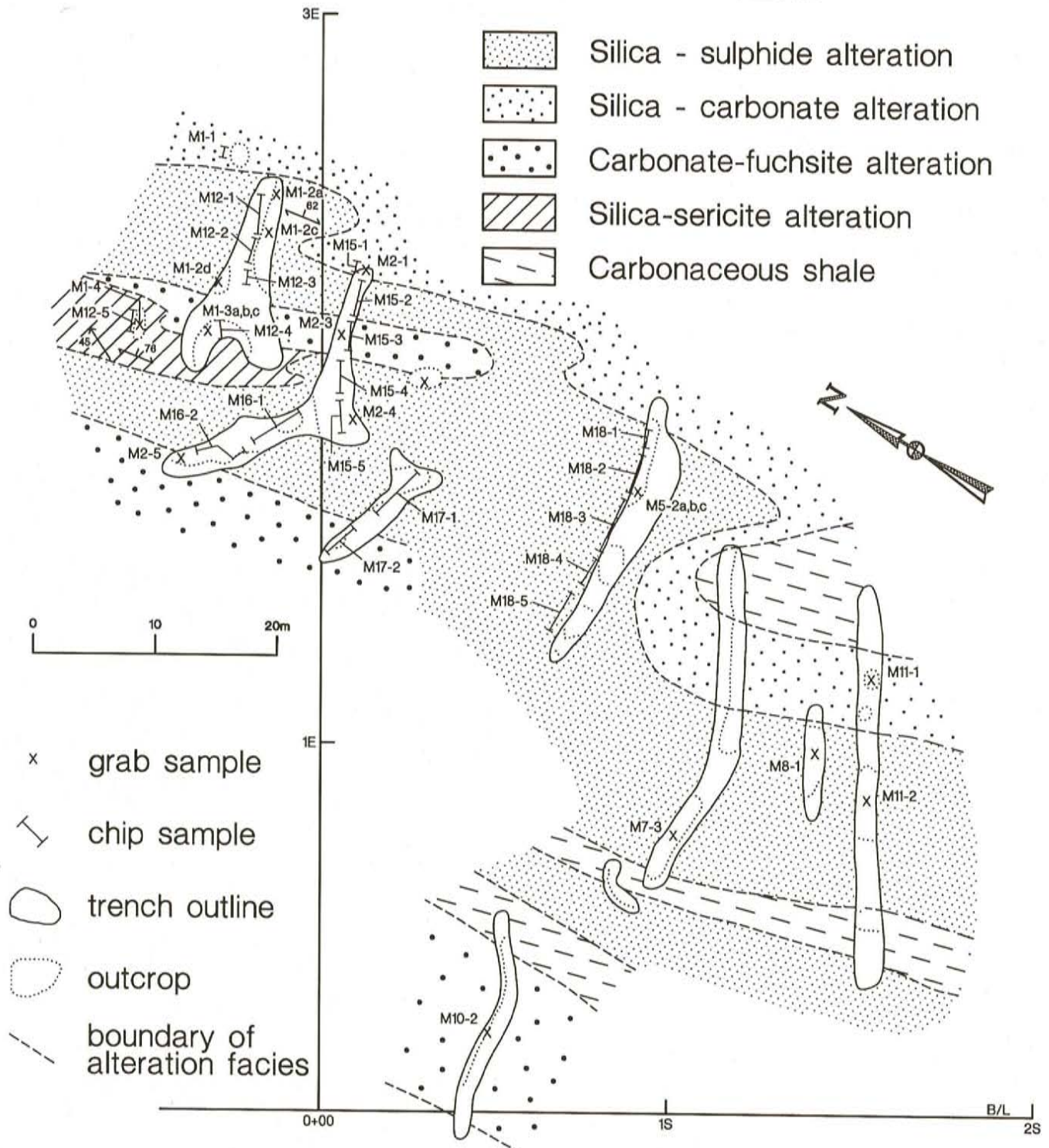


Figure 4. Map showing the distribution of alteration facies and samples in the trenches. Sample numbers keyed to Table 1, where they are prefaced by "92".

and evidence of multiple deformation is seen at both outcrop and thin-section scales. In zones of particularly high strain, pyrrhotite veinlets lie in the plan of the F2 fabric and are folded by tight minor folds within it (Plate 2c).

Chalcopyrite appears to generally postdate the maximum strain in the rocks and to occupy brittle rather than ductile structures. Chalcopyrite tends to be coarser grained than the pyrrhotite, and does not show evidence in hand specimen or

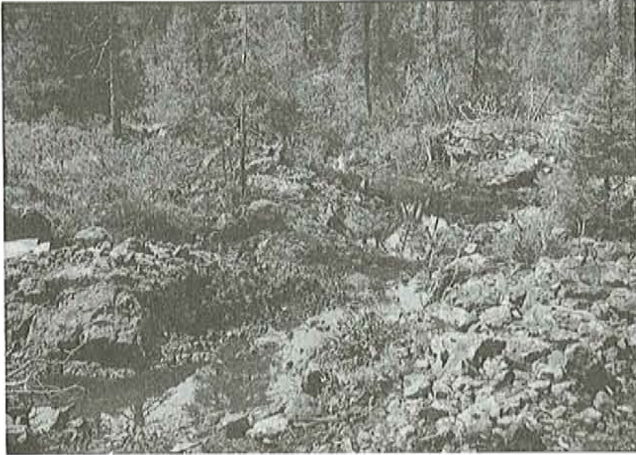


Plate 1. The main trench at the Montgomery Lake prospect, looking southwest. Silica-sulphide alteration facies rocks are in the foreground, carbonate-fuchsite alteration at the far end of the trench.

thin section of having been strongly deformed. It commonly occupies brittle fractures that crosscut the principal structural fabric.

GEOCHEMISTRY

ANALYTICAL METHODS

Forty-six samples representing all alteration facies and a range of intensities of sulphide impregnation were analyzed for major and trace elements. Results are presented in Table 1. Most samples come from the trenches or outcrops in the immediate vicinity of the Montgomery Lake prospect. However, one sample, 92-M-14 (Figure 3), was taken at the Montgomery North prospect near the shore of Montgomery Lake, and another (92-M13-1; Figure 3) from altered and mineralized outcrops approximately 500 m southeast of the showing. Samples were taken from slabbed sections of hand specimens, chipped by hand and then washed and pulverized in an alumino-silicate swing mill. All samples were analyzed

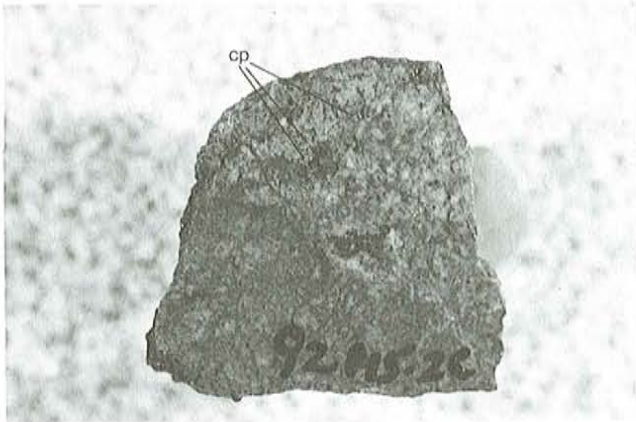


Plate 2. Photographs of silica-sulphide alteration; **a** (top left)—hand specimen of silicified pebbly conglomerate with disseminated chalcopyrite; **b** (top right)—polished section showing chalcopyrite and pyrrhotite in a silicate gangue. Reflected light; field of view—2 mm.; **c** (left bottom)—highly silicified, intensely deformed rocks with sulphide veinlets (black) folded and transposed into the plane of foliation. Rootless fold indicated by 'f'; **d** (right bottom)—photomicrograph of folded sulphide laminae (black) in silicified conglomerate; field of view—2 mm, crossed polars.

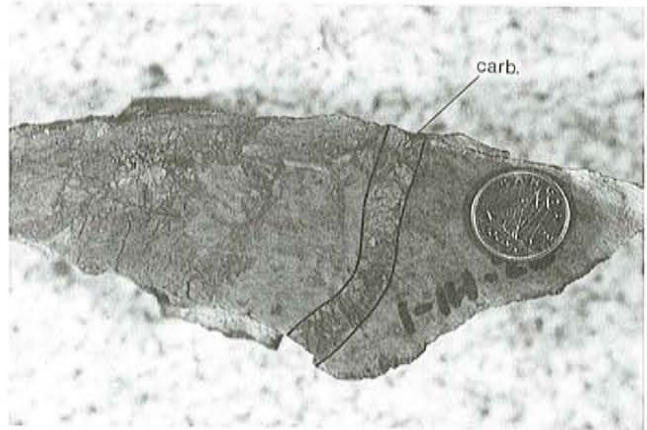


Plate 3. Carbonate–fuchsite alteration; **a** (left)—carbonate veins (under hammer handle) in outcrop of carbonate-fuchsite-altered rock; **b** (right)—carbonate veins in hand specimen.

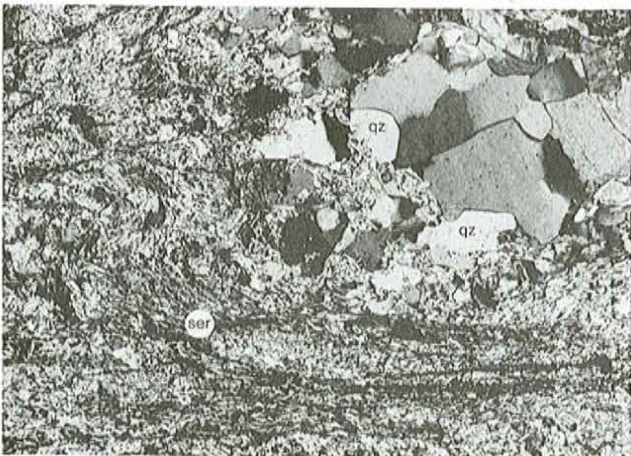


Plate 4. Photomicrograph of highly deformed silica–sericite alteration. An early foliation defined by sericite is folded and a crenulation cleavage developed.

for major elements and a comprehensive suite of trace elements in the Newfoundland Department of Natural Resources Laboratory. Major elements as well as Zr, Ba and Cr were determined by lithium metaborate fusion followed by Inductively Coupled Plasma–Optical Emission Spectrophotometry (ICP-OES) while Ni, Co, V, Ga, Sc, Rb, Sr, Y, Nb, Li, Cu, Pb and Zn were determined by multi-acid digestion and ICP-OES. The trace elements Ag, Cd, Mo, Rb were determined by atomic absorption spectrophotometry (AAS) in the Newfoundland Department of Natural Resources Laboratory, while Au, As and Sb were determined by Instrumental Neutron Activation Analysis (INAA) at Becquerel Laboratories Incorporated. The gasses H₂O, CO₂, and S were analyzed by an infra-red method in the Newfoundland Department of Natural Resources Laboratory as described by Wagenbauer *et al.* (1983). LOI was determined by heating to 1000°C.

RESULTS

The host rocks to the mineralization were extensively



Plate 5. Isoclinally folded quartz veins (F2?) in highly strained silica–carbonate alteration zone.

metasomatized during alteration and this is reflected in their major- and trace-element systematics. Mass-balance calculations have not been carried out and conclusions should therefore be regarded as preliminary. Major-element data show some clear contrasts between the various alteration facies. As might be expected, CaO is significantly enriched in the carbonate-altered rocks (78 percent of samples have

Table 1. Geochemical data for samples from the Montgomery Lake prospect; n/a—not analyzed. Alteration facies abbreviations: si—silica; carb—carbonate; sul—sulphide; fu—fuchsite

sample # alt'n facies	91-SS-114A si-fu-carb±sul	91-SS-114B si-sul	91-SS-114C si-sul	91-SS-114D si-sul	92-M1-1 si-carb±sul	92-M1-2A si-sul	92-M1-2C si-sul	92-M1-2d si-sul
SiO ₂	39.65	42.3	41.35	42.1	35.11	43.49	50.35	40.52
Al ₂ O ₃	12.77	11.43	11.4	13.89	10.11	10.93	17.55	12.81
Fe ₂ O ₃	5.34	14	7.05	11.81	7.63	11.94	3.87	11.58
MgO	6.19	2.83	6.03	3.18	6.88	3.55	3.26	3.48
CaO	11.3	5.89	1.48	5.73	13.25	6.43	5.56	6.42
Na ₂ O	5.3	6.33	6.65	6.45	3.82	6.17	5.34	6.41
K ₂ O	1.3	0.17	0.02	0.69	1.34	0.05	2.41	0.5
TiO ₂	0.56	0.83	0.19	1.05	0.732	0.421	0.947	0.69
MnO	0.19	0.12	0.18	0.1	0.19	0.112	0.099	0.125
P ₂ O ₅	0.05	0.09	0.09	0.07	0.668	0.182	0.087	0.067
H ₂ O	n/a	n/a	n/a	n/a	1.02	1.7	1.67	2.07
S	n/a	n/a	n/a	n/a	1.65	5.16	0.13	3.88
CO ₂	n/a	n/a	n/a	n/a	15.88	8.92	7.66	8.72
LOI	16.35	8.01	14.33	9.25	15.88	12.7	9.47	10.88
Cr	735	80	21	265	176	51	201	112
Ni	30	163	30	118	75	134	6	103
Co	11	90	18	55	76	128	3	61
Sc	n/a	n/a	n/a	n/a	45.1	7.7	38	21.9
V	190	55	22	440	283	49	484	205
Cu	162	34070	7190	34880	95	22600	1043	35000
Pb	15	33	0	4	6	5	11	8
Zn	46	187	51	152	12	57	7	34
Ag	n/a	n/a	n/a	n/a	<0.1	0.7	<0.1	0.9
Be	n/a	n/a	n/a	n/a	1.3	0.7	3.5	1.4
Cd	n/a	n/a	n/a	n/a	<0.1	0.2	<0.1	<0.1
Mo	n/a	n/a	n/a	n/a	5	5	4	6
Rb	n/a	n/a	n/a	n/a	23	<5	31	9
Au	n/a	n/a	n/a	n/a	1	227	19	424
As	n/a	n/a	n/a	n/a	108	71	0.8	21
Sb	n/a	n/a	n/a	n/a	73	0.51	0.43	0.67
Ba	136	21	3	94	220	25	380	100
Sr	n/a	n/a	n/a	n/a	78	45	54	52
Ga	n/a	n/a	n/a	n/a	18	10	37	21
Li	n/a	n/a	n/a	n/a	9	1.8	13.3	3.6
Nb	n/a	n/a	n/a	n/a	4	1	4	1
Zr	n/a	n/a	n/a	n/a	44	80	82	52
Y	n/a	n/a	n/a	n/a	13	7	7	7

Major elements in wt. %; Trace elements in ppm except gold in ppb.

CaO > 7 percent) and shows a strong negative correlation with SiO₂ (Figure 5a), indicating that concentrations of these oxides are controlled by dilution of one by the other. In contrast, the silica-sulphide rocks have CaO < 7 percent in 85 percent of the samples and lack any clear relationship with SiO₂, indicating that dilution by carbonate is not a major factor in SiO₂ variation in these rocks.

Figure 5b shows that iron, dominantly present as iron sulphides, exerts a principal control on major-element variation in the silica-sulphide facies rocks. Both alteration facies show a negative correlation between Fe₂O₃ and SiO₂;

however Fe₂O₃ abundances in the carbonate altered rocks are very low (generally < 10 percent) whereas in the mineralized rocks, they are substantially higher at equivalent SiO₂ concentrations.

Carbonate and silica-sulphide facies rocks do not show any significant contrasts in alkali contents but silica-sericite facies rocks have clearly undergone significant Na₂O depletion and K₂O enrichment (Table 1).

Geochemical studies reveal some interesting relationships between metals in the deposit. Cu varies widely but is

Table 1. (Continued)

sample # alt'n facies	92-M1-3a si-fu-carb±sul	92-M1-3b si-fu-carb±sul	92-M1-3c si-fu-carb±sul	92-M1-4 si-ser	92-M10-2 si-carb±fu	92-M11-1 si-carb?	92-M11-2 si-sul	92-M12-1 si-sul
SiO ₂	34.74	44.42	40.91	60.68	11.97	42.48	51.6	32.19
Al ₂ O ₃	11.07	13.04	11.37	10.56	3.36	11.52	12.97	8.39
Fe ₂ O ₃	7.12	3.67	5.21	2.67	10.9	12.97	8.8	24.15
MgO	6.06	5.35	5.96	4.07	11.61	3.55	2.33	2.96
CaO	12.33	9.5	11.47	6.11	22.91	8.78	5.12	5.82
Na ₂ O	5.28	6.71	6.37	0.14	1.71	4.84	6.83	4.75
K ₂ O	0.82	0.48	0.2	3.08	0.15	1.73	0.24	0.08
TiO ₂	1.175	0.922	0.766	0.633	0.224	1.506	0.72	0.383
MnO	0.259	0.157	0.196	0.105	0.402	0.26	0.067	0.126
P ₂ O ₅	0.047	0.057	0.052	0.061	0.081	0.127	0.25	0.102
H ₂ O	1	0.64	0.48	1.83	0.73	1.12	2.22	3.42
S	0.71	0.04	0.1	0.06	0.04	0.08	2.98	9.32
CO ₂	16.36	12.92	15.28	8.4	30.56	10.62	5.64	8.02
LOI	17.81	14.88	17.47	10.25	35.83	12.72	10.09	16.5
Cr	124	164	82	130	33	7	80	45
Ni	23	3	13	17	1	26	144	324
Co	12	3	7	6	3	26	61	342
Sc	33.5	40	34.5	23.2	32.6	41.5	11.1	10.4
V	218	264	107	157	45	441	108	62
Cu	1819	24	35	25	16	22	1138	23000
Pb	5	7	6	7	<1	5	14	4
Zn	10	5	7	8	12	19	12	54
Ag	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.7
Be	1.3	1	0.6	2	0.3	0.4	1.1	0.7
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mo	7	3	5	3	5	4	3	3
Rb	15	13	7	67	<5	96	10	<5
Au	180	1	1	1	1	1	1	273
As	0.6	0.2	1.7	1.7	1.4	3.1	0.2	199
Sb	0.44	0.5	0.53	0.29	0.24	0.14	0.46	0.52
Ba	140	61	25	400	25	360	25	25
Sr	65	80	77	38	86	39	50	41
Ga	16	15	9	21	2	18	24	16
Li	4.5	3.2	1.6	8.4	1.6	15.6	3.6	1.8
Nb	4	3	2	3	11	7	3	<1
Zr	58	43	39	64	14	103	66	56
Y	8	6	5	7	8	11	49	6

Major elements in wt. %; Trace elements in ppm except gold in ppb.

substantially enriched within the silica-sulphide facies rocks, in accord with field observations. Cu is the principal base metal present. Zn is present in relatively minor amounts (generally <100 ppm), but tends to be slightly enriched in the silica-sulphide facies rocks relative to the carbonate-rich rocks (Figure 5c); the two samples having highest Zn values are also those with the highest Cu contents, suggesting that minor amounts of Zn were present in the mineralizing fluids. Au values were found to be generally low, in accord with previous work in the area. However, with the more precise analyses at low concentrations obtained during the present program (as opposed to previous results that were relatively imprecise assays), some trends are revealed that may be of

metalogenic significance. Samples that contain more than 1000 ppm Cu (i.e., most of the silica-sulphide rocks but very few of the carbonate-altered rocks) tend to be slightly enriched in Au relative to those containing less Cu (Figure 5d). Five of the six samples that yielded more than 100 ppb gold, were identified in the field as silica-sulphide altered rocks, the fifth as containing significant carbonate alteration. The samples with the most gold (i.e., those with Au > 200 ppb) tend to be the most Cu-enriched as well. One of the samples most enriched in Au was 92-M-14, taken at the Montgomery North prospect more than 700 m northwest of the main showings (Figure 3).

Table 1. (Continued)

sample # alt'n facies	92-M12-2 si-sul	92-M12-3 si-sul	92-M12-4 si-fu-carb±sul	92-M12-5 si-ser	92-M13-1 si-carb-sul	92 m13-2 gabbro	92-M14 sil-carb-sul	92-M15-1 si-carb±sul
SiO ₂	53.27	31.75	42.41	61.49	54.01	51.36	65.48	44.37
Al ₂ O ₃	18.09	10.2	11.04	14.75	15.79	10.65	15.57	12.01
Fe ₂ O ₃	3.77	10.94	4.97	3.41	5.81	18.13	3.18	6.76
MgO	2.34	6.31	5.93	2.93	2.24	6.1	0.39	4.63
CaO	3.89	11.88	11.5	3.49	4.36	0.25	1.11	9.9
Na ₂ O	7.93	4.86	5.98	0.32	9.15	2.35	8.88	6.5
K ₂ O	1.14	0.56	0.37	4.68	0.11	0.12	0.19	0.36
TiO ₂	1.156	0.605	0.833	0.852	0.496	0.397	0.664	1.659
MnO	0.077	0.216	0.191	0.102	0.149	0.012	0.009	0.319
P ₂ O ₅	0.082	0.077	0.062	0.071	0.088	0.272	0.18	0.147
H ₂ O	0.96	1.51	0.42	2.3	0.69	4.82	1.55	1.86
S	0.41	2.63	0.02	0.09	2.19	7.96	1.78	0.3
CO ₂	5.14	15.56	14.51	5.7	5.94	0.14	1.11	11.68
LOI	6.51	14.21	17.22	7.88	7.37	9.81	2.79	13.66
Cr	194	88	97	149	35	62	38	6
Ni	24	128	7	32	166	119	29	34
Co	12	55	7	14	122	73	16	12
Sc	24.4	25.3	38	33.3	6.5	13.3	4.2	38.6
V	332	168	135	281	30	175	59	318
Cu	1563	8754	31	49	9	638	6529	79
Pb	13	5	10	9	12	6	9	8
Zn	8	16	8	13	23	19	10	17
Ag	0.1	0.2	<0.1	0.1	0.1	<0.1	0.3	<0.1
Be	2.3	1	0.7	2.7	0.9	0.5	0.8	0.7
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mo	4	5	2	2	3	3	2	2
Rb	19	12	11	97	<5	<5	9	13
Au	20	45	1	1	1	17	368	1
As	3.1	1.4	26	40	27	286	139	1.3
Sb	0.63	0.35	0.39	0.37	0.39	0.33	0.38	0.18
Ba	200	94	25	530	25	25	25	25
Sr	51	60	70	23	42	11	26	49
Ga	28	14	14	29	15	20	14	13
Li	6.5	3.8	2.6	12.6	0.4	30.7	1.7	3.8
Nb	3	3	2	2	1	<1	2	7
Zr	104	55	40	78	48	80	144	95
Y	6	6	6	7	6	5	11	13

Major elements in wt. %; Trace elements in ppm except gold in ppb.

Gold does not show any clear relationship with other trace elements, particularly As or Sb, which are known to serve as Au pathfinders in some mesothermal environments.

DEPOSIT GENESIS

Although the results of this work are preliminary, they suggest that the deposit models appropriate for the shale-hosted Cu (i.e., Besshi-type or SEDEX massive sulphide; Swinden and Santaguida, 1993, 1994) and gabbro-hosted Ni-Cu (magmatic; Findlay *et al.*, 1990) seen elsewhere in the Howse Zone are not appropriate for the Montgomery Lake prospect.

Alteration, deformation and mineralization appear to be closely related. The alteration appears from field evidence to span the peak deformation with some alteration assemblages having been intensely deformed while others were not. Copper and gold mineralization is closely associated with the SiO₂ sulphide-alteration facies but seems to have occurred late in the mineralizing process, as it occupies brittle sites in the rocks and shows no evidence of having been deformed to the extent of the altered host rocks.

The Montgomery Lake prospect has many features typical of mesothermal Au mineralization including: i) localization of the mineralization in a high-strain zone

Table 1. (Continued)

sample # alt'n facies	92-M15-2 si-sul	92-M15-3 sil-fu-carb±sul	92-M15-4 si-sul	92-M15-5 si-sul	92-M16-1 si-sul	92-M16-2 si-sul	92-m17-1 si-sul	92-M17-2 sil-fu-carb±sul
SiO ₂	49.88	48.63	28.01	41.34	48.53	50.09	44.04	51.75
Al ₂ O ₃	13.3	14.02	7.68	10.07	11	14.47	10.91	11.59
Fe ₂ O ₃	12.46	5	32.9	25.7	11.94	6.56	20.37	13.05
MgO	1.98	4.12	2.15	1.29	2.68	3.22	2.11	2.16
CaO	3.86	7.56	4.56	2.47	5.86	5.85	4	4.2
Na ₂ O	6.97	6.28	4.23	4.91	6.18	5.94	5.2	6.26
K ₂ O	0.31	0.99	0.11	0.57	0.14	1.47	0.53	0.17
TiO ₂	0.674	1.119	0.335	0.667	1.368	0.892	0.453	0.405
MnO	0.108	0.157	0.147	0.097	0.124	0.141	0.107	0.112
P ₂ O ₅	0.144	0.14	0.064	0.098	0.124	0.068	0.101	0.126
H ₂ O	3.46	1.48	3.54	4.2	2.09	1.73	3.6	2.14
S	2.68	0.3	9.96	5.96	2.15	0.18	3.4	1.28
CO ₂	6.02	9.5	6.66	4.37	7.42	8.14	6.17	6.25
LOI	8.51	10.98	15.63	11.24	8.74	9.11	11.08	8.19
Cr	56	97	32	65	32	387	56	43
Ni	115	35	488	219	97	37	201	130
Co	41	18	728	252	51	23	125	101
Sc	11.1	25.6	9.8	15.5	21.4	27.9	10.4	9.9
V	95	256	35	123	71	260	108	65
Cu	6494	451	13400	16100	5868	213	4040	3380
Pb	7	13	1	5	5	12	3	6
Zn	19	11	35	33	18	19	22	16
Ag	0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1
Be	1.1	1.7	0.4	1	0.8	1.8	1.2	0.8
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mo	4	4	2	3	2	2	3	3
Rb	<5	17	6	11	9	25	<5	<5
Au	33	1	84	33	18	1	34	81
As	5.9	14	353	113	6.5	10	97	120
Sb	0.54	0.52	0.29	0.37	0.51	0.33	0.34	0.32
Ba	0.57	180	25	56	56	150	25	25
Sr	37	52	26	24	44	44	36	37
Ga	16	24	13	17	11	27	18	15
Li	2.3	4.4	1.3	4.3	1.9	6.1	3.4	1.9
Nb	1	4	<1	<1	1	2	<1	<1
Zr	81	96	44	65	73	60	75	72
Y	10	10	6	7	7	6	8	8

Major elements in wt. %; Trace elements in ppm except gold in ppb.

marginal to a major structure; ii) abundant carbonate alteration; iii) local presence of fuchsite associated with carbonate alteration; and iv) locally anomalous amounts of Au associated with base metals.

Our preliminary interpretation is that this occurrence is structurally controlled, probably of the mesothermal class, formed during movement on the Walsh Lake Thrust. It is similar to Archean-style gold occurrences as well as to the many of the Paleozoic gold prospects discovered in central Newfoundland in recent years (Dubé, 1990; Swinden, 1990; Evans, *in press*). Considerable work is needed to confirm the nature of the mineralization and its genesis.

SUGGESTIONS FOR FURTHER EXPLORATION

Detailed exploration in the immediate vicinity of the Montgomery Lake prospect has to date revealed a restricted area of good Cu values and slightly anomalous, although generally low, Au values. Diamond drilling has tested the mineralization under the northern end of the trenches and under the associated geophysical and geochemical anomalies immediately to the northwest. High Cu values were sporadic in the subsurface and there is no indication that Au values higher than those on surface were encountered (although analyses were relatively imprecise and anomalous values

Table 1. (Continued)

sample # alt'n facies	92-M18-1 si-sul	92-M18-2 si-sul	92-M18-3 si-sul	92-M18-4 si-sul	92-M18-5 si-sul	92-M2-1 si-carb±sul	92-M2-3 si-?fu-carb±sul	92-M2-4 si-sul
SiO ₂	33.24	54.31	29.72	54.03	52.61	41.44	17.41	49.63
Al ₂ O ₃	7.35	11.75	7.18	12.88	11.21	11.06	0.51	13.96
Fe ₂ O ₃	30.97	4.72	14.21	8.13	6.81	6.57	7.09	5.64
MgO	2.17	3.51	6.74	2.79	3.74	4.9	13.8	3.55
CaO	4.42	6.87	13.56	5.2	6.93	12.37	23.89	7.1
Na ₂ O	3.98	6.18	4.04	5.99	5.78	5.48	0.1	7.99
K ₂ O	0.13	0.33	0.07	0.73	0.27	0.59	0.11	0.18
TiO ₂	0.287	0.499	0.255	0.488	0.441	1.667	0.035	0.799
MnO	0.158	0.126	0.244	0.135	0.134	0.303	0.348	0.136
P ₂ O ₅	0.1	0.114	0.099	0.194	0.156	0.14	0.108	0.059
H ₂ O	5.38	1.1	1.74	1.77	1.14	1.08	0.36	0.84
S	7.12	0.29	2.94	0.41	0.39	0.1	-0.01	0.76
CO ₂	7.03	9.44	18.77	6.87	8.66	11.78	29.67	8.92
LOI	14.1	9.73	16.07	8.76	10.76	15.62	37.44	10.26
Cr	29	57	29	67	60	5	11	44
Ni	433	20	102	49	46	30	<1	55
Co	196	9	32	12	7	11	2	32
Sc	9.8	10.4	13.6	14.9	12.5	43	8.3	20
V	48	115	39	164	104	433	24	49
Cu	5960	388	3924	399	379	7	15	716
Pb	<1	12	1	10	9	6	<1	7
Zn	33	11	18	13	12	11	12	7
Ag	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Be	0.6	1.3	0.6	1.6	1.1	0.6	0.2	0.8
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mo	2	3	4	5	3	5	2	2
Rb	<5	8	6	13	9	22	6	6
Au	28	5	14	3.3	4.5	1	1	1
As	4	4.9	1.3	7	1.1	1.4	4.2	1.6
Sb	0.29	0.32	0.29	0.3	0.25	0.15	0.02	0.33
Ba	25	54	25	80	25	52	25	25
Sr	29	48	57	43	50	56	94	55
Ga	14	18	5	21	15	13	<1	3
Li	2	2.3	1.3	5.7	2.9	6.9	2	1.3
Nb	<1	2	2	1	2	7	5	2
Zr	52	74	47	89	91	95	6	43
Y	7	7	11	11	10	15	11	4

Major elements in wt. %; Trace elements in ppm except gold in ppb.

similar to those encountered on surface may well have been present). The direction and orientation of the drilling were controlled by stratigraphic rather than structural considerations. If, for example, the higher grade mineralization occurs in a structurally controlled linear feature rather than in a planar feature parallel to stratigraphy and the main foliation, then it might have been missed by the drilling. Detailed structural studies leading to an understanding of the geometry of the mineralization are needed to evaluate this possibility and such studies could reveal a further exploration potential for the prospect itself.

Elsewhere on the property, anomalous gold values were encountered at the Montgomery North prospect, indicating

that there is a significant exploration potential at the property scale and providing some confidence that Au was mobile in this environment beyond the immediate vicinity of the main showing.

However, the main significance of this prospect with respect to the exploration potential of this part of the Howse Zone is not necessarily in the potential of the occurrence itself but in the potential of the Howse Zone regionally. Although Au values in the surface and drillhole samples at Montgomery Lake are generally low, the presence of a few anomalous values up to about 450 ppb suggests that Au may have been present in the hydrothermal system that was responsible for the alteration and mineralization. The possibility exists that

Table 1. (Concluded)

sample # alt'n facies	92-M2-5 sil-fu-carb±sul	92-M20-1 si-carb	92-M5-2A si-sul	92-M5-2b si-sul	92-M5-2c si-sul	92-M7-3 si-sul	92-M8-1 si-carb
SiO ₂	38.5	32.8	31.18	43.29	60.38	5.02	68.56
Al ₂ O ₃	12.71	5.77	6.51	8.89	15.56	1.56	16.79
Fe ₂ O ₃	5.84	7.89	9.01	8.54	4.3	52.16	1.02
MgO	6.38	8.11	8.2	5.5	1.32	1.92	0.75
CaO	11.21	16.41	16.35	10.45	2.99	6.63	0.06
Na ₂ O	4.13	3.05	3.59	3.56	7.96	0.6	2.23
K ₂ O	1.93	0.22	0.07	0.75	0.17	0.11	4.15
TiO ₂	0.581	0.515	0.206	0.341	0.738	0.08	0.831
MnO	0.195	0.281	0.274	0.151	0.043	0.145	-0.001
P ₂ O ₅	0.035	0.084	0.107	0.142	0.344	0.03	0.036
H ₂ O	1.19	0.6	0.86	1.9	1.29	8.88	2.59
S	0.69	0.03	0.66	1.61	1.27	15.81	0.08
CO ₂	14.37	21.32	20.52	13.62	3.26	6.85	8.52
LOI	17.36	25.17	23.27	14.99	4.96	25.68	4.6
Cr	864	58	24	57	55	17	151
Ni	35	5	31	81	33	559	3
Co	17	3	15	34	17	196	4
Sc	34.1	28.9	16	17.1	5.7	10.1	24
V	265	65	32	176	99	28	545
Cu	175	30	363	853	8837	5072	44
Pb	6	2	1	3	17	<1	10
Zn	8	15	15	12	24	38	9
Ag	<0.1	<0.1	<0.1		0.2	0.1	0.4
Be	1.7	0.5	0.4	1.3	1.2	0.2	3.4
Cd	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mo	3	3	7	4	17	2	10
Rb	39	6	<5	13	6	10	90
Au	2.3	1	1	4.6	20	32	5.5
As	0.2	0.9	0.8	57.7	5	116	1.3
Sb	0.24	0.29	0.17	0.31	0.55	0.11	0.65
Ba	210	25	25	67	25	25	300
Sr	65	59	64	56	37	17	11
Ga	16	5	<1	13	17	2	33
Li	8.6	1.8	1.1	6.5	1.5	0.9	11
Nb	3	3	3	2	2	<1	8
Zr	26	31	39	65	101	13	146
Y	5	7	9	10	11	5	7

Major elements in wt. %; Trace elements in ppm except gold in ppb.

elsewhere along this fault system, the mineralizing process may have produced deposits that are larger and which contain higher concentrations of Au.

The presence of a mesothermal style of alteration and mineralization related to major faults in the Howse Zone has been previously postulated by Swinden *et al.* (1991) who cited as supporting evidence the presence of localized gold anomalies in regional lake-sediment samples that may be related to major faults in the Howse Zone (see Swinden *et al.*, 1991, Figure 5a). The possibility exists that these

anomalies are related to mineralization and coupled with our interpretation of the nature of the Montgomery Lake prospect, lends some credence to the notion that mesothermal gold occurrences may be present in western Labrador.

ACKNOWLEDGMENTS

Much appreciated logistical help in the field during 1992 and 1993 was provided by Dave Liverman and the Labrador West Quaternary mapping crews and by Wayne Tuttle in Goose Bay. The manuscript was reviewed by Dave Evans and Dick Wardle.

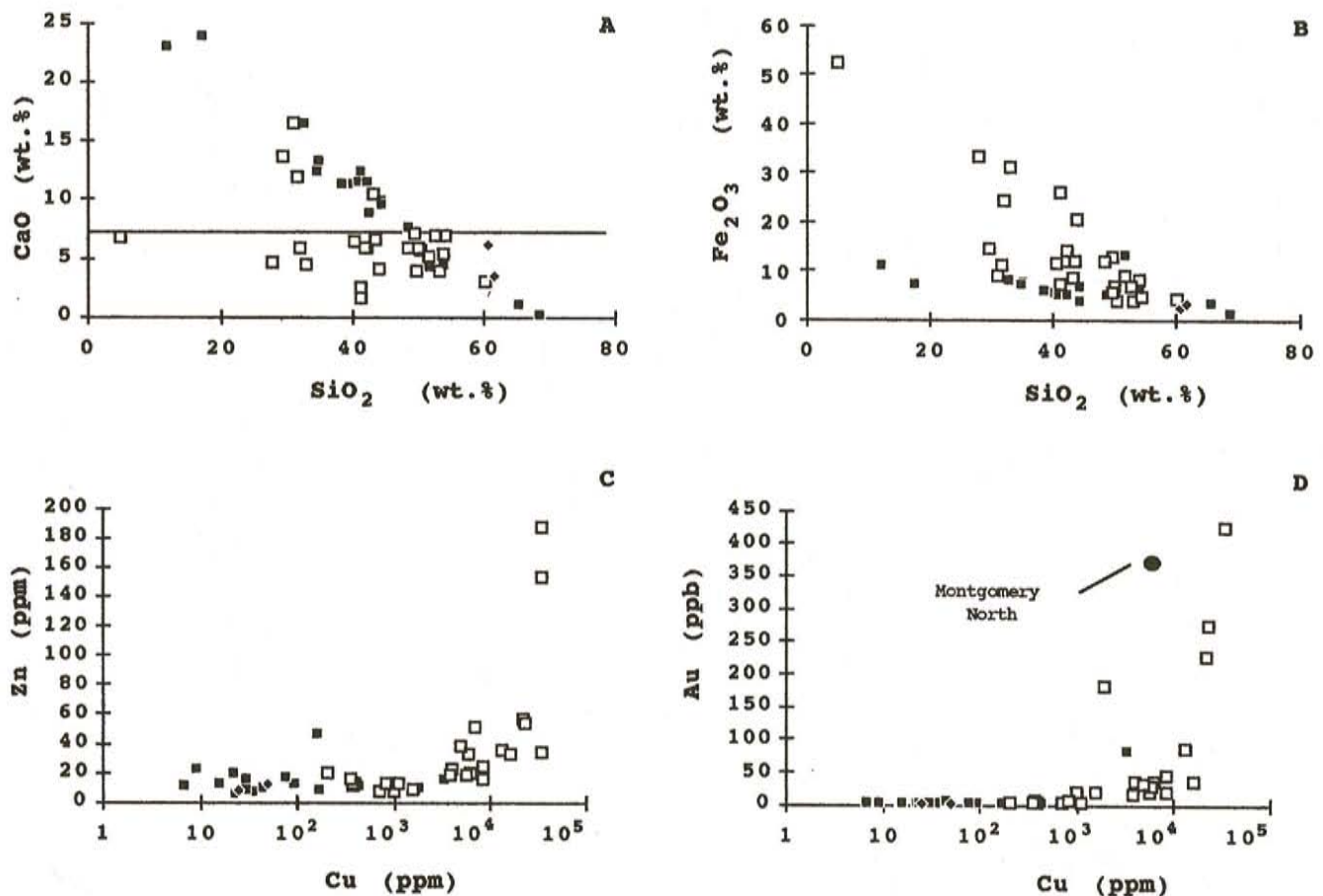


Figure 5. Geochemical relationships of the altered rocks: a—CaO—SiO₂; solid horizontal line is 7 percent CaO; b—Fe₂O₃—SiO₂; c—Zn—Cu; d—Au—Cu; sample from the Montgomery Lake North showing is indicated.

REFERENCES

- Baragar, W.R.A.
1967: Wakuach map area. Geological Survey of Canada, Memoir 344, 174 pages.
- Dubé, B.
1990: Contrasting styles of gold-only deposits in western Newfoundland: a preliminary report. *In* Current Research, Part B. Geological Survey of Canada, Paper 90-1B, pages 77-90.
- Evans, D.T.W.
In press: Epigenetic gold occurrences, central Newfoundland. Newfoundland Department of Natural Resources, Geological Survey.
- Findlay, J., Fowler, T.D. and Birkett, T.C.
1990: Geology of the Howse Lake area, western Labrador. Geological Survey of Canada, Open File 2204, 70 pages.
- Hoffman, P.F.
1987: Proterozoic foredeeps, foredeep magmatism and giant iron-formation. *In* Proterozoic Lithospheric Evolution. Edited by A. Kroner. American Geophysical Union, Geodynamics Series, No. 17, pages 85-98.
- Love, H.D.
1966: Montgomery Lake prospect: drilling operations and results, 1966. Unpublished report for Labrador Mining and Exploration Company Limited, Montreal, Quebec, 15 pages with appendices, maps and sections. [NFLD 231/15]
- Swinden, H.S.
1990: Regional geology and metallogeny of central Newfoundland. *In* Metallogenic Framework of Base and Precious Metal Deposits, Central and Western Newfoundland. Edited by H.S. Swinden, D.T.W. Evans and B.F. Kean. 8th IAGOD Symposium, Field Trip No. 1, Guidebook. Geological Survey of Canada, Open File 2156, pages 1-27.
- Swinden, H.S. and Santaguida, F.
1993: Shale-hosted sulphide occurrences in the eastern part of the Labrador Trough. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, pages 401-418.
- 1994: Sulphide occurrences in clastic sedimentary rocks in the Howse Zone, western Labrador. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 94-1, pages 253-261.

Swinden, H.S., Wardle, R.J., Davenport, P.H., Gower, C.F., Kerr, A., Meyer, J.R., Miller, R.R., Nolan, L., Ryan, A.B. and Wilton, D.H.C.

1991: Mineral exploration opportunities in Labrador—a perspective for the 1990's. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 91-1, pages 349-390.

Wardle, R.J. and Bailey, D.G.

1981: Early Proterozoic sequences in Labrador. *In* Proterozoic Basins of Canada. *Edited by* F.H.A. Campbell. Geological Survey of Canada, Paper 81-10, Supplement, pages 331-358.

Wardle, R.J., Ryan, A.B., Nunn, G.A.G. and Mengel, F.

1990a: Labrador segment of the Trans-Hudson Orogen: crustal development through oblique convergence and

collision. *In* The Trans-Hudson Orogen of North America: Lithotectonic Correlations and Evolution. *Edited by* J. Lowry and M. Stauffer. Geological Association of Canada, Special Paper 37, pages 353-369.

Wardle, R.J., Ryan, B. and Ermanovics, I.

1990b: The eastern Churchill Province, Torngat and New Quebec Orogens: an overview. *Geoscience Canada*, Volume 17, pages 217-222.

Wagenbauer, H.A., Riley, C.A. and Dawe, G.

1983: Geochemical laboratory. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, pages 133-137.

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