Current Research (1994) Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 94-1, pages 263-271

GEOLOGY OF STIBNITE MINERALIZATION AT THE HUNAN LINE PROSPECTS, CENTRAL NEWFOUNDLAND

P. Tallman and D.T.W. Evans[1]
Department of Earth Sciences, Memorial University of Newfoundland
St. John's, Newfoundland A1B 4J6

ABSTRACT

Antimony mineralization was discovered along the Hunan Line, within Paleozoic sedimentary rocks, in the eastern Dunnage Zone during the late 1980s. Exploration led to the discovery of three antimony prospects within an 8-km-long antimony soil-and-silt geochemical anomaly.

The Hunan Line area is underlain by fossiliferous Middle to Late Ordovician sedimentary rocks of the Davidsville Group, including a sequence of rhythmic bedded siltstone, pebble greywacke, and graphitic shale, which youngs to the east. Previously unrecognized Ordovician sedimentary rocks have been documented, which may help constrain the distribution of Ordovician and Silurian rocks in the region.

Antimony occurs as stibnite within veins that are categorized into three types: massive stibnite, quartz with minor stibnite, and distinct greenish sericite and chlorite with minor stibnite. These veins, which are uniformly developed in all rocks types, imply a regional mineralizing event. The pebble greywacke is variably sericitized and chloritized, however, these alteration styles appear to predate stibnite mineralization.

Preliminary structural evidence indicates that northeast-trending fault breccias, which are subparallel to bedding, are important factors in the localization of mineralization. Three, later, 100° -trending faults offset the geology and truncate geochemical anomalies.

Although stibnite veins along the Hunan Line do not contain gold, one drillhole intersected leucoxene-altered gabbro and this may indicate exploration potential for the element.

INTRODUCTION

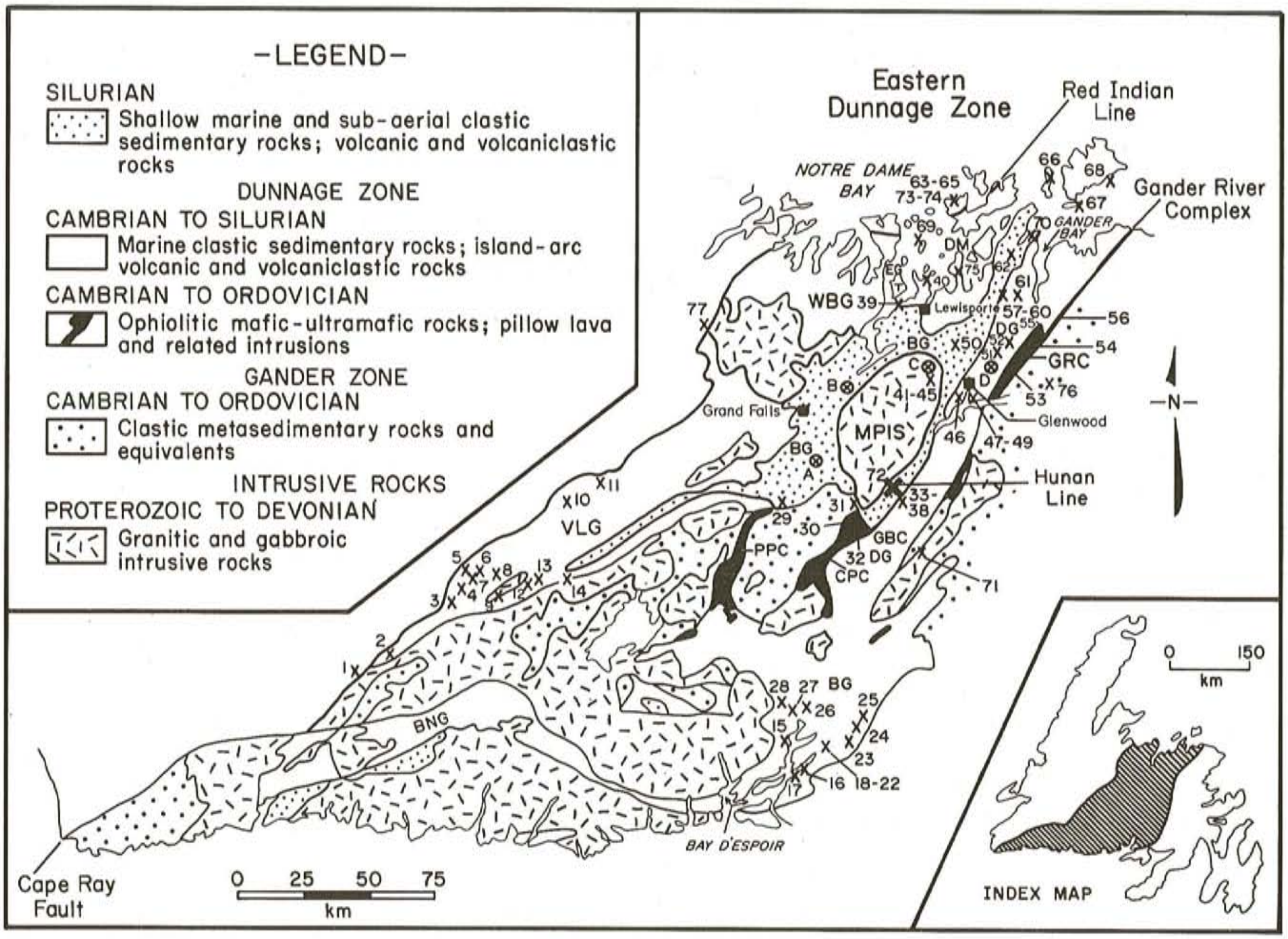
In 1989, Noranda Exploration Company Limited prospectors' discovered stibnite-bearing float in the Beaver Brook area. Subsequent exploration work led to the discovery of stibnite-rich veins at three separate localities, referred to as the Xingchang, Hunan, and Szechuan prospects. The three prospects occur within an 8-km-long zone of antimony-enriched silts and soils, informally termed the Hunan Line (Tallman, 1991c; Figure 1), which parallels the regional stratigraphy.

During August 1993, diamond-drill core from three antimony prospects in the Beaver Brook—Cooper Brook area was examined in detail as part of a regional metallogenic study of gold mineralization in the eastern Dunnage Zone (Evans, 1992). The data forms part of an M.Sc. dissertation by the senior author, which will investigate the geological setting and the geochemical and isotopic characteristics of stibnite veins and associated hydrothermal alteration. Field work also included mapping traverses along both Cooper and Beaver brooks.

Previous workers have produced disparate interpretations of the regional geology, particularly with respect to the placement and nature of the Ordovician—Silurian boundary (Anderson and Williams, 1970; Blackwood, 1981; Tallman, 1990c; Dickson, 1992). As a result, the interpretation of the age of the mineralized rocks along the Hunan Line has been revised several times. An additional problem relates to the

This project is funded by the Canada—Newfoundland Cooperation Agreement on Mineral Development (1990-1994); project carried by Geological Survey Branch, Department of Mines and Energy, Government of Newfoundland and Labrador.

[1] Mineral Deposits Section, Geological Survey Branch, Newfoundland Department of Mines and Energy



KEY (to Figure 1)

	OCCURRENCE	STYLE	GRADES	MINERALOGY	HOST ROCK	ALTERATION
1	SECOND EXPLOITS	Dilational Veins	7.5 g/t Au	Au,Gn,Sp,Hem,Pyr	Granite	Sil, Epi
2	WOODS LAKE	Dilational Veins	11.93 g/t	(Au),Asp	Metasediments	Seri
3	PATS POND	Dilational Veins	1.9 g/t Au	(Au,Ag),Cp,Gn,Sp	Felsic Volc	Sil
4	ROAD (CAMP)	Dilational Veins	5.5 g/t Au	(Au),Gn,Sp,Pyr	Felsic Volc	Seri, Pyr
5	WEST TULKS	Dilational Veins	N/A	(Au),Gn,Pyr	Felsic Volc	Seri, Sil
		Disseminated	N/A	(Au),Hem		Sil, Hem
6	MIDAS POND	Shear-Controlled	7.3 g/t Au	(Au),Pyr,Tour	Mafic Volc	Fe-carb, Pyr, Intense Argillic
7	GLITTER POND	Dilational Veins	2.55 g/t Au	(Au),Ba,Pyr	Felsic Volc	Seri
8	LONG LAKE	Dilational Veins	N/A	(Au),Pyr	Granite	Sil
9	VALENTINE LAKE	Dilational Veins	24 g/t Au	Au,Pyr,W,Tour	Trondhjemite, Conglomerate	Seri, Alb, Sil, Pyr
10	BOBBYS POND	Epithermal		Pyr,S,Pph,Ser,	Felsic Volc	Sil
11	VICTORIA MINE WEST/INCO	Veins	2.2 g/t	(Au),Asp	Felsic Volc	Sil
12	VICTORIA BRIDGE	Dilational Veins	32.5 g/t	(Au),Pyr	Trondhjemite	?
13	GUANO PIT	Dilational Veins	20.0 g/t	(Au),Pyr	Trondhjemite	?
14	SOUTH QUINN LAKE	Dilational Veins	N/A	(Au),Asp,Pyr,Po	Metasediments	Sil
15	RATTLING BROOK	Dilational Veins	6.5 g/t Au	(Au),Bi,Mo	Schist	
16	BOWERS TICKLE	Dilational Veins	13.7 g/t Au	(Au),Sb,Ag	Schist	Sil
17	LONG JACKS BIGHT	Disseminated	12.34 g/t Au	(Au,Ag),Pyr,Po,Ar,Gn	Schist	Sil
	LITTLE RIVER (18-22)				Felsic Volc	
18	WOLF POND	Dilational Veins	6.51 g/t	(Au),Asp,Pyr,Po,Sb	Felsic Volc	Sil
19	22 WEST/LITTLE RIVER	Disseminated	4.11 g/t	(Au),Asp,Pyr,Po,Sb	Felsic Volc	?
20	22 WEST/TILLICUM	Disseminated	4.9 g/t	(Au),Asp,Po,Pyr,Sb	Felsic Volc	Carb, Seri
21	38 WEST/42 WEST	Disseminated	3.09 g/t	(Au),Asp,Po,Pyr,Sb	Felsic Volc	?
22	89 TO 97 WEST/ESSO	Disseminated	3.8 g/t	(Au),Po,Pyr,Asp,Sb	Felsic Volc	Carb, Seri
23	LE POUVOIR	?	1.9 g/t	(Au),Asp,Sb	Schist	?
24	KIM LAKE #1	Veins	20.52 g/t	(Au),Gn,Sp,Cp	Felsic Volc	?
25	KIM LAKE #2	Veins	9.7 g/t	(Au),Sb,Asp	Felsic Volc	Carb, Seri
26	TRUE GRIT	Veins	30.2 g/t	(Au),Asp	Siltstone	?
27	GOLDEN GRIT TRENCH 4	Dilational Veins	16.9 g/t	(Au),Pyr	Pelite	Seri

KEY (to Figure 1, *Continued)*

	OCCURRENCE	STYLE	GRADES	MINERALOGY	HOST ROCK	ALTERATION
28	GOLDEN GRIT TRENCH 5	Dilational Veins		Sb,Pyr	Pelite	Seri
29	GREAT RATTLING Bk	Shear-Controlled	2.3 g/t Au	(Au),Pyr	Ultramafic, Metasediments	Sil, Seri
30	LIZARD POND	Shear-Controlled	12.6 g/t Au	(Au),Pyr,Asp	Ultramafic	Sil
31	CHIOUK BROOK	Disseminated	1.9 g/t Au	(Au),Pyr,Asp	Altered Seds	Sil
32	BRECCIA POND	Shear-Controlled	< 2 g/t Au	(Au)	Ultramafic	Sil, Hem
33	AZTEC	Epithermal	<1 g/t Au	(Au),Pyr	Altered Seds	Pyr, Argillic
34	HORNET	Dilational Veins	9.7 g/t Au	(Au),Pyr,Asp	Granite	Sil
35	A-ZONE EXTENSION	Dilational Veins	2.6 g/t Au	(Au),Pyr,Asp	Siltstone	Chlor, Potassic
36	ROAD GABBRO	Dilational Veins	7.9 g/t Au	(Au),Pyr,Asp	Gabbro	Sil, Fe-Carb
37	GOOSE	Dilational Veins	1.3 g/t Au	Au,Pyr,Asp	Greywacke	Seri, Sil
38	LBNL	Dilational Veins	1.8 g/t Au	(Au),Pyr,Asp	Porphyry	Sil
39	PORTERVILLE	Shear-Controlled	2.12 g/t Au	(Au),Pyr,Asp	Gabbro	Fe-Carb, Leucoxene
40	POWDERHOUSE COVE	Dilational Veins	78.2 g/t Au	(Au),Pyr,Asp	Felsic Dyke	Sil
	MOUNT PEYTON (41-45)					
41	HURRICANE	Shear-Controlled	4.6 g/t Au	(Au),Pyr,Asp	Diorite	Seri
42	CORSAIR	Shear-Controlled	3.2 g/t Au	(Au),Pyr,Asp	Diorite	Seri
43	COMANCHE	Shear-Controlled	1.3 g/t Au	(Au),Pyr,Asp	Diorite	Seri
44	SABRE	Disseminated	2.1 g/t Au	(Au),Pyr,Asp	Aplite Dyke	Sil
45	APACHE	Shear-Controlled	1.3 g/t Au	(Au),Pyr,Asp	Diorite	
46	THE OUTFLOW	Epithermal	12.23 g/t Au	(Au),Pyr,Sb	Greywacke	Sil
47	BULLET	Shear-Controlled	83 g/t Au	Au,Pyr,Asp,Gn,Cp	Shale	Fe-Carb
48	THE KNOB	Shear-Controlled	155 g/t Au	Au,Pyr,Asp,Cp,Bou	Greywacke	Fe-Carb
49	BOWATER	Dilational Veins	<3 g/t Au	(Au),Pyr	Greywacke	Sil
50	BIG POND	Dilational Veins	440 g/t Au	Au,Pyr,Asp	Gabbro	Fe-Carb
51	THIRD POND	Dilational Veins	4.6 g/t Au	(Au),Pyr	Greywacke	Sil
52	KNOB HILL	Dilational Veins	2.7 g/t Au	(Au),Pyr	Greywacke	Chlor, Pyr
53	JONATHANS POND	Shear-Controlled	6 g/t Au	(Au),Pyr,Asp		
54	BURSEY'S HILL	Disseminated	3.5 g/t Au	(Au),Cr	Ultramafic	Talc-Carb
55	CRIPPLE CREEK	Epithermal	9.6 g/t Au	(Au),Pyr,Asp	Trondhjemite	Sil
56	WEIRS POND	Dilational Veins	2.5 g/t Au	(Au),Asp,Pyr	Gabbro	Fe-Carb
	DUDER LAKE (57-60)					
57	FLIRT	Dilational Veins	N/A	(Au),Pyr,Asp	Gabbro	Fe-Carb, Chlor
58	GOLDSTASH	Disseminated	12.5 g/t Au	(Au),Pyr,Asp	Gabbro	Sil, Seri, Fe-Carb, Leucoxene
59	CORVETTE	Disseminated	N/A	(Au),Pyr,Asp	Gabbro	Sil, Seri, Fe-Carb, Leucoxene
60	STINGER	Shear-Controlled	N/A	(Au),Pyr,Asp	Siltstone	Seri, Fe-Carb
61	BURNT LAKE	Dilational Veins	N/A	(Au),Pyr	Greywacke	Sil
62	CLUTHA	Shear-Controlled	N/A	Au,Pyr,Asp	Gabbro	Fe-Carb, Sil
	MORETON'S HARBOUR (63-65)					
63	STUCKLESS COVE	Dilational Veins	20.2 g/t Au	(Au),Sb,Asp	Felsic Dyke	Sil
64	TAYLERS ROOM	Dilational Veins	13.3 g/t Au	(Au),Sb,Asp	Felsic Dyke	Sil
65	STEWARTS MINE	Dilational Veins	10.9 g/t Au	(Au),Asp,Pyr,Sp	Felsic Dyke	Sil
66	CHANGE ISLANDS	Dilational Veins	164.1 g/t Au	(Au),Pyr,Po,Cp	Felsic Dyke	Sil
67	INDIAN ISLANDS	Dilational Veins	8 g/t Au	(Au),Pyr,Asp	Felsic Dyke	Sil
68	CANN ISLAND	Shear-Controlled	3.1 g/t Au	(Au),Pyr,Cp,Sp	Mafic Volc	Chlor
69	POND ISLAND	Dilational Veins	<1 g/t Au	(Au),Cp,Sp,Sb,Bi,Ag, Asp,Tet	Granodiorite	Sil, Seri
70	CHARLES COVE	Dilational Veins	6.2 g/t Au	(Au),Pyr,Asp,W,Cp,Mo	Granodiorite	Sil
71	MIDDLE RIDGE	Shear-Controlled	1 g/t Au	(Au),Pyr,W	Granite	Seri, Sil
72	HUNAN	Dilational Veins			Greywacke	Seri, Carb
73	MORETONS HR. HEAD	Veins	9.11 g/t	(Au),Pyr,Asp,Sb	Mafic volc	?
74	PIERCE HR. EAST	Veins	4.79 g/t	(Au),Pyr,Asp,Sb	Mafic volc	?
75	SHOAL POINT	Shear-Controlled	4.67 g/t	(Au),Asp,Pyr,Cp	Gabbro	?
76	GANDER AIRPORT	Epithermal (?)		Pyr	Slate	Sil
77	HAND CAMP	Disseminated	10.6 g/t Au	(Au,Ag),Pyr,Gn,Sp	Sericite schist	Seri
	FLOAT					
A	PARADISE LAKE	Epithermal			Sandstone(?)	Sil
B	MOOSEHEAD	Dilational Veins	N/A	Au,Pyr,Asp	Sandstone(?)	Sil
C	SALMON RIVER	Dilational Veins	N/A	(Au),Asp,(Ag),Sp,Gn,Cp, Pyr,Po	Diorite	Sil
D	PANHANDLER	Dilational Veins	161 g/t Au	Au	Greywacke(?)	

( ) parentheses indicate that the mineral/commodity is present in minor or trace amounts or indicated by an assay.

Figure 1. *Regional geology of the eastern Dunnage Zone, central Newfoundland, showing the locations of significant gold occurrences (numbers are keyed to Table 1; geology modified after Tuach* et al., *1988). Abbreviations include: DG-Davidsville Group; BG-Botwood Group; DM-Dunnage Melange; EG-Exploits Group; WBG-Wild Bight Group; VLG-Victoria Lake Group; BNG-Bay du Nord Group; BG-Baie d'Espoir Group; PPC-Pipestone Pond Complex; CPC-Coy Pond Complex; GBC-Great Bend Complex; GRC-Gander River Complex; MPIS-Mount Peyton intrusive suite; T-Thwart Island (after Evans, 1993).*

recognized but mainly undocumented structural complexity in the area.

This study advances our understanding of the geological and mineralization history of the Beaver Brook–Cooper

Brook area. New fossil discoveries (S.H. Williams and P. Tallman, unpublished data) may help to resolve the age of the host rocks to the mineralization and to constrain the location of the Ordovician–Silurian boundary. Structural features that control stibnite veining have been identified and a preliminary structural history is inferred, although the absolute age of the various events remains uncertain. Rocks that host antimony mineralization are described in detail in this report. The data will contribute to an increased understanding of the general geology of the region and will form the basis for documenting the local geology of antimony mineralization.

LOCATION AND ACCESS

The Hunan Line prospects are located in central Newfoundland on the Eastern Pond (NTS 2D/11) map and lie 40 km southwest of Glenwood, and 1 km west of the Northwest Gander River (Figure 1).

The area is accessible from Glenwood via the abandoned Northwest Gander River forestry access road, which transects the central and eastern portion of the property. Newly completed forestry roads allow access to the western portion of the property from the Bay d'Espoir Highway. Drill roads, skidder trails and grid lines provide excellent access to the three mineralized zones.

The Hunan Line is situated on a moderately sloping east-facing hillside that ends at the Northwest Gander River. The area is characterized by spruce forest and bog-overgrown glacial-outwash deposits that form kame terraces along the river. Bedrock occurrences are limited to stream-and-trench exposures.

PREVIOUS WORK

Mapping at 1:250 000 scale by Anderson and Williams (1970) for the Geological Survey of Canada, was the first regional geological survey of significance in the Hunan Line area. The Newfoundland Department of Mines and Energy has mapped the region at 1:50 000 scale between 1981 and the present (Blackwood, 1981, 1982, 1983; Colman-Sadd and Russell, 1988; Dickson, 1992).

The potential of the eastern Dunnage Zone to host gold mineralization has been recognized for some time. Blackwood (1982) reported samples with anomalous gold concentrations from the Gander River Ultrabasic Belt in the Jonathan's Pond (NTS 2E/02) area north of Gander Lake, which sparked exploration interest in the region.

Noranda Exploration Company Limited was the first to investigate the gold potential of the Botwood and Davidsville groups south of Gander Lake. During 1987, Noranda prospectors discovered gold at Greenwood Pond approximately 15 km east of the Hunan Line (Tallman, 1989a). Further work in the area by Noranda with joint-venture partner Noront Resources Limited led to the discovery of numerous gold occurrences hosted by the Davidsville Group (Tallman, 1989a, 1990a, 1991a) and the Mount Peyton intrusive suite (Tallman, 1990b, 1991b) as well as to the discovery and exploration of three antimony prospects in the Cooper Brook–Beaver Brook area (Tallman, 1989b, 1990c, 1991c). Roycefield Resources Limited is currently exploring the Hunan Line area.

REGIONAL GEOLOGICAL SETTING

The Hunan Line area is underlain by Paleozoic sedimentary rocks included within the Exploits Subzone of the eastern Dunnage Zone (Williams, 1979; Williams *et al.*, 1988) (shown in Figure 1). Ordovician distal turbidites of the Davidsville Group and Silurian epiclastic sedimentary rocks of the Botwood Group are the dominant rock types. These rocks strike northeast–southwest, parallel to the axial planes of local-scale open folds and exhibit lower greenschist-facies metamorphism. The contact between the sedimentary rocks and the Siluro-Devonian Mount Peyton intrusive suite, a regional-scale polyphase batholith not examined during the field program, comprises a variety of gabbro, granodiorite, tonalite and granite phases (Dickson, 1992), and is reasonably well located (Anderson and Williams, 1970; Tallman, 1989b; Dickson, 1992).

Anderson and Williams (1970) considered the Hunan Line area to be underlain by Silurian Botwood Group sediments, based on lithological similarities to the Botwood Group type locality near Botwood, and placed the Ordovician–Silurian boundary 15 km to the east. Blackwood (1981) identified a graphitic shale horizon in Beaver Brook containing Carodocian graptolites and inferred this to be an areally restricted thrust wedge of the Ordovician Davidsville Group within the Botwood Group. Dickson (1992) significantly expanded the areal extent of Blackwood's Ordovician graphitic shale thrust-wedge unit to the southwest, based on the presence of Caradoc–Ashgill graptolites. He further interpreted the pebble greywacke hosting the Hunan antimony prospect to be another fault block containing Devonian or younger material on the basis of poorly developed bedding observed in limited surface exposures.

LOCAL GEOLOGY

Mapping results and fossil discoveries in Beaver and Cooper brooks require revisions to previous interpretations of the local geology. Three black shale horizons, which contain poorly preserved graptolites, are recognized in both brooks up to 1 km northwest of the pebble greywacke horizon. The general Hunan Line stratigraphy of rhythmic-bedded siltstone overlain by pebble greywacke and succeeded by graphitic shale has been identified in both brooks and is inferred to extend to the Szechuan prospect.

A new graptolite assemblage has been recognized in sandy micaceous siltstone within the rhythmic-bedded siltstone sequence in Cooper Brook (Figure 2), northwest of the pebble greywacke horizon. The assemblage, consisting of 5 species, has been identified as Llanvirn (H. Williams

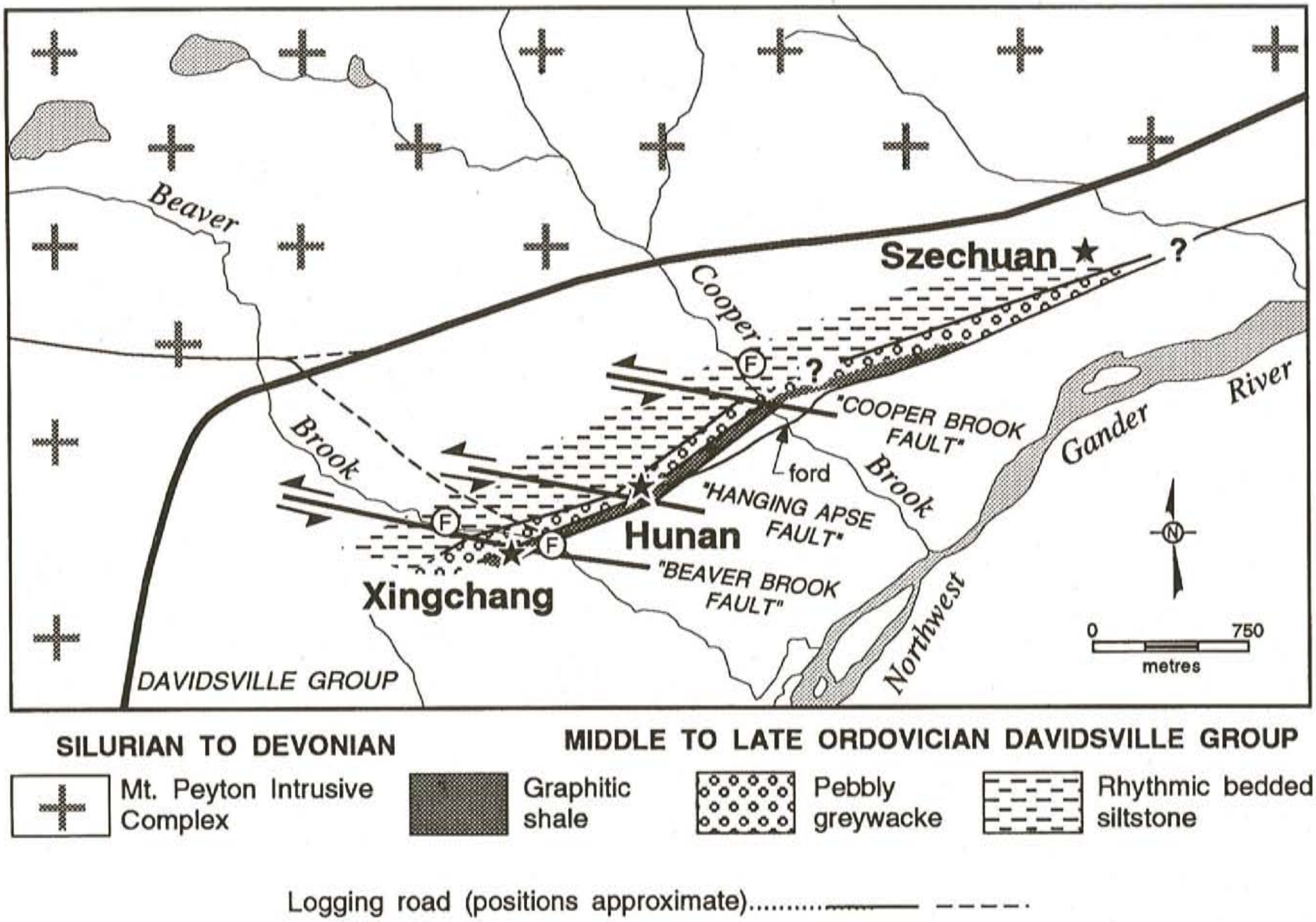


Figure 2. *Regional geology of the Hunan Line antimony prospects.*

and P. Tallman, unpublished data). Four fragments and two intact specimens of brachiopod collected from a sandy siltstone in Beaver Brook, Figure 2), also within the rhythmic-bedded siltstone sequence, have not yet been identified.

Graptolites from the graphitic shale unit of Blackwood (1981) in Beaver Brook have been re-examined and confirmed as Caradoc–Ashgill (S.H. Williams, personal communication, 1993). Several unidentified trace fossils and some oxidized and very poorly preserved graptolites were also noted at several localities in both brooks.

Results of diamond-drill-core logging allow a detailed description of the rock units within the Hunan Line succession. A general stratigraphic succession was recognized at the Hunan prospect and was extrapolated to both the Szechuan and Xingchang areas. This succession at the Hunan prospect includes: rhythmic-bedded siltstone (footwall sequence); pebble greywacke (Hunan sequence, host to the Hunan prospect); and graphitic shale (hanging-wall sequence) (Figure 2). The footwall and hanging-wall sequences are thought to be correlative with host rocks at the Szechuan and Xingchang prospects, respectively.

Intrusive rocks are rare within the immediate study area. A gabbro dyke was observed in a single drill-core intersection near the Xingchang prospect.

DESCRIPTION OF UNITS

RHYTHMIC-BEDDED SILTSTONE: FOOTWALL SEQUENCE

The 'footwall sequence' at the Hunan prospect consists of 1- to 10-cm-scale rhythmically interbedded carbonate-rich siltstone and sandstone interlayered with massive metre-scale units of carbonate sandstone and siltstone. A 5-m-thick brecciated graphitic shale unit also intersected in the 'footwall sequence' may be correlated with similar narrow graphitic shale horizons noted in both Cooper Brook and Beaver Brook.

Carbonate-rich siltstone and sandstone at the Szechuan prospect are rhythmically interbedded on a scale of 1 to 10 cm and are stratigraphically correlated with the micaceous carbonate-rich sandstone, which contains Llanvirn graptolites. One tectonically thickened intersection of this unit, informally named rhythmic-bedded siltstone, is at least 62 m in length across strike. Siltstone interbeds are dark grey in drill core.

The sandstone interbeds are light grey or white and have a granular texture.

Several individual limestone beds up to 27 m thick in drill section are interlayered with rhythmic-bedded siltstone. Limestone is internally massive and medium- to dark- brown-grey in drill core. White, diffuse elliptically 'patches' resembling 'donuts' approximately 1 cm in diameter occur locally within the limestone beds. These curious features may represent worm burrows.

One, 3-m-thick layer of matrix-supported polylithic pebble conglomerate contains angular to subangular clasts of black unfoliated siltstone–shale, limestone, rhythmically bedded siltstone, and very rare clasts of red sandstone. Clasts range from <1 to 10 cm in diameter. The matrix is silty and medium to dark grey.

PEBBLE GREYWACKE: HUNAN SEQUENCE

The 'Hunan sequence' consists of a 60-m-wide series of greywacke beds, which range from granule to cobble in clast size and include quartz-poor–feldspar-rich and quartz-rich–feldspar-poor varieties. Individual beds range in thickness from 2 to 15 m. Granule greywacke beds are massive and contain quartz and feldspar fragments as well as rare but slightly larger black shale clasts. Pebble greywacke is the most common unit. Both pebble and cobble greywacke horizons contain relatively more abundant black shale clasts, as well as a variety of sedimentary clasts, which include grey siltstone, yellowish carbonate(?) siltstone, green sandstone, and reddish sandstone. Cobble greywacke also contains rare clasts of black shale(?) with white spots of carbonate(?) and greenish siliceous clasts with round quartz eyes previously identified as 'diorite' and 'granite' respectively (Tallman, 1991c). Several of the coarser horizons can be correlated across sections and may be useful as marker beds within the greywacke stratigraphy.

The matrix of all greywacke beds within the 'Hunan sequence' contains approximately 30 to 40 percent carbonate, however, sericite and chlorite proportions are variable and produce significant colour variations ranging from light green for sericite-rich zones to very dark green for chlorite-rich zones. Preliminary examination of thin sections suggests the carbonate is present in all types of greywacke and may be a primary feature. Fine-grained white sericite, as well as some chlorite, may be produced by regional lower greenschist-facies metamorphism. A distinctive light-green sericite and much of the chlorite, however, overprints the pre-existing carbonate–sericite assemblage and appears to be attributable to hydrothermal alteration. There is no observed relationship between either primary or secondary mineral assemblages and stibnite veining.

GRAPHITIC SHALE AND GABBRO: HANGING-WALL SEQUENCE

The 'hanging-wall sequence' intersected in drill core at the Hunan prospect includes grey limestone with white elliptically shaped 'donuts', massive carbonate-rich sandstone, rhythmically interbedded siltstone, and a 3-m-wide highly graphitic fault breccia developed in black shale.

The Xingchang prospect at surface is hosted by brecciated and moderately graphitic black shale, which is correlated with similar rocks exposed in Beaver Brook that contain Caradoc–Ashgill graptolites. Sections in drill core indicate a sequence of variably graphitic shale and dark-grey siltstone, which is commonly fractured, brecciated and faulted. The siltstone units are rarely non-graphitic and generally finely laminated. The widest section of this unit outcrops in Beaver Brook, where it is has an exposed width of 150 m.

INTRUSIVE ROCKS

One gabbro dyke intrudes brecciated graphitic shale along strike from the Xingchang Showing. The shale host does not appear to be hornfelsed. The gabbro is observed in core recovered from a hole drilled toward a 100°-trending topographic lineament and coincident geophysical feature informally named the 'Beaver Brook fault'. It is variably altered to skeletal leucoxene, coarse patchy purplish leucoxene(?), carbonate, chlorite, and remnant plagioclase, and ranges from leucocratic to melanocratic in overall appearance. The upper gabbro contact exhibits a 15-cm-wide bleached and very fine-grained zone interpreted as a chilled margin. The contact has subsequently been weakly sheared. Several small zones of fault gouge crosscut the gabbro.

STRUCTURE

Ordovician rocks exhibit a prominent S_1 cleavage (except in the vicinity of the Szechuan prospect) that is parallel or subparallel to bedding. All rock types at the Szechuan prospect are unusual for their lack of bedding-parallel S_1 cleavage, potentially implying that these rocks are younger than Ordovician. However, the presumed stratigraphic correlative sequence at the Hunan prospect possess a well-developed S_1 cleavage and fossil evidence strongly suggests an Ordovician age. Further work is required to demonstrate that the rocks that host the Szechuan prospect are indeed correlatives of the 'footwall sequence' as observed within drill core from the Hunan prospect.

Successively imbricated quartz veins in drill-core samples indicate that a considerable amount of deformation may have been accommodated as slip along these bedding–cleavage planes, particularly in the siltstone and shale units. The age of this deformation is not constrained.

An F_2 folding event has produced S_2 axial-planar cleavage in these rocks. All units possess a cm-scale spaced S_2 fracture cleavage, which transects bedding and appears to be axial planar to folds observed in drill core. Folding, as indicated by shifts in orientation of bedding planes in core, is open and either upright or recumbent, although the latter possibility is discounted based on the orientations of similar structures observed at surface. Fold hinges are commonly truncated by zones of fault breccia.

F_2 fold hinges are locally preserved in outcrops in Cooper Brook at the ford (Figure 2) and in the first black graphitic shale unit upstream from the ford. These open folds are slightly inclined and plunge steeply to the northeast.

Fault breccias examined in drill core are oriented subparallel to the regional northeast-trending strike direction and locally can be found to transpose F_2(?) fold hinges. Individual breccias range in width from 1 to <10 m and are tentatively considered to be coeval with F_2 deformation.

Fault gouge zones observed in drill core locally transect fault breccias and are therefore later features. The orientation of fault gouge slip planes is not consistent but tends to be at a high angle to bedding and S_1 cleavage. These structures may be related to larger scale dextral faults informally named 'Cooper Brook fault', 'Hanging Apse fault', and 'Beaver Brook fault', which are inferred from topographic lineaments, geophysical surveys and geological evidence to trend approximately 100°. These faults offset the regional stratigraphy by approximately 50 m and also truncate antimony-soil anomalies.

MINERALIZATION

Although host rocks differ at each of the three antimony prospects along the Hunan Line, the stibnite veins are remarkably uniform in character and are strongly controlled by fracturing. Three distinct styles of stibnite veining are recognized. The economically significant veins contain approximately 95 percent massive stibnite as crystals up to 15 cm long, with grey translucent quartz lining vein margins. A second vein type contains approximately 95 percent white quartz with minor stibnite as crystals up to 1 cm long. A third mineralized 'vein' type is developed along 1- to 3-mm-wide fracture planes, which contain subhedral to euhedral crystals of stibnite in rare 1 mm clots associated with greenish sericite–carbonate–chlorite gangue.

The massive and disseminated stibnite vein types crosscut all rock types and putative alteration types. The only connection between alteration and mineralization appears to occur in the sericite–carbonate–chlorite–stibnite vein type, which contains hydrothermal sericite and chlorite within the gangue. All vein contacts are sharp and there is no visible alteration of wallrock. Massive stibnite veins within greywacke at the Hunan prospect have developed in localized stockworks and are generally wider than stibnite veins, which are hosted by either siltstone or shale.

DISCUSSION

Newly discovered graptolites indicate that at least the Hunan and Xingchang prospects occur within a continuous Middle to Late Ordovician stratigraphic sequence within the Davidsville Group, or their equivalents, which young to the east. There is no evidence, at present, to suggest this sequence is confined to a fault bound wedge as shown by Blackwood (1981) and adopted by Dickson (1992). Mapping in Beaver Brook suggests that the entire brook is underlain by a continuous sequence of Ordovician rocks that extends from the Mount Peyton intrusive suite to the Northwest Gander River. Micaceous sandstone found in the upper portion of Cooper Brook and west of the Szechuan prospect is 'Botwood Group' in appearance, however, a similar unit of micaceous and ripple-marked sandstone exposed in Cooper Brook contains Llanvirn graptolites.

The new fossil ages obtained during this study is that they indicate the stratigraphic succession in the area of the Hunan Line youngs to the east. This conflicts with regional stratigraphic interpretations and further work is required in the area between the Hunan prospect and the Northwest Gander River to document the lateral extent of the Ordovician rocks and determine if the Hunan Line stratigraphy is contiguous with Davidsville Group sediments 15 km to the east.

Data from traverses in Cooper Brook and Beaver Brook have been correlated with information from drill core to trace the local stratigraphic sequence along strike. Stratigraphic correlations between the Xingchang prospect and Cooper Brook can be made with some confidence. Lack of outcrop and geophysical information between Cooper Brook and the Szechuan prospect renders the extension of stratigraphy along strike to this area tenuous.

Sedimentary rocks at the Szechuan and Xingchang prospects are completely unaltered. The matrix of the Hunan pebble greywacke exhibits sericite and chlorite alteration. However, the alteration appears to predate stibnite veining. Three types of mineralized vein are recognized and are common to all three stibnite prospects. These veins contain hydrothermal sericite and chlorite and exhibit morphological and textural characteristics, which appear independent of the local host rocks, implying a regional antimony mineralizing event and significant structural controls on veining.

The magnitude of stibnite veining varies at each of the three Hunan Line prospects. Stibnite veins are best developed at the Hunan prospect where the greywacke host has responded to tectonic stress by forming stockwork fracture zones. Siltstone and graphitic shale at the Szechuan and Xingchang prospects appear to have accommodated a greater proportion of the tectonic stress as slip along bedding planes that did not allow significant dilatant zones to develop. It would appear that the rheological differences between host rocks at the three prospects would make the Hunan prospect a relatively more attractive exploration target.

The distribution of stibnite veining and antimony geochemical soil-and-silt anomalies parallel to stratigraphy also suggests the mineralization is controlled by bedding parallel structures. The later trending faults truncate or offset stratigraphy as well as the geochemical anomalies suggesting that these features postdate mineralization. The northeast-trending folds and faults are interpreted to be related to Silurian orogenesis and the later post-mineralization east–west-trending faults with Carboniferous activity. Much more work remains before this hypotheses can be tested.

The association of a gabbro intrusion with the 100°-trending Beaver Brook fault is interesting when considered in light of the speculated absolute timing of tectonic activity. The gabbro is transected by zones of fault gouge that appear to be linked to the east–west-trending faults, however, it lacks any deformational fabric clearly related to the regional northeast–southwest structural grain.

Leucoxene-altered gabbro in proximity to the Beaver Brook fault may also be a favourable exploration indicator for potential gold mineralization (Churchill and Evans, 1992; Churchill *et al.*, 1993).

ACKNOWLEDGMENTS

Rob Lane is thanked for his capable camp and field assistance and for finding brachiopods where they are not meant to be. Lawson Dickson provided accommodations at all hours, as well as maps, airphotos, and valuable discussions on the geology of the area. Kerry Sparkes is thanked for his work and geological insights in the early stages of exploration. Terry Brace is recognized for his re-discovery of Blackwood's (1981) graptolites in Beaver Brook, which made Tallman's work re-discovering this locality much easier. Bertin Bourgoin of Roycefield Resources Limited has kindly allowed access to the property and provided drill logs and section plans and in return we have respected his request for confidentiality of grades and widths of mineralization. S. Henry Williams is particularly thanked for quickly providing ages for the graptolite specimens. The study is partly supported by the Newfoundland Department Mines and Energy and by NSERC grants to M. Wilson at Memorial University. Mark Wilson, Rod Churchill and Scott Swinden are kindly thanked for reviewing this report.

REFERENCES

Anderson, F.D. and Williams, H.
1970: Gander Lake (west half), Newfoundland. Geological Survey of Canada, Map 1195A.

Blackwood, R.F.
1981: West Gander River (2D/11 east half) and Dead Wolf Pond (2D/10 west half). Newfoundland Department of Mines and Energy, Mineral Development Division, Map 81-100.

1982: Geology of the Gander Lake (2D/15) and Gander River (2E/02) area. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 82-4, 56 pages.

1983: Notes on the Geology of the Great Gull River map area (2D/06), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 82-71.

Churchill, R.A. and Evans D.T.W.
1992: Geology and gold mineralization of the Duder Lake gold showings, eastern Notre Dame Bay, Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 211-220.

Churchill, R.A., Wilton, D.H.C. and Evans D.T.W.
1993: Geology, alteration assemblages and geochemistry of the Duder Lake gold showings, northeastern Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, pages 317-333.

Colman-Sadd, S.P. and Russell, H.J.
1988: Miguels Lake (2D/12), Newfoundland. Newfoundland Department of Mines and Energy, Mineral Development Division, Map 88-50.

Dickson, W.L.
1992: Ophiolites, sedimentary rocks, post-tectonic intrusions and mineralization in the Eastern Pond (NTS 2D/11W) map area, central Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 97-118.

Evans, D.T.W.
1992: Gold metallogeny of the Eastern Dunnage Zone, central Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 92-1, pages 231-243.

1993: Gold mineralization in the Eastern Dunnage Zone, central Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Geological Survey Branch, Report 93-1, pages 339-349.

Tallman, P.
1989a: First year assessment report on Licence 3418 Noront-Paul's Pond (4716) NTS 2D/11. Unpublished confidential report, Noranda Exploration Company Limited, 5 pages. [2D/11 (204)]

1989b: First year assessment report on Licences 3361, 3468, 3536, 3480, 3418, 3547, 3539, 3549, 3537, 3538, 3559, NTS 2D/11. Unpublished confidential report, Noranda Exploration Company Limited, 19 pages. [2D/11 (221)]

1990a: First year assessment report on Licences 3361, 3468, 3536, 3480, 3418, 3547, 3539, 3549, 3537, 3538, and 3550. NTS 2D/11, for the period April 12, 1988 to April 11, 1989. Noranda Exploration Company Limited, unpublished report, 21 pages. [2D/11/0221]

1990b: First year assessment report on Licences 3544 and 3856, Noront–Mount Peyton (4719), NTS 2D/14, 2D/15, 2E/02 and 2E/03. Noranda Exploration Company Limited, unpublished report, 11 pages. [NFLD/1968]

1990c: Second year assessment report on diamond drilling at Noront–Beaver Brook project (6723), Licence 4012, NTS 2D/11. Noranda Exploration Company Limited, unpublished report, 9 pages. [2D/11/0240]

1991a: Second year assessment report on Noront–Greenwood (4717), Licence 3852. Noranda Exploration Company Limited, unpublished report, 6 pages. [2D/11/0227]

1991b: Second year assessment report on Licence 3544, geophysics, soils and diamond drilling, Noront–Mount Peyton (6719), NTS 2D/14). Noranda Exploration Company Limited, unpublished report, 13 pages. [2D/0247]

1991c: The 'Hunan Line' discoveries: antimony mineralization in central Newfoundland. *In* Ore Horizons, Volume 1. *Edited by* H.S. Swinden and A. Hogan. Newfoundland Department of Mines and Energy, Geological Survey Branch, pages 11-21.

Williams, H.
1979: Appalachian Orogen in Canada. Canadian Journal of Earth Sciences, Volume 16, pages 792-807.

Williams, H., Colman-Sadd, S.P. and Swinden, H.S.
1988: Tectonic-stratigraphic subdivisions of central Newfoundland. *In* Current Research, Part B. Geological Survey of Canada, Paper 88-1B, pages 91-98.

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