Nova Scotia Gold Grain Study: Background and Anomalous Concentrations of Gold Grains in Till from the Beaver Dam Gold District (NTS 11E/02) and Hillsvale (11D/13) Areas

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Introduction

During the 2006 field season, ten 10 kg till samples were collected from within and near the Beaver Dam Gold District, as well as from the Hillsvale area (Fig. 1) as part of the Nova Scotia Gold Grain Study, which began during the 2004 field season. The gold grains recovered from till samples were counted and their morphology characterized in order to provide additional information with respect to: (1) background concentrations of gold grains at a regional scale, (2) anomalous gold grain concentrations and the associated dispersal pattern within a known gold district (Beaver Dam Gold District) and (3) an estimate for the distance of glacial transport based on the morphology of each of the grains recovered. Additional till sampling

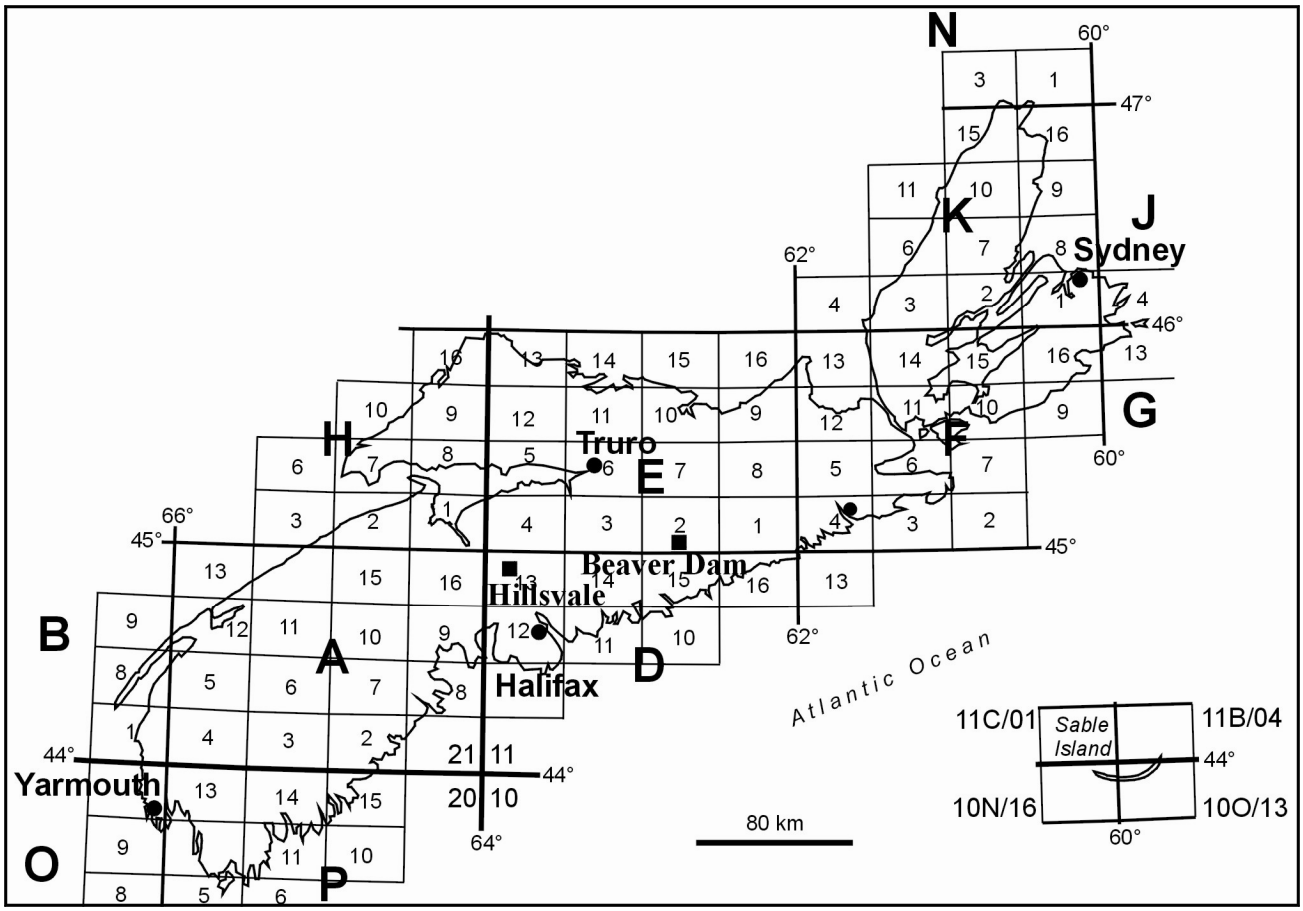

Figure 1. Map showing the general location of the Beaver Dam Gold District and the Hillsvale area.

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from within and near the Beaver Dam Gold District will help define the size and shape of the dispersal pattern down ice from the known gold occurrence.

Results from the 2006 field season support the earlier findings of Goodwin (2005, 2006) and have significance for mineral exploration programs, especially for gold, in Nova Scotia.

Regional Geology

Bedrock Geology

Southern mainland Nova Scotia lies within the Meguma Terrane, which is defined by the Meguma Group, a 9000 m thick succession of siliciclastics that hosts most of Nova Scotia's gold deposits (Ryan and Smith, 1998). The Meguma Group consists of two formations: the basal metasandstone-dominated Goldenville Formation and the conformably overlying, slate- and metasiltstone-dominated Halifax Formation (Keppie, 2000). The Meguma Group metasediments were intruded by Devonian granitoids, namely granodiorite, monzogranite and leucomonzogranite (MacDonald, 2002).

Gold generally occurs in quartz veins in the Goldenville Formation that are emplaced on the crests and flanks of regional anticlines or domal structures, which can measure up to 4 km long and up to 0.5 km wide (Sangster, 1990). Quartz is the dominant vein mineral but carbonates also occur commonly as do lesser amounts of the sulphides pyrite, pyrrhotite, arsenopyrite, galena, chalcopyrite and sphalerite (Ryan and Smith, 1998).

Arsenopyrite is characteristic of all the gold districts in variable amounts, up to a maximum of about 5%. It is most abundant in wall rocks but also occurs within quartz veins (Sangster, 1990).

Gold in Nova Scotia

The first vein-hosted gold deposit in the Meguma Terrane was discovered at Mooseland in 1858 by Lieutenant C. L'Estrange while hunting moose (Malcolm, 1929). This led to a major gold rush in Nova Scotia and by the turn of the century the Government of Nova Scotia recognized 60 gold districts throughout the province. Production continued relatively unabated until the beginning of the Second World War in 1939. Since 1939, only limited, sporadic production occurred, except from 1983-1987 when a federal exploration incentive coupled with relatively steady gold prices allowed for some consistent production (Ryan and Smith, 1998). For historic and descriptive geological details, Malcolm (1929) summarizes the first 70 years of gold exploration and mine development in the Meguma Terrane of Nova Scotia.

Bates (1987) summarizes the historic milling methods (stamp mills, etc.) used to crush the gold ore and gold extraction methods involving the use of shaker tables in combination with amalgamation (the addition of mercury) or cyanidation (crushed ore is dissolved in a mixture of lime and cyanide).

Beaver Dam Gold District

The Beaver Dam deposit is located on the south, overturned limb of the northeast-trending Beaver Dam-Fifteen Mile Stream anticline (Ryan and Smith, 1998). At the district scale, gold occurs in both high-grade quartz veins and disseminated in slate beds of the Goldenville Formation metasandstone (Ryan and Smith, 1998). Gold-bearing zones are displaced by the Mud Lake Fault to the east and by the River Lake Pluton to the west (Coker *et al.,* 1988).

Beaver Dam is characterized by a thick package of slate (argillite) beds interstratified with the dominant metasandstone (Sangster, 1990). The slate package consists of the Crouse Argillite, Papke Argillite and the Austen Argillite interstratified with the Hanging Wall Greywacke and the Millet Seed Greywacke (Sangster, 1990). The package has an average thickness of approximately 150 m, of which slate (argillite) constitutes approximately 75% of the total thickness, or about 105 m (Sangster, 1990). Gold occurs in all the slate (argillite) units, but recent (mid-1980s) underground development primarily focused on the Papke and Austin zones (Ryan and Smith, 1998).

Numerous small quartz veins in several 3 m thick (average) slate belts are also known to contain gold. Unveined slate belts further characterized by the presence of arsenopyrite are also known to contain discrete grains of gold. Grades in these belts vary from 0.5 to 2.5 g Au/t over widths of 5 to 15 m (Ryan and Smith, 1998).

Accessory minerals may include variable amounts of pyrrhotite, galena, sphalerite,

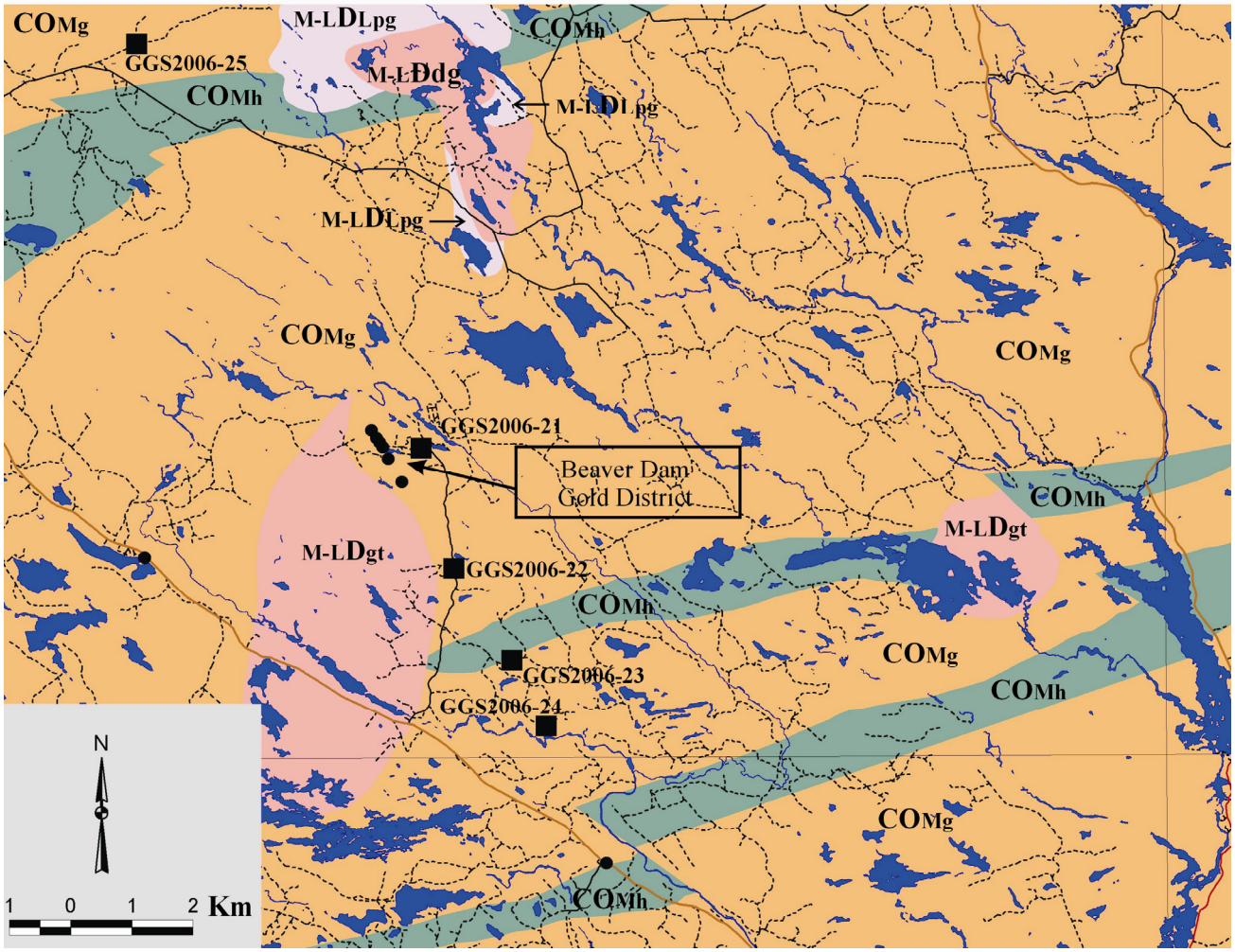

Figure 2. Simplified regional geology map of the Beaver Dam Gold District area showing the 2006 till sample locations (filled squares). The 2004 sample locations are filled circles. Geology after Keppie (2000). (COMg = Goldenville Formation, COMh = Halifax Formation, M-LDgd = granodiorite, M-LDLpg = paragneiss, M-LDdg = diorite-gabbro).

chalcopyrite, scheelite, stibnite, argentite, tetrahedrite, loellingite, molybdenite and tellurides (Sangster, 1990). Highly variable silica enrichment visually characterizes the Beaver Dam deposit (Kontak and Smith, 1987). A detailed summary of the stratigraphy, mineralization and alteration of the Beaver Dam Gold District is provided by Duncan (1987).

Hillsvale Area

The Hillsvale area (Fig. 3) is underlain by Cambrian-Ordovician Goldenville Formation metagreywacke with minor metapelite. There is no known gold in the Hillsvale area, but it is located on the steep to slightly overturned north limb of the Rawdon Gold Mines Anticline, host to the Rawdon Gold Mines located 15 km to the northeast. Gold occurs at the Mount Uniacke Gold District located approximately 5 km to the southeast along the southern margin of the Mount Uniacke Anticlorinum (Horne *et al.,* 2005). The Hillsvale area is characterized by approximately 30 bedding-parallel quartz veins, similar in character and frequency to quartz vein systems associated with other Meguma gold districts (Horne *et al.,* 2005).

Surficial Geology

Generally, most of the surficial deposits and associated landforms throughout Nova Scotia were formed during the Wisconsinan glaciation in the last 70 000 years (Lewis *et al.,* 1998).

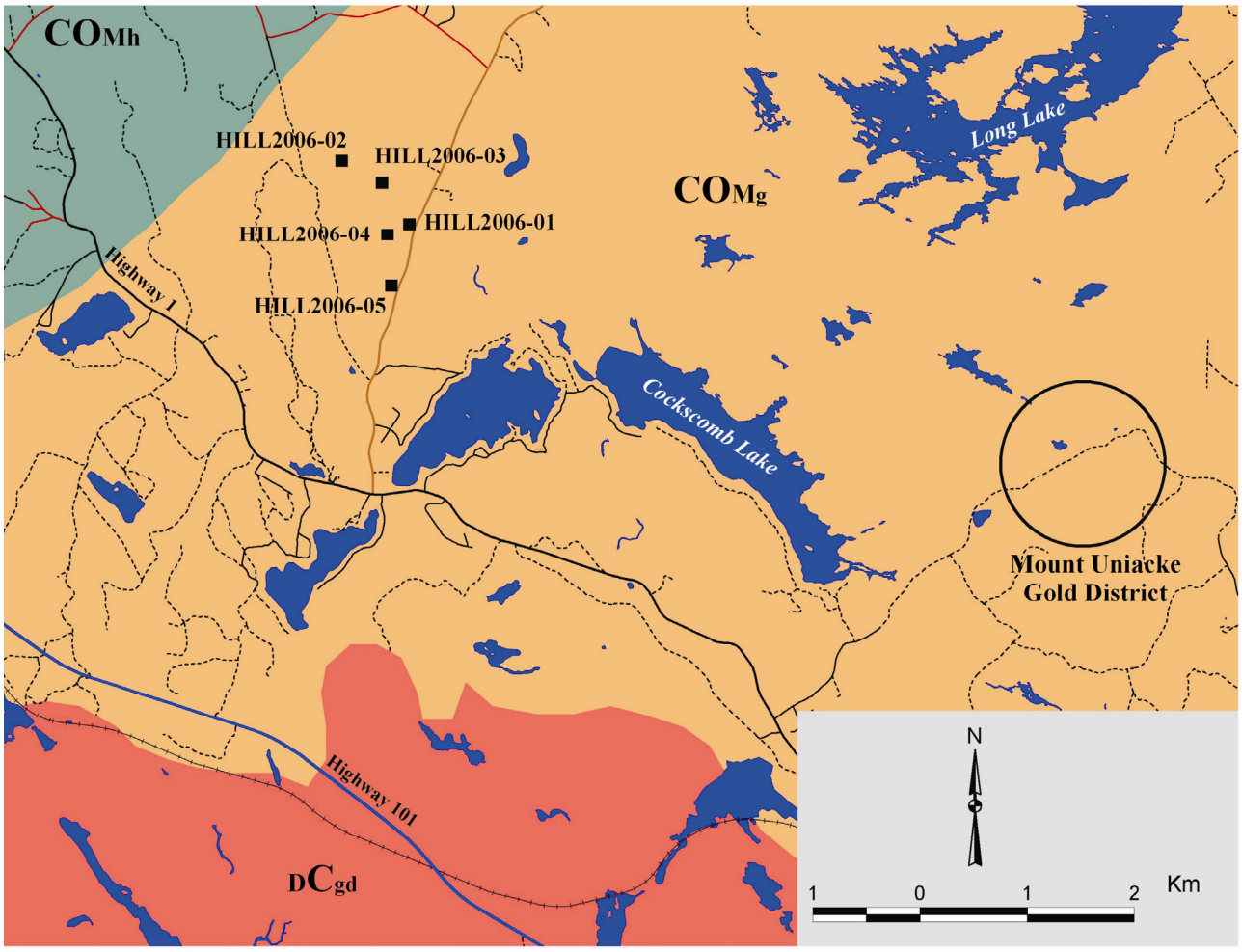

Figure 3. Sample locations for till samples collected within the Hillsvale area. Geology after Keppie (2000). (COMg = Goldenville Formation, COMh = Halifax Formation, DCgd = granodiorite).

Superimposed till sheets and various multiple-flow directional indicators have been mapped, and indicate that Nova Scotia is characterized by a relatively complex ice-flow history (Stea *et al.,* 1992; Stea and Finck, 2001).

The following summary of the glacial history of Nova Scotia is taken from Stea and Finck (2001). The oldest observed ice flow on land moved toward the east and southeast, and was responsible for the formation of the Hartlen Till. This first ice-flow event has been termed the Caledonia Phase (75-40 ka). South and southwest flow of the Escuminac Phase (22-18 ka) followed, and was responsible for deposition of the Lawrencetown Till. The Scotian Phase (18-15 ka), was characterized by an ice divide situated over most of Nova Scotia. The resulting ice flow varied from northwestward in northern Nova Scotia to south and southeast in southern Nova Scotia, followed by formation of the Beaver River Till. The Chignecto Phase (13-12.5 ka) was characterized by shifting ice flow associated with several small ice caps, the remnants of waning stages of the Scotian Phase glacier.

Enrichment of gold and arsenic, with lesser enrichment of copper, lead, zinc, tungsten, bismuth, tellurium and iron, characterizes many of the gold deposits of the Meguma Terrane (Kontak and Smith, 1993). These elements are commonly enriched in soil and till down-ice from known gold occurrences (Coker *et al.,* 1988), the result of mechanical dispersal (erosion, transportation and deposition) by advancing glacial ice. Glacial dispersal distances vary in Nova Scotia from hundreds of metres to several kilometres down-ice from source (Stea and Finck, 2001).

Beaver Dam Gold District

The Beaver Dam Gold District is characterized by relatively thin till (<5 m), although locally it reaches thicknesses of 25 m or more (Coker *et al.,* 1988). The till is characterized by the locally derived Quartzite Till of Stea and Fowler (1979). The Quartzite Till is now referred to as the Beaver River Till, metagreywacke (or metasandstone) facies (Finck and Stea, 1995).

Coker *et al.* (1988) indicate the dominant ice-flow direction in the Beaver Dam Gold District is toward the southeast (145°) and is also the youngest ice-flow event recorded in the district. The oldest recorded ice-flow direction, however, is toward the south (180°) with an intermediate ice flow toward the east (090$^{\circ;}$ Coker *et al.,* 1988).

Hillsvale Area

The surficial geology of the Hillsvale area is characterized by a blanket of locally derived Quartzite Till (Stea and Fowler, 1981). The Quartzite Till is now referred to as the Beaver River Till, metagreywacke facies (Finck and Stea, 1995). Horne *et al.* (2005) suggest that the till is thin and its source of origin is unknown.

Regional ice-flow indicators mapped in the vicinity of the Hillsvale area indicate ice flow was toward the southeast (Stea and Fowler, 1981). Horne *et al.* (2005), however, suggest at least one episode of ice flow toward the north.

Methods

Introduction

During the 2006 field season, ten 10 kg C-horizon till samples were collected from two areas (Fig. 1). Four samples (GGS2006-21 to GGS2006-24) were collected down ice of the Beaver Dam Gold District in order to add additional information to six detailed till samples previously reported by Goodwin (2004). The four new samples extended the 2004 line by an additional 6.5 km to the southeast and were collected to better define the down-ice dispersal pattern identified from the 2004 samples (Fig. 2). Samples were collected approximately every 2.0 to 2.5 km along the line. The fifth sample (GGS2006-25) was collected approximately 10.5 km north of the gold district to obtain more data on background gold grain concentrations.

Five samples (HILL2006-1 to HILL2006-5) were collected in the Hillsvale area (Fig. 3). The samples were collected approximately every 400 to 500 m along a roughly north-south line near a recently uncovered quartz vein system (Fig. 4).

Detailed field descriptions were recorded at each sample site and a digital photograph was taken for future reference. Notes regarding each sample site included sample depth, till type, colour, texture, and clast type and percentage were recorded. Sample sites were geo-referenced (NAD 83) to the Universal Transverse Mercator (UTM) grid using the averaging function of a GARMIN 12 GPS (Table 1).

Field Sampling Methods

A 10 kg till sample was collected at each sample site. Samples were typically collected from hand-dug till pits approximately 1.0 to 1.5 m in depth along roadside till exposures. All samples were collected by shovel and were passed through a 1 cm plastic sieve in the field prior to placement in a 4 ml plastic bag.

Laboratory Preparation and Analytical Methods

All samples collected during the 2006 field season were sent to Overburden Drilling Management (ODM) Limited of Nepean, Ontario. ODM processed the 10 kg till samples and produced a heavy mineral concentrate (HMC). The company also reported the number of gold grains present as well as the gold grain morphology.

ODM removed the >2 mm fraction by wet screening and placed it into pre-labelled bags for future lithologic identification. The <2 mm fraction was preconcentrated by density separation while being passed across a shaking table; visible gold grains were identified and counted during this stage.

Where necessary, the table concentrate was also (micro) panned and an additional gold grain count was performed. The table concentrate was then subjected to a heavy liquid separation in methylene iodide (S. G. 3.3). A ferromagnetic

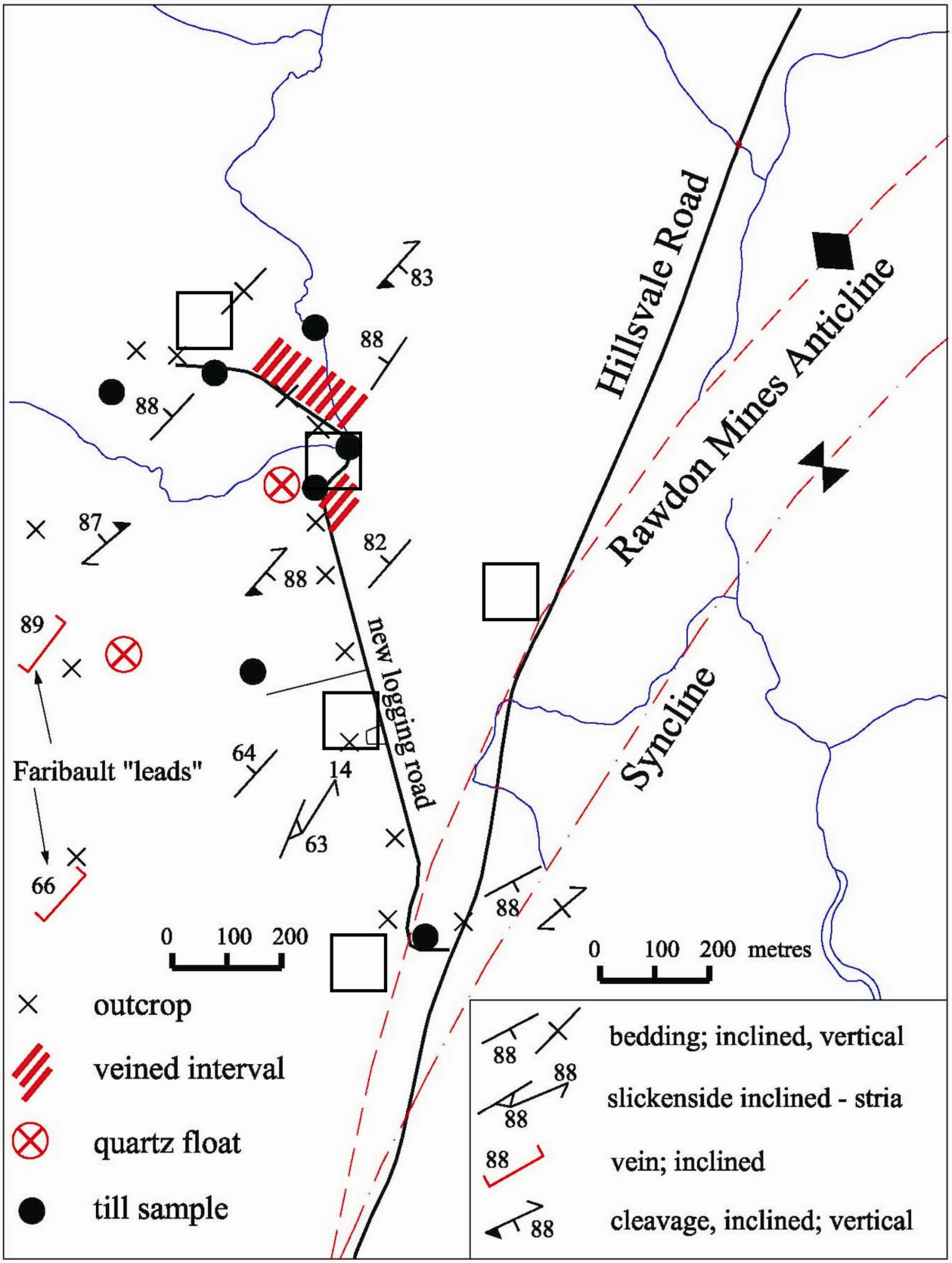

Figure 4. Detailed map showing the spatial relationship between the Hillsvale vein array and the 2006 till sample locations (open squares). Map modified after Horne *et al.* (2005).

Table 1. Till samples with UTM (NAD27) co-ordinates.

Sample #	utm-E83	utm-N83	Bedrock Geology	Comments
GGS2006-21	522102	4990205	Meguma Group, metasandstone	Beaver Dam area
GGS2006-22	522857	4987401	Meguma Group, metasandstone	Beaver Dam area
GGS2006-23	524209	4985263	Meguma Group, metasandstone	Beaver Dam area
GGS2006-24	525002	4983719	Meguma Group, metasandstone	Beaver Dam area
GGS2006-25	515497	4999623	Meguma Group, metasandstone	Beaver Dam area
HILL2006-01	430105	4977239	Meguma Group, metasandstone	Hillsvale area
HILL2006-02	429472	4977831	Meguma Group, metasandstone	Hillsvale area
HILL2006-03	429848	4977626	Meguma Group, metasandstone	Hillsvale area
HILL2006-04	429898	4977140	Meguma Group, metasandstone	Hillsvale area
HILL2006-05	429935	4976665	Meguma Group, metasandstone	Hillsvale area

separation was performed on the resulting HMC and the non-magnetic HMC was weighed and placed in pre-labelled vials.

ODM recorded sample weights after each processing stage and all material was retained for future reference. All equipment was thoroughly cleaned between samples. ODM is well recognized for its ability to recover and describe gold grains from glacial sediments and completed the work previously reported by Goodwin (2005 and 2006).

Geochemical analysis for gold in the HMC was not completed as part of this study. Estimates of the calculated visible gold grade of the HMC, however, were provided by ODM.

Results

Results for the number and morphology of gold grains recovered from each till sample, including the calculated (ppb) gold concentration of the HMC, are presented in Table 2. Tabulated weights for the bulk till sample, table split, >2 mm size fraction and table feed, as well as the magnetic and non-magnetic fractions of the HMC, are presented in Table 3.

Sample GGS2006-21 returned the highest gold grain counts from till samples collected within and near the Beaver Dam Gold District (Fig. 2). This sample was collected from a small borrow pit within several hundred metres of a former decline that was in use when the property was being developed during the late 1980s. Of the 27 gold grains (total) recovered, 20 were pristine and 7 were modified, suggesting the grains are likely less than100 m from their source (DiLabio, 1990).

Till samples GGS2006-22 and GGS2006-23 were collected approximately 3.5 km and 6.0 km, respectively, down ice from the Mill Shaft, an area of known gold in quartz. Total gold grain counts drop off to background levels of 3 gold grains per sample, none of which are pristine. Sample GGS2006-24 was collected approximately 7.75 km down ice from the Mill Shaft and returned 8 gold grains: 4 were pristine, 1 was modified and 3 were reshaped. The slight increase in the total gold grain count, combined with the presence of pristine gold grains, suggest that either a small mineralized source is located immediately up ice of the sample or the grains (in particular the pristine gold grains) may have been released from sulphides by post-glacial weathering processes (Henderson and Roy, 1995). Sample GGS2006-25 was collected approximately 10.75 km up ice of the Beaver Dam Gold District and returned 5 gold grains: 3 pristine and 2 reshaped.

The till was locally derived and the vast majority of the clasts recovered from each till pit were angular to sub-angular, reflecting the local Meguma Group bedrock. Quartz clasts were only noted in sample GGS2006-21, which also returned the highest gold grain count.

Figure 5 is an x-y plot combining till samples collected in 2004 and key samples from the 2006 field season. Total gold grain counts are projected to fall to background levels of 3 gold grains or less between 2.0 and approximately 3.5 km down ice from source.

Table 2. Summary of the number of recovered visible gold grains and the calculated content (ppb) of visible gold in the heavy mineral concentrate (HMC).

Sample #	Number of Visible Gold Grains				Calculated PPB Visible Gold in HMC			
	Total	Reshaped	Modified	Pristine	Total	Reshaped	Modified	Pristine
GGS2006-21	27	0	7	20	77	0	24	53
GGS2006-22	3	1	2	0	4	1	2	0
GGS2006-23	3	1	2	0	6	3	3	0
GGS2006-24	8	3	1	4	1	1	1	<1
GGS2006-25	5	2	0	3	27	26	0	1
HILL2006-01	25	13	6	6	1182	1009	130	43
HILL2006-02	2	2	0	0	416	416	0	0
HILL2006-03	6	1	3	2	60	1	2	57
HILL2006-04	2	0	0	2	6	0	0	6
HILL2006-05	17	3	9	5	309	41	221	47

Table 3. Summary of the sample weights at the various processing stages.

	Weight (kg wet)				-2.0 mm Table Concentrate Weight (g dry) Heavy Liquid Separation (S.G. 3.3)				
					HMC				
Sample #	Bulk Rec'd	Table Split	+2.0 mm Clasts	Table Feed	Total	Lights	Total	Non Mag	Mag
GGS2006-21	11	10.2	4.3	5.9	299.7	270.3	28.6	27.3	1.3
GGS2006-22	10.3	9.5	3	6.5	410.6	385	24.8	16.8	8.0
GGS2006-23	10.5	9.7	2.5	7.2	341.5	305.7	35.1	31.4	3.7
GGS2006-24	9.7	8.9	2.2	6.7	295.7	251.7	43.5	39.9	3.6
GGS2006-25	9.7	8.9	3.2	5.7	268.5	121.7	146.2	145.5	0.7
HILL2006-01	13.0	12.2	2.7	9.5	384.0	365.9	18.1	17.6	0.5
HILL2006-02	14.1	13.3	2.4	10.9	263.1	257.6	5.5	5.3	0.2
HILL2006-03	13.6	12.8	4.3	8.5	327.7	316.1	11.6	11.5	0.1
HILL2006-04	16.5	15.7	4.0	11.7	386.7	372.1	14.6	14.6	0.0
HILL2006-05	13.0	12.2	2.5	9.7	453.4	441.2	12.2	11.8	0.4

Till samples collected in the Hillsvale area ranged from a low of 2 (total) gold grains to a maximum of 25 (total) gold grains. Till sample HILL2006-01 contained the maximum number of (total) gold grains: 6 pristine, 6 modified and 13 reshaped grains. Till sample HILL2006-05 contained 17 (total) gold grains: 5 pristine, 9 modified and 3 reshaped grains. Based on the number of total gold grains recovered, both samples would be considered anomalous. The relative abundance of reshaped gold grains in sample HILL2006-01 requires further explanation. The remaining three samples returned 6 (total) gold grains or less.

Clasts recovered from the till indicate that 80-90% of the clasts are locally derived from the

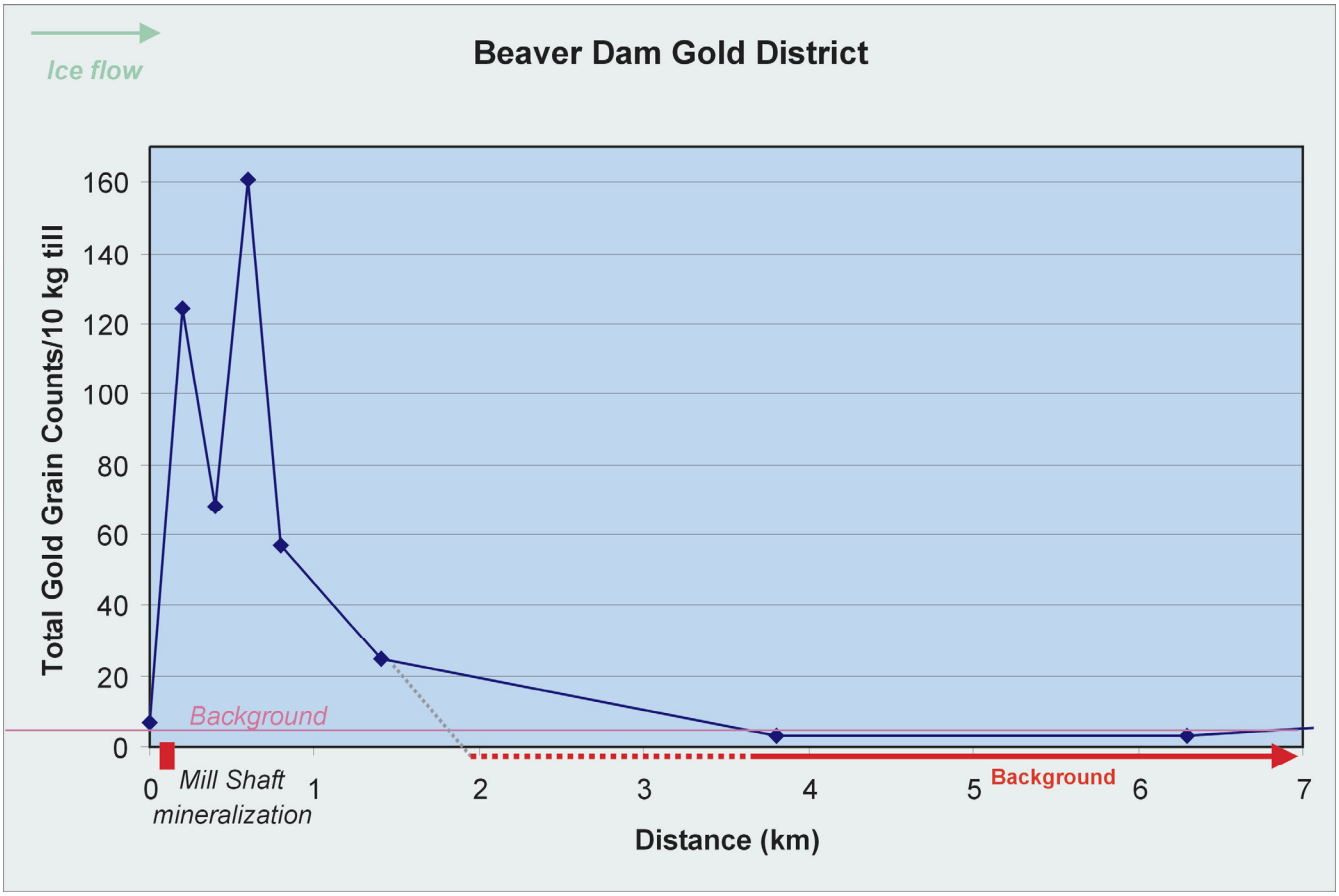

Figure 5. Down-ice dispersal of gold grains recovered from till samples collected during the 2004 and 2006 field seasons from the Beaver Dam Gold District.

underlying Meguma bedrock. Clasts were typically angular to sub-angular, suggesting proximity to source. Quartz clasts were noted only in till pits HILL2006-01 (12 angular clasts) and HILL2006-05 (6 angular clasts), suggesting ice flow to the southeast. The highest gold grain counts correspond with the highest quartz clast counts and suggest a spatial relationship between gold and quartz veins. Two sets of striations (150°-330° and 130°-310°) were noted during the 2006 sampling program.

The results of the 2006 till sampling program, in many ways, contradict results reported by Horne *et al.* (2005) and enhance the prospectivity of the Hillsvale area, as well as the northern limb of the Rawdon Mines Anticline between the Hillsvale vein array and Rawdon Gold Mines.

Conclusions

Ten 10 kg till samples were collected in 2006 as part of the Nova Scotia Gold Grain Study (cf. Goodwin, 2005, 2006). Five samples were collected from within and near the Beaver Dam Gold District to further define the size and shape of the gold grain dispersal pattern down ice from the known gold deposit. Five samples were also collected from the Hillsvale area, which is characterized by approximately 30 bedding-parallel quartz veins that are similar in character and frequency with quartz vein array systems in other Meguma gold districts. All samples were processed by Overburden Drilling Management (ODM).

Results from Beaver Dam indicate (total) gold grain counts are projected to fall to background levels between approximately 2.0 and 3.5 km down ice of the Mill Shaft, the inferred source of the gold recovered in the till samples. Results from Hillsvale indicate that the two till samples that contained the highest percentage of quartz clasts also returned the highest gold grain counts (up to 25 gold grains in HILL2006-01), suggesting a

spatial relationship between gold and quartz veins. The number of reshaped gold grains, particularly in till sample HILL2006-01, requires further explanation. Regardless, these results suggest that the northern limb of the Rawdon Mines Anticline between Hillsvale and Rawdon Gold Mines has good gold potential.

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