

Gold mineralization in the upper Hyland River area: A non-magmatic origin

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ABSTRACT

Gold occurrences in the upper Hyland River valley form a 50-km-long belt that is considered to be the easternmost portion of the Tombstone Gold Belt (TGB). Mineralization is thought to have a genetic association with nearby Cretaceous plutons, which were important in the formation of most mineralization in the TGB. However, an evaluation of the Hyland River occurrences indicates that evidence supporting an intrusion-related gold model is mostly lacking. Plutons and dykes do not occur in the vicinity of the gold occurrences; there are no obvious zones of hornfels; contact metamorphic minerals and skarns are mostly absent; there is no known mineral or metal zonation typical of intrusion-related systems; and aeromagnetic lows result from massive, variably altered quartz grit and conglomerate and not from unroofed 'low-mag' intrusions. Mineralization consists of four types: 1) disseminated pyrite and arsenopyrite in altered grit; 2) quartz-arsenopyrite veins; 3) quartz-pyrite-galena veins; and, 4) massive arsenopyrite veins. Auriferous quartz veins have characteristics similar to orogenic gold veins, and thus potentially relate to regional metamorphism and large structural features.

RÉSUMÉ

Les occurrences d'or dans la haute vallée de la rivière Hyland sont regroupées en une zone d'une longueur de 50 km que l'on estime être la partie la plus orientale de la ceinture aurifère de Tombstone (CAT). On estime qu'il y a association génétique entre la minéralisation et les plutons d'âge Crétacé adjacents qui ont été importants pour la plupart des minéralisations dans la CAT. Cependant, une évaluation des occurrences de la rivière Hyland révèle plutôt l'absence d'indications à l'appui d'un modèle de formation de l'or relié à l'intrusion. Les plutons et les filons intrusifs ne se trouvent pas à proximité des occurrences d'or; il n'existe aucune zone apparente de cornéennes; les minéraux et skarns du métamorphisme de contact sont principalement absents; il n'y a aucune zonation évidente des minéraux ou des métaux telle que celle qui pourrait exister aux environs d'un pluton; et les creux aéromagnétiques sont attribuables à des grès grossiers quartzeux et des conglomérats massifs diversement altérés plutôt qu'à des intrusions faiblement magnétisées exposées. On trouve quatre types de minéralisation : 1) pyrite et arsénopyrite disséminées dans le grès grossier altéré; 2) veines de quartz et arsénopyrite; 3) veines de quartz, pyrite et galène et 4) veines d'arsénopyrite massive. Les veines de quartz aurifère présentent des caractéristiques similaires à celles des veines d'or orogéniques et pourraient ainsi être reliées au métamorphisme régional et aux grandes entités structurales.

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INTRODUCTION

Since the discovery of the intrusion-related Fort Knox gold deposit in Alaska in the early 1990s, gold exploration in Yukon has increasingly focused on plutons of mid-Cretaceous age. So prevalent is the association of gold mineralization with mid-Cretaceous intrusions of the Tombstone and Mayo plutonic suites, that it provided the foundation for an intrusion-related gold model that has gained widespread acceptance and application (e.g., Thompson *et al.*, 1999; Lang *et al.*, 2000; Goldfarb *et al.*, 2005). Intrusion-related gold mineralization in Yukon is preferentially concentrated in the Tombstone Gold Belt, which is part of the Tintina Gold Province (Hart *et al.*, 2002), and forms a 550-km-long belt across central Yukon (Fig. 1) that is coincident with the distribution of more than 100 reduced, 'low-mag' plutons. The gold occurrences at the eastern end of the belt are apparently less significant as they have attracted less exploration attention. Most intrusion-related mineralization in this region consists of tungsten skarns related to the Tungsten plutonic suite.

However, exploration, mostly in the late 1990s, resulted in the discovery of several gold occurrences and widespread soil anomalies that together form a 50-km-long, northwest-trending belt of gold occurrences in the upper Hyland River valley in northern NTS mapsheet 105H. Jones and Caulfield (2000) recognized a distinct style of gold mineralization on the Fer property that they interpreted

as a distal style of intrusion-related mineralization that formed 2-3 km above buried intrusions. Additionally, a pronounced, north-trending aeromagnetic low could be interpreted as an unroofed, low-mag, ilmenite-series, or reduced pluton, similar to those that characterize the Tombstone Gold Belt. These and other features have encouraged the use of an intrusion-related gold model as an exploration model for gold in the upper Hyland River valley.

Herein, we evaluate the role that granitoids play in generating gold mineralization in the upper Hyland River valley. In doing so, we also evaluate the regional geological setting of these occurrences and the geological controls on mineralization.

REGIONAL GEOLOGY AND STRATIGRAPHY

The regional geology of the upper Hyland River valley area is poorly understood, having received little attention since the mapping of the Frances Lake (105H) map area in the early 1960s (Blusson, 1966). However, information from more recent mapping to the north (Gordey and Anderson, 1993) and interpretations in Gordey and Makepeace (2003) have been used in conjunction with reconnaissance mapping to present the geological interpretation described below and illustrated in Figure 2. Aeromagnetic images indicate that the region has a moderate response with a distinctive large, south-trending low that is flanked by highs. This feature is discussed later.

Rock distribution is dominated by Neoproterozoic to Lower Cambrian clastic strata with lesser Paleozoic clastic and carbonate strata. Generalized stratigraphic relations between the main units are shown in Figure 3. The region west of the Little Hyland River is largely underlain by Neoproterozoic to lowest Cambrian Hyland Group clastic sedimentary rocks which are divisible into 1) coarse-clastic, quartz-rich grits, conglomerates and quartzites of the dominantly Neoproterozoic Yusezyu Formation, and 2) overlying maroon and green argillites, grey shales and lesser grits and sandstone, of the dominantly Lower Cambrian Narchilla Formation. The Yusezyu Formation is locally dominated by finer grained lithologies, but is characterized by the coarser grained ones. Thin discontinuous limestone horizons occur near the contact between the Yusezyu and Narchilla formations. East of the Hyland River, essentially coeval Neoproterozoic to Lower Cambrian brown and grey siltstone and shale with

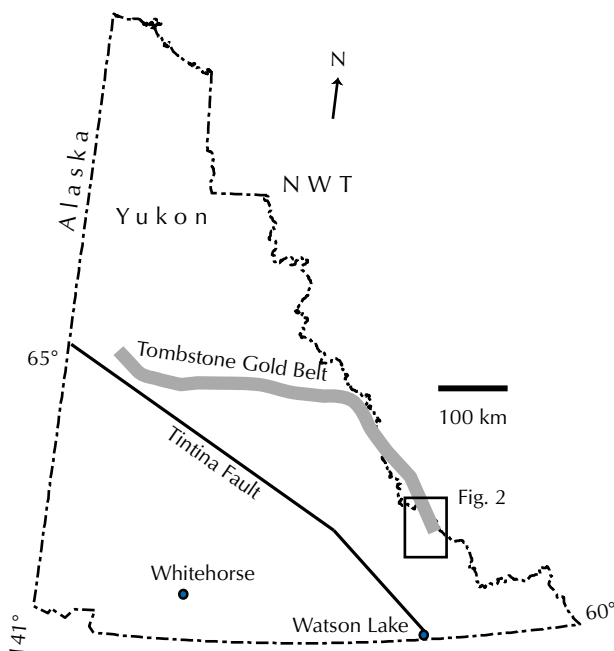


Figure 1. Regional location map of the upper Hyland River study area with respect to the Tombstone Gold Belt.

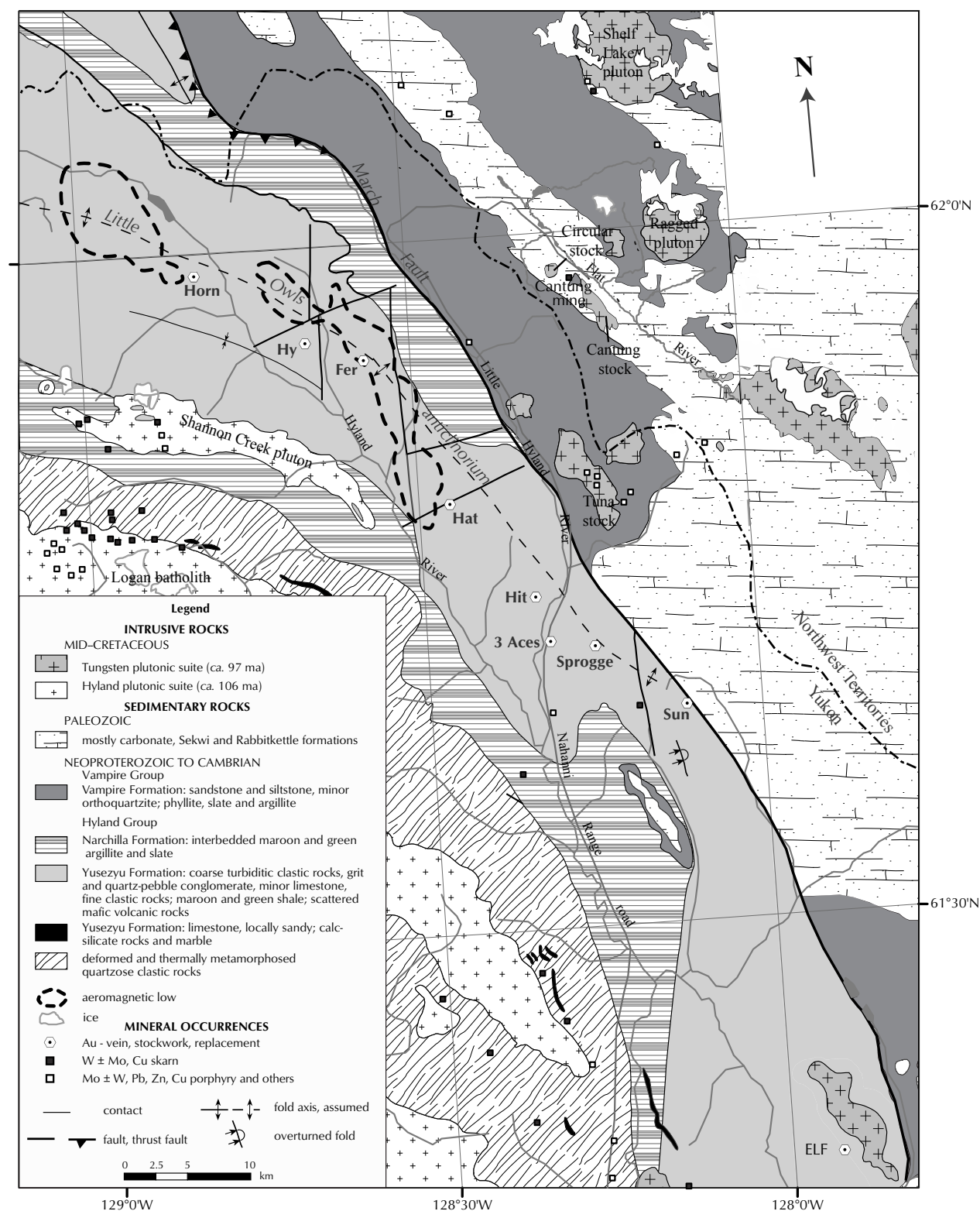


Figure 2. Regional geological and structural map for the upper Hyland River area showing gold properties and other mineral occurrences (after Gordey and Makepeace, 2003). Hyland plutonic suite plutons form a southwestern belt with a tungsten-molybdenum-copper-lead-zinc metal association. Tungsten plutonic suite plutons form an eastern belt with a tungsten-molybdenum-copper association. A central belt lacking intrusions has a gold-arsenic metal association.

fine-grained sandstone are assigned to the Vampire Formation.

Narchilla and Vampire formation strata are locally overlain by orange-brown weathering recessive shale of the Lower to Middle Cambrian, locally archaeocyath-bearing, Gull Lake Formation. Basal Gull Lake Formation limestone-conglomerate and limestone may be equivalent to off-shelf Lower Cambrian Sekwi Formation carbonate which is prevalent east of the Little Hyland River. Yusezyu, Vampire and Gull Lake formations are all unconformably overlain by Upper Cambrian to Lower Ordovician buff-weathering undulose-laminated and locally nodular limestone of the Rabbitkettle Formation. Rabbitkettle Formation is conformably overlain by undifferentiated Road River Group strata. Paleozoic rocks are rare except in the south of the study area and in the Flat River valley.

Significant within the region are the differences in the time-equivalent Neoproterozoic to Middle Cambrian stratigraphy on each side of the Little Hyland River valley (Figs. 2 and 3). Most distinctive are the lithological differences between the essentially time-equivalent Narchilla and Vampire formations, the largest difference being the presence of coarse-clastic strata in the Narchilla Formation. This lithological contrast continues into the Middle Cambrian with differences between the partly co-eval Sekwi and Gull Lake formations. The Sekwi Formation reflects platformal carbonate growth, whereas the Gull Lake Formation records dominantly slope to off-shelf clastic sedimentation. Paradoxically, the Vampire Formation represents a deeper water facies to the east of the contemporaneous Narchilla Formation, whereas Sekwi Formation represents shallow water compared to the Gull Lake Formation. The dramatic facies change across this boundary is best explained by an active structure, which is described later.

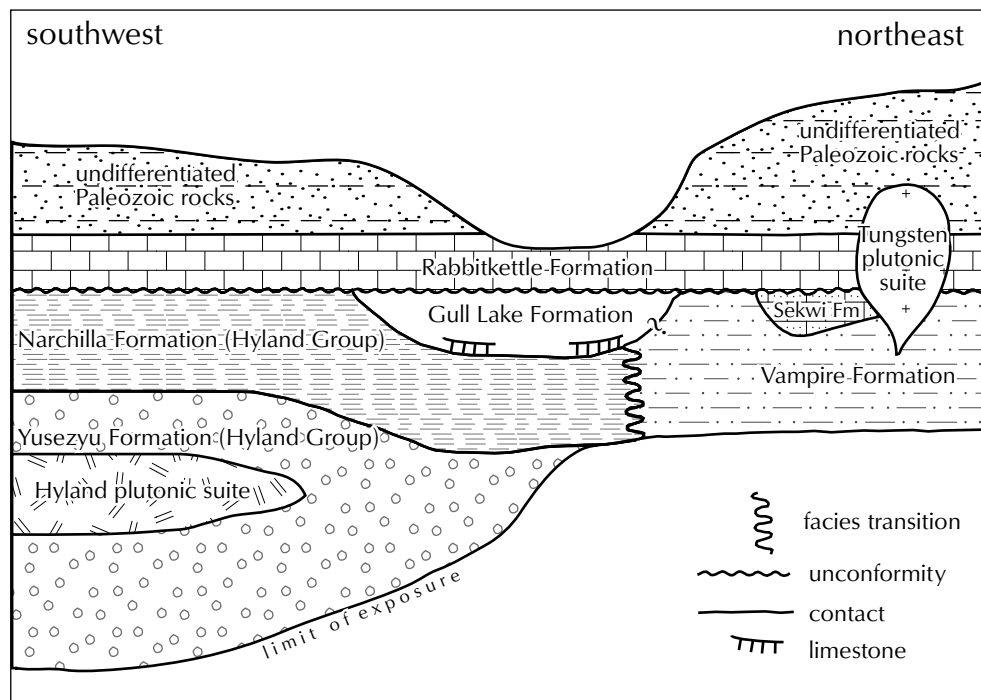


Figure 3. Generalized stratigraphic cross-section for the upper Hyland River area, modified from Gordey and Anderson (1993).

PLUTONIC ROCKS

Two suites of intrusive rocks are recognized in the study area: the Hyland and the Tungsten plutonic suites. The Hyland plutonic suite includes large heterolithic felsic batholiths, located in the southwest of the study area, that have contacts that are concordant with the fabric of the Hyland Group. These include the Logan Mountains and Shannon Creek batholiths (Figs. 2 and 4). The occurrence of the intrusions as thick flat concordant sheets suggests that they were emplaced at mid-crustal levels (~10-15 km). Hyland plutonic suite (introduced by Hart *et al.*, 2004a) includes part of the Anvil plutonic suite of Mortensen *et al.* (2000) and Heffernan *et al.* (2005). Tungsten plutonic suite intrusions include small to medium, circular to irregularly shaped, discordant bodies of generally homogeneous felsic compositions that occur east of the Little Hyland River. Associated plutons include Shelf Lake, Ragged and Tuna stock, as well as the Circular and Cantung stocks, which are associated with tungsten mineralization of the Cantung deposit. These plutons have steep sides and flat tops and were likely emplaced in the upper crustal levels (5-7 km). U-Pb isotopic dating indicates that the Hyland plutonic suite is approximately 106 Ma and the Tungsten plutonic suite is about 97 Ma (Hart *et al.*, 2004a,b, unpublished; Heffernan, 2004). Aeromagnetic imagery indicates moderate to moderately

high responses from Hyland suite plutons and moderate to moderately low responses from Tungsten suite plutons.

STRUCTURAL GEOLOGY

The study area is part of the Selwyn fold belt. Few faults and folds were indicated in previous mapping, and some features described below are newly interpreted from reconnaissance mapping, aeromagnetic data, maps available in assessment reports, or are newly extrapolated from those described to the north by Gordey and Anderson (1993). Regional structural features are shown in Figures 2 and 4.

Regional structural fabric

Most non-igneous rocks have a weak to moderate, northwest-trending, shallowly to moderately steep-dipping fabric. The fabric is defined by phyllitic partings with mica development on foliation surfaces. The intensity of phyllite development is highest in the southwest, proximal to Hyland plutonic suite intrusions, and diminishes to the northeast where slaty cleavage is mostly dominant. The fabric developed in response to deformation that transposed bedding through a series of northeast-verging overturned folds that are locally cut by thrust faults (Fig. 5). Quartz-rich beds of conglomerate, grit and quartzite are mostly undeformed, particularly where massive, but margins are mostly modified by minor faults.

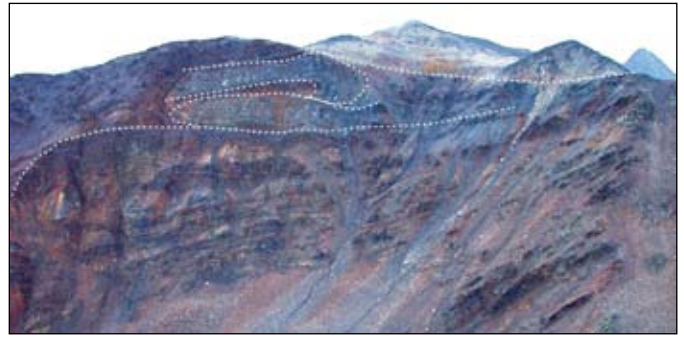


Figure 5. A north-facing ridge on the northern part of the Hy property, where Hyland Group is deformed into a series of moderately shallowly southwest-dipping overturned folds and thrusts, outlined in white.

Smaller units are 'rolled' among more ductile argillaceous host rocks. Lineations north of the map area plunge northwesterly (Gordey and Anderson, 1993), whereas those in the study area plunge shallowly to the south and southeast. The timing of fabric formation is uncertain but may be related to the emplacement of the mid-Cretaceous Hyland plutonic suite batholiths, which are similar in age to mid-Cretaceous deformation in the Tombstone strain zone near Mayo (Murphy, 1997; Mair, 2004). East of the Little Hyland River valley, the phyllitic sheen is rarely developed, but slaty cleavage is widely observed.

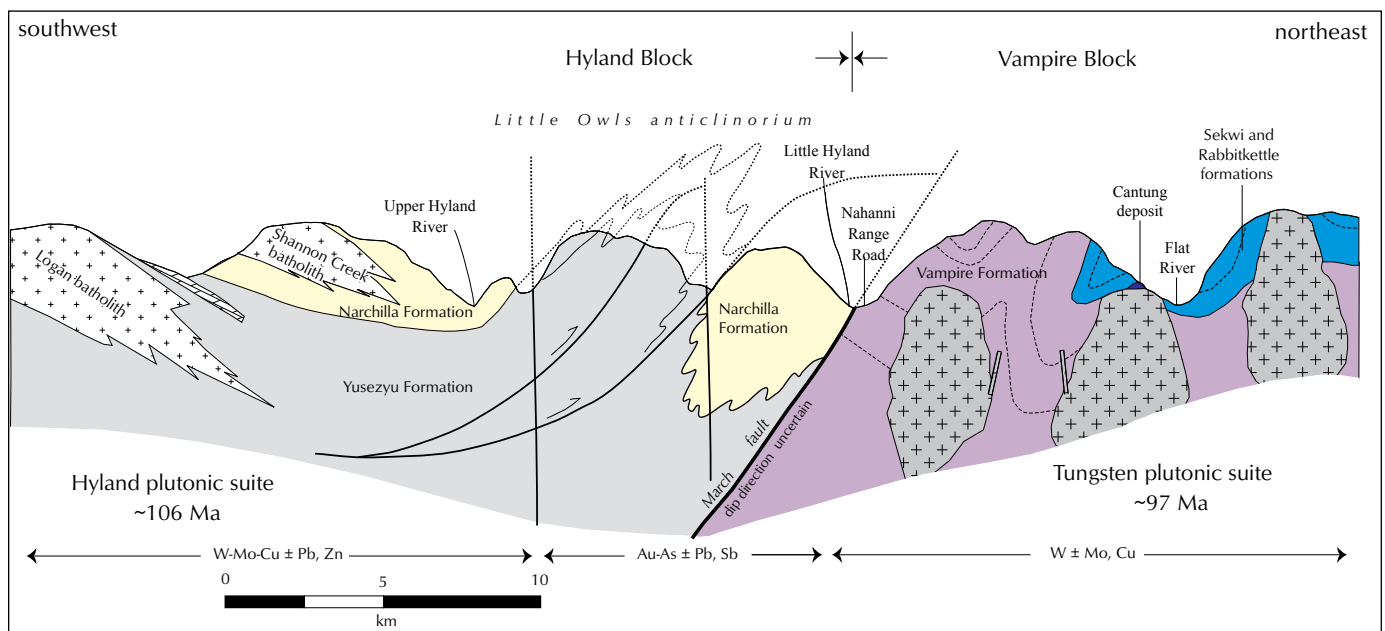


Figure 4. Schematic cross-section of the upper Hyland River valley area near the latitude of the Hy and Fer properties. Vertical scale is exaggerated such that dips are apparently steeper than actual. Late, steep northerly trending faults that cut the area are not shown.

Little Owls anticlinorium

Geological mapping in the upper Hyland River valley indicates that Yusezyu Formation strata, characterized by grits, conglomerates and sandstone, are flanked to the east by Narchilla Formation argillites and shales. Similarly, Narchilla Formation strata occur to the west, near and within the contact aureole of the Hyland plutonic suite. As such, a regional anticlinorium is recognized, and may be the southern extension of the Little Owls anticline (LOA) as defined by Gordey and Anderson (1993). The core of the LOA is mainly a structural culmination of overturned, south-dipping, northeast-verging folds. This feature is about 12 km wide and can be traced for about 70 km.

The structural geometry in this area is, however, complex and confusing. From southwest to northeast, near the latitude of the Hy and Fer occurrences, four structural domains are recognized: 1) a highly deformed package of Yusezyu and Narchilla formation strata proximal to the Hyland plutonic suite batholiths forms a northeast-dipping domain that includes many overturned folds and dips away from the uplifted batholiths; 2) east of the Hyland River valley is a less-deformed package of Yusezyu Formation that is southwest-dipping and also includes many overturned folds; 3) a south-dipping package of weakly deformed Narchilla Formation, with locally overturned beds; and, 4) east of the Little Hyland River valley are mainly northeast-dipping, weakly deformed Vampire Formation rocks.

The nature of the relations between the four domains is uncertain, but the style of deformation indicates that either overturned folds, thrust faults or a combination of both can accommodate the observed patterns. Overturned, potentially thrust anticlines likely generated a structural culmination that resulted in the anticlinorium. Similarly, overturned and thrust south-dipping Yusezyu coarse clastic rocks overlie Narchilla Formation strata and are likely in thrust-contact. A syncline is interpreted to reconcile the dip differences between the first and second domains; however, the northerly dips on the south limb may result from later uplift of the batholiths and not directly relate to fabric development. A syn-deformation backthrust may also accommodate this relationship (A. Fonseca, pers. comm., 2005).

March fault

We propose that a fault underlies the 40-km-long, linear, north-northwest Little Hyland River valley where it juxtaposes purplish and grey (lower?) Narchilla Formation strata with dark brown slates of the (upper?) Vampire Formation. As well, parallel structures are mapped immediately east of the Little Hyland River valley (Blusson, 1968). Differences in the contemporaneous Gull Lake (west) and Sekwi (east) formations also exist across this feature. The present-day, long-linear nature of the feature is characteristic of a large strike-slip fault, but the Neoproterozoic and Cambrian facies variations indicate ancient vertical motion. To the north, in the Nahanni map-area, this fault is mapped as a northeast-vergent thrust that is moderately southwest- to near-vertical-dipping. It places Hyland Group over Cambro-Ordovician Rabbitkettle Formation and Ordovician-Silurian Road River Group, and is termed the March fault (Gordey and Anderson, 1993). In the southern part of the study area, the steeply east-dipping fault is observed east of the Sun property, where Hyland Group strata are juxtaposed with Rabbitkettle and younger carbonate units to the east. In addition, there are differences in the styles of emplacement of nearly coeval plutonic rocks on each side of this feature (see Plutonic Rocks, above), which suggests west-side up displacement. These three apparently different types of offset likely reflect movement on, and reactivation of, the same fault.

We interpret this fault to represent a Neoproterozoic structure that caused the Neoproterozoic and Cambrian facies variations now observed as stratigraphic differences between Hyland Group and Vampire Formation. As well, neither Gull Lake nor Sekwi formations were deposited across this fault, which indicates that it was a facies-controlling structure that was active in the mid-Cambrian (noted by Gordey and Anderson, 1993). Additionally, west-side-up movement along this fault likely resulted from Cretaceous reactivation due to northeast-directed thrusting, as observed to the north and south of the study area (described above). As well, there are different styles and intensities of deformation and fabric development across this structure, which also indicates syn- to post-mid-Cretaceous displacement.

North-trending faults

Numerous small north- and northwest-trending faults cut deformed Hyland Group strata, particularly within rocks of the LOA. As a result, several straight, north-trending valleys are also interpreted to be larger north-trending

faults that have been preferentially downcut by erosion. The nature of the offset is not well known, but is likely normal motion with displacements of less than one kilometre. North-trending structures are also indicated by north-trending veins, north-trending geochemical anomalies, and north-trending lineations. This series of faults cut deformation, but are, in turn, cut by northeast-trending faults.

Northeast-trending faults

The youngest structural elements are northeast- to east-northeast-trending faults. These faults are easily recognized cutting north-trending ridges, and are a dominant control on the orientation of secondary drainages. They offset the general northwest trend of the other geological features, as well as the north-trending structures, which show an apparent dextral offset. To the north, Gordey and Anderson (1993) show similar faults with normal, north-side-down displacements. Offset on these faults is typically less than 1 km.

METALLOGENY

As indicated by Jones and Caulfield (2000), the following three different, intrusion-related metallogenic associations are present in the upper Hyland River valley: (1) a tungsten-molybdenum-copper $\pm$ lead, zinc signature associated with skarns in Hyland Group carbonate rocks adjacent to Hyland plutonic suite batholiths in the western part of the study area; (2) a tungsten $\pm$ molybdenum, copper signature associated with skarns and lesser porphyry-style occurrences in Cambrian calcareous strata near Tungsten plutonic suite plutons in the eastern part of the study area; and (3) a central gold zone with a gold-arsenic $\pm$ lead, antimony metallogenic signature that has no known igneous association.

REGIONAL GEOCHEMISTRY

Regional geochemical stream silt data indicate that the central zone hosts several gold and numerous and widespread arsenic anomalies, but is not particularly well endowed in other metals (Fig. 6; Hornbrook and Friske, 1989). Widespread, moderate tungsten anomalies, weak antimony anomalies, and moderate lead anomalies occur in the south. Gold values in stream silts of >46 ppb are considered highly anomalous (>98 th percentile), although the exploration significance of values 18-46 ppb should not be overlooked, particularly if associated with elevated arsenic. Many of the properties discovered to date have

resulted from follow-up and detailed silt sampling programs that targeted areas identified by the government regional stream sampling program (Hornbrook and Friske, 1989).

HYLAND RIVER GOLD OCCURRENCES

There are six properties within the central Hyland River gold belt that have significant gold values. From north to south, they are the Horn, Hy, Fer, 3 Aces, Sprogge and Sun (Fig. 2). All properties are still in the grassroots exploration stage, with most efforts directed towards prospecting, surface sampling and mapping. The entire belt has seen only 15 diamond drill holes divided among 4 of the properties.

All properties are underlain by uppermost Yusezyu Formation quartz-rich grits, phyllites and shales, locally with thin beds of limestone, and Narchilla Formation phyllite, slate, argillite, wacke and shale with Yusezyu-like grit beds. Locally, the grits are altered and gossanous. Barren quartz veins are abundant throughout the region, occur mainly in extensional zones in brittle quartzose rocks, and were emplaced during regional deformation at some time prior to intrusion of the Hyland plutonic suite intrusions. Mineralization post-dates deformation such that barren quartz veins are overprinted by mineralized ones.

Property descriptions below are compiled from a variety of sources including Yukon MINFILE¹ Yukon mineral assessment reports, press releases and company websites.

Horn

The Horn property was staked following a 1996 stream-silt geochemical sampling program that outlined gold anomalies. A follow-up soil survey on the northern part of the property revealed three apparently north-trending >20 ppb gold-in-soil anomalies that are >200 m long (Buchanan 1999a). One anomaly consists of four samples with values of 141 to 340 ppb Au and up to 300 ppm As. This anomaly is likely continuous with samples from 200 m to the south with values of 390 and 60 ppb Au. The most significant anomaly in the southwestern part of the grid may be >600 m long, is open to the south and west, and has gold values up to 650 ppb, with many >50 ppb, and arsenic values >300 ppm. Bismuth values are all very low (<2 ppm) and have no association with gold.

¹All references to Yukon MINFILE are from Deklerk and Traynor (2005).

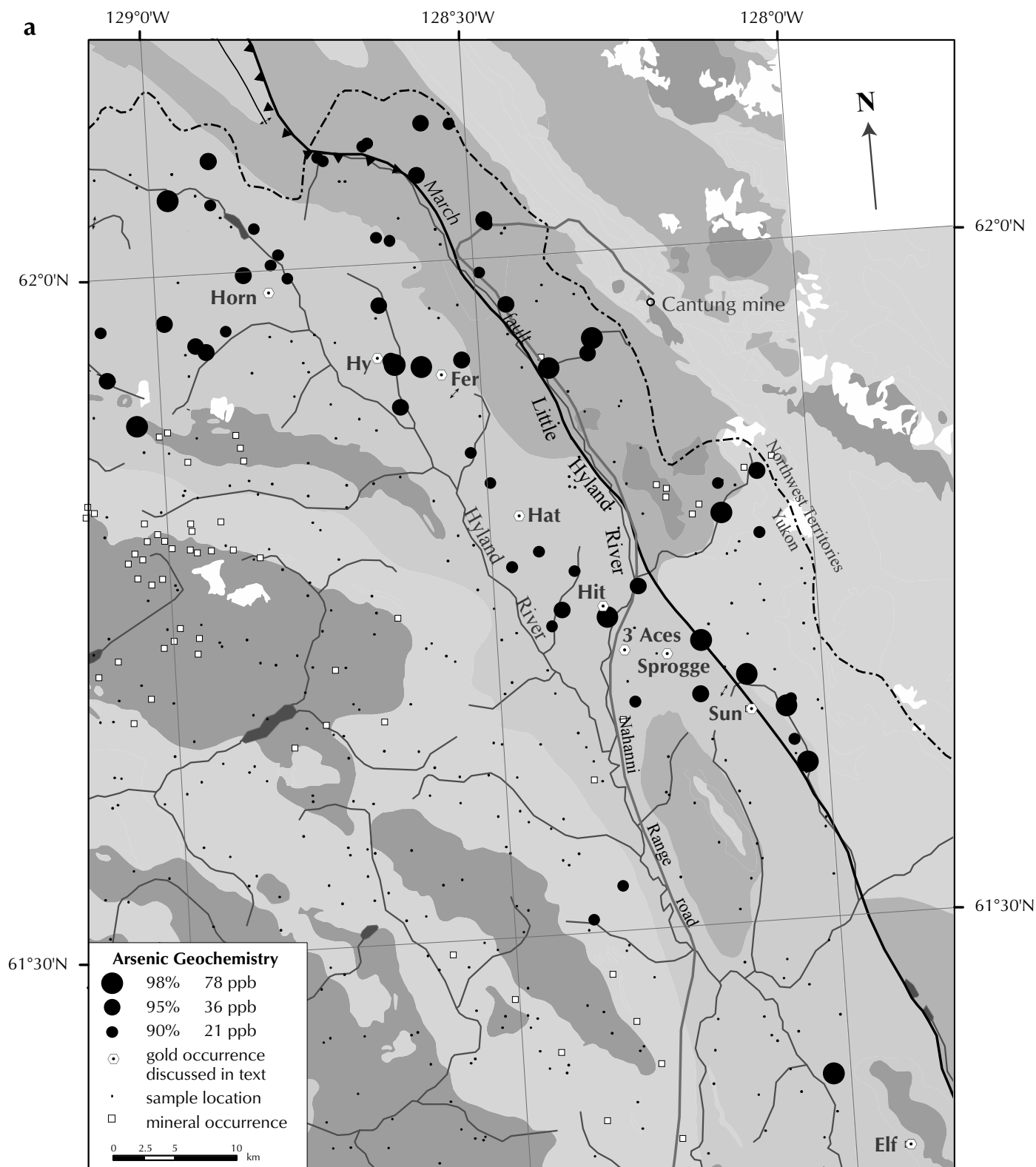


Figure 6. Regional silt stream geochemistry for (a) arsenic and (b) gold for the upper Hyland River valley area. Two separate surveys provide coverage for the area. North of 62° (NTS 105I), samples were analysed using instrumental neutron activation (INA), whereas south of 62° (NTS 105H), samples were analysed using fire assay-neutron activation (FA-NA). The second numbers for percentile cut-offs (46 ppb, 18 ppb and 9 ppb) are those samples analysed by FA-NA. Data north of 62° from Friske et al. (2001) and data south of 62° from Hornbrook and Friske (1989). Geology in background is as in Figure 2.

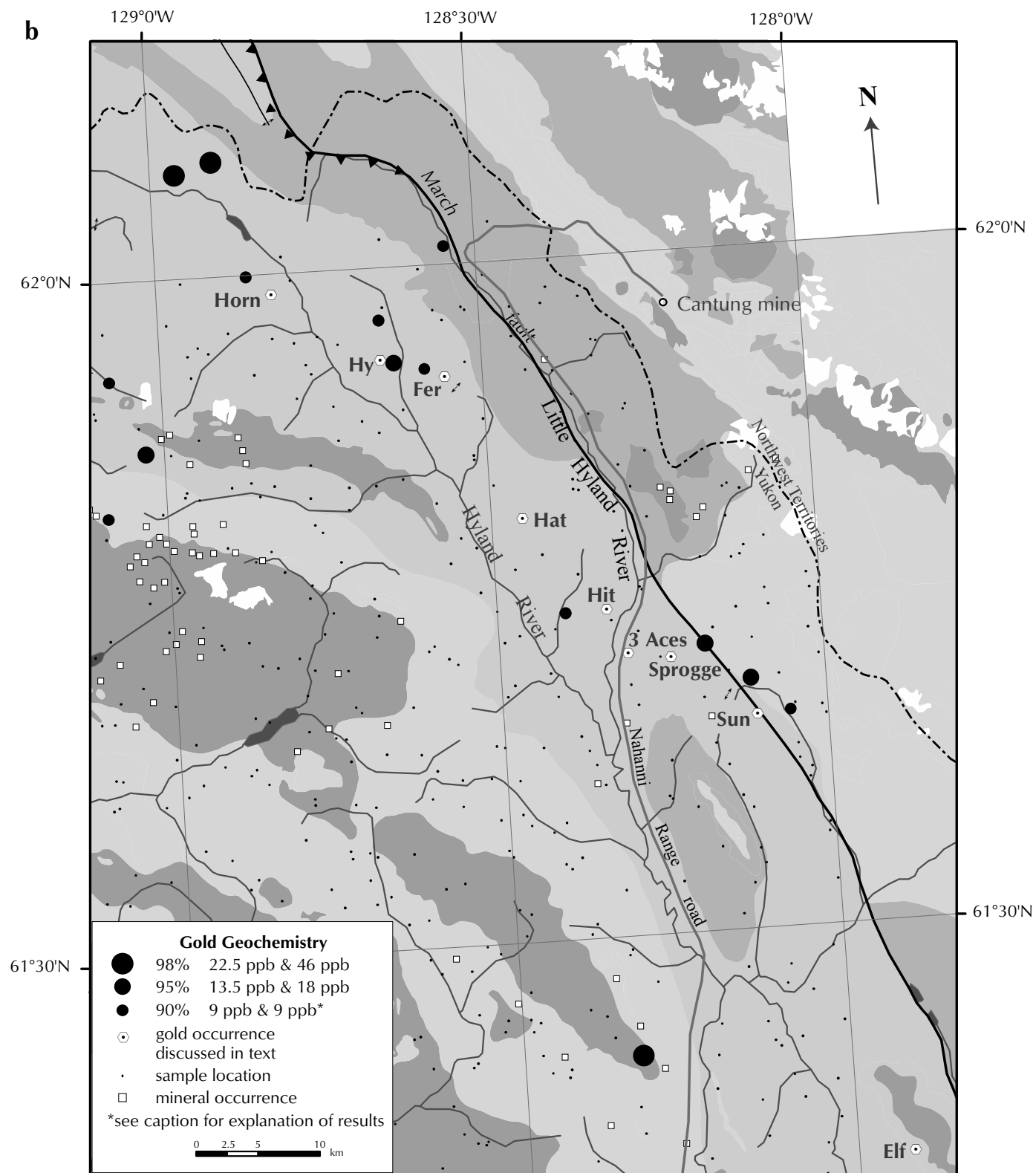


Figure 6. continued, caption on facing page.

Hy (Yukon MINFILE 105H 102 (Fer))

Highly anomalous gold, arsenic and antimony in stream silt samples collected in 1996 encouraged exploration on the Hy property. Three areas contained high-grade gold mineralization associated with strongly anomalous (>50 ppb) gold-arsenic-antimony soil geochemistry (Fox, 1998; Harris, 2000). The 1400 x 100 m West Zone has anomalies in soils up to 909 ppb Au and up to 253 ppm As. Rock samples assayed up to 144.2 g/t Au. Approximately 800 m away, the East Zone is 900 x 350 m and has soil values of up to 1259 ppb Au and 1783 ppm As, and up to 37.6 g/t Au in rock samples from talus. A chip sample of a quartz vein in phyllite obtained from the northeast part of the claims contained 23.05 g/t Au.

Gold mineralization is controlled by north- to northwest-trending, steep westerly dipping faults (Fig. 7). The most important type of mineralization consists of quartz-arsenopyrite veins and stockwork cutting quartzite. Galena and pyrite are common, and visible gold has been observed in a talus sample. Sulphide content generally ranges from a few percent up to 10%; however, higher gold values tend to be associated with higher sulphide contents, particularly arsenopyrite. The quartz veins range from 0.2 cm to 40 cm thick and occur in swarms of up to 5 to 10 veins per metre. Veins are white to grey-blue, massive to ribbon-banded and locally vuggy or with wallrock fragments (Fig. 8). Ribbon-banded veins indicate formation from numerous seismic events and are characteristic of orogenic gold vein deposits (Sibson *et al.*, 1988). Such veins are generally considered to form from metamorphogenic fluids (Groves *et al.*, 2003; Goldfarb



Figure 7. Looking northeast towards the eastern shoulder of the Hy property, where a diamond drill is targeting a north-trending, southwest-dipping structure (dashed line). Note resistant conglomerate (cg). Auriferous soil and rock samples are associated with this structure.

et al., 2005). Muscovite is a sparse but characteristic alteration mineral. Other types of mineralization include quartz veins within shaly horizons, quartz breccias and 'replacement-style' disseminated mineralization within quartzite, and less commonly phyllite, layers.

Fer (Yukon MINFILE 105H 102)

The Fer property was staked in 1996 to cover a cluster of strong stream-silt anomalies. Three mineralized zones were recognized from soil surveys and prospecting, as indicated by Jones and Caulfield (2000). Gold-in-soil anomalies correlate with elevated arsenic and lead; bismuth values are uniformly low. The gold anomalies are primarily associated with thick quartz-rich clastic units and faults. The Southern Grid anomaly is 2 km long and thickens where cut by north-trending faults. Gold-in-soil values are up to 1870 ppb, with three consecutive grid samples averaging 1590 ppb Au; arsenic values are up to 5430 ppm. The 500 x 200 m Northeast Grid soil anomaly is up to 665 ppb Au and overlies mineralization in quartz-rich clastic units near an east-trending fault. Similar but spotty soil anomalies occur in the Camp Cirque area, but the region has heavy talus cover and yields locally exceptional values such as a composite chip sample of bedrock that contains 1970 ppb Au over 8 m (Jones, 1997).

There are widespread indications of mineralization throughout the Fer property, such as large gossanous conglomerate outcrops, alteration of conglomerate, ferricrete gossans, and boxwork after pyrite (Fig. 9). Mineralization consists of stockwork to wide-spaced veins

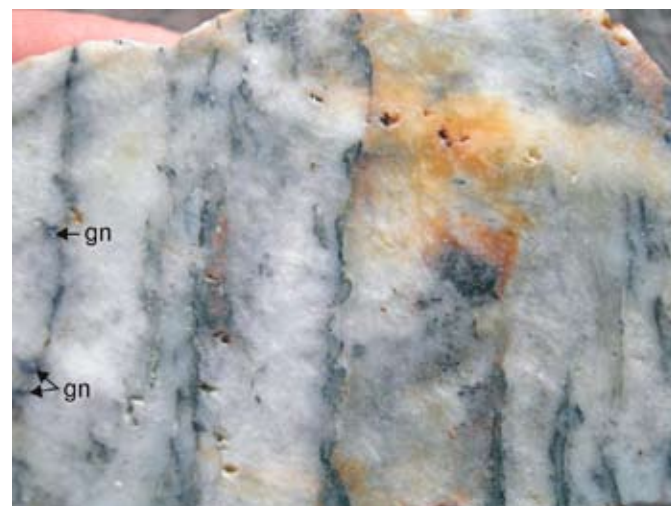


Figure 8. Ribbon-banded quartz veins separated by graphitic septa. Galena (gn) occurs along some of the septa. The rock is approximately 12 cm across.



Figure 9. Resistant, but altered and limonitic, quartz-grit and conglomerate, with ferricrete and limonitic sludge forming in creek (foreground). Note backpack in the mid-distance for scale, circled.

and fractures that occur in zones with disseminated mineralization and pervasive silicification (Fig. 10). Some linear zones strike 110° . Stockwork with pervasive silicification preferentially forms at contacts between upper conglomerate and phyllite, and between upper conglomerate and limestone (Jones and Caulfield, 2000). Sulphide minerals are widespread but in low concentrations and dominated by disseminated pyrite. Local arsenopyrite and rare galena are observed, but are more common in late quartz veins. Locally, pyrite occurs as bleb-like replacements of up to 10% of rock volume.

Hit (Yukon MINFILE 105H 036 (Road))

Very little public information is available for this property that straddles the Hyland River. Most exploration occurred on the west side of the river, where eight significant >50 ppm gold-in-soil anomalies up to 1500 m long cover areas more than 500 x 500 m (Buchanan,

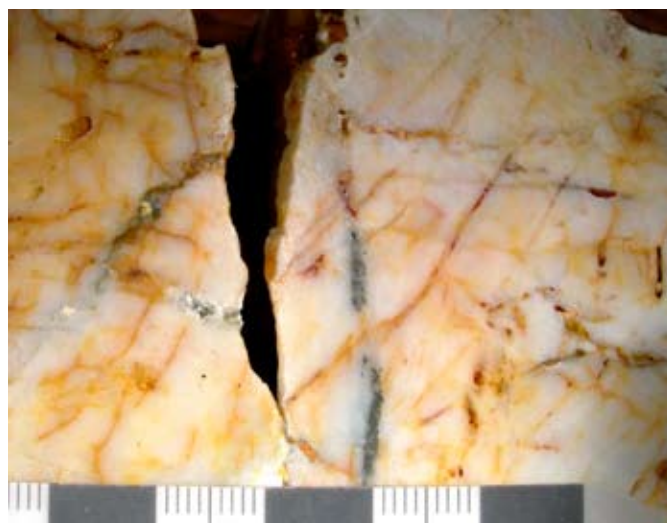


Figure 10. Early white and waxy barren quartz vein cut by later fractures, including a vertical fracture that hosts sulphide minerals (dark grey). Scale is in centimetres.

1999b). Many of the samples are >100 ppb Au, several values are >1000 ppb Au, and one soil value is 5810 ppb Au. The soil anomalies largely correlate with the location of quartzite and grit units. There is no record of rock sampling or geological mapping, but a four-hole diamond drill program (660 m) followed up the soil survey and intersected significant gold mineralization in one hole. Intersections included 4505 ppb Au over 1.5 m, 723 ppb Au over 4.5 m, and 275 ppb Au and 358 ppm As over 44.5 m within arkosic wacke (Buchanan, 2000).

3 Aces (Yukon MINFILE 105H 036 (Road))

This property is contiguous with the Hit property and straddles the Little Hyland River. Two >20 ppb gold-in-soil anomalies, each covering more than 200 x 200 m, have been outlined to the west of the river (Buchanan 1999c). Samples contained >200 ppb Au, >500 ppm As and anomalous lead. Outcrops hosting mineralization have

been discovered in two locations. One is located near the soil anomalies about 2 km west of the highway. A sample containing visible gold in conglomerate outcrops yielded an assay value reportedly as high as 5400 g/t Au (A. McMillan, pers. comm., 2004). A second zone of mineralization also contained visible gold. Quartz veins have been discovered in the Little Hyland River valley, adjacent to the highway and the river. In particular, north-trending gold veins have been discovered, and exposed beneath overburden, for approximately 6 m in a ditch parallel to the road (A. McMillan, pers. comm., 2004). The host rocks are Hyland Group quartz grits and conglomerates that contain disseminated arsenopyrite. Assay values of up to 30 g/t Au have been reported by the prospector Alex McMillan (pers. comm., 2004).

Sprogge (Yukon MINFILE 105H 103)

The Sprogge property includes the Sugar Bowl prospects, which were discovered following up 1996 regional geochemical stream silt anomalies. The Sugar Bowl consists of numerous mineralized zones within a >2 x 2 km northwest-trending area of gold, arsenic and trace metal values mainly related to quartz-arsenopyrite veins and disseminated quartz and arsenopyrite in altered and gossanous quartz-rich conglomerate and grits (Fig. 11; Scott, 1999). A 1200 x 600 m main area of >200 ppb gold-in-soil values assayed up to 10.3 g/t Au. Additionally, over 50 of the rock chip samples taken along the 2.5-km-long ridge gave multi-gram gold values. Most notably, the Ridge zone hosts the Matilda vein, a 0.4-m-wide variably



Figure 11. Siliciclastic Hyland Group grit from the Sprogge property with disseminated blebs of pyrite and arsenopyrite (dark grey) in the matrix.

oxidized arsenopyrite-in-quartz vein that returned values up to 32.9 g/t Au. The Sheila/KD zone yielded 1.83 g/t Au over a 2-m arsenopyrite-bearing monzonite dyke, but the zone also hosts stockwork or fracture-controlled veining. A 4-km-long northwest-trending gold-in-soil anomaly, with values between 30 and 875 ppb, links the Dayo Creek and Swagman zones. Most of these zones are characterized by high arsenic values. Bismuth is typically low except in highly mineralized samples.

Mineralization is in variably altered and locally quartz-veined coarse clastic grits, siltstone, shale and silty limestone along the hinge of a broad anticline that is cut by east- and northerly trending faults. Four diamond drill holes (762 m) tested a small portion of the lower Sugar Bowl anomaly in late 2000 and, except for a single sample of 705 ppb Au over 0.3 m of brecciated quartz with pyrite and arsenopyrite, failed to intersect values similar to surface samples.

Sun (Yukon MINFILE 105H 015)

This property is the only gold property in the Hyland area recognized prior to 1995. It was discovered in 1964 and drilled in 1988 (four holes for 389 m). Also known as Rain, Snow and Justin, the Sun prospects are at the southern end of the Sprogge property, 9 km from the Sugar Bowl, and consist of a 3000 x 700 m Au-Cu-Bi-As soil and rock anomaly that defines the Main, Confluence and Kangas zones. These showings are described in a Novagold News Release³ and on the Eagle Plains website⁴. The Main Zone consists of a 600 x 250 m area underlain by gently southeast-dipping calc-silicate skarn pods and brecciated phyllite that is proximal to a monzonite dyke. Mineralization consists of abundant pyrrhotite and pyrite that replaces host rocks and chalcopyrite- and arsenopyrite-bearing veins. Chip samples yielded 2.38 g/t Au over 22.5 m and 4.24 g/t Au over 4.5 m. The Confluence Zone consists of 500 m of silicified, limonitic and clay-altered, locally brecciated coarse clastic strata with arsenopyrite and 'chalcedonic-looking' veinlets that returned values of 4.2 g/t Au over 4.5 m in bedrock. Other rock samples assayed up to 15.8 g/t Au. The 400 x 75 m Kangas Zone includes skarn and replacement-style mineralization in calcareous siltstone and widespread anomalous gold including 1375 ppb over 3.5 m and grab samples of up to 3460 ppb. Most high values in the zone are from north-trending fractures and

³Sept. 14, 2000, <http://www2.cdn-news.com/scripts/ccn-release.pl?/enews/2000/09/14/45325.html>.

⁴<http://www.eagleplains.ca/yt/sprogge.html>.

shears, and have elevated arsenic and bismuth. Gold-in-soil values on the property correlate best with copper, bismuth and arsenic, but in skarned rocks, gold correlates best with antimony, silver, cadmium and zinc (Scott, 1999).

All zones include calc-silicate skarn pods and andalusite hornfels, and are cut by north-trending monzonite dykes. These features indicate a proximal intrusion; however, it is uncertain if the auriferous mineralization is related to the skarning or to later quartz veins (Scott, 1999). Unlike other properties described herein, the Sun locally hosts significant base-metal mineralization, and samples have returned values of ~0.3% Cu, 0.1% WO₃, 3.1% Pb, 178 g/t Ag and anomalous bismuth.

SUMMARY OF CHARACTERISTICS

Gold-associated mineralization in the upper Hyland River valley is diverse but divisible into a few main types:

- Disseminated pyrite and arsenopyrite in conglomerate;
- Sulphidized 'sheeted' fractures in brittle quartzose sedimentary units and early quartz veins;
- Bleb-like (1-5 cm) sulphide replacement minerals within conglomerate;
- Stockwork quartz veining with a minor sulphide mineral component, in quartzose units;
- Solitary, or widely spaced, quartz-sulphide (either arsenopyrite or pyrite-galena) veins.

Skarn and calc-silicate with sulphide mineral replacement or cross-cutting quartz veining is a feature of the Rain prospects, but is not found elsewhere.

Prominent features typically associated with the first three styles of mineralization include extensive limonitic, and locally jarositic, gossans that are well developed in the resistant conglomerate units. These regions are also typically highlighted by the presence of ferricrete gossans in the valleys and creeks that drain from the conglomerate. Examination of the conglomerate typically indicates boxwork development after pyrite, or limonitic fractures that previously hosted sulphide minerals. Alteration within these conglomerates is widespread. Feldspar clasts are clay-altered and the matrix is altered to fine-grained sericitic fuzz, probably illite. Quartz-vein-style mineralization is characterized by silicification and local muscovite development.

Weathering of the altered and weakly mineralized conglomerates also generates broad low to moderate (Au >25 ppb) gold and arsenic geochemical anomalies in soil. Quartz-vein-style mineralization yields long, narrow, continuous and high (Au >60 ppb) geochemical anomalies. In addition to arsenic, lead and antimony may be pathfinders to mineralized regions. Bismuth does not correlate with gold, and is typically below 2 ppm.

Three main geological characteristics of this region are responsible for focusing hydrothermal fluids and for precipitating sulphide minerals: (1) the high permeability of coarse-grained clastic sedimentary rocks promotes fluid flow and precipitation of sulphide minerals within these lithologies; (2) the presence of limestone, conglomerate with a dominantly calcareous matrix, and other calcareous sedimentary rocks, which are preferentially reactive lithologies that are susceptible to sulphide mineral replacement and silicification; and (3) the presence of faults that act as conduits for mineralizing fluids. Additionally, deformation preferentially fractures the brittle quartzose conglomerate, grit and quartzite units, and thus further enhances the permeability of these lithologies.

Therefore, three types of potentially economic gold deposits exist: bulk-tonnage low-grade deposits in clastic-sedimentary rocks; high-grade quartz-sulphide veins; and auriferous sulphide replacement deposits in calcareous lithologies. Exploration for large low-grade resources should focus on thick packages of quartzose conglomerate, grit and quartzite. Emphasis should be directed towards high intensity of alteration or high fracture density that may be associated with faulted or fractured margins. Surface exposures underlying gold-in-soil anomalies may appear unmineralized or fail to return anomalous results due to intense weathering and leaching of sulphide minerals. These highly altered quartz-rich conglomerate units may be the cause of the south-trending magnetic lows near the Hy and Fer properties.

Exploration for high-grade quartz sulphide veins should focus on north-trending faults or fractures, particularly where they cut brittle units. The few available observations indicate that these are steep west-dipping features. Consequently, soil or geophysical survey lines, or wildcat drilling, may be most effective in an easterly direction. Locally, very high gold values in soil and rock samples, and the recognition of visible gold, indicates that metallic-type analyses may be required to obtain accurate values for samples with coarse and nuggety gold. East-trending faults are also common features in the region,

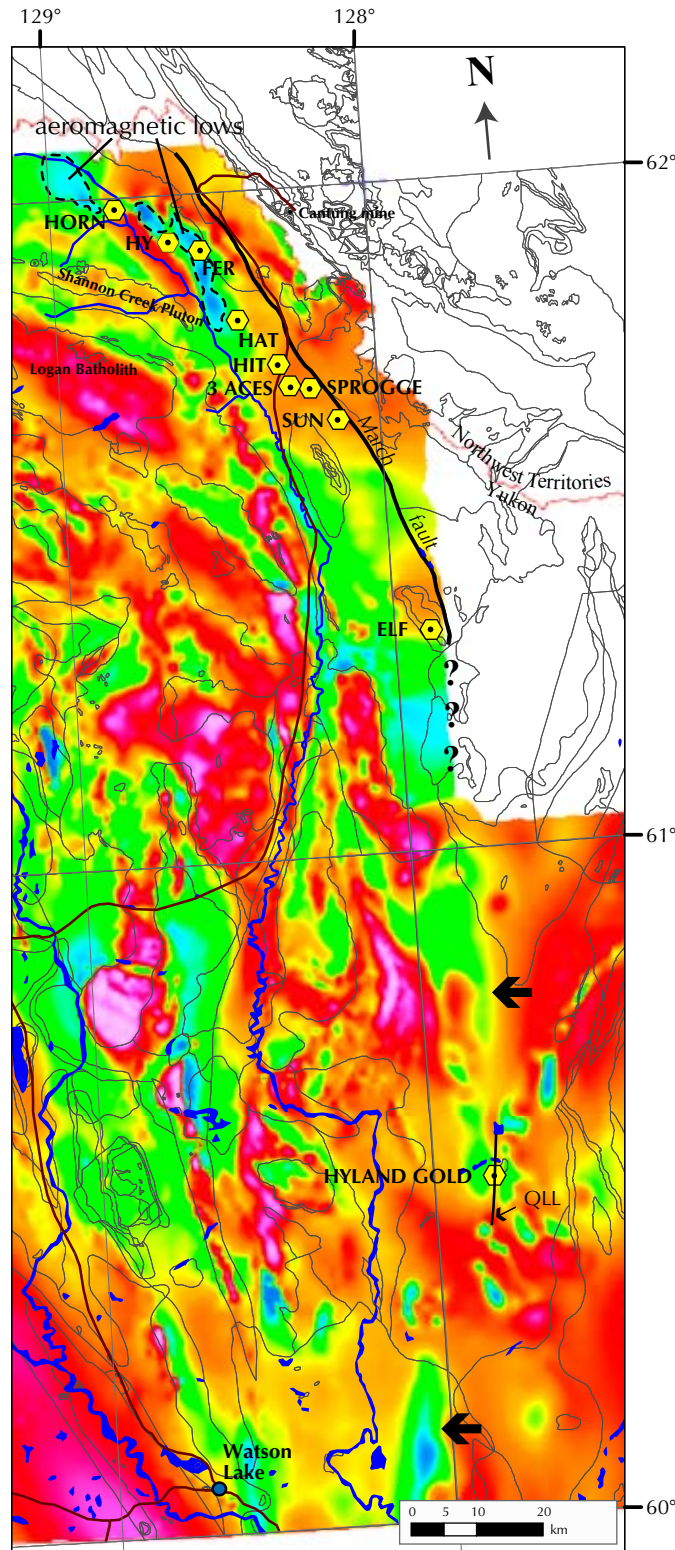


Figure 12. Regional aeromagnetic image⁵ of the Hyland River area with outline of major geological elements and distribution of gold occurrences and deposits. Note the north-trending linear magnetic breaks (shown with arrows) that may be the southerly continuation of the March fault. QLL=Quartz Lake lineament.

and although they appear to cut the north-trending structures, they may also be targets.

Regional mapping indicates that calcareous units occur at the top of the Yusezyu Formation and at the base of the Gull Lake Formation above the Narchilla Formation, and that these horizons should be targeted. However, structural complexities have hindered mapping at more detailed scales, and maps at an optimal scale for exploration are not available. In places where property scale geology maps are available, these calcareous horizons, particularly where underlain by fractured conglomerate, are favourable sites for mineralization.

Igneous rocks, hornfels and calc-silicate rocks were not observed on most properties, and are exposed only west of the Hyland River and east of the March fault, leaving the central gold belt mostly barren of igneous activity. The Hit property has numerous mafic dykes on both sides of the highway (A. Fonseca, pers. comm., 2005), but their association with mineralization is unknown. Felsic dykes, mostly north-trending, are prominent features at only the south end of the Sprogge property (i.e., Sun), where skarn and base metals (copper, tungsten, lead, bismuth, antimony) are present. This is likely the only location within the central gold zone where an unroofed intrusion may exist.

REGIONAL CONSIDERATIONS

The distribution of gold prospects form a northwest-trending belt that is proximal to, parallel to, and always to the west of the dominant structural feature in the area: the March fault. This structure is recognized as locally displaying thrust, normal and strike-slip characteristics, and has been active during Neoproterozoic and Cretaceous times. It appears to be of crustal scale and should have continuity to the north and south. To the north it is beneath Earn Group strata, indicating that most of its activity was pre-Upper Devonian (G. Abbott, pers. comm., 2005). To the south, its distribution is not apparent; however, several features assist in indicating its presence.

The distributions of Hyland Group and Vampire Formation strata as compiled by Gordey and Makepeace (2003) are such that a north-trending contact could separate the two units. As well, there is a prominent, 60-km-long, north-trending linear aeromagnetic break (Fig. 12) that is

⁵<http://www.mapsyukon.gov.yk.ca/webmaps/geoscience/bedrockgeology>. See also http://gdr.aggr.nrcan.gc.ca/wms/index_e.html (Canada Geophysical Data Repository, Survey 25902, 25903).

interpreted to continue another 60 km to the Yukon-British Columbia border. Along this southerly anomaly is the Hyland gold deposit, which is a significant pyrite and arsenopyrite mineralized gold system that hosts a near-surface oxide resource of 3.1 Mt of 1.1 g/t Au (Stratagold website⁶, 2005). The deposit is located on the north-trending Quartz Lake lineament. Regional gold- and arsenic-in-silt geochemical data define an approximately 20-km-long, north-trending region of anomalous values (Hornbrook and Friske, 1989) south of the Hyland gold deposit. These observations indicate that not only is there likely a crustal-scale structure along this trend continuous with the March fault, but that it is locally mineralized, and may play a role in controlling the distribution of gold mineralization throughout the region.

EXPLORATION MODEL

Proximity of gold mineralization to a felsic intrusion is a powerful and compelling feature that encourages explorationists to focus on them as exploration targets, and indeed, such is the focus of the intrusion-related gold model that was developed in the Tombstone Gold Belt of the Tintina Gold Province (Lang *et al.*, 2000; Hart *et al.*, 2002). In the absence of an observable intrusion, distal plutonic features such as dykes, hornfels, skarning, contact metamorphic minerals and element zonation can be called upon to support a plutonic association; however, such features are missing from the Horn, Hy, Fer and Hit prospects. Those features are recognized at the Sprogge, and more fully at the Sun, suggesting a proximal pluton, but the role of the magma in forming gold mineralization is not confidently known. In addition, none of the mineralization herein described, except at Sun, is similar to that typically related to the intrusion-related gold model (Lang *et al.*, 2000; Hart *et al.*, 2000, 2002).

Jones and Caulfield (2000) recognized gold mineralization in the Hyland River area as distinct and lacking associated intrusive rocks and hornfels. They interpreted the Fer to represent mineralization that formed distal (4-6 km) to a related intrusion, potentially similar to an origin ascribed to the Telfer deposit in Australia (Rowins *et al.*, 1997). Like Telfer, mineralization at Fer is focused in structural zones in axial planar regions of folds, and preferentially hosted by quartz-rich lithologies.

The lack of evidence for plutonic activity at most of the Hyland River gold prospects makes an intrusion-related model unlikely. The association of mineralization with

north-trending structures, the proximity to a large crustal-scale structure, and the orogenic characteristic of some veins support a non-magmatic origin. Mineralization may instead be related to metamorphogenic fluids focused by the March fault and distributed along second-order, north-trending faults. Such fluids may have been generated in response to regional deformation, prograde metamorphism and generation of melts that formed the Hyland plutonic suite intrusions.

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⁶<http://www.stratagold.com/s/Hyland.asp>

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