The Fer property: A plutonic-related gold property in southeastern Yukon

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ABSTRACT

The Fer gold property lies only 5 kilometres southwest of the Nahanni Range Road (Highway 10) in southeastern Yukon. It is underlain by a broadly folded sequence of coarse siliciclastic, calcareous and phyllitic, continental margin sedimentary rocks of the Neoproterozoic to Lower Cambrian Hyland Group. The extensive belt of Hyland Group rocks hosts gold mineralization in numerous occurrences from southeastern Yukon to the Dawson City area and is part of the Tintina gold belt.

The Fer property was originally staked in 1996 to cover the largest cluster of gold anomalies (>90th percentile for gold) in a regional fine-stream-sediment sampling program. Soil geochemistry on the property has outlined an area of about 2000 by 500 metres in the Southern Grid area with anomalous gold and arsenic values (>25 ppb Au, >125 ppm As). These values range up to 1870 ppb Au and 5430 ppm As. As well, a 500 by 200 metre Au-As anomaly is present in the Northeast Grid.

Mineralization is largely controlled by structure and host rock lithology, and is spatially associated with the most intense zones of silicification and quartz vein stockwork. Gold correlates best with As, Ag, Pb, and Sb. Values up to 2.3 g/t Au have been found in select rock samples in the mineralized areas. The Fer property mineralization likely represents a distal end-member of the plutonic-related gold deposits in the Tintina gold belt.

RÉSUMÉ

La propriété Fer, une propriété aurifère, est située à seulement 5 km au sud-ouest de la route Nahanni Range (route n^{o} 10), dans le sud-est du Yukon. Elle est sous-tendue par des roches sédimentaires de marge continentale du Groupe de Hyland, d'âge Protérozoïque supérieur à Cambrien inférieur, qui incluent des roches siliciclastiques à grain grossier, calcaires et phyllitiques, et qui sont déformées par des plis ouverts. Les roches du Groupe Hyland recouvrent une grande étendue et de nombreux indices aurifères depuis le sud-est du Yukon jusqu'à la région de la ville de Dawson, qui font partie de la ceinture aurifère de Tintina.

La propriété Fer a été jalonnée pour la première fois en 1996 de manière à couvrir le plus grand groupe d'anomalies aurifères (les anomalies >90^{e} percentile pour l'or) découvertes dans le cadre d'un programme d'échantillonnage des sédiments fins de ruisseau. Un levé géochimique d'échantillonnage du sol a permis de délimiter une zone d'environ 2 000 sur 500 m de la grille sud qui contient des teneurs anomales en or et en arsenic (>25 ppb d'Au, >125 ppm d'As). Les concentrations en métaux des échantillons atteignent 1 870 ppb d'Au et 5 430 ppm d'As. De plus on a mis à jour une anomalie en Au-As de 500 sur 200 m sur la grille nord-est.

La minéralisation est surtout contrôlée par la structure et la lithologie de la roche hôte et elle est spatialement associée aux zones de silicification et de stockwerk de veines de quartz les plus intenses. L'or présente de fortes corrélations avec les éléments suivants : As, Ag, Pb et Sb. On a obtenu des teneurs atteignant jusqu'à 2,3 g/t Au, dans des échantillons choisis provenant des zones minéralisées. La minéralisation de la propriété Fer représente un assemblage distal des gisements aurifères de la ceinture aurifère de Tintina.

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INTRODUCTION

The Fer gold property is situated in southeastern Yukon, 200 km north of Watson Lake, in the southeast end of the Tintina gold belt (Fig. 1). The property is located 5 km southwest of the Nahanni Range Road (Highway 10), which runs north from the Robert Campbell Highway in the Yukon, to the town of Tungsten, Northwest Territories, the location of the dormant Cantung mine.

The Tintina gold belt follows a trend of genetically related, mid-Cretaceous, felsic intrusions, which extend from east-central Alaska, across central Yukon. The gold deposits of the Tintina gold belt exhibit a wide variety in styles of mineralization, which largely reflects the depth of formation and location of the mineralization relative to the intrusions (Thompson et al., 1999). Intrusion-hosted deposits usually consist of sheeted veins and breccias, whereas distal deposits are normally skarn, disseminated replacement and vein styles. The sulphide content of these deposits is low, normally less than 3% overall, consisting primarily of pyrite-arsenopyrite. Tungsten and molybdenum mineralization, and generally bismuth content, increases with depth and proximity to the intrusions. More distal deposits are commonly dominated by arsenic (-antimony) and may have a base metal signature. Mineralization is associated with sericite, biotite, silica and carbonate alteration. Structure plays an important role, both providing conduits for fluids, and in ground preparation. Although country rocks exert no control on these deposits in a regional sense, lithological control plays a role in localizing mineralization through contrasts in competency and chemistry.

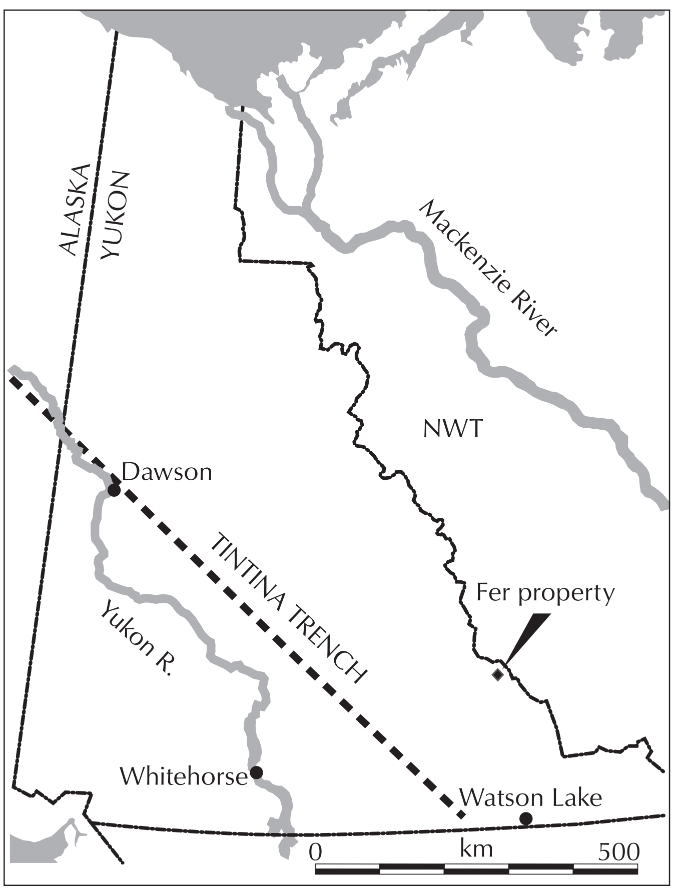

Figure 1. *Location of the Fer property, southeastern Yukon.*

PROPERTY EXPLORATION HISTORY

The Fer property was originally staked by Westmin Resources Limited in 1996, and was targeted in order to cover the strongest cluster of anomalous gold and arsenic results (>90th percentile) from a regional fine-sediment-sampling program conducted by Westmin in 1994. This survey was designed to test for distal (Telfer-style), sediment-hosted gold deposits in the Hyland Group sedimentary rocks, and covered approximately 7000 km^2, stretching from the B.C.-Yukon border to the headwaters of the Hyland River. There is no record of exploration work on the property prior to this program.

Westmin (now Boliden Westmin (Canada) Ltd.) did contour soil sampling, geological mapping (1:10 000; 1:5000) and rock sampling in 1996 (Jones, 1997) and 1997 (Gale and Terry, 1998). The results of this work indicated extensive areas of moderately to strongly anomalous results for gold and arsenic in soils on the south slope and in the east-central area, primarily associated with thick quartz-rich clastic sedimentary units. Work by Rimfire Minerals Corporation in 1998 (Jones, 1999) followed up the anomalous gold and arsenic values in soils on the South and Northeast grid areas by taking samples over significant widths as closely spaced as possible, to examine the potential for large tonnage, disseminated gold deposits. As well, minor detailed mapping of the anomalous zones was completed in conjunction with the sampling. Prospecting was carried out over the soil anomalies and beyond, to search for additional mineralization.

The area has been mapped by the Geological Survey of Canada (Roots et al., 1966), and covered by a stream-sediment sampling program sponsored by the federal government (Hornbrook and Friske, 1989). The government stream-sediment sampling identified the Fer property area as having highly anomalous arsenic and local anomalous gold values. As well, the claim group was covered by an airborne magnetic survey, also sponsored by the federal government (GSC, Aeromagnetic Series, 1961).

REGIONAL GEOLOGY

Figure 2 shows a compilation of geological, geophysical and metallogenic features of the upper Hyland River valley area, surrounding the Fer property. The area is underlain by siliciclastic and bioclastic, platformal or continental-margin sedimentary rocks of the Neoproterozoic to Lower Cambrian

Hyland Group (Fig. 2). Crosscutting the Hyland Group metasedimentary rocks are granitic, mid-Cretaceous intrusions of the Tay River and Tungsten suites. Two types of intrusions are distinguished based on their size and contact characteristics. The larger batholiths (Tay River suite), to the south and southwest of the Fer property, have ill-defined boundaries consisting of mixed intrusive, migmatitic and gneissic rocks. The smaller intrusions (Tungsten and Tay River (?) suites) have sharp contacts and pronounced metamorphic aureoles characterized by gossans (after pyrite, or biotite?). An elongate example of this type of intrusion occurs just south of the Hyland River, about 5 km south of the Fer property.

Generally, bedding and axial planes trend northwest, turning westerly, west of the Fer property, with moderate to steep dips. Shallowly plunging fold axes also follow this overall trend. North-trending, linear valleys are common in this area, indicating the presence of significant faults (also interpreted from the regional magnetic patterns). The Hyland River and Little Hyland Rivers, just to the northeast, occupy large, linear, northwest-trending valleys, which may represent major strike-slip or thrust faults.

REGIONAL GEOPHYSICS

The regional airborne magnetic patterns (Fig. 2, only available for NTS 105H) show different responses for the two types of intrusions in the upper Hyland River area. There is a relatively strong positive response recorded over the large batholiths well to the south and west of the Fer property. However, several intrusions, closer to the Fer property, have a flat to weakly negative response. This includes the elongate intrusion 3-4 km south, as well as a group of small intrusions 10-15 km east-southeast of the Fer property, which lie within the Tungsten Suite intrusions. These Tungsten Suite intrusions are outlined by a 100 gamma magnetic low in this area. A similar, slightly deeper, magnetic low lies over the Fer property, within a southeast-trending low which extends northwest (to the edge of magnetic coverage) from the confluence of the Hyland and Little Hyland rivers. This magnetic feature is not restricted to any particular sedimentary unit. Distinct magnetic high "shoulders" are present on the northeast and southwest sides of the magnetic low, with the greatest contrast situated adjacent to the Fer property. The trend of the magnetic low could represent the axis of a series of buried intrusions or structurally controlled hydrothermal activity.

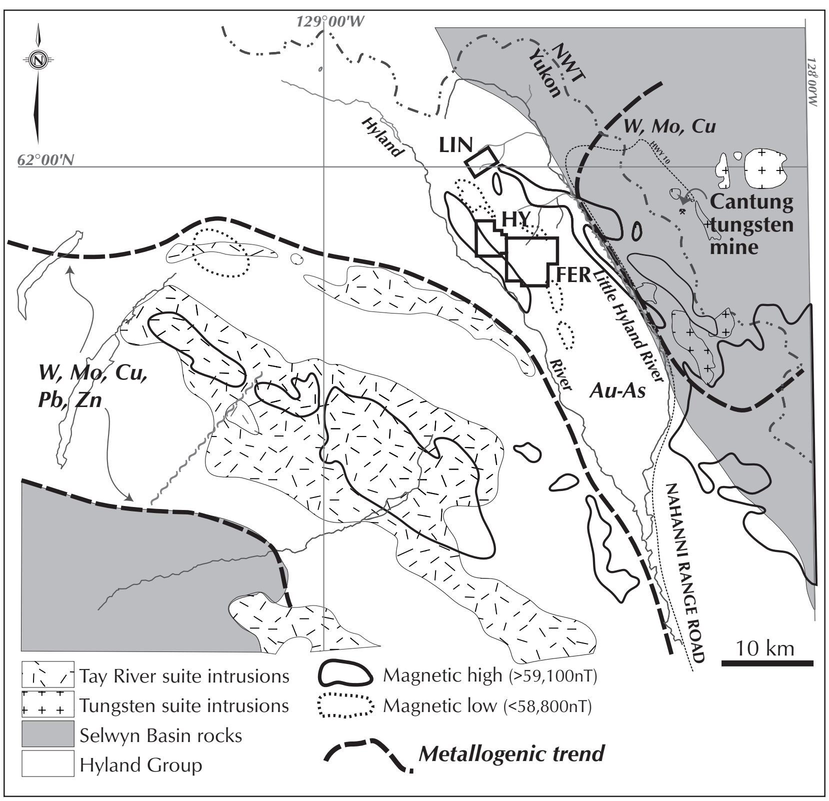

***Figure 2.** Compilation map of regional geological, geophysical and metallogenic features of the Upper Hyland River area.*

REGIONAL METALLOGENY

Three distinct provinces are apparent in the regional metal distribution in the upper Hyland River area (Fig. 2). The mineral occurrence maps for this area (105H, I; Yukon Minfile, 1997) indicate a concentration of tungsten-molybdenum mineralization, as skarn, porphyry, and veins, coincident with the distribution of intrusions (both Tay River and Tungsten suites) to the northeast and to the southwest of the Fer property. As well, there is a distinct southeast gold-arsenic trend bisecting these two areas, defined by stream geochemistry and known showings, following the magnetic low which lies over the Fer property. This gold-arsenic trend is the focus of recent exploration activity in this region.

Recent exploration work in the area has turned up numerous showings. Work on Phelps Dodge's Hy Property, immediately west of the Fer claims, has uncovered several high-grade gold-bearing grab samples (Burke, 1999). Mineralization is similar in character to that found on the Fer property with disseminated to clotty arsenopyrite, pyrite and galena in quartz veins and breccias, and is related to northwest- to north-northwest-trending structures crosscutting lithologic units. Two mineralized structures have been discovered to date with gold values up to 144.2 g/t and 9.9 g/t, respectively, found in select quartzite-quartz vein material. Other companies active in the area include Viceroy Resources Ltd. (Burke, 1998) and Hudson Bay Exploration and Development Ltd. In 1999, Hudson Bay completed a diamond-drilling program on the Hit Claims, southeast of the Fer property.

Rocks of the Hyland Group host the Hyland Gold occurrence (Bremner and Ouellette, 1990), about 150 km to the south-southeast. This sediment-hosted gold deposit has been reported to have inferred oxide reserves totalling 6.75 Mt at a grade of just under 2.0 g/t Au based on sampling in surface trenches. Alteration and mineralization are controlled by north-trending structures, cutting through relatively flat-lying, Hyland Group phyllite, quartzite and grit units. There are no intrusions mapped in the area.

The Cantung deposit, located at Tungsten in the Northwest Territories is a high-grade tungsten skarn deposit (9 Mt at 1.42% WO_3). The deposit is related to a Tungsten suite intrusion, which intrudes carbonate-rich rocks of the Selwyn Basin.

PROPERTY GEOLOGY

The Fer property is underlain by a section of Hyland Group units consisting of quartzite, arkosic grit and quartz pebble conglomerates, interbedded with phyllite and much lesser limestone (Fig. 3). The quartz-rich units are primarily calcareous in the northeast corner of the property, but are devoid of calcite southwest of this area. In general, the quartz-rich units are thicker in the southwest area, ranging up to a couple hundred metres in thickness with minor interbedded phyllite. Whereas the stratigraphy in the northeast corner of the property forms a relatively homoclinal sequence, the structure of the rest of the property is more complex. The southwest area is dominated by an apparent broad synform, which traverses the area in a southeast direction, plunging shallowly to the southeast. Minor folds and crosscutting faults also complicate the geology in this area. North-northeast-, northwest- and east-trending faults are quite common and these structures are mostly associated with intense alteration and mineralization.

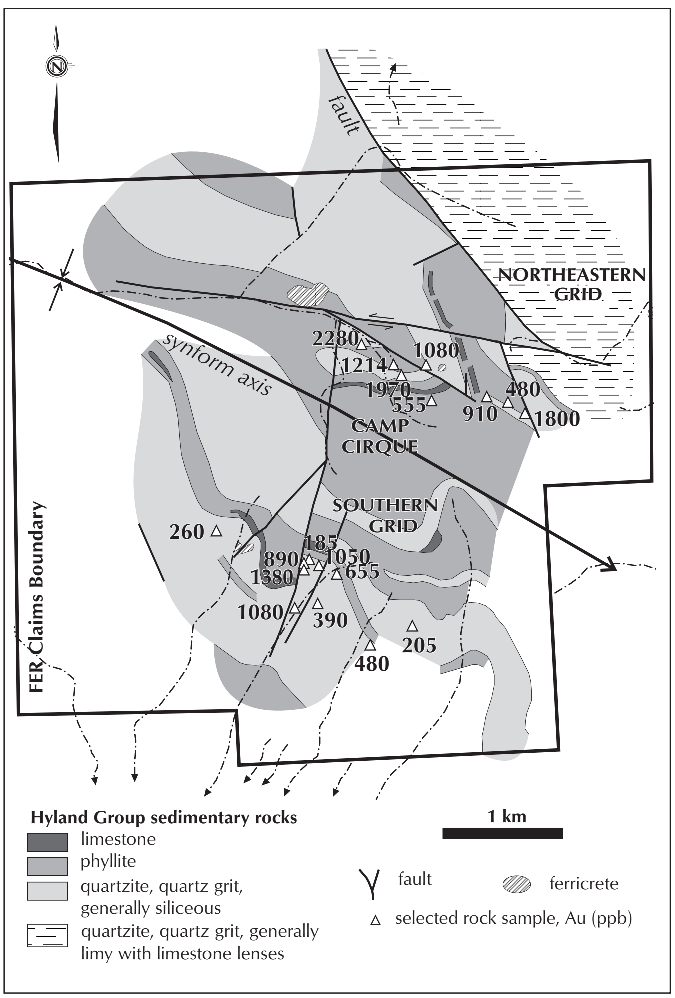

Figure 3. *Simplified geology and selected rock geochemistry for the Fer property.*

ALTERATION AND MINERALIZATION

Quartz veining and stockwork are the most common characteristics of the mineralized areas, in particular, the quartz-rich units (Jones, 1997). The veins are generally of two types: 'older,' deformed veins which are ubiquitous and generally not mineralized, and 'later,' stockwork to wide-spaced vein systems, which are commonly spatially associated with disseminated auriferous mineralization and zones of pervasive silicification. These stockwork and vein occurrences commonly form silica-rich zones with strike lengths up to 300 m, thicknesses of several metres, and a dominant strike of about 110°, with near vertical dips. As well, pervasive silicification and widespread stockwork is commonly concentrated in quartz-rich units adjacent to the phyllite contact, which may have acted as an impervious barrier to hydrothermal fluids. Several of these silicified zones can be found on the property, particularly in the Southern Grid area, where silica alteration and quartz veining occur in patchy zones over at least 2 km of strike. Similar intense veining occurs in the Camp Cirque area and on the Northeast grid. An example of structural control on mineralization is observed in the Northeast grid area, where disseminated and vein-hosted mineralization is found associated with a fold nose adjacent to a north-northeast-trending fault.

Sulphide mineralization is widespread on the Fer property, but normally at low concentrations. Pyrite, and much lesser arsenopyrite are disseminated and occur as blebs in altered host rocks. Locally, they are concentrated to 10-15% of the rock as poddy or lensy occurrences, but generally form less than 1-2% of the rock. Both sulphides also occur in quartz veins, as large blebs, fracture coatings and disseminated as fine grains. Galena was noted in quartz veins and less commonly disseminated in the host rocks, particularly in the Camp Cirque area. Generally, the sulphides are more commonly peripheral to the zones of quartz stockwork and silicification. Boxwork after sulphides is common, indicating that the overall sulphide content of the rocks prior to weathering was somewhat higher than observed on surface. Although weathering of these sulphides has created extensive gossans and ferricrete throughout the property, some zones of typical pyrite-arsenopyrite mineralization do not have any significant gossan associated with them, such as the mineralized zones on the Northeast grid. As a result, mineralization in the Northeast grid area was only recognized after anomalous soil sample results were identified.

The rock sampling on the Fer property (314 samples) generally shows anomalous gold values associated with sulphide mineralization. Gold values to date are generally less than a few hundred parts per billion, although a high percentage of these samples are representative grab samples over large widths. Higher grade samples, which ranged up to 2.28 g/t Au and greater than 1% arsenic, tend to be select samples of more visible or sulphide-rich mineralization. Elements showing correlation with gold include arsenic (r^2=0.51), silver (r^2=0.38) and antimony (r^2=0.53; Jones, 1999)

SOIL GEOCHEMISTRY

A total of 1748 soil samples have been taken to date on the Fer property. Statistical analysis of the results from all samples shows that gold has a significant correlation with arsenic (r^2=0.49), silver (r^2=0.51) and lead (r^2=0.42). Significantly, bismuth is rarely found in concentrations above 2 ppm in soils. The distribution of gold and arsenic are plotted on Figures 4 and 5. Statistics are summarized in Table 1.

In the Southern Grid area, soil sampling has delineated an extensive anomaly, defined by the 85th percentile for gold, and stretching about 2 km along the exposure of a thick, shallowly dipping quartz-rich, clastic unit (Fig. 4). The anomaly pinches and swells along this unit, generally thickening in proximity to major crossing faults (north-northwest to north-northeast). Anomalous results are generally associated with quartz stockwork and silicification within the quartz-rich unit, in particular near the upper contact of the unit with a phyllite-limestone unit. Gold values within this anomaly range up to 1870 ppb, including three consecutive samples, spread out over 60 m, which average 1590 ppb Au. Arsenic values are similarly elevated ranging up to 5430 ppm. The Southern Grid covers several areas of heavy talus, which may have muted results, and this possibility should be considered

Table 1. *Soil geochemical thresholds for all soil samples, Fer property.*

Percentile	Au (ppb)	Ag (g/t)	As (ppm)	Pb (ppm)
50th	-	-	64	28
70th	10	-	126	38
85th	25	0.2	230	50
95th	85	0.4	504	74
98th	166	0.6	787	104
Note: All values below detection shown as negative detection limit.				

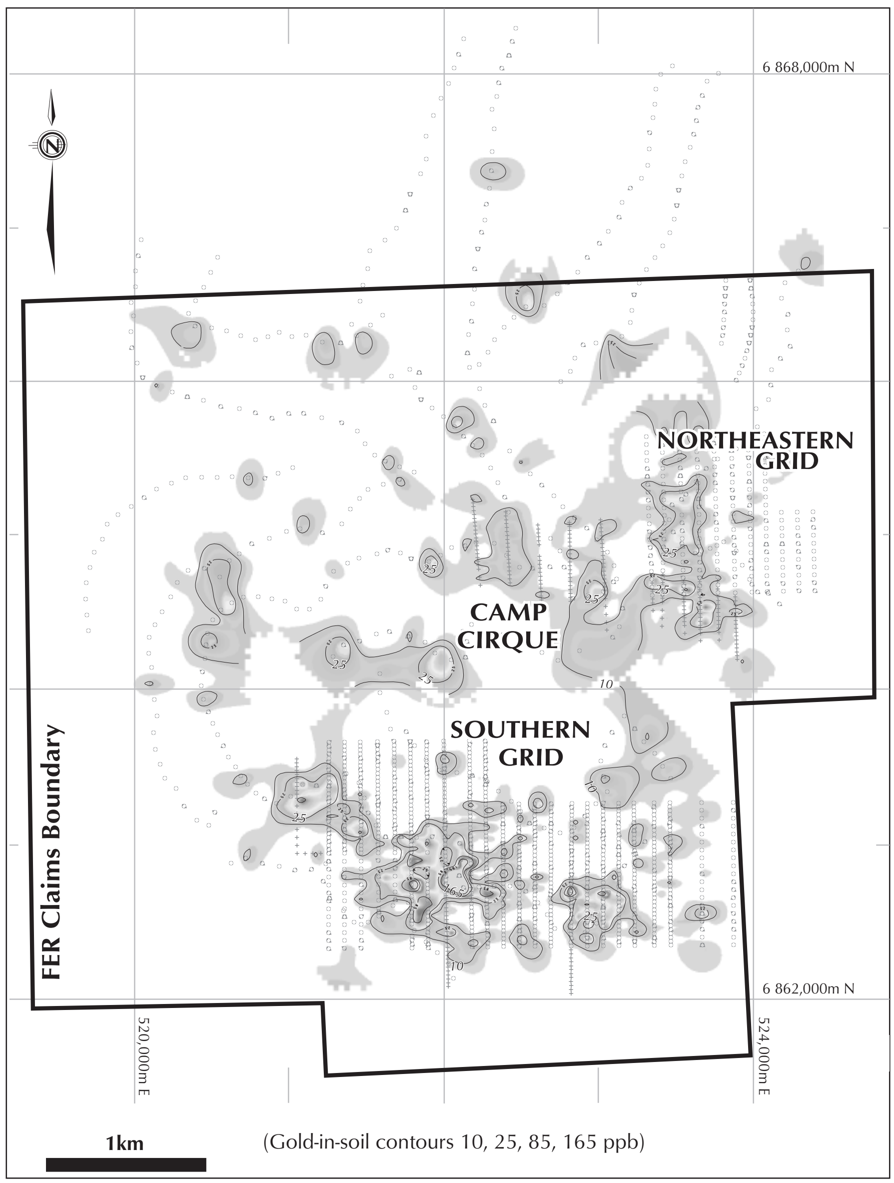

Figure 4. *Contoured gold-in-soil geochemistry of the Fer property. Shading indicates more detailed gradations in gold values.*

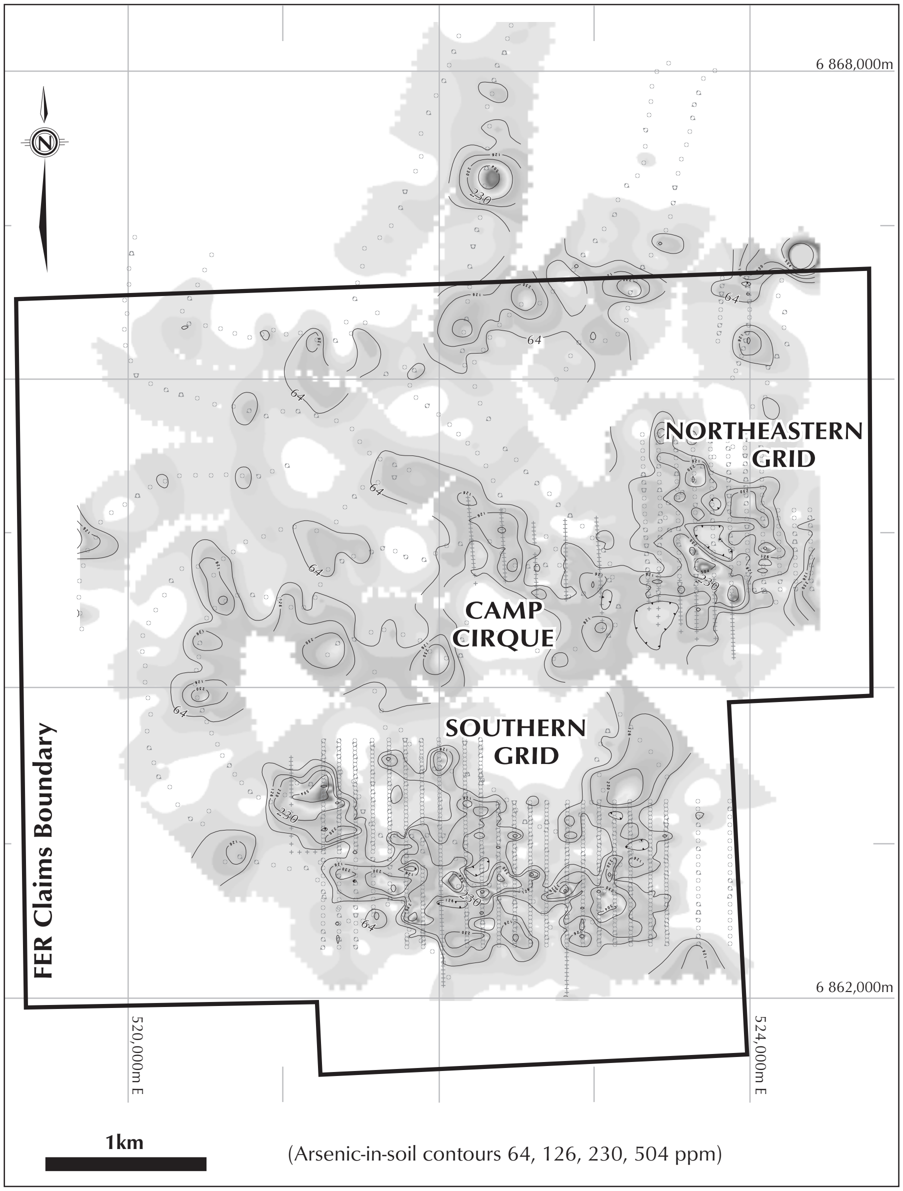

Figure 5. *Contoured arsenic-in-soil geochemistry for the Fer property. Shading indicates more detailed gradations in arsenic values.*

when evaluating the continuity of the Southern Grid anomaly. As well, the talus may be concealing the source of the anomaly, which has not been detected by the rock sampling done to date.

Sampling has delineated an approximately 500 m by 200 m, moderate gold-in-soil anomaly in the southwest part of the Northeast grid. This corresponds to mineralization in several quartz-rich sedimentary units which cut through the grid area, located primarily south of a major east-trending fault (Fig. 3). Sampling on grid lines in the Camp Cirque area, to the west of the Northeast grid and south of the major fault, detected spotty anomalous results, despite the talus and valley fill which covers a large portion of this part of the grid. These results could indicate a continuation of mineralization into this area.

EXPLORATION MODEL

The Fer property hosts a distinct style of gold mineralization within the spectrum of intrusion-related, gold-lithophile deposits found throughout the Tintina gold belt. The belt includes intrusion-hosted deposits, such as the Fort Knox deposit (200 million grams; 7 million oz. Au), high temperature (deep) vein-hosted deposits, such as Pogo (160 million grams; 5.2 million oz. Au), and disseminated and fracture-controlled deposits peripheral to intrusions, such as True North (40 million grams; 1.3 million oz. Au) among others. The variations in style of mineralization seen in the Tintina gold belt generally reflect the relative depths of formation and proximity to intrusions. The Fer property is quite distal to the nearest visible intrusion, an elongate, magnetically subdued, mid-Cretaceous granite pluton 4 km southwest of the property. Indicators of the distal nature of the mineralization at the Fer property include the lack of intrusive rocks or significant hornfels, and a metal signature dominated by As-Pb-Sb with low Bi. Distal mineralization (i.e., 2-6 km from intrusion) has not yet been well described in the Tintina gold belt. One possible analogue for this style of mineralization could be the distal, plutonic-related gold mineralization at the Telfer deposit in Western Australia.

The Telfer deposit (340 million grams; 11 million oz. Au) is a sediment-hosted, gold-lithophile element deposit (Rowins et al., 1998). It formed from circulating mineralizing fluids, driven by a distal intrusive heat source (1-6 km), which were focussed along structural conduits. Mineralization at Telfer consists of extensive replacement by sulphides of a 1- to 3-m-thick, chemically and structurally receptive stratigraphic unit, the Middle Vale Reef. The reef is continuous over 3 km of strike along the axial plane of the Telfer Dome anticline and up to 1 km down-dip along the limbs of the anticline. There are several such mineralized zones, stacked within, and focussed on the axial plane of the Telfer Dome, which acted as a fluid conduit (Fig. 6).

Mineralization at the Fer property exhibits both structural and lithological controls, similar to the Telfer deposit and other non-intrusion-hosted Tintina gold belt deposits. The majority of mineralized rocks are at least spatially associated with faults. In addition, silicification, quartz veining and stockwork commonly show a linear, planar morphology, crosscutting bedding. The predominant orientation for these alteration zones is similar to the inferred orientation of the axial plane of a broad synform present on the property. Quartz-rich lithologies are the dominant, though not exclusive hosts for significant alteration and mineralization. Strong fracturing in these silicic rocks, as a result of faulting and folding, creates permeability for extensive hydrothermal fluid-rock interaction. As well, these rocks may have been chemically reactive hosts. The lack of significant interstitial calcite in the rocks hosting mineralization may be a result of decalcification, with subsequent healing and replacement by silica and sulphides. This could explain the predominant occurrence of sulphides (pyrite and arsenopyrite) as pervasive disseminations, blebs and pods associated with well-healed, quartz-rich siliciclastic rocks.

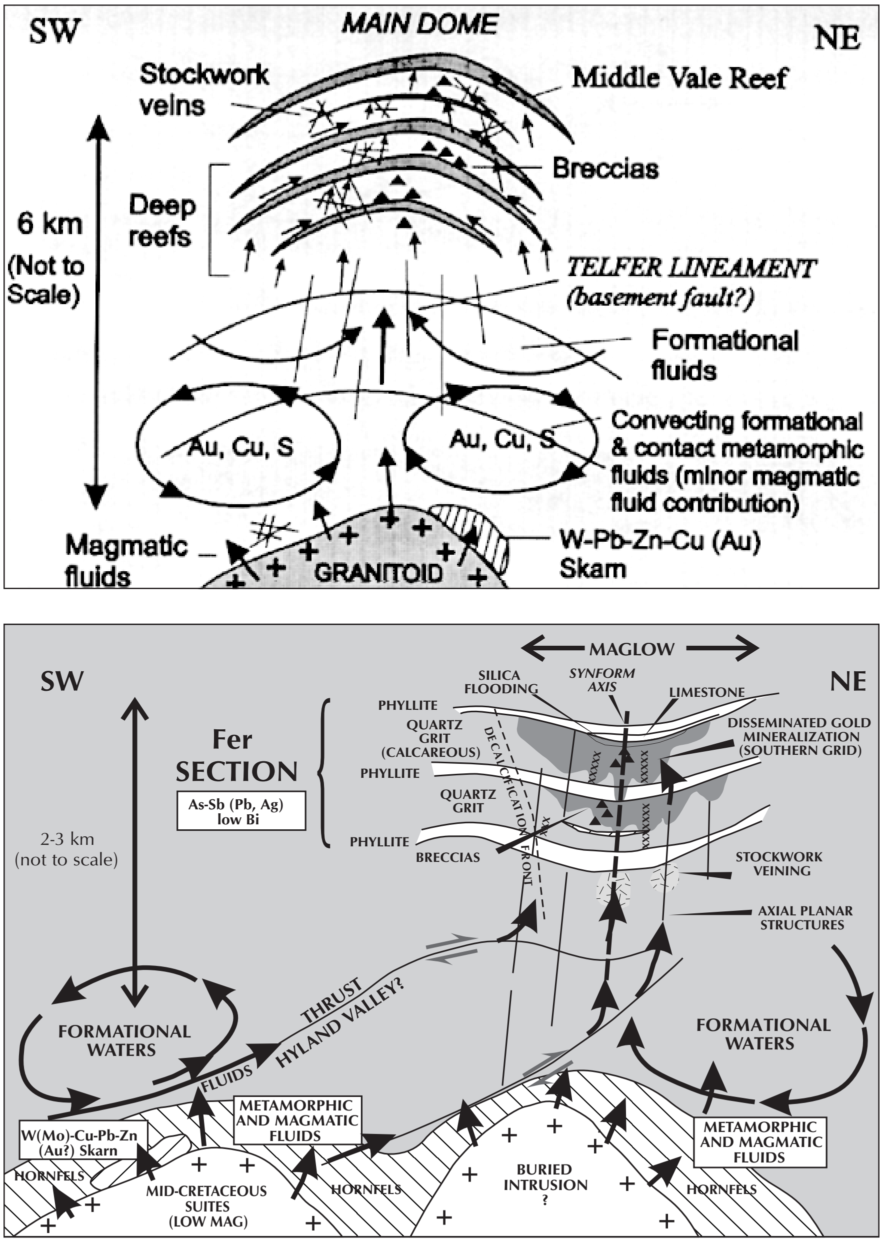

Figure 6. *Top: Schematic cross-section of the Telfer mineralization model (Rowins, et al., 1997). Bottom: Speculative model for formation of mineralization at the Fer property. Fluids emanating from mid-Cretaceous plutons (metal source?) follow regional scale structures, mixing with formational waters (sulphur source?), and eventually entering local structures (axial planar?). At the local scale, reaction with interstitial carbonate and boiling lead to silicification and mineralization.*

Figure 6 shows the genetic model for the Telfer deposit developed by Rowins, et al. (1997), and a derivative model for the formation of mineralization at the Fer property. For the Fer model, it is envisaged that fluids related to felsic intrusions of intermediate oxidation state (W (Mo)-Cu-Au signature) are channelled along structural conduits such as reactivated major lineaments or regional scale thrust faults (Hyland River valley?). As they rise, these fluids find their way into secondary structures, such as the axial planar cleavage of the synform at the Fer property. At some distance from the intrusion, the fluids deposit dissolved metals as a result of interplay between various factors, primarily reactions with interstitial carbonate in the fractured, quartz-rich clastic rocks (resulting in decalcification), and fluid cooling and boiling (resulting in silicification and quartz vein formation). The locally pervasive nature of alteration and mineralization in wall rocks suggests that the volume of hydrothermal fluid may have been higher than typical deposits of the Tintina gold belt, perhaps indicating mixing with formational waters as these fluids ascended.

The broad soil geochemical anomalies associated with the mineralization and the regional magnetic low on the Fer property record hydrothermal alteration of a large volume of rock. This is corroborated by rock sampling, which has detected widespread gold mineralization, though values to date have been generally low. The potential for narrow, higher grade, Telfer-style, stratabound mineralization is exhibited by the combined structural and lithological controls on mineralization present on the Fer property.

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