Structural controls on alteration and mineralization at the Coffee gold deposits, Yukon

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ABSTRACT

The Coffee gold deposits are controlled by east and north-striking structures that initiated in the Jurassic and were re-activated in the Cretaceous. Cretaceous igneous rocks and Jurassic-altered Paleozoic rocks were overprinted by Late Cretaceous (or younger) gold mineralization and the paragenetic sequence for the main prospects has been established. Jurassic alteration is characterized by zones of pervasive quartz sericite alteration of metamorphic minerals and disseminated brassy pyrite. Jurassic pyrite is locally anomalous in gold, but is generally barren. Cretaceous gold mineralization overprints Jurassic sericite alteration and is characterized by veins and breccia infilled with gold-bearing, dark grey, 'sooty' arsenian pyrite. In biotite-rich host gneiss, disseminated arsenian pyrite extends outwards from fracture zones along biotite-rich metamorphic foliation and pre-existing Jurassic shears. In altered Late Cretaceous igneous rocks, gold-bearing arsenian pyrite replaces primary biotite. Compared to other nearby prospects, the Coffee gold project is most similar to the Boulevard trend but textures suggest it formed at shallower levels.

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INTRODUCTION

Heightened gold exploration activity in central Yukon from 2007 to 2010 yielded several significant new discoveries, such as the White Gold deposit and Boulevard trend (Fig. 1; MacKenzie and Craw, 2010; MacKenzie *et al.*, 2010; Bailey, 2013; McKenzie *et al.*, 2013). Deposits in the Coffee Creek area (Fig. 1; Wainwright *et al.*, 2011) were discovered during this time, and have been advanced since then with a major drilling program. A preliminary economic assessment is planned for early 2014. The drilling program was accompanied by detailed surface geochemical sampling and site-wide airborne geophysical surveying, yielding a large amount of new data on the geology of the area.

This paper reports on work from the 2013 summer season in which these large data sets were integrated with new mapping and examination of drill core to produce a new geological map for the mineralized area (Fig. 2). The geological structure of the Coffee Creek area has been placed into the context of the regional geology (Figs. 1, 2, and 3) in order to better understand the geological development of the immediate host rocks for the gold deposits. From this basis, the structure and alteration mineralogy of the Coffee gold deposits have been integrated into the framework of tectonic and structural evolution of basement rocks and hydrothermal systems of the wider Yukon-Tanana terrane.

GEOLOGICAL SETTING

The main prospects at the Coffee Gold Project (Coffee) are hosted in metamorphic basement rocks of the Yukon Tanana terrane (Mortensen, 1992, 1996; Ryan *et al.*, 2013; Fig. 1). South of Stewart River through to the Dawson Range, basement rocks consists of Paleozoic schist and gneiss that were intruded by a least three generations

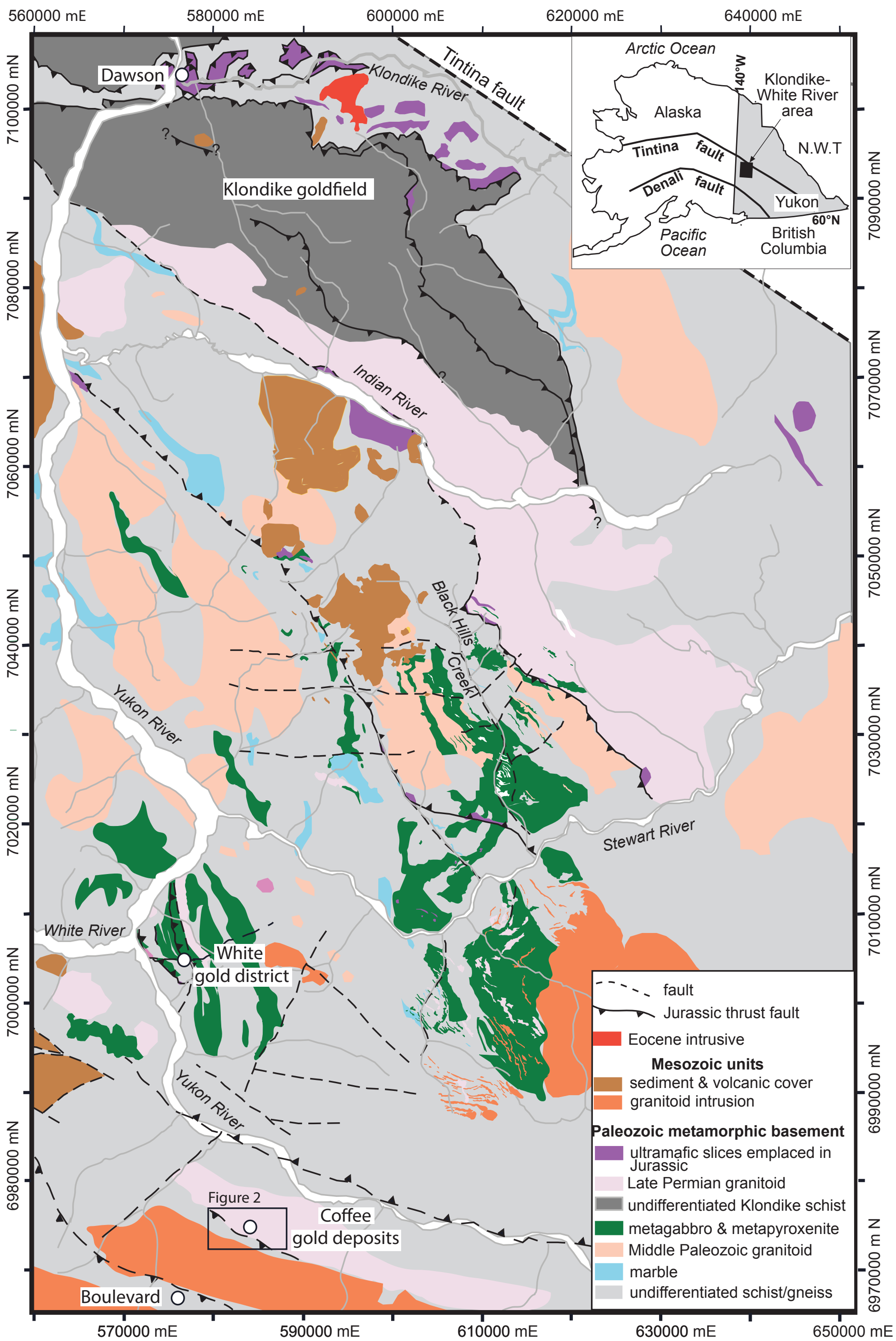


***Figure 1**. Geological map of the Klondike – White River and Coffee Creek area, central western Yukon (modified after Ryan and Gordey, 2004; MacKenzie et al., 2008a,b, 2010, 2013; MacKenzie and Craw, 2010, 2012). Rectangular box shows the location of the area mapped in this study (Fig. 2).*

of pre and synmetamorphic granitic, gabbroic, and pyroxenite intrusions in the Devonian, Mississippian and Permian (Ruks *et al.*, 2006; MacKenzie and Craw, 2012). All of these rocks were subjected to Late Permian amphibolite facies metamorphism (Berman *et al.*, 2007; Beranek and Mortensen, 2011). The rocks were completely recrystallized and developed a pervasive metamorphic foliation. This foliation, designated S_2 (Table 1), is a composite feature made up of at least two almost completely transposed foliations (S_1+S_2). S_1 is rarely seen, as isolated, foliation-parallel, isoclinal folds along the foliation. S_2 foliation dominates in the Coffee Creek area and in most outcrops throughout the region.

Metamorphic basement rocks and the metamorphic foliation were deformed and folded in the Jurassic when kilometre-scale slices of rock were tectonically stacked along regional-scale thrust faults (F_3, Table 1; Mortensen, 1996). Thrust stacking incorporated lower grade, greenschist facies mafic and ultramafic rocks of the Slide Mountain Terrane (Mortensen, 1996; MacKenzie *et al.*, 2008b; Table 1). Greenschist facies shear zones and alteration developed at this time in zones of intense semi-ductile F_3 folding and accompanied regional-scale thrust faulting. Later stages of more brittle kink folding and fracturing (F_4, Table 1) subsequently developed in the region and these structures were locally infilled by orogenic quartz veins formed from fluids generated at depth within the thickened metamorphic pile (MacKenzie *et al.*, 2008a). Hydrothermal alteration and disseminated gold mineralization in the White Gold district is controlled by extensional fractures and E-W striking Jurassic faults and shear zones (MacKenzie *et al.*, 2010; Bailey, 2013).

Extensional tectonics dominated from Early to Late Cretaceous when granitoids of the Dawson Range batholith (Middle to Late Cretaceous age; McKenzie *et al.*, 2013) intruded along pre-existing fault zones in

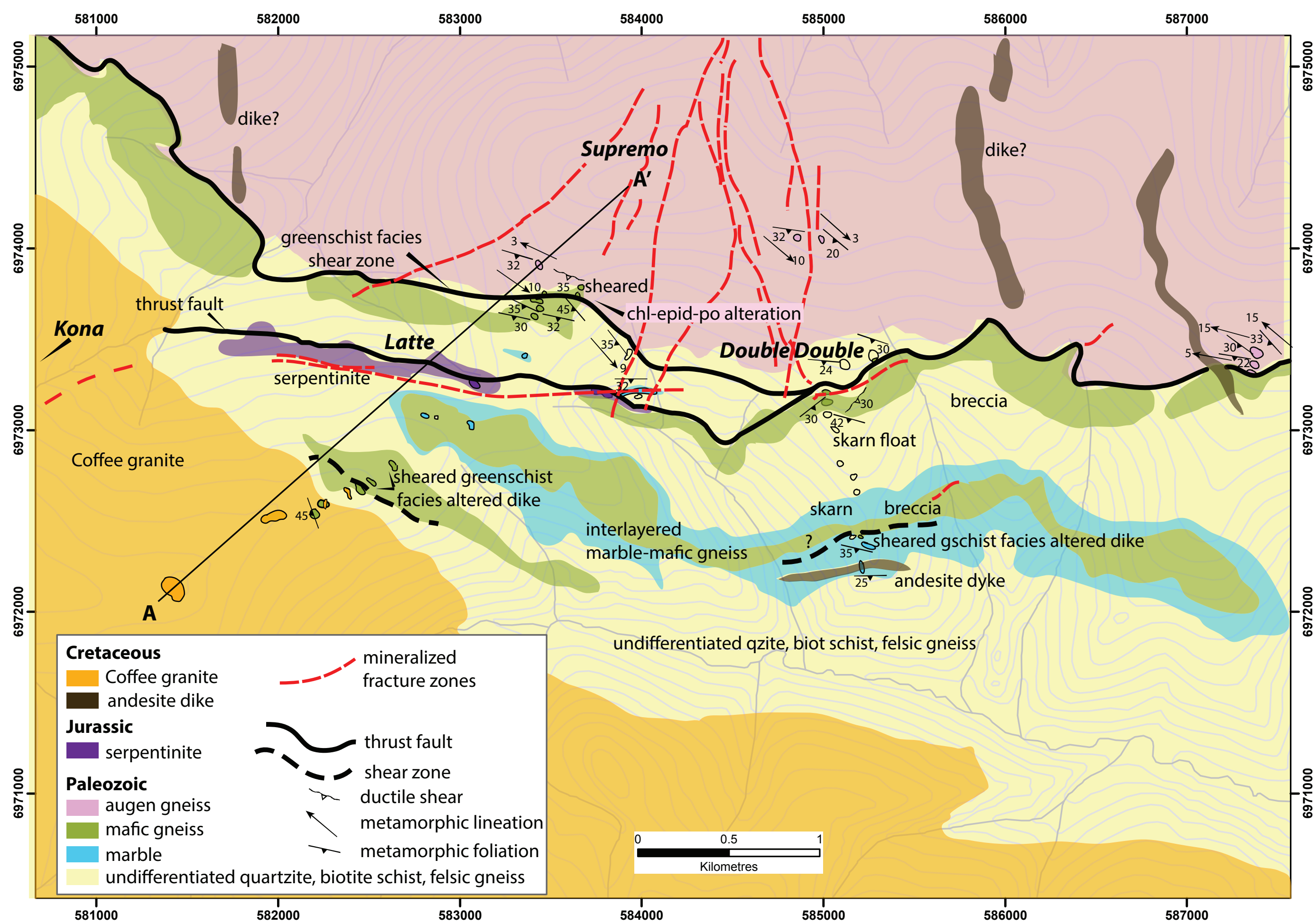


***Figure 2**. Geological map of the Coffee Creek area, showing the line of cross section A-A′ in Fig. 3. chl= chlorite, epid=epidote, po=pyrrhotite.*

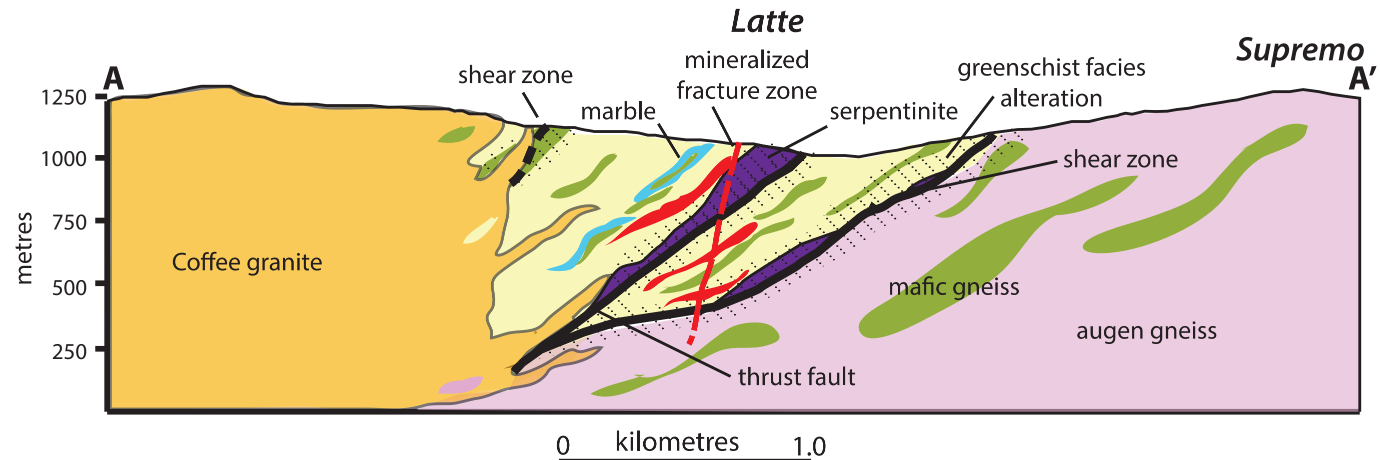


***Figure 3**. Interpretive geological cross section through line A-A' Fig. 2.*

the metamorphic package south of Coffee (Figs. 1 and 2). Extension continued through to the Eocene with the initiation of the Tintina fault as a major regional transcurrent structure (Gabrielse *et al.*, 2006).

COFFEE CREEK BASEMENT ROCKS

The metamorphic basement rocks in the Coffee Creek area (Figs. 2 and 3) include early Paleozoic clastic sedimentary rocks that are now amphibolite facies biotite schist and quartz-muscovite schist, and minor quartzite and marble. These are interlayered with middle to late Paleozoic hornblende-bearing mafic orthogneiss, biotite-quartz-feldspar gneiss, and Late Permian granitoid orthogneiss (locally with K-feldspar augen; Ryan *et al.*, 2013). The Paleozoic rocks are cut by a series of east-trending faults and shear zones that locally contain Paleozoic greenschist facies ultramafic and mafic rocks that were tectonically emplaced in the Jurassic (Figs. 2 and 3). Cretaceous granitoids cut the sequence and a large Cretaceous granite (99 Ma; McKenzie *et al.*, 2013), the Coffee Creek granite, intrudes the metamorphic rocks in the south (Figs. 1,2, and 3).

A greenschist facies shear foliation has been superimposed on, but locally obliquely crosscuts, the pervasive amphibolite facies foliation. The shear foliation (S_3, Table 1) occurs in narrow (100 m scale) east-trending zones, north and south of the Latte prospect, and in another subparallel zone in the metamorphic rocks just north of the Coffee Creek granite (Figs. 2 and 3). In the basement gneiss, the shear foliation consists of highly deformed zones rich in epidote, actinolite ± tremolite, and chlorite. These minerals have been derived by retrogressive alteration of pre-existing amphibolite facies minerals such as hornblende and biotite. The shear foliation is locally crosscut by apophyses of the Coffee Creek granite. Retrograde greenschist alteration, associated with the shear foliation, does not extend into any of the Cretaceous igneous rocks. Magnetite-bearing skarn occurs where greenschist facies shear zones cut through Paleozoic marble.

The ultramafic bodies are generally 5 to 50 m across and occur as irregularly shaped pods (Figs. 2 and 3). Two or more such pods can occur along a zone that lies parallel or subparallel to the adjacent amphibolite facies foliation. The pods are variably deformed internally, and parts of some pods retain their primary mineralogy and texture. Zones of deformed rocks within the ultramafic pods have a characteristic phacoidal texture on the outcrop scale, where anastomosing, pervasively serpentinized and foliated rock surround lenses of less-deformed rock. Serpentinized rock contains serpentine, chlorite, actinolite, talc, and magnesite; serpentinization also produced abundant magnetite.

Open folding and related fractures (D_4, Table 1) are relatively rare in the limited amount of outcrop that has been mapped in the Coffee Creek area, but this style of folding is commonly observed in drill core as small-scale kink and chevron folds. The folds have rounded to angular hinges and have steeply dipping fold axial surfaces relative to the metamorphic foliation. A steeply dipping fracture, subparallel to the axial surface F_4, is common and this is locally infilled with white orogenic quartz veins (discussed below).

Table 1. *Paragenetic sequence for the main minerals and structures in the Coffee Creek area.*

Age	Early Paleozoic	Late Paleozoic	Permian	Jurassic		Jurassic to Late Cretaceous	Late Cretaceous				Pliocene - Recent
Event	Host rock sedimentation	Pre-syn metamorphic intrusions	Late metamorphic intrusions	Slide Mountain terrane collision and thrusting			main gold event Supremo Latte		high grade zones in Latte	late breccia	oxidation, weathering
Regional tectonics		Assembly of Yukon -Tanana terrane (D1-D2)		Orogenic collision, uplift, thrust stacking (D3-D4)	early silicification and pervasive sericite alteration		dark grey fine grained sulphides, veins and breccia infill	euhedral quartz, carbonate, translucent quartz	Fe(Mg) carbonate veinlets and breccia infill	late fractures calcite, hematite	regional uplift & erosion
Metamorphism		Amphibolite facies		localized Greenschist facies							groundwater alteration
gold	syn-depositional enrichment?			white quartz veins			Au in solid solution				Au liberated
arsenian pyrite							fine breccia sooty py	local realgar			altered to limonite
pyrite		metamorphic brassy cubes		white quartz veins	replace Hb, cubic, brassy blebs & masses along foliation						
chalcopyrite		metamorphic in mafic rocks		white quartz veins							
hematite									specular hematite	fractures in mafic rocks	
sericite ± fuchsite					sericite, local fuchsite		minor sericite				
chlorite-epidote-actinolite				disseminated in shears, alteration							
Fe(Mg) carbonate											altered to limonite
calcite		metamorphic		remobilized in shears				multiple phases euhedral, banded vuggy carbonate		late white cc fractures	
quartz		quartz segregations		early white quartz veins silicification of fold hinges	pervasive silicification		grey quartz	euhedral vuggy quartz			
dacite dikes, andesite dikes											
Coffee Granite											
serpentinite, talc schist				tectonically emplaced							
cataclasite, gouge							mineralized breccia	mineralized breccia	non-mineralized	non-mineralized	
ductile shears				S3							
folds			intrafolial F2	asymmetric F3	chevron kink F4						
foliation		S2	local crenulation cleavage								

COFFEE GOLD DEPOSITS

EARLY (JURASSIC) ALTERATION

Sericitic alteration is a common feature in core from the Coffee gold deposits and occurs in irregular patches or zones (cm to m-scale) that overprint the metamorphic host rocks, and in narrow vein selvages on the margins of early quartz veins. The alteration is characterized by pervasive quartz-sericite-hematite alteration that overprints the foliation in biotite-bearing orthogneiss rocks (Fig. 4). This sericitic alteration occurs in metamorphic rocks throughout the region but is most intense near regional scale, east-striking D_3 shears and thrust faults at Latte and Double Double and north-trending fault zones at Supremo. The alteration zones are mineralized with brassy coloured subhedral pyrite (Fig. 4a), and are generally barren, however, with little or no gold, unless overprinted by later sericitic alteration and arsenian pyrite (As-pyrite), discussed below.

Some of the early sericitic alteration zones are spatially associated with cm-scale, early white orogenic quartz veins (Table 1). Sericite + pyrite haloes extend (5 to 15 mm) outwards from some vein margins into host rock and locally contain elevated As. Some of these veins are folded and locally contain S_3 shear fabric and other veins infill brittle fractures associated with F_4 axial surface fractures. This generation of veins also appears to be barren and predates the main phase of overprinting Cretaceous gold mineralization.

CRETACEOUS GOLD MINERALIZATION

The main phase of gold mineralization at Coffee is associated with relatively high angle fractures and breccia that overprint earlier, Jurassic shear fabrics (D_3 to D_4) and sericitic alteration zones (Table 1; Fig. 4b). These mineralized brittle structures cut across all of the mapped rock types on the property, including the 99 Ma Coffee Creek granite (McKenzie *et al.*, 2013). Gold mineralization is therefore Late Cretaceous or younger. The main paragenetic stages of Coffee gold mineralization are listed in Table 1.

Much of the mineralized Coffee core is oxidised and paragenetic relationships are difficult to distinguish. Where oxidation has been limited, however, by low permeability (Fig. 5), early dark grey, ‘sooty’, arsenian pyrite (As-pyrite) replaces biotite along the metamorphic foliation. The Cretaceous mineralization is distinct from earlier sulphides deposited during Jurassic alteration (Figs. 4 and 5). The As-pyrite is relatively finer grained (typically <100 μm) than Jurassic ‘brassy’ pyrite (Fig. 6) and concentrated along micaceous layers, replacing biotite. Earlier generations of pyrite (metamorphic and Jurassic pyrite) are more euhedral, often cubic, and can be enclosed in quartz segregations and veins (Fig. 6).

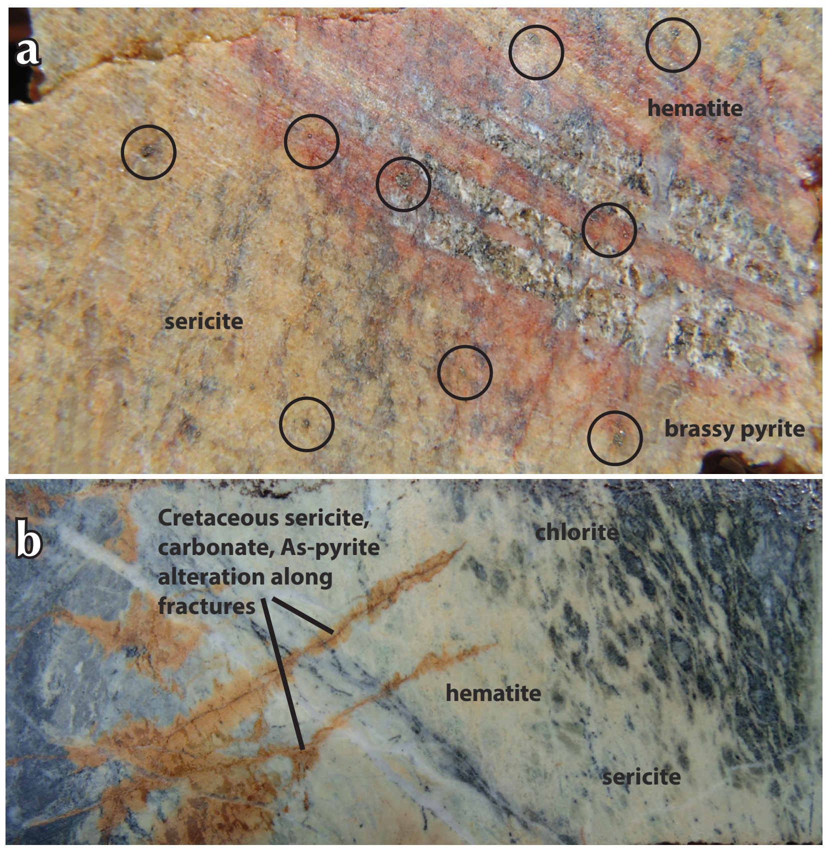


***Figure 4**. Coffee core samples showing Jurassic sericitic alteration of granitoid orthogneiss from Supremo prospect: (a) unmineralized sericitic alteration zone (pale brown) and relict biotite-bearing host rock (centre right). A zone of red hematite-rich weak sericitic alteration occurs near the boundary between the relict host rock and the main sericitized zone. Brassy pyrite with little or no associated gold is scattered through the alteration zone (larger grains in black circles); and (b) unmineralized disseminated sericitic alteration and variable hematite staining is overprinted by fracture-controlled Cretaceous gold-bearing alteration. Cretaceous carbonate and As-pyrite is variably oxidised along the fractures.*

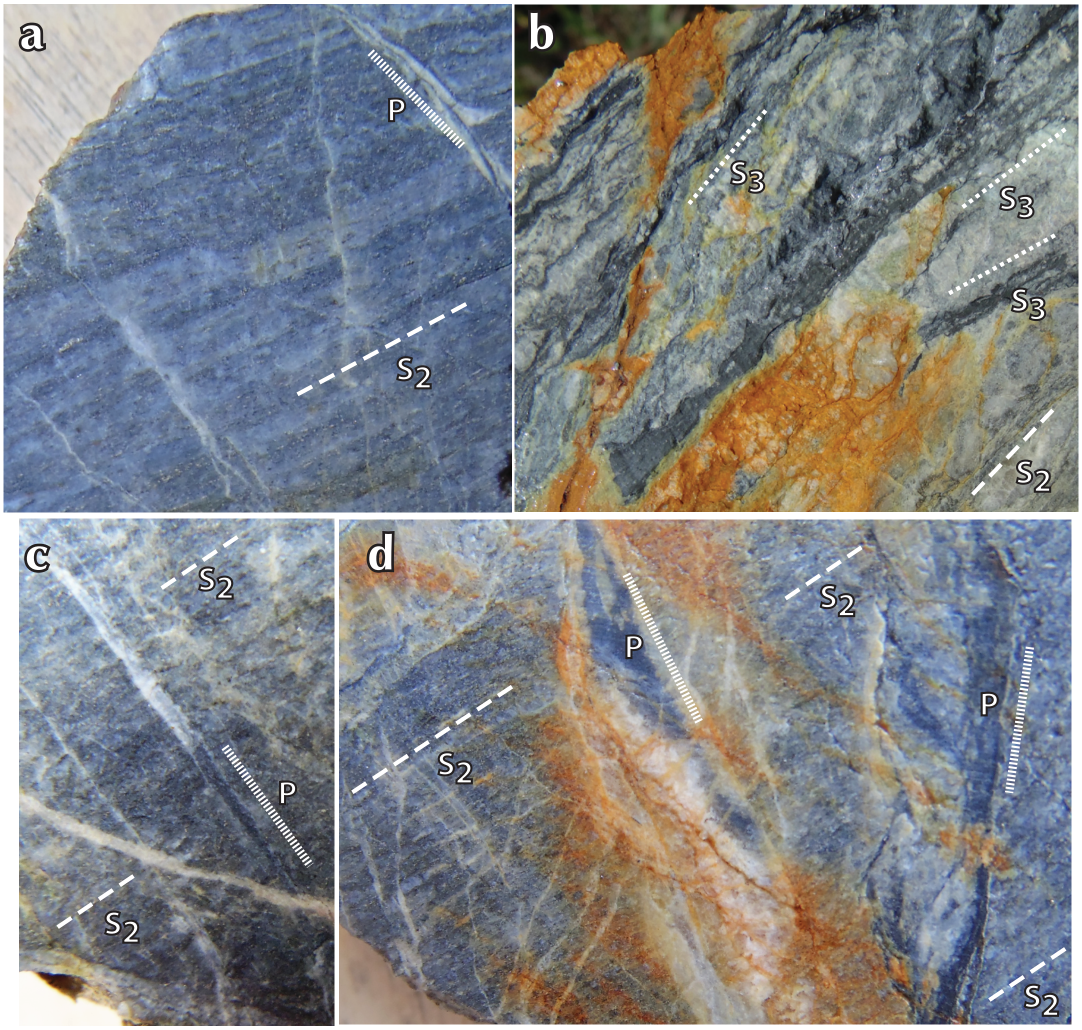


***Figure 5**. Core photographs of mineralized biotite gneiss from the Latte prospect at Coffee, in samples where oxidation has been limited by low permeability. Biotite has been largely replaced by As-pyrite (dark grey) along foliation (S_2 in all images); pyrite-rich zones occur along Jurassic shears (S_3 in b) and crosscutting microveinlets (P in a, c, d).*

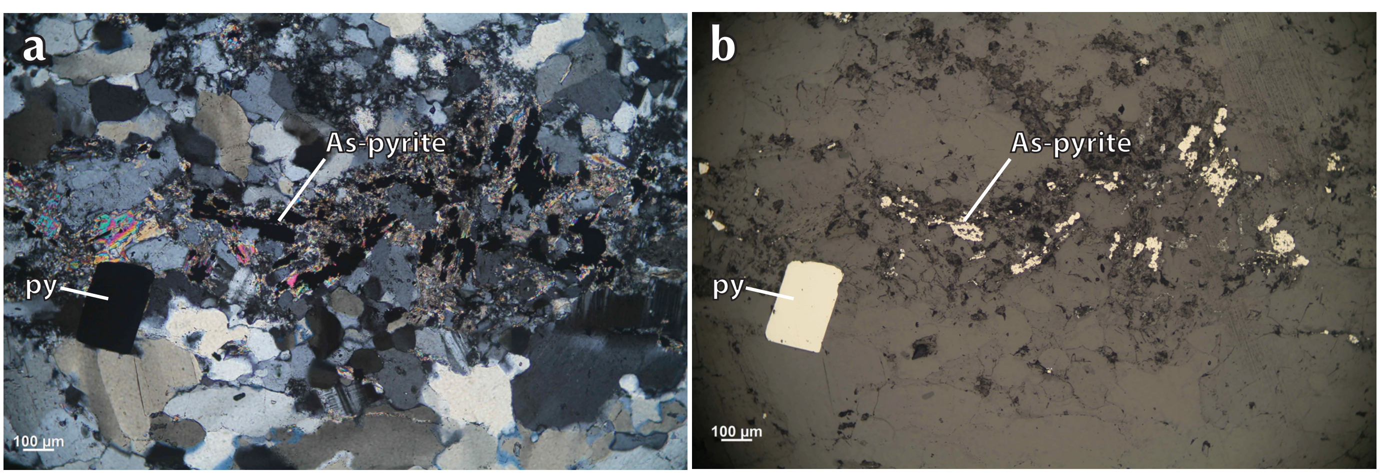


***Figure 6**. Photomicrographs of early euhedral pyrite (py) and Cretaceous arsenian pyrite (As-pyrite): (a) transmitted light, crossed polars; and (b) Reflected light. The early pyrite is intergrown with relatively coarse quartz grains. The As-pyrite is finer grained, anhedral, and occurs in the micaceous layers replacing biotite.*

The presence of As-pyrite gives the Coffee gold deposits a strong As signature (Fig. 7) that is distinct from most Yukon gold deposits (MacKenzie *et al.*, 2008a, 2010, 2013). Typical As concentrations in mineralized samples are >> 100 ppm, and strongly altered samples contain between 1000 and 10 000 ppm, the upper analytical limit to this ICP assay method (Fig. 7a). Many mineralized samples contain several % As, as detected by portable XRF.

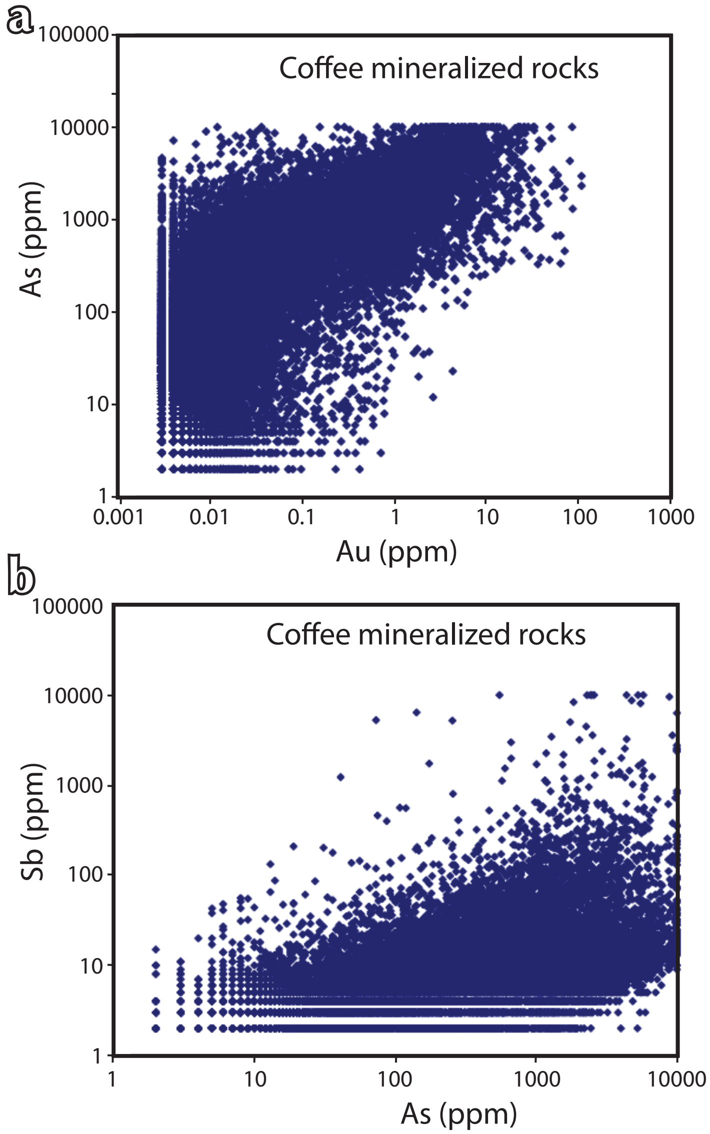


***Figure 7**. Arsenic and antimony concentrations in relation to gold contents for Coffee mineralized rocks (1 m core segments): (a) measured arsenic concentrations. The upper limit of 1 wt% to As contents is an analytical limit for the method used (ICP), not a real limit, and As contents >3 wt% are commonly measured with portable XRF; and (b) Measured antimony concentrations.*

As-pyrite occurs in both high angle mm-scale veins and as fine disseminations concentrated along micaceous layers in gneiss, and along pre-existing Jurassic shears (Fig. 5). The As-pyrite is generally dark grey, anhedral, and sooty in appearance, and associated with titanite where the two minerals have replaced metamorphic biotite. The greatest concentrations of sulphide occur where mineralized rocks have been brecciated and infilled with this As-pyrite. Grey, translucent quartz occurs with As-pyrite in microveinlets, and minor sericite extends (mm-scale) into wallrock (Table 1). Breccia dominates in mineralized rocks at Supremo and good gold grades (>1 ppm) correlate well with the 'sooty' As-pyrite-rich zones. The paragenetic sequence is more complex at Latte and Double Double where As-pyrite bearing rock and breccia are locally crosscut by additional phases of mm-scale prismatic quartz veins and banded carbonate veins (Table 1). These overprinting veins contain 'sooty' As-pyrite as well, and have locally enriched the gold grades (>3 ppm). Volumetrically, however, the bulk of the mineralized rock at all prospects is composed of the earlier As-pyrite that infills veins and breccia. Crosscutting Fe(Mg) carbonate veins and breccia cut the mineralized rocks (Table 1) but these phases are generally barren, as are other late-stage vein generations (Table 1).

Alteration and mineralization of the Coffee Creek granite is evident in zones of bleaching that extend outwards from high angle fractures (Fig. 8). Biotite in these zones is altered to sericite and the primary feldspars are albitized and sericitized. Where alteration is most intense, the biotite has been completely replaced by As-pyrite (Figs. 8c and 9).

High angle mineralized fractures and pyrite-bearing veins and breccia (with high As contents measured by bench top XRF) crosscut a variety of rock types at Latte (Fig. 10) including the ultramafic rocks emplaced along Jurassic thrust faults (Figs. 10d,e). Tectonically emplaced serpentinite is generally a poor host for gold but Cretaceous mineralized fractures locally extend into these ultramafic rocks, particularly in areas where they have been deformed and altered by Jurassic shears (S_3)

COMPARISONS TO OTHER YUKON TANANA TERRANE GOLD DEPOSITS

The style of mineralization at Coffee has some important similarities to, and differences from, other gold-bearing deposits in this part of the Yukon Tanana terrane (Table 2). The main difference between deposits at Coffee and the

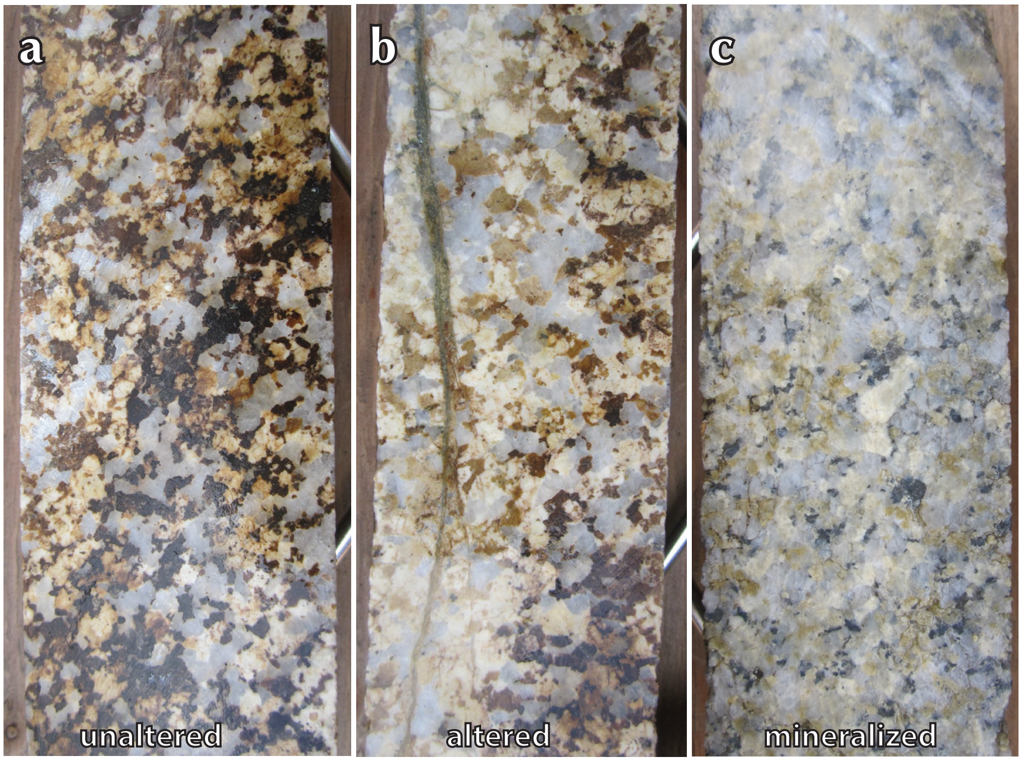
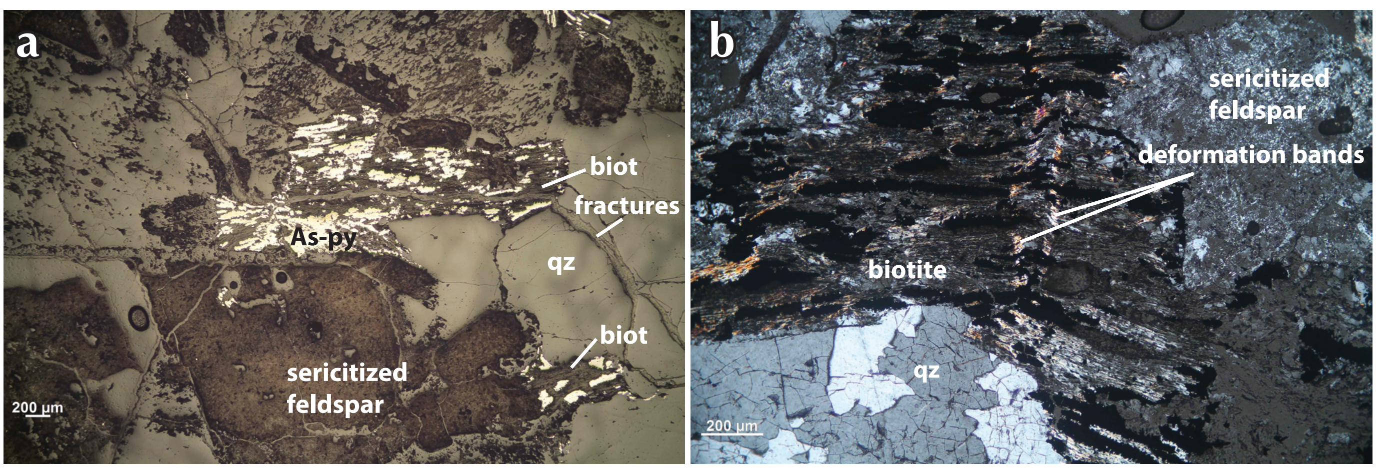


Figure 8. Progressively altered and mineralized core from the Kona prospect: (a) unaltered Cretaceous Coffee Creek granite containing quartz, feldspar, and biotite; (b) altered Coffee Creek granite. Biotite is sericitized and feldspars are albitized; and (c) Mineralized and altered Coffee Creek granite. Feldspars are sericitized and biotite has been replaced by As-pyrite.



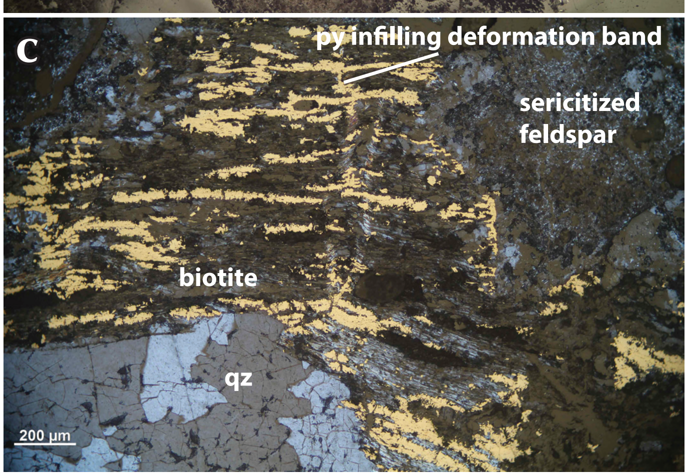


Figure 9. Photomicrographs of mineralized Coffee Creek granite from Kona drill core: (a) reflected light image of fractured and mineralized Coffee Creek granite. Quartz (qz) is unaltered, primary igneous feldspar is extensively sericitized and biotite is replaced by As-pyrite (bright white) along cleavage; (b) close-up, crossed polars, of deformed and altered biotite in mineralized granite. Pyrite has replaced biotite along its cleavage and partially infills kink deformation bands in the biotite; and (c) Reflected light.

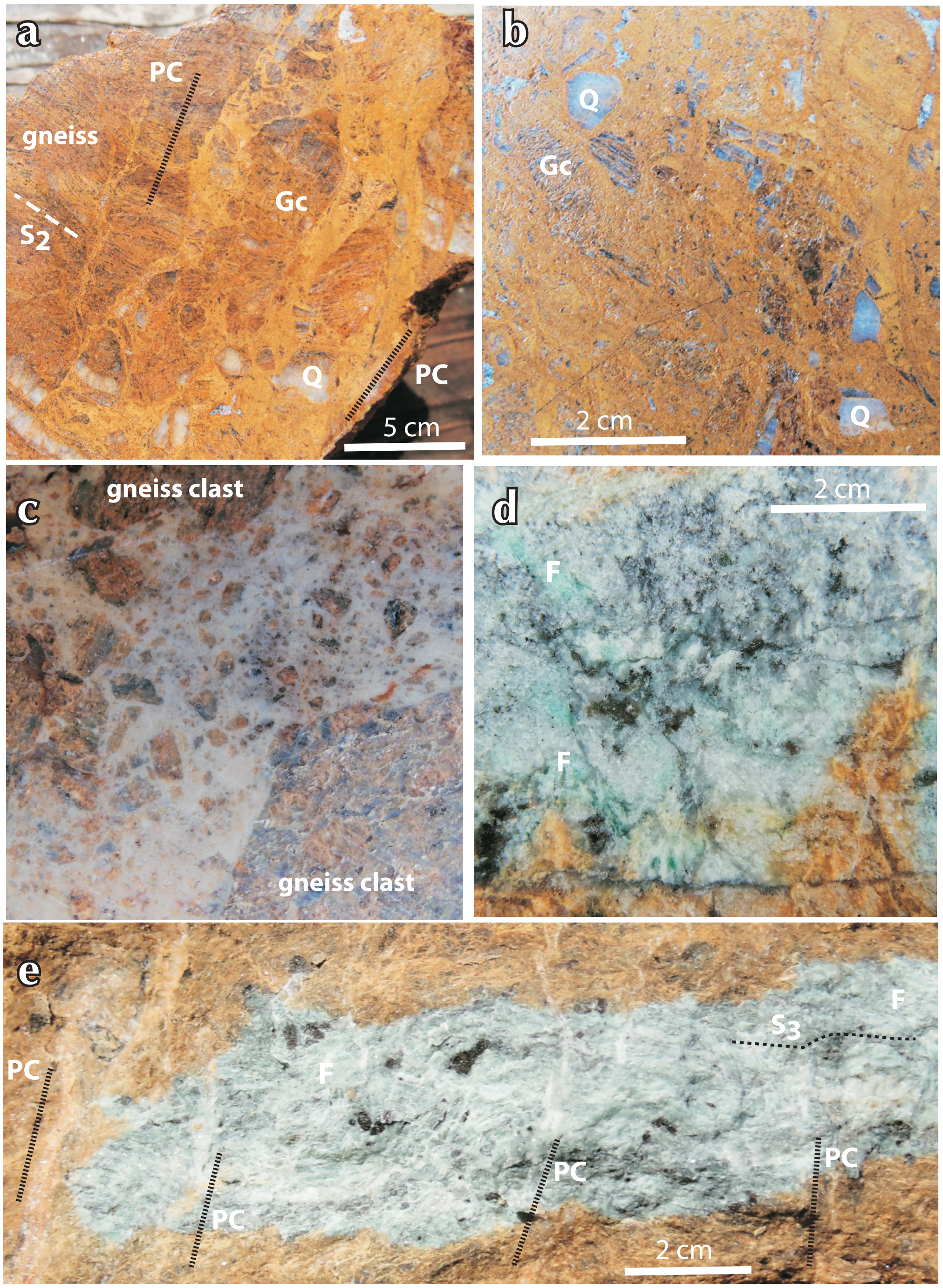


***Figure 10**. Photographs of samples of fracture-controlled and brecciated mineralized zones in the Latte prospect at Coffee: (a) slabbed boulder of biotite gneiss (relict S_2 foliation preserved on margins) cut by steeply dipping brecciated zones with clasts of gneiss (Gc) and quartz (Q). Fractures with hydrothermal As-pyrite and carbonate (PC) cut the rock in the indicated steep orientations, and both clasts and host rock have been impregnated by disseminated As-pyrite and carbonate; (b) cut slab of a boulder more intensely brecciated than in (a); (c) core photograph of quartz-dominated mineralized breccia; (d) Boulder of serpentinite altered to talc, chlorite, carbonate, and fuchsite (F) with As-pyrite (dark seams) along numerous fractures; and (e) boulder of altered serpentinite (as in d) with steeply crosscutting fractures containing carbonate and As-pyrite (PC).*

nearby White Gold district is that mineralization at Coffee is superimposed on White Gold-style alteration. Gold mineralization at Coffee is characterized by gold-bearing As-pyrite that overprints earlier sericitic alteration. The early sericitic alteration is associated with Jurassic D_3 and D_4 structures and minor local orogenic quartz veins. In the White Gold district, this stage of alteration is accompanied by gold-bearing disseminated pyrite and little or no As (in orthogneiss rocks). At Coffee, this stage of alteration is accompanied by brassy pyrite that looks similar to the pyrite at White Gold but is generally barren. The main stage of gold mineralization at White Gold is thought to be Jurassic (Bailey, 2013) whereas gold mineralization at Coffee is no older than Late Cretaceous (McKenzie *et al.*, 2013). Mineralization in both areas is hosted in regional scale east and north-trending structures. These structures probably initiated in the Jurassic and were reactivated in the Cretaceous. Molybdenite associated with gold-bearing pyrite veins and sericite alteration in fault rocks at the Golden Saddle deposit on the White Gold property has been dated Late Jurassic (Re-Os ages, 163-155 Ma; Bailey, 2013). However, additional Early Cretaceous dates were obtained from hydrothermal altered rocks containing illite and fuchsite at Golden

Table 2. *Summary of mineralization characteristics of the Coffee hydrothermal gold system, in comparison to some other known gold deposits in the Yukon region (partly after Johnston et al., 1996; Baker and Lang, 2001; MacKenzie et al., 2008a, 2010; McKenzie et al., 2013,).*

Deposit:	Coffee gold deposits	Boulevard	White Gold district	Klondike goldfield	Tintina Au belt Intrusion-related	Carmacks	Casino
Metal(loids)	Au, As, Sb	Au, As, Sb	Au (Mo, As)	Au	Au, Bi, As, Te (W, Mo)	Au, Cu, Ag	Cu, Au, Mo, Ag
Age	Cretaceous?	mid-Cretaceous	Jurassic	Jurassic	mid-Cretaceous	Late Cretaceous	Late Cretaceous
Principal host rocks	Granitoid orthogneiss, biotite gneiss; Coffee Ck granite	Mafic schist	Granitoid orthogneiss, graphitic quartzite	Felsic schist, mafic schist	Felsic-intermediate intrusive rocks	Gneiss, hypabyssal intrusive rocks	Gneiss, Dawson Range & Casino complex felsic intrusive rocks
Primary structural control	Jurassic extensional fractures, faults, reactivated in Cretaceous	Cretaceous faults	Jurassic extensional fractures, faults	Jurassic extensional fractures in fold axial surfaces	Extensional fractures	Normal faults	Cretaceous faults
Secondary structural controls	Paleozoic foliation; Jurassic foliation-parallel shears	Fault-related extensional fractures	Paleozoic foliation, Jurassic foliation-parallel shears	Localised extensional fracture sets	Extensional fractures	Fractures	Intrusive breccia
Alteration	Biotite replacement, sericitization, silicification, carbonation; overprints Jurassic sericitization	Sericitization, silicification	Sericitization, silicification, graphitisation	Minor carbonate	Minor muscovite, carbonate, feldspar, sulphide zones; skarns	Sericitization, clay alteration	Potassic core, phyllic, weak argillic and propylitic
Mineralization style	Breccia, disseminated	Quartz veins, breccia	Breccia, disseminated	Quartz veins	Sheeted quartz veins	Veins, disseminated	Disseminated
Gold	Solid solution in arsenian pyrite	Microparticulate in sulphides	Free grains, microparticulate in sulphides	Free grains	Free grains; microparticulate in sulphides	Disseminated, with pyrite	Disseminated with sulphides
Inferred mineralization type	Epizonal orogenic	Mesozonal orogenic	Mesozonal orogenic (local epizonal signatures)	Mesozonal orogenic	Intrusion-related	Epithermal	Porphyry, breccia pipe
Inferred metal source	External, regional tectonic processes	External, regional tectonic processes	Local, lithologically controlled	Local, lithologically controlled	Magmatic	Magmatic	Magmatic

Saddle (Ar/Ar ages, 139-114 Ma; Bailey, 2013). So timing of hydrothermal alteration minerals at White Gold suggests mineralization extended from the Jurassic to at least mid-Cretaceous. The main phase of gold mineralization at Coffee is associated with Late Cretaceous (or younger) As-pyrite that overprints the earlier Jurassic White Gold-style alteration.

There are other deposits in the region that were mineralized in the Cretaceous. Mineralization at the Casino deposit is related to an intrusive breccia pipe and is dated as Late Cretaceous (75-74 Ma; Selby and Creaser, 2001). Geochemically, structurally, and mineralogically this deposit is very different from the deposits at Coffee. Similarly, the magmatic-related deposits at Carmacks, and the intrusion-related gold systems in the Tombstone plutonic suite in the Tintina gold belt are characterized by very different mineralogical and metal associations (Table 2). Furthermore, mineralization at Coffee is dominated by disseminated mineralization and breccia, not epithermal-style or intrusion-related veins.

Coffee gold deposit rocks have been affected by some of the same structural features that host gold in the Klondike goldfield (MacKenzie *et al.*, 2008a). Coffee core contains some orogenic-style quartz veins hosted in F_4 fold axial surface fractures, but these are relatively minor and, unlike coeval veins in the Klondike, the Coffee orogenic veins contain little or no gold.

Gold mineralization at Coffee is most similar to the deposits along the Boulevard trend in the Independence Creek area (McKenzie *et al.,* 2013; Table 2). These occurrences are dated as Cretaceous and mineralization is hosted in similar rocks. Mineralization at Coffee is characterized by more brittle structures, lacks abundant Mo, and is likely a shallower (epizonal) deposit. In contrast, the deposits in the Independence Creek area are mesozonal, and the Toni Tiger showing contains abundant quartz molybdenite veins.

CONCLUSIONS

Mineralized rocks at Coffee record a succession of biotite replacement, sericitization, silicification, and carbonatization events that overprint earlier Jurassic sericitic alteration (Table 1). Au, As, and Sb-bearing fluids (Fig. 7) were structurally controlled along regional-scale Jurassic faults and shear zones that were reactivated in the Late Cretaceous. Mineralization, in primarily Paleozoic gneiss but also Cretaceous igneous rocks, was focused along high angle fracture systems and breccia. Disseminated mineralization extended outwards from brecciated zones in biotite-rich host rocks. Disseminated mineralization in these rocks was controlled and enhanced by pre-existing biotite within metamorphic foliation and Jurassic shears. As-pyrite replaced metamorphic biotite in gneiss and igneous biotite in Cretaceous granitoid rocks.

Cretaceous mineralization superimposed over Jurassic alteration can be distinguished on the basis of pyrite colour and morphology. Jurassic pyrite is generally brassy coloured and euhedral, and is commonly disseminated as isolated grains or clusters throughout sericitic alteration zones. Cretaceous As-pyrite is typically darker grey ('sooty') and more anhedral (Fig. 6). As-pyrite generally occurs as breccia infill, narrow veinlets, or as fine-grained aggregates disseminated along micaceous layers replacing biotite.

Coffee mineralized rocks show a strong positive correlation between Au and As, and Au and Sb (Fig. 7). As values are several orders of magnitude higher than As concentrations in mineralized rocks from orogenic gold occurrences in the Klondike goldfield and mineralized orthogneiss at Golden Saddle in the White Gold district (<100 ppm; MacKenzie *et al.*, 2008a, 2010). Sb contents are similarly elevated in Coffee mineralized rocks compared to mineralized rocks from the Klondike goldfield and the White Gold district (MacKenzie *et al.*, 2008a, 2010), but the Sb/As ratios are broadly similar.

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