Kena Gold Mountain Zone - Early Middle Jurassic Porphyry Au±Cu Mineralization, SEBC

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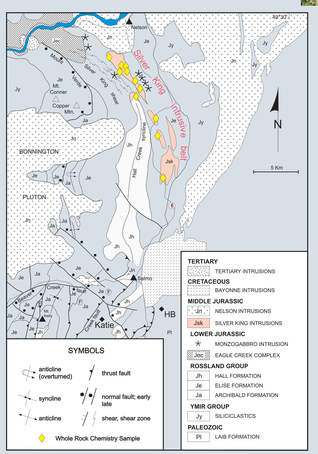
GEOFILE 2003-6

British Columbia Geological Survey

INTRODUCTION

*The **Kena Gold project** is a private-public partnership developed between the Ministry of Energy and Mines, Sultan Minerals Inc. and CANMET-MMSL to study and report on the new gold mineralization discovered 5 km south of Nelson. The Gold Mountain Zone (**GMZ**) was discovered by Sultan Minerals in 2000 by follow-up trenching of gold-in-soil anomalies which straddle the contact between Rossland Group volcanic rocks and the "previously considered to be unmineralized" Silver King pluton. The Silver King pluton is one of six intrusive bodies that comprise a north to northwest trending, 4 x 20 km long prospective, and largely untested, magmatic belt that extends from Ymir north to Nelson.*

REGIONAL SETTING

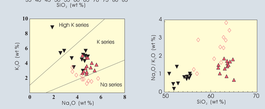


Geology map of the Nelson-Salmo area, southeast British Columbia (082F/SW) shows location of Silver King magmatic belt and select deposits (after Höy and Dunne, 1997, 2001).

The Kena property is underlain by mafic, shosonitic volcanic and sedimentary rocks of the Rossland Group, an Early Jurassic volcanic arc succession that developed along the eastern margin of Quesnellia. The stratigraphy and tectonic setting of the Rossland Group have been well documented by Höy and Dunne (1997), who describe a tripartite subdivision (after Frebold and Little, 1962) including the Archibald, Elise and Hall formations, for the Nelson area.
The Early Jurassic, Sinemurian Rossland Group, in the Nelson area is intruded by comagmatic (Eagle Creek plutonic complex, Shaft monzogabbro complex), synkinematic (Silver King intrusions) and post-tectonic plutons (Nelson suite, Bayonne suite and Coryell syenites) as well as numerous mafic and felsic dikes (Little, 1960; Höy and Dunne, 1997, 2001).
It is the mafic volcanic and synvolcanic intrusive rocks of the Elise Formation and younger synkinematic intrusions, which host mineralization on the Kena property.

SILVER KING INTRUSIVE SUITE

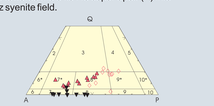
Analyses of the Silver King intrusive suite fall in the subalkaline field on the total alkali-silica plot in contrast to the alkaline nature of the subvolcanic, monzogabbro intrusive suite; a reflection of their comagmatic relationship with the shoshonitic Elise volcanic suite (Höy and Andrew, 1997). Samples from the Silver King pluton also show elevated potassium content relative to other feldspar porphyry bodies analyzed from the Silver King magmatic belt. Some of the potassium and sodium enrichment can be related to hydrothermal alteration processes, but the majority of samples from the Silver King pluton have consistently elevated potassium content (relative to other Silver King intrusives) that cannot be entirely related to secondary alteration. Separation of the intrusive suites and the isolation of the Silver King pluton data from the other feldspar porphyry bodies in the belt are shown clearly on a Na_2O-K_2O vs. SiO_2 plot.



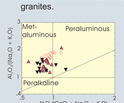
PETROLOGY/GEOCHEMISTRY

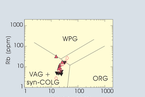
The Silver King intrusive data define three distinct clusters on the QAP diagram:

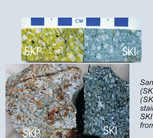
- peripheral dikes (Cu Zone) and separate feldspar porphyry plutons (Cariboo, Three Friends, Salmo River) - cluster at the borders of granodiorite-monzogranite-quartz monzonite and monzodiorite.
- least altered samples from the Silver King pluton but distal from the GMZ - plot as quartz monzonite
- drill core samples of potassium and sodium enriched (altered) rocks from the GMZ - are displaced towards the alkali feldspar apex (P) into the quartz syenite field.



All three intrusions are metaluminous and show Nb and Y trace element abundances of volcanic arc and syn-collisional granites.







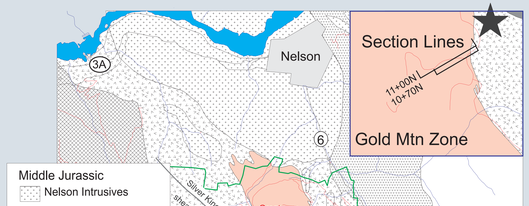
Samples of Silver King pluton (SKP) and Silver King intrusives (SKI). Thin section off-cuts stained for potassium feldspar. SKI from Hall Creek area, SKP from discovery trench zone.

MINERAL DEPOSITS

Surface exposure of metavolcanic-hosted quartz-pyrite-chalcopyrite±gold vein at the Starlight showing.

The Kena property hosts a number of gold and gold-copper occurrences covering a large area located south of the town of Nelson. Mineralization occurs within the early Jurassic, Elise Formation metavolcanic rocks (Silver King, Starlight, Cariboo) and subvolcanic intrusive rocks (Shaft/Cat, Kena); early Middle Jurassic, Silver King intrusive rocks (Gold Mountain zone, Great Western), and is locally concentrated along the north-northwesterly trending contact zone between these units (Gold Mountain zone).

Silver King porphyry cut by sheeted-quartz-pyrite-chlorite veinlets. Veins strike parallel to regional S, but with shallower dips. Grab sample of veinlet material returned 31 ppb Au.



Geology map of the northern part of the Kena property, showing location of mineral deposits. Inset shows location of section lines (modified from Höy and Dunne, 1998).

GOLD MOUNTAIN ZONE

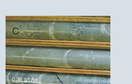
ALTERATION

Hydrothermal alteration mineral assemblages present in drill core in and around the Gold Mountain zone are similar to the principal alteration types developed around gold-rich porphyry deposits of the Pacific rim. These alteration types include: **potassium-silicate** (K-spar, quartz), **propylitic** (chlorite, epidote, calcite, albite), **intermediate argillic?** (sericite, clay, chlorite, hematite) and **sericite** (quartz-sericite-pyrite). A study of rocks in the vicinity of the Kena Gold Mountain Zone identified six (6) alteration mineral assemblages (Dunne, 2001).

POTASSIC

MAGNETITE

PROPYLITIC



SERICITIC

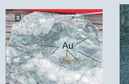
ALTERATION AND MINERAL ASSEMBLAGES, GOLD MOUNTAIN ZONE AND SURROUNDING AREA

Potassic	
tourmaline stockwork	tourmaline+quartz+Kspar+pyrite
magnetite dominant	magnetite+K-spar+biotite±chlorite±epidote±hematite ± tourmaline±pyrrhotite
magnetite + pyrite	magnetite+pyrite+K-spar+biotite±chlorite±epidote ±carbonates sericite±quartz
Propylitic	
magnetite + quartz dominant	magnetite+quartz+chlorite+sericite±epidote±pyrite±carbonate
Sericitic	
pyrite dominant	pyrite+sericite+Kspar+chlorite±quartz±carbonates tourmaline
quartz stockwork	quartz+pyrite+sericite+Kspar+chlorite±hematite±molbdnite ± chalcopyrites tourmaline±gypsum (after anhydrite)

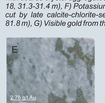
(Dunne, 2001).

MINERALIZATION

Pyrite, pyrite+magnetite or magnetite is present in varying amounts in the Silver King pluton (Dunne, 2001). **Pyrite** occurs as disseminated blebs, crystal aggregates associated with epidote-calcite±chlorite assemblages or as fracture-fillings in quartz-calcite-sericite±tourmaline±chlorite veinlets.
Magnetite occurs as disseminations and replacement zones comprised of patchy intergrowths with biotite and chlorite in the matrix of the porphyry, as veinlets crosscutting plagioclase phenocrysts and as matrix to magnetite breccias.
Minor to trace amounts of **chalcopyrite** are present as fracture-fillings, inclusions and intergrowths with pyrite. A light grey mineral, probably **sphalerite** or tetrahedrite (trace amounts) is associated with, and fills fractures in pyrite from drill hole 01GM-7. Trace amounts of **molybdenum** are also present in quartz-sericite veinlets.
Mineralization at the GMZ consists primarily of disseminated blebs of pyrite±chalcopyrite and rare pyrrhotite (Rhys, 2000; Dunne, 2001) and lesser stringers and fracture veinlets. Gold values of 1 to 3 g/t Au correspond directly with intervals of pervasive potassium alteration and pyritization, which coincide with higher fracture and veinlet densities.



Drill core from the Kena Property with gold assay values from respective 2 metre sampling interval. D) Visible gold from GMZ (01GM-03, 48.77 m). E) Silica-sericite altered foliated SK porphyry with coarse crystal aggregates of pyrite, up to 3 cm across (01GM-18, 31.3-31.4 m), F) Potassium altered SK porphyry, pyritized and cut by late calcite-chlorite-sericite stockwork, (01GM-17, 81.7-81.8 m), G) Visible gold from the Starlight showing (02SL-03).

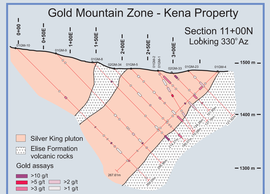


GOLD DISTRIBUTION

Definition drilling of the Gold Mountain Zone shows wide zones of alteration and gold mineralization within the pluton and locally, extending beyond the contact zone into the metavolcanic country rocks. Section 11+00N and Section 10+70N reproduced and modified from Dandy (2002), show the geology and gold assays from 2000 and 2001 diamond drilling at the GMZ.
Drill core was sampled on 2 metre intervals and analyzed for gold and other metals. From this raw assay data, continuous intervals of greater than 1 g/t Au were isolated, the assay values combined and an average grade determined. This average grade was then applied to the entire intersection, grouped into populations of greater than 1, >2, >3, >5 or >10 g/t Au and plotted onto the section lines.
On section L11+00N, higher-grade and wider intersections of gold mineralization occur in a zone below the "discovery" trenches (3+00E), giving continuity to, and expanding the area of anomalous gold values outlined by surface chip sampling. A second zone of higher-grade intersections straddles and follows the porphyry/metavolcanic contact zone. Some of the highest gold assays have come from intervals of porphyry and metavolcanic rocks located within 20 m above and below this contact zone.

Centimetre wide zones of S, parallel pyrite flooding in potassic altered porphyry, 01GM-3.

Gold occurs primarily as free grains but in a variety of relationships and mineral associations. Grain size varies from very fine less than 2um, "snow-flake" gold (Wells, 2001) to millimetre-sized blebs of visible gold (D). Gold always occupies late fractures. It occurs as fine, sub-rounded inclusions in veinlet-pyrite, as fracture-fillings to brecciated veinlet pyrite and as colloidal grains in quartz and a late calcite (?) gangue. Gold also occurs together with pyrite and magnetite in a veinlet (01GM-4, 84.3m) that crosscuts pervasive potassium alteration.



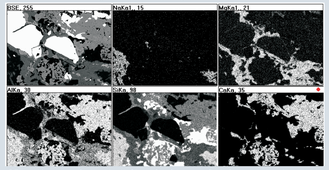
Section Line 11+00N and Line10+70N showing geology (from Dandy, 2002) and calculated average gold grades of the Gold Mountain Zone.

OPTICAL AND ELECTRON MICROSCOPY

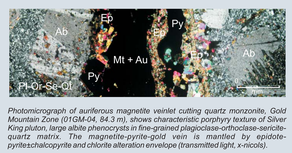
EARLY?

EPIDOTE-PYRITE-MAGNETITE-GOLD

Optical photomicrographs showing. A: fine-grained gold particles encapsulated in pyrite, chlorite and quartz gangue, B: fine-grained gold particles in magnetite and epidote and C: disseminated in matrix of magnetite and chlorite; sample 01GM4-84.3m.



BEI and X-ray maps for Na, Mg, Al, Si and Ca of the same field of shown in A, to illustrate the distribution and relationships of the different alteration/gangue minerals (albite, chlorite, aluminosilicate, quartz, and epidote); Sample 01GM4-84.3m.

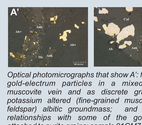


Photomicrograph of auriferous magnetite veinlet cutting quartz monzonite, Gold Mountain Zone (01GM-04, 84.3 m), shows characteristic porphyry texture of Silver King pluton, large albite phenocrysts in fine-grained plagioclase-orthoclase-sericite-quartz matrix. The magnetite-pyrite-gold vein is mantled by epidote-pyrite±chalcopyrite and chlorite alteration envelope (transmitted light, x-nicols).

Energy dispersion X-ray spectrum of gold (with low Ag content) particle enclosed in chlorite; sample 01GM4-84.3m.

LATE?

ANKERITE-MUSCOVITE-CALCITE-ELECTRUM

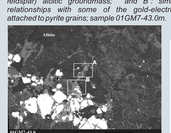


Optical photomicrographs that show A': fine-grained gold-electrum particles in a mixed ankerite-muscovite vein and as discrete grains within potassium altered (fine-grained muscovite+alkali feldspar) albitic groundmass; and B': similar relationships with some of the gold-electrum attached to pyrite grains; sample 01GM7-43.0m.

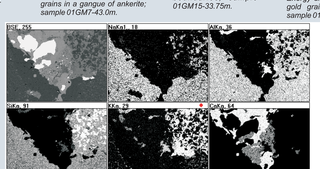
Optical photomicrograph that shows pyrite with minor amounts of chalcopyrite and small euhedral arsenopyrite grains in a gangue of ankerite; sample 01GM7-43.0m.

BEI that shows micro-inclusions of hessite (Ag telluride) at pyrite grain boundaries; sample 01GM15-33.75m.

Energy dispersion X-ray spectrum of a silver-rich gold grain (electrum) encapsulated in calcite; sample 01GM7-43.0m.



BEI that shows part of the pyrite-rich vein, with pyrite grains (including fine-grained gold/electrum, white) associated with carbonates (mainly calcite and ankerite) that cuts potassium flooded (albite+K-spar+muscovite matrix) albite porphyritic monzonite; sample 01GM7-43.0m (area A corresponds to A' although at a different orientation , whereas area B, corresponds to B' also at a different orientation).



*BEI and X-ray maps for Na, Al, Si, K and Ca of the same field of shown in **B'**, to illustrate the distribution and relationships of the different alteration/gangue minerals (albite, muscovite, alkali feldspar, quartz, calcite and ankerite); Sample 01GM15-33.75m.*

Optical photomicrograph that shows tetrahedrite, chalcopyrite and sphalerite together with pyrite; sample 01GM7-43.0m.

Controls on Mineralization

ALTERATION

Gold and trace metal abundances were determined by neutron activation analyses for a limited suite (12) of Silver King intrusives. All six samples of quartz monzodiorite collected from separate plutons across the Silver King magmatic belt contain less than 2 ppb Au, while most samples of Silver King pluton contain elevated gold values and show variable alteration. Two least altered samples of Silver King pluton, however contain less than 2 ppb Au, indicative that mineralization and alteration are closely associated and related to discrete hydrothermal centres.

Samples from the Gold Mountain Zone showing the degree of potassic alteration in the pluton (A), immediate footwall volcanic rocks (B) and beyond the pervasive alteration (C). Section through the northeast contact in vicinity of discovery trenchs.

STRUCTURE

Pale-weathering Silver King porphyry cut by quartz stockwork, quartz-tourmaline-pyrite, pyrite+chalcopyrite and magnetite veinlets. Orientation of veins include 125/43', 65/72' and 100/86'. Grab sample of veinlet material returned 250 ppb Au.

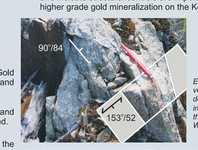
Gold±copper mineralization within Elise Formation metavolcanic and subvolcanic intrusive rocks occupies structures that generally parallel the dominant northwest-trending foliation, but may have steeper dips (Silver King, Starlight, Cariboo). These occurrences fall into the synkinematic shear-related or conformable gold category of (Höy and Dunne, 1989).
Highly discordant to the regional foliation shears are **east-trending quartz-pyrite±sericite veins**, that are well developed at the Kena Gold zone in altered metavolcanic rocks and within the Silver King pluton at the Gold Mountain and Great Western zones. The easterly-trending quartz-pyrite veins at the Kena Gold consistently carry >2 g/t Au (Rhys, 2000). Mineralization hosted within the Silver King pluton occupies fractures and veinlets, which also show a preferred easterly trend and steep south dip (Gold Mountain Zone, Rhys, 2001 and Great Western area, this study) and indicate structural controls are important hosts for some of the higher grade gold mineralization on the Kena property.

Age of Mineralization

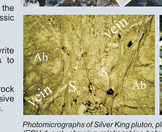
Mineralization at the Kena, Shaft/Cat, Great Western and Gold Mountain zones is affected by the main deformational event and development of S, (regional foliation).

- Veinlets cutting the volcanic rocks are frequently folded and transposed; veins within the Silver King pluton are less affected.
- Hydrothermal biotite associated with mineralization at the Shaft/Cat is aligned parallel to S, suggesting that potassic alteration was synkinematic (Andrew and Höy, 1989).
- Rhys (2000) has recognized isolated pyrite-chalcopyrite stringers at the Gold Mountain Zone that he interprets to represent late remobilization of disseminated sulphides.

The dominant northwest-trending foliation and deformation of rock units as young as 174-179 Ma are truncated by Nelson suite intrusive rocks that constrain the main deformation event to pre 170-166 Ma.



East-trending sheeted quartz veinlets (parallel magnet) cut dominant foliation S_1 (153/52°) in Silver King pluton, east of the "A Vein" portal, Great Western showings.



Photomicrographs of Silver King pluton, plane light (FOV 2 cm) and crossed nicols (FOV 1 cm), showing relationships between regional foliation (S_1) and quartz-pyrite veinlets.

SUMMARY

Results from the 2002 Kena project support an intrusion-related Au-Cu porphyry system, related to the Silver King pluton as causative to the alteration and gold mineralization at the Gold Mountain zone. Some of the peripheral showings (i.e. Kena, Shaft/Cat) may also be related to this same system. The age and style of mineralization is similar to other syn-collisional Cu-Au porphyry deposits of the BC Cordillera (*i.e.* Mt Milligan and Katie).

Gold mineralization at the GMZ occurs in areas of pervasive pyritized Silver King pluton and within 20 m of the contact with volcanic rocks. It consists primarily of disseminated blebs of pyrite±chalcopyrite and lesser stringers and veinlets.

There is evidence for two distinct styles of gold mineralization: silver-poor gold (3-4 wt% Ag) associated with magnetite-epidote-chlorite (+pyrite and chalcopyrite) assemblage and silver-rich gold (16-27 wt % Ag) associated with a carbonate dominated assemblage that includes pyrite, sphalerite, galena and tetrahedrite. Temporal relations are uncertain but a transition from higher to lower temperatures is suggested by the assemblages (Ag-poor to Ag-rich + base metals respectively).

Syn to post tectonic veinlets follow a preferred easterly trend, and similar oriented structures at the Kena, Great Western and Silver King mine have localized consistently higher-grades of mineralization. Identification of these potential higher-grade targets and/or structural corridors has important economic significance for the larger lower-grade zones.

ACKNOWLEDGMENTS

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