PLUTONIC-RELATED AU QUARTZ VEINS & VEINLETS L02

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Refer to preface for general references and formatting significance.

May 30, 2005

IDENTIFICATION

SYNONYMS: Intrusion-related gold systems, gold porphyries, plutonic-related gold quartz veins. Plutonic-related gold, Au-lithophile element deposits, Fort Knox-type Au, high arsenic and/or bismuth plutonic-related mesothermal gold deposits, intrusion-hosted gold vein and brittle shear zone deposits.

COMMODITIES (BYPRODUCTS): Au (Ag, W).

EXAMPLES: **(Yukon): Dublin Gulch (106D 025), Clear Creek (115P 014), Scheelite Dome (115P 003), Brewery Creek (116B 160);**
(British Columbia - *Canada/International*): Cam Gloria? (082M266), Ridge Zone, Rozan Property (082FSW179); *Fort Knox, Cleary Hill (Alaska, USA), Mokrsko (Czech Republic), Timbarra (New South Wales, Australia).*

GEOLOGICAL CHARACTERISTICS

CAPSULE DESCRIPTION: Gold mineralization hosted by millimetre to metre-wide quartz veins hosted by equigranular to porphyritic granitic intrusions and adjacent hornfelsed country rock. The veins form parallel arrays (sheeted) and less typically, weakly developed stockworks; the density of the veins and veinlets is a critical element for defining ore. Native gold occurs associated with minor pyrite, arsenopyrite, pyrrhotite, scheelite and bismuth and telluride minerals.

TECTONIC SETTINGS: Most commonly found in continental margin sedimentary assemblages where intruded by plutons behind continental margin arcs. Typically developed late in orogeny or post-collisional settings.

DEPOSITIONAL ENVIRONMENT / GEOLOGICAL SETTING: Veins form in tensional fractures and shears within, and near, the apices of small (<3 km^2) granitoid intrusions at depths of 3-8 kilometres.

AGE OF MINERALIZATION: Any age, although they are best known (preserved?) in Paleozoic to Mesozoic rocks. Cenozoic deposits generally not yet exposed by erosion. Deposits in Alaska and the Yukon are Cretaceous age. Central Asian and European deposits are Carboniferous.

HOST/ASSOCIATED ROCK TYPES: The host rocks are granitic intrusions and variably metamorphosed sedimentary rocks. Associated volcanic rocks are rare. The granitoid rocks are lithologically variable, but typically granodiorite, quartz monzonite to granite. Most intrusions have some degree of lithological variation that appear as multiple phases that can include monzonite, monzogranite, albite granites, alkali syenite and syenite. The more differentiated phases commonly contain feldspar and quartz and less than

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5% mafic minerals. Some deposits have abundant associated dykes, including lamprophyres, pegmatites, aplites and phases that have been fractionated from the main intrusion. Medium-to coarse-grained intrusions are commonly equigranular, but can contain megacrysts of potassium feldspar or porphyritic phenocrysts of quartz, , plagioclase, or biotite. Biotite is common, hornblende is only locally observed, pyroxene is rare, and muscovite and tourmaline is common in more highly fractionated phases, aplites or pegmatites. The intrusions have a reduced primary oxidation state. Evidence of fluid saturation, such as miarolitic cavities, locally up to several centimetres, can be common; some intrusions exhibit much larger ones. Many of the granitoid intrusions have contact metamorphic aureoles that extend up to several km from the intrusion and can be much larger than the surface exposure of the intrusion. The stocks generally intrude variably metamorphosed sedimentary rocks (sandstone, shale, carbonate), however, some cut sequences which include metavolcanic rocks. In some cases the deposits are hosted by relatively high-grade metamorphic rocks including orthogneiss that may reflect the emplacement of the intrusions and veins at greater depths.

DEPOSIT FORM: Mineralization can be divided into intrusion-related, epizonal and shear-veins. Intrusion-related mineralization typically occurs widespread sheeted vein arrays. The arrays typically consist of numerous sheeted, or less commonly stockwork, veinlets and veins that form zones that are 10's of metres wide, and continuous for several 10's of metres. The veins are commonly hairline to centimetres wide, while some veins may be up to tens of metres thick. Epizonal mineralization is typically less focused, and may be disseminated, or occur as replacements. The thicker shear-veins veins are typically in fault zones outside of the pluton. The sheeted and stockwork zones extend up to a kilometre in the greatest dimension, while individual veins can be traced for more than a kilometre in exceptional cases.

TEXTURE/STRUCTURE: The sheeted veins are planar and often parallel to regional structures. The veins are generally extensional with no offset of walls, although some vein systems may also include shear-hosted veins. The veins may have minor vugs and drusy quartz. While most veins and structures are steeply dipping, shallowly dipping pegmatite and quartz bodies occur in some deposits, particularly those in the plutonic apices.

ORE MINERALOGY [Principal and *subordinate*]: Sulphide minerals are generally less than 3% and can be less than 1%. A number of deposits/intrusions have late and/or peripheral arsenopyrite, stibnite or galena veins. Native gold, sometimes visible, occurs with associated minor pyrite, arsenopyrite, loellingite, pyrrhotite, variable amounts of scheelite or more rarely wolframite, and sometimes *molybdenite, bismuthinite, native bismuth, maldonite, tellurobismuthinite, bismite, telleurides, tetradymite, galena and chalcopyrite*. Epizonal veins are arsenopyrite-pyrite rich and lack associated Bi, Te and W minerals. The thicker, solitary veins typically contain higher percentages (<20%) of sulphide minerals. Generally, sulphide mineral content is higher in veins hosted in the country-rocks.

GANGUE MINERALOGY [Principal and *subordinate*]: Quartz is the dominant gangue mineral with associated minor *sericite, alkali feldspar, biotite, calcite and tourmaline*. In some deposits the quartz veins grade into pegmatite dykes along strike - a relationship that has been referred to as vein-dykes or pegmatite veins. The pegmatites in some deposits can carry significant amounts of gold or scheelite, although they do not usually constitute ore. Many "veins" may lack gangue and are simply sulphide mineral coatings on fracture surfaces.

ALTERATION MINERALOGY: These deposits are characterized by relatively restricted alteration zones which are most obvious as narrow alteration selvages along the veins. The alteration generally consists of the same non-sulphide minerals as occur in the veins, typically albite, potassium feldspar, biotite, sericite, carbonate (dolomite) and minor pyrite. Pervasive alteration, dominated by sericite, only occurs in association with the best ore zones. The wall rocks surrounding the granitoid intrusions are typically hornfelsed and if carbonaceous, contain disseminated pyrrhotite. Alteration appears to be more extensive with shallow depths of emplacement or greater distances from the intrusion. Epizonal deposits may have clay alteration minerals.

WEATHERING: The quartz veins resist weathering and can form linear knobs. Since alteration zones are frequently weak and the veins often contain only minor sulphide minerals, associated gossans or colour anomalies are rare. However, oxidized sulphide-rich epizonal mineralization may yield gossans.

GENETIC MODELS: The veins are genetically related to proximal granitoid intrusions, which explains their association with tungsten, bismuth and other lithophile elements, and the transitional relationships with pegmatites seen in some deposits. Mineralization likely formed from late stage fluids that accumulated in late-stage melts of differentiating granitic intrusions at depths of 2 to 8 km below the surface. These fluids typically contain elevated PCO_2 and have lower salinities which enable them to transport gold and/or tungsten and only limited amounts of base metals. At some point following sufficient differentiation to concentrate anomalous concentrations of elements, such as Au and W, the fluids are released along fractures that developed in response to regional stresses and faults that accommodated pluton emplacement. Locally fluids infiltrate permeable or reactive rock units to form replacement mineralization or skarns. Stockwork mineralization is not common, but may have higher grades due to increased vein density. The deeper vein systems had little or no meteoric water input. In most deposits there are several other styles of mineralization, such as skarns and distal sulphide-rich veins that can be related to the same granitic intrusions but have different metallogenic signatures as they formed from rapidly evolving fluids. These characteristics are typical of an intrusion-centred mineralizing system, but are not characteristic of the shear-veins that do not show any metallogenic zonation or associated deposit types. The epizonal deposits may have evidence vectoring towards a higher-temperature zone, but typically form outside of the steep thermal gradients that are proximal to a cooling pluton.

ORE CONTROLS: The mineralization is strongly structurally controlled and spatially related to highly differentiated granitoid intrusion. Mineralization is commonly hosted by, or close to, the most evolved phase of the intrusion (differentiation index greater than 80).

ASSOCIATED DEPOSIT TYPES: W and Au skarns (K05, K04), W veins (I12), stibnite-gold veins (I09), Au-quartz veins (I01), disseminated gold sediment-hosted deposits (E03) and possibly polymetallic veins (I05). The veins commonly erode to produce nearby placer deposits (C01, C02).

COMMENTS: Differentiated reduced granites also host Sn greisens, but these may indicate too much fractionation to be a good gold mineralizer. Porphyry deposits, which may have associated tungsten mineralization and stibnite-base metal-gold veins are typically associated with oxidized magmas. Epizonal deposits, such as the Donlin Creek and Brewery Creek deposits have characteristics that include high sulphidation epithermal deposits. These granites are emplaced at relatively shallow depths (less than 2 kilometres) and can occur in the same regions as W-Au veins.

EXPLORATION GUIDES

GEOCHEMICAL SIGNATURE: Placer gold in creeks draining plutons or hornfels is the best geochemical indicator. Analysis of heavy mineral or silt samples for W, Au, As and Bi is particularly effective. Elevated values of Au-W-Bi-As ± (Sn-Sb-Ag-Mo-Cu-Pb-Te-Zn) can be found in stream sediments, soils and rocks. Distal Sb and proximal Bi is a common association in the Yukon deposits.

GEOPHYSICAL SIGNATURE: Aeromagnetic data may be entirely flat as reduced granites have no magnetic signature. If the country rocks are reducing (e.g. carbonaceous), aeromagnetic signatures may produce “donut” anomalies with high magnetic values associated with pyrrhotite in the contact metamorphic zone fringing a non- magnetic intrusion.

OTHER EXPLORATION GUIDES: The number of deposits correlates inversely with the surface exposure of the related granitoid intrusion because stocks and batholiths with considerable erosion are generally less prospective. Evidence of highly differentiated granites and fluid-phase separation, such as pegmatites, aplites, unidirectional solidification textures (USTs) and leucocratic phases, indicates prospective settings. Lamprophyres indicate regions of high extension and potentially good structural sites for mineralization.

Gold, wolframite, and scheelite in stream gravels and placer deposits are excellent guides. The associated deposit types (e.g. skarns) can also assist in identifying prospective areas.

ECONOMIC FACTORS

TYPICAL GRADE AND TONNAGE: The bulk mineable, intrusion-hosted low grade sheeted vein deposits contain tens to hundreds of million tonnes of ~ 0.8 to 1.4 g/t Au. The epizonal deposits have slightly higher grades, 2-5 g/t Au and the shear veins have form high grade deposits contain hundreds of thousands to millions of tonnes grading ~10 to 35 g/t Au. Gold to silver ratios are typically less than 1. Some gold-producing veins have produced W when it was deemed a strategic metal or it reached unusually high commodity prices.

Intrusion-related
Fort Knox, Alaska - 143.5 M tonnes grading 0.82 g/t Au (cutoff of 0.39 g/t)
Dublin Gulch (Eagle Zone), Yukon - 100 Mt grading 1.2 g/t Au
Epizonal
Brewery Creek, Yukon - 13 Mt of 1.44 g/t Au
Donlin Creek, Alaska
Shear-veins
Pogo, Alaska - 9.05 Mt grading 17.83 g/t Au (cutoff of 3.43 g/t)
Ryan Lode, Alaska
Cleery Hill - ~1.36 Mt grading better than 34 g/t Au

ECONOMIC LIMITATIONS: The Fort Knox deposit has a low strip ratio and the ore is oxidized to the depths of drilling (greater than 300 m). A carbon-in-leach gold absorption with conventional carbon stripping process is used to recover the gold. The refractory nature of the arsenic-rich mineralization below the oxidation zone could render an otherwise attractive deposit sub-economic. Intrusion-hosted deposits may have a high work index.

IMPORTANCE: These deposits represent a potentially important gold resource which is found in regions that have seen limited gold exploration in recent years. A number of deposits are now known that contain more than a 100 tonnes of gold. In virtually all regions the production of gold from placers related to these deposits has far exceeded the lode gold production.

ACKNOWLEDGEMENTS: This deposit profile draws heavily from presentations and related articles by Jim Lang, John Thompson, Jim Mortensen and Tim Baker summarizing research completed by the Mineral Deposits Research Unit of the University of British Columbia, Dan McCoy of Placer Dome and Moira Smith of Teck Exploration. Mike Cathro kindly reviewed the profile and provided constructive comments.

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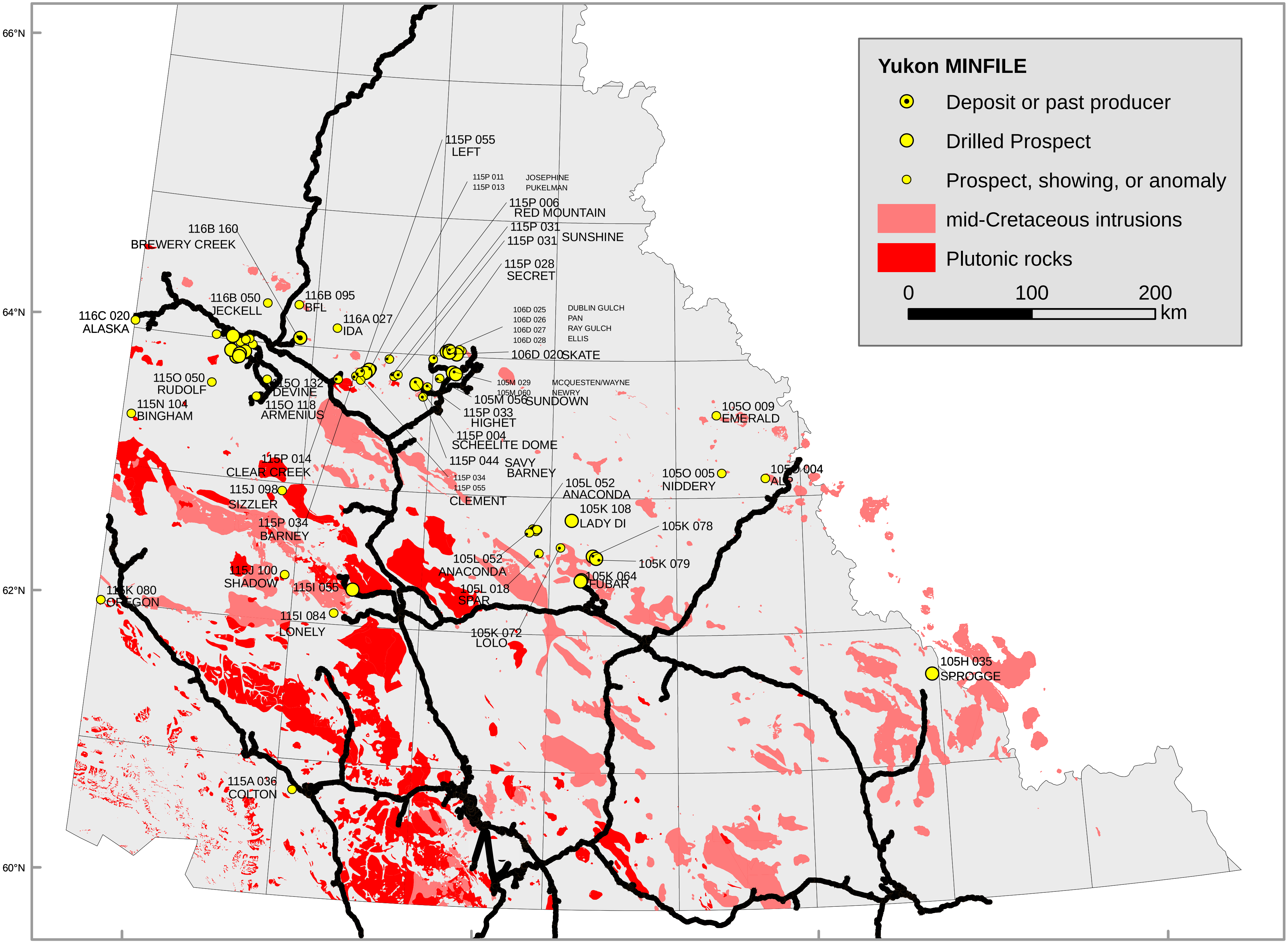
L02 - Plutonic-related Au quartz veins and veinlets - Yukon and Alaska deposits

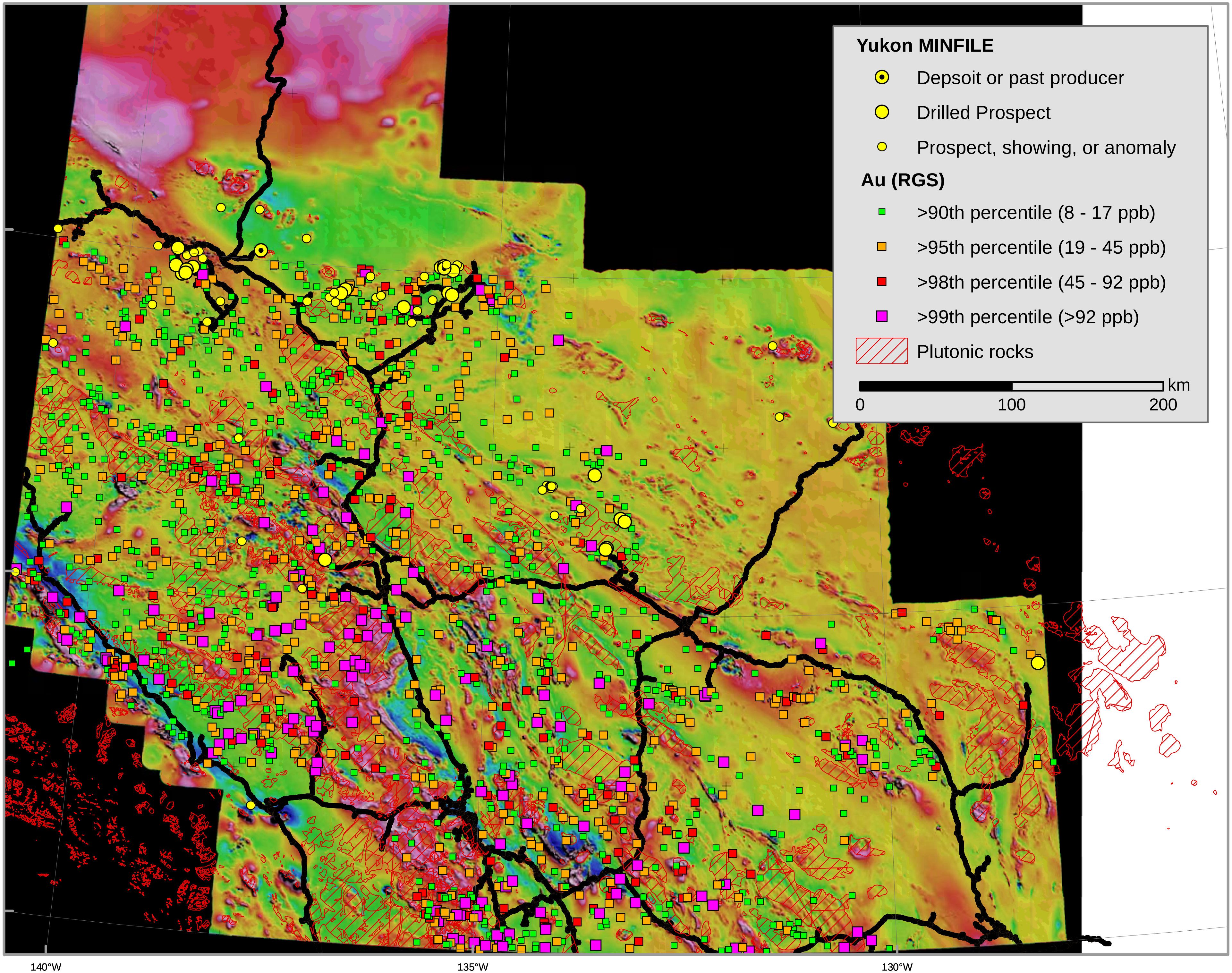
Deposit	country	tonnes	Au (g/t)	cutoff (g/t)
Ryan Lode	USAK	4 390 300	3	
Pogo	USAK	9 050 000	17.8	
Gil	USAK	9 700 000	1.37	
Brewery Creek	CNYT	13 300 000	1.44	
True North	USAK	16 500 000	2.46	
Shotgun	USAK	55 000 000	3.05	0.55
Dublin Gulch	CNYT	99 000 000	1.2	
Donlin Creek	USAK	110 700 000	2.91	1.5
Fort Knox	USAK	169 000 000	0.93	

Yukon MINFILE

MINFILE	NAMES	STATUS
115O 072	LONE STAR	UNDERGROUND PAST PRODUCER
105M 029	MCQUESTEN, WAYNE	OPEN PIT PAST PRODUCER
116B 160	BREWERY CREEK	OPEN PIT PAST PRODUCER
106D 025	DUBLIN GULCH	DEPOSIT
105H 035	RAIN	DRILLED PROSPECT
105K 064	JACOLA	DRILLED PROSPECT
105K 078	KEGLOVIC, MARK, DANA, HAL, HALO	DRILLED PROSPECT
105K 079	IVAN, DANA, TER, IRMA, HALL	DRILLED PROSPECT
105K 108	LADY DI	DRILLED PROSPECT
105O 058	LM	DRILLED PROSPECT
106D 020	SKATE, LYNX, LEN, JAY	DRILLED PROSPECT
115O 087	CARMACKS	DRILLED PROSPECT
115O 146	VICTORIA, LONE STAR	DRILLED PROSPECT
115P 006	HOBO, RED MOUNTAIN	DRILLED PROSPECT
115P 013	PUKELMAN	DRILLED PROSPECT
115P 023	LEWIS, SLEET, BEAR PAW	DRILLED PROSPECT
115P 033	HIGHET, SCHEELITE DOME PROJECT	DRILLED PROSPECT
116B 095	TK, SANDOW	DRILLED PROSPECT
116B 126	QUIGLEY, GC	DRILLED PROSPECT
105O 005	NIDDERY	PROSPECT
115P 031	BIX, SUNSHINE, SP, A	PROSPECT
116B 006	UNEXPECTED, SURPRISE CLAIMS	PROSPECT
105M 056	SUNDOWN	SHOWING
106D 018	ERIN	SHOWING
115O 088	TRILBY	SHOWING
115P 011	JOSEPHINE	SHOWING
115P 034	BARNEY	SHOWING
115P 061	BIG	SHOWING
116A 037	HEIDI	SHOWING
095E 052	ELF	ANOMALY
105K 072	PAIGE, ALTA, LOLO	ANOMALY
105L 018	SPAR	ANOMALY
115P 028	SECRET	ANOMALY
115P 055	LEFT, BARNEY	ANOMALY
116B 050	JECKELL, IRON KING	ANOMALY
116B 159	STUTTER, SPEC, JOE, ALPHA	ANOMALY
116C 020	ALASKA	ANOMALY
115K 080	CALIFORNIA, OREGON, LUCKY STRIKE	UNKNOWN
115N 104	BINGHAM	UNKNOWN
115O 050	RUDOLF	UNKNOWN
115P 044	SAVY	UNKNOWN



Mapof Yukon showing plutonic related Au occurrences, distribution of all plutonic rocks, and the distribution of mid-Cretaceous intrusions



Map of Yukon showing plutonic related Au occurrences, Au geochemistry, regional magnetics and the distribution of plutonic rocks