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# THE FORT KNOX PORPHYRY GOLD DEPOSIT, EAST-CENTRAL ALASKA: AN OVERVIEW AND UPDATE

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**Abstract** - The Fort Knox gold mine near Fairbanks, Alaska, began commercial production in 1997. Gold mineralisation is hosted by the Late Cretaceous Fort Knox Pluton, a granitic intrusive suite. Gold occurs within, and along the margins of pegmatite vein swarms and quartz veins and veinlets. Numerous northwest-southeast trending shear zones influence the orientation of the vein swarms and the geometry of ore zones. Weak to moderate development of vein controlled phyllic, potassic, albitic, and argillic alteration styles are present. Gold is closely associated with trace amounts of bismuth and tellurium. The overall sulphide content of the orebody is very low.

## Introduction

The Fort Knox gold deposit is located 22 km northeast of Fairbanks, Alaska (Fig. la and 1b). The topography surrounding the deposit is characterised by unglaciated uplands and valleys ranging in elevation from 250 m to 800 m a.s.l. The property can be reached by paved and improved roads.

Since discovery in 1902, the Fairbanks District has become Alaska's premier gold producer with recorded production estimated to be 275 tonnes, almost entirely accounted for by placer mining. Placer and lode production, and exploration, has taken place in the valleys and hills surrounding the Fort Knox deposit since discovery of the district.

During the 1980's, composite nuggets of bismuthinite and gold were found in the sluicing operations on Monte Cristo Creek, which directly drains the Fort Knox deposit. This encouraged prospectors to explore the hillside, which was entirely covered by shallow soil. Gold values in soil samples, and subsequent bulldozer trenching, successfully delineated the potential size, and demonstrated the intrusive hosted nature of the mineralisation. From 1987 to 1995, a number of companies explored and developed Fort Knox. Bakke (1995) details the discovery and exploration history of the area.

Amax Gold, Inc. began construction and pre-strip mining in 1995, gold production began in November 1996. In July 1998, Kinross Gold, Inc. merged with Amax Gold, Inc., and now own and operate the Fort Knox mine under the name of Fairbanks Gold Mining, Inc., a wholly owned subsidiary.

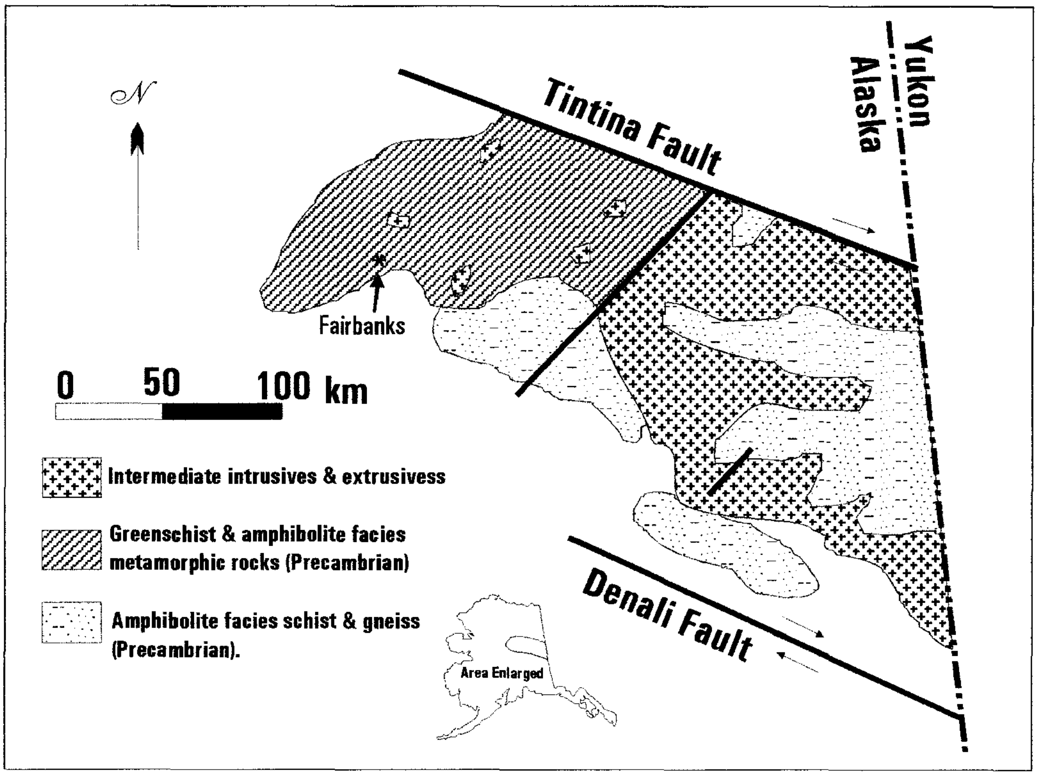


Figure 1a. Generalized regional geologic map of the Yukon-Tanana terrane, eastern interior Alaska. Modified from Foster and others (1973).

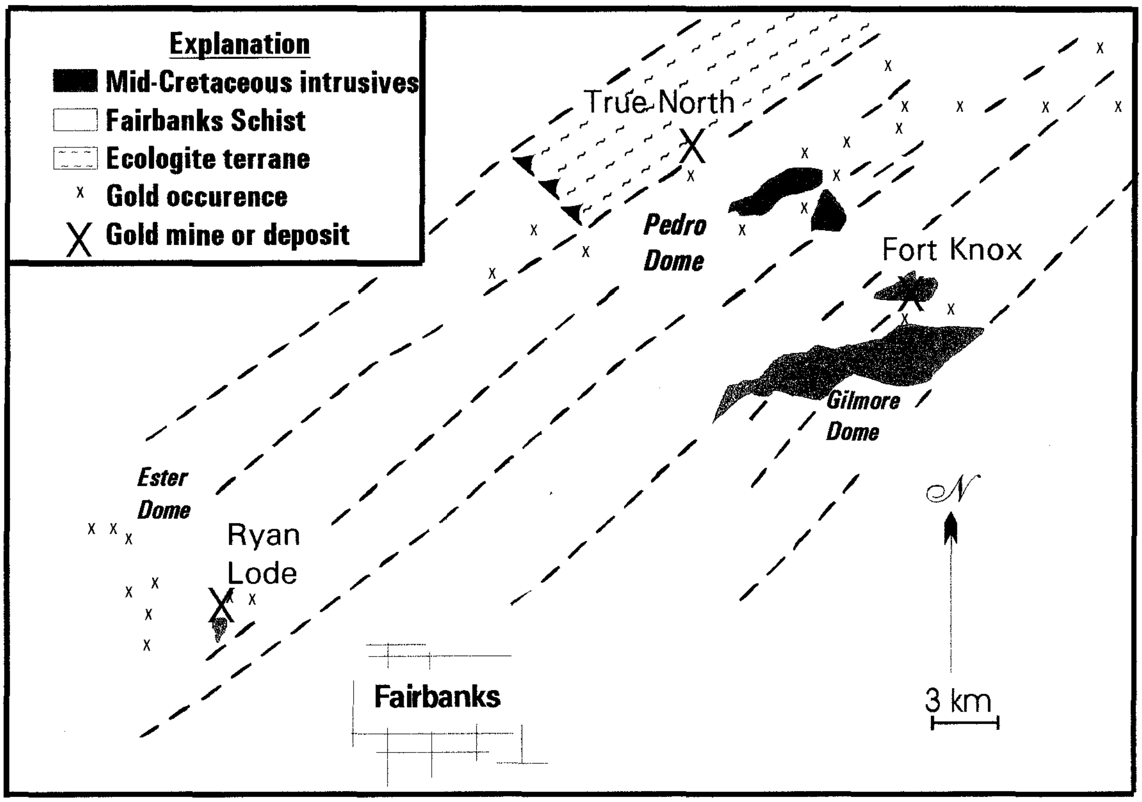


Figure 1b. Generalized geologic map of the Fairbanks District. Modified from McCoy and others (1997).

## Regional Geology

The Fort Knox deposit lies within the northwest part of the Yukon-Tanana terrane (Jones and others, 1982), which consists of Precambrian to mid-Paleozoic polymetamorphic schist of primarily sedimentary origin. The Yukon-Tanana terrane is bounded on the north by the Tintina Fault system and on the south by the Denali Fault system, the major geologic features of the region (Fig. 1a).

The metamorphic rocks have been penetrated by several, primarily felsic, bodies of Mid- to Late-Cretaceous intrusive rocks. Northeast trending faulting, presumably related to the movement on the Tintina and Denali Fault systems, has created different levels of crustal exposure, as evidenced by the areal extent of the intrusive bodies (i.e. large batholitic size bodies near the Yukon border, and small plutons around Fairbanks)(Fig. 1a).

## Fairbanks Mining District Geology

The unit of the Yukon-Tanana terrane, which is host to much of the mineralisation in the Fairbanks mining district, is the Fairbanks schist (Fig. 1b). The dominant lithologies present include amphibolite-greenschist facies, grey to brown, fine-grained micaceous-quartz schist and micaceous quartzite. Interlayered within the Fairbanks schist is the Cleary Sequence, a more varied assemblage of metamorphic lithologies. In the northern part of the district, high-grade metamorphic rocks, including eclogites, are in fault contact with the Fairbanks schist and are host to the True North gold deposit (Fig. 1b) (Robinson and others, 1990).

The Fort Knox, Gilmore Dome, and Pedro Dome plutons are postmetamorphic Late Cretaceous (~90 Ma) granitic complexes that intrude the Fairbanks schist. A granodiorite body has been mapped at the Ryan Lode gold deposit on Ester Dome, in the western end of the district (Fig. 1b).

The dominant structural trend of the district is expressed by numerous northeast trending faults (Fig. 1b). However, east-west to northwest directed faulting and shearing is present and is locally an important structural control to gold mineralisation (McCoy and others, 1997).

A plutonic origin has been ascribed to the gold mineralisation in the Fairbanks District (McCoy and others, 1997). Fort Knox is hosted entirely within granite; whereas, the Ryan Lode, True North, and other gold occurrences are found in favorable metamorphic units or structures near plutonic rocks.

## Deposit Geology

The country rock in the immediate vicinity of the Fort Knox deposit is micaceous quartzite and fine-grained biotite-quartz schist. These units are unmineralised, were mined during pre-stripping, and comprise the highwall.

The Fort Knox deposit is hosted entirely within the Fort Knox Pluton. The pluton is elongate and measures approximately 1100m east-west and 600m north-south. The contact with the

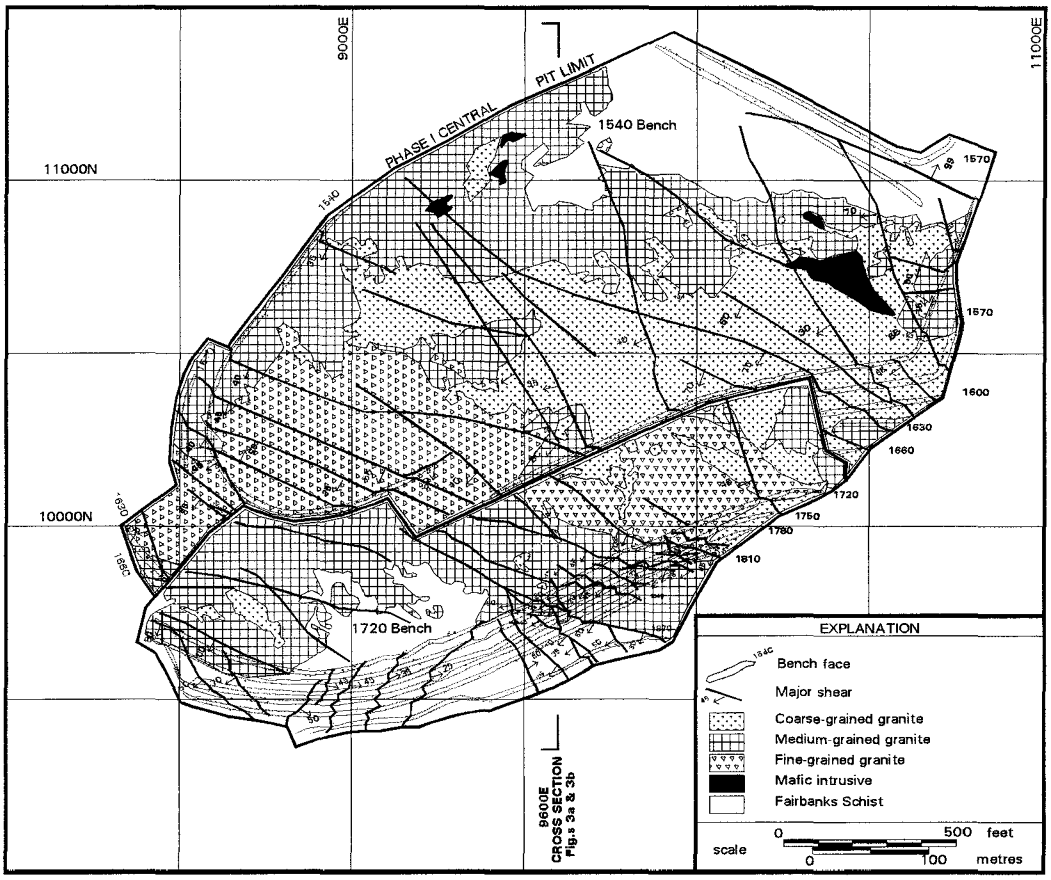


Figure 2a. Composite geologic map of the 1720 and 1540 bench levels.

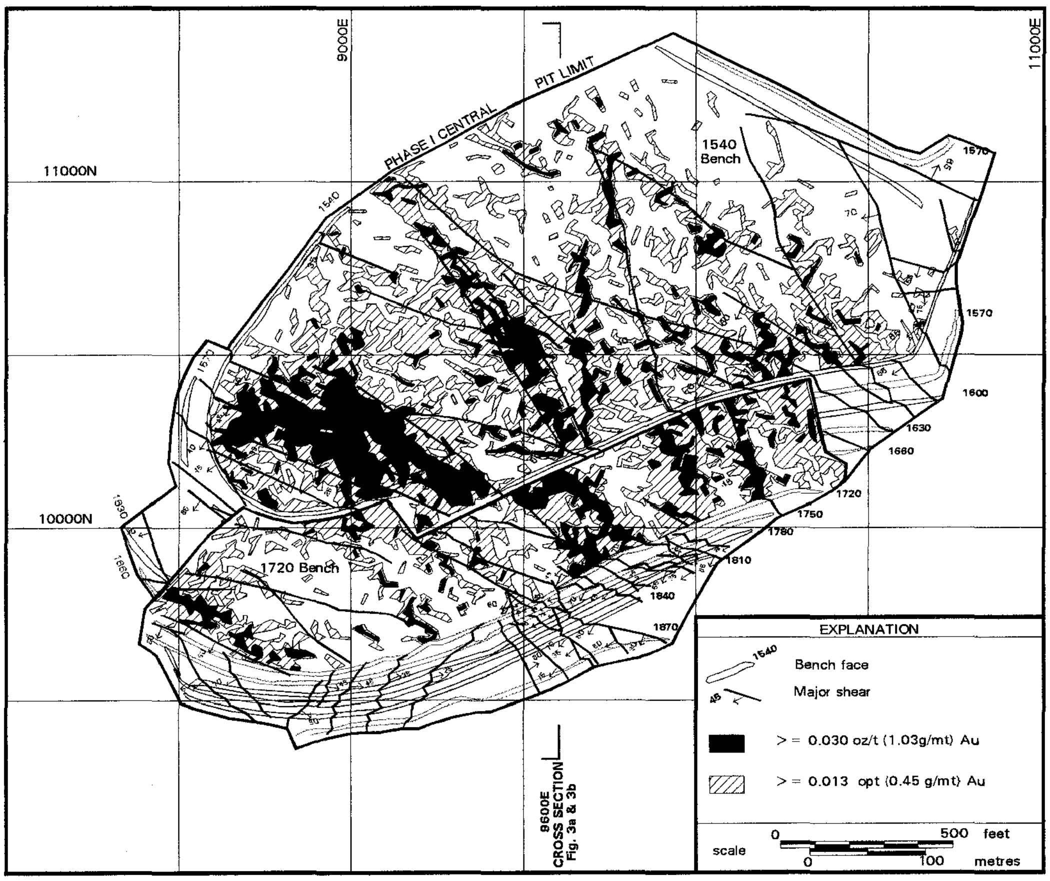


Figure 2b. Contoured gold values from blastholes -- 1720 and 1540 bench levels.

Fairbanks schist is abrupt, and drilling indicates the pluton contacts plunge steeply to the east and moderately to the north, south, and west. The Fort Knox pluton has been subdivided into three mappable phases based on textural differences. A composite geologic map of the central pit is shown in figure 2a and a cross-section showing the distribution of the three phases is shown in figure 3a. Intrusion of the biotite-rich fine-grained granite was followed by the medium-grained porphyritic granite. The youngest intrusive phase is a coarse-grained, seriate porphyritic granite. A volumetrically minor, biotite-hornblende rich phase (mapped as "mafic"), that commonly displays a medium-grained texture is locally present as pendants near the schist-granite contact. Bakke (1995) provides whole-rock, trace element and a classification profile for the three main phases of granite.

### Mineralisation

Gold-bismuth-tellurium mineralisation, is restricted to the Fort Knox pluton and is strongly structurally controlled. Gold occurs within, and along margins of pegmatite veins, quartz veins and veinlets, within shear zones, and along fractures within the granite. The overall sulphide content is very low (< 0.1%) and the orebody is oxidized to the depths of the drilling.

The following is a description of vein types and associated alteration styles found at Fort Knox.

1) Pegmatite veins and veinlets: Range in thickness from micro-scale to 8cm. Composed of clear to grey quartz, large K-spar megacrysts, and micaceous clots. Potassic alteration haloes, rarely exceeding 1cm thick, consist of an assemblage of variable amounts of secondary biotite and K-spar overgrowths on primary K-spar within the granite matrix.

2) Pegmatite veins similar to (1) above with alteration envelopes consisting of a variably developed phyllic (sericite ± pyrite) assemblage.

3) Quartz veins and veinlets (stockwork): Range in thickness from micro-scale to 15cm. These veins possess thin albitic alteration haloes.

4) Quartz veins and veinlets similar to (3) above with phyllic alteration envelopes that range in thickness from 0.5-3cm.

5) Low-temperature fracture coatings and chalcedonic veins and breccia: Low temperature assemblage of zeolite + calcite + clay ± chalcedony. Pervasive throughout the deposit in the form of fracture coatings and breccia zones. Argillic alteration haloes as much as 7m in width are developed adjacent to the larger chalcedonic breccia zones.

Bakke (1995) and McCoy and others (1997) note the strong geochemical correlation of gold with bismuth and tellurium. Bismuth and tellurium mineral species that have been identified include: native bismuth, Bi; maldonite, AuBi; bismuthinite, $Bi_2S_3$; tellurobismutite, $Bi_2Te_3$; bismite, $Bi_2O_3$; tetradymite, $Bi_2Te_2S$; and eulytite, $Bi_4(SiO_4)_3$. Other ore minerals that are found include trace to minor amounts of molybdenite and scheelite.

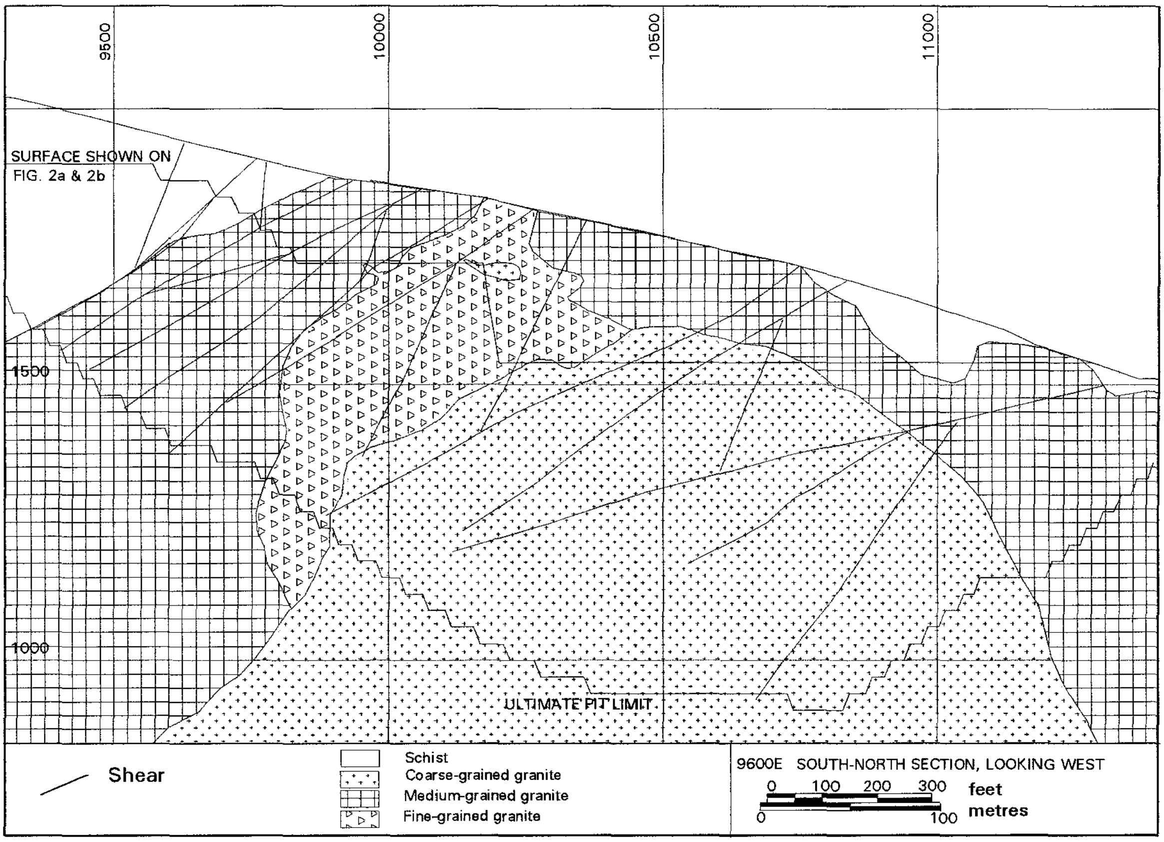


Figure 3a. Geologic cross- section -- 9600E South-North, looking West.

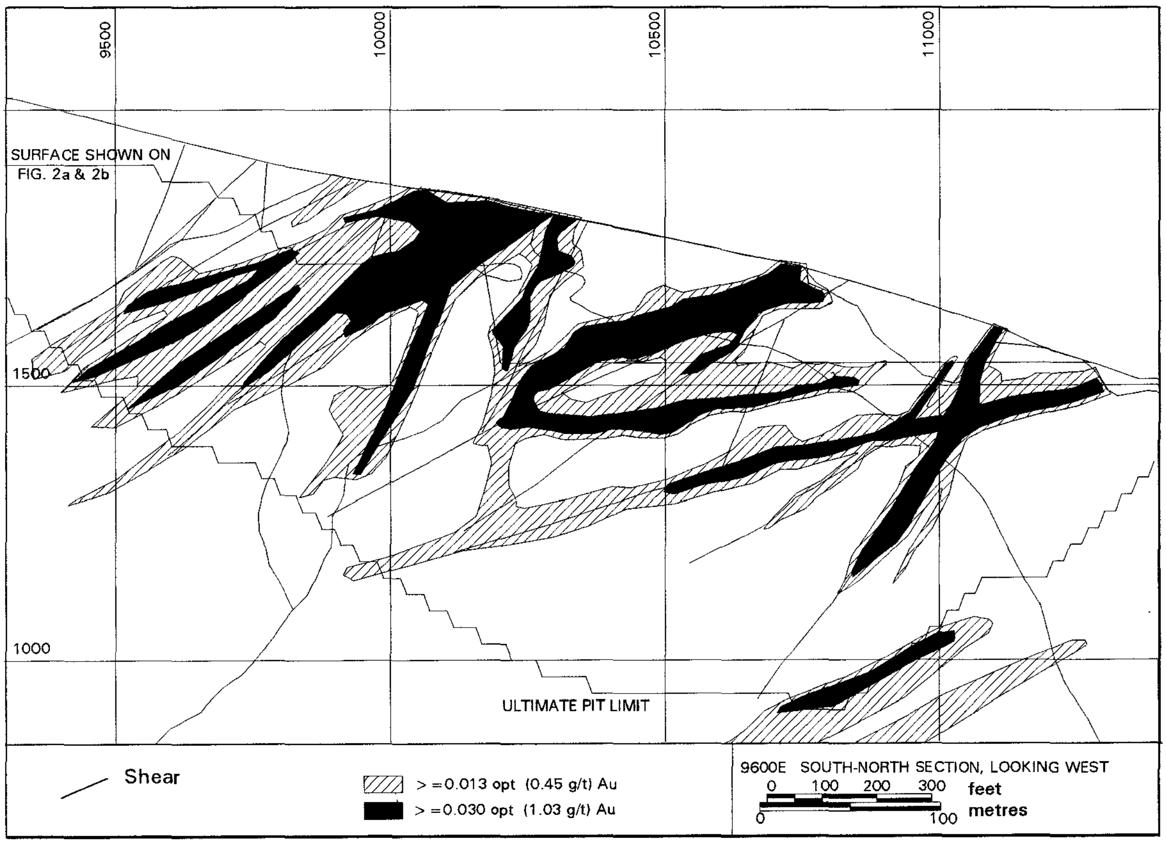


Figure 3b. Contoured gold values from blastholes and 30 foot drillhole composites. 9600E South-North cross-section, looking west.

**Shear Zones**

The major structural trend controlling vein orientation and mineralisation is defined by southeast-northwest trending, moderately to shallowly southwest dipping shear zones (Fig. 4). The shear zones are typically filled with granulated white quartz, and range in thickness from 0.3-1.5m. They possess mixed phyllic and argillic alteration assemblages and contain abundant iron oxide clay gouge along the margins. In the vicinity of the shear zones, vein density increases and vein orientations are predominantly parallel to the shear direction. Contoured gold values shown in figures 2b & 3b strongly demonstrate the importance of the major shear zone trend to mineralisation. Abundant, thin, subsidiary shears are abundant between, and especially adjacent to, major shears.

**Geochronology**

Previous work, (Blum, 1982; Bakke, 1995; and McCoy and others, 1997) using a variety of dating methods, generally agree that the intrusion of the Fort Knox Pluton, subsequent cooling, veining, alteration, and mineralisation occurred between 93 and 87 Ma. Tertiary thermal overprinting has been suggested through fission track analyses of zircon and apatite from the Fort Knox Pluton (Murphy and Bakke, 1993).

**Resource Drilling and Ore Reserves**

Both diamond drill core and reverse circulation (RVC) methods were used for resource drilling. A "cross" pattern was designed on a 200ft (61m) north-south-east-west grid so that core holes were sited approximately in the center of four adjacent RVC holes. Beginning in 1997, a pre-collar strategy was implemented. When target zones were below (>50m) zones of proven ore or waste, the drillhole was pre-collared with RVC and finished with core. A RVC drill rig, using a center return hammer, would drill a 6.25 inch (15.9cm) hole to the desired depth. Then, 5.5" (14mm) threaded PW casing was set. A core rig using a PQ triple-tube (PQ3) drill system was used to drill the target zone. PQ3 core diameter is 3.3 inches (8.4cm). As of September 1998, 505 holes have been drilled (347 RVC, 128-core, and 30 pre-collar) with a total footage of 322,693 (98,358m). The average drillhole depth was 640 ft (195m) and samples were collected every 5ft (1.53m).

**Reserves** (Waste to Ore Ratio = 1.2:1)

| | M Tonnes | Average Grade g/t | Cuttoff Grade g/t | Gold Price |
|---|---|---|---|---|
| Prior to Production | 158.3 | 0.83 | 0.39 | $400 |
| As of September 1998* | 143.5 | 0.82 | 0.39 | $350 |

*Reserve figure includes a low-grade stockpile containing 8.5Mt of 0.51 g/t.

View looking east over the Fort Knox central pit. Mining is taking place on the 1480 foot level. Photo taken September 1998.

Figure 4. Photo of the "Last" shear zone, 9m bench height.

## Mining and Milling Operations

Mining at Fort Knox is done by conventional open pit methods, seven days a week, 365 days a year. At present, the number of employees stands at 248. Total gold production for the project, as of September 1998, is 637,750 ounces.

The following is a list of mining and milling parameters:

Mining Parameters

| | |
|---|---|
| Bench Height | 30 feet (9.1m) |
| Pit Wall Slope | 42° to 45° |
| Blasthole Diameter | 6.75 inches (17.1cm) |
| Blasthole Depth | 32-35 feet (9.75-10.7m) |
| Blasthole Spacing | 15-18 feet (4.6-5.5m) |
| Density Factor | 12.5 cf/t Bank |
| Daily Pit Production | 72,000 – 90,000 Tonnes |

Primary Mining Equipment

(2) 23-yard Caterpillar 5230 Hydraulic Shovels
(1) 23-yard Caterpillar 994 Front End wheel Loader (Backup)
(9) 150-Ton Caterpillar 785B Haul Trucks
(4) Track Blasthole Drills Ingersoll Rand DM45E

Milling involves crushing, SAG milling, ball milling, and carbon-in leach gold absorption with conventional carbon stripping and gold recovery. Detoxification of cyanide is applied in the tailings stream prior to discharge from the mill.

## Mine Geology

The role of the mine geologist involves both intermediate and final pitwall mapping at 1:600 scale. Data recorded includes: rock type, alteration, structural data necessary for slope stability studies, and information about veins (type, density, and orientation). Special attention is also documented regarding rock hardness and "slab" rock contacts. This information is transferred to the weekly mine planning map. Blasthole chip piles are also mapped daily. The map data is added to the geologic model and utilized by the ore control engineer in defining ore zone boundaries.

## Conclusions

Fairbanks Gold Mining, Inc. poured the first gold bar from Fort Knox in December, 1996. This accomplishment has spawned a revival of far reaching interest for exploration geologists, especially in Alaska. At the time of writing this paper, 7 major exploration companies, and numerous juniors are exploring the region.

Multiphase granitic intrusive, strong structural control, vein controlled alteration style, Au-Bi-Te association, and very low sulphide content are the primary distinguishing geologic characteristics of the Fort Knox deposit. The success of soil sampling in delineating the size and nature of mineralisation is also notable.

Other features contributing to the success of Fort Knox and should not be overlooked are: Low strip ratio, low reagent consumption, proximity to Fairbanks, and availability of a workforce whose heritage is mining.

**Acknowledgments**

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