A report prepared for International Tower Hill Mines Ltd.

GEOLOGIC MODEL AND POTENTIAL OF THE LIVENGOOD GOLD PROSPECT, ALASKA

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SUMMARY

- The results of the recent drilling by International Tower Hill Mines have shown that the higher-grade gold mineralization at Livengood defines a 350º-striking core zone that is considered to reflect the position of a fault in the allochthonous basement beneath the mineralized thrust stack.

- Beyond the core zone, the gold mineralization appears to become progressively lower grade and more selective, giving rise to a broad, strata-bound gold zone. Confinement of the gold mineralization beneath a less-permeable ultramafic thrust slice may have contributed to the strata-bound geometry.

- The core zone is characterized by a greater concentration of monzonite porphyry dykes, including early, well-mineralized, feldspar-bearing and late, poorly mineralized, biotite-bearing families.

- The entire mineralized system underwent a systematic hydrothermal evolution, from early biotite-dominated potassic through albite-quartz to sericitic alteration. The gold accompanies arsenopyrite and pyrrhotite at the potassic stage, but occurs with arsenopyrite and pyrite in the albite-quartz and sericitic zones.

- Quartz ± carbonate-sulfide veinlets and related disseminated sulfides appear to have been formed throughout the alteration sequence, although the amount of gold remobilization from one alteration stage to the next is difficult to ascertain.

- Livengood is interpreted as an intrusion-related gold system linked to an inferred cupola emplaced within the hypothetical basement fault. The alteration and gold mineralization evolved from high-temperature potassic to lower-temperature sericitic as the cupola and its underlying parental chamber progressively cooled.

- Although the intrusions at Livengood are of unusual reduced alkaline character, geologic analogies with the Tien Shan gold belt of Uzbekistan and Kyrgyzstan are apparent. The evidence for widespread potassic alteration at Livengood confirms a relatively deep erosion level, well beneath the epithermal environment.

- Lateral extensions to the currently defined Livengood system remain to be fully tested, particularly to the north where the core zone may have been dextrally displaced by the west-northwest-striking Lillian fault.

- Depth extensions may also exist at Livengood, a fact emphasized by the importance of the potassic alteration. These could conceivably include additional strata-bound gold zones, but are considered unlikely to be in the form of steep, high-grade feeders.

INTRODUCTION

At the request of Jeff Pontius, the writer spent five days in Alaska to undertake a follow-up geologic review of the Livengood gold prospect on behalf of International Tower Hill Mines. Following an office presentation by Russell Myers and Chris Puchner, most of the time was devoted to inspection of key drill core.

This report, prepared on site, summarizes the principal geologic observations and interpretations stemming from the visit, preparatory to presentation of a preliminary geologic model and its implications for exploration potential.

The fieldwork was carried out with Russell Myers and Chris Puchner of International Tower Hill Mines and Paul Klipfel of Mineral Services Inc., who are thanked for instruction and wide-ranging discussions. Gratitude is also due to Russell Myers for compilation of Figure 1, Evan Twelker for digitization of Figures 2 and 6, and Paul Klipfel for taking the photographs.

GEOLOGIC BACKGROUND

Lithologic setting

Interpretation by International Tower Hill Mines personnel of the company's drilling results at Livengood shows that most of the known gold mineralization is confined to a shallowly inclined, broadly strata-bound zone, which is >1 km across and up to at least 200 m thick. The main mineralized lithologies, part of the Devonian section, comprise upper and lower sedimentary sequences separated by a volcanic unit of possible trachyandesitic composition.

The volcanic unit, comprising flows and breccias underlain by moderately welded ash-flow tuff, is the most extensively mineralized part of the sequence, with vesicular flow tops being a particularly prominent host. However, the gold mineralization also occurs widely in the upper sedimentary sequence, which comprises partly calcareous mudstone and siltstone along with sandstone and minor conglomerate. In the southern part of the prospect area, the mineralization also extends into carbonaceous mudstone and siltstone of the lower sedimentary package.

The strata-bound zone of mineralization is transected by a swarm of narrow (0.5-2 m wide) monzonite porphyry dikes, which are concentrated in a 350º-striking zone of higher-grade gold mineralization, some 900 m long and 150 m wide, which marks the core of the prospect area (Fig. 1). An early family of dikes, typically feldspar (including K-feldspar) dominant, are consistently well mineralized, whereas a late-mineral dike set, characterized by abundant, small biotite phenocrysts, is only weakly altered and mineralized. The porphyry dikes (and associated alteration sericite) reportedly returned a ~90-Ma age, thereby confirming them to be part of the Fairbanks-Tombstone plutonic suite.

The main strata-bound zone of mineralization is tectonically overlain throughout approximately 80 % of the prospect area by ultramafic rocks and associated ophiolitic lithologies (including chert) of Cambrian age (Fig. 1), which, in general, are more weakly mineralized. Nevertheless, gold concentrations are present in places, particularly within and alongside crosscutting feldspar porphyry dikes.

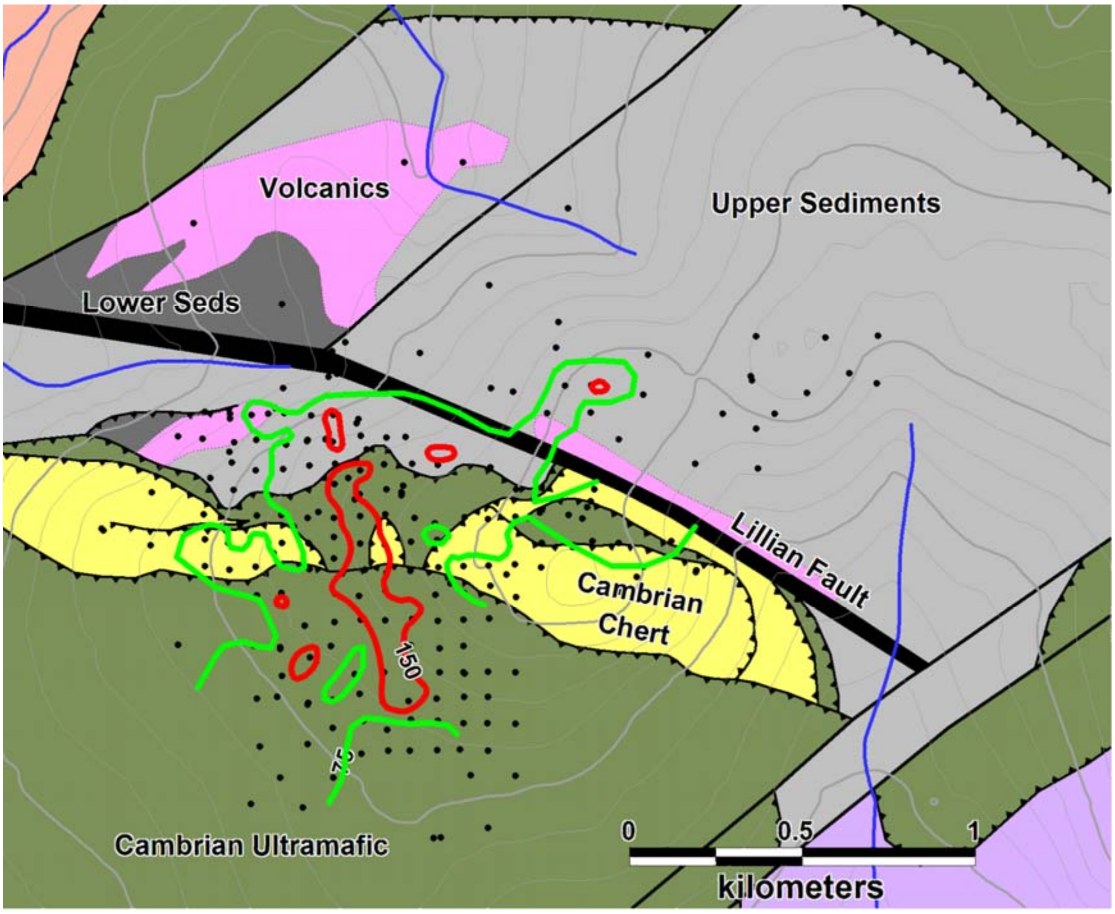

Fig. 1 Summary geologic map of the Livengood gold prospect, showing the higher-grade core zone defined by 150 gm-m Au (red) and 75 gm-m Au (green) contours.

Structural setting

The host rocks to the Livengood mineralization are part of a fold-thrust belt of late Paleozoic and/or Late Cretaceous age. Within as well as beyond the prospect area, the rocks constitute an imbricate thrust stack, which occurs as an erosional outlier over the autochthonous basement, reportedly of late Proterozoic through early Paleozoic age. The main mapped thrust faults dip shallowly south, and are located at the base of the Cambrian ultramafic unit and within the lower sedimentary sequence. The upper and lower sedimentary sequences and intervening volcanic unit occupy a recumbent fold structure, the axial plane of which plunges approximately 45º south.

The project team currently favors an uncertain, but probably fairly limited amount of normal motion on the steeper parts of thrust ramps during post-contractional relaxation. The resulting extensional faults facilitated emplacement of the monzonite porphyry dikes, the majority of which dip 40-50º south. The dikes are observed to be more numerous within the higher-grade core zone, in which a few of them are steeper and strike north. Many auriferous veinlets within the mineralized zone also dip broadly south, but reportedly more steeply than the dikes. In this regard, it is interesting to note that the gold mineralization displays a southward rake within the higher-grade core zone as well as showing an overall statistical trend that broadly parallels the south-dipping dike swarm.

The higher-grade core zone at Livengood appears to end abruptly to both the north and south (Fig. 1). Northward, the core zone abuts the west-northwest-striking Lillian fault (Fig. 1), which appears to have undergone an unknown amount of post-mineral, dextral strike-slip displacement, in keeping with the post-85-Ma structural regime in this part of Alaska. The reason for the abrupt southern termination of the core zone is less evident, although post-mineral faulting cannot be ruled out. Although a dextral strike-slip fabric of post-mineral timing is reportedly developed pervasively at Livengood, the main gold zone appears to have retained its structural coherence.

ALTERATION-MINERALIZATION RELATIONSHIPS

Early potassic stage

During the drill-core inspection, it became apparent that the strata-bound gold zone at Livengood, including the feldspar porphyry dikes, was affected by an early stage of pervasive potassic alteration (Fig. 2), which is now represented by remanent patches of fine-grained, brown, phlogopitic biotite (Fig. 3). The potassic alteration remnants were observed in the ultramafic, sedimentary, and volcanic rocks as well as in the early monzonite porphyry dikes, both within the higher-grade core zone and near the currently defined outer limits of the system. However, only a few percent of the core and cuttings recovered to date display the potassic remnants.

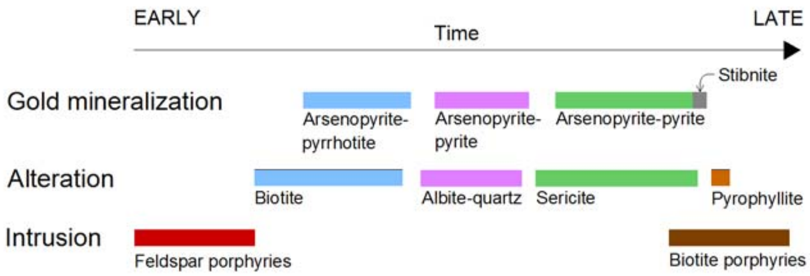

Fig. 2 Schematized evolution of intrusion, alteration, and gold mineralization at Livengood

Quartz ± carbonate (dolomite or calcite) veinlets were emplaced during the potassic event and these, along with surrounding disseminated mineralization, are gold bearing and characterized by arsenopyrite and pyrrhotite. The quartz veinlets are clearly biotite stable, and some display biotite concentrations along their margins.

Albite-quartz stage

The albite-quartz alteration is largely confined to the volcanic rocks and early porphyry dikes, where it is locally observed to overprint and obliterate the biotite alteration (Figs. 2 and 4). The fine-grained quartz, which is intergrown with the pervasive albite, is commonly black, probably due to the presence of finely dispersed carbon derived from the carbonaceous sedimentary rocks.


Fig. 3 Remanent patches of potassic (dark) in sericitic alteration (light). MK-08-33, 190 m


Fig. 4 Remanent patches of potassic (dark) in albite-quartz alteration (light). MK-06-05, 337 m

Gold mineralization was introduced during or soon after the albite-quartz alteration, in close association with arsenopyrite and pyrite (Fig. 2). The pyrrhotite characteristic of the potassic stage underwent pyritization. Quartz ± carbonate veinlets containing arsenopyrite and pyrite occur in the albite-quartz zones and, given the absence of observable alteration selvages, are assumed to be albite stable.

Sericitic stage

Much of the known Livengood gold mineralization, probably >80 %, is hosted by sericitic alteration, the majority of which appears to have developed by destruction of

Fig. 5 Veinlets of sericitic (pale gray) cutting albite-quartz alteration (darker gray). MK-09-35, 75-77 m

the early biotite alteration (Figs. 2 and 3). Where the sericitic alteration affects the ultramafics, quartz and carbonate (listwaenite) are abundant besides sericite, some of which is fuchsitic because of the elevated chromium content of the rock. Albite-quartz alteration zones are cut by sericitic veinlets (Fig. 5), thereby providing clear evidence that the latter post-date the former (Fig. 2). The sericitization generally results in a pale-colored rock, but in carbonaceous mudstone the black color may be retained because of carbon stability.

The sericitic alteration is cut by auriferous quartz ± carbonate veinlets containing arsenopyrite and pyrite (Fig. 2), sulfide minerals that are widely disseminated as well. Locally, where the sericitic alteration overprints biotitization, diamond-shaped arsenopyrite crystals appear to have been removed at the same time as the accompanying pyrrhotite was transformed to pyrite.

Massive stibnite veinlets, up to 1 cm wide, some containing subordinate quartz, apparently cut all the quartz ± carbonate-arsenopyrite-pyrite veinlets, and may well bring sulfide deposition at Livengood to an end (Fig. 2).

End-stage pyrophyllite

A single observed zone of massive pyrophyllite development, approximately 3 m wide and within and alongside a feldspar porphyry dike, appears to overprint pre-existing gold, arsenopyrite, and stibnite mineralization. The pyrophyllite was determined using XRD analysis by Rainer Newberry, thereby confirming that end-stage advanced argillic alteration locally overprinted the Livengood gold zone (Fig. 2).

Alteration-mineralization summary

The above observations show that the entire Livengood prospect displays a systematic alteration history, commencing with potassic and ending with sericitic events. The albite-quartz alteration occurred between the potassic and sericitic stages, but only in selected, presumably more favorable igneous lithologies.

On the basis of the current data, the quartz ± carbonate-arsenopyrite-pyrrhotite/pyrite veinlets along with the closely associated disseminated mineralization appear to have been introduced throughout the alteration sequence (Fig. 6), although pyrrhotite was restricted to the potassic stage and pyrite generated thereafter (Fig. 2). Indeed, it is difficult to know if any observed quartz ± carbonate-sulfide veinlet surrounded by sericitic alteration was generated during the sericitization or inherited from the preceding potassic event. Similarly, gold appears to have been introduced with the sulfides, in both veinlet and disseminated form, throughout the three main alteration stages, although the highest concentrations consistently occur in the quartz ± carbonate-sulfide veinlets. Carbonate, mainly dolomite or calcite, also seems to have been formed as a disseminated and veinlet mineral from the potassic through sericitic stages.

Fig. 6 Quartz-carbonate-sulfide veinlets generated during potassic and overprinted sericitic alteration. MK-09-35, 75-77 m.

GEOLOGIC MODEL

Structural and magmatic localization

Notwithstanding the apparent southerly dip of many of the porphyry dikes and auriferous veinlets as well as the gold-mineralized zone itself, it is clear from grade-thickness contouring that the most fundamental control on gold localization is the steeply inclined, 350º-striking feature that controls the higher-grade core zone (Fig. 1). The feature is believed to reflect a subvertical fault in the underlying autochthonous basement, which, although not causing any observable offset of the overlying thrust stack, focused ascent of the auriferous ore fluid. It is interesting to record that if the 350º-striking core zone is projected north for 4 km, it would pass through a prominent magnetic offset in the autochthonous basement. If this correlation were correct, the mineralization could occupy a well-developed arc-transverse structure.

The basement fault is considered likely to have localized a cupola on the roof of a composite monzonite porphyry intrusion, which was the source of the early feldspar porphyry and late biotite porphyry dikes as well as the magmatic fluid responsible for the gold mineralization. If this hypothesis is correct, then a more substantial monzonitic intrusion may be anticipated at the base of the thrust stack (Fig. 7). An intrusive source beneath the higher-grade core zone would nicely explain the increased number of dikes as well as the appearance of steep, north-striking dikes within it.

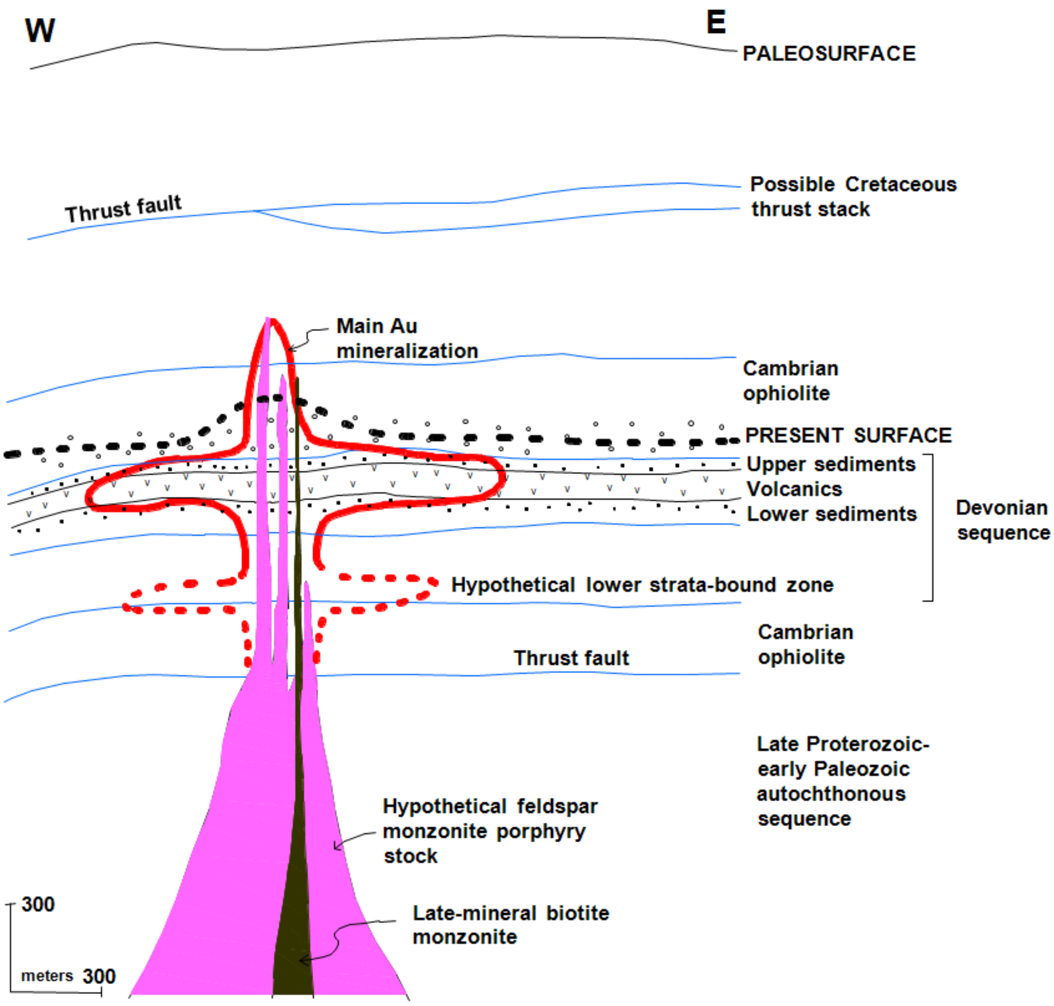

Fig. 7 Preliminary geologic model of the Livengood gold system

Intrusive composition

Intrusive composition

In contrast to the well-described calc-alkaline character of much of the Fairbanks-Tombstone magmatic suite, the Livengood intrusive center, along with others that help to define a ~120-km-long, northeast-trending belt to the southwest of Livengood, is distinctly alkaline in composition.

However, notwithstanding the alkalinity, the intrusive rocks (and derivative magmatic fluid) are chemically reduced, in common with the entire Fairbanks-Tombstone suite, presumably as a direct result of widespread interaction of the magma with reduced lithologies during its ascent. As a consequence, the resulting gold mineralization, like that elsewhere in the Fairbanks-Tombstone belt, is notably deficient in base metals. This is the only reduced alkaline intrusive belt known to the writer.

Gold mineralization

Magmatic fluid from the inferred cupola at depth ascended from south to north to generate the higher-grade core zone, which appears to have affected all lithologies more or less equally throughout a corridor that mirrors the assumed strike of the basement fault. Where the ascendant fluid encountered permeable wall rock, an appreciable component of lateral flow gave rise to the strata-bound gold mineralization. The main strata-bound zone encompasses the volcanic and upper sedimentary horizons (Fig. 7) where enhanced permeability may be ascribed to the vesicular nature of flow tops, sandstone and conglomerate beds, and decalcification of calcareous mudstone and siltstone. The mineralization appears to be more selective outward, where only the most permeable beds, commonly within the volcanic unit, are appreciably auriferous.

In addition to the lithologically or hydrothermally induced permeability, the elevated organic carbon contents of certain mudstone beds in the upper sedimentary sequence appear to be responsible for localization of particularly high-grade gold mineralization. However, such carbonaceous mudstone tends to be relatively impermeable so the beds only become well mineralized where fluid ingress proved possible, generally within the core zone.

The overlying ultramafic thrust slice may have acted as an aquitard (Fig. 7), particularly where its basal portion was subjected to extensive quartz-carbonate-sericite-serpentine (listwaenite) alteration. Permeability contrasts between the crosscutting early dikes and their wall rocks also guided fluid ascent and provided sites for effective gold concentration. Additional strata-bound gold horizons could be present at depth if suitably receptive rock volumes exist, as speculated in Figure 7.

The earliest, highest-temperature magmatic fluid caused potassic alteration and gold mineralization throughout the Livengood system. As fluid temperatures progressively declined, albite-quartz and sericitic overprints were extensively developed, apparently during ongoing gold mineralization. However, as noted above, at least some of the later gold mineralization may have involved remobilization of gold originally precipitated during the potassic stage. As gold mineralization progressed, the sulfidation state of the fluid increased, with the consequent conversion of pyrrhotite to pyrite.

As the hydrothermal system waned, but still under relatively high-temperature conditions, acidic fluid gave rise to the localized pyrophyllite overprint, which seems likely to represent the root zone of a now largely eroded advanced argillic lithocap. Lithocaps are shallow manifestations of systems driven by magma bodies, from which the required volatiles are directly derived.

Mineralization type

Certain features at Livengood, including the strata-bound nature of the gold mineralization within a previously thrusted rock package, its local accompaniment by hydrothermally induced decalcification, its close association with dikes emplaced during incipient extension, and its arsenic-antimony-mercury geochemical signature, are reminiscent of Carlin-type mineralization in north-central Nevada. Nevertheless, the Tien Shan gold belt of Uzbekstan and Kyrgyzstan is considered as a closer analogue.

There, several deposits, particularly Chaarat in Kyrgyzstan, display a close spatial and temporal association with felsic stocks and dikes emplaced into fine-grained, commonly carbonaceous sedimentary packages. Although the intrusive rocks are calc-alkaline in composition, as they are throughout much of the Fairbanks-Tombstone belt, they are reduced and contain tungsten and molybdenum mineralization but no appreciable base metals. The gold mineralization is closely related to arsenic and antimony and, although sericitic alteration generally predominates, potassic assemblages also occur.

Some investigators might assign Livengood, as they do deposits in the Tien Shan belt, to the orogenic gold category. In the case of Livengood, however, a close, probably genetic relationship to intrusive activity is strongly favored by the fact that gold introduction spans the intrusive activity, with the early feldspar porphyry dike family being strongly altered and mineralized whereas the late biotite porphyry family is only weakly sericitized and contains low-order gold values.

Although the Livengood prospect is centered on a dike swarm rather than a coherent stock, like that at Fort Knox, the widespread presence of potassic alteration confirms that the exposure level must be appreciable, certainly >1 km paleodepth. The shallow part of the required cover sequence may have included thrusted Cretaceous rocks, as speculated in Figure 7. Certainly, no epithermal features, such as crustified veinlets, are observed at Livengood. The geochemical signature of Livengood is Au-As-Sb-W, although the last two metals show little direct correlation with the gold. Perhaps surprisingly, in the context of other gold deposits closely tied to intrusive centers in the Fairbanks-Tombstone belt, Bi and Te are not anomalous; however, both may reasonably be expected to increase downward.

EXPLORATION POTENTIAL

Lateral extensions

The currently defined, broadly strata-bound gold mineralization at Livengood may remain open to both the northeast and southwest (Fig. 1). Northward, there is every chance that the 350º-striking, higher-grade core zone was offset by post-mineral dextral displacement on the Lillian fault. The amount of displacement is unconstrained, although it is possible that the gold mineralization already encountered north of the fault, ~800 m east of the northern tip of the core zone, represents the offset portion (Fig. 1). Southwestward, geologic relationships are less clear and the position of any fault(s) remains undefined, but the gold mineralization (as defined by the 75 gm-m contour) remains open (Fig. 1).

Additional, currently unknown gold zones may well exist at Livengood, particularly to the east, where the ultramafic thrust slice may conceal strata-bound mineralization. The proposed northeast-oriented drill fence will provide an initial test of the gold potential in this eastern quadrant, which could conceivably be related to additional basement faults of either 350º or other directions.

Depth extensions

Recognition of the importance of potassic alteration at Livengood emphasizes the depth potential of the core zone, which remains open downward in its southern parts. However, any mineralization that may exist below currently drilled depths is more likely to be similar to that already known, albeit characterized by better preservation of the early potassic event, rather than being confined to steep, high-grade feeder zones of the type known, for example, in the Carlin trend of Nevada.

Another possibility, difficult to assess until the planned deeper drilling investigates the Devonian section at greater depths, is the existence of additional strata-bound gold horizons, similar to that already known (Fig. 7) or possibly even of skarn type if suitable carbonate host rocks were present. Any such horizons would, of course, need to have relatively high average gold contents if they were to be amenable to eventual open-pit extraction.

The hypothesized cupola beneath Livengood may also be gold bearing, most probably in the form of veins. Even if these were sheeted and closely spaced, as at Fort Knox, they are unlikely to constitute ore given their likely appreciable depth.

Livengood camp
21st June 2009 — Richard H. Sillitoe