

A report prepared for International Tower Hill Mines Ltd.

**COMMENTS ON THE LIVENGOOD, CHISNA, AND TERRA
PROSPECTS, ALASKA**

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SUMMARY

- **Livengood** is interpreted as a strata-bound gold prospect located distally with respect to a parent pluton at depth. Numerous, narrow monzonite porphyry dikes connect the inferred pluton with the site of mineralization.
- Permeable stratigraphic horizons, most notably amygdaloidal andesite flows, moderately welded ash-flow tuff, and overlying decalcified calc-siltstone, host most of the gold, with minor amounts present in the feeder dikes. An exceptionally thick volcanic section, interpreted as the fill of a paleovalley, contains much of the gold.
- Tonnage extensions to the coherent zone of gold mineralization already defined are most likely to be found along the strike projections of the paleovalley, but could also occupy sites of enhanced permeability elsewhere. The concept of low-order geochemical values representing leakage from concealed gold zones at depth is valid and merits a scout-drilling program.
- **Chisna Southeast** is a well-zoned and probably fairly deeply exposed porphyry copper-gold center, in which much of the copper and gold mineralization appears to be contained within a central potassic core. Peripheral sodic-calcic and propylitic alteration are poorly mineralized.
- Much of the potassic core may be obscured by glacial valley fill, although traversing along the opposite side of the valley to the exposed potassic zone may reveal evidence for its extensions. It is possible that the best copper and gold values lie beneath the valley floor.
- A copper geochemical anomaly on the opposite, eastern side of the ridge is likely to be a discrete porphyry center rather than a direct extension of the partly exposed system to the west. Further work is clearly warranted.
- **Chisna Pow** is a copper- and gold-bearing structure hosted by volcanic rocks. It does not appear to be the marginal manifestation of a porphyry copper center or of epithermal affiliation. It may offer modest gold potential, but is not a copper target.
- Careful chip sampling of the structure at several sites along its length should reveal if it has gold potential worthy of follow-up work.
- **Terra** is interpreted as a low-sulfidation quartz vein related to the host diorite intrusion. A relatively shallow level, but deep epithermal origin is preferred. Gold introduction must have accompanied vein formation rather than having been introduced later following burial and exhumation. An orogenic affiliation lacks supporting evidence.
- Construction of longitudinal sections showing contoured gold grade, gold grade x thickness, and Ag/Au ratios should assist with definition of high-grade ore shoots and any metal zoning and, hence, the siting of future drill holes.

INTRODUCTION

At the request of Jeff Pontius, the writer spent six days in Alaska to review selected prospects under exploration by International Tower Hill Mines. Eventually, weather conditions allowed field visits to the Livengood gold and Chisna copper-gold prospects along with a brief examination in Fairbanks of core from three holes at the Terra gold prospect. The work at Livengood involved mainly inspection of drill core, whereas that at Chisna comprised exclusively field traverses. The key geological observations and interpretations, along with brief exploration recommendations, are summarized in this report.

The fieldwork was carried out with Jeff Pontius, Russell Myers, and Chris Puchner of International Tower Hill Mines, who are thanked for instruction and wide-ranging discussions.

LIVENGOOD GOLD PROSPECT

Geologic background

The results of drilling to date by International Tower Hill Mines have shown that the known gold mineralization at Livengood is confined to specific stratigraphic horizons within a thrust-faulted Paleozoic succession. The main gold concentrations are broadly strata-bound within shallowly dipping volcanic and sedimentary rocks of Devonian age located in the immediate footwall of a low-angle thrust fault (Fig. 1). The gold-bearing horizons are underlain by an essentially barren, carbonaceous siltstone-shale package. The overlying upper-plate rocks comprise ultramafics and associated greenstone lithologies of Cambrian age. The entire succession is cut by numerous narrow (0.5-2 m) dikes of monzonite porphyry, most of which appear to be steep (as schematized in Fig. 1). The porphyry reportedly returned a 90-Ma age, thereby confirming it to be part of the Fairbanks-Tombstone plutonic belt.

Host lithologies

The most important hosts for the gold mineralization are the volcanic rocks, which may be divided into two main lithologies. The upper and best-mineralized unit consists of amygdaloidal flows (Fig. 1), probably of trachyandesitic composition. A more felsic composition is ruled out by the absence of quartz phenocrysts. The reportedly high tantalum and niobium contents favor an alkaline affinity. The flow unit is underlain by a moderately welded ash-flow tuff (Fig. 1) that is crystal and fiamme rich but contains few accidental lithic clasts. The absence of quartz crystals in the tuff suggests that it may also be of trachyandesitic composition.

The amygdaloidal flow and ash-flow tuff units have been shown by the drilling to thicken markedly over relatively short horizontal distances. An east-striking zone, some 150 m wide, marked by more than twice the normal thickness of volcanic rocks is the site of much of the best gold mineralization (Fig. 1). The feature is interpreted as a paleovalley, which guided dispersal of both the amygdaloidal flow and ash-flow tuff units. Abrupt local variations in the volcanic stratigraphy suggest erosion as well as deposition took place in the paleovalley, an observation that argues against its interpretation as a narrow graben. Moreover, it is difficult to see how the feature could

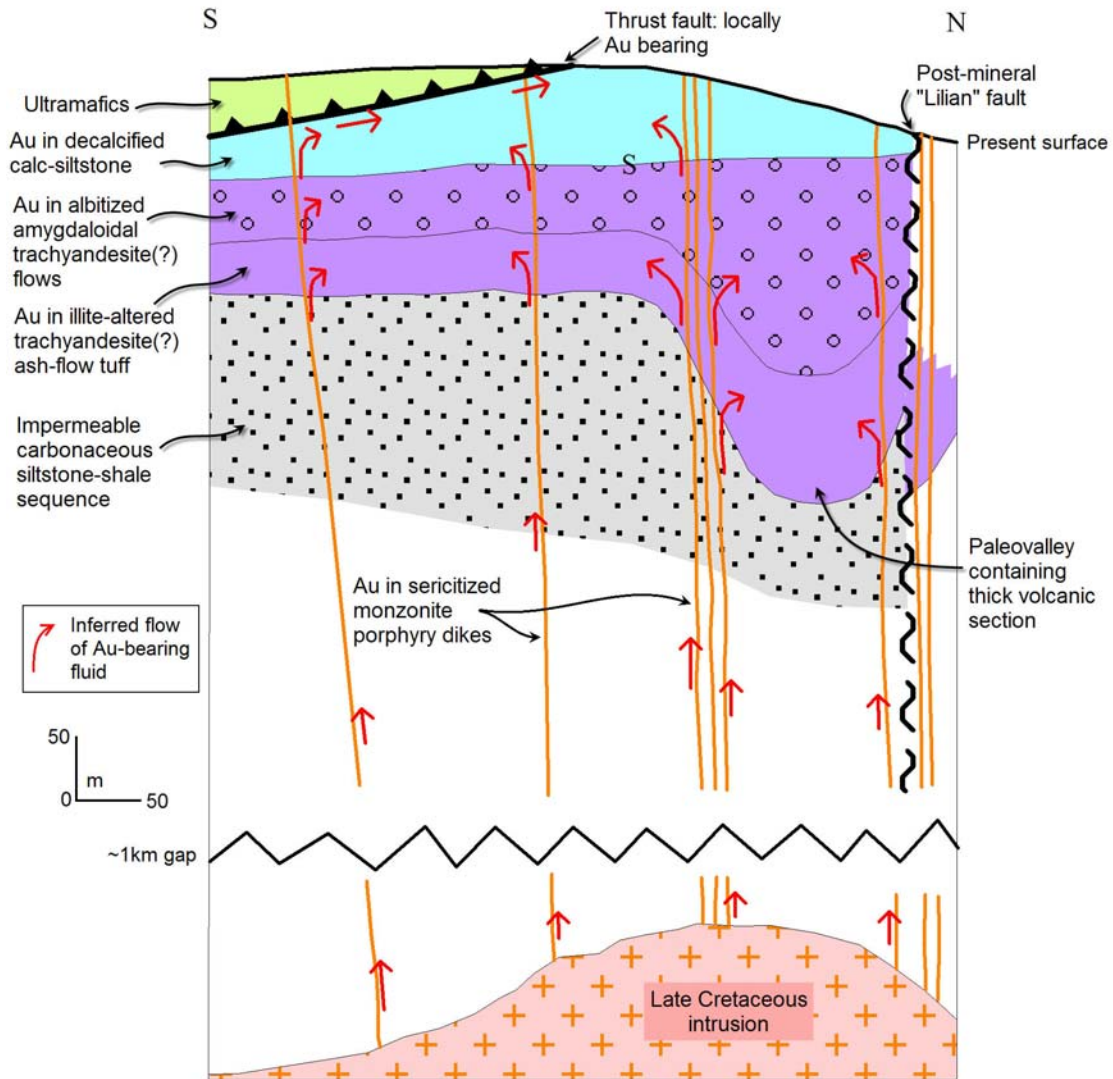


Fig. 1 Schematic section of Money Knob sector, Livengood

be a product of either later faulting or folding. Nevertheless, the inferred paleovalley broadly parallels the Lillian fault (Fig. 1), which appears to be post-mineral in timing but may represent reactivation of a pre-existing zone of structural weakness.

The volcanic rocks are overlain by a calc-siltstone unit (Fig. 1), which contains interbeds of sandstone and conglomerate. This unit appears to have accumulated on a roughly planar surface, suggesting that the paleovalley had been filled by this time. The calc-siltstone unit acts as a host for gold mineralization in places, but does not appear to be as well mineralized as the volcanic rocks.

The paleovalley was incised into a thick carbonaceous siltstone-shale package (Fig. 1), which implies a radical change in the paleo-environment. Nevertheless, the lithochemical signature suggests that the carbonaceous siltstone-shale and volcanic units are transitional, implying that volcanic debris was available during the final stages of siltstone-shale deposition.

Gold-related alteration

The four main host rocks for the Livengood gold mineralization display markedly different alteration features. The amygdaloidal flows have been convincingly shown to be pervasively albite altered, a process that appears to have embrittled the unit to a greater degree than the other gold-bearing rock types.

In contrast, the underlying ash-flow tuff unit displays illite alteration, particularly of the fiamme. The rock remains relatively soft and, hence, was not as readily fractured. The calc-siltstone capping the volcanic rocks underwent decalcification and pyrite introduction where gold values are present, although widespread supergene weathering masks the details. There are local concentrations of gold in the thrust zone above the calc-siltstone but the gold content of the ultramafic rocks is generally low, notwithstanding the intense alteration to carbonate, sericite, and fuchsite.

The fourth gold-bearing rock, the early generation of monzonite porphyry dikes, underwent alteration to distinctive greisen-like muscovite. The later dikes, most containing needle hornblende phenocrysts, are little altered, although their margins may be gold mineralized.

Gold mineralization

A two-stage introduction of the gold at Livengood is confirmed, with the two stages likely parts of a single, continuous mineralizing event. The early stage resulted in dispersed gold mineralization in the albitized amygdaloidal flows, illitized ash-flow tuff, decalcified calc-siltstone, and muscovite-altered monzonite porphyry dikes. The gold likely accompanies disseminated pyrite and arsenopyrite, although contemporaneity of gold introduction in the different alteration types cannot be confirmed. Some of the sulfides, along with quartz and calcite, in the amygdaloidal flows occupy the amygdales themselves.

Several veinlet generations appear later than much of the dispersed gold mineralization. The most common are pyrite- and arsenopyrite-bearing, white, vitreous to crystalline quartz veinlets, which are most abundant in the brittle, albitized amygdaloidal flows. A late auriferous quartz-veinlet generation is distinguished by the presence of massive arsenopyrite. An uncommon auriferous veinlet type comprises irregular stringers and pods of massive stibnite unaccompanied by quartz or other sulfide minerals.

Mineralization model

The observed distribution of alteration and gold mineralization at Livengood is ascribed mainly to the availability of permeability, which is lithologic, hydrothermal, or structural in origin.

Most of the gold is localized by primary lithologic permeability, chiefly the amygdaloidal character of the flow unit and, to a lesser degree, the eutaxitic texture of the ash-flow tuff unit. Both these volcanic textures are well known for their ability to preferentially channel hydrothermal fluids. Amygdaloidal flows localize manto-type copper deposits in Chile, where they also act as important hosts for distal-

disseminated gold mineralization around the Andacollo porphyry copper deposit. Variably welded ash-flow tuff controls gold mineralization in many epithermal deposits, including Round Mountain, Nevada and several high-sulfidation deposits in the central Andes.

Carbonate dissolution provided the hydrothermal permeability that seems to have localized much of the gold in the calc-siltstone unit. Structural permeability is believed to have guided ascent of the monzonite porphyry dikes and subsequent auriferous fluids both below and within the mineralized stratigraphic units. The fluids failed to penetrate the basal carbonaceous siltstone-shale unit because of its intrinsic lack of permeability. The overlying ultramafics seem to have acted as an aquitard, although some gold was deposited along the basal thrust, possibly during lateral fluid flow (Fig. 1), and within quartz veinlets cutting the altered ultramafics.

The ultimate source of the gold-bearing fluids at Livengood is likely to be an underlying pluton (Fig. 1). The narrow monzonite porphyry dikes must have been derived from magma batches of the same composition within a sizable chamber. In view of the large number of dikes distributed throughout the mineralized area and its surroundings, a subjacent magma chamber is preferred to one situated elsewhere in the district. The presence of gold mineralization in and alongside the dikes cutting the barren basal carbonaceous siltstone-shale unit shows that the gold source is at greater depths, possibly well in excess of 1 km (Fig. 1).

If these conclusions are accepted, then the Livengood gold mineralization is yet another of the many styles present in association with the reduced mid-Cretaceous plutonism that defines the Fairbanks- Tombstone gold belt. Livengood would fall into the distal deposit category, as further confirmed by its Au-As-Sb-Hg geochemical signature and the absence of tungsten and bismuth. Notwithstanding the relatively low temperatures indicated by the metal association, the gold mineralization is not of epithermal type. Therefore it might be grouped with Ryan Lode and True North, although these two deposits display more structural than stratigraphic control on the gold distribution.

Exploration potential and recommendations

The amygdaloidal flow and ash-flow tuff units, especially where they are at their thickest in the inferred paleovalley, are the main controls on the known gold mineralization at Livengood. Within these units, a coherent gold zone, averaging some 50 m in thickness, has already been defined. Extensions to this zone provide the best chances of adding to the resource. The planned step-out drilling along the strike of the paleovalley is the obvious approach.

Nevertheless, any lithologic, hydrothermal, or structural permeability in nearby areas could also localize additional gold concentrations. Pre-mineral fault zones, additional paleovalleys or different receptive stratigraphic units might all be envisioned. Therefore scout drilling elsewhere in the district, particularly beneath the upper-plate ultramafics, would definitely be worthwhile. Targeting weak geochemical anomalism, which may represent upward leakage from concealed gold zones, is strongly supported. The scout drilling need not be deeper than, say, 150 m because only relatively shallow gold zones will make ore given the modest average grades (~1.5 g/t

Au) encountered to date. The inferred pluton at depth does not constitute a viable exploration target because of its excessive depth.

CHISNA SOUTHEAST COPPER-GOLD PROSPECT

Geologic background

A volcano-sedimentary sequence of reported Permian age is the host for the intrusive rocks, alteration, and mineralization at Chisna Southeast. Volcaniclastic rocks of andesitic composition dominate the sequence, although epiclastic and limestone horizons are also present.

The intrusive rocks are mainly dike-like in form and range from hornblende diorite to quartz diorite in composition. Early dikes, possibly related to the Permian volcanic sequence, are fine-grained quartz diorite porphyries, whereas the later intrusions are coarser-grained diorite porphyries. The early diorite porphyry is strongly altered and mineralized, whereas later ones are much fresher in appearance.

Alteration zoning

The main field traverse revealed a well-marked alteration-zoning pattern at Chisna Southeast, with central potassic alteration transitional outward through sodic-calcic alteration to a peripheral propylitic zone.

The core zone, exposed at the lowest elevations, comprises a diorite porphyry stock emplaced into fine-grained andesitic volcanic rock that has the appearance of hornfels. Both lithologies display potassic alteration: biotite and magnetite in the volcanic rock, but K-feldspar, biotite, and magnetite in the porphyry. The potassic alteration is cut by both sheeted and multidirectional quartz veinlets of A-type, which lack alteration selvages.

At higher elevations to the east, volcaniclastic rocks of probable dacitic composition are altered to a sodic-calcic assemblage of pervasive albite (or oligoclase) within which patches and veinlets of actinolite (or actinolitic hornblende) and magnetite are prominent. As the elevation increases, the actinolite is progressively more strongly retrograded to chlorite, and epidote becomes increasingly more abundant. Locally, hydrothermal biotite pseudomorphed by chlorite was noted. Sodic-calcic alteration is much more weakly developed in even the early quartz diorite porphyry dikes.

At still higher elevations and northeast of the potassic core, a propylitic assemblage of epidote, chlorite, and magnetite becomes dominant. Epidote is more abundant than in most propylitic zones. Banded aggregates of massive epidote and magnetite are suspected to be replacements of calcareous epiclastic beds. Vuggy veinlets contain quartz, chlorite, magnetite, and calcite. Specular hematite lines fractures in places. Outward, epidote decreases in amount and magnetite is confined to isolated veinlets.

Copper-gold mineralization

The copper-gold mineralization is centered on the quartz-veined potassic core, in which chalcopyrite lines fractures as well as occurring as disseminated grains in the

quartz veinlets. Pyrite/chalcopyrite ratios approximate 1/3. Surficial malachite and neotocite result from chalcopyrite oxidation. Outward and upward in the potassic zone, the pyrite content increases to about 3 volume % and the pyrite/chalcopyrite ratio abruptly changes to 2-5/1. This pyrite halo continues outward and upward into the sodic-calcic alteration zone. On the basis of the soil geochemistry, the inner parts of the pyrite halo may contain low-order gold values but little copper. The outer parts of the sodic-calcic zone and the enclosing propylitic zone are essentially sulfide-free.

The only observed copper mineralization accompanying the sodic-calcic alteration is confined to a small magmatic-hydrothermal breccia dike. The breccia comprises albitized diorite porphyry clasts cemented by chlorite plus lesser amounts of quartz, chalcopyrite, pyrite, and calcite.

In the propylitic zone, gold, accompanied by elevated zinc and lead values, appears to be confined to widely spaced veinlets containing crystalline barite. It is uncertain if the magnetite and chlorite in these veinlets is part of the barite-gold event or the product of an earlier mineralization stage.

Mineralization model

Chisna Southeast is a porphyry copper-gold system in which sodic-calcic besides potassic alteration is well developed. As is typical, the potassic core of the system contains most of the copper and gold, which become progressively lesser in amount outward. The sodic-calcic alteration appears to flank the potassic core and is suspected to be the remnants of an early alteration event that preceded the potassic alteration and much of the copper and gold introduction.

The propylitic periphery of the system is unusually rich in epidote, which may reflect outward transport of calcium displaced by albite development in the sodic-calcic zone. The barite-zinc-lead veins appear to be the outermost manifestations of the system.

Sericitic alteration is notable by its absence at Chisna Southeast. Sericitic alteration is commonly poorly developed in gold-rich porphyry copper systems, although an alternative and viable explanation would be that the erosion level at Chisna Southeast is simply too deep for the sericitic zone to be preserved.

The geologic characteristics at Chisna Southeast are those commonly observed in gold-rich porphyry copper systems. The porphyries are dioritic in composition and hydrothermal magnetite contents are distinctly elevated. Most of the gold is likely to accompany the chalcopyrite in the potassic core, although the geochemical response suggests the possibility that gold may be laterally a little more extensive than the copper. These features are typical of many gold-rich porphyry copper deposits worldwide, although the sodic-calcic alteration is particularly well preserved at Chisna Southeast as it is at the Río Grande prospect in Argentina.

Exploration potential and recommendations

The outcropping potassic alteration at Chisna Southeast is interpreted as the southern edge of the potassic core, which seems likely to continue northward beneath glacial

valley fill. Although the potassic core appears likely to be relatively small, perhaps 300-400 m across, it may span the valley and subcrop along its northern side. Traversing there in search of quartz veinlets cutting either porphyry or andesitic volcanic rock is strongly recommended. It should be stressed that the chalcopyrite-bearing breccia is not part of the potassic core.

The exposed potassic alteration is estimated to be fairly low-grade, perhaps 0.2-0.3 % Cu plus associated gold values. Although this observed material is likely to prove subeconomic, there is a possibility that central parts of the potassic zone, potentially beneath the valley floor, are higher grade. Supergene copper enrichment may be ruled out because hypogene sulfides exist at surface. Surface rock-chip gold values may be taken to approximate the gold grades at depth, although copper in the potassic zone may have been slightly leached where goethitic limonite is present.

Anomalous copper-in-soil geochemistry is also found on the opposite (eastern) side of the ridge at Chisna Southeast. This largely concealed area was not examined on this occasion, but is suspected to represent a separate porphyry copper center. This conclusion is reached because it seems most unlikely that the sodic-calcic alteration overlies the copper-bearing potassic zone, as it would have to do if the copper anomalies east and west of the ridge were connected at depth. Rather, the sodic-calcic zone occupies a lateral position with respect to both porphyry centers, thereby separating them. The copper anomaly east of the ridge merits further attention, with particular emphasis placed on the search for quartz veinlets and alteration mapping.

CHISNA POW COPPER-GOLD PROSPECT

Geologic observations

The target at Pow is an N10°W-striking structural zone, up to 10-15 m wide, cutting andesitic flows and volcanoclastic rocks of reported Permian age. The structure is external to a reported diorite porphyry stock and associated magnetite alteration zone that may represent a sulfide-deficient porphyry copper center.

The mineralized structure displays chlorite-epidote alteration and contains stringers and impregnations of limonite after pyrite along with reported copper and gold anomalism. Narrow, discontinuous veins of milky, crystalline quartz are present locally within the pyritized zone. The quartz contains remanent pyrite and subordinate chalcopyrite in places, up to 20-volume %, although much of it at surface has been weathered out.

Geologic interpretation

The Pow structure is interpreted as a fault-controlled zone of mineralization possessing an ultimate intrusive source. However, the lack of anomalous zinc and lead values suggests that the structure is not the marginal manifestation of a porphyry copper center. The overall mineralogy and crystalline nature of the quartz further rules out an epithermal origin.

Exploration potential and recommendations

The Pow structure is too small to be of interest as a copper target. Therefore any contained copper is incidental to the gold content. In order to assess the gold potential, rock-chip sampling of the structure at a minimum of five sites along its length is recommended. Samples should be continuous chips taken over the full outcropping width of the structure. Additional work, including trenching, would be merited if gold contents prove to attain several gm/t.

TERRA GOLD PROSPECT

Geologic observations

On the basis of the three vein intercepts inspected in core, the main Terra structure seems to consist of a 20-30-cm-wide quartz vein along with a series of closely associated quartz veinlets. The veins and veinlets cut fine-grained biotite diorite, reportedly part of an elongate, dike-like body dated at 67 Ma. Ductile deformation features and post-mineral faulting were not observed.

The fine-grained auriferous quartz is weakly crustified in places and possesses a distinctive mottled texture. Dolomite and calcite are intergrown with the quartz in places. The quartz contains <2 volume % sulfides, mainly pyrite and arsenopyrite plus traces of sphalerite, chalcopyrite, and silver sulfosalts. Vugs, carbonate-replacement texture, and colloform banding are all absent.

The quartz veins and, to a lesser extent, the veinlets possess narrow alteration halos in which magmatic biotite is altered to white mica, interspersed with lesser amounts of probable fuchsite. Arsenopyrite occurs as disseminated grains in the alteration halos, where it tends to be more abundant than in the veins themselves. Similar alteration affects wall-rock clasts within the vein quartz as well as occurring as selvages to a later generation of reportedly barren, carbonate-dominated veinlets.

Mineralization type

Based on these preliminary observations, the Terra quartz vein may be assigned to the low-sulfidation rather than intermediate-sulfidation epithermal category because of its weakly developed crustification, low total sulfide and base-metal contents, prominence of arsenopyrite, and lack of manganese carbonate. The lack of vugs, carbonate-replacement texture, and boiling-induced features, such as adularia, would favor a deep epithermal level.

However, the intimate association of the veins with the host biotite diorite suggests a genetic connection, which is further supported by a reportedly similar 67-Ma age for the alteration mica. A shallow intrusion-related origin would be essentially the same as a deep epithermal origin. The reported 1-km vertical extent of reportedly identical quartz veining and gold mineralization further emphasizes the diorite connection and rules out a classical epithermal model, in which ore shoots would be expected to span only 200-300 vertical meters.

The proposal that the coarse gold at Terra was introduced long after quartz vein formation gains no support whatsoever from this inspection. If the vein was formed, buried, subjected to metamorphism, exhumed, and then mineralized, as proposed, it is difficult to understand why the gold is confined to a particular variety of quartz rather than being more widely distributed. Nevertheless, metamorphism that was of sufficiently low grade to cause no mineralogic transformations cannot be ruled out.

Assignment of the Terra vein to the orogenic category can also be ruled out on the basis of the nature of the quartz, the high silver content, and the absence of any evidence for a controlling brittle or brittle-ductile shear zone.

Exploration recommendations

Drilling to date suggests that the main Terra vein is consistently mineralized throughout much of its known vertical and lateral extent, and the Ice vein has also returned promising gold values. Prior to infill drilling on the veins, it is recommended that all existing drill intercepts and surface data be plotted on longitudinal vein sections. Concurrent construction of sections showing contoured gold grade (g/t), gold grade x thickness (g/t x m), and Ag/Au ratios should define the positions of high-grade shoots and any lateral or vertical zoning that may exist. Hopefully, the sections will show where high-grade ore shoots remain open and untested



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