British Columbia Geological Survey
Geological Fieldwork 1996

THE TAURUS PROJECT, A BULK TONNAGE GOLD PROSPECT NEAR CASSIAR, BRITISH COLUMBIA, NTS 104P/5

By Andre Panteleyev*, David Broughton** and David Lefebure*
* Geological Survey Branch; ** Cyprus Canada Incorporated

KEYWORDS: Gold, economic geology, Cassiar, quartz veins, bulk tonnage, mineralization, alteration, Sylvester allochthon, Cretaceous intrusions.

INTRODUCTION

The Taurus project is a large tonnage, low grade gold prospect in the vicinity of the past producing Taurus gold mine, the surrounding quartz vein systems and auriferous massive pyritic replacement zones to the west of the mine. The property is about eight kilometres east of the former townsite and asbestos mill of Cassiar (Figure 1). The area of interest is alongside Quartzrock Creek and straddles the paved Cassiar access road, about 5.5 kilometres from its junction with the Stewart Cassiar highway (Highway 37). Taurus mine, previously know as the Cornucopia or Hanna workings, on the Copco claims, produced 1 102.5 kilograms gold from 288 863 tonnes of ore for Taurus Resources Limited between 1981 and 1988. This includes production of about 5,000 tons of ore from the Plaza adit and some material from a small open cut on veins at 88 Hill (B. Spencer, personal communication, 1996).

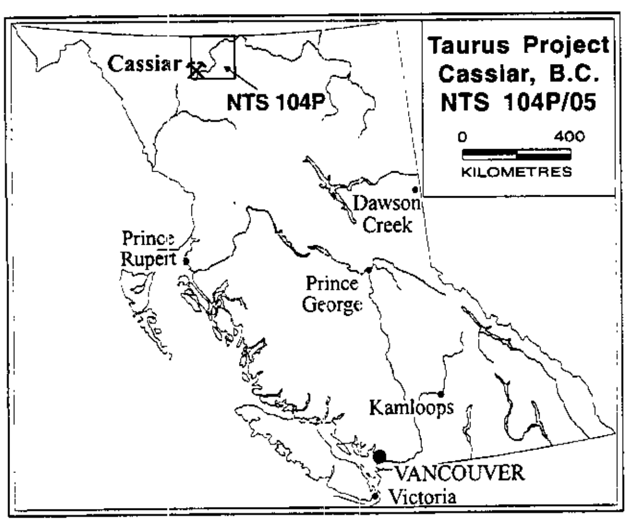

Figure 1. Location map.

Taurus is just one of a number of gold mines in the Cassiar gold belt. Gold production in the Cassiar district began in 1874 from placer deposits on McDame Creek. The Cassiar, or McDame camp, is one of British Columbia's major placer districts with recorded production of 74,500 ounces gold, mainly between 1874 and 1895 (Holland, 1950). Placer gold from the Cassiar valley in the Taurus mine area was won from Snowy and Troutline (Trout) Creeks, and Quartzrock Creek at Wings Canyon. Most of the production came from further downstream in the drainage system of McDame Creek, its tributaries and some high river benches between Cassiar road junction with Highway 37 and Centerville, 15.5 kilometres to the east.

Gold production from bedrock sources has come from a number of the auriferous quartz veins that occur over a distance of 15 kilometres along a northerly-trending belt; the commonly used names of some of the quartz vein workings are shown on Figure 2. Erickson Gold mine at Erickson Creek on Table Mountain produced 7 232 kilograms of gold from 507 215 tonnes of ore between 1979 and 1988. Most of the production was from steeply dipping, volcanic-hosted quartz veins carrying about 15.6 grams gold per tonne in the Erickson Creek vein system but about 110 000 tonnes came from the ribboned, carbonaceous, flat-lying Vollaug vein at an argillite-volcanic and altered ultramafic pod (listwanite) contact. The Vollaug vein material contained, on average, about 10.5 grams gold per tonne. The currently operating Table Mountain mine of Cusac Gold Mines Limited started operating in 1993. It has produced approximately 900 kilograms of gold from 52 500 tonnes of ore to the end of 1995, and is expected to achieve a 600 kilogram gold production target in 1996. Additional reserves are being developed at the mine as well as from the formerly producing Vollaug vein.

In addition to these larger milling operation a small amount of gold production (mainly unrecorded) has come from open cuts at Quartzrock Creek where a stamp mill was operated by John Hope and family at the Mack and Hopeful property; open cuts and a short adit at the Hanna (Cornucopia) workings; and hand workings at Pete's vein on the north flank of Needlepoint Mountain, the Rich vein on Snowy Creek, veins on Troutline Creek, and probably other veins as well. A summary of the 1930s to 1980s mining history is given in Diakow and Panteleyev (1981).

The area surrounding the Taurus mine was explored by the property owners during operation of the mine in the 1980s. More widespread exploration and drilling starting in 1993 demonstrated the expansive nature of the gold mineralization. Compilation of exploration data

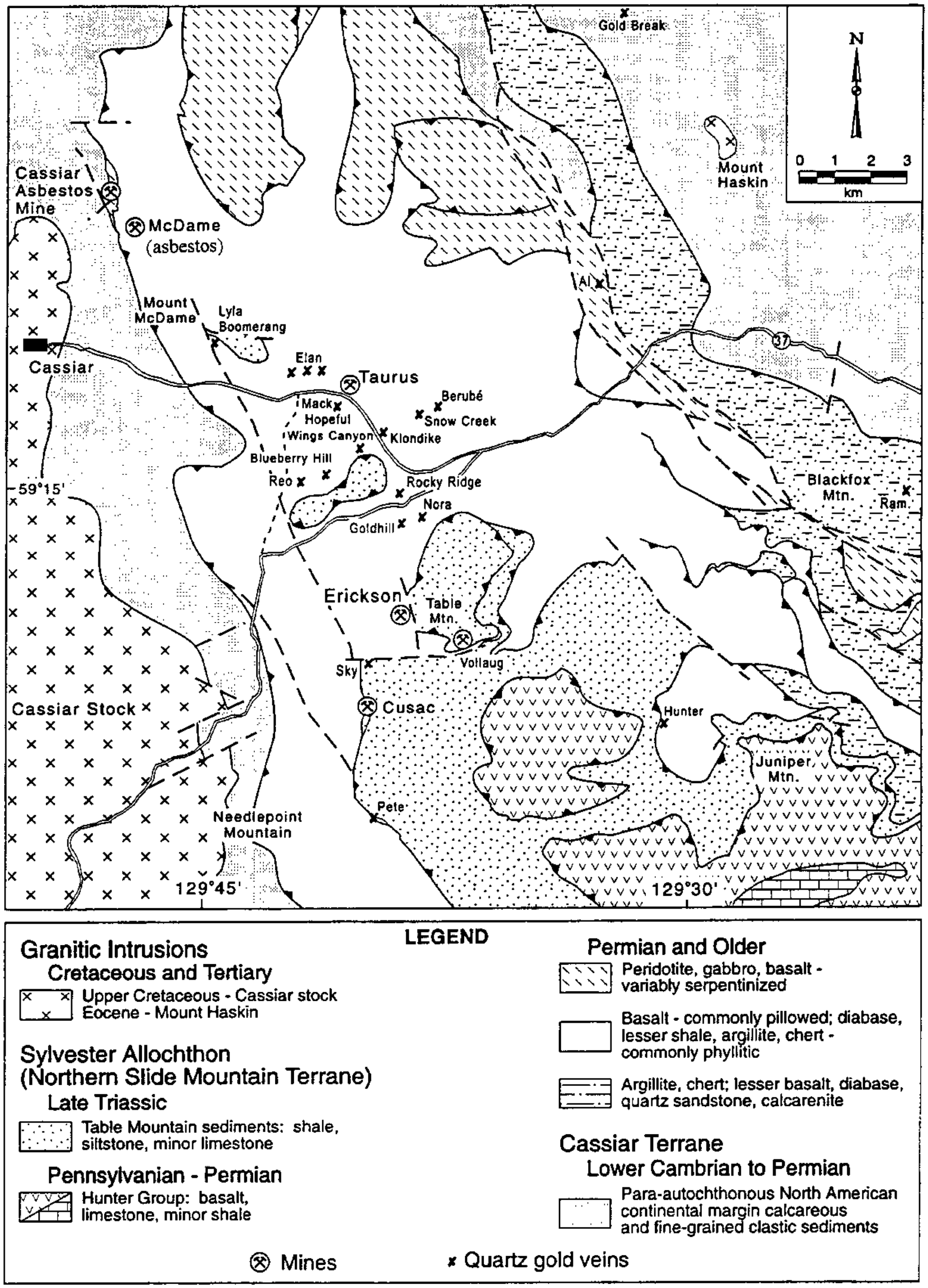

Figure 2. Generalized geology of the Cassiar area, with location of mines and quartz vein gold prospects; modified from Ash *et al.* (1996) after Harms (1989) and Nelson and Bradford (1993).

revealed that gold mineralization occurs at shallow depths in an area of at least 500 by 1500 metres and this led to the realization that a potentially bulk mineable gold deposit might be developed. In 1995 Cyprus Canada Incorporated became involved with the property under joint ventures with International Taurus Resources Incorporated, Cusac Gold Mine Limited and Douglas Busat. Cyprus conducted a $2.8 million program in 1995 consisting of 13,496 metres drilling [12,670 core, 826 metres reverse circulation] as well as trenching, geophysical surveys, geochemical sampling and geological mapping (Broughton, 1996). Drill holes were mainly at 100 metre intervals on lines spaced 200 metres apart. In 1996 an additional 12 drill holes [1457 metres core drilling] and some trenching were completed. Most work has been concentrated in three areas: 88 Hill, Taurus West and Taurus mine. In mid July 1996 Cyprus withdrew from the property and subsequent exploration was conducted by International Taurus. Their work was mainly in the 88 Hill zone and consisted of 36 in-fill reverse circulation holes [3950 metres] and 5 step out diamond drill holes to the west. Since 1993 a total of 29 505 metres of drilling has been completed on the property (Figure 3). Based on drilling to the end of 1996, a drill indicated reserve of 13.7 million tonnes with 1.01 grams gold per tonne has been estimated in the 88 Hill area, with additional inferred reserves of 25.1 million tonnes at 0.67 grams gold per tonne (International Taurus Resources Incorporated news release, 1996).

The concept that a potentially bulk mineable gold deposit could be developed at the Taurus property stems in large part from the concurrence of significant placer gold production in the region and the widespread distribution of near surface swarms of closely spaced auriferous quartz veins. The presence of nearby Cretaceous granitic bodies, and an apparent Cretaceous age of the vein mineralization, suggest additional similarities to the geological settings of the bulk mineable, unoxidized gold mineralization at Fort Knox mine, near Fairbanks, Alaska (Bakke, 1995) [161 million tonnes at 0.86 grams per tonne gold, A.A. Bakke, personal communication, 1996] and Dublin Gulch prospect, Yukon (Hitchins and Orssich, 1995). At Dublin Gulch a mineable reserve of 36 million tonnes containing 0.92 grams gold per tonne has been identified in the Eagle zone, within a larger area of mineralization (Smit *et al*, 1996]. Another example of a gold-quartz vein camp with unoxidized, primary sulphide ores that are being bulk mined is the Dome mine, Canada. At Dome, open pit reserves of about 26 million tonnes with 2.0 grams gold per tonne and 0.5 grams per tonne cutoff were developed in an area selectively mined in the 1940s. At the long-lived vein camp at Kalgoorlie, Australia, open pit (oxidized) reserves announced by Kalgoorlie Consolidated Gold Mines in 1989 at the inception of the 'superpit' were 68.1 million tonnes with 2.9 grams gold per tonne (D.I Groves, personal communication, 1996). This resulted in gold production in 1990 of 231,000 ounces gold, making it the 4th largest gold producer in the state in that year (*Engineering and Mining Journal*).

This study conducted some geological mapping to determine trends of major lithologic units, to relate them to regional stratigraphy and to confirm the Triassic age by sampling for microfossils of the sedimentary unit north of Highway 37 along Troutline Creek. Extensive use was made of company geological and drill information. The main effort was to determine the age of vein mineralization and resolve its relationships to various rock units, notably the Cretaceous intrusions. A suite of hydrothermal mica samples from veins has been submitted for Ar $^{40/39}$ step heating studies, as well as other samples for conventional K-Ar and U-Pb (zircon) dating.

GEOLOGY

REGIONAL GEOLOGY

The first regional geological mapping completed in Cassiar area was by Gabrielse (1963) who named the volcanic-rich Sylvester Group that hosts the Taurus deposit. The description of the Sylvester allochthon by Gordey *et al.* (1982) provided a three-fold subdivision of the Paleozoic assemblages of greenstone, chert, clastic and ultramafic rocks (Slide Mountain Terrane), and outlined a model for their thrusting in mid-Jurassic to Early Cretaceous time over autochthonous strata of North America (Cassiar Terrane). The Sylvester rocks are preserved in the core of the gently southeasterly plunging McDame synclinorium that overlies Lower Cambrian to Permian autochthonous rocks of Cassiar Terrane, mainly Ingenika, Atan, Kechika and Road River Group rocks. To the west of the synclinorium are Cretaceous granitic rocks of the Cassiar Batholith (Figure 2).

Detailed studies of stratigraphy, structural style and tectonic history of the Sylvester allochthon are discussed by Harms (1989) and Nelson and Bradford (1989). Geological mapping is presented on maps by Harms *et al.* (1989) and Nelson *et al.* (1989). This and other recent work is summarized in Nelson and Bradford (1993). They describe the Sylvester allochthon as having three structurally stacked divisions. Division I, the lowest, is primarily a sedimentary sequence that is similar to Earn Group rocks and overlying Mississippian to Early Permian chert and argillite of the Cassiar Terrane. The middle, Division II, is an ophiolitic assemblage comprising fragments of oceanic, ultramafic-gabbroic basement and stratified early Mississippian to Early Permian sequences of interbedded basalt, sediments and diabase intrusions. The sequences of basaltic flows and tuffs in this unit are characteristically interbedded

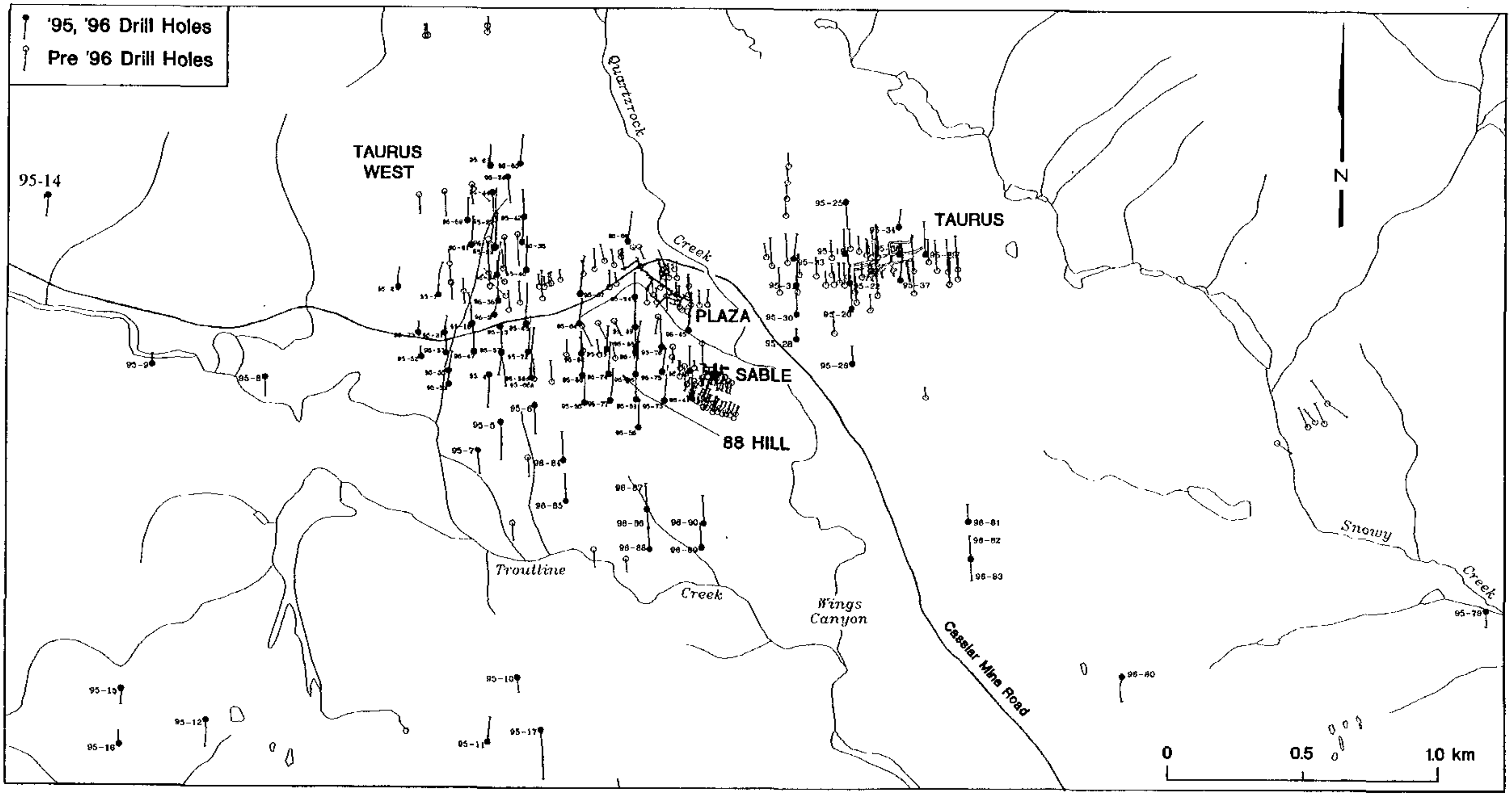

Figure 3. Locations of drill holes and adit sites, Taurus property. The location of underground workings (Taurus, Plaza, Sable adits) and drill hole pattern indicate the distribution of the main gold mineralized areas.

with siliciclastic rocks. Triassic sediments form a discrete map-unit within this division. The Triassic rocks occur above thrust planes at the highest structural level of Division II. The Division III rocks comprise a late Paleozoic island-arc unit that resembles Yukon Tanana and Harper Ranch Terrane assemblages. The unit consists of three distinct suites of volcanic, epiclastic and sedimentary rocks and at least two Paleozoic plutons. According to Nelson and Bradford, igneous rocks of Divisions II have mid-ocean ridge geochemical signature and are chemically distinct from rocks of Division III which have an island arc signature.

The Cassiar batholith intrudes stratified units of Cassiar Terrane to the west of the Sylvester rocks. The batholith has been considered to be a single intrusive mass about 100 Ma in age, based mainly on radiometric dating done by the Geological Survey of Canada. These K-Ar cooling data, as well as the roughly 130 Ma age of quartz vein mineralization, are summarized by Sketchley (1986) and Sketchley *et al.* (1986). Christopher *et al.* (1972) identified younger rocks of the Cassiar batholith along the east side of the intrusion. The younger phase called the Cassiar stock or Troutline Creek quartz monzonite by Panteleyev (1983) is about 72 Ma in age. Another younger suite of granitic stocks recognized by Christopher, and co-workers, is 50 Ma in age. These small intrusions near Reed and Haskin Mountains, approximately 20 kilometres east of Cassiar, contain molybdenum-bearing quartz stockworks and have associated base metal skarn mineralization.

DEPOSIT GEOLOGY

The Taurus veins are hosted by massive to pillowed basaltic flows belonging to the middle structural unit of the Sylvester allochthon. The basalts, referred to as map-units IIb and IIPPvs by Nelson and Bradford (1993), are Permian or older in age. The basaltic rocks are the most widespread unit and crop out over most of the Taurus property. They are present in the collar of every 1995 and 1996 drill hole shown on Figure 3, except the most remote southeast drill hole (T96-80), which was started in graphitic argillite. Chert, siliciclastic rocks and graphitic argillite underlie the basaltic rocks and form the ridges in the northeast part of the property to the east and northeast of Snowy Creek (Figure 3). All major rock units strike northwesterly in the property area and dip southwesterly. The siliceous rocks on the northeast ridges, and their overlying basalt units, dip moderately to steeply southwest but in the Taurus mine area, and further to the west, the rocks seem to be relatively flat lying.

The basalts now consist of uniform, aphanitic grey-green to dark green greenstone with mainly flow and lesser diabasic (subvolcanic) intrusive and locally volcaniclastic origins. Pillows, rare amygdules and relict fragmental textures are locally preserved primary structures. Chloritic fracture fillings and streaks are common and rarely impart a weak foliation. At depth in many drill holes jasperoid nodules a few to tens of centimetres in size are present sporadically throughout the basalt. The nodules, probably in pillow interstices, are composed of mainly orbicular to massive red chert but magnetite is also present. Where it is abundant it can impart a mesh to intersertal fabric to the jasperoid nodules. This magnetite-rich jasperoidal chert basalt forms a subunit at depth in the basalt sequence. It consistently underlies the massive pillowed basalts in the 88 Hill area, and undoubtedly elsewhere on the property. The jasperoidal basalt has a pronounced magnetic geophysical response.

In thin section (Read and Psutka, 1983) little remains of the original basalt mineralogy and fabric beyond outlines of relict, fine grained to sparsely porphyritic plagioclase and augite grains. Metamorphic minerals are chlorite, actinolite, clinozoisite-epidote, carbonate, albite and rare stilpnomelane, muscovite, iron-rich pumpellyite and quartz. Read and Psutka have recognized scattered dark green diabase, meta-gabbro and quartz diorite bodies in the volcanic rocks. These rocks are similar in colour and weathering characteristics to the volcanic rocks but lack pillows, are slightly coarser grained and generally are not carbonate altered.

The metasedimentary sequence in the northeast part of the property, and at depth in drill holes in Taurus mine area, consists of chert, phyllitic chert, siliceous phyllite and graphitic argillite. The rocks are Pennsylvanian/Permian in age based on microfossils (conodonts) in samples taken two kilometres southeast of the mine by J.F. Psutka in 1983 and reported on by M.J. Orchard *in* Nelson and Bradford (1993). One sample of pale grey-green chert is Late Carboniferous (Pennsylvanian) and the other, a grey bedded chert and argillite, is Late ? Carboniferous (Pennsylvanian) in age. In outcrop these rocks are massive to thin-bedded with thin phyllitic layers separating cherty beds between one and three centimetres in thickness. In thin section predominant quartz, 0.02 millimetres or less in size, is accompanied by muscovite, minor chlorite and 'dustings' of carbonaceous material.

Triassic sedimentary rocks, the Table Mountain sediments (unit IITRTMS) of Nelson and Bradford, 1993), crop out along the southernmost part of the property along Highway 37 west of Troutline Creek, south on Table Mountain, and to the north on McDame Mountain. The sequence of thin bedded slaty siltstone, sandstone and calcareous mudstones forms thin klippen that overly the pillowed basalt unit. Locally the base of this map unit has a listwanite (quartz-carbonate-fuchsite) alteration assemblage, presumably derived from thin structurally emplaced slivers of ultramafic rock, but some of the carbonate-mica alteration extends into the Triassic sedimentary rocks as well.

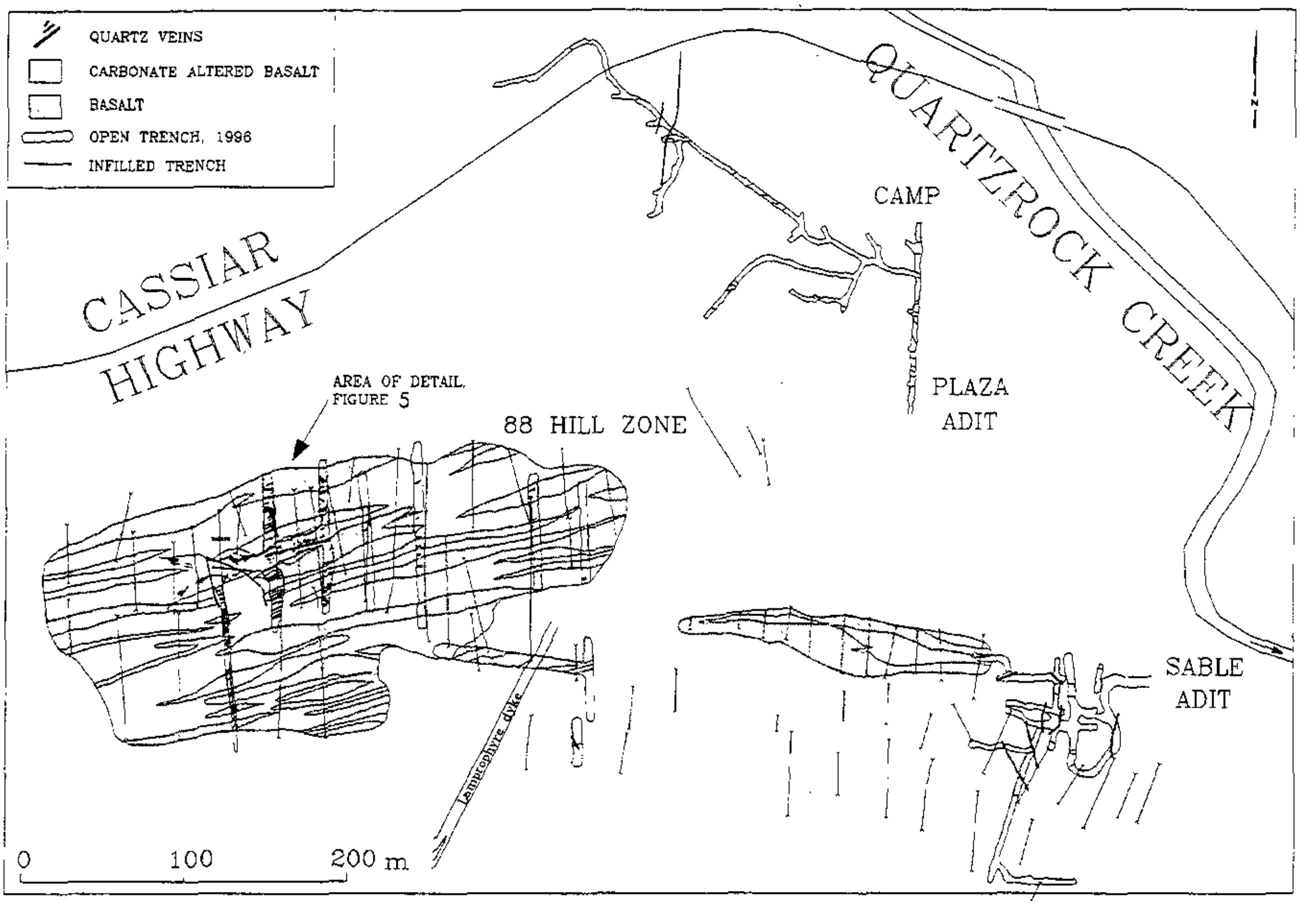

Figure 4. Generalized alteration patterns in trenched areas in the 88 Hill zone showing relationships between unaltered and carbonate altered basalts, after company plans. Sampling data are shown on Figure 5.

Lamprophyre and dioritic dikes, from less than 1 to 5 metres in thickness, trend northerly or east-west and are abundant in the Taurus mine area. The lamprophyre dikes crosscut both the quartz veins and their carbonate-altered alteration envelopes. The lamprophyres are classified by Read and Psutka (1983) as spessartite or camptonite on the basis of their augite or titanaugite phenocryst compositions. They also contain abundant biotite, some amphibole, a metamorphic assemblage or amygdales with albite, orthoclase, calcite, chlorite, prehnite, and abundant accessory apatite. Lamprophyre dikes locally contain a few scattered grains of quartz but can have up to 30 per cent granitic xenoliths. The inclusions are commonly rounded and range from less than a centimetre to a metre in size. Two granitic types are present. The more common type is a pink porphyritic granite with embayed and partly resorbed quartz phenocysts up to 6 millimetres in size in a matrix of plagioclase, orthoclase, fine grained quartz and accessory chlorite, stilpnomelane and allanite. It closely resembles lithologically similar pink granitic rocks of the 72 Ma Cassiar stock. The less common clast type is a dark grey, porphyritic granodiorite with abundant coarse grained amphibole.

A structural study in the mine area by Read and Psutka (1983) confirms that polyphase deformation has taken place in the region, based mainly on the presence of folded foliations. Beds in the metasedimentary map units strike northwesterly and have moderate southwesterly dips with steeply southwest dipping to vertical axial-plane foliation. In greenstone foliation is developed only here and there. Mesoscopic and minor fold axis orientations indicate that the rocks lie on the southwest limb of a gentle northwesterly plunging antiform. Faulting described by Read and Psutka (1983) and Gunning (1988) defines four main trends. The sequence, from oldest to youngest, consists of northwest-trending, gently dipping (thrust) faults, and east to east-northeast striking and steeply south dipping, northwesterly subvertical, and northerly with moderate to steep easterly dipping faults. The first two fault sets apparently formed during emplacement of the Sylvester allochthon and the east-northeasterly faults provided sites for quartz vein development; the latter two sets offset the quartz veins and cut the east-northeast faults and lamprophyre dikes.

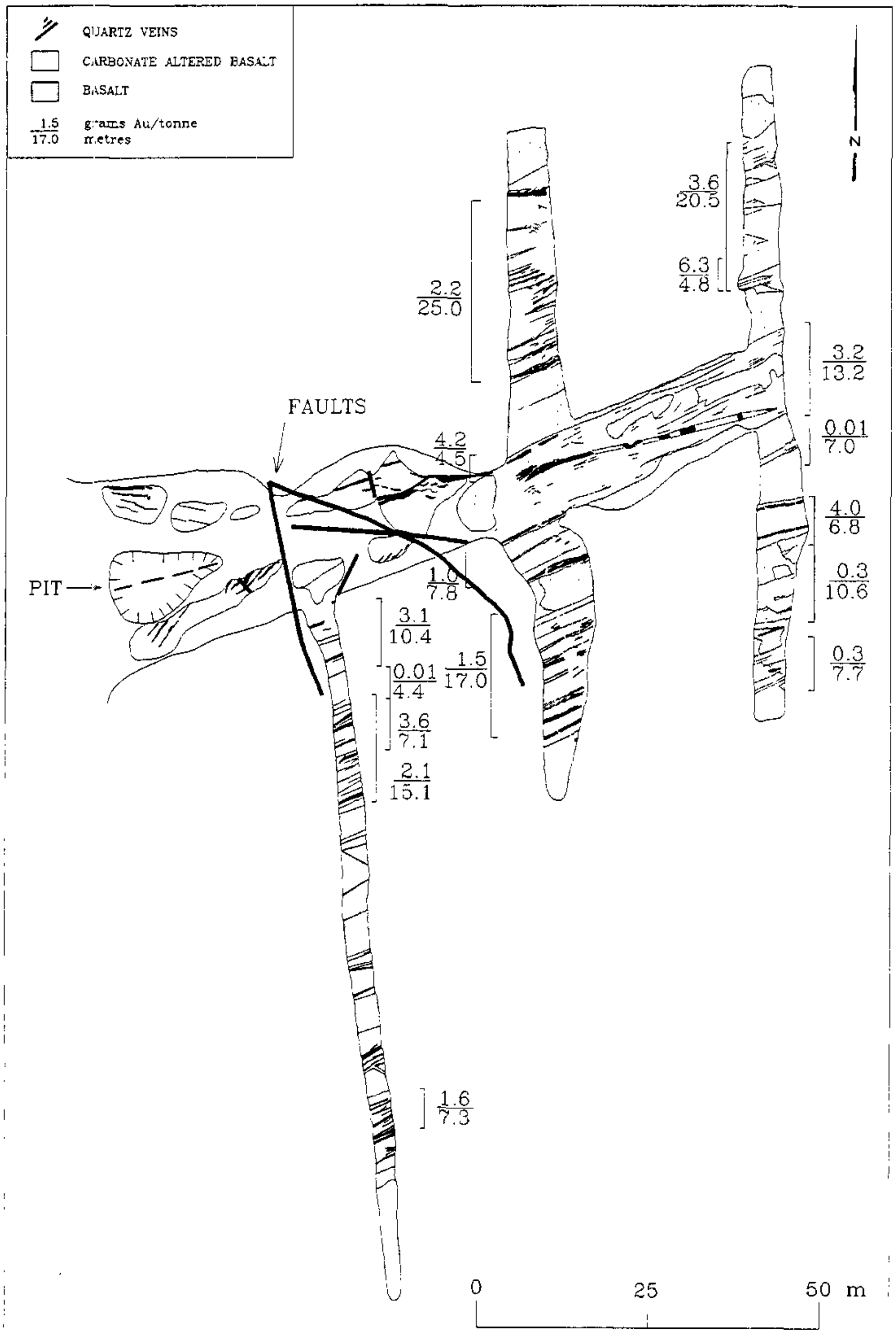

Figure 5. Detail of selected 1996 trenches in western 88 Hill zone shown on Figure 4, illustrating quartz vein distribution, alteration patterns and gold assay data; modified from company plans.

MINERALIZATION

Gold mineralization occurs in the hostrock basalts in two styles - in quartz veins and pyritic replacement zones. In the 88 Hill and Taurus mine area the gold vein mineralization bottoms at an average depths of about 100 metres against a flat lying to shallow dipping chert unit that is separated from the overlying basalt sequence by a thrust-faulted contact. The cherts contain few quartz veins, little pyrite, and are of no apparent economic interest. The mineralized zones are cut locally by lamprophyre dikes and by northwest trending faults with small displacements.

Most of the gold is found in zones of pyritic quartz in the larger quartz veins within the pyritic bleached, carbonate altered zones that are commonly between 2 and 30 metres in width. The veins strike roughly east-west and dip steeply; individual quartz veins are rarely more than 30 centimetres wide, although locally thicker vein and large quartz knots are present. Most veins are lenticular in shape, with strikes of a few metres at best, and they commonly display typical sinuous, sigmoidal and small-scale cymoid loop geometries with bifurcating and horsetailing or, less commonly, sharp wedge-like terminations. Closely spaced, parallel, stacked arrays of veins are typical, commonly with en-echelon patterns at vein terminations. The quartz veins occupy from about 5 to 15 per cent of the altered zones within the carbonate-altered basalts. The veins contain mostly milky white quartz in coarse to fine-grained crystalline intergrowths. There are rare, vuggy patches in the veins with clear crystalline quartz and clear crystal terminations that form the coarsest-grained parts of the veins. Carbonate minerals (ankeritic to dolomitic carbonate) in quartz veins generally form discrete grains up to two centimetres in size, or finer grained crystal intergrowths with quartz, commonly at or alongside vein margins. The carbonate characteristically weathers to a bright orange-red, powdery, amorphous limonite. Other minerals in the veins are small amounts of pyrite, chalcopyrite, tetrahedrite, sphalerite, rare galena and gold; locally seams and fracture fillings have fine grained, flaky, pearly-lustrous sericite. Chlorite can be present in the margins of quartz veins, and locally, black tourmaline (schorlite) is present in abundance in the veins. The wallrock alteration of basalt produces a dense, massive bleached rock with euhedral pyritohedrons that vary from fine grained up to one centimetre in size; they can constitute up to 10 per cent of the rock. Pyrite in the wallrocks is accompanied locally near vein margins by fine grained crystals of arsenopyrite. Ribs of barren, little-altered, dark green basalt occur between the carbonate altered and quartz veined zones. Mesoscopic alteration in the basalt is mainly dark green to black chloritic fractures that locally impart a reticulate hairline stockwork to the rock.

The second type of gold mineralization, the extent and economic importance of which has been recognized only recently at the Taurus West zone, is the disseminated to 'dusty' semi-massive to massive pyritic replacement mineralization in shear or fault zones. The pyrite forms between 10 to 40 per cent of the altered basaltic material, is generally very fine grained but locally is banded and contains narrow quartz veins; the veins are generally unmineralized. The overall distribution of the pyritic zone(s) appears to be in a panel of shallow east-dipping mineralization, similar in attitude to the enclosing thrust faults. The geophysical expression (induced polarization) suggests a northerly strike to the (Taurus West) mineralization at surface, probably following the outcrop expression of a fault zone with a gentle eastward dip, similar to underlying thrust faults. Trenching and drilling reveal that individual pyritic bodies within the mineralized panel occupy shear and fault zones that trend east-west and have steep dips, a geometry similar to the quartz veins systems elsewhere on the property. Similar pyritic material was noted in the lower level of the Taurus mine along the main decline where it forms a zone about 3 to 5 metres thick as an apparent replacement along a shallow-dipping thrust fault. The abundance of the auriferous highly pyritized material makes it an important exploration and economic target. More work is required to define the distribution and geometries of the pyritic bodies. Also additional metallurgical work is needed; preliminary bench tests using conventional milling and cyanide leaching methods suggest that the pyritic gold mineralization is refractory.

Gold Distribution

Most gold is associated with pyrite, mainly in quartz veins but also in the altered pyritic wallrocks. Some of the gold is present in the larger veins as coarse grains. The overall gold content of the altered zones, including the quartz veins contained in them, constitutes the bulk mineable resource. Some gold mineralization intersected in the 88 Hill areas illustrates some highlights of the 1995 drilling program. The results reported are: 1.42 grams gold per tonne over 54 metres; 1.59 grams gold per tonne over almost 55 metres; and 1.65 grams gold per tonne over 46 metre drill intercepts. Gold distribution and the relationships between altered zone and unaltered barren rocks are shown on Figures 4 and 5. In pyritic replacement zones at Taurus West some of the better 1995 drill intercepts contained 2.47 grams gold per tonne over 86 metres, 1.64 grams over 44 metres and 1.78 grams gold over 24 metres (Broughton, 1996).

A study of gold distribution in the (narrow) veins from the Taurus mine workings by Gunning (1988) illustrates the distribution of gold and the variations between quartz veins, their sulphide-rich margins and the alteration halos. For the seven veins studied by Gunning, average quartz vein widths are 50 centimetres, vein margins almost 10 centimetres and alteration halos about 41 centimetres. The weighted mean gold content over the total width of about 100 centimetres is 3.81 grams per tonne. The quartz vein centres with 1.81 grams gold per tonne contain 24 per cent of the gold, the alteration halos with 2.2 grams gold per tonne contain 23 per cent, and the remaining 53 per cent of the gold occurs in the sulphide-rich vein margins. The 1995 and 1996 trench samples shown on Figures 4 and 5 illustrate similar patterns of gold distribution, but over much wider zones of carbonate alteration that contain more closely spaced quartz veins within them.

Pyritic mineralization, probably similar to the West Taurus pyritic zone, was studied by Gunning (1988) and sampled where it was exposed in the Taurus mine decline at the 3300 level. This mineralization is part of a 15 metre-thick alteration zone that has formed along a north-northwest striking, moderately east dipping reverse fault in the hanging wall, and parallel to, the basal thrust fault at the underlying basalt-chert unit contact. Within the sheared, brecciated and clay-chlorite-graphite altered zone there is a 3 metre thick massive pyrite to highly pyritic auriferous zone. Sampling returned assay values of 2.06 grams gold per tonne from the upper half of the zone, and 15 grams per tonne from the lower part.

DEPOSIT MODEL

A general model for 'mesothermal' gold-quartz veins applicable to the Cassiar gold deposits proposes that the veins form where abundant fluid flow has been focused in structurally complex zones especially where thick, competent volcanic blocks are present in alternating sequences of competent/less competent rocks. Also chemical precipitation is induced by wallrock-fluid reactions. This commonly occurs in basaltic sequences, notably where there are also ophiolitic rocks that are tectonically emplaced along major crustal breaks, and where high Fe/Fe+Mg rock compositions facilitate gold precipitation by sulphidation of the wallrocks. This setting for gold-quartz vein mineralization is similar to other greenstone belts throughout the world. Ash *et al.* (1996; in preparation) present a similar tectonically influenced model for ophiolite-related (mesothermal) gold mineralization in the Cordillera. Their model suggests that the Cassiar veins are mesothermal type, are related to tectonic activity during emplacement of the Sylvester allochthon, and they could be as old as 170 Ma in age.

Most other workers in the Cassiar district, including Read and Psutka (1983) at Taurus mine, have used conventional structurally influenced mesothermal vein models to interpret the Cassiar quartz vein mineralization. This model suggests that the east-northeasterly striking faults and joints that contain most of the auriferous quartz veins developed during the (mid-Jurassic to early Cretaceous) emplacement and deformation of the allochthon. The other related veins and pyritic auriferous bodies formed in the faults and subparallel structures separating the thrust sheets. The gold mineralization is post-Triassic because the Triassic rocks are hydrothermally altered and apparently acted as an effective chemical and physical barrier that localized the veins.

However, the style of mineralization in mesothermal districts related to major, crustal-scale fault zones can produce large vein systems in which quartz veins have large vertical extent, for example the California Motherlode or Bralorne districts. In contrast, the Cassiar veins occur in relatively small fracture zones with short strike length and limited vertical extent. More germanely, Nelson and Bradford (1989) have identified the main problem with a conventional mesothermal vein origin for the Cassiar district. They observe: '*The pattern of east-west veins at Taurus mine area in an overall regional north-south distribution of quartz veins in the Cassiar belt does not fit the configuration of en echelon fracture sets and extensional dilations formed during strike-slip motion on the northwest-trending large faults in the area. Similarly compression during emplacement of the Cassiar batholith that might have generated large scale joint and fracture zones occurred at approximately 100 Ma and therefore appears to post date the age of vein development by about 25 Ma.*'

The alternative proposal offered by Nelson (1990) is that the gold mineralization is intrusion-related and is associated with a cryptic intrusion. If indeed there is a genetic relationship between gold mineralization and a cryptic intrusion, then the age of that intrusion should be about 130 Ma, the same as the apparent age of the vein mineralization. K-Ar dating of alteration minerals provides apparent mineralization ages of 137 Ma at Taurus mine and dates of 112, 122 and 127 Ma from Erickson Gold mine (Sketchley, 1986). Panteleyev and Diakow (1982) report a 131 Ma K-Ar date on sericite from a Snowy Creek quartz vein; similar-looking, tourmaline-bearing quartz vein material from Quartzrock Creek near the Sable adit portal has returned a 131 Ma $Ar^{40/39}$ plateau age (Chris Ash, personal communication, 1996). The lamprophyre dikes in the region are observed to cut the quartz vein mineralization. K-Ar dating of a lamprophyre dike in the Huntergroup and Pooley Creeks area, near Needlepoint Mountain has returned an age of 110 Ma from the biotite-rich dike. Nelson and Bradford (1990) report a 77.6 Ma age from a dike at Erickson Gold mine and a 63.7 date from a granite clast-bearing dike in the Berubé vein prospect. In order to further investigate the relationships between intrusive rocks and the gold mineralization, samples of hydrothermal micas from veins in the Taurus area have been submitted for

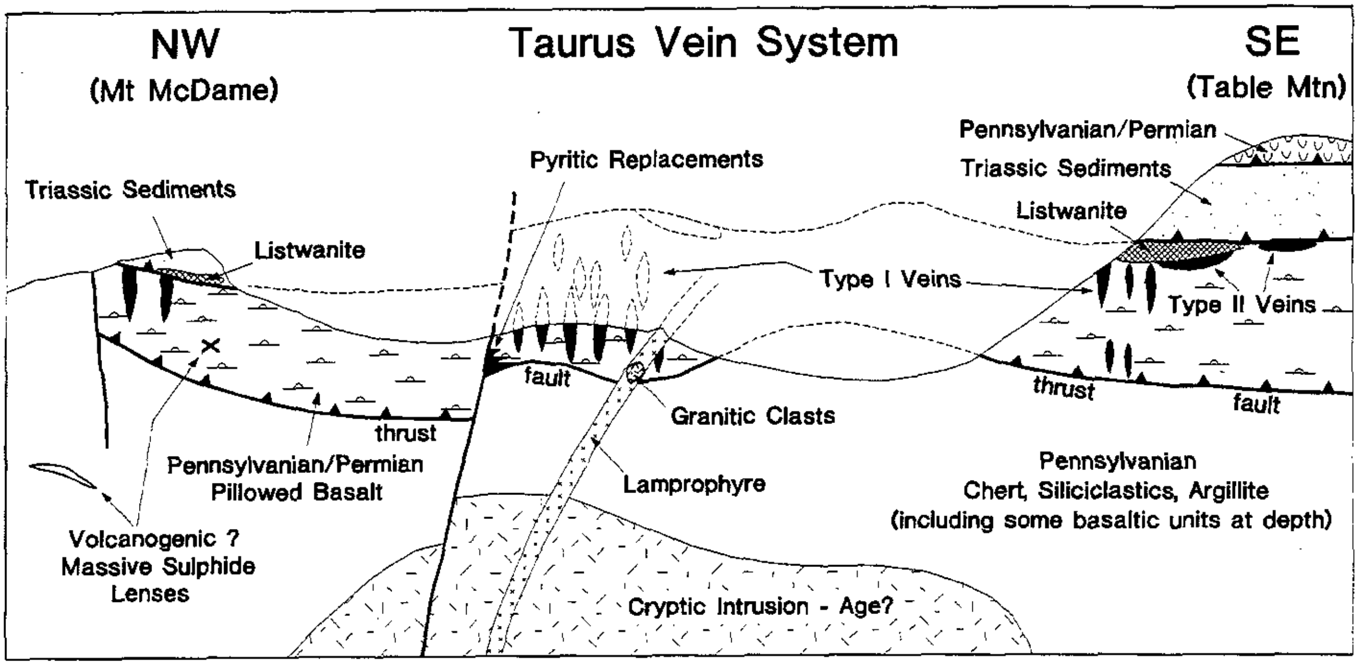

Figure 6. Schematic model for gold mineralization in the Cassiar district showing relationship between Type I steep, volcanic-hosted veins and Type II ribboned, carbonaceous veins at volcanic-sediment contacts, commonly thrust faults, with listwanite alteration. A hypothetical cryptic intrusion (Nelson, 1990) is shown, as suggested by the presence of granitic clasts in lamprophyre dikes that cut mineralization.

additional dating by $Ar^{40/39}$ and conventional K-Ar methods. Also some intrusive rocks and two samples of the granitic clasts in lamprophyre dikes in the Taurus mine area have been submitted for U-Pb zircon work.

A schematic model showing the distribution of quartz veins in basaltic rocks, with a classification of veins according to Panteleyev and Diakow (1982) as Type I and Type II veins, is shown on Figure 6. The figure shows a hypothetical intrusive body, the cryptic intrusion of Nelson (1990), that might underlie the Cassiar gold deposits and is in evidence as clasts in lamprophyre dikes that cut the auriferous quartz veins. If the age of the intrusion is the same as the apparent 130 Ma age of mineralization, there could be a genetic connection between it and the veins. If the intrusion post-dates the veins, the relationship is simply a structural one in which the intrusion has uplifted the veins, notably in the Taurus mine area where the underlying cherty rocks are near surface.

As matter of additional interest to exploration geologists, it is noteworthy that a drill intersection in basalts (drill hole T96-14) cut an approximately 1 metre-thick cupriferous, pyrrhotite-bearing massive pyritic body (or vein ?). Other massive sulphide mineralization occurs at Lang Creek (MINFILE 104P 008) in sedimentary rocks at the base of the Sylvester allochthon. The potential for volcanogenic massive sulphide mineralization in Sylvester rocks has not been extensively tested.

ACKNOWLEDGMENT

Appreciation is expressed to Geoff Sinnett for assistance in the field, for map information capture, digital data management and drafting of Figures 3, 4 and 5. The access to all Cyprus Canada Incorporated drill logs and other geological information, and the use of the Quartzrock Creek camp as well as the hospitality of Cyprus Canada and International Taurus geologists in the field are acknowledged. Bruce Spencer and Bill Howell, International Taurus Resources Limited, and Mike Glover and Leslie Hunt [formerly Mortimer], Cusac Gold Mines Limited, provided invaluable discussion, access to samples and information. Discussions with Chris Ash and the use of his unpublished figure and some of his information are acknowledged. Mike Fournier adeptly drafted and edited Figures 1, 2 and 6.

REFERENCES

Ash, C.H., Reynolds, P.R. and Macdonald, R.W.J. (1996): Mesothermal Gold-Quartz Vein Deposits in British Columbia Oceanic Terranes; *in* New Mineral Deposits Models of the Cordillera; *B.C. and Yukon Chamber of Mines*, 1996 Cordilleran Roundup Short Course, Vancouver, B.C., pages O1-32; and *Northwest Mining Association*, 1996 Short Course, Spokane, WA., pages Q1-32.

Ash, C.H., Macdonald, R.W.J. and Reynolds, P.R. (in preparation): Ophiolite-related Mesothermal Lode Gold in British Columbia: A Deposit Model; *British Columbia Ministry of Employment and Investment*, Bulletin.

Bakke, A.A. (1995): The Fort Knox 'Porphyry' Gold Deposit - Structurally Controlled Stockwork and Shear Quartz Vein, Sulphide-Poor Mineralization Hosted By a Late Cretaceous Pluton, East-Central Alaska; *in* Porphyry Deposits of the Northwestern Cordillera of North America, T.G. Schroeter, Editor, *Canadian Institute of Mining and Metallurgy*, Special Volume 46, pages 795-802.

Broughton, David (1996): Geology of the Taurus Gold Project; *British Columbia and Yukon Chamber of Mines*, Cordilleran Roundup 1996, Program with Abstracts.

Christopher, P.A., White, W.H., and Harakal, J.E. (1972): Age of Molybdenum and Tungsten Mineralization in Northern British Columbia, *Canadian Journal of Earth Sciences*, Volume 9, pages 1727-1734.

Diakow, L.J. and Panteleyev, A. (1981): Cassiar Gold Deposits, McDame Map-area (104P/4,5); *in* Geological Fieldwork 1980, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1981-1, pages 55-62.

Gordey, S.P., Gabrielse, H. and Orchard. M.J. (1982): Stratigraphy and Structure of Sylvester Allochthon, Southwest McDame Map Area, Northern British Columbia; *in* Current Research, Part B, *Geological Survey of Canada*, Paper 82-1B, pages 101-106.

Gabrielse, H. (1963): McDame Map-Area, Cassiar District, British Columbia; *Geological Survey of Canada*, Memoir 319, 138 pages.

Gunning, M.H. (1988) Cornucopia (Taurus Mine), Gold Distribution in the Taurus Mine Quartz Veins; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Exploration in British Columbia 1987, pages B95-B105.

Harms, Tekla (1989): Geology of the Northeast Needlepoint Mountain and Erickson Mine Areas, Northern British Columbia; *in* Geological Fieldwork 1989, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1990-1, pages 339-345.

Harms, T., Ball, M., Fischer, P. and Nelson, J. (1989): Geology of the Needlepoint Mountain Map Area; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-19, 1:25 000 map.

Hitchins, A.C. and Orssich, C.N. (1995): The Eagle Zone Gold-Tungsten Sheeted Vein Porphyry Deposit and Related Mineralization, Dublin Gulch, Yukon Territory; *in* Porphyry Deposits of the Northwestern Cordillera of North America, T.G. Schroeter, Editor, *Canadian Institute of Mining and Metallurgy*, Special Volume 46, pages 803-810.

Holland, S.S. (1950): Placer Gold Production of British Columbia, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Bulletin 28 (reprinted in 1980), 89 pages.

Nelson, J. (1990): Evidence for a Cryptic Intrusion Beneath the Erickson-Taurus Gold-Quartz Vein System, Near Cassiar, B.C. (104P/4,5): *in* Geological Fieldwork 1989, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1990-1, pages 229-233.

Nelson, J.L. and Bradford, J.A. (1989): Geology and Mineral Deposits of the Cassiar and McDame Map Areas, British Columbia (NTS 104P/3,5) *in* Geological Fieldwork 1988, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1989-1, pages 323-338.

Nelson, J.L. and Bradford, J.A. (1993): Geology of the Midway-Cassiar Area, Northern British Columbia (104O, 104P); *Ministry of Energy, Mines and Petroleum Resources*, Bulletin 83, 94 pages.

Nelson, J., Bradford, J., McLean, M. and Maddison, L. (1989): *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1989-9, 1:25 000 map.

Panteleyev, A. (1983): Cassiar Map-Area (104/4,5); *in* Geology in British Columbia 1977-1981; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Geology in British Columbia, pages 188-190.

Panteleyev, A. and Diakow, L.J. (1982): Cassiar Gold Deposits, McDame Map-area; *in* Geological Fieldwork 1981, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1982-1, pages 156-161.

Read, P.B. and Psutka, J.F. (1983): Surface Geology, Taurus Mine, Cassiar B.C.; Unpublished Company Report for Trenaman, Spencer and Associates Limited, *Geotex Consultants Limited*, 31 pages and appendices.

Sketchley, D.A. (1986): The Nature of Carbonate Alteration in Basalt at Erickson Gold Mine Cassiar North-Central British Columbia; unpublished M.Sc. thesis, *The University of British Columbia*, 272 pages.

Sketchley, D.A., Sinclair, A.J., and Godwin, C.I. (1986): Early Cretaceous Gold-Silver Mineralization in the Sylvester Allochthon, Near Cassiar, North Central British Columbia; *Canadian Journal of Earth Sciences*, Volume 23, pages 1455-1458.

Smit, H., Sieb, M. and Swanson, C. (1996): The Dublin Gulch Intrusive-Hosted Gold Deposit; *in* New Mineral Deposits Models of the Cordillera; *B.C. and Yukon Chamber of Mines*, 1996 Cordilleran Roundup Short Course, Vancouver, B.C., pages K1-13 and *Northwest Mining Association*, 1996 Short Course, Spokane, WA., pages F1-13.