Shan Deposit, East-Central British Columbia (NTS 103I/09): An Emerging Deposit Model

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INTRODUCTION

While no mineral deposit looks exactly like another, and none entirely follows the classic textbook models, molybdenum deposits seem to be even more individualistic. Likewise, true exploration case histories are rarely tidy. Our work to date at Shan is a work in progress, in terms of both finding a model for it and determining the exploration techniques most suited to investigating it. The following history may serve as an example of what worked and what did not, and will concentrate on the Shan South part of the property, where the Las Margaritas zone is substantially mineralized and largely intact.

GENERAL

The Shan property is located 20 km north-northeast of Terrace, British Columbia and is close to existing road, rail, power and port infrastructure. Logging roads enter the central part of the property along the north sides of Shannon Creek and Hardscrabble Creek. BCM Resources Corp. obtained a 100% interest in the property, then comprising six claims (112 hectares), from N.C. Carter in June 2005. It has since been expanded to 7604.5 hectares (Figure 1).

The topography of the Shan North and South prospects includes two ridges featuring relatively gentle terrain on ridge tops that are bounded by steep flanks, and more rugged terrain on the north side of Hardscrabble Creek in the area referred to as the McRea claims. A series of four creeks drains eastward into the Skeena River. Bedrock exposures occur principally in drainages and as scattered outcrops on ridge crests, although outcrop is more abundant north of Hardscrabble Creek in the McRea sector.

Molybdenum mineralization identified to date is located in three zones at Shan South (Las Margaritas zone, Camp zone and Triangle zone) and in the Banana Lake corridor at Shan North.

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GEOLOGICAL SETTING

Regional Geology

The Shan property is underlain largely by granite to granodiorite of the Eocene Carpenter Creek pluton, an eastern lobe of the Coast plutonic complex. The Carpenter Creek pluton, with a U-Pb date of 53 Ma on a zircon, underlies an area of >1000 km^2 and includes large areas of homogeneous granodiorite, tonalite and granite (Nelson et al., 2006). These granitic rocks intrude the Kitselas facies of the Lower Jurassic Telkwa Formation, the lowest unit of the Jurassic Hazelton Group. Kitselas rocks consist of a lower coherent rhyolite unit and an overlying volcaniclastic unit, as well as some thin (60–220 m) basalt horizons. All units are cut by later intermediate to mafic dikes and narrow (generally <1 m), pink, fine-grained aplitic dikes.

Property Geology

Molybdenum mineralization is hosted mainly by the intrusive rocks (hereafter referred to as 'granodiorite'), generally near the contact with the Hazelton volcanic rocks (Figure 2). Blocks of altered volcanic rock of intermediate composition, thought to be roof pendants or large xenoliths, also host significant mineralization locally, but most of the volcanic rocks appear to be only weakly mineralized and may mask underlying mineralization.

The Carpenter Creek pluton, as exposed on surface and in drillcore, is generally a medium-grained granodiorite with biotite as the major mafic mineral. The rock is generally hydrothermally altered and details of its original composition are obscured, making delineation of phases difficult. A somewhat coarser and possibly more potassic phase was drilled at depth in some holes. Given the extensive potassic alteration of the coarser phase where it was drilled, it is uncertain whether the original composition differed from that of the rest of the pluton.

The volcanic rocks are generally found as float on the surface and are best seen in drillcore. Textures vary from aphanitic to porphyritic, with plagioclase crystals up to a centimetre in length. The rocks are commonly altered, but the original composition is interpreted to have been intermediate to mafic. The volcanic rocks are commonly found in one drillhole but not in adjacent ones, and may occur as roof pendants or large xenoliths. In some instances, these rocks may be shallow intrusions. Rhyolitic rocks with textures typical of the upper Kitselas facies are found in some drillholes and surface exposures, but they generally occur in marginal areas away from significant mineralization. Contact metamorphic effects are not apparent.

Structural features include a north-northwest-striking strike-slip fault, along which a postmineralization dis-

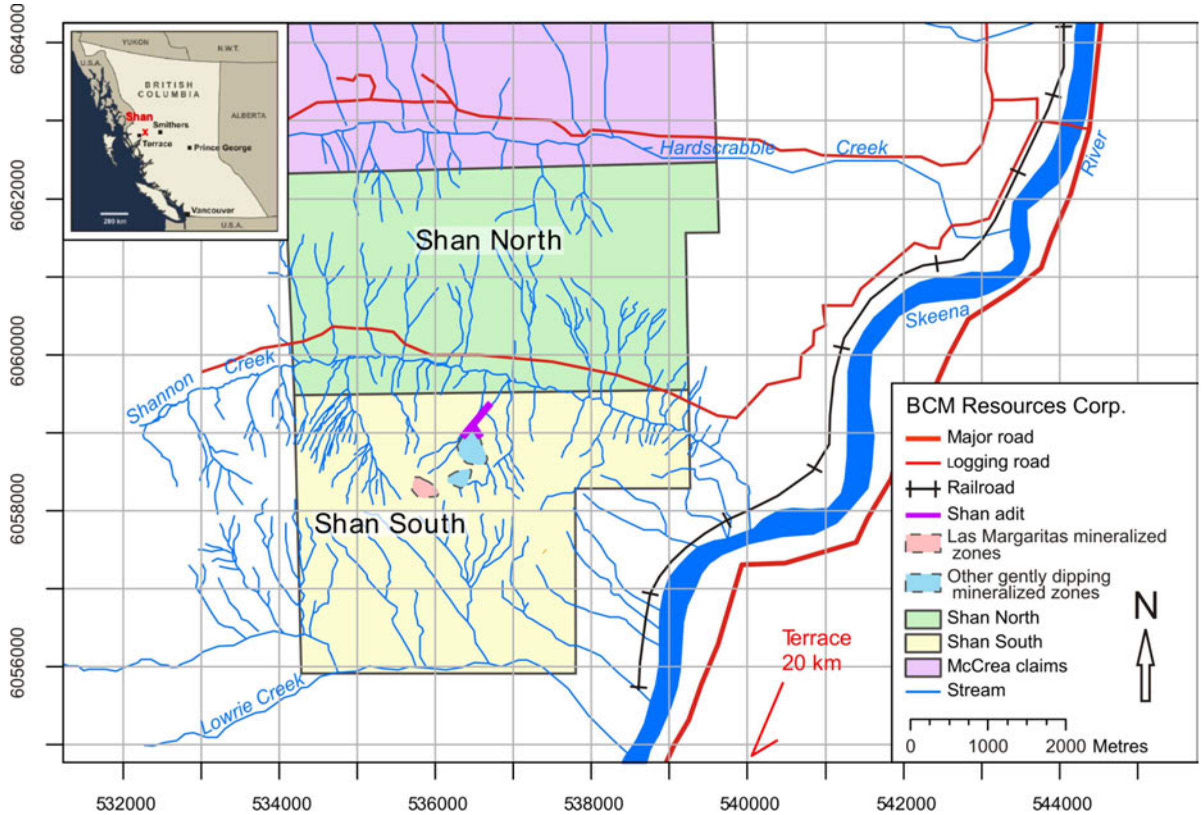

Figure 1. Location of the Shan South part of the BCM Resources Corp. property.

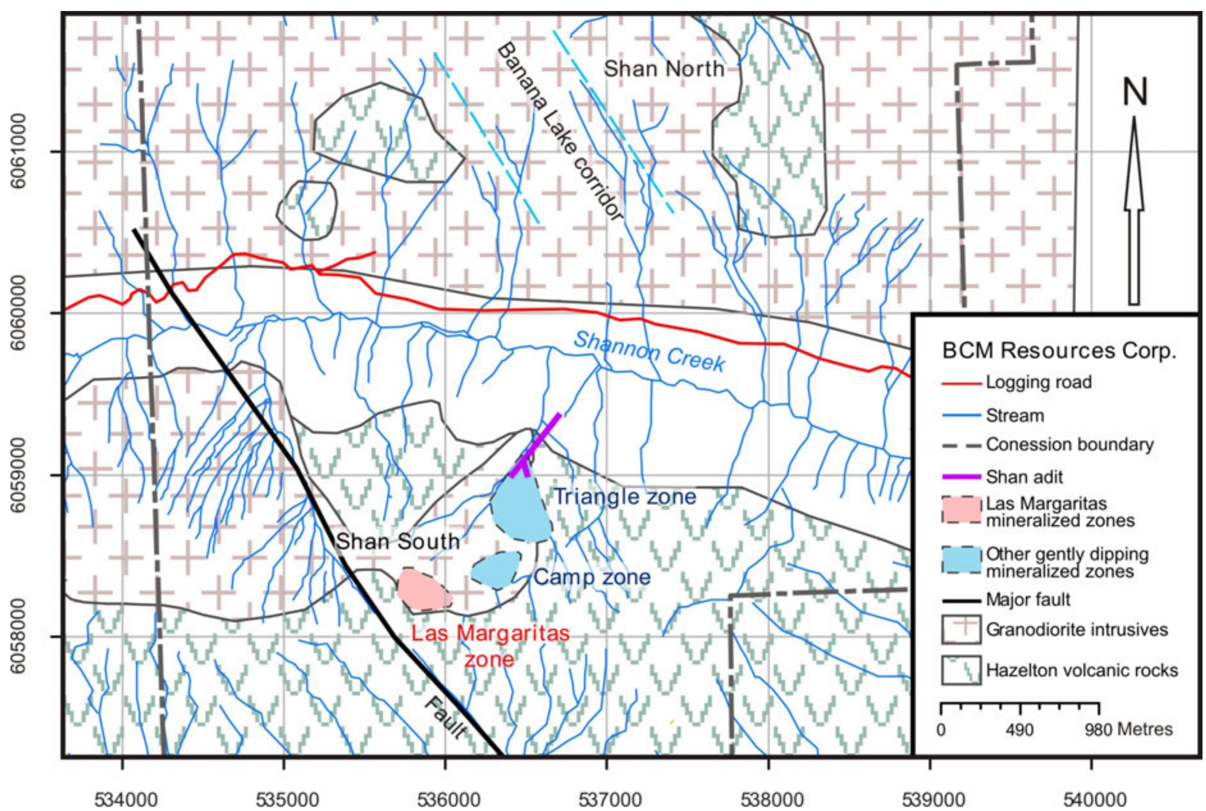

Figure 2. Geology of the Shan South property. Adapted from Nelson et al. (2006) and Riocanex 1:10 000 scale geological map, with modifications based on recent mapping.

placement of ~1 km is suggested from offset of modelled aeromagnetic data patterns. There may also be other faults featuring lesser displacement, such as a possible north-northeast-striking fault along Molybdenum Creek (unofficial name), the site of the historical Shan adit (Figure 2). This and other possible structures have been inferred from topographic breaks and linear depressions, and from observations of some drillholes and bedrock exposures. Both steeply dipping, brecciated, north-northeast- and north-northwest-striking veins and gently northeast-dipping sheeted veins have been observed on the property.

Several faults were intersected in drillholes. Some of these host Mo mineralization, while others appear to truncate mineralized zones. These generally occur as zones of fault gouge ranging up to several metres in width, but the sense and magnitude of displacement cannot be determined.

Molybdenum Mineralization

Molybdenum mineralization is principally in the form of molybdenite and is commonly found associated with quartz veins, generally in sheeted veins with densities of up to several veins per metre of core length. Veins range in width from a few millimetres to several metres, but most are no more than a few centimetres in width, and veins of greater widths are generally more weakly mineralized. Molybdenite also occurs as fracture coatings up to 1 cm thick without quartz, and locally as low-grade disseminations. Quartz-molybdenite veins may also contain pyrite, magnetite and hematite, in any combination of the three, and locally chalcopyrite as well.

A petrographic study of polished thin sections by Vancouver GeoTech Labs from a sample chosen for its variety of mineral phases reported the following (Vancouver GeoTech Labs, 2006):

> *"An early stage euhedral pyrite is now largely replaced by later hematite. This euhedral pyrite is followed by a later phase of more abundant anhedral pyrite lenses. The anhedral pyrite is cut by veinlets and fracture fillings of later chalcopyrite with bornite inclusions and calcite. The molybdenite appears to be late stage associated with sericite and spatially associated with the hematite replacement. Some of the hematite could be primary. The molybdenite is not associated with chalcopyrite and anhedral pyrite. Magnetite is only observed associated with chlorite development."*

Of the 2795 drillcore samples collected and analyzed by BCM Resources during its drill programs, 327 were at or above 0.06% Mo (maximum value of 2.80%), 56 contained 0.1% Cu or greater (maximum value of 1.74%), 39 contained 0.1% or more Zn (maximum value of 2%), 5 contained 0.1% or more Pb (maximum value of 0.27%), and 26 contained >10 ppm Ag (high of 299 ppm). There is little correlation between any of these elements, although Pb, Zn and Ag mineralization generally tend to occur together. Copper does not correlate with Mo, and high Mo assay values commonly occur in areas of low Cu, and vice versa. As can be seen in Table 1, high Cu values are more likely to occur in samples with Mo mineralization, but Cu can be nearly as abundant in low-grade Mo samples as high-grade ones, which is reflected in a decrease of the Mo:Cu ratio with increasing Mo grade. All mineralization appears to occur in the same general area, but the paragenesis is unclear, and the distribution of various elements may result from a number of factors. Notwithstanding this uncertainty, Mo is the most prevalent metal.

In 2008, a limited number of samples were assayed for Re content. Results indicate an average of 1 ppm Re for every 10 000 ppm Mo (i.e., sufficient to add economic value to the deposit). The Re content of the molybdenite is on the high end for Mo porphyry systems; in general, the higher the Re:Mo ratio, the more abundant the Cu (K. Krahulec, pers comm, 2008).

Anhydrite was observed in mineralized zones in several drillholes, and was initially misidentified as fluorite; three fluorine analyses were undertaken on previously submitted drill samples thought to contain fluorite and returned values of between 0.02 and 0.04% F. Riocanex reported values of up to nearly 0.5% F from their drillholes (Haynes and Knight, 1980).

Alteration

The typical alteration in the Las Margaritas zone is a mix of sericitic and potassic (K-feldspar), with local argillic. Potassic alteration is common along fractures and, in some cases, may overprint sericitic alteration, which is more pervasive. The strongest mineralization is commonly associated with sericitic alteration with or without a potassic overprint. Marginal to zones of better mineralization, molybdenite occurs in fractures and veins with potassic selvages, or in quartz veins and fractures in relatively unaltered hostrocks. Potassic and sericitic alteration are also present in areas devoid of molybdenite, although they are not commonly found together except in mineralized areas. Volcanic and related high-level intrusive rocks are commonly propylitized, although potassic alteration along fractures and argillic alteration within fault zones have been noted. Some late mafic dikes are essentially unaltered. An effort was made to identify a pattern in the various styles of alteration but none was found.

PREVIOUS EXPLORATION

First known as the Nicholson Creek and later as the Sak showings, quartz veins with pyrite and molybdenite were discovered south of Shannon Creek (formerly known as Nicholson Creek) prior to 1928. Exploration work completed by the Nicholson Creek Mining Company between 1934 and 1940 included an adit at an elevation of about 470 m, which was driven ~500 m in a south-southwesterly direction beneath a tributary of Shannon Creek known locally as Molybdenum Creek. The adit was excavated to explore for Au and Ag, which were not encountered, but Mo assays up to 0.42% were reported from small quartz veins (Kindle, 1937).

In the late 1960s, Kokanee Resources Ltd. blasted shallow trenches in the area of Shan South now referred to as the Camp zone, and subsequently completed 1650 m of diamond-drilling in 11 holes. This drilling program recovered small diameter (EX) core from shallowly inclined holes (N.C. Carter, pers comm, 2006). These holes encountered scattered Mo mineralization in all except one hole; modest intercepts in six holes included 50 m grading 0.065% Mo and 15 m grading 0.151% Mo.

Table 1. Comparison of Mo and Cu mineralization on the Shan South property.

Category	No. of Samples	Avg. Mo Grade (%)	Av Cu Grade (%)	Mo:Cu Ratio	High Cu Value (%)	Percentage of Samples >0.1% Cu	Correlation Coefficient Mo:Cu
0.1–2.8%	166	0.24	0.08	1:3	1.739	16	0.24
0.06–0.099%	161	0.07	0.035	1:2	0.596	4	0.02
0.01–0.059%	1253	0.02	0.02	1:1	0.794	1	0.15
<0.01%	1215	NA	NA	NA	0.363	1	NA

In 1971, New Gold Star Mines carried out soil sampling in the Shan South area, consisting of samples collected at 30 m intervals along lines spaced 125 m apart over 8.7 line-km of grid (Venkataramani, 1972). Soil samples were obtained using an auger and yielded up to 700 ppm Mo.

In 1975, International Shasta Resources Ltd completed a small program that included geological reconnaissance, stream sediment sampling and a fracture analysis study using aerial photos (Blanchet, 1975). Work was focused on the south side of the Shan South ridge, extending eastward nearly to the Skeena River. In addition to examining the Camp zone workings, the work identified two areas interpreted as having potential for Mo mineralization in granodiorite at shallow depth below relatively unmineralized volcanic rocks.

In 1979, Rio Tinto Canadian Exploration Ltd. (Riocanex) mapped and sampled Molybdenum Creek and its tributary, Calhoun Creek (unofficial name), and carried out 1:10 000 scale geological mapping over a broader area that included both the current Shan North and Shan South zones. A 60 line-km soil sampling survey was also completed over the mapped area and an experimental IP line was completed at Shan South (Haynes and Knight, 1980). The soil survey had a sample spacing of about 100 m along lines spaced 150 m apart over Shan South, and was a bit tighter over Shan North. This work was followed by 969 m of diamond-drilling in two inclined holes trending roughly east and west from the same collar on the north slope of the Shan South zone, immediately west of Molybdenum Creek. Reports indicate that the drillholes encountered narrow but occasionally high-grade intercepts of Mo mineralization. In 1980, Riocanex completed four additional IP lines around and to the north of the 1979 drillholes. The IP survey was hampered by steep terrain and, although it identified some anomalous areas, these were dismissed as having been tested by prior drillholes.

EXPLORATION BY BCM RESOURCES CORP.

Initial Work

BCM Resources Corp. commenced its exploration program with an aeromagnetic survey in November 2005, covering a 4.4 km^2 area about 2 km west and south of the Shan adit. The first fieldwork involved surface sampling and mapping on the Shan South ridge in the summer of 2006. Both the 1971 soil survey and the 1:10 000 scale geological and geochemical maps prepared by Riocanex in 1980 were used to identify potentially mineralized areas that were subsequently located and examined. While it was apparent early on that there was a correlation between anomalous Mo values in the 1971 soil survey and underlying mineralization, detailed prospecting and stripping of moss to find small mineralized outcrops was required. The limited bedrock exposure rarely allowed a clear determination of vein attitude. A series of steeply dipping mineralized zones was inferred, however, and initial drillholes were located to test the intersection of two major structures.

Several conclusions were drawn from this fieldwork. First, the 1971 soil sampling, which was done using an auger, proved to be far more effective in locating mineralization than the 1979 survey done with a mattock, possibly because the auger could collect samples at a greater depth. The earlier survey yielded Mo values in the hundreds of parts per million in mineralized areas, whereas the 1979 survey returned values in the tens of parts per million. Second, the 1979 geological mapping identified mainly the relatively fresh and barren bedrock that resists erosion. Detailed prospecting guided by the 1971 soil survey was more effective at locating better mineralized areas, which are generally recessive due to associated alteration and differential weathering. This suggests that it is more effective to do follow-up mapping to check geochemical anomalies than to map simultaneously with geochemical sampling. Our observations in this regard also led to targeting the low-lying swampy areas on the ridge top that might mask significant mineralization. Third, it was recognized that the 'spurious' pyrite observed in some areas could produce an IP response unrelated to molybdenum mineralization. Fourth, the highest-grade Mo mineralization seemed to coincide with areas of low magnetic intensity adjacent to magnetic highs. It was hypothesized that the magnetic highs might represent a causative intrusion.

Phase 1 and Phase 2 Drilling

Diamond-drilling began in the fall of 2006 (Figure 3). Initial holes intersected substantial mineralization and work continued until heavy snowfall ended the program in late November at a total of 20 holes (3496 m of BTW core). The new molybdenite zone, located 500 m west-northwest of the previously known Camp zone, was named 'Las Margaritas'. Thirteen holes contained significant molybdenite intercepts, most notably in drillholes 1, 3 and 7. However, some apparently good mineralization in surface outcrops was found not to extend to depth. Interpretation of the Las Margaritas zone was revised to include several steeply dipping mineralized structures or, alternatively, one gently dipping zone. Based on sparse surface data, a steep orientation for the mineralized zone was modelled to plan the next series of drillholes.

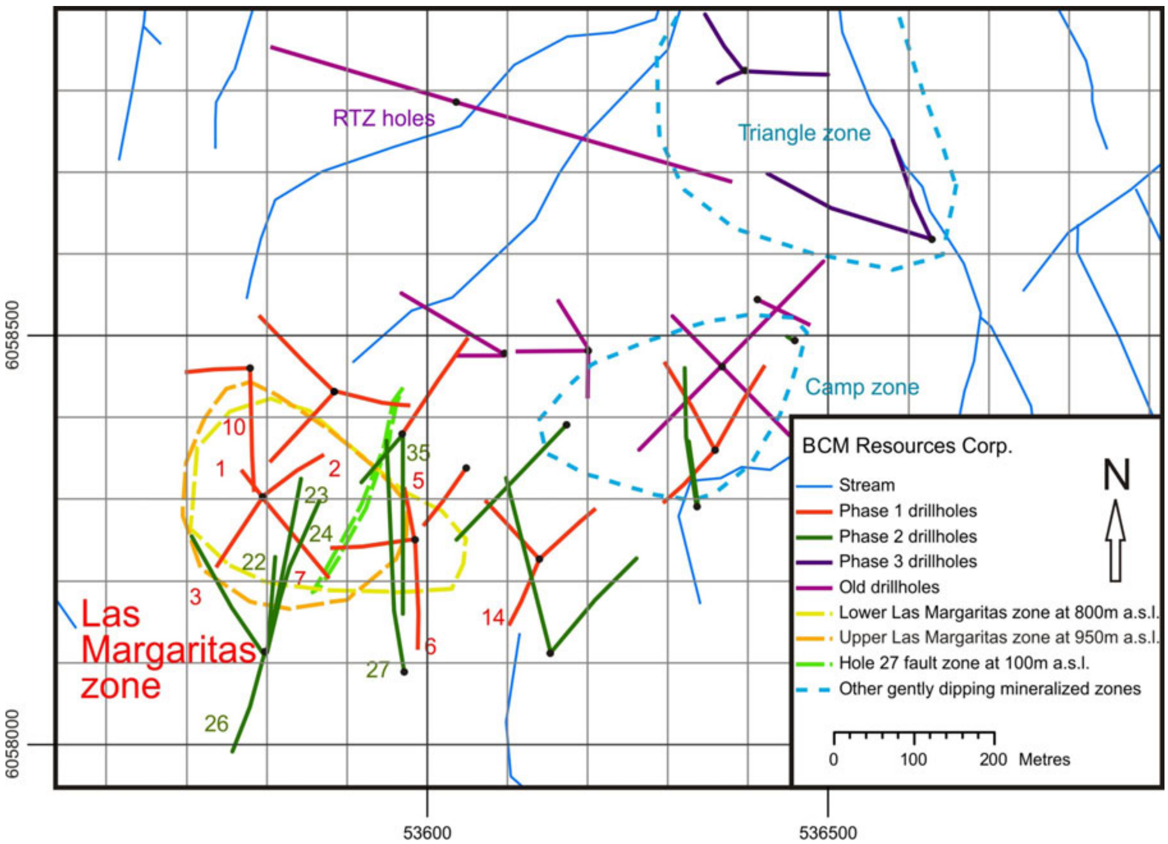

Figure 3. Locations of diamond-drill holes, Shan South property.

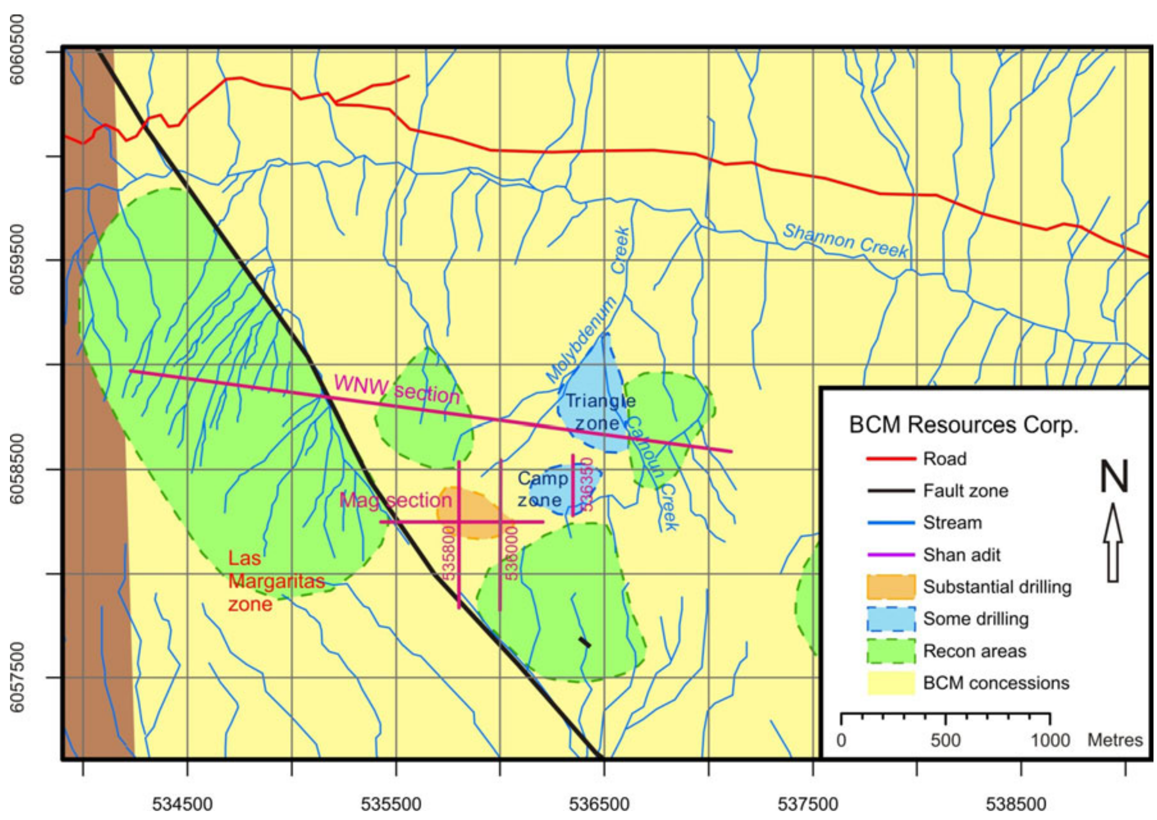

Figure 4. Locations of mineralized zones and sections, Shan South property.

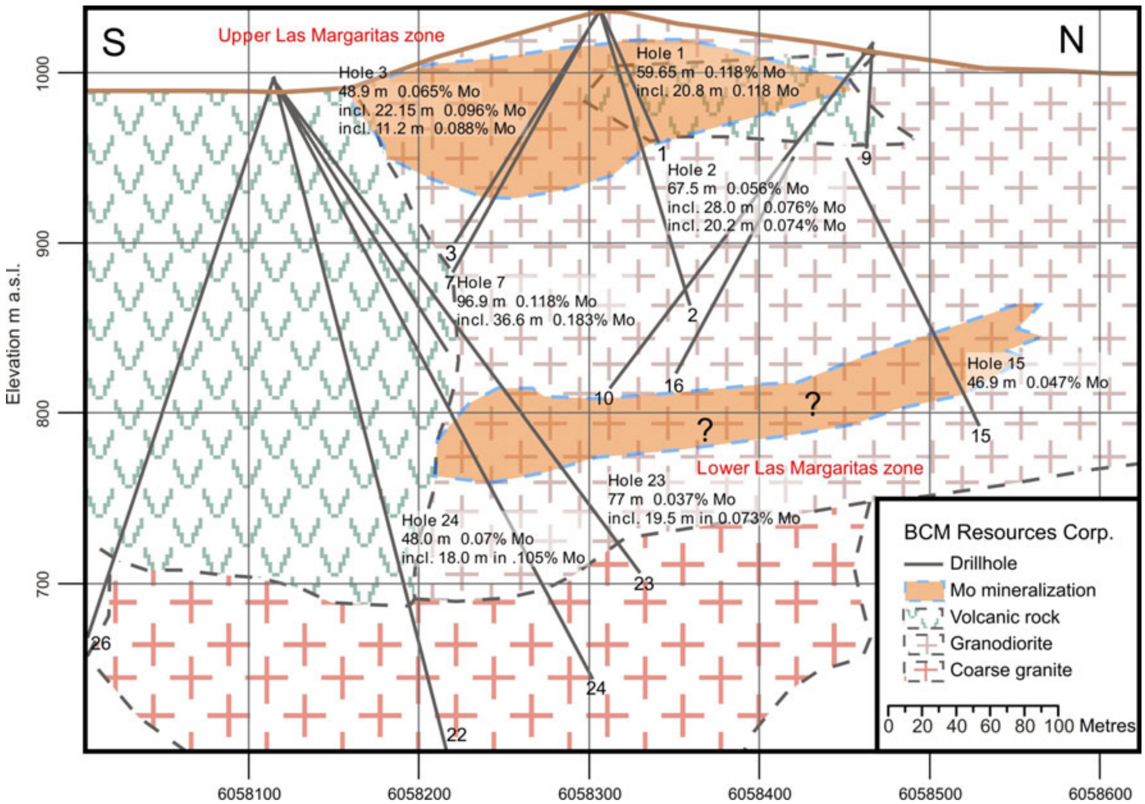

Figure 5. Section 535800 E through the Upper and Lower Las Margaritas zones, Shan South property (*see* Figure 4 for location). Note that zones of Mo mineralization are zones with significant visible Mo mineralization that should be tested with additional drillholes, and include intercepts with 0.06% Mo cutoff, as quoted in press releases (BCM Resources Corp., 2007).

Phase 2 drilling, consisting of 5682 m of HQ drilling in 16 holes, was carried out in the spring of 2007. The first fan of holes was drilled under the best phase 1 intercepts, to intersect what was hypothesized to be the principal structure, striking east and dipping steeply south. Although mineralization was intercepted at depth, it did not match the pattern that was expected in a steeply south-dipping mineralized body; in fact, holes 23 and 24 appeared to have intersected a shallowly north-dipping mineralized zone (*see* Figures 4, 5). A secondary drill target was the edge of a magnetic high interpreted to correspond to the contact between the granodiorite and the volcanic hostrocks, where mineralization and stronger alteration were encountered in phase 1 drilling. One of these holes, hole 27, encountered strong mineralization and has the longest and most highly mineralized drill intercept to date, beginning in granodiorite near the contact with the volcanic hostrocks and remaining in mineralized and altered rock throughout most of its length (Figure 6). Quartz-molybdenite veins in the hole are subparallel and intersect drillcore at a smaller angle than predicted for a steeply south-dipping zone. Gently dipping mineralized zones are a likely alternative, a conclusion supported by gently dipping veining encountered in several vertical holes drilled as part of the phase 2 program. Granodiorite above and between these tabular zones is generally less altered and contains only sporadic mineralization. Surface mineralization in the Camp zone is thought to be the eroded remnant of a gently dipping mineralized zone like those at Las Margaritas (Figure 7).

A zone of mineralized fault gouge encountered at the end of hole 27 (referred to hereafter as the hole 27 FZ) was not found in adjacent holes 36 and 37, which suggests that it might represent a steeply dipping structure; this could be a feeder zone (*see* Figure 3). Intervals of fault gouge, such as the one intersected at the end of hole 27 FZ, commonly contain Ag values ranging from 10 ppm to nearly 300 ppm, plus trace amounts of Pb and Zn. These are thought to be steeply dipping fault zones with multiple episodes of movement and mineralization. The current interpretation is that Mo was introduced along these conduits and spread out into a series of gently dipping fractures at shallow depth.

Summer 2007

In the summer of 2007, additional mapping and sampling were completed at Shan South, including rock, soil and stream sediments; similar mapping and sampling were started on Shan North. A gently dipping zone of mineralization, found in Calhoun Creek 400 m northeast of the Camp zone, was determined to be associated with strongly anomalous soils identified in both the 1971 and 1979 soil surveys. This was named the Triangle zone and was tested by phase 3 drilling.

In addition, an aeromagnetic survey was flown in July 2007 with 100 m line spacing and a 100 m drape over the greater Shan area (136 km^2). Subsequent 3-D modelling of the results of this survey was used to better define areas of magnetite destruction/alteration. The area of hole 27 FZ appeared as a magnetic low, and the two gently dipping zones now thought to form the Las Margaritas mineralized body also coincide with zones of low magnetic susceptibility

(Figure 8). A hand-held magnetic susceptibility meter gave readings of 0.01–0.02 SI units of magnetic susceptibility for unaltered intrusive rock, compared to less than 0.001 SI units for altered intrusive rock. It must be noted, however, that these low susceptibility zones are only permissive, and can be altered but not mineralized. The 3-D modelling also suggested a northwest-striking, steeply dipping fault zone immediately south of the Las Margaritas zone. Subsequent mapping encountered evidence of this fault in several drainages, and it was originally noted as a major structure in the 1975 airphoto interpretation work. Although the sense of movement along this fault is not known, faults of this orientation in the region commonly have right-lateral displacements of hundreds of metres (J. Nelson, pers comm, 2008). The magnetic data for this area can be interpreted to show 800 m of fault displacement. Such an offset would displace potentially mineralized rocks originally located to the southwest of Las Margaritas. Mapping and sampling in summer 2008, however, found only weak alteration and mineralization in the hypothesized, displaced southwestern Las Margaritas block.

Phase 3 Drilling

Phase 3 drilling in the fall of 2007 was limited and tested the Triangle zone on the north slope of Shan South

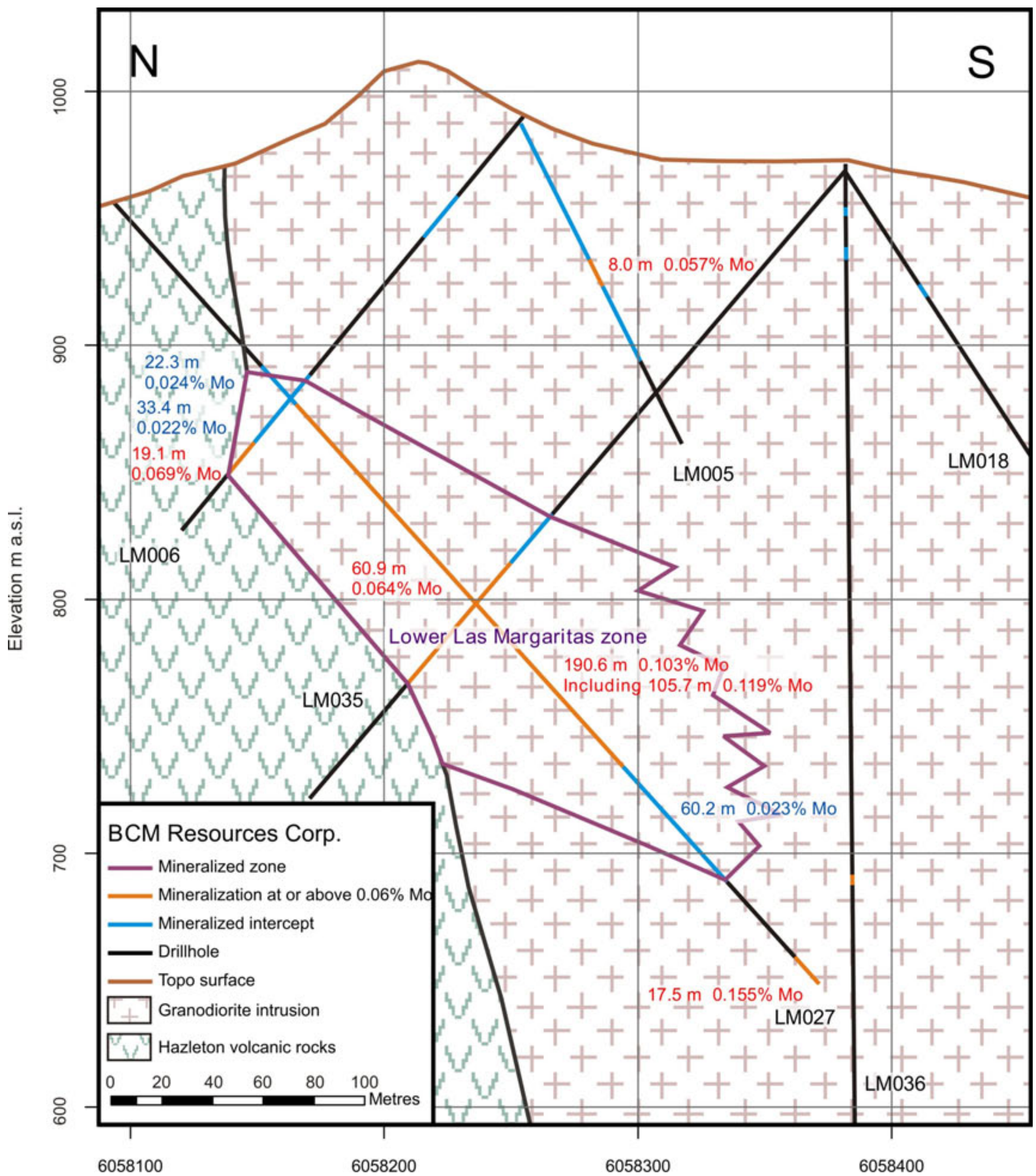

Figure 6. Section 536000 E through the Lower Las Margaritas zone, Shan South property (*see* Figure 4 for location). Note that zones of Mo mineralization are zones with significant visible Mo mineralization that should be tested with additional drillholes, and include intercepts with 0.06% Mo cutoff, as quoted in press releases (BCM Resources Corp., 2007).

and the Banana Lake corridor on Shan North. Holes in the Triangle zone were drilled beneath areas of good surface outcrop and intense Mo anomalies identified in both the 1971 and 1979 soil surveys, but encountered only scattered narrow zones of mineralization (generally <1 m). It was concluded that the mineralized zone dipped moderately north rather than being horizontal, as first thought, and that the holes drilled were entirely in the footwall of the mineralized zone. The zone may extend beneath volcanic cover east of Calhoun Creek and west of Molybdenum Creek (Figure 9).

Summer 2008

Additional mapping and sampling in the summer of 2008 identified five potential satellite zones of mineralization largely concealed beneath the less favourable volcanic strata (*see* Figure 4). The principal technique was soil sampling and moss-mat sampling in streams to detect zones of leakage through the volcanic strata, plus prospecting and sampling in stream drainages, which commonly form along fault and fracture zones. Moss-mat samples were collected because most streams contained little or no sediment suitable for sieved samples. Two satellite zones lie in the area covered by the 1975 reconnaissance work (Blanchet, 1975), and roughly coincide with the previously identified areas of high fracture density and anomalous stream-sediment geochemistry.

ECONOMIC POTENTIAL

Each of the two mineralized zones at Las Margaritas is about 350 m by 200 m in area and about 60 m thick, which represents between 10 and 12 million tonnes of Mo-miner-

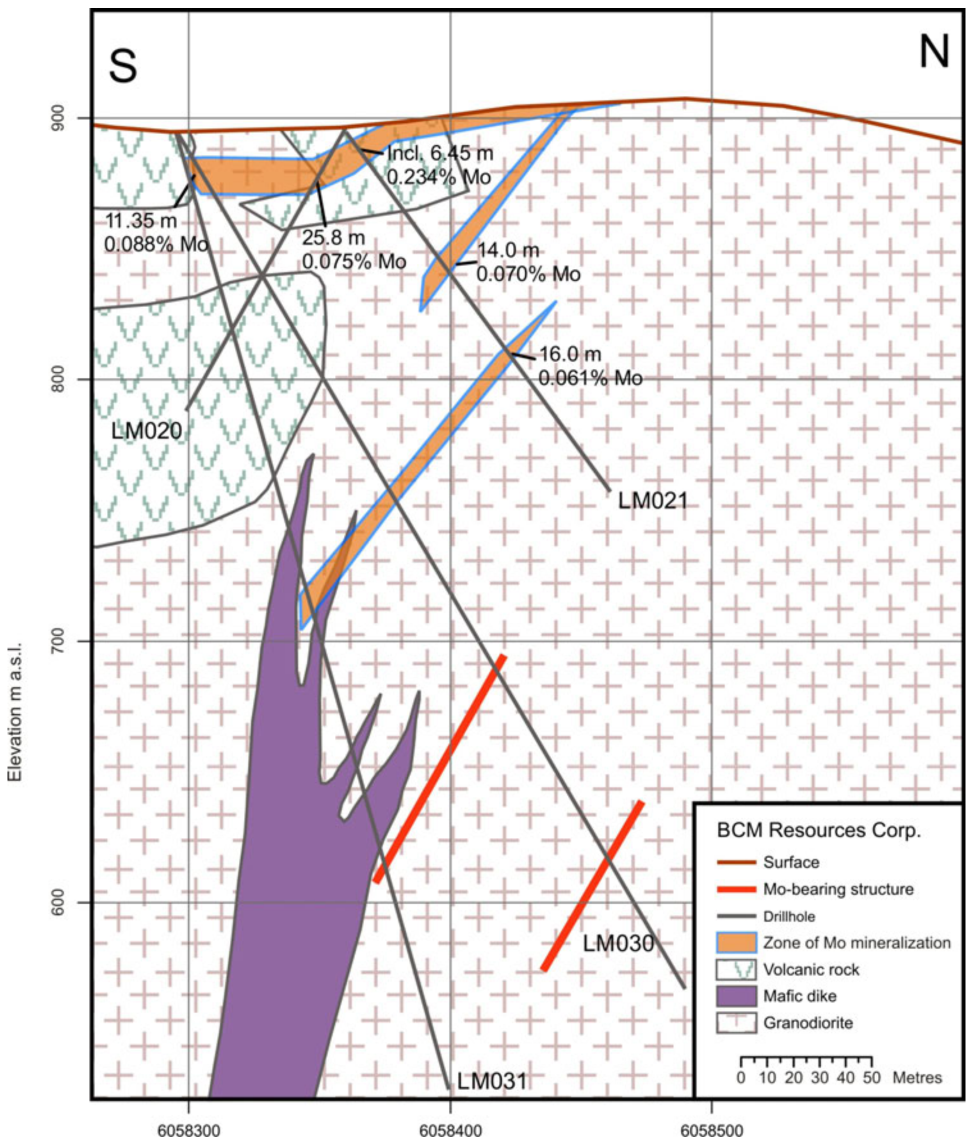

Figure 7. Section 536350 E, Shan South property (*see* Figure 4 for location). Note that zones of Mo mineralization are zones with significant visible Mo mineralization that should be tested with additional drillholes, and include intercepts with 0.06% Mo cutoff, as quoted in press releases (BCM Resources Corp., 2007).

alized rock in each. The upper zone is open to the west and the lower zone is open to the east. Average grades may be ~0.1% Mo throughout most of these two zones, although this is largely speculative and more drilling is required to delineate the mineralization. Additional zones may be present beneath volcanic cover and overburden, and exploration is ongoing.

DISCUSSION AND CONCLUSIONS

The understanding of the Las Margaritas mineralized zone and the exploration for similar satellite zones is a work in progress. Both the exploration techniques used to date and the model for the Mo mineralization are evolving with each stage of exploration. It now appears that the bulk of

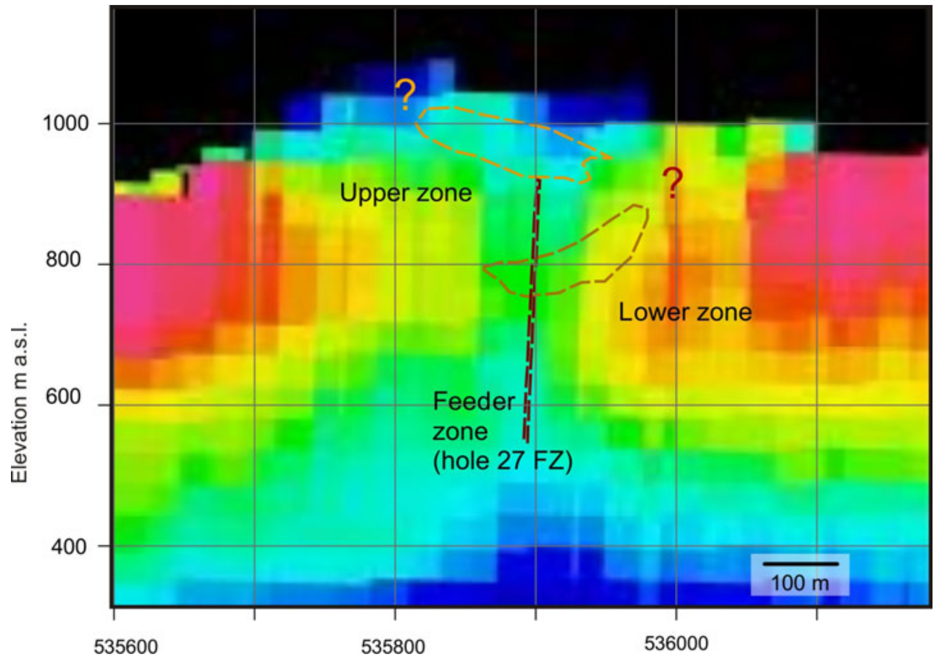

Figure 8. Magnetic susceptibility section (6058250 N) through the Las Margaritas zone, Shan South property (*see* Figure 4 for location).

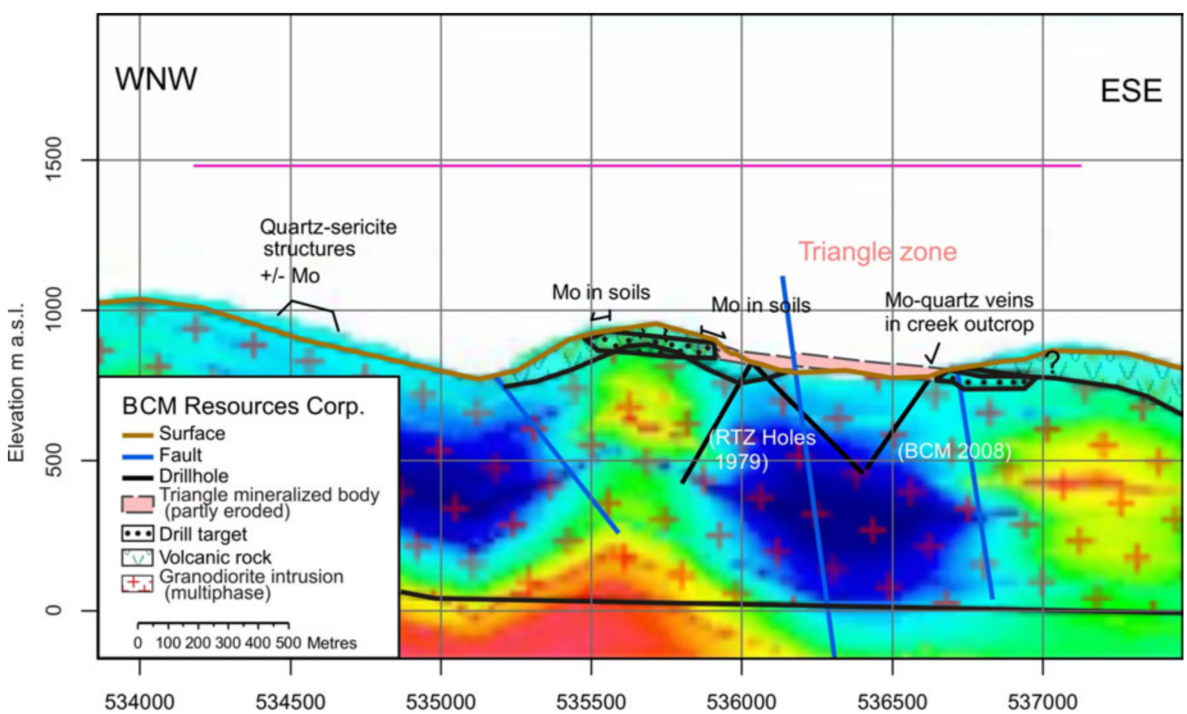

Figure 9. West-northwest-trending section through the Triangle zone superimposed on aeromagnetic modelling results, Shan South property (*see* Figure 4 for location).

mineralization is found in gently dipping tabular zones in the upper part of the granodiorite intrusive, and is associated with steep feeder zones along faults that underwent multiple episodes of movement and mineralization. There are at least three such zones and the possibility of several more.

Soil sampling has been an effective exploration technique, particularly if an auger is used for sample collection at 25–30 m intervals along lines spaced no more than 100 m apart. Detailed geological mapping can then be focused in areas of anomalous Mo values in soil to find alteration and mineralization.

Moss-mat results indicate that the technique may be highly effective for detecting mineralization beneath the less favourable volcanic cover. In the area of the hypothesized western extension of the Triangle zone (Figures 4, 9), moss-mat samples returned strongly anomalous Mo values (up to 658 ppm) in areas of weak to negligible soil anomalies. It is believed that this represents Mo brought up by circulating groundwater from mineralization at depth along structures responsible for the localization of the streams. Background values for samples from structurally controlled streams away from mineralization are less than 10 ppm Mo.

When drilling, it is advisable to drill at least one vertical hole in a strategic location fairly early on to gain a better understanding of the dip of mineralized structures; alternatively, techniques for recovering oriented drillcore might be used.

Molybdenum mineralization at Shan occurs in subhorizontal tabular zones near the roof of the Carpenter Lake granodiorite batholith. Location of the Mo zones is governed by a steep north-northeast-striking fault from which mineralizing fluids are interpreted to have spread laterally into gently dipping fractures, possibly developed in the case of the lower Las Margaritas zone near a subhorizontal contact between an upper medium-grained and lower coarse-grained phase of the pluton.

Although Cu is locally present, Shan belongs clearly to the stockwork Mo group of deposits; it is not a porphyry Cu-Mo deposit. Copper and molybdenum minerals have a different paragenesis and distribution and do not correlate. Rhenium content is comparable to stockwork Mo deposits and below the range commonly found in porphyry Cu-Mo deposits.

An ongoing study of stockwork Mo deposits in northwestern BC by the second author shows a clear separation into two groups. Shan is comparable to the Endako, Storie and Ruby Creek deposits. Molybdenite occurs in a subhorizontal zone near the margin or top of a batholith, commonly near a phase boundary that is characterized by a change in grain size rather than composition. A subvertical feeder zone may be present but is not (as yet) an economic component of the ore zone. Batholith-associated systems are passive (brecciation is rarely evident) and the amount of introduced quartz is low.

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