Big Onion: A supergene-altered porphyry copper-gold deposit, west-central British Columbia

P. WOJDAK
British Columbia Ministry of Energy, Mines and Petroleum Resources, Smithers, British Columbia

G.C. STOCK
British Columbia Ministry of Transportation and Highways, Vancouver, British Columbia

ABSTRACT

Big Onion is an inactive porphyry copper prospect located 16 km east of Smithers, British Columbia. It was explored during the 1960s and 1970s by a total of 16 708 m of core and rotary drilling. Recognition of supergene chalcocite in unsampled drill core and subsequent geological re-interpretation were instrumental in discovery of the Big Onion deposit. The Cu-Mo deposit is related to a multiphase intrusive suite emplaced into mafic volcanic and sedimentary rocks of the Hazelton Group. The core of a north to northeasterly trending quartz feldspar porphyry rhyolite dike was intruded by dikes of quartz diorite porphyry. The quartz diorite porphyry is considered responsible for mineralization but is relatively fresh compared to the quartz-sericite altered quartz feldspar porphyry. Principal hypogene ore minerals are chalcopyrite and molybdenite which occur within northeast trending veinlets, parallel to the fault-controlled intrusions. The original shape of the mineralized zone is a classic hood draped over the quartz diorite porphyry. A fresh, postmineral dike dated at 49.5 $\pm$ 1.9 Ma provides a minimum age of mineralization. Initiation of Basin-and-Range tectonism resulted in segmentation of the Cu-Mo deposit with different erosional levels being preserved in each block. Big Onion has a well-developed pyrite halo. Recent weathering of the deposit produced a supergene zone up to 100 m thick, characterized primarily by chalcocite and covellite coating chalcopyrite. The supergene zone has potential for development employing solvent extraction followed by electrowinning of copper.

Introduction

The Big Onion deposit is a small, partially drilled porphyry copper prospect located in west-central British Columbia (Fig. 1). The Big Onion prospect owes its name to early prospectors who named the nearby iron stained mountain the Big Onion, in allusion to them "peeling the onion" or striking it rich. Exploration was carried out primarily in the period 1964 to 1977 and, at the conclusion of that phase, the Big Onion prospect was judged to be sub-economic. The property lay dormant until the 1990s when there was a revival of interest as a solvent extraction/copper electrowinning (SX-EW) target.

The Big Onion deposit is the focus of a land use issue in the Smithers area. The arbitrary boundary of the Babine Mountains Recreation Area bisects the deposit. Big Onion's proximity to a population centre also works against its possible development because it is clearly visible from Smithers and open pit mining is perceived to be unattractive. Also, Big Onion's exploration trails have become popular for recreation. Once again, the Big Onion property is inactive pending both resolution of the land use issue and more favourable economic conditions.

The Big Onion property comprises 257 claim units located on the south slope of Astlais Mountain (Fig. 1), at the southern end of the Babine Range 16 km east northeast of Smithers, British Columbia (54°48′N and 126°55′W). The map reference is NTS 93-L-15W. Access to the property is provided by the Babine Lake all-weather road from Smithers.

The Babine Range, where the Big Onion deposit is situated, and flanking Bulkley Valley comprise elements of a northwest oriented Basin-and-Range geomorphology (Fig. 2). Fault blocks in the Babine Range are tilted southwest, toward the Bulkley Valley graben. The Babine Range is segmented by major northeast breaks such as the McKendrick Valley south of Big Onion.

Topography on the Big Onion property varies from flat-lying swampy areas at 800 m elevation to the alpine ridges of Astlais Mountain with its peak at 1840 m. The main zones of copper mineralization are located just below treeline at elevations between 900 m and 1500 m. Vegetation consists largely of mixed evergreen forest which has been logged by clear cutting along the foot of Astlais Mountain and burned by an old forest fire part way up the southern flanks. Astlais Creek flows down the centre of the northeasterly elongate mineralized zone.

History

Copper showings at the Big Onion deposit were discovered in 1917 by prospectors Axel Elmsted, Tommy Haig and Ben Benson. Two short adits were driven in the 1920s but intense exploration of the property did not occur until the porphyry copper boom 50 years later. In the early 1960s it was staked by Jack Hemelspeck, Sr. and optioned in 1964 to Noranda Exploration Co. Ltd. who carried out mapping, sampling, geophysical surveying and drilled two short holes. During 1966 and 1967, Texas Gulf Sulfur Co. Inc. completed an I.P. survey, bulldozer stripping and seven diamond drill holes (1217 m). In 1970-1971, Blue Rock Mining Corporation/Cyprus Anvil Mining Corporation completed 22 more diamond drill holes (7358 m). The most extensive exploration of Big Onion was carried out by Canadian Superior Exploration Ltd. from 1974 to 1977. Geological and geophysical mapping was extended and 67 percussion holes (5003 m) and 21 core holes (3058 m) were drilled. Following an estimation of geologic reserves, Canadian Superior Exploration Ltd. judged the Big Onion prospect to be sub-economic and declined to do further work.

In 1991, Varitech Resources Ltd. acquired an interest in the property from Mindoro Corp., who had optioned the claims from Jack Hemelspeck, Jr. of Telkwa, British Columbia. Varitech Resources drilled eight HQ core holes (1696 m) and estimated a supergene reserve of 32 million tonnes grading 0.34% Cu. Since 1991, the Big Onion property has been inactive.

Applied Exploration Techniques

Geological re-interpretation by Canadian Superior Exploration was the critical ingredient that led to discovery of the Big Onion indicate that this inlier possessed ›p-seated roots as might be expected beneath a volcano.

The following chronological sequence is postulated for the development of the Willa deposit.

1. Extrusion of andesitic flows and tuffs from the Willa volcanic centre, one of a number of discrete vents within the Lower Jurassic Rossland arc. Volcanism was followed by continued differentiation due to episodic tapping of the underlying magma chamber.
2. Intrusion of ring and radial dikes of quartz latite porphyry in a near-surface environment along extensional structures related to incipient collapse of the vent. Hydrothermal fluids exsolved during final solidification of the quartz latite porphyry magma yielded a poorly focused system of quartz-molybdenite veining and weakly developed phyllic alteration. Development of biotite and pyritization associated with emplacement of the porphyry preceded this hydrothermal activity.
3. Intrusion of the feldspar porphyry plug, perhaps localized along the main volcanic conduit. This episode was relatively forceful, judging by the brecciated nature of feldspar porphyry contacts. Some tilting of the adjacent volcanic strata may have occurred at this time. Feldspar porphyry crystallization and associated fluids formed pervasive potassium metasomatism that resulted in replacement by K-feldspar at the core of the plug and biotization on the margins, but did not precipitate metals.
4. Magmatic hydrothermal brecciation of intrusive and volcanic rocks localized along the same structure that controlled emplacement of the feldspar porphyry. This brecciation is thought to have been caused by explosive vapour release from a deep-seated, volatile-enriched, and as yet undetected intrusion.
5. Fluidization of the pipe-like zone of fragmented rock to produce the body of heterolithic breccia and, by abrasion, the rock flour.
6. Following brecciation and fluidization in the pipe, structural relaxation resulted in the development of an inward-dipping ring fracture around the remnant inlier of feldspar porphyry.
7. Hydrothermal fluids evolved from the postulated solidifying intrusion ascend along the ring fracture and are dispersed throughout the permeable body of the breccia pipe and less intensely into adjacent rocks. Calcium metasomatism associated with these solutions results in calc-silicate alteration of the breccia matrix and deposition of auriferous and argentiferous chalcopyrite, pyrite, pyrrhotite and magnetite mineralization.
8. Overprinting by a lower temperature retrograde calc-silicate assemblage as the hydrothermal system cools and collapses upon itself.
9. Emplacement of the Nelson Batholith in the Middle Jurassic results in restricted thermal and dynamothermal metamorphism and development of calcite, chlorite, quartz and gypsum veining.
10. Tertiary extension and detachment faulting results in north-striking normal faults which locally offset mineralized zones and may have localized the emplacement of young mafic dikes.
11. Erosion to the present day level with surface leaching and oxidation contributing to the formation of a limonitic coating up to several tens of centimetres thick.

The Willa porphyry system is particularly noteworthy in that it contains both an early phase of molybdenum mineralization with associated K-metasomatism (phyllic) and a younger phase of copper-gold mineralization with associated Ca-metasomatism. Superposition of these two distinct types of mineralization and alteration, previously considered by many to represent end-members in the spectrum of porphyry deposits, indicates that it is possible for both types of deposit to have evolved from a single intrusive complex of calc-alkalic affinity.

The close spatial relationship and succession of feldspar porphyry, a second event of K-metasomatism, volatile brecciation and Ca-metasomatism ı Cu-Au mineralization implies that these events are related. The feldspar porphyry might be the crystallized carapace of the unseen intrusion that subsequently underwent volatile saturation and brecciation. From the evidence described, this was apparently accompanied by a change from K- to Ca-metasomatism which bracketed in time the development of the breccia. The Cu-Au mineralization is, therefore, seemingly associated with but subsequent to the feldspar porphyry.

Acknowledgments

The authors are indebted to all Rio Algom Exploration, BP Minerals and Northair Mines exploration staff who contributed to the geological database and provided, through many hours of discussion, their insights on the geology and genesis of the deposits. The detailed work by K. Heather for his M.Sc. thesis was of significant help to the authors. Publication approval was granted by R. Trenaman of Treminco Resources, to whom the authors express their thanks.

REFERENCES

ARMSTRONG, R.L., 1981. Unpublished company report, Riocanex Ltd.

ARMSTRONG, R.L., 1988. Mesozoic and Early Cenozoic magmatic evolution of the Canadian Cordillera. *In* Processes in Continental Lithospheric Deformation. *Edited by* S.P. Clark, Jr., B.C. Burchfield and J. Suppe. Geological Society of America, Special Paper 218, p 55-91.

CAIRNES, C.E., 1935. Description of properties, Slocan Mining Camp, British Columbia. Geological Survey of Canada, Memoir 184, 237 p.

DURGIN, D.C., 1981. Aylwin Creek Project. Unpublished company report, Riocanex Inc., 110 p.

HEATHER, K.B., 1985. The Aylwin Creek gold-copper-silver deposit, southeastern British Columbia. Unpublished M.Sc. thesis, Queen's University, Kingston, Ontario, 273 p.

MURPHY, C.M., GERASIMOFF, M., VAN DER HEYDEN, P., PARRISH, R.R., KLEPACKI, D.W., McMILLAN, W.J., STRUIK, L.C. and GABITES, J., 1994. New geochronological constraints on Jurassic deformation of the western edge of North America, southern Canadian Cordillera. *In* Jurassic magmatism and tectonics of the North American Cordillera. *Edited by* D.M. Miller and R.G. Anderson. Geological Society of America, Memoir, in press.

PARRISH, R., 1984. Slocan Lake Fault: A low angle fault zone bounding the Valhalla gneiss complex, Nelson map area, southeastern British Columbia. *In* Current Research, Part A. Geological Survey of Canada, Paper 84-1A, p. 323-330.

SILLITOE, R.H., 1985. Ore-related breccias in volcanoplutonic arcs. Economic Geology, 80, p. 1467-1514.

SPENCE, C.D., 1982. Aylwin Creek project, Slocan district, British Columbia. Unpublished company report, Riocanex Inc., Vancouver, 150 p.

SPENCE, C.D., 1985. Shoshonites and associated rocks of central British Columbia. *In* Geological Fieldwork 1984. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1985-1, p. 426-442.

TIPPER, H.W., 1984. The age of the Jurassic Rossland Group of southeastern British Columbia. *In* Current Research, Part A. Geological Survey of Canada, Paper 84-1A, p. 631-632.

WONG, R.H., 1983. Aylwin Creek project, Slocan district, British Columbia. Final report on 1983 Diamond Drilling Program. Unpublished company report, BP Minerals-Riocanex Joint venture.

WONG, R.H., 1984. Aylwin Creek project, Slocan district, British Columbia. Final report on 1984 Field Program. Unpublished company report, BP Minerals-Riocanex Joint Venture.

WOODSWORTH, G.J., ANDERSON, R.G. and ARMSTRONG, R.L., 1991. Plutonic Regimes Chapter 15. *In* Geology of the Cordilleran Orogen in Canada. *Edited by* H. Gabrielse and C.J. Yorath. Geological Survey of Canada, Geology of Canada, No. 4, p. 491-531 (also Geological Society of America, The Geology of North America, Volume G-2).

deposit (J. Baker, pers. comm., 1993). Recognition of supergene chalcocite in drill core that had not been assayed by previous operators prompted Canadian Superior's reassessment of the property. Induced polarization surveys served to delineate the pyrite halo. Canadian Superior recognized the correlation between magnetite and copper mineralization. A magnetic survey outlined the mineralized quartz diorite porphyry and led to recognition of a transverse structure separating the North and South zones (Stock, 1977). MacIntyre and Desjardins (1988) have shown that lithogeochemical sampling is an effective regional method of delineating mineralized areas in the Babine Range.

Regional Geology and Tectonic History

The vicinity of the Big Onion deposit is underlain primarily by folded and faulted Hazelton Group volcanic and sedimentary rocks, described by Tipper and Richards (1976), MacIntyre et al. (1989) and Gaba (1992). The Hazelton Group in the Babine Range is subdivided into four formations: the Sinemurian or older Telkwa Formation, the Late Sinemurian to Pliensbachian Nilkitkwa Formation, the Toarcian to Bajocian Eagle Peak Formation and the Middle Toarcian to Early Callovian Ashman Formation. The Telkwa Formation consists of mainly subaerial dacite to basalt. The overlying Nilkitkwa Formation comprises marine shale, siltstone, conglomerate and minor limestone. Brick red crystal and lithic tuffs and related epiclastic rocks distinguish the subaerial Eagle Peak Formation and fossiliferous marine feldspathic sandstone characterizes the Smithers Formation.

Middle Jurassic to lower Tertiary strata overlie the Hazelton Group in the Babine Range but are remote from the Big Onion deposit. The Callovian Bowser Lake Group consists of marine to non-marine sedimentary rocks, mainly black shale and siltstone. The Skeena Group is early Cretaceous in age and comprises marine and non-marine clastic sedimentary rocks, ranging from pebble conglomerate to shale. The Upper Cretaceous Kasalka Group consists of andesite and related volcaniclastic rocks.

Northeast and northerly faults controlled emplacement of intrusive rocks, ranging in composition from diorite to quartz monzonite, in Cretaceous to Eocene time. These occur throughout the Babine Range but are particularly abundant at the south end of the range in the vicinity of the Big Onion deposit. Porphyry copper-molybdenum and silver-rich polymetallic veins are associated with these intrusions but the two deposit types appear to be unrelated (Gaba, 1992).

The tectonic history is divisible into three distinct regimes (MacIntyre et al., 1989). The Hazelton Group represents a calc-alkaline island arc and the Bowser successor basin received molasse from uplifted regions to the east and south. Secondly, plate collision in the mid-Cretaceous resulted in uplift of the Coast Range and detritus was shed eastward, represented by the Skeena Group. This was followed by development of an Andean-type volcanic arc represented by the Kasalka Group. Finally, a transtensional tectonic regime produced a Basin-and-Range geomorphology that is responsible for the present distribution of rock units.

Big Onion Geology

Stratified Rocks

The oldest rocks observed on the Big Onion property are green, hornblende and plagioclase phyric andesite flows, amygdaloidal basalt and mafic dikes of the Telkwa Formation (Stock, 1977; Gaba, 1992). These rocks are correlated with the subaerial Howson facies of the Telkwa Formation by Tipper and Richards (1976). The uppermost unit of the Telkwa Formation is an extremely fine-grained hematitic tuff containing angular feldspar fragments. Grey to black shaley mudstone with intercalated greywacke, feldspathic to quartzose sandstone and minor chert pebble conglomerate of the Nilkitkwa Formation and fossiliferous feldspathic siltstone and sandstone of the Smithers Formation overlie the volcanic succession (L'Orsa,

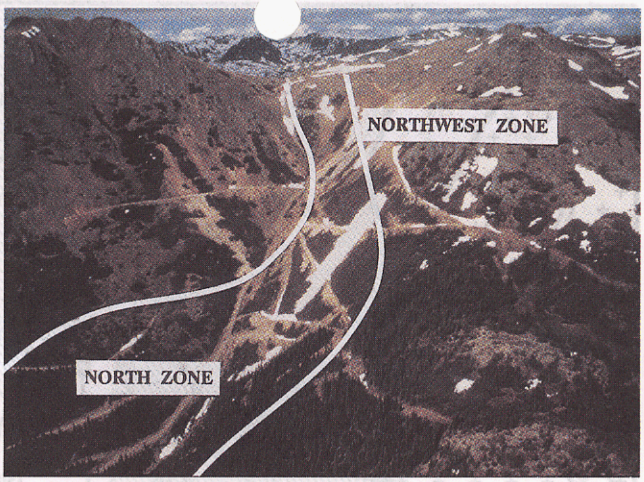

FIGURE 1. Big Onion, view to the northeast showing the gossan at the head of Astlais Creek.

1967; Gaba, 1992). The Eagle Peak Formation appears to be absent. Mesozoic strata have been complexly folded about southeast plunging axes so that strikes and dips are highly variable. However, most contacts between formations are northwest or northeast normal faults reflecting the Basin-and-Range tectonic style.

Intrusive Rocks

The oldest intrusive rock at the Big Onion deposit is a northeasterly-trending dike of quartz feldspar porphyry (QFP) lying within the valley of Astlais Creek (Fig. 3). The unit is rhyolitic in composition and characterized by quartz eyes and relict feldspar phenocrysts set in an aphanitic groundmass of quartz and feldspar. Welded quartz phyric ash and rhyolite flows 5 km south of the Big Onion property are regarded as Upper Cretaceous to Eocene in age (MacIntyre, pers. comm., 1993) and were interpreted by Stock (1977) as extrusive equivalents of the quartz feldspar porphyry. The QFP is approximately 200 m wide and at least 3 km long, with its southwestern projection under overburden in Bulkley Valley (Gaba, 1992).

Northeasterly-trending dikes of quartz diorite porphyry intrude the core of the QFP (Fig. 4). The quartz diorite exhibits well developed plagioclase phenocrysts, irregular hornblende clusters and rare fine-grained biotite set in a fine-grained matrix of quartz and plagioclase. Two cross-cutting dike phases complete the suite of intrusive rocks at the Big Onion deposit (Stock, 1977). A north-striking quartz monzonite porphyry cuts off the southern end of the mineralized zone. It consists of fine-grained plagioclase laths, conspicuous medium-grained biotite and irregular quartz set in an aphanitic K-feldspar matrix. Carter (1981) reported a biotite K-Ar age of 48.7 $\pm$ 1.9 Ma for this unit. Using revised K-Ar decay constants Carter's data is recalculated at 49.5 $\pm$ 1.9 Ma. A smaller hornblende porphyry dike at the north end of the mineralized zone consists of medium-grained to idiomorphic hornblende, relict subrounded to rounded plagioclase and very fine-grained irregular quartz, all set in an aphanitic plagioclase groundmass.

Carter (1976) correlated the Big Onion quartz diorite and quartz feldspar porphyries with the Eocene Nanika intrusions and noted that multiple intrusive events characterize Nanika intrusions. However, unpublished data cast doubt on a simple intrusive history at the Big Onion deposit. A sample of strongly sericitized QFP collected by C. Godwin and analyzed by J. Harakal in 1980 and 1982 at The University of British Columbia produced whole rock K-Ar ages of 117 $\pm$ 4 Ma and 112 $\pm$ 4 Ma (Mortensen, pers. comm., 1994).

A northeast-trending elongate body of fresh hornblende-biotite granodiorite, 5 km long by 3 km wide, is exposed 3 km southeast

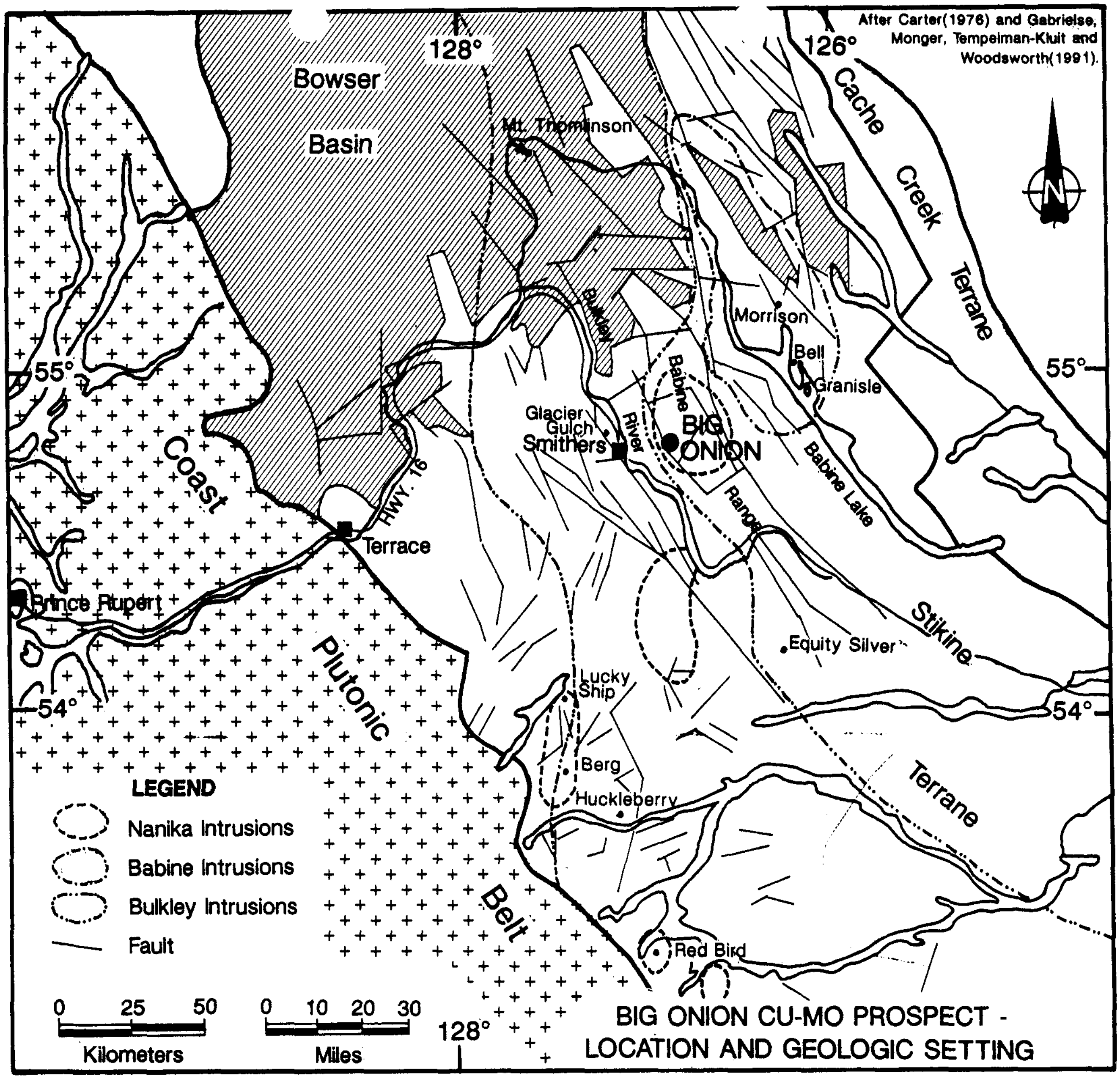

FIGURE 2. Location and geologic setting showing extent of Basin and Range normal faults and late Cretaceous - early Tertiary intrusive suites.

of the Big Onion deposit (MacIntyre and Desjardins, 1988; Gaba, 1992). A biotite K-Ar age of 74.7 ± 2.6 Ma (Godwin, unpublished data, 1979; Mortensen, pers. comm., 1994) indicates that this stock is correlative with the Bulkley intrusions (Carter, 1976).

Structure

The dominant structure at the Big Onion deposit is a northeast-trending, northwest-dipping shear zone parallel to Astlais Creek (Stock, 1977). The Astlais Creek Fault system controlled emplacement of intrusions and subsequent mineralization. The Astlais Creek Fault is parallel with, and may be related to, the McKendrick Fault, a prominent regional northeast-trending structure southeast of the property.

Slightly younger, transverse north-northwest faults cause left-lateral displacement of intrusive rocks and mineralized zones. The apparent offset between the North and South zones is 300 m. The quartz monzonite porphyry that marks the southern end of the South zone probably occupies another north-northwest fault, with unknown displacement. The abrupt change in strike of the mineralized zone at its north end is probably caused by a north-northwest fault which also controlled emplacement of QFP and quartz diorite porphyry intrusions.

Mineralization

Chalcopyrite and molybdenite occur primarily within the quartz feldspar porphyry. Minor amounts of mineralized veinlets crosscut thin quartz diorite porphyry dikes and Telkwa Formation andesite. Carter (1976) observed that contact areas between QFP and quartz diorite porphyry are preferred sites for mineralization, with chalcopyrite principally within the quartz diorite and molybdenite in the quartz feldspar porphyry. Stock (1977) deduced mineralization to be post quartz diorite porphyry but prior to the quartz monzonite and hornblende porphyry dike phases. Copper and molybdenum are concentrated in three areas. The North and Northeast zones are contiguous with a combined length of 1400 m and a width of 100 m to 200 m. The South zone is 600 m long by 200

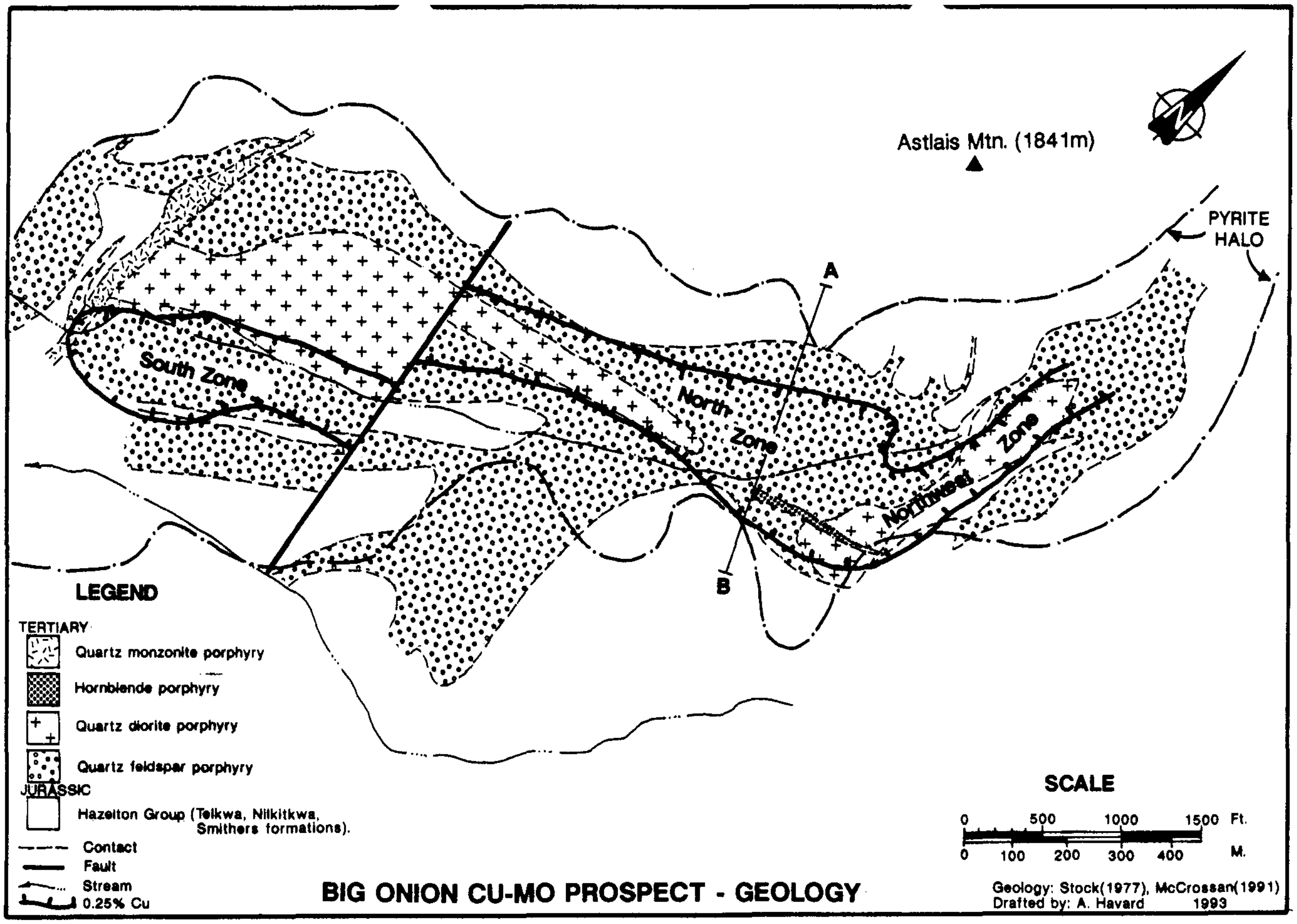

FIGURE 3. Big Onion Cu-Mo prospect, surface geology and ore zones.

m wide and, as discussed above, it is displaced 300 m south from the North zone.

Mineralized fractures strike approximately 065° and dip 50° to 70° northwest, parallel to the Astlais Creek Fault. Three mineralized pulses are recognized by Stock (1977):

- quartz + sericite + pyrite ± chalcopyrite;
- quartz + sericite + chalcopyrite ± molybdenite; and
- quartz + sericite + molybdenite.

The relative sequence of these events is not known. Molybdenum and copper grades correlate closely. Gold and silver grade of hypogene mineralization were not routinely determined and although the content is low, no representative values are available. Pyrite is ubiquitous in the intrusion and adjacent volcanic rocks at Big Onion. The pyrite halo is more than 2200 m long by 400 m to 800 m wide.

Hydrothermal Alteration

Phyllic alteration, defined by quartz and sericite, completely envelopes the copper-molybdenum zone and is directly related to ore deposition (Stock, 1977). Quartz-sericite is developed best in quartz feldspar porphyry. Intensity of alteration ranges from moderate, where relict plagioclase can be discerned, to extreme where quartz eyes are the only remnant of primary texture and mineralogy. Phyllic alteration is weakly developed in other rock units. Secondary biotite is rare in the South zone but is common in the North zone where it occurs in vein envelopes within quartz diorite porphyry. Quartz stockworks are also developed locally and less commonly pervasively silicified zones are present.

Propylitic alteration is developed peripheral to the quartz-sericite zone. Most prominent within the margin of the andesite unit, propylitic alteration is characterized by epidote, calcite, chlorite and weak sericitization of plagioclase. Within quartz feldspar porphyry, propylitic alteration is characterized by calcite and saussauritization of feldspar. In quartz diorite, propylitic alteration is marked by chloritization of hornblende and weak alteration of plagioclase to sericite and calcite.

Supergene Alteration

Reaction of ground water with pyrite in the mineralized zone initiated significant supergene enrichment processes at the Big Onion deposit. Acidic dissolution of chalcopyrite in the oxidized zone was followed by formation of chalcocite, covellite, subordinate bornite and rare native copper where reducing conditions occur at or near the water table. Deposition generally occurred on the surface of chalcopyrite grains. Ultimately chalcopyrite is completely replaced by supergene copper minerals. Pyrite is variably tarnished or coated with supergene mineralization but it is not a significant site of deposition. Intense sericite alteration has promoted supergene alteration by causing enhanced permeability (Stock, 1977).

Maximum thickness of supergene mineralization is 110 m in the North zone (Fig. 4) and 75 m in the South zone (McCrossan, 1991). Best tenor occurs in the North zone. The leached cap is typically 20 m to 40 m thick, beneath an average 10 m thickness of overburden. The shape of the supergene copper zone on cross sections mimics post-glacial topography and accordingly is interpreted to be a recent event.

Economics

Drill hole definition of the Big Onion deposit is comparatively sparse. Stock (1977) calculated a mineral inventory to a depth of 150 m:

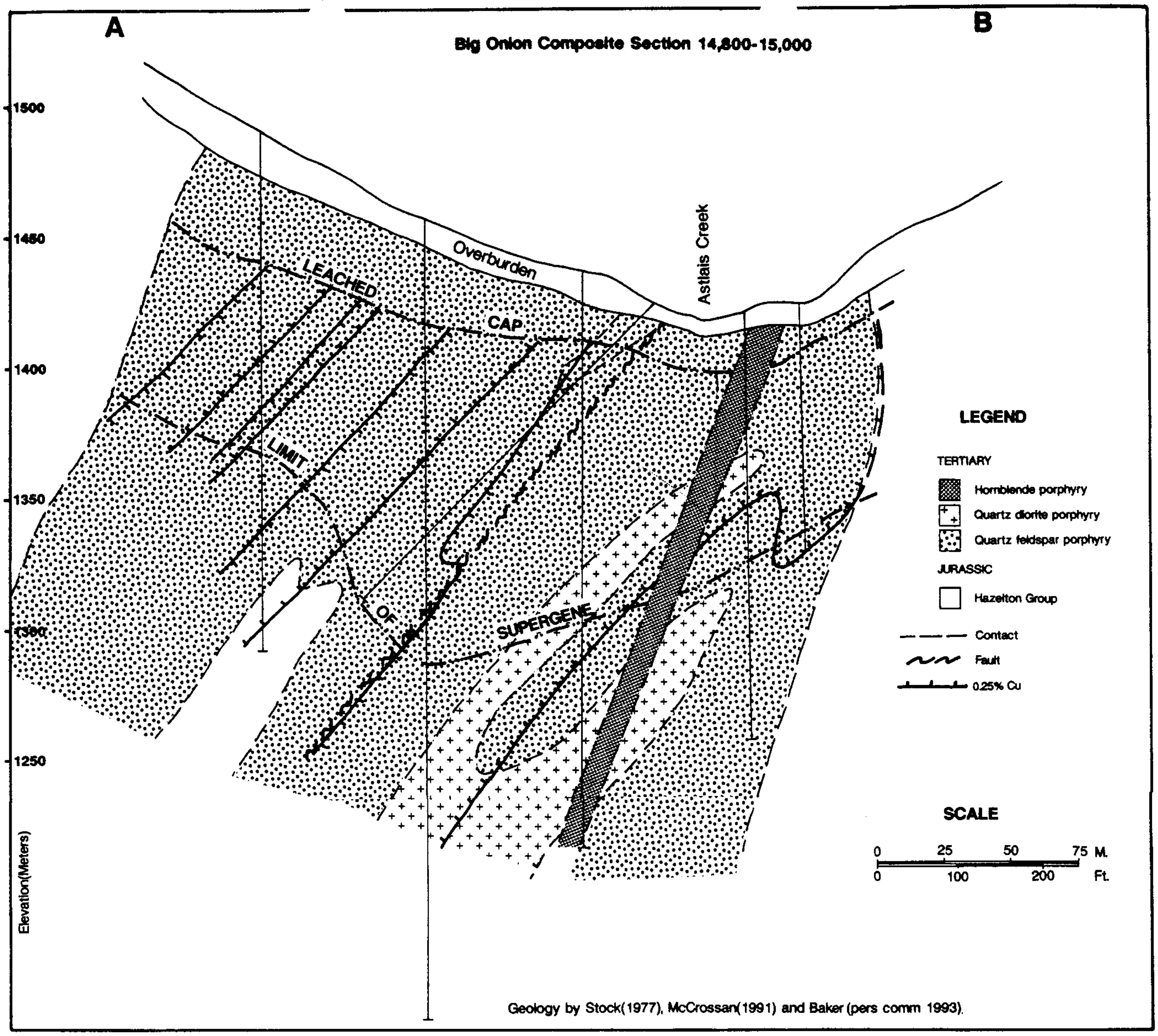

FIGURE 4. Composite section 14 800 to 15 000 N showing age relationship of Nanika intrusive rocks and extent of supergene mineralization.

Probable:	59 600 000 tonnes	0.43% Cu	0.020% MoS_2
Possible:	34 780 000 tonnes	0.42% Cu	0.020% MoS_2
Total	94 380 000 tonnes	0.42% Cu	0.020% MoS_2

In 1982, Canadian Superior commissioned a study to estimate mineable reserves and pit design. At a cutoff grade of 0.25% Cu equivalent, the Big Onion deposit was estimated to contain 69 million tonnes grading 0.397% Cu equivalent at a stripping ratio of 2.18 (Sampson, 1991). From its drill data, Varitech estimated the supergene portion of the reserve to be 32 million tonnes grading 0.34% Cu, 0.064 g/t Au and 1.0 g/t Ag (McCrossan, 1991).

In 1991, bench-scale metallurgical testing of Big Onion supergene copper mineralization was carried out to determine the extraction rate and ultimate yield that might be expected by solvent extraction (Beattie, 1991). The test sample contained 0.318% Cu as chalcocite and 1.22% total Cu. Despite the high proportion of chalcopyrite, leach kinetics are considered good. Preliminary tests with both ferric iron and bacteria present indicated a high initial rate of extraction followed by a more gradual rate. Over a 30-day leach period, 66% copper extraction was achieved. Beattie extrapolated that a leaching time of 6 to 9 months would be required to achieve 70% to 80% extraction.

Discussion and Conclusions

Stock (1977) developed an effective model for origin of the Big Onion Cu-Mo porphyry deposit (Fig. 5). Northeast faulting of the Hazelton volcanic sequence allowed intrusion of quartz feldspar porphyry. The Astlais Creek Fault which controlled intrusive emplacement is not shown in Figure 5 for simplicity and because displacement is unknown. The QFP vented, rhyolitic tuffs were deposited and are preserved in a fault graben. Quartz diorite porphyry was intruded soon after, perhaps while the QFP was still hot and caused sericitization of the older intrusion. Continued fault movement sheared the altered QFP and provided channelways for subsequent mineralizing fluids. Complementary north-northwest faulting both controlled quartz diorite emplacement and mineralization, and also caused fault offset. North-northeast faults must, therefore, be coeval to slightly younger than mineralization. The original geometry of the copper zone was a hood draped over the less sheared and altered quartz diorite porphyry. Supergene processes may have been initiated during early Tertiary time but if so, the supergene zone was substantially modified in post-glacial time.

The Big Onion porphyry system has not been completely explored. Silicified sedimentary rocks of the Smithers Formation 1.5

km northeast along trend are highly anomalous in copper and molybdenum (Gaba, 1992), suggesting another mineralized zone. The faulted southwestern trend of the Big Onion system is overburden covered and, like the northeastern area, has not been explored. An untested 600 m by 1200 m induced polarization anomaly 1 km south of Big Onion is also a prime exploration target.

Age and correlation of mineralized intrusions at the Big Onion prospect is uncertain. It remains enigmatic whether intrusion and mineralization is Eocene, or whether the mid-Cretaceous ages reliably indicate a much older event. The 112 Ma to 117 ± 4 Ma age is inconclusive because it is a whole rock K-Ar determination of extreme phyllic alteration of a premineral intrusion. It is also an anomalous date for west-central British Columbia where copper-molybdenum porphyry deposits are typically early Eocene or late Cretaceous. The 49.5 ± 1.9 Ma K-Ar date of a postmineral quartz-monzonite dike at Big Onion is similar to dates of Nanika intrusions which range from 56 Ma to 49 Ma (Carter, 1976). Nanika stocks at the Berg, Lucky Ship, Mt. Thomlinson and Red Bird prospects contain significant porphyry copper and molybdenum deposits. Carter (1976) notes that large pyrite haloes and deep oxidation characterize Nanika-type porphyry deposits. Like Big Onion, the Berg deposit has developed a Recent thick supergene enrichment zone (Heberlein, this volume). The Big Onion deposit is dissimilar to 50 Ma to 52 Ma Babine-type copper-molybdenum porphyry deposits such as Bell and Granisle located 40 km to the northeast which are associated with distinctive biotite-feldspar porphyritic granodiorite. Big Onion is also notably different from the Glacier Gulch porphyry molybdenum prospect, located 25 km west, associated with a 70 Ma Bulkley intrusive suite. The Big Onion prospect is tentatively correlated with Nanika-type porphyry deposits.

In a Basin-and-Range tectonic regime porphyry copper deposits with large pyrite haloes, such as the Nanika-type, have potential for creation and preservation of Tertiary supergene copper enrichment zones. Such deposits, known and undiscovered, may have a viable economic future as SX-EW projects.

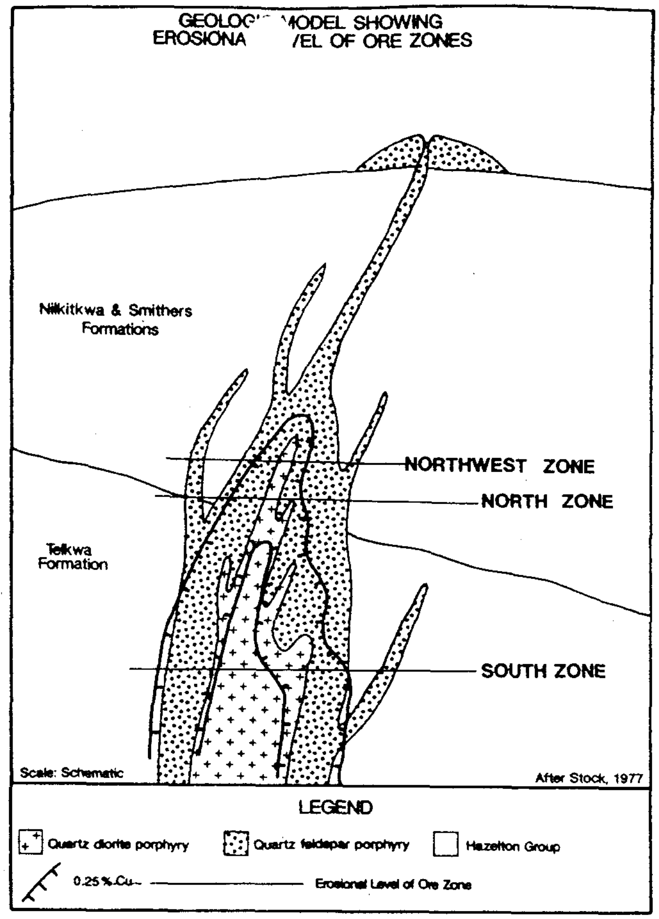

FIGURE 5. Big Onion geologic model showing erosional level of ore zones.

Acknowledgments

The senior author has very little first-hand familiarity with the Big Onion deposit and has acted primarily as a compiler of data obtained by Geoff Stock for Canadian Superior Exploration Limited and by Ed McCrossan for Varitech Resources Limited. John Baker, former exploration manager for Canadian Superior, provided considerable insight into the history of discovery and geology of the deposit, in particular the supergene zone. Tom Schroeter inspired and encouraged the writing of this paper and kindly supplied the photograph of the Big Onion deposit. Constructive comments by reviewers Don MacIntyre and Bob Cathro improved the manuscript, in particular, by pointing out existence of unpublished K-Ar ages, for which Jim Mortensen kindly provided details.

REFERENCES

BEATTIE, M.J.V., 1991. Preliminary metallurgical test work on a sample from the Big Onion deposit. Unpublished company report, Varitech Resources Ltd., Vancouver, British Columbia, 9 p.

CARTER, N.C., 1976. Regional setting of porphyry deposits in west-central British Columbia. *In* Porphyry deposits of the Canadian cordillera. *Edited by* A. Sutherland Brown. Canadian Institute of Mining and Metallurgy, Special Volume 15, p. 227-238.

CARTER, N.C., 1981. Porphyry copper and molybdenum deposits, west-central British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Bulletin 64, 150 p.

GABA, R.G., 1992. Geology and mineral resources of the Babine Mountains recreation area. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1992-5, 83 p.

GABRIELSE, H., MONGER, J.W.H., TEMPELMAN-KLUIT, D.J. and WOODSWORTH, G.J., 1991. Structural styles — Intermontane Belt. *In* Geology of the cordilleran orogen in Canada. *Edited by* H. Gabrielse and C.J. Yorath. Geological Survey of Canada, Geology of Canada, No. 4, p. 571-675.

HEBERLEIN, D.R., 1995. Geology and supergene processes: Berg copper-molybdenum porphyry, west-central British Columbia. *In* Porphyry Deposits of the Northwestern Cordillera of North America. *Edited by* T.G. Schroeter. Canadian Institute of Mining, Metallurgy and Petroleum, Special Volume 46.

L'ORSA, A., 1967. Final report; Big Onion Cu-Mo prospect, Smithers, B.C. Unpublished company report, Texas Gulf Sulfur Co. Inc.

MacINTYRE, D.G. and DESJARDINS, P., 1988. Babine Project. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1988-1, p. 181-194.

MacINTYRE, D.G., DESJARDINS, P. and TERCIER, P., 1989. Jurassic stratigraphic relationships in the Babine and Telkwa ranges. *In* British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1989-1, p. 195-208.

McCROSSAN, E., 1991. Drilling report on the Big Onion property. Unpublished company report, Varitech Resources Ltd., Vancouver, British Columbia. 23 p.

SAMPSON, C.J., 1991. Report on Big Onion property near Smithers, B.C. Unpublished company report, Varitech Resources Ltd., Vancouver, British Columbia, 30 p.

STOCK, G.C., 1977. Big Onion summary of exploration to 1977. Unpublished company report, Canadian Superior Exploration Limited, 27 p.

TIPPER, H.W. and RICHARDS, T. A., 1976. Jurassic stratigraphy and history of north central British Columbia. Geological Survey of Canada, Bulletin 270.