Au-Ag Vein Mineralization, West Zone,

Brucejack Lake, Northwestern British Columbia

[104B/8E]

By **Stephen Roach**, Newhawk Goldmines Ltd., 860-625 Howe Street, Vancouver, B.C., V6C 2T6, and **A. James Macdonald**, Mineral Deposit Research Unit, Dept. of Geological Sciences - UBC, 6339 Stores Rd., Vancouver, B.C., V6T 1Z4 (Telephone : 604-822-4563, Fax : 604-822-6088)

MDRU Contribution : 003

Keywords : Hazelton Group, Stikine assemblage, Sulphurets area, metallogeny, structure, gold, silver

R1 INTRODUCTION

The West Zone is one of over 20 mineralized zones and showings on the Sulphurets property (Newhawk Gold Mines Limited, 60%; Granduc Mines Limited, 40%), located 65 km north of Stewart, B.C. (Figures 1, 2). Intial fieldwork was completed by the first author in 1989 (Roach, 1990), comprising grid geological mapping of lithologies and alteration assemblages in the West Zone and the recording of structural data (attitudes of veins and principal fabrics). In 1991, the second author extended mapping to include traverses in the Brucejack Lake area in a 2 km radius around the West Zone. In addition, fourteen diamond drill holes on a section through the central portion of the West Zone were studied and sampled extensively in 1991. This contribution discusses the geology and structure observed at surface in the West Zone. Further objectives of the study are to define:

(a) Lithostratigraphic relationships between hostrocks to precious metal vein mineralization

(b) Alteration mineralogy and chemistry around mineralized zones

(c) Hypogene mineralogy of the vein systems in the Brucejack Lake area

(d) A reconnaissance of vein material to assess applicability for Fluid Inclusion studies

R1 HISTORY OF THE SULPHURETS PROPERTY

The Sulphurets property comprises 343 contiguous units in 65 mineral claims and covers approximately 85 km^2 (Figure 3). A small fraction (500 m by 20 m), located 5 km north of the West Zone, is owned by a third party. Exploration for placer gold in the Unuk River Valley and subsidiary valleys, such as that occupied by Sulphurets Creek, was first recorded in the 1880s, although no production data exist. In 1935, prospectors located copper mineralization in the area now referred to as the Main Copper zone (Figure 3). Prospecting in the Brucejack Lake area continued intermittently until 1959, when gold and silver mineralization was first reported. In 1960, Granduc Mines Ltd. staked the bulk of the area comprising the current property, and commenced an exploration program for porphyry copper mineralization, employing airborne and ground geophysics in addition to reconnaissance geology; as a result copper mineralization was reported in the ridge between the Mitchell and Sulphurets glaciers and gold and silver mineralization at the base of the Iron Cap area (Bridge et al., 1981). Exploration continued sporadically on the property from 1961 to 1974, concentrating on diamond drilling of anomalies identified by geophysical and geochemical prospecting techniques. During the period 1961-1963 R.V. Kirkham completed a M.Sc. thesis comprising geological mapping of the bulk of the property (Kirkham, 1963). The Brucejack Lake area was prospected in 1975. Relatively little exploration activity occurred at Sulphurets until 1980, when Esso Minerals Ltd. optioned the property from Granduc, and conducted detailed and reconnaissance geological mapping and geochemical sampling throughout the property, and diamond drilling, focussed principally on the West and Shore zones (Figure 3). In 1985, Newhawk Gold Mines and Lacana Mining Corporation optioned the property from Granduc and continued with intensive exploration on the West zone, driving an exploration decline to the 1150 m level, approximately 250 m below surface (Roach, 1990) permitting extensive underground diamond drilling and reserve delineation.

In 1989, Newhawk commissioned an independent report of *in situ* ore reserves by Watts, Griffis and McOuat, Consulting Geologists and Engineers, of Toronto. Using a cut off grade of 0.2 ounces per ton (equivalent to approximately 6.9 grams per tonne Au) and a minimum true width of 5 feet (equivalent to approximately 1.5 metres), Proven and Probable Reserves were announced (Newhawk Gold Mines, Press Release, February 6, 1990) as 715,400 tons (approximately 650,000 tonnes) at a gold grade of 0.431 oz/t (14.8 g/t) and a silver grade of 19.7 oz/t (675 g/t). Based upon the ore reserve, Corona Corporation, which holds a 42% interest in Newhawk, conducted a feasibility study for the West Zone, concluding that under existing conditions, including metal prices, infrastructure etc., the project was uneconomic (Newhawk Gold Mines, Press Release, October 25, 1990). The decline was allowed to flood in 1990.

R1 REGIONAL GEOLOGY

R2 Lithostratigraphy

The Sulphurets property and immediate area is within the Stikine terrane (Wheeler and McFeely, 1987), and is underlain by Upper Triassic/Lower Jurassic to Middle Jurassic Hazleton Group volcanic, volcaniclastic and sedimentary rocks (Grove, 1986). The lithostratigraphic assemblage in the Sulphurets area has been described by Kirkham (1963), Britton and Alldrick (1988), Alldrick and Britton (1991, in press, open file 1991-21) and Kirkham et al. (in prep.), and comprises a package, from oldest to youngest of alternating siltstones and conglomerates (Lower Unuk River Formation, Norian to Hettangian); alternating intermediate volcanic rocks and siltstones (Upper Unuk River Formation, Hettangian to Pliensbachian); alternating conglomerates, sandstones, intermediate and mafic volcanic rocks (Betty Creek Formation, Pliensbachian to Toarcian); felsic pyroclastic rocks and flows, including tuffaceous rocks ranging from dust tuff to tuff breccias and localised welded ash tuffs (Mt. Dilworth Formation, Toarcian); and, finally, alternating siltstones and sandstones (Salmon River and Bowser

Formations, Toarcian to Bajocian). Britton and Alldrick (1988) also describe at least three intrusive episodes in the area; (a) intermediate to felsic plutons that are probably coeval with volcanic and volcaniclastic supracrustal rocks, (b) small stocks related to the Cretaceous Coast Plutonic Complex, (c) minor Tertiary dikes and sills. Regional geological mapping (e.g. Britton and Alldrick, 1988; Anderson, 1989) has demonstrated the continuity of lithologies and formations from well-constrained areas, such as the Stewart mining camp to the south (e.g. Alldrick et al., 1987) to the Sulphurets area. In the immediate Sulphurets area, however, age constraints are poor at present, although considerable work in progress is addressing this problem, for example through employing high precision U-Pb and K-Ar geochronometry. Researchers include Anderson, Kirkham and Bevier (Geological Survey of Canada), Alldrick, Britton and co-workers (British Columbia Geological Survey), Bridge (M.A.Sc. candidate, UBC), J. Margolis (Ph.D. candidate, University of Oregon), and this study. In addition, P. Smith and G. Nadaraju (UBC) are employing paleontological studies in the area. It may be anticipated that a more tightly constrained framework for the relative and absolute ages in the Sulphurets area will be forthcoming in the near future.

R2 Structure

Britton and Alldrick (1988) and Kirkham et al. (in prep.) have described the regional structural geology; in brief, the Hazleton Group lithologies display fold styles ranging from gently warped (e.g. a mapped synform to the South and East of Brucejack Lake, Alldrick and Britton, 1988) to tight disharmonic folds displayed by the Salmon River and Bowser Formations. Synvolcanic, synsedimentary and synintrusive faults are suspected but as yet to be documented fully (Kirkham et al., in prep.); Britton and Alldrick (1988), however, describe a syndepositional fault to the northeast of the Sulphurets property. Northerly striking, steep normal faults are recognised (e.g. Britton and Alldrick, 1988), although certain prominent northerly striking lineaments, such as the Brucejack Lineament (Kirkham, 1963, 1991), to the immediate west of the West Zone, displays evidence for little, if any, motion - at least in the Brucejack Lake area. Kirkham et al. (in prep) note that elsewhere along this linear, hydrothermal alteration zones are truncated. Minor thrust faults, dipping westerly are common in the region, and are important in the northern and western portions of the Sulphurets property in regard to interpretation of mineralized zones. Ongoing research by the GSC (e.g. see Kirkham et al., in prep.) and by Peter Lewis (MDRU-UBC) will add significantly to the near-term structural understanding of the area.

During the 1991 field season, an intermediate to felsic flow dome complex has been defined at the Southeast corner of Brucejack Lake, first identified, apparently, by G. Albino and J. Margolis (Corona Corporation; oral communication, 1990). The rock is flow banded, locally flow folded and intrudes heterogenous, bedded to massive pyroclastic rocks, locally red/maroon or green coloured, and locally potassium feldspar and plagioclase-hornblende porphyryitic flows, ascribed to the Upper Unuk River and Betty Creek Formations by Alldrick and Britton (1988). The flow-banded unit exhibits gradational contacts with a voluminous breccia unit, comprising clasts of identical composition to the intrusive phase, in a hematitic, muddy and locally finely laminated matrix. The morphology and geometry of the breccias suggests conformity with enclosing flow rocks, including potassium feldspar and plagioclase-hornblende phyric flows; the breccias are interpreted as volcanic ejecta, cemented by subaqueous, iron-rich, pelitic material. Higher in the section to the south of Brucejack Lake, the flow banded intermediate to felsic unit rests in apparent stratigraphic contact upon marooon coloured, blocky tuff. These field relationships indicate that the flow banded unit passes up section from intrusive at depth, to complex interdigitations with related ejecta at intermediate levels, to extrusive at highest observed levels.

R1 GEOLOGY OF THE WEST ZONE

Rocks underlying the West zone are considered by Britton and Alldrick (1988) and Alldrick and Britton (1988) to be confined to the Unuk River Formation and consist of a 400-500 metre wide band of generally northwesterly-trending volcanic and sedimentary rocks, sandwiched between two plagioclase- and hornblende-phyric intrusive bodies (Kirkham, 1991). The hostrocks comprise dominantly intermediate volcanic (pyroclastic) rocks to the northeast of the zone, and intermediate volcaniclastic rocks and minor argillaceous rocks to the southwest (Roach, 1990; Figure 4). Geological relationships and original characteristics of the host lithologies become obscured in the vicinity of the mineralized rocks, as a result of intense hydrothermal alteration and the development of penetrative fabric(s) in the altered rocks.

In the immediate vicinity of the West Zone, intermediate tuffs and tuff breccias have been strongly silicified and (?) potassium feldspar altered, brecciated and fractured, with subsequent silica-influx into the zones of brecciation and fracturing, resulting in vein and stockwork zones containing up to 20% quartz, exhibiting widths to 35 metres on surface (Figure 4). Roach (1990) has identified a well developed zonation of hypogene alteration about the mineralized zone, up to 100 metres wide at surface; from the core of the West Zone to its macroscopically observable outer margins, with the first mineral listed in each assemblage being dominant :

1. **Quartz**±Sericite±Carbonate
2. **Sericite**±Quartz±Carbonate
3. **Chlorite**±Sericite±Carbonate
4. **Clay**

In addition, investigation of diamond drill core reveals the presence of considerable potassium feldspar and at least two carbonate species. Little petrographic and mineralogic investigation of the alteration mineralogy is available currently, and is a focus of on-going work.

R1 WEST ZONE MINERALIZATION

The West Zone, as defined by Roach (1990), comprises at least 10 quartz vein and veinlet shoots (Figures 4, 5), named R1, R2, R4, R5, R6, R7, R8, UTC, Bielecki, Eraser; the nearby Old Yeller Zone is approximately 150 metres SSE of, and on strike with, the West Zone. Not all shoots crop out on surface and are known from underground development and exploration (Figure 5). Description in this paper is restricted to geological relationships exposed on surface and in diamond drill core. The R6 shoot is the most extensive within the West Zone, exposed along a strike length of 250 metres, and ranges in thickness from 0.3 to 6 metres. Ore shoots tend to exhibit greater down plunge extent (to the northeast) than in the strike dimension (Kirkham et al., in prep); the structural geology of various elements of the West Zone are described in the next section. With the exception of R7, the other shoots with pre-fix R, are structures that splay off R6; these relationships are amplified upon below.

Vein gangue mineralogy is dominated by quartz, with accessory potassium feldspar, albite and sericite, and minor carbonate (at least two varieties noted in core: white calcite and an orange, calcium-magnesium carbonate, probably kutnohorite; R.H. Sillitoe, Oral Communication, 1991), barite, apatite and rutile (Harris, 1989). Sulphides in the veins include, in decreasing order of abundance, pyrite, sphalerite, chalcopyrite, and galena; silver is present in the veins as tetrahedrite, pyrargyrite, polybasite, electrum and native silver, with rare stephanite and acanthite; native gold has been described, although electrum is the principal auriferous phase (Harris, 1989; Kirkham et al., in prep.). At least six vein and veinlet assemblages have been documented macroscopically in this study, based upon cross-cutting relationships observed in diamond drill core; from earliest to latest:

1. Potassium Feldspar-Quartz microveinlets (< 1mm in width)

2. Quartz-Carbonate veins and veinlets - generation (i)

3. Pyrite-Sphalerite-Galena veinlets

4. Quartz-Carbonate veins and veinlets - generation (ii)

4. Quartz (alone) veins and veinlets - generation (i)

5. Quartz (alone) veins and veinlets - generation (ii)

This preliminary paragenesis is to be confirmed by petrography and will form the basis for a study of the applicability of the West Zone material for microthermometric analysis of fluid inclusions. Petrography and lithogeochemistry will also be employed to characterize the hypogene alteration related to West Zone mineralization.

R1 STRUCTURE OF WEST ZONE AREA

The West Zone exhibits an overall southeasterlyly strike, approximately 140° (Roach, 1990; Figure 4), although internal structural elements such as veins, veinlet arrays and associated penetrative fabric(s) are complex and variable (Figures 4, 5). Structural data presented herein were collected predominantly by the first author in 1989, during a surface mapping program conducted by Newhawk Gold Mines (Roach, 1990); additional data, collected by the second author in 1991, are also included. The dominant fabric observed in the rocks at some distance (> 100m) from the West Zone dips steeply and strikes to the south-southeast (160°; Figure 6). As the West Zone is approached, the fabric is rotated to between 110° and 130°, throughout a zone approximately 130 metres in width, that correlates spatially with the most altered and highly strained hostrocks; the sense of rotation suggests sinistral shear in the West Zone, based upon typical geometries of structural elements in a shear zone (e.g. Tchalenko, 1970). These relationships are, however, complicated by development of a northeasterly (30° to 70°) fabric over a 40 metre-wide zone to the northeast of the high strain rocks (Figure 6).

The majority of veins observed on surface in the West Zone dip steeply to the northeast and strike approximately parallel to the trend of the zone (i.e. 140^{O}), although locally exhibiting sygmoidal terminations (Figures 5, 6). Veins of this geometry correspond to Central Shear Veins and Oblique Shear Veins, using the terminology of Hodgson (1989-(i), -(ii)). Subsidiary, second order veins branch off the principal veins, and strike between 100^{O} and 130^{O}; again, this vein geometry supports a sense of sinistral shear, as described above. In addition, a restricted number of veins follow northeast structures, oblique to the general trend, and dip steeply to the southeast and northwest. [Note that attitudes at depth differ from those at surface - the vein system tends to steepen and dip to the southwest - oral communication, B. Way, Newhawk Gold Mines Ltd., 1991]. Individual veins and composite vein sets exposed on surface in the West Zone exhibit evidence for (a) crack-seal fill with slivers of altered wall rock included within veins; and, also (b) vein fill in an extensional environment, subjected to contemporaneous folding and localised brecciation <u>during</u> crystallisation of gangue minerals, for example quartz and carbonate (Roach, 1990; Kirkham et al., in prep; and this study); observed features at surface include (from apparently least strained to most strained) : (1) vug fills of quartz, with unbroken crystal terminations, (2) vug fills in small scale (5-10 cm wavelength) folds, (3) extension gash veins, (4) 2nd order central - or oblique - veins, (5) sigmoidal central - or oblique - veins, locally conjugate arrays of sigmoidal veins/veinlets. These geometrical relationships between veins are observed on several scales - from hand specimen to map scale (see Figures 4, 5) - and are consistent with fluid influx (and hydrothermal alteration) during predominantly ductile deformation, interrupted periodically by brittle failure in response to a fluctuating fluid pressure (e.g. Sibson et al., 1975).

R1 SUMMARY

Vein-hosted, Au-Ag mineralization in the West Zone at Brucejack Lake, Sulphurets Property, is hosted in a zone of intensely altered and highly strained volcanic and volcaniclastic rocks. Alteration is zoned about the mineralized veins and veinlet arrays, from a central silicified zone, passing outwards to sericite, to chlorite and finally to clay; accessory sericite and carbonate are found throughout each alteration facies. The geometry of structural elements observed on snrface in the West Zone described here are well described in high strain zones, as synthesised by, for example, Hodgson (1989-(ii)).

R1 ACKNOWLEDGEMENTS

The authors wish to thank the owners and management of Newhawk Gold Mines Ltd. for permission to publish this work. The second author also wishes to acknowledge the considerable logistical and technical assistance received from Newhawk; in particular, Fred Hewett, Barry Way and Dave Visagie. We have received much assistance from geologists visiting the West Zone in 1991: several MDRU (UBC) researchers, R.V. Kirkham (GSC, Ottawa), J. Margolis (Ph.D. Candidate, University of Oregon), R.H. Sillitoe (London); we are most grateful for the assistance received from these individuals. We are grateful for the efforts of Tim Kirby (Newhawk Gold mines- for providing digitised diagrams) and Kirk Simpson (Ibex Drafting - for diagram preparation). The second author has benfitted from discnssions with Peter Lewis (MDRU - UBC) concerning structural geology at Brucejack Lake; the paper has been improved by reviews from .....

This paper is dedicated to the memory of Phil Malone.

Figure Captions

1. Location of the Sulphurets property, British Columbia
2. Stewart-Iskut River district, Northwestern British Columbia
3. Sulphurets Property, with location of mineralized zones
4. Map of the West Zone (modified from Roach, 1990), showing distribution of mineralized and hydrothermally altered zones
5. Cross Section 51+00 S, West Zone
6. Lower hemisphere projections of poles to structural elements within, and adjacent to, the West Zone.

References

Alldrick, D.J., and Britton, J.M., 1988; Geology and Mineral Deposits of the Sulphurets area, BCMEMPR, Open File Map 1988-4

Alldrick, D.J., Brown, D.A., Harakal, J.E., Mortensen, J.K., and Armstrong, R.L., 1987, Geochronology of the Stewart Miining Camp; *in* Geological Fieldwork, 1986, British Columbia Ministry of Energy Mines and Petroleum Resources, Paper 1987-1, p. 81-92.

Anderson, R.G., 1989: A stratigraphic, plutonic, and structural framework for the Iskut River map area, Northwestern British Columbia,; in Current Research, Part E, GSC, Paper 89-1E, p. 145-154.

Bridge, D.A., Ferguson, L.J., and Brown, M.G., 1981: 1980 Exploration Report on the SDulphurets Property, Skeena Mining Division, B.C.; unpublished internal report for Granduc Mines Ltd., Esso Resources Canada Ltd., and Sidney F. Ross; 151 p., 3 appendices, 51 maps.

Britton, J.M., and Alldrick, D.J., 1988: Sulphurets Map area, BCMEMPR, Geological Fieldwork, 1987, Paper 1988-1, p. 199-209.

Grove, E.W., 1986: Geology and Mineral Deposits of the Unuk River - Salmon River - Anyox area; BCMEMPR, Bull. 63, 434 pages.

Harris, J.F., 1989: Petrographic Report 1989-1; unpublished report for Newhawk Gold Miners Ltd.; 34 pages, 2 appendices.

Hodgson, C.J., 1989-(i) : Patterns of Mineralization, p. 51-88, in Mineralization and Shear Zones, editor, J.T. Bursnall, GAC, Short Course Notes, Volume 6, 299 p.

Hodgson, C.J. 1989-(ii) : The structure of shear-related, vwein-type gold deposits : a review : Ore Geology Reviews, Vol. 4, p. 231-273

Kirkham, R.V., 1963: The geology and mineral deposits in the vicinity of the Mitchell and Sulphurets glaciers, Northwestern British Columbia, unpublished M.Sc. Thesis, University of British Columbia, 122 p.

Kirkham, R.V., 1991 : Provisional geology of the Mitchell-Sulphurets region, Northwestern British Columbia (104 B/8,9); GSC Open File 2416.

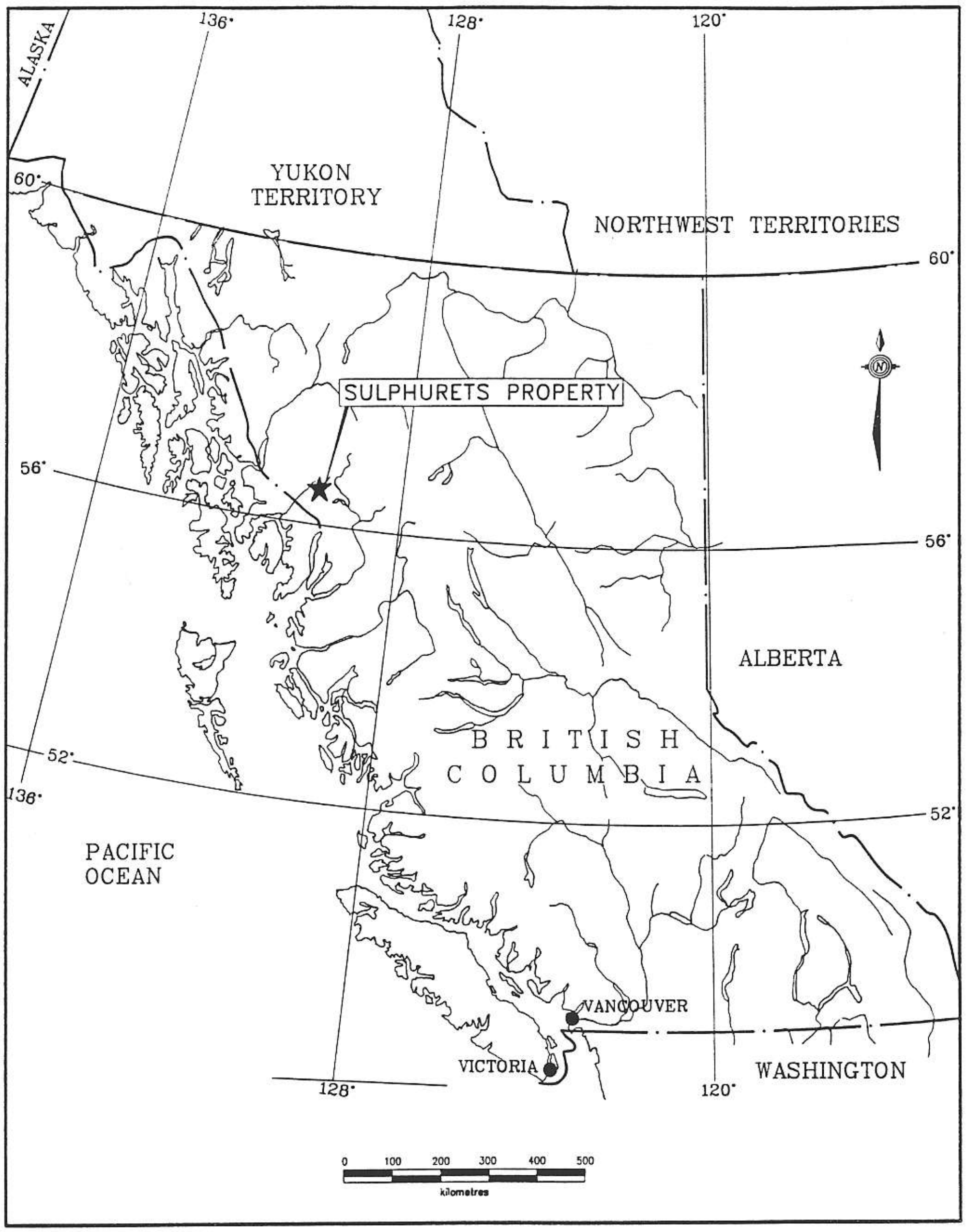
Kirkham, R.V., Ballantyne, S.B., and Harris, D.C., *in prep*, Sulphurets area, British Columbia - preliminary geology, geochemistry, and mineralogy of a deformed porphyry copper, molybdenum, precious metal system.

Roach, S., 1990 : 1989 Surface Exploration Program; Newhawk Gold Mines ltd., unpublished internal report, 34 pages, 2 appendices, 1 map.

Sibson, R.H., Moore, J.M., and Rankin, A.H., 1975 : Seismic pumping - a hydrothermal fluid transport mechanism; J. Geol. soc. Lond., v. 131., p. 653-659.

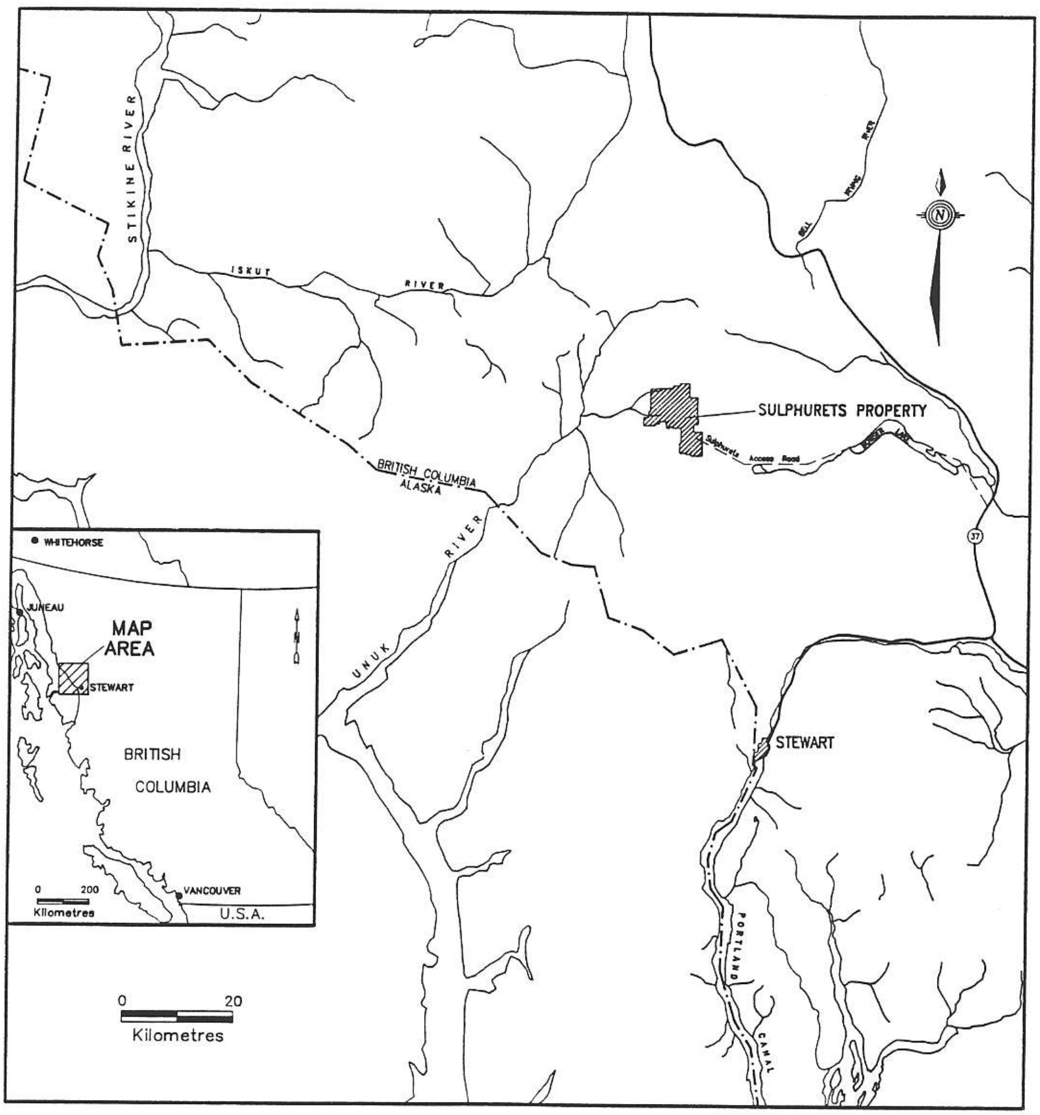
Tchalenko, J.S., 1970 : Similarities between shear zones of different magnitudes; BGSA, v. 81, p. 1625-1640.

Wheeler, J.O. and McFeely P., 1987: Tectonic Assemblage Map of the Canadian Cordillera and adjacent parts of the United States of America, Geological Survey of Canada, Open File 1565.

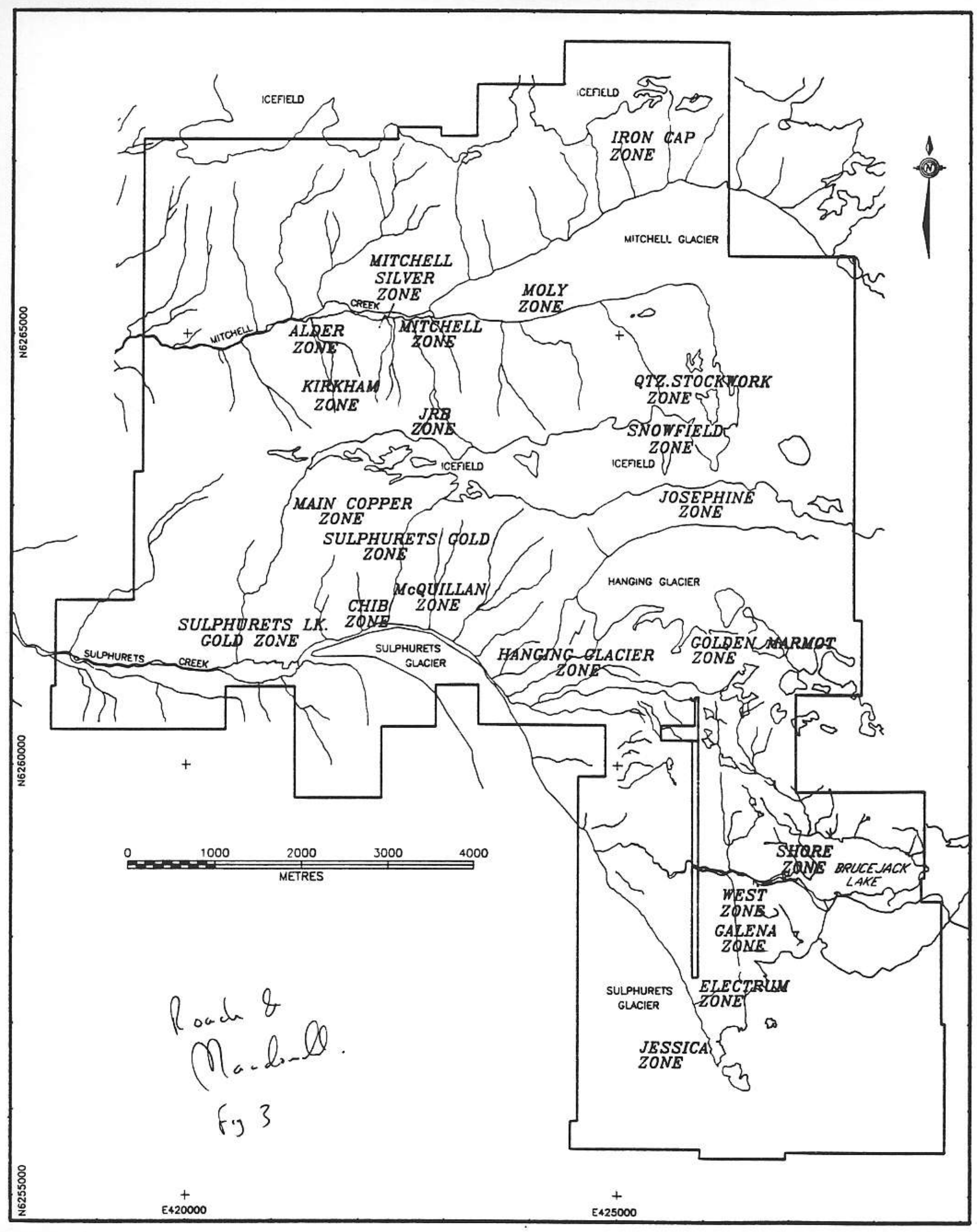


Roach & MacDonald

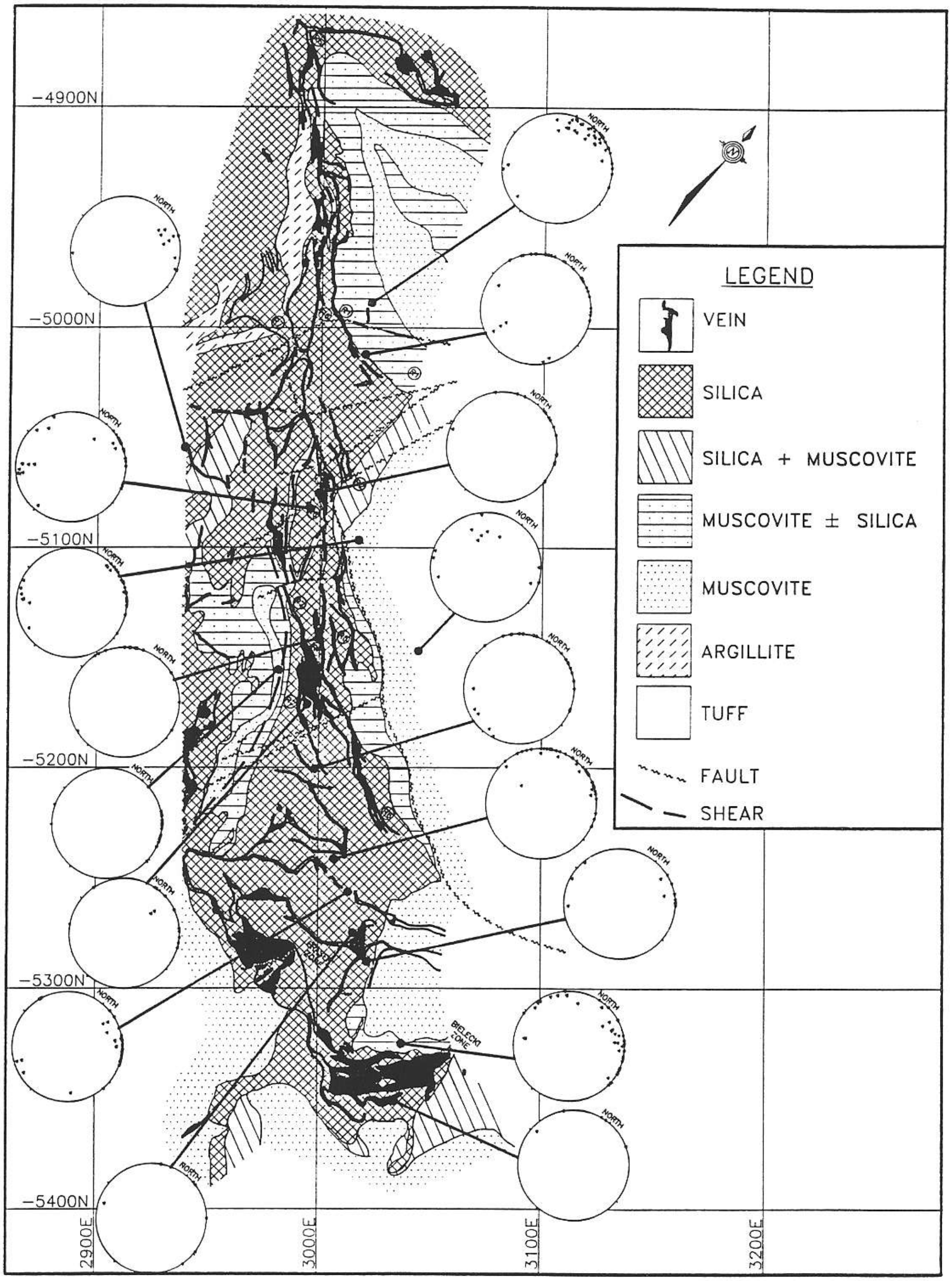
Fig I



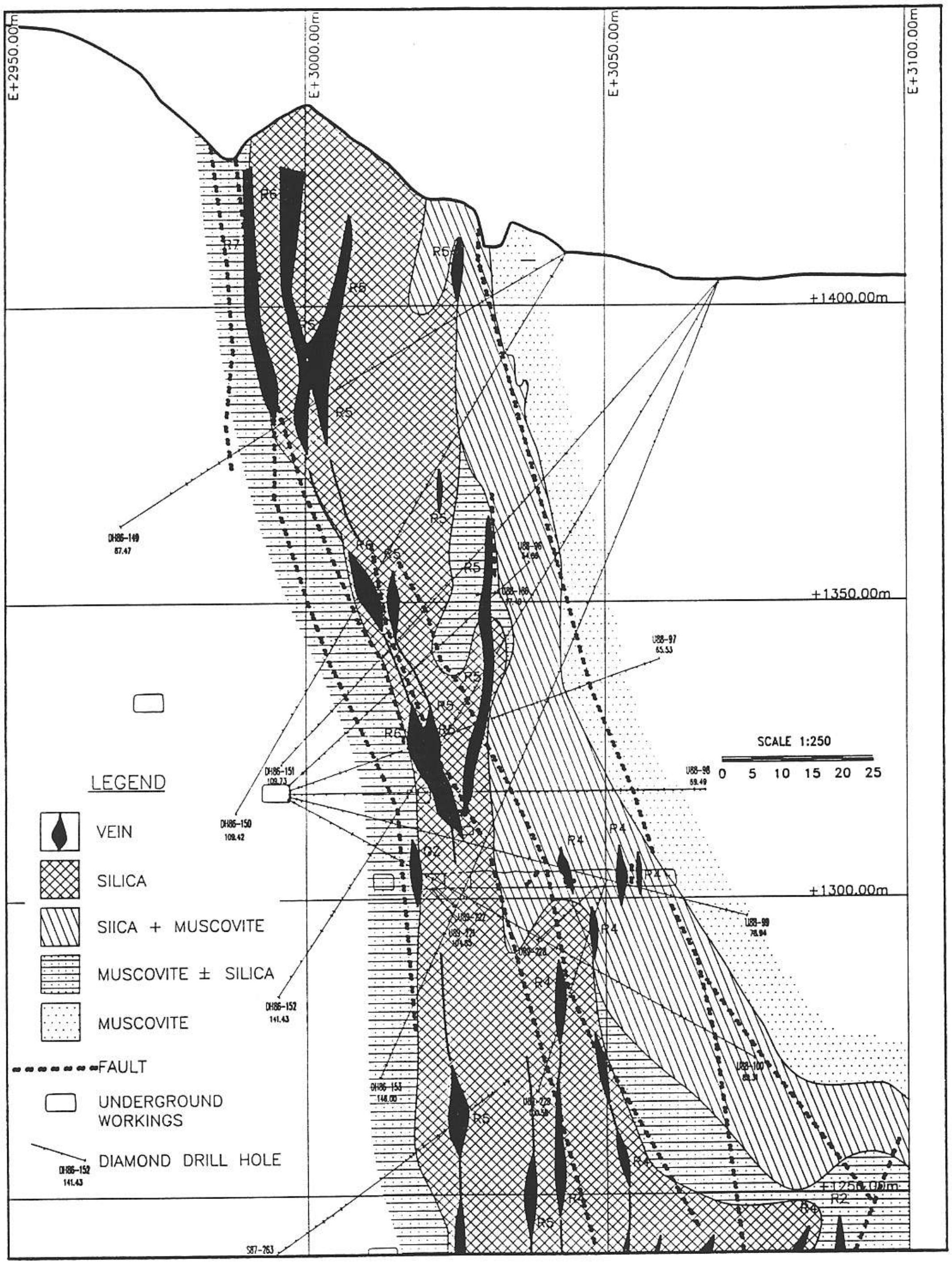
Roach & Macdonald
Figure 2



Roach & Macdonald. Fig 3



Roach & McDonald
Fig 4 - geol. soln.
6 w/ zones



Rouch & Macdonald Fig 5