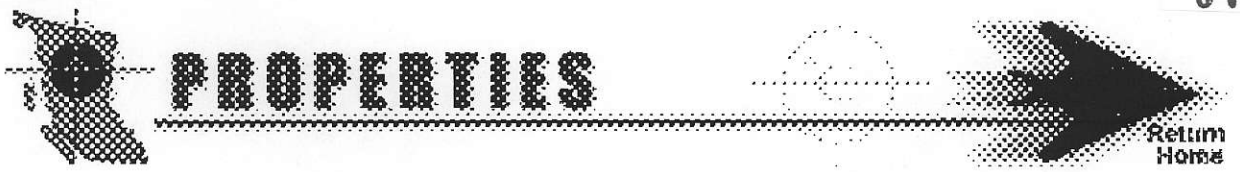

Porphyry Deposits of the Northwestern Cordillera of North America

The Pine property gold-copper and copper-molybdenum porphyry prospects, Kemess - Toodoggone district, northern British Columbia

ABSTRACT

The Pine property is located in the Kemess - Toodoggone district of north-central British Columbia, 450 km northwest of Prince George. Drilling has identified an initial geological reserve of 40 million tonnes grading 0.57 g/t Au and 0.15 % Cu. Potential for a larger reserve exists within the untested portions of an induced polarization chargeability anomaly. The gold-rich porphyry copper mineralization at Pine is genetically related to the intrusion of a high level quartz monzonite pluton which is comagmatic with the host Early Jurassic Toodoggone Formation volcanic rocks. Pyrite, chalcopyrite, minor bornite and lesser molybdenite occur as disseminations, fracture fillings and within quartz veins in both the pluton and adjacent volcanic rocks. Higher concentrations of gold and copper occur in the pluton and correlate with zones of intense quartz stockwork accompanied by intense potassium feldspar vein selvages, locally intense quartz-magnetite flooding and the persistent presence of magnetite stringers and disseminations. The core of the potassic zone has not yet been defined. The gold-copper mineralization and its associated potassium alteration are enclosed by a large area of phyllic alteration which laterally grades outward into a propylitic assemblage characterized by the presence of epidote and lesser chlorite. The deposit likely fits into the calc-alkaline platonic and/or volcanic porphyry class.

Introduction

The Pine property is located in north-central British Columbia at latitude 57°14'N, longitude 126°44'W, on NTS mapsheets 94E/2 and 94E/7 approximately 450 km northwest of Prince George (Fig. 1) and is 25 km due north of the Kemess South deposit. The property lies in the Arctic drainage system along the western margin of the Swannell Range of the Omineca mountains. Topography is dominated by the broad Finlay River valley with its moderately flat terrain of old river terraces (Fig. 2). Rugged, alpine terrains to the northwest and southeast flank the valley bottom. Elevations range from 1000 m to 2000 m.

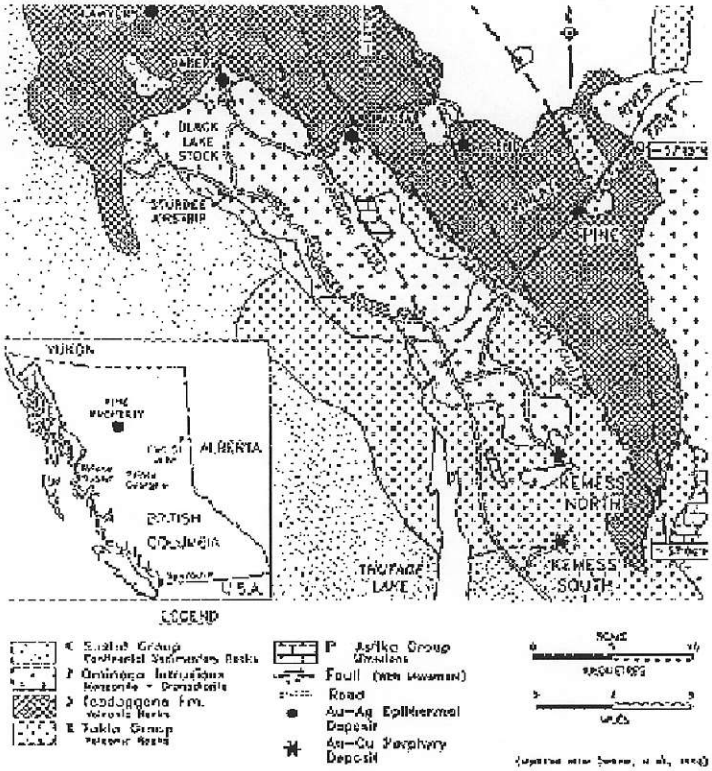

FIGURE 1. Location map and regional geology: Kemess - Toodoggone district.

History

The area that covers the Pine property was explored by Kennco Explorations (Western) Ltd. from 1968 to 1973. Silt and soil sampling surveys led to the discovery of the Fin prospect, a granodiorite-hosted, porphyry-style copper-molybdenum occurrence. It was tested by one 25 m X-ray diamond drill hole which assayed 0.25 % Cu over its entire length. Kennco abandoned the property in 1973.

The property was subsequently restaked by others and optioned to: Riocanex, from 1979 to 1980; Brinco, in 1982; and Cominco, in 1990. Prospecting work by Riocanex identified the Pine prospect, a quartz monzonite-hosted zone of porphyry-type gold-copper mineralization located some 2.5 km to the southwest of the Fin prospect (Fig. 3). Diamond driving by Riocanex at the Pine prospect, comprising 1354 m in 12 holes, encountered several well-mineralized gold-copper intercepts in a number of shallow holes. Brinco in 1982 and then Corninco in 1990 further tested the Fin prospect. Shallow percussion drilling by Cominco, comprising 23 holes totalling 2485 m, encountered low copper concentrations at the Fin prospect and low gold and copper concentrations in volcanic rocks at the nearby Tree prospect. In 1991, Cominco returned the property to its current owner, Electrum Resources Ltd.

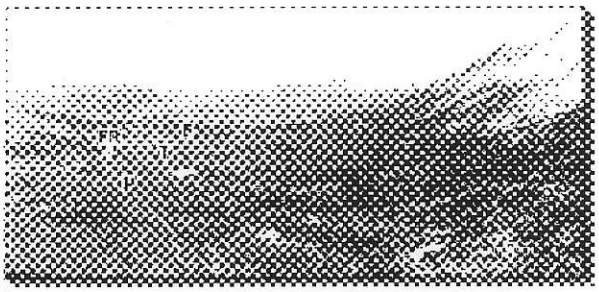

FIGURE 2. Pine property, looking northeast down Finlay River (FR) Valley at the Pine deposit (P), Tree (T) and Fin (F) zones.

In 1992, Romulus Resources Ltd. took an option on the property and carried out an integrated program which included 2485 m of HQ diamond driving in 13 holes. The drilling focussed on an underexplored induced polarization anomaly which measures some 3.5 km by 1.0 km and includes the Pine, Tree and Fin prospects (Fig. 4). Most Romulus drill holes intersected significant mineralization (Greater than or Equal to 0.1 % Cu + Greater than or Equal to 0.2 g/t Au), including hole 92-4 where 126 m contained 0.92 g/t Au and 0.16% Cu in altered quartz monzonite.

Regional Geology

The Pine property is located in the east-central portion of the Kemess - Toodoggone district which is predominantly underlain by mafic flows and breccias of the Upper Triassic Takla Group, and

pyroclastic volcanic and epiclastic sedimentary rocks of the Lower to Middle Jurassic Hazelton Group (Toodoggone Formation). Lower to Middle Jurassic Omineca Intrusions (Black Lake Intrusive Suite) cut older strata in the central and eastern parts of the region. To the west, these older rocks are unconformably overlain by subaerial sedimentary rocks of the Lower to Upper Cretaceous Sustut Group (Fig. 1).

Deep-seated, northwestern trending fault zones have controlled Lower to Middle Jurassic comagmatic intrusive, volcanic and hydrothermal events. Northeasterly trending faults comprise a subordinate fault system which is often an important control to mineralization in the district.

The Kemess - Toodoggone district is well-documented for its porphyry copper and epithermal precious metals mineralization (Diakow et al., 1993). Gold-rich perphyry copper deposits are hosted by both Takla Group and Toodoggone Formation volcanic rocks and are spatially and temporally associated with porphyry dikes and plutons. The Kemess North and Kemess South porphyry gold-copper deposits located 16 km and 22 km to the south of the Pine property have geological reserves of 175 million tonnes grading 0.37 g/t Au and 0.18 % Cu and 248 Mt grading 0.62 g/t Au and 0.22% Cu. respectively. The volcanic rocks also host epithermal gold and silver mineralization which is probably genetically related to the deeper seated porphyry copper deposits.

A more detailed summary of the regional geology is included in the Kemess peper by Rebagliati et al. (this volume).

Geology of Porphyry Prospects

Lithology

The geology of the central portion of the Pine property is shown in Figure 3. The oldest rocks are Toodoggone Formation, Upper Volcanic Cycle, Attycelley Member crystal turfs and other fine-grained pyroclastic rocks (Diakow et al., 1993). As observed in drill core, these altered rocks are mainly latitic to andesitic in composition, commonly quartz bearing and/or feldspar porphyritic and occupy the southwestern portion of the property. Omineca Intrusions underlie the northeastern portion of the property. The plutonic suite consists of mainly granodiorite and lesser granite and quartz monzonite.

At the Pine prospect, a body of quartz monzonite crops out and has been intersected in a number of drill holes. The monzonite is variably potassically altered, locally contains 2% to 8% magnetite, and is an important host to gold-copper mineralization.

A suite of postmineral dikes, including quartz latite porphyry, trachyte and minor manic varieties, crosscuts mineralization and all other rock types.

Structure

A series of moderate to high-angle faults, striking between 330° and due north, have controlled the emplacement of many of the late dikes and, in some diamond drill holes, are the abrupt contact between well- and less-mineralized rock.

Several areas of intense fracturing are exposed along northwest trending creek canyons. These structures are probably related to deep-seated, northwesterly trending fault zones which are regionally dominant in the Kemess - Toodoggone district.

Although major northeasterly trending faults have not been recognized to date at Pine, the main induced polarization anomaly is elongate in this direction. Northeasterly trending structures could be important controls for mineralization.

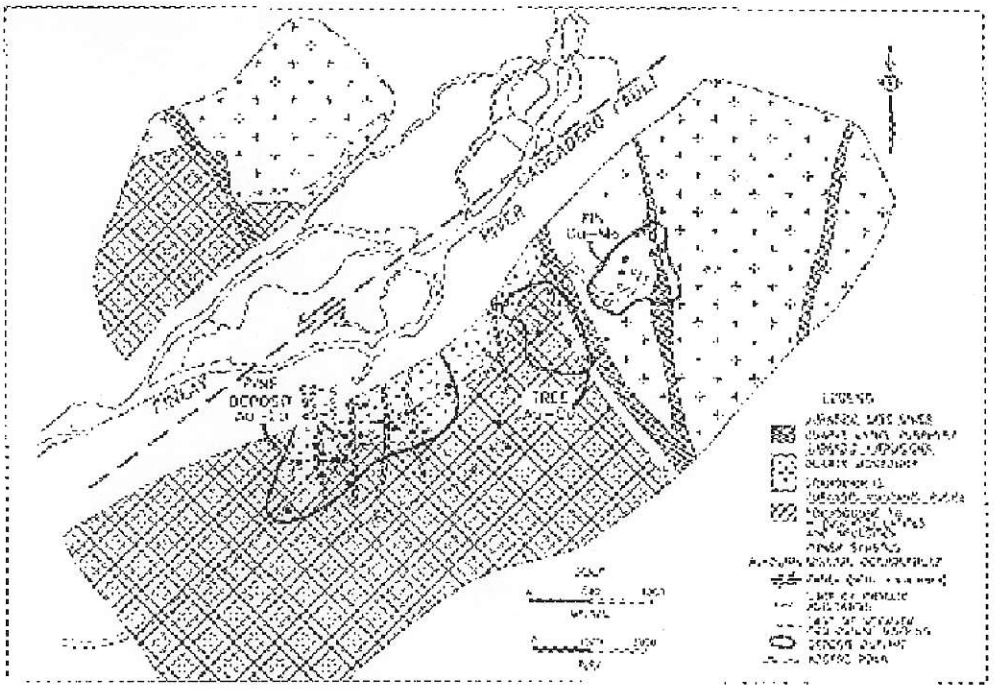

FIGURE 3. Geology of the Pine property.

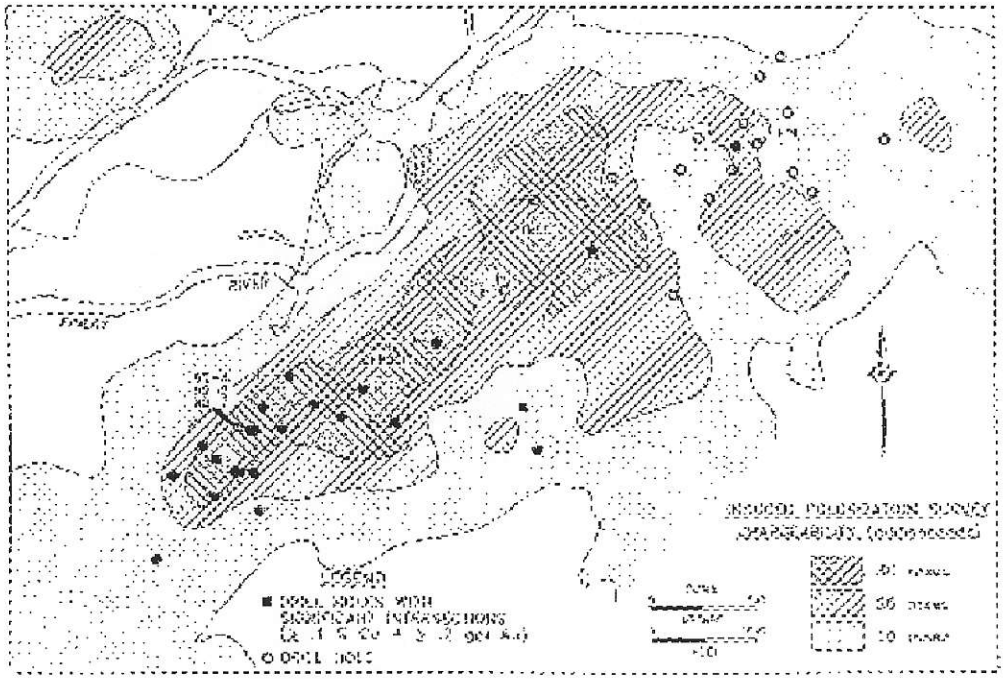

FIGURE 4. I.P. chargeability anomaly and drill holes with significant intersections.

Mineralization and Alteration

The Pine property is centred on a large induced polarization anomaly which covers over 4 km2 and contains three porphyry prospects: the Pine, a gold-copper system hosted by quartz monzonite; the Tree, a gold-copper system hosted by quartz latitic volcanic rocks; and the Fin, a granodiorite-hosted copper-molybdenum system (Fig. 3).

At the Pine prospect, drilling has partially outlined a mineralized zone which is in excess of 400 m

wide. Pyrite, chalcopyrite, minor bornite and lesser molybdenite occur as disseminations, fracture fillings and within quartz veins. Total sulphide content is estimated to be 2% to 4%. The average grade of the zone is 0.57 g/t Au, 0.15% Cu, 1.3 ppm Ag and 14 ppm Mo. Typical calc-alkaline potassic, phyllic and propylitic alteration suites are developed within and areund the quartz monzonite. Higher concentrations of gold and copper correlate with zones of intense quartz stockwork accompanied by intense potassium feldspar vein selvages, locally intense quartz-magnetite flooding and the persistent presence of magnetite stringers and disseminations.

Polished section examination of intrusion-hosted, hypogene mineralization indicates that gold is enclosed in gangue or attached to chalcopyrite grains. No native gold or other gold phases were found enclosed in pyrite.

Volcanic-hosted gold-copper mineralization at the Tree prospect grades in the order of 0.20 g/t Au and 0.12 % Cu. The gold-copper mineralization is open to extension. Pyrite and chalcopyrite occur as disseminated grains and fracture fillings and within quartz magnetite veins. Total sulphide content is estimated to be 3%. Alteration is typified by development of a weak to moderate quartz-magnetite stockwork accompanied by locally intense silica flooding, moderately to intensely pervasive sericite and weak K-feldspar in vein selvages.

The Pine and Tree prospects are enclosed by a large area of sericite-quartz-pyrite phyllic alteration which laterally grades outward into a propylitic assemblage characterized by the ubiquitous presence of epidote and lesser chlorite (Fig. 3). The core of the potassic zone, which may be common to both prospects, has not yet been defined.

At the Fin prospect, porphyry-style copper-molybdenum mineralization occurs in altered hornblende granodiorite. Drilling by Kennco and Cominco has outlined a zone measuring about 200 m by 300 m which returned assays greater than 0.1 % Cu. Pyrite, chalcopyrite and minor molybdenite occur as disseminations, fracture fillings and within quartz veins. Alteration is typified by the development of epidote as coatings along fractures and as disseminated replacernents of mafic minerals. Quartz stockwork development is generally weak, and pervasive sericite, where present, is mainly structurally controlled.

At the Pine and Tree prospects, the similarity of alteration and Au:Cu ratios suggest both are related to the high-level Pine quartz monzonite intrusion. The relative ages of the Pine quartz monzonite and the Fin granodiorite intrusions are not known, however, the authors speculate that granodiorite is an older and deeper seated ititrusion.

Weathering and Supergene Characteristics

The major part of the induced polarization anomaly is recessive and overburden covered. Weathering and supergene characteristics of the mineralization are not well understood.

Phyllically altered volcanic rocks exhibit intense shattering and limonitic staining and have probably undergone near surface copper depletion. Higher-grade porphyry gold-copper mineralization in the top portions of Holes 922 and 924 (Fig. 5) contains a sooty black mineral (supergene chalcocite?) coating pyrite and chalcopyrite. Malachite and azurite characterize oxide-copper mineralization which crops out in the Pine prospect area. A gypsum-anhydrite stockwork, which occurs throughout the mineralized area, is leached to depths of up to 200 m.

Genesis of Mineralization

Gold and copper mineralization at the Pine and Tree prospects is hosted by both Toodoggone Formation volcanic rocks and a high-level comagmatic (?) quartz monzonite pluton. Both prospects lie within a large hydrothermally altered sulphide system which is spatially and probably genetically related to the intrusion of the pluton.

At the Fin prospect, copper and molybdenum mineralization is granodiorite-hosted and contains little or no gold. Although it is in close proximity to areas of gold-copper mineralization, it is unclear as to what genetic relationship, if any, exists between the two types of mineralization.

Applied Exploration Techniques

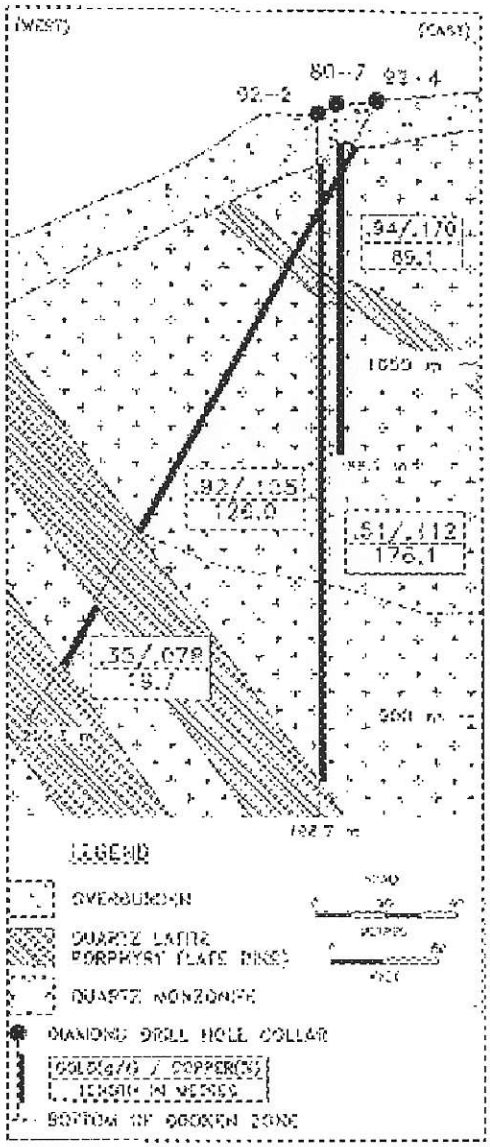

FIGURE 5. East-west cross-section looking north through DDH's 807, 922 and 924 (for location see Fig. 3).

Silt and soil sampling surveys, combined with conventional prospecting methods, led to the early discovery of surface mineralization on the Pine property. Limited shallow drill testing gave earlier workers some indication of the tenor of mineralization, but did not help them appreciate the ultimate size potential of the porphyry mineralized systems.

Important aspects of the 1992-93 Romulus program, which have helped in the reinterpretation of the setting of the gold-copper mineralization and its potential size, include: a thorough compilation of all previous data; additional induced polarization surveying to delineate the large sulphide system which had been partially outlined in 1990 by Cominco; additional detailed geological mapping in key areas to assist in geological modelling; relogging and fill-in sampling of old diamond drill core which had not previously been thoroughly and systematically assayed; drilling with larger diameter core and deeper holes; and project management by those with experience gained during work on the nearby Kemess project.

Economics

At the Pine prospect, driving has identified an initial geological reserve of 40 Mt grading 0.57 g/t Au and 0.15 % Cu. These geological reserves were calculated by the polygonal method using a 10 m bench interval, a polygon radius of 100 m and a density of 2.70. Potential for a larger reserve exists within the untested portions of the main induced polarization anomaly.

Discussion and Conclusions

Gold-copper mineralization on the Pine property is genetically related to the intrusion of a high-level quartz monzonite pluton. Exploration is still at too early a stage to categorize these calc alkaline deposits, but likely they fit into the phyllic and/or volcanic porphyry class (Sutherland Brown, 1976). The genesis of the copper-molybdenum mineralization at the Fin is uncertain. Given the absence of gold values and the fact that it is developed internally in a medium-sized granodiorite pluton, this mineralization may be of the platonic porphyry type.

The geological setting of the Pine gold-copper porphyry prospect is characterized by an intermediate depth of emplacemnent relative to other porphyry deposits and prospects in the Kemess-Toodoggone district. The Kemess North and South deposits are hosted by older Takla Group volcanic strata and monzonitic intrusions. The Brenda gold-copper porphyry prospect (Fig. 1) is hosted by quartz and quartz-magnetite stockworks in sericitically altered Toodoggone Formation volcanic rocks and monzonite porphyry dikes. Nearby zones of argillic and alunite alteration, suggest a higher level of porphyry emplacement.

As exploration in the district proceeds, more gold-rich porphyry copper deposits will likely be discovered, especially now that it has been clearly demonstrated that porphyry copper mineralization previously considered as being "too low-grade" can be associated with appreciable concentrations of gold.

Acknowledgments

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REFERENCES

• BOWEN, B., BOWER, B., COPELAND D. and REBAGLIATI, C.M., 1992. Summary report on the 1991 exploration program, Kemess North Property, Omineca Mining Division, B.C. Unpublished company report, El Condor Resources Ltd., Vancouver, British Columbia, 109 p.
• CANN, R.M. and GODWIN, C.I., 1980. Geology and age of the Kemess porphyry copper-molybdenum deposit, north-central British Columbia. Canadian Institute of Mining and Metallurgy, CIM Bulletin, 73, No. 821, p. 94-98.
• DIAKOW, L.J., PANTELEYEV, A. and SCHROETER, T.G., 1991. Jurassic epithermal deposits in the Toodoggone River area, northern British Columbia: Examples of well-preserved, volcanic-hosted, precious metal mineralization. Economic Geology, 86, p. 529-554.
• DIAKOW, L.J., PANTELEYEV, A. and SCHROETER, T.G., 1993. Geology of the Early Jurassic Toodoggone Formation and gold-silver deposits in the Toodoggone River map area, northern British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Bulletin 86, 72 p.
• FORSTER, D.G., 1984. Geology, petrology and precious metal mineralization, Toodoggone River area, north-central British Columbia. Unpublished M.Sc. thesis. The University of British Columbia, Vancouver, British Columbia, 313 p.
• HARRIS, J.F., 1987. Rock geochemistry, lithological classification and alteration studies in volcanic rocks from the central part of the Fin property. Unpublished company report for Bradford D. Pearson, Vancouver, British Columbia, 1987.
• HAYNES, L. and KNIGHT D., 1980. Geology and geochemistry of the Fin claims. Unpublished company report, Rio Tinto Canadian Exploration Ltd., Vancouver, British Columbia, 1980.
• HAYNES, L. and CAMPBELL C., 1980. Report on 1980 diamond drilling and geophysics on the Fin claims. Unpublished company report, Rio Tinto Canadian Exploration Ltd., Vancouver, British Columbia, 1980.
• MONGER, J.W.H., 1977. The Triassic Takla Group in McConnell Creek map area, north-central

British Columbia. Geological Survey of Canada, Paper 76-29.
• REBAGLIATI, C.M., COPELAND, D., HARRIS, M. and BOWER, B., 1991. Summary report on the 1991 exploration program, Kemess South Joint venture property, Omineca Mining Division, B.C. Unpublished company report, El Condor Resources Ltd., Vancouver, British Columbia.
• REBAGLIATI, C.M., BOWER, B.K., COPELAND, D. and NIOSI, D., 1995. Kemess South and Kemess North porphyry Au-Cu deposits, northern British Columbia. In Porphyry Deposits of the Northwestern Cordillera of North America. Edited by T.G. Schroeter. Canadian Institute of Mining and Metallurgy, Special Volume 46 (this volume).
• SUTHERLAND BROWN, A., 1976. Morphology and classification. In Porphyry deposits of the Canadian Cordillera. Edited by A. Sutherland Brown. Canadian Institute of Mining and Metallurgy, Special Volume 15, p. 44-51.
• WOODCOCK, J.R. and GORC, D., 1982. Geology and geochemistry of the Fin claims. Unpublished company report, Brinco Mining Limited, Vancouver, British Columbia.

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