

HYDROTHERMAL ALTERATION ASSOCIATED WITH THE SILVER QUEEN POLYMETALLIC VEINS AT OWEN LAKE, CENTRAL B.C.* (93L/2)

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INTRODUCTION

The Silver Queen polymetallic vein deposit is in the Intermontane Belt in central British Columbia (54°05'N; 126°44'W) about 100 kilometres southeast of Smithers and 35 kilometres south of Houston (*see Hood et al.*, 1991, this volume; Figure 2-3-1). The study area lies in the central portion of the Nechako trough, just south of the Skeena arch. The deposit occurs near the rim of the Buck Creek basin, interpreted as a resurgent caldera delineated by intrusions and a semicircular alignment of Upper Cretaceous to Eocene volcanic centres (Church and Barakso, 1990).

Hydrothermal alteration in the mine area has not previously been studied in detail. Church (1970) noted that wallrock alteration included kaolinization of feldspar and replacement of ferromagnesian minerals by fine-grained carbonates, epidote and pyrite; altered rock characteristically is nonmagnetic. Church and Pettipas (1990) noted that the veins commonly have an argillic envelope and a broad aureole of propylitic alteration. Fyles (1984) indicated that kaolinite with or without sericite is common, and that the principal carbonate is siderite.

This study concentrates on alteration mineral assemblages and their spatial relationships to the No. 3 vein, the most explored mineralized zone in the study area. Results are based on petrographic examination and X-ray diffraction analysis of rock samples collected during under-

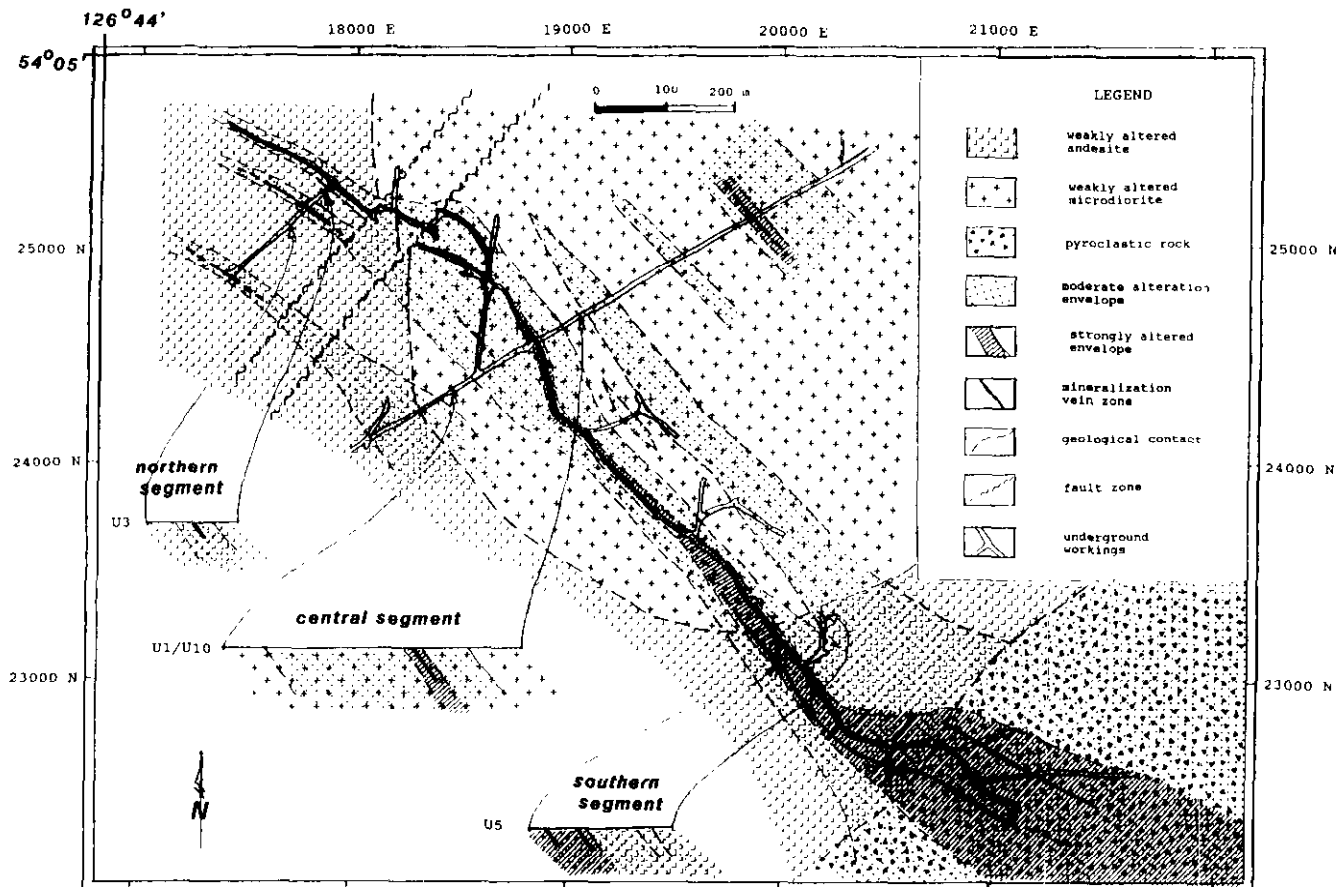


Figure 2-3-1. Schematic plan of alteration on the 2600-foot level, Silver Queen mine.

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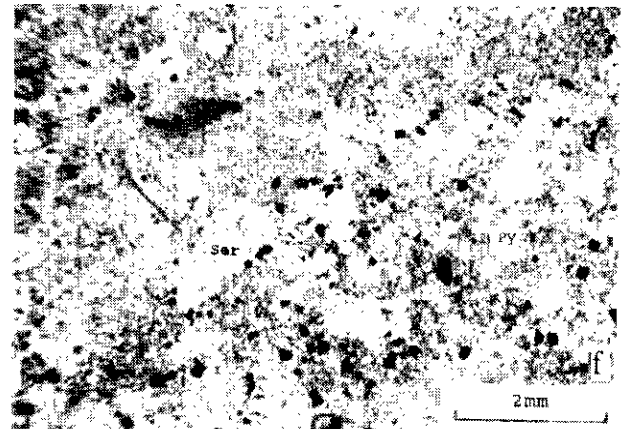
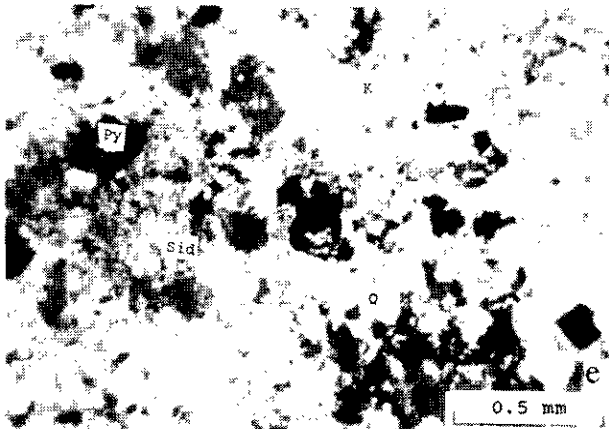
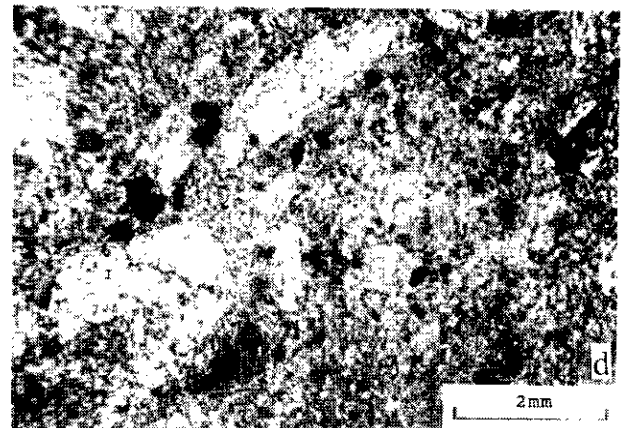
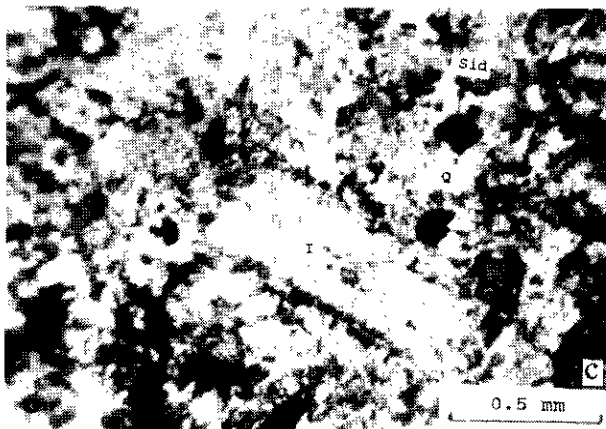
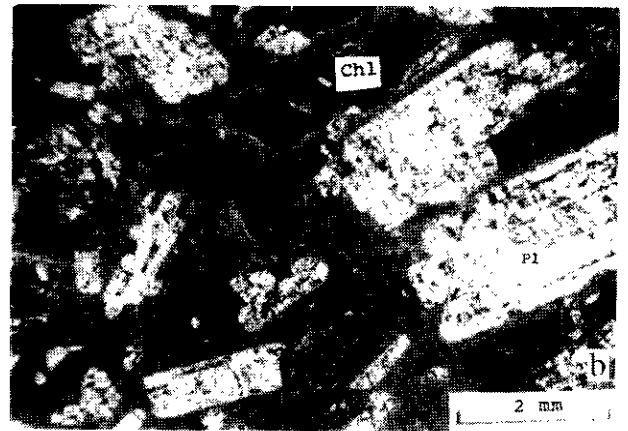
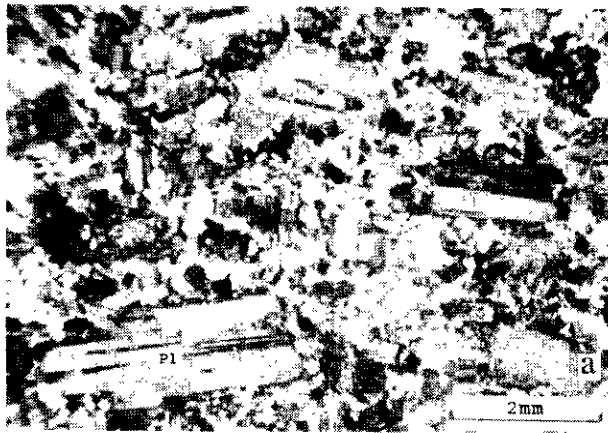


Plate 2-3-1. (a) Weakly altered microdiorite from the central segment of the No. 3 vein; (b) weakly altered andesite from the northern segment of the No. 3 vein. Photomicrographs a and b show that chlorite replaces augite, kaolinite partially replaces plagioclase along its margins and cleavages and aphanitic matrix remains unaltered; (c) moderately altered microdiorite from the central segment of the No. 3 vein; (d) moderately altered andesite from southern segment of the No. 3 vein. Photomicrographs c and d show that illite and kaolinite almost completely replace primary plagioclase, and the recrystallization and silicification of aphanitic matrix. (e) strongly altered microdiorite from the central segment of the No. 3 vein with kaolinite replacing plagioclase, carbonate replacing mafic mineral and matrix intensely recrystallized and silicified. Disseminated pyrite is common. (f) strongly altered andesite from the southern segment of the No. 3 vein with simple alteration mineral assemblage of sericite-quartz-pyrite. (Q = quartz; Pl = plagioclase; K = kaolinite; Sid = siderite; I = illite; Ser = sericite; Py = pyrite.)

ground mapping and drill-core logging. The sample base consists of 60 thin sections and their corresponding hand specimens, and 38 whole-rock analyses by X-ray diffraction. These samples represent northern, central, and southern cross-sections of the No. 3 vein on the 2600-foot underground level (Figure 2-3-1). Due to the fine grain size, the X-ray diffraction method has been used to distinguish different species among the phyllosilicates and carbonates including sericite, illite, kaolinite, chlorite, calcite and siderite, after methods suggested by Moore and Reynolds (1989).

DEPOSIT GEOLOGY

Rocks hosting the Silver Queen deposit are thought to be correlative with Upper Cretaceous Kasaska Group (Leitch *et al.*, 1990). At Silver Queen they consist mainly of porphyritic andesite flows, hypabyssal microdiorite and various pyroclastic units. The hypidiomorphic microdiorite texturally grades into the porphyritic andesite flows and they are interpreted to be two facies of the same volcanic event. Epithermal, polymetallic quartz-carbonate-barite veins with associated hydrothermal alteration cut these rocks on north-westerly and southeasterly trends.

No. 3 vein has a southeasterly strike (135°) and a steep to moderate northeast dip (55°). Width varies from a few centimetres to 1 metre in the sections studied in detail, but is locally greater. Pinching and swelling, branching and converging of the veins are common. The vein mineral assemblages are different in the northern, central and southern segments of the deposit. Sphalerite and rhodochrosite are the dominant vein minerals in the northern segment. Pyrite, sphalerite and hematite are the major components in the central segment. Quartz, calcite, barite and massive sphalerite-galena-pyrite are characteristic of the southern segment (Hood *et al.*, 1991, this volume). Correspondingly, the wallrock alteration varies from north to south, as discussed below.

WALLROCK ALTERATION

Hydrothermal alteration of the host microdiorite and andesite has been characterized as weak, moderate and strong.

Weakly altered rock is ubiquitous throughout the study area (Figure 2-3-1). The rock is black, hard, and magnetic. Primary plagioclase phenocrysts have limited alteration to clay along crystal margins and cleavages. Most primary mafic phenocrysts are extensively altered to chlorite and/or iron carbonate. Aphanitic matrix is largely unaltered (Plate 2-3-1, a and b). Based on petrographic similarities to rarely noted unaltered microdiorite and andesite, these weakly altered rocks are assumed, for the purpose of this study, to be the "fresh" rock parent to the moderately and strongly altered rocks described below.

Moderately altered rock occurs as broad envelopes around veins. It is buff coloured, softer than weakly altered rock, and nonmagnetic. Primary minerals have been altered almost completely. Generally, plagioclase is delicately pseudomorphed to sericite, illite or kaolinite. Mafic minerals are altered to chlorite or iron carbonate. Recrystalliza-

tion and silicification are obvious in the matrix (Plate 2-3-1, c and d). The contact between weakly altered and moderately altered rock is relatively sharp, commonly grading over less than 2 centimetres.

Strongly altered rock occurs as an envelope adjacent to the vein. It is commonly pale apple-green when freshly broken and orange-yellow on weathered surfaces; it is moderately hard and nonmagnetic. All primary minerals have been completely altered to quartz, sericite or kaolinite, carbonates and pyrite. Pseudomorphs of plagioclase are not as well defined as in moderately altered rocks. Recrystallization and silicification of the matrix are more intense than in moderately altered rock. Disseminated fine-grained pyrite is ubiquitous (Plate 2-3-1, e and f). The contact between moderately and strongly altered rocks is typically gradational.

As there is variation in the alteration assemblage perpendicular to the vein, so too there is variation in the assemblage parallel to the vein. These variations are described for each of the major segments.

In the northern segment of the No. 3 vein (north of section 24700N on the mine grid; Figure 2-3-1), the alteration envelope is narrow (about 7 metres wide). There is no significant difference between the alteration envelope at the hangingwall and the footwall. Consequently, only the alteration data from the hangingwall are presented in detail. The strongly altered envelope is 1 metre wide, followed outward by a moderately altered envelope 3 metres wide. Figure 2-3-2a presents the typical X-ray diffraction pattern charts for strongly, moderately and weakly altered samples.

The alteration envelope in the central segment of the No. 3 vein (between sections 24700N and 23600N on the mine grid) is wider than to the north. It extends about 30 metres into the hangingwall, but up to 100 metres into the footwall where dikes and fractures are more abundant. The hangingwall data are presented. The strongly altered rock envelope, 1.2 metres wide, is followed by the moderately altered envelope that is 30 metres wide. The weakly, moderately and strongly altered assemblages are not unlike those of the northern segment, as illustrated in Figure 2-3-2b.

Samples from the southern segment of the No. 3 vein (south of section 23600N on the mine grid) are limited to the hangingwall due to problems of access. The alteration intensity is stronger than in the northern and central segments of the vein, and the alteration mineral assemblage differs (Figure 2-3-2c). Kaolinite and siderite are absent from the strongly altered envelope (0 to 1.6 metres from the vein), which consists of quartz, mixed-layer sericite(2M₁)/illite(2M₂) and pyrite. Kaolinite and siderite appear in the moderately altered envelope (1.6 to 35 metres from the vein). The weakly altered andesite samples are similar to those from the north and central segments of the vein, however, the proportions of alteration minerals are relatively higher in the southern segment.

DISCUSSION

The mineralogical data presented above is preliminary and does not allow for rigorous treatment. However, the

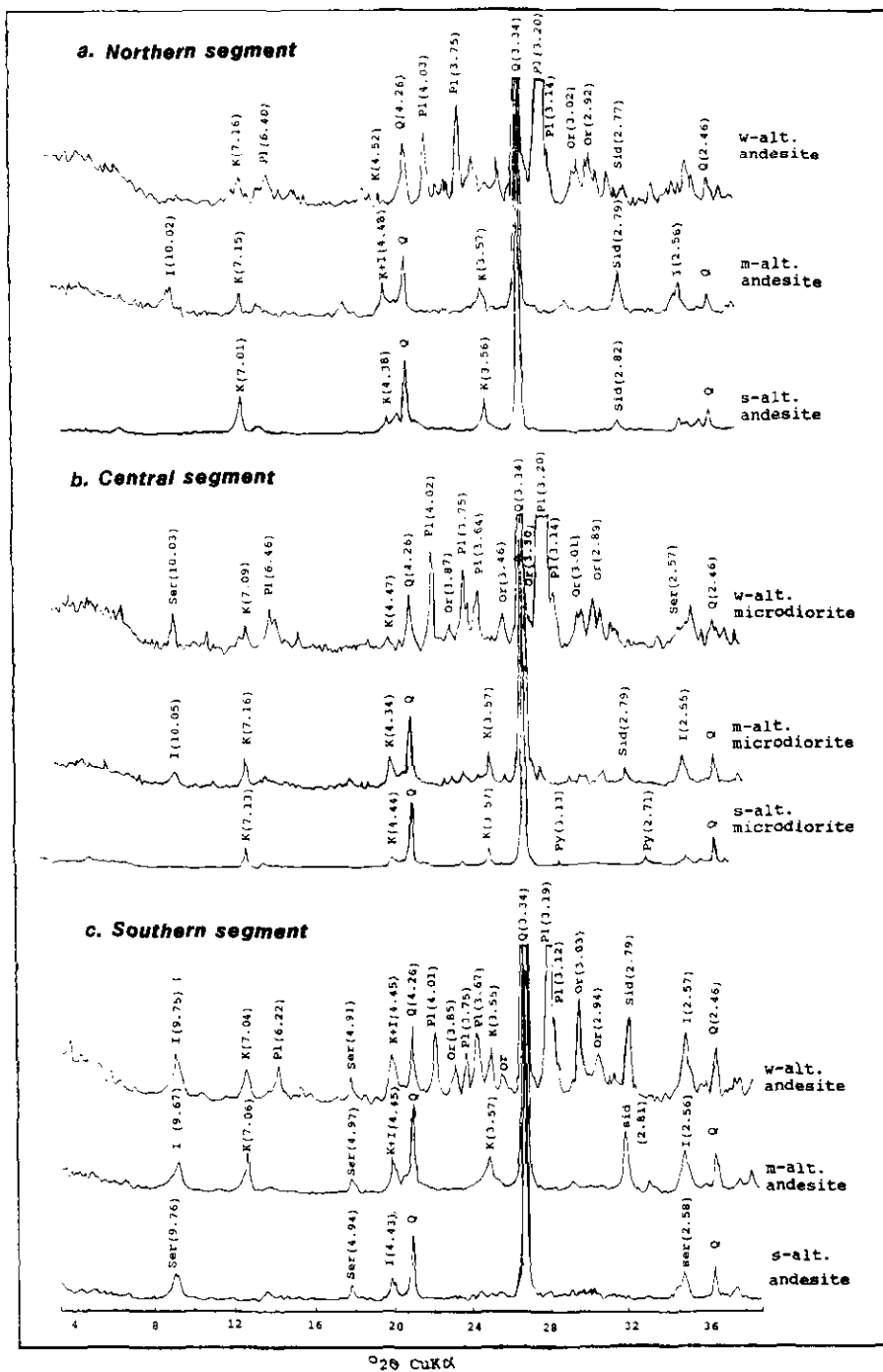


Figure 2-3-2. X-ray diffraction patterns for whole-rocks. Stack of three diffraction patterns represents sequence from weakly altered (w-alt.) to moderately altered (m-alt.) to strongly altered (s-alt.). Location of these sections (a) northern segment, (b) central segment and (c) southern segment are illustrated in Figure 2-3-1 (Symbols are the same as in Plate 2-3-1).

lateral or cross-section mineral zonation of weakly to strongly altered rocks, and the north to south mineralogical variation in the strongly and moderately altered envelope is significant.

The process related to the distribution of weakly altered rocks is unclear. This assemblage may represent either a low-temperature regional metamorphic effect resulting from loading, or the waning stages of the 78 Ma volcanic event (Leitch *et al.*, 1990). Thus it might predate the ore-forming hydrothermal activity, or represent incipient alteration related to it. More detailed petrography of regionally distal rocks will resolve this issue. Important, however, is the recognition that weakly altered rock represents the background or parent assemblage to the moderately and strongly altered rock.

The distribution of strongly to weakly altered rocks around the No. 3 vein is interpreted to be a function of decreasing intensity of alteration. Two processes may account for this decrease. Simple diffusion resulting in a chemical gradient, and therefore, reaction-front boundaries, may explain the variation on a small scale (less than 1 metre), but does not account for the large-scale alteration envelope up to 100 metres wide noted in this study. The second possible process involves varying water to rock ratios due to decreased permeability with distance from the vein. Thomson and Sinclair (1991, this volume) show that with decreased proximity to the vein, the intensity of fracturing also decreases. High water to rock ratios result in complete alteration of the hosting microdiorite and andesite as represented by the strongly altered rock assemblage, and low water to rock ratios result in the weakly altered rock. Moderately altered rock formed in intermediate conditions.

The processes accounting for the difference in the assemblage of quartz-sericite/illite-pyrite of the strongly altered rock in the southern segment compared to quartz-clay(kaolinite)-carbonate-pyrite in the northern and central segments may be twofold: presence of quartz-sericite-pyrite suggests the southern segment assemblage represent a higher temperature relative to the northern and central segment; and the activity of K^+ in the fluid increases to the south and Ca^{2+} decreases to the south. Further speculation on the specifics is beyond the scope of these data.

More questions are proposed from these data than are answered. Isotope and fluid inclusion analyses will facilitate the interpretation of the apparent variations.

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REFERENCES

- Church, B.N. (1970): Nadina (Silver Queen); *B. C. Ministry of Mines, Energy and Petroleum Resources*, Geology, Exploration and Mining 1969, pages 122-141.
- Church, B.N. and Barakso, I.J. (1990): Geology, Lithochemistry and Mineralization in the Buck Creek Area, British Columbia; *B. C. Ministry of Mines, Energy and Petroleum Resources*, Paper 1990-2, 95 pages.
- Church, B.N. and Pettipas, A.R. (1990): Interpretation of Second Derivative Aeromagnetic Maps at the Silver Queen and Equity Silver Mines, Houston, B.C.; *Canadian Institute of Mining and Metallurgy*, Bulletin, Volume 83, No.934, pages 69-76.
- Fyles, J.T. (1984): Report on Notes on Thin Sections of New Nadina DDH 84-15; Department of Geological Sciences, *The University of British Columbia*, unpublished report.
- Hood, C.T.H., Leitch, C.H.B. and Sinclair, A.J. (1991): Mineralogy of Vein Systems at the Silver Queen Mine, Owen Lake, West-central British Columbia (93L/2); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1990, Paper 1991-1, this volume.
- Leitch, C.H.B., Hood, C.T., Cheng, X-L. and Sinclair, A.J. (1990): Geology of the Silver Queen Mine Area, Owen Lake, Central British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1989, Paper 1990-1, pages 287-295.
- Moore, D.M. and Reynolds, Jr., R.C. (1989): X-ray Diffraction and the Identification and Analysis of Clay Minerals; *Oxford University Press Inc.* 332 pages.
- Thompson, M.L. and Sinclair, A.J. (1991): Syn-hydrothermal Development of Fractures in the Silver Queen Mine Area, Owen Lake Central British Columbia (93L/2); *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1990, Paper 1991, this volume.

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