



STREAM-SEDIMENT PETROGRAPHY USING THE COARSE FRACTION OF STREAM SEDIMENTS

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INTRODUCTION

The mining industry has traditionally relied upon stream-sediment geochemistry as a primary exploration technique. Its value in this regard is largely unquestioned and it is an important part of any regional program. However, there are limitations on its use in some environments, notably the British Columbia Coast Range.

In the Coast Range, many of the high-energy mountain streams, particularly the first and second-order streams, have little, if any, fine silt in their stream beds. This is a problem for conventional geochemistry because normally only the fines (-80-mesh fraction) are analyzed. The technique of sampling moss mats (Matysek and Day, 1988) has partly addressed this problem by increasing the range of materials that can be sampled. A second problem also exists in the Coast Range; active glaciation generates large quantities of silt that can dilute most geochemical signatures below detection. Both of these factors create significant sampling problems.

Interpretation of stream-sediment geochemistry in the Coast Range is difficult. Although it is largely underlain by plutonic rocks, there are many roof pendants which are the focus of most exploration activity. Contact metamorphic effects along the margins of these pendants has created numerous small skarns and quartz veins, many of which contain minor amounts of base metals. This mineralization generates numerous base metal anomalies, which may obscure more subtle geochemical signatures of economic mineralization. Compounding this problem is the fact that the primary exploration targets in the Coast Range are the volcanogenic massive sulphide deposits - a deposit type for which stream-sediment geochemistry is poorly suited unless mineralization is exposed on the surface.

Additional factors in the Coast Range include the extremely rugged terrain, the high rainfall and the dense coastal forest. Exploration is difficult and expensive. Stream-sediment geochemistry is routinely carried out, despite its widely recognized limitations, because there is moderately good access to streams for boat and helicopter-supported programs. However, in spite of the ease of access provided by helicopters and the advances in stream-sediment geochemistry over the past several decades, there have been few new discoveries. Most known occurrences were found by prospectors years ago, and most of the old mines and the better known properties are in the accessible areas of the islands (*e.g.*, Little Billie mine, Surf Inlet mine), or near access routes through the mountains (*e.g.*, Britannia mine).

Clearly there is a need for a regional technique which, like stream-sediment geochemistry, can detect mineralization from a distance, and can evaluate large areas with a limited number of samples in an economical and efficient fashion. The technique should be able to provide information to aid the interpretation of stream-sediment geochemical anomalies and be capable of evaluating areas where sampling problems exist.

A technique with the potential to satisfy these requirements is "stream-sediment petrography", here defined as the identification and interpretation of drainage-basin geology based on the microscopic examination of stream sediments. For the explorationist, this is a technique which can identify rock and mineral fragments in stream sediments which are normally associated with ore deposits, and can provide information about mineralogical anomalies, such as alteration zones, which may be important to the interpretation of geochemical anomalies.

Alteration zones are commonly the result of hydrothermal processes and are associated with many ore deposits. Generalizations about hydrothermal processes and wallrock alteration are not warranted in the context of this paper, other than to note that the alteration mineral assemblage often reflects additions or losses of the rock-forming elements, such as potassium, sodium, silica, magnesium and iron. These subtle changes in composition can be detected by soil geochemistry. However, a stream sediment is essentially a sample of a large area, and as there may actually be very little variation in the bulk chemistry of an area, these changes in the rock-forming elements are not usually identified by stream-sediment geochemistry. However, stream-sediment petrography does have the potential to detect these changes in mineral composition.

This paper describes the results of a study to develop a method of stream-sediment sample preparation suitable for binocular microscope examination and techniques to enhance the detection of alteration minerals in stream sediments.

COARSE FRACTION STUDY

The coarse fraction as defined for this study is the +80-mesh fraction; that is, material that does not pass through a screen which has a nominal opening of 180 microns. Such material is present in virtually all stream-sediment samples, but because it is coarser than the material used for analysis, it is usually discarded.

There are a number of reasons for choosing the coarse fraction, among them being the need to base interpretations on mineral associations, so the presence of rock fragments, as opposed to monomineralic grains, is essential. Also, the identification of alteration often depends upon being able to

see grain boundaries. Another consideration is that many sediment particles are coated with a rind of hydroxides. These particles must be large enough so that fresh rock is exposed in the centre when they are cut. There are also practical considerations, including the relative difficulty of examining small grains under a microscope, and the abundance of coarse material in the high-energy Coast Range streams.

Conventional stream-sediment geochemistry is a four-step process, consisting of: sample collection, sample preparation, analysis and interpretation. Stream-sediment petrography follows a similar process, albeit with a different type of preparation, and analysis is by microscope. The present study has focused primarily on the sample preparation and microscope examination steps.

Sample collection has not been addressed in the coarse fraction study. Field studies are needed to determine the characteristics and behaviour of alteration minerals in the fluvial environment before a specific type of sample site can be recommended. For the time being, it is assumed that samples for stream-sediment petrography will be collected from the active channel in the same manner as samples for geochemical analysis. The possibility that moss-mat samples contain a bias toward heavy minerals at the expense of lighter alteration minerals likewise has not been investigated.

The study utilized samples from two sources. Test samples were created from crushed and sieved altered rock, and stream sediments were obtained from the Geological Survey Branch. The test samples were made up from material such as: silicious pyritic ore from the Britannia mine and from the H-W orebody at Myra Falls on Vancouver Island; epidote and chlorite alteration envelopes from Gambier Group quartz veins; chlorite and sericite schists from the Gambier Group and the Eagle Bay assemblage; rhyolite from Westminster's Price and H-W orebodies; a high-potassium rhyolite from the Gambier Group; pyrite in quartz veins from the Harrison Formation; and orthoclase from the Beaverdell granite. This material was mixed in various concentrations with a quartz-plagioclase sand from Scuzzy Creek and with chlorite schist from the Gambier Group.

The test samples were augmented by stream sediments from the Geological Survey Branch sample library. These samples consisted of the -18 and +80-mesh fraction left over from recent Regional Geochemical Surveys in southwestern British Columbia. Samples were selected from a variety of deposit types, and included: the Britannia mine (volcanogenic massive sulphide), the OK porphyry (porphyry copper), the Merry Widow (skarn), Mount Washington Copper (porphyry copper), and Lara (volcanogenic massive sulphide). The lack of coarse material in the samples and limited sample density in the deposit areas precluded detailed studies of each area. The samples did, however, provide an opportunity to test the preparation techniques on stream sediments collected around ore deposits.

The coarse fraction study did not directly address the fourth step in the evaluation process – interpretation. The significance of alteration minerals in stream sediments must be based upon comparisons with stream sediments collected

around well-known deposits. This information can only be determined from detailed field studies.

SAMPLE PREPARATION

A variety of preparation techniques was investigated at various stages of the study. There were two objectives: to determine the best possible technique in terms of accuracy and repeatability, and to develop a technique which could be carried out in any medium-sized exploration camp, which at the same time did not significantly compromise the quality of information. Both objectives were achieved and are described below. It is worth noting that the technology for producing polished sections for the study of ore minerals is well developed and could produce excellent samples for stream-sediment petrography. However, in general, polished sections are too small to contain a representative-sized stream-sediment sample, and the equipment needed to prepare them would never be considered suitable for use in a field camp.

SIEVING

Choosing an appropriate sieve size is of considerable importance, and as noted above, the greater amount of information in rock fragments must be balanced against the more representative nature of samples of finer fractions. In the coarse fraction study, three sieve sizes were examined: -5 to +20-mesh, -10 to +35-mesh, and -20 to +40-mesh (U.S. standard sieve sizes). In the following discussion, reference to "fine material" is to sediment smaller than 1 millimetre in size, such as the -20 to +40-mesh fraction.

The Geological Survey Branch samples contained large amounts of coarse organic material, which considering that all the samples from Vancouver Island were moss mats, was not surprising. These organics were easily removed by lightly blowing over a shallow pan after dry sieving. However, if fine organics are a problem, then wet sieving may be the best solution. It is important to have clean sediment particles to ensure a good bond with the casting resin.

RESIN CASTING

Early tests with loose sediment demonstrated that it was not suitable for staining, and identification of minerals present in low concentrations was difficult. Casting the sample and working with a polished surface proved to be far superior in terms of the ease and accuracy of the microscopic identification.

Tests were carried out on a variety of potential casting media, including polyester resin, epoxy resin, plaster of paris and several cements. The following criteria were used to evaluate each medium:

- It must be inexpensive, easy to prepare and set quickly. It must be relatively inert and not react with the sample, the mould, or with any of the chemicals used in staining.
- It must be strong enough to hold the sediment fragments firmly during the cutting and polishing operation.

- It must not smear over the fragment faces during cutting and polishing, preventing them from being etched and stained.
- It must polish well and provide good contrast with the sediment fragments.

Both the polyester resin and the epoxy resin produced acceptable results. The polyester resin was chosen over the epoxy because it is less expensive and easier to mix and work with. This resin is a clear, waxable polyester resin of the type used by the fiberglass industry.

A variety of casting moulds were experimented with. The most suitable was found to be the petri dish. These inexpensive plastic dishes, which are normally used for growing biological cultures, are ideal for casting samples. They are about 9 centimetres in diameter, 1 centimetre deep and have a flat bottom. With a surface area of about 58 square centimetres on the prepared sample, a large number of sediment particles (approximately 20 000 in the -20 +40-mesh sieve interval) are exposed. The prepared sample disk is about 8.5 centimetres in diameter and this is approximately the maximum size that can easily be accommodated on a microscope stage.

The petri dish has a capacity of 62 cubic centimetres, although, an acceptable sample can be prepared from as little as 10 cubic centimetres (about 25 grams) of sediment. The sample is mixed with resin in a disposable cup, and poured into a dish in sufficient quantity to cover the bottom. The dish is then topped up with resin. A sample-disk thickness of 1 centimetre is necessary for strength and ease of handling. After the resin has set, the petri dish must be removed – a process which is made much easier by waxing the dish with a non-silicone-based paste wax prior to casting.

POLISHING

Several techniques of preparing the sample surface were tested, with mixed results. The type of finish has a large effect on the quality of information obtained and it is the critical step in the sample preparation process. The best results were produced by a commercial vibrating lap and this was apparent at an early stage in the testing. However, much of the testing was directed at developing a technique suitable for use in a field camp.

The vibrating lap was used with 220 and 600-grit silicon carbide abrasive and tin oxide polishing compound. A 1 kilogram weight was placed on each sample during grinding and polishing to speed-up the process. The lap yielded the best overall results in terms of the accuracy and ease of identification of all of the minerals studied. The only disadvantage of this technique is that it is very slow. A 15-inch lap can only produce about 8 samples per 24-hour period.

Alternative techniques, with a higher production rate and suitable for field use were investigated. They included *sawing samples into slabs with a rock saw, and preparing the sample surface with a variety of sanding and grinding media.*

Rock saws can produce samples which are quite adequate for identifying gross lithological features, such as common

rock types, and for identifying distinctive minerals such as epidote and pyrite if they comprise at least several per cent of the sample. The surface can be etched and stained to identify the presence of potassium minerals, although identifying the actual mineral may be difficult. Larger sample sizes are needed for sawing, typically about 200 cubic centimetres, and the best results are obtained with coarse fragments (larger than several millimetres in diameter). Material smaller than 1 millimetre produced poor results in the study due to the particles being plucked out of the resin.

The sawn samples can be polished with a vibrating lap, although there is no advantage gained by having cut the samples. Sawing produces neither a flat nor a smooth surface. Additionally, the forceful cutting action of a saw shatters brittle minerals such as quartz and pyrite. The mineral identification techniques use the resin surface as a reference, based on the assumption that the resin and mineral surfaces were smooth and contiguous prior to etching. The shattering caused by sawing creates negative relief which must be removed before it can be polished. This increases the time needed for the 220-grit grinding, because an entire layer of mineral grains must be removed. In addition, pieces of the shattered minerals break free and contaminate the grinding media with over size material, resulting in the need to replace the grit frequently.

A more useful polishing technique uses a sanding head. This is a flat disk, covered with sandpaper and fixed to an electric motor. Tests were carried out with a 15-centimetre diameter sanding head attached to a 0.25 horsepower electric motor which rotated at 1725 rpm. The samples, cast in petri dishes, were sanded with silicon carbide sandpaper in the sequence: 80, 120, 240, 320, 400 and 600. The first three in the sequence were sanded dry, the remainder wet. The paper was backed with a neoprene pad 5 millimetres thick.

Moderately good results were obtained using this method, and they were comparable to the polished samples produced by the vibrating lap. In terms of mineral identification and staining, sanding produced surfaces that were adequate for the -20 to +40-mesh fraction (marginal for the -10 to +35-mesh fraction and poor for the -5 to +20-mesh fraction). The coarser sizes are more difficult to prepare because the large grains are resistant to abrasion, while the relatively soft resin between the grains is worn away, leaving pits. The sanding technique proved to be poor for preparing samples containing more than several per cent sulphides. In contrast, the polished samples produced by the vibrating lap were excellent in all three sizes, and were much better for sulphide-rich samples.

The fine size material (<1 mm in diameter) can be rough polished using the 80, 120 and 240-grit dry-sanding sequence and this is adequate for identifying most minerals. This technique could be useful in a field camp setting because a sample can be prepared in about 5 minutes. The higher quality 600-grit polish requires much more time and effort and does not produce significantly more useful samples. If the fine grain sizes are of interest (such as in the detection level studies described later) and time is a constraint, then the best approach is to use the sanding technique to identify the interesting samples which can then be polished using the vibrating lap.

ETCHING AND STAINING

After the sample surface has been polished, it is etched with hydrofluoric acid and stained with sodium cobaltinitrite. The purpose of the etching is twofold: it prepares a fresh surface on potassium minerals so they can react with the sodium cobaltinitrite, and it variably etches the rock and mineral fragments allowing quartz to stand out in positive relief from the rest of the fragment. This is the primary method used to identify silicification, quartz-sericite schist, rhyolite and potassic alteration.

An important factor controlling the identification of these features is the length of time the sample is etched with hydrofluoric acid. Etching tests carried out on standard samples indicated that a 20-second etch time with 48 per cent hydrofluoric acid produced the best results on polished samples. All samples were stained by dipping them in a concentrated solution of sodium cobaltinitrite for 60 seconds. Shorter etching times reduced the contrast between quartz and most other minerals, although a 5-second etch time was able to remove the polish from most non-quartz minerals, allowing them to be readily identified with a hand lens. Etching in excess of 30 seconds bleached most minerals beyond recognition and reduced the effectiveness of the staining.

SAMPLE EXAMINATION

Samples were systematically examined under a binocular microscope using reflected light. It was found that 10-power was best for estimating percentages of easily identified minerals, and 30-power was useful for examining most fragments. A 45-power lens is useful for the occasional detailed examination of individual fragments smaller than approximately 20-mesh (850 microns). The value of the binocular microscope over the monocular microscope becomes readily apparent when examining the relief created by the acid etching, or when viewing fractures, cleavages and crystal shapes visible in the clear resin below the sample surface.

Many of the mineral properties used to identify hand specimens are also useful for identifying stream-sediment fragments. The binocular examination is augmented by the use of hydrochloric acid (for identifying carbonates), a magnet, and a needle (for testing hardness). It is difficult to identify metallic minerals with any confidence. Exhaustive test procedures for the metallic minerals are described by Short (1940). Samples prepared using a vibrating lap are polished to approximately the same standard as conventional polished sections, and detailed examinations of metallic minerals could be carried out with a reflecting light microscope. Similarly, thin sections can be cut from the sample disks for detailed petrographic work.

MINERAL IDENTIFICATION

The following list of minerals were chosen for study because they are commonly associated with alteration zones and ore deposits. The list is not exhaustive; further work in stream-sediment petrography will no doubt broaden the scope to include other minerals and refine the techniques of identification. The features listed are those characteristics

that were observed in the study and are based on a limited number of samples. All of the samples were etched and stained as described above.

PYRITE

- Brass-yellow colour, metallic lustre when polished, fine pebbled finish when viewed under 30-power.
- Chipped edges and conchoidal fractures common on edges of fragments.
- Cubic crystal form and striated crystal faces may be seen in resin below the surface.
- Hard, cannot be scratched by a needle.
- Rarely contained in rock fragments smaller than 1 millimetre.
- Surfaces may appear black (due to pyrite powder) if prepared using the sanding technique.

CHALCOPYRITE

- Distinctive greenish yellow colour.
- Polishes poorly, with broken edges, and has an irregular felted appearance on surfaces.
- Soft, can be easily scratched by a needle.

MAGNETITE

- Polishes to a silvery-grey colour with a metallic lustre, turns to a dark grey colour with a dull lustre after hydrofluoric acid etching.
- Magnetic.
- Hard, cannot be scratched by a needle.

CALCITE

- Effervescence when exposed to hydrochloric acid.
- Rhombohedral cleavage may be visible below the surface in resin.
- Soft, easily scratched.

EPIDOTE

- Distinctive green colour.
- Little effect from hydrofluoric acid etching.
- Hard, cannot be scratched by a needle.

CHLORITE

- Medium to dark green colour.
- Soft, but if associated with quartz or epidote, it may appear to be hard.
- High relief when etched, but this may not be apparent if associated with quartz or epidote.

QUARTZ

- Stands out in positive relief from the rest of the rock fragment after etching.
- Commonly has a glassy appearance.
- Polishes to a high lustre, polish turns to a slightly pebbled surface when etched for 20 seconds.
- Hard, cannot be scratched by a needle.
- Conchoidal fracture commonly visible in resin below the sample surface.

POTASSIUM-RICH MINERALS AND ROCKS

These minerals and rocks are identified as a group by the yellow potassium cobaltinitrite stain. All stained surfaces have been etched leaving negative relief.

- **ORTHOCLASE:** Identified by rich yellow stain which often has a frambroidal habit. The stain commonly leaves an irregular, linear pattern of yellow lines on a glassy background. The prominent c-axis cleavage may be visible below the surface of the resin.
- **SERICITE:** Identified in schistose fragments by tiny, pale yellow, wispy streaks which may form most of the fragment. A pronounced foliation is common, even in tiny fragments. Often associated with fine-grained quartz which stands out in positive relief.
- **RHYOLITE:** Included under potassic rocks because it is primarily identified by its potassium stain. A rhyolite in this context is defined as a fine-grained rock composed of potassium feldspar, quartz and plagioclase. The stain is subtle, being pale yellow and very wispy in appearance. Glassy quartz, either as small crystals or tiny threads, stands out in positive relief. Plagioclase is chalky white. The fragment may have a directed fabric defined by glassy shards, or it may have a spherulitic texture.

ALTERATION

The interpretation of alteration requires mineralogical evidence to support a change in the mineral assemblage of a rock. In stream-sediment petrography this information can only be obtained from rock fragments. Most of the minerals discussed above can be identified as alteration minerals based on a binocular microscope examination. However, the evidence of alteration is often subtle and it may be difficult to interpret with confidence. Evidence to support alteration includes:

- A mineral, commonly found in alteration zones, appears to crosscut other mineral grain boundaries or foliations. This may include tiny veinlets of quartz, or small indistinct crystals of orthoclase which may give a mottled appearance.
- Variations in the mineral assemblage which suggest selective replacement of a mineral in some fragments.

It is difficult to distinguish regional metamorphic effects from local effects and accurate interpretation requires knowledge of the local geology.

SIEVE SIZE AND DETECTION LEVELS

The sieve intervals chosen in the study contained a wide range of sizes and this is evident in the number of particles exposed on the prepared surface of the sample disks. The -5 to +20-mesh sample averaged 60 fragments per square centimetre or approximately 3400 per disk, the -10 to +35-mesh fraction averaged 110 and 6200 fragments, and the -20 to +40-mesh fraction averaged 350 and 20 000 fragments.

There is an important trade-off between the size of material being examined (sieve interval), the amount of information contained in the average-sized fragment (rock or min-

eral grains), the detection levels, and the difficulty of the examination. Clearly, how these factors are rationalized will depend upon the individual circumstances of each field area and exploration program. The average grain size of the rocks of interest in the drainage area has a large bearing on what is the best sieve interval for interpretative study. Fine-grained sedimentary or volcanic rocks can be easily studied from fragments averaging 1 millimetre in diameter, coarse-grained granites cannot.

For the explorationist, detection of a given indicator mineral will, at least initially, be a higher priority than interpretation. The chance of identifying a mineral present only in trace amounts, is obviously much better in a sample where there is a large number of particles. The polished surface of the sample disk is essentially a sample of the stream sediment sample, and by selecting a fine sieve interval, we can introduce a bias that is favourable to detect on. Detection level examinations can be easily carried out using the -18 to +35-mesh size (1 mm to 500 μ m). If these fragments are too small to provide information necessary for interpretation, coarser material, which is more appropriate to the grain size of the rocks in the drainage area, can be examined later.

In the study, test samples were made up using measured amounts of pyrite and epidote mixed with Scuzzy Creek sand. Both the pyrite and epidote were easily detected at concentrations as low as 1 part per 1000 in both the -10 to +35 and -20 to +40-mesh fractions. Polishing the sample surface improved the ease of detection considerably.

DEPOSIT STUDIES

Stream-sediment samples from the vicinity of several ore deposits in southwestern British Columbia were examined after completing the study of test samples. Only the -18 to +40-mesh fraction (1 mm to 425 μ m) was examined. As mentioned earlier the low sample density, the lack of information about background conditions, and the limited range of sediment sizes precludes any firm conclusions. Interpretation of stream-sediment petrographic identifications must be based on comparisons with studies of stream-sediments in areas of known mineralization. However, several observations can be made that support the usefulness of the technique and offer encouragement for further studies; these are:

- Some of the creeks draining the Moun Washington, Britannia and Merry Widow areas contain small grains of pyrite and chalcopyrite in concentrations which range from 1:1000 to 1:10 000.
- The Merry Widow skarn is easily distinguished by the large amount of magnetite in the sediments, up to approximately 5 per cent.
- There appears to be an increase in potassium-rich minerals in the vicinity of the Britannia mine.
- There appears to be an increase in epidote and quartz in the vicinity of mineralization in most of the areas.

APPLICATION TO EXPLORATION

Stream-sediment petrography may be of significant value to exploration in the British Columbia Coast Range, and it

may have widespread application in other environments. It can evaluate areas where sampling problems limit the use of geochemistry, and it can compliment the use of stream-sediment geochemistry by providing information about the presence of mineralogical anomalies, such as alteration zones. When integrated with geochemistry in regional exploration, it may be able to predict the type of mineralization generating geochemical anomalies and it can provide a second-level screen to help establish priorities for follow-up field programs.

The coarse fraction, utilized in stream-sediment petrography, is already contained in most stream-sediment samples collected by industry, but it is usually thrown away. This material contains valuable information which can be obtained for little additional cost, especially when compared to the cost of additional fieldwork. Stream-sediment petrography is a cost-effective method of enhancing the usefulness of stream-sediment samples in regional exploration programs.

DISCUSSION

Stream-sediment petrography has the potential to detect alteration minerals in stream sediments, and initial studies have been encouraging. However, the significance of the results is still speculative. Detailed studies of sediments from streams around ore deposits are needed to provide standards for comparison. This work should not be carried out in isolation from research on the weathering of altered rocks and their transport characteristics.

Alteration zones are larger than the orebodies they surround and they are potentially a much larger target to explore for. This is an important consideration now that most exploration targets are blind orebodies. Altered rocks may weather more quickly than fresh rocks and as a consequence, sediments may be biased toward the altered areas, to the benefit of the explorationist. Another consideration is that altered rocks may weather into small particles *in situ*, or may disintegrate a short distance after entering the stream environment. As a result, stream-boulder prospecting may be ineffective for locating some types of alteration unless the prospector is close to the source. Detecting alteration zones by a microscopic examination of stream sediments may be the only way to identify the alteration from a distance. However, some types of alteration, such as clay

alteration, may erode only into very fine particles which may not be detected in the coarse fraction. The range of alteration minerals to which this technique can be applied has not yet been fully defined.

The stream petrographic techniques are best suited for identifying alteration minerals, although it has been demonstrated that economic minerals, such as chalcopyrite, can be identified. In exploration, common sense dictates that the economic minerals themselves are often the best indicator minerals. Stream-sediment petrography relies on the skill of the person examining the sample, and the results are at best semiquantitative. The economic minerals are probably best identified by geochemistry, especially if detection can be enhanced by techniques such as heavy-liquid separation. In situations where samples from high-energy streams have no fines, the coarse fraction can be crushed and analyzed, and the geochemical results will probably be comparable to the petrographic work.

Stream-sediment petrography is able to identify minerals commonly associated with alteration, however the linkage with alteration zones is not easily established. The techniques identified in this study require further refinement. The identification of alteration zones through the use of stream-sediments may then be of significant value in mining exploration.

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REFERENCES

- Matysek, P.F. and Day, S.J. (1988): Geochemical Orientation Surveys: Northern Vancouver Island, Fieldwork and Preliminary Results, in *Geological Fieldwork 1987, B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1988-1, pages 493-502.
- Short, M.N. (1940): Microscopic Determination of the Ore Minerals, *United States Department of the Interior, Geological Survey Bulletin 914*, Second Edition, 314 pages.