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ONTARIO GEOLOGICAL SURVEY

Open File Report 5713

The Geological Setting and Distribution of Gold in the Cameron-Rowan Lakes Area, District of Kenora, with Emphasis on the Monte Cristo and Victor Island Prospects

by

D.R. Melling

1989

This project is part of the Canada-Ontario 1985 Mineral Development Agreement (COMDA), which is a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed by the governments of Canada and Ontario

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V.G. Milne

V.G. Milne, Director
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FOREWORD

This study of the gold occurrences in the Cameron - Rowan Lakes area south of Kenora is part of a continuing program in the Ontario Geological Survey to document the geology of lode gold deposits across the Province. Earlier contributions to this program have resulted in the development of a comprehensive model for the genesis of these deposits, which was released in 1988 as Miscellaneous Paper 139.

The known gold mineralization in the study area occurs in shear zones, localized near contacts between mafic intrusive and volcanic rocks. Differences in competency among the intrusive and both mafic and felsic volcanic and volcaniclastic rocks probably localize the shear zones. The results of the study will be of interest to all who are exploring or prospecting for gold in the Archean.

Funding for the project was provided through the Canada - Ontario Mineral Development Agreement (COMDA), which is a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed by the governments of Canada and Ontario.

V.G. Milne
Director
Ontario Geological Survey

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ABSTRACT

Based on field mapping, petrographic studies, and lithogeochemistry, the Archean rocks of the Cameron - Rowan Lakes area can be subdivided into two distinct volcanic successions. The lower Rowan Lake Volcanics consist of tholeiitic pillowed basalts. These rocks are overlain by the Cameron Lake Volcanics, a mixed succession of of tholeiitic to calc-alkaline, massive and pillowed basalts, and intermediate to felsic, volcaniclastic rocks.

Most of the gold concentrations in the Cameron - Rowan Lakes area are confined to the mixed Cameron Lake Volcanics. Most of these, including the Cameron Lake deposit, the Victor Island prospect, and the Monte Cristo prospect, are situated within shear zones localized near contacts between mafic intrusive and volcanic rocks. The contrast in competency between mafic flows, intermediate to felsic volcaniclastic rocks and intrusive rocks in the of the Cameron Lake Volcanics could have localized strain, forming shear zones into which the gold-bearing fluids gained access. The potential of successfully identifying economic gold concentrations seems greatest within such mixed volcanic successions, both in the immediate Cameron - Rowan Lakes area and elsewhere in the western Wabigoon Subprovince of Ontario.

THE GEOLOGICAL SETTING AND DISTRIBUTION OF GOLD IN THE CAMERON - ROWAN LAKES AREA, DISTRICT OF KENORA, WITH EMPHASIS ON THE MONTE CRISTO AND VICTOR ISLAND PROSPECTS

by

D.R. Melling[1]

Funding for this project was provided by the Canada - Ontario Mineral Development Agreement (COMDA), which is a subsidiary agreement to the Economic and Regional Development Agreement (ERDA) signed by the governments of Canada and Ontario.

INTRODUCTION

The Cameron - Rowan Lakes area is located in the Kenora Mining District of northwestern Ontario about 80 km southeast of Kenora (Latitude 49°17'N, Longitude 94°44'W). Although the area has yielded no significant precious metal production to date, gold showings have been discovered and sporadically worked since the 1800's. The recent rejuvenation of exploration activity in this and surrounding areas began in 1983, largely as a result of the discovery of the Cameron Lake gold deposit by Nuinsco Resources Limited. Since then, claim staking and

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exploration expenditures in the area have risen dramatically (The Northern Miner 1983a, b). Drill-indicated reserves at Cameron Lake in 1986 totalled 1,625,202 short tons grading 0.16 oz/ton Au, including 1,006,704 short tons grading 0.20 oz/ton Au (Archibald 1985). In 1986, Nuinsco Resources Limited and their partners, Echo Bay Mines, announced a major, $ 6.7 million underground exploration program at Cameron Lake. This two-stage program, which included a 2700 ft ramp to the 425 ft level, was intended to provide more detailed information about ore reserves *via* underground mapping, drilling, and sampling. Complete and colourful histories of mining in the Kenora-Fort Frances region and exploration in the vicinity of Cameron Lake are given by Beard and Garratt (1976) and Hunter (1985).

This study is a contribution to the continuing program of the Ontario Geological Survey to document the geology of Ontario's gold deposits and thereby develop a model for their origin (Colvine *et al.* 1984).

Previous Geological Work

Early geological work covering parts of the Cameron - Rowan Lakes area includes that by Burwash (1933), Thomson (1935), and Thomson (1938). Goodwin (1965) completed a volcanological and mineral potential study of a much larger area. Kaye (1973) mapped the Rowan Lake area at a scale of 1:15,840 (1 inch to 1/4 mile). Since 1981, the entire area has been remapped at property scales by exploration companies searching for gold. The scale of mapping varies, but is most commonly 1:4,800 (1 inch to 400 feet). All companies in the area generously provided the results of their geological investigations (including mapping and diamond drilling data) to the author, significantly increasing the available data base.

Detailed, field-based studies have resulted in several descriptive papers which characterize the alteration, geochemistry, and structural control of the Cameron Lake gold deposit (Melling and Watkinson 1985, Melling *et al*. 1985, Melling *et al*. 1986). More recently, investigations have broadened to encompass regional lithostratigraphic mapping (Melling and Watkinson 1986), volcanic facies models (Johns 1986, Chivers 1986), structural studies (Buck 1986), and additional gold deposit studies (Melling 1986b). University theses which concern the current work include completed studies by Wade (1985) and Melling (1986a), and one in progress by McNicoll. This report integrates many aspects of this extensive data base.

Present Geological Survey

Field work for this study was carried out by the author and one assistant during the summer of 1986. It consisted primarily of geological mapping in the central part of Rowan Lake. In addition, logging and sampling of several diamond drill holes from gold prospects in the area, several regional mapping traverses, and brief examinations of known gold showings, occurrences, prospects, and deposits were completed. Many aspects of this study are the outgrowth of gold exploration and research conducted by the author between 1983 and 1986 in the Cameron - Rowan Lakes area.

The study comprised four parts:

1) The geological setting of the Cameron - Rowan Lakes area, including its stratigraphy, lithogeochemical characteristics, and dominant structural features, was fully documented.

2) General information was gathered on the more significant gold showings, occurrences, prospects, and deposits in the area.

3) A detailed data base was compiled on the alteration, geochemistry, and structural control on the Monte Cristo and Victor Island gold prospects which occur in central Rowan Lake.

4) Comparisons between styles of gold mineralization within the area were completed and the findings and implications of the study critically assessed in terms of exploration models for the western Wabigoon Subprovince.

Access

Access to the Cameron - Rowan Lakes area is gained by several means. Northwestern Flying Services Limited provides an excellent charter service from Nestor Falls, some 24 km to the southwest. Nestor Falls is a small village on Highway 71 between the major centres of Kenora and Fort Frances. Alternatively, access is available *via* Swanson Airways from Dryden, about 65 km to the northeast. Airline service to most Canadian population centres is available from Dryden.

When the study was carried out in 1986, a private resource access gravel road linked the Cameron Lake deposit with Highway 71 about 30 km north of Nestor Falls. In addition, a winter truck route is available 18 km across Kakagi Lake to where it crosses a 2 km portage to Cameron

Lake. Year-round travel throughout the area is facilitated by a well-maintained system of short (< 2 km) portages between all lakes.

Acknowledgements

Grateful appreciation is extended to Nuinsco Resources Limited, particularly G.F. Archibald and H.D. Hume, for logistical support and for providing unrestricted access to data and properties in the Cameron - Rowan Lakes area. Appreciation is also expressed to Bigstone Minerals Limited, Calaveras Explorations Limited, Gold Fields Canadian Mining Limited, Inco Limited, Nucanolan Resources Limited, Silver Lake Resources Incorporated, and Tantalus Resources Limited for providing access to their properties and the data they have compiled while conducting exploration programs in the area.

Thanks are extended to C.E. Blackburn, L.B. Chorlton, A.C. Colvine, A.D. Hunter, P.L. Jones, K.H. Poulsen, and D.H. Watkinson for visiting the field area and contributing their ideas on the processes of deformation and gold metallogeny. M.D. McNicoll, M.P.G. Wade, and R. Westendorp provided able assistance during the field seasons. M.E. Cherry and D.H. Watkinson critically reviewed drafts of the manuscript, which assisted in improving its clarity.

REGIONAL GEOLOGICAL SETTING

The Cameron - Rowan Lakes area lies at the western end of the 300 km long, Archean, Savant Lake - Crow Lake metavolcanic-metasedimentary belt (Trowell *et al.* 1980) in the Wabigoon Subprovince of the Canadian Shield (Figure 1). The Wabigoon Subprovince is a major tectono-stratigraphic subdivison of the Superior Province, consisting of belts of metavolcanic rocks with lesser metasedimentary rocks which are intruded by granitoid bodies (Trowell and Johns 1986). It is bounded to the north by the English River Subprovince and to the south by the Quetico Subprovince.

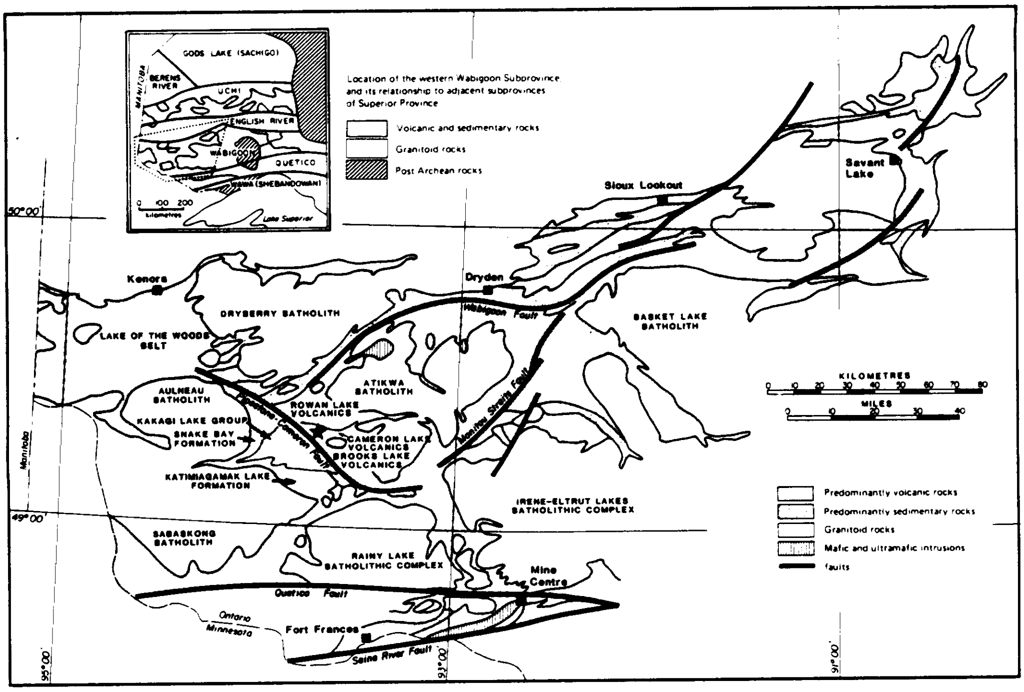

Figure 1. Geology of the western Wabigoon Subprovince (after Blackburn et al. 1985). The Cameron Lake gold deposit is located by the star.

The Cameron - Rowan Lakes area occurs within a small region of greenstones bounded on all sides by granitoid batholiths (the Dryberry, Atikwa, Aulneau, and Sabaskong batholiths). The region is divided geologically by the southeast-striking, northeast-dipping Pipestone - Cameron Fault, a major zone of deformation and displacement similar to the Larder Lake - Kirkland Lake, Destor - Porcupine, and Cadillac - Malartic Breaks recognized in other Canadian Archean gold camps.

Southwest of the Pipestone - Cameron Fault is a north- to east-facing, volcanic complex (Figures 1 and 2) centered on Kakagi Lake, which is underlain by thick (> 5 km) accumulations of mafic volcanic flows and sills of the correlative Snake Bay and Katimiagamak Lake Volcanics (Blackburn *et al.* 1985). These rocks are unconformably overlain by an equally thick succession of intermediate to felsic, pyroclastic rocks and metasedimentary rocks of the Kakagi Lake Group, which are intruded by differentiated mafic to ultramafic sills. The complex is bounded to the west by the Aulneau Batholith and to the south by the Sabaskong Batholith (Figure 1). Davis and Edwards (1986) have shown that the evolution of this volcanic-plutonic complex occurred over a period of 32 Ma and that the emplacement of early phases of the Sabaskong Batholith was coeval with the oldest volcanism. They also suggested that deformation of the volcanic successions occurred during late diapiric remobilization of the Sabaskong and Aulneau Batholiths, and that the younger Stephen Lake Stock may have intruded into a zone of dilatency developed during flexural slip folding marking the end of regional ductile deformation.

The study area lies northeast of the Pipestone - Cameron Fault (Figures 1 and 2). The structural geology of the area is dominated by the Shingwak Lake Anticline (Figure 2). The rocks exposed in the core of this anticline comprise a thick, south- to west-facing, subaqueous mafic flow succession (Rowan Lake Volcanics). These rocks are overlain by a mixed succession of subaqueous, pillowed and massive mafic flows, and intermediate to felsic pyroclastic and volcaniclastic rocks (Cameron Lake Volcanics). Mafic sills were emplaced at all levels in the succession before folding occurred. and felsic porphyry sills and dykes intruded all of these lithologies. All rocks have been metamorphosed to greenschist facies assemblages. Locally, amphibolite grade rocks occur within contact aureoles of the larger granitoid bodies, including the Nolan Lake Stock, which intrudes the volcanic rocks to the south.

South of the Cameron Lake Volcanics lies the thick mafic flow succession of the Brooks Lake Volcanics (Blackburn *et al.* 1985). These rocks are tentatively interpreted to overlie the Cameron Lake Volcanics.

LOCAL GEOLOGICAL SETTING

Studies by Trowell *et al.* (1980), Blackburn *et al.* (1985), and Trowell and Johns (1986) have shown that broad regional correlations can be made between several volcanic complexes within the Savant Lake - Crow Lake metavolcanic-metasedimentary belt (Figure 1). These correlations are based on similarities in superposition of strata, the continuity and projection of marker units, and geological similarities of the various complexes. They indicate that the volcanic stratigraphy commonly comprises lower mafic tholeiitic successions overlain by mixed mafic to felsic, tholeiitic to calc-alkaline successions, which in some areas are overlain by a second thick mafic tholeiitic succession.

The observations and data presented here allow comparison of the Cameron - Rowan Lakes area with other volcanic successions in the Savant Lake - Crow Lake Belt, as modelled by Trowell *et al.* (1980) and Blackburn *et al.* (1985).

Structure

Key structural elements of the Cameron - Rowan Lakes area (Figure 2) include the Pipestone - Cameron Fault, the Shingwak Lake Anticline, the Cameron Lake Shear Zone (CLSZ), and the Monte Cristo Shear Zone (MCSZ).

The Pipestone - Cameron Fault bounds the Cameron - Rowan Lakes area on the southwest. It consists of strongly foliated chlorite-sericite schists which are locally carbonatized. The fault has been defined over a strike length of 100 km. The sense of displacement remains contentious (Melling *et al.* 1985, Melling 1986a); however, major offset is suggested by the juxtaposition of the two volcanic complexes outlined in the preceding section, and the transposition of lithologies into the plane of the fault on a regional scale (Figure 2). Correlation of rock types across the fault, although suspected, has not been possible (Trowell *et al.* 1980). Recent work by Buck (1986) illustrates the complex and variable deformational history of the fault. Subhorizontal extension lineations and rotated structures to the northwest of the Cameron - Rowan Lakes area indicate that movement was dominantly horizontal with a dextral sense of displacement; however, to the south, shear fabrics, rotated structures, and lineations suggest

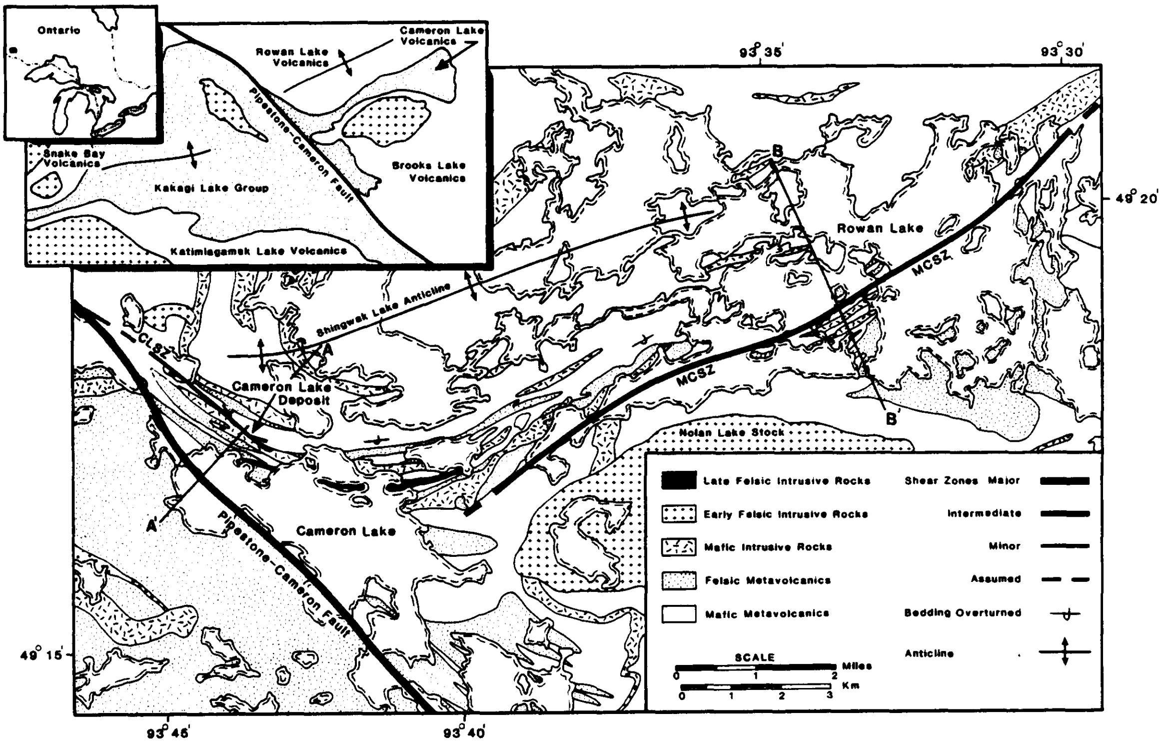

Figure 2. Geology of the Cameron - Rowan Lakes area (after Blackburn and Janes (1983) and Kaye (1973)). A-A′ and B-B′ are the positions of the stratigraphic cross-sections shown on Figure 4. CLSZ = Cameron Lake Shear Zone, MCSZ = Monte Cristo Shear Zone.

that the dominant movement was vertical with a north-side-up sense of displacement.

Kaye (1973) recognized the Shingwak Lake Anticline and determined the trace of its axial surface. Data obtained during this study have permitted further refinement of its geometry. Graded beds and well-formed pillows in the hinge zone of the anticline indicate that the fold faces west-southwest. On the south limb of the fold, overturned and north-dipping bedding measurements were obtained, primarily from volcaniclastic rocks. In the hinge zone on Shingwak Lake, mafic pillowed flows predominate and bedding measurements are not easily obtained. Bedding direction and structural facing were determined from the orientation of pillow shelves, using the methodology outlined by Sawyer *et al.* (1983). Although most measurements were from the southern limb and hinge zone of the fold, both the axial plane (287°/77°N) and plunge (040°/69°E)[2] of the fold were determined from these data (Figure 3). This geometry defines an asymmetric, synformal anticline with an south-southeast vergence.

Kaye (1973) inferred the presence of a synclinal keel localized through Sullivan Bay in southeastern Rowan Lake (Figure 2). This keel was not been confirmed by this study. Top determinations in central Rowan Lake, as far south as the Nolan Lake Stock, consistently indicate a steeply north-dipping, overturned succession facing south.

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2. All planar attitudes are given as azimuth/dip and linear attitudes are given as plunge/azimuth.

The Cameron Lake Shear Zone (315°/65°N) has been extensively examined (Melling *et al.* 1985, Melling *et al.* 1986, Melling 1986a) in the vicinity of the Cameron Lake deposit (Figure 2). It is a brittle-ductile shear zone, up to 60 m wide and over 3000 m in strike length, which exhibits evidence of dextral strike-slip displacement. It is interpreted as a splay of the Pipestone - Cameron Fault.

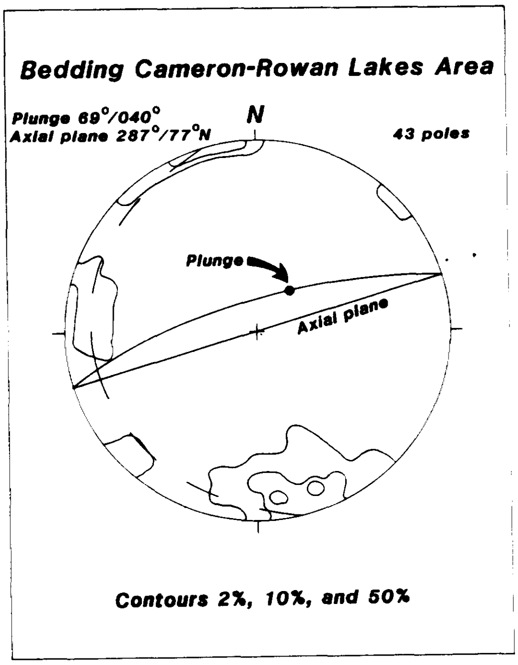


Figure 3. Contoured, lower hemisphere, equal area stereographic projection of poles to bedding in the Cameron - Rowan Lakes area. The dashed great circle is the plane containing the poles to bedding and is normal to the limbs and hinge of the Shingwak Lake Anticline.

The Monte Cristo Shear Zone (240°/80°N) occurs in south-central Rowan Lake (Figure 2) and has been studied by Wade (1985) and Melling (1986b). Wade (1985) showed that the displacement on the MCSZ has a significant dip-slip component, with the south side having moved up relative to the north. He noted the presence of S-folds of the shear foliation whose hinge line orientations are similar to those of measured stretching lineations. In addition, Wade (1985) recognized a brittle fault of unresolved sense along the southern boundary of the MCSZ. The geology and structure of the MCSZ are further discussed later in this report.

Stratigraphy

In order to assess the apparent stratigraphic control on gold mineralization in the Cameron - Rowan Lakes area, two stratigraphic sections were compiled (Figure 4). These sections extend south from the axial surface trace of the Shingwak Lake Anticline, one through Cameron Lake and one through Rowan Lake (Figure 2).

The oldest rocks exposed in the study area are the Rowan Lake Volcanics, which occur at the base of both sections and have a minimum thickness of about 3 km (Figure 4). The Rowan Lake Volcanics consist of aphanitic to fine-grained, subaqueous, pillowed, mafic flows and minor massive mafic flows. The best exposures occur on islands and along the shores of Shingwak Lake, where the pillows are well-formed and locally display shelf structures. Amygdules, comprising up to 20 percent of the pillowed flows, are filled by chlorite and carbonate. The rocks are weakly foliated, with the most prominent foliation in pillow selvages. This foliation is interpreted as axial planar to the Shingwak Lake Anticline. In north-central Rowan Lake, the pillows are irregular in shape and top determinations are not easily obtained.

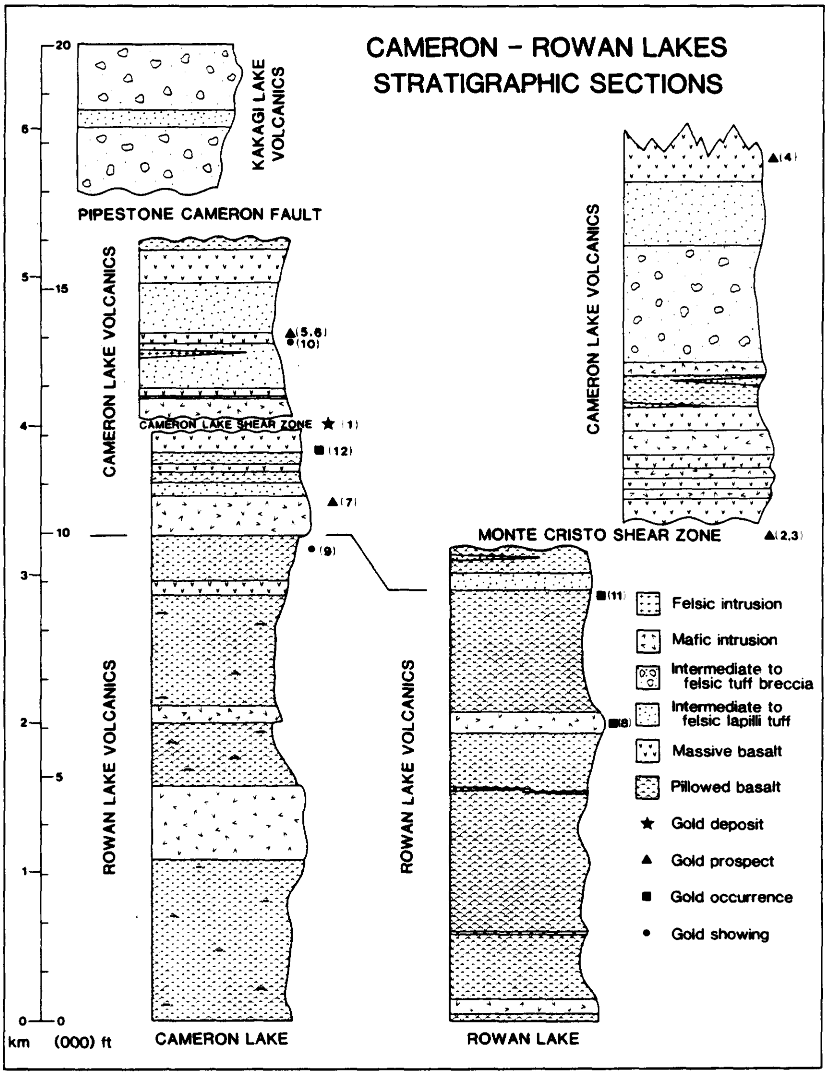


Figure 4. Stratigraphic sections of the Cameron - Rowan Lakes area, illustrating the distribution of gold and its relationship to major structures and rock types. Section locations are shown on Figure 2. Unit thicknesses are as exposed on surface, uncorrected for dip.

The overlying Cameron Lake Volcanics consist of approximately equal proportions of mafic volcanic flows and interbedded, intermediate to felsic, volcaniclastic rocks (Figure 4). The mafic volcanic rocks comprise both massive and pillowed flows. Amygdules locally comprise up to 30 percent of these flows. Massive flow units are more common in the

Cameron Lake Volcanics than in the underlying Rowan Lake Volcanics. Minor pillow breccia and mafic tuff are also present.

The intermediate to felsic volcaniclastic rocks comprise units of both monolithic and heterolithic lapilli-tuff, which commonly contain abundant plagioclase phenocrysts. The lapilli-tuff units are variable in composition, texture and grain size. In south-central Rowan Lake, a distinctive unit of tuff-breccia was interpreted by Kaye (1973) as indicative of a proximal vent facies environment. This interpretation is consistent with the occurrence of thicker volcaniclastic units in the Rowan Lake section and of the numerous dykes of intermediate composition observed in south-central Rowan Lake. The finer grain sizes observed in the Cameron Lake section may be indicative of a distal facies.

The contact between the Rowan Lake Volcanics and the overlying Cameron Lake Volcanics is defined by the first appearance of intermediate to felsic volcaniclastic rocks (Melling 1986b). In drill core from the Cameron Lake deposit, these consist of well-bedded pyroclastic rocks and interbedded, laminated, carbonaceous mudstones and epiclastic rocks. Disrupted bedding and rip-up clasts within the epiclastic beds suggest either shallow water conditions above storm wave base, or reworking due to gravity flows. Local thickening of this unit along strike may reflect deposition on an irregular erosional surface, which suggests an hiatus in volcanism coincident with the transition from mafic to intermediate to felsic volcanism.

Numerous mafic sills were intruded into both the Cameron Lake and Rowan Lake volcanic successions prior to folding. They are in general thicker and more abundant in the Cameron Lake section (Figure 3). This is compatible with Kaye's (1973) proposed relationship of these rocks to mafic-ultramafic rocks to the north. Minor felsic sills and markedly discordant dykes are also present.

Recently, Johns (1986) has subdivided the Cameron Lake Volcanics into a lower diverse member and an upper member, centred in west-central Rowan Lake, of intermediate pyroclastic rocks and minor intermediate flows. In addition, Johns (1986) correlated the mafic volcanic succession south of the Nolan Lake Stock with the Rowan Lake Volcanics, based largely on the presence of feldspar megaphyric flows (leopard rock) and minor pillow top reversals east of the stock. These rocks, termed the Brooks Lake Volcanics, were previously tentatively interpreted to overlie the Cameron Lake Volcanics (Trowell *et al.* 1980, Blackburn *et al.* 1985, Melling and Watkinson 1986b, Trowell and Johns 1986). The lack of structural data to document either the presence of a major synclinal axis, or the juxtaposition of strata in the vicinity of the Nolan Lake Stock, implied by both Johns (1986) and Kaye (1973), renders such interpretations speculative at best.

Lithogeochemistry

A lithogeochemical study of the volcanic rocks in the Cameron - Rowan Lakes area was completed in order to:

1) compare the compositions of the least altered volcanic rocks with their altered equivalents, which are associated with gold concentrations;

2) provide data to support the field-based stratigraphic compilation and further define the geologic setting of the area, and

3) facilitate comparison of the area with the general model for the organization of supracrustal rocks in the Savant Lake - Crow Lake metavolcanic-metasedimentary belt (Trowell *et al.* 1980, Blackburn *et al.* 1985).

The geochemical data presented here were discussed by Melling (1986a) and Melling and Watkinson (1986). Some of the data in Figures 5, 6 and 7 are from analyses provided by C.E. Blackburn (Resident Geologist, Ontario Ministry of Northern Development and Mines, Kenora). Analyses were done by the Geoscience Laboratories, Ontario Geological Survey, Toronto and by Bondar-Clegg and Company Limited, Ottawa.

Samples were grouped as Rowan Lake Volcanics or Cameron Lake Volcanics, using the field critera previously outlined. To facilitate comparison of data, similar volcanic rock classification schemes have been employed as were used by Blackburn *et al.* (1985).

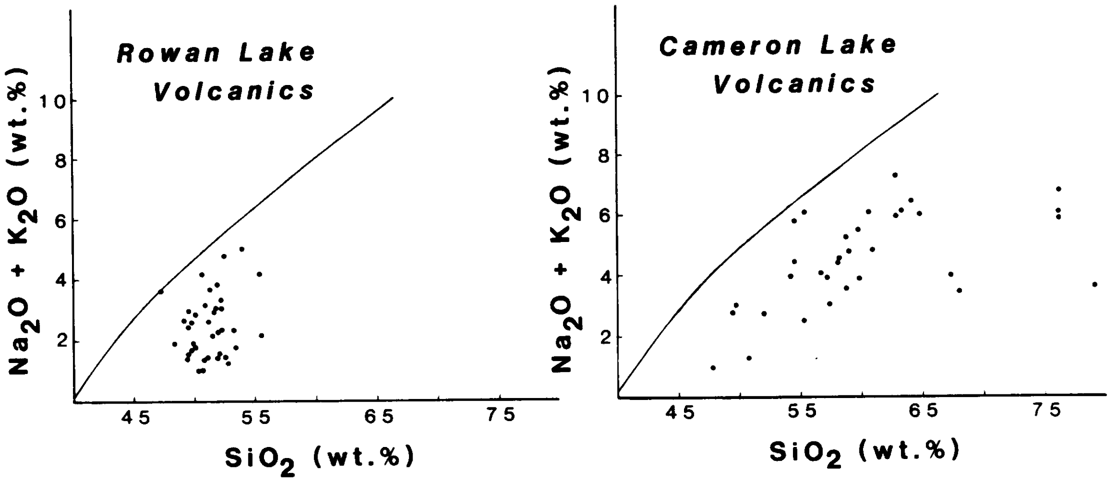


Figure 5. SiO_2 vs. $Na_2O + K_2O$ plots for volcanic rocks from the Cameron - Rowan Lakes area (after Irvine and Baragar 1971). The line separates subalkaline rocks (below) from alkaline (above) rocks.

The Rowan Lake Volcanics plot as subalkaline, tholeiitic basalts on standard classification diagrams (Figure 5). However, they do not exhibit well-developed chemical evolutionary trends on either the Jensen cation plot (Figure 6) or the Irvine and Baragar AFM plot (Figure 7). In general, the Rowan Lake Volcanics are less Fe-rich than the Katimiagamak and Snake Bay Volcanics, located to the west across the Pipestone - Cameron Fault.

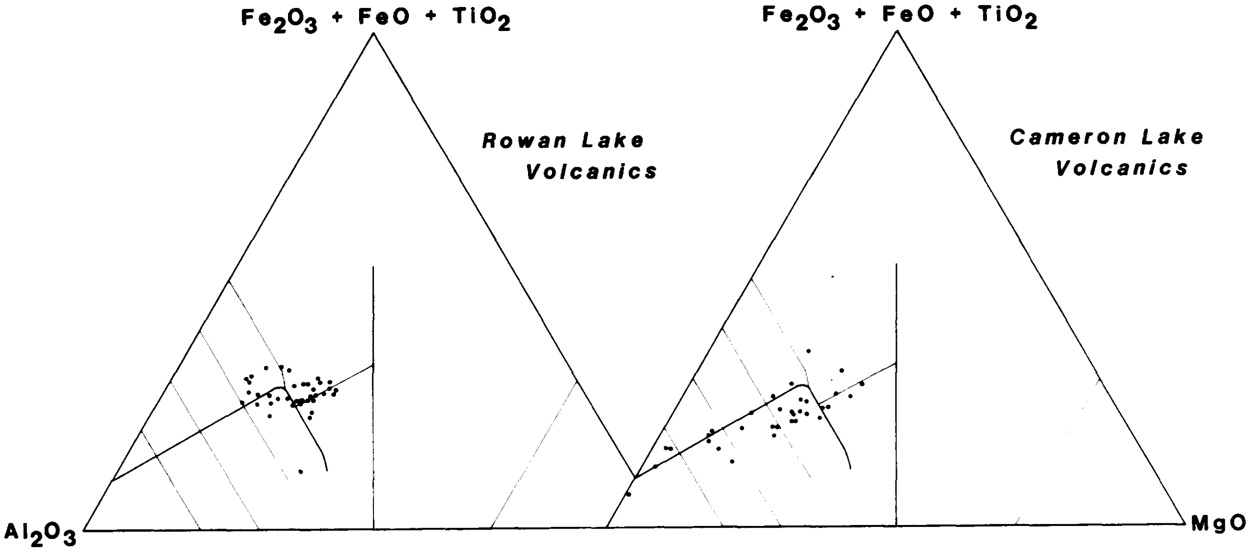


Figure 6. Jensen cation plot for volcanic rocks from the Cameron - Rowan Lakes area (after Jensen 1976). The komatiite field is on the right; tholeiite field, in the upper left; the high magnesian tholeiite field, slightly left of centre; and the calc-alkaline field, in the lower left.

The Cameron Lake Volcanics are geochemically variable. Compositions range from subalkaline basalts to rhyolites (Figure 5), and a well-developed calc-alkaline trend is shown on both the Jensen cation plot (Figure 6) and the AFM plot (Figure 7). These trends are similar to those of the Kakagi Lake Group, which overlies the Katimiagamk and Snake Bay Volcanics to the west.

Summary

Based on field mapping and geochemical criteria, the metavolcanic rocks in the Cameron - Rowan Lakes area can be divided into a lower mafic succession (the Rowan Lake Volcanics) and an overlying, mixed, mafic to felsic succession (the Cameron Lake Volcanics). The Rowan Lake Volcanics, which are the oldest rocks in the area, consist of tholeiitic, pillowed basalts, with minor, interbedded massive flows. The overlying Cameron Lake Volcanics consist of tholeiitic flows and calc-alkaline pyroclastic rocks.

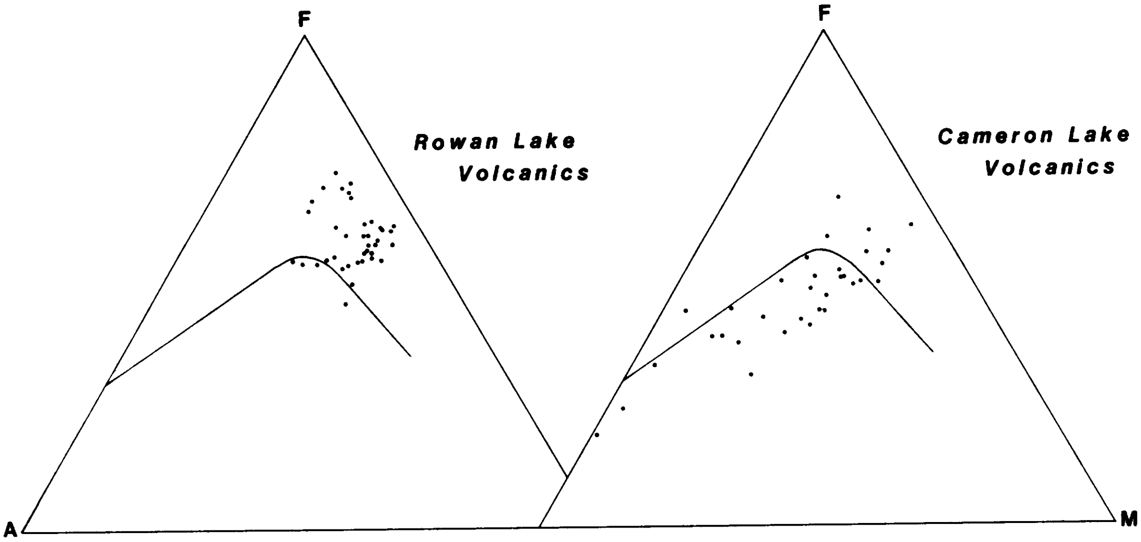


Figure 7. AFM plot for volcanic rocks from the Cameron - Rowan Lakes area (after Irvine and Baragar 1971). A = $Na_2O + K_2O$; F = total iron as FeO; M = MgO. The line separates tholeiitic rocks (above) from calc-alkaline rocks (below).

The transition between these two volcanic successions is defined by the first appearance of intermediate to felsic volcanic rocks. North of the Cameron Lake deposit, this transitional unit consists of interbedded pyroclastic rocks, thin-bedded sedimentary rocks, and epiclastic rocks. The irregular thickness of this unit, the presence of laminated sedimentary rocks and rip-up clasts, and the presence of the overlying, locally amygdule-rich, basaltic rocks and more abundant mafic massive flows, suggest both an hiatus in volcanism between the two successions, and possible shallow water conditions during the deposition of the Cameron Lake Volcanics. This could be due to either the regression of Archean seas or the emergence of local volcanic edifices. This is consistent with Johns' (1986) interpretation of the Cameron Lake Volcanics, wherein he envisaged deposition of the pyroclastic rocks in a shallow water, proximal volcanic environment by pyroclastic flow and fall-out mechanisms from eruptions of gas-rich magmas of intermediate composition. Based on regional, vertical-gradiometer survey data, Blackburn and Hailstone (1983) inferred the presence of an unconfomity at the base of the Cameron Lake Volcanics.

The geochemical and stratigraphic relationships between the Rowan Lake and Cameron Lake volcanic successions in the study area are similar to those observed within other volcanic complexes of the western Wabigoon Subprovince, as modelled by Trowell *et al.* (1980) and Blackburn *et al.* (1985).

DISTRIBUTION OF GOLD IN THE CAMERON - ROWAN LAKES AREA

The distribution of gold in the area and its relationships to major structural elements and to stratigraphy are illustrated in Figures 4 and 8. Where available data allow, gold concentrations have been classified as deposits (> 100,000 ounces proven reserves), prospects (some underground development or > 2000 feet of diamond drilling and trenching), occurrences (limited exploration which may include diamond drilling and trenching), and showings (significant assays but little exploration).

Several workers (Blackburn and Janes 1983, Blackburn and Hailstone 1983) have noted that these gold concentrations are, to a large extent, confined to the Cameron Lake Volcanics An integral part of this study has been to assess this apparent stratigraphic control on the distribution of gold concentrations.

Stratigraphic Control

The spatial relationship between distribution of gold concentrations and stratigraphy is clearly illustrated on Figure 4. Most gold concentrations, including the Cameron Lake deposit and the Victor Island and Monte Cristo prospects (Numbers 1, 2, and 3, Figure 4), occur within the Cameron Lake Volcanics, and many of these are at or near the contact with the underlying Rowan Lake Volcanics.

All sites of gold concentrations within the Cameron Lake Volcanics are in massive or pillowed basaltic rocks or their deformed equivalents. Carbonate-sericite wall rock alteration and the presence of pyritic breccia-veins are characteristic of these areas. To date, no significant exploration targets have been discovered in the intermediate to felsic volcaniclastic rocks of the Cameron Lake Volcanics.

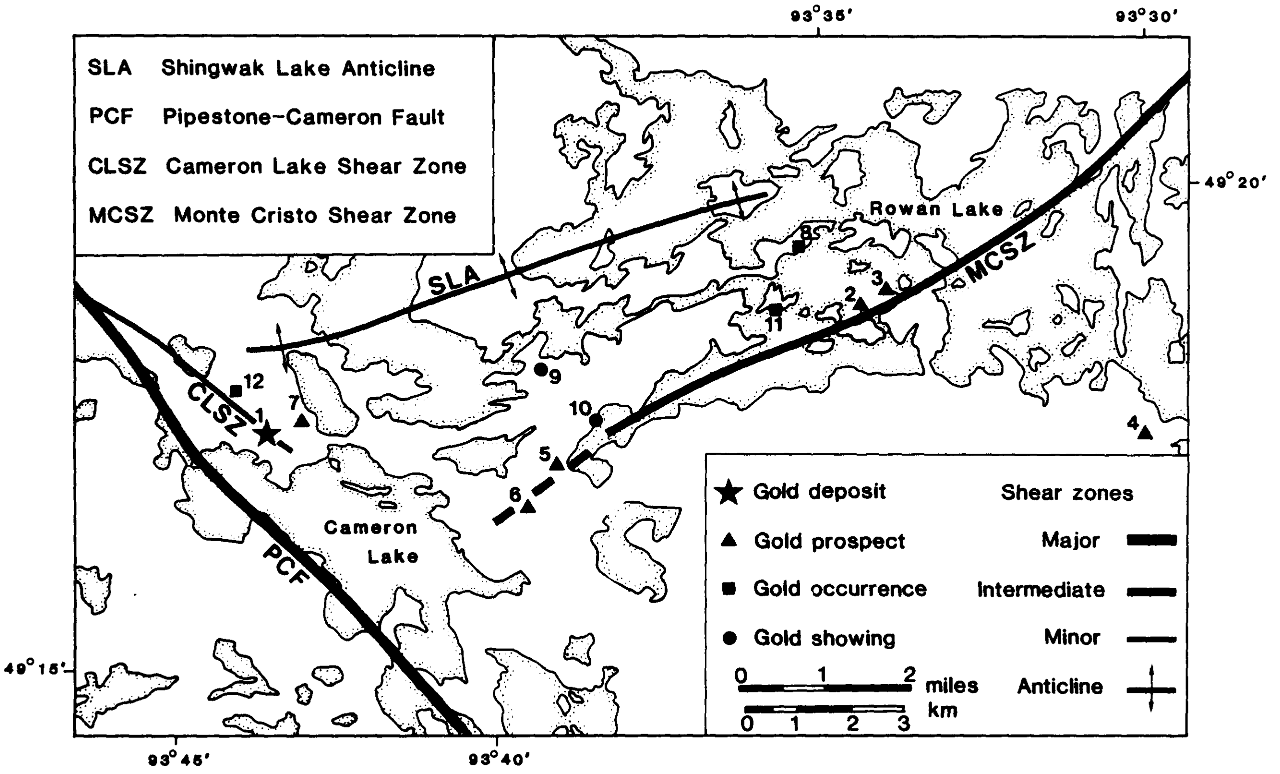


Figure 8. Major structural elements in the Cameron - Rowan Lakes area and their relationship to gold mineralization. 1 = Cameron Lake deposit; 2 = Victor Island prospect; 3 = Monte Cristo prospect; 4 = Wampum Lake prospect; 5 = Sullivan prospect; 6 = Meston prospect; 7 = Beggs Lake prospect; 8 = Patmour occurrence; 9 = Roy showing; 10 = Kuryliw-Sullivan Bay showing; 11 = Unnamed showing; 12 = Twilight occurrence. See Appendix I for exploration histories and sources of information.

Not all of the gold concentrations are in the Cameron Lake Volcanics. The Patmour occurrence and Begg's Lake prospect (Numbers 7 and 8, Figure 4) are in mafic intrusive rocks (locally termed gabbro/diorite). These occurrences are characterized by the presence of one or more quartz-carbonate veins, with minimal associated deformation and alteration of the host rocks.

Structural Control

The distribution of gold with respect to major structural features is shown on Figure 8. Two distinct, gold-bearing, high strain zones have been identified within the Cameron Lake Volcanics: the Cameron Lake Shear Zone (CLSZ) and Monte Cristo Shear Zone (MCSZ). These shear zones contain the largest gold concentrations discovered to date and remain the principal exploration targets.

The Cameron Lake deposit (Number 1, Figure 8) occurs within deformed basaltic rocks of the CLSZ. Exploration drilling along strike to the northwest of the deposit has commonly intersected deformed and variably altered rocks containing anomalous gold concentrations; however, no discrete gold zones have been discovered. The CLSZ is interpreted to be a splay of the major Pipestone - Cameron Fault Zone. No gold concentrations have been discovered within the Pipestone - Cameron Fault in the Cameron Lake area. However, several kilometres to the northwest, several gold prospects and occurrences are clustered about a flexure in this fault, immediately north of its projected intersection with the CLSZ.

The Victor Island and Monte Cristo prospects (Numbers 2 and 3, Figure 8) occur within the deformed rocks of the MCSZ. The geometry and gold distribution of both these prospects are controlled by structures in the enveloping shear zone. These structures, the associated alteration, and the lithogeochemistry of the occurrences are the focus of this study.

Other gold prospects possibly related to the MCSZ include the Meston and Sullivan Zones (Numbers 5 and 6, Figure 8), which occur between Rowan Lake and Cameron Lake close to the projected trend of the MCSZ. During 1986, Nucanolan Resources conducted an exploration program on these properties, which included overburden drilling, mapping, prospecting, trenching, and diamond drilling. Data acquired from the program indicate that the two prospects occur in weakly foliated mafic rocks, north of a broad, arcuate band of well-foliated rocks which appears to underlie the area.

Nuinsco Resources Ltd. has been unable to trace the MCSZ down the entire length of the Sullivan Bay by overburden drilling. However, the location and orientation of the bay are not considered fortuitous, and the MCSZ may be discontinuous toward the southwest. The Kuryliw - Sullivan Bay showing (Number 10, Figure 8), on the north shore of Sullivan Bay, is also spatially associated with the MCSZ. This showing was not located during this study.

West of the Victor Island prospect, International Platinum Corp. has drill tested a new, unnamed gold occurrence (Number 11, Figure 8) and obtained encouraging results. This occurrence is located within a discrete high strain zone which parallels the MCSZ (Figure 9). Styles of deformation and alteration at the occurrence are similar to those in the Victor Island and Monte Cristo prospects.

Several gold prospects and occurrences are near contacts between mafic intrusive and volcanic rocks. The Patmour occurrence, and the Wampum Lake and Begg's Lake prospects (Numbers 8, 4, and 7, Figure 8) all occur within small, discontinuous zones of deformation spatially associated with such contacts. In addition, the locations and orientations of both the CLSZ and MCSZ are at least in part controlled by the presence of mafic intrusive rocks, particularly in the vicinity of gold concentrations.

Summary

As shown by previous workers, most gold concentrations in the Cameron - Rowan Lakes area occur within the mixed, tholeiitic to calc-alkaline, Cameron Lake Volcanics, at or near the contact with the underlying, tholeiitic, Rowan Lake Volcanics. However, this stratigraphic control does not necessarily imply primary, synvolcanic gold enrichment, as suggested by Blackburn and Janes (1983). All of the deposits, prospects, occurrences, and showings occur in mafic rocks or their deformed equivalents. In addition, the largest gold concentrations discovered to date occur in the CLSZ and MCSZ, and smaller, but significant, concentrations occur in discontinuous high strain zones spatially related to mafic intrusive/volcanic rock contacts.

Both the distribution of gold concentrations and their relationship to structural features are interpreted to result from the contrasting competency of mafic flows, intermediate to felsic volcaniclastic rocks and mafic intrusive rocks characteristic of the Cameron Lake Volcanics. During deformation, strain distribution in the relatively monolithic Rowan Lake Volcanics was homogeneous; however, within the Cameron Lake Volcanics, strain distribution was heterogeneous and instrumental in the localization of high strain zones adjacent to lithologic contacts. Similarly, the preferential development of larger shear zones, such as the CLSZ and MCSZ, would have been enhanced by heterogeneous strain distribution. The greater frequency of gold concentrations in the Cameron Lake Volcanics is thus a function of more efficient ground preparation processes, and represents a structural control influenced by stratigraphy. Mafic lithologies probably formed the most chemically favourable hosts promoting gold precipitation.

THE GEOLOGY OF THE CENTRAL PART OF ROWAN LAKE

The geology of the central part of Rowan Lake is summarized on Figure 9. The southwest-trending, north-dipping Monte Cristo Shear Zone (MCSZ) has been traced by field mapping and diamond drilling for 9 km, from the northeastern shore of Rowan Lake, through the map area and into Sullivan Bay, where it is believed to continue a considerable distance beneath the water (Figure 1). In the central part of Rowan Lake, the shear zone varies from 125 m (410 ft) to 250 m (820 ft) in width.

The contact between the Rowan Lake Volcanics and the Cameron Lake Volcanics is beneath Rowan Lake, north of the MCSZ. Due to this lack of exposure, the position of the contact here is based on extrapolation from adjacent areas and island exposures.

Mafic volcanic rocks constitute the most abundant lithology, particularly in the northern portion of the map area (Figure 9). Mafic lithologies comprise units of pillowed and massive flows, pillow breccias, and ash tuff. The mafic flows are locally quartz-chlorite amygdaloidal and, rarely, variolitic. Within the Cameron Lake Volcanics, pillow selvages are up to 6 cm thick (Plate 1e).

Intermediate to felsic volcaniclastic rocks are interbedded with, but subordinate in abundance to, the mafic volcanic rocks. The volcaniclastic rocks are restricted to the Cameron Lake Volcanics and are most abundant in the southeastern corner of the map area. Recently, Johns (1986) divided the Cameron Lake Volcanics into a lower and an upper member. The lower member consists of units of ash tuff, quartz-feldspar crystal tuff, and heterolithic lapilli tuff. Individual units are commonly well-sorted and of variable thicknesses. Rare felsic flows have also been observed. Locally, finely laminated sediments occur, which display flame structures attributed to soft sediment deformation (Plates 1a and 1b). The laterally extensive crystal tuff units are interpreted to have been deposited by ash-flow mechanisms.

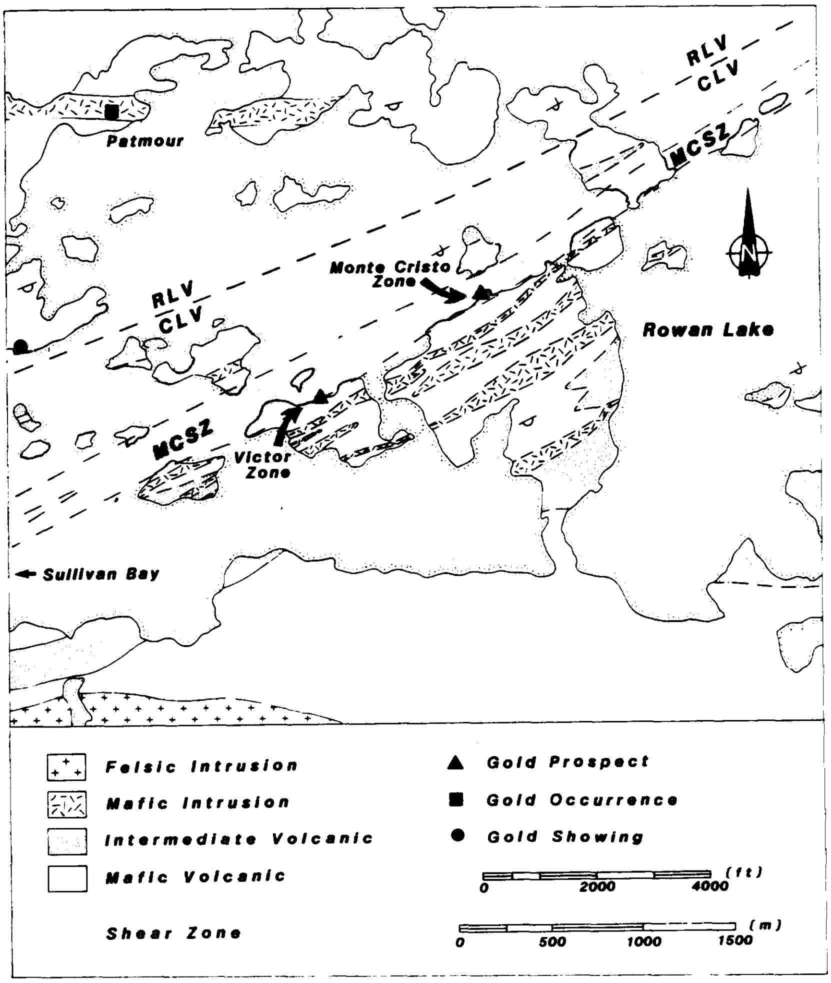


Figure 9. Geology of the central portion of Rowan Lake (modified from Jones 1985). RLV = Rowan Lake Volcanics; CLV = Cameron Lake Volcanics; MCSZ = Monte Cristo Shear Zone.

The upper member of the Cameron Lake Volcanics (Johns 1986) lies east of the map area. It consists of monolithic, intermediate pyroclastic rocks and subordinate intermediate flows. The most common clast type in the fragmental units is quartz amygdaloidal and feldspar-phyric dacite; scoriaceous varieties also occur. Bedding is generally very thick and massive, with local, thin, graded beds. These rocks are interpreted by Johns (1986) to have been deposited by pyroclastic flow and fall out mechanisms in a shallow water, proximal environment. This is consistent with the high frequency of occurrence of dykes of similar composition intruding these rocks and the larger clast sizes which predominate in this area.

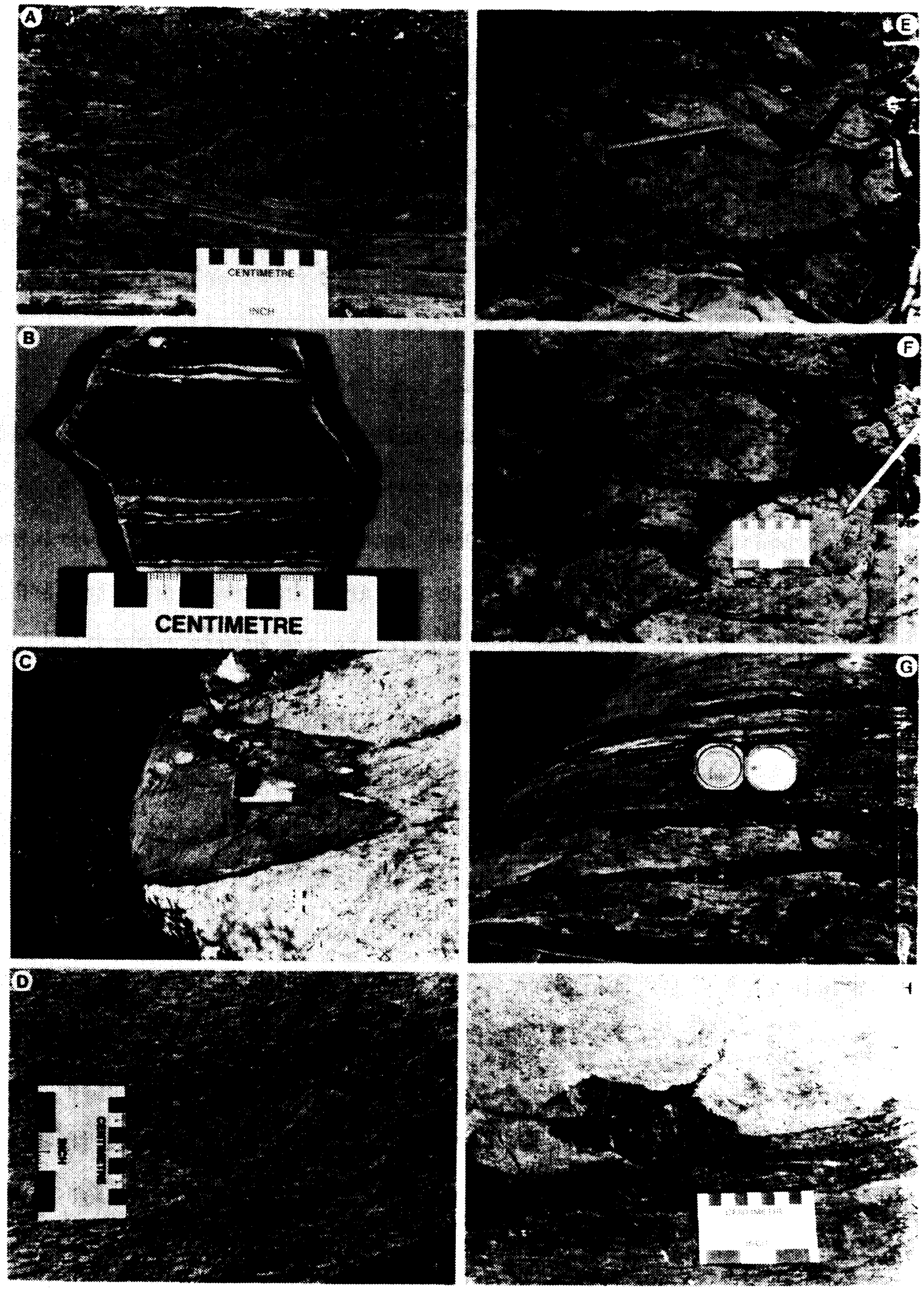
Concordant to subconcordant, gabbroic sills intrude both the Rowan Lake and Cameron Lake volcanic sequences. These intrusions are medium-grained and locally contain quartz megacrysts. Contacts between the sills and their host rocks are commonly sheared and locally carbonatized. Minor quartz-feldspar and feldspar porphyry dykes intrude both the volcanic rocks and the sills. Several generations of dyke emplacement are suggested by variations in texture, composition, and strain state. Within the MCSZ, some dykes display a strong penetrative foliation, while others are massive and contain unoriented xenoliths of the chlorite-sericite-quartz schist that is characteristic of the shear zone (Plate 1h).

The Nolan Lake Stock intrudes the volcanic rocks in the southern part of the map area. It consists of medium-grained quartz monzonite and is surrounded by an amphibolite grade contact metamorphic aureole up to a few hundred metres wide. Contaminated border phases locally occur, particularly along the northern and western contacts (Kaye 1973). A distinctive set of laterally persistent, parallel, quartz-rich tension veins was observed towards the western end of the stock. The veins are up to 25 cm thick, oriented about 150°/13°SW, and have no discernible alteration envelopes. They are best exposed on vertical rock faces; on horizontal exposures they are typically represented by widely dispersed angular blocks of quartz float up to 25 cm in diameter.

Bedding in the least deformed mafic volcanic and intermediate volcaniclastic rocks outside the MCSZ averages 250°/86°N (Melling 1986b). Reliable top indicators (graded beds, soft sediment structures, well-formed pillows) consistently show younging to the south, indicating

Plate 1. Volcanic rocks exposed in the central part of Rowan Lake.

(a) Ball and pillow structure and associated flame structures in water-lain, fine grained felsic tuffs. Located on the northwestern shore of the island immediately north of the Monte Cristo prospect.
(b) Slab of the bedded tuff in (a), showing centimetre-scale bedding and refracted fracture cleavage.
(c) Small fold, illustrating the relationships among bedding, cleavages, and fold orientations. The light coloured rock is felsic lapilli tuff, and the dark coloured rock is mafic tuff containing some felsic fragments. The contact between them is marked by a 1 cm seam of tourmaline. Located on a small island 1 km northwest of the Victor Island prospect.
(d) Close-up of a felsic clast in (c), illustrating the relationship between the two regionally developed cleavages. See text for discussion.
(e) Least deformed pillowed basalt, located about 700 m south of the Monte Cristo Shear Zone, on the western side of the peninsula.
(f) Weakly to moderately deformed pillowed basalt, located about 50 m south of the Monte Cristo Shear Zone, on the norhtern part of the peninsula.
(g) Strongly deformed pillowed basalt on the edge of the Monte Cristo Shear Zone, located on the southern side of the island immediately north of the peninsula.
(h) Quartz-feldspar porphyry dyke intruding the strongly foliated rocks of the Monte Cristo Shear Zone. Note the misoriented zenolith of strongly foliated rock included in the dyke, and the truncation of the shear foliation at the dyke contact.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an overturned succession. The presence of a compressed, or otherwise deformed, synclinal keel in the vicinity of Sullivan Bay, as suggested by Kaye (1973), has not been confirmed by the present study. Only one small scale (< 1m) fold closure was observed within the map area (Figure 7), with its axial plane oriented 278°/76°N, and hinge line plunging 082°/62° (Plate 1c). Small (< 10cm), asymmetric S-folds occur on the northern limb, and even smaller, symmetric M-folds occur in the hinge zone of the fold. The asymmetry of the fold and similarity of its orientation to that of the Shingwak Lake Anticline suggest it is parasitic to the anticline. To the east and southeast of the map area, reversals in younging direction and apparently isoclinal folding have been documented by both Johns (1986) and Chivers (1986); however, these folds have not been traced into the map area and their geometry and relationship to the Shingwak Lake Anticline are poorly understood.

The rocks display two foliations. The most prominent is extensively developed and oriented 268°/86°N (Figure 10a). It is interpreted as equivalent to the regionally developed foliation in the Cameron - Rowan Lakes area and is axial planar to the Shingwak Lake Anticline. Flattening of pillow structures and lapilli occurs subparallel to this foliation. The second foliation is poorly developed and has been observed only locally within the map area. It is best developed within the thinly bedded sediments north of the Monte Cristo prospect and in larger felsic clasts throughout the map area (Plate 1d). It is oriented 299°/73°N and is interpreted as being either synchronous with, or later than, the regionally developed foliation because it shows no evidence of being folded at the outcrop scale.

The state of strain in the least deformed rocks outside and north of the MCSZ was determined by using shapes of pillows and lapilli. Within horizontal sections, aspect ratios are small (< 5:1). Where vertical rock faces are available, aspect ratios are large (> 9:1), with steeply plunging long axes. This relationship suggests a significant component of regional, vertical extension. The state of strain increases near the shear zone boundaries, as illustrated by pillow shapes in the mafic volcanic rocks (Plates 1e, f, g). Aspect ratios in horizontal sections are higher (> 12:1) and flattening occurs sub-parallel to the shear zone boundaries.

North of the MCSZ, arrays of *en echelon*, asymmetric, quartz-rich, Z-shaped, tension veins are locally developed. The veins have pointed terminations oriented about 106°/74°S; the arrays strike about 255°.

The Monte Cristo Shear Zone

Several subparallel, northeast-trending, high strain zones occur within the map area (Figure 9). These zones of deformation are in general confined to the Cameron Lake Volcanics and are characterized by intense cleavage development and variable degrees of carbonatization and sericitization. The widest and most laterally persistent is the Monte Cristo Shear Zone (MCSZ), which contains the Monte Cristo and Victor Island gold prospects.

Structural Geology

Kaye (1973) did not recognize the presence of the MCSZ and described its fault rocks as "banded or layered volcaniclastics". He considered the folding to be parasitic to the larger Shingwak Lake Anticline. The MCSZ was formally defined by Melling *et al.* (1985) and subsequent studies by Wade (1985) and Melling (1986b) have focused on both the structural geology and the gold potential of the shear zone. Although the interpretations made here differ in part from those of Wade (1985), his work provides an excellent data base, which has been expanded.

The MCSZ is a long, subconcordant structure which trends 240°/80°N (Figure 2). Exposures of the deformed rocks which collectively define the MCSZ occur on several islands and peninsulas within Cameron Lake. It is defined as a zone of high strain by its discordant nature and the presence of strongly foliated, compositionally banded (mm to cm scale), chlorite-sericite-quartz ± carbonate schists (Plates 2a, b). Within the shear zone, bedding is not commonly recognized; primary textures and structures are generally either indeterminate or transposed into the shear foliation. Due to the paucity of outcrop and poor or incomplete boundary exposures, it was not possible to trace bedding or foliation into the shear zone; however, since the width of the MCSZ (up to 250 m) far exceeds that of any individual bedding unit recognized to date, it may be inferred that several rock types are present within the high strain zone. Locally, broad (tens of centimetre scale) color bands occur at a low angle oblique to foliation in the shear zone and may reflect primary bedding. In addition, elongate (> 15:1), white weathering clasts occur which are interpreted to be flattened felsic lapilli.

The mean foliation (shear foliation) attitude in the MCSZ is 246°/83°N (Figure 10b). In thin section, the foliation can be seen to be defined by mineralogical layering, consisting of quartz-rich domains separated by chlorite-rich lamellae. The quartz is generally recrystallized, fine grained and polygonal with well-developed triple junctions between grains. Chlorite displays a strong planar alignment and is partially replaced by sericite. Pull-aparts in dismembered quartz veins occur both down dip and along strike within the foliation and are infilled by chlorite and quartz (Plate 2d). Isolated, elongate, tapered, quartz-rich pods enveloped by the foliation are also common, and have been interpreted as boudinaged quartz veins (Plate 2e).

A steeply plunging, east-trending, mineral lineation occurs in the stongly foliated rocks, oriented 090°/82°E (Figure 10c). It is interpreted as a stretching lineation because of pull-apart structures which occur down plunge. The orientation of the stretching lineation indicates the direction of transport associated with the component of simple shear (Ramsay 1980). Thus a dip-slip transport direction is implied for the rocks in their present position.

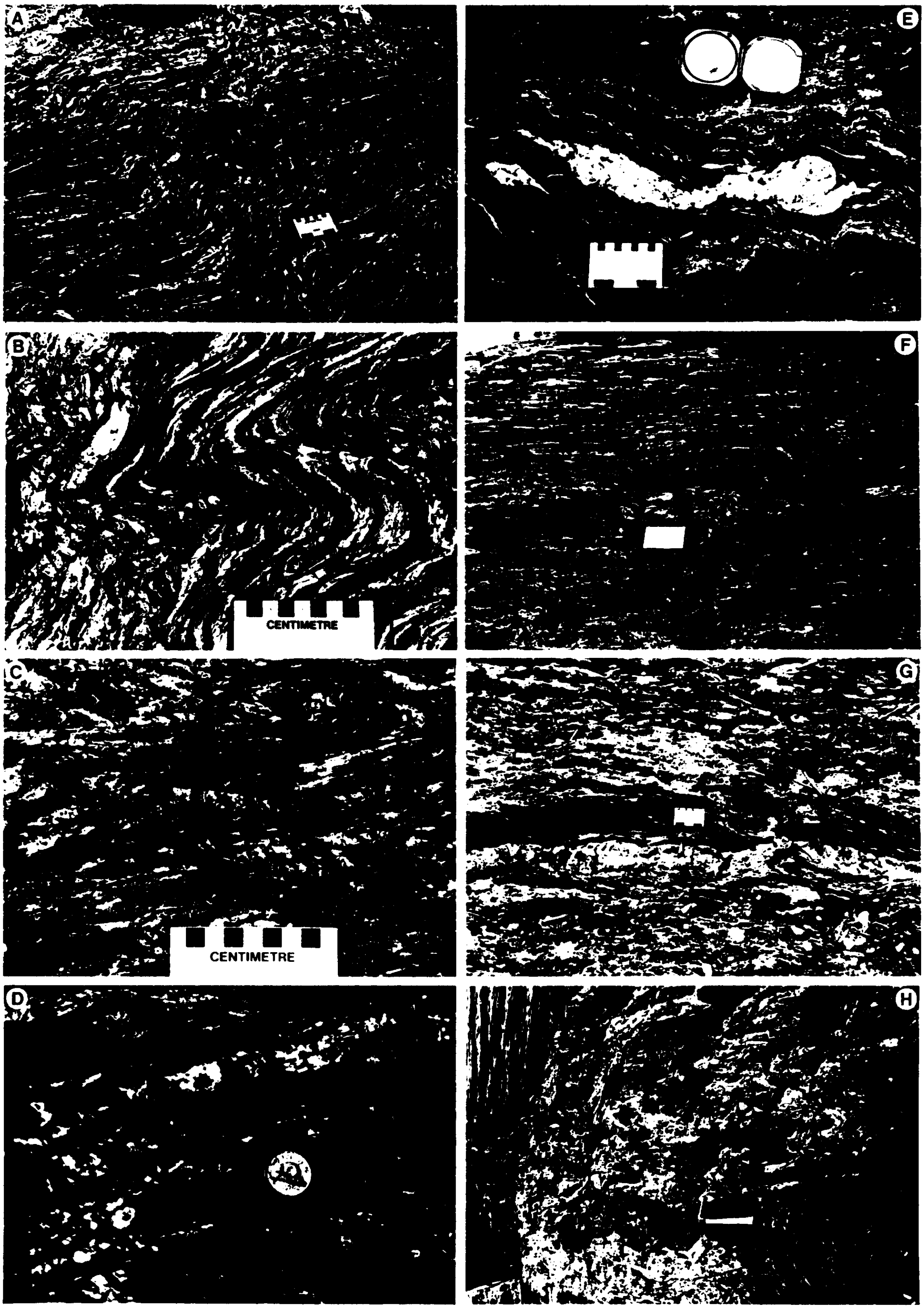
Unique to the MCSZ are asymmetric, steeply plunging, east-trending, S-folds of the shear foliation. This folding is widespread, but is most pronounced and tightest near the shear zone boundaries. Fold style varies considerably, from open to tight. The scale of folding ranges from several centimetres to about 1 metre for the short limbs, and axial surface traces are generally not continuous over more than a few metres. Hinge line plunge orientations average 080°/75°E

(Figure 10e), but are, in general, shallower in the west (about 70°) and steeper in the east (about 85°).

The axial surface traces of the S-folds are oblique to the overall shear foliation and commonly are curved or transposed towards the shear foliation (Plate 2b). This is illustrated by Figure 10d, on which poles to axial planes of the S-folds are distributed along a great circle girdle with a strong maximum at 258°/84°N, near the mean foliation trend (246°/83°N). Locally, the limbs of the tightest folds are apparently "sheared off", trapping fold hinges (Plate 2c). This complex fabric is characterized by subparallel, 1 to 3 cm wide segments or

Plate 2. Deformed volcanic rocks from the Monte Cristo Shear Zone (MCSZ), exposed in outcrops in the central part of Rowan Lake.

(a) Strongly foliated, S-folded, chlorite-sericite-quartz schist of the MCSZ. The shear foliation is defined by compositional layering and parallel mineral alignment. Note the S-folds of the shear foliation and the dismembered quartz veins.
(b) Close up of S-folded shear foliation in the schists of (a). Note the curved axial surface trace of the fold, and the dismembered quartz veins to the left.
(c) Trapped fold hinges in the chlorite-sericite-quartz schists of the MCSZ.
(d) Chlorite-filled pull aparts in deformed quartz viens in the chlorite-sericite-quartz schists.
(e) Boudinaged quartz vein in chlorite-sericite-quartz schist in a minor zone of high strain to the north of and paralleling the MCSZ. Note the S-folds of the shear foliation below the boudin.
(f) Conjugate set of Z- (right) and S- (left) kink bands in the strongly foliated rocks of the MCSZ. The intersection of the sets is slightly to the right of the scale card.
(g) Tabular, boudinaged carbonate-rich alteration type in strongly foliated rocks of the MCSZ. Note the pinch and swell of the layer and the crosscutting, steeply dipping, quartz-tourmaline tension veins. The altered layer is slightly discordant to the foliation.
(h) Dismembered, S-folded, carbonate-rich pods in the strongly foliated rocks of the MCSZ. Note the orientation of the folded pods. Such pods occur in a discrete zone of folding.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microlithons containing S-type asymmetric structures, separated by discontinuity surfaces of strongly foliated rock along which sericite preferentially replaces chlorite and oxide minerals are particularly abundant. In general, the microlithons show nearly complete transposition into the earlier formed shear foliation. Similar fabrics have been described by Kehlenbeck (1986) in the Beardmore - Geraldton fold belt. The intersection of the coeval axial planar foliation to the S-folds with the shear foliation has resulted in a weakly developed

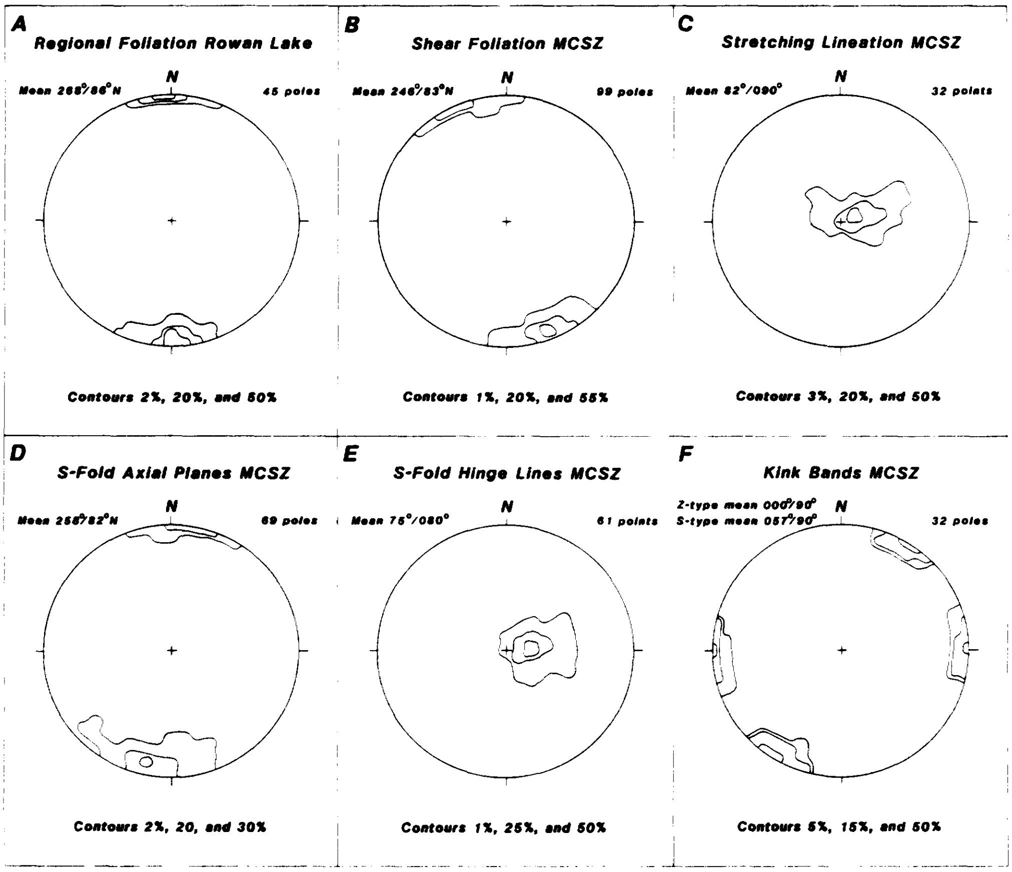


Figure 10. Contoured, lower hemisphere, equal area stereographic projections of structural data from Rowan Lake and the Monte Cristo Shear Zone. (a) Poles to regional foliation, Rowan Lake; (b) Poles to shear foliation, MCSZ; (c) Stretching lineation, MCSZ; (d) Poles to axial planes of S-folds of the shear foliation, MCSZ; (e) Fold hinges of S-folds, MCSZ; (f) Poles to axial planes of S- and Z- kink bands, MCSZ.

crenulation of the shear foliation and an intimately related, subvertical, intersection lineation.

Conjugate kink bands are locally developed within the strongly foliated rocks of the MCSZ near its boundaries (Plate 2f). Axial surfaces trend 000° and 057° for the Z- and S-type flexures, respectively, and both dip subvertically (Figure 10f). The kink bands show no evidence of further deformation (neither rotation, folding, nor dismemberment), and are interpreted as having formed late, possibly in response to tectonism unrelated to the development of the MCSZ.

On the southern boundary of the MCSZ, there is evidence of a brittle fault. Horizontal slickensides, developed on chloritic surfaces, overprint the stretching lineation in two localities (Wade 1985) and drill holes in the area commonly intersected a thin (< 1 m) zone of fault gouge, which separates the deformed rocks of the MCSZ from the rocks to the south. The sense of local displacement could not be resolved, due to a lack of cross-cutting markers or other suitable indicators.

Alteration

During field mapping, emphasis was placed on identifying zones of alteration within the MCSZ and interpreting their relationships to deformation. Two types of alteration zones were identified at the outcrop scale:

1) tabular layers of boudinaged carbonate-rich alteration, and

2) zones of S-folded and dismembered carbonate-rich pods (Melling 1986b).

Type 1 alteration was observed about 1 km east-northeast of the Monte Cristo prospect. It consists of a discrete layer, more than 2 m long and 15 cm thick, of intense carbonatization and sericitization within the chlorite-sericite-quartz schists of the MCSZ (Plate 2g). The altered rocks weather recessively and have a distinctive, bright reddish, rusty colour. Locally, thin chloritic seams and folia of the host schists occur within the altered layer. Contacts between the altered layer and the host schists are always sharp.

The tabular altered layer is at a low angle to the shear foliation, strikes 233° and dips steeply to the north. It pinches and swells along strike and is locally dismembered, with up to 0.6 m between individual boudins. The altered rocks are cut by several quartz-tourmaline veins, which strike about 345° and dip steeply to the east and west.

Type 2 alteration was observed about 1 km west of the Victor Island prospect. It consists of a zone, more than 6 m long and 2 m wide, of dismembered, S-folded, carbonate-rich pods, within the chlorite-sericite-quartz schists of the MCSZ (Plate 2h). The folded pods weather recessively and have a distinctive, bright reddish, rusty colour. Locally, thin chloritic seams and folia of of the host schists occur within the altered pods.

The size of individual pods within the zone varies from the centimetre to metre scale. Larger pods are commonly cut by small quartz-tourmaline tension veins oriented 177°/75°W. The folded, dismembered pods display an S-fold asymmetry. Hinge lines plunge about 075°/60° and axial planes are oriented 265°/75°N. The zone is subparallel to the shear foliation. Contacts between the altered carbonate-rich pods and the host schists are always sharp.

Summary

The preceding description clearly demonstrates that the Monte Cristo Shear Zone is a discordant zone of high strain. However, its deformational history and relationship to structures in the surrounding volcanic rocks are considerably more problematic. The following features are relevant to the kinematic interpretation of the MCSZ:

1) Within the high strain zone, bedding is not commonly recognized, primary features are flattened, and the host rocks have been transformed into compositionally layered, chlorite-sericite-quartz±carbonate schists, which display a strong planar mineral alignment and a coeval, steeply plunging, stretching lineation.

2) The shear foliation itself has been deformed into asymmetric, steeply plunging, east-trending S-folds, the axial surface traces of which are commonly curved or transposed towards the plane of the MCSZ. An axial planar foliation to the S-folds occurs both in areas of strong folding and elsewhere within the shear zone.

3) On the southern boundary of the MCSZ, subhorizontal slickensides overprint the stretching lineation. In addition, diamond drill data indicate that in some areas this southern boundary consists of a thin zone of fault gouge, separating deformed rocks of the MCSZ from least deformed rocks in the footwall.

4) In rocks outside the MCSZ, significant flattening has occurred and two foliations are developed. The first and most prominent is interpreted as axial planar to the synformal Shingwak Lake Anticline and subparallel to lithological flattening; the second is oblique to both the synform and the MCSZ and is of uncertain origin.

These characteristics indicate that two distinct episodes of deformation occurred within the rocks of the MCSZ. The first resulted in the formation of the shear zone and the development of the shear foliation and coeval stretching lineation. Wade (1985) evaluated the sense of displacement of this phase of deformation. Microtextures of kinematic significance observed by Wade in specimens from the MCSZ include flattened grains with both symmetric and asymmetric pressure fringes, pull-apart structures, microfolds, inclined fabrics, and displaced grains (microfaults) (Plate 6b). Since the majority of natural shear systems involve both pure and simple shear, the reliability of rotated structures is suspect (Hamner 1984). Accordingly, Wade (1985) emphasized inclined fabrics and displaced grains. The results of his study suggest that, when looking east at a vertical section through the MCSZ, the overall sense of shear is sinistral. This indicates that the south side moved "up" relative to the north side, in a direction parallel to the lineation.

The second episode of deformation resulted in the development of S-folds of the shear foliation and coeval axial planar foliation. The axial planar foliation occurs at a low angle (< 15°) to the shear zone boundaries. This sense of cleavage asymmetry, coupled with the transposition of the axial surface traces of the folds towards the plane of the MCSZ, is indicative of sinistral shear. This is also compatible with the evidence of a brittle fault along the southern boundary of the MCSZ, upon which horizontal slickensides occur.

Similar deformational textures (Plate 3c) observed in the smaller, subparallel, high strain zones north of the MCSZ (Figure 9) suggest related origins.

THE MONTE CRISTO GOLD PROSPECT

The Monte Cristo prospect occurs within strongly foliated rocks of the MCSZ and is situated on the northern edge of a prominent peninsula in south-central Rowan Lake (Figure 9). The gold zone is poorly exposed in outcrops, trenches, and shafts on the shoreline; most of its length is beneath Rowan Lake. It was originally discovered in 1899, when 6 trenches and 2 shafts of 4 m (13 ft) and 6.7 m (22 ft) were excavated on what was known as Little Bob's Mine (subsequently renamed Monte Cristo). In 1936, Lakeport Gold Mines Ltd. was formed to explore the Monte Cristo area and eight diamond drill holes totalling about 600 m (1970 ft) were drilled in 1937 (Jones 1983).

In 1983, Nuinsco Resources Limited drilled beneath the old shafts and intersected a thick zone of variably altered and sheared volcanic rocks and veining, which returned assays grading 0.17 oz/ton over 13.2 m (43.3 ft) [true thickness about 8.5 m or 28 ft]. Since then, about 4,500 m (14,750 ft) of diamond drilling have been completed, partially delineating the gold zones which constitute the Monte Cristo prospect.

The following descriptions are based on a review of all data (maps, cross-sections, drill logs, and longitudinal sections), and logging of selected drill core. Detailed mineralogical, geochemical and alteration studies were done on diamond drill hole NM-6, which provides a complete, unweathered cross-section through the gold zone (Figure 12). In addition, detailed (1:1,200) mapping (Figure 11) was completed by D.M. McNicoll as part of a B.Sc. thesis study. Acknowledgement of the work of P.L. Jones and G.F. Archibald of Nuinsco Resources Limited is made here rather than throughout the text.

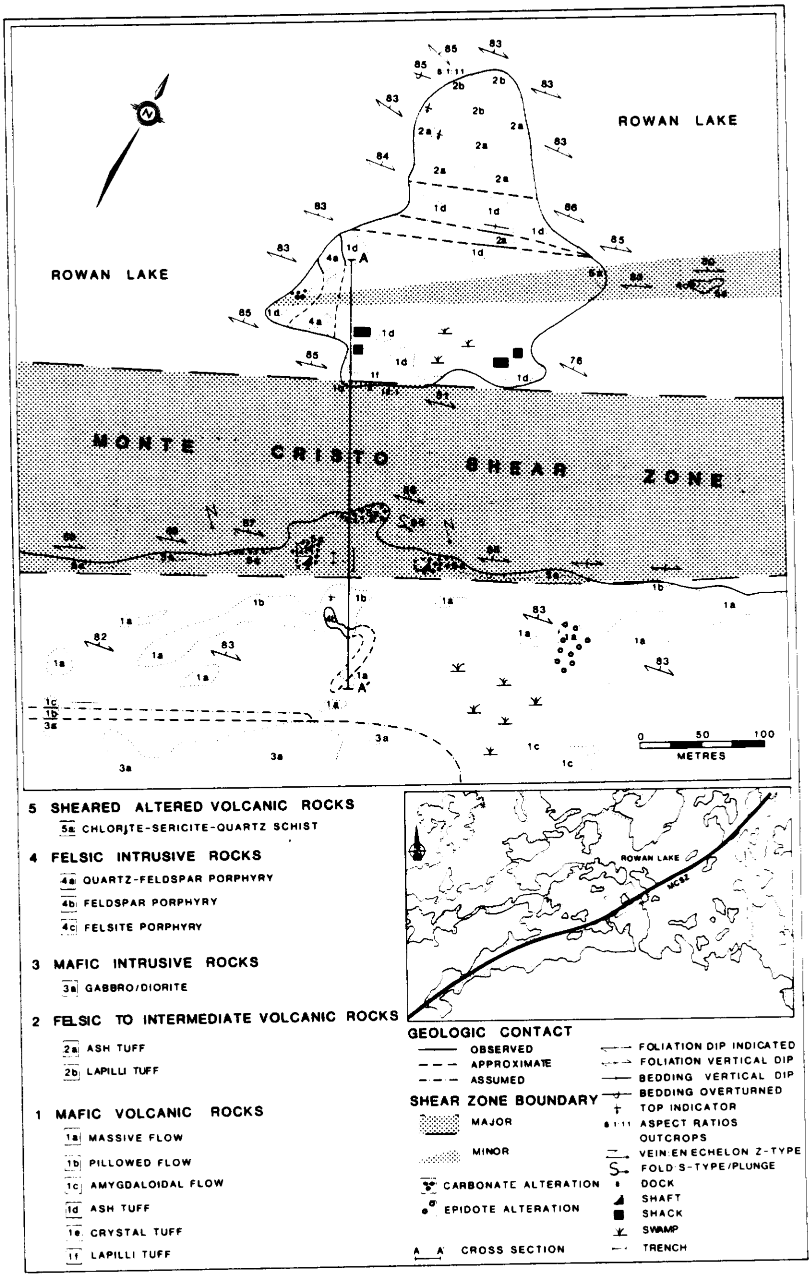


Figure 11. Geology of the Monte Cristo prospect, south-central Rowan Lake (after McNicoll 1987).

Geometry, Gold Distribution and Veining

The composite gold-bearing zone defined to date has an average strike length of about 73 m (250 ft) and an average true thickness of about 10 m (33 ft). It has been traced from surface to a depth of approximately 183 m (600 ft) (Figure 13). The gold zone roughly parallels the trend of the MCSZ and is apparently longer near surface than at depth. It dips approximately 85°NNW and plunges subvertically. Rather than consisting of one continuous zone of gold mineralization,

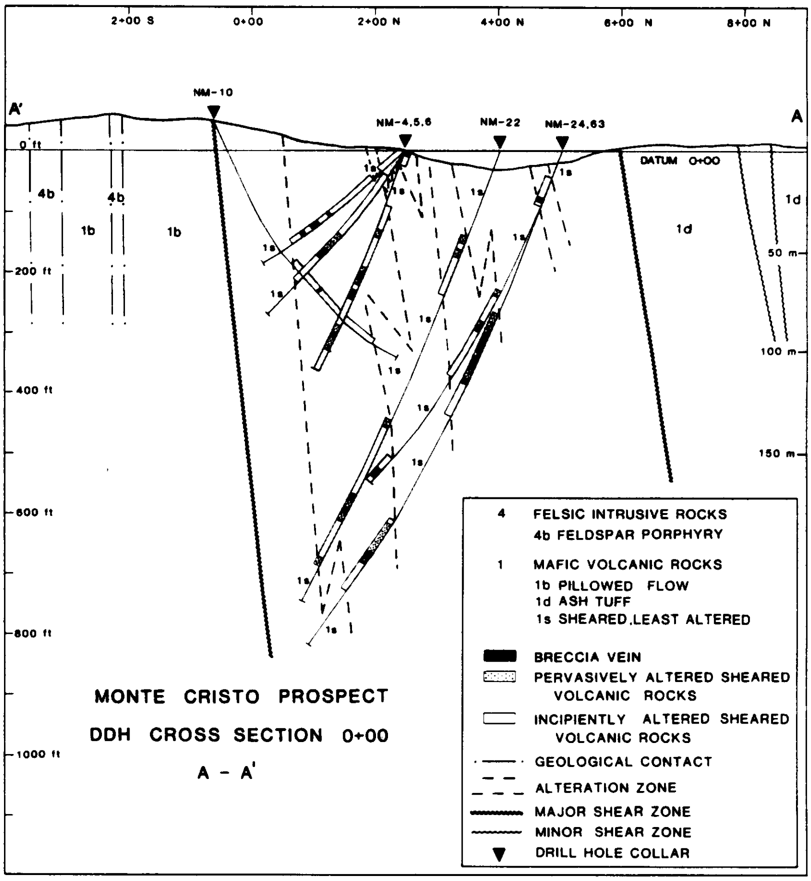


Figure 12. Diamond-drill cross-section A - A' through the Monte Cristo prospect, on line 0+00. Section is perpendicular to the Monte Cristo Shear Zone, looking west. Location of section is shown on Figure 11.

the Monte Cristo prospect is made up of several shoots or pods which are apparently discontinuous in both cross-section (Figure 12) and plan. It is open to depth and additional drilling is required to fully delineate its boundaries and permit quantitative ore reserve calculations.

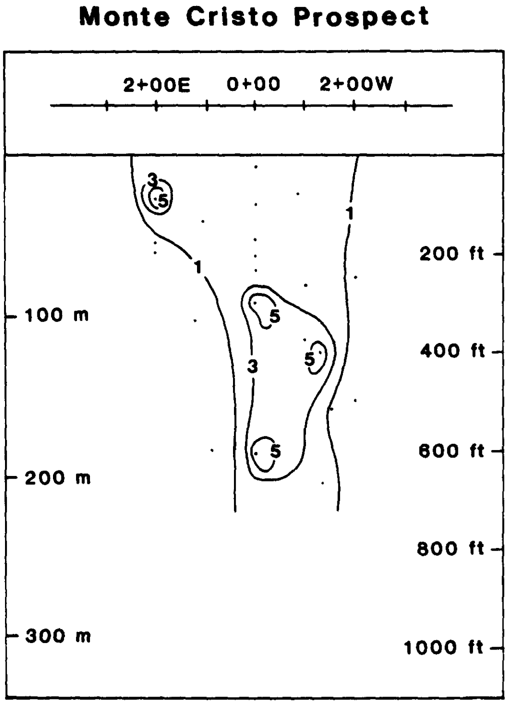


Figure 13. Longitudinal section through the Monte Cristo prospect, looking south and dipping 85°N within the plane of the Monte Cristo Shear Zone (modified after Jones 1985). Contours give the value of gold grade (oz/ton) times thickness (feet). Drill hole piercing points are represented by dots. Note the subvertical pitch of the gold zone.

The gold zone comprises light buff to tan, variably altered and sheared, volcanic rocks. The dominant alteration minerals are quartz, carbonate, and sericite, with lesser pyrite, green mica, and rare tourmaline. The highest gold grades in the altered rocks are proportional to pyrite content.

Three distinct vein types occur in the deformed and altered rocks of the Monte Cristo prospect:

1) a major system of gold-bearing, pyritic, quartz-albite breccia-veins (Plate 3g),

2) small, gold-bearing, pyritic, buckled, quartz-carbonate-albite veinlets (Plate 3j), and

3) a late group of straight quartz-carbonate-albite-chlorite-tourmaline tensional veins (Plate 3l).

Type 1 breccia-veins have a wide range of sizes and internal textures. Breccia-veins from several centimetres up to about 2 m thick have been intersected during diamond drilling; however, data on their strike length and vertical extent are unavailable due to lack of surface exposure and the 33m (100 ft) drill hole spacing.

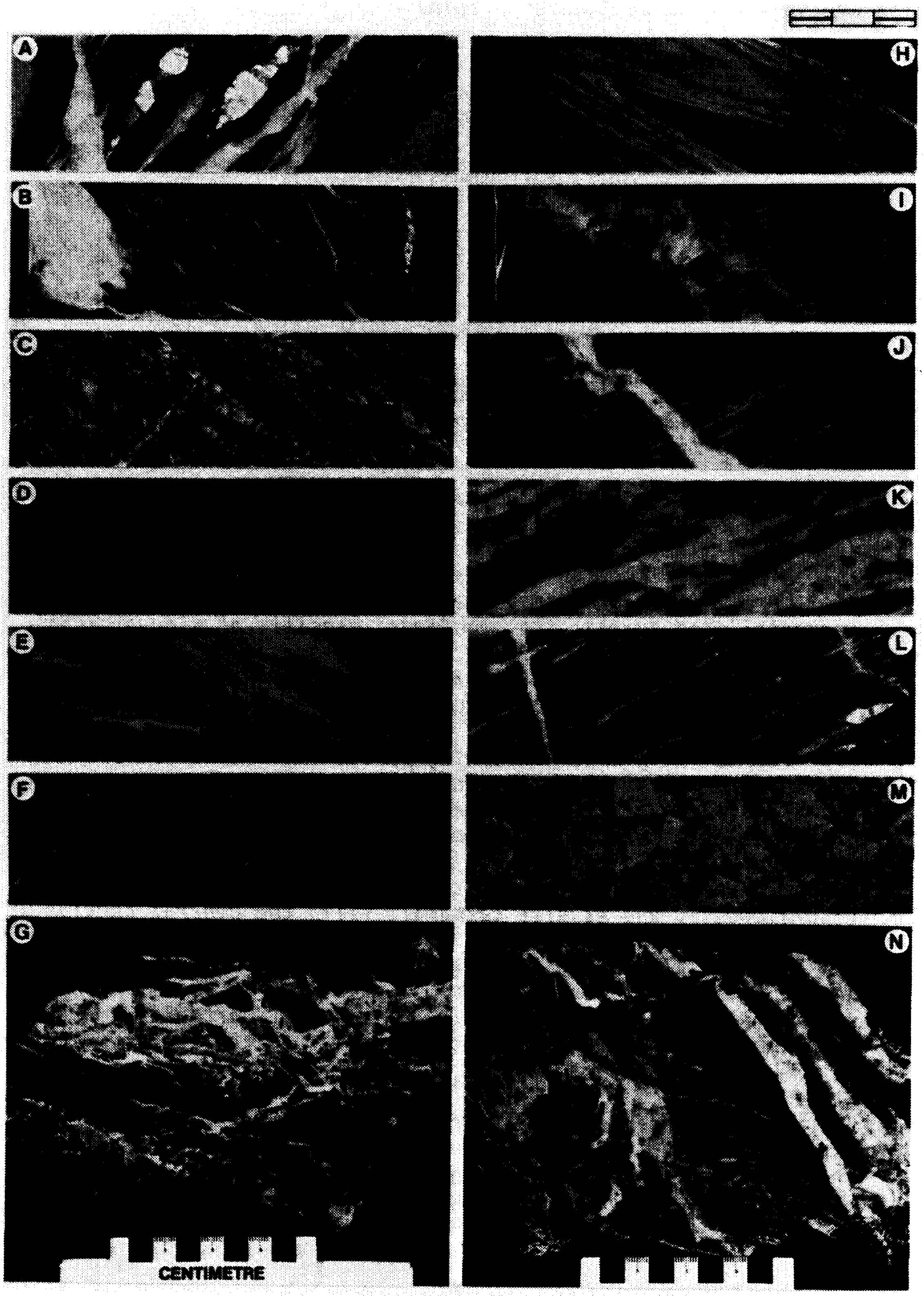
The breccia-veins consist of angular fragments of deformed and altered rocks in a matrix of fine-grained quartz and albite, with lesser carbonate and rare green mica. Both framework and matrix supported breccia types occur. Fragments have a wide range of shapes and sizes. In general, they are angular, elongate, and contain strong internal foliations which pre-date brecciation. Commonly, the breccias are chaotic, as indicated by the variable orientations of foliation within the fragments (Plate 3g), but *in situ* breccias do occur locally. In some of the larger slabs, multiple stages of cross-cutting veining have been observed. Pyrite is concentrated in the fragments and wall rocks adjacent to the veins, but rarely in the siliceous matrix. Quartz in the vein matrix displays undulatory extinction and is incipiently recrystallized into strain-free subgrains; albite twins are commonly bent. Locally, deformation post-dating vein formation has resulted in a medium grey to brown, "cherty", siliceous-looking rock in which the breccia textures are obscure. Drilling data indicate that a gold-bearing zone may, depending on its width, contain one or several breccia-veins and incorporate slices up to several metres thick of deformed and altered pyritic rock between the veins.

Type 2 buckled veinlets are less than 1 cm thick and of unknown lengths. The vein mineralogy consists of quartz, albite, carbonate and rare auriferous pyrite. Locally, carbonate coats the vein margins. These veins cut the foliation at a high angle and are ptygmatically folded. Quartz displays undulatory extinction in thin section, and is incipiently recrystallized into strain-free subgrains, and albite commonly displays bent or displaced twin lamellae (Plates 4g, h). In addition, albite is commonly variably altered to carbonate (Plates 4e, f). These buckled veins are enveloped by symmetrical, centimetre-scale, carbonate-sericite-pyrite-rich alteration halos (Plate 3j). They are interpreted to be genetically related to, and possibly coeval with, Type 1 breccia-veins, but are subordinate to them in abundance, volume, and economic significance.

Type 3 veins are, in general, less than 1 cm thick and of unknown length. They are planar, cut the foliation at a high angle and have pointed terminations. The vein mineralogy consists of quartz, carbonate, albite, chlorite, and rare tourmaline. The veins commonly display coxcomb, fibrous textures (Plate 4d). These veins are locally enveloped by symmetrical, chloritic alteration halos up to 1 cm thick in

Plate 3. Photographs of polished core samples and slabs of deformed and altered volcanic rocks and breccia-veins from the Monte Cristo and Victor Island prospects. All photographs of core samples are the same scale (scale bar = 3 cm); for photographs of slabs, scale card divisions are in centimetres.

(a) Least altered, sheared volcanic rock from the Monte Cristo prospect (sample NM-4-143). Note the transposition of veins parallel to the shear foliation, and the pressure fringes developed adjacent to the dismembered quartz clots.
(b) Least altered, sheared volcanic rock from the Monte Cristo prospect (sample NM-63-406). Note the well developed crenulation cleavage which contorts the shear foliation.
(c) Least altered, sheared volcanic rock from a samll shear zone subparallel to and immediately north of the MCSZ. Note the complex "trapped fold hinge" texture. See text for discussion, and Plate 2c for comparison.
(d) Least altered, sheared volcanic rock from the Victor Island prospect (sample NM-25-293). This rock is tentatively interpreted as mafic tuff.
(e) Incipiently altered, sheared volcanic rock from the Monte Cristo prospect (sample NM-6-65). Note the alternating carbonate-sericite-quartz-rich and chlorite-rich bands typical of this type of alteration.
(f) Pervasively altered, sheared volcanic rock from the Monte Cristo prospect (sample NM-6-31B). Note the seams of disseminated pyrite which parallel the foliation.
(g) Slab of breccia-vein from the dump of an old shaft at the Monte Cristo prospect. Host rock is pervasively altered, sheared volcanic rock. Note the misoriented, foliated, angular fragments isolated in the quartz-albite-rich vein matrix.
(h) Pervasively altered, sheared volcanic rock from the Monte Cristo prospect (sample NM06-15). Note the tight folding of the shear foliation and the small chloritic patch in the hinge of the fold.
(i) Buckled quartz-carbonate-albite-chlorite vein from the VIctor Island prospect (sample NM-25-157). Note the irregular carbonate-sericite alteration halo around the vein.
(j) Buckled quartz-carbonate-albite vein from the Monte Cristo prospect (sample NM-62-59). Note the irregular carbonate-sericite-quartz alteration halo around the vein.
(k) Breccia-vein from the Victor Island prospect (sample NM-53-260). Note the elongate, foliated, angular fragments in a quartz-albite vein matrix.
(l) Late, straight, quartz-carbonate-albite tension vein from the Monte Cristo prospect (sample NM-6-235). Note the symmetrical, quartz-rich alteration halo around the vein, which cuts the foliation at a high angle.
(m) Fault breccia from the footwall of the Victor Island prospect (sample NM-53-260). Note the angular, pervasively altered volcanic rock fragments in a chlorite-rich matrix.
(n) Pervasively altered, sheared volcanic rock from the dump of an old shaft on the Monte Cristo prospect. Note the complex cross-cutting vein network which probably includes tension veins.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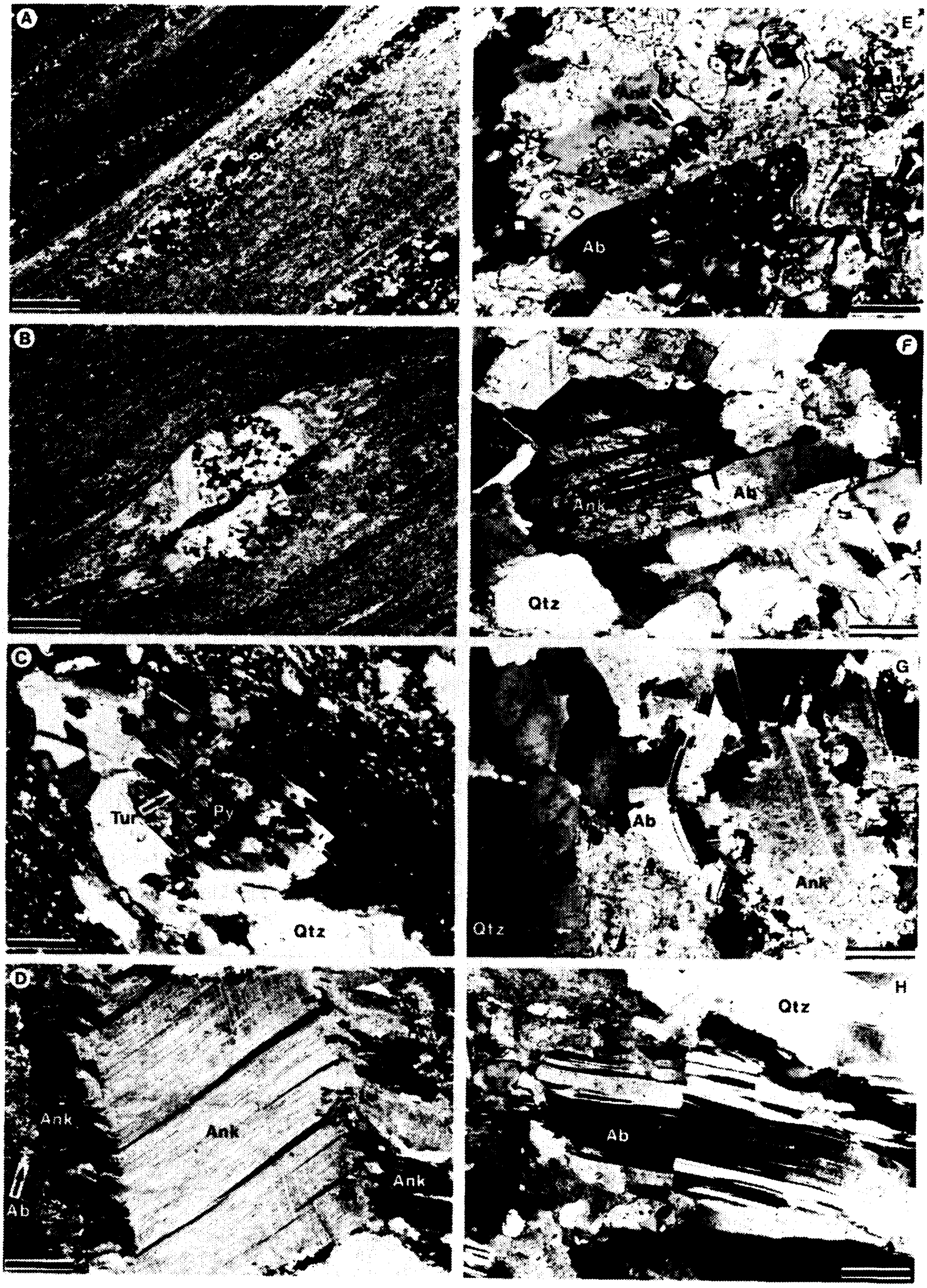
which chlorite appears to have replaced sericite (Plate 31). The type 3 veins are interpreted as tensional veins.

Plate 4. Photomicrographs from thin sections of variably altered, sheared volcanic rocks from the Monte Cristo and Victor Island prospects. All photomicrographs taken with crossed nicols and transmitted light.

(a) Elongate, lenticular domains of recrystallized quartz enveloped by strongly foliated sericite, chlorite and carbonate (sample NM-31-2, Victor Island prospect). Scale bar = 1.6 mm.
(b) Microfault cutting and displacing relict amygdule (sample B-16-1, from MCSZ). The amygdule is filled with carbonate and recrystallized quartz; the groundmass consists of fine-grained, well foliated quartz, sericite, chlorite and carbonate. Note the pressure fringes on opposite sides of the amygdule. This is one type of evidence for south-side-up movement on the MCSZ. Scale bar = 1.6 mm.
(c) Tourmaline grain, containing pyrite inclusions (sample NM-9-12, Monte Cristo prospect). Scale bar = 0.1 mm.
(d) Tensional vein, interpreted to have formed by crack-seal processes (sample NM-25-30, Victor Island prospect). Albite (partially altered to sericite) coats the vein walls, sigmoidal carbonate fibres coat the albite (with shapes suggesting minor displacement), and massive carbonate fills the central portion of the vein. Scale bar = 1.6 mm.
(e) Twinned albite grain, partially altered to carbonate (sample NM-6-257, Monte Cristo prospect). Scale bar = 0.05 mm.
(f) Twinned albite from breccia-vein matrix, partially pseudomorphed by carbonate which has retained the relict twinning of the albite (sample NM-6-328, Monte Cristo prospect). Scale bar = 0.2 mm.
(g) Bent twins in an albite grain from breccia-vein matrix (sample NM-6-328, Monte Cristo prospect). Scale bar = 0.1 mm.
(h) Microfault displacing twins in an albite grain from breccia-vein matrix (sample NM-6-328, Monte Cristo prospect. Scale bar = 0.4 mm.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Alteration

Diamond drill hole NM-6 (Figure 12) intersected 4 zones of altered, gold-bearing rock. These zones, in order of increasing depth, returned the following assays:

1) 0.10 oz/ton Au over 2.8 m (9.1 ft), about 1.5 m (5 ft) true thickness;
2) 0.09 oz/ton Au over 8.0 m (26.4 ft), about 4.0 m (13ft) true thickness;
3) 0.10 oz/ton Au over 6.5 m (21.4 ft), about 3.7 m (12 ft) true thickness; and
4) 0.14 oz/ton Au over 13.7 m (45.0 ft), about 7.6 m (25 ft) true thickness.

Core logging, thin section examination and X-ray diffraction studies have resulted in the recognition of three distinct zones of hydrothermal alteration that are spatially related to gold in the MCSZ. These assemblages, in order of increasing proximity to gold concentrations, are:

1) quartz-chlorite-ankerite-sericite-calcite-albite-epidote-rutile;
2) quartz-ankerite-sericite-albite-chlorite-calcite-rutile ± pyrite; and
3) quartz-ankerite-sericite-albite-siderite-pyrite-rutile-chlorite.

Their distribution with respect to gold, lithology, and structure is illustrated in Figures 12 and 14.

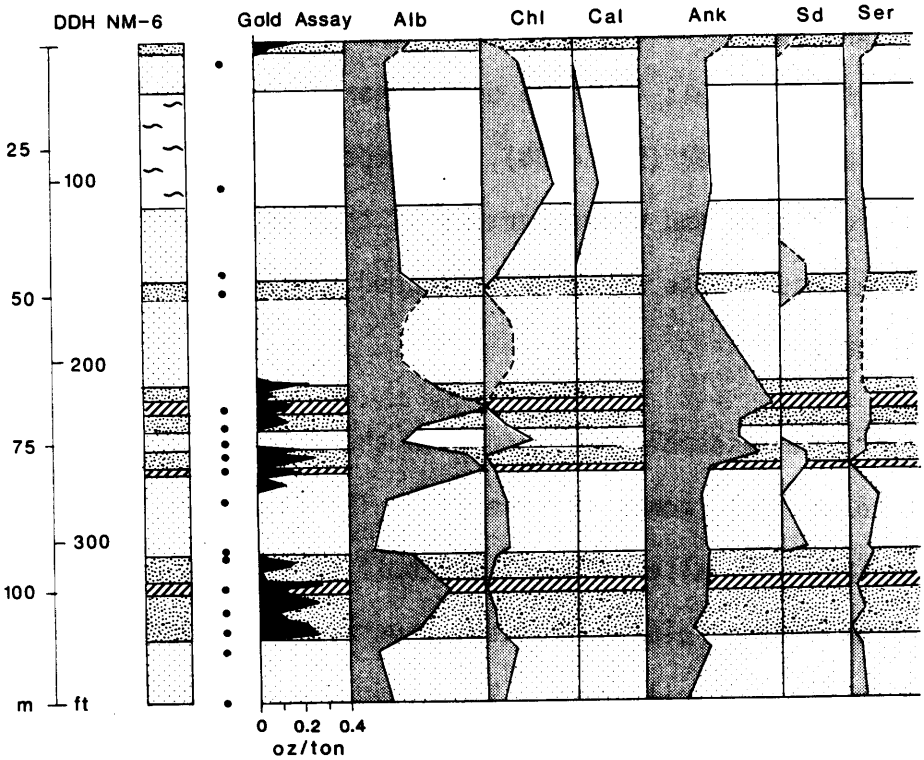


Figure 14. Alteration assemblage profiles from diamond drill hole NM-6, illustrating the spatial relationships among lithology, structure, alteration, veining and gold concentrations in the Monte Cristo prospect. Data correspond to measured X-ray diffraction peak heights. Sample locations are shown by the dots; gold assays are taken from drill logs. Dashed portions of profiles are approximates, due to lack of data. See text for discussion. Symbols: light stipple = incipiently altered volcanic rocks; heavy stipple = pervasively altered volcanic rocks; angled slashes = breccia veins. Abbreviations (after Kretz 1983): alb = albite; chl = chlorite; cal = calcite; ank = ankerite; sd = siderite; ser = sericite.

The first assemblage is recognized in the "least altered", sheared, volcanic rocks of the MCSZ and is considered to result, in part, from greenschist facies metamorphic conditions during and after deformation. It consists of abundant quartz, carbonate, albite, and sericite, with rare epidote and rutile. The carbonate minerals include ankerite and calcite. The rocks are medium green and display a strong shear foliation, defined by millimetre to centimetre scale compositional layering and the alignment of silicate and carbonate minerals. In addition, the shear foliation is commonly folded at a centimetre scale and crenulations result from the development of an axial planar foliation to the folds (Plate 3b). Transposition of early veins into the shear foliation and dismemberment of them are common (Plate 3a). Primary features in the rocks are obscured by the strong structural overprinting.

Alteration assemblage 2 occurs in the deformed rocks of the MCSZ adjacent to the gold zones (Figure 14). The rocks are fine-grained and colour banded, with alternating light buff to tan and medium green layers (Plate 3e). Folding of these layers at the centimetre scale was observed in diamond drill core. The alteration is characterized by the absence of epidote and calcite, a lower chlorite content than assemblage 1, and moderate quartz, albite, ankerite and sericite contents. Fine, disseminated pyrite is present in some places. Oxide minerals, including rutile, are disseminated along and concentrated within the micaceous lamellae. Low but anomalous gold concentrations are locally associated with this "incipient" alteration.

Alteration assemblage 3 occurs in the deformed rocks of the MCSZ and is spatially associated with the breccia-veins. This "pervasive" alteration contains the highest gold grades in the Monte Cristo prospect. It is characterized by the absence of epidote and calcite, a very low chlorite abundance, high quartz, albite, ankerite, and sericite contents and, locally, by the presence of siderite. Chlorite generally occurs within pressure fringes to pyrite (Plate 6e). Pyrite is generally present and tourmaline is locally observed. In one case, pyrite was observed completely enveloped by tourmaline (Plate 4c). Oxide minerals, including rutile, are also present. The rocks are light buff to tan, reflecting the diminished chlorite content. They are strongly foliated (Plate 3f), and locally contain small, infolded, chloritic patches (Plate 3h).

The alteration assemblages recognized in the Monte Cristo prospect are symmetric around the gold-bearing zones. Typically, the breccia-veins are enveloped by gold-bearing, pervasively altered (assemblage 3), sheared, volcanic rocks (Plate 3n), which in turn are enveloped by incipiently altered (assemblage 2), sheared, volcanic rocks. The incipiently altered, sheared, volcanic rocks grade over short distances (< 1 m) into the least altered (assemblage 1), sheared volcanic rocks, which comprise the bulk of the MCSZ.

Petrography of Sulfide Minerals

Polished thin sections from the Monte Cristo prospect were studied in order to:

(1) document the mineralogy of the opaque phases in the deformed and altered gold-bearing rocks,

(2) determine the mineralogical changes and paragenesis of sulfide/oxide mineralization which accompanied hydrothermal alteration, and

(3) describe the modes of gold occurrence.

Most of the samples were from diamond drill hole NM-6. The samples were grouped into three types, based primarily on their alteration: incipiently altered, sheared volcanic rocks; pervasively altered, sheared volcanic rocks, and breccia-veins. Mineralogical and textural data are summarized in Table 1.

Pyrite is the most abundant metallic mineral present and, although it rarely exceeds 13 modal percent of any sample, it constitutes greater than 95 modal percent of the opaque minerals present. No systematic differences in the textures or mineralogy of the opaque phases were noted among the three sample groups, except for the higher average pyrite content in the pervasively altered, sheared, volcanic rocks (alteration type 2).

Pyrite generally forms euhedral to subhedral grains up to 3 mm in size. Most of the coarser-grained pyrite is sieve-textured (Plate 5a) and contains small (> 0.03 mm) inclusions of silicate and carbonate gangue, chalcopyrite, rutile, pyrrhotite, and lesser magnetite, hematite, and gold. In one instance, a euhedral tourmaline grain was included within a pyrite grain (Plate 6b). Sieve textures in pyrite may result from nucleation and rapid growth in a solid medium (Frater 1985), in which growth involves the impingement and inclusion of silicate and carbonate minerals in the host rocks. The inclusion of all other opaque minerals and tourmaline within pyrite suggests either earlier or contemporaneous precipitation of these minerals. Coarse-grained, euhedral pyrite grains locally occur isolated within ptygmatic quartz-carbonate veinlets which cut the foliation at a high angle.

Fine-grained pyrite (< 0.2 mm) commonly lacks inclusions and is consistently euhedral. In sulfide-rich samples, fine-grained pyrite aggregates commonly occur in elongate seams parallel to, but overprinting, foliation in the carbonate/silicate groundmass (Plate 5d).

Table 1. Summary of sulphide/oxide petrography, mineralogy and textures of samples from the Monte Cristo Prospect.

			PYRITE													GOLD					CHALCOPYRITE					RUTILE				
			TEXTURES					INCLUSIONS																						
Sample	Rock Type	%	E	S	A	Bx	Sv	Au	Ccp	Rt	Mag	Po	Hem	Ga	In	Fx	At	Fr	Pr	In	Fr	At	Fr	Pr	In	En	Di	Ps	Assay
NM-6-23	PASV	2	X	X			X		X	X		X		X						X		X	X		X	X	X	X	0.112
NM-6-227	BRXV	8	X	X	X		X	X	X	X	X	X		X	X	X				X	X	X	X		X	X	X	X	0.136
NM-6-234	BRXV	2	X			X	X		X	X	X		X	X						X	X	X			X	X	X		0.022
NM-6-257	PASV	4	X	X		X	X		X	X	X	X	X	X		X				X	X	X	X	X	X	X	X		0.242
NM-6-262	BRXV	1	X				X		X	X	X	X	X	X						X		X	X		X		X		0.184
NM-6-310	PASV	2	X	X			X		X	X	X	X	X	X						X	X	X	X		X	X	X		n/a
NM-6-328	BRXV	1		X	X		X		X	X		X		X						X					X		X	X	0.088
NM-6-334	PASV	3	X	X			X		X	X		X		X			X	X		X	X		X		X	X	X	X	0.08
NM-6-345	PASV	2	X			X	X		X	X		X		X		X				X	X	X	X		X	X	X		0.251
NM-6-351	PASV	12	X	X			X	X	X	X		X	X	X	X					X	X	X	X	X	X	X	X	X	0.256
NM-6-365	IASV	1	X	X			X		X	X			X	X						X	X				X		X		n/a
NM-1-170	BRXV	11	X	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X		X	X	X		0.33
NM-2-313	IASV	3		X			X		X			X	X	X						X	X	X	X		X		X		0.04
NM-2-319	PASV	7	X	X			X		X	X		X		X						X		X	X		X	X	X		0.10
NM-4-202	PASV	5	X	X			X	X	X	X		X		X	X	X				X	X	X	X	X	X		X		0.31
NM-9-12	PASV	5	X				X		X	X		X		X						X		X							n/a
MC-11	PASV	8	X	X			X	X	X	X				X	X	X	X	X		X	X				X	X	X		n/a

Legend: % = percent opaques.

BRXV = breccia-vein; PASV = pervasively altered, sheared volcanic; IASV = incipiently altered sheared volcanic.

E = euhedral; S = subhedral; A = anhedral; Bx = brecciated; Sv = sieve textured cores.

Au = gold; Ccp = chalcopyrite; Rt = rutile; Mag = magnetite; Po = pyrrhotite; Hem = hematite; Ga = gangue.

In = included in pyrite; Fx = filling fractures in pyrite; At = attached to pyrite grain boundaries; Fr = free in silicate matrix;

Pr = in pressure fringes; En = engulfed by pyrite grain boundaries; Di = disseminated; Ps = pseudomorphing ilmenite.

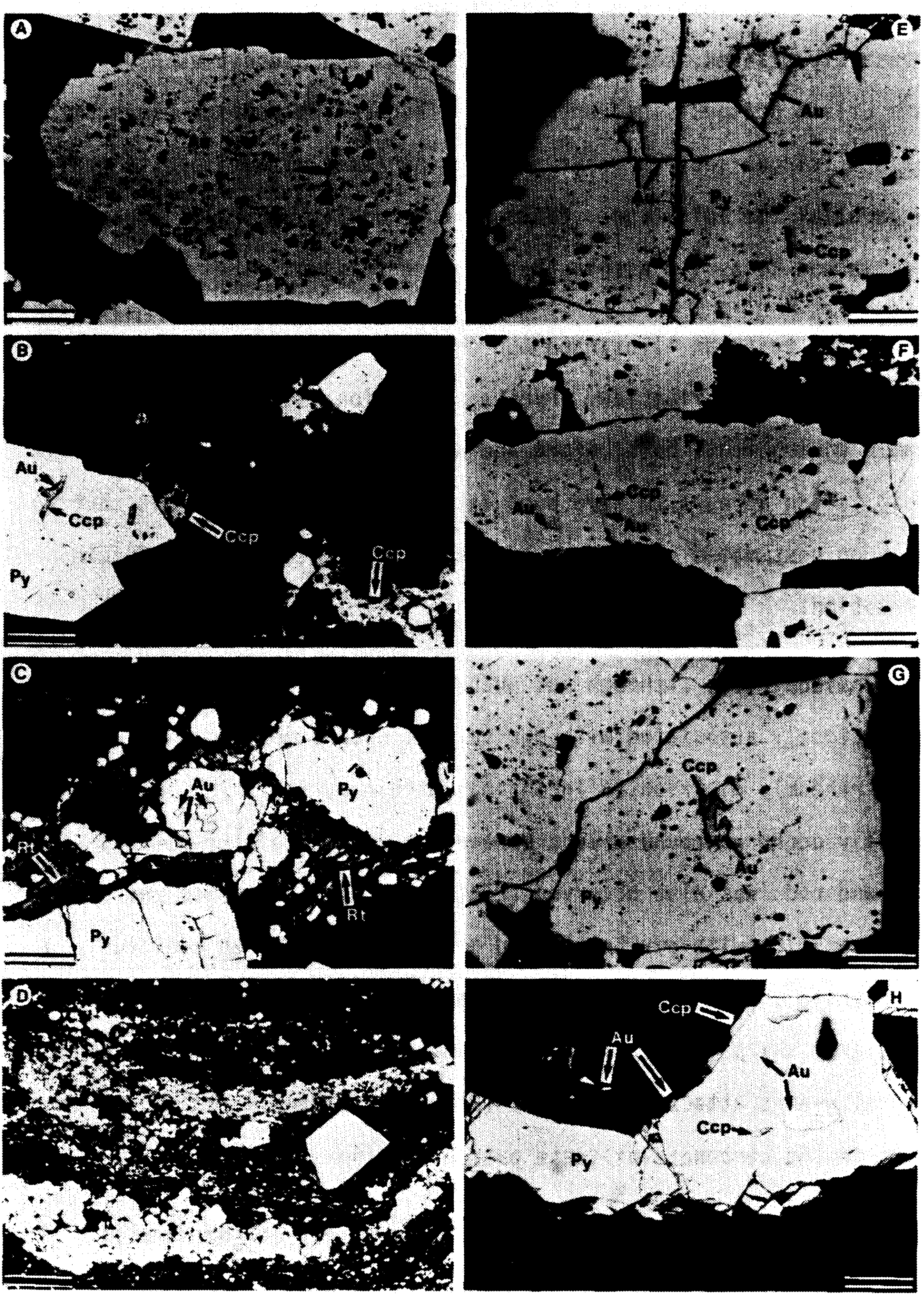
Assay = gold in troy oz/ton; n/a = assay not available.

Mineral abbreviations after Kretz (1983).

This suggests that hydrothermal fluid flow and pyrite nucleation occurred along foliation planes. In two samples, folding of these pyritic seams and associated foliation was observed at the thin section scale.

Plate 5. Photomicrographs of sulphides, oxides and gold in polished sections from the Monte Cristo and Victor Island prospects. All photomicrographs taken with reflected light.

(a) Subhedral, sieve-textured pyrite with inclusions of gangue, gold and chalcopyrite (sample NM-1-170, Monte Cristo prospect). Scale bar = 0.2 mm.
(b) Irregular, composite inclusion of gold and chalcopyrite in euhedral pyrite (sample NM-6-345, Monte Cristo prospect). Chalcopyrite (pitted) also occurs attached to pyrite, and as irregular anhedral grains in the carbonate-silicate gangue. Scale bar = 0.4 mm.
(c) Subhedral, brecciated pyrite containing several gold inclusions (sample NM-25-600, Victor Island prospect). Note the central grain of fractured pyrite in which the gold inclusion is also fractured. Small, medium grey mineral disseminated in the gangue and defining a weak foliation is rutile. Scale bar = 0.1 mm.
(d) Fine-grained, disseminated and locally aggregated pyrite, occurring along seams which define foliation (sample NM-2-319, Monte Cristo prospect). Note the larger pyrite euhedra which are also present. Scale bar = 0.4 mm.
(e) Gold filling fractures in subhedral pyrite (sample NM-25-600, Victor Island prospect). Smaller inclusions of gold and chalcopyrite are also present. Scale bar = 0.05 mm.
(f) Anhedral, sieve-textured pyrite with included blebs of gold and irregular chalcopyrite (sample NM-4-202, Monte Cristo prospect). Gold and chalcopyrite also fill a small fracture in pyrite. Scale bar = 0.2 mm.
(g) Irregular, composite inclusion of gold and chalcopyrite in euhedral, sieve-textured pyrite (sample NM-25-594, VIctor Island prospect. Additional chalcopyrite inclusions are also present. Scale bar = 0.1 mm.
(h) Elliptical gold and elongate chalcopyrite inclusions in subhedral, locally fractured pyrite (sample NM-1-170, Monte Cristo prospect). Chalcopyrite also occurs as small anhedra attached to pyrite and gold also occurs as free grains in the carbonate-silicate matrix. Scale bar = 0.05 mm.


A
E
Au
Au
Py
Ccp
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Rt
Rt
Py
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Py
D
H
Ccp
Au
Au
Ccp
Py

Cataclastic deformation of pyrite is common in deformed sulfide ores (Craig and Vaughan 1981, Edwards 1965, Frater 1985). Fracturing, pull-aparts, and local brecciation (Plates 6a, b) are common in pervasively altered, sheared, volcanic rocks and breccia-veins from the Monte Cristo prospect and appear to be favoured by coarser grain sizes. Pressure fringes locally occur on opposing faces of some pyrite grains and parallel the foliation. Chalcopyrite locally occurs as free grains and attached to pyrite within the pressure fringes.

These textures illustrate the intimate relationship between deformation and sulfidation. Pyrite nucleation and growth occurred in a dynamic environment, both before and after deformation. Pyrite precipitation appears to have post-dated foliation development, but to have been post-dated by folding of the foliation and by cataclastic deformation.

Chalcopyrite, although not abundant, was observed in all samples and is closely associated with pyrite. It occurs most commonly as small, randomly distributed inclusions within pyrite. The inclusions generally occur as round blebs; however, a variety of irregularly shaped clots and rods was also observed (Plates 5f, h). Composite inclusions of chalcopyrite with pyrrhotite and gold also occur. In addition, chalcopyrite occurs as fracture fillings within pyrite (Plate 5d), as irregularly shaped grains in the carbonate-silicate groundmass, and as anhedral grains attached to pyrite (Plate 5b). Rarely, chalcopyrite occurs in the carbonate-silicate pressure fringes on pyrite.

Hematite and magnetite were observed in most of the samples. They occur as inclusions in pyrite and as free grains in the carbonate-silicate groundmass. They are locally intergrown and display mutual lobate partial penetrations. Hematite in the groundmass is commonly subhedral to anhedral, lath-shaped, and associated with seams of disseminated rutile. Magnetite is most commonly subhedral to anhedral.

Pyrrhotite occurs in most of the samples, as small (> 0.01 mm) inclusions in pyrite. The inclusions are typically circular to elliptical and may also contain chalcopyrite. No pyrrhotite was observed as free grains in the carbonate/silicate matrix.

Rutile was observed in all the samples, as fine disseminations commonly concentrated along the foliation, as ragged inclusions in pyrite, and as engulfed masses along pyrite grain boundaries. Locally, short, thin, sinuous lamellae consisting entirely of rutile also occur (Plate 5f). In one instance, trellis-textured rutile intergrowths, which are interpreted as pseudomorphs after ilmenite exsolution lamellae in magnetite (Plate 6g), were observed.

Gold in pyrite-rich samples has several modes of occurrence:

1) isolated inclusions within pyrite (Plates 5a, h),
2) composite inclusions with chalcopyrite in pyrite (Plate 5b),
3) grains attached to and coating pyrite (Plate 5h),
4) free grains in the carbonate-silicate groundmass (Plate 5h),
5) fracture fillings within pyrite (Plate 5f), and
6) free grains in quartz-carbonate pressure fringes.

The gold grains are anhedral and up to 0.05 mm in size. Textural evidence suggests that gold precipitation was contemporaneous with and may have persisted after pyrite formation.

Lithogeochemistry

Chemical analysis of diamond drill core samples representing a cross-section through the gold zone of the Monte Cristo prospect was undertaken to:

1) characterize the bulk composition of the host rocks,
2) identify the major element variations which accompanied hydrothermal alteration, and
3) identify the trace elements associated with gold.

Composite samples were obtained from hole NM-6 by selecting several, 4 to 5 cm pieces of core over 1 to 2 m intervals. Care was taken to ensure that that the samples were representative of each interval. The samples were grouped as least altered, sheared volcanic rocks (alteration type 1); incipiently altered, sheared, volcanic rocks (alteration type 2); pervasively altered, sheared volcanic rocks (alteration type 3), and breccia-veins. Major and trace element analyses were carried out by the Geoscience Laboratories, Ontario Geological Survey, Toronto. The analytical data are tabulated in Tables 2 and 3 and illustrated in Figures 15 and 16.

The Jensen cation plot (Figure 15) was used to classify the rocks. This diagram is particularly well suited to rocks which have undergone appreciable metasomatism because, compared to K, Na, Ca, and Si which are commonly used in other classification schemes, the elements Fe, Mg, and Ti are less susceptible to chemical migration. One sample of the least altered, sheared, volcanic rocks was analysed. It plots within the tholeiitic andesite field, close to the field boundary between the tholeiitic and calc-alkalic fields. Seven samples of incipiently

Table 2. Whole rock analytical data for samples from diamond drill hole NM-6, Monte Cristo Prospect.

Sample	Rock Type	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	CO_2	S	LOI	Total	Au
NM-6-23	PASV	36.4	16.1	2.47	6.22	3.81	10.7	4.82	1.71	1.16	0.14	0.17	13.5	1.27	14.1	99.8	6260
NM-6-36	IASV	56.1	14.9	1.27	5.18	2.51	6.01	2.41	1.12	0.82	0.16	0.11	6.89	0.02	8.9	99.9	2
NM-6-105	LASV	54.1	13.5	1.45	6.52	2.68	7.46	2.23	0.55	0.78	0.06	0.13	7.17	0.01	9.5	99.3	3
NM-6-153	IASV	61.3	16.3	0.87	2.96	1.46	4.50	2.77	1.09	0.84	0.18	0.08	5.59	0.01	7.2	99.9	4
NM-6-163	PASV	59.7	15.8	0.51	2.81	1.31	5.13	4.96	0.82	1.03	0.15	0.08	6.44	0.03	7.4	100.0	9
NM-6-213	PASV	45.0	10.5	2.41	6.00	3.93	10.4	3.56	0.71	0.72	0.07	0.24	15.1	1.30	13.8	100.4	9060
NM-6-228	BRXV	45.2	13.4	2.02	4.89	3.16	8.87	6.86	0.23	0.58	0.04	0.13	13.0	0.96	11.3	99.6	1900
NM-6-237	PASV	47.8	13.7	1.67	5.33	3.26	8.01	4.34	1.39	0.72	0.12	0.17	11.9	0.29	11.6	99.9	160
NM-6-246	IASV	51.2	13.4	1.01	6.22	4.44	6.87	2.89	0.68	0.75	0.13	0.15	10.0	0.01	11.1	100.0	2
NM-6-254	PASV	44.8	15.5	4.32	4.22	2.31	7.25	5.81	1.32	0.93	0.16	0.13	10.3	2.56	8.8	100.3	9999
NM-6-262	BRXV	58.9	12.6	3.41	3.11	1.58	5.02	6.86	0.14	0.33	0.02	0.12	7.26	2.16	5.7	101.9	6240
NM-6-278	IASV	56.0	14.7	1.94	4.59	1.88	5.55	2.45	1.61	0.80	0.14	0.13	7.93	0.63	8.4	100.3	70
NM-6-306	IASV	50.3	13.9	1.11	8.00	2.55	7.28	0.99	1.65	0.71	0.14	0.17	10.6	0.44	11.6	100.2	27
NM-6-316	PASV	53.9	15.3	1.36	4.22	1.80	6.24	3.91	1.69	0.86	0.12	0.12	9.02	0.73	8.7	100.6	9999
NM-6-328	BRXV	73.8	10.2	0.62	1.63	0.59	2.84	5.03	0.12	0.23	0.06	0.06	3.76	0.56	3.1	99.8	780
NM-6-340	PASV	47.3	14.3	3.29	5.18	1.68	6.48	5.66	1.03	0.80	0.12	0.24	10.1	2.52	10.4	99.6	9999
NM-6-352	PASV	52.2	14.2	3.00	5.63	1.62	5.33	5.03	1.14	0.76	0.19	0.22	7.54	1.77	7.1	100.1	2320
NM-6-362	IASV	51.5	14.0	1.40	9.63	2.35	6.45	2.03	0.77	0.75	0.16	0.23	9.13	0.39	10.2	100.5	20
NM-6-390	IASV	56.0	16.2	0.62	4.81	1.73	5.46	2.90	1.38	0.95	0.17	0.11	7.04	0.03	8.0	99.8	3

Values reported as weight % except Au which is in ppb.

Last three digits in sample number are depths measured in feet.

Totals calculated using major oxides and LOI; CO_2 and S were excluded.

All analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Abbreviations: LASV = least altered sheared volcanic; IASV = incipiently altered sheared volcanic; PASV = pervasively altered sheared volcanic; BRXV = breccia-vein.

altered, sheared, volcanic rocks were analysed; all values plot close to the same field boundary. Tholeiitic andesite and dacite, and calc-alkalic basalt, andesite, and dacite are all represented. A somewhat wider distribution occurs within the pervasively altered, sheared, volcanic rocks. Samples analysed plot in the high-iron tholeiitic basalt, tholeiitic dacite, and calc-alkalic basalt, andesite, and dacite fields. This indicates that several chemically distinct lithologies whose primary textures have been obscured through deformation and alteration occur within the MCSZ. This is consistent with the chemically diverse succession comprising the Cameron Lake Volcanics which the MCSZ transects. Furthermore, the data suggest that gold mineralization in the Monte Cristo prospect was not restricted to a single, chemically favourable, host lithology. Three breccia-vein

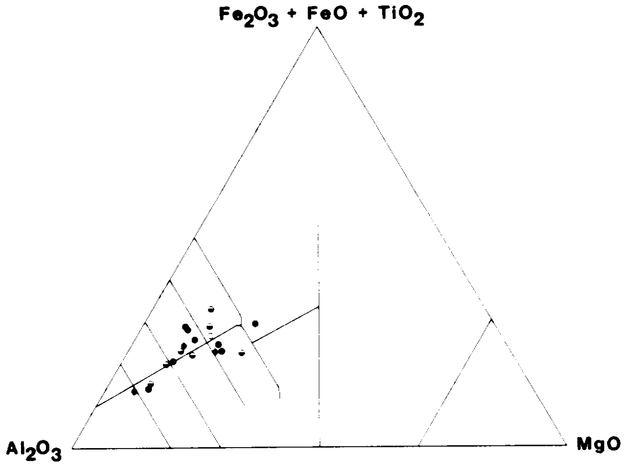


Figure 15. Jensen cation plot of samples from the Monte Cristo prospect.
Symbols: open circles = least altered, sheared volcanic rocks; half-filled circles = incipiently altered, sheared volcanic rocks; filled circles = pervasively altered volcanic rocks; diamonds = breccia-veins.

samples were analysed and exhibit a trend of aluminum enrichment, which probably reflects the addition of various proportions of vein matrix to the samples.

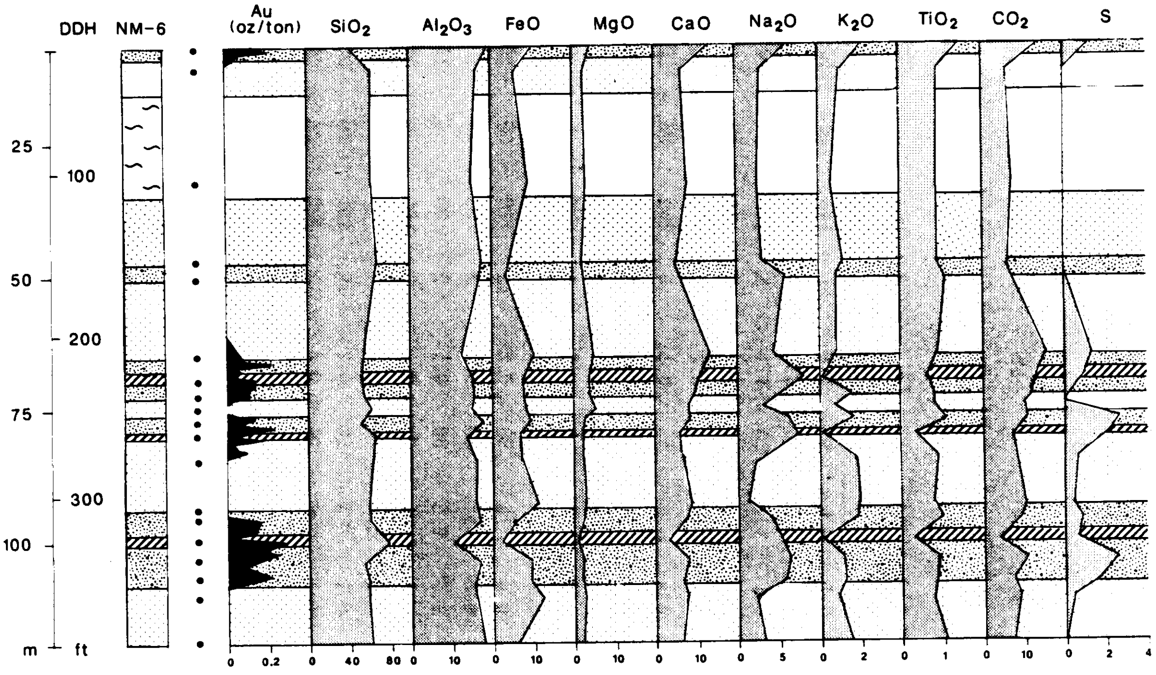


Figure 16. Lithogeochemical profiles for samples from diamond drill hole NM-6, illustrating the relationships among chemistry, lithology, structure, alteration, veining and gold concentrations in the Monte Cristo prospect.
Symbols: light stipple = incipiently altered volcanic rocks; heavy stipple = pervasively altered volcanic rocks; angled slashes = breccia-veins.

Several zones of gold enrichment in diamond drill hole NM-6 correlate with the pervasively altered, sheared, volcanic rocks; the breccia-veins, and, to a lesser extent, the incipiently altered, sheared, volcanic rocks (Figures 12, 13 and 14). Lithogeochemical profiles based on whole rock data from drill hole NM-6 are illustrated in Figure 16. Although it has been clearly demonstrated that several

Table 3. Trace element analytical data for samples from diamond drill hole NM-6, Monte Cristo Prospect.

Sample	Rock Type	Au	B	Hg	Cu	Zn	Co	Ni	Cr	Ag	Bi	As	W	Sb	Li	Ba	Rb	Pb	Be	Mo	U	Sn	Se
NM-6-23	PASV	6260	12	20	55	74	41	67	232	2	0.6	6	50	0.2	3	330	65	10	3	10	690	1.5	315
NM-6-36	IASV	2	18	20	44	84	25	70	164	2	0.1	2.5	50	0.1	12	200	40	10	1	10	450	2.0	30
NM-6-105	LASV	3	12	20	50	118	29	80	139	2	0.1	4.5	50	0.1	12	140	23	10	1	10	400	2.5	60
NM-6-153	IASV	4	25	20	52	46	12	39	146	2	0.1	1	50	0.2	8	290	38	10	1	10	450	2.0	52
NM-6-163	PASV	9	16	20	66	42	11	24	126	2	0.1	1.5	50	1.1	5	200	30	10	1	10	500	2.0	52
NM-6-213	PASV	9060	5	20	130	67	29	71	141	2	1.4	3.5	50	0.2	3	180	28	10	1	10	400	2.0	585
NM-6-228	BRXV	1900	6	20	32	54	23	60	93	2	0.8	6.5	50	0.2	3	90	11	10	1	10	300	2.0	240
NM-6-237	PASV	160	10	20	77	71	24	58	127	2	0.1	2	50	0.1	4	260	50	10	1	10	400	2.0	75
NM-6-246	IASV	2	44	20	36	72	21	58	127	2	0.1	1	50	0.1	14	160	26	10	1	10	400	2.5	30
NM-6-254	PASV	9999	40	20	36	46	37	84	148	2	2.8	14	50	0.4	3	260	50	10	1	10	550	1.5	750
NM-6-262	BRXV	6240	2	20	38	42	26	71	44	2	5.3	6	50	0.1	3	80	6	10	1	10	200	1.0	1200
NM-6-278	IASV	70	20	20	40	78	34	118	180	2	0.2	11	50	0.2	10	250	60	10	1	10	450	2.0	67
NM-6-306	IASV	27	21	20	50	113	31	108	150	2	0.4	15	50	0.2	12	220	60	10	1	10	400	1.5	60
NM-6-310	PASV	9999	13	20	48	61	20	65	160	2	0.6	13	50	0.1	3	280	60	10	2	10	500	1.5	172
NM-6-328	BRXV	780	2	20	37	20	12	41	42	2	1.7	6.5	50	0.1	3	80	5	10	1	10	150	1.5	165
NM-6-340	PASV	9999	9	20	91	76	28	85	140	2	0.9	8	50	0.1	3	200	39	10	1	10	450	2.0	555
NM-6-352	PASV	2320	8	20	65	94	28	76	174	2	0.9	8.5	50	0.2	4	220	41	10	1	10	450	1.0	435
NM-6-362	IASV	20	30	20	96	245	20	74	130	2	0.1	3	50	0.2	16	160	26	10	1	10	400	1.0	150
NM-6-390	LASV	3	30	20	53	70	20	58	214	2	0.1	2	50	0.4	11	240	25	10	1	10	500	1.5	30

Values reported as ppm except Au, which is in ppb.

Last three digits in sample number are depths measured in feet.

All analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Abbreviations: LASV = least altered sheared volcanic; QFP = quartz-feldspar porphyry dyke; IASV = incipiently altered sheared volcanic; PASV = pervasively altered sheared volcanic; BRXV = breccia-vein; LDVR = least altered volcanic; MINR = mafic intrusive rock.

chemically distinct lithologies occur within the data set, several observations and conclusions can be made concerning major element variations which accompanied hydrothermal alteration and gold precipitation.

Sulphur, reflected in the pyrite content, shows the strongest correlation with gold in the pervasively altered, sheared, volcanic rocks (Figure 16). Lower, but anomalous, S values are also characteristic of some of the incipiently altered, sheared, volcanic rocks. K_2O is enriched in both types of altered rock and occurs predominantly in sericite. CO_2 content, reflected in carbonate minerals, is highest in the incipiently and pervasively altered, sheared, volcanic rocks spatially associated with gold concentrations. CO_2-rich rocks form an extremely broad halo around the gold zones and their distribution is more extensive than sampling for this study. CaO displays a sympathetic distribution to CO_2 and is probably also related to the distribution of carbonate minerals. Na_2O displays a strong correlation with gold and is probably related to albite content in the altered rocks.

Three breccia-veins were sampled in drill hole NM-6. They contain high gold values, but these are not as high as gold values from the adjacent, pervasively altered, sheared, volcanic rocks. In general, the gold values correlate with the highest Na_2O values and high SiO_2 and S contents, which are reflected in albite, quartz, and pyrite respectively. All other major elements, including CO_2 and K_2O, are low compared to the adjacent sheared and altered wall rocks. This is interpreted to result primarily from dilution effects of the vein matrix relative to the included, pervasively altered, wall rock fragments.

Of the trace elements studied, only As, Bi, and Se show any enrichment within the altered rocks of the composite gold zone (Table 3). Arsenic is strongly correlated with gold in the altered rocks and breccia-veins and has a maximum value of 15 ppm within the incipiently altered, sheared, volcanic rocks. Bismuth is also associated with gold and has a maximum value of 5.3 ppm, which occurs within a breccia-vein. Selenium is enriched in the gold-bearing rocks and has a maximum value of 1200 ppm, occurring in a breccia-vein. Selenium probably substitutes for sulphur in the pyrite due to similarities in ionic radius.

THE VICTOR ISLAND GOLD PROSPECT

The Victor Island prospect occurs within strongly foliated rocks of the MCSZ in south-central Rowan Lake, about 900 m (3000 ft) southwest of the Monte Cristo prospect (Figure 9). The gold zone is poorly exposed in outcrops on the north shore of Victor Island and occurs throughout most of its length beneath Rowan Lake. The original gold showings were discovered in 1899 by the Victor Company and a shaft was sunk to a depth of not less than 7.6 m (25 ft). One diamond drill hole is recorded to have been drilled in 1937 (Jones 1983).

In 1984, Nuinsco Resources Limited drilled beneath the old shaft and intersected a thick zone of variably altered and sheared volcanic rocks which returned low, but anomalous, gold assays. Since then about 6000 m (20,000 ft) of diamond drilling has been completed, partially delineating the the gold zone which constitutes the Victor Island prospect. The following descriptions are based on a review of all drilling data (cross-sections, drill logs, longitudinal section), as well as logging of selected drill core. Detailed mineralogical, geochemical, and alteration studies have been completed on diamond drill hole NM-25, which provides what is considered a representative cross-section through the gold zone. Acknowledgement and reference to the work of Mr. P.L. Jones and Mr. G.F. Archibald (Nuinsco Resources Ltd. geologists), who compiled all the drilling data, are made here rather than throughout the text.

Geometry and Gold Distribution

The gold zone defined to date has an average strike length of about 61 m (200 ft) and an average true thickness of about 6.5 m (20 ft). It has been traced from a trench to a depth of approximately 213 m (900 ft). The gold zone plunges about 70° to the east-northeast and dips 87° WNW (Figures 17 and 18). In general, the overall form of the zone approximates that of a steeply plunging, flattened cigar or ribbon. In section (Figure 17) and plan, the gold zone parallels the southern

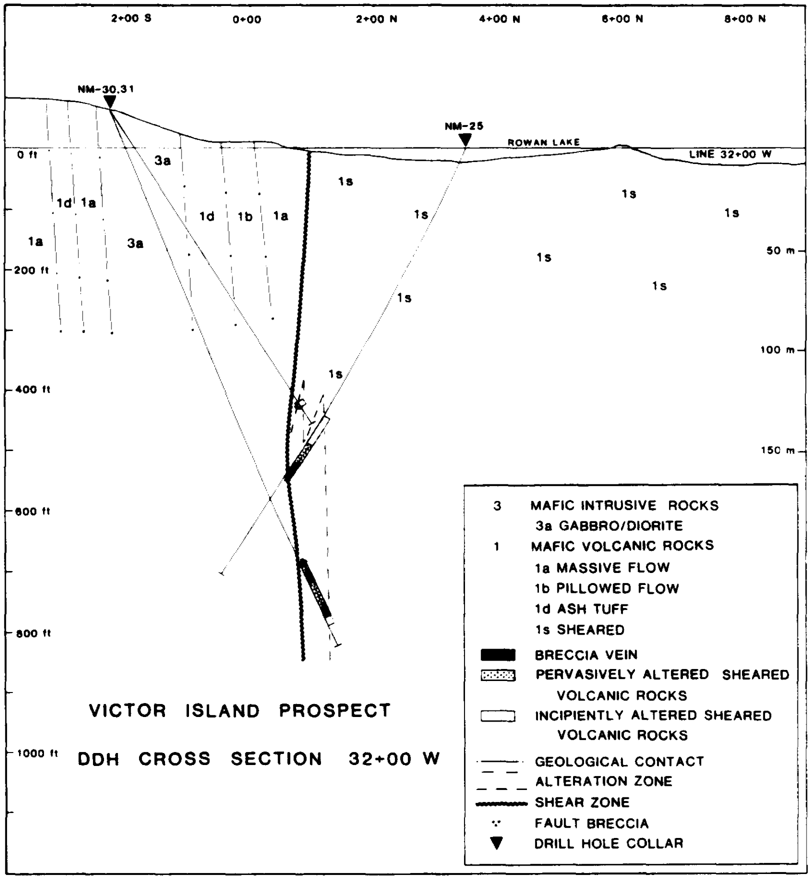


Figure 17. Diamond drill cross-section through the Victor Island prospect, on line 32+00. Section is perpendicular to the Monte Cristo Shear Zone, looking west.

contact of the MCSZ. It is open to depth and additional drilling is required to fully delineate its boundaries and permit quantitative ore reserve calculations.

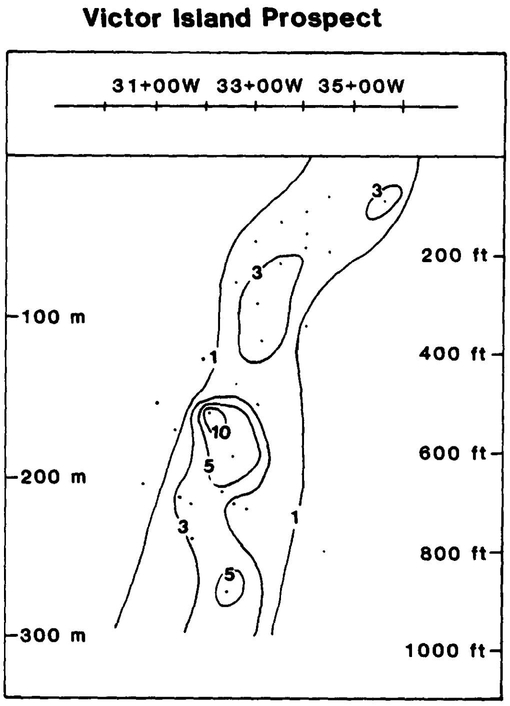


Figure 16. Longitudinal section, looking south, through the Victor Island prospect, dipping 85°N within the plane of the Monte Cristo Shear Zone (modified after Jones 1985). Contours represent the value of gold grade (oz/ton) times thickness (feet). Drill hole piercing points are represented by dots. Note the 70°E pitch of the gold zone.

The structural hanging wall to the gold zone consists of a diverse succession of strongly foliated, locally crenulated, chloritic, volcanic rocks. Within these rocks, deformation and structural overprinting have destroyed or obscured most primary features. Lithological subdivisions, although suspected (Plate 3d), were not established.

The gold zone comprises sheared and variably altered, volcanic rocks which are cut by a system of quartz-albite-rich breccia-veins. The altered rocks are fine grained, stongly foliated and light buff to tan. The dominant alteration minerals are quartz, carbonate, and sericite, with lesser pyrite. Gold grades in the altered rocks are proportional to pyrite content. The mineral assemblage filling the veins consists of quartz and lesser ammounts of albite and carbonate. Pyrite is concentrated primarily within the breccia fragments. The contact between the altered rocks of the gold zone and the foliated rocks in the hanging wall is sharp to gradational over a few metres. Several vein types similar to those recognized in the Monte Cristo prospect were documented (Plates 3i and 3k); however, detailed textural and mineralogical observations were not possible due to the condition of the hand-split core from the Víctor Island prospect.

The rocks in the footwall to the gold zone are weakly foliated, and interpreted to be outside the MCSZ. These least altered rocks comprise units of massive and pillowed flows and mafic tuff. A gabbro sill is located about 50 m (150 ft) into the footwall. The contact between the gold zone and the footwall rocks is abrupt and marked by a distinctive fault breccia unit up to 2 m thick. The breccia consists of angular fragments of altered rocks of the gold zone in a chloritic matrix (Plate 3m). Horizontal slickensides occur on fracture surfaces which cut the breccia. Across this unit, sheared and altered rocks of the gold zone are juxtaposed against the least deformed and least altered volcanic rocks in the footwall.

Alteration

Mineralogy and textures of the alteration assemblages were studied in drill hole NM-25 (Figure 17). This hole, drilled in 1984, returned assays of 0.270 oz/ton gold over 13 m (42.6 ft); about 8.2 m (27 ft) true thickness. As in the Monte Cristo prospect, three distinct zones of hydrothermal alteration were recognized, spatially related to gold in the MCSZ (Figure 19). These assemblages, in order of increasing proximity to gold concentrations, are:

1) quartz-chlorite-ankerite-sericite-calcite-albite-epidote-rutile;

2) quartz-ankerite-sericite-albite-chlorite-calcite-rutile ± pyrite, and

3) quartz-ankerite-sericite-albite-siderite-pyrite-rutile-chlorite.

The first assemblage is recognized in the "least altered", sheared, volcanic rocks of the MCSZ, which form the hanging wall to the deposit (Figure 19). It is considered to result, in part, from greenschist facies metamorphic conditions during and after deformation. The rocks are strongly foliated, locally crenulated, and may display lineations on fracture surfaces parallel to the foliation. Primary features in the rocks are obscured by structural overprinting. Quartz-carbonate clots, interpreted as amygdules, and early quartz-carbonate veins are dismembered and commonly have quartz-carbonate-chlorite-filled pressure fringes. The shear foliation is defined by millimetre to centimetre scale compositional layering and alignment of silicate and carbonate minerals. Lamellae of aligned chlorite and lesser sericite

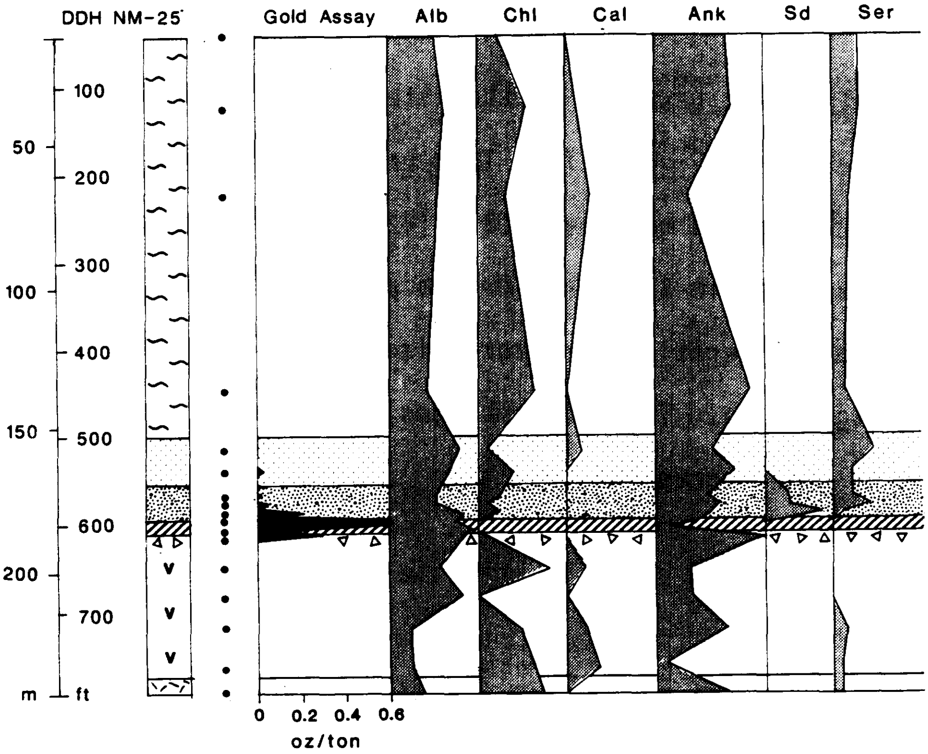


Figure 19. Alteration assemblage profiles from diamond drill hole NM-25, illustrating the spatial relationships among lithology, structure, alteration, veining and gold concentrations in the Victor Island prospect. Data correspond to measured X-ray diffraction peak heights. Sample locations are shown by the dots; gold assays are from drill logs. See text for discussion. Symbols: light stipple = incipiently altered volcanic rocks; heavy stipple = pervasively altered volcanic rocks; angled slashes = breccia-veins; triangles = footwall breccia. Abbreviations (after Kretz 1983): alb = albite; chl = chlorite; cal = calcite; ank = ankerite; sd = siderite; ser = sericite.

envelop elongate, lenticular domains of fine-grained quartz, carbonate and their aggregates (Plate 4a). The quartz is typically recrystallized, polygonal, and diplays well-developed triple junctions. Carbonate is generally anhedral, with irregular grain boundaries, but also locally occurs as recrystallized euhedra overprinting the foliation. Carbonate content, including both ankerite and calcite, is variable. The shear foliation is locally folded and crenulations result from the development of a strong axial planar foliation. The crenulations are asymmetric and shapes are related to their distribution about the fold limbs. Albite and minor epidote occur as accessory minerals in these rocks. Epidote appears to overprint the foliation. Albite is always partially altered to sericite and carbonate minerals. Oxide minerals, including rutile, are disseminated along and concentrated within the micaceous lamellae.

Alteration assemblage 2 occurs in the deformed rocks of the MCSZ adjacent to, and in the hanging wall of, the gold zone (Figure 19). The rocks are fine-grained, moderately to strongly foliated, and characterized by the absence of epidote, lower contents of chlorite and calcite, and more sericite, albite and ankerite. Fine-grained, disseminated pyrite is present in places. Low, but anomalous, gold concentrations are locally associated with this type of alteration. Trace amounts of euhedral tourmaline were observed overprinting the foliation. Rutile, hematite, and rare magnetite were also identified in these rocks. Megascopic textures consist of alternating, centimetre to decimetre scale bands of chlorite-rich and carbonate-sericite-rich rock. This type of "incipient" alteration has a true thickness of about 5 m (15 ft).

Alteration assemblage 3 occurs in the deformed rocks of the MCSZ and is spatially associated with the breccia-veins (Figure 19). This type of "pervasive" alteration contains the highest gold grades of the Victor Island prospect. It is characterized by the absence of epidote and calcite, lesser chlorite, and abundant ankerite, albite, quartz, sericite, and siderite. The rocks are light buff to tan, which reflects low chlorite content. Pyrite is most abundant within this type of alteration. Chlorite was observed, most commonly, to occur with quartz and carbonate in pressure fringes to pyrite grains. Tourmaline occurs in one instance as euhedral grains partially included within pyrite. Oxide minerals are also present in these rocks. Gold-bearing breccia-veins cut the pervasively altered rocks (Figures 17 and 18). The veins consist of fragments of pervasively altered rock in a matrix of quartz with lesser carbonate and albite. The brecciated textures are commonly obscured by later deformation.

Unlike the Monte Cristo prospect, the distribution of alteration assemblages enveloping the Victor Island prospect is not symmetric. In the hanging wall, least altered, sheared, volcanic rocks grade over a short distance through incipiently altered rocks into the pervasively altered, gold-bearing rocks and associated breccia-veins (Figure 19). However, in the foot wall, the deformed and altered auriferous zone is truncated by a fault. The fault is characterized by up to 2 m (6 ft) of fracturing and brecciation including local chloritic gouge. Locally, massive angular fragments of altered, gold-bearing rock occur within the gouge. Ankerite content is extremely high in fault gouge. Across this unit, the pervasively altered rocks and breccia-veins which comprise the gold zone are juxtaposed against least deformed volcanic rocks of the footwall (Figure 17). The footwall rocks are characterized by abundant chlorite and calcite and variable amounts of albite, ankerite, and sericite (Figure 19). This assemblage is considered to result in part from regional greenschist facies metamorphism.

Petrography of Sulfide Minerals

Twelve polished thin sections from the Victor Island prospect were studied to: (1) document the mineralogy of the opaque phases in the deformed and altered gold-bearing rocks; (2) determine the mineralogical changes and paragenesis of sulfide/oxide mineralization which accompanied hydrothermal alteration, and (3) describe the modes of gold occurrence. Most of the samples were obtained from diamond drill hole NM-25, for which both X-ray diffraction and chemical data are also available.

The samples were grouped into three types, based on alteration: incipiently altered, sheared volcanics; pervasively altered, sheared volcanics, and breccia-veins. Mineralogical and textural data are summarized in Table 4.

Pyrite is the most abundant sulfide mineral observed, and although it rarely exceeds 10 modal percent of any sample it constitutes greater than 95 modal percent of the opaque minerals present. Pyrite contents in incipiently altered volcanic rocks are, on average, less than in either the pervasively altered, sheared, volcanic rocks or the breccia-veins.

Pyrite forms euhedral to subhedral grains up to 1.5 mm in size. Most of the coarser-grained pyrite is sieve-textured (Plate 5g) due to small (> 0.03 mm) inclusions of silicate and carbonate gangue, chalcopyrite, rutile, hematite, magnetite, lesser gold and pyrrhotite. The inclusion of all other opaque minerals in the pyrite suggests either earlier or contemporaneous precipitation of these minerals. Fine-

Table 4. Summary of sulphide/oxide petrography, mineralogy and textures of samples from the Victor Island Prospect.

			PYRITE												GOLD					CHALCOPYRITE					RUTILE				
			TEXTURES					INCLUSIONS																					
Sample	Rock Type	%	E	S	A	Bx	Sv	Au	Ccp	Rt	Mag	Po	Hem	Ga	In	Fx	At	Fr	Pr	In	Fr	At	Fr	Pr	In	En	Di	Ps	Assay
NM-25-540	IASV	1	X			X	X		X	X	X	X	X	X						X	X	X	X		X	X	X		0.028
NM-25-583	IASV	1	X				X		X	X	X	X	X	X						X		X	X		X	X	X	X	0.018
NM-25-587	IASV	1	X				X		X	X	X	X	X	X						X		X	X		X	X	X		0.208
NM-25-594	PASV	7	X	X	X	X	X	X	X	X	X		X	X	X		X	X		X	X	X	X		X	X	X		0.528
NM-25-595	PASV	4	X	X	X	X	X	X	X	X	X		X	X	X		X			X	X	X	X		X	X	X		0.962
NM-25-598	PASV	3	X	X	X	X	X	X	X	X	X		X	X	X	X	X			X	X	X			X	X	X		0.604
NM-25-599	BRXV	2	X	X		X	X	X	X	X				X	X					X					X	X	X		0.604
NM-25-600	BRXV	13		X	X	X	X	X	X	X		X	X	X	X	X	X	X		X					X	X	X		0.604
NM-25-606	BRXV	1	X				X			X				X											X	X	X		0.234
NM-25-611	BRXV	4	X	X	X	X	X		X	X	X	X		X			X	X		X		X	X		X		X		0.292
NM-25-612	BRXV	5		X	X	X	X		X	X	X	X		X						X	X	X	X		X		X		0.292
NM-52-260	PASV	1	X				X	X	X	X	X	X	X	X	X					X		X	X				X		n/a

Legend: % = percent opaques.
BRXV = breccia-vein; PASV = pervasively altered, sheared volcanic; IASV = incipiently altered sheared volcanic.
E = euhedral; S = subhedral; A = anhedral; Bx = brecciated; Sv = sieve textured cores.
Au = gold; Ccp = chalcopyrite; Rt = rutile; Mag = magnetite; Po = pyrrhotite; Hem = hematite; Ga = gangue.
In = included in pyrite; Fx = filling fractures in pyrite; At = attached to pyrite grain boundaries; Fr = free in silicate matrix;
Pr = in pressure fringes; En = engulfed by pyrite grain boundaries; Di = disseminated; Ps = pseudomorphing ilmenite.
Assay = gold in troy oz/ton; n/a = assay not available.
Mineral abbreviations after Kretz (1983).

grained pyrite (< 0.2 mm) commonly lacks inclusions and is consistently euhedral.

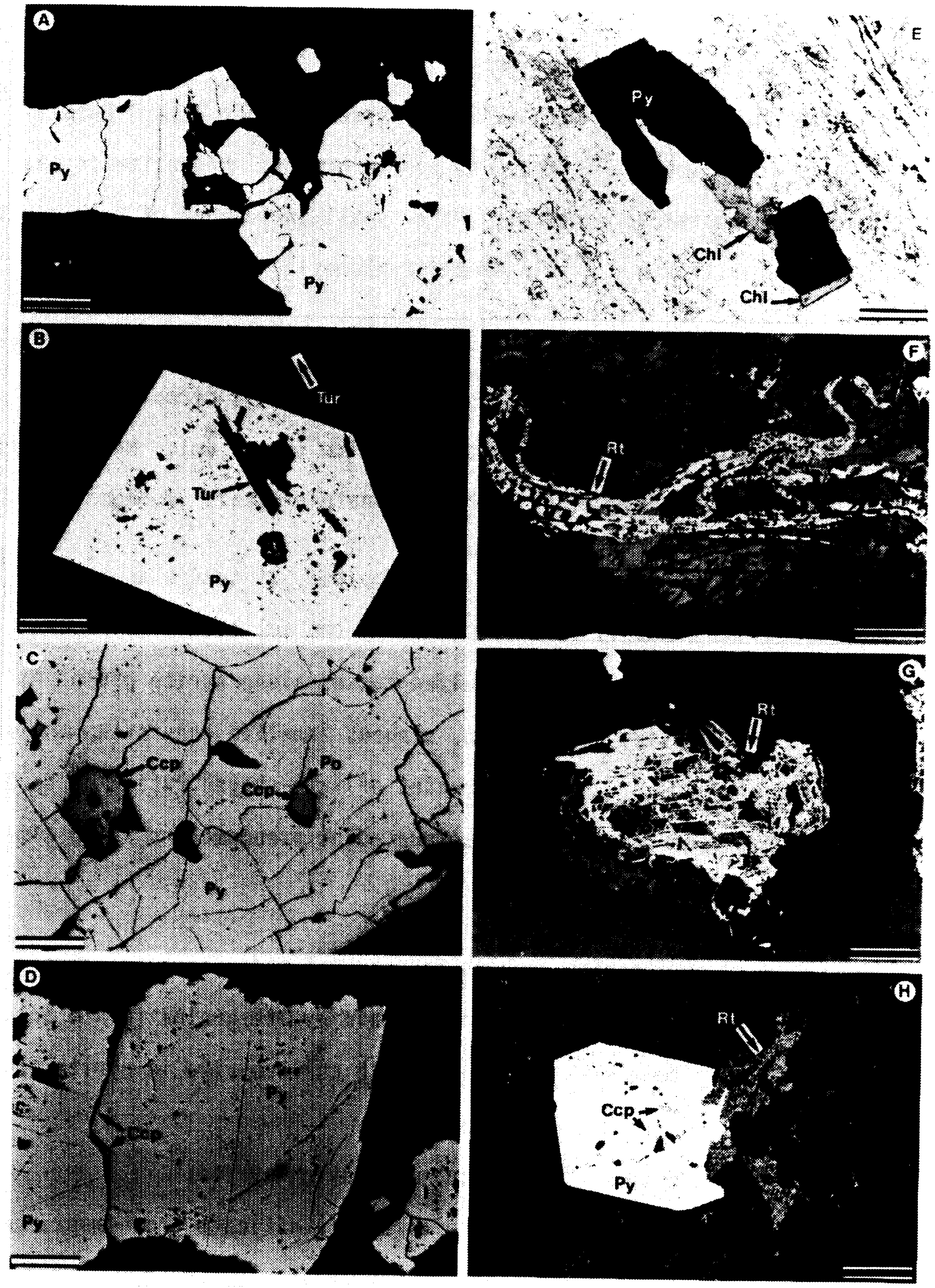
Fracturing (Plate 6c), pull-aparts, and local brecciation are common in samples of the pervasively altered, sheared, volcanic rocks and breccia-veins from the Victor Island prospect and appear to be favoured by coarser grain sizes. In one specimen (NM-25-600), a fracture transecting pyrite cuts and displaces an included gold grain (Plate 5c). Pressure fringes locally occur on opposing faces of some pyrite euhedra. In sulfide-rich samples, pyrite commonly occurs in elongate seams parallel to, but overprinting, foliation in the carbonate and silicate minerals. This suggests hydrothermal fluid flow and pyrite nucleation along foliation planes. Collectively these textures illustrate the intimate relationship between deformation and sulfidation. Pyrite nucleation and growth occurred in a dynamic environment both pre-dated and post-dated by deformation. The lack of deformation textures in incipiently altered samples may be due to lower carbonate mineral content in the matrix. Intense carbonatization promotes brittle failure under constant strain rates (Colvine *et al.* 1984).

Chalcopyrite, although not abundant, was observed in almost all samples and is closely associated with pyrite. It occurs most commonly as small, randomly distributed inclusions within pyrite. The inclusions tend to occur as round blebs (Plates 6c, h); however, a variety of irregularly shaped clots and rods was also observed (Plate 5e). In addition, chalcopyrite occurs as anhedra attached to pyrite and as fracture infillings within pyrite. Locally, isolated, irregular, anhedral masses of chalcopyrite exist within the carbonate/silicate groundmass. Chalcopyrite also forms composite inclusions associated with either pyrrhotite or gold.

Hematite and magnetite were observed in most of the samples, but are more abundant in the incipiently altered volcanic rocks. They exist both as inclusions in pyrite and as free grains in the carbonate-silicate groundmass. These oxides may be intergrown and display mutual

Plate 6. Photomicrographs of sulphides and oxides in polished section from the Monte Cristo and Victor Island prospects. All photomicrographs in transmitted light, except (e) which is transmitted light.

(a) Brecciated euhedral pyrite (sample NM-6-351, Monte Cristo prospect). Chalcopyrite locally fills healed fractures in the pyrite. Scale bar = 0.1 mm.
(b) Euhedral, sieve-textured pyrite with small pressure fringes developed on opposing crystal faces (sample NM-9-12, Monte Cristo prospect). Note the two euhedral tourmaline grains: one included in the pyrite and one in the carbonate-silicate groundmass. Scale bar = 0.4 mm.
(c) Composite chalcopyrite and pyrrhotite in fractured pyrite (sample NM-25-600, Victor Island prospect). Additional chalcopyrite inclusions are also present. Scale bar = 0.05 mm.
(d) Chalcopyrite filling fracture in subhedral, sieve-textured pyrite (sample NM-6-257, Monte Cristo prospect). Scale bar = 0.2 mm.
(e) Chlorite occurring in pressure fringes to brecciated pyrite (sample NM-6-257, Monte Cristo prospect). Plane polarized light, scale bar = 0.2 mm.
(f) Contorted lamellae of rutile, interpreted as a pseudomorph after ilmenite (sample NM-6-321, Monte Cristo prospect). Scale bar = 0.1 mm.
(g) Trellis-textured rutile intergrowth interpreted as pseudomorphs of ilmenite oxi-exsolution lamellae in primary magnetite (sample NM-6-328, Monte Cristo prospect). Scale bar = 0.1 mm.
(h) Sieve-textured, euhedral pyrite containing chalcopyrite inclusions (sample NM-25-583, Victor Island prospect). Note the partially engulfed rutile laths, interpreted as pseudomorphs after ilmenite. Scale bar = 0.1 mm.


A
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lobate partial penetrations or occur in isolation. Rare, trellis-textured hematite exsolution lamellae are found within magnetite inclusions. Hematite in the groundmass is commonly subhedral to anhedral and associated with seams of disseminated rutile. Locally, hematite forms anhedra attached to pyrite grains. Magnetite is most commonly subhedral to anhedral. Rare, small inclusions of both pyrite and chalcopyrite occur within hematite/magnetite aggregates.

Pyrrhotite occurs in about half the samples as small (> 0.01 mm) inclusions in pyrite. The inclusions are typically circular to elliptical and may also contain chalcopyrite (Plate 6c). No pyrrhotite was observed as free grains in the carbonate-silicate groundmass.

Rutile was observed in all the samples. It occurs as fine disseminations commonly distributed along the foliation, as ragged inclusions in pyrite, and as engulfed masses along pyrite grain boundaries. Locally, short, thin, sinuous lamellae consisting entirely of rutile also occur. Rare aggregates of lath-shaped rutile up to 0.25 mm long were observed and are interpreted as pseudomorphs after ilmenite (Plate 6h).

Gold in pyrite-rich samples has several modes of occurrence:

1) isolated inclusions within pyrite grains (Plate 5c);
2) composite inclusions with chalcopyrite in pyrite grains (Plate 5g);
3) grains attached to and coating pyrite;
4) free grains in the carbonate-silicate groundmass, and
5) fracture fillings within pyrite (Plate 5e).

The gold grains are anhedral and up to 0.05 mm in size. Textural evidence suggests that gold precipitation was contemporaneous with and may have persisted after pyrite formation.

Lithogeochemistry

As for the Monte Cristo prospect, chemical analysis of diamond drill core samples representing a cross-section through the gold zone was undertaken:

1) to characterize the bulk composition of the host rocks,

2) identify the major element variations which accompanied hydrothermal alteration, and

3) identify the trace elements associated with gold.

Composite samples were obtained from diamond drill hole NM-25 using the same procedures as outlined for the Monte Cristo prospect. The samples were grouped as sheared volcanic rocks, least deformed volcanic rocks, felsic intrusions, and mafic intrusions. All of the samples were altered. The sheared volcanic rocks were subdivided into least altered, incipiently altered, and pervasively altered sub-types. Breccia-veins were grouped as a distinct type. Samples were analysed by the Geoscience Laboratories, Ontario Geological Survey, Toronto. Geochemical data are tabulated in Tables 5 and 6 and illustrated in Figures 20 and 21.

On the Jensen diagram (Figure 20), the least altered sheared volcanic rocks, which form the hanging wall to the gold zone, plot close to the boundary between the tholeiitic and calc-alkalic fields. High-iron tholeiitic basalt, tholeiitic andesite, and calc-alkalic andesite

Table 5. Whole rock analytical data for samples from diamond drill hole NM-25, Victor Island Prospect.

Sample	Rock Type	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	CO_2	S	LOI	Total	Au
NM-25-41	LASV	61.5	12.7	0.79	4.15	2.22	5.56	2.13	1.05	0.74	0.16	0.11	6.85	0.03	8.6	99.7	2
NM-25-48	QFP	66.6	14.1	0.27	1.85	0.97	3.14	6.66	0.93	0.39	0.12	0.05	3.83	0.11	3.7	99.7	5
NM-25-124	LASV	56.2	12.7	1.09	6.74	2.65	6.46	2.46	0.66	0.82	0.16	0.13	7.76	0.23	9.4	100.2	3
NM-25-225	LASV	61.4	15.4	0.27	3.92	1.61	5.07	2.55	1.19	0.89	0.20	0.09	5.01	0.03	6.3	99.9	2
NM-25-248	QFP	62.5	15.7	0.78	2.96	1.29	3.35	6.82	0.82	0.62	0.28	0.07	2.64	0.04	3.2	99.7	2
NM-25-302	LASV	52.6	17.5	0.58	4.96	3.99	4.73	4.78	1.32	1.04	0.20	0.12	4.66	0.01	6.5	99.5	2
NM-25-447	LASV	45.7	11.9	1.54	10.2	4.61	7.78	2.04	0.98	0.58	0.11	0.28	9.67	0.36	12.2	98.4	20
NM-25-516	IASV	63.8	15.4	0.55	2.59	0.79	3.57	3.52	1.74	0.84	0.10	0.09	4.52	0.13	5.2	99.1	19
NM-25-540	IASV	46.7	13.4	2.03	6.59	3.51	7.04	3.67	1.38	2.14	0.08	0.16	9.67	0.90	10.1	99.1	120
NM-25-568	PASV	56.8	12.6	2.65	6.59	1.84	4.37	2.67	1.86	0.73	0.14	0.20	6.80	0.96	6.8	100.0	320
NM-25-578	PASV	55.6	10.9	4.03	5.04	2.29	5.69	1.33	2.22	0.50	0.03	0.17	8.74	2.55	9.0	100.3	4180
NM-25-587	PASV	46.3	11.7	3.45	10.1	2.82	5.72	4.60	0.48	0.71	0.11	0.23	11.9	1.39	11.7	100.7	1920
NM-25-597	BRXV	69.4	7.64	2.08	2.59	1.40	4.23	3.64	0.10	0.38	0.00	0.09	6.35	1.83	6.5	99.9	9999
NM-25-606	BRXV	82.1	6.21	1.48	1.04	0.37	1.90	3.00	0.00	0.29	0.05	0.06	2.18	1.14	2.1	100.1	9760
NM-25-616	PASV	40.3	9.62	2.54	8.15	3.94	10.8	4.89	0.36	0.73	0.03	0.20	15.7	1.92	14.8	99.6	6020
NM-25-650	LDVR	43.9	11.8	2.66	11.9	4.87	7.82	3.26	0.00	1.32	0.09	0.21	7.41	0.11	10.4	98.7	7
NM-25-683	LDVR	74.4	8.87	0.58	2.30	0.95	3.59	3.49	0.38	0.46	0.16	0.07	4.27	0.50	4.1	100.4	12
NM-25-720	LDVR	40.7	13.6	0.04	10.0	4.37	10.3	1.15	0.94	0.80	0.04	0.15	13.5	0.03	14.7	98.5	100
NM-25-765	LDVR	42.5	15.1	0.95	8.96	3.57	11.3	2.13	0.61	0.89	0.04	0.17	9.24	0.19	11.3	99.3	2
NM-25-795	MINR	43.7	12.2	1.09	7.85	8.91	7.38	2.55	0.53	0.73	0.13	0.16	9.15	0.01	12.6	97.6	2

Values reported as weight % except Au, which is in ppb.

Last three digits in sample number are depths measured in feet.

Totals calculated using major oxides and LOI; CO2 and S were excluded.

All analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Abbreviations: LASV = least altered sheared volcanic; QFP = quartz-feldspar porphyry dyke; IASV = incipiently altered sheared volcanic; PASV = pervasively altered sheared volcanic; BRXV = breccia-vein; LDVR = least altered volcanic rock; MINR = mafic intrusive rock.

and dacite are all represented. As at the Monte Cristo prospect, this indicates that several chemically distinct lithologies, whose primary features have been obscured by deformation, occur within the MCSZ, as might be expected from the chemically diverse Cameron Lake Volcanics which the MCSZ transects.

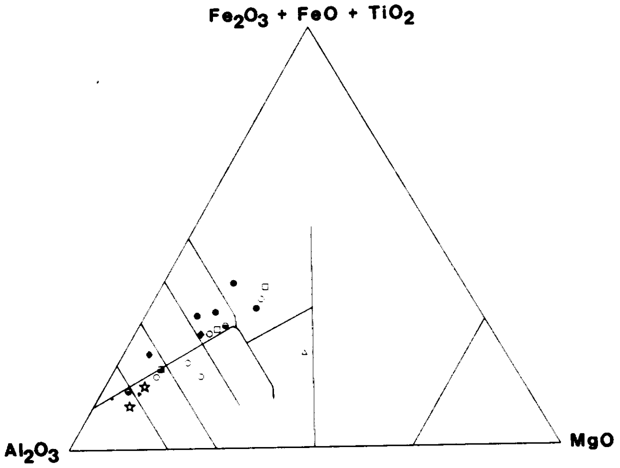

Figure 20. Jensen cation plot of samples from the Victor Island prospect.
Symbols: open circles = least altered, sheared volcanic rocks; half-filled circles = incipiently altered, sheared volcanic rocks; filled circles = pervasively altered, sheared volcanic rocks; diamonds = breccia-veins; open squares = least deformed volcanic rocks; half-filled squares = altered, least deformed volcanic rocks; triangles = mafic intrusions; stars = felsic intrusions.

The least deformed volcanic rocks, which form the footwall to the gold zone, comprise units of high-iron tholeiitic basalt and tholeiitic andesite. One sample of altered volcanic rock in the footwall plots in the calc-alkalic dacite field. Two felsic intrusive dykes plot as calc-alkalic dacite and rhyolite. One sample of the mafic intrusion in the footwall plots very close to the boundary between the basaltic komatiite and high-magnesium basalt fields, but within the latter. This, coupled with the high Cr and Ni content of the intrusion, is compatible with Kaye's (1973) proposed genetic relationship of these rocks with mafic-ultramafic intrusions to the north-northeast.

Both the incipiently altered and the pervasively altered, sheared, volcanic rocks from the gold zone plot in a diffuse cluster straddling the tholeiitic high-iron basalt and andesite field boundary, except for one incipiently altered sample taken from the outermost fringe of the altered zone. This suggests that alteration and gold mineralization may have been restricted to a specific, chemically favorable host rock. The breccia-veins follow a trend of aluminum enrichment, reflecting the addition of the quartz-albite vein matrix.

Lithogeochemical profiles are illustrated in Figure 21. Although it has been clearly demonstrated that several chemically distinct lithologies occur within the data set, several observations and conclusions can be made concerning major element variations which accompanied alteration and gold deposition.

There is a narrow zone of gold enrichment which correlates with the pervasively altered, sheared, volcanic rocks and breccia-veins. Sulphur, reflected in pyrite content, shows the strongest correlation with Au in the pervasively altered rocks. Lower, but anomalous, S values are also characteristic of the incipiently altered, sheared volcanic rocks. K_2O is enriched within both types of altered, gold-bearing rock and occurs predominantly in sericite. Lower K_2O values occur throughout the least altered, sheared, volcanic rocks in the hanging wall where sericite, although present, is less abundant. CO_2-rich rocks form an extremely broad halo around the gold zone. High CO_2

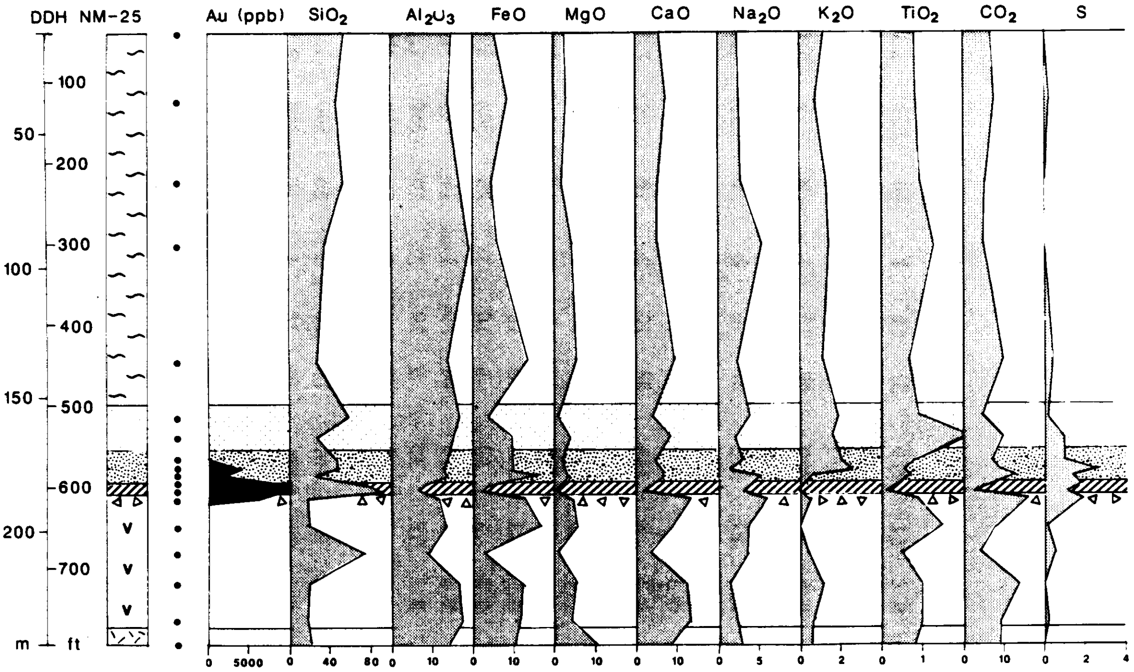

Figure 21. Lithogeochemical profiles for samples from diamond drill hole NM-25, illustrating the relationships among chemistry, lithology, structure, alteration, veining and gold concentrations in the Victor Island prospect.
Symbols: light stipple = incipiently altered volcanic rocks; heavy stipple = pervasively altered volcanic rocks; angled slashes = breccia-veins; triangles = footwall breccia.

content, reflected in carbonate minerals, is characteristic of both the hanging wall and footwall rocks. CO_2 distribution is more extensive than the sampling for this study. Na_2O displays a weak but positive correlation with Au.

Two breccia-veins were sampled. They contain the highest gold values and are correlative with high SiO_2, Na_2O, and S, reflected in quartz, albite, and pyrite, respectively. All other major elements, including CO_2 and K_2O, are low compared to the adjacent sheared and altered wall rocks. This is interpreted to result primarily from

Table 6. Trace element analytical data for samples from diamond drill hole NM-25, Victor Island Prospect.

Sample	Rock Type	Au	B	Hg	Cu	Zn	Co	Ni	Cr	Ag	Bi	As	W	Sb	Li	Ba	Rb	Pb	Be	Mo	U	Sn	Se
NM-25-41	LASV	2	22	20	47	58	18	44	137	2	0.1	1.5	50	0.2	11	210	31	10	1	10	530	2.0	52
NM-25-48	QFP	5	7	20	20	41	7	10	21	2	0.1	1	50	0.1	3	520	29	10	1	10	900	2.0	112
NM-25-124	LASV	3	24	20	49	106	31	79	131	2	0.1	2	50	0.2	15	170	21	10	1	10	500	2.5	435
NM-25-225	LASV	2	19	20	54	55	21	50	153	2	0.1	1.5	50	0.3	13	220	40	10	1	10	450	3.0	52
NM-25-248	QFP	2	4	20	9	80	11	6	10	2	0.1	1	50	0.1	7	1150	25	13	2	10	3370	2.0	37
NM-25-302	LASV	2	10	20	50	93	26	72	188	2	0.4	1	50	1.2	19	320	37	10	2	10	600	9.0	52
NM-25-447	LASV	20	7	20	36	108	27	114	68	2	0.1	2	50	0.5	14	410	33	10	1	10	500	4.0	82
NM-25-516	IASV	19	23	20	30	30	11	14	61	2	0.1	1.5	50	0.3	4	110	50	10	1	10	850	3.5	135
NM-25-540	IASV	120	11	20	82	104	44	72	170	2	0.3	3.5	50	0.3	8	340	43	10	2	10	100	2.0	345
NM-25-568	PASV	320	17	20	32	90	17	39	49	2	0.3	2	50	0.1	6	410	55	10	1	10	650	2.0	405
NM-25-578	PASV	4180	35	30	29	68	23	45	42	2	2.3	19	50	0.3	3	360	70	10	2	10	550	2.0	1020
NM-25-587	PASV	1920	5	20	177	120	21	42	42	2	0.7	4.5	50	0.4	6	250	22	11	2	10	550	3.0	480
NM-25-597	BRXV	9999	5	20	64	36	15	21	36	2	2.3	3.5	50	0.3	3	80	6	10	1	100	200	1.5	435
NM-25-606	BRXV	9760	1	20	13	15	6	9	12	2	0.6	1.5	50	0.4	3	80	5	10	1	25	300	3.0	120
NM-25-616	PASV	6020	85	74	74	82	29	44	113	2	2.1	6.5	50	0.2	3	120	16	26	1	10	340	21	600
NM-25-650	LDVR	7	1	20	158	126	39	26	65	2	0.1	1	50	0.1	12	30	5	10	2	10	150	1.5	187
NM-25-683	LDVR	12	50	20	64	250	8	8	11	2	0.2	6.5	50	0.6	3	110	13	10	1	10	700	5.0	210
NM-25-720	LDVR	100	30	20	101	108	45	110	236	2	0.1	1	50	0.4	18	90	23	10	2	10	150	1.5	112
NM-25-765	LDVR	2	20	20	138	104	47	105	255	2	0.1	1	50	0.2	24	80	15	10	2	10	100	1.5	225
NM-25-795	MINR	2	4	20	51	89	37	220	455	2	0.1	1	50	0.1	17	250	18	10	1	10	400	2.0	52

Values reported as ppm except Au, which is in ppb.

Last three digits in sample number are depths measured in feet.

All analyses by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

Abbreviations: LASV = least altered sheared volcanic; QFP = quartz-feldspar porphyry dyke; IASV = incipiently altered sheared volcanic; PASV = pervasively altered sheared volcanic; BRXV = breccia-vein; LDVR = least altered volcanic rock; MINR = mafic intrusive rock.

dilution effects of the vein matrix relative to the included, pervasively altered rock fragments.

Of the trace elements studied, only As, Bi, Hg, Mo, Rb, and Se show any enrichment within the altered rocks of the gold zone (Table 6). Arsenic is strongly correlated with gold and has a maximum value of 19 ppm within the pervasively altered, sheared, volcanic rocks. Bismuth is also associated with gold and has a maximum value of 2.3 ppm, which occurs in both the pervasively altered, sheared, volcanic rocks and the breccia-veins. Rb and Se are both enriched in the altered rocks and have maxima of 70 ppm and 1020 ppm, respectively. Neither appears to be related directly to gold content and both show negative to no correlation with the breccia-veins. Se probably substitutes for S in pyrite due to similarities in ionic radius. Mo and Hg have maxima within the gold zone, but due to the high detection limits of the analyses (10 ppm and 20 ppm, respectively), little can be said concerning their specific relationship to gold content.

DISCUSSION

Prior to 1986, it was recognized that the geometry and gold distribution of the Monte Cristo and Victor Island prospects were influenced by deformation processes within the MCSZ; however, the relative timing of deformation and gold mineralization were unknown. The similar orientation of S-folds of the shear foliation and the geometry of the gold zones is not fortuitous. Two hypotheses were considered:

1) deformation within the MCSZ significantly modified the geometry of early gold zones, or

2) gold mineralization occurred late in the structural development of the MCSZ and the fluids were channeled through dilatant fold hinges.

In order to evaluate these hypotheses, detailed mapping of exposures of the MCSZ was completed with emphasis placed on identifying small scale zones of alteration and interpreting their relationship to deformation and the Monte Cristo and Victor Island gold prospects.

Structural Controls and Timing of Gold-Pyrite Mineralization

The following features are relevant to the interpretation of the structural control and relative timing of gold mineralization within the MCSZ:

1) The MCSZ is a slightly discordant structure in which primary features (bedding, textures) are obscured or indeterminate due to deformation.

2) The deformed rocks within the MCSZ display a strong

chlorite-sericite-quartz compositional layering and planar mineral alignment interpreted as a shear foliation.

3) The dominant lineation observed in the MCSZ is interpreted as a stretching lineation, which, coupled with thin section analysis, indicates that the rocks underwent reverse, slightly oblique, dip slip movement.

4) S-folds and coeval crenulation cleavage of the shear foliation are interpreted as having developed late in the structural evolution of the MCSZ and indicate late subhorizontal sinistral shear.

5) In the footwall to the Victor Island prospect, the southern boundary of the MCSZ is defined by a distinctive fault breccia; subhorizontal slickensides were observed on fracture surfaces within it at depth and on surface.

6) The Victor Island gold zone is a long, flattened, cigar-shaped body which plunges steeply toward the east.

7) The Monte Cristo gold zone consists of discontinuous shoots which collectively define a long, subvertically plunging gold zone.

8) The tabular, boudinaged, carbonate-rich alteration observed on surface is subparallel to the shear foliation within the enveloping MCSZ.

9) The zone of S-folded and dismembered carbonate-rich pods observed on surface is subparallel to the shear foliation in the enveloping MCSZ.

10) The contacts between both types of alteration observed on surface and their deformed host rocks are sharp and interpreted as tectonic.

11) Both types of alteration on surface are similar to those observed in diamond drill-core from the Victor Island and Monte Cristo prospects.

12) In several localities felsic dykes cross-cut the MCSZ and contain misoriented xenoliths of strongly foliated rocks characteristic of the shear zone.

13) Chlorite is present within the pervasively altered gold-bearing rocks of both prospects and occurs most commonly with quartz and carbonate in pressure fringes to pyrite grains.

14) Pyrite is locally brecciated in both prospects.

Collectively, these features indicate an intimate relationship between deformation within the MCSZ and the orientation of contained gold zones. The Victor Island zone plunges approximately 70°E, which is similar to the orientation of S-folds observed nearby on surface. The Monte Cristo zone plunges vertically, which is again similar to the orientation of S-folds measured nearby on surface. The two types of alteration zones observed on surface are interpreted as small scale "gold zones" analogous to the larger gold zones identified by diamond drilling. Both types of alteration zone have been deformed during the S-folding event, as attested by their tectonic contacts, cross-cutting tensional veins, pinch and swell structures, dismemberment, and folding. The geometry of the Monte Cristo prospect is typified by the dismembered, S-folded carbonate-rich pods observed on surface, whereas the Victor Island prospect is more akin to the tabular, boudinaged, carbonate-rich type of alteration. The structural control manifests itself in the re-orientation of gold zone morphology rather than dilatency within fold hinges. The steep, elongate nature of both gold prospects is similar to the transport direction during early, major, subvertical displacement of the MCSZ. This suggests that hydrothermal fluid ingress and migration may have occurred at this time.

Constraints can be placed on the timing of alteration and gold-pyrite mineralization with respect to regional metamorphism, evolution of the MCSZ, and late magmatic events. Replacement of chlorite by sericite in the altered volcanic rocks suggests syn- to post-metamorphic hydrothermal alteration. This is compatible with the inferred temperature-pressure regime under which brittle-ductile deformation processes predominate. However, the presence of chlorite within quartz-carbonate pressure fringes to pyrite indicates that greenschist facies metamorphic conditions persisted after gold-pyrite mineralization. Felsic dykes cross-cut the deformed rocks of the MCSZ and incorporate misoriented xenoliths of strongly foliated rocks characteristic of the shear zone. It has been shown that gold-pyrite mineralization occurred early during the structural evolution of the MCSZ and, therefore, the dykes must postdate gold deposition. The dykes are probably genetically related to the Nolan Lake Stock.

Comparisons with the Cameron Lake Gold Deposit

Most of the gold deposits, prospects, occurrences, and showings in the Cameron - Rowan Lakes area have geological characteristics suggestive of a common genetic lineage. Minor differences in alteration assemblages and distribution, vein types, and deposit geometry may be a function of local variations in host rock composition, texture, and structural fabric, rather than representing fundamentally different hydrothermal systems. This can be illustrated by briefly comparing the geological characteristics of the Cameron Lake gold deposit with those of the Monte Cristo and Victor Island gold prospects. The following draws liberally from research conducted by the author between 1983 and 1986 at Cameron Lake (Melling *et al*. 1985, Melling, 1986a, Melling *et al*. 1986).

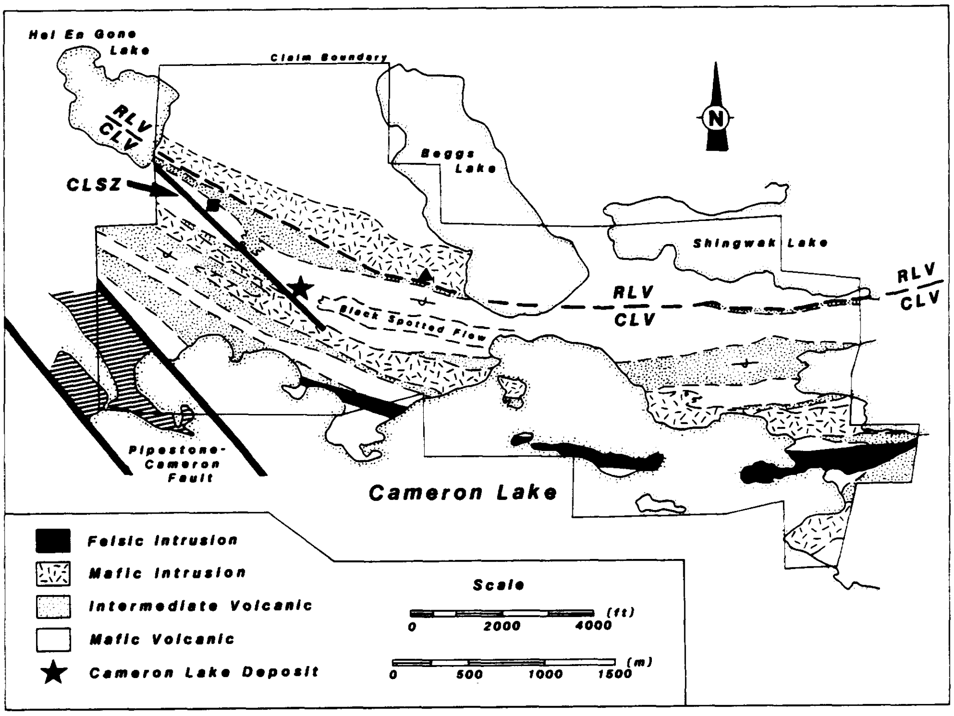

Figure 22. Geology of the Cameron Lake prospect (modified after Melling et al. 1986a). RLV = Rowan Lake Volcanics, CLV = Cameron Lake Volcanics.

The Cameron Lake deposit and the Monte Cristo and Victor Island prospects all occur in brittle-ductile high strain zones within the Cameron Lake Volcanic succession (Figures 9 and 22). All three occur within deformed mafic volcanic rocks, except that the Monte Cristo prospect may, based on lithogeochemical criteria, include host rocks of intermediate composition. All three occur near (< 150 m) mafic intrusive sills. The distribution of gold and orientation of associated veins can be demonstrated to be structurally controlled and related to progressive deformation within the shear zones. At Cameron Lake, the structural control is related to the intersection of the Cameron Lake Shear Zone with bedding-controlled sympathetic splays. In the Monte Cristo and Victor Island prospects, the structural control is manifested by late S-folds of the shear foliation in the Monte Cristo Shear Zone. Breccia-veins occur in all three and constitute the most common gold-bearing vein type.

The alteration assemblages and their spatial distribution with respect to gold are simmilar in all three cases. The assemblage associated with the most abundant gold concentrations consists of quartz-albite-ankerite-sericite-siderite-pyrite-rutile. Carbonate mineral abundances and distributions are zoned with respect to gold. The least altered rocks have calcite-dominated assemblages, which give way to mixed calcite-ankerite transitional assemblages in incipiently altered rocks, while the most abundant gold grades are associated with mixed ankerite-siderite assemblages in pervasively altered rocks.

The Cameron Lake deposit and the Monte Cristo and Victor Island prospects contain remarkably similar sulphide/oxide assemblages and abundances. These include pyrite, chalcopyrite, rutile, pyrrhotite, gold, hematite, and magnetite. The modes of gold occurrence and their relationship to pyrite are identical. Textural relationships suggest that sulphidation and gold precipitation in both areas may have been related to magnetite destruction.

IMPLICATIONS FOR EXPLORATION

Prior to 1983, a genetic model involving a relationship between gold mineralization and stratiform volcanogenic exhalations influenced exploration strategy at the Cameron Lake gold deposit and very little was known about the structural controls on gold distribution (Melling *et al.* 1986). This strategy was extended throughout the Cameron - Rowan Lakes area and is still favoured by some exploration geologists. Recently, the syngenetic model for gold mineralization at Cameron Lake has undergone rigorous testing and been found inadequate (Melling *et al.* 1985, Melling *et al.* 1986, Melling 1986a, b).

In the preceding descriptions, the relationships among stratigraphy, structure, alteration, veining, lithogeochemistry, and gold concentrations were emphasized. These may be synthesized into considerations which place constraints on future genetic models at both the regional and local scales.

Regional Considerations

Most of the gold concentrations in the Cameron - Rowan Lakes area occur within the mixed, tholeiitic to calc-alkaline, Cameron Lake Volcanic succession, at or near its contact with the underlying, tholeiitic, Rowan Lake Volcanic succession. However, this stratigraphic control does not necessarily imply primary, syngenetic gold enrichment as suggested by Blackburn and Janes (1983). It has been shown that all the deposits, prospects, occurrences, and showings occur in mafic rocks or their deformed equivalents. In addition, it has been demonstrated that the largest gold concentrations discovered to date occur in the

Cameron Lake and Monte Cristo Shear Zones, while smaller, but significant, concentrations exist in discontinuous high strain zones commonly spatially associated with mafic intrusive/volcanic rock contacts.

Both the distribution of the gold concentrations and their relationship to structural features are interpreted to result from the contrasting competency between the mafic flows, intermediate to felsic volcaniclastic rocks, and mafic intrusive rocks characteristic of the Cameron Lake Volcanic succession. During deformation, strain distribution in the relatively monolithic Rowan Lake Volcanic succession was homogeneous; however, within the mixed Cameron Lake Volcanic succession, strain distribution was heterogeneous and instrumental in the localization of high strain zones adjacent to lithologic contacts. Similarly, the preferential development of larger shear zones, such as the Cameron Lake and Monte Cristo Shear Zones, would have been enhanced by heterogeneous strain distribution. The greater frequency of gold concentrations in the Cameron Lake Volcanic succession is thus a function of more efficient ground preparation processes and represents a structural control influenced by stratigraphy.

These interpretations have broad implications in terms of exploration models elsewhere in greenstone terrains. First, the stratigraphy of the Cameron - Rowan Lakes area is not unique; similarly organized volcanic successions are recognized throughout the western Wabigoon Subprovince (*c.f.* Blackburn *et al.* 1985; Parker and Blackburn 1986). Second, the distribution of gold occurrences within other volcanic successions is commonly related to upper mixed successions or their lower or upper contacts. Consequently, the potential of successfully identifying economic gold concentrations seems greatest within these mixed volcanic successions, which, because of competency contrasts between different lithologies, have better developed ground preparation characteristics during deformation.

Local Considerations

The most significant gold concentrations discovered to date in the Cameron - Rowan Lakes area occur within large brittle-ductile shear zones. It has been demonstrated that in all cases deformation both predates and postdates gold-pyrite mineralization, and that the distribution of gold, alteration, and veins at the deposit or prospect scale is controlled by deformational processes. This by itself lends a degree of predictability which may be integrated into exploration methodology to increase the probability of successfully identifying and delineating new economic gold deposits.

Carbonatization associated with Archean gold deposits is common throughout the Superior Province of the Canadian Shield (Fyon *et al.* 1983, Kerrich 1983, Colvine *et al.* 1984). This study and others at Cameron Lake (Melling *et al.* 1985, Melling *et al.* 1986, Melling 1986a) have shown that carbonatization in the Cameron - Rowan Lakes area is widespread; however, it alone should not be considered indicative of gold concentrations. Gold-bearing fluids move along all zones of enhanced permeability, which may include shear zones, flow contacts, dyke margins and unconformities, in response to temperature, pressure, and chemical gradients.

It has been demonstrated that within the carbonatized rocks of the Cameron - Rowan Lakes area, gold is most closely associated with sulfides, especially pyrite, rather than the more extensive carbonate minerals. Furthermore, in most cases pyrite distribution has been shown to occur in and around systems of quartz-albite-rich breccia-veins. Field relationships suggest that early carbonatization and sericitization occurred during ductile deformation and were followed by brittle deformation, the formation of breccia-veins, and sulfidation. This is compatible with changes in the composition of the hydrothermal fluids which may have occurred as a result of the veining proccess.

As carbonatization proceeded, prior to brittle fracture and vein formation, the hydrothermal fluids may have become enriched, but not saturated, in gold and sulphur. The precipitation of carbonate minerals would have strengthened the rock relative to its mafic precursor, further enhancing local competency contrast, and this, coupled with high hydrothermal fluid pressures, may have resulted in brittle failure. Rapid fracturing and brecciation would have formed permeable conduits, facilitating hydrothermal fluid flux. The rapid drop in pressure associated with the formation of the breccia-veins would probably have promoted effervescence of the fluid. CO_2 phase separation would leave the remaining hydrothermal fluid saturated in a sulphur-bearing phase and gold. Gold complexes would have become unstable and precipitation of gold may have occurred when these fluids lost sulphur by reaction with the iron-rich tholeiitic rocks to form pyrite.

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APPENDIX I

DESCRIPTIONS OF GOLD DEPOSITS, PROSPECTS, OCCURRENCES AND SHOWINGS IN THE CAMERON - ROWAN LAKES AREA

1. Cameron Lake Deposit

Discovery Date: 1960

Geology:

Host: Mafic volcanic rocks adjacent to intrusive contact with a mafic sill.

Structure: Deposit occurs within deformed rocks of the Cameron Lake Shear Zone. Intersection of bedding with the shear zone produces an anastomosing network of shears which control the steep northerly plunging geometry of the deposit.

Alteration: Extensive zone of carbonatization with lesser sericitization; gold grades related to pyrite content and distribution in the altered rocks within and adjacent to veins.

Veining: Three vein types documented, but gold concentrations related to extensive systems of pyritic, quartz-rich breccia-veins up to 12 ft. thick and 500 ft in strike length.

Exploration History:

1960-61: 17 DDHs (total 3909 ft).
1972: 7 DDHs (total 2584 ft).
1974: 9 DDHs (total 2101 ft); trenching, geophysics, geological mapping, prospecting.
1981: 19 DDHs (total 5681 ft).
1983-36: About 90,000 ft of diamond drilling to delineate deposit; about 20,000 ft of diamond drilling to explore elsewhere on property; extensive stripping and trenching, geological mapping, geophysics, overburden drilling, prospecting.

Remarks: Deposit open to depth below 1300 ft; strike length of about 1300 ft and average thickness of about 30 ft; drill-indicated reserves of 1,625,202 short tons grading 0.16 oz/ton Au; exploration/development ramp being driven to 425 ft level.

References:

Beard and Garrett (1976)
Hunter (1980, 1982, 1985)
Melling (1986a)
Melling *et al*. (1986a)
Melling *et al*. (1986b)
Neilson and Bray (1981)
The Northern Miner (1987)

2. Victor Island Prospect

Discovery Date: 1899

Geology:

Host: Mafic to intermediate volcanic rocks near (150 ft) intrusive contact with mafic sill.

Structure: Prospect occurs within deformed rocks of the Monte Cristo Shear Zone. S-folding of the shear foliation controls the steeply plunging, flattened cigar shape of the gold zone.

Alteration: Extensive (100 ft) carbonatization and sericitization; gold grades related to pyrite content and distribution in the altered rocks within and adjacent to veins.

Veining: Several vein types, but gold concentrations related to quartz- and albite-rich breccia-veins up to 6 ft thick.

Exploration History:

1899: 1 shallow shaft (25 ft).
1931: 1 DDH.
1984-86: About 20,000 ft of diamone drilling, overburden drilling, geological mapping, geophysics and 1 small trench.

Remarks: Prospect is open below 900 ft; strike length of about 200 ft and true thickness of about 20 ft; requires additional drilling to fully delineate the gold zone and to explore the immediate area.

References:

Jones (1983, 1984, 1985)
Melling (1986b)

3. Monte Cristo Prospect

Discovery Date: 1899

Geology:

Host: Mafic to intermediate volcanic rocks near (300 ft) intrusive contact with a mafic sill.

Structure: Prospect occurs within deformed rocks of the Monte Cristo Shear Zone. Boudinage and S-folding of the shear foliation controls the geometry of the subvertically plunging, composite, gold zone.

Alteration: Extensive (150 ft) carbonatization and sericitization; gold grades related to pyrite content and distribution in the altered rocks within and adjacent veins.

Veining: Several vein types, but gold concentrations related to quartz- and albite-rich breccia-veins up to 6 ft thick.

Exploration History:

1899: 2 shallow shafts (13 and 22 ft); 6 trenches.
1936: 8 DDHs (total 1970 ft).
1984-86: About 14,750 ft of diamond drilling, overburden drilling, geological mapping, geophysics.

Remarks: Prospect is open below 700 ft; strike length is about 250 ft, average true thickness is about 33 ft; additional drilling required to fully delineate the gold zone and to explore the immediate area.

References:

Beard and Garratt (1976)
Jones (1983, 1984, 1985)
McNicoll (1987)
Melling (1986b)
Neilson and Bray (1981)

4. Wampum Prospect

Discovery Date: 1939

Geology:

Host: Mafic volcanic rocks near northern contact with a mafic intrusion.

Structure: Prospect occurs within an east-trending high strain zone at least 15-20 m wide.

Alteration: Carbonate - sericite - pyrite.

Veining: Abundant breccia-vein material on dumps.

Exploration History:

1939-42: 34 DDHs (total about 3000 ft); 200 ft, 2 compartment vertical shaft with development at 100 and 200 ft levels; about 180 ft of lateral development on the 100 ft level; 18 trenches.

1984: Geological mapping, prospecting, geophysics.

1986: Several DDHs, trench sampling.

Remarks: Two parallel zones of gold mineralization about 100 ft apart; 9 veins located on property; underground channel sampling assayed 0.72 oz/ton Au across a width of 9.9 ft for a length of 56 ft.

References:

Allen (1984)
Beard and Garratt (1976)
Kenny (1985)
Neilson and Bray (1981)

5. Sullivan Prospect

Discovery Date: 1899

Geology:

Host: Mafic volcanic rocks sandwiched between mafic intrusive rocks to the north and a felsic dyke to the south.

Structure: Well-foliated rocks near intrusive contacts, but several hundred metres north of the projected extension of the Monte Cristo Shear Zone.

Alteration: Carbonate - sericite - pyrite.

Veining: Breccia-vein material abundant on dumps.

Exploration History:

1899-1933: Two shafts (110 and 33 ft), with 111 ft of lateral development; one 48 ft adit; trenching.
1972-73: Diamond drilling (total 1511 ft); geological mapping and geophysics.
1980-81: 21 DDHs (total 3842 ft) on property, of which 7 were on Sullivan zones.
1986: 9 DDHs on property, 200 overburden holes, trenching, stripping, geological mapping and prospecting.

Remarks: Grab samples assayed up to 7.78 oz/ton Au. Very little drilling completed during recent exploration programs.

References:

Archibald (1982)
Archibald (1986)
Beard and Garratt (1976)

6. Meston Prospect

Discovery Date: 1937

Geology:

Host: Mafic volcanic rocks immediately south of contact with mafic intrusive rocks.

Structure: Weakly foliated rocks. Prospect occurs several hundred metres north of projected extension of the Monte Cristo Shear Zone.

Alteration: Carbonate - sericite - pyrite.

Veining: Breccia-veins up to 1 m thick exposed in trenches which strike approximately 090°.

Exploration History:

1937: Trenching and prospecting.

1972-73: 1511 ft of diamond drilling on property; geophysics, geological mapping.

1980-81: 21 DDHs (total 3842 ft) on property, 14 of which were on the Meston zone.

1986: 9 DDHs on property, 4 of which were on the Meston zone; 200 overburden holes on property; trenching, stripping, geological mapping and prospecting.

Remarks: Diamond drill hole intersection assaying 0.10 oz/ton Au over 21 ft reported in 1973; channel sample averages of 0.172 oz/ton Au over 20.1 ft and 0.144 oz/ton Au over 22 ft; in 1986, channel samples from breccia-veins assayed up to 0.2 oz/ton Au.

References:
Archibald (1982)
Archibald (1986)
Beard and Garratt (1976)

7. Begg's Lake Prospect

Discovery Date: 1960

Geology:

Host:	Mafic intrusive rocks near lower contact with mafic volcanic rocks.
Structure:	Appears to occur within narrow zone of east-trending, steeply north-dipping, foliated rock.
Alteration:	Carbonatization, sericitization and pyritization over narrow widths exposed in trenches.
Veining:	One apparently continuous quartz-carbonate vein, less than 3 ft thick and up to 500 ft in strike length.

Exploration History:

1961: 26 DDHs; geological mapping, prospecting, trenching, geophysics.
1980-86: Surface grab sampling.

Remarks: Drilled over 500 ft of strike length and about 150 ft vertical depth; fairly consistent results, in the range of 0.10 to 0.20 oz/ton Au were obtained over widths of only a few feet; two grab samples of pyritic altered wall rock taken in 1984 assayed greater than 1.0 oz/ton Au; needs additional trenching and stripping, detailed mapping and diamond drilling.

References:

Beard and Garratt (1976)
Hunter (1980)
Neilson and Bray (1981)

8. Patmour Occurrence

Discovery Date: 1939 (?)

Geology:

Host: Mafic volcanic rocks of Rowan Lake Volcanics, near lower contact with underlying Cameron Lake Volcanics.

Structure: Single vein occurs in a narrow (< 2 m) shear zone. Rocks are moderately foliated adjacent to the vein.

Alteration: Carbonate - sericite - pyrite. Carbonates are reported to include ankerite and calcite.

Veining: Massive, white to grey, quartz-carbonate vein; 1.5 ft thick, exposed on surface over 30 ft strike length.

Exploration History:

1939: Trenching and pitting, but no further work recorded.
1984: 11 DDHs (total 1130 ft); geological mapping, prospecting, trenching, geophysics.
1986: 3 DDHs (total 333 ft) on Patmour zone; 12 DDHs (total 3256 ft) of exploration drilling elsewhere on property.

Remarks: Grab samples taken in 1984 assayed 20.24 oz/ton Au and 26.88 oz/ton Au; best drilling results include a 3 ft intersection which assayed 0.126 oz/ton Au, and a 4 ft intersection which assayed 0.105 oz/ton Au.

References:
de Quadros (1986)
Kretschmar (1984)

9. Roy Showing

Discovery Date: 1899

Geology:
Host: Mafic volcanic rocks.
Structure: Not known.
Alteration: Not known.
Veining: Two lenticular quartz veins; one 6 to 8 ft thick and 250 ft in strike length, and one 8 ft thick and 72 ft in strike length.

Exploration History:
1899-1903: Trenching and sampling.
1974: 2 DDHs (total 205 ft).
1984: Geological mapping, prospecting, geophysics.

Remarks: Grab samples assayed 0.07 to 0.18 oz/ton Au and 0.23 to 6.2 percent Cu; showing was not visited during this study.

References:
Beard and Garratt (1976)
Kretschmar (1984)
Neilson and Bray (1981)

10. Kuryliw - Sullivan Bay Showing

Discovery Date: 1930s

Geology:
Host: Felsic porphyry dyke.
Structure: Possibly related to tensional stress.
Alteration: Not known.
Veining: Northwest-striking quartz stringers.

Exploration History:
1944: 7 DDHs.
1973: Geological mapping and geophysics.
1983: 7 DDHs (total 2246 ft) elsewhere on property; geological mapping, prospecting, soil sampling and geophysics on showing.

Remarks: Channel samples grading 0.2 oz/ton Au over 7.1 ft reported in 1973; not explored during Calaveras Exploration Ltd. 1983 program; showing not visited during this study.

References:
Beard and Garratt (1976)
Nelson (1983)

11. Silver Lake Resources Showing (unnamed)

Discovery Date: 1985

Geology:

Host: Deformed mafic volcanic rocks.

Structure: Showing occurs within small shear zone parallel to, but north of, the Monte Cristo Shear Zone.

Alteration: Carbonate - sericite - pyrite.

Veining: None reported.

Exploration History:

1985: 6 DDHs (total 3234 ft) completed on property; 1 DDH (497 ft) on showing; geological mapping, soil and rock geochemistry, prospecting, geophysics.

Remarks: Drill intersection of 0.022 oz/ton Au over 15 ft reported.

Reference: Burden (1986)

12. Twilight Showing

Discovery Date: 1982

Geology:

Host: Showing occurs in mafic volcanic rocks adjacent to contact with felsic volcanic rocks, and near (100 ft) intrusive contact with mafic sill.

Structure: Moderately deformed and foliated rocks, interpreted to be several hundred feet north of the Cameron Lake Shear Zone.

Alteration: Extensive carbonatization; sericitization restricted to foliated rocks; traces of disseminated pyrite.

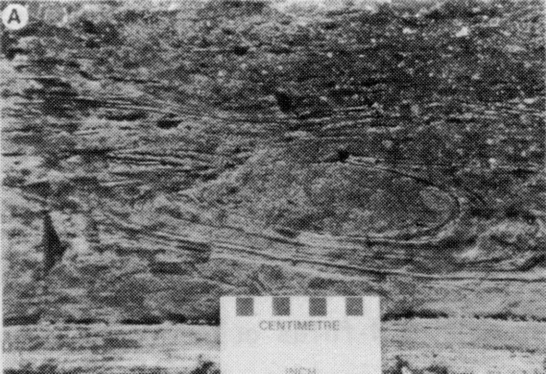
Veining: Minor quartz-carbonate veinlets parallel to and crosscutting the foliation.

Exploration History:

Pre-1982: None recorded, but equivocal evidence of early hand-dug pits.
1983: 1 DDH (607 ft); trenching and stripping, geological mapping, prospecting, geophysics, overburden drilling.

Remarks: Grab samples assayed up to 0.011 oz/ton Au; drill data discouraging.

Reference: Hunter (1982)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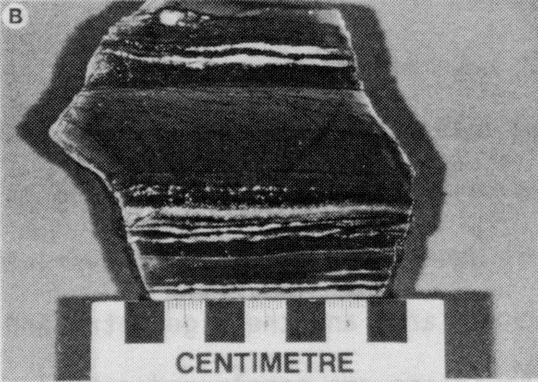

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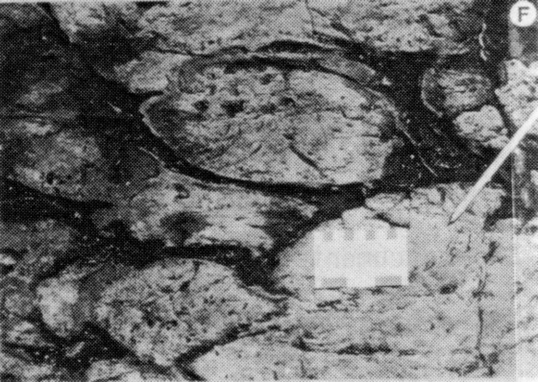
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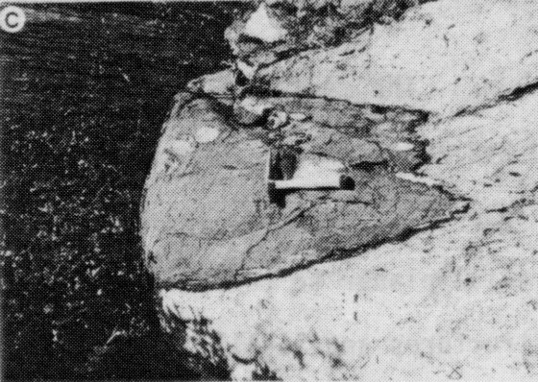
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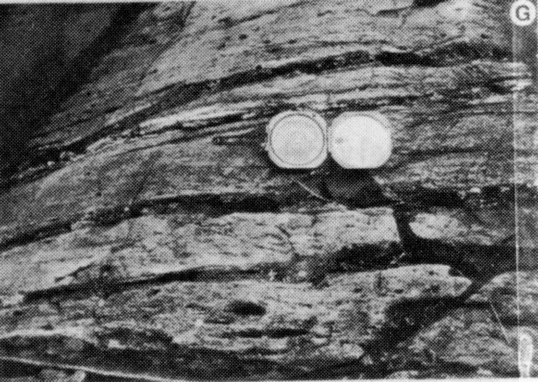
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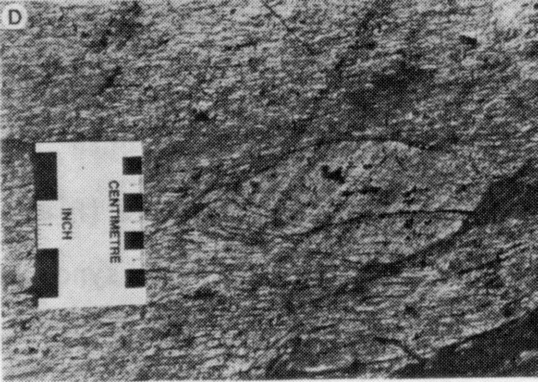
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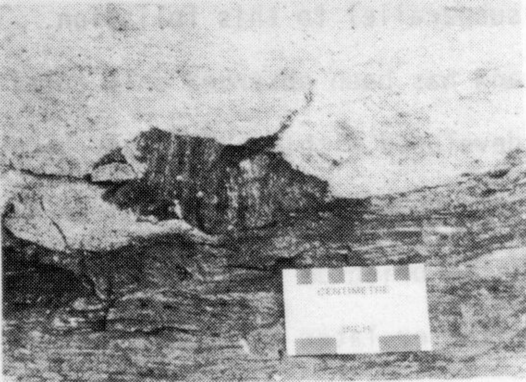
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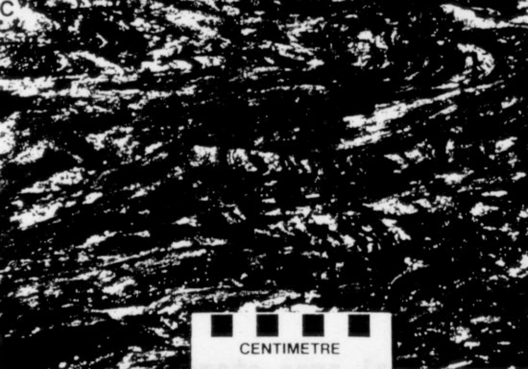
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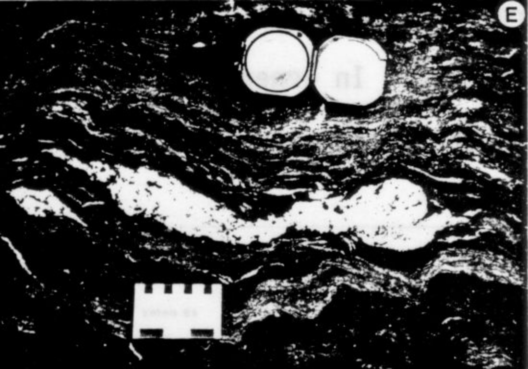
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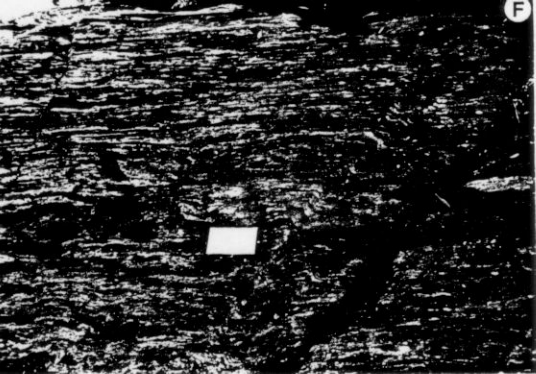
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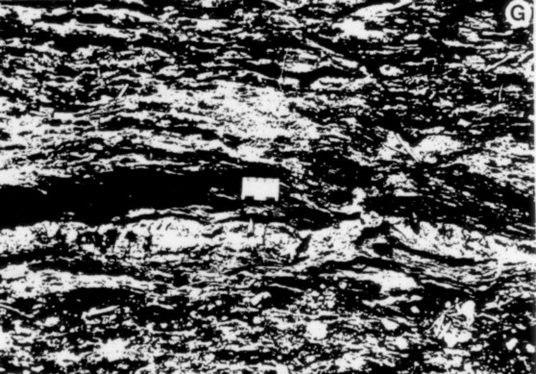
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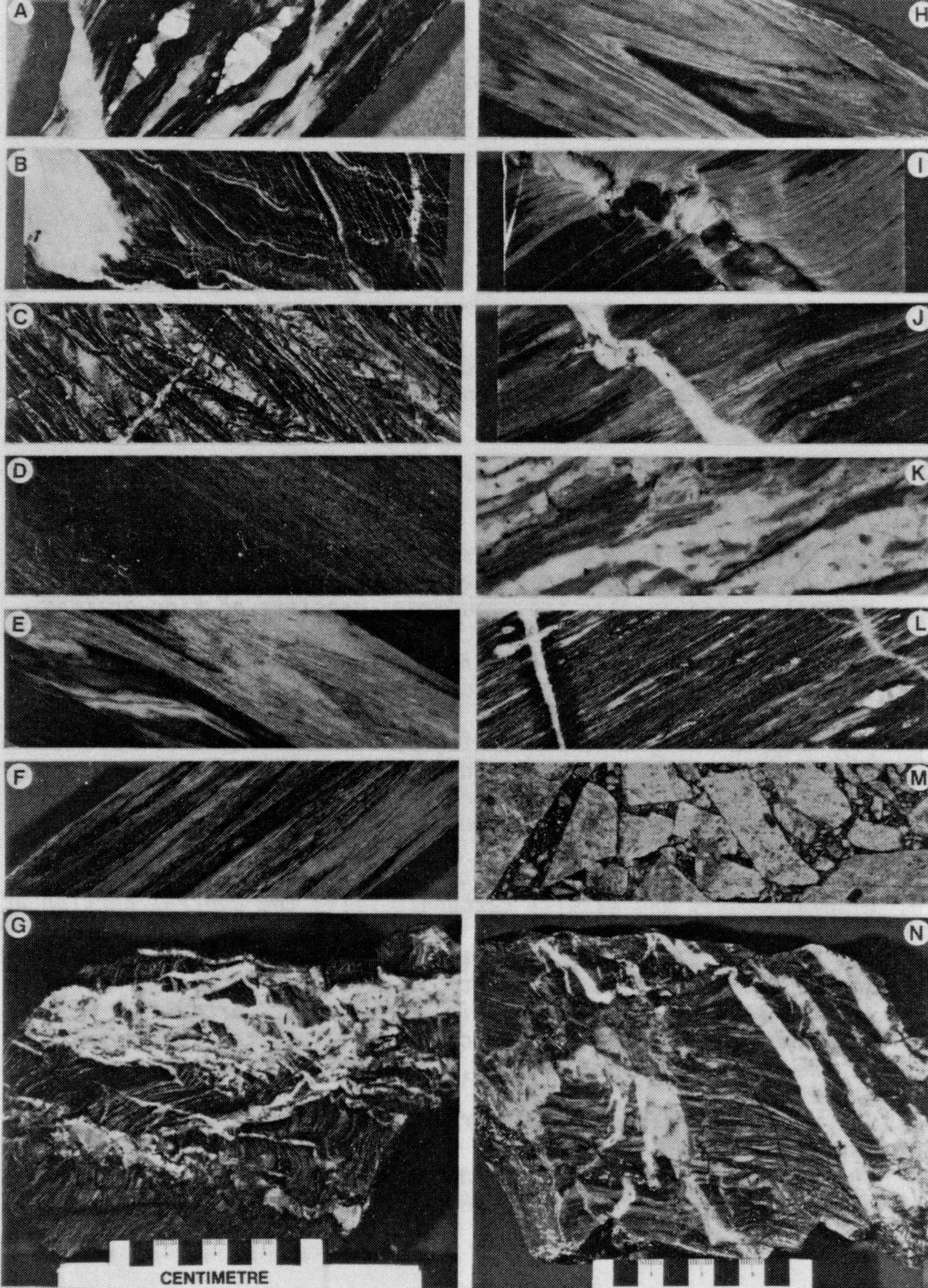
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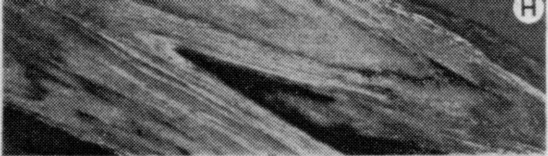
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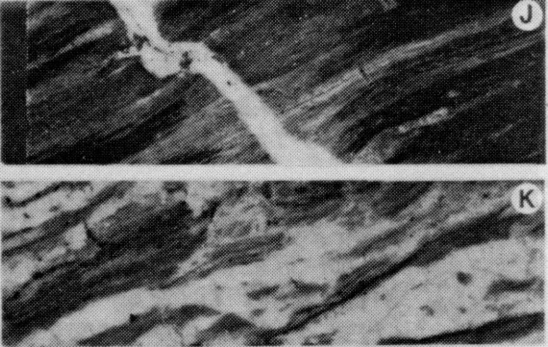
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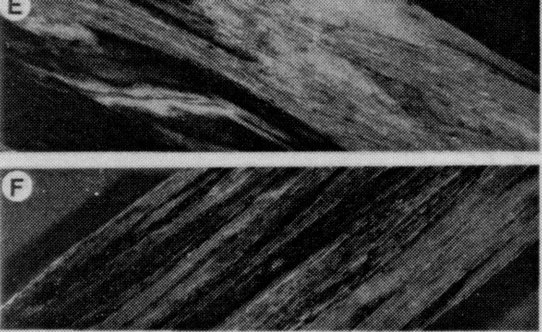
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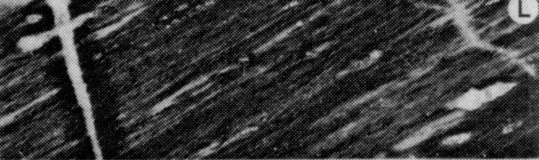
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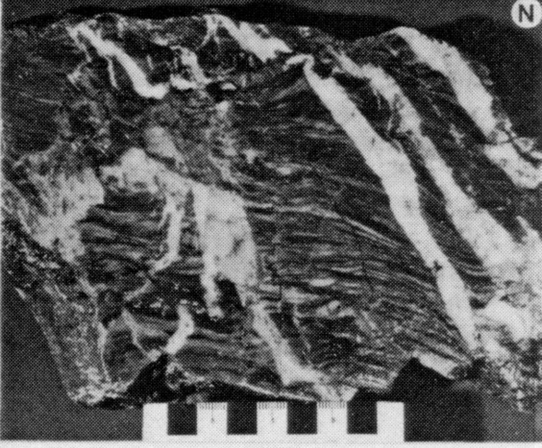
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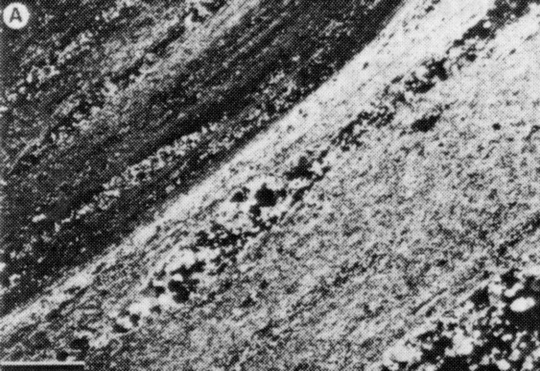
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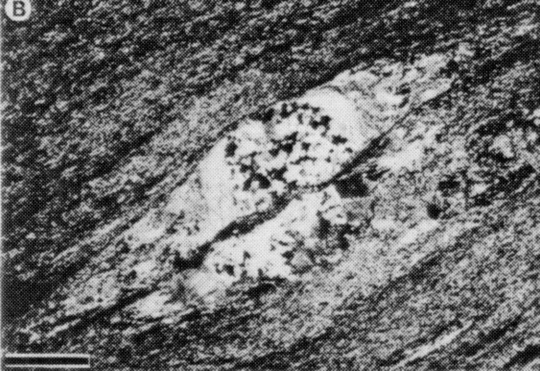
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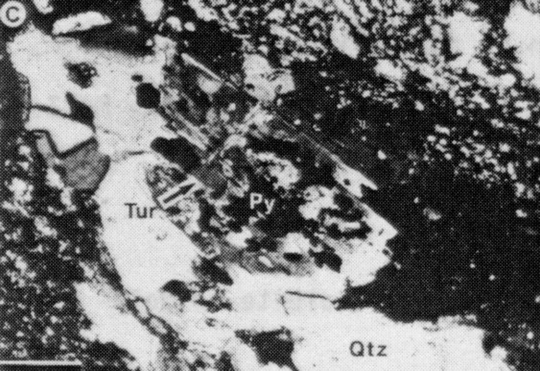
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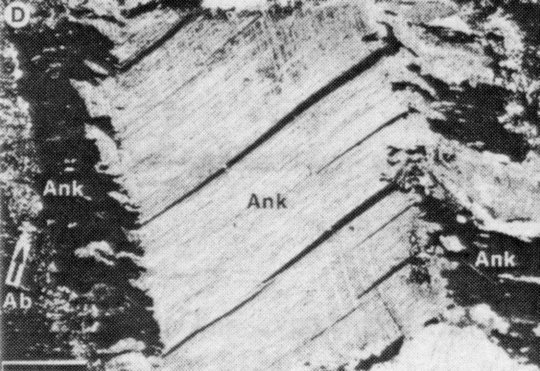
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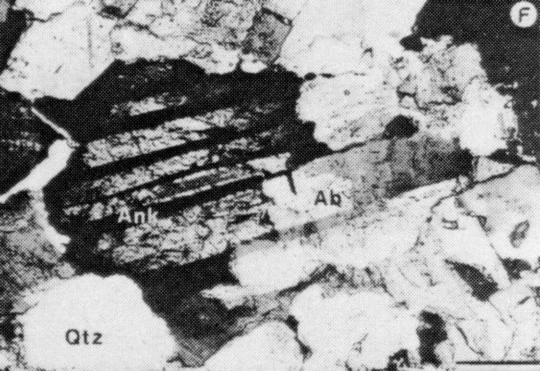
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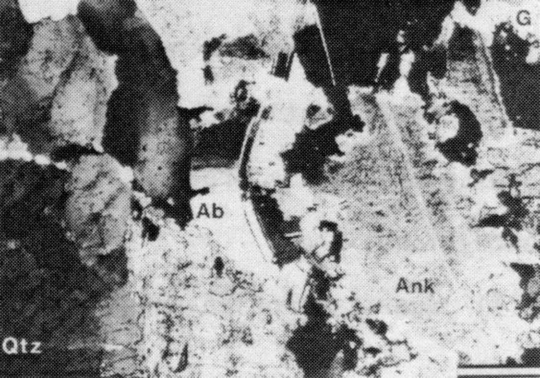
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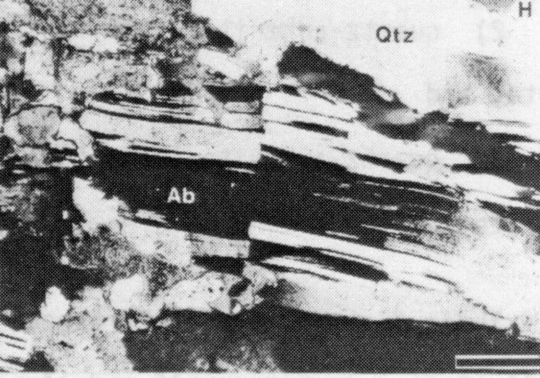
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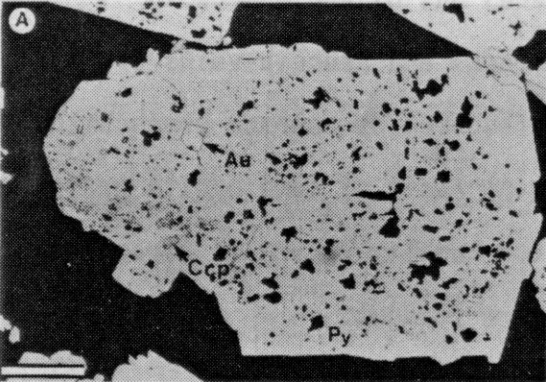
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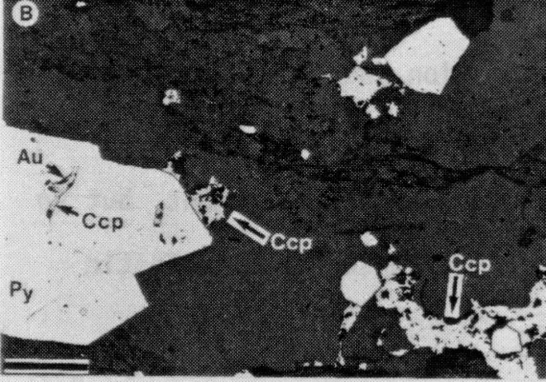
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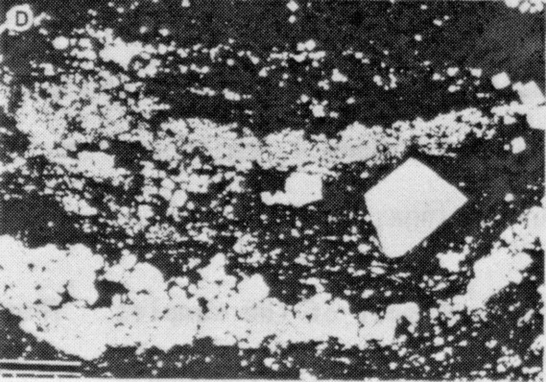
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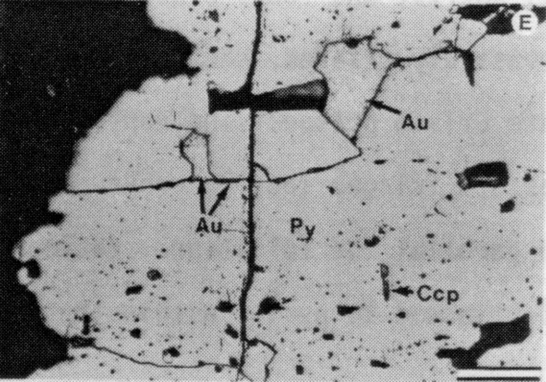
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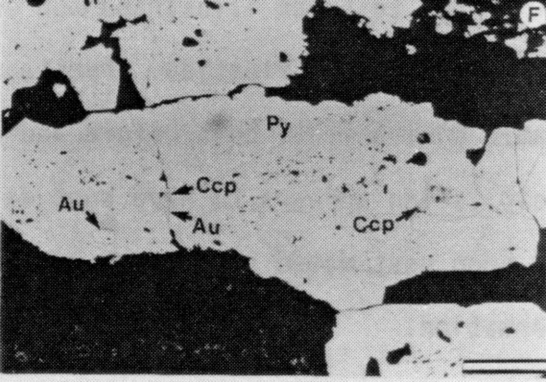
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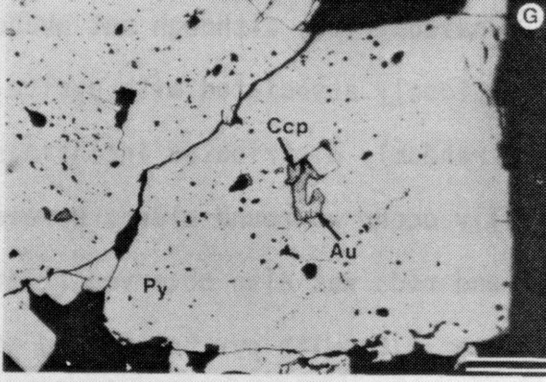
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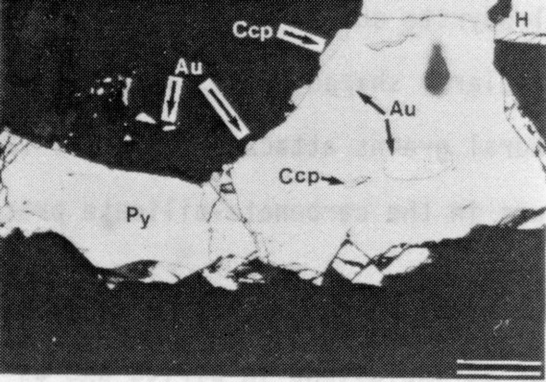
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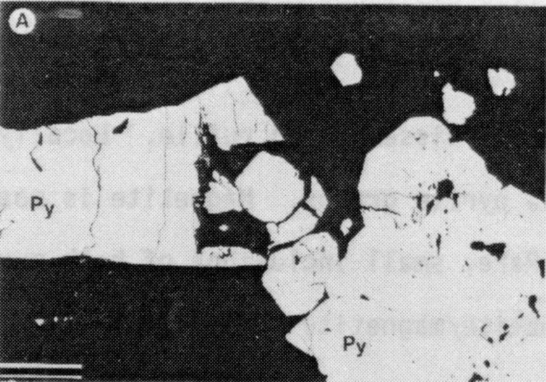
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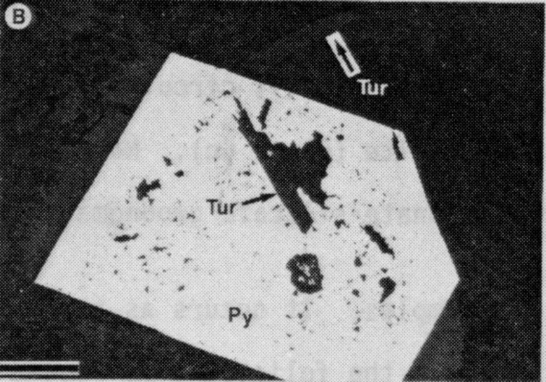
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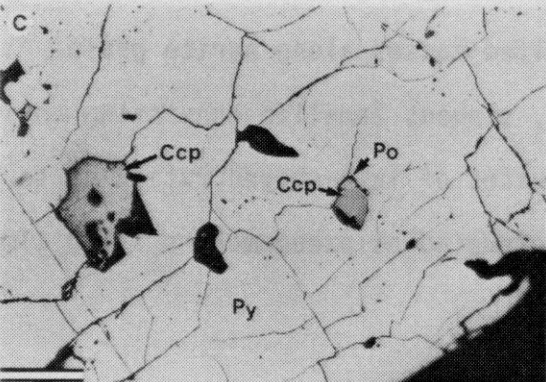
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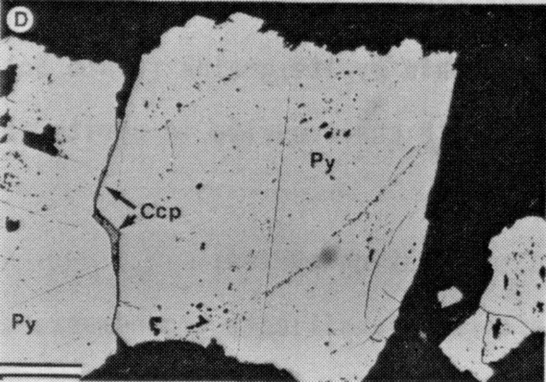
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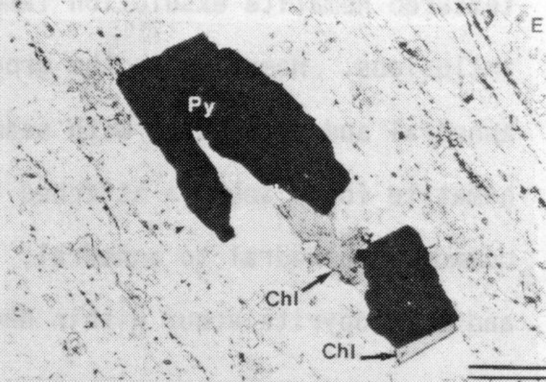
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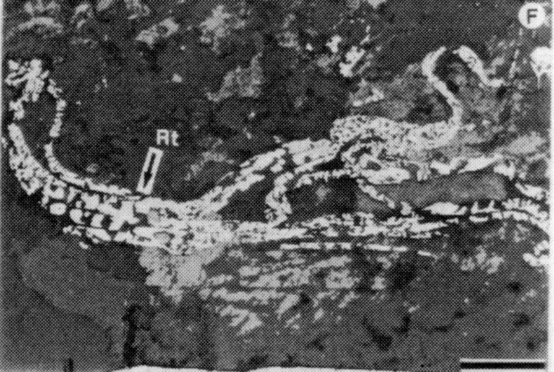
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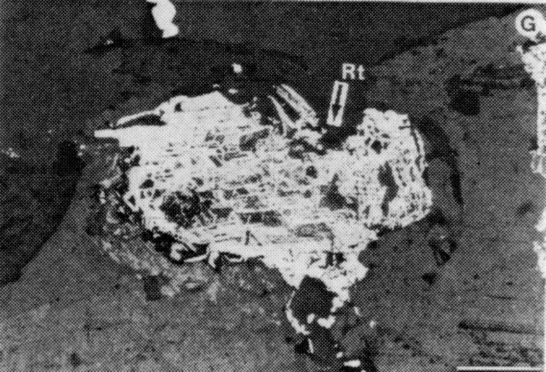
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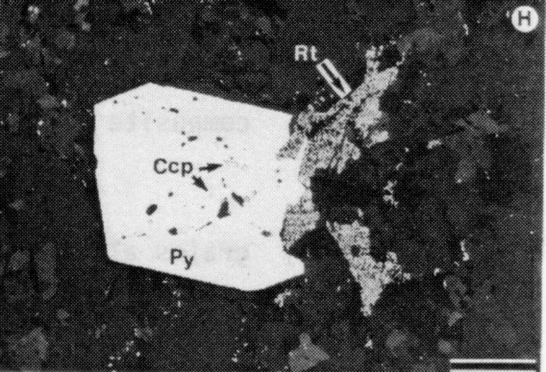
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