GEOLOGICAL SURVEY OF CANADA
OPEN FILE 2064

Continuation of a metallogenic/exploration study for granite-associated mineralized regions in the Gaspé peninsula, Quebec

Kirk Stevens

1989

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Canada

GEOLOGICAL SURVEY OF CANADA
OPEN FILE 2064

Continuation of a metallogenic/exploration study for granite-associated mineralized regions in the Gaspé peninsula, Quebec

Kirk Stevens

Contribution to the "Plan de développement économique
Canada/Gaspésie et Bas Saint-Laurent,
Volet Mines 1983-1988"

1989

ABSTRACT

Objectives of this study were to: 1. develop a vein mineral zoning model for Gaspesian granite-associated ore deposits. The approach is to i) refine existing knowledge of a hypothesized model by filling in data gaps in vein mineral zoning patterns at three type areas, and ii) to test the applicability of the model at other selected prospects or mineralized regions. 2. map average fluid inclusion homogenization temperatures in vein quartz and calcite samples in the Mines Gaspé vein system.

The vein mineral mapping studies show that Gaspesian granite-associated mineral deposits occur within zoned vein systems, with zones defined by vein mineral assemblages easily discernable in hand sized specimen. This zoning can be present at the local or regional scale. In the horizontal plane, zones, named for diagnostic vein mineral assemblages, comprise a central copper-quartz vein zone, a zinc-quartz vein zone which occurs completely within to mainly outside the copper-quartz zone, and a carbonate-sulphides vein zone which occurs inside and outside the copper-quartz and zinc-quartz zones. In the vertical plane, copper-quartz or zinc-quartz zones typically occur at, or extend to lower elevations than, the carbonate-sulphides zone. Economic Cu±Mo, and Zn-Pb ± precious metal, deposits occur in the copper-quartz and zinc-quartz zones, respectively. No economic deposit type is associated with the carbonate-sulphides zone.

Thermal mapping in the Mines Gaspé area reveals a clear association in the Copper Brook aureole between ore deposits and thermally anomalous zones mapped using fluid inclusions in vein quartz. Average sample-site homogenization temperatures in these thermal highs range from about 350° to about 450°C. These thermal highs are localized in turn in a zone where vein quartz:carbonate proportions attain a maximum for the Mines Gaspé system. Thermally anomalous portions of quartz-rich vein zones also host the Federal, Candego, and Madeleine deposits, situated 50 km west or southwest of Mines Gaspé. The existence of this same trend in the Mines Gaspé ore system indicates that hydrothermal systems with similar thermochemical characteristics operated over a large portion of the north-central Gaspé peninsula.

The most important result of the vein calcite thermal mapping is the delineation of two 5 km long thermal anomalies projecting outward from, and situated mainly in unaltered rocks outside of, the Copper Brook aureole. The maximum average homogenization temperatures commonly obtained in these thermal highs are from 200° to 320°C.

TABLE OF CONTENTS

Page

ABSTRACT.................................... i
TABLE OF CONTENTS............................ ii
LIST OF FIGURES.............................. iv

CHAPTER ONE - INTRODUCTION

1. Introduction.................................. 1

2. Specific goals................................ 3

CHAPTER TWO - VEIN MINERAL ZONING SURVEYS

1. Vein mineral zones in the type areas........... 5

2. McGerrigle Mountains/Lemieux Dome corridor..... 6

    Literature data.......................... 7
    Field data: vein calcite colour zoning... 14
    Discussion............................... 20

3. Isolated Prospects............................. 21

    Mount Brown.............................. 21
    Mid-Patapedia............................ 23
    St-Benoit-de-Matapedia................... 28
    St-Andre-de-Ristigouche.................. 31
    Basket Brook............................. 32
    Carleton Sb-Pb........................... 34
    New Richmond Sb-Au....................... 37
    Soquem Robidoux.......................... 38
    Soquem Reboul............................ 43
    Lac Arsenault............................ 45
    Raudin Zn-Pb............................. 46

4. Gaspesian vein zoning model: discussion........ 47

CHAPTER THREE - FLUID INCLUSION SURVEY, MINES GASPÉ AREA

1. Introduction................................... 51

2. Analytical procedure........................... 51

3. Fluid inclusion petrography.................... 54

4. Data presentation.............................. 57

5. Discussion..................................... 64

CHAPTER FOUR - CONCLUSIONS

1. Conclusions.................................... 66

ACKNOWLEDGEMENTS.................................... 68

REFERENCES.. 69

APPENDIX 1: LITERATURE SOURCES OF VEIN MINERAL DATA, McGERRIGLE MOUNTAINS/LEMIEUX DOME AREA..... 71

APPENDIX 2: FLUID INCLUSION HEATING AND FREEZING DATA.. 72

LIST OF FIGURES

Page

Figure 1: Distribution of Cu-Fe+Q, Zn-Pb+Q, and carbonate-rich vein zones in the Mines Gaspé, Lemieux Dome, and Candego/Madeleine mines area hydrothermal systems........................ 2

Figure 2: Map of Gaspé peninsula showing regions mapped in this project.............. 4

Figure 3: Map indicating sources of vein mineral data reported in this project................................... 8

Figure 4: Horizontal-plane vein quartz/ carbonate zoning at drill hole or surface sites in the Lemieux Dome region.................................... 10

Figure 5: Horizontal-plane vein pyrrhotite/ pyrite zoning at drill hole or surface sites in the Lemieux Dome region.................................... 11

Figure 6: Horizontal-plane distribution of common fracture-filling ore minerals at drill hole or surface in the McGerrigle-Lemieux Dome region............. 12

Figure 7: Horizontal-plane boundaries of copper-quartz, zinc-quartz, and carbonate-sulphides vein zones at drill hole or surface sites in the McGerrigle-Lemieux Dome region............. 13

Figure 8: Region south of McGerrigle pluton showing detail of copper-quartz and zinc-quartz vein zone boundaries........... 15

Figure 9: Vertical-plane vein quartz/carbonate mineral distribution in drill core south of McGerrigle pluton................. 16

Figure 10: Map of Candego and Madeleine mine area showing relations between the copper-quartz, and zinc-quartz vein zones of Figure 7, and zones characterized by a relatively high proportion of dark to white calcite at calcite-veined surface sites............ 17

Figure 11: Vein carbonate mineral zoning relations on surface of Lemieux Dome.................. 19

Figure 12: Vein mineral assemblages in Mount Brown area drill holes...................... 22

Figure 13: Map of Mid-Patapedia prospect area, showing locations of metamorphic aureoles, cross-section line N-S of Figure 14, and drill holes used to construct this cross-section................ 24

Figure 14: Vein mineral zoning trends at the Mid-Patapedia showing....................... 26

Figure 15: Vein mineral distribution in the St-Benoit-de-Matapedia alteration aureole.................................. 30

Figure 16: Vein mineral assemblages in the Basket Brook prospect....................... 33

Figure 17: Vein mineral assemblages observed in, and best assays obtained from, holes drilled in the Carleton Sb-Pb prospect area............................. 36

Figure 18: Map of SOQUEM Robidoux prospect area, showing drill hole locations with respect to the Grand Pabos Fault, and cross-section line E-W..................... 39

Figure 19: Vein mineral zoning trends in SOQUEM Robidoux',0,gauche showing................. 40

Figure 20: a) Distribution of altered rocks intersected by drill holes. b), c), d): ppm Zn, Pb and Ag in best metalized core (includes vein and disseminated sulphides)................... 42

Figure 21: Vein mineral assemblages in the Soquem Reboul prospect area................ 44

Figure 22: Schematic representation of horizontal-plane spatial relations between copper-quartz (CQ), quartz (ZQ) and carbonate-sulphides (C) vein zones in Gaspesian granite-associated mineralized systems......................... 48

Figure 23: Location map for vein calcite samples used in the fluid inclusion study........... 52

Figure 24: Location of vein quartz samples used in the fluid inclusion survey.............. 53

Figure 25: Percent abundance of A) LVS inclusions, and B) LLV inclusions, in total fluid inclusion population in vein quartz samples........................ 55

Figure 26: Average homogenization temperatures of A) LV, B) LVS, and C) LLV inclusions in vein quartz samples........... 58

Figure 27: Average melting points of A) ice in LV inclusions, B) CO in LLV inclusions, C) clathrate hydrate LLV inclusions, in vein quartz samples.................................... 59

Figure 28: Average homogenization temperatures, in °C, of fluid inclusions in vein calcite.................................... 60

Figure 29: a) Vertical zoning of Type 1 inclusion average homogenization temperatures in vein calcite. b) Sample locations........................... 61

Figure 30: Average melting points, in °C, of CO and ice in vein calcite fluid inclusions................................. 62

CHAPTER 1

INTRODUCTION

1. INTRODUCTION

The aim of this study is to investigate vein mineral and thermal zoning at selected Gaspesian granite-associated mineralized regions and to determine the extent to which this zoning resembles trends at previously studied type areas. The results of this investigation will be of use in the construction of a generalized metallogenic and exploration model for this deposit type in this area. A comprehensive elucidation of such a model is beyond the scope of this report; however important trends will be highlighted and discussed.

Recent research on Gaspesian granite-associated ore deposits has shown that they occur within vein systems mappable for 50 to 100 km^2 around a particular deposit (Figure 1). Vein mineral assemblages are zoned towards the economic deposits, which occur in the central portions of the vein systems. The Q-Cu-Fe, Q-Zn-Pb, and carbonate vein zones of Figure 1 are named after vein mineral assemblages, characteristic of those zones, which are visible in hand sized specimen. The large scale at which this zoning is developed and the fact that it is mappable on outcrop scale, suggests that this mapping technique holds considerable promise as a method of locating buried ore deposits. Similarities in zoning patterns between different regions suggests that such zoning could form the basis of a metallogenic model for this type of deposit.

Fluid inclusion thermal mapping results from the Federal mine area, and the Candego/Madeleine mines region, show that economic deposits occur in high-homogenization temperature zones localized in the central portions of the vein systems described above (Federal mine area: Stevens [1986]; Candego/Madeleine area: Stevens [1987]). Fluid inclusion data are therefore a useful complement to vein mineral mapping surveys in localizing favourable places in which to look for ore, and could be integrated into a metallogenic model.

This report presents new vein mineral and thermal mapping data obtained from selected regions described below. The aims of the mapping are twofold: 1) to improve the database on which a metallogenic/exploration model can be built, and 2) to locate zones in which future exploration efforts should be directed.Specific goals of this project, given below, range from the filling-in of data gaps in

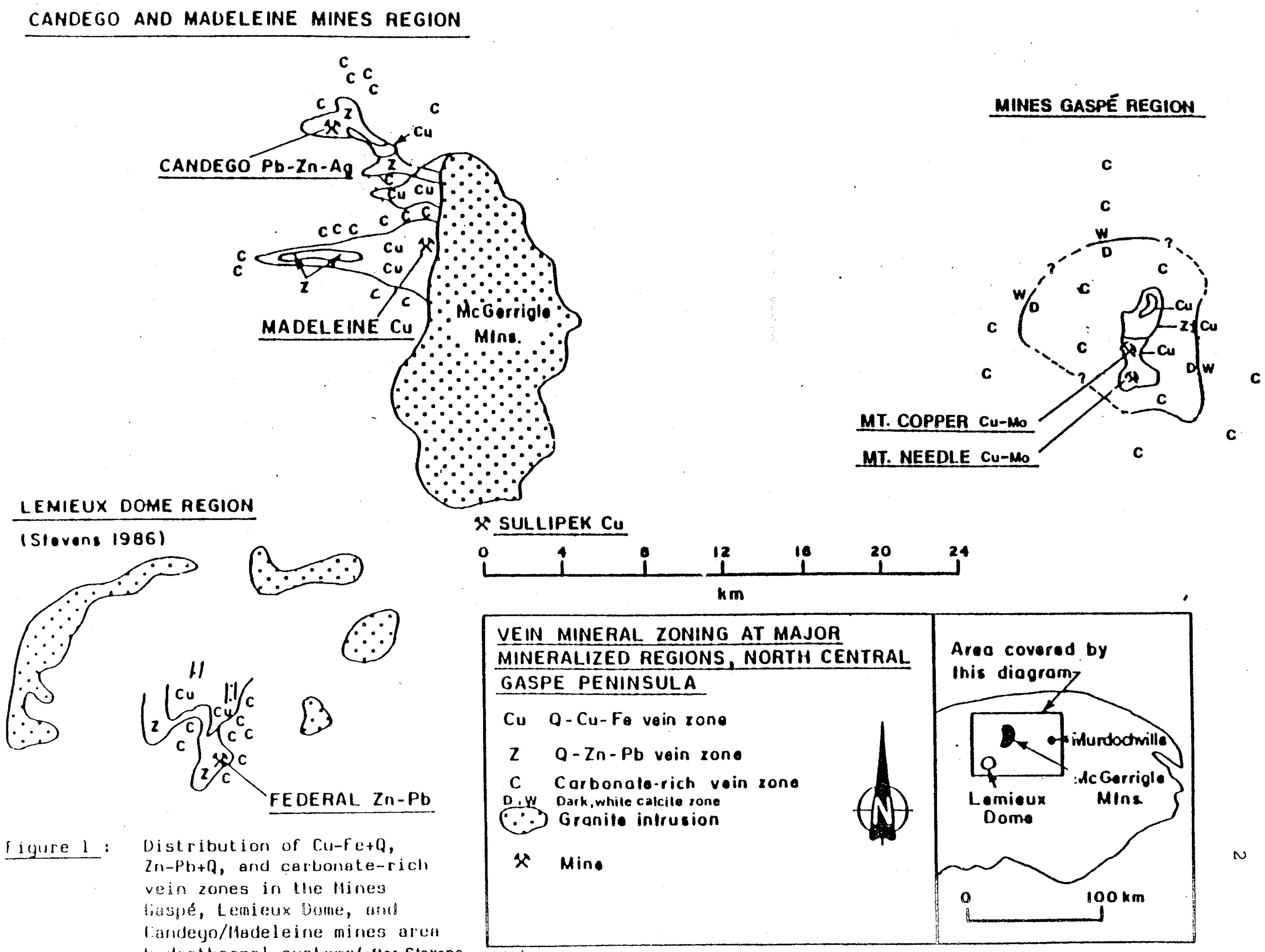


Figure 1 : Distribution of Cu-Fe+Q, Zn-Pb+Q, and carbonate-rich vein zones in the Mines Gaspé, Lemieux Dome, and Candego/Madeleine mines area hydrothermal systems(after Stevens, 1989b)

well-studied areas, to mapping previously unsurveyed territory.

2. SPECIFIC GOALS

LITERATURE VEIN MINERAL SURVEY

Vein mineral zoning is described at sites listed below, using data obtained from publicly available sources such as exploration company assessment files, government reports, theses, and articles in scientific journals. The surveyed regions are localized on Figure 2, and were selected on the basis of a known or probable association of mineralization with felsic intrusive rocks:

1) the "granite belt" of the north central part of the peninsula: the region extending from the south of the Lemieux Dome to the northern end of the McGerrigle granitic pluton,

2) the Mount Brown region,

3) selected sites in the southern part of the peninsula.

FIELD MAPPING OF VEIN CALCITE COLOUR ZONING

Vein calcite colour zoning data will be presented for the Lemieux Dome and Candego/Madeleine mines areas, to permit comparison of this zoning between these two regions and the relatively well-studied Mines Gaspé patterns. The required data was obtained by means of field traverses, and inspection of drill cores.

THERMAL MAP OF THE MINES GASPE AREA

The Mines Gaspé orebodies (Copper, Needle Mountain) occur in the quartz-rich part of the Mines Gaspé vein system (Stevens, 1989b); fluid inclusion data of Shelton (1983) show that the Copper/Needle Mountain area is a thermal centre or part of one. Shelton did not map the entire quartz-rich part of the vein system, so the extent of the Copper/Needle Mountain thermal centre, or whether it is the only one present, is unknown. A fluid inclusion homogenization temperature survey has therefore been carried out on the Mines Gaspé vein system. Fluid inclusion melting point data were collected from selected samples.

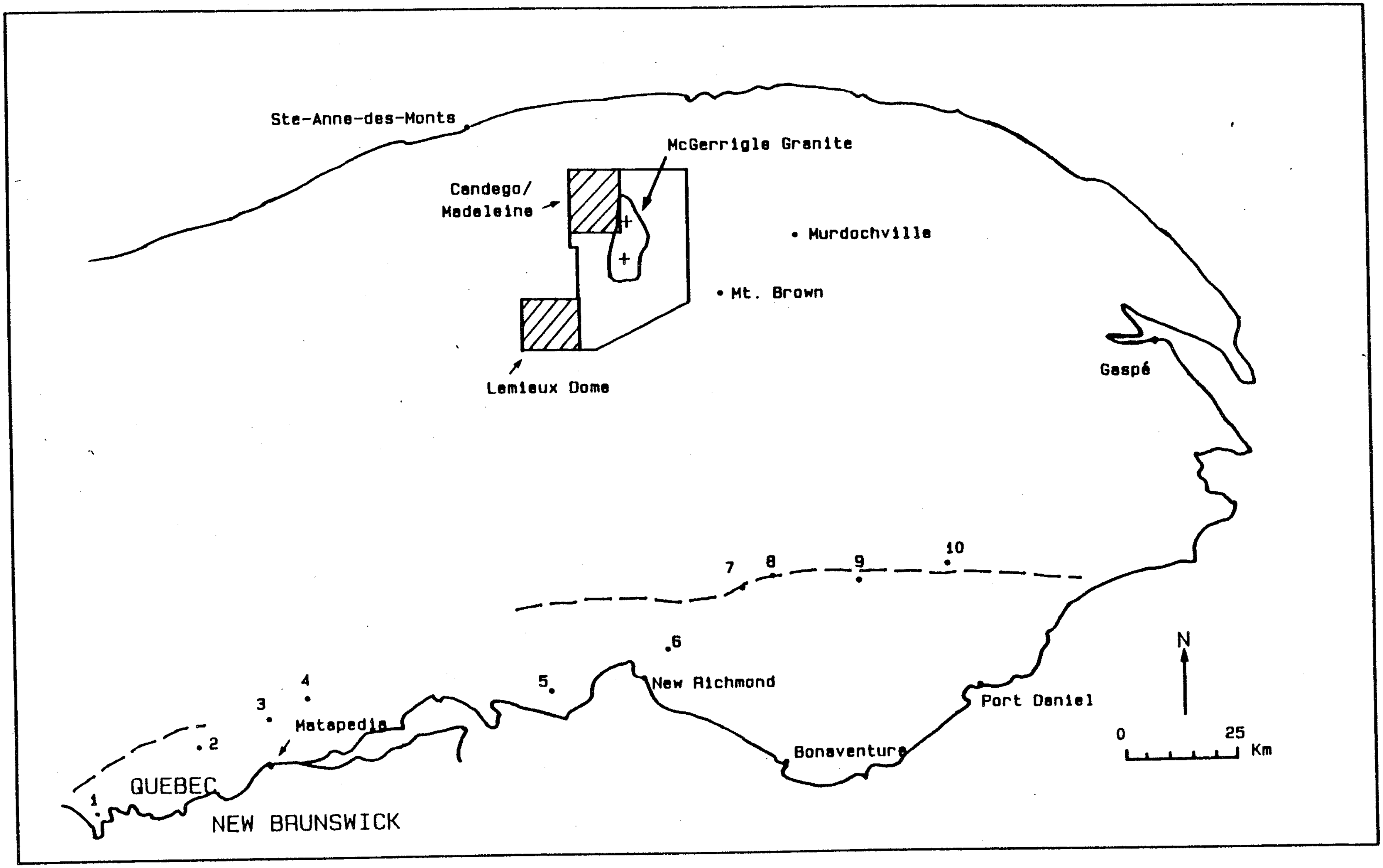


Figure 2 : Map of Gaspé peninsula showing regions mapped in this project . In the McGerrigle-Lemieux Dome area, shaded and blank areas indicate previously mapped regions, and regions mapped in this project, respectively. Numbered sites are also examined in this report. Dashed lines are faults.

CHAPTER TWO

VEIN MINERAL ZONING SURVEYS

1. VEIN MINERAL ZONES IN THE TYPE AREAS

The principal aim of the vein mineral mapping is to test whether the zoning model deduced for the Mines Gaspé, Candego/Madeleine, and Lemieux Dome areas, is applicable to mineralization in other localities. It is therefore convenient to designate these three areas as type areas, and the vein mineral zoning model developed for these areas becomes a yardstick against which trends in other regions can be compared. For this reason it is worthwhile summarizing the essential points of the type model, as understood at the outset of this project. The following paragraphs are intended as an introduction to previous work. For a more detailed account of vein mineral zoning patterns in the type regions, the reader is referred to Stevens (1986; 1987; 1989b).

The type model comprises three zones with similar spatial relationships in each type area (see Figure 1): a quartz-Cu-Fe zone, a quartz-Zn-Pb zone, and a carbonate ± sulphides zone. For simplicity, these three zone names are hereafter shortened to copper-quartz, zinc-quartz, and carbonate-sulphides zone, respectively. The zones are distinguished by characteristic assemblages of common vein minerals:

copper-quartz zone:

Cu-Fe-sulphides and/or Fe-sulphides and/or Fe-oxides with or without quartz or molybdenite. Up to 15% carbonate minerals can be present in the (quartz + carbonates) portion of the vein.

zinc-quartz zone:

Zn- and/or Pb-sulphides with or without quartz or Cu-Fe-or Fe-sulphides. Up to 15% carbonate minerals can be present in the (quartz + carbonates) portion of the vein.

carbonate-sulphides zone:

carbonate minerals with or without 0 to 84% quartz in the (quartz + carbonates) portion of the vein. Various sulphide minerals may be present.

Zoning described herein refers to the horizontal plane. In the type areas copper-quartz veins are concentrated in the core zone of the vein system, and are spatially associated with areas in which felsic intrusions and/or visible rock alteration are most abundant. Commercial concentrations of copper mineralization are associated with this vein type (e.g. the Copper and Needle Mountain deposits at Mines Gaspé, and the Madeleine mine). Zinc-quartz veins occur completely within to mainly outside peripheral portions of the copper-quartz zone. The richest zinc-quartz veins host important zinc-lead±precious metals deposits such as those in the Candego and Federal areas. Carbonate-sulphides veins occur inside and outside the copper-quartz and zinc-quartz zones. No ore deposit types are associated with these veins.

Still in the horizontal plane, the quartz:carbonate proportion of veins increases from periphery to core in a vein system to attain maximum values in the copper-quartz/zinc-quartz part of the system. Pyrrhotite and bornite occur mainly in the copper-quartz zone and to a lesser degree in the zinc-quartz zone; molybdenite is diagnostic of the copper-quartz zone. Sphalerite and galena have highest abundance in the zinc-quartz zone and can be common locally in the carbonate-sulphides zone. Chalcopyrite is commonest in the copper-quartz zone, and is locally abundant in the other two zones. Pyrite can be common in either or all of these three zones.

Little is known concerning vertical-plane relations between these three zones, due either to overprinting effects, or lack of topographic relief or drillcore, in localities where this zoning might conceivably be present. In a small portion of the Madeleine mine area copper-quartz zone, the latter was shown to underlie the zinc-quartz and carbonate zones (Stevens, 1987).

2. McGERRIGLE MOUNTAINS/LEMIEUX DOME CORRIDOR

The north-central Gaspesian "granite belt" extends from the southern part of the Lemieux Dome to the northern end of the McGerrigle Mountains pluton (Figure 1). The belt is a curving, northeast-trending zone, 40 km long by up to 12 km wide, and contains the largest exposed felsic intrusions in the Gaspé peninsula. The intrusions are of Devonian age, and cut Siluro-Devonian and Cambro-Ordovician sedimentary rocks in the southern and northern halves of the belt, respectively. The principal intrusion is the 100 km^2, north-trending, polyphase McGerrigle granitic complex, situated at the north end of the belt; much smaller felsic intrusions occur to the southwest. Base and precious metal mineralization is common in fractured sedimentary rocks at many localities but is rare in felsic intrusions. The richest known mineralized sites are shown in the following table.

DEPOSIT	SIZE	LOCATION
Candego mine	62,332 tonnes of 6.35 % Pb 4.28 % Zn 170 g/t Ag 0.68 g/t Au	6 km NW of McGerrigle pluton
Madeleine mine	7,876,050 tonnes of 1.15 % Cu 7.88 g/t Ag	NW of McGerrigle contact
Sulipek deposit	3,640,000 tonnes of 0.8 % Cu	2 km S of McGerrigle pluton
Federal Zn-Pb deposit	not available	18 km SW of McGerrigle pluton

Production figures from Lachance and Duquette (1977).

Production or tonnage figures are not available for the Federal deposit; however, the underground workings are only about 25% as extensive as those of the Candego mine (compare maps of Auger [1954], and Lachance and Duquette [1977], for the Federal and Candego deposits, respectively), and metal grades were similar at both deposits (Allcock [1921](Federal deposit); Lachance and Duquette [1977](Candego). It can therefore be assumed that considerably less metal was extracted from the Federal than from the Candego deposit.

LITERATURE DATA

The area mapped is shown on Figure 2. Under the present project, the work of Stevens (1986) in the Lemieux Dome region was extended by the collection of literature data and by field mapping of vein calcite colours. The only addition during this project to the work of Stevens (1987) in the Candego/Madeleine area came from field mapping of vein calcite colours. All other vein mapping data described for the granite belt in this report were obtained from literature sources, and were collected during this project.

The first part of this section presents a synthesis of all vein mineral data, except calcite colour zoning, for the entire granite belt, and integrates data obtained prior to this project with those collected during this project. Vein calcite colour zoning results will be treated later in this section. Literature data sources for areas mapped in this project are given on Figure 3 and in Appendix 1.

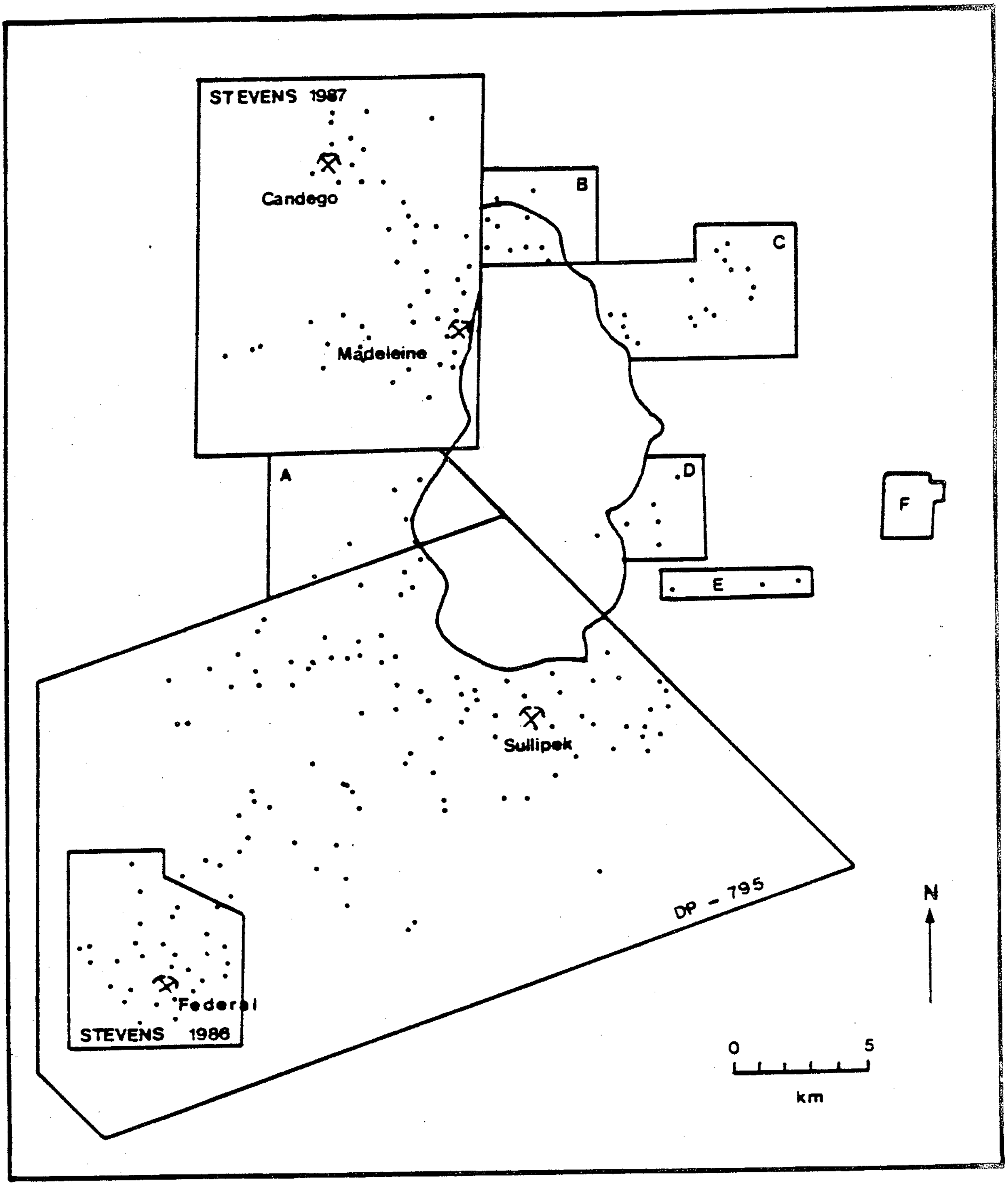


Figure 3 : Map giving sources of vein mineral data reported in this project, for each area in which these data are available. Outline of McGerrigle pluton included for reference. DP-795 is a M.E.R.Q. report number. See Appendix 1 for references for each of areas A through F.

Horizontal plane vein mineral mapping results are shown on Figures. 4, 5, 6, and 7, for quartz/carbonate, pyrrhotite/ pyrite, ore sulphides, and copper-quartz/ zinc-quartz/ carbonate-sulphides zoning trends, respectively. Most of the data sites on this figure represent drill sites; some are surface sites. In all figures, data from all elevations are projected onto a horizontal plane. Vertical plane zoning is dealt with later in ths report.

Figure 4 was prepared by estimating relative percent abundances of quartz and carbonate minerals at each drill hole or surface site. Where data sites were examined by the writer, quantitative boundary percent values were determined. Thus on the Lemieux Dome, there is ≤20% carbonates in veins of the quartz-rich zone, and this figure is ≤15% for the quartz-rich zones of the Candego/Madeleine area. Where data is completely from literature sources, quartz was qualitatively estimated as being more or less abundant than, or having an abundance equal to that of, carbonate minerals, based on reported vein widths and frequencies of occurrence. For areas mapped in this fashion, quartz-rich zones were defined as areas in which quartz is more abundant than calcite.

Figure 4 shows that quartz-rich vein zones are best developed on the west side of the McGerrigle pluton. Here there are three linear, east-trending zones up to 11 km long. The northern two contain the Candego and Madeleine deposits. Relatively small, east-trending quartz-rich vein zones occur on the east side of the pluton, at positions which are approximately along strike from the large quartz-rich vein zones on the west side of the pluton. An approximately circular, 4 km-diameter quartz-rich zone is centred on the Lemieux Dome and contains the Federal deposit. Isolated quartz-rich zones of relatively small dimensions are present locally south of the McGerrigle granite contact. The Sullipek deposit occurs in one of these small zones.

The distribution of fracture-filling pyrrhotite and pyrite is depicted on Figure 5. The pyrrhotite zones enclose areas characterized by the presence of pyrrhotite ± pyrite; outside these zones only pyrite is present. Figure 5 shows that vein pyrrhotite is concentrated in linear zones up to 7 km long which follow the contact of, or project outward from, the McGerrigle pluton. The Candego and Madeleine mines each show an obvious spatial association with a pyrrhotite zone striking perpendicular to the granite contact. The Sullipek deposit is in an area characterized by rare, isolated vein pyrrhotite occurrences.

The distribution of vein ore minerals is shown on Figure 6. Chalcopyrite has the widest area of occurrence; it is

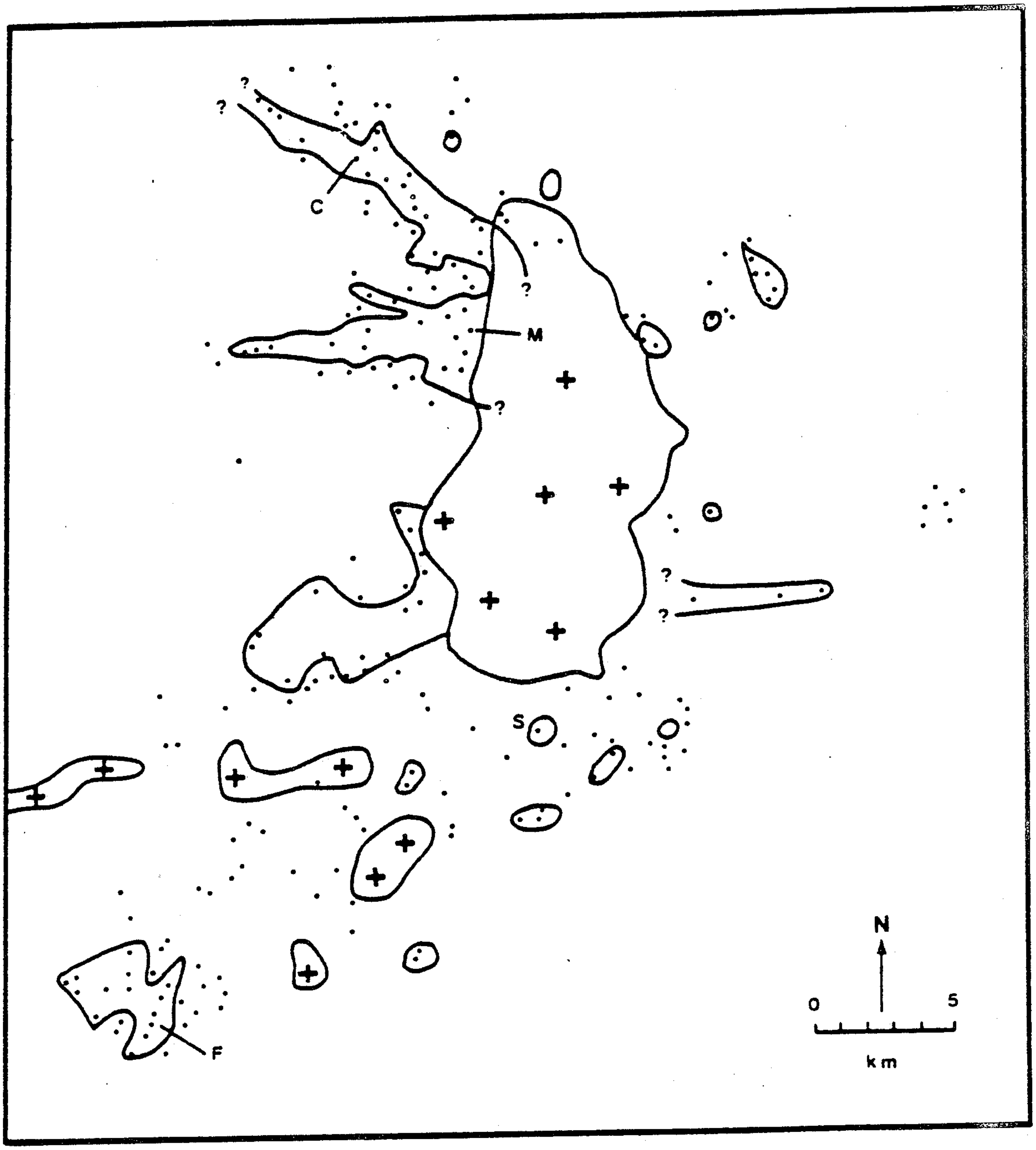


Figure 4 : Horizontal-plane vein quartz/carbonate zoning at drill hole or surface sites in the McGerrigle- Lemieux Dome region. Enclosed areas indicate where vein quartz greatly predominates over vein carbonate. See text for details. C, M, S and F are the Candego, Madeleine, Sullipek and Federal deposits, respectively. Felsic intrusions from Fig.1 included for reference.

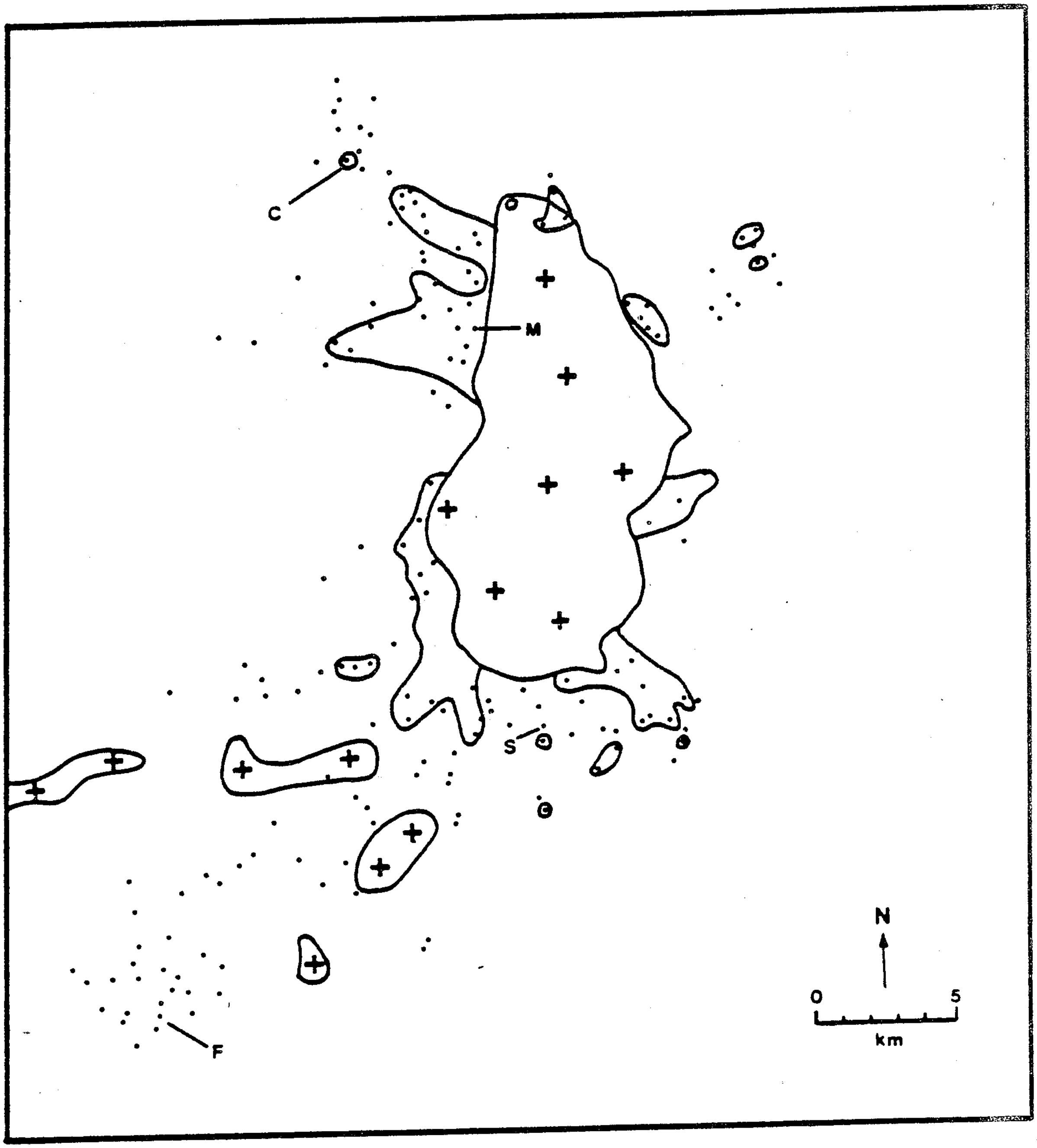


Figure 5 : Horizontal-plane vein pyrrhotite/pyrite zoning at drill hole or surface sites in the McGerrigle-Lemieux Dome region. Enclosed data points indicate presence of pyrrhotite ± pyrite; only pyrite occurs elsewhere. C, M, S and F denote the Candego, Madeleine, Sullipek, Federal deposits, respectively. Felsic intrusions from Fig.1 included for reference.

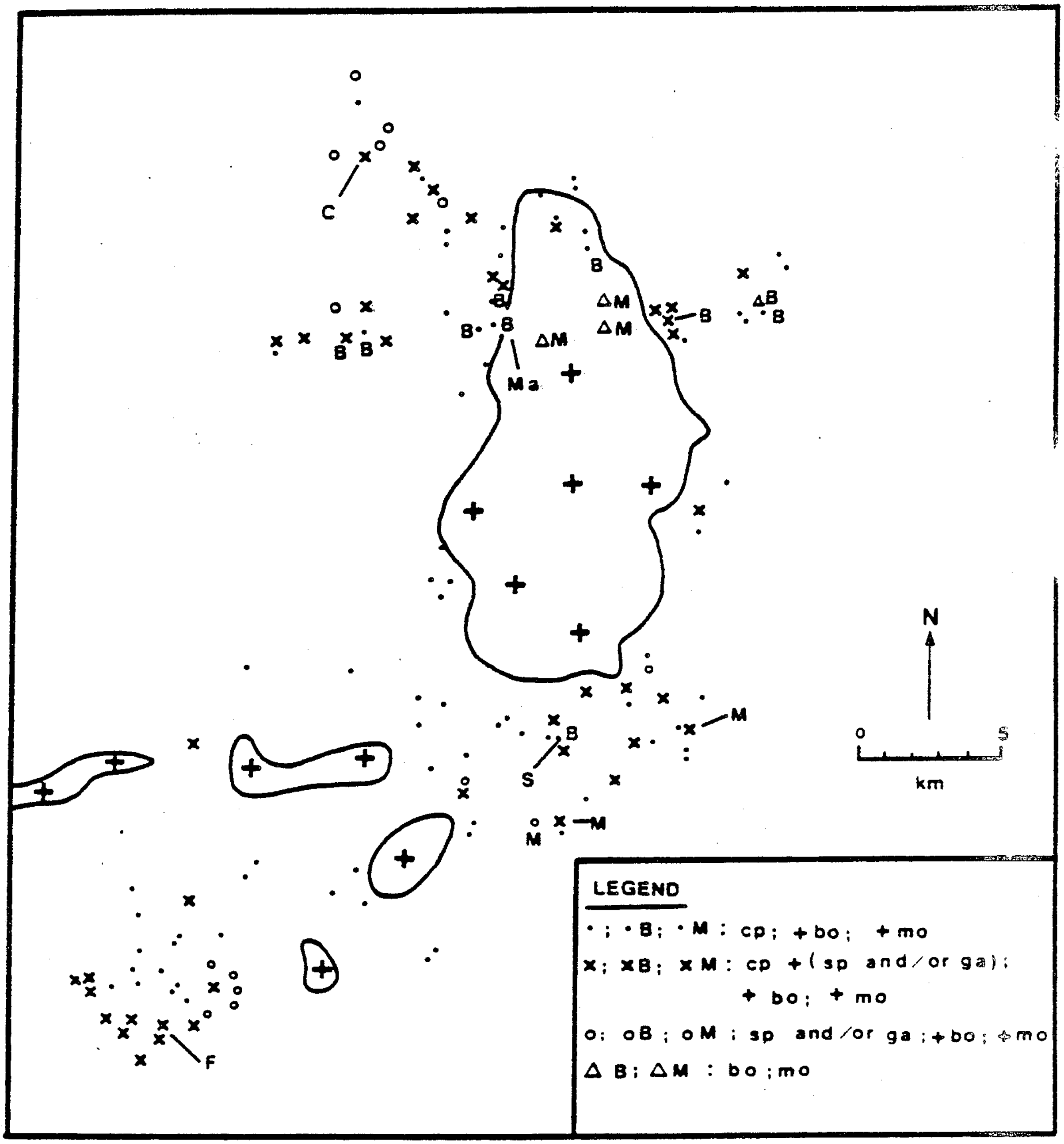


Figure 6 : Horizontal-plane distribution of common fracture-filling ore minerals at drill hole or surfac in the McGerrigle-Lemieux Dome region. See legen for key to symbols. Cp, bo, mo, sp, and ga chalcopyrite, bornite, molybdenite, sphalerite, and galena, respectively. C, M, S, and F denot the Candego, Madeleine, Sullipek, and Federa deposits, respectively. Felsic intrusions fro Fig.1 included for reference.

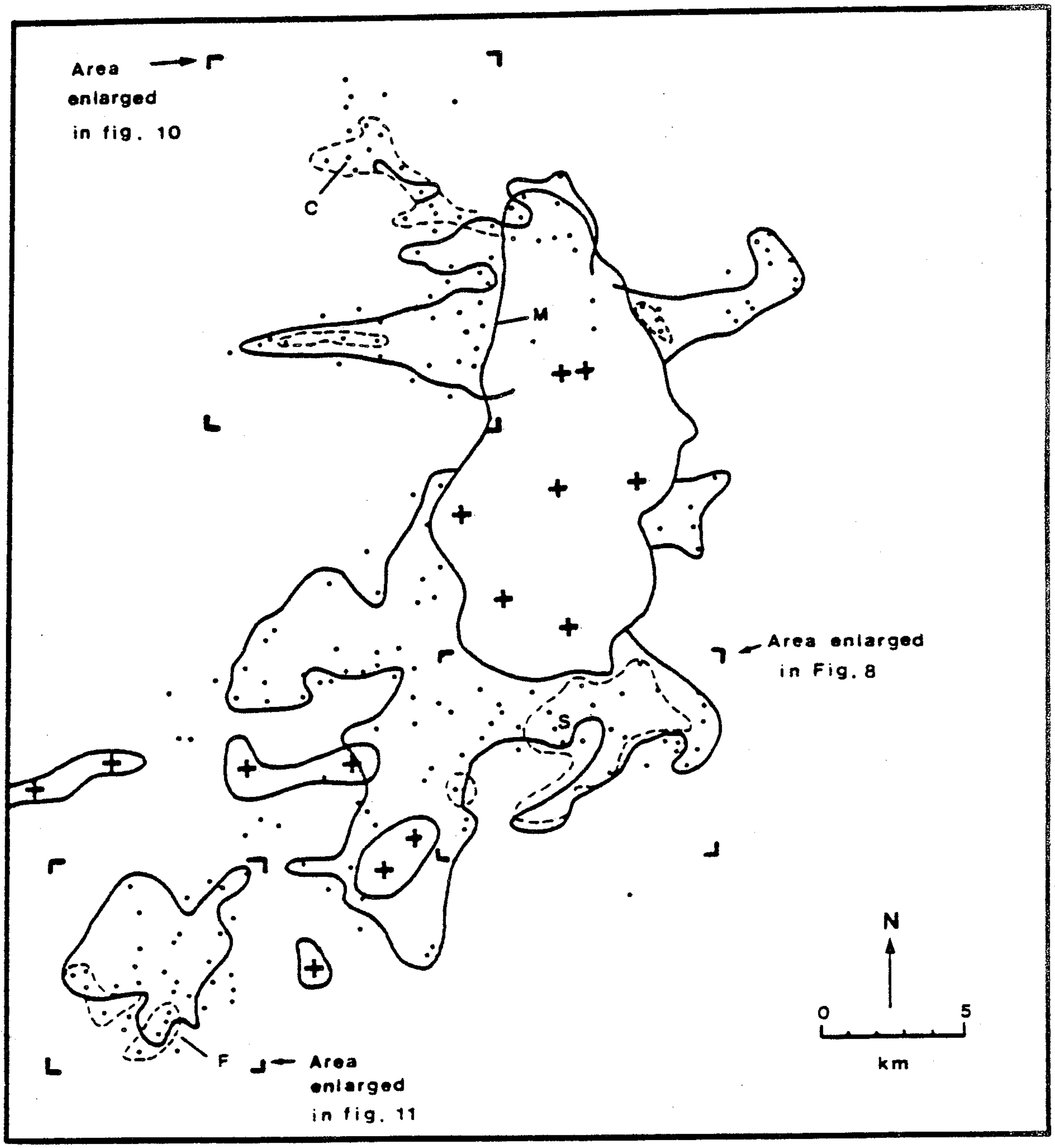


Figure 7 : Horizontal-plane boundaries of copper-quartz (solid line), zinc-quartz (dashed line), and carbonate-sulphides vein zones at drill hole or surface sites in the McGerrigle-Lemieux Dome region. Carbonates-sulphides veins occur inside and outside the other two zones. See text for definitions of these zone names. C, M, S and F denote the Candego, Madeleine, Sullipek, and Federal deposits, respectively. Felsic intrusions from Fig.1 included for reference.

absent only locally. Distinct zones where sphalerite and/or galena are abundant occur 1) in the Candego mine area, 2) 5 to 8 km west of the Madeleine mine, 3) an oval, trending zone which includes the Sullipek deposit, and 4) the southern part of the Lemieux Dome. Bornite is common at, and to the east and west of, the Madeleine mine, and is also present at Sullipek. Isolated bearing veins occur in the north-central part of the McGerrigle pluton, and at two sites to the south of the pluton.

Zoning relations among copper-quartz, zinc-quartz, and carbonate-sulphides veins are depicted on Figure 7 which shows that copper-quartz zones project outwards from the McGerrigle pluton approximately perpendicular to its contact, and are clustered about the southern third of the pluton, as well as on the east and west sides of the north-central part of the pluton. A distinct, circular copper-quartz vein zone is present in the Lemieux Dome area. Zinc-quartz zones occur within and/or outside the copper-quartz zones, at a number of locations. Carbonate-sulphides veins occur inside and outside copper-quartz and zinc-quartz zones.

The only clear evidence of vertical-plane zoning in the region covered in the literature survey comes from the area containing the zinc-quartz zone, south of the McGerrigle pluton (Figure 7). This area is shown at a larger scale on Figure 8; Figure 8 also shows the location of the line along which the cross-section of Figure 9 was constructed. Figure 9 depicts the distribution of quartz, quartz-carbonate, and carbonate veins, and shows that quartz and quartz-carbonate veins tend to occur at lower elevations than in the case of carbonate veins.

FIELD DATA: VEIN CALCITE COLOUR ZONING

Surface vein carbonate zoning trends in the Candego/Madeleine area are depicted on Figure 10, in relation to copper-quartz, zinc-quartz, and carbonate-sulphides vein zones for this same area. Figure 10 reveals that dark calcite portion of sample-site vein calcite contents is highest in two west-trending zones: one extending about 10 km west from the Madeleine mine, and another projecting about 5 km west from a point a few kilometres north of the Madeleine mine. Both zones narrow with increasing distance from the McGerrigle pluton and in both zones, dark calcite contents decrease with increasing distance from this pluton. These dark calcite zones are spatially associated with copper-quartz zones; this association is close in the case of the Madeleine mine copper-quartz zone, and less so for the northern copper-quartz zone.

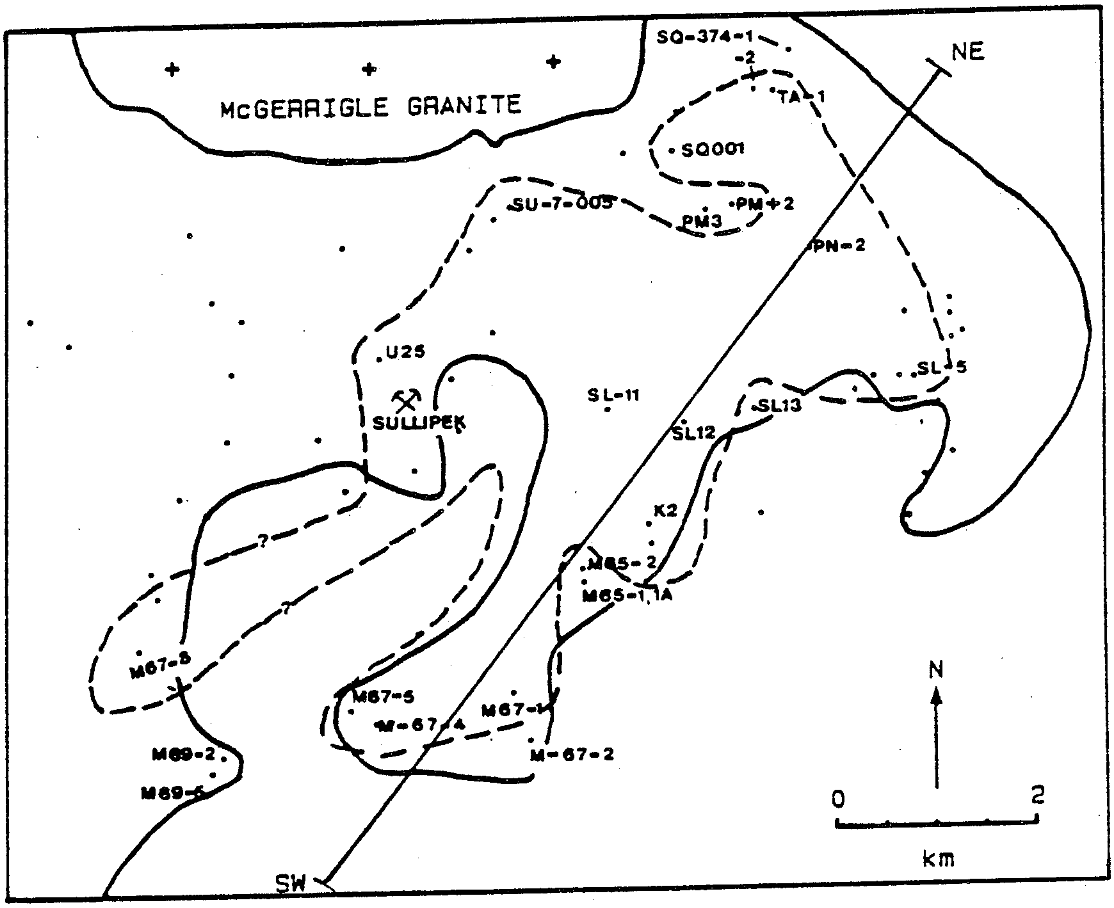


Figure 8 : Region south of McGerrigle pluton showing detail of copper-quartz (solid-line) and zinc -quartz (dashed line) vein zone boundaries; see Fig.7 for location of this figure. Points indicate drill hole sites, numbered points are holes used to construct cross-section NE-SW, shown in Fig.9.

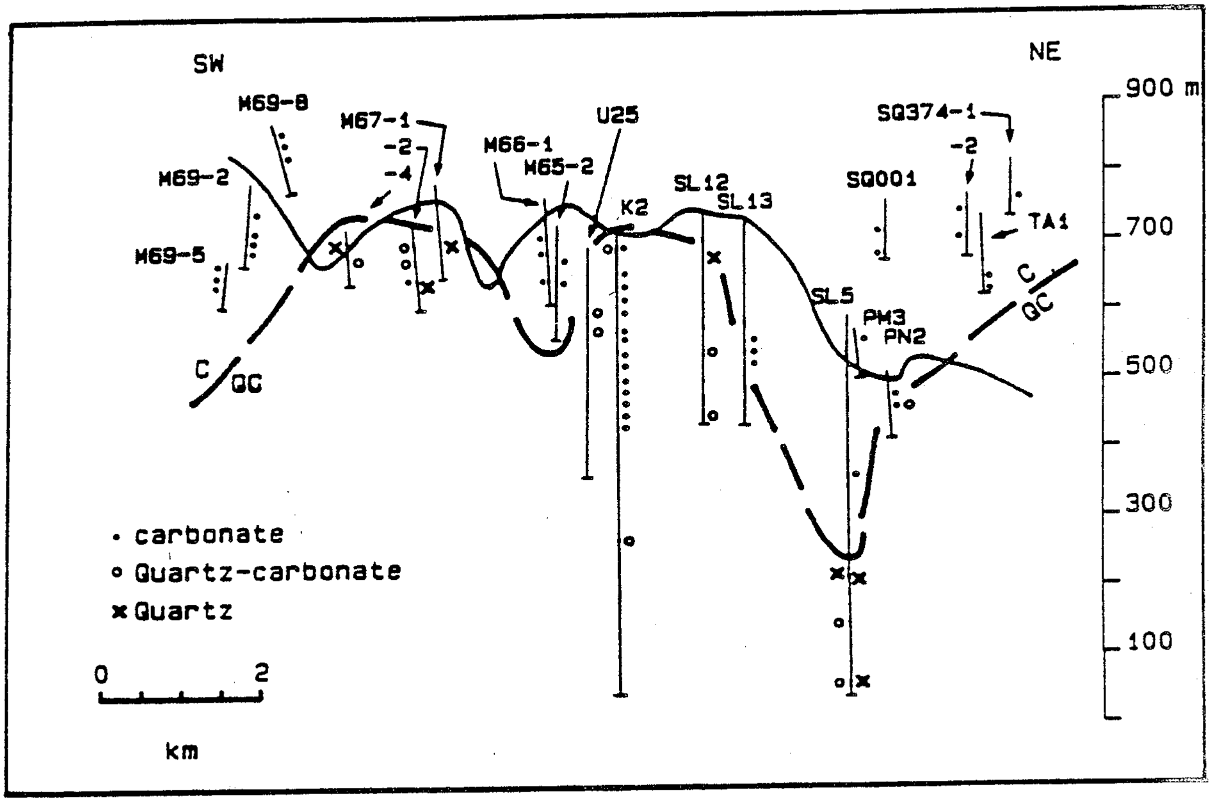


Figure 9 : Vertical-plane vein quartz/carbonate mineral distribution in drill core south of McGerrigle pluton. See Fig.8 for location of line SW-NE.

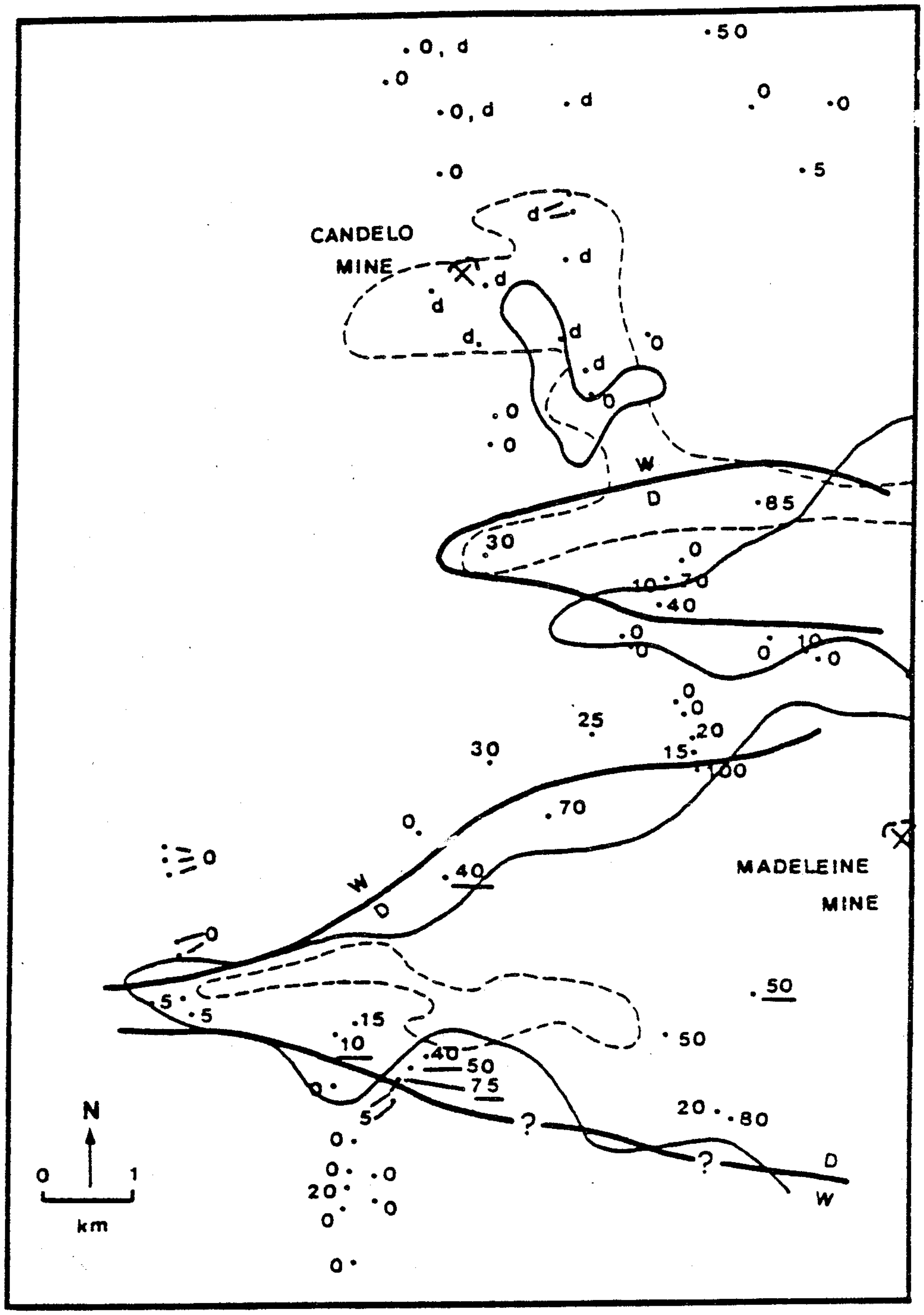


Figure 10 : Map of Candego and Madeleine mine area showing relations between the copper-quartz (thin solid line), and zinc-quartz (dashed line) vein zones of Fig.7, and zones characterized by a relatively high proportion of dark to white calcite at calcite-veined surface sites (heavy solid line). Numbers indicate percent dark calcite in the total sample-site vein calcite content; underlined percent values indicate sites where white calcite veins cut dark calcite veins. "d" indicates that dolomite is present or is the only vein carbonate mineral.

White calcite veins cut dark calcite veins at four widely-separated localities, indicated on Figure 10 by underlined dark calcite percentage numerals.

The other interesting feature of Figure10 is the transition from light-coloured vein calcite to dolomite as the dominant vein carbonate mineral, with increasing proximity to the Candego ore veins.

The search for vein calcite colour zoning on the Lemieux Dome was concentrated on the east and southeast sides of the dome. It is here that quartz/carbonate and ore mineral zoning patterns are best developed (Stevens, 1986), and it was believed that the best chances of detecting vein calcite colour zoning would occur here as well. A number of sites on the centre of the dome and on the northern periphery were also checked.

Surface vein carbonate zoning on the Lemieux Dome is shown on Figure 11, in relation to copper-quartz, zinc-quartz, and carbonate-sulphides zones for this area. Dolomite is by far the most common vein carbonate mineral present. Only one small area was found in which calcite predominates: this is on the eastern periphery. In this small area, dark calcite is the commonest at the southwestern-most two of the six sites mapped.

A number of drill cores from the central part of the dome were also searched for dark calcite. It was found only in hole 204, localized on Figure 11. The following table summarizes dark/white calcite, calcite/dolomite, and opaque mineral zoning trends in hole 204.

Vein calcite colour*	Ore Sulphide minerals	Gangue Carbonate minerals
0-135 D >> W	0-424 cp,py,hem	0-242 dol>> cal
135-382 W >> D	424-607 py,hem	242-607 cal >> dol
382-394 D >> W		
394-607 W >> D		

* Drill hole intervals in metres.

The preceding observations indicate that dark calcite is rare on the Lemieux Dome and does not form well-defined, large-scale zones. These data also show that dolomite predominates in or near areas in which sphalerite and/or galena have highest abundance, whereas calcite is the dominant vein carbonate mineral distal to sphalerite-galena-bearing zones (compare Figs. 11 and 6).

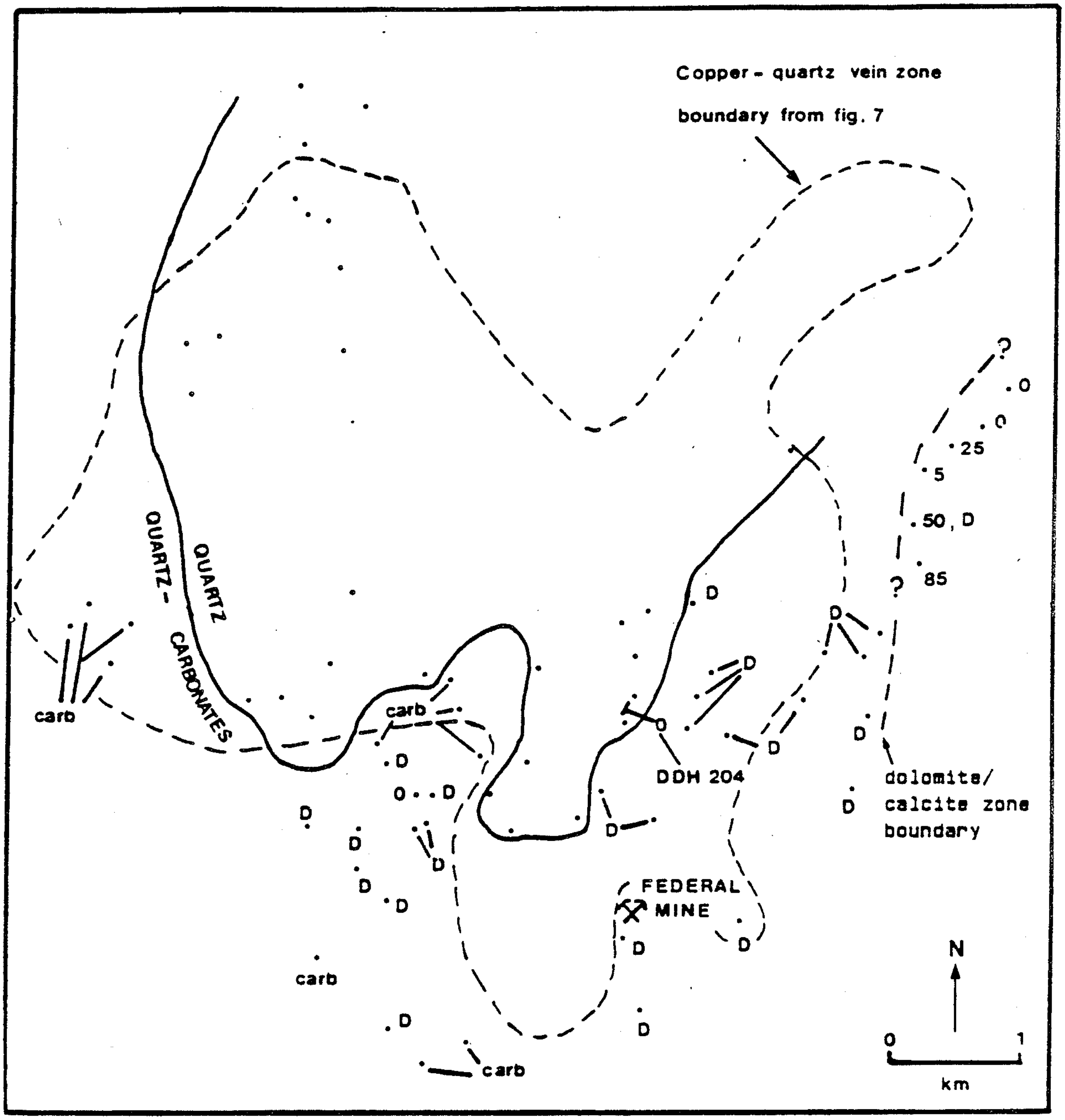


Figure 11 : Vein carbonate mineral zoning relations on surface of Lemieux Dome; see Fig.7 for location of this figure. No carbonate minerals occur at data-sites on the north-central part of the map area. At carbonate vein-bearing data sites, D means that dolomite is present or is the only carbonate mineral; a number such as 85, is the percent of dark calcite in the total vein calcite content; carb denotes unidentified carbonate minerals. Diamond drill hole 204 is referred to in the text.

DISCUSSION

Figure 7 shows that veined areas throughout the granite belt are characterized by the presence of central zones of copper-quartz and/or zinc-quartz veins, and peripheral carbonate-sulphides veins.The occurrence of the Sullipek deposit in a quartz-rich part of a copper-quartz vein zone is in keeping with the mode of occurrence of rich deposits, with respect to vein zoning patterns, in the type areas. Similarly, the increase in abundance of quartz with depth in the area south of the McGerrigle pluton finds a parallel in the carbonates + quartz to quartz downward zonation observed in the Madeleine mine area (Stevens, 1987). The restriction of pyrrhotite and bornite occurrence in newly-mapped areas around the McGerrigle pluton, to within copper-quartz or zinc-quartz zones, corroborates well with known trends in the Madeleine, Candego, and Mines Gaspé areas.

The most important previously-undocumented vein zoning feature revealed by the mapping of this project is the detection on the northeast and south sides of the McGerrigle contact of zinc-quartz zones which occur completely or to a large extent in the central parts of their associated copper-quartz zones. As previously described, zinc-quartz zones in the type areas are associated with the peripheral portions of the copper-quartz zones. Another important new feature is the small size, in the horizontal plane, of quartz-rich zones contained within the copper-quartz zones which emanate outwards from the northeast and south sides of the McGerrigle pluton. Quartz-rich vein zones in the type areas occupy substantial portions of copper-quartz and zinc-quartz zones. The occurrence of molybdenite in sphalerite-galena-bearing veins south of the McGerrigle pluton (Figure 6) has not been reported from the type areas.

In the Madeleine mine area, the dark/white calcite zoning pattern converges on, and has a similar shape to, the copper-quartz zone which contains the Madeleine mine. This suggests a genetic relation between development of this calcite zoning pattern and ore-forming processes within the copper-quartz zone. A similar link between dark/white calcite zoning and ore-formation in the Mines Gaspé ore system was suggested by Stevens (1989b). In contrast to the two preceding areas, dark calcite is rare to absent in the Candego and Lemieux Dome regions. Dolomite is common in veins at these latter two areas, and is rare in the Madeleine and Mines Gaspé areas. The preceding observations strongly suggest a genetic link between dolomite deposition and Zn-Pb±Ag deposit formation on the one hand, and dark calcite deposition and Cu±Mo deposit formation on the other.

3. ISOLATED GRANITE-ASSOCIATED PROSPECTS

Each of the eleven prospects treated in the following sections constitutes an isolated and presumably distinct occurrence of felsic intrusion-associated mineralization, and is localized on Figure 2. In each case only literature data are used to map vein mineral trends. The references consulted for each area are listed at the end of each section. GM numbers are M.E.R.Q. assessment work reports filed by exploration companies.

MOUNT BROWN

The Mount Brown area (Figure 2) is situated 20 km southwest of Murdochville, in the southwest corner of Bonnécamp Township. Very small amounts of chalcopyrite and sphalerite have been discovered in or near the altered sedimentary host rocks of a diabase dyke swarm from 1 to 4 km northeast of Mount Brown.

GEOLOGICAL SETTING

Calcareous rocks of the Gaspé limestone series underlie the northwest two-thirds of the Mount Brown area; these calcareous rocks grade into York River sandstones in the southeast third of the area (Figure 12). Near the contact between these two sedimentary sequences, the sedimentary pile is cut by the Mount Brown syenite porphyry plug. Another mass of felsic intrusive rocks was revealed by holes W-1 to W-4, drilled about 2 km southwest of Mount Brown. Relatively narrow diabase dykes or sills are common north and south of Mount Brown. Sedimentary wallrocks of the northern diabase group commonly exhibit progressive bleaching and progressive loss of calcite towards diabase. These alteration features are unevenly developed about a given intrusion and there is no relation between size of intrusion and size or intensity of the enveloping aureole.

Occurrences of hydrothermal mineralization are described below, along with the hole(s) in which they were observed:

1) local pyrrhotite, disseminated or in veinlets, in altered sedimentary rocks (hole 84-02),

2) pyrrhotite-chalcopyrite over 0.15 m in skarn (mode of occurrence not stated) (hole L-3),

3) local calcite-sphalerite veins in diabase adjacent to 2),

4) common calcite veins which cut intrusive rocks, and altered and unaltered sedimentary rocks (all holes),

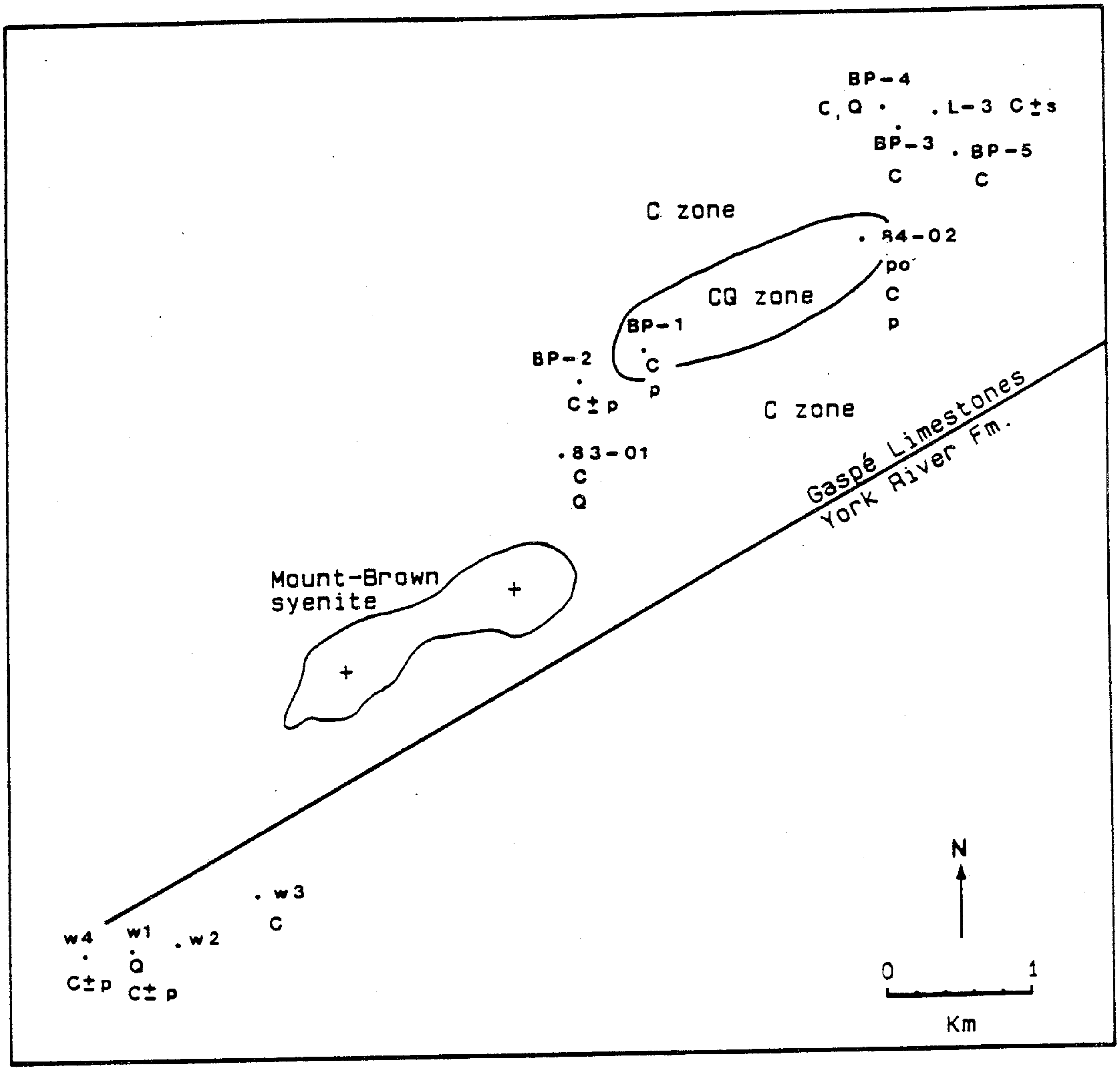


Figure 12 : Vein mineral assemblages in Mount Brown area drill holes. C = calcite, Q = quartz, p = pyrite, po = pyrrhotite, s = sphalerite. CQ and C zones refer to copper-quartz and carbonate-sulphides vein zones described in the text. Base map after Landry (1982) in GM 42870.

5) local calcite-pyrite veins cut unaltered sedimentary rocks (hole BP-2) or porphyry (holes W-1, W-4),

6) rare, local pyrite veinlets cut unaltered sedimentary rocks (hole BP-1) or diabase (hole 84-02),

7) rare, local quartz veins cut intrusive rocks (holes BP-4, W-1, 83-01).

VEIN MINERAL ZONING, DISCUSSION

Horizontal plane vein mineral data appear on Figure 12. There are no vertical zoning trends.

By applying the vein-type nomenclature of the proposed regional model to the Mount Brown area veins, it is apparent that copper-quartz veins occur in only two holes in the northeast part of the map area (holes BP-1, 84-02), whereas carbonate veins are present at all localities. This suggests that the area cut by these two holes was a hydrothermal centre or part of one. We can speculate that the hole in which pyrrhotite veinlets were observed is closer to the system's centre than the one in which only pyrite veinlets occur: pyrrhotite-pyrite zoning at other Gaspesian granite-associated mineralized areas has shown that pyrrhotite is diagnostic of the core zone of a hydrothermal system.

REFERENCES: GM numbers 18389, 18916, 21118, 34232, 39909, 41131, 42870.

MID-PATAPEDIA

The Mid-Patapedia showing (site 1, Figure 2) is a vertical chimney of sulphide-rich material located on the Quebec (north) side of the Patapedia River in the extreme southwest Gaspé peninsula. It has been evaluated as containing 4,000,000 tons of 0.25 % Cu and 17 g/T Ag.

The major observable feature of the hydrothermal system which produced this occurrence is a 2.5 km-diameter metamorphic aureole situated on the New Brunswick (south) side of the river (Figure 13). The Mid-Patapedia prospect is the only important hydrothermal feature on the Quebec side of the provincial boundary. Vein mineral data from New Brunswick sites were not available to this writer; it must therefore be recognized that the following account concerns only a small portion of the Mid-Patapedia system, albeit the most economically interesting portion known to date.

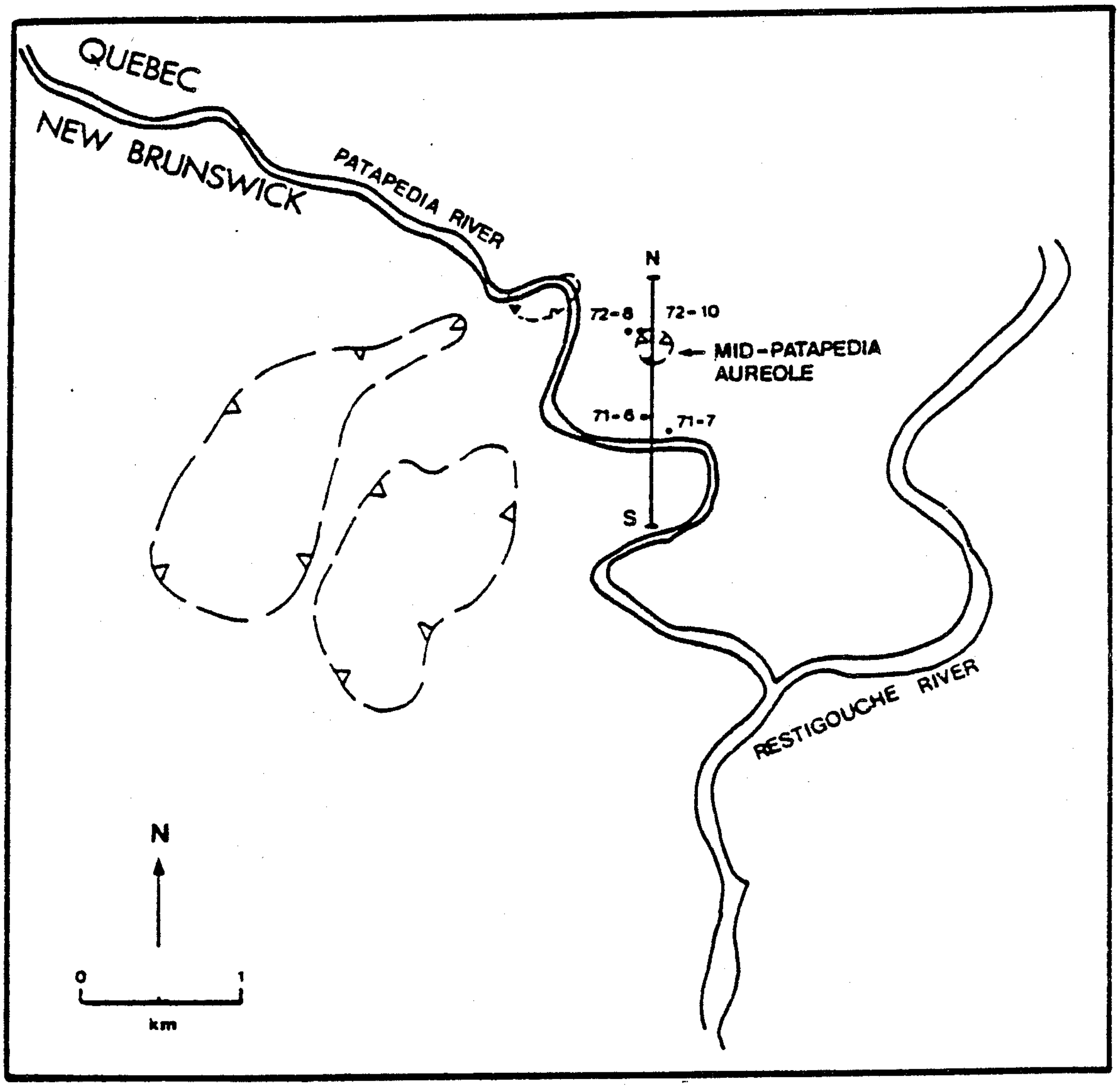


Figure 13 : Map of Mid-Patapedia prospect area, showing locations of metamorphic aureoles, cross-section line N-S of Fig.14, and drill holes used to construct this cross-section. Geological data from Williams-Jones (1982) and Lachance (1974).

GEOLOGICAL SETTING

The metamorphic aureole on the New Brunswick side of the river in fact comprises several distinct bodies of hornfelsed rocks, developed in limestones and argillaceous limestones of the Matapedia Group. The latter sedimentary group is also the host of the Mid-Patapedia chimney. Small felsic porphyritic dykes are common on both sides of the river, and have a average northeast trend, parallel to that of local sedimentary strata.

The mineralized chimney has surface horizontal-plane dimensions of 90 by 18 m and is oriented northwest. Drilling has shown it to be continuous downward for at least 300 m. The rocks surrounding the chimney are visibly altered (bleached) in an approximately 240 m-diameter aureole centred on the chimney. Most of the sulphide-bearing material within the chimney comprises concordant or discordant (with respect to bedding) masses or veins of sulphides which are commonly rich in carbonate minerals. Quartz is abundant locally. The relative abundance of sulphide minerals is pyrrhotite >>> pyrite > chalcopyrite > arsenopyrite > galena > sphalerite.

VEIN MINERAL ZONING

Vein mineral zoning is best observed in the vertical plane (Figure 14). The horizontal-plane location of Figure 14 is shown on Figure 13. The following changes take place from surface to depth or as the showing is approached:

1) the gangue mineral assemblage changes from carbonate to carbonates ± quartz, or rarely, quartz only,

2) pyrite gives way to pyrrhotite ± pyrite as the diagnostic Fe-sulphide assemblage,

3) the ore mineral assemblage changes from sphalerite-galena to sphalerite-galena-chalcopyrite to chalcopyrite. In addition, arsenopyrite becomes more common.

4) by expressing vein types in terms of the hypothesized model for the northern Gaspesian type areas, we see that a zone of carbonate-sulphides veins gives way to a zone in which carbonate-sulphides and copper-quartz veins are common.

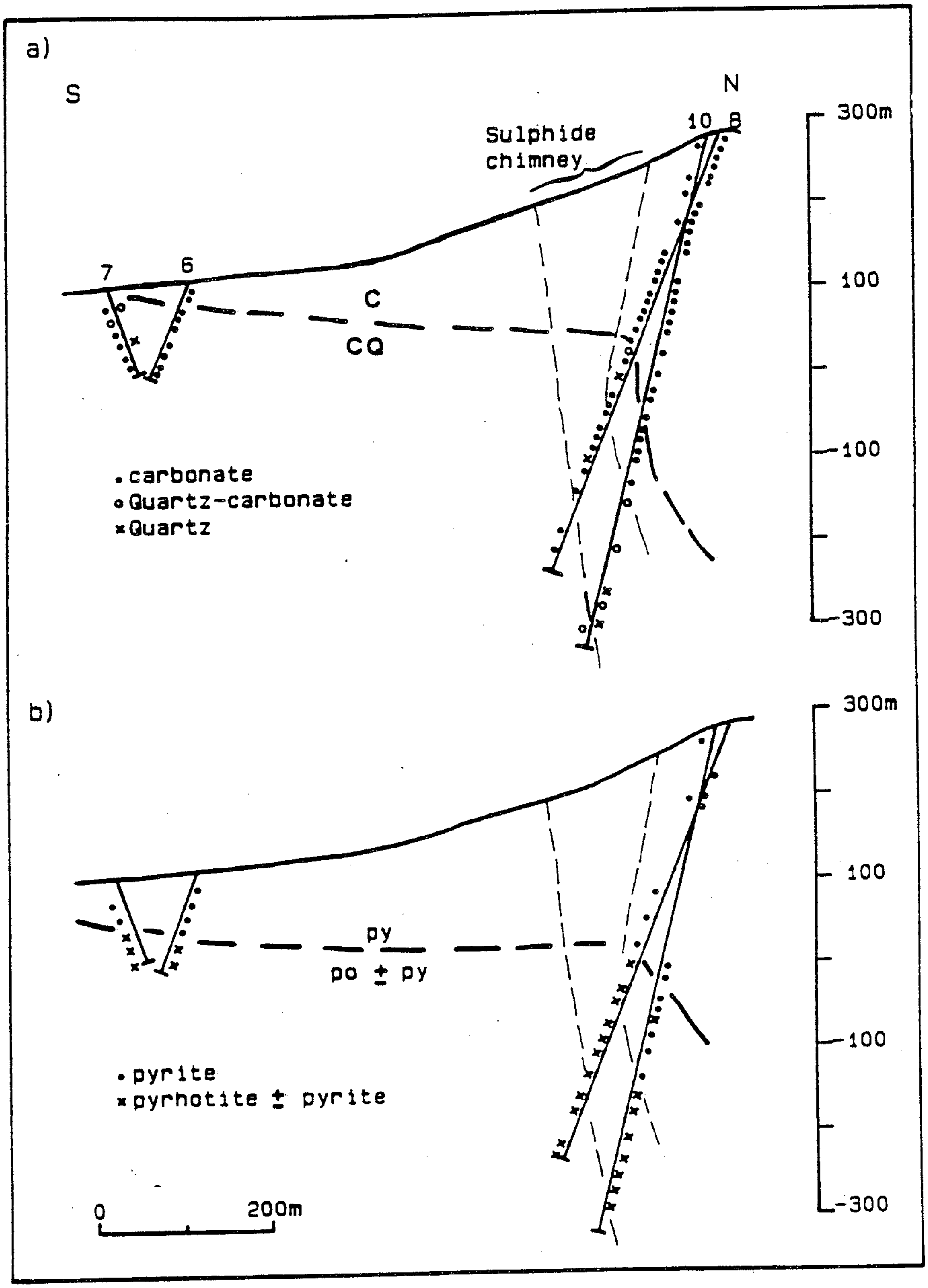


Figure 14 : Vein mineral zoning trends at the Mid-Patapedia showing: a) quartz/carbonate, b) pyrite/pyrrhotite, c) ore sulphides, d) copper-quartz, zinc-quartz and carbonate zones. Line N-S localized on fig. 13.

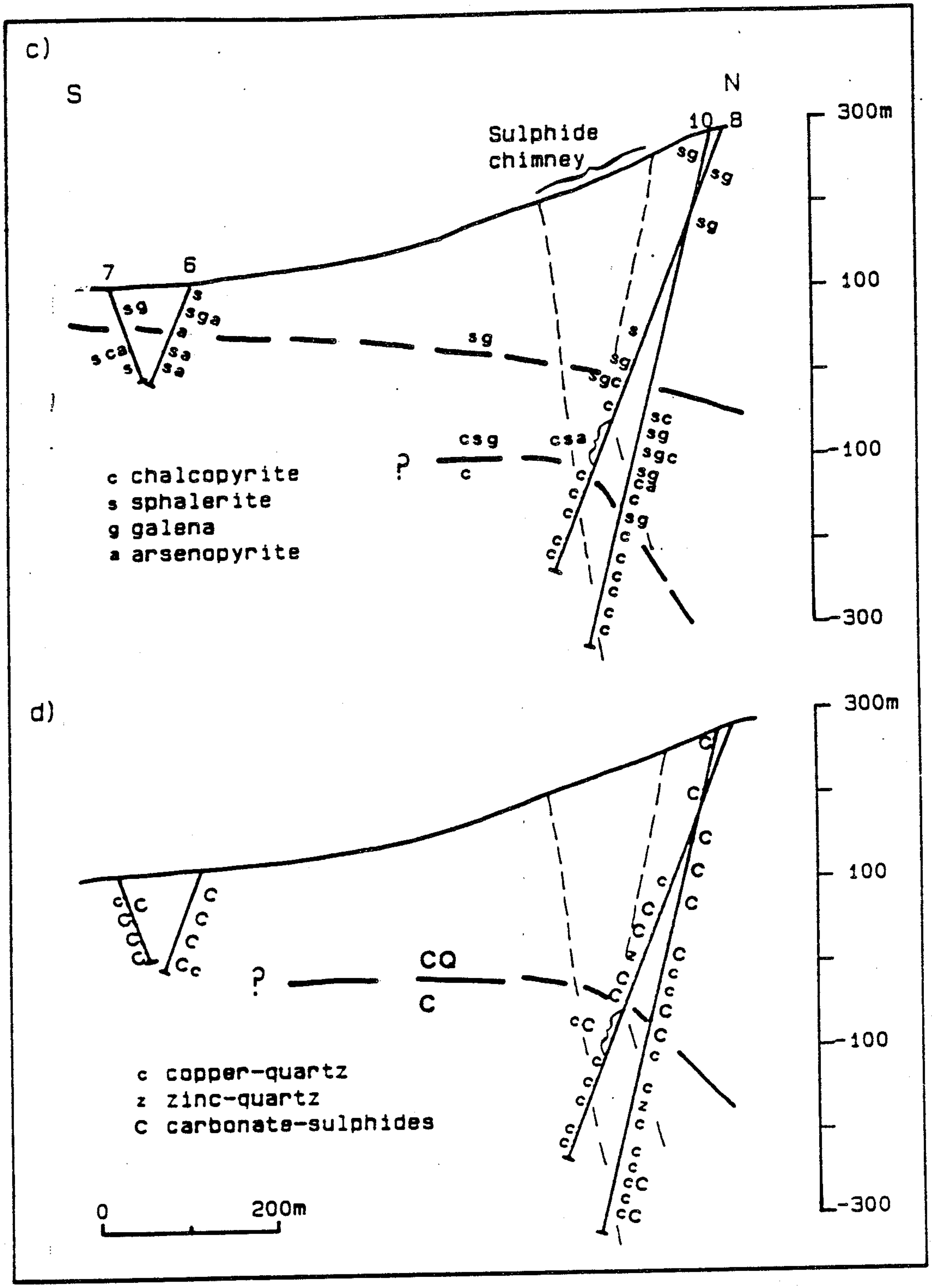


Figure 14 : continued.

DISCUSSION

The concentration of copper-quartz veins in the sulphide chimney, with carbonate veins occurring within and without the chimney, is in keeping with observations in the type areas that the former and latter vein zones are core and peripheral hydrothermal facies, respectively. In addition, a trend of copper-quartz veins becoming more common with depth has been documented in the Madeleine mine area (Stevens 1987).

The other vein mineral zoning patterns described above also occur at one or more of the type areas. A calcite to quartz transition towards ore zones is present in each type area. A change from pyrite to pyrrhotite towards ore is observed in the Mines Gaspé and Madeleine mine areas. In each type area zones of Cu-Fe-sulphide minerals are surrounded by zones in which Zn-Pb-sulphides are abundant. Finally, arsenopyrite in the Candego area occurs in the central zinc-quartz veins but not in peripheral sulphides veins.

Although only a small part of the Mid-Patapedia system has been examined, vein zoning trends in this portion are similar in all respects to those observed in the type areas. The fact that carbonate gangue is much more abundant than quartz may indicate that the Mid-Patapedia showing occupies a peripheral location with respect to a hydrothermal centre situated on the south side of the Patapedia River. However, with the limited data available the possibility of an inherently quartz-poor system cannot be ruled out. Note, for example, that parts of the copper-quartz zone south of the McGerrigle granite contact are quartz-poor, at least on surface (compare Figures. 4 and 7).

It is concluded that the type area model is applicable to the Mid-Patapedia area.

REFERENCES: Lachance (1974), Williams-Jones (1982), Savard (1985), GM numbers 28542, 29013.

ST-BENOIT-DE-MATAPEDIA

The St-Benoit-de-Matapedia showing occurs in the smaller of two alteration zones situated in or near the village of the same name (site 2, Figure 2). Best-mineralized drill intersections from the smaller aureole are on the order of 4.11 g/T Au over 1.52 m. or 1.56% Cu +7.54 g/T Cu over 0.21 m.

GEOLOGICAL SETTING

The alteration aureoles are developed in argillaceous limestones of the Matapedia Group. Alteration effects, metal values, and intrusive rock abundance are all much higher in the smaller than the larger of the two aureoles.

The smaller aureole (Figure 15) measures 680 by 80 m., trends northeast-southwest, and cuts bedding at a low angle. Altered rocks comprise marble and calc-silicate hornfels, and are clearly associated with felsic porphyritic intrusions which are small and numerous. Most altered rocks and intervening widths of porphyry contain disseminated sulphides: pyrite-pyrrhotite ± chalcopyrite ± galena ± bornite. This disseminated mineralization commonly extends into unaltered rocks near the altered sections. Fracture-filling mineralization is rare, and comprises four vein types:

1) one or more of pyrite-pyrrhotite-chalcopyrite ± galena ± bornite,

2) quartz-pyrrhotite ± pyrite-chalcopyrite,

3) quartz-calcite-sphalerite-pyrite,

4) non-sulphide-bearing quartz and/or calcite veins. All vein types except possibly 3) cut altered and unaltered rocks. Type 3) veins are known only from dump samples.

METAL TRENDS

The best grades of economic metals are obtained from disseminated sulphide-bearing sections of (altered rocks +porphyry) in the southwest end of the alteration aureole. Copper values are much higher in the southwest than in the northeast. Gold is absent in the northeast, has relatively low abundance in the middle of the alteration aureole, and is relatively abundant in the southwest.

VEIN MINERAL ZONING

Horizontal- and vertical-plane zoning is discernable among Cu-Fe sulphides in vein types 1) and 2) above (Figure 15). From northeast to southwest and from depth to surface, we see three successive zones characterized by the presence of diagnostic minerals: 1) pyrite, pyrrotite, 2) pyrite, pyrrotite, chalcopyrite, 3) pyrite, chalcopyrite, bornite. Sphalerite-bearing dump samples come from a shaft sunk into the upper part of the pyrite-chalcopyrite-bornite zone.

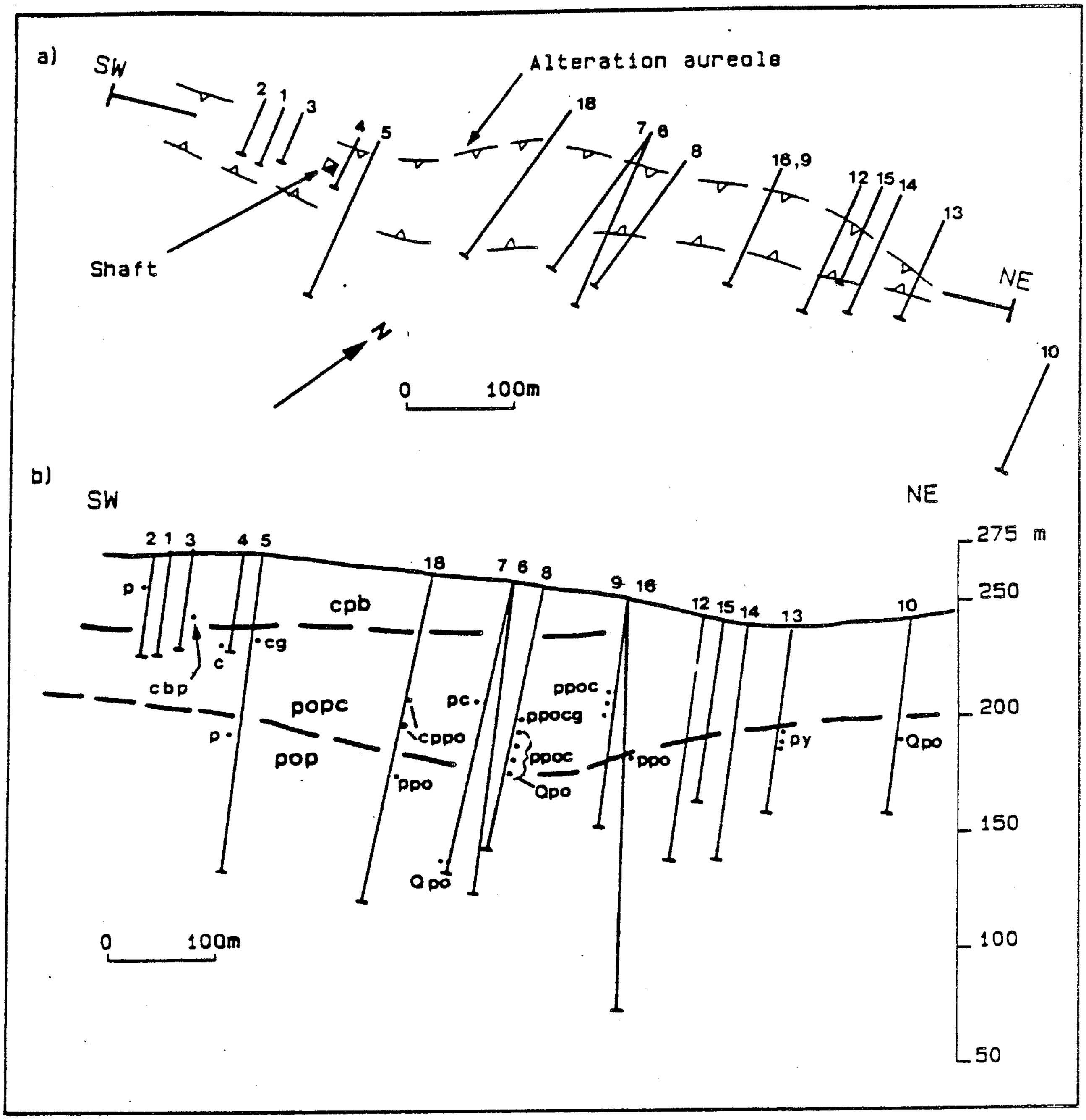


Figure 15 : Vein mineral distribution in the St-Benoit-de-Matapedia alteration aureole : a) plan view, b) cross-section along line SW-NE. b = bornite, c = chalcopyrite, p = pyrite, po = pyrrhotite, g = galena. Plan after Lachance (1977).

Sulphide-bearing quartz veins (quartz-pyrrhotite veins) occur relatively deep in the alteration zone. The only veins containing sulphides and calcite are the Type 3) veins, which occur at high elevation.

No zoning patterns are exhibited by non-sulphide-bearing quartz/carbonate veins.

DISCUSSION

In the context of a Gaspesian metallogenic model, the St-Benoit-de-Matapedia system can be said to comprise a lower copper-quartz vein zone, and a superjacent carbonate-sulphides vein zone. The system is extremely small by northern Gaspesian standards, but reproduces in miniature the following features vertical zoning features found in the Madeleine mine and Lemieux Dome areas:

1) the copper-quartz zone comprises a lower Fe-subzone and an upper Cu-Fe-subzone (c.f. Madeleine mine area [Stevens, 1987]),

2) the St-Benoit-de-Matapedia showing occurs in the Cu-Fe-subzone (c.f. Madeleine mine),

3) sphalerite is restricted to relatively high elevations, compared to the level of occurrence of the Cu-Fe-sulphide minerals (c.f. Madeleine mine, also the Lemieux Dome area [Stevens, 1986].

It is concluded that the northern Gaspesian type model is applicable to the St-Benoit-de-Matapedia prospect.

REFERENCES: Lachance (1977), GM 2822-B.

ST-ANDRE-DE-RISTIGOUCHE

This showing occurs in a 800 m by 100 m northeast-trending alteration zone, situated 2.5 km east of the village of St.-Andre-de-Ristigouche (site 3, Figure 2). The alteration is localized in the wallrocks of small felsic porphyritic intrusions which are fairly numerous within the alteration zone and strike parallel to its length. The alteration consists of low-grade calc-silicate hornfels developed in calcareous units of the Matapedia Group.

Two occurrences of sulphide mineralization are known at opposite ends of the alteration aureole: 1) at the showing site disseminated pyrite and minor chalcopyrite occurs in the altered wallrocks of a porphyry sill, and 2) 800 m southwest of the main showing, a small amount of pyrite is disseminated in the altered wallrocks of another intrusive body. Other secondary mineralization encountered in shallow (average length 60 m) drill holes spotted 0.6 to 1.2 km from the main showing in different directions consists of rare quartz and/or calcite veins.

There are no vein mineral zoning patterns relatable to the main showing, and the available data is insufficient to permit the positioning of this showing with respect to a system heat source. It seems probable that the fluids which produced the aureole carried very little base metals.

REFERENCES: Lachance (1979), GM 33808.

BASKET BROOK

The Basket Brook prospect is hosted by the smaller of two alteration aureoles located about 10 km northeast of the St.-Andre-de-Ristigouche occurrence (site 4, Figure 2). It has been evaluated as containing 170,000 tonnes of 0.57% Cu and 8.57 g/T Ag.

GEOLOGICAL SETTING

In the Basket Brook area, a narrow, northeast-trending microgranite dyke served as a structural control for the development of an alteration aureole 500 m long, up to 100 m wide on surface, and which narrows with increasing depth (Figure 16). Alteration intensity decreases away from the dyke. Pre-alteration host rocks were calcareous units of the Matapedia Group. 1.5 km southwest of and along strike from the Basket Brook aureole, there is a northeast-trending, 900 by 400 m zone of rocks less intensely altered than at Basket Brook.

Mineralization at Basket Brook occurs partly in fractures and partly in disseminated form; some of the latter is fracture-controlled. Ore minerals are mainly pyrite and pyrrhotite, accompanied by a little chalcopyrite, chalcocite, and bornite, and traces of sphalerite and galena. Fracture-filling mineralization occurs the most commonly as massive sulphides; in some cases it contains calcite gangue. Calcite veins with or without pyrite, chalcopyrite, or sphalerite, cut the main mineralized zone and nearby unaltered sedimentary rocks.

Sulphide mineralization in an aureole 1.5 km southwest of the Basket Brook aureole is rare and of local extent, and will not be considered in this investigation.

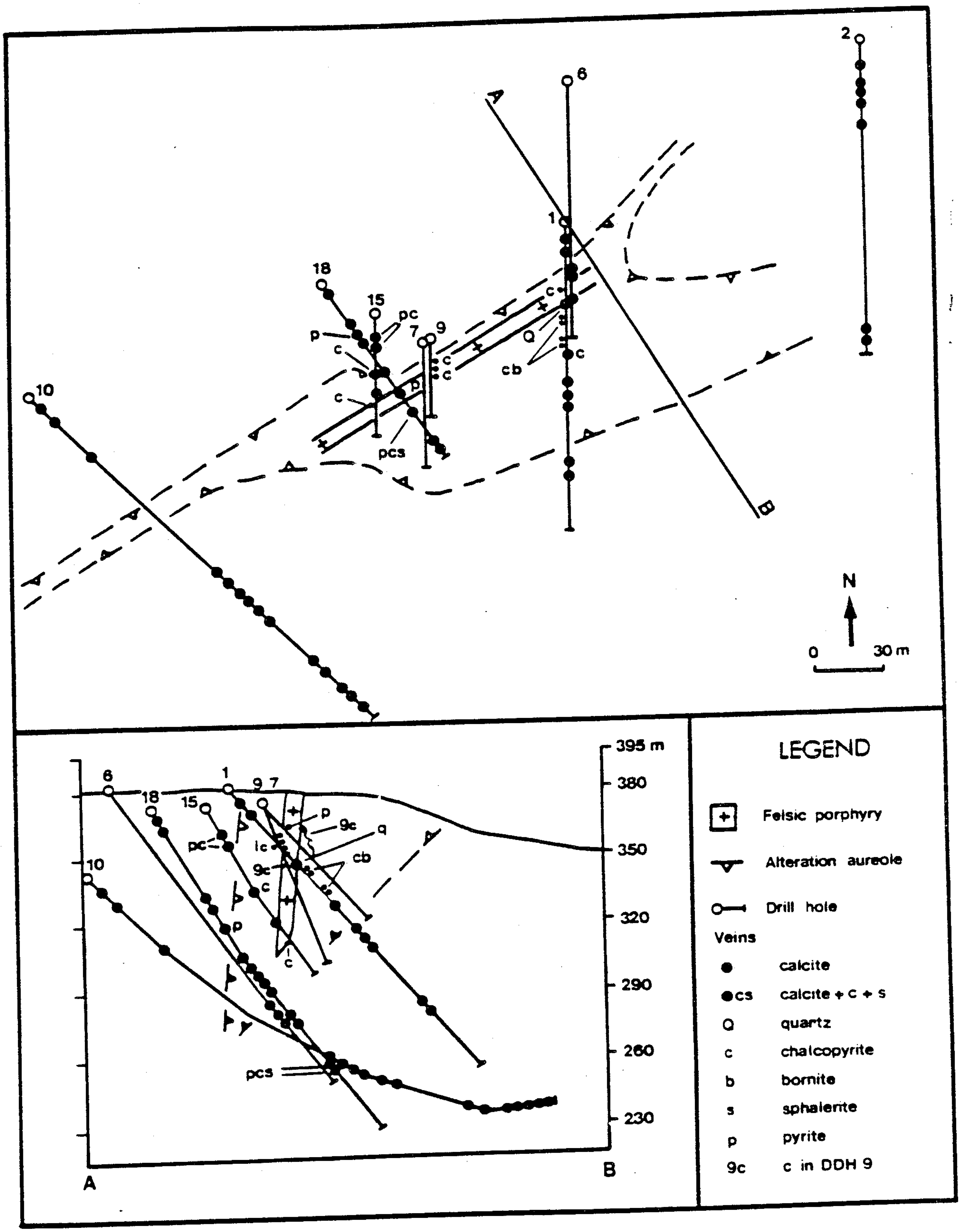


Figure 16 : Vein mineral assemblages in the Basket Brook prospect. Base map and base cross-section after Lachance (1979).

VEIN MINERAL ZONING

The distribution of fracture-filling mineralization at Basket Brook is shown on Figure 16. The following trends are displayed:

1) veins containing only Cu-Fe- or Fe-sulphides are restricted in occurrence to relatively near the microgranite dyke, and in the most intensely altered wallrocks,

2) calcite veins containing Cu-Fe- or Fe-sulphides occur mainly in or near peripheral parts of the alteration aureole,

3) barren calcite veins are common from peripheral parts of the alteration aureole, to positions well beyond the outermost occurrences of sulphide-bearing calcite veins,

4) the only quartz-bearing vein occurs near the dyke contact,

5) the only sphalerite-bearing vein occurs well outside the alteration zone.

DISCUSSION

The Basket Brook prospect can be said to comprise a core copper-quartz vein zone, and an enveloping zone of carbonate-sulphides veins, by interpreting the observations made above in terms of the vein mineral map units of the proposed regional model. The spatial disposition of these vein zones is the same as that observed in the northern Gaspesian type areas. The Basket Brook copper-quartz zone differs from those of the type areas in its low quartz content. It is similar in this respect to the near surface portions of the copper-quartz zone south of the McGerrigle pluton.

REFERENCES: Lachance (1979), GM numbers 26043, 31283.

CARLETON Sb-Pb

The Carleton showing consists of low-grade Sb-Pb mineralization contained in a felsic dyke and enclosing wallrocks, and situated about 5 km northwest of the town of Carleton (site 5, Figure 2). Best assays,in ppm, of vein and disseminated mineralization intersected in drill core are as follows:

	Cu	Pb	Zn	Sb	Ag	length of intersection
Vein	84	4600	160	660	6	0.66 m
Disseminated	1900	1300	400	110	10	not stated

GEOLOGICAL SETTING

The showing and nearby related mineralization is associated with two north-striking quartz-feldspar porphyry sills or dykes, separated from each other by 500 m, and hosted by Matapedia Group mudstones (Figure 17). The intrusive rocks are commonly weakly to intensely altered, displaying one or more of the following alteration types: epidotization, sericitization, carbonitization, and silicification. These intrusions locally contain disseminated chalcopyrite-pyrite-galena ± sphalerite. Quartz ± carbonates veins, commonly containing sphalerite and/or galena and local chalcopyrite, cut the disseminated mineralization and also sedimentary wallrocks of the intrusions. Holes drilled away from the two felsic intrusions encountered only barren quartz/carbonate veins; in one of these, there are traces of galena.

The best assays reported above are both from hole 7209 (Figure 17).

VEIN MINERAL ZONING

Two vein mineral zoning trends are discernable (Figure 17):

1) ore sulphides (sphalerite, galena, chalcopyrite) become more common from north to south,

2) dolomite is present in a central zone associated with the best-mineralized areas, whereas calcite is the vein carbonate mineral in weakly mineralized zones to the north and south. There is no vertical-plane zoning.

DISCUSSION

The Pb-rich nature of this occurrence, and evidence of a calcite to dolomite carbonate mineral zoning trend about it, strongly suggest an affinity with northern Gaspesian deposits such as the Candego and Federal deposits. The number of data points used to infer the presence of this calcite-dolomite trend may seem insufficient to some

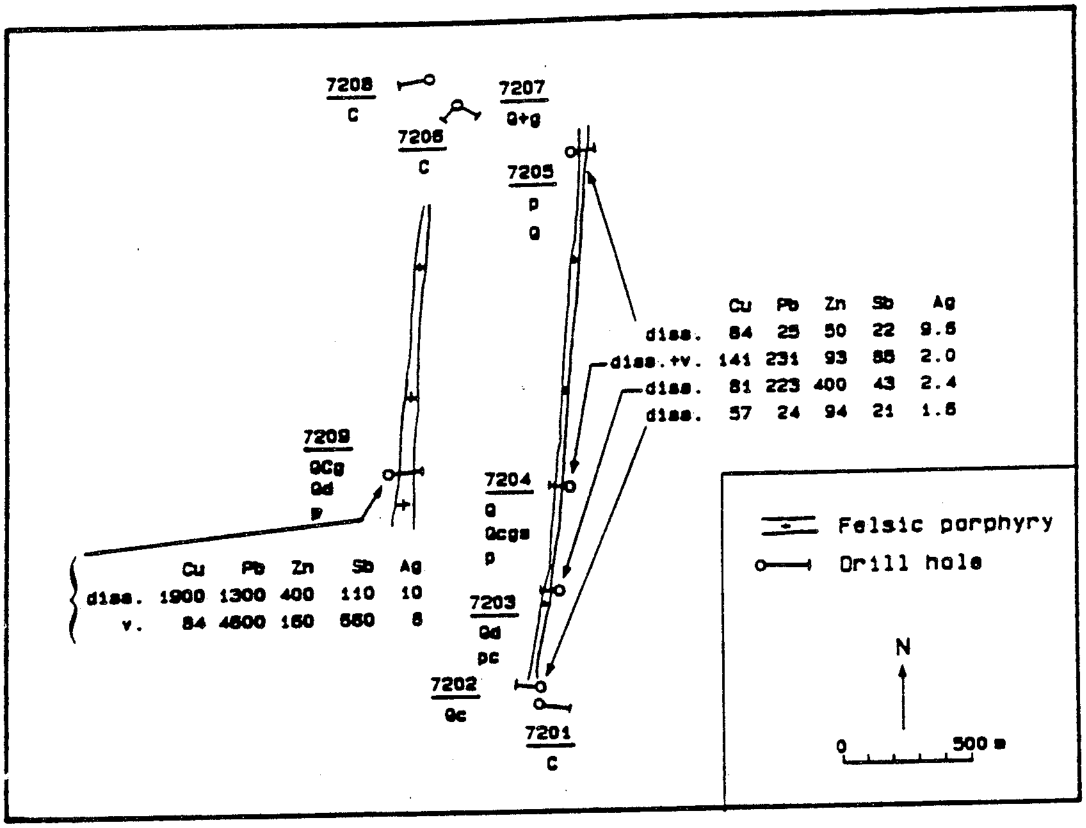


Figure 17 : Vein mineral assemblages observed in, and best assays obtained from, holes drilled in the Carleton Sb-Pb prospect area. Widths over which these metal values were obtained are not available. Diss. and v. denote disseminated and vein style mineralization, respectively. Q = quartz, C = calcite, d = dolomite, g = galena, s = sphalerite, c = chalcopyrite, p = pyrite. Base map after Simard (1986).

readers, if the Carleton showing area is considered by itself. However, it must be recognized that dolomite is a relatively rare mineral in Gaspesian granite-associated vein systems, and has a known association with zinc-lead mineralization. It is in this context that the Carleton area data assume their full significance.

The zinc-quartz veins which were the main ore producers at the above-mentioned northern Gaspesian deposits have a dolomite abundance which does not exceed 20% relative to quartz. Quartz/carbonate ratios are not reported for the Carleton veins, so it is not possible to positively identify them as zinc-quartz veins. On the other hand, a veritable zinc-quartz vein is reported in hole 7204 (Figure 17). It therefore seems reasonable to infer the existence of a zinc-quartz zone in the Carleton showing area. It follows that the calcite veins observed north and south of the showing belong to a peripheral carbonate-sulphides vein zone. Copper-quartz veins are present; these veins are not unusual in zinc-quartz zones in the type areas.

The limited evidence therefore suggests that the type area vein zoning model is applicable to the Carleton showing area.

REFERENCES: Simard (1986), GM 29056.

NEW RICHMOND Sb-Au

This showing occurs 10 km northwest of the town of New Richmond (site 6, Figure2), and consists of a single quartz vein enclosed by silicified sedimentary wallrocks. Selected samples analyzed around 1940 gave 0.75 oz./T Au and 42% Sb. Because the richest material was mined out at this time, the best values obtainable in 1982 by SOQUEM were 7958 ppm Sb and 1070 ppm Au.

GEOLOGICAL SETTING

The wallrocks of the vein are polymictic conglomerate on its east side and shale to the west; both belong to the Ordovician Honorat Formation. The vein has been exposed along strike for 25 m, and varies in width from almost 0 to 1 m. The east-wall conglomerate is silicified for up to 2.4 m from the vein; the best metal values were obtained from this silicified zone. There is no mention of which minerals besides quartz were present in the vein. The only vein mineral data reported from this showing is the occurrence within the 25 m length of exposed vein, of small quartz veins containing a little stibnite, pyrite, and chalcopyrite.

The scarcity of vein mineral data from this occurrence and absence of nearby veins make this locality unsuitable for vein mineral zoning studies.

REFERENCES: GM numbers 18613, 18614, 39686, 41654, 42700.

SOQUEM ROBIDOUX

The Soquem Robidoux showing is situated 30 km northeast of New Richmond, in Robidoux Township, near this township's eastern boundary (site 7, Figure 2). The showing contains Zn-Pb-Ag mineralization in veins and altered rocks, developed in close proximity to small felsic intrusions. Best metal values commonly obtained are: Zn: 1 to 2%, Pb: ≈0.2%, Ag: 10 to 30 ppm.

GEOLOGICAL SETTING

The showing occurs immediately south of the east-striking Grand Pabos fault (Figure 18). Host rocks south of the fault are siltstones (locally calcareous) and sandstones of the Honorat Group; Matapedia Group limestones occur north of this fault. Narrow felsic intrusions are common in the mineralized areas.

Exploration has been carried out along a 2 km portion of the Grand Pabos fault. Rock alteration is commonest in the central sector, in the vicinity of holes 7001, 7105, and 7106. Alteration types described are calc-silicate hornfels, silicification, and carbonitization. Sulphide mineralization comprises pyrite-sphalerite-galena with minor chalcopyrite, and occurs in altered rocks and in quartz-carbonate veins. The latter veins cut altered and unaltered rocks. Barren quartz-carbonate veins, cutting altered and unaltered rocks, are also present. Zn and Pb are the most abundant in the central sector (holes 7001, 7105, and 7106) (see analyses on Figure 20). Ag is on average more abundant in the eastern (holes 7002, 7107) than in the central sector.

VEIN MINERAL ZONING

There are three vein mineral zoning trends present (Figure 19):

1) there is an upper zone in which vein gangue is calcite, and a lower zone in which it is quartz and/or calcite; calcite is absent from the lowest part of this lower zone,

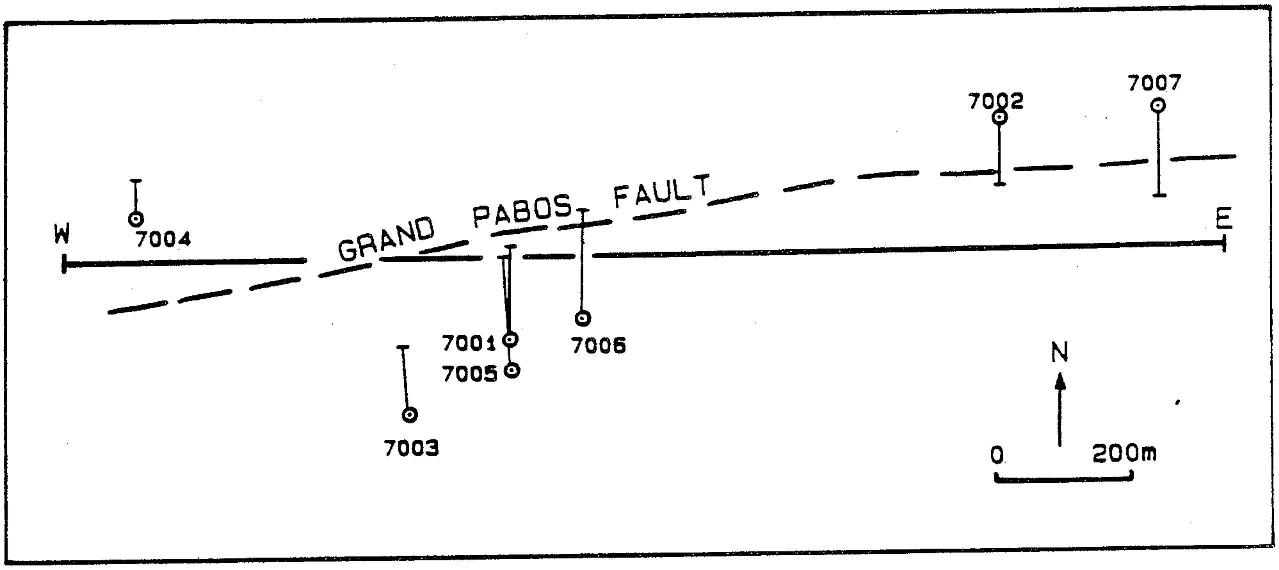


Figure 18 : Map of SOQUEM Robidoux prospect area, showing drill hole locations with respect to the Grand Pabos Fault, and cross-section line E-W. Map after Richard (1971) in GM 28011.

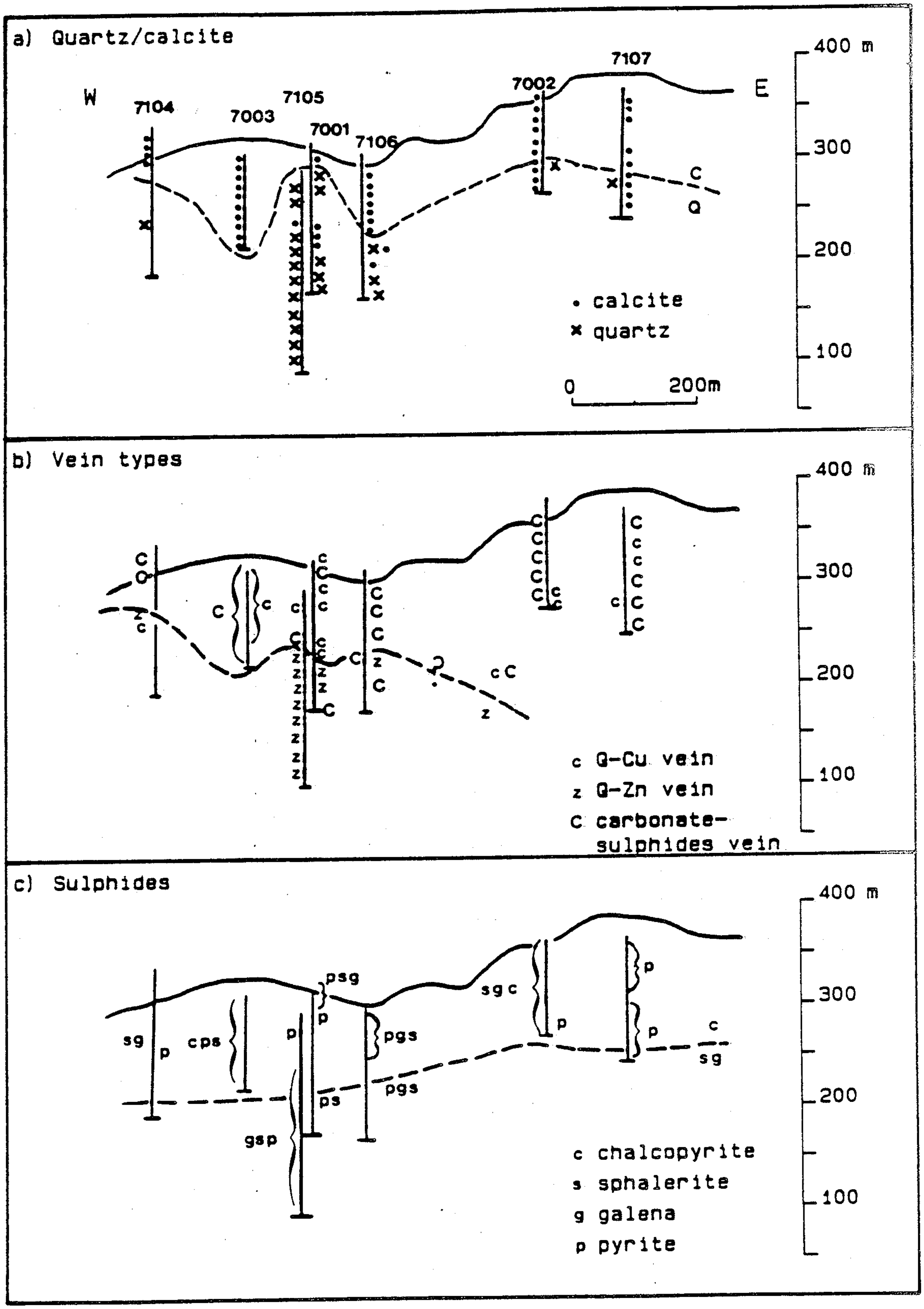


Figure 19 : Vein mineral zoning trends in SOQUEM Robidoux showing. See Fig.19 for location of line E-W in the horizontal plane. Numbers such as 7001 denote drill holes.

2) copper-quartz veins and carbonate-sulphides veins occur at medium to relatively high elevations in all explored sectors, whereas zinc-quartz veins occur at relatively low elevations and are concentrated in the central sector.

3) sphalerite and galena are common at all elevations, whereas chalcopyrite is restricted to relatively high elevations.

DISCUSSION

The Soquem Robidoux showing contains recognizable zinc-quartz, copper-quartz, and carbonate vein zones (the latter two are superimposed on each other). However, the occurrence of the zinc-quartz zone below the copper-quartz zone is the reverse of the situation observed in the Madeleine mine area, the only other area from which vertical-plane vein type zoning data concerning these two vein types is available. Likewise, the vertical zoning among chalcopyrite, sphalerite, and galena is the opposite of what occurs in the Madeleine, Mid-Patapedia, and St-Benoit-de-Matapedia areas.

Information on Figure 20 reveals a similarity between the Soquem Robidoux prospect and Zn-Pb-rich systems such as those containing the Candego and Federal deposits: occurrence of best Zn and Pb values in a quartz-rich zone. Figure 20 shows the location of the vein quartz/calcite vertical zoning boundary with respect to alteration and metallization patterns. The alteration diagram simply shows where altered rocks were intersected; it is not possible to deduce relative alteration intensities among a particular or different alteration types from the drill log descriptions. The metallization diagrams show the most economically interesting drill intersections.

Inspection of Figure 20 reveals a locality where 1) quartz-rich veining extends to highest elevations, 2) rock alteration is commonest, and 3) Zn and Pb values are highest. It is suggested that this locality is the centre of the system as thus far exposed.

It is concluded that the vein type zoning model proposed for the type areas should be modified to allow for the occurrence of vertical-plane zoning reversals between the zinc-quartz and copper-quartz zones.

REFERENCES: GM numbers 27261, 27262, 28011.

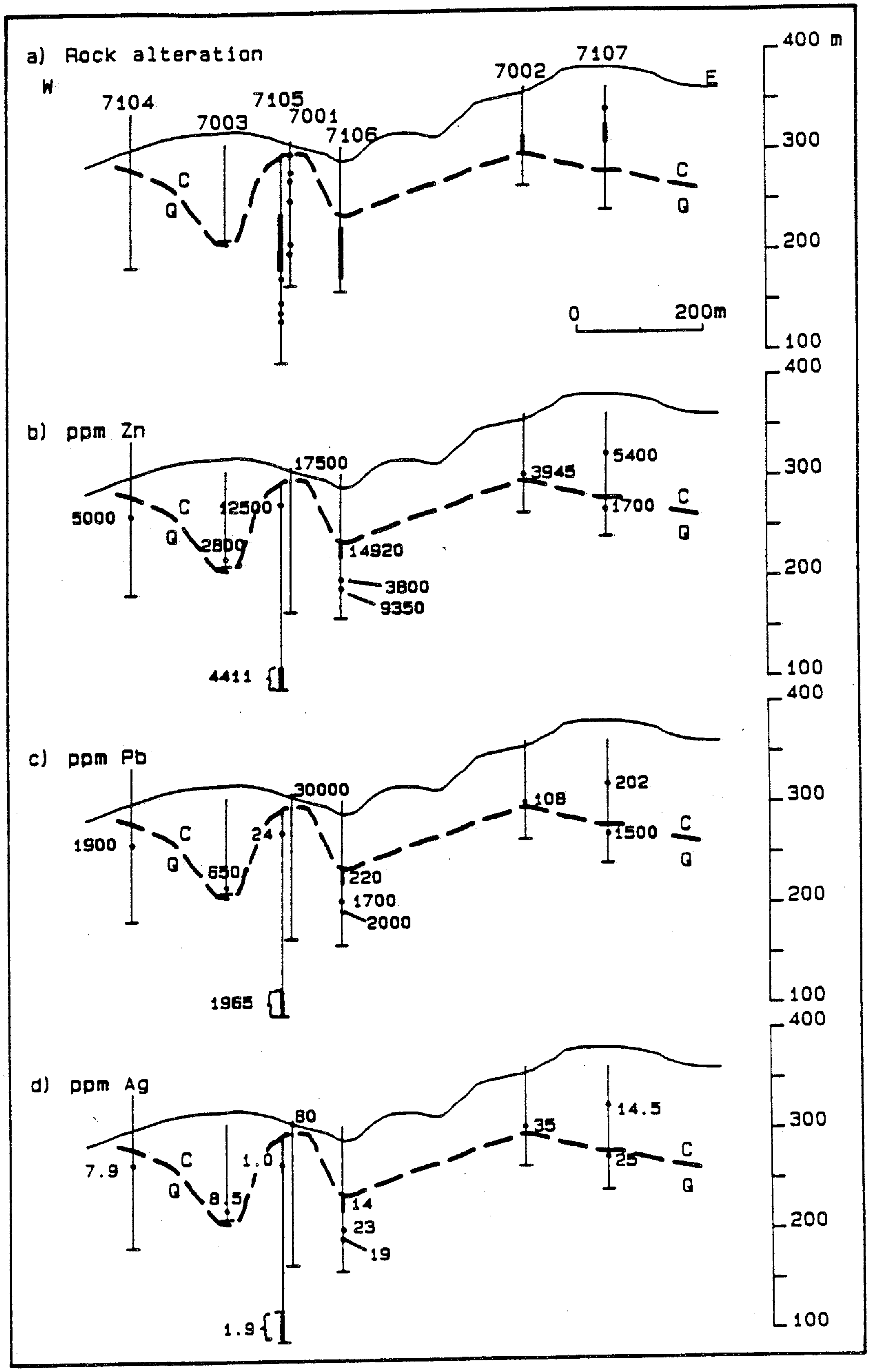


Figure 20: a) Distribution of altered rocks intersected by drill holes. b), c), d): ppm Zn, Pb and Ag in best metalized core (includes vein and disseminated sulphides). See fig. 19 for location of line E-W. Numbers such as 7001 denote drill holes.

SOQUEM REBOUL

The SOQUEM Reboul showing is situated in south-central Reboul township, about 35 km north of Bonaventure, and consists of skarn-hosted Cu-Zn mineralization (site 8, Figure 2). The best drill hole intersection obtained is 10.44 m of 1.9% Cu + 44 g/T Ag, including 4.5 m of 2.92% Zn.

GEOLOGICAL SETTING

The prospect occurs several hundred metres north of the Grand Pabos fault, which separates Matapedia Group argillaceous limestones to the north from Honorat Group graywackes and siltstones to the south (Figure 21). Showing host rocks are northeast-striking, steeply dipping beds of the Matapedia Group; these are altered on surface in a sinuous, east trending zone 800 m long and up to 125 m wide, as well as in smaller satellite aureoles. The altered rocks comprise marbles and calc-silicate hornfelses; some of the latter are garnet-bearing. Mineralization takes the form of pyrite-sphalerite-chalcopyrite and local chalcocite, either disseminated in altered zones or as massive sulphide-filled fractures which cut altered areas. Sphalerite and chalcopyrite have approximately equal abundances, and the best metal values occur, in this type of mineralization. Veins containing calcite with or without pyrite, sphalerite, or galena, cut altered and nearby unaltered rocks.

VEIN MINERAL ZONING

Vein mineral zoning data is plotted on Figure 21. The collar elevation of each drill hole is similar (all are between 325 and 335 m) and most holes are inclined at 45°C to the horizontal (the only exception is a hole inclined at 50°C). Thus, a given horizontal distance from the collars of holes on Figure 21 corresponds to approximately the same vertical elevation in each hole. Horizontal and vertical plane zoning are therefore depicted in the same diagram. The following vein mineral zoning sequence is present about the main alteration zone:

1) fracture-filling pyrite ± one or more of sphalerite, galena, chalcopyrite, or chalcocite, occur within the alteration zone,

2) veins containing calcite and one or more of pyrite, sphalerite, and galena cut altered rocks and unaltered rocks within about 70 m of the altered zones,

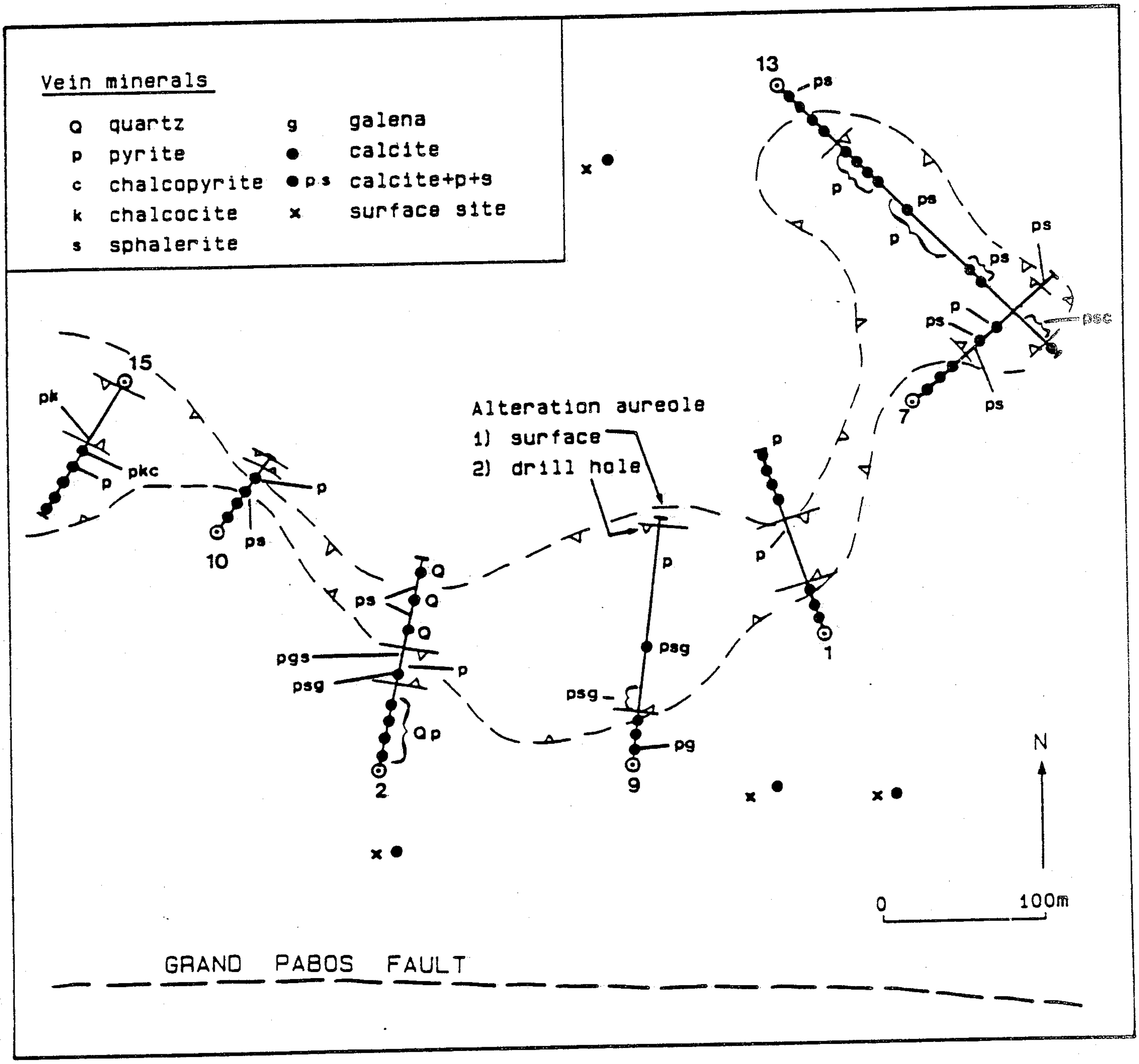


Figure 21 : Vein mineral assemblages in the Soquem Reboul prospect area. Collar elevation and dip angle are equal or similar for all holes, so that vertical and horizontal trends are portrayed simultaneously. Numbers denote drill holes. Base map after Landry (1984) in GM 42967.

3) barren calcite veins are common cutting altered rocks, and unaltered rocks at least 150 m south and 250 m north of the altered zone.

DISCUSSION

Although no granitic rocks occur in the vicinity of this showing, the skarn-type alteration and the concentric vein mineral zoning pattern are evidence of magmatic-hydrothermal affinity; it is therefore reasonable to include this occurrence in the present investigation.

Zoning in this system and in the type areas is similar in that a peripheral zone of carbonate veins surrounds a core zone of zinc-quartz veins. Note that although the massive sulphide pyrite-sphalerite-chalcopyrite veins in the alteration zone contain no quartz, they are zinc-quartz veins according to the definition given in Section 2.0. This quartz-poor nature of the core zone is an important difference between this area and other known zinc-quartz zones. Another difference is that the core of the present system is equally richer in copper than is the case of other zinc-quartz zones.

It is concluded that vein mineral zoning at this prospect is compatible with that predicted by the type areas model.

REFERENCES: GM numbers 41315, 41817, 42967.

LAC ARSENAULT

This showing is located in the northwest corner of Weir Township, about 35 km north of Paspebiac (site 9, Figure 2). The showing comprises Au-Ag-Pb-Zn-bearing quartz veins hosted by altered sedimentary rocks. The best metal values were obtained from a vein known as the Baker vein: 7.1% Pb, 14.9% Zn, 11 g/T Au, 146.7 g/T Ag over 1.4 m.

GEOLOGICAL SETTING

The mineralized veins occur in Honorat Group greywackes up to about 500 m south of the Grand Pabos Fault. Sulphide mineral- bearing quartz ± minor carbonates veins occur over about 1 km^2. Visible sulphide minerals are pyrite, sphalerite, galena, arsenopyrite, and rare chalcopyrite. Vein wallrocks are in places chloritized to different degrees; locally this chloritization has affected rocks cut by relatively little vein material. Barren quartz ±

carbonates veining is more or less continuous for about 2 km east and along strike from the showing area.

No vein mineral zoning patterns are displayed.

DISCUSSION

In the absence of intrusive rocks and concentric vein mineral zoning patterns, the question of whether this occurrence belongs to the magmatic-hydrothermal class of deposits needs to be addressed, before considering the applicability of the proposed regional model. Suggestive evidence of this type of origin is the presence of abundant arsenopyrite, a common mineral in many hypogene ore deposit types. In addition, quartz-sphalerite-galena-bearing, carbonate-poor veins are common: fluid inclusion average homogenization temperatures in quartz from these vein types in the Candego and Federal mine areas are typically in the 240-300°C range (Stevens, 1989 [Candego], 1986 [Federal]).

Assuming that the Lac Arsenault veins formed above a cooling pluton, then the lack of vein mineral zoning in the exposed part of the system could indicate that the known veins belong to a single zone (e.g. a zinc-quartz zone) whose outer boundaries have not yet been delineated. Note that the total area containing known veins is about 1 km^2, and that zinc-quartz zones in northern Gaspesian vein systems cover up to 4 to 5 km^2.

REFERENCES: Savard (1985), GM numbers 19127, 32162, 34955.

RAUDIN Zn-Pb

This showing is located 25 km northnorthwest of Port Daniel (site 10, Figure 2). It consists of low-grade Zn-Pb mineralization hosted by felsic lavas.

GEOLOGICAL SETTING

The showing area is underlain by felsic volcanic rocks intercalated with Matapedia Group calcareous siltstones; this volcanic/sedimentary package is intruded by masses of diorite. Low grade sedimentary rock alteration is irregularly developed proximal to or between concentrations of igneous rocks. Small amounts of pyrite, sphalerite, and galena occur locally in felsic flows, as vein fillings, blebs, and disseminations. Quartz-carbonate veins commonly cut sedimentary, and less commonly, igneous rocks. There is insufficient vein mineral zoning information available for this area to permit evaluation of possible zoning patterns. The presence of pyrite-sphalerite-galena veins suggests the presence of a zinc-quartz vein zone.

REFERENCES: GM numbers 12577, 13284.

4. GASPESIAN VEIN ZONING MODEL: DISCUSSION

In this chapter it has been demonstrated that vein mineral zoning is present at most Gaspesian granite-associated mineralized areas, and where present, can be described in terms of the copper-quartz, zinc-quartz, and carbonate-sulphides vein zones defined at the beginning of the chapter. Where this zoning was not detected, in most cases it has been due to a lack of available literature data. The geologists who recorded all the literature data examined in this project did not have elucidation of a generalized vein zoning model as one of their objectives; it is therefore possible (or even probable, given the high rate of success obtained in this project), that remapping and relogging of the field areas and cores in question would reveal vein zoning patterns in these areas.

Horizontal-plane spatial relations between copper-quartz, zinc-quartz, and carbonate-sulphides zones at different localities are schematically summarized on Figure 22. A typical zoning pattern is seen to comprise a central zone of copper-quartz veins with or without zinc-quartz veins, and carbonate-sulphides veins which occur inside and outside the copper-quartz and zinc-quartz zones. Copper-quartz zones are typically intruded by or project outwards from felsic intrusions, which is why the zoning relations of Figure 22 are shown with respect to a nearby intrusive body. The zinc-quartz zone can be mainly outside to completely within the copper-quartz zone. Zinc-quartz veins within the copper-quartz zone tend to occur near the periphery of the latter; in some cases they occur in the central portions. One locality (Soquem Reboul) is characterized by a core zone of zinc-quartz veins with no copper-quartz veins.

At most localities there is no vertical plane zoning of these vein types. The available evidence is summarized schematically in the following table.

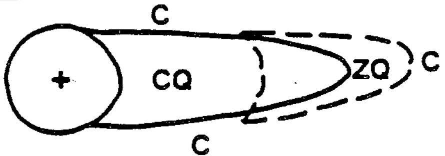
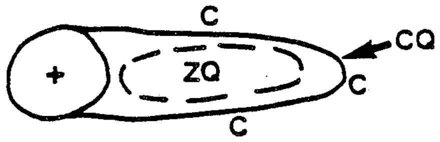
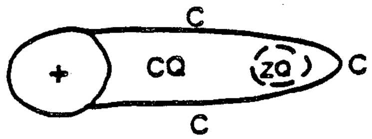
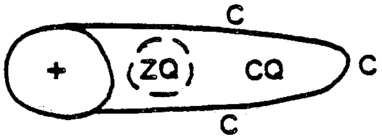
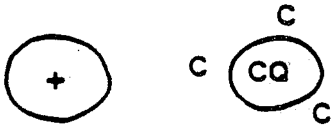
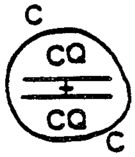
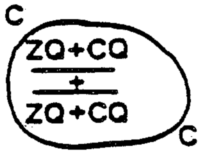
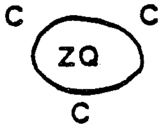
PATTERN	EXAMPLE
	Candego, Lemieux Dome, Mines Gaspé systems
	Sullipek system
	Madeleine system
	System on east side of McGerrigle pluton
	Mt. Brown system, Mid-Patapedia deposit
	Basket Brook deposit
	Carleton Sb-Pb system
	Soquem Reboul deposit

Figure 22 : Schematic representation of horizontal- plane spatial relations between copper - quartz (CQ), zinc-quartz (ZQ) and carbonate-sulphides (C) vein zones in Gaspesian granite-associated mineralized systems. " + " indicates a felsic porphyritic intrusion. In all cases, carbonate - sulphides zone veins are commun inside as well as outside the copper-quartz and zinc-quartz zones.

AREA	VERTICAL SEQUENCE
Madeleine	$\frac{ZQ + CQ + C}{CQ}$
Mid-Patapedia	$\frac{C}{CQ + C}$
St-Benoit-de-Matapedia	$\frac{C}{CQ}$
Soquem Robidoux	$\frac{ZQ + CQ + C}{ZQ}$

From this table it is seen that copper-quartz and/or zinc-quartz veins occur at or extend to lower elevations than do carbonate-sulphides veins. Copper-quartz and zinc-quartz veins exhibit opposing vertical zoning relations at the two sites which contain both vein types. In the Madeleine mine area the copper-quartz zone extends to lower elevations than and contains the zinc-quartz zone, whereas in the Soquem Robidoux area the reverse occurs. The latter instance constitutes the only example in the Gaspé peninsula of a zinc-quartz zone containing a copper-quartz zone, in the horizontal or vertical planes.

It is also clear from the above observations that vein mineral zoning can occur at the deposit scale or vein system scale. Here, a deposit is understood to mean a distinct economic or subeconomic mineral occurrence, whereas a vein system contains a group of distinct occurrences which can be related to each other by zoning parameters.

Within the vein type zoning scheme outlined above, certain individual vein minerals show preferred associations for certain vein type zones, and are also useful guide minerals to ore deposits contained within the zones. Quartz, pyrrhotite, bornite, and arsenopyrite are concentrated in the copper-quartz and zinc-quartz zones. Of the carbonate minerals present in the quartz-rich part of a vein system, dark-coloured calcite and dolomite are diagnostic of the copper-quartz and zinc-quartz zones respectively. Molybdenite is particular to the copper-quartz zone. Sphalerite and galena are commonest in the zinc-quartz and, to a lesser extent, carbonate-sulphides, zones. Chalcopyrite is most abundant in the copper-quartz zone, and is locally abundant in the other two zones. Pyrite is common to all three zones.

In all the systems or deposits where vein mineral zoning occurs, the richest copper mineralization occurs in the copper-quartz zone, and the richest zinc-lead±precious metal mineralization in the zinc-quartz zone.

CHAPTER THREE

FLUID INCLUSION SURVEY, MINES GASPÉ AREA

1. INTRODUCTION

The principal aim of this fluid inclusion survey is to determine whether average homogenization temperatures in vein quartz are zoned with respect to the Copper Mountain and Needle Mountain orebodies. These deposits occur in the central portions of a vein calcite-rich to quartz-rich, periphery to core zoning pattern which is centred on the Copper Brook aureole (Stevens, 1989b). Thermally anomalous portions of quartz-rich zones contain the Candego, Madeleine, and Federal deposits (Stevens, 1989a, 1986); the presence of such a trend at Mines Gaspé would be strong evidence that similar types of hydrothermal systems operated in all these areas. This chapter will also compare thermal zoning patterns obtained from vein quartz and vein calcite, in the Mines Gaspé area. Fluid inclusion melting point data were obtained at selected sites.

The Mines Gaspé area geology has been well documented elsewhere and will not be described here.

The locations of the quartz and calcite samples used in this survey are shown on Figures 23, 24, and 29.

2. ANALYTICAL PROCEDURE

Fluid inclusions were studied in 300 micron-thick slices of quartz or calcite polished on both sides. The microthermometric work was performed on a Chaixmeca heating-freezing stage which has been calibrated against the melting points of various pure standards. Homogenization temperatures for two-phase inclusions (liquid + vapour) were determined by gradually heating the inclusions and observing the temperature at which the vapour bubble in each inclusion shrank to disappearance or expanded to fill the inclusion cavity. Partial and total homogenization temperatures of three-phase inclusions (e.g. two immiscible liquids + vapour or liquid + vapour + solid) were determined from the temperatures of disappearance of different phases during heating. Melting points were determined by chilling inclusions until completely frozen, and then observing the temperature of disappearance of the last solid crystal, during gradual reheating. Melting points were determined before homogenization temperatures for inclusions from which both types of data were collected, because at high temperatures inclusions commonly decrepitate prior to

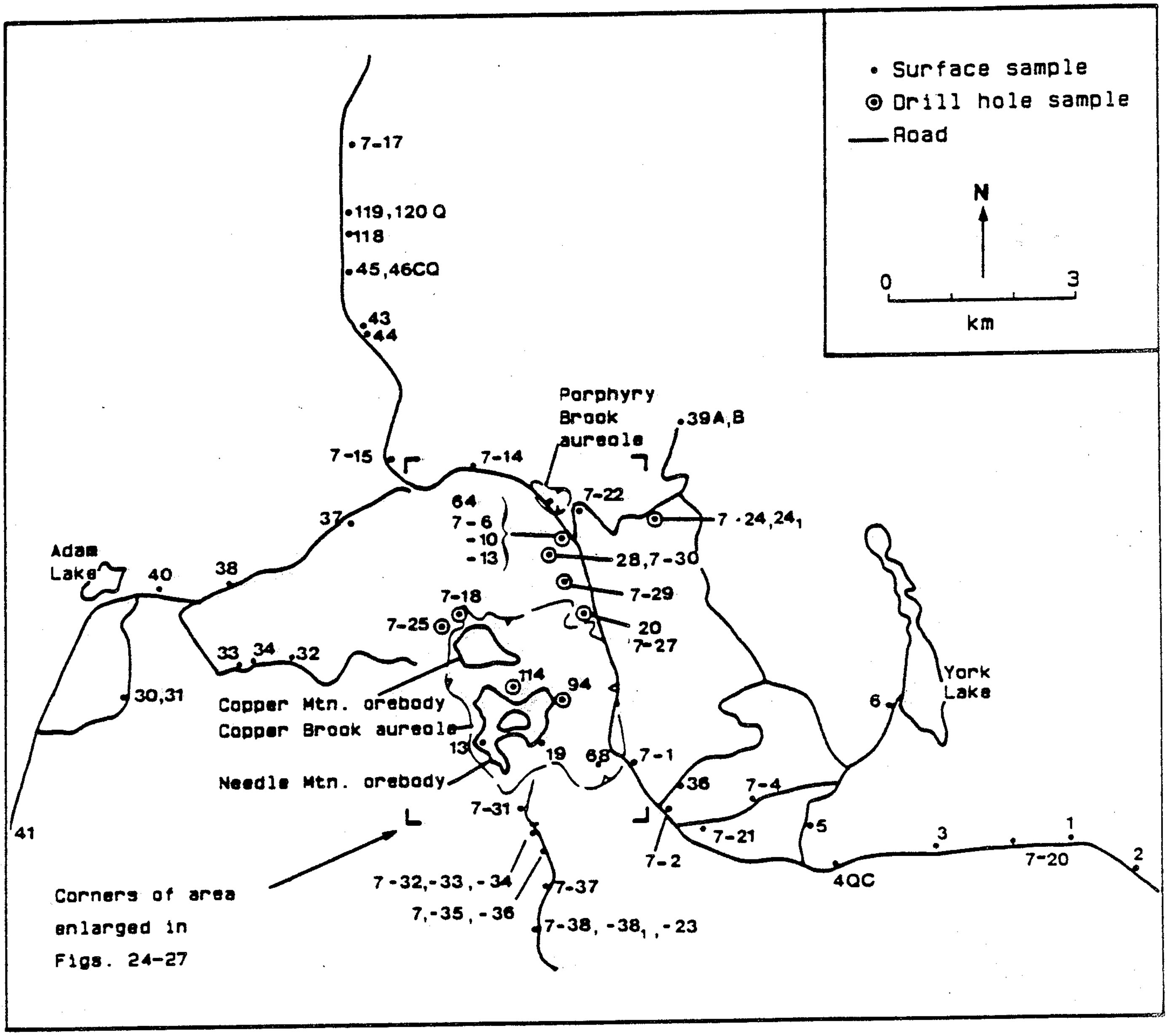


Figure 23 : Location map for vein calcite samples used in the fluid inclusion study. Sample numbers followed by Q or CQ indicates that a quartz or calcite-quartz vein was sampled.

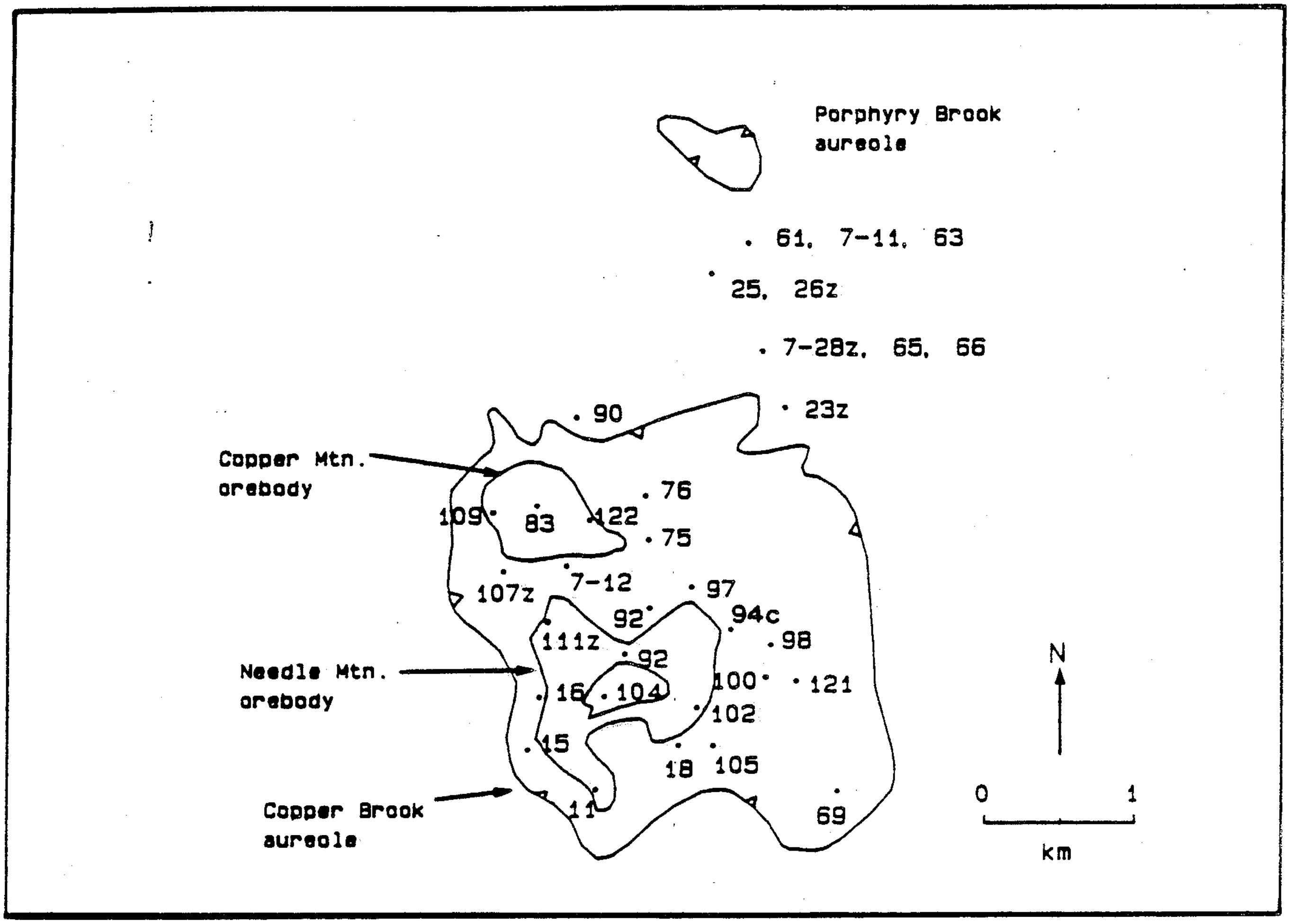


Figure 24 : Location of vein quartz samples used in the fluid inclusion survey. "z" and "c" indicate quartz from a zinc-quartz and carbonate-sulphides vein, respectively. All other samples from copper-quartz veins.

homogenization. Homogenization and melting points were checked regularly for repeatability.

3. FLUID INCLUSION PETROGRAPHY

Fluid inclusions are extremely numerous and well exposed in most vein quartz samples. Inclusion long dimensions average 19 microns, and shapes vary from negative crystals to rounded to irregular. The typical mode of occurrence is in trails or planes which are very abundant and diversely-oriented, and which commonly extend to but rarely traverse crystal boundaries. These inclusions are thus secondary or pseudosecondary. Primary inclusions (isolated, randomly dispersed) are relatively rare.

There are three types of inclusions encountered in quartz samples. They are classified according to phases visible at room temperature: 1) LV (liquid-vapour), 2) LVS solid(s)), and 3) LLV (liquid-liquid-vapour). The overall relative percent abundance of these inclusion types is approximately LV/LVS/LLV = 70/20/10.

LV inclusions contain an aqueous salt solution, and a water vapour phase which occupies from 5 to 95% of the inclusion volume; most vapour phase percentages fall into two ranges: 5 to 20% and 30 to 60%. Inclusions with 30 to 60% vapour constitute 80 to 90% of the LV inclusion population in the Copper Brook/Porphyry Brook aureole area. Outside this latter area, LV inclusions of the 5 to 20% vapour group greatly predominate over the 30 to 60% vapour group.

LVS inclusions in vein quartz contain aqueous solution, water vapour, and from one to three daughter crystals. In most cases only one daughter crystal, a cube, is present. This is assumed to be halite. Rare spherical or oblong daughter crystals can occur alone or accompany cubes in LVS inclusions. Cubes typically occupy from 10 to 30%, and other daughter crystals a similar or smaller portion, of the inclusion volume. The vapour phase in LVS inclusions occupies on average from 15 to 30% of the inclusion volume. Figure 25 shows that most LVS inclusions are concentrated in a sinuous zone which traverses the Copper Brook aureole from southeast to northwest. These inclusions are locally abundant between the Copper Brook and Porphyry Brook aureoles. The numbers on this figure denote the percent abundance of LVS inclusions in the total inclusion population at each site, with data from all elevations being projected onto a horizontal plane; no such zoning is present in the vertical plane. LVS inclusions are absent from quartz samples from outside the Copper Brook/Porphyry Brook aureole area.

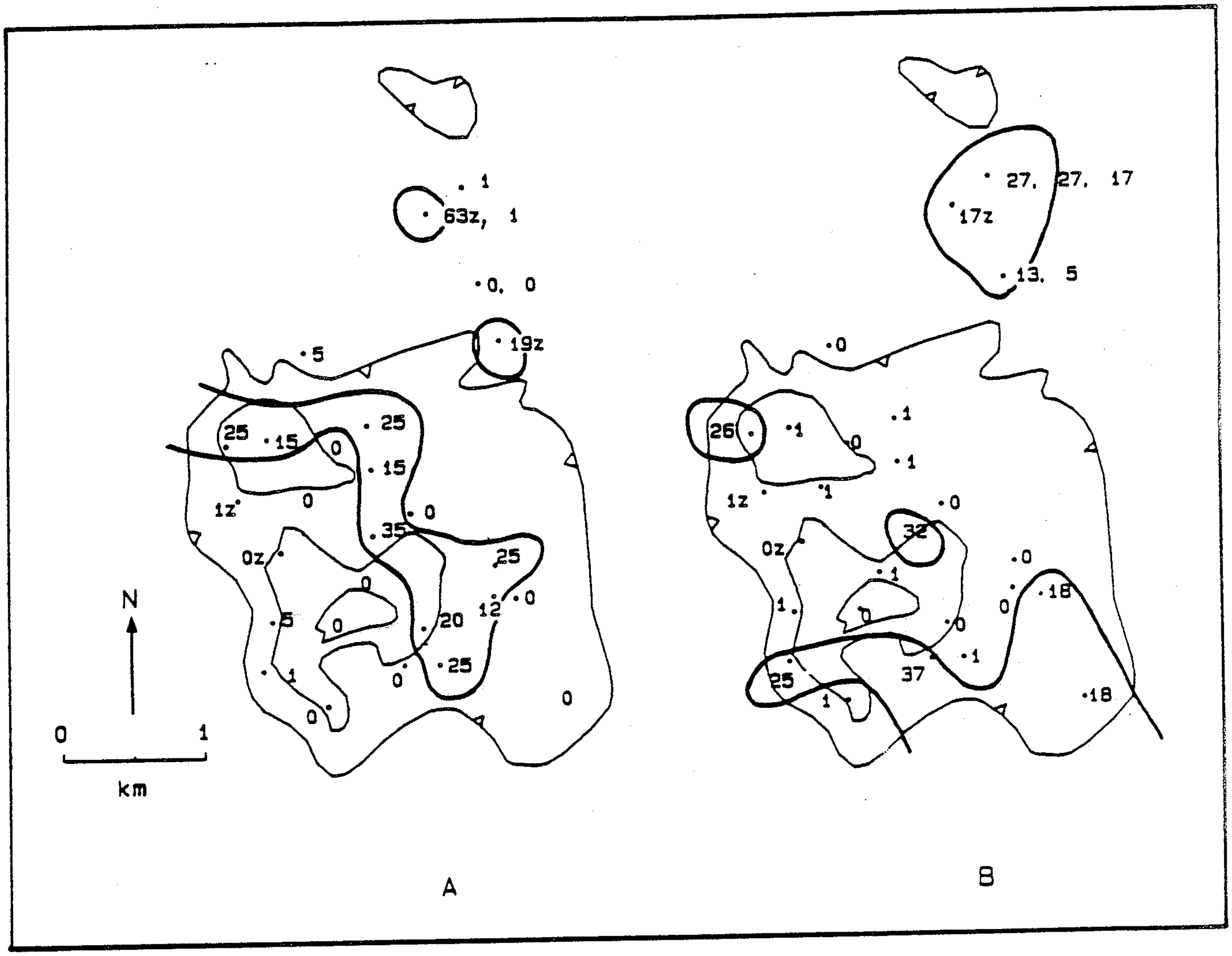


Figure 25 : Percent abundance of A) LVS inclusions , and B) LLV inclusions, in total fluid inclusion population in vein quartz samples.

LLV inclusions in vein quartz contain aqueous salt solution, liquid CO_2, and a CO_2 vapour bubble. The liquid CO_2 floats immiscibly within the aqueous fluid, and the CO_2 vapour occurs within the CO_2 liquid. The CO_2-rich portion of LLV inclusions occupies from 30 to 90%, and most commonly 40 to 60%, of the inclusion volume. LLV inclusion plane percent abundances are highest in local, small-scale zones distributed throughout the Copper Brook/Porphyry Brook aureole area (Figure 25). The percent abundance of these inclusions shows no zoning in the vertical plane. LLV inclusions do not occur outside the Copper Brook/Porphyry Brook aureole area.

Fluid inclusions in vein calcite are on average much smaller and more poorly exposed, and much less abundant than, fluid inclusions in vein quartz. Secondary and pseudosecondary inclusions predominate, but primary inclusions are common locally.

LV and LLV inclusions account for almost all inclusions hosted by calcite crystals; the former occur throughout the surveyed area and the latter are common in certain samples from the Copper Brook/Porphyry Brook aureole area. A third type of calcite-hosted fluid inclusion was encountered in one sample only (sample 7-21), from a site southeast of the Copper Brook aureole (Figure 23). This inclusion type, which is the main type present in the sample, contains one liquid or supercritical phase at room temperature, and evolves a vapour bubble on cooling the inclusion below about -20°C; these inclusions may contain a mixture of CO_2 and CH_4.

As in the case of vein quartz, LV inclusions in vein calcite contain aqueous liquid, and a vapour phase which occupies from 5 to 95% of the inclusion volume. The same two most commonly observed vapour phase percentage ranges seen in quartz, i.e. 5 to 20% and 30 to 60%, also occur in calcite. The 30 to 60% vapour inclusions make up about 50% of the LV inclusion population in or near the Copper Brook/Porphyry Brook aureole area, and is almost absent outside of this latter area.

The CO_2 (liquid + vapour) part of LLV inclusions in calcite occupies from 30 to almost 100%, and most commonly 50%, of the inclusion volume. These inclusions occur at two sample sites near the southern periphery of the Copper Brook aureole and three sites north of this aureole (Figure 28). At one of the two sites near the southern periphery of the Copper Brook aureole, and at all three sites to the north, LLV inclusions account for 80 to 100% of the fluid inclusion population in these samples. Recall that LLV inclusion percent abundances in vein quartz are in all cases less than 37% (Figure 25).

4. DATA PRESENTATION

Maps of average sample-site homogenization and melting points for different inclusion types in vein quartz and vein calcite are presented on Figs. 26 to 30. The average homogenization and melting points reported on these figures were obtained from inclusions with room temperature phase ratios representative of the majority of the inclusions in the sample, for each inclusion type concerned. Most of the data are from inclusions of secondary or uncertain age affinity.

Average homogenization temperatures of LV, LVS, and LLV inclusions in vein quartz are shown on Figure 26. Data from all elevations have been projected onto a horizontal plane. The majority of veins represented are copper-quartz veins (see Section 2.0 for definition). Some zinc-quartz and barren quartz veins are also represented. One quartz sample (94) on Figure 26 is from a carbonate-rich vein. LV inclusion homogenization temperature data from three sites outside the area of Figure 26 are reported on Figure 28. One of these latter three samples is of a barren quartz vein; the other two are from barren quartz-carbonate veins (see sample location map on Figure 23).

Average LV inclusion homogenization temperatures range from 167°C to 455°C. A prominent thermally anomalous zone is oriented northnorthwest and is approximately centred on the eastern lobe of the Needle mountain orebody. Values in this zone are mainly from about 370°C to 455°C. Other anomalous zones are associated with the western lobe of the Needle Mountain (332°C), and Copper Mountain (about 350°C) orebodies; another one occurs immediately northeast of the Copper Brook aureole (376-418°C). Average vein quartz LV inclusion homogenization temperature values obtained from outside the area of Figure 26 and reported on Figure 28 are from 183°C to 218°C. Average LVS inclusion total homogenization temperatures (Figure 26) vary from 264°C to 420°C; values are highest (364-420°C) in a zone extending diagonally across the Copper Brook aureole from southeast to northwest. Average LLV inclusion total homogenization temperatures range from 305°C to 444°C; a small north northwest-trending anomalous (414-444°C) zone occurs approximately centred on the eastern lobe of the Needle Mountain orebody.

Average melting point data from LV and LLV inclusions in vein quartz appear on Figure 27. Average CO_2, and clathrate hydrate, melting points in LLV inclusions vary from -55.6°C to -57.3°C, and 7.5°C to 10.0°C, respectively; no zoning is displayed. Average sample-site ice-melting values in LV inclusions vary from -0.2°C to -9.0°C, no zoning is present. An average LV inclusion ice melting point of -6.9°C was obtained from a quartz sample taken from a barren

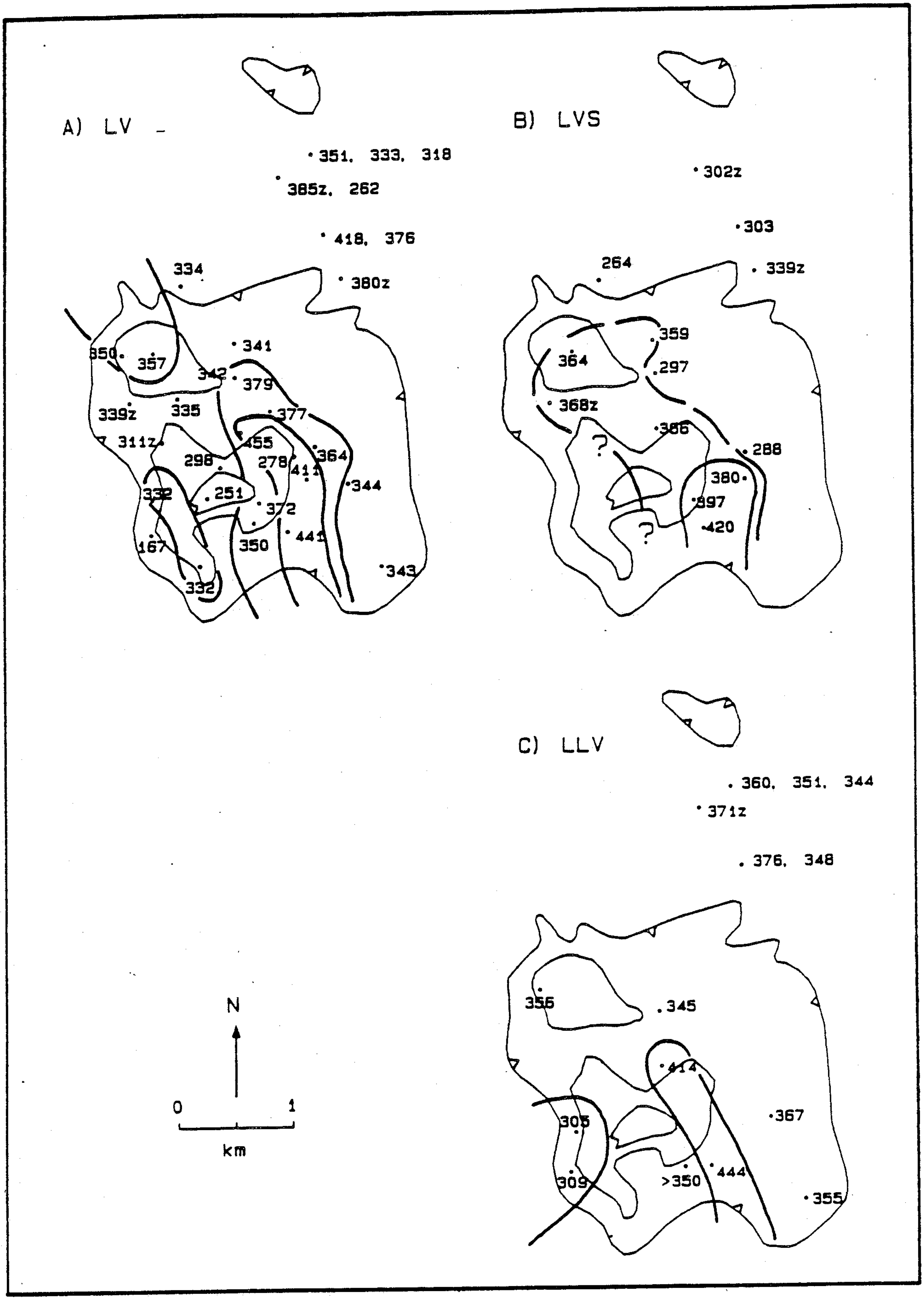


Figure 26 : Average homogenization temperatures of A) LV, B) LVS, and C) LLV inclusions in vein quartz samples.

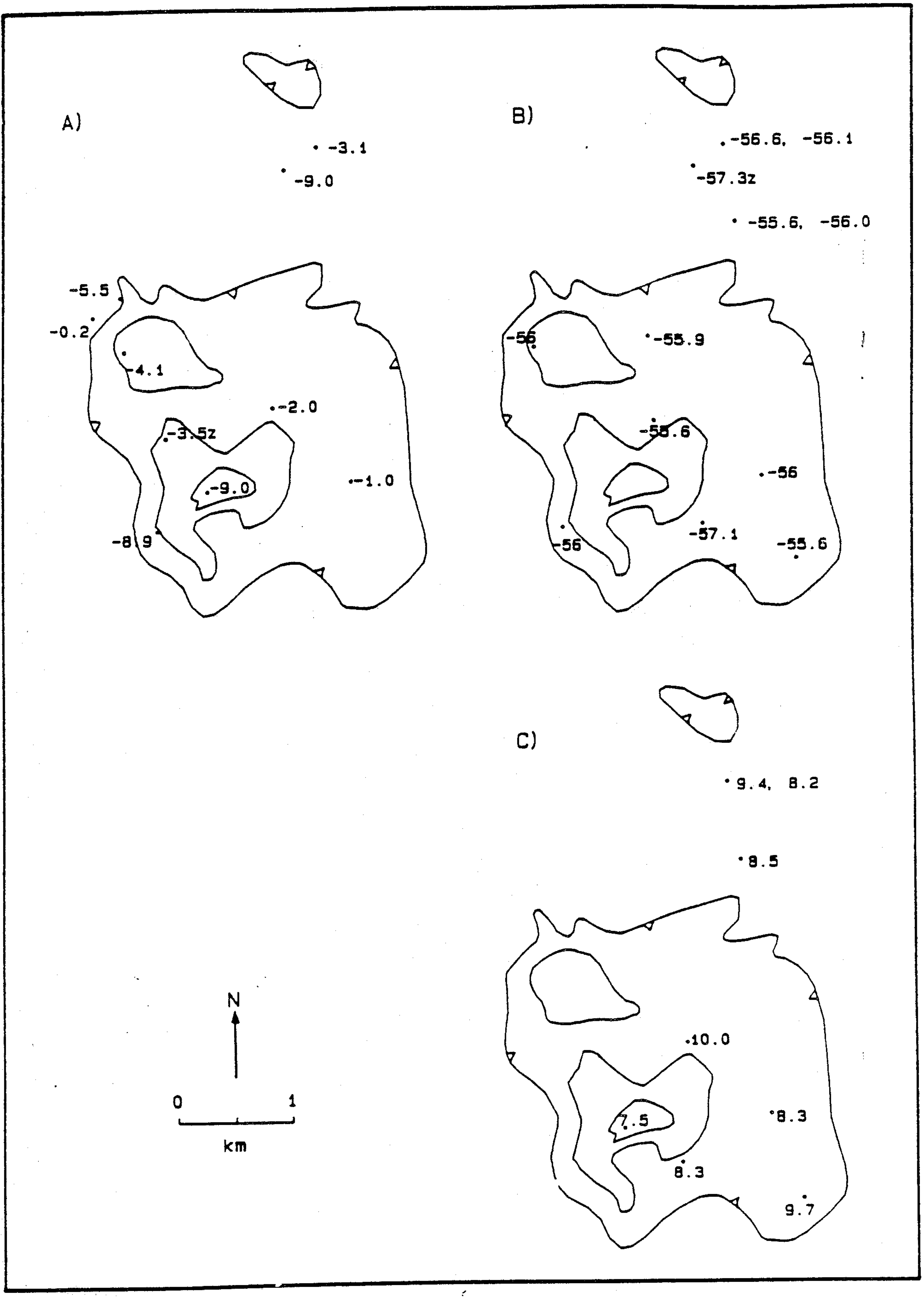


Figure 27 : Average melting points of A) ice in LV inclusions, B) CO_2 in LLV inclusions, C) clathrate hydrate LLV inclusions, in vein quartz samples.

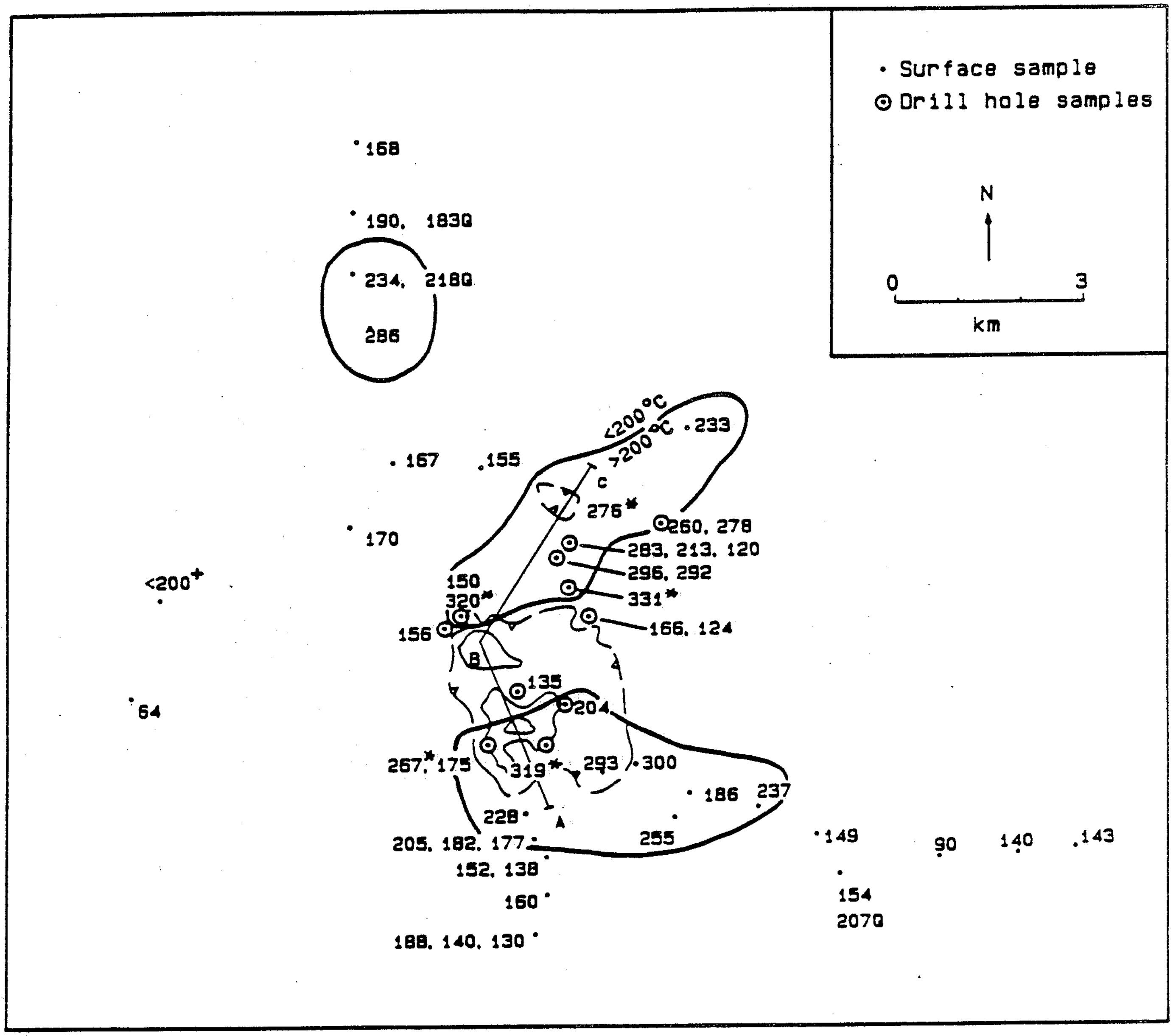


Figure 28 : Average homogenization temperatures, in °C, of fluid inclusions in vein calcite. * indicates average Type 2 incluson (liquid CO_2-bearing) value, all other data from Type 1 inclusions. + indicates a homogenization temperature estimated from room temperature phase ratios. Q signifies a vein quartz value. Outlines of alteration aureoles and orebodies from Fig.29 included for reference. ABC is a line of cross-section, shown on Fig. 29.

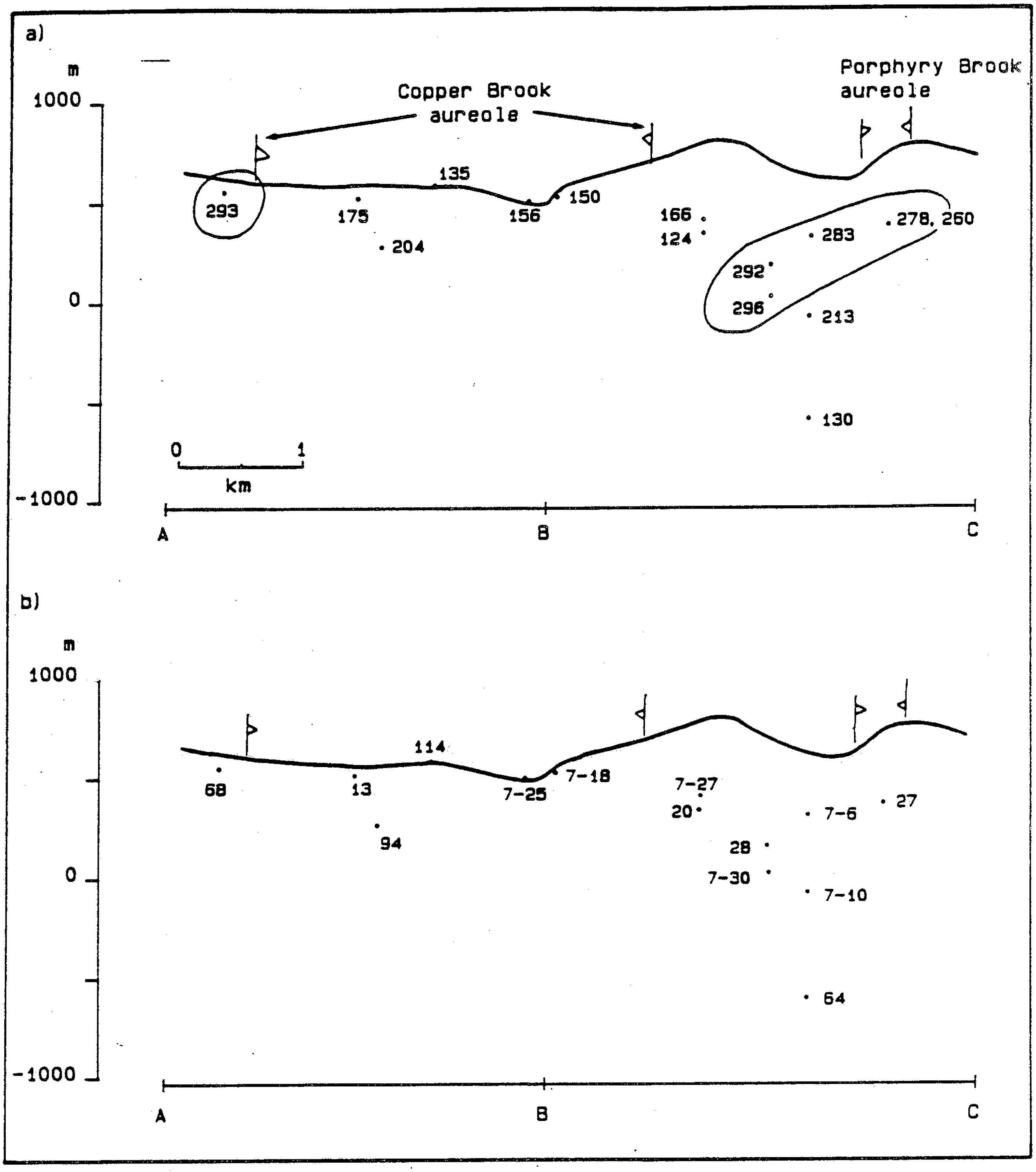


Figure 29 : a) Vertical zoning of Type 1 inclusion average homogenization temperatures in vein calcite. b) Sample locations. All data from carbonate-sulphides veins. See Fig.28 for location of cross-section ABC.

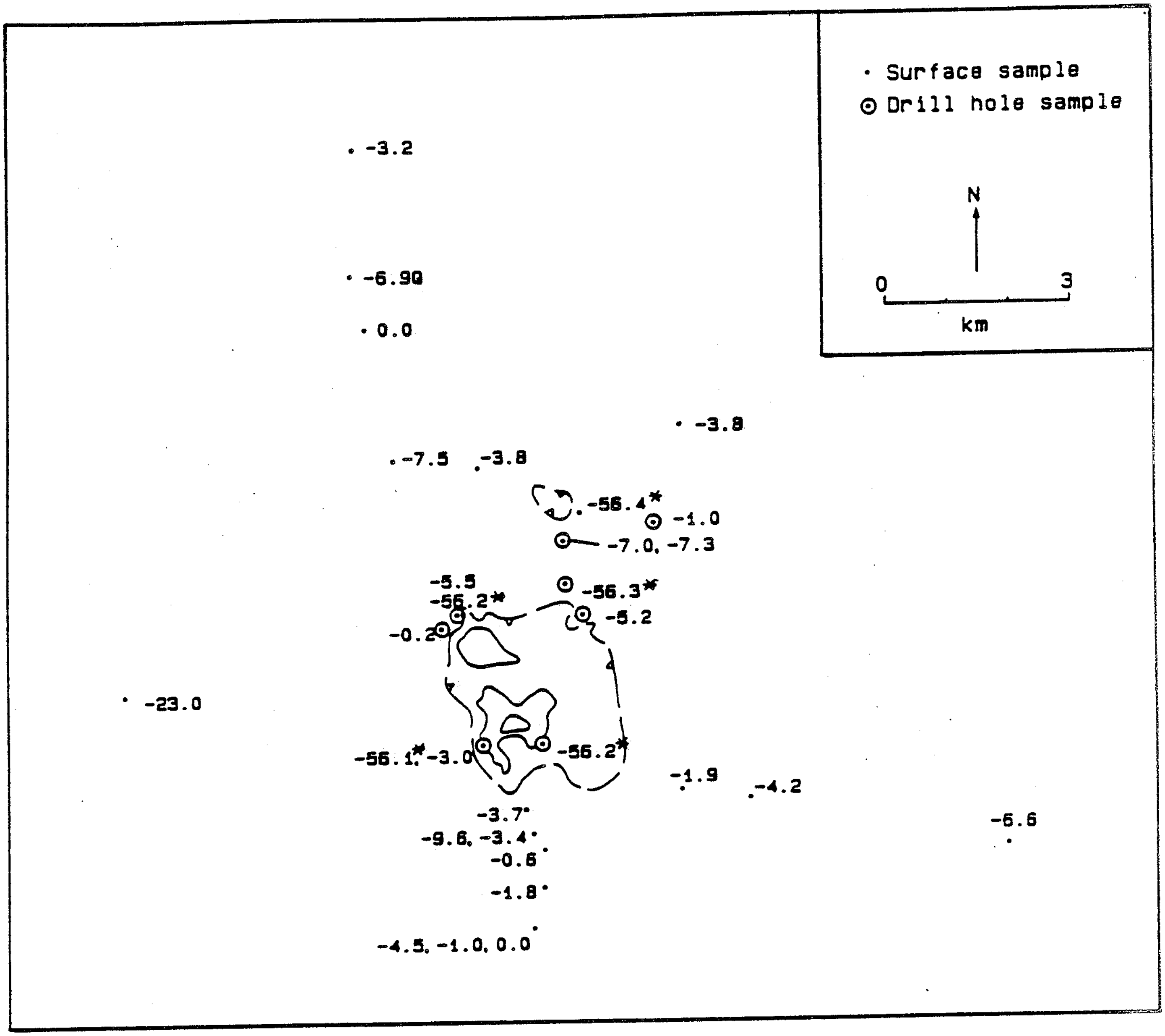


Figure 30: Average melting points, in °C, of CO_2 (*) and ice (all other values) in vein calcite fluid inclusions. Q signifies data from vein quartz. Outlines of alteration aureoles and orebodies from Fig.23 included for reference.

quartz-carbonate vein in the northern part of the survey area; this value is reported on Figure 30.

There are no vein type versus homogenization or melting temperature trends suggested by the data of Figures 26 or 27.

The data of Figures 26 and 27 do not display zonation in the vertical plane.

Average homogenization temperatures of LV and LLV inclusions in vein calcite samples from throughout the survey area are shown on Figure 28. Values from three vein quartz samples from outside the Copper Brook/Porphyry Brook aureole area are also included. In a calcite sample from the western part of the survey area LV inclusions are too poorly exposed to permit obtention of homogenization temperatures, however room temperature phase ratios indicate that these homogenization temperatures would be below 200°C. All calcite samples represented on Figures 28 to 30 are from carbonate-sulphides veins.

The most salient features of Figure 28 are two 5 km long zones which contain most sample-sites from which LV and/or LLV inclusion homogenization temperatures >200°C were obtained. One zone trends east-west; the western part of this zone overlaps the southern half of the Copper Brook aureole. The second zone trends northeast from the northern periphery of the Copper Brook aureole. LLV inclusions are not present outside these zones; within the zones their average sample-site homogenization temperatures range from 267°C to 319°C. Corresponding LV inclusion values within these zones vary between 150°C and 300°C, and are most commonly greater than about 230°C. A small zone in which average LV inclusion homogenization temperatures are 234°C to 286°C occurs about 5 km northwest of the Copper Brook aureole. Outside these relatively high homogenization temperature zones, average LV inclusion values are from 64°C to 190°C. Average LV inclusion values from vein quartz samples shown on Figure 28 range from 183°C to 218°C.

Average LV inclusion homogenization temperatures are zoned locally in the vertical plane (Figure 29). The location of the line of cross-section of Figure 29 is shown on Figure 28. Figure 29 reveals the presence of a well-defined, subhorizontal zone in which average LV inclusion homogenization temperatures are from 269° to 296°C, situated between the Copper Brook and Porphyry Brook aureoles. Examination of Figures 28 and 29 reveals that this zone dips toward the west.

Average melting points of ice in LV inclusions and CO_2 in LLV inclusions are shown on Figure 30 for vein calcite samples from the entire survey area. One value from a vein quartz sample is also shown, for a sample-site in the northern part of the survey area. Average LLV inclusion CO_2 melting points are in the -56.1°C to - 56.4°C range. Average ice melting points of LV inclusions vary from 0.0°C to -23.0°C, with most values falling between 0.0°C and -7.3°C. No zoning trends are displayed by the data of Figure 30. No vertical plane trends are present among these melting point data.

DISCUSSION

There is a clear spatial association in the Copper Brook aureole between ore deposits and thermally anomalous zones mapped using fluid inclusions in vein quartz (Figure 26). These thermal highs are localized in turn in a zone where vein quartz:carbonate proportions attain a maximum for the Mines Gaspé (Stevens, 1989b, Figure 8). Thermally anomalous portions of quartz-rich vein zones also host the Federal (Stevens, 1986), and Candego and Madeleine (Stevens, 1987, 1989a) deposits. The existence of this same trend in the Mines Gaspé ore system is thus convincing evidence of a similar thermochemical character of the hydrothermal systems responsible for ore deposition in each of these areas.

The data presented in this chapter permit several interpretations concerning the Mines Gaspé vein system. The thermal zoning patterns of LV, LVS, and LLV inclusions in vein quartz (Figure 26), and the percent abundance zoning of LVS inclusions in vein quartz (Figure 25), indicate that a northwest-trending fracture zone, traversing the Copper Brook aureole from southeast to northwest, was an important structure controlling fluid flow. This fracture zone played a major role in localizing the Copper Mountain orebody and the east half of the Needle Mountain orebody. The trend of this fracture zone, as determined from the zoning features described above, is the same as that of the most prominent regional joint. The local LV inclusion thermal high centred on the west half of the Needle Mountain orebody is evidence of a smaller fracture, trending parallel to the major one described above, which helped to localize this orebody.

Maximum homogenization temperatures of LV, LVS, and LLV inclusions in vein quartz were obtained in samples from the south-central part of the Copper Brook aureole. These are also the highest values obtained anywhere in the Mines Gaspé system. It is therefore reasonable to conclude that this locality is closest to the system heat and possibly fluid source.

The most important result of the vein calcite thermal mapping is the delineation of two 5 km long linear thermal anomalies striking away from, and situated mainly in unaltered rocks outside of, the Copper Brook aureole (Figure 28). Maximum average homogenization temperatures are significantly lower in these calcite-derived (300-320°C) than in the quartz-derived (400-455°C) thermal highs. This fact and the different locations and orientations of the thermal anomalies obtained using these two minerals could reflect changing fracture geometry with time about a gradually cooling pluton located below the south-central part of the Copper Brook aureole. As open spaces in the central part of the Copper Brook aureole became filled by early, high-temperature quartz deposition, later lower-temperature calcite-depositing fluids could have been channelled into peripheral fracture zones.

Average LLV inclusion CO_2 melting points fall in a narrow range of about -55°C to -57°C, in both quartz and calcite samples (Figures 27, 30). This fact and the relatively high homogenization temperatures characteristic of this inclusion type (305-444°C in quartz; 267-320°C in calcite) suggests that the CO_2 had a unique and probably magmatic source.

CHAPTER FOUR

CONCLUSIONS

The principal conclusions of this report are as follows:

1) Gaspesian granite-associated mineral deposits occur within zoned vein systems, with zones defined by vein mineral assemblages easily discernable with the naked eye. This zoning can be present at the deposit (local) or vein system (regional) scale.

2) In the horizontal plane, zones, named for diagnostic vein mineral assemblages, comprise a central copper-quartz vein zone, a zinc-quartz vein zone which occurs completely within to mainly outside the copper-quartz zone, and a carbonate-sulphides vein zone which occurs inside and outside the copper-quartz and zinc-quartz zones.

3) In the vertical plane, copper-quartz or zinc-quartz zones typically occur at or extend to lower elevations than the carbonate-sulphides zone.

4) Economic Cu±Mo, and Zn-Pb±precious metal, deposits occur in the copper-quartz and zinc-quartz zones, respectively. No economic deposit type is associated with the carbonate-sulphides zone.

5) Certain individual vein minerals have preferred associations with particular vein zones, and are useful guides to ore deposits within these zones. Thus, dark-coloured calcite, pyrrhotite, chalcopyrite, bornite, and molybdenite are diagnostic of the copper-quartz zone, whereas dolomite, sphalerite, and galena are characteristic of the zinc-quartz zone. Quartz and arsenopyrite are concentrated in the copper-quartz and zinc-quartz zones. Pyrite is common in all zones.

6) Mines Gaspé orebodies are associated with thermally anomalous portions of the quartz-rich core of a carbonate-rich to quartz-rich, periphery to core vein zoning pattern, centred on the Copper Brook aureole. The thermal highs were delineated by mapping average fluid inclusion homogenization temperatures in vein quartz samples. Average sample-site homogenization temperatures within the thermal highs range from about 350°C to about 450°C.

7) Mapping of average homogenization temperatures in vein calcite fluid inclusions has revealed two 5 km long thermally anomalous zones which project outward from the Copper Brook aureole into unaltered country rocks. Average sample-site homogenization temperatures in these zones are from about 200°C to about 320°C.

8) The highest average sample-site homogenization temperatures (400-450°C) were obtained from vein quartz samples from the south-central part of the Copper Brook aureole; it is suggested that this latter area is closest to the heat source responsible for fluid flow in the Mines Gaspé system.

ACKNOWLEDGEMENTS

Special thanks are due to Don Sangster of the G.S.C. for constructive criticism concerning the interpretations made in this report, and for efficient administrative assistance throughout the project. Vernon Arseneau and Robert Banville of Noranda Explorations Ltd. arranged for the writer to have access to the Mines Gaspé coreshacks on surface and underground. Robert Banville and Dave Macdonald of Noranda furnished certain samples used in the fluid inclusion survey. Noranda also assumed thin section preparation costs for selected samples. Gaston Pouliot of l'École Polytechnique de l'Université de Montréal arranged for the writer to use this institution's fluid inclusion laboratory. Most fluid inclusion polished sections were made by Vancouver Petrographics Ltd. Paule Brodeur of École Polytechnique drafted the figures. Louise Laverdure of École Polytechnique typed the manuscript.

REFERENCES

Alcock, F. J., 1921, Geology of Lemieux Township, Gaspé County, Quebec: Geol. Surv. Can., Sum. Rept., Part D, p. 71-96.

Auger, P. E., 1955, Zinc and lead deposits in Lemieux Township, Gaspé-North County, Quebec: Que. Dept. Mines, Geol. Rept. 63, 59 p.

Lachance, S., 1979, Géologie de la région de Saint-André-de-Ristigouche, Comté de Bonaventure: Que. Minist. des Rich. Nat. Rapport Préliminaire DPV-667, 19 p.

Lachance, S., 1977, Région de St-Alexis-de-Matapédia, Comté de Bonaventure: Que. Minist. des Rich. Nat. Rapport Préliminaire DPV-458, 23 p.

Lachance, S., 1974, Géologie de la Région de l'Ascension-de-Patapedia, Comté de Bonaventure: Que. Minist. des Rich. Nat. Rapport Préliminaire DP-273, 19 p.

Lachance, S., and Duquette, G., 1977, Région de Boisbuisson (NW): Que. Minist. des Rich. Nat. Rapport Géologique 187, 78 p.

Savard, M., 1985, Indices minéralisées du sud de la Gaspésie: Que. Minist. Énergie et Ress. Étude Terminale ET 83-08, 92 p.

Shelton, K. L., 1983, Composition and origin of ore-forming fluids in a carbonate-hosted porphyry copper and skarn deposit: A fluid inclusion and stable isotope study of Mines Gaspé, Quebec: Econ. Geol., v. 78, p. 387-421.

Simard, M., 1986, Géologie et évaluation du potentiel minéral de la région de Carleton: Que. Minist. Énergie et Ress. Étude Terminale ET 84-11, 27 p.

Stevens, K., 1989a, Fluid flow and mineral deposition northwest of the McGerrigle granitic pluton, central Gaspé region, Quebec: Geol. Surv. Can. Open File 1889,89 p.

Stevens, K., 1989b, Vein cineral zoning in the Mines Gaspé ore system: Geol. Surv. Can. Open File 1890, 38 p.

Stevens, K., 1987, Mineral zoning and fluid inclusion studies in the Candego/Madeleine mines area, Gaspé, Quebec: Geol. Surv. Can. Open File 1407, 73 p.

Stevens, K., 1986, Fluid inclusion and geological studies on the Zn-Pb-Cu vein system at Lemieux Dome, Gaspé, Quebec: unpublished M.Sc. thesis, McGill University, 150 p.

Williams-Jones, A. E., 1982, Patapedia: an Appalachian calc-silicate-hosted copper prospect of porphyry affinity: Can. Jour. Earth Sci., v. 19, p. 438-455.

APPENDIX 1

SOURCES OF VEIN MINERAL DATA, McGERRIGLE MOUNTAINS-LEMIEUX DOME REGION

The following references were used to map vein mineral zoning trends for regions A to F on Figure 3 of this report:

Region A: GM numbers 18477, 18773, 22231, 26244, 32860.

Region B: GM numbers 13644, 21647, 22121, 28440, 29903, 33207, 38418.

Region C: GM numbers 6335B, 11796, 18604, 20404, 21207, 21976, 24027, 24773, 40923. Jones, I. W., 1932, Que. Bur. of Mines Ann. Rept., Part D.

Region D: GM numbers 21232, 22008, 23058, 29113, 31269, 31414, 32488.

Region E: GM numbers 18261, 23306.

Region F: GM 18528.

APPENDIX 2

FLUID INCLUSION HEATING AND FREEZING DATA

EXPLANATION OF SYMBOLS

Note: Type 1 and Type 3 inclusions homogenized to liquid and H_2O phases respectively unless otherwise indicated.

I.G.	Inclusion Group No.: distinct group of spatially associated inclusions within a thin section.
I.T.	Inclusion Type No.: Type 1 = LV, Type 2 = LVS, Type 3 = LLV, Type 4 = CO_2-CH_4 inclusions.
P.R.	Visually estimated room temperature vapour:liquid or CO_2:H_2O ratio for Type 1, 3 inclusions respectively.
m.p. CO_2	CO_2 melting point.
m.p. ice	Ice melting point.
m.p. cla.	Clathrate melting point.
TLV	Homogenization temperature of LV inclusion.
TC	Homogenization temperature of CO_2-CH_4 inclusion or CO_2-rich portion of LLV inclusion.
TLLV	Temperature of decrepitation or total homogenization of LLV inclusion.
TLVS	Temperature of decrepitation or total homogenization of LVS inclusion.
d,	Td Decrepitation temperature.
p	Critical phenomena displayed.
v	Homogenized to vapour phase.
c	Homogenized to CO_2 phase.
Ts	Dissolution temperature of solid phase in LVS inclusion.
Tv	Temperature of disappearance of vapour bubble in LVS inclusion.

VEIN CALCITE SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K87-1	1, 1, 1:3				290			
	1, 1, 3:1				410			
K87-2	1, 1, 1:6				213			
	1, 1, 1:6				213			
	1, 1, 1:1.5				336			
	1, 1, 1:4				227			
	1, 1, 1:2				318			
	1, 1, 1:5				224			
	1, 1, 1:7				203			
	1, 1, 1:1				305			
K87-18	1, 3, 8:1	-56.2				28.1	241d	
	1, 3, 1:1					28.1	336d	
	1, 3, 9:1	-56.2				28.1	292c	
	1, 3, 2:1						41°C	
	2, 1				134			
	2, 1, 1:8		-3.3				172	
	2, 1, 1:8						140	
	2, 1		-7.6				157	
K87-20	1, 1, 1:23		-6.0		122			
	1, 1, 1:20				144			
	1, 1, 1:25				116			
	1, 1, 1:8				206			
	1, 1, 1:30				111			
	1, 1, 1:17		-6.7					
K87-36	1, 1, 1:11				137			
	1, 1, 1:9				136			
	1, 1, 1:7				143			
	1, 1, 1:15				138			
K87-38	1, 1, 1:7		-4.5		137			
	1, 1, 1:7		1.7		122			
K87-23	1, 1, 1:12		1.0		118			
	1, 1, 1:7		0.0		161			

VEIN CALCITE SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K87-10	1, 1, 1:7				218			
	1, 1, 1:8				163			
	1, 1, 1:9		-9.4		194			
	1, 1				157			
	1, 1, 1:8		-7.5		169			
	2, 1, 1:2				376			
	2, 1, 1:5		-5.1		217			
K87-14	1, 1, 1:6				148			
	1, 1, 1:10		-3.8		148			
	1, 1, 1:12		-3.8		148			
	1, 1, 1:6		-3.8		148			
	1, 1, 1:7				154			
	2, 1, 1:6				181			
K87-17	1, 1, 1:4		-1.9		156			
	1, 1, 1:7		-2.0		148			
	1, 1, 1:8				211			
	1, 1, 1:10		-5.7		156			
K87-15	1, 1, 1:10				124			
	2, 1, 1:4.5		-7.5		196			
	2, 1, 1:2.5				181			
K87-24	1, 1, 1:9				195			
	1, 1, 1:8				203			
	1, 1, 1:1			7.7	365d			
	1, 1, 1:5				249			
	1, 1, 1:10				203			
	1, 1, 1:5				190			
	1, 1, 2:1				414			
K87-25	1, 1, 1:12		-0.2		148			
	1, 1, 1:15		-0.1		164			

VEIN CALCITE SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K87-6	1, 1, 1:1			5.4	340			
	1, 1, 1:1				348			
	1, 1, 1:1				294			
	1, 1, 1:2				296			
	1, 1, 1:2				279			
	1, 1, 1:1				289			
	1, 1, 2:1				152			
	1, 1, 1:7		-7.0		267			
K87-27	1, 1, 1:8		-5.1		167			
	1, 1, 1:12		-9.6					
	2, 1, 1:4.5		-0.9		165			
K87-29	1, 3, 1:1			7.3			334	
	1, 3, 1:2	-56.2		6.0		29.3v	329	
	1, 3, 1:1						360	
	1, 3, 1:1	-56.3					310d	
	1, 3, 1:1						320	
K87-30	1, 1, 1:1				328			
	1, 1, 13:1				287d			
	1, 1, 7:1				271d			
	1, 1, 7:1				271d			
	1, 1, 1:1.5				323d			
K87-31	1, 1, 1:1.5				330			
	1, 1, 1:7		-4.2		152			
	1, 1, 3:1				357d			
	1, 1, 1:1				357			
	1, 1, 1:12				133			
	1, 1, 1:1				378			
	1, 1, 1:11				101			
	1, 1, 1:8		-3.5		118			
	1, 1, 1:5		-3.5		106			
	1, 1, 1:6				123			
	1, 1, 1:1.5				357d			

VEIN CALCITE SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K87-32	1, 1, 1:5				211			
	1, 1, 1:3				179			
	1, 1, 1:7				172			
	1, 1				184			
	1, 1, 1:7		-9.6		181			
	1, 1, 1:4.5				162			
	1, 1, 1:12				184			
	2, 1, 1:9			1.0				
K87-33	1, 1, 1:1			6.0	173			
	1, 1, 1:3				206			
	1, 1, 1:3.5				217			
	2, 1, 1:9				206			
	2, 1, 1:9				223			
K87-34	1, 1, 1:5		-3.4		177			
K87-35	1, 1, 1:12				15155			
	1, 1, 1:9				172			
	1, 1, 1:22				137			
	1, 1, 1:12		-0.65		150			
	1, 1, 1:13		-0.65		155			
	1, 1, 1:3				135			
	1, 1, 1:11		-0.65		157			
K87-22	1, 3, 8:1	-56.3						
	1, 3, 20:1					29.6p		
	1, 3, 10:1						240d	
	1, 3, 8:1	-56.4					268c	
	1, 3, 15:1						288d	
	2, 3, 2:1					31.0p	308c	
K87-37	1, 1, 1:11		-3.0		146			
	1, 1, 1:6				147			
	1, 1, 1:7				171			
	1, 1, 1:5		-0.6		132			
	1, 1				126			
	2, 1, 1:2.5				262			
	1, 1, 1:8				138			

VEIN CALCITE SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K87-38a	1, 1, 1:15				176			
	1, 1, 1:4.5				204			
	1, 1, 1:9				186			
	1, 1, 1:8				218			
	2, 1, 1:5		-1.0					
	2, 1, 1:5				157			
	2, 1, 1:8				218			
K87-24a	1, 1, 1:10				244			
	1, 1, 1:6				260			
	1, 1, 1:2			11.5	317d			
	1, 1, 1:1			11.5	325			
	1, 1, 1:1				325			
	1, 1, 1:5		-1.0		198			
	1, 1, 1:2		-1.0					
K87-4	1, 1, 1:8				205			
	1, 1, 1:5		-4.2		286			
	1, 1, 1:6.5		-4.2		219			
K88-37	1, 1, 1:10				167			
K88-1	1, 1, 1:20				151			
	1, 1, 1:14				131			
	1, 1, 1:9				80			
	1, 1, 1:4				249			
	1, 1, 1:20				115			
	1, 1, 1:6				134			
K88-3	1, 1, 1:1.5				54p			
	1, 1, 1.5:1				321			
	1, 1, 1:1.5				57p			
	1, 1, 1.5:1				66v			
	1, 1, 1:1				61p			
	2, 1, 1:1				59			
	2, 1, 1:3				55			
	2, 1, 1:5				46			

VEIN CALCITE SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-5	1, 1, 1:1				42v			
	2, 1, 1:2				255d			
K88-36	2, 1, 1:11		0.5		152			
	2, 1, 1:8				157			
	2, 1, 1:5				215			
	2, 1, 1:1.5		-4.3		205			
	2, 1, 1:3				200			
K88-43	1, 1, 1:15		0.0		284			
	1, 1, 1:2				287			
K88-94 calcite	1, 1, 1:8				125			
	1, 1, 1:12				138			
	1, 1, 1:5				401			
	1, 1, 1:6				151			
K88-94 quartz	2, 1, 1:5				249			
	2, 1, 1:15				112			
	2, 1, 1:1.5				328d			
	2, 1, 4:1				402			
	2, 1, 1:3.5				270			
	2, 1, 1:2				306d			
K88-39b	1, 1, 1:6				176			
	1, 1, 1:5		-3.8		176			
	1, 1, 1:5		-3.8		176			
	1, 1, 1:12				176			
	2, 1, 1:7				195			
	2, 1, 1:4				243			
	2, 1, 1:4				263			
	2, 1, 1:3				269			
	2, 1, 1:1				328			
	2, 1, 1:2				328			
K88-4 calcite	1, 1, 1:5.5				176			
	1, 1, 1:5				162			
	1, 1, 1:8				139			
	1, 1, 1:14				139	3.9		

VEIN CALCITE SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-4 quartz	2, 1, 1:11				148			
	2, 1, 5:1				300			
	2, 1, 1:11				148			
	2, 1, 1:3.5				205			
	2, 1, 1:3.5				234			
K88-13	1, 1, 2:1				311			
	1, 1, 2:1				267d			
	1, 1, 1:1				311d			
	1, 3, 1:1.5	-56.1				31v	267d	
	2, 1, 1:35				87			
	2, 1, 1:25				87			
	2, 1, 1:30		-4.0		95			
	2, 1, 1:30		-1.9		87			
	2, 1, 1:15				155			
K88-114	1, 1, 1:6				185			
	2, 1, 1:20				140			
	2, 1, 1:30				80			
K88-46 quartz	1, 1, 1:10				205			
	1, 1, 1:6				212			
	1, 1, 1:5				217			
	1, 1, 1:9		-6.9		250			
	1, 1, 1:3				243			
	1, 1, 1:5				207			
	1, 1, 1:6				190			
K88-46 calcite	2, 1, 1:9				238			
	2, 1, 1:6				233			
	2, 1, 1:4				295			
	2, 1, 1:7				211			
	2, 1, 1:4				195			
K88-64	1, 1, 1:8				146			
	1, 1, 1:10				147			
	1, 1, 1:20				128			
	1, 1, 1:10				119			
	1, 1, 1:9				108			

VEIN CALCITE SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-20	1, 1, 1:10				117			
	1, 1, 1:20				155			
	1, 1, 1:20				100			
K88-28	1, 1, 1:1				286			
	1, 1, 1:2				262			
	1, 1, 1:1				291			
	1, 1, 1:1				315			
	1, 1, 1:2				305			
K88-68	1, 1, 1:1.5				293			
	1, 1, 1:2				293			
	1, 1, 1:3				293			
	1, 1, 1:3				293			
	1, 1, 1:1				293			
	1, 1, 1:1				293			
K88-119	1, 1, 1:3.5				204			
	1, 1, 1:6				175			
	1, 1, 1:10				202			
	1, 1, 1:6				175			
	1, 1, 1:6				194			
K88-31	1, 1, 1:3		-21		61			
	1, 1				63			
	1, 1, 1:4		-32		69			
	1, 1, 1:14		-16		62			
K88-19	1, 3, 3:1						319	
	1, 3, 4:1						319	
	1, 3, 1.5:1	-56.2					319	

VEIN CALCITE SAMPLE

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K87-21	1, 4					-72		
	1, 4				148d	-37		
	1, 4					-20		
	1, 4					-20		
	1, 4					-20		
	2, 4					-46		
	2, 4					-27		
	2, 4					-27		

VEIN QUARTZ SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-121	1, 1, 1:10		-1.0		133			
	1, 1, 1:1				378v			
	1, 1, 1:1				378p			
	1, 1, 1:3				255			
	1, 1, 1:1				359			
	1, 1, 1:2				348			
	1, 3, 1:1	-56.0		8.3		10.0v	367c	
	1, 3, 5:1	-56.0		8.3		20.0v	367c	
K88-69	1, 1, 1:4				330			
	1, 1, 1.5				340			
	1, 1, 3:1				360			
	1, 1, 1:3				342			
	1, 3, 1:1					27.0v	360	
	1, 3, 1:2.5						338	
	1, 3, 3:1	-55.6		9.7		16.5v	352	
	1, 3, 4:1	-55.6		9.7		26.0v	371	
K88-109	1, 1, 1:10		-4.1		218			
	1, 1, 1:2				319			
	1, 1, 2:1				370v			
	1, 3, 1:1						336p	
	1, 3, 1:1.5	-56.0				29.1v	348	
	1, 3, 1:1	-56.0				29.1v	386c	
	1, 3, 2:1						348	
K88-15	1, 1, 1:9		-8.9		225			
	1, 1, 1:10		-8.9		147			
	1, 1, 1:14				128			
	2, 3, 1:1						291d	
	2, 3, 2:1					29.0v	357	
	2, 3, 1:1						285d	
	2, 3, 1:1						285d	
	2, 3, 3:1						285d	
	2, 3, 1.5:1						357	
	2, 3, 1.5:1					28.0v	310d	
	2, 3, 1:2	-56.0				30.0v		

VEIN QUARTZ SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-81	1, 1, 1:1				455			
	1, 1, 1:1				455			
	1, 3, 1.5:1	-55.6				21.7v	410d	
	1, 3, 2:1	-55.6				18.3v	442c	
	1, 3, 1.5:1						391c	
	1, 2					Ts=294,		Tv=301
	1, 2					Ts=187,		Tv=410
	1, 2							Ts=167
	1, 2				Ts2=97,	Tv=329,		Td=387
K88-122	1, 1, 1:1				342			
	1, 1, 1:1				342			
	1, 1, 1:1				342			
	1, 1, 1:1				342			
	1, 1, 1:1				342			
	1, 1, 1:1				342			
K88-90	1, 1, 1:1				319			
	1, 1, 1:2				329			
	1, 1, 1:1.5				319			
	1, 1, 1:1				330			
	1, 1, 1:1				354d			
	1, 1, 1:2				312			
	1, 1, 1:2				363			
	1, 2					Ts=189,		Tv=264
K88-66	1, 1, 1:1				359			
	1, 1, 1:1				361			
	1, 1, 1:1				368			
	1, 1, 1:1				376			
	1, 1, 2:1				416v			
	1, 1, 2:1				388			
	1, 3, 1.5:1	-56.0		8.5		28.9	348d	
	1, 4					20.0		
	1, 4					25.8		

VEIN QUARTZ SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-61	1, 1, 1:4				296			
	1, 1, 2:1				376v			
	1, 1, 1:1				361v			
	1, 1, 1:1				356			
	1, 1, 1:1				367			
	1, 3, 1:1.5					28.4v	355	
	1, 3, 1:1	-56.6		9.4		28.0v	358d	
	1, 3, 2:1					26.3v	367c	
K88-23	1, 1, 1:1.5				344			
	1, 1, 1:1				395			
	1, 1, 1.5:1				359			
	1, 1, 1:1				355			
	1, 1, 2:1				385d			
	1, 1, 1:1				429			
	1, 2					Tv=308,		Ts=434
	1, 2					Tv=214,		Ts=243
K88-102	1, 1, 2:1				368p			
	1, 1, 4:1				368v			
	1, 1, 2:1				379v			
	1, 2					Ts=263,		Tv=358
	2, 2					Ts=240,		Tv=435
K88-16	1, 1, 1:3				305			
	1, 1, 1:2				353			
	1, 1, 1:1				358			
	1, 1, 1:2				331			
	1, 1, 1:1				337			
	1, 1, 1:1				305			
	1, 3, 4:1						305d	
K88-75	1, 1, 1:1				397			
	1, 1, 1:4				329			
	1, 1, 1:1				356			
	1, 1, 1:1				420v			
	1, 1, 1:1.5				444			

VEIN QUARTZ SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-75 cont'd	1, 1, 2:1				348v			
	1, 1, 2:1				357v			
	1, 2						Ts=Tv=197	
	1, 2					Tv=328, Td=396		
	1, 3, 3:1						345c	
K88-92	1, 1, 1:4				322			
	1, 1, 1:2.5				335			
	1, 1, 1:7				162			
	1, 1, 1:2.5				323			
	1, 1, 1:1				331			
	1, 1, 1:2				331			
	1, 1, 1:1				325			
	1, 1, 1:3.5				253			
K88-11	1, 1, 1:1				348			
	1, 1, 2:1				393v			
	1, 1, 1:4				348			
	1, 1, 1:1				348			
	1, 1, 1:8				307			
	1, 1, 1:1				346			
	1, 1, 1:1				348			
	1, 1, 1:5				230			
K88-26	1, 1, 1.5:1				409v			
	1, 1, 2:1				309d			
	1, 1, 1.5:1				367d			
	1, 1, 1:1.5				405d			
	1, 1, 1.5:1				375			
	1, 2					Tv=193, Ts=281		
	1, 2						Ts=Tv=292	
	1, 2					Tv=258, Ts=315		
	1, 2					Tv=251, Ts=308		
	1, 3, 1:1.5	-57.3				23.9v	309d	
	1, 3, 1.5:1					23.9v	375c	
	1, 3, 1.5:1	-57.3				23.9v	367p	

VEIN QUARTZ SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-25	1, 1, 1:12				141			
	1, 1, 1:4.5				186			
	1, 1, 1:1				274			
	1, 1, 1:13				155			
	1, 1, 1:9		-9.0		246			
	1, 1, 2:1				345p			
	1, 1, 1:2				290d			
	1, 1, 1:1				345			
	1, 1, 1:1.5				382			
	1, 1, 1:6				261			
	1, 1, 1:2		-9.0		253			
K88-83	1, 1, 1:1				342			
	1, 1, 1:1				351			
	1, 1, 1:2				387			
	1, 1, 1:1.5				381			
	1, 1, 1:2				340			
	1, 1, 1:1				341			
	1, 2					Ts=294,		Td=364
K88-107	1, 1, 1:2				315			
	1, 1, 1:1				339			
	1, 1, 1:5.5				216			
	1, 1, 1:1				385			
	1, 1, 1.5:1				315			
	1, 2					Tv=296,		Td=385
	1, 2					Tv=220,		Ts=385
K88-111	1, 1, 1:2				331			
	1, 1, 1:11		-3.5		176			
	1, 1, 1:2.5				316			
	1, 1, 1:1.5				327			
	1, 1, 1:4				355			
	1, 1, 1:1				335			
	1, 1, 1:3				321			
	1, 1, 1:1.5				327			
	1, 1, 1:11				131			

VEIN QUARTZ SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-105	1, 1, 1:1				444			
	1, 1, 1:1				444			
	1, 1, 1:1				444			
	1, 1, 1:2				425			
	1, 2					Ts=235, Tv=411		
	1, 2					Ts=238, Tv=429		
	1, 2					Ts=209, Tv=357		
	1, 3 1:1						444	
K88-98	1, 1, 2:1				348v			
	1, 1, 1:1				443			
	1, 1, 1:1				333			
	1, 1, 1:9				300			
	1, 1, 1:1				314			
	1, 2					Ts=208, Tv=249		
	1, 2					Ts=176, Tv=293		
	1, 2					Ts=239, Tv=323		
K88-97	1, 1, 2:1				373			
	1, 1, 1:1				373			
	1, 1, 1:1				373			
	1, 1, 1:1			10.0	384			
	1, 1, 1:6		-3.4		241			
	1, 1, 1:1		-0.5		384			
K88-76	1, 1, 1:1				353			
	1, 1, 1:2				356			
	1, 1, 1:3				285			
	1, 1, 1:1				361			
	1, 1, 2:1				361			
	1, 1, 1:1.5				329			
	1, 2					Tv=162, Ts=327		
	1, 2					Tv=186, Ts=390		

VEIN QUARTZ SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-65	1, 1, 1:1				407			
	1, 1, 1:1				385			
	1, 1, 1:1				434v			
	1, 1, 2:1				438v			
	1, 1, 2:1				424v			
	1, 2							Tv=290, Ts=311
	1, 2							Tv=262, Ts=295
	1, 3, 2:1	-55.6				27.5v	384d	
K87-11	1, 1, 1:1				317			
	1, 1, 1:1				321			
	1, 1, 1.5:1				309			
	1, 1, 1:1				319			
	1, 1, 1:1				330			
	1, 1, 1:1				314			
	1, 3 1:1	-56.1		8.2			340	
	1, 3, 1:1	-56.1		8.2			352	
	1, 3, 1:1						340	
K88-63	1, 1, 1:3		-3.1		289			
	1, 1, 1:4		-3.1		289			
	1, 3, 1:1						345d	
	1, 3, 1.5:1						357	
	1, 3, 1:1						290	
	2, 1, 1:1				342			
	2, 1, 1:1				342			
	2, 1, 1:1				342			
	2, 1, 1:1				342			
	2, 1, 1:1				342			
	2, 1, 2:1				351			
	2, 1, 1:1.5				351			
K88-104	1, 1, 1:18				123			
	1, 1, 1:7		-9.0		190			
	1, 1, 1:9				143			
	1, 1, 1:9				163			

VEIN QUARTZ SAMPLES

	FLUID INCLUSION DATA							
Sample no.	I.G., I.T., P.R.	m.p. CO_2 °C	m.p. ice °C	m.p. cla. °C	TLV °C	TC °C	TLLV °C	TLVS °C
K88-104 cont’d	2, 1, 1:1				344			
	2, 1, 1:1				348			
	2, 1, 1:1				348			
	2, 1, 1:1			7.5	348			
K88-18	1, 1, 1:3.5				352			
	1, 1, 1:2.5				348			
	1, 1, 1:1				351			
	1, 1, 1:1				348			
	1, 3, 1:2	-57.1					375	
	1, 3, 1:2						391d	
	1, 3, 1:1	-57.1		8.3		25.1v	291d	
	1, 3, 3:1	-57.1					291d	
	1, 3, 3:1					26.1v	400	
K88-100	1, 1, 1:1				443			
	1, 1, 1.5:1				443			
	1, 1, 3:1				318			
	1, 1, 1:1				373			
	1, 1, 2:1				384v			
	1, 2					Ts=240, Tv=400		
	1, 2					Ts=219, Tv=376		
	1, 2					Tv=302, Ts=367		
	1, 2				Ts2=133, Tv=332, Ts1=376			
K88-120	1, 1, 1:4				161			
	1, 1, 1:9				145			
	1, 1, 1:4.5				187			
	1, 1, 1:4				167			
	2, 1, 1:7				201			
	2, 1, 1:4.5				239			