Preliminary stratigraphy and distribution of Devono-Mississippian massive sulphide-bearing volcanic rocks in the Mount Vermilion (Wolf) area, Pelly Mountains (105G/5 and G/6), southeast Yukon

J.A. Hunt
Yukon Geology Program

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ABSTRACT

The Mount Vermilion area is located at the southeast end of the Pelly Mountains volcanic belt, about 90 km southeast of Ross River, and includes the Wolf volcanogenic massive sulphide deposit. This well exposed area was mapped at a scale of 1: 25 000; several stratigraphic sections were measured across the belt. Results from this study show that the southeast end of the belt is made up of dominantly felsic volcaniclastic strata. The base of the succession consists of dominantly brown-pink lapilli tuff interbedded with argillite and lesser trachyte sills/dykes. The middle of the succession is made up primarily of heterolithic lapilli tuff with distinct argillite clasts, maroon matrix tuff with green lapilli-sized fragments and trachyte flows/sills/dykes; the upper part consists of chlorite-altered volcaniclastic rocks containing intermediate dykes and flows. The Wolf deposit is hosted within the middle portion of the volcanic succession proximal to a syenite intrusion.

To the west, towards the centre of the volcanic belt the felsic volcaniclastic component decreases as the number of sills, flows and dykes becomes more numerous, and the amount of intermediate volcanic material increases.

RÉSUMÉ

La région du mont Vermilion est située à l'extrémité sud-est de la ceinture volcanique des monts Pelly, à environ 90 km au sud-est de Ross River et contient l'amas de sulfure massif volcanogène de Wolf. Cette région bien exposée a été cartographiée à l'échelle du 1/25 000; plusieurs coupes stratigraphiques de cette ceinture ont été relevées. Les résultats de la présente étude montrent que l'extrémité sud-est de la zone est constituée principalement de roches volcaniclastiques felsiques. La base de la succession est surtout constituée de tuf à lapilli brun-rose intercalé d'argilite et de sills/dykes à trachyte moins abondants. Le centre de la succession est principalement constitué de tuf hétérolithique à lapilli présentant distinctement des clastes d'argilite, de tuf à matrice brune avec des fragments verts de la taille des lapilli et des coulées/sills/dykes de trachyte; la partie supérieure est constituée de roches volcaniques chloritisées renfermant des dykes et des coulées intermédiaires. Le dépôt de Wolf se trouve au centre de la succession volcanique, près d'une intrusion de syénite.

À l'ouest, vers le centre de la ceinture volcanique, l'élément volcaniclastique diminue au fur et à mesure qu'augmentent le nombre de sills, de coulées et de dykes, ainsi que la quantité de matériaux volcaniques intermédiaires.

INTRODUCTION

The Mount Vermilion area is located in the Pelly Mountains about 90 km southeast of Ross River (Fig. 1). The area lies at the southeast end of the Pelly Mountains volcanic belt (Fig. 2) which hosts several massive sulphide (VMS) occurrences (e.g., Gordey, 1977; Tempelman-Kluit, 1977; Chronic, 1979; Mortensen, 1979, 1981; Doherty, 1997; Holbek and Wilson, 1998; Yukon Minfile 105F 012, 013, 071, 073, 081,105G 008). Initial interest in this belt took place in the 1970s, sparked by exploration of a silver-lead-zinc occurrence known as the MM (Morin, 1977). After several years, the property became dormant, but interest was rekindled by the discovery of the Kudz Ze Kayah and Wolverine deposits in 1994 in time-correlative strata in the Finlayson Lake area immediately to the east (Fig. 1; Schultze, 1996; Tucker et al., 1997). Discovery of VMS mineralization on the Wolf property, at the southeast end of the belt, in 1997 triggered a staking rush and re-assessment of the mineral potential throughout the volcanic belt (Fig. 2; Holbek and Wilson, 1998; Gibson et al., this volume).

The belt was mapped at reconnaissance scale by the Geological Survey of Canada (Wheeler et al., 1960a, b; Tempelman-Kluit, 1977a, b; Gordey, 1978 and 1979), with more detailed thesis mapping by Gordey (1977), Chronic (1979) and Mortensen (1979). However, no systematic mapping or stratigraphic study had been carried out in the well exposed Mount Vermilion area which hosts the Wolf deposit. To investigate this area, a field mapping and stratigraphic study was conducted during the 1998 field season. Several additional traverses in the central and northwestern parts of the belt attempted to correlate volcanic stratigraphy throughout the belt. This paper presents results of the study.

REGIONAL SETTING

PELLY-CASSIAR PLATFORM

From Middle Proterozoic through Early Devonian time, a miogeoclinal sequence accumulated along the western margin of North America (Gabrielse and Yorath, 1991). Between mid-

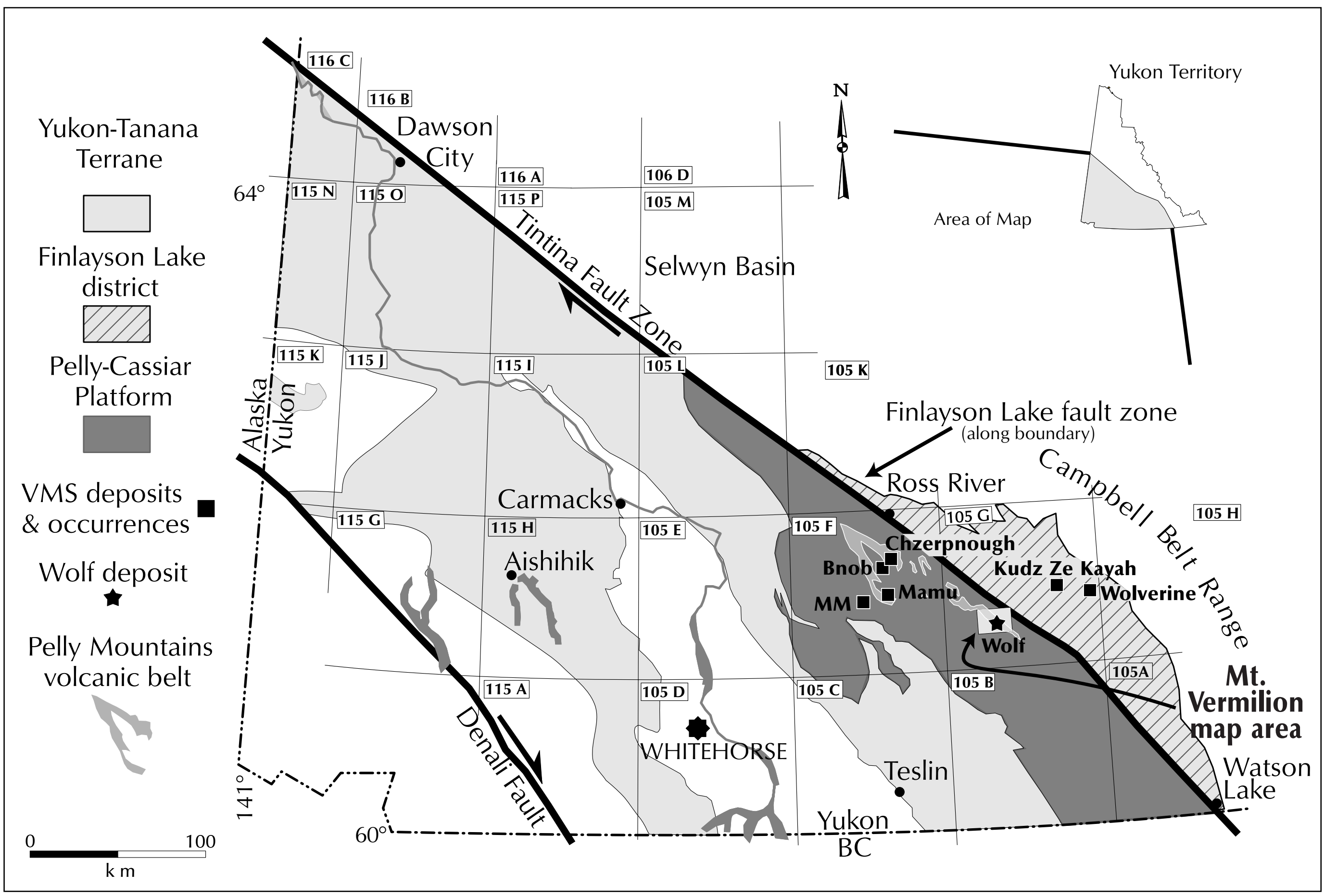


Figure 1. Location of the Mount Vermilion area, Pelly-Cassiar Platform, Finlayson Lake district and various VMS deposits and showings. This map is modified from Wheeler and McFeely (1991) and Johnston and Mortensen (1994).

Cambrian and Silurian time, a curvilinear shelf known as the Pelly-Cassiar Platform formed, roughly parallel to the craton edge but separated from it by the Selwyn Basin (Fig. 1; Gabrielse, 1967; Tempelman-Kluit and Blusson, 1977; Mortensen 1981; Fritz et al., 1991). Shallow water deposition on the Pelly-Cassiar Platform continued until Late Devonian time. Block faulting and local uplift during the Late Devonian and Mississippian resulted in deposition of carbonaceous shale and chert pebble conglomerate in the Selwyn Basin and across the Pelly-Cassiar Platform (Blusson, 1976; Gordey, 1978, 1979; Mortensen, 1981). Local explosive volcanism produced thick tuffs and flows whose extremities intertongue with surrounding black shale. Some of these volcanic centres contain base metal mineralization and are the subject of this report. Calcareous argillite of Upper Paleozoic to Triassic age was deposited above the shale and volcanic sequence (Tempelman-Kluit et al., 1976).

PELLY MOUNTAINS VOLCANIC BELT

The Pelly Mountains volcanic belt is arcuate, about 80 km long, up to 25 km wide and forms part of the Pelly-Cassiar Platform (Figs. 1 & 2). The present deformed thickness of the volcanic section is highly variable, ranging from less than 100 m to as much as 1700 m (Gordey, 1977, 1981; Mortensen, 1979, 1981).

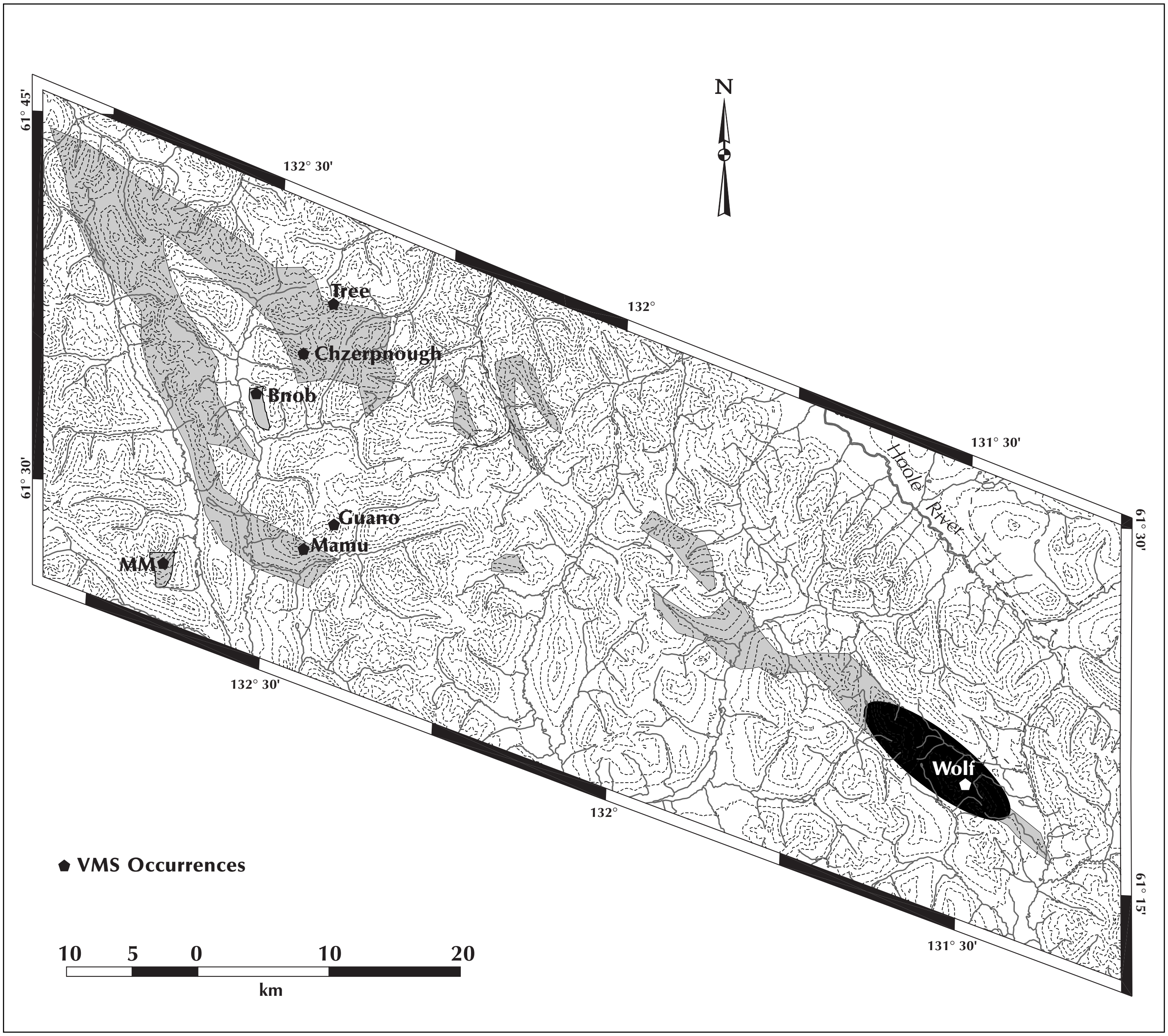


Figure 2. *Location of the Pelly Mountains volcanic belt (light grey area). The Mount Vermilion area lies at the southeast end of the belt. Also shown are the location of VMS occurrences.*

GEOLOGY

In the Mount Vermilion area, at the southeast end of the belt, the volcanic succession is made up primarily of felsic volcaniclastic material with lesser sills/dykes/flows and minor intermediate sills/dykes/flows. At the northwest end of the belt volcanic units of intermediate composition constitute the bulk of the volcanic succession, however, felsic volcanics occur midway through the volcanic sequence. Within these felsic volcanic rocks, Morin (1977) and Mortensen (1979) described several submarine volcanic complexes where extensive volcaniclastic strata are interbedded with flows and tuffaceous chert, and intruded by felsic domes and stocks. These syenitic intrusions were considered by Tempelman-Kluit (1976), Morin (1977) and Mortensen (1979, 1981) to be the subvolcanic equivalent of some of the felsic tuffs and flows. Locally, the felsic tuffs contain pyrite and are immediately overlain by massive sulphide lenses (Morin, 1977; Mortensen, 1979, 1981). Pervasive clay and carbonate alteration characterize the felsic volcanic unit.

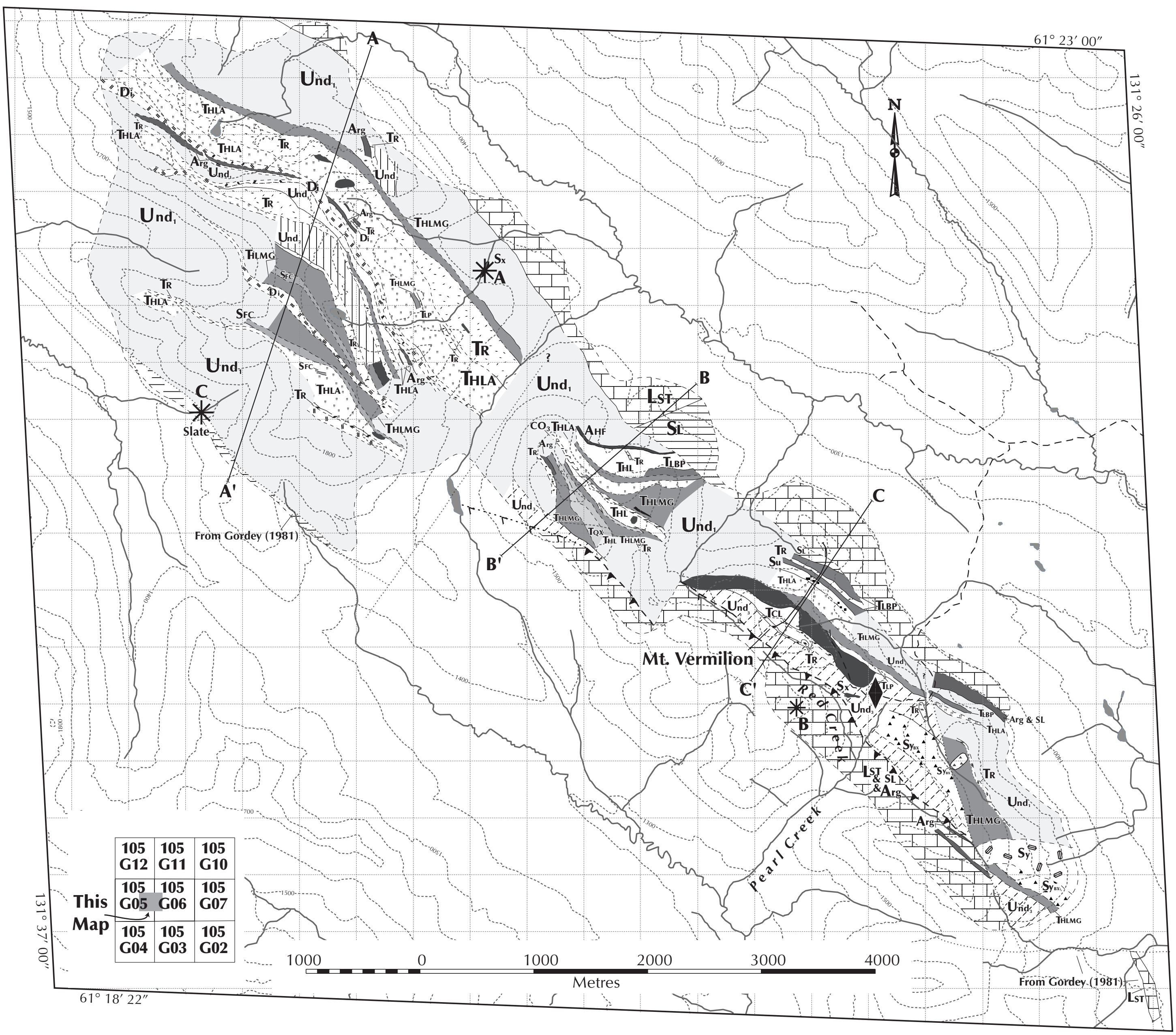
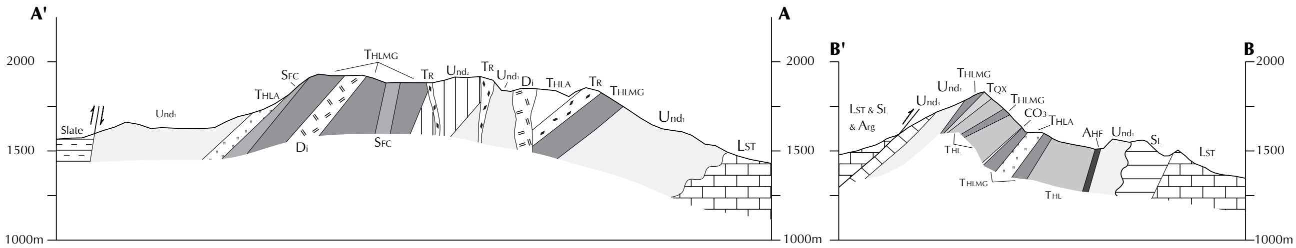
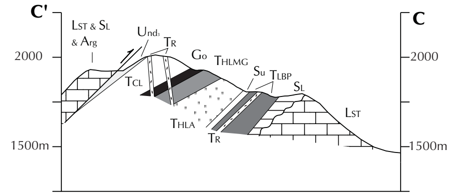


Figure 3. *Bedrock geology sketch map of the Mount Vermilion area, Pelly Mountains with some geological contacts taken from Gordey (1981).*





MINERAL OCCURRENCES

Yukon Minfile Number	Name	Deposit	Type
105G 008	Wolf	♦	VMS
Previously unreported mineral occurrences			
A		✳	
B		✳	
C		✳	

SYMBOLS

- Limit of mapping
- Geological contact (defined, approximate, assumed and/or covered)
- Fault (defined, approximate, assumed and/or covered)
- Thrust fault (defined, approximate, assumed and/or covered)
- Bedding — 24; VERTICAL
- Foliation — 67; VERTICAL
- Cross-section line — A — A'
- Stratigraphic-section location
- Winter trail

LEGEND

DEVONO-MISSISSIPPIAN

Non-fragmental Units

Sy — Syenite – grey weathering, grey to white or rarely pink, very fine-grained to pegmatitic with pink feldspar crystals up to 4 cm long. Disseminations and blebs of pyrite occur throughout the intrusion with rare fluorite.

TR — Trachyte flows, sills and dykes – dark rusty brown to yellow or grey weathering, fresh surfaces are dark pinkish brown to light grey with numerous iron carbonate filled vesicles. Locally fine-grained glassy needle-like feldspar crystals are visible.

Di — Diorite/andesite flows, sills and dykes – medium grey-green to brown weathering with a pitted surface. Fresh surfaces are medium green with relict biotite? and feldspar crystals and trace fine-grained disseminated pyrite. Locally the rocks is cut by numerous carbonate filled fractures.

Fragmental Units

TCL — Chlorite-altered tuff/brecciated diorite/andesitic lapilli tuff – black to dark grey weathering with rusty iron carbonate blebs and veinlets throughout. Rare light coloured, sub-angular fragments occur in a fine-grained dark grey matrix.

THLA — Heterolithic lapilli tuff with argillite clasts – This lithology is generally flaggy and weathers light pink-brown with silvery coloured fragments and weathered-out iron carbonate blebs. The fragments are dominantly pale green volcanic rock and lesser, but distinct, fine-grained black argillite fragments that average 0.5 to 1.0 cm across. Locally this unit is very coarse-grained with argillite clasts up to 50 cm across.

THL — Heterolithic lapilli tuff – this unit is similar to THLA but has no argillite clasts

CO3 — Narrow white limestone bands and lenses within the volcanic package.

THLAB — THLA interbedded with narrow bands of black argillite.

THLMG — Maroon and green heterolithic lapilli tuff – In general this unit has a maroon matrix with dominantly pale green and lesser pale grey clasts that average 1 to 3 cm across. Locally this unit is very coarse grained with trachyte fragments up to 60 cm across (locally may include narrow bands and lenses of argillite).

TLP — Pyritic/sulphidized lapilli tuff – weathers rusty yellow and gossanous to bleached. Pyritic clasts generally less than 1 cm across occur in a light grey matrix.

TQX — Quartz (feldspar) crystal tuff – weathers medium grey with cream and black fragments. Fresh surfaces are medium grey with trace to 5% glassy quartz crystals 1 to 3 mm in diameter.

TLBP — Brown-pink lapilli tuff – Flaggy, light pinkish brown weathering tuff with rounded, fine-grained, pale grey to pale green, rarely feldspar phyric, fragments (trachyte?) 2 to 15 mm across.

AHF — Heterolithic felsic agglomerate/breccia – Weathers light grey with rusty blebs. Angular, fine-grained, grey fragments up to 30 cm across occur in a medium to dark grey matrix.

SyBX — Syenite breccia – weathers light grey to white, monolithic with fine-grained angular fragments from 1 to 15 cm across. Locally the fragments include white feldspar and rounded quartz crystals.

Arg — Argillite - black to silvery grey, fissile, locally laminated, rarely finely striped grey and green.

SFC — Interbedded sandstone, shale/argillite and iron carbonate cemented breccia

Su — Undivided sedimentary rocks - made up of interbedded argillite and fine- to coarse-grained buff coloured sandstone.

Und1 — Undivided unit made up of Tr, THLA and THLMG

Und2 — Undivided unit made up of THLA and THLMG

Go — Gossan

"DEVONO-MISSISSIPPIAN" or "DEVONIAN or older"

Und3 — Undivided unit made up of grit, conglomerate and THLA. It is not clear if this unit is part of the Devono-Mississippian volcanic sequence or the overthrust package.

DEVONIAN or older

LST — Limestone/dolomite – cliff forming carbonate weathers light grey to brown, is massive to well bedded, locally brecciated, locally crinoidal and locally fine-grained and laminated.

SL — Limey siltstone/shale

S — Carbonate, sandstone, grit and argillite – brown to grey to cream weathering, massive, grey, locally fossiliferous and/or bioturbated carbonate with minor sandstone interbeds; dark brown weathering coarse-grained sandstone; polymictic grit made up of varicoloured fine-grained cherty clasts in an argillaceous matrix; black, fissile argillite.

Slate — Grey weathering lustrous tuffaceous slate; minor orange or grey weathering sandstone.

Figure 3. *(continued) Cross sections and legend for Figure 3.*

STRUCTURE

The Pelly-Cassiar Platform, including the Pelly Mountains volcanic belt, is internally repeated by folds and northeast-directed thrust faults which involve strata as young as Upper Triassic (Tempelman-Kluit, 1977a). The northwestern end of the volcanic belt has been affected by three phases of deformation (Mortensen, 1981). All three phases are seen together only near the MM occurrence (Fig. 2); in other parts of the belt the folding is less intense. The first two phases are coaxial with a general northwesterly trend; the third phase produced northeasterly trending regional warps (Mortensen, 1979; 1981). Mortensen (1981) suggested the first two phases of deformation reflect nappe development during thrusting, and the unrelated third phase is possibly the result of intrusion of Cretaceous granitic batholiths to the southwest, or initial wrenching on the Tintina Fault. The southeast end of the belt is less deformed than the northwest end and folds are rarely seen. Gordey (1977) shows that the Mount Vermilion area is essentially homoclinal with moderate dips to the south. Near Mount Vermilion, dolomite overlies the volcanic succession along a moderately to steeply southwest-dipping fault, the Vermilion thrust (Fig. 3; Gordey, 1977, 1981). This fault has an estimated stratigraphic separation of about 1800 m and minimum overlap of about 3.5 km (Gordey, 1977).

METAMORPHISM

Most of the volcanic strata are lower greenschist facies regional metamorphic grade (Gordey, 1981; Tempelman-Kluit et al., 1976); the southern part of the northwest end of the belt, around the MM occurrence, has undergone a higher degree of metamorphism. There the strata reach lower amphibolite facies (Mortensen and Godwin, 1982).

AGE

Based on the following comparisons with the northwest end of the belt and similar strata in the Selwyn Basin, the volcanic rocks in the Mount Vermilion area are considered to be Late Devonian to Early Mississippian (Gordey, 1977).

- Rare conodonts and brachiopods from the upper part of the shale unit which underlies, overlies, and is laterally equivalent to the volcanic succession in the northwest end of the belt (Mortensen, 1979 and 1981) were tentatively identified as mid-Mississippian (Visean; B.E.B. Cameron and E.W. Bamber, pers. comm., quoted in Tempelman-Kluit et al., 1976; Gordey, 1977). The volcanic rocks at the southeast end of the belt unconformably (?) overlie the Middle (?) Devonian dolomite and are intercalated with shale which resembles the Late Devonian to Early Mississippian Earn Group (Gordey, 1977).
- A Rb-Sr age date of 333.0 ± 10.0 Ma for the Pelly Mountains volcanism was obtained by Chronic (1979) from a skarn developed adjacent to a large syenite stock. This syenite may have fed the felsic tuffs near the middle of the volcanic pile; thus the volcanism is considered to be Middle Mississippian in age (Chronic, 1979; Mortensen, 1981; Mortensen and Godwin, 1982).
- Sedimentary strata in the volcanic belt include some with lithological similarities to Upper Devonian and Mississippian shales of the Selwyn Basin (Blusson, 1976; Gordey, 1978, 1979).

GEOCHEMISTRY

A plot of Nb/Y versus Zr/TiO_2 by Mortensen (1981) for rocks from the northwest end of the belt shows them to be trachytes. Analysis of ten unweathered specimens from the southeast end of the belt by Gordey (1977) shows they have a chemical composition intermediate between calc-alkali trachytes and calc-alkali rhyolites.

Geochemical data reported by Morin (1977), Gordey (1977), Chronic (1979) and Mortensen (1981) show that the volcanic rocks represent a highly metaluminous and peralkaline suite likely generated in an extensional regime. Contemporaneous extension has been documented within the Selwyn Basin and the unconformity which occurs beneath the volcanic sequence suggests at least local uplift (Blusson, 1976; Tempelman-Kluit and Blusson, 1977; Gordey, 1978, 1979).

Chronic (1979) described a poorly defined but high initial $^{87}Sr/^{86}Sr$ (0.7099 ± 12) for syenite suggesting the source of the syenite melt was crustal.

GEOLOGY OF THE MOUNT VERMILION AREA

The southeast end of the volcanic belt was mapped at a scale of 1: 25 000 (Fig. 3) and several sections across the stratigraphy were measured (Fig. 4 and Appendix 1). Although no marker horizons were recognized, general transitions may be followed. In the Mount Vermilion area, the Devono-Mississippian volcanic belt contains non-fragmental, fragmental, epiclastic and other rocks, all of which are described below along with brief summaries of over- and underlying rocks and previously unreported mineralization.

UNDERLYING ROCKS

In the Mount Vermilion area, the volcanic package unconformably overlies cliff-forming carbonate and limey siltstone/shale (Gordey and Tempelman-Kluit, 1976; Gordey, 1977). In the section measured on Mount Vermilion (Fig. 4 and Appendix 1), this contact is an angular unconformity where moderately east-dipping carbonate beds are overlain by the moderately south-dipping volcanic succession. The cliff-forming carbonate weathers light grey to brown and is massive to well bedded. It is also locally brecciated, especially near the contact with the overlying volcanic succession. Breccia fragments range from less than 1 to 3 cm across in a dark grey sandy to cherty matrix. The carbonate contains rare crinoid debris; locally, it is fine-grained and laminated.

The age of this carbonate unit is based on fossil collections from similar strata in the Pelly Mountains that range from probable mid-Silurian to Middle Devonian age (D.J. Tempelman-Kluit, pers. comm. in Gordey, 1981).

Near the base of the measured section on Mount Vermilion, a 1-m wide diorite dyke cuts the brecciated carbonate and is paralleled by a 0.3 m thick highly fractured, rusty weathering white quartz vein. There is also rare float of dark rusty weathering oxidized highly porous rock (remnant massive sulphide?) nearby.

DEVONO-MISSISSIPPIAN VOLCANIC BELT

NON-FRAGMENTAL

• *SYENITE - INTRUSION (SY)*

Rubbly weathering, fine to very coarse-grained syenite was seen only on the ridge crest immediately east of the Wolf deposit (Figs. 3 and 5) where it is partly buried by talus. However, drill hole and geophysical information suggests that it underlies a large part of the ridge and may form a thick sill-like body.

The border of the intrusion is very fine-grained and grey but becomes medium-grained within several metres of the contact with white feldspar crystals in a chloritized groundmass. Locally the intrusion is pegmatitic with dark pink potassium feldspar crystals up to 4 cm long. There are disseminations and blebs of pyrite throughout the intrusion and very rare fluorite.

This syenite is similar to those described by Morin (1977) and Mortensen (1979) for the northwest end of the belt where they are interpreted to represent former volcanic centres. Chronic (1979) describes melagranite and mafic dykes that are cogenetic with nearby Mississippian syenite at the northwestern end of the volcanic belt in the Guano area. In the Mount Vermilion area the syenite was not seen to be gradational with the trachyte flows and no proximal dykes or sills were found. However, no other possible source for the trachyte flows/dykes/sills has been found to date.

• *MONZONITE/TRACHYTE - FLOWS, SILLS, DYKES (TR)*

Dark generally rusty brown weathering monzonite/trachyte occurs throughout the area. Unweathered surfaces are dark pinkish brown with numerous iron carbonate-filled vesicles about 4 mm in diameter, to medium grey with white to cream

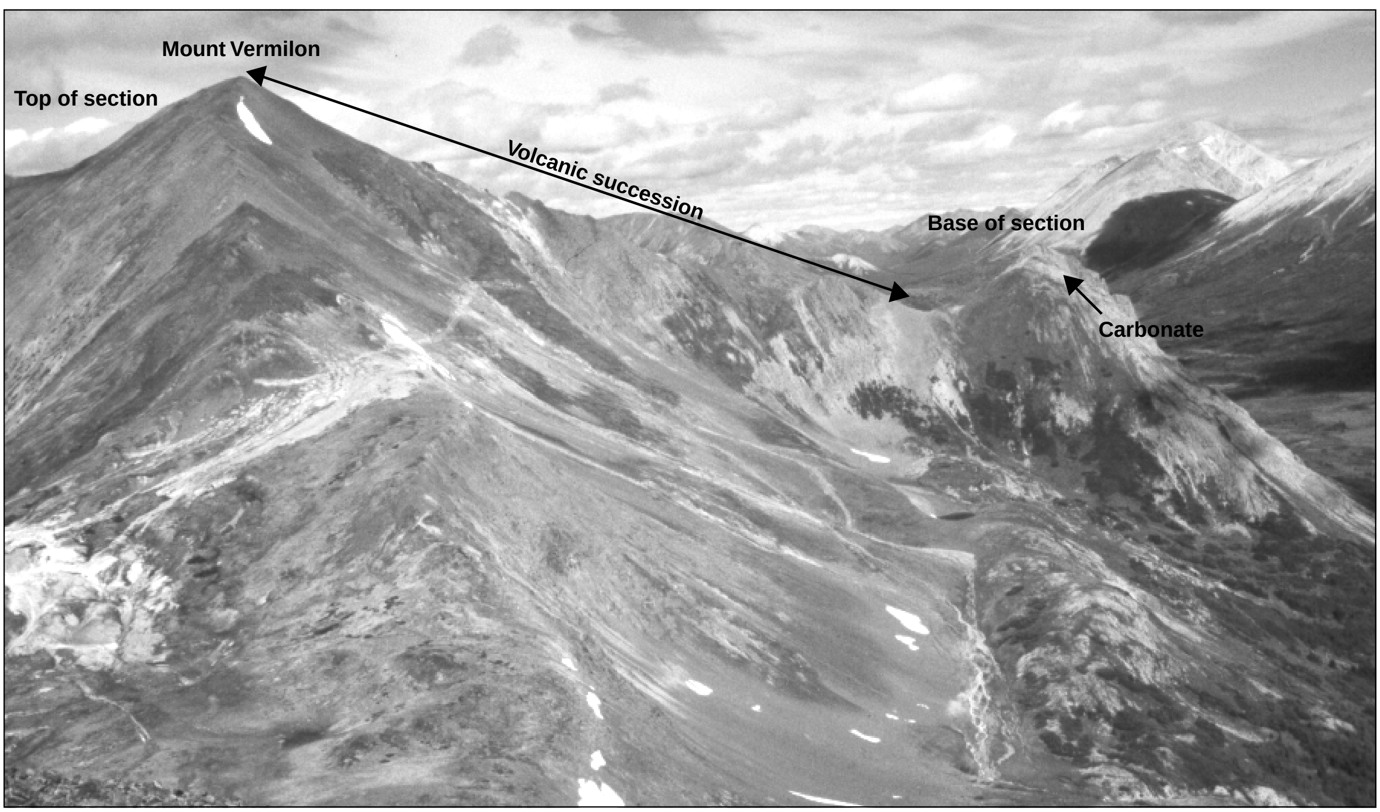


Figure 4. *View of the Mount Vermilion stratigraphic section, looking to the northwest.*

blebs (feldspar?; Fig. 6a). Locally the rocks contain 1 to 5% fine-grained disseminated pyrite blebs. Locally, this unit is siliceous and hard, especially at fine-grained margins (chilled?) which may be up to 5 m thick and commonly have numerous iron carbonate blebs, possibly the remnants of peperitic texture (Fig. 6b).

The trachyte locally weathers yellow to dark orange to dark hematitic maroon to brown; the contacts of this unit may weather bright rusty orange with iron carbonate blebs and veinlets. Fresh surfaces are locally light grey with about 1% fine-grained disseminated pyrite throughout. Locally fine-grained, glassy feldspar needles are visible throughout the rock (Fig. 6c). Very rarely quartz phenocrysts 1 to 2 mm in diameter occur within this unit. Locally, the surface of the trachyte is frothy suggesting it is a flow rather than a dyke/sill. Lower sill/dyke contacts are generally parallel to bedding, but upper contacts typically crosscut bedding.

In the lower part of the section, the trachyte is similar in appearance to the brown-pink lapilli tuff (Tlpb, see later) minus the fragments. This trachyte is amygdaloidal and vesicular with some quartz, and numerous iron carbonate-filled vesicles.

The description of trachyte flows by Morin (1977) from the northwest end of the belt matches that for the Mount Vermilion area, especially the presence of orange-brown siderite amygdules.

- ***DIORITE/ANDESITE - FLOWS, SILLS/DYKES (DI)***

This unit occurs near the top of the volcanic section where it forms resistant bands that can be traced from ridge to ridge. The intermediate rocks weather medium grey-green with black specks (chloritized mafics ?), to brown with a pitted (vesicular-looking) surface (Fig. 7 a & b); fresh surfaces are medium green with black relict biotite (?), relict feldspar that is locally needle-like, and trace fine-grained disseminated pyrite blebs. The rock is hard and dense, and locally very fine-grained near the margins.

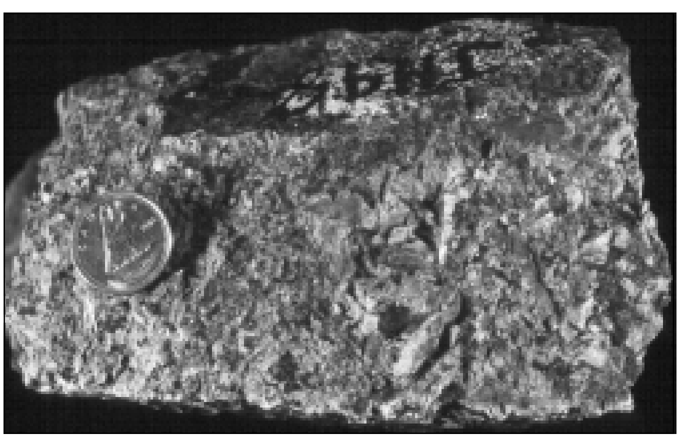


Figure 5. *(Sy) Coarse-grained syenite.*

In places the rock is strongly fractured with fractures/tension gashes filled by carbonate.

Near the base of the measured section on Mount Vermilion a 1 m wide diorite dyke cuts the underlying brecciated carbonate. The dyke is massive, fine-grained and weathers dark grey with rusty to buff coloured feldspar crystals. The weathered surface of the dyke is pitted and locally finely laminated flow banding is visible. It is not clear if this dyke is related to the intermediate flows/sills/dykes which occur in the Devono-Mississippian volcanic package or if it is part of a younger intrusive event.

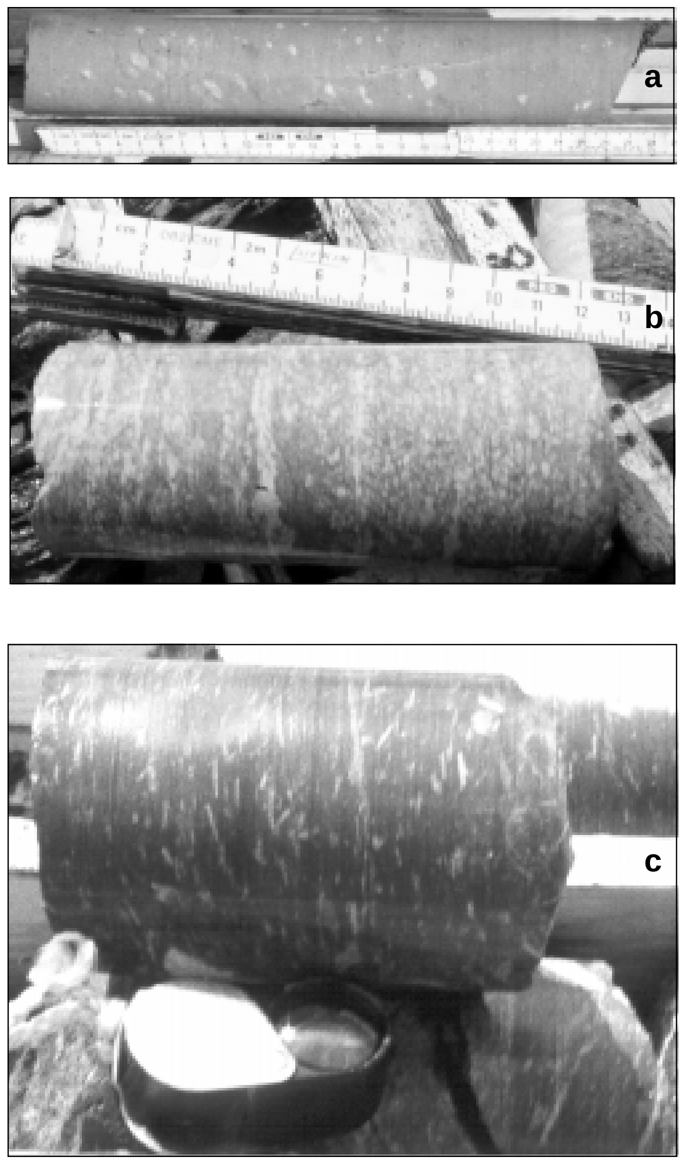
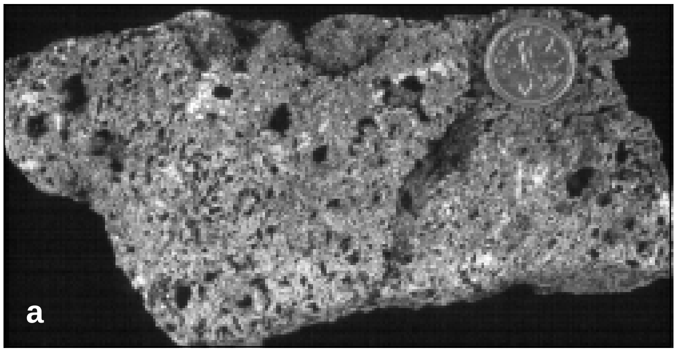


Figure 6. *(Tr)* ***a)*** *amygdaloidal trachyte;* ***b)*** *possible peperitic texture at the border of a trachyte sill;* ***c)*** *acicular feldspar crystals in trachyte. All drill core is from the Wolf property.*



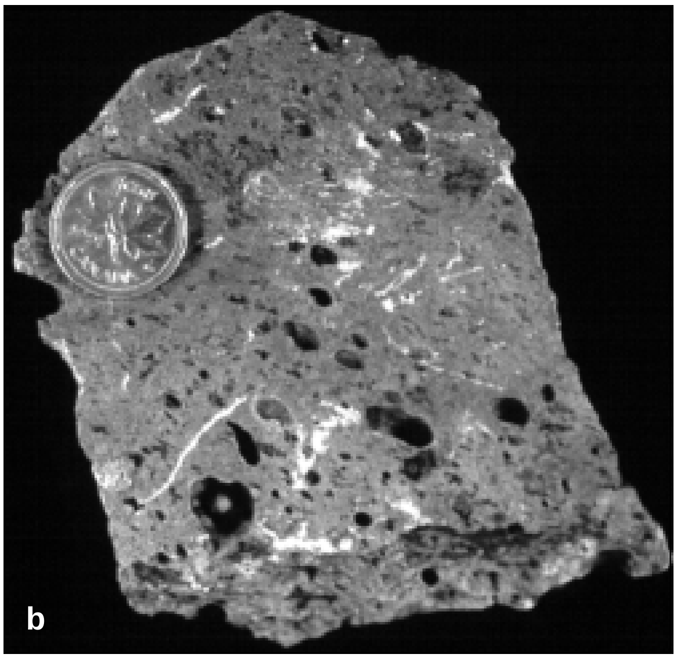


Figure 7. *(Di) Coarse- and fine-grained intermediate sills with a vuggy texture caused by the dissolution of iron carbonate blebs;* ***a)*** *coarse-grained,* ***b)*** *fine-grained.*

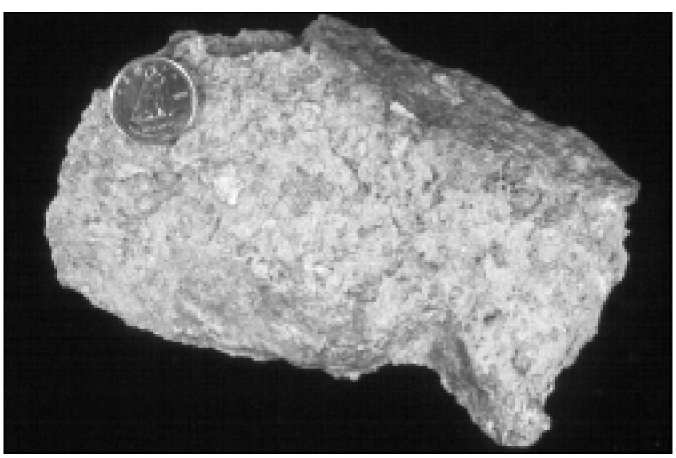


Figure 8. *(Tlbp) Pink-brown weathering lapilli tuff.*

FRAGMENTAL

- ***PINK-BROWN LAPILLI TUFF (TLPB)***

Pink-brown lapilli tuff near the base of the stratigraphic section measured on Mount Vermilion is light pinkish brown weathering and flaggy (Fig. 8). It is interlayered with trachyte flows, sills and narrow (1 m or less) argillite beds. Fragments within the tuff are dominantly rounded, fine-grained, pale grey to pale green (altered to sericite?), ranging from 2 to 15 mm in diameter. Locally, the fragments are concentrated in layers about 3 cm thick. Rare unaltered fragments are fine-grained and grey with white feldspar phenocrysts about 1 mm long (trachyte?). Very rare fine-grained black fragments, possibly argillite, also occur in this unit. Locally, the tuff is compositionally banded with waxy, green, fine laminations. The tuff matrix is fine-grained, contains 1 to 5% fine-grained disseminated pyrite and is locally hematitic. Iron carbonate blebs and veinlets occur locally within the tuff, as do minor quartz veinlets containing traces of galena.

- ***HETEROLITHIC LAPILLI TUFF WITH ARGILLITE CLASTS (THLA, THL, THLAB)***

This unit is generally flaggy and weathers light pink-brown with silvery coloured fragments and weathered out iron carbonate blebs throughout. This rock type is distributed throughout the map area and occurs at various stratigraphic levels. However, in general, it occurs above Tlpb and below or interbedded with maroon and green lapilli tuff (see below). Within the heterolithic lapilli tuff unit the fragments are dominantly green (sericitized?) volcanic rock with lesser, but distinct, fine-grained black argillite clasts which range from 0.5 to 3 cm and average 0.5 to 1.0 cm Fig. 9). Viewed altogether, the unit varies between very coarse-grained and very fine-grained end members.

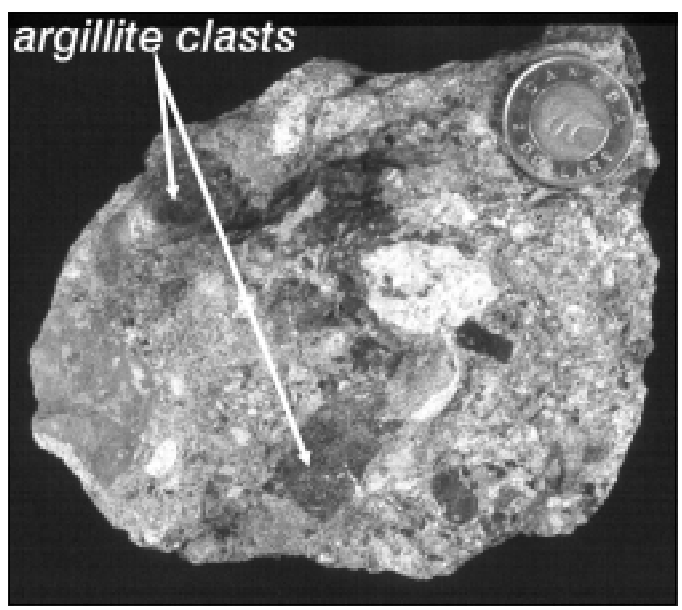


Figure 9. *(Thla) Heterolithic lapilli tuff with distinct argillite clasts.*

The very coarse-grained variety contains angular to sub-rounded argillite clasts up to 50 cm across which rarely show normally graded bedding. It is locally interbedded with medium-grained tuff beds about 20 cm thick. Rarely the coarse-grained end member is poorly foliated with blocky fractures.

The very fine-grained end member is dark grey, revealing beige flattened ellipses on the weathered surface 0.5 to 2 cm long. This fine-grained unit is locally hematitic and has minor argillite clasts 0.2 to 3 cm across and rare rectangular, sericitized finely laminated clasts.

Lithologically related to unit Thla are two sub-units, Thl and Thlab. Thl has no argillite clasts and Thlab is made up of Thla interbedded with narrow bands of black argillite.

- ***Maroon and green lapilli tuff (no argillite clasts; Thlmg)***

In general this rock unit has a distinctive maroon matrix that hosts green fragments (Fig. 10). This rock type occurs throughout the map area and commonly overlies or is interbedded with unit Thla. In the measured section on Mount Vermilion, fine-grained, rubbly, maroon tuff occurs at the top of this unit and underlies rusty and bleached rocks that likely represent the surface expression of the mineralization at the Wolf deposit. About 50 m east of the Mount Vermilion section, immediately underlying pyritic lapilli tuff (Tlp), the matrix is locally green and the fragments are hematitic maroon.

Within this unit, rounded to subangular fragments are dominantly pale green, or less commonly pale grey. Clasts average 1 to 3 cm across and are generally hosted in a fine-grained maroon matrix. Locally, this unit is intensely foliated, fine-grained and pale green (looks like sericite schist) or maroon; fissility increases as the fragment size decreases.

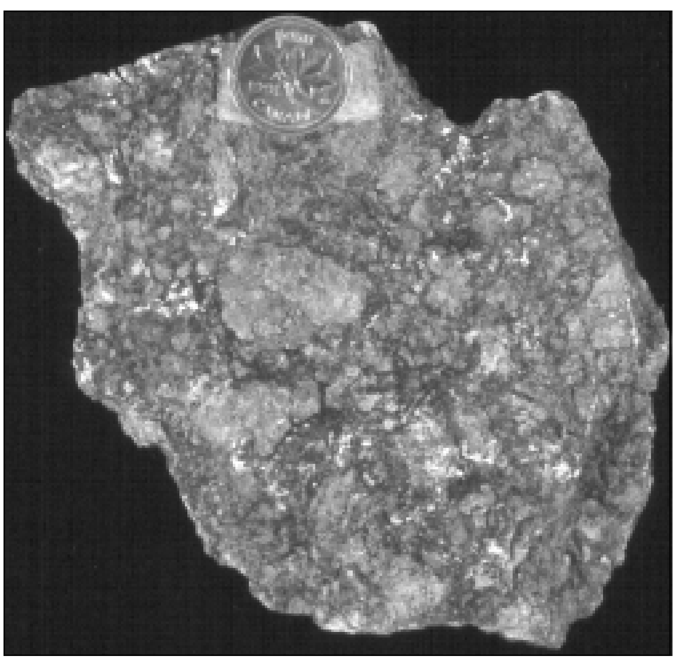


Figure 10. *(Thlmg) Maroon matrix tuff with green lapilli-sized fragments.*

In the centre of the horseshoe-shaped ridge 2 km west of Mount Vermilion, the maroon and green lapilli tuff is very coarse-grained with rounded frothy/vesicular light green trachyte fragments 5 to 60 cm across that average 10 cm, in a maroon matrix. This coarse-grained unit is monolithic, containing only trachyte fragments. The matrix is also fragmental, containing tiny grey cherty fragments as a minor component. In this location, Thlmg is interbedded with Thla which is also very coarse-grained. Together these two units form a section about 100 m thick with a limited lateral extent. This area may represent a site closer to a vent source or coarse-grained debris close to a fault scarp.

- ***Heterolithic felsic agglomerate/breccia (Ahf)***

These light grey weathering rocks were seen only at the base of the section made up of very coarse-grained Thlmg and Thla (see above). The agglomerate/breccia is made up of fragments which range from 5 to 30 cm and average about 10 cm across, in a medium to dark grey matrix. The matrix contains rare white crystals and grey cherty angular fragments less than 0.5 cm in diameter. The rock contains about 4% fine-grained, grey angular fragments, 30% grey, laminated angular fragments with black specks (mafics ?) and 1% rounded, foliated cream to grey fragments. The unit contains rusty blebs and minor iron carbonate alteration and is locally cut by a narrow fine-grained, grey siliceous dyke.

- ***Pyritic/sulphidized lapilli tuff (Tlp)***

This unit is recognizable in drill core but is rarely visible in outcrop because it weathers recessively to rusty yellow, bleached and gossanous material. This unit can occur stratigraphically above and/or below the mineralization (Holbek and Wilson, 1998; Atna personnel, pers. comm., 1998). In drill core, it contains pyrite clasts generally less than 1 cm across within a light grey matrix.

- ***Quartz (feldspar) crystal tuff (Tqx)***

This unit is rare and generally occurs close to the top of the section, above Thlmg. It weathers medium grey with cream-coloured fragments 0.5 to 2 cm across that are visible only on the weathered surface, and black fragments less than 0.5 cm across. Fresh surfaces are medium grey and siliceous with up to 5% glassy quartz crystals 1 to 3 mm in diameter. The unit has iron carbonate alteration and blocky fractures.

- ***Chlorite-altered tuff/brecciated diorite/Andesitic lapilli tuff (Tcl)***

This unit occurs near the top of the Mount Vermilion section, above the mineralized horizon. The unit is black to dark grey

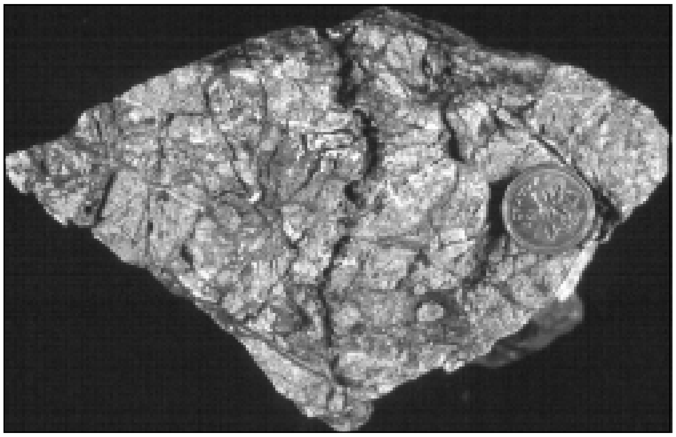


Figure 11. *(Sybx) Syenite fragments in a fine-grained matrix.*

weathering with rusty iron carbonate blebs and veinlets throughout. Rare light coloured, sub-angular fragments about 1 cm across are distributed in a fine-grained dark grey matrix. Although the base of this unit is strongly fractured and rubbly, there is an upward increase in competency, a change in colour to medium grey with a pitted brown weathered surface; iron carbonate blebs and small argillite clasts become more numerous and rare white amygdules are present. This fragmental unit is unique in that it has chlorite alteration.

- ***SYENITE BRECCIA (SYBX)***

Immediately east and south of the syenite intrusion is a monolithic breccia that weathers light grey to white with fine-grained angular fragments from 1 to 15 cm across (Fig. 11). Among the fragments are white feldspar crystals 1 cm long and rounded quartz crystals 1 cm in diameter. The matrix is fine-grained and light to dark grey and generally crowded with randomly oriented fragments. Locally, this unit has been silicified and/or has chlorite alteration.

This unit may be a tectonic breccia as it is near the contact with overlying carbonate and shale that is interpreted as a thrust. Alternatively it could represent the "explosive intrusion" of the syenite emplaced at shallow depths.

EPICLASTIC

- ***ARGILLITE (ARG, SU)***

Bedded, locally lensoid, argillite (Arg) occurs throughout the volcanic succession but is most abundant near the base where it is up to 14 m thick. The lenses decrease in thickness and number upsection. The argillite is black to silvery grey, generally fissile, and locally finely laminated. Rarely it is finely striped grey and green. Locally argillite is cut by trachyte sills/dykes, especially at the base of the Mount Vermilion section, suggestive of a sediment-sill complex. Near the top of the succession, dykes/sills of intermediate composition contain large argillite lenses.

Unit Su consists of interbedded argillite and fine to coarse-grained, buff coloured sandstone.

- ***INTERBEDDED SANDSTONE AND SHALE/ARGILLITE/IRON CARBONATE CEMENTED LAPILLI TUFF/BRECCIA (SFC)***

This unit weathers a distinctive bright rusty orange due to breccia bands about 20 cm thick that have sandstone fragments about 10 cm across in an iron carbonate matrix. In general this unit is weakly foliated (some clasts appear flattened) and varies from very coarse-grained to fine-grained. The shale/argillite component is black and silky with beds 5 to 10 cm thick. The sandstone is dominantly coarse-grained and poorly sorted with minor fine-grained black (argillite?) and light grey cherty clasts up to 1 cm across. Fine-grained sandstone, a minor constituent, has rare cross-bedding. Grading within the sandstone beds indicates they are the right-way-up.

Figure 12. *Gossan horizon on Mount Vermilion that likely represents the surface expression of the main mineralized horizon at the Wolf deposit.*

Figure 13. *Polymictic grit made up of vari-coloured cherty fragments in an argillaceous matrix.*

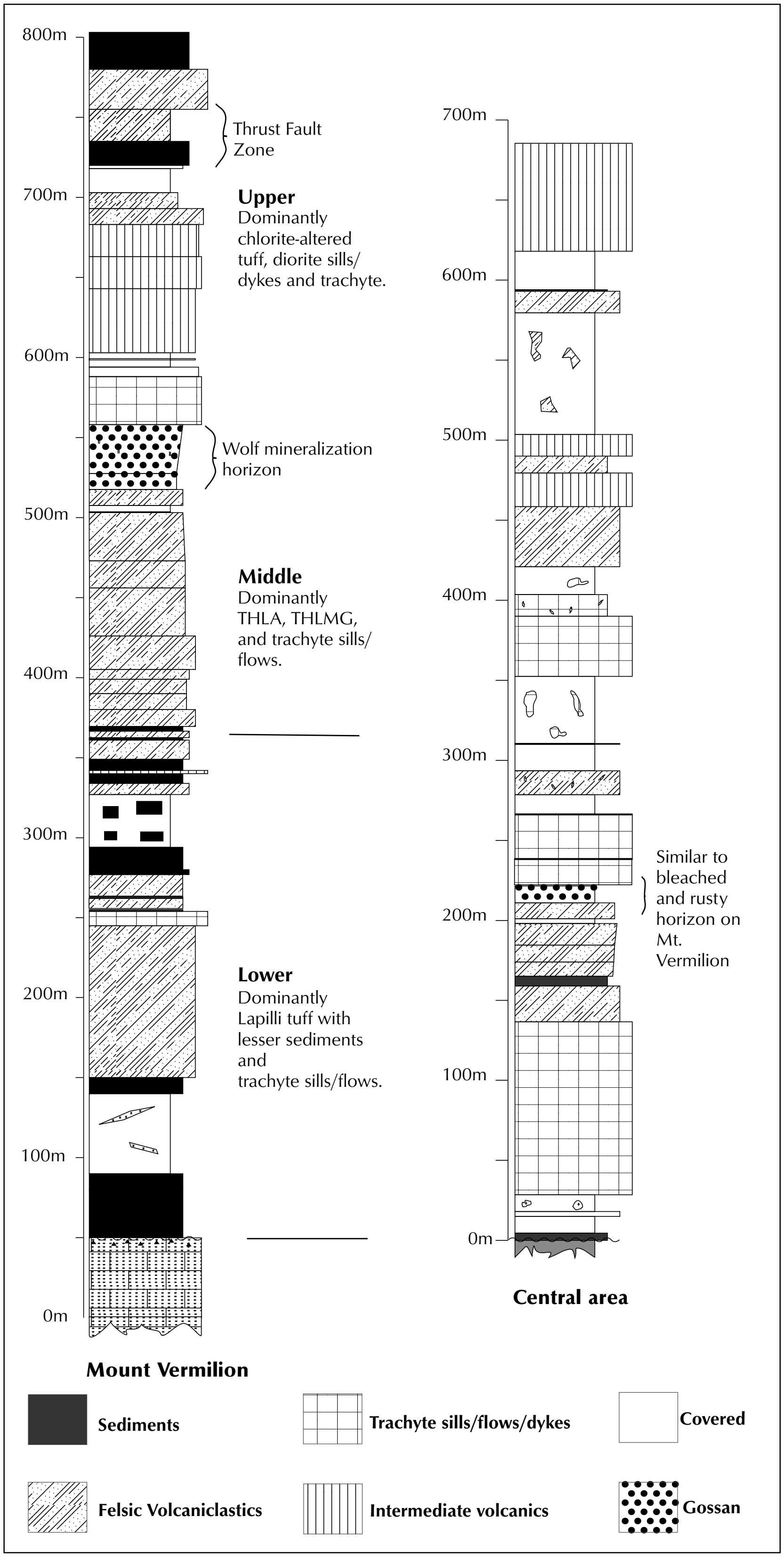


Figure 14. *Simplified stratigraphic sections for the southeast and central areas of the Pelly Mountains volcanic belt. For more detailed sections see Appendix 1.*

OTHER

- ***GOSSAN/SULPHIDE HORIZON AT SURFACE (SULPHIDES AND TRACHYTE BRECCIA?)***

In the Mount Vermilion section, the approximate level of the Wolf sulphide horizon has decomposed to white quartz ± barite that is bleached and weathers rusty yellow (Fig. 12). Within this gossanous "horizon" are fine-grained, bleached, locally baritic rocks, and white fine-grained rock with rare cream-coloured blebs (fragments?) that is pitted (weathered out sulphides?). Upsection, fine-grained fragments are easier to see on the weathered surface where they vary from grey with white amygdules (trachyte?), to cream-coloured to grey. Locally the rock is siliceous and in some places has a frothy texture. Rare fresh rock is medium grey and glassy, with no visible fragments.

OVERLYING ROCKS

SANDSTONE, GRIT, ARGILLITE, LIMESTONE/ DOLOMITE (OCS, UND$_3$)

In the Mount Vermilion area the volcanic succession is topographically overlain by coarse-grained sandstone and grit, argillite, and massive rusty weathering carbonate. These rocks were interpreted by Tempelman-Kluit et al. (1976) and Gordey (1977, 1982) as Ordovician Road River and ?Earn Group-equivalent strata that had been thrust over the volcanic package, however, this contact is not directly exposed and at least locally, the bedding is roughly parallel above and below the contact.

Immediately south and east of Mount Vermilion, close to the mapped contact, is a unit of interlayered coarse-grained sandstone, polymictic grit and argillite (Und$_3$) which may include some Thla. It is not clear if this unit is part of the volcanic succession or the overlying carbonate and argillite package. The coarse-grained sandstone is locally siliceous and weathers dark brown. Polymictic grit is made up of vari-coloured fine-grained cherty clasts in an argillaceous matrix (Fig. 13). Massive grey carbonate with minor sandstone interbeds weathers brown, grey and cream-coloured, and is locally fossiliferous and bioturbated. Most of the overlying rocks are iron carbonate altered, especially near the thrust contact. Within these sedimentary rocks are rare patches of porous rusty "fericrete-like" rubble that may be the remnants of massive sulphide mineralization.

The massive carbonate is similar to that which underlies the volcanic succession. In general it is resistant and weathers rusty brown to light grey with a nodular surface. The carbonate is thick bedded and is exposed on the ridges immediately south of the thrust fault (Fig. 3).

DISCUSSION – MOUNT VERMILION AREA

Within the map area no marker units were identified and no single unit could be traced for more than a few hundred metres, with the exception of trachyte and intermediate sills/dykes. This may be due to rapid facies changes and/or faulting. For example, about 1 km west of Mount Vermilion, very coarse-grained fragmental volcanic strata (Thla, Thlmg, Ahf), approximately 100 m thick, occur over a lateral distance of only a few tens of metres. This area likely represents a site closer to a vent source or a fault scarp.

Three stratigraphic sections were measured across the volcanic belt and the following transitions were observed (Fig. 14 and Appendix 1).

At the southeast end of the belt, the volcanic succession has a lower part that consists of interbedded volcaniclastic rocks and argillite with minor trachyte sills/dykes, a middle section of volcaniclastic rocks and trachyte flows/sills/dykes, and an upper chlorite-altered part containing intermediate dykes and flows.

To the west, towards the centre of the volcanic belt the volcaniclastic component decreases as the number of sills, flows and dykes becomes more numerous, and the amount of intermediate volcanic material increases.

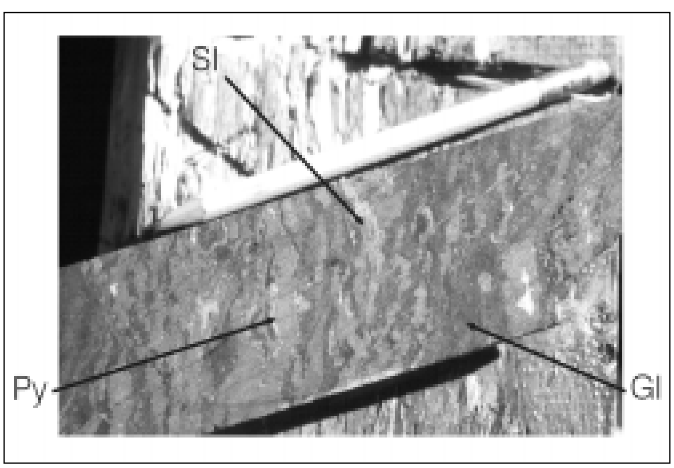


Figure 15. *Pyrite (Py)-sphalerite (Sl)-galena (Gl) mineralization from the Wolf deposit.*

At the northwest end of the belt, Mortensen (1979) described a volcanic succession of intermediate composition with felsic, dominantly volcaniclastic rocks near the middle. This succession does not resemble that in the southeast end of the belt, where the volcanic succession is primarily felsic with some intermediate flows, sills and dykes in the upper part. However, the middle felsic portion is similar to the felsic rocks in the Mount Vermilion area.

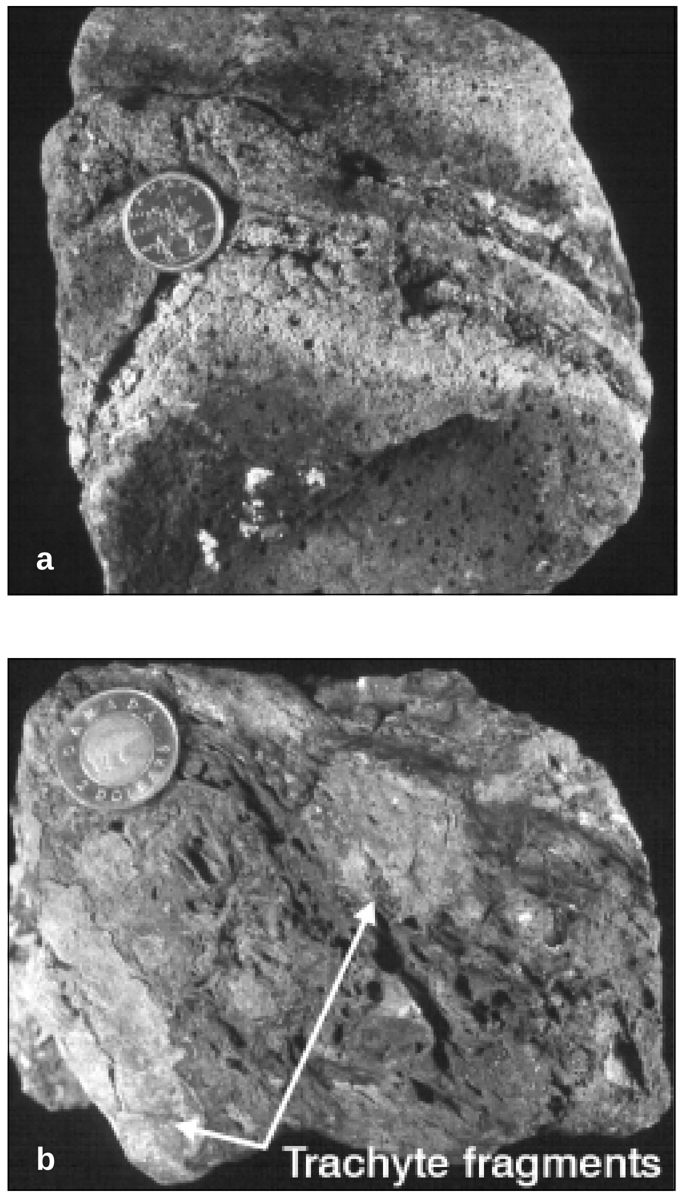


Figure 16. a) *bands of massive pyrite in trachyte;* ***b)*** *massive "frothy" pyrite with inclusions of trachyte.*

MINERALIZATION

WOLF

The Wolf Zn-Pb-Ag deposit is a tabular massive sulphide body that varies from 2 to at least 25 m thick, and has been traced for over 500 m along strike (Holbek and Wilson, 1998). The massive sulphides are primarily very fine-grained pyrite with bands of amber-coloured sphalerite and fine-grained steely-grey galena (Fig. 15). Barite appears to occur laterally, peripheral to the sulphide mineralization. In general the massive sulphides occur immediately below a feldspar phyric, locally amygdaloidal, trachyte flow within a pyritic tuff unit.

PREVIOUSLY UNREPORTED MINERALIZATION

- Massive sulphide boulders occur in a creek 4.2 km northwest of Mount Vermilion (*A on Fig. 3) and are believed to originate from a showing located about 250 m upstream. The mineralization consists of bands of massive pyrite several centimetres thick in fine-grained, silicified trachyte (Fig. 16a) and massive "frothy" pyrite with fragments of trachyte (Fig. 16b).

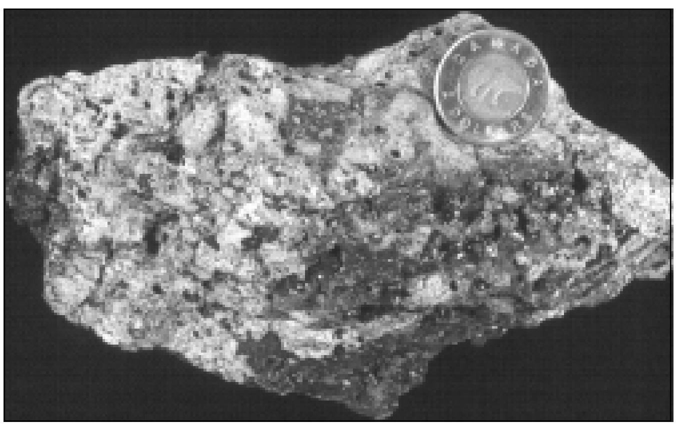


Figure 17. *Possible massive sulphide rubble in massive carbonate.*

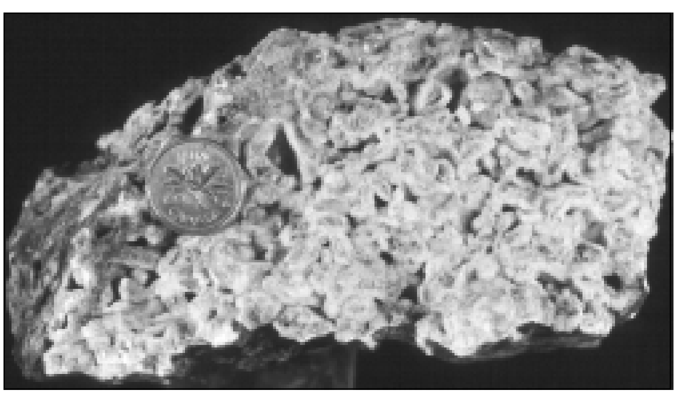


Figure 18. *Carbonate ± barite tufa.*

- Possible relict massive sulphide mineralization was found on a ridge top about 700 m south of Mount Vermilion (*B on Fig. 3). The porous, ferrous oxide rubble appears to be hosted by the carbonate sequence which overlies the volcanic succession (Fig. 17).
- Carbonate ± barite? tufa deposits were located in a creek 5.45 km northwest of Mount Vermilion (*C on Fig. 3; Fig. 18).

OTHER

Southwest of the Mount Vermilion area, mylonitized metamorphic rocks rest as a flat thrust sheet on unmetamorphosed strata of the Upper Triassic, and Upper Triassic and (?) Lower Jurassic assemblages (Gordey, 1977). On the basis of composition of the mylonitic rocks, Gordey (1977) suggested that they may be the metamorphosed and cataclastic equivalent of parts of the Devono-Mississippian volcanic assemblage. Thus this area has the potential to host massive sulphide deposits similar to Wolf.

Gordey (1977) depicts volcanic rocks, correlative to those in the Mount Vermilion area, in the Kechika map area of northern British Columbia which forms part of the Kechika Trough, the southern extension of the Selwyn Basin.

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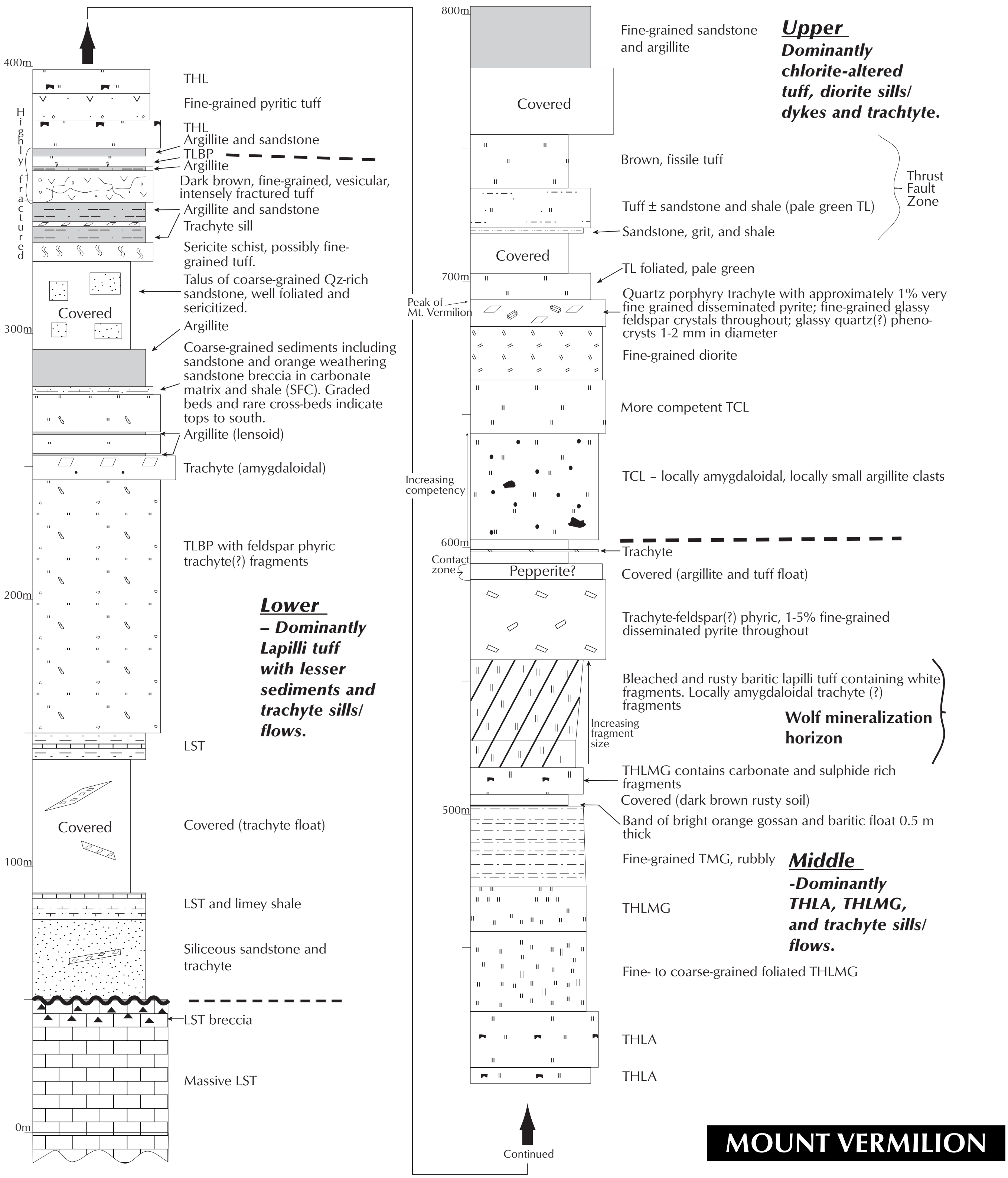
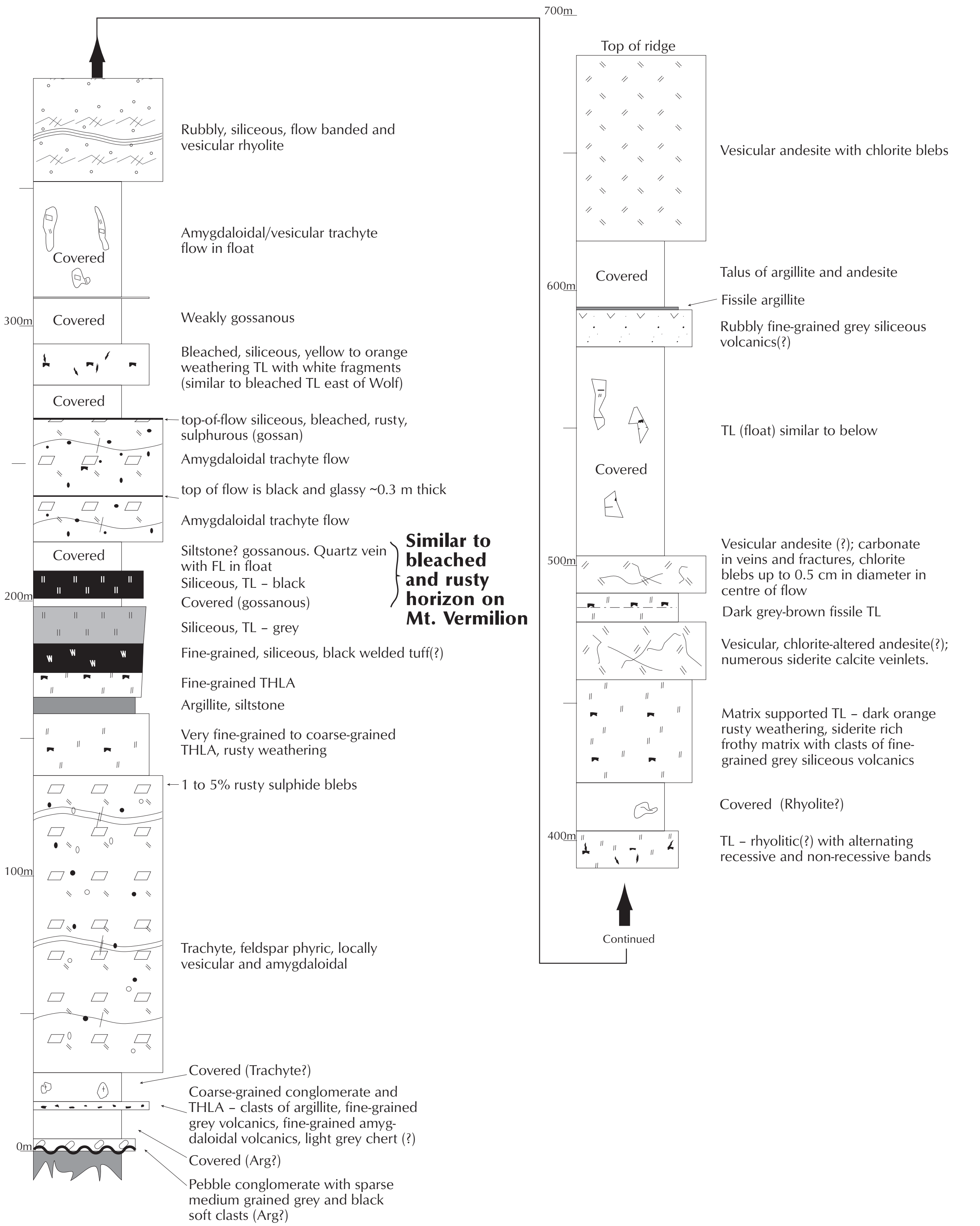
APPENDIX 1

STRATIGRAPHIC SECTIONS

Abbreviations are the same as those used in Figure 3 legend.





CENTRAL AREA