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FIELD GUIDE ANVIL PB-ZN-AG DISTRICT YUKON TERRITORY, CANADA

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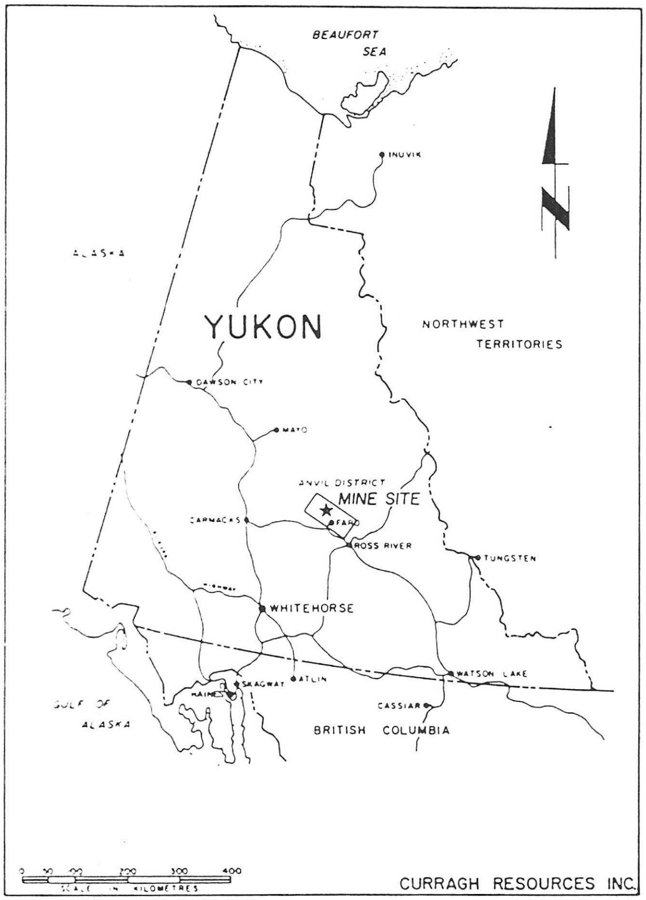


Figure 1 Location map of Anvil District in Yukon Territory, Canada. Concentrates are trucked to tidewater at Skagway, Alaska through Carmacks and Whitehorse.

INTRODUCTION

The Anvil Pb-Zn-Ag District is located near the town of Faro in central Yukon Territory 200 kilometers northeast of Whitehorse (Figure 1). Five deposits of the stratiform, massive pyritic sulphide type (Gustafson and Williams, 1981) have defined reserves within the district (Table 1). The mineral deposits define a curvilinear trend in plan (Figure 3) and occur within a 150 meter thick upper Proterozoic to Cambrian stratigraphic interval (Jennings and Jilson, 1986). The total geological reserves for the district is similar to that for other major stratiform Pb-Zn deposits (Figure 4). If all sulphide lithologies are considered, irrespective of grade, the district contains an estimated total of 225 million tonnes of sulphide-bearing rock (Jennings and Jilson, 1986).

Intensive exploration within the district began after Al Kulan discovered the Vangorda deposit in 1953 using conventional prospecting. Exploration methods are discussed by Aho (1966, 1969), Brock (1973), Chisholm (1957), and 1 Morton (1973). Anvil Mining Corporation began open-pit mining of the Faro deposit at rates of up to 10,000 tonnes per day in late 1969. The mine is currently owned and operated by Curragh Resources Inc. Open pit mining of the Faro deposit is continuing on a year-round basis with the concentrator processing 13,500 tonnes of ore per day. Concentrates from the mine are trucked to Skagway, Alaska (Figure 1) and then shipped to markets around the world.

Curragh Resources Inc. is also working on developing several additional mines in the district. Underground exploration has begun on a high grade portion of the Faro deposit. Pre-development and environmental studies are being undertaken for the Vangorda and Grum deposits. These latter two deposits will be open pit mines with the ores being processed at the Faro mine concentrator. The remaining deposits have not yet been developed, although a pilot drill hole is being planned for the Dy deposit.

This paper will discuss the general nature of the deposits including ore types, zoning patterns, alteration patterns, and subsequent metamorphism and deformation. The field trip will look first at the ore types and metamorphism-deformation in the Faro underground mine. Additional stops at the Grum and Vangorda deposits are planned depending on time constraints and development progress for these deposits.

Table 1 Summary of tonnage and grade figures for Anvil district ore deposits as of June 1983*

	Tonnage X 10^6 tonnes	Pb (%)	Zn (%)	Ag (g/mt)	Cutoff (%Pb+ Zn)
Faro (1)**					
Geological reserves before mining	57.6	3.4	4.7	--	5.0
Remaining geological reserves (1983)	33.0	3.0	4.6	36	4.0
Remaining open pit reserves (1983)	25.2	2.9	4.3	36	4.0
Grum (2)					
Geological reserves	30.8	3.1	4.9	49	4.0
Open pit reserves	16.9	3.0	4.9	47	4.0
Vangorda (3)					
Geological reserves	7.1	3.4	4.3	48	4.0
Open pit reserves	5.2	3.4	4.2	47	4.0
Dy (4)					
Geological reserves	20.3	5.7	7.0	82	9.0
Swim (5)					
Geological reserves	4.3	3.8	4.7	42	6.0
Total					
Geologcial reserves before mining	120.1	3.7	5.6	--	N/A
Remaining geological reserves (1983)	95.5	3.7	5.2	51	N/A
Remaining open pit reserves (1983)	47.3	3.0	4.5	41	4.0

* Compiled from various "in house" reports of Cyprus Anvil Mining Corp. and Kerr Addison Mines.
** Refers to the number on Figure 3

REGIONAL GEOLOGY

Roddick and Green (1961) first systematicaly mapped the Anvil District. After discovery of the Vangorda, Swim, and Faro deposits, Tempelman-Kluit (1972) undertook a more detailed geological study. More recently Gordey (1983) and Gordey and Irwin (1987) correlated rock units in the district with previously mapped areas to the east and southeast.

The Anvil District is part of Selwyn Basin (Figure 2), a large area of central Yukon where deep water clastics, chert, and minor carbonate accumulated along the ancient North American continental margin during late Proterozoic and Paleozoic (Gabrielse, 1967). Sediments in the basin contain several large-scale compositional sequences which reflect its evolutionary development. An excellent summary of these stages is presented in Abbott et al. (1986).

The late Proterozoic to early Cambrian "Grit Unit" (Gabrielse et al., 1973) is the oldest unit exposed in the basin. It consists of a thick sequence of

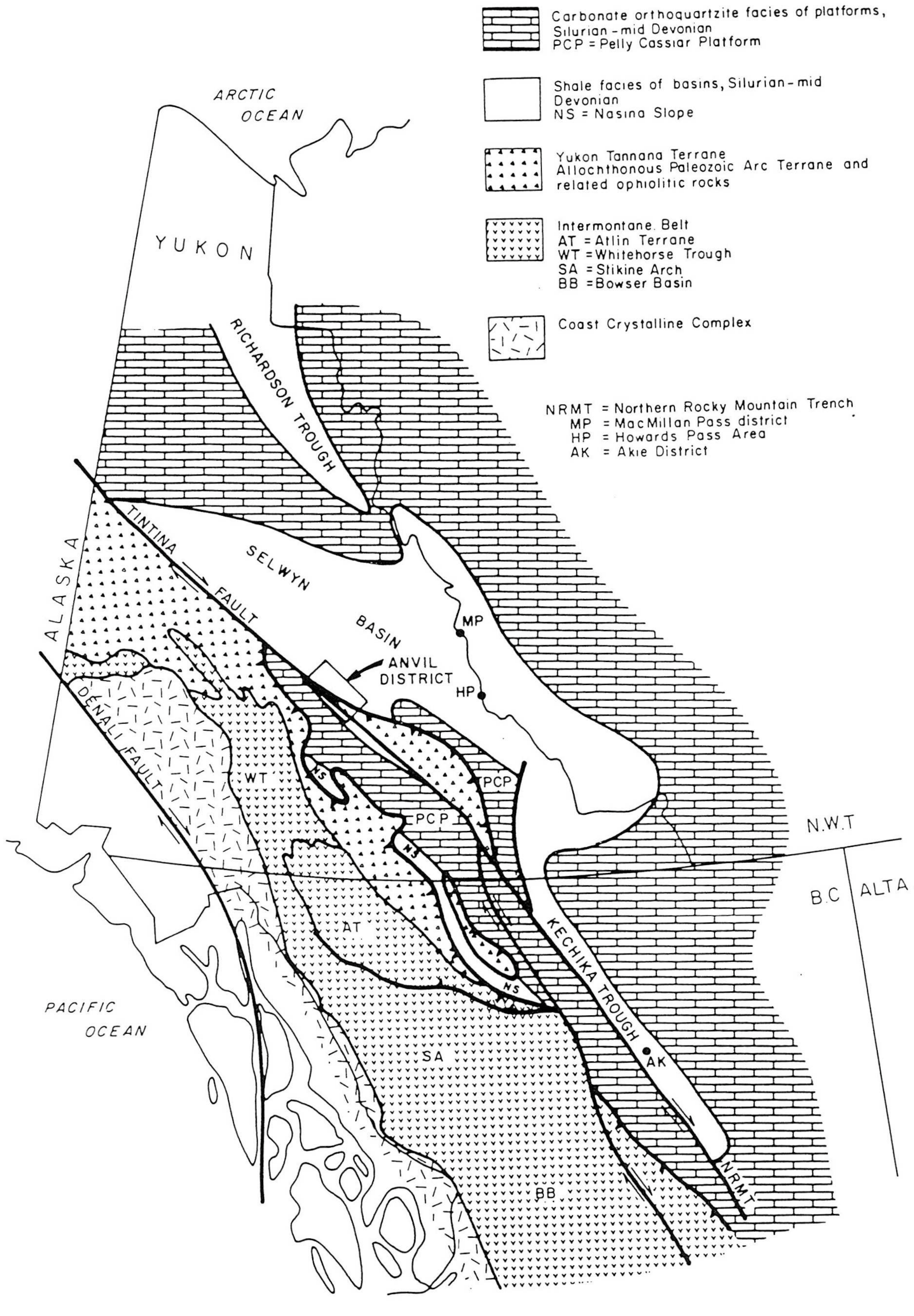


Figure 2 Location map of Anvil District. The major sulphide deposits are indicated in tectonic features of northwestern Canada.

quartzofeldspathic turbidites and shales. The lowermost portion of the sequence reflects initial rifting forming the ancient continental margin (Eisbacher, 1981).

During the interval early Cambrian to middle Devonian the basin is characterized by passive continental margin sedimentation of dominantly carbonaceous fine clastics and chert with a shallow carbonate platform to the northeast (Mackenzie Arch) (Abbott et al., 1986). Scattered occurrences of Ordovician basaltic flows, volcaniclastic breccias, and tuffs indicate intermittent extension within the basin.

A transgressive shale and chert sequence replaced carbonate platform sedimentation in the Mackenzie Arch during middle Devonian to Mississippian time. Intrabasinal or westerly derived chert and quartz-rich coarse clastics interbedded with carbonaceous shales and cherts in Selwyn Basin indicate a tectonic event during this interval which resulted in local extension (Abbott et al.,1986). Extension is also indicated by the local occurrence of felsic volcanics and plutonics during this interval (Mortensen, 1982).

Locally preserved Mississippian to Triassic fine grained shallow water clastics and cherts delineate a return to an oxygenated, stable, marine continental margin depositional pattern.

Selwyn Basin is immediately northeast of the Yukon-Tanana suspect terrane (Coney et al., 1980), a mid-Paleozoic volcanic-plutonic assemblage built on continental crust (Mortensen and Jilson, 1985). At least part of the Yukon-Tanana terrane was emplaced as an allochthon overlying North American rocks along the outboard edge of Selwyn Basin. This structure is thought to be part of a transpressive suture developed during oblique collision of the suspect terrane with North America in Jurassic through Cretaceous (Mortensen and Jilson, 1985). This collision initiated metamorphism and deformation of the basin with development of northeast directed thrusting and folding. Collisional deformation culminated with the intrusion of mid-Cretaceous granites.

Right lateral, transcurrent movement along the Tintina Fault in latest Cretaceous or early Tertiary time completed the deformation history of Selwyn basin. Estimates of offset along the Tintina Fault range from 450 kilometers (Tempelman-Kluit, 1970a) to 750 kilometers (Gabrielse, 1985).

The clastics of Selwyn Basin host most of Canada's large stratiform lead-zinc deposits, making it a metallogenic province of world-wide significance (Carne and Cathro, 1982). Mineral deposits within the basin range from Cambrian through Devonian in age. The Anvil District differs from the remainder of the Selwyn Basin because the rocks and ore deposits are metamorphosed and significantly recrystallized. This has resulted in coarser grain size with improved metallurgical performance. This geologic factor and the size and location of the Faro deposit have combined to determine that Faro is as yet the only producer of Selwyn Basin.

DISTRICT STRATIGRAPHY

The stratigraphic sequence of Anvil District ranges in age from latest Precambrian to Permian (Figure 3). The lower part of the sequence is divisible into three major mappable units. From the base these are noncalcareous metapelite of the Mount Mye formation, calcareous pelite of the Vangorda formation, and basalt of the Menzie Creek formation (Figures 4, 5; Jennings and Jilson, 1986). All formational names in this interval are informal. The aggregate thickness for this pre-Silurian sequence is approximately 5 kilometers.

The overlying sequence is characterized by shale, chert, basalt, minor limestone, and coarse clastics rich in chert fragments. Strata of the Earn Group (Gordey et al., 1982) and Anvil Range Group (Tempelman-Kluit, 1972) are present. This sequence ranges in age from Devonian to Permian. All or part of this upper sequence may be allochthonous with respect to the underlying units. The Earn Group locally contains stratiform barite deposits.

The Devonian and younger rocks are not related to the ore deposits in the district and consequently are not discussed further. The three older units either host the ore deposits or bear a possible relationship to the ore and are considered in more detail below.

Mount Mye formation

The Mount Mye formation (Figure 5) consists dominantly of noncalcareous, biotite-muscovite-andalusite-staurolite +/- garnet schist in areas of amphibolite facies metamorphism and noncalcareous, weakly carbonaceous, light to medium

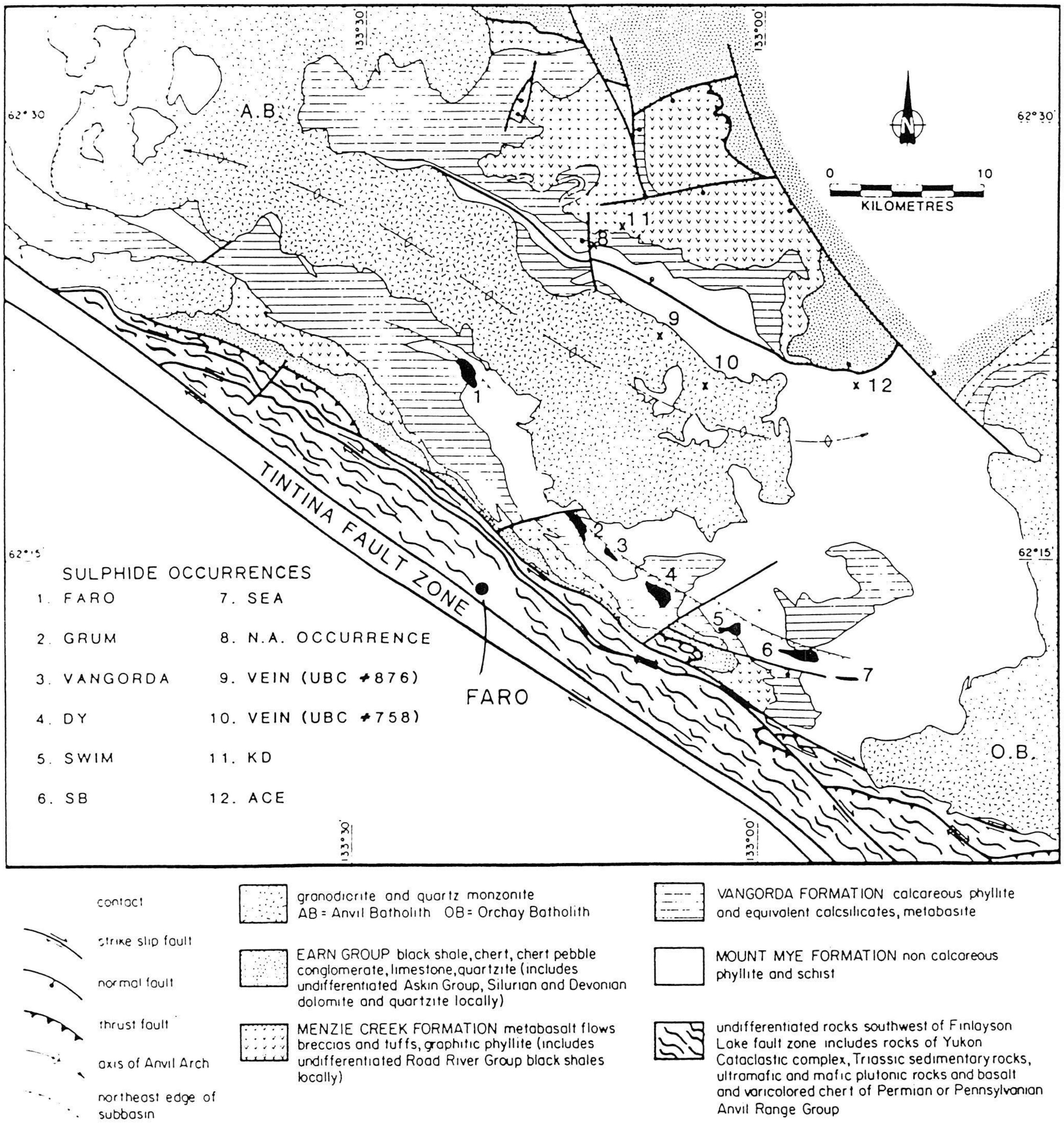
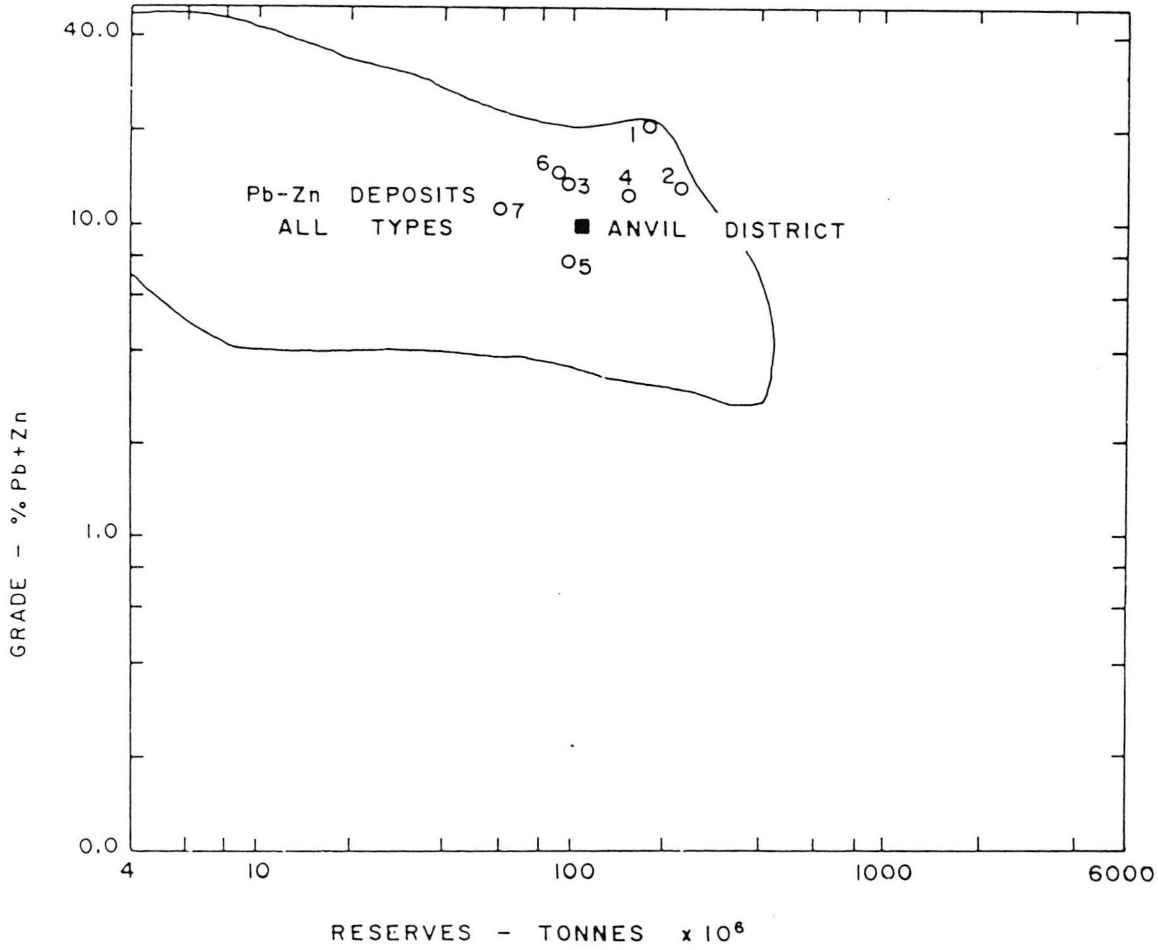


Figure 3 Geology map of Anvil District. The major sulphide deposits are indicated in black.



1 BROKEN HILL, AUSTRALIA
2 McARTHUR RIVER, AUSTRALIA
3 MT. ISA, AUSTRALIA
4 SULLIVAN, CANADA
5 HOWARDS PASS, CANADA
6 RED DOG, ALASKA
7 MEGGEN, WEST GERMANY

Figure 4 Comparison of size-grade characteristics of some major lead-zinc deposits. Modified from Gustafson and Williams (1981).

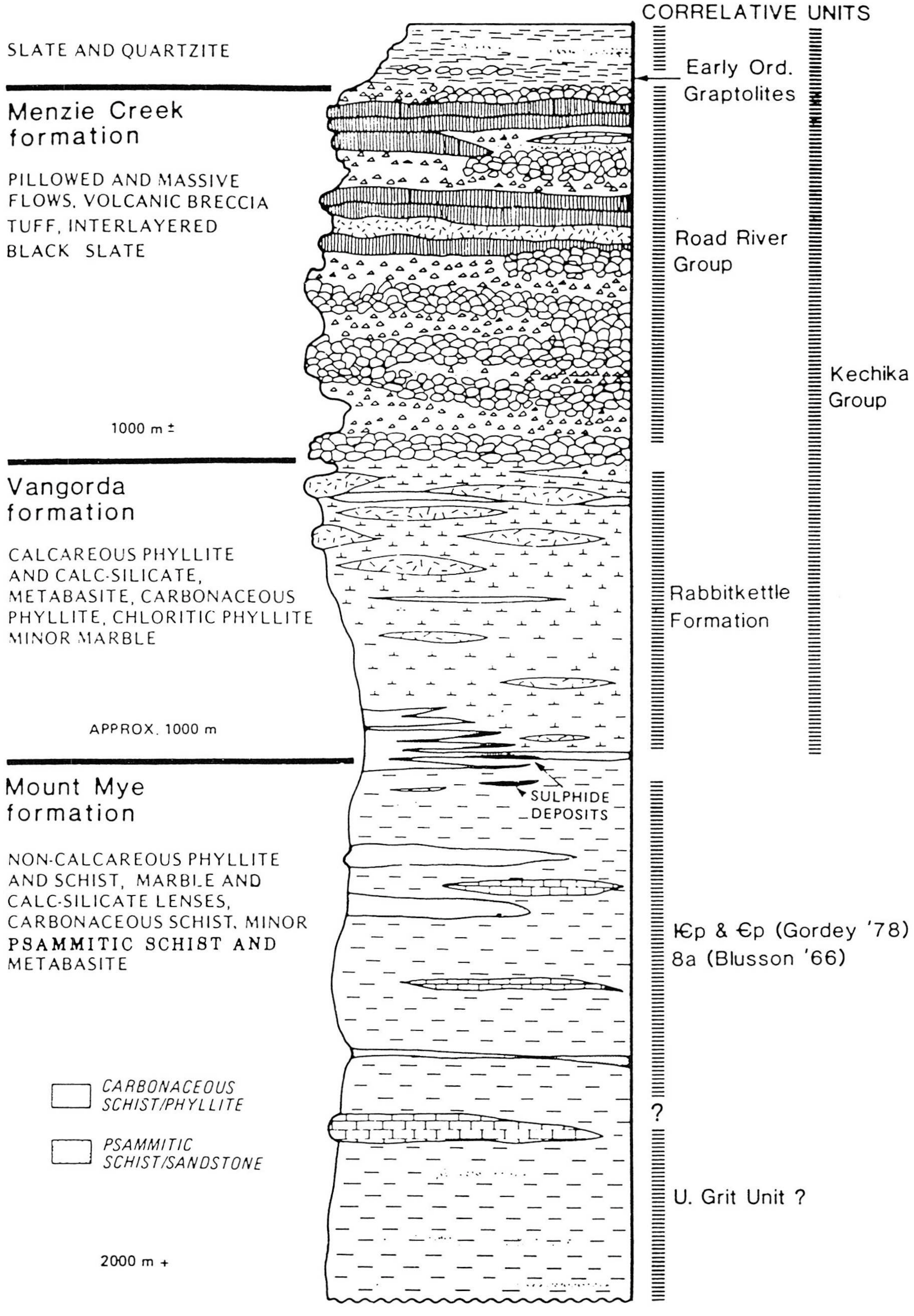


Figure 5 Stratigraphic column of the older portion of the rock units in the Anvil District.

gray muscovite-chlorite phyllite in areas of greenschist facies metamorphism. It contains lesser, interlayed, black carbonaceous phyllite or schist, calcitic marble, calc-silicate phyllite or schist, metabasite, and psammitic schist. The unit has a structural thickness of at least 2 kilometers with the base not being exposed. The reddish brown weathering color of the unit is characteristic and helps distinguish it from noncalcareous portions of the overlying Vangorda formation.

Dark grey to black carbonaceous phyllite or schist members comprise about 10 per cent of the formation. They are more abundant in the upper 200 meters of the unit.

Calcitic marble and calc-silicate schist or phyllite also constitute about 10 per cent of the Mount Mye formation. The marble is light grey, medium crystalline calcite with boudins of pelite, amphibolite, and calc-silicate. Marble bodies may be up to 75 meters thick but are generally only a few tens of meters thick; they can be traced laterally for several kilometers. The calc-silicate lithology is a thinly interbanded sequence of purplish brown biotite pelite and pale green actinolite-epidote calc-silicates. Typically the calc-silicates are spatially associated with the marbles. A persistent marble and calc-silicate horizon occurs about 200 to 400 meters below the top of the Mount Mye formation.

Metabasite bodies are generally only a few meters thick and have small to moderate lateral dimensions. Volumetrically they constitute less than 1 per cent of the Mount Mye formation. They are generally strongly foliated, dark green amphibolites lacking relict igneous texture. Compositions are similar to basalts of the Menzie Creek formation (Jennings and Jilson, 1986). They are interpreted as subvolcanic feeder dykes and sills of the Menzie Creek basalts.

The upper portion of the Mount Mye formation is very similar to the buff weathering mudstone and blue-gray mudstone units described by Gordey (1978) to the east near Howards Pass and to unit 8A of Blusson (1966). Correlation with these units would imply the top of the formation is lower Cambrian or possibly middle Cambrian. Jennings and Jilson (1986) suggested that the persistent marble and calc-silicate package may correlate with the widespread early Cambrian limestone conglomerate of Selwyn Basin. Parts of the Mount Mye formation also resemble rocks underlying those presumed correlative units, implying that the Mount Mye probably includes rocks as old as Hadrynian.

Vangorda formation

The Vangorda formation is characterized by light to medium-gray, calcareous, phyllitic rocks made up of very thin (0.1-2 cm) interlayers of medium grey, non-calcareous, weakly carbonaceous, muscovite-chlorite pelite and light grey, generally calcareous quartz-calcite +/- dolomite siltstone. At the higher metamorphic grade of amphibolite facies, the Vangorda phyllites are transformed to a thinly banded, pervasively foliated, green, cream, and purplish brown, calc-silicate. Major interbanded units include metabasite, carbonaceous pelite, and phyllitic limestone. The Vangorda formation varies between 0.5 and 2 kilometers in apparent thickness. The formation becomes more calcareous up section. The light grey to tan colored drusy weathering of the formation is characteristic both within the district and elsewhere.

The metabasite bodies range from 1 to 100 meters in thickness and are up to several kilometers in length. They comprise approximately 15 per cent of the Vangorda formation and are more prevalent near the top of the formation. Whole rock analyses show that the metabasites are compositionally similar to the overlying Menzie Creek basalts (Jennings and Jilson , 1986). Locally the metabasites contain coarsely crystalline serpentinized pyroxenite subunits. Most metabasite bodies have medium-grained, equigranular centres with strongly foliated margins. Although marginal contacts of the bodies are superficially conformable, detailed inspection indicates the units are locally slightly crosscutting. The metabasites are thus interpreted as subvolcanic dyke and sill feeders to the Menzie Creek formation.

Typically the Vangorda formation adjacent to the metabasites is a thinly banded, hard, pale green, calcareous, chloritic phyllite. Originally this lithology was interpreted as a marginal tuff adjacent to basaltic flows. More extensive drill intersections and additional outcrop exposures indicate that instead it represents a slight contact metamorphic aureole caused by intrusion of the metabasite bodies.

Black, slightly calcareous to dolomitic, carbonaceous pelite members occur throughout the

Vangorda formation. Dimensions and lateral continuity of these members are poorly known. The thickest and most extensive of these occurs at the base of the formation; it ranges from only a few tens of meters to 100 meters in thickness. This basal member becomes thicker in the immediate vicinity of the ore deposits and appears to be laterally equivalent to black, sulphide-bearing, ribbon-banded, carbonaceous, quartzite ores within the mineral deposits.

The Vangorda formation is lithologically similar to, though more argillaceous than the Rabbitkettle Formation seen to the east (Gordey, 1978; Gabrielse et al., 1973). Based on this correlation the Vangorda formation may range in age from middle or late Cambrian through early Ordovician.

Menzie Creek formation

The Menzie Creek formation is a unit of basaltic metavolcanic rocks consisting of pillowed and massive flows with comparable amounts of massive, coarse, monolithic breccias and lesser, thin-bedded, tuff and/or volcanic sandstone and siltstone. The formation reaches a maximum structural thickness of 1.5 kilometers in the district. Whole rock major element and trace element data (Jennings and Jilson, 1986) imply that the flows of the Menzie Creek volcanic unit are dominantly alkali basalt erupted in a within-plate setting. Similar major and minor element compositions for the metabasites in the Mount Mye and Vangorda formations suggest the metabasites are subvolcanic feeders for the Menzie Creek formation.

Carbonaceous phyllite and brown siltstone immediately overlying the Menzie Creek formation northeast of the Anvil Batholith contain graptolites of middle Ordovician or early Silurian age (Tempelman-Kluit, 1972; Gordey, 1983) suggesting correlation of the Menzie Creek volcanics with the widespread Road River Formation black shale and chert to the northeast. The Menzie Creek formation has been traced for 100 kilometers along strike and 30 kilometers across strike, showing that it is one of the largest of several basaltic units of its age in Yukon.

Relation of Stratigraphy to Ore Deposits

The ore deposits of Anvil District are stratiform and confined to an approximately 150 meter thick interval straddling the contact of the Mount Mye and Vangorda formations (Figure 5). This stratigraphic position indicates the mineralization is Cambrian in age. The deposits consist of one to five sheets of sulphide mineralization with interbanded metasedimentary rocks. For those deposits with more than one sulphide horizon, the mineralized horizons are generally stacked one above the other. At least three of these mineralized horizons appear to be laterally equivalent to part of the basal carbonaceous pelite member of the Vangorda formation. Unlike other sedimentary exhalative deposits of Selwyn Basin, the Anvil deposits are not characterized by a host stratigraphic section dominated by black carbonaceous rocks. Instead the carbonaceous rocks in the district are thin and subordinate or locally not even present.

DEFORMATION, METAMORPHISM and PLUTONISM

The structural and metamorphic history of the Anvil District is complex and of considerable significance to the present form and nature of the ore deposits. Five deformation phases have been recognized within the metasedimentary and metavolcanic rocks of the district. The first two are periods of intense mid-Mesozoic fold deformation and concurrent metamorphism which determined the gross structure of the mineral deposits (see Figure 6). The remaining deformations are only locally developed and do not generally form large or significant structures.

The first deformation (D1) produced a regional metamorphic foliation (S1) axial planar to tight to isoclinal mesoscopic folds (F1) in bedding (S0). Mesoscopic D1 early folds are rarely preserved in the district; they are ubiquitously north-easterly inclined to upright, northeasterly verging structures with shallow northwesterly or southeasterly plunging axes (Figure 6).

During the second deformation event (D2), S1 was strongly crenulated and ubiquitous close to tight mesoscopic folds (F2) in S1 were produced. S0 primary bedding was transposed into near parallelism with the S1 foliation. Parallel to the axial planes of the D2 folds is a crenulation cleavage (S2) which imparts a well developed lithon structure to most rocks of the district, especially the strongly banded phyllites of the Vangorda formation. F2 axial planes and S2 axial plane foliations dip shallowly to the southwest or northeast, with fold axes subparallel to F1 fold axes. Southwest of the Anvil batholith (see Figure 3) the S2 surfaces dip dominantly southwest, and F2 minor folds have southwest

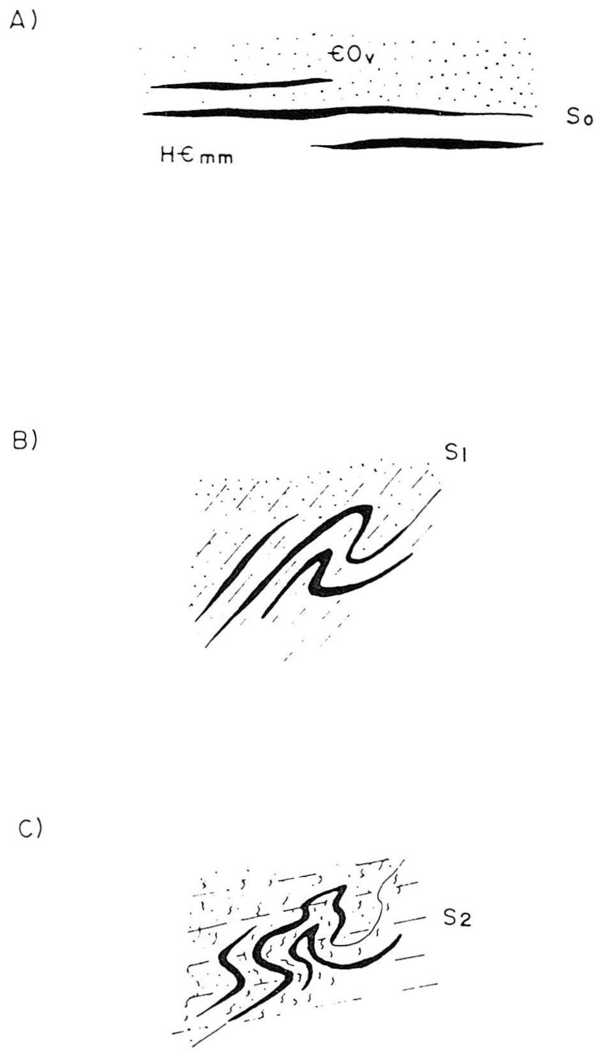


Figure 6 Schematic cross-section through the Grum deposit. Section oriented SW-NE and looking northwest. Stacked en echelon ore horizons are shown in black. This section shows the sequential development of the type 3 interference pattern between D_1 and D_2 folding deformations.

A) Deposition of sulphide ore horizons parallel to S_0.

B) Formation of northeast-verging, steeply dipping, D_1 minor folds.

C) Formation of type 3 interference pattern with development of southwest-verging, shallowly dipping, D_2 minor folds.

vergence. Northeast of the batholith S2 surfaces dip dominantly northeast, and F2 minor folds have northest vergence.

The largest megascopic folds known to have been formed during D2 are those at the Grum Deposit (Figures 10, 11) and comparable folds in the Swim Deposit. Three later, less intense periods of folding and associated faulting followed. The later events (D3 through D5) generally produced open folds and weak crenulations in S2 related to broad, regional structures. An important exception to this general rule is found in the vicinity of the Faro deposit where the fourth event (D4) is intense with tight mesoscopic folds developed in nearly pervasive S2. D4 minor folds have appreciable mica growth along S4 axial plane crenulation cleavages (see Figures 8 and 9 for examples of fourth phase folds affecting the outline of the Faro deposit).

During the later stages of this deformation history a large granitic body (Anvil batholith) was intruded into the metamorphic sequence. Anvil batholith ranges in composition from a biotite-muscovite peraluminous granite to a metaluminous to peraluminous hornblende-biotite granodiorite (Pigage and Anderson, 1985). Textures include equigranular massive, megacrystic massive, and various strongly to weakly foliated variants. Foliation within the intrusive rocks is concordant with S2 surfaces in the surrounding metasediments. Several K-Ar ages on the granitic rocks yielded ages of 85-100 Ma (Templeman-Kluit, 1972). Rb-Sr isochron ages of 99-100 Ma (Pigage, and Anderson, 1985) are concordant with the K-Ar ages and indicate rapid cooling after high-level emplacement.

Intrusion of the Anvil batholith further deformed the metamorphic sequence so that the overall structure of the district is an elongate dome cored by the batholith (Figure 3). In the later stages of emplacement large extensional fault displacement occurred along the margins of the batholith (Pigage and Jilson, 1985). S-C mylonitic banding within these fault zones is consistent with development of the faults during late D2 deformation. These faults determine the present day limits of several of the deposits.

Anvil batholith and surrounding metasedimentary rocks are crosscut by two general types of post-tectonic dykes. The majority of the dykes are northeast-trending, medium to dark green, porphyritic, unfoliated, hornblende-biotite quartz diorite. These quartz diorite

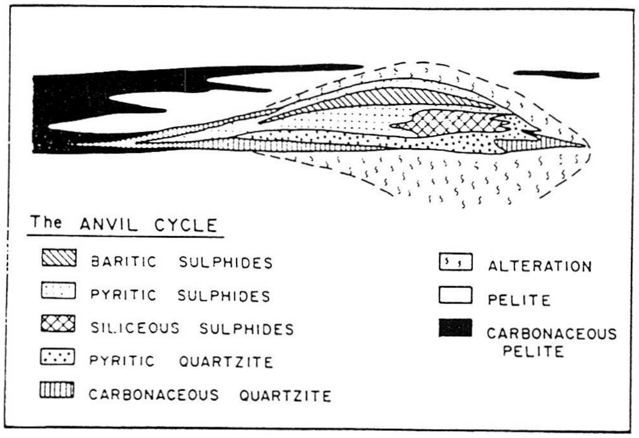


Figure 7 Idealized Anvil cycle of ore type facies variatinos based largely on the Faro and Vangorda deposits. The section is greatly vertically exaggerated.

dykes appear to be associated with late extensional faults. Unfoliated, pale tan, smoky quartz-feldspar porphyry also occurs as late crosscutting dykes. These dyke suites have not been isotopically dated; their absolute ages are uncertain.

Metamorphism was concurrent with deformation and was most intense during the major D1 and D2 folding deformations. D1 metamorphism has been largely overprinted by the later D2 metamorphism. Metamorphic grades during these two events appear to be comparable since mica mineral assemblages between microlithons (i.e. S1 foliations) are similar to those defining the S2 foliation surfaces. The rest of the discusion will focus on the D2 metamorphism.

Metamorphic grade ranges from upper amphibolite facies (sillimanite-muscovite zone) to lower greenschist facies (muscovite-chlorite zone) in a low pressure Buchan type facies series. In pelites adjacent to the intrusions the typical assemblage is andalusite-staurolite-garnet-biotite-muscovite-quartz-plagioclase with laocal fibrolite and cordierite. Lower greenschist facies pelites contain the assemblage muscovite-chlorite-quartz-plagioclase.

Metamorphic isograds are roughly concentric about the Anvil batholith. Locally isograds are truncated and juxtaposed by the late D2 extensional faults. The Faro deposit (closer to the batholith) is metamorphosed to amphibolite facies. All other deposits are only weakly metamorphosed to lower greenschist facies. This difference in metamorphism is reflected in decreased grain size and increased degree of mineral intergrowth in the less metamorphosed deposits (Tempelman-Kluit, 1970b). This has a significant impact on metallurgical response of Anvil district ores.

ORE DEPOSITS

General Description

The lead, zinc, silver deposits of Anvil District are of the sediment hosted, stratiform, massive pyritic sulphide type (Gustafson and Williams, 1981; Large, 1980) or sedimentary exhalative (sedex) type (Carne and Cathro, 1982). They occur either as a thick sulphide lens with little or no interbanded metasedimentary rocks (e.g. Faro) or as several thinner lenses stacked approximately one above the other with substantial metasedimentary interlayers (e.g. Grum and Dy).

There are presently five known lead-zinc bearing mineral deposits along a curvilinear trend on the south flank of the Anvil batholith (Figure 3). From northwest to southeast they are Faro, Grum, Vangorda, Dy, and Swim. Additionally two base metal deficient sulphide occurrences, the SB and Sea, are also known.

The Anvil deposits are distributed through a 150 meter thick stratigraphic interval straddling the boundary of the Mount Mye and Vangorda formations. They are associated with the regionally developed, but laterally discontinuous carbonaceous pelite unit forming the base of the Vangorda formation. Some sulphide lenses are, or appear to be, the lateral facies equivalent of this carbonaceous pelite. Some lenses (such as the upper horizons of Grum) are at the base of fingers of the carbonaceous pelite unit on a local scale as well as being its lateral equivalent on a more regional scale. In other cases, the ore lenses occur at lower or higher stratigraphic intervals than the carbonaceous pelite.

Detailed mapping and drilling suggest the linearly distributed deposits lie close to a northeasterly "pinch out" or "zero edge" of the associated carbonaceous pelite (the basal member of Vangorda formation). To date, no sulphide deposit lithofacies have been encountered in a moderate number of drill holes through the ore-bearing horizon southwest or northeast of the deposit line. Taken together, these observations suggest some relationship between sulphide deposits

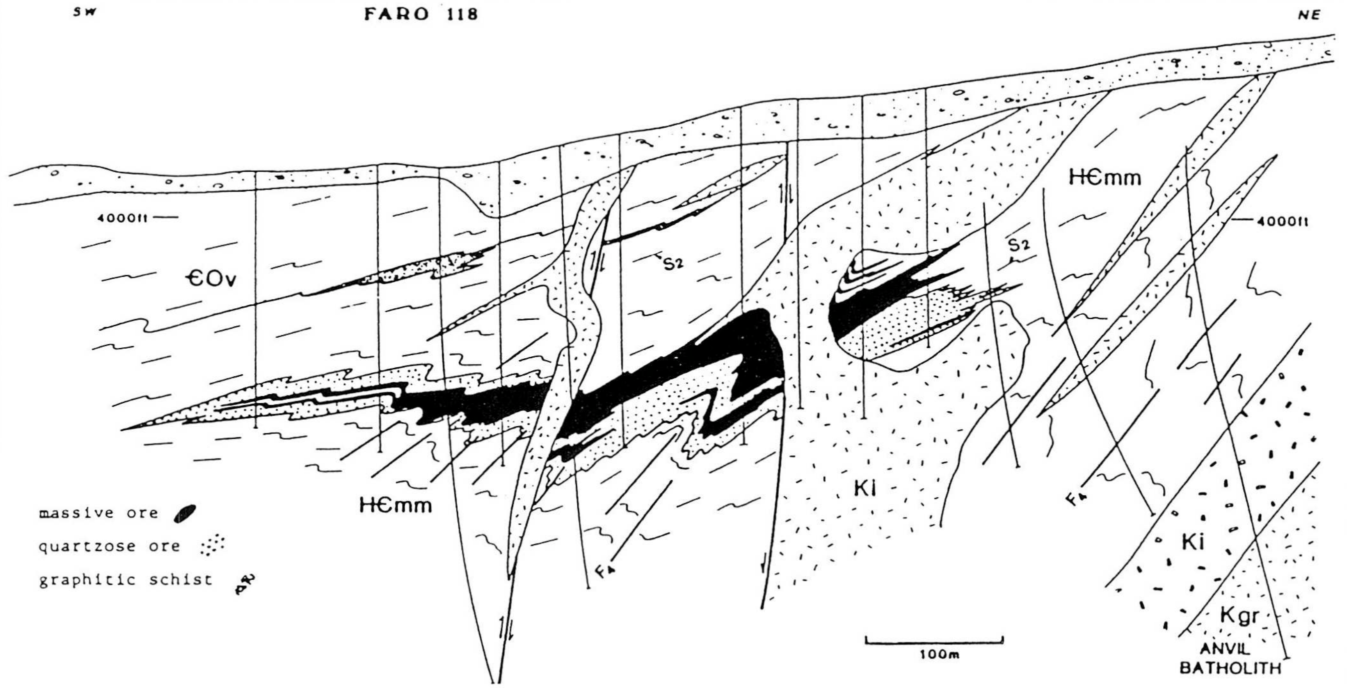


Figure 8 Vertical cross section 118+000 through Faro deposit. Section is oriented SW-NE looking northwest. Northeast-verging D_4 folds strongly affect the shape of the ore body. Deposit is generally concordant with S2 foliation. Ki are massive hornblende-biotite and smokey quartz feldspar porphyry dykes which postdate the Anvil batholith.

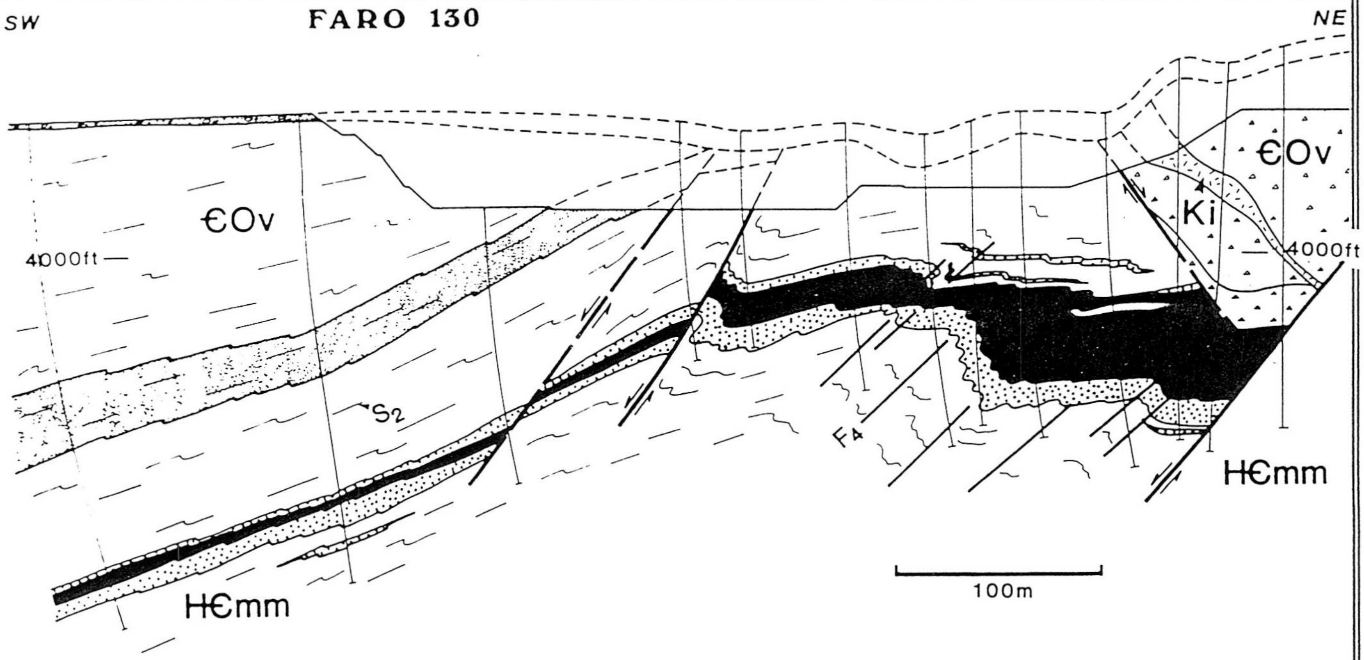


Figure 9 Vertical cross section 130+000 through Faro deposit. Section is oriented SW-NE looking northwest. Rock unit patterns are the same as in Figure 8. Triangles in far right unit indicate the breccia cap (see text).

and facies changes at a reduced basin margin.

All deposits are composed of a small number of different ore types. The ore types are broadly divisable into massive sulphides and quartzose disseminated sulphides. There are pyritic, baritic, pyrrhotitic and carbonate bearing variants of the massive sulphide ore types and carbonaceous and non-carbonaceous variants of the quartzose ore types.

Lead-zinc grade and metallurgical performance varies by ore type. The baritic massive sulphides are high grade, easily grindable and yield good grade concentrates with good recoveries. On the other hand carbonaceous quartzites are typically low grade, hard, and produce lower grade concentrates with low recoveries. Other ore types exhibit intermediate grade and recovery characteristics and performance.

These sulphide sheets or horizons are deformed into complex fold structures. The deposits are elongate parallel to the D2 fold axes and associated lineations in the host metasediments. The Faro deposit, which superficially does not appear to be complexly folded, actually shows great internal complexity in the geometry of high grade and waste layers.

Present deposit lengths are generally two to three times widths; unfolded, the deposits have an ameboid shape with diameters up to 4000 meters. Individual sulphide horizons commonly are 10 to 40 meters in thickness. The upper and lower contacts of sulphide horizons are invariably sharp while lateral extensions grade into the enclosing host rocks.

All deposits show a variably developed, white mica-dominant, alteration overprint in the wallrocks. At lower metamorphic grade this alteration is footwall biased. For the Faro deposit, this alteration encloses the entire mineralized sulphide lens.

Description of Sulphide Lithofacies

All ore types in the Anvil District are completely recrystallized metamorphic tectonites containing well developed S1 and/or S2 foliations. In the following sections the general characteristics of the massive and quartzose ores are described.

Massive Sulphide Ores

Massive Pyritic Sulphides

The massive pyritic sulphides consist of banded to homogenous, usually weakly foliated and/or lineated, massive pyrite with lesser sphalerite and galena. Total sulphide content is at least 60%, generally greater than 80% and commonly nearly 100%. Gangue consists of quartz and/or barite and/or carbonates (calcite, dolomite, ankerite). Accessory minerals include pyrrhotite, chalcopyrite, magnetite, arsenopyrite and marcasite. At amphibolite facies metamorphic grade, variants of this rock type with high lead-zinc grades commonly develop a porphyroblastic buckshot texture of pyrite in a matrix of dark reddish brown to black base metal sulphides.

Baritic, Massive Pyritic Sulphides

This ore type is a strongly and thinly banded massive sulphide/sulphate rock consisting of pyrite, galena, sphalerite and commonly magnetite in a gangue of off-white barite and lesser carbonates (calcite, dolomite, ankerite, and probably barytocalcite). Barite content ranges up to 50%; non-sulphide bearing, massive barite does not occur in the Anvil deposits. There is a complete gradation between this ore type and the massive pyritic sulphide ore type. Lead-zinc grade is typically high (10-15% combined Pb+Zn). Sphalerite is characteristically honey coloured to reddish brown. Pyrrhotite is not commonly seen in the baritic facies except in the Faro deposit where pyrrhotite is more abundant overall.

Carbonate-bearing, Massive Pyritic Sulphides

This ore type is similar to the massive pyritic sulphides but contains 10% carbonate (calcite, dolomite, ankerite) either as interstitial gangue or as coarse patches and irregular blebs. It is a minor facies and is not known with certainty to always be an original composition variant. The most common occurrence of coarse pinkish beige to tan, ankerite patches may represent recrystallized original carbonate or re-worked pre/syn-metamorphic veins.

Pyrrhotitic Massive Sulphides

This ore type consists of massive, finely crystalline, usually well foliated pyrrhotite with less than 50% pyrite porphyroblasts and highly variable amounts of sphalerite and galena. Minor chalcopyrite is characterisistic of this relatively copper-rich facies. Rounded to angular, rotated, foliated quartzite or quartz-vein clasts 2 cm or less in diameter are typical. This is a minor facies and is not known with certainty to be primary as some pyrite in the massive sulphide ore types may invert to pyrrhotite during regional metamorphism. The pyrrhotitic facies is volumetrically more important in Faro than other deposits. At Faro pyrrhotite-rich ores are generally much finer grained than non pyrrhotitic ores.

General Comments on Massive Sulphides

Breccia textures are more common in the massive pyritic and pyrrhotitic facies than in the barite or carbonate bearing facies. Pyritic breccias generally involve fragments of more quartzose or less base metal rich pyritic facies in a massive pyrite plus base metal sulphide matrix. Fragments are be angular to subrounded, poorly sorted, and either clast or matrix supported. In some cases, margins of fragments can be fit back together. In all cases, the breccias are post-metamorphic since they involve variably oriented, foliated clasts. The origin of the breccias appears to be related to ductility contrasts between the affected lithologies during sulphide flow induced by deformation ad metamorphism. These are clearly not primary breccias related to feeder zones or paleoslumps prior to sulphide lithification.

Friable and porous massive sulphides are relatively common and when strongly developed often degenerate to pyrite sand. The porous massive sulphides are commonly carbonate or barite bearing and originate by post-metamorphic groundwater leaching and oxidation, especially near faults.

Quartzose Disseminated Sulphide Ores

Post-metamorphic breccias are also common in the quartzose disseminated sulphide ore types. Pyritic quartzite breccias are often spectacularly developed in the sphalerite-rich high grade facies where ductility contrasts between the sulphides and quartzite bands dictate ductile flow in the sulphides and brittle failure, rotation and brecciation in the quartzites. Where less intensively developed, the breccias grade into examples of sulphide mobilization into D2 or later cleavages.

Ribbon banded, "Graphitic", Pyritic Quartzite

This ore type is a dark grey to black, well banded, sulphide-bearing quartzite (metamorphic usage). Bands are:

(a) dark grey, very fine grained, carbonaceous, phyllitic quartzite to siliceous phyllite (presumed metachert),

(b) light grey, more coarsely crystalline, quartz-sulphide (pyrite-sphalerite-galena) interbands.

Banding is on a scale of 0.2-2.0 centimeters. Total sulphide content usually is between 10% to 30% although the entire range encompasses 2% to 60%. Pyrite is usually the dominant sulphide species but higher grade examples have sub-equal pyrite and lead-zinc sulphides ranging to lead-zinc dominant variants with little pyrite. Strong sulphide species differentiation between bands, such that barren pyrite bands are adjacent to or near sphalerite or galena rich bands, occurs but is uncommon.

S_0 bedding is typically transposed into the S1 cleavage. Microlithon textures with S2 forming a spaced carbonaceous parting with intervening folded S0-1 surfaces are typically well developed. Possibly the prominent ribbon-banding is a transposed primary stockwork veining (?).

Pyritic Quartzite

This ore type consists of a light grey, generally poorly banded, moderately to weakly foliated, micaceous quartzite with highly variable base metal and pyrite contents. Pyrite contents are generally 10% to 40% ranging between 2 and 60%. Although there is a complete gradation from massive sulphide ores to quartzose ores, there is usually little problem in separating this facies from the massive pyritic sulphides as the vast majority of the quartzite examples have less than 40% total sulphides. A minor variant of this facies contains low pyrite (5%) content with base metal sulphides predominant. Barite in major amounts is uncommon in this facies; carbonate species are not typical but are locally abundant. Chalcopyrite, pyrrhotite and magnetite-bearing varieties are common. Sphalerite in the high grade examples is characteristically a vibrant reddish brown.

In the Grum and Vangorda deposits, detailed drill hole intersections have shown that adjacent to metabasites the carbonaceous ribbon-banded pyritic quartzites show a gradual alteration to pyritic quartzites. This decarbonization represents a contact metamorphic effect adjacent to the metabasite sills and dykes cutting through the ore deposit.

At Faro the northeast edge of the deposit contains a thick interval of extremely pyritic quartzite. This quartzite is spectacularly barren of lead and zinc but contains elevated copper contents and is rich in magnetite. A similar facies is developed at Vangorda where it is quite gold rich (1 gram/tonne) and more clearly occurs in the deposit footwall.

Idealized Anvil Deposit (Anvil Cycle)

All deposits have a distinct arrangement of sulphide ore types. This arrangement in a vertical and lateral sense is so commonly seen within and between deposits, it has been termed the Anvil Cycle (Jennings and Jilson, 1986). Figure 7 is a generalized, pre-deformation, vertically exaggerated cross-section of an ideal Anvil District deposit. It is based largely on the Faro and Vangorda deposits.

The base of the cycle is marked by ribbon-banded, carbonaceous, pyritic quartzites. The carbonaceous quaratzites are succeeded upward by pyritic quartzites, siliceous pyritic sulphides, massive pyritic sulphides and baritic massive pyritic sulphides. This array is also seen laterally with ribbon-banded, carbonaceous, pyritic quartzites forming the marginal or distal facies of a deposit progressing inward to the baritic massive pyritic sulphide facies.

It is important to note that Anvil cycles are developed on a wide variety of scales and to varying degrees of completeness. The most common scale is that of a cross-section through an entire deposit making recognition in individual boreholes or exposures often difficult. A series of complete and partial cycles may cumulatively form a mega-cycle on the scale of a complete horizon (e.g. Faro) or on the scale of a single sulphide horizon within a multilayered deposit (e.g. Grum or Dy). Complete cycles are also seen over a one meter or less stratigraphic interval, emphasizing the wide range of scales at which facies ordering can occur.

Facies zoning can be used in a tenuous way as top indicators in poly-deformed ore horizons to decipher fold patterns. This facings indicator is used with a greater degree of confidence if the complete Anvil cycle is present. It is stressed that stratigraphic tops directions defined by the unambiguous distribution of Mount Mye and Vangorda formation lithologies always take precedence over those interpreted from sulphide facies ordering.

Metal zoning crudely complements this facies distribution pattern. The quartzose disseminated sulphide facies at the base of an ideal cycle tend to be zinc enriched. The upper, massive sulphide facies are slightly lead-silver enriched, with the uppermost baritic facies containing the highest lead and silver grades. On the basis of scanty and preliminary data, copper and to a lesser extent gold are preferentially distributed in the siliceous facies of the footwall-biased alteration overprint and in the pyritic quartzite and siliceous pyritic sulphides facies of the stratiform ore types.

Individual horizons, however,do not commonly show any evidence of zonation in the assays. Studies of metal zoning are greatly hampered by the structural complexity of the Anvil deposits.

Alteration

Both wallrocks and certain ore facies of the Anvil deposits are overprinted by a prominent, easily recognized, light beige, white mica dominant, alteration assemblage. This overprint facies is not a depositional unit and may have formed as a reaction product between wallrocks and deposit forming hydrothermal fluids, as a metamorphic reaction envelope between sulphides and silicates (unrelated to ore forming fluids), or as a combination of these processes.

Many mineralogical variants of the alteration facies are recognized including siliceous, carbonate-bearing, talcose, chloritic, pyritic, pyrrhotitic, chalcopyrite-bearing, magnetite-bearing and lead-zinc bearing species. Careful attention has been paid to the distribution of these facies in an attempt to define feeder zones for each deposit. To date, no unequivocal feeder zones have been recognized. Recognition of a feeder zone is considerably hampered in this terrane by the polydeformational overprint. Several instances of suspected pre-D2 quartz-chlorite- pyrrhotite-chalcopyrite veinlets or stringers have been observed in the altered stratigraphic footwalls of several horizons (Swim deposit in particular) but not in sufficient abundance to define a stringer or feeder zone comparable to volcanogenic deposits.

In the multi-layered deposits at greenschist facies metamorphic grade, all mineralogical variants of the alteration facies are commonly recognized, often with the best degree of development in the footwall of a mineralized horizon. This alteration overprint commonly appears discontinuous.

The only amphibolite grade example, the Faro deposit, shows a much less varied alteration assemblage (muscovite- quartz-pyrite + marcasite) with development of a substantial hanging wall as well as footwall alteration envelope. This simplified phase assemblage may be due to re-equilibration of the greenschist facies alteration assemblage to higher grades of metamorphism. The prominant hanging-wall alteration may be related to continued post-deposition hydothermal activity or to sulphurization or other metasomatic reactions in the wallrocks during metamorphism. These metamorphic reactions may be coupled with the occurrence of mobile sulphur caused by the inversion of pyrite to pyrrhotite within the deposit. It is interesting to note that the Faro deposit shows the greatest development of the massive pyrrhotitic ore facies and also the most well defined, broadest, and most symmetrical alteration envelope.

Genetic Model

The Anvil deposits are examples of synsedimentary, stratiform, massive sulphide deposits considered to be syngenetic/diagenetic and dominantly submarine exhalative in origin. Evidence for their essentially synsedimentary origin includes:

1. The prevalent and well developed compositional layering or banding in many or most sulphide facies, commonly with large variation in proportions of sulphide species between bands.

2. Thin interlayering of sulphides with totally unmineralized metasedimentary rocks, commonly on a scale of centimeters.

3. The occurrence of all deposits within a relatively restricted vertical stratigraphic interval.

4. The curvilinear depositional trend crudely associated with a carbonaceous pelite facies change.

5. The metamorphic and deformational overprints which clearly show the ores are pre-metamorphic.

No unequivocal evidence supporting the notion of an exhalative origin is preserved in the district. Alternative interpretations of some of the ore facies in the deposits are possible. For example, all or part of the footwall siliceous ore and alteration facies could be silicified and sulphidized host sediments rather than exhalative cherty sediments.

Reconnaissance studies by Kuo (1976) demonstrated the presence of chloride-rich fluid inclusions in barite, quartz, and sphalerite of several of the Anvil deposits, implying that metalliferous brines played a role in deposit formation. The ubiquitous development of generally footwall biased alteration envelopes further suggests that these brines were relatively hot. The curvilinear distribution of the deposits suggests a synsedimentary fault which could have provided the conduit for exhalative ore fluids reaching the sea floor.

In summary, the ore deposits are thought to have formed from hot metalliferous brines discharged from submarine fumaroles localized along a synsedimentary fault or hinge line which developed in response to lower Cambrian extensional tectonism. This tectonism influenced basinal geometry resulting in reduced second order basins truncating against the hinge line. Hydrothermal fluids moved up this fault zone and exhaled into a relatively deep water reduced marine basin which was otherwise receiving distal turbidite sediments. Sulphides may have been deposited from plumes along the hinge line or from relatively dense exhaled brines ponded in local topographic depressions near the hinge line.

This model accounts for the crude associations of known deposits with apparent depositional limits of reduced, carbonaceous sediments. The hinge line or related fault sets could have provided the channelways for the first pulse of basaltic volcanism associated spatially with the deposits. A regular and repetitive change in the environment of deposition or of the ore fluid composition is required to explain the origin of the Anvil cycle.

DESCRIPTIONS OF DEPOSITS TO BE VISITED

Faro

History

The Faro deposit was discovered in 1964 by the drill testing of airborne electromagnetic anomalies supported by other indications. Mining at Faro began in late 1969 and continued until 1982 when high costs and falling prices forced temporary closure of the mine.

In November 1985, Curragh Resources Inc. bought the Faro mine and other deposits in the Anvil District from Cyprus Anvil Mining Corporation. Waste removal from the Faro Pit resumed in early 1986. The Faro concentrator resumed production in June 1986.

General Geology

The Faro deposit occurs in the Mount Mye formation approximately 100 meters structurally beneath the Vangorda formation. Strati- graphically this may equate to the position of the lowest horizons in the Grum, Vangorda, and Dy deposits.

The orebody is hosted by biotite-muscovite-andalusite schist. With increasing metamorphic grade this schist changes into a coarse, gneissic biotite-muscovite schist. The Vangorda formation at Faro is represented by hard, dense, banded calc-silicates.

Post-metamorphic igneous intrusive rocks are more widely developed at Faro than any of the other deposits. There are two clans of dykes:

a) equigranular to subporphyritic hornblende-biotite quartz diorite,

b) smoky quartz-feldspar porphyry.

The hornblende-biotite quartz diorite forms large dykes at the northwest and northeast margins of the deposit. These dykes appear to be associated with extensional faults. The smoky quartz-feldspar porphyry is associated with an extensional fault bounding the deposit on the southeast side.

A large mass of heavily silicified post-metamorphic breccia occurs at the northeast edge of the central part of the deposit. This "breccia cap" is associated with irregular dykes belonging to both of the above clans and with the intersection of two extensional faults. The hornblende-biotite quartz diorite also occurs as clasts within the breccia. The deposit has been disrupted by the breccia and ore clasts occur within it. This breccia presumably resulted during intrusion of the dykes as the vapour pressure of the intrusive melts exceeded the confining pressure of the overlying metasedimentary sequence.

Before mining, the Faro deposit was 2000 meters along strike, 800 meters across strike and about 70 meters thick. The deposit is a flat-lying, elongate, asymmetric lens with a thick northeast side and a thin tapering southwest side (Figures 8, 9). The deposit is cut by several extensional faults which form a graben structure with the central portion of the deposit being downthrown. This central portion contained the majority of the remaining reserves when Curragh Resources Inc. acquired the deposit.

The Faro deposit exemplifies the classic Anvil cycle. It contains a massive sulphide variably baritic upper portion and a quartzose variably carbonaceous lower and peripheral part (Figure 8). In addition there is a prominent very low grade semi-massive siliceous pyritic sulphides zone along the northeast edge of of the deposit. Unusually abundant (compared to other Anvil district deposits), but erratically distributed, pyrrhotitic mineralization occurs in the southwest part of the deposit, especially where the deposit thins dramatically.

Grade zoning follows ore type zoning so that the base and northeast edge of the deposit contains the lower grade mineralization and the upper and southwest portion of the deposit contains the higher grade mineralization. In plan the deposit was also zoned with the northwest part of the deposit consisting largely of baritic massive sulphides with high lead-zinc grades, and the southeast part consisting dominantly of carbonaceous quartzose ores with low lead-zinc grades.

Gold grades in the Faro deposit are significantly lower than other deposits in the Anvil District. Gold distribution is erratic with a few high values associated with fractures. This erratic distribution and lower grade is related to the amphibolite facies metamorphic grade for the deposit.

The southwest thinning and southwest dip of the deposit combine to make the southwest edge of the orebody uneconomic for mining by open pit methods. A small southwest extension of the deposit immediately southwest of the ultimate pit walls is being mined by room and pillar underground methods from a ramp developed into the pit wall.

Field Trip Stops

An overview of the Faro deposit will be presented from the lookout point on the southwest edge of the present open pit. This overview will discuss metamorphic grade, ore type distibution, metal zoning patterns, fault and fold patterns, and mining history.

A more detailed look at ore types and deformation patterns is planned by viewing exposures in the underground mine developed in the southwest tail of the deposit.

Grum

History

The Grum deposit was discovered in 1973 by AEX Minerals in joint venture with Kerr Addison Mines. Discovery was through drill testing a gravity anomaly in an area structurally down fold plunge from the Vangorda deposit.

Surface drilling in 1973 and 1974 indicated significant mineralization; in 1975 and 1976 an underground sampling and drilling program was carried out to further define the deposit. Kerr Addison sold the deposit, along with the Vangorda and Swim deposits, to Cyprus Anvil Mining Corporation in 1979. From 1980 to 1982 Cyprus Anvil drilled additional holes in and around the deposit and relogged all existing holes. All available sulphide intersections were re-sampled and re-assayed at that time. In 1985 Curragh Resources Inc. purchased the deposit from Cyprus Anvil. Limited surface drilling programs in 1987-89 further refined the locations of mineralized horizons in near surface areas.

Curragh Resources Inc. is currently preparing plans for the development and operation of the Grum deposit. Development of the Grum and Vangorda deposits will supplement and eventually replace production from the nearly exhausted Faro pit. A haul road has been constructed between the Grum deposit and the Faro concentrator. Curragh Resources Inc.has also constructed a mine dry and water treatment plant for the Grum and Vangorda deposits. An Initial Environmental Evaluation has been prepared to identify environmental problems and directly related socio-economic impacts of the development.

General Geology

The Grum deposit subcrops beneath morainal tills and glaciofluvial silts, sands, and gravels. Overburden is thin to absent in the northwest end of the deposit and thickens to 100 meters towards the southeast.

It consists of three to five layers of massive and disseminated sulphide mineralization with interbanded pelitic phyllites. The most important mineralized horizon occurs just beneath the basal carbonaceous pelite member of the Vangorda formation. There are thin low grade horizons within the Vangorda formation and more important horizons in the upper part of the Mount Mye formation.

At Grum, the Vangorda formation consists of soft, highly fissile, calcareous, muscovite-chlorite phyllites. Metabasites are minor and tend to be highly foliated chlorite phyllite rather than the blocky, massive greenstones that typify the Vangorda metabasites elsewhere. The basal carbonaceous pelite member of the Vangorda formation thickens across the deposit from about 10 meters in the northeast to as much as 80 or 100 meters southwest of the deposit. The sulphide horizons appear to be associated with the northeast pinchout of this unit. Immediately above the main ore horizon the carbonaceous rocks are soft and highly sheared and gouged. Elsewhere they are moderately hard, highly fractured, black, siliceous phyllites.

The Mount Mye formation consists of soft muscovite-chlorite phyllites. They are distinguished from the Vangorda formation phyllites by being noncalcareous. The ore layers at Grum are define a complex, shallowly northwest plunging, polyphase fold structure (Figure 10, 11, 12). The prominant S-shaped folds (in cross section looking northwest, see Figure 10) are second phase structures. They are superimposed on a larger Z-shaped first phase fold (Figure 10). The dominant plane of fissility (S2) in the phyllites at Grum is axial planar to the second phase folds and dips shallowly (10o-30o), generally to the southwest. This fissility is a major factor in assessing slope stability for a Grum pit. The overall deposit elongation parallels the axial direction of the second phase folds. The first and second phase folds plunge towards the northwest with a dip of approximately 12o (Figure 12).

There are several important extensional faults at Grum. The largest displacements occur on moderately (35o-45o) dipping structures that truncate the deposit at

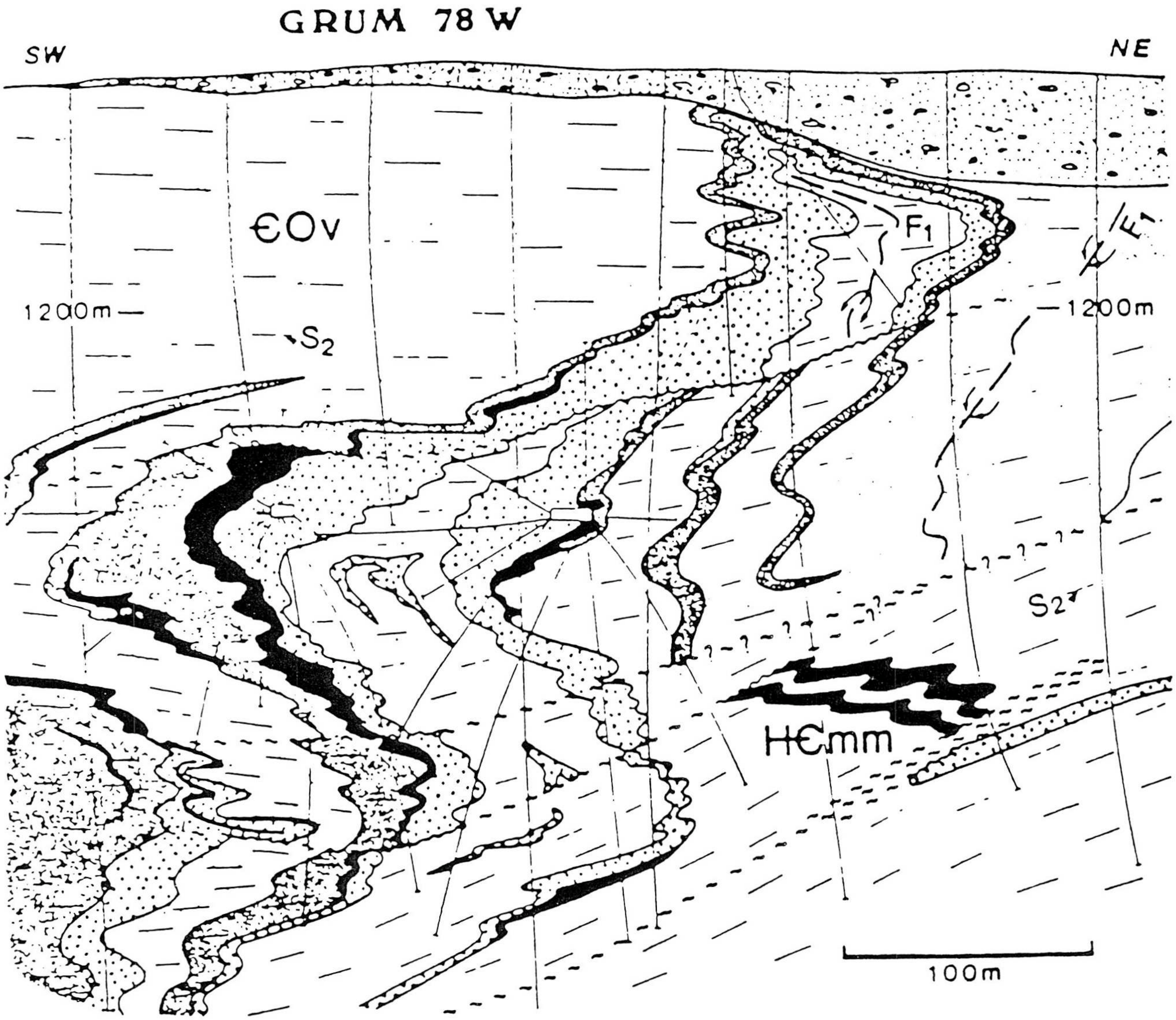


Figure 10 Vertical cross section 78+00W through Grum deposit. Section is oriented SW-NE looking northwest. Rock unit patterns are the same as in Figure 8. Section shows type 3 interference pattern between D^1 and D^2 fold structures. Anvil cycle is also evident with massive sulphides overlying quartzose sulphides.

both its northwest and southeast ends (Figure 12). The extensional fault on the northwest end has a minimum displacement of one kilometer. Fabrics in these fault zones indicate they formed late during the D2 deformation with emplacement and uplift of the Anvil batholith. Neither of these major structures would crop out in an open pit.

Several smaller subparallel faults will be found in the proposed Grum pit. A myriad of smaller faults were

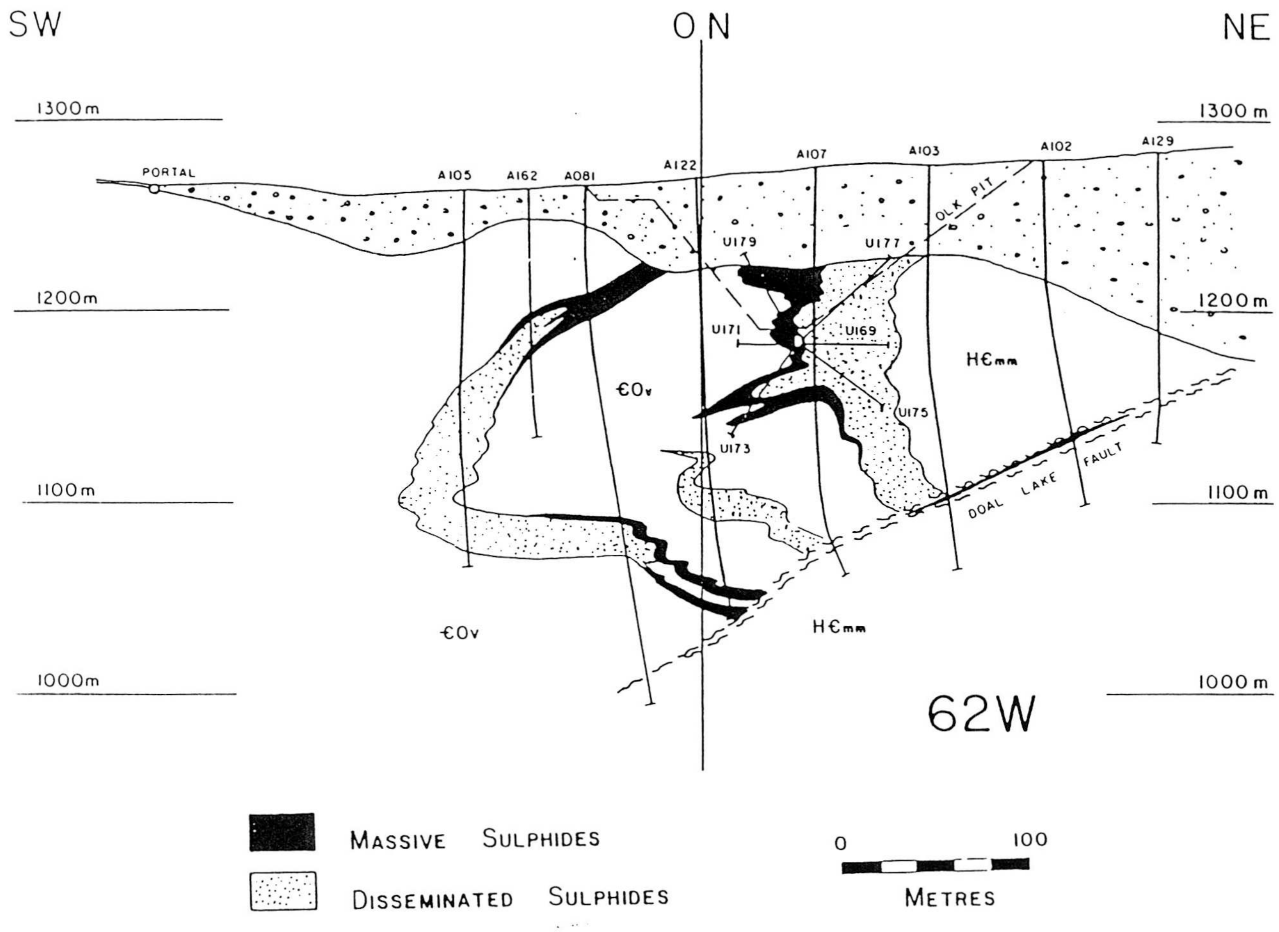


Figure 11 Vertical cross section 62+00W through Grum deposit. Section is oriented SW-NE looking northwest. Type 3 interference pattern is less obvious because D^1 fold closure has been eroded. Doal Lake Fault is a large extensional fault which forms the southeast boundary of the Grum deposit.

mapped underground by Kerr Addison trending on the average 080° and dipping steeply. One of these faults has an interpreted normal displacement of 60 meters. Points mapped underground and on surface tend to strike 060° and dip subvertically.

As with other deposits in the Anvil Range a given ore horizon at Grum has a massive sulphide upper portion and a quartzose, disseminated sulphide lower portion. The horizons can be up to 30 meters thick but are mostly 15 meters or less in thickness. The sulphide horizons are separated by significant thicknesses of barren phyllite. Interfaces between ore and waste tend to be sharp at the stratigraphic hanging wall and gradational both at the footwall and laterally. Quartzose ore types at Grum constitute about 50% of the deposit; this proportion is significantly higher than the other deposits.

As with all Anvil District deposits, overall grade is strongly partitioned into massive, particularly baritic, sulphides. Therefore the stratigraphic tops of horizons tend to have high Pb+Zn grade and stratigraphic bottoms low Pb+Zn grade. The average gold content of Grum is several times higher than Faro. The sphalerite at Grum is richer in zinc. Both of these

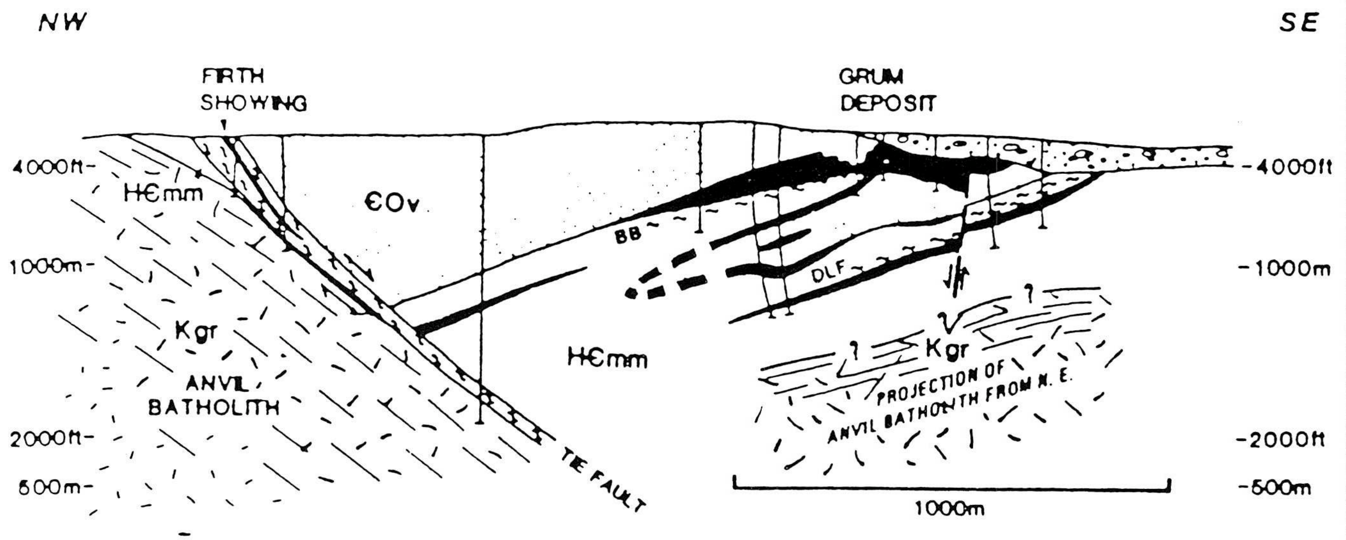


Figure 12 Vertical long section through Grum deposit. Section is oriented NW-SE looking northeast. Section shows the northwest plunge of the Grum fold structure. Firth showing represents slivers of Grum mineralization in the Tie Fault, a large extensional fault zone that juxtaposes footwall amphibolite facies rocks against hanging wall greenschist facies rocks.

variations are due to the lower metamorphic grade at Grum.

Grum ores also have a finer grain size and more complex mineral intergrowth than the Faro deposit. This necessitates finer grinding than Faro ores. Cyprus Anvil Mining Corporation had already made modifications to its mill to accommodate this fine grind prior to shutdown in 1982.

Locally drill holes within the deposit contain substantial metabasite intersections. The metabasites are typically substantially altered to a pale beige or grey muscovite-carbonate (calcite, dolomite, ankerite)-quartz assemblage. Typcially the carbonated metabasites units are highly foliated. Extremely altered metabasites also contain scattered occurrences of a bright green mica. XRD and SEM work indicated that this micaceous mineral is a chromium-rich kaolinite or serpentine (Modene, 1982).

Field Trip Stops

The Grum deposit will not be exposed at the time of the field trip. A brief stop will be made to look at the typical mesoscopic type 3 interference pattern for the D_1 and D_2 minor folds and axial plane surfaces. The fold patterns will be exposed in the calcareous phyllites of the Vangorda formation.

If time permits, core intersections of some of the typical rock types in the Anvil District will be viewed.

Vangorda

History

Vangorda was the initial discovery in the Anvil Range. Attention was drawn to the area by a small stream exposure of highly oxidized sulphides with a prominent red iron oxide stain in Vangorda Creek. The deposit was drill tested from 1953 to 1955 by Prospector Airways, a predecessor to Kerr Addison Mines. This drilling outlined a significant deposit, but a production decision was not warranted at that time. The deposit remained idle for the following decade. Minor additional drilling was done by Kerr Addison largely for metallurgical sampling. In 1979 Kerr Addison sold the

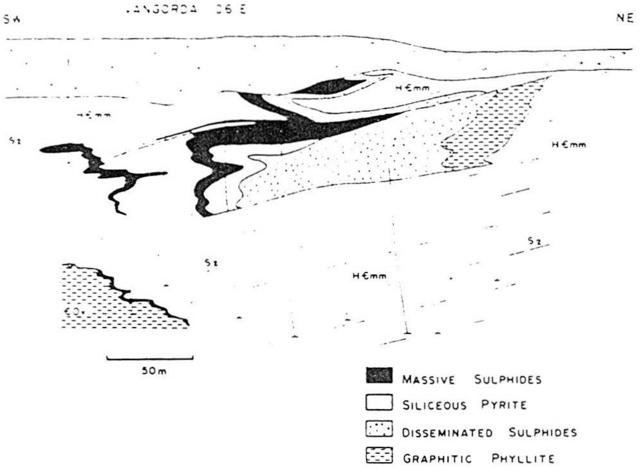


Figure 13 Vertical cross section 06+00E through Vangorda deposit Section is oriented SW-NE looking northwest. Upper part of deposit is overturned with quartzose ores structurally overlying massive sulphides. Major portion of deposit is upright. Quartzose ores and siliceous pyrite underlying massive sulphides show gradational transition to underlying altered Mount Mye phyllites.

deposit to Cyprus Anvil Mining Corporation.

Cyprus Anvil geologists examined the available drill core and concluded that it would be necessary to redrill the deposit to provide adequate material for re-evaluating it. In 1979 the northwest portion of the deposit was re-drilled with NQ core holes. Scattered core holes were put down in the southeast part of the deposit. Because of anticipated poor recoveries in this area it was judged advisable to drill this part of the deposit with rotary methods. This fill in drilling was done in 1981.

Curragh Resources Inc. acquired the Vangorda deposit in 1985. In 1987 selected fill-in diamond drill holes were completed. Test holes were also completed in the southeast portion of the deposit at this time. Because the test holes showed good recovery, the remainder of the deposit was redrilled in 1988 using NQ core holes.

General Geology

The Vangorda deposit is quite shallow, in most places subcropping beneath glacial till. It has been traced over a 1300 meter by 200 meter area. The till blanket is up to about 30 meters thick in the northwest part of the deposit and thins to less than 5 meters in the southeast. Northwest of Vangorda Creek the till cover is also quite thin. Locally the basal overburden and uppermost broken bedrock are cemented by iron oxides into a tough "ferricrete" breccia.

The deposit consists of one major sulphide horizon structurally located about 50 to 120 meters beneath the basal carbonaceous pelite member of the Vangorda formation. Several thin horizons occur above the main horizon. One of these occurs at the base of the Vangorda formation basal carbonaceous pelite member. This ore horizon may equate to the main horizon at Grum. In general these upper horizons are too thin or low grade to be mineable.

The host rocks for the deposit are dominantly noncalcareous phyllites, presumably part of the Mount Mye formation. Formational assignments near this deposit, however, are ambiguous due to the strong wall rock alteration. Most phyllites in the deposit footwall are bleached, locally silicified and/or chlorite and sulphide bearing.

The Vangorda deposit occurs in the hinge of a large second phase fold. Overall the deposit has the shape of a reclining "M" or a "three" in cross section (Figure 13). The major part of the deposit is structurally and stratigraphically upright. There is considerable uncertainty, however, in the details of fold morphology. The deposit is elongate in the northwest-southeast direction parallel to F_2 fold axes. The northwest half of the deposit plunges about 10o towards the northwest, and the southeast half is subhorizontal. The S_2 foliation generally dips shallowly southwest; its orientation is locally quite variable.

The deposit is truncated by a steep normal fault at its northwest end. Displacement along this fault is uncertain; it has been correlated with similar normal faults in the district (such as the faults truncating the Grum deposit). Many other gouge zones were observed in drill core but the orientation of the structures responsible for them is not known.

A number of faults parallel to S_2 are predicted. These are "required" to make the structure and stratigraphy fit (see Figure 13). These low angle structures are best thought of as sheared out fold limbs. They are not generally gouge zones and will probably pose no more serious a problem for slope stability than the S_2 foliation and the myriad of small gouge zones that parallel it. Several analogous structures are thought to be present at Grum.

The deposit consists of the same sulphide rock types as the other deposits. Two ore types are particularly prominant. The massive sulphides forming the stratigraphically highest portion of the deposit are commonly baritic and rich in lead and zinc. This unit is actually a mixture of about 50% pyritic massive sulphide and 50% baritic massive sulphide ore types. Within a given drill hole the two ore types are interbanded on a scale of 0.5-5 meters. Immediately underlying themassive sulphides is a very pyrite-rich quartzite. This quartzite grades downwards sequentially into pyritic quartzite, siliceous phyllite, and ultimately altered phyllite of the Mount Mye formation. Concordant with this downward decrease in silica is a similar downward decrease in the abundance of sulphides from quartz rich semi-massive pyrite at the top to slightly pyritic altered phyllite at the base. Although pyrite is the dominant sulphide in the quartzite, pyrrhotite is generally present and locally abundant or dominant. Magnetite is also unusually well developed in the pyritic portion of the quartzite. The quartzite contains only minor lead and zinc but is relatively rich in copper and unusually high in gold. This pyritic quartzite to siliceous pyrite is similar to the semi-massive zone along the northeast edge of the Faro deposit.

Of the other ore rock types only the carbonaceous ribbon-banded pyritic quartzite occurs to any greatextent. This carbonaceous quartzite tends to have low Pb+Zn grades and is peripheral to the deposit.

The gradational and conformable change from the extremely pyritic quartzite immediately beneath the massive sulphides to slightly altered Mount Mye footwall phyllites has important implications concerning ore genesis. This pattern strongly suggests that the quartzose ores in the Vangorda deposit are not exhalative in origin. Rather they represent a strongly silicified and sulphidized footwall to the massive sulphides. In this scenario the only exhalative mineralization in the Anvil cycle would be the massive sulphides. Feeder zones for the exhalative mineralization would ideally be demarcated by the quartzose ores.

Field Trip Stops

There is a strong possibility that the southeast portion of the Vangorda deposit will be partially exposed at the time of the field trip. If this is the case then it will be possible to view a complete Anvil cycle from the massive sulphides through the quartzose ores into the altered footwall phyllites. It will present an excellent opportunity to discuss zoning patterns, deformation textures, and genetic models.

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