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Field Guide to the Anvil Range Pb Zn Ag District, Yukon

by

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Curragh Resources

Portions exerpted from Jennings, D.S. and Jilson, G.A. (in press) Geology and Sulphide deposits of the Anvil Range in CIM Special Volume on Mineral Deposits of the Northern Cordillera.

Introduction

The Anvil Range Pb-Zn-Ag District is located in the central Yukon Territory near the town of Faro. The district contains one of the world's largest reserves of lead and zinc in several deposits (figure 3) including the ~~recently re-opened~~ Faro mine. This ore can support mining activities in the Anvil District for many years following the exhaustion of the Faro deposit. Most of these deposits are within economical haulage distance to the Faro concentrator.

Regional Geology

The Anvil District is part of the Selwyn Basin (figure 1), a large area of central Yukon where deep water ~~shales~~ accumulated along the ancient North American continental margin during the Paleozoic. The shales of the Selwyn Basin host most of Canada's large stratiform lead-zinc deposits, making it a metallogenic province of world-wide significance.

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 response. This geologic factor, along with the size of the Faro deposit and its location, have combined to determine that Faro is as yet the only producer of the Selwyn Basin.

District Stratigraphy

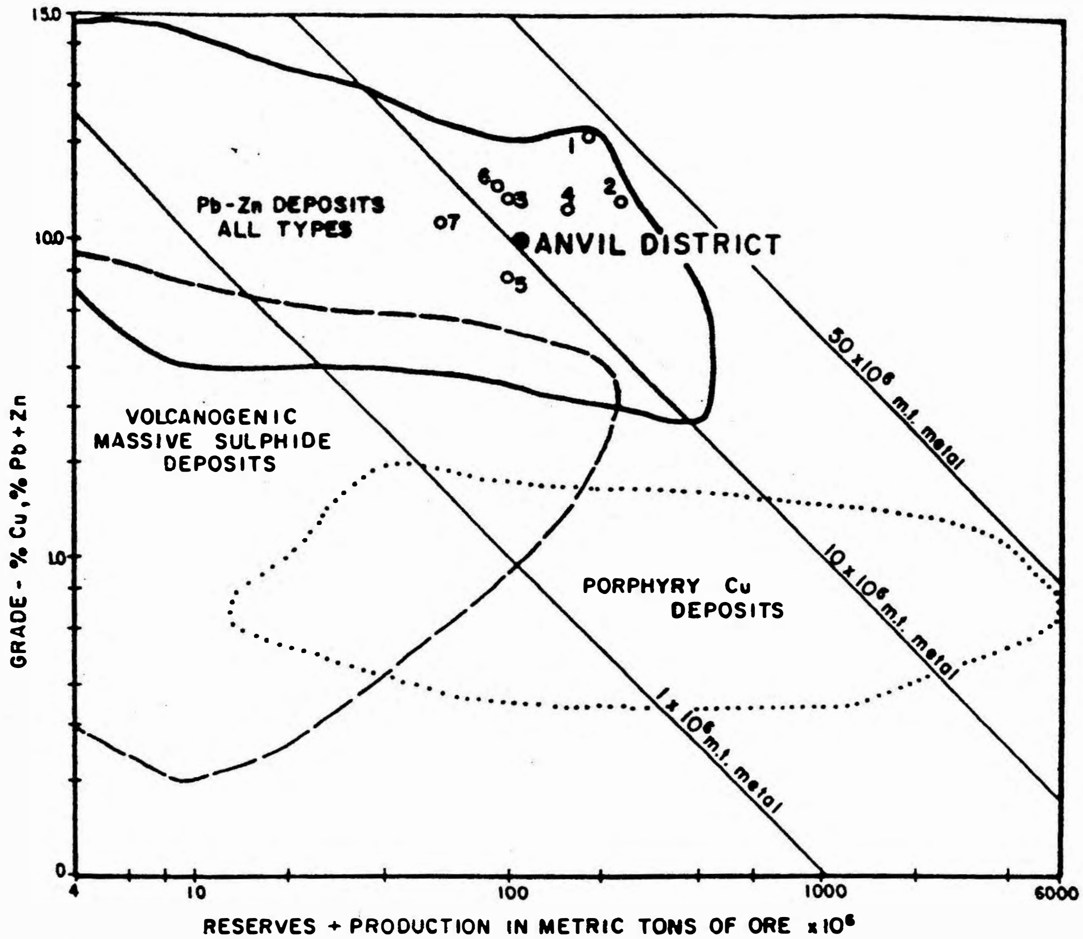
The stratigraphic sequence of Anvil District ranges in age from latest Precambrian to Permian. Two major divisions or assemblages of strata are present. They are separated by a poorly exposed interval of black shale of uncertain affinity which contains late middle Devonian limestone lenses (Templeman-Kluit, 1972).

The lower division ranges in age from late Precambrian to perhaps Early Silurian. It is approximately 5 km thick and divisible into three major mappable units (fig. 4). From the base these are non-calcareous metapelite of Mt. Mye formation, calcareous metapelite of Vangorda formation and basalt and black phyllite of Menzie Creek formation. Established formal stratigraphic nomenclature does not apply directly to this area or interval but the rocks are very similar to those of Kechika Group (Gordey, 1981) south of the district in Pelly Mountains. All formational names applied to the lower division are informal.

The upper division includes rocks ranging in age from Devonian to Permian. In contrast to the lower division, the upper division is ~~characteristically~~ chert and ~~conspicuously coarsely~~ clastic. Strata of the Earn (Gordey et al., 1983) and Anvil Range (Tempelman-Kluit, 1972) groups are present. All or part of the upper division may be allochthonous with respect to the lower.

The lead zinc deposits occur within a restricted portion of the lower division. The upper division is host to stratiform barite deposits and to a number of interesting geologic problems beyond the scope of this summary.

The Mt. Mye formation varies from non-calcareous, biotite-muscovite schist to non-calcareous, weakly carbonaceous, light to medium gray muscovite-chlorite phyllites with lesser, interlayed, black graphitic phyllite, marble, calc-silicate phyllite or schist, metabasite and psammitic schist. The unit is at least 2 kilometers thick but its base is not exposed in the district. The



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

see note (11)

COMPARISON OF SIZE GRADE CHARACTERISTICS OF SOME MAJOR LEAD-ZINC DEPOSITS

FROM GUSTAFSON & WILLIAMS, 75th ANNIVERSERY VOLUME, SOCIETY OF ECONOMIC GEOLOGISTS.

G.J./rwr JUNE 1986

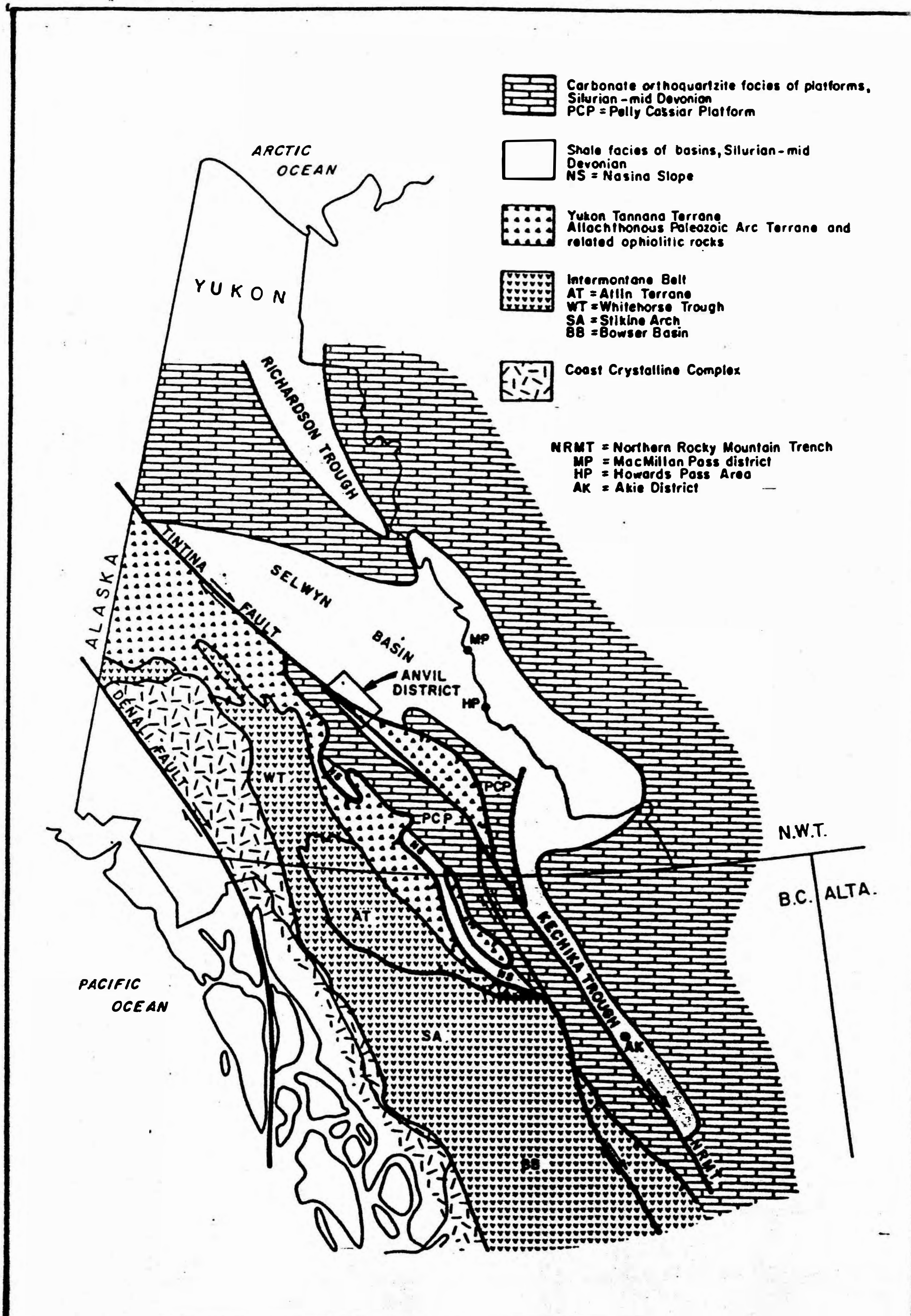
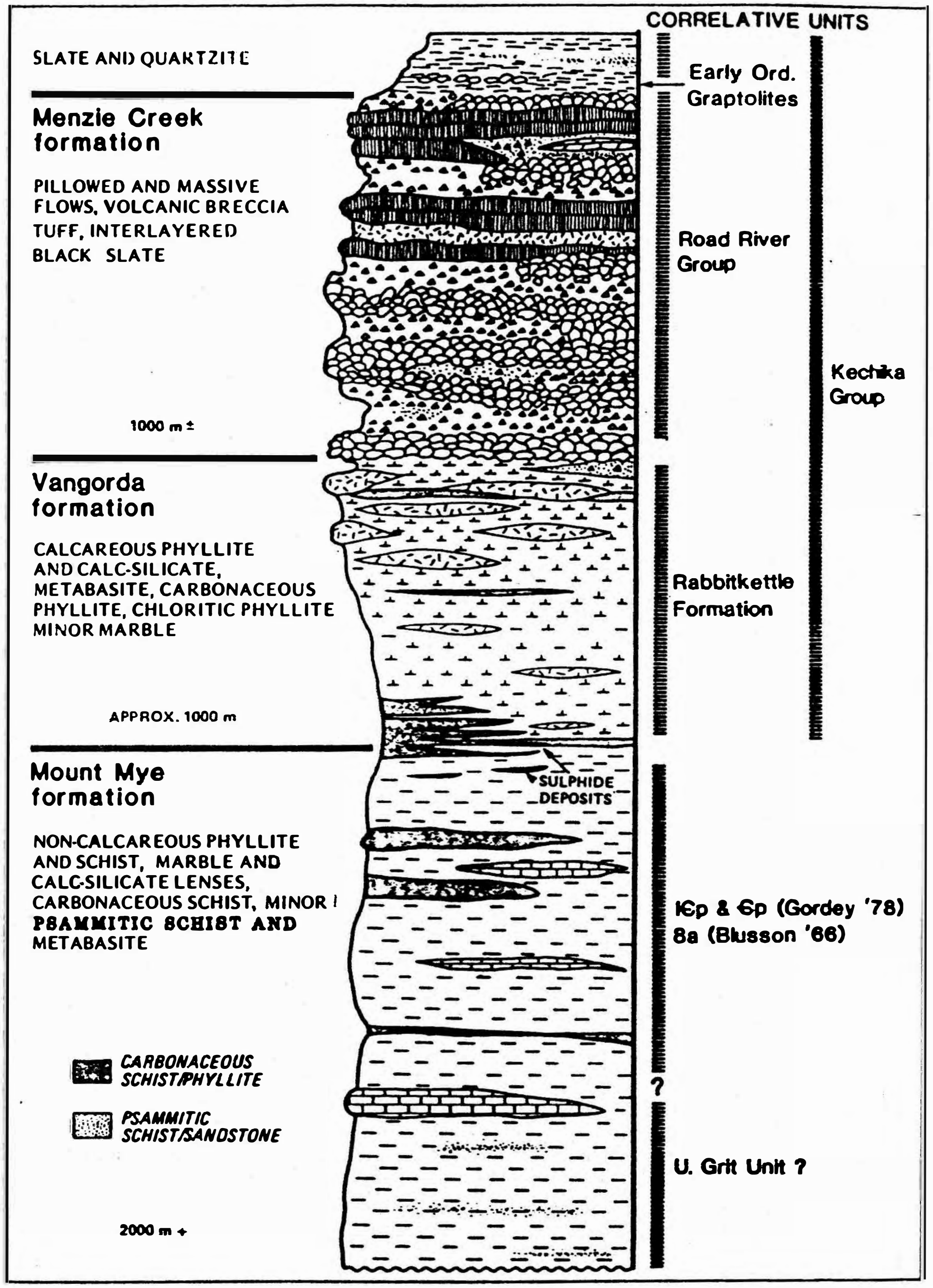

Carbonate orthoquartzite facies of platforms, Silurian - mid Devonian
PCP = Pelly Cassiar Platform
Shale facies of basins, Silurian - mid Devonian
NS = Nasina Slope
Yukon Tannana Terrane
Allochthonous Paleozoic Arc Terrane and related ophiolitic rocks
Intermontane Belt
AT = Atlin Terrane
WT = Whitehorse Trough
SA = Stikine Arch
BB = Bowser Basin
Coast Crystalline Complex
NRMT = Northern Rocky Mountain Trench
MP = MacMillan Pass district
HP = Howards Pass Area
AK = Akie District
ARCTIC OCEAN
YUKON
RICHARDSON TROUGH
ALASKA
TINTINA FAULT
SELWYN BASIN
ANVIL DISTRICT
DENALI FAULT
WT
PCP
N.W.T.
B.C.
ALTA.
AT
KECHIKA TROUGH
PACIFIC OCEAN
SA
AK
BB
NRMT

Figure 1


CORRELATIVE UNITS
SLATE AND QUARTZITE
Menzie Creek formation
PILLOWED AND MASSIVE FLOWS, VOLCANIC BRECCIA TUFF, INTERLAYERED BLACK SLATE
1000 m ±
Vangorda formation
CALCAREOUS PHYLLITE AND CALC-SILICATE, METABASITE, CARBONACEOUS PHYLLITE, CHLORITIC PHYLLITE MINOR MARBLE
APPROX. 1000 m
Mount Mye formation
NON-CALCAREOUS PHYLLITE AND SCHIST, MARBLE AND CALC-SILICATE LENSES, CARBONACEOUS SCHIST, MINOR PSAMMITIC SCHIST AND METABASITE
CARBONACEOUS SCHIST/PHYLLITE
PSAMMITIC SCHIST/SANDSTONE
2000 m +
SULPHIDE DEPOSITS
Early Ord. Graptolites
Road River Group
Kechika Group
Rabbitkettle Formation
?
lЄp & Єp (Gordey '78)
8a (Blusson '66)
U. Grit Unit ?

(5)

Figure 4

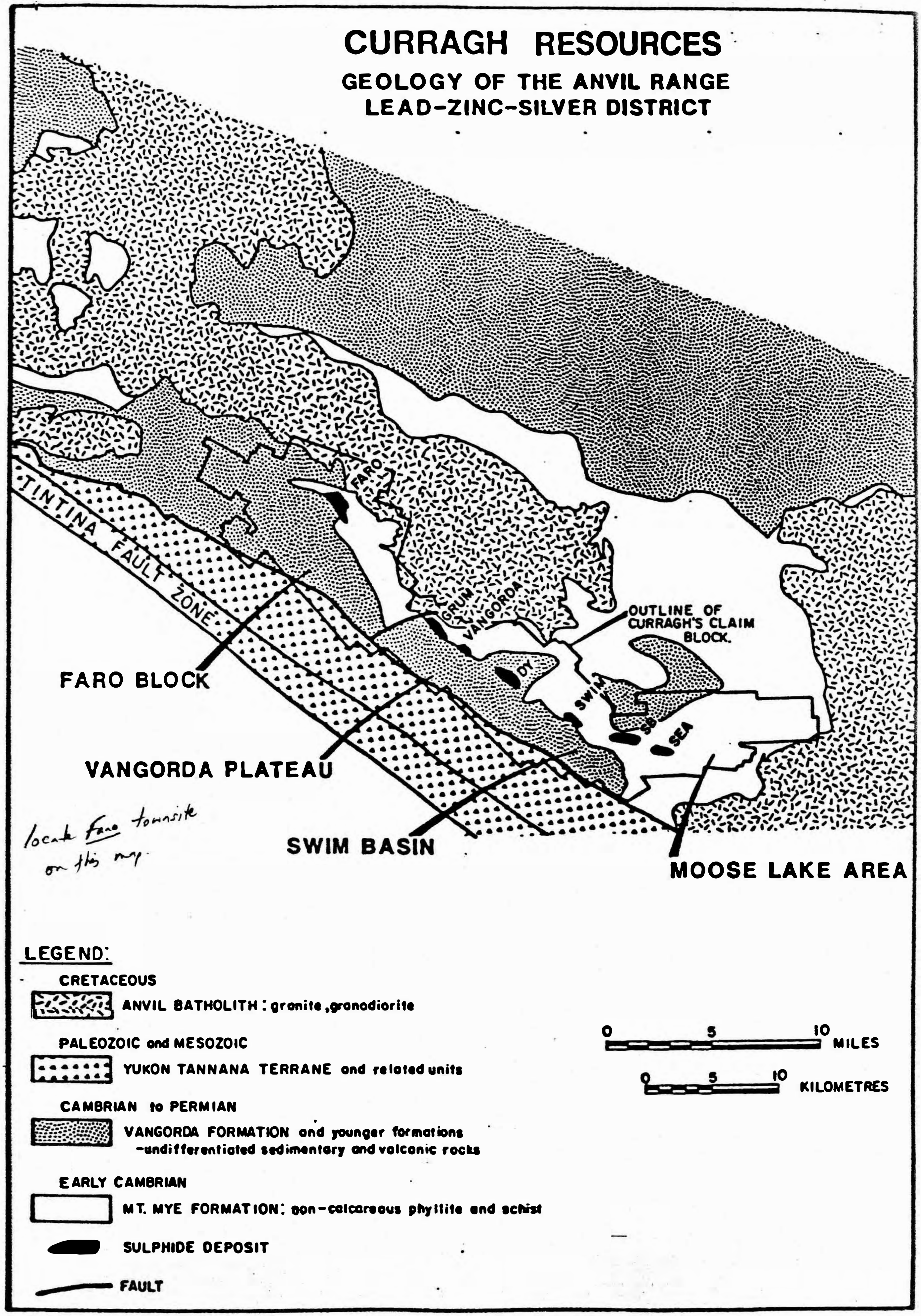

CURRAGH RESOURCES
GEOLOGY OF THE ANVIL RANGE
LEAD-ZINC-SILVER DISTRICT
TINTINA FAULT ZONE
FARO
GRUM
VANGORDA
DY
SWIM
SB
SEA
OUTLINE OF CURRAGH'S CLAIM BLOCK.
FARO BLOCK
VANGORDA PLATEAU
SWIM BASIN
MOOSE LAKE AREA
locate Faro townsite on this map
LEGEND:
CRETACEOUS
ANVIL BATHOLITH: granite, granodiorite
PALEOZOIC and MESOZOIC
YUKON TANNANA TERRANE and related units
CAMBRIAN to PERMIAN
VANGORDA FORMATION and younger formations -undifferentiated sedimentary and volcanic rocks
EARLY CAMBRIAN
MT. MYE FORMATION: non-calcareous phyllite and schist
SULPHIDE DEPOSIT
FAULT
0 5 10 MILES
0 5 10 KILOMETRES

Figure 2

reddish brown weathering color of the unit is characteristic and helps distinguish it from non-calcareous portions of the Vangorda formation.

The upper portion of the formation is very similar to the buff weathering mudstone and blue-grey mudstone units described by Gordey (1978) to the east near Howards Pass and to unit 8A of Blusson (1966) near Cantung. Correlation with these units would imply the top of the formation is lower Cambrian or possibly middle Cambrian. Parts of the Mt. Mye ~~also~~ resemble rocks underlying those presumed correlative units ~~locally, implying the Mt. Mye probably includes rocks as old as Hadrynian~~.

The Vangorda formation is characterized by light to medium-gray, calcareous, phyllitic rocks made up of very thin (0.1-2 cm) interlayers of a) medium grey, non-calcareous, weakly carbonaceous, muscovite-chlorite pelite and b) light grey, generally calcareous quartz ± calcite ± dolomite siltstone. Major interbanded units include metabasite and meta-tuffs, graphitic phyllite, and phyllitic limestone. Because of the very thin banding, the Vangorda formation characteristically has a well developed lithon structure. The light grey to tan colored drusy weathering of the formation is also characteristic both within the district and elsewhere.

Most metabasite bodies are medium-grained and equigranular, thus they may have been sills; however, locally amygdaloidal margins and a common association with thin bedded, tuffaceous rocks suggests at least some were flows. Whole rock compositional data shows that the metabasites are all of basaltic composition. The bodies range from 1 to 100 meters in thickness and are up to several kilometers in length.

The Vangorda formation varies between 0.5 and 2 kilometers in apparent thickness with basic igneous rocks comprising approximately 15% of the section. The formation becomes more calcareous up section, paralleling an increase in metabasaltic units. A major carbonaceous member occurs at the base of the formation.

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 upper Cambrian through lower Ordovician.

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.

Whole rock major element and trace element data (Jennings et al., 1980) imply that the flows of the Menzie Creek volcanic unit are dominantly alkali basalt erupted in a within-plate setting similar to metabasites of Vangorda formation. Carbonaceous phyllite and brown siltstone interbeds northeast of the Anvil batholith contain graptolites of middle Ordovician or lower Silurian age (Tempelman-Kluit, 1972) suggesting correlation with the widespread Road River Formation black shale and chert to the northeast. The Menzie Creek formation varies from zero to about 1.5 kilometers in thickness in and near the district. It 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 ~~stratabound~~ to an approximately 150 m thick interval straddling the contact of the Mount Mye and Vangorda formations. The deposits consist of one to five sheets of sulphide mineralization stacked one above the other within this interval. They appear to be related to facies changes involving the basal carbonaceous member of the Vangorda formation.

Deformation, Metamorphism and Plutonism

The structural and metamorphic history of the Anvil Range is complex and of considerable significance to the form and nature of the ore deposits. During mid-Mesozoic, the district suffered two periods of intense fold deformation and concurrent metamorphism during which the gross structure of the mineral deposits was determined.

The first deformation (D_1) produced a regional metamorphic foliation (S_1) axial planar to tight to isoclinal mesoscopic folds (F_1) in bedding (S_0). Mesoscopic early folds are rarely preserved in the district. Northeasterly inclined to upright, northeasterly verging megascopic folds with shallow northwesterly or southwesterly plunging axes appear to have formed at that time.

During the second event (D_2), S_1 was strongly crenulated and ubiquitous close to tight mesoscopic folds in S_1 were produced. The largest megascopic folds known to have been formed during D_2 are those at the Grum Deposit (Fig. 5, 10) and comparable folds in the Swim Deposit (Fig. 12). Parallel to the axial planes of these D_2 folds is a crenulation cleavage (S_2) which imparts a well developed lithon structure to most rocks of the district, especially the strongly banded phyllites of the Vangorda formation. F_2 axial planes and S_2 dip shallowly, with axes subparallel F_1 axes. Three later, less intense periods of folding and associated faulting followed.

The later events (D_3 through D_5) generally produced open folds and weak crenulations in S_2 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 (D_4) is quite intense, with tight mesoscopic folds developed in nearly pervasive S_2 with appreciable mica growth along S_4 (see Figs. 7 and 8 for examples of fourth phase affecting 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 granodiorite to quartz monzonite and textures include equigranular massive, megacrystic massive and various strongly to weakly foliated variants. Several K-Ar ages on the granitic rocks yielded ages of 85-100 ma (Tempelman-Kluit, 1972). 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 4). In the later stages of ~~Batholith~~ emplacement large extensional fault displacement occured along the margins of the Batholith. These faults determine the present day limits of several of the deposits.

Metamorphism was concurrent with deformation and was most intense during the early deformations, especially D_2. Metamorphic facies range from middle amphibolite facies to lower greenschist facies in a low pressure Buchan type facies series.

Metamorphic isograds are roughly concentric about the Anvil Batholith. Faro, close to the Batholith is strongly metamorphosed, while deposits such as Vangorda are only weakly metamorphosed. This difference in metamorphism is reflected in decreased grain size and increased degree of mineral intergrowth in the less metamorphosed deposits. This has a significant impact on metallurgical response of Anvil district ores.

Ore Deposits

General Description

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

An individual mineralized layer was deposited parallel to the bedding of the host sediments. It consisted of an upper, often centrally positioned, massive base metal-bearing sulphide facies and a lower and peripheral, disseminated, quartzose sulphide facies.

These sulphide sheets or horizons have since been deformed into complex fold structures. The deposits are thus elongate parallel to the fold axes and associated lineations in the host metasediments. The Faro deposit, which appears to be an exception to this generalization, actually shows great internal complexity in the geometry of high grade and waste layers.

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

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

The simple arrangement of the ore types in the ore horizons is important since lead-zinc grade and metallurgical performance varies by ore type. The baritic massive sulphides are always high grade, easily grindable and yield good grade concentrates with good recoveries. On the other hand the lower and distal graphitic quartzites are commonly low grade, hard and produce lower grade concentrates with low recoveries. Other ore types exhibit intermediate ~~characteristics and performance.~~ grade and recovery.

All deposits show a variably developed, white mica-dominant, alteration overprint in the wallrocks.

There are presently five known lead-zinc bearing mineral deposits along a ~~prominant~~ curvilinear trend on the south flank of Anvil Arch (Fig. 4). From northwest to southeast they include Faro, Grum, Vangorda, Dy and Swim. Additionally two base metal deficient sulphide occurrences, the SB and Sea, are also known. The Firth showing is best considered a faulted part of Grum while the Champ is the subcrop of one of the upper horizons of Grum.

(1) These are not located on Figure 4

The Anvil deposits are distributed through a 150 m stratigraphic interval straddling the boundary of the Mt. Mye and Vangorda formations in association with a regionally developed, but laterally discontinuous "graphitic" (carbonaceous) phyllite unit. ~~Individual sulphide lenses are, or appear to be, the lateral facies equivalent of graphitic phyllite.~~ Some lenses of some deposits (such as the upper horizons of Grum) are basal to the carbonaceous phyllite units as well as being their partial lateral equivalents. In other cases, lateral equivalence of graphitic phyllite and ore lenses has not been established.

Some confusion: here there is one "graphitic" phyllite / here there are several "carbonaceous" phyllite units

While the bulk of basaltic meta-igneous rocks occur up-section of the Anvil deposits, the first significant pulse of basaltic activity is roughly coincident with the sulphide horizons (fig. 3) suggesting at least a temporal relationship between ore formation and basaltic magmatism. ~~Despite this,~~ there is generally poor spatial association of sulphide deposits and metabasaltic rocks. The ~~Dy and, to a lesser extent, the Grum deposits are exceptions to this generalization.~~ In this sense, the Anvil deposits are dominantly pelitic sediment hosted.

Detailed mapping and drilling suggest the linearly distributed deposits lie close to a northeasterly "pinch out" or "zero edge" of the associated graphitic phyllite (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 of the deposit line. Taken together, these observations suggest some relationship between sulphide deposits, facies changes at reduced basinal margins and basaltic ~~activity.~~ magmatism.

Description of Sulphide Lithofacies

In the following paragraphs, unit 2 refers to amphibolite facies ore types (Faro), and unit 4 to greenschist facies (all others).

Massive Pyritic Sulphides: (Unit 2E/4E) 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, this rock type commonly develops a buckshot porphyroblastic texture of pyrite in a matrix of dark reddish brown to black base metal sulphides. This texture usually is restricted to rocks with economic lead-zinc grades. (Unit 4F/2F).

Baritic, Massive Pyritic Sulphides: (Unit 2G/4G) 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). The amount of barite may be as high as 50%; non-sulfidic, massive barite does not occur in the Anvil deposits. There is a complete gradation between this and the above facies with 10% visible barite by volume being the dividing line. This facies is usually quite high grade (10-15% combined lead-zinc). Sphalerite is characteristically honey coloured to reddish brown. Pyrrhotite is not commonly seen in the baritic facies except in the Faro deposit where overall pyrrhotite is more abundant.

Carbonate-bearing, Massive Pyritic Sulphides: (Unit 2K/4K) similar to massive pyritic sulphides but contains 10% carbonate (calcite, dolomite, ankerite) either as interstitial gangue or as coarse patches and irregular blebs. This 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: (Unit 2H/4H) massive, finely crystalline, usually well foliated pyrrhotite with less than 50% pyrite porphyroblasts and highly variable amounts of sphalerite and galena. Minor chalcopyrite is characteristic 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 facies may invert to pyrrhotite during regional metamorphism. The pyrrhotitic facies is volumetrically more important in Faro than other deposits. Pyrrhotite-rich ores are generally much finer grained than non pyrrhotitic ores at Faro.

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 can be angular to subrounded, poorly sorted and may be 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 relate to ductility contrasts between the affected lithologies during sulphide flow induced by deformation and metamorphism. These are clearly not, primary breccias related to feeder zones or paleoslumps prior to sulphide lithification.

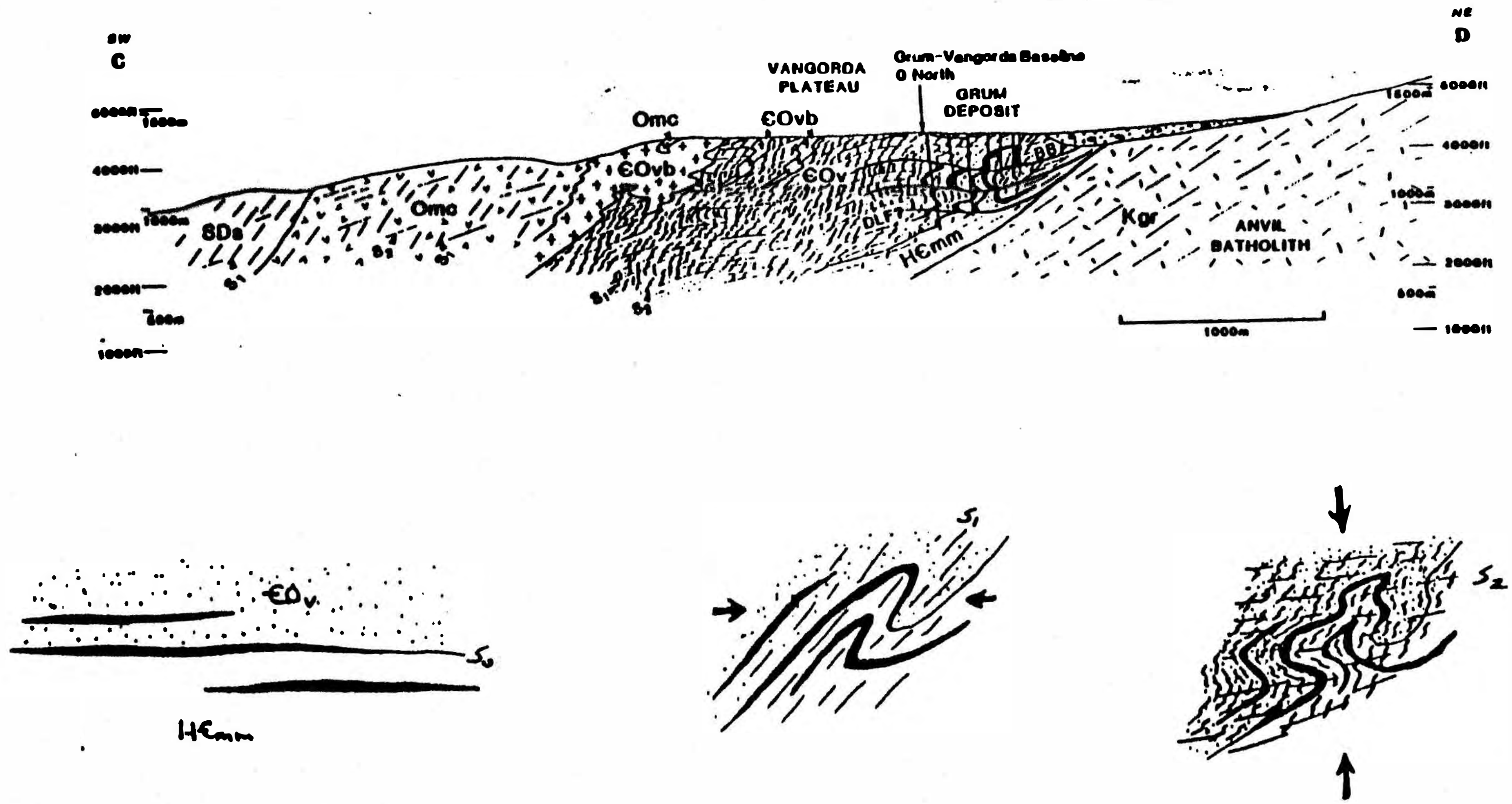
Friable and porous massive sulphides are relatively common and when strongly developed often degenerate to pyrite sand. The porous massive sulphides are commonly carbonate or barite bearing and originate by post-metamorphic groundwater leaching and oxidation especially near faults.

Quartzose Disseminated Lithofacies

Ribbon banded, "graphitic", pyritic quartzite: (Unit 2A/4A) 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) and (b) light grey, quartz-sulphide (pyrite-sphalerite-galena) bands. These bands are usually 2 mm to 2 cm thick with a total sulphide content usually between 10 to 30% but ranging from 2% to 60%. Pyrite is usually the dominant 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 not generally the case.

Pyritic quartzite: (Units 4B, C, D/2B, C, D) light grey, generally poorly banded, moderately to weakly foliated, micaceous quartzites 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 to quartzose ores there is usually little problem in separating this facies from the massive pyritic sulphides as the vast majority of examples have less than 40% total sulphides. A minor variant of this facies (unit 2B/4B) shows low pyrite (5%) content with base metal sulphides predominant. Barite in major amounts is uncommon in this facies; carbonate species are not typical but locally are abundant. Chalcopyrite, pyrrhotite and magnetite-bearing varieties are common. Sphalerite in the high grade examples is characteristically a vibrant reddish brown. At Faro the more sulphide rich variants of this facies are well developed along the northeast edge of zone 3. They are spectacularly barren but contain elevated copper contents and are rich in magnetite. A similar facies is developed at Vangorda and locally at Grum where the rocks are also quite gold rich and more clearly in the deposit footwall.

Post-metamorphic breccias are also common in the disseminated sulphide lithofacies. Pyritic quartzite breccias are often spectacularly developed in



DEPOSITION D_1 D_2

Figure 5. Cross section through Vangorda Plateau and Grum deposit (86 W). The Grum deposit provides the best example of the D_1/D_2 interference pattern in the district. The deposit is involved in a large Z (or N) shaped D_1 fold refolded by S shaped D_2 folds. The steeply dipping S_1 crenulated by shallowly dipping S_2 is typical of the structural relations on the Vangorda Plateau where greenschist facies rocks dominate. Post D_2 folds gently warp the S_2 foliation. The inserts show the sequential development of Grum from a sequence of stacked en echelon ore layers parallel to S_0 through D_1 and D_2

the sphalerite-rich high grade facies where again ductility contrasts between the sulphides and quartzite bands dictate ductile flow in the sulphides and brittle failure, rotation and brecciation on the quartzites. Where less intensively developed, the breccias grade into examples of sulphide mobilization into D_2 or later cleavages.

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 (Unit 4L). This overprint facies is not a depositional unit and may have formed as a reaction product between wallrocks and deposit forming hydrothermal fluids, or as a metamorphic reaction envelope unrelated to ore forming fluids or as combination of these processes. In the multi-layered deposits, this alteration overprint appears discontinuous and often best developed in the footwall of a given lens or deposit as a whole. At Faro, a continuous envelope of this lithology encloses the entire deposit with local (especially Zone 1) best development in the hangingwall.

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 all deposits. To date, ~~little success has been had in this regard as~~ no unequivocal feeder zones have been recognized. Several instances of suspected pre-D_2 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. Recognition of a feeder zone is considerably hampered in this terrane by the polydeformational overprint.

In the multi-layered deposits at greenschist facies 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. The only amphibolite-grade example, the Faro deposit, shows a much less varied phase assemblage (muscovite, quartz, pyrite $\pm$ marcasite) in altered rocks with development of a substantial hangingwall as well as footwall alteration envelope. This simplified phase assemblage may be due to re-equilibration of the greenschist alteration assemblage at higher grades of metamorphism. The prominant hangingwall alteration may be due to continued post-hydrothermal activity or to sulfurization or other metasomatic reactions in the wallrocks during metamorphism perhaps caused by mobile sulfur from the inversion of pyrite to pyrrhotite in the deposit. It is interesting to note the development of massive pyrrhotitic facies is greatest in the Faro deposit which also shows the most well defined, broadest, and most symmetrical alteration envelope.

Idealized Anvil Deposit

There are sufficient similarities between the Faro deposit and other Anvil district deposits for it to serve as a model of common deposit characteristics. Figure 6 is a generalized, pre-deformation vertically exaggerated cross-section of Faro illustrating these features. In addition to all deposits showing a spatial relation to the Mt. Mye/Vangorda boundary and having a variably developed alteration overprint, they have a distinct arrangement of sulphide lithofacies. This arrangement in a vertical and lateral sense is so commonly

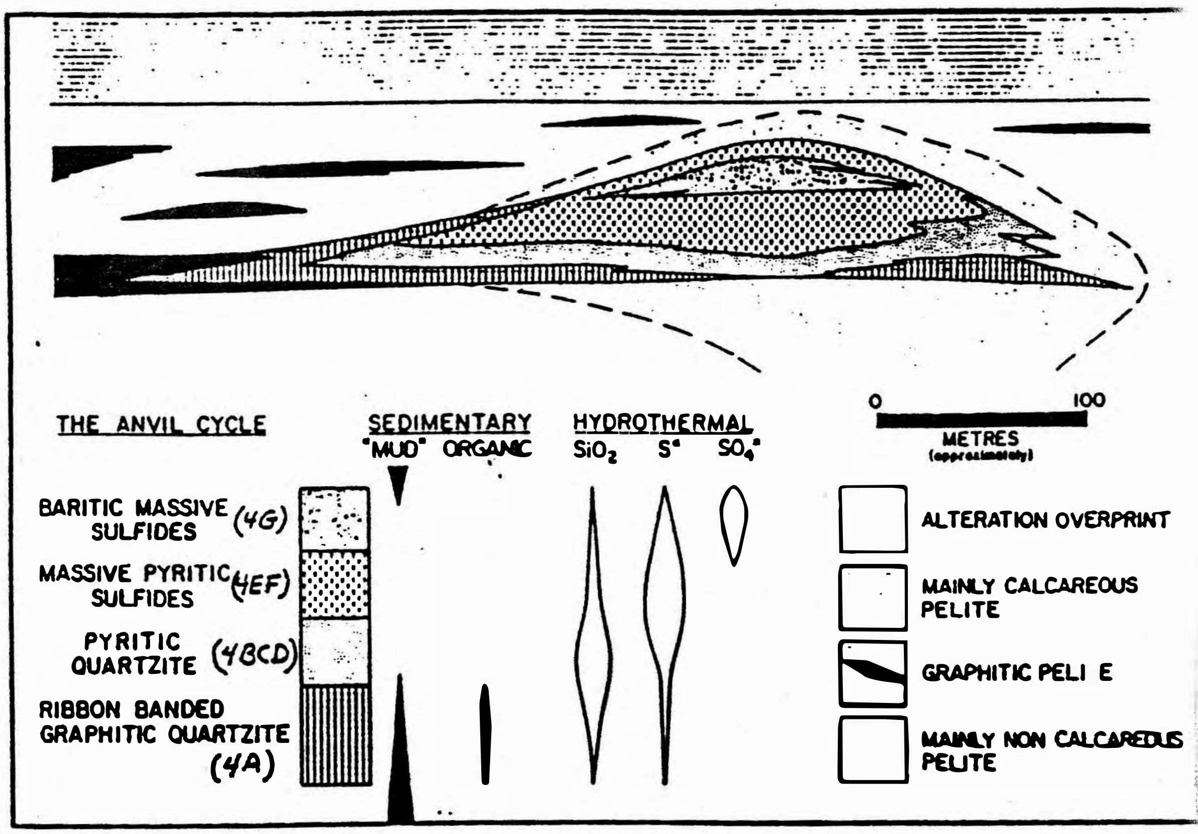


Figure 6. An idealized Anvil deposit based on cross sections of the Faro deposit. Such lateral and vertical zoning can be found i all deposits of the district. Massive sulphides are the central a upper lithofacies with pheripheral and lower quartzose disseminat lithofacies.

seen within and between deposits, it has been termed the Anvil Cycle (Jennings et al 1980). The base of the cycle is marked by ribbon-banded, graphitic, pyritic quartzites succeeded upward by pyritic quartzites, massive pyritic sulphides and baritic massive pyritic sulphides (fig. 6). This array is also seen laterally with ribbon-banded, graphitic, pyritic quartzites forming the marginal or distal facies of a deposit inward to the baritic massive 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 multi-layered deposit, e.g. Grum or Dy. Complete cycles are seen over a one meter stratigraphic interval (or less), emphasizing the scale at which facies ordering can occur.

Metal zoning in some cases crudely complements this facies distribution pattern ~~in a crude way.~~ The quartzose disseminated sulphide facies at the base of an ideal cycle tend to be zinc enriched. The massive, upper facies are slightly lead-silver enriched, particularly the upper most baritic facies. However, commonly there is no evidence in the assays of metal zonation in an individual horizon. ~~As might be expected~~ Studies of metal zoning are greatly hampered by the structural complexity of the Anvil deposits. ~~Consequently, definitive deposit wide studies are not yet available.~~

On the basis of scanty and preliminary data, copper and to a lesser extent gold seem to be preferentially distributed in siliceous facies of the footwall-biased alteration overprint or in the pyritic quartzite facies of the stratiform sulphides; this again is a characteristic that varies from deposit to deposit.

Facies zoning can be used in a tenuous way as top indicators in poly-deformed horizons to decipher fold patterns: the more complete facies cyclicity shown, the greater degree of confidence. It is stressed that top directions defined by the unambiguous distribution of Mt. Mye and Vangorda formation lithologies always take precedence over those interpreted from sulphide facies ordering.

Genetic Model

The Anvil deposits are examples of synsedimentary, stratiform, massive sulphide deposits considered to be 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 meta-sedimentary and probable metavolcanic rocks, commonly on scale of centimeters.

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

4.) The curvilinear depositional trend crudely associated with graphitic 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 however and it is important to realize that alternative interpretation of the deposits are possible. For example it is possible that all or part of the footwall siliceous facies are silicified and sulfidized host sediments rather than exhalative cherty sediments.

Reconnaissance studies by Kuo (1976) demonstrate the presence of chloride-rich fluid inclusions in barite, quartz, and sphalerite of several deposits perhaps implying metalliferous brines played a role in deposit formation. The ubiquitous development of generally footwall biased envelopes further suggests these brines were relatively hot. The curvilinear deposit ~~array may further indicate control of sedimentary facies and hence basin geometry by~~ a synsedimentary fault, ~~or fault bundle~~, ~~which could have~~ provided the locus of ~~exhalative~~ ore fluids migration into the basin(s).

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 extentional tectonism. This tectonism influenced basinal geometry resulting in reduced second order basinal facies truncating against the hinge line. Hydrothermal fluids moved up this fault zone and exhaled into a relatively deep water reduced marine basin which was receiving distal turbidite sedimentation. 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 sediments. The hinge line or related fault sets could have provided the channelways for the first pulse of basaltic volcanism associated temporally with the deposits (or vice versa). 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.

Faro

History

The Faro deposit was discovered in 1964 while drill testing airborne electro-magnetic 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 bought the Faro mine and other deposits in the Anvil Range 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 approximately 100 m beneath the Mt. Mye/Vangorda formation boundary. Stratigraphically this may equate to the position of the lowest horizons in the Vangorda Plateau deposits.

The immediate host rock of the orebody is biotite-muscovite-andalsite schist that grades downwards into a coarse, gneissic botite-muscovite schist.

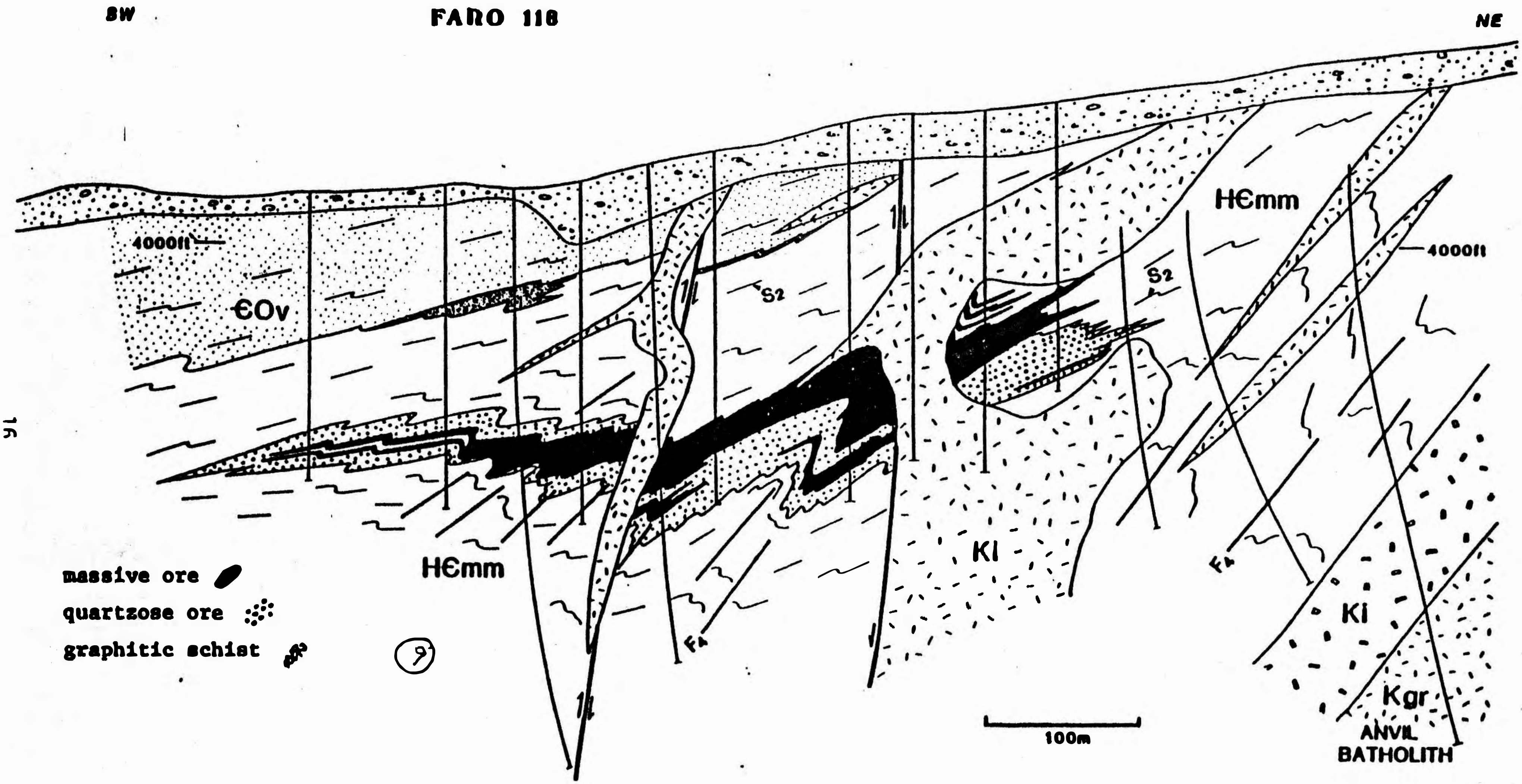


Figure 7. Cross section 118 through the northwest end of Faro zone 3. The present pit outline is not shown. The dykes are thin steeply dipping bodies cutting across the section at a small angle. At Faro S_2 is a nearly pervasive metamorphic foliation which is generally parallel to unit boundaries. S_2 is extensively crenulated by post D_2 folds that deform the deposit outline. In general in higher grade and structurally deeper portions of the district such as at Faro

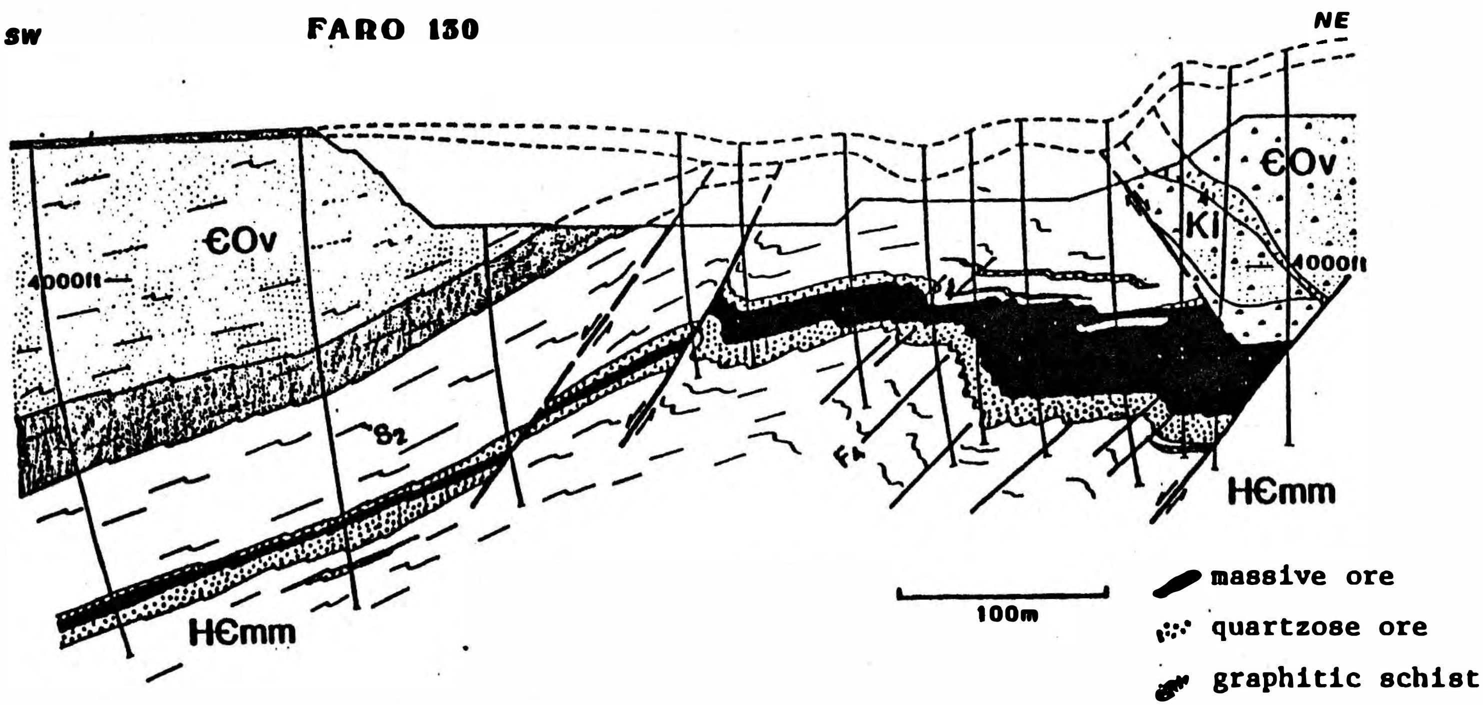


Figure 8. Cross section 130 through the southeast end of Faro zone 3. The pit outline shown is ~~the present outline~~ (as of June 1982. ~~at suspension of mining)~~. The faults are part of the Big Indian Fault set that separated zone 2 from zone 3, they are normal faults and cut across the section at a small angle. The triangular symbols at the northeast end of the section indicate the "breccia cap", a large body of post metamorphic breccia

The Vangorda formation at Faro is represented by hard, dense, banded calc-silicates rather than the usual calcareous phyllite. This fact is of considerable importance in blasthole drilling at Faro because of the rocks hardness.

Post metamorphic igneous intrusive rocks are more widely developed at Faro than on the Vangorda Plateau. There are two clans of importance: a) a equigranular to subporphyritic hornblende diorite to quartz diorite clan and b) a quartz-feldspar porphyry clan.

Associated with these dykes or irregular intrusive bodies and the intersection of 2 important faults is a large mass of heavily silicified post metamorphic breccia at the northeast edge of the deposit in Zone 3. This "breccia cap" exaggerates the problems of blast hole drilling because of its extreme hardness.

There is essentially one thick horizon at Faro a~~lthough this horizons~~ contains numerous Anvil cycles and several thin waste bands ~~are included~~. Locally a thin upper horizon is differentiated from the main mass of the deposit, generally this is too thin to be mineable.

Before mining, the Faro deposit was 2000 m along strike, 800 m across strike and about 70 m thick. The deposit is a flat-lying, elongate, asymmetric lens with a thick northeast side and a thin tapering southwest side. The deposit is cut by several important faults which form a graben structure, the mined out zones 1 and 2 were the upthrown blocks, and zone 3 the central graben. Zone 3 contains the remaining reserves.

Ore type zoning is particularly strong at Faro. It follows the scheme outlined above with a massive variably baritic upper portion and a quartzose variably carbonaceous lower part (figure 7). In addition there is a prominent very low grade semi-massive zone along the northeast edge of zone 3 and unusually abundant (compared to other Anvil district deposits), but erratically distributed, pyrrhotic mineralization in the southwest part of the deposit. Grade zoning follows ore type zoning so that the base and northeast edge of the deposit contains the lower grade mineralization whereas the upper and southwest portion contains the higher grade mineralization. Zoning ~~was~~ also ~~obvious in plan view~~ at Faro. Zone 1 was rich in baritic ores ~~thus~~ high grade, zone 2 at the other end of the deposit was rich in carbonaceous quartzose ore types ~~thus~~ low grade and metallurgically undesireable. Zone 3 has intermediate characteristics.

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 down ~~fold~~ plunge from the Vangorda deposit ~~along what was then a, as yet, poorly defined favourable trend.~~

Surface drilling in 1973 and 1974 indicated a significant deposit; in 1975 and 1976 an underground sampling and drilling program was carried out to further define it.

Kerr Addison sold the deposit, along with Vangorda and Swim, 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 in it. All available sulphide intersections were re-sampled and re-assayed at that time.

General Geology

The Grum deposit consists of three to five layers of massive and disseminated sulphide mineralization. The most important mineralized horizon occurs just beneath the basal carbonaceous 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 Mt. Mye formation.

At Grum, the Vangorda formation consists of soft, highly fissile, calcareous phyllites. Metabasites in the Grum area are minor and tend to be highly foliated chlorite phyllite rather than blocky, massive greenstones that typify the Vangorda formation elsewhere. The basal carbonaceous member of the formation (unit 5A) thickens across the deposit from about 10 m in the northeast to as much as 80 or 100 m 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 but elsewhere they are moderately hard, highly fractured, black siliceous phyllites.

The Mt. Mye formation also consists of soft phyllites which being non-calcareous, are distinguished from those of Vangorda formation.

There are no significant dykes at Grum. The Anvil Batholith crops out 1.5 km northeast of the deposit but is separated from it by major faults. It is unrelated to the deposit and does not appear to have significantly affected it.

The ore layers at Grum are contorted into a complex, shallowly northwest plunging, polyphase fold structure (fig.9,10). The prominant S shaped folds (in cross section looking northwest) are second phase structures. They are superimposed on a larger Z shaped fold. The dominant plane of fissility (S_2) in the phyllites at Grum is axial planar to these folds and dips shallowly (10^{o} 30^{o}) 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.

There are several important faults at Grum. The largest displacements occur on moderately (35^{o} - 45^{o}) dipping structures that truncate the deposit at both its northwest and southeast ends. Neither of these structures would crop out in an open pit but smaller subparallel faults will be found in the pit. A steeply northwest dipping fault trending about 060^{o}, passes between sections 70W and 72W and downdrops the deposit about 60 m on its northwest side. A myriad of smaller faults were mapped underground by Kerr Addison trending on the average 080^{o} and dipping steeply. Joints mapped underground and on surface tend to strike 060^{o} and dip subvertically.

The subcrop of the ore deposits is covered by up to 100 m of morainal material (tills) and better sorted glaciofluvial silts, sands and gravels.

As with other deposits in the Anvil Range a given ore horizon at Grum tends to have a massive sulphide upper portion and a quartzose, disseminated sulphide lower portion. The horizons can be up to 30 m thick but are mostly 15 m or less thick. The sulphide horizons are separated by significant thicknesses of barren phyllites. Interfaces between ore and waste tend to be sharp at the stratigraphic hangingwall and gradational both at the footwall and laterally. As with all Anvil District deposits overall grade is strongly partitioned into massive, particularly baritic, sulphides thus the tops of horizons tend to be high grade and the bottoms low grade (except of course where the horizons are overturned).

Grum, like Vangorda and Dy, has several characteristics that distinguish it from Faro. In large part this is due to the lower metamorphic grade the deposit has reached. The most outstanding difference between Grum, plus all

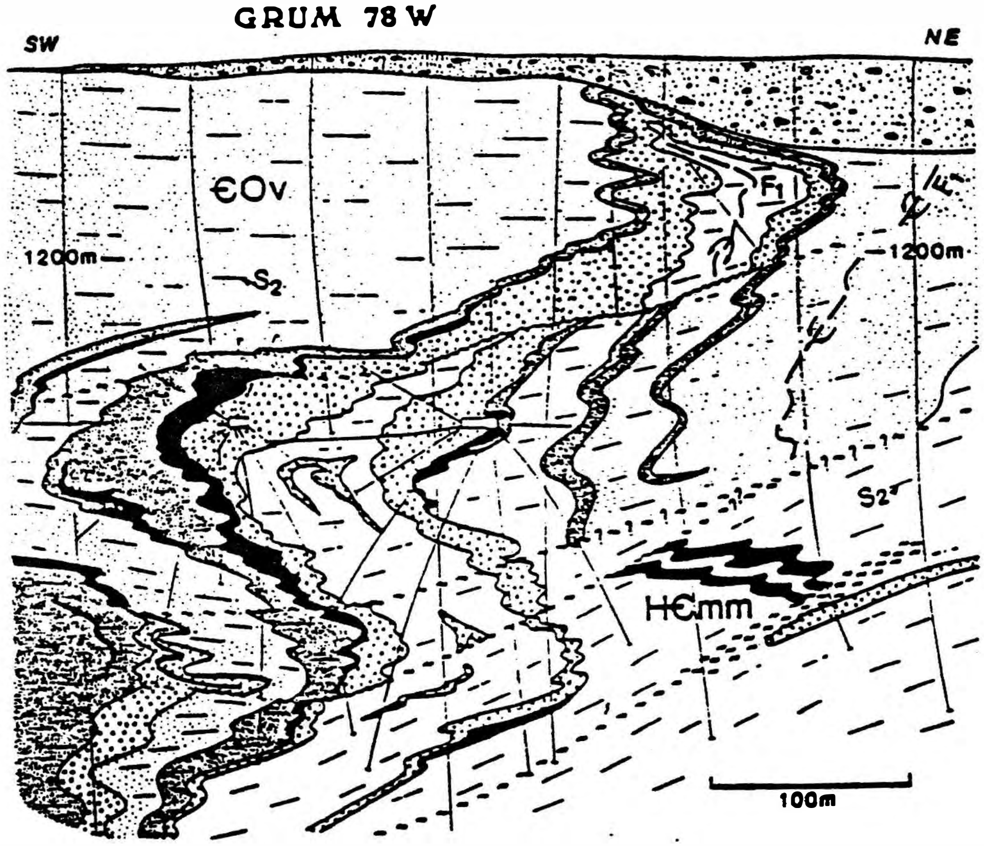


Figure 9. Cross section 78 W through the Grum deposit. The deposit forms a complex D_1/D_2 interference pattern which, despite the densi of drilling, is not yet completely resolved. The faults appear to have slip lines directed across the plane of the cross section such that they "telescope" different deposit domains and appear not to make good sense on an individual section. The F_1 closure just beneath the overburden is confirmed on several densely drilled sections to the northwest down fold plunge.

massive ore

quartzose ore

graphitic phyllite

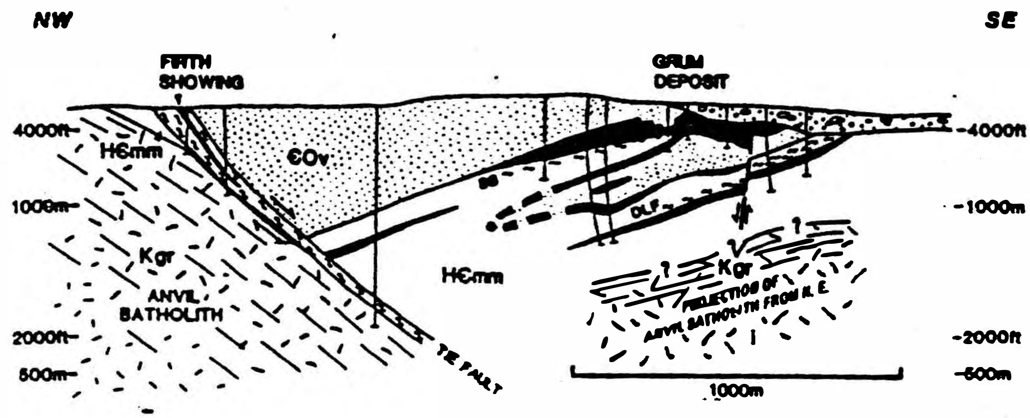


Figure 10. A diagramatic longitudinal section showing the plunge of th
Grum folded structure and the relation of the Grum deposit to
Firth showing. Firth appears to represent slivers of Grum caug
in a large extensional fault, the Tie Fault, that separates
footwall amphibolite facies metamorphic and granitic intrusive
rocks from hangingwall greenschist facies

all sulphide lithofacies

the other Vangorda Plateau deposits, and Faro, is the form of the deposit. All deposits other than Faro consist of several distinct, highly contorted horizons separated by barren phyllite waste, whereas Faro is one thick horizon in overall outline.

The next most obvious difference is a finer grain size and more complex mineral intergrowth, necessitating finer grinding than Faro ores. ~~Cyprus Anvil Mining Corporation had already made modifications to its mill to accomodate this fine grind prior to shutdown in 1982.~~

At a given Pb + Zn cutoff grade, ores at Grum are higher grade than those remaining at Faro, particularly in precious metals relative to base metals. The average gold content of Grum is several times higher than Faro. The sphalerite at Grum, and likely other Vangorda Plateau deposits, is richer in zinc due to lower metamorphic grade and resulting lesser iron content.

A feature unique to Grum among the Vangorda Plateau deposits is the relative abundance of quartzose ore types, particularly carbonaceous pyritic quartzites. This is partly the reason silver is high at Grum since that is a characteristic of this ore type.

Vangorda

History

Vangorda was the initial discovery in the Anvil Range. The deposit was drill tested from 1953 to 1955 by Prospector Airways, a predecessor to Kerr Addison Mines. This drilling showed a significant deposit existed 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 until the deposit was sold to Cyprus Anvil in 1979. Cyprus Anvil geologists examined the available drill core and concluded that it would be necessary to redrill the deposit to provide adequate material or re-evaluate it.

In 1979 ~~the~~ portion of the deposit from [redacted] 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. Since 1981 no additonal drilling has been done.

General Geology

The Vangorda deposit consists of one major sulphide horizon about 50 to 120 m beneath the basal carbonaceous member of the Vangorda formation. The host rocks for the deposit are dominantly non-calcareous phyllites, probably part of the Mt. Mye formation however formational assignments near this deposit are ambiguous. The reason for the ambiguity is largely due to the strong wall rock alteration developed around the deposit. Most phyllites especially in the deposit footwall are bleached, locally silicified and/or chloritic and sulphide bearing.

A number of thin horizons occur above the main horizon; one at the base of the carbonaceous phyllites southwest of (stratigraphically above) the deposit may equate to the main horizon at Grum. In general these horizons are too thin or too low grade to be mineable.

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 3-in cross section, however there is considerable uncertainty in the details of fold morphology.

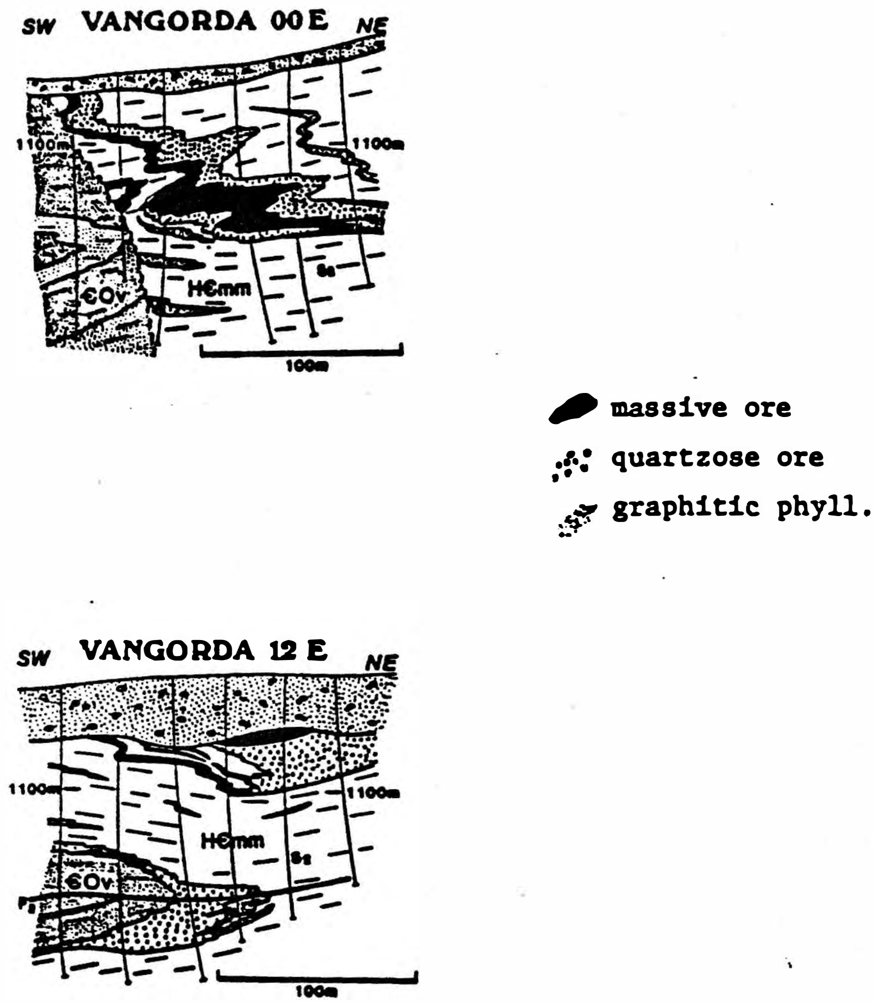


Figure 11. Cross sections OE and 12E through the Vangorda deposit. These sections are similar to those produced by J. Paxton of Kerr Addison and are not those used in the C.A.M.C. ore deposit model. Field relations at Vangorda imply this geometry as does the expecte similarity to Grum.. Many unresolved problems remain. It is likely that unrecognized F_1 folds and/or low angle faults are preser

The deposit is elongate in the northwest southeast direction parallel to F_2 fold axes. It has been traced over a 1300 m X 200 m area.

The northwest half of the deposit plunges about 10^0 towards the northwest but the southeast half is sub-horizontal. The S_2 foliation dips shallowly toward the southwest as at Grum but is locally quite variable.

The deposit is truncated by a steep normal fault at its northwest end. 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. 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 itself and the myriad of small gouge zones that parallel it. Several analogous structures are thought to be present at Grum.

The deposit is quite shallow, in most places subcropping beneath glacial till. The till blanket is up to about 30 m thick in the northwest part of the deposit but thin in the southeast. Northwest of Vangorda Creek till cover is also quite thin. Locally the basal overburden and uppermost broken bedrock are cemented by iron oxides into a tough breccia.

The deposit consists of the same sulphide rock types as the other deposits but 2 types are particularly prominant. In the interpreted footwall of the deposit is a sulphide rich quartzite (4C and 4EC). This quartzite grades downwards into siliceous phyllite and ultimately altered phyllite. Parallel to this downward decrease in silica is a downward decrease in the abundance of sulphides from quartz rich semi-massive sulphide (4EC) at the top to pyritic altered phyllite at the base (4L). Most of the sulphides in the quartzite are pyrite, however pyrrhotite is generally present and locally abundant or dominant. Magnetite is unusually well developed in the quartzite. The quartzite contains only minor lead and zinc but is relatively rich in copper and unusually high in gold. The quartzite is similar to the semi-massive zone along the northeast edge of Zone 3 at Faro and one of the lower ore panels at Grum.

The massive sulphides that overlie the pyritic quartzite are commonly baritic and rich in lead and zinc. The unit is actually a mixture of about 50% 4E and 50% 4G ore types but separate treatment of pure types at Vangorda is not realistic from either the point of view of mining or the level of detail carried in this model.

Of the other sulphide rock types only 4A is of any importance. As is usual for these deposits it tends to be low grade and peripheral to the deposit. Much of the 4A is actually part of the upper horizon associated with the carbonaceous phyllite.

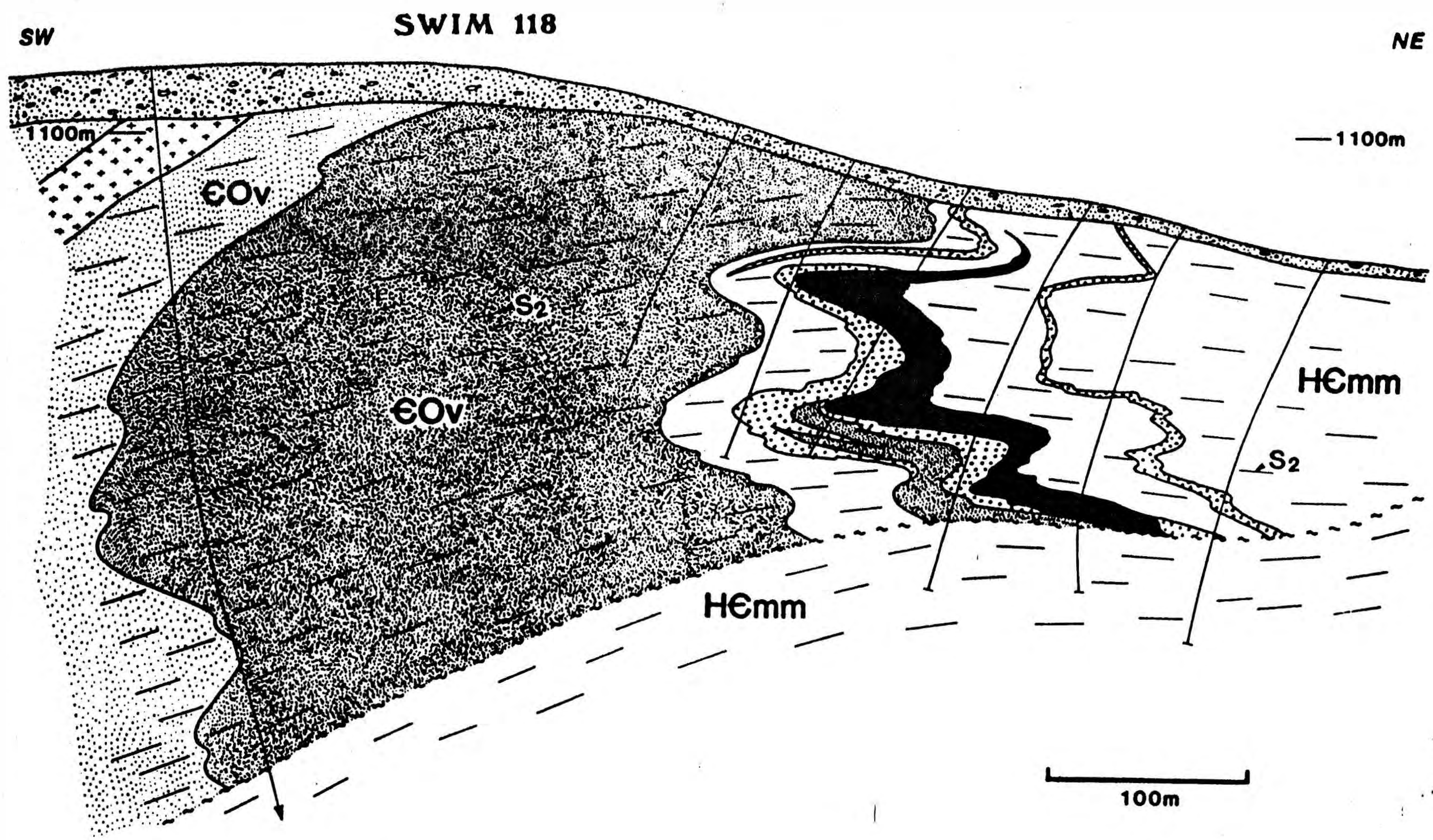


Figure 12

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Curragh Resources Faro Mine

There are currently two active mining areas in the Faro pit. The JB phase is at the southeast end of zone 3 where relatively shallow ore involved in fault blocks of the Big Indian fault zone is being mined. The AY phase is at the northwest end of zone 3 in this area stripping is currently in progress to uncover the main part of the massive sulphide zone. There is currently only minor ore exposed in the AY phase.

The first stop will be at an observation where the overall pit can be viewed and the gross structure of the deposit will be outlined.

We will then proceed into the JB phase pit where the following features will be examined depending on the availability of time and outcrop.

1. The major ore types present which will certainly include 2EF, massive pyritic sulphides, 2A ribbon banded "graphitic" quartzite and 2H, massive pyrrhotitic sulphides. With luck it might be possible to find additional ore types and they are not common in this part of the deposit.

2. Biotite muscovite andalusite schist of the Mt. Mye formation, the hanging-wall of the ore deposit.

3. The white mica dominant alteration envelope surrounding the deposit.

4. The Big Indian Fault system that forms one of the bounding structures of the zone 3 graben and good examples of the low grade graphitic quartzites at the base of the deposit.

We will then proceed into the AY phase part of the pit where the following features will be examined:

1. Calc-silicates (unit 3D) of the Vangorda formation and possibly carbonaceous phyllite and chloritic phyllites of the basal member of the formation.

2. Quartz feldspar porphyry (unit 10F) one of the two major subdivisions of the Anvil Dyke suite at the Faro pit. The other major member a hornblende quartz diorite may also be visible in the southeast wall of the pit.

3. Baritic massive sulphides (unit 2G) from one of the thin upper horizons of the deposit - if still present.

On the way out of the pit we will make a slight diversion to examine the breccia cap, an enigmatic body of post metamorphic breccia at the northeast edge of the pit.

If time permits we will make a quick stop in the now mined out Ramp zone where a small extension of zone 2 in the footwall of the Big Indian fault zone was mined recently. In this area second and third(?) phase fold structures involving thin metabasite layers in the basal part of the deposit can be seen.

From the pit we will proceed to the mill for a quick tour of the concentrator.

District Tour

After leaving the mine site several stops will be made to examine the stratigraphy and structure of the district as well as the Grum and Vangorda deposit areas. For the first leg distances are measured from the mine guardhouse.

The first several stops will be in the higher grade part of the district where metamorphic assemblages and structures typical of the lower structural levels of the district will be seen.

Stop 1 (0.4 km) - Vangorda formation

Right at the intersection of the mine access road and a road leading northwest to the tailings pond area. The outcrop is about 400 m down this road.

Biotite-muscovite-calcite-quartz-chlorite-actinolite +- epidote phyllite/schist.

This outcrop represents the transitional lithology between the calc-silicates (3D) seen in the pit and the calcareous phyllite (5B) to be seen on the Vangorda Plateau. These rocks are also transitional in the degree of development (or better, preservation) of lithon structure better examples of which will be seen later.

At 1.7 km after passing the tailings outfall in the former Faro Creek valley is more outcrop of Vangorda formation calcareous phyllite at the site of DDH 456-75-14, one of the deep drillholes on section 118.

At 2.8 km is the C.I.L. explosives plant and at 3.3 km the road crosses the North Fork of Rose Creek.

At 4.0 km on the left side of the road is a borrow pit exposing carbonaceous phyllite that may be the stratigraphic equivalent of the Faro Deposit although recent work suggests it may actually be as much as 100 m beneath the deposit horizon. Quartz feldspar porphyry also occurs here.

Stop 2 (4.8 km) - Mt. Mye formation

Near the intersection of the mine access road and the road to the fresh water supply dam.

Biotite-muscovite-quartz-andalusite schist.

This outcrop is a good example of the mottled schist (1DO) of the upper part of the Mt. Mye seen in the pit. The dark patches on the S_2 foliation surface are thought to be after andalusite. This outcrop is thought to be in the footwall of the Faro deposit horizon.

At the base of the dam near a small pumphouse is outcrop of similar schist mixed with carbonaceous phyllite and chloritic phyllite similar to the transition zone (3A) at the base of the Vangorda formation.

From 4.8 to 5.7 km is more outcrop of the same schist package. On the other side of the reservoir are outcrops of calc-silicate of the basal part of the Vangorda formation.

At 6.5 km the road crosses a small creek, there are good outcrops of calcite marble a short distances up this creek, similar marble to be seen at next stop.

Stop 3 (8.6 km) - Mt. Mye formation

Turn off to left just after a small stream into a gravel "parking lot". The outcrop is about 700 feet up the stream.

The major lithology here is a banded biotite + muscovite + quartz + adalusite + garnet + staurolite schist. In parts of the outcrop there are clasts, grading into bands, of andalusite surrounded by biotite. The prominent foliation is S_2, as is typically the case on the southwest flank of Anvil Arch the foliation dips shallowly away from the Anvil Batholith. Here there is little preservation of the earlier S_1 foliation, it is mainly evident only in thin section as microscopic intrafolial isoclinal folds or lithons. The S_2 foliation is crenulated by a later deformation event ~~here~~ but only the lineation, not the related crenulation foliation, is well developed here. Near the road the schists are finer grained and there is better development of lithon structure.

Compositionally this outcrop is typical of the lower parts of the Mt. Mye. Near the road and particularly a few hundred meters to the northwest, marble and calc-silicate occur in the vicinity but the bulk of the formation is non-calcareous pelitic schist. Thin relatively pure marble is not uncommon in the Mt. Mye formation and its occurrence is in marked contrast to the lack of relatively pure marble in the overall more calcareous Vangorda formation. The marble horizon near here is approximately 200 m beneath the Faro deposit, discontinuous marble lenses are widespread at approximately this level in the Mt. Mye. These marbles may be the stratigraphic equivalent of the lower Cambrian arceocyathid bearing limestone breccias of the Selwyn Basin further east.

At 8.8 km is a small trench on the left side of the road exposing calc-silicate identical to that at the Faro pit. This calc-silicate is however thought to be in the Mt. Mye formation largely on the basis of the porporation of associated marble and its position. The amount of calc-silicate developed to the northeast of the road may indicate that there is an unrecognized structure repeating the Vangorda formation, a matter of considerable exploration significance.

At 11.6 km the road crosses another small creek. Just northwest of the creek are outcrops and rubble of calc-silicate and granitic rock thought to be part of a thin S_2 foliaform sill just above the also generally S_2 parallel contact of the Anvil Batholith.

Stop 4 (12.3 km) - Anvil Batholith

At the intersection of the mine access road and the road to the Vangorda Plateau.

This is one of the few accessable outcrops of the Anvil Batholith. It is unfortunately not typical of the Batholith. This outcrop represents the biotite-muscovite bearing equigranular phase of the Batholith but it is near the transition into the megacrystic phase. There is a weak foliation developed here which is much stronger to the east. This is a mylonitic foliation related to deformation in the footwall of the Tie fault zone. S and C bands indicating extensional displacement with the southeast side down are developed to the east but are not well developed here. Considerable tourmaline is developed here and a small amount of scheelite has been found. As a matter of interest, marbles beneath the Faro deposit near the Batholith have well developed skarn assemblages and minor scheelite is associated with them.

Zircon samples from this area confirm the approximately 100 ma age of the Batholith (Mortensen, personal comm., 1985) indicated by K-Ar and Rb-Sr work (work Pigage and Anderson 1986).

From this point on distances will be measured from this intersection.

At 0.5 km the road crosses another small creek, on the left side of the road are several blocky, grey outcrops of granitic rock. The more easterly of these exposures show a strong mylonitic foliation and well developed S and C bands.

Stop 5 (1 km) - Tie fault zone

A black phyllite can be seen in rubble in a clearing along the road. The contact of the black phyllite with medium grey phyllite marks the hangingwall contact of the Tie fault zone. The Tie fault is a large extensional fault with a minimum of 1 km of displacement. The fault trends 060° and dips 45° to the southwest. The fault has been intersected by a number of deep drill holes in this area. In all holes the fault zone consists of highly sheared black phyllite with lenses of tan, carbonated metabasite and bull quartz. The Fault marks an abrupt change from greenschist facies rocks of the Vangorda Plateau to strongly foliated amphibolite facies rocks of the Faro area such as we have seen so far today. The Grum deposit is truncated by the fault and the Firth showing represents the dismembered distal portions of Grum within the shear zone. The lack of significant horizontal shift of the Grum trend and the position of Firth, despite the large vertical separation, constrains the sense and minimum amount of displacement on the Tie fault. This sense of displacement is consistent with S and C band orientations in the footwall. Highly sheared phyllites of the fault zone are cut by an unsheared quartz feldspar porphyry. Since the porphyry is thought to be a late stage differentiate of the Batholith is sheared we surmise that the fault is related to the late stages of emplacement or uprise of the Batholith through its metamorphic cover. Future dating may show however that this dyke is part of a 580 ma intrusive event recorded elsewhere in the district (Gordey, personal comm., 1986).

Several other similar faults are now known to be present in the district, one of the most significant is beneath the Dy deposit and may have separated Dy from the up-plunge extension of the Vangorda deposit.

The medium grey phyllite here is a non-calcareous, non-lithon bearing part of the Vangorda formation.

Across the road in a small quarry is an outcrop of amphibolite within the shear zone typical of metabasite in the Mt. Mye formation of the footwall of the fault.

At 1.7 km the Firth showing can be seen to the north of the road. Blocky outcrops along the right side of the road are metabasite (greenstone) of the Vangorda formation.

At 2.5 km is the turn off to the Grum camp. There are good outcrops of calcareous chloritic phyllite annd metabasite at the intersection. A small quarry south of the intersection exposes calcareous phyllite, carbonaceous phyllite and tan weathering carbonated metabasic phyllite all these lithologies are part of the Vangorda formation.

This area will be part of the future Grum open pit. The main part of the deposit is located just north of the road where the red and yellow stakes are most numerous. The northeast wall of the Grum pit will be located at the far side of the small pond (Doal Lake).

Stop 6 (at Grum portal and dump, no distance) - Grum Deposit

A short stop will be made to discuss the structure of the Grum Deposit and examine specimens of the ore types for comparison to those of the Faro deposit. (Return to intersection and resume distance measurement at 2.5 km).

Stop 7 (4.4 km) - Mt. Mye formation and Vangorda formation overview

Turn off to left and proceed to survey marker.

This locally provides an excellent overview of the Vangorda Plateau. The Grum (to WNW), Vangorda (to S in valley) and Dy (to SE) deposit areas are visible. The Swim deposit is located on the north end of the far ridge across Blind Creek (to SE). To the south is Sheep Mountain where good exposures of Anvil Range Group basalt and underlying chert occur. The Vangorda Fault zone passes south of Sheep Mountain and separates "Klondike Schist" from rocks of the Anvil District on the low ridge northwest of Sheep Mountain across the Vangorda Creek valley from here. The Menzie Creek formation runs in a northwest trending belt passing through the low ground in front of Sheep Mountain. Most of the rest of the area is underlain by recessive phyllites of Vangorda and Mt. Mye formations except for the Knob southwest of Grum camp where good exposures of metabasites in the upper Vangorda formation occur.

A short distance down the road to the northeast is an outcrop of brown weathering, medium to dark medium bluish grey, non-calcareous phyllite typical of the Mt. Mye formation in greenschist facies areas of the District. The shallowly west dipping foliation is S_2 and a number of later crenulations can be seen. Although it is not easy, one can demonstrate in hand specimen that there is an earlier foliation (S_1) here.

This outcrop is lithologically similar to the Gull Lake Formation in the Howards Pass area with which the Mt. Mye formation at least in part correlates. (continue measurement at road - 4.4 km).

From 5.1 to 5.6 there are excellent outcrops of phyllites of the upper part of the Mt. Mye formation on either side of the road. There are excellent examples of all aspects of the fabric of Mt. Mye phyllites here but time will not permit examination.

At 5.8 km the road crosses Vangorda Creek.

OPTIONAL STOP (right just after Vangorda Ceek.) - Vangorda Showing

Proceed 0.5 km along road to cabin on left. The deposit is just beneath this area. Turn right and continue to right at 0.8 km. Vangorda Creek is at 1.0 km from turn off. The showing is about 175 m downstream on the northwest side of the Creek near a large gossan in the creek bed.

The exposure here is actually one of the thin upper horizons not the main part of the deposit. This area will be on the southwest wall of the Vangorda pit.

(Return to main road and continue measurement at 5.8 km)

Stop 8 (right at 8.7 km) - Vangorda formation structure

Turn right and proceed 0.4 km along road, outcrop is on right about 25 m into bush. There is a good turn-around a few tenths of a km further along the road.

NO HAMMERS AT THIS LOCALITY PLEASE!!

In this outcrop is the best accessible example of a first phase fold in the District. The fold is preserved in the strain shadow of a metabasite body. It is Z shaped looking to northwest (i.e. verges northeast) as most F_1 folds in the district are. The axial plane dips on the average steeply southwest and is crenulated by a shallowly southwest dipping S_2 foliation. This is an excellent small scale example of the large scale structure of the Grum deposit. (return to main road and continue measurement)

Stop 9 (9.3 km) - Vangorda formation

There are many good examples of the metabasites of Vangorda formation here. The purpose of this stop is particularly to examine banded green phyllites associated with the metabasites, these are best seen at the last outcrop on the left side of the road.

The metabasites of the Anvil District are typically medium grained and equigranular as seen here. The interpretation that some of these were volcanic flows was based on the common association of green and white thin banded phyllites that may be meta-tuffs. The authors preference is that these phyllites are Vangorda formation phyllites chloritized and contact metamorphosed near a mafic sill prior to regional metamorphism. This interpretation is supported by a gradual change into typical grey calcareous phyllite seen in drill core. We thus believe that most metabasites of the Vangorda formation were sills rather than flows.

Stop 10 (9.4 km) - Vangorda formation

On right side of road about 30 m through bush. (not visible from road)

This is an excellent natural outcrop of the medium grey calcareous phyllite that typifies the Vangorda formation. The S_2 foliation dips southwest parallel to the ubiquitous F_2 fold axial planes seen here.

At 10.4 km is the turn off to the Dy drill grid.

At 10.7 and 11.1 km there are additional examples of Vangorda calcareous phyllites in road cuts with well developed examples of the D_2 deformational fabric. The drusy weathering and silvery grey foliation surface is characteristic of the formation and helps distinguish non-calcareous portions of the Vangorda from the Mt. Mye. The Dy deposit is about 700 m directly beneath this point.

There are many additional outcrops of Vangorda formation phyllites along this road. The portion of the Vangorda Plateau road paralleling Blind Creek (on the left) can be considered to be the type locality of the formation. At 11.4, 12.1 and 12.3 km are additional metabasite outcrips, at 11.4 km the relationship of the green banded phyllite is well exposed.

At 15.4 km Anvil Range Group basalt and underlying red and green chert are visible to the right.

At 16.0 km is Blind Creek and the turn off to Faro. Across the creek at 16.1 km on the left is an example of the Triassic polymict conglomerates that is found along the Vangorda fault. The fault zone itself is not well exposed but is located at about 15.9 km. On the road back to Faro about half way up the grade out of blind Creek is an outcrop of sheared gabbro and basalt that is common in the fault zone.