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ORE DEPOSITS OF THE ANVIL DISTRICT CENTRAL YUKON

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The Anvil District is located in central Yukon Territory, Canada, approximately 225 km northeast of Whitehorse (Figure 1). To date 5 stratiform, sediment-hosted lead-zinc-silver deposits have been discovered in a 25 km long northwest-southeast curivilear trend (Figure 3). Before mining, the aggregate size of these deposits using a 4% Pb+Zn cutoff was approximately 125 million tonnes averaging 9% Pb+Zn, 40-50 g/t Ag, 0.1-0.2% Cu, and 0.7-1.0 g/t Au (Table 1). The Faro deposit has been in production intermittently since 1969. It is currently mined by open pit methods and feeds a 13,500 tonne per day concentrator. Two additional open pits, Grum and Vangorda, are being prepared for production starting in 1990. A small down-dip extension of the Faro deposit will also be mined underground starting in 1990.

Anvil District stratigraphy has strong affinities with that of the Selwyn Basin and represents the most southwestern (outboard or basinward) present day examples of Lower Palaeozoic Selwyn Basin strata preserved northeast of Tintina Fault, a major Cordilleran strike slip structure (Figures 2, 3). The Late Proterozoic (?) and Lower Cambrian Mt. Mye formation forms the basal stratigraphic unit in the Anvil District (Figure 4). It consists of a monotonous, noncalcareous, pelitic schist and phyllite sequence at least 2 km thick, and is lithologically correlated with the Gull Lake Formation toward Mackenzie Platform northeast of the District. Calcareous phyllites and lesser basaltic intrusive rocks of the Cambrian and Ordovician (?) Vangorda formation overlie the Mt. Mye formation with a gradational contact. An important carbonaceous pelite member locally occurs at the base of the formation. The 1 km thick Vangorda sequence is correlated with the more calcareous Rabbitkettle Formation eastwards toward the Mackenzie Platform.

A 1 km thick basaltic metavolcanic sequence named the Menzie Creek formation overlies and is interbedded with the uppermost Vangorda formation. Carbonaceous phyllites, slates and siltstones containing early Ordovician to early Silurian graptolite fauna are interbedded with and overlie the Menzie Creek volcanics. These metasediments are lithologically and faunally similar to strata of the Road River Group with which the Menzie Creek is correlated. The Menzie Creek formation is one of the largest of several Ordovician mafic volcanic accumulations in the Selwyn Basin. The mafic intrusive sills in the Vangorda Formation may be related to the Menzie Creek volcanism.

The ore deposits occur in a 150m thick stratigraphic interval including the upper Mt. Mye and lower Vangorda formations; they are thus assumed to be Cambrian. The deposits are comprised of one to five sulphide horizons in that interval. The deposits are spatially associated with a local pinchout of the basal carbonaceous member of the Vangorda formation.

The Mt. Mye, Vangorda, and Menzie Creek formations are interpreted to represent deep marine sediments which accumulated on a trailing continental margin subject to episodic extensional tectonism during which the basaltic component of the section was emplaced.

Basaltic volcanism was much more important after the deposits formed, but there is some evidence of volcanism occurring during ore formation. In general the carbon content of these formations is much lower than the strata hosting other northwest Canadian SEDEX deposits.

Anvil District has a complex polydeformational/polymetamorphic history. Two Mesozoic regional syn-metamorphic folding events are recognized in a low pressure, Buchan-type metamorphic facies series ranging from greenschist to amphibolite facies grade. Metamorphic zones decrease in grade radially outward and structurally upward from a granite cored central culmination which domes the metamorphic sequence.

First phase deformation is largely overprinted but where evidence is preserved the event appears to have produced northeast verging folds with a steep axial planar cleavage. Second phase folds are coaxial with first phase but have shallowly dipping axial planes with a prominent low angle, southwest dipping, axial planar crenulation cleavage that characterizes rocks of the District. At deeper structural levels the recrystallization and transposition into the second schistosity is very intense resulting in a low angle schistosity that parallels lithologic contacts. The individual deposits are elongate parallel to the second phase fold axis and the overall line of deposits follows the regional trajectory of the second phase lineations.

Three additional, less intense, deformation episodes of only local importance were superimposed on the earlier structures. An episode of major extensional faulting may record the final stages of uprise of the plutonic plus high grade metamorphic core of the district through the flanking low grade metasediments.

Structural and metamorphic considerations are very important in the district since the form of the orebodies was determined by the first two deformations and the limits of several of the deposits are due to truncation by large displacement (1 km+) extensional faults. Metallurgical performance of the ores is largely determined by the degree and type of recrystallization and annealing which is dependent on the metamorphic and deformational history.

All ore deposits are comprised of similar ore lithologies; they differ mainly in form and proportion of ore types and metamorphic grade. The ore deposits are thought to have originated as thin laterally extensive sheets with an amoeboid outline, diameters up to 2,000m and thicknesses up to 30m (possibly as much as 75m). Within each of the sheets, the central and uppermost ores are massive pyritic sulphides with the upper portion of the massive ores typically being barite bearing (see Figure 5). Below and peripheral to the massive sulphides are disseminated sulphide bearing quartzites. The lowest and most peripheral pyritic quartzites are typically carbonaceous and very strongly sulphide banded. The quartzites are thought to have originated either as chert sulphide exhalite interbed or as silicified and sulphide impregnated host sediments. Some of the deposits are asymmetric in cross-section with one side consisting of a thick low grade pyritic quartzite and semi-massive sulphide wedge which tapers to a thin banded carbonaceous pyritic quartzite at the other side.

Metal zoning is not well developed but in general a given horizon tends to be relatively lead and silver rich at the top and zinc rich at the bottom. Marginal zones for a given horizon also are relatively zinc rich. This metal zoning parallels the ore type zoning. Some deposits have a footwall greatly enriched in copper and gold relative to lead-zinc. At Faro, the uppermost ores are relatively rich in gold as well as lead and silver.

Altered rocks are abundant around all of the ore deposits. At the Faro deposit the altered rocks are bleached schists rich in white mica. Texturally these schists are identical to schists further from the ores. The altered schists form a true envelope locally best developed in the hanging wall. This alteration may originate at least partially by fluid induced metamorphic interaction between the massive sulphides and the host rocks.

The other deposits are at lower metamorphic grade and have a different type of alteration. Bleached phyllites occur but are minor and are definitely footwall biased. Other altered phyllites are more widespread; typically these are medium green-gray phyllites similar to phyllites further from ore but with much reduced content of carbonaceous material and enhanced chlorite content. Pyrrhotite, chlorite and carbonate bearing stringers are present locally. More strongly bleached, altered phyllites are locally quartz rich, and contain disseminated sulphides. These grade into the pyritic quartzites noted above. The alteration in the less metamorphosed deposits occurs mainly in horizon footwalls but the stacked nature of horizons make alteration distribution ambiguous in many cases. This alteration is thought to be related to ore transporting fluid interacting with host sediments.

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 early Cambrian extensional tectonism. Hydrothermal fluids moved up this fault zone and exhaled into a relatively deep water, reduced marine basin which was otherwise receiving distal turbidite sediments. A regular and repetitive change in the depositional environment or in the ore fluid composition is required to explain the origin of the regular ore type variations in the deposits.

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Table 1. Pre-Production Reserves for Anvil District Deposits (from Jennings and Jilson, 1986)

Deposit	Discovery Date	Geological Reserves tonnes $*10^6$	Grade Pb (%)	Grade Zinc (%)	Grade Silver (g/t)	Cutoff (Pb+Zn) (%)
Faro	1965	57.6	3.4	4.7	-	5.0
Grum	1973	30.8	3.1	4.9	49	4.0
Vangorda	1953	7.1	3.4	4.3	38	4.0
Dy	1976	20.3	5.7	7.0	82	9.0
Swim	1964	4.3	3.8	4.7	42	6.0
Total		120.1	3.7	5.6	-	N/A

Figure 1. Map of Yukon Territory, Canada showing the location of the Anvil District.

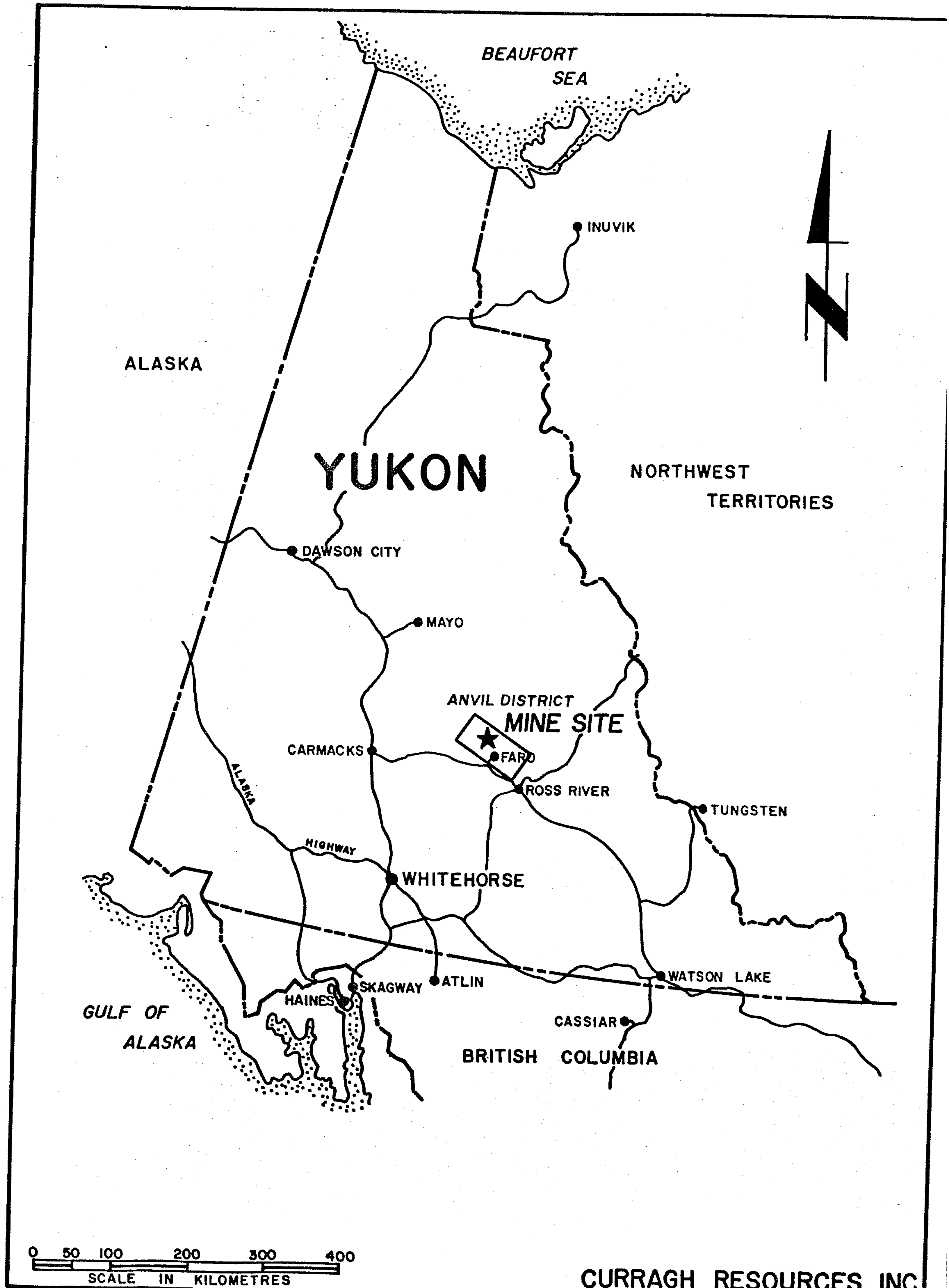
Concentrates are trucked from Faro through Carmacks and Whitehorse to tidewater at Skagway, Alaska.

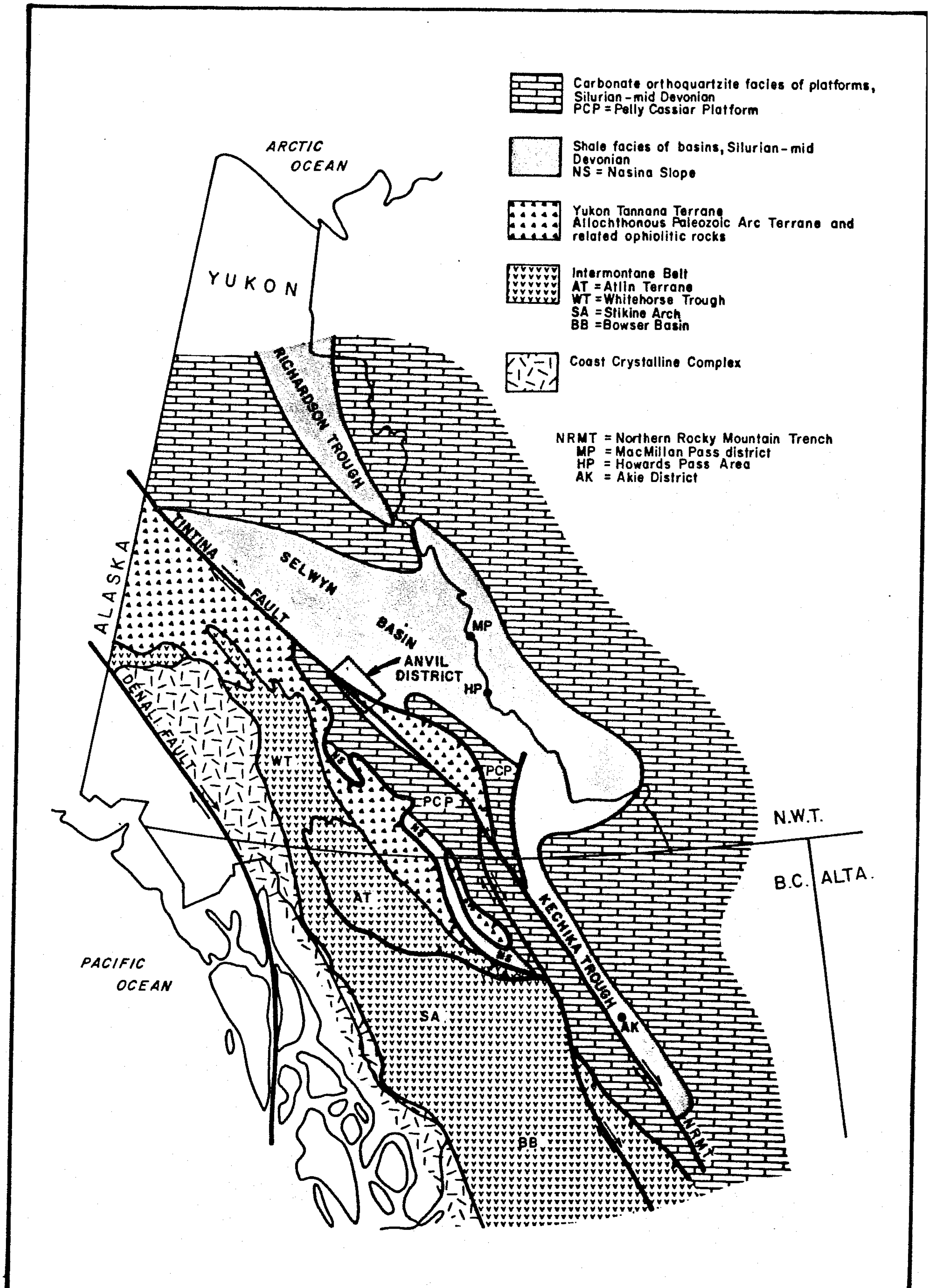
Figure 2. The Anvil District in relation to Selwyn Basin and other major tectonic features of Yukon Territory, Canada.
(modified from Jennings and Jilson, 1986)

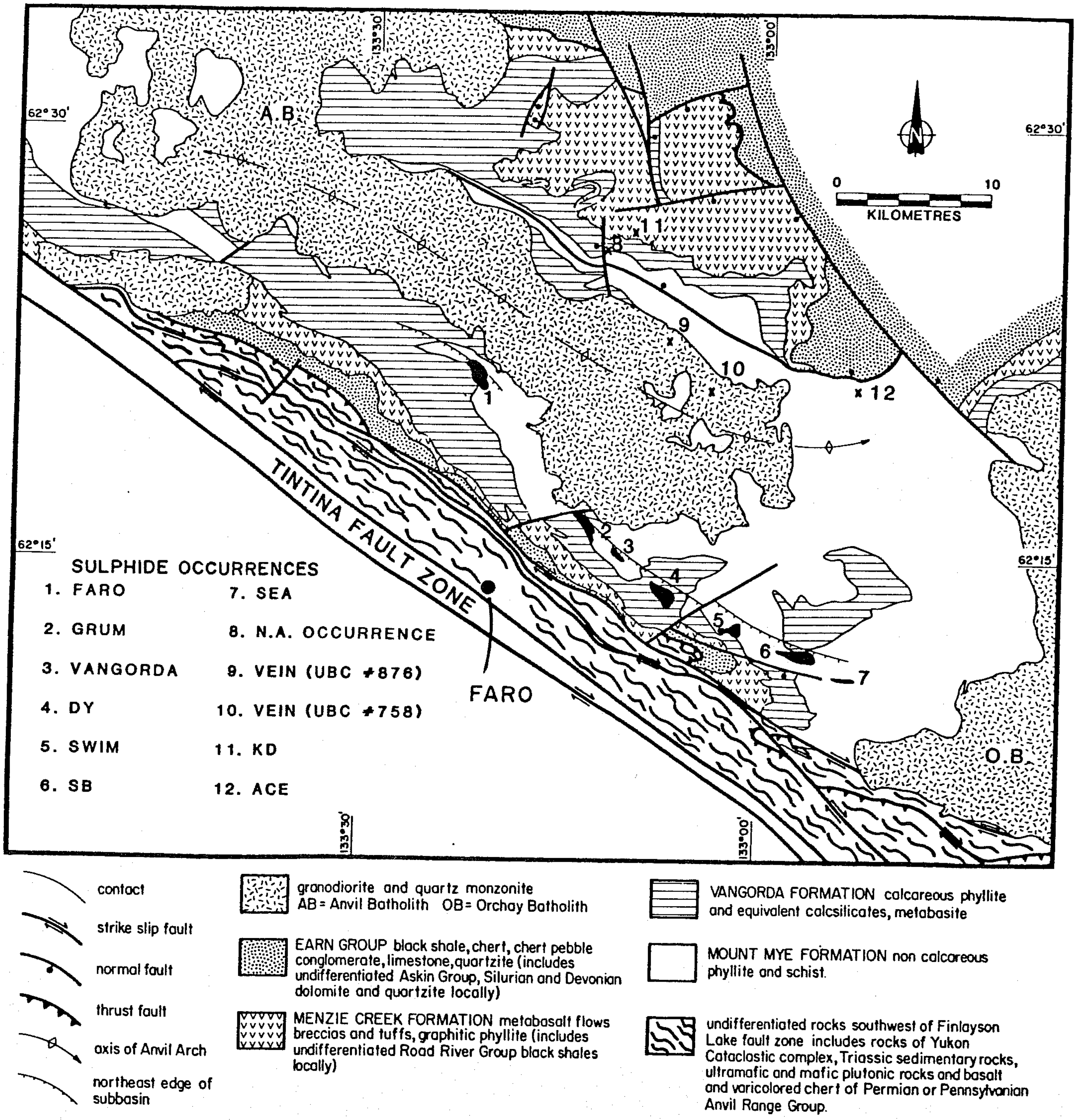
Figure 3. Geological Map of the Anvil Basin. The major sulphide deposits are indicated in black.
(modified from Jennings and Jilson, 1986)

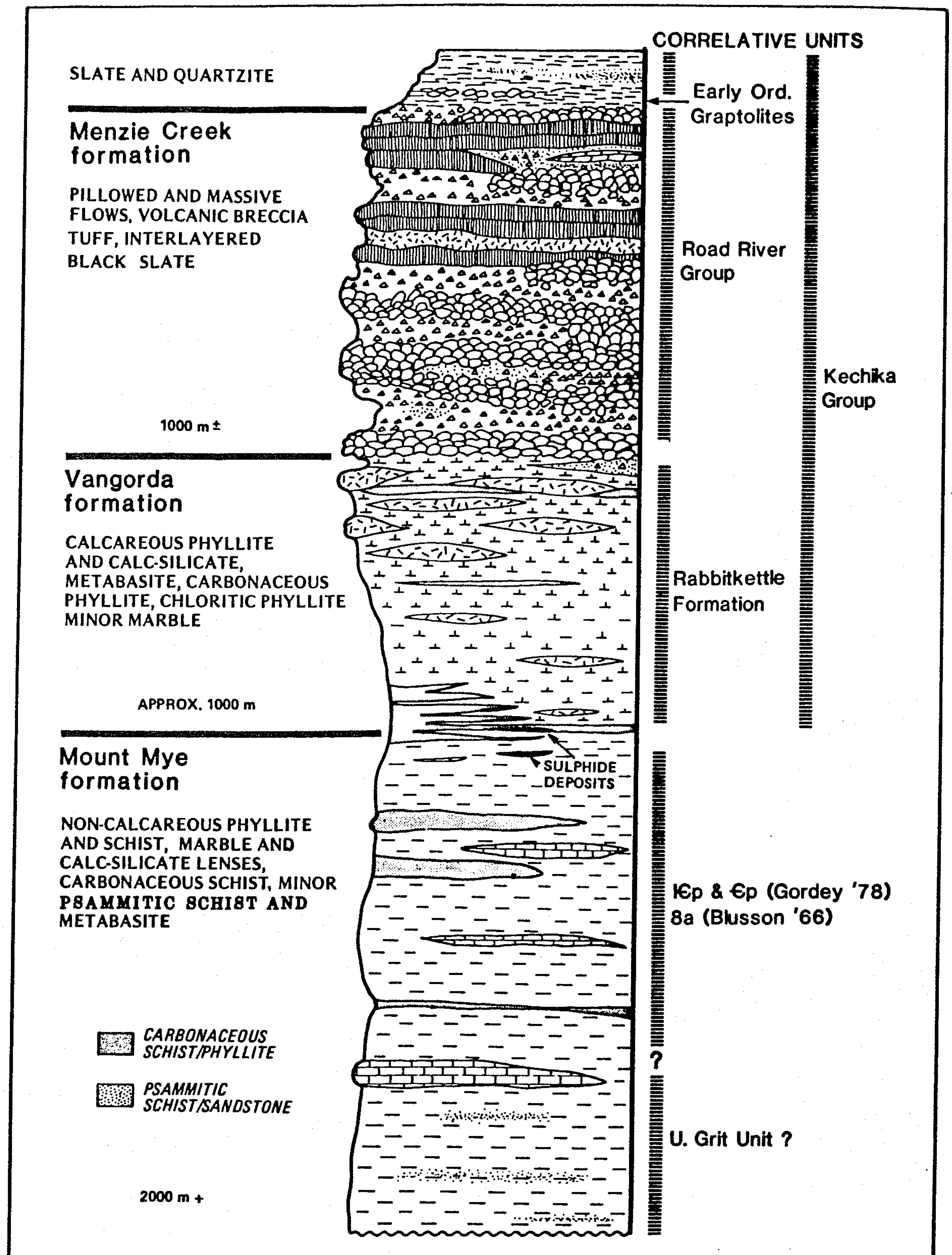
Figure 4. A schematic stratigraphic column of the rock units in the older portion of the Anvil District. The sulphide deposits consist of several horizons in the uppermost Mt. Mye and lowermost Vangorda formations (from Jennings and Jilson, 1986).

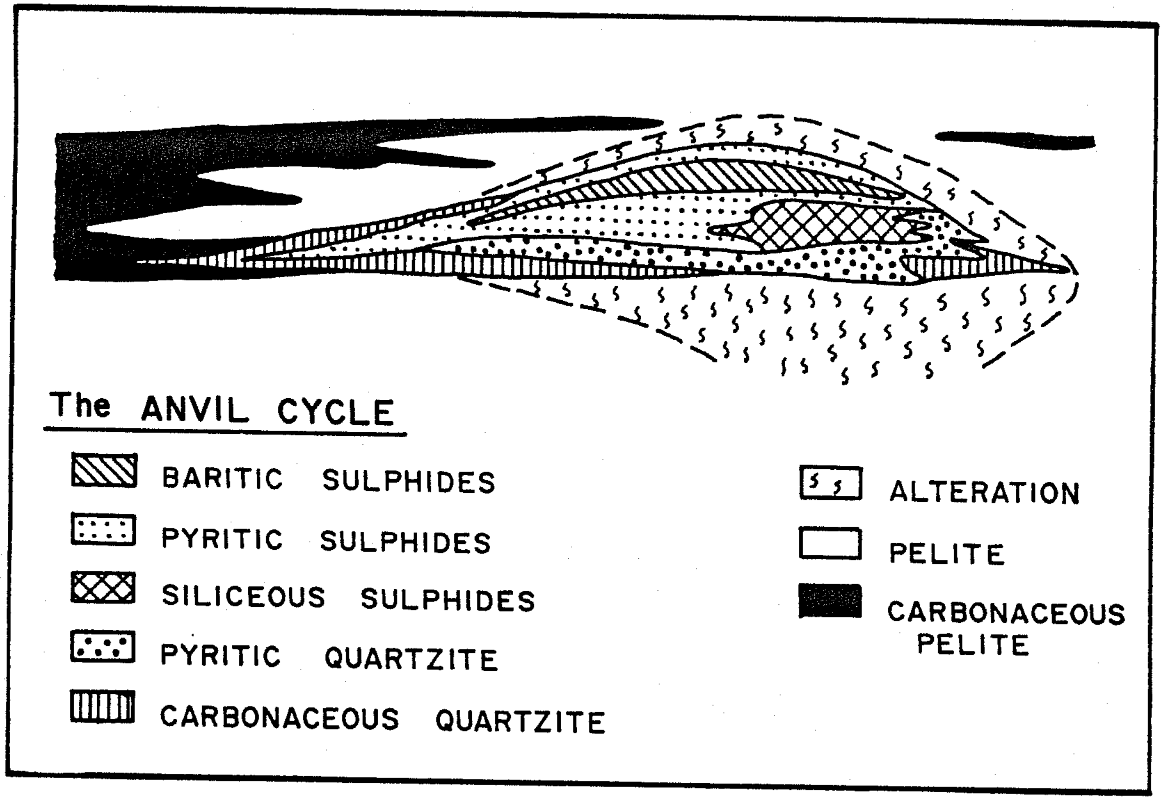
Figure 5. An idealized Anvil deposit based largely on the Faro and Vangorda deposits. This sectional view is greatly exaggerated vertically.

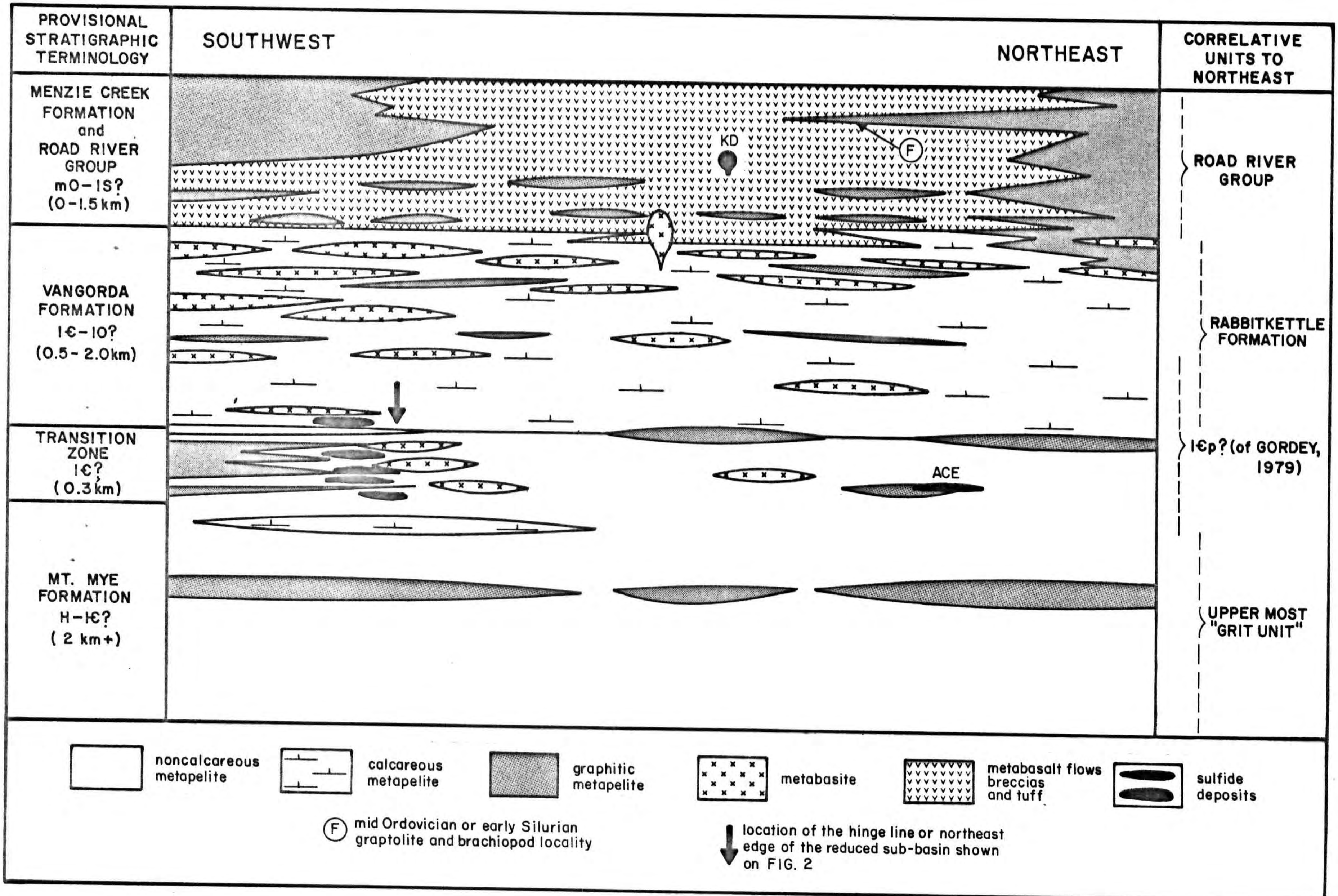

BEAUFORT SEA
INUVIK
ALASKA
YUKON
NORTHWEST TERRITORIES
DAWSON CITY
MAYO
ANVIL DISTRICT
MINE SITE
CARMACKS
FARO
ROSS RIVER
TUNGSTEN
ALASKA HIGHWAY
WHITEHORSE
GULF OF ALASKA
HAINES
SKAGWAY
ATLIN
WATSON LAKE
CASSIAR
BRITISH COLUMBIA
0 50 100 200 300 400
SCALE IN KILOMETRES
CURRAGH RESOURCES INC.


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
MP
ANVIL DISTRICT
HP
DENALI FAULT
WT
PCP
PCP
N.W.T.
B.C.
ALTA.
AT
KECHIKA TROUGH
PACIFIC OCEAN
SA
AK
BB
NRMT


A.B.
O.B.
62° 30'
62°15'
133°30'
133°00'
0
10
KILOMETRES
TINTINA FAULT ZONE
FARO
SULPHIDE OCCURRENCES
1. FARO
2. GRUM
3. VANGORDA
4. DY
5. SWIM
6. SB
7. SEA
8. N.A. OCCURRENCE
9. VEIN (UBC #876)
10. VEIN (UBC #758)
11. KD
12. ACE
contact
strike slip fault
normal fault
thrust fault
axis of Anvil Arch
northeast edge of subbasin
granodiorite and quartz monzonite AB = Anvil Batholith OB = Orchay Batholith
EARN GROUP black shale, chert, chert pebble conglomerate, limestone, quartzite (includes undifferentiated Askin Group, Silurian and Devonian dolomite and quartzite locally)
MENZIE CREEK FORMATION metabasalt flows breccias and tuffs, graphitic phyllite (includes undifferentiated Road River Group black shales locally)
VANGORDA FORMATION calcareous phyllite and equivalent calcsilicates, metabasite
MOUNT MYE FORMATION non calcareous phyllite and schist.
undifferentiated rocks southwest of Finlayson Lake fault zone includes rocks of Yukon Cataclastic complex, Triassic sedimentary rocks, ultramafic and mafic plutonic rocks and basalt and varicolored chert of Permian or Pennsylvanian Anvil Range Group.


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
CORRELATIVE UNITS
Early Ord. Graptolites
Road River Group
Kechika Group
Rabbitkettle Formation
l€p & €p (Gordey '78)
8a (Blusson '66)
?
U. Grit Unit ?


The ANVIL CYCLE
BARITIC SULPHIDES
PYRITIC SULPHIDES
SILICEOUS SULPHIDES
PYRITIC QUARTZITE
CARBONACEOUS QUARTZITE
ALTERATION
PELITE
CARBONACEOUS PELITE


PROVISIONAL STRATIGRAPHIC TERMINOLOGY
SOUTHWEST
NORTHEAST
CORRELATIVE UNITS TO NORTHEAST
MENZIE CREEK FORMATION and ROAD RIVER GROUP mO-lS? (0-1.5km)
VANGORDA FORMATION l€-lO? (0.5-2.0km)
TRANSITION ZONE l€? (0.3km)
MT. MYE FORMATION H-l€? (2 km+)
KD
F
ACE
ROAD RIVER GROUP
RABBITKETTLE FORMATION
l€p? (of GORDEY, 1979)
UPPER MOST "GRIT UNIT"
noncalcareous metapelite
calcareous metapelite
graphitic metapelite
metabasite
metabasalt flows breccias and tuff
sulfide deposits
F mid Ordovician or early Silurian graptolite and brachiopod locality
location of the hinge line or northeast edge of the reduced sub-basin shown on FIG. 2