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INTRODUCTION

The purpose of this mineralogical study is to examine textures, mineralogy, and paragenesis of the Mount Alcock, Cirque, Pie and Elf stratiform Ba-Pb-Zn-Ag deposits. Paragenesis of this type of deposit is very difficult to interpret from polished section examination. If the deposit is unmetamorphosed, genetic relationships interpreted from textural evidence are valid. However, the four deposits dealt with in this study have been subjected to low grade metamorphism resulting from thrusting and folding. The textures examined are not of primary origin, but of secondary origin, as a result of metamorphism. Thus, a paragenetic sequence for secondary textures can be constructed and a sequence for the original textures hypothesised.

LOCATION AND ACCESS

Located within the Rocky Mountain fold and thrust belt of Northeastern British Columbia, the four deposits, Mount Alcock, Cirque, Pie and Elf, are contained within a 180 kilometer long belt which is centered approximately 70 kilometers north of Williston Lake, British Columbia (Figure 1).

The northern most of the four deposits is Mount Alcock which lies within the southwest corner of Kwadacha Wilderness Park, thereby making it out-of-bounds for mineral exploration. Proceeding in a southward direction down the belt, the Cirque, Pie and Elf deposits are encountered. There are many other showings in the belt, but the four discussed above seem the most significant economically. The belt containing these deposits is referred to as 'The Driftpile Creek-Akie River Area' and it lies within the Ware Map Sheet, British Columbia.

Access into the area is by float plane from either Mackenzie, British Columbia or Watson Lake, Yukon. The 2 hour trip brings one to Pretzel Lake which is a 20 minute helicopter trip from the various properties.(Figure 2). In the summer of 1980 Cyprus Anvil Mining Corporation opened a fixed wing airstrip on the banks of the Finlay River at their base camp 'Finbow.' (Figure 2). An alternate access route is by barge up the Finlay Reach of Williston Lake from Mackenzie, British Columbia.and then a 30 minute riverboat trip up the Finlay River to Finbow.

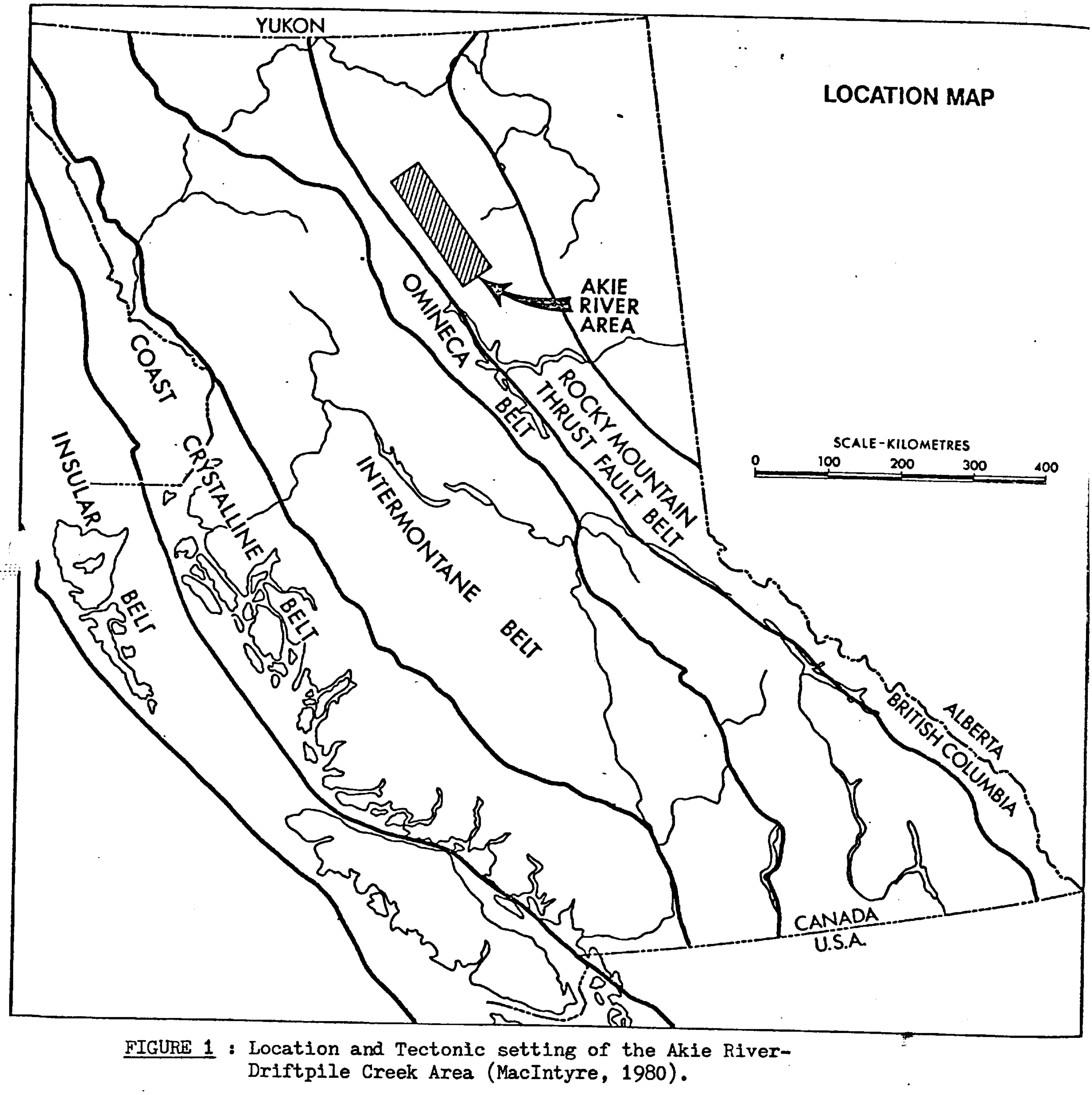


FIGURE 1 : Location and Tectonic setting of the Akie River-Driftpile Creek Area (MacIntyre, 1980).

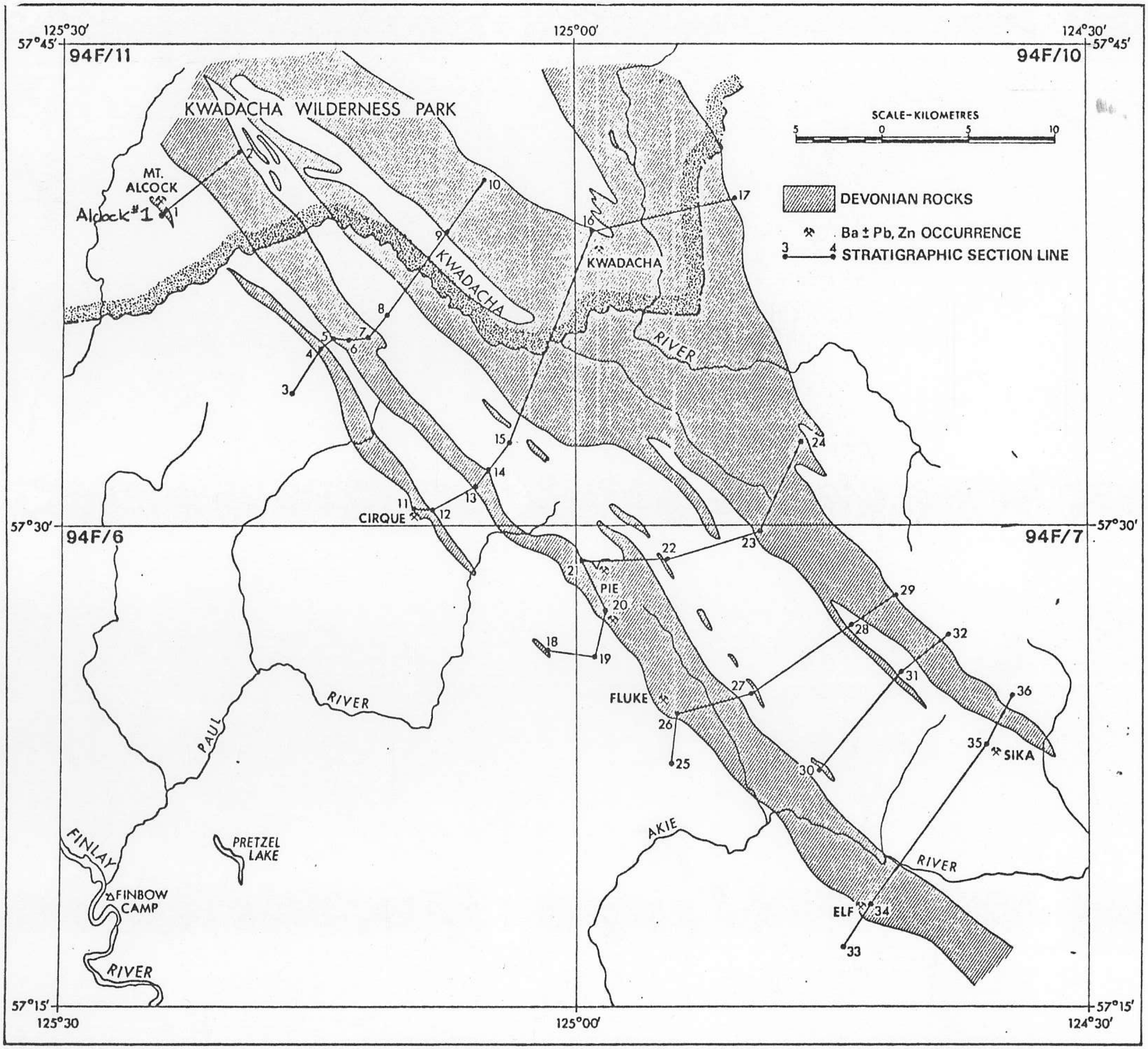


FIGURE 2 : Location map showing the Cirque, Pie, Mount Alcock and Elf deposits in relation to Pretzel Lake and the Finbow Camp (MacIntyre, 1980).

TOPOGRAPHY

The map area is characterized by northwest trending ridges, locally rising to 2,200 meters elevation, truncated by broad northeast trending drainage corridors (MacIntyre, 1980). Resistant units such as siltstones tend to form the high ridges, whereas recessive units such as shales tend to form the low ridges and valleys. The northeast facing ridge faces tend to be steep and exhibit excellent exposure, whereas the creeks contain very little outcrop.

REGIONAL GEOLOGY

The area of study is underlain by sedimentary strata ranging in age from Proterozoic to Early Triassic (Figure 3). The various formations are arranged in narrow discontinuous belts bounded by northwest trending thrust faults. The stratiform Ba-Pb-Zn-Ag deposits dealt with in this report all lie within the Devonian Black Shale Unit. The Devonian, conformably to disconformably, overlies the Silurian Siltstone Unit. The Triassic Siltstone disconformably overlies the Devonian locally, but in general the erosion level is the Upper Devonian.

The stratiform deposits are contained within a siliceous argillite facies, of the Devonian, ranging from 20 meters to 150 meters in thickness, this siliceous facies is in turn overlain by a fissile, pyritic, black shale facies.

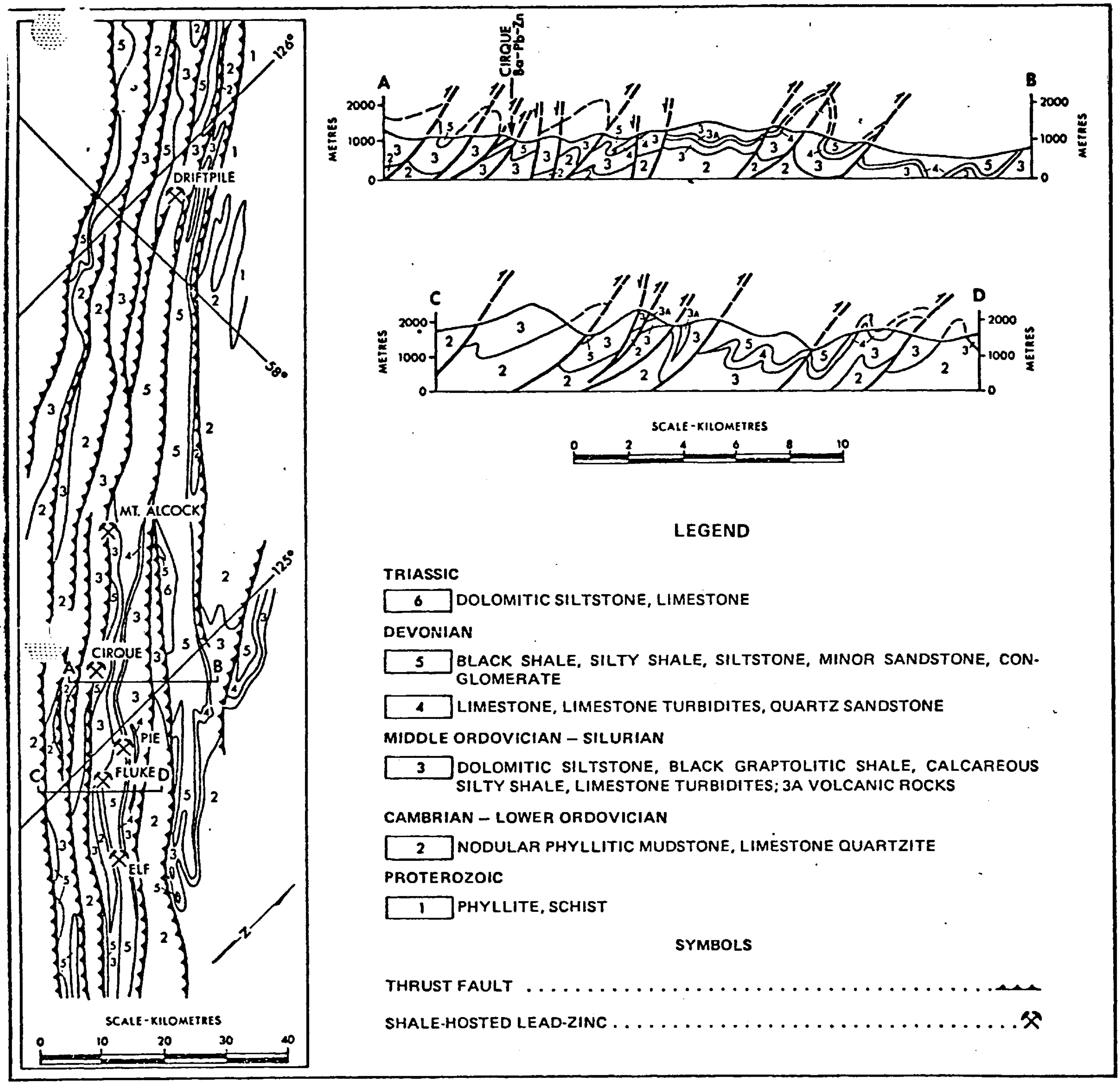


FIGURE 3 : General Geology, Driftpile Creek-Akie River Ba-Pb-Zn-Ag District. (MacIntyre, 1980).

MOUNT ALCOCK SHOWING

GENERAL GEOLOGY

The Mount Alcock showing, in Kwadacha Wilderness Park, occurs on the northeast ridge of Mount Alcock as a prominent white barite kill zone (Plate 1 and Plate 2). A bedded barite horizon 25 to 30 meters thick, dipping 45°-75° to the southwest, is contained within a fault bounded wedge of siliceous shale surrounded by Silurian Siltstone. A 2 to 3 meter thick zone of grey bedded barite contains very fine laminations (i.e. less than 1mm thick) of galena and sphalerite (Plate 3 and Plate 4). One polished section was examined from this showing.

Assays of grab samples collected from the mineralized zone (Plate 3) follow:

Sample No.	Ag ppm	Ba per cent	Cu per cent	Pb per cent	Zn per cent
AL–1	24	50.5	0.002	13.0	0.11
AL–2	17	49.3	0.002	10.8	1.41
AL–3	15	50.3	0.001	8.4	2.41
AL–4	20	50.8	0.001	10.0	4.81
AL–5	15	51.8	0.002	6.8	1.07

TABLE 1 : Assays from five grab samples taken at the Mount Alcock showing. (MacIntyre, 1980).

MINERALOGY

Megascopic examination shows interbedded light grey and dark grey barite ranging in thickness from less than 0.5mm to 3mm. Fine laminations of galena are observed within barite beds, but no sphalerite or pyrite are seen. The hand specimen is highly oxidized with Goethite which forms a thin rind.

Microscopic examination of polished section Alcock #1 shows the rock to be 80% gangue-20% sulphide. The predominate sulphide is galena (70%), followed by sphalerite (25%) and pyrite (5%), with the principle gangue mineral being barite. Assay values for silver (Table 1) are significant, but no silver minerals were identified.

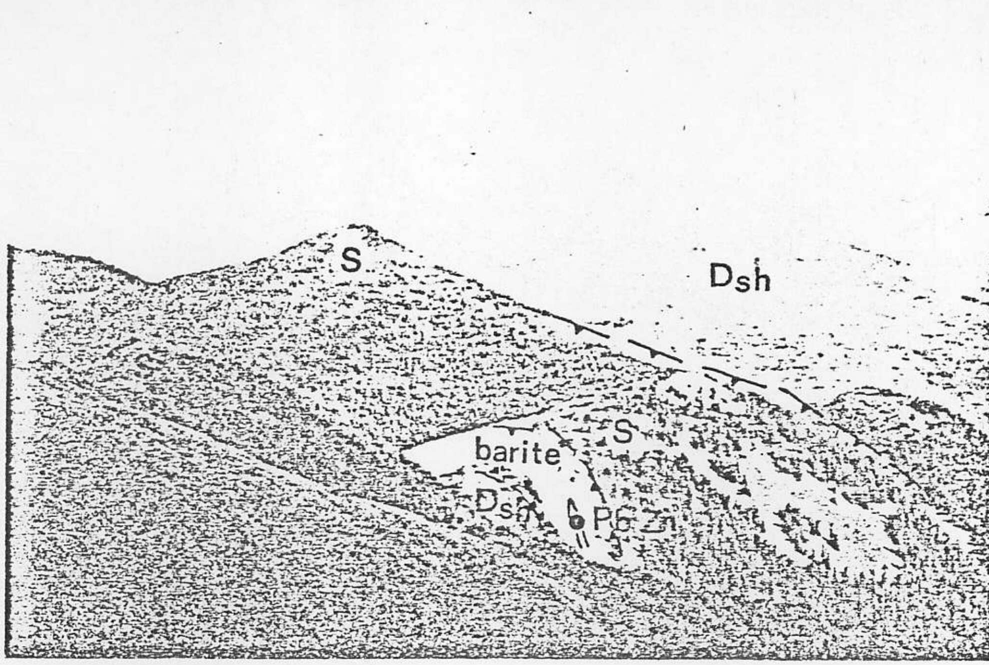


Plate 1 : View from Mt. Alcock looking NE. White area is barite kill zone. See Figure 2 for legend. (MacIntyre, 1980).

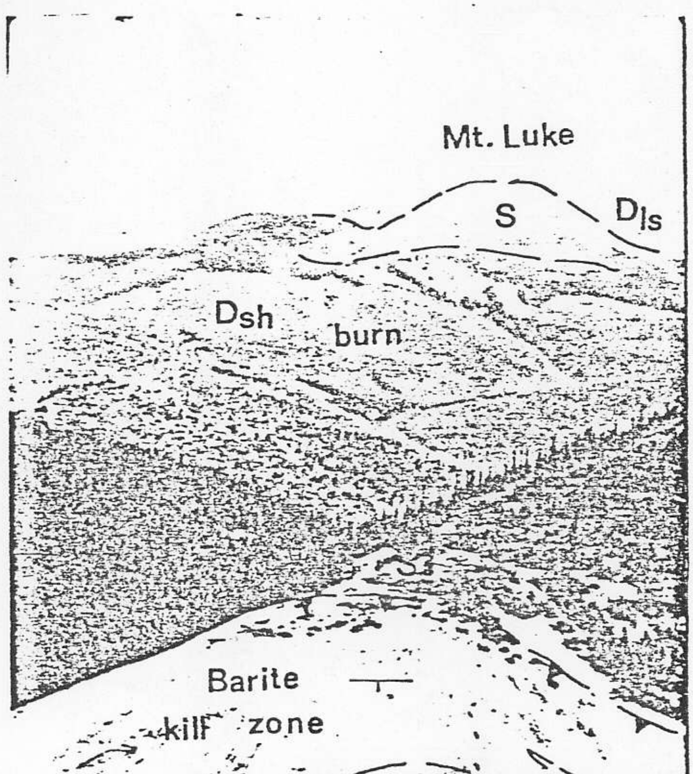


Plate 2 : View E toward Mt. Luke with barite kill zone in foreground. Note location of Pb-Zn zone within kill zone. (MacIntyre, 1980).

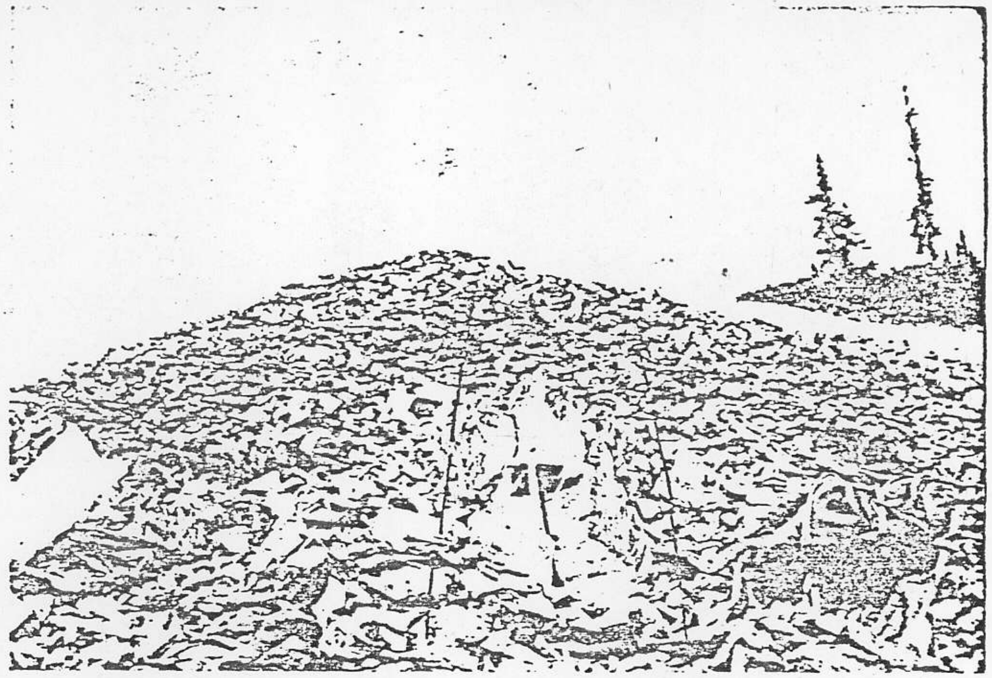


Plate 3 : Close-up of Pb-Zn showing within barite talus slope. Location of photo marked by dot in Plates 1 and 2. (MacIntyre, 1980).

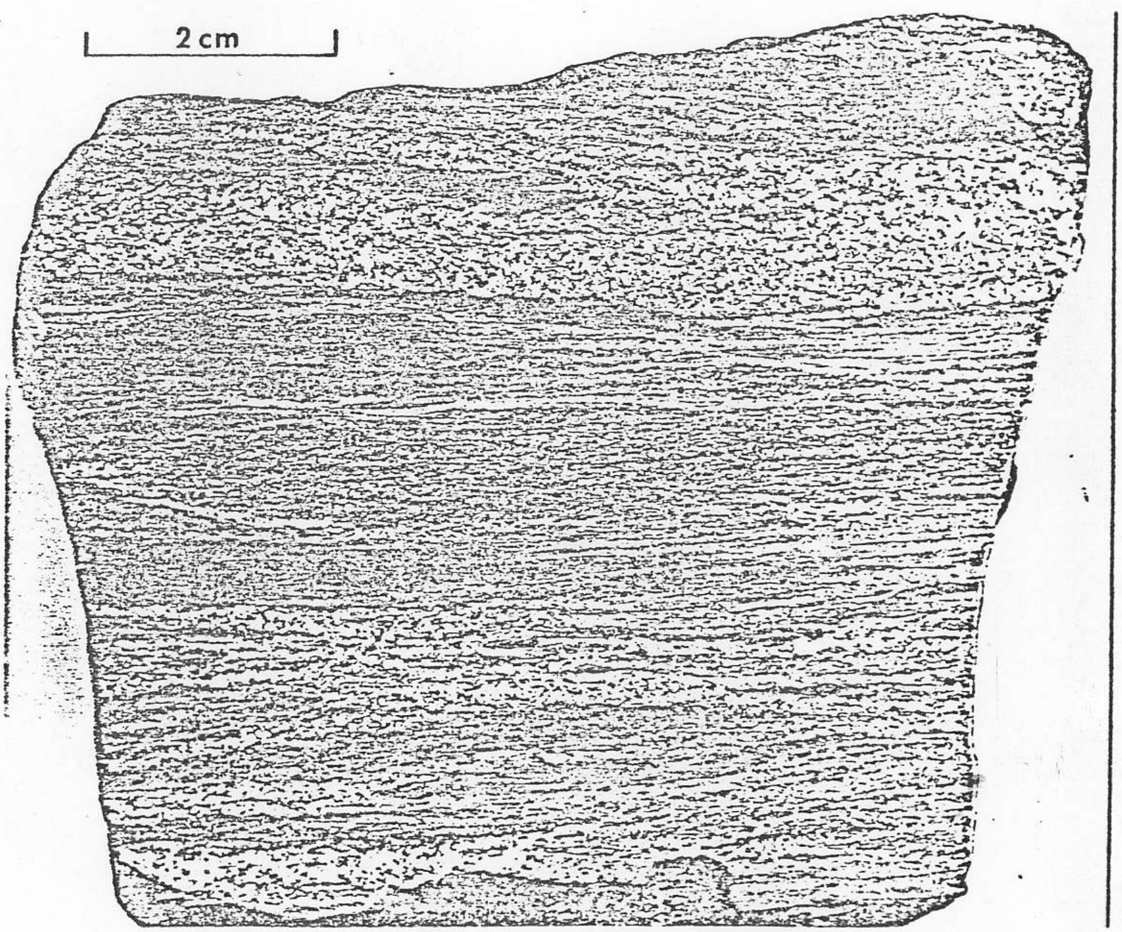


Plate 4 : Polished slab of massive dark grey bedded barite with diffuse bands of galena (white specks). Sample assays 50.3% Ba, 8.4% Pb, 2.41% Zn and 15 ppm Ag. (MacIntyre, 1980).

TEXTURES

The Mount Alcock showing sulphides are very fine grained. Pyrite seems to be predominately as diagenetic framboids (Sketch 1) which are found within sphalerite and to a lesser extent within barite gangue. There are well defined layers of pyrite rich-sphalerite poor sulphides and sphalerite rich-pyrite poor sulphides. Commonly sphalerite is seen within galena filled 'vugs' (Sketch 1A). The galena, in these 'vugs', appears to be replacing the sphalerite as evidenced by the caries texture, but this could just be contemporeneous deposition of galena and sphalerite. There is no diffinitive prove to support the replacement theory, but it is worth keeping in mind. Galena seems to have mobilized under the deformational pressures, associated with thrusting, and subsequently has flowed plastically into fractures in the barite gangue. This mobilization has given galena a very irregular shape, although some galenas are euhedral indicating they have undergone recrystallization. However, the most striking texture, observed in the Alcock section, is the relatively undeformed beds of barite and associated sulphides (Plate 4).

PARAGENESIS

Since only one polished section (i.e. Alcock #1) was examined, development of a paragenetic sequence is difficult and statistically meaningless. However, a highly speculative and statistically invalid sequence was determined. I feel that any data can help in understanding the deposit. Therefore, based on observed textures the following line diagram is proposed:

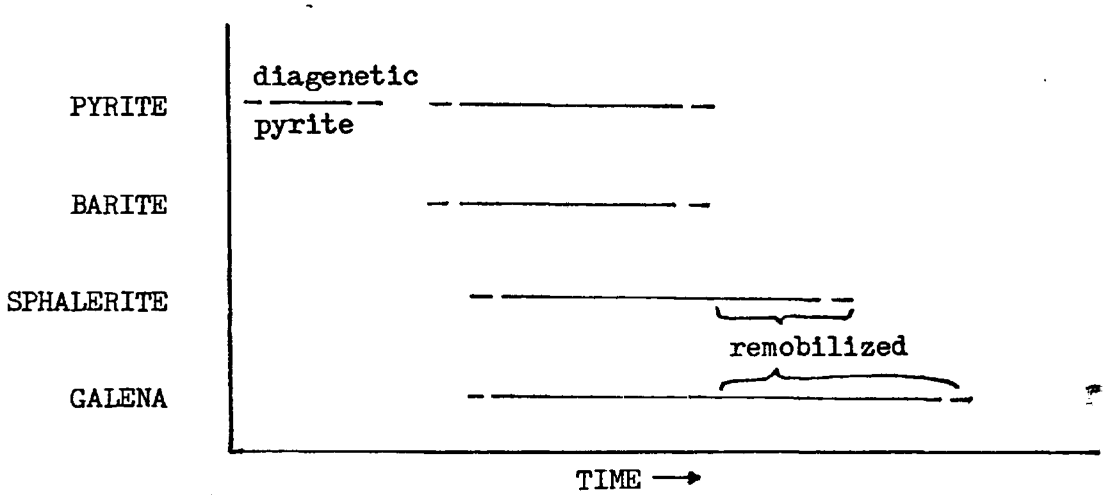
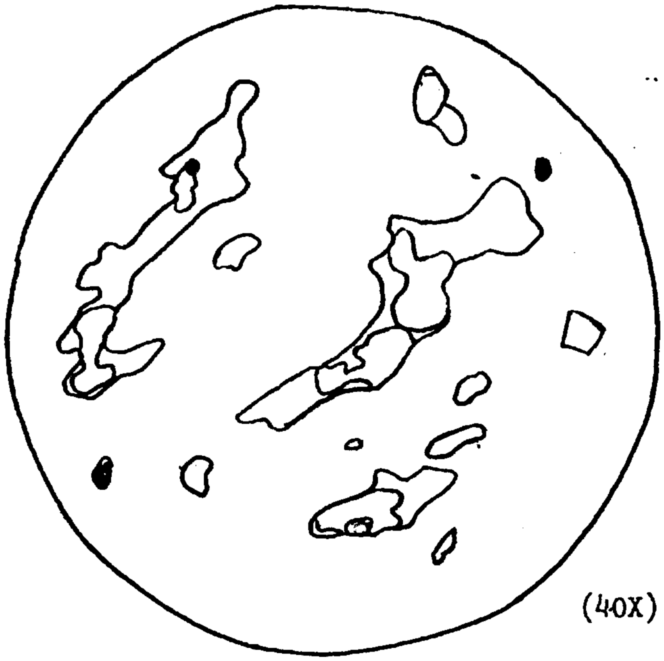


FIGURE 4 : Representative line diagram for the Mount Alcock showing.

SKETCH 1 : Framboidal pyrite (yellow) showing structure of hundreds of minute cubes. Note spherical shape of framboid. (from polished section Alcock #1).



SKETCH 1A : Galena (white) and sphalerite (grey) filling voids in barite (blue) gangue. Note how galena appears to be replacing sphalerite to some extent. Pyrite (yellow) is restricted to sphalerite and barite. (from polished section Alcock #1).

The line diagram indicates initial diagenetic pyrite formation, as framboids, in black pelagic muds on the ocean bottom. A nearby vent provides an exhalative brine rich in barium, lead, zinc and minor silver. As this brine exits the vent it's tempemture is quickly cooled by the surrounding bottom ocean waters. This cooling causes sulphides, and related sulphates, to precipitate and settle to the sea floor gravimetrically. Different sulphides settle at different rates, thus a banding of sulphides is observed on the sea floor and in present day samples. There are multiple pulses of brine input into the basin and the chemistry of the individual brine inputs will determine what sulphides, and how much of each, are present.

The Mount Alcock showing is predominately galena (70%) with minor sphalerite (25%) and pyrite (5%) hosted in massive bedded barite. From this it can be hypothesised that a Ba-Pb rich brine was responsible for the part of the showing sampled and possibly for the Mount Alcock deposit in general. Assays from five grab samples (Table 1) support the hypothesis of a Ba-Pb rich brine (i.e. Zn-Cu poor brine) precipitating out the Mount Alcock showing. However, since no subsurface data exists, one must take into account that there may be some type of metal zonation and that possibly only the galena rich zone has been sampled. This is a definite possiblilty as the deposit dips into the mountain and is obscured from view. Stratiform Ba-Pb-Zn deposits commonly show sulphide and sulphate zonation, both vertically and laterally away from the exhalative vent.

A possible paragenetic sequence for the Mount Alcock showing would start with the formation of diagenetic pyrite framboids. Framboidal pyrite forms diagenetically in black muds on the ocean floor. Anaerobic sulphate reducing bacteria, such as Desulfovibrio or Desulfotomaculum, produce H_2S which reacts with iron to form non-crystalline FeS (i.e. troilite, plus others). At the same time some of the H_2S is oxidized, either by sulphur oxidizing bacteria or inorganically, to elemental sulphur. Some of this elemental sulphur in turn reacts with FeS to form pyrite by the reaction:

$$FeS + S^{\circ} \rightarrow FeS_2$$

The framboidal shape of the pyrite is due to FeS nucleating about a piece of organic matter and subsequently reacting with elemental sulphur causing dewatering and formation of pyrite. The resulting pyrite is controlled by the original spherical shape of the nucleating FeS.

After forming diagenetic pyrite a nearby vent expells a metal rich brine from which predominately PbS and $BaSO_4$ are precipitated, with minor ZnS and FeS_2.

The deposition of the various sulphides is approximately contemporeneous and is very cyclic as evidenced by the layering in the Mount Alcock samples. Later, after lithification of the sulphide bearing strata, and all later sediments, the Mount Alcock deposit underwent minor regional metamorphism. This metamorphism is a result of folding and thrusting caused by the Columbian Orogeny. This low grade metamorphism causes galena and sphalerite to be remobilized and recrystallized. Sphalerite seems to fill fractures and flow into irregular shapes. The galena becomes plastic and flows into fractures in the barite gangue and some galena grains are euhedral-cubic grains having a diameter of 0.1mm. Galena remains in the plastic state after sphalerite plasticity ceases, as evidenced by sphalerite sharing mutual curved boundaries within a galena filled 'vug'. The galena seems to have flowed around the sphalerite and possibly replaced it.

A Van Der Veer diagram for this showing proves to be of little use compared to the line diagram given earlier.

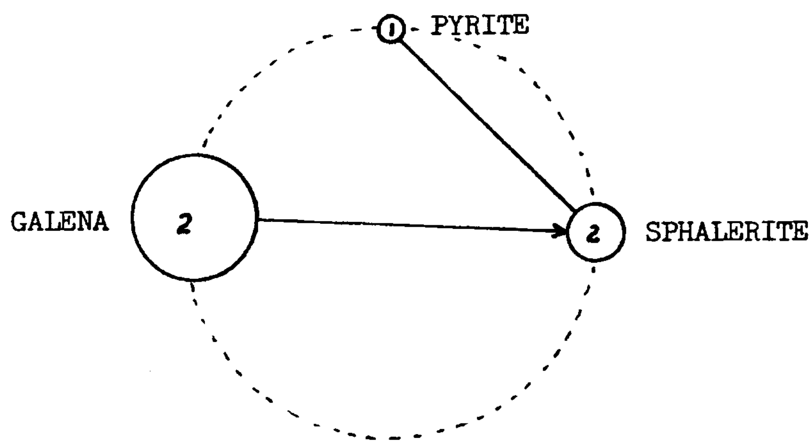


FIGURE 5 : Representative Van Der Veer diagram for the Mount Alcock showing.

PIE SHOWING

GENERAL GEOLOGY

The Pie showing is the working property of Rio Tinto Ltd. with the main exploration target being several barite beds containing varying amounts of galena and sphalerite. The barite beds occur in a silty shale facies, of the Devonian, and are exposed on the southwest limb of an anticline cored by Devonian limestone facies. No stratigraphic thickness of barite is available, to the author, for this showing. Two polished sections were examined from this showing. There are also galena showings in the Devonian limestone, but no samples were taken from this showing.

MINERALOGY

Megascopic examination shows massive, white crystalline barite containing a band like structure, approximately 2cm thick, of coarse crystalline brown sphalerite. Minor pyrite is also associated with the sphalerite band.

Microscopic examination of polished sections Pie #1 and Pie #2 show the Pie to be approximately 60% gangue-40% sulphide. The predominate sulphide is sphalerite (87%), with pyrite (10%) and exsolved chalcopyrite (3%) making up the balance. Very minor amounts of a mineral tentatively identified as Bornite (i.e., Properties: brown bireflectance, poor anistropy, contains crystallographically oriented laths of exsolved chalcopyrite.). Associated with this bornite-chalcopyrite assemblege is minor covellite alteration. An interesting observation is that no galena was found associated with these polished sections, however, as was stated in the general geology there is a galena showing within the nearby limestone facies. The principle gangue mineral, in the bedded sphalerite, deposit is barite.

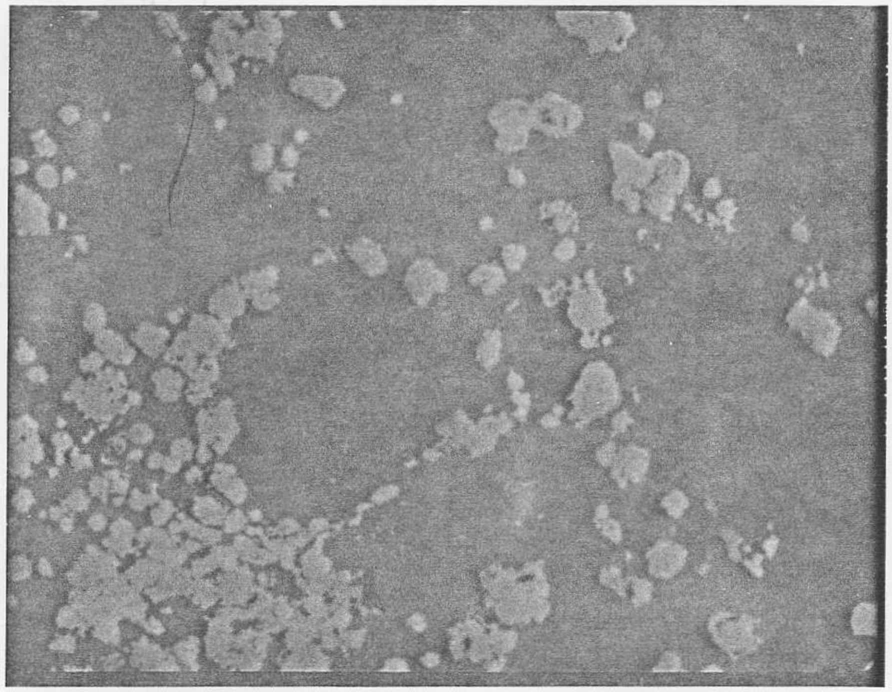
?

TEXTURES

The Pie showing sulphides, particularly the sphalerite, are quite coarse grained (i.e., 4-5mm in diameter) compared to the other showings in the belt. The barite is also coarse grained and resembles some of the white crystalline barites encountered on the Cirque showing. The size of the sphalerite grains indicates recrystallization has taken place, as evidenced by annealed sphalerite

Barite Vein material!

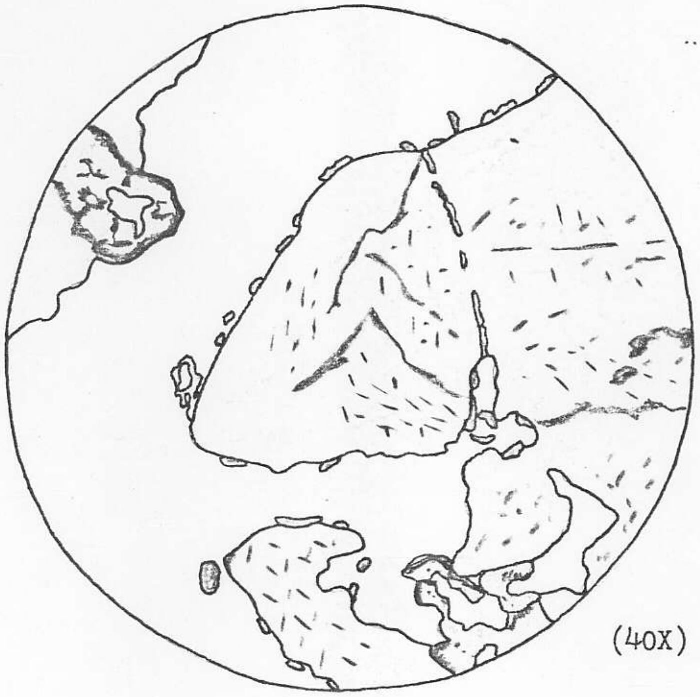
grains (Photomicrograph 1). Annealed sphalerite grains are rimmed by pyrite grains indicating that annealing was a late stage process (Sketch 2).



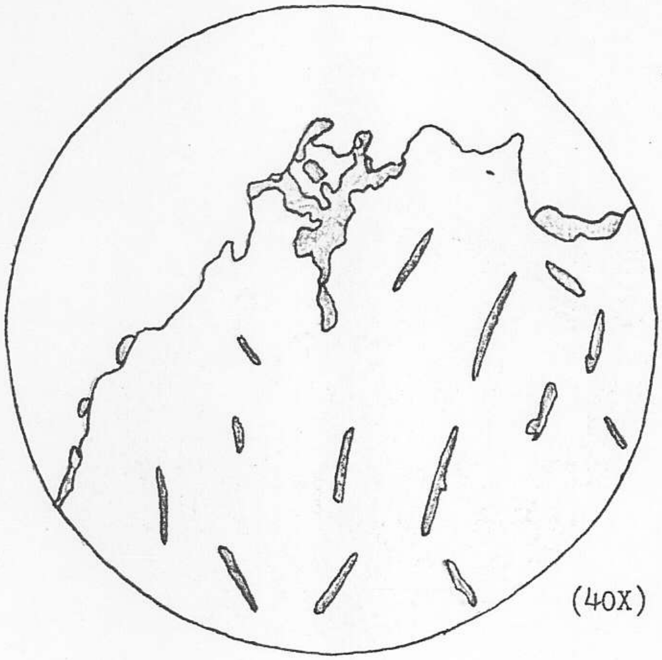
PHOTOMICROGRAPH 1 : G-2, plane light, (461X). Annealed sphalerite grains (light grey) outlined by rimming pyrite grains (white).

The process of annealing allows stresses, and accumulated strains built up due to deformation, to be reduced and eliminated within the sphalerite crystal structure.

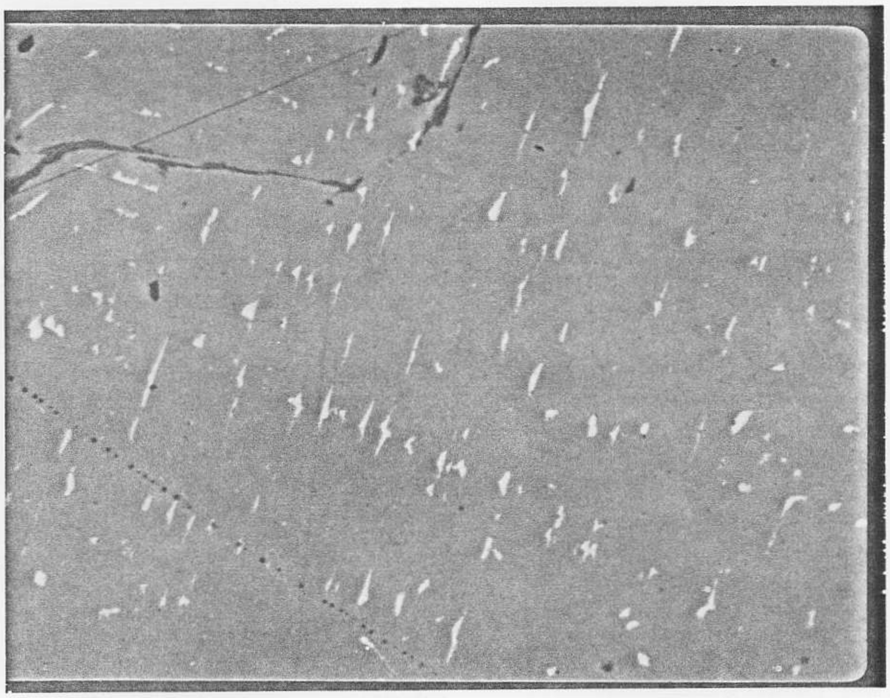
Another interesting texture observed, in the Pie showing sulphides, is sphalerite containing exsolved chalcopyrite (Photomicrograph 2). The exsolution is of two stages; The first is crystallographic (i.e., coherent) exsolution and the second is emulsion (i.e., incoherent) exsolution (Sketch 2 and Sketch 3). Upon cooling of a homogeneous phase, a solution of chalcopyrite separates out forming a myriad of minute blades crystallographically orientated throughout the sphalerite. The chalcopyrite blades are orientated along the (111) and (100) directions (Edwards, 1954) of the sphalerite. Further cooling reveals crystallographic exsolution transforming to an emulsion texture due to loss of crystallographic coherency between the solute and solvent (i.e., chalcopyrite and sphalerite in this case). Not all the sphalerite grains



<u>SKETCH 2</u> : Sphalerite (grey) showing crystallographic exsolution of chalcopyrite (orange). Sphalerite is also rimmed by pyrite (yellow). Note the chalcopyrite which has concentrated outside the grain boundary of the lower most sphalerite grain.(from polished section Pie #1).



SKETCH 3 : Sphalerite (grey) exhibiting crystallographic exsolution of chalcopyrite (orange). Pyrite (yellow) appears to be filling a defect in the sphalerite or actually replacing the sphalerite. (from polished section Pie #1).



PHOTOMICROGRAPH 2 : Pie #1, plane light, (640X). Crystallographic exsolution of chalcopyrite (white) in sphalerite (light grey).

exhibit chalcopyrite exsolution. A texture associated with exsolution is, sphalerite grains, adjacent to coarse grained exsolution bodies of chalcopyrite, seem to be depleted in chalcopyrite. This texture is a result of progressive unmixing in which chalcopyrite actually starts to separate out from its sphalerite host. Also, chalcopyrite is seen to concentrate, as irregular grains, outside adjacent to sphalerite grains which are depleted in exsolved chalcopyrite (Sketch 2). The theory to explain this phenomenon is not well understood, but when chalcopyrite is exsolving from sphalerite it forms along crystallographic orientations within the sphalerite. High temperature deposits that are, locally, quickly cooled tend to allow the chalcopyrite to migrate by diffusion, along crystallographic planes, to the host's grain boundary. An approximate temperature of between 350°C and 400°C is needed for chalcopyrite to exsolve from sphalerite. Locally, higher temperatures and concentrations of solute will cause granular chalcopyrite to exist at grain boundaries of sphalerite.

Polished section Pie #1 contains a single grain of, tentatively determined, bornite showing exsolved chalcopyrite blades in crystallographic orientations (Photomicrograph 3).

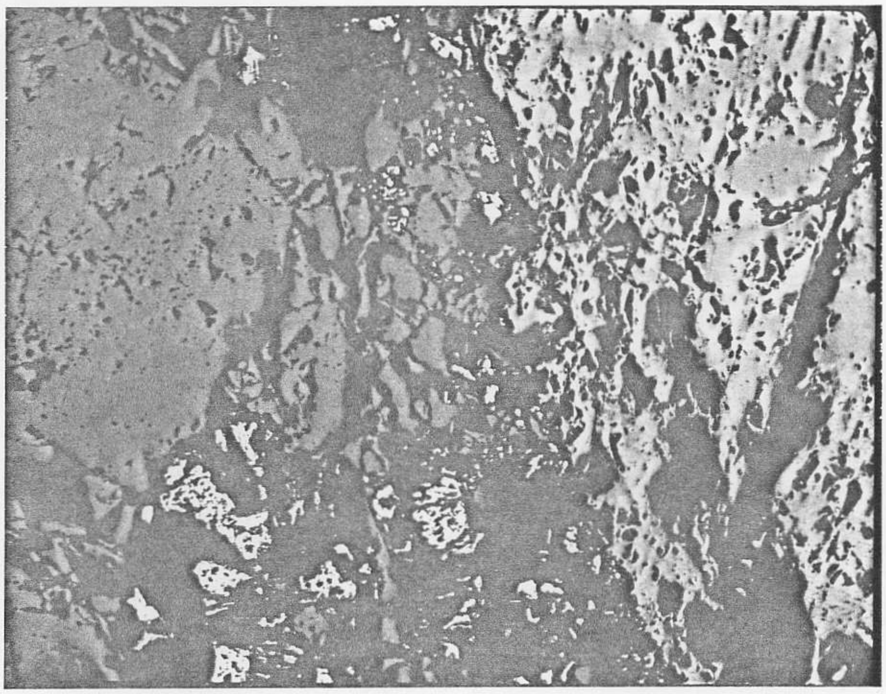
PHOTOMICROGRAPH 3 : Pie #1, plane light, (800X). Bornite ? showing crystallographic exsolution of lathy chalcopyrite (white laths). Also, covellite (dark dendritic pattern) is altering the bornite-chalcopyrite assemblege. Note intergrowth of chalcopyrite. Also note the mutual boundaries shared with sphalerite.

The bornite also contains a vermicular intergrowth of chalcopyrite (Photomicrograph 3). Sphalerite shares mutual grain boundaries with this bornite-chalcopyrite assemblege indicating contemporeneous deposition. Covellite is seen to be altering from the bornite-chalcopyrite assemblege (Photomicrograph 3). This isolated occurence of bornite-chalcopyrite is very anomalous and therefore it will not be dealt with in to great a detail.

Pyrite appears to form what at first glance looks like crystallographic exsolution in sphalerite (Photomicrograph 4). However, pyrite does not exsolve from sphalerite as is indicated on any phase diagram for the pair. The explanation is the pyrite is replacing the sphalerite along defects, which in this case coorespond with cleavage directions, within the sphalerite lattice. Grain boundaries also control pyrite replacement of sphalerite. Anhedral pyrite is commonly seen up to 0.5mm in diameter. This pyrite surrounds sphalerite grains and fills fractures in both the sphalerite and barite.

PHOTOMICROGRAPH 4 : Pie #1, plane light, (160X). Pyrite (anhedral white grains) replacing sphalerite (light grey) along cleavages within the grain and also replacing sphalerite along grain boundaries.

The polished sections from the Pie locally exhibit brecciation (Photomicrograph 5). Both barite and pyrite appear to be brecciated by the infilling of an unknown gangue mineral (i.e., Properties: blackish-grey bireflectance, bluish-white under crossed nicols).



PHOTOMICROGRAPH 5 : Pie #2, plane light, (70X). Unknown gangue (black) infilling fractures in brecciated barite (dark grey), sphalerite (light grey) and pyrite (white).

PARAGENESIS

Based on observed textures,from polished sections Pie #1 and Pie #2, the following line diagram was developed:

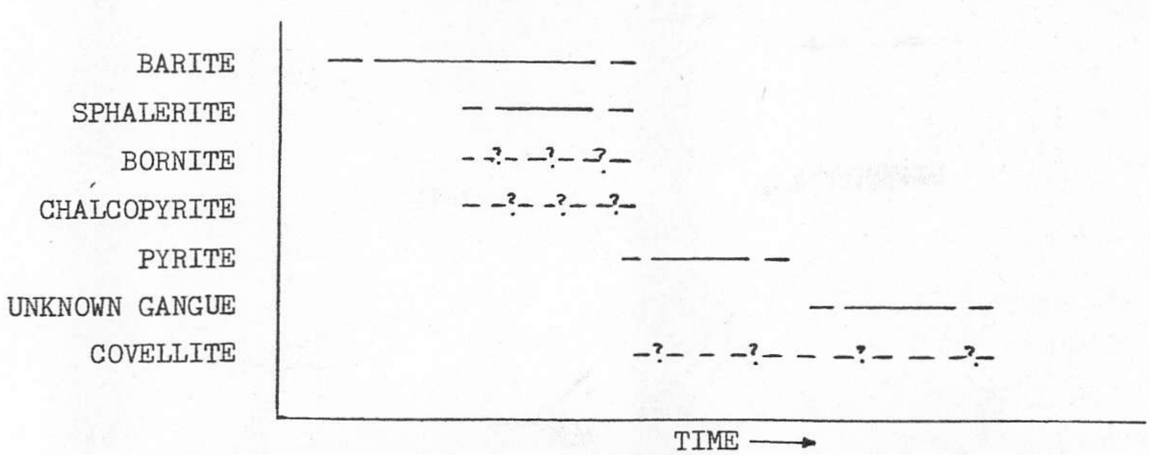


FIGURE 6 : Representative line diagram for the Pie showing.

The line diagram indicates initial barite precipitation in a hydrothermal type of situation, as evidenced by the presence of exsolved chalcopyrite and lack of diagenetic framboidal pyrite. Exsolution chalcopyrite occurs at a temperature of between 350° C and 400° C , indicating the Pie was locally at a higher temperature then the surrounding deposits.

The presence of chalcopyrite exsolved in bornite indicates a temperature of approximately 475° C (Edwards, 1954). Thus, the brine containing the Zn and Cu was likely in the 500° C range when it entered into the cool ocean waters at the vent mouth. Sphalerite, chalcopyrite and bornite are all contemporeneous along with the barite gangue. After cessation of these mineral's precipitation there is a sequence of pyrite deposition. Pyrite occurs as rims and cleavage fillings in sphalerite indicating it was precipitated during the waning part of sphalerite deposition. The sphalerite grains are then annealed, explaining why pyrite stringers are found between individual sphalerite grains. Annealing of the sphalerite grains must have occured over a sufficiently long period of time, so as to allow the chalcopyrite, observed outside adjacent to depleted sphalerite grains, to diffuse unarrested (Edwards, 1954).

The last stage of mineral deposition is precipitation of the unknown gangue by hydrothermal solutions passing through the ore deposit. the unknown gangue surrounds all the sulphides as well as the barite gangue. Covellite alteration of the bornite-chalcopyrite assemblege completes the paragenetic sequence. A representative Van Der Veer diagram follows:

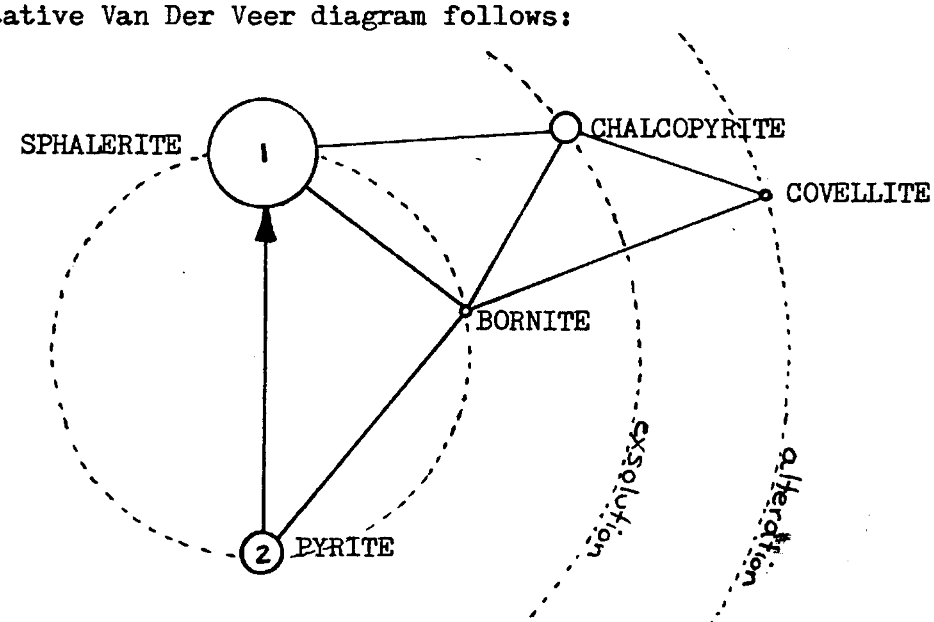


FIGURE 7 : Representative Van Der Veer diagram for the Pie showing.

B.S.
This is no more stratiform than worse policy
lack of stratiform indicators:
- framboidal pyrite
- coarse grained
- high Zn/Cu
- high temp!

CIRQUE DEPOSIT

GENERAL GEOLOGY

The Cirque deposit is by far the most significant deposit in the belt with 30 million tons,of 2.3% Pb, 7.9% Zn and 49g/ton Ag, having been defined and still the deposit is thickening down dip. The Cirque deposit is contained within a thrust panel of Devonian shales with the mineralization occuring in a 100 meter section of siliceous argillite, chert and carbonaceous black shale (Figure 8). These rocks are of Late Middle to Upper Devonian age. The deposit is preserved in an overturned synclinal structure which has been overridden by three thrust plates of Silurian Siltstone (Figure 9). Seven polished sections were examined for this deposit.

Assays of four grab samples and one piece of core follow:

Sample No.	Ag	Ba	Cu	Pb	Zn
	ppm	per cent	ppm	per cent	ppm
Cirque 1	<10	57.03	15	1.7	13
Cirque 2	17	51.34	6	10.4	581
Cirque 3	<10	56.52	5	2.6	133
Cirque 4	18	0.03	155	0.33	1 850
79–CQ–51	<10	19.60	45	0.013	40

SAMPLE DESCRIPTIONS

Cirque 1-3 – massive coarsely crystalline white barite with blebs of galena; samples from barite kill zone, K showing.

Cirque 4 – laminated pyrite in siliceous black shale; float in creek, southeast of K showing.

79–CQ–51 – nodular barite in carbonaceous black shale; outcrop on ridge, 700 metres east-southeast of K showing.

TABLE 21: Assays of five samples from the Cirque Deposit (MacIntyre, 1980).

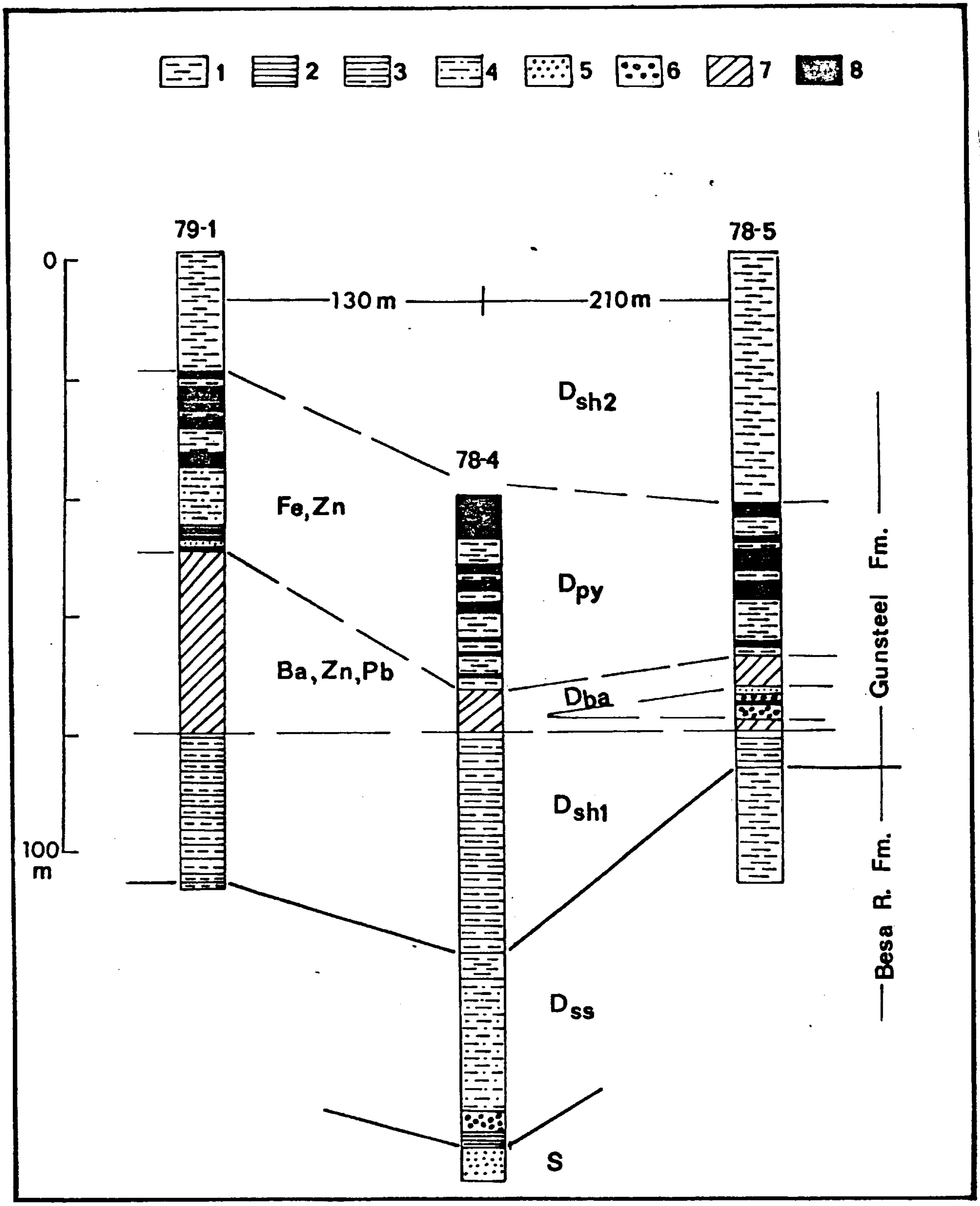


Figure 8 : Composite drill section, Cirque claims (see Figure 10 for location of drill holes). (1 = weakly to moderately siliceous shale and argillite, 2 = siliceous argillite, chert, 3 = interbedded siliceous argillite, chert and shale, 4 = silty shale, 5 = siltstone, 6 = conglomerate, 7 = massive barite, 8 = laminated pyrite in shale). (MacIntyre, 1980).

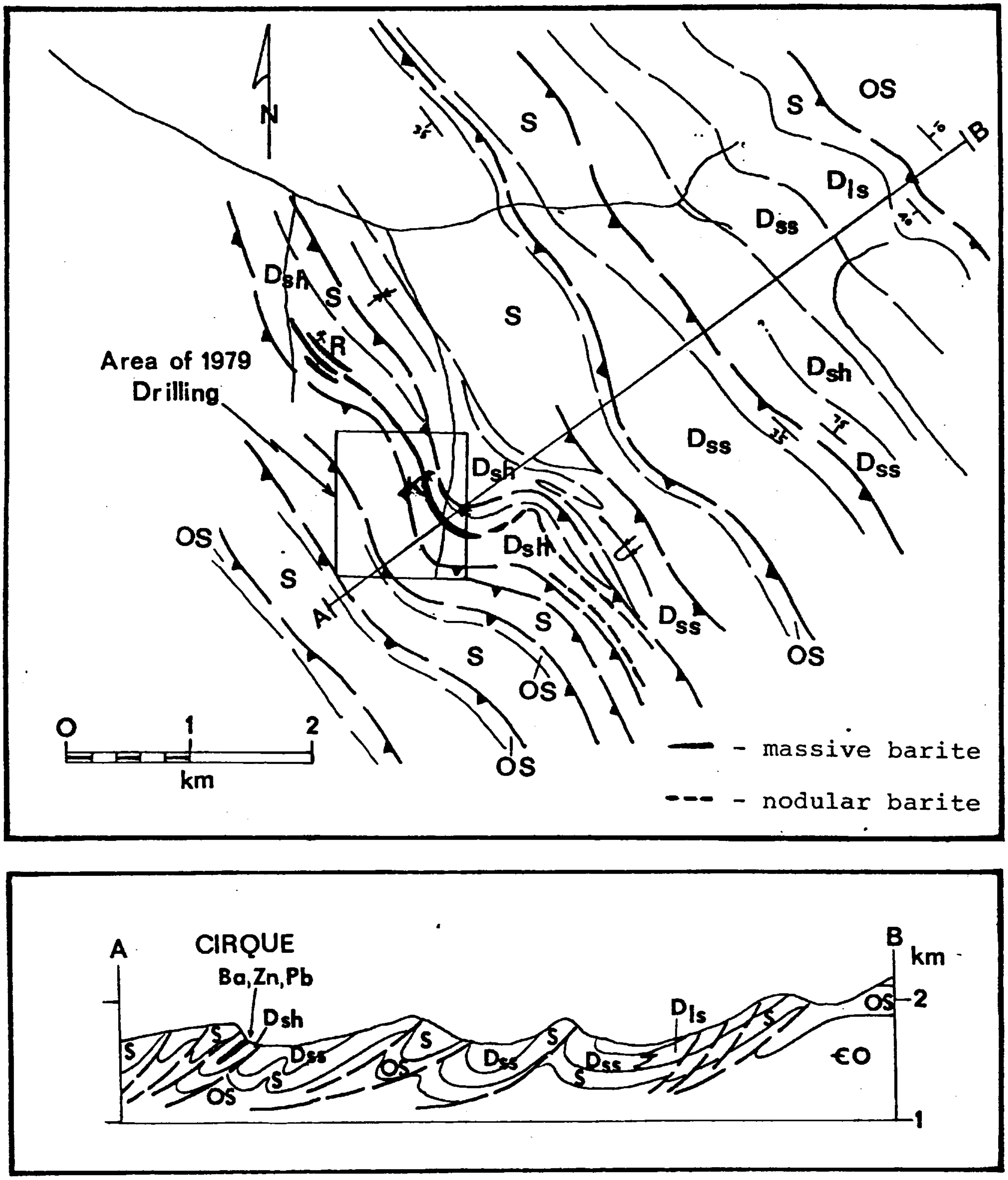
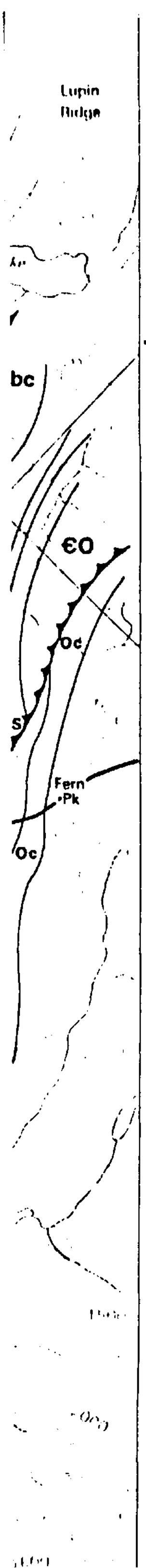


Figure 8 : Geology of the Cirque claims (see Figure 9A for legend). (MacIntyre, 1980).



LEGEND

UPPER TRIASSIC

TR BROWN–WEATHERING FOSSILIFEROUS DOLOMITIC SILTSTONE, MINOR ARGILLACEOUS LIMESTONE; BASAL UNIT OF CHERT

MIDDLE/UPPER DEVONIAN

Dbc BLACK CLASTICS, UNDIFFERENTIATED

Dcc GREY TO BROWN – WEATHERING SANDSTONE, SILTSTONE AND POLYMICTIC PEBBLE CONGLOMERATE; MINOR PELAGIC CHERT AND SHALE

Dsh BLUE–GREY–WEATHERING, BLACK CARBONACEOUS SHALE, SILTY SHALE, SILICEOUS ARGILLITE LOCALLY WITH NODULAR AND MASSIVE BARITE AND LAMINATED PYRITE INTERBEDS; MINOR CHERT, LIMESTONE, SILTSTONE (GUNSTEEL FORMATION)

LOWER/MIDDLE DEVONIAN

Dss GREY TO BROWN – WEATHERING SILTY SHALE, SILTSTONE, SANDSTONE; MINOR SILICEOUS ARGILLITE, LIMESTONE (BASINAL EQUIVALENT OF UNIT Dls)

Dls THICK–BEDDED GREY–WEATHERING FOSSILIFEROUS LIMESTONE; LIMESTONE TURBIDITES AND DEBRIS FLOWS WITH INTERBEDDED CHERT, QUARTZ SILTSTONE, CALCAREOUS SILTSTONE, GRAPTOLITIC SHALE, AND BLACK FETID LIMESTONE

SILURIAN

S BROWN TO ORANGE–WEATHERING, LAMINATED AND FLASER–BEDDED DOLOMITIC SILTSTONE; BASAL UNIT OF GREY BLOCKY LIMESTONE, DOLOSTONE, AND INTERBEDDED BLACK CHERT AND SILTY SHALE IN AKIE RIVER AREA

MIDDLE ORDOVICIAN/SILURIAN

OS ROAD RIVER FORMATION: BLACK GRAPTOLITIC SHALE; CREAM, BROWN, AND GREY–WEATHERING, LAMINATED CALCAREOUS SILTSTONE AND SILTY SHALE; BASAL UNIT OF LIMESTONE TURBIDITES AND DEBRIS FLOWS IN AKIE RIVER AREA

Ov ORANGE AND GREEN–WEATHERING VITRIC, CRYSTAL, AND LAPILLI TUFF, GREEN MICRODIORITIC FLOWS; LOCALLY INTERBEDDED WITH BLACK GRAPTOLITIC SHALE IN AKIE RIVER AREA

Oc SKOKI FORMATION: MASSIVE DOLOSTONE, DEBRIS FLOWS

UPPER CAMBRIAN/LOWER ORDOVICIAN

€O KECHIKA GROUP: LIGHT GREY TO CREAM–WEATHERING, TALCY, NODULAR PHYLLITIC MUDSTONE; ARGILLACEOUS, WAVY BANDED LIMESTONE; MINOR CRYSTAL TUFF INTERBEDS

LOWER/MIDDLE CAMBRIAN

€ GREY–WEATHERING, THICK–BEDDED, MASSIVE MICRITIC LIMESTONE, QUARTZITE; MINOR BLACK SHALE, DOLOMITIZED BRECCIA, AND QUARTZ PEBBLE CONGLOMERATE

PROTEROZOIC/CAMBRIAN

P€ PHYLLITE, SCHIST, QUARTZITE, PEBBLE CONGLOMERATE; MINOR LIMESTONE

FIGURE 9A : Legend for Figures 9 and 10 (MacIntyre, 1980).

SYMBOLS

THRUST FAULT ....

OVERTURNED SYNCLINE, OVERTURNED ANTICLINE ....

SYNCLINE, ANTICLINE ....

GOSSAN/Fe SEEP .... ×

NODULAR BARITE .... □

MASSIVE PYRITE (± Zn, Pb) .... ■

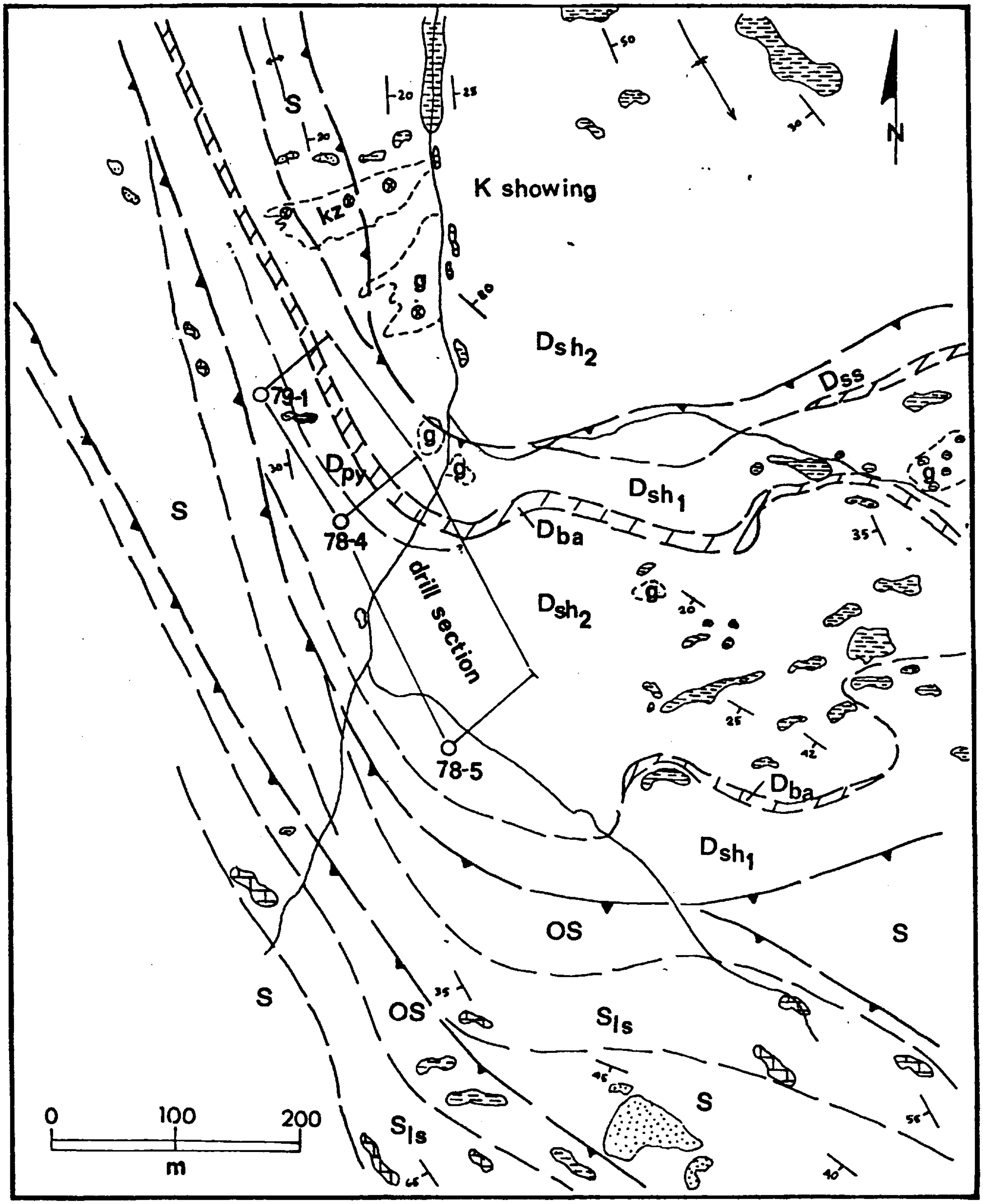


Figure 10 : Detailed geology in the vicinity of the K showing as modified from company plans (see Figure 2 for location of map-area and Figure 9A for legend). Lithologic units are described in text. (g = gossan, Kz = kill zone, x - barite, Pb, Zn float). (MacIntyre, 1980).

MINERALOGY

Megascopic examination shows various types of massive and layered sulphides. There are two types of sulphide ore observed within the Cirque deposit. The first type is massive white crystalline barite containing discontineous lensoidal bands of galena approximately 1mm thick. The banding is relic bedding and is somewhat wavy in appearance. There is no visible sphalerite or pyrite in handspecimens of this ore. Galena also seems to form pods interstitial to the barite. The second type of ore is very pyritic with little sphalerite or galena visible in handspecimen. Barite and black shale host the layered sulphides. Bedding is distinct but somewhat deformed. The two sulphide ore types are based only on handspecimen examinations.

Guess again

Microscopic examination of polished sections Cirque #1, Cirque #4, G-2, G-6, G-7, G-8, and G-11, show the Cirque deposit to be characterized by three distinct ore types. From field knowledge of the deposit I will suggest that there are five ore types that characterize the Cirque deposit. The seven polished sections examined are from three of the five ore types. The reason for this is that two of the five ore types are strictly barite and contain no sulphides. The five ore types that characterize the Cirque deposit are as follows:

(1) Nodular diagenetic barite.

(2) Massive bedded barite with no sulphides.

(3) Massive, white crystalline barite containing predominately galena (85%) with minor sphalerite (11%) and pyrite (4%).

(4) Layered bands of predominately pyrite-sphalerite (93% combined) with little or no galena (7%). Slightly deformed bedding is distinct.

(5) Massive pyrite (85%) with very minor galena-sphalerite (15% combined). Pyrite is principally of diagenetic origin.

Of the seven polished sections examined in this section; two are from ore type (3), four are from ore type (4) and one is from ore type (5).

TEXTURES

There are many textures encountered in the Cirque deposit ores, so this report will deal with each ore type and it's related textures in order to be systematic.

Ore Type (3)

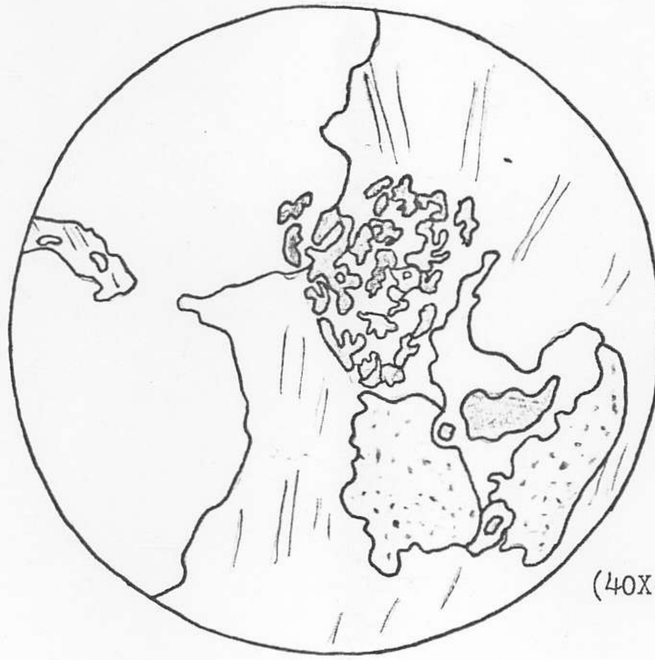
Two polished sections, Cirque #1 and Cirque #2, were examined from this ore type.

Pyrite is a minor sulphide in this ore type and it occurs as sub-rounded anhedral grains associated with sphalerite rich layers.

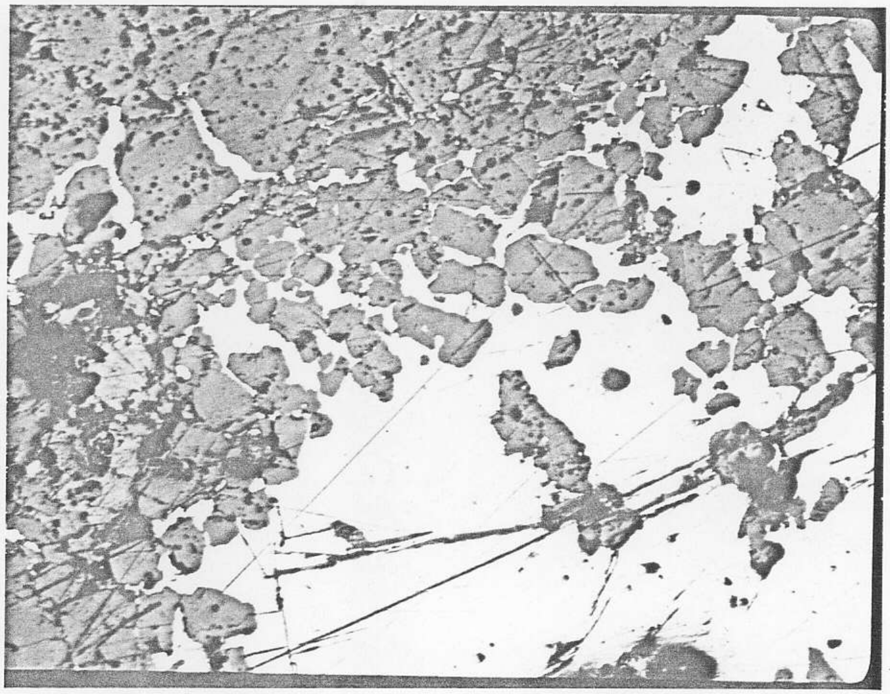
Sphalerite appears to be of two types, one of which is not found in abundance. The predominate type of sphalerite surrounds the sub-rounded pyrite grains mentioned above. The minor type of sphalerite is only found in polished section Cirque #1 and constitutes approximately 0.2% of the total sphalerite found in that section. This minor sphalerite contains incoherent exsolution of chalcopyrite.

Galena is the dominate sulphide in this ore type and it is commonly seen infilling fractures in the barite gangue. Rounded barite grains are seen to 'float' in galena adjacent to barite gangue walls (Photomicrograph 6). This texture indicates that galena has been emplaced by an open space filling hydrothermal solution or by remobilization from an existing bed and plastically 'shot' into barite fractures.

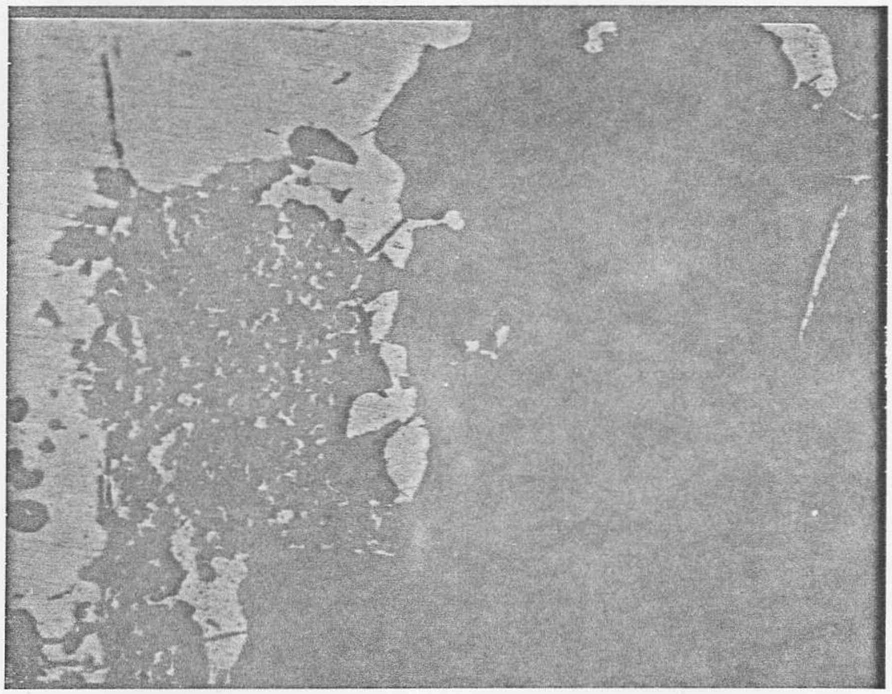
There is also an unknown gangue mineral (i.e., Properties: brown colour, cross-hatched yellow anistropy). Galena seems to be replacing the barite that is intamately intergrown with the unknown gangue (Photomicrograph 7 and Sketch 4). It is very difficult to determine whether the galena is actually replacing the unknown gangue or the barite. However, galena replacing the barite seems the most reasonable considering the textural evidence.



SKETCH 4 : Sphalerite (grey) containing pyrite (yellow). Unknown gangue (red) is being replaced by galena (white) at first glance, but is in fact being replaced by none of the minerals. The galena (white) is replacing the barite (blue) which is intamately intergrown with the unknown gangue (red). (from polished section Cirque #1).



PHOTOMICROGRAPH 6 : Cirque #1, plane light, (109X). Galena (white) infilling fractures in barite (grey). Note rounded shape of the barite grains.



PHOTOMICROGRAPH 7 : Cirque #1, plane light, (270X). Galena (white) replacing barite (dark grey) which is intamately intergrown with an unknown gangue mineral (mottled grey within the galena).

Ore Type (4)

Four polished sections, G-2, G-6, G-7 and G-11, were examined from this ore type.

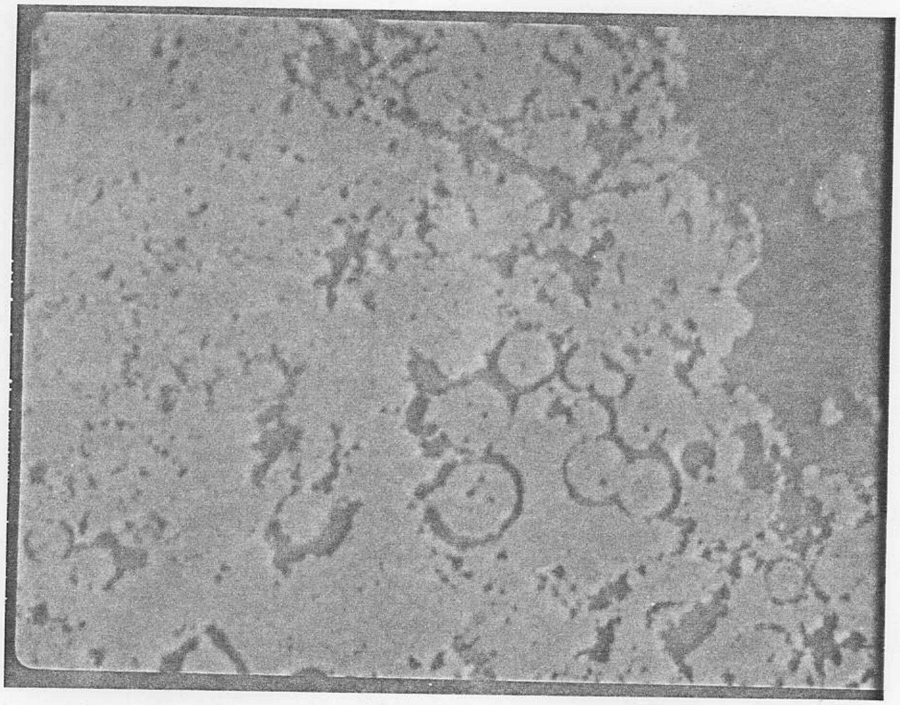
Galena is the minor sulphide in this ore type and occurs as inclusions in sphalerite and is also seen filling radial fractures developed in pyrite. Galena does not seem to be directly associated with pyrite except where pyrite grains, rimmed with barite gangue, are 'floating' in galena 'matrix'.

Sphalerite and pyrite are the dominate sulphides in this ore type. Sphalerite contains framboidal pyrite with both being alined in bedding planes. Sphalerite is of two types; the first type being originally precipitated and subsequently annealed by metamorphism and the second type being a remobilized type one sphalerite that has been 'shot' into fractures in pyrite. This second type of sphalerite also includes sphalerite that is found as zones in colliform pyrite. Sphalerite also occurs as annealed grains which is classified as a type one sphalerite. These annealed sphalerite grains are commonly rimmed by pyrite (Photomicrograph 1).

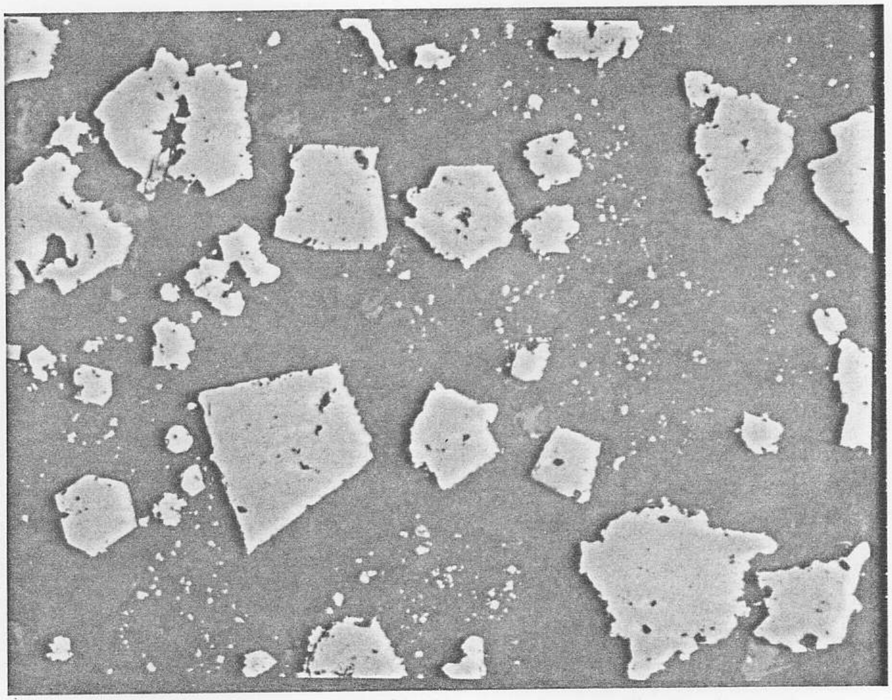
Pyrite exhibits the most interesting texture found in this ore type. There are two types of pyrite present in this ore type. The first type of pyrite is of diagenetic origin and occurs in the form of framboids (Sketch 5). The second type of pyrite is derived from an exhalative brine and occurs as colliform pyrite, commonly with a diagenetically derived core (Sketch 5). This second type of pyrite includes framboidal pyrites that have formed aggregates due to addition of FeS_2 from exhalative brines (Photomicrograph 8). These aggregates are in turn seen to be forming recrystallized euhedral pyrite grains (Photomicrograph 9).

However, the most interesting textures found within this ore type are, sphalerite filled curved fractures in pyrite and sphalerite rich zones in colliform pyrite (Photomicrograph 11 and Photomicrograph 10).

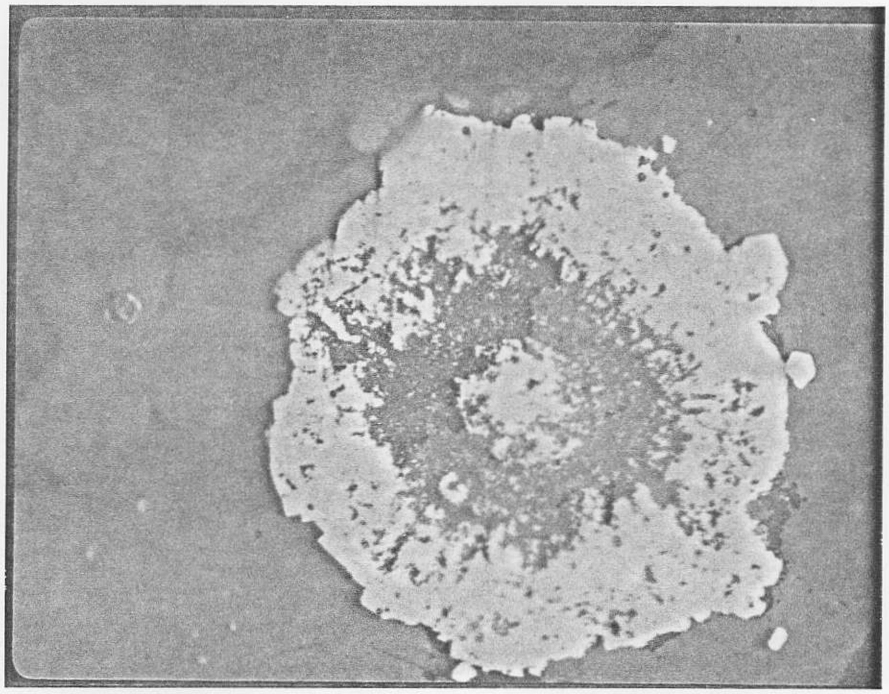
Atoll Structure



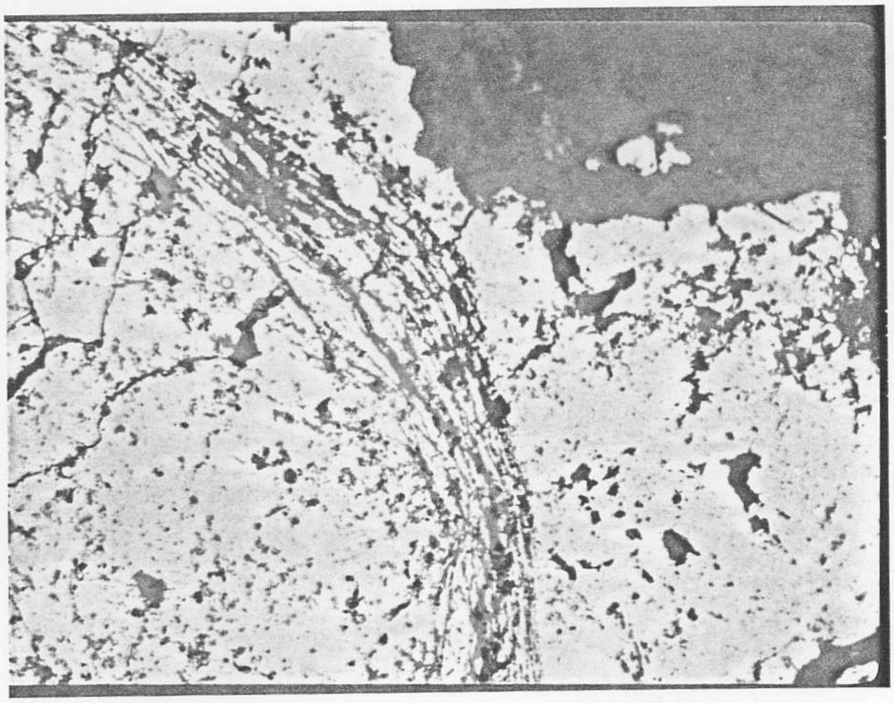
PHOTOMICROGRAPH 8 : G-11, plane light, (832X). Pyrite (white) aggregate showing relic framboidal texture (dark rings).



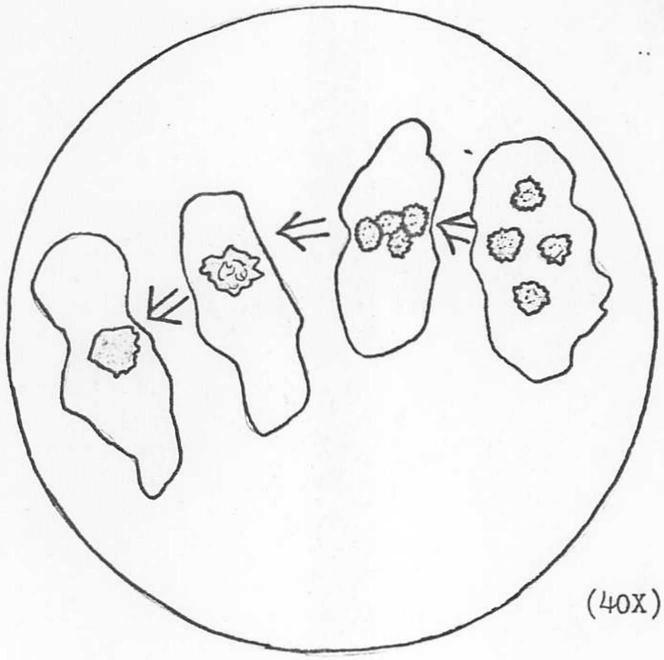
PHOTOMICROGRAPH 9 : G-7, plane light, (384X). Euhedral pyrite grains (white) in barite gangue (groundmass).



PHOTOMICROGRAPH 10 : G-6, plane light, (1840X). Colliform pyrite (white) containing a concentric zone of sphalerite (light grey) and unknown gangue material (dark grey). All are within sphalerite (light grey). Note euhedral pyrite facies on the edges of the outer layer of the colliform pyrite.



PHOTOMICROGRAPH 11 : G-11, plane light, (461X). Concentric fractures in pyrite (white) filled by sphalerite (light grey) and unknown gangue (dark grey).



SKETCH 5 : Various stages of pyrite crystal developement as observed in polished sections from the Cirque deposit. The stages progress from diagenetic framboidal pyrite (far right), to clustered framboidal pyrites (middle right), to aggregated pyrite showing relic framboidal structures (middle left), to the final stage observed of euhedral pyrite (far left). (from polished section G-2).

Ore Type (5)

One polished section, G-8, was examined from this ore type. This ore type is characterized by framboidal pyrite occuring in a sphalerite 'matrix'. Unlike ore type (4), where sphalerite was replacing and filling fractures in pyrite, here sphalerite is not seen replacing pyrite. The sphalerite and pyrite occur together as bands, some pyrite-rich-sphalerite poor and some sphalerite rich-pyrite poor.

The minor galena that is found is predominately interstitial to the barite gangue and occassionly is found as inclusions in sphalerite.

PARAGENESIS

An individual paragenesis for each of the three ore types will be constructed and then incorporated into an overall paragenetic sequence for the Cirque deposit.

Ore Type (3)

Paragenesis of ore type (3) is based on textural relationships observed in polished sections Cirque #1 and Cirque #4. The following line diagram is proposed:

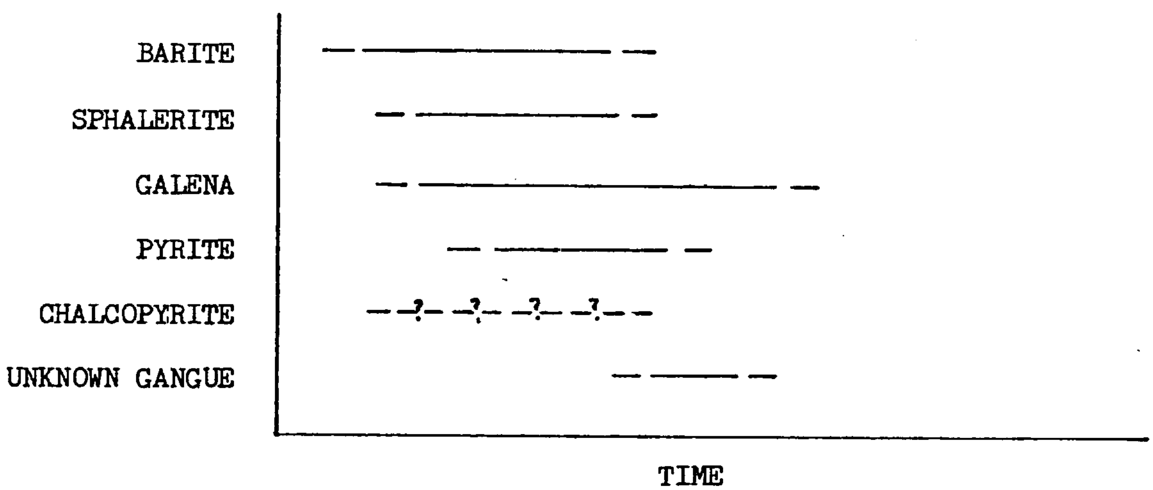


FIGURE 11 : Representative line diagram for Ore Type (3).

The line diagram indicates barite, sphalerite and galena where deposited more or less contemporeneously. Exsolution of chalcopyrite in sphalerite can not be determined as is indicated on the line diagram. Some sphalerite layers are rich in pyrite and others are devoid of pyrite. This indicates that pyrite was deposited purely randomly, but with sphalerite as an associate. Locally, sphalerite due to higher temperatures, and increased copper concentrations, shows exsolution of chalcopyrite. At approximately 400°C the chalcopyrite exsolved out of the sphalerite. This process is a minor one in the Cirque deposit as it was not very pervasive.

Generally, barite and galena are associated and appear to be contemporeneous with each other. Meanwhile, sphalerite and pyrite form a second contemporeneous assemblege with sphalerite commonly occuring alone. Galena has later, due to regional metamorphism, flowed plastically into fractures in the barite gangue and also replacing the barite locally.

The following Van Der Veer diagram proves to be of little use, but is included to stress just this point:

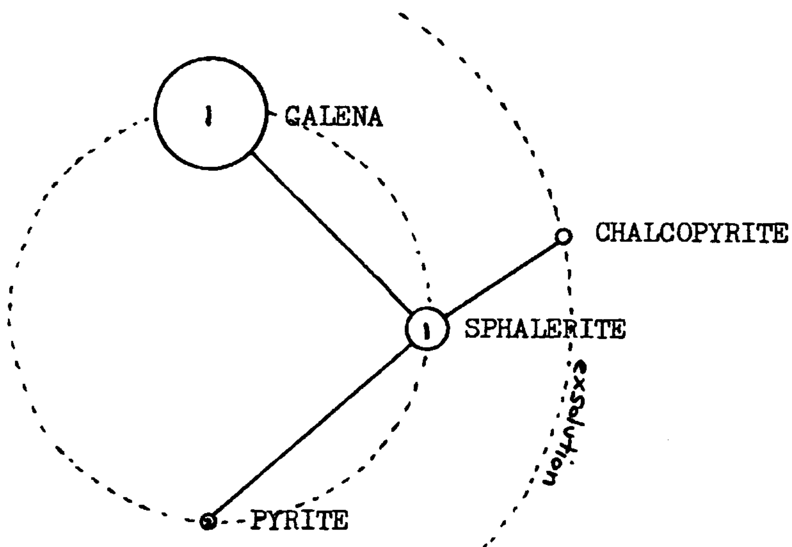


FIGURE 12 : Representative Van Der Veer diagram for Ore Type (3).

Ore Type (4)

Paragenesis of ore type (4) is based on textural relationships observed in polished sections G-2, G-6, G-7 and G-11. The following line diagram is proposed: (see following page).

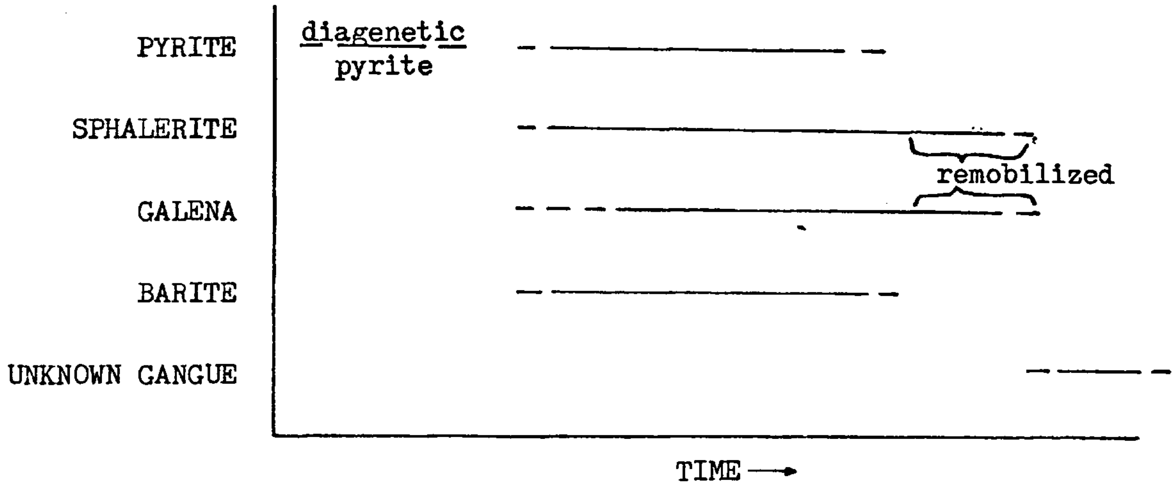
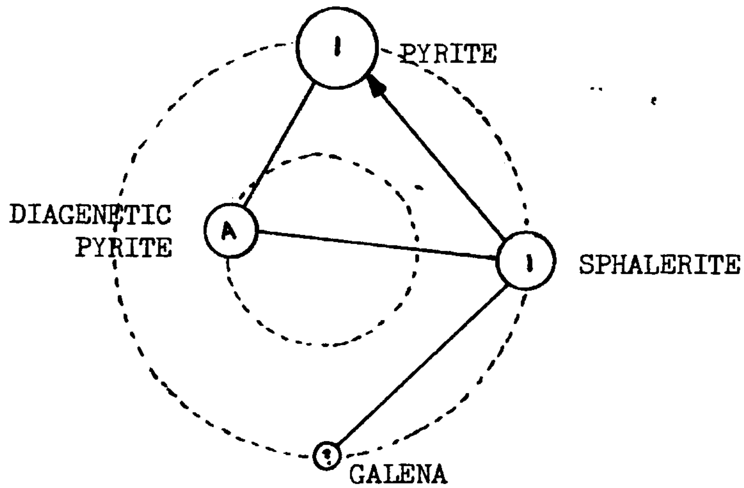


FIGURE 13 : Representative line diagram for Ore Type (4).

Diagenetic pyrite is the first sulphide to appear. This early pyrite takes on a framboidal shape while hosted within the black muds of the ocean bottom. Then an exhalative brine is expelled from a nearby vent and sulphides and sulphate begin to precipitate out. The first two sulphides to form are sphalerite and pyrite. Existing framboids of pyrite become nucleating centers for the new sulphides, as is evidenced by the colliform pyrite. Another process happening contemporenously is the growth and accretion of individual framboids into massive aggregates. Relic impurity rings, from the earlier framboidal pyrites, are seen in these massive aggregates (Photomicrograph 8). Galena begins to settle out during the sphalerite sequence.

Both galena and sphalerite show signs of remobilization into fractures in pyrite and barite. Sphalerite is remobilized into concentric fractures in massive pyrite and into radial like fractures in the colliform pyrite. Some this sphalerite may be replacing the pyrite,but it is very difficult to be certain. The last stage of mineralization is the influx of an unknown gangue via late, migrating hydrothermal solutions.

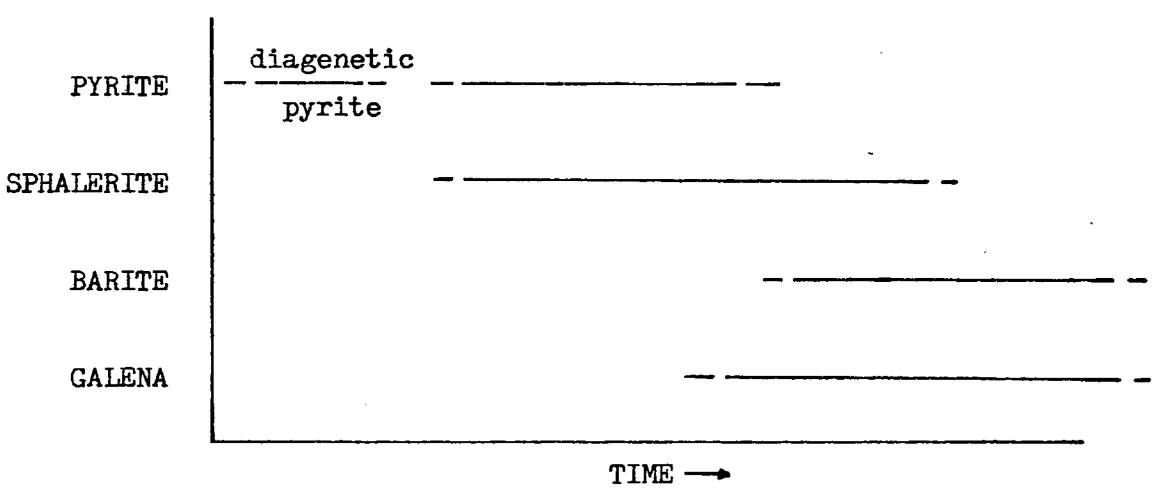
The following Van Der Veer diagram is a generalization of four seperate Van Der Veer diagrams constructed for each of the four polished sections examined in this ore type: (see following page).



<u>FIGURE 14</u> : Generalized Van Der Veer diagram for the Ore Type (4).

<u>Ore Type (5)</u>

Only one polished section was examined from this ore type so no conclusive paragenetic conclusions can be made. However, as was the case for the Mount Alcock showing, the paragenetic sequence will be postulated on the available data. The following line diagram illustrates this paragenetic sequence:



<u>FIGURE 15</u> : Representative line diagram for Ore Type (5).

Diagenetic framboidal pyrite is the first sulphide phase to form. Sphalerite, pyrite and barite seem to be contemporeneous with sphalerite and pyrite occuring together in layers. Once again the fact that the some layers are pyrite rich and others sphalerite rich indicates that the brines were of varying compositions. The little amount of galena that is present appears to be contemporeneous with the latter stages of barite deposition and also with the latter stages of sphalerite deposition. The former is evidenced by galena commonly being found interstitial to the barite in void like structures. The latter is evidenced by inclusions of galena found in sphalerite grains.

The Van Der Veer diagram for this ore type proves to be of little use again:

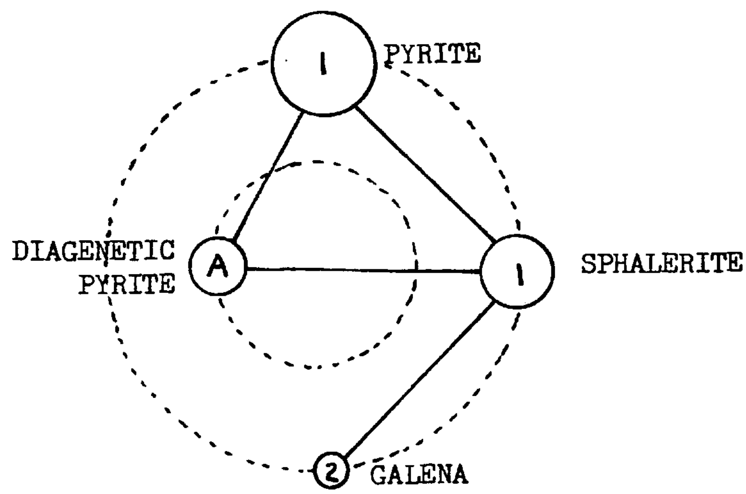


FIGURE 16 : Representative Van Der Veer diagram for Ore type (5).

OVERALL PARAGENESIS FOR THE CIRQUE DEPOSIT

Paragenesis for the Cirque deposit will now be discussed on an overall scale taking into account that the five ore types have a particular stratigraphic relationship to each other and thus, a particular paragenetic sequence (Figure 8 and Figure 17).

However, first a depositional environment will be constructed for the Cirque deposit. During Middle Devonian time a fault scarp and associated secondary rift system developed within the Kechika Trough Shale Basin. Associated with these rifts were small scale horst and graben structures which formed second and thrid order basins. The graben blocks were surrounded by deep seated faults that acted as potential solution guides for ascending hydrothermal brines.

The first event of importance was the deposition of the footwall found in the Cirque deposit. The footwall is composed of banded bluish-grey weathering siliceous argillites interbedded with carbonaceous black shales. Within this, and an overlying black shale unit, developement of diagenetic pyrite takes place. The first ore deposition to take place (Figure 17) is a pyrite rich, laminated black shale containing minor sphalerite and galena. Polished section G-8 represents ore type (5) which is equivalent to the laminated pyrite found at the bottom of the section in Figure 17. The second stage of ore deposition is a massive sulphide layer approximately made up of 30% barite. Then there is an overlying zone of predominately massive barite which contains approximately 20% sulphides. The next stage is precipitation of another massive sulphide layer which is in turn overlain by another massive barite layer. Polished sections G-2, G-6, G-7, and G-11 represent ore type (4) which is equivalent to one of the massive sulphide layers dicussed above. Polished sections Cirque #1 and Cirque #4 come from an anomalous barite kill zone (Figure 10) on the Cirque deposit. Similar ore has not been intersected in drill holes on the property (G. Gorzynski, personal comm.). Thus, the two Cirque sections do not come from one of the ore units presented in Figure 17, but according to Gorzynski (personal comm.) they could be highly recrystallized equivalents of the massive barite horizons and indicate the vent region. The possibility of this being the vent would explain why similar rocks have not been intersected in any drill holes to date. This idea is highly speculative but worth considering. The ore sequence is completed with a final layer of pyritic shale deposition and diagenetic pyrite formation.

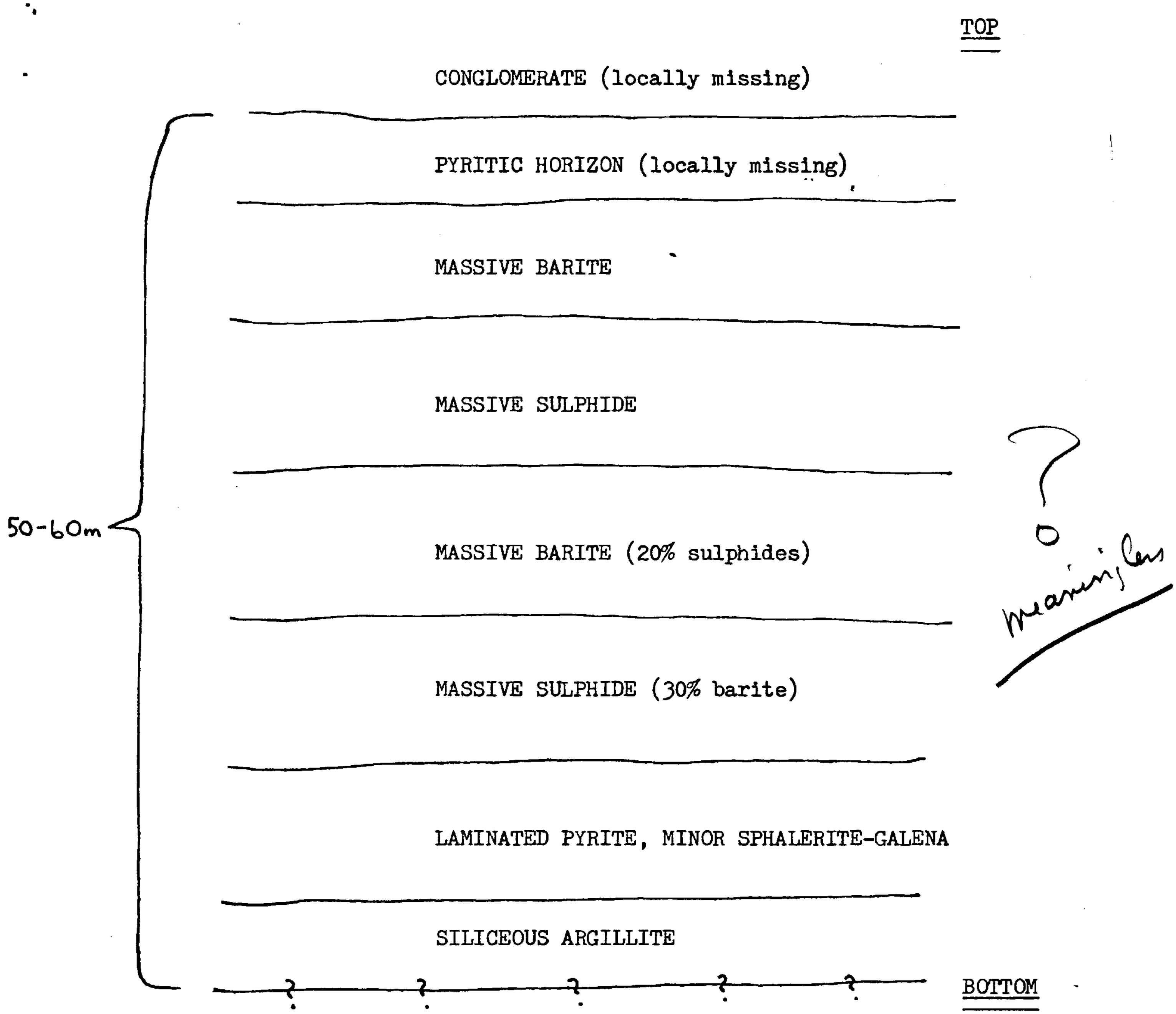


FIGURE 17 : Generalized vertical cross-section and sulphide zoning pattern found within the Cirque Deposit (G. Gorzynski, personal comm.). as approx. in DDH-79-C-14.

Note that the two massive barite horizons grade laterally into nodular diagenetic barite. After emplacement of the ore deposit an influx of terrigenous material occurs in the form of conglomerates. These conglomerates locally contain clasts of laminated pyrite which have been ripped up from the upper pyritic horizon (Figure 17). Locally the pyritic horizon has been completely removed by these conglomerates which themselves are locally missing. These conglomerates indicate that the horst and graben structures where tectonically active during the latter stages of the mineralization. The upper pyritic horizon is 20-30 meters thick and represents the hanging wall of the Cirque deposit. Sulphide concentrations decrease vertically away from the ore body (G. Gorzynski, personal comm.). Overlying the conglomerate unit is a thick sequence of Upper Devonian siliceous black shales which represent a major transgression in this region (MacIntyre, 1980).

The final episode of geologic activity important to understanding the Cirque deposit is the folding and faulting and related metamorphism, inflicted by the Columbian Orogeny.

ELF DEPOSIT

GENERAL GEOLOGY

The Elf deposit is the working property of Cyprus Anvil Mining and Hudson Bay Oil and Gas Limited. The deposit occurs within a northwest trending belt of Devonian shale, southwest of the Akie River, on a heavily timbered southeast facing slope. The mineralization occurs in a zone of siliceous pyritic argillite and shale, which ranges in thickness from 4 to 5 meters. The mineralization is in 10-20 cm thick beds of dark grey barite and is predominately thin fine grained galena bands. The mineralized sections seem to be in wedges of Devonian shale trapped beneath overthrust plates of Silurian Siltstone (MacIntyre, 1980). Assay values for four grab samples from the Elf showing are:

Sample No.	Ag	Ba	Cu	Pb	Zn
	ppm	*per cent*	*ppm*	*per cent*	*ppm*
ELF–1	15	51.5	35	3.0	37
ELF–2	33	30.1	88	32.0	1 408
ELF–3	43	47.1	70	16.8	687
ELF–4	93	12.1	383	15.0	115

Zn anomalously low ? not typical

Sample Descriptions

ELF–1 — white crystalline barite with interstitial galena, float in creek.

ELF–2, 3 — dark grey bedded barite with diffuse galena bands, from trenches.

ELF–4 — thin, very fine-grained band of galena and interstitial barite, from trenches.

TABLE 3 : Assays of four grab samples from the Elf deposit (MacIntyre, 1980).

One polished section was examined (i.e., Elf #1) from this deposit.

MINERALOGY

Megascopic examination shows massive galena of medium grain size acting as a groundmass for various sized (i.e., Up to 1cm in diameter) pieces of calcite. No bedding is visible and goethite staining coats the rock in numerous places.

Microscopic examination of the polished section Elf #1 shows the rock to be made up of 80% gangue-20% sulphide. The predominate sulphide is galena (95%) with minor pyrite (5%). The principle gangue minerals are barite and calcite. No sphalerite was observed in the polished section, but sphalerite is known to exist within the deposit,as the Zn assays (Table 3) show. Silver assays are significant but no silver minerals were identified.

TEXTURES

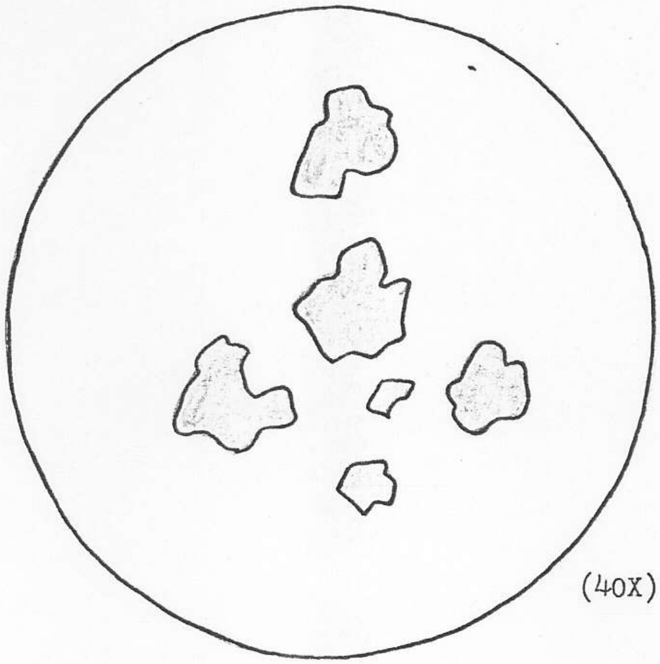
Since the mineralogy of the polished section is so simple so are the resulting textures. The most interesting texture is the presence of calcite in the ore. The calcite grain boundaries are very irregular compared to the barite grain boundaries. The calcite surrounds the barite grains in many locations, but the reverse is not true.

Pyrites are very anhedral and seem like 'buckshot ore' (Sketch 6). Pyrite grains are associated with barite and seem to be concentrated within the barite gangue. Pyrite that does occur in galena has a thin rim of gangue around them.

Galena fills inbetween the barite and calcite gangues and locally appeare to be replacing calcite. The galena in this polished section shows no triangular cleavage pits.

PARAGENESIS

Only one polished section (i.e., Elf #1) was examined from this deposit. Paragenesis for this deposit was very difficult to construct because of the lack of data and the unstatistical nature of the collected data. For instance no sphalerite was observed in the polished section, yet sphalerite is known to exist within the deposit. However, I am going to assume that a paragenetic sequence for the data available is needed. A line diagram for the Elf deposit



SKETCH 6 : Buckshot ore texture exhibited by pyrite (yellow).

follows:

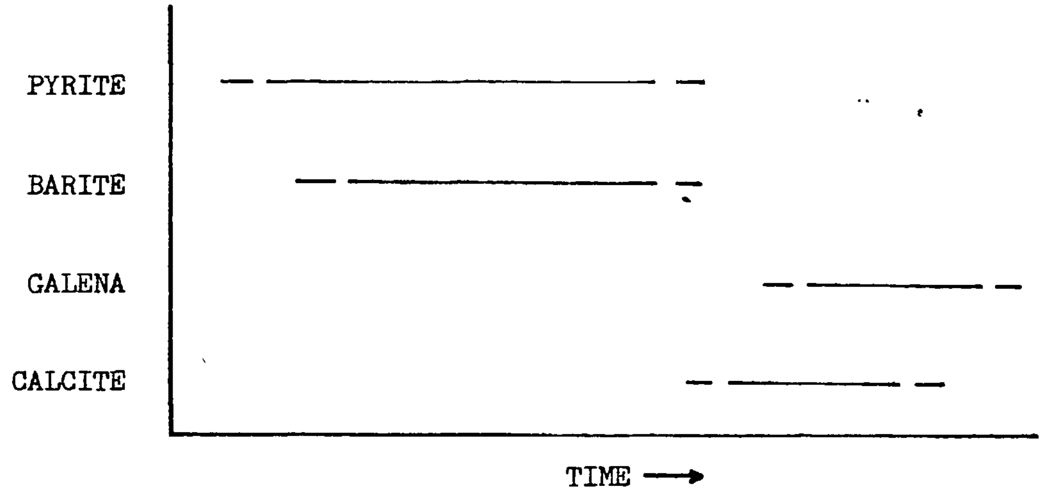


FIGURE 18 : Representative line diagram for the Elf deposit.

The line diagram indicates pyrite was slightly earlier than the barite, but the two become contemporeneous after this initial pyrite deposition. Calcite is later than barite and pyrite, as evidence by the calcite surrounding the two mentioned minerals. The calcite is likely derived from solutions passing through the nearby Devonian limestone facies and subsequently migrating through the ore deposit. Galena has been mobilized into fractures, in the barite and calcite gangues, due to regional metamorphism. A Van Der Veer diagram proves to be of little use:

whats wrong with $CaCO_3$ dep'n contemp with barite

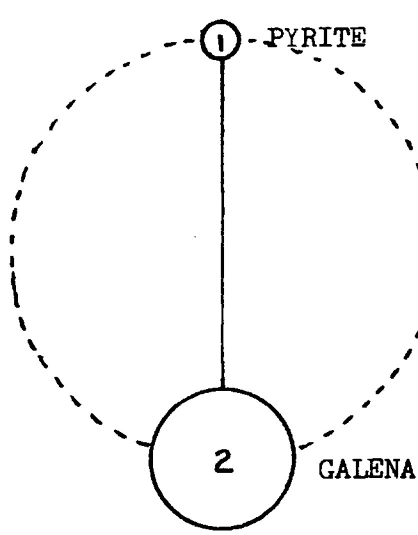


FIGURE 19 : Representative Van Der Veer diagram for the Elf deposit.

SUMMARY AND CONCLUSIONS

The four deposits, Mount Alcock, Cirque, Pie and Elf are all of very simple mineralogy. Paragenetic relationships are very difficult to accurately determine because of the affects of regional metamorphism. However, the following conclusions summarize the findings of this mineralographic study:

(1) The four deposits are characterized by a simple mineralogy made up of pyrite, sphalerite, galena and barite with local chalcopyrite.

(2) No silver bearing minerals were observed in any of the polished sections.

(3) Locally higher temperatures and/or higher copper concentrations cause chalcopyrite to exsolve coherently, and incoherently, from sphalerite.

(4) Diagenetic framboidal pyrite is common and generally they serve as a nucleating center for future pyrite (and sphalerite) deposition.

(5) Sphalerite grains are locally annealed.

(6) The Cirque Deposit is characterized by five ore types; three sulphide ores and two barite ores.

(7) The Pie Deposit is a higher temperature deposit as indicated by chalcopyrite exsolution in sphalerite. The coarser grained nature of the sphalerite in this deposit indicates it has undergone recrystallization due to higher temperatures.

(8) Regioal metamorphism, of all the deposits, has caused galena and sphalerite to be mobilized into fractures in the surrounding pyrite and barite.

(9) Each of the four deposits has undergone a slightly different degree of deformation.

I recommend that more detailed studies of each of the deposits be undertaken in order to understand paragenetic relationships more accurately. Possible SEM or Microprobe work should be done to determine what the silver is tied up in. A study geared towards milling of these ores and possible resulting problems should also be performed.

Kevin B. Heather

KEVIN B. HEATHER

ACKNOWLEDGMENTS

I would like to thank George Gorzynski and Cyprus Anvil Mining Corporation for the use of polished sections G-2, G-6, G-7, G-8 and G-11 from the Cirque Deposit. I also wish to extend thanks to George Gorzynski, Shun Kun, and Dr. A. J. Sinclair for their help throughout this study.

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APPENDIX 'A'

Rough Sample
Description
Sheets

SHOWING : Mount Alcock Showing

SAMPLE #: Alcock #1

HANDSPECIMEN

Description: Banded (bedded) light grey an dark grey barite. Very oxidized rock. Goethite rine.

Minerals: Galena, barite., Goethite

Textures: Bedding; Fine beds of galena (>0.5mm thick) are seen but barely.

POLISHED SECTION

Mineral Associations:

Sulphides: Galena, Sphalerite, Pyrite

Gangue: Barite

Proportions:

Gangue: 80%
Total Sulfides: 20%

POLISHED SECTION (CON'T)

Mineral	Modal Grain Size	% of total Sulfides
Galena	mm	70%
Sphalerite	mm	25%
Pyrite	mm	5%

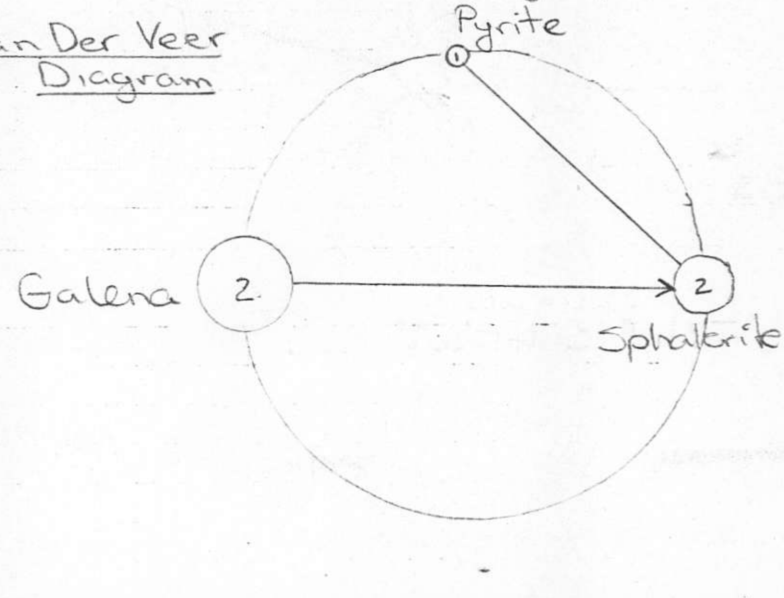
Mineral Textures :

- sulphides are very fine grained
- pyrites are well rounded and some are made up of very small grains ((ie ❀) framboidal ?)
- galena seemed to plastic as it seems to flow into nocks and fractures giving the grains an irregular shape.
- commonly see sphalerite within galena filled "vug". (see fig)
- pyrite found most commonly within sphalerite but also as individual rounded grains within the barite gangue.
- some galena grains psuedo-cubic indicating a higher degree of rex-tallization.
- there sphalerite-pyrite rich bands and sph. - galena rich bands (pyrite poor).

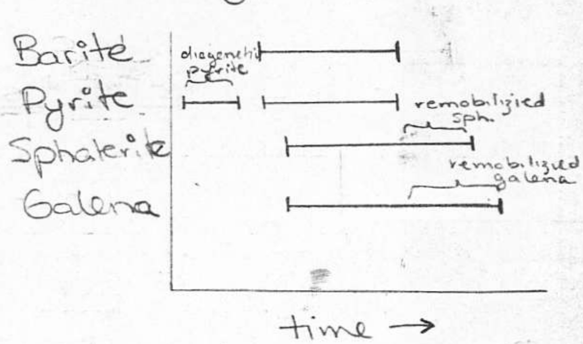
Paragenesis :

- pyrite found in sphalerite and barite.
- all sulphides are more or less contemporeneous
- galena replacing sphalerite ???

Van Der Veer Diagram



Line Diagram



Amount of Recrystallization :

SHOWING : Pie Claims

SAMPLE #: Pie 1

HANDSPECIMEN

Description: Massive coarse x-talline white barite containing band like structure (~ dcm thick) of sphalerite.

Minerals: Barite, Sphalerite, Pyrite.

Textures: Band of brown sphalerite in coarse white barite

POLISHED SECTION

Mineral Associations: Sulphides Pyrite, Sphalerite
Chalcopyrite
Cubanite (Bornite ?)
Covellite

Gangue Barite, unknown gangue

Proportions :

Gangue : 65%
Total Sulfides : 35%

POLISHED SECTION (CON'T)

Mineral	Grain Size Max.	Grain Size Min.	% of total Sulfides
Sphalerite	3-4mm	0.02mm	90%
Pyrite	0.5mm	micro	7%
Chalcopyrite	0.15mm	micro	3%
Possibly Bornite → Cubanite	—	—	one grain found
Covellite	—	—	trace

Mineral Textures:

- Sph. contains inclusions of Chalco.; both coherent (crystallographic) and incoherent
- (emulsion & segregated vein???)
- Pyrite occurs as open space fracture fillings in Barite; pyrite is located near sph. (ie around sph. grains.). (see fig. 1)
- Sph. also contains xenoliths? of barite (rounded).
- Barite contains sph. also.
- Pyrite is also seen as stringer-discontinuous veinlets in sph. (FIG. 1)
- pyrite grains are anhedral and appear to be replacing sph. locally in fractures. and also see replacement at grain edges (fig. 2).
- pyrite is between two annealed grains in places.
- locally chalcopyrite shows covellite oxidation.
- chalco. found in barite gangue surrounding sphalerite grains containing exsolved chalcopyrite. Chalco. mobilizied due to pressure? on sphalerite grain due to thrusting? (black circle)
- there appears to be a second type of gangue which rims sphalerite and barite grains. Properties: Bluishgrey colour, bluish-white under x-nicols.

Paragenesis:

- covellite after chalcopyrite
- chalcopyrite same time as sphalerite
- pyrite after sphalerite
- unknown gangue after sphalerite and barite and pyrite.
- cubanite, chalco., sphalerite are contemporaneous.
  ↑ bornite?

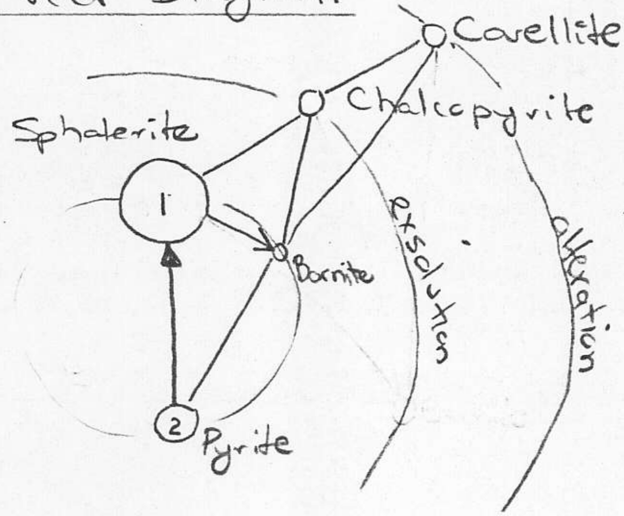
Mineral Textures (con't):

- unknown mineral found in only one place. Seems to be in solid solution with chalcopyrite. Properties: brown mineral contain fine exsolved laths of chalcopyrite. most probably cubanite. (bornite?)
- cubanite ($CuFe_2S_3$) is altering to covellite

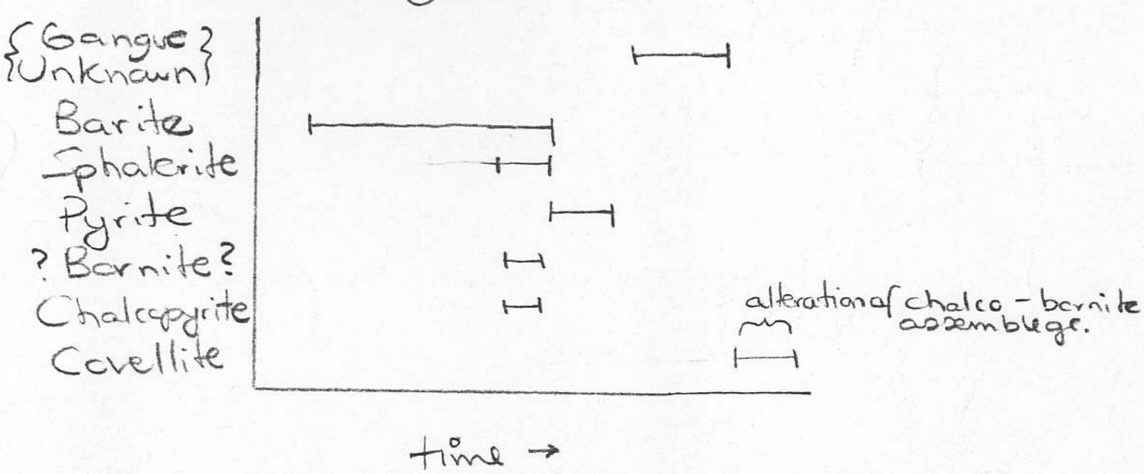
Amount of Recrystallization:

Paragenesis (con't) : (Pie # 1)

Van Der Veer Diagram



Line Diagram



SHOWING : Pie Claims

SAMPLE #: Pie #2

HANDSPECIMEN

Description : Massive coarse x-talline white bari
containing psvedo banded sphalerite.
(similiar to sample Pie #1)

Minerals : Barite, Sphalerite, Pyrite, Chalcopyrite
Covellite.

Textures : Dark brown sphalerite looking more
like a vein filling or rex-tallized
bed. White barite contains orangy
brown to pink oxidation.
Sphalerite is fairly coarse grained
ie up to 2mm in diameter.

POLISHED SECTION

Mineral Associations :

Sulphides : Chalcopyrite, Sphalerite, Pyrite

Gangue : Barite, unknown gangue {similiar to that found
in sample Pie #1

Proportions :

Gangue : 60 %
Total Sulfides : 40 %

POLISHED SECTION (CON'T)

Mineral	Grain Size Max.	Grain Size Min.	% of total Sulfides
Sphalerite	5.7mm		85 %
Chalcopyrite	very small.		3 %
Pyrite	brecciated?		12 %

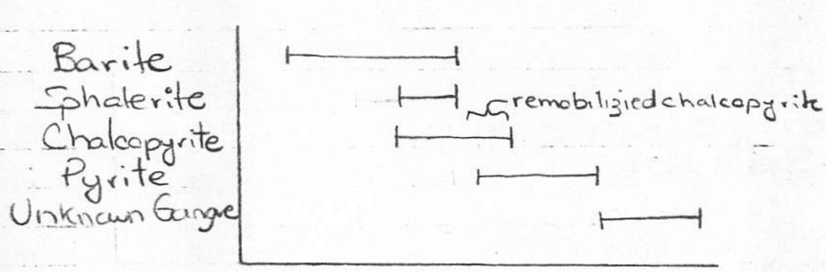
Mineral Textures :

- sphalerite has exsolved chalcopyrite. sphalerite is also replaced by pyrite along imperfections (such as fractures & cleavage).
- sphalerite surrounds bits of barite.
- similiar textures as seen in sample # Pie-#1, except no cubanite or covellite has been found here.
- unknown gangue surrounds sphalerite, barite pyrite. (replacement?)
- pyrite occurs in cleavage or fractures of sphalerite.
- pyrite seems very anhedral and almost "brecciated" in places.
- pyrite has blueish tarnish on it (oxidation).
- sample seems brecciated in many places.

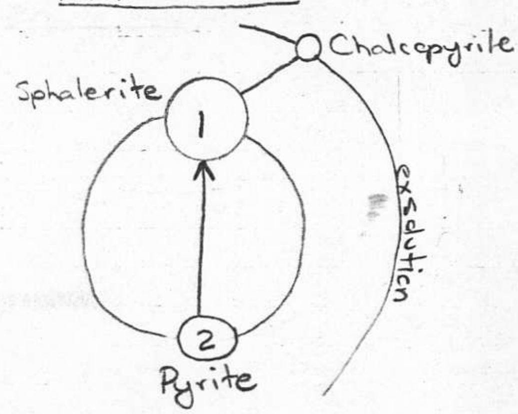
Paragenesis :

- blueish tarnish after pyrite
- sphalerite and chalcopyrite contempereneous
- pyrite after chalco, sphalerite and barite
- barite before sphalerite.
- unknown gangue mineral after sph, chalco and pyrite, barite.

Line Diagram



Van Der Veer



Amount of Recrystallization :

SHOWING : Cirque Claims

SAMPLE #: Cirque #1

HANDSPECIMEN

Description : Massive white x-talline barite containi rex-tallized and deformed discontineous bands (~1mm thick) of galena (lensoid shaped pods of galena).

Minerals : Barite, Galena, Geothite, Jarocite

Textures : Banding is likely relic bedding texture of galena.
Banding is somewhat wavy in nature locally.

POLISHED SECTION

Mineral Associations :

Sulphides : Galena, Pyrite

Gangue : Barite
unknown gangue ⇒ brown colour
crossed hatch or woven anistropy (yellow-greenish brown anistropy).

Proportions :

Gangue : 75%
Total Sulfides : 25%

POLISHED SECTION (CON'T)

Mineral	Grain size Max.	Grain size Min	% of total Sulfides
Galena	–	–	96%
Pyrite	–	–	2%
Sphalerite	minor		2%
Chalcopyrite	minor		trace

Mineral Textures :

- galena appears to be replacing barite or at least infilling the fractures.
- rounded barite grains floating in galena next to barite gangue wall?
- minor sphalerite which contains exsolution texture of chalcopyrite (minor?)
- pyrites are sub-rounded and anhedral.
- unknown gangue occurs in the barite gangue as well as in galena near barite gangue. *galena seems to be replacing the unknown gangue

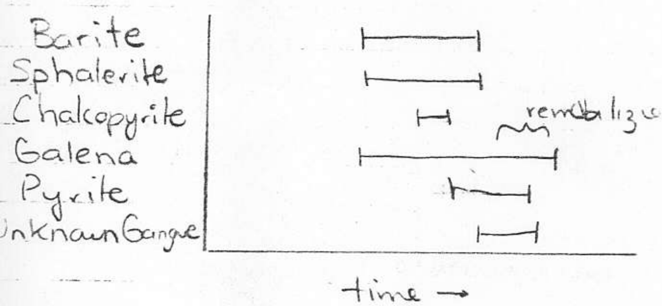
X-gangue replaces gn and x-cuts barite

Paragenesis :

limonite

- sphalerite and chalcopyrite contemporaneous
- unknown gangue replacing barite ?
- barite and unknown gangue replaced by galena
- sphalerite before galena
- sphalerite before pyrite.
- sphalerite contemporaneous with barite?

Line Diagram



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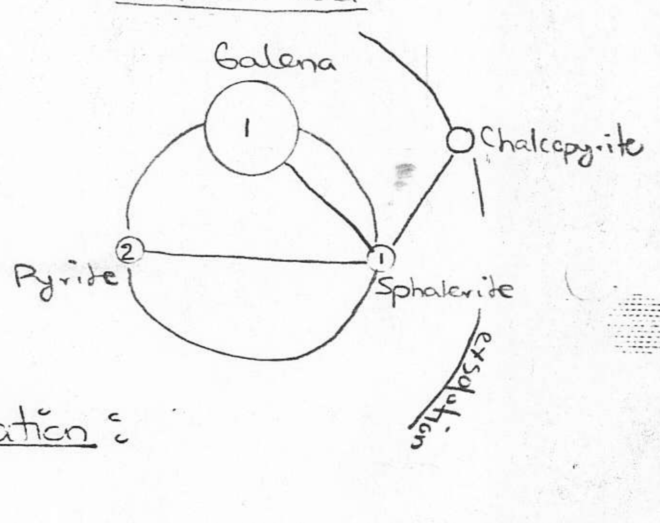


Amount of Recrystallization :

SHOWING : Cirque Claims

SAMPLE # : Cirque #4

HANDSPECIMEN

Description : Sample is isoclinally folded on a scale of ~(3cm diameter.)

Minerals : Galena, Barite, Goethite.

Textures : Banding of Galena very distinctive. Core of fold seems to contain the massive rex-tallized, coarser grained galena. Limb galena tends to be more layered in nature.

POLISHED SECTION

Mineral Associations :

Sulphides : Galena, Sphalerite, Pyrite

Gangue : Barite

Proportions :

Gangue : 40%
Total Sulfides : 60%

POLISHED SECTION (CON'T)

Mineral	Grain Size Max	Grain Size Min	% of total Sulfides
Galena			75%
Sphalerite			17%
Pyrite			8%

?

Mineral Textures:

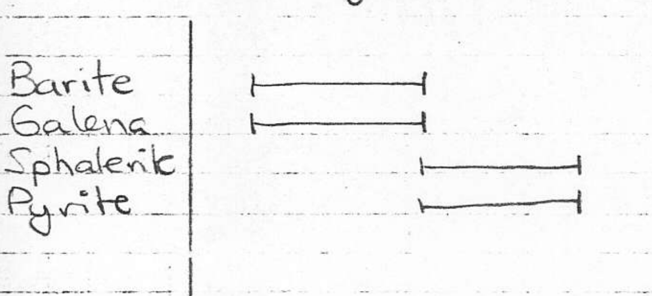
- can see relic bedding, but somewhat smeared due to metamorphism.
- pyrite and sphalerite grains seem to occur together (within same bands) and both are anhedral and somewhat rounded.
- pyrite predominately found in the sphalerite.

✓

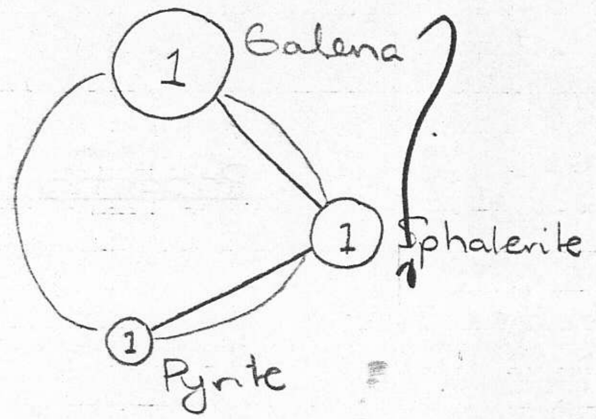
Paragenesis:

- barite and galena cyclic and contemporeneous.
- similiar to Cirque #1

Line Diagram



Van Der Veer



Amount of Recrystallization:

SHOWING :

SAMPLE #: G-2

HANDSPECIMEN (Split Diamond Drill Core)

Description : * No handspecimen.
* Polished sections recieved from Cyprus Anvil.

Minerals :

Textures :

POLISHED SECTION

Mineral Associations :

Sulphides : Pyrite, Sphalerite, Galena

Gangue : Barite

Proportions :

Gangue : 65%
Total Sulfides : 35%

POLISHED SECTION (CON'T) G-2

Mineral	% of total Sulfides
Pyrite	40%
Sphalerite	50%
Galena	10%

In the text you talk about cpy?

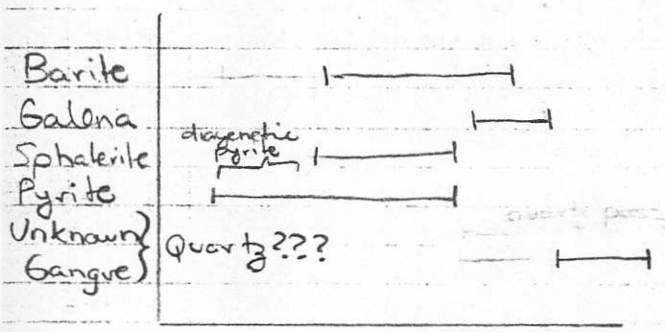
Mineral Textures :

- Pyrite grains are randed and range in size up to 0.05mm, some of the smaller grains have graped together to form aggregats or framboidial pyrite.
- sphalerite contains framboids of pyrite, both are alined as bedding
- pyrite also fand in barite gangue
- galena doesn't contain pyrite, except where pieces of pyrite bearing gangue are seen "floating in galena. highly irregular
- pyrites appear to be forming large aggregates which are in turn forming large re-xtallizied grains.
- pyrites shawing framboidal texture show ring of impurties and then later acreation of more pyrite grains.
- sphalerite is anhedral., appears to be annealed as one can see pyrite within sphalerite and the pyrite seems to outline a relic grain which naw has joined with others.
- yellow mineral exsolved in sphalerite looks like pyrite but could be chalco.
- pyrite seems to be at 2 or 3 different stages of re x-tallization (see fig.)

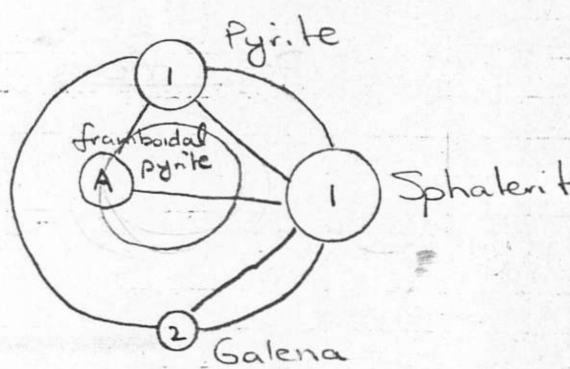
Paragenesis :

- barite + Sphalerite + pyrite ⇒ galena
- ie sphalerite and pyrite are contemporeneous, with galena filling in the voids.

Line Diagram



Van Der Veer



Amount of Recrystallization :

SHOWING :

SAMPLE #: G-6

HANDSPECIMEN (Split Diamond Drill Core).

Description : * no handspecimen
* Polished Section received from Cyprus Anvil.

Minerals :

Textures :

POLISHED SECTION

Mineral Associations :

Sulphides : Sphalerite, Pyrite, Galena

Gangue : Barite

Proportions :

Gangue : 75%
Total Sulfides : 25%

POLISHED SECTION (CON'T) G-6

Mineral	Grain Size Max.	Grain Size Min.	% of total Sulfides
Sphalerite			65%
Pyrite	0.12mm	0.01mm or smaller	34%
Galena	very small		1%

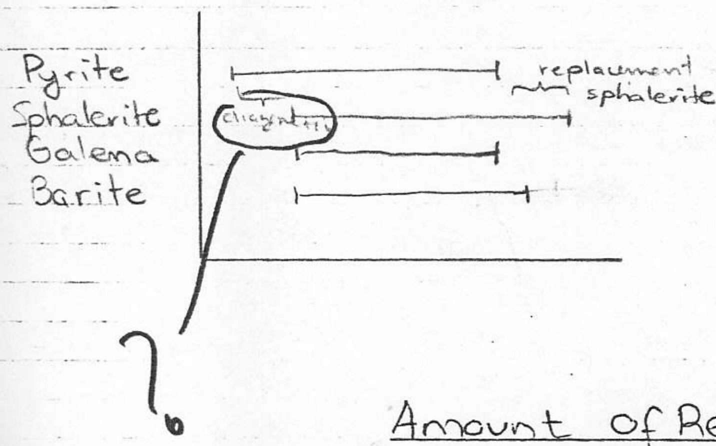
Mineral Textures:

- pyrite is the colliform type (oolitic?) (ie can see a ring of impurities (likely gangue).
- also can see where sphalerite has replaced? impurity zones in pyrite
- ~~galena is very minor and appears to occur as fine laths in sphalerite.~~
- py in sph.

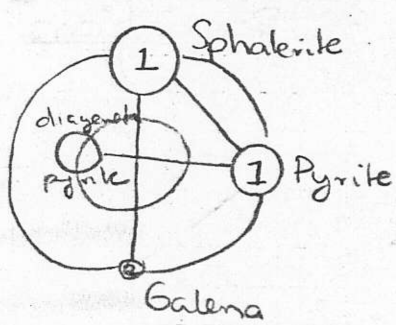
Paragenesis:

- pyrite came first, then impurties rimed the pyrite core (impurties Zn rich?)
- then get addition of pyrite again
- sphalerite and galena came later
- gangue was contemporeneous with sph. and later.

Line Diagram



Van Der Veer



Amount of Recrystallization:

SHOWING :

SAMPLE # : G-7

HANDSPECIMEN

Description : * no hand specimen
* polish section received from Cyprus Anvil.

Minerals :

Textures :

POLISHED SECTION

Mineral Associations :

Sulphides : Pyrite, Sphalerite, Galena

Gangue : Barite and unknown

Proportions :

Gangue : 25%
Total Sulfides : 75%

POLISHED SECTION (CON'T) G-7

Mineral	Grain Size Max.	Grain Size Min	% of total Sulfides
Pyrite			70%
Sphalerite			25%
Galena			5%

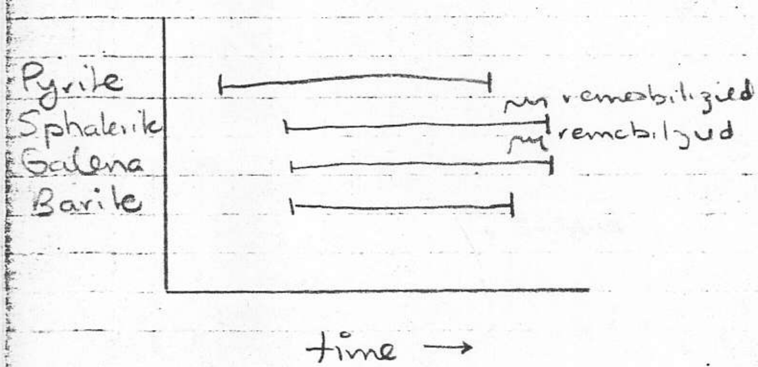
Mineral Textures:

- pyrites range from framboidal (minior) to randed aggregates shawing cubic x-tal faces.
- sph. is infilling fractures in the pyrite.
- sph. may be replacing impurities in pyrite but difficult to tell.
- sulphides still mimic relic bedding.
- also very pyrite grains have developed radial fractures and have subsequently been filled in by "plastic" galena and sph.

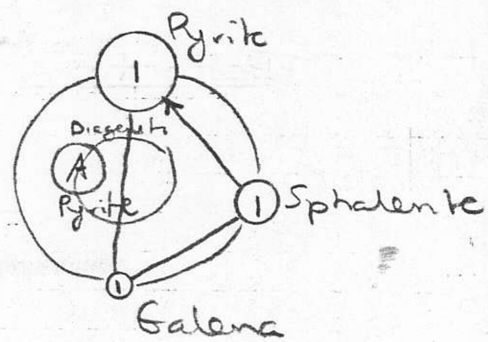
Paragenesis:

- pyrite seems to first
- then pyrite - sphalerite
- galena is late again
- Sph. and galena overlap to some extent.

Line Diagram



Van Der Veer



Amount of Recrystallization:

SHOWING :

SAMPLE #: G-11

HANDSPECIMEN (Split Diamond Drill Core)

Description: * No hand specimen
* Polished Sections received from Cyprus Anvil.

Minerals :

Textures :

POLISHED SECTION

Mineral Associations:

Sulphides : Pyrite, Sphalerite, Galena

Gangue: Barite

Proportions :

Gangue : 15%
Total Sulfides: 85%

POLISHED SECTION (CON'T)

Mineral	Grain Size Max.	Grain Size Min.	% of total Sulfides
Pyrite			75%
Galena			10%
Sphalerite			15%

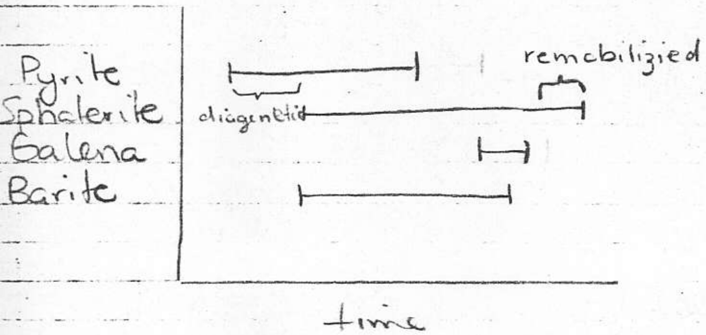
Mineral Textures :

- sphalerite seems to be replacing pyrite along curved to straight microfractures. (gangue also appears to fill fractures).
- some layers of pyrite show good framboidal nature others are nice x-tals (ie don't have x-tal faces however).
- galena again seems to be flowing into nooks and fractures of the other minerals, kind of filling in the spaces.
- sphalerite and galena have been effected by regional metamorphism whereas pyrite still shows some original textures. ie diagenetic pyrite.
- sphalerite in pyrite could be due to continuous deposition ie (PY) ⇒ (PY) SPH. ⇒ (PY) PY or due to colliform pyrite containing Zn rich impurities, then get later replacement by sphalerite of the pyrite.

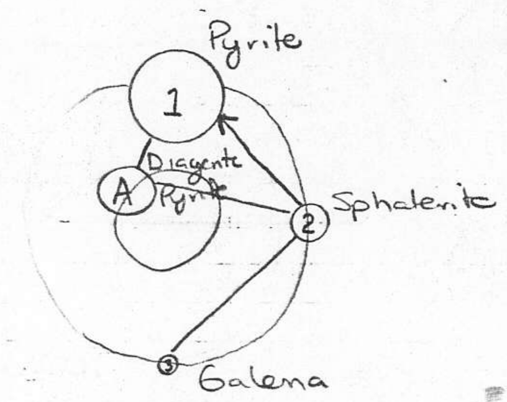
Paragenesis :

- pyrite + sphalerite, sphalerite, galena

Line Diagram



Van Der Veer



Amount of Recrystallization :

SHOWING :

SAMPLE #: G-8

HANDSPECIMEN (Split Diamond Drill Core)

Description : * No handspecimen
* Polished Section Received from Cyprus Anvil

Minerals :

Textures :

POLISHED SECTION

Mineral Associations :

Sulphides : Pyrite, Sphalerite, Galena

Gangue : Unknown, barite?

Proportions :

Gangue : 3%
Total Sulfides : 97%

POLISHED SECTION (CON'T)

Mineral	Grain Size Max.	Min.	% of total Sulfides
Pyrite			88%
Sphalerite			10%
Galena			2%
cpy (?)			Tr

Mineral Textures :

- frambodal pyrite (colliform)
- colliform pyrites seem to be cemented together by a sphalerite cement or matrix.
- no evidence for sphalerite replacing pyrite.
- pyrite and sphalerite occur together as bands some sph rich - pyrite poor and others pyrite rich sph. poor.
- galena seems to be associated with barite gangue bands.
- some galena found late in sphalerite.

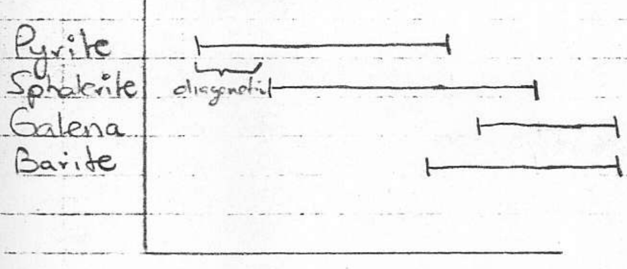
Concentric structure to some framboids.

- pronounced layered structure - contacts are gradational in terms of texture.

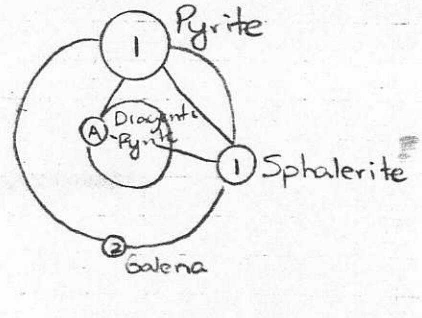
Paragenesis :

- sphalerite and pyrite contemporaneous with sphalerite deposition continuing after pyrite
- galena is filling in after sphalerite and pyrite
- barite and galena are after sph. and pyrite.
- possible explation is waters passing threw the ZnS and FeS_2 become heated (ie hydrothermal) thus the pH and eH change causing SO_4 to precipatate as barite and Pb to form PbS. Sulphide (S^{-2}) derived from FeS_2 ?.

Line Diagram



Van Der Veer



Amount of Recrystallization :

SHOWING : Elf Claims

SAMPLE #: Elf #1

HANDSPECIMEN

Description : (see below).

Minerals : Galena, Calcite, Goethite

Textures : Massive galena (medium to fine grained) containing x-taline white calcite as xenoliths. (<1mm in size to <1cm diameter.). No bedding Hydrothermal looking.

POLISHED SECTION

Mineral Associations :

Sulphides : Galena, Pyrite

Gangue : Barite, Calcite

Proportions :

Gangue : 80 %
Total Sulfides : 20 %

POLISHED SECTION (CON'T)

Mineral	Grain Size Max.	Min	% of total Sulfides
Galena	grand mass		95%
Pyrite	0.1mm	very small	5%

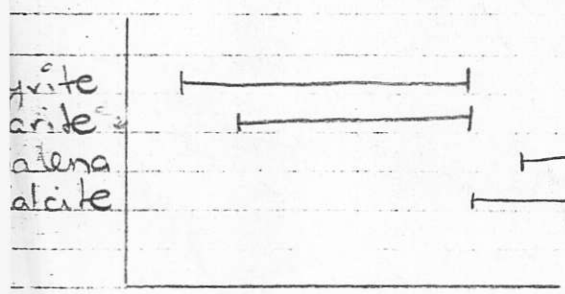
Mineral Textures :

- Galena seems to fill inbetween the barite gangue and calcite
- Galena doesn't show much triangular pitting or cleavage.
- Pyrites are very anhedral and some seem somewhat rounded like buckshot ore. Pyrites appear to be concentrated in the barite gangue but there are some rounded to sub rounded grains in the galena (possibily have thin barite gangue rims). ie "floating" in galena.
- galena appears to be replacing calcite
- Barite gangue grains are well rounded in comparison to the calcite gangue grains which have irregular grain boundaries.
- barite grains are surrounded by calcite in many places

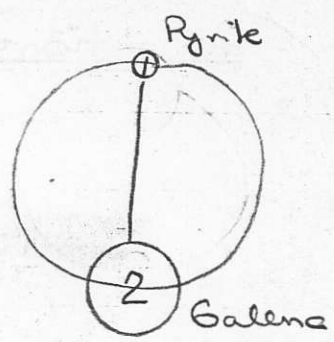
Paragenesis :

- pyrite before or contemporeneous with barite
- barite before calcite
- calcite before galena
- some galena may be contemporeneous with the calcite ?

Line Diagram



Van Der Veer



Amount of Recrystallization :