Comparison of Sulphide Textures at Bonnet Plume, N. W. T., Robb Lake, B. C. and Pine Point, N. W. T.

Submitted by

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Abstract

Polished sections, examined under the reflecting microscope, from Robb Lake, B. C., Bonnet Plume, N. W. T., and Pine Point, N. W. T. show similar economic mineralogy but differing iron content and widely differing texture.

At Bonnet Plume, sphalerite and scarsely galena occur as vug filling, breccia matrix and replacement masses. Intense silicification of dolomite may be of sedimentary or intrusive,tectonically controlled,origin. Silica locally has completely replaced the dolomite matrix.

At Robb Lake, galena and sphalerite occur with coarse white crystalline dolomite as matrix of angular dolomite breccias. Sphalerite preferentially rims dolomite fragments and precedes galena paragenetically.

Pine Point contains high percentages of galena and marcasite. Sphalerite occurs as colloform layering, stalactitic growths, vug filling and intercrystalline material. Galena replaces cores and selective bands of sphalerite masses.

A similar depositional model for the three deposits as proposed by Jackson and Beales (1967) is possible but more field work must be done to prove this theory.

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Robb Lake

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Introduction

This report examines mineralogy and textures of three lead-zinc deposits in carbonate rocks in an attempt to determine genetic and mineralogical similarities and differences among the three deposits.

Method of Examination

Conclusions are based on a random suite of 10 samples from each deposit examined under the reflecting and binocular microscopes at a varying magnification up to 400 power. Xray diffractograms were analysed for selected specimens. The samples are chosen for their display of ore textures, thus percentage estimates are biased and of little value.

Location

The Bonnet Plume deposit (Figure 1) (Goz Creek showing) was discovered during the summer of 1973 in Lower Cambrian dolomitized and silicified carbonate at the junction of Goz Creek and Bonnet Plume River in the Northwest Territories, 125 miles northeast of Mayo.

Robb Lake (Figure 1), explored since 1971, is located in Middle Devonian dolomitized and brecciated carbonate rock near the head waters of Halfway River in the Rocky Mountains of northeastern British Columbia.

Pine Point (Figure 1), operating since 1965 is an ore field of 40 known ore bodies in 180 square miles of Middle Devonian dolomitized reefal carbonate on the south shore of Great Slave Lake.

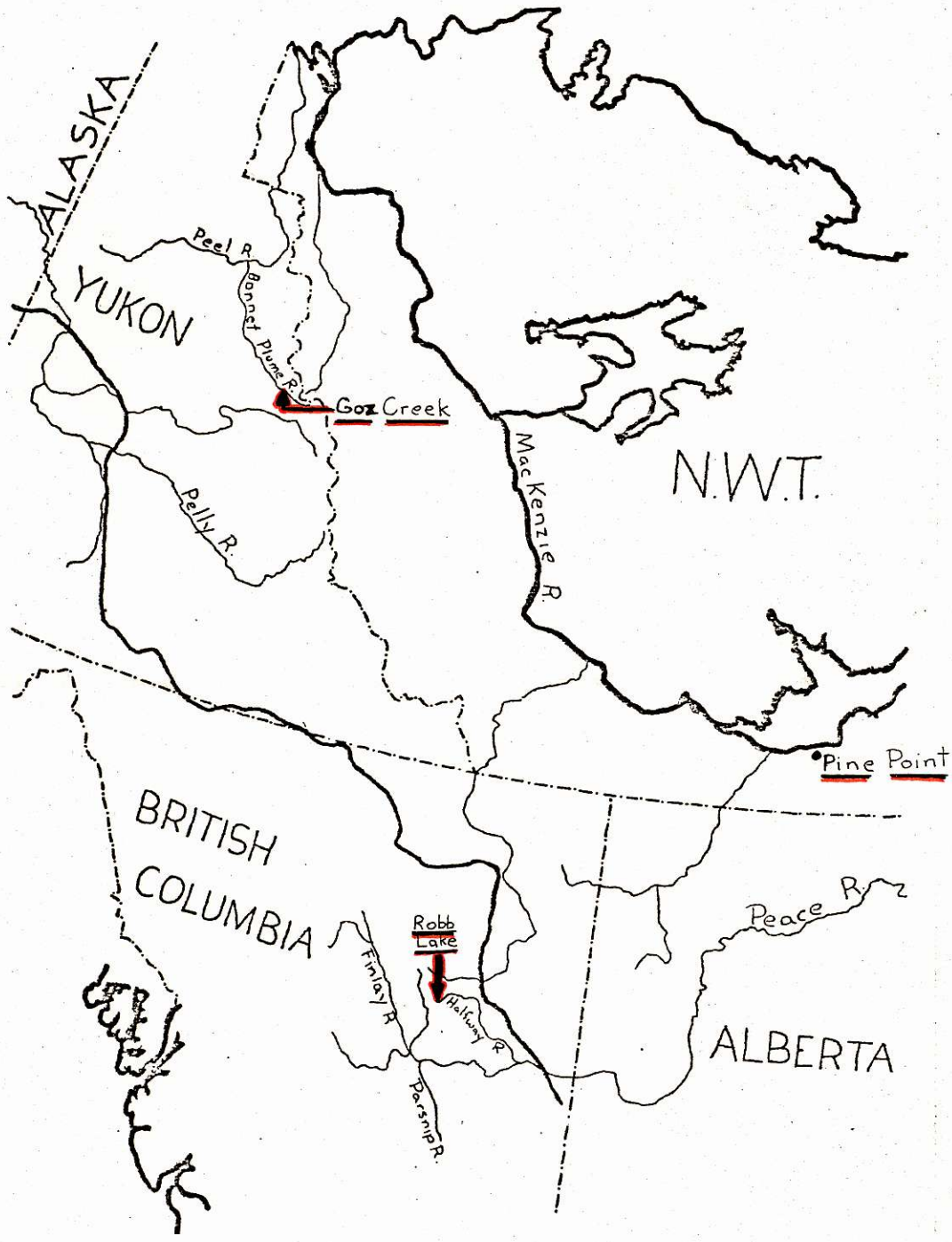


Figure 1. Location Map, Bonnet Plume, Robb Lake, Pine Point

Acknowledgements

The author appreciates the assistance of Cordilleran Engineering in making available rock suites and company geologic reports of Robb Lake and Goz Creek showings. The Pine Point suite is part of U.B.C.'s ore specimen collection.

Previous Work

Bonnet Plume

The regional geology of this deposit is roughly described by a one page report and sketch map, Nadaleen River (106C) and Bonnet Plume (106B) (Blusson et. al. 1970).

Robb Lake

The regional geology of the Robb Lake area is covered by Irish (1961) in the geology of Halfway River (94B).

The local geology of both of these deposits is discussed most adequately in company reports of Cordilleran Engineering (Hamilton 1973 (1)&(2)).

Pine Point

Ruelle (1973) recently studied textural and mineralogical features of the Pine Point ores. Skall's "Geologic Sitting and Mineralization of the Pine Point Lead Zinc Deposits" is an excellent geological account of the area. Previously, Norris (1965) and Jackson and Beales (1967) discussed the Devonian geology and ore horizons at Pine Point.

A great deal of geochemical work has been done on Pine Point ores.

Sasaki and Krouse (1969) suggest from S^{34} values that sulphur in the sulphides originates in the Middle Devonian evaporite basin (Elk Point Basin).

Beales and Jackson (1967) believe that the O^{18} content of hydrothermal dolomite reflects stratafugic origins for the metal bearing fluids. The Jackson and Beales (1967) model for ore deposition at Pine Point and probably many Pb-Zn stratabound deposits.

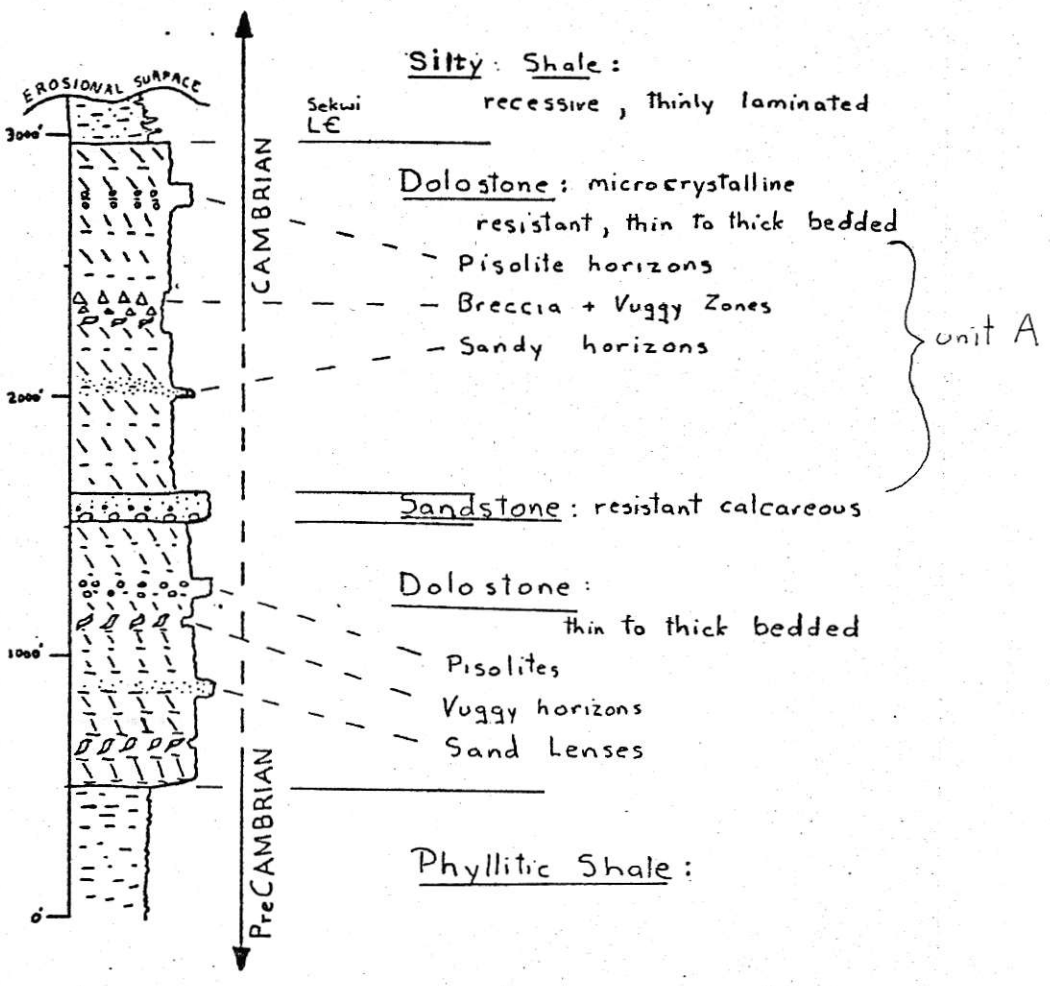
General Geology

Bonnet Plume (Hamilton 1973 (1))

The host rock for the mineralization is a porous vuggy dolostone with local breccia and silicification. This lithology occurs intermittently throughout a Lower Cambrian or possibly Upper PreCambrian grey, massive, thick bedded, fine to microcrystalline, calcareous dolostone (Unit A of Figure 2). The host is sanwiched between shales along conformable and fault contracts. Variable thicknesses of the eroded Sekwi Formation, carbonate and clastics, cap the stratigraphy throughout the area.

Stucturally, west-northwest trending folds and faults dominate with block thrusting northeast of probably Laramide orogeny. A high angle reverse fault cuts off the favorable horizon and the mineralization in the south and a vertical north side up fault removes the favorable horizon in the north. All mineralization is on the south limb of a west-northwest trending anticline.

Mineralization occurs intermittently over $5\frac{1}{2}$ miles of outcrop associated with rusty limonite gossans.



GOZ CREEK STRATIGRAPHY

Unit A contains ore horizons

Figure 2. (generalized from geological description, Hamilton 1973(1)).

Robb Lake (Hamilton 1973 (2))

The mineralized host is intensely brecciated crystalline dolostone cemented with coarse white crystalline dolomite (Figure 3), within the Middle Devonian tan to grey, fine to medium crystalline, arenacous dolostone. This unit is part of a thick sequence of Devonian sandy dolostones, quartz sandstones and crystalline dolostones capped by the Upper Devonian, Besa River Shales and cherty and argillaceous limestone of the Prophet Formation (Mississippian).

Middle Devonian carbonates are folded into a broad southeast plunging anticline with 30° dips on the flanks (Figure 4). Westward thrusting and high angle reverse faults striking northwest repeat the section and remove the Middle Devonian from the western section.

Ore occurs as crudely stratiform dolomitized "collapse" and "crackle breccias" (partial collapse). White secondary crystalline dolomite is the most common cement. "Zebra rock", light and dark coloured dolomite in 2-5 mm bands, is often associated with the ore.

Pine Point (Skall 1972)

The host rock is coarsely crystalline buff to grey brown extremely vuggy dolomite of the Middle Devonian Presqu'ile Formation, barrier complex. Open vugs from a few millimeters to a meter in size constitute up to 15% of the Presqu'ile dolomite. Vug filling is the most common occurrence of economic quantities of ore. The Presqu'ile Formation, separating back-reef evaporites from basinal shales to the northwest (Figure 5), subcrops south of Great Slave Lake (Figure 6) and gently dips under Mesozoic strata westward. Eifelian evaporites unconformable underly the favorable stratigraphy. The series is capped by tight bedded carbonates and shale lying unconformably over the

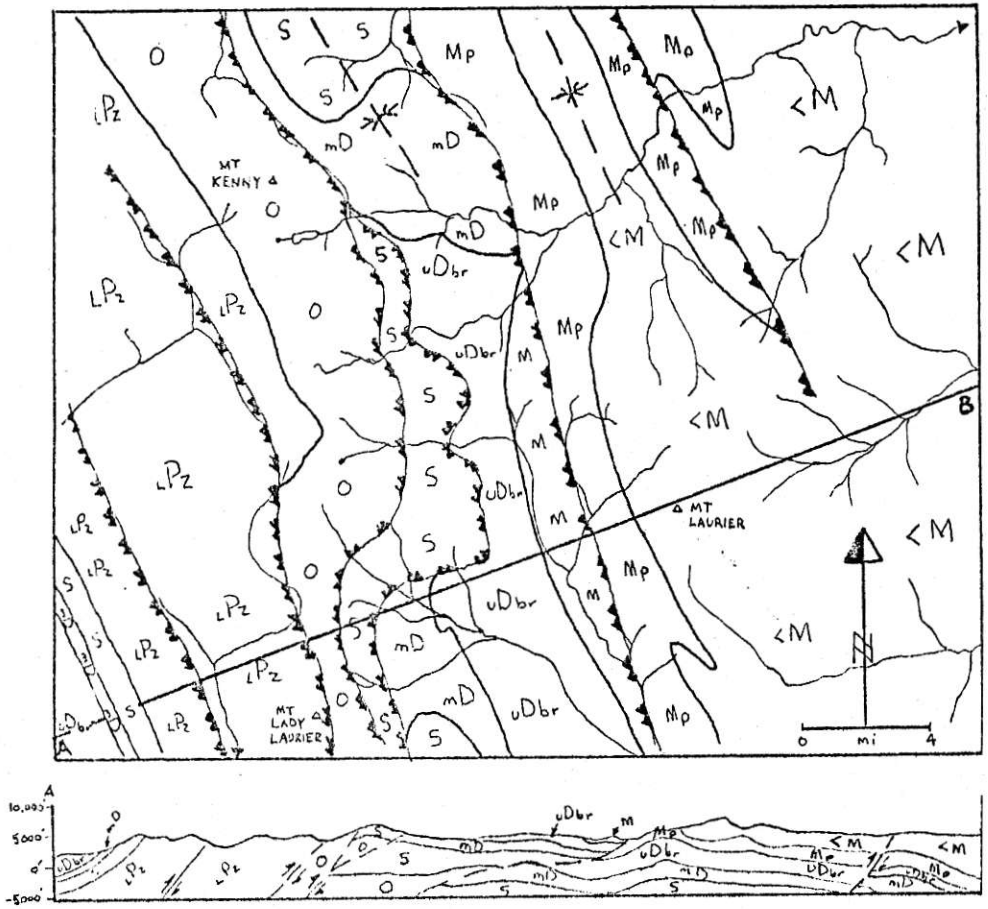


Figure 4. Robb Lake Geology; O-Ordovician, S-Silurian, $_{l}P_{z}$-lower Paleozoic, $_{m}D$-middle Devonian, $_{u}D_{br}$-upper Devonian Beas River Shales formation, M-Mississippian, M_{p}-Mississippian, M-younger than Mississippian (after Irish, (1970)).

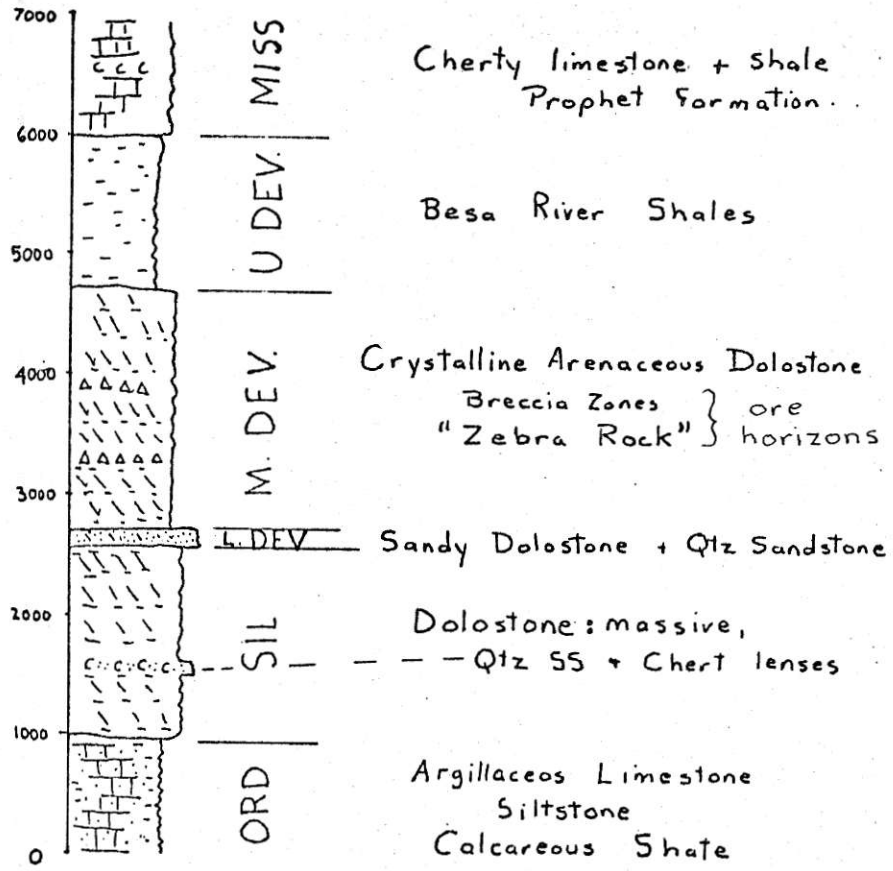


Figure 3. (generalized from geological descriptions, Hamilton 1973(2)).

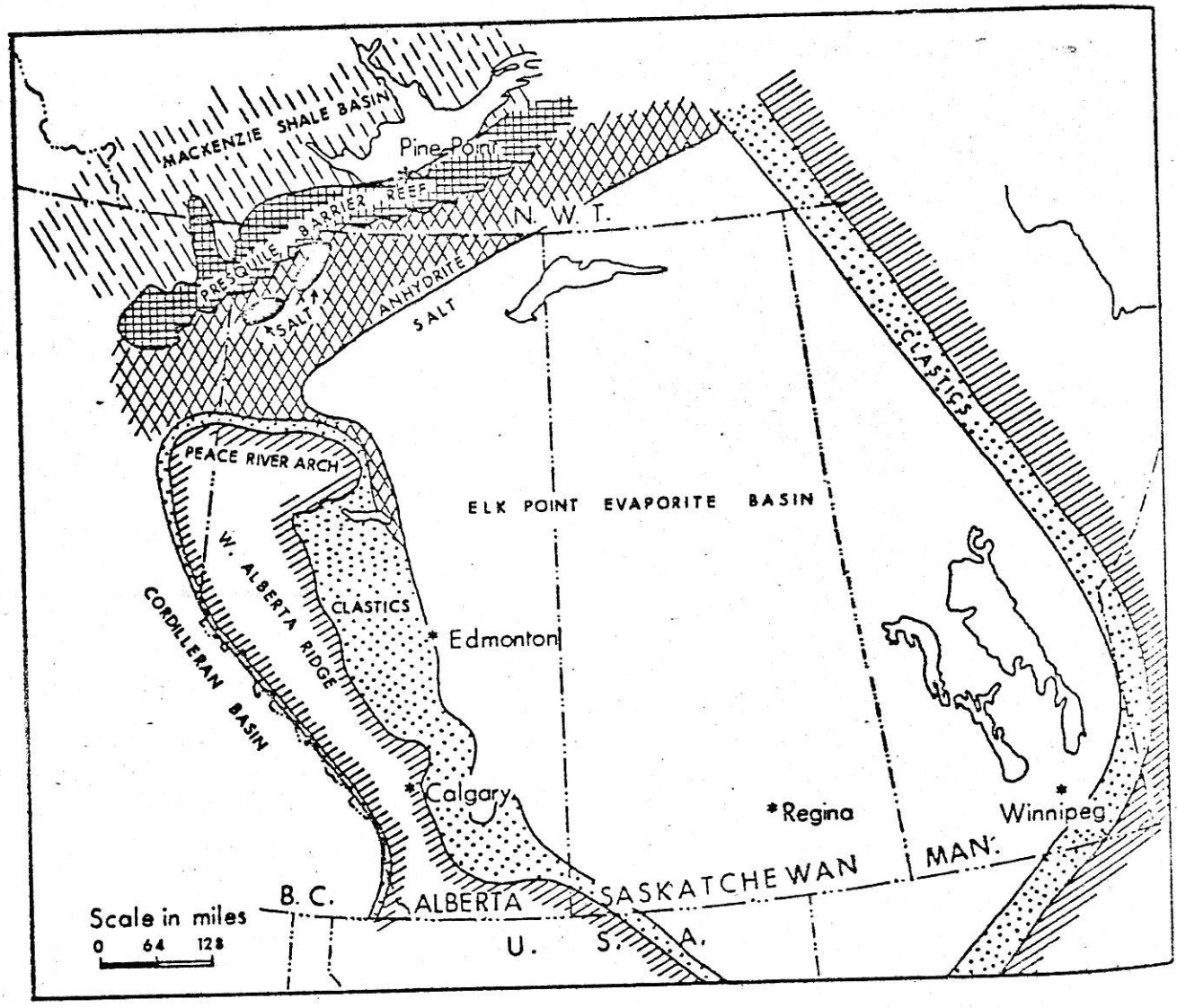


Figure 5. Paleogeography of Western Canada during Middle Devonian (from Jackson and Folinsbee (1969)).

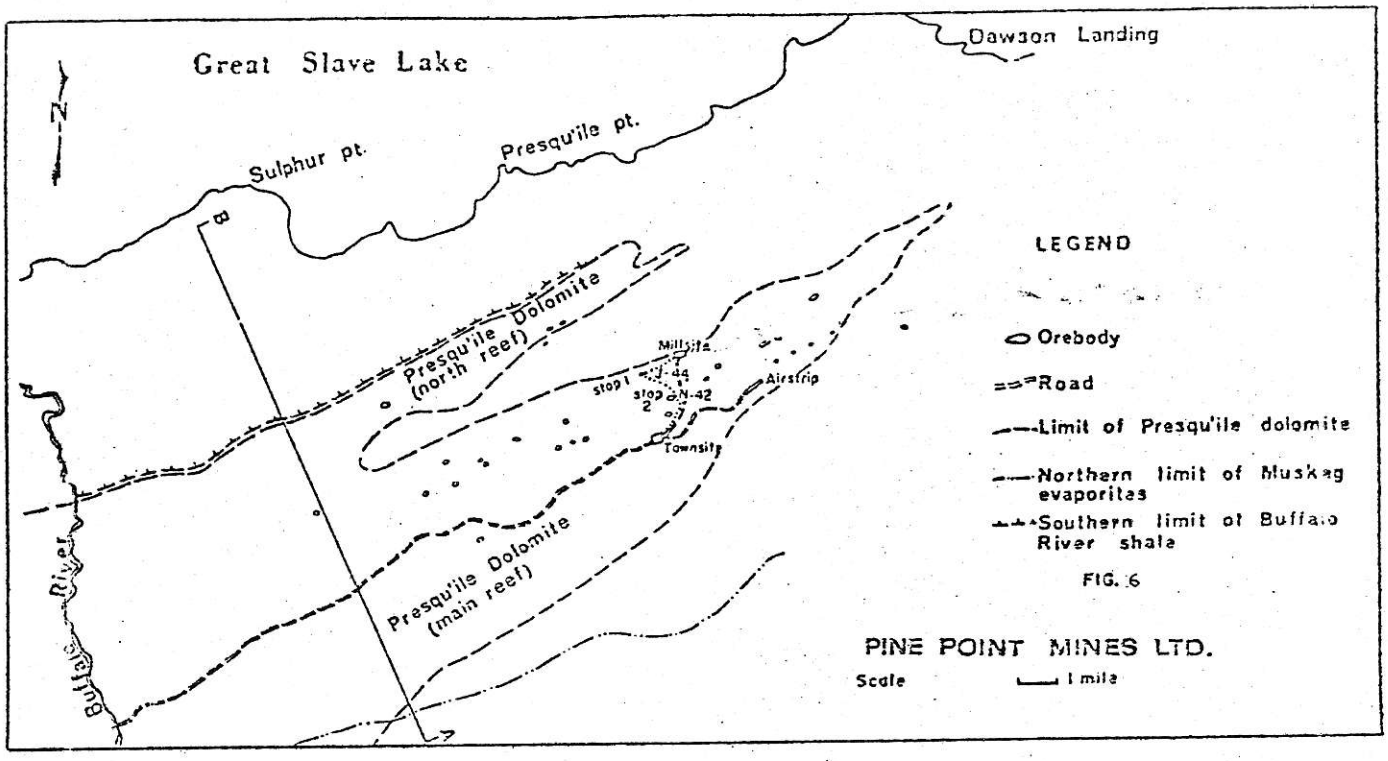


Figure 6. Pine Point Geology (after Skall (1972)).

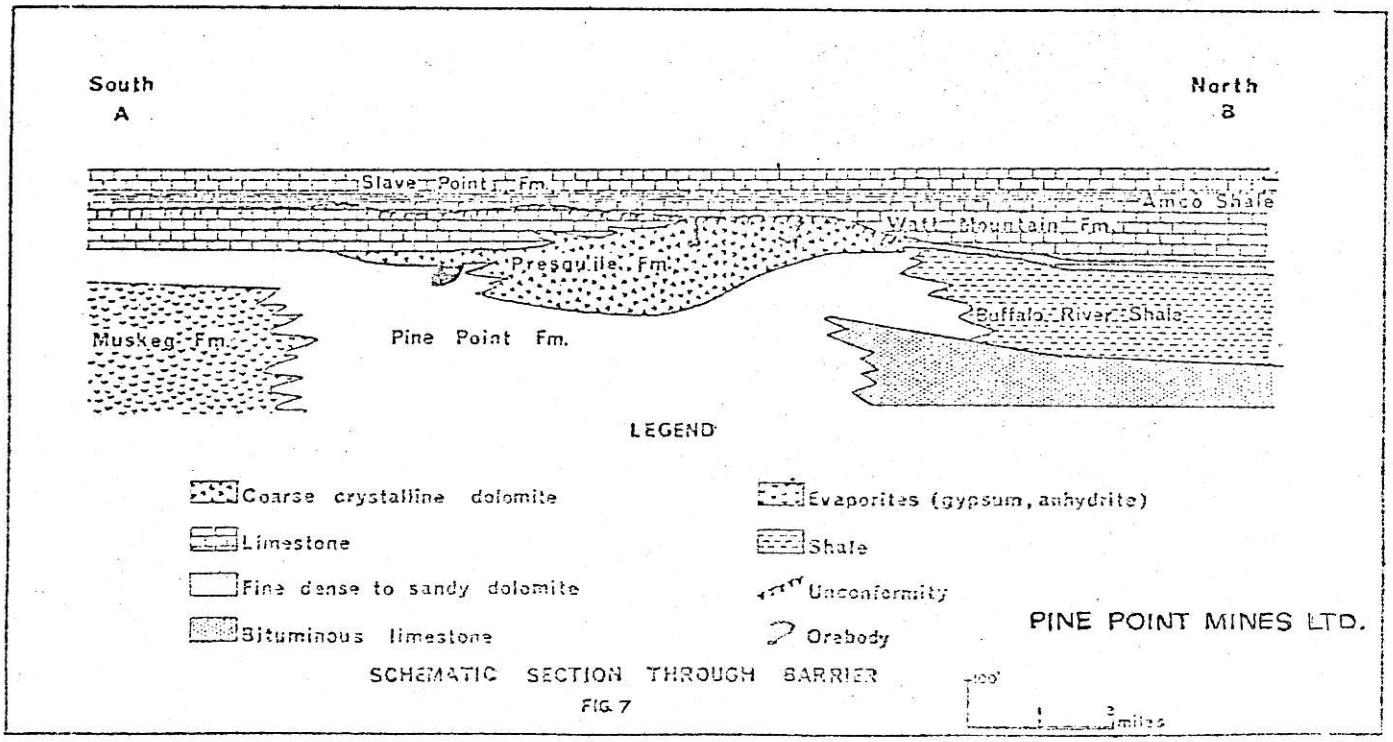


Figure 7. Schematic Section Through Barrier (after Skall (1972)).

barrier along a karst surface.

Reflux dolomitization producing fine sucrosic dolomite dominates in the lower portion of the barrier whereas coarse crystalline secondary dolomite is possibly formed by hot Mg-rich fluids migrating upward from the East Arm fault system (Skall 1972).

Fluid inclusion studies on sphalerite led Rhoedder (1968) to suggest ore forming temperatures of 100° at salinities of 35%, certainly not meteoric water.

Mineralogy and Texture

Bonnet Plume

Sphalerite, the major economic mineral, and minor galena are associated with pyrite and traces of boulangerite. Weathered outcrops contain smithsonite, hydrozincite and limonite. Bitumen is sparse.

Sphalerite occurs in two main colours and 5 distinct modes. Dark reddish brown high iron and olive green low iron varieties of sphalerite make up to 80% of some specimens. One specimen contains granular masses of reddish brown sphalerite in a rock of 30% green sphalerite.

The five modes are:

1. Crystalline granular equidimensional olive green or reddish brown sphalerite with a silicious matrix and no dolomite (Plates 11 & 12).

   This texture occurs in rocks containing green, reddish-brown or reddish-brown and green sphalerite. Thin bands which appear graded vary from coarse grained (0.5 mm) light green bands to dark finer grained bands. Late quartz veins produce larger recrystallized grains in the dark red brown specimen. Quartz in this specimen is interstitial extremely fine grained and interfingers with the rims of the sphalerite. Traces of euhedral pyrite (0.03 mm) with slightly embayed edges occurs in both sphalerite and quartz. No exolutions can be seen in the sphalerite.

2. Irregular, jagged, light reddish brown coloured sphalerite masses, approximately 0.25 mm in a laminated quartzose rock with very little dolomite (Plate 13).

   The host consists of dark and light siliceous bands of varying hydrocarbon or carbon content. Larger sphalerite grains (1.0 mm) and

higher percentages of sphalerite occur in the lighter bands. Locally granular masses (5 mm) of aphalerite ignore previous structure. Sphalerite shows strong concave embayments whereas pyrite which is present in trace amounts is euhedral to sub rounded.

3. Crystalline light reddish brown coloured sphalerite with quartz as matrix of dolomite breccias (Plate 14).

Sphalerite in granular masses up to 5 mm occur in this texture. Quartz is very finely crystalline and replaces dolomite of the fragments of one specimen. Locally the dolomite fragments have fine euhedral pyrite up to 0.5% . Cracks and nearby intercrystalline areas in quartz and dolomite have a faint appearance of sphalerite, especially under crossed nicols, from very thin films of sphalerite.

4. Crystalline light brown sphalerite as vug filling in silicified dolomite (Plate 16).

Light reddish brown coloured sphalerite occurs with coarse crystalline dolomite and quartz and traces of boulangerite, in vugs up to 1 cm across. Intercrystalline porosity is good and crystal faces have thin films of sphalerite. It is difficult to distinquish some of these spaces as cracks or vugs.

5. Dark brown granulated sphalerite with fine broken dolomite as matrix of brecciated dolomite (Plates 17 & 18).

Fragments consist of finely crystalline white dolomite silicified along cracks and flooded with euhedral pyrite. Excellent examples of coxcomb open space filling, sphalerite rimmed by quartz protruding into a cavity, occur rarely in the matrix of this rock type. Masses of galena in the matrix up to 1 cm have fine sphalerite rims. Sphalerite is strongly zoned with iron content decreasing outward. Cadmium substitutes in sphalerite avering .06%. Iron ratios in

sphalerite vary from low % in green varieties up to moderate% in darker varieties. Silver substitutes in galena up to 4.7 oz/ton. Galena was only observed in one specimen.

Porous weathered crusts of quartz smithsonite and hydrozincite cap surfaces of outcrop and float, where mechanical weathering is slow.

Bitumen occurs sparsely as intercrystalline masses in the dolomite of breccia fragments. Limonite gossans provide an exploration tool, however the hand specimens and polished sections of this report contain very little limonite.

Robb Lake

Textures within the Robb Lake suite are very uniform and easier to interpret. Sphalerite and galena are associated with coarse crystalline white dolomite as matrix of brecciated fine grained grey to white dolomite. Pyrite is common in the fragments, sparse in the matrix and bitumen is common in the fragments.

Sphalerite

Red brown and green sphalerite occur with reddish brown varieties most common. Three textures of sphalerite are evident; coxcomb, crystalline and brecciated, at times all in the same specimen. Coxcomb textures describes sphalerite crystals (1 mm) radiating from grey dolomite fragments into the coarse white dolomite matrix (Plate 1). These crystals are zoned with iron decreasing towards the perimeter as are some but not all of the granular crystals. Coxcomb sphalerite growths rim granular sphalerite masses protruding into the white dolomite matrix (Plate1). This texture is zoned from low iron in the granular mass and high iron decreasing outward in the coxcomb sphalerite. Thin films of bitumen often separate sphalerite from dolomite fragments. Pyrite inclusions or possibly exsolution in sphalerite are very sparse.

Pyrite is abundant in grey finely crystalline dolomite of some fragments. There are many types of angular dolomite fragments with varying pyrite and bitumen content.

Brecciated crystalline green to brown sphalerite from 1 cm masses to finely crushed material occurs with 1% galena and 15% white crystalline dolomite in one sample (Plate 4). Plucked fragments of sphalerite float in white dolomite. Galena occurs as crystals up to 5 mm with irregular boundaries with sphaleri and interstitial fingers along cracks in the sphalerite. Dolomite fragments occur with the brecciated sphalerite matrix in one sample.

Patches of creamy dolomite with irregular boundaries rimmed by bitumen provide a very strange but infrequent breccia texture. Bitumen in this sample occupies 3% and rims every dolomite patch. Eight to 10% sphalerite in the rock occurs as crystalline masses and vug filling.

Galena

Galena occurs as crystalline masses restricted by surrounding material resulting in very irregular boundaries. Galena occurs in six of the 10 specimens studied primarily in the matrix as previously stated but also sparsely in the dolomite fragments as intercrystalline growths. Percentages are usually low but do reach 3%.

Substitution percentages in sphalerite or galena are not known.

Pine Point

Sphalerite galena marcasite and pyrite comprise almost all the sulphides of this deposit.

Sphalerite of variable iron content occurs as concentric bands, and crystalline granular masses.

Concentric banding includes crustiform layering, colloform banding and

stalactitic growths (Plates 21 & 22). Colour changes reflecting varying iron content are the major cause of banding however grain size increases in the darker, higher iron, marmatitic varieties. The lighter sphalerite bands appear amorphous. These textures appear most commonly filling large vugs and cavities.

One type of crystalline sphalerite is also common in cavities. It occurs in several millimeter crystalline rhythmic bands with coarse white dolomite (Plate 19). These bands vary along sharp contracts from virtually 100% sphalerite to 100% dolomite. Slight diffusion of iron is common into the dolomite. The sphalerite bands are coarser (1 mm) towards the outside. Crystalline sphalerite is common as disseminations and small vug fillings throughout the crystalline dolomite host.

Galena commonly appears to have been the nucleus of concentric banding, often occupying a central position in stalactites (Plate 21). Irregular shaped crystal and galena filled fractures commonly cut across banding. Dendritic growths of galena in sphalerite are observed. In some cavities galena occupies a central position crystallizing in voids that remain when sphalerite stopped crystallizing.

Marcasite appears more abundant than pyrite from this suite. It usually occurs as finely crystalline radiating mamillary textured growths (Plate 23) associated with sphalerite galena and dolomite and as framboided fine grained masses.

Paragenesis

Paragenetic conclusions from these rock suites fail to predict the genesis of the individual deposits. Reversals of the paragenetic sequences and the lack of field interpretations make it difficult to characterize the chemistry of the mineralizing fluid.

Bonnet Plume

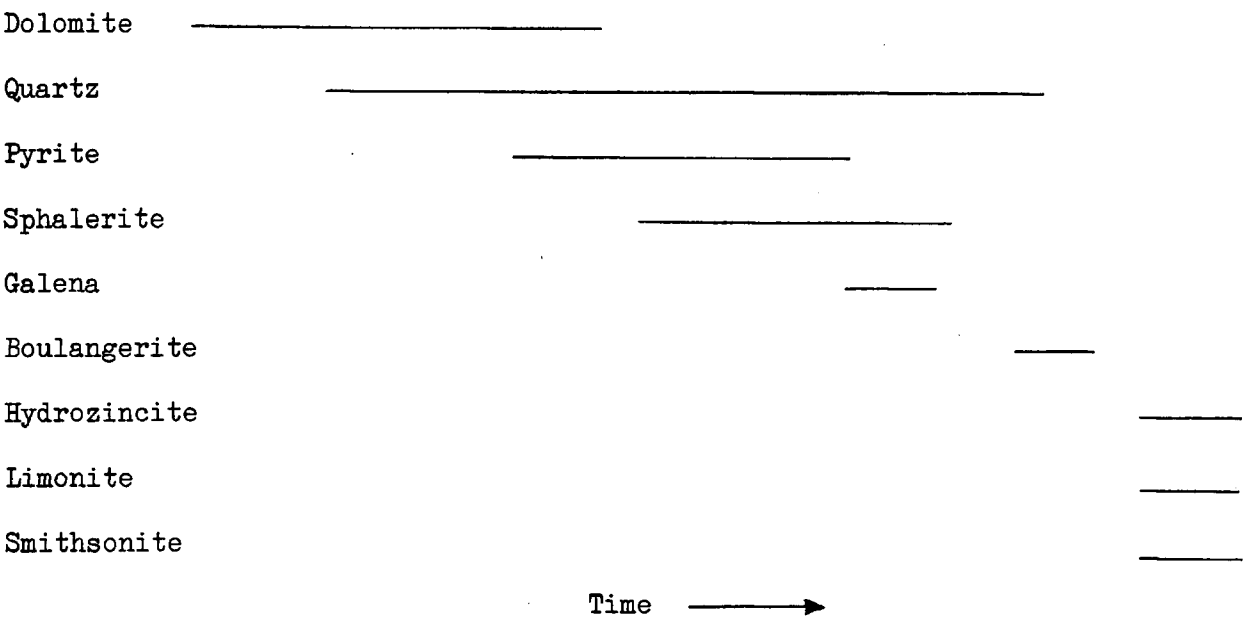


Figure 8 Paragenesis at Bonnet Plume

Robb Lake

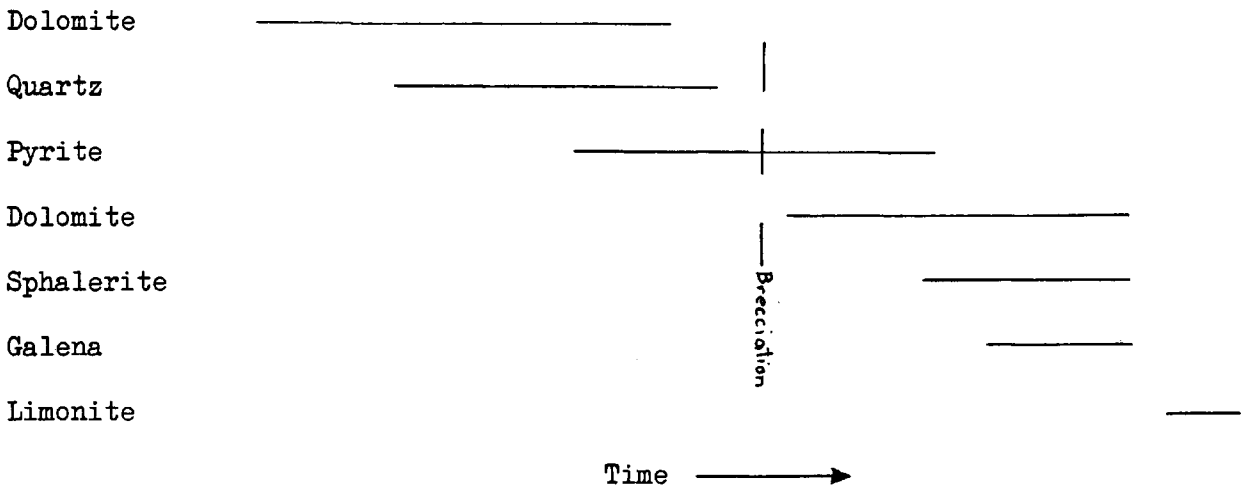


Figure 9 Paragenesis at Robb Lake

Pine Point

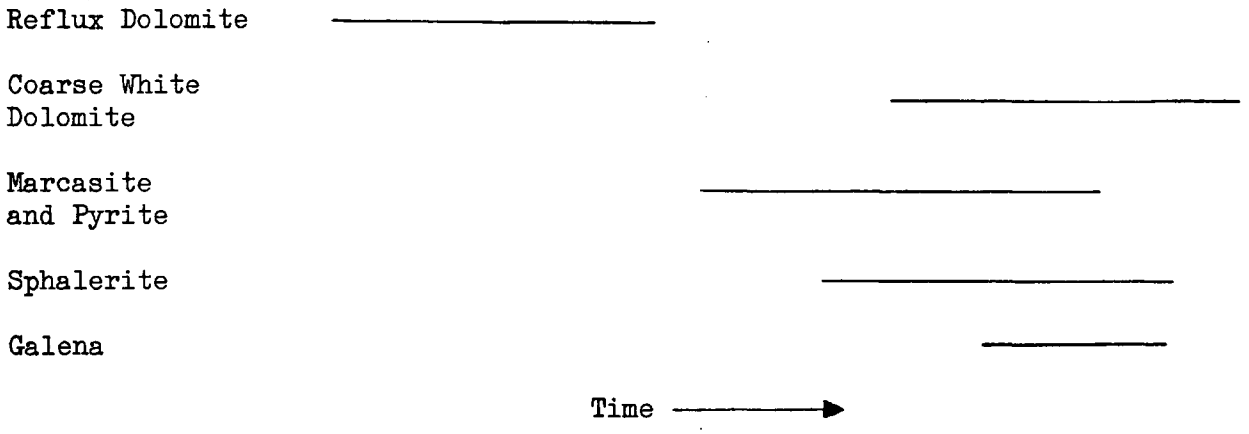


Figure 10 Paragenesis at Pine Point

Reversals within these paragenetic sequences are frequent. Figures 8, 9, & 10 attempt to present an average paragenesis.

Conclusions

Bonnet Plume

This deposit is primarily a sphalerite deposit with minor galena. Sphalerite locally exhibits textures interpretable as syngenetic but usually is definitely epigenetic. Graded bedding cycles in a rock composed of 80% olive green equidimensional sphalerite appear to be a sedimentary texture. This texture could also result from recrystallization, which appears more probable microscopically, suggested by intergrowths of sphalerite with interstitial quartz matrix. Intense silicification is revealed by microcrystalline interstitial quartz, post ore quartz stringers and quartz matrix of breccias. In specimens lacking dolomite it is not known whether silica replaced dolomite pre or post ore emplacement or whether dolomite ever exists in the rock. Most probably there was silicification pre and post ore. Sphalerite is definitely epigenetic where it appears as vug fillings, matrix of breccias and replacement grains.

Colour variations reflect changing availability of iron. Monochromatic sphalerite rock probably reflects iron percentages of the source. However red and green sphalerite in the same specimen suggest variable iron content within the rock being replaced. High iron content results in dark sphalerite.

Silicification is probably fracture controlled and magmatic induced however the actual source of mineralization is undeterminable. Boulangerite may be associated with later stages of silicification.

Robb Lake

This deposit contains sphalerite and galena in proportions greater than 25:1 (according to this suite). Sphalerite and galena are epigenetic, both

occurring with coarse crystalline white dolomite in the matrix of breccias. Sphalerite crystallized preferentially on rims of dolomite fragments. Galena rimmed by sphalerite suggests galena crystallizing earliest, however idiomorphic galena crystals would be expected and there is evidence of interstitial galena. Brecciation continued locally after ore emplacement.

Bitumen appears to play an important part at Robb Lake. It is anomalously abundant and occurs as thin films separating sphalerite dolomite fragments.

Pyrite and silica were introduced before brecciation and may have played a part in making the dolomite brittle.

Pine Point

At Pine Point sulphides comprise up to 90% of the rock locally. Sphalerite and galena are the economic minerals at approximately ratios of 2:1, associated with marcasite and pyrite.

Iron content in sphalerite varies rhythmically causing colour banding in the layered growths. Colloform banding, crustiform layering and stalactitic growths typify epigenetic crystallization in vugs and large cavities.

Galena appears as nucleus for some stalactites as well as late stage cross cutting crystals attesting to reverals of the paragenetic sequence.

Comparisons

All three deposits could conceivably fit into Jackson and Beales (1967) model for lead-zinc genesis. All have shales stratigraphically nearby, are near facies changes from carbonate to shale. Evaporites have not been mentioned in the literature for Bonnet Plume. Bonnet Plume has also undergone signifigant silicification and recrystallization not evident at Robb Lake or Pine Point. Low iron content at Robb Lake and Bonnet Plume probably reflect lack of available iron during formation as opposed to the common idea of low iron reflecting low temperature.

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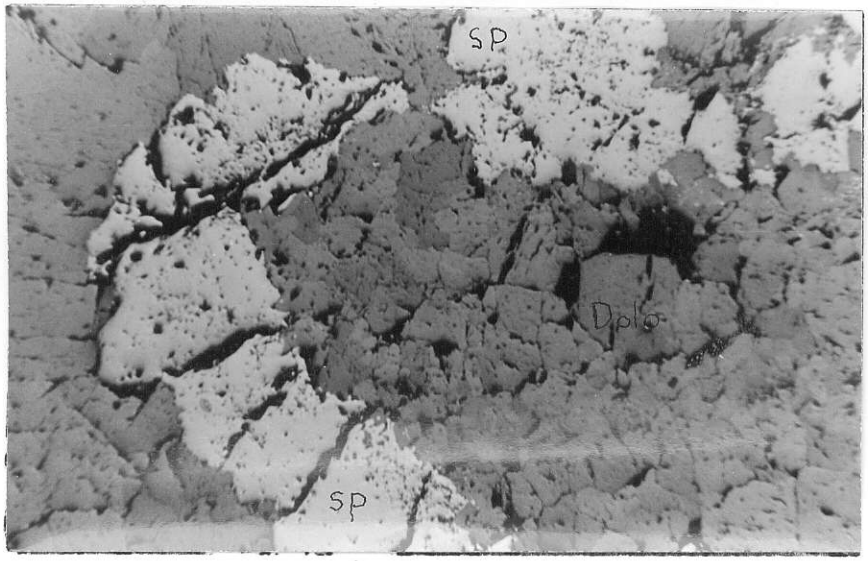
APPENDIX I

Robb Lake sample

descriptions and photographs

Plates 1 to 9



MINERALOGY

Sphalerite
Galena
Pyrite
Dolomite: 2 stages

Zoned colloform sphalerite rimming dolomite breccia fragment and intruding in coarse white dolomite matrix. Zoning not evident in plane light. 40x
Iron decreases outward.

TEXTURE

Sphalerite- reddish brown to yellowish brown granulated and colloform crystals; preferentially rims dolomite fragments; crystals zoned, decreasing iron towards perimeter; colloform sphalerite coats granular sphalerite masses; rarely blebs of pyrite 0.01 mm occur in sphalerite.

Pyrite- primarily as pre-brecciation euhedral crystals in grey dolomite fragments; not seen in matrix white dolomite.

Dolomite- grey fine grain fragments flooded with pyrite; coarse white crystalline matrix.

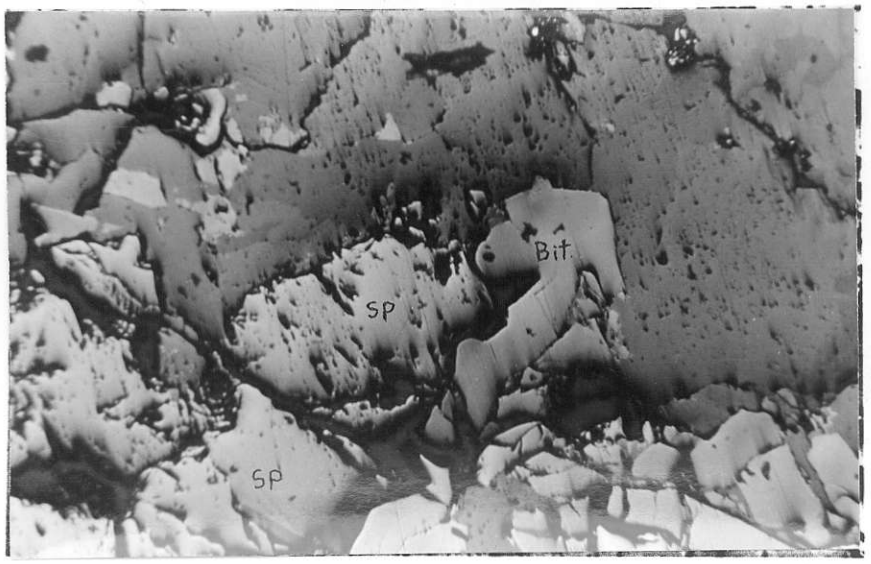
MODE + GRAIN SIZE

Sphalerite	27%	microscopic to 1.4 mm
Galena	0.5%	0.8 mm
Pyrite	2.5%	0.01 mm
Dolomite	70%	

COMMENTS

Does sphalerite replace white dolomite or vica versa or did they crystallize synchronously. Probably sphalerite crystallized at same time or later than white dolomite.

Plate 1



MINERALOGY

Sphalerite

Bitumen

Pyrite

Dolomite: 2 stages

Bitumen- smooth boundaries with sphalerite; brecciated.
Sphalerite- rounded grains with corroded edges. 40x

TEXTURE

Angular grey dolomite fragments floating in matrix of coarse crystalline white dolomite.

Sphalerite- angular crystal of two stages, early low iron large crystals and later higher iron small crystals.

Pyrite- very fine grain; anhedral to subhedral occuring at contact of dolomite fragments and matrix dolomite or sphalerite.

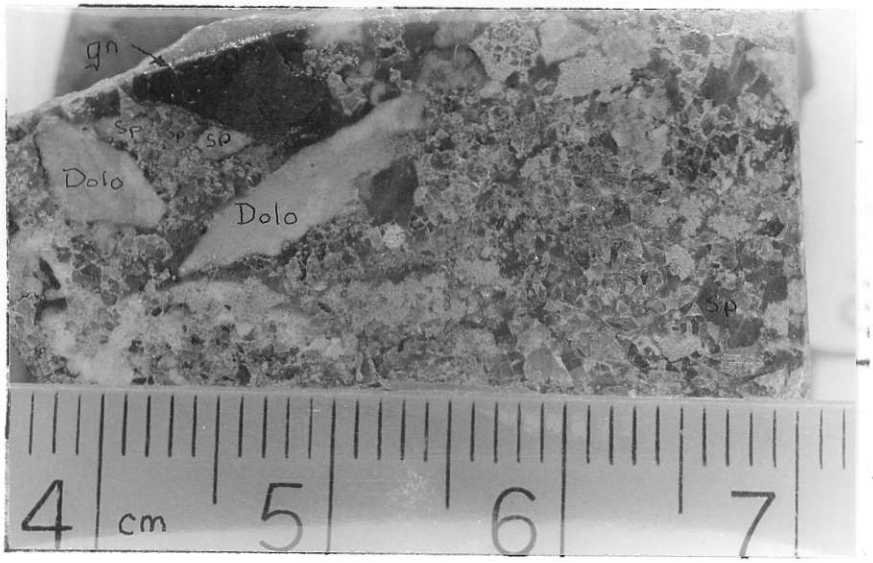
Bitumen- Rims fragments locally; also in matrix; bent and broken fragments.

MODE + GRAIN SIZE

Sphalerite	10%	0.4--4 mm
Pyrite	0.5%	0.07 mm
Bitumen	0.5%	0.6 mm
Dolomite fragments	9%	
Dolomite matrix	80%	

COMMENTS

Pyrite in this specimen does not seem to be pre brecciation; although it is in the dolomite fragments it concentrates at their rim.



MINERALOGY

Sphalerite
Galena
Pyrite
Dolomite: 2 stages
Quartz

Brecciated sphalerite and dolomite with minor coarse white dolomite as matrix for dolomite fragments. Matrix is primarily granulated sphalerite. Large anhedral galena crystal. 40x

TEXTURE

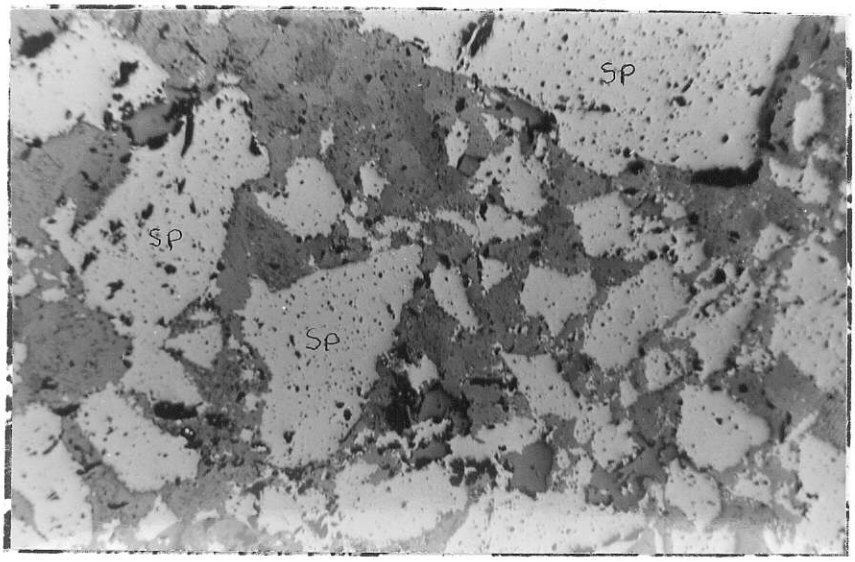
Sphalerite- brecciated; low iron; green sphalerite; occurs in matrix.
Galena- large anhedral crystal; intrudes marix at its edge.
Pyrite- scarce; 0.05 mm anhedral grains.
Dolomite- white fragments; grey fragments.
Quartz- microcrystalline; with white dolomite in groundmass.

MODE + GRAIN SIZE

Sphalerite	35%	0.8 mm
Galena	1%	8 mm
Pyrite		0.05 mm
Dolomite fragments	29%	10 mm
Quartz matrix	25%	microcrystalline
Dolomite matrix	10%	0.2 mm

COMMENTS

Silica appears to replace dolomite of the matrix. Where is the silica from.



Sphalerite breccia with 20% white crystalline matrix. 40x

MINERALOGY

Sphalerite
Galena
Dolomite

TEXTURE

Sphalerite- angular green low iron sphalerite; jagged boundaries with coarse white dolomite matrix suggesting reaction; plucked grains lie only Millimeters from parent fragments.

Galena- fills cracks in the sphalerite locally.

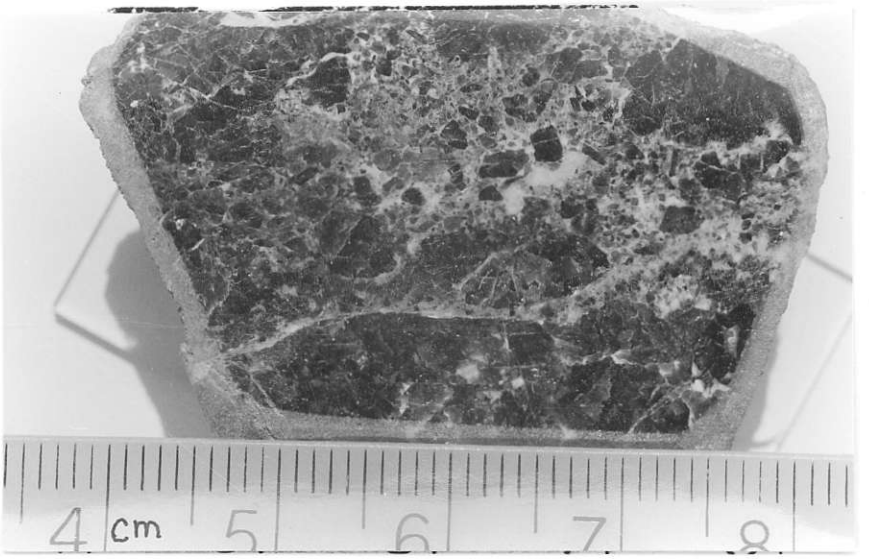
MODE + GRAIN SIZE

Sphalerite	79%	variable
Galena	1%	0.1--2 mm
Dolomite	20%	

COMMENTS

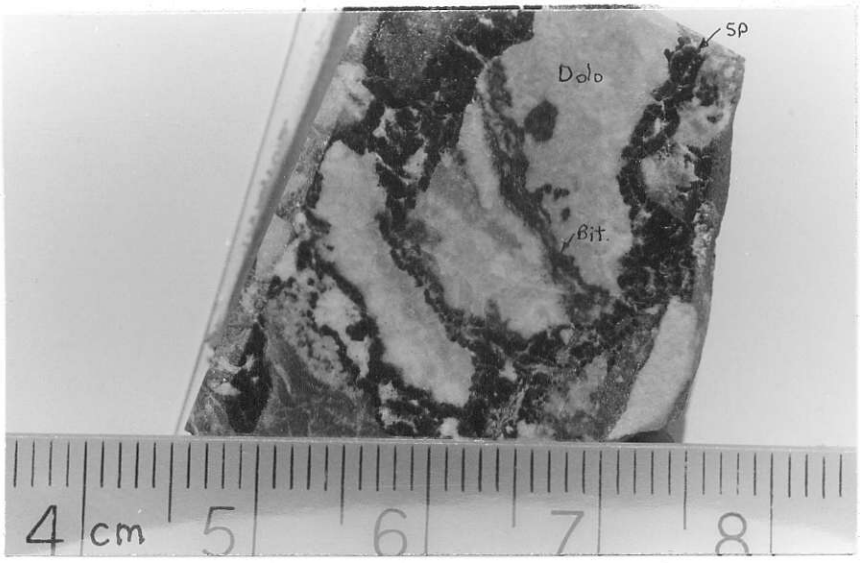
Galena appears to be latest; sphalerite has reacted with dolomite.

RL-4



Brecciated sphalerite in white crystalline dolomite matrix. Galena up to 2 mm fills in cracks in sphalerite.

Plate 5



Dolomite breccia fragment containing intercrystalline bitumen with sphalerite and white crystalline dolomite as matrix. 40x

MINERALOGY

Sphalerite
Bitumen
Pyrite
Dolomite: 2 stages
Galena

TEXTURE

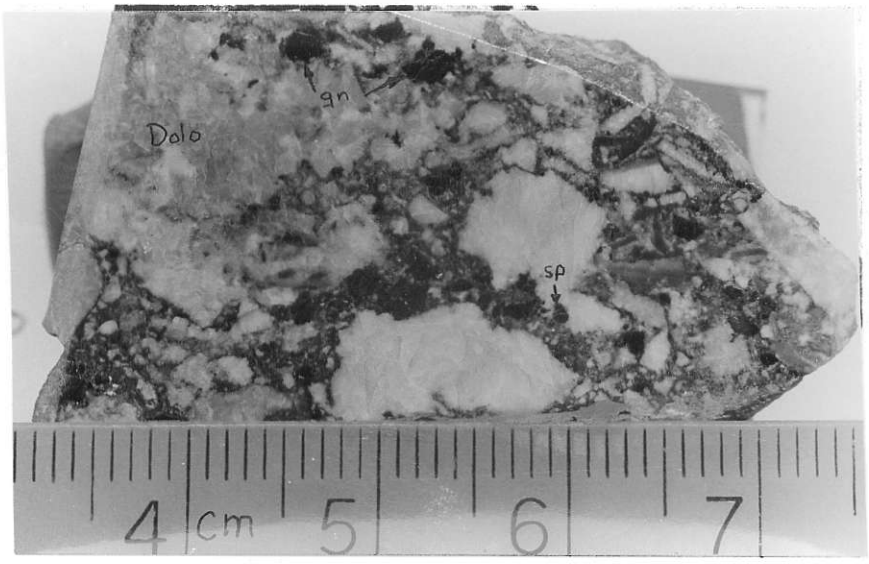
Sphalerite- dark crystalline in matrix ; also colloform growths in fragments.
Bitumen- abundant; intercrystalline masses in fragments.
Pyrite- subhedral; in fragments and rimming fragments.
Galena- traces in fractures in sphalerite.
Dolomite- finely crystalline in fragments, grey moderately crystalline in matrix.

MODE + GRAIN SIZE

Sphalerite	15%	0.8 mm
Bitumen	3%	
Pyrite		0.05 mm
Dolomite	82%	
Galena		0.1 mm

COMMENTS

Pyrite again aften separates fragments from sphalerite. Abundant bitumen.



Sphalerite and galena with bitumen and dolomite as matrix for grey dolomite fragments. 40x

MINERALOGY

Sphalerite

Galena

Pyrite

Bitumen

Dolomite: 2 stages

TEXTURE

Sphalerite- crystalline dark coloured masses in matrix.

Galena- anhedral masses in matrix intruding into matrix along perimeter.

Pyrite- fine. subhedral; in grey dolomite fragments.

Bitumen- intercrystalline in matrix.

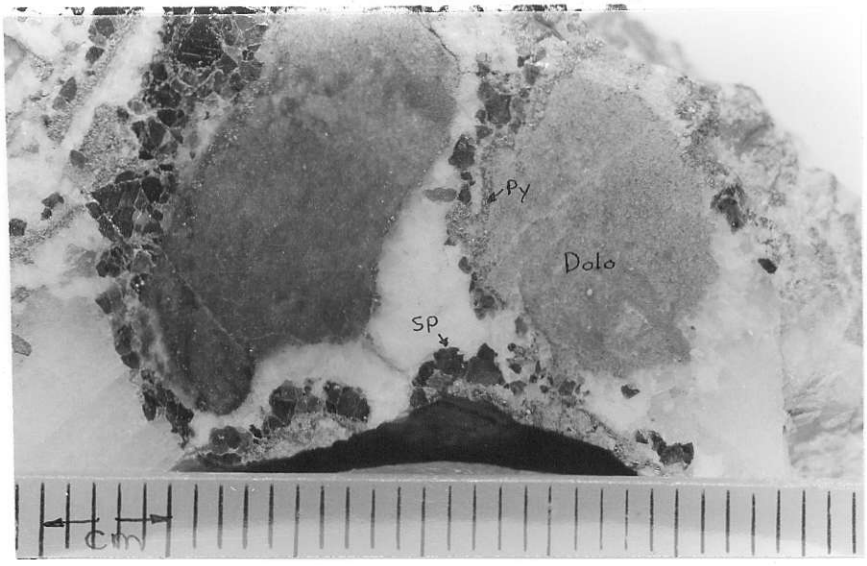
Dolomite- finely granulated in matrix; crystalline in matrix and as large fragments.

MODE + GRAIN SIZE

Sphalerite	1.5%	1 mm
Galena	3%	2 mm
Pyrite		0.08 mm
Bitumen	2%	
Dolomite	93.5%	

COMMENTS

Galena appears interstitial (i.e. late). Bitumen is abundant rimming fractures.



Grey dolomite rounded fragments rimmed by pyrite with golden brown sphalerite in matrix. 40x

MINERALOGY

Sphalerite

Pyrite

Galena

Dolomite: 2 stages

TEXTURE

Sphalerite- crystalline and poor colloform growths on grey dolomite fragments.

Pyrite- rims dolomite fragments; often between fragments and sphalerite.

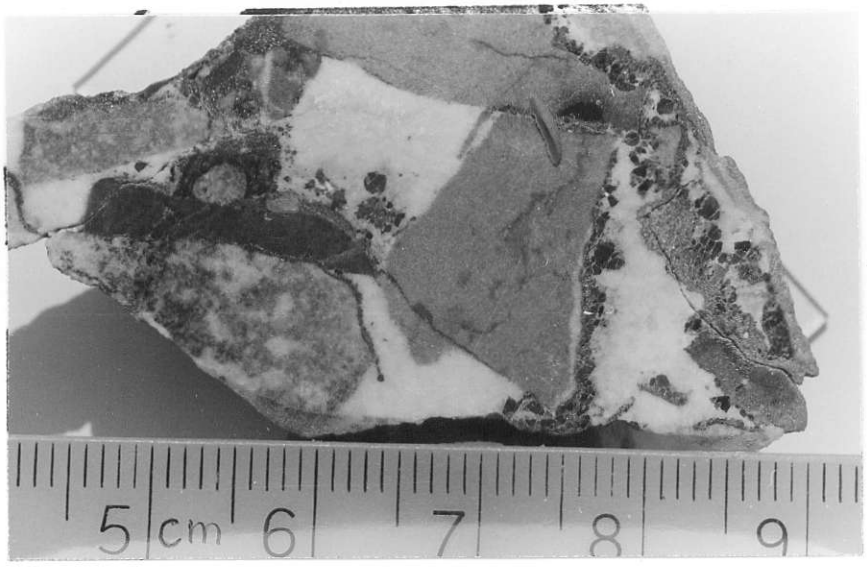
Galena- in matrix; anhedral

MODE + GRAIN SIZE

Sphalerite	2%	1 mm
Pyrite	1%	0.7 mm
Galena	0.25%	1.5 mm
Dolomite	96.75%	

COMMENTS

Possibly pyrite came in along early fractures along which the dolomite latter seperated. This could explain the textural distribution.



Brecciated dolomite with coarse white crystalline dolomite and sphalerite in the matrix.

MINERALOGY

Sphalerite

Pyrite

Bitumen

Dolomite: several types

TEXTURE

Sphalerite- crystalline light brown occurring preferentially at fragment borders.

Pyrite- euhedral in some dolomite fragments.

Bitumen- in grey dolomite; intercrystalline.

Dolomite- fragments-grey, black or matted; matrix-coarse, crystalline, white.

MODE + GRAIN SIZE

Sphalerite	4%	1 mm
Pyrite	0.5%	0.06 mm
Bitumen	0.5%	
Dolomite	95%	

COMMENTS

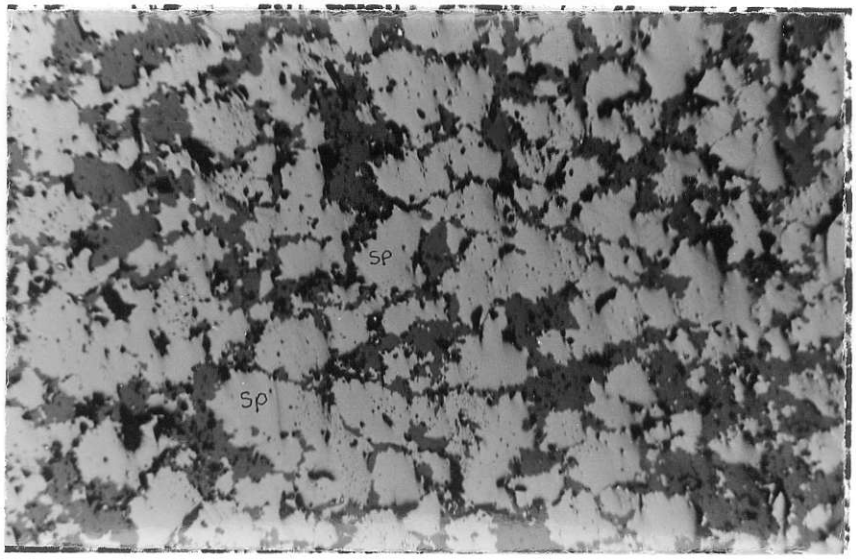
The variety of dolomite fragments suggests that this is not a true collapse breccia but an aggregation of several rock types.

APPENDIX II

Bonnet Plume sample

descriptions and photographs

Plates 10 to 18



Red sphalerite equidimensional grains with irregular contracts against quartz matrix. 40x

MINERALOGY

Sphalerite

Pyrite

Quartz

TEXTURE

Sphalerite- red brown high iron; equidimensional grains; irregular contracts with quartz suggest reaction.

Quartz- is microcrystalline and interstitial.

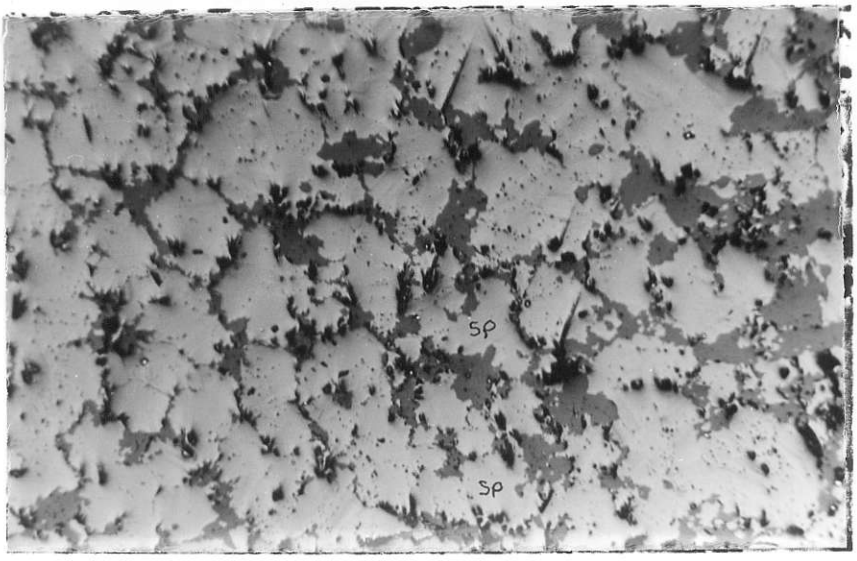
Pyrite- euhedral embayed somewhat; occurs in sphalerite and quartz.

MODE + GRAIN SIZE

Sphalerite	50%	0.02--1 mm; 0.8 mm average in quartz veins
Quartz	50%	1 mm
Pyrite		0.03 mm

COMMENTS

Quartz veining has increased the grain size locally.



Green sphalerite, equidimensional, irregular boundaries with quartz matrix. 40x

MINERALOGY

Sphalerite

Quartz

Pyrite

TEXTURE

Sphalerite- green equidimensional irregular boundaries very similar to BP-1, (Plate 10).

Quartz- interstitial microcrystalline

Pyrite- euhedral embayed scarse.

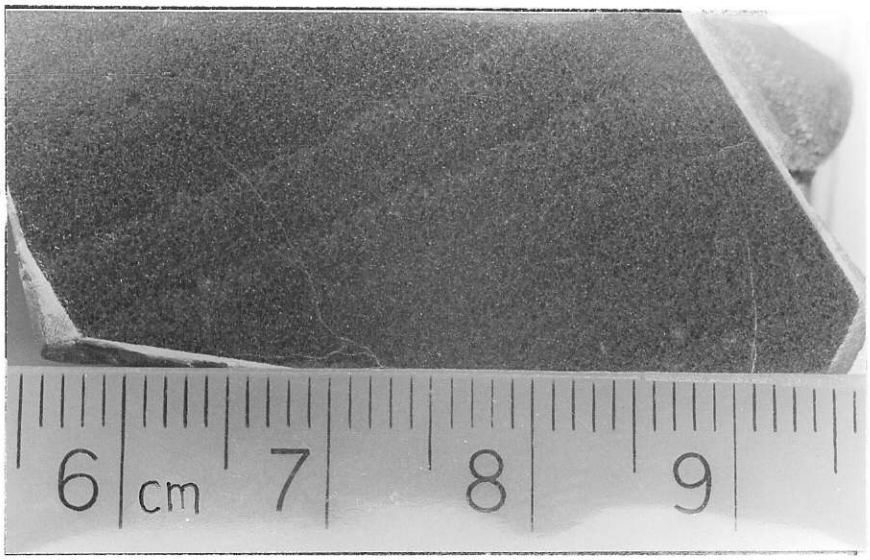
MODE + GRAIN SIZE

Sphalerite	80%	0.3 mm
Quartz	20%	
Pyrite		0.25 mm masses

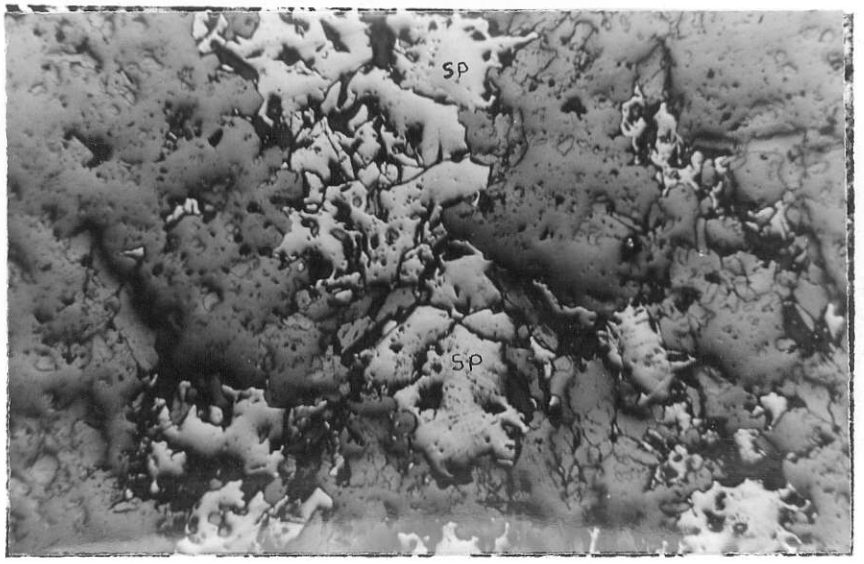
COMMENTS

Striking similarity BP-1 and BP-2. Varying Fe and possibly CoCd or Mn.

BP-2



Green granular sphalerite showing graded bedding; quartz matrix.



Irregular shaped sphalerite in banded silicious rock.
40x

MINERALOGY

Sphalerite
Quartz
Pyrite

TEXTURE

Sphalerite- is selective occurring most commonly and in larger grains within the light coloured bands, however it is disseminated throughout. Sphalerite has very jagged boundaries with quartz. The layering probably results from carbon or clay mineral variation.

Quartz- is microcrystalline.

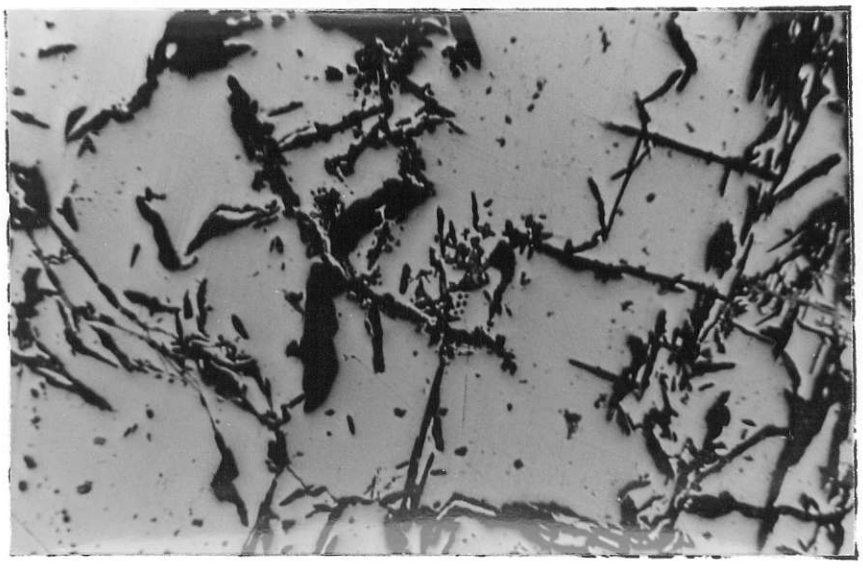
Pyrite- euhedral disseminated.

MODE + GRAIN SIZE

Sphalerite	2%	0.25 mm disseminated; 1 mm locally
Pyrite		0.01 mm
Quartz	98%	

COMMENTS

Silicification has probably increased the grain size of certain bands.



Well developed cleavage in sphalerite. 40x

MINERALOGY

Sphalerite

Pyrite

Dolomite

Quartz

TEXTURE

Sphalerite- dark red; occurs in crystalline masses; corroded deeply along grain boundaries and cleavage, possibly due to weathering.

Quartz- crystalline; occurs with sphalerite as matrix for dolomite breccia fragments; also replaces dolomite of fragments along cracks.

Dolomite- stained yellow by weathering of disseminated pyrite.

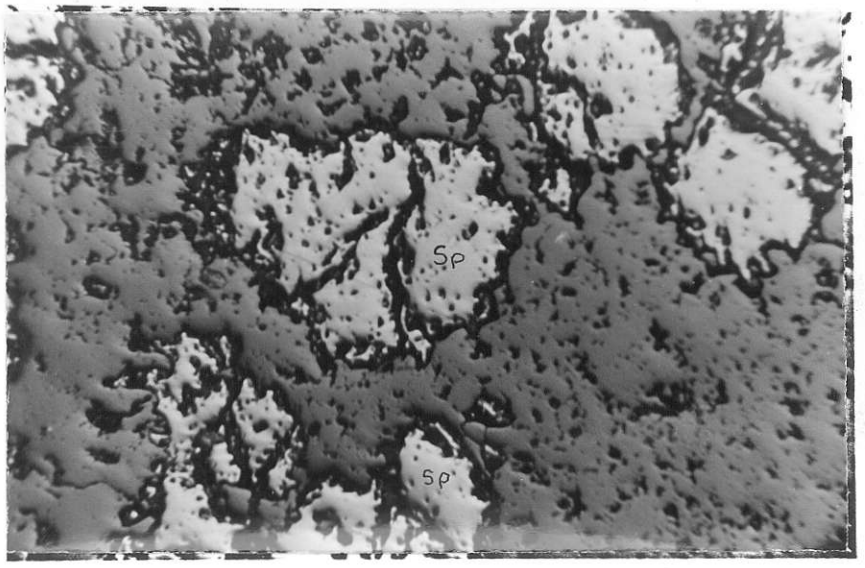
Pyrite- disseminated euhedral.

MODE + GRAIN SIZE

Sphalerite	8%	15 mm masses; 0.8 mm crystals
Quartz	6%	0.6 mm
Dolomite	85%	
Pyrite	1%	0.02 mm

COMMENTS

Plate 14



Sphalerite, equidimensional grains with jagged edges in quartz. 40x

MINERALOGY

Sphalerite

Quartz

Dolomite

TEXTURE

Sphalerite- light green to red; equidimensional corroded grains; smooth to jagged contacts with quartz.

Quartz- matrix, finely crystalline.

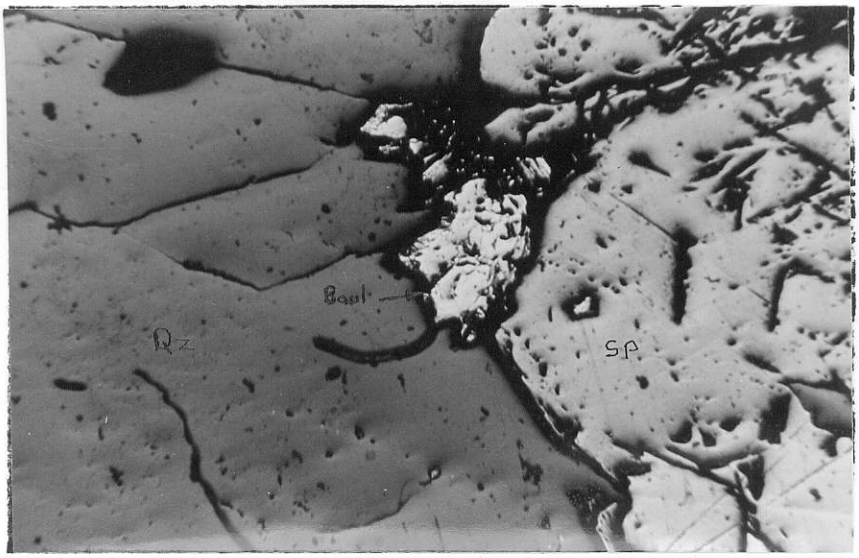
Dolomite- only recorded on X-ray diffractogram.

MODE + GRAIN SIZE

Sphalerite	35%	0.8 mm
Quartz	65%	0.2 mm
Dolomite	only on X-ray diffractogram	

COMMENTS

Possibly replacement of hosts containing variable iron cause the variable colour in sphalerite. Was the host dolomite originally. Has all the Ca and Mg gone.



Boulangerite imbedded in notch in sphalerite. Quartz gangue. 40x

MINERALOGY

Sphalerite
Galena
Boulangerite
Quartz
Dolomite

TEXTURE

Sphalerite- light brown, weathered; appears to be in vugs and possibly fractures.

Galena- occurs rarely rimming sphalerite.

Boulangerite- occurs rimming sphalerite.

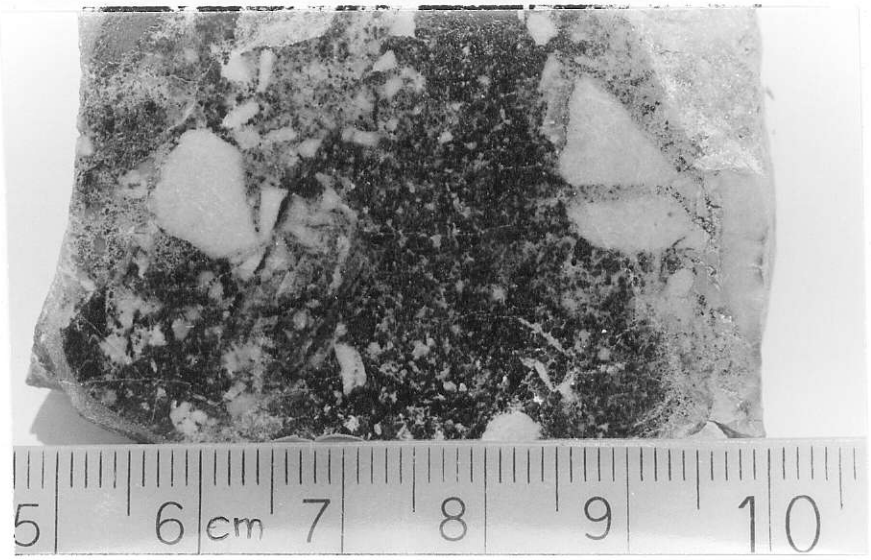
Quartz- crystalline; fills vugs with sphalerite; microcrystalline, replaces dolomite in most of the rest of the rock.

MODE + GRAIN SIZE

Sphalerite	3%
Galena	trace
Boulangerite	trace
Quartz	
Dolomite	

COMMENTS

Boulangerite- late stage low to moderate temperature vein mineral. Is it associated with the same silicification that produced the silica matrix of BP-1, BP-2, and BP-8.



Dolomite fragments in sphalerite dolomite and quartz matrix. Galena late replacement in matrix.

MINERALOGY

Sphalerite

Galena

Dolomite

Pyrite

TEXTURE

Sphalerite- granulated crystalline sphalerite occurs in the matrix with quartz and dolomite. Rarely coxcomb sphalerite growing from vug is coated in quartz (Plate 19).

Galena- occurs in matrix; certain galena crystals have microscopic rims of sphalerite (Plate 19).

Dolomite- angular fragment and in the matrix.

Quartz- late mineral of matrix.

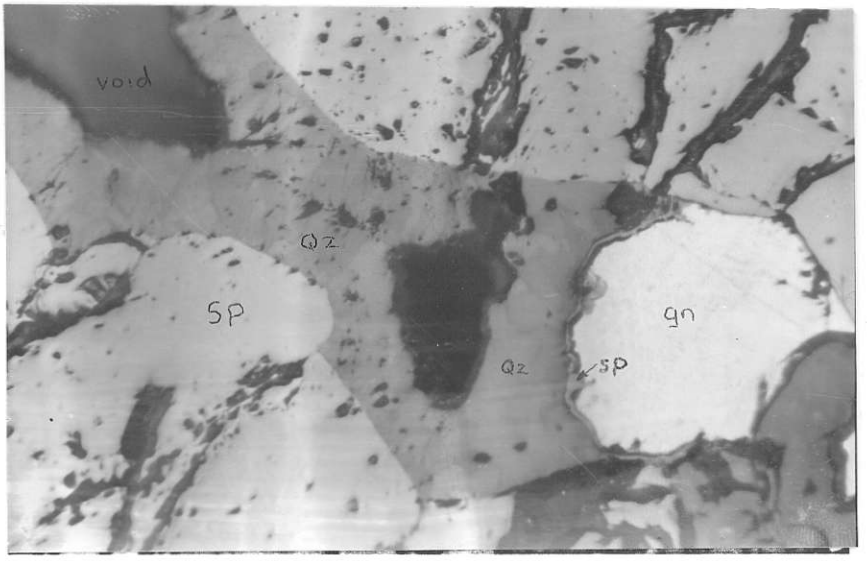
MODE + GRAIN SIZE

Sphalerite	30%	0.8 mm--1 mm
Galena	3%	2 mm
Dolomite	65%	
Quartz	2%	0.05 mm

COMMENTS

Paragenesis from coxcomb sequence (Plate 19), galena: sphalerite: quartz with time.

BP-11



Galena rimmed by colloform sphalerite which in turn is rimmed by quartz growing in a vug. 40x

Plate 18

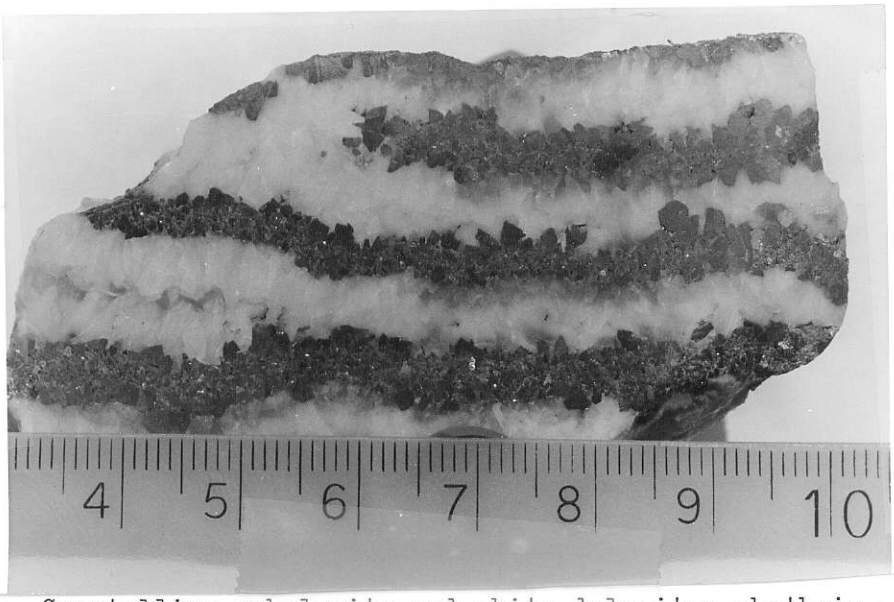
APPENDIX III

Pine Point sample

descriptions and photographs

Plates 19 to 23

E73.006.001



Crystalline sphalerite and white dolomite; rhythmic layering.

MINERALOGY

Sphalerite

Dolomite

Calcite

TEXTURE

Sphalerite- euhedral crystalline dark, high iron; grain size increases towards perimeter of each layer.

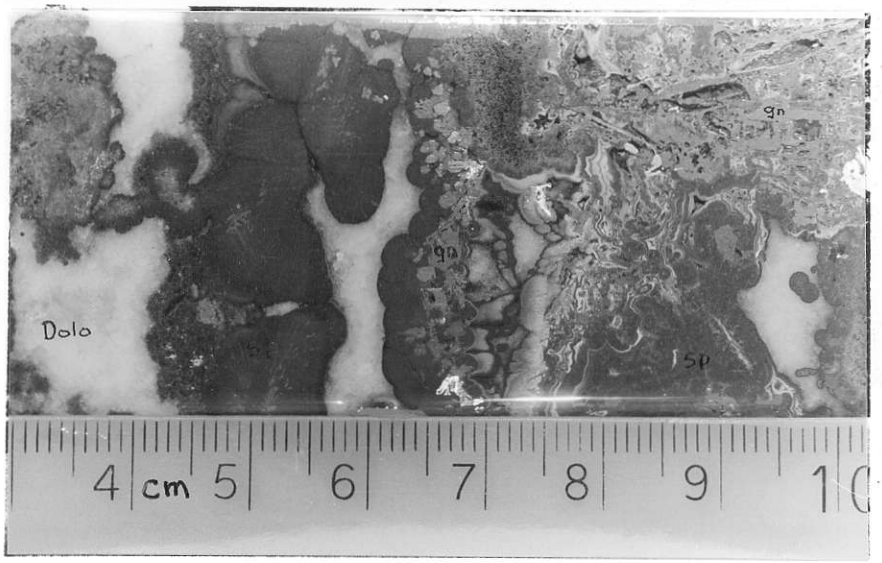
Dolomite- crystalline, white; minor calcite in intercrystalline voids.

MODE + GRAIN SIZE

Sphalerite	40%	0.2 mm --1.5 mm, average 0.8 mm
Dolomite	60%	1 mm
Calcite		1 mm

COMMENTS

E73.006.007



Drill core section. Colloform sphalerite replaced by galena at cores and along cracks.

MINERALOGY

Sphalerite

Galena

Marcasite

Dolomite

TEXTURE

Sphalerite- granular fine grained sphalerite grades to colloform amorphous sphalerite at rims. Variable iron content.

Galena- replacement cubes, replacement along cracks and dendritic galena in sphalerite (0.02 mm diameter).

Dolomite- white crystalline late stage vug finning.

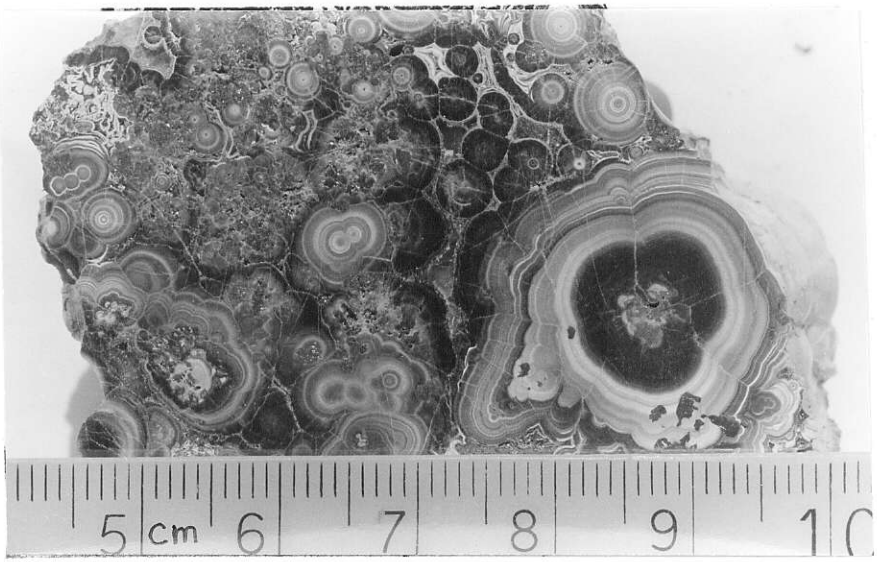
MODE + GRAIN SIZE

Sphalerite	65%	amorphous to 0.2 mm
Galena	15%	1 mm
Dolomite	20%	2 mm

COMMENTS

No host rock present. Massive cavity finning.

E73.006.009



Stalactitic sphalerite locally replaced by galena.

MINERALOGY

Sphalerite

Galena

Calcite

TEXTURE

Sphalerite- stalactite up to 2.5 cm and unknown length; variable iron content causes banding in the amorphous sphalerite. Pearly lustre results from fine grain texture.

Galena- replaces sphalerite along cracks in isolated anhedral masses and at cores of stalactites.

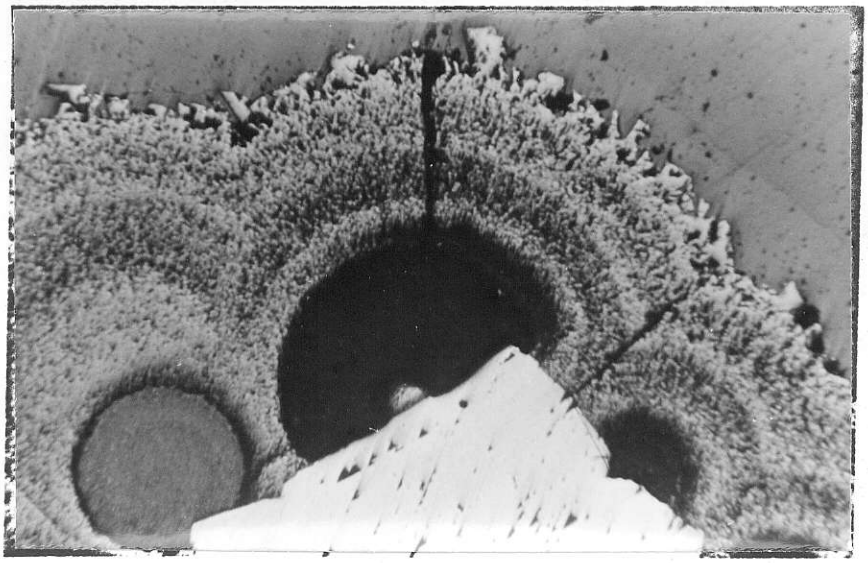
Calcite- crystalline filling between stalactites.

MODE + GRAIN SIZE

Sphalerite	90%	amorphous
Galena	8%	1 mm
Calcite	2%	2 mm

COMMENTS

E73.006.024



Galena crystal cutting colloform sphalerite. Grain size and iron content increase toward perimeter. 40x

MINERALOGY

Sphalerite

Galena

Dolomite

TEXTURE

Sphalerite- colloform sphalerite replacing crystalline dolomite. Grain size varies from amorphous to about 0.01 mm increasing outward. Highest iron content is at the rim.

Galena- replaces sphalerite as coarse cubes and colloform pseudomorphs (anhedral crystalline masses).

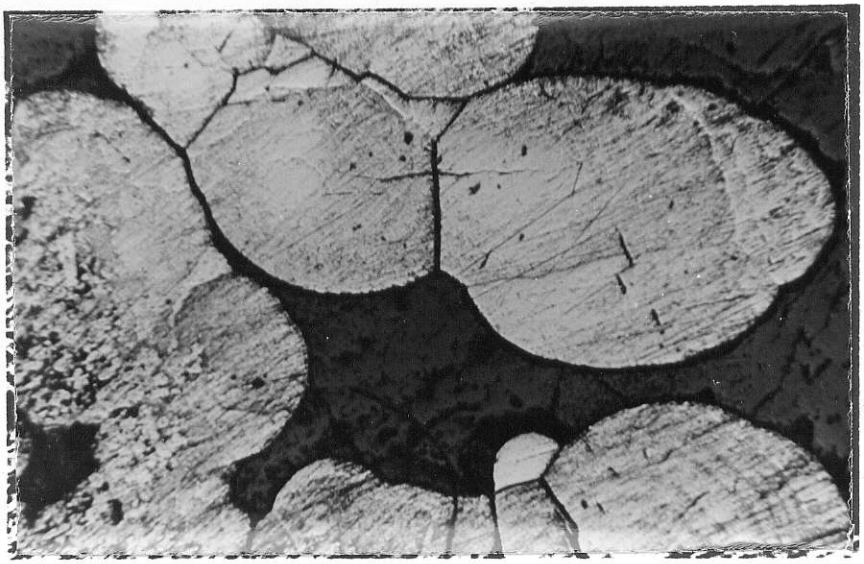
MODE + GRAIN SIZE

Sphalerite	40%	amorphous to 0.01 mm
Galena	20%	average 1 mm
Dolomite	40%	5 mm

COMMENTS

Paragenesis: dolomite: sphalerite: galena with time.

E73.006.033



Botryoidal marcasite in dolomite and calcite. 40x

MINERALOGY

Marcasite

Dolomite

Calcite

TEXTURE

Marcasite- botryoidal growths up to 2 mm, smooth boundaries with dolomite and calcite.

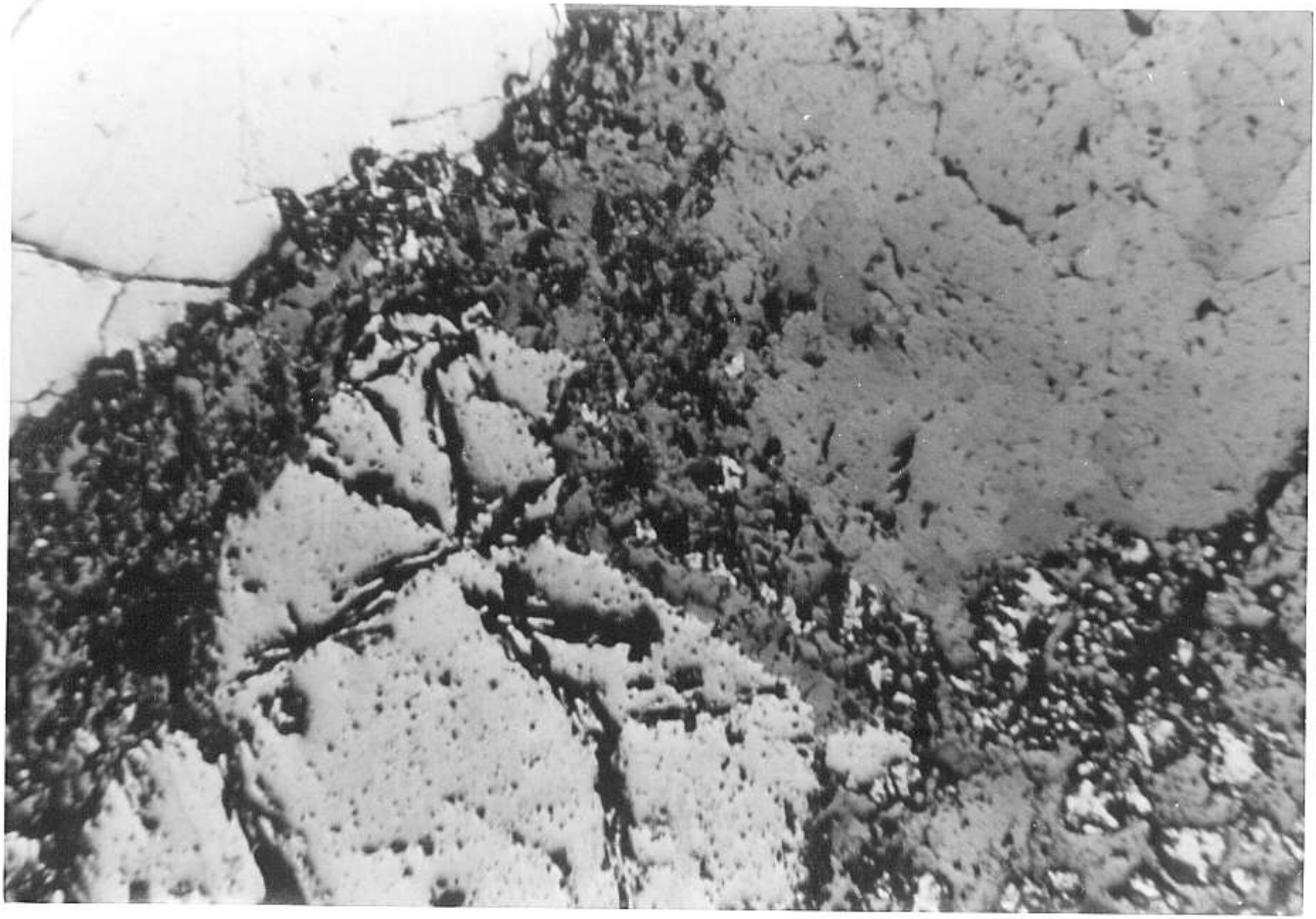
Dolomite and Calcite- crystalline intergrowths in matrix.

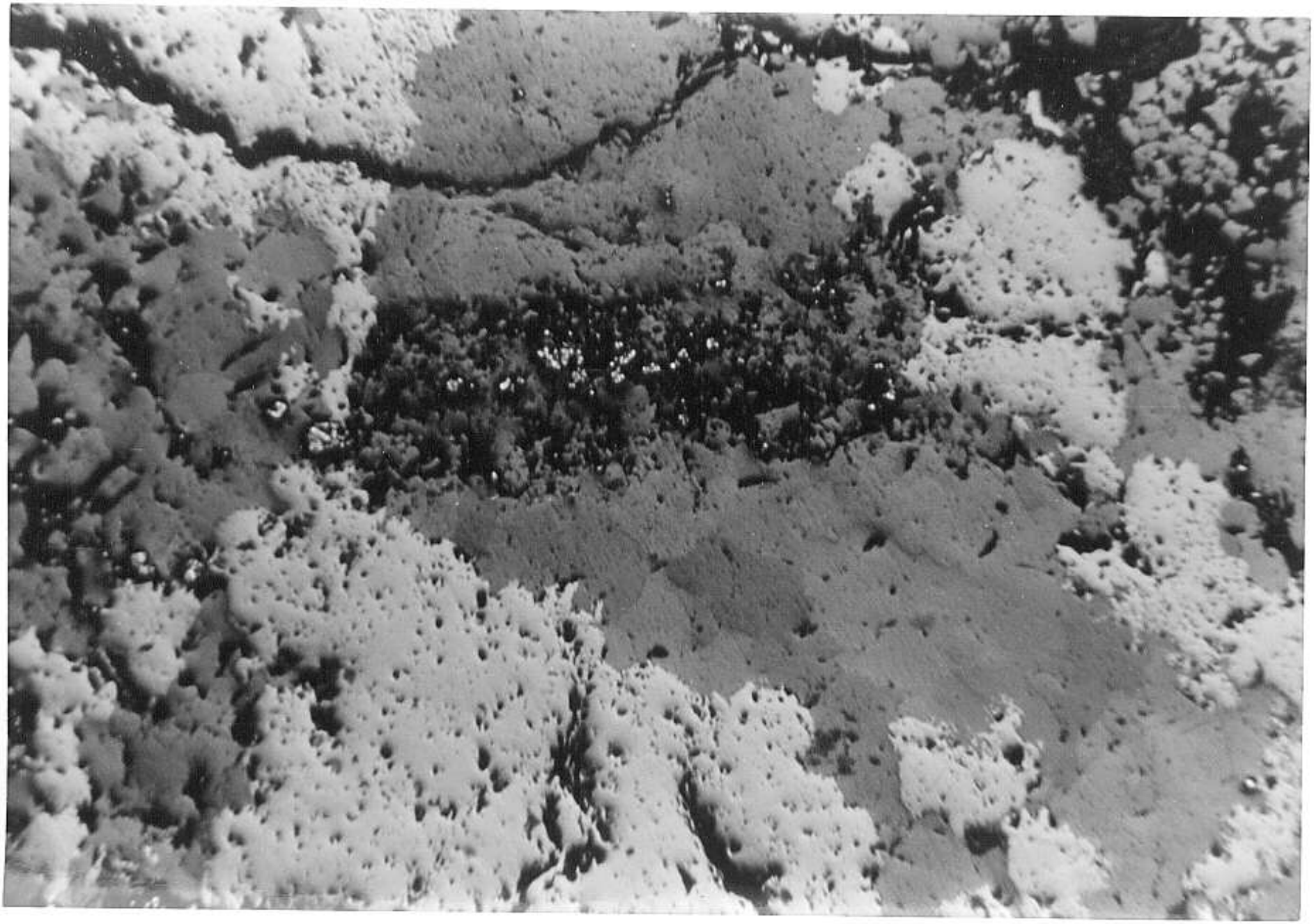
MODE + GRAIN SIZE

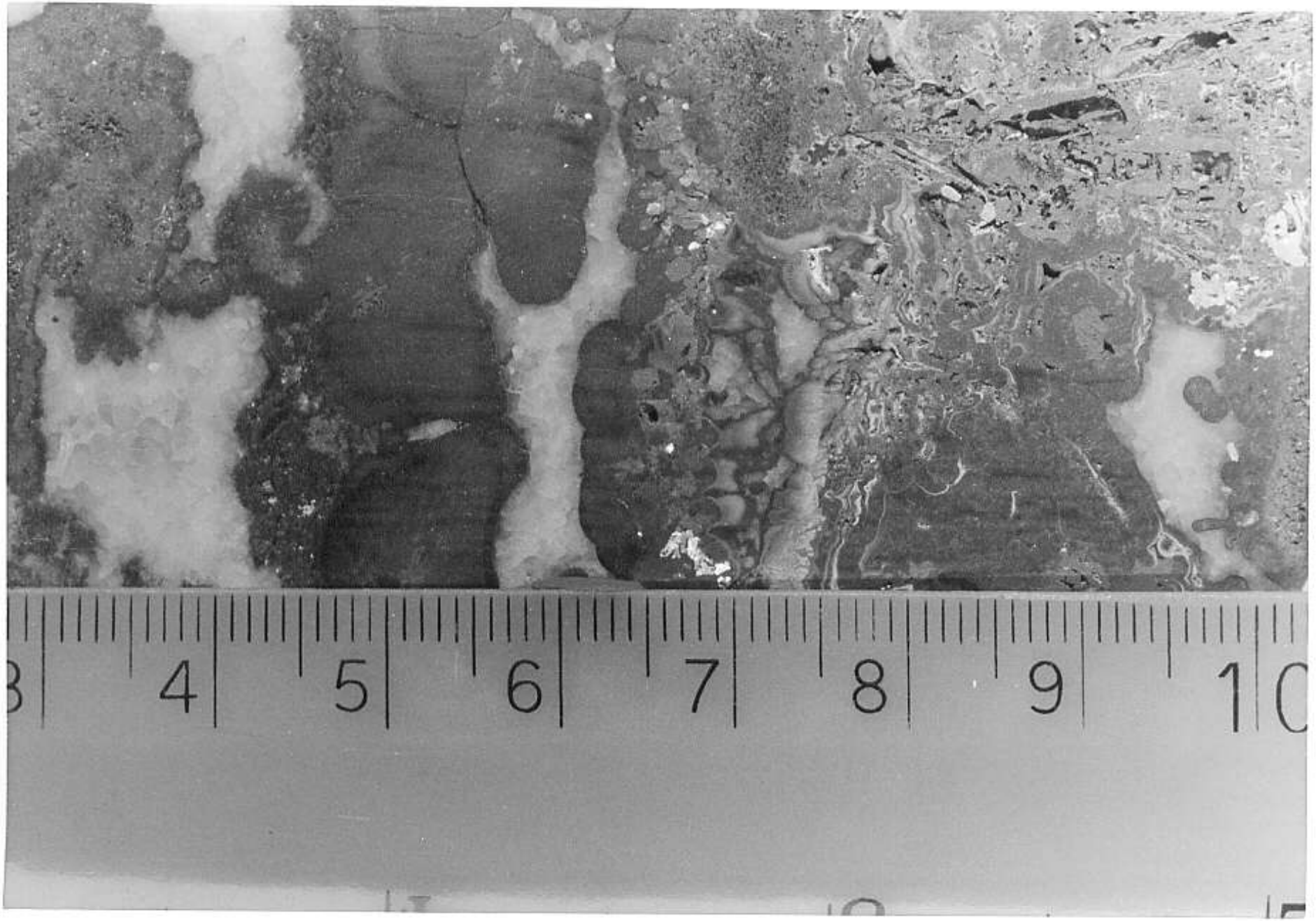
Marcasite	55%	2 mm
Dolomite	45%	0.5 mm
Calcite		

COMMENTS

Plate 23



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