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GEOLOGY OF THE  
MOUNT HUNDERE LEAD-ZINC- SILVER DEPOSITS,  
WATSON LAKE

April, 1964

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April 6, 1964.

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Dear Sir:

I hereby submit this thesis entitled "Geology  
of the Mount Hundere Lead-Zinc-Silver Deposit, Watson  
Lake, Yukon Territory" in partial fulfillment of the  
requirements necessary to obtain a Bachelor's Degree in  
Honours Geology.

Sincerely yours,

*Kenneth M. Dawson*

Kenneth M. Dawson

GEOLOGY OF THE MOUNT HUNDERE  
LEAD-ZINC-SILVER DEPOSIT,  
WATSON LAKE, YUKON TERRITORY

A Thesis submitted during the Fourth  
Year in the Faculty of Science at the  
University of British Columbia

KENNETH M. DAWSON

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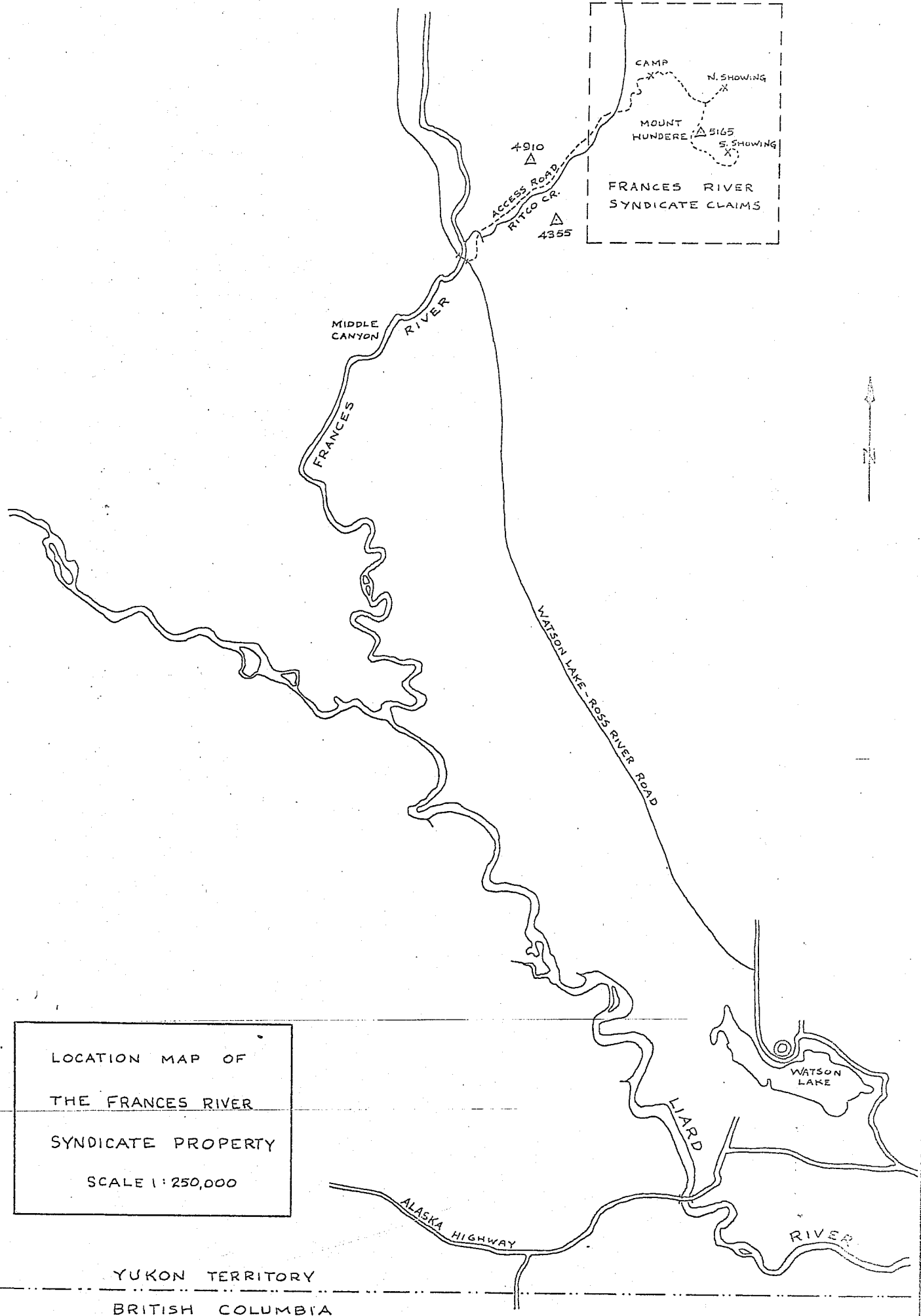
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LOCATION MAP OF  
THE FRANCES RIVER  
SYNDICATE PROPERTY  
SCALE 1:250,000

YUKON TERRITORY  
BRITISH COLUMBIA

## INTRODUCTION

During the months of May, June and July, 1963, development work on the Mount Hundere lead-zinc-silver deposit was undertaken by the Frances River Syndicate. This venture was the outcome of discovery of promising base metal showings by prospectors Jake Hundere and Pete Ritco the previous summer. Two main lead-zinc-silver showings, each at 4700 feet elevation and on eastward-projecting noses of the highest ridge of Mount Hundere, are located 32 miles due north of Watson Lake, Yukon Territory. Following the discovery and staking of the showings, regional mapping and preliminary development work was supervised by Dr. A. E. Aho, assisted by R. G. Davis, during the late summer of 1962. A twelve mile access road from the Frances River bridge on the Ross River Road was constructed, some bulldozer stripping and trenching of the North and South Showings was done, and general prospecting, geological mapping and geochemical sampling of the area was started. Assays from the trenches sampled ran as high as 33% combined lead-zinc with up to 6 ounces per ton silver. The two main ore zones showed promise of continuity along strike and to depth.

Three mining companies, Kerr-Addison, Newconex and Canex Aerial Explorations formed the Frances River Syndicate for the purpose of developing the property. Additional staking during the fall and winter of 1963 increased the original property to 320 claims. Canex, with managerial control of the joint venture, provided exploration staff for the 1963 field season. A permanent camp was constructed in the early spring of 1963, and a comprehensive program of drilling, trenching and mapping was initiated in May. During the months of May, June and July, 1963, the writer was employed by Canex as field assistant to chief geologist Dr. S. J. Melihercsik and assistant geologist E. T. Lonergan.

#### CLIMATE

Watson Lake, located in the south-central Yukon, has a microthermal continental taiga climate. Summers are short and cool and winters are severe. Temperature of the coldest month averages below 32°F, and the warmest month averages slightly above 50°F. Precipitation occurs throughout the year with most rainfall in the spring and fall. Watson Lake lies within a zone of discontinuous permafrost.

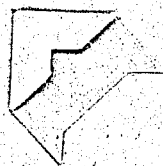


Plate 1

An aerial view of northeast spur of Mount Hundere,  
looking eastward. North Showing is in middle  
background

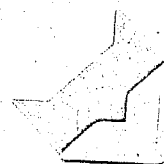


Plate 2

An aerial view of North and South Showings,  
looking northeastward along the fault

## VEGETATION

The upland areas in the vicinity of Mount Hundere are sparsely covered by vegetation. The open hilltops at 4500-5000 feet elevation are covered with moss and lichen which gives way to buck brush and stunted black spruce on the slopes. Thicker stands of spruce and willow grow on lower, more sheltered slopes and valley bottoms.

## TOPOGRAPHY

Mount Hundere, at elevation 5165 feet, is the highest peak in a northwest-trending range of hills bounded on three sides by the Liard Plain. The maximum relief is about 2700 feet and the local relief in the vicinity of Mount Hundere is about 1500 feet. The hills are round-topped, rolling features with few steep slopes or bedrock outcrops. The region is marked by wide interstream areas and poorly-drained lowlands. Glacial features such as kames and lateral moraines are common in the wide, rounded valleys. Permafrost action is evident by stone rings on open hilltops and frost-heaved rock debris.



Plate 3  
Diamond drilling on the North Showing



Plate 4  
Diamond drilling on the South Showing. Northerly-trending "fault valley" on eastern spur of Mount Hundere in background

GENERAL GEOLOGY

The Mount Hundere lead-zinc-silver deposits occur within an extensive area of low-grade metamorphic and sedimentary rocks. Regionally, the rocks have a northerly strike and a westerly dip. A central area, including Mount Hundere, consists of highly-deformed argillite and phyllite interbedded with limestone. The area is six miles long in a north-south direction, and four miles wide. The dip varies from flat to vertical, the average dip being about 40 degrees west. To the west of the central phyllite-argillite-limestone area a band of sandstone, siltstone and shale with a general westerly dip extends about three miles westward. These sediments in turn are flanked by a chert formation which forms the high northwest-trending ridges fronting the Frances River and the Liard Plain. Four miles north of Mount Hundere argillite and limestone beds give way to shale, slate, limestone and quartzite beds which are less-deformed than the rocks of the central area and of more northerly-trending dip. Two miles south of Mount Hundere the central argillite and limestone beds are bounded by a broad zone of impure, clastic, quartz-rich sediments, greywacke, conglomerate, slate, limestone, quartzite, and sandstone. These rocks are less-deformed than those of the central area, and show the same northerly-striking, westerly dipping attitude. The central argillite-limestone area is flanked to the east

7

by about three miles of greywacke and shale which forms lower ridges trending north-northwest. These rocks give way to a zone of chlorite schist, quartz garnet gneiss, gabbro and serpentine which strikes north, dips steeply westward and forms the most easterly ridges between Mount Hundere and Stewart Creek.

The stratigraphic sequence of the rocks in the Mount Hundere area is largely unknown. Detailed stratigraphic correlation was not undertaken by the geologists on the property in 1963 for several reasons. Economic aspects of the ore showings were of primary importance during these early stages of development and only limited regional mapping was undertaken. The problems of complex structure in the contorted argillite-limestone beds, lack of fossils, limited outcrop and absence of published geological data combined to make stratigraphic correlation of the observed rocks unfeasible.

Some general conclusions were reached by the writer by observation of regional rock types and major structural trends. The rocks farthest to the east are medium grade metamorphics; i.e. schist and gneiss. Westward these rocks give way to greywacke and shale, possibly of geosynclinal origin, bordering the central area. The contorted argillite, phyllite, and limestone beds of the central zone are deep-water marine sediments which have undergone low-grade regional metamorphism. Flanking these rocks to the west are

beds of relatively undeformed sandstone, shale and chert probably laid down in shallow marine environment. The general trend from east to west is a decrease in degree of metamorphism which possibly reflects relative depth of burial of the beds before uplift and tilting westward. The regional westerly dip of the rocks also indicates a decrease in geologic age from east to west. The above conclusions are reached with some reservations. Apparent decrease in degree of metamorphism from east to west may be fortuitous. Gabbro intrusions have been noted near the schist and gneiss zone by A. E. Aho (1962) and the higher grade of metamorphism may be a local, rather than a regional, effect. Regional mapping is incomplete and the apparent general westerly-dipping attitude in successively younger beds may prove to be a more complex structure.

The interbedded limestone and argillite of the contorted central area may correspond to rocks of similar composition in the Pelley Mountains to the west. The Tintina Silver property was mapped by Wheeler, Green and Roddick (1963) where interbedded limestone and argillite contain archeocyathids of Lower Cambrian age. Slatey limestone of Mid to Late Cambrian age succeeded these beds.

Dr. Lew Green, during a brief visit to the Frances River Syndicate property in the summer of 1963, remarked on the resemblance of the limestone beds to those of the

Lower Cambrian elsewhere. No fossil evidence of the Lower Paleozoic was found by geologists on the property in 1963. More detailed information will be made available when the G.S.C. completes its proposed mapping of the area in 1964 or 1965.

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CENTRAL ARGILLITE-PHYLLITE-LIMESTONE AREA

Rocks of the central area are predominantly thin-bedded, dark grey argillite. (Map 1: "Central Argillite-Phyllite-Limestone Area") Argillite grades into phyllite in tightly-folded and contorted areas with the development of a micaceous sheen and cleavage across the bedding. Several zones of phyllite occur near the North and South showings. Impure, bluish-grey limestone beds of varying thickness alternate with argillite and phyllite throughout the central area. The limestone, probably of chemical origin, is dense and unfossiliferous.

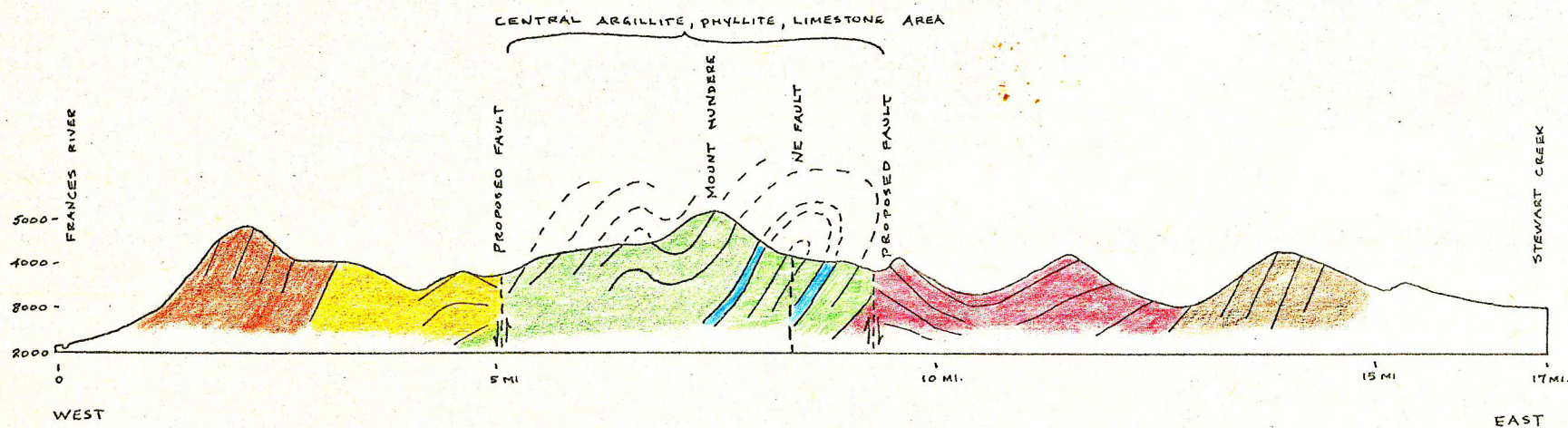
A cross section of the central area and adjacent beds from Frances River to Stewart Creek illustrates the proposed structure of the uplifted and folded argillite and limestone beds (Figure 1). The section is taken along an ENE line passing through Mount Hundere, and is projected, for the most part, from a regional 1 mile-to-the-inch map prepared by Gordon Davies in January 1963. The structural interpretations are those of the writer.

The rocks of the central area exhibit complex structure with predominantly steep to moderate westerly dips and much minor folding. The cross section shows two anticlinal structures which diagrammatically represent a zone of north-south fold axes west of Mount Hundere and complex

FIGURE 1






HORIZONTAL SCALE 1" = 2 MILES

VERTICAL SCALE 1" = 4000'



A Regional ENE Cross Section Through Mount Hundere from Frances River to Stewart Creek.

Legend

-  Chert
-  Sandstone, siltstone
-  Argillite, phyllite, limestone
-  Greywacke, quartzite
-  Shist, gneiss, gabbro

foldings along a NE fault near the South Showing. Numerous minor folds are not depicted on the section. The attitude and relative elevation of the beds indicates uplift with folding and possibly overturning to the east. The area is cut by a NE-trending fault and may be bounded by similar faults to the east and west. Lead and zinc sulfides occur as replacements in limestone beds adjacent to the NE fault in the eastern part of the deformed area. The structure and mineralogy of the lead-zinc deposits is discussed under following headings.

## THE SOUTH SHOWING

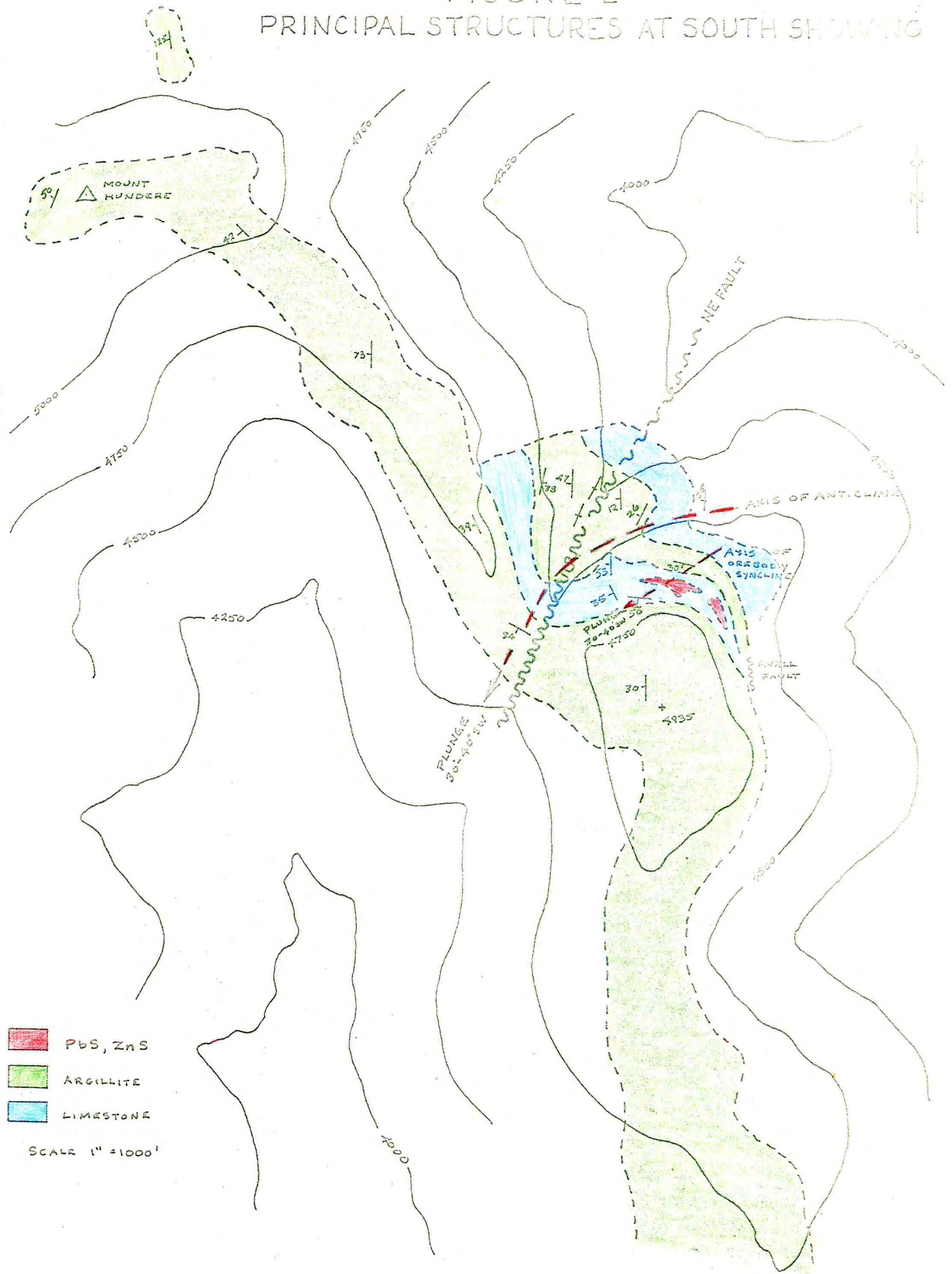
### General Structure and Topography

The South Showing is located on a south-east spur of Mount Hundere. (Map 2: "South Showing") The spur is cut by a narrow, steep-sided valley leaving on isolated peak. (Plate 2) Erosion of relatively incompetent rock along a NE fault zone created the valley. On the northern slope of the peak massive sulfides outcrop as a 200-foot long lense in limestone. The orebody outcrops between 4650 and 4700 feet elevation. A smaller showing of mineralized skarn that is strongly oxidized is 200 feet southeast of main orebody in the same limestone bed. Below main orebody the slope falls away gently at first, then steepens sharply about 600 feet to the northwest at the edge of the "fault valley". Several small bodies of skarn and gossan in limestone outcrop along the slope about 150 to 200 feet below main orebody. The trace of the NE-striking fault, not shown on Map 2, is the center line of the "fault valley". The center line is 800 feet northwest of main orebody and 250 feet lower in elevation at the closest point. Steep bluffs in argillite and limestone form the northwest side of the "fault valley".

### Structure

Principal structures at the South Showing are shown in Figure 2. The folding of the beds shows a significant

FIGURE 2  
PRINCIPAL STRUCTURES AT SOUTH SHOWNING



trend. Attitude of bedding, plunge of fold axes and trace of limestone-argillite contacts all combined indicate a south-westerly-plunging anticlinal structure. The fold axis has a general plunge of 30-40° SW. The fold axis strikes westerly on the east side of an NE fault, and is warped southward on the west side of the fault. The warped fold axis and the NE fault converge near the South Showing. The fault is almost parallel to the axial plane of the anticline southwest of the showing. Contacts between limestone and argillite have little or no obvious displacement across the fault, but minor folds in the area suggest some dragging of the beds parallel to the fault plane. A steep argillite bluff on the northwest side of the "fault valley" shows joints dipping 70° southeast, parallel to the valley wall. The fault plane is believed to parallel this joint system.

The South Showing contains minerallized replacement bodies in contorted limestone beds. In the vicinity of the main orebody, the limestone bed is essentially a broad convoluted syncline that has a 30° to 40° southwest plunge. The bed decreases in thickness rapidly along strike to the southeast, and the plunge flattens out as it trends more to the south. An anticlinal axis that plunges gently south-westerly lies about 200 feet northwest of the main orebody. Complex drag folding and crenulation occurs along the northwest limb of this anticline. Numerous small folds of a general southerly plunge occur in both limestone and

argillite beds downslope to the north.

The probable sequence of events related to structure at South Showing was as follows:

- (1) Folding of the beds at depth.
- (2) Uplift and faulting. A regional NE fault intersected the axial plane of a SW-plunging anticline.
- (3) Late release of stresses with minor fault movement. Fracturing of ore and minor folding.

#### Orebodies

The main orebody at the South Showing is in a shallow syncline in limestone. Minor folding with SE plunge is evident near the collar of DDH-S-3. Two small SW-plunging undulations occur within the orebody. The orebody thins rapidly from 25 feet to 10 feet as shown by drill intersections. (Figure 3) Geologists on the property noted the decrease in thickness of ore 80 feet down dip, and interpreted the trend as an indication of pinching-out of ore.

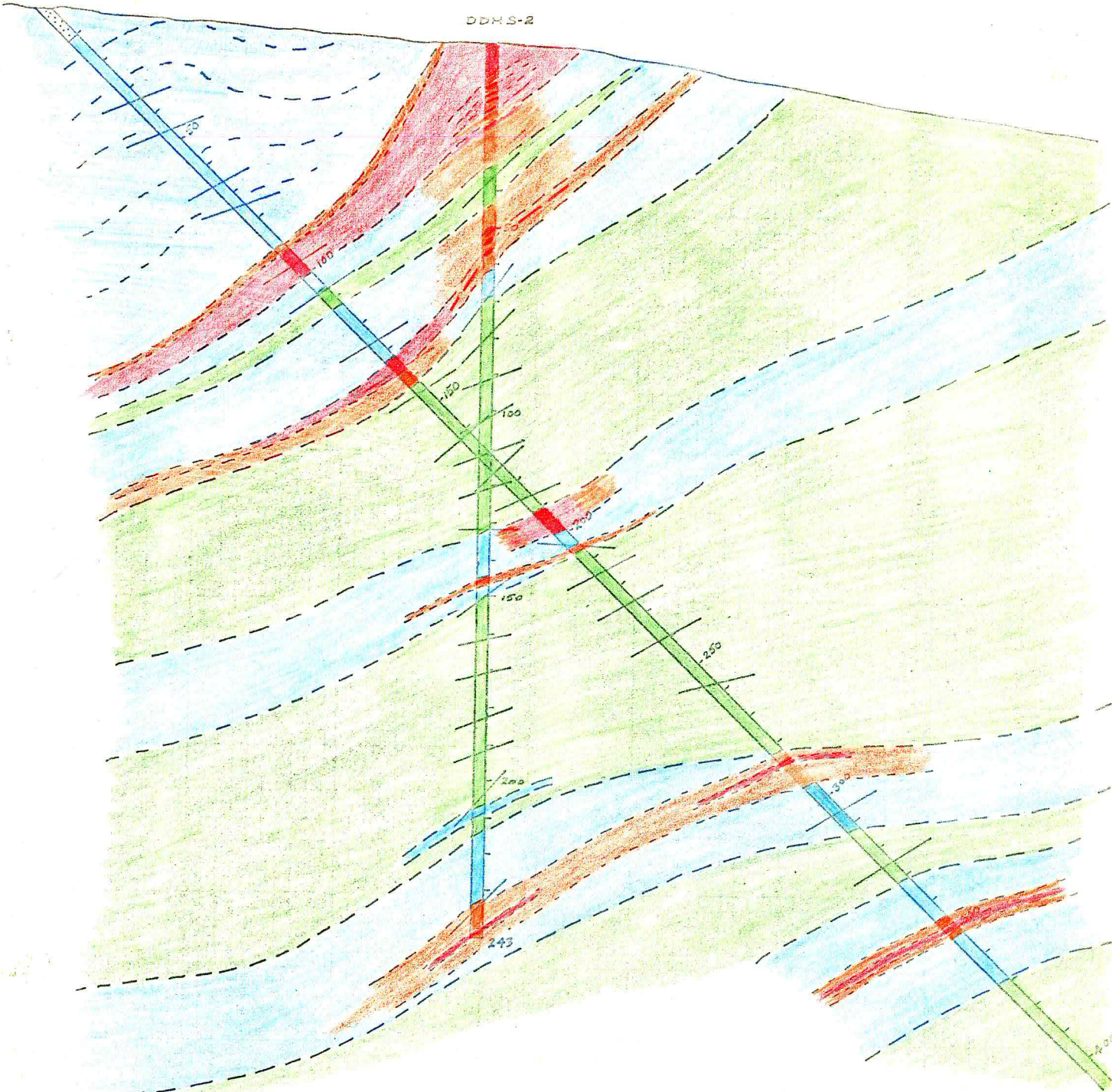
The top 8 to 10 feet of the orebody is massive galena with minor amounts of sphalerite and skarn minerals. With depth the ore grades into sphalerite, actinolite skarn and a little galena. Orebody in main limestone bed is bounded below by an unmineralized argillite bed 5 to 10 feet thick.

— SW —

— NE —

DDHS-3

DDHS-2



CROSS SECTION OF DIAMOND  
DRILL HOLES S-2 AND S-3  
LOOKING NORTHWEST

	DDHS2	DDHS3
COLLAR ELEV.	4659'	4664'
DIP	90°	45°
BEARING	-	N65E
DEPTH	243'	459'

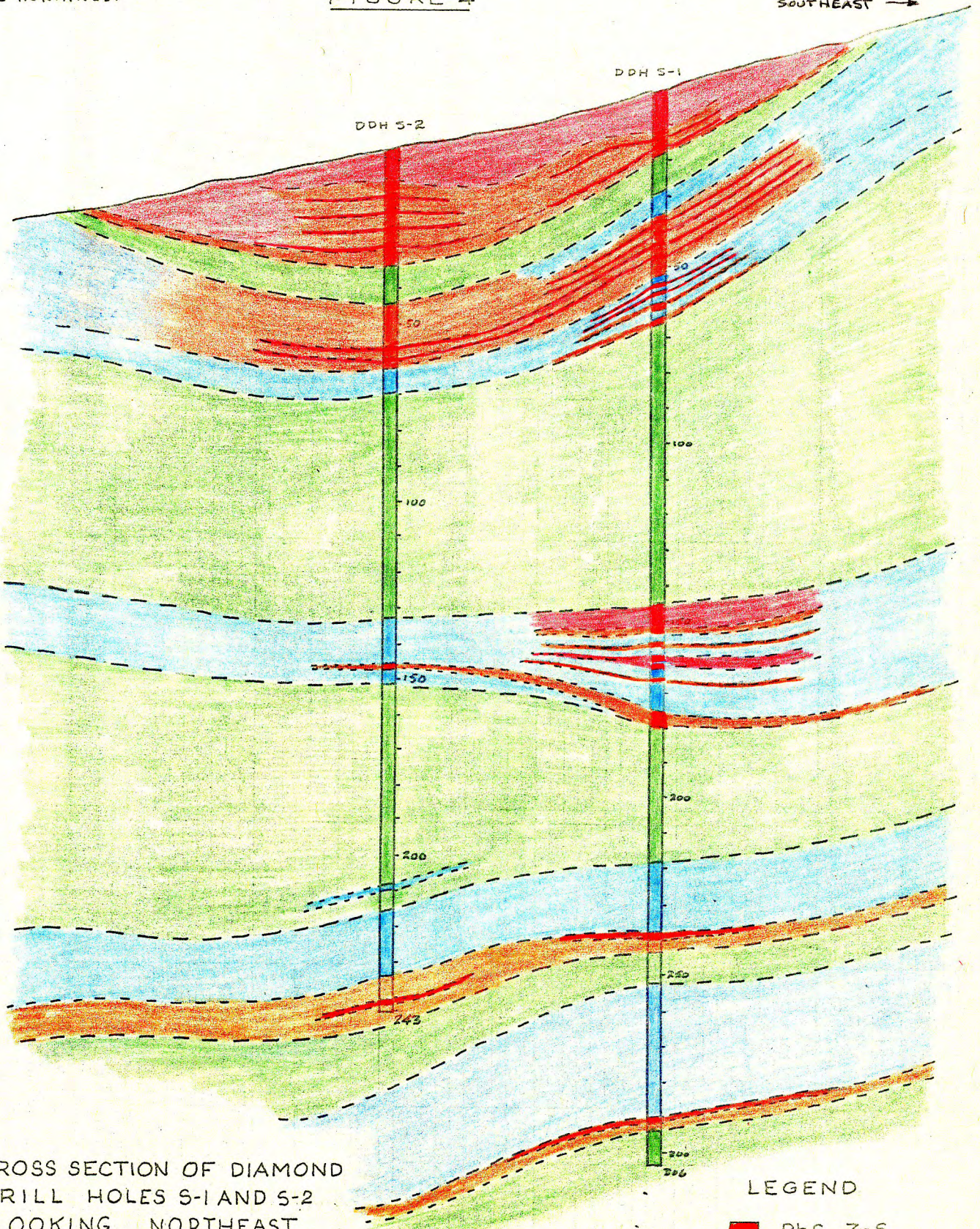
LEGEND

- PbS, ZnS
- SKARN
- LIMESTONE
- ARGILLITE
- SCALE 1" = 40'
- APPROXIMATE DIP OF BEDDING

NORTHWEST

FIGURE 4

SOUTHEAST



CROSS SECTION OF DIAMOND  
 DRILL HOLES S-1 AND S-2  
 LOOKING NORTHEAST

	DDH S-1	DDH S-2
COLLAR ELEV	4673'	4659'
DIP	90°	90°
BEARING	-	-
DEPTH	306'	243'

LEGEND

- PbS, ZnS
- SKARN
- LIMESTONE
- ARGILLITE

SCALE 1" = 40'

A second, lower-grade body of mineralized skarn occurs in a lower horizon of the main limestone bed. This zone outcrops as a narrow skarn parallel to the ore zone a few feet to the northeast, and is probably a continuation of the oxidized mineralized zone in the limestone 200 feet southeast. The synclinal shape of the two sulfide bodies is indicated by a cross section along strike in Figure 3. Mineralization terminates abruptly at the contact of a 60-foot-thick argillite bed below the limestone. Three narrower beds of limestone are intersected by drill holes at 132 and 212 feet in DDH S-2, and at 331 feet in DDH S-3. Narrow horizons of mineralized skarn occur in all three beds with sphalerite predominant over galena. These small zones correspond to lenses of skarn and gossan outcropping several hundred feet downslope from main orebody.

Trenches outline an oxidized skarn zone 200 feet southeast of main orebody in the same limestone bed. Small lenses of loose, rusty skarn with lead-zinc mineralization occur in favorable limestone beds. Mineralized limestone outcrops for about 200 feet along strike and disappears under overburden southeast of Trench 3. The zone intersected by drill holes S-4 and S-5 is about 55 feet thick. The limestone bed dips at  $45^\circ$  into the hill at the surface and flattens out at 60 feet depth. The overlying argillite bed is 15 feet thick at this point and about 10 feet thick at DDH S-6 200 feet westward. A thickening of the limestone is

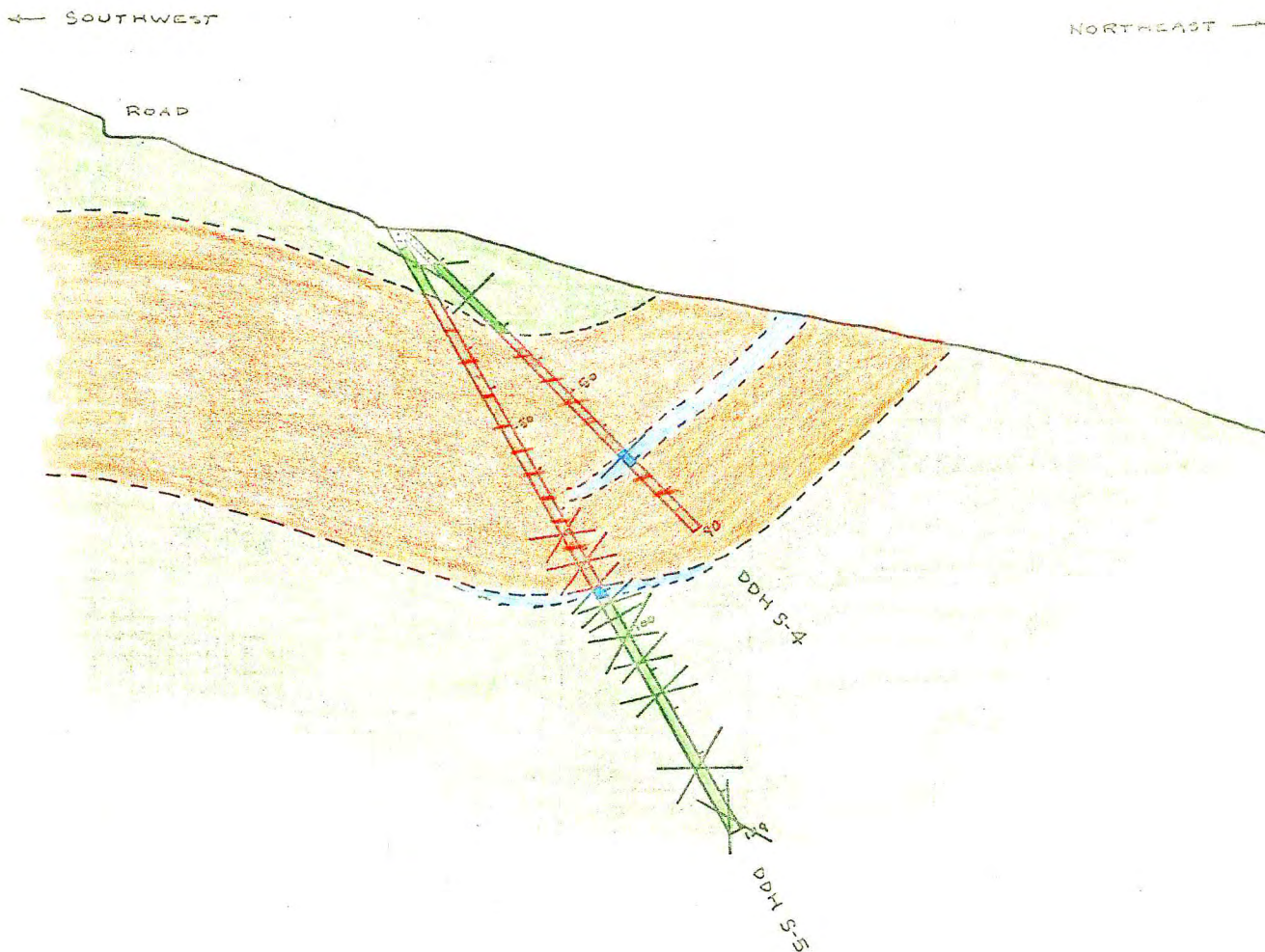
noted to the west of the oxidized zone at DDH S-6. The drill intersected 145 feet of limestone containing a few sparsely-minerallized skarn zones. The bed apparently pinches out southeast of Trench 3 as there is no limestone in bulldozer cuts south of the trench.

A zone of rusty siliceous argillite is exposed in a road cut 300 feet south of Trench 3. The beds dip steeply westward and are cut by three small faults approximately parallel to the bedding. The northern-most fault is marked by a black graphitic zone, the fault 40 feet to the south has a 4-inch gouge zone and the southern-most fault which is not shown on Map 2: "South Showing", strikes N20°W, dips 72°W, and has a 1-inch gouge zone. Argillite immediately above the rusty silicified zone is unaltered. The small faults are probably part of a northerly-trending fault zone related to the main NE fault. The virtual absence of lead and zinc sulfides at this place is probably due to the absence of favourable limestone host rocks.

### Ore Controls

Lead-zinc mineralization at the South Showing apparently is controlled by the following factors:

1. Favourable limestone. All the deposits are replacements in limestone beds. Within these beds, zones of impure limestone and limestone-argillite contacts appear




CROSS SECTION OF DIAMOND  
DRILL HOLES S-4 AND S-5  
LOOKING NORTHWEST

	DDH S-4	DDH S-5
COLLAR ELEV.	4718	4718
DIP	45	60
BEARING	N40E	N40E
DEPTH	90'	149'

LEGEND

- PbS, ZnS
- OXIDIZED SKARN
- LIMESTONE
- ARGILLITE

SCALE 1" = 40'

 APPROXIMATE  
DIP OF BEDDING

most favourable to mineralization.

2. Structural traps. Deposits occur within steeply to moderately-dipping beds of limestone enclosed by argillite. Flat-dipping or contorted portions of these beds are preferentially mineralized.

3. Proximity of fault. The main orebody is 800 feet southwest of the major NE-trending fault. A smaller, northerly-trending fault occurs to the south of the ore showings. Quartz and fluorite veins cut limestone and argillite beds in the "fault valley" and a small lense of skarn near the fault has quartz-fluorite gangue. Argillite beds near the small fault are altered and silicified. The main fault and an inter-connected system of small faults or joints might have served as passageways for emanations rising from an igneous source at depth.

THE NORTH SHOWINGTopography

The North Showing is two miles due north of the South Showing near the eastern extremity of a NE spur of Mount Hundere. Sulfides outcrop near the crest of an eastern slope of the spur at 4825 feet elevation. Below the rounded peak, slopes fall away steeply north and south of the showing. A small knoll marks a reversal in slope 200 yards east of the crest, and beyond this rise the hillside drops steeply. A fault passing close to the North Showing exhibits no topographic expression. The reversal in slope below the North Showing suggests erosion in a zone of incompetency but no field evidence of faulting exists in the saddle.

An eastern spur of Mount Hundere, halfway between the two showings, is cut by a steep-walled, north-south valley. (Plate 4) Gossan outcrops on the south slope near the valley and Gordon Davis reported lead-zinc float on both slopes of the spur (1962). A fault is believed to pass through the valley and connect with faults observed at North and South Showings.

Structure

The orebody at the North Showing consists of lenticular galena-sphalerite replacements in a narrow

limestone bed. The limestone averages 50 feet wide, 500 feet long in a N-S direction, and pinches out at both ends. Nine bulldozer trenches outline the surface trace of the limestone and one trench exposes a NNE fault 100 feet west of the limestone. DDH N-1 is collared in argillite 80 feet west of the ore outcrop and dips 60° eastward. The limestone bed is probably less than thirty feet thick throughout. The crests of folds in underlying argillite are exposed in Trenches 1-JP and 7-JP. No limestone was intersected in drilling. The bed is a thin, tightly folded structure consisting of at least four small northerly-plunging folds. Minor folds of similar attitude are encountered in surrounding argillite beds.

Argillite with slatey, limey, siliceous and phyllitic phases ~~outcrops throughout the area of the North Showing.~~ A continuous bed of argillite at least 500 feet thick encloses the small, mineralized limestone bed. Small gossans in argillite are exposed in roadcuts in the vicinity but none show significant mineralization. The general structural trend of the area is northerly and the bedding dips steeply westward or vertically. (Map 3: "North Showing")

An argillite-limestone contact with a small skarn zone in limestone outcrops 2500 feet north of the showing. Another similar contact with a gossan in argillite outcrops 1200 feet north of the showing. No other indications of

mineralization occur along the northerly projection of the fault zone. The limestone encountered north of the orebody is probably the same bed which outcrops on the eastern and northern slopes of the small knoll, and also further down the southern slopes of the spur.

### Orebody

The main mineralized zone in limestone is about 120 feet long and of varying width. Small lenses of oxidized, mineralized skarn and massive sulfides alternate with barren limestone and phyllite. Ore is concentrated in troughs of small northerly-plunging folds. Trenches 1-JP and 2-JP cut contorted beds of alternating rusty skarn, massive sulfides and barren limestone. Trench 3-JP cuts a folded phyllite bed enclosing a small lense of sulfides. Other trenches in limestone cut small gossans and sparse mineralization in generally barren rocks.

No limestone was cut by DDH-N1. (Figure 6) Two unmineralized skarn zones occur at depths 40 to 50 feet and 340 to 350 feet. Slatey argillite with rusty fractures, quartz and calcite veinlets, and disseminated pyrite is intersected from the collar to the bottom at 388 feet. Fault gouge is intersected at 196 to 204 feet. A vertical fault through this zone would cut the center of the orebody.

### Ore Controls

The lead-zinc deposit at the North Showing shows.

structural and petrographic controls similar to those observed at the South Showing.

1. Favourable limestone. Ore selectively replaces limestone beds and generally terminates abruptly at argillite horizons. Beds of barren limestone in contact with mineralized beds suggest preferential replacement of more reactive, impure limestone has taken place. Sparse minerallization also occurs as gossans in limey argillite.

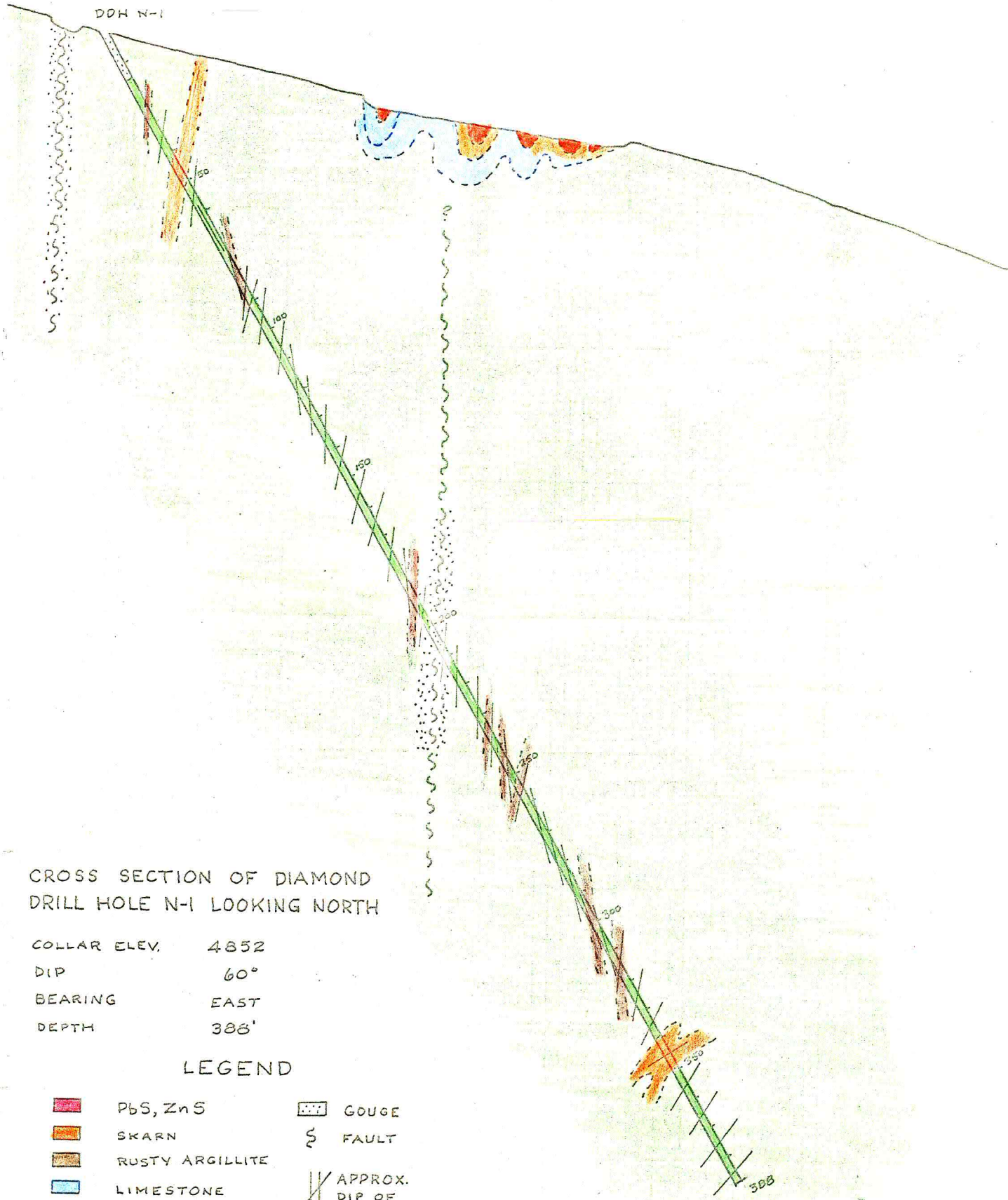
2. Structural traps. The contorted limestone bed is enclosed by steeply-dipping argillite beds. Small folds with shallow northerly plunge extend along the strike of the bed. Axial regions of the minor folds are replaced by skarn and lead-zinc minerals.

3. Proximity of faults. A steeply-dipping NNE fault cuts argillite 80 feet west of the showing. Fault gouge intersected in DDH-N1 indicates the existence of another fault that may parallel the first and cut the limestone bed. Late magmatic emanations are suggested by the highly silicified ore and the presence of a small aplite dike 500 feet east of the showing. The 3-foot-wide dike strikes NE, dips  $80^{\circ}$ SW and cuts argillite beds. The limestone was replaced in a similar manner to corresponding beds at the South Showing. Emanations from an igneous source at depth might have risen along one or more fault zones to alter and minerallize preferentially the limestone beds.

FIGURE 6

← WEST

EAST →



CROSS SECTION OF DIAMOND  
DRILL HOLE N-1 LOOKING NORTH

COLLAR ELEV. 4852  
 DIP 60°  
 BEARING EAST  
 DEPTH 388'

LEGEND

- |  |  |
|--|--|
| <span style="display:inline-block; width:15px; height:10px; background-color:red; border:1px solid black;"></span> PbS, ZnS          | <span style="display:inline-block; width:15px; height:10px; border:1px dotted black;"></span> GOUGE  |
| <span style="display:inline-block; width:15px; height:10px; background-color:orange; border:1px solid black;"></span> SKARN          | <span style="display:inline-block; width:15px; height:10px; border-bottom:1px wavy black;"></span> FAULT   |
| <span style="display:inline-block; width:15px; height:10px; background-color:brown; border:1px solid black;"></span> RUSTY ARGILLITE | <span style="display:inline-block; width:15px; height:10px; border-left:1px dashed black; border-right:1px dashed black;"></span> APPROX.<br>DIP OF<br>BEDDING |
| <span style="display:inline-block; width:15px; height:10px; background-color:lightblue; border:1px solid black;"></span> LIMESTONE   |  |
| <span style="display:inline-block; width:15px; height:10px; background-color:lightgreen; border:1px solid black;"></span> ARGILLITE  |  |

SCALE 1" = 40'

MINERALOGYObjects of Study

A study was made of hand specimens and drill core from vicinity of North and South Showings. Thin sections and polished sections were prepared for microscopic study. The objects of study were:

1. Identification of minerals
2. Paragenetic sequence
3. Special structures and textures
4. Classification of deposit

Hand Specimens

Massive, coarse-grained galena occurs at both showings. Sphalerite is of the low-iron variety and shows resinous orange-brown colour. In most outcrops the sphalerite and galena are fine-grained, with sphalerite predominant over galena. Rocks from the North Showing are loose, oxidized diopside-hedenbergite skarn. Euhedral grossularite garnets are common in the samples. Early silicification of the rock created a quartz and calcite matrix for later minerals. Large, glassy, euhedral quartz crystals are scattered randomly throughout specimens. Early minerals are commonly replaced by epidote, calcite and limonite. Sphalerite alters to limonite and smithsonite. John Fairley, in a mineralo-

graphic study of the ore (1963) noted hydrozincite ( $Zn(OH)_2$ ) as a white, fluorescent alteration on sphalerite. Massive white cerussite coating on galena is common in the area.

Rocks from the South Showing are less siliceous, and generally not as oxidized as those from the North Showing. Ore-bearing rocks are silicified grossularite-actinolite skarn. Radiating prisms and fibrous bundles of actinolite form a sharp contact with crystalline calcite. Massive galena at the surface of the main orebody grades with depth into pitchy brown sphalerite and a little galena in actinolite skarn. Euhedral grossularite garnet of light green to brown colour is a major skarn mineral. Calcite and quartz form a matrix for later garnet, sphalerite, galena, actinolite, diopside and epidote. The ore shows fracturing and silicification after galena was deposited. Main orebody is not extensively oxidized but samples from the small showing to the southeast have disseminated galena and sphalerite in altered, limonitic skarn.

#### Paragenesis of Minerals at South Showing

Three thin sections were prepared from rocks at the South Showing. Two sections were taken from a skarn zone intersected by DDH S-1, at depths of 150.5 and 155 feet. A third thin section was made of actinolite-calcite contact near the south end of the orebody.

S-1 150.5 The thin section is from a skarn zone with calcite quartz and euhedral grossularite the dominant minerals. The earliest phase of mineralization is represented by large interlocking quartz grains. (Plate 5) Quartz is cut by large rhombs and small interlocking grains of calcite. Clusters of euhedral grossularite garnet replace calcite. Many of the garnets show birefringence (Plate 13) and zoning (Plate 6). Sphalerite cuts garnet and is replaced by galena along grain boundaries. Late epidote almost completely replaces sphalerite. Small laths of diopside replace all minerals except epidote (Plate 5). Diopside is normally an early-formed skarn mineral which precedes sulfide mineralization. Late diopside may have been deposited during a late period of metasomatic activity. Galena was remobilized during this period. (Thin section S-1 155)

S-1 155 The thin section is from a skarn zone showing euhedral green grossularite, equigranular galena and sphalerite, quartz and crystalline calcite. Large equigranular interlocking grains of quartz represent the earliest mineralization. Calcite crystals cut quartz as in S-1 150.5. Garnet, the next mineral in the paragenetic sequence, is mainly massive and greenish-grey colour in section. Large, equant grains of sphalerite replace garnet and are, in turn, partially replaced by galena. A post-depositional period of fracturing followed, then the fractures were filled with

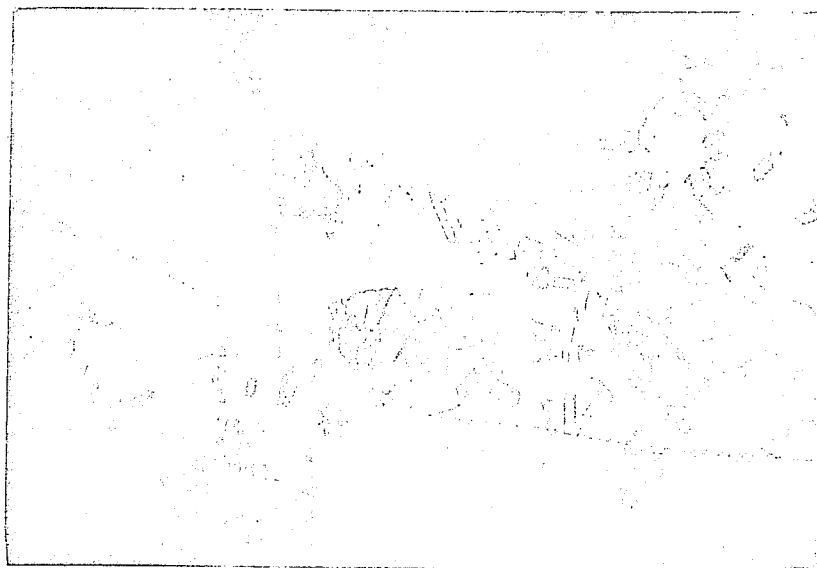


Plate 5

S-1 150.5 Medium power, crossed nicols. Birefringent garnet with sectorial extinction, small diopside laths and calcite crystal in matrix of large, interlocking quartz grains



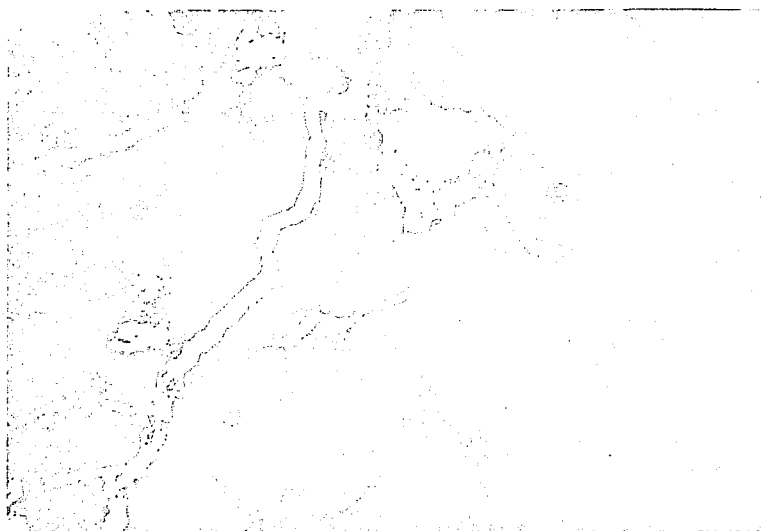
Plate 6

S-1 150.5 Medium power, birefringent rim on garnet in calcite. Epidote has replaced some garnet (1). Small euhedral birefringent garnet (2) in more massive, isotropic garnet

fine-grained quartz (Plates 7 to 11). In some places galena is brecciated along the fractures and fragments are supported in quartz (Plate 9).

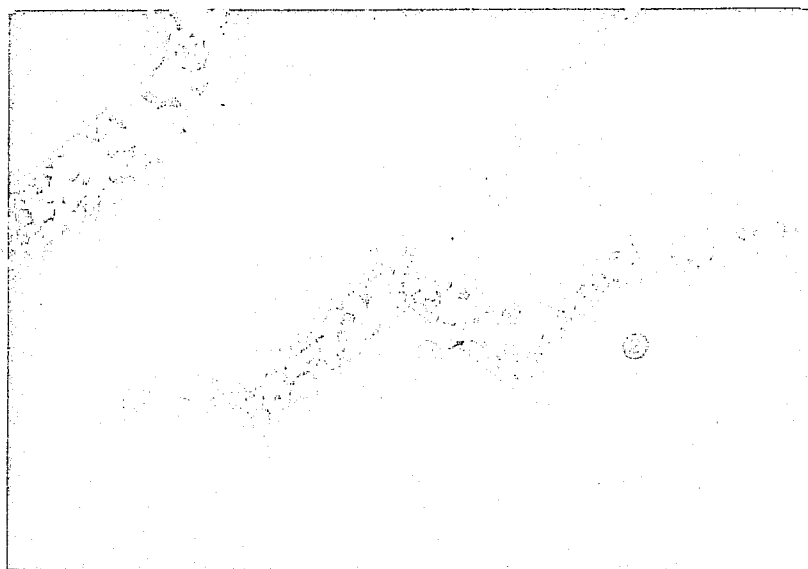
An interesting feature of the late silicification is alteration of garnet along walls of quartz-filled fractures (Plates 8, 10 and 11). Most of the garnet adjacent to silicified fractures shows a narrow, well-defined zone of alteration. The mineral composing the alteration zone has low birefringence and index of refraction between that of quartz (1.55) and grossularite (1.70). The mineral composition of the alteration zone was not ascertained. The alteration mineral shows similarity in appearance and optical properties to birefringent rims on isotropic grossularite in this section (Plate 6) and in other sections. The "silicification" of fractured garnet may be related to processes involved in the formation of birefringent mantles on hydrogrossularite discussed later under "Birefringent Garnet".

After fracturing and silicification galena was apparently remobilized by late metasomatic activity and tended to replace quartz in fractures. Plate 11 illustrates galena projecting into a fracture previously filled by quartz, silicified walls of fracture extend beyond projecting nose of galena. Epidote is the last mineral deposited.



## Plate 7

Sl-155 Medium power. Quartz-filled fractures cutting galena (1) sphalerite (2) and garnet (3)



## Plate 8

Sl-155 Medium power, crossed nicols. Fine granular quartz in fracture cutting garnet (1) and sphalerite (2). Alteration rim on garnet along fracture (3)

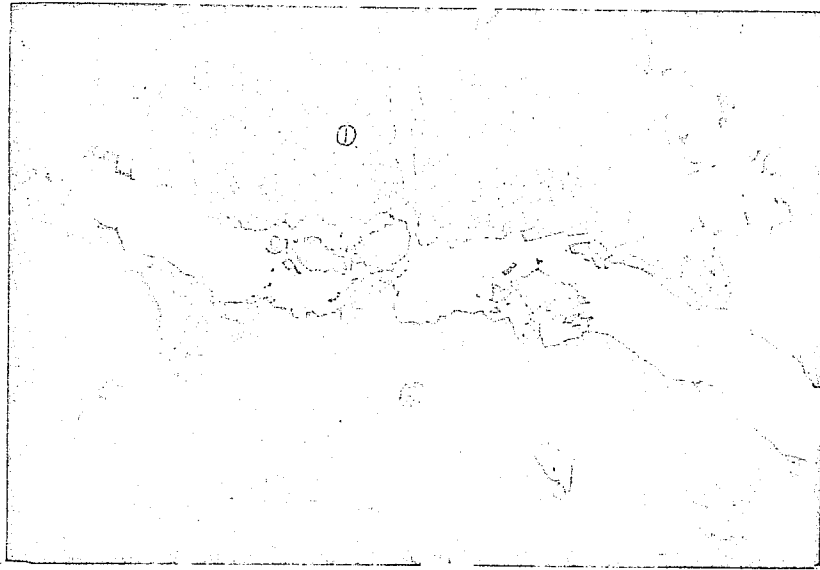


Plate 9

S1-155 Medium Power. Galena which has replaced garnet (1) and sphalerite (2) is brecciated along a quartz-filled fracture

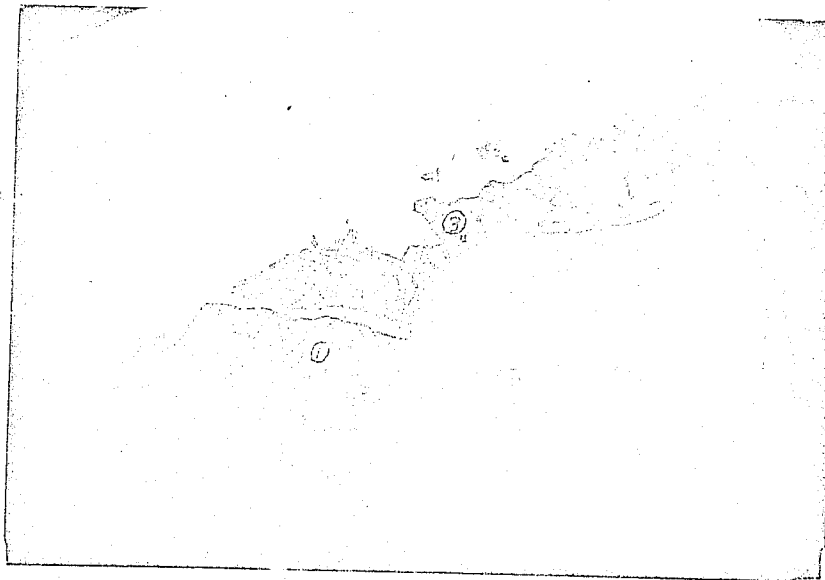


Plate 10

S1-155 Medium power. Fracture in garnet (1) and sphalerite (2). Quartz fills the fracture in garnet and surrounds the sphalerite grain. Small alteration rim in garnet (3)

SH-1 The section is from a sample of actinolite-calcite contact of main orebody. No quartz occurs in the sample. Long, radiating prisms of actinolite are in sharp contact with calcite. Earliest mineral is calcite. Small irregular grains of calcite near contact grade into larger crystals farther away. Skarn mineralization followed the recrystallization of limestone. The "marble line", where metasomatic replacement of limestone ceased, is a sharp contact (Plates 13 and 14). Long, fibrous prisms of actinolite are the main skarn mineral. (Plates 12 to 15) Garnet replaced some actinolite prisms, then was itself replaced by sphalerite. (Plate 15) Galena partially replaced sphalerite. Post-galena fracturing cuts actinolite (Plate 14) but does not persist in more plastic calcite. Some actinolite has altered to epidote. Fractures in actinolite are filled with epidote (Plates 12 and 14).

The paragenetic sequence of mineralization at South Showing is as follows:

1. quartz
2. calcite
3. actinolite
4. garnet
5. sphalerite
6. galena
7. post-galena fracturing, silicification

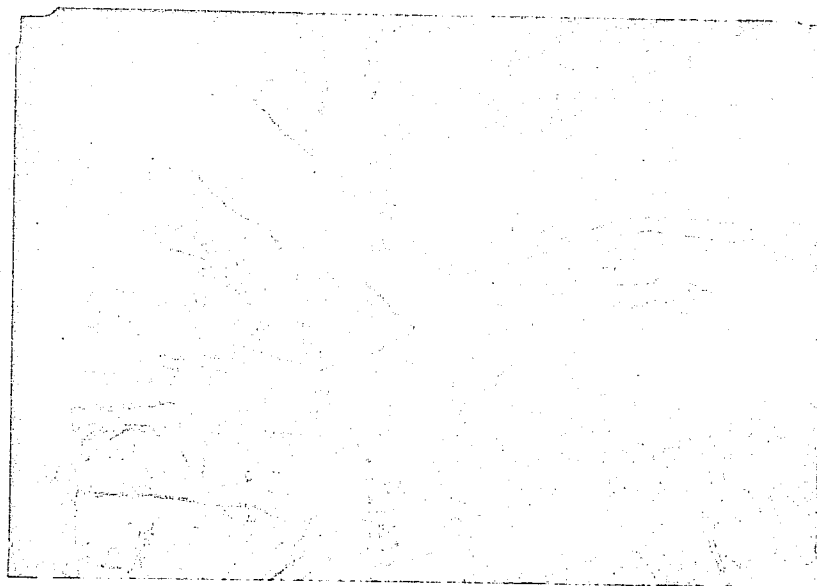


Plate 11

S1-155 High power. Sharply-defined alteration rim in garnet along quartz-filled fracture. Galena has replaced some late quartz (1)

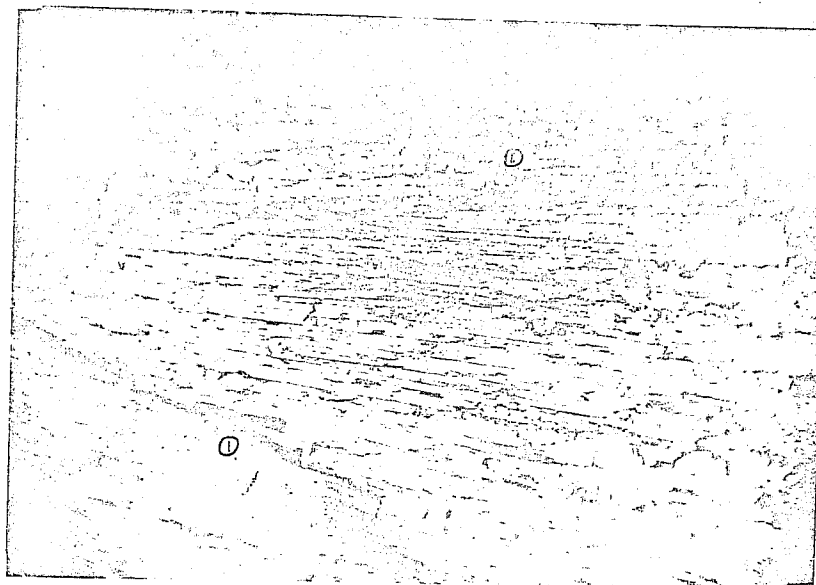


Plate 12

SH-1 Medium power. Long fibres of actinolite partially altered to epidote. Epidote fills fractures in actinolite (1)

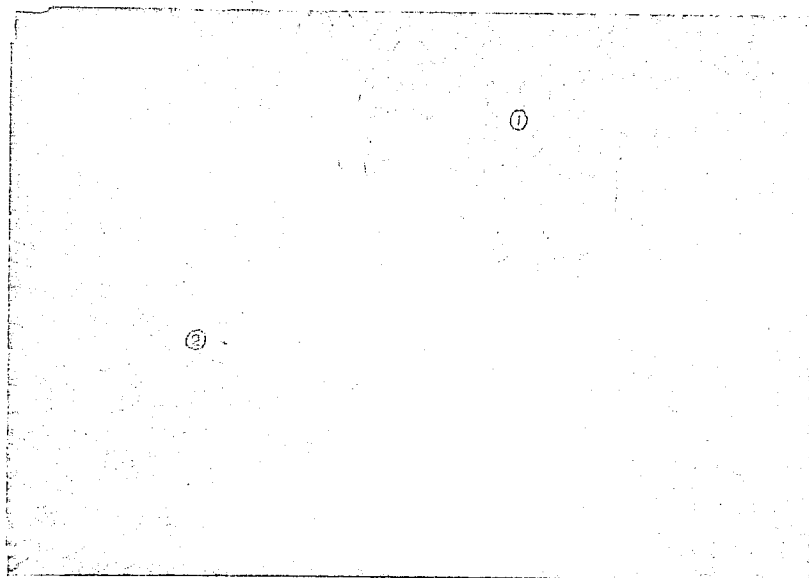


Plate 13

SH-1 Medium power. Contact between calcite (1) and actinolite (2). Garnet (3) galena (4) and epidote (5) near contact

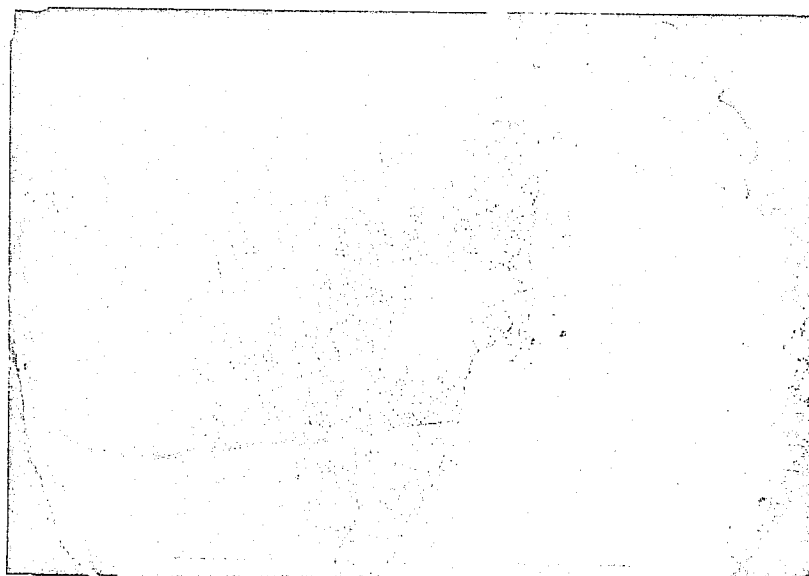


Plate 14

SH-1 Medium power. Galena on calcite-actinolite contact. Epidote-filled fractures stop at contact

8. diopside, remobilization of galena
9. epidote, limonite

Quartz and calcite precede the skarn minerals actinolite and grossularite. Sphalerite and galena replace skarn minerals. Post-galena fracturing is probably related to late fault movement. Silicification of ore and replacement by diopside follows fracturing. Galena was remobilized and replaced some late quartz during a period of metasomatic activity associated with the deposition of diopside. The alteration of actinolite to epidote was the last stage of mineralization. Oxidation of some of the orebodies occurred much later. Sulfides and iron silicates were altered to limonite.

#### Paragenesis of Minerals at North Showing

Five thin sections taken from rocks in vicinity of North Showing exhibit similar paragenetic sequence of mineralization. Four sections were taken from hand samples and one from drill core.

N-1 342 Section was taken from a skarn zone intersected at 342 feet in DDH N-1. Early calcite is replaced partially by garnet. Epidote, pyrite and limonite follow in that order. Plate 16 illustrates limonite surrounding pyrite grains in a groundmass of garnet, calcite and epidote.

J4 The hand sample from ore zone shows banding of

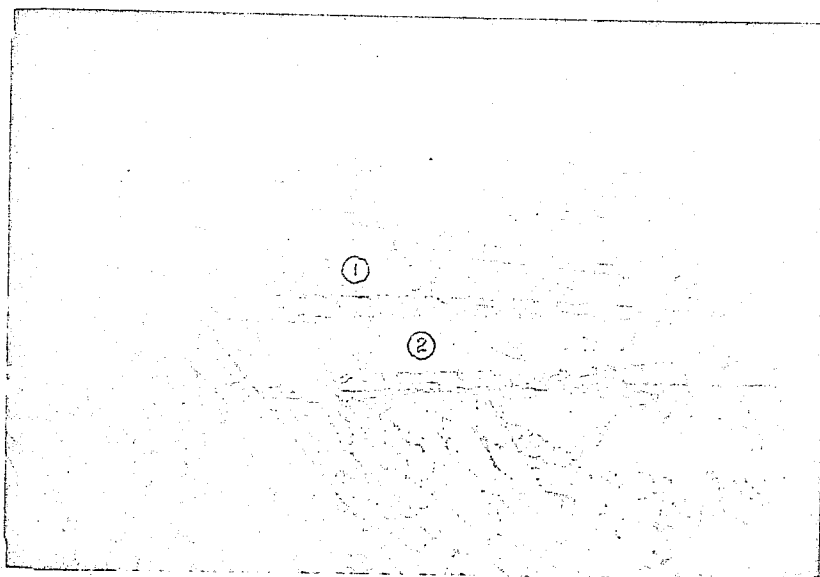


Plate 15

SH-1 Medium power. Actinolite (1) has been replaced by garnet (2), which was in turn replaced by galena (3)

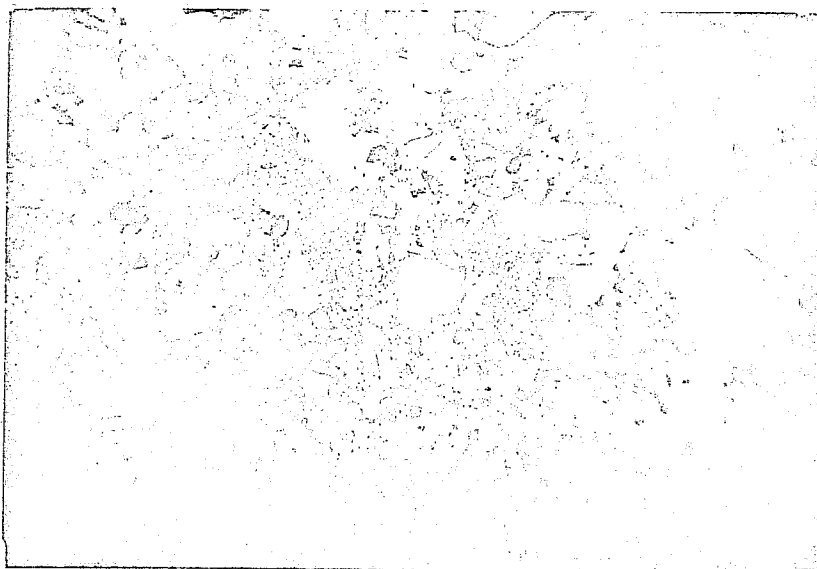


Plate 16

N-1 342 Medium power. Dark limonite grains surrounding pyrite in a groundmass of garnet, calcite and epidote

galena and sphalerite. Thin section examination showed the earliest mineral to be large interlocking grains of quartz. Isotropic massive garnet encloses small laths of diopside and is replaced by small equant grains of sphalerite (Plate 17). Galena partially replaces sphalerite along the perimeter of the grains (Plates 17 and 18).

J11 The hand sample from the ore zone shows bands of sphalerite and galena in altered, calcified rock. A small fold in limestone is replaced by ore. The thin section studied showed small scattered grains of quartz to be the first mineral. Irregular grains of garnet with some birefringent zones replaced quartz and is in turn replaced by euhedral crystals of calcite. Small fibrous bundles of wollastonite replace calcite and are replaced by sphalerite and galena (Plate 19). ~~Reddish-brown, fibrous, secondary~~ calcite replaces most of the earlier minerals.

PlB The hand specimen taken near the ore zone shows predominantly sphalerite mineralization in a matrix of hedenbergite and epidote. The earliest mineral is calcite. Only a few quartz grains were seen in section. Some grains of massive yellow-brown garnet enclose small euhedral birefringent garnets (Plate 24). Sphalerite and galena show the same paragenesis as in other samples. Hedenbergite is the most common mineral. Interlocking grains and random laths of hedenbergite cut all minerals except epidote (Plate 20). The deposition of late hedenbergite is probably contemporaneous

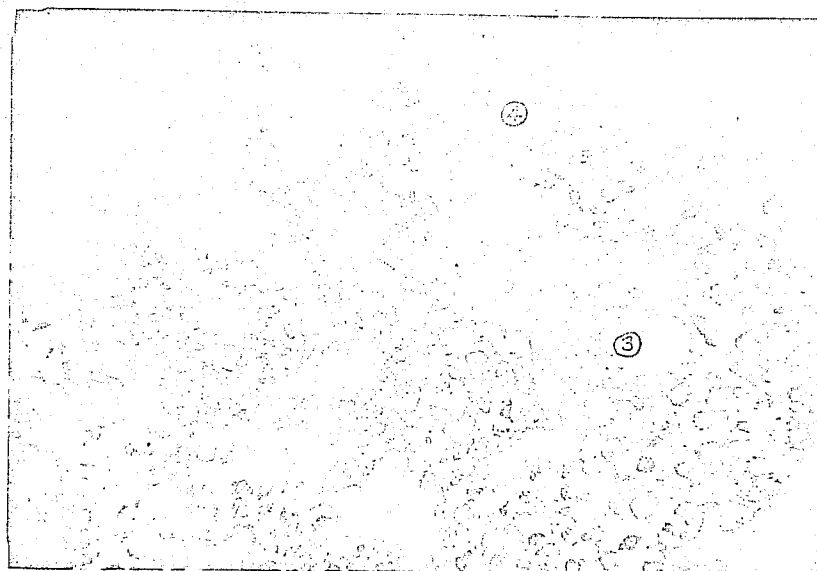


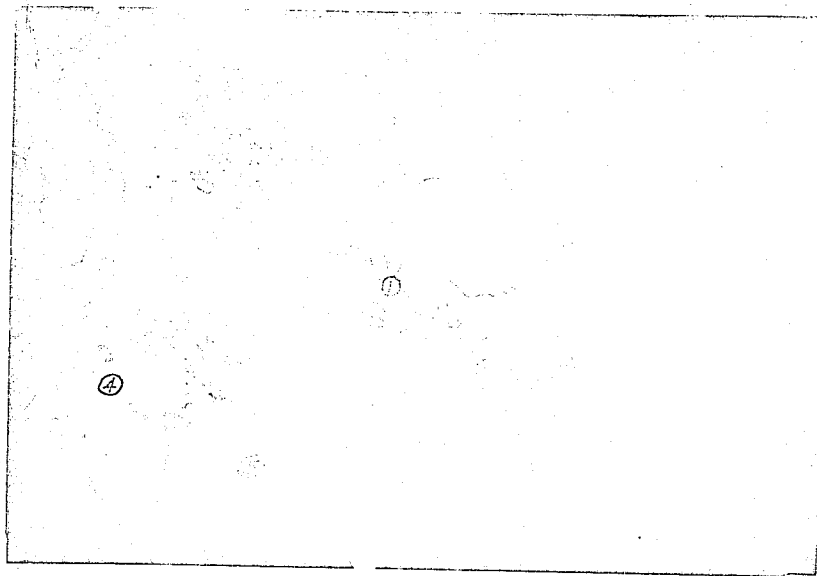
Plate 17

J4 Medium power. Equant grains of sphalerite (1) and galena (2) in banded ore. Massive garnet (3) and scattered diopside (4) in quartz matrix.



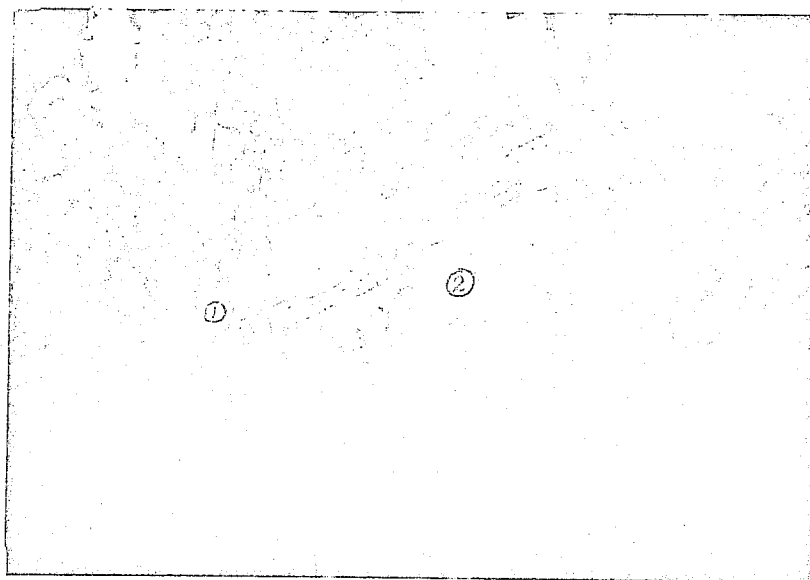
Plate 18

J4 Medium power. Galena (1) has partially replaced sphalerite (2) in garnet (3)



## Plate 19

J11 Medium power. Wollastonite (1) replaced by sphalerite (2). Galena (3) and crystalline early calcite (4) partially replaced by late fibrous calcite (5)



## Plate 20

P-1-B Medium power. Prismatic and massive hedenbergite (1) in calcite (2). Epidote has replaced some of the hedenbergite (3)

with deposition of late diopside at South Showing.

NH3 This section was made from a very siliceous hand sample taken from frost heave near trenches. The dominant mineral is large interlocking grains of quartz. Garnet replaces quartz and a few fibres of wollastonite replace garnet. Diopside and epidote are the last silicates in the sequence. Some limonite stains occur on quartz (Plate 21).

The paragenetic sequence of mineralization at the North Showing is as follows:

1. calcite -
2. quartz
3. garnet
4. wollastonite, diopside (hedenbergite)
5. sphalerite
6. galena
7. hedenbergite
8. epidote, calcite
9. pyrite, limonite

Calcite and quartz precede skarn mineralization. Excess silica is unusual at this stage since all silica introduced normally combines with lime to form lime silicates. The excess quartz may have been sweated out of the argillite beds during metamorphism. Sulfides replace the skarn minerals. Late hedenbergite has replaced earlier minerals. Post-sulfide

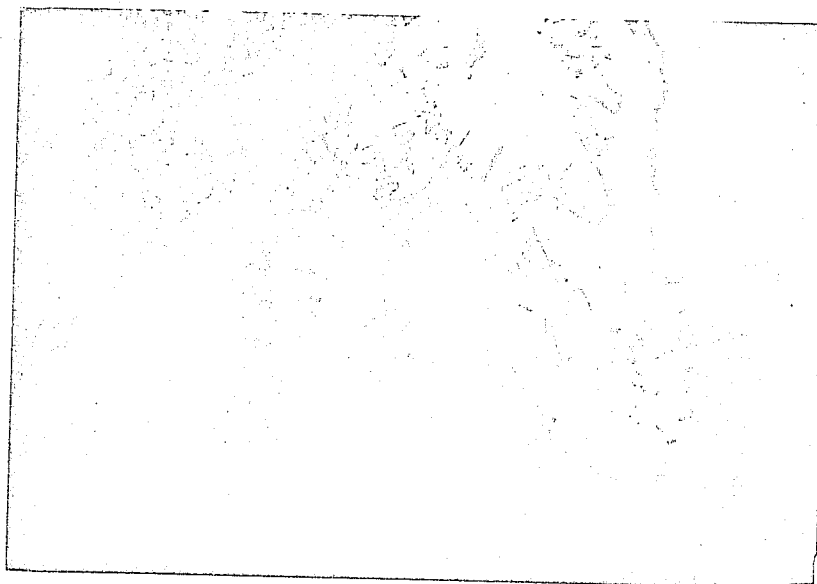


Plate 21

NH3 Medium power, crossed nicols. Fibrous wollastonite and small grains of epidote in crystalline quartz matrix



Plate 22

GD1 Medium power, crossed nicols. Large euhedral quartz phenocryst with albite inclusions. Matrix of subhedral albite laths and fine-grained quartz and albite

epidotization and calcification is widespread. Bedding control is evident in the deposition of minerals.

### Aplite Dike

The only intrusive rock in the central argillite-limestone area is a small aplite dike. The three-foot-wide, steeply-dipping dike cuts argillite beds near the North Showing. Thin sections of the rock show large euhedral quartz phenocrysts in an albite and quartz matrix. Small subhedral laths of albite are surrounded by a groundmass of very fine-grained quartz and albite (Plates 22 and 23). Quartz phenocrysts have inclusions of plagioclase crystals and fine-grained matrix. The albite is an  $Al_1$  in composition and has normal zoning due to non-equilibrium cooling.

The dike cuts unmineralized argillite hence no structural evidence exists about the timing of the intrusion with respect to the ore deposit.

### Birefringent Garnet

Many garnets in sections studied show anomalous anisotropism. A few euhedral grains of birefringent grossularite show sectorial extinction (Plate 5). Most garnet is isotropic with a narrow, well-defined birefringent rim (Plate 6). Small, clear, birefringent grossularite euhedra may be enclosed in massive, yellowish-green isotropic garnet (Plate 24). Some garnet from the North Showing exhibits

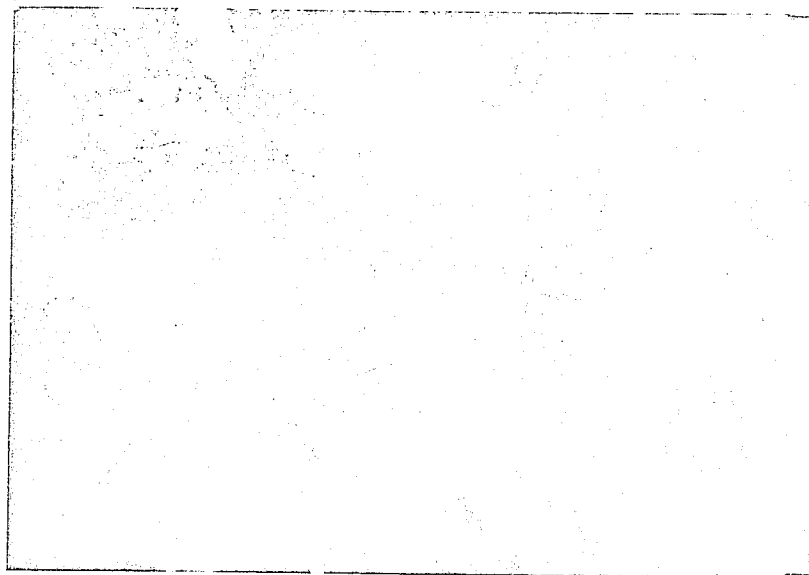


Plate 23

GD-1 Medium power, crossed nicols. Albite laths in quartz-feldspar groundmass

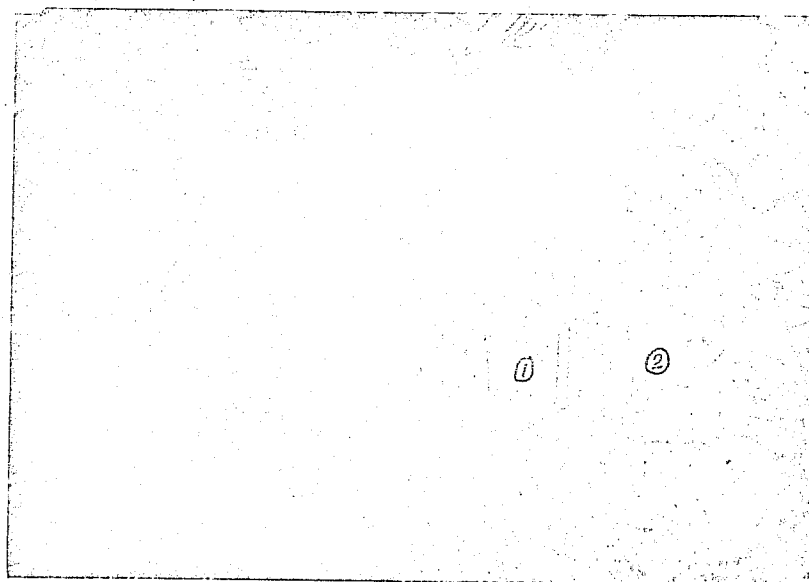


Plate 24

PlB High power. Birefringent euhedral garnet (1) in massive isotropic garnet (2). Galena (3) and epidote (4) replace garnet

compositional zoning (Plates 25 and 26).

Several researchers in the field have noted loss of birefringence in garnet on heating. H. E. Merwin (1915) heated birefringent andradite and noted inversion to isotropic form at 800°C. Stose and Glass (1938) performed similar experiments on birefringent ugrandite garnet. The garnet became isotropic at 860°C and did not invert on cooling. More recent work by J. G. Stone (1959) on Mexican grossularite showed garnet to lose its birefringence at 700-800°C. The nature of garnet inversion is not clearly understood. H. S. Yoder (1950) did extensive work on the synthesis and stability fields of grossularite. He found no change in X-ray pattern to indicate a change in lattice structure. He noted that a change in structure such as ordering of atoms in a rapidly reversible reaction like alpha-beta quartz transformation could have been obscured.

No attempts were made by the writer to test the inversion point of birefringent garnets from Mount Hundere. In personal communication with the writer, D. F. Sangster expressed his belief that inversion of birefringent grossularite is not a reliable temperature indicator. In many cases the reverse condition apparently exists. That is, anisotropism is a high temperature phenomenon and garnets revert to isotropic state at lower temperature. The writer noted many occurrences of early, euhedral birefringent garnet enclosed in later, massive isotropic garnet (Plate 24).

The garnets which are completely birefringent are earlier, probably higher temperature forms.

Isotropic garnets with narrow, well-defined birefringent rims are common in sections studied. Similar garnets were described by C. O. Hutton (1943). He did work on hydrogrossularite, a mineral of the grossularite family containing water and having a lower index than grossularite. Hutton described garnets with mantles of low birefringence and lower index. Mount Hundere garnets have an average index of 1.70 compared to grossularite 1.72-1.74, and the birefringent rim is of slightly lower relief. Hutton relates the birefringent rim to a failure of hydrogrossularite to attain equilibrium in a down-grade metamorphic process. H. S. Yoder states the majority of grossularite is actually in the hydrogrossularite series (1950, p. 253). The dry end member does exist, but not in presence of water at higher temperatures. The garnet studied herein may be of the hydrogrossularite variety.

Compositional zoning is evident in some of the garnet from the North Showing (Plates 25 and 26). Central euhedral part of the garnet is weakly birefringent and has calcite inclusions. Surrounding the core, and terminating abruptly against it, is a blackish mass of amorphous isotropic material. This mass is probably impurities in limestone pushed ahead of growing garnet crystals. A pause in growth occurred when core had attained present size.

A narrow birefringent rim circles the core. A second period of growth allowed garnets to attain present size. A narrow birefringent rim occurs at the outer edge. These garnets are similar to other garnets of the hydrogrossularite series but grew in an impure limestone environment.



Plate 25

NH2 Medium power. Compositional zoning of garnet in calcite

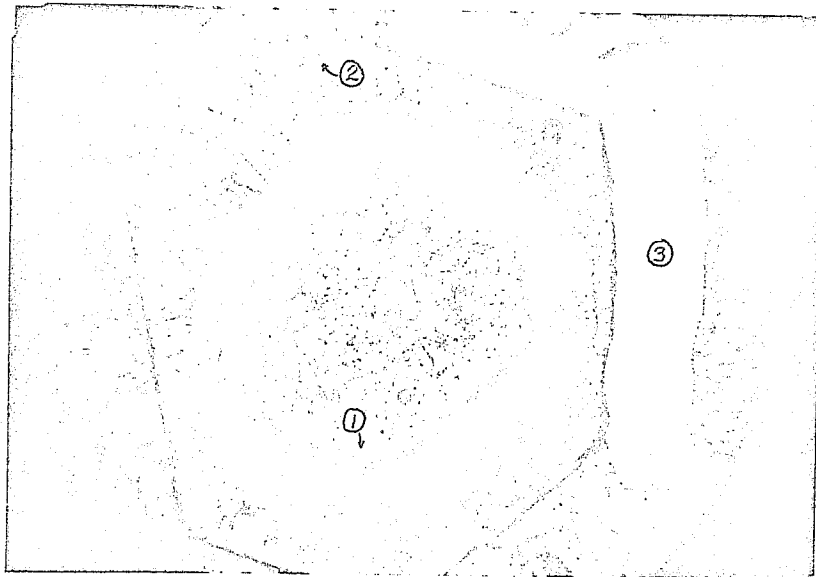


Plate 26

NH2 High power. Compositional zoning in garnet. Birefringent core with calcite inclusions surrounded by black amorphous material. Birefringent rims on core (1) and perimeter (2) of garnet. Quartz-filled fracture (3) adjacent to garnet

CONCLUSIONS

It is concluded that the Mount Hundere lead-zinc deposit is a pyrometasomatic deposit, having the following distinctive features:

1. Distant from igneous rock. No intrusive rocks occur in the region of the ore deposit. Emanations from an igneous source at depth altered and mineralized the rocks.

2. Structural control. All orebodies conform to bedding in favourable limestone.

3. Temperature range between 500 and 800°. Wollastonite has a stability range above 500°C. Birefringent garnets may indicate an upper limit of 700-800°C.

4. Mineralogy. Typical skarn minerals actinolite, wollastonite, diopside and garnet occur in the deposits. The sulfides are generally later than the lime silicates.

The sequence of geologic events related to the ore deposit is as follows:

1. Folding of the limestone and argillite beds at depth.

2. Uplift and faulting of the beds, perhaps accompanied by an igneous intrusion.

3. Replacement of limestone beds in vicinity of a NE fault by rising igneous emanations. Intrusion of aplite dike is probably contemporaneous.

4. Late fault movement in vicinity of South Showing with fracturing of beds.

5. Late metasomatic or hydrothermal activity--silicification, fluoritization, epidotization.

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APPENDIX I

Drilling

A total of 7 diamond drill holes were bored. Holes with the prefix N are on the "North" showing; prefix S identifies those on the "South" showing. All of the drill data are compiled and shown below in tabular form:

SUMMARY OF DRILLING PROCESS

Hole No.	Date		Length	Bearing	Dip	Collar Elev.Ft.	% Core Rec'y	Progress of Drilling
	Start	Complete						
N-1	June 17/63	June 22/63	388'	East	-60°	4852'	81	388'
S-1	" 25/63	" 28/63	306'	-	-90°	4673'	91	694
S-2	" 28/63	" 30/63	243'	-	-90°	4659'	90	937'
S-3	" 30/63	July 3/63	459'	N65°E	-45°	4664'	92	1396'
S-4	July 4/63	" 6/63	90'	N40°E	-45°	4718'	29	1436'
S-5	" 6/63	" 8/63	149'	N40°E	-60°	4718'	56	1635'
S-6	" 8/63	" 11/63	205'	-	-90°	4723'	61	1840'

SUMMARY OF DRILL HOLE ASSAY DATA

Hole No.	Mineralized Intervals, Ft.		Assay			Remarks
	From	to	Zn	Cu	Gr.Ag	
S-1	Interval					
	0	20	15.6	13.4	2.74	Vertical hole on main "South" showing
	20	30	0.1	1.7	0.13	
	30	40	1.8	4.4	0.24	
	40	49	0.6	1.2	0.22	
	49	57	4.5	4.1	0.48	
	58.5	67.5	Ni1	1.3	0.08	
	145	150	0.5	1.7	Tr	
	150	154.5	20.8	19.8	2.68	
	154.5	169	1.3	2.1	0.19	
220	244	0.7	1.1	0.13		

Depth of Hole: 306'

Hole No.	Mineralized Intervals, Ft.		%Pb	%Zn	Gr. Ag	Remarks
	From - to Interval					
S-2	0 - 34.5	34.5	23.0	23.3	3.42	Vertical hole on main "South" showing
	34.5 - 47.5	13	N11	0.6	0.06	
	47.5 - 50	2.5	12.8	15.8	1.73	
	50 - 60	10	5.5	8.9	0.76	
	60 - 70	10	0.1	0.5	0.03	Depth of Hole: 243'
S-3	90 - 100	10	17.2	20.4	2.73	45° Angle Hole collared in limestone and directed to intersect 'mineralization' under DDH No. S-2
	100 - 105	5	N11	0.7	0.06	
	185 - 190	5	0.1	N11	Tr	
	190 - 197	7	10.1	9.9	2.00	
	197 - 200	3	N11	N11	0.04	
	345 - 355	10	1.3	2.0	0.23	Depth of Hole: 459'
S-4	20 - 30	10	N11	0.1	0.15	45° Angle Hole to intersect gossan zone in trenches on "South" showing
	30 - 50	20	4.6	9.5	4.45	
	50 - 60	10	5.7	9.5	1.88	* Hole blocked @ 90' stopped hole and redrilled @ -60'
	60 - 90	30	3.0	7.3	1.40	Depth of Hole: 90'
S-5	10 - 40	30	0.5	2.6	0.42	60° Angle Hole to intersect gossan in trench system on "South" showing
	40 - 50	10	7.1	15.7	3.66	
	50 - 70	20	5.8	14.0	1.57	
	70 - 90	20	2.4	9.6	1.38	Depth of Hole: 149'
S-6						No assay data yet available. No significant mineralization in core.

Note: Drill hole N-1 was bored at 60° to intersect gossan zone in trench system on "North" showing. The hole did not encounter any mineralization whatsoever and therefore no samples were sent for assay.

SJM:jhw  
25 July, 1963

APPENDIX II

Trench Sampling

A visual estimate of sulphide content in last year's trenches suggested that the assays, as reported by Aho & Associates, were somewhat high. Consequently, the trenches showing the best values were re-sampled by Canex personnel.

The comparative assay results and the respective discrepancies are tabulated below:

SUMMARY - TRENCH SAMPLING: 1963 vs 1962

Trench	%Pb	%Zn	Oz. Ag	Combined Pb/Zn	Interval Ft.	Remarks
2 JP South Wall North Showing	6.6	7.8	0.76	14.4	56'	per Canex 1963
"	20.0	13.3	1.21	33.3	54'	per Aho 1962
2 JP North Wall North Showing	9.4	4.9	0.88	16.3	55'	per Canex 1963
"	10.6	5.6	1.04	16.2	40'	per Aho 1962
3 JP South Wall North Showing	11.6	9.5	1.10	21.1	82'	per Canex 1963
"	20.0	13.3	1.84	33.3	76'	per Aho 1962
* No. 1 South Wall South Showing	7.2	5.1	2.26	12.3	125'	per Canex 1963
"	20.3	7.6	6.42	27.9	43'	per Aho 1962
No. 2 South Wall South Showing	3.4	4.7	1.70	8.1	60'	per Canex 1963
"	12.5	6.5	2.54	19.0	69'	per Aho 1962

SUMMARY OF DISCREPANCIES

TRENCH SAMPLING: 1963 vs 1962

Trench	% Comb. Pb/Zn Canex	Aho	Discrepancy Units	Factor
2 JP South Wall	14.4	33.3	18.9	2.3 x Higher
2 JP North Wall	14.3	16.2	1.9	1.1 x Higher
3 JP South Wall	21.1	33.3	12.2	1.5 x Higher
* No. 1	12.3	27.9	15.6	2.2 x Higher
No. 2	8.1	19.0	10.9	2.3 x Higher

\* Note: Aho's sampling on Trench No. 1 included only an interval of 43' vs. an interval of 125' for Canex and therefore the comparison would appear unfair at first glance. However, the highest Canex assay for combined Pb, Zn in this trench comes only to 24.9% for a 5 ft. interval.

All of the Canex sampling was on a channel basis with intervals taken at 5 ft. or less. The sampling was set up by S.J. Melihersik and partially supervised by him. Melihersik accepts full responsibility for the sampling as reported herein.

Respectfully submitted,

  
S.J. MELIHERSIK.

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