# METALLOGRAPHY

# OF THE

# SULLIVAN MINE, B.C.

by

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## Introduction.

### Location.

The Sullivan mine is situated in the East Kootenay district, two miles north of Kimberley, a little mining town connected to the Crow's Nest branch of the C.P.R. by a spur from Cranbrook. Other mining properties in the Kimberley area include the North Star and the Stemwinder. The Sullivan is the largest mine in the neighbourhood.

### History.

The Sullivan was discovered in 1895 and developed by the Sullivan Group Mining Company of Spokane. This company built a smelter at Marysville, about six miles south of the mine, but it was never a success. In 1910 the Consolidated Mining and Smelting Company bought out the Sullivan and many nearby claims, and the ore has, since then, been shipped to their own smelter at Trail.

### Production.

The Sullivan mine is the largest producer of silver-lead-zinc ores on the North American continent. Before 1920 less than one million tons of ore were taken from it, but, due to progress in the metallurgical treatment of lead-zinc ores since that date, the output has increased steadily. In the last ten years the mine has produced between ten and eleven million tons, and with its present equipment its capacity is 6,000 tons a day, or roughly 2,000,000 tons a year. The actual production in 1930 was 1,942,137 tons of ore. The ore produced in 1928 yielded 5,595,565 oz. of silver, 292,757,130 lbs. of lead, and 167,842,300 lbs. of zinc, with a total value of $25,870,000. The development openings to date total about 23 miles, and the estimated life of the mine at the present rate of production is at least 50 years.

## General Geology.

The Sullivan mine is geologically situated near the base of the Purcell series, a group of Pre-cambrian or Beltian sediments which outcrop in the Purcell range. This mountain range lies to the west of and parallel to the Rockies, being separated from the latter by the Rocky Mountain Trench. The Palaeozoic strata of the Rockies lie unconformably on the Purcell series. The latter rocks form the western part of the Rocky Mountain geosyncline. The Sullivan mine is slightly to the west of the western boundary of this geosyncline, and is thus in the oldest rocks of the series, the Aldridge quartzites.

The following table gives the rocks of the Purcell series. They outcrop in this order from west to east on the eastern flanks of the Purcell range.

| | Formation | Lithology | Thickness |
|---|---|---|---|
| | Palaeozoic | Sediments | |
| | Unconformity | | |
| Purcell series<br>Pre-Camb. (Beltian) | Gateway | Conglomerate & limestone | 2000 ft. |
| | Purcell Lava and Sills | Amygdaloidal or porphyritic basalt. | 100 |
| | Siyeh | Argillites, sandstones and conglomerates | 4000 |
| | Kitchener | Quartzites and limestones | 4500 |
| | Creston | Greyish argillaceous quartzites | 6000 |
| | Aldridge | Argillaceous quartzites | |

The members of this series were deposited conformably on one another. The Purcell lava made its way to the ancient Siyeh surface through several fissures in the underlying formations, and some of the molten rock forced its way into the bedding planes of the sediments through which it passed. This explains the presence of the Purcell Sills, some of which occur in the Aldridge formation, not far below the ore horizon.

## Structural Geology.

The Sullivan ore-body is situated in the Aldridge quartzites on an anticline with a general north and south axis. The rocks dip to the east, under the younger formations of the Purcell series, into the Rocky Mountain geosyncline, while on the west they are folded into the Purcell range. This structure is modified by minor folding and faulting in the same general direction as the main folds.

The Aldridge formation consists of thin-bedded argillaceous quartzites intercalated with heavy-bedded, purer quartzites. The prevailing dips in the vicinity of the mine are to the east at angles varying between 10 and 60 degrees. The ore-body follows the bedding of the quartzites. Close folding since the ore deposition has in some places increased the normal width of the deposits.

## Character of Ore-bodies.

The fine-grained argillaceous quartzites have been replaced by sulphides, which grade into the country rock so that the boundaries of the ore-bodies are indistinct. At some points, however, the purer quartzites form well defined hanging-walls and foot-walls.

At the centres of the ore-bodies we find a fine-grained mixture of galena and sphalerite, in which occur lenses of purer galena, also fine-grained. Gangue minerals are absent in this zone, with the exception of a few small idiomorphic crystals of pink garnet. This inner zone gradually gives way to one in which fine-grained pyrrhotite, sphalerite, and galena occur with a gangue of diopside, garnet, actinolite, calcite, and quartz. The sulphides diminish steadily as we pass outward into the country rock, and the last traces of ore are microscopic fingers of galena penetrating the quartzites. The actual boundaries of the ore-bodies are commercial rather than structural.

In some parts of the periphery of the deposits the replacement is very well shown by alternate banding of ore and quartzite due to the relative susceptibility of successive laminae. In other parts the mineralization terminates abruptly in a wall of fine-grained chert, formed from the purer quartzites when in contact with the ore-bearing solutions. These solutions were restricted to the argillaceous quartzites, and appear to have entered between the quartz grains before attacking the grains themselves. The various stages of replacement can be observed in properly selected polished specimens. At the centres of the ore-bodies the replacement is complete.

The gangue minerals seem to have come in during the same period of mineralization as the sulphides, as they are found in the outer parts of the ore-bodies and not in the surrounding quartzites. They must have crystallized before the sulphides because their outlines are in many cases sharply defined, and their crystallographic properties are often well developed; this is especially noticeable in the case of the garnets. It is probable that gangue minerals crystallized in the inner zones of the ore-bodies in the early stages of replacement; if so, they have been entirely replaced themselves by succeeding sulphides, the action having gone on for a considerable period of time.

## Mineralogy.

### Sulphides.

The specimens used in the preparation of this report contained galena, pyrrhotite, and sphalerite. No pyrite, arsenopyrite, or chalcopyrite were observed, although S.J. Schofield reports their presence in the Sullivan ore-body (C.G.S. Memoir 76, p.107).

Galena, PbS. Lead sulphide is very widely distributed throughout the deposit and is the most important mineral because of the silver values which it carries. These range from 3 to 4 ounces of silver to one per cent of lead.

The galena occurs in the fine-grained form with a steely appearance. In the inner zone of the ore-body are lenses of almost pure galena surrounded by an intimate mixture of fine-grained pyrrhotite, sphalerite, and galena, the galena being generally continuous (Fig. 2). In the outer zone this mixture is complicated by the presence of the gangue minerals, but the galena still predominates. At the periphery it ends as microscopic stringers which penetrate the quartzite.

Sphalerite, ZhS. Zinc-blende occurs as a fine-grained, very dark coloured mineral in intimate association with galena and pyrrhotite (Fig. 2). Its distribution is fairly even throughout the deposit.

The presence of zinc-blende was at first a severe handicap to the mine, but the development of selective flotation has made it a valuable constituent.

Pyrrhotite, $Fe_7S_8$. Pyrrhotite occurs abundantly in association with the other sulphides.

Gangue Minerals.

The gangue minerals are very rare in the inner zone, but their occurrence becomes more common as we go outward.

Diopside, $CaMg(SiO_3)_2$. Diopside is a fairly common gangue mineral in the Sullivan ore-body. It occurs as light green, transparent crystals of irregular outline (Fig. 5).

Quartz, $SiO_2$. Quartz occurs near the periphery of the ore-body as irregular, glassy grains (Fig. 3).

Garnet. Small, idiomorphic, transparent crystals of garnet are found embedded in the fine-grained sulphides (Fig. 5). They are more numerous in the outer zone, where they are of a very pale yellow colour or sometimes colourless. In the inner zone the dodecahedral form is more fully developed and the colour is a pale pink.

Actinolite, $(MgFe)SiO_3$. Actinolite occurs rarely as radiating aggregates (Fig. 4) on the periphery of the ore-body.

Calcite, $CaCO_3$. Calcite occurs as pale green or colourless, transparent crystals embedded in the sulphides (Fig. 1). These crystals sometimes have a very definite rhombic outline.

## Genesis.

No feeders to the Sullivan ore-body have ever been found. There are no outcrops of igneous rocks within four miles of the deposit, but sills of gabbro and small stocks of granite and granite porphyry in the surrounding country suggest the presence of a large igneous body at depth. It is thought that these igneous apophyses, and the mineralization of the Sullivan, the St. Eugene, and other similar deposits in the neighbourhood, are directly related to the West Kootenay batholith. The ore deposits are therefore of Upper Jurassic age.

## Summary.

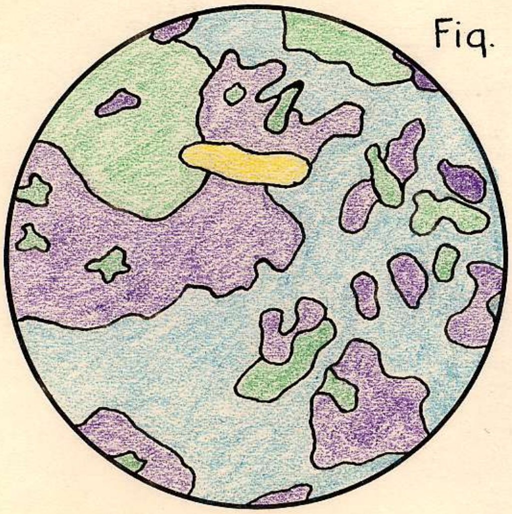
The minerals found in the Sullivan ore deposit are all of primary origin, the zones of oxidation and of secondary enrichment having been removed by glaciation. Hydrothermal solutions came in along the less resistant horizons of the Aldridge formation, and replaced the quartzites by the deposition of sulphides and gangue minerals in the following order:-

1. Actinolite.
2. Garnet, diopside.
3. Calcite.
4. Pyrrhotite.
5. Sphalerite.
6. Galena.

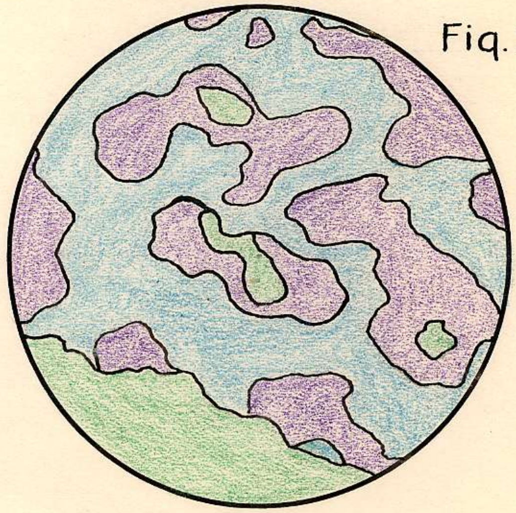
This order of formation can be understood by a study of the accompanying diagrams, which were drawn from polished specimens of rocks and ores from the deposit.

## Acknowledgment.

This report is based on the examination of specimens in the laboratory. Having done no field work in the Kimberley area, the writer has taken a great deal of information from the reports of S.J. Schofield in G.S.C. Memoir 76 and "Economic Geology", Volume VII, p.352.



Fiq. 1.



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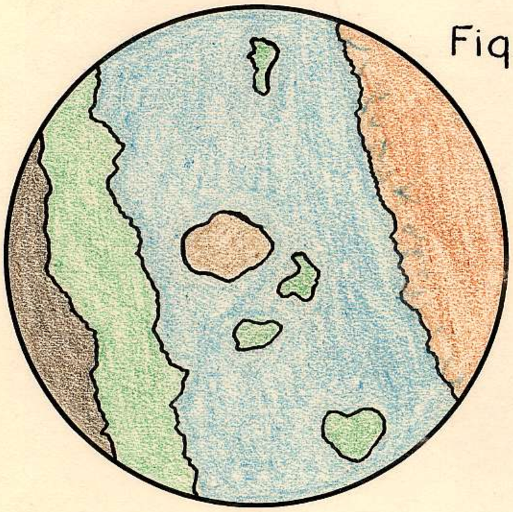

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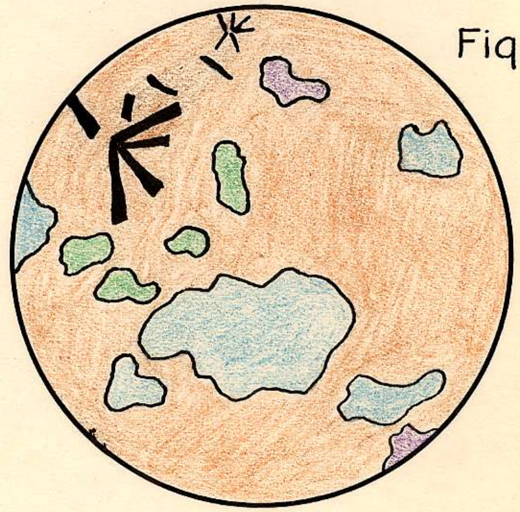

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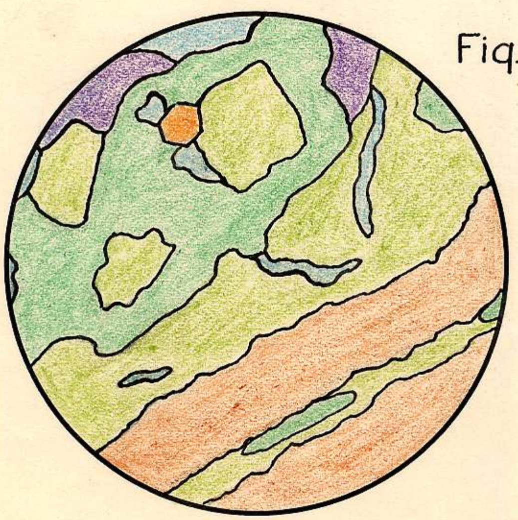

Fiq. 5.

MAGNIFICATION: 34.

- Chert.
- Quartzite.
- Quartz.
- Garnet.
- Actinolite.
- Diopside.
- Calcite.
- Pyrrhotite.
- Sphalerite.
- Galena.