Controls on ore deposition, Polaris mining district, Pioneer Mountains, Beaverhead County, Montana
by Thomas Edward Davis

A thesis submitted in partial fulfullment of the requirements for the degree of MASTER OF SCIENCE in Earth Sciences
Montana State University

Abstract:
The Polaris silver mining district is located along the southern margin of the Cretaceous Pioneer batholith. The silver ore replaces Mississippian age Madison Group limestone though in other districts of the Pioneer region Cambrian carbonates may also be mineralized. Other stratigraphic units present in the Pioneer district are the Precambrian Missoula Group and the Cambrian Meagher, Park, and Pilgrim Formations.

These strata underwent six stages of faulting, probably during the Laramide orogeny. In chronological order, the fault systems strike: N 33° W; N-S; E-W; N 60° E; N 40° E; and N-S. A N-S fold set formed after the first stage of faulting, and an E-W fold set developed after all faulting. A third folding episode, evident only underground, has folded the Polaris (N 60° E) fault.

The batholith intruded passively after the fifth and perhaps after the sixth episode of faulting. Ore mineralization is presumed to have followed intrusion of the batholith, at least of its deeper levels, by analogy with other ore districts in the Pioneer region. Ore replaces Madison Group limestone along N 60° E faults; only these faults were open at the time of mineralization since they were parallel to the direction of maximum stress.

In the Polaris Mine, the principal mine of the district, the paragenetic sequence of mineralization is: pyrite, sphalerite; galena; pyrargyrite(?); and native silver.

Quartz is the principal gangue mineral; limestone in ore-bearing areas is stained dark brown. Zoning of metals within the Polaris Mine from surface downward is: (1) Cu-Ag; (2) Ag; (3) Pb-Zn-Ag. Ore is deposited for several feet into the Madison limestone from the Polaris fault. High grade orebodies (averaging 40 oz/ton Ag) are disc-shaped and appear controlled by breccia zones formed at the intersections of the Polaris fault with E-W and N 45° W faults.

Future exploration in the district should emphasize ¦ (1) Madison limestone where adjacent to a N 60° E fault, and (2) skarn zones in the Madison formed by metasomatism from the batholith. Included in Category (1) are the lower workings of the Polaris Mine, the Silver King Mine, and two newly discovered N 60° E faults. Metals to be prospected for are Ag and Pb in Category (1) settings and Ag-W-Mo in the Category (2) environment.

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Signature Thomas Edward Davis

Date November 10, 1980

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ABSTRACT

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In the Polaris Mine, the principal mine of the district, the paragenetic sequence of mineralization is: pyrite, sphalerite; galena; pyrargyrite(?); and native silver. Quartz is the principal gangue mineral; limestone in ore-bearing areas is stained dark brown. Zoning of metals within the Polaris Mine from surface downward is: (1) Cu-Ag; (2) Ag; (3) Pb-Zn-Ag. Ore is deposited for several feet into the Madison limestone from the Polaris fault. High grade orebodies (averaging 40 oz/ton Ag) are disc-shaped and appear controlled by breccia zones formed at the intersections of the Polaris fault with E-W and N 45° W faults.

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INTRODUCTION

Purpose

The Pioneer Mountains are a major region of ore production, but few mining districts within it have been studied in detail. The purpose of this study is to determine the structural and chemical controls on ore deposition within one of these mining districts, the Polaris mining district. Favorable areas for future exploration are recommended based upon the results of this study.

Access and Location

The Polaris mining district is located 42 miles west of Dillon, Montana on the western flank of the Pioneer Mountains, Beaverhead County, Montana (Figure 1). This district is an area of 2¼ square miles comprising a portion of the Billings Creek drainage and part of the Farlin Creek drainage.

The major access is via a 2 mile long dirt road which follows Billings Creek north from the town of Polaris. The road is kept open year round by the present mining operation at the Polaris mine.

Climate and Topography

In the area of the Polaris mine, access is governed by the elevation and the climate. The climate in the vicinity of Polaris, Montana is semiarid with temperatures ranging

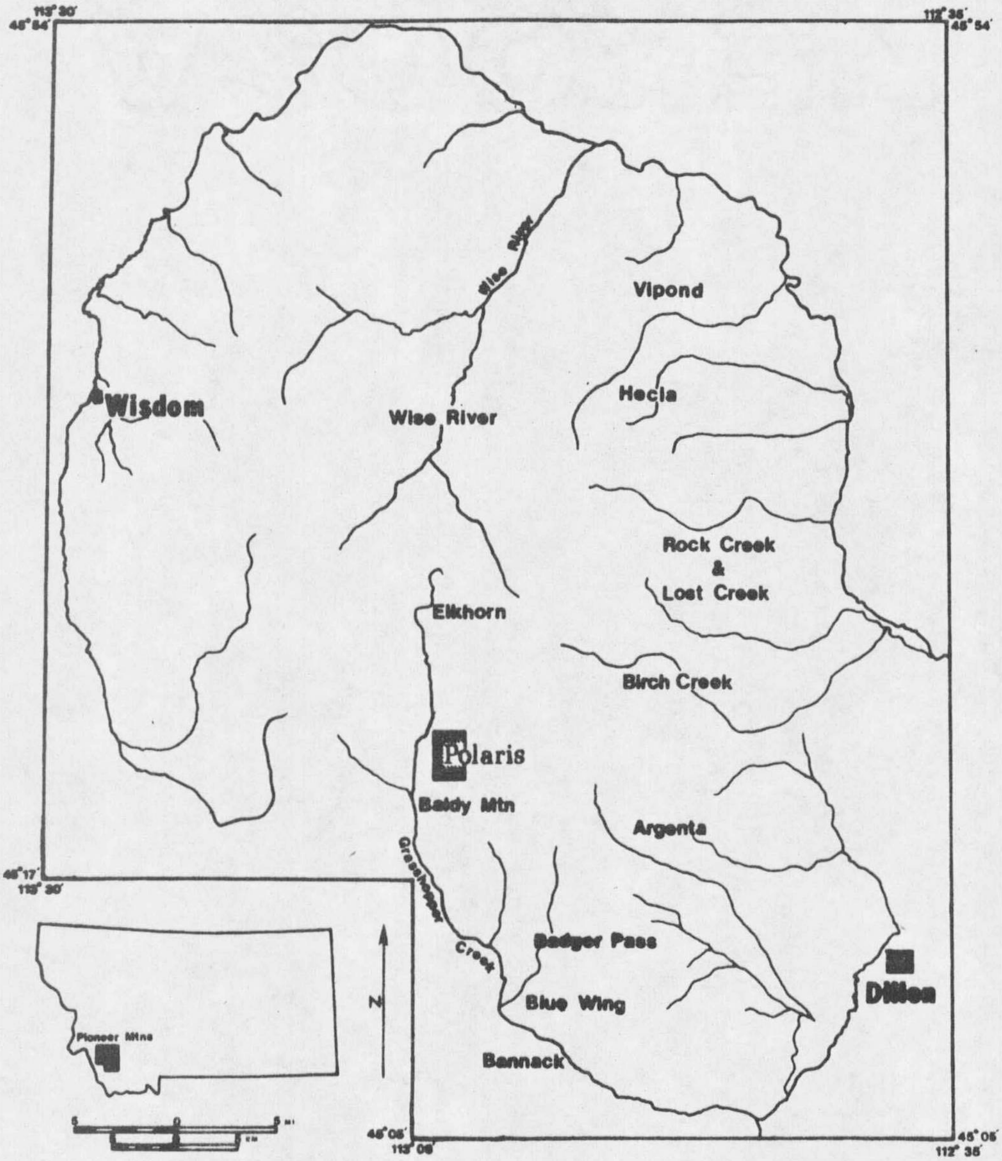

Figure 1. Index map showing the location of mining districts in the Pioneer Mountains. Study area is shaded as are the towns of Dillon and Wisdom.

from 100°F in the summer to -40°F in the winter (Geach, 1972). Snow can be a problem as early as September, but it does not usually remain on the ground until late October or early November. Snow frequently remains on forest-covered, northern slopes until May, at which time the snow rapidly melts. Southern slopes, which are covered with sagebrush, can be snowfree year-round during mild winters. Precipitation is highest from April to July and is lowest from November to February (Geach, 1972).

The elevation of the region around the Polaris mine rises from 6,400 feet at Grasshopper Creek to 10,568 feet on the top of Baldy Mountain. The Polaris mining district is from 6,500 feet to 7,900 feet elevation.

The region around Polaris is composed of east-west and northeast-southwest trending valleys and ridges. The major stream valleys are linear, but the tributaries are randomly oriented so that the overall drainage pattern is dendritic. The slopes rising eastward from Grasshopper Creek have the appearance of a dissected pediment.

History and Production

The Polaris mine deposit was discovered in 1883 and by 1885 the principal quartz claims were located (Corry, 1918). Ore was first hauled by ox team to Fort Benton and then shipped by boat to the east; some ore went to Swansea, Wales (Pardee, 1933).

In 1886 the Polaris mine was reported to have produced $60,000 worth of silver (Corry, 1918). However, Winchell (1914) believed that the $60,000 was produced from the Silver Fissure mine and not the Polaris mine. Twenty men operated the Polaris mine at this time, and they sunk a shaft that was 200 feet long (Geach, 1972).

In 1891, the Polaris Mining and Milling Company purchased the mine and drove the lower Polaris adit to a length of 2,300 feet, which was about 600 feet in elevation below the vein outcrop. Drifts were driven on the adit level and an inclined raise connected the older upper workings with the adit. By the time the company ceased operations in 1901(?), $250,000 worth of ore had been mined (Geach, 1972).

The property was later acquired by J. E. Morse at a sheriff's sale and sold in 1905 to the Silver Fissure Mining Company (Geach, 1972). This company built a 100-ton smelter, quarters for miners, an assay office, a business office, storage houses, and other facilities (Corry, 1918). Due to an insufficient supply of ore the smelter was in operation for less than one year.

Lease holders worked the property until 1918, when it was leased to the similarly-named Silver Fissure Silver Mining Company (Geach, 1972). Reserves were reported by a mining consultant, Arthur Corry, to be 69,000 tons of ore containing 1,500,000 ounces of silver and 1,300 ounces of gold. The company erected a 50-ton mill employing chloridizing roasting and hyposulfite leaching of the ore. Small shipments were made in 1919 and in 1922, but operations by the company ceased soon thereafter.

Production for the property was small and sporadic until 1959. Lee James of Polaris maintained production from a surface cut (Geach, 1972) until 1968 when the Midnight Mines Corporation leased the property. Since 1968 this corporation has opened up old workings on the 130-foot level and on the 260-foot level. Present operations are attempting to open up the 570-foot level to permit access to the lower workings. Table 1 shows production from the Polaris mining district between 1902 and 1965.

Previous Investigations

Very little geologic work has been done in this region until recently. In the last couple of years, a flurry of activity in the Pioneer Mountains has resulted from the rise in the price of silver, gold, and petroleum, as well as from proposals to classify the region as a wilderness.

Table 1

Production of Ore, Polaris District, 1902-65
(After Geach, 1972)

Year	Ore (tons)	Gold (oz.)	Silver (oz.)	Copper (lb.)	Lead (lb.)	Zinc (lb.)
1902-07	none					
1908	11	65	2,811	2,204	----	----
1909	none					
1910	2	----	196	----	----	----
1911	none					
1912	51	8	4,309	628	----	----
1913	none					
1914	19	3	2,363	198	----	----
1915	10	1	1,223	125	----	----
1916	none					
1917	446	14	13,768	----	----	----
1918	193	15	12,035	3,680	----	----
1919	56	4	3,400	1,236	----	----
1920	87	6	5,239	1,299	----	----
1921	none					
1922	275	8	10,955	493	126	----
1923	none					
1924	3	<1	247	33	----	----
1925	1	1	11	----	----	----
1926-33	none					
1934	151	83	266	675	379	----
1935	85	19	1,056	747	4,450	----
1936	366	39	626	----	----	----
1937-38	none					
1939	8	----	436	----	----	----
1940	5	----	180	44	80	----
1941-51	none					
1952	32	4	157	75	1,105	----
1953-54	none					
1955	1	----	161	----	100	----
1956	26	1	2,274	200	1,700	900
1957	none					
1958	7	----	107	----	----	200
1959	29	----	165	----	----	----
1960	none					
1961	920	17	17,230	700	2,200	10,000

Table 1 (continued)

Year	Ore (tons)	Gold (oz.)	Silver (oz.)	Copper (lbs.)	Lead (lb.)	Zinc (lb.)
1962	481	9	4.673	1,600	----	----
1963	450	6	12,324	2,400	----	----
1964	588	5	11,673	2,300	----	----
1965	581	4	12,138	2,300	1,000	1,000
Total	4,884	312	120,023	20,937	11,140	12,100

In 1914, Winchell conducted a reconnaissance of the mining districts in the Dillon, Montana region. This general study provided only limited information for many of the mining districts.

In 1918, Arthur Corry visited the Polaris mine as a consultant. He estimated the ore reserves at the mine, but spent little time looking at the geology.

Pardee and Schrader (1933) reported on the Greater Helena mining region. They put together a history of structural geology, described the formations, and discussed the zoning within this region.

The physiography and the ground-water supply in the Big Hole Basin was studied by Perry in 1934. He summarized the order of landform development within this region.

Klepper (1950) conducted a structural and stratigraphic reconnaissance of parts of Beaverhead and Madison Counties, Montana, and reported upon the nonmetallic resources of these counties.

In 1953, Alden published his work on the physiography and glacial geology of western Montana. This paper contains sections dealing specifically with the Polaris region.

Breit (oral and written communications) prepared a geologic map during a geochemical study of the Polaris mining district, which formed part of the East Pioneer Wilderness study of the U.S. Geological Survey (Berger and others, 1979).

Cox (oral communication) of the Montana Bureau of Mines and Geology is currently mapping the Polaris quadrangle.

Methods

Field work was conducted in the spring and fall of 1979 and in the summer of 1980. Surface mapping utilized a base map with a scale of 1:8,000. The base map was enlarged from a U.S. Geological Survey T-type map of the Polaris quadrangle which had a scale of 1:24,000.[1] Underground mapping could only be done on the 260-foot level. The workings were mapped on a scale of 1:500 with a Brunton compass and a 30 meter cloth tape. Backsightings were taken with the Brunton compass in order to correct for the magnetic deviations occurring within the mine.

Rock samples were taken where available on the surface and in the mine. Nine polished sections and twenty thin sections were prepared in order to identify mineralogy and determine the paragenetic sequence. A scanning electron microprobe (Montana State University Physics Department) was

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[1]T-type map is an unpublished U.S. Geological Survey topography map.

used to determine the identity and distribution of the elements within the ore.

REGIONAL GEOLOGY

Regional Stratigraphy

The stratigraphy of the region in and around the Pioneer Mountains differs lithologically from that of most of Montana. The stratigraphy is described for the Pioneer region. Formations not found in the Polaris mining district are included, as a knowledge of the complete stratigraphic column is necessary for proper interpretation of field data (Figure 2).

The regional stratigraphy was compiled from many sources. References are stated at the start of the discussion of each formation, or included in the text where deemed appropriate.

Precambrian Belt. The Precambrian Belt Supergroup has not been studied in Beaverhead County in any detail. However, the Missoula Group is known to be present within the Pioneer Mountains (Myers, 1952; Geach, 1972).

Myers (1952) measured a thickness of 10,000 feet for the Missoula Group near Argenta, but observed that it rapidly thinned to 2,000 feet. The unit consists of a lower, red, cross-bedded, arkosic quartzite and an upper, light-colored quartzite (Geach, 1972).

The lower unit is the Bonner Formation, which consists of pink or red arkosic quartzite in beds ranging in thick-