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Ore controls and formation of the ore-bearing structures in the Idarado mines, San Miguel and Ouray Counties, Colorado

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ORE CONTROLS AND FORMATION OF THE ORE-BEARING STRUCTURES IN THE IDARADO MINE, SAN MIGUEL AND OURAY COUNTIES, COLORADO

by

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Chairman

Dean of the Graduate School

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ABSTRACT

Two major ore-bearing veins were studied on two levels in the Idarado mine, on the northwestern flank of the San Juan Mountains of southwestern Colorado. The Argentine vein, striking N. 10°-20° W. and dipping 75°-85° W., and the Cross vein, striking N. 45°-50° W. and dipping 50° W. represent the two systems to which all productive veins of the mine belong. Although not formed simultaneously, all veins represent mid-Tertiary mineralization associated with volcanism that formed the San Juan Mountains. Vein minerals are galena, sphalerite, chalcopyrite, silver (probably as sulfides), and gold in a gangue of pyrite, quartz, calcite and epidote.

Geological mapping, field investigations, and mineragraphical and petrological studies were used in determining the ore controls and the sequence of formation and mineralization of the ore-bearing structures. Five stages in this sequence can be detected. Although the primary mechanism of vein formation was simple fissure-filling, differences were detected in ore controls in the two structures. These differences are conspicuous where typical fissure-filling veins have been enlarged

by replacement of favorable wall rock. Favorable wall rock consisted of relatively permeable conglomeratic beds with a calcitic or dolomitic matrix. In the older Argentine vein, this matrix was epidotized during intrusion of a pre-ore andesite dike. During ore mineralization, the epidotized material reacted similarly to the unchanged carbonate-bearing matrix of the younger Cross vein. In both veins, metasomatism was most extensive where fractures, joints, or original permeability are present in combination with the chemical wall-rock control.

INTRODUCTION

Purpose

The aim of the present study is to contribute to the understanding of the ore controls in the Idarado mine, a leading producer of metals in Colorado. The study deals with the Argentine and Cross vein structures at the 2400- and 2900-foot levels, where marked differences in the ore body characteristics suggest that detailed study might yield information of benefit to future mine planning and operations.

The mine study was carried out during the summer of 1966 and consisted of mine mapping, structural analysis and sampling for laboratory study. The laboratory work was carried out in the winter of 1966-67 in the laboratories of the Department of Geology at the University of North Dakota.

Geographic Location

The Idarado mine, in the northwestern part of the San Juan Mountains, is located at lat 37°56' N; long 107° 45' W. The mine workings extend through a mountain range from the Pandora area of the town of Telluride, San Miguel County, eastward for a distance of 7 miles to the vicinity of Red Mountain in Ouray County (fig. 1).

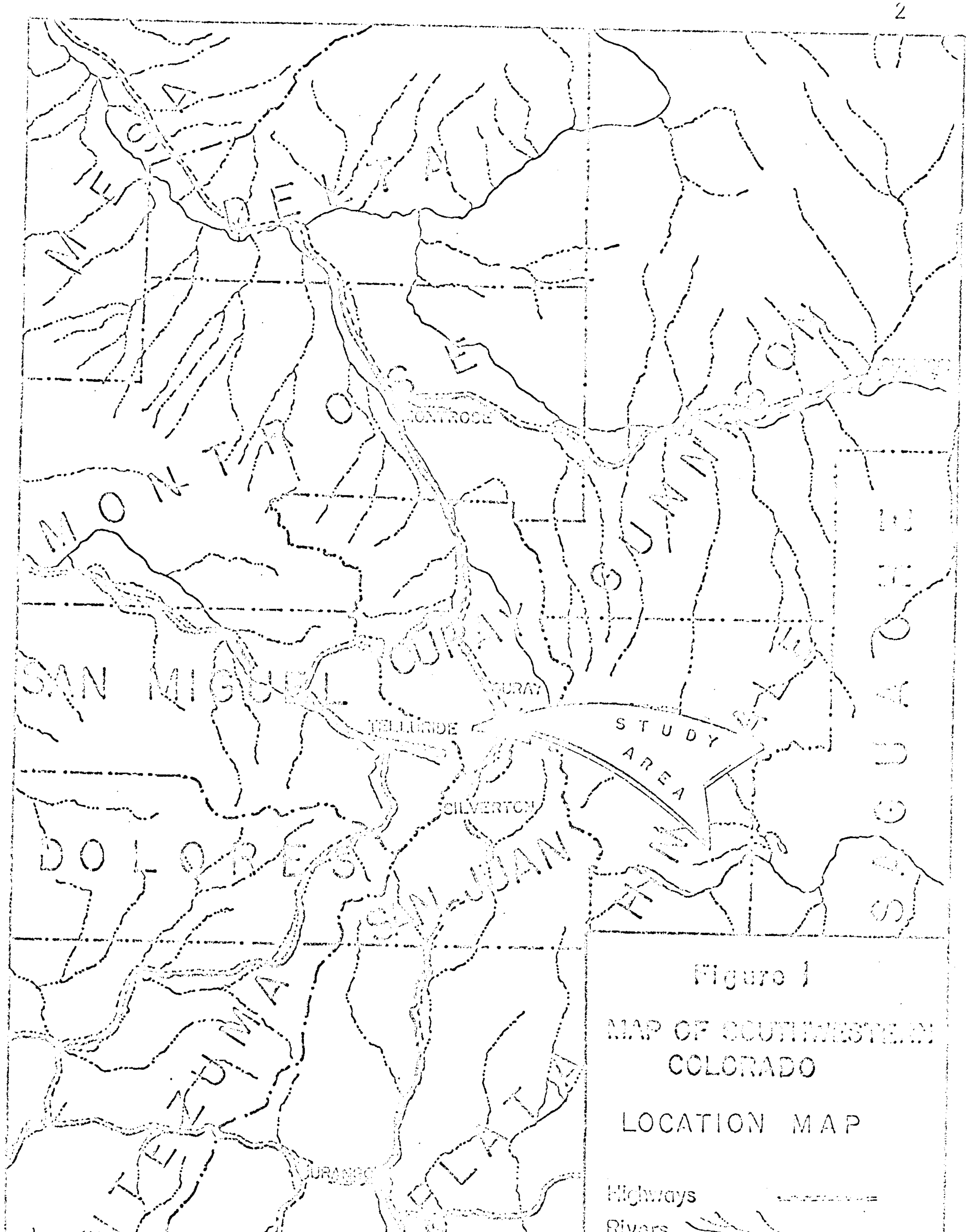


Figure 1
MAP OF SOUTHWESTERN COLORADO
LOCATION MAP

The elevation of the mine workings ranges from 9,000 feet above sea level at the mine portal near Telluride to 12,500 feet in the upper parts of the mine. Drainage from both sides of the range penetrated by the Idarado mine ultimately goes into the Colorado River; that from the San Miguel County goes by way of the San Miguel River, whereas that from the Ouray County side goes by way of the Uncompahgre River.

Geologic Setting

The mine is located near the northwestern margin of the San Juan Mountains, the dominant feature of southwestern Colorado. The range is essentially a domal uplift with a Precambrian core, flanked by younger sedimentary rocks and capped by thick sequences of Tertiary volcanic rocks. The capping volcanic pile, including tuff, breccia and associated intrusives, reaches elevations in excess of 14,000 feet. Alpine glaciation during the Pleistocene strongly modified the geomorphology of the range, which is now characterized by features such as cirques, horns, and hanging valleys.

The ages of the exposed rocks in the area of Telluride range from Paleozoic to Tertiary. The exposed Paleozoic and Mesozoic rocks are sedimentary, and largely of continental origin. The Tertiary rocks are mainly volcanic and intrusive, but also include some continental sedimentary rocks. Quaternary deposits are primarily of glacial origin and consist chiefly of moraine and outwash.

During much of the Paleozoic era the San Juan region was a positive area exposed to erosion. During the Permian period, the area was an aggrading plain of low relief. Following erosion during much of the Triassic time, continental sediments of late Triassic age were deposited. There is no marked angular discordance representing this hiatus. Partial erosion of the Triassic deposits was followed by deposition of fluviatile and lacustrine Jurassic sediments. Cretaceous sediments representing marine transgression were then deposited on the Jurassic sediments. Deposition continued until it was interrupted by doming and igneous intrusion near the end of the Cretaceous. Strong erosion of the domed beds in Tertiary time was followed by deposition of a conglomerate comprised of eroded material from the older formations. Great thicknesses of Tertiary volcanic rocks, in large part tuffs and breccias of mid-Tertiary age, were then deposited over the conglomerate throughout the San Juan Mountains. In addition to this extrusive igneous activity, dikes were intruded into the country rock and an epoch of mineralization followed. During this epoch the ore-bearing veins were formed in the mine. The Quaternary was characterized by deep dissection of the volcanic pile by stream erosion and mountain glaciation.

Historical Background

History of the mine

The mine that presently is operated by the Idarado Mining Company has been worked since the latter part of the 19th Century. Several different small companies, operating from several locations, worked the property that today is known as the Idarado mine.

The first active search for gold and silver in the area of Telluride was in 1975. Since then, development of the mine has continued, and in the last 20 years development has been rapid.

Among the companies that worked the mine property are the Black Bear Mining Company and the Colorado Superior Mining Company that worked the part corresponding to the so-called Black Vein from 1900 to 1920. The Smuggler Union operated for 52 years before closing down in 1928. The Tomboy Gold Mines worked the Montana Vein (north part of the Argentine Vein) in its upper levels from 1900 to 1930. The Revenue Mines Company worked the Revenue and Ophir levels (in the upper part of the mine) from 1900 to 1930, and Telluride Mines, Inc., worked these same levels from 1930 until 1953.

In 1940, Idarado Mining Company began to work this mine and since then has expanded its works. This company started development in large scale in 1943 when the Metals Reserve Company (a government agency) assisted the company with the necessary capital to develop the mine, particularly in the extension of the Treasury tunnel from Red Mountain westward to the Black Bear vein. In 1953, Idarado Mining Company purchased Telluride Mines, Inc. At the present time, Idarado alone controls and works the mine area.

The Idarado mine is at present the largest producer of metals in southwestern Colorado. Yearly mine production is approximately one half million tons of ore, yielding several millions of dollars worth of zinc, lead, copper, silver and gold.

Previous published works

One of the earliest geologic studies done in the area resulted in publication of a U.S. Geological Survey Folio in 1899 (Cross, 1899). Later, Atwood and Mather (1932) described the Quaternary geology of the San Juan Mountains. Burbank spent several years in the San Juan Mountains and has published a number of papers on the area (Burbank, 1933, 1940, 1941, 1951). In 1966, he and Luedke published a geologic map of the Telluride quadrangle (Burbank and Luedke, 1966); this is the latest published regional geology of the area. Kelley (1957a) published an article on the general geology and tectonics of the San Juan Mountains. The same author (Kelley, 1957b) also published a paper on the vein and fault systems in the San Juan Mountains. Larsen and Cross (1956) authored a U.S. Geological Survey Professional Paper on the geology and petrology of the entire San Juan region. Vhay (1962) published on the geology and mineral deposits of the area south of Telluride.

Because the San Juan Mountains offers such a variety of geologic phenomena, including economic mineral deposits, there have been many people who in one way or another have done research on the area. Unfortunately, much of this [illegible] ...en published; in other cases, the extent of the issues was not enough to fill the libraries and to serve as reference material.

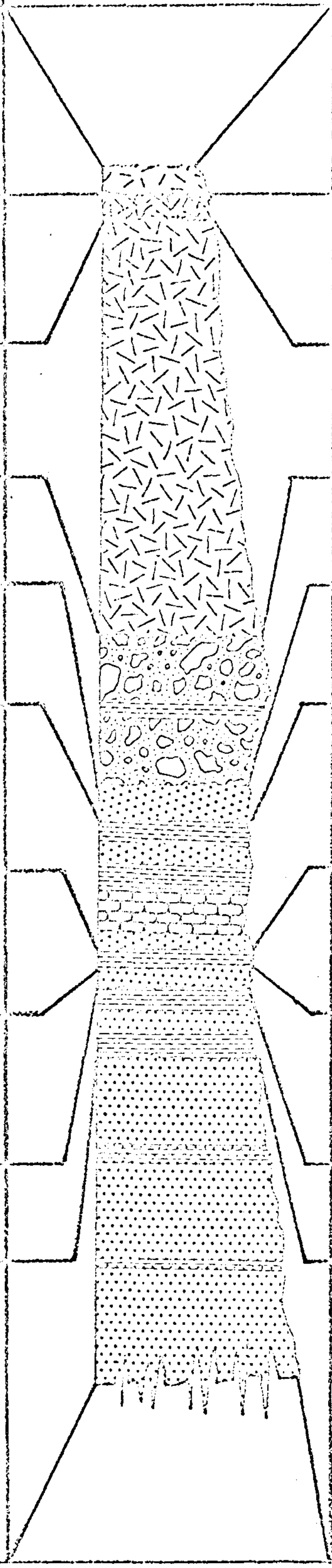
GEOLOGY OF THE MINE AREA

Stratigraphy

Rocks exposed in the Telluride area range in age from Permian to Tertiary. The geologic formations observed or inferred to be present are shown in figure 2. Formations exposed near the Idarado mine are described below briefly.

Cutler Formation

The Cutler Formation is represented by the lower layers of outcropping rock at the level of the town of Telluride. It consists of an alternation of siltstone, shale, sandstone and conglomeratic sandstone. Some of the sandstones are locally arkosic. The rocks are generally pinkish red, red, and brownish red. Many of them show cross bedding. The Cutler Formation constitutes the greater part of the "red beds" of southwestern Colorado. According to Larsen and Cross (1956, p. 48), it was apparently deposited in environments ranging from marine to continental. It is nonfossiliferous, but is considered to be Permian in age (Burbank and Luedke, 1966). The formation constitutes the country rock in the 2900 level of the mine. The outcrop near the town of Telluride measures nearly 1,000 feet in thickness.



SYSTEM	SERIES	FORMATION	COLUMNAR SECTION	CHARACTERISTICS
TERTIARY	MIOCENE Silverton Volcanic	EUREKA		Medium to dark rhyodacitic to quartz latitic welded ash-flow tuffs.
		PICAYUNE		Dark porphyritic and amygdular flows, breccias and tuffs.
	MIOCENE	SAN JUAN		Predominantly massive rudely bedded rhyodacitic tuff.
	OLIG.	TELLURIDE		Reddish gray to red-brown conglom., and shales.
CRETAC.	U.CRET.	DAKOTA		Gray to yellow quartzitic sandstone and gray shale.
JURASSIC	UPPER JURASSIC	MORRISON		Mudstone, sandstone, interbedded with limestone.
		WANAKAH		Green to red-brown limy mudstone with limestone and sandstone.
		ENTRADA		Light-colored crossbedded fine to coarse sandstone
TRIASS	U.TRI.	DOLORES		Brownish-red shale, siltstone and sandstone.
PERMIAN	U. PERMIAN	CUTLER		Reddish-brown micaceous shale, sandstone, siltstone and conglomerate.

Figure 2. Generalized columnar section (geologic formations observed and inferred) near the area of Telluride.

Dolores Formation

Unconformably overlying the Cutler Formation is the Dolores Formation, a silty or clayey sandstone containing several conglomeratic beds whose pebbles are principally limestone. The fine grained beds are red, but the coarser and more permeable beds are grayish red. In outcrop, however, even the coarse beds are generally colored red by iron stain. The Dolores Formation, according to Larsen and Cross (1956), is of late Triassic or possibly Jurassic age, but Burbank and Luedke (1966) consider it Triassic. The origin of this formation is terrestrial. It crops out on the steep valley side near the town of Telluride, where it is 220 feet in thickness.

Entrada Sandstone

Unconformably overlying the Dolores Formation is the Entrada Sandstone. The unit is light colored, generally white to light yellow, but in some places it shows a pink coloration. It is medium to coarse grained, friable and locally cross-bedded. The age of this sandstone has been considered as lower Jurassic (Burbank and Luedke, 1966). The outcrop near the town of Telluride is 50 feet thick, its light colors standing in sharp contrast with the red colors of the underlying Dolores and Cutler Formations. Because of its conspicuous light colors the Entrada was used as a key formation in the geologic reconnaissance.

Wanakah Formation

Conformably overlying the light colored Entrada Sandstone is the Wanakah Formation, an alternating sequence of limestone, mudstone and sandstone. The coloration is predominantly greenish gray, but the limestone is dark gray and the mudstone greenish to reddish brown. Most of the beds possess lime cement. The Wanakah Formation is considered to be of Jurassic age. The exposures of this formation near Telluride are about 25 feet thick.

Morrison Formation

Following the chronologic sequence of geologic formations, and in conformity with the Wanakah Formation, is the Morrison Formation of Jurassic age. The outcrop near the town of Telluride can be divided in two parts; the lower part is predominantly sandstone, whereas the upper part is predominantly shale. The coloration of these rocks is grayish yellow, with some red by iron stain. This formation is of nonmarine origin. The outcrop near the town of Telluride is approximately 300 feet thick.

Dakota Sandstone

Cropping out in the western part of the town of Telluride is the Dakota Sandstone. It is fine grained, and is yellowish, reddish and locally light gray in color. In some places it is quartzitic. This sandstone is considered to be upper Cretaceous. The exposure of this unit near the town of Telluride is approximately 80 feet thick. It is of continental origin.

Telluri Formation

T elluride F ation, consisting primarily of a conglome e, is one of ore prominent xposed formations. The c glomerate conta pebbles and co es of schist, grani e, quartzite, li one, shale, sla Intercalations of siltstone, sandstone nd mudstone wer lso observed. In some places it is tight cemented by cal um carbonate. Near the own of Telluride ormation is more than 300 feet thick and forms conspi us reddish colored high cliffs whe ver exposed.

The Telluride Form on, according to Burbank and Luedke (1966), is Oligoc in age. It overlies older formations with angular onformity and marks the base of the Tertiary rocks in t area. The conglomerate constitutes the country rock in he 2400 level of the mine.

San Juan Formation

Overlying the Telluride Formation is the San Juan Formation. It is commonly called San Juan tuff and San Juan breccia because of its high content of coarse pyroclastic material. In general it consists of an alternation of tuff breccia and some andesitic and rhyobasaltic flows. The coloration of this formation is dark red or purplish red. It is the oldest volcanic formation in the area. According to Larsen and Cross (1956, p. 75), "The bedding, the sorting and the rounding in the San Juan material show that it was deposited by water. Part of the material was probably derived from older volcanic rocks, but perhaps a major part was derived from pyroclastic eruptions that took place during the accumulation of the San Juan tuff". It is considered to be of Miocene age (Burbank and Luedke, 1966). The exposure near the town of Telluride is approximately 1,300 feet thick.

Picayune Formation

Near the tops of the mountain peaks of the area, there is a unit formed by interlayered grayish flows and tuffs of andesitic to rhyodacitic composition. Dark colors are predominant in this formation. It is a relatively thin unit in a thick volcanic sequence and is considered to be of Miocene age (Burbank and Luedke, 1966). The exposure near Telluride is 60 feet thick.

Eureka Tuff

Capping some of the highest peaks are erosional remnants of a rhyolitic ash flow of grayish color believed by Burbank and Luedke (1966) to represent the Eureka Tuff. This tuff contains abundant inclusions of andesite. Outcrops reach 55 feet in thickness on the high peaks near Telluride.

The Eureka Tuff, along with the Picayune Formation, is a remnant of the Silverton Volcanic Group of early Miocene age (Burbank and Luedke, 1966).

Quaternary deposits

Pleistocene glaciofluvial deposits and Recent alluvium cover the valley floor at Telluride. Exposures of glacial till were observed in places, principally along the north side of the town.

The Quaternary depositional features are far less important in the area than are the erosional features produced by alpine glaciation. U-shaped valleys, hanging valleys, cirques and horns distributed in a marvelous display are responsible for the nomination of this area as the "Switzerland of America".

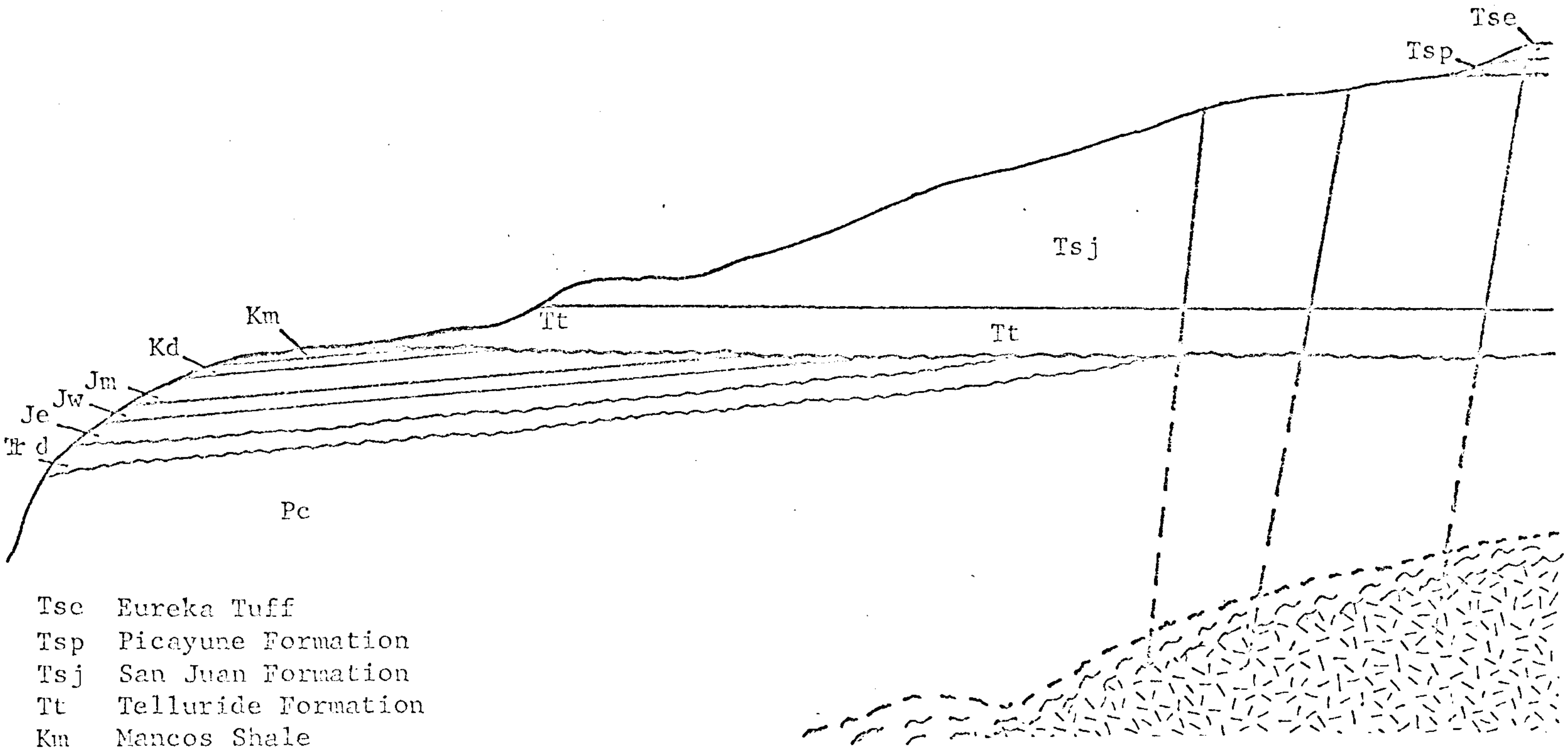
Structure

The mine is situated on the northwestern flank of the San Juan Mountains. The structural features of the area reflect the orogenic and igneous activity associated with the formation of this range.

Structural setting

Two important structural features can be distinguished in the northwestern part of the San Juan Mountains. One is positive, a domal uplift called the San Juan dome, on the flanks of which the mine is located. The other is a negative, or "sagged", feature called the Silverton caldera.

Laramide doming of the San Juan Mountains is reflected in the sedimentary beds on the flanks of the dome near Telluride. A major angular unconformity exists between the truncated, gently dipping Cretaceous and older beds and the overlying, nearly flat, Tertiary beds. The truncated beds dip away from the apex of the dome at angles of about 15°. A post-Laramide conglomerate, nearly flat-lying, covers the unconformity. This Tertiary basal conglomerate is deeply buried by mid-Tertiary volcanics (fig. 3).



Tse	Eureka Tuff
Tsp	Picayune Formation
Tsj	San Juan Formation
Tt	Telluride Formation
Km	Mancos Shale
Kd	Dakota Sandstone
Jm	Morrison Formation
Jw	Wanakah Formation
Je	Entrada Sandstone
Ŧr d	Dolores Formation
Pc	Cutler Formation
	Dike
	Intrusive rock ?

Figure 3. Diagrammatic illustration of the structure near the area of Telluride.

The volcanics thicken considerably in the Silverton area, reflecting the collapse that formed the Silverton caldera.

Persistent north-northwest trending fractures in the mine area are of economic interest. The writer infers that these fractures, now mineralized and filled, are genetically related to the intrusion of a subjacent igneous body. This inference is based on the observation that the fractures are aligned between two plug-like igneous bodies of similar composition. These igneous bodies are presumed to represent surface manifestations of a larger subjacent intrusive. The general trend and attitude of the fractures could well indicate tension in rocks overlying such an intrusive.

Major ore-bearing structures

The ore-bearing structures of the mine can be grouped into two principal systems, one represented by the Argentine structure, and the other represented by the Cross Vein structure. All major veins in the area appear to belong to one or the other of these two systems. The Argentine and the Cross Vein structures are described in detail under "Ore Deposits".

ORE DEPOSITS

Description of the Veins

Two ore bearing veins, the Argentine and Cross Veins were studied in a part of the Idarado mine that is presently being worked. In general, all veins in the mine belong to two principal systems: one, striking N. 10°-20° W., is typified by the Argentine Vein; the other, striking N. 50° W., is typified by the Cross Vein. The Argentine and Cross veins were studied in detail on the 2400-and 2900-foot levels near their intersection. This part of the mine was chosen for study, because two important types of mineralization, fracture filling and replacement, can be compared.

Argentine Vein

The Argentine Vein is a concentration of sulfide minerals and gangue (principally quartz) associated with the regional trend of the dike of the same name.

Relationship to the Argentine dike.--The vein is closely associated with the Argentine dike, an andesitic dike formed before the emplacement of the vein. A graphic portrayal of this occurrence is seen in figure 4. The vein is irregularly associated with the dike, following the trend of the fault plane along which the dike was intruded.

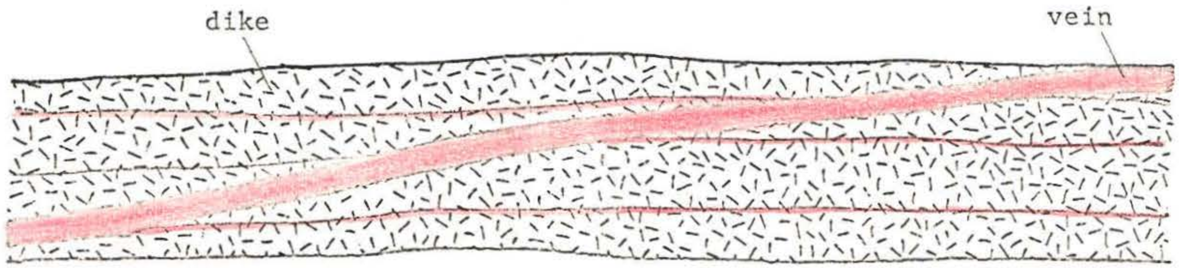


Figure 4. Diagrammatic section showing typical relationship of Argentine vein to Argentine dike.

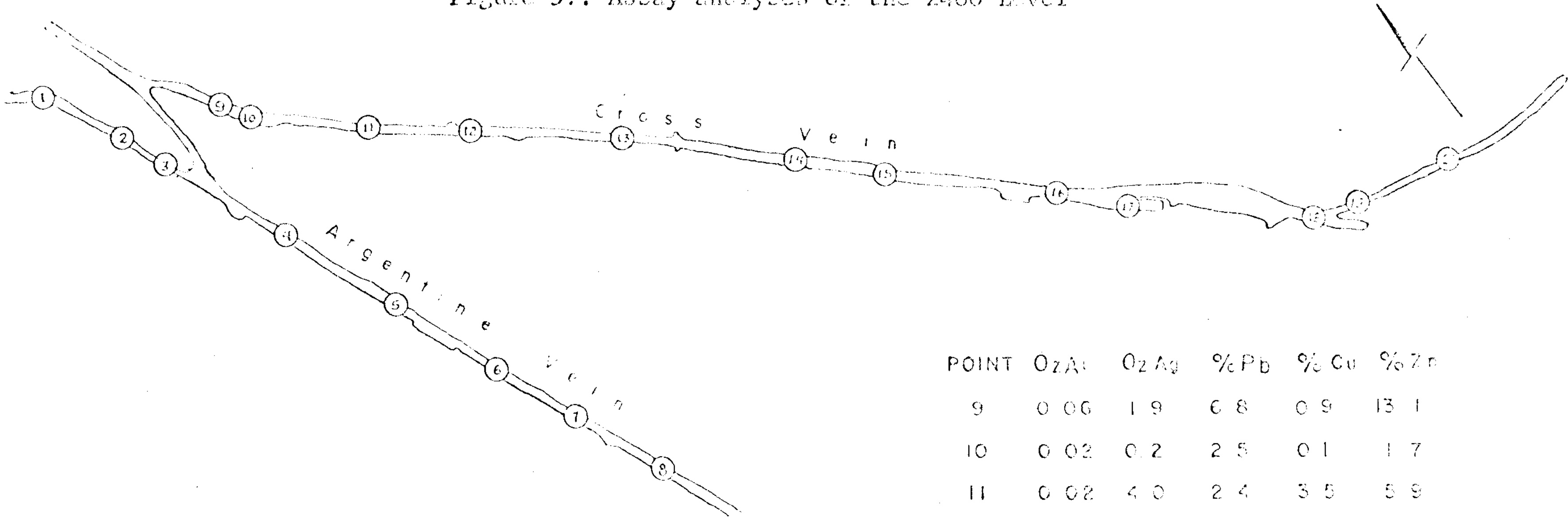
Strike and dip.--The general strike of the vein is N. 10°-20° W.; dips range from 75° to 85° W. This attitude corresponds closely with that of the Argentine dike. Some abrupt variations in strike and dip were observed, but the largest percentage of them paralleled the general trend of the dike.

Extent and width.--The total length of the Argentine Vein was not observed because of hazardous abandoned stretches. Taking into account the old drifts, it is estimated that the length of the vein is nearly 3 miles. The width of the vein ranges from 1 to 3 feet.

Mineral composition.--The vein carries galena, sphalerite, chalcopyrite, silver and gold, with a gangue of quartz, pyrite, calcite and epidote. The silver and gold are not visible underground, but are shown by the assays (figs. 5 and 6); these minerals are difficult to recognize underground. Silver and silver sulfides are associated most commonly with galena, whereas gold is associated with quartz veins.

Concentration and distribution of minerals.--The concentration and distribution of the galena, sphalerite, chalcopyrite, pyrite and quartz vary both in vertical and horizontal planes. This produces irregular concentrations of these minerals throughout the vein. However, there is a predominance of galena, sphalerite and quartz in the vein. Sporadic concentrations of chalcopyrite occur throughout the vein. Figures 5 and 6

Figure 5.. Assay analyses of the 2400 Level



POINT	Oz Au	Oz Ag	% Pb	% Cu	% Zn
1	Tr	Tr	1.2	0.2	2.1
2	0.02	0.9	3.4	0.5	6.3
3	0.04	0.9	4.8	0.4	5.3
4	0.04	1.2	5.7	0.3	20.8
5	0.10	0.3	0.8	0.2	6.9
6	0.02	9.7	11.4	4.0	16.4
7	0.01	0.9	1.2	0.5	3.2
8	Tr	0.2	0.8	0.1	0.8

POINT	Oz Au	Oz Ag	% Pb	% Cu	% Zn
9	0.06	1.9	6.8	0.9	13.1
10	0.02	0.2	2.5	0.1	1.7
11	0.02	4.0	2.4	3.5	5.9
12	0.02	1.2	4.3	0.0	5.0
13	0.04	4.6	13.0	3.0	11.4
14	0.14	2.0	6.0	0.7	1.1
15	0.04	6.2	7.[illegible]	3.1	12.4
16	0.01	2.9	5.3	1.8	7.7
17	0.03	2.0	3.4	1.0	10.0
18	0.02	0.8	2.2	0.4	4.3
19	0.03	0.03	0.4	0.2	[illegible]8
20	0.03	2.8	3.0	0.4	5.5

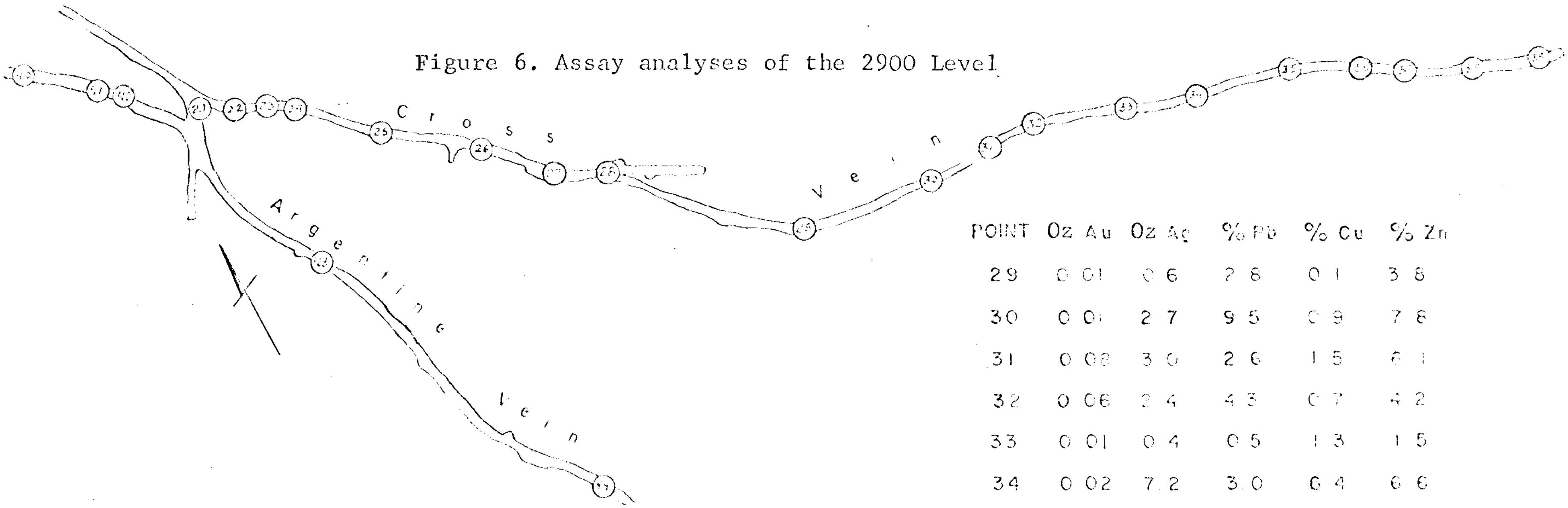


Figure 6. Assay analyses of the 2900 Level

POINT	Oz Au	Oz Ag	% Pb	% Cu	% Zn
21	0.06	15.7	13.8	4.6	24.8
22	0.04	6.4	6.7	4.8	9.2
23	0.02	0.7	0.5	0.3	1.3
24	0.03	4.2	4.6	2.0	11.8
25	0.02	2.8	1.2	1.2	7.2
26	0.20	1.8	0.8	0.7	6.5
27	0.02	3.0	2.6	0.6	5.4
28	0.03	1.3	2.2	0.5	4.5

POINT	Oz Au	Oz Ag	% Pb	% Cu	% Zn
29	0.01	0.6	2.8	0.1	3.8
30	0.01	2.7	9.5	0.9	7.8
31	0.08	3.0	2.6	1.5	6.1
32	0.06	3.4	4.3	0.7	4.2
33	0.01	0.4	0.5	1.3	1.5
34	0.02	7.2	3.0	0.4	6.6
35	0.02	1.2	0.5	0.6	4.3
36	0.02	0.7	1.0	0.5	2.4
37	0.02	2.8	0.5	3.6	7.5
38	0.06	2.5	1.4	1.7	6.6
39	0.06	3.8	4.0	0.9	10.7
40	0.02	2.5	4.8	2.0	8.1
41	0.02	0.5	1.2	0.3	2.5
42	0.04	1.7	27.9	[illegible]	9.5
43	0.02	2.15	3.70	0.94	7.67
44	0.02	2.3	1.7	0.6	3.0

show the metal concentration and distribution in the veins, as indicated in the assay analyses performed by the Idarado Mining Company.

Horizontally, the vein appears to be a continuous mineralized body with local thickened zones where metasomatism was extensive. Vertically (in transverse plane), the vein shows that the original mineralized body was reopened by fractures, which were then filled principally by gold bearing quartz (fig. 7). The vertical section also shows "bulges" where metasomatic replacement formed extensive ore bodies in favorable sedimentary beds (plates III and IV).

Behavior of the vein.--The vein, emplaced along a fault plane, is very persistent, there being no interruptions in either its horizontal or vertical extent. The greatest variations in width are expansions of the mineralized zone by metasomatic action where the vein intersected a favorable sedimentary unit.

A structural analysis of the intersection of the Argentine and Cross veins (plates I and II) reveals that, before the formation of the Cross Vein, the Argentine Vein was cut by a fault, along which the Cross Vein was later formed. The principal movement that took place was dip-slip, complemented later by strike-slip movements. The structural deformation that appears in the Argentine Vein near its intersection with the Cross Vein will be discussed

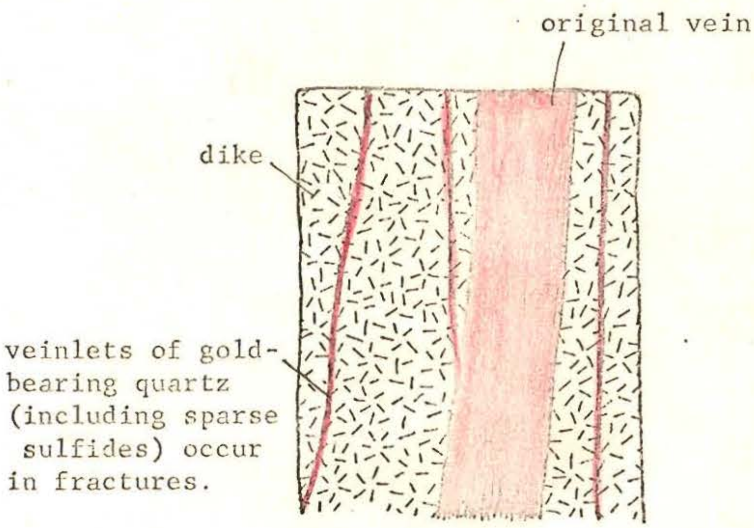


Figure 7. Diagrammatic section of the Argentine vein showing relationship between original vein and later gold-bearing quartz.

later under "Genetic interpretation of the ores".

Cross Vein

The Cross Vein was so named because its trend crosses that of the principal veins, represented by the Argentine Vein.

Strike and dip.--The Cross Vein has a general strike of N. 45°-50° W. and a dip of 55° W. This vein differs considerably from the Argentine Vein in strike and, notably, in having a considerably flatter dip. The Cross Vein has many local variations in strike, especially where its original structure has been largely obliterated by metasomatism.

Extent and width.--The average width of the Cross Vein is approximately 2 feet, but where replacement has taken place the vein approaches 15 feet in width. The original vein was fractured longitudinally and the open spaces were filled by quartz veins 1 to 6 inches wide. These conspicuous veins can be followed along the strike and apparently represent the last stage of mineralization.

The Cross Vein has been enriched by metasomatic activity, which has been the principal mechanism in enrichment and expansion of the vein. Two types of sphalerite occur: one is black or brownish black and the other yellow or yellowish brown. They represent differences in iron content, the darker having the greater concentration of iron.

Mineral Composition.--The Cross Vein, like the Argentine Vein, consists of an irregular concentrations of galena, sphalerite, chalcopyrite, quartz, calcite and rhodochrosite. Some of these minerals show variations in color and composition; for example sphalerite ranges from brownish to grayish brown, corresponding to variations in iron content. Gold and silver are also present, the concentration and distribution of these and other metals are expressed in figures 5 and 6.

Behavior of the vein.--The vein follows the direction of the fault plane in which it was emplaced, keeping a regular orientation throughout this plane. The replacement zones associated with this vein are exceptions. In these the direction of the vein is hard to distinguish.

One of the characteristics of this vein is that it has many vugs that follow a subtransverse direction relative to the general direction of the vein (fig. 8). The vuggy cavities are sometimes filled with well developed crystals of calcite and quartz which provide abundant samples for laboratories, private collections and museums (fig. 9).

The presence of many joints and fracture cleavage (Billings, 1960, p. 337), reveals that the vein had undergone post-mineralization stress that changed the original texture of the vein. One example of this occurrence is clearly visible on the 2400-foot level between the survey stations 37 and 38. Figure 10 is a photograph showing

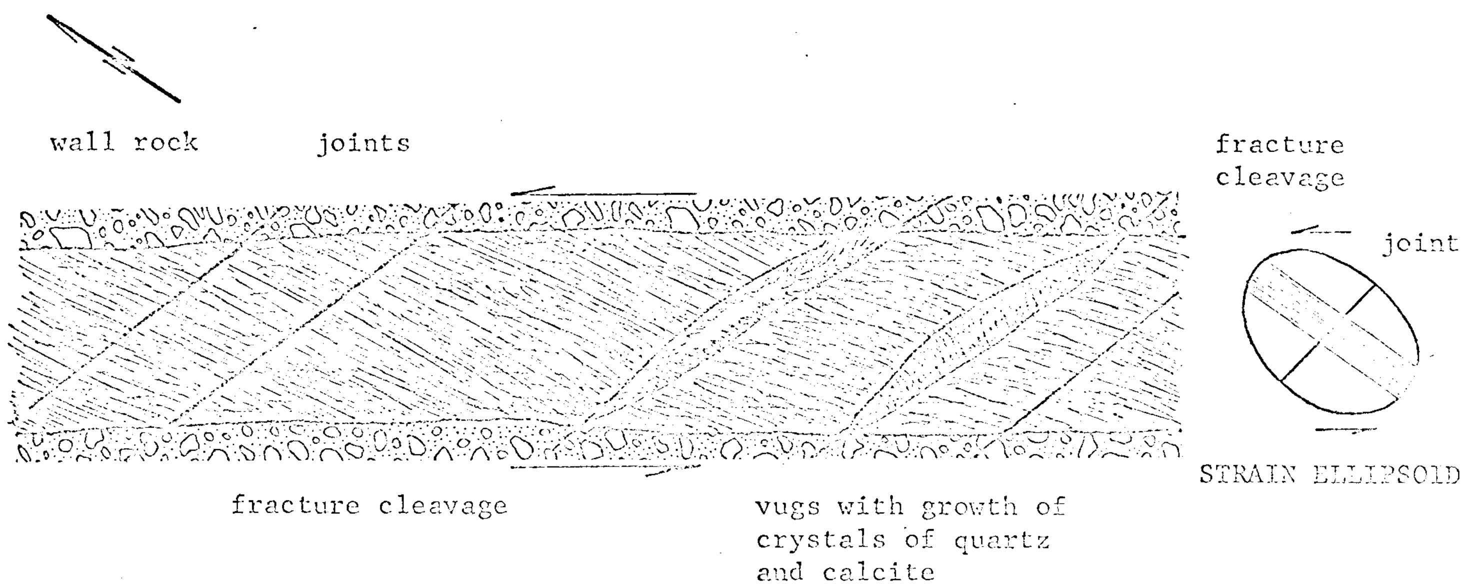


Figure 8. Sketch of Cross Vein in 2400 level, relating vugs joints and fracture cleavage to horizontal movements. Compare with strain ellipsoid.

Figure 9. Crystals of quartz lining a vug in the Cross vein. Natural size.

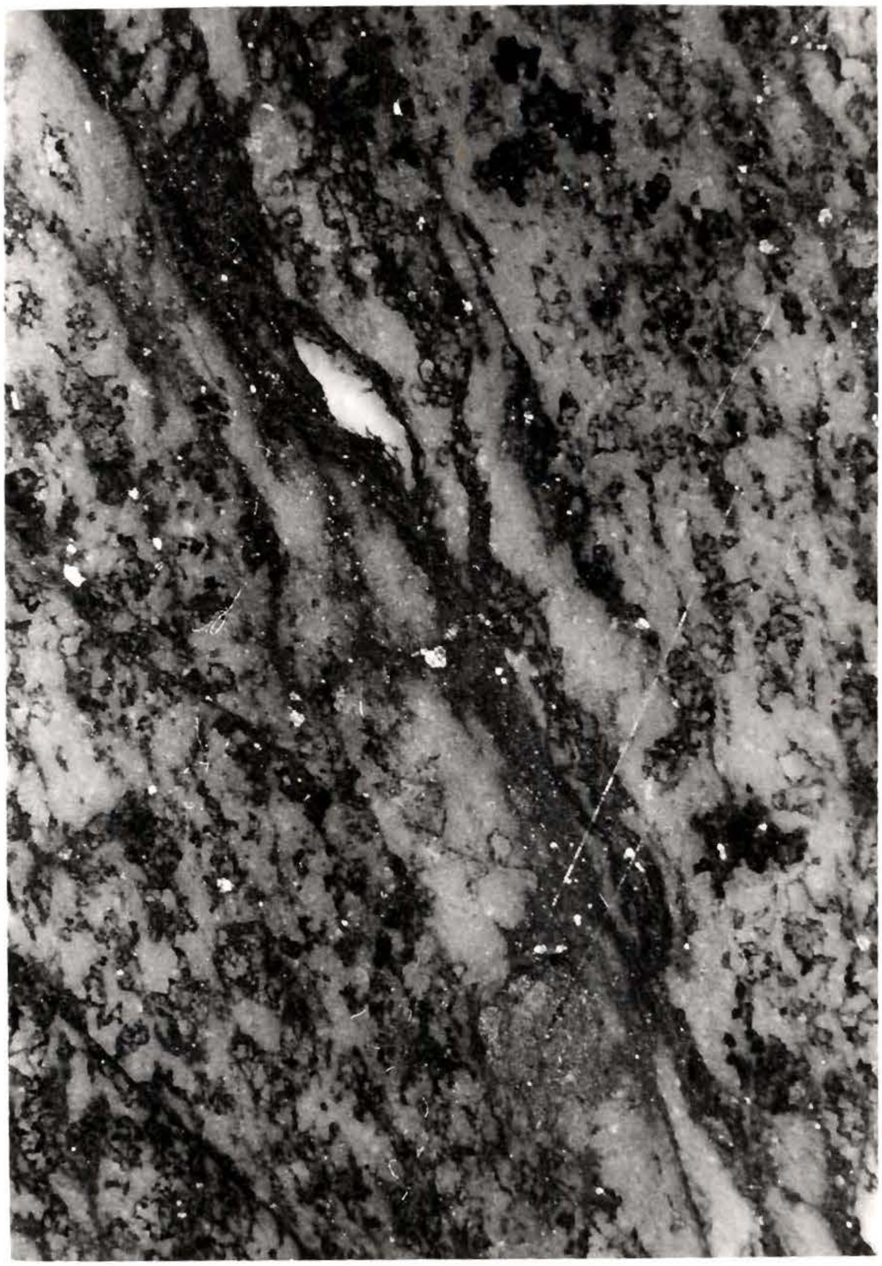


Figure 10. Fracture cleavage in the Cross vein

fracture cleavage in the vein.

Characteristics of the metasomatic zones

Where the Argentine and Cross Vein structures have undergone metasomatic replacement, it has been expanded by the action of solutions on favorable wall rock. These solutions replaced the wall rock and filled the fissures that were caused initially by tectonic movements. The metasomatic zones are easily observed on the 2400-foot level, between the survey stations 17 and 21 (plate I) and in the 2412 stope (plate III). The metasomatic zone is also observed on the 2900-foot level between the survey stations 7 and 9 (plate II). Where the ore is highly concentrated, spots of sulfides in the adjacent wall rock give a typical representation of arrested metasomatism.

The observed underground characteristics of the metasomatic zones that are associated with the veins are: (a) irregular boundaries exist between the mineralized zone and the wall rock. These limits are without any structural connection and suggest only metasomatic activity (fig. 11); (b) the metasomatic activity that began from the fractures and replaced the country rock with ore, appears to be developed through fronts of metasomatism. Metasomatic ore is less intense farther from the fissures (fig. 12); (c) spots of sulfides in the country rock is an example of a typical metasomatic effect (fig. 13); (d) in the 2412

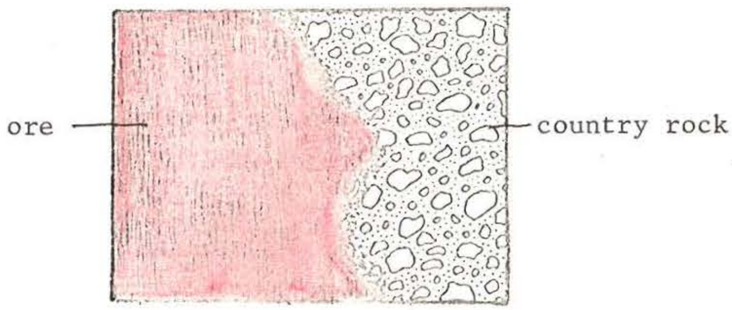


Figure 11. Diagrammatic illustration of the metasomatic front showing irregular boundary of the ore.

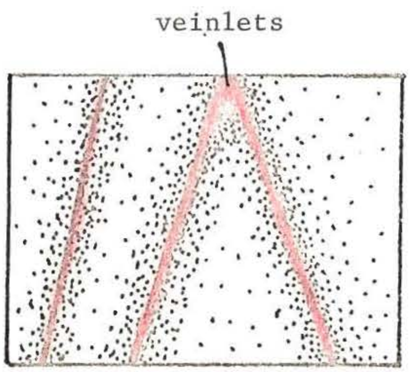


Figure 12. Diagrammatic sketch showing decreasing intensity of metasomatism away from veinlets.

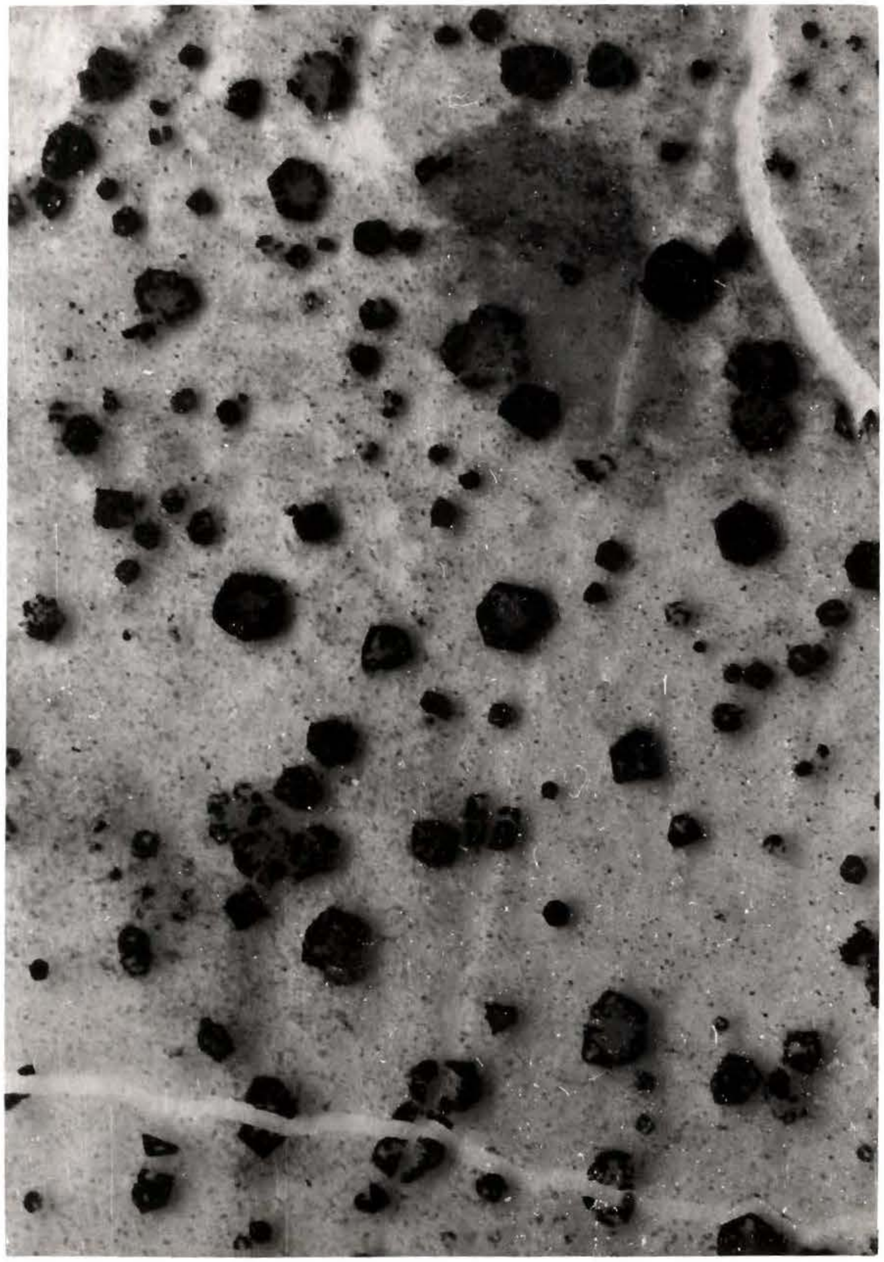


Figure 13. Spots of sulfides in country rock

stope (plates III and IV) the metasomatic zone is enlarged horizontally. This was controlled by the relatively high permeability of certain horizontal conglomerate layers and by the presence of epidotized country rock. Further explanation will be given under "Ore controls".

Genetic Interpretation of the Ores

Mechanisms of ore formation

The Argentine Vein and the Cross Vein are emplaced along fault planes. These planes have been the principal and most favored places for the circulation of solutions and also were the favorable zones for the concentration of minerals. The mineralization appears to be a result of two types of processes, fissure filling and metasomatism.

Fissure filling.--The assumption that the Argentine and Cross veins were originally formed by fissure filling are based on the following evidence: (a) the veins follow fractures. The Argentine Vein follows a definite rupture plane in the Argentine dike and is confined to the general direction of the dike; (b) the presence of gouge and slickensides on the walls of both the Argentine and Cross veins. The presence of a fault is also suggested by the characteristic sharp boundary between the wall rock and the vein; (c) the linear persistence of the mineralization, confined between sharp lateral boundaries, is characteristic of the fissure-filling type of vein.

Metasomatism.--Replacement by metasomatism was the second important factor in the deposition and concentration of the minerals. The metasomatic activity occurred on the joints and shear planes, and in permeable country rock. Field observations reveal that the replacement started from the fractures which were the principal means for the circulation of the solutions. This is shown in figure 9 in which it is observed that the metasomatic effect begins with the veinlets. The permeable wall rock permitted the penetration of the solutions from the fractures. Where the fractures intersected favorable ground (such as limestone pebbles), or where permeable zones occur in the wall rock, spots or zones of mineralization may now be seen. A graphic portrayal of this occurrence is shown in figures 9 and 10.

The metasomatism that began from the fractures appears to be developed through "fronts". The dissemination of the ore and growth of the crystals occur by addition of solutions with advance of the metasomatic front.

In the 2412 stope of the Argentine Vein (plate III) the metasomatism was mainly developed in the horizontal dimension. This was affected by the porosity and the permeability of an original stratum of conglomerate and by the previous alteration, or "epidotization," of this conglomerate wall rock (plates III and IV). The "bulge" of metasomatic ore constitutes a valuable deposit in this stope.

In the 2400-foot level in the Cross Vein near the survey station 2419, the metasomatic activity reached such degree that the replacement is almost complete with the change of the country rock into valuable ore. The metasomatic activities appear to be better developed at those places where closely spaced jointing has facilitated the circulation and increased the area exposed to reaction with the ore-forming solutions.

At those places where the vein is emplaced in the middle part of the Argentine dike, the metasomatism is only slight. It appears that the dike is not a favorable place for replacement. Here are involved chemical and physical factors that are discussed under "Ore controls". Replacement ore has been developed mainly in the Telluride conglomerate on the 2400-foot level in both veins and in the conglomerate unit of the Cutler Formation at the 2900-foot level in the Cross Vein structure.

Origin of the mineral structures

Questions that have concerned geologists working in the area are: (1) was the Argentine dike formed before the appearance of the Argentine Vein, and (2) what are the age relationships of the Argentine and Cross Vein structures? The answers to these questions will be explained in the following paragraphs.

That the Argentine dike was formed before the Argentine Vein is readily seen by the fact that the vein was emplaced in fractures in the dike (figs. 4 and 7). The dike itself was intruded along a fault plane, and later faulting along this plane was followed by circulation of mineralizing solutions that produced the Argentine Vein.

The Argentine Vein appears to be displaced by the Cross Vein at their place of intersection (plates I and II). A fault apparently cut the Argentine Vein before mineralizing solutions circulated along this fault plane to form the Cross Vein. The movement along this fault was dip-slip and the inclination of the fault plane was 50°-60° W, which coincides with the present dip of the Cross Vein. The Cross Vein-Argentine Vein relationship is shown in figure 14.

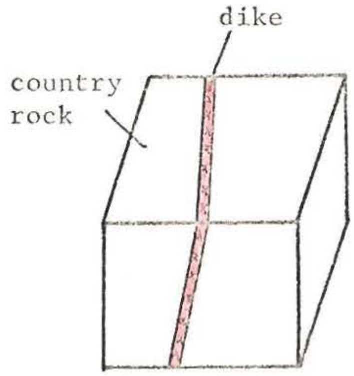
At the point of intersection of the Argentine structure and the Cross Vein structure, a drag effect can be observed (plates I and II). This drag is principally due to fault movement along the Argentine structure, caused by strike-slip movements along the Cross Vein. Evidence of this movement is seen in slickensides in the wall rock of the Cross Vein structure, in the presence of fracture cleavage in the veins, along which new ore veinlets later formed (fig. 14), and in the presence of joints and vugs as shown in figure 8.

In conclusion, the following points are summarized:

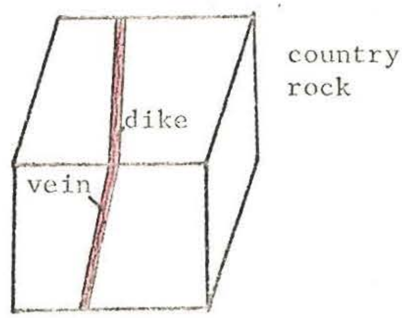
(a) The Argentine dike was formed before the appearance of the Argentine Vein.

(b) The Argentine Vein was formed before the Cross Vein.

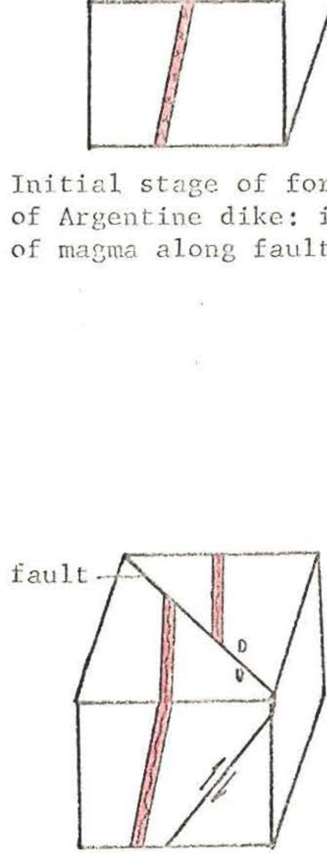
(c) Later strike slip faulting on the Cross Vein structure



A. Initial stage of formation of Argentine dike: intrusion of magma along fault.



B. Repeated movement along the dike producing fissure, formation of the Argentine vein.



C. Structural readjustment, producing transverse fault(the host for Coss Vein).

D. Horizontal movements producing drag in the Argentine structure and causing fracture cleavage and joints, Continued movement producing vugs, as shown in fig. 9.

Figure 14. Diagrammatic interpretation of a sequence of events in formation of Argentine and Cross Vein structures.

was responsible for the presence of drag effect on the Argentine structure.

Stages of structural development

A brief summary of the stages involved in the formation of the structural elements that have been discussed above will follow:

First stage.--Intrusion of igneous material into fault planes of the country rock (probably during post-Laramide orogeny). This is represented by the andesitic Argentine dike. (fig. 14 A).

Second stage.--Reopening of the Argentine structure and splitting of the Argentine dike occurred as a result of continuing a recurring tectonism. Mineralizing solutions penetrated these new fissures, and mineral precipitation formed the Argentine Vein in the Argentine dike (fig. 14 B).

Third stage.--As a result of the readjustment of the structure, new movements produced a second system of dip-slip faults, having dips of 45°-50° W. Along these secondary fault planes were emplaced the minerals of the Cross Vein system (fig. 14 C).

Fourth stage.--Principally horizontal movements produced a drag of the Argentine structure and new small fissures into which minerals were precipitated. Metasomatism has been active since the third stage. Because the remaining solutions were impoverished in sulfur content, gold-bearing quartz with only small amounts of sulfides was precipitated. Because of the low sulfur content in these solutions, hematite (in the form of maghemite) and pyrrhotite in very small amounts were precipitated simultaneously with the quartz. This is shown in figure 22 (camera lucida).

Fifth stage.--The tectonic cycle was still active, as there was still movement that produced joints, shear planes and vugs. The vugs provided favorable places for the growth of calcite and quartz crystals (fig. 9). In some places where the quartz crystals were not formed, silica was deposited in the form of chalcedony. Some of the cavities are still open and show intergrowths of chalcedony and quartz crystals.

Mineral paragenesis

As a result of the mineragraphic studies, the following conclusions were derived concerning the mineralogic sequence in the ore body:

(a) Pyrite is one of the oldest minerals formed. Some was formed first as marcsite which inverted later to pyrite. This is shown in figure 15 (camera lucida).

(b) Sphalerite present in the mine was originally in solid solution with the chalcopyrite, which sometimes by exsolution segregates chalcopyrite after the formation of the sphalerite (fig. 16).

(c) There are two types of sphalerite present in the samples. One is yellow to brownish yellow, and the other is brown to grayish brown. The two types represent different concentrations in iron content.

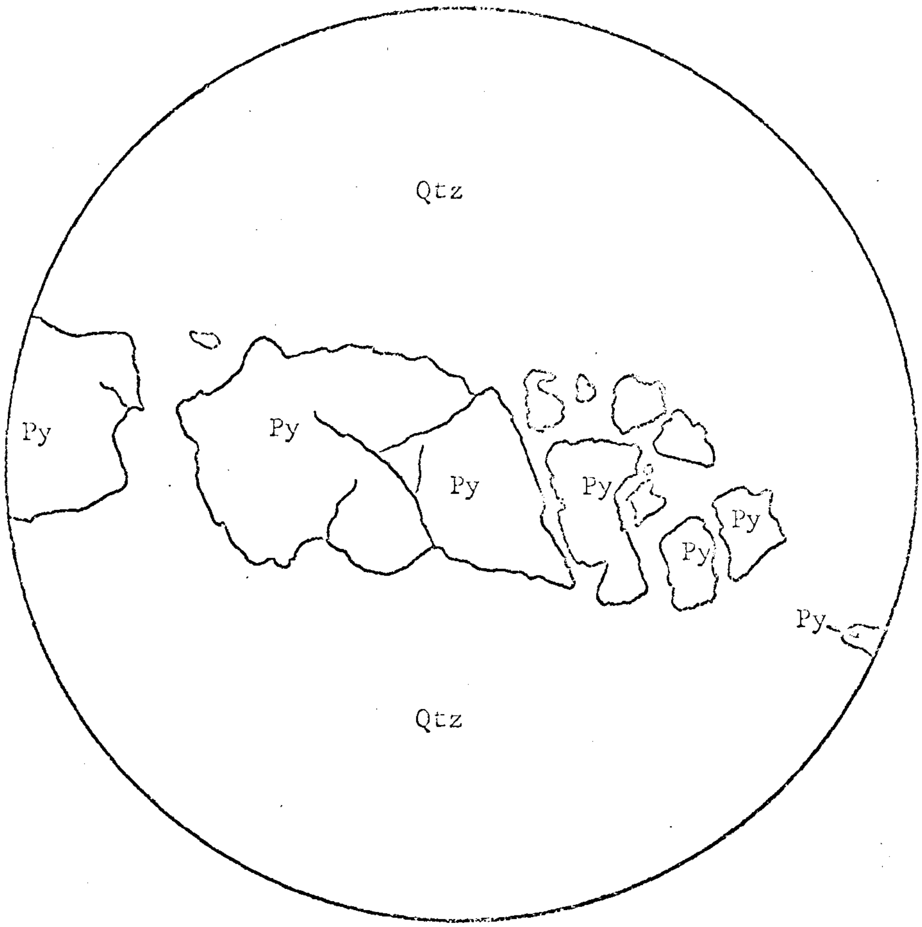


Figure 15. Pyrite (Py) inverted from marcasite and quartz (Qtz). Camera lucida .X65.Sample 34.

Figure 16. Exolution of chalcopyrite from sphalerite

(d) There are two types of galena; one is older than the other. The older generally shows corrosion by the other minerals. The older galena is associated with the old pyrite described in (a).

(e) In the last stage of mineralization, represented by the deposition of gold-bearing quartz, we observe some inclusions of hematite (maghemite) and pyrrhotite in very small amounts. This is believed to represent a change in the bulk composition of the solutions.

In the following paragraphs these observations will be explained.

The pyrite that is present as a gangue mineral in the mine shows a wide range of deposition. It is one of the first and last minerals deposited, although in its late stages only very small amounts were precipitated. The crystals of pyrite that there were formed first always show fracturing and corrosion by later solutions (fig. 17, camera lucida). The late pyrite, formed simultaneously with the latest quartz, appears as uncorroded "fresh pyrite" exhibiting well developed faces. Some of the old pyrite was probably deposited first as marcasite, and afterward inverted to pyrite. This is shown by a mineral grain in figure 15 (camera lucida) which represents a former marcasite grain now inverted to pyrite.

Macroscopically, the sphalerite shows two types of coloration. One is yellow to yellowish brown, and the other

Figure 17. Corroded pyrite (Py) and chalcopyrite (Cpy) in a matrix of quartz (Qtz) with some crystals of maghemite (M), galena (G) and pyrrhotite(Pte). Camera lucida .X65.Sample 18.

is grayish brown. This can be interpreted as a variation in the iron content, with the lighter colors corresponding to the lesser content of that element. Under the microscope it is not possible to observe this change in coloration because the appearance of both is the same in polished sections. It appears to be that the lighter colored sphalerite was formed before the darker colored sphalerite, but in many cases they are intergrown. Another important characteristic that has been observed is that the sphalerite is in solid solution with the chalcopyrite. This is shown in figure 16, a photograph. The chalcopyrite appears as small dots in the sphalerite, and can be seen only under the microscope. The same effect in the sphalerite has been observed at Darwin, California, by Park (1964, p. 47). The sphalerite showing this property has released some chalcopyrite by exsolution from solid solution. The quantity of chalcopyrite present in small blebs in the sphalerite is not of appreciable economic value. Only the chalcopyrite formed by direct precipitation from solutions is economically mineable.

Some of the more massive chalcopyrite was formed simultaneously with the sphalerite, but other chalcopyrite continued to be precipitated after the sphalerite. Figure 18 illustrates the continuing deposition of chalcopyrite.

The galena is of two generations. One was formed in a very early stage of mineralization and the other formed later, mostly by replacement. The early galena (Galena I)

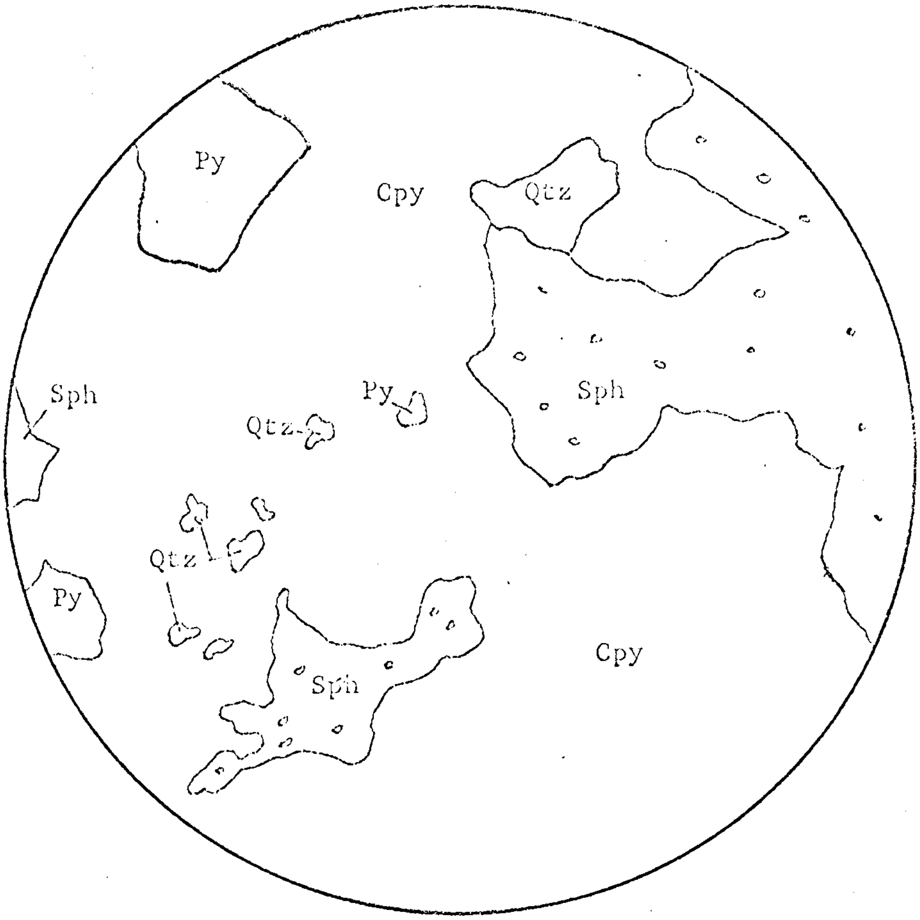


Figure 18. Pyrite (Py), quartz (Qtz), chalcopyrite (Cpy) and sphalerite (Sph). The dots in the sphalerite represent the blebs of chalcopyrite in the sphalerite. Chalcopyrite here is the latest mineral. Camera lucida .X65.Sample 15.

is always corroded and shows spots of alteration or corrosion by the other minerals. A characteristic example of this situation is shown in figure 19. The late galena (Galena II) was formed at the expense of the other minerals by replacing them (fig. 20). The galena formed by replacement contains, in some places, relict minerals in its mass. That these minerals are older than the galena is shown in figure 21.

The veins and veinlets of quartz occurring in the Argentine and Cross veins represent the last phase of the ore mineralization cycle. Gold was precipitated with this quartz, as were very small or incipient crystals of hematite (as maghemite) and pyrrhotite (fig. 22). This represents a final impoverishment in the sulfur content of the mineralizing solutions. Hematite and pyrrhotite were formed after the depostition of the base metal sulfides, indicating an incipient oxidizing phase in the mineralizing cycle.

The calcite, along with the silica that appears in the form of chalcedony and quartz crystals, was formed in the very last stages of the mineralization. These minerals fill some of the fissures and cavities that were formed by the tectonic movements and subsequent readjustment. It is possible that some of the quartz crystals were formed more recently by solutions passing through the fissures, concentrating and depositing their silica content. The general paragenetic sequence of the ore formation is given in

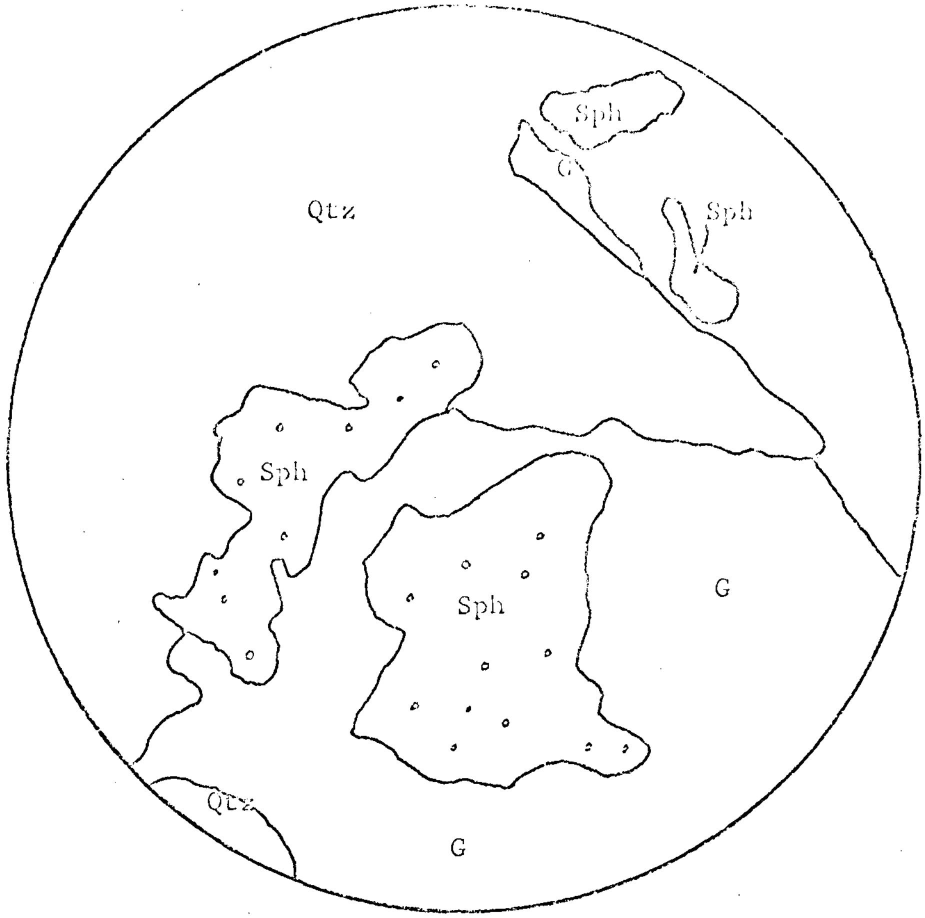


Figure 20. Quartz (Qtz), sphalerite (Sph) and galena (G) the latest mineral. The galena is galena II. Camera lucida .X65. Sample 10.

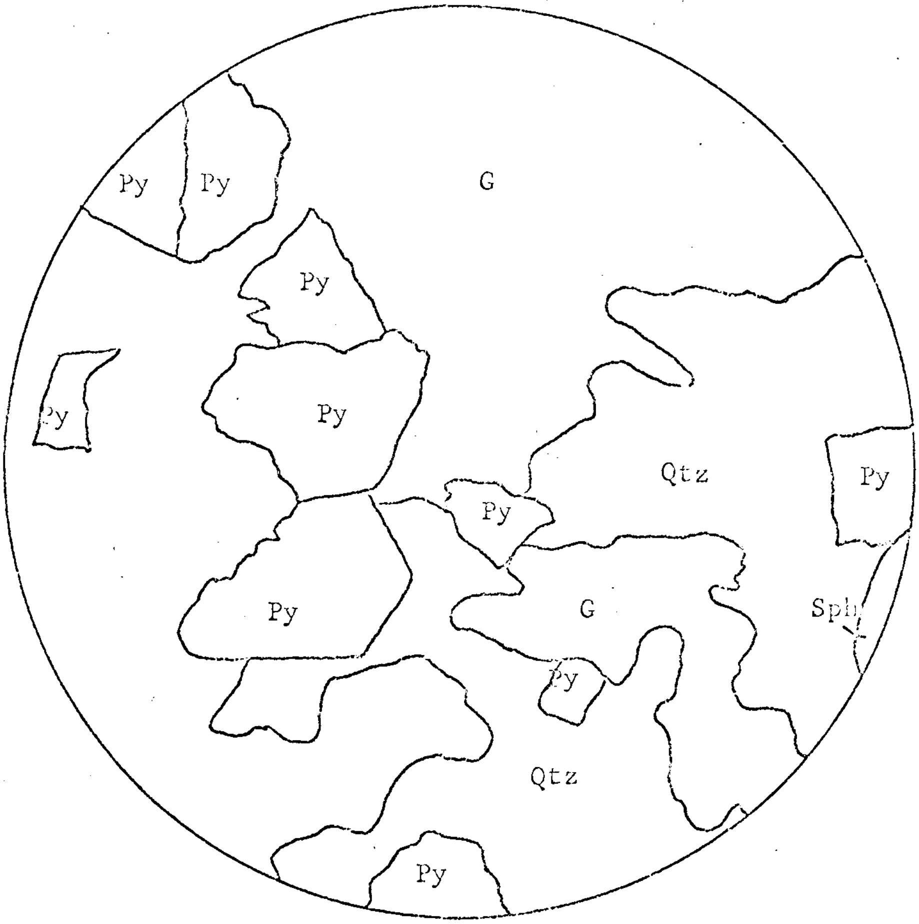


Figure 21. Galena II containing relict minerals. Note the crystals of pyrite "corroded" by replacement. Pyrite (Py), galena (G)and quartz (Qtz). Camera lucida .X65.Sample 37.

Figure 22. Sphalerite (Sph), chalcopyrite (Cpy), galena (G) quartz (Qtz) and maghemite (M). The maghemite is associated with quartz and occurs in the veins in microscopic amounts. Camera lucida .X65.Sample 5.

figure 23. It is necessary to point out that there were many repetitions in the ore formation. Some of the relationships are obscured by the newly generated minerals, by the repeated sequences of ore formation, and by metasomatism.

<u>Origin and behavior of the ore-forming solutions</u>

It is difficult, if not impossible, to find out the nature or the source of the mineral forming solutions, because at the present time we do not have any specific facts to explain this situation. However, based on paragenetic and mineralogical studies, an interpretation of the origin and behavior of the mineral forming solutions can be postulated.

The solutions that formed the mineral deposits at the Idarado Mining Company appear to be related to a late stage of the magmatic cycle that caused emplacement of the igneous bodies of the region. There was a natural segregation and original concentration of S, Pb, Zn, Cu, Ag, Si, Fe, in the pro-magmatic waters which later formed the ore. This fact does not mean that the waters were highly concentrated with those elements. Through constant precipitation over long periods of time under favorable environmental conditions even fluids with low concentrations of solutes can presumably form mineral deposits.

At the beginning, the solutions appear to have been relatively acidic, as shown by marcasite which later inverted

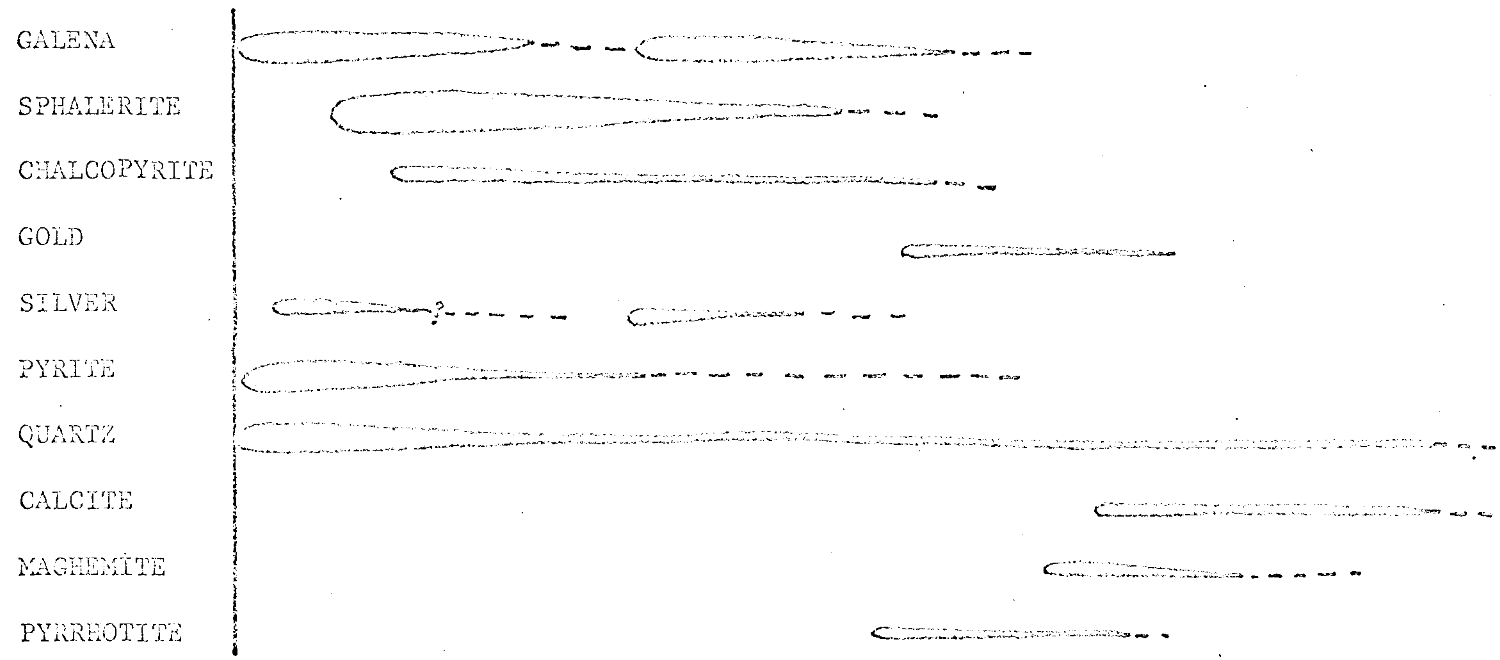


Figure 23. Generalized paragenetic sequence in the Idarado mine.

to pyrite (fig. 15). Precipitation of some quartz, marcasite, pyrite, galena and sphalerite occurred. The marcsite later inverted to pyrite, the more stable form under the new conditions. Since the waters were still acidic, the wall rock was dissolved and silica and quartz were carried away in solution.

Because of the precipitation of the elements in the base-sulfides form, the waters were losing their sulfur content and were giving rise to more chalocopyrite (fig. 19) probably according to the following succession of minerals.

$F_e S_2$	$(F_e, C_u) S_2$	$F_e C_u S_2$
(pyrite)	(cupriferous pyrite)	(Chalcopyrite)

After the precipitation of the elements in the form of galena, sphalerite, pyrite, chalcopyrite and quartz, the waters were still bearing iron and silica, along with a remaining very small amount of sulfur. This caused the precipitation of the last elements that appear as accessories in the quartz, namely pyrrhotite and hematite (maghemite fig. 22). This was probably due to the following reactions controlled exclusively by the impoverishment in sulfur content and the still active concentration of F_e and S_i :

$$F_e S_2 + F_e^{++} \quad 2 F_e S$$ pyrrhotite

$$4 F_e + 3 O_3 \quad 2 F_{e_2} O_3$$ hematite (maghemite)

Pyrrhotite was the last sulfide deposited. After that the sulfur content was depleted, and hematite (maghemite) began to be precipitated (fig. 22). In this stage, gold was also precipitated; both hematite and gold are associated with the last quartz. As the waters were losing their acidity, calcium in the form of calcite crystals was precipitated in the cavities.

The crystals of quartz that line the cavities seem to be related to the last cycle of mineralization, in which the waters contained mainly silica. This silica could have been brought in by meteoric waters. The fact that the quartz and chalcedony are found chiefly in the fissures and cavities that were produced in the last tectonic cycle suggests they were the last mineral formed (fig. 9).

Ore Controls

The emplacement of the ore bodies at the mine had its primary and main control in the original fissure which became filled with igneous material to form the Argentine dike. Since then, the behavior of the wall rock (Argentine dike, Cutler Formation and Telluride conglomerate) has controlled the ore emplacement. The ore controls can be divided into two broad types: (1) physical or mechanical controls and (2) chemical controls; both, in combinations or independently, played an important role in the ore control.

Physical controls

Lithology.--Lithologic factors were important in the emplacement of the ore, principally when this ore was formed by metasomatic replacement. The minerals were concentrated much more readily in the conglomeratic layers (Telluride conglomerate) than in the sandstone or siltstone layers (Cutler Formation). Bedding planes controlled the ore deposition, principally in the sandstone and siltstone layers.

Structural control.--Faults, shear planes, joints and fracture cleavage are the structural controls for ore deposition. The faults are the primary and main channels for the mineral-forming solutions, but the shear planes, joints and fracture cleavage in the fault zones were important sites for the precipitation of these ore minerals. It is around these later fractures that the replacement principally occurred. The replacement started by interaction of sulfide solutions between adjacent veinlets and progressed until there was complete replacement of the country rock between these veinlets.

Porosity and permeability.--Porosity and permeability have controlled the emplacement of the ore. This is most apparent when the Telluride conglomerate and Cutler sandstones are compared. The Telluride conglomerate is very porous and permeable (fig. 24). The sulfide-forming solutions penetrated the pore spaces and sulfide minerals were deposited there. The sulfur of the sulfide-bearing solutions also reacted with the iron content of the wall rock to form some of the pyrite.

The pore spaces of the sandstone unit of the Cutler Formation were already filled with silica prior to the ore

Figure 24. Replacement in conglomerate of the Telluride Formation.

deposition and thus rendered relatively impermeable. Therefore, mineralizing solutions were not able to penetrate readily into it. As a consequence, the sandstone units of the Cutler Formation do not contain disseminated ore.

Chemical controls

Chemical composition of the country rock.--The chemical composition of the country rock was a factor in ore emplacement. Changes in the chemical conditions of the wall rock, and probably the concentration of N_a, C_a, and M_g in the wall rock, appear to have served as catalysts in the precipitation of the minerals. Near the walls of the Argentine andesitic dike, metasomatic replacement is not common. This indicates that the dike was unfavorable for ore replacement. The amount and concentration of the circulating solutions and the chemical composition of the wall rock are general controls in ore formation.

Alteration of the wall rock.--The alteration, or the chemical changes of the country rock, previous to the emplacement of the ore, is an important control in the ore formation in some of the metasomatized zones (2414 stope, plate III and IV). The previous epidotization of the country rock was due to the action of solutions associated with Argentine dike. The epidotization affected the formation of the later metasomatic ore deposits. A summary of the ore controls in the veins of each geologic formation will be discussed next.

Ore controls in the Argentine structure

Cutler Formation.--Ore controls in the Argentine Vein in the Cutler Formation were mainly structural. The formation of the Argentine Vein in this geologic unit was controlled by a fault plane which passed through a weak zone in the country rock. Prior to formation of the vein, magmatic solutions were injected into the fault to form the Argentine dike. Tectonic movements then produced longitudinal fissures adjacent to and within this dike. The Argentine Vein was formed by the filling of these fissures.

Since the pore spaces of the adjacent Cutler wall rock became filled with silica when the dike was emplaced, subsequent mineralizing solutions were not effective in penetrating the wall rock. Only very small amounts of ore were formed, therefore, by metasomatism. In very few places, where there was some porosity, pyrite was formed by the reaction of sulfur (from the sulfide solutions) with the iron of the wall rock.

Telluride Formation.--The ore controls in the Argentine Vein in the Telluride Formation were more complex than in the Cutler Formation. They were structural, lithologic and chemical in character, although the primary control was structural.

Before formation of the Argentine Vein, andesite was injected along the original fault plane to form the Argentine dike. Some of the solutions or gases emanating from the

Argentine dike were trapped in the conglomeratic layers of greatest permeability. Reactions of these solutions or gases with the country rock produced epidotization of the conglomeratic country rock. Epidote was formed because it was the stable phase after the solutions emanating from the dike had reacted with the country rock. In the process of epidotization, rock permeability and jointing were important factors.

Subsequently, faulting occurred along the Argentine dike. Mineralizing solutions precipitated ore along the newly formed fractures, forming the Argentine Vein inter-laced with the dike. The 2412 stope (plates III and IV) shows that the premineral epidotization was an important control in the formation of ore by metasomatism. These epidotized zones provided a favorable environment for ore emplacement. Consequently, ore bodies formed in the Argentine Vein by metasomatism characteristically occur in epidotized country rock associated with the Argentine dike. Both epidotization and ore mineralization are best developed in the horizontal dimension, reflecting the high permeability of certain conglomerate beds.

Ore controls in the Cross Vein structure

Cutler Formation.--Within the Cutler Formation, the controls of ore mineralization in the Cross Vein were structural and lithologic. As elsewhere in the mine, the presence of a major fracture was the primary control.

In sandstone and siltstone horizons of the Cutler, local metasomatic ore is found along bedding planes and secondary fissures, such as joints. In conglomeratic horizons of the Cutler Formation, the ore controls were similar to those in the Telluride conglomerate, discussed in the next section.

Telluride Formation.--The ore controls in the Cross Vein in the Telluride conglomerate were structural, lithologic and chemical. The Cross Vein fault was, of course, the primary control.

Minor fractures and joints originated simultaneously with the formation of the original Cross Vein fissure. The oritinal fissure was mainly filled with ore by fracture-filling mechanisms. The metasomatic ore found in the vein originated by the action of solutions in zones of closely spaced joints and fractures. Mineralization fronts moved outward from these openings, replacing wall rock by ore.

A feature of the Telluride conglomerate in the vicinity of the Cross Vein is the presence of ore minerals in the matrix among the pebbles. Both the permeability and chemical composition of the matrix are believed to have contributed to this occurrence. Because the conglomerate here has calcitic or dolomitic cement, it is suggested that this carbonate cement was particularly susceptible to metasomatism. On the 2400 level, the replacement took place to such a degree that in some places the wall rock lost its original characteristics. Ore replacement in the country rock extended to more than 15 feet in width on that level.

The difference between ore controls in the Cross Vein and Argentine Vein in the Telluride conglomerate is in the epidotization of certain permeable beds of the country rock adjacent to the Argentine structure, with the result that these beds were uniquely favorable to metasomatism. Except for this difference, which was peculiarly related to the intrusion of the Argentine dike, the structural, chemical and lithologic controls were similar, as described in the previous paragraphs.

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PLATE I

IDARADO MINING COMPANY
GEOLOGY OF THE 2400 Lv.

SCALE 1in = 50 ft

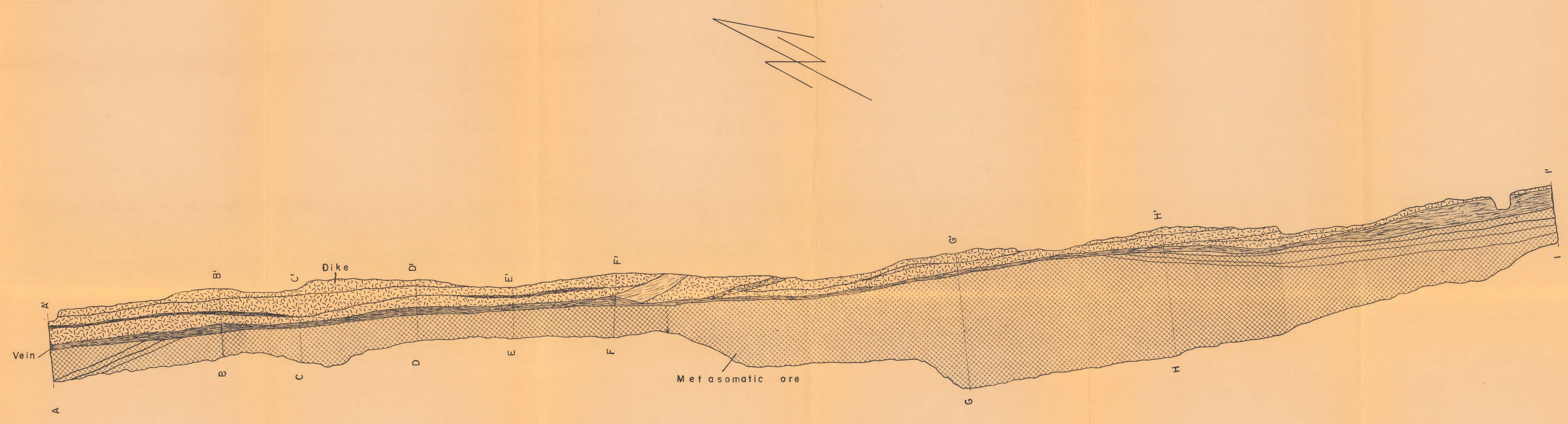
Sample | Survey station | Vein
Fault | Disseminated ore | Joints

RAUL A. SANJINES S.

Mapped summer 1966


PLATE II
2900 LEVEL
Vein of gal, chpt, pt, qtz. 2, 2.1/2 ft wide
dissapears in foot wall, presence of many joints
Vein of gal, sph, pt, chpt, qtz,
wit predominance of gal, in
higly jointed country rock
Fault with little
displacement.
Gal, sph, chpt, pt, qtz, in highly jointed and
fractured zone, wall rock with ore dissemination,
country rock indicates replacement
Ore dissemination
starting from beding plane
Veinlets of qtz
2, 2.1/2 wide
Vein of galena, sph, chpt, pt, qtz
4 ft wide, predominance of gal- qtz.
jointing
Vein of qtz, 3/4 ft. wide
Vein of gal, sph, chpt, pt, qtz,
4ft wide, with predominance of
qtz, there are drussy cavities.
Vein of gal, sph, pt, qtz,
wit predominance of
chpt 1ft
fault with very little displacement
Vein of gal, sph, chpt, pt, of
1ft wide, but with qtz and
disseminated ore is near 3 ft
Vein of gal, sph, chpt, pt, with abundant
qtz, the vein is 3 ft wide and has
veinlets of qtz splitting long the
original vein.
Gal, sph, chpt, pt, qtz
is cutted by fault.
Vein of gal, chpt, qtz, sph,
pt, of 1/2 - 1 - 1.1/2 ft wide
N54000
N53500
E E 39500
E 40000
E 40500
E 50000
N53000
IDARADO MINING COMPANY
GEOLOGY OF THE 2900 Lv.
SCALE 1in=50ft
Sample
Survey station
Vein
Fault
Disseminated ore
Joints
RAUL A. SANJINES S.
Mapped summer 1966

PLATE III



IDARADO MINING COMPANY
GEOLOGY OF THE 2412 STOPE

SCALE 1 in = 10 ft

(2) Sample — Survey station — Vein
Fault — Disseminated ore — Joints

RAUL A. SANJINES S.   Mapped summer 1966

PLATE IV

A
A'
sulfides with quartz, predom. pyr
sulfides pred. gal.
pred qtz
qtz and sulfides
B
B'
sulfides pred. py and gal
sulfides pred. gal
qtz and sulfides
qtz 1"
C
C'
sulfides pred. py and gal
sulfides and qtz, pred. qtz
qtz and sulfides 1"- 3"
D
D'
sulfides pred. gal and cpy
sulfides pred gal and sph
qtz and sulfides
E
E'
sulfides pred. gal and sph
sulfides
qtz and sulfides
F
F'
sulfides pred. sph
gal
qtz and sulfides
mainly qtz
G
G'
sulfides pred. sph and cpy. cpy mainly disseminated in the ore
sulfides
mainly qtz
fault
H
H'
sulfides pred sph, py and cpy
mainly galena
qtz and sulfides
qtz 1-4"
I
I'
sulfides pred py
qtz 1"
qtz and sulfides
mainly sulfides
sulfides and qtz
EXPLANATION
Epidotized country rock, bearing sulphides (galena (gal) sphalerite (sph) chalcopyrite (cpy) pyrite (py)) and quartz (qtz)
Argentine dike
Telluride conglomerate
Veins and veinlets (pred = predominantly)
Fault
IDARADO MINING COMPANY
TRANSVERSE SECTIONS 2412 STOP.
SCALE 1in. = 5ft.
Sample
Survey station
Vein
Fault
Disseminated ore
Joints
RAUL A. SANJINES S.
Mapped summer 1966