STATE OF MONTANA

M. A. BRANNON, *Chancellor, The University of Montana*

BUREAU OF MINES AND GEOLOGY

FRANCIS A. THOMSON, *Director*

MONTANA BUREAU OF MINES AND GEOLOGY BULLETIN

ISSUED QUARTERLY—PRICE 50 CENTS

No. 6 January, 1931

GEOLOGY AND ORE DEPOSITS OF BANNACK AND ARGENTA, MONTANA

by

PHILIP J. SHENON

MONTANA SCHOOL OF MINES

BUTTE, MONTANA

Entered as second class matter January, 1931, at the postoffice at Butte, Montana, under the Act of March 3, 1879.

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PREFACE

Bannack and Argenta are part of the Old West. Bannack was the first placer camp of significance in Montana and the scene of the first successful gold dredging operations in America, whereas it was at Argenta that the first successful lead-silver mining and smelting operations in Montana were begun. At Bannack the wave of civilization sweeping eastward from the Pacific met the westward advancing wave from the Atlantic. It was here that the gap between the two frontiers was closed and that "forty-niners" from California taught men from the "states" to use the pan, the rocker, and the sluice-box.

But the history of the past is only an incidental feature of this publication. The prime purpose is to illustrate the application of the new geology to the old camps in the hope that by careful scientific analysis of the causes which have led to the formation of the bonanzas of the past, stimulus may be given to the revival of productive activity in the future.

Bannack and Argenta are typical of the numerous and more or less deserted mining camps which are dotted as a group of satellites about the Boulder batholith and from which, in the aggregate, several hundred million dollars in gold and silver have been produced. A mine is a wasting asset, and it is doubtless true that certain of the richly productive ore-bodies of the Boulder batholith have been exhausted. On the other hand, it is doubtless equally true that certain mines of the past were abandoned either because of failure to understand the genesis and structure of the ore-bodies, or because of inability to deal successfully with the refractory and complex ores by the metallurgy then current.

To the solution of the problems—geological and metallurgical—presented by these formerly productive areas, the Bureau hopes to make a substantial contribution through such studies as are typified by this publication, "The Geology and Ore Deposits of Bannack and Argenta." It has been the endeavor throughout the preparation of this report to make it easily understood by the intelligent miner, prospector, and layman; but at the same time to include the essential basic scientific facts needed by the trained geologist or engineer in order that he may make an intelligent detailed examination of a specific property, for without a favorable report from a competent engineer there is no hope of interesting capital in mining development.

FRANCIS A. THOMSON, *Director.*

THE GEOLOGY AND ORE DEPOSITS OF BANNACK AND ARGENTA, MONTANA

By Philip J. Shenon

SUMMARY

The areas described in this report include 30 square miles near Bannack and 20 square miles in the immediate vicinity of Argenta, Montana. The Argenta area lies 5 miles northeast of the Bannack area.

These two districts include the first important placer and lode mines in Montana, and many of them have been worked intermittently up to the present time. The mines have produced gold, silver, lead, zinc, and copper in considerable quantity. The total production of the Bannack area is estimated at $12,000,000 and that of the Argenta area at $1,500,000.

The oldest known rocks of sedimentary origin exposed in the Bannack district are limestones of Mississippian age. The youngest stratified rocks exposed in the vicinity are "Red Beds" of probably Triassic age. Consolidated sedimentary rocks ranging in age from pre-Cambrian to Pennsylvanian are found in the Argenta area. They include thick deposits of limestones, quartzites, and shales. The unconsolidated materials include terrace gravels and glacial moraine. Because of their positions the terrace gravels have been classified into "Upper Bench Gravels" and "Lower Bench Gravels".

Former igneous activity manifests itself in both areas as flows, tuffs and intrusives. The ore deposits are closely related to intrusive rocks of intermediate composition.

All of the consolidated rocks have been folded and displaced by overthrust faulting. Normal faults have caused displacements on a smaller scale.

Valuable ore deposits occur in both sedimentary and intrusive rocks but are everywhere located at or near the intrusive contacts. Most of the deposits were small or moderate in size but practically all were high grade. The deposits with obvious exposures have been largely exhausted but it is altogether possible that additional discoveries may be made.

INTRODUCTION

PURPOSE AND SCOPE OF THE REPORT

The first part of the field work for the Bannack report was done during the summer months of 1925. Another month was spent at geological investigation in 1928. The field work for the Argenta report covered a period of nearly two months during the summer of 1929.

The report on the Bannack area was first assembled at the University of Minnesota[1] during the winter and spring of 1925-26 and, except for condensation and rearrangement and the added description of the Hendricks mine, remains essentially as originally written. The Argenta report was prepared during the spring and summer of 1930 at the Montana School of Mines.

Section corners served as the principal horizontal control for the construction of the topographic maps whereas the secondary points were located by Brunton intersections and by pacing. The plane-table was used for part of the work in the Bannack area but all of the elevations in the Argenta area were determined by aneroid barometer. The formation boundaries were followed out and mapped and are delineated as accurately as the topography. Broken lines are used where the contacts are doubtful.

Fifty mines and prospects were visited during the course of the work but due to the pressure of time only a few of them were mapped. However, the characteristics of each have been described in more or less detail.

ACKNOWLEDGMENTS

It is a pleasure to acknowledge the numerous courtesies which have facilitated the field work. Among many others, Messrs. William Dunn, C. H. Stallings, Frank Sinnott and F. L. Graves (now deceased) of Bannack; George Metlen, John Coppin, J. B. Somers, D. V. Erwin, William Corbett and G. V. Elder of Dillon; A. H. French, George W. French, W. J. Cushing and George Knapp of Argenta; and Alexander Leggat and Samuel Barker, Jr., of Butte, were generous in giving time and information.

1. A report on the geology of the Bannack district was submitted by the writer to the Graduate School of the University of Minnesota in partial fulfillment for the degree of Doctor of Philosophy.

During the preparation of the Bannack report the writer received assistance and many suggestions from the members of the Geology Department of the University of Minnesota. Special acknowledgment is due Dr. W. H. Emmons and Dr. F. F. Grout for helpful suggestions and criticisms. Mr. R. J. Leonard identified the fossils that served to correlate the sedimentary rocks. Acknowledgment also is due Dr. G. M. Schwarts for assistance and advice rendered during the study of the polished sections. Mr. W. S. Yarwood made one complete rock analysis and Dr. R. J. Leonard one incomplete analysis.

The writer wishes to express his thanks to President Francis A. Thomson of the Montana School of Mines for his help and criticism throughout the preparation of the report. Thanks are also due Dr. E. S. Perry for his criticism and for assistance in photography. Mr. L. H. Hart of the Anaconda Copper Mining Company was generous with information and comments on the geology of the Tuscarora and Governor Tilden mines. Mr. George H. Girty of the U. S. Geological Survey identified the fossils from the Argenta district. Credit is due Mr. Romer H. Guenther and Mr. S. F. Hornbeck of the Anaconda Copper Mining Company for the drafting of the maps.

GEOGRAPHY

SITUATION

The Argenta and Bannack areas (fig. 1) are centrally located in Beaverhead County, southwestern Montana, and for the most part lie within the Dillon Quadrangle[2]. The Argenta area is in T. 9 S., Rs. 11 and 12 E., and comprises an area of 20 square miles; the Bannack area is in Tps. 7 and 8 S., R. 11 W., and includes an area of 30 square miles. The Blue Wing mining district occupies approximately the northern half of the Bannack area and the Bannack mining district the southern half (Pl. I).

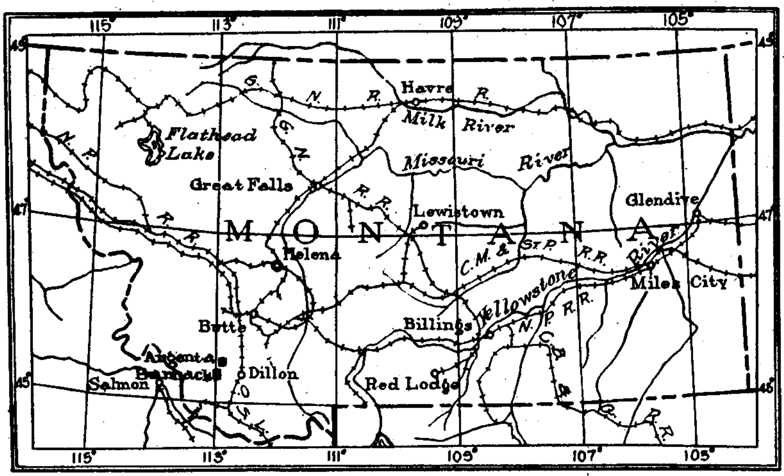


FIGURE 1. INDEX MAP OF MONTANA SHOWING BANNACK AND ARGENTA

Dillon is the nearest railroad shipping point for the Argenta and Blue Wing districts which lie, respectively, 14 and 18 miles west of Dillon. Ore from Bannack is shipped from Grant, 12 miles to the west, on the Gilmore and Pittsburgh railroad. A direct water-grade highway to connect Bannack with the Oregon Short Line railroad at Barratt Station, a distance of about 14 miles, is under consideration.

TOPOGRAPHY

The Bannack and Argenta areas lie in a section of the Rocky Mountain province characterized by a series of north-south trending mountain ranges which are separated by broad intermontane troughs. The main mountain masses are well rounded and charac-

2. Winchell, A. N., U. S. Geol. Survey Bull. 574, 1914.

terized by flat summit areas which Umpleby[3] has described as an old erosion surface. The smooth mountain slopes are, however, dissected by steep V-shaped valleys that have locally been widened by glaciation.

The maximum relief within the mapped areas is approximately 1800 feet. The highest point in the region, Robbers' Roost, is located in the northern part of the Bannack district; it attains an altitude of 7600 feet (Pl. I) and because of its prominence was used as a lookout station by the early-day road agents, and hence the name. The lowest point is just south of the junction of Spring Gulch and Grasshopper Creek at an elevation of 5800 feet. The high range, composed largely of tilted limestones and quartzites, running north and south through the Bannack and Argenta areas weathers into sharp cliffs and jagged gulches in marked contrast with the more rounded topography developed in the gravels to the west and the lavas and gravels to the east of this central highland.

The region described in this report is drained by Rattlesnake and Grasshopper Creeks, both of which flow into Beaverhead River, a large tributary of the Missouri. Rattlesnake Creek has its headwaters in a series of wide glaciated valleys south of Mt. Torrey. Thence it flows southeastward, partly through glacial debris, to a point about 4 miles from Argenta, where the creek leaves the narrow V-shaped valley to enter a wider valley through which it travels the remainder of its course to Beaverhead River, four miles south of Dillon. Near Argenta, Rattlesnake Creek has carved a well-defined terrace into gravel beds deposited by an ancient drainage system[4].

Grasshopper Creek rises near the base of Baldy Mountain and flows southward through a wide, alluvial-filled valley for about 20 miles and then, west of Bannack, turns almost at right angles and flows the remainder of its course through a narrow gorge, whereas the ancient gravel-filled stream channel continues southward to Horse Prairie Creek. According to Atwood[5], the early Tertiary drainage of southwestern Montana was to the southwest instead of to the northeast as it is today. After the early Tertiary drainage was blocked by lava flows and warping, there followed a long period of deposition in the intermontane basins while the headwaters of the Missouri were advancing westward. By active headward erosion the Missouri finally captured the drainage of southwestern Montana; and yet, for the most part, the present drainage, although

3. Umpleby, J. B., Jour. of Geol., vol. 20, pp. 139-147 (1912).
4. Atwood, W. W., Economic Geology, vol. 11, No. 8, pp. 698-732, 1916.
5. Op. cit.

reversed in direction, still follows the ancient stream valleys. Immediately west of the mapped area, Grasshopper Creek follows one of these old valleys to a point not far from Bannack where the stream is sharply diverted eastward through a youthful valley to Beaverhead River. The apparent entrenchment meandering in the NW.¼ of sec. 16 is due to the adjustment of the stream to the rock structures during headward erosion and is entirely local (Pl. IV-B).

CLIMATE AND VEGETATION

The climate is semi-arid, the annual precipitation ranging from 15 to 20 inches. The summers are warm and pleasant but the winters are usually cold. The mean average temperature is about 42 degrees F. and the extreme maximum and minimum temperatures are about 90 degrees F. and 30 degrees F., respectively. The following tables give precipitation and snowfall data for Dillon but can be considered as representative of Bannack and Argenta[6]:

Monthly and Annual Precipitation, in Inches, at Dillon, Montana (1920)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
.35	1.40	1.71	1.95	3.41	2.44	2.70	0.91	1.26	0.88	0.51	0.40	17.92

Monthly and Annual Snowfall, in Inches, at Dillon, Montana (1920)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
3.0	8.0	4.1	11.0	Tr.	0.0	0.0	0.0	3.0	2.0	5.0	3.5	39.6

Medium-sized evergreen trees are quite abundant although in certain sections of the area the timber has been nearly depleted. The remaining timber is practically limited to the highland area extending north and south through the region. Only isolated patches of timber grow in the areas occupied by the volcanic rocks and much of the accessible timber in the lowlands has been utilized. Sufficient timber for extensive mining operations is, however, still available. Most of the untimbered country is covered with greasewood and sagebrush. Bunch grass is abundant so that the region supports a considerable number of sheep and cattle during the grazing season.

6. Report of the Chief of the U. S. Weather Bureau for 1920-21.

BIBLIOGRAPHY

The large scale topographic map of the Dillon Quadrangle prepared by Frank Tweedy in 1887 and 1888 for the United States Geological Survey, includes the Argenta district and the eastern part of the Bannack area, as mapped by the writer. The scale of the map is 1 to 250,000 or about four miles to the inch, and the contour interval is 200 feet. The following publications relate to the geology and mining industry of the Argenta and Bannack districts:

1868. BROWNE, J. ROSS, Mineral resources of the United States for 1866, Montana, pp. 498-506.

1868. KEYES, W. S., Mineral resources of the United States for 1866, Appendix, pp. 38-56.

1869-1877. RAYMOND, R. W., EATON, A. K., WHEELER, W. F., etc. Mineral resources of the region west of the Rocky Mountains, for 1869, pp. 134-152; for 1870, pp. 204-217; for 1871, pp. 261-273; for 1872, pp. 216-221; for 1873, pp. 367-374; for 1874, pp. 323-327; for 1875, pp. 237-245.

1885. LEESON, M. A., History of Montana, 1739 to 1885, Chicago, 1885, 1867 pages.

1885. EMMONS, S. F., Geological sketch of the Rocky mountain division: Tenth Census, vol. 13, pp. 94-100.

1890. BANCROFT, H. H., History of Washington, Idaho, and Montana, 1848 to 1889, San Francisco, 1890, pp. 589-808, particularly pp. 620-627, and pp. 721-728.

1897. BARREL, R. W., The mineral formation of the Golden Leaf mines (Beaverhead County, Montana): Eng. and Min. Jour., vol. 64, p. 64.

1903. WEED, W. H., Ore deposits near igneous contacts: Trans. A. I. M. E., vol. 33, p. 732.

1905. DOUGLAS, E., Some notes on the geology of southwestern Montana: Carnegie Museum Memoir 3, pp. 407-428.

1914. WINCHELL, A. N., Mining districts of the Dillon Quadrangle, Montana and adjacent areas: U. S. Geol. Sur. Bull. 574.

1915. BILLINGSLEY, PAUL: The Boulder Batholith of Montana: Trans. A. I. M. M., vol. 51, pp. 31-56.

1915. NOYES, A. J., Dinsdale's Vigilantes of Montana, Montana State Publishing Co., Helena, Montana.

1916. ATWOOD, W. W., The physiographic conditions at Butte, Montana and Bingham Canyon, Utah, when the copper ores in these districts were enriched: Econ. Geol. vol. 11, No. 8, pp. 697-740.

1916. BILLINGSLEY, PAUL, and GRIMES, J. A., Ore deposits of the Boulder Batholith of Montana: Trans. A. I. M. E., vol. 58, pp. 284-361.

1916. JENNINGS, HENNEN, The history and development of gold dredging in Montana: U. S Bureau of Mines Bull. 121.

1927. SHENON, P. J., Gold at Bannack, Montana: Eng. and Min. Jour., vol. 123, p. 326.

1930. FRENCH, G. W., Argenta, first lead-silver camp in Montana, still shipping ore: Mining Truth, Spokane, Wash., April 3, 1930, p. 23.

GENERAL GEOLOGY

CHARACTER AND DISTRIBUTION OF THE ROCKS

The prevailing rocks of the region are igneous and are most abundant in the eastern half of the area. They include granodiorite, andesite, dacite, rhyolite and basalt. Of these the extrusive rocks greatly predominate.

The sedimentary section in the Bannack district is far from complete, although over 2000 feet of sediments are included, ranging in age from Lower Mississippian to unconsolidated Quaternary gravels. Limestones of Mississippian age are widespread, but Jurassic and Cretaceous sediments were not observed. Erosion has removed the consolidated post-Carboniferous sedimentary rocks except where they have been protected by overthrust faulting. The distribution of the rocks is shown on the geologic map forming Plate I.

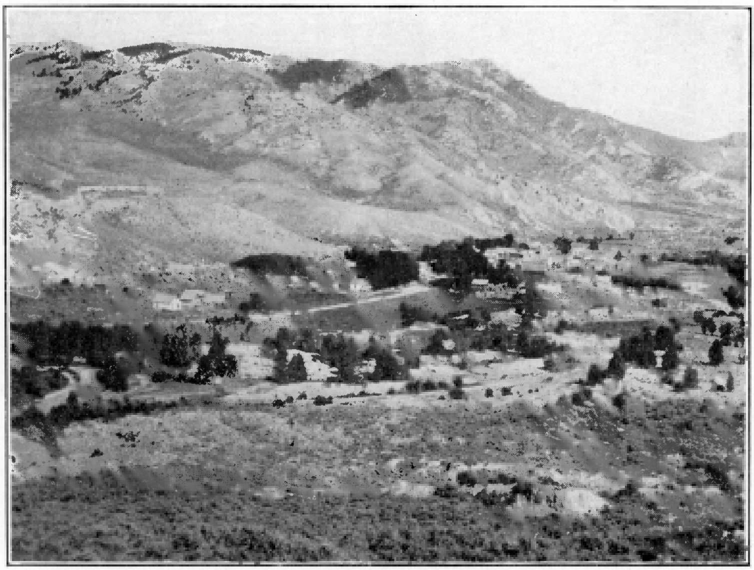
CARBONIFEROUS SYSTEM

MADISON FORMATION

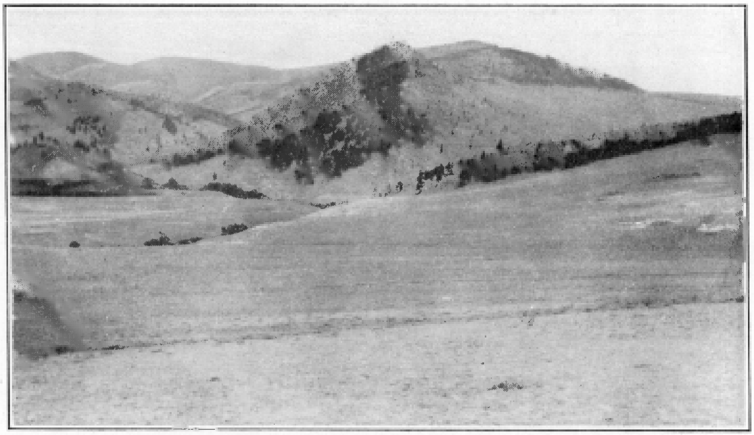
The Madison formation, consisting mainly of grayish-blue limestone, is very well developed in the Bannack region where it attains a thickness of about 1200 feet. Although the base of this formation was not definitely fixed, fossil evidence indicates the presence of the basal beds. Some grayish-green and maroon-colored shales, immediately west of the fault in the SE.¼ of sec. 8, were tentatively mapped with the Madison although no fossils to fix their age were found.

About 200 feet of the lowest exposure of the Madison formation is comprised of alternating grayish-blue, bluish-white, and pinkish crystalline limestone. Above this comes about 200 feet of bluish-gray limestone with abundant organic remains. Then follows about 150 feet of dark grayish-blue limestone with numerous lenses and nodules of grayish-black and black chert. This is followed by about 400 feet of massive grayish-blue limestone, while nearer the top the formation becomes predominantly red in color and the rocks are more arenaceous. A peculiar grayish-blue conglomerate composed of limestone fragments was noted near the top of the formation. It is exposed on the high point in the W.½, sec. 17. Although the red arenaceous limestones were mapped with the Madison formation it is quite possible that they correspond with

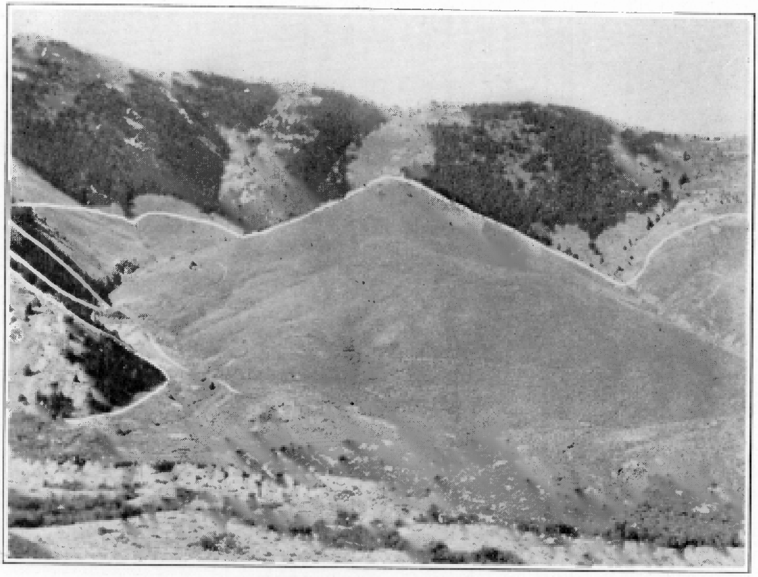
7. Peale, A. C., U. S. Geol. Survey Folio 24, p. 2, 1896.



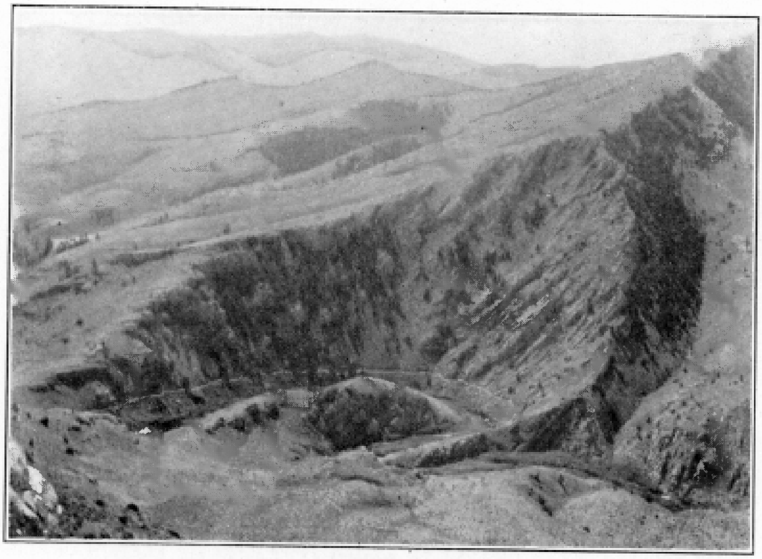
A. BANNACK, MONTANA, LOOKING NORTHEAST. TERTIARY GRAVELS IN LEFT BACKGROUND AND TILTED LIMESTONE IN RIGHT BACKGROUND.



B. TILTED FLATHEAD QUARTZITE (center) JUST EAST OF FRENCH CREEK, ARGENTA DISTRICT. THE QUARTZITE BORDERS SPOKANE SHALE WHICH OCCUPIES THE CENTER OF A BROAD ANTICLINAL FOLD.



A. INTRUSIVE CONTACT OF GRANODIORITE WITH MADISON LIMESTONE JUST EAST OF BANNACK. NOTE APOPHYSIS OF INTRUSIVE EXTENDING INTO LIMESTONE IN LEFT FOREGROUND.



B. ADJUSTMENT OF GRASSHOPPER CREEK TO THE TILTED "RED BEDS" IN THE N.W.¼ OF SEC. 16

north of Mann Gulch where it occupies two synclinal troughs. the "red" limestones of the Three Forks area[7] where they are included with the Quadrant formation. Fossils from the Argenta district identified by G. W. Girty of the U. S. Geological Survey, indicate that limestones of both Brazer (upper Mississippian) and Wells (Pennsylvanian) age are present in that district, and a more complete fossil collection from the Bannack region will, no doubt, prove the same thing to be true in that area. The fossils collected from the Madison formation were identified by Dr. R. J. Leonard and are listed below:

Amplexus sp.
Camarotechia metallica
Camarotechia sp.
Cleiothyris roissyi
Crania laevis
Crinoid stem fragments
Cyathophyllum sp.
Derbya crassa?
Eumetria marcyi
Fenestella sp.
Murchisonia sp.
Nodosinella
Orthotetes inflatus?
Pleurophorus sp.
Productella concentrica?
Productus arcuatus
Productus cora
Productus laevicostus
Productus semireticulatus
Rhombopora sp.
Schizophoria swallovi
Spirifer centronatus
Spirifer (Delthyris) cf. tullius
Spiriferina cristata
Spirifer rockymontanus
Straparollus luxus?
Straparollus cf. similis
Syringopora sp.
Zaphrentis excentrica
Zaphrentis stansburyi

QUADRANT FORMATION

The Quadrant, which overlies the Madison formation, is exposed mainly in the extreme northern and southern ends of the area. It consists predominantly of quartzite which grades upward into a fine-grained sandstone. Talus developed on the steep slopes by the weathering of these rocks usually conceals the contacts with the other formations. The top of the formation has been removed by erosion but the base is well exposed in the saddle just south of Bannack Point where it rests upon a bed of woody-appearing shale about two feet in thickness. Beneath this woody-appearing shale is a thin layer of black organic shale, less than an inch in thickness, which in turn rests upon a massive blue limestone. Beneath this blue limestone are the red and pink arenaceous limestones. The vitreous quartzite which comprises the lower part of the Quadrant formation is white or pinkish-white in color but weathers to reddish-brown on exposed surfaces. Bedding was not recognized. Because of the intense fracturing and jointing the quartzite has a hackly appearance. Microscopic examination proved this to be an unusually pure quartzite composed largely of rounded quartz grains, showing marked secondary growth, with some interstitial silica and a few isolated grains of biotite. The quartz grains are uniform in size and average about 0.15 mm. in diameter. The thickest section of the Quadrant formation is exposed just

The synclinal trough occupied by Robbers' Roost, the highest point in the region, includes a section over 500 feet in thickness.

The age of the formation correlated with the Quadrant is probably Pennsylvanian. Calkins[8] obtained Pennsylvanian fossils from the Quadrant formations in the Philipsburg quadrangle and Girty[9] regards the fossils found in the Quadrant formation of the Snowcrest mountains, southwest of Virginia City, as of early Pennsylvanian age. No fossils were obtained from this formation in the Bannack district, but those found in the red arenaceous limestones beneath it were identified as upper Madison. Fossils of probable Wells (Pennsylvanian) age were found in limestone beds beneath the quadrant quartzite in the Argenta district.

MESOZOIC SYSTEM

"RED BEDS"

The "Red Beds" are exposed for the most part in the southern end of the area, disconformably underlying Madison limestones. Their preservation is due largely to the fact that the overthrust Madison limestones have protected them from erosion.

The "Red Beds" consist largely of alternating beds of red conglomerate and sandstone with some beds of grayish-blue conglomerate. The beds are persistent and range in thickness from about 1 to 20 feet. The pebbles in the conglomerates vary considerably in composition, size, and angularity. Although blue limestone pebbles often containing organic remains typical of Madison limestone predominate, brown and white quartzite, pink, buff, and black chert, brown sandstone and white quartz pebbles are common. The largest pebbles observed were less than a foot in diameter, but the average size is probably less than an inch. The quartzite, sandstone, quartz, and chert pebbles are usually well rounded, whereas those of blue limestone are frequently angular. Both sandstone and conglomerate are well cemented, the latter usually with a brownish-red to brick-red sandy material. Several beds of volcanic rocks, purplish to pinkish in color, are present in the lowest exposed portions of the "Red Beds". They are in well defined beds and are clearly members of the strata that comprise the "Red Beds". The microscope shows these rocks to be made up largely of volcanic glass, some with marked flow structures (Pl. VI, 3). Although these rocks are greatly altered, several feldspars showing carlsbad twinning could be seen and one with albite twinning showed

8. Emmons, W. H., and Calkins, F. C.: U. S. Geol. Sur. Prof. Paper 78, pp. 70-74, 1913.
9. Condit, D. Dale: U. S. Geol. Sur. Prof. Paper 120, p. 116, 1919.

an extinction angle of 10 degrees. As quartz was observed, the rocks are probably trachyte or latite, porphyry and tuff.

Neither the top nor the bottom of the "Red Beds" are exposed. Erosion has removed the upper members while the lower beds are in fault-contact with the Madison limestone. The thickness from the contact with the Madison limestone to the exposed top on the south side of Grasshopper Creek was measured roughly and approximates 700 to 800 feet. Cross sections indicate a thickness of at least 1500 feet.

No fossils were found in the "Red Beds" except those included in Madison pebbles. They probably correspond, however, with the Chugwater formation (Permian and Triassic) of southwestern Montana[10] and Wyoming[11] and, to the north, of the Pryor Mountains near Billings, Montana[12].

TERTIARY GRAVELS

The extreme western part of the region is occupied by Tertiary gravels, and terrace gravels are found above Grasshopper Creek in several places (plate I).

The predominating rock is red quartzite, but light-colored quartzite comes next in order. The pebbles are well rounded and although usually about two inches in diameter, they vary from less than an inch to about a foot. Lesser amounts of angular limestone fragments, as large as three feet in diameter, and some sandstone and lava pebbles are present as are a few rounded pebbles of magnetite. The gravel is cemented with coarse sandy material and is quite well indurated.

The gravels are later than the volcanic rocks of Tertiary age and antedate the advent of stream piracy in the region. According at Atwood[13] the closed drainage of southwestern Montana was opened by stream piracy during middle Pliocene.

AURIFEROUS GRAVELS

Most of the auriferous placer gravels are in the present stream channel, although some of the older "bench gravels" were also mined for their gold content. The stream gravels include pebbles of all the rock formations of the region as well as some not found in the vicinity but red quartzite pebbles predominate.

10. Condit, D. Dale, op. cit. p. 119.
11. Darton, N. H., U. S. Geol. Sur. Prof. Paper 40, p. 140, 1906.
12. Kemp. J. F. and Billingsley, Paul, Bull. Geol. Soc. America, vol. 32, p. 466, 1921.
13. Atwood, W. W., op. cit. p. 706.

INTRUSIVE IGNEOUS ROCKS

GRANODIORITE

Granodiorite, the characteristic intrusive rock of the Bannack area, is exposed in both the Bannack and Blue Wing mining districs. In all, the exposures aggregate less than two square miles. These small outcrops are probably isolated exposures of the main Boulder batholith[14].

The Boulder batholith[15] is exposed over an area of 1100 square miles in the mountainous region of western Montana. This batholith is probably a satellite of the Idaho batholith which is situated 150 miles to the west and covers and area of 20,000 square miles[16]. Between the two are many smaller exposures of intrusive rocks. Field work indicates a genetic relationship between the isolated exposures of granitic rocks in Montana so that Billingsley[17] has enlarged the term "Boulder Batholith" to include the outlying tracts.

The prevailing rock of the Bannack district is a fine-grained, medium-to-dark-colored granodiorite. It is more basic and noticeably finer than the prevailing rocks of the greater portion of the Boulder batholith[18] and quartz is not readily discernable in the hand speciman.

In the Bannack mining district there are three distinct outcrops of the granodiorite but in the Blue Wing mining district, with the exception of several small exposures, it occurs as a continuous mass. Although a number of apophyses extend out into limestone, the exposures are more or less elliptical in outline.

The intrusive nature of the granodiorite is made evident by the marked contact metamorphism in the sediments about the edges, by the projection of apophyses into the sedimentary rocks, and by the manner in which the granodiorite truncates the upturned beds of Madison limestone. Garnetization is common along the contact between the granodiorite and the limestone in the Blue Wing district and extensive in the Bannack vicinity. Apophyses of granodiorite can be observed extending into the limestone in the Barton drift at the Kent mine and in a prospect hole just northwest of the Del Monte shaft. Some of the important ore deposits at Bannack occur along apophyses that cut across bedded limestone; the Excelsior mine furnishes a splendid example.

The upper surface of the intrusive masses are rudely dome-

14. Billingsley, Paul, Trans. A. I. M. E., vol. 51, pp. 31-56, 1915.
Winchell, N. H.: U. S. Geol. Sur. Bull. 574, p. 55, 1914.
15. Weed, H. W., U. S. Geol. Sur. Butte Special Folio, 1897.
16. Umpleby, J. B., Jour. of Geology, vol. 20, p. 145, 1912.
17. Billingsley, Paul, op. cit.
18. Weed, W. H., op. cit.; Knopf, Adolph, op. cit.

like but they cut across the bedding and are not laccoliths in the strict sense of the term. The outcrops lack the more rugged features developed in the tilted limestone and are eroded into well rounded topographic forms (Pl. IV. 1). The rock is traversed by pronounced systems of closely spaced joints and tends to break into small rhomboidal-shaped blocks upon weathering. Because of this pronounced jointing the granodiorite has no economic value as a building stone.

In the Bannack mining district all the contacts are sharp and boundaries were easily mapped, but in the Blue Wing mining district the intrusive rocks are in contact, on the east, with an altered grayish-green rock of slightly porphyritic or fine texture which closely resembles the granodiorite, and, as a result, considerable difficulty was experienced in mapping. Microscopic study proved this green porphyry to be an altered phase of a volcanic rock.

PETROGRAPHY

The granodiorite is prevailingly fine-grained and grayish to grayish-green in color. Feldspars constitute about 75 per cent of the rock and biotite, hornblende and magnetite make up the greater part of the remainder. Quartz is not readily discernible in the hand specimens. Pyrite commonly occurs along joint planes.

In thin sections the microscope shows the bulk of the rock to be made up of lath-shaped plagioclase feldspars, usually striated, which show very marked zoning and usually, reaction rims (Pl. V). The extinction angles on the twinned plagioclase indicates a composition of Ab_{63} An_{37}, whereas the composition calculated from the norm is Ab_{58} An_{42}. The andesine crystals vary in size from about 0.03x0.05 millimeters to 0.28x0.70 millimeters and average about 0.14x0.20 millimeters. Optically abnormal orthoclase is present largely as interstitial material but generally constitutes about 15 per cent of the rock. The feldspars are usually fresh but occasionally have a dusty appearance. The central zones of the plagioclase show the most alteration, largely to sericite and kaolin. Small amounts of interstitial quartz are present, generally less than 15 per cent. Biotite is the commonest dark constituent and makes up about 10 per cent of the rock. It frequently shows alteration to chlorite. The biotite often includes magnetite, plagioclase and zircon poikilitically, the zircon showing pleochroic haloes. Green hornblende is usually present in amounts ranging from 5 to 10 per cent. Sometimes brown biotite takes the place of hornblende, especially around the borders. The hornblende is usually somewhat altered to chlorite, epidote, limonite and calcite. Augite is generally present in small amounts. Magnetite, apatite, zircon, and titanite occur as accessory minerals. Magetite grains, commonly square in outline, are disseminated through the sections but are most abundant in or near the ferromagnesian minerals. Magnetite usually comprises from 1 to 5 per cent of the rock but apatite, zircon, and titanite generally make up less than 1 per cent.

A complete chemical analysis of the Bannack intrusive and a partial analysis of a contact phase are given below. Analysis of rocks from the Elkhorn intrusive and from the main Boulder batholith are included in the table for comparison.

Analysis of intrusive rocks from Bannack and adjacent areas

	1	A	B	C	2
SiO_2	61.21	60.84	63.87	64.17	46.65
Al_2O_3	15.20	16.36	15.39	15.25	13.79
Fe_2O_3	2.49	2.40	1.93	2.16	10.17
FeO	3.30	3.23	3.08	2.98	
MgO	4.12	3.85	2.23	2.60	6.75
CaO	6.05	4.96	4.30	4.24	19.42
Na_2O	3.32	2.90	2.76	2.62	
K_2O	2.31	4.10	4.18	4.34	
H_2O	.92	1.03	.69	.65	
H_2O	.24	.48	.19	.16	
TiO_2	.62	——	.65	.67	
	99.78	100.15	99.28	99.84	96.78

1. Bannack, Mont., W. S. Yarwood, analyst, Biotite hornblende granodiorite.
A. Elkhorn district, Montana, E. C. Sullivan, analyst, Mica diorite.
B. Butte, Mont., Alice Mine, W. F. Hillebrand, analyst, Quartz monzonite.
C. Helena, Mont., Frohner Mine, H. N. Stokes, analyst, Quartz monzonite.
2. Bannack, Mont., R. J. Leonard, analyst, Contact phase of granodiorite.

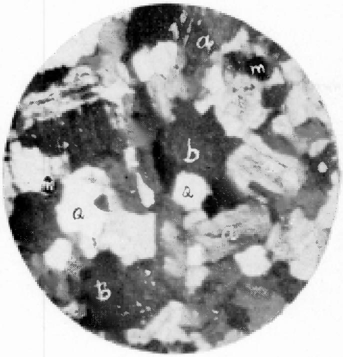
The normative mineral composition as calculated from the chemical analysis according to the rules proposed by Cross, Iddings, Pirrson and Washington[19] may be stated as follows:

	1	A	B	C
Quartz	15.18	11.10	18.84	19.38
Orthoclase	13.34	24.46	25.02	25.58
Albite	27.77	24.63	23.06	22.01
Anorthite	20.02	19.19	17.23	16.96
Diopside	7.97	4.48	2.72	2.69
Hypersthene	9.41	11.27	7.57	7.84
Magnetite	3.71	3.48	2.78	3.25
Ilmenite	1.22		1.22	1.22

Comparison of chemical analysis and normative calculations brings out a marked relationship between the main Boulder batholith and the satellites exposed at Bannack and Elkhorn.

Although the intrusive rock near the contact is essentially the same as the central masses certain changes were noted. At some places along the main contact, and particularly where blocks of limestone were included in the granodiorite, the intrusive rocks were greenish-black to almost black in color or in some cases of a salt and pepper appearance with greenish-black orbicular segregations, generally about an inch in diameter. Under the microscope

19. Washington, H. S., U. S. Geol. Sur. Prof. Paper 99, 1917.



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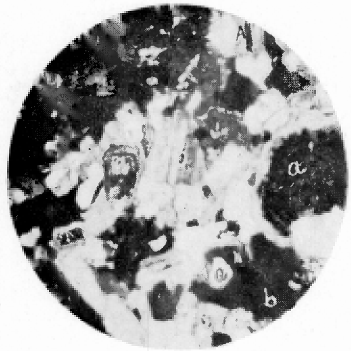

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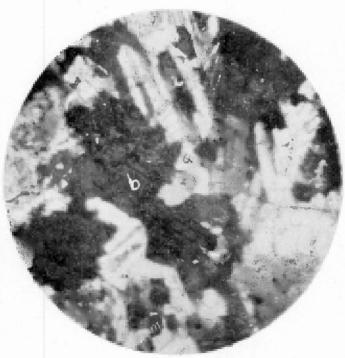

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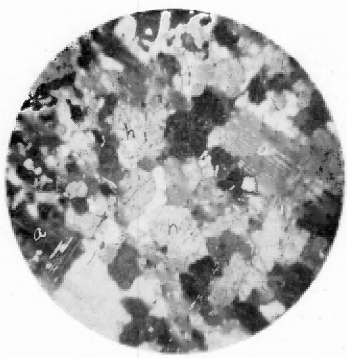

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PHOTOMICROGRAPHS OF GRANODIORITE FROM THE BANNACK DISTRICT, MONTANA.

1. Typical granodiorite from the main intrusive south of Grasshopper Creek, Bannack mining district. Andesine feldspar (a), biotite (b), magnetite (m), quartz (q). Polarized light. Magnification 45 times.
2. Same showing zonal growth in andesine feldspars. Polarized light. Magnification 45 times.
3. Typical granodiorite from the Blue Wing mining district. Andesine feldspar (a), biotite (b), magnetite (m), quartz (q). Polarized light. Magnification 45 times.
4. Granodiorite from near limestone contact. Hedenbergite (h), andesine feldspar (a), quartz (q). Polarized light. Magnification 7 times.

these dark-colored rocks were found to be made up largely of iron-bearing pyroxene (hedenbergite 70 per cent, diopside 30 per cent) with lesser amounts of plagioclase. No biotite or hornblende was observed in the thin sections studied (Pl. V, 4). This type of variation was observed in the Golden Leaf mine. However, here the intrusive contained noticeable amounts of chalcopyrite and pyrite. In some places on the surface it was possible to trace the gradation from the hedenbergite phase into a light green garnetized limestone which the microscope showed to be made up almost entirely of isotropic garnet. The absence of biotite and hornblende and the very marked increase in hedenbergite confirms the data of the analysis which shows that there was an addition of lime, magnesia, and iron. The relationships of the hedenbergite rock with the limestone contacts and particularly with the blocks of limestone included in the intrusive would suggest the limestone as the source of the lime and possibly some magnesia. The additional iron and magnesia must have been derived from the intrusive itself because an analysis shows the white crystalline limestone, some distance from the contact, to be very pure. The results of the analysis of the crystalline limestone are given below. This variation is therefore considered to be largely an endomorphic contact effect.

EXOMORPHIC CONTACT EFFECTS

Contact effects of the granodiorite were observed only in the limestone so that the alterations produced were quite similar from place to place. The most marked metamorphism was observed along the apophyses where the contacts were exposed by mining operations, as at the apex of the arm-like extension of the granodiorite into the limestone at the Excelsior mine.

A common effect observed was the marmarization of the limestone near the contacts with the intrusive rock. The recrystallization may be due in part to movement because white marble is at places found away from the intrusive contacts. An analysis of a specimen of the white marble from just west of the Bannack Gold Mining Company mill gave the following analysis:

$CaCO_3$	97.14
$MgCO_3$	1.17
Impurities (Fe, SiO_2, Al)	1.12
	99.43

Garnetization is common near the contacts of the intrusive with the limestones. At the surface the garnetized limestone has a citron color but the garnets observed underground were predominantly brownish or reddish-brown. Several other minerals were noted with the garnet but epidote is probably the most common.

AGE

The age of the granodiorite in the Bannack district has not been definitely fixed. These intrusive rocks are known, however, to be later than the folding and probably later than the thrust faulting. The "Red Beds" are the youngest rocks of the district known with certainty to be involved in the folding and thrust faulting; therefore the granodiorite in this region is at least as late as Mesozoic.

Although Weed[20] assigned a Miocene age to the Boulder batholith, more recent work indicates it to be Eocene or late Cretaceous in age.[21] Some of the larger exposures are known to intrude rock of Livingston (late Cretaceous) age[22] and the main Boulder batholith is overlain by Oligocene sediments west of Cliff Mountain[23] and at Pipestone Springs, near the southwest portion of the mass.[24]

Since it is believed that the outlying granitic masses in western Montana are isolated exposures of the main Boulder batholith, the granodiorite at Bannack can be tentatively assigned to late Cretaceous or Eocene.

BASIC DIKES

Only two dikes were noted cutting the limestone. A grayish-black, fine-grained dike with glassy borders cuts the garnetized limestone immediately east of the open pit at the Gold Bug mine. It strikes N. 50 degrees E., and dips 60 degrees N. Another dike was noted in the Norman stope of the Wadams mine. It is fine-grained and somewhat lighter colored than the one at the Gold Bug mine. It strikes N. 40 degrees E., and dips 70 degrees S. The microscope proved the specimen from the first dike to be a basalt. The second was not studied under the microscope.

EXTRUSIVE IGNEOUS ROCKS

DISTRIBUTION AND THICKNESS

Volcanic rocks consisting of varieties of andesite, dacite, rhyolite, and basalt occupy half of the mapped area. The lavas extend from the level of Grasshopper Creek, at an elevation of 5,800 feet, to an elevation of 7,100 feet on the high point in sec. 11, but no

20. Weed, W. H.: U. S. Geol. Sur. Prof. Paper 74, p. 29, 1912.
21. Knopf, Adolph,: U. S. Geol. Sur. Bull. 527, p. 34, 1913.
22. Emmons, W. H. and Calkins, F. C.: U. S. Geol. Sur. Prof. Paper 78, p. 83, 1926.
22. Stone, R. W. and Calvert, W.R.: Econ. Geol. vol. 5, pp. 551-557, 662-669, 744-764, 1910.
23. Douglas, Earl: Annals Carnegie Mus. Pittsburg, vol. 5, pp. 197, 263, 1909.
24. Mathew, W. D.: Bull. Am. Mus. Nat. Hist. vol. 19, p. 197, 1903.

remnants of them were found above that elevation. The relationship of the volcanic rocks was not studied in detail nor could the distance to which they extend below the present drainage lines be determined, but it is certain that they accumulated to a great thickness.

ANDESITE

GENERAL CHARACTER

Andesite, consisting largely of unbroken flows but with lesser amounts of breccias and tuffs, is the commonest volcanic rock of the Bannack region. Although, when examined in detail, they comprise a number of varieties, two types predominate. The commonest variety is a grayish-green, fine-grained rock which usually shows well-developed flow banding and prominent, rhombic-shaped, white phenocrysts. The other common variety of andesite is a purplish, fine-grained rock with very prominent white feldspar phenocrysts commonly about 1 millimeter in length, showing striations. Greenish and purplish andesite breccias occur in lesser amounts. Fragments ranging in size from 5 millimeters to 3 or 4 centimeters are abundant in these rocks.

PETROGRAPHY

The green andesite contains phenocrysts of feldspar in an altered, fine-grained groundmass. The feldspar phenocrysts which comprise about 70 per cent of the rock are usually altered but even those showing the greatest change are visibly striated. Quartz is absent in most of the sections. Residual patches of epidote and calcite, commonly including grains of magnetite, probably represent former ferromagnesian phenocrysts. One of the fresher specimens contained the following minerals in approximately the amounts indicated: Andesine ($Ab_6 An_4$) 60 per cent, orthoclase 15 per cent, quartz 1 per cent, magnetite 1 per cent, titanite and apatite 1 per cent, epidote 12 per cent, calcite 5 per cent, chlorite and sericite 5 per cent.

The purplish andesite contains phenocrysts of feldspar, augite, hornblende, and small amounts of magnetite in a microcrystalline groundmass which is stained a brownish-red color with hematite dust. (See Fig. 2, Pl. 7). Although the groundmass is considerably altered, flow-structure is apparent. The feldspar phenocrysts average about 1 millimeter in length and 0.5 millimeters in width, and comprise about 50 per cent of the rock. A few rhombic-shaped feldspars with marked zoning occur here and there. The plagioclase phenocrysts, which have the composition of andesine ($Ab_6 An_4$) are prominently twinned according to the albite and carlsbad laws and frequently contain numerous tiny inclusions. Orthoclase comprises less than 5 per cent of the feldspar. Phenocrysts of light green augite and hornblende with black reaction rims occur in less amounts.

Magnetite, titanite and zircon occur as accessory minerals, the first usually altering to limonite around the borders.

DACITE

GENERAL CHARACTER

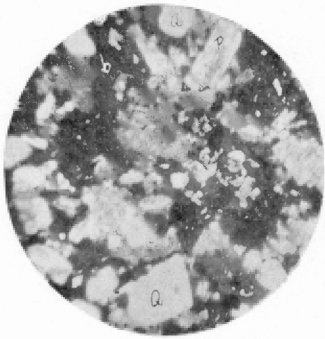
Dacite occurs in the Bannack district but not as abundantly as the andesitic rocks. The most common variety is a grayish-green, medium to fine-grained porphyritic rock. Feldspar, biotite, and quartz phenocrysts can readily be distinguished with the naked eye. Some breccias also apparently contained enough quartz to be classed as dacite but were not studied in thin section.

PETROGRAPHY

Phenocrysts of feldspar, quartz, biotite, hornblende and magnetite occur in a fine-grained groundmass (Pl. VI, 1). The phenocrysts comprise about 65 per cent of the rock. Striated andesine plagioclase ($An_4 Ab_6$), averaging about 1 millimeter in length and 0.5 millimeters in width, comprise about 65 per cent of the phenocrysts. They are somewhat dusty in appearance due to alteration. The rounded quartz phenocrysts, which are clear and glassy, show corrosion and embayment. Quartz sometimes almost entirely surrounds lath-shaped feldspars and poikilitic inclusions of feldspar, magnetite and biotite are common. The average size of the quartz phenocrysts is about 0.5 millimeters. Orthoclase comprises less than 10 per cent of the phenocrysts. Biotite and hornblende, constituting less than 5 per cent of the phenocrysts are the predominant dark constituents. Magnetite, commonly showing alteration to limonite, is the commonest accessory mineral. It occurs disseminated through the groundmass and as square-shaped crystals about 0.2 millimeters across. Apatite and titanite occur also as accessory minerals. Calcite is abundant as a secondary mineral. Because of the abundance of quartz the rock is classified as a dacite.

RHYOLITE

Rhyolite is relatively rare in the region. It is commonly fragmental in structure and white or pink in color. A pink breccia is the most widespread (Pl. VI, 4). The fragments, contained in the breccia, frequently show flow structures, and range in size from 1



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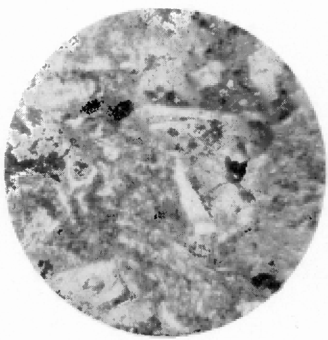

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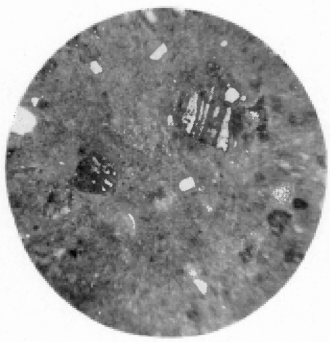

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PHOTOMICROGRAPHS OF EXTRUSIVE ROCKS FROM THE BANNACK DISTRICT.

1. Dacite porphyry showing phenocrysts of quartz (q), biotite (b), plagioclase (p). Polarized light. Magnification 7 times.
2. Andesite porphyry showing plagioclase phenocrysts in a microcrystalline groundmass. Polarized light. Magnification 7 times.
3. Tuff from lower portion of "Red Beds" showing glass shards. Ordinary light. Magnification 7 times.
4. Rhyolite tuff showing fragmental texture. Light colored mineral is quartz. Darker fragments are mostly rock material. Polarized light. Magnification 7 times.

millimeter to several centimeters. A white fine-grained lava with conspicuous phenocrysts of quartz and altered biotite occurs in lesser amounts. It contains small vesicles and solution cavities. A very fine-grained white rhyolite tuff occurs in some abundance. It contains some rounded pebbles of foreign material and in most places is noticeably banded.

BASALT

Basalt is rare. A few basaltic rocks were noted but because of their infrequent occurrence they were not studied in thin section. Winchell[25] mentions the occurrence of a basalt-capped mesa about 5 miles south of Bannack.

AGE OF THE VOLCANIC ROCKS

No evidence definitely fixing the age of the volcanic rocks was found within the region. It is quite probable that there were two periods of volcanic activity. The andesite rocks may have shared in the deformation of the region which, in part at least, pre-dated the intrusion of the granodiorite. The intense hydrothermal alteration of the andesite suggests that they may have been intruded by the granodiorite. These rocks may correspond in age with the andesitic rocks in the Butte and Helena regions which Knopf[26] has assigned to the late Cretaceous. The basalt in the Bannack region and to the south is probably of Tertiary age.

DEFORMATION

FOLDING

Several major folds are developed in the area and minor folding is pronounced. Immediately east of Bannack the sedimentary rocks have been folded into a broad overturned anticlinal dome. Intrusive rocks occupy the core of this dome and may have caused the increase in dip in their immediate vicinity. A series of well-developed folds occurs in the northern end of the region. Quadrant quartzite occupies the synclinal troughs and the older Madison limestones are exposed at the crests of the anticlines (Pl. III, 1). In the vicinity of the Kent Mine, about two miles northeast of Bannack, an anticlinal dome is exposed and its crest eroded.

Minor folding is pronounced in the vicinity of thrust faults, especially on the hanging-wall side (Pl. VII, 2). It is usually complex and can only be represented on the cross sections in a general way.

25. Op. cit. p. 50.
26. Knopf, Adolph: op. cit., pp. 23-29.

FAULTING

East of Bannack the Madison limestone can be seen resting discordantly upon folded "Red Beds". The discordance is due to overthrust faulting, the fault having a general northerly strike. The fault zone is present in the Blue Grass and Pioneer mines[27] and was observed in the main tunnel of the Ingersoll mine. This tunnel was run its entire distance (150 feet) in a white limestone gouge. In sec. 9, an outlier of blue Madison limestone rests upon the "Red Beds" and contains abundant fossils. It caps the high point just northwest of Bon Accord. Considerable evidence points to the fact that the thrusting was not limited to one surface but occurred along a number of surfaces. The fault exposed in secs. 9 and 14 is the best example of this minor faulting (Pl. VII, 2). Normal faults were observed throughout the district.

The thrust faulting at Bannack is of more than local interest because it probably belongs to the great system of overthrusting faults which extend at least from Canada on the north, well into Utah on the south.

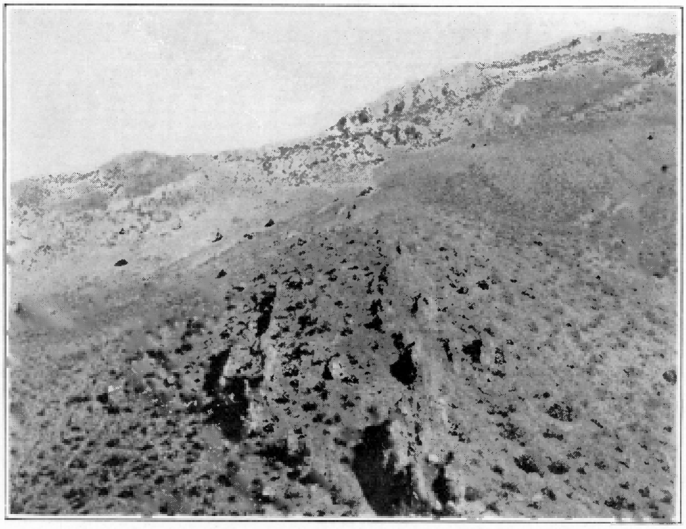
The Philipsburg Quadrangle[28] north of the Bannack area, is traversed from north to south by an overthrust or zone of overthrusts bringing Algonkian rocks into contact with Carboniferous and Jurassic rocks. Still farther north, the Lewis overthrust, with a displacement of about 7 miles, brings Algonkin rocks into discordant contact with Cretaceous rocks.[29] The Bannack overthrust in Idaho, south of the Bannack area, has been described by Richards and Mansfield.[30] Rocks from Cambrian to Mississippian age have been thrust on Triassic to Cretaceous formations and involve vertical displacements of 8,000 to 12,000 feet or more while the horizontal displacement is estimated at not less than 12 miles.

ORE DEPOSITS

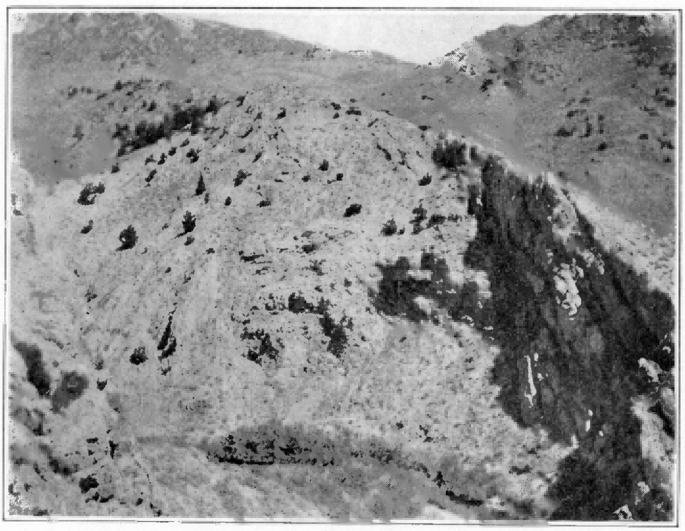
HISTORICAL SKETCH OF MINING

Although gold was found in Deer Lodge county as early as 1852, the first important discovery of metallic wealth in Montana was the discovery of placer gold at Bannack in August, 1862. Before the end of the year over 400 people had rushed to the new "diggings". However, after the discovery of the rich gulch near Virginia City, Montana, in 1863, placer mining was practically abandoned at Bannack until after the completion of the Smith and

27. Dunn, William, personal communication.
28. Emmons, W. H., and Calkins, F. C., op. cit. p. 146.
29. Willis, Bailey, Bull. Geol. Soc. American, vol. 13, pp. 305-352, 1902.
30. Richards, R. W., and Mansfield, G. R., Bull. Geol. Soc. America, vol. 23, p. 675, 1913. U. S. Geol. Sur. Bull. 577, pp. 34-38, 1914.



A. MADISON LIMESTONE OVERLYING FOLDED "RED BEDS."



B. MINOR FOLDING DEVELOPED ALONG FAULT IN THE S.W.¼ OF SEC. 9.

Graeter ditch in 1866. This company furnished water to the miners at the high rate of 75c per miner's inch. This ditch proved inadequate to work the bench gravels, so the Bannack Mining and Ditch Company constructed a 30-mile ditch at a cost of $35,000; and shortly afterward, the Pioneer ditch, 10 miles long, was constructed to work the bench gravels north of Bannack. By 1870 two other ditches had been completed: White's ditch, which took water out of Grasshopper Creek to work the bars below Bannack, and, the Canyon ditch, also from Grasshopper Creek, to work the Bon Accord placers.

The construction of these ditches renewed the placer mining activities for awhile, but it was only a matter of time until all the suitable ground was worked over. The placer production gradually declined until the spring of 1895, when a gold dredge, the Fielding L. Graves, was launched near Bannack. This was the first successful gold dredge launched in the United States.[31] It was electrically operated and had a capacity of 600 yards per day. In the richest ground this dredge took out $22,000 in one week and $38,000 the following week.[32] The Molly A. Gibson, the second successful dredge, was launched in the fall of 1895, just north of the Excelsior mine. The A. F. Graeter was launched May 23, 1896. It recovered about $200,000 in the first year, which paid for itself and the placer ground on which it operated. A fourth dredge was launched at Bon Accord a short time later. The fifth dredge, the Coast, was built 2 or 3 miles below Bon Accord but capsized when it was launched.

The first quartz mine in Montana, the Dakota, was located in 1862. The claims were located according to the local mining rules and regulations of 1862[33], which provided that the claims be limited to 100 feet along the lode and 25 feet on either side. The numerous small claims and divers ownerships led to confusion, and inefficient mining. The Wadams, Excelsior, Wallace and numerous other gold properties were located shortly after the Dakota.

The first quartz mill was built in 1862-63, by Allen and Arnold to treat the Dakota ore. It was a 6-stamp mill, entirely hand-made, and was driven by water power. The first steam-operated stamp-mill, with 24 stamps, was built by Butterfield and Hopkins in 1864, at a cost of $25,000. Three other mills were built before 1870. The cost of treating ore in these mills was about $4 per ton. All these

31. Jennings, Hennen: The history and development of gold dredging in Montana. U. S. Bureau of Mines, Bull. 121, 1916.
32. This information was kindly furnished by Mr. F. L. Graves of Bannack.
33. Noyes, A. J.: Dimsdale's Vigilantes of Montana, p. 222, 1915.

mills have been dismantled. In 1914 a cyanide mill of 200 tons capacity was constructed by the Bannack Gold Mining and Milling Company. It ran only for a short period and has since been idle. A stamp-mill was built on the Hendricks property in 1920, and operated for about two years.

The silver mines of the Blue Wing mining district were discovered in 1864. Although rich, the ore was not free milling. Some of it was shipped to Wales for treatment, but after the construction of the smelters at Argenta and Bannack most of it was treated locally. In 1868 three smelters were in operation: one at Bannack, one at Argenta, and a third on Taylor Creek, between Bannack and Argenta. Eaton[34] estimates that the smelting cost was at least $38 per ton, and Keyes[35] estimates that ore of less value than $100 per ton could not be profitably smelted.

The mines at Bannack have been worked intermittently in recent years, largely by lessees, and have produced considerably from time to time. Thus within the last 15 years Mr. William Dunn has mined about $200,000 worth of ore and shipped about $100,000 from the old dumps.

PRODUCTION

The total production of the region including the yield in placer gold, lode gold, and silver is not accurately ascertainable but is estimated to be about $12,000,000. Mr. William Dunn,[36] who is probably most familiar with past production records, estimates the total placer production of the Bannack region to be roughly $8,000,000. Mr. Carl Hand,[37] who was associated with mining activities at Bannack, both as mine superintendent and private operator, for a number of years, estimates the lode gold production, excluding that of the Hendricks mine, to be over $2,000,000. The silver production, chiefly from the Blue Wing mining district, probably did not exceed $2,000,000.[38] Placer mining in the region is now insignificant, probably yielding not over $1,000 yearly, while lode production varies from a few thousands yearly to as much as $100,000, depending largely upon the activity of the lessees.

MINERALOGY OF THE ORES

Gold and silver minerals are the most important in the ores of the Bannack region, although minor amounts of lead, zinc and

34. Mineral Resources of the States and Territories west of the Rocky Mountains for 1868, p. 496.
35. Op. cit. Appendix, p. 55.
36. Personal communication.
37. Private report.
38. This figure is considerably less than Winchell's estimate, but is believed by the writer to be a reasonable one.

copper are produced. Practically all the gold has come from the Bannack mining district. The Blue Wing district has produced most of the silver.

ORE MINERALS

The following minerals which occur in the Bannack district are arranged according to Dana's classification:

Gold, native gold is found throughout the Bannack region. It occurs both in the placers and lode deposits at Bannack and is found in small amounts in the ores of the Blue Wing district.

Silver, native silver has been reported as occurring in the Golden Leaf mines and probably occurs associated with the silver ores of the Blue Wing district.

Stibnite, antimony sulphide, is found at the Del Monte mine, where it occurs as needle-like crystals in a quartz gangue.

Tetradymite, bismuth telluride, is found in the gold ores of the Bannack district. It is particularly abundant in the Excelsior and Gold Bug ores where it has been known as a gold telluride. In appearance it resembles graphite. Metallic gold can usually be seen scattered through it, even in hand specimens.

Galena, lead sulphide, is widely distributed but rarely occurs in amounts sufficient to constitute a valuable lead ore. A good grade of galena ore was encountered on the lower level of the Kent mine.

Argentite, silver sulphide, has been recognized in both the Bannack and Blue Wing districts.

Jalpaite, a finely disseminated mineral with microchemical reactions corresponding with those of jalpaite was noted in the ores from the Kent mine. Jalpaite is a copper-bearing silver sulphide.

Sphalerite, zinc sulphide, is found in considerable amounts in the silver ores of the Blue Wing district.

Covellite, copper sulphide (CuS), occurs in small amounts as a secondary mineral at the Kent mine.

Chalcopyrite, copper iron sulphide, is found in most of the sulphide ores in the Bannack region.

Pyrite, iron sulphide, is probably the commonest sulphide mineral in the Bannack region. It is found in all the mines.

Jamesonite, lead antimony sulphide, occurs at the Kent and New Departure mines.

Pyrargyrite, silver antimony sulphide, has been noted in the sulphide ores at the Del Monte and Kent mines. It was an important ore mineral at the Del Monte mine.

Tetrahedrite, copper antimony sulphide, (gray copper), occurs in considerable amounts at the Kent, Del Monte and New Departure mines.

Polybasite, silver antimony sulphide, was noted in polished sections of the Del Monte ore.

Cerargyrite, silver chloride, (horn silver), is found in the oxidized silver ores of the Blue Wing district.

**Bromyrite,* silver bromide, and embolite, silver chloro-bromide, have been reported in association with cerargyrite, but their occurrence has not been proved positively in the oxidized ores of the Blue Wing district.

Stibiconite, yellowish antimony oxide, is found as an oxidation product in the antimony ores at the Del Monte mine.

Melaconite, black copper oxide, is found in the ores of the Golden Leaf mines. Considerable amounts of it occur in a stope near the collar of the Priscilla winze in the Golden Leaf mine.

Psilomelane, a small deposit of this hard black manganese dioxide occurs at the New Departure mine. Some of the material has been shipped as a manganese ore.

Smithsonite, zinc carbonate, is known to occur in the oxidized ores of the Kent and Del Monte mines.

Cerussite, lead carbonate, is a common mineral in the oxidized ores of the Blue Wing district. It is an important ore mineral at the Kent mine.

Malachite, the green basic copper carbonate, is a common oxidation product in nearly all of the mines of the region.

Azurite, the blue basic copper carbonate, was noted at the gold mines at Bannack and at the Kent and New Departure mines in the Blue Wing district.

Calamine, zinc silicate, was noted as drusy coatings and as aggregates of needle-like crystals in the oxidized ores of the Kent mine.

Chrysocolla, copper silicate, ranging in color from light green to dark brown, occurs in the oxidized ores of the Bannack mines.

Bindheimite, a hydrous antimonate of lead, is found as yellowish or greenish-yellow waxy and earthy material at the Kent and New Departure mines.

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*The time-worn myth of silver "bromides" dies hard. Unless the presence of bromine can be established beyond a doubt, it is safe to assume that these greenish-stained silver-bearing minerals are derived from argentiferous tetrahedrite, and are merely silver chloride colored by copper carbonate.—F. A. T.

Anglesite, lead sulphate, is found in the oxidized ores of the Blue Wing district. It is an important ore mineral at the Kent mine.

Caledonite, a basic sulphate of lead and copper, was noted as a light blue waxy material at the Kent mine.

Linarite, an azure blue basic sulphate of lead and copper, occurs in small amounts at the Kent mine.

Wulfenite, lead molybdate, occurs sparingly in vugs as orange-red crystals at the New Departure mine.

GANGUE MINERALS

Sulphur in the native form is found in the Golden Leaf mines where it occurs massive and as drusy coatings.

Quartz is the most wide spread and abundant gangue mineral. It is found in all of the mines in the region.

Hematite, the specular iron oxide, occurs as a primary mineral in the gold ores at Bannack. Red earthy hematite is found in the outcrops of the ores throughout the region.

Magnetite, magnetic iron oxide, occurs in considerable amounts in the contact metamorphic deposits in the Bannack vicinity.

Pyrolusite, the soft black manganese dioxide, is found in all of the oxidized outcrops of the Blue Wing district. It also occurs as needle-like crystals in veinlets cutting psilomelane at the New Departure mine.

Limonite, the name limonite is here applied to all of the brown earthy iron oxides of the district. It is the most widely distributed mineral in the oxidized outcrops.

Calcite, calcium carbonate, is one of the most common gangue minerals in the region. It is found in the ores of all the mines.

Siderite, iron carbonate, occurs as a gangue mineral in the ores of the Blue Wing district.

Rhodochrosite, manganese carbonate, was observed in the sulphide ores at the Kent mine.

Garnet, garnets are common gangue minerals in the gold ores at Bannack.

Vesuvianite, a basic silicate of calcium and aluminum, is found in the contact metamorphic deposits at Bannack.

Epidote, a dark green complex silicate, is a common mineral in the gold deposits at Bannack.

Chlorite, the fine-grained green mica is a common gangue mineral in the gold ores at Bannack.

Gypsum, hydrous calcium sulphate, is found in the Golden Leaf mines as a secondary mineral.

BLUE WING MINING DISTRICT

The Blue Wing mining district is in the northern part of the Bannack area (Pl. I). The ore bodies of this district occur predominantly as replacement veins[39] in limestone and granodiorite. Most of the production has come from the deposits in limestone. All the deposits in limestone lie close to the contact of the limestone with the granodiorite. The close proximity of the intrusive contact and the replacement silver deposits suggests the granodiorite as the source of the ore in the Blue Wing mining district.

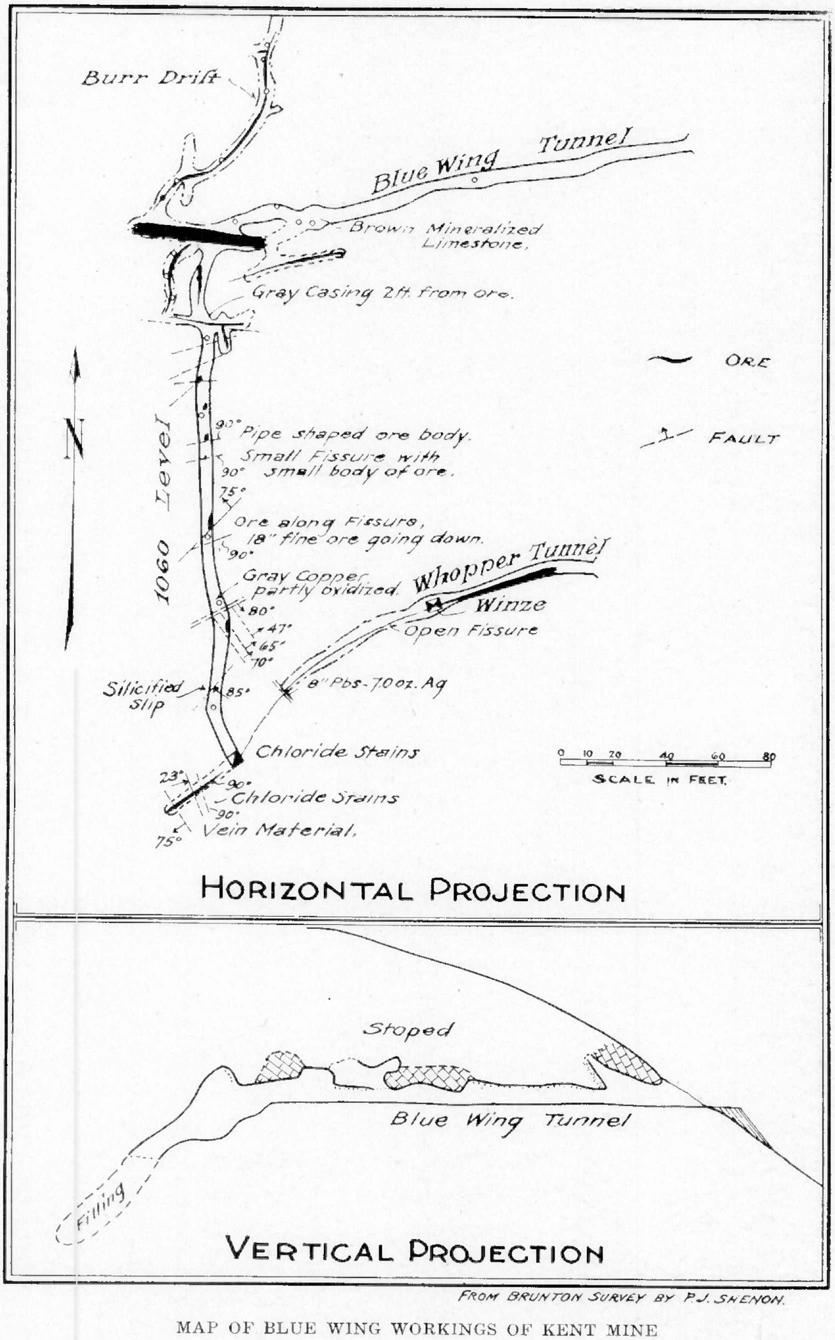
The ore minerals in the Blue Wing mining district include gold, silver, stibnite, galena, argentite, jalpaite, sphalerite, covellite, chalcopyrite, pyrite, pyrargyrite, tetrahedrite, polybasite, ceragyrite, bromyrite (?), stibiconite, pyrolusite, hematite, limonite, psilomelane, smithsonite, cerussite, malachite, azurite, chrysocolla, calamine, mimetite, bindheimite, anglesite, linarite and wulfenite. The commoner gangue minerals are calcite, quartz, rhodochrosite and siderite.

KENT MINE

The Kent mine is located near the head of Spring Gulch, about three miles northeast of Bannack. The claims lie within secs. 28 and 33, T. 7 S., R. 11 W., and are about one-half mile south of the old Bannack-Dillon stage road. The property comprises one unpatented and four patented claims.

The Kent veins were located in 1864[40], and were known as the Blue Wing, Kent, and Bannack Chief. These were the first silver deposits located in Montana. John F. O'Leary, who worked the mines successfully during the 'sixties and 'seventies, shipped the ore by ox-team to the Central Pacific railroad at Corrinne, Utah, thence by rail to San Francisco, and from there by water to smelters at Swansea, Wales. In the early 'eighties lessees mined ore worth $68,000 within a period of fourteen months. A short time later, Philip Shenon* acquired a two-thirds interest in the property. Mr. Shenon ran an 850-foot tunnel from the Edith claim into the hill between the Blue Wing and Kent. This adit, which is the main entry to the mine, intersected a body of lead-zinc ore near the contact between the intrusive and limestone which averaged 25 ounces in silver per ton. This sulphide deposit is known as the "blind lead". In 1910, S. P. Burr, operating under a bond and lease, exposed a

39. Lingren, Waldemar: Mineral Deposits, McGraw-Hill Pub. Co., N. Y., pp. 69, 604, 1919. Also Bull. Geol. Soc. Amer., vol. 36, pp. 247-262, 1925.
40. O'Leary, John F.: From a report written in 1908.
* Father of the writer, F. A. T.



MAP OF BLUE WING WORKINGS OF KENT MINE

small body of ore in the Blue Wing workings which netted approximately $10,000. Mr. John O'Leary estimates the production of the Kent property to be approximately $750,000.

The ores of the Kent mine occur as shoots along fissures in white crystalline limestone and as veins in granodiorite but the deposits in limestone alone have been worked. The fissures in limestone strike N. 80 degrees E. and dip 70 degrees N. and all the deposits in limestone occur a short distance from the granodiorite contact. The Kent and Whopper ore bodies were tabular deposits along well-defined fissures. The Kent ore-body which raked to the west at an angle of about 20 degrees was the largest in the mine. The Whopper ore body was an irregular deposit along the Whopper fissure, and its downward extension has not yet been found. The Hayes and Ewing ore-shoot was a pipe-like deposit occurring at the intersection of the Blue Wing fissure with the contact of a white marble and a dense bluish-gray limestone (Pl. VIII). Above the tunnel a small seam of ore extended out along the fissure to the portal. The Burr ore shoot was a peculiar winding pipe extending away from the Hayes and Ewing ore body. The Kent and the Hayes and Ewing stopes average from 8 to 10 feet in width, but the Whopper was considerably narrower. The walls of the ore bodies are usually well defined although the ore is sometimes "frozen" to the walls. The limestone for several feet adjacent to the larger ore shoots is frequently altered to a chocolate-brown color and sometimes a gray clay-like casing is found next to the ore.

The veins in granodiorite have well-defined walls which are frequently slicken-sided. The ore in the Shenon tunnel, known as the "blind lead", is exposed by crosscuts for a distance of 170 feet. It strikes east and dips about 30° to the south. The ore band is associated with two or three feet of gouge impregnated with pyrite on the foot-wall side. The ore itself is cut by slicken-sided fractures, the result of post-mineral movement. The relationship between the veins in granodiorite and those in the limestone could not be ascertained because of the condition of the old workings.

The chief gangue minerals of the ores in limestone are quartz and calcite and the ore minerals include galena, tetrahedrite, jamesonite, sphalerite, covellite, pyrite, jalpaite (?), cerargyrite, bindheimite, linarite, caledonite, cerussite, anglesite, malachite, azurite, chrysocholla, smithsonite, calamite, limonite, and manganese oxides. Much of the ore, particularly in the Kent vein, is soft porous material predominantly brown in color, but containing green and yellow "splotches" of lead, copper, and silver minerals. The ore from the Blue Wing and Whopper veins is predominantly greenish and yellowish in color, usually well indurated, and sometimes waxy in appearance. Because the harder ore is sometimes "frozen" to the walls skillful mining is required to prevent heavy losses.

Residual remnants of sulphide, known locally as "black metallics", occur in the oxidized ore. Pyrite and galena are the oldest minerals in the residual patches. The pyrite is partly oxidized to limonite and the galena shows typical alteration to anglesite along cleavage planes (Pl. IX, 2). The tetrahedrite and jalpaite (?) account for the very high silver content of the sulphide patches. The jalpaite (?) is commonly seen replacing pyrite. Covellite in turn replaces jalpaite (?), showing splendid intergrowths and replacement borders (Pl. IX, 1). Although the evidence is not complete it is believed that the jalpaite (?) and covellite are both supergene minerals. Neither are known in the sulphide ore of the "blind lead."

The sulphide ore in the granodiorite is in a gangue of quartz and calcite. Galena, sphalerite and pyrite are the commonest ore minerals and chalcopyrite was noted as inclusions in sphalerite. Pyrargyrite is visible locally and probably accounts for the high silver content shown in some of the assays. Both gangue and ore minerals have been brecciated and re-cemented but the galena is sometimes deformed without fracturing. The sulphide ore shows no oxidation, and secondary enrichment only locally. In 1908 lessees made a shipment of the "blind lead" ore from near the contact with the limestone which gave the following smelter returns:

Gold	Silver	Lead	Zinc	Silica	Iron	Sulphur
0.09 oz.	29.7 oz.	1.5%	3.6%	40.2%	5.8%	11.8%

Samples from the ore-body in No. 2 crosscut 230 feet east of the limestone contact gave the following assays:

Silver	Lead	Zinc
17.4 oz.	30.1%	8.5%
20.0	20.0	—
38.5	32.4	19.0

The veins in the limestone which were readily seen at the surface have been mined at a handsome profit, nevertheless, little search has been made for new deposits. The most favorable place to prospect for high-grade ore is along the contact of the white marble and the bluish-gray limestone.

DEL MONTE MINE

The Del Monte mine is in sec. 28, on the old Bannack-Dillon stage road, about a mile northwest of the Kent mine. The property

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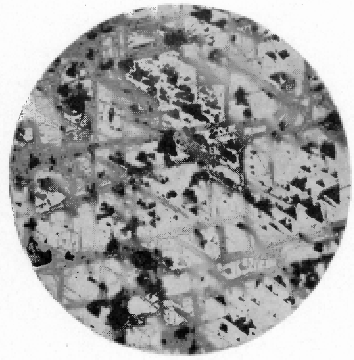

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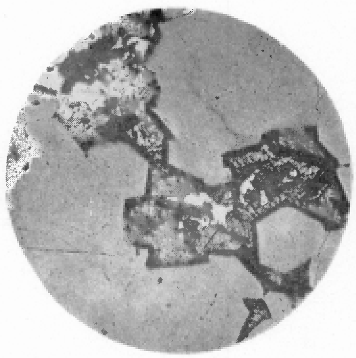

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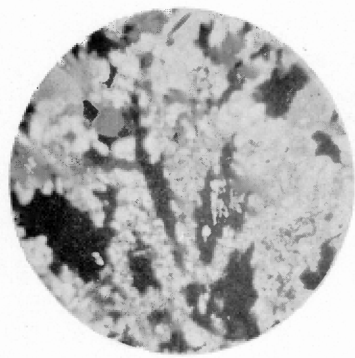

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PHOTOMICROGRAPHS OF ORES FROM THE KENT AND DEL MONTE MINES

1. Covellite (dark gray) replacing jalpaite (?) (white). Fracture filled with quartz. Magnification 540 times.
2. Galena (white) being replaced along cleavage planes by anglesite (gray). Black spots are holes. Magnification 50 times.
3. Tetrahedrite (white) partly replaced with polybasite (etched with cyanide). The gray mineral with euhedral outlines is quartz. Polished section. Magnification 14 times.
4. Stibnite (black) in quartz cut by a veinlet of later quartz. Thin section. Ordinary light. Magnification 7 times.

comprises six patented claims, and is owned by the West Butte Mining Company.

Very little was learned of the history and production. Some early-day shipments were made[41] but records of the returns are not available. Lessees who took out considerable ore in the late 'nineties are said to have netted a profit. One of the cars shipped averaged over 500 ounces in silver per ton. Since these lessees sank a shaft to a depth of over 250 feet, and handled considerable water, besides doing a good deal of drifting, it is estimated that they must have taken out at least $30,000 and probably not over $50,000. The West Butte Mining Company purchased the property from the Graves estate of Bannack, in 1922 and, after cleaning out and retimbering the Del Monte shaft, ran a number of prospect drifts, chiefly on the upper levels. Prospecting was abandoned after a year's work, and the property has since been idle.

The underground workings[42] with the exception of a few tunnels and open cuts, are all driven from the Del Monte shaft, which reached a depth of 253 feet. At present the shaft is full of water below a depth of 50 feet.

The ores in the Del Monte mine occur chiefly in well-defined veins in granodiorite which strike about N. 80° E. and dip at steep angles to the south. Veins in the limestone usually have a low silver content but some contain small deposits of high-grade antimony ore. According to F. M. Wichman[43] faulting has been extensive in the neighborhood of the Del Monte mine. The faults trend in all directions but the northerly and northeasterly ones are the most prominent.

Two veins in the granodiorite have been mined, the Del Monte and the Bonaparte. The Bonaparte is the larger but is lower grade than the Del Monte vein, and is said to assay from 20 to 40 ounces in silver per ton. It is about six feet wide on the surface. The Del Monte vein ranges in width from 4 to 14 inches on the bottom level and averages 60 ounces of silver per ton. Some assays run as high as 450 ounces.

Near the surface these veins are much oxidized and are filled with brownish to black porous material consisting largely of quartz with oxides of manganese and iron. Casts of the original minerals are plainly visible. The sulphides appear about 50 feet beneath the surface and in the lower levels no evidence of oxidation is visible. Sphalerite, galena, chalcopyrite, pyrite, polybasite, tetrahedrite and

41. Raymond, R. W.: Mineral resources west of the Rocky Mountains for 1872, 1873, and 1874.
42-43. Wichman, F. M.: Letter of May 17, 1925.

pyrargyrite occur in a gangue of calcite, rhodochrosite and quartz (Pl. IX, 3).

Small deposits of high-grade antimony ore occur on the Francis H. claim along vertical fissures which strike N. 60° E. in crystalline limestone. Stibnite is found in quartz gangue (Pl. IX, 4), and is associated with about two feet of a reddish-brown gouge. Slickensided fractures cutting the stibnite give evidence of post mineral movement.

NEW DEPARTURE MINE

The New Departure mine is situated about 16 miles southwest of Dillon, in the NW.¼ of sec. 26. The property comprises seven patented claims but the Signal and Quien Sabe produced all the ore. The property was located in 1871 by George W. Stapleton[44] who sold it to Lawrence A. Brown and Joshua E. Clayton in 1880 for the sum of $2,500. Brown purchased Clayton's interest seven years later for $3,500, and operated the mine continuously until the time of his death in 1905. The mine was then sold to the New Departure Mining Company for $50,000. This company operated for two years, having as many as forty miners working at one time. The property was then operated by lessees until 1918, when it was sold to O. M. Best of Dillon. John Coppin of Dillon worked it under a bond and lease agreement until 1928, when it was sold to J. L. Templeman of Butte. The mine is credited with a production of over a million dollars.

The ore bodies at the New Departure mine, which strike easterly and dip south, occur chiefly along fractures in massive bluish-gray Madison limestone. Some of the largest deposits are found along the intersections of fractures. The Farrell stope rakes down the intersection of two fractures. Intersecting northwest and northeast fractures are also responsible for the large ore body at the head of the incline in the Homeside tunnel. The ore shoots commonly terminate on the lower side of flat slips which are usually slickensided and striated by movement. Thus in the Badger workings the ore which stood at an angle of about 45° flattened and pinched out after reaching a flat slip. Some large ore bodies have been mined just beneath the slips, after the ore shoot flattened.

Cerargyrite, cerussite, bindheimite and other oxidation products with residual patches of sulphides composed chiefly of sphalerite, galena, and tetrahedrite occur in a gangue of quartz and calcite. Argentite (?), smithsonite, anglesite, malachite, azurite, gyp-

44. Historical date was supplied by John Coppin of Dillon.

sum and oxides of manganese and iron occur in lesser amounts, and assays indicate the presence of gold. Wulfenite occurs in small amounts.

A small deposit of high-grade manganese ore occurs just below the Stapleton tunnel. It strikes northeast and dips to the south. Psilomelane is cut by small veins filled with fibrous pyrolusite. A small deposit of oxidized gold ore said to carry $10 per ton in gold was found just north of this deposit.

HURON MINE

The Huron mine is just north of the Kent and comprises seven claims all of which are in sec. 28. The claims were located in the 'sixties by a man named Batchelor who mined considerable ore, some of the early shipments being sent to Swansea. The property was later acquired by John Costello who sold a half interest to Frank Sinnott in 1910. The latter became the sole owner after Costello's death. Mr. Sinnott estimates the total production to be about $30.000.[45]

The deposits at the Huron mine occur as replacements along fissures in white crystalline limestone. The principal fissures strike east and dip about 70° to the south. The ores are similar to those of the Kent mine. Cerargyrite with patches of residual sulphides occur in a gangue of quartz and calcite.

POMEROY MINE

The Pomeroy mine is northwest of the Del Monte mine and comprises three claims. The property was located in the 'sixties and produced considerable ore in the early 'seventies.[46] The main workings consist of an incline shaft with open stopes which reach the surface. The ore which occurs in a bluish-white limestone is in well-defined fissures which strike N. 80° E. and dip 60° N. The chief ore mineral is lead carbonate which carries silver. A red gouge varying in thickness from 2 to 4 feet is associated with the ore.

RANDALL MINE

The Randall mine adjoins the Kent mine on the south. It includes one claim and is owned by Mr. H. C. Paddock of Bannack. The property was located in the 'sixties and has produced considerable ore which has been mined chiefly for its silver content, although considerable galena is associated with it. The ore occurs as replacement deposits along fissures in a white crystalline limestone which strike east. The shoots terminate against a massive bluish-gray limestone.

45. Sinnott, F. F., Personal communication.
46. Raymond, R. W., Mineral resources west of Rocky Mountains for 1872, p. 267.

SILVER STAR MINE

The Silver Star mine is in SW.¼ of sec. 33, T. 7 S., R. 11 W., just west of the limestone-granodiorite contact. It is owned by the Monroe Mann estate. The ores occur as replacements in veins which strike N. 50° W. and dip 60° to the south and along bedding planes in flat-lying Madison limestone. The ore is chiefly oxidized material and is reddish-brown in color with occasional green and yellow patches of copper and silver minerals.

INGERSOLL MINE

The Ingersoll mine lies just south of the Silver Star in sec. 4, T. 8 S., R. 11 W. and includes three claims. It is owned by the Amede Bessette estate of Bannack. The property was discovered in the 'sixties and is credited with considerable early-day production, from open cuts and tunnels. In 1912 Phillip Lonergran, working under a bond and lease, sank a winze to a depth of about 200 feet. This winze crossed the contact between the limestone and granodiorite and was extended into the granodiorite for some distance.[47] A tunnel 150 feet in length connects the Lonergran winze with the surface. This tunnel was driven its entire length in a white limestone gouge. The ore deposits occur as replacement veins in a white limestone and strike east. The ore minerals which occur in a quartz and calcite gangue include cerussite, cerargyite, bromyrite (?), and malachite.

CHARTER OAK MINE

The Charter Oak mine, which is south of the Ingersoll, was located in the 'sixties and has produced considerable ore. It is owned by Foy Herr of Bannack. The ore occurs as replacement veins in a white crystalline limestone and includes oxidized silver and lead minerals in a quartz and calcite gangue.

WHEAL ROSE MINE

The Wheal Rose property is in sec. 27, T. 7 S., R. 11 W., and is owned by Archie Gibson and the Graves' estate of Bannack. It is credited with some production. The ore occurs along fissures in Madison limestone which strike east. The ore minerals include cerargyrite and cerussite in a gangue of quartz and calcite.

IRON MASK MINE

The Iron Mask mine is in the SW.¼ of sec. 28, T. 7 S., R. 11 W. Little was learned of the history and production, although it is known that ore was shipped in the early days. The main entrance is a shaft which is said to have reached a depth of 200 feet. The ore is in well-defined veins in granodiorite which strike east. Near the surface the ore is composed largely of black porous material consisting predominantly of quartz and calcite with oxides of manganese and iron. Sulphides are reported in the lower workings. On the surface the Iron Mask vein resembles those of the Del Monte, but no specimens were secured from the lower levels.

BANNACK MINING DISTRICT

The Bannack mining district is in the southern part of the Bannack area (Pl. 1). The ore deposits are at or near the contact between granodiorite and limestone and occur chiefly along or near the apex of apophyses (granodiorite outliers) which extend into the limestone. Well-defined fracturing appears above and in front of the apophyses, as illustrated by the mineralized fractures in the Excelsior mine and in the Dollar winze and Green raise of the Wadams mine. The fact that ore bodies are present along or at the apexes of the apophyses suggests that the apophyses were intruded along zones of weakness or that their intrusion caused the fracturing, which permitted ready access to mineralizing solutions. Although some rich deposits distant from the contact have been mined, the largest and most important ones occur as irregular bodies in limestone near the contact with the granodiorite. These deposits which are almost entirely oxidized in some of the mines, are found in greater abundance on the limestone side of the garnet zones. According to Umpleby[48] this relationship is a general one. Since fractures containing ore were observed cutting both limestone and garnet rock it is believed that the ore minerals were introduced after the garnetization. Bodies of magnetite and some pyrite and chalcopyrite were observed in the garnet zone. Lindgren[49] states that the silicates and magetite are earlier than the sulphides in contact deposits but that the periods of deposition overlap. The presence of garnet, vesuvianite and certain other minerals suggests that the deposits at Bannack were formed under conditions of high temperature and pressure[50] although specularite is present the favorable temperature for the formation of which in contact deposits is supposed to be about 490°.[51]

The ore minerals in the Bannack mining district include: native gold, tetrahedrite, argentite, cerargyrite, tetradymite, galena, cerussite, anglesite, sphalerite, chalcopyrite, tenorite, chrysocolla, azurite, melanconite, native sulphur, pyrite, specularite, magnetite, iron and

47. Sinnott, F. F.: Personal communication.
48. Umpleby, J. B., Univ. of Calif. Pub. in Geol., p. 25, 1916.
49. Lindgren, Waldemar: Mineral deposits, p. 718, McGraw-Hill Pub. Co., N. Y., 1919.
50. Emmons, W. H.: Principles of Economic Geology, p. 44. McGraw-Hill Pub. Co., N. Y., 1918.
51. Butler, B. S.: Economic Geology, vol. 10, p. 400, 1923.

manganese oxides. The gangue minerals include quartz, calcite, chlorite, garnet, siderite, epidote and vesuvianite.

THE BANNACK GOLD MINING AND MILLING COMPANY

The Bannack Gold Mining and Milling Company owns 14 lode claims and five placer claims in the Bannack mining district. Most of the production has come from the Excelsior, Blue Grass, and the Golden Leaf group, (which includes the Wadams, Wallace and Golden Leaf claims). All of the claims were located in the 'sixties and 'seventies, most of them under the early-day mining regulations which provided that claims be limited to 100 feet along the lode and 25 feet on either side. All have since been relocated in accordance with the Federal laws. Philip Shenon, who operated the mines for a number of years, sold the properties to the Golden Leaf Co., Inc., in the 'nineties. This company in turn sold to the Great Western Mines & Exploration Co., and the latter sold to the present owners in 1910. The Bannack Gold Mining and Milling Co. did considerable exploration work and constructed a 200-ton cyanide mill. This mill operated for but a short time. In 1930, the I. B. Mining Co. was operating the Golden Leaf group under a bond and lease agreement.

EXCELSIOR MINE

The Excelsior mine is near the eastern border of the granodiorite intrusive. The ore shoot has been mined to a depth of about 300 feet and has produced approximately $300,000.[52] The old shaft is now inaccessible. The Excelsior ore body occurred at the contact between crystalline limestone and granodiorite; at the apex of a granodiorite aphophysis. The limestone granodiorite contact at the mines strikes N. 35°W. and dips about 45°W. The stope at the tunnel level extends for about 30 feet along the contact and is about 8 feet in width. Intense garnetization had taken place near the contact. The garnet is clear citron-brown in color, in contrast to that in the Golden Leaf mine, of a dull reddish-brown color. Coarse crystalline calcite and specularite are associated with the garnet. The gold is either free or in tetradymite and is found in a light green gangue composed chiefly of calcite, chlorite, garnet, specularite and some quartz. The ore shoot occurring chiefly on the limestone side of the garnet zone was offset to the southwest by a series of step faults[53] in the lower workings.

52. Hand, Carl: Private report.
53. Dunn, William: Personal communication.

GOLDEN LEAF GROUP

The Golden Leaf group, including the Wadams, Wallace, and Golden Leaf claims, is at the western border of the granodiorite contact. The mines are all connected by raises and ore can be delivered to the mill from any of the workings through the tunnel known as the Priscilla level. The difference in elevation between

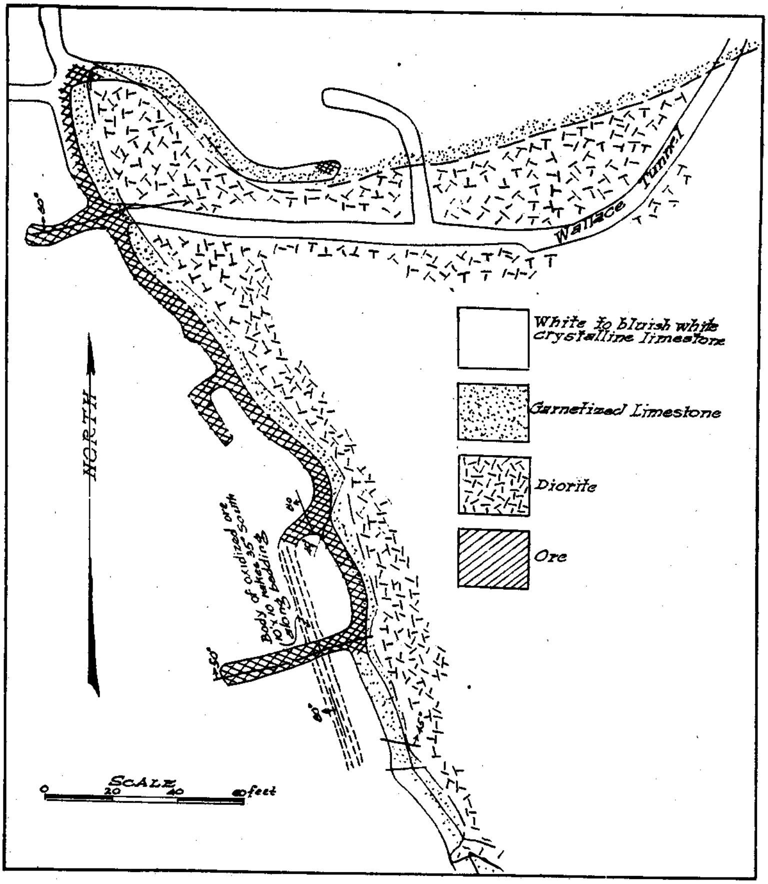


FIGURE 2. MAP SHOWING INTRUSIVE RELATIONS ON WALLACE LEVEL OF WADAMS MINE.

the Priscilla level and the upper workings of the Wadams mine is about 475 feet. The Dunn level, which is reached through an inclined winze is about 140 feet below the Priscilla level. Mr. Hand estimates the production of the Golden Leaf group to be about $1,320,000.[54]

The ore deposits are in a white or bluish-white crystalline lime-

54. Hand, Carl: op. cit.

stone at or near the contact with the granodiorite. Some of the best deposits occur along apophyses which extend out into the limestone. The deposits in the Wadams and Wallace mines are of this type (Fig. 2). The limestone is usually intensely garnetized near the contact with the granodiorite. The ore, which lies predominantly outside of the garnet zones, is almost entirely oxidized in the upper levels but the sulphides become more prominent in the lower levels. A large body of sulphide ore, about 15 feet wide, consisting largely of pyrite with lesser amounts of chalcopyrite, occurs in an intensely garnetized limestone in one of the crosscuts off the Priscilla level. The relative insolubility of the garnet gangue may account for the fact that these sulphides are quite fresh, although ore bodies in limestone on the same level are highly oxidized. Chalcopyrite and pyrite occur on the Dunn level in a dark green gangue composed largely of calcite and chlorite with lesser amounts of quartz, epidote and specularite (Pl. X, 4). Native gold with calcite was observed along fractures in the chalcopyrite (Pl. X, 3). Partly oxidized galena ore carrying silver occurs on the Priscilla level and deposits of magnetite were noted in several places along the limestone-diorite contact.

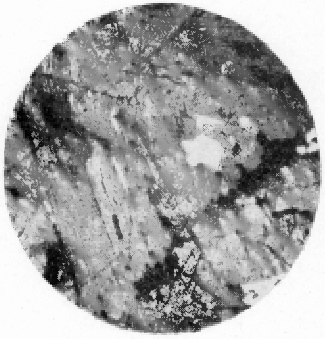
The ore minerals include native gold, tetrahedrite, chalcopyrite, malachite, azurite, chrysocolla, tenorite, galena, cerussite, anglesite, sphalerite, smithsonite, native sulphur, pyrite, specularite, magnetite, limonite, and manganese oxides.[55] The gangue minerals include calcite, quartz, siderite, garnet, epidote and vesuvianite.

BLUE GRASS AND GOLD BUG MINES

The Blue Grass mine is owned by the Bannack Gold Mining and Milling Company and the Gold Bug is owned by the Graves' estate of Bannack. The claims include a number of the earliest locations in the Bannack district. The Gold Bug embraces the original Dakota locations. Mr. Hand estimates the production of these properties to be about $550,000.[56]

The ore deposits are at or near the contact of a white crystalline limestone with a small tabular body of granodiorite. The limestone, which is intensely garnetized near the contact, contains abundant specularite. The ore is found predominantly outside of the garnet zone. These deposits occur in a region of minor folding and faulting. Gold in a quartz and calcite gangue or in tetradymite, (Pl. X, 1 and 2), is the most important metal but assays show the presence of silver. In 1925 Mr. Austin Hale opened a pipe-like

55. Shenon, P. J.: Gold at Bannack, Montana, Eng. & Min. Jour., vol. 123, p. 326, 1927.
56. Hand, Carl: op. cit.



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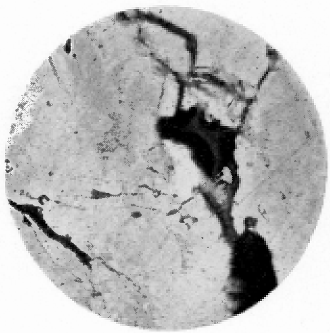

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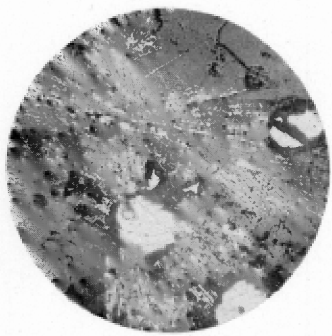

4

PHOTOMICROGRAPHS OR ORES FROM THE BANNACK DISTRICT, MONTANA.

1 and 2. Native gold (white) in tetradymite (gray) showing tendency of the gold to follow parting planes. Tetradymite etched with nitric acid. Note structures developed by etching. (Gold Bug mine.) Magnification 14 times.

3. Gold (white) occurring along fracture in chalcopyrite (light gray). Surface etched with nitric acid. Calcite associated with the gold along fracture (black) was removed by the acid. (Dunn level, Golden Leaf mine.) Magnification 110 times.

4. Specularite (with radiating structure) in quartz (dark gray) terminating against pyrite. (Dunn level, Golden Leaf mine.) Magnification 14 times.

deposit of granular pyrite which carried about $30 in gold, and in 1927 some work was done by C. W. Stalling. This deposit strikes N. 50° W., and rakes to the north at an angle of about 25 degrees.

HENDRICKS MINE

The Hendricks mine is about a quarter of a mile south of Bannack and on the opposite side of Grasshopper Creek. Two claims are included in the group, the Hendricks and the Suffield. Although the property was first located during the early days of Bannack, little ore was produced until 1918, when the Bannack Mining and Milling Company, operating under a bond and lease, put up a 5-stamp, amalgamation mill. A small ball-mill, a classifier and two cyanide tanks were added in 1919. In 1920 a new 10-stamp mill was built. It contained a ball-mill, a classifier, two agitators, four thickeners and six cyanide tanks and had a capacity of 50 tons in 24 hours. This mill was closed down in 1921. The underground workings include about 1,500 feet of drifts and one 50-foot winze. The property is now owned by the Graeter Park Realty Company of Dillon.

The ore occurs as shoots along bedding planes in limestone of Madison age which has undergone considerable minor folding. The ore of milling grade was in six different shoots within a distance of 200 feet, although the mineralization was continuous throughout.[57] Only one of the ore bodies came down as far as the working level. The shoots raked about 7° N. and dipped from 65° W., to less than 20° W., depending upon the bedding of the limestone. Ore occurred along at least two different bedding planes. The wall rock next to the ore bodies is considerably altered and some gouge was noted along bedding planes. Altered garnet was observed in the wall rock of one stope but no intrusive rocks are known underground. The ore is almost entirely oxidized and because of the oxidation about 50 per cent of the gold was saved by amalgamation.

C. W. Stallings estimates the total production of the property at $40,000.

PLACER DEPOSITS

The first important placer deposits discovered in Montana were those at Bannack in 1862. They produced $600,000 within the first year. Although some of the bench placers have been worked, the most productive were those in the stream bed of Grass-

57. Stallings, C. W.: Personal communication.

hopper Creek or along tributary gulches. Mr. Dunn[58] estimates the total placer production of the Bannack district to be about $8,000,000 distributed as follows:

Bannack Creek Placers—6,000,000 yd. @ $1 per yd.	$6,000,000
Bannack Gulch and Bench placers—4,000,000 yd. @ 30c per yd.	1,200,000
Bon Accord Placers—3,000,000 yd. @ 30c per yd.	900,000
Total	$8,100,000

Winchell estimates that Grasshopper Creek produced $3,000,000 in gold during the 'sixties.

The lode gold deposits are undoubtedly the source of the placer gold since no valuable deposits are found in Grasshopper Creek above Bannack and the gold content decreases downstream.

58. Dunn, William: Personal communication.

THE ARGENTA AREA

GENERAL GEOLOGY

CHARACTER AND DISTRIBUTION OF THE ROCKS

The prevailing rocks in the Argenta area are sedimentary. Consolidated sediments ranging in age from Algonkian to Pennsylvanian are found in the region, and Permian and Mesozoic rocks and Tertiary "Lake Beds" have been described in the Melrose and McCarthy Mountain areas, which are situated a few miles northeast of Argenta.[59] The unconsolidated rocks in the Argenta area include terrace gravels and glacial moraine.

The total outcrop of intrusive igneous rocks aggregates hardly more than one square mile and but few isolated outcrops of extrusive rocks are exposed within the map limits. This is in sharp contrast with the Bannack area where extrusive rocks prevail. Quartz monzonite, granodiorite, andesite porphyry, and dacite porphydy occur as intrusives and trachyte and rhyolite are the predominating extrusive rocks. The distribution of the various rocks is shown on the geologic map comprising Plate 1.

ALGONKIAN SYSTEM

SPOKANE FORMATION

The rocks assigned to the Spokane formation crop out for several miles along the crest of an anticlinal fold which strikes about N. 25° E. Only the uppermost part of this formation is exposed and consists of shales, quartzitic sandstones and at least one well-defined conglomerate bed. The shales are thin-bedded and fissile and characteristically have a high luster along the parting planes. The color is predominantly dark red, but beds of pale olive-green are abundant. Dark or brick-red colors prevail in the sandstones which show well-preserved ripple marks and mud cracks (Pl. XII). On the steeper slopes the top of the Spokane formation is difficult to delineate because of the thick talus of Flathead quartzite and, in other places, because of the difficulty in distinguishing the lower beds of the Flathead quartzite from similar appearing beds in the Spokane formation.

The rocks beneath the Flathead quartzite have been correlated with the Spokane formation, described by Calkins in the Philipsburg quadrangle, because of the marked resemblance to them and

59. Richards, R. W. and Pardee, J. T.: U. S. Geol. Sur. Bull. 780, pp. 1-32.

because of their position directly beneath the Flathead quartzite. No estimates have been made of the thickness of these beds in the Argenta district owing to the incomplete exposures, but Calkins estimates the formation to be over 10,000 feet thick in the vicinity of Philipsburg.*

CAMBRIAN SYSTEM

Two lithologically different formations have been tentatively assigned to the Cambrian system. The lower member is correlated with the Flathead quartzite because of its lithologic similarity to that well-defined horizon and because of the stratigraphic sequence of dark-red fissile shales and quartzitic sandstones beneath the vitreous pink and white Flathead quartzite in other parts of southwestern Montana.

The beds above the Flathead quartzite are comprised principally of gray sandy limestone. They are termed the Tilden formation in this report and are tentatively assigned to the Cambrian system. No angular discordance was noted between the Flathead quartzite and the Tilden limestones, where these beds were known to be in normal contact, although folding and faulting have caused a marked apparent non-conformity in several places. The Tilden limestone has about the same position in the stratigraphic column as the Gallatin formation of the Three Forks region[60] and the beds embraced by the Silver Hill, Hasmark, and Red Lion formations of the Philipsburg quadrangle.[61] The absence of shales at the top of the Flathead quartzite and throughout the Tilden formation is, however, in marked contrast with the Three Forks and Philipsburg regions where shales make up a considerable part of the Cambrian system.

FLATHEAD FORMATION

The beds assigned to the Flathead formation are largely pink to red medium-grained quartzite. The darker colors predominate toward the bottom of the formation and, in general, the grain size increases. The bedding is distinct, the beds usually being several feet thick. Some indurated conglomerate beds occur interbedded with the quartzite. One well-defined conglomerate horizon is exposed near the base of the formation and another pebbly quartzitic sandstone, composed largely of rounded quartz grains from one to 5 millimeters in diameter, occurs 60 feet below the top of the formation.

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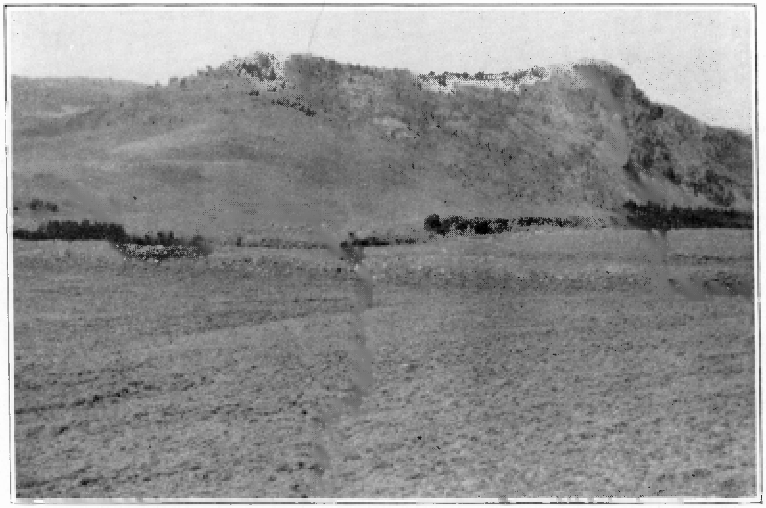
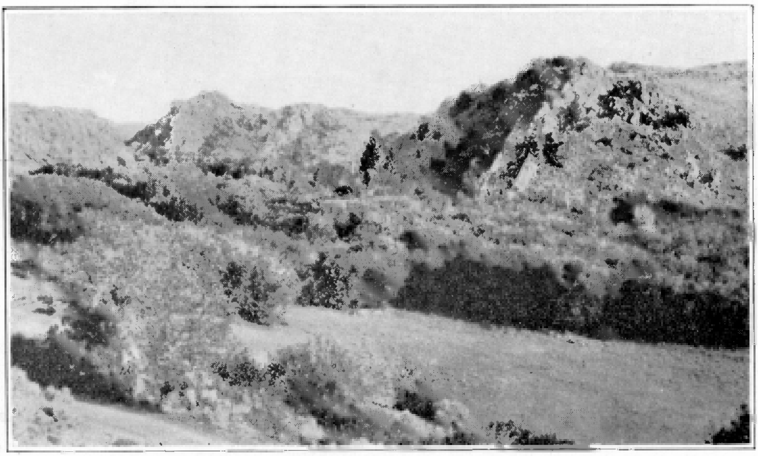
* Emmons, W. H. and Calkins, F. C.: U. S. Geol. Sur. Prof. Paper 78, p. 45, 1913.
60. Peale, A. C.: U. S. Geol. Sur. Geol. Atlas, Three Forks folio (No. 24).
61. Emmons, W. H., and Calkins, F. C., op. cit.

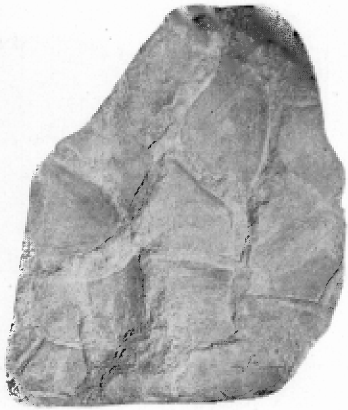


A. GLACIAL MORAINE AT THE MOUTH OF RATTLESNAKE CREEK CANYON IN SEC. 15.



B. STEEPLY INCLINED LIMESTONE BEDS IN THE N.E.¼ OF SEC. 34.

1



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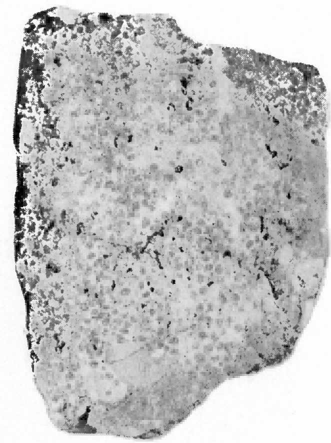

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1. Current ripple marks, characteristically developed in the quartzitic sandstone beds near the top of the Spokane formation. (1/6 natural size.)
2. Mud cracks from near the top of the Spokane formation. (1/3 natural size.)
3. Oolitic limestone from near the top of the Tilden formation. (3/5 natural size.)
4. Black magnesian limestone with twiglike bodies from base of Ermont formation. (1/3 natural size.)

The bottom limit of the Flathead formation could not everywhere be accurately fixed because of the resemblance of some of the lower beds to some of the upper beds of the Spokane formation. The top of the formation is, however, very definite where it is in contact with Tilden limestone. The maximum thickness of the Flathead formation in the Argenta district is believed to be about 500 feet.

TILDEN FORMATION

The Tilden formation which lies directly above the Flathead quartzite is composed principally of gray to pinkish-gray sandy limestone. The more sandy beds occur near the base. Several of the most important ore deposits of the Argenta region occur in this formation. It is best exposed northwest of the Ermont mine where the following section was measured:

Section of Tilden formation in canyon northwest of Ermont mine

Black thin-bedded Devonian limestone

	Feet
Muddy-colored sandy limestone. Beds 1 to 4 feet thick. Oolitic limestone bed, 8 inches thick, 10 feet up from base	102
Light-gray thin-bedded sandy limestone, Weathers buff	12
Massive crystalline bluish-gray sandy limestone	190
Fine-grained pinkish-gray limestone. Weathers tan	10
Gray sandy limestone	20
Thin-bedded white siliceous limestone	12
Gray sandy limestone with 6 outstanding beds. Mostly massive. Pebbly limestone at base contains angular quartz fragments mostly .5 millimeters across	75
	421

Flathead formation.

No fossils were found in the Tilden formation at Argenta. Trilobite remains and other fossils have been found, however, in the Upper Cambrian beds of the Three Forks region[62] and a number of fossils have been collected in the Philipsburg district.[63]

A sill of dark green andesite porphyry closely parallels the contact between the Flathead quartzite and the Tilden formation for some distance north of Rattlesnake Creek.

DEVONIAN SYSTEM

ERMONT FORMATION

The rocks assigned to the Devonian system include a series of limestone beds about 1,500 feet thick. This formation is termed the Ermont formation in this report and correlates fairly well with the Jefferson formation of the Three Forks region[64], although no shale beds corresponding in position with the Three Forks shale are present in the Argenta district. Mr. George H. Girty of the

62. Peale, A. C.: op. cit.
63. Emmons, W. H. and Calkins, F. C.: op. cit., p. 63.
64. Peale, A. C.: op. cit.

United States Geological Survey identified Devonian fossils from near the top of the formation. Cup corals have since been found in the basal beds just south of the Coolidge mine.

The color contrast between the Ermont beds and the underlying Tilden beds clearly marks the base of the Ermont formation. In addition, the basal beds contain twiglike bodies that give the rock a peculiar mottled appearance (Pl. XII, 4). The top of the Ermont formation is not definite but was fixed at a cherty horizon in rocks that resemble the Madison formation. Devonian fossils were found 230 feet below this horizon and Madison fossils a short distance above it.

Section of Ermont formation in vicinity of Ermont mine

Massive bluish-gray limestone with black chert beds

	Feet
Poor exposures but probably bluish-gray limestone. Devonian fossils from dense bluish-gray limestone bed at base	230
Poor outcrop. Probably gray shale	100
Dense light-gray massive limestone. Effervesces readily with dilute acid	30
Sill of dark-green andesite porphyry	80
Dark-colored magnesian limestone with buff-colored patches which may be due to alteration	248
Black shaly limestone beds similar to basal beds	80
Sill of dark-green andesite porphyry	228
Black shaly magnesian limestone with sugary appearance. Beds mostly less than 6 inches thick. Bed 2 feet thick with twiglike bodies 10 feet from base	490
	1,486

Tilden formation.

The Ermont beds strike about N. 20° E., and have a fairly constant dip of from 20° to 25° southwest near the Ermont mine. A few hundred feet eastward from the top of the section, however, there is considerable minor folding.

CARBONIFEROUS SYSTEM

MISSISSIPPIAN SERIES

Mississippian rocks are the most widespread of the consolidated formations in the Argenta area. Fossils indicate the presence of both Madison and Brazer beds, but these have not been differentiated. The Madison formation is made up largely of massive bluish-gray limestone but black chert becomes abundant toward the top of the formation. Fossils were found throughout but are most abundant in the upper horizons. The most common organic remains are white cylindrical crinoid stems. Some beds appear to be made up almost entirely of them. Cup corals are the next in abundance. They are shaped like a cornucopia and in cross section the vertical partitions resemble somewhat the spokes of a wheel. Other fossils occur in less abundance. The Brazer formation does not differ greatly in appearance from the Madison beds. It likewise includes numerous fossils and, like the Madison, contains beds made up almost entirely of crinoid stems.

No outcrop in the Argenta vicinity is suitable for the measurement of a section across the Mississippian beds, principally because of the faulting and folding. Faulting has caused an apparent thickening, particularly in the westerly part of the area. About 1,300 feet of Madison beds are exposed in the Melrose region[65] and about 1,200 feet were measured in the Bannack district.

PENNSYLVANIAN SERIES

The Pennsylvanian series embraces two distinct rock types in the Argenta district, a lower limestone formation and the quartzite and sandstone which overlie it. The lower Pennsylvania beds (Wells) resemble the Upper Mississippian (Brazer) beds in lithologic appearance and were not mapped as separate units. Fossil collections, however, indicate that both formations are present. Wells fossils were collected about 300 feet stratigraphically beneath the quartzite beds.

The Quadrant quartzite, which overlies the Wells formation, is exposed in several places within the map limits. The largest outcrops are in secs. 15 and 34 and a smaller remnant occupies a synclinal trough in sec. 20. Several other small patches have been mapped. Quadrant quartzite crops out continuously from the northern end of the Bannack district into the Argenta area and is everywhere similar in character. The lower beds are composed largely of white and pink vitreous quartzite which changes to sandstone toward the top of the formation. The upper part of the formation has been removed by erosion but the remaining beds are over 500 feet in thickness.

TERTIARY GRAVELS

The older gravel deposits of the Argenta district have been designated as "Upper Bench Gravels" and "Lower Bench Gravels" because of their relative positions. The "Upper Bench Gravels" reach an elevation of 6,800 feet. The lower terrace has been cut into the upper gravels and is best represented by the flat upon which the town of Argenta is built. Still more recently, Rattlesnake Creek has cut a deep channel into the lower bench and is now actively engaged in the process of degradation.

The formations underlying the terraces are not well exposed,

65. Richards, R. W. and Pardee, J. T.: op. cit.

although Rattlesnake Creek has cut through beds of sandstone and gravel east of Argenta. The surface of the terraces is nearly everywhere covered by a mantle of coarse, unconsolidated gravel. This loose material may have come from the weathering of the underlying beds or it may have been deposited by more recent streams. The superficial material is composed largely of rounded quartzite pebbles and boulders ranging from less than an inch to over a foot in size. They are mixed with some sand and black chert. The quartzite pebbles are predominantly pink or white and many show bedding plainly. Fossil remains found by Douglas[66] in beds similar to the terrace deposits indicate an Oligocene age.

QUATERNARY DEPOSITS

The Quaternary deposits are represented by recent stream gravels and glacial moraines. Rattlesnake Creek is depositing gravels in its present channel and, part of the superficial gravel covering the terraces may have been deposits by recent streams.

GLACIAL MORAINE

A well-developed glacial moraine has been deposited by a valley glacier at the mouth of the narrow canyon of Rattlesnake Creek in sec. 15 (Pl. XII, 1). Erosion has also left a small remnant of a moraine on a bench in the SE.¼ of sec. 15. These moraines represent the lower limits of the mountain glaciers that have moved down the present canyons. The boulders in the moraines consist mainly of granite or quartz monzonite with lesser amounts of quartzite and limestone. A moraine has been utilized to form a reservoir about a half-mile north of the map limits where Rattlesnake Creek cuts a narrow canyon through a glacial deposit.

INTRUSIVE IGNEOUS ROCKS

GENERAL FEATURES

The intrusive rocks of the Argenta district include quartz monzonite, granodiorite, andesite porphyry and dacite porphyry. The former two have been intruded into older rocks as large irregular bodies whereas the latter two occur as sills and dikes. The quartz monzonite and granodiorite rocks, like the intrusive rocks of the Bannack district, are, no doubt, genetically related to the "Boulder batholith"[67] and probably represent the high points or cupolas of a much larger body which erosion has not yet exposed to view. The most recent work indicates that the Boulder batholith

66. Douglas, Earl: Carnegie Mus. Annals, vol. 4, pp. 278-281, 1908.
67. Billingsley, Paul: Trans. A. I. M. E., vol. 51, pp. 31-56.

is of late Cretaceous or early Eocene age.[68] The andesite porphyry dikes cut the larger intrusive masses so that they were evidently intruded at least after the outer portions of the latter had cooled.

QUARTZ MONZONITE

Two exposures of quartz monzonite occur in the Argenta region. One mass crops out west of the town of Argenta and another is exposed near the southeast corner of sec. 17. Both outcrops resemble each other closely in lithologic appearance.

PETROGRAPHY

The rock is gray and medium to coarse-grained, but the light-colored minerals predominate over the dark ones. Quartz is clearly discernible in the hand specimens. The microscope shows the rock to be made up largely of light-colored minerals with biotite, hornblende and magnetite constituting the bulk of the dark minerals. The plagioclase crystals are lath-shaped and vary from 0.2 to over 2 millimeters in length and average about 0.5 by 1.0 millimeters in cross sections. They show very little alteration. Extinction angles show the plagioclase to be andesine (Ab_6-An_4) in composition. It constitutes about 45 per cent of the rock. Orthoclase is present in smaller amounts, estimated at 30 per cent. It occurs as tabular crystals or irregular masses and is characteristically zoned. Some of it is partly altered to sericite. Quartz is present as interstitial material and makes up about 15 per cent of the rock. The ratio of biotite to hornblende varies from place to place. In the sections studied the biotite was estimated at 7 per cent and the hornblende at about 3 per cent. The biotite commonly contains feldspars as poikolitic inclusions. Magnetite, titanite and zircon occur as accessory minerals. Magnetite comprises about 1 per cent of the rock, and apatite and zircon together constitute a still smaller amount.

GRANODIORITE

Two outcrops of granodiorite are exposed near the Dexter mine in sec. 17. They are separated by a narrow belt of altered limestone and are, no doubt, a continuous body beneath it. The exposures aggregate about a quarter of a square mile. No direct relationship was found between the granodiorite and the quartz monzonite. It seems probable, however, that they have had a common origin and that the latter represents a stage of deeper erosion. Some assimilation near the top of the cupolas may account for the lower silica content in the granodiorite.

68. Knopf, Adolph: U. S. Geol. Sur. Bull. 527, p. 34, 1913.
Stone, R. W. and Calvert, W. R.: Ec. Geol., vol. 5, pp. 551-557, 662-669, 744-764, 1910.

PETROGRAPHY

The granodiorite is a medium to fine-grained rock in which the light and dark minerals appear to be in about equal proportions. No quartz can be observed in the hand specimens. Thin sections show the rock to be composed principally of plagioclase, orthoclase and hornblende with little or no biotite. The boundaries of the mineral grains tend to coalesce, especially in the dark finer-grained phases. This same characteristic is marked in the quartz monzonite near the contacts with limestone. The lath-shaped plagioclase crystals have an average cross section of 0.5 by 0.2 millimeters and a maximum extinction angle of about 25 degrees which would classify it as andesine (Ab_6-An_4). The plagioclase is decidedly zoned and shows considerable alteration, particularly along fractures. Andesine constitutes about 50 per cent of the rock. Orthoclase is present as interstitial material and as rounded grains, some of which are over 2 millimeters across. The larger orthoclase crystals show zoning but it is not as marked as in the quartz monzonite. The amount present is estimated at 20 per cent. Green hornblende makes up about 25 per cent of the rock. It is variable in size and shape but averages about 1.3 by 0.4 millimeters in cross section. Basal sections show very perfect amphibole cleavage (Pl. XIII, 2). The hornblende commonly includes grains of magnetite and feldspar and some of it is partly altered to chlorite and limonite. In general, however, the hornblende is fairly free from alteration. Quartz makes up less than 5 per cent of the rock and occurs as interstitial grains. Magnetite constitutes about 3 per cent and titanite and zircon less than 1 per cent of the rock.

ANDESITE PORPHYRY

The andesite porphyry intrusions in the Argenta district occur chiefly as sills although some andesite porphyry was found to occur as dikes. The largest outcrops of andesite porphyry are exposed near the Ermont mine, in secs. 26 and 35. The Ermont intrusives have the general characteristics of sills and in places they clearly cut across the bedding planes of the limestone. It is possible that the sills north of Rattlesnake Creek, in sec. 24, are the northward extensions of the intrusives near the Ermont mine. They are similar in appearance although, in general, the Rattlesnake sills are more intensely altered. A. H. French found andesite porphyry in a tunnel on the Tuscarora property. Thin sections show some of the dikes across the creek from Argenta in sec. 29, to be andesite porphyry, although most of these dikes usually contain considerable quartz.

PETROGRAPHY

Two types of andesite porphyry prevail in the Argenta region. One type is a dense grayish-green rock that does not show marked porphyrytic characteristics in hand specimens and the other is a grayish-green rock with very evident lath-shaped phenocrysts of black augite in a dense groundmass. No doubt, both have come from a common source.

The microscope shows the former to be comprised of a microcrystalline groundmass with phenocrysts of altered plagioclase and orthoclase and alteration remnants of ferromagnesian mineral (Pl. XIII, 3). Magnetite grains are disseminated throughout the entire rock. Extinction angles indicate that the plagioclase has the composition of andesine. Most of it is wholly or partly altered to calcite and sericite and the orthoclase largely to sericite. Only the alteration remnants of the ferromagnesian minerals remain. They consist chiefly of chlorite, talc, and limonite. Patches of calcite occur throughout the rock. Quite a little secondary silica is present in the groundmass. Little primary quartz was noted. Although alteration makes the classification of the rock uncertain, evidence indicates that it is an andesite porphyry.

The andesite porphyry with the abundant augite phenocrysts is not so highly altered as the dense rock. Feldspar and augite phenocrysts occur in a microcrystalline groundmass composed largely of small lath-shaped feldspars and constitute about one-third of the rock. The plagioclase phenocrysts range in length from about 0.5 to 1.0 millimeters and the average augite crystal is about 1.0 millimeters long by 0.3 millimeters wide. Occasional augite phenocrysts are over 1 centimeter in length. The plagioclase feldspars have the composition of andesine and are considerably altered but many still retain the twinning striae. Orthoclase phenocrysts are less abundant than andesine. The augite is light-green in ordinary light and most of the crystals are twinned. Calcite occurs along fractures but, in general, the augite is only slightly altered. It commonly includes magnetite and irregular patches of groundmass material. Augite constitutes about 50 per cent of the phenocrysts. Magnetite constitutes about 2 per cent of the rock. Little or no quartz was noted in the thin sections. This rock is classified as an augite-andesite porphyry.

DACITE PORPHYRY

A number of dikes cut the quartz monzonite west of Argenta.

They are similar in appearance to andesite porphyry, some contain considerable quartz. They range in color from almost white to grayish-green, depending upon the degree of alteration. All contain some quartz but only those containing it in appreciable amounts are termed dacite porphyries. All are probably phases of the same intrusive.

PETROGRAPHY

The dacite porphyry is almost white to grayish-green in color and is noticeably porphyritic. Phenocrysts of bleached feldspar and glassy quartz are clearly visible in the hand specimens. Small patches of limonite give the rock a spotted appearance.

Thin sections show the rock to contain phenocrysts of feldspar, augite and quartz in a felted groundmass. The phenocrysts make up about one-third of the rock. Except for the presence of more quartz, the dacite porphyry does not differ greatly in appearance from the andesite porphyry. Both phenocrysts and groundmass are considerably altered but the twinning striae are still visible on the plagioclase crystals. All of the quartz phenocrysts observed were rounded in outline and most of them showed marked embayments (Pl. XIII, 4).

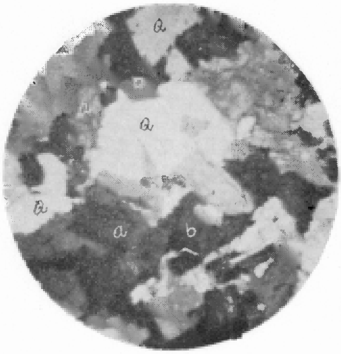
RHYOLITE PORPHYRY

A highly altered igneous rock occurs across the creek from Argenta. It is a white porous rock with numerous casts, some lined with limonite. The rock has a sugary appearance and is characterized by a high porosity. The square shape of the cavities and the fact that many are entirely free from limonite indicates that they may once have been occupied by pyrite. This rock is said to contain gold in small amounts. It is tentatively classified as an altered rhyolite porphyry because of the light color and the presence of quartz phenocrysts.

CONTACT METAMORPHIC EFFECTS

The most intense metamorphic effects have been observed in the limestone beds near their contact with granodiorite and quartz monzonite. Granodiorite has intruded shale beds near the Dexter mine but the contact effects are much less noticeable than in the limestones near by. The shales have been silicified and are rust-brown in color—apparently due in part to the weathering of included iron-bearing minerals.

The most common effects in the limestones are recrystallization and garnetization. Vesuvianite, epidote and tremolite were observed in association with the garnet but epidote is much less com-



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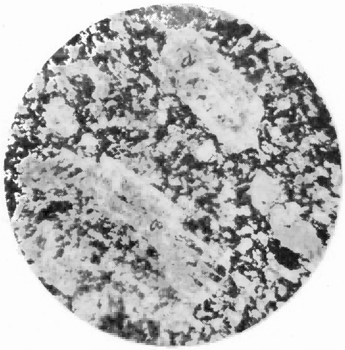

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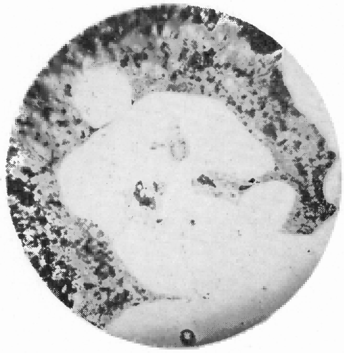

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PHOTOMICROGRAPHS OF INTRUSIVE ROCKS FROM THE ARGENTA DISTRICT

1. Quartz monzonite from N.E.¼ of sec. 20. Quartz (white), biotite (b), andesine (a). Polarized light. Magnification 23 times.
2. Diorite from N.W.¼ of sec. 17. Andesine (a), hornblende with well-developed amphibole cleavage (h), black mineral in center of hornblende is magnetite, irregular black patch is hornblende at extinction. Polarized light. Magnification 28 times.
3. Andesite porphyry from the larger intrusive body in N.E.¼ of sec. 35. Shows partly altered andesine crystals in silicified microcrystalline groundmass. Polarized light. Magnification 28 times.
4. Dacite porphyry dike from N.W.¼ of sec. 29. Shows microcrystalline groundmass and partly resorbed quartz crystal (white). Ordinary light. Magnification 14 times.

mon than in the Bannack district. The most widespread contact metamorphic product is a dense greenish-yellow greasy-appearing rock. It is well-developed around the northern border of the quartz monzonite mass across the creek from Argenta. Thin sections show this rock to be composed largely of isotropic garnet. In addition to the garnet, the ore bodies around the contacts afford further evidence of introduced material.

The granodiorite and quartz monzonite also show a difference near the limestone contacts. They are darker-colored and noticeably finer-grained. Thin sections show a lower quartz content and a marked tendency to coalescence of the feldspar grains. Analyses of the intrusive rocks near the limestone contacts in the Bannack district show an increase in lime, magnesia and iron.[69]

The contact metamorphic effects of the andesite porphyry are much less intense than those of the granodiorite and quartz monzonite. Silicification of the limestone beds is the most evident result. The andesite porphyry itself is denser in appearance near the contact.

EXTRUSIVE IGNEOUS ROCKS

RHYOLITE PORPHYRY

A patch of dense light-gray porphyritic rock occurs near the southeast corner of sec. 36. It contains in a highly altered groundmass, many phenocrysts of angular quartz and numerous patches of calcite, which may be the decomposition product of feldspar. Because of the abundant quartz and light color this rock is classified as a rhyolite porphyry.

TRACHYTE PORPHYRY

A dense gray rock with well-developed phenocrysts of orthoclase occurs on top of the Quadrant quartzite in the southeast corner of sec. 34 and a similar appearing rock was found on the top of the ridge in the NE.¼ of sec. 22 and another outcrop on the high ridge near the center of sec. 14.

The microscope shows the rock to be composed of orthoclase phenocrysts, aggregating about 25 per cent of the rock, in a dense, partly silicified groundmass. Very little primary quartz was noted. The orthoclase phenocrysts are slightly altered to sericite.

69. Idem, p. 16.

DEFORMATION

GENERAL FEATURES

The structure of the Argenta region is complex and only the broader features are shown on the map and sections. The sedimentary beds have been compressed into a series of folds with a northerly trend. In places these folds have been broken and displaced along fault surfaces. Two distinct types of faults have been developed. East-west compressional forces have caused older rocks to be shoved over younger rocks along thrust faults, and later, other forces resulted in the further breaking of the formations by normal faults. The faults are made evident by the cutting out of beds, the severe folding and tilting that interrupt their continuity and in places by the direct observation of the fault surfaces.

The deformation in the Argenta district is merely the local expression of a great system of folding and overthrust faulting which is known to extend from Canada into Utah. It has been described in the Philipsburg district by Calkins,[70] by Richards and Pardee[71] in the Melrose district, by Richards and Mansfield[72] in Idaho, and by Willis[73] in northern Montana, and in the Bannack area elsewhere in this report.

PRINCIPAL FOLDS AND FAULTS

The most prominent structural feature is the broad anticlinal fold which occupies much of the Argenta area and extends to the north beyond the limits of the map. It is around this fold that the best records of the sedimentary rocks are available. The fold is not intact but has been broken by faults. A smaller anticlinal fold separates two small synclines in the eastern part of the district. North of Argenta the eastern syncline is occupied by Quadrant quartzite which erosion has not entirely removed. Another less conspicuous fold is developed near the western border of the mapped area. Minor folds are abundant. Intense minor folding can be observed from the road just northeast of the southwest corner of sec. 19.

Thrust faults account for much of the deformation. One has shoved Madison beds over Quadrant quartzite in the western part of the area and another fault of less displacement has moved Spokane beds into contact with Tilden limestone in the vicinity of

70. Emmons, W. H. and Calkins, F. C.: U. S. Geol. Sur. Prof. Paper 78, 1913.
71. Richards, R. W. and Pardee, J. T.: U. S. Geol. Sur. Bull. 780, 1925.
72. Richards, R. W. and Mansfield, G. R.: U. S. Geol. Sur. Bull. 577, 1914.
73. Willis, Bailey: Geol. Soc. of America, Bull. vol. 13, pp. 305-52, 1902.

the Midnight mine. A major normal fault trending north and south with several splits has dropped upper Madison beds into contact with Ermont limestones in the western part of the area. Numerous small normal faults were noted in many places but because of the scale these are not shown on the areal map.

Folding evidently took place before intrusion of the igneous rocks in the Argenta district because they can be observed cutting across the folds. As the late Tertiary lavas have been folded and faulted also, it is evident that there were at least two periods of deformation or else the process was continuous. The most intense folding probably occurred in the Cretaceous period. Billingsley[74] has placed the beginning of the deformation in western Montana in the late Cretaceous.

ORE DEPOSITS

HISTORICAL SKETCH OF MINING

After most of the available claims had been staked in the Bannack district numerous prospectors spread over the nearby hills in search of new "diggings". Some placer ground was discovered near Argenta but it was not until the spring of 1865 that A. M. Esler of Bannack discovered the Legal Tender, the first important mine in the Argenta district.[75] The ore was rich but as the shipment charges to Swansea, Wales, the nearest smelter, consumed most of the profit, Mr. Esler decided that same year to build a smelter, the first in the State of Montana. It had a capacity of six tons per day.[76] Subsequently a refining furnace or cupel was added because the freight charges prohibited the shipment of the lead. Mr. Esler sold his smelter to S. H. Bohm and Company of Helena, Montana, who operated it as a custom plant. They also acquired the Ferdinand and Brownell mines. A second smelter was built in 1866 by Tootle Leach & Co. of St. Louis, for the treatment of the Tuscarora ore. This smelter was purchased by W. A. Clark, in 1869. The third smelter was built in 1867 by the St. Louis & Montana Mining Co., principally for the treatment of the Iron Mountain ore. It was afterward owned and operated by E. S. Ball, who in turn sold to the P. J. Kelly Placer, Quartz & Reduction & Smelting Co. A fourth furnace, constructed of inferior fire-brick, melted upon the first heating.

For a number of years the various smelters continued to treat

74. Billingsley, Paul: Trans. A. I. M. E., vol. 51, pp. 31-56, 1915.
75. French, G. W.: Mining Truth, Spokane, Wash., p. 23, April 3, 1930.
76. Browne, J. Ross, Mineral Resources of the United States for 1866. Montana, pp. 310, 1868.

ore mainly from Argenta, though some ores from the Blue Wing and other district were treated also. In later years the ores have been hauled to the railroad at Dillon and shipped to various smelters and mills in Montana and Utah.

Like those in the Bannack district, the mines at Argenta have been worked at intervals in recent years. In 1928 the Ferdinand, Iron Mountain and Brownell shipped considerable ore, although little activity was evident during the summer of 1929. In general, the activity follows the trend of the metal market.

Lead and silver are the most important metals produced in the Argenta district. The gold production is next in importance and considerable copper and zinc have been mined. Of 30 or more mines and prospects in the district, 15 account for nearly all the production. Seven account for most of the lead and silver produced, four for most of the gold, two for much of the copper and one for most of the zinc.

Practically all the production has come from the lode mines. Some placers were worked but no figures are available as to the amount of gold produced. Many of the lode mines were operated before statistics were recorded so that the production figures for a number of them are merely estimates based largely upon the size of the underground excavations and the grade of the ore. Messrs. A. H. and George French, who are familiar with the history of most of the mines, have contributed much information. The total production of the Argenta district is estimated at $1,500,000.

CLASSIFICATION OF THE ORE DEPOSITS

Ore deposits are commonly classified for descriptive purposes according to their metal content; according to the enclosing wall rock; according to their genesis; or according to the forms of the ore bodies. A combination of the latter three is used in the following description and comparison of the deposits:

1. Pipe-like ore bodies in limestone:
   Tuscarora
   Gov. Tilden
   Florida
2. Tabular ore shoots along bedding planes in limestone:
   Legal Tender
   Spanish mine
   Fraction (in part)
   Wooley " "
   Coolidge " "
3. Tabular ore shoots along fissures in limestone:
   Brownell
   Mauldin
   Anaconda

Coolidge (in part)
Goldsmith " "
Fraction " "
Wooley " "

4. Contact deposits in limestone:
   Iron Mountain
   Argenta Mining Company
   Ermont
5. Deposits along fissures or shear zones in quartzite:
   Carbonate
   Ground-hog
   Goldfinch (in part)
   Lookout
6. Deposits along fissures in shale:
   Golden Era
   Rena
   Midnight
   Goldfinch (in part)
   Dexter
   Gladstone
7. Ore shoots along veins and shear zones in quartz monzonite:
   Ferdinand
   Jack Rabbit
   Copper Bell
   Bella

PIPE-LIKE ORE BODIES IN LIMESTONE

Pipe-like ore bodies in limestone have been the source of much of the lead and silver produced in the Argenta district. The deposits of this type usually consist of pipe-like shoots which commonly split and rejoin as they are followed along the dip of the limestone beds. The mineral-bearing solutions, no doubt, followed lines or zones of weakness, but control fissures are usually not obvious. The shoots are usually continuous except where they are interrupted by faults. Prescott[77] has clearly described the underlying principles of deposits of this type in Mexico. In prospecting this type of deposit the ore should be followed as closely as possible for even with a thorough knowledge of the stratigraphy and the principles involved it is extremely hazardous to run long exploration tunnels for the intersection of the ore shoots.

TUSCARORA MINING AND SMELTING CO. PROPERTY

The Tuscarora Mining and Smelting Co., property includes two of the most important mines in the Argenta district. The group embraces the Tuscarora, Gov. Tilden, Florida, Wooley, Fraction, Fraction Placer, Reform, Burleigh, and Spring claims, all in sec. 18. Most of the work and production has been confined to the first two. The B. F. White estate of Dillon, Montana, owns one-half interest

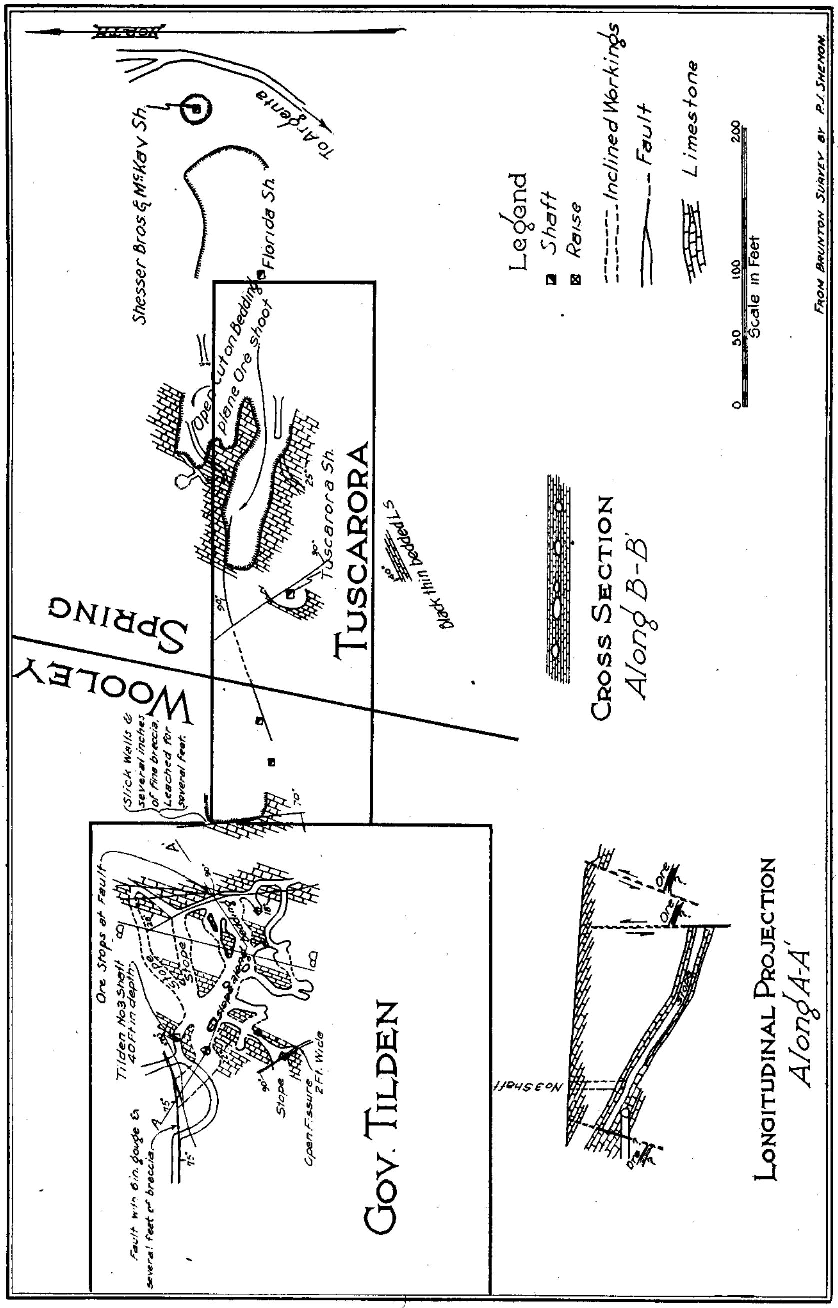
77. Prescott, Basil: Eng. and Min. Jour. vol. 122, pp. 246-253, 289-296, 1926.

and the Anaconda Copper Mining Co., one-half interest in the Gov. Tilden, Florida, Wooley, Fraction, Fraction Placer, Reform, Burleigh, and Spring claims. The Anaconda Copper Mining Co., has the entire ownership in the Tuscarora.

The Tuscarora was discovered in 1865, by Amede Bessette and Wash Stapleton. The Gov. Tilden was discovered a short time later. W. G. Gallagher and LaFayette Scott acquired the mine from the locators and extracted considerable ore in the late 'seventies. W. A. Clark bought LaFayette Scott's interest in the early 'eighties and continued to run the smelter partly with ore from the Tuscarora and partly with custom ores. During this time the incline was run from the Tuscarora into the Florida, where a fault is said to have terminated the ore. Clark shipped several cars of ore from the Tuscarora and the Gov. Tilden in 1895-96, following which Gallagher made several shipments. Frank Benton leased the property in 1898-99, and shipped 195 tons of ore from a pipe-like shoot in the Gov. Tilden which ran south and west along the bedding and then turned and crossed over the incline. None of his workings are now open. During the period from 1914-21, Messrs. A. H. French and W. G. Graeter shipped ore and some concentrates from the Gov. Tilden, which had a gross value of $30,000. The concentrates were made by jigging the dumps. With the exception of two cars washed by McKay and Ross these are the only concentrates that are known to have been shipped from the property. The size of the excavations indicate that the Tuscarora and Florida produced from 5,000 to 7,000 tons of ore and the Gov. Tilden from 2,000 to 3,000 tons. These figures are in accordance with estimates made by A. H. French.[78]

Most of the ore from the Tuscarora claim was extracted from open cuts although considerable ore is said to have been taken out of the incline extending from the Florida shaft which ran directly beneath the open cuts. This incline, which is no longer accessible, connected with the Tuscarora shaft to the west and with the Shesser Bros. and McKay shaft to the east. Old maps from the files of W. A. Clark show several stopes just north of the Florida shaft. This shaft was 80 feet deep, the Shesser Bros. and McKay shaft 130 feet, and the Tuscarora shaft about 120 feet deep. All of the ore from the Gov. Tilden claim was mined by underground methods. About 300 feet of inclined workings were opened on ore and, in addition, about 600 feet of exploration drifts were driven.

78. Personal communication.



MAP OF THE TUSCARORA AND GOV. TILDEN MINES

The ore deposits at the Tuscarora and Gov. Tilden mines are in the gray crystalline Tilden limestone just beneath the contact with the black thin-bedded Ermont limestone. The limestone beds strike, in general, N. 20° E., and have an average dip of about 25° SE. The principal ore shoots were pipe-like in cross section and followed the bedding planes of the limestone. The inclined working beneath the open cuts indicates that there are at least two productive horizons. The shoots, although commonly splitting around blocks of limestone, have a definite east-west trend. This trend may be controlled by fissures, but, if so, they are not clearly defined. The ore is displaced by a series of normal faults, striking north and northeast. These faults have steep dips which vary from 70° to 90° and are characterized by well-defined walls, usually several inches of gouge and, in some cases, by several feet of brecciation. The Gov. Tilden ore shoot is terminated on its eastward extension by one of these faults which strikes north and dips about 90°. The black limestone bed with the twig-like bodies serves as an excellent horizon marker for structural correlation.

The ore was almost entirely oxidized, although residual patches of galena still remain along the walls of the deposits. A. H. French[79] describes the ore from the Tuscarora as a "sand carbonate" which he says was reported to assay as high as 60 per cent lead and 60 ounces silver. The average metal content was probably considerably lower. The ore was shipped directly to the smelter without concentration and with very little sorting. Ore shipped from the Gov. Tilden in 1898-99 gave gross smelter returns of $27.60 per ton. The average quotations for lead and silver for those years were $4.12 and 59c, respectively. Assays indicate that the ore carried $3 to $5 per ton in gold and that the ratio of silver was less than one ounce to the unit or per cent of lead. On the basis of this ratio, these shipments must have averaged about 20% lead. This figure is in accordance with the metal content of the ore shipped from the Gov. Tilden by Messrs. A. H. French and W. G. Graeter at a later date.

Practically no commercial ore is exposed in either the Tuscarora or Gov. Tilden at the present time. Some low-grade jasperoid wall-rock remains but it has no commercial value at present. A careful study of the normal faulting should lead to the discovery of segments of the faulted ore bodies. Although the ore shoots occasionally split around limestone blocks, there is little doubt that

79. Personal communication.

they were continuous on the dip of the limestone beds, except where displaced by faults.

No exact measurements were secured on the throw of the faults so that the position of the ore indicated as probable in the longitudinal projection through the Gov. Tilden ore body is arbitrarily placed (Pl. XIV). Any work contemplated in these properties should be carefully planned and all available sources of information should be consulted in order to determine the position and extent of the older workings.

The Wooley claim overlaps parts of the Gov. Tilden and Tuscarora claims. Practically all of the work on the Wooley has been confined to a 30-foot inclined shaft and an open cut along a fissure striking N. 10° W., and dipping about 90°. Most of the ore occurred along the fissure although some mineralization is evident along the bedding planes. The production from the Wooley has been small.

The Florida claim is situated south of the Gov. Tilden and overlaps much of the Tuscarora. It is 1,500 feet long by 550 feet in width and was located with the long direction almost at right angles with the Tuscarora. Most of the work has been confined to the Shesser Bros. and McKay shaft, the Florida shaft, and the incline mentioned above. Some pits, a shallow inclined shaft and a short tunnel have been opened near the southern boundary of the claim. The production, which could not have been large, came mostly from the incline south of the Tuscarora.

The Fraction is situated south of the Florida and Wooley and overlaps portions of each. Practically all of the work has been confined to the extreme southwest corner of the claim where two shafts, one inclined, and several cuts have been opened. Drifts have been run from the bottom of the shaft. Small stopes indicate that the property has produced some ore. The ore apparently was along bedding planes in limestone and also along a well-defined fissure cutting across the limestone beds. The ore resembles that from the Tilden and probably had about the same metal content.

Little or no work has been done on the Fraction Placer, Burleigh, Reform or Spring claims. The buildings are located on the last-named claim.

TABULAR ORE SHOOTS ALONG BEDDING PLANE IN LIMESTONE

Only one important property in the Argenta district, the Legal Tender, has produced ore solely from tabular ore shoots along bedding planes in limestone. The mineral-bearing solution may have followed fissures in its course upward, but development work has thus far shown the ore in the Legal Tender to occur only along the bedding planes. The ore follows one horizon but is not continuous along it for it pinches out laterally and is displaced by faults. In prospecting ore deposits of this type, unless there are good reasons to suspect that other bedding planes are mineralized, it is advisable to follow the horizon of known production.

LEGAL TENDER MINE

The Legal Tender mine, which is located in the SE.¼ of sec. 24, was discovered in 1865 by A. M. Esler of Bannack. It was one of the first silver-lead mines discovered in Montana and had the distinction of supplying ore for the first smelter built in the state.[80] The ore was at first shipped to Omaha by ox-teams, from there by train to New York and thence across the Atlantic to Swansea, Wales. George M. Brown bought the property from Mr. Esler and leased to Cornelius Bray, who mined ore worth $10,000 from a small pocket. Bray also shipped some ore from the Colin McDonald property, just south of the Legal Tender. George Dart of Dillon and J. A. Brown of Melrose later acquired an interest in the property. It is now owned by James Eddy, a nephew of George M. Brown, and the J. A. Brown estate. The production of the Legal Tender is estimated at $150,000.[81]

The ore occurs along the bedding in Tilden limestone not far beneath the contact with the Ermont formation. The beds in the vicinity of the mine strike N. 15° E., and dip 45° S. Most of the ore was mined through an inclined shaft over 100 feet in depth which is now only partly accessible. The stopes average about four feet in width, but the fresh appearance of the walls suggests that the ore body may have been narrower. The ore was a soft "sand carbonate" which ran about 300 ounces in silver per ton. A few residual patches of galena remain along the walls near the termination of the ore shoots.

SPANISH MINE

A small ore shoot was mined on the Spanish claim about 500 feet north of the Legal Tender ore body. The workings consist of a shallow shaft and some small stopes. The property is owned by the Anaconda Copper Mining Company. The ore occurs along a bedding plane in Tilden limestone which here strikes N. 30° E., and dips 48° S. The ore appears to be along the same bed as the Legal Tender ore shoot, but it has been offset 50 feet to the west

80. French, George W.: Mining Truth, Spokane, Wash., April 3, 1930, p. 23.
81. French, A. H., personal communication.

by steeply-dipping faults which strike N. 60° W. The production of the Spanish Lode has been small.

TABULAR ORE SHOOTS ALONG FISSURES IN LIMESTONE

Tabular ore shoots along fissures in limestone have accounted for a considerable part of the production in the Argenta region and therefore warrant consideration. The ore bodies are found along steeply dipping fissures and are usually not far distant from igneous rocks. The fissures are well-defined and can be easily traced. The mineral-bearing solution of course, followed the fissures. Cross fractures are common but most of them appear to bear no relation to the ore deposition. The junction of two splits in the Anaconda vein tended to localize the ore and it is probable that pre-mineral cross-fractures were also effective. To that end, no important cross-fractures were noted in the short time spent in the examination of these mines but a more thorough examination of these mines would probably reveal them. The most significant structural feature noted, and one that might assist in the search for ore, is the "slickensided" fissures and slump fractures developed in the vicinity of the ore bodies. It seems quite clear that slumping is an important post-mineral process which should be a significant aid to prospecting along the fissures.

BROWNELL MINE

The Brownell claim is long and narrow and lies partly in sec. 19 and partly in sec. 30. It was located in 1865 by Harry Griffiths, and was the second mine discovered in the Argenta district. Considerable ore was shipped to the St. Louis & Montana smelter in the late 'sixties and early 'seventies by E. S. Ball and others. S. H. Bohm & Co., of Helena bought the Brownell in 1871, and shipped ore to their smelter. A. J. Shoemacher shipped 1,000 tons of ore to the St. Louis & Montana smelter during the years 1882-85. The property lay idle until 1890, when lessees took out ore worth several thousand dollars. J. E. Oppenheimer of Butte, Montana, bought the property a short time later and it is still owned by the Oppenheimer estate. James and George Knapp shipped 20 cars from the west vein in 1922 and George D. Spafford has since shipped eight cars from the same vein. The production is estimated at 5,000 tons.

The Brownell ore bodies were worked through a shaft which was sunk to a depth of 150 feet, but which is now open only for 110 feet. Part of the old workings are no longer accessible. The principal working, the 80-foot level, is open for but 50 feet south of the shaft. The ore occurs in shoots in limestone along a well-defined fissure which strikes north and dips 80° W. The vein splits on its downward course into the east and west ("Knapp stope") veins. A short shoot about 15 feet wide was mined at the junction of the splits on the 80-foot level. Stopes with an average width of three feet and a south rake extend to the surface on the north side of the shaft. The "Knapp stope" pinched and swelled but averaged about two feet in width. The hanging wall is slickensided and highly altered, whereas the foot-wall is usually a hard crystalline limestone with numerous vugs. The "slickensided" walls have irregular rolling surfaces and in places show copper carbonate.

The ore was almost entirely oxidized and was predominantly a "sandy" lead carbonate. Hard jasperoid ore is found near the walls. The ore shipped from the Knapp stopes averaged 28 per cent lead, and shipments by Mr. Spafford averaged 31 per cent lead, 6 ounces per ton in silver, 0.8 per cent copper and 90 cents per ton in gold.[81] A small car of ore from the top of the large stope on the 80-foot level contained 11 per cent copper.

MAULDIN MINE

The Mauldin property includes two claims, the Rittenhouse and the Louis Philip, which are located in the NW.½ sec. 29. James Mauldin located the property and did considerable prospecting. He and E. S. Ball had an early-day lawsuit over ownership which was decided in favor of Mauldin. The Mauldin estate has recently sold the property to Frank Wilson. Four shafts and a long tunnel are the principal openings, but only part of them are now accessible. The deepest shaft was sunk in limestone to intersect the quartz monzonite contact, but was abandoned because of the heavy flow of water. No ore was encountered. Another shaft was sunk to a depth of 30 feet on a 50° incline and then 20 feet vertically. Ore was encountered near the bottom and about 150 tons were mined. The Eaton shaft, which was named after Professor Eaton, who was probably the first mining geologist in the district, encountered an ore body at a depth of 100 feet. The shaft was sunk on a fissure striking N. 10° W., which dipped 80° W. The wall rock next to the ore body is strongly "slickensided" and brecciated material resembling an old filling occupies fractures near the top of the stope. The slickensides and brecciated material are believed to have formed from slumping due to the shrinkage which resulted from the removal of material during oxidation of the sulphide ore. Smith Ball mined the ore and shipped it to the Stapleton smelter. No

81. Spafford, George D., personal communication.

figures are available as to the production from this ore body, the old stope is partly filled and none of the old smelter records are available. Soft lead carbonate was the principal ore mineral. The silver content was about 3 ounces per ton and the ore carried about $1.00 to the ton in gold. The ore resembles that of the Brownell and probably had a similar metal content, although the average copper content is said to have been higher.

ANACONDA MINE

E. S. Ball located the Anaconda property after he had lost his lawsuit with James Mauldin. He sank a 30-foot shaft and encountered an ore body, and later he sank a working shaft 60 feet deep. The ore was treated at the St. Louis & Montana smelter. Before the ore body was worked out the property was sold to the P. J. Kelly Placer, Quartz & Reduction & Smelting Company, who continued to ship ore to the smelter. This concern finally went into receivership. The property was later acquired by J. E. Oppenheimer of Butte, Montana.

The ore occurred as an irregular tabular body along the Mauldin fissure, a short distance north of the Mauldin incline. The ore was largely a soft lead carbonate with a low silver content. The property produced about 500 tons of ore.

COOLIDGE MINE

The Coolidge mine, formerly known as the St. Joseph, was located in the early 'seventies by Thomas E. Tuttle, and is situated in the SE.¼ of sec. 18. It was taken over by E. S. Ball who shipped considerable ore to the St. Louis & Montana smelter. The Golden Era Company then sank an inclined shaft to a depth of 170 feet, but made no shipments. Alfred Graeter shipped 200 tons of ore from the dumps in 1898. The property was later located by Messrs. George W. and A. H. French, who are the present owners.

The ore at the Coolidge mine is enclosed in the basal beds of the Ermont formation, and for the most part followed along a well-defined fissure. Near the surface the fissure parallels the bedding but steepens and leaves the bedding at a depth of 40 feet. A sill of andesite porphyry forms the hanging-wall of the ore to the point where the vein steepens. The ore shoot was about 10 feet high and from two to seven feet wide. It extended for about 100 feet beneath the surface and raked to the south at an angle of 35°. The stopes indicate a production of about 500 tons.

The ore is largely oxidized but contains residual patches of galena. The average metal content is about 10 per cent lead, 20 ounces in silver, and $1.80 in gold per ton.

GOLDSMITH MINE

The Goldsmith mine is in the NE.¼ of sec. 30. It was located in the late 'eighties by Thomas Judge and Thomas Fox, who made no shipments. Mark Bray relocated the property and shipped a little ore, but soon sold a half interest to a Mr. Smeed. Mr. Bray's half interest was shortly afterward purchased by W. A. Clark, who mined most of the ore produced. J. E. Oppenheimer of Butte, Montana, bought the Smeed interest, which is still owned by the Oppenheimer estate. In the transfer of 1928, the Anaconda Copper Mining Company acquired the Clark interest. A. H. French[82] estimated the production of the Goldsmith at 300 tons, which is corroborated by the size of the stopes.

Access to the property is gained through three short tunnels and a shallow incline. One tunnel is 120 feet long, another 60 feet and a third 25 feet long. The second and third and the incline intersect the ore body, but the first has encountered only brown-stained marble. The ore was mined in underhand stopes which are now, for the most part, closed.

The ore, found along a well-defined fissure in a coarse-grained white marble, strikes N. 80° W., and dips 70° N. The ore is predominantly hard and siliceous and is irregular in width, although it is never wide. The principal minerals of commercial importance are chrysocolla, malachite, tenorite, cuprite, copper pitch, native copper and gold. Near the ore bodies the marble is stained a chocolate-brown color, a fact which should prove a helpful guide in prospecting for further ore, particularly as the outcrops are covered by gravel. According to Mr. French,[83] his shipments from the Goldsmith had a gross value of $75 per ton.

CONTACT DEPOSITS IN LIMESTONE

Two types of contact deposits in limestone are found in the Argenta district. Silver-lead deposits at the contact between quartz monzonite and Upper Mississippian limestones are represented by the Iron Mountain and the Argenta Mining Company's property, and gold deposits at the contact between andesite porphyry and limestone are represented by the Ermont mine. The Iron Mountain mine which belongs to the first group has been one of the important producers in the district. The Argenta Mining Company's property

82, 83. French, A. H. personal communication.

was not sufficiently developed, in 1929, to determine its worth. The Ermont mine is probably the newest mine in the Argenta district, and has a tonnage of low-grade gold ore partly tested. The work on the property is being directed toward proving a low-grade ore deposit large enough to justify a mill.

IRON MOUNTAIN MINE

The Iron Mountain mine was discovered in 1869, and was worked by the St. Louis & Montana Mining Co., and later by E. S. Ball, who purchased both the mine and smelter from the original company. Mr. Ball sold the property to P. J. Kelly Placer, Quartz & Reduction & Smelting Company, and it was finally acquired by Oppenheimer estate. No figures are available as to the production of the Iron Mountain mine, but the size of the stopes indicates that considerable ore was produced. Much of the ore was shipped to the local smelters in the early days. The mine is located in the NE.¼ of sec. 30.

Two tunnels and two inclined shafts are the principal openings into the Iron Mountain mine. The longer incline started in quartz monzonite, intersected the limestone at 100 feet and continued down the contact another 200 feet. Near the bottom the shaft becomes very flat. The upper part of the incline is no longer accessible but the stopes can be entered through the lower tunnel. The lower tunnel starts near the level of Rattlesnake Creek and runs northward about 700 feet to connect with the longer inclined shaft. A considerable head of water, most of which comes from near the contact, flows from this tunnel. Another incline, called the No. 1, is caved near the surface but access can be gained to the old stopes through the Knapp tunnel, which is about 250 feet long.

The ore in the Iron Mountain mine is found in limestone at the contact with quartz monzonite. The contact is usually sharply marked by a band of white altered material from six inches to a foot wide. The ore shoots, where observed, were more or less tabular bodies paralleling the contact but varying considerably in size both vertically and horizontally. The stopes on the 100-foot level of the main incline have a maximum width of about 20 feet. These stopes are said to have reached the surface. Steeply-dipping fractures appear to have localized the ore in the vicinity of the Knapp stope. The No. 1 incline intersects the same fissure that cuts the most productive part of the Knapp ore body. The enrichment along the north-south fissures may not have been primary.

The ore is almost entirely oxidized although residual patches of galena and unaltered pyrite cubes are scattered through the ore on the lower levels. The richer ore is massive brown cerussite and limonite with patches of dark-gray anglesite and irregular green disseminations of malachite. Malachite stains are found throughout the ore and usually a band of it is found along the hanging wall of the deposits. Dark gray anglesite of a greasy luster is the predominating ore mineral among the specimens collected from the lower level. Native copper is found in the lower stopes and was observed in lumps as large as 6 inches across. It is mixed with cuprite and malachite. The average metal content[83] of the ore shipped from the Knapp stope was 18 per cent lead, 12 oz. silver, and $3.00 in gold per ton. Three cars shipped from the lower workings had a similar metal content.

The contact in the vicinity of the Iron Mountain mine rarely carries commercial ore. Nevertheless the contact merits careful prospecting. The heavy flow of water at the contact should be seriously considered before attempting work below the level of the lower tunnel.

ERMONT MINE

The Ermont mine property includes 31 claims which lie, for the most part, in sec. 30, T. 6 S., R. 11 W. The claims were located in 1926 by D. V. Erwin and W. J. Corbett, who prospected the ground until 1927, when the property was bonded to the Standard Silver & Lead Company of Spokane, Washington. This company dug several trenches and sank several shallow shafts and one incline to a depth of 110 feet. A drift over 100 feet long was run southward from the bottom of this shaft. In 1929 the property was bonded to James Kidwell of Portland, Oregon, who was operating the property during the period the field work was being done for this report. Some ore of good grade has been shipped from the Yellow Bird claim where the ore occurs along a fissure in limestone. But the main prospecting at the Ermont mine has been directed toward developing a tonnage of low-grade ore sufficient to justify the construction of a mill.

Andesite porphyry has been intruded into the Ermont limestone in the vicinity of the mine. It tends to follow the bedding planes of the limestone, but in some places clearly cuts across the bedding. Two sill-like bodies of andesite porphyry crop out east of the mine but, as exposed at the surface and in the prospect holes, these appear to join and form a nearly circular southern boundary.

83. Knapp, George, personal communication.

The ore is found in limestone at the contact with the andesite porphyry, which is usually highly altered and may be brown or almost white in color. Next to the ore the limestone is also apt to be stained a brown color and to have a peculiar mottled appearance, which has caused it to be locally termed "zebra limestone". Fracture zones in the vicinity of the mine strike north of east. The limestone in the vicinity of these fractures has been highly silicified and in places carries gold and silver. The ore in the vicinity of the main shaft also is frequently siliceous, though it is more often a soft porous non-siliceous material. Large irregular bodies of a low-grade ore have been prospected near the surface. A sample of the oxidized ore from the lower tunnel assayed 25 oz. in silver and $2.00 in gold per ton. This sample, which was taken by the writer, was higher in silver and lower in gold than the average.

ARGENTA MINING CO. PROPERTY

The Argenta Mining Co. property consists of five patented claims and six unpatented claims. The company was organized in 1928 by Judah Judah of Argenta, G. V. Elder and Ralph Rowlands of Dillon, Montana. The upper tunnel, which intersects an oxidized ore body, is 60 feet long and a winze 55 feet deep has been sunk at the end of this tunnel. A lower level, 100 feet below the upper level, has been driven 180 feet toward the ore body exposed in the upper tunnel but had not reached it in 1930. All of this work has been done on the Sir Walter Scott claim.

The ore occurs at the contact between quartz monzonite and limestone. All the limestone except a small outcrop is covered with the "upper bench gravels" on the surface. The ore is entirely oxidized and consists largely of a soft porous limonite said to carry considerable gold. Bismutite (hydrous basic bismuth carbonate) is found with the oxidized material. Some ore has been shipped.

DEPOSITS ALONG FISSURES AND SHEAR ZONES IN QUARTZITE

The deposits along fissures and sheer zones in quartzite have not accounted for much of the production in the Argenta district. The Carbonate has been the most important mine of this group, but thus far the ore has not been continuous. Deposits of the Groundhog type where quartz and gold have been introduced into brecciated quartzite along a well-defined fault fissure warrant more attention, provided the sampling proves the ore to be of commercial grade.

CARBONATE MINE

The Carbonate mine is in the NW.¼ of sec. 18, and was located by Phil M. Brown in 1890. He shipped about 10 cars to the local smelters and then sold the property to the St. Louis & Montana Co., who sank a shaft to a depth of 75 feet near the south end-line of the Rena claim. The property was relocated by W. M. McMannis and Alfred Graeter, and was finally acquired by A. H. French and George W. French of Argenta, who are the present owners. McMannis and Graeter mined some ore but practically all of the production is credited to Mr. Brown. The main shaft is 90 feet deep and several shallower shafts have been sunk besides the 75-foot shaft sunk by the St. Louis & Montana Co.

The ore is found in a well-defined vein in Flathead quartzite. The vein strikes N. 70° W., and dips 70° S., at the surface but reverses to a northerly dip at 40 feet depth. A grayish-green andesite porphyry dike follows along the hanging-wall of the ore and in one place a segment of the vein is offset 50 feet to the west. The ore occurs in lenses and is broken and associated with gouge. Most of the ore shipped was a dark-gray lead carbonate.

GROUNDHOG MINE

The Groundhog mine is southeast of the Carbonate, in sec. 18. A. H. French and George W. French located the property in 1895, and have shipped one car of ore which assayed $20 per ton in gold. Shallow shafts have been dug along the vein at intervals for over 1,100 feet, and a shaft 100 feet deep has been sunk near the portal of the principal tunnel which is 75 feet long.

The ore occurs in Flathead quartzite along a fault fissure which strikes N. 30° W., and dips 80° N. The quartzite has been brecciated for a width of three feet along the fault, and this brecciated material has been re-cemented with quartz carrying gold and pyrite. The vein is strongly marked by slickensides, and horizontal striations are very well defined.

DEPOSITS ALONG FISSURES IN SHALE

Deposits along fissures in shale have probably produced ore valued at $200,000. They have been the source of a considerable part of the gold production of the district as well as much of the lead and silver. Because of the nature of the wall-rock, most of the underground openings are now caved, and little information can be gained regarding the underground geological conditions. A considerable expenditure would, in most cases, be necessary to recondition the old workings for a development program.

GOLDEN ERA MINE

The Golden Era mine, which is in the NE.¼ of sec. 13, was discovered in 1880, by W. D. Booth. It was afterward re-located by A. I. Watts, but neither locator shipped ore. George W. French and Henry Laughlin bought the property in 1884 and shipped a small tonnage to local smelters. The St. Louis & Montana Mining Co. purchased the mine and shipped considerable ore besides taking out about 1,000 tons of second-class material which was later milled by a Mr. Taylor. The prospect is now owned by the J. F. Imbs estate.

An inclined shaft 300 feet deep is the principal entry into the mine. The shaft starts in thin-bedded quartzite but enters green and red shales at a depth of 10 feet. The shaft is now closed 20 feet below the collar. The ore occurs in a well-defined vein, striking about N. 5° E., and dipping 60° S., at the surface. The shale beds dip at flat angles to the south in the vicinity of the mine. The vein has been stoped to the surface near the shaft and was from one to four feet wide. The best ore consisted principally of galena and pyrite in a quartz gangue and, although water was encountered at a depth of 60 feet, the ore was partly oxidized on the bottom level. Five carloads of the ore had an average metal[84] content of 25 per cent lead, 21.54 oz. silver, and 4.35 oz. gold per ton.

RENA MINE

The Rena mine is in the NW.¼ of sec. 18, and was located by Homer Lawrence and John Miles in 1884. They sank a shaft to a depth of 70 feet and shipped considerable ore to smelters in Omaha, Nebraska. They sold the property to the St. Louis & Montana Mining Co., who sank a shaft to a depth of 300 feet and made a crosscut to the vein. The St. Louis & Montana Co. shipped only a small amount of ore, but lessees later made some shipments. A. H. French acquired the property in 1922. He estimates a production of 250 to 300 tons.

The ore occurred as a shoot 60 feet long in a well-defined vein which is in flat-dipping Spokane beds. Caved stopes indicate that the vein had a strike of about N. 40° W., and a dip of about 60° S., but according to Mr. French[85] the vein turned and dipped to the north near the bottom of the deeper shaft. A fault is said to have terminated the ore shoot on the south. The primary ore minerals include principally pyrite and galena with gold and silver in a

84. From smelter returns given to A. H. French by J. F. Imbs.
85. French, A. H., personal communication.

quartz gangue. Much of the sulphide ore on the dump is in brecciated quartzite, which has been recemented with quartz and sulphide minerals. Very little oxidation was found below water level at 40 feet. Shipments by Mr. French[86] assayed 20 per cent lead and 2.0 oz. in gold per ton, but the oxidized ore shipped by Lawrence and Miles is said to have had an average gold content of about 5 oz. per ton.

MIDNIGHT MINE

The Midnight mine is in the SE.¼ of sec. 13. The mine was located by Robert Wing in the early 'seventies. He sank a shaft to a depth of 60 feet, but made no shipments. H. R. Paddock and Fred Randolph later relocated the property and shipped some ore. A. V. Clark bought the mine and worked it for several years. He shipped considerable ore and then sold to the Monida Trust Co., which still retains the ownership. The property has probably produced[87] 50 cars of ore with a gold, silver and lead value of about $40 per ton.

The principal openings at the Midnight mine consist of five shafts, one 265 feet deep, another 180 feet, one 150 feet, one 80 feet, and a fifth 60 feet deep. The ore in places has been stoped to the surface. Most of the workings are now inaccessible. The vein is in flat-lying Spokane shales and quartzites and strikes N 40° W., and dips 70° N., at the surface. It varies considerably in width and in some places splits around "horses" of shale. The principal primary ore minerals are galena and pyrite in a quartz gangue. Oxidation has extended downward for a distance of about 200 feet.

GOLDFINCH MINE

The Goldfinch property, which includes five claims, is in the NW.¼ of sec. 24. The original location was made in the late 'eighties by A. V. Clark. He dug a number of surface pits, sank one shaft to a depth of 60 feet and shipped several cars of ore. The property was purchased in 1890 by George W. French and A. H. French, who are the present owners. Since 1890 owners and lessees have worked the mine intermittently. The total production is about 250 tons.

An inclined shaft at the north end of the Dolphin claim is the principal entry into the mine. Stopes have been opened on the north and south sides of the shaft for a distance of 120 feet. The ore is in shoots along a well-defined vein in Spokane shale. A highly altered porphyrytic dike follows along the vein. The dike is irregu-

86, 87. French, A. H., personal communication.

lar in width and the walls are considerably "slickensided". The vein varies from about one to seven feet in width. The ore is in shoots in the vein and is partly oxidized even on the lower level. The primary minerals are principally pyrite and galena in a quartz gangue. Shipments of the ore ran from 0.8 to 1.20 oz. in gold, from 7 to 15 oz. in silver per ton, and about 7 per cent lead.

A tunnel has been run for 200 feet along a shear-zone in Flathead quartzite on the south end of the Dolphin claim. The quartzite is sheared and brecciated for a width of 12 feet. No shipping ore has been encountered in the quartzite.

DEXTER MINE

The Dexter mine is in the NW.¼ of sec. 17. The nearest shipping point, Bond, is on the Oregon Short Line railroad, seven miles to the west. The property consists of six claims and was being operated in 1929 by the Continental Divide Mines Company, under the direction of W. J. Cushing. The old workings are no longer accessible but according to Mr. Cushing[88] the ore was exceptionally high-grade in silver. William Dudley shipped most of the ore in the early 'eighties but considerable work was later done by the St. Louis & Montana Co. Following this very little work was undertaken until 1929, when the Continental Divide Mines Co. started an exploration program.

Several shafts were sunk, one by the St. Louis & Montana Co., to a depth of 317 feet. It is connected with the surface by a tunnel 260 feet long. A crosscut from this tunnel enters the old stopes, now inaccessible. The principal ore deposits were found in veins in shale not far from the contact with granodiorite. Almost the entire length of the tunnel passes through brecciated rocks cut by a number of well-defined fault surfaces. The old stopes are situated to the southwest of the tunnel. Fragments of the ore on the dump are composed mainly of partly oxidized galena, pyrite and tetrahedrite.

Some contact metamorphic deposits in limestone have been explored in the flat northeast of the St. Louis & Montana Co. shaft. The limestone is garnetized and contains much recrystallized calcite. In 1929 the principal operations consisted in sinking the Galena shaft, which is about 2,000 feet southeast of the old mine. The shaft had been sunk to a depth of 60 feet on a vein striking S. 20° E., with a dip of 70° S. The enclosing rock is largely garnetized limestone with granodiorite along the hanging-wall at a depth of 20 feet.

88. Cushing, W. J., personal communication.

The vein had widened from a few inches near the surface to about two feet near the bottom of the shaft. The ore consists mostly of galena, pyrite and some tetrahedrite. It is partly oxidized on the bottom level.

GLADSTONE MINE

The Gladstone and Argenta claims comprise the Gladstone group. They are in the SE.¼ of sec. 13, T. 6 S., R. 11 W., and were located in the late 'eighties, the Gladstone by Mark Bray and the Argenta by James McKay. The Argenta produced 150 tons but the Gladstone has had little or no production. The J. E. Morse estate of Dillon, George W. French of Argenta, and the Amede Bessette estate of Bannack, Montana, own the property.

A shaft 200 feet deep has been sunk on the Argenta and a few drifts were run from it. The principal working on the Gladstone claim is a 50-foot shaft. Neither shaft is now accessible. The vein, which strikes N. 45° W., and dips 80° N., is in the shale and thin-bedded quartzite of the Spokane formation. Much brecciated material cemented with calcite is found on the dumps of the Argenta claim; the vein is said to have entered "clay" near the bottom. The principal value of the ore was in gold, although it carried considerable lead. The ore from the Argenta claim carried $50 per ton in gold, but that in the Gladstone shaft was of much lower grade. A vein five to six feet wide and carrying $12 per ton in gold is said to exist at the bottom of the Gladstone shaft.

ORE SHOOTS ALONG VEINS AND SHEAR ZONES IN QUARTZ MONZONITE

The most recent notable production in the Argenta region has come from the Ferdinand mine, a deposit in quartz monzonite. The ore was of shipping quality and occurred in a good-sized deposit. Prospecting is made difficult at present by the condition of the shaft. Little water was found in the Ferdinand, but water became a serious problem in the lower level of the Jack Rabbit mine.

FERDINAND MINE

The Ferdinand group is in the SE.¼ of sec. 29, and consists of 11 small claims 100 by 200 feet in size. The mine was discovered in 1868 by Thomas Harrison, who shipped some ore to Swansea, Wales; later the Ferdinand ores were treated at local smelters. Mining ceased when the sulphide ores were reached and the property lay idle for 20 years, until the St. Louis & Montana Mining Co. were able to treat the sulphide ore by giving it a preliminary roast. The mine supplied ore to the Argenta smelters for two years at this period. LaFayette Scott acquired the property from the St. Louis Co., and it was owned by his estate until 1909, when his administrator sold it to the Argenta-Dillon Mining Company. This company opened up the shaft and shipped some ore. In 1925 G. A. Decker and Roy B. Herndon of Dillon secured a lease and stoped ore from the 80-foot level. In 1927-28 Mr. Decker and Harry Renz of Argenta shipped 17 cars from the same ore body. Theodore Nelson, William D. Ross and Martin Sorensen of Dillon now own the Ferdinand.

A shaft 115 feet deep is the principal entry into the mine. One level was opened northwest of the shaft at a depth of 80 feet, and another near the bottom of the shaft. The ore occurs near the contact of quartz monzonite with Mississippian limestone along a shear zone which strikes N. 30° W., and dips 90°. The stopes are now caved in but during the writer's visit to the property in 1927, about 12 feet of ore was exposed in the face of the drift. It was not solid ore but sulphide material alternating with bands of soft, highly altered and partly mineralized quartz monzonite. Part of the material was shipped as it was mined and part of the material was sorted. A carload of the better grade material contained 22.1 per cent lead, 15.5 per cent zinc, 1.18 per cent copper, 6.1 per cent iron, 8.5 oz. silver, and 0.01 oz. gold per ton. A carload of unsorted ore contained 10.4 per cent lead, 12.5 per cent zinc, 0.54 per cent copper, 6.0 per cent iron, 4.1 oz. silver, and 0.01 oz. gold. The principal minerals in the sulphide ore are galena, sphalerite, chalcopyrite and pyrite. Polished sections show the presence of pyrargyrite in small amounts. Chalcopyrite is disseminated through the sphalerite as oriented grains, some less than 1/400 of a millimeter across but with an average diameter of about 1/200 of a millimeter. The ore is only slightly oxidized at a depth of 80 feet. Because of the clay-like nature of the wall-rock next to the ore, considerable difficulty was experienced in preventing caves.

JACK RABBIT MINE

The Jack Rabbit mine, which has the distinction of being the deepest mine in the Argenta district, is in the NW.¼ of sec. 29, about one-half mile northeast of Argenta. It was discovered by J. P. Fletcher in the 'seventies, on a small outcrop of the ore. An inclined shaft was sunk to the 140-foot level. The Conda Mining Company operated the property from 1915 to 1919, and sank a shaft to a depth of 300 feet, besides running 200 feet of crosscuts on the 200 and 300 levels to the Jack Rabbit and Copper Bell veins. Water was encountered at 90 feet, and at a depth of 300 feet two pumps were used to handle the flow. The shaft is now closed. The Conda Mining Company shipped about 15 cars of ore.[89]

The ore is in quartz monzonite not far from the contact with limestone. The ore from the lower levels consists principally of chalcocite and pyrite in a quartz gangue. The ore shipped by George D. Spafford assayed 16 per cent copper and 32 oz. silver per ton.[90]

COPPER BELL MINE

The Copper Bell claim is half a mile north of Argenta, and west of the Jack Rabbit. It was located in the late 'seventies by J. P. Fletcher, and later relocated by A. J. Shoemacher, who did most of the work on the property. Mr. Shoemacher let the property go by default and it was relocated by Alexander Pilon, who sold it to J. E. Oppenheimer estate and William B. Orem of Butte. The production has been small, probably not over one car.

The Copper Bell vein is opened by a shaft 112 feet deep and has been prospected for a short distance along the strike on three levels, the 45, the 60 and the 112-foot levels. The shaft is now filled to the 60-foot level. The ore occurs along a vein in quartz monzonite near the limestone contact. The vein, which has "slickensided" walls, strikes N. 5° E., and dips about 80° SE. The ore is entirely oxidized on the 60-foot level but is said to be largely sulphides on the lower level. The oxidized ore minerals include cuprite, chrysocolla, malachite, copper pitch, and limonite. One car of ore shipped by Mr. Shoemacher ran 10 per cent copper and carried some silver and gold. Oxidized ore at the surface assays $20 in gold per ton.

BELLA MINE

The Bella mine is on the outskirts of Argenta on the south side of Rattlesnake Creek. It was located by A. H. French in 1906, and was called the Whopper. In 1907, the Argenta Mining Co., of Dillon, sank a shaft to a depth of 200 feet and made a crosscut 20 feet to a vein striking north. The vein was solid sulphide material consisting of pyrite and a little galena and sooty chalcocite. The vein starts in quartz monzonite, but encounters limestone at 50 feet.[91] The outcrop contains cuprite, malachite, tenorite, and limonite. The vein is about three feet wide at the surface, but mineralization extends for several feet on either side of the vein.

89, 90. Spafford, George D., personal communication.
91. French, A. H., personal communication.

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