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GEOLOGY AND ORE DEPOSITS
OF THE
ROYAL JOHN AREA
Swartz District, Grant County, New Mexico
by
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ILLUSTRATIONS

ABSTRACT

A small area in the vicinity of the Royal John mine was mapped in detail on a large scale to supplement an earlier small scale map of the Swartz district.

The Royal John area is underlain by Paleozoic limestones, shale, and sandstone except for the extreme western part which is covered by

rhyolite extrusives; a few andesite dikes cut the sedimentary rocks. The Royal John area occupies a horst between the north-trending Mimbres and Owens faults. In the horst the sediments dip gently to the south. They are cut by a number of small faults, most of which tend to parallel the Mimbres and Owens faults. The most important ore deposits are found as replacements in thin beds of white limestone and black chert which form a mappable unit in the Ordovician Montoya limestone. Mapping indicates that these deposits lie close to faults. Ore is also found in some of the fault zones, notably along the Sunshine fault. At places in the Royal John area a bed near the base of the Montoya carries disseminated mineralization but no deposit of economic importance has been found in it. The ore minerals are sphalerite, galena and chalcopyrite; gangue minerals are quartz and calcite with small amounts of pyrite.

Recommendations are made for diamond drilling in five parts of the area.

INTRODUCTION

The Royal John mine is in the southern part of the Swartz mining district on the western slope of the Mimbres Mountains in eastern Grant County, New Mexico. The Swartz district is 25 miles east of the Central mining district and is reached by a graded dirt road which leaves the Mimbes River road a mile south of Sherman. The Royal John mine is about 14 miles by road northeast of the Mimbres River.

Very little is known of the early prospect work in the Royal John area. Some of the first operations undoubtedly were in the area now known as the Discovery workings. Albert Owen, the present owner, acquired the property in 1914. During World War I the Black Range Mining Company operated the mine and shipped a small tonnage of lead-zinc ore. During this period 9 churn drill holes were drilled to the north of the Sunshine cut. A steam-operated jig mill was used to concentrate the ore. The mine was operated by the American Smelting and Refining Company between 1927 and 1929. The mill was improved by the addition of diesel electric power, tables and flotation equipment, but the lack of adequate crushing equipment is said to have limited the efficiency of milling operations. Mining was resumed by Albert Owen early in 1942. In June 1942 the mill burned and since then hand sorted ore has been hauled to the Blackhawk mill at Hanover, New Mexico, a distance of 35 miles. In June and July 1943 the Peru Mining Company of Silver City held an option on the property and drilled 12 diamond drill holes. The deepest hole, No. 1, bottomed at 708 feet; all the other holes were shallow. This prospecting was to the north of the ore showings in the West cut and to the west of the No. 3 working.

During the spring and summer of 1943 a Geological Survey field party 1/ mapped the entire Swartz district on air photographs, scale

1/ R. L. Griggs, H. C. Wagner, S. P. Ellison

1 inch equals 667 feet. Certain areas were mapped in detail by planetable and alidade, and an area was recommended to the Bureau of Mines for exploratory drilling. Bureau of Mines drilling project 15-115 was begun at the Grandview mine in September 1943. The Bureau of Mines later requested a more detailed geologic study at the Royal John mine and recommendations for prospecting. The field work was done between June 26 and July 28, 1944. A. E. Weissenborn of the Geological Survey

spent 10 days in the field during which time all the underground and some of the surface mapping was done. The Peru Mining Company of Silver City, J. H. Taylor, President, Harrison Schmitt, Consulting Geologist, furnished a transit survey of the area and the logs of 12 diamond drill holes in the area. Messrs. Albert and John Owen, owners of the Royal John mine, gave much valuable information and assistance during the course of the field work.

GEOLOGY

The Royal John area is underlain by Paleozoic limestones, shale and quartzitic sandstone, these sediments being cut by an andesite intrusive. The lithology, thickness, and age of the sedimentary units known to be present in the area are given in Table I.

Sedimentary Rocks

El Paso limestone: Some question exists as to the upper limit of the El Paso limestone. For mapping purposes in the present investigation the top of a 15 to 20 foot quartzitic sandstone bed has been used as the top of the formation. Actually this sandstone may belong to the overlying Montoya limestone. The total thickness of the El Paso is not known in the Royal John area, but the Peru Mining Company's D.D.H. No. 1 penetrates 575 feet of sediments below the top of the above mentioned quartzitic sandstone (Plate II, Section A-A'). It is believed that this hole ended in El Paso, failing to reach the underlying Bliss sandstone of Cambrian age.

Table I
Formations Present in Royal John Area

System	Series	Formation	Thickness (feet)	Lithology
Carboniferous	Pennsylvanian, Middle & Upper	Magdalena limestone	365	Interbedded gray limestone and shale with some irregular chert that weathers to a greenish brown. Limestone and chert conglomerate at base.
Carboniferous	Pennsylvanian, Lower	Magdalena limestone	165	Interbedded gray limestone and shale with some irregular chert that weathers to a greenish brown.
Carboniferous	Pennsylvanian, Lower	Magdalena limestone	170	Massive, fine grained, dark gray limestone containing large nodules and lenses of gray chert.
Carboniferous	Pennsylvanian, Lower	Magdalena limestone	12	Thin dark gray blocky shale.
Carboniferous	Mississippian	Lake Valley limestone	60	Coarsely crystalline, light gray massive crinoidal limestone with large white chert nodules.
Carboniferous	Mississippian	Lake Valley limestone	60-70	Very fossiliferous bluish gray, dense limestone with thin chert beds.
Devonian		Percha shale	200	Black fissile shale with hard siliceous siltstone beds near base. Fossiliferous black calcareous shale between segments of Owens fault in Cold Springs Canyon.
Ordovician	Upper	Montoya limestone	160	Light gray, massive fine grained limestone, apparently unfossiliferous, with beds and nodules of light colored gnarly chert. May include some Fusselman (Silurian) limestone at top.
Ordovician	Upper	Montoya limestone	60	Thin bedded fossiliferous black chert and white limestone. Very fossiliferous limestone bed at top. Ore bearing zone in the Royal John area.
Ordovician	Upper	Montoya limestone	50	Coarse grained, dark gray massive limestone containing rounded and polished sand grains. Twenty foot bed containing large black chert concretions near middle.
Ordovician	Lower	El Paso limestone	575+	Light to medium gray, fine grained limestone, apparently unfossiliferous. Fifteen to twenty foot quartzitic sandstone bed at top.

Montoya limestone: The Montoya limestone has been divided into three mappable units. These units are shown on Plate I, as are also traceable horizons within two of the units. One of these horizons is in the lowermost member at the base of a zone containing large black chert concretions. This horizon was used by Griggs and Ellison 2/ as the base of the Montoya limestone in the Royal John area. However, the limestones that carry the chert nodules are very similar to the non-cherty limestones that directly underlie them, even to the presence of polished sand grains. In the present report, therefore, the base of the Montoya has been drawn at the top of the quartzitic sandstone bed. A horizon about 10 feet above the sandstone has been weakly mineralized at a number of places in the area.

The middle member of the Montoya limestone, 60 feet thick in the Royal John area, is of great economic importance for the principal replacement deposits have been formed within it. The top of this thin bedded black chert and white limestone member has been taken as a 3 to 6 foot bed of fine grained grey limestone containing abundant well preserved Upper Ordovician (Richmond) fossils. Where ore is present the thin bedded member is nearly always overlain by a variable thickness of fine grained, white, friable calcareous sand. This material seems to be a product of the action of the ore bearing solutions on limestone, but

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2/ Griggs, R. L. and Ellison, S. P., Geology and Ore Deposits of the Swartz District, Grant Co., N. M.: Unpublished report, U. S. Department of the Interior, Geological Survey, March 1944 this type of alteration does not invariably indicate the presence of ore; it has been observed above the thin-bedded limestone where the beds are not mineralized.

The upper member of the Montoya contains zones of gnarly chert in fine-grained grey limestone. The top of such a zone of gnarly chert is shown on Plate I. More detailed mapping of these horizons would perhaps show the presence of small faults which because of uniform lithology are not now discernable. The gnarly zones in the area north and west of the Sunshine cut contain small amounts of sulfide mineralization associated with minor fractures. The upper part of the gnarly zone may be the Silurian Fusselman limestone which Darton reports as 40 feet thick in the Deming area south of the Mimbres Mountains. As the interval just below the Percha shale is apparently unfossiliferous in the Royal John area, it has been mapped as one unit and shown on Plate I as Ordovician Montoya gnarly chert and limestone.

Percha shale: The Percha shale is very distinctive; its base is easily mapped as it lies on the resistant upper member of the Montoya limestone. Only the lower 50 feet of the shale has been recognized in the Royal John area although a considerably greater thickness must be present between the branches of the Owens fault between coordinates 9,500 and 11,000 North. In small outcrops the Percha shale may be confused with shale intervals in the lower part of the Magdalena limestone.

Lake Valley limestone: The Lake Valley limestone does not crop out in the mapped area, but must underly the Magdalena limestone at no great depth on the east side of the Owens fault. As shown by the mapping of Griggs and Ellison, the Lake Valley is exposed both north and south of the Royal John area. As the formation is mineralized in a number of districts in New Mexico, it is a potential ore horizon in the Swartz district.

Magdalena limestone: The Magdalena limestone crops out on the east side of the Owens fault. The exact part of the Magdalena section exposed in the area is not known but it probably is in the lower half of the formation. A limestone conglomerate in the Magdalena limestone at an elevation of 8028 feet and coorindates 10,924 N. and 10,917 E. is believed to be about 350 feet above the base of the Magdalena by comparison with sections measured by Griggs and Ellison elsewhere in the Swartz district.

Igneous Rocks

Griggs and Ellison have recognized two types of extrusive igneous rocks and three types of intrusive igneous rocks in the Swartz district. Only one of the extrusive and one of the intrusive igneous rock units are present in the Royal John area. Both units are considered by Griggs as Tertiary in age.

Extrusive rocks: Rocks identified by Griggs as rhyolite and quartz latite are present west of the Mimbres fault in the Royal John area. The mapping of the Mimbres fault in the area is based on the contact of cherty Montoya limestone with the pink, purple and brown weathered igneous rocks. In part, this fault contact may be shown too far to the east on Plate I as small pieces of quartzite float were found in places on the hillside above and to the west of the mapped contact. The rhyolite and quartz latite unit is considered by Griggs to be the youngest of the extrusive rocks in the area. The thickness of the unit is not known but is probably greater than 500 feet as it extends southwest to the Mimbres River.

Intrusive rocks: A greenish grey slightly porphyritic rock, identified by Griggs as andesite, crops out on the south side of Cold Springs Canyon as a dike striking N. 50° E.; it is exposed along the tramway leading to the Sunshine cut and along the road leading to the West cut from the mine camp. Three other small semi-circular to elliptical areas of andesite have been mapped to the west of the termination of the dike. The dike crosses the Discovery Workings fault without interruption at a point where the fault has a displacement of about 100 feet. This indicates clearly that the dike was intruded after the faulting.

Structure

Folding: Folding in the Royal John area has been relatively unimportant. Such folding as can be demonstrated is directly related to known faulting, the folds being due to drag. The average dip of the sediments between the Mimbres and Owens faults varies from five to ten degrees in a southerly direction.

Faulting: Faulting is the dominant type of structure. The Ordovician and Devonian rocks in the central part of the Royal John area occupy a horst between the Mimbres fault on the west and the Owens fault on the east. Within the area these two faults trend about N. 20° W. Other observed faults probably resulted from the failure of the limestone during the development of the Mimbres and Owens faults. Little is known about the dip and throw of the major faults. On the basis of topographic expression, Griggs regards the Mimbres fault as dipping steeply to the west and the Owens fault as dipping steeply to the east, but the evidence is not conclusive. Actually the faults are not single breaks but are spread over zones of appreciable width. The zone of faulting is well shown to the west of the Owens fault between coordinates 9,500 and 11,000 North where a block of Percha has ben mapped between branches of the Owens fault. The Mimbres fault has been shown by a dashed line which represents the contact between the extrusive rhyolite and limestone. As mentioned in the discussion of the extrusive rocks, the western edge of this fault zone may be farther uphill (west) than is mapped, as fragments of white quartzite were found at an elevation of 7,700 feet.

Discovery Workings Fault: The Discovery Workings fault trends a few degrees west of north and seems to die out or split into a number of smaller unmappable faults to the north. Its dip from surface exposures varies from 38 to 68 degrees to the east. However, a more reliable dip of 30 degrees to the east is shown by connecting the surface trace of the fault and the intersection of the fault zone as mapped in the Mill Adit. The low eastward dip is indicated by the swing of the fault trace where it crosses Skull Creek. The fault cannot be followed with any degree of accuracy across the Cold Springs

Canyon and is therefore shown by a dashed line in this area as is the extension beyond the No. 3 working.

The Discovery Workings fault apparently has been an important channelway for rising mineralizing solutions. The thin bedded middle member of the Montoya limestone has been replaced in the Discovery and No. 1 workings and it is believed the fault was the feeder for the solutions which formed the replacements deposits in the West cut and the No. 3 workings. The fault was shown as dying out to the southward on Griggs' map, but it may join the Mimbres fault zone. The fault as shown on the cross sections will intercept the Owens fault at depth and is probably subsidiary to it.

Sunshine fault: The Sunshine fault along which ore has been mined in the Sunshine cut has also been a channelway for ore bearing solutions. In the open cut the fault is approximately vertical but to the north, sections through the mine show a dip of 80 degrees to the east. As the west side of the Sunshine fault is downthrown, it is a reverse fault. The change in dip of the fault from vertical to east-dipping may be the result of the branching of the fault towards the northeast. Northward the Sunshine fault intersects the Owens fault and southward Griggs has traced it for almost 2,000 feet before it dies out.

Minor unnamed faults: A number of generally northwest-striking faults have been mapped near the bottom of Cold Springs Canyon between coordinates 8,500 and 9,600 North. They are related to the Mimbres fault and if exposures were better, probably many more could be mapped between the bottom of Cold Springs Canyon and the Mimbres fault. A number of northeast striking faults in this area are believed to be the result of unequal stresses developed during displacement along the northwest striking faults.

Minor faults of small displacement are exposed in the West and New cuts. They appear to have influenced the localization of the ore in these areas. These faults are of such small displacement that they would be overlooked in ordinary surface mapping. West of the West cut the dip of the upper member of the Montoya limestone increases markedly. It is believed that these small faults are adjustments to the drag developed between the Mimbres fault and the Discovery Workings fault.

Unmapped faults: It is doubtful if all the faults crossing the heavily wooded hillsides have been mapped. It is particularly difficult to trace faults through areas in which the Percha shale is the surface formation. The shale weathers to a smooth slope making the exact location of contacts difficult or impossible. Other unmapped faults probably exist in the area between the Sunshine fault and the Discovery Workings fault. This area shows a number of shears and fractures striking about N. 50° W. carrying some sulfide mineralization. Since the exact location of these faults is unknown, they can not be shown on the various cross sections; instead their presence is indicated by notes. It is probable that the northwest course of the underground stream which drained the limestone cavern opened by the Discovery Workings is along one of these fault zones.

ORE DEPOSITS

Ore minerals: Ore minerals at the Royal John mine consist of sphalerite (ZnS) and galena (PbS). Chalcopyrite ($CuFeS_2$) at some places is abundant enough to make hand sorting of the copper-rich ore profitable. Silver in the ore averages between 1 and 2 ounces per ton. Gangue minerals are quartz and calcite. Much of the sphalerite in the West cut is of the light lemon yellow variety; the galena in this area is localized along certain zones of fracture and is not abundant. Small amounts of pyrite (FeS_2) occur with the ore. The ore bearing beds at the surface usually have a very characteristic dark brown color from the oxidation of the small quantities of included iron and manganese minerals.

Types of deposits: Two general types of deposits occurs in the Royal John area. In the first type the mineralization occurs in fault zones and does not extend any great distance into the surrounding rock. This type of deposit is common where the rock adjacent to the fault is other than the thin bedded member of the Montoya limestone. Examples of this type of deposit are in the winze level of the Sunshine cut, in the shaft at 8,710 N. and 10,620 E., and in the small mineralized areas west of Cold Springs Canyon and near the old mill site.

The second type of deposit occurs as replacement in the thin bedded member of the Montoya limestone but is not localized along faults although faults are present in the immediate area and were no doubt channels for the ore bearing solutions. The best example of a replacement type deposit is in the West cut area and the No. 3 working to the east. Here the ore beds appear to form a small anticline in the footwall of the Discovery Workings fault. The ore solutions have replaced the thin-bedded limestone some distance along the beds from the small faults that cut the anticline. The anticlinal structure is probably the result of opposing drag along the Discovery Workings and Mimbres faults. The small faults exposed in the West cut might well be explained by the failure of the thin bedded Montoya limestone during the development of the anticline and the larger faults. The best grade of ore at the Sunshine cut and also at the No. 1 working was replacement type ore in the thin bedded Montoya limestone adjacent to prominent faults.

The ore occurrences at the Sunshine cut, Discovery workings, No. 1 working, West cut and No. 3 working are in upthrown blocks or horsts. It is possible that economic mineralization in the Royal John area may be limited to the upthrown blocks. However, the thin bedded member of the Montoya limestone does not crop out in the down faulted blocks adjacent to extensively mineralized areas and consequently the most favorable ore horizon has not been tested.

One horizon in the lower member of the Montoya limestone a short distance above the underlying quartzitic sandstone bed carries traces of replacement type ore. This bed is mineralized in the shaft just north of Skull Creek; on the road just to the west of the compressor house; and in the No. 1 diamond drill hole of the Peru Mining Co. The replacement of this horizon in the Royal John area does not seem to make commercial ore deposits.

RECOMMENDATIONS

Recommendations for exploratory work, principally diamond drilling, in the Royal John area are:

1. To test the Lake Valley limestone to the east of the Owens fault. The Lake Valley limestone is one of the important ore-bearing formations in the Central district and elsewhere in New Mexico but has not been adequately tested in the Swartz district. If ore is found in the Lake Valley, it would enormously increase the possibilities of the district. The formation does not crop out in the Royal John area but is present at shallow depths (50-200 feet) beneath the Magdalena limestone immediately east of the Owens fault (Plate I). In the Sunshine cut area it could be tested at the bottom of Skull Creek, coordinates 9,184 N. and 11,686 E., and north of Skull Creek, coordinates 9,450 N. and 11,550 E. A vertical hole in the bottom of Skull Creek should enter the Lake Valley between 50 and 100 feet and an additional 120 feet would penetrate it. The location north of Skull Creek should reach the Lake Valley between 150 and 200 feet. A third test to the east of the mineralized West cut area should be made by a vertical hole in the bottom of Cold Springs Canyon at coordinates 10,200 N. and 11,310 E. This should enter the Lake Valley between 100 and 150 feet. A fourth test could be made along section A-A' at coordinates 10,700 N. and 11,000 E.; the Lake Valley should be reached about 400 feet.

2. To test the thin bedded member of the Montoya limestone on the west and downthrown side of the Sunshine fault. The exact location was staked before the Geological Survey field party left the

field and is shown on section E-E'. The hole is to be drilled to the east at a 45-degree angle. It should penetrate the thin bedded Montoya limestone between 210 and 275 feet. The test should be continued to locate definitely the downward extension of the Sunshine fault. The basis for finding the thin bedded member of the Montoya limestone between these depths is the southward projection of the thin bedded member found in the face of the Mill Adit, and the thickness of the upper member of the Montoya limestone. Cross section E-E' is drawn using the average of calculations based on these two projections. If the Sunshine fault continues at depth as a vertical fault, it should be cut at 275 feet. Total drilling depth should not be over 325 feet.

Two additional holes should be drilled along coordinates 9,175 N. and 9,250 N. The location and inclination of these holes will depend upon information obtained in diamond drill hole 1. A total of not over 500 feet should complete these two holes if vertical drilling is used. Slightly more footage will be required if angle holes are drilled.

3. To test the southward extension of the thin bedded mineralized Montoya limestone south of Skull Creek and east of the Sunshine fault. A prospect shaft at coordinates 8,870 N. and 11,310 E. exposes well mineralized thin bedded limestone east of the Sunshine fault. A drill hole, 70 feet south of the prospect shaft was drilled during World War I, but no log is available. The extension along the fault of the mineralized beds in the shaft should be tested by vertical holes located 10 feet east of the Sunshine fault and at intervals of 50 feet. The first hole

should be drilled along 8,820 N., the second at 8,770 N. and the third at 8,720 N. Careful search should be made to determine the surface trace of the Sunshine fault along these coordinates before drilling locations are chosen. Slight changes in the exact location of the drill holes may be necessary because of the steep topography in the area, and new locations must be chosen with the distance east of surface trace of the fault being the deciding factor. These three holes should not require more than 150 feet of drilling.

4. To test the thin bedded middle member of the Montoya limestone on the downthrown (east) side and the Discovery Workings fault. The ore horizon could be tested from the surface by a 250 foot vertical drill hole at coordinates 9,500 N. and 10,885 E. or from an underground station in the Mill Adit by a 50 foot vertical hole at coordinate 10,885 E. The water supply of the Royal John mine camp is stored behind the cement bulkhead in the Mill Adit and permission to drain this water would have to be secured from the owners if underground drilling is selected

5. To test the thin bedded Montoya limestone between the No. 3 working and the Discovery Workings fault. Cross sections through the No. 3 working (Plate III) and structure section A-A' through the Peru Mining Company D.D.H. 1-5 indicate that much favorable but unprospected ground exists to the east of the present No. 3 workings. The mineralization on the east side of the No. 3 working is very weak but a suggestion of ore deposition control by rolls in the bedding is shown on the mine map (Plate III). It is possible that mineralization in the thin bedded

Montoya limestone will increase as the Discovery Workings fault is approached. Such is true on the No. 1 working and in the Discovery workings. This favorable territory could best be tested by drifting eastward from the No. 3 working. However, it could also be tested by a diamond drill hole located along section A-A' at coordinate 10,460 E. Such a test should pass through the Discovery Workings fault before entering the ore bearing beds. A complete test of the fault zone and the Montoya thin bedded member should not require more than 150 feet of drilling. Additional tests could be made at 50 foot intervals north and south of the above recommended drill hole.