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A Geological Reconnaissance in the Little Wood River (Muldoon) District, Blaine County, Idaho

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A Geological Reconnaissance in the Little Wood River (Muldoon) District, Blaine County, Idaho

By
ALFRED L. ANDERSON AND WARREN R. WAGNER

ABSTRACT

The Little Wood River (Muldoon) district has numerous silver-lead deposits in Garfield Canyon and the canyon of Muldoon Creek in the high Pioneer Mountains in eastern Blaine County, Idaho, but most of the production has come from the now long inactive Muldoon mine which produced about $200,000 in silver-lead ore, mostly in 1881 to 1886. Since the beginning of World War II, two of the old mines have been reopened.

The part of the district containing the silver-lead deposits is underlain by folded and faulted Paleozoic sedimentary strata belonging to the Wood River (?) formation which are in fault contact with Chalcc volcanics (Oligocene or Miocene) and are cut by dikes of diverse composition and by two small stocks of quartz monzonite porphyry (Tertiary).

The deposits at the two active mines are replacements along bedding plane reverse faults and high-angle strike-slip faults in limestone members of the Wood River (?) formation. The deposit at the old Muldoon mine is a replacement along the bedding of quartzitic rock with a porphyry hanging wall. The ore is composed of argentiferous galena, some pyrite, sphalerite, and chalcopyrite in quartz or altered country rock. In some deposits the ore contains abundant arsenopyrite; in other deposits arsenopyrite is wholly lacking. Though formed largely by replacement, ore shoots are structurally controlled. Ore bodies uncovered so far are relatively small but the ore is of good grade. The deposits were formed at moderate temperatures and at moderate depths below the surface but the development has not revealed the full vertical range of the ore. The mineralization is probably associated with early Tertiary igneous activity.

INTRODUCTION

PURPOSE AND SCOPE

This report presents the findings of a reconnaissance survey in the long inactive Little Wood River (Muldoon) district in Blaine County, Idaho, which is known for its many silver-lead deposits of which only one, the Muldoon, has had any noteworthy production. With the onset of the war, interest in the district was revived and two of the old mines were reopened but were not brought into production, except for small shipments in 1943, until mid-summer in 1945. Most of the present study was confined to these two mines which were the only ones in which the underground workings were accessible and the deposits adequately exposed for examination.

The reconnaissance revealed that most of the deposits are distributed along a relatively narrow belt connecting and extending beyond two small bodies of Tertiary quartz monzonite porphyry intrusive into folded and faulted Wood River (?) formation (Pennsylvanian) with especial concentration close to each of the porphyries. It was also found that the deposits are replacements either along steeply dipping strike-slip faults or along bedding plane faults in the Wood River (?) formation, particularly in the limestone members close to the top.

In the short time that they were in the district the writers prepared a geologic sketch map based on a photographic enlargement of a part of the Mackay quadrangle and examined and mapped the underground workings of the two mines in detail. Old tunnels were spotted on the map but few of them were visited.

The writers hope that this report will serve to attract attention to this geologically little-known district and aid in its development, and perhaps pave the way for a more detailed and comprehensive investigation.

PREVIOUS GEOLOGIC WORK

The district is one that has received little attention by geologists and the only information on its geology and mineralization is in a report by E. H. Finch who spent three days in the district in 1913 and published his findings in U. S. Geological Survey Professional Paper 97, a report by J. B. Umpleby on the geology and ore deposits of the Mackay region. This report discusses the local geology in some detail and provides considerable information on the Muldoon mine. Another report by C. F. Ross refers
Fig. 1. Index map showing location of Area.
Plate 1A. Garfield Canyon

View of Garfield Canyon from the canyon's mouth to the highest point in the district at its head. The light colored rock in the ridge that projects into the canyon near its head is composed of quartz monzonite porphyry.

Plate 1B. Glaciated Canyon of Muldoon Creek

View of the glaciated canyon occupied by Muldoon Creek. The bold rocky canyon wall in the middle distance is carved in the quartzite breccia and graywacke which makes up the upper part of the Wood River (?) formation. Concrete structure in the foreground housed the power plant at the old Muldoon mine.
to the stratigraphy of the Muldoon area but repeats essentially the information contained in Prof. Paper 97 with some additional data supplied by Stewart Udell of the Idaho Bureau of Mines and Geology who examined the Muldoon area during the summer of 1930. The western part of the district drained by Little Wood River has been mapped and described in U. S. Geological Survey Bulletin 814, which deals with the geology and ore deposits of the Wood River region. The border of the geologic map of the Wood River region extends to within two miles of the area described in the present report.

The publications that contain information on or refer to the geology of the district are listed below.


ACKNOWLEDGMENTS

The writers wish to acknowledge their appreciation of the many courtesies extended by Messrs. J. D. Bulen, D. M. Jacobs, and L. E. Heagle, operators of the Eagle Bird mine, and to Mr. T. U. Williams of the Idaho Muldoon mine.

GEOPHraphY

LOCATION

The Little Wood River (Muldoon) district, which includes much of the mountainous terrain drained by Little Wood River and its tributaries, is in the east-central part of Blaine County, a few miles east of Hailey, the county seat (Fig. 1). The mineralization does not extend through the entire area but is mostly confined to the drainage of Copper Creek to 8 miles above Muldoon, principally in the canyon of Muldoon Creek and in Garfield Canyon. This part of the district covers parts of T. 3N., R. 21E., T. 3N., R. 22E., T. 4N., R. 21E., and T. 4N., R. 22E., Boise meridian, and lies about 24 miles in air-line east of Hailey.

TOPOGRAPHY

The district is in the high rugged Pioneer Mountains which form the parting shed between the headwaters of Wood and Lost Rivers. These mountains are among the highest in the State, reaching 12,078 feet in Hyndman Peak about 15 miles northwest of the district. Locally, the highest point, an unnamed peak at 10,664 feet (Plate 1), is at the head of Garfield Ranger station at the canyon's mouth, 3 miles to the southwest. The lowest point in this part of the district, taken at the mouth of Muldoon Creek, is about 6,200 feet, thus giving a maximum difference of relief of about 4,450 feet.

The mountain slopes rise steeply, in places even precipitously from the valley bottoms to narrow, in part jagged, inter-stream divides. Lower Copper Creek valley is relatively broad but the valley narrows upstream and near its head becomes almost gorge-like, bordered by very steep slopes. On the other hand some of the tributary valleys from the high divide separating Copper Creek from the headwaters of Lost River tend to open at their heads into glacial cirques with almost vertical walls. The upper valley of Muldoon Creek is a glacial trough with a broad U-shaped bottom from which rise very steep walls (Plate 1-B), but the cirque at its head is not particularly well-defined. Garfield Canyon is less like a glacial trough but it too has steep, cirque-like openings at its head. The main divide separating the heads of these valleys from the headwaters of Lost River and Antelope Creek is very rugged and on the north-east side drops precipitously into great glacial cirques which are much larger than those of the south-west side and which form the heads of broad glacial troughs that extend many miles downstream.

CLIMATE AND VEGETATION

Because of its mountainous setting the district has a rigorous climate characterized by long cold winters and short, relatively cool summers. The great local relief, however, induces some differences in the temperatures and precipitation in the lower and higher parts of the district. Along lower Copper Creek the winters are fairly open, though at times snow plows may be necessary to keep the road open into Muldoon. In the higher parts of the district the winter snowfall is heavy and the snow may remain on the upper slopes into June. Snowstorms during early June and late September are not uncommon,
neither are hail storms during July and August. Summers are relatively dry. The precipitation in the lower parts of the district may correspond to that at Hailey, which over a period of 18 years had an annual total precipitation of 16.48 inches of which 3.39 inches fell in the months of May to August. The total precipitation in the higher part of the district may be somewhat greater. Winter temperatures may drop to 20 or 30 degrees below zero; summer temperatures are usually delightful, daytime temperatures rarely becoming oppressively high in the lower parts of the district and never so in the higher parts.

The character of the vegetation shows a marked dependence on the altitude. In the lower, less rugged parts of the district the valley bottoms and lower slopes are mostly treeless and are covered by sagebrush and grass. Ordinarily the stream banks are lined with willows. With increasing altitude trees become more abundant but are confined to patches of scree at the middle altitudes (Plate 1A) and patches of evergreens at the higher altitudes, especially in the deeper, more shaded valleys (Plate 1B) and on the north slopes of ridges. About half the district is in the Sawtooth National Forest but the trees do not make a continuous forest. Above 9,000 feet the forest growth becomes more and more sparse and at 10,000 feet virtually disappears.

ACCESSIBILITY

The district may be reached from Hailey through Bellevue by an improved and graded road across the divide separating the drainage of Big Wood River from Little Wood River. This road passes through Muldoon and extends up Copper Creek to Garfield Ranger station, 36 miles from Hailey. Roads passable by car branch to the mines in the canyon of Muldoon Creek and in Garfield Canyon. The road across the divide east of Bellevue is likely to be blocked by snow in winter and to become muddy in places in the Little Wood River drainage during rainy weather. When this road cannot be used, the district may be reached from Carey on U. S. Highway 20 and 99-A by a road up Little Wood River which joins the one from Bellevue 3 miles west of Muldoon. This second route is open throughout the year but increases the distance from Hailey by 24 miles. The nearest shipping station on the Union Pacific Railroad is about 26 miles from Muldoon.

GEOLOGY

FOREWORD

Most of the Little Wood River district is underlain by Paleozoic sedimentary rocks, which are concealed in part beneath a blanket of Challis volcanics (Oligocene or Miocene), by flows of basalt (Quaternary), by deposits of morainic and outwash character (Pleistocene), and by stream alluvium (Recent). In the mineralized area the rocks belong chiefly to the Wood River (?) formation (Pennsylvanian), which is in fault contact with Challis volcanics along Copper Creek on the west and probably also along Muldoon and Anchor Creek on the south. The Wood River (?) formation has been folded, broken by faults both before and after blanketing by Challis volcanics, and has been intruded by Tertiary magma. Upper valleys hold morainic deposits and lower courses are floored with glacial outwash and deposits made by the present streams.

SEDIMENTARY ROCKS

WOOD RIVER (?) FORMATION (PENNYSYLVANIAN)

The rocks of the Wood River (?) formation occupy about half the map area (Fig. 2) and compose the high mountain mass east of Copper Creek above the mouth of Muldoon Creek. Neither the base nor the top of the formation is exposed, but altogether the beds must measure more than 8,000 feet thick.

The formation consists in the main of calcareous and quartzitic beds but contains also shale, dolomite, grit, breccia, and graywacke. The sequence was not examined in detail but Udell reports 7,000 feet of thin-bededded, dark gray carbonaceous shale, interstratified with argillaceous quartzite and argillaceous limestone and overlain conformably by 2,000 feet of impure, white, thin-beded limestone with numerous partings of calcareous sandstone and shale. This lower group of rocks grades upward into 2,000 to 4,000 feet of quartzite, which contains thin beds of shale and intercalated lenses of conglomerate in the lower part. Becoming argillaceous near the top, the quartzite is overlain conformably by about 1,000 feet of arenaceous shale with numerous thin beds of sandstone and some limestone.

The reconnaissance did not allow more than a casual examination of the rocks but did permit recognition of the lower great thickness of calcareous, shaly, and quartzitic beds, the overlying relatively light colored limestone with its intercalated sandstone, shale and grit, and the upper great thicknesses of

quartzitic rocks. Instead of conglomerate the basal part of the upper quartzitic series, which is exposed in the upper canyon of Muldoon Creek (Plate IB) and the high ridges at the head of Garfield Canyon, was found to be composed largely of coarse breccia and graywacke with breccia fragments measuring up to several inches long, even a foot or two long. The graywacke and breccia are alike, except for the size of particles, and are composed of black flint or gray quartzite in a quartzitic groundmass. The breccia and graywacke are very resistant to erosion and make up the higher, most rugged topography in the district.

The formation is not very fossiliferous and fossils are not well preserved. Some forms which suggest fusulina were recognized and some beds with a gastropod fauna were found. Both suggest that the formation is Pennsylvanian and therefore Wood River. The formation does not resemble the Milligen in either the Wood River region3 just to the west nor in the Lava Creek district4 a few miles to the east. On the other hand it does have much in common with the Wood River formation in the type locality. The breccia and graywacke at the top may be equivalent to the more than 1,100 feet of coarse conglomerate at the top of the Wood River in the high hills between Big Lost River and its East Fork5.

QUATERNARY DEPOSITS

The sedimentary deposits of Quaternary age comprise the morainal material laid down by the Pleistocene glaciers and outwash from their lower ends, the elasic debris from the damming of Little Wood River and lower Copper Creek by flows of Quaternary basalt, and the gravel, sand, and silt of the present flood plains. These various deposits have not been differentiated on the geologic map but are shown as a single unit.

The morainal material is confined to the lower part of the canyon of Muldoon Creek and Garfield Canyon and is represented mostly as an irregular sheet of bouldery debris on the valley sides and bottoms, forming a low, poorly outlined terminal morain near the mouth of the canyon occupied by Muldoon Creek. The streams flowing from these former glaciers, however, were overloaded with debris and covered the valleys downstream with outwash gravels, in places to depths of several hundred feet. Such outwash deposits now occur as terraces along the sides of Copper Creek valley 100 feet or more above the present stream bed. The most prominent terrace is along the east side of Copper Creek from Muldoon Creek to and beyond the mouth of Garfield Canyon. In front of Garfield Canyon the outwash terrace has the shape of an alluvial fan as much as 400 feet thick extending outward from the canyon mouth. Some of the terrace building, however, may be due to the damming of lower Copper Creek by basalt but the relation of the gravel thus put down to the glacial outwash has not been determined.

Since the melting of the glaciers, the streams have been attempting to clear the valleys of the outwash fill but much of the earlier debris remains as terraces rising steeply above the present, relatively narrow valley flats, that are floored by gravel and sand of the flood plains.

IGNEOUS ROCKS

TERTIARY INTRUSIVE ROCKS

The intrusive rocks are represented by a few small dikes of undetermined composition and two small bodies of quartz monzonite porphyry. The dikes are most numerous in the northern part of the district but neither those nor the few found elsewhere were mapped. The two small stocks are in the area of most extensive mineralization.

QUARTZ MONZONITE PORPHYRY

The larger of the two quartz monzonite porphyry bodies is near the head of Garfield Canyon where, because of its light color and bold outcrop, it is a conspicuous feature in the landscape, offering sharp contrast to the darker rocks around it; the other is about two-thirds of the distance up Muldoon Creek where it is prominently outlined in the west valley wall. Both bodies are somewhat oval-shaped, the one in Garfield Canyon having a diameter of about three-quarters of a mile, the other in the canyon of Muldoon Creek having a length of about one-half mile and a width of about one-fourth mile.

The rock of both stocks is pinkish gray in color and conspicuously porphyritic, being studded with numerous white phenocrysts of andesine from 4.0 to 7.0 mm. long and smaller and fewer ones of dark greenish-black biotite, augite, and hornblende, all embedded in a fine-grained pinkish groundmass composed largely of orthoclase and quartz. The andesine phenocrysts are well-shaped, somewhat zoned, and some combined albite and earlsbad twinning. They comprise about 30 per cent of the rock. The other phenocrysts also show crystal outlines and consist of about 7 per cent biotite, 3 per cent augite, and 2 per cent hornblende. In addition to orthoclase and quartz the groundmass minerals also include mag-

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Fig. 2. Topographic and geologic map of a part of the Little Wood River (Muldoon) mining district.
petite, zircon, apatite, and a little biotite. The quartz forms a cement between the orthoclase crystals, which except against grains of their own kind, are well-shaped and very turbid because of alteration to a sericite or kaolinite dust. The orthoclase forms about 40 per cent of the rock, the quartz about 15 per cent, and the remaining minerals not more than 3 per cent. There are also some grains of chlorite and epidote produced chiefly by alteration of the dark minerals, and patches of fairly coarse grains of sericite in the andesine.

The rock near the margin of the stocks is somewhat finer grained and has more phenocrysts than that further in. The composition ranges from granodiorite porphyry at the margins to granite porphyry at the center, with quartz monzonite porphyry closely approaching granite porphyry making much of the mass.

AGE

The stocks and most of the dikes are in Paleozoic rocks but a few dikes have intruded Challis volcanics. Those in the volcanic rocks were not examined and whether they are similar to the dikes in Paleozoic rocks is not known. Porphyry dikes both older and younger than the surface volcanics are known in the Wood River region, the lava in places resting on a surface that truncates the porphyry dikes. The dike is that older than the Challis volcanics may perhaps be correlated with the early Tertiary porphyritic intrusives in Kootenai County4 and the Clark Fork district5 in the north part of the State. The dikes that cut the volcanics may be closely related in age and genesis to the Miocene (?) extrusives6. Direct evidence bearing on the age of the dikes and stocks in the Paleozoic rocks locally is lacking, but the ore deposits believed to be associated with them genetically are like the deposits in the Wood River region which have been related to the Idaho batholith and its satellites7. Inasmuch as the ore deposits are pre-Challis volcanics, the intrusives with which the deposits are associated must be pre-Challis volcanics (Miocene or Oligocene), but the textures of the porphyries and porphyritic dikes show that these rocks consolidated much closer to the surface than the granitic rock of the Idaho batholith and therefore are probably not satellites of the Idaho batholith but products of early Tertiary igneous activity.

TERTIARY EXTRUSIVE ROCKS

The Tertiary extrusive rocks are a continuation of those that blanket fully a third of the Wood River region and vast areas in other parts of south-central Idaho, achieving perhaps their greatest development in the vicinity of Challis, Idaho, from which the great series of lava flows and intercalated pycroclastics and sedimentary beds has taken its name8.

CHALLIS VOLCANICS (Oligocene or Miocene)

The Challis volcanics total several thousand feet of flows and tuffaceous materials which in the Wood River region are divisible into three groups consisting of a lower series of blackish augite andesites and basalts, a very thick middle series of reddish latites and hornblende andesites, and rare, upper flows of light-colored glassy rhyolite9. The volcanics are thus differentiated on the geologic map of the Hailey quadrangle, which shows that the middle group of latites and hornblende andesites is the one which extends into the Little Wood River (Muldoon) district. These rocks may also contain some augite andesite and possibly basalt as well as some intercalated water-laid tuff. They abut against the block of Paleozoic rocks along Copper Creek and extend across the south end of the district, in part along Muldoon and Argosy Creeks, covering about half the mapped area (Fig. 2).

The flows were not examined but they are probably like those along Little Wood River and other parts of the Wood River region. There the blackish, in general non-porphyratic augite andesites, are composed of andesine, augite, and magnetite, in some cases with inconspicuous labradorite and colorless augite phenocrysts, and the reddish, generally porphyritic latites and hornblende andesites are made up essentially of olivoclase or andesine, orthoclase, quartz, biotite, hornblende, with augite in some of the more calcic varieties and glass in some of the more silicic10.

On fossil evidence in Custer and Lemhi Counties the volcanics are believed to be Oligocene or, at the youngest, early Miocene11.

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[11]
STRUCTURE

GENERAL FEATURES

The Paleozoic rocks are strongly though not complexly folded, but structural relations have been complicated by faulting more or less closely associated with the folding, and by the faulting which came after the folded strata had been covered by Challis volcanics. The unconformity between the Tertiary and Paleozoic rocks is very useful in fixing limits to the possible age of structural disturbances, but where the volcanics have been stripped off by erosion, it is difficult, if not impossible to determine whether some of the faults were formed during the earlier folding or were associated with the post-Challis disturbance. The unconformity cannot be used to ascertain the number of disturbances that took place either before or after its formation; it merely places the disturbances into either one or two groups. Were all the facts known, the record may show several disturbances prior to the formation of the unconformity and several after.

FOLDS

The Paleozoic strata apparently form the northeast limb of a broad anticlinal structure which has been broken by a fault along Copper Creek. This fault has dropped the top of the anticline and its covering of Challis volcanics against the rocks that comprise the east limb. The beds on this limb have a north-northwest trend ranging from N.10°W. to N.40°W., but the average is about N.20°W. The dip is mostly 30°NE. to 35°NE. but in places increases to 40° and in the vicinity of the stock in Garfield Canyon to 57°NE.

The volcanics in the district are tilted but the tilting locally is associated with faulting, not with folding. In the several fault blocks the flows have dips of 14°, 29°, and 36°, all in an easterly direction.

Folding of the Paleozoic rocks may have been associated with the orogeny that just preceded the emplacement of the Idaho batholith in late Jurassic or in Cretaceous time or it may have reached its main development during the Laramide disturbance at the close of the Cretaceous. There is nothing in the district to indicate just when the main folding took place except that it all happened before the region was covered by Challis volcanics.

FAULTS

For convenience the faults may be divided into two groups. In one group may be placed those faults which are confined to the Paleozoic rocks and which for the most part may have been formed during the early crustal disturbance; in the other may be placed those faults which cut the Challis volcanics and which therefore are comparatively young.

FAULTS IN THE PALEOZOIC ROCKS

The faults in the Paleozoic rocks include bedding plane faults, high-angle strike-slip faults, and others of uncertain kind and origin.

Bedding Plane Faults

The bedding plane faults appear to be conformable with the bedding in strike and dip. They are inconspicuous and would easily escape notice were not some of them channels for the circulation of the ore-bearing solutions and receivers of ore. There are several of them at the Eagle Bird mine at the head of Garfield Canyon, one at the Idaho Muldoon mine, and apparently another at the Muldoon mine. These last two mines are in the canyon occupied by Muldoon Creek. At the Eagle Bird mine the faults strike N.15°-40°W. and dip 35°-65°NE. The one at the Idaho Muldoon strikes N.20°W. and dips 35°NE. Walls are tight and unmineralized where dips are steep, but they are not so tight and contain ore where the dips are more gentle. This behavior suggests that the movement has been relatively upward on the hanging wall, which has tended to lift the walls apart wherever there was a local flattening of the dip. The movement has generally been along several rather than a single plane and has produced faulted zones 4 to 10 feet wide.

The faults probably have little actual displacement but may be classed as reverse faults which found easiest movement along the bedding planes. Such movement may have accompanied the folding or may have come later under the influences of pressures that existed at about the time the porphyries were intruded.

Strike-slip Faults

Faults which have a prominent strike-slip component of movement have been recognized at the Idaho Muldoon mine. These faults show marked changes in strike, from N. 30° E. to N. 70° E. in less than 40 feet. Their dip is steep, above 65°, and may be either northwest or southeast. Commonly the dip exceeds 90° and may become vertical and change direction. The zone of broken rock along the fault may
be several feet wide, made up of subsidiary fractures of diverse strike and dip. Grooves and striations on fracture surfaces dip north at angles of 25°. Ore-bearing solutions also have found access to these fractures and some of them hold ore shoots. The movement is largely pre-mineral and probably the product of nearly horizontal shearing stresses acting in a northeast-northwest direction, perhaps at the time of the Laramide disturbance.

Other Faults

Among the other faults is one at the Idaho Muldoon mine that strikes about N.10°W. and dips 67°-68°NE. The fault is not strongly defined and the direction of movement has not been determined. It is slightly mineralized. One at the Eagle Bird mine strikes N.15°W. and dips 30°NE. It is more strongly defined than the one at Idaho Muldoon and the disturbed zone is 8 feet wide. Another fault strikes N.77°W. and dips vertically. Still another fault strikes N.20°E. and dips 48°SE. This last one guides a solution channel in limestone.

FAULTS IN THE CHALLIS VOLCANICS

The faults that post-date the Challis volcanics include among them the largest and most impressive earth fractures in the district. These faults are normal faults, the hanging wall having moved downward relatively with respect to the footwall, and they may be traced for miles along the base of eroded but still readily discernible escarpments. Actually they border tilted blocks of the earth's crust. The displacement along them may be measured in hundreds and even in some thousands of feet. Two of these faults are shown on the geologic map (Fig. 2) and are named and described as the Copper Creek and Muldoon faults. A third is probable. These fault trends northwest and northeast; those of northwest trend are the larger and cut across those of northeast trend. There are also minor faults, some of which strike about N.66°E. and dip steeply northwest to southeast, but these were not mapped or studied in detail.

Copper Creek Fault

The Copper Creek fault is the largest in the district in length and vertical displacement. It may be traced in a northwest-easterly direction for not less than 12 miles, being bordered on the northeast by a prominent escarpment composed of Challis volcanics in the southern part of the district and of Paleozoic rock in the central and northern part. The upper valley of Copper Creek is aligned along the creek for a considerable distance, but after the creek changes its course to southwest near the mouth of Muldoon Creek, the trace of the fault continues along a series of aligned saddles across ridges for some miles to the southeast. The actual strike of the fault is N.55°-35°W. and the dip steeply southwest. The fault has dropped the Challis volcanics against the Paleozoic rocks along the upper valley of Copper Creek, indicating a throw of probably more than 4,000 feet. The volcanic flows on the southwest are inclined toward the fault at an average angle of 14°.

Muldoon Fault

The Muldoon fault controls the lower course of Copper Creek to and a short distance beyond Muldoon. The fault strikes about N.25°-30°E. dips steeply northwest, and may be traced for about 6 miles, apparently disappearing beneath Quaternary basalt a mile or two south of Muldoon and abutting against the Copper Creek fault at the old town of Muldoon at the mouth of Muldoon Canyon. The Challis volcanics form the rock on the downthrow as well as on the upthrow side. On the downthrow side the lava flows dip about 12° toward the fault; on the upthrow they dip away from the fault at an angle of 20°. The stratigraphic throw must exceed 600 feet.

It is possible that the Muldoon fault may continue on the northeast of the Copper Creek fault and mark the boundary between the Paleozoic rocks and the Challis volcanics along lower Muldoon Creek and upper Argoey Creek. If so, its strike changes to about N.50°E. and its dip changes from northwest to southeast.

Age of Faulting

Because the Copper Creek and Muldoon faults are so strongly reflected in the topography, they must have come into existence at a fairly recent date, perhaps in late Tertiary and early Quaternary time as have many other faults of similar characteristics in other parts of Idaho. They had apparently become inactive by Pleistocene time for the glacial and other deposits on them show no evidence of disturbance.

Some of the minor faults must be considerably older, perhaps mid-Tertiary, for one N.65°E. fracture near the mouth of Blackspur Canyon has been mineralized but with ore wholly unlike that in the Paleozoic rocks in Garfield Canyon and in the canyon occupied by Muldoon Creek. The mineralization along this fault correlates with the Miocene mineralization in the Challis volcanics in other parts of Idaho.


[13]
ORE DEPOSITS

HISTORY AND PRODUCTION

While in the district the writers were able to obtain very little information on the early mining history and production. According to Finch, the deposit at the Muldoon mine, the only mine that has had any important production, was discovered in 1881. The surface showings were very promising and within a few weeks the property was sold for $50,000. The discovery attracted many prospectors to the district and about 50 locate claims were made. Work at the Muldoon and other properties progressed very rapidly and before the end of the year a smelter was erected and ready for operation. The work continued to expand through 1882 and by autumn there were two 40-ton smelters and a concentrator engaged in handling the ore. Development at the Muldoon mine then totalled 1,400 feet of workings. The smelters and concentrator continued to operate during the summers of 1883 and for a few years after, but production then ceased and the smelters and mill were dismantled. There was some renewed activity in the district in 1902, but just what work was done at the Muldoon mine has not been reported.

Work apparently then remained at a standstill until 1907 when another development program got underway at the Muldoon mine, which continued through 1909. A new concentrating plant of 200 tons daily capacity was built and put into intermittent operation, the concentrates being shipped to Utah smelters. Shipping of the concentrates necessitated a wagon haul of about 28 miles to Bellevue over roads that were open for only a part of the year. Several hundred tons of concentrates were shipped in 1910, but the work had not been financially successful, and in December the company went into the hands of a receiver. The mine was practically idle in 1911 and since then has apparently remained completely inactive. Some attempts have since been made to open up and develop some of the other properties, which have long been idle, but until the entry of this country into World War II very little was actually accomplished.

Since 1942 two of the old properties have been reopened, the Eagle Bird in Garfield Canyon and the Idaho Muldoon in the canyon of Muldoon Creek, and both made small shipments of ore in 1943 and of mine tailings during August 1945.

While the Muldoon mine was most active there was a small settlement, Muldoon, at the smelter site at the mouth of the canyon occupied by Muldoon Creek, and another, Tustin, at the mine about 3 miles by road up the canyon. At the present time nothing is left to mark the site of either of these old settlements and all that remains of mills and smelters are the rock foundations and several broken-down concrete foundations for the smelter and mill. The post office at Muldoon has been moved to a ranch on Copper Creek about 5 miles below its old location.

The production of the district is not known. The only important production has come from the Muldoon mine, which, according to Finch, produced about $200,000, most of which came from silver in the lead ores. The production from the two mines active in 1945 was not learned.

CHARACTER OF DEPOSITS

The deposits that were examined are replacements along bedding plane and strike-slip faults in the calcareous and quartzitic rocks of the Wood River formation. They are probably representative of most of the deposits in the district and are lead-silver replacements characterized chiefly by the presence of argentiferous galena which provided silver ore in the shallow oxidized and enriched zone. The deposits appear to be very much alike, except that some contain notable quantities of arsenopyrite and others little, if any, arsenopyrite. In the deposits examined the arsenopyrite was confined to replacements along the bedding plane faults.

Low-grade copper ore with galena has been reported in the extreme north part of the district but this part was not included in this reconnaissance study.

DISTRIBUTION

Most of the lead-silver replacement deposits are concentrated in the canyon of Muldoon Creek about 3 miles above its mouth and in Garfield Canyon almost at its head. In each canyon the deposits are close to the two small bodies of quartz monzonite porphyry and appear to reflect two rather closely spaced centers of mineralization separated only by the high ridge between the two canyons. The mineralization, however, is not restricted entirely to these two places but appears in widely scattered deposits within and beyond the map boundaries. Some of the outlying deposits are in the volcanic rocks but these deposits are fundamentally unlike those along Muldoon Creek and Garfield Canyon.


[14]
STRUCTURAL RELATIONS

The replacements along the bedding plane faults accord closely with the prevailing trend of the sedimentary strata and strike about N.20°W. and dip 35°NE., but there are local departures wherein bedding faults and the containing strata show a variation in strike ranging from N.15°W. to N.40°W. and in dip from 35°NE. to 50°NE. The replacements along the strike-slip faults also show marked changes in trend ranging from N.30°E. to N.70°E., with the ore mostly concentrated along the zone where the strike is close to N.30°E. The strike-slip fault replacements dip steeply, and because of alteration of dip from southeast to northwest, stand almost vertically.

Whether most or all the deposits in the district are controlled by bedding plane faults and high-angle strike-slip faults was not learned.

MINERALOGY

The deposits contain notably few minerals and these include mainly galena, locally abundant arsenopyrite, subordinate sphalerite, and a little pyrite and chalcopyrite, all of which are either in bleached limestone or altered quartzite and porphyry or in limestone that has been replaced by quartz. In the oxidized parts of the deposits are variable amounts of cassiterite and anglesite after galena, various reddish and brownish limonite oxides of iron, and in those deposits with arsenopyrite, much greenish scorodite.

The minerals are in part somewhat intimately associated but each also occurs in separate but closely spaced irregular masses, veins, and disseminated grains. They compose ore that is moderately coarse-grained, locally massive. Much of the galena forms granular aggregates, but some is disseminated as grains and cubic crystals. It is commonly the most abundant mineral but locally may be surpassed by arsenopyrite, which in places is the only mineral readily apparent. The arsenopyrite, like the galena, may be disseminated as scattered crystals but generally it forms aggregates of relatively large, well-shaped rhombic crystals. Because of a dark brownish black to black color and almost metallic luster, the sphalerite is not easily distinguished from the galena and consequently may be more abundant in some of the ore than is evident on cursory examination. In places it appears to be entirely wanting. The scanty pyrite grains seem in general to be smaller than the grains of other minerals but there is some variation in the grain size of all minerals. The chalcopyrite is inconspicuous; in places it may be detected in widely scattered grains and small irregular veins and masses.

The minerals appear to be the product of one, little interrupted stage of deposition. Some arsenopyrite veins have central cores of pyrite and galena, but generally galena forms a cement between grains of pyrite and arsenopyrite; less commonly it occurs as veins cutting these minerals and sphalerite. Chalcopyrite has been observed in tiny veins penetrating the galena. The pyrite and arsenopyrite must have been deposited early, probably just after the quartz with which some of the ore is associated; and the sphalerite must have been added a little later. The sphalerite was then followed by galena and the galena, by chalcopyrite.

DISTRIBUTION AND OCCURRENCE OF ORE

Some of the ore is in grains and small irregular veins and masses scattered through the rock in and along the fractured rock of the fault zones, but some of it also occurs in compact seams in and along bedding plane fractures, here and there forming bodies of massive ore. Where mineralization has proceeded along bedding plane faults, much ore is generally concentrated along the footwall and hanging wall forming layers or lenses a few inches thick with other layers and irregular bunches and stringers in the rock between. The ore in general shows a marked guidance by fractures with fracture filling accompanied by extensive replacement of the bordering rock. Unfortunately, in some places considerable of the filling and replacement has been by arsenopyrite and the ore as a consequence is not nearly so high-grade nor so extensive as the abundance of minerals might suggest. The ore is not uniformly distributed along the fault zones but forms irregular bodies or masses, comprising well-defined shoots.

LOCALIZATION OF ORE SHOOTS

The localization of ore bodies appears to show a marked dependence on variations in strike and dip of the gulling faults. In the replacements along the bedding plane faults the ore shoots are apparently confined to the less steeply dipping parts of the fault zones and they pinch horizontally and probably vertically wherever the angle of dip increases. Along the drifts the ore shoots are marked by a notable deviation of the line of strike, produced by local flattening of the dip, and the resulting change of strike may be as much as 15°. The ore shoot thus conforms to a "roll" in the wall. Development has not yet extended to the bottom of the shoots now open to inspection and the effect of any change in dip with depth cannot be observed directly, but pinching or impoverishment with increase in dip may be expected.

In the strike-slip replacements the ore shoots appear to be controlled by changes in the direction of strike, a change from N.70°E. to N.30°E. apparently marking a zone especially favorable for the localization of ore. Changes in the angle of dip appear to have little influence on the formation of ore shoots, although the amount of ore is somewhat greater where the dip is steepest and changes its direc-
tion from northwest to southeast or vice versa. Replacement along subsidiary fractures increases the width of the ore body.

Localization of ore by changes in the angle of dip on the one hand and in the direction of strike on the other denotes the zones of easiest permeability and hence the channels most favorable for the circulation of ore-bearing solutions. Upward movement along the bedding plane faults tended to lift the hanging wall from the footwall along the more gently dipping parts of the fault zone and to bring the walls tightly together along the more steeply dipping parts. Near horizontal movement on the strike-slip faults pressed the walls tightly together in some places, preventing circulation of the ore-bearing solutions, and separated them slightly in others (where fractures developed obliquely to the direction of movement) by limiting the movement of the mineralizing fluids.

The kind of country rock apparently had little to do in localizing ore shoots. Although the Eagle Bird and Idaho Muldoon ore bodies are replacements in limestone, the largest or most productive ore body was at the Muldoon mine where the ore replaced quartzite and igneous rock. Favorable guiding or localizing structures and the quantity of ore carried and left by the mineral-bearing solutions have apparently been the most important factors in the formation of ore shoots and in determining their size.

SIZE OF THE ORE BODIES

The report by Finch\(^{18}\) quotes the statement of others that the ore body at the Muldoon mine was 12 to 20 feet at the surface and several sets wide in stopes below, but no reference is made of length. The ore bodies in the mines now open to inspection are relatively small. The bedded replacement at the Idaho Muldoon may be traced for about 100 feet on the surface and in places shows as much as 3 feet of sulfides, but the ore is spotty and in most places the ore body is less than 10 inches wide and even pinches out altogether. The sulfides include a considerable proportion of arsenopyrite.

The ore body along the strike-slip fault is also small. At one place in the main underground workings stoping had been carried along the strike for about 20 feet and upward possibly 40 feet. The ore remaining at the ends of the stope is distributed through a zone 1 to 2 feet wide. The body that had been opened in 1945 had been exposed along the strike for about 40 feet, the mineralized part measuring 2 to 3 feet wide but not all of it sulfides. A drift from the bottom of the newly sunk shaft on the ore shoot showed scattered bunches and stringers of sulfides in both side walls and across the roof.

The main ore body at the Eagle Bird mine is larger than those at the Idaho Muldoon. A stope above the main tunnel level is about 40 feet long and has not revealed the full size of the ore body. At one end of the stope sulfides are distributed through a zone about 10 feet thick, mostly in bands up to 18 inches thick along the upper and lower walls with lesser bands and stringers in the rock between. The ore may continue along the strike for at least a dozen feet beyond the end of the stope, but is known to pinch within a few feet at the other end. The shoot has a maximum thickness of 12 feet. It has been partly mined to the surface, a distance of about 80 feet up the dip, and it is also exposed along a 90-foot winze below the level for at least 45 feet, the level at which water stood in the winze.

WALL ROCK ALTERATION

The rock in and along the replacement deposits has undergone considerable change in its appearance and to some extent in its composition. Most of the limestone has lost its dark gray to black color and is nearly white. Some of it has been replaced by quartz and some of the limestone closely associated with the ore contains sericite. Even the quartzite and the porphyry at the Muldoon mine have been partly converted to sericite, particularly where alteration was intense.

The bleaching and locally the conversion of some of the rock to quartz and sericite apparently denote attack and alteration of the rock by the ore-bearing solutions. Much of the alteration has been merely bleaching and softening, especially in the limestone, but in some places the alteration was more intense and was accompanied by silicification and sericitization.

ORIGIN OF THE DEPOSITS

The deposits have the characteristics of replacement deposits of hydrothermal origin and were probably made by ore-bearing solutions ascending from a deep magmatic source, perhaps from the same source which supplied the injections and partly crystalline magma that gave rise to the stocks and dikes. The ascending ore-bearing solutions apparently found the bedding plane and strike-slip faults particularly favorable for their use and were directed along them, reacting with and altering the rock and depositing ore largely by replacement.

Although the ore-bearing solutions may have been notably not at the beginning of their journey, they had cooled to moderate temperatures by the time they had reached the levels at which deposition began. The presence of arsenopyrite suggests that the temperature of the solutions may have been moderately high at the beginning of deposition, but the nature of the other minerals indicates that tem-

peratures had declined appreciably before deposition had gone very far. Deposition apparently took place at moderate depth beneath the surface and under conditions that may be regarded as mesothermal. The solutions carried but little silica and potash but transported considerable quantities of arsenic, sulphur, iron, lead, and silver, and also a little zinc and copper.

The deposits have no resemblance to the known Miocene deposit in the Challis volcanics at the mouth of Blackspar Canyon a mile or two away but are like the pre-Miocene deposits in the Wood River region. Consequently, they are believed to have been formed in early Tertiary time during the declining stages of igneous activity manifested locally in the dikes and stocks.

CONCLUSIONS

From examination of two mines alone it is difficult to draw conclusions applicable to the district as a whole. The large number of old tunnels and dumps in the canyon of Muldoon Creek and in Garfield Canyon suggest many deposits, few of which have been noteworthy producers. The deposits now uncovered are relatively small but the ore is of moderate grade. The ore apparently has been localized along the less steeply dipping parts of bedding plane faults and in the more open zones determined by local changes in strike in the high-angle strike-slip faults. The depth to which the ore may extend has not been determined but may continue some distance below the present deepest workings. The ore shots show no variation in texture or mineral composition which might imply a shallow vertical range and for that reason may be expected to extend downward for some hundreds of feet. It is possible that the low-grade material found in the two lower levels of the Muldoon mine may mark a zone where the structural conditions were not particularly favorable for ore deposition; on the other hand, the bottom of the ore may have been reached. Whether arsenopyrite in the ore may indicate temperatures too high for the deposition of much lead and silver with increasing depth cannot be determined from the present limited development. It is likely, however, that ore shoots may pinch in depth as controlling structural features become unfavorable, but from what is known of the mineralization so far, there is no reason why other shoots may not appear at greater depth as structural conditions again become favorable.

The district seems to offer a fertile field for prospecting and development, but no positive assertion can be made until the district has been given a very detailed geologic examination. It is worthy of more attention than was possible to give it in the present reconnaissance.

MINES

EAGLE BIRD

Location and Development

The Eagle Bird mine is near the head of Garfield Canyon at an altitude of 9,100 feet almost on the line separating sections 35 and 26 in T. 4N., R. 21E., Boise meridian. It is accessible by steep road with many short, sharp switchbacks ascending from the floor of the canyon about 2 miles above its mouth. The mine appears to be an old one but how much ore was shipped in the early days was not learned. Ore that was mined was dragged by stone boat to the road in the canyon bottom more than 1,800 feet below, measured vertically. Present ownership rests with Minnie Havens, Denver, Colorado, who has leased the mine to J. D. Dehlin, who with D. M. Jacobs and L. E. Haigle of Hailey, Idaho, began to ready the mine for operation not long after the entry of the country into World War II. One car (30 tons) of ore was shipped direct to the smelter in 1943. The road to the mine was rebuilt and trucking of ore from the old mine dumps was begun in August 1945.

The development comprises about 523 feet of workings in the main tunnel (Fig. 3) and some cuts and short tunnels above. There are also many tunnels on the slope below and to the east but these are on other deposits and whether all these are included in this or in other properties was not learned. The workings shown in Figure 3 include drifts, a stope, two raises to the surface, and a 90-foot winze on one mineralized fault zone, and a crosscut driven 160 feet but not yet within reach of another mineralized fault exposed on the surface and in a short tunnel just below.

Occurrence and Distribution of Ore

The mineralization is confined to bedding plane faults of which two have ore shoots worthy of attention. Both are contained along beds of thick- to thin-bedded, dark gray to black limestone which turns light gray on exposure to weather. Underground these beds strike about N.20°W. to 40°W. and dip 35°NE. to 55°NE. The mineralized bedding plane fault exposed in the workings shows a corresponding variation in strike and dip. It is barren where the dip is relatively steep and contains ore where the dip drops to 35° or 40°.

Fig. 3. Geologic map of the underground workings at the Eagle Bird mine.
Two ore shoots have been opened underground, one small, the other of moderate size. The first has not been very productive and all that remains of the shoot is a little galena in the walls and at the bottom of a 65-foot inclined raise, which extends to the surface. The footwall fracture dips about 30° NE.; the hanging wall fracture, which is 6 feet above, dips 40° NE. The dip steepens on each side of the raise and the walls become tight and the rock barren.

The main ore body lies beyond the first and has been partly stoped to the surface 80 feet above. For half the distance the stope is about 40 feet wide but from there to the surface it is not much wider than an 8-foot raise. The stope is about 10 feet high but the ore shoot measured up to 12 feet thick and in places some ore still remains in the roof. Ore also has been left in the wall at the south end of the stope, which shows about 15 inches of mixed sulfides and limestone along the hanging wall, separated from 30 inches of like substance below by 18 inches of little-mineralized limestone. Below the 30 inches of sulfide-impregnated limestone are about 5 feet of rock with scattered stringers and disseminated grains of ore minerals and then 15 inches of almost massive ore, which forms the footwall. The ore, however, is bumpy and the sulfides do not make up continuous bands. Ore also is exposed in the 90-foot winze but the lower half of the winze was under water and could not be examined. Minor seams and bunches of sulfides are visible at the north edge of the stope, but in the drift below the ore pinches as the dip steepens and the shoot gives way to 8 feet of crushed and fractured rock with thin seams of gouge on the principal fracture planes.

The crosscut driven to intersect the second mineralized fault zone passes through a fault about 50 feet from the drift. This fault apparently conforms with the bedding and dips 31°NE. The faulted zone is about 8 feet thick and contains broken rock heavily stained and crusted with limonitic oxides. A vertical fault just beyond strikes about N.80°W. It shows no sign of mineralization.

**Mineralogy**

The ore contains abundant arsenopyrite but otherwise is made up chiefly of galena accompanied by subordinate sphalerite and here and there by a little chalcopyrite. At the surface the partly oxidized ore is stained by greenish scorodite, and in addition to residual galena contains a little cerussite and anglesite. The quantity of lead and silver in the ore was not learned, but ore broken with the waste in the early development made shipment of the mine dump profitable.

**Outlook**

By the end of August 1945 the material from the dumps had been trucked to the railroad and work was then to be transferred to underground mining and development. Some ore yet remained at the south end of the main stope as well as here and there in the roof. Much of the future mining, however, will have to be carried on from the 90-foot winze below the tunnel level and on whatever ore shoots may be found in the second mineralized fault.

**IDAHO MULDOON**

**Location and Development**

The Idaho Muldoon mine is on the east wall of the canyon of Muldoon Creek across from and about one fourth of a mile above the old Muldoon mine. It lies at an altitude of about 7,800 feet in unsurveyed Section 7, T. 3N., R. 22E., Boise meridian, and is accessible by newly constructed road from the lower canyon. The mine is an old one but the early production could not have been very large. In 1945 the mine was being operated by T. U. Williams, who had rehabilitated the main tunnel, had sunk a 40-foot shaft 160 feet from the portal of the tunnel, and had driven a 40-foot drift from the bottom of the shaft. Twenty-four tons of lead-silver ore were treated at a custom concentrating mill in Utah in 1945. Additional shipments were made in 1945.

**Occurrence and Distribution of Ore**

The mine has two replacement deposits of note, one along a bedding plane fault and the other along a high-angle strike-slip fault. There are also several minor faults which have been lightly mineralized but which contain no ore. All the deposits are in the thick- to thin-beded, dark gray to black but light weathering limestone, apparently at the same horizon as the limestone at the Eagle Bird mine in Garfield Canyon. The beds locally strike about N.20°W. and dip 30°-35° NE.

The bedded deposit is exposed in cuts along the outcrop for about 100 feet. Some work has been done just under the cropping, but the openings are not accessible. The deposit conforms with the bedding and strikes N.20°W. and dips 35° NE. The rock has not been much broken and replacement has not been extensive. In places sulfides have spread through a zone about 3 feet wide but such bulges are few and the ore commonly is contained along a layer less than 10 inches thick, which here and there pinches out completely. Apparently little ore has actually been mined.

The deposit along the strike-slip fault exposed in the main workings has provided most of the production. Near the portal is a lightly mineralized high-angle fault which has been drifted on for about
Fig. 4. Geologic map of the underground workings at the Idaho Muldoon mine.
70 feet. The fault strikes N.30°E, where it is cut near the portal, but in less than 20 feet its strike changes to about N.70°E. Its dip is 65°-70°NW. Some scattered grains of galena and stringers of calcite are exposed in the drift where the strike is N.70°E, also in a 10-foot raise at the same place. The main deposit is a short distance ahead on what appears to be an over-lapping high-angle fault. Where first exposed the fault strikes N.70°E. and dips 77°NW, but in a 40-foot raise and stopes the dip changes to 85°SE. About 1 foot of ore is exposed at the two ends of the raise. Just beyond the raise the strike changes to N.80°E. and the dip to 80°SE, but in the shaft still farther ahead the dip changes back to 70°NW. The ore shoot appears to be 40 feet long and to plunge north-east at a moderate angle. The ore zone is 2 to 3 feet wide on the tunnel level but in the drift at the bottom of the shaft, patches and stringers of sulfides are present on both sides and across the roof. The fracturing is complex and the main fracture surfaces have nearly horizontal striations.

Other fractures, some lightly mineralized, some barren, except for gouge, are shown in Figure 4. One which has been drifted on in a southerly direction for 100 feet shows slight alteration but no sulfides. Intersecting it near the far end of the drift is a fault which strikes N.70°E. and dips 80°SE, and which contains stringers of calcite across a zone 4 feet wide. Another at the far end of the main workings has a similar east-northeast strike and a dip of 85°NW. It has two inches of gouge.

**Mineralogy**

The character of the mineralization differs somewhat in each of the deposits. Arsenopyrite is abundant in bedded replacement and apparently absent in the strike-slip. Otherwise the deposits contain variable amounts of galena, pyrite, sphalerite and in places a little chalcopyrite. In the bedded replacement the sulfides occur as grain disseminations, as short irregular veinlets, and as small bunches in the quartz, which replaces the limestone. In the other deposits the sulfides occur similarly but replace limestone directly. Both contain cerussite, anglesite, and limonite oxides in the outcrop and just below, but the bedded replacement also has greenish scorodite and the strike-slip has considerable greenish malachite.

**MULDOON**

**Location and Development**

The old Muldoon mine is on the west side of the canyon of Muldoon Creek less than 3 miles above the canyon's mouth at an altitude between 6,800 and 8,000 feet. It is contained in Sec. 12, T. 3N., R. 21E., and in Sec. 7, T. 3N., R. 22E., Boise meridian.

The early history of the district is virtually the history of the Muldoon mine and need not be repeated. Most of the $200,000 production came between 1881 and 1886 with intermediate activity and production in later years. No work has been done for a long time and present ownership was not learned.

Workings were generally inaccessible when the mine was visited by Finch in 1913 and remain so today. The development comprises several thousand feet of drifts and crosscuts on 5 levels. According to Finch, the lowest level, the No. 7, is reported to be about 225 feet long and to have two crosscuts, each 100 feet long, driven from the main drift. Several other crosscuts are reported to extend from these two 100-foot crosscuts. The No. 6 level is about 250 feet above and is about 700 feet long with a 200-foot crossect to the north and a 400-foot crossect to the south, each started about 400 feet from the portal. Level No. 5, which is 70 feet above the No. 6, is about 1,000 feet long. It has several crossect, measuring up to 100 feet extending from it, also one large stope several sets wide, 50 feet long, and 200 feet high. Level No. 4, which is 60 feet above No. 5, is 500 feet long and has several short crossect on each side, and at least three large stopes. Level No. 3 is reported to be 40 feet long and to have four stopes to the surface. No data are available on Level No. 2, except that all ore was stope to the surface.

**Geologic Features**

The ore occurred as a replacement deposit along bedding in the quartzitic and slaty rocks of the Wood River formation, particularly along the contact of quartzite and porphyry, which is reported to have formed the hanging wall of the deposit. In the mine the strata strike N. 8°-45° W. and dip 23°-40°NE. It is presumed that the deposit had a corresponding strike and dip. Ore was found in altered rocks of different kinds including the porphyry. Ore on the two lower levels is reported to have consisted largely of disseminated grains in quartzite, none of it of milling grade. The grade of ore improved upward and on the No. 5 level ore was stope which contained 50 to 60 per cent lead and 46 ounces of silver to the ton. The most and best ore, however, was found on the No. 4 level. At the surface the ore body was 12 to 20 feet wide and is reported to have contained 70 per cent lead. No data were found pertaining to the length of the ore body, except that the stope on the No. 5 level was 50 feet long and that there were three large stopes on the No. 4 level.

The ore consisted of argentiferous galena, pyrite, and some sphalerite, and chalcopyrite with quartz in altered rocks of different kinds.

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OTHER MINES

Tunnels with workings of considerable size but now generally inaccessible extend into the canyon walls north of the Muldoon and Idaho Muldoon mines and also east and southeast of the Eagle Bird mine. Some of the smaller tunnels east of the Eagle Bird and on the north of the Idaho Muldoon were visited, but little could be learned about the deposits. The two tunnels on the property north of the Idaho Muldoon were blocked and a large stream of water was pouring from the lower tunnel. Specimens of ore in the nearby cabin contain massive galena and little or no arsenopyrite.

Considerable work has been done in more recent years on the south side of Garfield Canyon across from the Eagle Bird but there apparently was little, if any, production. Old workings also are located well up Mutual Gulch east of Garfield Ranger station. A mine at the mouth of Blackspar Canyon, which was once the scene of considerable activity, is completely inaccessible. The deposit there is in the Chaliis volcanics and it has minerals that are reported to contain antimony.