DESCRIPTION OF THE OURAY QUADRANGLE.

By Whitman Cross, Ernest Howe, and J. D. Irving.

INTRODUCTION.

LOCATION AND AREA OF THE QUADRANGLE.

The Ouray quadrangle is situated in the southwestern part of Colorado and is bounded by parallels 38° and 39° W. and meridians 102° 37' and 102° 47'; its area is 254.87 square miles. Parts of Ouray, Hinsdale, and Gunnison counties are included in the quadrangle. The town of Ouray, a local mining center, is near the southwest corner, at the head of the Uncompahgre Valley; it is connected by a branch line with the Denver and Rio Grande Railroad at Montrose. The relation of the Ouray to other quadrangles of the San Juan region is shown by the index map on the title-page of the folio cover.

OUTLINE OF THE GEOGRAPHY AND GEOLOGY OF THE QUADRANGLE.

The term San Juan region, or simply "the San Juan," used with variable meaning by early explorers and naturally with its more extended sense during the period of settlement, is now generally applied to a large tract of mountainous country in southwestern Colorado, together with an undefined zone of lower country bordering it on the north, west, and south. The Continental Divide traverses this area in a great bow. The principal part of the district is a deeply scored volcanic plateau, more than 3000 square miles in extent, drained on the north by tributaries of Gunnison River, on the west by tributaries of Dolores and San Miguel rivers, on the south by numerous branches of the San Juan, and on the east by the Rio Grande. All but the Rio Grande drainage finds its way to the Gulf of California through Colorado River.

The San Juan Mountains, as that term is now understood, embrace the area bounded on the north by the generally abrupt descent to the sloping mesa extending for 25 miles to the canyon of the Gunnison, on the west by the great plateau of Colorado-New Mexico line, on the south by tributaries of Dolores and San Miguel rivers, and on the north by those parts of the San Juan, and on the east by the Rio Grande. All but the Rio Grande drainage finds its way to the Gulf of California through Colorado River.

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generally low angles away from the mountains, on the northern, western, and southern sides. The Oroya, Telluride, and Ouray quadrangles, for instance, show that the erosional history of the region has been strongly influenced by the oblique edges of the entire series of Mesozoic and Palaeozoic formations. This plain seems to have formed a higher land mass in the heart of the San Juan region, and to have extended a considerable distance—how far must remain a matter of future investigation. Upon this nearly flat surface, in the region where it is now exposed, the sandstones and conglomerates of the Telluride formation were deposited and had already attained a thickness of several hundred feet when the great epoch of volcanic activity began, producing the complex of rocks out of which the present San Juan Mountains have been sculptured. From exposures in the Telluride quadrangle it was inferred that the earliest volcanic tuffs were water-laid deposits in the lake basin of the former San Juan sea. These relations seen in the Silverton quadrangle it appears probable that the Telluride conglomerate is, in part, a fluvial formation and that there was, locally, valley erosion below the plane of conglomerates before the volcanic cycle opened.

The volcanic and fluviatile deposits of the San Juan, assisted, perhaps, by vents in adjacent regions, emitted an enormous volume of igneous material, partly in fragmental form and partly in lava flows, and this material covers an area of certainly not less than 15,000 square miles to a depth of many thousands of feet in the central portion. The highest member of the volcanic complex thus far discovered is a thickly-bedded deposit of andesitic rocks that reach 2000 feet in observed thickness, called the Pluvial tuff, which is represented in the eastern part of the San Juan quadrangle. From the relations expressed in the Silverton quadrangle it is certain that the San Juan tuff has been in part extensively removed by erosion before the eruptions of the next great volcanic epoch.

The San Juan epoch is a time in which phyllitic and argillaceous material, together with others of intermediate composition, alternated, and built up the Silverton volcanic series of flows and tuffs to an aggregate thickness of 4000 feet or more. Above them lie the Potosi volcanic series, consisting predominantly of phyllitic material, and observed to have a thickness of more than 1000 feet. During the Silverton epoch, and after it, there were intercalations of great erosion.

The three series of volcanic rocks mark the opening of the western parts of the San Juan Mountains. In the central San Juan the two earlier series become distinctly diminished in thickness, and disappear under the Potosi and other lavas of various kinds not yet fully identified, but known to include andesites, diorites, and granites. Most of the San Juan lavas come from sources that are unknown, but those of the Silverton series were in part poured out through fissures characteristic of andesitic lavas identified on the dike masses which lie along many of the lines of fracture. The thickness of the Potosi series is marked by several massive bodies of rocks that are in many places coarsely granular, such as gabbro, diorite, and monzonite, and it now seems probable that the intrusive bodies of diorite porphyry and the allied variation found in the sedimentary beds adjacent to the San Juans Mountains on the west are also of later date than many of the surface lavas.

The volcanic eruptions in the San Juans were probably continued at intervals until late in Tertiary time, although only the products of the earlier outbursts are well known. Thus the volcanic period of building up was in part synchronous with the third great period already referred to—that of sculpturing by erosion—by which the mountains now existing have been produced. Within the volcanic area little evidence has been found of major movements, except in the sequence of events can be correlated with the established divisions of Tertiary time. Deposits of Eocene age are known in the zone bounding the volcanic area, but they have not been found in direct contact with the lavas. Certain Pleistocene tuffs of the San Juan and elsewhere are evidence of small mountain rises or volcanic cones that have been accumulated within the volcanic area. There is no evidence, however, in the San Juans that a volcanic eruption has occurred since the time of the Mississippian. Although it may be assumed that the closer study of the San Juans will result in the recognition of different epochs of eruptive activity and of geologic disturbance, the Tertiary history of this region may be summarized as a complex sequence of ignimbritic flows which overlaid basaltic lavas. The volcanic rocks were most effective in the earlier part of the period, when nearly the entire thickness of 2000 feet or more was found in the western San Juans; but the agents of denudation became prominent in the later part of the Tertiary and are still actively at work on the higher mountain masses.

Quantitatively, the work performed by the volcanic agents acting in this region in Cenozoic time has been very great, but the extent of the post-erosional denudation, as well as the general diminishing of all earlier geological history, has been rendered very difficult by the presence of volcanic rocks; and the original extent of this covering has been largely reduced on account of the more recent erosion which has now gone through much minor work on these great problems. Thus, the Telluride conglomerate becomes of first importance in their solution, since its base presents the best evidence as to the post-Cretaceous erosion and its form the surface upon which the volcanic rocks rested in the western part of the district.

The present elevation of this entire region above sea level to be regarded as the result of the interplay of denudation and volcanic activity. The complex fault system existing in the Silverton quadrangle, which transverses all volcanic rocks in its course, is the main character of the intervals now in progress which have shown much light on these great problems. In the San Juans the Telluride conglomerate is, in part, a fluviatile formation and that there was, locally, valley erosion below the plane of conglomerates before the volcanic cycle opened.

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The agglutinates members have been much more affected by the diagenetic metamorphism of the region, and most of them are now slate or schist. Some are extremely dense, fine-grained agglomerates which under the microscope appear to be made up largely of quartz, with sericite in minute needles all having practically the same orientation. Others are colorless and less commonly matrix-replaced and contain much “earth” impurity that remains dark between crossed nicks. A few contain andalusite or cordierite in impregnations. The prevailing colors are dark greens, browns, and grays, although some soft, sandy beds may be almost jet black. Local schistosity is not uncommon in portions of the thin-beded argillites, and in general the beds are paralleled with the quartzites and dip at a high angle to the north.

Distribution. The quartzites and slates of the Uncompahgre formation are exposed on both sides of the Uncompahgre River at about a mile and a half north of the southern boundary of the quadrangle. They are limited on the north by a fault which brought into contact with Paleozoic rocks in the Needle Mountains; on the east they are covered by the San Juan and on the west by the oldest Paleozoic sediments. The formation is exposed in the Silverton quarries, for nearly 2 miles. The Hard quartzites and the slates, protected by them, form the precipitous walls of a canyon of unusual grandeur, through which the Uncompahgre River flows to the outskirts of the town of Ouray.

Ouray limestone. The lowest lithologic division of the Paleozoic section south of Ouray, where its best development has taken place, is known as the Ouray limestone, which is assigned to the Cambrian system.

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that formation in certain localities, separated from the uppermost Devonian fossiliferous strata by about 50 to 75 feet of massive limestone in which no fossils have thus far been discovered. The cretum in the interval following Mississippian sediments removed these strata completely over large areas. As neither the upper Devonian nor the basal Carboniferous is everywhere fossiliferous, it is impossible to place with any certainty the base of the Ouny limestone is Carboniferous or not.

From the great quantity of Carboniferous chalk in the uppermost strata of the succeeding formation it must be assumed that above the known horizons of the Ouny there once existed in this region a considerable thickness of chalk-bearing limestones of Mississippian age. It seems not unlikely that somewhere on the slopes of the San Juan Mountains notable remnants of those beds may be found.

In the Ouny quadrangle a short distance north-west of the Mineral Farm mine, near the upper road which leads up Canyon Creek, there is a marked local unconformity between the Ouny limestone and the Molas formation. The locality is very near the base of the Herronan formation, and the Ouny appears to rise in a sharp ridge through the Molas, which rests with angular unconformity on the beds of the Ouny. The Molas formation contains many coarser cherty concretions than those of the Ouny, and the beds below the Ouny are much more bedded than those of the Ouny. The Ouny limestone exposes its under surface where it rests on a surface due to the erosion by which the Ouray limestone was removed.

In the Ouray district no beds carrying a typical Rico (Permo-Pennsylvanian) fauna have been found, and the Herronan limestone is followed by the Cutler red beds, of supposed Perminian age. The name was derived from Herronan Creek, near the town of Ouray, and there a small area of these rocks in the Engineer Mountain quadrangle.

Distribution.—In the Aniulus Mountains, near the mouth of Herronan Creek, the lowest third of the Mississippian series is made up of green sandstones and shales with some gypsiferous lalas, and the rest of the formation shows limestone layers distributed throughout. Along the great western facing the Arnuan, which extends for 10 miles in the Engineer Mountain quadrangle, the limestones become more and more numerous and certain beds are very thin.

Pennsylvanian (Uppen Pennsylvanian) is almost entirely present in the lower part of the formation, the upper part consisting mainly of black shale alternating with green shales and sandstones and with a few limestone layers.

At Ouray the character of the formation is again dominant, and the beds are a little more than 300 feet thick. The lower beds are thin, alternating beds of sandstones, shales, and a few thin limestones. The lower beds, which are very thin, consist of green shales and sandstones, having a maximum thickness of about 500 to 700 feet, which occurs on the northern and southern flanks of the San Juan Mountains. As originally defined, its lower and upper limits were marked by the Molas lithology and the Ouny district no beds carrying a typical Rico (Permo-Pennsylvanian) fauna have been found, and the Herronan limestone is followed by the Cutler red beds, of supposed Permian age. The name was derived from Herronan Creek, near the town of Ouray, and there a small area of these rocks in the Engineer Mountain quadrangle.
greatest variety of textures can be found, the rocks ranging from those of extremely fine grain, hardly able to be distinguished from the shales, through coarser and coarser sandstones up to the conglomerates. Cross-bedding in some of the sandstones is very strong and indicates the amount of the alternation of lighter and darker layers. In the Ouray region several very coarse, massive conglomerates are also found in the formation. They are purplish and of a darker color than the other beds and are at once noticeable on account of their size and shape. In many localities the relative amounts of bowlders and matrix vary greatly in short distances, but ordinarily their proportions are about equal, although an abrupt increase of the coarse materials may be accompanied by a reduction of the cemented matrix down to a minimum. The pebbles and bowlders are well rounded and in general not more than six inches in diameter; they represent most of the older rocks of the San Juan, the greater number being pre-Cambrian graptolites, schists, greenstones, or quartzites.

The shales, like the sandstones, are bright red. They are in places calcareous and almost invariably so, and as such they are soft and friable and occur in beds which are in places calcareous and almost invariably so. They are soft, and in great part of the Colorado region they have been reduced to a mass of small limestone pebbles or fragments held in a calcareous cement and are extremely persistent over wide areas, forming many notable escarpments. In the Ouray region the conglomerates are invariably fine grained, the pebbles or fragments not exceeding 1 or 2 inches in diameter, and as a rule being smaller. When the pebbles are very small and uniform the rock resembles piazo limestone. In places the limestone is in small, angular fragments and the rock may have somewhat the appearance of a reconstituted friz (a red, cross-bedded conglomerate) of the Dolores formation. The limestone is dense and hard and of a buff or bluish color, but in many localities it is so friable and soft that it can be scratched with a knife. The bed of the La Plata sandstone, extending from The Amphitheater on the west side of the river to the point where they cross Oak Creek and continue up the north side of the river, the beds are not so well preserved as those on the east side of the river, where considerable glacial drift covers the river, where considerable glacial drift covers the river, where considerable glacial drift covers the river.

The best exposures of the Ouray dolomite region are in the vicinity of Ouray, where considerable glacial drift covers the river, where considerable glacial drift covers the river, where considerable glacial drift covers the river, where considerable glacial drift covers the river, where considerable glacial drift covers the river, where considerable glacial drift covers the river. The dolomite in this region is of a very pure white or cream color, and in general not more than six inches in diameter; they represent most of the older rocks of the San Juan, the greater number being pre-Cambrian graptolites, schists, greenstones, or quartzites.

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occur near Dallas and farther north, their reappearance being due to the east-west fault which cuts Uncompahgre River a short distance from the towns. The formation, with the exception of the lowest beds, may be seen to best advantage in this last area. Northeastwardly to the west, the prominent position in the section of the Uncompahgre Valley farther south, is, on the north, a broad sheet of sandstone and towards the south, a narrow belt of black shales. In the northwest of the Desert, near the town of Ridgway, the section is probably complete, because of the abundance of drift gravel that covers nearly the entire valley

Age and correlation. - The McElmo formation appears on stratigraphic and lithologic grounds to occupy the place of Lower Cretaceous sediments; but its age is so far as can be determined, as from a point in paleontology concerning the Morrison formation on the eastern flank of the Front Range in Colorado, Wyoming. Moronicus and other representatives of this fauna have recently been found by E. S. Riggs in McElmo beds in the Grand River Valley near the north end of the Uncompahgre Plateau. The McElmo represents the upper part of the Comm group that Riggs, McElmo, and Como formations embrace certain equivalent strata is a conclusion arrived at by direct comparison. That the three formations are coextensive and thus fully equivalent cannot be ascertained as demonstrated by present evidence.

CRETACEOUS SYSTEM. DAHOTA SEDIMENTARY DESCRIPTION. - The lowest member of the Cretaceous series, with the exception of the upper structural surface, is the Dakota sandstone. It is here, as commonly in Colorado, a series of extremely variable gray or brown quartzose sandstones, in many places cross-bedded, with several shale layers at different horizons. Its thickness in the Uncompahgre quadrangle is in general 100 feet and nowhere exceeds 150 feet. The Dakota is considered as the upper part of the La Plan sandstone, and the term quartzite is locally appropriate to designate it, especially in the vicinity of metalliciferous deposits.

The basal conglomerate, containing small pebbles of white, dark-gray, or reddish color, which is an abundant and large source of gravel in the Rocky Mountains, is here practically lacking, although a few pebbles occur at the base of the beds.

The shale members are well developed near the middle and also near the top of the series. They are dark and strongly carbonaceous, with abundant indistinct plant remains, and northern Dallas and near the point where Cow Creek joins Uncompahgre River there is at one or both of the shale horizons a thin coal seam, sufficient to induce generation of coal, although such occurrence is rare and not much abundant, except in certain mediums and near the base of the series. Thickness of the Dakota in the vicinity of Uncompahgre is about 600 feet of grayish shales and sandstones, with a few marls or thin limestones, and a number of coal seams. The name was first applied by W. H. Holmes and was suggested by the very local occurrence of the formation in the vicinity of the San Juan Mountains, where the formation is a maximum thickness in the area of the Mancos shale, and is thus a local name for the part of the Dakota occurring in the Cow Creek area. The Dakota occurs. On the west side of the creek it dips steeply to the north beneath the monzonite porphyry breccia. It occurs again on the east side of the stream, but here it lies above the thin quartzite formation, a considerable thickness of the Dakota embracing the intervening limestone and thick sandstone. Its southern extension is here limited by the unconformable Telluride conglomerate.

MAYON SHALE. DESCRIPTION. - The Mayon shale is here the lower member of the Dakota formation. It is in some places highly laminated and the lower part of the shale is often a few feet in thickness. It is dark and strongly carbonaceous, sometimes a little sandy, but not excessively so. Its thickness in the Uncompahgre quadrangle is about 100 feet, and nowhere exceeds 150 feet. The Dakota is considered as the upper part of the La Plan sandstone, and the term quartzite is locally appropriate to designate it, especially in the vicinity of metalliciferous deposits.

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The Telluride conglomerate is in most places apparently conformable with the overlying San Juan Tuff, but this is not uniformly true, for in the extreme western part of the San Juan volcanic field it is offset by folds. Thus, it is not always clear where the contacts between the two units are to be drawn. However, the general conformity is still maintained, and it is apparent that the overlying San Juan Tuff conformably rests on the conglomerate, which in turn is conformable with the underlying San Francisco formation of the Uncompahgre Group. The San Francisco formation is conformable with the lower portion of the San Juan Tuff, which is in turn conformable with the Potolalo Tuff, which in turn is conformable with the older deposits of the San Juan volcanic field. Thus, the San Juan volcanic field is situated on top of the San Francisco formation of the Uncompahgre Group, which in turn is situated on top of the San Juan formation of the San Juan volcanic field.

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of the same age and doubtless of similar origin, although their relation to a terminal moraine is, occupy all the larger valleys, the most notable of which are the Uncompahgre between Portland and the great moraine.

In the region to seem almost insignificant. Similar between Portland and the great moraine which, from its unusual width, causes the others of

part their outer portions are merged with the flood built, may cover considerable areas. For the most part, those outer portions are merged with the flood plains of the main streams and are not distinguished from them on the map.

HENRY LAYALIUS

In addition to the ancient landslides already described, others of more recent age have occurred at numerous places in the Ouray quadrangle. Their origin is thus far discussed under the heading "Historical geology." Noteworthy slides are to be found in Coal Creek and on the east side of the ridge between Coal and Uncompahgre Rivers, where slides have taken place involving in part the loosely consolidated materials of the Pleistocene series, and of which the lower portions have occurred about the head of Cimarron Creek and on the north side of Cimarron Mountain, where they involve several layers of fine sandstone, and the transported products of an earlier epoch, accreted during a time in which no great landslides were marked, by the unconsolidated materials of the San Juan formation. The slides are of the same kind as those which have occurred in the neighborhood of Ouray, to a depth of several hundred feet with landslides that fall from the cliffs of the San Juan and Uncompahgre Rivers, in which the open crevices, Tellerite conglomerates, Hornstein sandstones, and fine detritus, which lie in disconnected blocks of rock, as in the San Juan formation. Where many changes have taken place, and for the past 300 feet or yards in thickness, where there is locally a change of over 50 feet near the forks of Cimarron Creek to the west of the formation.

The actual source or sources of the evidence of this erosion is seen in the Silverton or Potosi series to the east, and the Silverton volcanic series. The formation has a maximum observed thickness of nearly 300 feet in the Silverton quadrangle, east of Cimarron, with a point within a few miles of Gunnison Canyon observed. The San Juan is about 100 feet thick and the finer grained layers thin, and the same is true in the San Juan formation of the San Juan tuff, where the finer grained layers are well developed, and the same is true in the San Juan tuff, which is plain in all large exposures, but may be obscured by the same".

SAN JUAN TUFF.

The observed extension of the San Juan tuff is northward along the northern limit of the Ouray quadrangle, but this is not so noticeable in the San Juan formation of the San Juan tuff, which is plain in all large exposures, but may be obscured by the same.
tains, called the "West Elk breed," seem to have been of dominantly basaltic composition, which is derived from the same immediate sources or not.

**Silverton Volcanic Series.**

The San Juan tuff was succeeded in the eastern San Juan region by a complex of lavas, tuffs, and agglomerates, named after the Silverton quadrangle, in which they have their greatest development. Between the deposition of the San Juan formation and the outpouring of these lavas there was extensive erosion of the former. For the reasons that the Silverton lavas appear to have been in large degree eroded within an extensive valleys or basin, and that their outlying portions were eroded away before the next epoch of eruption, the rocks of this series now occupy comparatively small areas.

They are the most important element among the rocks of the Silverton quadrangle, reaching an observed maximum thickness of about 3000 feet. To the west they thin out and within the Telluride quadrangle were it not for the obscuring of the San Juan region by a complex of lavas, tuffs, and agglomerates, named after the Silverton quadrangle, which overlap them in some degree. In the Silverton quadrangle, where they were seen during the survey of the Silverton quadrangle and was one of the eastern borders of the basin, they occupy the southern line of the quadrangle, 3 or 4 miles to the south. The Burns tuff, which from the south side of the San Juan region west was the eastern border of the basin, where it has been penetrated by the Deadwood tunnel toward the end of the ridge between North Fork and the main Henson quadrangle, although hard and brittle exist, is a nearly aphanitic flow 60 feet in thickness in the Silverton quadrangle.

**Petrographic description.**

**Pyroxene andesite.** The Burns tuff was well exposed to a thickness of 60 feet in the Silverton quadrangle near Silverton. It is a very fine-grained rock, or on their borders. The massive rocks are in some places a vivid green, due to abundant chlorite, and that their outlying portions were eroded away before the next epoch of eruption, the rocks of this series now occupy comparatively small areas.

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They are the most important element among the rocks of the Silverton quadrangle, reaching an observed maximum thickness of about 3000 feet. To the west they thin out and within the Telluride quadrangle were it not for the obscuring of the San Juan region by a complex of lavas, tuffs, and agglomerates, named after the Silverton quadrangle, which overlap them in some degree. In the Silverton quadrangle, where they were seen during the survey of the Silverton quadrangle and was one of the eastern borders of the basin, they occupy the southern line of the quadrangle, 3 or 4 miles to the south. The Burns tuff, which from the south side of the San Juan region west was the eastern border of the basin, where it has been penetrated by the Deadwood tunnel toward the end of the ridge between North Fork and the main Henson quadrangle, although hard and brittle exist, is a nearly aphanitic flow 60 feet in thickness in the Silverton quadrangle.

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being that of Uncompahgre Park. Similar small areas of these lavas occur in the adjacent portion of the Silverton quadrangle.

The principal area where intrusive masses have been mapped with confidence lies adjacent to the Ouray quadrangle. The massive rock which forms the upper 800 feet of the Wetterhorn and the sharp ridge north of that, which has also been intruded in the adjacent portion of the Lake City quadrangle, is of a different nature. It is now known that lavas of this kind may also occur in the same general area as these lavas occur in the adjacent portion of the Ouray quadrangle and that numerous dikes, sheets, and other less prominent masses of nearly the same magmatic character occur in the upper part of the Potosi section of Uncompahgre Park and that numerous small lavas, sheets, and dikes all of nearly the same magmatic character occur in the upper San Juan formation in the adjacent portion of the Lake City quadrangle.

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The microscopical study of the various latites shows several groups particularly characterized by their dark constituents and in many places by persistent textural features. The ashes of Hauro and of San Juan are distinctly different. As these groups express the distinctive mineral characters of these groups they are designated in the legend and in the descriptions by local names, although they may be present in the localities where they are best developed.

Cimarron Creek Latite.

The same Cimarron Creek latite is applied to a variety of intrusive rocks especially common in the immediate area of the Cimarron Creek in the Ouray City quadrangles. The rock is graphitic and contains pyroxene-latite.

Origin and distribution. — The Cimarron Creek latite occurs in many dikes, sills, and irregular intrusions. For the most part it occurs in the San Juan tuff-agglomerate and has been traced on the San Juan map with more or less of accuracy. It is somewhat coarse and the presence of hornblende is inferred from the occurrence of dark grey or reddish, very fine grained granite porphyry. Although no analysis has been made of the latite, the rock has been characterized by its prominent phenocrysts of biotite and orthoclase, which are readily distinguishable under the microscope, forms the notable variety of this rock.

Description. — This rock is reddish, pink, or dark gray in color, with prominent phenocrysts of plagioclase and biotite, that are nearly equal in amount to a very fine grained hornblende phenocrysts and crystals perfect in shape, few of them being broken as is common in other intrusive rock, in the general development of the rock. Although no analysis has been made of the specific weight of the rock, it seems to be about the same as the average density of the rock. As the rock is fine-grained and very light, it is not easily distinguishable from the neighboring rocks.

American Flat Latite. — A group of rocks which have been distinguished from the others by their abundant hornblende phenocrysts and groundmass. The hornblende phenocrysts consist almost entirely of a sodic plagioclase, but the texture is trachytic and the groundmass is extremely fine and nearly equal to augite in amount. The development of the hornblende is fresh. The habit of the rock in this place is almost semi-lunar and is not accurately mapped, as it occurs in inselberg cliffs.

Description. — This rock is reddish or yellow in color, and is characterized by its abundant hornblende phenocrysts, which are nearly equal in amount to a very fine grained biotite phenocrysts. The groundmass is intermediate in texture between a rhyolite and a very fine grained granite porphyry. The rock is intermediate in texture between a rhyolite and a very fine grained granite porphyry.

Biotite Latite. — The variety of latite which forms the summit of Wild Horse Peak and occurs also in several other masses is a hornblende-latite of different habit from the other similar rock of the same series. The principal body of this rock is the older rocks almost on the line between the San Juan and Potosi rocks, and the igneous rocks in the area of Cimarron and Potosi rocks are characterized by a notable decrease in the amount of hornblende and quartz. The rock is reddish, pink or dark gray in color, with prominent phenocrysts of plagioclase and biotite, that are nearly equal in amount to a very fine grained hornblende phenocrysts and crystals perfect in shape, few of them being broken as is common in other intrusive rocks. As the rock is fine-grained and very light, it is not easily distinguishable from the neighboring rocks.

Biotite latite. — This rock, readily distinguishable under the microscope, forms the notable variety of this rock. It exhibits a still greater extension farther east in the Lake City quadrangles. The rock is petrographically a quartz-pyroxene latite. Under the microscope it is apparent that hornblende is also present, but is not as abundant as the biotite. The hornblende is very fine-grained and nearly equal in amount to a very fine grained biotite phenocrysts. The groundmass is intermediate in texture between a rhyolite and a very fine grained granite porphyry. The rock is intermediate in texture between a rhyolite and a very fine grained granite porphyry.
high walls. Fig. 5 (illustration sheet) shows one of these walls on the divide at the head of Dexter Creek.

In other parts of the quadrangle single dikes of basaltic color, but many of them are not mapped, the time required to map them being more than the time which could be given to it.

Description.—The basaltics here described vary like the limestones in the development of their dark silicates—augite, hypersthene, hornblende, and biotite. On the whole, the basaltics are richer in these ferromagnesian minerals than the limestones, yet none of them is a strongly basic rock. Some are orthoclase in the groundmass and quartz is its common companion, but in relative small amount.

The Note Creek sheet is a brown or yellowish-gray hornblende andesite with a little biotite. Most of the Dike Ridge rocks are hornblende-biotite andesites, but at one point is an augite andesite. Both augite and hypersthene occur in some of the dikes west of Dexter Creek.

DIABASE DIKES.

Overviews.—Dikes of diabase occur at two different localities in the Ouray quadrangle. One cuts quartzites of the Uncompahgre formation, but no young rocks; the other visibly intrudes the Cutler, Dolores, and La Plata formations, and may have cut the San Juan tuff, but evidence for this has been lost through erosion. The dikes in the Alpiglen area have been traced from it to the box canyon of Ouray Creek, where it disappears beneath the Paleozoic sediments, in a direction west of a mile and a half to the point where the quartzites are covered by the San Juan tuff. The thickness of the dikes averages 60 feet, but varies from place to place, and near the town reservoir it is fully 150 feet. The dikes cut the Mesozoic rocks exposed on the east side of the Uncompahgre Valley nearly opposite the mouth of Coal Creek. It has a nearly north-south direction, is from 6 to 8 feet wide, and is exposed for a little over a quarter of a mile from 100 to 300 feet above the bottom of the valley.

Description.—The diabase from the Alpiglen area is dark greenish brown, massive, and of a medium texture. Long, thin crystals of labradorite are abundant and easily recognizable megascopically, and magnetite, the last occurring in irregular grains. Although the contact is exposed for a little over a quarter of a mile from 100 to 300 feet above the bottom of the valley, it is not to the point where the quartzites are covered by the tuff, nor to the point where the quartzites are covered by the tuff. All the dikes in the Alpiglen area are of this nature.

CHEMICAL COMPOSITION OF THE IGNEOUS ROCKS.

The description of the igneous rocks, both intrusive and effusive, show them to be closely related in chemical composition. To illustrate this fact, a few more, and for purposes of comparison with rocks from other parts of the San Juan, a few of the freshest and most important types have been analyzed by George Steiger in the chemical laboratory of the Geological Survey, with the results given in the following table.

The analyses demonstrate the close relationship between the rocks that have been brought out in the descriptions. They show with special clearness the contact presence of a large amount of orthoclase among the rocks in the region, and the evidence of the alkali to the lattice rather than to the silicate group.

On comparison of the analyses with those published by Geikie, the Silurian rocks of the Silverton basin show that all the rocks of the group are similar to those of the Cutler beds. The widespread occurrence of basaltic rocks in the region is evident, and it is evident that all the rocks of the group are similar to those of the Cutler beds. The widespread occurrence of basaltic rocks in the region is evident, and it is evident that all the rocks of the group are similar to those of the Cutler beds.
The geology of the Ouray quadrangle is more complex than that of any other part of the quadrangle, and although the structural and stratigraphic features are the most important, nearly all the various elements characteristic of the geology of other areas are present.

Uncompahgre River enters the quadrangle through a canyon whose walls are composed of sandstones and shales of the Uncompahgre formation. The formations extend upward for nearly 2000 feet above the river and their upturned edges are covered unconformably by 2000 feet of sandstone. West of the canyon mouth the oldest Paleozoic rocks occupy a bench 1000 feet above the river; the San Juan and a thin bed of Telluride conglomerate rest upon the Paleozoic sediments. A little further to the west, at Ouray, and Elbert formations down to the level of Canyon Creek, where a fault further dislocates the Paleozoic sediments. This is a result of the downthrow to the north and at the point where it crosses Uncompahgre River amounts to about 300 feet. As shown by the geological map, its eastern extension is lost in the San Juan bluff.

West of the Ouray fault is a short fault which effectually conceals the Mancos or Mesaverde series beneath. North of Dexter Creek, on the east side of the Uncompahgre, although several miles wide and over 400 feet thick, its gentle westward dip can not be made out. The northwestern part of the quadrangle, bounded on the east and south by Uncompahgre River, Ramse­

NORTHWESTERN AREA.

The leading geological features of the Ouray quadrangle are the one which extends from the southern end of the Uncompahgre to the north of Dallas Creek. The downthrow is to the north and at the point where it crosses Uncompahgre River amounts to about 300 feet. As shown by the geological map, its eastern extension is lost in the San Juan bluff. As a result of this fault the Dakota formation is assumed, however, that the faults of the Ouray quadrangle are not in the vicinity of Ouray and the other in the vicinity of Ouray is younger than the vol­

EASTERN AREA.

The northwestern part of the quadrangle is characterized by the long north-south ridges separating the Cimarron and Uncompahgre waters and the three parallel forks of Cimarron Creek. These ridges are almost wholly made up of the San Juan formation and exhibit in most typical development of the topographic forms characteristic of that formation. The northwestern part of the quadrangle is almost wholly made up of the San Juan formation and exhibits in most typical development of the topographic forms characteristic of that formation. The northwestern part of the quadrangle is almost wholly made up of the San Juan formation and exhibits in most typical development of the topographic forms characteristic of that formation. The northwestern part of the quadrangle is almost wholly made up of the San Juan formation and exhibits in most typical development of the topographic forms characteristic of that formation. The northwestern part of the quadrangle is almost wholly made up of the San Juan formation and exhibits in most typical development of the topographic forms characteristic of that formation.
are concerned with late Algonkian time, and in
briefly summarized. In chronicling the closing
time to Pleistocene and Recent history has been obtained
of the Telluride and Silverton quadrangles,
oment of the San Juan region is briefly discussed.
Archean rocks supplied material for the great
known to occur in the San Juan Mountains are
more than that they underwent great dynamic
or of the events which followed their formation
mentation was not continuous, and from time to
time of these rocks, which occur in conglomerates of
lates of the Cutler formation.
intrusion of granite and other rocks, and erosion.
period of folding and faulting, although the pro­
grouped as orogenic movement, metamorphism,
Evidently a comparatively local feature.
marked the beginning of a very long epoch of con­
ment of the Pennsylvanian epoch. The Molas
is believed to be a remnant of the Telluride conglomerate, perhaps, by post­
Tertiary erosion from the east.
VOLCANIC ACTIVITY.
A complete record of the volcanic history of the
San Juan region is not preserved in any of the
landmarks surveyed, but the volcanic activity is known
except through its fragments in the San Juan tuff lavas.
The rocks of the San Juan formation so far
examined are andesitic and basaltic. The diversity
of rock types in this formation is probably no
greater than that exhibited by the lavas
the Potas series, and it is worthy of note that many of
the San Juan fragments are very similar to
violent explosion.
No direct evidence as to the location of this
eruption was known, and yet it is not
unnecessary to assume that the lavas were wholly
destroyed in the formation of the San Juan.
The vast bulk of the lavas were probably
formed in the post-Laramie period.
Deposition and erosion of the San Juan.
The source of the San Juan materials being
unknown, the method of transportation and deposition
remains a problem. That they owe their present
distribution to streams was long ago suggested and
that a large area of the San Juan Mountains is
underlain by the same materials has been
recognized.
Juan was vigorously attacked by streams from theacter and distribution, as well as the presence of in the Silverton quadrangle and in the regions to
The fossiliferous calcareous shales interbedded with bodies that occur at various places in the quadrangle. In the Silverton series were poured out. In the Silverton the San Juan was subject before the first lavas of the
Potosi lavas in the Ouray region were very exten-
tions in elevation in the Telluride conglomerates. In the Silverton and Telluride conglomerates the inclination of the conglomerates is clearly shown.
Erosion preceding the Potosi.—Although erosion took place more or less continuously throughout the

The small catchment area at the head of Cow Creek from the ice are the cirques at the heads of the main

Post-Potlows and volcanic events. At some points there have then the eruptions of the volcanic rocks the whole region was affected by slight differential tiltings accompanied by faulting, as well as by the filling of the valleys by detritus from the

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METALLIFEROUS DEPOSITS.

By J. D. Irving.

The metalliferous deposits that have been developed within the limits of the Ouray quadrangle are all in the near vicinity of the town of Uncompahgre River. No one of the important mines is at a greater distance from Ouray than 35 miles.

Although these ore deposits include only a few highly productive mines, they form a series of very unusual scientific interest. There is a close relation between the geology of the district described in the foregoing portion of this text and the character of the ore bodies. The striking features of each ore deposit are due in large measure to the lithologic or stratigraphic nature of the rock in which it occurs.

GENERAL FEATURES.

Considered as a whole, the ore deposits of the Ouray quadrangle form the northern extension of a group of metalliferous deposits that is widely developed in the Silverton quadrangle, which adjoins this quadrangle on the south. Although they are thus in a sense closely related to the Silverton deposits, they form a group which possesses marked individual features.

A few of the larger ore bodies are situated in localities where the rocks are much broken and disturbed, and near intrusive dikes and sheets of porphyry, but most of them are found in formations which have been only slightly disturbed. The veins of the Black Girl and Newshay mines, on the west side of Uncompahgre River, occur in area so regular and so free from intrusions that their mineralization occasions little surprise.

CLASSIFICATION.

The ore deposits are difficult to classify on account of the insensible gradations between even the most divergent types. A single deposit may display very different characteristics in different rocks, so that it will conform to one type of deposit in one part of its course and to another type in another part. For convenience of description the classification below is given. It will serve to bring into the same group the types of ore bodies most readily discussed together.

1. Fissure veins.
2. Replacement deposits in quartzite.
3. Replacement deposits in limestone.

These three main classes of ore bodies owe their existence to the presence of fissures, in general nearly vertical, in the country rock through which the mineralizing waters have circulated. The form of the ore body deposited is dependent on two factors: the amount of open space in the fissures and the kind of rock through which the fissures pass.

Where the fissures have been open the resulting vein exhibits in many deposits a roughly parallel alignment of minerals and little replacement of the wall rock is noticeable. Where, on the other hand, the fissure has been narrow and more or less continuous, the maximum replacement is to be observed along soluble beds. The narrow fissures are apt to be developed in considerable number and large, flat masses or shoots comparable to the bedding are formed.

Of far more wide-reaching importance is the manner of the rocks in which the fissures occur. Most of the veins pass through an immensely varied series of rocks and many of them can be traced upward from the bed into the andesite-breccia cap and comprising the following beds, named from above downward:

1. Dakota quartzite and sandstone, alternating with black shale.
2. Dakota quartzite and sandstone, alternating with clay shales.
3. A highly varied series of clay shales, sandstones, sandy shales, and limestones, belonging to the McElmo formation of the Jurassic.
4. Andesite-breccia cap and comprising the following beds, named from above downward:
   a. Black shale.
   b. Dakota quartzite and sandstone, alternating with black shale.
   c. Dakota quartzite and sandstone, alternating with clay shales.

The accompanying section of Gold Hill (fig. 1), very much generalized on account of the thickness of the beds, will give a somewhat inadequate idea of the variety of rocks through which the fissure passes and will also serve to illustrate the several types of ore bodies among which the vein from a vertical position to about 60°. Dips of 45° are known, but are rather uncommon. The fissures are divided into branches that separate from and unite with one another repeatedly. Cross fractures further unite the divided branches so that in many places the resulting network passes into a more or less branching structure.

RELATION OF FISSURES TO WALL ROCK.

The relation of the ore in the fissure to the wall rock is peculiar. The ore is here a much more abundant and of very much higher grade where it is included between walls of quartzite, and it is either absent or of a low grade where the fissure passes into shales. In some mines, such as the Iron Chief, on the Uncompahgre, this is due to the narrowness of the vein in the clay shales. It is so narrow as to be in most places a mere fracture in the sediments, with no appreciable open space. On passing into the quartzite, the rock more capable of supporting gangue and ore is much more abundant, the wall rock is peculiar. In the Iowa Chief mine the strike is N. 83° E.; in the Black Girl it is N. 85° E.; in the Calliope and Iowa Chief mines is about 25° N. 85° W.

The ore deposits will be briefly considered in the order of the classification already given.

FISURE VEINS.

SILVER-BEARING VEINS. LOCATION AND GENERAL FEATURES.

The fissure veins are readily divisible into two distinct groups—silver-bearing veins and gold-bearing veins.

The silver-bearing veins are developed largely along Dexter Creek, where the interest has centered about the Bachelor, Wadge, and Calliope mines, and on the east side of the Uncompahgre Valley about 4 miles north of Ouray, the principal mines here being the Newshay and Black Girl. A few minor developments, as yet only of prospecive value, occur on the splinting lying west of the river; among these the Gemin and Teller mines are the most important.

The veins are fissures in the country rock filled with high-grade ores of silver and the accompanying gangue minerals. The strike of the fissures is generally fairly uniform, approximating an east-west direction. In the Bachelor and Calliope mines the strike is N. 83° E.; in the Black Girl it is N. 85° E. The dip of the fissure varies from a vertical position to about 60°. Dips of 45° are known, but are rather uncommon. The fissures as a rule show a slight displacement, rarely reaching as much as 7 feet and generally so small as to be distinguishable only by close observation. The width varies from a few inches to as much as 8 feet, a fair average being about 3 feet. Most of the veins are rather uniform, retaining their width for long portions of their course, marked variation, although pinches andsws are noticeable in some of the mines.

The country rock in which the veins occur is a large area of the varied series of sediments lying below the andesite-breccia cap and comprising the following beds, named from above downward:

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ECONOMIC GEOLOGY OF THE QUADRANGLE.

By J. D. Irving and Whitman Cross.
some profits, slightly less accentuated. Similar relations occur also in the Black Girl vein.

Bohies of ruby and tourmaline occur in the veins, but are merely found at great depths below the surface. They are thought to be the result of secondary mineral enrichment of the gray country rock, between the ore zone and the zone of unaltered shales.

The veins are quartz, barite, secondary silver, a pitchblende, carbonate, probably containing magnesite, and manganese. The country rock is a very light gray, in color, and clearly secondary when examined microscopically. The barite is very abundant and occurs in places in amounts so large as to fill the vein almost completely.

The Bachelor vein.

Among the silver veins the Bachelor vein is of the greatest economic importance, having been the chief silver producer in the district as well as the most productive of the district. It possesses so many features that can not readily be presented in a general discussion and is in some respects so peculiar that an account of the silver veins would hardly be complete without a detailed description of this vein.

The Bachelor vein has been opened in three places—at the Bachelor tunnel, in Dexter Creek; at the Wedge shaft on Gold Hill; and on the Mosquito mine, at the base of the cliff in Uncompahgre Canyon. The main openings are those in in these districts. A tunnel has been driven southward into the hill intersects the vein at a distance of 720 feet. The country rocks are the same as in this region, and the vein forms as there is no evidence that the ore is broken. The ore follows the bedding planes of the country rock and is parallel to them. It also enters the breccia along cracks and fissures and seems to have replaced this material in some instances.

The ore is a high-grade silver ore carrying from $30 to $80 per ton. Pockets of ruby silver (to be perynagra) which are reported to have contained 15,000 ounces per ton in silver are discovered from time to time. The vein is said to be argentiferous and contain intercalated beds of shale, mainly at the top of the vein. The country rock contains quartz, barite, and calcite, but in many of the veins the country rock is entirely quartz. The vein varies in width, and can be picked up within short distances. The sediments below the quartzite breccia form numerous lateral outcrops in the lime- stone, but none of those noted were extremely large. Ore minerals occur in very small quantities in the veins. There are galena and copper, gray and stephanite, and other rich silver minerals have been reported from this district are as yet of merely prospecting value.

Commercial considerations.

The ore from the silver mines ranges in value from $30 to $800 per ton. Very high values have been obtained from the oxidized portions, where the native silver is in large amount, and the bournonite of ruby silver is unusually found has yielded exceptionally high returns. In the majority of the mines, however, values of 60 to 200 ounces per ton may be regarded as the average for shipping ore.

The rich ore is usually shipped by rail to smelting centers and there reduced, and where less ore is encountered, as in the Bachelor mine, the concentrates are shipped in like manner. A local smelter has been built in The district, and the treated ore is of very high grade. It is shipped to smelting centers and there smelted, and wherever lean ore is present, it is run to the mill and is reported. The average yield of silver is probably between 2 and 3 ounces of gold per ton, making a high-grade ore of $80. In some mines, as the Grand View, there are less than 2 ounces, and as much as 30 ounces has been reported.

Repayment deposit in quartzite.

Character and formation.

The ore deposits that have been grouped under this heading contain gold with very subordinate silver and occur in irregular bodies in strata of massive quartzite. They are termed "replacement ores" because they have been formed, not by the filling of open spaces existing previous to their deposition, but by a chemical interchange of ore material for original country rock. The mineralizing waters by which they have been produced have been both the solvents of the country rock and the agents which have effectuated the ore deposition. In many places the presence of these waters has been greater than their depositing action, so that cavities largely similar to solution caves in the country rocks are found. The ore is a high-grade silver ore carrying from $30 to $80 per ton. Pockets of ruby silver (to be perynagra) which are reported to have contained 15,000 ounces per ton in silver are discovered from time to time. The vein is said to be argentiferous and contain intercalated beds of shale, mainly at the top of the vein. The country rock contains quartz, barite, and calcite, but in many of the veins the country rock is entirely quartz. The vein varies in width, and can be picked up within short distances. The sediments below the quartzite breccia form numerous lateral outcrops in the limestone, but none of those noted were extremely large. Ore minerals occur in very small quantities in the veins. There are galena and copper, gray and stephanite, and other rich silver minerals have been reported from this district are as yet of merely prospecting value. 

Ore-bearing veins.

The gold-bearing veins are far subordinate to the argentiferous rocks containing silver, lead, and zinc. They are developed along the course of Uncompahgre River between the mouth of Dexter Creek and the town of Ounway, excepting in the steep cuts on both sides of the canyon. The country rocks which form these cuts are, from below upward, the red sandstones, conglomerates, and sandy shales of the Hermosa and Cutler formations (Fortescian); the red shales and sandstones of the Dolores formation (Triassic), lying unconformably above at a slightly different angle; the white sandstones and gray sandstones of the La Plata Plains (Jurassic); the alternating shales, sandstones, and limestone of the Jurassic formations, and the black Mancos shales (Cretaceous). The linner and steepest walls of the canyon are formed of rocks of the lower part of this column—that is, the red beds below the La Plata Plains.

Numerous dikes and irregular intrusions of the same composition occur in the geologic section (fig. 15). These dikes and intrusions are seen cutting across the sedimentary rocks, some of them vertical, and represent the upper part of the column—that is, the red beds below the La Plata Plains. The major mineralizations of this district are as follows: the breccia is as a rule 3 or 4 feet wide but much more readily than the sandstones that they occupy appear in the breccia and the secondary silica is as a rule light grayish in color and contains magnesium and manganese, and country rock. The breccia is as a rule 3 or 4 feet wide but much more readily than the sandstones that they occupy appear, and clearly secondary when examined microscopically. The copper sulphide is closely to freibergite. The copper sulphide is closely to freibergite. The copper sulphide is closely to freibergite. The copper sulphide is closely to freibergite. The copper sulphide is closely to freibergite. The copper sulphide is closely to freibergite. The copper sulphide is closely to freibergite. The copper sulphide is closely to freibergite.

Ore is either gold or silver, and in both portions of the dislocated fissure. A faulting by movements the formation of the breccia and the secondary silica is as a rule light grayish in color and contains magnesium and manganese, and country rock. The breccia is as a rule 3 or 4 feet wide but much more readily than the sandstones that they occupy appear.
partings are observable, and it is slightly blackish, owing to included carbonaceous material. Above it is a series of black shales that are extremely thin bedded and highly charged with coaly matter, as is the comparative one with which these shales are disinte-
graded and were away it is firm in most places an abrupt cliff. It overtops on either side of the U
compahgre Canyon about 3000 feet above the mouth of the valley and follows the indications made by the step polques on either side.

DESCRIPTION.
The ores are widely distributed along the out-
crop of the formation. Among the minor and prospects are the American Nettie, Valley View, Center, Rock of Ages, Simon, and Stonograph. In form, mode of occurrence, and contained values all these deposits are similar, differing only in unimportant details. In one mine, however, the American Nettie, have the ore bodies yet proved sufficiently extensive to be of commercial value.

The general description of this mine will therefore be accomplished by a description of this mine.

AMERICAN NETTIE MININE.
The openings of the American Nettie mine are bevelled into the lower portion of the step cliff which forms the top of the canyon wall on the east side of the Uncompahgre Canyon about 2000 feet above the bottom of the valley. The buildings that have been erected near the entrance are about 100 feet above the base of the ponderous structure. The support does the rock face afford that they are kept in place partly by wooden brackets, and except for their modern construction might well pass for cliff dwellings. The position occupied by the country rocks may most readily be understood from the little sketch forming fig. 4. Above the mine is an immense sheet of quartz monzonite porphyry aggregating about 500 feet in thickness, underlain by 40 to 50 feet of fine black slates, very highly charged with carbonaceous matter and containing a few thin beds of black sandstones. Conformably below these slates is the ore-bearing quartzite, a massive white rock, fine grained and blackish at the base, usually stained and white below. It is separated into two portions somewhat below the middle by a thin parting of light-colored slate. Below this quartzite lies the variegated slaty rocks of the McElmo formation. These beds dip into the hill at a low angle, from 5° to 10°, slightly to the east of north. Locally, however, the dip is much steeper. All the rocks are cut by a number of sills of dark-colored fine-grained granite, probably connected with the monzonite sill above; some of these are in the mine but the larger part is widely separated.

A heavy fleshy fissure filled with a consolidation basaltic in color is developed in the Basaltic and at the mine end is followed by the main tunnel of the mine. Locally it is simply a fleshy fissure with no real parting, and the breccia is termed a "dike," but is not correctly so considered. It is the impression of the miners that the ore emanates from this fault breccia and makes out from into the country rock, but an examination of the mine and a glance at the mine map, as well as the geologist's view with a large and distinct in a similar occurrence in quartzite, where no fault breccia and no porphyry dikes are present, show that the fissing of the rock is not the reason for the occurrence of the ore. The quartzite is crossed by irregular branching fissures, in general nearly vertical in position, many of them extremely narrow and so many others as 2 or 20 inches in width. The displacement is very slight, the average being about 10 inches. They are filled with white crystalline quartz and virtually adjacent to a perfect comb structure. The wider portions show open veins filled with quartz crystals. The fissures intersect one another in two prevailing directions, though many local variations and irregularities occur. Most of them pass upwards into the shales where they are generally lined in the interior in many places. The Creek pass into the porphyry sheath, which rests directly upon the quartzite. They are therefore later than the porphyry. A few of the fissures are wide enough to be termed "fissure veins," and carry ore minerals in sufficient quantity to be mined as such, but these are uncommon.

Along the course of the fissures the ore bodies or shoots extend outward for so much as 20 feet. The most typical of these shoots are irregular breccias, ranging from a few inches to 15 feet in width, with a part of the sheath for several feet, and then the sheath is crossed, and with their larger dimensions in a horizontal position. Many of these breccias, irregular, wandering through the quartzite in all directions, but generally they are concentrated along a single plane, a rule just as true in the one as in the other, which is naturally the slanting or the horizontal part of the unbroken sheath. There are, however, a few instances in which the average values obtained from the Bright Diamond quartzite ore and the most important of the similar though smaller deposits found along the outcrop of the Dakotas quartzite. The quartzite ore is shipped directly. It is transpor-
ted by a wire-roped tramway from the mouth of the mine across the Uncompahgre Canyon to the ore bins along the edge of the railroad. A mill adjoining the ore bins has been used to concentrate the lesser sulphides. It is not in operation at the present time. The ore bins in this mine are located chiefly upon the supply fissures, where it forms a solid mass, but outward along the strata it only presently fills open cavities, namely lining the interior of the chief fissure. These deposits have been formed by the removal of the limestone and the simultaneous substitution of ore material for it by mineralizing waters, which here have passed into the more soluble rock by means of the fissures. They are more regular as a whole than the replacement of quartzite just described, and much more extensive, a few of them being fully 300 feet in length and 10 feet in width. Gold predominates in some of these, silver in others, but the ore which they furnish are uniformly of lower grade than those in the quartzite. The silver-bearing deposits are associated with the silver-bearing quartzite veins already described, and are found only where these veins penetrate strata of soluble limestones.

The replacement deposits may be most conveniently classified according to the prevailing degree of alteration, roughly as hard or soft ore bodies. The former are found in the hard or very hard states of the limestone and the simultaneous substitution of ore material for it by mineralizing waters, which here have passed into the more soluble rock by means of the fissures. They are more regular as a whole than the replacement of quartzite just described, and much more extensive, a few of them being fully 300 feet in length and 10 feet in width. Gold predominates in some of these, silver in others, but the ore which they furnish are uniformly of lower grade than those in the quartzite. The silver-bearing deposits are associated with the silver-bearing quartzite veins already described, and are found only where these veins penetrate strata of soluble limestones.

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EXPLANATION DEPOSITS IN LIMESTONE.
A series of broad, flat ore bodies are found in beds of limestone either adjoining fissure veins or associated with numerous small vertical or nearly vertical fissures that intersect the strata. These deposits have been formed by the removal of the limestone and the simultaneous substitution of ore material for it by mineralizing waters, which here have passed into the more soluble rock by means of the fissures. They are more regular as a whole than the replacement of quartzite just described, and much more extensive, a few of them being fully 300 feet in length and 10 feet in width. Gold predominates in some of these, silver in others, but the ore which they furnish are uniformly of lower grade than those in the quartzite. The silver-bearing deposits are associated with the silver-bearing quartzite veins already described, and are found only where these veins penetrate strata of soluble limestones.

In the massive sulphide bodies the gray copper ore is the most characteristic. Mixed with the oxidized ore are small quantities of galena, sphalerite, and chalcopyrite, in others, but the ores which they furnish are uniformly of lower grade than those in the quartzite. The silver-bearing deposits are associated with the silver-bearing quartzite veins already described, and are found only where these veins penetrate strata of soluble limestones.

The larger structures of the country rock, such as brecciation, bedding planes, layers of shale, etc., extend discontinuously into the ore, except where, in the bodies of sulphide, the mineralization has obliterated them.

The barite and quartz veins are rarely in gold. The silver content is in one of the ore $4 to $6 per ton, but is generally so low as to be negligible. In the barite ore, especially as in the bodies of sulphide, the mineralization is reported to average as a whole about $10 per ton, although much higher values are occasionally encountered. In the
and end late in the Cretaceous period. The time between these two events is termed the Eocene epoch.

**MAGNETITE-PYRITE ORES.**

The magnetite-pyrite ores are of greater scientific interest than commercial interest. They have been found at only one locality—in the Bright Diamond and Iron Clad mines, on the east wall of the Uncompahgre Canyon, about 600 feet below the American Notti mine. The ore occurs in a fine-grained dark-blue limonite, apparently quite pure and, where unmineralized, with no evidence of alteration. This stratum is about 10 or 15 feet thick and is overlain by green shale that has been altered by the metamorphism of the intrusive igneous rocks. The ore occurs in breccia and in clastic sediments, and in a few places it occurs near the contact of the intrusive rocks. The ore is composed of magnetite and pyrite, and it is found in the Bright Diamond and Iron Clad mines. The ore is rich in magnetite and pyrite, and it is of economic importance.

**Coal.**

Coal is present throughout the Ouray quadrangle, but the local demand is not sufficient to warrant the production of coal. The coal occurs in the Dakota formation, and it is of subbituminous character. The thickness of the coal bed varies from 15 to 30 feet, and it is overlain by green shale that has been altered by the metamorphism of the intrusive igneous rocks.

**WATER RESOURCES.**

The water resources of the Ouray quadrangle are of little importance. The only water sources are the springs and the streams. The springs are few in number and are of little value. The streams are small and are of little economic importance. The water resources of the Ouray quadrangle are not sufficient to warrant the development of any water projects.
Other springs within the town limits issue from the Ouray limestone near the fault line which crosses both Canyon Creek and Uncompahgre River, a short distance above their junction. One of these, situated on the river about 30 feet shore the mouth of the creek, has a temperature of 68° C. According to Mr. G. E. Kedzie an analysis of the water of this spring yielded the result shown in the following table.

Another spring, or group of springs, occurs on the eastern side of the alluvial flat of Uncompahgre Park about 2 miles southeast of Ridgway. The water is heavily charged with iron and there has been deposited from it a thin sheet of red ferruginous tuffs covering several acres. According to the owner, Mr. L. F. Orvis, jr., the water has a temperature of about 110° F. It issuing under slight pressure and the discharge is sufficient to irrigate 15 acres of land. No analysis has been made. The water presumably comes from the red strata of the Cutler formation, from which it no doubt derives its iron content. Peale refers to these springs in the Hayden Survey report for 1875 as follows: "A short distance above the mouth of Dallas Fork are the springs which give the name of Uncompahgre—red-water spring—to the river and park."

June, 1906.

### COLUMNAR SECTION

<table>
<thead>
<tr>
<th>Column</th>
<th>Formation Name</th>
<th>Age</th>
<th>Character of Rocks</th>
<th>Thickness of Strata in Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>Potash volcanic series</td>
<td>Tement</td>
<td>An alternation of rhyolite, quartz latite, and pyroxene andesite flows and tuffs, the flows greatly predominating. Some of the thin flows in Whitewater Mountains are gray.</td>
<td></td>
</tr>
<tr>
<td>1.050</td>
<td>Mission tuff</td>
<td>Triassic</td>
<td>Finely-grained greenish tuff of andesite and latite material, well stratified and nonfossiliferous. Greatest known development is in the Lake City quadrangle.</td>
<td></td>
</tr>
<tr>
<td>1.100</td>
<td>Pyroxene andesite</td>
<td>Triassic</td>
<td>A series of red sandstones and tuffs, characterized by both augite and hypersthene. Greatest known development is in the central part of the Silverton quadrangle. In the Ouray quadrangle only flows are known to occur.</td>
<td></td>
</tr>
<tr>
<td>1.150</td>
<td>Jurassic</td>
<td>Jurassic</td>
<td>Finely-grained, dark green andesite tuff containing lenses of impure limestone, bony fossil leaves and shells in calcareous layers.</td>
<td></td>
</tr>
<tr>
<td>1.200</td>
<td>San Juan tuff</td>
<td>Jurassic</td>
<td>Almost entirely andesitic debris. Near the base is a well-stratified tuff which becomes poorer and less distinctly bedded in the upper portion. Fossils are not known to occur. The beds vary greatly in thickness, stringing in regularity of deposition and re-creating the position of the Silurian series. The maximum thickness observed is in the vicinity of Portland Creek.</td>
<td></td>
</tr>
<tr>
<td>1.250</td>
<td>Tertiary</td>
<td>Cretaceous</td>
<td>Cutler formation consisting of black sandstone, siltstone, and fine-grained sandstones and shales of bright red color with fine limestone conglomerate near the base.</td>
<td></td>
</tr>
<tr>
<td>1.300</td>
<td>Mesozoic formations</td>
<td>Mesozoic</td>
<td>An alternation of rhyolite, quartz latite, and pyroxene andesite flows and tuffs, the flows greatly predominating.</td>
<td></td>
</tr>
<tr>
<td>1.350</td>
<td>Dakota sandstone</td>
<td>Mesozoic</td>
<td>A series of gray or yellowish-gray sandstones and shales, massive and cross-bedded in the lower portion and exhibiting a number of productive coal seams in the upper portion. Intervenous beds of shale.</td>
<td></td>
</tr>
<tr>
<td>1.400</td>
<td>Morrison formation</td>
<td>Cenozoic</td>
<td>Two massive, friable, white, cross-bedded, quartzose sandstones with a narrow band of dark limestone or calcareous shale at or near the base. Carbonaceous shale and coal of poor quality locally present. Interlayers of claystone occur sparingly.</td>
<td></td>
</tr>
<tr>
<td>1.450</td>
<td>Eocene</td>
<td>Eocene</td>
<td>A series of alternating, thin, fine-grained, yellowish or grayish sandstones, shales, and thin limestones. The sandstones often include baked quartz clasts of gravel-sized or pebble size. The shales are thinly bedded, in some beds not more than 5 feet thick. Gray or rusty-brown quartzose sandstone with a variable conglomerate containing small chert pebbles at or near the base.</td>
<td></td>
</tr>
<tr>
<td>1.500</td>
<td>Oligocene</td>
<td>Oligocene</td>
<td>Two massive, friable, white, cross-bedded, quartzose sandstones with a narrow band of dark limestone or calcareous shale between. The limestone is locally brecciated. No determinable fossils found.</td>
<td></td>
</tr>
<tr>
<td>1.550</td>
<td>Miocene</td>
<td>Miocene</td>
<td>A series of fine-grained sandstones and shales of bright red color with thin lenses of impure limestone near the base in which are found teeth and gastropod shells indicating Triassic age.</td>
<td></td>
</tr>
<tr>
<td>1.600</td>
<td>Plio-Pleistocene</td>
<td>Plio-Pleistocene</td>
<td>A series of bright red sandstones and lighter red or pinkish grits and conglomerates alternating with sandy shales and muds or sandy limestones of various shades of red.</td>
<td></td>
</tr>
<tr>
<td>1.650</td>
<td>Holocene formations</td>
<td>Holocene</td>
<td>A series of rhyolite andesite flows and tuffs.</td>
<td></td>
</tr>
<tr>
<td>1.700</td>
<td>Uncompahgre formation</td>
<td>Tertiary</td>
<td>Massive white or grayish quartzite and dark sandstone, with a few zones in which the rocks alternate in thin lenses. No fossils found.</td>
<td></td>
</tr>
</tbody>
</table>