Ogden Tweto

COLORADO SCIENTIFIC SOCIETY PROCEEDINGS

Burbank

Rel. of Struc. & Strat. to Ore

VOLUME 12

No. 6

PUBLISHED BY THE SOCIETY
DENVER, COLORADO
1930

[Presented before the Society February 22, 1930]

REVISION OF GEOLOGIC STRUCTURE AND STRATIGRAPHY IN THE OURAY DISTRICT OF COLORADO, AND ITS BEARING ON ORE DEPOSITION[1]

W. S. BURBANK[2]

CONTENTS

[1]Published by permission of the Director of the U. S. Geol. Survey and the Colorado Metal Mining Fund.

[2]Associate Geologist, U. S. Geological Survey.

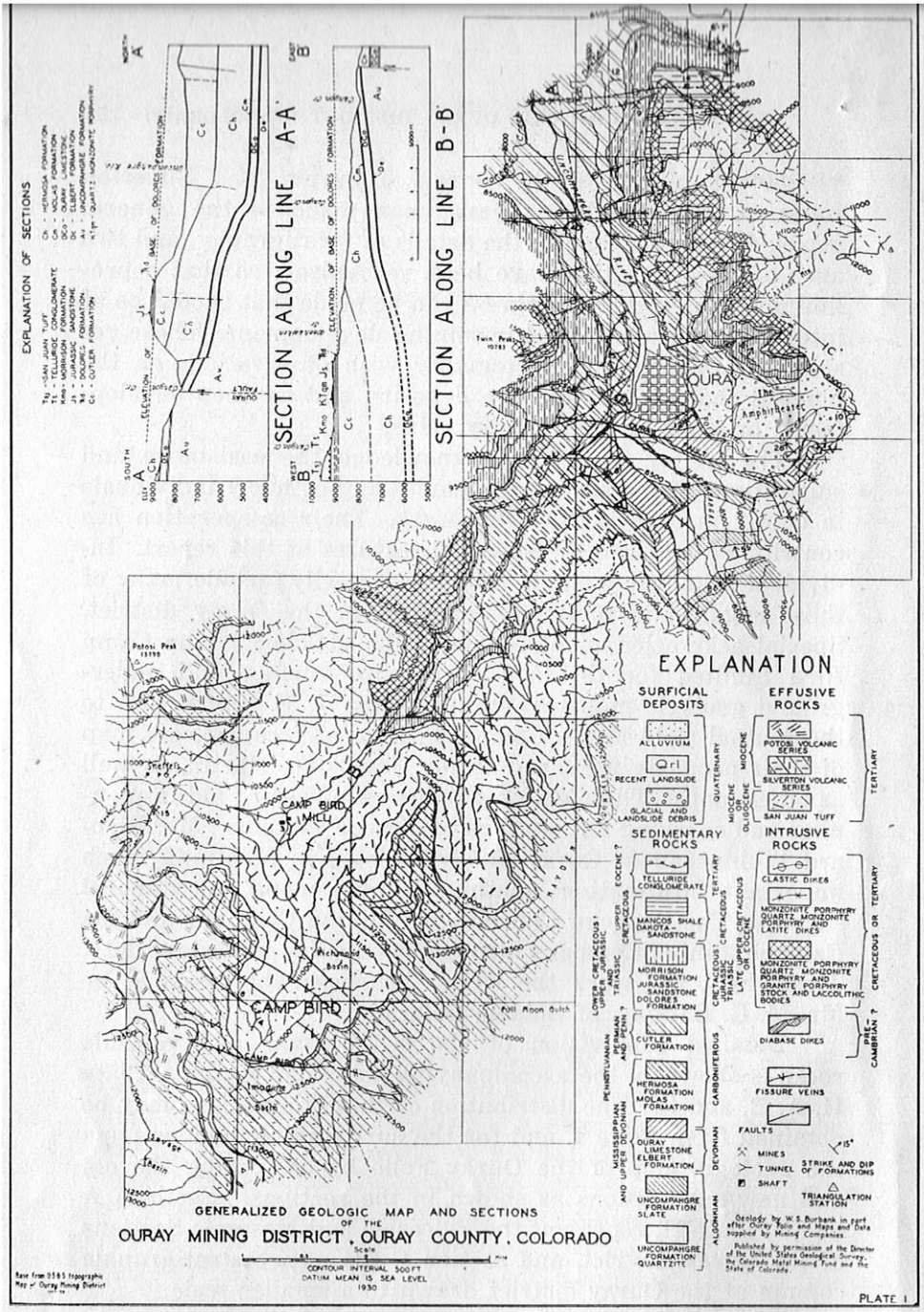
INTRODUCTION

One of the projects of the co-operative program of the Colorado Metal Mining Fund, the State of Colorado, and the United States Geological Survey is a resurvey of the Ouray-Telluride-Silverton "triangle" of the San Juan region. This project was begun at Ouray in 1928 and will be extended at least through 1930. The excellent topographic base map prepared by C. A. Ecklund on a scale of 1:12000 (1 inch equals 1000 feet) has permitted the geologic mapping to be carried on in much greater detail than was possible on the scale of

1:62500 employed in the Ouray, Telluride, and Silverton folios. Certain revisions have been made in the general geologic structure, and in the details of stratigraphy, and two ages of ore-deposition have been recognized, so that a preliminary statement of progress can be made that should be of interest to those engaged in mining development. These results are presented here, together with observations on the general character of the ore deposits, and on deep developments on some of the Tertiary veins.

The writer wishes to acknowledge the assistance and suggestions of the mining companies and of many individuals in Ouray in carrying out this work. Their co-operation has contributed much to the essential features of this report. Individual acknowledgments would necessarily include many of those engaged in mining enterprises in the Ouray district. Special acknowledgment is due to the officials of the Camp Bird Limited for the loan of detailed surface and underground geologic maps prepared by Mr. J. E. Spurr, and to the Mutual Gold Mines Company for a surface geologic map of their property prepared by Mr. James W. Martin, as well as other maps. These geologic maps have been of aid in planning and carrying out surveys of fissure systems. Mr. Richard Whinnerah of Ouray kindly assisted in obtaining much important information relating to mine maps and mineral surveys. The Bachelor Consolidated Mining Company and the Calliope Mining Company also freely supplied important data. Throughout the work the writer has been ably assisted by Mr. M. G. Barclay, of Golden, Colorado.

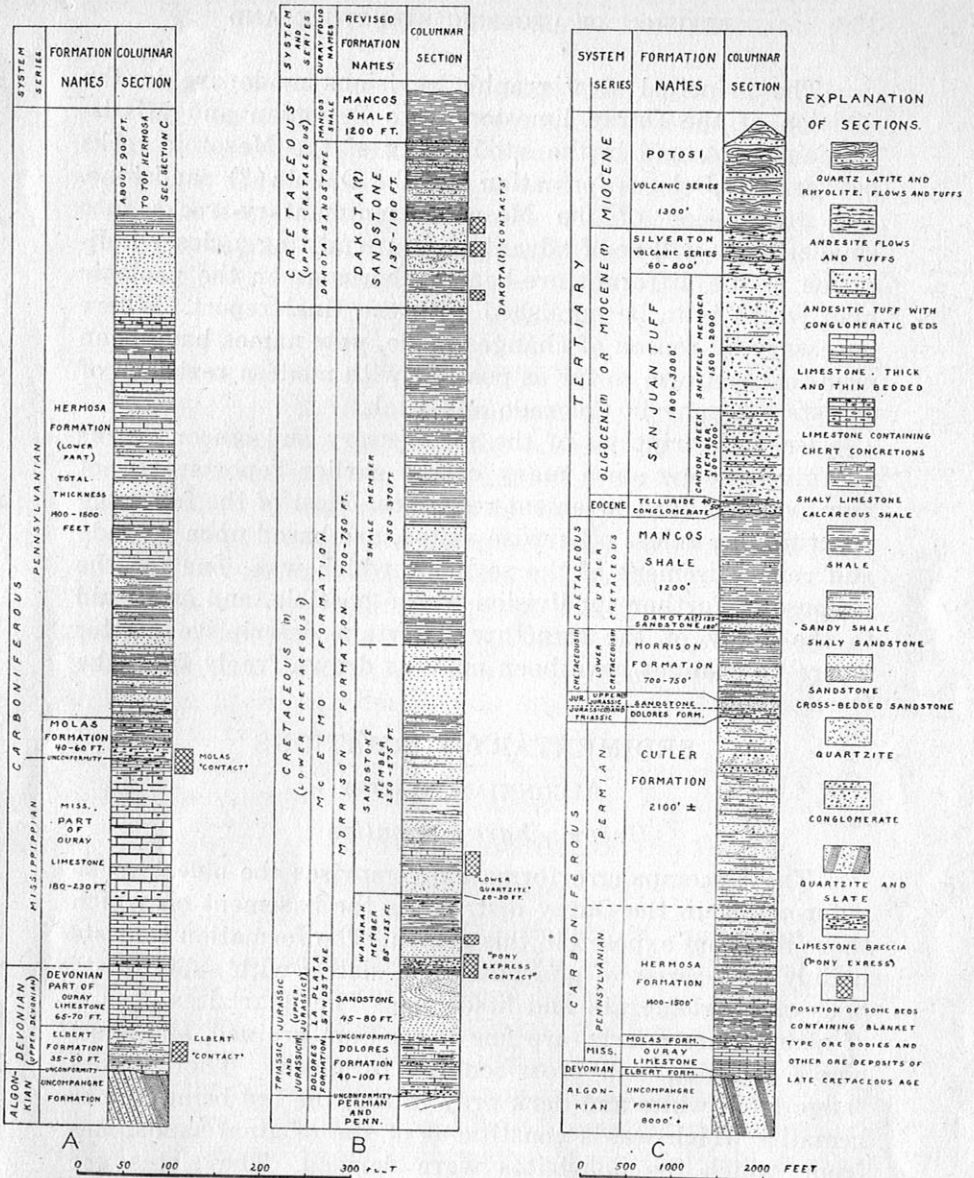
Detailed subdivision of the sedimentary and volcanic rocks is shown in the accompanying columnar sections, Plate II, A, B, and C. The distribution of these formations may be obtained from Plate I, and for the surrounding regions from the geologic map of the Ouray Folio by comparing the old and new subdivisions as shown in the sections. Sections A and B, Plate II, represent the Paleozoic and Mesozoic Sections of the Ouray district, and section C the entire stratigraphic column of the Ouray district drawn to a smaller scale.



List of Mines Shown On Map

1. American Nettie mine.
2. Bimetallist mine.
3. Camp Bird mine, 14th level tunnel.
4. Camp Bird mine, 3rd level tunnel.
5. Calliope mine.
6. Hidden Treasure mine.
7. Khedive tunnel, Bachelor Cons. mine.
8. Mineral Farm mine.
9. Pony Express mine.
10. Portland mine.
11. Rock of Ages mine.
12. Syracuse tunnel, Bachelor Cons. mine.
13. Wanakah mine.
14. Wedge shaft, Bachelor mine.
15. Wheel of Fortune mine.

PLATE II



Stratigraphic sections of the rocks of the Ouray mining district. A. Section of part of Paleozoic sedimentary formations, based upon sections measured south of Ouray, and upon the section of the Molas and Hermosa formations near Oak Creek. B. Section of the Mesozoic sedimentary formations. Morrison formation measured on cliffs north of The Amphitheatre. Dakota sandstone measured near Schofield Tunnel, American Nettie mine. C. Generalized section of complete stratigraphic column of the Ouray district.

The principal stratigraphic revisions made are in the division of the Ouray limestone into Devonian and Mississippian parts, and in the subdividing of the Mesozoic rocks between the Dolores formation and the Dakota(?) sandstone. The subdivision of the Mesozoic sedimentary rocks into smaller units will be of advantage in permitting a closer indication of the different ore-bearing horizons on the geologic map which is to be published with the final report. Where necessary by reason of changes made, new names have been used that conform so far as possible with modern revisions of the stratigraphy in Colorado and Utah.

Brief descriptions of the sedimentary and igneous rocks are given below since many of the earlier reports are not now available for convenient reference. Most of the following descriptions, unless otherwise stated, are based upon restudy and remeasurement of the sections, which was done for the purpose of further subdivision where possible, and as an aid to the study of the structure. Certain descriptive matter where no changes have been made is drawn freely from the Ouray folio.

SEDIMENTARY FORMATIONS

ALGONKIAN SYSTEM

Uncompahgre Formation

The Uncompahgre formation comprises the oldest rocks outcropping in the Ouray district, as the basement on which these lie is not exposed in this region. The formation consists mainly of a series of quartzites and slates, with subordinate beds of conglomerate and limestone. The quartzites consist of nearly pure quartz, are fine to medium grained, and show ripple marking and cross-bedding in places. Their colors range from white and dark gray to red, the red being due to hematite which was a constituent of the original sandstones from which the quartzites were derived. The slates are mostly dark colored and hard, and are locally crumpled and slickensided as a result of deformation between the more rigid beds of quartzite.

Quartzites are the predominant rocks of the formation, the slates occurring in five or more conspicuous bands, the thicker of which are 600 to 700 feet; but in addition there are a few zones in which slate and quartzite alternate in thinner layers. The total thickness of the formation has not been remeasured, but the Ouray and Silverton folios give a total thickness somewhat in excess of 8,000 feet.

CAMBRIAN SYSTEM

Ignacio Quartzite

So far as has been determined, the Upper Cambrian quartzite which is present at the base of the Paleozoic section in the Animas canyon south of Silverton, and at one place on Cow Creek northeast of Ouray, is not present in the vicinity of Ouray, where the Devonian rocks rest directly on the tilted Algonkian quartzites and slates.

South of Silverton, the Ignacio quartzite is about fifty feet in thickness, and consists in the lower part of massive pink or reddish quartzite, whereas the upper beds are nearly white. A basal conglomerate is often found in hollows of the floor at the base of the formation.

Its absence near Ouray is evidently due to erosion prior to the deposition of the Devonian beds.

DEVONIAN SYSTEM

Elbert Formation

The Elbert formation in the vicinity of Ouray consists of thin beds of conglomerate, quartzite, shale, and limestone, that form the base of the Paleozoic sedimentary rocks. The Ouray Folio is followed in assigning this series of beds to the Devonian, based upon fish remains found on the south slopes of the Needle Mountains, and at Rockwood.[3]

A typical section of the Elbert formation measured on the cliffs west of the Uncompahgre River south of Ouray, is as follows.

---

[3]Cross, W., Howe, E., and Irving, J. D., U. S. Geol. Survey, Geologic Atlas, Ouray Folio 153, p. 3, 1907.

Section of Elbert formation:

		Feet
11.	Limestone, sandy and marly; buff; weathers into rounded forms; contains in places beds of purplish limy shale and sandstone	15.0
10.	Limestone, sandy; weathers dark brown	3.0
9.	Shale, siliceous; greenish	3.0
8.	Shale, soft and chocolate brown, somewhat limy	1.5
7.	Quartzite, greenish	1.6
6.	Limestone, very fine, siliceous; gray, weathering buff	1.0
5.	Sandstone, soft marly partings, and pure grit lenses; at base 2 feet reddish and white shaly and limy partings	6.0
4.	Shales, thin bedded; contain siliceous limestone beds 2 to 5 inches thick, and soft marly layers	8.0
3.	Conglomerate, lenticular; contains pebbles ½ inch to 4 or 5 inches in diameter	1.5
2.	Shale, calcareous; gray or buff	2.0
1.	Sandstone and quartzite; shale partings; colors greenish and reddish brown; 1 to 2 feet of coarse grit at base	7.0
	Total thickness of Elbert formation	49.1

Unconformity, upturned beds of Uncompahgre formation.

The sections of the Elbert formation are very different in detail at different localities, but are of the same general composition, and usually contain a characteristic impure limestone at the top. The base of the overlying Ouray limestone is at places marked by sandy and conglomeratic beds containing fragments of crinoid stems. The thickness of the Elbert ranges from 30 to 50 feet.

No ore deposits of commercial importance are known in the Elbert about Ouray, but it contains shales and porous limy beds in association that might be replaceable by ore under favorable structural conditions. Where the Elbert formation is exposed in Ralston gulch small replacement deposits of sulphide occur in it, but these have not been developed.

Devonian Part of the Ouray Limestone

As shown in the columnar section, Plate II, the Ouray limestone at Ouray is divisible into two lithologic units, one of Devonian and the other of Mississippian age. The lower or Devonian part, where measured on the cliffs west of the Uncompahgre south of Ouray, is about 68 feet thick. It

consists predominantly of gray, buff, or white limestones of fine or medium grain. Some beds weather to smooth surfaces which have an ocher color, a feature particularly characteristic of the lower member. At places the division between the underlying Elbert formation and the Devonian Ouray limestone is difficult to draw sharply, but at other places a sandy or conglomeratic bed containing crinoid fragments marks the base of the Ouray limestone. About 15 to 20 feet above the base of the limestone at one locality, a four-foot bed of pinkish coarsely crystalline limestone was found that contained numerous fossils. According to Dr. Edwin Kirk of the United States Geological Survey, who examined this collection, "these fossils are characteristic of the Upper Devonian Ouray fauna."

No other fossiliferous horizons were found in the Devonian part of the limestone, but the top of the Devonian beds is taken at the base of a blue-gray, thin bedded limestone that commonly contains nodules of black chert. An inconspicuous limestone-breccia occurs at places in these overlying beds. At Box Canyon the dark colored chert-bearing beds and the breccia are both absent, but the base of the Mississippian limestone seems to be marked by sandstone layers containing calcareous cement.

This lithologic division of the Ouray limestone is of more than local occurrence as has been determined by recent studies of Dr. Kirk of the United States Geological Survey in Colorado, and by the writer[4] at Kerber creek west of Villa Grove.

Dr. Chas. H. Behre[5] has recently described a division in the Leadville limestone in the Iowa Gulch area of the Mosquito Range which he tentatively correlated with the divisions worked out by Dr. Kirk.

The Devonian part of the Ouray limestone is barren of ore deposits so far as is known, and the impurities in it

[4]Burbank, W. S., Geology and ore deposits of the Bonanza district, Colo.: U. S. Geological Survey (Publication in preparation).

[5]Behre, Chas. H., Revision of the structure and stratigraphy in the Mosquito Range and the Leadville district, Colorado: Proc. Colo. Sci. Soc., vol. 12, pp. 38-41, 1929.

make it unsatisfactory for quarrying as a source of limestone.

CARBONIFEROUS SYSTEM

MISSISSIPPIAN SERIES

Mississippian Part of the Ouray Limestone

Mississippian beds comprise the greater part of the Ouray limestone. They are about 235 feet in thickness as compared with the 68 feet of Devonian beds. (Pl. II-A.) Fossil collections were made in two sections at the horizons ranging from 55 to 235 feet above the base of the Mississippian part. Dr. G. H. Girty of the United States Geological Survey, reports as follows on these collections:

> "Some of the faunas are very meager and all of the specimens are in a poor state of preservation. Nevertheless, I feel little doubt that the geologic age of the collections from both sections is early Mississippian (Madison). Such is my personal conviction, but the paleontologic evidence is not in itself really conclusive save in one or two instances."

Although the lower 55 feet of beds in the Mississippian part appear to be unfossiliferous in the vicinity of Ouray, the presence of a lithologic break at their base and their greater similarity to the overlying fossiliferous beds is believed to be sufficient evidence for their inclusion in the Mississippian series.

The lower 50 or 60 feet of beds, where unaltered, are predominantly dark blue-gray or brown evenly bedded limestone, but contain interbedded gray crystalline limestone and sandy layers. At places the limestone has been recrystallized and probably bleached by circulating solutions, possibly related to local mineralization, so that the distinction in color probably cannot be relied upon to recognize the basal beds of this member. Above the lower beds the Mississippian part of the Ouray is composed largely of massive gray or brownish gray crystalline limestone alternating with beds of limestone-breccia containing red shaly seams. The greater ease with which the shaly layers have weathered has caused the upper part of the limestone to form a series of step-like benches where it outcrops. The more massive crystalline layers com-

monly contain fossils, but these may be scarce and poorly preserved. Near the top of the limestone some coarsely crystalline beds are found, consisting largely of fossils and fossil fragments. The beds at a number of horizons contain chert nodules or chert layers. Near the top the shale layers and breccias become more prominent and coarse in texture. The fragments of the breccias form a mosaic set in a matrix of red shale. In the bed of Canyon Creek below the Box Canyon the upper limestones are overlain by alternations of shales and impure ferruginous limestones. Some of the uppermost limestones are siliceous and delicately banded with chert layers. At most places this uppermost shaly horizon appears to have been eroded away before the deposition of the overlying Molas formation of Pennsylvanian age.

The only horizon of the Mississippian limestone known to be ore-bearing comprises the uppermost beds immediately beneath the chert conglomerates and red shales of the Molas formation. Where the limestone has been cut by Tertiary fissure veins at the head of the Amphitheatre there is however some replacement of the brecciated limestone wall immediately adjacent to the veins. The greater part of the Mississippian limestone is massive and tough, a feature probably unfavorable to easy replacement, unless the beds were intensely shattered.

The lower unfossiliferous beds of the Mississippian, up to 50 or 60 feet above the base, are softer and more brittle and would appear to possess physical properties more favorable to brecciation and replacement, but no ore deposits of commercial importance are known to occur in these beds, perhaps because of the absence of an impervious cover.

PENNSYLVANIAN SERIES

Molas Formation

The base of the Molas formation marks the first important unconformity above the base of the Paleozoic section at Ouray. That the deposition of the Molas beds was preceded by considerable erosion is shown by the large amount of Mississippian chert included in the basal beds of this forma-

tion. The absence at most places of the uppermost shale and chert-bearing beds of the Mississippian part of the Ouray limestone may be interpreted as due to their removal during this period of erosion. There is not, however, any noticeable angular unconformity between the formations.

A typical section of the Molas formation measured on the north side of Canyon Creek below Box Canyon is given below.

Section of Molas formation on north side of Canyon Creek below Box Canyon:

		Feet
16.	Shale gray	2.5
15.	Sandstone, greenish; shaly partings	1.0
14.	Shale, red; grading up into sandstone	5.0
13.	Conglomerate; chert fragments with red cement; lenticular	1.5
12.	Shale, red	3.0
11.	Conglomerate; sandy, grading up into red shaly sand and red shale; many quartzite pebbles, probably from the Algonkian	1.0
10.	Shale; red and sandy; contains chert pebbles scattered through it	10.5
9.	Conglomerate; cemented with red sandy matrix; chert and quartzite pebbles	2.0
8.	Shale; reddish brown	2.5
7.	Conglomerate; red sandy matrix; chert pebbles	1.2
6.	Shale; sandy, reddish brown	4.5
5.	Conglomerate; calcareous cement; chert pebbles	1.4
4.	Shale; sandy and calcareous; blocky	2.7
3.	Conglomerate; many chert pebbles; reddish cementing material	1.4
2.	Shale; reddish; contains many scattered chert pebbles from small ones less than an inch to 3 inches in diameter; fractures blocky	3.5
1.	Conglomerate; coarse; composed mostly of chert pebbles ¼ inch to 6 inches; cemented by red sandy material	3.7
	Total thickness of Molas formation	47.4

The base of this particular section rests upon the uppermost shales of the Ouray limestone, which appear to have been eroded away at most other places in the Ouray district. The top of the Molas is taken at the base of a conglomeratic bed which grades up into a coarse sandstone or grit more typical of such beds in the overlying Hermosa formation. The base of the Molas has a considerable range in the nature and thickness of its beds, which are of lenticular character

and change within short distances. At places there are 10 or 15 feet of reddish shale like No. 2 of the above section, which rests upon the basal chert conglomerate. The Molas formation as a whole is distinguished by the large amount of black and gray chert fragments included in its beds, and by the predominance of red shaly cementing material, both of which appear to have been derived from the uppermost shales, and cherty limestone of the Ouray formation.

The range in thickness of the Molas where it is exposed for measurement is between 40 and 50 feet.

The following comment is made in the Ouray Folio[6] regarding the age of the Molas:

> "In the uppermost part of the formation at a single locality in the Needles Mountain quadrangle, some thin limestone beds are intercalated between sandstones, and these contain a Pennsylvanian fauna which, according to Girty, is 'related to that of the Hermosa formation, but contains no species in common with the Ouray limestone. Some points of individuality distinguish the Molas fauna from that of the Hermosa, but it cannot be conjectured how far this would be borne out by full collections.' "

The lower chert-bearing shales and conglomerate beds of the Molas, together with the uppermost part of the Ouray limestone constitute the horizon within which most of the ore-deposition at the Mineral Farm mine took place. At several places in the Amphitheatre east of Ouray the lower beds of the Molas also seem to have influenced the localization of ore. The possible causes of this influence will be considered in later paragraphs.

Hermosa Formation

The Hermosa formation lies conformably upon the Molas in the Ouray district, and comprises the beds extending up to the Cutler formation, of Permian age. The total thickness included in the Hermosa measured near Oak Creek amounted to approximately 1450 feet. A detailed section of the beds of the Hermosa will not be given here, but the character of the formation may be obtained from the columnar sections, Plate II, A and C.

The lower 450 feet of the Hermosa consists predom-

[6]Op. cit. (Folio 153) p. 4.

inantly of thin alternating beds of sandstone, shale, and thin fossiliferous limestones, with a few thin layers of conglomeratic sandstone. The Hermosa section above a basal chert-bearing conglomerate begins with a series of thin alternating beds of greenish-gray sandstone, shales, and sandy limestones. At places there are a few thin dense limestone beds near the base, interbedded with black carbonaceous shales. Between 180 and 450 feet above the base six or seven thin limestone beds were seen, but there may be several others which were not well exposed. Most of these range in thickness from one to five feet, but the top limestone of the section is about 25 feet in thickness. It was found that the correlation of different limestone beds from place to place was impracticable, apparently because individual beds thin out laterally or grade into beds of limy shale. Many of the limestones are gnarly and contain siliceous concretions, and other beds are dark colored, dense limestones. None of the beds appear to be favorable horizons for ore-deposition. Many of the limestones and dark colored shales are fossil-bearing. The sandstones in the lower part of the Hermosa are prevailingly of gray or greenish color, but some of the coarser grits are pinkish. The shales are prevailingly dark, but some are greenish or reddish.

The middle 700 feet of the Hermosa consist of massive beds of grit, sandstone, and red sandy shales, separated by dark colored fossil-bearing shales and thin gnarly beds of limestone. The massive beds of grit or coarse sandstone range from 50 to 80 feet in thickness and are of pinkish color; some of them about midway of the Hermosa contain conglomerate lenses.

The upper part of the Hermosa formation comprises about 300 feet of coarse arkosic sandstones or grits, and conglomerate beds, with intercalated shales and limestones. It differs from the middle Hermosa below it in that it contains more abundant conglomerate lenses, and a greater proportion of feldspathic material in the sandstones. In this respect it also differs from the sandy shale beds of that part of the Cutler which immediately overlies it.

The coarse conglomerates and the arkosic character of the sandstones found in this upper 300 feet of the Hermosa would appear to reflect certain crustal disturbances in upper Pennsylvanian time. As this change in character of the sedimentation is more pronounced at these horizons than in the underlying beds or in the unfossiliferous "red beds" immediately above these horizons, and as the fossil-bearing beds contain a large proportion of molluscs as compared with brachiopods, it was thought that they might possibly correspond to the Rico formation of the Rico Mountains. However, Dr. Girty[7] of the United States Geological Survey gives his opinion that the collection of fossils made from these beds should be included in the Hermosa. He states:

"Lot 0-26344 came from a higher horizon and about this the question was raised whether the formation was not Rico rather than Hermosa. The fauna of this collection is large and varied, and although the brachipod element in it is small and the molluscan element large (one of the peculiarities of the Rico fauna), it is not the Rico fauna, neither is it Permian in facies. The fact last mentioned stands out more clearly than the other, fortifying but not establishing it. The statement that this horizon is not established as Hermosa by the circumstance that its fauna is decidedly Pennsylvanian, whereas the Rico fauna is generally regarded as Permian, rests in the fact that the Permian age of the Rico is, I believe, debatable. The inclusion of this horizon in the Hermosa, however, finds support on other grounds. If the Rico fauna and the fauna of lot 0-26344 are compared by their lists, it will be found that they contain a considerable number of species in common, but that, on the other hand, each has a considerable number peculiar to itself. If the two faunas are compared through the actual specimens this difference finds additional significance in the abundance in which certain species occur, species that in some instances are found in only one of the faunas and are important diagnostically. Primarily because the fauna from Ouray has a facies that appears to be decisively Pennsylvanian, together with the general if tentative acceptation of the Rico as Permian, and secondarily, because of the unquestionable differences in the faunas themselves together with the faunal affinities between lot 0-26344 and lot 0-26343 (typical Hermosa beds below) that should not be disregarded. I believe it would be wise to include the horizon from which lot 0-26344 came in the Hermosa formation.

"The species which I have identified in this collection are as follows:

6765 (0-26343)[8]		6766 (0-26344)[9]
	Coelenterata	
		Topophyllum

[7]Personal communication to the writer.

[8]Lot 0-26343 came from about 1150 to 1200 feet above the base of the Hermosa.

[9]Lot 0-26344 came from beds about 200 feet stratigraphically above lot 0-26343.

Brachiopoda	
Chonetes mesolubus	Orbiculoidea sp.
Productus coloradvensis	Productus coloradocusis
Productus cora	Productus cora
Pustula nebraskensis	Pustula nebraskensis
Marginifera muricata	Marginifera muricata
Spirifer rockymontanus	Squamularia perplexa
Squamularia perplexa	Composita subtilata
Composita subtilata	Hustedia mormoni
Cleiothyridina orbicularis	
Pelecypoda	
Schizodus- sp.	Edmondia ovata
	Edmondia n. sp.
	Allerisma granosum?
	Nucula beyrichi?
	Leda bellistriata
	Anthraconeilo? sp.
	Parallelodon tenuistriatus
	Parallelodon? sp.
	Schizodus ovatus
	Schizodus affinis?
	Deltopecten occidentalis
Gastropoda	
Pleurotomaria sp.	Lolenomya? n. sp.

The top of the Hermosa formation is arbitrarily chosen at about 130 feet above the upper fossiliferous horizon where the succeeding beds are unfossiliferous in this vicinity, and correspond more closely in lithologic character with the great thickness of Cutler "red beds" above.

The Hermosa near Ouray does not contain replacement deposits of the blanket type, but close to the walls of fissures related to the "Blowout" stock, pyritic replacement deposits occur in some of the beds. Whether the lack of large replacement deposits in this formation is due to unfavorable characteristics of its beds, or to some unfavorable structural conditions is a matter of some uncertainty. It is probably significant, however, that the breccia "contacts" or blankets that are characteristic of the Hermosa further south and southwestward and which contain ore deposits at Rico[10] are not present at Ouray.

PERMIAN SERIES

Cutler Formation

The Cutler formation lies conformably upon the Her-

[10]Ransome, F. L., Economic Geology of the Rico quadrangle: U. S. Geol. Survey, Geol. Atlas, Folio 130, pp. 17-18, 1905.

mosa formation. The upper 300 feet of the Hermosa resembles the Cutler much more closely than it does the lower and middle Hermosa below it, and consequently the division between the Hermosa and Cutler formations cannot be sharply drawn. The only logical division that could be made was to place the base of the Cutler at the top or near to the top of the highest fossiliferous limestone, or shale, of Hermosa age. The conditions about Ouray indicate, however, that there is little assurance that uniformity can be obtained by such a method. The upper limits of the Hermosa and the base of the Cutler must therefore be considered only as an arbitrary division. There is exposed approximately 2150 feet of the Cutler formation along the Uncompahgre Valley between Ouray and the vicinity of Corbett Creek. The thickness of Cutler that is preserved decreases southward toward Ouray because of the unconformity at the base of the Triassic (Dolores formation), until in the Amphitheatre east of Ouray the Triassic rests directly upon the Hermosa. This unconformity is illustrated in the cross-section figure 1.

The following statement is made in the Ouray folio regarding the age of the Cutler formation:[11]

> "In the earlier reports on the San Juan region the present Cutler formation was provisionally considered as a lower unfossiliferous part of the Dolores and was supposed to be of Triassic age. The discovery at Ouray, however, of the unconformity at the base of the lowest known fossiliferous Triassic showed that this grouping was incorrect, and the Cutler, in the entire absence of fossil evidence, is now regarded as of probable Permian age, succeeding as it does without stratigraphic break, the Permo-Pennsylvanian Rico formation in the Animas Valley and Rico Mountain sections."

As already stated, the difficulty of defining the boundary between the Hermosa and Cutler at Ouray introduces the possibility that, at least in this locality, an unknown thickness of the lower part of the Cutler may be of Pennsylvanian age.

The lower part of the Cutler is characterized by red sandy and limy shales, similar to the thinner parting shales in the upper Hermosa, but the thick sandstone and conglomerate beds like those characteristic of the upper Hermosa,

[11] Ouray Folio, No. 153, p. 4.

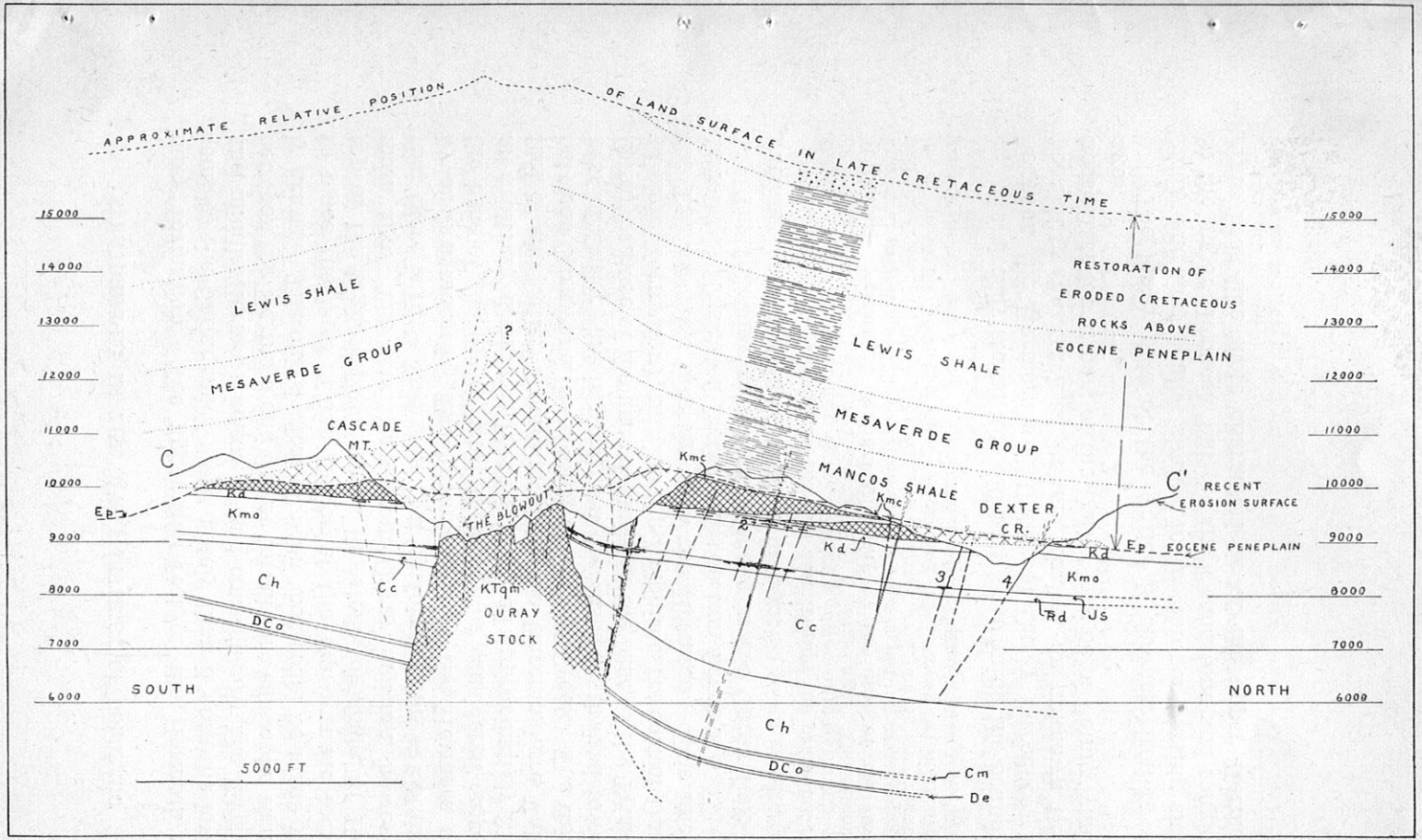


Fig. 1—Restoration of geologic conditions in late Upper Cretaceous time, showing the probable relation of the Ouray stock and its associated mineral deposits to the Upper Cretaceous formations and the land surface in late Upper Cretaceous or early Eocene time. Elevations give the present position of land with reference to sea-level. Ep, surface of Eocene peneplain. Rs, recent erosion surface. De, Elbert formation; DCo, Ouray limestone; Cm, Molas formation; Ch, Hermosa formation; Cc, Cutler formation; TRd, Dolores formation; Js, Jurassic sandstone; Kmo, Morrison formation; Kd, Dakota (?) sandstone; Kmc, Mancos shale; KTgm, late Upper Cretaceous or early Eocene intrusions of quartz monzonite porphyry. See geologic map Plate I, section C-C', for position of section.

Figures show relative position of certain mines with respect to the Ouray stock: 1. Wanakah and Bright Diamond mines; 2. American Nettie mine; 3. Bachelor mine; 4. Calliope mine.