THE MCCOY FORMATION OF EAGLE COUNTY COLORADO

1939

By E. E. Marshall

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INTRODUCTION

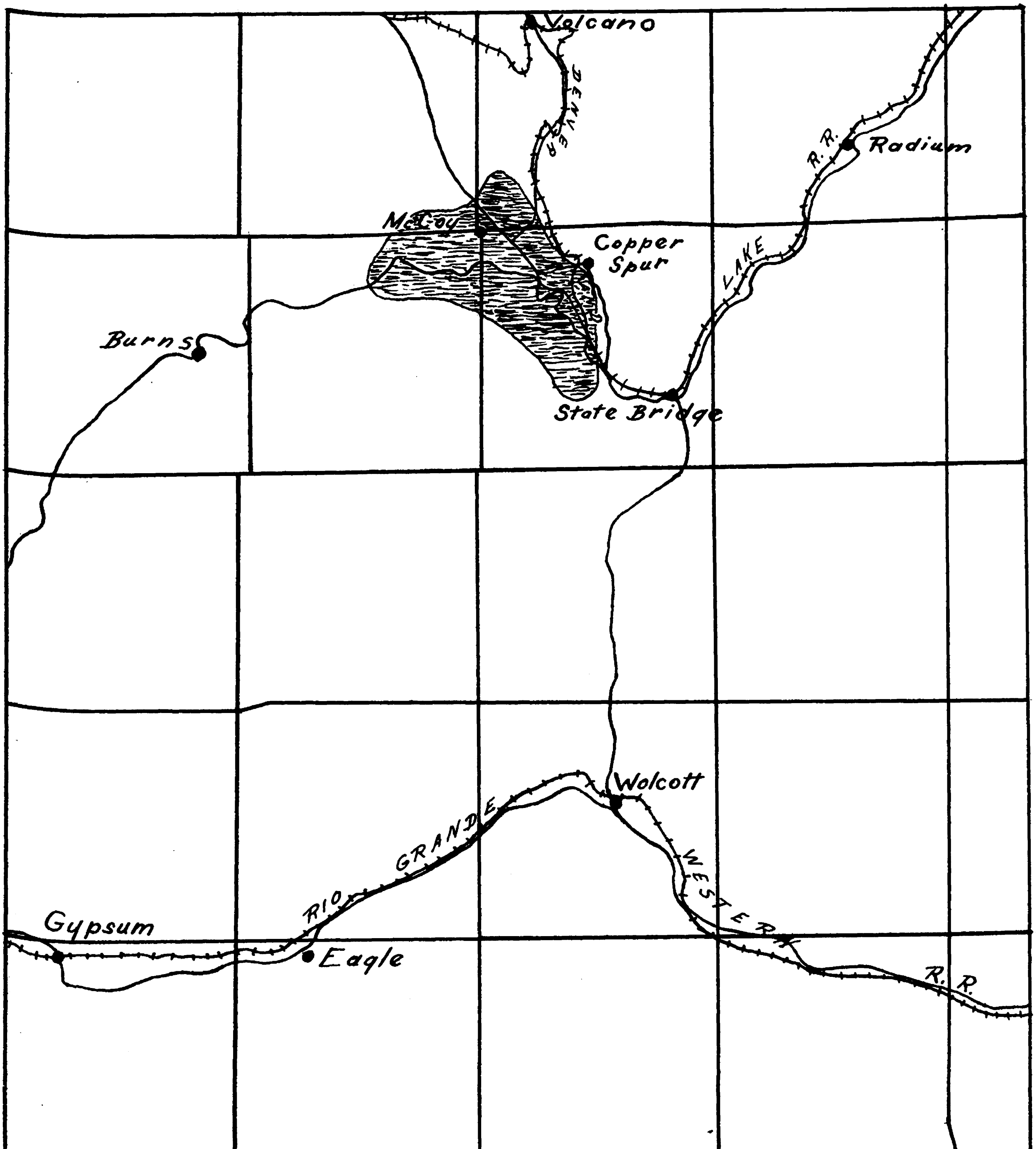
Location of the Area

The region which has furnished the data upon which the following paper is based is an area of Pennsylvanian sediments located in the extreme northern part of Eagle County Colorado. It lies some sixty miles northeast of Glenwood Springs and is approximately midway between the towns of Eagle and Kremmling. Representing as it does a local phase in Pennsylvanian sedimentation, the exposed area of the formation is small,- perhaps not exceeding fifteen or twenty square miles which, except for certain isolated outcrops, lies along the valley of the Colorado River to the south and west of the village of McCoy. Here in its type section it forms the northeastern flank of a regional structural basin lying to the southwest and rapidly disappears under younger sediments and lava flows in that direction. On the southwest flank of this same structural basin Pennsylvanian outcrops again appear along Sweetwater Creek, Deep Creek, and the Colorado River near the station of Dotsero; but with a facies so different that the exact relationship with the McCoy cannot easily be determined.

Purpose of the Study

It is not within the scope of this paper to make an extensive study of the entire Pennsylvanian record

MAP OF THE MCCOY AREA



Major Area of the McCoy Outcrop

of this region even though such a study is essential to a complete stratigraphic history of the area. In Eagle County strata of the Pennsylvanian period are the surface formations in three widely separated areas, all of which are so lithologically different that correlation of each with the other is extremely difficult. The Minturn-Redcliffe area lies a considerable distance to the south of McCoy; the Dotsero-Sweetwater area is a similar distance to the southwest. Both of these areas differ from the one under study in the greater abundance of limestone appearing in the section, the presence of thick gypsum beds, and the character of the grits and conglomerates which make up the coarser clastics. All of these areas show to some extent the effect of an actively eroding land mass sometime during their sedimentary history. In the case of the McCoy formation however, its extremely local character, its coarse and highly colored clastics, and its inconsistent lateral changes in lithology make it a problem unique in its origin and environment of deposition.

The primary purpose of the study therefore, is not an attempt of correlation of widely separated areas with the McCoy, but rather to present the latter as one phase of the sedimentary history of the Pennsylvanian in this region. Its problem is three-fold:- (a) the source of the sediments of which it is composed, (b) the conditions under which they were transported and deposited, and (c) the paleogeographic changes which may have taken place during their deposition. Any points which suggest some correlative value are carefully noted and discussed but it is the specific aim of the paper to present data on one phase of a more extensive problem which the writer believes is pertinent to a complete stratigraphic study of the region. That problem is the paleogeography of the region in Pennsylvanian times.

Methods of Study

Field work in the area was done during the summer of 1938 under the direction of the University of Michigan Geological Camp located at State Bridge. It consisted for the most part of the measurement and description of various sections and the securing of samples for petrographic study. Samples were collected and sections measured on the slopes of resistant topographic ridges formed by the steeply dipping beds and in artificial exposures made by the cuts of the highway and the Denver and Salt Lake railway. In practically every instance the thickness of the strata was determined by tape measurement. Samples were taken only from the coarser clastics such as the sandstones, grits, and conglomerates with the exception of those ocassional samples taken from thin limestone members for the microscopic study of insoluble residues. In all sections studied particular attention was given to the lime content of the arkosic materials as well as the character of the pebbles and boulders found within the conglomerates.

Laboratory work on the samples collected was done in the laboratories of the Kansas City Junior College and the University of Kansas City and extended over several weeks of the late summer and fall. Much of the time spent in the laboratory was devoted to the petrographic study of the heavier, more stable minerals to supplement field observations of the consistent vertical change in the composition of the pebbles making up the conglomerates of the section. Some one hundred and fifty samples were examined. These included a few selected samples from the Minturn and Dotsero-Sweetwater region, all significant intervals of the type section, and many samples from scattered sections of the formation as well as a number of samples of crushed Pre-Cambrian crystalline rocks of nearby localities.

The procedure utilized was to first crush the samples gently and pass through a ten, twenty, and thirty mesh sieve. That which passed through the thirty mesh sieve seemed a more desirable grade for microscopic study although the coarser grades were examined for the more easily recognizable minerals. Before the heavy mineral separation the samples were carefully boiled and washed in water for the removal of iron oxide stains. In cases where a small amount of dilute hydrochloric acid was added to facilitate the process, a portion of the original sample was retained for the study of minerals which might be destroyed by the acid treatment. Samples in which the lime content was especially high were first treated with dilute hydrochloric acid and the percentage by weight of the lime was calculated.

Acetylene tetrabromide was the liquid used for the separation of the mineral groups. In each separation from thirty to fifty grams of materials were used and by weighing before and after treatment the percentage by weight of each mineral group was calculated. After the separation process was completed, all of the heavy mineral concentrate was mounted on slides for identification and study with the petrographic microscope. A small portion of the lighter mineral group was likewise mounted for a similar study. The procedure employed for the crushed samples of the Pre-Cambrian crystalline rocks was essentially the same as for the clastics with the exception of the acid treatment used in the case of the latter.

Acknowledgements

The writer is indebted to Professor G. M. Ehlers of the staff of the University of Michigan for suggestions and cooperative assistance in the summer's field work. To Kenneth Brill, graduate student of the University of Michigan, and Mary Elizabeth Cooley of Mount Holyoke College, South Hadley Massachussetts grateful appreciation is expressed for personal communication of field observations in nearby areas

in which they too were working. The writer's interest in the problem was developed and stimulated through information given him by Dr. Charles F. Bassett of the University of Kansas City. For his personal interest in the work and his cooperation in extending the facilities of his department for laboratory study, the writer is especially grateful.

THE McCOY FORMATION

Geology of the Region

The formations that outcrop in the McCoy area range in age from Pre-Cambrian to Recent but for the purpose of this study none but the McCoy is discussed in detail. The Pre-Cambrian lies mostly to the north and east of the area and consists of gneisses and schists with intrusions of granites and pegmatites. On this Pre-Cambrian surface many of the younger formations are known to overlap. The Cambrian is represented by a basal quartzite (Sawatch) overlain by the Peerless shale. Donner gives its thickness at Glenwood Springs as thirty five feet. He also states that it disappears to the north of the area. Twelve miles north of the village of McCoy it is very thin and overlain by the Morrison formation of Jurassic age. Six miles east of Yarmony Mountain it is lacking entirely and the Pennsylvanian is resting upon the Pre-Cambrian.* The Leadville limestone of Mississippian

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H. F. Donner, Geology of the McCoy Area. Doctor's dissertation 1935 age lies unconformably upon the Cambrian in this area. In places near McCoy only remnants of this formation are found and the Pennsylvanian rests upon the Sawatch. The Leadville is a very dense, fine grained, gray limestone and locally contains chert in its upper part. Some distance to the southwest in the Dotsero-Sweetwater region it often carries an oolitic phase and weathers into huge, massive blocks. Its unconformable contact with the Pennsylvanian above shows its upper surface to have been eroded before the deposition of those sediments.

That the McCoy formation which lies above the Leadville limestone is of Pennsylvanian age seems certain but whether the overlying maroon formations should be so classed is still a question. These maroon formations include the Rock Creek conglomerate immediately above the McCoy followed by the State Bridge siltstones. Most geologists who are familiar with the region prefer to speak of these formations as Permo-Pennsylvanian. Recently it has been suggested that the base of the Rock Creek be brought lower in the section, perhaps at the base of interval 124 (See Type Section of the McCoy). In this paper however, the writer has found it more convenient to identify the Rock Creek with those conglomerates which lie immediately below the red beds (State Bridge siltstones) and above the lithographic limestone which has been designated by the field name of Leadvilloides limestone by previous

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* H. F. Donner, The Geology of the McCoy Area
Doctor's dissertation, 1935

investigators. The Rock Creek or a formation so correlated is known to overlap upon the Pre-Cambrian in the vicinity of Radium to the northeast. The correlation is apparently based upon its stratigraphic position below the red beds and above the McCoy arkoses. There is however a great change in its litholoby in this area. Here it is a typical conglomerate composed of rather uniformily sorted pebbles of gray granite and quartz throughout. The maroon color so typical of the Rock Creek in the McCoy area is lacking and the supply of coarser sediments from which it was derived seems to have been more constant and uniform.

The Jurassic is composed of the Entrada sandstone overlain by the Morrison formation. These beds are overlain by the Cretaceous which consists, in ascending order, of the Dakota sandstone, the Benton shale, and the Niobrara formation. The Tertiary record is mostly igneous in nature and consists of several hundred feet of extrusive volcanics which form the resistant covering for many of the higher topographic features of the region. A few intrusions of porphyry have also been assigned to the Tertiary Period.

The beds of the McCoy have been thrown into a series of folds many of which have been broken by both major and minor faulting. This makes the measurement of sections in places very difficult and the walking of certain beds extremely uncertain, The major faults of the region have a general north-northeast trend and a displacement which is sufficient to bring formations, far apart in the sequence of time, in contact with each other.

Summary of the Stratigraphy

Recent	Eluvium
Pleistocene	Alluvium
Tertiary	Extrusive volcanics Porphyry intrusions
Cretaceous	Niobrara formation Benton shale Dakota sandstone
Jurassic	Morrison formation Entrada Sandstone
Permo-Pennsylvanian. . . .	State Bridge siltstone Rock Creek conglomerate
Pennsylvanian	Mc Coy formation
Mississippian	Leadville limestone
Cambrian	Peerless shale Sawatch conglomerate and quartzite
Pre-Cambrian	Various schists, gneisses, granites, and pegmatites.

The McCoy formation, as here used, includes those beds which lie between the Leadville limestone and the Rock Creek conglomerate. The total section measures some 2500 feet in thickness and is composed chiefly of arkosic sandstones, grits, and conglomerates interbedded with maroon and grayish black shales. The limestones are less abundant but are found at certain horizons and in most cases carry a well defined fauna. The type section which follows is one which has been revised from previous sections. Final checking was done by Ehlers, Brill, Bassett and the writer in the course of the summer's field work.

TYPE SECTION OF THE MCCOY FORMATION

Section measured along Rock Creek west of McCoy

Rock Creek Conglomerate

143	"Leadvilloides" limestone, light gray, lithographic, compact, similar in texture to the Leadville limestone	8'
142	Conglomerate, arkosic, central 30feet with pebbles of acid igneous rocks up to .3' in diameter, maroon and gray, massive with cross bedding. Maroon-green limestone 1' below Leadvilloides	183'
141	Limestone, weathers purplish-gray, two layers of dark gray limestone .3' thick, shale pinches out leaving both limestones about 2.5' thick, weathers into rectangular blocks due to joint system, contains gastropods	8'
140	Grit to conglomerate, quartz and feldspar pebbles, red with white blotches, cross bedded with color differentiation	9.3'
139	Grit, arkosic and micaceous grading into a sandstone, gray and maroon streaks follow the bedding, cobbles 1inch in diameter at the base of the next interval	7'
138	Shale and arkosic sandstone, shale maroon, sandstone gray and crossbedded	4'
137	Grit, arkosic, gray to pink, massive and crossbedded, weathers to very rounded surfaces	25.5'
136	Shale, micaceous, maroon	13'
135	Grit, arkosic with granite and pegmatite pebbles, massive, pink and white beds	35'
134	Shale, sandy, maroon	11'
133	Sandstone, medium grained to conglomeratic, contains much feldspar, maroon with gray bands indicating crossbedding	32'
132	Shale, micaceous and arenaceous, some sandstone near the center, shale maroon, sandstone maroon and green mottled	17.5'
131	Sandstone, maroon with buff gray banding, arkosic conglomeratic at base, nodular areas of calcareous materials at base	17'
130	Shale, maroon and gray, micaceous with calcareous nodules near base	5'
129	Shale, calcareous with a nodular limestone layer about 1' thick 2.5' above the base. Shale gray and maroon. Limestone contains fossils (coarsely plicated Spirifers and Gastropods)	4,8'

128	Sandstone, fine grained with a .5' to .'8 band of shale near the center and a .5' band of shale near top. Sandstone increasingly calcareous near top. Maroon and greenish gray	3.5'
127	Shale, micaceous at base and grades into a maroon and green mottled sandy nodular limestone. Exposure mainly in the form of soil	6.5'
126	Conglomerate, arkosic, pebbles of feldspar, granite, pegmatite, greenstone, micaceous sandstone, and some basic igneous rocks, maroon to buff gray, massive with crossbedding	20.5'
125	Shale, with sandy and micaceous layers, maroon mottled with gray	20.6'
124	Conglomerate, pebbles of granite, quartz, feldspar, mica schists, and compact nodular limestone. Might be basal conglomerate of Rock Creek beds (Ehlers). Angular and subangular pebbles to .6' in diameter. Limestone is red and pinkish banded and resembles the McCoy	16'
123	Sandstone, arkosic, finely conglomeratic near top, maroon with gray bands, thin to massive crossbedded	33'
122	Shale, micaceous, maroon, badly weathered nodular limestone near top	25'
121	Sandstone, fine grained with nodules of impure limestone, gray	1.2'
120	Grit, breccia, angular fragments up to .5 " in diameter, light gray limestone pebbles, weathers buff	2'
119	Shale, with nodules and lenses of limestone, shale greenish gray, limestone dark gray . . .	5'
118	Sandstone, medium grained, micaceous with nodules of limestone at top	1.3'
117	Conglomerate, arkosic, fine, massive	1.8'
116	Shale, gray at the base, greenish gray at the top	3.5'
115	Shale, micaceous, maroon	1'
114	Conglomerate, arkosic, maroon with gray bands, pebbles of granite, quartz, and feldspar, Lower 10' contains pebbles up to 1" in diameter. Crossbedded and sorted	45'
113	Sandstone with some arkosic layers, micaceous, maroon but weathers light gray	20'

Section measured along railroad cut
about 1 mile north of Bond

112	Shale, micaceous with about 4' of sandstone 8' above the base. Shale maroon with thin gray layers. Sandstone gray with some maroon layers	20'
111	Limestone, compact, interbedded with green shale. Upper part contains nodules of reddish gray chert. Fossiliferous (Productids, Spirifers, Compositas).	8'
110	Grit, arkosic with some granite and quartz pebbles up to .1' in diameter. Banded maroon and gray with light greenish gray mottling	8'
109	Shale, very micaceous and arenaceous with arkosic bed at base, maroon mottled with greenish gray. Layers of gray nodular fossiliferous limestone .1' to .9' thick. Weathers to a nodular surface	13'
108	Grit, arkosic, maroon with light gray banding. Shaly band about.6' thick near the center of the interval. Grit is conglomeratic above the .6' band. Massive crossbedding indicated by the color	43'
107	Grit,arkosic, calcareous. At base is a thin maroon shale. At top is a .4' layer of light gray lithographic limestone with calcite veinlets. Maroon with small circular mottlings of light gray. Weathers to nodular surface .	9.3'
106	Grit, arkosic, micaceous. Contains large pebbles of feldspar. Light gray, massive, resistant to weathering	2.5'
105	Shale, with some calcareous pebbles, 5 or 6 layers of nodular fossiliferous limestone .25 to .3' thick. Shale maroon mottled with green. Limestone maroon and greenish gray mottled	5.5'
104	Grit, arkosic, upper .3' much finer grained, light gray with maroon banding in upper part. Bedding .5' to 2.5 thick	10'
103	Sandstone, micaceous, dull maroon and white banded, coarse textured with thin maroon shale beds near top	40'
102	Shale, micaceous with nodules of green and red mottled limestone near base. Shale hard and resisting at base. Beds of medium gray arkosic sandstone increasing in thickness from .25' to 1' near the top. Shale dark dull maroon. Sandstone lighter maroon with light gray bands Massively bedded	12.6'

101 Limestone, dense, interbedded with thin layers of shale. Upper limestone layers nodular and impure with sand and mica. Limestone dark gray and massive to fine bedded at top. Bryozoans or algal structures present. Shale gray and maroon. . . . . 5'

100 Shale, slightly micaceous with a few pebbles containing quartz and feldspar. Light bluish gray with lenses of gray limestone. Shale contorted with angular fragments. Limestone filled with calcite veins and with bryozoans or algal markings and other invertebrates . . . . 4'

99 Shale, micaceous, crumbles to angular fragments. Near the top is a micaceous sandstone .5' to 1' in thickness. Below sandstone are irregularly shaped nodules of gray limestone. Shale dark maroon . . . . 6.7'

98 Fine conglomerate to grit, arkosic. Near top is a .7' layer of maroon shale. Gray and maroon colors follow crossbedding. Massive . . . . . . 35'

97 Shale, micaceous, red with light gray arkosic sandstone .1' thick about 1' above base. (.2' reddish gray arkosic grit about .5' below the top . . . . 3'

96 Sandstone or grit, arkosic, light gray, massive . . . . 3.8'

95 Shale, very micaceous and arenaceous, interbedded with arkosic medium grained micaceous sandstone. Shale chiefly maroon. Sandstone light gray and generally thin bedded . . . . 28'

94 Shale, with pyrite, gypsum, and selenite. Carbonaceous and locally crumbly. Interbedded with arkosic sandstone containing pyrite, selenite, and limonite- also a few carbonized plant remains. Shale dark gray to black. Sandstone gray to brown in layers .1' to 1' thick . . . . 25.8'

93 Sandstone, micaceous, light gray, massive . . . . . 11.8'

92 Shale, laminated, contains much selenite and mica, dark gray to black. Layer of sandstone similar to interval 91 about one foot above the base . . . . 10.6'

91 Sandstone, micaceous, light gray, massive . . . . 2.9'

90 Shale, carbonaceous with selenite crystals, very dark gray to black . . . . 5.9'

89 Sandstone to grit, arkosic, micaceous, massive with crossbedding. 3' of friable, very micaceous sandstone at base and .9' of conglomerate with

pebbles 1" to 1' indiameter.(Acid and basic igneous
rocks) near the center of the interval. Chiefly
dull maroon and thin grayish-white beds. 5' of
greenish-gray beds on top . . . . 98'

88 Shale, micaceous, arencaeous, laminated, inter-
bedded with very gray, micaceous medium grained
sandstone, arkosic,nodules of dark gray limestone
in shale. Shale dark gray. Sandstone gray . . . . 12'

87 Sandstone to grit, arkosic. Near the middle of
interval is a 2' to 3' bed of calcareous, gray
shale with mica, selenite, and lenses of arkosic
sandstone. Near the base of the shale is a bed
of nodular, compact, dark gray limestone . . . . . 16'

86 Shale, micaceous, very carbonaceous and laminated.
Contains selenite crystals. Interbedded especially
in the center of the interval with layers of
medium grained sandstone, containing pyrite, mica,
limonite, and selenite. Shale dark gray. Sandstone
light gray . . . . 20'

85 Sandstone and grit, arkosic, less micaceous than in-
terval 84. A few thin seams of shale with selenite
near the top. Beds run from .1' to massive. Light
gray in color . . . . 23'

84 Shale, carbonaceous with gray and black carbonaceous
and argillaceous sandstone layers about .3' thick.
Both shale and sandstone are very micaceous, con-
tain selenite and have ripple marks on the top
surface of the bed. Sandstone massive and contains
fossil plants. Fault occurs here . . . . 26.7'

83 Grit, conglomeratic, very arkosic, subangular
pebbles of quartz and feldspar, reddish gray with
greenish streaks . . . . 21'

82 Sandstone, micaceous, grading into micaceous
shale at top. Lenses of thin bedded green arkose
which is light gray on fresh fracture - a finer
equivalent of interval 81. . . . . 5'

81 Conglomerate, arkosic, micaceous, contains quartz
and feldspar pebbles, massive, greenish-gray (color
due to chlorite) . . . . 13.4'

80 Shale, with small layers of srkosic sandstone.
Shale dark gray and black. . . . . 5'

79 Grit, arkosic, micaceous. Lower 5' thinly bedded;
above that conglomeratic, arkosic, and with quartz
and feldspar pebbles up to .2' in diameter.
Massive, light gray . . . . 17.4'

78 Shale, carbonaceous, dark gray, laminated, con-
tains some micaceous, arkosic, light gray sand-
stone. Shale with selenite crystals and very
much crumpled . . . . 26'

77	Grit, arkosic, conglomeratic, crossbedded, fresh fracture gray	6.5'
76	Shale, micaceous with some thin layers of sandstone	1.5- 3'
75	Grit, arkosic, conglomeratic (pebbles of granite, pegmatite, and schist), reddish gray, massive	19.8'
74	Sandstone, micaceous, interbedded with fine beds of shale. This bed has many peculiar markings-ripple and rill marks. Light greenish gray. Flora and stems and leaves of Walchia. Known as "Walchia Beds"	68'
73	Grit, arkosic with seams of conglomerate. (pebbles of igneous rock and Leadville (?) limestone), crosbedded	13'
72	Shale, micaceous, maroon and green , thin bedded, conglomeratic sandstone near center	8 -24'
71	Conglomerate, arkosic, becomes finer grained above, (Pebbles of igneous rocks up to .7' in diameter. Few Leadville (?) limestone pebbles). Gray to pinkinsh gray. Shale member .5" to 1' thick about 3 ' above base	8- 12'
70	Shale, micaceous, dark gray	3- 7'
69	Conglomerate, arkosic. (Pebbles of igneous rocks up to .7' in diameter. Gray to pinkish gray	10'
68	Shale, micaceous, maroon	6'
67	Grit, arkosic, light gray to maroon, crossbedded, interbedded with beds of maroon, micaceous shale	16'
66	Shale, micaceous, green and maroon, some gray limestone interbedded. Few fossils in both . . .	4.5'
65	Grit, arkosic, gray	1.5'
64	Shale, micaceous, dark gray	1.5'
63	Grit, arkosic, gray	5'
62	Shale, micaceous, greenish gray and maroon . . .	19'
61	Grit, arkosic and conglomeratic, maroon and gray, crossbedded. Interbedded with maroon, micaceous shales	40'
60.	Limestone, sandy and nodular with much reworked material from lower beds. Fresh fracture dark gray. Some thin seams of micaceous greenish shale. A few poor fossils	1'
59	Sandstone, medium grained , micaceous, gray to light reddish gray, massive. Fucoids at base . .	11'
58	Shale. lower member laminated, dark greenish gray with a 3' bed of concretionary, nodular crystalline limestone in center. Upper member red micaceous shale. In limestone and lower shale occur Lophophyllum, Composita, Spirifer, Crinoid columnals. " Cup Coral Nodular Bed ". .	6'

57 Grit, arkosic, some pebbles of quartz and granite, light gray with some maroon layers, highly cross-bedded and massive . . . . 22'

56 Shale, interbedded with several sandstone layers each about 1' thick. Both micaceous. Sandstone has small feldspar pebbles. Shale brownish red. Sandstone gray and brownish red . . . . 32'

55 Grit, arkosic with pebbles of quartz and microcline. Purplish red with white blotches, crossbedded with color differentiation . . . . 16.5'

54 Shale to argillaceous sandstone, very micaceous throughout, Shale red at base, gray above, thin bedded. Sandstone red . . . . 10'

53 Conglomerate, arkosic with arkosic grit at base. Contains pebbles of quartz, feldspar, and granite. Purplish red with white bands, massive and crossbedded . . . . 35.8'

52 Shale, micaceous with about 1' of micaceous sandstone near center. About 10' micaceous red shale near top. Sandstone buff gray. Shale black, laminated with irregularly shaped calcareous nodules, weathers greenish gray . . . . 14'

51 Shale and sandstone, arkosic. Sandstone is crossbedded. Shale and sandstone interbedded. Reddish maroon with some gray layers . . . . 54'

50 Shale, micaceous, friable, arenaceous, with selenite crystals and small fossiliferous nodules. Dark gray, laminated, weathers greenish gray . . . . . . 6'

49 Sandstone, micaceous, arkosic, conglomeratic. Contains pebbles of quartz and feldspar. Top .5' is a dark gray, compact limestone containing ostracods. Sandstone is thin bedded and yellowish gray . . . . 8'

48 Sandstone, micaceous with discoidal nodules and worm like casts, weathers into soft gray sandy soil, thinbedded, contains Bellerophon-like gastropods in some discoidal nodules. Called by field name " Discus Bed " . . . . 5'

47 Shale, micaceous, red and green. Lower 14' red; Upper 7' green. Laminated . . . . 21'

46 Conglomerate, arkosic. Contains pebbles of quartz feldspar and granite. Puprlish maroon with white to gray bands. Massive and crossbedded . . . . . . 25'

45 Sandstone, arkosic, coarse to fine, interbedded with green micaceous shale. Sandstone is increasingly arkosic toward the top of the interval. Sandstone pinkish-gray with purplish maroon streaks of finer material. Thinbedded . . . . 13'

44. Shale, micaceous with selenite and pyrite crystals. Contains calcareous nodules. Fresh fracture dark gray, weathers light gray, laminated . . . . 28'

43	Limestone, fine grained, somewhat impure, fossiliferous, dark gray. Contains Jonesina, crinoid columnals, brachiopods, pelecypods, Bellerophon. "Jonesina Bed"-Roth and Skinner 184	1'
42	Shale, micaceous with selenite crystals, dark greenish gray. laminated, crumbly	8.2'
41	Grit, micaceous and arkosic, buff gray, massive ..	8.6'
40	Shale. micaceous and crumbly, contains some white powdery gypsum. Beds contorted by folds. Dark gray to greenish gray, laminated	5.2'
39	Grit, arkosic, very micaceous with a few pebbles of quartz, feldspar, and granite. Crossbedded, pinkish gray. Contains fossil wood (Log found in old road)	10.5'
38	Shale, very micaceous, laminated, greenish gray, - several lenses of arkosic sandstone near the top	4.5'
37	Sandstone, arkosic with conglomeratic layers, light gray with purplish red bands, finer material red, coarser light gray. Massive and crossbedded	27'
36	Shale, micaceous, greenish gray, with numerous calcareous and fossiliferous nodules. (Contains fossil wood and large fauna of Roth and Skinner # 183	30.6'
35	Limestone, arenaceous and micaceous, dark gray on fresh fracture, weathers to dark brown. Contains Myalina, Productus etc. Called "Myalina Bed" . .	0.8'
34	Shale micaceous, greenish gray	2'
33	Grit, very micaceous and arkosic, gray weathering into layers 1 to 6 inches thick	19'
32	Shale, gray and black, micaceous, selenite crystals in black beds	9'
31	Grit, arkosic, gray with some layers of gray micaceous shale	21'
	Section measured from the bottom of valley to top of ridge ¼ mile southwest of Tunnel 43	
30	Shale, very micaceous, grayish green with a few layers of gray micaceous sandstone. Calcareous nodules 1 to 2 inches in greatest diameter present in lower part of interval. Plant bed near the middle (1' of brown sandstone). Structure of the plants lacking	30-60'
29	Conglomerate, arkosic with pebbles of quartz, pegmatite, granite, and chert. Thickness varies. Thicker in places than here	17'

28	Partly covered. With little doubt consists of green and red shale and arkosic grits and sandstone	39'
27	Conglomerate, arkosic, red and white alternating with red micaceous shale and sandstone. (A part of this interval can be seen in the railroad cut northwest of tunnel 43)	50'

Section measured along the tracks
west of Tunnel 43

26	Shale, green and red	
25	Sandstone, maroon and white mottled with many beds of conglomerates containing pebbles of quartz, granite and pegmatite. Conglomerates are from 2 to 4 feet in thickness	45'
24	Shale, micaceous, brownish red with a few thin layers of gray sandstone	50'
23	Sandstone, very micaceous, gray with purple bands, even bedded, upper 2' red	5.8'
22	Grit, arkosic, micaceous with very few pebbles . .	6.6'
21	Shale, like interval 19	15'
20	Grit, arkosic, micaceous, gray with layers of quartz pebbles	15.5'
19	Shale, micaceous, brownish red	10'
18	Sandstone, micaceous, arkosic, gray. Lower half is a conglomerate with pebbles of quartz having an average diameter of $1\frac{1}{2}$ inches	10.3'
17	Shale, micaceous, brownish red	7'
16	Sandstone, arkosic, micaceous, greenish gray . . .	7.7'
15	Shale, micaceous, brownish red with a few layers of micaceous greenish gray sandstone	4'
14	Grit, arkosic, somewhat micaceous, conglomeratic with pebbles up to 2 inches in diameter	10.5'
13	Shale, micaceous, brownish red with a few thin layers of sandstone. Interval ranges from 12' on south side of track to 34.5 feet on the north side	12-34.5'
12	Grit, conglomeratic, greenish gray	16.5'
11	Shale, brownish red with some beds of arkosic sandstone. Exposed at the west end of Tunnel # 43	22 '

Section measured from fault $\frac{1}{4}$ mile
northeast of Tunnel # 43 to top of the ridge extending
through the tunnel.

10	Grit, arkosic, micaceous, gray. Probably some red shale and arkosic grit in yht upper part . . .	40'
9	Shale, similar to interval 7	6.8'

8	Sandstone, arkosic, conglomeratic with numerous quartz pebbles 1 to 2 inches in diameter near the base, gray. (Top bed of the east face of Tunnel 43)	11.4'
7	Shale, slightly micaceous, brownish red	17.7'
6	Sandstone, similar to interval 4 except mote conglomeratic	11.4'
5	Shale, micaceous, brownish red	4.6'
4	Sandstone, arkosic, gray, few quartz pebbles near the base	2.5'
3	Shale, micaceous, brownish red, fissile	13.7'
2	Sandstone, conglomeratic, gray to pinkish gray with prominent conglomerate of quartz pebbles at the base. Conglomerate is about 2' thick, Sandstone is finer grained toward the top of the interval	13.3'
1	Shale, slightly micaceous, brownish red, thin-bedded, weathers into angular fragments. Rests upon the eroded surface of the Leadville limestone	11'
	Leadville Limestone - Mississippian	
	Total Thickness	2460 feet

From the quantitative point of view the sandstones, grits, and conglomerates form the most important part of the section. These materials are all arkosic. The grits are often conglomeratic and the conglomerates are more typically a zonal distribution of pebbles and boulders within coarse grits. The colors which are dominantly gray and maroon seem to have an alternating sequence throughout the section. In the first 145 feet of the section (Intervals 2 to 22) the arkosic material is gray. This is followed by 95 feet of section (Intervals 25 to 27) in which the arkoses are maroon. Gray arkoses again dominate the next 107 feet (Intervals 31 to 49) and are followed by 90 feet containing arkoses that are maroon (Intervals 55 to 61). This condition

Figure 1. Steeply inclined beds of the McCoy formation along the Bond-McCoy road about a mile north of Bond. The Walchia Beds are those viewed directly along the tracks.

Figure 2. Upper part of the McCoy formation looking north along the strike of the beds on the ridge just west of the village of McCoy.

persists in a general way throughout the section although the boundaries are made indefinite by those zones which are maroon and gray streaked. The greatest interval of gray arkoses seems to be about 300 feet in thickness (Intervals 63 to 88) and includes the Walchia beds which are one of the most easily recognized horizons. The greatest thickness of maroon arkoses is near the upper part of the section and includes approximately 400 feet immediately below the Leadvilloides limestone.

The pebbles and boulders making up the conglomerates vary both in size and composition. Fragments as large as 18 by 13 inches were noted but its calcareous character makes it possible that the mass was contemporaneous in its origin rather than being transported. One boulder of white quartz measuring 11 by 9 inches was found and granite boulders of similar proportions are common. Perhaps more significant than the size of the boulders is the change in the composition of the dominant types making up the conglomerates. In the basal beds (lower 125 feet) quartz and chert are the only coarse materials found (Intervals 2 to 10). Interval 25 marks the first appearance of crystalline rocks and these are mostly red granites and pegmatites. Three horizons in the section show outstanding conglomeratic zones which seem to reflect a change in the type of materials from which the sediments were derived. These are Intervals 29, 69, and 124. In the first and lowest of them (Interval 29) an even grained, coarse textured, mottled red and white granite reaches the maximum of its abundance and is found sparingly if at all in the other horizons. In Interval 69 a coarse grained red and green granite is the most conspicuous constituent among the boulders which also include many fragments of gneiss and schist. It is in this member that the largest of the boulders are found. Most of the varieties of rocks heretofore found seem to make up Interval 124 with the exception of the granite which is characteristic of Interval 29. A gray to white granite is seen ocassionally in this interval and becomes a dominant constituent of the Rock Creek conglomerate. An interesting phase of some of the conglomerates is the presence of limestone boulders or irregular lenses within the horizon. Obviously these must be explained as reworked older limestones or materials of contemporaneous origin. That the arkoses carry some lime content is definitely known but it is not a condition that persists throughout the section. Those below Interval 53 (lower 900 feet of the section) contain little or no lime. Most of those above that interval carry lime in varying amounts. The limestone boulders appear for the first time in Interval 69 and are confined largely to that horizon along with Intervals 71, 73, and 124.

The shales of the section are nearly all micaceous and vary in color from maroon to grayish-black. The sequence of their distribution seems to be, in ascending order, exclusively maroon shales, grayish black shales, maroon and gray

Figure 3. Outcrop of the Rock Creek conglomerate in a syncline along the Colorado River southwest of McCoy.

Figure 4. Contorted beds of gypsum of likely Pennsylvanian age in the Dotsero-Sweetwater area.

shales, grayish-black shales, and exclusively maroon shales. The lower 350 feet of section contain maroon shales totaling 190 feet. 114 feet of grayish-black shales make up the next 430 feet of section. The interstratified maroon and gray shales total 111 feet in thickness and make up the next 450 feet. In the next 460 feet the shales are grayish-black and have a total thickness of 135 feet. The upper 850 feet are again made up of maroon shales but in amounts much smaller in proportion to the maroon arkoses present. Many of the shales have a marked development of calcareous nodules. This is particularly true of the shales in the upper part of the section. The grayish-black shales frequently contain gypsum in the form of selenite crystals. Its presence is quite marked in the intervals immediately above the lower conglomerate (28) and above the Walchia Beds (74).

The limestones of the section are all comparatively thin although they are known to thicknen elsewhere and in some instances separate into two or more beds separated by shale. Some are quite impure and contain an abundant insoluble residue of clastic minerals. Others yield little insoluble material. They are dominantly dark gray in color and weather to a brownish-gray. Some are red and gray mottled and a few horizons like the Leadvilloides are lithographic in character. Many of the limestones are fossiliferous and make reasonably good horizon markers, either because of their fauna or their lithologic character. Among these are the " Myalina

Bed ", "Jonesina Bed ", "Nodular Cup Coral Bed " , " McCoy Limestone " , and the " Leadvilloides Limestone" .

Most of the horizons of the McCoy formation show a marked lateral change in their thicknesses and facies. The arkoses are dominantly cross-bedded where there has been abundant and rapid deposition. Often the cross bedding coincides with the color changes from maroon to gray. Throughout the middle part of the section cross-bedded zones are found intermittently. The lower gray grits show little tendency to this type of structure. The greatest development of crossbedding is found in the upper part of the section and makes up about 250 feet of sediments immediately below the Leadvilloides limestone. At some horizons irregular contacts are found between the conglomerates and the beds upon which they lie. These suggest a scour and fill condition and are found at the bottom of the lowest prominent conglomerate (29) and similar horizons. Ripple marks and current marks are found in the Walchia Beds and in those immediately above them. Unconformable contacts are strongly indicated at certain horizons. Along the Burns road to the southwest of McCoy beds of arkose dip toward the south-southeast and are truncated by horizontal arkoses above. A similar break is suggested at the base of interval 140 at the point where the section was measured. Such breaks may be contemporaneous with deposition rather than tectonic in nature and may mark places where marine currents have eroded the surface of former deposits during periods of a decreased supply of sediment from the land.

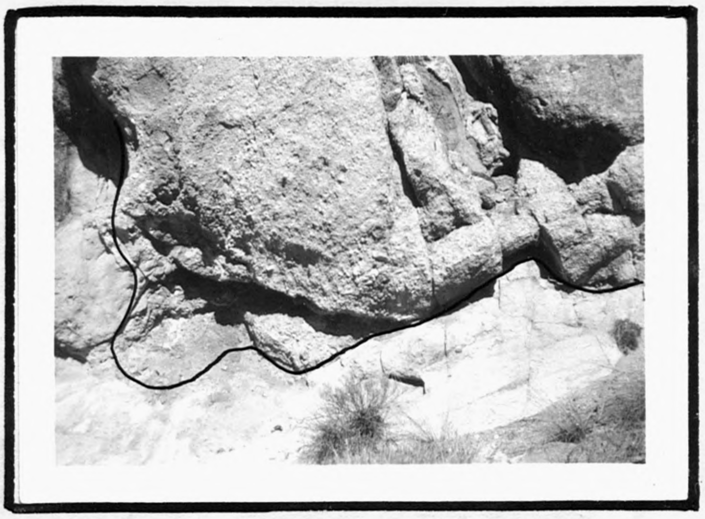

Figure 5. Contact of conglomerate 29 with the finer grained sandstone upon which it lies.

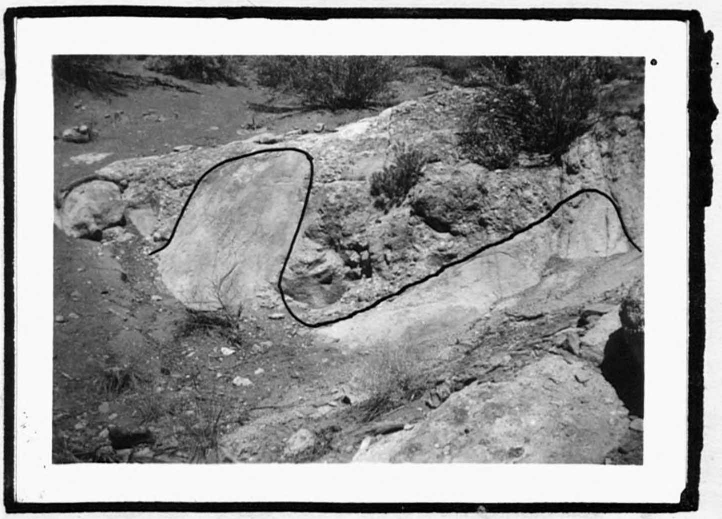

Figure 6. The same condition as is shown in Figure 5.

Figure 7. Unconformable contact in the arkoses along the Burns road southwest of McCoy.

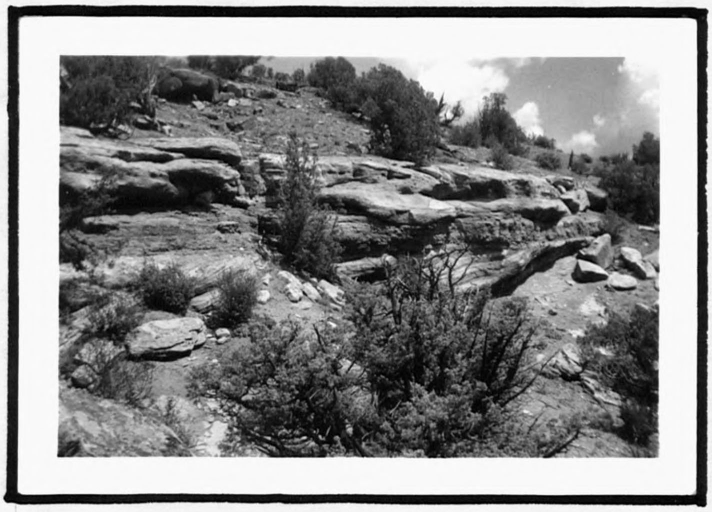

Figure 8. Same horizon $\frac{1}{4}$ mile northeast of the outcrop shown in Figure 7.

PETROGRAPHIC STUDY OF THE PRE-CAMBRIAN

Rocks of the Pre-Cambrian age are exposed in certain scattered areas which lie to the north and east of the outcrops of the McCoy formation. They consist chiefly of gneisses and schists into which granites and pegmatites have intruded. Mention has already been made of the association of the boulders of the conglomerates in the McCoy formation with this area of crystalline rocks. That the latter has been the distributive province for most of the Pennsylvanian clastics of the adjoining area, can hardly be questioned. Similarly, the correlation between the vertical distribution of the boulders in the section and the geographic location of the probable source areas indicates that as deposition of the arkoses progressed new rock types were continually being exposed to the active erosion of streams which were extending their courses into the land mass to the north and east. As evidence of this condition may be mentioned the presence in the lower conglomerates of pegmatite boulders which are so characteristic of the Pre-Cambrian outcrop four and one-half miles northeast of Copper Spur. This crystalline area is the nearest exposure of the ancient crystallines to the present McCoy outcrop. Likewise can be cited the red-green hornblende granite boulders which appear for the first time five hundred or more feet higher in the section. These boulders are typical of the Pre-Cambrian area along Sheephorn Creek in the vicinity of Radium several miles farther to the north and east. Thus it is believed that a careful examination of the accessory minerals of the Pre-Cambrian rocks is an essential aid in establishing a more detailed relationship between the areas of derivation and deposition of the sediments. The methods of procedure have already been described. Crushed samples of the crystalline rocks were treated in the same manner as were the sediments in determining their heavy mineral content. Specimens from five different areas were actually examined and data given by Donner were used as the sixth. (See Map. Page 30).

Pre-Cambrian Areas

From the area at Volcano which lies a few miles north of the village of McCoy, Donner describes three rock types.* First he mentions a dark gray granite-gneiss or granodiotite in which plagioclase and quartz make up two-thirds of the rock and biotite and hornblende the other. Apatite, zircon, magnetite, and titanite make up the accessory minerals. Second he describes from the same locality a pink granite composed of microcline, quartz, and scattered grains of biotite and yielding apatite, magnetite, titanite, and hematite as accessory minerals. The third rock type he suggests may be an aplitic phase of the pink granite and carries apatite, titanite, zircon, magnetite, and hematite in the accessory mineral group.

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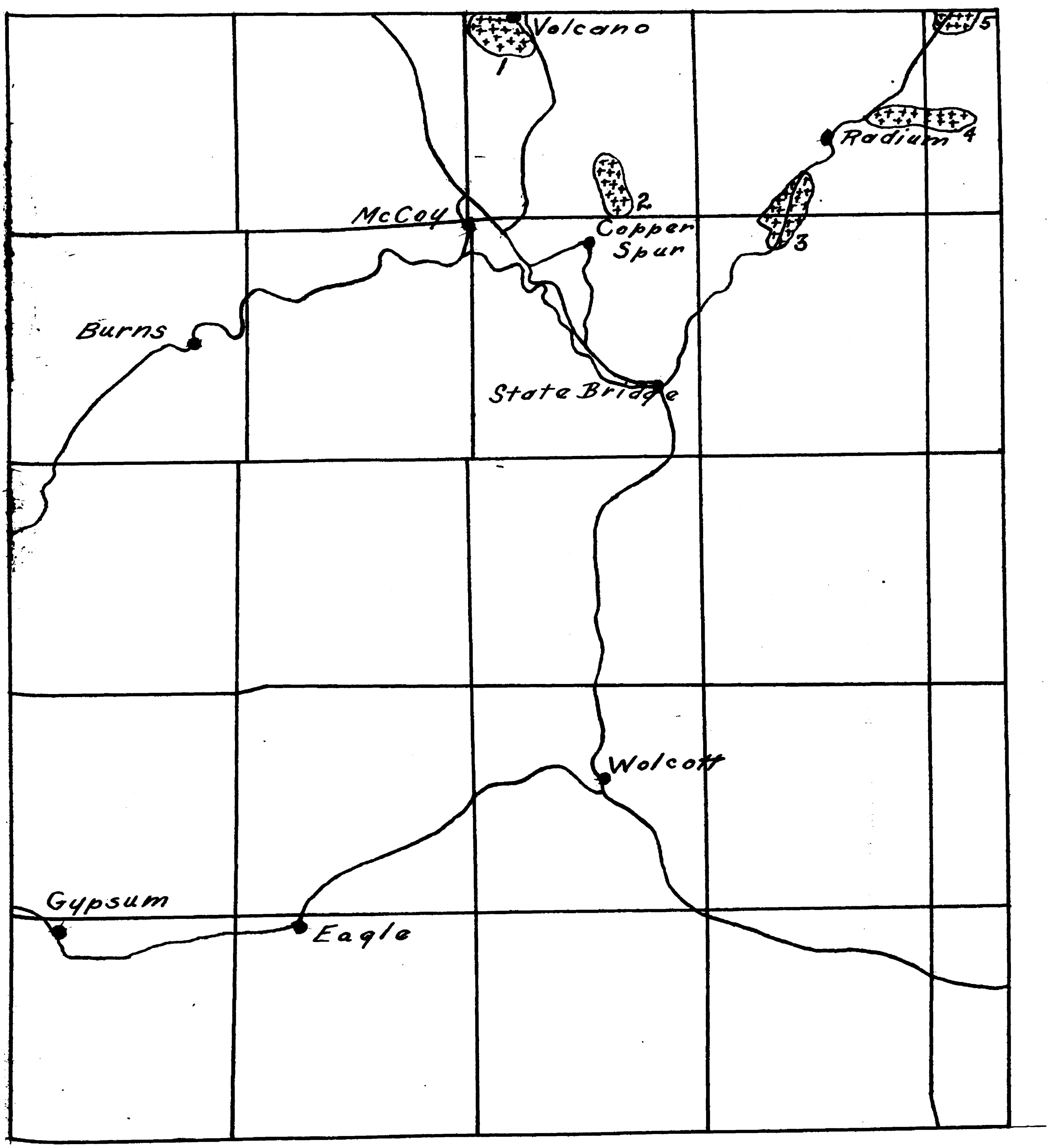
* H. F. Donner, The Geology of the McCoy Area
Doctor's dissertation 1935

MAP OF THE MCCOY AREA



Areas from which samples of the Pre-Cambrian were studied.

1. Volcabo Area
2. Copper Spur Area
3. Red Gorge Area
4. Sheephorn Creek Area
5. Gore Canyon Area

Figure 9. Red Gorge. An area of Pre-Cambrian along the Colorado River just south of Radium

Figure 10. Gore Canyon. An area of Pre-Cambrian along the State Bridge - Kremmling highway.

The nearest area to the McCoy type section lies four and one-half miles northeast of Copper Spur and appears to have supplied much of the materials in the lower conglomerates (Interval 29). Samples of a pink pegmatite in this area gives an abundance of magnetite, hematite, muscovite, sillimanite, and prismatic hornblende grains with smaller amounts of apatite, garnet, and biotite. A mica schist from the same locality had biotite, hornblende, and tourmaline making up its heavy mineral concentrate.

Excellent exposures of the Pre-Cambrian are are found along the Colorado River just south of Radium. They consist mostly of red gneiss, red pegmatites, and a black augen-gneiss containing areas of pink feldspar. The latter is made up almost entirely of hornblende and biotite. The red gneisses carry in addition to these minerals considerable amounts of apatite and zircon with smaller amounts of hematite and magnetite. The pegmatites consist of apatite, hornblende, tourmaline, and sillimanite.

The area which lies along the north side of Sheephorn Creek on the road leading east from Radium is made up entirely of the ancient crystallines. Dominant rock types here include a coarse grained dark gray granite, a red-green hornblende granite, a prominent pinkisk gray pegmatite, a red and black gneiss, and mica schists. Tourmaline, hornblende, biotite, apatite, epidote, hematite, muscovite, garnet, sillimanite, and a very little zircon can be identified from these rock types.

The Gore Canyon area lies a few miles to the north of the Sheephorn Creek locality. Samples were collected from the State Bridge- Kremmling highway. The rocks consist entirely of mica schists and coarse grained gray granites and have hornblende, biotite, tourmaline, apatite, epidote, and zircon making up the heavy mineral assemblage.

The locality at Gore Pass is somewhat removed from the area under study. Samples of a dark gray granite were collected alon the Kremmling-Toponas highway and were found to contain hornblende, epidote, and hematite in the heavy mineral concentrate.

Distribution of the Heavy Minerals

Essentially all the minerals found in the above localities are also found in the sediments. The widespread occurrence of such minerals as hornblende and biotite, which of all the minerals identified cannot be considered accessory minerals, accounts for their dominance or the dominance of their altered products in the clastic materials. They are also excellent criteria as to the conditions of weathering of the land mass and the environment of transportation and deposition of materials. Titanite, which seems to be confined to the granites alone, is only to be found in the Volcano area. It occurs quite sparingly in the sediments and likely reveals little as to their genesis and deposition. Zircon is recorded in appreciable amounts from the gneisses, granites, and schists of the Volcano, Red Gorge, and Gore Canyon localities. This mineral has a sporadic distribution in the sediments and is found in greatest abundance in the lower and upper parts. The only garnets recorded are from the Copper Spur and Sheephorn Creek pegmatites. Muscovite is abundant in the pegmatites of the Copper Spur locality and the red and black gneisses of Sheephorn Creek. In other localities it is scarce. It is quite abundantly concentrated in the upper and lower parts of the section but is found in less quantities throughout the middle part. Sillimanite is found in the pegmatites of the Copper Spur, Red Gorge, and Sheephorn Creek localities. It is quite generally found in the sediments but decreases in amount from the lower formations upward. Apatite is present in considerable amounts in all of the Pre-Cambrian rocks except the Gore Pass locality. It is found in all the rock types and likewise proves to be one of the most abundant and evenly distributed minerals in the sediments. Hematite appears in all localities except the Gore Canyon and is found exclusively in granites and pegmatites. In none of these areas however is it over-abundant. It is found in great abundance in certain horizons of the section but seems to be mostly lacking in others. Biotite is wide-spread in both crystallines and sediments. Likewise tourmaline, with which biotite seems easily to be confused, is fairly common.

Magnetite is largely confined to granites, pegmatites and gneisses of the Copper Spur, Volcano, Red Gorge, and Sheephorn Creek districts. It is quite dominant in the sediments and shows a tendency toward flooding at many horizons. Epidote is found in greatest amounts in the granites and gneisses of the Red Gorge, Sheephorn Creek and Gore Pass areas. It has not been identified with certainty in any of the sediments. Samples from the Gore Pass district strongly suggest an origin from the alteration of a dark green hornblende. It seems likely that its absence in the sediments might have been due to its origin as an alteration product of the iron-bearing minerals after the deposition of the sediments were complete. Ilmenite is found in the red and black gneisses of Sheephorn Creek. In the sediments it is often found partially altered to leucoxene.

Summary of the Minerals by Localities

Volcano	Copper Spur	Red Gorge	Sheephorn Creek	Gore Canyon	Gore Pass
....	Tourmaline	Tourmaline	Tourmaline	Tourmaline	....
Hornblende	Hornblende	Hornblende	Hornblende	Hornblende	Hornblende
Biotite	Biotite	Biotite	Biotite	Biotite	Biotite
Apatite	Apatite	Apatite	Apatite	Apatite	....
....	....	Epidote	Epidote	Epidote	Epidote
Hematite	Hematite	Hematite	Hematite	....	....
Magnetite	Magnetite	Magnetite	Magnetite	....	....
....	Garnet	....	Garnet	....	....
....	Muscovite	....	Muscovite	....	....
....	Sillimanite	Sillimanite	Sillimanite	....	....
Zircon	....	Zircon	Zircon	Zircon	

The above summary is by no means intended to represent a complete and comprehensive investigation of the Pre-Cambrian crystallines. Such a study would entail a much more detailed sampling and examination. Again in the treatment of the crushed materials great quantities of heavy minerals as biotite and hornblende were given in the concentrate. Such minerals can easily be seen in the megascopic study of most of the rocks and their great abundance may have tended to obscure the presence of the more rare minerals.

PETROGRAPHIC STUDY OF THE MCCOY FORMATION

The heavy mineral suites of the McCoy formation as a unit suggest three interesting phases of study. First is the relative abundance of the more stable minerals at different horizons. Second is the vertical distribution of the mineral species that are present. Third are the data which may have an interpretative value in seeking to reconstruct the environment under which the sediments were derived and deposited.

Relative Abundance of the Heavy Mineral Assemblages

The quantitative study of the mineral groups can have only a relative importance under any conditions since the complete separation of the heavier from the lighter grades is sometimes a matter of considerable difficulty. Data obtained from this study show a considerable variation in the actual percentage by weight of the heavy mineral concentrates at different horizons. Certain horizons gave a residue so small that it could not be computed in terms of tenths of a percent. In others it reached a maximum of five percent. The average is near one percent by weight of the total sample used. The small amount of concentrate does not necessarily signify a limited variety of the mineral species present. Nor does an abundant concentrate insure variety of mineral species. Coarser sediments as a rule gave smaller concentrates in proportion to the amount of sample used. The variety of mineral species might easily be due to the varied composition of the rocks from which they came or to their relatively stability under those particular conditions of weathering. As examples, interval 25 and 29 is each characterized by a small concentrate. Each is a coarse clastic and separated from the other by less than 100 feet of sediment. The mineral assemblage of the former is exclusively magnetite, limonite, and leucoxene, two of which are alteration products. In the latter there is a mineral group which consists of magnetite, apatite, leucoxene, tourmaline, garnet, muscovite, sillimanite and zircon. In most cases of an extremely great residue percentage great amounts of bronze-like scales of iron oxide are present. These are apparently the partially altered products of the iron-bearing minerals of the crystalline rocks. Ocassionally the abundant residues consist almost exclusively of magnetite or other of the more stable minerals. Certain of these horizons occur under conditions which are suggestive of erosional breaks during the process of sedimentation.

Mineral Species

The individual mineral species of the McCoy formation vary little from those mentioned in the summary of the Pre-Cambrian but because of their relation to the problems of sedimentation are here discussed in greater detail.

Tourmaline occurs in the sediments in two distinct varieties. The greenish brown variety has been identified in the crystalline rocks and is usually found in irregular fractured grains which give fairly distinct interference figures. A mauve colored type is found at certain horizons throughout the section but never in great amounts. It is in prismatic grains and distinctly pleochroic. This particular type of tourmaline was not observed in the samples of the crushed crystallines to the northeast but a detailed investigation of many samples might have disclosed its presence. The only cases of extreme rounding of the tourmaline grains are in the gray grits at the base of the section. The rounded basal plates, although few in number, are here associated with equally well rounded zircon grains under conditions which suggest a derivation from pre-existing sediments.

Zircon has a much more restricted occurrence than does tourmaline. With the exception of the case just mentioned, zircon grains show admirably well their crystal form or broken crystal fragments. They reach their greatest abundance in the lower gray grits and approach a condition of flooding immediately preceding the deposition of the first maroon sediments. After the first prominent conglomerates (29) which appears to have had its source in the crystallines of the Copper Spur region, it is very scarce until it is again found in one of the conglomerates just below the Walchia Beds. Above this horizon it is lacking entirely until in the intervals 98 to 131 where it is found ocassionally but not in great abundance.

Apatite occurs as colorless to bluish-white rounded grains. It is very rare in the basal part of the section but with zircon becomes quite abundant in the beds immediately preceding the first maroon arkoses. Above that the mineral is quite persistent and evenly distributed although at certain horizons it shows decided effects of weathering by solution.

Muscovite presents a variety of characteristics throughout the section. Of the many distinct types that are present, only two were identified in the samples of the Pre-Cambrian rocks. These include that type which is spotted with amber inclusions of hematite and a clear, greenish, "ragged" variety. The first of these types is characteristic of the pegmatites of the Copper Spur locality and the second was identified in the red and black gneisses of Sheephorn Creek. Both of these types along with the clear, colorless variety are confined largely to the middle portion of the section. In the upper intervals there is a dominance of types not found in either the light or heavy concentrate of the Pre-Cambrian rocks examined. Most important of these types are those grains filled with fibrous, hair-like inclusions which at times are so numerous as to give the grain a cross-hatched appearance. The restricted occurrence of this type in the section may give it some correlative value. A second type found in the upper horizons is a fibrous variety showing distinct and more or less parallel black lines. Without careful examination they are easily mistaken for sillimanite. They are thought to be the edges of small aggregates of grains such as might be expected in schists. A third type contains small zircon-like inclusions and are also more common in the upper part of the section.

Magnetite occurs quite commonly throughout the section beginning with the upper part of the lower gray grits. The grains sometimes show considerable though not excessive wear and seldom to the extent of the complete removal of all traces of their crystal structure. In conglomerate 69 below the Walchia Beds the heavy mineral assemblage consists almost exclusively of magnetite. The change in interval 71 to a concentrate of varied mineral species, each of which is abundant, makes an erosional break at this horizon seem likely.

Garnet, while found sparingly in the sediments, is believed to have a rather important correlative value. It first appears in conglomerate 29 at the base of the second group of gray arkoses. The color is a deep reddish-brown to pink and is characteristic of the garnet observed in the pegmatites of the Copper Spur locality. The presence of garnets along with the dominance of pink pegmatite boulders in this conglomerate affords good reason for regarding that area as an important source locality during that phase of deposition. Garnet is not found throughout the entire middle portion of the section. It appears again in even greater abundance in the section west of McCoy (intervals 124 and 126) and also in the so-called gray Rock Creek conglomerate which overlaps the older formations in the vicinity of Radium. As has been previously suggested this conglomerate has likely been called the Rock Creek because of its stratigraphic position above the arkoses and below the redbeds in its outcrop at Radium. It has however, a mineral assemblage which is essentially identical with that of conglomerate 126 west of McCoy and it is the writer's opinion that one is the equivalent of the other. But disregarding the likelihood of such a correlation for the present, the distribution of the garnet bearing horizons in the McCoy formation indicates a near-by source for those lower in the section and the shifting of that source several miles to the north and east as deposition progressed. Obviously this condition might be obtained through the continued extension of the streams into the land mass but without a change in the position of the shoreline. A field study of the arkoses of the Radium area however, more logically suggests the gradual overlap of those seas to the north and east, perhaps reaching its maximum during the time of deposition of the Radium "Rock Creek" conglomerate which the writer suggests is contemporaneous with interval 126 west of McCoy.

Hornblende is found at scattered horizons in the section and makes a rather persistent apperance in the upper part although never in great abundance. It occurs as irregular fractured fragments of deep blue-green color and as prismatic grains of brownish-freen color and pronounced pleochroism. The factors determining its presence seem to be largely the particular conditions of weathering existing at the time of the origin of the sediments. Sillimanite is present in small interlaced needles as the variety fibrolite. Straight extinction is found in all the grains but good interference figures are difficult to obtain. It is rather evenly distributed throughout the section, is especially abundant near the base of the section, and quite consistent in its occurrence above interval 126. Biotite is likewise quite common in the sediments considering its somewhat unstable character. Partial alteration to chlorite and other minerals is common. Its relative abundance in a concentrate is sometimes difficult to determine due to its easy confusion woth tourmaline when that mineral is present. Hematite resembles closely the types that are found in the granites and pegmatites of the Pre-Cambrian area. It is found only at a few horizons but in rather abundant amounts when present.

Limonite and leucoxene are the only minerals recorded in the sediments which are not also found in the Pre-Cambrian rocks. Their presence creates no problem since they are both doubtless products of the weathering processes upon primary minerals. Leucoxene in many cases shows its orgin from the alteration of ilmenite in the sediments. Limonite on the other hand is a secondary product from the iron-bearing minerals of the parent rock. The latter is widely distributed throughout the section and reaches the stage of flooding at several horizons. It occurs in two main types. In the lower gray grits and in the upper-most maroon arkoses it is found abundantly as irregular grains and powdery aggregates. Its appearance in each case is such that might be expected of any sediment whose origin is not closely associated with a distributive province of crystalline rocks or where complete decomposition of original iron bearing minerals and considerable reworking of materials has taken place. If such an interpretation is correct, completeness of the weathering process is evident, then, in the very lowest horizons and in those immediately below the Leadvilloides limestone. This characteristic as seen in the lower beds persists through the deposition of the first maroon arkoses. Above these arkoses however (interval 37) it occurs in the greater part of the remainder of the section as bronze like scales or flakes. This form has evidently resulted from the partial alteration of the minerals biotite and hornblende. Certain horizons show a faint green -brown color on the thin edges of the plates which have a bronze luster in reflected light. Others show the presence of prismatic bronze-like fragments usually associated with similar grains of highly pleochroic hornblende. Between intervals 114 and 140 the sediments lack the mineral in either of these forms. On the previously suggested basis of overlap of the seas to the east, its absence might easily be explained in this part of the section.

Interpretative Data

An analysis of the individual mineral species present in the mineral suites described above shows a persistency of those minerals which are both stable and of wide spread occurrence in the Pre-Cambrian crystallines to the north and east. Such minerals include tourmaline, zircon, sillimanite, magnetite, and muscovite. The latter three are found in greater abundance. It seems entirely probable that a source other than the Pre-Cambrian area studied may have at times contributed to the sediment supply.especially in the later phases of deposition. The sediments in the upper part of the section (above interval 106) contains muscovite which not only becomes a dominant species in the mineral assemblage, but occurs as types which are characteristic of neither the lower arkoses nor the ancient crystallines. Between intervals 29 and 106 it has a more sporadic distribution and is found in less quantities. It is however more closely related in its characters to that found in the crystalline rocks to the east. Again, the bluish-black grains of tourmaline which are scattered in sparse amounts throughout the section becomes more abundant in the upper part and has not been identified in any of the Pre-Cambrian rocks examined. Finally, the pebbles of the upper conglomerates themselves are less typical of those types found in the crystalline area to the east. Other stable minerals which occur in much smaller quantities and less frequent intervals are garnet and titanite. Obviously their irregular distribution has been occasioned by their restricted presence in the rock types undergoing erosion. The same may be said of leucoxene which is found at certain horizons. Its alteration from ilmenite found in at least one gneiss along Sheephorn Creek seems certain.

The presence or absence of the less stable minerals gives even more conclusive data upon the problem sediment supply and environment of origin. These minerals include apatite, biotite, and hornblende. The degree of their alteration varies at different horizons in the section. All are essentially absent from the lower gray grits of the section but are present throughout the greater part of the remainder either as fresh or partly altered grains. Apatite sometimes shows partial alteration in a surface etched by solution. Hornblende shows a tendency to the development of bronze-like fragments of limonite. Biotite shows the same characteristic as well as the change to chlorite. Thus the general characters of the mineral groups present suggest, first a crystalline source for most of the sediments, second climatic conditions favoring incomplete decomposition, and third the nearness of their place of origin to the site of their deposition.

The colors of the McCoy arkoses are thought to be controlled more by land conditions in the environment of their origin than by marine conditions at the place of their deposition. Three factors are involved in the interpretation of their color. First is the degree to which it is controlled by the parent rock; second is the climatic conditions under which the sediments were formed; and third, the conditions at the time and place of deposition. The conditions under which the sediments originated appear not radically different from the conditions at the time and place of deposition and can be treated essentially as one environment.

The nature of the parent rock has doubtless had some bearing upon the color of some of the arkoses. Certain pinkish-gray colors are due to the presence and abundance of pink and gray feldspar. Green and black tinges are accentuated by a greater abundance of hornblende, tourmaline, biotite, or magnetite. The light gray grits at the very base of the section owe their color to the dominance of worn quartz grains and the absence of the more highly colored constituents. But to regard each major color change as being due entirely to a difference in the rock undergoing erosion is inconceivable. The alternating sequence of arkoses dominantly gray with those dominantly maroon has already been emphasized. Maroon colors are due to iron oxide which appears in two distinct forms. In the lowest of the maroon arkoses (intervals 25 to 28) iron oxide appears aburdantly as irregular grains and powdery aggregates which suggest complete decomposition of the iron bearing minerals. It is the type that might be found in any residual soil under certain conditions of weathering. The plate-like iron oxide with its bronze luster dominates the purple-maroon horizons of most of the section. It suggests a much less complete decomposition of the iron bearing minerals, mainly biotite and perhaps hornblende. Where crossbedding has developed through differentiation of color the maroon layers are made up almost entirely of this type. The gray streaks consist of coarser and less micaceous material. Conditions which are analogous to those which may have brought about cross bedding by color differentiation have been observed along present sandbars in the Colorado River. Water movement tends to keep the scale-like minerals in suspension for great lengths of time while coarser grades are deposited. A slight variation in conditions often permits these micaceous to settle upon irregular slopes and undulations present in a manner not unlike that indicated by color differentiation in the cross bedding. Thus, lamination of this type may have been due to both a difference in the composition of materials as well as a coarseness and shape of their grains, either condition of which is induced by the proper conditions of weathering. The gray arkoses have a deficiency in their iron oxide content, and are commonly associated with gray and black carbonaceous shales which contain selenite crystals and carbonized plant remains. That these two phases represent contrasting conditions of climate seems evident and their alternating sequence points to frequent changes from dry to moist conditions. The gray arkoses are invariably more limited in thickness and imply a regular and more uniform supply of sediment. The maroon arkoses on the other hand are often of considerable thickness and reflect a condition of a sudden influx of sediments such as might result from torrential rains of a semi-arid region.

The dominance of one or more mineral species to the near exclusion of others is quite common at certain horizons of the section. Such flooding of mineral species implies but does not prove the presence of an erosional break or a break in the continuity of deposition. The most common tendency to flooding is in the presence of the bronze-like iron oxide found in certain of the beds. It appears at such frequent intervals as to apparently have no significance when applied in its relationship to erosional breaks. Rather it seems to import conditions in changes of rainfall and influx of sediment upon the land. Horizons of this nature are commonly followed by beds whose mineral suites are composed of iron oxide scales intermingled with partially altered but recognizable flakes of mica and prismatic grains of hornblende. It seems credible that such conditions might originate in minor climatic changes where increased rainfall would first bring the decomposed residual soils into the streams and expose to erosion those less decomposed parts of the sub-soil. Magnetite constitutes an almost exclusive mineral assemblage in interval 69 and to a less degree in interval 46. In the former its occurence may not be without meaning. Here is the horizon of some of the most conspicuous conglomerates of the section. Following the dominance of magnetite in interval 69 is the varied composition of the next interval (interval 71) which carries considerable amounts of magnetite, iron oxide, muscovite, tourmaline, biotite, apatite, and zircon. This horizon likewise marks the first presence of limestone boulders in the conglomerates and their origin has evoked considerable interest. In other conglomerates of the section limestone boulders occur largely in lense-like masses and are known to contain pebbles of feldspar within them. Their origin is thought to be contemporaneous with deposition and it is possible that such an origin holds true in most of the cases. In the above conglomerates however, there seems reason to believe that they have in part been the result of the reworking of materials. Pebbles within the fragments have not been observed. Many of the fragments are fossiliferous; others are dense; still others are crystalline or show the tendency to develop an oolitic phase. Such variety in form tends to oppose rather than favor the view of contemporaneous origin.

ENVIRONMENT OF ORIGIN AND DEPOSITION

The major phases of the processes at work during the McCoy times can be conveniently presented by units which are defined by the dominant conglomerates of the section. To regard them as petrographic units however, is to place too great an emphasis upon the importance of their respective mineral assemblages. There is no striking differences in their mineral groups and it is only as they are considered in their relation to all the possible factors of origin and deposition, that they have a specific significance.

Unit I includes both the basal gray grits and the lower maroon arkoses of the section. Unit II embraces those beds which lie above conglomerate 29 of the type section and below the conglomerates underlying the Walchia Beds. Unit III extends from that horizon upward to the conglomerates 124 and 126 in the type section west of McCoy. Unit IV is composed of all those sediments lying above those same conglomerates.

Unit I

With the spread of the Pennsylvanian seas over the eroded surface of the Leadville limestone in this area, the immediate source of materials seems to have been mainly from the residual soils which had formed upon the surface. Any evidentce of a Pre-Cambrian source for the sediments is non-apparent. Either the whole of the local Pre-Cambrian was covered with the Sawatch of the Cambrian, or the actual exposed area was so far removed that it had no part in maintaining the sediment supply. Rather, both the Leadville and the Sawatch appear to have been the contributory provinces in the early stages of deposition. Each characteristic noted seems to point to a derivation from pre-existing sediments. The lenses of pebbles found in the lower grits consist entirely of worn quartz and chert. The former is typical of present local outcrops of the Sawatch and the latter of local phases of the Leadville limestone. Only the most stable minerals are present in the lowest beds. These include limonite as a secondary product, muscovite, sillimanite, magnetite, zircon, and tourmaline. The lighter constituents are made up almost exclusively of quartz with little or no feldspar. Materials of this kind might be said to have originated under conditions of climate which were favorable to efficient decomposition rather than disintegration but the physical characters of the mineral grains do not point to this condition as being the controlling factor. Mechanical wear of the fragments imply a second cycle of deposition. Zircon and tourmaline grains, though not abundant, are extremely worn. The same is true for the quartz grains and marks a condition not found in any other part of the section. These conditions must have prevailed throughout the first 150 feet of the section. Just where the initial effect of a crystalline source is seen, is difficult to say. No crystalline pebbles are noted until the first maroon grits (Interval 25). A greenish-gray grit (Interval 12) affords the first megascopic evidence of a new source of materials and a petrographic study of the same horizon suggests that to be true. The change is accompanied by the abundant development of both zircon and apatite (Intervals 22 and 23). The latter makes its first appearance at this horizon and both approach the stage of flooding. It seems possible that unusual sorting by wave and current action during a time of decreased sediment supply may have been responsible for this concentration. At any rate they have disappeared during the interval of deposition of one of the thickest shale beds of the entire section and are entirely lacking in the first of the maroon arkoses.

The maroon arkoses which make up intervals 25 to 28 are the first sediments to record crystalline rocks among the pebbles within them. They are, however, not typical of other maroon arkoses in the section. They still have a limited content of unaltered feldspar as compared to later types. Powdery aggregates of limonite and grains of magnetite make up their heavy mineral group and they seem to show a completeness of decay that is not present in many of the later maroon arkoses. That they have been produced on land under conditions of semi-aridity and a low water table permitting deep oxidation, is entirely conceivable. Their place as a part of the land mass must have been as a deep residual soil consisting principally of iron-coated quartz grains or perhaps as piedmont deposits of temporary streams existing under such conditions. Climatic change rather than tectonic causes must have been responsible for their rapid transportation and deposition. A change from a semi-arid to a more humid climate - a condition entirely consistent with the succeeding record of gray arkoses and shales containing plant remains - would increase the competency of the streams. Erosion of weathered materials would proceed rapidly to exposed the less altered crystallines beneath.

Unit II

In the beginning of the next sedimentary unit the lower formation marks not only the first of the great conglomerates but also the change to gray arkoses, grayish-black shales, plant fossils, and impure fossiliferous limestones. A conglomerate such as interval 29 can be explained by tectonic causes which have increased the capacity of streams to transport their load or by climatic changes from dry to rainy whereby the volume and hence the velocity of the streams have been increased. The latter condition has already been suggested but that both may have taken place is not unlikely. Certainly the efficiency of the agent which transported materials the size of those found within the conglomerate cannot be disregarded. The effectiveness of those currents in scouring the deposits previously made is manifest in its lower contact. The conditions following its deposition appear to be those of a relatively stable shore line whose position perhaps lay not far to the east of the present outcrops. The proximity of the source of the material for these earlier beds are revealed in the mineral suites which are so typical of the Copper Spur locality as well as the boulders contained within the conglomerates. It seems probable that much of the following section until at least after the deposition of the Walchia Beds resulted from the streams eroding more deeply into a land mass and giving over their load to a static sea. Both marine and continental agents worked together in forming a deposit somewhat deltaic in nature. At times land conditions dominated and the supply of sediments exceeded the ability of the waves and currents to erode. At other times a decreased supply of sediments permitted the waves and currents to remove a part of the materials already deposited and marine conditions prevailed. It was perhaps then that the marine waters invaded the realm of continental deposition and permitted to formation of many of the impure limestones found at this horizon. Mineral species over this period of time varied in both their persistency and their associations but never to the extent of suggesting radical changes in either the location or the types of rocks in their source areas.

Unit III

The conglomerates of intervals 69 to 73 do not bring this sequence of events to a close but rather suggests a culmination of the proeesses which have been at work. They mark the second important horizon of conglomerates and contain the largest size and greatest variety of boulders found anywhere else in the section. A flood of magnetite grains followed by an abundant and varied mineral suite in the overlying beds implies to some extent a break in the process of deposition. This may have been accompanied by a slight retreat of the sea due to uplift or by a prograding of sediments under a static condition of the sea. In the latter case the deposits would eventually have been removed had those static conditions been maintained for any great length of time. If however, they had been interrupted by a rise of sea level and a migration of the shore line to the east, coarse deposits would have accumulated over those previously made. Certainly sediments of this general horizon denote conditions of sedimentation near if not actually above the level of the sea. The wave and current marks in the Walchia Beds imply very shallow water and at times perhaps an area exposed at low tide. Limestone boulders in the conglomerates give a remote indication of the partial reworking of sediments. The oldest arkoses of the Radium area show a mineral suite much like that of interval 108 of the type section. The arkoses just below the "Rock Creek" conglomerate of the same area give a mineral assemblage which is strikingly similar to that of interval 114. Assuming that such similarity of mineral suites is significant, the record of the section from the Walchia beds up to interval 114 would be one of a progressive spread of the sea to the east. A number of features support this view. It is in that portion of the section that the most pronounced limestone beds have been developed under conditions farther removed from land. The relatively unstable mineral, apatite, shows a considerable amount of weathering beginning with the Walchia beds and extending to interval 104. In a few of the intervening horizons it is absent entirely. The horizons which have yielded the smallest amounts of residue are found in this portion of the section.

Unit IV

It is believed that the time of maximum overlap was being recorded in the contemporaneous deposition of intervals 124-126 west of McCoy and the so-called Rock Creek conglomerate of the Radium area. It has been previously suggested that on the basis of their respective mineral suites one should be considered the equivalent of the other. If these beds represent the same unit of deposition the present terms by which they are designated become misleading. In the Radium area the red beds lie immediately upon what has been called the Rock Creek conglomerate. In the type section west of McCoy several hundred feet of beds lie between the redbeds and the horizon which seems to be contemporaneous with the Radium "Rock Creek" conglomerate. These beds include what has been considered to be the upper McCoy formation and the typical Rock Creek conglomerate. On the basis of such a correlation either the term Rock Creek should be discarded as it applies to the conglomerate beneath the red beds at Radium or it should be made to include all the beds which are younger than the 124-126 interval of the type section and older than the red beds. The conditions which prevailed following the marine overlap to the east cannot be to confidently stated without a more comprehensive study of the areas involved.

The sediments younger than interval 126 and older than interval 139 show a much finer grade of shales, sands, and grits in their exposure west of McCoy. The mineral assemblage is not radically different from those of the older beds. Limonite is entirely absent from the section and hornblende becomes a persistent but not an abundant constituent. The change in the size of the mineral grains is what might be expected with the more wide spread seas. Distinct types of muscovite grains and a more common occurrence of buish-black tourmaline may denote a slight change in the source of the sediment supply. It seems probable that in the extreme upper part of the section and perhaps continuing on through the deposition of the typical Rock Creek conglomerate rapid deposition by streams was in progress. The source might conceivably have been from the north. A change in materials is reflected in the type of pebbles found in the RockCreek conglomerate. Sedimentation seems to have been concentrated and local and the environmental conditions more definitely deltaic in nature than at any other place in the section. With a continuance of such an environment conditions must have changed from the deposition of sediments which were partly marine to those which were mostly if not wholly continental. The writer is inclined to regard the conglomerates (Rock Creek) above the Leadvilloides limestone as largely the work of the deposition of streams under subaerial conditions. The presence of the lithographic limestone separating them from the sediments below presents a problem to which he offers no solution, except the tentative suggestion that its deposition might have resulted from fresh waters carrying calcium carbonate in colloidal form as they intermingled with the saline waters of the sea.

POSSIBILITIES OF CORRELATION

The correlation of widely separated areas of the Pennsylvanian with the McCoy formation is not within the scope of this study. From incomplete studies of sections elsewhere however, the writer is inclined to believe that the same methods of study might be applied advantageously in the correlation of the McCoy with the Pennsylvanian section of the Minturn and the Dotsero areas. The very conditions of sedimentation which are indicated in McCoy deposition show the impracticability of any attempt to correlate its detailed horizons with their equivalents elsewhere. However, the projection in time sequence of certain broad phases of its deposition into sections to the south and west seems possible. Among those likely traceable horizons might be mentioned the first appearance of an igneous source, the depositional break which has been postulated for the approximate horizon of the Walchia beds, the time of maximum overlap to the east, and the deposition of the conglomerates above the Leadvilloides limestone. The fact that other areas may have had a different source area has not been disregarded. In the Minturn area this might easily have been the case and if so, its paleogeographic problems should be carefully studied before an attempt to reconstruct the details of the Pennsylvanian sedimentation as a unit. The Dotsero-Sweetwater area situated to the southwest may have an interfingering relationship with the McCoy sediments which a more detailed study might establish. It is to be understood that the following relationships are suggested but cannot be definitely established without a more careful investigation of the areas involved.

The following partial section is typical of the rapid changes in lithology of the McCoy formation. The locality from which it was measured lies along the Burns road about four and one-half miles southwest of McCoy. It is thought to represent the best available outcrops of McCoy sediments under conditions farther removed from the shore.

PARTIAL SECTION OF THE MCCOY

Along the north side of the Burns road, four miles southwest of its juncture with State Highway 131

30 A.	Conglomerate containing large boulders of gneiss, granite, and pegmatite.................	30'
29 A.	Grits, maroon and gray, inlayers 1 - 2 feet in thickness interbedded with maroon shale.......	18'
28 A.	Grit, arkosic, maroon streaked with gray	45'
27 A.	Shale, mostly covered, maroon to dark gray and black, contains gypsum	15'
26 A.	Sandstone and grit, arkosic, greeniah gray weathering to a greenish buff. Certain layers show a greater resistance to weathering	15'
25 A.	Shale, dominantly dark gray to black and containing selenite crystals. Interbedded in the lower part with thin lenses of dark gray limestone and in the upper part with buff gray beds of arkosic sandstone................................	128'
24 A.	Grit, arkosic, maroon streaked with gray. Some pebbles as large as an inch in diameter. Crossbedded. In the middle is a 3' bed of maroon shale. Upper half not so crossbedded and and consists of thin zones of small pebbles and rather large disc-like boulders of grit.........	26'
23 A.	Shale, micaceous, maroon with streaks of greenish-gray near the top	4'
22 A.	Limestone, light gray, dense with sugary texture, weathers buff, prominent vertical jointing, Lower one foot is nodular and fossiliferous and separated from the upper by a thin seam of maroon shale	5.5'
21 A.	Sandstone, arkosic, maroon and gray in thin layers alternating with thin lenses of maroon shale	3.5'

20 A.	Grit, arkosic, maroon and gray mottled, contains lenses of red and gray mottled limestone	3.5'
19 A.	Shale, micaceous, maroon, streaked with greenish gray. In center is a bed of maroon arkosic sandstone 2' thick. Two layers of gray arkosic grit near the top..................................	12'
18 A.	Grit, arkosic, regularly bedded, gray weathering to buff. Contains abundant pink feldspar	5.5'
17 A.	Shale, lower 2 feet contains many calcareous nodules, is fossiliferous, and dark gray in color. Upper half purplish gray and contains thin layers of arkosic sandstone	20'
16 A.	Grit, arkosic, gray, with 1' of limestone on the top. Limestone weathers buff-gray. Light gray on fresh surface, contains fossils	4.5'
15 A.	Shale, micaceous, purplish gray with think maroon and gray streaked sandstone near its base	7.5'
14 A.	Grit, arkosic, gray with pink feldspar	2.5'
13 A.	Shale, lower half maroon. Layer of gray micaceous sandstone near the center. Upper half purplish streaked with very thin micaceous grayish green shale and sandstone................................	10'
12 A.	Limestone. Upper half in layers 6 inches thick. Weathers reddish gray. Contains lenses and nodules of chert. Lower half nodular with purplish color of weathered surface. Fossiliferous.	11'
11 A.	Grit, arkosic, gray, consisting of a few layers of interbedded maroon shale.........................	16'
10 A.	Shale, maroon with a thin layer of arkosic sandstone near the base. Greenish gray shale at the top...	6.5'
9 A.	Grit, arkosic, crossbedded, gray streaked with maroon..	18'
8 A.	Shale, maroon and gray	3'
7 A.	Grit, arkosic, gray streaked with maroon	6'
6 A.	Shale, maroon	5'
5 A.	Grit, arkosic, crossbedded, gray streaked with maroon	30'
4 A.	Shale, dark gray with selenite crystals in the lower part. Upper part maroon and greenish gray with thin beds of sandstone..........................	10'
3 A.	Shale, lower 5' is arenaceous and maroon streaked with gray. Upper 6' is dark gray, gypsiferous, and contains a few thin beds of dark gray limestone and limestone concretions..................	11'
2 A.	Grit, arkosic, gray and maroon	13'
1 A.	Limestone, nodular, dark greenish gray, fossiliferous	1'

Limestone 12 A of the preceding section resembles interval 111 of the type section in both lithology and faunal content. On the basis of that correlation the overlying beds should represent the interval in the type section which comprises the upper part of the section as measured south of McCoy and the lower part of the section as measured west of McCoy. The dissimilarity in the characters of the two sections is apparent and since correlation of the area west with the area south of McCoy was based upon the presence of fusilinids it is entirely possible that a portion of this section is lacking from the type section.

Heavy mineral suites of a few samples selected from this section strongly indicate an equivalency in time between these beds and those west of McCoy. Interval 20A yields a mineral suite which is quite characteristic of both 114 and 124 of the type section. In the greater abundance of its magnetite it suggests interval 114 and in the presence of its red and gray mottled limestone lenses as well as its mineral concentrate it is like interval 124. Interval 24A is not unlike interval 126 in its mineral assemblage but seems more nearly the equivalent of interval 131. Since in the section measured this horizon really consists of two arkoses, it is likely that both of the latter intervals are represented. Thus from the petrographic approach there seems some support to the belief that Limestone 12A may be correlated with Limestone

111 of the type section and that the succeeding formations owe their difference to the off-shore environment of their deposition. The dolomitic limestone 22A occupies a position in the section corresponding to the approximate horizon of 124 and 126 and deposited at about the time of the maximum overlap to the east. The thick shales of interval 25A seem to be the finer equivalent of those beds extending upward to about interval 137 of the type section. On the basis of that correlation little of the section has actually been missed, - certainly not more than from 13A to 19A - and a part of that is doubtless exposed to view in the lower part of the section west of McCoy.

Little data has as yet been secured upon the relationship of the McCoy formation to sediments of the same age to the southwest. The section near Dotsero consists of a considerable thickness of alternating dolomitic limestones and black shales resting upon the Leadville limestone. These are followed by alternating shales and gray grits below succeeding beds of gypsum. Extremely fine grained sandstones and shales make up the interval lying above the thick beds of gypsum and below the red beds. These beds have colors of pastel shades and are nicely exposed along Highway 24 near Gypsum. Incomplete data secured from this area indicates a similarity of mineral content between the gray arkoses of the Dotsero area with the lower gray grits of the McCoy section at the approximate horizon of interval 14. The mineral suites of the sandstones above the gypsum tentatively implies a unit of deposition contemporaneous with the approximate horizon of 37 in the type section. If a more complete study supports this relationship, then the basal Pennsylvanian of the Dotsero area would have been deposited before the deposition of the first arkoses of the type locality. The gray grits would mark the basal equivalents of the McCoy in its type section and show a condition of overlap of the sea to the north and east after the deposition of alternating limestones and shales. The gypsum would have been deposited at the same time as the first maroon arkoses of the type section. The pastel beds above the gypsum would constitute the greater part of the McCoy type section. That this relationship exists, is problematical in view of the limited data the writer has at hand, but the problems evident in those two areas seem worthy of careful and detailed study.

SUMMARY

The McCoy formation in its type locality has been derived mainly from the Pre-Cambrian land mass to the north east and has been deposited as near-shore sediments under conditions of a combined marine and continental environment. Climatic conditions that prevailed over the period of its accumulation were such that favored incomplete decomposition of the detrital material formed through the weathering processes.

Over a greater part of that period, semi-arid climates seem to have dominated although evidence points to an alternation of such conditions with those more humid. It is conceivable, that before the seas began their record in this area, they were already occupying the region to the south and west and were building up a succession of alternating thin limestones and shales upon the eroded surface of the Leadville limestone. Little sediment other than that supplied by the weathered surface of the Mississippian formations is evident in this part of the section. With the gradual overlap of the seas to the north and east, not only were new areas of derivation brought into active contribution, but the actual record of McCoy sedimentation began. The basal beds in the type locality indicate a source, sedimentary rather than crystalline, - a reworking of Sawatch sediments and, in part, the Leadville limestone. Later, perhaps through uplift, quickened erosion brought great quantities of the first maroon sediments to their depositional site. Completeness of weathering is indicated in their mineral constituents and a semi-sridity of climate is thought to have prevailed in the near-by area of their origin. Perhaps, even, this aridity of climate was accompanied by deposition of gypsum beds farther seaward to the south and west. The first maroon arkoses are followed by a record whose genesis undoubtedly lies in the crystalline areas to the north and east. Their advent was marked by the deposition of the lowest of the prominent conglomerates upon the scoured surface of finer sediments. In the basal beds the sediment source seemed confined to areas very near the site of deposition but as the sedimentary record continued under conditions of an essentially stationary sea, provinces of origin shifted farther to the north and east. Shortly before the deposition of the Walchia beds, these conditions were interrupted either by a retreat of the sea permitting subaerial erosion locally or by a slackening of deposition permitting the partial removal of those sediments already deposited. This phase of deposition was essentially contemporaneous with the origin of the second prominent conglomerates which lie immediately below the Walchia Beds. Then began the advance of the sea to the east. Its maximum overlap is recorded with the deposition of the Radium "Rock Creek" conglomerate and the intervals 124 and 126 west of McCoy. Beginning with interval 124 the writer favors either including all of the succeeding beds as the Rock Creek conglomerate or discarding the name as it applies to the Radium area. During the time of maximum overlap the McCoy formation is a record of finer sands and shales and more numerous limestone horizons in the area to the southwest. This was seen to be followed by conditions which were gradually changing from those of marine to those of continental environment. The change may have been instigated by a partial withdrawal of the sea or by a concentration of deposition as a deltaic deposit in the region west of McCoy. Certainly a portion of the beds lying above intervals 124 and 126 show an environment dominantly marine. Below the Leadvilloides limestone lies the greatest accumulation of maroon conglomerates found anywhere in the entire section. A change to more nearly continental conditions might easily have begun with them. Above the Leadvilloides limestone are the thick conglomerates heretofore known as the Rock Creek conglomerate. Deposition by streams are thought to have been quite active at the time of their deposition. Subaerial conditions of weathering and deposition are thought to have prevailed, The entire local area was experiencing a change to emergent conditions and the sedimentary environment of the McCoy passed into those conditions which were to dominate the record of the succeeding red beds.
