THE NEW RIVER

CRIPPLE CREEK

MINERAL REGION.

McCreath and d'Invilliers.

THE

NEW RIVER-CRIPPLE CREEK

MINERAL REGION

OF

VIRGINIA,

BY

ANDREW S. McCREATH AND E. V. d'INVILLIERS.

HARRISBURG, PA.
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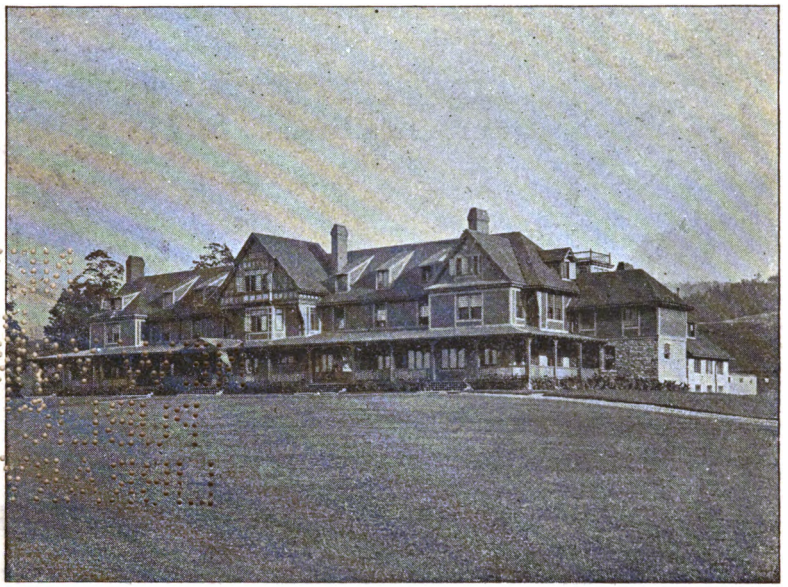

"MAPLE SHADE INN,"
Pulaski, Virginia.

Junction of the Main Line Norfolk and Western Railroad with the Cripple Creek Extension.

Erected for the accommodation of parties visiting the Cripple Creek Mineral Region.

PREFACE.

The Norfolk and Western Railroad Company first directed attention to the mineral region tributary to its then proposed "Cripple Creek Extension" by the publication of a report made by Andrew S. McCreath in March, 1883, entitled "The Mineral Wealth of Virginia," which treated of the entire mineral territory tributary to the Norfolk and Western and Shenandoah Valley Railroads. A subsequent and revised edition of this report was made in July, 1884.

The completion of a portion of the "Cripple Creek Extension" in October, 1886, and the practical development of the mineral territory tributary to that line, rendered it desirable that a further examination and report of that especial region be made. To add to the completeness of the geological features of the work, Mr. McCreath secured the co-operation of Mr. E. V. d'Invilliers, formerly geologist of the Pennsylvania State Geological Survey, and the result of their labors is shown in the accompanying report, which is published for gratuitous distribution, with the view of inviting attention to the advantages offered by the New River-Cripple Creek Mineral Region for the manufacture of iron, zinc and lead, and to Pulaski and Radford as manufacturing centers.

In the midst of a rich agricultural country; with a healthful climate; an abundant water supply furnished by New River, Cripple creek and their numerous tributaries; in close proximity to the Pocahontas-Flat Top coal field; with good facilities offered by the Norfolk and Western railroad and its connections for the transportation of raw and manufactured materials to the various markets of the country; and with an abundance of rich and cheaply mined ores, this portion of south-western Virginia offers advantages for the establishment of industrial enterprises which are believed to be unsurpassed by any other section of the country.

It is the intention of the management of the Norfolk and

Western railroad to extend the Cripple Creek branch from point to point as mines are opened and furnaces erected.

As no report of this section would be complete without reference being made to the character and quality of the coal and coke from the Pocahontas-Flat Top coal field, there has been included in this report a general review of the field together with a brief statement regarding its rapid development.

On the following page will be found a directory of the mines and furnaces in operation January 1st, 1887.

F. J. KIMBALL,
Pres't N. & W. R. R. Co.

PHILADELPHIA, *June 1, 1887.*

Charcoal Furnaces on or near the line of the Cripple Creek Extension.

NAME OF FURNACE.	Location.	Stack.	Owner or Agent	Address.
Radford, ...	Mack's Creek, Pulaski county, . . .	35′×10′	Enoch Phillips, ...	Pulaski, Virginia.
Boom, ...	Little Reed Island Cr., Pulaski co., .	33′×9′	John W. Robinson, ...	Graham's Forge, Wythe co., Va.
Barren Springs, . .	New River, Wythe county, ...	35′×8′	Manning & Squier, ...	111 Liberty street, New York.
Pierce Furnace, . .	Foster's Falls, Wythe county, ...	36′×10′	John W. Robinson, ...	Graham's Forge, Wythe co., Va.
Cedar Run, . . .	Cedar Run, Wythe county, ...	32′×9′	John W. Robinson, ...	Graham's Forge, Wythe co., Va.
Walton, ...	New River, Wythe county.	33′×8′	George G. Lobdell, ...	Wilmington, Delaware.
Brown Hill, . . .	Cripple Creek, Wythe county, ...	40′×8½′	George G. Lobdell, ...	Wilmington, Delaware.
Raven Cliff, . . .	" "	29′×9′	John W. Robinson, ...	Graham's Forge, Wythe co., Va.
Eagle, ...	" "	34′×9′	" "	" " "
Beverly, ...	" "	33′×9′	" "	" " "
Cave Hill, ...	" "	47′×10′	Robert Sayers, ...	Speedwell, P. O., " "
Irondale, (Noble or Norma,) . . .	" "	41′×13′	Clinch Valley Coal & Iron Co.,	147 S. Fourth street, Philadelphia.
Wythe, ...	" "	33′×9′	John W. Robinson, ...	Graham's Forge, Wythe co., Va.
Speedwell, ...	" "	32′×9′	" "	" " "
White Rock, . . .	Smyth county, ...	38′×8½′	George G. Lobdell, ...	Wilmington, Delaware.

Coke Furnaces in Process of Erection.

NAME OF FURNACE.	Location.	Stack.	Owner or Agent.	Address.
Pulaski, ...	Pulaski, Virginia, ...	75′×17′	Abm. S. Patterson, Treas., .	330 Walnut street, Philadelphia.
Ivanhoe, ...	New River, Wythe county, Va., . . .	42′×12′	Geo. H. Seeley, ...	32 Burling Slip, New York.

Miners and Shippers of Iron Ore.

NAME OF COMPANY OR PROPERTY.	Location of Mines.	Owner or Agent.	Address.
Pulaski Iron Company, . .	Little Reed Island Creek, Pulaski county,	Abm. S. Patterson. Treas., .	330 Walnut street, Philadelphia.
Hematite Iron Company, . .	New River, Wythe county, ...	L. & R. Wister & Co., Ag'ts.,	257 South Fourth street. Phila.
Foster's Falls Iron Company,	Foster's Falls, Wythe county.	John W. Robinson, ...	Graham's Forge, Wythe co., Va.
Rich Hill Mine, ...	New River, Pulaski county, ...	D. F. Houston, Gen'l Man.,	Roanoke, Virginia.
Old Home Mine, ...	New River, Pulaski county, ...	L. S. Calfee, ...	Pulaski, Virginia.
Eva Mine, ...	Little Reed Island Creek, Pulaski county,	L. S. Calfee, ...	Pulaski, Virginia.
Reed Island Iron Company,	" "	John W. Robinson, ...	Graham's Forge, Wythe co., Va.

Miners and Shippers of Zinc Ore.

NAME OF COMPANY OR PROPERTY.	Location of Mines.	Owner or Agent.*	Address.
*Bertha Zinc Mine, ...	New River, Wythe county, ...	Thomas Jones, Sup't, . . .	Pulaski, Virginia.
*Wythe Lead and Zinc Mine,	Austinville, "	John C. Raper, Agent, . . .	Max Meadows, Virginia.
Barren Springs, ...	Barren Springs, ...	Manning & Squier, ...	111 Liberty street, New York.
Pulaski Iron Company, . .	Little Reed Island Creek, Pulaski county,	Abm. S. Patterson, Treas., .	330 Walnut street, Philadelphia.

*NOTE.—Also Manufacturers of Zinc, Spelter, and Lead.

Coal and Coke Operators.

OPERATOR.	Address.	No. of Ovens in Operation.	No. of Ovens contracted for or under construction.
South-West Virginia Imp. Co.,	H. Wickham, Prest., 244 So. 3d st., Phila., ...	300	100
Cooper & Co., ...	Coopers, Mercer Co., W. Va., .		
Caswell Creek Coal & Coke Co.,	Freeman & Jones, Supts., Bramwell, Mercer Co., W. Va.,	20	30
William Booth & Co., . . .	Bramwell, Mercer Co., W. Va.,	10	60
Stephenson, Mullin & Co., .	" " "	26	25
Mill Creek Coal and Coke Co.,	John Cooper, Supt., Cooper's, Mercer Co., W. Va., .	50	
Mercer Coal and Coke Co., .	John Freeman, Supt., Bramwell, Mercer Co., W. Va.,	20	80
Moore, Deaton Bros. & Co., .	Bramwell, Mercer Co., W. Va.,	. . .	
McDowell Coal and Coke Co.,	Bramwell, Mercer Co., W. Va.,	. . .	200
Elkhorn Coal and Coke Co., .	Geo. Robertson & Co., Bramwell, Mercer Co., W. Va.,	. . .	100
Shamokin Coal and Coke Co.,	Bramwell, Mercer Co., W. Va.,	. . .	100
Goodwill & Douty, ...	" " "	. . .	100
Marshall & Goodwill, ...	" " "	. . .	100
Clinch Valley Coal & Iron Co.,	Richlands, Tazewell Co., Va. .	. . .	. 250

The "Pocahontas Coal Company," Roanoke, Virginia, are the general agents of the producers for the sale of all *Line Trade Coal*, Castner & Curran, 308 Walnut st., Philadelphia, for *Tide Water Coal.*

Parties desiring to purchase *Coke*, should address the individual operators as above.

In *June, 1883*, the first shipment of coal was made from the Pocahontas-Flat Top Coal Field, and the total for that year aggregated . . . . . 105,805 tons.

In 1884, ... 272,173 "

1885, ... 651,987 "

1886, ... 929,635 "

Owners of Coal Lands from whom Leases can be made.

NAME OF COMPANY OR PROPERTY.	Owner or Agent.	Address.
So.-West Virginia Imp. Co.,	H. Wickham, Pres't, .	284 South 3d st.. Phila.
Flat Top Coal Co., ...	C. H. Duhring, "	Bramwell, Mercer co., W.Va.
Trans-Flat Top Coal Co., .	E.W. Clark, Chairman,	35 South Third st., Phila.
Constant A. Andrews, . .	. . . . .	78 Broadway, New York.
S. A. Crozer, ...	. . . . .	Uplands, Chester co., Pa.
Clinch Valley C. & I. Co., .	E. R. Dick, Treasurer,	147 South 4th st., Phila.

For Freight Rates and all general information as to transportation, address,

CHAS. G. EDDY,

Vice-President Norfolk and Western R. R. Co., Roanoke, Va.

LETTER OF TRANSMITTAL.

HARRISBURG, PA., *May 31st, 1887.*

F. J. KIMBALL, Esq., *President Norfolk and Western Railroad Company, 333 Walnut street, Philadelphia:*

DEAR SIR: We have the honor to herewith submit our joint report upon the resources of the "New River-Cripple Creek Mineral Region," tributary to the line of the Cripple Creek extension of the Norfolk and Western railroad.

While it may seem needless to review in detail the numerous causes which have led to the delay in the preparation of this report, it is perhaps well to state that they have been many, and totally beyond our control.

Our field work, begun about the middle of November, with an intention of being able to complete the same and our report prior to the first of the year, was first seriously interrupted by the unusual and severe snow storms in the early part of December; and it was not possible to renew our examinations until about the middle of March.

Early in April renewed storms and bad weather again postponed our investigations until the middle of that month, when field work was once more taken up, and finally completed during May. While, therefore, all these causes have combined to delay the preparation of this report, we trust that the additional information we were enabled to obtain by reason of the increased number of developments made during the interims of our several visits to the region, may result in some measure of compensation for the consequent delay.

It will be manifest to those reading this report, that certain properties or localities in this district have been but casually referred to, and others entirely unmentioned; but we have endeavored, as far as information came to us, to speak of all properties developed according to your circular, which required the examination of only such tracts as were opened

by pits or shafts. In almost all cases, for those properties having no developments upon them, and which have been incorporated in this report, the information was obtained in the course of our investigations while proceeding regularly through the district; in other cases, where such reference occurs, the information was derived from private surveys made at various times and published with permission.

Frequently property owners made additional openings subsequent to our examination of their tracts, the results of which might or might not have modified our opinion in certain localities; but your instructions, to proceed regularly through the district from east westward, precluded the possibility of our re-visiting and reporting upon such new developments.

With but two exceptions, noted in the body of the report, all samples were personally collected by us, and every sample so taken has been analysed, and the results of the analyses recorded. Wherever possible, they were secured by taking a large number of pieces from stock piles with the view of obtaining a fair average of the shipping ore; and, in the case of wash-ores, a shovel sample was taken from all parts of the ore pile, the larger lumps crushed and thoroughly mixed, and from this about 15 or 20 pounds were taken for analysis.

The character of samples from new developments has, in nearly every case, been stated in giving the analysis thereof. It might be just as well to state here, to save repetition, that in every case the ore was dried at 212° Fahrenheit previous to analysis, thus securing a fixed basis for comparison.

Except where noted, manganese was determined in every ore in which it showed in appreciable quantity.

In the preparation of the accompanying map, use has been made of various manuscript illustrations, for which acknowledgments have been made in a note on the map itself. A good base was secured by the reduction of the railroad line up New River and Cripple creek, and the balance of the map has been compiled from various sources, corrected by our personal surveys; and upon it all openings and properties mentioned in the report have been approximately located.

The extent and character of the different rock formations are shown by separate colors, and the position of the ore-bearing areas and principal structural features indicated.

A considerable area between the Cripple Creek railroad and Draper mountain, largely occupied by red slates and barren limestone measures, has been but partially studied, owing to the absence of any developments there, and the probable lack of any mineral resources. This portion is colored a light red.

The same remarks are applicable, to a less extent, to Draper mountain itself which, although containing a considerable extent of ore-bearing territory, did not seem to us to merit that detailed attention given to the New River-Cripple Creek mineral region proper. Moreover, the structural features of that mountain range are exceedingly complicated and not yet thoroughly understood; and in the absence of sufficient developments at present, in an area so large, to warrant a thorough examination of the various rock formations occurring there, it has not been possible to color that portion of the map with as much detail or accuracy as a final study of that region would permit.

Trusting that the report, as submitted, may meet your approval, we remain

Yours truly,

ANDREW S. McCREATH
E. V. d'INVILLIERS.

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THE NEW RIVER-CRIPPLE CREEK MINERAL REGION.

CHAPTER I.

General Description of the New River-Cripple Creek Mineral Region.

The area comprised in this region consists roughly of 300 square miles in Pulaski and Wythe counties, lying between the Cripple creek railroad bridge over New River on the east and Speedwell on the west. The Norfolk and Western main line between Pulaski and Wytheville fairly limits the district on the north, while the Iron mountain range along the Grayson and Carroll county lines forms the southern boundary.

The **New River** flows through the district with a general northeast course from the gap in Iron mountain south of Ivanhoe for 17 miles, to the neighborhood of Draper station, and indicates through that distance the approximate location of a portion of the Cripple Creek railroad.

Cripple Creek is the principal tributary of that river, rising in the high plateau west of Speedwell, and flowing for 18 miles through the region to its junction with the river between the Wythe Lead and Zinc Mines and Ivanhoe. It is second only in importance to the river itself, both on account of its large drainage area and as indicating the natural location for the extension of the Cripple Creek railroad from Ivanhoe to Speedwell furnace. It is a large and persistent stream of water, furnishing within itself abundant means for washing purposes and numerous sites for the location of manufacturing industries. This is of course equally true of the New River, which magnificent stream is already largely utilized for such purposes, and really is the main drainage channel for every stream in the district.

Reed Creek, another of its important tributaries rising along the Norfolk and Western railroad in the neighborhood

of Crockett's depot, and in the mountain area north of the main valley, skirts the northern base of Lick mountain on an east and west course to the gap between Lick and Draper mountains south of Max Meadows, where, taking a southeast course, it flows across the region to New River above Barren Springs. It receives the waters of many branch streams from the mountains flanking it on either side, and from Max Meadows southwards it takes a very sinuous course through one of the richest and most fertile grazing districts in Southwest Virginia.

As a means for furnishing water for washing purposes, it is of minor importance as compared with the two first mentioned streams, not so much on account of the volume of water it possesses—for this is very large and persistent at all seasons—but, as an examination of the map will show, it flows largely through an area devoid of ore-bearing rocks, although in places it could be advantageously used for mining purposes.

Big and Little Reed Island Creeks are two important streams entering the district from the south, which unite a short distance south of the railroad before entering New River above Reed Island depot. They drain a large area of this section of the district, and one of them—Little Reed Island creek—has already been utilized for the location of the branch railroad extending some five miles from the river up to the Pulaski Iron Company's property. Both streams will bear an important part in the future development of this portion of the field; for with numerous tributaries from Mack's and Dry Pond mountains, they carry a large volume of water at all seasons of the year.

Poplar Camp Creek is another stream of considerable importance lying further west and on the south side of New River, entering the district from the Poplar Camp gap, and flowing north to the river above Foster's Falls. Its drainage basin north of the mountain, is not, however, very large.

Peak Creek hardly affects the mining portions of the region at all, although it is a stream of some importance as the present source of the water supply to Pulaski and as furnishing numerous available sites for building purposes

along the main line of the Norfolk and Western railroad. It takes its source from various springs in the vicinity of Clark's Summit, and flows in a general eastern course along the railroad to the Cripple Creek junction, after which it soon joins New River.

The map will show the occurrence of numerous tributaries to Cripple creek, entering from the north and south through almost every mile of its course from Speedwell to the river. All of these streams furnish a more or less persistent supply of water, and many of them can be relied upon for washing purposes throughout the year.

The chief of these are perhaps; Fisher's branch, Henley creek, Thorn creek and Chaney run entering from the north; while Cove branch, Rutherford branch, Francis Mill creek, and Dry run are the principal tributaries from the south.

It may be seen, therefore, that the advantages of the region as having a suitable water supply through its entire length are exceptional; and it is moreover a fact that any one of these branch streams mentioned creates a natural avenue for the location of cheap lateral railroad lines for the development of the area through which they flow.

The Cripple Creek extension of the Norfolk and Western railroad is at present in active operation as far as Foster's Falls, a distance of 23.9 miles from the main line at Pulaski, and is being extended rapidly for 6½ miles further to Ivanhoe furnace.

Between the latter place and Speedwell furnace, 17 miles, the line has already been located and largely graded, and no barriers exist to its extension that far to meet the requirements of any new operations. The Little Reed Island branch has already been mentioned in connection with the creek of that name, and it is now equipped and ready for business for a distance of five miles from the river.

An examination of the map will show the close relationship of both these railroad lines to the most prolific ore-territory in the region; and the cheapness and facility with which branch lines can be located, as required, is a point of great and manifest advantage to the development of the mineral resources of this field.

CHAPTER II.

Geology of the District.

To the casual observer passing through the New River-Cripple Creek region by train or on horseback, the district would seem topographically to consist of a range of mountains on the north and south, between which lies a valley some 5 to 7 miles wide at the east end, contracting westward to about half that width. A closer inspection will bring out the fact however, that the mountains do *not* form continuous ridges on either side of the valley, but are split up into several ranges, coursing at different angles with one another, and that the valley itself is subdivided by many subordinate ridges of greater or less prominence.

Still further study will convince him that the region presents an exceedingly diversified topographical aspect, which has been brought about largely by the geology and structural features of the district.

A short review, therefore, of the rocks occurring here, and their relationship to each other, which is the result of the geological structure, may not be out of place, inasmuch as the question of the commercial resources of the region is largely dependent upon the proper grouping of the different rock systems.

The *New River-Cripple Creek region* is but a division of the Great Valley, which under different local names, extends all the way from the Hudson river in the State of New York, south into Alabama; and everywhere throughout its course presents outcrops of the lower Palaeozoic formations.

These Palaeozoic formations of the Great Valley lie upon the Primary rocks of the Blue Ridge, which, in this part of the country, flank the valley on the south and constitute the rocks of Carroll and Grayson counties.

The members of the upper series have been given names as well as numbers in the various states through which they pass; but the following is a simple scale for their classification, numbered from below upwards:

XIII.	Coal measures proper, ...	Carboniferous.
XII.	Conglomerate, ...	
XI.	Umbral red shale, ...	
X.	Vespertine gray sandstone, ...	
IX.	Ponent red sandstone, ...	Devonian.
VIII.	Vergent shales, etc., ...	
VII.	Meridial sandstone, ...	
VI.	Pre-meridial limestone, ...	Upper Silurian.
V.	Scalent red shale and fossil ore, ...	
IV.	Levant sandstone, ...	
III.	Matinal slates, ...	Lower Silurian.
II.	Matinal limestone, ...	
I.	Primal slates and sandstone, ...	
	Primary rocks of the Blue Ridge, . . .	Azoic, (Archæn.)

With the possible exception of portions of Draper mountain, the only members of this series with which we have to deal in the geology of the "New River-Cripple Creek Region," are comprised in the three lowest formations, Nos. I, II, III;—the Potsdam sandstone, Cambro-Silurian limestone and the Hudson river slates, all of which are embraced in the lowest grand division, "Lower Silurian."

1st. *The Potsdam sandstone formation No. 1,* (or the Primal slates and sandstones) is really a tripple group, consisting of an upper and lower slate and a central series of sandstones.

Throughout Pulaski and Wythe counties, only the upper slates and the sandstone are well exposed, and with a great combined thickness. The lower slates are either concealed from view or lie without the limits of the area embraced in the map accompanying this report, except perhaps in isolated places along the flanks of the backbone of Lick mountain.

These Potsdam rocks are given a yellow color on the map, an inspection of which will show the very considerable area they occupy in the region, owing to their duplication by rolls and faults.

For instance, members of this formation cover square miles of territory in Wythe county, under the name of the Lick mountain, which consists of a group of parallel ridges between the main valley and Cripple creek, variously known as Lick, Stuart, Sand, Henley or Davis, and Swecker mountains.

So likewise on the south side of the valley, along the Grayson and Carroll line, the same rocks occur in the Iron mountain range and the subordinate ridges, such as Ewing, Farmer, Poplar Camp and Dry Pond mountains, together with the auxiliary spurs which extend out like fingers from the main range into the valley proper, known as Hussey mountain and Fry's hill; Taylor mountain, Cove knob and Raven Cliff ridge. The same rocks create the backbone of two prominent detached ridges in the middle of the valley, viz: Gleaves' knob on the west and Roaring Falls mountain on the east.

The former, justly called the "Sentinel of the Cripple Creek Valley," is made the more prominent from the fact that it rises up out of the middle of the valley plain at Eagle furnace, where its crest is some 900 feet above Cripple creek. Its striking dome-shaped knob is thus made conspicuous over all the surrounding country, and is visible for many miles up and down the valley.

The Roaring Falls mountain, lying towards the eastern end of the valley, south-east of the New River at Foster Falls, is not quite so noticeable, being a ridge some four or five miles long, extending on both sides of the river, with its crest largely marked by the Potsdam sandstone measures.

In Pulaski county, rocks of this group make the crest and body of Mack's mountain, lying south and east of the New River, and the crest of a subordinate spur of Dry Pond mountain, between Big and Little Reed Island creeks.

It is even claimed by some geologists and observers, that the crest of Draper mountain is composed of these same rocks, although nothing definite has as yet been proved concerning that fact.

It must be admitted that the pressure of duties elsewhere in the field prevented a proper detailed study of this most interesting mountain mass, which, lying between the main line of the Norfolk and Western railroad and the Cripple Creek extension, can hardly be called tributary to the developments along the latter branch through the New River-Cripple Creek mineral region.

For the time being, it would appear that this whole mount-

ain area is to be associated with higher rocks than any found elsewhere in the region, within the Upper Silurian group, Nos. IV, V, and VI, and by reason of a great fault or vertical thrust in the rocks extending along its north base, Devonian and Sub-carboniferous measures are brought within the area between the main mountain and the Norfolk and Western railroad.

For the present, the crest of the mountain itself and the prominent knobs at each end may be considered as Medina sandstone No. IV, with Hudson River slates No. III on the north flank, and perhaps Clinton No. V, and Lower Helderberg limestone No. VI, on its south flank, and in the valley between Draper mountain and the two knobs.

In further support of this conclusion regarding the horizon of the rocks of Draper mountain, it might be stated that in appearance, these grayish-white and red massive sandstones bear little, if any, resemblance to the hard, brittle, white, and angular sand rocks of Lick mountain and the various Potsdam sandstone ridges flanking the south side of the valley.

The characteristic fossil worm, the *Scolithus linearis* of the lower (No. I) formation, was nowhere noticed in Draper mountain, while such may be eventually found to clear up the doubt; and the great thickness of the Potsdam sandstone formation developed through other contiguous parts of the district have dwindled down here to a few hundred feet, if indeed the Draper mountain sandstone be No. I.

Finally, the topography of the mountain is distinctly different from that seen in the hills conclusively proven to be Potsdam sandstone, and partakes strongly of the clear, straight, unbroken crests of the mountains of No. IV throughout the Great Valley. The synclinal structure of the mountain is further emphasized by the occurrence of terraces and sandstone cliffs on the *north* side of the main mountain and the *south* side of the two knobs, which would not be the case if the dip was south-east throughout the mountain. No arbitrary opinion is herein set forth, for the question still merits much additional thought and work before its many effects upon the geology of the region can be definitely adjusted.

The peculiar structure which has brought about this abnormal state of affairs will be referred to elsewhere in this report, and perhaps in detail on some future occasion.

The map coloring will show the approximate areas of the different rock groups and their relation to each other, together with the territory occupied by Devonian and Sub-carboniferous measures to the north of Draper mountain.

2d. The *Cambro-Silurian limestone*, embracing the Knox shale and limestone of the southern geologists and forming No. II in the Palaeozoic series, is essentially the "valley maker" throughout the entire area of the Great Valley, as well as in the subordinate New River-Cripple Creek region.

In New York, this formation is capable of several subdivisions, based largely upon palaeontological grounds. This is so to a less extent in Pennsylvania, and still less in Virginia, where the formation is not so thick and seems to have lost most of the upper and more fossiliferous Trenton member. Although no careful measurements of its thickness were made in the New River-Cripple Creek region, it will not fall far short of 3,500 feet.

Stratigraphically it may be conveniently divided into three parts:

1st. A lower, more or less magnesian limestone or dolomite, roughly 1,000 feet thick, which occurs immediately on top of the Potsdam upper slate measures, and in its decomposition gives rise to a somewhat gray and harsh soil. Throughout a large portion of the region this part of the formation carries, a little above its base, a conspicuously mottled blue and white limestone, of varying thickness and persistency.

The face of the limestone is thickly pock-marked with intrusions of calc-spar in white masses and veins, and this band is rendered conspicuous as being more or less a guide to the location of the lowest deposits of iron-ore in the limestone formation, and a key to the geology wherever it is found. These mottled limestones apparently *underlie* the ore, and may be seen in a great number of places through the valley, notably at the Clark bank, Rich Hill, along Little Reed Island creek, at Foster Falls, the Hematite Iron Company property, Ivanhoe, etc., and on the Norma and Speedwell properties.

Along the south base of Lick mountain, where the lower magnesian limestones occur for several miles in a wide belt, the mottled limestones are conspicuously absent, which may, in a measure, account for the meager display of iron ore so far exposed in that territory. They may also be seen in Draper's valley, on the Rock road, extending east from the Lick mountain spur and along the south side of the Draper's valley fault. Here, too, but little iron ore is reported, although this section has not been systematically prospected.

2d. A middle member of red slates and thin sandstones, with intercalated beds of impure limestones. These rocks especially create the "barren areas" of the district as far as mineral resources are concerned, while through a wise dispensation of nature, the soil derived from them seems to be particularly suitable for grazing purposes.

An inspection of the map will show what a large outspread these red slates have in the district; but this feature is caused more from a duplication by faults, or a succession of closely folded anticlinals and synclinals, than from any great thickness of the measures. The series, as a whole, is so nearly identical through all its parts, that it is well-nigh impossible to note the numerous small folds which occur, although more calcareous at the top and holding more sandstone at the bottom; but the presence of one or more important faults is made clear by the map coloring. In thickness they may be anywhere from 500 to 1000 feet, rarely falling below or rising above either figure.

These rocks give rise to a peculiarly smooth and rounded topography, creating hills of no great height but of great continuity in strike and elevation, although gapped by the many small streams which meander through the area occupied by them.

The eye readily acquires a habit of picking out the slate ridges, whose contour is quite different from that formed by the limestone and sandstone rocks.

Perhaps the most conspicuous feature of their occurrence in the district is that they are to be generally found on the *north* side of the river and Cripple creek, at least as far west as Gleaves' knob. At this point new structural features arise

which tend to break down this generalization; for the slates are there seen to flank the creek on both sides, though still more largely exposed on the north. Their absence on the south side of the valley and synclinal basins further east, may be explained by the larger area occupied by the lower limestones there, or by faults along the southern mountain range, burying these slate measures; or perhaps by a combination of both causes.

3d. An upper division of purer, fatter limestones, hardly referable to the Trenton age, but here occuring *above* the red slate member of the Knox group and between it and the Hudson River slates of formation No. III.

These limestones are *generally* less magnesian and less siliceous than the lowest member of the group. They are likewise ferriferous, and occupy a large area in the region in the central part of the synclinal basins and in the "Back valley" extending between Carter's ferry on the river and Gleaves' knob. They are more frequently seen east of the latter place than west of it, owing to the greater depth of the main New River basin and consequent wider outspread of these higher limestones. They will furnish good furnace fluxing-stone, which is equally true of the purer portions of the lower division.

The *Hudson River Slates*, No. III, were nowhere positively identified in the main valley, although possibly present in patches on the tops of the high hills at Mr. J. A. Sanders' place on Cripple creek, and on Cave hill, near Speedwell. They are also to be found along the north flank of Draper mountain, where, however, they are not so red in color as is usually the case in the South.

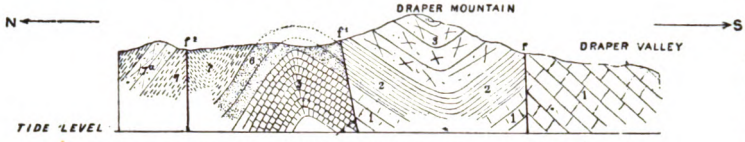
Some few characteristic features of the geology in and around Draper mountain will be mentioned in connection with the description of the ore-properties of that area.

CROSS-SECTIONS ACROSS DRAPER MOUNTAIN

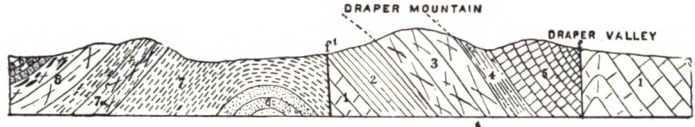
TO ILLUSTRATE THE STRUCTURE

EQUAL HORIZONTAL AND VERTICAL SCALES

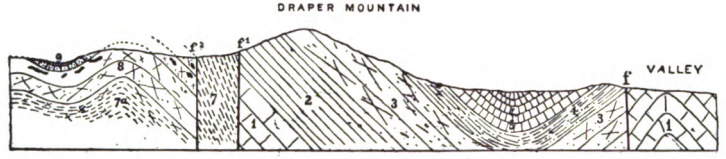
1 Cambro-Silurian (Knox) Limestone №II
2. Hudson River Slate №III
3 Medina Sandstone №IV
4. Clinton Shales and Sandstone №V
5 Lower Helderberg Limestone №VI
6 Oriskany Sandstone №VII
7 & 7a Hamilton & Chemung Slates & Sandstones №VIII
8 Vespertine Sandstone №X
9 Umbral Limestone №XI



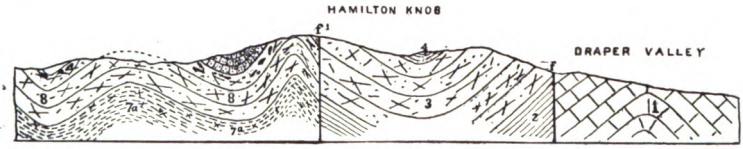
1. A-B. Section through PEAK KNOB from Draper Valley to Peak Creek.
f Draper Valley Fault. f¹ Draper Mountain Fault. f² Small Fault.?



2. C-D Section along mountain road from Draper's Valley to Pulaski.
f¹ Draper Valley Fault. f² Draper Mountain Fault.



3. E-F Section in vicinity of the Pulaski-Wythe county line.
f Draper Valley Fault. f¹ Draper Mountain Fault. f² Hamilton Knob Fault.



4 G-H. Section across Hamilton Knob. Faults same as №3.

E.V.D'L.

CHAPTER III.

Structure: Anticlinals, Synclinals and Faults.

The structure of the New River-Cripple Creek region is quite varied, and to a considerable extent affects the economical resources of the district.

Beginning on the north, along the Norfolk and Western railroad, there is a well marked anticlinal extending nearly east and west, and between the railroad and Lick mountain. This anticlinal, which may be conveniently called the *Reed Creek axis*, brings up the lower limestones of No. II, along Reed creek as far as the Rock road, after which the higher red slates fold over the axis. No detailed work has been done along this line, it being in no sense tributary to the Cripple Creek extension; but it is quite probable that this anticlinal is to be associated with the Draper's Valley fault, to be now described.

The Draper's Valley fault was first noticed on the road from Max Meadows to Fort Chiswell, where the red (Knox) slates are apparently faulted. Further east, on Reed creek and the stream leading up to Henson's property, the limestones are faulted, until in approaching the western extremity of Draper mountain the fault carries No. II Knox limestone on the south side and No. IV Medina sandstone on the north, in Hamilton's knob.

If the geology and structure of Draper mountain has been correctly read, this fault along its south side extends from Reed creek on the west to and beyond the Cripple Creek railroad; not in a straight line however. The lower limestones are always found on the south side of the break and generally dip northward, and along the fault are brought in contact with Nos. III, IV, V, and VI, as the map and plate of four cross-sections will show, on the north side.

Draper mountain is for many reasons, perhaps the most conspicuous feature, topographically and geologically, in this part of the Great Valley. It extends for nearly 12 miles as a straight unbroken crest, with a nearly due east and west course, between Pulaski and Max Meadows. Its summits

rise to over 3,000 feet above tide, with the railroad running along the valley to the north, with elevations between 1,900 and 2,000 feet. At each end the mountain is curiously hooked and turned back on itself, and where these hooks meet the main mountain, high peaks are created. That on the eastern end is known as Peak knob (3,300' A. T.); and the one on the west as Hamilton knob, (3,000' A. T.)

Both hooks or spurs subside rapidly into the valley on the south side of the mountain, and between the ends of the spurs there is a space some 3 or 4 miles wide along the Rock road from which the mountain is entirely cut out, although a line of short and low hills of calcareous slate and limestone fairly serves to connect the two spurs topographically.

It is only posible, within the province of this report, to summarize briefly some of the peculiarities of structure in this badly broken region.

South of Pulaski a line of rather low hills extends east and west parallel to Draper mountain to the south. They are composed of the Sub-carboniferous and Devonian measures, like the Peak hills to the north of Pulaski.

A cross-fault must extend in a northerly direction from the railroad here: for east of Pulaski the valley is entirely occupied by the lower Silurian limestones; west of Pulaski by the Sub-carboniferous rocks.

The Draper Mountain road, leading south from Pulaski, passes first over No. XI Umbral limestone, which is ferriferous a little further east as well as to the west, on the north-west side of Hamilton's knob. This formation is succeeded south by No. X Vespertine sandstones with streaks of coal, in a low foot hill of the main ridge. These rocks are not thick and are underlaid and succeeded south by No. VIII Chemung sandstones, conglomerate and shales, and Hamilton black slates, of Devonian age, to and beyond the center of the valley between this front ridge and the mountain. So far the dip of the rocks has been everywhere northwest at angles of from 45° to 65°, the more gentle toward Pulaski. (See cross-section C–D on page plate.)

Along the north base of Draper mountain however, the *Draper mountain fault* occurs, breaking down an anticlinal

fold in the Devonian shales and bringing up the No. III Hudson River slates on the south side of the valley and fault against Draper mountain.

Continuing south up the mountain, the slates of No. III are seen to extend almost to the crest, dipping conformably S. 30°-40° E. 35° to 50° beneath the massive sandstone of No. IV, making the crest of the mountain. In the gap through which the road passes, the coarse-grained gray and white sandstone dips S. 35° E. 45°, and maintains that dip for some distance down the south flank.

Finally this sandstone is lost sight of, and some few red sandstones and variegated decomposed shales (Clinton No. V?) occur to the south base and continue nearly to Draper's house. At this point limestone occurs dipping steeply southeast. This limestone has been provisionally classed as No. VI, Lower Helderberg, upon apparent structural grounds solely, for no fossils were seen in it, and in appearance it closely resembles the valley limestone. It extends for some distance east and west from the road, towards the hooks or coves in the mountain, and beyond its limit the Clinton shales and slates occur to the sandstone wall of the mountain, encircling the head of the valley at either end.

The map and the plate of cross-sections will show these features plainly and save description. All dips seen have been noted; and it will be observed that all the southern side of the Draper mountain synclinal has been cut out by the *Draper Valley fault*, leaving, in the two mountain hooks and in the line of small hills between them along the Rock road, evidences of the former continuity of the mountain as well as a record of the great destruction it has undergone.

The *Draper Valley fault* would appear to converge eastward towards the *Draper mountain fault* already mentioned. At all events, the latter is seen on the railroad south of the Junction, with the Devonian slate on the north side and No. III slates on the south, as shown in cross-section A–B, towards the east end of the Draper mountain synclinal; while still further east the Devonian measures are in contact with the limestones of No. II, and the two faults have probably merged into one.

The Vespertine No. X hills do not cross the Cripple Creek railroad or Peak creek; but west of the mountain road, they can be followed for a long distance along the Norfolk and Western railroad to Clark's Summit, where a narrow belt of No. XI limestone occurs, only to be succeeded again by the sandstones and thin coals of No. X, apparently lying on the north side of a basin here. The exposures of these rocks along the railroad are very good; they show gentle folds in the series, which cause them to outcrop over wide areas. But this part of the field is further troubled by a cross-fault, which seems to rise rapidly from the *Draper Valley fault* in the neighborhood of Reed creek south of Max Meadows, and bearing north-east and south-west at an angle with Draper mountain. Its position and effect have been laid down with some hesitation on the map, for it was not personally observed except towards the western end of Draper mountain. While it has been drawn from Hamilton's knob to Pulaski, its position there is only possibly correct, and close study may reveal its connection with the *Draper mountain fault* already described. If so, it must curve greatly near the Wythe and Pulaski county line, and moreover no evidence is seen along the railroad line, between Clark's Summit and Pulaski, of the wide belt of Chemung rocks which occurs south of Pulaski. Hence it has been assumed that this new fault has cut them off on the west as shown on the map.

The apparent structure of this portion of the mountain area is illustrated in cross-sections E–F and G–H.

At the forks of the stream, at the west base of Hamilton's knob, a rather narrow ridge rises going north-east, which marks the line of fault, and from a distance looks like a terrace on the side of the main mountain. It, however, is composed of the Vespertine sandstone No. X, dipping on the stream about 50°–60° south-east, and exposing some thin and impure coal beds which have been slightly opened up. Consequently the fault here brings No. II on the south side, against No. X on the north, creating a break of several thousand feet.

That this break has occurred along or near the crest of an anticlinal axis, as is the case so frequently elsewhere with

these Virginia faults, is substantiated by outcrops further east along the crest, where a ledge of these sandstones is dipping steeply north-north-west, on the north side of the anticlinal.

Only a limited thickness of No. X is held in the jaws of the fault here; for immediately along the north flank of the ridge, the Umbral limestone No. XI outcrops, rising well up the hill, and showing in the numerous little mountain streams, with dips of N. 15°–25°, W. 70°–80°. How far east these two formations extend, was not determined; but we are reliably informed that the limestone can be followed in a continous belt to Clark's Summit on the railroad, where limestone certainly does occur, succeeded south and south-east by the sandstones of No. X, which extend thence nearly to Pulaski. The Umbral limestones along Hamilton's knob are ferriferous, and quite a handsome showing of iron ore has recently been made on the Henson farm, now owned by Mr. Lobdell and others.

Returning once more to the forks of the stream at the base of the knob, the map will show a ridge rising to 2,300′ above tide, extending in a north-west direction from this point nearly to Max Meadows, situated between the left hand fork of the stream and Reed creek, which flows along its west base. Unfortunately no study could be made of this area; for its peculiar trend, at variance with every other hill in the region; its bold, straight crest line, said to be formed of sandstone; and the occurrence of slate dipping steeply westward all along the eastern base, serve to associate it closely with the structural irregularities of the region. It is apparently a continuation of either Hamilton knob or the Vespertine ridge already noted. The latter would seem the more probable from the character of the rocks exposed along the railroad west of Clark's Summit, and it is so colored.

Another ridge lies east of the small stream, which, in approaching the forks near Henson's, changes its north-west course to a north-east one, and runs along north of the Umbral limestone No. XI towards Clark's Summit.

This hill is also reported to be sandstone; but its character and the dip of its rocks are unknown.

In this Draper mountain area, iron ores have been found

in the Umbral limestones of No. XI at Henson's, Clark's Summit, and south-east of Maple Shade Inn at Pulaski. The Devonian measures also yield ore on the Clayton and Radford (Peak knob) properties, while iron ore has also been found, to a limited extent as yet, both at Peak knob and Hamilton's knob, apparently associated with the No. IV Medina sandstone making the crest of that mountain.

Lick mountain is an anticlinal of Potsdam sandstone, or really a triple anticlinal, speaking of the group of hills as a whole. The central ridge of Stuart and Lick mountains brings up the lowest rocks, and this main axis can be traced far east of the area of Potsdam sandstone shown on the map, to beyond Reed creek and along the Rock road.

Sand mountain on the north, and Henley and Swecker mountains on the south, are lesser anticlinals on each side of Lick mountain. Between these anticlinals occur the compressed synclinal troughs of Stroup's run and Henley's flat, in which narrow basins only the very lowest limestones are caught in patches. The decomposed Potsdam slates occupy the largest part of these interior valleys, mixed with the white quartz sand wash from the mountains.

The *Iron mountain range*, on the south side of the valley, consists also of a series of anticlinal ridges of Potsdam sandstone, between which tongues of limestone occur in narrow and tightly folded troughs, as the map will show.

On the west, the best known of these anticlinal spurs is that of *Hussey mountain*, dying eastward along Rutherford branch, where the limestones arch over the axis on the Rosenbaum farm.

The *Cove Knob anticlinal* is another similar spur of the mountain between Rutherford and Cove creeks; but it is quite short and insignificant in its effect upon the general region.

The *Raven Cliff anticlinal* next east, is of far more importance, extending from New River above Ivanhoe west at least as far as Raven Cliff furnace, and carrying throughout that distance the Potsdam rocks on its crest. West of the furnace the Knox red slates and impure limestones occur, and its extension can not be definitely made out. Topographically

the ridge here becomes forked and takes two names, Raven Cliff on the north, and Crab Orchard on the south; both red slate, and separated from each other by a narrow basin of the higher blue limestones. Approaching Cripple creek, nothing but south and south-west dips were observed, so that the axis has either expired there or been over-ridden by the greater effect of the fault to the north.

This *Cripple Creek fault* has been approximately laid down on the map, extending from New River at Carter's ferry on the east, to Mill creek on the west.

The vertical displacement of the rocks caused by it is not great; but the red slate hill between the main valley and the little "Back valley" is due to this break, and throughout its extent nothing but south east dips were observed.

Near Eagle furnace it cuts off the red slate ridge entirely, beyond which it brings limestones together, and at Gleaves' knob it brings No. II limestones on the north side, against Potsdam No. I on the south side, at the western end of the New River-Cripple Creek basin. Beyond the knob, only red slates are shown on both sides of the fault.

Another small fault overlaps this on Mill creek, about half a mile to the north, which was traced west to the Mud pike. How much further it may extend was not determined; but to its presence and the frequent folding of the rocks is due the wide outspread of these red barren measures between Lick mountain and Cripple creek.

No doubt through the large area of these same slates, sandstones and impure limestones, contained between the Rock road and the Graham or "Back valley" on the south, will be found faults in many places.

That its rocks are twisted and folded into innumerable sharp anticlinals and synclinals, was made evident from two trips across that area; but this region is so entirely devoid of mineral wealth, that no special attention was paid to its geological structure.

Roaring Falls mountain, as shown on the map, is a short axis, extending from Little Reed Island creek, to a short distance beyond New River at Foster Falls.

Potsdam sandstone rocks occupy its crest too, until cut off

with the anticlinal, by the *Cripple Creek fault* east of the Galena church. This axis practically cuts off the lower ore-field and limestone basin from that between Foster Falls and Gleaves' knob.

The main mountain to the south is likewise composed of Potsdam rocks, one flat anticlinal roll extending in a spur north-eastward between Big and Little Reed Island creeks.

Many other anticlinals and synclinals occur in the limestone area itself, which do not call for any special mention, other than what they will receive in the description of the various properties of the region to follow.

Big and Little Reed Island creeks both indicate synclinal basins of ore-bearing limestones, and a similar trough extends from the neighborhood of the Clark ore-bank to a little north of the Bertha Zinc mines, and from there to R. H. Baker's land, on the river, where it is cut off by the *Cripple Creek fault.*

The "Back valley" may be considered an arm of the main basin, although it shows only a monoclinal structure, the southern side of the basin being interrupted by the same fault.

The second principal basin of the region may be said to begin in the cove between Roaring Falls and Dry Pond mountains on the east, extending west practically along New River to the mouth of Cripple creek. The axis of this trough passes about ½ a mile south of the Pierce mill, touches Cripple creek at the Simmerman ford, and finally spoons out in Gleaves' knob.

This basin is not a simple, regular trough throughout. A pronounced anticlinal passes through the Wythe Lead and Zinc mines to the river above Porter's ferry; and another subordinate roll extends west from the sandstone ridge on the Oglesby property to Poplar Camp run, south of Foster Falls.

The limestones are largely ore-bearing throughout this general basin.

The upper Cripple Creek basin extends from the west base of Cove knob to and beyond Speedwell. It has the same general course as the one just described, but extends *en échelon* with it and a little further south.

Its axis crosses Rutherford branch about 1½ miles south of Cripple creek; Francis Mill creek about 1 mile from Beverly furnace; Cripple creek south of Stephen Porter's, and thence through the high hill on the J. A. Sanders' place to Cave hill at the head of the valley. It was last noticed near the Andis farm house, about two miles west of Cave Hill furnace, beyond which place the floor of the valley rises and brings up the underlying Knox red slates.

One little sub-division of this main trough has been already noted between Raven Cliff and Crab Orchard ridges; another detached area of limestone occurs in the narrow basin south of the Wythe furnace between Hussey and Taylor mountains; and a third basin is shown on Cove branch, cut off by Raven Cliff ridge on the north, but carrying a little patch of limestone measures at the east base of Cove knob.

With this general account of the structure of the region, the reader can sufficiently detect the chief features affecting its mineral resources; further details will follow in the next chapter, in connection with the special properties described.

Chapter IV.

Description of Properties.

In the description of properties it has been thought best to follow regularly from the east westward, as far as the structural features of the district would permit. Accordingly the main New River basin will be described first—extending from the railroad bridge over New River above Draper station to Gleaves' knob, and including the two detached basins of Big and Little Reed Island creeks. A description of the Graham-Carter Valley—really the north side of the main basin, but cut off from it by the fault extending from Carter's ferry to and beyond Gleaves' knob—will follow, after which the upper Cripple Creek basin between Cove knob and Speedwell will be taken up. The Lick mountain area will then be described, and finally the developments in the Draper mountain region.

Inasmuch as there seems to exist a misunderstanding on the part of a large number of the people of the district as to what is meant by the terms limonite, brown-hematite, limestone ores, mountain ores and Potsdam sandstone ores, it has been thought well to briefly describe the different varieties of ore.

All ores occurring in the New River-Cripple Creek region mentioned in this report are *Brown-hematites*, the several names given to them in different parts of the field being simply used to describe special varieties of this class of ores.

The brown-hematites consist essentially of hydrated sesquioxide of iron or ferric oxide. There are, however, several hydrates of ferric oxide containing different amounts of water of hydration. The principal ones are *Limonite, Gœthite* and *Turgite;* and these, either singly or more generally mixed together, form the bulk of our so-called brown-hematite iron ores. They are characterized by giving a yellowish brown streak on unglazed porcelain and a yellowish brown powder. They are usually more or less intimately mixed with clay, sand, flint, &c.; and sometimes the oxide of iron is replaced by varying proportions of oxide of manganese, forming what

are commonly known as *manganiferous iron ores.* This variety, when the percentage of phosphorus is low enough, becomes very valuable in the production of spiegel and ferromanganese, which are now so extensively used in the manufacture of steel.

The three principal hydrates of ferric oxide already referred to, when chemically pure, have respectively the following composition:

	Limonite.	*Gœthite.*	*Turgite.*
Metallic iron,	59.92	62.93	66.29
Oxygen,	25.68	26.97	28.41
Water,	14.40	10.10	5.30
	100.00	100.00	100.00

The Potsdam sandstone formation, as a whole, contains two well recognized ore-horizons:

1st. An upper one, associated with the upper Potsdam slates, and called for convenience of description, "the mountain ore;" 2d. A geologically lower one, occurring in the body of the Potsdam sandstone itself, and called the "Potsdam ore;" but *both* are brown-hematites, and may or may not contain enough water of hydration or chemical composition to be classed as mineralogical *limonites.*

So likewise can similar distinctions be made with regard to the ores occurring in different parts of the limestone formation, all of which occur geologically *above* the Potsdam sandstone, and have been designated as "limestone ores," but which are also true brown-hematites, and may or may not have the composition of the true limonite. Consequently the term "limestone ore" has nothing whatever to do with the mineralogical limonite.

The *Clark bank* (R. D. Wood & Co.) comprises about twelve and a half acres of land, situated on the summit of a broad hill 175 feet above the railroad at Harper's store, and about three quarters of a mile distant. The situation here commands excellent facilities for mining, although lacking water for washing the ore-material. The mine was not in active operation when visited, but showed a roughly oval pit with a diameter of about 100 feet and from 35 to 40 feet deep.

The ore shows well on three sides of the pit, entrance being obtained from the south where the ore seems thinnest. From the bottom of the open cut a shaft has been sunk some 60 or 70 feet all in good ore-material, a large proportion of which is lump ore.

The visible ore-deposit on this tract is roughly confined between two narrow drafts running up from the northern side of the hill. No outcrop of wash-ore extends beyond the limits of these two ravines. The deposit as a whole could be best developed by entering the hill on the north side somewhere in the vicinity of the vacant house, about 120 yards northwest of the opening. Should the territory between the ore-bank and this house prove as rich as the surface indications would lead one to suppose, an ore-face of some 60 or 70 feet could be gained by developing at the level of that house.

The entire area occupied by the ore-outcrop is about 200 yards east and west and possibly 150 yards north and south. No limestone outcrops within this area, so that it is fair to assume that this portion of the hill will be commercial territory. The ore-deposit may be traced for some slight distance to the southeast towards the ravine leading down to New River in the vicinity of the Company's washer; but as yet no developments have been made in this portion of the tract. The ore here is situated fairly within a narrow basin, which spooning rapidly to the northeast, soon carries the ore-bearing limestones out to daylight before reaching New River where it takes its prominent bend to the northwest a little below the bridge.

The character of the ore is shown by the following analysis of a sample, 185 pieces, taken from stock pile at Radford furnace:

Metallic iron,	55.925
Phosphorus,	.128
Siliceous matter,	3.600
Phosphorus in 100 parts iron,	.228

Some few trial shafts have been located upon the *James Rogers* tract, lying south-south-east of the Clark farm and

west of the public road leading from Harper's store to Calfee's ferry. The shallow pits above Rogers' house have developed an excellent quality of cellular hematite, resembling the ore of the Clark bank; but the deposit is closely associated with walls of limestone dipping towards the north-west, and some of it shows quite an appreciable amount of manganese.

Higher on the hill, towards the west, a somewhat leaner variety of ore has been dug from a number of shafts and pits. Some of these openings are almost entirely barren of results; others have developed an encouraging amount of ore. But all the ore lies under a heavy stripping, and is not well situated either for mining or washing.

The hill sides are well covered with a white chert rock, which effectually conceals the outcrop.

A large area of ground has been worked over by numerous pits and shafts overlooking the river about a mile east of the Clark bank, upon property leased by D. S. Forney. No one could give any information concerning the character of the material met with; but to judge from the dump pits, the developments could hardly have been of a satisfactory character, as almost without exception the material seen was very lean.

The A. B. Clark property lies about 400 yards north-east of the Clark ore-bank, and on the north-east side of the public road leading from Harper's store to Calfee's ferry, where some holes have been put down to a moderate depth. Two 20 to 30 foot shafts, situated close to the road, were quite barren of results, judging from the character of the material thrown out from them; and a third, 51 feet deep, a little higher up the hill side, showed mostly a soft yellow clay material, with an occasional good sized lump of ore. The amount of ore developed so far in any of these openings seems to be very limited.

Henry Clark's property joins A. B. Clark's on the top of the ridge, extending thence down to the river southwards on a bluff above the river, and only 200 to 300 yards distant. A

small amount of ore has been thrown out from a shaft 125 feet deep. The record of this shaft is claimed to be 48 feet through wash ore, and 30 feet additional with ore on one side; but the character of the material on the dump hardly justifies this assertion. Many smaller and shallow pits have been sunk along the summit of the hill east of the river bluff below the New River bridge; but none of them would seem to warrant the belief that the Clark deposit could be duplicated in this part of the hill. The measures at the north end of the bridge are to be associated with the lower part of the limestone formation, showing the red slates (Knox shale?) interbedded with magnesian limestones. These slates seem to be from 500 to 600 feet thick here. On the south side of the river the railroad runs for some distance along the base of Mack's mountain in the blue quartzite rocks of No. I, succeeded by brown slates of the upper part of the Potsdam formation, and finally by siliceous limestone, all dipping south-south-west until about a mile above the bridge at the mouth of a small ravine.

Henderson Flanagan's property runs back some little distance from this point towards the base of the mountain. Quite close to the railroad, there is an old tunnel driven in blue and white magnesian limestones, somewhat cherty, which is said to have developed zinc and lead ore. The developments are meager however, and both classes of ore seem to occur in small crevices in the limestone rock and not in any appreciable quantity, although about 80 tons of lead ore are said to have been taken from the drift 60 to 80 feet long, on the Graham and Robinson side of the ravine and shipped to New York.

About one quarter of a mile up the draft, the same blue-gray limestone is opened in a quarry on the Graham and Robinson farm, where it seems much purer and more massive and dips S. 65° W. 85°.

Nearly 1,000 yards east up the mountain flank from the quarry, Mr. Flanagan has dug a trench 6 feet long and 3 feet wide in quest of the mountain ore. The opening was very unsatisfactory and the material won from it showed only

about one tenth ore, the small excavation simply proving nothing. Going up the railroad half a mile to Reed Island station, limestone after limestone appears on a conformable south-west dip for one quarter of a mile, until a blue limestone shows a dip of 80° against another bed dipping 20°, possibly marking a small fault in the measures. A little beyond this there is an anticlinal fold with dips of 20° each way and then a south-west dip again up to Reed Island station.

The *Widow Smith* opening is about three quarters of a mile due east from Reed Island station, on the summit of the ridge, 300 feet above the railroad track. At the time of inspection Mr. Forney (lessee) was opening the side hill by an open drift, designed to strike the ore material which here seems to be associated with the Potsdam slates, dipping 60° to 70° south-west. The character of the ore resembles the mountain ore deposits; is about 10 feet thick with associated slates, and is capped by fully 15 feet of barren clay. A shaft had been sunk here on the top of the knoll through 22 feet of rather lean ore material; and the ore at best will be rather expensive to convey to the railroad. Recently the developments have been extended to a depth of 65′, according to information received from Mr. Forney, and show a persistent bed of lump ore. Opportunity did not permit us to visit the property a second time to confirm this statement, and no ore had been sufficiently exposed when inspected to warrant a sampling and analysis.

The *Cowan Ore bank* lies in a hollow along the east base of this same ridge, and presents quite similar ore. It was formerly worked to a small extent for the benefit of the old Radford furnace, but is now abandoned. The mineral right of this tract is still owned by R. D. Wood & Co., who last mined here; and with the present location of the railroad along New River, the property could be advantageously reopened, if the ore, not now exposed, would justify the development on the basis of quantity and quality.

Big Reed Island Creek.

A short distance from the river there is a splendid exposure of massive and slaty limestone on Big Reed Island creek just above Mrs. Earley's, and extending southward nearly to the first sharp bend in the creek. This limestone creates high bluffs along the creek and marks the expiring end of the Dry Pond mountain, just as the foot hills and spurs of Mack's mountain flank the creek on the east. The general course of the creek is nearly south for about three miles, where it turns abruptly eastward to a gap in Mack's mountain. Along the flank of this mountain facing the creek, there is a more or less interrupted outcrop of the upper mountain ore occuring near the top of the Potsdam sandstone formation, upon properties of the Reed Island Iron Co., Cox and Faris. No well defined bed, however, has as yet been uncovered, although some small pits have been sunk.

The developments along this creek, at least as far as the eastern side is concerned, have been mostly made on the *Faris property*; but no holes over 3 to 4 feet deep were dug, so it is impossible to say much concerning the future of this range. In some of the openings the ore is quite cellular and partakes of the characteristics of the limestone ores; but it is probable that, with one or two exceptions, every opening along the flank of this ridge will be associated with the mountain ore horizon. The last opening is only about 400 yards from the creek, a short distance above where the stream turns at right angles eastward. The strike of the rocks here is not much off a north and south line, and the ore openings coincide with this course.

A sample taken from a small pile of ore on this property, from a small open cut situated about ¼ mile east from Allison's house and Big Reed Island creek, and well up the flank of the mountain, yielded on analysis:

Metallic iron,	51.100
Phosphorous,	.399
Siliceous matter,	10.150
Phosphorus in 100 parts iron,	.780

The rather high percentage of phosphorus shown by this

analysis would seem to confirm the belief that this ore is to be referred to the Potsdam sandstone formation.

Further up the creek and in lower sandstone measures of Mack's mountain, some little prospecting has been carried on upon the *Gallagher tract* belonging to the Reed Island Iron Company. Considerable surface ore occurs there, and a shaft 60 feet deep was reported by Mr. Tipton. The outcrop varied considerably in character: sometimes showing a rich looking brown-hematite; again, a very lean variety, being nothing more than quartz grains cemented together by iron oxide. However, developments made since inspection are reported to have furnished very satisfactory results.

No further openings were reported upon this creek, which seems to run largely in a compressed synclinal basin between two anticlinal ridges made up of the lower rocks: a very small area near the river alone holding the higher limestones with which the Cripple Creek ores are associated.

Little Reed Island Creek.

Little Reed Island creek is a branch of the larger creek of the same name, meeting it within a few hundred yards of the river, and separated from the main stream by a spur of Dry Pond mountain. It is far more important in an economical sense than the larger stream, and will furnish a large ore-tonnage to the branch railroad now being extended about five miles up its valley from the main Cripple Creek railroad.

The *Rich Hill property* of the Crozer Steel and Iron Company lies on the high bluff facing New River a short distance above the mouth of Little Reed Island creek. The developments so far made lie mainly towards the southwest corner of the tract (which comprises about 450 acres) where the ore-deposit is worked in terraces on the southwest side of a ravine extending up from the river. The present opening (Dec., 1886,) lies well toward the top of the hill and shows a roughly oval pit with a diameter of 100 feet

and about 20 feet deep. Some dead black clay shows in places mixed with fine shot ore; but the early developments of this deposit turned out a large amount of very excellent ore. The ore material is possibly 20 feet thick, holding a knob of dead clay in the center, which had been worked around, but which will eventually be removed when the lower terraces are worked up to this point. Quite a small proportion of the output in this part of the field is lump ore; the characteristic features of the opening showing a fine wash ore dipping towards the south-west and carrying rolls of barren "buck-fat" clay, greatly impairing the integrity of the deposit and adding somewhat to the difficulties of its extraction. This feature was seen in each level, the ore seeming to occur in wedge shape bodies cut out in places by the clay, which rolls over and extends beneath good ore again. This renders the ore-face very variable in appearance; and the developments during the early part of the year 1887 have shown the ore material to yield not over one fourth in wash ore. This no doubt is largely due to the topographical features of the property, which somewhat cramp the operations of the company and require the removal of a large amount of lean material which under other circumstances would not be put through the washer.

The company have, however, thoroughly prospected their property in advance of their present workings, and have a handsome body of ore to the west of the main cut, towards which their workings are being systematically extended. From the floor of the mine in this portion of their tract up to the top workings, there is probably exposed a 100 foot face of ore, trending generally north and south, and proven for a considerable distance through their land. Preparations were being made in the spring of this year to develop the eastern portion of their property; but no results have as yet come to hand.

In December, 1886, the company were washing about 100 tons of ore daily, the washer being situated on the brow of the hill and the water for washing purposes pumped from New River, a vertical height of about 125 feet. The wash ore is conveyed through schutes directly to the cars below

upon the railroad track. The disadvantage in this method of working is the excessively wet condition in which the ore is furnished to the furnace; but it is rendered almost necessary by the topographical features of the situation.

Beyond the public road southwest of the top workings, there are some shallow openings mainly dug for lump ore, which, however, sufficed to identify the deposit for half a mile towards the southwest. The appearance of the ore in these pits is very favorable. On the western end of the tract, along the ravine dividing it from the Calfee lands, there is a most excellent outcrop of surface lump ore, where moreover excellent facilities exist for attack. Indeed this seems to present the most encouraging point on the property for cheap ore, as a 100 foot face could be readily and economically opened here and worked quite independently of the present openings to the eastward. The ore is rich and plentiful. Probably 16,000 tons have been shipped from this property, and fully fifty acres have been proved as productive ore territory, comparatively few of the shafts sunk yielding barren results.

The general average character of the ore is well represented by the following analysis of a sample, 176 pieces, taken from nine different openings:

Bisulphide of iron,	None.
Protoxide of iron,	None.
Sesquioxide of iron,	76.214
Sesquioxide of manganese,	.051
Oxides of nickel and cobalt,	.040
Oxide of zinc,	None.
Oxide of lead,	None.
Oxide of copper,	None.
Alumina,	2.365
Baryta,	None.
Lime,	.820
Magnesia,	.486
Sulphuric acid,	.157
Phosphoric acid,	.171
Water,	12.072
Siliceous matter,	7.480
	99.856

Metallic iron,	53.350
Metallic manganese,	.036
Sulphur,	.063
Phosphorus,	.075
Phosphorus in 100 parts iron,	.140

The *Calfee property* joins Rich Hill on the west, fronting on the river, and consisting of about 450 acres, extending back nearly to Little Reed Island creek. The property narrows southwards towards Little Reed Island creek, but has a good frontage along the railroad and New River. Nearly all the developments have been made in the river bluff immediately opposite the west end of the Rich Hill property and on the west side of the ravine. Probably half a dozen shafts and a couple of short drifts and trenches have been dug; and while some of them have turned out a fair amount of lump and wash ore, the general results are not as encouraging as the showing on the west end of the Rich Hill property. In fact, a large portion of this property extending up New River lies well towards the north-west side of the Little Reed Island synclinal and ore-basin, and largely contains lower limestones than those associated with the Rich Hill ores, until a gentle anticlinal roll about one and a quarter miles above Reed Island bridge, again temporarily reverses the dip, and creates another belt of higher ore-bearing limestones through to Barren Springs. But the shafts on the eastern end of this property have proven a thickness of perhaps 100 feet of ore material, two openings being located well down the bluff towards the river. Along the ridge westward, however, towards the Wheeler tract of the Crozer Company (which joins Calfee on the west) the few openings made were not productive of much ore, and showed a large preponderance of reddish-brown tough clay.

A sample of the lump ore taken from the several openings yields on analysis:

Metallic iron,	55.800
Phosphorus,	.079
Siliceous matter,	6.410
Phosphorus in 100 parts iron,	.141

The *Wheeler property* lies next west of Calfee's along New

River. This large property is owned by the Crozer Steel and Iron Company, who, however, have not as yet done anything of moment towards testing or developing the ores supposed to exist there.

Leaving the river and following up the Little Reed Island Creek basin, the first property adjoining the Rich Hill on the south-west is the—

Southern tract, comprising about 250 acres, the mineral right in which is owned partly by the Reed Island Iron Company, and partly by Calfee and Barrett. The tract lies on both sides of the creek, having a wedge-shaped area on the north side, between the Rich Hill and Johnson properties, and occupying on the south side of the stream a roughly rectangular area extending up on the anticlinal spur of Dry Pond mountain. On that portion owned by the Reed Island Iron Company, several shallow openings, showing a large proportion of lump ore, have been dug along a south-west line extending from the Rich Hill workings nearly to the Johnson ore-bank. In all of them the showing is excellent, and the quality of the ore very good; and there can be but little doubt that a large quantity of first class limestone ore will be eventually mined here.

The character of the lump ore is shown by the following analysis:

Metallic iron,	57.900
Phosphorus,	.052
Siliceous matter,	5.310
Phosphorus in 100 parts iron,	.089

The ore lies well back from the creek, the latter cutting through a high limestone bluff where the rocks at Southern's house are dipping nearly due west about 15°. On the south side of the creek and property, much lower limestones are exposed in ascending the flank of Dry Pond mountain, and a totally different class of ores occurs, suggesting an horizon coincident with the mountain ores, and not unlike them in physical and chemical features. Up along a narrow draft heading south-east from the creek at Southern's place, a series of small pits and trenches have been dug close to the ridge at between 100 and 200 feet above the level of the creek.

A general sample of the ore was taken from several of them, as all showed about the same characterics. The uppermost pit is the best, showing a rather solid face of ore material 12 to 15 feet thick, considerably mixed with clay and underlaid with a tough yellow clay. The dip westward is marked and the stripping unusually severe. The ore is rich only in places and in casual lumps, and the ore material may not wash over a fourth or a fifth.

The horizon of this ore is certainly lower than the Rich Hill ores and the line of deposits occuring north of the creek, and is provisionally classed with the mountain ore deposits; and, morever, this classification is further strengthened by the results of the analysis given below—for nowhere has any of the Cripple Creek limestone ore been found to yield as high a phosphorus result as this ore shows. The ore has a lemon-yellow color, is largely mixed with clay and will be somewhat difficult to wash and expensive to mine, owing to the large amount of overburden.

Samples taken from the different openings show the ore to contain:

Metallic iron,	44.700
Phosphorus,	.539
Siliceous matter,	19.590
Phosphorus in 100 parts iron,	1.205

The *Johnson property* joins Southern on the west, and lies north of the creek. It is at present worked on a lease to the Reed Island Iron Company. The main opening here lies about half a mile north-west of Boom furnace, and shows an irregular open cut, 125×60×35 feet, exposing a rich mass of excellent cellular brown ore at the bottom, with a general north and south trend, and from 10 to 15 feet thick. The ore material is almost entirely free from foreign matter, and mining and washing is done upon an exceedingly cheap basis. Above the more massive portion of the deposit, already stated at 10 to 15 feet thick, there is from 10 to 30 feet of finer wash ore material, yielding about 40 per cent. of ore in the washers and carrying above it a varying but small amount of stripping, sometimes 10 feet, again practically nothing.

A few boulders of limestone have been developed in the cut, but in general they are conspicuously absent. The best showing is along the west face, where the ore-material is very rich and yields fully one half ore in the washer. The entire output of the mine is carried to Little Reed Island creek on a tramway, there washed and then hauled to the furnace. An accurately kept record of the expense of preparing ore at this operation and delivering it to the furnace, covering a year's mining, shows the cost to be 77 cents per ton. This includes all expense incident to mining, washing and hauling to the furnace—the latter item, in the absence of railroad facilities, being estimated at 10 cents per ton—thus making the cost of the ore at the washer 67 cents, exclusive of 25 cents royalty. The whole appearance of the bank is most favorable; and no better place exists to study the characteristic features of the New River–Cripple Creek limestone ores.

The fine quality of the ore in this bank is shown by the two following analyses of the lump and wash ores respectively:

	Lump ore.	*Wash ore.*
Metallic iron,	56.500	56.400
Phosphorus,	.047	.065
Siliceous matter,	5.750	5.820
Phosphorus in 100 parts iron,	.083	.115

These analyses show a great uniformity in metallic contents, the only difference being a slightly higher percentage of phosphorus in the wash-ore.

Several other openings have been made further south-west on this hill on lands owned by the Reed Island Iron Company; and while the prospects were all favorable, none of them will be actively worked pending the duration of lease on the Johnson bank. In all of them the ore was well developed; but in some, limestone was more of a feature than in the larger bank, especially in the old workings close to the road and ravine. All of this ore belt shows a rich brown-hematite ore associated with a reddish clay soil, which does not ball in the washer, and consequently is but little detriment to the thorough cleansing of these ores. The limestone rocks hereabouts dip about 12° W. N. W.

The openings were formerly operated in conjunction with the *King bank* to be presently described; and the ores from each were considered essentially similar and were put through the same washer. A mixed average sample from the ore pile at washer shows:

Metallic iron,	55.300
Phosphorus,	.085
Siliceous matter,	7.270
Phosphorus in 100 parts iron,	.153

The *Tipton property* (recently purchased by the Reed Island Iron Co.) lies due east of the Boom furnace, rising up to about 300′ above the creek and showing an out-crop of blue limestone with a gentle 10° to 20° dip towards the south-west, and about one quarter of a mile from the creek. The ore deposit occurs generally between walls of limestone, and the indications do not point to a very great depth of ore. The surface showing, however, is most encouraging, the ore being an excellent, somewhat cellular brown-hematite, rich in iron and accompanied by an easily washed clay;—in all respects a counterpart of the Johnson ore-bank on the north-west side of the creek. Indeed it is quite probable that the Tipton ore is to be referred to the same horizon in the limestone as the Johnson ore already described.

The Tipton property seems to mark the beginning, on the south-east side of the creek, of a long line of productive territory extending up Little Reed Island creek to the Stephens and Wheeler farms. The map will show the approximate position and relationship of the different properties passed through by Little Reed Island creek, and also how the limestone ore deposits are confined within a comparatively narrow area lying between the spurs of Dry Pond mountain on the east and Roaring Falls mountain on the west. This line of deposits may be said to commence at the Southern place, extending thence in a south-west direction, with comparatively little interruption of outcrop, for at least 6 miles up the creek. In places the surface showing is more favorable than others; but almost every property upon the line of the Little Reed Island railroad extension, could furnish more or less freight to that

branch. The Tipton property has recently changed hands, and will no doubt be developed in connection with the Boom furnace property. When visited in December, 1886, no pits over 4′ deep had been sunk, although a considerable amount of surface lump-ore had been carted from the hillside to the furnace. The excellent character of the ore is shown by the following analysis:

Metallic iron,	55.850
Phosphorus,	.114
Siliceous matter,	6.820
Phosphorus in 100 parts iron,	.204

The *King bank* is about 100′ above the creek and opposite the Boom furnace. A thick outcrop of magnesian blue and white mottled limestone is seen at this place, above which the ore-bearing rocks occur and extend eastward to the Johnson and Rich Hill deposits. The ore-face at this bank shows probably 30′ of wash material, with varying amounts of stripping. The cut is perhaps 60′ long, 30′ wide and 30′ deep, with knobs of partially decomposed limestone showing in various places, and dipping from N. 70° to S. 70° W. 15°. No work has been done here for over two years, and the sides are greatly washed. The bank is owned by the Reed Island Iron Company who are holding this ore in reserve, pending the lease of the Johnson ore-bank. Towards the south end of the cut, a shaft 24′ deep went down all the way in a rich wash-ore. A little further south (100′) a second shaft went 26′ through the same material. Both shafts turned out a very fine ore. Limestone crops in the cuts on top of the ore. The cuttings are extended for several hundred feet along the bluff opposite the furnace, always overlaid by a rotten limestone.

The limestone carries thin ribs of ore all through it, much of which could be washed for furnace use.

Mrs. Hall's property of 46 acres joins the King line on the south-west, but on the same side of the creek. Numerous small openings have been made there to develop the ore, but as yet sufficient work has not been done to warrant any opinion as to the quantity or quality of ore in this small tract.

A short distance further up the creek, the *King heirs* have about 200 acres, upon which some old ore pits have been sunk. They are reported to have been quite successful; but their long abandonment has completely effaced all traces of their existence. The property faces the creek almost opposite the Tipton land, and the only visible ore is to be seen outcropping along the creek bluff, where some slight development has been attempted between walls of gently dipping limestones—showing a rich looking brown-hematite ore carrying considerable iron pyrites.

The *Chas. Hurst property* extends about 300 yards along the creek, with limestone dipping N. 50° to 60° W. 20°, forming a bluff along the west side of the creek. The ore shows in a strip about 20′ above creek level, capped with a bluff of thin bedded limestone, under which the ore is exposed some 10′ to 15′ thick in places. It has a yellowish brown color and a honeycombed structure, and shows a considerable amount of undecomposed iron pyrites. The exposure is between the public road and the creek, and is visible for possibly 50 yards along the bluff.

No iron ore has as yet been found west of the road towards the divide between the waters of Little Reed Island creek and New River. The Hurst farm contains 165 acres, of which Mr. Hurst owns the mineral right in 10 acres, the balance being held by Messrs. Forney and Baumgardner. The same outcrop of ore extends to that portion of the Wm. Hurst property now owned by Mr. Crozer, apparently rising topographically a little higher above the creek; and most of the abandoned openings show merely wash ore. This strip of land divides the Chas. Hurst farm from the King property further down the creek. The same difficulty would be encountered here in mining the ore as has already been described in connection with the King and Hurst properties, *i. e.* the occurrence of the ore within interstices between limestone.

A sample of the *Chas. Hurst* ore shows it to contain:

Metallic iron,	54.400
Phosphorus,	.048
Siliceous matter,	6.320
Phosphorus in 100 parts iron,	.088

On the rear portion of the Wm. Hurst property, possibly 500 yards back from the creek, and from 600 to 800 feet lower geologically than the ore along the creek, a good quality of iron ore has been sparingly uncovered along the flank of the ridge west of Skin Pine hollow. The ore is soft and cellular; and a general sample taken here from two or three openings shows the following constitution:

Metallic iron,	52.500
Phosphorus,	.198
Siliceous matter,	6.800
Phosphorus in 100 parts iron,	.377

A ravine (Skin Pine hollow) heads up back of this ridge, which roughly marks the line between the Hurst and the Reed Island Iron Company properties, and also at this point approximately divides the limestone and sandstone formations. The ore just mentioned is more closely associated with the limestone formation, and no doubt is to be classed with ores of the same character occurring to the south-west and so handsomely developed on the Stephens land. The hill rises above the outcrop to the north-west and catches a face of at least 50′ of ore, provided stripping is not too heavy.

What is undoubtedly the same ore geologically has been opened on the *Houston property* (Crozer Steel and Iron Co.) about 100 yards from the Sayers line and about 300 yards from the creek, in a small pit 6 to 8 feet deep and 10′ wide. The opening shows a rich red clay with wash ore and a fair amount of lump ore, from which a sample was taken. This opening is on the slope of the hill facing the creek, and certainly a 35′ to 40′ face could be opened at this point. This same outcrop of ore is found at the head of the ravine leading up from Sayers house.

The Houston property extends well up the ridge, taking in the foot hills of Dry Pond mountain, and joins the Reed Island Company and W. Hurst on the north-east and Stephens on the south-west. The property does not front on the creek, being cut off by the Sayers land. A sample of the ore shows it to have the following composition:

Metallic iron,	52.875
Phosphorus,	.082
Siliceous matter,	6.910
Phosphorus in 100 parts iron,	.155

The *Sayers property* extends on both sides of the creek, running up about a half mile on the west side of the road and not quite so far on the east. That portion of the property lying on the south-east side of the creek contains a continuation of the same geological formations as already mentioned upon the properties further down the stream; but close to the creek limestones outcrop boldly in successive beds on a northwest dip of about 20°, and practically throw the ore-deposit into the higher hills back from the creek.

In a considerable portion of this property lying on the south side of a small stream heading up eastwardly nearly opposite the dwelling house, an interest in the mineral right is owned by Mr. Palmer, along the line of the Stephens tract. The surface showing in this area is very limited, and no estimate of the amount of ore contained therein is possible except by comparison with the developments made by the Pulaski Iron Co. in adjoining territory further south. These, however, would indicate the probability of a considerable amount of ore there under more or less overburden. The hills in the south-eastern portion of this area rise to about 150′ above the creek, so that any duplication of the results obtained on the adjoining Stephens (Pulaski Iron Co.) tract would insure a handsome body of ore here. In a narrow hill between two branches of the stream already referred to, a very considerable outcrop of attractive brown-hematite ore can be seen, although more or less associated with limestone rocks. The undoubtedly good quality of this ore may be judged from the results of the following analysis* from a sample taken from all parts of the ridge:

Metallic iron,	53.750
Phosphorus,	.065
Siliceous matter,	8.120
Phosphorus in 100 parts iron,	.120

*This analysis is published through the courtesy of Messrs. R. D. Wood & Co. for whom it was made.

North of this stream and a little nearer the creek, a somewhat prominent hill rises well above all visible limestone rocks; and though the outcrop of surface ore is not so profuse, yet the ore is undoubtly of first-class quality, quite similar in character to the sample taken from the opening west of Little Read Island creek below the house. The same statement might be made of the north-eastern portion of the property where, on the top of a hill, 170′ above the creek and close to a sink-hole, an excellent outcrop of the same character of ore shows through a considerable area, but a short distance west of the Hurst opening.

On the west side of the creek, and between it and the public road, a sloping cultivated hill shows an encouraging outcrop of iron-ore. One 12 foot pit yielded excellent material; a second one near by not so well; but a large portion of the sloping hill is covered with an attractive outcrop. The ore is well exposed to a vertical height of 30′ in a gully washing down the hill side, and shows a fair amount of lump ore. No estimate of quantity is possible on account of the limited developments that have been made; but the excellent quality of the ore is shown by the following analysis of a sample of small lump ore taken from the pit and from the natural outcrop in the gully:

Metallic iron,	57.500
Phosphorus,	.046
Siliceous matter,	5.180
Phosphorus in 100 parts iron,	.080

No other portion of the property west of the creek has been at all developed for iron-ore; and the limited amount of surface outcrop is almost entirely confined to the extreme north-western corner of the tract, where a small 4 foot pit has demonstrated the presence of a shelly ore, largely mixed with clay, but apparently of good quality. Most of the territory near by is covered with a wash of loose sandstone boulders from the flank of Roaring Falls mountain, which effectually conceals both the limestone formation and any ores which may be associated with it.

Towards the south-western corner of the property, in the woods adjoining the Barren Springs line, an occasional piece

of ore is found in the vicinity of a sink-hole. This latter topographical feature would undoubtedly point to the presence of limestone; but the surface is entirely covered with mountain wash, and the ore associated with it has unquestionably all the characteristics of the mountain ore, and has probably been derived from that horizon in Roaring Falls mountain.

Before concluding with this property, it may be well to mention the occurrence of lead and zinc in an old shaft sunk many years ago, 200 yards west of the creek and towards the Stephens line. No inspection could be made of either the old workings or the new shaft which entered a portion of them; but all testimony agrees as to the finding of these ores here, a fact made further probable by the recent developments on the Stephens tract in precisely similar limestones.

The Sayers tract comprises 350 acres, the mineral rights in which are now owned in various proportions by several different interests; in addition to which the mineral right in 150 acres lying on both sides of the creek and along the south side of the property is owned solely by Mr. Palmer, and has been included in the description of this tract.

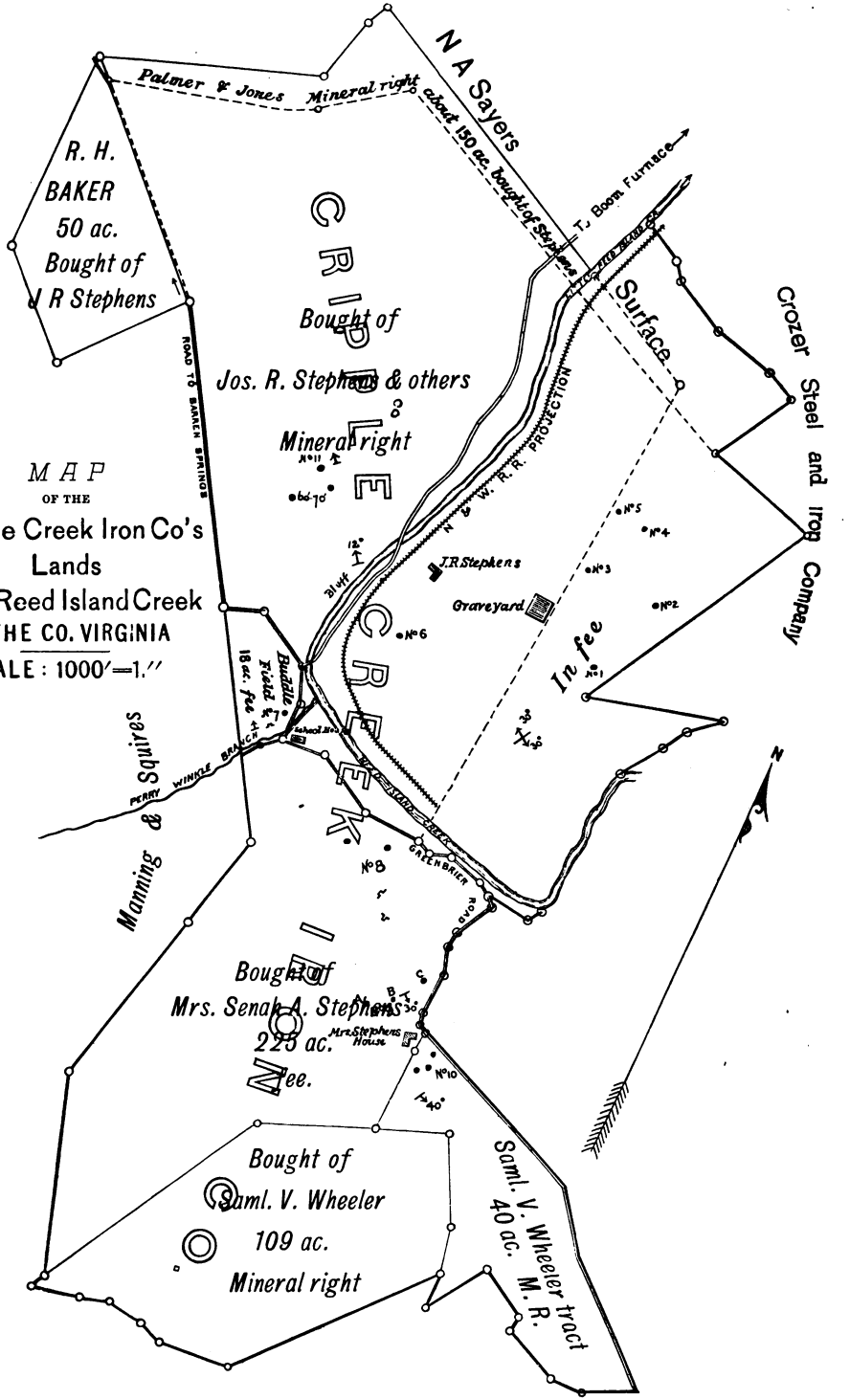
Joseph R. Stephens, Widow Stephens and Sam'l Wheeler Tracts.

Inasmuch as a private report has but recently been made of these properties, and as nothing further can be at present added to this, it is here embodied in full, with the permission of the owners.

The lands of the "Cripple Creek Iron Company"* are situated on Little Reed Island creek, in the south-eastern corner of Wythe county, Virginia; about 20 miles by railroad from Pulaski on the main line of the Norfolk and Western railroad, and between 4 and 5 miles up the creek from New River and the line of the Cripple Creek extension.

The accompanying page plate will show the number and position of the component parts of the property and their

*This property has recently been transferred to the Pulaski Iron Company, who are now developing it for an ore supply for their furnace at Pulaski.



relationship to Little Reed Island creek and the branch railroad intended for development.

The entire property comprises about 1,022 acres, divided somewhat as follows:

1. Jos. R. Stephens, 648 acres,—425 acres in mineral right,—175 acres in fee simple, and 48 acres additional of surface rights only.
2. Mrs. Senah A. Stephens, 225 acres in fee.
3. Saml. V. Wheeler, two tracts (in mineral right) of 109 and 40 acres respectively.

Little Reed Island creek flows for about 1½ miles through the property, furnishing ample washing water at all seasons, and a natural avenue for the location of the railroad line.

The properties adjoining the inclusive survey of the Cripple Creek Iron Company's land are also shown on the page plate.

Topography. The topographical features of the property are well marked and simple, and in all respects quite favorable to an economical development of the ore-deposits.

The long north-east and south-west line, shown as one of the eastern boundaries of the J. R. Stephens tract, marks the crest of a limestone ridge, with a general elevation of about 200 feet above the level of the creek. This ridge is cut in two by the creek along the Greenbrier road, which road is the dividing line between the Jos. Stephens' and Widow Stephens tracts.

On the south side of the creek this ridge is marked by high ground through Mrs. Stephens' land, although here it has lost some of its distinctive character and is more broken up.

From its base line the ground slopes very gently on the J. Stephens tract north-west to the creek, and somewhat more abruptly to Perrywinkle branch.

The Wheeler tracts are largely made up of hilly but cleared land, cut up by narrow ravines which head up from the main creek; while all that portion of the Jos. Stephens tract lying west of the creek and extending along the Barren Springs road is occupied by a broad, flat limestone ridge, rising in bluffs from the creek, while rising gradually westward to the crest of a spur of the Roaring Falls mountain,

the latter being the main water-shed between Little Reed Island creek and New River.

Geology. The rocks which outcrop through the various portions of the property can all be referred to the two lowest formations of the Palaeozoic series viz: the *Potsdam sandstone* No. 1, and the *Cambro-Silurian limestone* No. II.

Both are well recognized ore-bearing formations in the valley of Virginia, and are the same measures which outcrop from New York to Alabama, and everywhere the repositories of the *brown-hematite* or *limonite* iron ores in the States of New York, New Jersey, Pennsylvania, Virginia, Tennessee and Alabama.

In the New River-Cripple Creek valley of Virginia, these same rocks have been identified by the same characteristics; the lower formation, or Potsdam sandstone, forming the general mountain range along the Carroll and Grayson county lines, known locally as Mack's, Dry Pond, Poplar Camp or Iron mountain on the south side of the valley, and making up the general mass of Lick mountain on the north side, between Cripple creek and the main line of the Norfolk and Western railroad.

The iron ores occurring in the formation are distinguished by the name of "mountain ores." They occupy two distinct horizons in the whole formation (which is of great thickness,) *a*, a lower horizon associated with the *Potsdam* sandrock itself, and *b*, an upper one, occurring in the slates which divide the Potsdam sandstone from the Silurian limestone formation No. II.

Both horizons carry an iron-ore generally more dense, more siliceous, and more cold-short than the limestone ores of the higher formation; and, as compared with each other, the ores referred to the transition slates between the Potsdam sandstone and the limestone are far more persistent and economically important, and usually of much higher grade.

The *lower* Potsdam ore need not be looked for on any part of this property, as the rocks with which it is associated nowhere come to daylight within the limits of the tract.

The *higher* Potsdam ores have not as yet been opened anywhere, though it is possible they may be found in the future

along the extreme south side of the property in the Wheeler tracts, where alone the Potsdam sandstone formation outcrops sparingly.

All the developments so far made for iron ore have been confined entirely to the limestone formation, and on the south-east side of the Little Reed Island creek and the Barren Springs road.

So far, two ore-bearing horizons have been developed; separated by about 800 to 1000 feet of limestone—although this interval between the two horizons may not be so great.

The ridge before mentioned as forming an eastern boundary to the J. Stephens tract is an anticlinal of limestone, with dips to the north-west and south-east of about 30°.

Going south-east and up the creek along the Greenbrier road, the dip gradually begins to stiffen up to 50° at the junction of the limestone and sandstone, the latter rock appearing first about Wheeler's mill, with increased boldness of topography and a south-east dip of 60–70°.

The arch in the limestone rocks is very beautifully displayed on both sides of the creek; and to the duplication of ore bearing limestone, caused by its presence, is due the wide outspread of ore through the Stephens tract.

On the north-west side of the ridge and anticlinal, the incipient dip of 30° dwindles down to only 12° in the limestone bluff on the creek facing J. Stephens' house, so that all that portion of the property lying west of the creek, along the Barren Springs road, is made up of limestones with a very flat dip, and occuring higher in the general series than those east of the creek. At the same time in no portion of this part of the property (west of the creek) have iron-ores been as yet found; and none outcrop on the surface.

Of the two horizons of ore before mentioned as having been recognized here, the lower ore, occuring along the line of the anticlinal in the (geologically) lowest limestones, has a somewhat compact nature, a dark brown to reddish color, and is characterized by its association with a stiff red clay, rendering the washing of these ores somewhat more difficult than those of the higher range.

The latter contains an ore much more porous and cellular,

often occurring in plates, and largely free from refractory wash material.

Both classes of limestone ores are of excellent quality, and show a great uniformity of character; and the wash material will probably yield fully one half clean ore.

Developments. The property has been developed by means of various shafts and pits, and the approximate position of these is shown on the accompanying page plate. The larger number of developments has been confined to the J. R. Stephens tract, where both the lower and upper ranges of ores have been quite well shown up,—the former, or that associated with the lower limestones, has been developed in two pits, (Nos. 1 and 2,) located nearest the eastern side of the property, and close to the anticlinal.

No. 1 *opening* is situated near the head of a draft leading up from the Greenbrier road, and close to the boundary line; about 600 yards east from Stephens' house, and about the same distance north from Little Reed Island creek.

The shaft has been put down some 41 feet; 15 feet of ore from surface down, then 6 feet of dark barren clay, and then 20 feet more of ore-material, with bottom of shaft still in ore, and with the showing much better than at the top. Practically no lump ore has been found in this shaft. A sample of the wash material, 21½ pounds, was washed at the creek, and yielded 11½ pounds, or 53 per cent. of clean ore. Dried at 212° F., the ore shows:

Metallic iron,	57.900
Phosphorus,	.173
Siliceous matter,	4.600
Phosphorus in 100 parts of iron,	.298

No. 2 *opening* lies about 1000 feet north-north-east of No. 1, and a little further down the slope of the hill. The development consists of a circular pit 4½ feet wide by 12 feet deep. Ore shows within 18 inches of the surface, and the bottom of the shaft is still in ore. A band of what seems to be a rather siliceous cellular ore shows in the sides of the pit; but, as is sometimes the case with Cripple creek ores, the silica may practically all show as crystalline quartz on the

outside, injuring the *appearance* of the ore, without however seeming to affect its *quality*. This would appear to be the case here, for an analysis of a sample of the lump ore, taken from a pile lying at the pit mouth, yielded, when dried at 212° F.:

Metallic iron,	56.500
Phosphorus,	.053
Siliceous matter,	5.400
Phosphorus in 100 parts of iron,	093

A sample of the wash material, 16 pounds, was washed at the creek, and yielded 9½ pounds, or 59 per cent. of clean ore. An analysis of this, dried at 212° F., shows:

Metallic iron,	52.050
Phosphorus,	.116
Siliceous matter,	10.380
Phosphorus in 100 parts of iron,	.222

No. 3, *or "Cedar Tree" opening*, is situated in a corn field about 500 yards from the creek at Stephens' house, and about 150 yards north from the family grave-yard. Although not geographically far distant from the first two openings mentioned, it would seem that the ore from this opening, and that of the two pits to be immediately described, is associated with slightly higher (geologically) limestones; and if this be true, we would naturally expect some slight differences in the character of the ore. However, neither the physical character of the ore, nor its chemical analysis brings out such a sharp distinction; and, until developments are made on a large scale, it is perhaps premature to speculate upon differences due to geological horizons where the rock exposures are so meager and obscure. The development consists of a circular pit, 4½ feet in diameter and 12 feet deep. Ore shows quite conspicuously in the sides of the pit, coming to within a foot of the surface. There is quite a good showing of lump ore, apparently lessening however in quantity with the depth of the pit. The ore is a clean looking, cellular limonite, seemingly of quite uniform quality. About a ton of lump ore was lying at the mouth of the pit; and from this a sample was taken from nearly every piece. It yielded, when dried at 212° F.:

Metallic iron,	57.300
Phosphorus,	.045
Siliceous matter,	4.620
Phosphorus in 100 parts of iron,	.078

A sample of the wash material, 14 pounds, was washed at the creek, and yielded 8 pounds, or 57 per cent. of clean ore. When dried at 212° F., this contained:

Metallic iron,	55.050
Phosphorus,	.055
Siliceous matter,	6.610
Phosphorus in 100 parts of iron,	.100

Two more pits, Nos. 4 and 5, have been sunk about 500 feet north-north-east from the "Cedar Tree" opening. Both practically show the same character of ore, and are not more than 100 yards apart.

No. 4 *opening* consists of a circular pit 4½ by 12 feet. At this point fully 2 feet of stripping shows. The ore seems to be of the same general character as at the last opening, but the proportion of lump ore is not so great. A sample of the *lump ore* yields, when dried at 212° F.:

Metallic iron,	56.925
Phosphorus,	.050
Siliceous matter,	5.380
Phosphorus in 100 parts of iron,	.088

No. 5 *opening* shows practically the same record as the last, except that the ore comes to within a foot of the surface. A sample of the lump ore from this pit yields, when dried at 212° F.:

Metallic iron,	57.875
Phosphorus,	.040
Siliceous matter,	4.260
Phosphorus in 100 parts of iron,	.069

14 pounds of the wash material from this pit yielded 8½ pounds, or 60 per cent. of clean ore.

This gives on analysis, dried at 212° F.:

Metallic iron,	53.000
Phosphorus,	.043
Siliceous matter,	8.430
Phosphorus in 100 parts of iron,	.081

All of these pits just described are located within the boundary of the Stephens tract held in fee simple. All of them can be easily reached by short tram-roads up natural drafts leading from Little Reed Island creek. The ore found at No. 1 opening, and such as may be developed south of it, could be most economically moved to the creek along the Greenbrier road; while the natural outlet to the more northern portion would seem to be to the creek near the Sayres line.

Even from the limited amount of development already made on this portion of the tract, it may safely be assumed that the yield of high grade ore will be considerable; for the relationship of these openings is such as to warrant the opinion that by far the larger part of the 175 acres may be regarded as productive territory.

Of that portion of the J. R. Stephens tract lying west of that just described, but east of Little Reed Island creek, and also the "Buddle field tract" of 18 acres lying west of the creek and between the Barren Springs road and Perrywinkle branch, no such general statement as to productiveness can be made, although the developments in certain portions of it, especially in the Buddle field tract, are extremely favorable to the future of this portion of the property. So far only one locality (No. 6) has been tested east of the creek; but here the ore has been developed to a considerable extent by two openings. The first and most western of these is located along a bluff immediately below the orchard south of Stephens' house, showing a trench 15 feet long, 8 feet wide and 4 feet deep. The proportion of lump ore is considerable, with a generally laminated structure, and in some places carrying a little iron pyrites, although this is not appreciable in the whole mass.

The second opening lies about 30 yards east of this along the bluff, about 250 yards from the creek, and about 30 feet above water level. It shows a trench 11 feet wide and 15 feet long, developing a face of ore about 5 feet in thickness. The ore is of a soft, shelly, laminated character, more or less mixed with clay. It shows within a foot of the surface. So much mixed is it with clayey material, that much of the

mass would naturally go through the washer. A sample, however, was taken of the whole, by cutting a section across the entire face. It yields, dried at 212° F.:

Metallic iron,	52.150
Phosphorus,	.051
Siliceous matter,	8.670
Phosphorus in 100 parts of iron,	.098

The "*Buddle field tract*," consisting of 18 acres in fee, lying just west of the creek from the last described openings, has been considerably developed. The various openings here may be conviently classed under the general heading No. 7.

The first development is along a bluff just above where Perrywinkle run enters Little Reed Island creek. The ore comes to the surface, and it has been stripped for a length of 50 feet; then an interval not exposed of about 40 feet; then a boulder of ore 4 or 5 feet wide has been uncovered.* To the top of the ridge it is probably 75 feet, the opening being 25 or 30 feet above the creek. Limestone shows at both ends of the exposed ore, pitching into the hillside northwest; but no limestone shows within the ore-mass, nor above it to the hill top. A sample clipped from all along the ore face yields, when dried at 212° F.:

Metallic iron,	57.700
Phosphorus,	.058
Siliceous matter,	4.280
Phosphorus in 100 parts of iron,	.100

About 15 feet above and about 10 yards south-west of this opening, a small pit 4×4 feet shows lump ore from the surface down, of the same general character as below. Still some 15 feet above it and 20 yards west-north-west of the first opening, a shaft has been put down about 20 feet, with bottom in ore, and with wash ore within 2 feet of the surface. This shaft shows a large proportion of lump ore of similar character to that already noted. A limestone boulder was encountered on the south-west side of the shaft at the bottom, but the ore continued down on the north-east side. Another shaft has been put down along the brow of the hill

*Since this report was made, the ore-face has been stripped for a length of 100 feet, and the present showing is a very handsome one.

about 100 feet distant. Ore was struck at the surface, and the bottom of the shaft is still in ore-material. Although the lump ore seems to be of the same general character as at the other openings, the proportion is not nearly so large, nor does the wash-material seem quite so rich in ore.

Before describing the zinc developments made on that portion of the J. R. Stephens tract lying west of Little Reed Island creek, (where no iron ores have as yet been met with,) it would seem advisable to continue the description of the iron ore developments through the Widow Stephens and Wheeler tracts.

The Widow Stephens tract lies entirely south and west of Little Reed Island creek and the Greenbrier road. The anticlinal ridge, forming a portion of the eastern boundary of the J. R. Stephens tract, is continued in a north-east and south-west direction approximately through the center of the Widow Stephens tract, the crest of this arch crossing the Greenbrier road about 500 yards south-east of the schoolhouse; and to its presence is due the reversal of dips in the limestone seen there, and it perhaps accounts for the geographical outspread of the same iron ores associated with its rocks, as on the J. R. Stephens tract. The same structural effects have likewise caused a duplication of the same iron ores on either side of the axial line; and while it has been already stated that the association of iron ores with particular horizons of limestone rock is somewhat tentative to a more general development, yet both the appearance of the ore and the results obtained by chemical analysis go far towards rendering this conclusion justifiable. At all events, in the neighborhood of the continuation of this anticlinal arch, the iron ores sampled all show the same characteristic features as those developed in pits Nos. 1 and 2 on the J. R. Stephens tract; while the ore occurring on the north-west and south-east, in geologically higher limestones, both on the Widow Stephens and Wheeler tracts shows a relationship to similarly situated ores in the openings Nos. 3, 4, 5, 6 and 7.

The developments thus far made on the Widow Stephens

tract are rather meager. What have been conveniently termed the lower limestone ores have been sparingly developed in a few shallow pits or trenches (No. 8) a short distance south of the Greenbrier road, on either side of the anticlinal. The ore obtained from them is considerably mixed with a stiff, reddish yellow clay, which adheres closely to the lump ore, and which might necessitate the washing of much of the smaller lumps to effect its removal. The ore itself is rather compact and close-grained, and has not the rich-appearing character of the J. R. Stephens ore, although from the analysis given below it is almost equally rich in iron.

A sample of the lump ore taken from 3 different pits yields, when dried at 212° F.:

Metallic iron,	54.075
Phosphorus,	.073
Siliceous matter,	7.950
Phosphorus in 100 parts of iron,	.135

A little further south-east of these openings, on a knoll adjoining the Wheeler tract, 3 other pits (No. 9) in somewhat higher limestones dipping south-east, and consequently on the south side of the anticlinal, have developed ore more closely associated with the character of the J. R. Stephens deposits; and although largely accompanied with limestone beds, a fair amount of ore may be expected from them before being cut off by the solid limestone. One of these shafts, *a*, (see page plate,) well up the hill side, is 25 feet deep: 10 feet through ore material, 5 feet barren clay, and then 10 feet more of ore, with bottom of shaft still in ore. The limestones here dip S. 60°, E. 30°. A second shaft, *b*, 5 or 6 feet deep, yielded no ore at all; while the third, *c*, and nearest the road, went down 10 feet all in ore. A mixed sample of the lump ore taken from pits *a* and *c* yielded, when dried at 212° F.:

Metallic iron,	56.400
Phosphorus,	.047
Siliceous matter,	5.690
Phosphorus in 100 parts of iron,	.083

Although as yet unopened, this same character of ore associated with similiar limestones may reasonably be expected to occur on the north-western part of this tract, on the south

side of Perrywinkle branch, and opposite the No. 7 opening of the Buddle field, to which ores they may be closely compared.

The Wheeler property adjoins the Widow Stephens on the south-east. Extending back from the ridge to a hill running down to the creek near Wheeler's house, the surface has been scratched in 4 or 5 different places, south-east of a narrow draft and close to the Stephens line. The ore has about 10 inches of over-burden. Nothing can be said about quantity in the absence of deeper shafts; but as the outcrop extends for some little distance south-east parallel to the Greenbrier road, there is no reason to doubt a considerable auxiliary output to the ores of the other two tracts. A sample of lump ore taken from 3 shallow pits (No. 10) contains, when dried at 212° F.:

Metallic iron,	53.875
Phosphorus,	.038
Siliceous matter,	7.260
Phosphorus in 100 parts of iron,	.070

Zinc Ore. The developments for zinc ore have been entirely confined to that portion of the J. R. Stephens tract lying west of Little Reed Island creek. On the flat north-east of Barren Springs road there have been several shafts sunk for zinc. One of these, (No. 11,) 400 yards west from the creek, was put down 20 feet, from which a fair amount of lump and wash ore has been obtained. The ore-bearing limestone was struck at a depth of 16 feet, and has so far been developed to a thickness of 4 feet. From the bottom of the pit, drifts have been run 10 feet on either side, north-east and south-west, the limestone dipping gently north-west. In these drifts the ore material was found mixed with clay and some little solid limestone. At the end of the south-east drift a large mass of ore some 2 feet thick shows, and although the appearance of the ore-material near-by is quite irregular,—as is the nature of these deposits,—yet the showing at this point is quite encouraging. In the north-west drift, gangue-material is much more intimately mixed with

the zinc ore, although this portion of the drift may all yield a fair wash ore.

A sample of the lump ore taken from this shaft yielded when dried at 212° F.:

Metallic zinc,	39.37
Metallic lead,	8.77

A sample of the wash ore was taken by mixing up a considerable quantity of the material lying at the pit mouth. Of this mixed portion, 6½ lbs. were washed and yielded 3 lbs. or 46 per cent. of clean ore. This analyzes, dried at 212° F.:

Metallic zinc,	32.84
Metallic lead,	1.32

None of the other pits (3) have struck ore as yet, although all but one, (sixty or seventy feet deep, and a little south-east of the productive shaft,) are shallow, and none of them have struck limestone. The actual occurrence of zinc ore, as seen at the Bertha, Manning & Squires and other developments north-west of this place, in similar rocks and probably on the west side of this same basin, is very sporadic; and any of these shafts may or may not prove productive on further development. There is considerable territory lying to the west of these shafts, to the north-western boundary of the Stephens property, in which such development may be inaugurated before finally proving the property as a zinc property.

Summary. The salient features of the entire property seem to be:

1. The excellent quality of the iron ores, both as to richness in iron and freedom from phosphorus—many of the analyses showing ore suitable for Bessemer pig iron. Nine samples of the *lump ore* yield an average of:

Metallic iron,	55.866
Phosphorus,	.050
Siliceous matter,	5.945
Phosphorus in 100 parts of iron,	.089

The extremes are:

Metallic iron,	52.150 to 57.875
Phosphorus,	.038 to .073
Siliceous matter,	4.260 to 8.670

Four samples of the *wash ore* yield an average of:

Metallic iron,	54.500
Phosphorus,	.097
Siliceous matter.	7.505
Phosphorus in 100 parts of iron,	.178

The extremes are:

Metallic iron,	52.050 to 57.000
Phosphorus,	.043 to .173
Siliceous matter,	4.600 to 10.380

2. The remarkable richness of the wash-ore material,—the four tests made showing that it will yield from 53 to 60 per cent of clean ore.

3. The great width of the developed ore territory, owing to the slight dip of the limestone measures on either side of the anticlinal.

4. The admirable facilities for attacking the ore deposits,—natural drafts existing at many points leading directly to the creek and providing for an economical movement of the ore-material to the washers.

5. The limited amount of over-burden to be removed, and the ease with which the ore-material can be cleansed.

6. The abundant washing facilities furnished by Little Reed Island creek, which can be relied upon at all seasons for a persistent and bountiful supply of water. This point becomes of prime importance when it is remembered that by far the larger portion of the ore to be mined will be *wash ore.*

7. The quite promising indications for a workable and paying deposit of zinc ore.

Respectfully submitted,

ANDREW S. MCCREATH.

The *Swecker property* consists of 257 acres, bounded on the west by Foster's Falls, on the east by a small strip of Manning and Squiers' (dividing it from the Stephens property,) and runs south to the crest of Roaring Falls mountain, where it joins the Crawford lands, and north nearly to the Bertha Zinc mines. Absolutely no developments have been made to warrant any opinion as to the prospective value of this property. Some little mountain ore, of an uncertain quality, out-

crops on the north flank of the mountain, and the tract also carries some limestone ore exposed most conspicuously on both sides of the ravine below Swecker's house. The tract is watered by narrow streams which head together and flow to Little Reed Island creek on one side, and to the Bertha Zinc mines on the other. The property is one deserving more attention, as it is comprised in an ore-bearing territory.

Barren Springs property. (Manning & Squiers.) The ridge dividing Little Reed Island creek from the river rises in a broad flat plateau about 200 feet above the creek, and it is almost without exposure of limestone rock. Descending the north-west slope towards the river and back of the church, some developments have been made upon the Manning and Squiers property in two or three 30′ shafts. This property comprises from 1,600 to 1,800 acres, and so far has been only developed for its zinc ores. The shafts just mentioned have turned out a fair amount of ore; but the principal developments of the company lie to the west of the church joining the Bertha mines on the east. The openings are in a ravine, with ridges to the north and south of it. The open cut shows the usual features of barren, gritty magnesian-limestone domes, between which the ore-bearing clays have been removed by pick and shovel. The occurrence of zinc between these barren pillars is exceedingly treacherous, and the ore must be followed wherever it appears and skinned off the undecomposed limestone masses. From 8 to 10 test shafts have been put down upon the bluff rising to the north of the mine, with varying results. In December, '86, the mine presented a mass of excellent zinc-ore in a very attractive face, capped with a tough red and yellow clay, which rendered the stripping very expensive. The dip of the limestone is obscure by reason of decomposition; but in any case is very flat. No washing of the ore has as yet been carried on*, the ore being separated rudely by hand and stocked for washing and future shipment. The proportion of lump ore may reach one sixth, the balance being wash-ore. Of the material mined out already Mr.

*Since the examination in December, 1886, the company have erected one washer just south of Barren Springs.

Sayers (Superintendent) estimates that the wash-ore material when roasted and screened yields two thirds ore, and that the other third, passing through the screen, will offset the clay still remaining with the lump ore. Of course no account is taken in these estimates of the amount of "dead work" done to obtain the ore-material; nor could this be expected at present, inasmuch as the work so far partakes of the nature of exploitation. No plan of development has as yet been laid out, the object being to determine the quantity of ore present. A sample of the clean lump ore was obtained in March, 1887, from a small pile near the open cut, yielding on analysis:

Metallic zinc	44.553
Metallic lead,	trace.

Quite a prominent outcrop of iron-ore shows along the public road south and east of the church; and additional ore territory is indicated by a profuse and attractive outcrop on the hill facing the river north of the store. But when the property was visited in the fall of 1886 no developments on the iron-ore had been made, and the results obtained from a large number of shafts put down since our visit are reported to have yielded varying degrees of success.

The *Bertha property* joins Manning and Squiers on the southwest, and the developments upon it practically continue the line of deposit just described, parallel with Roaring Falls mountain. The appearance of the cut in December, '86, was very favorable; but at that time, very little development was being made pending the negotiations for the sale of the property. The recent re-organization of the company however will no doubt lead to an enlarged excavation during the present year. The cut shows an increasing stripping going to the south-west, fully 30′ of barren clay capping the ore on the western end of the opening. At the same time the hill rises topographically, thereby increasing the difficulty of mining by open cuts towards the west.

In many places the ore comes practically to the surface, and it has been proven to a depth of 65 feet. It consists chiefly of the silicates and carbonates of zinc. The ore was dried in

kilns at the mine and carried to the furnace at Pulaski, although recently the company are making extensive improvements looking to the washing of the ores at the mines.

When first examined in 1881, two thousand five hundred tons were being shipped yearly from these mines, although a greatly increased output is assured at present. A sample of the crushed and roasted ore, selected in 1882 at the Pulaski works, yielded:

Metallic zinc,	37.836
Metallic lead,	none.

The following additional facts concerning this property are extracts from a report of the superintendent, Mr. Thomas Jones, made to the company in September, 1886, and published here by permission, with the accompanying map showing the character of the developments at the time of our visit:

"Since the Bertha Zinc Company have been the owners of the property, they have smelted from this mine by actual weight 12,775 tons of ore. We have in addition at the mines an amount of wash-ore that will yield 5,000 tons of clean ore.

"I estimate the amount of ore in our present cuts not bottomed, outside of all headings and all ore stripped and not cut, at three thousand tons, making a total of twenty-one thousand seven hundred and twenty-five tons from our present opening, excepting, however, from said total, an amount that came from a small opening near the Bertha Zinc Company's eastern boundary line where it joins the property of Messrs. Manning & Squiers. I estimate that one thousand tons will fully cover all ore gotten from that opening, which we had to abandon for the want of dumping ground, which we could not buy at that time.

"On Ground Plan (Fig. 1,) a cut from '*a*' to '*b*' is shown 322 feet long. This cut was made for a gangway to 'roasters' and to drain the mine. In this cut was found no ore for the first 150 feet from '*a*,' then for next 100 feet only part ore; but at 250 feet from entrance of cut was found a good body of ore; also from '*b*' to '*c*,' and to *d*, and to *f*, and to *n*, (except where the chimneys of magnesian limestone appear, the bases of which are shown in Fig. 1.)

"The dotted line shows the full size of opening, at surface of ground, including slopes of the cuts; the full line represents the base of the cuts.

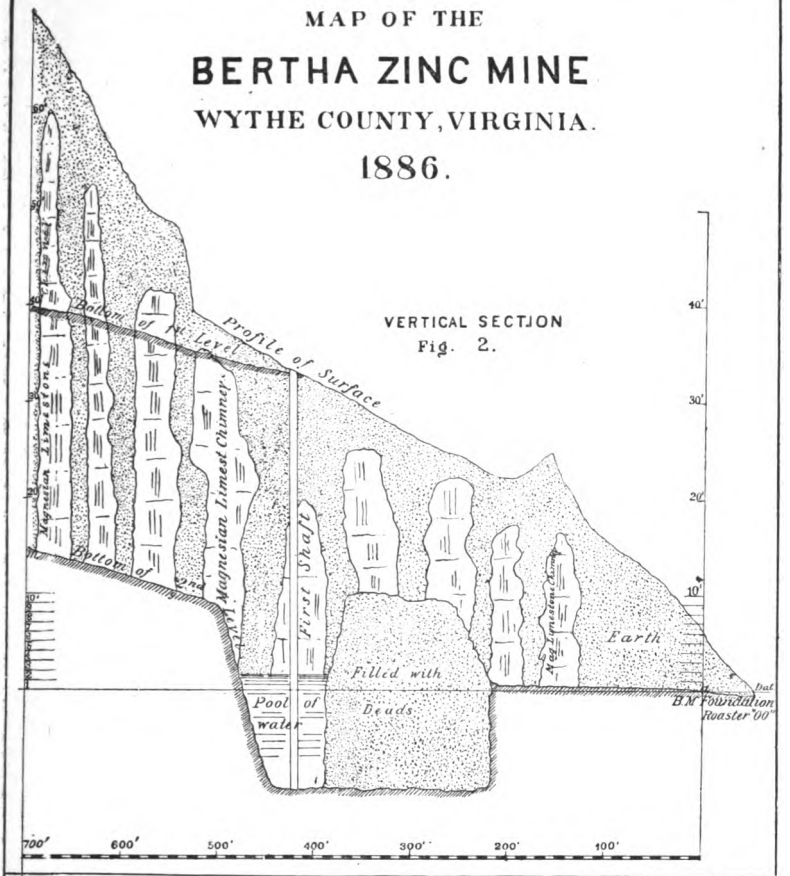
"At '*d*' we have a large body of ore stripped, showing at three points in the heading with an average of fifteen feet of earth over the ore. From '*c*' to entrance of tunnel, the ore has not been bottomed. At the head of this cut the ore shows in three places, but seems to go down deep. This tunnel was driven through earth, with ore on the east side, for forty feet. At this point we came to a solid heading of ore. A branch was driven out at 24 feet, 20 feet long and came to a solid heading of ore. From '*e*' runs a cut from second level through which is hauled out ore and dead work. This cut at the entrance is very shallow, and but little ore was taken out until we came to '*n*.' From '*n*' to '*o*' there was a good body of ore with earth between the ore masses, and but little limestone. From

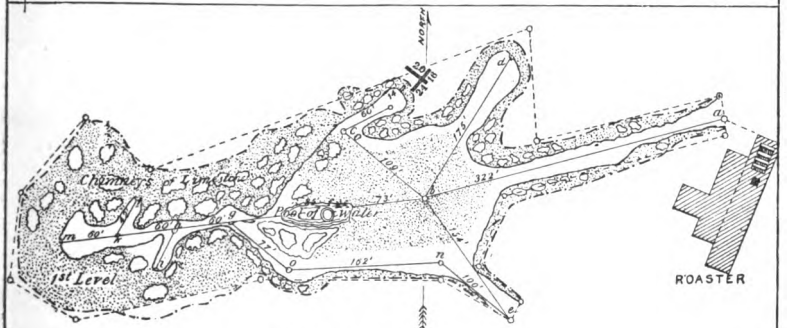
MAP OF THE

BERTHA ZINC MINE

WYTHE COUNTY, VIRGINIA.

1886.





'*o*' to '*g*' there was a good deposit of ore between the limestone. The limestones at this point came very close together; but whenever this occurs, the ore is generally very fine and solid and with very little earth mixed with it. The same is the case on the south-west side between '*g*' and '*b*.'

"At '*f*' a shaft was driven 45 feet deep, the first 4 feet through earth, the remaining 41 feet through ore. At '*f*' we have bottomed the ore and left the cavity unfilled for the purpose of a water supply. The dotted part around '*b*' shows a fill to second level, to get out from '*c*' and '*d*' to '*n*.' From '*g*' to '*k*' was a good body of ore, and at '*k*' we have driven an entry south to a good body of ore which is now exposed. At the head of this entry comes our first level and runs from the bottom to the top of the cut and continues around '*k*' to '*m*,' thence to '*l*,' and on the north side back to '*k*.' This is the best deposit of ore we have struck, and the whole face at '*m*' is ore and has not been bottomed. The first bench above this point ('*m*') shows a very large body of ore exposed in some places near the top of the ground. Also on the south side of '*m*' and back to '*k*' there is a fine body of ore. The face of ore at '*m*' is about 40 feet wide, and the limestone does not appear here except in one small space about 6 feet wide at the bottom of the second level. * * * * * * * * *

"The ores at such places form large chimneys and spread out and connect together without the interference of limestone, until the second level is reached. For instance, the ore at '*m*' was struck within 3 feet of the top of the ground and has continued to be solid ore down to '*m*,' and has not been bottomed; so at this point the ore is 40 feet wide and before cut off at the top was 52 feet deep to '*m*,' not counting the bottom, which I think is 15 or 20 feet deep in ore."

Figs. 1 and 2 show a ground plan and section of this mine, and illustrate the occurrence of the barren chimneys of magnesian limestone, around and between which the zinc ore is found and mined. They make the fact sufficiently clear that no systematic method of mining can be pursued, and that the ore must be followed wherever it leads to. These illustrations were made from data furnished by the company with the superintendent's report.

The *Falling Cliff property* lies to the south-west of the Bertha mines and consists of 100 acres in fee, with a rudely parallelogram form, and 112 acres in mineral right, extending northwards to the river. It has a frontage of about a mile on the railroad and river and extends back to the Barren Springs and Foster's Falls road. Some two or three shallow pits in limestone have been dug near this road; but these, as well as the deeper shafts on the hill, were all closed to inspection, and the following information has been obtained from Mr. David S. Forney, half owner of the property.

Near the road some slight amount of zinc-ore has been thrown out, a portion of the deposit containing some lead. One shaft 40′ deep was sunk to a tunnel drifted on a 3′ bed, not now exposed. The several openings are claimed to have yielded about 50 per cent. of wash and lump ore. On the hill summit, Mr. Forney stated that some 500′ of tunneling had been made, all of which was upon ore, and extending from the bottom of several shafts from 60′ to 80′ deep. The tunnels are necessarily very irregular, following wherever the ore led. The deepest shaft is 80′, striking the ore on the north-west dip in varying thickness from 4 to 16 feet.

The "Walnut Tree" shaft is 70′ deep, and in the "Hickory Tree" shaft 500 feet distant, the ore was found 12′ thick. Mr. Forney states that the greatest thickness of the bed throughout the works is unknown; but in many parts a 7′ tunnel passed entirely through ore. However, the bed pinches laterally frequently, and it is extremely doubtful whether it may not do likewise along the dip of the measures towards the river. Almost all the shafts are within 500 yards of the Bertha line, and the ore certainly throughout the property will only be found beneath a heavy barren stripping. A general sample of the clean lump ore from all the openings shown us, except those claimed to show an appreciable percentage of lead, gives the following result upon analysis:

Metallic zinc,	47.578
Metallic lead,	.198

The *Crawford property* lies mainly on the south flank of Roaring Falls mountain, extending well up the ridge from Perrywinkle branch, and about one and a half miles up that stream from Little Reed Island creek. This property has been recently purchased by Mr. D. F. Houston and others, and consists of about 950 acres, extending from a prong of Poplar Camp mountain on the south, to a little beyond the crest of Roaring Falls mountain on the north. The limestone measures are confined to that portion of the property lying north of the branch, and extending westward in a narrowing trough to a little beyond Crawford's house, and in places carry the same ores as those already described along Little

Reed Island creek. Several shallow openings have been made between two drafts a little north from Mr. Crawford's house, and the deposit has been tested likewise for some distance to the north-east, where it swings pretty well up the flank of the ridge and possibly joins the limestones in the cove on the north side of the spur near Swecker's house.

The ore is an open cellular variety, somewhat laminated, and occurs associated with the same limestones as at the Stephens place. Many of the pits were located dangerously near the outcropping limestones, so that the opportunities for getting a large amount of cheap ore in them were somewhat lessened. In many places the ore is accompanied by a yellow clay, somewhat injuring its appearance. In two shafts close together, immediately back of the house, one showed a record of 48′ mostly in good wash-ore; the other 30′ deep, turning out a much larger proportion of lump-ore, much of which, however, was impregnated with iron pyrites to such an extent as to render it almost worthless. The first 10′ showed no ore at all; and the pyrites was found mostly at the bottom. The same hurtful ingredient was found to a less extent in the first shaft, also near the bottom.

A sample of the ore taken from the shallow pits north of Crawford's house, yields on analysis:

Metallic iron,	54.000
Phosphorus,	.050
Siliceous matter,	6.820
Phosphorus in 100 parts iron,	.092

Probably half a mile west along the base of Roaring Falls mountain, there is an extensive natural showing of mountain ore lying well up the mountain flank and probably 300′ above Crawford's house. The sandstone measures of the mountain are visible here dipping towards the south-south-east. A general sample of the ore was taken from this exposure which is locally known as the "outburst," from the large masses of ore occurring in boulders and massive beds. It yielded the following results upon analysis:

Metallic iron,	49.550
Metallic manganese,	5.267
Phosphorus,	.117
Siliceous matter,	8.810
Phosphorus in 100 parts iron,	.236

The Potsdam ore has been opened in a narrow ravine on the flank of Poplar Camp mountain, about 200′ above the level of the creek. The contact of the limestone and sandstone is well seen about 150 yards south-east of the creek, and the ore crops with a sandstone foot-wall having a northwest dip of nearly 50°. The exposure is uncovered for 50′ along the face of the ravine, and the bed may be from 20′ to 25′ thick. It is a massive, close grained, dense ore, and will all require blasting.

A general sample from along the face of the cut shows as follows:

Metallic iron,	46.400
Phosphorus,	1.070
Siliceous matter,	15.350
Phosphorus in 100 parts iron,	2.306

The *Oglesby property* consists of over 1,200 acres with a very irregular shape, lying on both sides of the Reed Island-Poplar Camp road, and extending between the Dry Pond mountain on the south to the base of the Roaring Falls mountain on the north. It joins the Pierce furnace (Foster's Falls) property on the north, and most of the developments made are comparatively close to that property line. A ravine leads westward from this portion of the property down to Foster's Falls, and any development of the property would be by means of an extension from the railroad at that point. Several shafts and pits are located in this ravine close to the line fence, and all of them on the north side of the draft, showing an encouraging amount of lump and wash-ore of an excellent quality.

A general sample taken from four different openings yields on analysis:

Metallic iron,	56.225
Phosphorus,	.143
Siliceous matter,	6.360
Phosphorus in 100 parts of iron,	.254

One 12′ shaft showed the ore in lumps of considerable size mixed with a rather tough red clay, like the ores on the Widow Stephens place. The accompanying limestones here have a considerable dip to the south-east, with a tendency to carry

the ore soon beneath water level and provide for but little surface outcrop. Some recent developments south of the ravine certainly show a continuation of the ore deposit in that direction; but none of them are as satisfactory as those already mentioned. The material from them shows a little top wash-ore mixed with rounded boulders of quartz rock, beneath which a reddish plastic clay exists until limestone is struck. The ravine has been opened in places for a distance of about 250 yards, generally in shallow shafts and in a comparatively uniform character of ore. The material accompanying the ore is a reddish yellow clay, somewhat hard to wash; but the ore itself is of an excellent quality.

Some recent developments have been made along a small ridge in the valley about a quarter to a half mile south-east of the ravine just mentioned, and possibly consisting of an intermediate saddle of Potsdam rocks between the two main ridges. Mr. Oglesby has sunk here some twenty small holes or drifts, eight of which turned out more or less ore, somewhat slaty and mixed with red clay, and some of it quite manganiferous. Five of the pits show very encouraging prospects for a considerable quantity of ore; but the quality is quite different from those of the limestone openings to the north-west, and is most probably to be referred to the mountain ore horizon. A sample was taken from an opening on the south side of this ridge. It shows about the best and cleanest ore yet developed there, and gives the following result upon analysis:

Metallic iron,	44.825
Metallic manganese,	2.227
Phosphorus,	.147
Siliceous matter,	17.170
Phosphorus in 100 parts iron,	.328

The mountain ore has also been opened further north-west and nearer the junction of the limestone in the ravine along the south base of Roaring Falls mountain; and a general sample of the clean lump ore from two pits gave:

Metallic iron,	46.200
Metallic manganese,	2.575
Phosphorus,	.305
Siliceous matter,	12.870
Phosphorus in 100 parts iron,	.660

Three shallow pits, none of them over 6′ deep, have been put down on the south-western end of this intermediate ridge and close to one another, which have developed a small amount of manganiferous ore. All three show about the same characteristics, and none of them have indicated as yet a commercial quantity of this ore. An average sample was taken from the material thrown out, which gives the following composition:

Metallic iron,	19.000
Metallic manganese,	22.309
Phosphorus,	.160
Siliceous matter,	19.620

The *R. J. Tipton heirs* property of 200 acres lies mostly along the Poplar Camp road, and is joined by the Oglesby property on the east and west. It runs well up the mountain flank, and the developments so far made are entirely on the mountain ore. These consist of two or three small pits along the north base of an outlying ridge of Potsdam sandstone, separated from the main mountain by a narrow ravine. No rock in place outcrops. The best exposure of the ore is on the north-east end of a ridge where a natural outcrop, dipping steeply north-west, has been scraped sufficiently to expose the ore-bed to a depth of about three or four feet, and of a thickness between 6′ and 7′. The ore is very hard and dense, with a dark brown to black color. One or two other small pits suffice to show the ore to a limited extent; but the developments are very meager and entirely inadequate to warrant any opinion concerning the continuation or amount of the ore. These developments are about two and a half miles south-east from Foster's Falls. A general sample was taken from the two or three exposures, which upon analysis gave the following result:

Metallic iron,	52.400
Metallic manganese,	1.894
Phosphorus,	.554
Siliceous matter,	7.620
Phosphorus in 100 parts iron,	1.057

Mr. R. J. Tipton has 188 acres further west along the mountain, but separated from the 200 acre tract by the land of another Tipton. No developments have been made here, although a fair amount of ore is said to outcrop.

The *Prim property* lies to the eastward between the Tipton and the Crawford lands, and it is claimed that a similar showing of ore exists there. No developments have been made, and the property was not visited; but it is fairly possible that, with barren intervals, a good deposit of ore may be found to exist along the mountain flank from the Crawford opening south of his house well towards Poplar Camp gap. This range, however, has received but little attention, owing to the lack of development and want of appreciation of notices given. The geology of the district would seem to make this line of ore quite similar to that occurring on the south flank of the Roaring Falls mountain, with a basin of limestone occurring through the Oglesby and Jackson farms, widening westward as the river is approached.

The *Jackson property*, or so much of it as lies east of the Poplar Camp creek and a little west of Ogelsby's house, is well within the upper limestone area; and while no developments whatever have been made either here or upon his large farm west of the creek, there can be but little doubt that intelligent investigation would result in the finding of a considerable amount of the limestone ores in this portion of the field. The outcrop indications are very striking in the small hill first mentioned to the west of Mr. Ogelsby's house; but so far Mr. Jackson has not prospected himself, or permitted the development of his property by others.

The *Foster's Falls* or *Pierce furnace* property near Foster's Falls station, comprises nearly 2,100 acres, occupying a large portion of the western end of Roaring Falls mountain, and closing south on the Oglesby farm. At this point a small development has been made in a strip of limestone land near the Oglesby fence, consisting of four or five shallow pits and a trench a little to the west of them. The latter shows a lean and poorly developed ore-face, and was not sampled. A mixed sample of the lump ore thrown out from the pits to the east of the small ravine was selected, with the following result upon analysis:

Metallic iron,	55.750
Phosphorus,	.205
Siliceous matter,	5.670
Phosphorus in 100 parts iron,	.367

The ore is a rich brown-hematite, and will no doubt have a considerable area upon the south flank of the spur of Roaring Falls mountain. This mountain is decidedly the most conspicuous feature upon the property, and owes its presence to a saddle in the rocks bringing to daylight along its crest, and for some distance down its sides, the lower Potsdam sandstone rocks which make the floor of the valley. This anticlinal is very well seen upon the river, throwing off dips of about 10° to the north-west and south-east, which dips, however, increase rapidly north and south from the axis line. The strike of the mountain is nearly east and west, and the line of ore-deposits, both in the mountain and in the limestones at its south base, coincide closely with this course.

The mountain ore is opened at but one place, in the *Hammer bank*, on the south flank of the mountain, fully 400 feet above the railroad and, in an air line, a little over a mile from the river. Although the cut is not large, the exposure of ore is very impressive. The bed itself is fully 20 feet thick and dips regularly from 40° to 50° towards the south. The ore could be cheaply mined, although rather inaccessible and difficult to work economically without a branch line being extended from the river, or the deposit traced further westward so as to be opened nearer the present location of the railroad. There is no doubt an extensive bed of ore here and to the west of the cut, and the topography is very favorable for its attack. Another large and natural exposure of this ore is said to outcrop further east in a bluff some 50′ long; but at the time of our visit no one seemed capable of directing us to its location.

A sample of the Hammer bank ore taken by Mr. Wesley Shockley, superintendent of the ore mines, yielded on analysis:

Protoxide of iron,	.161
Sesquioxide of iron,	77.071
Sesquioxide of manganese,	.020
Sesquioxide of cobalt,	.020

Oxide of zinc,	.020
Alumina,	2.250
Lime,	.460
Magnesia,	.497
Sulphuric acid,	.300
Phosphoric acid,	.455
Water,	11.514
Siliceous matter,	7.175
	99.943
Metallic iron,	54.075
Metallic manganese,	.014
Sulphur,	.120
Phosphorus,	.199
Phosphorus in 100 parts iron,	.368

The limestone ores are well exposed also, and have been largely developed in the past to supply the Pierce furnace. The principal developments have been made along a line a little south of west and north of east, extending from about a mile east of the river in an almost continuous outcrop to the Hematite Iron Company's openings on the western side. There are five or six narrow open cuts with numerous other test pits, which have fairly demonstrated the continuity of the deposit. The furthest east of these and the closest to the mountain has been sparingly developed, and is reported to have left exposed a face of 33 feet of ore of unusually good quality. The sides of this cut, however, have naturally fallen in from exposure, and this statement could not be personally verified. Here as elsewhere on this range, the dip of the limestones (and with which the ore is conformable) is steeply (50°) south-south-east, and consequently the ore rapidly takes cover. The stripping in this part of the field is quite heavy also, and further west where it is lighter, the walls of limestone enclose the ore in narrow trenches, and the ore itself contains quite an appreciable amount of sulphur in the form of iron pyrites. Otherwise the deposit shows uniformly a rich brown cellular hematite, occurring in the mottled blue and white limestones so characteristically accompanying the lower line of ore-deposits through the New River-Cripple Creek valley. None of these pits along the ravine to the river are at present worked, possibly on ac-

count of the larger part of the cheap ore having been mined, and the increasing amount of stripping necessary to uncover what still remains; but the character of the wash-ore is shown by the following analysis:

Metallic iron,	57.200
Phosphorus,	.074
Siliceous matter,	5.300
Phosphorus in 100 parts iron,	.129

The present workings are situated at the base of a small ridge close to the railroad (which closely limits the operations) and within about a half mile of the railroad station. The trench exposed was about 100 feet long and from 10 to 20 feet wide, the ore itself being about 15′ thick, and yielding now, (March 30,) about one half clean ore in the washer.

The character of the wash-ore at this point is shown by the following analysis:

Metallic iron,	55.775
Phosphorus,	.072
Silica,	5.680
Phosphorus in 100 parts iron,	.129

It is probable that the thickness mentioned above hardly represents the total ore-face that could be obtained by opening up the side hill; for higher on this ridge, towards the pine tree grove, the ore has been found quite to the hill top, where three small shafts, less than 10′ deep, have yielded some excellent brown ore associated with red clay; and samples from the *lumps* exposed show the ore to contain:

Metallic iron,	55.350
Phosphorus,	.030
Siliceous matter,	5.300
Phosphorus in 100 parts iron,	.054

The property extends still for half a mile along the river westward to the ravine leading down to Jackson's ferry; but it has been nowhere developed, and it is impossible to say how far the excellent showing on the river front opposite the Hematite Iron Company's workings may be extended towards the western line. The cost at present of mining these limestone ores is stated at about forty cents per ton; and the property is certainly one of great future promise.

A sample of the *charcoal pig-iron* made at the Pierce furnace shows the following partial analysis:

Silicon,	.387
Sulphur,	.040
Phosphorus,	.144

The *Hematite Iron Company property* consists of 350 acres on the opposite side of the river from Foster's Falls. Until recently this property was owned by Mr. J. P. Sanders; but within the brief space of three months, since the present company commenced operations, developments have been made sufficient to demonstrate the presence of ore through a large portion of the property, and to furnish upon April 1st, some 2,000 tons of superior hematite ore. The principal development on that date showed a cut in the eastern face of the hill some 100 feet wide and about 30′ high. The ore is associated with the same blue mottled limestone as at Foster's Falls and Rich Hill, dipping south-east about 30°, away from the mountain ridge to the north, which is but a continuation of the same axis and measures described as occurring on the Roaring Falls mountain on the east side of the river. The company have an excellent water front nearly a mile long, the north property line running along the crest of Roaring Falls mountain for about half a mile.

So far but little limestone shows in the cut, the operation being conducted upon the rise of the hill, with a continually increasing ore-face, which shows no limestone in place for a considerable distance above the cut. The railroad siding crossing the river by means of a bridge from Foster's Falls to the mine opening, also cuts the ore at a lower elevation, and shows an excellent character of lump and fine wash-ore, extending the upper ore-face first mentioned downwards probably an additional 25 feet.

The character of the wash-ore obtained from this mine is shown by the following analysis of a large sample taken from the stock pile:

Metallic iron,	55.850
Phosphorus,	.068
Siliceous matter,	6.730
Phosphorus in 100 parts iron,	.121

The following additional analysis of a sample taken by

Mr. Jones Wister will show more in detail the general composition of the ore:

Metallic iron,	56.025
Metallic manganese,	.375
Sulphur,	.059
Phosphorus,	.061
Alumina,	.670
Lime,	1.010
Magnesia,	.569
Silica,	5.390
Phosphorus in 100 parts iron,	.109

A narrow ravine, a little to the north of the opening, and heading westward, divides the mountain rocks from the limestone, and closely defines the ore area towards the north. Well up on top of the hill a shaft has been put down 84′ through wash ore; and the territory between this shaft and the large open cut has been cross-cut by numerous narrow trenches along the ravine, demonstrating the presence of paying ore well up towards the top of the hill.

Several additional small pits located still further west on the summit, show an excellent wash-ore; and there seems to be but little interruption to profitable territory as far west as the private road connecting the two Sanders' houses.

About 50 yards from the deep shaft another hole has been put down 42′ deep, slightly more to the south and in somewhat different limestone, and with bottom of shaft still in ore. The ore derived from it shows a slightly more dense character and is very largely lump. The wash-material to be obtained here may not be quite so rich as that being mined at present; and moreover the ore has about 20 feet of stripping at this point.

The quality of the *lump ore* obtained from these shafts is shown by the following analysis:

Metallic iron,	55.125
Phosphorus,	.071
Siliceous matter,	7.240
Phosphorus in 100 parts iron,	.128

Further outcrops show as the hill rises, exposed in narrow trenches until the summit is reached at about 420 feet above railroad grade, where the stripping has increased considerably and somewhat obscures the outcrop.

A small trench has been opened on the south-western

slope of the property, showing a large mass of lump ore, massive and dark brown in color, opened for fully 125 to 150 feet in length along the natural outcrop. The dip of this ore could not be determined, although it is probably southwards and so maintaining the integrity of the basin already mentioned as existing between Roaring Falls mountain on the north and Dry Pond mountain on the south.

A sample of the ore from this cut yielded upon analysis:

Metallic iron,	54.300
Phosphorus,	.139
Siliceous matter,	10.630
Phosphorus in 100 parts iron,	.256

The ore presents a rather peculiar appearance, and might at first sight be considered as very siliceous—for it is full of little drusy cavities lined with quartz crystals. The sample however, was taken from all along the exposure, and it is believed that it fairly represents the average character of the ore. Since examined, this outcrop has been opened up, and a daily shipment of some 20 tons of the ore is now (May) being made.

There is but little reason to doubt the continuity of this same ore deposit through the hill upon the balance of the Sanders property, to the Galena branch; for though undeveloped, a large portion of the territory still owned by him shows an encouraging amount of surface ore.

The *Lobdell company* have purchased, apparently for farming purposes, a small portion (about 40 acres) of the Guy Sanders property, lying immediately west of the Galena branch and in a direct line with the ore properties just mentioned; but so far no developments whatever have been made there.

Continuing directly westward through one field, the ore shows in considerable quantity upon the property of *William J. Raper*, who owns a large tract of land on the north side of the river, about midway between Foster's Falls and the Wythe Lead and Zinc mines. The larger portion of it lies in the area between the forks of the roads uniting near

his house. The ground rises from the river in two prominent hills, divided by a narrow valley, and it is on the eastern side of this ravine that two small six foot holes have been dug through the outcrop. The lower and most western one of these has turned out some rather soft ore, pieces of it somewhat dark and apparently manganiferous. The other, higher on the hill, shows a dense brown-hematite, with a peculiar fracture in plates, and quite different in character from the first shaft, and unique in this part of the field. The two pits, however, are so close together that a general sample was taken at both places to show, if possible, the approximate character of the ore through the whole hill.

The analysis yields:

Metallic iron,	56.350
Metallic manganese,	1.514
Phosphorus,	.103
Siliceous matter,	3.900
Phosphorus in 100 parts iron,	.182

The deposit extends apparently eastward into the Lobdell property; and although the surface outcrop there is not so pronounced, both seem to be upon the same general ore horizon as developed at Foster's Falls and the Hematite Iron Company's tract. All indications point to a favorable deposit upon Mr. Raper's land at least, which is well situated for ready attack; is above any visible outcrop of limestones; convenient to an abundant supply of water for washing purposes along the river front, and it is certainly a property well worthy more systematic development. The ore material is undoubtedly rich and could be readily and cheaply washed.

Mr. John Raper owns property to the west of William Raper and the public road; and while undeveloped, the ore just mentioned probably extends through his land, gradually approaching the river until again well opened upon the Wythe Lead and Zinc Company's property.

The *Wythe Lead and Zinc Company* property proper, comprises a large acreage along New River from the neighborhood of the Jackson farm for probably two and a half miles

west, and extending southward to and across the Wythe County line into the main ridges of the Iron mountain. The property has furnished iron, lead and zinc, although it has been more largely developed for its lead ores than for the other two. The principal opening is almost upon the crest of an anticlinal of white sandy magnesian limestone, a short distance south of the river. Formerly the property was developed by means of tunnels and drifts, which have exploited the lead-bearing limestones for probably a distance of two miles north-east and south-west through the property; but the policy of the company now is to work their valuable deposit by means of open cuts, and with that end in view, they have abandoned all of their underground workings and have concentrated their force of men at the large opening about half a mile south-west of the store and the ferry.

The saddle in the rocks is very well displayed here, and the resulting synclinal on the north passes a short quarter mile north of the river at the ferry, the limestones at the latter place dipping about 50° to the north-west. As far as developments have gone in the large open cut, the lead and zinc deposit shows quite a similarity to the Bertha and Passaic Zinc companies' mines at Barren Springs, although the two latter have as yet no association of lead. The ore occurs here in very similar measures; and the usual features of barren dome-like masses of limestone around and between which the ore material occurs, is as conspicuous here as in the more eastern openings further down the river. As far as could be determined in the somewhat hasty survey of this attractive deposit, the lead (galena) seems to occur in the lower limestones; the silicates and carbonates of zinc occurring slightly higher geologically, although no very definite horizon can be given to either ore-bearing limestone. Some little iron pyrites occurs in the limestone occasionally and some zinc blende.

The most instructive showing of the lead ore is probably at the south-west end of the open cut, where a marked south-east dip of from 30° to 50° occurs in the limestone, and where the ore is plainly visible. Down to the level of the disintegration of the limestone exposed in the open cut, some 25

or 30 feet, the zinc ore occurs associated with a tough red clay, mostly as silicate and carbonate, the bed being fairly well defined and apparently grading into zinc blende and galena as the ore is followed upon the dip. The galena is handsomely exposed in an open shaft sunk from the bottom of the open cut, and at present, March 30th, possibly 125 feet deep. Further additional information concerning this interesting deposit may be derived from the following description of the mines by Prof. J. J. Stevenson,* which is inserted almost without change:

"The ore was discovered and first utilized not far from 130 years ago, but systematic mining has been prosecuted for barely 50 years. The reduction works have a capacity of between 600 and 700 tons per annum, and are of interest, as they were practically the only lead works within the limits of the Confederacy, and yielded nearly all the lead employed in the manufacture of bullets of the Confederate soldiers.

The lead and zinc ores occur in an enormous impregnation deposit. * * *

The conditions in the surface workings are approximately as follows:

1. Gray limestone, ... 25′

The upper part shows a net-work of galena; some excellent blende almost free from galena is found midway; while lower down both galena and blende occur abundantly. The lower half of the rock, which has been digged extensively, is said to contain a large amount of both blende and galena; but it was concealed by a slide at the time of examination.

2. Gray sandy limestone, ... 10′

This appears to be barren.

3. Ore.

This consists of carbonate and silicate of zinc, associated with much galena. The calcareous matter has been leached out, and the ore is in irregular honeycomb masses.

4. Limestone, evidently barren, ... 9′

5. Ore, ... 8′

The conditions are the same as those in No. 3.

6. Limestone, gray, ... 25′

This contains a very large amount of blende and galena, but the ore is not sufficiently concentrated to make working profitable.

7. Ore, ... 2′ to 10′

The conditions in this are the same as in Nos. 3 and 5. The deposit shows more irregularity than was observed in the others.

8. Limestone, apparently barren, ... 10′ to 12′

9. Ore, ... 6′ to 10′

Here too the calcareous matter has been removed and the ore, which consists of zinc silicate and carbonate, with only a trace of galena is cavernous.

10. Limestone, barren, seen, ... 5′"

*Transactions of the American Philosophical Society, March 18, 1887.

From this main opening the outcrop has been developed at various places for one and a half miles north-east and south-west, or from the Fulton farm to and beyond Bunker hill. A considerable amount of zinc ore was obtained from some open cuts on the south side of Ball knob, where, under a former lease to Mr. Noble, a very large portion of the cheap ore was removed by a somewhat destructive method of mining, the operations being mainly confined to securing the lump ore and leaving the wash. At present the company have on hand probably five or six thousand tons of zinc ore awaiting the extension of the railroad or the erection of furnaces upon the ground, as there are no facilities for either roasting or shipping the ore at present.

It is claimed that the old tunnel developments cross-cut three different ore-bearing limestones 30 feet apart, upon a south-east dip of about 50°, or possibly 50 feet apart vertically; and it is said that all three beds or "veins" come together at some point about a mile to the south-west of the open cut. The foot-wall seems everywhere to be a hard, somewhat brittle, white magnesian limestone. None of these old openings were open for inspection; but there seems to be no doubt of the continuity of both the lead and zinc bearing limestones at least as far west as the Ivanhoe and Quesenbury properties, 3 or 4 miles distant, on the west side of the river. At present all the pig lead obtained in the reduction furnaces is conveyed to Foster's Falls for shipment.

The iron ore so far *developed* upon this property is very limited, as no facilities for shipment exist, and the company have never thought it worth their while to pay much attention to this ore in the presence of lead and zinc. Quite a prominent and a very rich outcrop, however, extends north-east and south-west on a course fairly parallel to that of the lead and zinc, but a short distance to the north of those deposits, and a considerable amount was developed in shafts formerly sunk for lead. The quality of the material developed in the few shafts and pits already sunk is above the average of the iron ores of these lower rocks, although nothing can yet be said as to the amount of ore that may be taken from this portion of the property.

Samples were taken from two small cuts on the south-western flank of Ball knob, the limestones associated with the ore there dipping about 30° to the south-east. The material was very rich, and the ore showed a somewhat open, porous mass, which would yield richly in the washer. The same ore extends on south-west through Bunker hill and the Lewis farms, and is no doubt to be associated with the extensive deposits starting from the Ivanhoe property and continuing for several miles westward.

The analysis shows:

Metallic iron,	56.050
Phosphorus,	.051
Siliceous matter,	4.220
Phosphorus in 100 parts iron,	.090

Samples, 115 pieces, were taken (in 1883) from the loose surface ore extending over quite an area. They yielded on analysis:

Metallic iron,	53.925
Phosphorus,	.105
Siliceous matter,	5.400
Phosphorus in 100 parts iron,	.194

The mountain ore has been opened for inspection at one or two places close to the county line, at the base of Iron mountain ridge. The outcrop is quite bold; and in a ravine a few hundred yards west of the public road leading over the mountain, quite an exposure of this ore has been made, possibly 20 to 25 feet thick, along the bank of a small stream. It is somewhat impaired by a mixture of siliceous matter separating richer portions of the ore-bed and also associated with the ore itself; but barring this objection, the circumstances all favor the presence of an excellent ore-bed and one which will furnish a large amount of cheap ore in future development.

Two samples were taken for analysis. 1. Lump ore from several pits sunk in a flat along the base of Poplar Camp mountain about 2 miles south-south-east from Austinville. 2. Lump ore from outcrop in ravine west of Sisk's house and a few hundred yards west of sample No. 1, on the Col. John Jackson 110 acre tract. These yield on analysis:

	No. 1.	*No. 2.*
Metallic iron,	49.450	43.750
Metallic manganese,	2.854	——
Phosphorus,	.530	.878
Siliceous matter,	10.020	20.910
Phosphorus in 100 parts iron,	1.071	2.006

Two miles north-east from these openings there is a conspicuous outcrop of the mountain ore along the base of Poplar Camp mountain, on the Gallimore property—the mineral right being owned by the Wythe Lead and Zinc Co.—and samples taken at this point (in 1883) show the ore to contain:

Metallic iron,	49.550
Phosphorus,	.179
Siliceous matter,	13.710
Phosphorus in 100 parts iron,	.361

But a small proportion of the Wythe Lead and Zinc Company's property was examined, our attention being largely confined to the places where the greatest and most active developments had been made; but whether we judge from what has already been done or what is still to be done in the future, this property should certainly afford a rich field for prospecting; and unless all signs fail, a very large development of all the three classes of ore already spoken of is to be expected. At present, mining is carried on in a rather perfunctory manner, and, as already stated, the attention of the Company is almost solely directed to the mining of lead ore and its reduction to pig lead. A new tramway has recently been constructed from the opening to the washers upon the river, and a favorable grade suffices to deliver the ore at the works with great celerity and cheapness. Once arrived there, the ore is passed through a Blake crusher with a capacity of 80 tons in 24 hours; then through a pair of Cornish rolls, from which the crushed material passes directly to the washers, and after cleansing there, the washed ore is elevated by buckets to three sets of screens where it is graded into four different sizes. From there it passes to the jigs, the coarser material not passing through the largest size screen being returned to a closer pair of Cornish rolls where it goes through the process once more. After being first dumped

into the Blake crusher, the operation is entirely automatic. The screens have a mesh of 5 m. m., 3 m. m., and 2 m. m., corresponding to the size of the jigs. After jigging, the material finally passes into a hopper, the waste being carried off through sluice boxes and the different sizes of galena passing to a water sump and there collected for the retorts. The finest grade is roasted in a reverbatory furnace into a matte, and taken to a Scotch hearth for smelting. The product of the works is from 20 to 25 pigs of 56 pounds each per day of 10 hours.

The following analyses will suffice to illustrate the quality of the lead and zinc ores.

No. 1. Sample of *lead ore, second separation.* Crude ore yields about six per cent. similar to sample. An analysis shows:

Metallic lead,	65.836
Metallic zinc,	5.408

No. 2. *Concentrated zinc blende.* Crude ore yields five to six per cent. similar to sample. It contains:

Metallic zinc,	32.797
Metallic lead,	10.090

No. 3. *Concentrated zinc silicate and carbonate.* Crude ore yields about thirty per cent. similar to sample. An analysis shows it to contain:

Metallic zinc,	36.368
Metallic lead,	5.629

The same decomposed magnesian limestones occurring at the Lead Mines pass south-west through the Lewis and Sharp places to New River just above Porter's ferry, where they again create the crest of an anticlinal and show the same dome-like masses impregnated with zinc and lead and associated with heavy iron ores. Neither of the farms between the Wythe Lead Company's property and New River have been at all developed; but the outcrop tells the story with a fair amount of distinctness, and certainly warrants some more active development.

The *George T. Lewis* property, consisting of 412 acres, the surface of which is owned by Mr. Simmerman, fronts along

New River for nearly a mile, a little below Ivanhoe furnace, and extends southward nearly the same distance. In shape it is nearly a parallelogram, being separated on the west from the Ivanhoe property by a small strip of land along the river owned by J. Sharp and others. The property is entirely undeveloped, although containing quite a profuse outcrop of iron ore, extending in seemingly parallel deposits in a north-east and south-west direction.

The first and most northern of these begins on the river opposite the Jackson place, and extends with more or less continuity across the property to the Simmerman farm house and the small branch which enters the river near here. The two best outcrops on this line of ore are those close to the river and near the Lead Mines tract on the east. At the latter place some slight shafting was done several years ago in quest of zinc and lead, one shaft having turned out quite a large amount of good material. A general sample was taken from lump ore at this place and near the river, with the following results upon analysis:

Metallic iron,	55.750
Phosphorus,	.061
Siliceous matter,	4.810
Phosphorus in 100 parts iron,	.109

Some little distance further south, another line of ore, locally known as the "zinc and lead outcrop," has also been developed by two or three shafts, the result of which has been a small amount of zinc and considerable iron ore. The records of these shafts could not be obtained; but the one located near the center of the property is said to have been 50 or 60 feet deep, and a considerable amount of material has been thrown out from it. The other shaft 40 feet deep, is situated on the eastern side of the small ravine and between it and the Lead Mines tract. Here quite a large amount of good iron ore was developed, both in the shaft itself and in several small pits located in a bunch near by. The outcrop too, at the latter place, was quite prominent, and there can be but little doubt that both localities are to be associated with similar ores found on the Lead Mines tract, which have been more or less developed from the main opening there

westward to the Lewis line. The territory between the two shafts presents a rather scant outcrop; but the same ore shows between crevices in limestone rocks along the New River on Mr. Sharp's place, and the continuity of the deposit through the Lewis farm may be reasonably expected, although only a thorough testing can assure this to be the case.

The character of the ore is shown by the following analysis of samples taken from the outcrop and from several shafts:

Metallic iron,	56.775
Phosphorus,	.031
Siliceous matter,	4.120
Phosphorus in 100 parts iron,	.054

A third line of ore, locally called the "Apple Tree deposit" (from the fact that two such trees situated high on the hill fairly indicate the line of ore) may be traced along a nearly parallel line some two or three hundred yards south of the last mentioned deposit. Quite a profuse outcrop covers the hill on top of the river bluff close to the Sharp line on the west, there being several acres well covered with an extensive deposit. The limestones in the bluff here dip gently about 10° north-west.

Eastward the hill rises steadily for perhaps 250 yards, but the outcrop ceases almost entirely near this point, and any ore to be developed in the future must necessarily lie beneath considerable overburden. Along the slope facing the branch creek on the west side, the hill is considerably scalded, showing barren spots almost devoid of vegetation and yielding more or less fine wash-ore; but to the east of the branch the territory is very flat and the outcrop not visible. All the ore seen along this belt of country shows an excellent character, fully up to the standard of the best Cripple Creek ores; and it needs but the testimony of a few well directed shafts to demonstrate whether this outcrop extends to a mining depth. The topographical features here, as elsewhere, through this tract, are all favorable to the presence of such a commercial deposit, the hills being almost entirely free from visible limestone outcrops, except along the river bluff and in a few places along the branch stream on the east. A general

sample of this line of outcrop was also secured, largely from the territory contiguous to the Sharp line, where the outcrop is most distinct, which yielded the following results upon analysis:

Metallic iron,	56.900
Phosphorus,	.075
Siliceous matter,	4.930
Phosphorus in 100 parts iron,	.131

It is fairly probable that these three last mentioned lines of deposits may be eventually proven to belong to practically the same horizon of limestone rocks. The structure along the river would seem to indicate such a duplication of measures, a fact further re-enforced by the presence of an anticlinal axis passing directly through the Lead Mines opening, causing a duplication of iron ore deposits there on either side of the rock, which if extended westward, should pass in the vicinity of the two shafts located on the "lead and zinc outcrop."

A fourth belt of ore, generally parallel to the last in direction, extends through the property from the south-west corner with almost uninterrupted distinctness to the small stream on the eastern side, and presents by far the most attractive and plentiful outcrop of iron ore on the property. Between this deposit and the last one described there occurs a distinct anticlinal roll in the lower limestone measures, scarcely visible upon the river, but very distinct on the branch stream, where a bluff on the eastern side exhibits the rocks with dips of about 15° north-west succeeded a short distance south by similar south-east dips, the latter increasing in strength to about 35° in approaching the Gray line about 300 yards further up the stream. Between the creek and the river bluff there is practically no interruption in the outcrop, which presents lumps of varying sizes, some quite large and cellular and more or less associated with red clay, but all of good quality. This line of ore is no doubt the same as that which outcrops on the western side of the river in magnesian limestones on the Painter farm; and should this handsome surface-showing be found to continue in depth, there can be but little doubt that a large tonnage

will be won from this part of the property. In places the outcrop is a couple of hundred yards wide; and as the hills carrying it are almost entirely free from outcrops of limestone, a good working face of ore should be secured anywhere between the western property line and the small branch on the east. East of this stream the anticlinal axis before mentioned increases rapidly in strength, and may probably carry to daylight the ore-bearing limestones, and expose the underlying Potsdam sandstone rocks on its crest before the eastern property line adjoining the Lead Mines tract is reached. A general sample of this ore was taken through the entire length of the deposit, and it will fairly represent the character of the surface ore through this portion of the property. The analysis yields the following result:

Metallic iron,	55.200
Phosphorus,	.075
Siliceous matter,	6.500
Phosphorus in 100 parts iron,	.135

The *Gray farm* lies to the south of the Lewis tract; and though largely made up of the Potsdam sandstone measures, there is contained within its boundaries quite a proportion of the lower limestones, and it is quite probable that the anticlinal axis just described will cause a duplication of the ores last described on the Lewis farm. No developments have been made on this property, although the outcrop is quite distinct.

The *Ivanhoe property* of the New River Mineral Company lies just west of New River where it makes its right angle bend at Porter's ferry, and extends for possibly a mile and a half still further west along Painter creek. Some recent purchases have added considerably to the area of the tract examined by us in the winter of '86, the property then comprising about 475 acres, separated from Painter creek on the north by a strip belonging to the Lobdell Company, and extending south to what is known as the Back road, leading along the flank of Ewing's mountain to Cripple creek near George Simmerman's house.

A small strip of land belonging to this company extends from the public road eastward to New River, upon which tract the furnace is located; and the company likewise own the small piece of land on the north side of Painter creek through which the railroad extends. There has been but little ore found on this portion of the hill north of the ravine, and all the four pits so far put down were rather barren of results; and if the ore is found at all there, it will be under at least 20 feet of stripping. But in the draft at the base of the hill, there is a good showing of wash-ore associated with magnesian limestones, and coincident with the excellent showing along the tramway leading directly to the open cuts where the principal supply of ore for the furnace was obtained in the past. This cut shows the ore occurring closely interbedded with the magnesian limestones dipping N. 40° W. 20° to 25°. The ore has an open, shelly character, and has been dug from between and around limestone boulders. The open cut is not very extensive, but nevertheless has furnished a large amount of ore.

It has not been worked for some years, and the following, written in 1883, will perhaps suffice for a description of the workings:

The present working face is one hundred and fifty feet long and twenty-five feet deep. Occasional noses or ledges of limestone come in and cut out the ore, but at present these are insignificant. The ore material washes one third to one half clean ore. So far as the ore territory has been proven—some ten acres—about an average of one third is lump ore, but at some points practically the whole of the ore is lump.

In addition to the workings above mentioned, tunnels have been driven in an east and west direction for one hundred and fifty feet, and in a north and south direction for a distance of three hundred feet. But few limestone boulders were encountered in these drifts. At deepest point the tunnel is forty-five to fifty feet from surface.

Ore was taken out from these tunnels until it was deemed cheaper to open out the bank to daylight on the tunnel level; and since that time much cheap ore has been taken

from this open work. As is usual in limestone deposits, there is a greater proportion of solid limestone to the ore-bearing mass on the lower level than was found above. The ore bank is now yielding a full supply of ore for the use of the furnace at a very low cost, and the prospects are favorable for their continuing to receive such supply for a long period.

Ore is said to have been proven to a depth of one hundred feet; but average developments are not over twenty-five feet. In the deeper workings occassional masses of iron pyrites are encountered; and at some points on the property there are good indications for both zinc and lead.

At present there are two single shaft washers—one at the furnace and one at the ore bank. That at the furnace is twenty-two feet long, and has a daily capacity of twenty-five tons. The one at the ore bank—now being used—is thirty-two feet long, and has a daily capacity of thirty-five to forty tons of clean ore. A small stream flowing alongside of the ore deposit furnishes water for washing, but in dry seasons it does not yield a sufficient supply. A well sunk near the washer to a depth of twenty-five feet struck a strong supply of water, sufficient for all present purposes.

The lump ore is generally roasted before being used; but the stock supplied to the furnace is nearly all wash ore. Separate analyses were made of each.

A sample of the *lump ore*, two hundred and fifteen pieces, was selected from small ore piles at the different openings. It yields the following analysis:

Bisulphide of iron,	.064
Protoxide of iron,	.047
Sesquioxide of iron,	80.618
Sesquioxide of manganese,	.103
Oxides of nickel and cobalt,	.060
Oxide of zinc,	.150
Oxide of lead,	.184
Oxide of copper,	Trace.
Alumina,	1.476
Baryta,	None.
Lime,	.750
Magnesia,	.515
Sulphuric acid,	.092
Phosphoric acid,	.110

Water,	11.174
Siliceous matter,	4.500
	99.843
Metallic iron,	56.500
Metallic manganese,	.072
Sulphur,	.071
Phosphorus,	.048
Phosphorus in 100 parts iron,	.085

A sample of the *wash-ore*, consisting of fifteen pounds, was selected from different parts of the ore pile at washer. It yields:

Metallic iron,	51.600
Phosphorus,	.068
Siliceous matter,	8.810
Phosphorus in 100 parts iron,	.131

Two samples of the *pig-iron* made at different dates were analyzed with the following results:

Silicon,	2.640
Sulphur,	.040
Phosphorus,	.124

A second sample, made two months later, shows the following:

Carbon, combined,	.733
Carbon, graphitic,	2.950
Silicon,	2.074
Sulphur,	.020
Phosphorus,	.166
Manganese,	.194
Iron, (by difference,)	93.863
	100.000

The blue mottled limestone, so frequently identified as an ore horizon in the country lying further east, crops here immediately back of the workings, and extends along a ravine westward with a dip of N. 25° W. 48°, and has been extensively quarried for furnace use. North and above this geologically, on the south flank of the ore hill, an excellent showing of wash-ore crops and has been tested considerably through a series of fields west to the Porter's ferry road. One hundred yards west of the open cut, the first shaft, 31 feet deep, struck ore under 8 feet of stripping, and was continued

the balance of the distance through rich wash material. The ore territory is probably 200 yards wide on this hill; and a sample of the material from the sides and bottom four feet of this shaft was taken, weighing originally 92 pounds as it came from the pit, and yielding, by weight, 38 pounds of washed ore, or about 41 per cent. Its analysis shows:

Metallic iron,	56.775
Phosphorus,	.060
Siliceous matter,	4.580
Phosphorus in 100 parts iron,	.105

All along the ravine westward between the two principal ridges the surface showing is excellent and it can be followed nearly to the Hendricks house.

On the south side of the ravine ore has likewise been developed in a somewhat lower limestone, a 12 foot shaft on the north-east end of this hill, not far from the public road, showing some excellent ore associated with red clay. A sample of the lump ore taken from this pit gives the following result upon analysis:

Metallic iron,	52.750
Phosphorus,	.094
Siliceous matter,	7.460
Phosphorus in 100 parts iron,	.178

Between the public road and the river, and lying east of the southern portion of the Ivanhoe property, the R. F. Jackson, the Eversole and the Walters tracts show more or less indications of ore until joining the Painter tract on the south. One or more of these properties have been included in the purchase recently consummated by the Ivanhoe Company. Between the ore-bearing territory extending west from the main open cut and the line fence marking the northern side of the property and dividing it from the Lobdell tract, some considerable zinc has been mined in former times. Indeed it was for this ore that the property was originally bought; and it has only been within the past few years that the development of the property for iron has completely taken the place of the original zinc developments.

The *Painter farm*, lying about a mile south of Ivanhoe furnace and west of New River and across the county line,

shows a limited amount of development at a distance of about half a mile from the river, and in limestones low down in formation No. II, a short distance north of the base of Ewing's mountain. The ore is largely found between limestone walls, dipping conformably with the rock towards the north-west, and extending along the strike for a considerable distance. The magnesian limestone of No. II outcrops in a low but sharp ridge by itself, a small ravine intervening between it and higher limestones on the north, and also another ravine on the south dividing it from the Potsdam sandstone formation. The measures on this, the south side of the synclinal, have a dip of about 40° to the north-west, and it is on the south side of the magnesian limestone hill that the ore outcrops conspicuously in three rather well defined beds, separated from each other by some 15 to 20 feet of impure limestone. The upper deposit practically marks the crest of the ridge, but is evidently quite thin; the middle one is some 20 feet geologically lower, and though sparingly opened shows a thickness of about 8 feet, from which quite an appreciable amount of ore has been thrown out from a preliminary test pit, until the rapidly dipping ore-bed got beneath too much cover to warrant further prospecting on the dip. The ore has mostly a light yellowish-brown color and occurs sometimes as a spongy, rather porous mass, and also in rather thin plates.

The character of the ore is shown in the following analysis:

Metallic iron,	48.775
Phosphorus,	.079
Silica,	10.940
Phosphorus in 100 parts iron,	.162

This ore horizon is reported to have been opened a considerable distance to the west along the ravine; but this statement lacks confirmation by development, and is highly improbable on account of the rapid wedging of the deposit as seen by traveling up the stream. Some development has been made, possibly one and a half miles south-west of the Painter opening, just at creek level and in the mountain ore;

but no material worthy of the name of ore has been won at this point, most of that thrown out showing a white and yellow quartzite rock coated with a thin film of iron oxide. This little stream possibly marks the course of a tight and narrow synclinal between two anticlinal spurs of the main ridge, here called Farmer's mountain. To the north of this stream the Ewing mountain rises, showing first the drab-colored slates of the upper Potsdam formation folding gently around its eastern base, about a mile and a half from the river, and in all respects resembling rocks of the same horizon on New River south of Rogers' house.

At this latter point (Rogers) two miles south of Ivanhoe on New River, there is good evidence of the presence of a fault bringing the upper Potsdam slates upon a nearly vertical dip against the lower magnesian limestones dipping north-west at angles of 40° to 60°, brushed up to a rather steeper dip near the immediate line of the fault. Certainly no signs of the Cambrian red slates appear here; and if they are to be placed beneath the limestone at Rogers' house (which seems to be justified by correllation of the geology on the north side of the basin along Lick mountain,) there would be a vertical displacement of perhaps more than a thousand feet at this point, and the partial concealment of the ferriferous slates of the Potsdam formation on the south side of the fault. However, the upper Potsdam measures are seen upon a nearly vertical dip outcropping for nearly half a mile southward up the river, mixed with thin sandstone beds, sometimes showing a dip of from 50° to 60°, but generally standing near the vertical.

Going north from the fault, down the river towards Ivanhoe, the incipient steep dip to the north of the limestone is soon followed by a tight synclinal crimple, and this in turn by a narrow saddle again reversing the dip towards the north. For nearly three quarters of a mile across the measures, the limestones dip towards the north with gradually lessening angles, until another synclinal basin is met with a short distance south of Sharp's house. The south dip, however, is of short duration, for in the vicinity of Sharp's house the measures turn quickly to the north-west, with dips gradu-

ally rising from 15° to 50°, and continue on this dip to and beyond the bend in New River. The whole section from the mountain to this point, a distance of nearly two miles, does not comprise a thickness of more than 400 or 500 feet of limestone, apparently associated with the lower portion of the Cambro-Silurian formation.

Along the Old Town road the Potsdam slates, as before mentioned, rise to the north-west and arch over Ewing's mountain, standing vertically, however, along the north base of Farmer's mountain. This Ewing mountain is but the commencement of the important anticlinal axis which, rising at this point, steadily increases in strength and brings to daylight lower measures for possibly three and a half miles from the river, where it begins to subside in the same direction, crossing Cove creek about a mile and a half south of Raven Cliff furnace, where its arch is still covered with the Potsdam formation, and where the ridge west of the creek becomes known as the Raven Cliff mountain. In another mile Crab Orchard creek is passed, and the subsidence has become so great as to admit of a considerable area of the Knox red slates of the limestone formation to appear in all the territory west of that stream to and beyond Cripple creek. These slates at this point seem to form a double ridge, the most southern prong of which extends in a very straight east and west line, exposing south dips, sometimes as steep as 85°, but with more gentle north dips on the north side of the axis. This ridge makes a marked feature in the topography of the country, being cut through by Cripple creek near the mouth of Mill branch, and subsiding in another mile westward along Thorn branch, where higher limestones are seen.

Along the Porter's ferry road curving along the north-east base of Ewing's mountain, successive crimples in the lower limestone measures are passed over, roughly corresponding to those exposed along the river, except that the dips most seen lean to the north-west. The main synclinal of the region lies considerably to the north, passing through the high hill north of Painter's creek, touching the forks of the road near George Simmerman's house, and the first ford of the creek to the west. It then takes up the general line

of Cripple creek going westward, passing between the Sampson and Alexander Painter farms, and expiring, as before mentioned, in Gleaves' knob. Here, just north from Eagle furnace and near the junction of the Fisher branch and Cripple creek, a cliff of the lower blue and white mottled limestones 100 feet thick shows with a very flat dip, sloping nearly due east as the basin spoons out in the knob on the west side of the creek. Here too it has already been said the Carter valley fault expires, so that Gleaves' knob which perhaps, is topographically the most conspicuous feature in traveling westward up the New River and Cripple creek valley, becomes likewise one of the most important geological features, marking as it does the western boundary of the two prolific ore basins which extend regularly westward from the New River bridge. The geology of this knob is made rather obscure by reason of the blending of so many structural features within its boundaries; but the eastern side, facing Fisher's branch, undoubtedly contains the lower limestone measures, which in turn are encircled further west by the Knox red slate measures still lower in No. II.

Pierce Mill property. (New River Mineral Co.) The ore developments west from Ivanhoe are very meager. The Ivanhoe furnace property ores all expire with the synclinal trough holding them against Ewing's mountain; but they come up again with steep south-east dipping limestones along the north side of the basin, where some excellent ore is exposed through a considerable area on the Pierce mill property. This property, consisting of some 500 acres, has been recently purchased by the New River Mineral Company, who no doubt will develop it in connection with their ore lands in its vicinity. When visited, in December, '86, only two small openings sufficed to expose the ore which, however, had an ample outcrop along the southern slope of the hill facing the mill on Cripple creek. Samples were taken from both of these pits, one (*a*) situated close to the road leading from Simmerman's to Pierce mill, and the other (*b*) close to the line fence dividing this property from the J. Simmerman land on the east. These samples give the following results upon analysis:

	a.	*b.*
Metallic iron,	51.800	56.900
Phosphorus,	.030	.148
Siliceous matter,	5.140	5.700
Phosphorus in 100 parts iron,	.058	.260

The *Quesenbury property* adjoins the Ivanhoe lands on the south-west. It lies on the south side of the basin and contains both the limestone and the mountain ores. Neither of these deposits have received any attention whatever, the former showing a profuse outcrop along the Porter's ferry road, going west from the Quesenbury house, and the latter reported as showing an extensive outcrop some little distance south of the road along the base of the mountain. Some old zinc developments have likewise been made in north-west dipping limestones at the edge of the woods, 200 yards north of the road. Quite a respectable amount of ore was mined at this point by Mr. Noble; but its extraction under the methods pursued must have been quite expensive. It is no doubt associated with the same horizon of ore already traced from the Wythe Lead and Zinc mines west through the Lewis, Sharp, Ivanhoe and Lobdell properties lying further east.

The *Lobdell property* lies next west of Quesenbury along the Porter's ferry road. This property also runs back to the mountain, but it has a large proportion of limestone lands through which a fair amount of surface outcrop is visible. No effort, however, has been made to develop this property in any form, and it is not possible therefore, to say how far the somewhat attractive outcrop will hold good beneath the surface of the ground.

The *Chadwell property* (George Simmerman) joins Lobdell on the north and west; wholly contained within the limestone basin, and as yet but little more developed than the property last described. With the possession of an excellent frontage along Cripple creek, and fairly within the range of ore-bearing limestones; favored in many ways for cheap development; overspread with an exceedingly attractive showing of brown hematite ore of good quality, it only remains for a little de-

velopment here to demonstrate the value of the property. The only opening in the iron ore-deposit which could be found lies close to the Porter's ferry road, about a half a mile south of the creek. Even this had fallen entirely shut, so that nothing could be seen of the character of its ore-faces; but in a former visit, four years ago, this pit was sampled, the results of which are shown in the following analysis:

Metallic iron,	56.500
Phosphorus,	.145
Siliceous matter,	4.570
Phosphorus in 100 parts iron,	.256

In the rear portion of this property some rather ferruginous manganese ore outcrops east and west of the road, and near the crest of the small ridge dividing Painter's creek from Cripple creek. No openings have been made on this ore either, so that nothing can be stated definitely as to its quality or quantity.

The *Sampson property* of 350 acres joins the Chadwell on the west, lying on the south side of Cripple creek and about four miles in an air line from Ivanhoe furnace. The limestones cropping all through this property always show a north-west dip, and through a large portion of the tract they come to daylight and cut out the ore. The southern portion of the tract lies close to the base of Iron mountain, but does not extend far enough south to contain the horizon of the mountain ore deposits.

The same manganese ore referred to as outcropping on the Chadwell tract has been opened here in two or three narrow trenches, sufficiently deep, however, to obtain samples from. Two of these openings are close to each other in the woods near his eastern property line, and both show a similar character of ore. The material from them gives about one fifth lump-ore; and the entire deposit might wash 40 per cent. of clean ore. To judge from the dimensions of an old opening at this point, the ore must have obtained a considerable trial in some of the old furnaces of the valley many years ago; but in the presence of the richer iron-ores of the valley this ore must seek different markets.

Samples of both the lump and wash ore were taken from this locality, yielding on analysis:

	Lump.	*Wash.*
Metallic iron,	6.700	5.075
Metallic manganese,	37.314	35.835
Phosphorus,	.102	.103
Silica,	15.070	16.610

The third opening is situated on the top of a small limestone knob about 100 yards west from the main development. The ore thrown out here is limited, and it was not deemed necessary to sample it. To the north of the ravine separating this hill from the creek ridge, the best outcrop of *iron ore* shows.

A sample taken in 1883 shows it to contain:

Metallic iron,	52.275
Phosphorus,	.113
Siliceous matter,	8.020
Phosphorus in 100 parts iron,	.216

A qualitative test shows the presence of maganese in quite appreciable quantity; but it has not been thought necessary to determine the percentage.

The results of five shallow shafts, none of them over 10 feet deep, were not at all favorable to the presence of a commercial ore-deposit here, unless beneath considerable stripping. These shafts were located as far apart as possible so as to best develop the 40 or 50 acres contained in the north-eastern corner of the property. The limestones showing on their basset edges along this ravine on the south, extend through the hill on a gentle north-west dip and create bluffs along the creek below Sampson's house, so that at best but a limited portion of the top of the hill could be expected to furnish commercial ore. To the west of the ravine and his house, these same features are largely duplicated, and no further development has been attempted in advance of our examination. The ore-basin through this part of the field is necessarily quite shallow, and is rapidly growing more so as the spoon end of the synclinal is reached near Eagle furnace. The territory between Sampson's and this point on both sides of the creek, through the Painter farm and the Whitmel tract, west of Sampson on the south side of the creek, shows in

places a fair amount of surface ore; but no recent development has been made in this part of the field, and it is unlikely that a large ore-body can be obtained free from limestone masses in this constantly narrowing boat-shaped trough.

The *Old Field bank* (Crockett & Company) is located about half a mile south-east of Eagle furnace, and in the upper limestones. Only the Whitmel property of 160 acres, running from Cripple creek southwards to the base of the mountain, and carrying a fair amount of surface ore towards the southern side, separates the Sampson and another small property on the east from Crockett & Company's land. The latter property extends westward as far as Cove branch, and from there to Gleaves' property, and takes in a large portion of mountain land on the south.

The Old Field bank, now entirely abandoned, shows a pit about 10 to 15 feet deep, 100 feet north and south, and 75 feet east and west, of which area nearly one third is occupied by limestone knobs. The general character of the deposit here is a fine shot-ore, quite rich, but with no great depth to it. The limestones are dipping very gently northwards, and consequently carry the ore-crop southwards over a wide area; but all the openings show a very shallow deposit, and the work done through a large part of the hill seems to have been entirely confined to obtaining cheap ore from shallow surface workings. All the ore had to be carried to Cripple creek for washing, so that only the richest portion of each opening could be economically mined.

The character of the ore is shown by the following analysis of a sample obtained (1883) from the stock pile at Eagle furnace:

Protoxide of iron,	None.
Sesquioxide of iron,	81.142
Sesquioxide of manganese,	.268
Sesquioxide of cobalt,	.060
Oxide of zinc,	.020
Alumina,	1.510
Lime,	.370
Magnesia,	.720
Sulphuric acid,	.065

Phosphoric acid,	.293
Water,	11.014
Siliceous matter,	4.835
	100.297
Metallic iron,	56.800
Metallic manganese,	.187
Sulphur,	.026
Phosphorus,	.128
Phosphorus in 100 parts iron,	.225

Huddle property. This property lies immediately north of Cripple creek and east of Eagle furnace, and directly opposite the Crockett & Co. tract last described. It might have been appropriately discussed in connection with the line of ore-deposits extending from New River, at Carter's ferry, westward to Gleaves' knob, and contained between the two prominent red slate ridges lying north of the river and Cripple creek—inasmuch as the southern slate hill, marking the line of fault, dies out near Eagle furnace and permits the limestone measures on either side of it to come together in one basin.

This portion of the Huddle farm facing Gleaves' knob, lies well within the center of the basin; and practically through a large portion of it the only dips noticed are eastward ones, due to the general westward rise of the synclinal axis. The developments here are two old, small and shallow pits, sunk upon a deposit of manganese-ore, of which there is a fair amount of surface outcropping on the crest of the hill. The openings are about 200′ above the creek and are therefore somewhat inaccessible. Limestones form high bluffs both on Cripple creek and Fisher's branch to the west; but above them a considerable portion of the hill top to the eastward rises clear of all visible outcrop, and consequently admits of the presence of a large body of free clay soil, with which the ores are associated. The manganese ore occurs as black oxide, generally in small lumps; and while the developments are very meager, yet as far as could be seen both pits showed a considerable proportion of wash-ore. Inasmuch as the quality of the ore as shown by the analysis below is really quite good, and so little of this desirable ore has as yet been

found throughout the region, the circumstances should warrant further systematic development of this territory: for abundant facilities exist near at hand for washing the ore material; in addition to which the Cripple Creek railroad is designed to run quite close to the property by either of the alternate lines proposed.

Samples of the ore from both pits show as follows:

Metallic iron,	2.550
Metallic manganese,	46.215
Phosphorus,	.118
Siliceous matter,	3.010

On the south flank of Gleaves' knob, only about 150 yards up the hillside from Crockett & Company's saw-mill on Cripple creek, a limited amount of excellent iron-ore has been found on *Capt. R. H. Gleaves' property*, and in several pits on the small piece of land owned by *Crockett & Company*, lying a little further eastward.

The ore in the L-shaped trench opened by Captain Gleaves, shows a considerable mixture of boulder wash, although in places the ore rises well to the surface. The ore itself is quite cellular in character, and mixed within and without with red clay. A sample of the lump-ore from one or two pits here gives the following results upon analysis:

Metallic iron,	55.600
Phosphorus,	.163
Siliceous matter,	6.960
Phosphorus in 100 parts iron,	.293

This locality seems to mark the western extension of the limestone measures, as the Potsdam sandstones completely encircle it and are found rising up the hill, until cut off by the fault before mentioned, permitting other limestones to outcrop on the north side of the hill.

The ore on the Crockett place a little further east from Gleaves' seems to occur at about the same horizon, although some of it appears more dense and is more or less associated with quartz. One pit ten feet deep seemed to carry eight feet of clay at the bottom, almost entirely devoid of wash-ore. An old opening a little further west and further down the hill, yielded some fair material; but the ore is conspicuously

marked by cavities holding drusy quartz. It is, however, within limestones, dipping south 15° east 20°. No large amount of ore need be expected from this locality; for owing to the contraction of the limestone basin holding the ore and the faulted condition of affairs a little to the north, it is extremely doubtful whether any commercial deposit could be uncovered.

Before continuing the description of properties lying west of Gleaves' knob and in the upper Cripple Creek ore basin, it would seem proper to first take up those which occur along the northern side of the general river basin, from the place where the synclinal trough was first divided by the ridge of slate occurring within its limits.

In the early part of the report, attention was called to the existence of a range of ore-bearing limestones extending from the vicinity of Carter's ferry for 14 miles south-west to Gleaves' knob near Eagle furnace. It was then stated that this field of limestone was cut off and separated from the main New River-Cripple Creek valley, by reason of a fault along the southern side of the northern valley, which duplicated lower rocks of non-ore-bearing measures. An inspection of the map and its coloring will sufficiently explain this feature, and will also show how narrow but how sharply defined this little ore-bearing limestone valley is. From Carter's ferry all the way to Eagle furnace, nothing but south-east dips are seen; and while the limestones themselves frequently project in forbidding outcrops in many places between these two points, yet, in the region considered as a whole, a large amount of ore will no doubt be mined. There is but little difference in the character of the ore from one mile to another, and nearly all is to be referred to an upper limestone horizon above the red slates occurring near the base of the limestone formation. The largest developments yet made have been close to the river and in the neighborhood of the Walton furnace; and both places well show the character and manner of occurrence of these ores.

While in places the topography is such as to preserve for future attack a large amount of readily moved ore-material,

yet operations in this part of the region must anticipate more or less difficulty from the occurrence of limestone in the ore deposits.

The *Graham property* is the first developed on the eastern end of this belt, and the "Carter bank" situated on the south side of the Cedar Run furnace ridge was formerly largely mined from to supply the furnace and forge on Cedar run. The ore-belt here is possibly confined to the flank of this ridge, the topography becoming very much broken as the river is approached, and yielding very little opportunity for a commercial deposit of ore to have been retained.

The following, written in 1883, will suffice to describe the Carter bank: It is situated one and one fourth miles south-east from the furnace and about three quarters of a mile west-north-west from New River. The bank exhibits a series of openings from which a large amount of ore has been mined. The workings consisted of a circular pit eighty feet in diameter and fifteen to eighteen feet deep, with ore in bottom not gone through. No limestone was observed at this point.

Thirty yards further south it has been worked on a lower level to a depth of fifty feet; and a shaft sunk on the floor of this cut has gone through ore to an additional depth of seventy-five feet, making at least one hundred and twenty-five feet of ore material at this point.

Forty yards south-east from the present workings, one shaft has been sunk in ore for one hundred and two feet; and a second has gone down eighty feet in ore, with bottom of shaft still in ore. Numerous other cuts and shafts have been made, but these are now fallen shut. The bank has been worked in such a way that it presents the appearance of a series of benches or terraces on the face of a hill. Ore crops to the surface generally, although sometimes as much as six feet of stripping had to be removed. Occasional horse-backs of clay, carrying little or no ore, were encountered; but neither these nor limestone boulders have been very pronounced in any of the workings. An area of four to five acres has been proven by shafts to be ore-territory. Every

indication points to a large body of ore—principally wash-ore.

An analysis of the wash-ore shows:

Metallic iron,	54.400
Phosphorus,	.137
Siliceous matter,	7.870
Phosphorus in 100 parts iron,	.251

A sample of the pig-iron made from this ore in the Cedar Run furnace shows the following:

Silicon,	.547
Sulphur,	.052
Phosphorus,	.205

New Bank.—About 400 yards west along the ridge from the Carter bank a new opening was made about two and a half years ago after work had ceased at the Carter bank. This opening shows an irregular shaped pit 100×20×15 feet, the sides of which have been pretty well destroyed by weathering; but the proportion of wash-ore is quite as large as at the Carter bank. Indeed, there is no reason to doubt the continuity of the ore bed between both openings. The ore occurs as a rich, cellular, brown-hematite associated at both places with a readily yielding clay. A shaft, 56 feet deep, at this New bank showed a good record; and a tunnel some 65 feet below the top of the ore-bank was being driven, at the time of our visit, north-west to strike the ore-deposit at a somewhat lower level, thus securing a handsome face of cheap ore for future development.

An analysis of the ore from this bank shows:

Metallic iron,	51.850
Phosphorus,	.075
Siliceous matter,	9.010
Phosphorus in 100 parts iron,	.144

Some little prospecting has been done on the south side of this little valley, close to the bottom of the ridge bounding the property upon the south, and apparently at this point in somewhat lower, dolomitic limestone. One 30 foot shaft with 8 feet of stripping is reported to have gone 22 feet through ore, with the bottom in light, yellow-colored clay. Higher on the hill, a 16 foot shaft furnished a good amount of ore; but the proportion of lump to wash is quite small.

A sample of the *lump ore* gave the following analysis:

Metallic iron,	53.050
Phosphorus,	.093
Siliceous matter,	8.800
Phosphorus in 100 parts iron,	.175

The ore is associated at this latter place with a tougher and more reddish-colored clay, like that occurring upon the Widow Stephens and Oglesby properties. The ore itself is more compact and dense than that occurring on the north side of the valley; and if it could be otherwise demonstrated that these ores and limestones belonged to a lower horizon than those occurring at the Carter and New banks, the fault line could be definitely located at this point along the base of the south bounding ridge. The Graham lands extend west for probably one and a half miles through this valley, the upper blue limestone range becoming narrower and narrower until, approaching Dr. R. W. Sanders' line fence, the lower gray and dolomitic limestones, immediately overlying the slates, completely lap over the narrow valley and carry a large amount of the denser variety of ore associated with these limestones.

Some few developments have been made in them towards the base of the ridge on the south side of the valley and in a field close to a dwelling house; but none of them showed ore in appreciable quantity. On the top of the ridge, however, to the south-west of Major Graham's house, a much more encouraging development has been reported, showing a promising body of good ore.

R. W. Sanders' property. In Dr. Sanders' first field upon his Mt. Zephyr farm, the same ores and rocks occur, the bounding ridges being made up of red slates and thin limestones, just as was the case at Major Graham's. But proceeding west, the second field carries a richer soil and ores of a more open character and more closely allied to the upper limestone variety. A profuse outcrop shows almost continuously in this and the third field; but it has been sparingly developed and has its future still to prove. In the fourth field the limestone comes well to the surface, still dipping from 30° to 40°

towards the south-east, and the ore shows again at this point, and thence nearly to the Wytheville pike. The ore territory in this farm may be roughly stated as extending over a distance of about 1,500 yards east and west, and occupying ground from the crest of the ridge on the north nearly to the valley on the south. At the eastern end, the ore outcrops over a width of probably 200 yards. The middle field has an ore width of about 180 yards; but west of that field the outcrop contracts rapidly to about half that width at the west end of the third field, after which the limestones outcrop prominently, while the hill slopes towards a small branch along the Wytheville pike, and reduces the available ore territory in that portion of the property. Samples were taken of the lump ore at the various small pits that had been sunk for inspection; and the result of the accompanying analysis shows the excellent character of the material through this part of the ore field:

Metallic iron,	53.875
Phosphorus,	.092
Siliceous matter,	6.610
Phosphorus in 100 parts iron,	.170

The ore is last well exposed in two small openings about 200 yards east of the road. Considerable ore was hauled from these open cuts for the benefit of the old charcoal furnaces of the region; but when visited the sides had fallen in from constant weathering, and prevented the exposure of any new or fresh ore-faces.

West of the public road a considerable area of land is owned by Mrs. Sanders; but the ore-outcrop is not very profuse until the neighborhood of the Walton furnace bank is reached.

The *Walton furnace bank* is situated upon the farm of Mrs. Sanders, from whom it is leased, about one half mile north-east from the furnace and a little over two miles north from New River. The property has been considerably developed, but as yet no definite or persistent ore-deposit has been thoroughly determined. It is true that several large open cuts have been opened which show a fairly developed face of ore, in which the customary barren spots and limestone boulders

are quite prominent, and in which irregular masses of ore of varying richness have been worked; but there seems to be as yet no well defined continuity either along the strike or along the dip of the limestones, and the workings as far as visible all indicate an exceedingly irregular body of ore, bearing the appearance more of a secondary deposit than one occurring *in sitû*.

On March 30, '87, the best exposure was in a narrow cut, about three quarters of a mile from the furnace, hitherto only worked by carts, the tramway not having as yet been extended that far. The ore material carries a rich dark red or purplish ore, in a face from 15 to 20 feet thick. This cut yields an exceedingly good wash material, washing fully one half clean ore; but as far as developed, the deposit seems to be quite narrow, with barren yellow clays almost entirely devoid of ore cutting in on either side of the iron-bearing clay, and confining the productive portion of the cut to a width of only about 20 feet; but a few weeks' development may present an entirely different aspect.

The ore seems to be dipping south-east, conformably with the limestone at this point, and seems rather more regular in its occurrence and decidedly richer than the material exposed in any of the older cuts further west. The tram-road is being extended to strike this pit at a somewhat lower level than the present workings, and at this date was only about 100 yards distant. In places, as the tramway has been extended, material is loaded for washing that will not yield more than one fifth or one sixth ore, from which the uncertainty of the deposits in this part of the field may be judged. It is fair to assume, however, that the company naturally wished to make the tramway extension pay for itself if possible, and material consequently would be carried to the washers, under these circumstances, which would otherwise have been thrown aside as unprofitable. To the north of the valley, the hillside shows no surface cropping whatever, although on the north flank of the small ridge along which the ore has been most largely developed, it is common report that a considerable amount of ore was mined in past times. Some 500 or 600 tons of clean wash-ore was stocked at the washer on Mill

creek, preparatory to putting the furnace in blast in May; and a general sample taken from this pile containing the mixed ore from several openings, yielded upon analysis the following result:

Metallic iron,	57.175
Phosphorus,	.065
Siliceous matter,	6.820
Phosphorus in 100 parts iron,	.113

The ore from the old workings, sampled in 1883, showed the following analysis:

Metallic iron,	51.625
Phosphorus,	.111
Siliceous matter,	10.730
Phosphorus in 100 parts iron,	.215

The unusual variation in these ores as shown by the two above analyses—the second from a sample taken prior to the development of that part of the property yielding the *red ore*—suggested the propriety of sampling the red ore variety alone, to determine, if possible, how far its mixture was responsible for the improved condition of the furnace stock. The results obtained in the following analysis would seem to indicate that the improved condition was in a great measure due to the admixture of the red ore. Its analysis shows:

Metallic iron,	59.500
Phosphorus,	.066
Siliceous matter,	4.300
Phosphorus in 100 parts iron,	.110

Before continuing along the valley west from Walton furnace, reference should be made to the *Glade Manganiferous ore bank* which, although not visited during the present examination, was actively worked by shaft and tunnel several years ago for Walton furnace, from which it is distant about 3 miles north, at the base of Lick mountain. The character of the ore seems to vary somewhat, being sometimes a rich brown-hematite—often fibrous and quite free from manganese; while on the other hand, portions of it are highly charged with manganese—this element not unfrequently predominating. The ore is simply screened, there being no water for washing purposes in the vicinity of the mine. About one

twelfth of the burden of the Walton furnace at one time consisted of this ore. A sample, one hundred and forty-three pieces selected from small ore pile at furnace, yields:

Metallic iron,	50.450
Metallic manganese,	4.971
Phosphorus,	.444
Siliceous matter,	5.440

Going west from the Walton furnace, still in this valley, the integrity of the district as an ore-bearing region is further impaired by the constant succession of limestone ledges outcropping in hard ribs, running east and west through the country, and cutting off all chances for profitable ore territory.

The Blair and Zimmerman farms show this feature especially, and it is more or less the case on the Gray and Robinson farm next west, although here the central hill in the valley rises quite clear of limestone, and it is reported to carry a well-defined ore outcrop, extending for some distance through this farm westward to the Blair and then to the Porter farm. All through this portion of the field, however, the ground is rendered rather treacherous by these outcropping limestones; otherwise the geological features are the same here as elsewhere. Red slates flank the purer limestones on the north and south sides; and being less easily affected by weathering, create ridges of considerable prominence as compared with the small broken limestone hills in the valley itself.

From Brown Hill furnace westward one may continue upon the same features just described as occuring west of the Walton furnace, the topography of the valley rising somewhat in that direction, but otherwise quite similar to what is passed over to the east. For three miles along this line, the various property owners claim to have good ore in considerable quantity; but there has been an entire failure to demonstrate this fact by such pits as would have sufficed to furnish reliable information concerning the quality and quantity of the material; and certainly no profuse outcrop was noticed there.

West of the divide at Mr. Groome's house, a very excellent outcrop of ore occurs profusely as far as the Swecker branch to the west of the Huddle farm. The ore is a somewhat dense but pure limonite, and extends for perhaps half a mile through the *Moore* and *Huddle* farms, occurring between limestone beds dipping from 50° to 60° south-east, and in places spread over the valley from 300 to 400 feet wide.

The character of the ore is shown by the following analysis of samples taken from Capt. W. O. Moore's Locust Grove farm:

Metallic iron,	56.775
Phosphorus,	.092
Siliceous matter,	4.330
Phosphorus in 100 parts iron,	.162

Although experience elsewhere would seem to suggest the shallowness of the deposits on account of the presence of the outcropping limestones, yet there is a very considerable surface outcrop in this part of the valley which, if combined in the hands of a single company, would yield a very handsome return by its development. A short lateral line up Swecker's branch from the Cripple Creek railroad, and thence northeast through this Huddle and Moore valley, would reach profitable ore territory in less than a mile; and it is quite probable that through a large portion of the year, the branch creek would furnish sufficient water for all washing purposes. This deposit can be traced for some distance west of the branch, although the outcrop is not so distinct in that direction. The limestones here begin to change their course somewhat, shallowing up as the basin rises and spoons out in Gleaves' knob.

A short distance south of the old Raven Cliff furnace, a small quarry opening displays the Potsdam slates in place, dipping due north about 15°, and cropping again beneath the furnace, whose foundations indeed are built upon them. Raven Cliff ridge presents a magnificent exposure of these rocks, facing Cripple creek above the furnace, with a somewhat increased dip before passing beneath the limestones. The railroad grading has displaced large masses of them and the mottled limestones above them, the point of con-

tact on the creek being close to Crockett's mill. West of the mill, the dip becomes more and more north-east, owing to the expiration of the synclinal of the lower Cripple Creek valley; consequently the sandstone and slate measures gradually begin to encircle the western base of Gleaves' knob, rising, in conformity to the laws governing the structure of this basin (which have been already described,) until they meet the fault passing a little south of the center of Gleaves' knob. Here the sandstones on the south side of the fault dip north-eastward at angles of about 65°, and abut against the slates and limestones on the north side of the fault, the latter having a dip to the south-east of about 50°.. This fault, together with the spooning of the basin westward, apparently completely cuts off the sandstone going west, and with it buries all signs of the synclinal axis; for, all the way up to Captain Gleaves' house, the red slates and impure limestones show with a general south-east dip and with a strike coincident with the course determined by this break.

Going south along Cove branch from Cripple creek towards the Raven Cliff ridge, the dip increases somewhat, until, at the contact line between the limestones and the slates of the Potsdam sandstone formation in Raven Cliff ridge, it is nearly 25° northwards. The contact of the two formations is marked by a ravine into which Big Sinking spring sinks before finally entering Cove branch. At this point along Cove branch, the Potsdam upper slates are seen dipping conformably northwards 25°, passing beneath the lower (mottled) limestone; and going up the branch, a distinct roll in Potsdam sandstone is seen, with dips of only about 10°, about half way to the school-house. This roll marks the Raven Cliff anticlinal. Still further up the branch, the lower limestones appear on the south side of this axis and a short distance above the school-house, showing south dips, and held apparently in a shallow synclinal basin between Raven Cliff ridge and the main mountain. The map will show a small area of limestone at this point lying at the north-east base of Cove knob, which latter also seems to be an anticlinal of Potsdam sandstone measures.

The dips in this small limestone basin vary largely around

its rim, owing to the peculiar structural features just mentioned, the Raven Cliff and the Cove knob axis having quite a different course. The limestone can be traced some little distance up Cove branch between the knob and Ewing mountain.

No ores have, as yet, been developed in this area, although a considerable outcrop can be seen on the old *Wampler tract*, now owned by Messrs. Moore and Collins. The ore may be associated with the lower portion of the limestone formation; but it is not probable that any large quantity will be mined from here.

The Cove knob anticlinal extends from this point southwestwardly until it joins the main mountain at Mike's gap, near the head waters of Rutherford branch, and on its northern flank, well down in the valley, it carries the limestones of the main upper Cripple Creek basin.

The Raven Cliff ridge occupies a similar position on the north side of this basin, its anticlinal being well marked on Crab Orchard creek, passing about half a mile south of Raven Cliff furnace, and at this point carrying only the upper Potsdam slates on its crest. As it sinks westward, the anticlinal seems to be subdivided by a small and narrow basin of limestone, some two miles long, extending from a little east of Rutherford's branch westward to the vicinity of St. Peter's church. That portion of the ridge to the north of it still goes by the name of Raven Cliff; but the anticlinal causing it apparently subsides, or else it is faulted when reaching Cripple creek a little west of Captain Gleaves' house. The southern division, lying south of the small limestone basin, takes the name of Crab Orchard ridge, west of the creek of that name, and seems to be wholly formed of red slates with nearly vertical dips, extending as a narrow band across the country almost to Thorn branch, some four or five miles. This strip of red slate land is cut through by every stream entering Cripple creek from the north, and in addition to being a prominent topographical feature of the country, it practically marks the northern edge of the main ore-basin of the upper Cripple Creek valley.

The synclinal axis of this basin extends west from the western base of Cove knob, crossing Rutherford and Francis Mill creeks on the south side of Cripple creek, and passes to the north side of Cripple creek a little below the mouth of Rock branch; thence through the Porter and Simmerman farms until it recrosses to the south side of the creek at J. A. Sanders'. From here it passes directly to the Percival house on Dry branch, and into Cave hill.

Captain R. H. Gleaves, in addition to the openings on the south side of Gleaves' knob, which have been already described in a previous part of this report, has uncovered an attractive looking ore at the eastern end of the small limestone basin occurring between the Raven Cliff and Crab Orchard ridges, and about a mile and a half south of his house. Four or five holes sunk close together here were quite barren of ore, soon striking the limestone rocks, which dip but gently (10°) and consequently create a very shallow basin.

A trench some 15 feet long, and in places from 10 to 15 feet deep, turned out some excellent ore, showing two quite distinct varieties: one very porous and laminated; the other more dense and of much better quality. Considerable sulphur, in the form of iron pyrites, is associated with this ore, which, as already stated, is contained within a very shallow basin of limestone at this particular point, and cannot be productive of a large deposit. A general sample of the lump ore of both varieties taken from this trench yields as follows:

Metallic iron,	54.700
Phosphorus,	.177
Siliceous matter,	7.610
Phosphorus in 100 parts iron,	.321

Some little distance north, down the creek, an attractive hill between two slate ridges would seem to warrant prospecting; otherwise the territory hereabouts seems to be largely occupied by red slates and impure limestones, and is generally unproductive of ore-material.

Taking up the main basin of the upper Cripple Creek valley, the first openings on the east show on the *Martin Rosen-*

baum Farm of 225 acres, watered by the Rutherford branch, and lying some two and a half miles south of Cripple creek. This farm is largely made up of limestone soil; but in the area east of the creek, the limestones crop boldly through a considerable portion of the farm and militate against the probability of much cheap ore being mined here.

The basin is divided into two portions by a secondary anticlinal ridge of limestone, occurring near the center of the limestone area but creating a well recognized roll. This no doubt is but a continuation of the anticlinal of Hussey and Fry's mountain further west. On this farm, the crest is marked by dips of only 15° north and south, although this inclination increases rapidly on both sides of the axis in the resulting synclinal sub-basins.

The main opening is located nearly on the crest of this subordinate axis, some 500 yards east of the creek, and on the north side of the ridge. The ore is exposed in the sides and bottom of a narrow and shallow trench, and covers the ground profusely in the neighborhood of the cut over an area of 75×50 yards, beyond which all *surface* indications fail entirely. The ore is certainly an excellent cellular brown-hematite, and for four feet beneath the surface occurs largely as lump, mixed with some barren clay. This locality will, no doubt, furnish a fair auxiliary tonnage to the developments in this region; but there is but little probability of its yielding ore in large quantities. A general sample of the lump-ore thrown from the pit shows the following results upon analysis:

Metallic iron,	53.650
Phosphorus,	.194
Siliceous matter,	8.550
Phosphorus in 100 parts iron,	.361

A rather prominent and rounded hill, free of visible limestone rocks, lying on the west side of Rutherford creek, and occupying the valley between Fry's hill and Crab Orchard ridge deserves attention; for though the outcrop is scant, the geological conditions are favorable to the presence of iron-ore. Along the road a dense variety of ore outcrops, which as far as surface samples go, is certainly of good character and should warrant the development of the hill to the west.

The limestone along Rutherford branch swings completely around to the south side of Fry's hill, the latter being composed, like Hussey mountain further west, of the sandstones and slates of the Potsdam sandstone formation. Both these hills mark an anticlinal axis, which like the Cove knob anticlinal, extends in a north-eastern direction out from the main Iron mountain range.

Between the Hussey mountain anticlinal and Cove knob there are probably two, if not more, rolls in the Potsdam sandstone measures, so that it might be said of the area south of the limestone basin, that the Iron mountain is but the back-bone of several smaller ridges which project out from its northern side in successive prongs, and create the exceedingly picturesque features of this portion of the region. Economically they are of quite as much importance, for the duplication of the ore-bearing rocks which they contain renders all this portion of the field an attractive subject for future development, although as yet but little has been done to prove or disprove its claim to notice.

The country between Rutherford branch and Francis Mill creek, lying north of Fry's hill, shows no developments as yet; but in the little cove which runs up on the southern side of the hill quite an appreciable amount of iron-ore shows in the limestones, although, like Rosenbaum's, the deposits are generally shallow, and are not at present worked. Still further up Rutherford branch, in the Potsdam sandstone measures, an old opening known as the *Black ore bank* shows a fair amount of the Potsdam ore; but its sides were so badly fallen in, that it was not possible to get any information about it on the ground, or to obtain samples of the ore. It is located on land of Crockett & Company, and but a short distance north of the Grayson county line.

What is apparently the same ore-bed has been exposed in a pit six feet deep, ¼ mile west from this point and about 100 yards north-west from Rutherford branch.

A sample of the ore taken by Mr. James Crockett gave the following analysis:

Metallic iron,	51.200
Phosphorus,	.713
Siliceous matter,	10.940
Phosphorus in 100 parts iron,	1.392

The same company have recently proved the presence of the mountain ore on the divide between Rutherford branch and Francis Mill creek, and just south of the road leading to Little Wythe furnace. Limestone heads up in opposing coves on either side of this divide; but it does not pass entirely through, and it is in the area of Potsdam sandstone measures dividing the two tongues of limestone that several shafts have been put down to the mountain ore. Much of the ore seen was more or less inpregnated with drusy quartz, especially in the pit furthest up the hillside and furthest south. The ore seems to dip slightly northward towards Fry's hill, and in two of the pits shows quite solid under 5 or 6 feet of cover, the thickness however not being determined. All of the pits seem to lie just north of the Norma line and between it and the road, and they certainly afford an indication of the trend and persistency of the mountain ore deposit.

Samples of the lump ore taken from the different pits show the ore to contain:

Metallic iron,	49.500
Phosphorus,	.104
Siliceous matter,	17.700
Phosphorus in 100 parts iron,	.210

The *Norma property* comprises some 3,800 acres lying on both sides of Francis Mill creek, and taking in a large area from the Noble or Norma furnace south to the Grayson county line, along the crest of Iron mountain. The eastern half of this property, which is comprised in the above acreage, is the only part upon which any developments have been made. This portion has recently changed hands and has become the property of the Clinch Valley Coal and Iron Company.

Their tract has roughly a parallelogram shape, the northern line of which extends along the north base of Hussey mountain between Francis Mill creek at Noble furnace and Rock creek on the west. Quite a strip of limestone land is thus secured between the sandstones of Hussey mountain and the Porter property to the north, and it is upon this portion of the property that the company will have to look for their supply of limestone ores.

A considerable area of limestone is shown upon the map,

occupying a roughly oval space on the south side of Hussey and Fry's hill, which was formerly controlled by the Norma Iron Company; but through sales and exchanges almost the entire limestone area, consisting of some 130 acres is now owned by the Beverly and Little Wythe furnace, (Crockett, Oglesby & Company.)

Rock creek is the irregular western boundary of this property now, while its eastern line occupies the divide between the waters of Francis Mill creek and Rutherford branch before crossing the latter further south into the mountain area along the Grayson county line. The structural features are in the main simple, but very important, for they largely illustrate the occurrence of the different classes of ore found on the property.

The Hussey mountain anticlinal has already been described and located, and its position is plainly shown on the map. It consists of the Potsdam sandstone measures. On its southern base occurs the little limestone basin, rather boat-shaped, and extending up Little Horse Heaven creek a short distance west of Francis Mill creek. As already stated, but a very small portion of this limestone area is on the Norma property. South of this basin, another anticlinal in sandstone measures shows between Little Horse Heaven creek and Taylor branch, and it is by no means certain that these rolls are not duplicated before the southern side of the property is reached on the crest of Iron mountain.

The *Porter ore bank*, on the Norma property, occurring on the north base of Hussey mountain and about 1¼ miles west of Francis Mill creek, is probably one of the best known openings in this region. The ore occurs here in an opening 125 feet long, east and west, 60 feet wide, and 40 feet deep. The ore is in a measure quite peculiar, being largely what is termed "shot-ore," and yielding probably one half clean ore when washed. The ore bed dips conformably with the limestones, north-west about 70°, and it is owing to the perpendicular position of the bed that its outcrop is so largely concealed by wash from the mountain on the south. The lump-ore in the Porter bank is confined to the north or

upper side of the bed, which shows a thickness of fully 60 feet, and which, moreover, has been proved by a 70 foot shaft to continue at least 45 feet beneath the level of the present cut. No fresh samples of this ore were deemed necessary, inasmuch as the bank has not been worked for several years; but the following analysis well shows the composition and excellent character of the deposit:

Metallic iron,	57.200
Phosphorus,	.111
Siliceous matter,	4.730
Phosphorus in 100 parts iron,	.194

Some recent developments have been made on this portion of the property, and have successfully determined the continuation of the deposit from Rock branch eastward for nearly a mile.

An old opening near Rock branch has been cleaned out and shows quite a rich wash, although the bed itself was partially concealed here. Most of the lump-ore taken from it has a rich, red color, though occasionally mixed with some quartz grains. An interval of probably 400 yards separates this cut from the Porter bank, and for fully half that distance a rather distinct outcrop has been sparingly tested by four or five shallow pits, just sufficient to prove the continuity of the deposit.

Eastward from the Porter bank across a small hill, another cut has been made in this same ore-bed, heading towards the Porter opening. A very rich wash-ore is exposed for the first 20 feet from the top of the cut; but, dipping north-west so steeply, the drift soon passed into the tough clay and loose sand rock underlying the ore. Another cut still further east, and located further south, failed to obtain much ore, being largely located in the underlying red clays and sandy measures.

From this point eastward to the ravine which partially divides Hussey mountain, quite a number of shafts and test pits have been located, with more or less success, and at the time of our visit the company were still endeavoring to trace this attractive ore-deposit all along the northern front of their property.

Most of the remaining developments on this property have been made in either the Potsdam ore or the geologically higher mountain ore-bed, and there is perhaps nowhere else in the New River-Cripple Creek region, where such an attractive and impressive showing of these ores has been made.

The "Outburst" opening is perhaps the best known of these, and it certainly indicates the presence of an exceedingly large body of ore. It is situated at the head of a small ravine which enters Francis Mill creek just below Nichol's house, and is not far from the line of the Crockett property to the south of the Little Wythe mine. The opening itself is possibly 60 feet north and south, 25 to 40 feet wide, and from 10 to 20 feet deep, and shows everywhere a heavy outcrop of mountain ore, which dips about 50° north-west and has been tested by trial pits on the hill to the south for a width of at least 150 feet additional, although in the absence of larger developments it cannot be said with a certainty that this is all ore territory. A sample of the ore from different parts of the main opening, taken prior to its present large development, yielded on analysis:

Metallic iron,	51.550
Phosphorus,	.126
Siliceous matter,	7.760
Phosphorus in 100 parts iron,	.244

A general sample of the ore, including portions of the main cut and extending southwards along the ridge over the entire outcrop, yielded:

Metallic iron,	50.750
Phosphorus,	.168
Siliceous matter,	8.560
Phosphorus in 100 parts iron,	.331
Combined water,	13.080

On the east side of this little hill, at the level of the stream, an open drift has been carried 35 feet into the hill, and at the face is 25 feet high. At this point ore was met with to within ten feet of the bottom, largely wash but containing a fair proportion of lump-ore, and beneath which some clays appear on either side of a mass of soft lump-ore. The front part of the cut is largely through wash-ore clays, which will yield

well when washed, although not so attractive in appearanec as the massive lump-ore of the "outburst" itself.

Some little distance further down the stream and opposite the north end of the "outburst" opening, a second cut in the hillside has developed a handsome body of ore, largely lump, except where disintegration has taken place. Still further north, on the point of the hill, 50 feet from the outburst opening, another small cut shows excellent ore, so that the continuity of this bed over a considerable width of territory may be considered proven.

Further west along the hill, some 350 or 400 feet, a series of cross cuts and shafts, for about 275 feet south of the ravine which limits the property on the north, have splendidly developed the presence of this mountain ore-bed on a northwest dip. The first opening south of the ravine is an open trench 20 feet long and 4 feet deep, which yielded mostly wash-ore with some few lumps. The next opening, directly south and further up the hill, is a shaft 15 feet deep, yielding wash-ore, some quite red in color and similar to the "outburst" opening, but not much lump-ore. The next one higher up the hill marks the beginning of the massive ore-deposit, which is cut continuously from here for over 150 feet across the bed to the back of the tunnel, showing ore exactly like the "outburst," with an occasional intrusion of sandstone in the solid mass, the whole underlaid by white clays. Samples were taken (150 pieces) representing the wash and lump-ore exposed on the whole length of the cut, which analyzed as follows:

Metallic iron,	50.075
Phosphorus,	.325
Siliceous matter,	14.020
Phosphorus in 100 parts iron,	.649
Combined water,	10.460

The whole appearance of both these openings is certainly very striking; and while it has not yet been possible for the company to expose similar showings elsewhere on their property, there can be no doubt of a very extensive deposit of this ore lying along the north base of the ridge, south of the little limestone basin before mentioned, and possibly

swinging around the western end of that trough on Little Horse Heaven creek, and to the south side of Hussey mountain. Indeed one opening on the north side of Little Horse Heaven creek has exposed ore of quite similar character, dipping south-east about 60,° and about 14 feet thick. This cut is not large, but serves to prove the continuity of the deposit on the north side of the little basin. Its position is shown on the map.

The "Back bed" (a name usually given to that class of ore occurring in the body of the Potsdam sandstone formation, and consequently geologically lower than the "outburst ore") is opened in several places on the same ridge between Francis Mill creek and the small creek several hundred yards to the east and flowing northwards through the property. In two places on the eastern side of the stream, the ore of this bed has been opened, and indicates a thickness of some ten or twelve feet. This ore carries considerably more phospborus than the upper bed, and in many ways it is not as valuable or as desirable a product; nevertheless, it will be largely used for mixture in the future with the purer limestone ores of the valley, especially for foundry purposes, and the company may feel reasonably assured of a large tonnage of it on their property.

A sample from the lowermost of these two openings, taken in 1883, yields as follows:

Metallic iron,	49.725
Phosphorus,	1.388
Siliceous matter,	7.880
Phosphorus in 100 parts iron,	2.791

The same bed is again opened between the "outburst" and the tunnel, and higher up on the hill than those openings. At this cut the ore appears to be at least 15 feet thick, and dips northward about 50°. It has a dark, somewhat pitchy-black color, and has been stripped for a length of 50 feet and a depth of 20 feet.

The same ore-bed has apparently been cut recently in three shallow shafts between the tunnel and the public road along Francis Mill creek, where its thickness has not been determined, although over ten feet. Some difference of opinion

exists as to the horizon of this bed, it being claimed that the ore fairly represents the upper horizon. But the whole appearance of the ore, as well as its geological position, would indicate its lower relationship. Other old openings in the lower bed have been made on the west side of Francis Mill creek, well up on the divide between Little Horse Heaven and Rocky branch; but they are insignificant except as showing the continuity of the ore bed over a considerable length of territory.

The character of the ore in this part of the field is sufficiently well shown by the following analysis of a sample taken several years ago:

Metallic iron,	52.225
Phosphorus,	1.228
Siliceous matter,	6.560
Phosphorus in 100 parts iron,	2.351

Both of these ores from the "back bed" show quite an appreciable amount of manganese, but it has not been considered desirable, under the circumstances, to determine its percentage.

The property as a whole will be, no doubt, an important factor in the future tonnage of the upper Cripple Creek region; and were it not for the fact that the integrity of the tract has been somewhat impaired by the loss of the 129 acre tract of Crockett, Oglesby & Company—which carries most of the limestone ores—the company would possess in itself all the desired grades of ore for suitable furnace mixtures.

Crockett, Oglesby & Company own this small tract of land known as the "Porter tract," lying within the inclusive survey of the Norma Iron Company on the south side of Hussey and Fry's hill. Their property consists of two small tracts, respectively 45 and 129 acres, all of which is practically limestone land. The small tract (45 acres) resulted from the transfer of 30 acres from the larger tract, which originally consisted of 159 acres. These 30 acres, extending on both sides the Francis Mill creek, were deeded to the Norma Company to enable them to acquire sufficient facili-

ties for reaching their mountain ore-deposits at the outburst opening.

Two principal openings have been made and quite extensively worked upon the 129 acre tract. The first is the *Porter bank* of the Beverly furnace, locally known as the "Red Ore Bank," and is situated on the eastern side of Francis Mill creek, a short distance from the Little Wythe furnace. The ore occurs here associated with the lower blue mottled limestones, dipping gently south-east in obedience to the structure caused by the Hussey mountain anticlinal on the north. The Potsdam upper slates, with a drab to black color, are last seen outcropping at the stock-house of the Little Wythe furnace, and are immediately succeeded by these lower ore-bearing limestones going southwards up stream, which, as already described, soon form a gentle synclinal basin and cause a duplication of similar ore deposits on the south side of the synclinal, as far as the limestones extend, close to the Nichols house.

The "Red ore bank" is opened by a cut probably 200 yards north-east and south-west, 40 feet deep, and about 30 feet wide, although these latter dimensions vary considerably along the line of ore-deposit. The limestones, rising practically to the surface everywhere, prevent the occurrence of much surface ore, so that all the developments have been carried on between walls of rock, and have been followed wherever the ore led to. Quite a large proportion of the output is lump-ore, some of it honey-combed and containing red clay within cavities, and elsewhere breaking up into a fine wash-ore. A considerable amount of sulphur in the form of iron pyrites is found associated with the larger lumps, which might be inferred from the position of the deposit between solid walls of limestone. Geologically, the occurrence of the ore here is in every respect like that found at Foster's Falls, where practically the same method is pursued for its extraction, and the hill side riddled with small cuts and trenches wherever the ore could be secured with least expense and trouble. A sample of the washed ore was secured at the Beverly Furnace stock-house, which may very well show the general character of the ore of this bank

although it necessarily varies somewhat in different parts of the deposit. The results of the analysis of this ore are as follows:

Metallic iron,	53.450
Phosphorus,	.164
Siliceous matter,	8.830
Phosphorus in 100 parts iron,	.306

In regard to the results obtained in this analysis, it should perhaps be stated that the sample was taken from a pile of ore which, owing to the severity of the weather, had been rather imperfectly washed; and it would only be reasonable to expect a better showing from the ore prepared under more favorable circumstances.

A tramway leads from the washer on Francis Mill creek to a second cut, a little south of the first, which is about 40 feet deep, 80 feet long, and 60 feet wide, and is mostly in wash-ore. The same features are to be remarked here as in the main cut, and the two are practically opened in one and the same deposit.

The *Little Wythe furnace bank*, known locally as the "Yellow Ore bank," to distinguish it from the one last described, is situated also on the east side of the creek and towards the southern edge of the limestone basin. Like the Porter ore bank, it occurs in the lower mottled limestones, and, upon structural grounds, should yield ores quite identical in character. In this part of the field, however, the clay that is associated with the ore has a much more distinct yellow color, and it is this difference perhaps which has led to the naming of the bank. The ores themselves present a lighter hue than those of the Beverly furnace opening. In this respect the two ores closely resemble the comparative features presented in the Gannaway banks which lie further west, although at that point both classes of ore occur on the same side of the basin, and in distinctly different limestones.

The Little Wythe bank has not been worked for several years, which statement is also true of the furnace supplied by its ores. Very little is to be seen at present at this point the ore-faces being largely concealed by a wash of surface drift in the main cut, although several smaller test pits

further east present an attractive appearance, and assure the presence of a considerable amount of ore yet to be mined in this portion of the field. The amount of ore, however, is in any case fairly limited, both on account of the occurrence of the lower Potsdam measures immediately to the south, and from the fact that the ore to be won in future will have to be mined from between limestone walls.

The quality of the ore is shown by the following analysis:

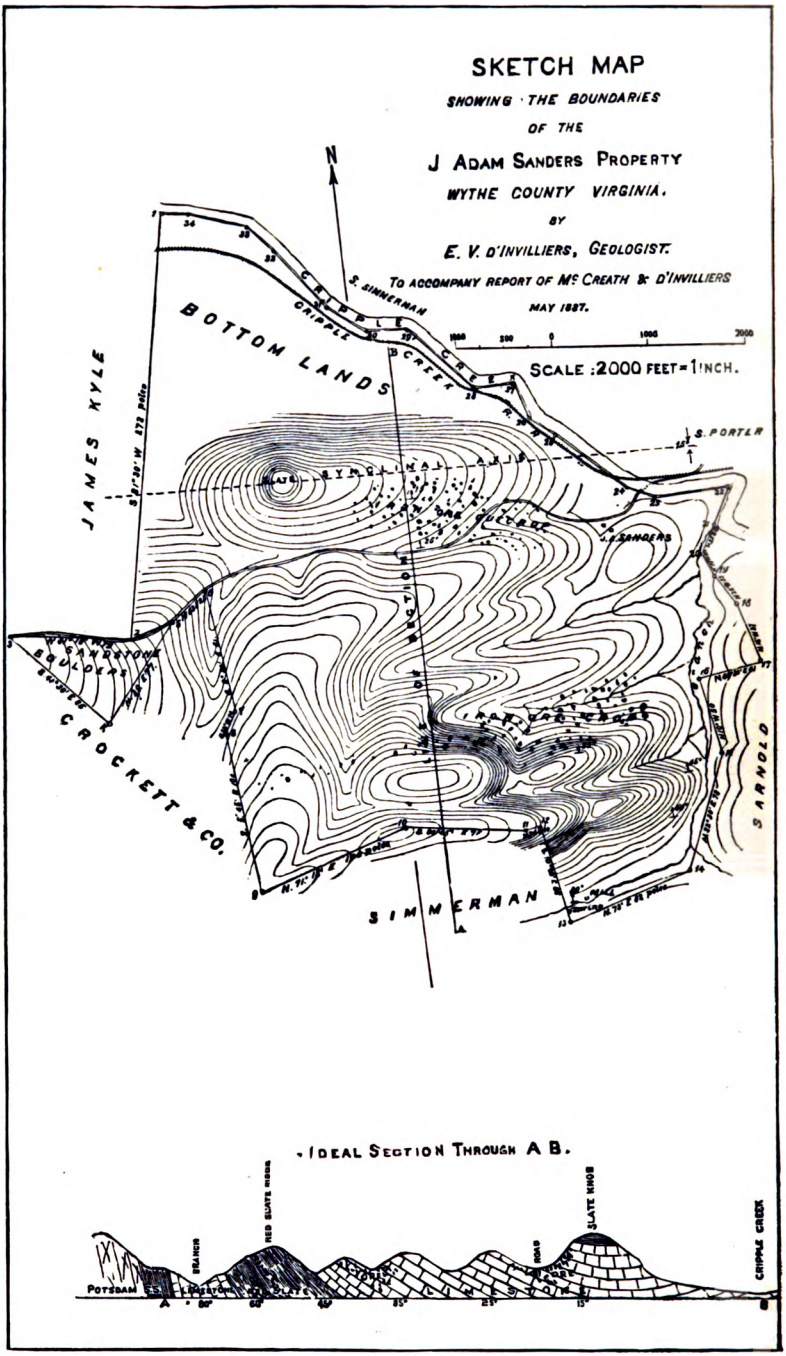
Metallic iron,	55.400
Phosphorus,	.127
Siliceous matter,	7.960
Phosphorus in 100 parts iron,	.229

The western half of the Norma property was not included in the purchase of the Clinch Valley Coal and Iron Company. It lies entirely west of Rock creek and along the Grayson county line, and with the possible exception of limestone, it should present the same geological features as the eastern half already described. Its owners so far have failed to make any developments whatever which would have warranted an examination on our part; but common report agrees upon the presence of a large amount of the mountain ore on this tract, and possibly an extension westward from Rock creek of the limestone ore deposits coincident with the Porter ore bank. The tract is a large one consisting of about 4,000 acres, and its development will undoubtedly add largely to the resources of this field.

The *J. Adam Sanders property* is entirely undeveloped and was, therefore, not examined for this report. But the following private report made for Mr. George T. Mills, and published here with his permission, will suffice to show the value of the property and the quality of its surface ores.

Report on the J. Adam Sanders property.

Location. The J. A. Sanders tract is located on the south side of Cripple creek, about 3½ miles east from Speedwell and about 2½ miles west from Gleaves' knob and Eagle furnace. The tract is said to contain about 700± acres of land, the



boundaries of which are sufficiently well shown on the accompanying map, (page plate,) platted from the deed courses. These courses and the distances in poles or rods are given on the map.

It will be seen by reference to this plat that the property has an excellent water front along Cripple creek nearly 1¼ miles long. The remaining boundaries are somewhat irregular. The eastern one runs south about 4,000 feet along the eastern side of a small branch, dividing the property from the S. Arnold tract. The south line runs along a terrace of Iron mountain until opposite the spring on the branch, where it is offset northwards to the crest of a red slate ridge (Sta. 12) along which crest the line again bears west for 176 poles. Simmerman's and a strip of the Crockett & Co's land lie to the south and west of the tract.

From the last corner (Sta. 9) the line extends northward to the public road leading to Speedwell (Sta. 6), where a triangular shaped piece creates another offset south of the road before the line takes a direct course to Cripple creek.

The lands of James Kyle and Crockett & Co. lie to the west side of the tract. The public road to Speedwell nearly divides the tract in half, although probably 400 acres, more or less, lie on the south side of it. The Cripple Creek extension is designed to pass along the bottom near the creek; and a spur from this road south along the small branch on the eastern side, will render almost the entire area of the tract available for mining purposes.

Topography. Inasmuch as almost the entire tract is composed of limestone and associated slate rocks, the topographical features are quite similar through all parts, consisting of a series of three or four small and nearly parallel ridges, trending north-east and south-west, and separated from each other by gentle valleys.

The drainage is all north and east, and consequently the lowest levels and greatest depressions are along Cripple creek and a small branch heading up back of Mr. Sanders' house. The least variation of contour occurs towards the west and south-west ends of the property, where too the only timber land exists, the balance being cultivated.

Perhaps the most conspicuous feature is the high terraced hill lying on the north side of the road and to the west of the dwelling house, which slopes gently on the east and south, but rapidly on its north flank to the wide bottom lands between it and the creek.

On the whole the topography is very pleasing to the eye, and in no part of the tract does it present any barrier to the location of side lines and tramways for the development of the property.

Geology and Structure. As might be inferred from the brief statement of the topography, the geological and structural features of the property are simple in the extreme.

With the possible exception of a small dome of slate, caught in the high knob north of the road, which may be a remnant of a higher formation, the Hudson River, Matinal or No. III slate, the entire area of the property is occupied by the next lower formation, No. II, or the Cambro-Silurian limestone, which makes up so large a part of the New River-Cripple Creek valley.

This limestone formation may be conveniently divided into three parts: a lower and an upper limestone and a central band of red slates. The first and lowest rests upon the Potsdam sandstone or "mountain rock," and comprises a series of banded and mottled magnesian limestones, some 600 to 800 feet thick, occurring between the mountain rock and the red slate measures. These latter are of varying thickness throughout the Cripple creek region as a whole, or else their true section is concealed by folds and faults. They consist of a mass of red, green and yellow slate (with the red predominating) and impure limestones, and on this property seem to be about 700 feet thick, and create the ridge forming a portion of the southern property line.

Above these slates, *geologically*, come a series of purer and fatter limestones, which on this property extend northwards from the red slate ridge to the creek.

The main synclinal axis or basin of the upper Cripple Creek valley is very well displayed on S. Porter's land, a couple of hundred yards north of the creek on the public road. Westward it soon passes to the south side of the stream,

a short distance in front of Mr. Sanders' house, striking directly through the high knob already mentioned, and on to the Percival house and Cave hill on Dry run, 2 miles west.

Owing to the presence of this axis, all the measures lying to the *south* of that line are dipping *northwards* into the basin, and this dip becomes gentler the farther removed from the mountain on the south.

In point of fact, along the ravine between the mountain and the red slate ridge on the south side of the property, the lower limestones are standing at angles of nearly 80°, dipping north-west, and are succeeded northward by the slates dipping 60° in the same direction, but only 45° on the north side of the ridge. Still further north, the upper limestones come in first with a dip of N. 15° E. 35° until along the public road they incline only 25° and 15° in the high hill to the north. These facts are clearly brought out by the ideal section on page plate, which is designed to picture the relationship of the rocks along a general north and south line A–B.

Ore Outcrops, Acreage, etc. Throughout a large portion of the New River-Cripple Creek region, quite a plentiful and persistent supply of good brown hematite iron-ore is found associated with the lower series of mottled limestones, or those occurring along the narrow valley on the south side of the Sanders property. This is the ore found at Rich Hill and along the east side of Little Reed Island creek, Foster's Falls, Hematite Iron Co., Beverly furnace bank and other places. Unfortunately these ore-bearing measures outcrop for only about 1,200 feet in length on this property, owing to the shape of the boundary lines, and moreover are tilted up to such high angles as to be exposed to the maximum erosion, until no traces of this ore can be found in them.

Nor does the southern property line extend far enough up the flank of Iron mountain to warrant the belief that any of the "mountain ore" deposits, except in loose boulders, will exist in place there.

Consequently, the available ore-supply from the Sanders property must be derived from the upper series of limestones, or those lying *geologically* above the barren red slate measures.

It is true that some effort has been made tending to associate a species of "red hematite" with these slate measures through this and adjoining properties; but no tangible results have as yet been obtained by anybody, and the experience in similar measures elsewhere throughout the region would tend to make it doubtful that such ore will be found in commercial quantities through this belt.

Of the areas north of the slate, two outcrops give promise of yielding merchantable ore in considerable quantity.

The first and lowest outcrops in the limestone immediately above the red slate, and shows most conspicuously in the flanks of the limestone ridges just west of the small branch. The surface showing can hardly be termed profuse; but it is fairly continuous for about 500 yards westward, after which only occasional pieces show towards the crest of the ridge and the western line of the property.

In breadth, north and south, the ore shows for about 250 to 300 yards a short distance west of the creek, thinning somewhat along the strike of the rocks; so that to judge from surface indications alone, 25 acres would be a maximum area of visible ore-territory in this part of the property.

Any extension of the deposit westward must be at the expense of heavier stripping; otherwise there is no good reason why this ore may not be proved in that direction beyond the limits of the present outcrop.

The character of the surface ore is very fine, and it seems to be quite uniform in quality throughout the length of the outcrop. Samples were taken to represent a fair average. They yield when dried at 212° F.:

Metallic iron,	56.375
Phosphorus,	.163
Siliceous matter,	5.460
Phosphorus in 100 parts iron,	.289

This represents a first-class quality of iron ore: rich in metallic iron and quite free from injurious admixtures.

The second horizon of ore can be seen along the public road west of Mr. Sanders' house and in the hill to the north. Between this ore deposit and the lower one last described, there seems to be an area, occupied by two ridges and two

valleys, quite barren of ore. So too, near the dwelling house, in direct line with the upper horizon, the surface showings are meager, owing perhaps to the greater erosion there and the presence of outcropping limestone ledges. But ascending the ravine through which the road passes, the ore outcrops abundantly, both in the road and along the small ridge to the south for a distance of nearly 700 yards from the house.

Limestones outcrop with gentle north and north-east dips along the road in two or three places; but are not very conspicuous; while in the hill north of the road they are essentially absent. The south and east slope of this ridge carries a handsome surface outcrop of attractive ore, much of it dense in structure, with a steel-blue color, and consisting largely of lump ore. The visible crop extends well to the edge of the terrace westward, until the hill quickly rises and is capped with a fine decomposed slate, entirely concealing the ore.

The outcrop, therefore, is confined to from 40 to 50 acres here, which is a liberal estimate of ore-territory. It would be interesting to shaft the hill to demonstrate or disprove the existence of an ore body beneath this covering; but in the absence of any openings whatever, we could not feel justified in including it in an estimate of ore-territory. A handsome face of ore could be secured on this hill, and the material conveniently moved to the creek for washing, or water pumped to it.

The character of the ore is shown by the following analysis of samples taken throughout the length of the outcrop:

Metallic iron,	57.075
Phosphorus,	.091
Siliceous matter,	5.330
Phosphorus in 100 parts iron,	.159

This is a remarkably rich and in every respect desirable ore.

Summary.

The property is undoubtedly a valuable one, and its main features may be summed up as follows:

1. While the absence of any developments on the property prevents the expression of any positive opinion as to the extent in depth of the ore outcrop, yet the indications are

favorable for obtaining a good workable ore face on several parts of the property, as already indicated.

2. The excellent character of the ore, as shown by the analyses of the samples from both outcrops—the percentage of iron being higher than in the average Cripple Creek ore.

3. The readily cleansed character of the material with which the ore is associated.

4. The unusual facilities offered by Cripple creek for washing operations.

5. The topographical features are very favorable for an easy development and working of the ore deposits.

6. The extension of the Cripple Creek railroad to this point will render ore shipments convenient and inexpensive, the located line running quite close to the most promising ore outcrops.

Respectfully submitted,

ANDREW S. MCCREATH,
E. V. D'INVILLIERS.

The *Stephen Simmerman farm* lies just north along Cripple creek, and, in a measure, the same remarks are applicable to it as to the Sanders. The bulk, if not the whole, of his tract lies on the northern side of the creek; but, like the Sanders farm, only the presence of a good outcrop exists to suggest its value as an ore property. Just north of the ford, on the road leading to the Porter house, the synclinal passes and carries in its trough the same limestones and ores visible at Sanders', although not quite in such quantity as upon the Sanders farm. Going northeast along the road to the Porter house, limestones outcrop with dips of from 15 to 30° southward, and create a prominent feature in the topography of the country. Their presence here, outcropping in bold ledges, effectually prevents the occurrence of cheap or profitable ore deposits, and in a short distance still further north the red slate measures of the Raven Cliff and Crab Orchard ridges cut off entirely all chance of its occurrence between Thorn branch and St. Peter's church.

The *Gannaway property* lies about a mile east of Dry run

and the Grayson pike, and on the south side of the road leading from the Percival house eastward down Cripple creek. The Speedwell company own in fee about 500 acres of the Thomas Gannaway tract, and the Cave Hill company control the mineral right in the property of John Gannaway lying a little further west and nearer the pike.

The occurrence of ore on these farms is in a measure unique, and shows two distinct varieties, known locally as the "yellow ore" and the "red ore." The former occurs in geologically higher limestones, and a little further north than the lower or red ore deposit.

The yellow ore bank of the Speedwell company shows a cut of about 100 feet long and from 15 to 25 feet deep, quite irregular in shape and having the form of a crescent. The ore dips quite steeply (40°) to the north-north-east, and carries from five to ten feet of stripping of a yellow, puffy clay, and, rapidly taking cover on the dip, will soon become quite expensive to mine. Owing to this feature in the deposit, which applies equally to the red ore, both companies mining here have conducted their operations superficially over a large amount of territory, and no workings deep enough have yet been instituted to warrant an assumption concerning the continuity of these deposits to any distance beneath their outcrop. The latter, however, is very profuse, covering several acres along the top of the hill, north to the public road. The yellow ore bank first mentioned shows a light, yellow-colored hematite, occurring in thin plate-like masses, from one eighth to half an inch thick, very thoroughly mixed with the dry clay, and reported to yield about 50 per cent. clean ore in the washer. This variety of ore seems to occur rather more profusely on the Thos. Gannaway tract than on the property controlled by the Cave Hill company, its outcrop describing quite a regular curve northwards, and being fairly limited westward by the dividing line between the two farms.

The character of the "yellow ore" is shown by the following analysis:

Metallic iron,	51.300
Phosphorus,	.207
Siliceous matter,	10.990
Phosphorus in 100 parts iron,	.403

It should perhaps be stated here that, owing to the severe weather, the ore pile from which sample was taken was badly prepared, being largely mixed with clay; and it is quite probable that under more favorable circumstances for washing, the ore would show up considerably richer in iron.

The red ores were largely present on both properties and seem to occur in limestones some 400 feet lower in formation No. II. The openings in these ores are likewise meager as to depth, nowhere showing over five or six feet, although developed over a large territory. On the basis that the "best ore is the cheapest to mine," both companies seem to have been content to raise the sod and about two feet of soil, wherever an attractive outcrop led them, without at all going into anything like regular mining operations. The absence of wash-water in this locality is possibly largely responsible for this method of work, for there is nothing in the character of the exposure to suggest a thin covering of ore. Once that the depth of the deposit can be assured, by either test pits or a regular mining cut, the locality should furnish a large amount of exceedingly cheap and valuable ore. A sample was taken of the red ore variety from the Speedwell furnace stock pile, which yielded upon analysis the following result:

Metallic iron,	50.250
Phosphorus,	.110
Siliceous matter,	14.760
Phosphorus in 100 parts of iron,	.219

The same remarks made in regard to the preparation or washing of the "yellow ore," apply equally well here, for the appearance of the clean outcrop ore would certainly justify the expectation of a much richer ore than the above analysis shows.

The hill immediately south of the ridge containing these ores seems to be made up partly of red slate measures. This fact could not be positively assured; but if so, it would be an important extension of similar measures noted upon the J. A. Sanders farm, along the southern side of the valley in proximity to the range of Potsdam sandstone hills everywhere making up the southern boundary line of the New River-Cripple Creek valley.

Dry run, coursing along the Wytheville and Grayson mud pike, lies but a short distance west of the Gannaway tract. Although a small branch here, its numerous tributaries have created much erosion in past times; and immediately along its banks no evidences now exist which might serve to connect the line of ore deposits to the east and west of it. Nor were any signs of the red slate measures noticed in ascending the stream from Cripple creek, the Potsdam slates showing in the bed of the stream at the old saw-mill, and creating a natural foundation for the dam site. They dip steeply north-west, and are apparently comformable with the overlying limestones.

The *Cave Hill* ore bank, situated a little more than a mile due south of the Speedwell furnace, lies immediately back of the Cave Hill furnace, upon the southern flank of Cave Hill. The opening shows a rather small and irregular open cut, about 100 feet long, 25 feet wide and 15 feet deep, tapering somewhat towards the north-east and south-west, and now entirely abandoned. The sides were badly fallen in, and the ore faces covered with a surface wash, almost entirely obliterating their character, so that at but few places could the ore-material be seen. Leading up to the bank from the furnace, quite a conspicuous outcrop of ore is visible, sometimes showing a rather rich-looking dark brown ore, but again a highly manganiferous variety, while occasionally almost pure pieces of the black oxide of manganese show through the deposit. Owing to these variations in the character of the ore, and the concealment of a large portion of the ore in place, it was deemed inadvisable to take any sample for analysis, as no correct idea could be formed of the relative proportions of the different ore masses which the bank might yield in regular mining operations. The bank was abandoned long prior to the stoppage of the furnace in 1884, largely owing to the excess of manganese found in the deposit, which caused the production of a white, brittle iron showing at times a cleavage quite similar to that of Spiegel.

A sample of this metal was analysed with the following results:

Silicon,	.140
Manganese,	3.524
Phosphorus,	.459

This amount of manganese in the metal will give but little idea of the percentage in the ore, for it is quite likely that, with the low heat obtained in a cold-blast charcoal furnace, much of the manganese has gone into the slag.

The dip of the limestones and accompanying ore near the bank is to the north-west at angles of from 20° to 25°, and consequently the opening lies on the southern side of the synclinal. Dry run skirts the hill to the south-east and, cutting deeply into the limestone measures, it fairly eliminates all traces of the ore-material found higher on the hills on either side. The Grayson pike follows the line of this creek closely into Grayson county, and the limestone measures of No. II are last seen on the creek just below the old saw-mill dam, which is built upon the upper slates of the Potsdam formation, No. I, dipping steeply north-north-west.

Proceeding up the hill to the south-west, the outcrop shows less distinctly; but were it not for the character of the ore in this portion of the field, no doubt a handsome opening could be made upon this portion of the property. The company obtained all their ore for their last blasts from the leased bank on the Gannaway farm, about a mile east of the creek, which has already been mentioned in connection with property held in that vicinity by the Speedwell furnace company.

The Wythe and Speedwell Mining and Iron Manufacturing company own or control about 12,000 acres of land lying on both sides of Cripple creek, but largely on the southern side, extending from the creek well into the Iron mountain range and Grayson county. A portion of their ore is in a direct line with the Cave Hill deposit just described, and that portion of it lying on the southern side of the synclinal axis has been the part most largely developed. About a mile west of the Cave Hill furnace and Dry Run, the principal opening has been made, about 300 feet in elevation above the creek and about a mile and a half south-west of their furnace on Cripple creek. This pit is 125 feet long, 60

feet wide and 25 feet deep; somewhat irregular in shape, and yields material washing about one third of clean ore. The bank furnishes largely a fine wash-ore; and although its idleness at the time of our visit prevented a thorough inspection of its ore-faces, there seems to be no doubt of the abundance of the deposit here and in the immediate vicinity. The washers are located a little further down the hill towards the north, and water is pumped to them a distance of 2160 feet from Dry run, so that the facilities for cleansing the ore are not so favorable here as at some other points in the region.

The character of the ore from this bank is shown by the following analysis:

Protoxide of iron,	None.
Sesquioxide of iron,	73.107
Sesquioxide of manganese,	1.334
Sesquioxide of cobalt,	.110
Oxide of zinc,	.220
Alumina,	1.410
Lime,	.710
Magnesia,	.677
Sulphuric acid,	.012
Phosphoric acid,	.451
Water,	10.576
Siliceous matter,	11.510
	100.117
Metallic iron,	51.175
Metallic manganese,	.929
Sulphur,	.005
Phosphorus,	.197
Phosphorus in 100 parts iron,	.384

A variety of manganiferous ore is likewise visible in some portions of the cut, but not to that extent already noted at Cave Hill. The limestones, too, which outcrop here upon north-west dips of about 20° to 25°, seem to occur rather lower in the formation than those of the neighboring operation.

The ridge to the south of the opening rises regularly with a gentle slope to about 450′ above the creek, divided there by a deep ravine from the first spur of Iron mountain and Potsdam sandstone rocks to the south. On the summit

of this hill, a considerable amount of shallow work has been done in the ore deposit through quite an extensive outcrop of ore; and a recent pit twelve feet deep was sampled, in which ore occurred all the way to the bottom. The ore itself has a rather massive character, but with a fairly open structure, and occurs considerably mixed with wash-ore through the pit. The clay here is of a red color, although the ore is apparently associated with a lower range of limestones than those first described in the deep workings further north. But the outcrop between the two places is almost continuous through a distance of 300 to 400 yards, a large portion of which would yield handsomely if all put through the washer.

A sample of the lump ore taken from the twelve foot shaft yields on analysis:

Metallic iron,	55.950
Phosphorus,	.112
Siliceous matter,	4.250
Phosphorus in 100 parts iron,	.200

All these openings so far described are on the company's Percival farm of 400 acres. This farm is joined on the west by the Andis farm of 200 acres, extending for about a quarter of a mile west to the location of some additional pits on that portion of the company's land. Here, in a cove along the south side of the synclinal, an 18 foot shaft has been sunk through yellow clay and wash-ore, the latter showing a liver-colored ore, and not very rich. A little further west a 14 foot shaft turned out a considerable amount of lump-ore, and was stopped with good lump-ore in the bottom. A light yellow clay accompanies the ore at this place; and the horizon of the deposit, owing to the contraction of the basin westward, cannot be far, if any, above the contact line of Nos. I and II. Indeed, in all essential particulars, the ore resembles closely the mountain ore of the upper Potsdam formation.

An analysis shows it to contain:

Metallic iron,	43.775
Metallic manganese,	4.570
Phosphorus,	.368
Siliceous matter,	17.320
Phosphorus in 100 parts iron,	.840

Just west of these openings, a ravine leads northwards to Cripple creek; and a little further south-west of the shafts and around the western nose of the hill, some few additional openings have been made in a somewhat lower grade ore. One shaft, 35 feet deep, turned out some wash and lump-ore, the latter associated with a drusy quartz occurring in cavities, and accompanied also with some iron pyrites. No sample was taken from this locality; but the appearance of the ore itself suggests the Potsdam horizon.

The blue limestone exposed on the south side of Cave hill crops westward from Dry run for nearly a mile, rising in that direction as the basin shallows up, and succeeded by lower and lower limestones. The position of the synclinal is very well seen, as already stated, just at the Andis farm house, where converging dips of 20° on either side of the axis demonstrate the compressed character of the basin. Indeed the trough is scarcely more than 250 yards wide at this place; and so rapidly is the basin spooning towards the west that, in a very short distance beyond this farm, the underlying red slate measures lap around the fold, creating a characteristic and somewhat sharp topography. If these red slates are to be associated with the band of similar measures already described as occupying a position along the Grayson pike between Cripple creek and Speedwell post-office (which is quite probable), the Andis farm house practically limits the western extension of the ore-bearing limestones in this portion of the field, until, proceeding still further west, and crossing a dividing ridge on to the waters of the Holston, a corresponding basin of these limestones begins and continues regularly in that direction into the Rye valley.

This portion of the field was not examined, the Speedwell furnace being the limit of our investigations westward.

At Speedwell furnace the limestones seem to be quite pure, occurring in bluffs along the creek, with dips of about 25° nearly due south. Striking east from this point, and occupying a strip of land about half a mile wide between the creek and the red slate band upon the Grayson pike, they again carry a fair amount of excellent iron-ore, which has been tested to some slight extent upon the company's Kitchen

farm. Here five shafts have been put down to the west of the farm-house, generally developing a very fine wash-ore with some few lumps, to a depth of 10 or 12 feet, and usually with about two feet of overburden. Two of the shafts, located well on top of the limestone ridge, have yielded but a small amount of lump, and were not sufficiently developed through the wash-ore to warrant sampling. But immediately back of the house, an old cut and two shafts above it have yielded an attractive brown-hematite showing an excellent character of reddish ore, very pure in itself and free from hurtful clay-material. A general sample was taken at this point, with the following results upon analysis:

Metallic iron,	53.450
Phosphorus,	.064
Siliceous matter,	9.640
Phosphorus in 100 parts iron,	.119

The Speedwell company, as has already been intimated, have also mined from a portion of the Gannaway farm lying to the east of Dry run, and almost the entire ore supply was being obtained from that point during the latter portion of 1886.

An inspection of the map will show what a broad belt of red slate country extends north of Cripple creek and west from Gleaves' knob, almost without a break to Thorn branch, where the expiration of the Raven Cliff anticlinal permits the lapping over and extension northward of the purer limestone measures to within a half mile of the Fleming church. With the exception of this small area of limestone north of Cripple creek and west of Thorn branch, it may be safely said that, through all the belt of country just mentioned, running close to the base of Davis or Henley mountain, no commercial ore territory exists. In going up any one of the numerous branch streams which enter Cripple creek from the north, nearly parallel and similar sections of these red slaty rocks can be seen. In places thin bedded limestones occur, dipping conformably to and lying between the red slate measures; but there is not a single ore development throughout the entire area of these rocks, in spite of the fact that various enticing outcrops have been reported. On account

of the economical poverty of this belt of country, no time was spent in endeavoring to work out its geological structure too closely; but enough was seen to suggest the exceedingly complicated structure of the region and the existence of one or more faults in the western portion of the area, at least along the Wytheville and Grayson mud pike. One rather prominent anticlinal roll can be detected on both sides of Cripple creek, between R. H. Gleaves' and J. Crockett's; but none such is visible further west along Mill creek, where the axis has either entirely expired or has been broken vertically, and exposes nothing but south-east dips, with minor rolls, for at least two miles and a half north of Cripple creek.

A series of nearly vertical dips can likewise be noticed upon each of the branch streams about the middle of the belt, creating a rather prominent and straight ridge, extending from the forks of Fisher's branch in a very direct line past the Fleming church to a little north of the Speedwell Post Office, on the Mud pike. At the latter place, this nearly vertical dip is immediately succeeded on the north by similar measures, with a dip of only 45° to the south-east, so that there is a strong suggestion of a non-conformability in these measures and a duplication of them. The same ridge may be traced from the forks of Fisher's branch for many miles eastward to New River below Carter's ferry, and forming the northern wall of the ore-bearing limestone valley already described. A section, from the position of this fault (?) on the Mud pike northwards, shows a conformable south-east dip in red slate and limestone measures of from 45° to 60° through a distance of perhaps half a mile, when a geologically lower limestone is met with, partaking of the character of a dolomite, with a blue to blue-gray color, and everywhere flanking the spurs of Lick mountain along their southern base. Through this lower limestone belt, especially on the southern slope of Davis mountain, some perfunctory developments have been attempted; but so far, no very attractive ore deposit has been opened. The western branch of Fisher's creek, which crosses the rear road running along the base of Davis mountain, about a mile below Major Wythe Gleaves' and near the Welsh house, is the dividing line between the red slate land

and the lower limestone. The latter has a dip at this point of about S. 30° E. 60°, rising for some little distance on to the slope of Davis mountain.

Grosclose property. Some slight development has been made upon this property, about 2½ miles north-west of Eagle furnace, and on the southern slope of the Henley mountain. Near the base of the hill, back of Grosclose's house, some slight showing of manganese ore occurs, both on the Aaron Cordell tract (24 acres) and on the J. H. Grosclose tract, (100 acres) largely associated with boulder clay and mountain wash; and also showing some lean iron ore mixed with drift. About 250 feet up the mountain slope from the house, a trench has been made in a lean mountain ore, filled with siliceous matter and commercially worthless; and 100 feet above this ,a small pit has been sunk through a dark, blue-black manganiferous clay, carrying some few pieces of lean, siliceous ore. No exposure of rock occurs here, but the dip is probably a steep south-east one.

A large number of pits have been sunk along the terrace north and east of Grosclose's house. Almost every one of them was more or less productive of ore-material; and indeed in some of them the showing was quite abundant. But to one familiar with the characteristics of the New River-Cripple Creek ore deposits, an inspection of these pits would at once disclose the fact that the ores developed here are not deposits in place. The terrace is formed of the lowest limestone rocks, or those occurring between the Potsdam sandstone and the Knox red slates. These rocks are concealed by a heavy mountain sand wash; but their presence beneath this wash is confirmed by numerous sink holes and outcropping limestone ledges to the east and west. Even in the pits themselves, a large amount of foreign material is mixed with the ores, much of it rolled and water-worn, while the ore itself partakes largely of a rather lean and, in some places, manganiferous mountain ore, which no doubt has been derived from precisely similar measures outcropping in place further up the hill side. Under these circumstances, in the absence of railroad facilities, and on account of the extreme irregularity

of these secondary deposits, it is doubtful whether the amount of work done so far has demonstrated the presence of a commercial body of ore. A single exception might be made to this general statement, viz: the occurrence, in a very shallow pit, of a considerable quantity of bomb-shell ore—a variety not hitherto specially noticed in other parts of the field, but which may probably be identified as in place in these lower limestones. The bombs are largely filled with clay, though in themselves they show an ore of good quality. In any event, any commercial ore-body to be found along this terrace in the future, will have to be sought for under this stripping of secondary wash-deposits.

Going west along the road towards the Grayson pike, the same sandy ore is exposed in a flat back of Henley's house, about 200 yards north of the public road. The ore here, into which a pit is said to have been sunk about 30 feet, is again a mere ferruginous cherty sandstone, and is utterly worthless.

Between the Potsdam sandstone occurring here at the base of the mountain and the red slate belt to the south, the hard dolomitic limestone, near the base of No. II, crops through the valley south of the road, on a 60° south-east dip, with some gray slaty layers, but generally breaking out in small angular ten inch blocks, due to cleavage. This limestone is from 1,200 to 1,500 feet thick before the first band of red slate is met with going south, and cropping on the north flank of the first ridge south of the road. From this line of junction south to Cripple creek no very large ore deposit need be anticipated, as experience elsewhere throughout the entire region has failed to demonstrate any paying territory within the borders of these red slate lands.

About one mile beyond A. B. Harris' house the Grayson pike is reached, the limestone swinging a little north on a somewhat flattened dip, and consequently presenting a wider area between the red slate lands and the Potsdam sandstone of the Davis mountain spurs. The total thickness of these red slate measures along the Grayson pike, going south, would approximate four thousand feet, provided no duplication by anticlinal or fault was made, as has already been suggested was the case.

The southern limit of this slate belt, here nearly a mile wide along the pike, is seen to occur at about the middle of the ridge extending east and west just south of Speedwell post office, and a little north of Cripple creek. Passing immediately south of this, the higher limestones of the upper Cripple creek ore-bearing basin come in on a south-east dip of about 40°.

Lick Mountain Area.

Lick Mountain, as has been already stated in the early part of this report, occupies nearly the entire area of land between the upper Cripple creek region and the main line of the Norfolk and Western railroad. It consists almost entirely of the Potsdam sandstone rocks, and, structurally, may be considered as one main anticlinal in the center, with two subordinate anticlinal ridges on the north and south, and with compressed synclinal basins between them and the main mountain.

The central ridge goes by the name of Lick mountain on the east, and Stuart mountain on the west. The southern range is variously known as Henley, Davis and Swecker mountain, these being merely different names for the same ridge and anticlinal in different parts of the field. Sand mountain lies to the north, between the main crest and the railroad, and is so called from the ready disintegration of its rocks.

Henley's flat is the name given to the valley between the main crest and the southern anticlinal; and although its soil is largely composed of sandstone boulders and wash from the mountains on either side, yet quite an appreciable amount of limestone is held in different parts of the trough between the two pikes leading south from Wytheville.

Mr. W. A. Stuart owns a very large area of these mountain lands, his several tracts footing up to about 14,000 acres. He alone may be said to have developed different portions of this large survey, although by far the larger number of his openings cannot in any way be considered as tributary to the Cripple Creek region. Several of them were visited along Henley's flat and the mountain slopes on either side; and in general it may be said, that the quality of the

mountain ore developed in them is hardly up to the standard of similar deposits in the mountain area along the southern side of the New River-Cripple Creek valley. It is but proper to state, however, that only a limited portion of his property was gone over, and, of the portion not seen, a large number of the openings are said to exhibit a character fully up to the requirements of shipping ore. Opportunity permitted the examination first of the

Dungeon bank, which is situated on the north-east side of a spur of Lick mountain, separated from the main crest by Dungeon branch, the latter flowing in a narrow ravine a little west of the Wytheville and Ivanhoe turnpike until it sinks in the limestone rocks of the main valley.

The opening is about five miles north-north-west from the Brown Hill furnace, via the Wytheville pike, and lies about 125 feet above the level of the creek. The ore itself shows the usual mountain type, and is located geologically well within the body of the sandstone, apparently at the horizon of the lower Potsdam ore. The opening shows a rather dark pitchy-brown hematite, regularly bedded and apparently dipping west-north-west. The opening is a somewhat rough open cut, in which the ore is exposed for some 8 or 10 feet along the line of strike, possibly 25 feet thick, and developed on the dip for a distance of about 20 feet. But the opening is so irregular and the bedding so obscure, that the above dimensions may be somewhat at fault. A sample was taken with the object of securing a general average representation of the entire deposit; and the results of its analysis are as follows:

Metallic iron,	51.450
Metallic manganese,	1.642
Phosphorus,	.637
Siliceous matter,	9.330
Phosphorus in 100 parts iron,	1.238

The *Paint bank* (Manganese) lies probably one and a half miles west-north-west from the Dungeon bank, and on the south flank of Lick mountain, a considerable distance beyond where the spur last mentioned joins the main hill. Swecker mountain has also risen from the valley plain on the south, and between it and Lick mountain the Paint branch de-

scends eastward. No limestone shows in the valley at this point, although a large sink hole exists about half a mile further west and up stream, to which the limestone, superficially concealed, probably extends. The Paint bank shows a somewhat circular pit, low down on the mountain flank and about 100 yards north of the creek. When visited, the open cut was somewhat fallen in, and the ore-faces gave only an indication of the presence of manganese, in the form of a black earthy wad mixed with a somewhat tough yellow clay, in which sometimes a thin streak of hard black oxide of manganese is exposed. It is claimed that a car load or more of commercial ore was shipped from this opening to the Cambria Iron Company at Johnstown, Pennsylvania, in 1885; but certainly no merchantable ore is visible now. Some few excellent lumps still lay in the dirt bank, and these are said to represent the character of the ore shipped; but there was not a sufficient amount of this on the dump to warrant sampling.

The *Sink hole opening*, also a manganese bank, lies still a half mile further up the branch, and close to the center of the valley. It is fairly a duplication of the Paint bank opening in its general characteristics showing, however, a little more hard ore, which seemed to be somewhat ferruginous. The opening is close to the synclinal basin, the approximate dips being north and north-east about 15°. The Paint branch sinks at this point and disappears for nearly a quarter of a mile along the ravine; and the presence of limestone in the basin this far west is made still more probable by its occurrence in small pieces in the bank accompanying the manganiferous iron ore. The thickness of the bed exposed here may measure ten or twelve feet, and it is shown for about the same width along the face. The ore is more or less disintegrated, although a good deal of solid ore occurs in places. Occasionally pieces of quartz spoil the appearance of the lump ore; but this is not a conspicuous feature. The bank is about seven miles north-west from Brown Hill furnace, and is not very accessible. The product from this opening also formed a portion of the shipment to the Cambria Iron Com-

pany; and, from a small pile of ore still left, it may be assumed that only the best portion of the deposit was shipped. A general sample of the ore in place and the loose lumps near by yields as follows:

Metallic iron,	39.712
Metallic manganese,	11.519
Phosphorus,	.047
Siliceous matter,	12.840

The *Stuart and Tuttle opening* is situated on the north flank of the Henley mountain, about two miles west from the Matney place and south, about a quarter of a mile up a small branch, from Henley flat. Between this point and Matney's, some impure magnesian limestone shows on the flank of the mountain as a rather isolated patch, dipping about 45° northwards. In itself it is of little importance, except in so far as it proves the former existence of the limestone formation this far west, and assists in a demonstration of the structure of the mountain mass. The ore is opened in two places, between which there is an interval of about 40 feet uncovered. The uppermost opening shows an ore bed probably six or eight feet thick dipping north-west, and the face, otherwise apparently attractive, is ruined by the almost constant intrusion of white sandstone nodules, which seem to make up about one half the ore-mass. The pit is shallow, and nothing can be predicated, in advance of deeper explorations, as to what it may eventually yield; but all indications are at present decidedly detrimental to the commercial value of the whole deposit. The lower opening shows a shaly lean ore, occurring in the form of a mere shell covering the sandstone rocks, and apparently separated from the more southern cut by a roll or wedge of clay. No sample was taken from either of these openings, inasmuch as the quality of the ore exposed hardly justified it.

The valley rises still, for probably a mile further west, to a divide, from which the waters flow west and south. Near this point a considerable amount of work has been done on the flank and top of a small spur, but absolutely no ore worthy the name has been shown up. A considerable open

cut and a shaft some twenty feet deep have been sunk, largely in a sandstone rock barely coated with a thin film of iron oxide, and there is really nothing in the appearance of either place to justify further explorations at this point. Down the ravine towards the Patton house, some further shallow openings have been made close to the junction of the Potsdam sandstone rocks and the limestones which extend around the western base of Henley mountain, and for about a mile up the Patton valley from the Wytheville mud pike. The limestones north of Patton's house dip about 50° south-east, and several shafts have been sunk in the neighborhood in quest of ore, some on Stuart's land, and others on Patton's. When last seen none of them had demonstrated the presence of commercial ore, the bulk of the material resembling a ferruginous slate with an occasional piece of good ore, but in general quite lean. The limestone valley, however, need not necessarily be condemned, for the same rocks have elsewhere proved prolific of good ore.

Several other openings were mentioned in correspondence with Mr. Stuart as occurring nearer the crest of Lick mountain and towards its eastern base; but no opportunity presented itself for an examination of these, and in general they are hardly accessible to the Cripple Creek extension.

The north side of Lick mountain facing the main valley is likewise spoken of as a future ore-field; but necessarily any deposits on that side of the mountain should be developed from the main line, and consequently their examination did not come within the scope of the present report. The occurrence of limestone might also be mentioned along Stroup's branch, between Lick and Sand mountains, extending about a mile eastward from the Mud pike along the Matney gap road. It is also reported to show more or less of an outcrop of iron-ore which, if true, would warrant its development for tonnage to the main line. This limestone is caught in a gentle synclinal basin between the two mountain crests.

Properties in the Draper Mountain Area.

The *Henson farm* lies about 2 miles south-west from Max Meadows, on the north side of Hamilton knob; and the ore most developed here occurs close to the junction of Nos. X and XI, generally in a decomposed grey and buff clay.

The first opening is near the summit of a small divide, about half a mile east of the forks of the stream, and the ore-bed is there cross-cut for about 20 feet by a trench from 4 to 8 feet deep. The ore is sometimes a rather dense brown hematite, though much of it is quite cellular, with the cells largely filled with clay, and it carries an appreciable amount of gypsum in the form of crystals of sulphate of lime. The general appearance of the ore, however, is rather massive, showing boulders of irregular size and shape. The opening had not been carried far enough to tell much about either the thickness or the depth of the ore, which statement indeed is true of all the other openings shown us. The association of sulphate of lime here is unique in the region.

A second opening has been made a little further east of the knoll, just above a small ravine. Here the ore has been cut in a trench some 50 feet long. It is somewhat more cellular, carries less visible sulphate of lime, and is obscure as to dip and thickness. Quite a large amount of ore has been dug from the trench, and it seems to be still associated with the clays before mentioned. The limestone to the north of it is grey in color, and has a crystalline structure, carrying thin streaks of carbonaceous matter through the mass.

A third and irregular opening, largely mixed with clay, occurs about 100 feet still further east, which has been so far developed as to expose the ore in dome-shaped masses, divided from one another by barren clays.

A fourth opening is situated beside another ravine about 200 yards further east, cross-cut for 50 feet. The ore shown in the cut looks very well indeed, and again has become quite dense and close grained, and shows very little gypsum.

Finally, the same ore-bed is reported to be exposed naturally in a ravine ¼ mile east from here, so that the continuity of this ore is fairly well established for at least half a

mile, with the usual barren intervals occurring in all hematite banks.

The general character of the ore is so well maintained in each of the four openings that but one sample of the whole deposit was deemed necessary.

The analysis yields the following results:

Metallic iron,	45.550
Phosphorus,	.387
Siliceous matter,	17.510
Phosphorus in 100 parts iron,	.849

This sample was taken with the view of obtaining a representative analysis of the entire bed so far as exposed, although it is but proper to state that the whole appearance of cuts Nos. 3 and 4 showed a rather higher grade ore, due to its freedom from clay association, which was quite marked in the other openings.

The company were considering (May 1st) the advisability of sinking a deep shaft at the fourth opening.

Such a development would be very desirable, not only as determining the depth and persistency of this class of ores, of which our knowledge is limited in Virginia; but it would also be interesting to note the character of the ore as well, at some distance beneath the surface.

Near the western extremity of Hamilton knob, and more than half way down the slope of the hill, another different class of ore has been found and slightly opened. It is a dense ore, but darker in color and rougher in appearance than the limestone ore last described, and associated with the sandstone rocks of No. IV making the crest of Draper mountain. The opening is locally called the "outburst," from the conspicuous occurrence of the ore mass on the crest of a little knob, and seems to lie near the base of IV, though evidently in those measures which, near by, dip about S. 60° W. 40°, on the north side of the knob. Occasionally lumps show an intrusion of sandstone in them, spoiling an otherwise handsome-looking ore. The deposit would seem to be fairly local, although no special effort has been made to trace it around the knob. A general sample of the ore from the face and loose pieces yields:

Metallic iron,	49.850
Phosphorus,	.131
Siliceous matter,	13.600
Phosphorus in 100 parts iron,	.271

The fault which extends along the north-western base of Hamilton knob, and brings there Nos. II and X in contact, soon buries the Lower Silurian measures going east, and brings No. IV against No. X. It is altogether reasonable to imagine this fault to be directly connected with the one already located along the north base of Draper mountain, south of Pulaski, in which case its course would have to change to a more easterly one somewhere in the vicinity of the Wythe and Pulaski county lines, south of the railroad; or, in other words, to form an opposing crescent to the Draper valley fault line on the south side of the mountain, making the whole mountain area a wedge of the Upper Silurian measures, faulted against higher measures on the north and lower measures on the south.

It only remains now to mention a few additional points of interest occurring toward the eastern side of the mountain area, and give a brief description of the ores found there.

The *Clayton property* embraces a large area of mountain land lying south of Pulaski, upon which iron-ore has been partially developed.

The *Martin bank* is a little over half a mile south-east of the town, near a gap in the mountain, and apparently in the Umbral limestone, No. XI, as at Henson's on Hamilton knob.

The ore is exposed near the side of a narrow ravine through which a small stream breaks from the valley between Draper mountain and the range of hills to the north, and finds its way northward into Peak creek.

The limestone carrying the ore is dipping at a stiff angle northwards, and, immediately behind and below it geologically, the sandstones of No. X occur, with a conformable dip, carrying their slaty coal streaks, as at Reed creek at the west end of the mountain. The ore would seem to be in a precisely similar horizon as the Henson ore; and as no recent developments have been made at this point, the following

from "Mineral Wealth of Virginia," may serve to describe it and show its chemical character:

"The ore has been developed by a cross-cut along the edge of a narrow ravine. The face is now considerably covered by wash, but quite a rich-looking mass of ore, probably ten feet thick, may still be seen. The deposit has been tested in an east-south-east direction for several hundred feet, with a fairly rich ore showing in some of the pits; and the outcrop is quite pronounced at several points. The ore is more compact and fine-grained than at the Honaker bank. A sample, one hundred and seventy-five pieces, selected from a pile of twenty to twenty-five tons of ore, yields:

Metallic iron,	51.850
Phosphorus,	.321
Siliceous matter,	9.800
Phosphorus in 100 parts iron,	.619 "

Going south through this gap a very similar section is obtained to that ½ mile west along the Draper road. The Vespertine and Chemung sandstones of Nos. X and VHI make up the outer mountain and carry respectively about the same thickness as in the main gap. Once inside the gap, the stream heads south-east, diverging slowly from the base of the ridge, and exposing again the Hamilton black slates of No. VIII for some distance before they are concealed by debris. It is noticeable, however, that there is not nearly as great a thickness of the No. III slates exposed here on the south side of the valley, as on the public road west, the fault steadily absorbing these measures, which at the same time are evidently sinking eastward.

The structural difficulties going east are still further augmented by the ruggedness of the region, the amount of debris from both mountains, and consequent paucity of exposures.

The *Honaker bank*, of the Clayton property, is nearly a mile from the gap last mentioned, and 1½ miles from Pulaski. Nothing recent has been done at this point either, but the showing of ore, made in a series of trenches across the end and up the slope of a small spur or central dome-shaped

hill, is certainly very impressive. The developments, however, are such as hardly to warrant any opinion as to quantity here, although two or three shafts would let in a flood of light. Immediately to the *south* of any visible outcrops of ore at this place, white, brittle, vitreous sandstones occur, filled with quartz crystals and quite unlike any thing seen on either of the ridges bounding this interior valley. These rocks make the back-bone of this and a number of similar somewhat isolated knobs and spurs to the east, and, at the Honaker bank, dip but 20° *north-west*, almost immediately underlying the ore conformably (?), and to the south side of the deposit. This white vitreous sandstone is probably the Oriskany sandstone, No. VII; the ores, Marcellus No. VIII or Oriskany, occurring at the junction of the two formations; and the black slates to the north, Hamilton. And, furthermore, it would seem that this 20° dip is close to the crest of a broken anticlinal, the fault, passing immediately south of the central ridge, bringing VII and either III or IV together. On the *west* slope of the central ridge, the black slates are dipping 50° or 60° north-west, and maintain that angle to the gap. Such a structure—while the merest suggestion derived from a hasty reconnaissance of the region—would also explain how a shaft, located towards the *western* side of one of the trenches, passed a considerable distance (50′ or 60′ ?) through ore, the real thickness of which could have been much better tested near the crest of the broken anticlinal. This may be a surmise; but whatever its horizon, the slight dip of the sandstone to the south of the deposit could hardly admit of any such thickness of ore.

Nevertheless, the bed is of apparent good thickness, and has been opened in several such trenches, with large ore boulders outcropping between, fairly to the top of the ridge. The ore is a handsome looking, somewhat cellular brown hematite, but some of the leaner ore is cherty and filled with sandstone intrusions; and the whole deposit bears a close analogy in appearance and character to some of the Rockbridge Co. ore along the C. & O. R. R. A sample of this ore, 143 pieces, taken (1883) from the face of several cross-cuts,

will fairly represent the shipping ore. The analysis shows it to contain:

Protoxide of iron,	None.
Sesquioxide of iron,	69.107
Sesquioxide of manganese,	.733
Sesquioxide of cobalt,	.090
Oxide of zinc,	.050
Alumina,	1.511
Lime,	.520
Magnesia,	.425
Sulphuric acid,	.177
Phosphoric acid,	.252
Water,	11.670
Siliceous matter,	15.400
	99.935
Metallic iron,	48.375
Metallic manganese,	.511
Sulphur,	.071
Phosphorus,	.110
Phosphorus in 100 parts iron,	.227

The eastern end of this same hill has been somewhat developed by trenches, without as yet much success, for 500 yards from the last successful cut on the west side; and it will take some patient and close study to determine how far the course and throw of the fault will affect the economical features of the region.

Radford Iron Company property. A short distance east, on the Radford Iron Company's land, the central (No. VII?) sandstone seems to spread across the entire narrow valley, making a drainage divide for the waters of this depression, and effectually concealing all signs of the black slates, the last dip being an east south-east one, as if they were arching over a dying anticlinal.

The *Martin Carter* bank is located some little distance east of the divide, on the Radford Iron Company's property, showing ore in many respects like the Honaker bank, although as yet more associated with sandstone intrusions.

This opening occurs on the west slope of a small central spur; the ore-mass shows 6′ to 10′ thick, somewhat irregular in character, and dipping 40° to 50° north-west. The same

geological formations occur here as at Honaker's, only with steeper dips, more intrusions of sandsone in the ore-mass, making it somewhat difficult to select commercial ore, and with probably a somewhat less thickness of ore.

Some few recent developments here have moreover drifted through the bed, and found a dark blue impure limestone, impregnated with crystals of iron pyrites in all stages of oxidation, forming the base rock of the ore, and behind which tough gray clays occur.

The same ore-bed has been cross-cut a little further north-east, near the crest of a small knoll, and a fair amount of wash-ore exposed. At the north end of this cut, a shaft has been sunk through clay for about 30 feet, showing some little ore near the bottom at the time of inspection. If this ore is the same as that in the open cut, the ore-bed has quite a steep dip. Preparations were being made to drift southwards from the bottom of shaft to cut the bed.

The side cutting here was not extensive, and very little can be said about the *amount* of ore at any of these openings, although recent advices by letter report encouraging developments to the south-west of the places already noted.

Jefferson Carter's pit, on the same property, is opened on the summit of the next knob north-east, and a little closer to the main mountain. It shows about the same character of ore in an open cut 20′ long, north and south, exposing lump-ore in boulders for 3 or 4 feet beneath the surface.

The Vespertine ridge expires to the north about opposite this last opening, and the interior line of dome-shaped hills, marking the line of the Draper mountain fault, creates terraces on the north side of the main mountain. The interior valley begins to widen out toward the railroad and Peak creek, flanked on the north by Chemung sandstone hills, (No. VIII.)

The path from the Jefferson Carter opening leads east-south-east through the Johnson farm, (where there is a slight showing of sandy ore in patches.)

The *Wardell opening* lies about ½ a mile south-east and up

the mountain flank, and apparently in No. IV, Medina sandstone. The surface here is strewn with sandstone boulders from Peak knob. The ore is highly manganiferous, and pieces of it quite siliceous.

The *Loman pit* is situated still further up the flank of Peak knob, and rather on its north-east extremity. The deposit of ore seems quite profuse here, and is spread over a considerable area of ground, showing large boulders of a dark brown to pitchy-black, dense brown hematite, exceedingly hard and quite free from siliceous matter. The ore is undoubtedly rich in iron, and its appearance would suggest its being rather cold-short; but it is apparently free from manganese.

Other small pits have been sunk in this ore further east, which tend to show the deposit folding around the knob to the south-east, with the sandstones with which it is associated. The dip of the rocks is very flat here and into the mountain, which broadens the outcrop of ore.

Magnetic iron ore along the New River in Carroll and Grayson counties.

During the past six months, considerable interest has been manifested in the deposits of magnetic iron ore occurring along New River in Carroll and Grayson counties; and while it would be premature, owing to the meager developments which have as yet been made, to speak positively as to the character and extent of these deposits, yet the quality of the ore—in its freedom from phosphorus—is such as to warrant a thorough prospecting of the region.

Two samples were taken from different openings for analysis—not from the mining portions of the beds alone but including much of the leaner ore associated with hornblende and chlorite. The results of the analyses show these samples to contain:

	R. F. Williams.	*J. L. Pugh.*
Metallic iron,	35.800	45.100
Phosphorus,	.008	.008
Silica,	29.270	22.810
Phosphorus in 100 parts iron,	.022	.018

It is undoubtedly true that the ore will show much richer in iron when the bed has been properly opened up, and the mining portions of it alone selected. The analyses are, however, chiefly interesting as showing a very low phosphorus result; nor has this low phosphorus been found in these two samples only, but in many others examined from the region for the parties who are conducting the prospecting.

It will be manifest that the proving of workable deposits of such ores in this section will be of great advantage to the New River-Cripple Creek region—for their mixture with many of the limestone ores will permit the production of a strictly first-class Bessemer iron.

CHAPTER V.

Coal and Coke.

No report on the New-River Cripple creek mineral region would seem complete without at least a brief reference to the Pocahontas-Flat Top coal field, from which it will undoubtedly and naturally draw its supply of coal and coke. Whether it be in the production of pig iron within the district already described, or in the utilization of the same in the various manufacturing industries which generally accompany the establishment of blast furnace plants, this coal-field possesses within itself coal of such unusually good quality as to be fit for all purposes for which fuel is required in such industries; and in such quantity as to readily meet any demand which may be made upon it.

This coal-field is now so widely known, and has already been so frequently described, that it would seem superfluous to speak of it here in detail. But as an illustration of its rapid growth as a producer of coal and coke, the following table of shipments since it was first opened in 1883 may be instructive:

YEAR.	TONS OF 2,000 LBS.	YEAR.	TONS OF 2,000 LBS.
1883, ...	105,805	1885, . . .	651,987
1884, ...	272,173	1886, . . .	924,361

Thus far in 1887, the increase in shipments has averaged nearly 50% above those of the previous year; and in view of the increasing demand for this coal at tide-water and the numerous new connections being made, it is fairly probable that the output will not fall below 1,500,000 tons for the year.

As is well known, the coal in this Pocahontas-Flat Top coal-field occupies a very large area in Tazewell county, Virginia, and in Mercer, Wyoming, McDowell, and Raleigh counties of West Virginia. Throughout a large portion of

the Flat Top mountain area the beds are above water level and lie most conveniently for cheap development and mining. A considerable portion of this field has already secured outlets to markets through the New River division of the Norfolk and Western Railroad, and the numerous laterals extending along the Bluestone and its branches; while the near completion of the tunnel at the head of Coal creek on to the waters of Elkhorn, will open up an additional territory on the north side, in McDowell county.

Geologically, these coals belong to the lowest member of the coal measures, and are the equivalent of the Quinnimont group of the Kanawha region and the Pottsville conglomerate of Pennsylvania.

The section at Pocahontas shows the presence of at least three workable beds above water level, although almost the entire output of the region at present comes from the No. 3, Nelson or Pocahontas bed.

This handsome coal bed is everywhere present, so far as explored, with a workable thickness, being 11′ 3″ thick in the vicinity of Pocahontas, and holding its workable dimensions through the field for five miles eastward to the waters of Flipping creek, where it becomes split into two beds about 4½ and 5½ feet thick. To the west of Pocahontas along Laurel creek, for a distance of eight miles, the bed carries its full thickness fairly well, and shows nearly the same section for a long distance north of the dividing ridge on the waters of the Elkhorn and the Tug fork of Sandy.

Reference to any map of that region will show what a large area of country is underlaid by this coal bed. It should yield at least 10,000 tons of coal to the acre; while the two upper beds should each add probably 6,000 tons more.

The good quality of this coal has been well established by numerous tests, both in the laboratory and in actual practice; and its character may be conveniently shown by the following table, which comprises the analyses of fifteen average samples taken from different parts of the field:

Number.	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.
1,	.932	20.738	73.728	.618	3.984
2,	.684	19.964	73.021	.656	5.675
3,	1.398	19.902	71.171	.834	6.695
4,	.492	19.278	73.948	.847	5.435
5,	.768	18.532	71.170.	.670	8.860
6,	.560	18.545	74.683	.712	5.500
7,	.568	19.337	77.335	.800	1.960
8,	.516	17.639	74.272	.998	6.575
9,	.786	18.939	76.077	.793	3.405
10,	.564	18.166	72.147	.683	8.440
11,	.600	18.020	76.833	.622	3.925
12,	1.366	17.484	74.625	.575	5.950
13,	3.336	18.394	72.216	.549	5.505
14,	1.092	17.148	77.319	.711	3.730
15,	1.506	20.089	75.295	.875	2.235

To make a more complete comparison between these Flat Top coals and some other well known standard coals,* the following table is added:

Name of Coal.	Water.	Volatile matter.	Fixed Carbon.	Sulphur.	Ash.
1. Flat-Top Coals—average of 15 samples,	1.011	18.812	74.256	.730	5.191
2. Cumberland Coal—average of 2 samples,	.958	19.139	72.708	.787	6.408
3. Clearfield Coal—average of 3 samples,	1.186	22.168	69.270	.933	6.443
4. Broad Top Coal,	.594	17.551	71.334	.976	9.545
5. Connellsville Coking Coal,	1.260	30.107	59.616	.784	8.233
6. Westmoreland Coal,	1.430	36.145	55.891	.939	5.595
7. Cardiff Coal, Wales,	2.552	33.123	56.774	1.326	6.225

Not only has the Poçahontas coal been found to answer all the requirements of a good steam and rolling-mill coal, but it has proven itself a first-class coking coal as well.

* All of these samples were taken personally by us and will be found incorporated and localities described in the reports on "Mineral Wealth of Virginia," and "West Virginia and Ohio Railroad."

Abundant facilities exist for the location of coke oven plants on both sides of Flat Top mountain, where also a plentiful supply of water is always at command. Indeed, in the possession of such sites near the mines, and with the advantage of a large and cheaply mined coal-bed, there is nothing to retard the increase of coke oven plants to any extent the market may demand. Already the enlargement of this branch of the coal industry has been almost as phenomenal as that of mining and shipping the raw coal itself.

The directory accompanying this report will show how large the present capacity for furnishing coke is, and the building of 1,000 additional ovens this year, made necessary by the increased popularity of this coke, assures a very largely increased output in the near future. This coking field is within 100 miles of Pulaski and about 15 miles nearer to Radford.

The Pocahontas coke has already been largely used in the blast furnaces of Roanoke and Lynchburg, and in numerous foundries in the south and south-west; and its good quality is made apparent from the three following analyses of samples taken by us from the two active operations in the region:

	No. 1.	No. 2.	No. 3.
Water,	.182	.196	.664
Volatile matter,	.719	.494	1.059
Fixed carbon,	92.248	92.585	92.816
Sulphur,	.565	.677	.548
Ash,	6.286	6.048	4.913
Total,	100.000	100.000	100.000

No. 1. Southwest Virginia Improvement Co.'s ovens, Pocahontas; sampled January, 1887.

No. 2. Southwest Virginia Improvement Co.'s ovens, Pocahontas; sampled June, 1886.

No. 3. Stephenson, Mullen & Co.'s ovens, Pocahontas; sampled January, 1887.

To make a more complete comparison between this Pocahontas coke and other well known cokes, the following table is given:

	Water.	Volatile matter.	Fixed carbon.	Sulphur.	Ash.
1. Pocahontas coke; average of 3 samples, ...	.347	.757	92.550	.597	5.749
2. Birmingham, Alabama, district; average of 4 samples,	.157	.803	87.299	1.195	10.545
3. Chattanooga, Tennessee, district; average of 4 samples,	.447	1.101	80.513	1.595	16.344
4. Connellsville coke of Pennsylvania; average of 3 samples, ...	.060	.427	88.962	.810	9.741

These average analyses show, that so far as chemical purity is concerned, the Pocahontas coke ranks high, being lower in both sulphur and ash and higher in fixed carbon than the cokes from the other well-known districts.

CHAPTER VI.

Summary.

In reviewing the different subjects treated of in this report, certain facts seem to make themselves prominent, which may be briefly summarized as follows:

1. Character and quality of the ore. All of the iron ore at present mined and to be mined in the New River-Cripple Creek region proper may be conveniently classed under the general heading of *brown-hematite ore*, and is found associated in at least four well recognized horizons or belts, extending in a general north-east and south-west direction through the region, with the trend of the rock formations to which they have been referred.

The first and lowest *geologically* of these is the "Potsdam sandstone ore," occurring in the body of the formation from which it takes its name. These ores are locally known as the "back vein" or "bed" and are characterized by having a dark brown to pitchy black color, and are generally quite dense and brittle. Their composition is shown by the following average analysis of 5 samples already incorporated in the body of this report.

Average composition of the Potsdam sandstone ores.

Metallic iron,	50.200
Phosphorus,	1.007
Siliceous matter,	10.012
Phosphorus in 100 parts of iron,	2.006

The extremes are:

Metallic iron,	46.400 to 52.225
Phosphorus,	.637 " 1.388
Siliceous matter,	6.560 " 15.350

The second horizon is also associated with the Potsdam formation, or rather with the upper slates of that formation marking the transition between the Potsdam and the Cambro-Silurian limestone formations, and variously known as Potsdam, Cambrian or Knox slates.

This class of ore, usually very persistent and often occurring in great thickness along the north base of the Iron

mountain range on the south side of the valley, and likewise to be naturally expected in similar rocks in the Lick mountain range on the north side, is known and spoken of in this report as "Mountain ore," and is the same ore so largely found and mined along the foot-hills of the Blue Ridge in Virginia, and along the South Mountain hills in Pennsylvania. This ore has no specially distinguishing features, being largely, however, a massive brown or liver-colored ore, not perhaps so dense in structure or so dark in color as the Potsdam ore, and it is usually much more free from phosphorus.

While it is largely a lump ore, a considerable proportion of the material from this ore bed will be found to yield a wash-ore variety; and inasmuch as the bed is associated with slates whose decomposition gives rise to variegated colored stiff clays, the thorough preparation and cleansing of this wash-ore is attended with some difficulty. However, the presence of an ample water supply through nearly all parts of the New-River Cripple Creek district where this ore is found, should remove the one difficulty in its proper preparation for the market. The quality of this ore varies somewhat, but is fairly well shown by the following average analysis of 15 samples:

Average composition of the Mountain ores.

Metallic iron,	48.750
Phosphorus,	.329
Siliceous matter,	12.892
Phosphorus in 100 parts iron,	.675

The extremes are:

Metallic iron,	43.750 to 54.075
Phosphorus,	.104 " .878
Siliceous matter,	7.175 " 20.910

The limestone formation, making up the rocks of the general valley, contains in various parts of the region that class of ores known as the "limestone ores." While our surveys have tended to suggest the propriety of dividing them into two general classes: a lower one, associated with the magnesian or Knox limestones in the bottom portions of the Cambro-Silurian formation, characterized by a white and blue mottled limestone with blotches or seams of white calc-

spar; and an upper one, occurring several hundred feet higher in the same geological formation, in less magnesian limestones; yet it has not been found possible to arbitrarily fix the limit of the occurrence of either of these two classes of limestone ores, and consequently the third and fourth divisions or horizons may be conveniently treated together.

The occurrence of a rather tough red clay both within and surrounding the ore of the lower line of these limestone deposits suggested the differentiation already noted, quite as much as the difference in the appearance of the limestones with which they are associated; and the freedom of the second or higher line of deposits from this distinguishing clay, and their consequent slightly greater purity and more readily cleansed nature would seem to be the principal point of difference.

In either case, all the ores occurring within the limestone formation may be said to show wonderful uniformity over a territory 40 miles in length and from 1 to 3 miles in width. They are all brown-hematite ores of exceptionally good quality—rich in metallic iron, and low in phosphorus—many of them being well within Bessemer limits; comparatively free from siliceous matter, and with a generally open, cellular structure.

Their composition is shown by the following analysis representing the average of 74 samples.

Average composition of the Limestone ores:

Metallic iron,	54.999
Phosphorus,	.093
Siliceous matter,	6.810
Phosphorus in 100 parts iron,	.169

The extremes are:

Metallic iron,	48.775 to 59.500
Phosphorus,	.030 to .207
Siliceous matter,	3.600 to 14.760

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2. Richness of the ore material. Although the ores of the Potsdam sandstone formation, embracing the first two varieties described, have not hitherto been mined to a large extent, owing to the absence of such furnace plants as could best

utilize these massive ores, yet the richness of the material which these beds would furnish cannot be doubted by anyone investigating their properties. While no data are at hand by which we could judge of the practical results to be obtained from mining these ores in a large operation, their position above water level through much of the area will prevent the necessity of underground work for many years, and consequently provide for such a selection of material as will yield from one third to one half clean ore.

The limestone ores on the other hand, by reason of their greater accessibility, higher percentage of iron and more ready reduction in the small charcoal furnaces which have hitherto alone occupied this field, have been sufficiently developed and worked in a large number of places to warrant an opinion as to the richness of the ore-material. From the best information we could obtain bearing upon this subject the general claim is that two tons of ore-material will yield one ton of clean wash-ore; and this would seem to be confirmed by our own tests made from five different pits, and from samples weighing from 14 to 93 pounds, which yielded the following percentages of clean ore: 41 per cent., 53 per cent., 57 per cent., 59 per cent., and 60 per cent. But in estimating an average for the region, based upon the large production required for a modern coke furnace, it would not perhaps be safe to assume a yield of more than one ton of clean ore from every three tons of ore-material, a percentage which is certainly quite as great as, if not greater than, that obtained from any other brown-hematite ore region known at present.

3. Facilities for mining and washing ores. A casual inspection of the map will show the proximity of the Cripple Creek extension to the two main ore-fields in the lower and upper end of the valley. It will also show how readily branch lines can be located to develop properties not contiguous to the main line itself; so that the possession of proper railroad facilities for the movement of ore and other materials would seem sufficiently manifest. Indeed mention has already been made in this report of the existence of favorable locations for such lateral lines in almost all parts of the district,

and also of the double purposes which the numerous tributaries of New River and Cripple creek serve for the projection of such lines as well as supplying in many cases water for washing the ores. In this latter respect, this ore territory certainly enjoys exceptional advantages over any other developed brown-hematite ore field known to us; and it is in the possession of such an ample water supply that this region will be able to prepare its ores cheaply. The bulk of the limestone ores to be mined in the future will be largely of the wash-ore variety, consequently the question of a constant water supply is one of prime importance.

The ores themselves have hitherto been found associated with a clay which is readily removed by washing; and it is rare that any clay balls are to be seen in the washers in operation or in the prepared ore.

The cost of mining ores in this district will naturally vary with the location of the mining plant and the class of ore being mined. For instance, the expense of mining those ores occurring in the Potsdam formation is as yet purely problematical, for no regular mining has ever been as yet attempted on them. The limestone ores on the other hand have been developed and worked from one end of the field to the other; and while it is true that the quantity of ore mined has not been great at any one place, being simply used as a supply for small charcoal furnaces—yet sufficient work has been done to demonstrate the great ease and cheapness with which the ore-material can be moved and washed.

Certain exceptions have been taken to a statement made by us in a paper* read at the Scranton meeting of the American Institute of Mining Engineers, February, 1887, relative to the cost of mining and preparing these limestone ores. But upon further investigation the figures then given, viz: 75 cents a ton for actual mining operations, washing and putting upon the cars, but exclusive of royalty and interest on the plant, have been found applicable throughout a large part of the region, and have been confirmed by a number of the largest operators in the district. Indeed the statements furnished us, covering periods of from one to twelve months,

* See Transactions of the American Institute of Mining Engineers, vol. xv.

have varied between 40 and 80 cents; and while the former price is necessarily only applicable in the most favorable condition of affairs, the latter has been maintained under circumstances quite the reverse.

However, in estimating for a supply to a large modern furnace, where it is not always possible to make the same selection of territory and proceed with the same care in the preparation of the ore as is the case for charcoal furnaces, and where the operation must cover a long period of years, and perhaps involve mining below water level—which is nowhere necessary now—it would be reasonably safe to put the cost at one dollar per ton as an average for the region. The mining of the mountain ore deposits should not cost any more, although, as already stated, we have no data on which to base an estimate, and can only judge from the great thickness and advantageous position of the ore-beds here as compared with other regions where such ores are being operated.

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4. Fuel and Flux. The coke supply for smelting ores in this region will all be drawn from the Pocahontas-Flat Top field. The analyses of this coke as given in a previous part of this report show its superior character. It is unnecessary to comment upon the quality of a coke showing 92% fixed carbon and with a low sulphur and ash. Its burden-bearing qualities in the furnace have already been sufficiently demonstrated by practical use; and the almost unlimited coal supply in the Flat Top field should be a sufficient guarantee of the permanency of the coke supply.

This coke is now delivered on board the cars at the mines at $1 75 per ton, and it could be laid down at Pulaski or Radford at about $2 60.

In flux, the region contains within itself an abundant source of supply. This will be obtained from the purer portions of the Cambro-Silurian limestone formation, the extent of which is shown by the blue color on the map.

While no attempt has been made to take samples of the limestone available throughout the district, or from the quarries now operated for blast furnace use, the following analyses

will serve to show the character of the stone at several convenient points:

Analyses of Limestones.

Locality.	Carbonate of lime.	Carbonate of magnesia.	Oxide of iron and alumina.	Silica.
1. Bohannon property; from bluff facing Peak creek and 500′ from railroad near Cripple Creek junction; near Pulaski,	81.964	13.780	.940	3.270
2. Bohannon property; quarry opening 100′ from Cripple Creek extension,	70.857	19.553	1.940	7.180
3. Dyer's ferry cliff; section 15 on Cripple Creek extension. Bluff, 140′ to 160′ high and 1,300′ long,	84.553	11.404	1.010	3.030
4. Barren Springs bluff; section 16 on Cripple Creek extension,	54.019	41.794	1.100	2.770
5. Foster's Falls property; on New River just west of bridge over the river at Hematite Iron Co.'s mine. Face, 125′ long and 30′ high,	84.732	11.351	.790	3.090
6. Pulaski Iron Co.'s property; from bluff facing school-house at Buddle field tract,	82.142	11.736	1.450	4.220

It is usually the case in the limestone formation that the different beds or layers vary widely in their composition—both in the proportion of lime and magnesia as well as silica; and, as these samples represent a great thickness or number of beds, it is only reasonable to suppose that a proper selection of one or two of the beds separately will give results even more favorable than shown here.

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5. Quality of the water supply. Sufficient has already been stated to show that the region has an abundant supply of water for mining and manufacturing industries. So far as the question of washing the ores is concerned, the *quantity* rather than the *quality* of the water is more important; but for steam purposes and for various manufacturing industries, the quality of the water is often one to be seriously considered. Fortunately in this respect, too, the region is

unusually favored; for the following analyses will show that the water is of remarkable purity and admirably adapted for steam purposes. During evaporation, the various waters examined deposited but a very small sediment, so that there should be little or no trouble experienced in keeping the boilers clean—thus avoiding what is often a serious impediment to generating steam rapidly and economically.

Analyses of Waters.

	New River, at Foster's Falls.	Peak Creek, at Pulaski.	Artesian Well at Pulaski.
TOTAL GRAINS OF SOLID MATTER PER GALLON.	2.97	2.45	4.83
Lime,	.46	.42	1.20
Magnesia,	.25	.15	.68
Oxide of iron and alumina,	.10	.14	.12
Chlorine,	Trace.	.19	.12
Sulphuric acid,	.11	.12	.09
Silica,	.83	.61	.78

6. Estimated cost of making pig iron. Eligible sites for blast furnaces are numerous throughout the region, which possesses all the requisites for making a good quality of pig iron at a minimum cost: rich and cheaply mined ores, an abundance of limestone and easy access to a first-class fuel. The cost of making pig iron will necessarily vary somewhat at different points—depending on the cost of mining the ore and its richness in iron; but the following estimate for making pig iron at the Pulaski Iron Co.'s furnace, at Pulaski, may be taken as a reasonably fair average for the region—so far as the total cost per ton is concerned; but manifestly the different items will not be the same at every point:

Cost of making pig iron at Pulaski.

2 tons ore, @ $1 35,	$2 70
Freight, @ 35 cents,	70
1⅛ tons coke, @ $1 75,	2 40
Freight, @ 90 cents,	1 24
Limestone,	40
Labor,	1 75
Incidentals and repairs,	1 00
	$10 19

It is believed that, for the present at least, the figures given for ore are somewhat higher than the actual cost will be; but the estimate is made to cover a period of years, and it is considered a conservative one and well within the range of practical accomplishment.

Conclusions.

1. The New River-Cripple Creek mineral region may be assumed to contain 300 square miles, probably one half of which may be considered as ore-bearing territory.

2. While it would be injudicious, from the very nature of the occurrence of the brown hematite ore-deposits everywhere, to estimate the tonnage that any single square mile of this territory would yield, yet it must be manifest from the details given in this report that the total amount of iron-ore to be mined in the region will be very great.

3. The quality, uniformity, and richness of the ore is unsurpassed by any other developed brown-hematite iron-ore district.

4. The accessibility of the ore deposits to your Cripple Creek extension, and their proximity in a large part of the field to unusually good washing facilities, as well as the small cost of mining the ore itself, should result in the production of a cheap and well prepared ore for furnace use.

5. The occurrence here of a first-class and cheaply mined iron ore; the proximity of a magnificent coking coal-field; with limestones for fluxing purposes everywhere throughout the region; with a constant supply of pure water; surrounded by a fertile agricultural and grazing district capable of supporting a large population; and with numerous eligible sites for manufacturing purposes, this New River-Cripple Creek region certainly offers unusual advantages for the investment of capital.

Respectfully submitted,

ANDREW S. McCREATH,
E. V. d' INVILLIERS.

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