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Small's Ranch and Field's Mountain on John Day River.

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The Geology and Mineral Resources of the John Day Region by
Arthur J. Collier

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MARCH, 1914

THE MINERAL RESOURCES OF OREGON

*A Periodical Devoted to the Development
of all her Minerals*

PUBLISHED MONTHLY AT CORVALLIS BY
THE OREGON BUREAU OF MINES AND GEOLOGY
H. M. PARKS, Director

*THE GEOLOGY AND MINERAL RESOURCES OF THE JOHN DAY REGION.

By Arthur J. Collier.

The John Day river basin in the north central part of Oregon has been for many years a favorite place for geologic exploration, on account of the occurrence there of vertebrate fossils. In recent years, however, attention has been further directed to this region from time to time by reports of the discovery of coal, oil, gas and other mineral resources. Such discoveries would be of great importance in the development of Oregon because of the general scarcity of workable beds of coal on the Pacific coast. A large part of the fuel supply of Portland and the Willamette valley towns is imported from the Rocky Mountain coal fields in Wyoming, Colorado, Utah and other states, and the average cost of such fuel is more than doubled by the railroad charges.

During the summer of 1913 the writer, in the employ of the United States Geological Survey and the Oregon Bureau of Mines and Geology, was assigned the task of investigating these reports. Although the investigation disclosed no coal bed of commercial value under present conditions, it is thought that the best interests of the region will be served by a report giving detailed descriptions of the beds seen, together with the possibilities of future development in the

*The field work and preparation of this report was done under a contract of co-operation between the Oregon Bureau of Mines and Geology and the U. S. Geological Survey.

various districts visited and clearly setting before the people of Eastern Oregon just what the minimum requirements are to make a coal bed workable with some profit to the capital invested.

In this work the writer was ably assisted by Graham J. Mitchel, to whom much of the value of the present paper is due. Grateful acknowledgment is also due to Dr. J. C. Merriam, who published "A Contribution to the Geology of the John Day Basin,"¹ and whose outline is followed in the present paper. The writer wishes to express his thanks to H. H. Hendricks, Wm. J. McGreer, J. Campbell Martin, Floyd Officer, Kenneth Macrae, L. V. Stewart, William Cummings, Frank Foster, B. C. Trowbridge, Wm. Herron and many others for their genuine hospitality and kindly co-operation in collecting the information given in this report.

PREVIOUS EXPLORATION.

For the past fifty years the John Day river basin has been more or less known to geologists. As early as 1862, attention was directed to it by Dr. Thomas Condon, then a minister of the gospel at the The Dalles, Oregon. Under his direction several of the well known paleontologists and geologists of a generation back visited the field and have contributed much to the literature of the John Day.

In the years 1899, 1900 and 1901, Dr. John C. Merriam, of the University of California, made a more thorough exploration of the whole basin than had yet been attempted, and published in 1901 "A Contribution to the Geology of the John Day Basin," in which the various formations represented are described.

For a review of the history of explorations the reader is referred to the above paper. The formation names given by Merriam are used in this report, though it has been necessary in some cases to define them with a little more precision. It should be borne in mind, however, that any classification of strata made after such brief reconnaissances will be subject to revision.

A full bibliography of the literature published on the John Day Basin is given by Merriam and Sinclair in "Tertiary Faunas of the John Day Region."¹ In this paper, however, no mention is made of the work of W. Lindgren in the Blue Mountains, which covers a part of the area in question.²

(1) Univ. of Cal. Pub. Bul., Dept. of Geol., Vol. 5, pp. 171-205.

(2) W. Lindgren, Gold Belt of the Blue Mountains, 22nd Ann. Report U. S. G. S., 1900-1901, pp. 551-775.

GEOGRAPHY.

The drainage of the John Day River includes all of Grant and Wheeler counties and parts of Sherman, Wasco, Crook, Gilliam, Morrow and Umatilla counties, and covers an area of approximately 8000 square miles. The general location of the area here discussed is shown on the index map, pp. 6-7, while in the special map, opposite page 18, an effort is made to present its geography in some detail.

For the first 100 miles from its junction with the Columbia, the river's course is approximately north. Above this point the river turns abruptly to an east and west course for about 100 miles to its source in the Blue Mountains. The John Day forks about forty miles above this bend, the northern branch continuing in an east and west direction, while the southern branch, which is called the main river, flows for about eighteen miles from the south, above which it again flows west from its source in the Blue Mountains.

A large part of the area is almost without railroad communication. There is a branch from the Oregon Short Line which reaches Condon, the county seat of Gilliam county, and a narrow gauge railroad extends from Baker to Prairie City in Grant county, which point is well within the drainage of the John Day.

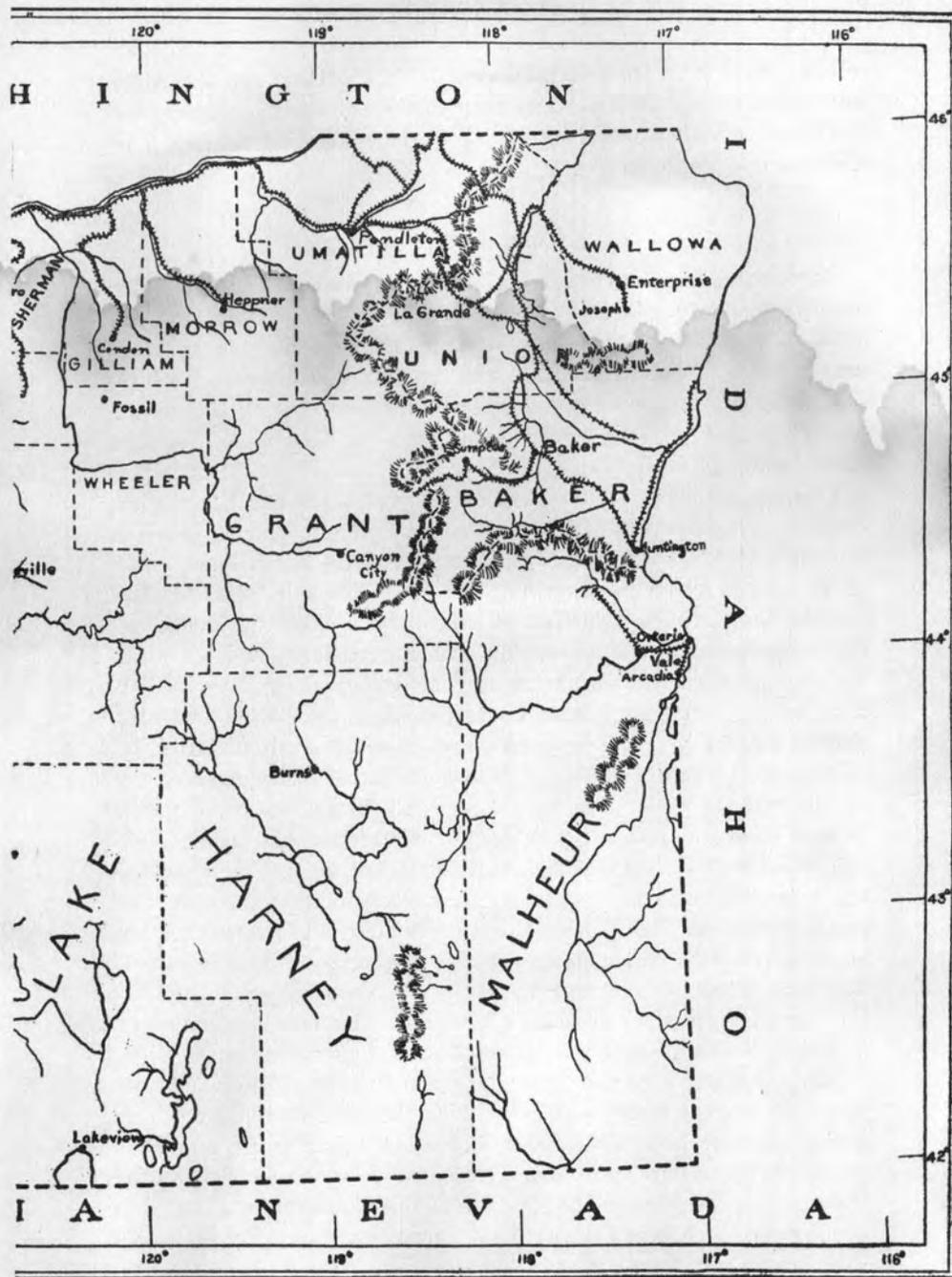
The population of this part of Oregon has not increased perceptibly in the last ten years, while in many other parts of the state it has doubled and even trebled. The principal towns and their population in 1910 are as follows: Fossil, 421; Spray, 125; Mitchell, 210; Monument, 119; Heppner, 880; Condon, 1009; Dayville, 100; John Day, 258; Canyon City, 364; and Prairie City, 348. A comparison of the census of 1900 with that of 1910 will show how lack of transportation will retard development.

As will be seen from the description of the topography, there is only a part of this region which could be cultivated profitably. At present the farming is confined to small irrigable tracts along the narrow valley floors, and the produce is largely alfalfa or grain to be fed to stock. Even stock-raising is at a disadvantage on account of the lack of transportation.

It is on this account that some of the residents of the district have sought for coal, believing that such a discovery would induce railroad building. It is claimed that a short route avoiding some high points



Outline Map Showing Area



Described in this Report.

can be found from Ontario northwest to Prairie City, and thence by water grade along the John Day river to the Columbia. Should such a railroad be built it would surely lead to the cultivation of much land which is now unproductive.

TOPOGRAPHY.

Topographically, the region appears to the writer to be in a state of early maturity. It is a plateau varying in elevation from about 1,000 feet in the neighborhood of the Columbia river to approximately 6,000 feet along the flanks of the Blue Mountains. Much of this plateau surface is even and does not appear to be greatly eroded. The river and larger creeks flow in more or less narrow canons, often 1,000 feet in depth.

This topography is the result of an important geological formation consisting of numerous flows of basalt reaching in some instances a thickness of 2,500 feet, which is believed to have covered the whole of the area in question. Over much of the region this formation has been left approximately horizontal, and in such places the surface of the interstream areas is universally level enough for plow-land, while the streams often flow in narrow canyons with rim rocks exposed in their walls. In many places where the basalt formation has been either very thin or has been folded, faulted or otherwise disturbed by subsequent mountain building processes, it has been removed by erosion and the underlying and often softer formations are exposed. In such cases the topography is more or less broken and variable.

The John Day river through much of its course, and many of the small creeks, lie in narrow canyons cut into, but not through, this basalt formation. In such cases the lands along the river which can be irrigated with water taken from it are very limited in extent. The large areas of land near the river which are subject to cultivation are those in which the basalt is covered with later formations or in which erosion of the river has reached the underlying rocks.

There is much evidence of an older channel, approximately 500 feet above the present river level, over which the river flowed for a long period of time and developed a broad flood-plain with numerous meanders, which have since been intrenched. The meanders shown for this river on the maps of the state are of this character, and the parts of the river which show them are those in which it flows over the basalt without cutting through it.

GEOLOGY.

THE GEOLOGIC MAP.

All of the lands in the John Day region were surveyed by the United States General Land Office from twenty to thirty years ago, and though many of the corners have been obliterated, much of the land has passed into private ownership and is held in large ranches. The accompanying geologic map is based on the land office surveys. In its preparation, however, the writer wishes to acknowledge the assistance gained from a map prepared by H. F. C. Heitchman, the county surveyor of Wheeler county, and a map of Grant county purchased from the forest supervisor at John Day.

The geologic formations as given by Merriam are mapped very roughly. None of the areas has more than sketch value, and some parts of the region mapped have not been examined by the writer. It is, however, the first attempt yet made to publish a geological map of a very interesting region, and because of this it should be accepted for what it is worth. There are many doubtful points which can be settled only by a thorough survey, requiring the work of a large party through several seasons.

THE GEOLOGIC SECTION.

The following geologic section is based, with some modification, on that given by Merriam and Sinclair in "Tertiary Faunas of the John Day Region," published in 1907. The geologic names and classification used are those of Merriam and Sinclair.¹ This publication is of later date than that of Merriam, referred to above, and gives a more mature interpretation of the facts presented.

The writer's modification of the section above consists in an abbreviation of the treatment of the John Day Series, the addition of estimates of the thickness of the various formations, and a statement of economic values. Since in many places one or more of these formations is wanting, due either to irregular deposition or erosion intervals, the thickness is given from zero to the maximum.

1. John C. Merriam and William Sinclair, Tertiary Faunas of the John Day Region, Univ. of Cal. Pub. Bul., Dept. of Geol., Vol. 5, No. 11, pp. 171-205.

GENERALIZED SECTION OF THE ROCKS OF THE JOHN DAY REGION.

Age	Formation	Thickness	Characteristics	Economic Value
Quaternary	Terrace deposits		Equus and Elephas remains.	
	Erosion interval		Tilting of the Rattlesnake and erosion of John Day Canyon.	
Pliocene	Rattlesnake	100 ft.	Tuffs, gravels, ashy soil and rhyolitic lavas.	An extensive bed of rhyolite tuff used as building stone.
	Unconformity		Tilting and erosion of the Mascall.	
Miocene	Later	1000 ft.	Tuffs, ashes and gravels.	Beds of lignite of doubtful value. Deposits of diatomaceous earth.
	Earlier	0-2500ft	Basalt and interstratified basaltic tuffs.	Yields artesian water in some places.
	Unconformity		Slight folding of the John Day. Interval of erosion.	
Oligocene	John Day Series	0-2000ft	Upper Mainly buff-tinted tuffs. Sands and gravels near top.	Extensive clay deposits.
	Middle		Drab and bluish-green tuffs.	
	Lower	Unconformity	Red, white and green tuffaceous shales.	
Eocene	(Upper) Clarno	0-2000ft	Shales, tuffs, andesitic and rhyolitic lavas. Has yielded abundant flora but no vertebrate remains have yet been found.	Coal beds of doubtful value. Asphaltum prospects said to have yielded opals.
	(Lower) Unconformity			
Pre-Tertiary			Sandstones, conglomerates and shales, other rocks in various degrees of metamorphism, including slates, limestones, sandstones and conglomerates with intrusions of Plutonic igneous rocks such as diorite, gabbro and serpentine.	The gold and silver and copper of Eastern Oregon are derived from rocks of this type. Contains some beds of limestone.

PRE-TERTIARY.

No fossils older than the Cretaceous have yet been found in the areas here considered. Lindgren,¹ however, has located some carboniferous formations in the Blue Mountain region which joins this area on the east, and Washburne² has published some evidence which confirms that classification.

Washburne also made a small collection of Carboniferous fossils from limestone near the town of Izee on the south fork of the John Day river forty miles south of Dayville.

1. W. Lindgren, The Gold Belt of the Blue Mountains of Oregon, U. S. Geol. Survey 22, Ann. Rept., Part 2, p. 578, 1901.
2. Chester Washburne, Notes on the Marine Sediments of Eastern Oregon, Journal of Geology, Vol. 11, p. 225, 1903.

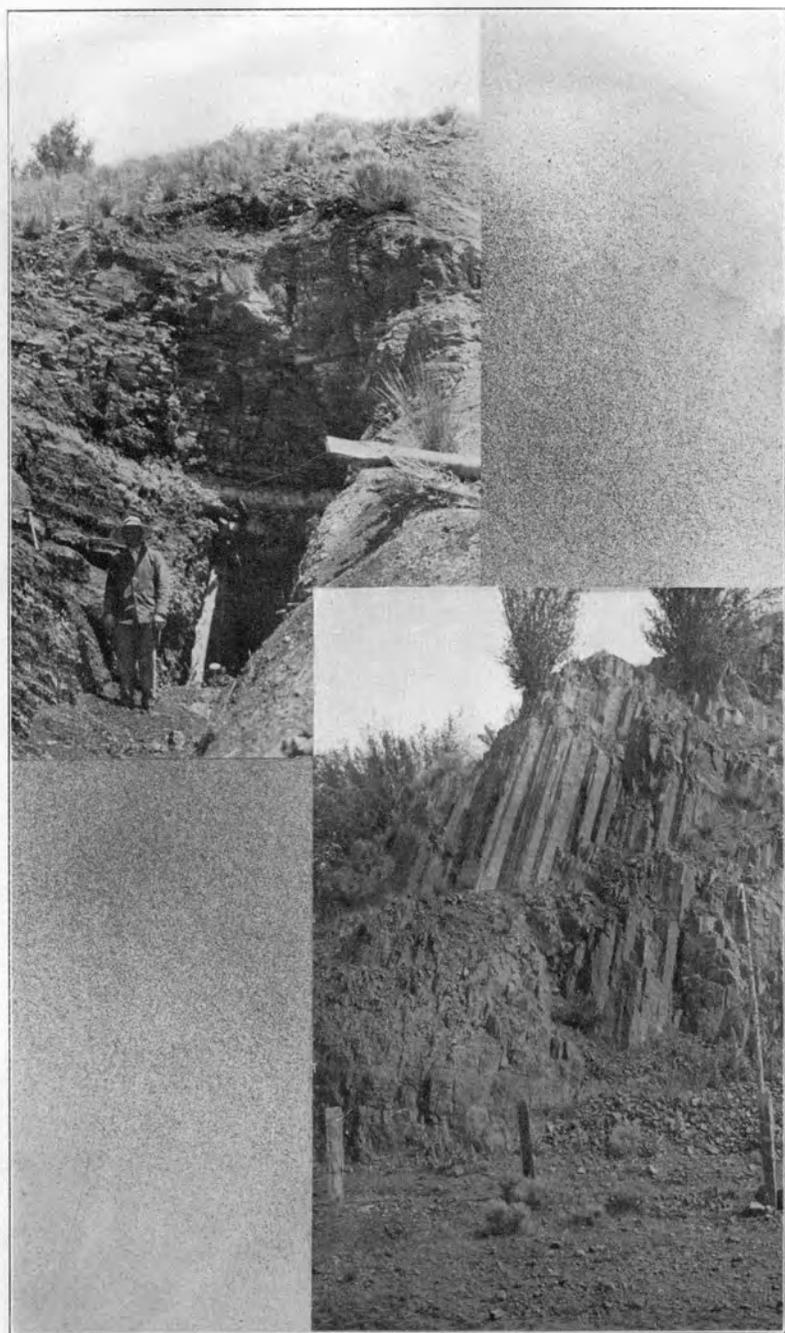


Fig. 1. Dry Hollow Coal Prospect.
Basalt Sill in the Clarno Formation at Fossil.

During the past summer the writer had the pleasure of meeting the late Charles W. Parish, of Canyon City, who formerly lived near Izee, and who has for many years been an enthusiastic collector of fossils. His collection contains many specimens of the zaphrentis noted by Washburne and of a large pecten. In the same vicinity, Washburne collected an aviculo pecten, probably of Triassic Age. While in the Blue Mountains, Lindgren has located areas of Triassic, containing large deposits of limestone.¹ Along Silvies river, south of Canyon City, Alphius Hyatt has described fossils which are of the Jurassic² and the writer saw specimens from some of these localities in the collection of the late Charles Parish. Merriam found some fine specimens of fossiliferous Cretaceous on Spanish Gulch about twenty miles east of Mitchell. To these the writer would add a note of some collections, of the same age, made near the south fork of the John Day a few miles south of Dayville. In the latter locality the formation containing Chico fossils was found lying approximately horizontal and resting on the upturned edges of the older rocks, which included limestone, metamorphic shale and serpentine. A small area of conglomerate, probably Cretaceous, is to be seen in the center of Turtle Cove, and in the region south of Richmond there is a large area of conglomerate and sandstone which appears to rest conformably on a series of highly altered shales containing a large bed of limestone. The limestone used in the construction of some of the buildings in the town of Fossil came from this place. The formation is said to be fossiliferous at a point about one-half way between Richmond and Mitchell. There is evidently a large area of Cretaceous rocks in the vicinity of Mitchell which could not be thoroughly explored during the past season, but in which the rocks are not greatly altered.

Associated with the Cretaceous and older bodies of rock there are often intrusions of igneous rock of various kinds, and it is not possible in a short exploration like the present to determine their positions on the map with any certainty. On the accompanying map, therefore, all the Cretaceous and older rocks are shown by a common symbol and no attempt is made to distinguish between them.

¹ Washburne, Op. Cit., p. 226.

² Lindgren, Op. Cit., pp. 279-282.

³ Bul. Geol. Soc. Am., Vol. V, pp. 401-420.

THE CLARNO FORMATION.

Above the Cretaceous and older rocks described there is found in many places a formation consisting often of shales, sandstone, conglomerate, ash and tuff interbedded with lavas of various kinds. This formation often carries fossil plants of the Eocene age, and has been called "The Clarno" by Dr. Merriam from a typical exposure near the post-office of that name. In many places it contains coal beds which are of rather high grade as far as metamorphism is concerned, but as far as they have been explored and examined they always contain a large percentage of foreign matter, making it doubtful if they can be utilized.

Rocks of this formation extend from Clarno, on the John Day river, near the mouth of Pine creek, in a northeasterly direction to a point in the divide between the slopes of the Columbia and the John Day south of Heppner, a distance of approximately seventy-five miles. West from the John Day at Clarno the formation extends for an unknown distance, and south along the John Day river it is probably continuously exposed for about twenty-five miles to the celebrated localities on Currant and Cherry creeks, from which Professor Condon made collections of fossils in 1862.¹ Southeast of these points it has been noted at several localities in small areas, as, for instance, along the river between Picture Gorge and Basin, in the area northeast of Mitchell, and probably southeast of Mt. Vernon. In the area extending eastward from Clarno there are many places where the formation cannot be identified with certainty, for it consists almost wholly of volcanic rocks and does carry fossils. At the eastern end of this area near the town of Heppner, the formation consists of sandstone, containing little if any tuff or ashes, and it is thought to be free from volcanic rocks. The locality is not typical and the rocks here do not resemble the formation as exposed near Clarno. At the latter locality the formation consists of beds of hard, blocky tuff overlain by softer materials which might be mistaken for the John Day formation, but for the fact that these are again covered by some plant bearing beds. The tuffs strike to the northeast and dip from 4° to 5° to the northwest. Along Dry Hollow about fifteen miles southeast of Clarno the rocks seem to dip to the south for about twelve miles. In this portion the Clarno seems to have been stripped of all

1. Condon, Thos., Oregon Geology, p. 151.

higher formations. At the summit of the divide between Dry Hollow and Rock creek the elevation is at least 2,000 feet above the river.

The thickness of the Clarno formation was estimated by Merriam to be 400 feet. This estimate is misleading and in the writer's opinion the thickness is at least 2,000 feet in some places. At the head of Dry Hollow the Clarno is at least 1,000 feet thick, and it may be found to be a great deal more than that. At Fossil the fossil-bearing Clarno rests on a great thickness of andesite and is overlain by approximately 1,000 feet of light colored tuffs which make up Black Butte. The capping of Black Butte is approximately 100 feet of rhyolite or andesite. It dips to the north and has the John Day exposed between it and the Columbia lava. This exposure of the John Day is reported to have yielded some fossil vertebrates, from which fact the town of Fossil took its name. At this point the whole thickness of the Clarno cannot be seen, but it is certainly more than 1,000 feet, and it may be twice that. Mendenhall, taking into consideration the part of the formation exposed and that revealed by drilling, states that near Heppner it may be 2,000 feet in thickness. In other parts of the field it is, however, very probable that the Clarno may be much thinner, and there are undoubtedly areas in which it is altogether wanting.¹ Since it is known that this formation was laid down unconformably on an old and very much eroded surface, such irregularities in thickness and in material of which it is composed are to be expected in it.

The fossil plants from the Clarno formation have been examined by Dr. Knowlton of the United States Geological Survey, who recognizes two stages or time periods, called an upper and a lower Clarno, both of which he decides are Eocene.²

JOHN DAY FORMATION.

Overlying the Clarno with apparent conformity in many places is a softer formation, the John Day, composed largely of ash beds but containing some beds and sheets of rhyolite and cut by dikes of basalt. This formation has yielded a large part of the vertebrate fossils for which the John Day valley is famous, and is described in detail by Dr. Merriam. It is divided on paleontologic evidence into three parts or stages. The whole of the John Day has been found to be mainly devoid of fossil plants. At one locality south of Lone Rock

1. Mendenhall, W. C., A Coal Prospect on Willow Creek, Morrow County, Oregon, Bul. U. S. Geol. Sur. No. 341, pp. 406-8, 1909.

2. Knowlton, F. H., Fossil Flora of the John Day Basin, Oregon, Bull. U. S. Geol. Sur. No. 204, p. 113, 1902.

a small collection was made by the University of California party, and in Turtle Cove a single leaf has been reported.

The lower division, estimated to be from 200 to 300 feet thick, is described as consisting of highly colored shales which break down and form mud-covered domes. It is described in the Bridge creek and Clarno localities, and is said to have yielded very few fossils. The fossils which have been found indicate that it belongs with the John Day series. In the neighborhood of Clarno it is conformable with the Clarno and perhaps slightly unconformable with the middle division.

Northeast from Clarno's bridge about three miles the line of contact between the Clarno and John Day was observed. Here the Clarno contains flows of igneous rocks and characteristic tuffs, while the John Day consists of rounded mud-covered hills through which an intermittent stream flows in a canyon spanned by a natural bridge, a feature common to the John Day formation as will be shown later. Along this canyon in shales so soft and friable as to make it impossible to collect them there is a layer of fossil plants, while strewn along the stream bed were frequent fragments of such fossils contained in a much harder matrix. A search showed the source of the fossils to be a hard layer from 100 to 200 feet above.

The difficulty in recognizing and deciding upon the boundary between the Clarno and John Day in the neighborhood of Fossil has already been mentioned. In Turtle Cove also there is similar difficulty, and between the beds that are undoubtedly Clarno and those that are John Day there is a succession of highly colored beds, which often form low mud-covered hills and which may belong to either formation. From these facts it seems probable that the lower division of the John Day might be regarded as Clarno.

The middle division of the John Day has yielded by far the greatest number of vertebrate fossil remains and has been studied with greater care than any other formation of that region. It is estimated by Dr. Merriam to be at least 500 feet thick at Turtle Cove and 800 feet or 1,000 feet thick at the Bridge Creek locality. ¹

This part of the John Day often forms rounded hills, but more commonly it is exposed in steep pinnacles and ribbed bluffs.

Officer's Cave. In the region north of Clarno, what is presumably this part of John Day often forms sink-holes, underground passages and

¹ Merriam, J. C., Op. Cit., p. 294.

natural bridges in the process of erosion. Such erosion forms are very well shown in what is called Officer's Cave in the vicinity of Turtle Cove in S. 21, T. 11 S., R. 26 E., between the Turtle Cove and the Blue Pass fossil beds. This cave was explored a good many years ago by Mr. Floyd Officer and others, who report that they entered it in the morning and remained nearly all day in its underground passages and rooms. Above the entrance to this cave there is a cliff about twenty feet high of approximately undisturbed John Day sediments. The entrance is a large room, approximately fifteen feet wide, fifteen feet high, and one hundred feet long. Many large pieces have fallen from the roof, making progress difficult. Beyond this room the cave narrows to a single stream channel often fifteen feet wide, but as low as two feet in height for some distance, to another large room somewhat like the first, though smaller. Along the bed of the passage there is much drift material from the surface, but in the chamber near the entrance the walls and roof were blackened, presumably by bats which are said to pass the winter there. After penetrating approximately 500 feet of this cave, the present survey party returned to the outside and made an examination of the surface. At a distance of 700 feet, more or less, S. 80 degrees E. from the entrance, there is a large depression twenty feet in depth and sixty feet in diameter, into which several water channels run, and what was thought to be the upper end of the cave was found. This cave has many of the features of a limestone cavern, but does not, of course, have either stalactities or stalagmites, and is confined, so far as it was observed, to a single channel. On the surface above the cave, fragments of fossil bones were found.

The upper John Day is estimated to be not less than 300 to 400 feet thick. It consists of slightly harder materials standing out in vertical cliffs, and contains some sands and gravels, evidences of older formations. This division is exposed along the John Day river from Spray to Hamilton on the north fork and probably to Basin on what is called the main river. It is always capped by the basalt of the overlying formation and is cut at many places by dikes of basalt, supposed to be the channels through which the formation above the John Day flowed.

In general, it may be said that the John Day formation does not have well defined boundaries. There is always much uncertainty in locating its contact with the Clarno, which underlies it. In many

places there are large thicknesses of strata whose place in the column is in doubt, as in the instances noted northeast of Clarno and the region north of Fossil. The bright red beds commonly attributed to the base of the John Day may be found to be an upper part of the Clarno. Very frequently the John Day formation is entirely wanting between the Clarno and the overlying basalt. In such cases it leaves an open question whether the John Day has been eroded away before the deposition of the basalt or whether it may have been only locally deposited.

COLUMBIA LAVA.

Overlying a large part of the area in question and responsible for much of the topography is a great series of lava flows making up what is called by Merriam the Columbia lava.¹ Merriam counted twenty-three flows in the exposure at Picture Gorge, where it may be presumed to have its full thickness since in that place the overlying and underlying formations are well exposed.

To the northward from the John Day this formation is continuously exposed, making up the extensive lava plateau, through which the Columbia river takes its course. It is probably the same series of lava flows as is called the Yakima basalt in the neighborhood of Ellensburg, and that has been found extending eastward from Ellensburg to the vicinity of Spokane, Washington.²

Over much of the area covered by the Columbia lava it lies approximately horizontal and is of uniformly great thickness, but in the position here described it lies on the flanks and westward projections of the Blue Mountains and was probably relatively thinner than in the region further north. Proceeding from the Columbia river at Arlington southward across the formations exposed and noting the structures, the Yakima basalt probably rises to an anticline in the vicinity of Condon, south of which there is probably a structural depression in the valley. Beyond Thirty-Mile Creek the formation rises in the vicinity of Fossil to such a height that it has been

¹ Merriam, *Op. Cit.*, pp. 303-305.

² Smith, G. O., *The Ellensburg Folio*, U. S. Geol. Sur. Atlas of U. S. Folio, No. 19. Contribution to Geol. of Wash., U. S. Geol. Sur. Prof. paper No. 19, 1903.

Smith, G. O., and Calkins, F. C., *Geologic Reconnaissance Across the Cascade Range near 49th parallel*, U. S. Geol. Sur. Bull. 235, 1904.

Calkins, F. C., U. S. Geol. Sur. Water Supply Paper No. 118.
Collier, A. J., *Tin Ore at Spokane, Wash.*, U. S. Geol. Sur. Bull. 346, pp. 295-305.
Gold Bearing River Sands of the Columbia, U. S. Geol. Sur. Bull. 315, pp. 56-70.

entirely eroded, leaving the Clarno exposed. From Fossil, south to John Day river the rocks exposed all appear to be Clarno and form a summit approximately 1,000 feet above Fossil. South of the river near Twickenham there is a syncline and the basalt is again in evidence, but beyond this towards Mitchell the base on which the basalt rests rises again and is eroded, leaving the John Day, Clarno and Cretaceous formations exposed as far as explored. See Fig. 1 a structure section from Condon to Mitchell. Twenty-five miles to eastward in the section (Fig. 2) exposed from the forks of the John Day river south, the basalt apparently lies nearly horizontal for about eighteen miles. Then it is down folded abruptly, dipping as much as sixteen degrees at Picture Gorge, beyond which it is concealed. Three miles south of that place it appears again with a very high dip to the north. This fold has been found extending eastward for forty miles to Canyon City and perhaps further. At Flat creek, about eight miles east of the Picture Gorge locality and one mile south of the John Day river, the whole of the basalt formation is exposed. Here it stands vertically and measures approximately one-half mile in thickness. The range of mountains south of this fold extends westward from the Blue Mountains for sixty miles, more or less, and is made up of several high points of older rocks such as Canyon Mountain, Fields Mountain, etc. Between them are many lower hills capped with the basalt resting on the older rocks but lying nearly horizontal. The Yakima basalt has been recognized along the north side of this structure from Picture Gorge to Mt. Vernon, at which place it is at least 500 feet thick and conformably overlies a great thickness of conglomerate which rests on serpentines and associated rocks. The basalt is concealed from Mt. Vernon to John Day, to the south of which place it shows in the canyon of Canyon creek;¹ while a short distance to the north are beds of tuff resembling the Clarno and containing seams of coal.

MASCALL FORMATION.

Resting on the Yakima basalt with apparent conformity is the Mascall formation described by Merriam.²

This formation is represented only in the depression or syncline in the basalt that extends along the John Day from Canyon City west-

¹ Lindgren, W., Gold Belt of the Blue Mountains, U. S. Geol. Sur., 22nd Ann. Report, Part 2, p. 718.

² Merriam, J. C., Op. Cit., pp. 301 to 308.

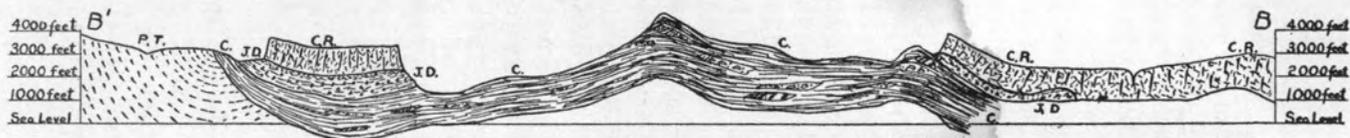


Fig 2 Generalized section from Condon to Mitchell

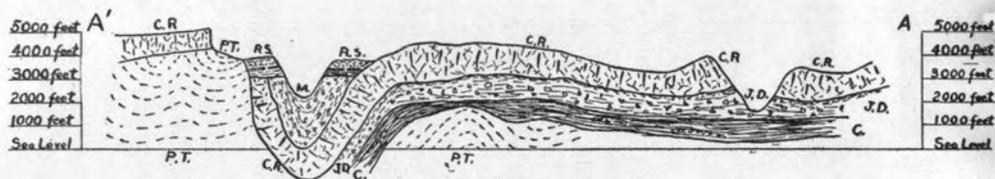


Fig 3. Section near the boundary line between Grant and Wheeler Counties

LEGEND



ward for about fifty miles, and is not more than five miles wide at most. It is best seen on or near the Mascall ranch, where its relation to the underlying and overlying beds is well illustrated.¹

It is estimated to have a maximum thickness of from 800 to 1,000 feet as exposed on Rattlesnake creek. The formation east of Rattlesnake creek presents a variety of materials. On Rattlesnake creek it is composed, according to Merriam, of generally light-colored ash and tuff. About eight miles east of Dayville, on a tributary from the south, known as Bridge creek, it contains 400 to 500 feet of conglomerate. Diatomaceous earth is found at several points near the base of the formation, and at the Cummings and Belshaw ranches twelve to fifteen miles east of Dayville, fossil plants have been found in material which is essentially a diatomaceous earth.²

The Mascall formation is correlated with the Ellensburg formation described by Smith and Calkins as being about one hundred feet thick where exposed north of the Columbia river. The formation known as The Dalles Group is probably also to be correlated with the Mascall.³ It is exposed in the high hills south and west of The Dalles and apparently overlies the Yakima basalt of that place. Mr. P. L. Kretzer, a well driller of The Dalles, has reported to the writer that there is found in many wells south of that city a formation composed of light colored sandstone with a maximum thickness of 500 feet. This formation, he reports, carries beds of lignite. Below this formation, basalt is found to a depth of 1,700 feet, for which distance he has kept the drill cores from one well. This well was put down in an attempt to find anthracite coal thought to be present at great depth. In the region between the Columbia river and Condon, as seen from the car windows, there is probably a similar thin formation mantling the basalt for a part of the way.

Down the Columbia between The Dalles and Hood River the Yakima basalt is well exposed on the north side of the river, where it has a decided dip of from five to ten degrees to the southeast and a thickness not less than 1,000 feet. Near the west end of this exposure there is evidence of faulting.

1. Merriam, J. C., *Op. Cit.*, Fig. 1.

2. Calkins, F. C., *A Contribution to the Petrology of the John Day Basin*, Univ. of Cal. Pub. Bull., Dept. of Geol., Vol. 31, p. 166. Calkins notes the presence of diatoms, but assumes that much of the material consists of angular glass fragments.

3. Knowlton, F. H., *Fossil Flora of the John Day Basin*, U. S. Geol. Sur. Bull. 204, p. 112.

RATTLESNAKE FORMATION.

Like the Mascall formation the Rattlesnake is confined to the synclinal trough extending east and west across the southern part of the area explored. This formation is described by Merriam as being composed of gravels, sands and rhyolite. It is characterized by a bed of rhyolite tuff, averaging approximately twenty-five feet in thickness, that occurs near the middle of the formation and that can be recognized with practical certainty over the area covered by it. This tuff is best seen along the northern edges of the area covered by the Rattlesnake formation, where it stands out, forming the cap rocks of many mesas at an approximate elevation of 3,000 feet above the sea. It is slightly above the wagon road along Badger creek in T. 12 S., R. 23 E., and forms the rim rock around the canyon of Rock creek in T. 12 S., R. 24 E. It is slightly above the wagon road at the crossing of Birch creek in T. 12 S., R. 25 E. At Picture Gorge in T. 12 S., R. 26 E., it stands out conspicuously, forming mesas about 1,000 feet above the John Day river. It is about 500 feet above the river at Cummings creek, T. 13 S., R. 28 E., and from 100 to 200 feet at Mt. Vernon, in T. 13 S., R. 30 E. Lindgren shows in the section along Canyon creek in T. 13 S., R. 31 E., a rhyolite tuff which is thought to be of the Rattlesnake.¹ The tuff deposit lies more nearly horizontal than is shown in the illustration given on page 17. This tuff has been used to a considerable extent by settlers in building chimneys, smoke houses, cellars, etc., and in both Canyon City and John Day more extensive buildings have been constructed from it. Although it is a comparatively soft rock and is easily worked, it resists weathering well and will undoubtedly be of importance in the development of the country.

The Rattlesnake formation universally, where it has been seen, has a dip of from one to six degrees to the south. Along the north side of the area which it occupies it is usually well exposed. It has never extended farther north than its present limits, for it lies nearly horizontal and rests against the basalt, which dips as much as sixteen degrees and rises to higher elevations. On the south side the Rattlesnake formation is usually covered with later gravels and its contact with the basalt and other rocks exposed there cannot be seen. The gravels which overlie it consist in some instances of pebbles of other

1. Lindgren, W., Gold Belt of the Blue Mountains, U. S. Geol. Sur., 22nd Ann. Report, Part 2, p. 718.

rocks than the basalt, contributed by the erosion of the high hills and mountains that form the southern boundary of the field. Such gravels are seen at Canyon City where they carry placer gold, and are shown in the Humbolt mine pictured by Lindgren.²

ECONOMIC GEOLOGY.

Introduction.

As the first object of this investigation was the collection of data in regard to coal in the John Day valley, it is thought best to preface the economic report by clearly setting forth just what can be considered as constituting the commercial value of a coal bed.

There are three conditions which it is necessary to consider in determining the commercial value of a coal bed, namely, thickness of bed, its extent and quality of coal. Beds of a high grade bituminous, semi-bituminous and anthracite coal which has a heat value of from 13,000 to 15,000 British thermal units and which do not exceed eighteen inches in thickness have been worked profitably. Beds of sub-bituminous which has a lower heat value than the coals just mentioned are not worked at thicknesses below twenty-four inches, and beds of lignite which average somewhere about 7,000 B. t. u. as received from the mine are not considered workable below three feet in thickness; regardless of the thickness of the beds, the last are always appraised at the minimum rate.

The coals which will be described are all of them so impure, that, though considered bituminous in some cases, still have low heat values. One exposure of coal on Dry Hollow will probably yield a heat value of about 7,000 B. t. u. In the Heppner field, although no analysis has been made for the writer, it is thought that there may exist in some one of the five tunnels a bed of coal at least three feet thick that will show about this same heat value. These beds, if other things are favorable, would be of such thickness and quality as to make them commercial coal, but of the lowest grade that is workable.

In regard to their extent, the writer is not able to express a positive opinion. The beds are usually exposed at only the one place, and very often the nature of the enclosing rocks and the deposition of the coal show irregularities. The determination of the actual extent of these beds must be left to future prospecting and further excavation.

2. U. S. Geol. Sur., 22nd Ann. Report, Plate LXIV.

The fact that all of the fields have been opened up more than ten years, and that they have since lain with no attempt to develop them further, makes it appear that the exploiters must have concluded that they are of little value. This is particularly true of the field that lies south of Heppner. This field is developed by at least five tunnels, which have a total length of over 1,000 feet. One of these tunnels has at its mouth a rather extensive set of bunkers. The field is reached by a wagon road in good condition during the summer and a down hill haul all the way to Heppner. It is reported that there is always a demand for coal in that place. In spite of this fact, the mines have lain idle for ten years or more. There is, however, a large extent of territory between Clarno and Heppner which has been scarcely touched by the prospector and in which there may be coals of greater value than those that have been investigated.

The coals in the Mascall formation are of no value, mainly on account of their low quality. The coal exposed is a lignite, and as far as samples were obtained, has been found to be very impure. It probably would not show a heat value above 5,000 B. t. u. The Mascall formation, as can be seen from the map, is not very extensive. Although in an east and west direction it has been found for a distance of about fifty miles, its north and south extent is never more than five miles, and is probably in many instances as narrow as one or two miles. This fact would be sufficient to cause anyone to look with suspicion on a coal bed or a coal mine that it contained. There is, moreover, no evidence that the lignite beds noted in this formation are extensive, and it must be regarded as extremely doubtful whether there is any great quantity of even the poor quality that is present.

COAL PROSPECTS IN THE CLARNO FORMATION.

Prospects of bituminous or possibly a high grade sub-bituminous coal have been found and reported in the Clarno formation from the neighborhood of Clarno eastward to the region south of Heppner. As far as these prospects have been seen, none of them promise either extensive beds or a clean coal. The formation is irregular in its deposition, being, as noted, composed largely of volcanic tuff and interbedded flows of andesite and other igneous rocks.

In addition to the complexity due to the materials of which it is composed, it has been faulted and folded by subsequent stresses and strains, making it impossible to trace the outcrops of any of the

beds far or to determine the structural relations from one part of the field to another with any degree of certainty.

As far as they have been seen, the coal beds contain such a high percentage of impurities as to make their use questionable. Small samples, representing only a few inches of clean coal between layers of carbonaceous slate or bone can be found at many places which show a low percentage of ash, but no bed as thick as two feet has yet been found that contains less than thirty per cent of ash. The quality of the coal might be improved in some cases by washing, separating the heavy parts from the lighter by gravity. Large beds of coal that can be economically mined must be found before this can be done profitably.

The Clarno formation in the type locality has been correlated with the Manastash of the Ellensburg region in Washington. It has not yet been studied sufficiently to show that parts of the formation may not be correlated with the Roslyn formation of the same region, which is chiefly noted for the Roslyn coal, and there is no reason for believing that this horizon may not be represented.

COAL PROSPECT ON DRY CREEK.

This prospect is situated near the west line of Sec. 20, T. 8 S., R. 19 E., about four miles south of the Clarno bridge. It was opened about fourteen years ago by Wm. J. McGreer and others who report taking a sack of the coal to Antelope, where it was burned and pronounced as good as Wyoming coal. It is said to have contained a rather large percentage of sulphur. The prospect has been long abandoned, but the old shaft about twenty-five feet in depth is still to be seen, though badly caved. The dump of this shaft shows a great deal of black shale or bone, containing some fragments of bright coal with thin layers of quartz in the joints. The bed has a thickness of from three to five feet, but it was impossible to measure it accurately, and it does not contain more than a few inches of clean coal. The bed dips at an angle of about sixty degrees to the east and strikes nearly north and south. It was impossible to trace it north further than a few feet from the opening. The dark slate was traced south for 200 yards when it was lost. The rocks exposed along Dry creek from its mouth up to this prospect are all andesites and tuffs, and it is thought they belong to the Lower Clarno.

About three miles northwest of Clarno there is said to be a prospect of coal which was opened at approximately the same time as that mentioned above. Though some time was spent in searching for this prospect, it was not found and its locality cannot be given. It is supposed to be in the Clarno formation near the contact with the John Day.

DRY HOLLOW COAL PROSPECTS.

These prospects are situated in T. 8 S., R. 21 E., near the wagon road from Fossil to Mitchell about seven miles north of the John Day river. They consist of one abandoned mine, which is so caved now that only the dump remains to show its location, one open tunnel and several outcroppings of coal blossom. These prospects were discovered and explored by Charles Miller some twenty years ago. During the past summer, a company represented by A. Mohr and backed largely by the people of Fossil, spent some time endeavoring to prospect the field with a core drill, to determine whether or not it carries coal of value. The search was abandoned, however, owing to the dry season and the failure of the drill.

The tunnel referred to, situated in the SW $\frac{1}{4}$ of the SE $\frac{1}{4}$ of S. 28, T. 8 S., R. 21 E., is driven into the hill on the east side of Dry Hollow and is about a quarter of a mile from the wagon road, from which it is plainly visible. It is approximately 130 feet in length, runs into the hill north eighty degrees east and is well timbered. At the entrance (shown in Fig. 1) the bed has a thickness of at least eleven feet, and consists of alternating layers of coal, bone, sandstone and shale. None of the seams of pure coal has a thickness greater than four inches.

The exposure as shown in this tunnel is represented in figures 7 and 8. Near the entrance is a large body of foreign material, evidently an old water channel filled with gravel and sand that may have been formed either as an open stream bed during the deposition of the coal or an underground stream in a cavern. The face of the tunnel shows very little coal, a condition due to a fault which brings the upper and poorer part of the bed in contact with the lower part. This fault appears to strike NE and SW, making the better part of the coal fail on the south side of the tunnel before it does on

the north. The maximum vertical displacement of this fault is about four feet.

Twenty feet inside the tunnel, which is about seven feet high, two samples were taken and analyzed. The first sample represents the whole thickness of the bed except for a layer of white sandstone nine inches thick near the top. The other sample represents twenty-one inches of coal of slightly better quality found just below the above sandstone. The analyses are seen on page 26.

Outside of the tunnel the coal bed is not exposed and it is impossible to follow the croppings more than a few feet. Near the southeast corner of section twenty-eight an attempt to reach this bed of coal with a drill was unsuccessful. Underlying the coal apparently there is a coarse grained tuff, while above it for some distance is a brownish shale. From this brownish shale a few feet above the tunnel Mr. Mitchell obtained two fragments of fossil plants, one of which appears to be the seed of a conifer and the other a palm leaf. No palms were reported from the Clarno by Merriam and Knowlton, though Condon mentioned them as being found at the Cherry creek locality.¹ They were found by members of the writer's party in at least three localities during the past season.

Coal outcrops in section thirty-six, about one and one-fourth miles southeast of the tunnel, but no attempt to open it has ever been made. The evidence of its presence consists of streaks or blossom of coal shown in the cut banks of a small stream channel.

An outcropping of coal in the NW $\frac{1}{4}$ of section twenty-seven has been opened at some time, and the dump is still in evidence, showing fragments of coal mixed with black shale. North of this exposure there is evidently some disturbance of the strata, making the coarse-grained tuff and volcanic ash stand out in high crags. The old Miller mine lies to the north of these crags. Its position is shown now only by an extensive dump and an old roadway leading up from the Dry Hollow road. At this mine, when it was in operation, the coal bed is reported to have stood nearly vertical.

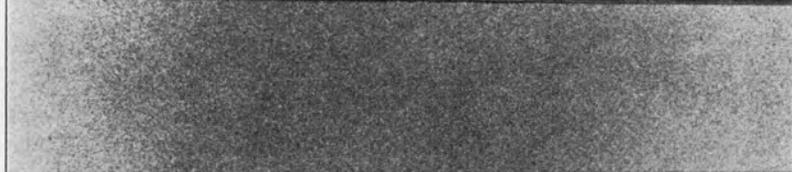
It is reported that there is a prospect of coal which is in the condition of natural coke from contact with an igneous intrusion near the John Day river almost due south from the Dry Hollow locality. This was not seen by the writer, however.

1. Thomas Condon, Oregon Geology, p. 151.

Analyses of Coal Samples from Dry Hollow.

A. C. Fieldner, Chemist in Charge.

Laboratory No.	Quarter	Sec.	T.S.	R E	Thickness of part Sampled	Air Drying Loss	Form of Analysis	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulphur	Heat Value	
													Calories	British Thermal Units
18,126	S.E.	28	8	21	7 ft.	7.2	As received.....	13.78	22.48	29.19	34.19	.47		
							Air dried.....	7.13	24.60	31.44	36.83	.51		
							Moisture free.....		26.49	33.86	39.65	.55		
							Moisture and Ash free..		43.89	56.11		.91		
18,127	S.E.	28	8	21	1 ft. 9 in.	6.6	As received.....	13.41	23.73	23.07	30.79	.46	4038	7268
							Air dried.....	7.33	25.40	34.32	32.95	.49	4322	7780
							Moisture free.....		27.41	37.03	35.56	.53	4663	8393
							Moisture and Ash free..		42.54	57.46		.82	7236	13025



Volcanic Tuff used as Building Stone, in Canyon City.
Office of U. S. Forest Service at John Day, also Volcanic Tuff.

COAL PROSPECTS NEAR FOSSIL.

A coal prospect is reported a short distance northeast of Fossil in the N $\frac{1}{2}$ of S. 33, T. 6 S., R. 21 E. The development work at this place consists of a shaft forty feet in depth and a drift from it. The rock exposed contains some carbonaceous material, but nothing that can be considered as coal. Coal is also reported to have been found in a well several miles up Butte creek from Fossil, but no effort has been made to exploit it, and it is thought to be of the same character as that north of Fossil.

SOUTH OF HEPPNER.

Through a considerable part of the distance between Fossil and Heppner no examination has been made by the writer and the map herewith submitted is based on statements of others. For example, it is known from Merriam's report that the John Day formation is exposed a few miles south of Lone Rock. South of Heppner there is an exposure of pre-Cretaceous igneous rock, and though through a part of this area such rocks may prevail, they will probably be of limited extent.

Twenty-one miles southeast of Heppner on the west fork of Willow creek, a great deal of prospecting for coal was done about ten years ago. This work consisted of six tunnels, having a total length of 2,400 feet, and two diamond drill holes to a vertical depth of 620 feet and 625 feet. It is reported that seven beds of coal were discovered, of which six were workable. The field was visited and reported on by W. C. Mendenhall of the United States Geological Survey in 1907.¹

The principal workings are in sections 33 and 34, T. 4 S., R. 28 E., but in the vicinity, both to the northeast and southwest for an estimated distance of fifteen miles, coal prospects have been found, most of which have not been developed to any extent. The region was again visited by the writer in company with William Herron, the discoverer of the prospects, in October, 1913, but owing to the very bad weather that prevailed at the time, he has little to add to the information given to the public by Mendenhall.

The rock formation is probably Clarno, though in this locality it does not present the same characteristics as in the type locality near Clarno's bridge. The sandstone and shales represented here do not

1. Mendenhall, W. C., Coal Prospects on Willow Creek, Bull. U. S. Geol. Sur. 341, pp. 406 to 408.

contain as much volcanic material as in the type section, and they appear to be much more promising as a source for coal. Mendenhall described this formation as a coarse feldspathic sandstone which overlies an older formation consisting of coarse-grained, dark-colored rock of various kinds. The sandstone formation has a thickness that is probably less than 2,000 feet, and is overlain on the divide between the waters of the Columbia and John Day by the Columbia lava.

At the time of the writer's visit only one of the openings, that known as the Conser tunnel, was reported as accessible. In the face of this tunnel one of the best prospects of coal had been uncovered, but this was inaccessible on account of water. However, in the part of the tunnel that was open there was a showing of coal which probably is characteristic of the whole region. The coal, which was not over three feet in thickness, thinned out and passed into sandstone within a few feet. There is also some evidence of faulting causing the seam of coal to be squeezed and dropped down. At the furthest point reached in the tunnel a few inches above the water the upper part of a body of fairly clean coal, said to have a thickness of approximately four feet, was seen. Fragments taken from this large body of coal are more or less slickensided, indicating that there has been considerable movement along the bed since the coal was deposited. Picked samples taken from this body of coal have been examined closely. One of these is evidently a section of a tree trunk about six inches in diameter, which has been somewhat crushed and flattened and its surface slickensided. Another shows the intimate association of streaks of clean coal with streaks of bony coal or carbonaceous shale.

While in Heppner the writer had an opportunity to look over two reports made to the company by its engineers who had charge of the development work, and these reports describe the coal as containing from eight to ten per cent of ash, and give the following analysis:

	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur
Heppner Coal	.1.85	41.86	47.29	8.30	.82

It seems clear to the writer that such an analysis cannot be obtained from samples which are representative of the beds as a whole, but represent only picked samples from small stringers of pure coal.

COAL NORTH OF JOHN DAY IN S. 15 T. 13 S., R. 31 E.

On Davis creek north of the town of John Day and about sixty miles south of the Heppner prospects there are a number of old prospects of coal in a formation which appears to be in the same position with regard to the basalt as the Clarno. This formation consists of shales, sandstones and massive tuffs, and has a dip of about ten degrees to the south. A short distance up Davis creek from the exposure of coal there is an outcropping of tuff which appears to have the same character as some of the tuff about Clarno, in that it stands out in pillars and columns, referred to by Merriam as bad land types. A short distance down the creek from this prospect there is a large area of similar tuffs. South of this point, showing in the canon walls of Canyon creek immediately south of the town of John Day, what is inferred to be the Columbia lava is exposed. The dip, both of the lava and the underlying rock, is to the south. The basalt is not exposed from this point westward to within a mile of the town of Mt. Vernon, south of which there is an extensive exposure, which, although it is not more than 500 feet in thickness, is composed of many flows and is thought to be the Columbia lava. This rock outcrops with a strong dip to the south. Immediately north of this outcrop and underlying it conformably, there is a great thickness of sandstone, shale and conglomerate which rests upon serpentine. It is thought that tuffs exposed near John Day may overlie this conglomerate formation and that they are probably to be correlated with the Clarno.

The data regarding this coal are as follows: The coal prospects are situated in S. 15, T. S., R. 31 E., along Davis creek, which flows into the John Day about one-half mile below the town of that name.

The following is a section of coal bed as shown in the bank of Davis creek:

	Feet	Inches
Bony coal.....	6	
Coal	2	
Carbonaceous shale.....	8	
Bony coal.....		1/2
Carbonaceous shale.....	8	
Bony coal and carbonaceous shale.....	3	.

The thickness of the whole bed is five feet. The coal, which appears to be less altered than that near Dry Hollow and Heppner,

carries fragments of resin. At this place there is evidence of many old drifts made in a search for coal. These drifts which have since been filled by the creek were not accessible.

A short distance down the creek from this exposure there is an old shaft which displayed the following section.

Section from shaft on S. 15 T. 13 S., R. 31 E., as given by P. A. Snyder:

	Feet	Inches
Clay and boulders.....	12	..
Slate	3	3
Gravel	2	..
Sandstone	1	2
Coal .....	.	2
Slate .....	.	8
Coal .....	.	4
Slate .....	.	11
Coal	1	.
Slate	1	.
Coal .....	.	6
Slate .....	.	7
Clay .....	.	4
Coal and shale.....	.	10
Slate .....	.	4
Coal	2	5
Slate .....	.	9
Coal .....	.	6
Slate	1	.
Coal	1	.
Slate .....	.	8
Coal .....	.	2
Slate	3	.
Coal	1	.
Slate	4	.
Coal	1	6
Slate	5	6
Coal .....	.	6
Slate	3	6
Sandstone	1	.
Coal	3	.
Soapy shale.....	1	.

It was impossible at the time of the writer's visit to examine the shaft as it had partially caved and was full of water, but from a conversation with Mr. P. A. Snyder, of the company interested, it seems doubtful whether the three-foot seam of coal reported near the bottom of the shaft was more than carbonaceous shale. There is no doubt that if a three-foot bed of good coal had been found, an effort would have been made to mine it for local use. It is the writer's opinion, however, that before all hope of finding coal at this point is abandoned, the field should be prospected with a core drill.

Along the John Day river below this point for several miles fragments of coal, some of them reported to be "as large as a wash tub," were discovered in the process of placer mining. Such coal is of the same age as that described above.

SUMMARY OF THE COAL FOUND IN THE CLARNO.

From what has been said, it will be seen that none of the coal beds as yet found in the Clarno formation are very promising, though all of them, with the exception of that in the vicinity of John Day, are bituminous. They are, however, so intimately associated with partings of bone and other impurities as to make them of little value. The coal from Dry Hollow is perhaps the best showing thus far made, but

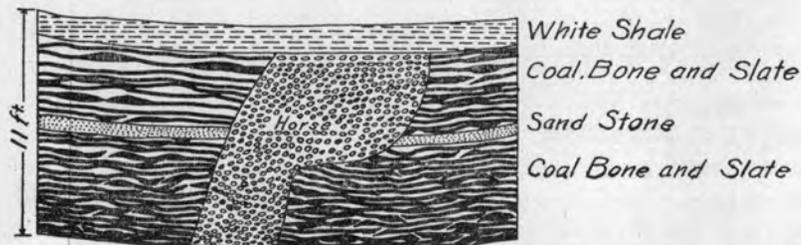


Fig. 7. Old water channel across the coal bed exposed in the tunnel near Dry Hollow.

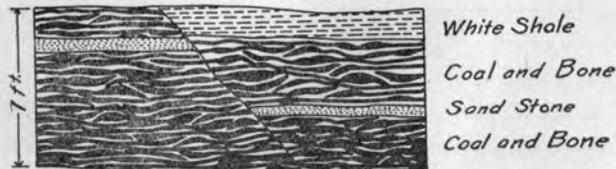


Fig. 8. Fault near the face of the tunnel on Dry Hollow.

it contains at least thirty per cent of impurities and is probably not a very continuous bed. This coal, however, in spite of the fact that it had been exposed to the atmosphere for over ten years and that it contains a high percentage of ash, gave on analysis a heat value of 7,268 British thermal units as received from the mine. Such a heat value is equal to the best of the lignite coals, and if a bed of this kind could be opened up, covering a comparatively large area, it would probably be of value either as fuel for the neighboring country or it might be used in gas engines for generating power.

The coal near Heppner seems to be of still higher grade than that in Dry Hollow. The fragments of coal all show more or less slickensiding, thus resembling some anthracite, but according to the report made by the owners of the prospects to Mr. Mendenhall, a fair sample across the face of one of the drifts yielded only about twenty-six per cent of commercial coal. In other places the coal forms from twelve to forty per cent of the total thickness of the bed.

The coal displayed on Davis creek near the town of John Day is probably sub-bituminous, but no sample of it could be taken for analysis on account of the condition of the openings. As far as it has been seen there is no bed of this coal of sufficient thickness and purity to be worked at a profit.

COAL PROSPECTS IN THE MASCALL FORMATION.

Prospects of lignite coal are to be found at a number of places in the Mascall formation, usually near the John Day river. These coals have not as good a quality as the coals described in the Clarno formation. They invariably slake when exposed to the air, and all of them will ultimately go into fine fragments.

The investigations that have been made indicate that the beds are not continuous for any great distances and it is probable that each of the several localities mentioned has its individual bed of coal with no connection between them. None of the beds seen is of such quality as to make it of commercial value.

At several places along the river large pieces of coal are to be found resting on the gravel bars. A thorough search of the river above these prospects shows that they probably do not represent coal beds, but isolated tree trunks which have been altered into coal. In some instances this coal is of a quality which might be used and in

a great many places it has been taken from the river bars and burned by people living near.

The Mascall formation is of the Miocene system, in which coal has seldom been found in Oregon and never in workable deposits.

The localities in which attempts have been made to develop coal in the Mascall formation will be described in order, beginning at the most westerly point and proceeding eastward.

WEST OF SPANISH GULCH, T. 13 S., R. 24 W.

Near The Dalles military road in the vicinity of Spanish Gulch, coal is reported to have been found on several sections. This coal was first shown to the writer by Mr. S. S. Wolover, who resides on Rock creek, three-quarters of a mile below Antone post office. He reported that he had found fragments in one of his fields after plowing. He attempted to locate the bed from which these came, but was unable to do so.

A coal prospect of the same character is said to occur on the ranch of Mrs. Erikson in S. 13 or 14 T. 13 S., R. 24 E. At this place after some search, small fragments of coal were found, and the writer was informed that several years ago miners from Spanish Gulch had attempted to locate the bed; they had failed, however, to find more than a few large fragments of coal. These probably came from isolated trunks of trees that were inclosed in the rock.

There are similar reports of coal being found in several other places in the neighborhood, but none that is said to be thicker than one-half foot.

NEAR JOHN DAY RIVER BELOW DAYVILLE, T. 13 S., R. 26 E.

A prospect of coal has been seen by a number of people on a branch of the John Day river from the north side about two miles below Dayville. The writer's party spent two days searching for this locality, but failed to find it. Evidently the coal, if such exists, has been covered by recent wash.

ON THE MACRAE RANCH, S. 4, T. 13 S., R. 27 E.

Coal has been known at this place for a great many years, and it was considered by Dr. J. Campbell Martin as being one of the important localities to be visited. A search of the river below Mr. MacRae's

house showed several large pieces of coal. One of these pieces was about two feet square by one foot thick. On searching along the banks coal was found just below Mr. MacRae's bridge, which apparently consists of fragments of old drift wood, and is not a continuous bed of coal. In order to determine the exact nature of the bed, an auger was used and two holes were bored to depths of approximately twelve feet into the underlying strata. Neither of these showed any traces of coal, except the small bed noted above. The stratum underlying the coal to a depth of eleven feet was found to be a fine grained clay, having a bluish color when wet.

PROSPECT ON THE STEWART RANCH, S. 11, T. 13 S., R. 27 E.

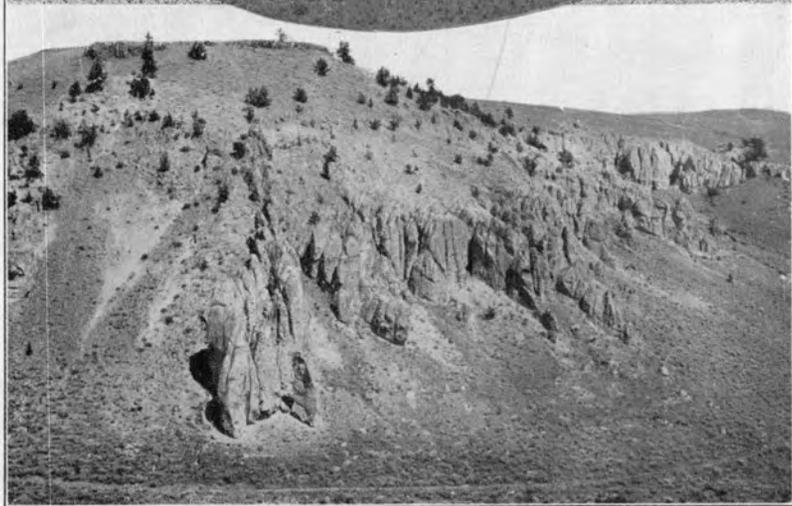
An attempt was made to work a coal bed here several years ago by parties whose names were not obtained. It was reported that they had found two beds of coal, and that the lower bed was of better quality than the upper one. The old prospecting tunnel is still in existence and from the face of this tunnel the following section of the bed was obtained.

Section of coal bed exposed on Stewart ranch:

	Feet	Inches
Alluvium, about.....	.	6
Coal	1	.
Sandstone .....	.	6
Coal	2	2
Sandstone .....	.	4
Coal	1	8
Sandstone floor.		

An examination of the bed showed that the upper twelve inches of coal was the most pure. The twenty-six inches of coal had a great deal of foreign matter in it in the form of sandy grains, while the lower twenty inches was very impure and should be considered as bone. A sample of twenty-six-inch bed was taken by the regular method of spreading down a piece of canvas and cutting a trench across the whole of the bed. The sample was then gathered up on the canvas, and after crushing and quartering, was sealed up in a galvanized iron can and sent to the Federal Bureau of Mines at Pittsburg for analysis.

The results of the analysis are as follows:



Fossil, Oregon.
Typical Clarno Formation, Dry Hollow.
Supposed Clarno Formation, Davis Creek near John Day.

Analysis of Lignite Sample from the Mascall formation.

A. C. Fieldner, Chemist in Charge.

Lab- oratory No.	Quarter	Sec.	T S	R E	Thick- ness of part Sampled	Air Dry- ing Loss	Form of Analysis	Mois- ture	Vola- tile Matter	Fixed Car- bon	Ash	Sul- phur
18,125	NW	11	13	27	2ft. 2 in.	27.4	As received...	34.73	20.00	14.17	31.10	1.41
							Air dried....	10.08	27.55	19.52	42.85	1.94
							Moisture free.		30.64	21.71	47.65	2.16
							Moisture and Ash free....		58.53	41.47		4.18

A search was then made along the banks of the river to discover if possible the outcropping of the lower bed from which it was supposed the few large pieces of coal had come that were deposited on the river bars. This search was made with an auger, and from a point about four feet below the bed already described a hole was sunk to a depth of eleven feet without finding any evidences of coal. At eleven feet the auger struck hard rock and work was given up. It is supposed that the hard rock found in this hole is the Columbia river lava, which outcrops a short distance north of the locality.

The Mascall formation at this point strikes N. 60 W. and dips ten degrees to the south. It consists very largely of cream-colored tuffs. Below the coal bed the material brought up by the auger was mainly blue-colored clay.

ON THE SMALL RANCH.

The next set of prospects visited was found on what is known as the Small ranch in S. 16, T. 13 S., R. 28 E. A great many pieces of coal have been found on the river bars both above and below this place. The prospecting was done about ten years ago by a small company, including R. A. Hines, Frank McBean and a number of others who reside in Canyon City. They report that the enterprise was abandoned because of the attitude of Mr. Small, the owner of the property, who considered that they should pay him a royalty of thirty cents a ton on all the coal mined.

This company made a number of prospect holes near the river, and a few back some distance from it to the south, where they worked in a black serpentine rock. The best prospects found were near Mr. Small's bridge across the river. The company made several excavations near this place, among them a drill hole about two

hundred feet in depth. It was reported by Mr. Hines of Baker City that, although they found some coal through nearly all of this depth, the largest bed had a thickness of only eighteen inches.

An attempt was made by the survey party, with the assistance of Mr. William Cummings, who resides on an adjoining ranch, to bore into and test the thickness of this bed. A hole was sunk underneath the bridge, where the rocks have a dip to the south of forty degrees and strike N. 70 W. The auger penetrated several layers of stringers of coal, one of which was about eighteen inches in thickness. In passing down to greater depths the auger cut through approximately three feet of fairly clean lignite, but with a dip of forty degrees this would indicate a bed only about eighteen inches thick. No sample was taken, as it was not possible to get at a face of the bed, and owing to the water in the auger hole it was impossible to collect a sample by that means. The lignite, however, that was brought up by the auger appeared to be of greater purity than that described on the Stewart place.

SUMMARY OF THE MASCALL LIGNITE.

Although prospects of lignite have been found by residents of the district at many localities between Antone and the Small ranch, none that could be shown the writer is of sufficient thickness and purity to be of commercial value. Lignite at best is a fuel of low grade, always contains a large percentage of water, and has a low heat value of from 6000 to 8000 British thermal units as it is received from the mine. If in addition to the water there is also a high percentage of ash the heat value is necessarily reduced.

The United States government, therefore, in examining and appraising coal lands, has adopted the rule that only fairly pure lignite beds having a thickness of three feet and over shall be considered. Lands on which such beds are found are appraised at the minimum rate.

As has been shown, the Mascall formation containing this lignite is limited in its extent, being confined to a long but narrow syncline, never more than five miles in width. The materials of which it is composed vary from place to place and there is no evidence of any bed which is continuous for any great distance.

Taking these things into consideration, therefore, it is the writer's opinion that lignite beds of commercial value will never be found in the Mascall formation.

ASPHALTUM IN THE CLARNO FORMATION, T. 7 S., Rs. 19 AND 20 E.

Indications of oil and gas are not found generally in the John Day region. Reports of such discoveries are usually based on seepages of water having iron carbonate floating on its surface. Such water can readily be distinguished from oil seeps by simply breaking this coating, which breaks will remain open if the coating is a solid substance like iron ore, and will flow together and close up if composed of oil. An occurrence of the former type was reported to the writer near the John Day river a short distance above Dayville in the Mascall formation. They were seen at many other places during the exploration, but generally no records of such common phenomena were made.

Deposits of oil and gas are often indicated, however, by asphaltum found on or near the surface. For confirmation of this statement the reader is referred to the several reports issued by the U. S. Geological Survey in regard to the oil fields of California.¹ In these cases the asphaltum is regarded as a residual product from the evaporation of petroleum.

While at Clarno during the past summer the writer heard reports of asphaltum deposits that had been found in the neighborhood, and in company with Mr. Wm. J. McGreer, visited one of the localities. The exact location cannot be given on account of the unsatisfactory condition of the survey corners, but it is thought to be in S. 26, T. 7 S., R. 19 E. It is situated near the head of the first creek below Cove creek, which has been known for the geodes and separate crystals found near it. The asphaltum occurs in the geodes in small grains associated with crystals of quartz and calcite. It was reported that one large geode was found which contained a quart or more of asphaltum. One-half of this geode is to be seen at the ranch just below Cove creek. It is approximately one foot in diameter, nearly spherical, and smooth on the outside. The material composing it is merely a crust about one inch thick, lined with crystals of quartz. Many fragments of similar geodes are to be seen scattered over the surface around the head of the creek, but few, if any, perfect ones remain in an unbroken condition. Though some search was made, no asphaltum

1. U. S. Geol. Sur. Bull. Nos. 321, 322, 357, 398, 309, etc.

was found either in the tuff or the andesite which prevail as the country rock.

This asphaltum occurs in rocks of the Clarno, which at this place strike approximately northeast and dip at a low angle to the northwest. It is from 200 to 300 feet below the contact of the Clarno and the John Day. The tuff at this point is overlain by a thin flow of andesite, but whether the geodes came from it could not be determined in the time that was available.

In the latter part of August, 1913, Mr. Mitchell and the writer made a visit to the Huntley ranch, a short distance above the mouth of Cove creek, where a body of asphalt said to have contained several bushels was reported to have been found. This ranch is situated in S. 31 T. 7 S., R. 20 E., and the asphalt was found on the bluff along the south side of Pine creek, about 100 yards southwest of the barn. The rock forming the hillside is tuff with no beds of harder rocks exposed. Although the large mass of asphaltum had been mined and carried away, the tuff for some distance away from the opening contained a great many rounded grains of the material ranging in size from a pin-head to a pea. Other fragments were found along the foot of the bluff, where they had been worked out by squirrels. Mr. Huntley reported another occurrence of asphaltum several miles away from his ranch in what is probably either a bed or vein, but owing to severe sickness in his family he was unable to act as guide, and the asphaltum was not seen.

While none of the exposures seen are of commercial value, there is a possibility that they indicate the presence of petroleum. The rock formation does not appear favorable for the accumulation of oil or gas, but in a new field there have always been new facts to be learned, as will be readily seen from a comparison of the structures in the Pennsylvania, Texas, Colorado and California oil fields. For a discussion of these structures the reader is referred to the papers of F. G. Clapp and M. R. Campbell on this subject, published a few years ago in *Economic Geology*.¹

In the opinion of the writer, therefore, the sinking of one or two deep wells would be justified in a search for oil and gas. The Huntley ranch seems the most favorable locality for such an attempt at the present time, for the reason that it is situated far down in the Clarno and probably near the axis of an anticline; also that such

1. *Economic Geology*, Vol. V, p. 503, Vol. VI, pp. 363-395.

a well is needed for water on the Huntley ranch, and the capital invested will not be altogether wasted. It should be borne in mind, however, that the chances of finding either oil or gas in a new locality are very much against success, but the chances are better here than at many other places in Oregon where wells have been drilled.

CEMENT MATERIAL.

As has been noted, the pre-Tertiary rocks of the John Day region contain some limestone. This is true of the region near Dayville, and in the area south of Richmond. In the latter locality the limestones have been used as a source of lime for some of the buildings in Fossil, and it is reported that the Wheeler county courthouse was one of these. Lime has been burned from time to time in this place for use in making sheep dip, and is said to have produced very satisfactory results for this purpose. Late in the season the writer proceeded to investigate this limestone, with a view to its availability as a source of lime or material for the manufacture of Portland cement. The limestone deposit is situated near the headwaters of a small stream known as Shoo Fly creek in T. 11 S., R. 22 and 23 E. As has been noted, there is a large area of pre-Tertiary rocks in this vicinity. Beginning in S. 24 of T. 10 S., R. 23 E., the rocks exposed are all Cretaceous. They strike northwest and southeast and dip at rather high angles to the northeast. Proceeding up Shoo Fly creek, the rocks change and are of an older formation, probably the Carboniferous, but no fossils were found which would indicate the horizon. In these rocks supposed to be Carboniferous there are occasionally small beds of limestone, which crop out on the hills on either side of the creek. In S. 1 of T. 11 S., R. 22 E., the old quarry made in burning limestone was found, and near it some other smaller deposits of lime were seen. At the old quarry there are approximately three beds of limestone, neither of which is more than ten feet in thickness, and which strike nearly N. W. and S. E. and stand approximately vertical. Two of these beds are so near together, however, that they could probably be worked as one bed. These beds of limestone can be traced to the north about half way through section 36 of township 10 south, range 22 east, and to the south they can be traced for an unknown distance. The quantity of the limestone present here is probably not of sufficient extent to warrant any very great developments. The examination was

not a very complete one, and if there should be any interest taken in this deposit, it would be well for another examination to be made.

In connection with this limestone deposit it is well to note that from it a good grade can be found along Shoo Fly creek to the John Day river and from the mouth of Shoo Fly creek down the river to Twickenham. At the latter place there is an immense supply of clay of the John Day series. This clay could be used along with limestone in the manufacture of Portland cement. It should be further noted that Twickenham is near the mouth of Dry Hollow, and that it is within easy reach of the coal mine situated there. While the coal of Dry Hollow is of such poor quality that it can probably never be burned as fuel for ordinary purposes, it would make gas which could be used in the manufacture of Portland cement by merely placing the gas producer in the vicinity of the coal mine and laying a pipe down to Twickenham to carry the gas to the cement works which might be placed there. While the development of such an enterprise is open to a great deal of question at the present time on account of the small supply of limestone on Shoo Fly creek, it is, in the opinion of the writer, worth while to call attention to it and to suggest this as a possible enterprise. Such a move could be made after a railroad was constructed up the John Day river as far as Twickenham, or the railroad which now extends to Condon could be prolonged to Fossil and thence over the divide to Twickenham. Such a railroad, however, would be at a great disadvantage on account of the high summits that must be passed over first in reaching Fossil from Twickenham, and then in reaching Condon. It is stated here merely as a possibility without great hope that it will ever develop into anything more.

Another occurrence of limestone is to be found on the south fork of the John Day river a short distance above Dayville. At this place the rocks are all of them pre-Tertiary and there are some large exposures of Chico formation resting on the upturned edges of the older rocks, presumably of the Carboniferous. These rocks contain at least one large bed of limestone, which outcrops on the bank of the river and which stands nearly vertical. The full width of the limestone outcrop is not more than ten feet and is probably somewhat less than that. No effort has ever been made to work this limestone. The ranchers along the John Day river have often spoken of it, but they always have preferred to get their lime from Prairie City.

In S. 13, T. 13 S., R. 26 E., there is an exposure of basalt, covering several acres, in which there are a great many small seams and veins, which are filled with a white mineral resembling a zeolite. This mineral, however, is a variety of lime carbonate called aragonite. While it is not thought that the aragonite is in sufficient quantity here to supply the lime for making Portland cement, it may be that by the use of the other body of limestone in this vicinity a Portland cement can be produced from these two localities. It should be investigated, however, before anything further is done with it.

BUILDING STONE.

This region is well supplied with building stones of various kinds, among the most promising of which is some rhyolite tuff, a prominent member of the Rattlesnake formation. As has been noted, the Rattlesnake formation lies in an almost horizontal position in the syncline in the southern part of the field. The rhyolite stands out as the capping rock for a great many mesas and shows by this that it is capable of resisting the weather in a notable way. Although this rock is to be seen along the valley all of the way from the town of John Day to and beyond Antone, the rock is most accessible near the town of Mt. Vernon, where it is approximately twenty-five feet thick and where there are several quarries from which small amounts have been taken at various times. A rock very similar to this and possibly the same is to be found scattered over the Mascall formation in large boulders. The rock has been used for building smokehouses, cellars and chimneys from Canyon City to Antone, and it can be seen in some larger buildings in John Day and Canyon City. It is light colored, pleasing to the eye, and in a climate as dry as that of the John Day region, its porous nature is not a disadvantage. Whether it would resist the weather as well in the Willamette valley is an open question, but it probably will be found to work as well as in the John Day valley.

The rock owes its origin to some violent volcanic eruption either in the Cascade Mountains or nearer at hand. The materials of which it is composed were thrown up into the air and settled over the land surface. While they are nearly all light pumiceous fragments that could be carried for some distance by the winds, there are some fragments of more dense glass, the pressure of which would seem to indi-

cate that water had been instrumental in bringing them to their present position.

POSSIBLE ROOFING SLATE.

In the forks of Currant creek, S. 29, T. 8 S., R. 19 E., there is a large area of slate, most of which lies west of the wagon road.¹ This slate is marked for having an almost perfect cleavage, a feature that is not very common in Oregon.

The cleavage and quality appear to be good enough to make roofing slate, but owing to the hasty nature of the examination made, this conclusion may not be justified. The fragments large enough to be considered roofing slate are rather few, but it must be borne in mind that only the outcroppings were seen, and if excavations are made larger pieces of slate may be obtained. The rock is rather soft and on this account may not be suitable for the purpose suggested. However, since the material examined is from the croppings which have been exposed to the weather for a great many years, it may be found harder in depth. At any rate it is the writer's opinion that this exposure is worthy of consideration, and with the building of railroads into this country some effort should be made to ascertain whether or not a deposit of roofing slate can be developed.

BASALT.

In the northern part of the field there is an abundance of rocks of the Clarno formation, but these have not as a general rule been found very good for building purposes. In the town of Heppner there is, however, a large store building which is made of basalt from the Columbia lava. The color of the basalt is rather objectionable in a building, and is not pleasant to look at, but it is comfortable for those who build of it. For such purposes as road material and crushed rock to be used as a filling for concrete an abundance of basalt can be found within a few miles of any part of the area.

CHROMITE.

On the south side of John Day river opposite the mouth of Cummings creek in S. 21, T. 13 S., R. 28 E., there is a large deposit of dark colored serpentine, and in contact with it a body of chromite was found.

1. Merriam, J. C., Contributions to the Geology of the John Day Basin, Bull. Dept. of Geol., Univ. of Cal., Vol. 2, p. 280.



Canyon City, showing Humbolt Bench Placers.

Chromite or chromic iron ore is a mineral which was at one time produced in California, but for a number of years the European competition has been so active that the California mines have yielded only a small production. It is used as a lining for furnaces. It is reported from various parts of California, Oregon and Washington. As this locality is a new one, mention of it is made here among the economic possibilities. Should the demand for chromite ever warrant it, the material can be produced here.

COPPER.

In the range of high hills that lies south of the John Day basin, the formations are in the main of the pre-Tertiary age and consist of older crystalline and metamorphic rocks. On the south fork of the John Day, therefore, it was not surprising to learn that efforts have been made for some time to prospect for copper, and the writer was piloted to several of the prospect holes by Dr. J. Campbell Martin. At one of these prospects there is said to be some native copper found on the surface of the ground. The prospect consists of a shaft, possibly a hundred feet deep in serpentine rock. Materials on the dump consist of a great many fragments of serpentine showing a copper stain. There is certainly not enough copper in sight at this place to justify the expectation of developing a mine, but with such rocks as the region contains there is always the possibility of future discoveries.

GOLD AND SILVER.

Gold and silver are known to be present in several districts in the southern and eastern parts of the area covered by the special map. No attempt was made to examine these deposits during the summer, for the reason that they were assigned to other parties. A brief mention of the various districts will be given.

The gold and silver mines of the Blue Mountain region are well known.¹ At the southeast corner of the area under discussion is the town of Canyon City, which has been a notable producer of gold for a great many years. At one time there was a population of five or six thousand at Canyon City. Most of the gold obtained was taken from placer mines, which are now nearly worked out, and much of the mining is suspended. There are several prospectors who spend their time looking for pockets in the hard rocks, and with such success

1. Lindgren, *Op. Cit.*, pp. 279-282.

as to indicate that the lode claims may ultimately be operated. The placers at this point extended down the John Day river for several miles below the mouth of Canyon creek, and there is said to be some gold to be found along the bottom of the river as far as the Picture Gorge.

Another region which has produced gold and silver is Spanish Gulch, approximately sixty miles west of Canyon City. At this place along Spanish Gulch and one of its tributaries called Mule creek there has been a great deal of gold obtained, possibly as much as \$100,000 in all. This camp, like that of Canyon creek, is nearly worked out, but there are at least two good prospects of hard rock mines. One of these is being guarded by some parties who are in litigation over it. The other, to which the title is good, is wholly undeveloped.

Gold and silver are also found in a district on the southwest corner of the map, which was not visited by the writer.

In the pre-Tertiary area north of Richmond it is said that some prospects of gold and silver have been found, but there is no one living in the vicinity who has seen any of the metal produced.

ARTESIAN WATER.

In a dry region like this under discussion, the question of water supply is one of the economic problems to be considered. Near the level of the river it is always possible to obtain water for irrigating purposes by the use of ditches, and there are already many such enterprises in operation, supplying all the water that is needed at the present time. If, however, this region were supplied with railroad communication, many new ditches could be built and a much larger part of the area could be made productive in this way. For example, there is now a project under consideration for some high ditches in the vicinity of Canyon City, which would tap the headwaters of a number of creeks and supply all the high bench lands on both sides of the valley as far as the vicinity of Dayville. Such a system of ditches would probably be successful and should not injure the present ranches along the river, for none of these use all of the water of the John Day, and there is always a good run-off at Picture Gorge.

There are many places on the high plateau surface where the lands must be worked by dry farming processes, and in such areas it will

often be necessary to haul water even for drinking purposes. In the northern part of the area around Condon and Heppner, deep wells have been drilled, and it is found that water can usually be reached at depths less than 500 feet. Some of the wells drilled to the limit of the machines used are dry, however, and one or two attempts have been successful in striking a stream of water which rises above the surface and forms a flowing or artesian well. Such wells are highly prized because they do not require pumping.

The principles governing them are as follows: The seam or vein of water is enclosed between impervious layers, or at least has an impervious layer above it, so that it cannot escape upward towards the surface. Such a seam of water must extend for a long distance and must have a source in the neighboring mountains or in higher ground than that on which the well is drilled. When a well is drilled to strike such a seam of water, the water will rise to the height of its source by hydrostatic pressure. In many places where there are wells of this kind the strata are very evenly laid down and consist of a porous sandstone underlying a great thickness of shale, which can be traced to higher ground hundreds of miles away. Such a condition of affairs is to be found in the Dakotas. In other places the beds are somewhat folded, forming anticlines and synclines. An anticline is an upfold or axis from which the beds of rock dip away in two directions. A syncline is a down fold or an axis towards which the beds dip. Flowing wells are often found in the synclines.

The Columbia lava consists of beds of basalt interstratified with beds of basaltic tuff, which are often so porous as to serve as water carriers. Wherever the structure is right, that is, the water carrier dips down and underlies low places, it may be expected to yield flowing wells, or at least wells in which the water rises towards the surface. In some cases the water will rise part of the way until it reaches another porous bed, into which it will flow away and be lost. In such cases the water may still be brought to the surface by shutting off the escape with a casing.

At Mayville there is a well 106 feet deep, from which the water rises ten feet above the surface. As will be seen from the map and the structure section, Fig. 2, Mayville is situated in a syncline towards which the basalt dips from both directions. The log of the well is reported to be about as follows:

	Feet	Inches
Soil	1	.
Basalt	10	.
Soapstone	4	6
Basalt.		

The soapstone layer is probably a bed of rather compact basaltic tuff. A small flow of two gallons per minute was found when it was first struck, but the main flow is from the contact of the soapstone, with the basalt beneath. The well was tested with a 2-inch pump and pipe, and by raising all the water that could be forced through the pipe with a pressure of eighty pounds of steam, they were able to lower the water twenty feet below the surface. Several other wells in the neighborhood raise the water to within five feet of the surface, and the only well that failed to reach water is one 500 feet deep on the edge of Thirty-Mile canyon. The water contained in all these wells is practically free from impurities.

Two other areas were noted by the writer as being promising for artesian water, though no wells have been drilled in them. One of these is situated southeast of Fossil on the John Day near the crossing of the wagon road from Fossil to Richmond. There is here a large area of Columbia lava laying in a syncline, the base of which is below the level of the river. This locality is not a very desirable one for artesian water, for the reason that it lies near the river and there is not very much agricultural land in the neighborhood.

The second area in which there is promise of artesian water is in the neighborhood of Dayville. There is here, as has already been shown, a very marked syncline where the Columbia lava bends downward in a rather sharp fold. This part of the valley of the John Day is also the most promising one for agricultural purposes. Along the river there are a great many springs, most of which are near the river level, but one or two are back some distance from the river. These springs suggest to one who examines them that the reason for their presence is in some way connected with the geological structure. In the opinion of the writer, a well located here would lead to a flow of artesian water. Some shallow wells bored in the Mascall formation would probably yield small flows, but for larger flows wells must be bored down into the Columbia lava. This lava on the north side covers a very large and extensive plateau and dips down below the level of the valley. On the south side the lava rises, but is

more or less broken. There is a chance, then, that flowing water can be found in this lava at an elevation of 100 feet or more above the valley floor.

Artesian wells might be found in the other formations, notably in the Clarno, which covers a large area on the map. The Clarno formation, however, is composed of a great many kinds of rock, and it is not probable that artesian water can be predicted at any place. There is, however, in the town of Fossil a well of this kind, which was drilled there several years ago, and that does yield a small flow. While such occurrences are known, they cannot be forecast from a study of the geologic structure.