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WASHINGTON GEOLOGICAL SURVEY

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HENRY LANDES, State Geologist

BULLETIN No. 3

The Coal Fields of King County

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By GEORGE WATKIN EVANS

OLYMPIA, WASH.:
E. L. BOARDMAN, PUBLIC PRINTER
1912

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LETTER OF TRANSMITTAL.

Governor M. E. Hay, Chairman, and Members of the Board of Geological Survey:

GENTLEMEN: I have the honor to submit herewith a report entitled "The Coal Fields of King County," by George Watkin Evans, with the recommendation that it be printed as Bulletin No. 3 of the Survey reports.

Very respectfully,

HENRY LANDES,

State Geologist.

University Station, Seattle, May 1, 1912.

CONTENTS.

ILLUSTRATIONS.

PLATES.

FIGURES. *Page*

ABBREVIATIONS USED IN DESCRIBING SECTIONS.

Ark. . . . . arkose or arkosic
Bl. or Bk. . . . . black
Bn. . . . . bone or bony
Br. . . . . brown
Brit. brittle
Conc. . . . . conchoidal
Cr. . . . . coarse
Crb. sh. . . . . . . carbonaceous shale
Dk. . . . . dark
Dp. . . . . dip
Gd. . . . . good
Gr. . . . . grain
Gy. . . . . gray
Gyp. gypsum
Ig. . . . . igneous
Imp. . . . . impure
Lam. . . . . laminated
Len. . . . . lenticular or lense
Ma. . . . . massive
Nod. nodular
Plas. . . . . plastic
Sa. . . . . sandstone or sandy
Sa. sh. . . . . sandy shale
Sh. . . . . shale or shaly
Sh. sa. . . . . shaly sand
Sk. . . . . strike
Wh. . . . . white

THE COAL FIELDS OF KING COUNTY.

INTRODUCTION.

NATURE AND PURPOSE OF PRESENT REPORT.

King county has been examined very carefully, with a view of determining the extent and character of its coal areas. Every outcrop of coal that could be found has been examined and notes taken on its occurrence; other areas, containing sedimentary rocks, but not coal, have been studied to determine if possible the relation of such outcrops to the coal bearing strata. Igneous areas have also been studied and mapped, establishing wherever possible the relationship of such areas to the underlying or overlying coal beds.

The principal faults and folds have been studied in the mines themselves and in the intervening areas wherever possible. Methods of working and washing coal have been studied in a general way, data have been collected on the local markets and other markets that King county coals enter; and the classification of coal lands has been discussed in more or less detail. Analyses are given of the coals of King county, as well as analyses of other coals coming into competition with the local products. California fuel oils are such strong competitors of Washington coals that some attention has been given to this matter.

It has been the aim to gather data for a geologic and economic report on the coal fields of King county and allied subjects, so that mine operators, mining engineers, miners, consumers and the public in general will get some benefit from a careful reading of it.

EARLY DEVELOPMENT OF THE COAL INDUSTRY.

*In 1853 Dr. M. Bigelow found coal on Black river near the present site of Renton. A mine was opened and operated in a small way until the Indian outbreak in 1855. Two of Bigelow's partners, Fanjoy and Eaton, were killed by the Indians and the mine was abandoned. Several attempts have since been made to open these beds, but they are so impure that they do not pay to operate.

In 1863 coal was discovered in a creek near the present town of Issaquah and a few months later on Coal creek, near the present site of Newcastle.

Daniel Bagley, G. F. Whitworth, John Ross and other well known Seattle pioneers of those days, began the active development of the Coal Creek beds. The coal was transported to Lake Washington by wagons, carried across the lake in barges and hauled to Seattle by wagons. In 1867 the Lake Washington Coal Company, consisting of the above named gentlemen and others, was organized for the purpose of developing this property on a larger scale. A new opening was made at the mine, the coal was transported from the east side of the lake to Black river, thence down the Duwamish to the Seattle water front.

In 1870 the property was sold to the Seattle Coal Company. This company constructed a tram road from the mine to Lake Washington and another tram road from Union bay to Lake Union. From Lake Union the coal was distributed in different parts of Seattle.

Early in the seventies, Seattle was making determined efforts to get into communication with the outside world. The Northern Pacific Railway had decided upon Tacoma as its western terminus. Seattle citizens then decided to build a railroad of their own, and as a result they organized the Seattle and Walla Walla Railroad and Transportation Company. They built the

*The Coal Deposits of Washington, Volume 1, pp. 257-9, Washington Geological Survey.

line from Seattle to Renton and Newcastle. This road is now known as the Columbia and Puget Sound Railroad. After this road was built, the coal was hauled over it instead of by the lake route.

Coal was discovered at Renton in 1873 by Mr. E. M. Smithers. Together with T. B. Norris, C. B. Shattuck and others, he organized the Renton Coal Company, for the purpose of developing the property. The coal was carried by the railroad to Duwamish river, from which point it was taken on a barge to Seattle.

The Talbot mine was opened near the Renton mine in 1874. John Leary, John Collins and J. F. McNaught organized the Talbot Coal Company. After a few years of operation the bed was found to be so badly faulted that it was abandoned.

The Green River field at Franklin and Black Diamond began development in the early eighties. Later the coal fields at Raging River, Kangley, Durham, Cumberland, Ravensdale, Occidental, Taylor and Bayne were prospected and some of them developed.

PREVIOUS GEOLOGICAL WORK.

A book entitled "Coal Mines of the Western Coast" was written and published by W. A. Goodyear in 1877. This report describes in a graphic and accurate manner the various coal fields of California, Oregon and Washington. His description of the Newcastle-Coal Creek field is in considerable detail. His conclusions at that early date, both as to the geology of the fields described and their future importance were remarkably accurate.

In the early eighties Mr. Bailey Willis, with a large force of men, working under the auspices of the Northern Transcontinental Survey, spent about three years making a careful examination of the King county coal fields in connection with his study of the entire coal fields of the state. It is remarkable what accurate work this geologist did in those early days. It is difficult enough at the present time, with all the later develop-

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ment work that has been done, to accurately map the geology of so complex an area.

Dr. Ruffner published a report on the coal fields of Washington in 1887. This report deals more particularly with the Issaquah-Raging River areas. The Seattle and International Railroad Company was at that time interested in the development of these fields. Dr. Ruffner's report has been drawn upon for some of the data regarding the Raging River district. Many openings were made at the time of his examination, which have since completely caved in and may be no longer examined.

In 1901 and 1902 the Washington Geological Survey made a report on the coal mines of the state under the direction of Professor Henry Landes. The results of this work have been published in Volumes 1 and 2, Washington Geological Survey. These reports, as far as King county is concerned, dwelt for the most part with descriptions of the mines and details of the coal beds, along with some analyses. The appropriation for the work was too small to attempt a detailed geological survey.

In 1896 Mr. Bailey Willis and Dr. George Otis Smith, of the United States Geological Survey, mapped the area known as the Tacoma quadrangle. This quadrangle does not extend east of Franklin, neither does it reach very far north of Renton. It necessarily omits the New Castle-Issaquah-Grand Ridge area to the north, the Taylor-Raging River field to the northeast and the Green River field east of Franklin. The results of this work were published by the United States Geological Survey as The Tacoma Folio No. 54. In this folio will be found the most complete paleontological study of the Puget formation and it is from this folio that some of the data covering that phase of the report have been taken.

The United State Geological Survey has cooperated with the Washington State Geological Survey in making a collection of samples of Washington coals. These samples were analyzed in the laboratories of the United States Geological Survey and published as Bulletin No. 474.

BASE MAPS.

The map on which the geology and classification are shown is compiled from various sources. Free use has been made of the United States General Land Office maps and the King County Engineer's maps. The United States Geological Survey maps of the Seattle and Tacoma quadrangles have been used as checks on the work. The surface lines of the various coal companies' mine maps have been the bases for the section lines surrounding the coal properties.

The maps of the various railroads have been used in locating their respective lines.

The accurate maps in the King County Assessor's office have been used in filling in some of the topography and the roads and trails.

CHARACTER OF FIELD WORK.

It has been the aim in the field work to examine every coal and sedimentary outcrop within the area mapped. This has been accomplished by sending out men in various directions from a given center and mapping all the outcrops found. Complete notes were taken, and surveys for distance and direction to some section corner were made. Work in a region covered for the greater part with glacial drift, as well as a heavy growth of trees and underbrush, is necessarily slow. Day after day was spent without finding an outcrop. In and around the developed mines, cross-sections were made of all coal beds and rock tunnels. Samples of all commercial coal beds were collected, and the analyses were made by the United States Geological Survey.

In the Green River area, a detailed stadia survey was made from the northwest corner of S. 28, T. 21 N., R. 6 E. to a point one mile up the river from Palmer Junction. Stations were set at numerous points along the course of the river, all the coal and bony beds were accurately located and detailed sections taken wherever possible. This detailed survey and classification of material are the bases for the three columnar sections in the Green River series, viz., the Kummer, Franklin and Bayne series.

The Green River section has been used as a basis for correlating wherever possible the other coal areas. It has been the endeavor to work out the geologic structure and correlate the beds of widely separated areas. The principal folds and faults have been studied and their positions mapped. Underground water problems have been studied as much as the limited time would permit.

The character and extent of the principal areas of igneous rocks within the coal fields have been studied and mapped. The methods of working the coal and preparing it for market have been studied in a general way.

PERSONNEL.

In addition to the writer, the following men have been employed at various times upon the survey of the King county coal fields:

C. E. Weaver, E. J. Saunders, E. E. Smith, W. M. Stephen and Charles Fettke for the summer of 1909. E. J. Saunders, H. E. Taylor and Charles O'Connor for part of the summer of 1910 and for a few weeks in 1911. C. H. O'Connor, H. E. Taylor, Guy L. Putnam, Wm. Ruggles, Earl Packard and J. J. Runner were employed in checking some former work and getting data on later developments. In addition to the above men, who did the field work as noted, the following draftsmen have been employed to prepare the plates for the report: F. B. Lassoie and Miss Silena Brown.

ACKNOWLEDGMENTS.

The writer is under obligation to the following gentlemen for information and hearty cooperation with the work of the Coal Survey:

To Mr. James Anderson, chief engineer of the Pacific Coast Coal Company, for valuable suggestions bearing on the geology of the coal areas of the entire county.

To Mr. William Hann, general superintendent of the above mentioned company, for hearty cooperation and suggestions having direct bearing on the Black Diamond-Franklin field.

To Mr. Nat Moore and Mr. Ray Smith, assistant chief en-

A—Outcrop of Franklin Sandstone along Green River, near town of Franklin.

B—Looking north from Lizard Rock, toward Durham and Kanaskat.

gineer and assistant engineer, respectively, of the same company, for the use of mine maps and other data, and a most hearty cooperation with the work of the Survey.

To Mr. John J. Jones, superintendent of the Newcastle-Coal Creek Mines, same company, for valuable assistance and suggestions in the study of the field about his mines.

To Mr. Rasmus Christensen, superintendent of the Black Diamond mines, for many favors and a willingness to assist at all times.

To Mr. C. R. Claghorn, general manager, and Mr. John Pott, chief engineer, of the Northwestern Improvement Company (coal department of the Northern Pacific Railway), for hearty cooperation at all times with the work of the survey and especially for maps and data having direct bearing on the area in the vicinity of the company's property at Ravensdale. Also to Mr. T. T. Edwards, superintendent of the Northwestern Improvement Company's mines at Ravensdale, for valuable suggestions and assistance.

To Captain F. A. Hill, general manager of the Wilkeson Coal and Coke Company, who was formerly connected with the Seattle Electric Company, for his hearty cooperation at all times with the work.

To Mr. George Harrington and Mr. Lewis D. Jones, general superintendent and superintendent, respectively, of the Seattle Electric Company's mine at Renton, for valuable help in the study of the Renton coal field.

To Messrs. J. R. Miller, John Keenan, S. A. Tomes (deceased), William Lawton, and Manchester Walters, general manager, local manager (Taylor), former superintendent, and mine foremen, respectively, of the Denny-Renton Clay and Coal Company, for valuable assistance and suggestions in the study of the field adjacent to their mine at Taylor. Also to Mr. J. Ward Harris of the same company, superintendent of the company's mine at Kummer, for cooperation in the study of the Kummer district.

To Mr. Eugene Lawson, independent operator, for many valuable suggestions and data in the study of the Green River fields in general.

To Mr. Andrew Reynolds, superintendent of mines for the Central Coal Company, for courtesies shown while studying the Issaquah-Grand Ridge fields.

To Mr. George G. Bayne, Griffith Llewellyn, George Rockefeller, general manager, former superintendent, and superintendent, respectively, of the Carbon Coal and Clay Company, for the valuable assistance rendered the survey while studying the coal area in the vicinity of Bayne and Occidental.

To Mr. P. Gibbon of the Occidental Coal Company for data and assistance regarding the Occidental property.

To Mr. John Williams of the Independent Coal & Coke Company, for valuable assistance and suggestions in the study of the Lizard Mountain and Cumberland districts.

To Mr. Joe Marshall, general manager of the Rose-Marshall Coal Co., for the use of maps and cooperation in the study of the Rose-Marshall and Sunset fields.

To Mr. John McWade for assistance in the new coal field at May Creek.

To Mr. John Harris, pioneer explorer, for many valuable suggestions in the study of the entire field lying east of Green river.

To Mr. David C. Botting, State Inspector of Coal Mines, for a most hearty cooperation at all times with the work of the coal survey.

To Messrs. Charles E. Weaver, Edwin J. Saunders, H. E. Taylor, Charles O'Connor, W. M. Stephen, E. E. Smith, Charles Fettke, Guy Putnam, W. W. Ruggles, J. J. Runner and Earl Packard, field assistants at various times, for valuable assistance in the field.

To many of the miners working in various parts of the county, for a willingness to cooperate and help at all times.

To all of these and many others too numerous to mention, but not too numerous to remember, the writer is under a lasting obligation for the great help rendered. With the hearty cooperation of these gentlemen the work of a difficult problem has been made pleasanter and easier than it would otherwise have been.

CHAPTER I.

GEOLOGY OF COAL.

COAL AS A ROCK.

When we consider coal in geology, it is customary to consider it as a rock and treat it with reference to its relationship with other rocks. Coal is found in connection with sedimentary rocks, the roof and floor of a coal bed* consisting of sediments that have been laid down in water. Coal bearing strata are often 5,000 to 10,000 feet in thickness with the coal beds occurring at various horizons throughout the sedimentary layers. The beds range from a very few inches to over a hundred feet or more in thickness. Some of the beds are of pure coal with no partings of bone or shale, as in the instance of the lower bench of the McKay bed at Franklin and Black Diamond, while other beds are alternating layers of coal, bone, shale or rock.

COMPOSITION OF COAL.

Coal is treated by some writers as a mineral and by others as a rock, but since it has no definite chemical composition, it will be treated throughout this discussion as a rock. Coal is composed principally of carbon along with other elements such as hydrogen, oxygen, nitrogen and sulphur, as well as the ash, which is usually a combination of such substances as silica, potash, soda, alumina and iron.

The chemical compositions of different coals are shown in the table below:

ELEMENTARY ANALYSES OF DIFFERENT COALS.*

	Carbon	Hydrogen	Oxygen	Nitrogen	Sulphur	Ash	Analysts
1. Coal, Eastern Penn....	90.45	2.43	2.45	....	....	4.67	Regnault
2. Coal, Clay county, Ind.	82.70	4.77	9.39	1.62	0.45	1.07	Cox
3. Coal, Ohio	73.80	5.79	16.58	1.52	0.41	1.90	Wormley
4. Coal, Breckinridge, Ky.	68.13	6.49	5.83	2.27	2.48	12.30	Peters
5. Coal, Bovey	66.31	5.63	22.86	0.57	2.36	2.27	Vaux
6. Peat	59.47	6.52	31.51	2.51	....	....	Websky

* Ashley, George H., Twenty-third Annual Report, p. 14, Indiana Geological Survey.

*Erroneously called vein, sometimes seam.

It is generally agreed that coal is fossilized vegetal matter, and is made up principally of the elements as shown in the above table. Part of the carbon is free and is represented by the fixed carbon in a coal analysis, while some of the carbon is combined with hydrogen, forming the hydro-carbons. The moisture in the coal is a combination of part of the hydrogen and oxygen; the nitrogen is inert; and the ash represents the natural ash to be found in ordinary peat and in some cases the silt that collected in the bed during deposition.

In the process of burning coal the carbon and hydro-carbons, with part of the sulphur, are the only heat producing elements. The fixed carbon gives off heat when combined with oxygen, as do the hydro-carbons; the water or moisture gives up no heat, but is a detriment, in that it takes a portion of the heat units of the burning coal to drive off the water. The ash also is of no value as a heat producer. So it can readily be seen that the greater the proportion of moisture and ash, the smaller will be the heating value of the coal.

CHEMICAL AND PHYSICAL PROPERTIES OF COAL.

CAKING COALS.

Some coals have the property of caking when thrown on the fire; a coking coal will usually do so, but this is true of very few free burning coals.

One advantage a caking coal has over a free burning coal is that the fine particles can be burned, from the fact that the entire bed of burning coal cakes, whereas if the coal did not cake the fine particles would fall through the grate-bars and be lost in the ashes.

COKING COALS.

Few of the coals of King county coke. The bituminous coals of Snoqualmie, also some of the coal from the beds at Kangley, Durham and the Big Six mines coke more or less. This is a property very marked in some coals and entirely absent in others. It is not known why some coals will coke and others will not. It is a well-known fact that of two coals with identically the same chemical analysis, one may coke and the other will not. It has been suggested that the coking property is due to the physical character of the coal. One theory is that it is due to the presence or absence of certain bacteria that lived in the plants at the time of the deposition of the vegetal mass that constitutes the coal.

HARDNESS.

Some bituminous coals are very soft, and in fact will stand little or no handling. This is true of a great deal of the best coal in the Controller Bay coal field of Alaska. It is also true of the Snoqualmie coal in this county, and the Wilkeson coal in Pierce county. This property is not such a very great handicap for a caking or coking coal, but for a free burning coal it is a very serious one. A great deal of the profit in mining coal for the domestic market depends upon the percentage of lump the coal bed can produce.

The sub-bituminous coal of Renton, Newcastle and Grand Ridge are hard enough to produce a fair percentage of lump coal.

FRACTURE.

Some coals, such as the McKay coal at Franklin, have a cubical fracture. Many bituminous coals have this property. Most of the Renton-Newcastle-Issaquah-Grand Ridge coals have a conchoidal fracture, while the lignites of Lewis county have a shaly fracture.

CLASSIFICATION OF COAL.

Ordinarily coal is classified as follows, in a descending order of the fixed carbon constituent: anthracite, semi-anthracite, semi-bituminous,* bituminous, and sub-bituminous. Of still lower grade in percentage of carbon we have lignite and peat. The following table shows the analyses of certain peats, lignites

*Note here the unfortunate placing of the semi-bituminous between the semi-anthracite and the bituminous, thus leading to more or less confusion.

and coals in the ascending order. The various classifications of coal will be discussed under another head:

PROXIMATE ANALYSES OF PEAT, LIGNITE, and COALS.*

	PEAT	LIGNITE			BITUMINOUS COALS			ANTHRACITE	
	Dismal Swamp	Athens, Texas	Atascosa cou'ty, Texas	Leon cou'ty, Texas	Waldrip, Texas	Pennsylvania	Pennsylvania	Pennsylvania	Pennsylvania
Moisture	78.89	9.10	13.285	14.670	4.55	0.9	1.3	2.74	2.93
Volatile matter..	13.84	42.20	59.865	37.320	38.50	25.63	20.87	4.25	4.29
Fixed carbon ...	6.49	7.37	18.525	41.070	44.80	51.30	67.20	81.51	88.18
Ash	.78	41.32	8.325	6.690	12.14	17.77	8.80	10.87	4.04
Sulphur	....	0.62	2.360	0.250	7.96	4.4	1.83	0.62	0.55

* Tarr, R. S., Economic Geology of United States, page 312.

The classification commonly adopted since 1877 is the one proposed by Mr. Persifor Frazer, Jr., assistant geologist of the Second Geological Survey of Pennsylvania. This classification is based on fuel ratios, expressed by the quotient of the fixed carbon divided by the volatile combustible matter.

The following classification was adopted for the coals of Pennsylvania:

NAME OF COAL.	FUEL RATIO.
Anthracite	100 to 12
Semi-anthracite	12 to 8
Semi-bituminous	8 to 5
Bituminous	5 to 0

This classification worked very well for the coals of Pennsylvania, except that the term semi-bituminous is a misnomer and does not state correctly the relationship of the bituminous and semi-bituminous coals. Correctly speaking semi-bituminous would be considered a lower grade coal than the bituminous. It will be noticed that no provision is made for the sub-bituminous coals and lignites, into which class the greater portion of Washington and western coals will fall.

In an attempt to overcome this oversight, it was proposed by Collier* that the percentage of moisture in a coal be used as

*Bulletin No. 218, U. S. Geological Survey.

a basis of classification. Collier's scheme was to class all coals with less than ten per cent. moisture as bituminous and those with more than ten per cent. as lignites. This arrangement was found to have its shortcomings, in that it classed some acknowledged lignites as bituminous and *vice versa.* There has been a great deal of discussion during recent years as to the best method of classifying coals and lignites. Mr. M. R. Campbell of the United States Geological Survey has treated this subject very fully in Professional Paper No. 48, U. S. Geological Survey. After arranging a great number of analyses of coals from various parts of the United States into a classification, according to their fuel ratio, Mr. Campbell found that the anthracites and the higher grade bituminous coals fell within the proper limits, but that there was great discordance in the lower grade coals, so he suggested that the fuel ratios be discarded. He further tabulated a list of analyses of various coals and lignites on the fixed carbon basis with the result that the fixed carbon basis agreed closely with the fuel ratios and as a result did not properly classify the lower grade coals.

He then arranged a series of coals and lignites based on their calorific values, or the British thermal units, calculated on a pure coal basis. He found that the lower grades of coal are taken proper care of on this basis, but that certain of the bituminous coals are rated higher than known anthracite coals.

He next classified a great number of coals and lignites on the hydrogen basis, in which case the air-dried analysis was used, and the percentages re-calculated on the basis of excluding ash and sulphur. He found that the results were satisfactory in so far as the higher grade coals were concerned, but it was not satisfactory for the lower grade bituminous and lignite grades, and decided that the hydrogen basis was not satisfactory.

Next he arranged the various analyses according to their carbon-hydrogen ratio, and discusses the scheme as follows:*

*Campbell, M. R., Classification of Coal. Professional paper No. 48, p. 168, U. S. Geological Survey.

"The schemes of classification so far given, take account of all the fuel elements of the coal or all the elements upon which a classification can logically be based. The percentage of carbon forms the most satisfactory basis of classification so far tried, but carbon is only one of the important fuel elements of coal. Hydrogen is almost equally valuable, yet, as has been shown in a previous table, this, taken alone, does not afford a satisfactory basis.

"The increase in the value of coal from the grade of brown lignite to that of anthracite involves both carbon and hydrogen; it depends upon an increase (or at least no diminution) in the amount of the former and a direct loss of the latter. For this reason the ideal classification should take account of both elements.

"Since the percentage of hydrogen decreases as the percentage of carbon increases the two elements should not be combined by addition or by multiplication, for both of these processes would tend to equalize the results, and this is undesirable for purposes of classification. Subtraction or division, therefore, must be used to express the desired relation. The latter seems to be the most satisfactory, and, therefore, a table has been prepared showing these quotients or ratios."

Mr. Campbell then shows a table of various coals and lignites arranged on the carbon-hydrogen ratio basis and classifies then into ten groups. Continuing, he says:

"In considering schemes of classification, it must be remembered that our present knowledge of the chemical composition of coal is very imperfect, and that any scheme which may be proposed depends to a certain extent on unknown or little-understood factors. For this reason any scheme must be regarded as provisional.

"The points of greatest weakness are our ignorance of the nature of the volatile combustible matter and also of the form or nature of what is usually called moisture."

After discussing the details of the moisture contents, Mr. Campbell states that in his judgment the carbon-hydrogen

A—Outcrop of a Coal Bed on Green River.

B—Outcrop of Gem Bed, New Franklin Mine, Green River.

ratio as a basis is the best obtainable. He feels that it will cover all classes of coal with the possible exception of cannel coal. He then proposes a grouping or classification as follows:

PROPOSED GROUPS OF COAL AND ALLIED SUBSTANCES.

		Carbon-Hydrogen Ratio.
Group A:	Graphite	∞ to (?)
Group B:	Anthracite	(?) to 30 (?)
Group C:	Anthracite	30 (?) to 26 (?)
Group D:	Semi-anthracite	26 (?) to 23 (?)
Group E:	Semi-bituminous	23 (?) to 20
Group F:	Bituminous	20 to 17
Group G:	Bituminous	17 to 14.4
Group H:	Bituminous	14.4 to 12.5
Group I:	Bituminous	12.5 to 11.2
Group J:	Lignite	11.2 to 9.3 (?)
Group K:	Peat	9.3 (?) to (?)
Group L:	Wood (cellulose)	7.2

Summarizing, Mr. Campbell states:

"1. Fuel ratios, or any of the components of coal, as determined by a proximate analysis, are worthless for purposes of classification except for highly carbonized fuel, such as anthracite, semi-anthracite, and semi-bituminous coal.

"2. Calorific values are equally unsuited, but in this case the failure is particularly well marked in the upper part of the coal column.

"3. Of the elements shown by an ultimate analysis, carbon is the only one at all satisfactory, and this fails in detail.

"4. Carbon-hydrogen ratios form a satisfactory basis for classification. This scheme applies perfectly to all samples of fuel tested at St. Louis during the past year, and these include representatives of all classes, except cannel coal and some classes of anthracite and semi-anthracite coal.

"5. Twelve classes of coal and allied compounds are suggested, as shown in the table given."

For the purpose of classifying a coal according to Mr. Campbell's method, it is necessary to have an ultimate analysis for the purpose of getting the elements carbon and hydrogen.

To partly overcome this last feature, Mr. D. B. Dowling of the Canadian Geological Survey* has proposed a scheme based on a proximate analysis, which he called the "split volatile ratio." It may be expressed as follows:

$$\frac{\text{Fixed carbon} + \frac{1}{2} \text{ volatile combustible.}}{\text{Moisture} + \frac{1}{2} \text{ volatile combustible.}}$$

Mr. Dowling proposes the following classification:

SCALE OF RATIOS.

Anthracite	15 up
Semi-anthracite	13 to 15
Anthracite coal	10 to 13
High carbon bituminous	6 to 10
Bituminous	3.5 to 6
Low carbon bituminous	3 to 3.5
Lignitic Coal	2.5 to 3
Lignite	1.2 to 3.5

Mr. Dowling experimented with a set of analyses made by the United States Geological Survey at the St. Louis station. He found that by arranging the same set of analyses in the form of coordinates on the carbon-hydrogen basis suggested by Mr. M. R. Campbell, that the resulting curve agreed very well with a curve produced by arranging the analyses on the split volatile ratio basis.

The writer simply calls attention to these various classifications to show the need of a basis whereby all coals can be classified, so that one might know the character of the coal from its classification. The Dowling method of classification appears to suit the requirements of Washington coals and lignites the best of any method yet observed.

IMPURITIES IN COAL.

SULPHUR.

Generally speaking King county coals are remarkably free from sulphur. This element appears in coal in different forms; sometimes combined with iron, forming pyrites, while at times it is combined with calcium, forming calcium sulphate. Sulphur balls or nodules of pyrites occur, but not frequently, in King county coals. Some beds, as No. 1 at Issaquah and No. 3,

*Dowling, D. B., Bulletin No. 1035, page 44, Canadian Geol. Survey.

Independent mine, have considerable sulphur, combined with lime, forming gypsum.

PHOSPHORUS.

Very little phosphorus occurs in the coal of this county and since very little of the coal is used for making coke, the presence of this element is not a serious factor.

NITROGEN.

The presence of much nitrogen in the coal detracts from its value, for the reason that this element is inert and hence adds considerable to the weight and does not assist combustion.

OXYGEN AND WATER.

These ingredients are as undesirable in coal as nitrogen, since they add to the weight without assisting in combustion.

OCCURRENCE OF COAL.

COAL OCCURS IN BEDS.

Coal beds were originally laid down in horizontal or nearly horizontal layers. The accumulating vegetal matter grew in a swamp and each autumn there would be an abundance of vegetal substance that would fall and be preserved beneath the surface of the shallow water. This swamp subsided sufficiently so that there was an approximate elevation at which the surface of the water would remain above the roots of the plants. This accumulation continued for a great period of time, at least for the production of the thicker beds. It is estimated that it has taken five feet of vegetal matter to form one foot of bituminous coal; at this rate it would take twenty-five feet of material to form a bed such as the McKay, which averages about five feet over a great part of its area.

EXTENT OF COAL BEDS.

Nearly all, if not all, the coal beds of King county have been formed in place and are fairly uniform over comparatively good sized areas. When compared with such beds as the famous Pittsburg bed in the East, the local beds are very irregular, but when compared with the beds of Whatcom county, this state, and most of the coal beds or lenses of the Controller

Bay coal field, of Alaska, they are remarkably regular. The McKay bed in the Franklin-Black Diamond field, (to which reference has been made several times) is a very regular bed and extends over a comparatively large area. The physical conditions of this bed indicate that at the time of its accumulation and deposition, land areas were very stable in its vicinity, and the streams entering into the estuary or swamp were remarkably free from silt, for we find that there is very little more ash in the coal of this bed than would be had from a similar amount of vegetal matter. On the other hand, such beds as the Bagley at Newcastle, show that after the deposition of the lower part of the bed, certain areas subsided, allowing a deposition of shale and clay before the upper bench had accumulated. It is these variations in elevations of land areas during the interval between the deposition of separate benches of the same beds or of separate beds, that make the correlations of coal beds in this county a difficult problem.

COAL BASINS.

It has been stated that coal beds were laid down in a horizontal position. One would naturally infer from this that the upper and lower parts of the bed were parallel. In a sense this is true, yet when looked at on a large scale, every coal bed or series of coal beds are at best elongated lenses that have accumulated within certain basins, estuaries and swamps. Every swamp had its margin, so has every coal field its limit. It appears from the best data at hand, that the present mine at Coal Creek occupies the site of the center of the great estuary in which the Newcastle-Issaquah-Grand Ridge series were deposited. The beds and the material between them thin out to the east and west of the Coal Creek mine.

COAL HORIZONS.

During the Carboniferous period, in some parts of the world, coal beds were deposited over large areas. In other regions it was the Cretaceous period that was productive of coal beds. In King county it was the Puget formation of the Eocene period in which all or nearly all the coal beds were deposited. At the close of this period, physical conditions changed so that they were unfavorable for the accumulation of coal beds. Hence we find the Puget formation of the Eocene period the coal horizon for King county.

ROCKS ACCOMPANYING COAL.

Generally speaking, the material underlying a coal bed is the soil upon which the vegetal matter took root. There are instances where the sub-soil is pure sandstone, but these are rare compared with a subsoil of shale, carbonaceous shale or clay.

The material overlying a coal bed may be bony coal, carbonaceous shale, shale or sandstone, depending entirely upon the materials the currents were carrying into the swamp after the subsidence which caused the death of the plant life of a particular bed.

In the King county coal areas bony coal, carbonaceous shales, shales, sandstones and igneous rocks accompany the coal beds. Little or no limestone has been observed within the coal measures. In other areas in the United States and Great Britain, limestone, as well as iron ores, occur very frequently within the coal measures, but neither of these conditions prevail in King county.

BONE COAL.

Frequently bone beds occur associated with coal beds, and sometimes there are streaks of bone within the coal bed itself. At other times the entire bed is made up of bone. Instances have occurred where bone beds have been found to change to coal in parts of the bed, and other instances are on record where a coal bed has become so bony that it no longer pays to work it. The bone in the coal represents a layer of vegetal matter that became thoroughly impregnated with silt at the time of deposition.

CARBONACEOUS SHALES.

Carbonaceous shales represent areas of growing vegetation where large quantities of silt were being brought into the swamp at the time the vegetation was growing. Such shales grade from a very impure bone to a shale, representing the varying amounts of silt brought into the swamp or estuary during the deposition of the vegetal matter.

SHALES.

Shales vary in color from light colored to very dark, depending on the amount of carbonaceous matter and the amount and condition of the iron constituent. They also vary greatly in smoothness and feel. Some are very fine grained and have practically no grit, while others contain coarse particles and much sand, so that they are termed sandy shales. Shales represent particles of silt that have been deposited, usually in water too deep for the growth of vegetation. The shales occurring in the coal horizons of King county are sometimes mined and manufactured into various clay wares, as at the following places: Kummer, Taylor, Bayne and Durham. The shales quarried at Renton overlie the coal bearing horizon at that place. Shales vary in character from place to place. The coal measures of King county are very rich in shales that make high grades of vitrified ware of various kinds. In fact there are enough high grade shale beds in this county to supply the entire Pacific Coast with paving brick and sewer pipe, and other vitrified wares.

SANDSTONES.

The sandstones represent rounded particles of silica, with sometimes mica and other ingredients that have been deposited and solidified. Sandstones occur more frequently than shales in the coal horizons of King county. In one instance, near Kummer, there is a sandstone stratum that is over 400 feet thick. Sandstones vary more rapidly in thickness than do shales. They represent clear water deposition and usually a shallow water condition. Frequently cross-bedding occurs, which indicates changes in currents at the time of deposition. The cementing material in sandstone is sometimes iron and sometimes lime. Some of the sandstones of this county have been used for glass making purposes. The glass factory at Renton has used some of the sandstone from the Renton mine. Very little of the sandstone is suitable for building purposes.

The Franklin sandstone as it outcrops near Cumberland has been used to a limited extent for building stone.

LIMESTONES.

Very little, if any, limestone occurs in this county among the coal bearing strata. Some of the beds at Taylor and Kummer are so full of fossil shells that they constitute impure limestones.

ORIGIN OF COAL.

There is hardly any question but that coal is of vegetal origin. The chemical analyses, the physical structure of lignites, a microscopic examination of a thin particle of coal, all prove the vegetal origin of coal. Some coal beds have trees extending from the bed into the roof. This is true of one bed at Newcastle and is also true of No. 2 at Renton. In the Newcastle bed one tree is well exhibited, the bark showing very plainly; the woody part of the tree has been replaced by silica and is now solid rock; but the annular rings may be plainly seen in some of the specimens.

STAGES OF CARBONIZATION.

With careful chemical analyses of vegetal matter, it may be clearly shown that the elements which form wood are to be found in coal; in fact, every step can be followed through the various degrees of metamorphism from peat to lignite, lignite to lignitic coals, then to sub-bituminous coals, bituminous coal, semi-bituminous coal, semi-anthracite, anthracite, and finally graphite.

CONDITIONS OF COAL FORMATION.

Vegetal matter decaying in air is soon carried away, but when it falls beneath water a great part of it is preserved. In swamp or peat bogs we find the plant growing near the surface, farther down we find dead plants, and near the bottom of the swamp we find the black vegetal muck that has taken its first step toward forming coal. It is assumed that in past ages, such as the Carboniferous, Cretaceous, and Eocene, when the most important coal fields were formed, climatic conditions were far more favorable to the formation of coal than at the present time. Large areas occurred in which there were luxuriant growths of tree ferns, palms, mosses and other plant families. Some areas were covered sufficiently with water so that as the plant life grew and the leaves or other parts of the plant fell, they were preserved. The swamps were usually close to the sea and the water sometimes brackish. After a period of time in which a large quantity of vegetal matter grew and accumulated, subsidence took place, and the vegetal matter became covered with either mud or sand, depending upon what material the streams were carrying into the swamp at that time. These muds formed shales, while the sands were hardened into sandstones.

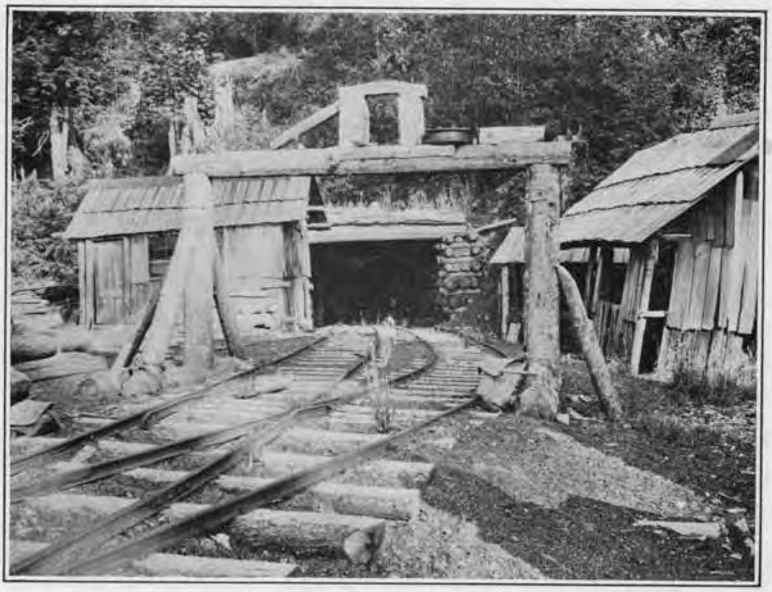
PRESENT POSITION AND STRUCTURE OF COAL.

While coal beds were originally laid in a horizontal position, it is seldom we find beds in that position at the present day. Particularly is this true in the coal beds of King county. In addition to the change in elevation, there are other irregularities such as the following:

1. Irregularities of original deposition.
2. Irregularities due to movements of the earth's crust.
3. Irregularities due to subsequent erosion.

IRREGULARITIES OF ORIGINAL DEPOSITION.

If the swamp in which a coal bed was formed was the result of gradual sinking of the land for a considerable distance, and that at no time had the bottom of the swamp been far above the general drainage level, the resulting coal bed is likely to be regular as far as the bottom is concerned. On the other hand, had the bottom of the swamp been at a considerable distance above the general drainage level, it is more than likely that a part at least of the area was eroded, and as a result we find the bottom of the coal bed very irregular. After the vegetal matter had grown for a considerable period of time, and sudden subsidence takes place over the entire area, the material carried into the swamp forms the roof of the bed, and the bed is preserved intact. In cases where there were slight elevations after deposition, erosion took place and we find some beds with



A—Entrance to Big Six Mine.

B—Outcrop of Coal Bed near Bayne.

portions of the bed eroded. This is true of No. 4 bed, Newcastle and Issaquah.

Splitting of beds developed from the fact that only portions of the swamp subsided. For example, after a portion of a bed was formed, subsidence took place more rapidly in one part of the swamp than the other, with the result that before the upper part of the bed was formed the material accumulated much thicker in the lower part of the swamp than the other. A familiar example is the splitting of the well known McKay bed at Black Diamond. At the No. 14 mine, near the outcrop, the distance between the lower and upper benches is only a few feet and this interval is composed of carbonaceous shale. In the north end of the Morgan slope there is over ninety feet of material between the two benches. After the deposition of the lower bench and the overlying shale, rapid subsidence took place to the westward, while the area around No. 14 mine remained more or less stationary. The sand was deposited over the subsiding western area, after which came a period of rest and another swamp was formed for the accumulation of the upper bench.

IRREGULARITIES DUE TO MOVEMENTS OF THE EARTH'S CRUST.

In this county every bed is inclined at least a small amount, while some of the beds are nearly vertical. The inclined positions are due to the great compression the earth's crust has been subject to at the time mountain building forces were in action. After the coal beds were deposited, there came a great uplift whereby a great series of folds were produced. These folds were formed in a line more or less paralleling the great uplift. Hence we find the Green River coal field thrown into a series of folds, their axes lie in a general north and south direction. When the strata are bent in the form of an arch, the fold is called an anticline; when in the form of a basin or trough, it is termed a syncline (see accompanying sketch).

The axes of these folds are not always horizontal. In the Green River field they plunge south, south of a point west of

Kanaskat and plunge north in the area north of this point. Some of these folds disappear when traced lengthwise. At Renton, for example, near the surface of the Talbot mine the syncline is very sharp, while down at the eighth level it has broadened so that it is hardly perceptible. Some folds develop into faults at certain points along their axes.

IRREGULARITIES DUE TO SUBSEQUENT EROSION.

After the coal beds were formed, and the subsequent uplift that has brought them into the positions we now find them, there was a later stage in which the entire area up to certain elevations was covered with glaciers or fields of ice. The various streams that drained this area after the uplift and prior to the Glacial period, accomplished a great work in the general erosion of the land.

Some of these streams, but not many, retain at the present time approximately the channels they occupied prior to the coming of the great ice sheet. Certain areas, prior to the glacial period, were considerably higher than they are at present. For example, the district around Issaquah was relatively much higher at one time than at the present. Issaquah creek, or its predecessor, eroded this district to a much greater depth than the present sea level. Later subsidence took place, and at the close of the Glacial period the ice sheet with its burden of clay, sand, and gravel, deposited its load. As a result we find in the lower levels of the Issaquah mine, sand and gravel at a point far below the present sea level. The land surrounding Renton has also subsided from a former higher position and it would not be strange if to the north of the Renton mine, along the Cedar River valley, it were found that there was a pre-glacial bed considerably below the present sea level. In the Green River district this condition prevails. At one point in section 34, T. 20 N., R. 6 E., a hole was sunk entirely in gravel to a distance of over two hundred feet below the present bed of Green river. This indicated then that as we get away from the hills of rock we are liable to encounter at almost any point pre-glacial valleys that were filled with sediments at the

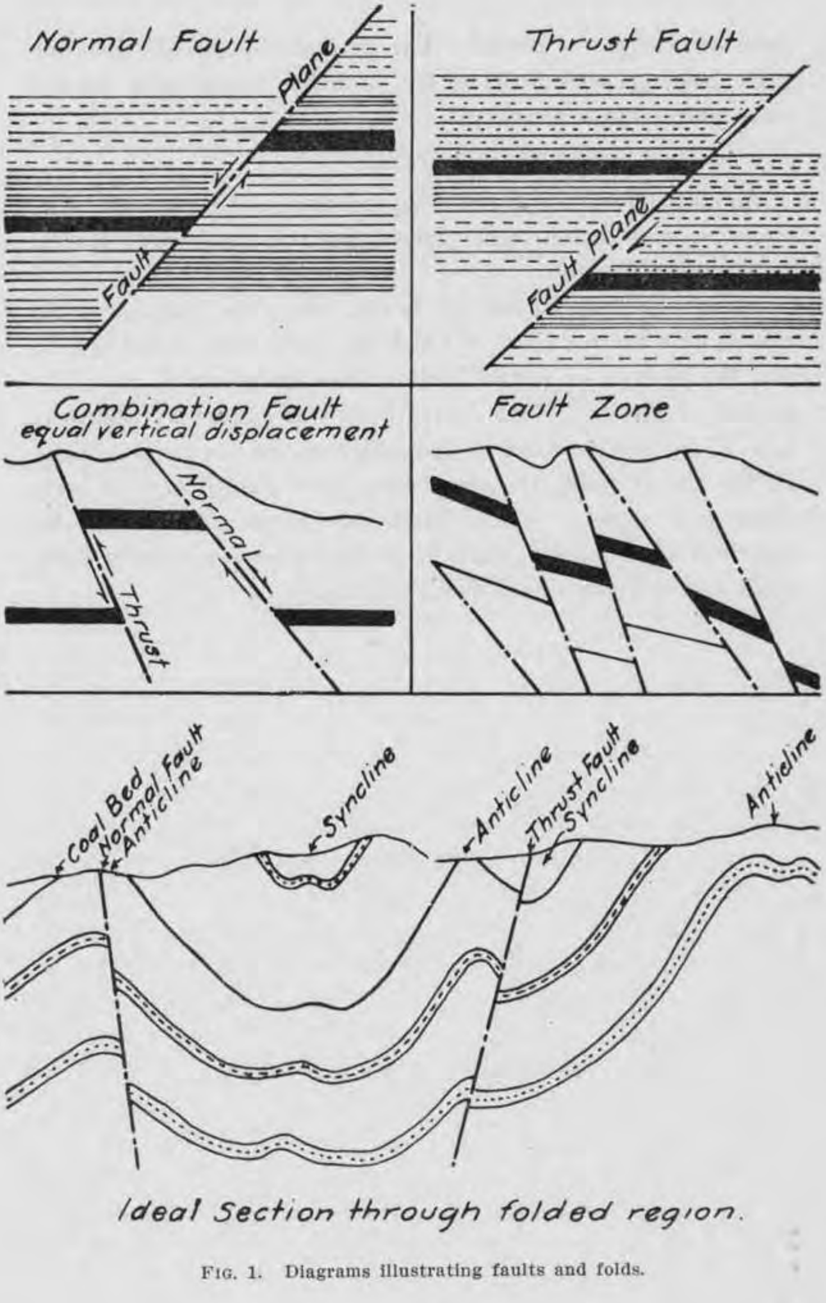


FIG. 1. Diagrams illustrating faults and folds.

close of the glacial period. The present topography has but little bearing in indicating the probable topography of the area underlying a gravel pit.

FAULTS.

Accompanying the forces that produce anticlines and synclines we find certain other forces, or their component forces, that develop faults.

There are two classes of faults, viz.: the normal fault, caused by a tension force in which the parts were pulled apart; and the reverse, or thrust fault. (See figure which shows direction of arrows.) This latter fault was caused by compression, or the reverse force to that which caused the normal fault. In the thrust fault, the parts have been pushed beyond each other (see sketch). Some faults are clear cut and can be identified and classified, while other fault planes are really fault zones and at times very difficult to classify.

CHAPTER II.

GENERAL GEOLOGY OF KING COUNTY COAL FIELDS.

GEOGRAPHIC POSITION.

By an inspection of the geologic map of the King county coal fields, it will be seen that the known and probable coal areas in this county are irregular in outline and in some instances widely separated.

Beginning in the western end of the county, we have the Black River-Renton district, in two areas, separated by the alluvial valley of Black river. Northeast and east of this field is the May Creek-Cedar Mountain area. This area, as will be noticed, is narrow, and has a southeasterly and southerly trend. North of the May Creek area lies the Newcastle-Coal Creek-Issaquah-Grand Ridge area, a narrow belt having an easterly and northeasterly trend with a northern and northwestern dip. We then have the Tiger Mountain-Raging River area with its many faults and intrusions of igneous rocks. This area lies partly on the east margin of T. 23 N., R. 6 E. and extends northeasterly, then southeasterly into townships 24, 23 and 22 N., R. 7 E. In sections 30 and 31, T. 23 N., R. 7 E., is the Hobart area, whose limits are more or less obscured by glacial drift and lava flows. In parts of sections 33 and 34, T. 23 N., R. 7 E., and parts of sections 2, 3, 4, 9, 10 and 11, T. 22 N., R. 7 E. lies the Taylor area. South of Cedar river and more particularly in sections 24 and 26, T. 22 N., R. 6 E. is the small area surrounding the Danville prospects. South and east of this latter area lies the largest and most productive district in King county, containing the Ravensdale, Black Diamond, Franklin, Kummer, Krain, Cumberland, Bayne, Durham, and Kangley fields. It occupies parts of townships 20, 21, 22 N., R. 6 and 7 E.

The coal areas, as will be seen in the accompanying map, lie between Puget Sound on the west and the main range of the

Cascades on the east, between Lake Sammamish and the Snoqualmie river on the north and White river on the south. Future developments will doubtless extend the known coal areas into some of the undetermined country lying adjacent to the developed areas.

PHYSICAL FEATURES.

MOUNTAINS.

Within the coal field itself there are few, if any high mountains. Along the western margin of the field we have the low glacial hills south and east of Renton; these rise to heights varying from 350 to 500 feet above sea level. North and east of Renton extends a glacial area to the base of the igneous rock that constitutes the core of Newcastle-Squak and Issaquah mountains. This igneous ridge varies from 450 feet at Etta Cartney's lake to 2,900 feet at the top of Issaquah mountain. This ridge is a noticeable topographic feature and may be plainly seen from Seattle. To the north of the ridge at Coal creek the hills rise to elevations of from 1,000 to 1,500 feet, and then gradually slope northward toward Sammamish lake.

Tiger and Taylor mountains are the southeastern extensions of this same elevated belt. The area between Renton and Tiger mountain is made up mainly of glacial plains which rise from 450 to 550 feet, containing characteristic glacial topography and lakes. The topography of the Raging River area is rugged, with many streams having steep gradients.

The hills in this vicinity range from 1,500 to 3,000 feet, and to the eastward gradually increase in height until they join the main foot hills of the Cascades, near the eastern margin of the coal area.

South of this group of high hills are occasional sedimentary buttes that rise out of the glacial plain, such as those at Ravensdale, Black Diamond, Sugar Loaf, Lizard mountain, Bayne mountain, and Cumberland mountain. These hills range from 1,100 to 1,600 feet above sea level and from 500 to 600 feet above the level of the surrounding glacial plain. East of this group of sedimentary hills are the igneous bluffs and ridges that form the real foot hills of the Cascades. These hills are to be seen east of Kanasket and Palmer, and the ranges of ridges at the head of Cumberland creek.* Their summits vary from 3,200 to 4,200 feet above sea level.

RIVERS.

Western Washington has an abundance of mountain streams, all of which are clear except those coming from glaciers. Some of the principal streams draining the coal fields of King county are the Snoqualmie and its tributaries at the north end of the field; Black and Cedar rivers, draining the western and central portions; Green and White rivers drain the south central and southern areas. These streams are clear except White river, which has its source in White River glacier, at the foot of Mount Rainier. The city of Seattle gets its supply of pure mountain water from Cedar river, and the city of Tacoma is at present installing an extensive water system on the upper Green river.

Raging river, which is a tributary of Snoqualmie river, has eroded a considerable area in the northeastern part of the field. Many outcrops of sedimentary rock are to be seen along that stream and its tributaries.

Black river has its source at the south end of Lake Washington and joins White river at Black River Junction, from which junction point to Elliott bay the river is known as the Duwamish. The lower part of the Renton series of rocks is partly exposed on the west side of the river. Cedar river rises in the igneous area east of the coal field and flows in a general westerly direction, joining Black river near Renton.

Green river has its source near the summit of the Cascades and flows in a westerly direction, entering the coal area about a mile east of Palmer Junction. From this point westward and southwestward the river has cut a channel that thoroughly exposes the Puget formation in many places. Some of the box

*Cumberland creek was formerly called Coal creek. There were two Coal creeks in King county, resulting in more or less confusion. Hence the change of name.

canyons are 300 feet deep. The coal measures appear along the course of this river from Palmer Junction to S. 28, T. 21 N., R. 6 E., at which point they disappear beneath the glacial drift.

GLACIAL PLAINS.

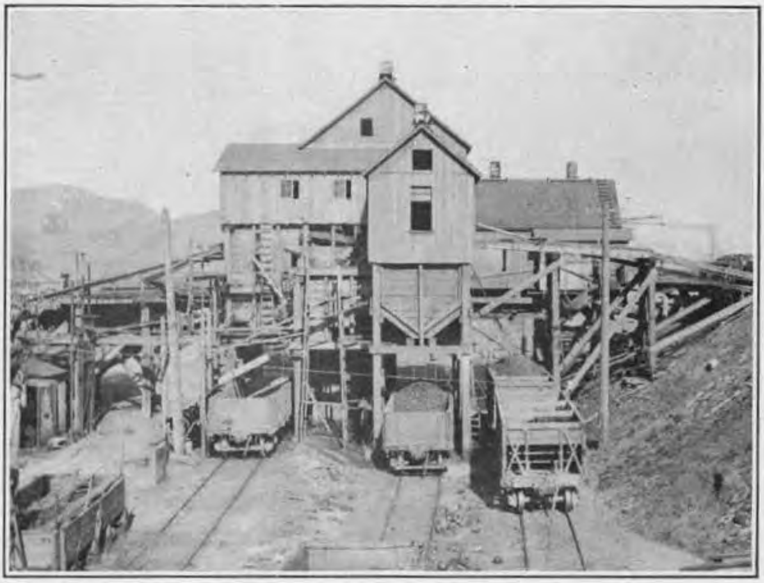
All of the coal lands west of the foot hills of the Cascades, with the exception of the hills noted above, are covered with glacial drift, which was left as a covering for this area at the close of the Glacial period. Glacial drift has been observed at elevations as high as 800 feet above sea level, and a prospect hole, sunk to a depth of 235 feet below the bed of Green river, was still in gravel at that depth. This plain has characteristic glacial topography, the sedimentary and igneous hills that rise above it appearing as islands rising out of the sea.

STRATIGRAPHIC POSITION.

The geological column is divided into the following subdivisions.*

Quaternary	Recent. Pleistocene.
Tertiary	Pliocene. Miocene Oligocene. Eocene.
Cretaceous.	
Jurassic.	
Triassic.	
Carboniferous	Permian. Pennsylvanian. Mississippian.
Devonian.	
Silurian.	
Ordovician.	
Cambrian	Saratogan. Acadian. Georgian.
Algonkian.	
Archean.	

*U. S. Geological Survey classification.



A—Bunker at Renton, mine of Seattle Electric Company.

B—Mine Cars loaded with coal, Coal Creek Mine, Newcastle.

From the paleontological data collected by Bailey Willis in 1896, it has been definitely determined that the coal beds of King and Pierce counties belong to the Eocene.

By referring to the foregoing table, it will be seen that, compared with the geologic age of the earth, the Eocene is quite recent. In fact, when compared with the periods that preceded it, the length of time between the present and the Eocene* is much shorter than the list would indicate, since the Eocene, Oligocene, Miocene, Pliocene and Pleistocene were much shorter than many of the former divisions. Nevertheless the changes that have taken place in North America since the beginning of the Eocene are very marked.

At that time the sea occupied portions of the valley of California, much of western Oregon and western Washington. The Sierra Nevada were comparatively low and the Coast ranges were only partially developed. The invertebrates living in the Eocene seas were quite different from those to be found in the present seas, although a few Eocene species have survived until the present time. The plants of that day were different from the present, except for a few forms which have remained practically unchanged to the present time.

The Puget Sound basin during Eocene times was the site of an extensive estuary or arm of the sea, of as yet undetermined extent. It is known, however, that this arm of the sea extended over a portion of western Washington, including parts of the Cascades. The site of the present Olympic mountains was in all probability a land area, either an island or a coastal plain.

The land areas surrounding this estuary were hilly rather than mountainous and were composed of older sedimentary rocks as well as granite and other igneous materials.

The climate was warmer and more moist than at the present time. Magnolias, figs, palms and tree ferns grew in abundance in the many swamps of that time. These swamps were subsequently filled and coal beds formed after which other swamps

*Willis, Bailey, U. S. G. S. Folio No. 54.

were formed and overlying coal beds made. The hills surrounding this estuary were gradually being eroded and the materials carried into the swamps to form the sandstones and shales now found between the beds; also the impurities in some of the coal beds themselves.

PUGET FORMATION.

Mr. Willis in his reports refers to the coal bearing portion of the Eocene period as the Puget formation. The same name will be used throughout this report in the same manner.

The Puget formation, as surveyed in Green river, shows a thickness of 8,392 feet, without reaching the underlying strata. The base of the series, as far as could be observed, is on the axis of an anticline near the east line of section 8, T. 21 N., R. 7 E. The top of the column is at the center of the Kummer syncline in the S. E. ¼ of section 25, T. 21 N., R. 6 E.

The strata of the Puget formation are made up of arkoses, concentrated quartz sands, sandstones, shales, carbonaceous shales, bony beds and coal beds. No arkose beds were observed in Green river, but in the Franklin series in section 27, T. 21 N., R. 7 E., a bed more than forty feet thick was observed. Concentrated quartz sands were observed in two or more places in Green river, in section 8, T. 21 N., R. 7 E.

The sandstones range in color from a light gray to almost white. Generally speaking they are softer and coarser grained near the top of the column than at the base. The shales range from shaly sandstones to rich dark shales, which are very desirable for making vitrified wares, and in many places are mined and used for that purpose. The carbonaceous shales vary from those which are slightly carboneceous to beds almost bone, while the bony beds grade from shaly bone to almost coal. The bone and coal beds are very numerous throughout the column.

The writer has for convenience sake separated the Puget formation into three divisions and calls them, beginning with the uppermost, the Kummer, Franklin and Bayne series. This subdivision is not based on any paleontological evidence, but as a line of division between the Kummer and Franklin series, a light colored massive sandstone, with nodules or boulders of harder sandstone, has been used. This bed of sandstone lies directly under the Kummer coal beds at Kummer, dipping eastward, and reappears on the east side of the Kummer syncline, down the river from the new Franklin incline; at this point the dip is westward. The line of division between the Franklin and the Bayne series is the close grained massive sandstone beneath the county bridge that crosses Green river at Franklin.

The remaining coal areas in the county are undoubtedly of Eocene age, and belong as far as can be determined to the Puget formation. It is probable that the beds at Danville and Taylor belong to the Kummer series or the upper part of the Franklin series. The fossil evidence does not place them differently, and the character of the shales and sandstones is similar. The Renton-Cedar Mountain areas are undoubtedly closely related. The same is true of the Newcastle-Coal Creek-Superior-Issaquah-Grand Ridge series. There is some question regarding the horizon to which the newly discovered beds at May creek belong. It is believed that they represent the Newcastle coal beds on the south side of an anticline and they have, therefore, been placed in that relative position. Further development of this part of the field is the only way in which this question can be answered accurately. The Tiger Mountain area is so badly faulted, and the surface is so densely covered with trees and underbrush, that it has been practically impossible to get the direct relationship of the coal beds to the igneous masses on both sides. Issaquah mountain, to the northwest of the coal outcrops in this area, consists of a large mass of igneous rock. Tiger mountain to the eastward is also made up of similar material. The Grand Ridge-Issaquah series rest on a mass of igneous rock similar to both of these mountains. It appears that extensive normal faulting, with a down-throw to the southeast, has taken place in the Tiger Mountain area, whereby the coal beds have been brought to their present position. The beds appear to dip beneath the igneous mass of Issaquah mountain, but the lignitic character of some of the upper coal beds, and the unhardened condition of some of the sandstones, do not suggest that conclusion. If these beds belonged beneath the igneous mass and a portion of the former overlying igneous rock had been eroded, then the coal beds would show more of the bituminous character and the sandstones would be more compact than they are. The fossils found, and the characters of the sandstones and shales, are similar to the Newcastle-Issaquah series. One of the coal beds, however, appears to be a little more bituminous in character than the Issaquah beds. This is probably due to metamorphism, produced by great movements to which this area has been subjected.

The Raging River area is placed in the same stratigraphic horizon as the Tiger Mountain beds, and in fact, they are connected. This area too has been subjected to a great deal of movement, and, in addition to this, there have been numerous intrusions of igneous rocks. These have been the cause of more or less regional metamorphism, for the beds of this area appear to be more or less bituminous in character.

The Snoqualmie coal area probably corresponds to the lower beds of the Raging River area. The former area has been subjected to the same metamorphic actions from folding, faulting, and Post-Eocene intrusions that the latter have.

There is no doubt but that all the coal bearing strata in King county belong to the Eocene and it is more than likely that they represent some stage of the Puget formation. It is probable that sometime in the future, after a great deal more development has been done, when the now disconnected areas are connected and a very careful paleontological survey has been made, that all the areas will be correlated and the various areas placed in their proper positions in the stratigraphic column.

IGNEOUS ROCKS.

By referring to the geologic map accompanying this report, the reader will notice portions indicated as igneous areas. In the western part of the field, northwest and south of Renton, are several disconnected areas; south of Cedar mountain is another small area; south and southeast of the Newcastle-Issaquah-Grand Ridge coal fields is a large area of many square miles extent. In the Tiger Mountain district is another area. Between Preston and Fall City, in the northeast corner of the district, is an area whose boundaries have not been mapped. East and southeast of the Green River field is another area that extends eastward beyond the eastern limits of this map. All these areas, which are colored alike, represent areas of igneous rocks, similar in kind. The above described igneous rocks are nearly all basic in character and represent lava flows that occurred during Eocene times.

The relative age of the large mass of igneous rock beneath the Newcastle-Issaquah area is not definitely known, and will probably not be determined until the relationship of the May Creek and Newcastle beds is determined. The structure suggests that the coal strata have been given an anticlinal form by a laccolith, the coal beds formerly lying on the igneous rock having been eroded within the area lying between May creek and Coal creek. The question thereupon arises: does this laccolith occupy a position between two coal series or is the dirty bed underlying the Jones bed the base of the coal series? The igneous mass is over 2,700 feet thick, but how much thicker is unknown.

The igneous rocks near Renton underlie the Black River-Renton beds; those of Tiger mountain are beneath the coal beds of that district. There are several igneous sills in the eastern and southeastern part of the Green River field, and the farther east one goes into this field, the more numerous and thicker they become. East of Kangley-Durham, Palmer Junction and Cumberland creek, there occurs a great series of lava flows that completely cover the entire coal bearing formations. They covered this area at some date prior to the uplift, for they dip eastward at about the same angle as to the coal beds.

Northeast of Barneston at some point whose position has not been determined is the source of a second series of lava rocks of different character and age. These dikes and sills are acidic in character and have followed fault and bedding planes. Some of them were formed at the beginning of the uplift, for they conform to the folding of the sedimentaries, but many of them are of a later date and follow the fault planes developed at the time of folding.

The Taylor-Barneston area is particularly affected by these intrusions. Many of the coal beds at Taylor have been rendered valueless over certain areas. In the region north of Barneston all, or nearly all, of the bony beds that occur at this place have been penetrated by these dikes. One of the dikes has gone as far south as section 8, T. 21 N., R. 7 E. At this point the dike follows a fault plane developed in the section 8 syncline. This dike carries a great deal of arsenic sulphide, both orpiment and realgar. The arsenic was first prospected about twenty-four years ago and was at that time supposed to be cinnabar. This series of dikes seems to concentrate east of Barneston, radiating from this point north, west and south and gradually thinning out in the three directions, some of them extending as far north as the Snoqualmie coal property.

Where igneous sills are far enough from the coal so that they have not had any detrimental effects, they are not serious factors, but where the coal beds are intruded by these later dikes it makes the development of that area expensive, and, in some instances, commercially doubtful.

SUBDIVISIONS OF THE PUGET FORMATION.

KUMMER SERIES.

The Kummer series represents the material overlying what has been termed the Kummer sandstone, a white massive sandstone that underlies the coal beds worked at the Kummer mine. This sandstone, where measured, is 475 feet thick and contains nodules of harder sandstone. The nodules stand out prominently in the face of the bluffs wherever the sandstone outcrops. The Kummer series has a total thickness of 1,751 feet, where measured, from the center of the Kummer syncline down the river to the base of the Kummer sandstone. The thickness of this series to the east of the syncline appears to be greater but this is probably due to some faulting and a probable low subordinate anticline and syncline. Nine coal and bony beds, varying in thickness from 2 to 12 feet, have been observed within this series, and it is probable that the two concealed areas contain either coal or bony beds. The coal throughout this series is more lignitic in character than in either the Franklin or the Bayne series. The moisture in the lower beds ranges from 12.4 per cent. to 14.1 per cent. The high moisture may be due to the fact that these beds are not as old, or that they have not been folded as severely, as the beds in the lower series. These beds are also high in ash. Coarse grained, light colored sandstones predominate throughout this series. There are numerous shale beds, near the center of the column; some of these are of economic importance and have been used extensively for making sewer pipe and other vitrified wares. One fire clay bed also occurs within this series; it lies about 7 feet below the bottom of bed No. 0. The series shows evidence of comparatively shallow water conditions during the greater part of its deposition. There were doubtless several oscillations of the surface at that time, and naturally the beds of this series would vary somewhat in character and thickness. In fact, some of the beds that occur on one side of the Kummer syncline almost thin out entirely by the time they reach the land area that represents the opposite side of the fold. This is true of the fire clay bed mentioned above. As the bed is developed toward the north, on the west side of the fold, it changes in appearance and thickness, becoming gradually thinner and more sandy in character.

FRANKLIN SERIES.

The intermediate series of the Puget formation, as represented in the Green River district, has been named the Franklin series. It is very well exposed between the massive sandstone occurring beneath the county bridge at Franklin (under which bridge occurs the Franklin sandstone) and the massive sandstone that outcrops in the bend of Green river, about half a mile west of the new Franklin mine.

In the section that represents the Franklin series, as measured along Green river and the railroad track near Franklin, there are twenty-seven coal and bony beds, also fifteen concealed areas, some, or all of which, may contain coal or bony beds. The beds of this series, in which most of the mining has been done are the Harris, Gem, McKay, Fulton or No. 12, No. 11 and No. 10. The other beds are too impure where they have been uncovered. It is possible, however, that in some parts of the southeastern district these beds contain workable coal.

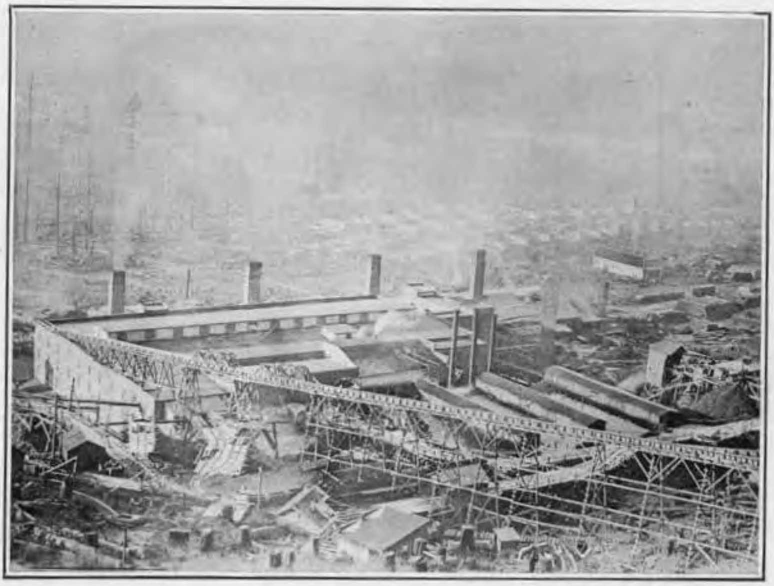
The Franklin series is 3,620 feet thick where measured. The coal and bony beds are distributed throughout the series, the better beds occurring near the central part. Sandstones and shales accompany the coal and bony beds, with sandstones and sandy shales predominating. There are also four igneous sills in the series, conformable to the rest of the strata.

By referring to the detailed section of the series, which accompanies this report, the various beds and their positions may be seen. It will also be seen that a massive sandstone 210 feet thick occurs at the base of the series. This massive sandstone has been used as the line of division between the Franklin and Bayne series, and it is called the Franklin sandstone.

BAYNE SERIES.

Underlying the Franklin sandstone is another series of coal and bony beds and their accompanying sandstones and shales. This series is 3,021 feet thick as measured along Green river. The top of the series occurs, as stated above, at the Franklin sandstone, which outcrops at the Franklin bridge and at two points farther up the river, but appears for the last time near the center of section 17. From the center of section 17 up the river to the east line of section 8, the beds exposed represent the beds of the Bayne series. The strata are folded several times within this area and the resulting columnar section accompanying this report is the result of careful measurements on both sides of the axes of the folds, after eliminating all duplications.

A—Bunker at Grand Ridge Mine.



B—Plant of Denny-Renton Clay and Coal Company at Taylor.

By referring to the columnar section it will be seen that there are twenty-seven coal and bony beds, and four concealed areas, all of which may or may not contain coal or bony beds.

It has been impossible to correlate these beds with the beds in the Bayne-Occidental mines, but it is safe to say that the upper part of this column represents the beds that have been worked at the Fleet, Bayne and Carbon mines, and the upper beds of the Occidental mine. The beds of this series vary so from place to place that it is not possible to absolutely correlate the beds of the Fleet and Bayne mines. How much thicker the coal measures are than is represented in this column, is not known.

The base of the column, as shown here, rests on the axis of an anticline and the coal measures probably extend downward for a considerable distance beneath. It would be instructive and perhaps profitable to drill a hole on this anticline and find out what occurs below the coal measures that outcrop on Green river.

This series contains a far greater percentage of shale than the Franklin series. Some of these shales have been exploited at the new clay plant of the Little Falls Fire Clay Company. It is claimed by the owners of this property that the shale in the face of their quarry is suitable for making a high grade product. Some of these shales were also experimented with about twenty years ago at Durham.

PALEONTOLOGY.

In order to make a paleontological study of the coal strata of King county, that would be of any greater value than the work already done by Bailey Willis and his associates of the United States Geological Survey, it would require a great deal of time and money. It was decided, therefore, that for the present at least the classification worked out by Mr. Willis would be accepted.

It is likely that a definite system of correlation could be worked out, by a close and exhaustive study of the fossil evi-

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dence, so that the widely separated parts of the field could be placed in their relative stratigraphic positions and perhaps the beds identified in separated areas.

Several collections of fossils were made but no attempts made to classify them, owing to the brief amount of time at hand.

About the most complete statement covering this subject is to be found in Folio No. 54, United States Geological Survey, page 3:

"The flora of the Puget formation is an exceedingly rich one. Over 100 species have already been named and described, and from the material in hand it seems safe to assume that the number will reach 250. Inasmuch as a very large proportion, perhaps more than nine-tenths, of the plants are new to science it becomes extremely difficult to settle their affinities and determine satisfactorily their bearing on the question of age. It is only by a study of their general facies that results along either line can be obtained.

"While the Puget flora as a whole may be considered relatively uniform, there are well-marked differences between the plants found in the lower beds, as represented at Carbonado, Wilkeson, and South Prairie creek, and those found in the upper beds at the highest points in the Carbon river canyon, the Clay mine on Green river, Snoqualmie pass, and at Steel's crossing near Black River Junction. Certain few genera are found throughout the series, but thus far no species has been noted as common throughout. On the other hand, both lower and higher beds are characterized by a considerable number of genera. Thus Quercus, Juglans, Rhamnus, Populus and Laurus are found from base to summit. The following genera have thus far been found in the lower beds, but not at all in the upper: Cladophlebis, Lastrea, Dryopteris, Anemia, Calamopsis, Sabal, Siphonites, Ficus, Eucalyptus and Aralia; and the following have been detected in the upper but not in the lower: Rhus, Castanea, Betula and Platanus.

"The lower beds, on account of the abundance of ferns, gigantic palms, figs, and a number of genera now found in the

West Indies and tropical South America, may be supposed to have enjoyed a much warmer, possibly a subtropical temperature, while the presence of sumacs, chestnuts, birches and sycamores in the upper beds would seem to indicate an approach to the conditions prevailing at the present day.

"A number of species of plants have been found to be common to the west and east sides of the Cascades. This number is not large, but they are important and easily recognized forms, and there is indication that the number will be increased when the material in hand has been more thoroughly studied. This would indicate that approximately similar conditions of climate and topography prevailed throughout this general area during the Puget epoch. The Cascade range as it now exists did not then intervene."

GENERAL STRUCTURE.

For the purpose of discussing the general geological structure of the King county coal field, it is here separated into three districts, viz.: northwestern, northeastern and southeastern.

The northwestern area might properly comprise the districts of Black River, Renton, Cedar Mountain, May Creek, Newcastle, Coal Creek, Issaquah and Grand Ridge. These areas and their coal beds are all somewhat similar in character. The sandstones and shales are similar, the lava rocks are also the same, or nearly so, in each area.

The axes of the folds lie in a general east and west direction and in the case of the Renton and Cedar Mountain localities, the axes plunge eastward. The direction of these axes, it will be noticed, is at right angles to the general axis of the Cascade range, but nearly parallel with the Newcastle-Issaquah mountain chain of hills.

With the exception of the Talbot syncline, in the Renton district, the folds are gentle, and the coal shows, by still containing a considerable amount of moisture, that it has not been metamorphosed by severe movement and folding.

In the northeastern area are placed the Tiger Mountain, Raging River, Hobart and Taylor districts. They are characterized by sharper folds and more faulting than occur in the northwest area. The folds in this instance begin to swing in a more southerly direction. The Sherwood anticline and the Taylor syncline have a northwest and southeast strike and also plunge to the southeast. The folds in the Raging River area were not definitely mapped, because of the extremely faulted condition of the strata; but where observed they also had a northwest and southeast strike.

This district is also affected by the same character of late intrusive rocks, especially the eastern part of it. The same variety of older lavas occur that are found in the northwest district.

In the southeastern area, in which lie the Danville, Ravensdale, Black Diamond, Franklin, Cumberland, Durham and Kangley coal fields, the folds strike in a general northerly and southerly direction with most of them striking a little east of north. There are a few local variations, such as may be found in the area lying between Ravensdale and Black Diamond. In the region lying south of the Northern Pacific railway, as it passes from Kanasket to Ravensdale, the axes plunge southerly and in the area north of that line the general inclination of the axes is northerly.

By following the probable course of the Franklin sandstone, it will be noticed that it passes through this district in a very sinuous manner. The area lying east of the Franklin sandsone at its western outcrop, north of it on its southern outcrop, and west of it on its eastern outcrop, represents the area occupied by the Bayne series of coal beds and accompanying shales and sandstones.

The area lying stratigraphically above the Franklin sandstone, or in other words, west of it areally, at its western outcrop, south of it at its southern outcrop, and east of it at its eastern outcrop, represents the area occupied by the Franklin series and its accompanying coal beds, sandstones and shales.

This series is limited at its uppermost margin by the Kummer sandstones.

The position of the Kummer sandstone has not been determined west of Black Diamond, due to the fact that there are no outcrops west of that place upon which a basis for correlation may be established.

FAULTS.

There are numerous faults in the beds of the southeastern area. They occur in nearly all of the working mines. The character and extent of some of them have been determined, while others have not. The principal displacement of this district is the Franklin fault. This is the fault that was struck in the McKay gangway south of Green river many years ago. Its true character was not determined until a few years ago. Mr. Bailey Willis had reasoned, from the small amount of data at hand at that time, that the bed faulted on an anticline and that the trace of the bed would be found to the eastward. However, upon further prospecting in Green River, the McKay and the Gem beds were found and identified west of the fault. This work was done prior to the first field work of the coal survey. The survey later worked on different lines and checked the conclusions of Messrs. James Anderson and William Hann, officials of the Pacific Coast Coal Company.

The fault appears to be an overthrust with a displacement to the northwest. The actual amount of horizontal displacement is difficult to determine, for we have no means of knowing where the eastern end of the break occurred, but it is apparent that the amount lies between the limits of 800 and 1,100 feet. There was also a downward displacement of the block south of the fault line. There is in reality here a series of faults, confined to an area having an easterly and westerly trend, which might properly be called a fault zone.

The above faulted zone extends westward into the Lawson-Black Diamond mines and follows a path almost parallel with the Columbia and Puget Sound railway. The topography in this area indicates that the block south of the track has dropped, but we have no means of knowing how much, for this area has been modified by erosion since the faulting took place.

A fault with about 900 feet of horizontal displacement has occurred in the Daly mine at Bayne. The direction of this fault is northwest and southeast. The No. 5 bed appears to have jumped to the northwest to a point opposite No. 1 bed. This is a thrust fault. The amount of vertical displacement has not been determined.

Another fault of undetermined extent occurs along the north side of Lizard mountain. This fault has a northeast and southwest strike and the block north of the fault has dropped. The fault appears to die out to the southwest and increase to the northeast. The Occidental mine beds have struck this fault in their southern ends.

Several of the folds, especially the synclines, are faulted. The section 8 syncline is faulted, whereby the block east of its axis has a vertical displacement of about 400 feet.

Various other faults occur throughout this area. The district around Palmer Junction is especially troubled by reason of numerous faults.

CHAPTER III

DETAILED GEOLOGY OF KING COUNTY COAL FIELDS.

BLACK RIVER-RENTON DISTRICT.

This district contains the beds that outcrop on both sides of Black river and those occurring south of Cedar river in the Renton-Panther creek locality.

Within the Black river district there is a syncline with a general easterly strike. On the south side of this syncline the beds of Jorgensen's ranch dip northward at about 25 degrees near the outcrop and gradually flatten as they approach Black river. North of the river the beds, where prospected, dip southward at from 10 to 12 degrees. The materials underlying these beds, on opposite sides of the fold, agree very closely and the beds themselves have certain similarities. Another coincidence is that igneous rock of the same character underlies the strata on both sides of the fold.

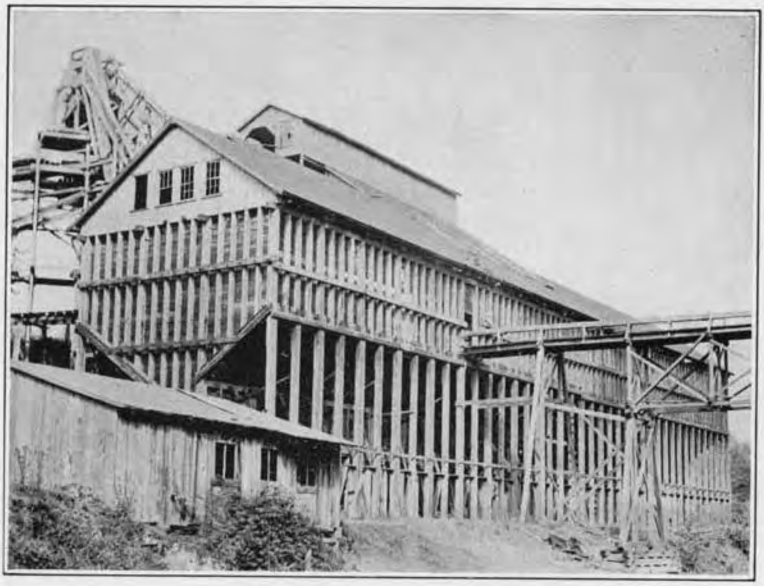
The eastern extension of this fold and its relationship to the Renton beds are not known. The fold passes under the alluvial valley west of Renton.

In the Renton area proper there occur three coal beds, numbered from top downward, as 1, 2 and 3. These beds are contained within the sandstones and shales near the lower part of the series as exposed at the Renton mine.

Overlying the Renton coal beds there are certain strata which were measured along the Columbia & Puget Sound railway track from the crossing of Cedar river to the base of the shale quarry at the Denny-Renton clay works. Beginning at the railway bridge, there is first a stratum of iron-stained conglomerate 165 feet thick; then occurs some concealed beds 335 thick, followed by an outcrop of Post-Eocene beds that contain granite pebbles, tuffs, gray sandstones, with fragments of shales that contain particles of Eocene coals. This outcrop, where exposed, is 230 feet thick. Then comes another concealed area that represents a stratigraphic thickness of 285 feet. Beneath this concealed area occurs the shales that are being quarried by the Denny-Renton Clay & Coal Company. The shales are closely laminated and are 240 feet thick where exposed. They become sandy near the base of the deposit. At this junction occurs what appears to be a slight unconformity. Particles of Eocene shales have been re-deposited in the lower part of the main shale bed. It is probable that the upper part of the series from this point to the top, represents deposits layed down during Oligocene times. These beds dip at about the same amount as the underlying coal beds of the Renton mine. Underlying this unconformity is forty feet of sandstone and beneath this comes bed No. 1 of the Renton coal beds. This bed is 16 feet and 11½ inches thick. Below it lies a series of sandstones and shales 110 feet thick, then comes bed no. 2, 13 feet and 4 inches thick between walls. Below bed No. 2 occurs sandstones and shales 72 feet thick and these overlie bed No. 3, which is 11 feet and 5 inches thick. Beneath bed No. 3 is a massive coarse grained sandstone, stained with iron. This is at least 42 feet thick and how much thicker we have no means of knowing. No. 3 is the lowermost bed of the Renton beds proper. It is reasonably certain that the beds west of Black river represent two or more beds that lie between No. 3 bed and the underlying igneous rock. The area lying between the Black river outcrops and those at Renton has been deeply eroded and partially refilled with valley alluvium.

We then have in the Renton series, in the upper 1,250 feet, strata that are probably Oligocene in age, the next 300 feet contains the workable coal beds of the series and are of Eocene age; the material below this is indefinite but appears to be made up of two or more impure coal beds and sandstones, and shales of undetermined thickness. These all rest on the igneous rock that outcrops at Black River Junction.

The Renton beds proper have been thrown into three folds, viz.: two anticlines and an intervening syncline. The Renton



A—Bunker at Issaquah Mine.

B—No. 1 Mine at Ravensdale.

anticline is broad and passes southeastward through the southern workings of the Renton mine. It broadens as the lower levels are reached and will probably disappear entirely. The Talbot syncline occurs west of the old Patton and Talbot mine and passes in a southeasterly direction into the mine workings of the Renton mine. The eastern limb of this syncline is gentle, but the western limb is steep, dipping 55 or more degrees to the north. South of this occurs what is believed to be another anticline, which may be called the Panther Creek anticline, from the fact that the only sedimentary outcrop in this area occurs on the above mentioned creek. This lone outcrop consists of a thin bed of carbonaceous matter that outcrops near the northeast corner of section 31, T. 23 N., R. 5 E. The bed dips southwesterly at 47 degrees. A small area of igneous rock similar in character to that at Black River Junction outcrops in the east half of section 30 near its center. These two occurrences suggest the existence of an anticline within this area.

The rock in which the carbonaceous bed occurs on Panther creek is a sandstone similar in character to the Renton beds proper, and probably represents the portion of the series lying beneath the Denny-Renton shales.

NEWCASTLE-ISSAQUAH-GRAND RIDGE DISTRICT.

The beds of this district extend southeasterly, then easterly, and finally northeasterly, through townships 24 N., ranges 5 and 6 E. The dip is northerly throughout the district, being 38 degrees at Newcastle, 35 to 28 degrees at Superior and Issaquah, 22 degrees at Grand Ridge and 65 to 75 degrees at the United States' Coal Company's property. The structure is monoclinal but suggests a broad synclinal basin, with its axis passing south through Issaquah. To the northeast of Grand Ridge the beds appear to form an anticline, but whether the anticline is complete or the beds faulted near the east line of R. 6 E., we have no means of knowing, for at this point the beds disappear under the thick glacial drift. The coal of this district is interbedded with a series of sandstones and shales, with the sandstones predominating. The sandstones are all light in color, and usually coarse grained. The shales are somewhat sandy, but there are some that are doubtless pure enough to make good vitrified wares.

A detailed section of the Newcastle strata, as measured in the rock tunnels of the Coal Creek mine, accompanies this report. Overlying bed No. 4 is a massive sandstone 115 feet thick and above this comes 25 feet of shale. Above these are several layers of coal and bone, among which occurs the Primrose bed and others. These coals are not worked at present and probably will not be worked for many years to come; they represent what might be called a future reserve. Overlying this upper series of beds, there are several layers of shale that contain fossils which are later than Eocene in age. The thickness of these strata could not be determined, due to the covered areas which intervene between the upper bony beds and the younger shales.

The strata are 870 feet thick that lie between bed No. 4, the uppermost, and the Jones bed, the lowermost one shown in the rock tunnels of the Coal Creek mine. These strata are made up of light colored, coarse grained sandstones, shales, carbonaceous shales and bony beds. An interval of about 117 feet occurs between bed No. 4 and bed No. 3, the next below in the geologic column.

Between bed No. 3 and the Bagley bed is an interval of 165 feet, made up principally of sandstones and sandy shales. Between the Bagley bed and the Muldoon bed is an interval of 135 feet, made up of sandstones and shales, and one impure coal bed called the May Creek.

Between the Muldoon and the Ragtime beds are 175 feet of strata made up of shales and sandstones, and one bed of low quality called the Shoo Fly. From the Ragtime to the Jones bed the stratigraphic distance is 208 feet, made up of sandstone, some of it shaly. One coal bed, the Dolly Varden, occurs within this space. Underlying the Jones bed, at an undetermined distance, is an impure bed that outcrops on China creek. The stratigraphic interval between the Jones bed and the underlying igneous mass is from three hundred to four hundred feet, at a point near the Coal Creek mine. This interval varies from place to place.

There occurs within this part of the Newcastle series ten coal and bony beds, ranging from two feet to twenty-five feet in thickness. Only four of these beds are considered workable under present conditions, viz.: 4, 3, Bagley and Muldoon.

Faults occur within the coal beds in this part of the district, especially in the Newcastle end of it. The beds at the western end turn to a more northerly course and this change in direction is accompanied by more or less faulting. The beds vary in thickness from place to place. Two of the beds, the Bagley and Muldoon, split in portions of the field. Bed No. 4 has been eroded away in parts of this district. This erosion occurred, as stated in another part of this report, after the vegetal matter had accumulated, and before the overlying strata were deposited. Evidently the land area was raised some distance above the general level of the swamp and streams entering the swamp carried away parts of the accumulated vegetal matter. Subsidence took place later and the sandstones etc. were deposited on top of this bed.

The Post-Tertiary shale, the upper bony series, and the productive series represented within this area, all lie apparently conformably upon the mass of igneous rock that occurs between Coal creek and May creek.

It should be stated, however, that the exact relationship of this igneous formation to the overlying sedimentary rock has not been definitely determined. It has been suggested that the coal beds were laid down upon the floor of igneous rock at a time when the latter was submerged beneath the sea. The evidence of this theory is based on the fact that at the contact with the overlying sedimentary rock, there occurs what may be called a basal conglomerate, made up of water-worn fragments of the same igneous rock. As a matter of fact, such water-worn fragments of lava rock occur throughout the body of the mass, and may be seen at almost any point along the road that passes through the canyon between May creek and Tibbett's creek.

A second suggestion has been that the igneous rock represents a flow of lava younger than the coal beds. This belief is based on the fact that masses of sandstone that contain what appear to be Eocene fossils occur within this igneous mass, and the further fact that at May creek, just west of McWade's slope, the igneous rock, while in its fused state, outflowed over a portion of the coal beds at that point.

The entire occurrence also suggests perhaps a laccolith, or intrusion of lava, that has come up from beneath and flowed between some of the layers in the coal series. It is possible that this large laccolith was the means of tilting the beds as we find them at present. This same belt of lava extends to the eastward and northeastward as indicated on the geological map.

We have no means of computing the thickness of this prominent mass of igneous rock. We do know, however, that the top of Issaquah mountain is composed of this material and that this mountain is twenty-nine hundred feet high. We know also that the material at the bottom of Issaquah creek, at an elevation of 200 feet, is a similar igneous rock. From this we can compute that we have a represented thickness of at least 2,700 feet. It is probable that there exists beneath this mass a series of coal beds, or, on the other hand, the laccolith may occupy a position between the older formation and the Eocene coal beds. The former condition is suggested by the fact that at the time of the extrusion, the lava picked up many fragments of Eocene sandstones, presumably from beneath the flow, rather than from the upper part.

The coal series, as represented in the Newcastle-Coal Creek mines, passes eastward into the next township and has been mined at the Superior mine and the Issaquah mine. No. 4 bed at Coal creek has been identified as the No. 4 bed at Issaquah. It has the same cross-section, the same overlying and underlying materials and the same characteristic eroded areas. The Superior mine was opened on what is very likely the Jones bed on its eastern extension. It has many of the characteristics of the Jones bed and occupies the proper position in the columnar section. The intervening beds, while not positively correlated with those at Coal creek, represent without doubt the same beds that occur at the latter place, with their local variations.

The stratigraphic distance from the No. 4 bed to the igneous rock is 1,320 feet, as exposed along the grade of the Superior railroad spur. Beginning at No. 4, the uppermost bed worked in this series, and going down the column, we come to bed No. 3, at a distance of 80 feet.

No. 2 underlies No. 3 at a distance of 82 feet. Then from the bottom of No. 2 to the top of No. 1, the distance is 85 feet. The intervening strata are made up of shales and sandstones. Three hundred and forty feet beneath bed No. 1 is another bed which does not appear on the Issaquah side, and 75 feet beneath this is another bed unknown to the Issaquah section. Whether or not these beds are merely local and do not occur at Issaquah, or that they do in fact occur on the Issaquah side, but have not yet been found, we do not know. One hundred and thirty feet beneath the lower new bed is No. 5, and 75 feet beneath this bed is No. 0. Then comes an interval of 240 feet to No. 6. About 150 feet below No. 6 is the igneous mass composed of the same material that underlies the Newcastle-Coal Creek beds.

There are nine beds outcropping in the series as observed at Superior. Of these, Nos. 4, 1, 5, 0 and 6 are workable. In addition to these the two new beds contain coal that in all probability can be worked.

At Issaquah proper, the beds are not very well exposed and the accompany columnar section has been made up partly from surface outcrops and partly from mine maps. No. 4 is about 315 feet above No. 1. Then comes an interval of 300 feet to No. 5. It is probable that Nos. 3 and 2 occur in the concealed areas. Seventy feet below this is No. 0 and 245 feet below the latter is No. 6. It is then 113 feet to a carbonaceous shale that resembles the shale that outcrops on China creek and underlies the Jones bed at Newcastle. Twenty-eight feet beneath the latter bony bed is the igneous rock. The workable beds of this series are the same as those on the Superior side, viz.: Nos. 4, 1, 5, 0 and 6.

The valley through which Issaquah creek flows on its way to Lake Sammamish has been eroded to a depth considerably below the present sea level. In driving the east gangway on the 1,700-foot level, water, sand and gravel were encountered. How much deeper the old valley was eroded we do not know. It is well to suggest that when the mine is opened again and lower levels worked to the eastward, that a long drill hole be kept in advance of the gangway, so as to get the indications of an approach to an old erosion channel before the entire gangway is driven into it, as was done two or three times in the past.

In the eastern part of the Issaquah mine the beds begin to turn slightly to the northeast. Very evidently they continue to swing around to the northeast, for at Grand Ridge we find coal beds and layers of sandstone and shale that agree very closely with those of Coal Creek and Issaquah.

The coal beds at Grand Ridge are thinner than those at Issaquah or Coal Creek, while the distances between the beds are also less. It appears as though the Grand Ridge district was approaching the northeastern edge of the original coal swamp. The beds at this place strike northeast and dip northwest at about 22 degrees.

Seven coal beds are exposed in the rock tunnel of the Grand Ridge mine. Beginning at the uppermost bed, called No. 2, and going down the column, we have an interval of 50 feet to No. 1. From No. 1 to No. 3, the stratigraphic distance is 35 feet; from No. 3 to No. 4, 38 feet; from No. 4 to No. 5, 26 feet; from No. 5 to No. 6, 63 feet; and from No. 6 to No. 7, 52 feet. The entire series, as exposed in the rock tunnels, has a thickness of about 300 feet. No attempt has been made to correlate these beds with those at Issaquah.

The igneous rock outcrops along the railroad track about 1,000 feet east of the center of the Grand Ridge bunker. If this outcrop represents the probable point of contact between the underlying igneous rock and the sedimentary formations, it places the igneous rock at this point about 300 feet stratigraphically beneath No. 7 bed. This is about the distance at Coal Creek from the Jones bed to the igneous rock. Whether or not another bed underlies No. 7 at Grand Ridge is not known, but the bony bed overlying the igneous rock should occur at some point in this interval.

These beds and the underlying igneous rock extend to the northeast into the property of the United States Coal Company. Where these beds go beyond section 13, T. 24 N., R. 6 E., has never been determined. It is possible that they continue eastward into the Snoqualmie river valley. There is more or less faulting in this area, and probably a large amount in sections 23 and 13 of this township. While they might prove troublesome in mining, they should not prove fatal in the matter of obtaining the coal.

MAY CREEK-CEDAR MOUNTAIN DISTRICT.

These localities are combined into the same district because it is believed that the May Creek beds swing toward the southeast and join the Cedar Mountain beds on their swing to the northwest.

The May Creek outcrops occur in section 2, T. 23 N., R. 5 E. One of the beds on which the slope is sunk dips south at the outcrop at an angle of 64 degrees, but increases in dip at the foot of the slope. A slope was sunk on this bed to a depth of 325 feet where a rock tunnel 450 feet long was driven to the south across the strata. The strata are so nearly vertical at the foot of the slope and through the rock tunnel that it is difficult to determine whether the beds are dipping north or south.

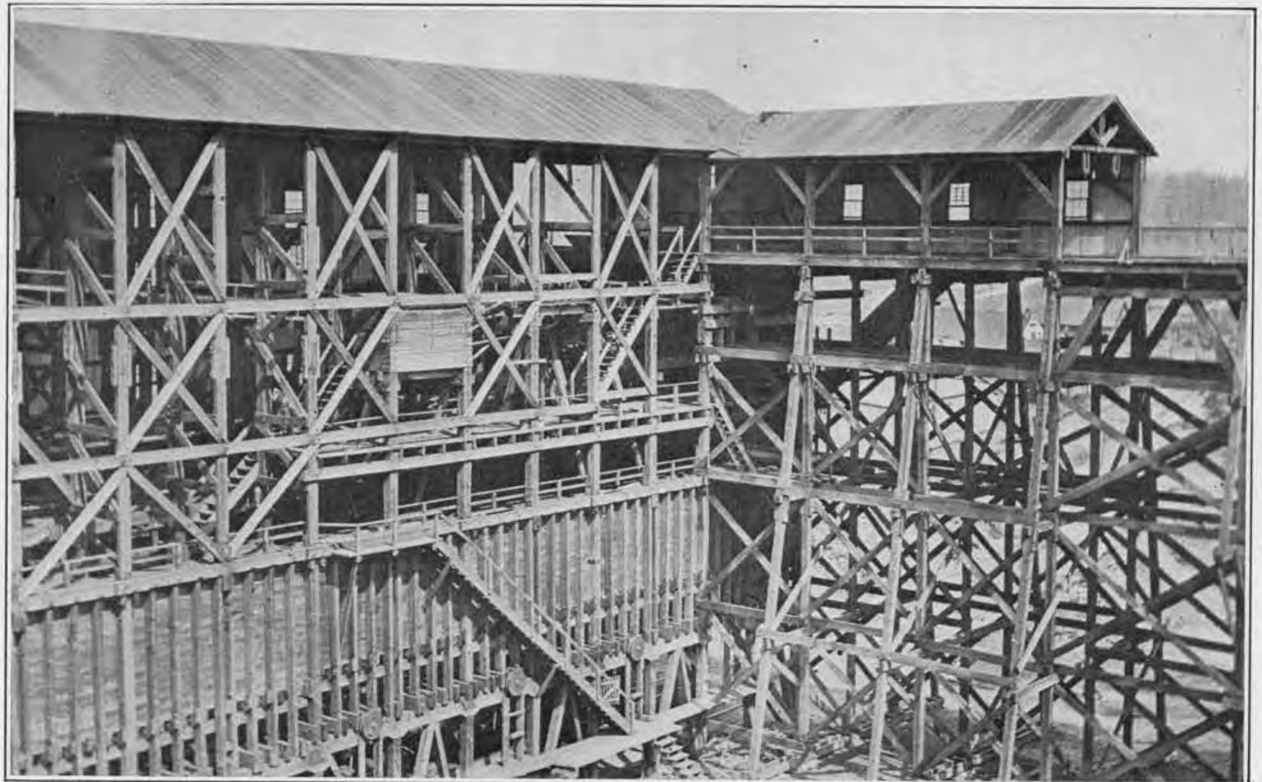
A section along the rock tunnel from the slope south is about as follows:

Slope bed	10′
Shale	50′
Coal and bone	6′
Shale	35′
Coal and bone	17′
White massive sandstone	107′
Gray shale	7′
Gray sandstone	76′ 6″
Gray shale	33′ 0″
Carbonaceous shale and a little coal	1′ 0″
White massive sandstone	114′

The geological structure of this locality has not been definitely worked out. Mention has been made in another part of this report to the theory that the outcrops of this area represent beds that dip beneath the lava mass to the north. It is more likely true that the May creek beds dip to the south and represent the Newcastle beds on the opposite side of an anticline. A shaft is now being sunk south of May Creek, which, when down to the coal beds, should prove beyond a doubt the true conditions in this part of the field. If it proves that these are the Newcastle beds, on the opposite side of an anticline, it doubtless means that a coal field of high commercial value will be developed.

The strata of the Cedar Mountain area, though here coupled with the May Creek locality for descriptive reasons at least, resemble the strata at Renton very closely. These beds, as will be seen on the geological map, outcrop in sections 29 and 30, T. 23 N., R. 6 E. They outcrop partly along Cedar river and partly on the county road lately constructed through that part of the field. The total thickness of the beds as exposed along the county road is about 2,000 feet. Only the lower 800 feet contain any coal beds, and the workable beds are near the top and center of this eight hundred feet.

At the top of the series there occurs a great thickness of shales. They are about 500 feet thick, and those which lie next above bed A resemble very closely the shales at the Denny-



Part of Coal Washing Plant at Ravensdale.

Renton plant at Renton. At the base of these shales occurs a probable unconformity as is also the case at Renton. In the upper part of the 38 feet of sandstone that immediately overlies bed A occur redeposited fragments of shale.

Bed A shows signs of erosion after deposition. In some parts of it the carbonaceous matter has been eroded and the sand washed in to fill its place. Bed No. 1 underlies A at a distance of 75 feet, the interval being made up of shale. No. 2 is 365 feet stratigraphically below No. 1. This interval is made up of sandstones and shales. Three hundred and ten feet beneath No. 2 occurs an impure coal bed about 10 feet thick and below this, at a distance of 28 feet, another 10-foot bed of impure coal. It will be noticed that there is a decided similarity between this series and the Renton series. We have here the overlying shales and the suggested unconformity, as well as the impure coal bed A, which agrees somewhat with No. 1 at Renton. Then bed No. 1, which might be correlated with No. 2 at Renton, and beneath this No. 2, which is probably represented in the Renton series by No. 3. Below these three beds we have two or more impure beds that probably correspond to the two beds in the Black River locality. The distance between the beds at Cedar Mountain is greater than at Renton, but this could easily be accounted for. The strata here dip to the eastward at from 14 degrees in the lower beds to 40 degrees in the upper beds. They swing from a northeasterly direction in section 30 to a northwesterly direction in section 20.

The relationship of the igneous outcrop near Otter lake to the coal strata is not definitely known. It is likely that it represents an intrusion into this part of the area and does not occur at any point on Cedar river.

A fault of undetermined character or extent was struck in the gangway to the southwest of the river. Prospecting is being done beyond this fault, to find if possible the continuation of the beds in this field.

TIGER MOUNTAIN-RAGING RIVER DISTRICT.

The outcrops in the Tiger Mountain area lie in sections 12 and 13, T. 23 N., R. 6 E. There are four or more coal beds that occur in the sandstones and shales of this area. Sections of some of the beds accompany this report. The sandstones resemble very closely those in the Newcastle-Issaquah series, and they are light colored, coarse grained and poorly cemented. There are numerous faults in this area, seven of them occurring within a less distance than half a mile.

As stated in another part of this report, these beds can not be definitely correlated with any well known beds. About the best interpretation that can be had from the data at hand is that these beds have been brought into their present positions by a great fault with a downthrow to the southeast. These beds are described in more or less detail in another part of this report.

The Raging River area has also been discussed in more or less detail elsewhere in this report and it is needless to repeat it at this point. It should be stated that, due to the extremely faulted condition of this area and its small value as a commercial coal field, the Survey did not feel justified in spending any more time in the district than it did, for the economic development of this field is a problem of the distant future.

TAYLOR-HOBART DISTRICT.

In sections 2, 3, 4, and 10 of T. 22 N., R. 7 E., and sections 33 and 34, T. 23 N., R. 7 E., occur the coal and shale beds that are being developed by the Denny-Renton Clay and Coal Company. The beds, as exposed in the rock tunnel of mine No. 1, are about 1,150 feet thick. About 170 feet of massive shale and sandy shale overlie No. 1. Then comes about 20 feet of shaly sandstone between No. 1 and an underlying intrusive sill. The sill of igneous rock is about 23 feet thick and has followed along an impure coal bed which it immediately overlies and has altered. About 90 feet of massive sandstone occurs between this impure coal bed and No. 2. Then an interval of 13 feet of shale between No. 2 and No. 3. A massive sandstone 125 feet in thickness underlies No. 3, and then comes another intrusive sill and an impure coal bed. Seventy-five feet beneath this impure coal bed and sill is No. 4, the interval consisting of sandstone and shale. Twenty feet of shale lie between Nos. 4 and 5, and 80 feet of shale between No. 5 and No. 6. Massive sandstone, with a little shale at the top and bottom, occur in the 180-foot interval between Nos. 6 and 7. A bony bed underlies No. 7 at a distance of about six feet. Ninety feet of sandstone and shale occur between No. 7 and the lowermost coal bed of this series. Below this occurs about 80 feet of massive sandstone. The intrusive rocks in this series vary in position from one part of the field to the other. The intrusive rock beneath No. 1 in the tunnel overlies No. 1 in the shaft level. The intrusive rocks in nearly every instance have followed some line of weakness in the strata, such as a fault plane, a bedding plane, or a coal or bony bed.

In portions of this property the intrusive rock in its decomposed and also in its original state is used for making brick and other products. The shales are also extensively used for such purposes.

This part of the field has a synclinal structure, the axis of the syncline striking southeasterly and plunging the same direction. In other words, we have as it were a spoon-shaped formation with the highest part of the spoon's bowl in the northwest part of section 3. The beds in No. 1 mine strike northwest and dip to the southwest at a high angle. The beds in No. 2 mine strike northwest and dip to the northeast.

West of Taylor, in the Sherwood area, the lava rocks and accompanying lower shales are thrown into an anticlinal fold. The axis of this anticline is nearly parallel to the axis of the Taylor syncline and it plunges to the southeast also.

The lava flows, with intercalated shales, underlying the Taylor beds probably represent the southeastern extension of the lava flows underlying the Issaquah series. These lavas are slightly different in character, however, and are further complicated by the presence of the later intrusives in this part of the field.

East of Taylor the bed rock is so covered with soil and glacial drift, and the area is so badly affected by late intrusions of igneous rocks that it is difficult to determine with any degree of accuracy the eastern continuation of the coal beds. It is likely that to the eastward the intrusives become thicker and more numerous, so that this part of the field will prove to be of much less commercial value than the present Taylor field. The coal beds, as far as they can be traced toward the east, change their direction in the southwest quarter of section 2 and strike more easterly. Whether or not they are approaching another anticline somewhere in section 2 cannot be determined from the data at hand.

In section 31, T. 23 N., R. 7 E., is an outcrop of coal on Issaquah creek. At this point the creek turns from its general southeasterly course to a northerly one. There are only a few outcrops of sedimentary rocks within this area, most of the district being deeply covered with glacial drift so that it is next to impossible to get the true relationship of this coal bed to the many and confusing outcrops of lava. The bed appears to be on the axis of an anticline and dips beneath the lava to the southeast. Issaquah creek, as it flows northward through sections 30 and 20 of this township, passes along a fault plane and there are numerous other faults in this vicinity.

The Northwestern Improvement Company, several years ago, drilled a hole in section 31, but after expending considerable money abandoned the venture. This area is so close to transportation, however, that it is probable that at some future time it will be prospected and perhaps proved to be of value. It stands a much better chance than either the Tiger Mountain or the Raging River areas.

DANVILLE-RAVENSDALE DISTRICT.

The Danville and Ravensdale areas lie in the southeast portion of T. 22 N., R. 6 E. and the northeast portion of T. 21 N., R. 6 E. The Danville mine is in sections 24 and 25 of this township. The beds at this place strike northeast and have dips that are practically vertical. It is probable, however, that these beds represent the upper part of the Ravensdale beds on the opposite side of a synclinal fold. There are a number of coal beds outcropping at this mine, only two of which will probably prove to be of value.

This area has been prospected more or less since 1896. Several attempts have been made to operate a mine successfully at this place, but the beds have been found to be so irregular in character and so badly disturbed by faulting that each time the operators have given up in despair. The last attempt was made since the Chicago, Milwaukee and Puget Sound railway was built through section 24. It was supposed that with the increased shipping facilities, something could be done with this property. This last attempt has not been crowned with any greater success than former attempts.

The coal beds and the sandstones and shales of this area are similar to the beds in the upper part of the Ravensdale district. Definite correlation is impossible, due to the small amount of exposed strata at Danville, and the indefinite positions of the beds, relative to each other, due to faulting. It is possible, of course, that as greater depth is reached these beds will prove to be less faulted. In other words, the area might be broken by a series of faults with more or less horizontal planes and as depth is reached the breaks would eventually disappear. On the other hand, the area is probably so badly disturbed that no part of it will ever pay to work. Future development alone will reveal the true condition.

The Ravensdale beds occur in section 36, T. 22 N., R. 6 E., and section 1, T. 21 N., R. 6 E. The upper beds, or those worked in mine No. 1, strike northeasterly and dip northwesterly at from 28 to 50 degrees. Several faults are struck in these mines, the details of which are explained in the section of this report covering the description of mine No. 1.

One of the lower beds outcropping in this district is the McKay bed, on its northern extension from the Black Diamond area. This bed at Ravensdale has some folds that do not appear in the upper beds or the beds in No. 1 mine. Beginning at the fault in the southern part of section 1, the McKay swings to the northeast, changes direction at the axis of the syncline, near the center of the section, and swings to the northwest. Near the northern part of the section the bed is disturbed by numerous faults. North of the north line of section 1 the bed strikes north and dips west at a high angle; and a little farther north it is cut off by a fault. In the northeast part of section 1 is a bed which has been identified by the officials of the Northwestern Improvement Company as being the McKay. The McKay at this point strikes a little north of west and dips to the east at a very high angle. The only interpretation of the data at hand is that the McKay bed is thrown into a sharp anticline near the north line of section 1 and is also disturbed by numerous faults. This sharp anticline is not pronounced in the workings of mine No. 1, but it is probably represented by the slight bend in the strata near the No. 1 slope. The extension of the McKay beyond the east line of section 1 is not known, but it is probable that it curves to the northward in section 6 and then to the northward through section 31, dipping westerly.

There is little or no data to be had in this area from surface examination, and the only information to be had is from the mine workings and a very few surface outcrops. The extension of the McKay south of the fault in section 1 is to be had in the Morgan slope at Black Diamond and the area intervening.

The columnar section, as measured in this area from a coal bed overlying No. 9 to the McKay, is 1,533 feet. The columnar section which accompanies this report is based on data obtained in the rock tunnel in No. 1 mine, and from a profile cross-section of some prospect holes furnished to the Survey by Mr. Pott, chief mining engineer of the Northwestern Improvement Company.

It will be seen from the section that there are about sixteen coal and bony beds in this series, besides the 35-foot bed which has been separated into three beds and called Nos. 3, $3\frac{1}{2}$ and 4. Of this number of beds only Nos. 9, 5, 4 and 3 are worked at present. The Gem, Jones and McKay beds have been worked in the past.

The bed locally called the Gem lies about 650 feet above the McKay, while the Gem at Franklin lies about 750 or 800 feet above that bed. Whether or not the Gem at Ravensdale is represented at Franklin by the bed bearing the same name, cannot be stated definitely. A correct section of the Gem bed at Ravensdale cannot be obtained at the present time because of caving. There is a decided difference in the columnar section at Ravensdale with that shown in the Franklin series along Green river. If the upper beds, as worked in the No. 1 mine, Ravensdale, represent the upper beds of the Franklin series on Green river, the interval between these beds and the McKay is much less at Ravensdale than at Franklin. The interval at Franklin is about 500 feet greater than at Ravensdale. It is probable that the beds in mine No. 1, Ravensdale, are represented at Franklin by what is locally called the Graveyard beds, composed of eight beds underlying the Kummer sandstone. It should be stated, however, that at Ravensdale these beds are of much better quality than at Franklin.

The amount of coal represented in a section of the Ravensdale measures is very great. All of these beds do not contain workable coal, but those that do would total a very large tonnage.

BLACK DIAMOND-FRANKLIN DISTRICT.

The coal beds developed in this district are those that outcrop in the Franklin series of rocks along Green river at Franklin. Beginning at the north end of the Morgan slope workings, the beds strike a little south of west and dip northerly; within a half mile they turn more nearly westward, then curve to the south and finally near the center of section 14 they turn eastward and dip south. As they enter the east half of section 14, they strike the Franklin fault (described elsewhere in this report). The beds have not been found south of the fault.

Judging from the position of a bed of coal found in the rock tunnel south of the fault, and the strata in Green river, the beds south of the fault follow some such line as suggested in the accompanying colored map. This dotted line is the probable position of the McKay bed on the 400-foot datum plane. It will be noticed that the curves do not connect on this plane, and that there is a gap extending from a point north of the river to a point south of the river where the bed is supposed to reappear at the 400-foot datum plane.

The position of the McKay bed south of the river is based on information furnished the writer by a man who drilled in this district, and who is well qualified to pass an opinion on the probable existence of the McKay bed. He states that his drill hole caved when the strata were reached that are supposed to contain that bed, but he is reasonably sure that the coal brought up from the hole at a given depth is McKay coal. The probable position of the McKay bed at the 400-foot datum plane south of the river is, therefore, based on this information and the appearance and position of certain beds on the east side of the anticline. The axis of the fold north of the river plunges south, and south of the river the axis plunges north. Should future developments, which alone can demonstrate the correctness of the above suggestion, prove that the McKay bed does follow as indicated, it means a valuable field of coal in the area south of Black Diamond.

West of Black Diamond there is little or no information to suggest the probable behavior of the McKay bed. At the bottom of the accompanying colored map, the cross sections represent a series of folds, the solid portions of which are based on known conditions and the dotted portions upon probable conditions. The position of the axis of the probable western syncline is based almost entirely upon theory. There is no certain knowledge that any such fold exists. It is suggested partly by the position of the strata at Danville on the north, and in sections 27 and 28, T. 20 N., R. 6 E., on the south.

North of the Franklin fault in the Lawson mine, on the east

A—No. 1 Slope Mine, Ravensdale.

B—Bunker of Naval Coal Company.

side of the Black Diamond anticline, the beds dip east and strike northerly; they swing to the eastward in section 12, T. 20 N., R. 6 E., and section 7, T. 21 N., R. 7 E., dipping south as they pass the north end of the Kummer syncline; they next swing to the south, dipping west as they pass along the east side of the syncline and thence southward to the Franklin fault.

About a mile north of Franklin occur what are commonly known as the section 8 coal prospects. Some development work was done here in 1887-9 and eleven or more coal beds were opened at that time. Work was finally suspended in 1893. The beds found here are presumably the continuation of those mined at the Bayne and Occidental mines, described below.

KUMMER-KRAIN DISTRICT.

The coal beds, as developed on the west side of the Kummer syncline at the Kummer mine, dip eastward and strike northward. They go north into sections 24 and 13, then swing south and reappear on the north side of Green river in the east part of section 23. These beds, and the remainder of the Kummer series in which they occur, are described elsewhere in this report.

The Kummer syncline extends south of the river into sections 35 and 36 of the same township and also into sections 1 and 2 of the township south.

In the Krain district to the south, these beds outcrop in section 1, dipping west. Very little work has been done in the Krain district, but it is reasonably certain that no other beds than those found at Kummer outcrop within this area.

CUMBERLAND-BAYNE DISTRICT.

This district includes the area lying east and south of Green river in T. 21 N., R. 7 E. It contains a number of mines and each part of the district will be discussed in turn.

Southeast of Franklin is the Rose-Marshall mine. At this mine a slope has been sunk on a coal bed that outcrops in the northwest quarter of section 29, T. 21 N., R. 7 E. This bed has always been supposed to be one underlying the Franklin series, and outcropping at some point in Green river in sections

17 or 8. It will be noticed by referring to the geological map that there occurs between this slope and the Franklin mines, two anticlines and two synclines. The Franklin anticline and section 8 syncline are well developed, at one locality for each in section 17 and two localities for each in section 8 to the north. It is probable that the McKay bed, just before reaching the Franklin fault in the gangway south of the river at Franklin, passed partly around the axis of the Franklin anticline. The two folds pass into the area just north of the New Franklin mines and are more or less connected with the Franklin fault. East of the section 8 syncline, is a well developed anticline that shows plainly near the east line of section 8, and also observed in the Lawson drill hole in section 31, T. 21 N., R. 7 E. This fold may be called the Lawson anticline. East of this anticline is a syncline which is developed in the eastern part of section 9. The axis of this fold is placed as passing nearly parallel to the Lawson anticline and west of the Rose-Marshall slope. A trace of the McKay bed on the 400-foot datum plane under these conditions would be about as suggested by the dotted line, which indicates the probable position of that bed southeast of Green river. The writer has collected all available data on the subject and the conclusion is drawn from the best evidence at hand that the bed on which the Rose-Marshall slope is sunk is the No. 12 bed at Franklin. The folds substantiate such a conclusion, and the bed itself, along with the underlying igneous sill justified this correlation.

The igneous sill underlying the Rose-Marshall slope outcrops east of the slope and strikes in a southerly direction until near the center of section 29, when it turns eastward. The writer has, therefore, connected an anticline in the east part of section 9 in Green river with this point, and continued the fold southwestward into section 6 of the township south.

The beds outcropping on opposite sides of Lizard mountain dip toward each other, indicating conclusively that the axis of a syncline passes through that area. The beds opened at the Occidental mine are on the western limb of this syncline and dip southeasterly. A fault with considerable vertical displacement passes in a northeasterly direction along the northwest face of Lizard mountain. The block north of the fault has dropped considerably, thereby complicating the structure in this part of the field.

The beds at Bayne dip to the east and are on the east limb of an anticline that passes southwesterly between the Bayne mine and Lizard mountain. This same anticlinal axis passes through the workings of the Fleet mine, and beyond a doubt it was the axis of this fold that the south workings of the Naval mine were in when work was stopped. The axis of this fold passes out into the fault west of the Sunset and Independent mines.

The Sunset and Independent beds are on the eastern limb of this fold and dip to the southeast and are beds supposedly higher in the series than the Naval bed. The suggestion has been recently made to the writer, by a very careful observer of conditions in this part of the field, that the principal bed at the Naval mine is the same bed as No. 6 at the Independent. There is a decidedly strong resemblance between the two beds, as may be seen from a study of the accompanying sections of those beds. If this condition prevails, the massive sandstone underlying the No. 6 bed is the Franklin sandstone.

The Naval bed at its southern end dips southeasterly, as does Independent bed No. 6. In order that the Naval bed might occur in section 33 as the Independent No. 6, it could have been brought to this southern position only by an overthrust fault with a horizontal displacement to the southwest of over 3,000 feet. This fault plane would necessarily pass into the eastern portion of section 28, to the east of the Fleet mine. The area into which this fault would pass has very few outcrops of any kind, and it is almost impossible to get data on this problem.

The Sunset beds strike northeasterly and dip southeasterly, and continue toward the northeast into section 27. The Independent beds, which are the southern extensions of the Sunset beds, strike nearly north and south, and dip east. How far these beds extend to the south is not now known, but they probably continue southward into section 4 and then swing to the southwest.

The beds at Bayne dip eastward at the Daly mine, then swing eastward through the Carbon mine, and then south on the opposite side of the Bayne syncline, the axis of which passes through Bayne mountain. East of Bayne mountain is the Hudson anticline which passes nearly north and south through the area lying between the Big Six mine and the branch line of the Northern Pacific railway. The beds of the Big Six mine dip easterly on the east limb of the anticline. The probable trace of the Franklin sandstone outcrop can be seen passing through this area in a sinuous manner. The trace of this dividing line between the Bayne and Franklin series is based on the best evidence available, which is not conclusive, and is presented to suggest the probable positions of the outcrops of overlying and underlying beds.

DURHAM-KANGLEY DISTRICT.

It will be noticed that the Franklin sandstone is carried north from the Big Six mine and passes through the Durham property, placing the Durham beds 1 and 2 below the sandstone and placing the Kangley and upper beds at Durham with the Franklin series. The lines of separation in this part of the field are more or less hypothetical.

The folds developed south of Green river present great variations when projected into the area lying north of the river. There are so few data to be had in this northern district that it would be largely guess work to suggest the probable structure for this part of the field.

The lower beds at Durham appear to swing to the northwest, the probable northern extension of the Cumberland anticline. The region north of Durham is characterized more or less by faulting and it is difficult to correctly interpret the structure.

The Durham-Sugar Loaf area gives promise of a considerable tonnage of a very fair grade of coal. There are several prospects in section 28, T. 22 N., R. 7 E., but so far nothing of much value has been found.

BARNESTON-SNOQUALMIE DISTRICT.

At Barneston there are, as stated elsewhere in this report, several beds of bony coal, as well as a large number of intrusive sills and dikes. The commercial value of these beds is negligible and it was not deemed worth while to spend much time in this part of the field.

The Snoqualmie field, with its four or more outcropping coal beds, is a more or less isolated area, bordered on the east by igneous rock while to the west the strata are obscured by glacial drift. There are some igneous sills in this area. The coal beds have been subjected to considerable movement along the bedding planes. The coal is badly crushed and parts of the roofs show slickensided surfaces, indicating movements of the walls. These beds have been rendered highly bituminous by reason of the local metamorphism caused by earth movements and intrusions.

KERRISTON PROSPECTS.

In section 26, T. 23 N., R. 7 E., near the sawmilling town of Kerriston, are several coal outcrops called the Kinney prospects. Six coal beds are reported from this area, ranging from four feet and six inches to fourteen feet and four inches in thickness.

The writer spent some time in this area trying to locate these outcrops. Several were found and they were so badly altered by earth movements that the original coal had been changed almost to graphite. The beds strike northeast and dip southeast. Outcrops are reported to occur in section 35, which lies south of section 26. Very little can be seen in this field, and that is not the least encouraging for the development of good mines. Intrusive dikes and numerous sills are known to exist in this locality. The town of Kerriston is located on an area made up of volcanic rock.

RAGING RIVER DISTRICT.

Raging river crosses T. 23 N., R. 7 E., in a northwesterly direction. The river rises in the southeast corner of the township and crosses the north line of the township in section 4. The area west of the river is made up of deep gulches and high hills. In some of these gulches coal and bony beds outcrop.

In 1886-7-8 there was a great deal of active prospecting done in this field. In sections 8 and 9 of this township there were several prospect holes sunk. Mr. Niblock uncovered several coal and bony beds in section 8. In section 16 are located the old Ruffner prospects. In this area from six to eight coal and bony beds are exposed, ranging in thickness with their partings of impurities, from one foot and three inches to twenty-three feet and one inch. All the beds have many partings of impurities. The country is very badly broken by faults and several intrusions of igneous rocks may be observed in parts of the field.

In section 21, same township, there are several outcrops of coal and bone, probably belonging to the same series that is exposed in section 16, on the opposite side of a broad fold. The beds in section 21 dip south, while the beds in section 16 dip west and northwest. Of all the outcrops examined by the writer, there were very few that looked encouraging for any future development of this field, and the field as a whole is very badly faulted.

A great amount of money was spent in early days on this field and the old Seattle, Lake Shore and Eastern Railroad (now the North Bend branch of the Northern Pacific Railway) planned on this being the great high grade coal field of the state. Mr. W. D. Ruffner, an Eastern geologist, made a report on this field for the railroad company, which was published in 1887. The report covers the details as seen at that time and does not hold out much encouragement for the district. The company finally abandoned further work in the Raging River field and it is doubtful if any further work, profitable to the investor, will be done in this field until such time in the distant future when all the coal will have been mined out of the present well known and far more accessible fields. Some of the beds in the field have the following sections, according to Mr. Ruffner:

BED NO. 2.

Roof, fine grained sandstone, under which is seven inches black slate.

	Ft.	*Inches.*
Coal	0	6
Slate	2	0
Coal	0	7
Slate	0	4
Coal	0	5
Slate	0	5
Argillaceous and Ferruginous rock	1	7
Coal	0	1½
Bone	0	5
Coal (main bench) of good quality	7	0
Nigger-head	0	2
Coal	1	0
Slate	0	1½
Coal, good	0	6
Slate and clay	0	7
Lignite (brown coal)	2	1
Bituminous slate	1	8
Coal	0	½
Nigger-head	0	4½
Clay and bony slate	0	7
Coal	2	1
Nigger-head	0	1½
Bituminous slate	1	2
Coal	0	1
Slate	0	7
Coal	0	7
Slate and sandstone bottom	..	..
Total	23 ft.	1½ in.

SEAM NO. 4.

The second seam from the bottom, descending:

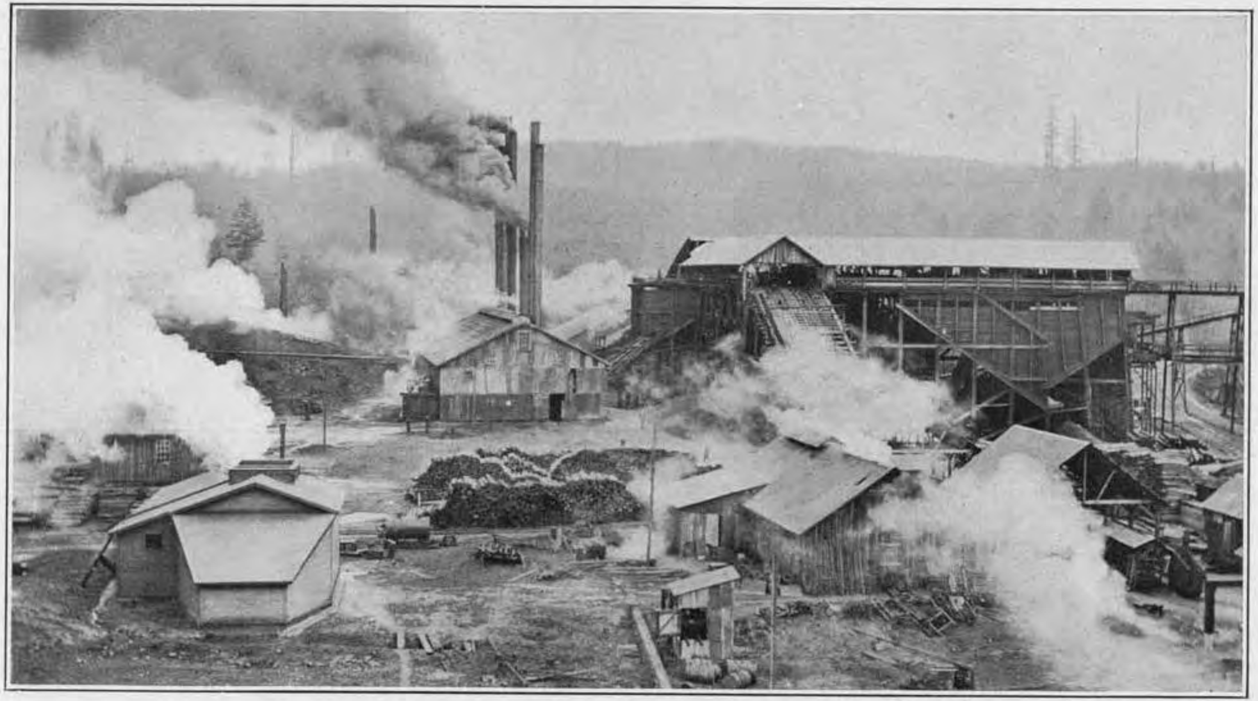
	Ft.	Inches.
Roof, slate	2	0
Bone	2	0
Coal	0	6
Fine-grained sandstone, average	2	2
Natural coke	0	6
Bituminous shale	0	6
Coal	4	2
Bottom, sandstone	4	2

The coal of this seam is soft, black and lustrous. An entry was driven in fifty feet, which required much propping, the roof being unstable. At the end of this distance the miners came squarely up against a wall of sandstone, showing a fault. These details are given for the reason that at the time the members of the Survey visited this field all the open cuts and outcrops were caved more or less and no full detailed section could be obtained.

SKYKOMISH DISTRICT.

About twelve or fourteen years ago the Great Northern Railway Company spent considerable time and money prospecting the region south of the Skykomish river in the vicinity of the town of Skykomish.

Work was done on Foss river, Anthracite creek and Maloney creek. This area has some lenses of carbonaceous matter that will burn, but they are so irregular in size that as yet no commercial bed has been found. On Maloney creek the lenses of carbonaceous matter occur in altered shales among the intrusive granites and diorites. Some of these carbonaceous lenses have been altered to an impure graphite by the metamorphic action of the intrusives, and movement by faults. A good deal of money has been spent on Maloney creek by parties expecting that the graphite would prove to be valuable. As a matter of fact the graphite, or rather the graphitic shale, is too impure and irregular in size and continuity to ever be of any commercial value. As far as may now be observed, this area will never produce coal of any commercial value.



Morgan Slope Mine, Black Diamond.

COAL OUTCROPS ALONG GREEN RIVER.

Below is given the detailed cross-sections of 52 coal outcrops that occur along Green river, between a point a little below Kummer and Palmer Junction. The exact positions of these outcrops, with the strike and dip of the beds, is indicated on plates XXII and XXIII.

No. 1.

	Ft.	In.
Shale	..	..
Carb. shale	2	1
Clay	..	1
Coal	..	1
Clay	..	3
Coal	..	2
Carb. shale	..	10
Coal	..	1
Carb. shale	..	6
Coal	..	2
Clay	1	9
Coal	..	½
Clay	..	½
Coal	..	2
Carb. shale	1	2
Coal	1	10
Shale	8	..
Shale-black carb.	3	..
Shale	..	..
Total thickness	20'	3"

No. 2.

	Ft.	In.
Pure shale	..	..
Carb. shale	1	6
Coal	..	2
Carb. shale	2	8
Clay	..	2
Carb. shale	2	..
Hard flinty shale	..	..
Total thickness	5'	10"

No. 3.

	Ft.	In.
Sandstone	..	..
Coal	..	6
Carb. flinty lam. material	2	6
Carb. shale	..	7
Coal	..	4
Carb. shale	..	10
Carb. material	1	7
Shale	..	..
Total thickness	6'	4"

No. 4.

	Ft.	In.
Shale	..	..
Carb. shale	2	4
Clay	..	2
Carb. shale	..	6½
Coal	..	½
Hard shale	..	6
Carb. shale	1	..
Coal—good	1	..
Sandy shale	2	4
Carb. material (almost coal)	..	8
Carb. shale	1	1
Sandy clay	..	..
Total thickness	8'	8"

No. 5.

	Ft.	In.
Sandstone	..	..
Carb. shale	1	2
Shale, small am't carb. mat.	1	8
Coal, with st. of shale	1	..
Carb. shale	..	7
Shale, pure	..	4
Carb. shale	5	..
Sandy shale	..	..
Total thickness	9'	9"

No. 6.

	Ft.	In.
Shale	..	..
Carb. shale	1	6
Shale	..	4
Coal, good	..	7½
Shale	..	½
Coal and shale	..	8
Carb. shale and coal	..	10
Coal and shale	..	5
Shale	..	2
Coal	..	1
Carb. shale	..	5
Shale and coal	1	4
Carb. shale	..	5
Coal and carb. shale	..	7
Carb. shale	1	6
Total thickness	8'	1"

No. 7.

	Ft.	In.
Shale, sandy	..	..
Carb. shale	..	1
Coal, bony	..	1½
Shale and carb. shale	..	5
Shale and coal	1	4
Shale, pure	..	5
Carb. shale and coal	..	3
Shale	3	8
Carb. shale and coal	1	1
Coal, dirty	2	2
Shale	..	..
Total thickness	9′	4″

No. 8.

	Ft.	In.
Sandy shale	..	..
Carb. shale	1	..
Coal	..	1
Carb. shale	..	6
Coal	..	8
Carb. shale	1	..
Coal	1	2
Shale	..	1
Coal	..	3
Carb. shale	..	9
Coal	..	2
Carb. shale	1	2
Coal	..	7
Shale	..	3
Coal, bony, and carb. shale	..	8
Shale	..	3
Sandstone	..	4
Shale, sandy	5	10
Carb. shale	..	11
Shale	1	..
Coal	1	9
Shale, hard	1	8
Carb. shale	1	2
Coal	..	3
Shale	..	8
Coal	..	1
Carb. shale	1	2
Massive shale	..	..
Total thickness	21′	9″

No. 9.

	Ft.	In.
Shale	..	..
Carb. shale	..	11
Coal	..	3
Carb. shale	..	5
Shale, fissile, gray	6	2
Carb. shale	..	4
Coal	..	2
Carb. shale and coal	1	6
Shale	..	1
Carb. shale and coal	..	10
Shale	..	..
Total thickness	10′	8″

No. 10.

	Ft.	In.
Sandy shale	..	..
Carb. shale	..	4
Shale	..	2
Coal	..	6
Shale	..	9
Coal	..	1
Shale	..	3
Coal	..	7
Shale	..	2
Shale	..	..
Total thickness	2′	10″

No. 11.

	Ft.	In.
Carb. shale	1	..
Coal	..	3
Gray shale	..	3
Coal, bone	..	4
Shale	..	1
Carb. shale	..	11
Coal	..	4
Shale	..	1½
Coal	..	½
Carb. shale	..	2½
Shale	..	6
Coal	..	10
Coal, bony	..	10
Shale	..	1
Coal, bony	1	2
Carb. shale	..	3
Carb. shale	..	10
Shale	..	..
Total thickness	8′	½″

No. 12.

	Ft.	In.
Shale	..	..
Carb. shale	..	2
Coal	..	2
Shale	..	2
Coal	..	2
Coal, bony	..	8
Shale, sandy	..	6
Sandstone	..	..
Total thickness	1′	10″

No. 13.

	Ft	In.
Massive sandy shale	..	..
Shale	..	4
Coal, bony	..	9
Carb. shale and coal	1	..
Carb. shale and little coal	..	8
Shale	..	5
Shale, sandy	..	5
Shale, pure	..	8
Carb. shale	..	8
Shale, pure	..	1
Coal, bony	..	8
Shale	..	1
Carb. shale	..	5
Coal, bony	..	3
Carb. shale	1	8
Shale, fs. and carb	1	..
Sandy shale	..	5
Shale	..	3
Carb. shale	..	2
Sandy shale	..	6
Shale and coal	1	6
Carb. shale	1	..
Shale	..	5
Carb. shale	..	3
Shale	..	4
Carb. shale	..	11
Shale	..	6
Carb. shale	..	7
Shale	..	2
Massive sandstone	..	..
Total thickness	16′	1″

No. 14.

	Ft	In.
Shale clay	..	..
Shale	..	3
Bone	1	6
Coal, slightly bony	1	3
Carb. shale	..	3
Clay, wh. plastic	..	1
Carb. shale	..	9
Clay shale	..	..
Total thickness	4′	1″

No. 15.

	Ft	In.
Carb. shale	1	2
Coal	..	½
Carb. shale	1	..
Clay and coal	..	3
Coal	..	2
Carb. shale	1	..
Coal, bony	..	2
Carb. shale	..	8
Coal	..	1
Carb. shale	..	6
Shale	..	..
Total thickness	5′	½″

No. 16.

	Ft	In.
Shale	..	..
Coal—bone	..	9
Clay	..	4
Carb. shale	1	2
Shale	..	..
Total thickness	2′	3″

No. 17.

	Ft	In.
Shale	..	..
Carb. shale	..	2
Coal	..	8
Coal, bony	..	6
Carb. shale	..	11
Coal	..	2
Carb. shale	1	..
Coal, bony	..	3
Carb. shale	..	6
Clay, pure white	..	3
Carb. shale	..	2
Shale sandstone	..	3
Carb. shale	..	9
Coal, bony	..	9
Carb. shale	..	3
Carb. shale	1	..
Shale, hard	..	½
Carb. shale	..	1
Shale	1	6
Sandstone	..	3
Shale	..	10
Carb. shale	1	..
Coal, bony	..	6
Carb. shale	2	..
Shale	..	..
Total thickness	13′	11½″

No. 18.

	Ft	In.
Shale	..	..
Shale	..	5
Carb. shale	..	6
Shale, fine	1	10
Carb. shale	1	1
Shale, fine	1	8
Carb. shale	1	..
Sandstone, hard layer	..	5
Carb. shale	2	6
Shale, sandy	..	2
Coal, bony	1	..
Carb. shale	2	..
Clay	..	1
Coal, bony	..	10
Carb. shale	1	6
Shaley sandstone	..	..
Total thickness	15′	0″

No. 19.

	Ft	In.
Shale	..	..
Shale, hard sandy	..	4
Carb. shale	..	8
Coal, bony	..	2
Carb. shale	..	5
Coal, bony	..	1
Shale	..	3
Carb. shale	1	6
Shale and coal	..	8
Carb. shale	..	8
Coal	..	6
Carb. shale	..	5
Coal	..	½
Carb. shale	..	6
Carb. shale	..	5
Coal, bony	..	2
Carb. shale	..	6
Coal, bony	..	4
Shale	..	1
Carb. shale	..	3
Shale	..	2
Carb. shale	..	5
Coal, bony	..	1
Carb. shale	..	4
Coal, bony	..	11
Carb. shale	3	..
Blue-gray shale	..	..
Total thickness	12'	10½"

No. 20.

	Ft	In.
Sandstone	..	..
Carb. shale	..	8
Coal, bony	..	6
Carb. shale	1	..
Coal, bony	..	4
Carb. shale	2	..
Shale	..	3
Carb. shale	..	7
Shale	1	8
Bone	..	11
Carb. shale	1	4
Bone	..	5
Carb. shale	1	10
Sandstone	..	..
Total thickness	11'	6"

No. 21.

	Ft	In.
Shale	..	..
Carb. shale	..	6
Shale	..	2
Carb. shale and bone	1	1
Clay, white	..	3
Shale	..	2
Bony coal	..	11
Carb. shale	1	2
Coal, bony	..	3
Carb. shale	..	11
Shale	..	2
Carb. shale	1	4
Shale	..	4
Carb. shale	..	10
Shale	..	2
Carb. shale	..	7
Shale	..	2
Carb. shale	..	4
Bone	..	2
Shale	..	3
Carb. shale	1	1
Sandy shale	..	..
Total thickness	10'	10"

No. 22.

	Ft.	In.
Shale	..	..
Bony coal	..	6
Shale and layers of coal	..	10
Shale	..	2
Carb. shale	..	9
Shale and st. of coal	..	3
Shale	1	2
Bony coal	..	2
Shale	..	9
Shale and carb. layers	..	7
Carb. shale	..	3
Sandstone	..	1
Carb. shale	1	2
Shale	1	5
Sandstone	..	3
Carb. shale	1	..
Bony coal	..	10
Shale	..	1
Carb. shale	1	11
Shale	..	8
Carb. shale	..	3
Shale	..	4
Carb. shale	..	6
Bony coal	..	7
Carb. shale	1	3
Clay	..	..
Total thickness	15'	9"

No. 23.

	Ft.	In.
Shale	..	..
Shale	..	4
Carb. shale	..	7
Bony coal	..	4
Carb. shale	..	11
Shale	..	3
Carb. shale	..	3
Shale	..	3
Carb. shale	..	3
Bone	..	2
Carb. shale	..	5

Shale	..	6
Carb. shale	..	5
Bone	..	1
Carb. shale	..	3
Bone	..	9
Shale	..	3
Shale	..	7
Bone	..	2
Shale	..	7
Carb. shale	..	7
Shale	..	6
Carb. shale	..	6
Shale	..	5
Carb. shale	..	8
Shale	1	6
Carb. shale and bone	1	2
Bone	..	2
Carb. shale	1	10
Shale	1	1
Carb. shale	..	2
Shale	..	2
Carb. shale	..	4
Sandstone	..	10
Carb. shale	1	3
Shale	..	3
Carb. shale	..	8
Bone	..	6
Sandstone	..	2
Carb. shale	..	9
Bone	..	2
Carb. shale, bony	2	..
Shale	..	1
Carb. shale	..	10
Shale	..	1
Carb. shale	..	10
Shale	1	7
Carb. shale	..	2
Sandy shale	..	..
Total thickness	26′	7″

No. 24.

	Ft.	In.
Sandy shale	..	..
Carb. shale	1	1
Shale	..	4
Carb. shale	1	7
Bone	..	11
Shale	..	3
Bone	..	7
Shale	..	1
Carb. shale, bony	..	6
Shale	..	1
Bony coal	..	1
Sandy shale	..	..
Total thickness	5′	6″

No. 25.

	Ft.	In.
Sandstone	..	..
Carb. shale	..	9
Coal, bright, hard	..	4
Carb. shale	..	7
Bone	..	2
Carb. shale	..	4
Shale	..	..
Total thickness	2′	2″

No. 26.

	Ft.	In.
Clay, yellow, hard	..	..
Coal, bony, carb. shale	2	6
Clay, yellow, hard, massive	..	6
Carb. shale	..	3
Bony coal	..	2
Carb. shale	..	2
Clay, yellow	1	9
Coal	..	9
Bone	..	6
Bony coal	..	7
Bony coal	..	4
Shale	..	4
Carb. shale	..	2
Bone	..	5
Carb. shale	..	4
Coal	1	..
Coal, some bone	1	..
Coal	..	3
Carb. shale	..	3
Shale	..	..
Total thickness	11′	3″

No. 27.

	Ft.	In.
Shale	..	..
Coal, some covered, 8″ good	2	5
Sandstone	..	..
Total thickness	2′	5″

No. 28.

	Ft.	In.
Sandstone	..	..
Carb. shale	..	5
Bone	..	4
Clay	..	3
Carb. shale	..	3
Carb. shale st.	..	3
Carb. shale	..	7
Bony coal	..	6
Clay	..	2
Bony coal	..	8
Carb. shale	..	11
Shaley sandstone	..	..
Total thickness	4′	4″

No. 29.

	Ft.	In.
Sandy shale	..	..
Coal, good	1	3
Bony coal	..	11
Carb. shale	..	9
Bony coal	1	3
Shale	5	4
Carb. shale	1	..
Bony coal	..	9
Bone	..	1
Shale	..	1
Bony coal	1	11
Carb. shale	2	4
Shale and st. of coal	..	9
Carb. shale	..	6
Shale	..	7
Carb. shale	1	..
Bone	..	8
Shale	..	4
Bony coal	1	4
Coal	1	..
Carb. shale	1	3
Massive shale	..	..
Total thickness	23′	1″

No. 30.

	Ft.	In.
Sandstone	..	..
Carb. shale	..	8
Shale	..	1
Bony coal	..	3
Carb. shale	..	5
Bony coal	..	4
Carb. shale and bone	..	8
Carb. shale	..	7
Shale	1	3
Shale	..	6
Carb. shale	1	1
Shale, slightly sandy	4	3
Covered	1	7
Shale, slightly carb	..	10
Carb. shale	1	6
Shale	1	..
Bony coal	..	6
Carb. shale	..	9
Shale	..	..
Total thickness	16′	3″

No. 31.

	Ft.	In.
Shale	..	..
Carb. shale	..	2
Coal	1	3
Carb. shale	..	3
Shale	..	3
Coal	..	5
Carb. shale	..	2
Coal	..	5
Shale	..	1
Carb. shale	..	3
Shaley sandstone	..	..
Total thickness	3′	3″

No. 32.

	Ft.	In.
Shale sandstone	..	..
Carb. shale	..	9
Shale	..	4
Bone	..	4
Carb. shale	..	6
Bone	..	2
Carb. shale	..	3
Shale	..	2
Carb. shale	..	10
Shale	..	1
Bone	..	2
Carb. shale	..	4
Shale	..	2
Bony coal	..	3
Carb. shale	..	3
Shale	..	2
Bony coal	..	3
Shale	1	2
Bone	..	6
Coal, somewhat bone	..	9
Bony coal	..	5
Carb. shale	..	10
Shale	..	2
Carb. shale	..	3
Shale	..	8
Carb. shale	..	5
Bony coal	..	4
Carb. shale	..	8
Shale	..	2
Carb. shale	..	4
Bony Coal	1	2
Shale	..	2
Carb. shale	..	8
Shale, st. of coal	1	3
Coal	..	1
Carb. shale	..	4
Bony coal	..	5
Carb. shale	..	4
Shale	..	1
Bony coal	..	1
Shale	..	1
Carb. shale	..	7
Shale	..	1
Bone	..	2
Carb. shale and coal	..	6
Shale	..	4
Coal	..	4
Carb. shale	..	2
Shale	..	6
Bony coal	..	3

	Ft.	In.
Shale	..	1
Carb. shale	..	3
Bony coal	..	5
Shale	..	2
Carb. shale	1	2
Coal	..	2
Carb. shale and st. of coal	1	2
Shale	..	5
Carb. shale	..	8
Shale	..	2
Carb. shale and coal	..	8
Shale	..	2
Carb. shale	1	7
Shale	..	1
Carb. shale	1	3
Coal	..	1
Carb. shale	2	7
Coal	..	3
Carb. shale	2	..
Massive sandstone	..	..
Total thickness	33'	7"

No. 33.

	Ft.	In.
Shale	..	..
Carb. shale	..	4
Bone	..	2
Carb. shale	..	1
Bony coal	..	3
Carb. shale and coal	1	..
Shale	..	1
Carb. shale	..	9
Shale	..	1
Carb. shale	..	5
Shale	..	1
Carb. shale	..	3
Shale	..	2
Coal	..	1
Carb. shale	1	8
Carb. shale	..	6
Coal	..	2
Shale	..	1
Bone shale	..	2
Carb. shale	2	..
Bone	..	3
Covered	..	..
Total thickness	8'	7"

No. 34.

	Ft.	In.
Shale	..	..
Carb. shale	..	7
Bony coal	..	4
Shale	..	3
Bony coal	1	10
Shale	..	1
Coal, slightly bony	1	2
Bony coal	..	7
Carb. shale	..	3
Shale	..	4
Carb. shale	..	5
Shale	..	1
Bone	1	..
Carb. shale	2	7
Coal and shale	..	6
Coal	..	1
Shale	..	2
Bone	..	3½
Carb. shale	..	3
Coal and bone	1	5
Carb. shale	..	3
Bony coal	..	4
Carb. shale	..	3
Coal	..	5
Carb. shale	..	3
Coal	..	5
Carb. shale and coal	..	5
Bone	..	4
Bony coal	..	8
Shale	..	3
Shale, some bone	..	6
Carb. shale	..	2
Bone	..	7
Carb. shale	..	6
Sandstone	..	3
Carb. shale	..	7
Bony coal	..	5
Shale	..	5
Bone	..	7
Carb. shale	..	8
Bony coal	..	4
Bone	..	6
Coal	..	5
Bone	..	7
Carb. shale	..	9
Carb. shale and bone	1	3
Sandy shale	4	..
Carb. shale	..	2
Coal	..	5
Bony coal	..	2
Coal	..	8
Carb. shale	..	6
Bone	..	4
Carb. shale	..	8
Covered	2	8
Bony coal	..	7
Covered	..	10
Carb. shale	..	6
Shale	..	..
Total thickness	35'	9½"

No. 35.

	Ft.	In.
Shale	..	..
Shale, slightly carb	1	9
Carb. shale	..	4
Bone	..	6
Carb. shale	..	3

	Ft.	In.
Shale	..	2
Carb. shale	..	4
Sandstone	..	3
Carb. shale	..	9
Bony coal	..	6
Carb. shale	..	4
Shale	..	1
Carb. shale	..	3
White clay	..	2
Covered	1	3
Carb. shale	1	2
Shale	..	4
Carb. shale	..	4
Shale	..	2
Carb. shale	..	6
Covered	1	4
Carb. shale	..	2
Shale	..	..
Total thickness	10′	11″

No. 36.

	Ft.	In.
Sandstone	..	..
Bony coal	..	5
Covered	..	6
Bony coal	..	6
Carb. shale	..	4
Shale	..	1
Carb. shale	..	2
Shale	..	3
Shale, carb. layers	2	5
Carb. shale	..	8
Shale	..	11
Carb. shale	..	8
Shale	..	1
Bone	..	8
Covered	6	9
Shaly sandstone	..	..
Total thickness	14′	5″

No. 37.

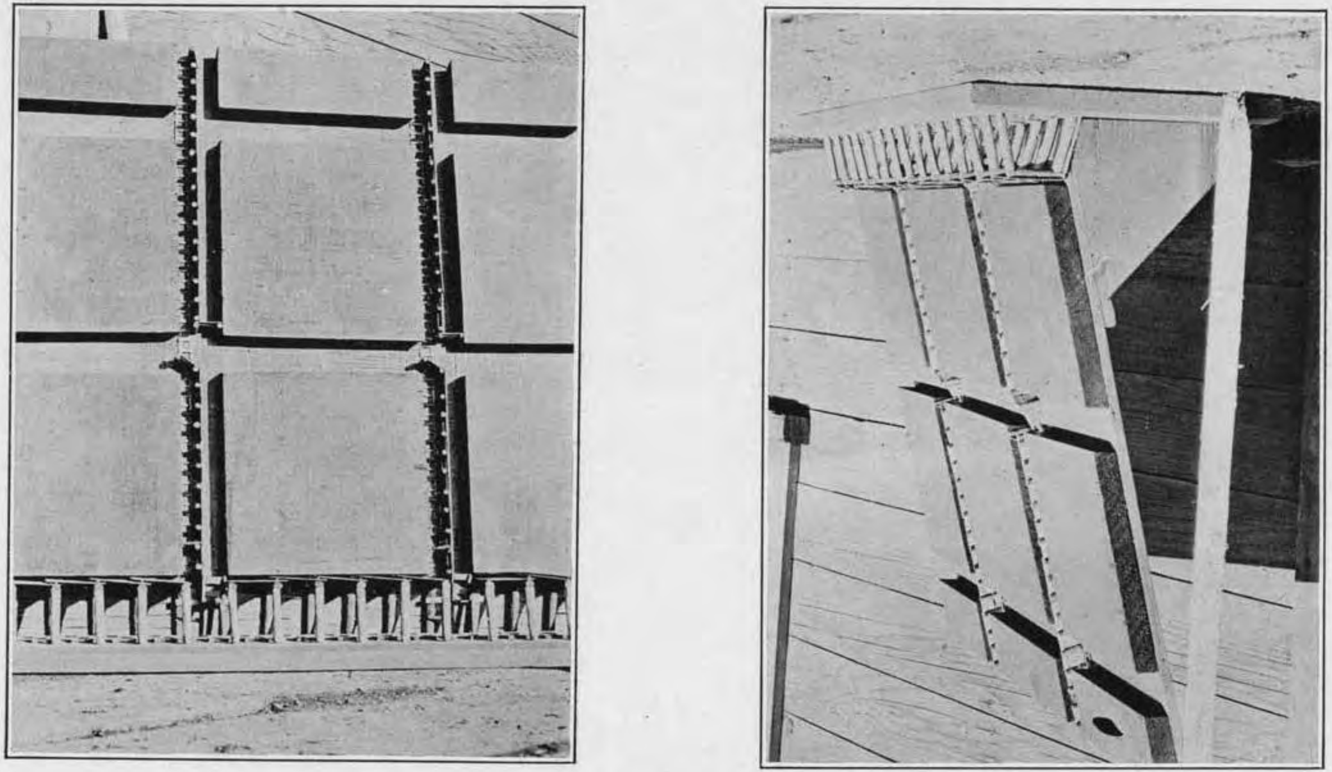
	Ft.	In.
Shale	..	..
Carb. shale	..	3
Covered	2	6
Carb. shale	1	4
Shale	..	1
Carb. shale	..	2
Shale	..	1
Carb. shale and some bone	2	1
Sandstone	..	4
Carb. shale	1	1
Shale, flinty	..	1
Carb. shale	..	2
Carb. and st. of bone	1	10
Bony coal	..	10
Carb. shale	1	1
Bone	..	3
Shale	1	6
Shale, slightly carb	1	3
Carb. shale	1	3
Shale	..	3
Shale & bands of carb. shale	1	6
Carb. shale	..	6
Shale	..	8
Waterfall	1	6
Bony coal	1	2
Carb. shale	..	6
Sandstone	..	5
Carb. shale	..	8
Bone	..	3
Shale and bone	..	5
Shale	..	6
Bone	1	2
Carb. shale	..	4
Shale	..	3
Carb. shale and bone	..	10
Sandstone	..	3
Bony coal	..	5
Sandstone and shale	..	3
Coal and lenses of bone	1	2
Shale	..	5
Carb. shale and bony coal	2	9
Sandstone	..	2
Carb. shale	..	1
Sandstone	..	3
Carb. shale	..	3
Sandy shale	..	5
Carb. shale	..	2
Sandy shale	1	2
Carb. shale	..	10
Sandy shale	..	..
Total thickness	35′	8″

No. 38.

	Ft.	In.
Shale	..	..
Carb. shale	..	3
Coal	..	2
Carb. shale and coal	..	8
Carb. shale	..	8
Carb. shale	..	11
White clay	..	1
Carb. shale	..	3
Shale, slightly carb	..	6
Shaly sandstone	..	..
Total thickness	3′	6″

No. 39.

	Ft.	In.
Sandy shale	..	..
Carb. shale	1	7
Good coal	..	2
Shale, slightly carb	2	..
Carb. shale and st. of coal	1	1
Shale	..	4
Carb. shale, almost bony cl.	1	3
Bony coal	..	9



Models showing methods of mining in Taylor Mine.

	Ft.	In.
Shale	..	4
Carb. shale and st. of coal	2	6
Boney coal, carb. shale	..	5
Shale fissile	..	11
Carb. shale	..	6
Shale	..	11
Carb. shale	..	6
Bony coal	..	5
Shale	1	5
Carb. shale	..	3
Shale	1	1
Shale	..	7
Shale, slightly carb	1	7
Shale, coarse, sandy	..	3
Carb. shale	..	9
Good coal	..	5
Shale, coarse, sandy	..	2
Good coal	..	1
Carb. shale	..	7
Coal	..	4
Carb. shale and st. of coal	1	4
Bony coal	1	..
Shale	..	..
Total thickness	23'	6"

No. 40.

	Ft.	In.
Shale	..	..
Shale, slightly carb	1	4
Carb. shale	..	6
Coal, broken	..	2
Carb. shale	..	5
Shale	..	8
Good coal	..	1
Shale, carb. and sandy	..	7
Coal	..	8
White clay	..	2
Carb. shale	..	8
Covered	..	10
Carb. shale and coal	..	8
Sandstone, coarse & shaley	..	7
Bony coal	1	4
Carb. shale	..	10
Carb. shale	..	3
Carb. shale	..	2
Bony coal	..	9
White clay and carb. bands	..	10
Carb. shale	..	6
Shale, sandy and coal	..	9
Good coal	..	10
Shale, sandy and coal	..	3
Shale, hard sandy	..	3
Carb. shale	1	8
Bony coal	..	3
Coal	..	2
Clay, sandy	..	10
Carb. shale	..	11
Shaley clay	..	..
Total thickness	17'	11"

No. 41.

	Ft.	In.
Snale	..	..
Bony coal	1	8
Carb. shale	1	9
Shale	..	6
Shale, slightly carb	1	8
Carb. shale and bands of cl.	1	6
Carb. shale	..	6
Clay, br. and sandy	..	1
Carb. shale	..	6
Clay, coarse sand	..	2
Shale, soft carb	..	7
Bony coal	1	4
Shale, soft carb	..	8
Bony coal, carb. shale	1	1
Shale	..	..
Total thickness	12'	0"

No. 42.

	Ft.	In.
Sandstone and coal bands	..	..
Coal	..	4
Carb. shale	..	4
Bony coal	..	9
White clay	..	2
Sandstone and coal bands	..	1
Carb. shale and st. of coal	1	..
Good coal	2	1
Carb. shale, graphitic	1	2
Good coal	..	6
Hard carb. shale	..	5
Shale	..	1
Carb. shale	1	6
Shale	..	..
Total thickness	8'	5"

No. 43.

	Ft.	In.
Shale	..	..
Carb. shale	..	4
Shale	..	4
Carb. shale	..	9
Bony coal	..	6
Coal	..	3
Carb. shale and st. of coal	..	10
Coal	..	3
Carb. shale	..	10
Bone	..	2
Carb. shale and coal	..	9
Carb. shale	1	1
Carb. shale and coal lenses	2	4
Shale	..	4
Carb. shale	..	8
Bony coal	..	5
Covered	..	10
Sandy shale	..	..
Total thickness	10'	8"

No. 44.

	Ft.	In.
Shale	..	..
Carb. shale	..	6
Bone	..	9
Bony coal	1	10
Shale	..	1
Bony coal	..	8
Shale	..	8
Carb. shale	..	4
Shale	..	..
Total thickness	4'	10"

No. 45.

	Ft.	In.
Shale	..	..
Carb. shale	2	4
Shale	..	1
Carb. shale and coal	..	6
Shale	..	2
Bone	..	3
Carb. shale	..	6
Bony coal	..	4
Carb. shale	..	7
Shale	..	2
Shale	..	4
Carb. shale	..	8
Shale	..	..
Total thickness	5'	11"

No. 46.

	Ft.	In.
Shale	..	..
Carb. shale	1	1
Bony coal	..	10
Carb. shale	..	6
Bony coal	1	2
Carb. shale	..	2
Bony coal	..	8
Sandstone, shaly	..	7
Bony coal	1	..
Carb. shale	..	7
Shale, slightly carb.	2	8
Shale	..	..
Total thickness	9'	3"

No. 47.

	Ft.	In.
Massive sandstone	..	..
Carb shale	..	3½
Bone	..	4
Shale	..	4
Shale and bone	..	3
Shale	..	4
Carb. shale	..	11
Bony coal and shaley	..	10
Shale	..	2
Bony coal	..	9
Shale	..	6
Covered	..	..
Total thickness	4'	8½"

No. 48.

	Ft.	In.
Shale	..	..
Carb. shale	..	10
Coal	..	2
Carb. shale	..	2
Bony coal	..	7
Shale	..	3
Coal	..	8
Covered	1	5
Sandstone	..	..
Total thickness	4'	1"

No. 49.

	Ft.	In.
Sandstone	..	..
Carb. shale	..	4
Bone and st. of coal	1	8
Carb. shale	..	10
Sandstone	..	..
Total thickness	2'	10"

No. 50.

	Ft.	In.
Unknown	..	..
Met. coal, shale & quartzite.	3	..
Met. coal, shale & quartzite.	1	9
Quartzite	..	8
Covered	3	8
Carb. shale	2	..
Covered	3	..
Met. coal and s. s.	1	10
Covered	4	6
Bony coal	..	6
S. s. st. of coal	2	8
Bony coal	..	10
Shale	..	4
Bony coal	..	6
(Covered) shale	..	9
Carb. shale and st. of coal	1	7
Sandstone	..	7
Bone	..	8
Shale	..	..
Total thickness	28'	10"

No. 51.

	Ft.	In.
Shaley sandstone	..	..
Bone	..	4
Coal	..	3
Bony coal	..	9
Sandstone	..	4
Coal		5
Carb. shale	..	5
Bone	..	1
Shale	..	5
Coal, bone	..	6

	Ft.	In.
Shale	..	2
Bony coal	..	6
Shale	1	2
Bony coal	..	8
Coal	1	5
Bony coal	..	6
Coal	..	8
Carb. shale	..	4
Bony coal	..	10
Carb. shale	..	6
Shaley sandstone	..	..
Total thickness	10′	3″

No. 52.

	Ft.	*In.*
Sandstone, covered	..	..
Bony coal	..	10
Coal, good	..	9
Bone	..	4
Carb. shale	..	9
Sandstone, shaley	..	..
Total thickness	2′	8″

No. 53.

	Ft.	*In.*
Sandstone, quartzite	..	..
Bone	..	2
Shale	..	2
Shale	..	3
Carb. shale	..	11
Shale	..	2
Bone	..	4
Carb. shale	..	1
Bone	..	4
Carb. shale	..	1
Bone	..	4
Carb. shale	..	1
Bone	..	6
Sandstone	..	5
Bone	..	3
Carb. shale	..	7
Shale	..	2
Carb. shale	1	..
Shale	..	3
Covered	1	5
Shale, carb.	1	6
Covered	..	..
Total thickness	9′	0″

CHAPTER IV.

THE CLASSIFICATION OF COAL LANDS.

GENERAL STATEMENT.

The following statements on the classification of coal lands in King county are in general keeping with a report written by Mr. George H. Ashley and published by the United States Geological Survey as Bulletin No. 424. The object in presenting this part of the report is to call attention to the many factors that enter into the question of the classification of coal lands. Much has been printed in the daily press as to the great profits from mining coal and the natural conclusion is drawn that all coal lands are valuable, and the erroneous idea prevails with some people that all coal lands are equally valuable. This is far from the truth. There are many areas in which coal beds outcrop, where, owing to the character of the coal or the geological conditions surrounding it, the coal can not be mined and marketed at a profit, and hence is of no value as coal land. On the other hand, there are areas where the coal is of good quality, mining conditions are good and the coal can be mined at a profit. It is the endeavor in this report to cover the various areas in King county and classify them into the following subdivisions:

Known coal areas.
Probable coal areas.
Known coal areas, unworkable.
Areas, principally of igneous rocks.
Areas where the contents are unknown.

SOURCE OF VALUE OF COAL LANDS.

Coal land derives its value from the fact that the coal underlying its surface is of such a character that it can be profitably mined. When land is known to contain workable coal and of a character that it can be mined and marketed at a profit, the land containing such coal should bring a price corresponding to the character, amount and condition of the coal beds contained within this land.

Coal is a commodity that is eagerly sought for and is almost of universal use. The cost of transportation, rival fuels, such as imported coal, wood and oil, have direct bearing on the price that any coal will bring on the open market. For example, if the coals at some of our local mines are so high in ash and the costs of mining are such that these coals cannot be mined, cleaned and transported to the market and successfully compete with other coals, local or imported, wood or oil, then this land at this time has very little market value as coal land.

PRICES OF COAL.

The price of coal may be taken as the price at the mine or the selling price at the retail bunker, less transportation, bunker charges, etc. It will be simpler and more convenient to consider the price of coal as the price at the mine.

A little study will convince one that the price of coal should vary according to its value as a heat producer. Coals like the McKay coal at Franklin, Black Diamond and Ravensdale are more valuable than other coals, such as those mined at Newcastle, Issaquah and Grand Ridge, for the reason that the McKay coal is higher in B. T. U. (British Thermal Units), lower in ash and moisture, and is in all respects a better coal than the other mentioned coal, and should command a correspondingly higher price.

The sale price of coal at the mine may be divided into

1. Cost of coal in the ground.
2. Cost of mining, transporting to surface, and washing or preparing for the market.
3. Profit.

The cost of coal in the ground may be calculated in different ways, such as the cost of the coal when purchased as coal land, either from the government or from individuals. In the first case the former price was twenty dollars per acre if the area was within fifteen miles of a completed railroad, and ten dollars per acre if more than fifteen miles away. This law was in force prior to 1906. Since then the law has been changed and all unoccupied lands are now classified as coal or non-coal land and sold according to a tonnage estimate of the coal in the ground at so much per ton. In purchasing from an individual the surface right might be separate from the right to mine coal. The cost of coal might also be the royalty paid on a leasehold at so much per ton and with a minimum yearly royalty.

The cost of removing the coal from the ground and preparing it for market includes all costs of equipment, labor, materials, interest on the investment, cost of marketing and amortization (or a fund laid aside for recouping the equipment when rendered useless). It includes also an accident or insurance fund. These costs are usually considered "fixed charges."

The profit, if any, is necessarily the difference between all the costs combined and the selling price of the coal.

In purchasing an area underlain with coal it is always necessary to consider how long it will be before the coal is actually mined and marketed. This is an important item, for it is necessary to figure the interest on the investment and the accumulating taxes. The price per ton at which a coal can be leased and paid for by the ton as it is mined is usually considered the best basis on which to place a value on the coal in the ground. In considering this item it is necessary to take into account the supply and demand. For example, the McKay coal of Black Diamond is nearly always in demand and commands a correspondingly high price, whereas the coals of other beds from this or other mines may have less demand and a correspondingly lower price. The same is true of the lignite coals that are mined in Lewis county. There is little demand for the Lewis county coals at present, hence the lands are not as valuable as they will be at some future time when the market conditions change or some better method is devised for burning this low grade coal.

Therefore, it is obvious that such coals as the McKay can be leased at a considerable higher figure than the lower grade coals, and that a person owning lands underlain with the lower grade coals should be willing to lease at a low price so that he could get returns soon. In general, the leasing prices in King county range from ten cents to as high as forty cents per ton, the bulk of the leases being twenty-five cents per ton as the coal is being mined, with a minimum royalty of about fifteen hundred dollars per year per section.

Below is given a list of royalties paid in some coal districts of the United States; all except the royalties for Washington were selected from Bulletin No. 424, U. S. Geological Survey, page 10.

ROYALTIES PAID IN SOME COAL DISTRICTS OF THE UNITED STATES.

LOCALITY	Royalty in Cents	Minimum Yearly Royalty	Bonus on Lease
Pennsylvania:			
Anthracite fields	Up to 50		
Clearfield district	5 to 15	$1,000 per 100 acres	None
Connellsville district—			
Coal	16 to 20		
Coke	24 to 30		
Pittsburg district	10 to 15		
Ohio:			
Massillon district	10 to 15(a)		½ cents ton
Hocking Valley district	8		
West Virginia:			
Fairmont district	6	$600 to $300,000	None
Pocahontas district—			
Coal	10 to 15	$12.50 an acre to $45,000	$25 an acre to $200,000
Coke	15 to 24		
Kanawha district	5½ to 10	$10 per acre to $20,000	$25 an acre
New River district	10	$10 an acre	$25 an acre
Kentucky:			
Northeastern Kentucky district	8 to 12	$300 to $500	None
Southeastern Kentucky district	10 to 11		
Western Kentucky district	3		$100 to $500 a year
Tennessee:			
Jellico district	10		None
Alabama:			
Walker County district	7 to 10	Amount equivalent to taxes on land	
Jefferson County district	7 to 12½	$100	
Indiana:			
Vigo County district	3		
Greene County district	4 to 10(a)	$100 to $200	None
Evansville district	2 to 3½		
Illinois:			
LaSalle district	10 to 25(a)		$15 to $50 an acre
North Illinois district	5		
South Illinois district	2		
Arkansas	3		
Oklahoma	8		
Colorado:			
State lands	10	$100 to $500 ?	
Boulder County district	8 to 27½		
Trinidad district	8 to 12½	Up to $20,000	
Routt County district	8 to 10		
Wyoming:			
Wyoming state lands	2 to 6		
Southwestern Wyoming	10		
Small local mines	Up to 100.		
Indian reservations	8 to 10		
Utah:			
Small mines	Up to 75		
Montana:			
Miles City district	15		
Roundup district	15		
Washington:			
King county	10 to 40		

(a) Royalty computed on screened coal; in other districts royalty computed on run of mine.

In the table below is given the terms of some of the leases on record in the King county auditor's office in Seattle. These areas are all in King county and are all leased by the same company. It is stated on the authority of some people who have recently made leases that more recent ones have been made on a 25 cents per ton basis and a minimum yearly royalty of $2,500 per section:

DATE	Section	T.	R.	Royalty	Minimum Yearly Royalty	Years to run
November, 1904	15	21	6	15c. (a)	$1,500 (b)	20
	23	21	6	15c. (a)	$1,500	20
January, 1896	NE¼ 21	21	7	15c. (a)	$750	25
	S½ 15	21	7	15c. (a)	$750	25
April, 1899	NE¼ 23	21	7	15c. (a)	$1,000	20 (c)
1901	680 acres	24	6	10c. (a)	$3,000	20 (c)

(a) Per ton of 2,240 lbs. (b) Plus taxes. (c) Timber at $1.00 per thousand. Mine props 2c. each.

Generally speaking the amount of royalty charged depends upon the character of the coal. However, there are exceptions to this statement, for in Colorado a lower rate is charged for the high grade Trinidad coal than is charged for the lower grade coal near Boulder. This is due to the fact that the Boulder coal is closer to the principal market (Denver).

It will be noticed that the royalties in Illinois and Indiana are very low, due to the fact that there is such an abundance of coal within these areas and the owners are contented at receiving a small earning for their properties rather than allow them to remain idle indefinitely.

The highest royalties charged, such as those in Wyoming and Utah, are due to the local conditions. In the Appalachian region there is no marked difference except in the case of anthracite and the high grade coking coals. These prices are high for the reason that the quantities of these coals are limited and command a correspondingly higher market price.

Royalties in the east are on the increase. The same condition will undoubtedly prevail in the State of Washington especially in the better grades of coal, which are rapidly becoming exhausted.

ROYALTIES AND LAND PRICES.

A coal bed one foot thick with a specific gravity of 1.35 (which is the average specific gravity for bituminous coal) will contain approximately 1,750 tons per acre. Fifteen hundred tons per acre-foot production is considered very good mining, and as a rule about thirteen hundred tons per acre-foot is the average. However, in order that the operator be given the benefit of the doubt, it may be assumed that only one thousand tons per acre-foot be recoverable; then with a coal bed such as the McKay of Franklin and Black Diamond, which averages about five feet for the lower bench, we would get five thousand tons per acre for this bed alone. If the value of the coal in the ground be based on the royalty rate, we would have, at ten cents per ton, a value of $500 per acre for the one bed alone; and obviously if the royalty were twenty cents per ton we would have a valuation of $1,000 per acre. As an example of the value of coal land, based on a royalty basis, Ashley quotes an instance where the Pittsburg bed in the Connellsville region, which averages seven feet thick, brings a royalty of from sixteen to twenty cents per ton, so that this land would yield on a royalty basis from $1,400 to $2,100 an acre, and it is stated that this land brings a price of $1,700 to $2,000 an acre. If this Connellsville land is not worked out for a period of ten years, the land at the end of that time, when the rate of interest is five per cent., and is compounded, along with a tax rate of $1.50 per $100, will bring more than $3,000 per acre. As a matter of fact, the leases made today are calculated with this future value in view. In Colorado there are instances where the exact contents of the land were known and where the land was purchased on a full value of ten cents per ton royalty, calculated on one thousand tons per acre-foot recovery.

*"In general, however, the sale price of coal land must necessarily be less than the gross royalty income that the same land would bring at the prevailing royalties. In the first place, the net royalty income derived by the lessor may be quite different

*Ashley, George H., U. S. G. S. Bulletin No. 424, pp. 13-14.

from the gross income. There is the cost of collection, and possibly of inspection, which may amount to five to ten per cent. or more of the gross income. In the second place, the operator who buys his coal land rather than leases it must pay interest and taxes on it from the time of the purchase until the coal has been mined out. These should be computed on the average length of time each acre is carried. If mining is started immediately after purchase and is continued regularly for twenty years, the average time of carrying the coal will be ten years. The first cost of the land may be increased one-half to three times or more, the increase depending on the rate of interest, so that a tract of land bought for $100 an acre may have actually cost $150 to $300 or more an acre by the time the coal is mined. In other words, an acre of land that, when mined ten years hence, would yield $500 in royalties would be worth today, if interest is five per cent. and taxes are left out of account, $314; with interest at seven per cent. it would be worth today $253; at ten per cent. only $108. Taxes would still further decrease these amounts. If twenty years be taken as the life of the average active mine, the first acre of coal will be mined out the first year, the last acre the twentieth year, and the average acre in ten years. On a tract of land, therefore, that, it is confidently estimated, will be mined out within twenty years, the purchase value can hardly be more than one-half the estimated royalty value. If that value be again cut in half on the possibility that the estimated tonnage may be too large, the buyer is made doubly secure; and a still further reduction from one-fourth to one-fifth the estimated royalty value, such as is made on the highest government valuations, is just that much more in favor of the buyer."

It may therefore be confidently said that where the conditions are favorable to the almost immediate development of a piece of coal land, its purchase value may be estimated at from one-fifth to one-half its estimated royalty value. The estimated royalty value may differ from the actual royalty value by as much as the estimated amount of coal in the land differs from the actual amount. Exceptionally the estimate may be larger than the actual value, but as a rule, since the estimate must be made on only a part of the facts, it will fall below the real value.

GOVERNMENT METHODS OF VALUATION.

The government in arriving at values on its public lands, rates the value per ton in the ground at one-fifth the royalty value, and this on a basis of 1,000 tons per acre-foot. This estimate applies only to a single bed, the other beds, if there are any, being rated at a lower figure and usually as follows: the second bed at one-eighth its estimated royalty value, the third bed at one-twelth, and any other bed at one-sixteenth of the royalty value. In general the price for land containing several beds will average about one-tenth the estimated royalty value. This is true for the higher grade bituminous coals, while the lower grade coals are scaled down according to their calorific values.

FACTORS THAT AFFECT THE VALUE OF COAL LANDS.

Some of the factors that affect the value of coal lands are as follows:

1. Quality or character of coal.
2. Quantity of known coal.
3. Competition.
4. Knowledge of coal content.

All these factors have direct bearing on the value of the land, and they change appreciably from place to place.

QUALITY OR CHARACTER OF COAL.

The selling price of a coal should be proportional to its quality, but this is not always the case, since some very inferior coals occasionally sell for the same price as better grades of coal. This is perhaps due to the clever advertising on the part of some operators, and the lack of information on the subject on the part of the unsuspecting public. Of recent years there is more attention paid, especially among the large consumers, to the heating value of coal and many large contracts are let on the agreement that the coal will come up to a specified standard of B. T. U. (British Thermal Units) and a certain specified minimum per cent. of ash. For example, the McKay coal at Black Diamond sells for a better price than the coal from Newcastle because the former is higher in B. T. U. and contains less ash than the latter.

In the Green River field of King county the geological column has been separated into three parts, named, from top to bottom, the Kummer, Franklin and Bayne series. The Kummer, or upper series, contains coals that are high in moisture and high in ash, and are, therefore classed as lower grade coals; while the Franklin or intermediate series contains the Gem, McKay and other beds, most of which are particularly good coals. The Bayne, or lower series, contains beds that are low in moisture but high in ash, and, while more desirable than the Kummer coals, are not as eagerly sought for as the McKay coal for general use. Hence any land underlain with the Kummer formation would be less valuable per acre for coal than the areas containing the Franklin formation, in which the McKay and Gem beds are not exhausted; also areas containing the Bayne series would be rated at a less price per acre than the Franklin areas. In other words, lands containing the better grade of coal should command a correspondingly higher price per acre. When the higher grade coals, such as the McKay and Gem, are exhausted there will necessarily be a greater demand for the lower grades of coal, provided there is no outside influence such as the introduction of Alaska or British Columbia coals to take the place of the better grade coals at about the same price.

When the better grades of coal are exhausted, then the lands containing the poorer grades of coal will become more valuable. If some cheap coal washing process were to be discovered and installed, so that the ash in the Bayne and Occidental coals could be removed at a minimum expense, then these coals would be in greater demand and the land containing these beds would have a correspondingly higher market price. Or, if some new use could be found for the lower grade coals, then would a greater market open for them and a better price be had for the land.

QUANTITY OF KNOWN COAL.

Throughout the eastern coal regions of the United States, particularly in Indiana and Ohio, the character of the coal beds is such that a very close estimate can be made of the coal content of a given tract of land. However in the greater part of King county the geological conditions, and the character of the beds are such that it is hazardous to make an estimate of the quantity of coal on an unimproved tract.

In the eastern part of the Green River field, in the vicinity of the Occidental, Bayne and Cumberland mines, the folds and faults are so frequent that it is difficult to state just what particular beds lie within given areas. Then again the beds themselves change in character within comparatively short distances, and, therefore, do not maintain a uniform thickness.

Again it is not always the thickness of the coal bed that determines the amount of coal that can be mined from it. Much depends upon the character of the roof and the system of mining that can be applied to a given area. It is sometimes possible to mine from a three-foot bed as much coal by the longwall system as can be mined from a four- or five-foot bed by other methods. Often in areas where there is more than one bed it is customary to mine only the best and most accessible bed, disregarding the future welfare of the others.

The methods of mining adopted are sometimes instrumental in losing large quantities of valuable coal. An example of this is found in the early history of the Franklin mine. Through mismanagement and incorrect mining methods there are today hundreds of thousands of tons of the famous McKay coal that can never be recovered. One of the mistakes made by operators is that too little attention is paid to the prevention of waste. If more managers would forecast, when planning the development of a certain bed, what effect the mining of such bed would have on the probable future mining of a lower grade bed, more of the apparent coal content of a coal area could be recovered.

It is also true that in certain areas the coal beds are faulted and the operators have been unable to find their continuation beyond the fault lines. An example of this is the closing of the Cedar Mountain mine, due to the inability of the miners to discover the bed beyond the fault.

Crushing of the coal within certain areas has often rendered the coal valueless within these crushed zones.

Another factor that makes the percentages of recovery of the apparent coal content less than the original estimate, is the absence of the bed within certain local areas. In the instance of No. 4 bed at Newcastle, there are hundreds of acres of this bed from which the coal was removed during the general period of deposition of the vegetal matter and even though the two walls are regular the coal originally between the walls is now missing.

It is equally true that all the coal in an excessively thick bed cannot be mined, so that the amount actually recovered from such a bed will be much less than the original estimate would indicate. Sometimes in estimating the value of an unusually thick bed, it is customary to separate the bed into fifteen-foot sections, considering the first fifteen feet as the first bed, the second fifteen feet as the second bed, the third fifteen feet as the third bed, and give them corresponding values.

COMPETITION.

Without competition our coal would command a considerably higher price than at present. As an illustration, some of the first coal mined in the Issaquah mine brought a price of $22 per ton in Seattle, but as soon as the Newcastle mines were opened the price of coal dropped very materially.

California oil is a factor that has had direct influence on the price of coal on the Pacific Coast. Within the past ten years the use of California oil has increased 27 times while the use of coal has increased less than twice. Many of the railroad and steamship companies are installing oil burners, where formerly they used coal. Should the production of California oil continue to increase, then local coal lands will continue to be in less demand, but, on the other hand, should the supply of California oil decrease suddenly, then will the demand for local coal increase with a bound and a correspondingly higher price be had for the coal lands. Were it not for competition of other coals and other fuels, then as high as $1 per ton could be had for the coal in the ground, since in parts of Utah as high as $1 per ton royalty is being paid, where local conditions preclude competition with other fuels.

The fact also that British Columbia coal, of a higher grade than most of our local coals, can be mined, transported and sold on the Seattle market at a price such that some of our local coals cannot compete with, is a factor against the development of some of our local coal lands.

It is sometimes stated that the Alaska coal field, when developed, will be a strong competitor of our local fields, and that coal land values will depreciate materially when the Alaska fields are opened. It is the confident belief of the writer, based upon a close examination of the Alaskan and local fields, that, with the exception of a little anthracite for domestic use, Alaska coal will have but little effect upon the Puget Sound market. Alaska steam coal cannot be mined and placed upon the latter market at a price that will compete with King county steam coal.

As an illustration of the very low value of a known coal area, the history of the Raging River coal field may be given. Some twenty years ago this field, reaching from near the town of Preston up the Raging river valley to the sawmill town of Kerriston, was exploited as the coming high grade coal field of the Northwest; in fact the old Seattle and International railroad (now the Snoqualmie branch of the Northern Pacific railway) was built primarily to develop this field. After spending many thousands of dollars in prospecting for coal, the promoters decided that because of the faulted and intruded character of the coal beds, the field could not be opened and placed on a competitive basis with other developed fields such as those about Issaquah, Newcastle, Black Diamond, etc.

In the above instance there were the coal outcrops (and some of the coal analyzed from this field showed that it was of high grade), and transportation provided, yet the expensive mining of the coal prevented its being mined and marketed on a competitive basis with other fields in which there are yet millions of tons of coal. This same illustration will apply to what is called the Tiger Mountain field, lying between Cedar mountain and Issaquah. The broken character of the formations in this field will prevent its being worked at a profit, so long as other better favored fields are supplying coal.

However the time will come in the future when the more favored coal areas will have become exhausted to such a degree that these broken areas will pay to mine. But the time of their development is so far in the future that it would not be just to class the latter areas as valuable coal lands at the present time.

As an example of the present value of lands that will be mined at some future time, Ashley,* in discussing the competitive value of coal land, says in part: "In one area in Utah the difference between the cost of mining and the selling price was $1.15. In another it was estimated to be $1.25. Suppose the future profit of mining at the first place be reduced to $1 per ton. The coal being mined is 22 feet thick, of which 14 feet is obtained, a recovery equal, at the conservative estimate of 1,000 tons per acre-foot, to an output of 14,000 tons per acre, selling for $14,000 more than the cost of mining. The land was originally purchased from the government at $20 an acre. It has therefore yielded an income (aside from the interest on $20) of $13,980. Suppose that an acre of such land were purchased January 1, 1910, and mined out within a year. It is evident that $13,000 an acre might be paid for it and yet the investment might yield fifteen per cent. Of course such conditions are rare and uncertain of continuance. The example given, however, shows that where competition is lacking or is controlled an acre of land just ahead of an active mine will yield a good return on a seemingly abnormally high purchase price. It is

*Ashley, George, U. S. G. S. Bulletin No 424, pp. 22-23.

usually impossible to purchase a tract so small that it will not take several years to mine out, and the interest and taxes on the land for the average number of years the coal is carried, together with the uncertainty that present conditions will continue, tend to reduce an apparently safe purchase price 50 to 75 per cent. or more.

"The preceding example may be looked at in another way. The lessor is actually receiving a royalty of 75 cents a ton, the other 40 cents being the profit of the operator. If such a tract of land, under lease at such a royalty, be mined out in twenty years and yield 14,000 tons per acre, what would it be worth to the owner at the beginning of the twenty years at a price that will yield ten per cent. interest on the investment, compounded annually, with taxes at one per cent. of the purchase value? If X equals the purchase price, then

$$X = \frac{14{,}000 \times \$0.75}{1(1.10^{10} + 20 \times 0.01)} = \$3{,}684.00.$$

Interest is computed for the average time the coal is carried, or ten year. This gives $3,684 as the purchase price that the lessor might pay and get ten per cent. on his investment, if only the items of interest and taxes be considered.

"Were the royalty only ten cents a ton, as doubtless it would be if competition were open, the same land, in the same time, would yield the lessor ten per cent on an investment or purchase price of $491 per acre, if the purchase covered only this one bed. Actually there are three beds under the land. These two prices, however, show clearly the possible difference in value in the West between land in one place, where there is competition, and in another where there is none. This land was purchased from the government for $20 per acre."

In the east, where competition is keen, and coal is abundant, coal lands are selling for a very low price. George S. Rice* states that coal lands in Illinois, containing two workable beds of coal, have sold for as low as $10 per acre.

*Transaction, American Institute Mining Engineers, Vol. XL, page 32.

KNOWLEDGE OF COAL CONTENT.

It is necessary to have a fairly accurate idea as to the quantity and quality of coal within a given area. In the eastern states, e. g. Pennsylvania, Ohio and Illinois, where the geology of the coal beds is so thoroughly known, it is possible to predict with a fair degree of accuracy the character and quantity of coal within a given area. In Washington, especially in the western part of the state, the geology of the coal fields has not been mapped in sufficient detail to give a very close estimate of the actual tonnage which a given area will yield. In King county the coal beds vary a great deal within very short distances; the adjacent strata vary also, so that it is next to impossible to identify a bed unless it is carefully traced from one point to another. One of the marked exceptions to this rule is the McKay bed at Franklin and Black Diamond. This particular bed is uniform over a considerable area, especially the lower bench of the bed.

In areas where coal outcrops are of frequent occurrence, it is not very difficult to trace a given bed from place to place. But in areas where the glacial drift covers the coal beds at depths varying from 10 to 200 feet, it is very expensive to prospect for the coal.

An example of an area that has been rather thoroughly prospected and where the coal content could be approximated with a fair degree of accuracy is the Newcastle-Coal Creek-Superior-Issaquah-Grand Ridge coal belt. Along this belt the various beds that outcrop at the old Newcastle mine can be traced with their local variations from Newcastle to the eastward through Issaquah and to the northeastward to Grand Ridge. While it might not be possible to identify particular beds at Newcastle as being the same beds at Issaquah or at Grand Ridge, yet it is reasonably certain that these beds with their local variations continue in the series as indicated. It is true that the beds vary from place to place, as they do within the limits of the old Newcastle mine, yet the total amount of workable coal within this coal zone may be estimated with reasonable accuracy.

As a contrast to the above field, the area lying between Cedar mountain and Ravensdale may be cited, where the bedrock is covered with varying depths of glacial drift. It is highly probable that the coal beds at Cedar mountain and the beds at Ravensdale represent areas that at one time were connected, so that it might be surmised that beneath the veneer of glacial sediments there exists a large field of coal that represents the continuation of the above mentioned coal beds. Because no coal beds are known to outcrop and little or no drilling has been done, it is impossible to state what the underlying coal resources may be.

An area representing conditions intermediate between the two extremes just noted is the area lying southeast of Franklin in T. 21 N., R. 6 E. In this district coal is found on its west margin along Green river and also on its east margin near the Northern Pacific railway. Between the two margins, wherever a drill hole has pierced the glacial covering and penetrated into the bedrock beneath coal has always been found. Since all data secured from outcrops and by drilling, indicate that the McKay bed passes through this area, it is reasonable therefore to assume that this is coal land and that it is of considerable value.

Not only is the area just described largely covered by glacial sediments, but there will be considerable difficulty encountered in the opening up of the coal beds, due to the presence of underground waters. Almost all of the area lying east of the Northern Pacific railway, in the vicinity of Durham-Kanaskat, Bayne-Cumberland, Veazie and Birch is drained by a system of underground streams. The water flows above ground until it reaches points immediately west of the railway, where the several streams sink underground through the gravel and probably follow along the contact between the glacial drift and the bedrock to various places along the course of Green river, where very large springs are produced. It is difficult to determine the amount and character of pre-glacial erosion within the coal fields and to estimate the amount of coal that was removed thereby. In mining such fields, where deep glacial deposits are the rule, it will always be necessary for the operator to leave a barrier pillar of coal between the mine workings and the outcrop of coal, to prevent the water flooding the mine. Therefore it will be seen that a portion at least of this coal must necessarily be lost as barrier pillars. It will sometimes happen that mines will be flooded and very much coal lost due to the breaking in of the ground waters. Hence it will be seen that there are many factors that enter into an estimate of the minable coal contents of an area.

CHAPTER V.

THE COAL MINES OF KING COUNTY.

BLACK RIVER MINE.

In the north half of section 24, T. 23 N., R. 4 E., at Black River Junction, a mine was opened in the latter part of the

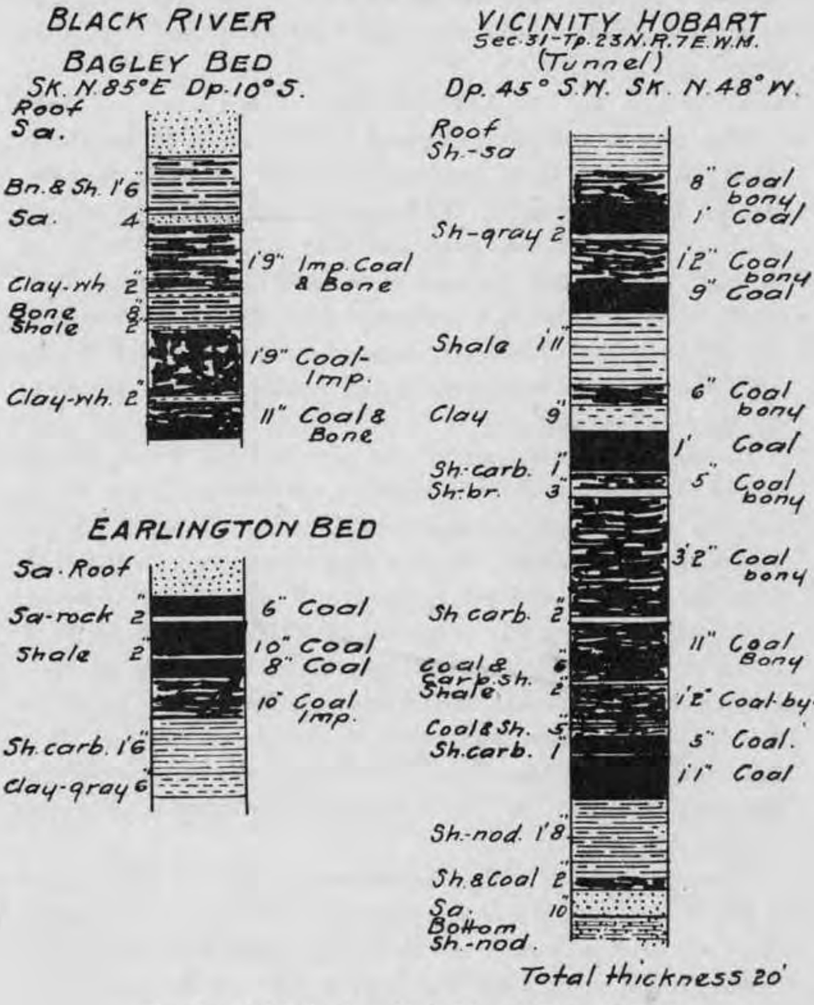


FIG. 2. Coal Beds along Black River and near Hobart.

eighties. A small slope was sunk for a distance of 207 feet on the bed which dips to the north at 25 degrees. At the foot of the slope the bed flattened considerably, evidently approaching the syncline that lies between this point and the beds that outcrop north of the Columbia and Puget Sound railroad in section 13.

No great amount of work was done here, but the writer is informed that what coal was mined was of good quality. The mine was closed in 1892, and has remained closed since that date.

RENTON MINE.

This mine was originally opened in 1874 by E. M. Smithers, T. B. Morris and C. B. Shattuck, who with others formed the Renton Coal Company. The coal was transported by a railroad to the Duwamish river and then shipped by barge to Seattle. About 1886 the mine closed and did not reopen until 1895, when the Renton Cooperative Coal Company took over the property and sunk a new slope to a depth of 584 feet. In 1901 the mine was purchased by the Seattle Electric Company, the present operator.

In the early development of the mine, bed No. 2 was opened on the Cedar river side by means of a water-level. Later No. 2 bed was opened from the first level south on the No. 1 bed by means of a rock incline. After a time a rock tunnel was driven from the second level north on the No. 3 bed to the No. 2 bed. The north gangway was driven about 1,150 feet, and south of the rock tunnel the gangway was driven about 2,100 feet. Later a rock incline was driven from the fourth level south on the No. 3 bed. Gangways were driven about 300 feet each way on this level. Also a water level tunnel was driven from the fifth level south to the No. 2 bed, but very little mining was done at this point.

The principal bed in the Renton series is No. 3. It underlies 1 and 2 at a distance of 85 feet below the latter. The main slope was originally sunk on this bed. Later a rock tunnel was driven from a point below the outcrop through the underlying

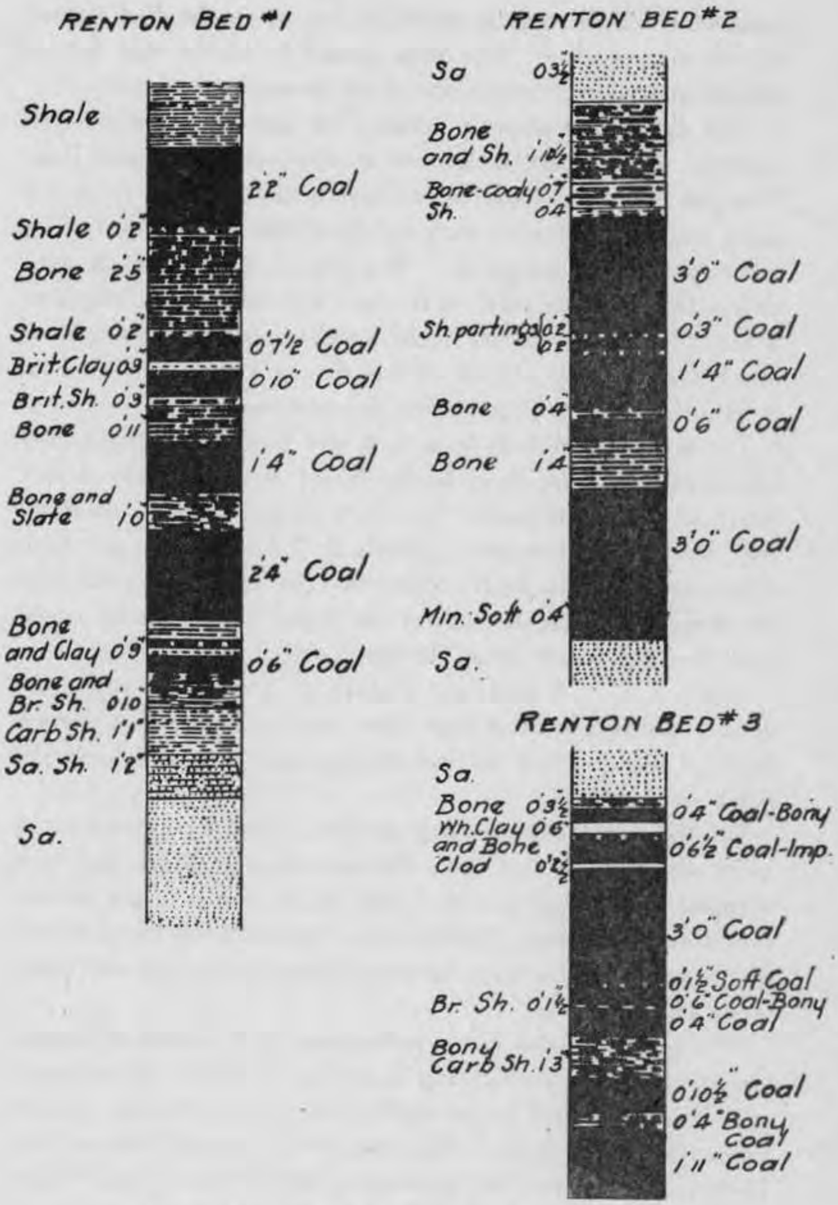


FIG. 3. Cross-sections of Beds 1, 2, and 3 at Renton.

sandstone. This rock tunnel comes out at the level of the top of the coal washer. The rock tunnel is nearly 900 feet in length, and intersects the slope at the second level north.

The dip of the slope is between 10 and 11 degrees and is uniform, except that it flattens a trifle near the ninth level. Ten gangways north and south have been turned off from this main slope at distances varying from 250 to 300 feet along the slope between gangways. The slope is a single track slope and is 15 feet in the clear at the top, with an average height of 7 feet. Nine car trips are hauled up the slope, each car holding about 2,800 pounds of coal. From the top of the slope the coal is hauled by means of an electric locomotive.

Levels numbered 1, 2, 3, 4, 5, 6, and 7 north are practically abandoned. All of these levels, except 6 and 7 were driven north of the north fault. This is a normal fault of above 20 feet vertical displacement. Levels 6, 7 and 8 have not been driven north of this fault. Gangway No. 10 north is the only one being driven on this side of the slope. Coal is being mined from levels 8, 9 and 10 on the north side.

Levels 1, 2, 3, 4, 5, 6, and 7 south are also practically abandoned. Level 6 south is kept open as a water way. A normal fault of about 6 feet vertical displacement was struck on the south side.

On the south side a sharp synclinal fold was struck at a point about 5,200 feet from the main slope. Work has been stopped on the eighth level at this point, owing to the broken condition of the coal. Levels 9 and 10 south are being driven at present. Coal is being mined in the eighth, ninth and tenth levels south.

The coal is hoisted in the main slope by a Litchfield engine, size 20x42. Electric lighting is used in the mine. Electric tail rope haulage is used in the eighth level south, while the rest of the haulage is by mules. The mine is ventilated by means of a 15-foot McCrimmon fan, producing 56,000 cubic feet. Electric pumps are used, consisting of three turbines, two four-stage and one three-stage pumps; also three electric plungers, two pumping 400 gallons per minute, through a four-inch pipe, and one 50 gallons through a two-inch pipe.

The plan of working is by the breast and pillar system. In ventilation it is the aim to have the air go up or down the plane,

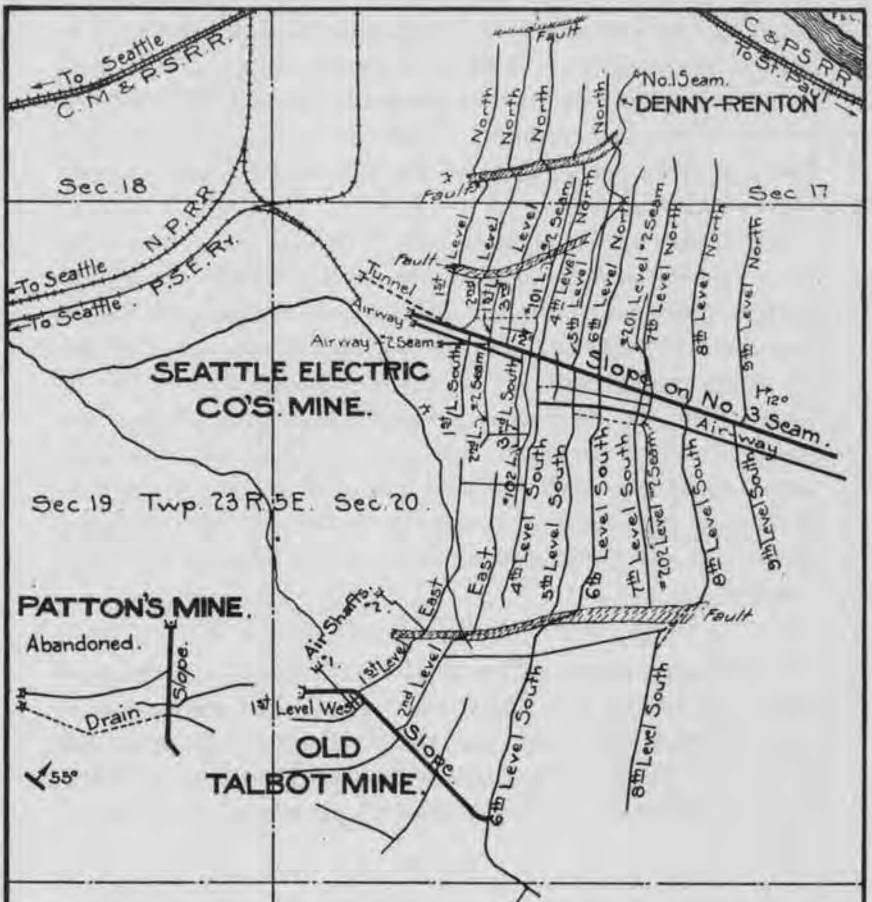


Fig. 4. Map of Mines at Renton.

depending upon most favorable conditions. When the upgoing plane is within about 60 or 70 feet of the gangway above, the bottom bench of coal is left intact and a chute is driven in the upper bench. This is done in order that the water from the upper gangway will not trouble the lower level.

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After the plane is driven to the gangway above a level, a breast 20 feet in width is started and driven 120 feet. All the coal up the pitch above the lower rib is mined. The coal is loaded in cars at the face of the breast, the cars are pushed out to the side of the plane, at this point the car is pulled up the pitch to a back switch, then let down the plane by means of an electric hoist. Two-car trips as a rule are used.

Experience has shown that ordinarily 45 to 50 feet between breasts is the best distance. However, conditions vary from place to place and the size of the pillars must vary to meet these conditions.

The former system of mining was to drive diagonal breasts up the pitch at about 70-foot centers. After experimenting with various methods, the present system has been adopted as the best for this particular bed. Overlying the coal bed is a clod, 30 inches thick, consisting of clay and bone. This clod is removed when the pillar coal is being mined. An attempt was made in former times to hold this clod up, but experience proves that it is much better to remove it. With the present system, as high as 95 per cent. extraction has been obtained. At present about 800 tons per day are mined during the winter months.

DENNY-RENTON CLAY & COAL COMPANY.

The Denny-Renton Clay & Coal Company's gangway is driven on bed No. 1 of the Renton series. The gangway is in about 2,300 feet on coal. This bed overlies No. 2 Renton about 110 feet. The coal from this mine is used entirely for power and burning bricks at the company's brick plant at Renton.

PATTON MINE.

The Patton mine was opened in 1872. It is located in the S. E. ¼ of S. 19, T. 23 N., R. 5 E., southwest of the town of Renton. A slope was sunk on one of the Renton beds at this point and gangways driven to the east and west. The dip of the beds at this point is from 7 to 8 degrees, dipping a little east of south.

The foot of the slope approached the axis of the Talbot syncline. Only two levels were worked to any extent at this mine.

CEDAR MOUNTAIN MINE.

This mine is located in sections 29 and 30, T. 23 N., R. 6 E. Coal was first shipped in July, 1884, but in 1888 the slope was abandoned. A new slope was started on the opposite side of Cedar river in 1888, which was sunk to a depth of 500 feet. In March, 1892, this mine was closed and was not reopened until December, 1895. In 1897 a new slope was sunk on the same side of the river as the first slope. In all there were three slopes sunk, and a long drift driven from the outcrop of one of the beds.

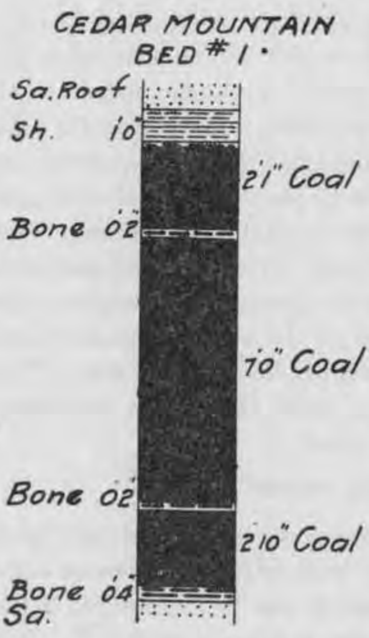

FIG. 5. Cross-section of Bed No. 1 at Cedar Mountain.

On bed No. 1, which is the bed farthest up the river, a slope was sunk on the east side of the river and two levels worked. As the lower gangway was driven north the coal came out in a crushed condition, showing evidence of considerable disturbance. To the southwest the gangway struck the fault that crosses the beds west of Cedar river. This bed dips at an angle of about 27 degrees.

Beneath bed No. 1 is bed No. 2, which was opened by a water level gangway. From a point on this a slope was sunk to a lower level. A fault was struck to the west of this slope, at the place indicated on the accompanying plate. This bed dips to the southeast at about 14 degrees.

This mine is closed at present and has been closed for the last six or seven years. Attempts are being made at present to find the beds southwest of the fault. If the beds are found to be fairly regular beyond the fault, it is likely that the mine will be reopened and become once more a producer of coal, that, when clean, found favor in the local market.

MAY CREEK COAL COMPANY.

This company has within the past three years been developing a new coal area at Coalfield, in S. 2, T. 23 N., R. 5 E.

At present there is a slope down 325 feet on a bed that dips southerly at an angle of 64 degrees. From the bottom of the slope a rock tunnel has been driven south across the strata a distance of 400 feet. While the slope bed dips south beyond any doubt, the other two beds struck in the rock tunnel at a point south of the slope, stand nearly vertical. The managers are satisfied that they have the Newcastle series on the opposite dip. They are at present sinking a shaft through the gravel to strike a bed which they believe is one of the upper Newcastle beds. Only enough coal is hoisted to supply the local demand. If the coal series proves to be what they think it is, a new and important field will be opened at this place.

NEWCASTLE-COAL CREEK MINE.

The first opening of the Newcastle coal mine was in S. 27, T. 24 N., R. 5 E. A water level drift was driven on either the upper or lower split of what is now called the No. 3 bed. These splits come together near the east line of section 27. This tunnel was continued from the junction of the two splits on the full bed eastward into section 26, and, at a point just east of the center of the section, a slope was sunk to the fifth level, or four lifts below water level. While this work was progressing in section 26, a slope was also being sunk to the westward on the lower split of the No. 3 bed, at that time called the No. 2 bed. The main slope was sunk to the third level.

The old Coal Creek mine in section 26 caught fire and the mine in section 27 was rapidly developed. In time the coal was prac-

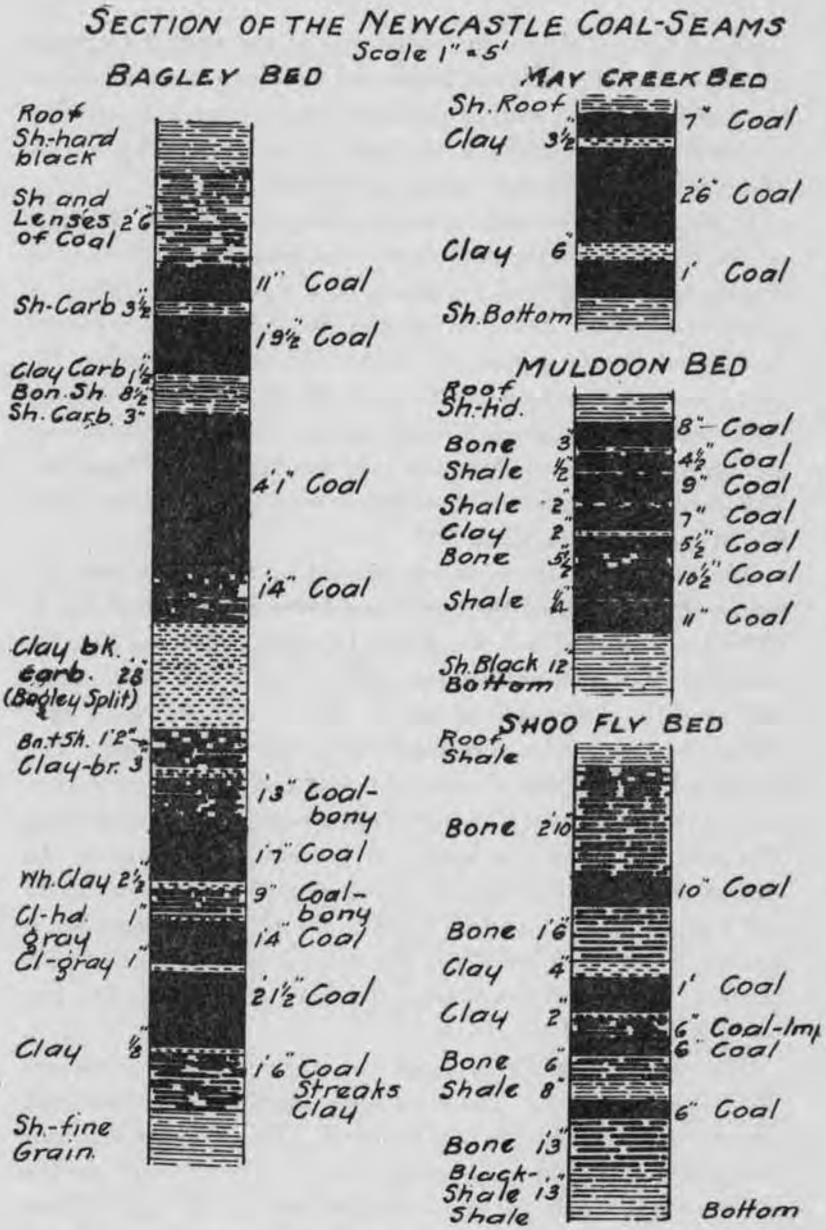

FIG. 6. Cross-sections of the Bagley, May Creek, Muldoon and Shoo Fly Beds at Newcastle.

tically exhausted within the boundaries of the company's property in section 27. Several faults and rolls were encountered in the workings of this section and there was more or less variation in direction of the strike of the beds. The average dip in this area was about 40 degrees to the northward.

While the old Newcastle mine was being worked out, the drift on No. 3 bed was being pushed eastward into section 25 and the Bagley bed was opened by means of a water level drift at a point east of the center of section 26, and driven eastward to the east line of section 25. Near the center of section 25, going eastward, a split occurred in the Bagley bed, separate drifts being driven on each of the splits. Near the east line of section 25 the splits are found to come gradually closer together. The Newcastle mines are distributed over three sections, viz., 27, 26 and 25, T. 24 N., R. 5 E.

The old Newcastle mine was opened in section 27 first by means of the drifts on the upper and lower splits of bed No. 3. (The lower split of bed No. 3 was formerly called bed No. 2.) The slope was sunk on the lower split of bed No. 3 to the third level, and the upper split of bed No. 3 and also bed No. 4 were worked by means of a rock tunnel from their main slope. The lower and upper splits of bed No. 3, and bed No. 4 were worked out within the property lines of the company within this section. The latter workings were known as the Old Coal Creek mine. In section 26 the drift on bed No. 3 was continued from section 27 and a slope was sunk on bed No. 3 to the fifth level. Bed No. 4 was worked on each level from the main slope by means of rock tunnels. Bed No. 3 was nearly all worked prior to the fire, but not a great deal of bed No. 4.

The present Coal Creek mines have their openings in section 26, T. 24 N., R. 5 E. The Ford slope, the principal opening at present, was sunk on the Muldoon bed. This slope is well constructed and is modern in every detail. The turnouts on the bottom are as nearly perfect as can be made. The slope is down to the first level below the outcrop, called locally the second level.

The beds in this field strike a little north of west and dip

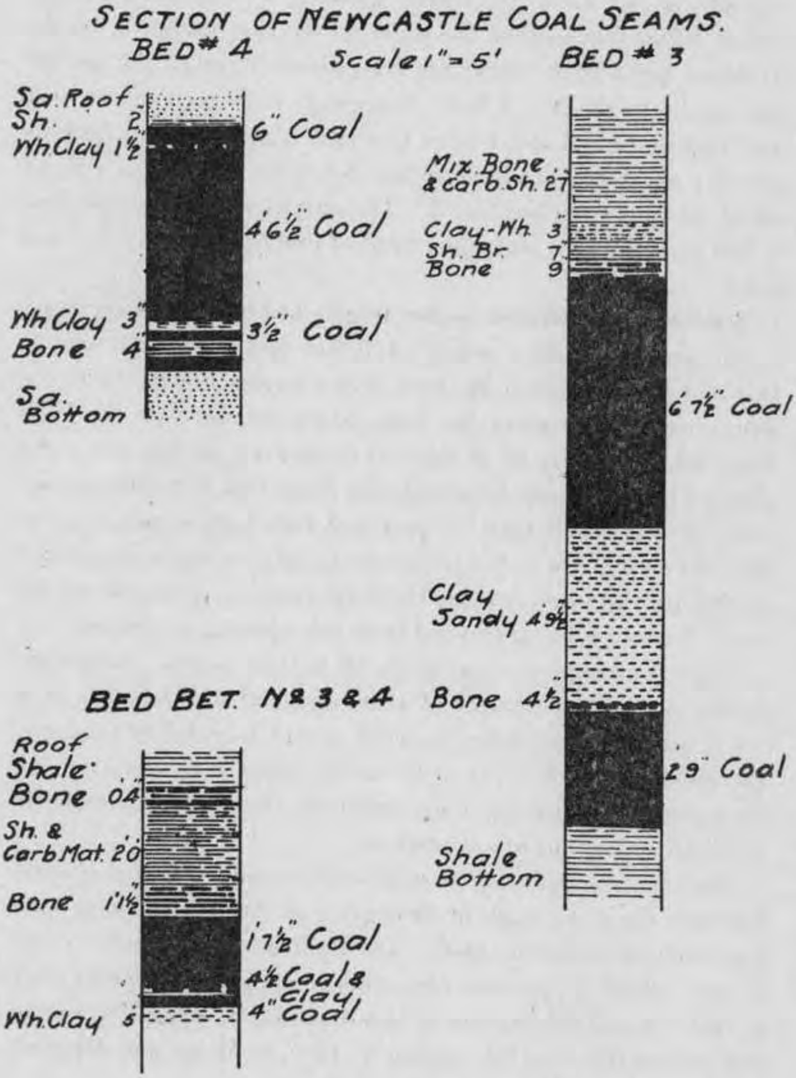

FIG. 7. Sections of Newcastle Coal Beds.

northerly at an average dip of 38 degrees. The beds are very regular, in fact about the most regular in western Washington. About 3,200 feet east of the slope on the east gangway of the Muldoon bed a rock tunnel has been driven through the overlying strata to the No. 4 bed. Gangways have been driven east and west on beds 3 and 4 from this rock tunnel. About 50 tons per day are being mined from bed No. 4 at present, as well as about 50 tons from bed No. 3. The output of the Muldoon bed is 500 tons per day, making a total of 600 tons per day for this mine.

A drift has been driven on the Bagley bed to the eastern limits of the property. At a point 1,400 feet east of the entrance to this mine a rock tunnel has been driven across the strata to the Jones bed. A gangway has been driven eastward on the Muldoon bed, and nearly all of the coal worked out on this level. An attempt has been made to operate the Jones bed, but without success. It was found that the roof and floor both caused a great deal of trouble, due to the presence of a plastic white clay which swelled on exposure, besides the very variable character of the roof. No coal is being shipped from this opening at present.

There is no explosive gas given off in these mines. A dust explosion occurred a number of years ago, but of late years very few, if any, accidents have occurred, except from fall of roof, etc. The mine as a whole is one of the model mines of the country and the management deserve much credit for the excellent manner in which all operations are carried on.

Machine mining has been successfully conducted at this mine. The beds dip at an angle of 38 degrees so that the ordinary mining machine cannot be used. The Sullivan post puncher seems to have solved the problem of machine mining on a pitch as steep as this. A full description of this drill and its operation can be seen in an article by Mr. Austin Y. Hoy, in Mines and Minerals for September, 1910.

The pumping is done by means of a 18″x6″ pump, with a 14″ stroke. Two fans of the cyclone type are used, one fan 4′ 8″x14′ 0″ diameter; the other 4′ 0″x14′ 0″ diameter.

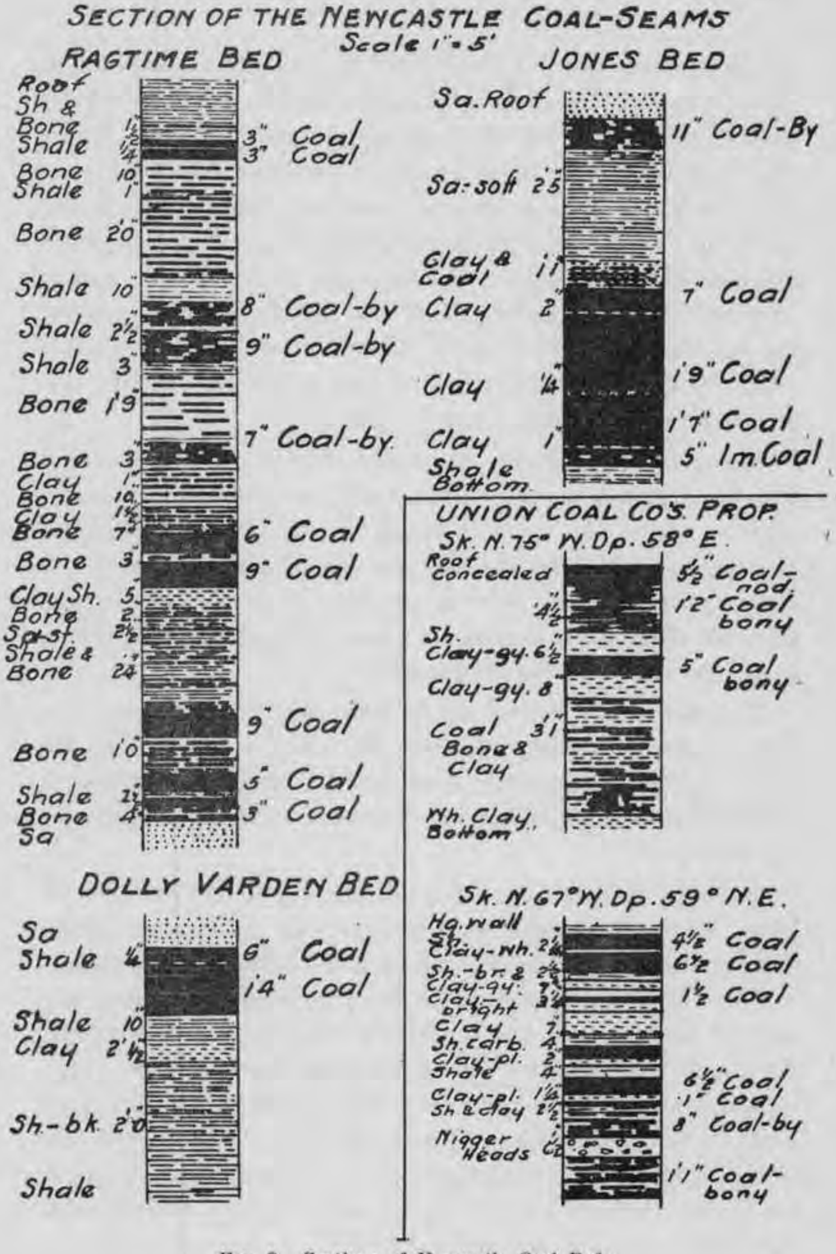

Fig. 8. Sections of Newcastle Coal Beds.

The Muldoon bed has about 5′ 8″ of minable coal, with a firm roof. A system of breasts and pillars is used in this bed. Chutes ten feet wide are driven off the gangway every 100 feet. These are continued narrow up to a point 40 feet above the first crosscut, which is 50 feet up from the gangway. At a point 40 feet above the first crosscut the face is gradually widened to a breast 50 feet wide, leaving a 50-foot pillar between each breast. Crosscuts are driven every 100 feet up the pitch to connect the breasts. After the coal is all mined out of the breasts a chute 10 feet wide is started off the gangway, splitting the pillar in two. In this manner the pillar coal is mined.

In the Bagley bed only the upper split is mined at present. This bed has such a poor roof that it is necessary to thoroughly lag the sets as the chute is driven up the pitch. The chutes are ten feet wide and the sets are placed five feet apart. A center post is placed between the legs of the set and lagged. One side of the chute is used for a manway and the other side to carry the coal down to the gangway.

The chutes are carried up to the chain pillar above. The pillars which are thirty-five feet wide are then mined down the dip. By careful mining most of the pillars are removed. Methods of working beds 3 and 4 are shown in the accompanying plates.

Hoisting from the Ford slope is done by a 36″ cylinder engine. Compressed air is used in operating the machine drills; this is produced by a modern plant at the surface. Two motors are used in the gangways of the Ford slope and one motor used to haul the coal from the top of the Ford slope to the bunker. The bunker is equipped with a Robinson-Howe washer with a capacity of 62.5 tons per hour. Nine small screens are used, over which the coal runs. The lump coal is hand picked; the screenings pass to the washer; and from the washers the product passes through a revolving screen, making a further separation into nut and pea coal.

NEWCASTLE COAL COMPANY.

This company has about 320 acres of land in the north half of section 30, T. 24 N., R. 6 E. The beds that outcrop on this property overlie the present workable beds of the mines at Newcastle.

The bed that was examined by the writer, and on the strength of which the stock of the company is being sold, has very little coal in it. In this report is given a section of this seam, under the name of the Union Coal Company. The Union Coal Company was the name of the former stock selling concern that tried to exploit the property.

SUPERIOR COAL AND IMPROVEMENT COMPANY.

This company opened a drift on what is probably bed No. 6 on the Issaquah side of this series of coal beds. A drift 1,000 feet long was driven on this bed from the outcrop near Tibbett's creek. The coal beds at this point strike a little north of west and dip to the north at about 35 degrees.

The coal that was shipped from this opening was hauled by mule from the mine to a small bunker, at which place it was cleaned; then loaded into railway cars and transferred along the branch line of the Northern Pacific railway to the main line.

ISSAQUAH COAL COMPANY.

The above company's mines are located in sections 32 and 33, T. 24 N., R. 6 E., at the coal mining town of Issaquah. The original opening of this mine was on bed No. 6, sometimes called the Andrews bed. This bed was worked by a water level drift, and had been driven a distance of 1,800 feet by 1890, at which time it was closed.

Bed No. 5, which overlies No. 6, was opened by a water level drift and about 2,400 feet of gangway driven. Bed No. 1, overlying No. 5, was also worked by a water level drift. This drift was in a distance of 2,800 feet when stopped.

Bed No. 2, overlying No. 1, was worked at the water level by a drift 1,700 feet long. Bed No. 4, overlying bed No. 2, was

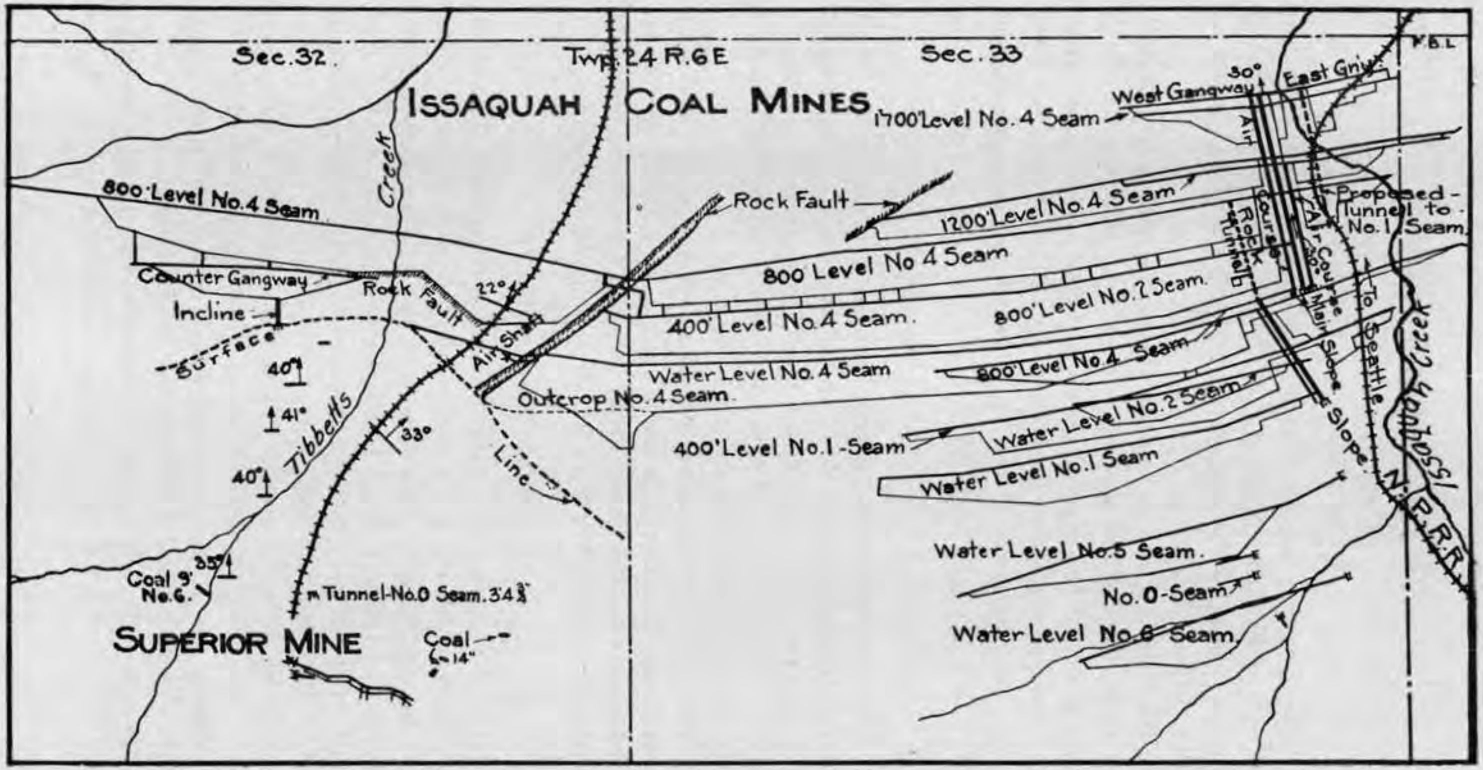

FIG. 9. Map of Issaquah and Superior Mines.

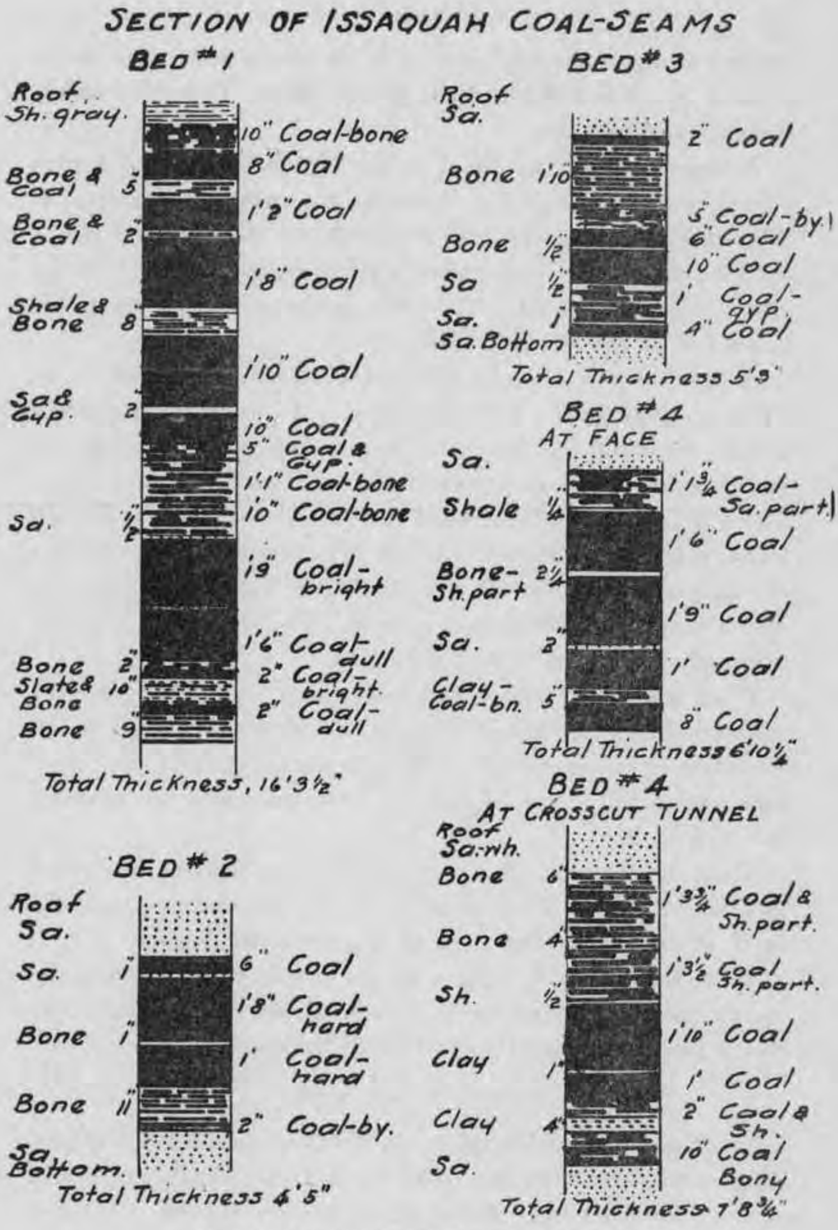

FIG. 10. Cross-sections of Issaquah Coal Beds.

worked at the water level and by a lift above that. The water level of No. 4 was driven through the hill to Tibbett's creek a distance of 5,800 feet.

A slope was sunk on No. 1 to the 800-foot level, and a rock tunnel driven through the strata to the overlying bed No. 4. The 800-foot gangway, which was driven east on bed No. 1 struck sand, gravel and water, a few hundred feet east of the east line of section 33. The west gangway was driven about 3,100 feet on the 800-foot level.

Another slope was sunk, this time on the overlying bed No. 4. This was sunk to the 1,700-foot level. A gangway was driven east on the 1,200-foot level and the same pre-glacial channel was struck as in the east gangway of No. 1 bed on the 800-foot level. The 400-foot level of bed No. 4 had been driven eastward 3,600 feet to a fault near Tibbett's creek. The 800-foot level west was driven across sections 33 and 32. The 1,200-foot level was driven westward 2,000 feet to a fault. The 1,700-foot level was driven about 900 feet in each direction.

When the sand, gravel and water were encountered to the eastward in the pre-glacial channel, the mine was flooded and it has since remained closed. The pre-glacial channel has never been successfully crossed and we have no means of knowing how wide it is.

There are at least six and probably more beds in this series that can be mined. They all strike nearly east and west, and dip north at angles varying from 26 degrees to 32 degrees.

There is a 3,000-ton bunker on the property, but most of the equipment has been removed. The coal was shipped over the North Bend branch of the Northern Pacific railway.

GRAND RIDGE MINE.

The Central Coal Company, of Seattle, operates the Grand Ridge mines in section 26, T. 24 N., R. 6 E. Work was begun on this mine prior to 1889 but during the years 1889, 1890 and 1891 very little was accomplished. In 1893 a slope was sunk to a depth of 150 feet. The mine did not produce any coal from

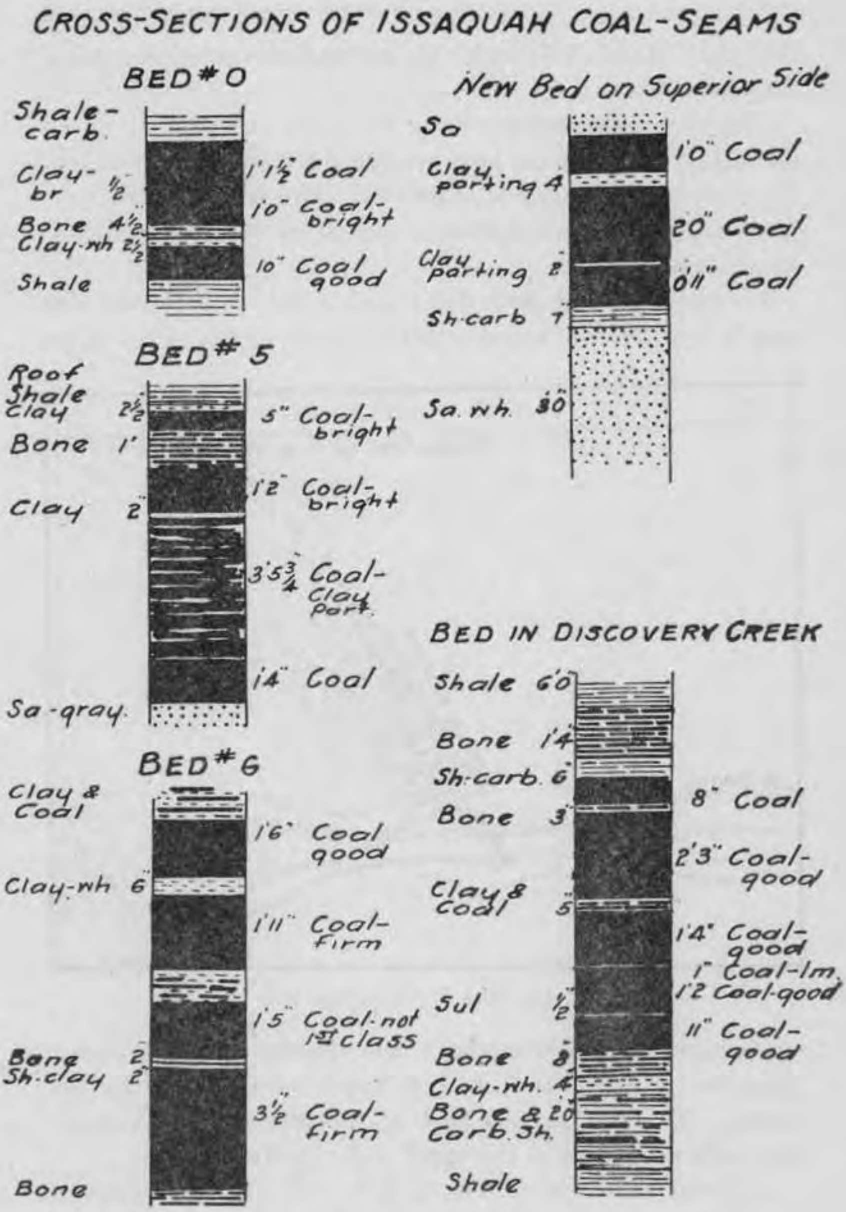

FIG. 11. Cross-sections of Issaquah Coal Beds.

1893 until March, 1909, when the present owners began getting the mine in shape.

There are seven beds known in this series and there are in all probability two or more beds overlying the present No. 2 bed, the uppermost bed exposed at present. This series of beds is unquestionably the northeastern extension of the Newcastle-Issaquah series.

The slope, which is down 330 feet on a dip of 22 degrees, was sunk on bed No. 1. A rock tunnel has been driven to No. 2, an

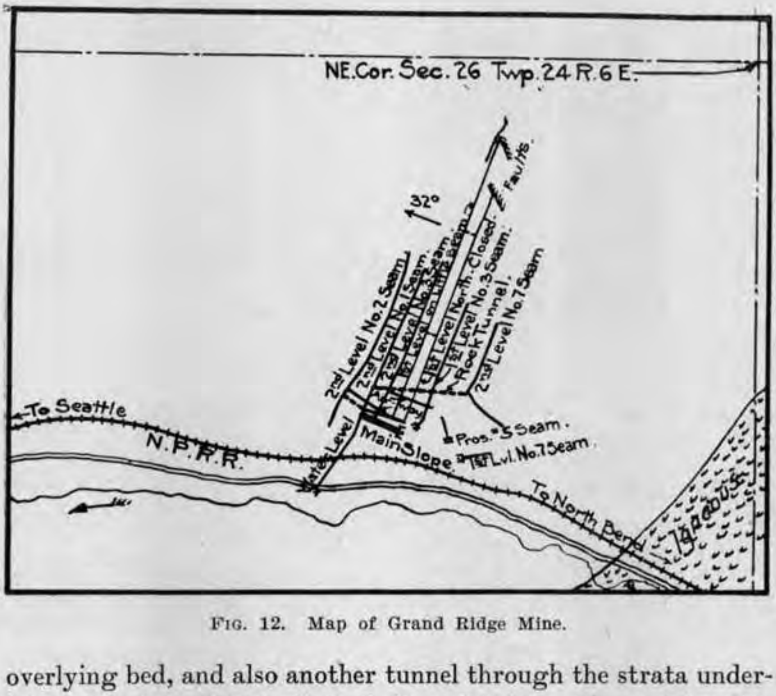

FIG. 12. Map of Grand Ridge Mine.

overlying bed, and also another tunnel through the strata underlying No. 1; and beds 3, 4, 5, 6, and 7 have been cut by this tunnel. The beds in this part of the field are very regular. One fault was struck in the upper water level of No. 1.

Coal was mined out of beds 1, 2, 3, and 7 from the slope at various times, but at present the coal is mined from No. 3 bed by means of a water level driven on that bed from a point near the bunkers. The output from this bed at present is 150 tons per

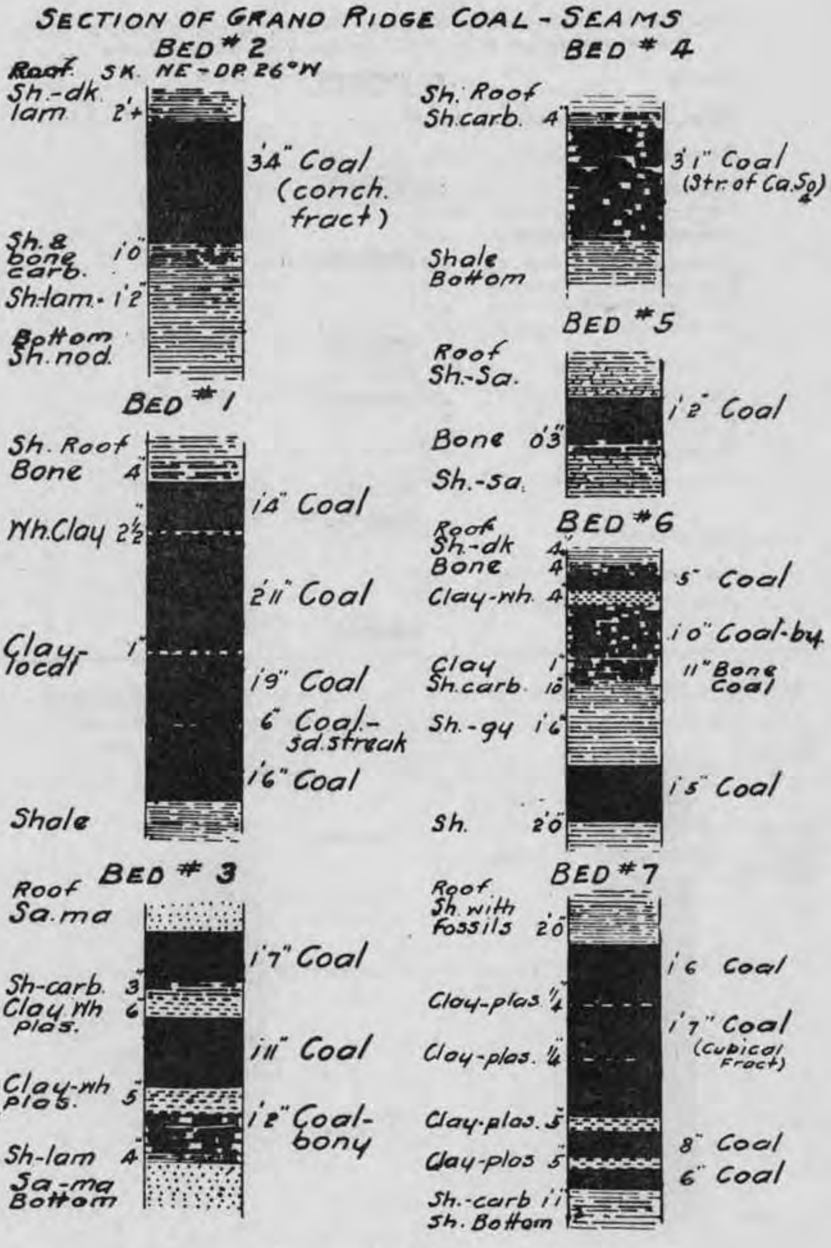

FIG. 13. Cross-section of Grand Ridge Coal Beds.

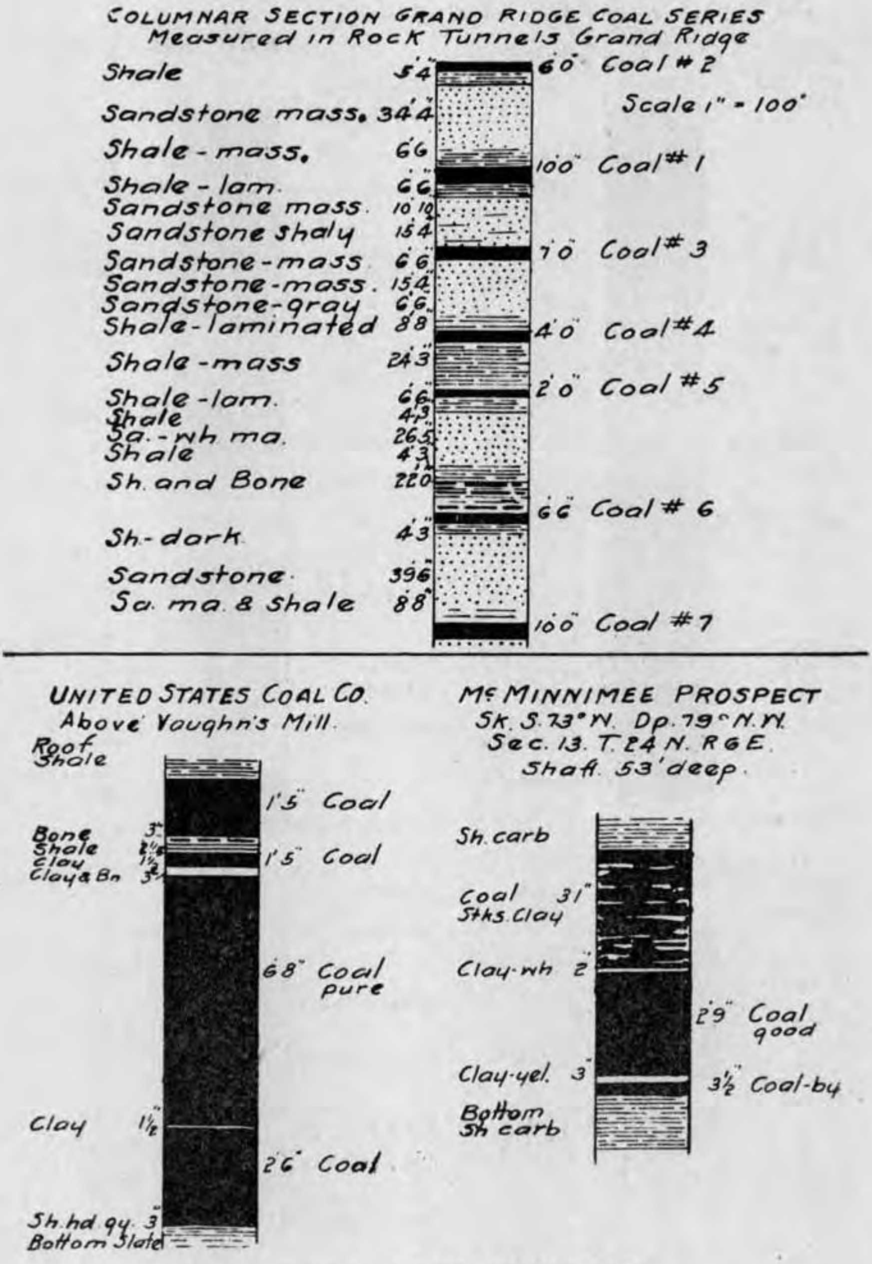

FIG. 14. Sections in the vicinity of Grand Ridge.

day. In a short time 100 tons per day additional will be mined from No. 7 bed and hauled up the slope.

The system of mining used at this mine in bed No. 1 is the breast and pillar method. The chutes are started off the gangway 10 feet wide and at a point 30 feet from the gangway a crosscut is driven to connect the next chute back. From the crosscut upward the chute is widened into a breast 20 feet wide and crosscuts cut through from breast to breast at about every 60 or 70 feet. The chutes are on 50-foot centers, and this leaves a 30-foot pillar between each breast. The coal is hauled to the foot of the slope by mules, and hoisted to the surface by a 60-horse-power engine made by the Denver Engineering Company. The water is drained from the mine by means of a water level gangway, which has been driven to the surface from the foot of the slope.

The nut and pea coal is washed in a Robinson-Howe washer, of 50 tons daily capacity. Three classes of coal are produced, viz., lump, nut and pea. The bunker is located on the North Bend branch of the Northern Pacific railway and the coal shipped to Seattle and Everett over this line and its branches.

UNITED STATES COAL COMPANY.

On section 13, T. 24 N., R. 6 E., four or more coal beds outcrop. One of these beds is over eleven feet thick, and another over six feet thick. They are undoubtedly the northeastern continuation of the Grand Ridge coal series. In this area the beds strike northeasterly and dip to the northwest at from 65 to 79 degrees. The slope is down on bed No. 1 about 360 feet. A small amount of gas was found in this bed, but it is not common to the beds of this series.

There is some faulting in this area and more or less disturbance generally as might be inferred from the high dip of the beds at this point. The coal is similar in character to that at Grand Ridge and Issaquah.

The company plans on extending a railroad from the North Bend branch of the Northern Pacific railway, at some point between Issaquah and Monohon, eastward to the property.

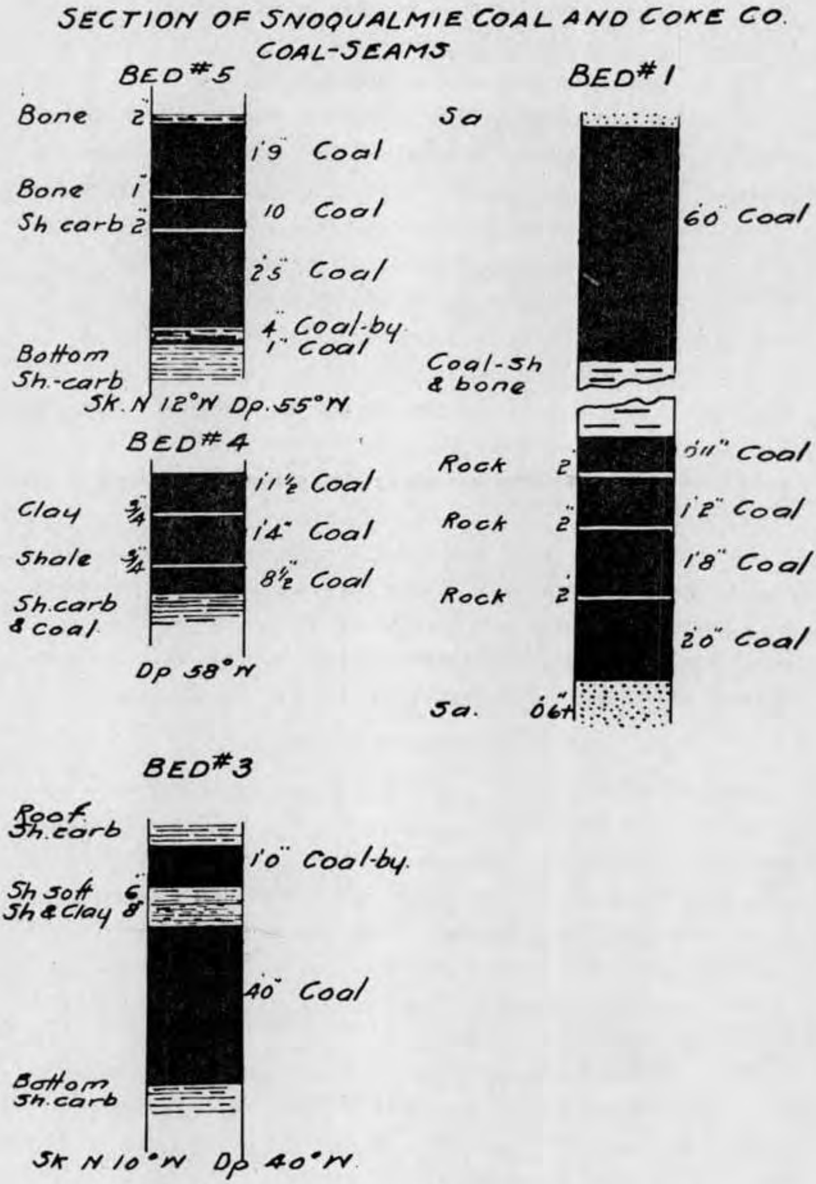

FIG. 15. Cross-sections of Beds at Snoqualmie Mine.

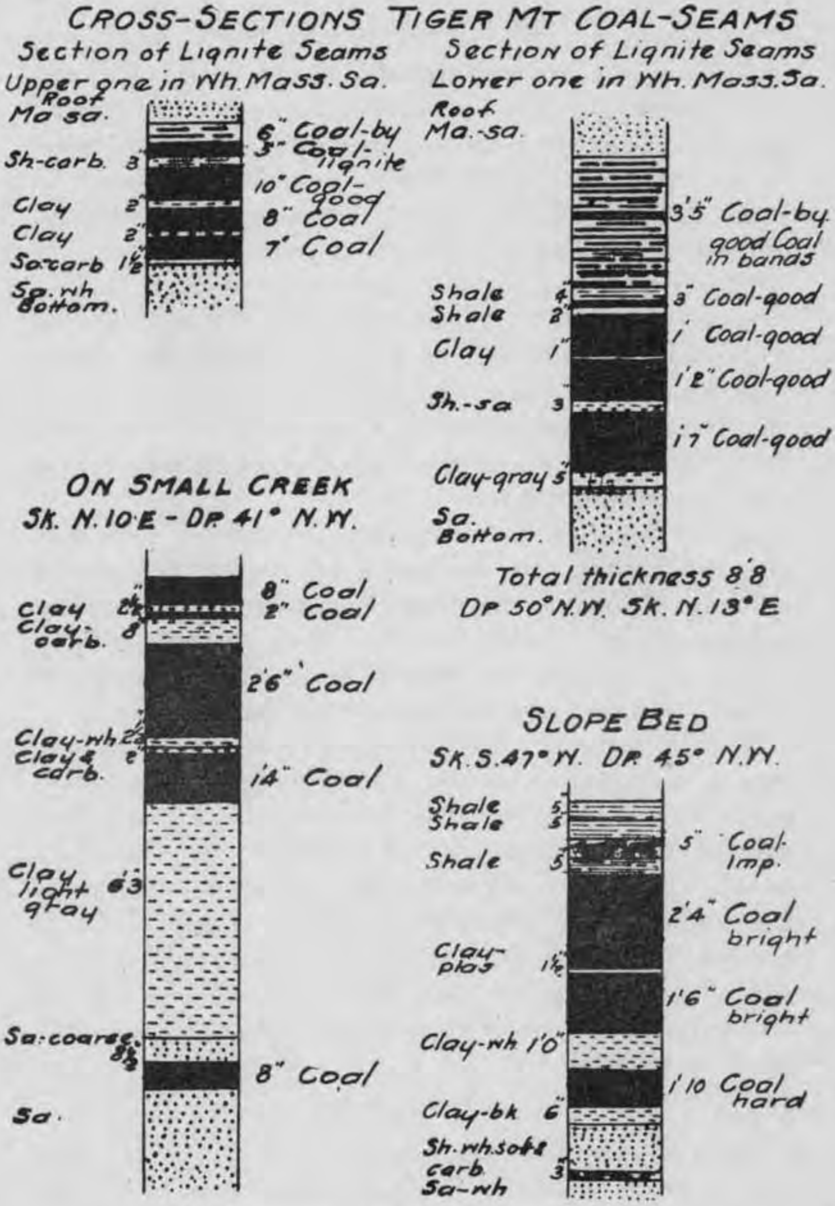

FIG. 16. Cross-sections of Tiger Mountain Coal Beds.

UNITED COLLIERIES COMPANY.

This company was formerly called the Snoqualmie Coal and Coke Company, but by some rearrangement of the stockholders, the company has within the past three years reorganized under the name first given above. The property lies in section 1, T. 23 N., R. 7 E., and was originally known as the Niblock mine. Nothing is being done with the mine at present.

The openings consist of frequent drifts on several of the beds in this series. Drift No. 1 is in a distance of 600 feet. The bed strikes southeast and dips to the southwest at high angles. Drift No. 2 is in a distance of 1,100 feet on the coal. This bed also strikes southeast and dips at a high angle to the westward. Drift No. 3 is near the southeast corner of the section. It is in a total distance of 650 feet.

Mining from time to time has been attempted on these beds, with indifferent results; whether it was due to the disturbed character of the coal, remoteness from transportation or mismanagement, or a combination of all three, has not been determined. At any rate, the property is not now operating and probably will not be successfully operated for some time.

The coal that was mined was hauled from the various openings to the washer and bunker, which were placed at a considerable distance from the drifts. Here the coal was washed and attempt made to produce coke. A number of coke ovens, of the bee-hive type, were constructed. The product was then hauled over a spur of the Northern Pacific railway to the main line of the North Bend branch, near the town of Snoqualmie. The crushed condition of the coal, and the expensive mining and transportation charges, work materially against the successful development of this field.

TAYLOR MINES.

These mines are located in section 3, T. 22 N., R. 7 E. They were originally opened by the Denny Clay Company in 1891. At that time the prospect was called the Sherwood mine, due no doubt to its proximity to the logging camp of that name. The

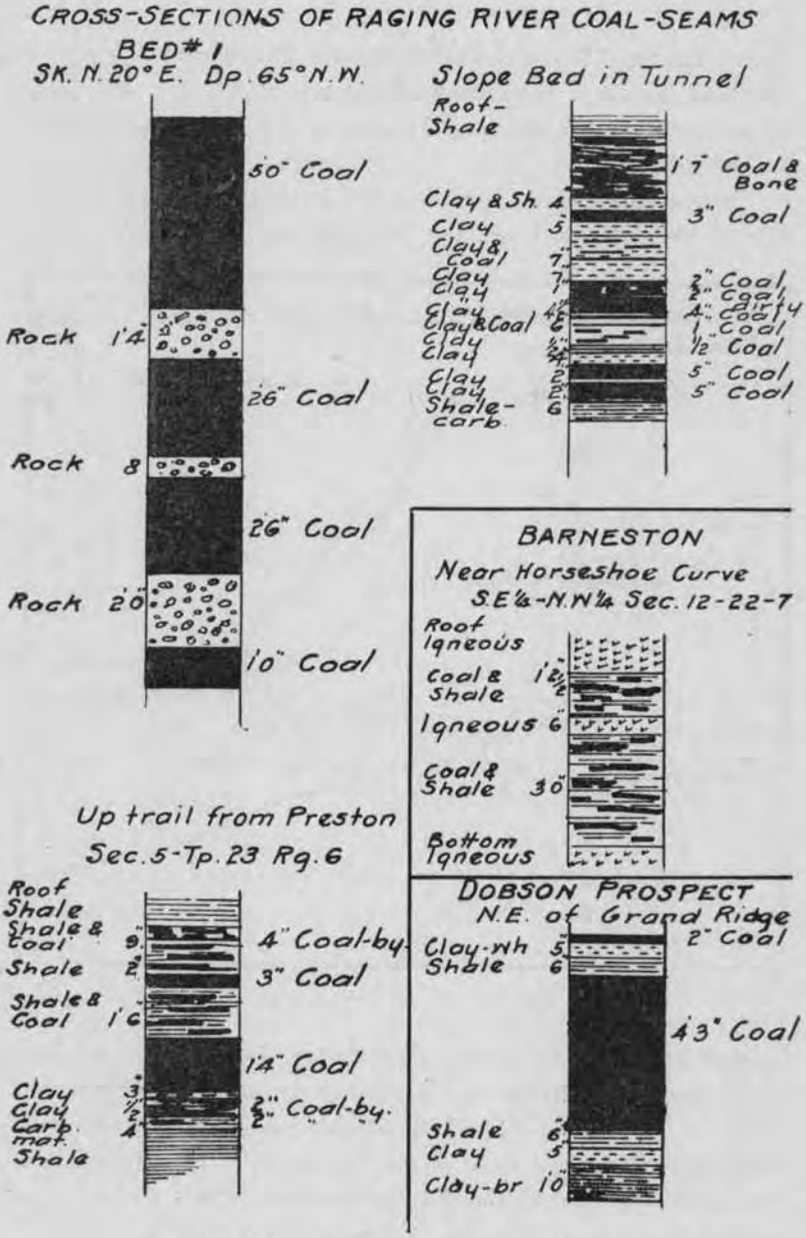

FIG. 17. Cross-sections of Raging River Coal Beds.

Denny-Renton Clay and Coal Company has bought the property and increased the output of the coal and shale, and built large factories for the manufacture of sewer pipe and other hollow ware.

There are four mines opened on this property, but Nos. 1 and 2, and the new shaft are the principal ones. Mine No. 1 is

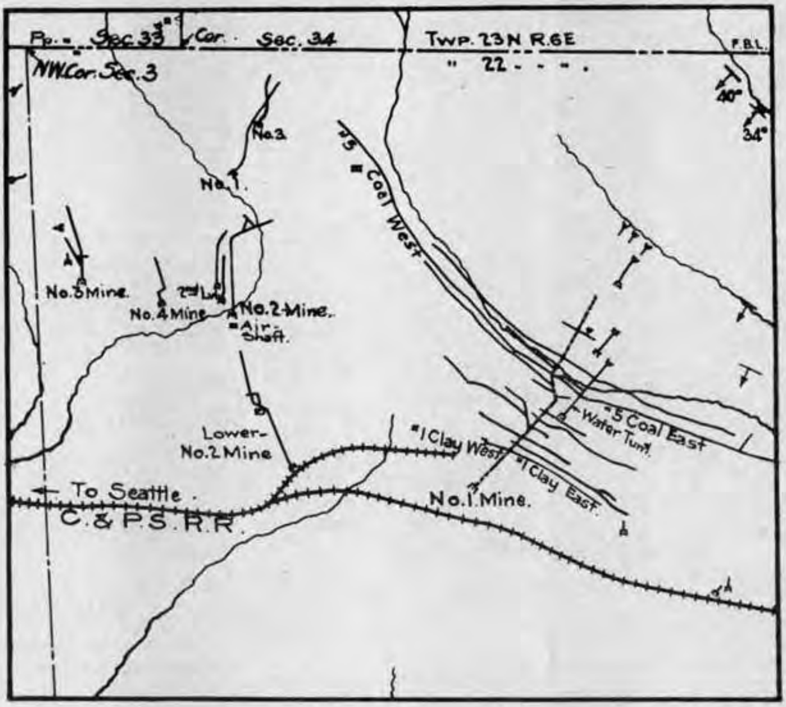

FIG. 18. Map of Taylor Mine.

opened by means of a rock tunnel over 1,500 feet in length. This tunnel was driven in a northeasterly direction across the strike of the strata. The beds at this point strike northwest and dip southwest at from 60 to 70 degrees. This mine is on the northeast side of the Taylor syncline, which passes in a northwest-southeast direction through this property.

Gangways have been driven on bed No. 1, both east and west. An intrusive dike has followed this bed very closely and at times

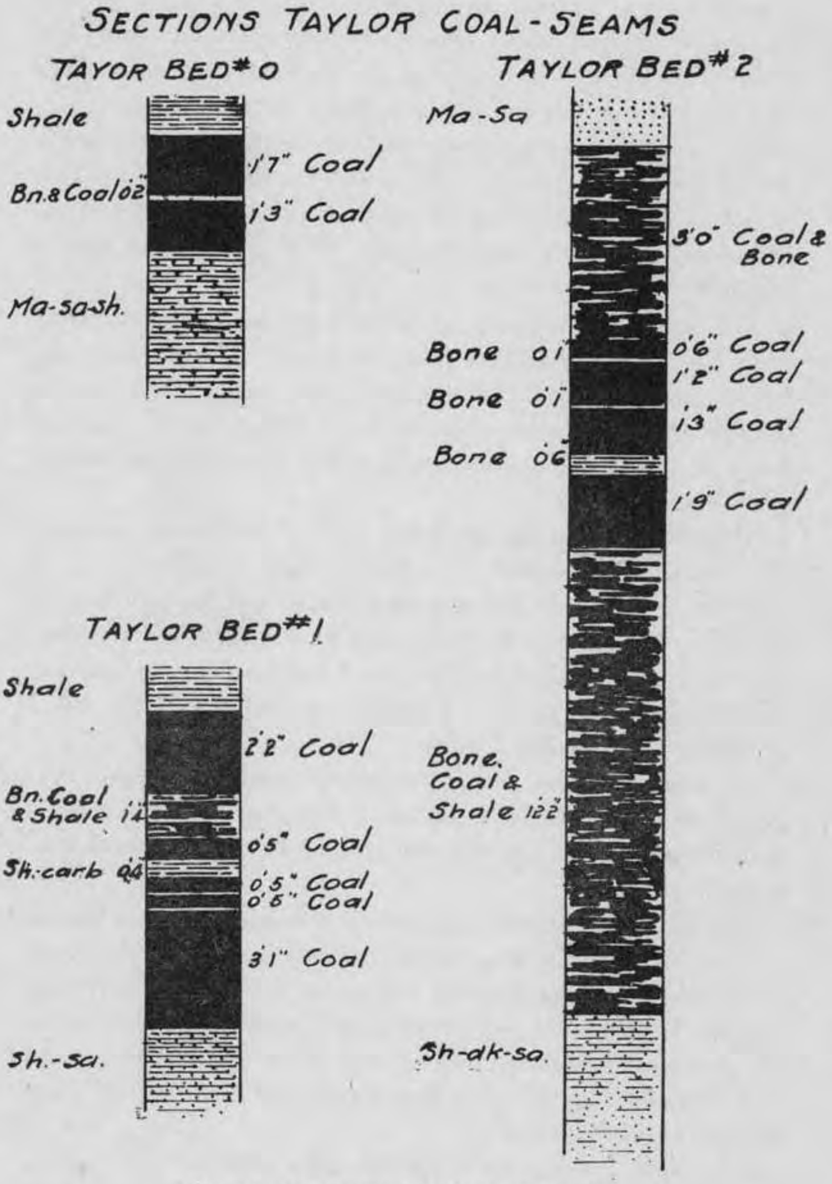

FIG. 19. Cross-sections of Taylor Coal Beds.

it is so close as to have destroyed the coal. No. 2 bed of coal has been developed rather extensively both east and west. No. 5 bed is the one on which most of the work has been done. The east gangway on this bed has been driven to the east line of section 3, and the west gangway has been extended to the north end of the synclinal basin. No. 6 bed has been developed to a considerable extent, but not as much as No. 5. No. 7 bed has been developed only a small amount. No. 8 bed has been opened recently.

This mine is producing at present about 70 tons per day from No. 5 bed and 45 tons from No. 8 bed. The coal is hauled by means of motors to the washers and bunkers located on the Taylor branch of the Columbia and Puget Sound railway. Shale of a very fine quality is also mined from this part of the property.

Mine No. 2 is on the southwest side of the Taylor syncline. The entrance to the drift is on Bed 0, which overlies No. 1. A rock tunnel has been driven across the strata through beds 1, 2, 3, 3½, 4, 5, and to 6. Gangways have been driven considerable distances on beds 5 and 6. No. 5 bed has been continued to the northeastward to a point almost connecting with the No. 5 gangway from the No. 1 mine.

At present bed No. 3½ is producing about 65 tons per day; No. 5, 60 tons; and No. 6, 42 tons. The coal from this mine is hauled by means of a motor and cleaned in the same washer as noted above.

The shaft is 500 feet deep, and is a well constructed double compartment shaft. It is located between the entrance to No. 1 mine and the coal washer, and was begun in the strata overlying bed No. 1. From the foot of the shaft a rock tunnel is driven to the northeast across the several beds of the series. At present beds 1, 2 and 5 are being developed and produce a total of about 20 tons of coal per day.

The same igneous rock that intrudes into the beds on the upper level also affects the strata in the level off the shaft. Some of the sills and dikes occupy slightly different relative po-

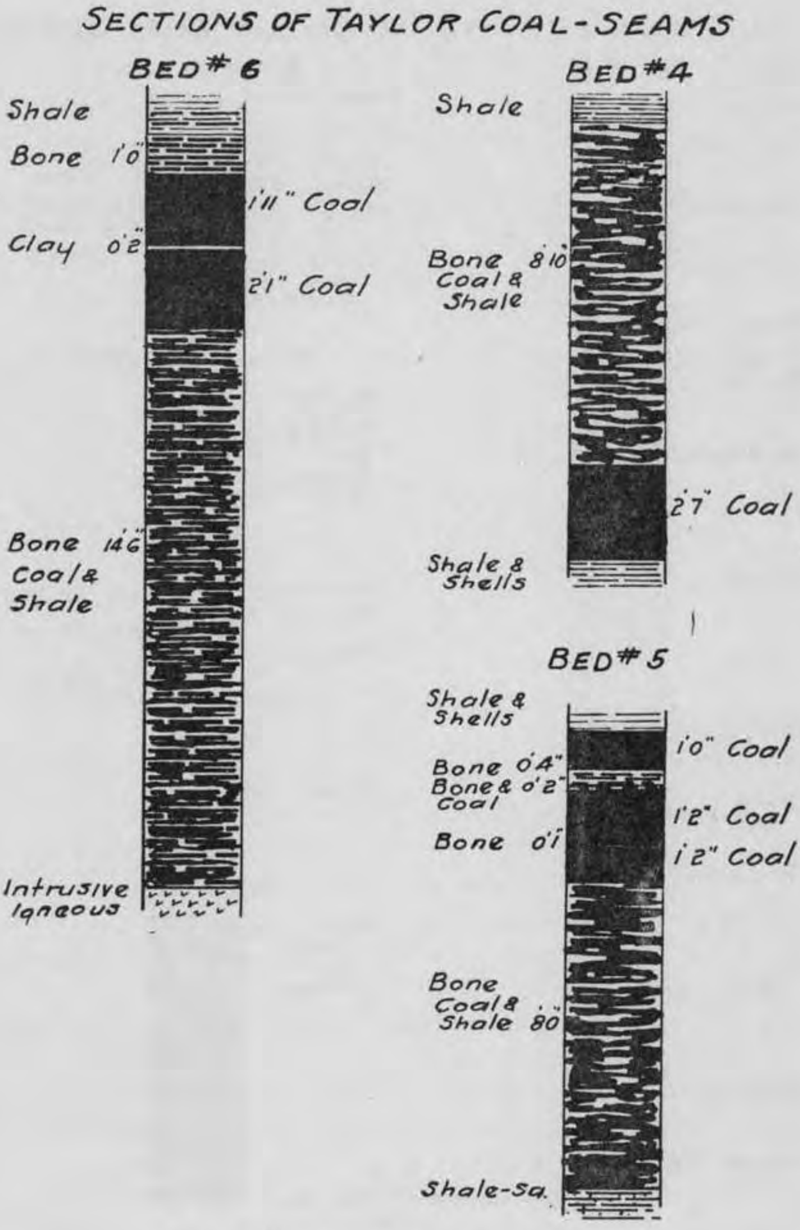

FIG. 20. Cross-sections of Taylor Coal Beds.

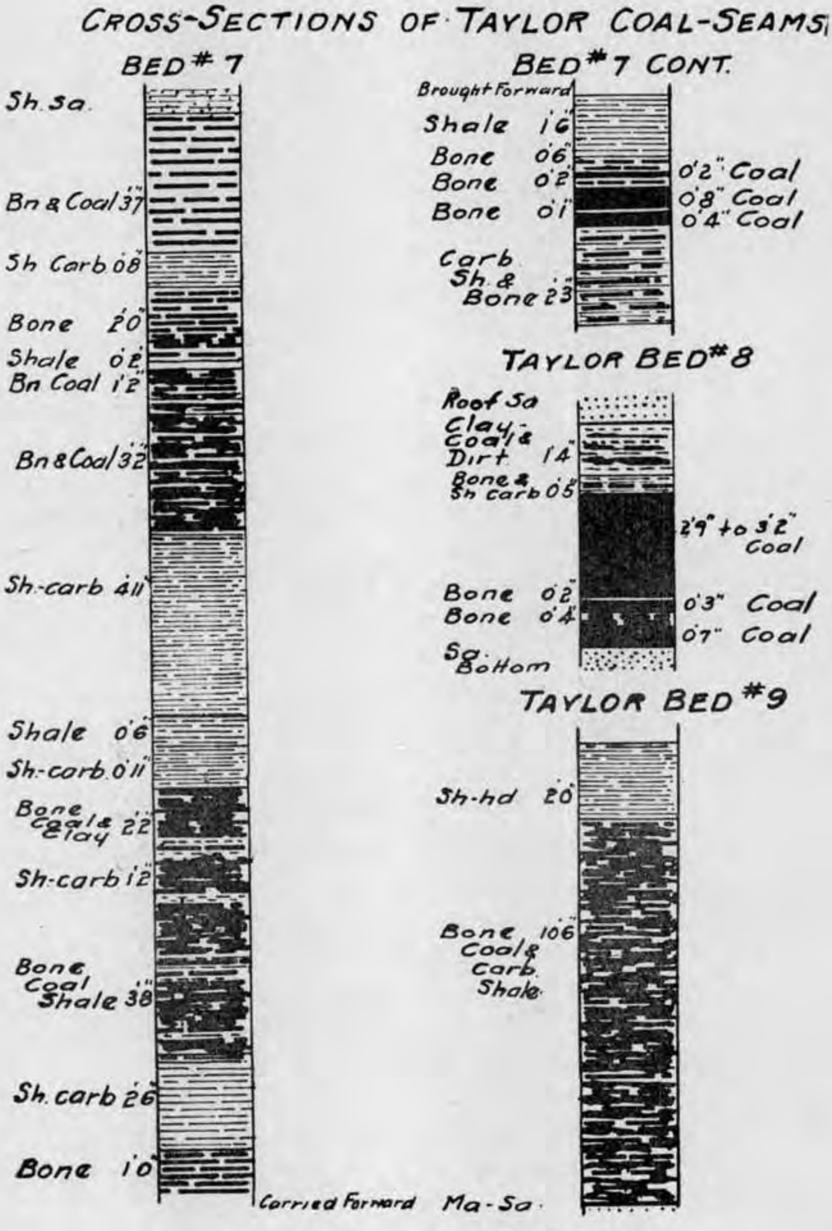

FIG. 21. Cross-sections of Taylor Coal Beds.

sitions in this lower level. In some places the coal in bed No. 1 is in splendid condition and produces a high grade coal; in other areas the coal is practically destroyed. The coal from the shaft is cleaned in the same washer as the coal from mine Nos. 1 and 2. Other smaller openings are scattered at different places on the western side of the syncline, in the northwest part of section 3.

The intrusive rocks of this area are branches of the same system of intrusive rhyolites that ramify through the Barneston area; only that in the Taylor area they are fewer in number and of smaller size. These intrusions do not extend beyond the west limb of the Taylor syncline. Some of these intrusive dikes and sills have decomposed in place and the resulting material is used extensively in the factory for manufacturing various wares.

The coal is washed by means of a Blair washer. Very little of the coal is used in the open market; most of it is used at the clay burning plants at Taylor and Van Asselt. The system of mining on such steep pitches is shown in the accompanying photograph. The photograph is of a model showing the method of working one of the coal beds.

DANVILLE MINE.

This mine, which is located in section 24, T. 22 N., R. 6 E., was originally opened in 1896. At this time a rock tunnel was driven across the strata to the coal and a short gangway opened on one of the beds. A small amount of coal was shipped in 1896, but the work was suspended that same year. Later the property was taken over by others than the original owners and attempts made to successfully operate the mine.

The North Coast Colliery Company has in the last two or three years spent some money trying to find something better than had been previously found. The writer is informed that they have entirely abandoned the property.

There are several beds outcropping on this area, but there is a great deal of faulting; these appear to be a system of hori-

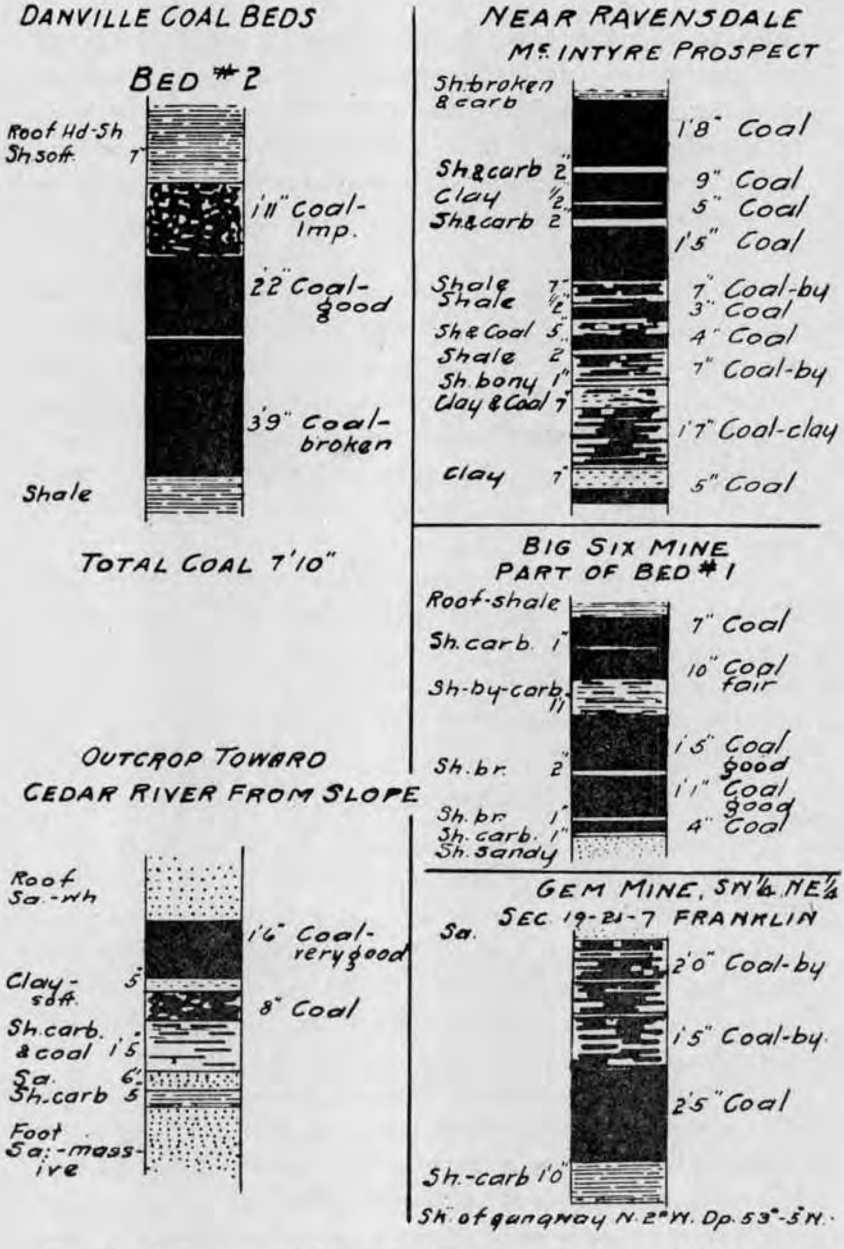

FIG. 22. Cross-sections of Beds at Danville, near Ravensdale and elsewhere.

zontal faults. It is difficult to determine how the beds dip; they are all nearly vertical. At one place they appear to dip northwest, while at other points the dip is apparently southeast. It is probable, however, that these beds are on the opposite sides of the western syncline and probably dip towards Ravensdale.

The development work to date consists of a short rock tunnel, with a drift to the southwest on one of the beds. A slope has been driven diagonally across the dip, and a rock tunnel to bed No. 3. Gangways have been driven on beds 2 and 3 for short distances.

A spur off the main line of the Columbia and Puget Sound railway connects with this property.

Section across part of measures at Danville:

	Ft.	In.
Shale, hard	..	..
Bed No. 2	7	10
Sandstone	86	..
Shale	7	..
Sandstone	22	..
Bed No. 3	11	+
Shale	74	..
Shale, nodular	21	..
Total	228′	10″

RAVENSDALE MINES.

This property, now operated by the Northwestern Improvement Company, is located in section 1, T. 21 N., R. 6 E., and section 36, T. 22 N., R. 6 E. The mines were opened by the Seattle and San Francisco Railway and Navigation Company, in 1899. Four levels were being worked in 1900. Later the Northwestern Improvement Company bought out the former company and two mines, Nos. 1 and 2, have been opened on the property.

NO. 1 SLOPE.

This slope is down 1,280 feet, on a dip varying from 50 degrees at the top to 28 degrees at the lowest point, sunk on No. 5, near the bottom of that bed. The hoisting is done by a direct connected 22x40 Litchfield twin engine, geared drums.

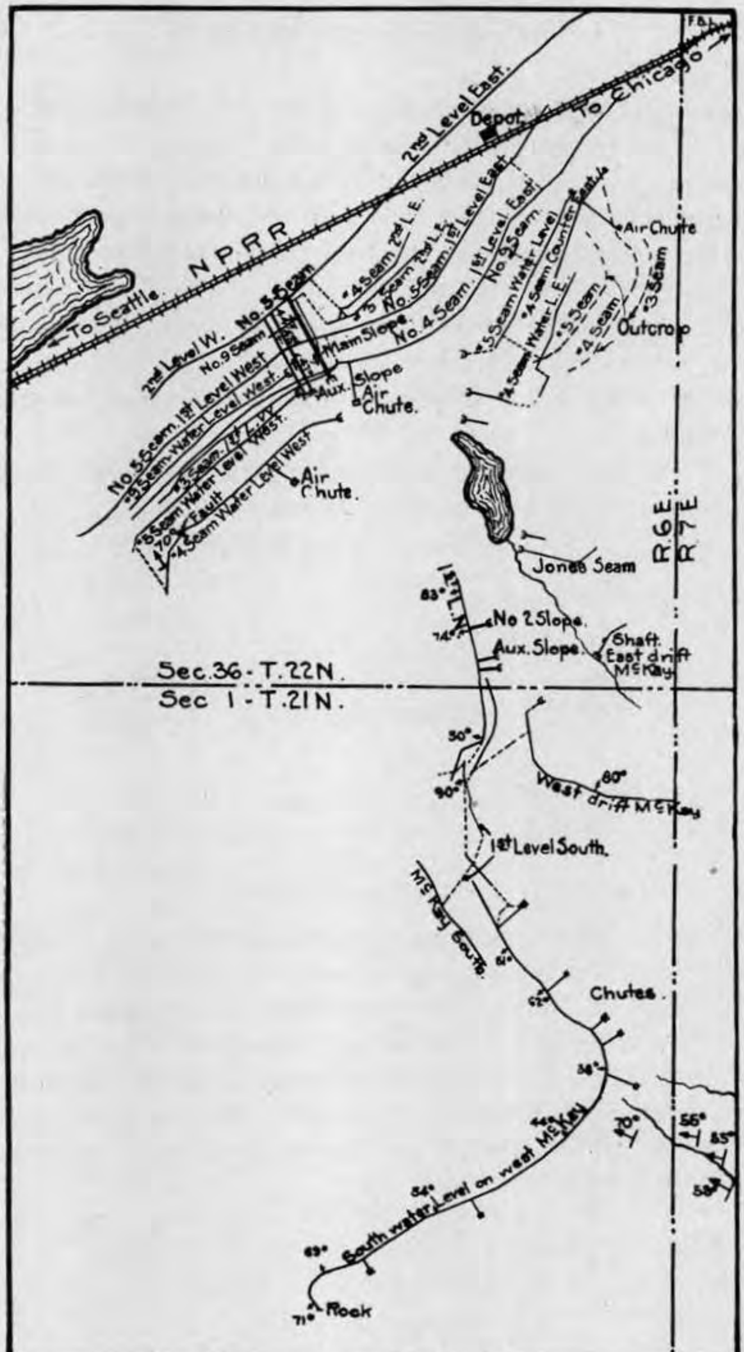

FIG. 23. Map of Ravensdale Mine.

Coal is now hoisted by means of skips, but it is planned to change from the skips to covered cars, the same as used at Carbonado. The coal is conveyed from the bin at the head of the slope to the No. 1 end of the dry cleaning plant by means of an electrically propelled larry.

NO. 9 BED.

This bed is reached by means of a rock tunnel driven across the strata from the No. 1 slope at both the first and second lifts. The first lift of No. 9 is practically abandoned; on the second level the east gangway is in a distance of 600 feet. On the west side, the gangway is 1,500 feet long, and at this point a normal fault of unknown extent was encountered. The strike of this fault is nearly north and south, the downthrow is to the east, but how much has not been determined. The plan of operation, from this date on, is to mine the coal from the fault back toward the slope. This bed is about $4\frac{1}{2}$ feet thick from wall to wall, and it is all mined. The mine is ventilated by a rock plane connecting with the main airway. No explosive gas occurs and hence naked lights are used.

NO. 5 BED.

The first lift, No. 5 west, is driven about 1,800 feet to the same fault that cuts off No. 9 bed, above described. This mine took fire four or five years ago and is still on fire, but is not causing any trouble. The east side gangway on the first lift is in about 2,400 feet, at which point it was stopped for the reason that the breasts were approaching gravel and surface water. This lift is completely abandoned. No. 5 bed is about 25 feet in thickness. All the coal in this bed is being mined. The systems of mining are breast and pillar, and chute and block.

In the breast and pillar system, breasts 20 feet wide, on fifty-foot centers, are driven up the pitch to a pre-determined stopping point; crosscuts are driven between breasts, 50 feet apart. These are staggered, i. e., not placed opposite each other. The mining is done in the bench next to the bottom, from five to seven feet in height, varying as the partings of the bed vary.

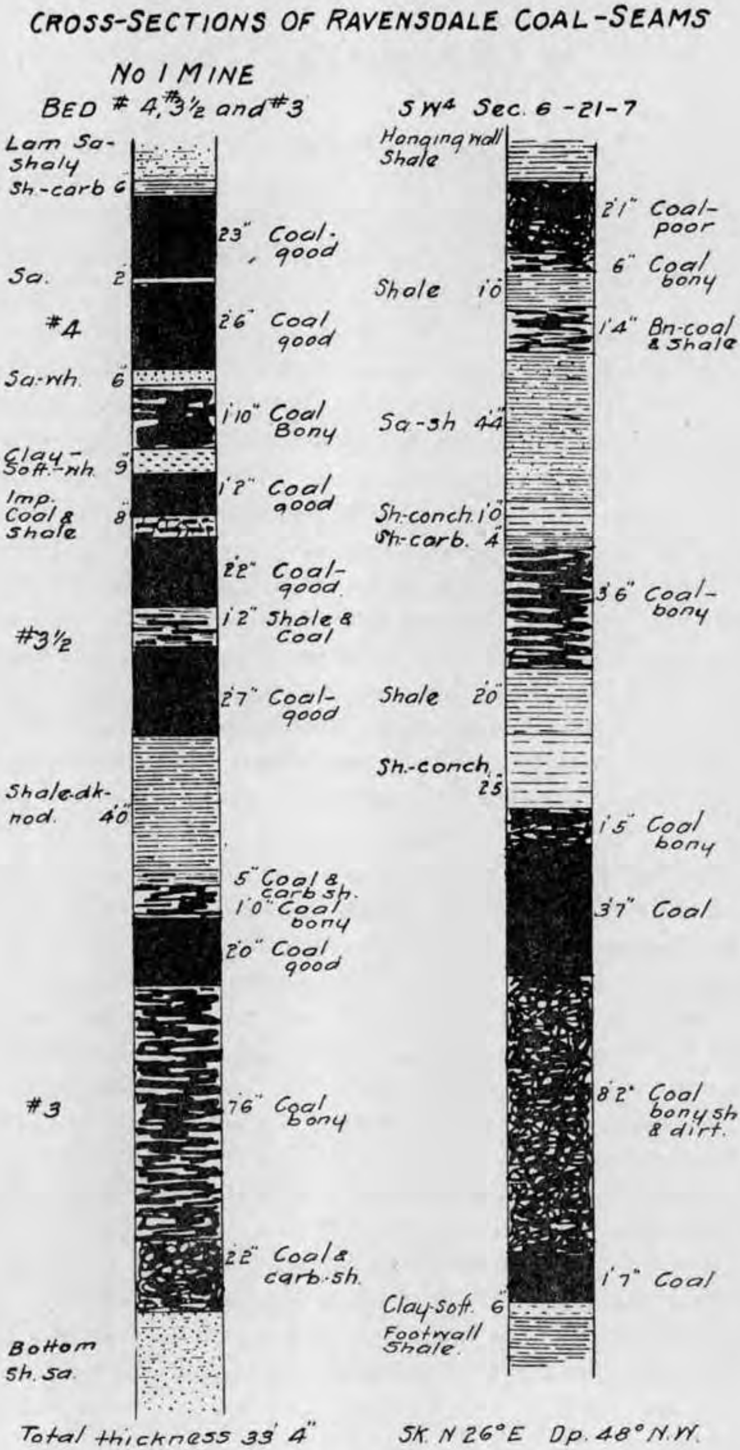

FIG. 24. Cross-sections of Ravensdale Coal Beds.

When the distance to be driven is reached, the breasts are all connected at the highest points by a large crosscut. One block below the face crosscut the top coal is taken down, and the top coal of the first and last breast of each panel is not mined until the others are finished, thus assuring good ventilation until the coal is all recovered.

In the chute and block system, six-foot chutes on fifty-foot centers are driven up, the chutes being connected each fifty feet by crosscuts. When the chutes are finished a skip ten feet wide is taken off each side of the chute and the top caved. The upper block is also left intact in this method and the first and last breast are the last to be worked.

The second lift, No. 5 west, is driven about 1,100 feet and was stopped because the coal fired from spontaneous combustion. This part of the mine is practically abandoned. On the east side of the second lift the gangway is in 3,800 feet. At this point a fault of undetermined character or extent has been struck. The direction of the fault plane is northwest and southeast. This part of the mine is worked by two systems, chute and block, and breast and pillar, the distance between centers being 50 feet in each instance. On the third level, No. 5, the west side gangway is in 200 feet and still driving; the east side is in 600 feet and still driving.

NO. 4 BED.

First level west is in about 1,800 feet, at which point it struck the fault encountered in No. 5 west. This part of the mine fired from spontaneous combustion when the mine was nearly finished.

No. 4 east, first level, was driven about 2,400 feet at which point surface water and gravel stopped further progress. This part of the mine is abandoned.

On the second level the east gangway is driven about 1,400 feet and the coal recovered for that distance. Work in this part of the mine was stopped as the railroad right of way was approached. The west gangway is in 1,500 feet and will probably go 400 feet more before reaching the westerly fault which

FIG. 25. Cross-sections of Ravensdale Coal Beds.

has cut off Nos. 9 and 5. No mining has been done on this side except driving the gangway.

NO. 3 BED.

Water level No. 3 on the east side has been driven through the east hill. This part of the mine was worked on the breast and pillar system, on the retreating plan. This mine is practically worked out. The west drift water level is in 750 feet and still driving. The method of mining is to drive 20-foot breasts on 50-foot centers, the pillar being taken out from the upper crosscut down the dip.

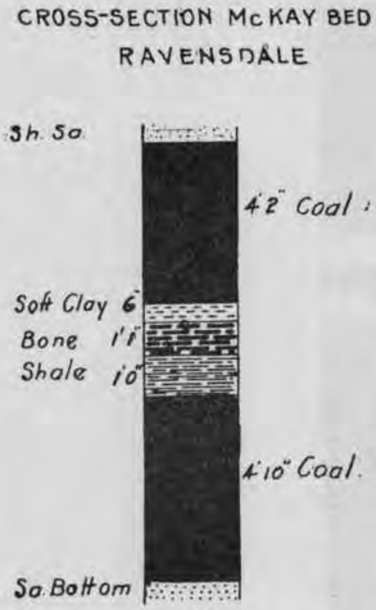

FIG. 26. Cross-section of McKay Bed at Ravensdale.

On the first level, No. 3 bed, practically no work has been done, on either side of the slope, due to the fact that the mine caught fire about the time this part of the property was opened.

On the second level the last gangway has been driven 1,400 feet, at which point the Northern Pacific right of way was reached. Breast and pillar system of mining is used in this part of the mine. The breasts are on 50-foot centers and worked on the retreating plan. The west gangway is in 1,500 feet, being about 400 feet from the westerly fault. No work has been done on this side except driving the gangway.

No. 1 mine is ventilated by a ten foot Capell fan, running 200 revolutions per minute, exhausting about 70,000 cubic feet of air per minute. The water in this mine varies from 200 gallons per minute in summer to 3,000 gallons per minute in the winter months. Five pumps, three steam and two electric, handle this

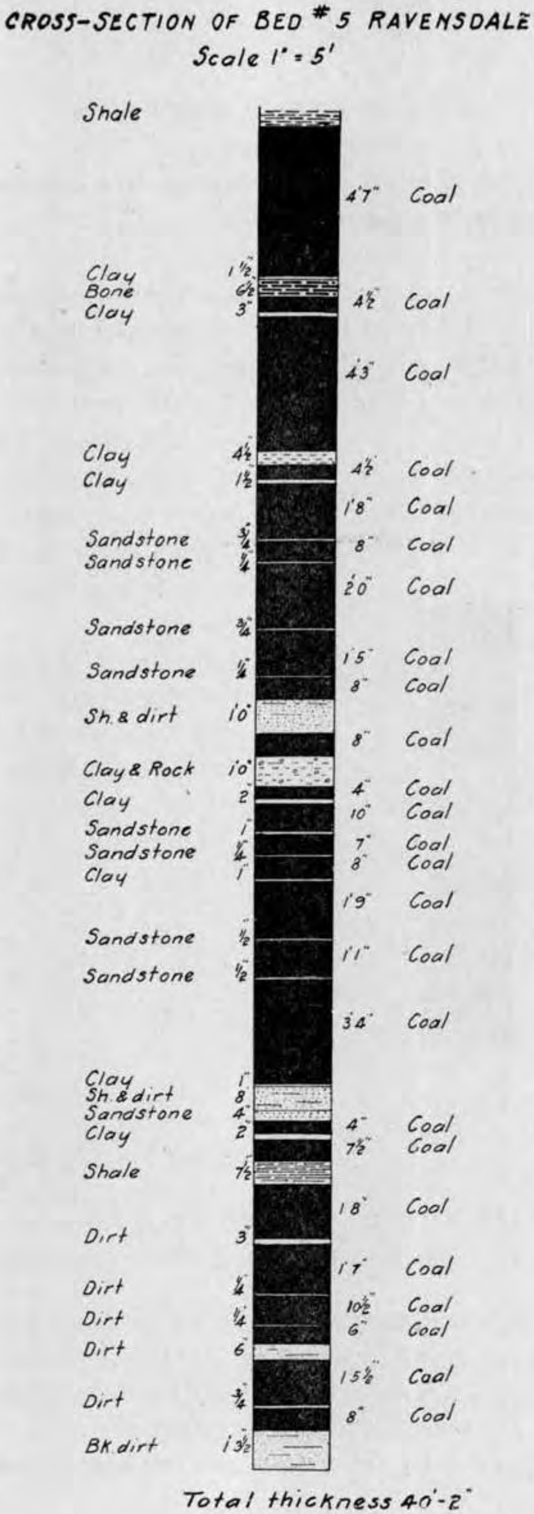

FIG. 27. Cross-section of No. 5 Bed at Ravensdale.

water from the first level; and one steam and one electric pump handle the water from the second to the first.

MCKAY NO. 2.

The first work done on the McKay was the water level gangway on the eastern dip. This gangway was driven about 1,300 feet to the east boundary line of the property. The next work was on the water level on the western dip; this was driven for a distance of 4,500 feet to an undetermined fault. This level is abandoned at present.

A main slope has been sunk on the western dip, to a depth of 300 feet. An auxiliary slope has been sunk 700 feet. The south gangway on the first level has been driven on the coal and through rock for a total distance of 3,200 feet. This part of the mine is not operating at present. The gangway to the northward on this same lift has been driven 300 feet.

On the second lift the south gangway was driven 800 feet, to the fault zone. On the north side the gangway was driven 1,100 feet to a fault. This bed varies in dip from 76 to 50 degrees.

McKay No. 2 is not operating at present, having been closed since August 24, 1911. The water from this mine was lifted by an electric pump from the first level. The hoist at the main slope is a twin 24x48 engine built by the Vulcan Iron Works. The ventilation was by means of small booster fans. Chute and block was the system of mining. The lower bench of the McKay bed averages about 5½ feet in thickness; only the lower bench was worked. There is apparently a considerable tonnage of McKay coal in the south or main slope, but at present all work is concentrated on mine No. 1.

BLACK DIAMOND MINES.

"B" MINE.

This mine is opened on a bed that overlies the lower bench of the McKay bed about 300 feet stratigraphically. The slope is down to the third level and work is now going on. This mine is yet in its development stage. At present fifty tons per day are hoisted from this opening by means of a skip.

MORGAN SLOPE.

The Morgan slope at Black Diamond (sometimes called No. 11 mine) was started on a dip of 31 degrees in the material overlying the upper bench of the McKay bed. At a point 420 feet down the slope, the upper bench of the McKay was followed for 1,050 feet on a dip varying from 23 degrees at the upper part to 17 degrees at the point where the slope was started through the strata lying between the upper and lower benches of this bed. The slope was continued on a dip of 30 degrees until the lower bench of the McKay was struck; then it followed on the same dip as the lower bed of the McKay, that being from 18 to 20 degrees. The slope is now down 4,750 feet and it is planned to sink another level below the tenth. The mouth of the slope is in the southwest quarter of section 11, T. 21 N., R. 6 E., and is driven west on the dip of the bed. The main slope goes to the fifth level, and from this point down the dip there is an electric slope.

Ten levels and one counter gangway have been driven on the northern extension of the bed, and ten levels have been driven southward to connect with the north levels of the No. 14 mine. Driving south, a thrust fault was struck at a point 1,800 feet south of the slope. The direction of this fault is nearly north and south. This fault line separates the Morgan slope and the No. 14 mine.

About 6,300 feet north of the slope, the second level struck a fault of unknown character and extent. The other levels in turn as they came to this line of faulting struck what appeared to be this same fault zone. In the sixth level north, a fault was encountered about 4,300 feet from the slope. This fault is a normal one and a rock tunnel has been driven to the coal on the other side of the fault.

The strike of the McKay bed swings through this area from a position nearly north and south, with a west dip, to a position nearly east and west, with the dip north. The dip varies from 22 degrees at the south end of the mine to 45 degrees at the north end. The lower bench of the McKay is about 10 feet from the upper one near the outcrop, but at the eighth level the

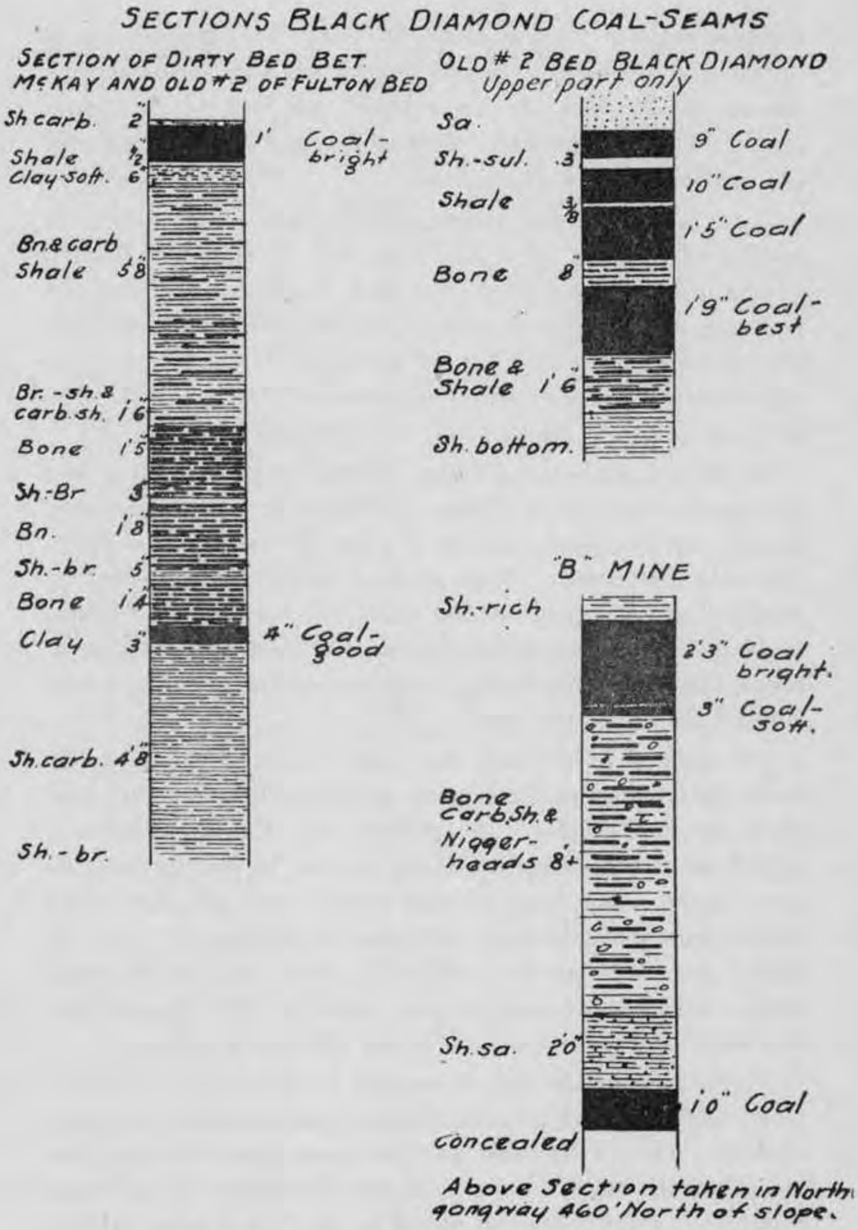

FIG. 28. Cross-sections of Black Diamond Coal Beds.

distance between them is about 90 feet. The upper bench is operated at the fifth, sixth and seventh levels by means of rock tunnels driven from the lower bench gangway to the upper bench. The mine produces more or less gas and safety lamps are used in all the working faces.

By reference to the accompanying plate, which shows the method of working, it will be seen that in the sixth level, a system of breasts and pillars was used, the chutes were driven 8 feet wide up to the first crosscut and then widened to 24 feet. The first crosscut was driven 30 feet above the gangway, while other crosscuts were driven at intervals of 75 to 100 feet. The chutes were driven each 50 feet, center to center.

On the seventh level a different system was used, wider pillars and breasts being tried. Chutes 10 feet wide were driven every 66 feet up the pitch, and at a point 30 feet up the pitch, crosscuts were driven. Each alternate chute was continued up the pitch and at a point 30 feet above, the crosscut was widened to 40 feet. This breast was then carried up to the chain pillar above, three crosscuts being driven between the gangway crosscut and the top of the breast.

The method of working the upper bench is shown in the same plate, and also the position of the rock tunnel that connects the two benches. At present only the sixth, seventh, eighth and ninth levels are being worked in the big seam or lower bench. One hundred and twenty tons per day is the output from the sixth level, 120 from the seventh, 210 from the eighth and 210 from the ninth. The little seam or the upper bench, on the eighth level, has an output of 180 tons per day. The total output for this mine is now 840 tons per day.

At the surface the coal is handled by automatic conveyors. Originally the cars were dumped into separate bins in the large bunkers. The arrangement was very poor, due to the fact that in placing the bunkers too close to the slope there was not room enough to properly control the cars, the curves being entirely too sharp. Under the present management, this difficulty has been overcome by an excellent system of conveyors. The coal is screened and picked, but not washed.

MINE NO. 14.

This was the earliest opening in this part of the King county coal field. The slope is sunk on the McKay bed, in the S. E. 1/4 of section 14, T. 21 N., R. 6 E. The McKay bed at this point strikes a little south of east and dips to the southwest at an angle varying from 15 to 39 degrees.

The main slope is sunk on the bed to the third level. The dip of the bed at this point varies from 24 to 30 degrees. At the third level a gangway is driven to the westward a distance of 1,800 feet, and from this point downward another slope is sunk on the same bed. This latter slope is commonly called the Electric slope. It is sunk from the third level to the ninth, and preparations are being made to sink it to the tenth level.

Gangways are driven east and west from the main slope. Driving westward and northwestward toward section 11, two normal faults were struck. Driving eastward the Franklin fault zone was struck. The McKay bed has not yet been found in place to the southeast, beyond this fault. Each succeeding lift downward has encountered this fault as the gangways were driven to the southeastward. The direction of the fault zone is in a general east and west direction. A rock tunnel has been driven south from the seventh level and a bed of coal closely resembling the Gem has been struck. This bed strikes southeast and dips to the southwest at an angle of 31 degrees. The mine produces more or less explosive gas and safety lamps are used in the greater part of it.

Both the lower and upper benches of the McKay bed are worked in this mine. The accompanying plate shows the method of working the lower bench in the eighth level north, where the pitch is 28 degrees. A breast and pillar system is used. Chutes 10 feet wide are driven every 70 feet, and at 30 feet up the pitch crosscuts are driven to connect the ends of the chutes. Above this lower crosscut the breasts are widened to 24 feet, leaving the left rib in line with the left rib of the chute. Four crosscuts are driven to connect the breasts in the remaining distance up the pitch.

At present 80 tons of coal daily are being mined from the eighth level, 330 tons from the ninth, all in the lower bench, and 60 tons from the little seam in the ninth level.

NO. 2 MINE.

This mine is not operated at present. The slope was sunk on what is locally called the No. 2 bed, but which corresponds to the No. 12 or Fulton bed at Franklin. The slope is down to the fifth level, a total distance of 1,750 feet. The dip increases from top to bottom and varies from 22 to 30 degrees.

The second level was driven eastward 1,100 feet, and to the westward about 500 feet. The third level was driven east about 650 feet and west about 700 feet; the fourth level east about 550 feet and west about 900 feet; the fifth level east 200 feet and west 1,500 feet. It is reported that the coal became poorer as the various gangways were developed. The decreasing demand for this coal necessitated the closing of the mine.

The coal was hoisted through the main slope and dumped into the old No. 2 bunker, which has since burned down. The slope is kept open from the fourth level to the surface. A rock tunnel connects this level of the No. 2 mine with the third level of the No. 14 mine and this acts as an airway and escape.

Section along the rock tunnel between the McKay bed, No. 14 mine, and the old No. 2 mine, Black Diamond:

	Ft.
McKay bed	..
Shale	6
Stratified sandstone	18
Gray shale	58
Coal bed	1
Gray massive sandstone	44
Shaly sandstone	22
Coal bed, impure	18
Brown shale	3
Stratified gray sandstone	26
Gray cross bedded sandstone	175
Bed No. 2 or Fulton	..
Total	370

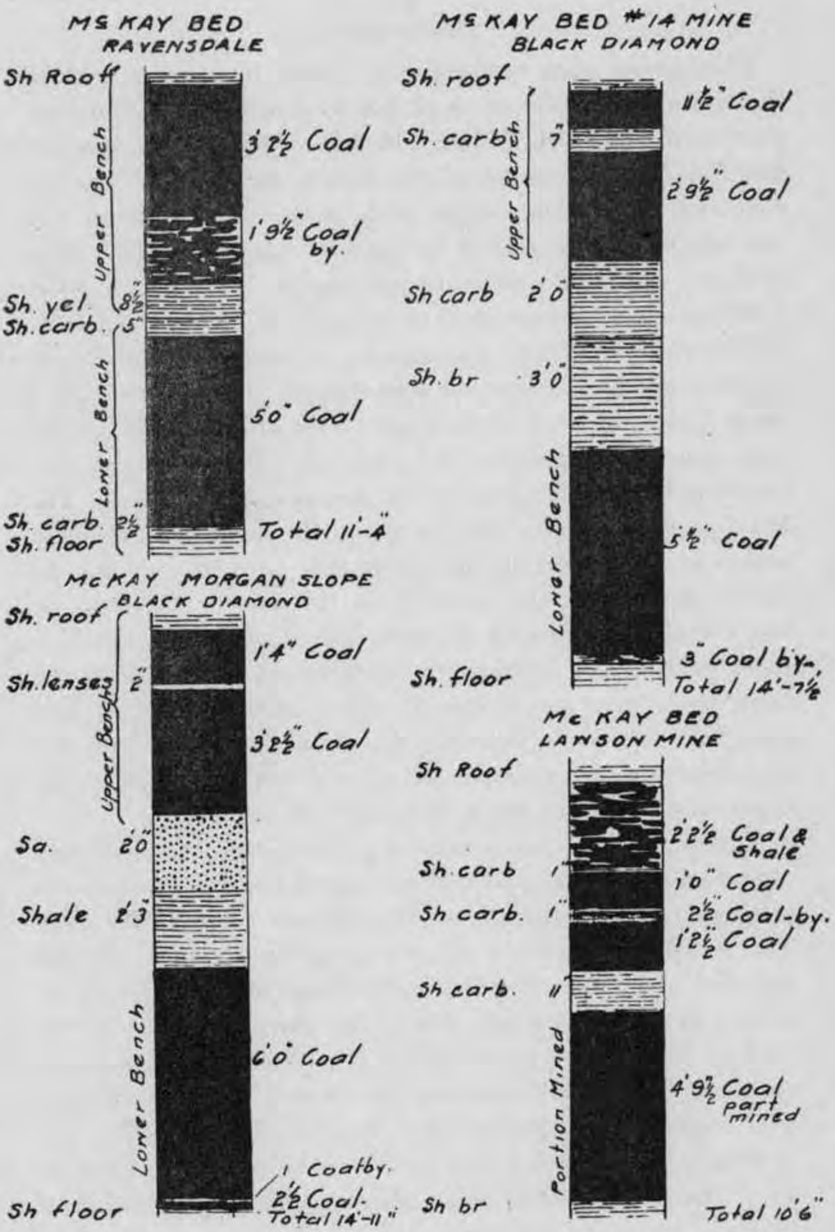

FIG. 29. Cross-sections of McKay Bed at various mines.

LAWSON MINE.

The Lawson mine was originally opened by a water level on the McKay bed. The entrance was by a drift in the southeast quarter of section 13, T. 21 N., R. 6 E. At a distance of about 600 feet from the mouth of the drift a normal fault was encountered with a down throw to the west. A rock tunnel 112 feet long caught the coal on the opposite side of the fault. This drift was continued northward into section 13, and at a point 2,100 feet from the entrance to the drift another normal fault with downthrow to west was struck. A rock tunnel 50 feet in length found the coal on the opposite side of the fault. At a point 1,650 feet from the entrance to the original drift a main slope was driven down on the coal bed. The slope was continued to the sixth level, or a total distance of 1,656 feet. The bed dips at 61 degrees near the top of the slope, and gradually lessens in angle until at the bottom it is only 40 degrees. As stated above there are six levels in this mine. The first, or water level, was driven to the north line of section 13, at which point more or less faulting was encountered. The second and third levels were also driven to points near the section line. Each level crossed the fault that was struck in the first level, but the amount of throw diminished in each level downward. The direction of the fault was a little north of east.

The fourth level was continued north beyond the north line of section 13 and the coal that was mined from the area up the pitch above this gangway was brought out through this level. The fourth level and the counter gangway above it changed direction near the section line, and swung from a northerly direction to an easterly one, due to the change in strike of the McKay bed as it swung around the north end of the Kummer syncline. The fourth level and the counter gangway above it were continued into the northeast quarter of section 13. The sixth level was continued to a point near the east line of section 13. The gangway was but a short distance below the fault that was struck in the levels above. This fault continued to diminish until near the east line of the section it disappeared almost entirely.

South of the slope the second, third, fourth, fifth and sixth levels were driven through the fault struck in the first level going north from the original entrance. This fault like the one noted above diminished as it was struck in level after level below the first. The levels were driven south on the strike, until the Franklin fault zone was reached, at a point about 2,300 feet south of the main slope. Unsuccessful attempts have been made to cross to the south of this fault zone.

The McKay bed was opened at this mine on the west limb of the Kummer syncline. The bed dips from 61 to 40 degrees east, striking north 25 degrees east at the slope, and as the north end of the syncline is approached the strike changes to an easterly direction, then finally due east, and dips south at angles varying from 19 to 26 degrees. As the levels approached the Franklin fault zone, south of the main slope, the dip increased to 81 degrees at the first level and 51 degrees in the fifth level. Only the lower bench of the McKay bed is mined.

Section of McKay coal bed at Lawson mine:

	Ft.	In.
Coal with carbonaceous shale	2	2½
Carbonaceous shale	..	1
Coal	1	..
Sandy shale	..	1
Bony coal	..	2½
Coal	1	2½
Carbonaceous shale	..	11
Coal (partly mined)	4	9½
Brown shale at bottom	..	..

The character of the roof changes from place to place in the mine, with the result that the methods of mining have been changed to suit varying conditions. Several modifications of pillar and breast, chute and crosscut systems have been tried, varying the sizes of the breasts and pillars to suit the character of roof and the amount of squeeze on that particular portion of the mine.

The plate accompanying this report shows the methods used on the south side of the slope on the fourth and fifth levels. The dip at the third level was 57 degrees and 50 degrees at the fifth. It will be noted that in the fourth level chutes and crosscuts were used. Eight-foot chutes, forty-five feet from center to center, were carried up the pitch and crosscuts driven from chute to chute at every forty feet center to center.

In the fifth level a different system was used. Eight-foot chutes were driven at intervals of fifty feet and at a point 30 feet up the pitch from the gangway a return crosscut was driven, every alternate chute being continued up the pitch to the chain pillar beneath the fourth level gangway. After the gangway crosscut was driven, crosscuts about 100 feet apart were driven to connect with the other chutes.

An explosion occurred at this mine on November 6th, 1910, in which sixteen men were killed and the mine completely wrecked. This mine produced gas from time to time and safety lamps were used throughout the workings. Several theories have been advanced as to the cause of the explosion, but since it has been impossible to visit the place of explosion since it occurred, the real cause will never be known.

The mine has been closed since the explosion and will probably never be reopened. The coal, while of very good quality, was expensive to mine, due to heavy squeezes in the lover levels. This mine was down 800 feet below sea level and the sixth level was under about 2,000 feet of cover, the thickest cover of any mine in the state.

MINE NO. 12.

This mine, now abandoned, is located in section 12, T. 21 N., R. 6 E. The slope was sunk on the McKay coal bed by the old Black Diamond Coal Company, prior to 1889, and eventually reached the fifth level. It was started not far from the east line of section 12, which was at that time the limits of the property. The east gangways were not driven very far. The west gangways were driven to a series of troublesome faults that changed the dip of the coal from its normal dip of from 16 to 21 degrees to that of 70 to 80 degrees. The bed in this disturbed area was very difficult to mine.

In April, 1894, a fire broke out in the pump room in the mine, and the fire soon extended over the entire mine. The mine was allowed to fill with water and has not been entirely opened since that date.

The McKay bed at this point is at the north end of the Kummer syncline. The strike is nearly east and west and the dip is to the southward, usually at from 16 to 21 degrees, but farther to the west is from 70 to 80 degrees, due to the faulted character of the ground.

The coal was hoisted up the main slope and the cars run to the old bunkers located on the No. 12 branch of the Columbia and Puget Sound Railroad. No washers or pickers were necessary, since the coal as it came from the mine was remarkably free from impurities. The mine produced a small amount of explosive gas, but the ventilation was so well taken care of that there were but few accidents from explosions.

MINE NO. 7.

The Pacific Coast Coal Company opened this mine on the McKay bed in section 7, T. 21 N., R. 7 E. It was opened in 1893 and the slope sunk 240 feet the first year. In 1894 the mine was closed temporarily for repairs. From 1895 until the mine was finally closed in 1907, it continued to produce coal.

The slope was sunk southward on the southern dip of the McKay, where the dip varied from 20 to 40 degrees. The McKay through this area outcrops along the north rim of the Kummer syncline. There is a subordinate anticline west of the No. 7 slope. To the eastward the gangways turned south to correspond to the strike of the beds in the old Franklin mine.

Eight levels in all were sunk in this mine. The bottom of the slope struck a fault that was not crossed at this point. The coal was hoisted up the main slope and dumped into the bunker which was located on the No. 12 spur of the Columbia and Puget Sound railroad. Since the abandonment of this mine the spur has been taken up.

FRANKLIN MINE.

The Pacific Coast Coal Company owns the property on which the Franklin mine has been opened. The principal bed in the series here is the McKay and on it most of the work has been done. As early as 1887 drifts were driven on this bed at the level of Green river and also above the level of the old railroad grade, on what was at that time called the upper McKay. The Green river drift was often referred to at that time as the section 19 mine, due to the fact that the opening was on that section in T. 21 N., R. 7 E. The drifts were driven northward along the strike of the bed, close to the north line of section 18. The bed within this area was remarkably free from faults and the dip, which was westward, was steep enough so that the coal would run easily on sheet iron. The dip varied from 50 degrees at Green river to 30 degrees at the north end of the gangway.

Sometime in the early part of 1887 a large and well equipped slope was sunk diagonally across the dip on the No. 12 bed, which underlies the McKay. A rock tunnel was driven across the strata on a curve through the overlying strata to the McKay bed. A slope, known as the Thomas slope, was sunk from this point, which was a little higher than the level of Green river, on the McKay bed. Also a slope was sunk from the outcrop of the McKay at Green river, called the Sullivan slope. Gangways were driven north and south to connect these two slopes. Part of the coal was hauled out of the Sullivan slope, but most of it was hoisted up the Thomas slope and the big slope. Later another level was sunk on the Thomas slope and two more levels on the Sullivan slope.

A slope was also sunk on the No. 13 bed, which lies between the No. 12 bed and the McKay. Rock tunnels were driven across from this slope to the overlying McKay. This slope reached the seventh level of the McKay. The south gangway of the McKay, on the sixth level, struck a fault at a distance of 2,900 feet. Mine fires and explosions compelled the management to close the mine from time to time. The early (not

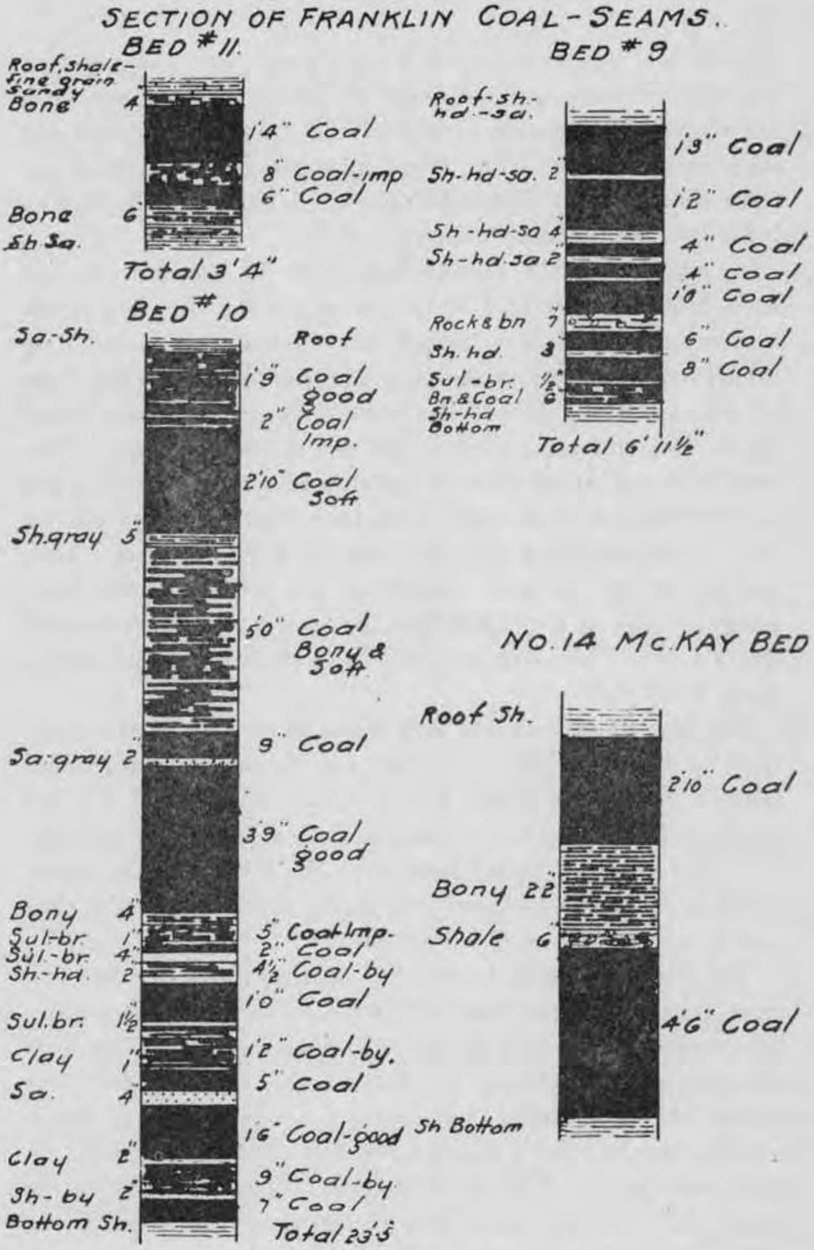

FIG. 30. Cross-sections of Franklin Coal Beds.

the earliest) operators of the mine showed poor judgment on various occasions and for want of better management there are scores of thousands of tons of this splendid coal that can never be recovered. The latest management has proved far more efficient and it is probable that at a lower depth the McKay bed might yet produce some coal.

In addition to the McKay bed, Nos. 10, 11 and 12 were worked in the lower part of the series and the Gem bed in the upper part. The No. 12 bed was worked by a water level tunnel from the river, connecting with the foot of the big slope on the same bed. It was also worked by a water level tunnel driven from the same level as the top of the big slope. This later drift was driven north a distance of 3,000 feet. This bed was also worked in the third level from No. 1 slope on No. 11 bed, which connected with this bed by a rock tunnel. Both benches of No. 12 were worked on this level, and the south gangway was driven 1,500 feet, or nearly to a point under Green river. The north gangways on both benches were driven about 3,900 feet.

Bed No. 11 was worked only from slope No. 1, which was sunk on this bed. The gangway was driven south from this slope a distance of 1,600 feet to Green river. Bed No. 10, which underlies bed No. 11, was worked only slightly and this by means of a rock tunnel from slope No. 1 through the underlying strata. The gangway was driven south toward the river and about 250 feet to the northward.

The Gem bed, which overlies the McKay bed about 800 feet stratigraphically, has been extensively worked, first by a water level drift near the level of the old railroad grade. This drift was continued northward for 6,300 feet. Later a drift was started near the level of Green river and this was driven over a mile northward. At a point 1,200 feet north of the entrance on Green river, a slope driven diagonally has been sunk to the third level. On the third level the gangway has been driven northward and also south to the Franklin fault, which crosses the measures south of the river. The operators are at present

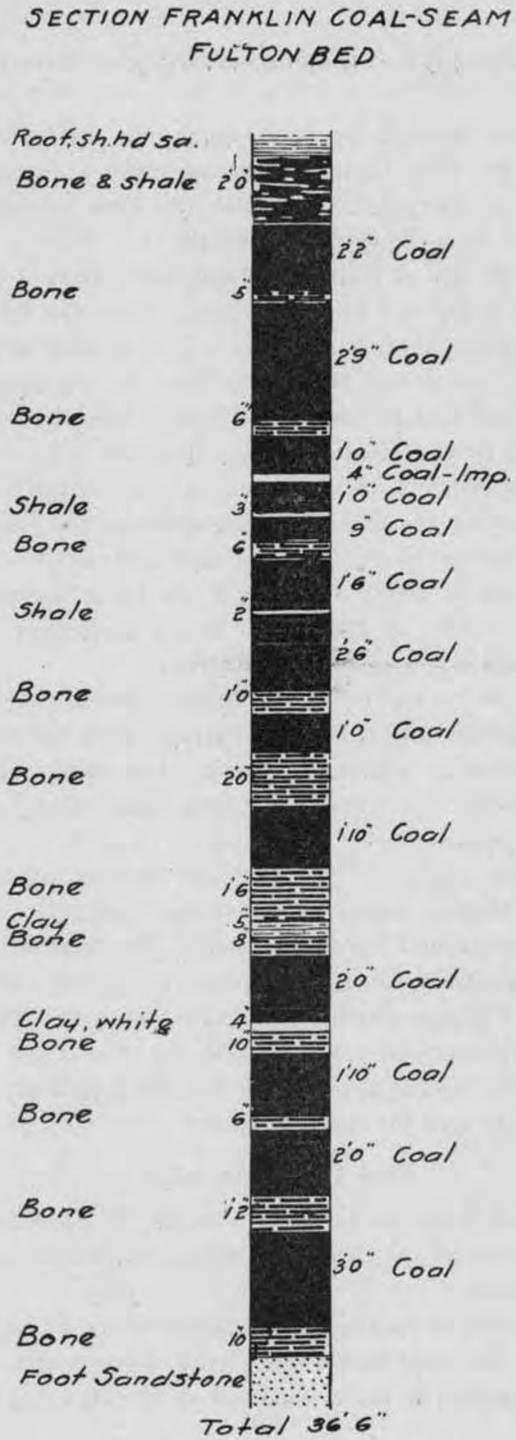

FIG. 31. Cross-section of Fulton Bed at Franklin.

driving south through the fault, hoping to reach the McKay bed which has been thrown westward about a thousand feet. This mine is now producing about 180 tons per day, all of which comes from the third level north.

Prior to the fire of February, 1909, the system of mining in use was the pillar and 24-foot breasts. After the fire the system was changed so that now two chutes, six feet wide on 56-foot centers, are driven 50 feet up from the gangway. Then crosscuts are driven to connect the chutes; then they are driven up 320 feet to the 150-foot chain pillar left below the upper gangway. Crosscuts are driven at intervals of 50 feet up the pitch connecting the chutes. After reaching the chain pillar, the chutes are opened up 25 feet on each side and the coal taken out downward to within 100 feet of the lower gangway. By this means a pillar of 50x50 feet is left to protect the lower crosscut which serves as the return airway.

Only two chutes are driven up together, then a block 200x376 feet is left intact until it is time to retreat from the face of the gangway, when it is planned to take these blocks out. It is thought that by this system mine fires, should they occur, can be easily regulated.

An electric engine is used to hoist the coal up the inside slope. An electric engine on the surface generates electricity for the underground lighting system. The ventilation is effected by an exhaust fan 10 feet in diameter by two and one-half feet wide. The mine produces no explosive gases. The coal is subject to spontaneous combustion in the mine if not properly handled. The ccal is not washed, but hand picked. Most of the product is used for steam purposes.

NEW FRANKLIN MINE.

In the southwest quarter of section 19, T. 21 N., R. 7 E., the Pacific Coast Coal Company has recently commenced opening a new mine.

The Gem bed, in its position southwest of the Franklin fault, outcrops at this point on the south bank of Green river. It was originally planned to drive southeast on the Gem bed for some

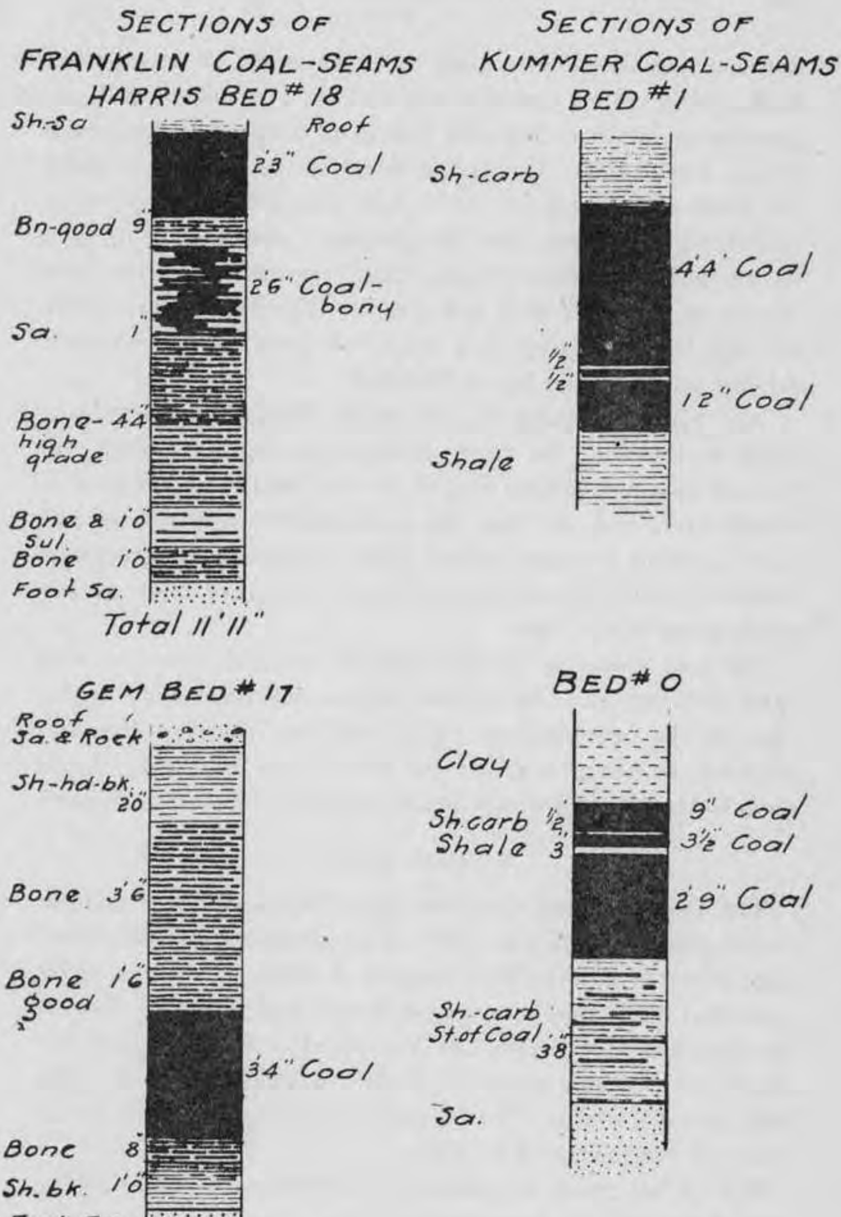

FIG. 32. Cross-sections of Coal Beds at Franklin and Kummer.

distance and then drive a rock tunnel eastward to intersect the McKay bed which underlies the Gem. The miners had not gone many hundred feet with this drift until an underground stream was struck. It was not practical to try to get under the stream at this point, so a rock tunnel was driven to an underlying bony bed, then the gangway continued southward on this bed. But little progress had been made until the same stream or a branch of it was struck. The miners then drove through the underlying rock to another bony bed and are now driving southward on top of that bed.

It is planned to mine the coal in the McKay and Gem beds, lying southeast of the river, through this mine. A slope will be sunk soon on the Gem bed, to the first level below the level of Green river, and the coal will be worked from this level and lower, leaving a large surface pillar to protect the workings from the underground channels that will prove more or less troublesome in this area.

The coal from the old Gem will be brought down the west bank of Green river by electric motors and hoisted up an incline to the new bunkers. The coal from the New Franklin mine will be brought across the river to the west side, thence down to the foot of the new incline and hoisted up to the bunker.

KUMMER MINE.

The Denny-Renton Clay and Coal Company has a mine in section 26, T. 21 N., R. 7 E. This property was originally opened by the Denny Clay Company in 1889. Three beds were opened at that time, but only sufficient coal mined to operate the company's clay plant at Van Asselt. Labor trouble occurred in 1891 that necessitated the closing of the mine. The mine was operated in a limited way, supplying the wants of the company for their clay factories.

Within late years the company has changed hands, and the present owners have been operating the mine in much the same manner as the former company. Only shale and fire clay have been mined recently. Gangways have been driven on bed No. 1

and on the upper bed from the edge of Green river to the north section line of the property. No. 1 gangway is in section 26 and the gangway of the upper bed starts on section 26, but crosses the line into section 25, where most of the work has been done.

No work either on the shales or coal is being done at present. There is a large stock of shale on hand and the Taylor mine, operated by the same company, furnishes all the coal desired for the clay plants.

When coal was mined, it was hauled out of the gangways by mules to the foot of the incline, then hoisted up to the top of the bluff and dumped into the bunkers which were located on a spur of the Columbia and Puget Sound railway.

These beds are on the west limb of the Kummer syncline and dip eastward at about 52 degrees. Sandstone, fire-clay, shale and coal have been mined from this portion of the Kummer series.

Log of Eugene Lawson's drill hole, in the southeast quarter of the southeast quarter, section 27, T. 21 N., R. 6 E. The drill hole was vertical, the strata dipping about 16 degrees to the westward. The McKay bed is believed to have been reached at 1,369 feet, where the hole caved:

	Ft.	*In.*
Surface soil	2	..
Clay, not glacial	45	..
Sandstone	72	..
Carbonaceous shale	34	..
Stratified sandstone	25	..
Gray stratified shale	30	..
Sandy shale	31	..
Bone and impure coal	4	..
Dark shale	5	..
White sandstone	93	..
Black carbonaceous shale	13	..
White sandstone	134	..
Sandy shale	15	..
Dark shale	6	..
Hard dark sandstone	4	..
Coal and bone	6	..
White sandstone	12	..
Light colored shale	9	..
Dark shale	43	..
White sandstone	62	..
Dark shale	2	..

	Ft.	In.
Bone	1	..
Light shale	40	..
Coal	1	..
Shale	15	..
Fine grained sandstone	6	..
Light shale	16	..
Dark shale	6	..
Bone and coal	10	6
Shale	5	6
Light colored stratified sandstone	117	..
Very hard dark shale and sandstone	32	..
Light shale	13	..
Dark shale	16	..
Light shale	7	..
Fine grained white sandstone	41	..
White shale	5	..
Fine grained white sandstone	33	..
Dark gray shale	6	..
Bone and coal	18	9
Coarse grained sandstone	129	..
Coal and bone	14	..
Dark sandy shale	50	..
Light brittle shale	47	..
Shale, coal and bone	41	..
White sandstone	38	..
Bone and coal	2	6
Shale and bone	2	..
Bone and shale	3	..
Light stratified shale	23	..
Dark shale	17	3

KANGLEY MINE.

This mine was opened by a slope in 1888, in section 26, T. 22 N., R. 7 E. By the close of 1889 the slope had reached the third level, and in 1891 was down a distance of 1,350 feet.

Considerable gas was given off in this mine and there was much faulting, especially in the south gangways. By the close of 1892 the south gangway had been worked out and the pillars removed. Several men were burned by minor explosions during the years 1892-93.

Three gangways were driven north, and the lowest level reached a distance of 2,000 feet. The mine was closed in 1897 and is still closed, so that the writer had no opportunity to get underground in the mine and there is very little to be seen on the surface at this place. On the rock dump there is a considerable amount of material similar to the late intrusive rocks that are so prominent in the Barneston-Taylor area. These

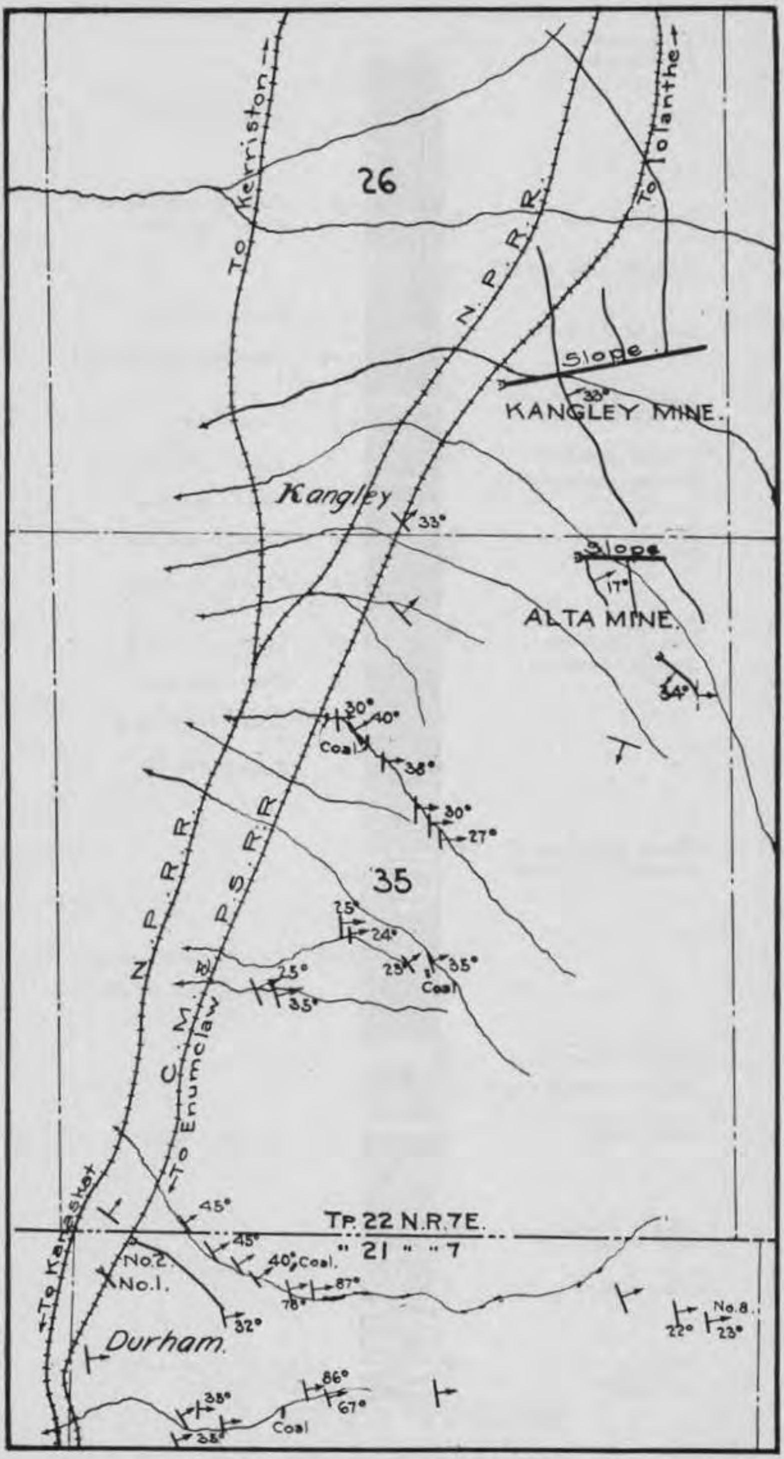

FIG. 33. Map of Outcrops near Kangley and Alta Mines.

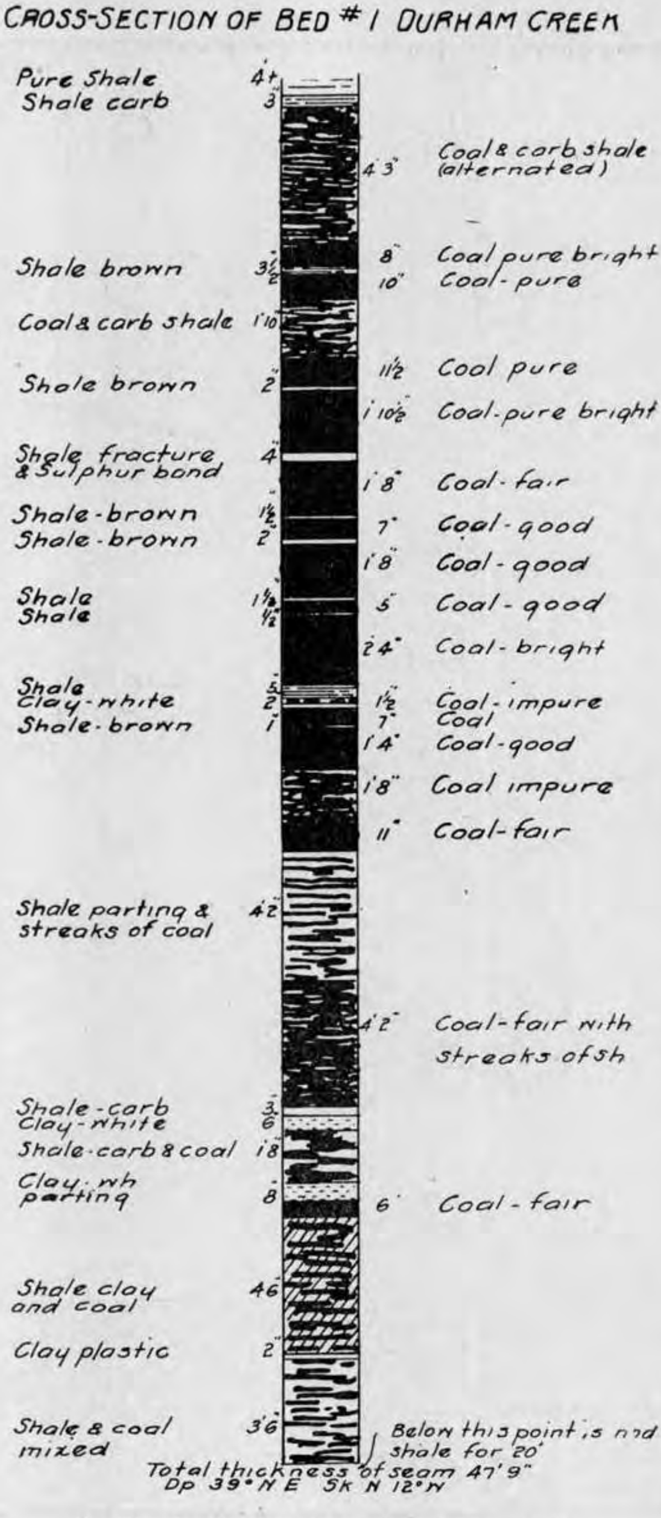

FIG. 34. Cross-section of No. 1 Bed, Durham Creek.

pieces of rock evidently came out of the mine and the only conclusion that can be drawn is that dikes or sills were encountered in the mine workings. It is possible that some of the supposed faults were none other than dikes crossing the strata. Such dike rocks are sometimes hard to distinguish from fine grained sedimentary rocks, especially to the untrained eye. The beds strike northerly and dip easterly at 33 degrees.

This mine produced very satisfactory coal. When operating, the coal was hoisted up the slope and dumped in the bunker, which was built on the Kangley branch of the Northern Pacific railway. The bunker and all other surface buildings connected with the mine are burned.

ALTA MINE.

This mine, now closed, was opened in section 35, T. 22 N., R. 7 E. It was started prior to 1891, for by this date the slope bed had reached a depth of 300 feet. The slope was opened on a bed that agrees very closely in appearance with the Kangley bed, opened in the section north.

The opening was made so close to the north line of section 35 that most of the work was done south of the slope. It was found on going south that the area was badly faulted and, after trying in vain to get beyond the faulted ground, the mine was abandoned in May, 1894.

Three levels were driven, two in the slope and one water level at the top of the slope. The beds at this point strike nearly north and south and dip easterly at 17 degrees. Some distance southeast of the slope a drift was started but this did not proceed far until faults were met. The bed at this point strikes northwesterly and dips southwesterly at 34 degrees. There is seemingly an anticline between this opening and the slope, but this apparent fold might be in reality a badly faulted zone.

When operating the coal was sent down an incline to a bunker on the Kangley branch of the Northern Pacific railway.

DURHAM MINE.

The Durham mine was opened in 1886-1887. The drifts are located near the north line of section 2, T. 21 N., R. 7 E. In

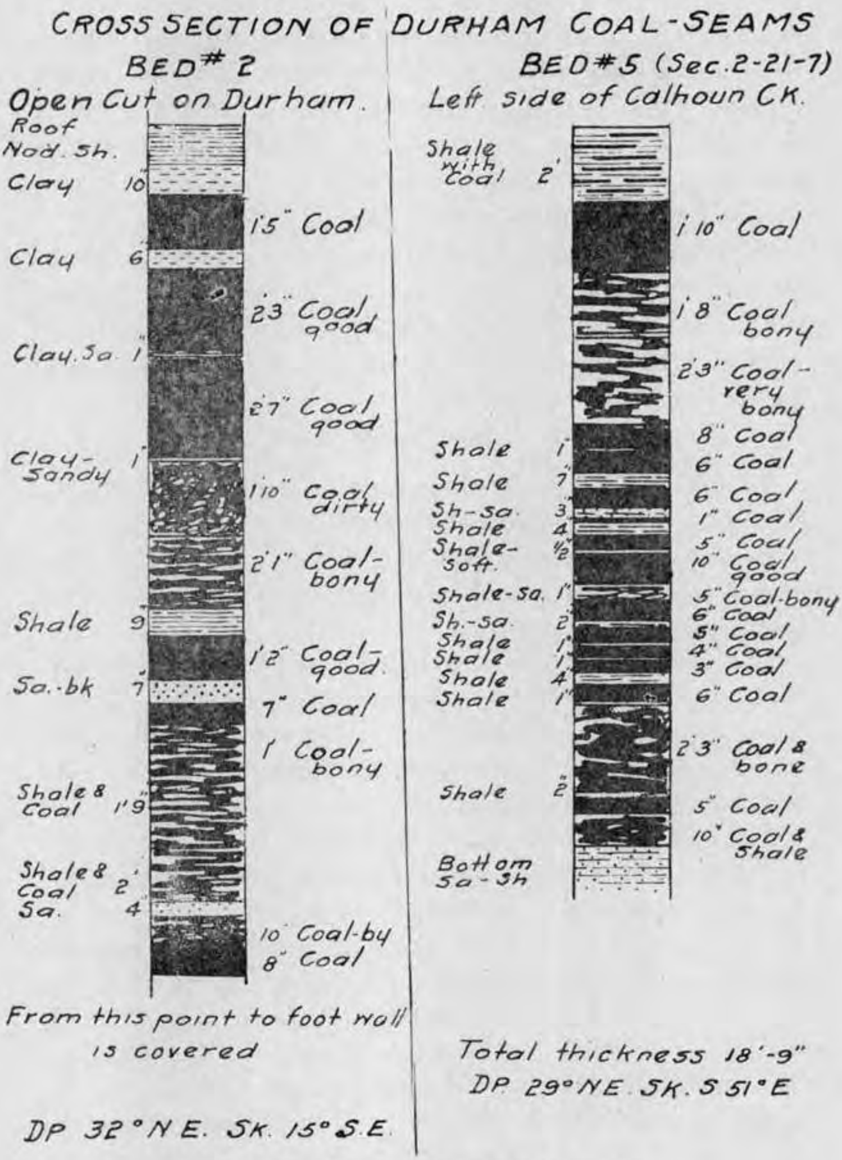

FIG. 35. Cross-sections of Coal Beds at Durham.

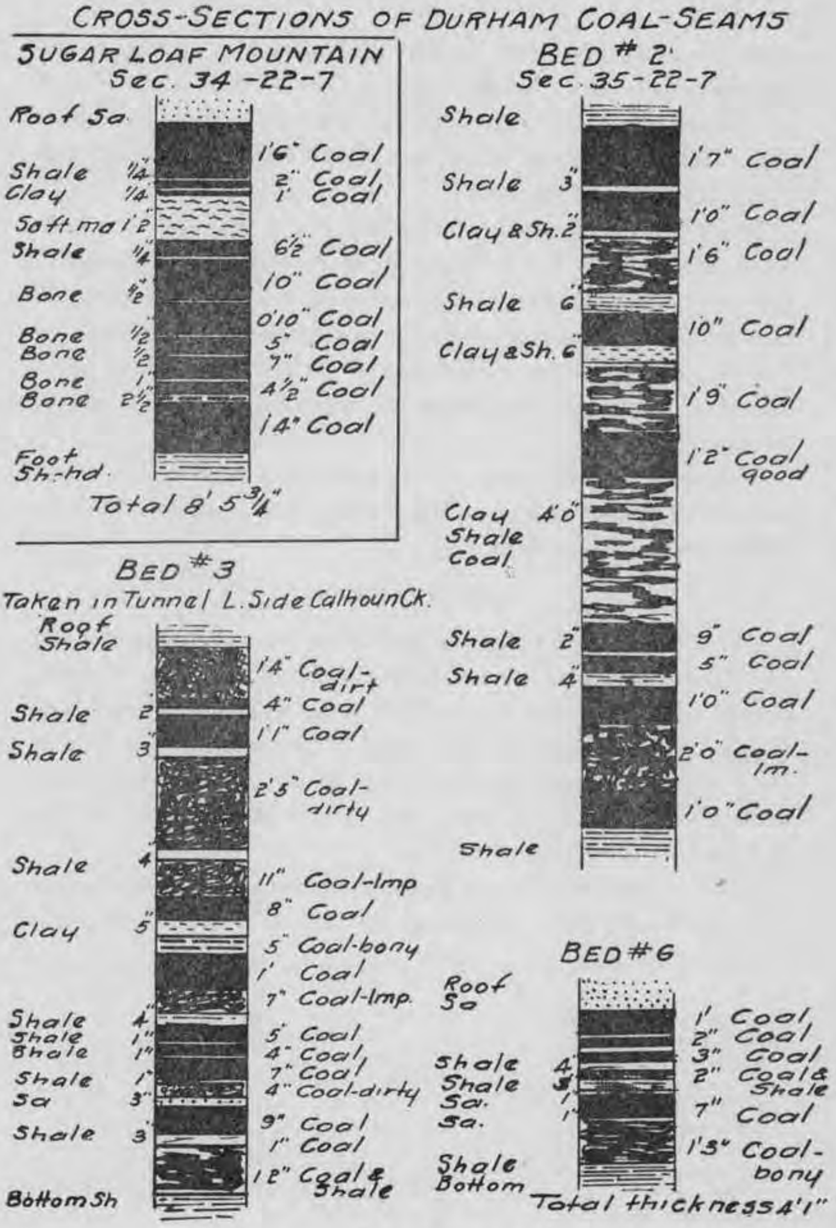

FIG. 36. Cross-sections of Coal Beds at Durham.

1888 the company spent a great deal of money in surface improvements, building houses, etc. In July of that year the mine was closed and little or no work has been done there since that date. No. 1 gangway was driven 1,350 feet to the southeast, along the strike of the bed.

No. 2 gangway, which overlies bed No. 1, was driven southward about 1,150 feet. Eight or more coal beds outcrop in this area and there are several beds outcropping in section 35 that evidently pass south through this property under the area that is covered between beds 6 and 8. It is reported that plans are afoot to reopen this property, but nothing definite can be learned.

The mine at the time it was operating produced a small amount of explosive gas. The bunker that had been built in 1888 was burned in 1889.

PALMER MINES.

The Palmer Coal Company has taken over the properties of Mr. Hudson, located in section 14, T. 21 N., R. 7 E. Considerable work has been done in this area and several coal beds exposed. To date very little coal has been mined from any of these beds. The beds on which most of the work has been done probably represent the lower beds of the Bayne series on the east limb of the Hudson anticline.

Details of outcrops along Moore spur, between Carbon bunker and the Big Six mine, in sections 14 and 15, T. 21 N., R. 7 E.:

CENTER N. E. ¼, SECTION 14, 21, 7.	Ft.	In.
Shaly sandstone	..	..
Carbonaceous shale	..	4
Shale.	..	3
Carbonaceous shale	..	3
Shale	..	3
Carbonaceous shale	..	1
Coal	..	3
Carbonaceous shale	..	4
Impure coal	..	6
Carbonaceous shale	..	9
Total	3'	0"

NEAR CENTER OF N. E. ¼, SECTION 15.	Ft.	In.
Sandstone	..	..
Carbonaceous shale	..	8
Shale	..	2
Carbonaceous shale	..	2
Shale	..	3
Bony coal	..	5
Carbonaceous shale	..	5
Shale	1	4
Carb. shale and some coal.	1	..
Concealed	..	..
Total	4'	5"

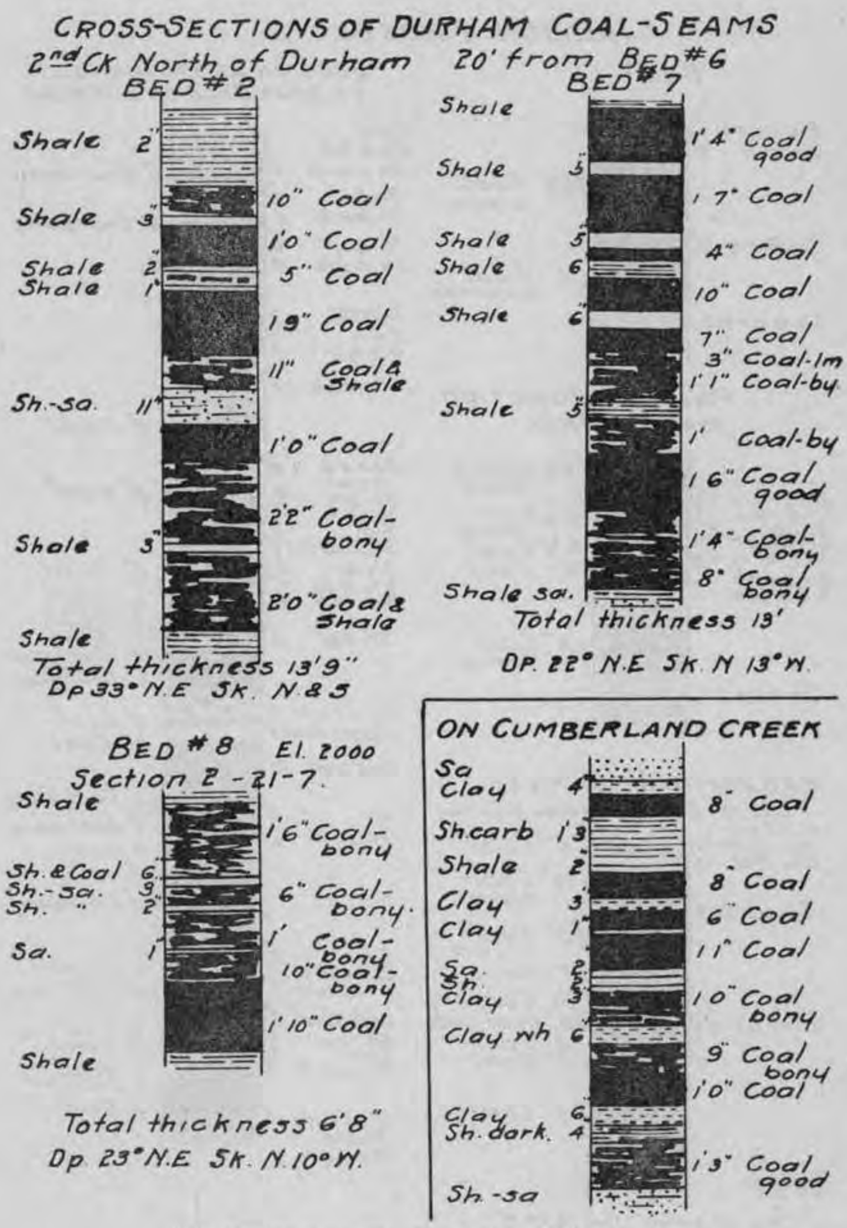

FIG. 37. Cross-sections of Coal Beds at Durham.

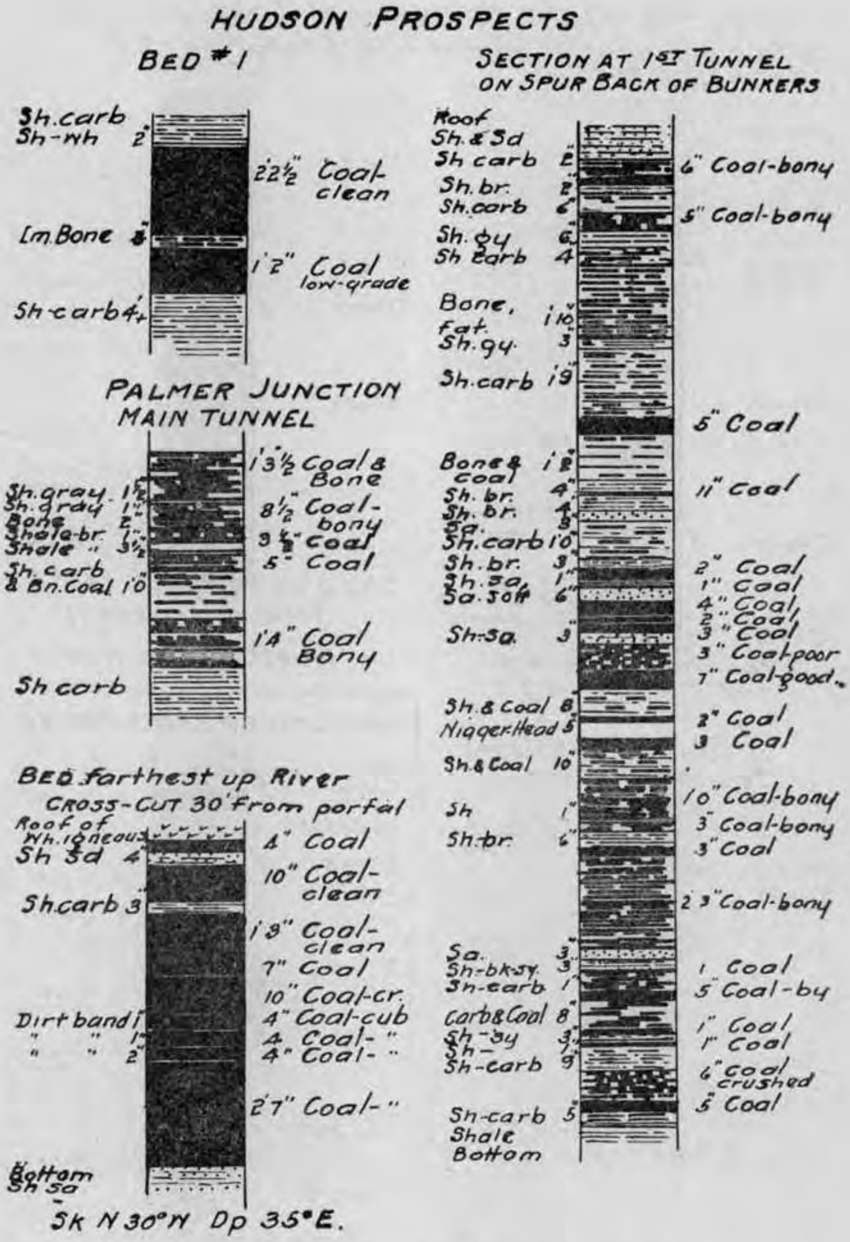

FIG. 38. Cross-sections of Coal Beds near Palmer Junction.

N. W. ¼ of N. W. ¼, Section 14.	Ft.	In.
Sandstone.	..	..
Carbonaceous shale	1	6
Yellow clay	..	3
Carbonaceous shale	..	3
Clay	..	2
Carbonaceous shale	..	3
Shale	..	4
Carbonaceous shale	..	11
Shale	1	4
Yellow clay	..	11
Carbonaceous shale	..	8
Shale	..	9
Carbonaceous shale	..	7
Clay	..	2
Carbonaceous shale	..	6
Bony coal	..	11
Carbonaceous shale	..	6
Shale	..	..
Total	10'	0"

N. E. ¼ of N. E. ¼, Section 15.	Ft.	In.
Sandstone	..	..
Carbonaceous shale	..	5
Shale	..	1
Bony coal	1	..
Carbonaceous shale	..	5
Shale	..	3
Coal	..	2
Clay	..	5
Coal	..	4
Shale	1	3
Coal	..	7
Clay	..	3
Bony coal	1	2
Clay	..	5
Bony coal	..	7
Clay	..	6
Carbonaceous shale	..	6
Sandstone	..	..
Total	8'	4"

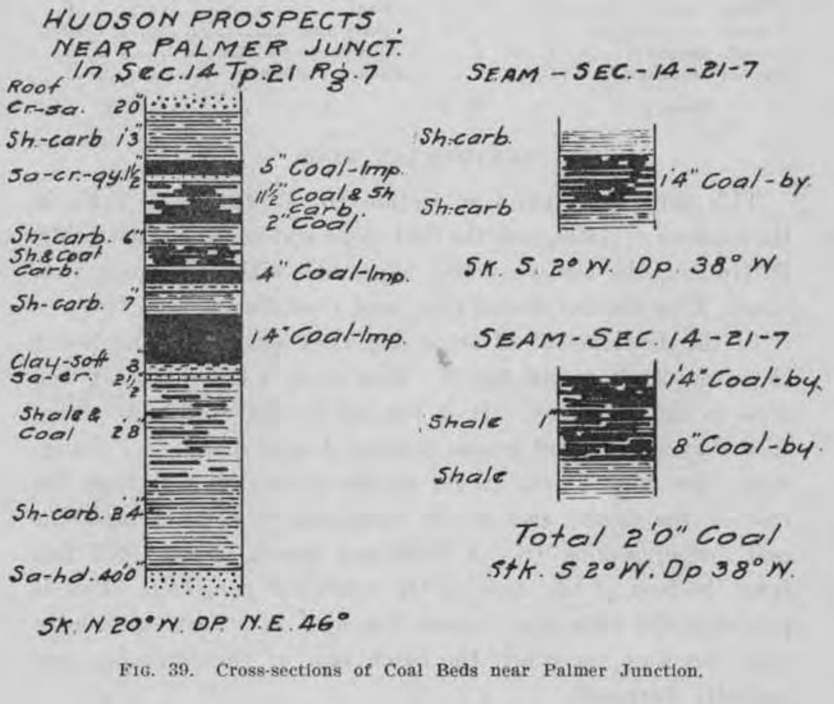

Fig. 39. Cross-sections of Coal Beds near Palmer Junction.

Section on the east side of Bayne mountain, west of Moore spur, near derail switch:

	Ft.	In.
Massive sandstone	300	..
Bed No. 4	11	..
Massive sandstone	72	..
Shale	32	..
Igneous rock	2	..
Bed No. 3	4	6
Massive sandstone	162	..
Bed No. 2	6	6
Massive sandstone	83	..
Bed No. 1	10	6
Concealed	..	..
Total	683′	6″

BED NO. 2.

	Ft.	In.
Massive sandstone	..	..
Bone	2	3
Clay	..	6
Bone	..	4
Clay	..	3
Bone	1	5
Shale	..	4
Coal, impure	1	..
Massive sandstone	..	..
Total	6′	1″

BED NO. 3.

	Ft.	In.
Shale	..	..
Intrusive rock	2	..
Bone	4	6
Massive sandstone	..	..
Total	6′	6″

BED NO. 4.

	Ft.	In.
Massive sandstone	..	..
Coal	1	..
Carbonaceous shale	3	6
Coal	1	6
Carbonaceous shale	5	..
Massive sandstone	..	..
Total	11′	0″

BED NO. 1.

	Ft.	In.
Massive sandstone	..	..
Shale	..	10
Bone and carb. shale	4	..
Coal	1	6
Bony coal	1	10
Carbonaceous shale	2	..
Massive sandstone	..	..
Total	10′	2″

OCCIDENTAL MINE.

This mine was opened on section 16, T. 21 N., R. 7 E., in the summer of 1898, and the first slope was sunk in 1901. Mr. P. Gibbon, the owner of this mine, has within the past year leased it to the Occidental Coke and Coal Company.

In the development of the mine, what was called the No. 2 slope was sunk on bed No. 3. This slope is 350 feet long and dips to the southeast. It is located on the west limb of the Lizard syncline, which passes through Lizard mountain. Gangways have been driven to the southwest on this bed from the foot of the slope; also to the northeast to a point near the east line of section 16. A fault was struck about 1,200 feet from the foot of the slope on the southeast gangway. This is probably the fault that crosses this area in a northeast-southwest direction, in which the block east of the fault has apparently dropped.

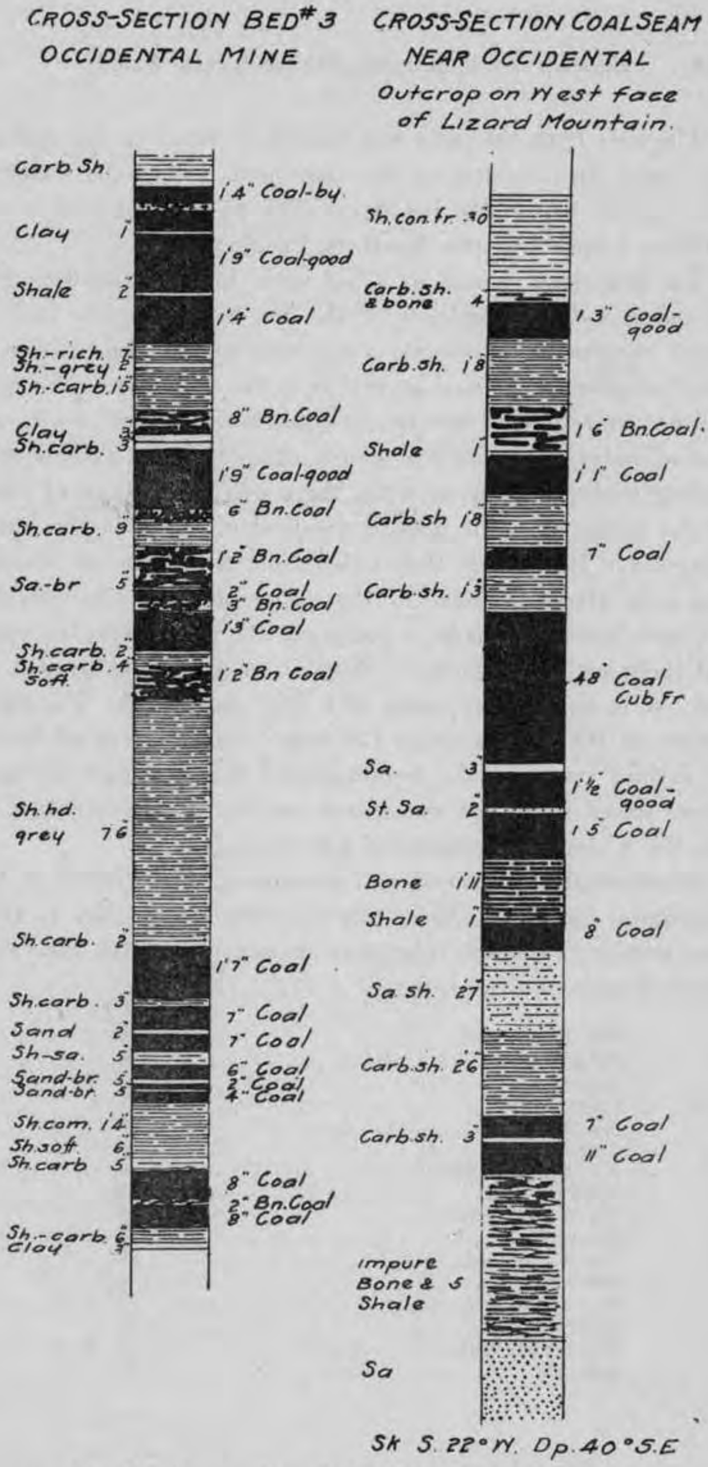

FIG. 40. Cross-sections of Coal Beds at Occidental Mine.

The coal from the mine was hauled by mules to the foot of the slope, then hoisted up the slope and run to the washers. The washers are of the jig type. The washer and bunker are built on a spur from the Northern Pacific railway.

The new slope is sunk on a bed lower in the series than No. 3, and is located northeast of the No. 2 slope. The bed on which the new slope is sunk is not very regular, and varies in the character of the coal as well as in the thickness. The coal will not average over two feet in thickness, but from five to six feet of material all told are mined. This bed was worked only during winter months or when there was a shortage of coal. Water broke into this mine in September, 1910, in the south gangway. It appears that water from a pre-glacial channel had been struck in some of the upper chutes. Unsuccessful attempts have been made to pump out the water from the slope but the mine is still flooded. Work is being done at present on bed No. 6, and this by means of a drift on the bed. The daily output of the mine is about 150 tons. Gas is given off freely in various parts of the workings and safety lamps are used where naked lights are considered unsafe. The ventilation of the No. 2 slope is by means of a 4′ blade fan.

Stratigraphic section of coal measures in the vicinity of the Occidental collieries. Measurements furnished by Mr. P. Gibbon, owner. Prospect holes were inaccessible at the time survey was made of this property.

	Ft.	*In.*
No. 1 coal bed	16	..
Interval	55	..
Bone bed	2	6
Interval	42	..
No. 2 coal bed	8	..
Interval	36	..
No. 2½ coal bed	4	..
Interval	43	..
No. 3 coal bed	35	..
Interval	50	..
No. 4 coal bed	20	..
Interval	54	..
No. 5 coal bed	7	..
Interval	26	..
No. 6 coal bed	4	6
Interval	24	..

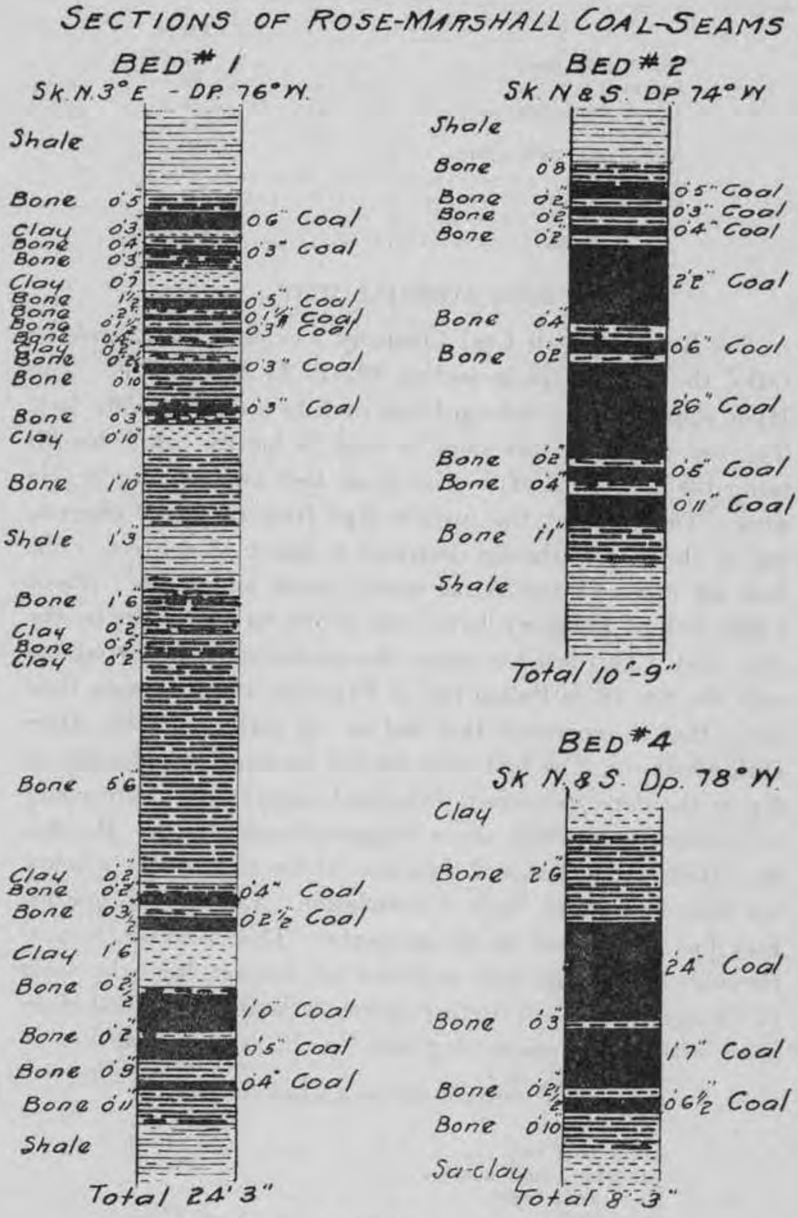

FIG. 41. Cross-sections of Coal Beds at Rose-Marshall Mine.

	Ft.	In.
No. 7 coal bed	1	5
Interval	58	..
No. 8 coal bed	8	..
Interval	544	..
Slope bed, new mine	..	..
Interval	96	..
Coal bed	..	..
Total	1,134′	5″

ROSE-MARSHALL MINE.

The Rose-Marshall Coal Company own what was formerly called the Hyde slope in section 29, T. 21 N., R. 7 E. The Hyde slope has been enlarged and sunk to a depth of 587 feet. The bed on which this slope is sunk is locally called No. 6, being the uppermost of a series of six beds outcropping in this area. The slope at the surface dips from 65 to 70 degrees, but at the bottom the dip decreases to about 45 degrees. The beds all dip west and strike nearly north and south. About 1,000 feet of gangway have been driven to the south on the slope bed. This bed has many characteristics that correspond with the No. 12 or Fulton bed at Franklin, and it is more than likely that it represents that bed on the east side of the Marshall syncline. The fact that the bed lessened considerably in dip as the slope was driven downward, apparently approaching a syncline, favors the above suggested correlation. Besides, the details of the bed and the material for some distance below the bed, strengthen such a correlation. One sill of igneous rock has been found on the property. This, however, is conformable to the coal beds and does not detract from the value of the area. This sill further agrees in position, size and character with the sill underlying bed No. 12 at Franklin.

SECTION IN VICINITY OF ROSE-MARSHALL SLOPE.

	Ft.	In.
No. 6 coal bed	28	6
Sandstone and shale	115	..
No. 5 coal bed	4	..
Concealed	40	..
Carbonaceous shale	2	..
Sandstone and shale	69	..
Carbonaceous shale and bone	2	..
Sandstone and shale	55	..

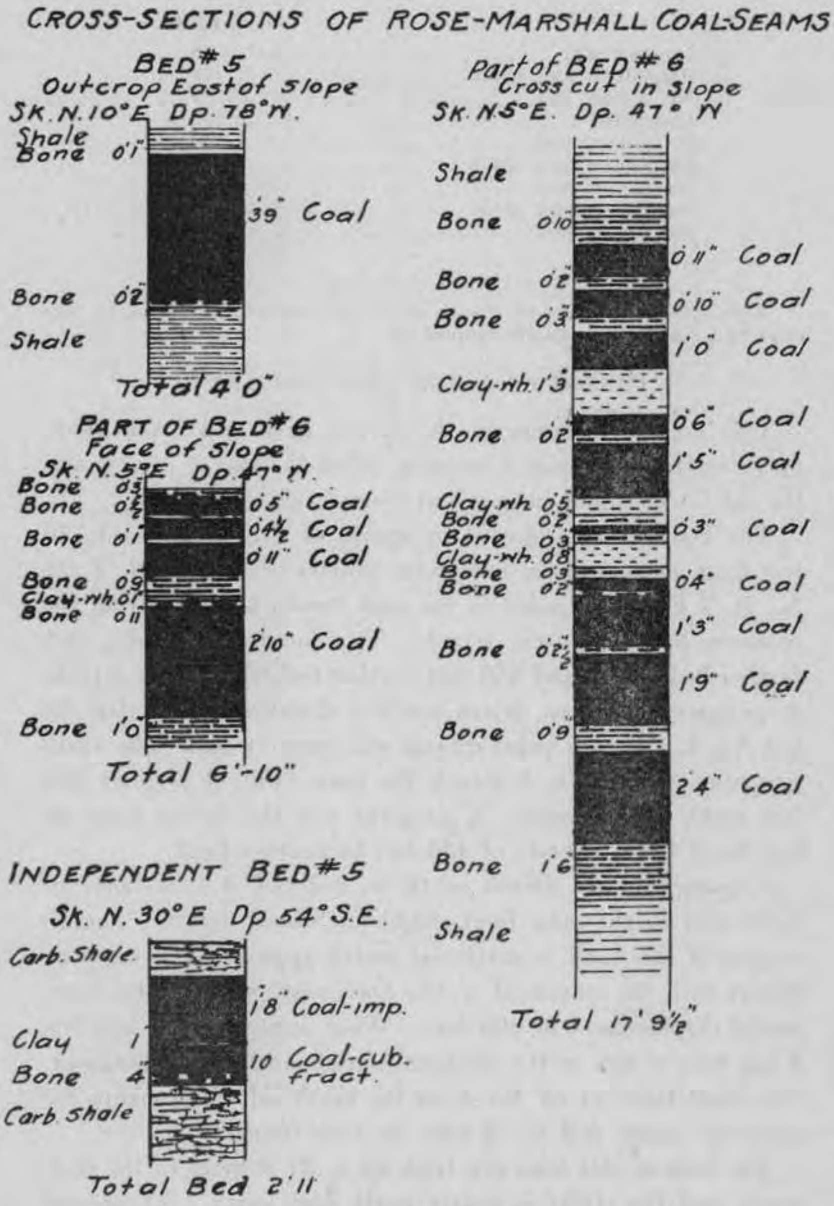

FIG. 42. Cross-sections of Coal Beds at Rose-Marshall Mine.

	Ft.	In.
Igneous sill	80	..
Sandstone and shale	72	..
No. 4 coal bed	8	3
Concealed	178	..
No. 3 coal bed	4	6
Sandstone and shale	50	..
No. 2 coal bed	10	5
Sandstone and shale	74	..
No. 1 coal bed	23	6
Total	788′	2″

NOTE.—The strata between Nos. 1 and 4 are more or less faulted, as indicated by a fault in the adjacent railroad cut.

CARBON COAL AND CLAY COMPANY.

This company, formerly the Green River Coal Company, operates the Daly mine (formerly called the Bayne mine), and the old Carbon mine, upper and lower levels.

The Daly mine is opened by means of a rock tunnel 1,150 feet long, located in the northwest quarter of section 22, T. 21 N., R. 7 E. At a point in the rock tunnel 225 feet from the entrance bed No. 1 was struck. Two hundred and fifty feet farther bed No. 3, and 660 feet farther bed No. 5, were struck. A gangway has been driven south a distance of 800 feet on bed No. 1, at which point a fault was encountered. The south gangway on bed No. 3 struck the same fault at a point 850 feet south of the tunnel. A gangway was also driven north on bed No. 3 for a distance of 450 feet to another fault.

A gangway was driven south on bed No. 5 a distance of 1,050 feet to the same fault struck in Nos. 1 and 3. The direction of this fault is northwest and it appears to be an overthrust with the movement to the northwest, with a total horizontal displacement of 800 feet. What appears to be bed No. 5 has been struck in the southern extension of No. 3 gangway. The fault that cut off No. 3 on the north side is probably the one that crosses bed No. 5 near the rock tunnel.

The beds in this mine dip from 34 to 37 degrees to the eastward, and the strike is nearly north and south. At present only the bed south of the fault in No. 3 gangway is being worked in this mine and this produces about 100 tons per day.

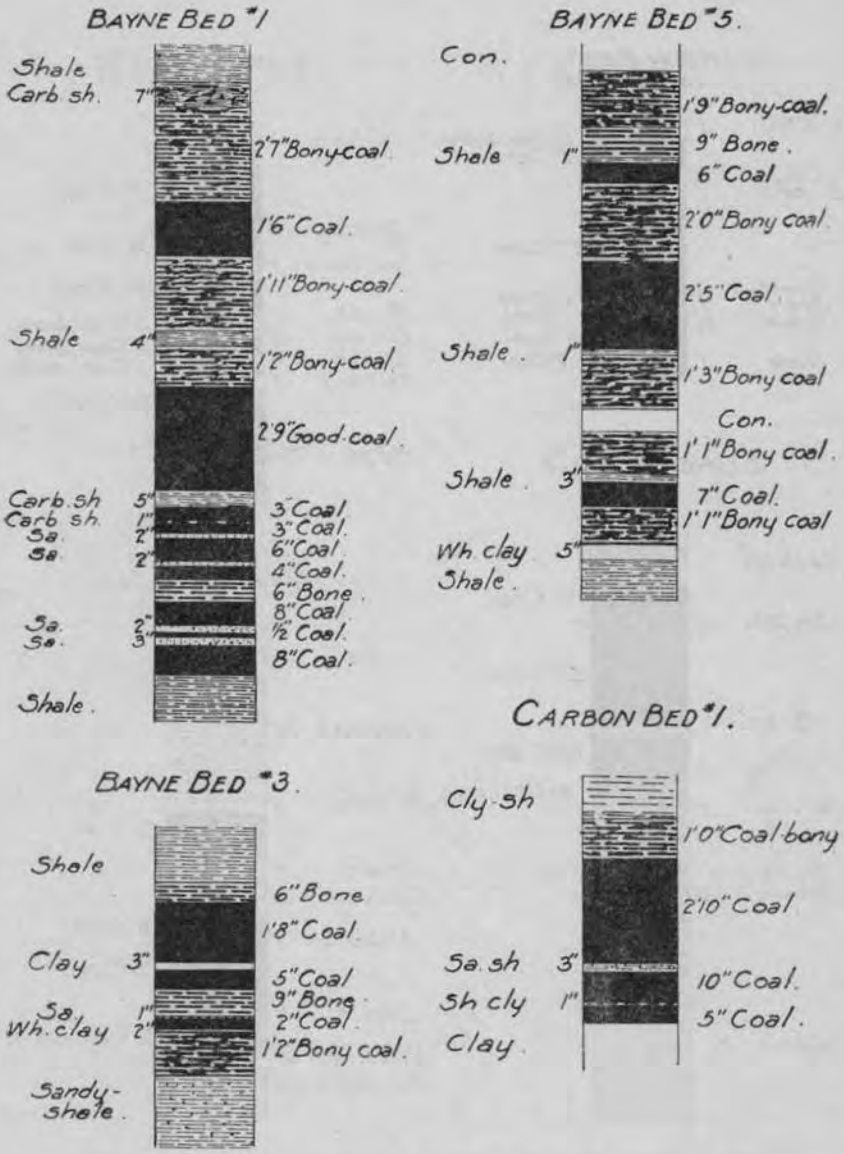

FIG. 43. Cross-sections of Coal Beds at Bayne.

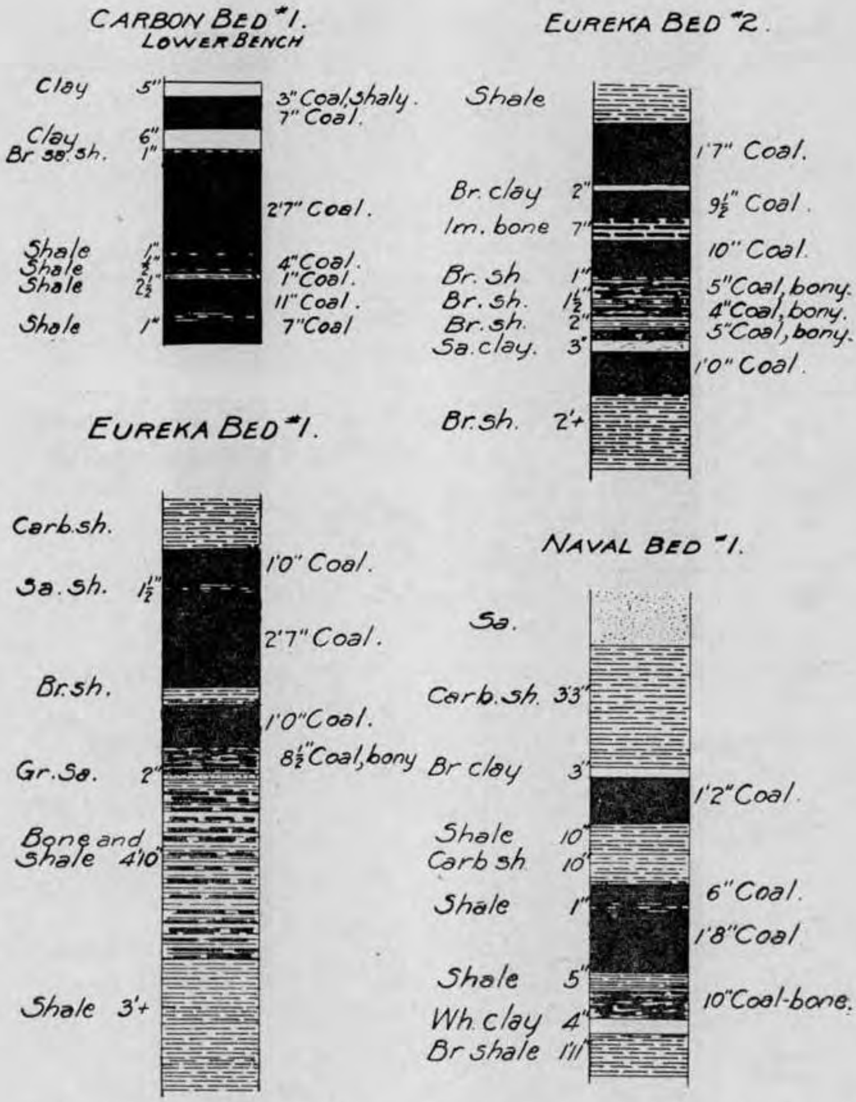

FIG. 44. Cross-sections of Coal Beds at the Carbon, Eureka and Naval Mines.

CARBON MINE, UPPER LEVEL.

This mine is also operated by the Carbon Coal and Clay Company. It was formerly owned by Fred Nolte and operated as the Nolte mine.

The gangway begins near the outcrop of the coal bed, in the southwest quarter of section 15, T. 21 N., R. 7 E. At the entrance the direction of the drift is nearly east and west. It gradually turns farther in, until at the face of the drift the strike is north and south and the dip is west. In other words, the gangway has swung around the north end of the Bayne syncline. The gangway is over 3,000 feet in length.

The coal from this mine is dumped into a chute not far from the mouth of the drift, and from the chute it is hauled by electric motor to the Daly mine bunker. Two beds are being mined at this place, Nos. 1 and 3. At the outcrop near the entrance to the mine the beds are 27 feet apart; at the face of the gangway 3,000 feet away, they have practically come together. Bed No. 1, lowermost, produces about 50 tons per day. The overlying bed, No. 3, produces 200 tons per day.

The mine is worked by a system of chutes and pillars. The dip is so flat, being only 13 degrees, that buggies are used in bringing the coal from the face of the chute to the gangway.

The lower Carbon mine is opened at a lower point on these same beds. A rock tunnel crosses the strata until the coal is reached. This is indicated on the map of this field as the New mine. About 20 tons per day is the present output of this new opening.

The coal from the Daly, Old Carbon and New Carbon mines is all picked and washed at the Daly bunkers. The washer is the Pittsburg type with a capacity of from 50 to 60 tons per hour. Two Erie boilers of 100 horse-power furnish the power for the well equipped electric plant and other machinery used around the mine. Motors of the Jeffery type are used for haulage purposes. The ventilating is done by means of a Stevens fan, 7′ 0″x2′ 6″, 350 revolutions per minute, capacity 100,000 cubic feet per minute, with 3″ water gauge.

Stratigraphic section of material on the face of the Little Falls quarry near Bayne:

	Ft.
Concealed	..
Massive sandstone	20
Stratified sandstone	20
Concealed	10
Carbonaceous shale	1
Stratified sandstone	27
Gray shale	4
Hard sandstone	4
Shale, nodular	30
Shale, closely stratified	4
Shale, nodular	30
Coal bed	6
Shale, nodular, with coal streaks	27
Coal bed	8+
Shale	4
Coal	1
Shale	6
Carbonaceous shale	2
Shale	16
White massive, shaly sandstone	150
Concealed	..
Total	370′

Stratigraphic section across the coal series in the Daly mine at Bayne:

	Ft.	*In.*
Bed No. 5	13	6
Shale	5	9
Sandy shale	15	..
Massive sandstone	64	..
Shale	10	..
Massive sandstone	60	..
Shale	6	..
Massive sandstone	6	7
Carbonaceous shale	2	4
Shale	4	..
Sandstone and shale	2	..
Sandy shale	10	..
Shale	8	..
Sandstone	2	5
Shale	22	..
Gray sandstone	2	6
Shale	6	..
Massive sandstone	15	..
Shale	14	..
Coal bed No. 3	5	4
Sandy shale	..	7
Shale	22	..
Massive sandstone	22	..
White clay	..	7
Shale	6	..

	Ft.	In.
Carbonaceous shale	..	5
Sandstone	5	..
Shale	34	..
Sandy shale	12	..
Shaly sandstone	12	..
Shale	4	..
White clay	..	7
Carbonaceous shale	4	..
Massive shale	48	..
Coal bed No. 1	15	8
Sandy shale	2	..
Sandstone	15	..
Total	478′	3″

OLD CARBON MINE.

Some years ago Fred Nolte opened a drift on a coal bed that outcrops near the southeast foot of Lizard mountain, in the northeast quarter of section 21, T. 21 N., R. 7 E. This bed probably represents one of the three beds worked at the Fleet coal mine. The bed dips west at 75 degrees near the entrance to the drift, but flattens to 50 degrees a few hundred feet north of the entrance. This mine produced only a small amount of coal. The bunker, which formerly stood near the Northern Pacific railway, burned several years ago. No work is being done here at present.

EUREKA MINE.

The Eureka mine was opened prior to 1893, and by that date 1,000 feet of gangway had been driven and ten rooms had been opened. This mine has its drift in the southeast quarter of section 21, T. 21 N., R. 7 E. A drift has been started from the surface on the No. 1 bed. At first the bed strikes in a southeast direction and dips southwest at 33 degrees, but south of the south line of section 21 the strike is first eastward and then northeastward, with dips to the southeast. A rock tunnel was driven from bed No. 1 to beds 2 and 3. There is some faulting along the line of the rock tunnel. The beds appear to swing around the axis of the Cumberland anticline, which evidently passes through this area.

The mine is not operating at present. The bunker was repaired during the past two years and attempts made to operate

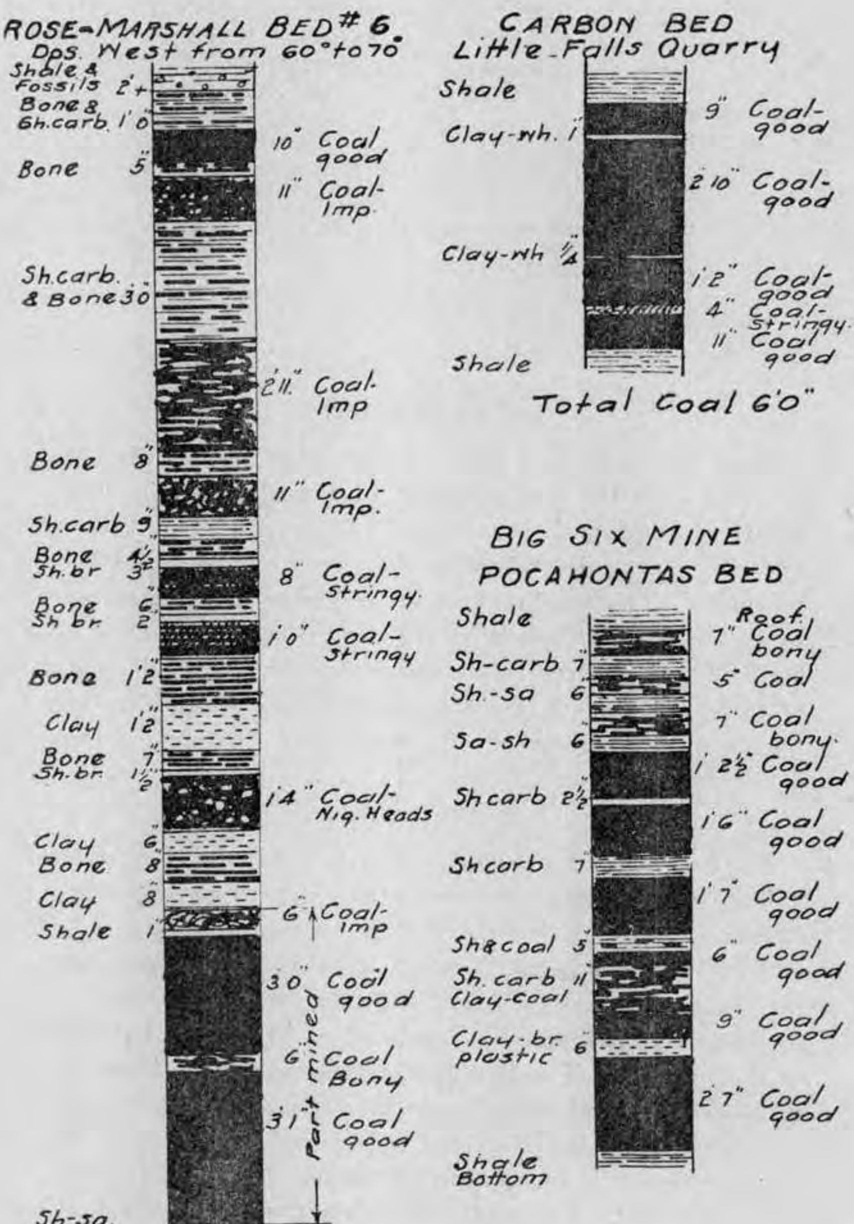

FIG. 45. Cross-sections of Coal Beds at the Rose-Marshall, Carbon and Bix Six Mines.

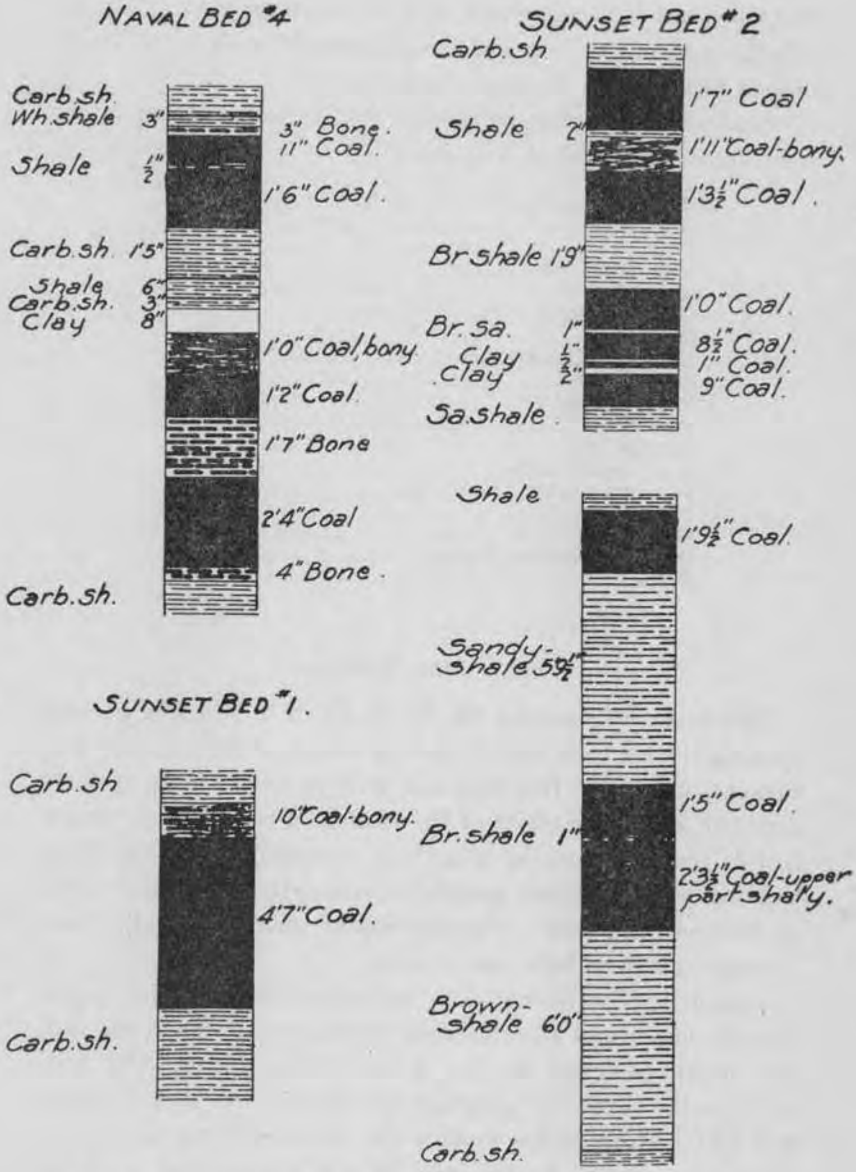

FIG. 46. Cross-sections of Coal Beds at the Naval and Sunset Mines.

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the mine, but for some reason it is not working now. Both the Northern Pacific railway and the Chicago, Milwaukee and Puget Sound railway pass through the property.

Stratigraphic section across the coal series as shown in the rock tunnel at the Fleet coal mine:

	Ft.	*In.*
Bed No. 3	8	..
Gray shale	18	..
Coal	1	..
Gray sandstone	34	..
Gray shale	19	..
Coal bed No. 2	7	..
Gray shale	23	..
Laminated sandy shale	8	..
Sandstone	16	..
Sandy shale	18	..
Pure shale	33	..
Impure coal	3	..
Gray sandy shale	56	..
Pure gray shale	28	..
Bed No. 1	10	8
Concealed	10	..
Gray massive sandstone	54	..
Shale	32	..
Total	378′	8″

NAVAL COAL COMPANY.

This mine is in section 28, T. 21 N., R 7 E. The present opening is by a rock tunnel near the center of the section. The tunnel is about 200 feet long and has been driven in an easterly direction across the strike of the strata. Two beds were struck in this tunnel before the large bed, commonly called the Navy bed, was struck. Short gangways were driven north and south on the overlying beds. The coal was of such poor quality that the work on these beds soon ceased.

Considerable work was done on beds 4 and 6, which represent the upper and lower benches respectively of the Naval bed. The north gangway on No. 6 was driven about 1,000 feet, while to the south the gangway on this bed was driven nearly 600 feet. More or less trouble was found driving southward. What appears to be the axis of the Cumberland anticline crosses through this area to the south, and the troubled ground was probably due to this fold.

The beds at this point dip westward and the strike is nearly north and south until the anticline is approached, when the beds begin to strike eastward and dip south. The dips vary from 35 degrees at the south end to 65 degrees at the north end. This mine is not operating at present. A small bunker is located on a spur of the Northern Pacific railway not far from the mouth of the tunnel.

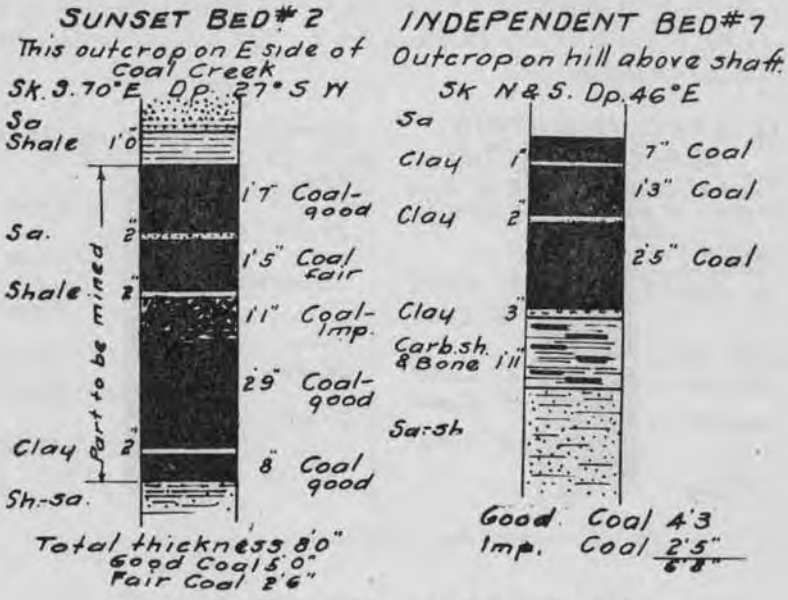

FIG. 47. Cross-sections of Sunset and Independent Beds.

SUNSET MINE.

The Sunset mine was originally opened by the Cooperative Syndicate of Seattle, in 1897-98. Since that time it has changed hands several times. At present it is operated by the Deep Lake Coal Company.

The mine is located in section 28, T. 21 N., R. 7 E. Water level drifts have been driven on beds 1 and 2, which are the upper ones in the Sunset series. The coal in No. 1 above water level has been practically exhausted in section 28 on the eastern dip. A drift on No. 2 has been continued through the south end of Cumberland mountain to Cumberland creek, and a new drift started on the east side of Cumberland creek on the same bed. It is planned to continue this drift into section 27.

There are several other beds outcropping on this property. Preparations are being made by the company to open one or two of the lower beds. The coal is transferred from east of Cumberland creek, through the hill by means of the drift on No. 2, then by a tram road to the bunker which is located on a spur of the Northern Pacific railway. The haulage is done by mules or horses.

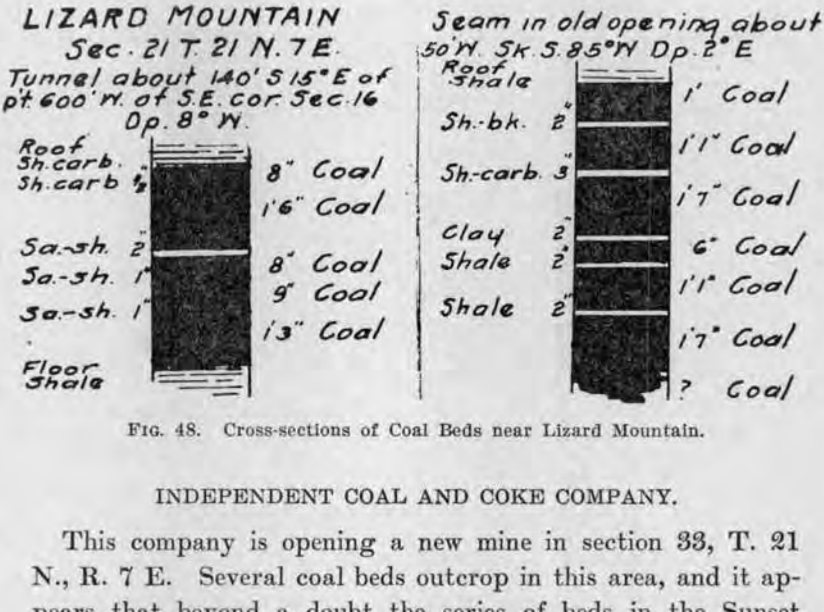

FIG. 48. Cross-sections of Coal Beds near Lizard Mountain.

INDEPENDENT COAL AND COKE COMPANY.

This company is opening a new mine in section 33, T. 21 N., R. 7 E. Several coal beds outcrop in this area, and it appears that beyond a doubt the series of beds in the Sunset property pass southward through this section. So few rock exposures are to be seen in this vicinity that it is very difficult to correlate the coal beds absolutely.

The present plans are to sink a modern slope, about 500 feet deep, on bed No 6 in the southwest quarter of section 33, and then crosscut with a rock tunnel the overlying and underlying beds. A drift has been started at water level on the No. 3 bed. The coal from the new slope will be hauled along the track to

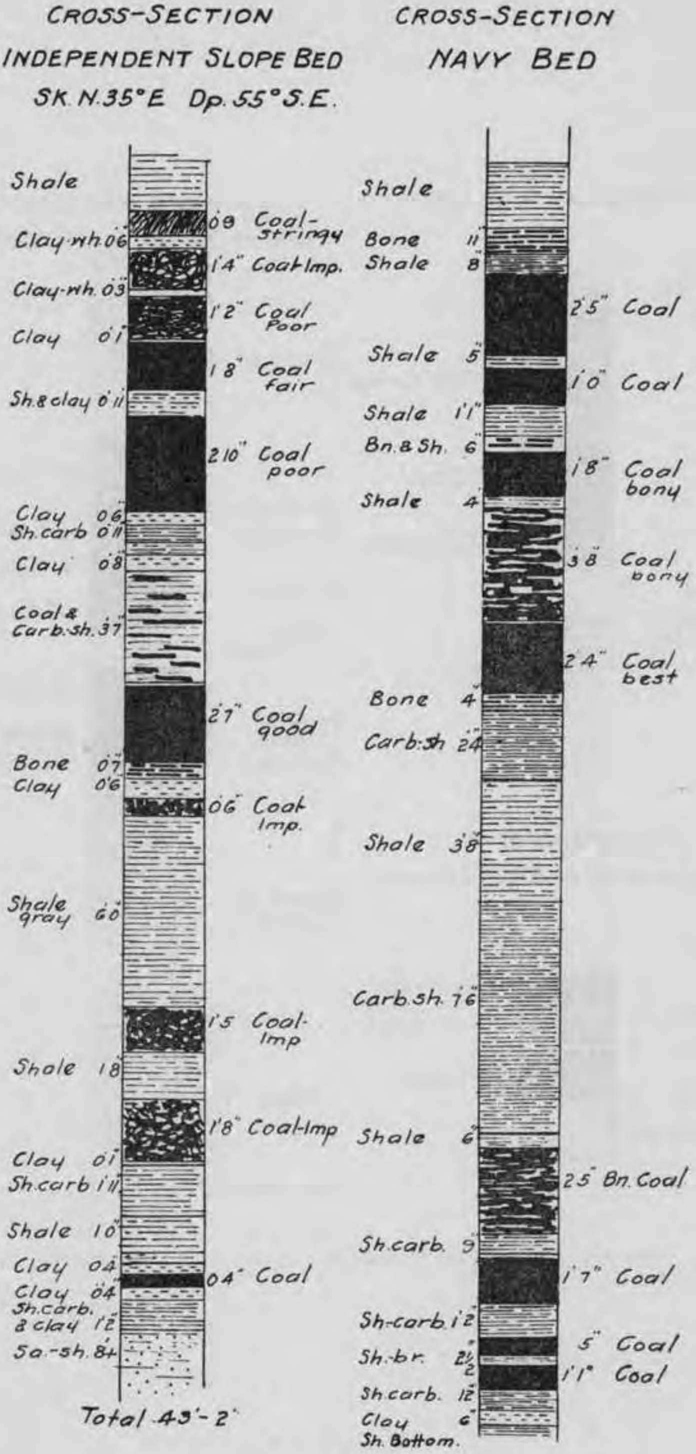

Fig. 49. Cross-sections of Independent and Navy Beds.

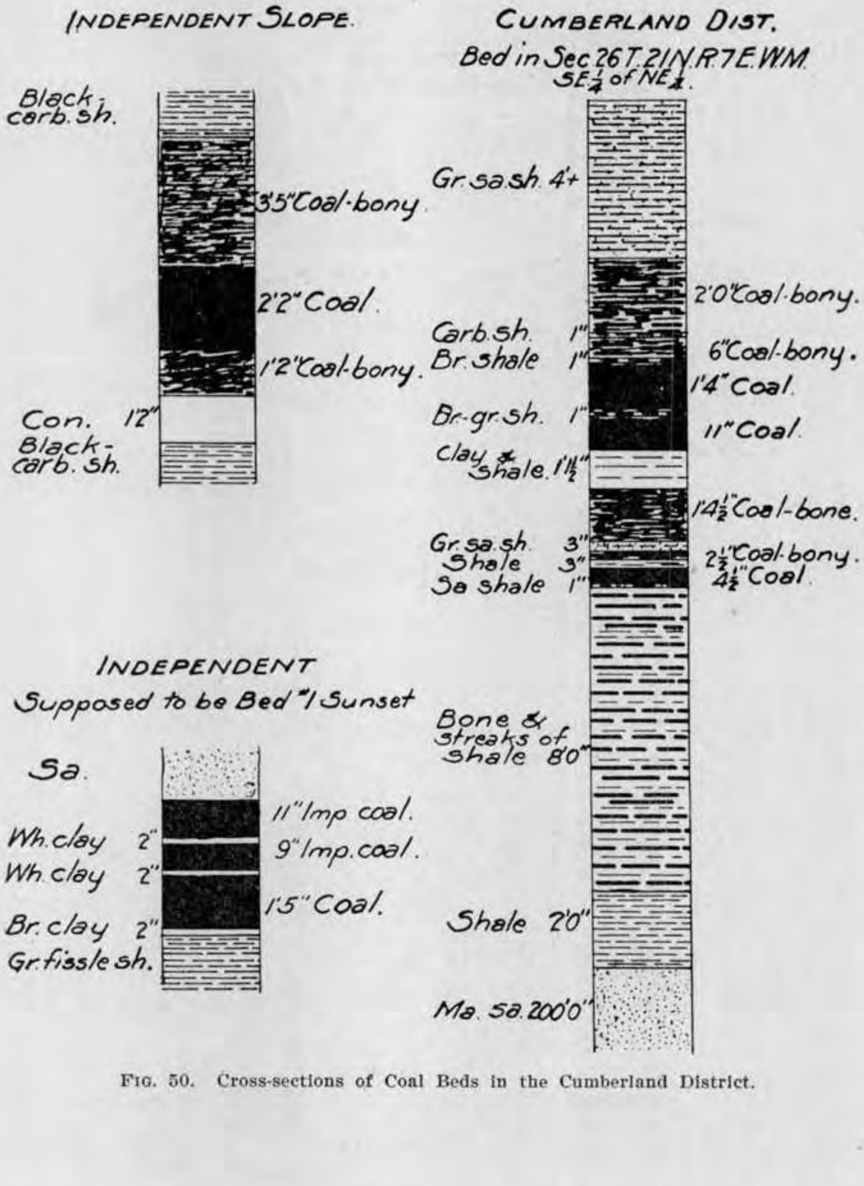

FIG. 50. Cross-sections of Coal Beds in the Cumberland District.

the new bunker and washer, which is being erected on a spur off the main line of the Northern Pacific railway.

POCAHONTAS MINE.

The Pocahontas Coal Company, sometimes called the Cannel Coal Company or the Big Six Coal Company, has a mine in the northeast quarter of section 23, T. 21 N., R. 7 E. The opening is by means of a rock tunnel 1,200 feet long, which crosses the strata at about right angles to the strike of the coal beds. The beds in this area strike north 12 degrees west and dip northeast at about 31 degrees. Three beds, 1, 2 and 3, were struck in the rock tunnel. A gangway was driven south on bed No. 2. This property has not produced much coal. Some coal was shipped in the years 1905 and 1906. The coal beds give off considerable explosive gas, and several people have been burned by explosions in this mine. Several more beds of coal and bone outcrop in this area. There are also a number of igneous sills and one dike in the material overlying No. 2 bed.

The method of handling the coal from this mine was laborious and expensive. The coal was hauled out of the long rock tunnel, then let down a surface incline by gravity, and from the foot of the incline a tail-rope car haul carried the coal to a little chute built on a spur off the Northern Pacific railway.

Stratigraphic section of hill above Big Six mine, section 23, T. 21 N., R. 7 E.:

	Ft.
Concealed	..
Basalt	240+
Carbonaceous shale	22
Concealed	94
Igneous rock (similar to large mass of igneous rock underlying Newcastle series)	270
Concealed	13
Shale	50
Intrusive igneous rock	60
Bony bed, partly altered	20
Shale	62
Bony bed, No. 3 coal	6

	Ft.
Massive sandstone	16
Lava flow	62
Shale, conchoidal fracture	43
Coal bed No. 2	20+
Shale	14
Massive sandstone	95
Shale	40
Coal, No. 1	3
Concealed	..
Total	1,130

COAL PRODUCTION OF INDEPENDENT MINES IN KING COUNTY FROM 1888 TO 1911.*

MINE	COMPANY	TOWN	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906 (b)	1906 (s)	1907	1908	1909	1910	1911
New Castle	O. I. Company (j)	New Castle	14,963 a	76,102 b	No rep'rt (c)	160,514	154,225	153,000	139,817	79,827	125,337	138,024	163,000	113,715	26,804												
Coal Creek		New Castle												41,517	165,538	130,957	140,841	145,374	148,312	133,750	106,495	61,865	269,932	166,473	233,791	223,728	224,342
Gilman	Seattle Coal & Iron Co. (1)	(Gilman) Issaquah	9,138 a	41,482 b	No rep'rt	55,956	102,105 e	121,378	81,623	92,890	138,836	112,085	115,370	124,238	126,706	121,829	117,184	105,643	50,896	Not operating							
Renton		Renton	(d)	(d)	(d)	(d)				2,420 h	7,000	11,200	35,000	38,000	37,170	72,865	104,071	134,743	91,777	117,120	81,817	34,635	168,203	154,338	145,732	161,141	155,275
Black Diamond	Black Diamond Coal Company	Black Diamond	30,880 a	105,255 b	No rep'rt	111,472	89,935 f	127,442	120,694	115,028	100,337.2	99,956	109,000	227,538	220,346	227,000	258,996	278,922	107,763 n 162,892 p	110,624 n 201,666 p	71,958 n 194,047 p	25,635 n 75,828 p	93,633 n 231,984 p	49,983 n 209,805 p	94,713 n 278,981 p	131,079 n 272,662 p	123,851 n 255,736
Cedar Mountain		Cedar Mountain	10,878 a	23,120 b	No rep'rt	15,866	12,573			500	20,000	12,000	8,500	11,150	6,000	13,500			14,500	35,000	17,500						
Franklin	O. I. Company	Franklin	(missing)	136,844 b	No rep'rt	44,557	73,500	88,000 A	99,180	70,584	56,063	105,268	168,000	148,612 k	128,000 k	92,711 k	65,107 q 72,238 k	190,150 q 82,480 k	100,454 q 47,046 k	96,615 q 63,347 k	60,894 q 43,261 k	26,690 q 12,723 k	83,863 q 11,199 k	18,050 q			
Gem		Franklin												17,629	39,600	36,460	52,735	65,646	58,274	2,324	49,217	21,865	86,645	94,068	8,923	37,528	47,108
Durham		Durham	6,360 a	22,319	No rep'rt																						
Kangley		Kangley			No rep'rt	5,544	14,152	16,673		7,190	1,519																
Alta		Kangley			No rep'rt	2,000	13,500	9,000	3,500																		
Snoqualmie	Snoqualmie Coal & Coke Co.	Snoqualmie			No rep'rt													5,000	3,200		Not operating	827	3,120				
Black River		Black River Junction			No rep'rt																						
Denny		Kummer					3,200	5,474	7,000	6,500	3,500	2,000	6,600				10,044	10,705	16,062	15,060	8,680		9,589	2,507	2,158	3,121	2,057
Grand Ridge		Issaquah						591																	6,913	39,484	40,411
Eureka								800	16,000	8,000					35												2,400
Navy									4,800	3,347	1,706	3,018	3,500 g	3,600	650								6,236	7,616			
American Coal Mine	Carbon Coal Company	Near Cumberland								3,500	8,500																
Lawson	Lawson & Company (i)	Lawson									11,000	28,860	45,834	52,161	78,000	97,329	107,750	186,987	98,587	79,200	63,226	29,470	91,935	73,015	83,694	83,687	7,099
Danville	Danville Coal Company	Danville									500		1,000	1,500					1,447	Not operating			7,720	2,547			
Occidental		Palmer												15,000	13,427		3,225	16,024	16,786	18,242	20,700	11,134	38,038	20,984	29,711	34,562	10,467
Sunset Mine	Co-operative Coal Company	Cumberland												2,276	4,719	9,000	8,600	6,700					23,556	1,693			
(Leary) Ravensdale	Leary Coal Company (m)	Ravensdale													48,000	63,578	71,426	187,900	183,883	184,370	170,815	86,890	261,688	32,545	162,625	152,327	166,018
Carbon Coal	Carbon Coal Company	Cumberland																235	15,000	20,500	16,500	5,800	21,177	26,934	31,816	11,926	41,291
Taylor	Denny-Renton Coal & Coke Co.	Taylor																		15,500	11,750	3,359	21,891	47,365	47,652	68,309	85,045
Cannel Coal Mine	Cannel Coal Company	Palmer																		540	849	30					
Denny-Renton	Denny-Renton Coal & Coke Co.	Renton																			9,817	2,547	16,556	8,619	16,837	30,945	19,784
Bayne	Green River Coal Company	Bayne																						30	17,255	48,171	26,022
Cumberland	Rose-Marshall	Cumberland																								8,165	12,175
May Creek	May Creek Coal Company	Coalfield, Wash.																									3,003
Superior	Superior C. & I. Company	Issaquah																								5,035	2,672

* Reports of the State Mine Inspector, 1888 to 1911. A—Nos. 1 and 7 mines. a—Ton—2,000 pounds. b—Year ending September 30. c—Mr. Edw. Morgan's Report for District No. 2 does not give tonnage.
d—The Renton-Talbot mines have not been operated since 1886; 35,000 tons produced prior to that date. e—Nos. 1 and 4 mines. f—Nos. 2, 12 and 14 mines. g—Estimated. h—Reopened by Renton Co-operative Company.
i—Later bought by Pacific Coast Company. j—O. I. Company changed to Pacific Coast Company. k—No. 7 mine. l—Later changed to Issaquah Coal Co. m—Later N. W. I. Company. n—Mine No. 14. p—Morgan Slope mine.
q—Mine No. 1. s—October, November and December. 1—Later called Issaquah.

CHAPTER VI.

COAL MINING METHODS.

OPENING THE MINE.

The methods employed in opening a coal mine depend in large measure upon the dip or pitch of the beds and the topography of the country. Where the beds lie flat and do not outcrop above the general drainage level of the surrounding country, shafts are sunk and gangways driven off from the foot of the shaft. Where the bed outcrops at a sufficient height for general drainage, drifts are driven in directly on the coal. In Western Washington all the beds dip more or less. Where a bed outcrops above the general drainage of the country, a drift is driven in on it and the coal lying up the pitch above the level of the drift or entry is mined out as close to the surface as conditions will allow.

After the available coal is worked out above the level of the drift, a slope is sunk. A slope is an opening or haulage way, usually for a double track, that is sunk down on the dip of the bed. If the bed dips over 45 degrees the slope is sometimes sunk across the dip so as to lessen the degree of the incline, since an exceedingly steep dip is dangerous for men to work in while timbering the slope; furthermore considerable coal is lost off the cars if covers are not placed on top of them. In most of the coal mines in King county the first coal was usually obtained from drifts and then slopes were sunk to mine the coal lying below the water bed.

It frequently happens that the outcrop of the bed is so situated that it is not practicable to drive an entry on the coal. Then rock tunnels are driven, crossing the strata to the desired beds.

Only two shafts have been sunk in King county. One instance was at Franklin several years ago, in an attempt to mine the coal from the lower levels of the McKay bed at that place.

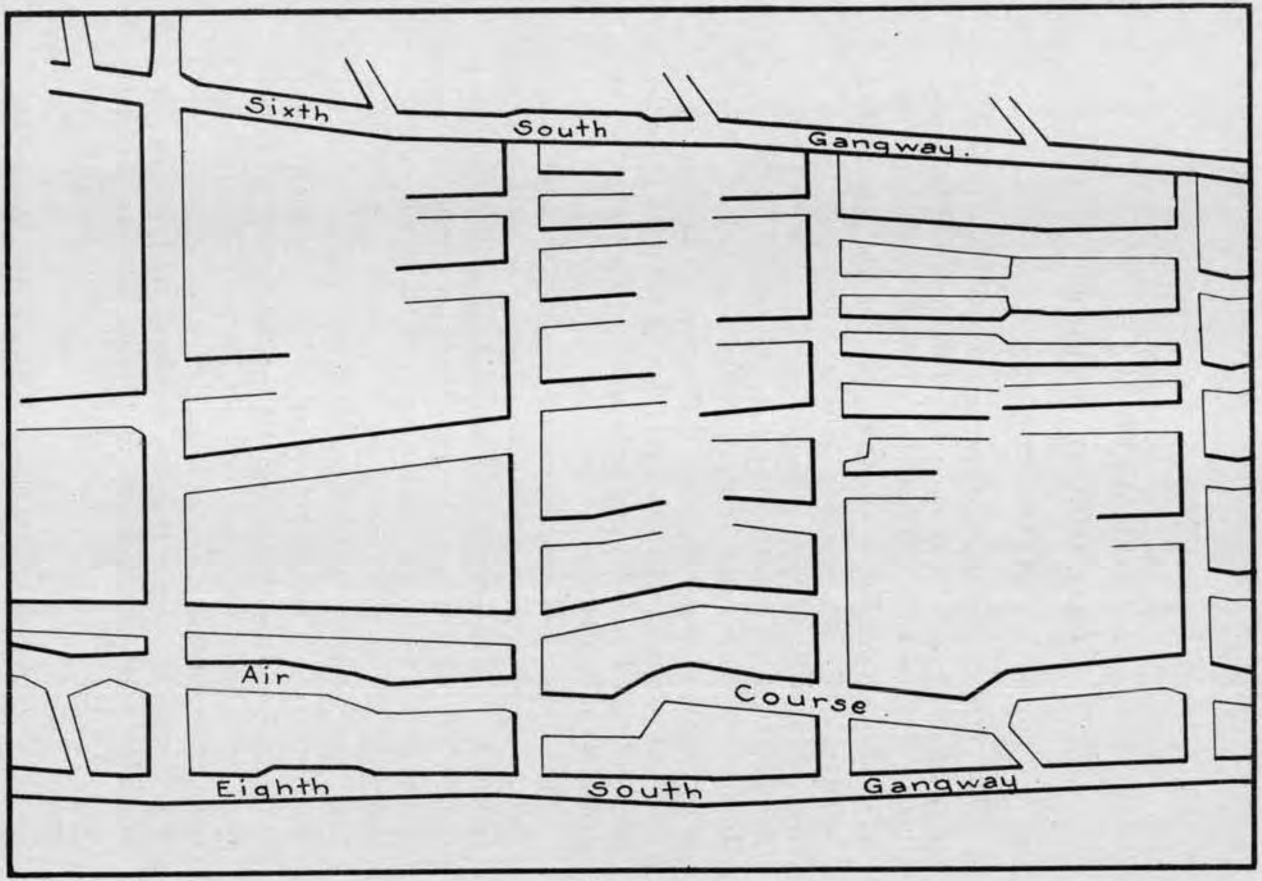

FIG. 51. System of Mining, No. 3 Bed at Renton.

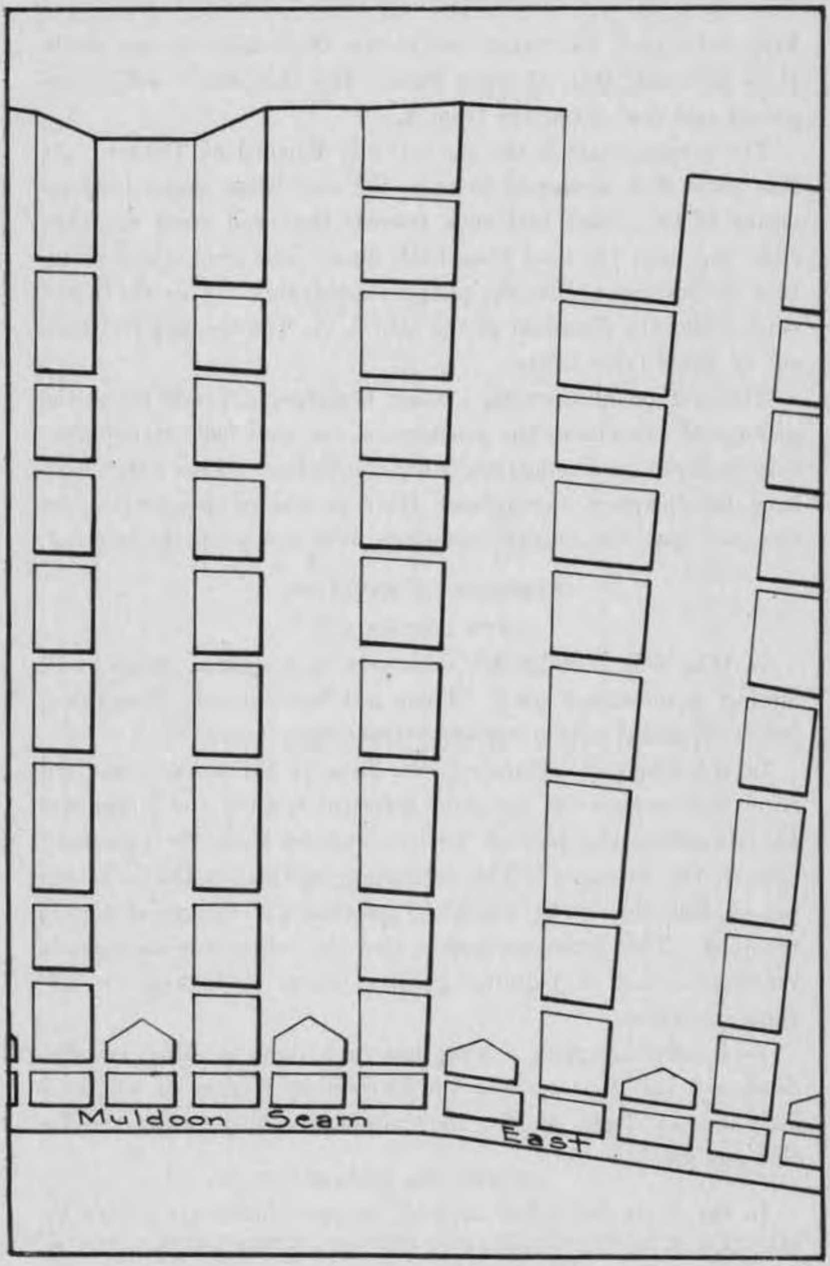

FIG. 52. System of Mining, Muldoon Bed at Newcastle.

Very little coal was taken out of the shaft after it was sunk. It is probable that at some future day this shaft will be repaired and coal taken out from it.

The second shaft is the one recently finished at Taylor. At this place it is proposed to mine the coal below water level by means of this shaft and rock tunnels that will cross the syncline and mine the coal from both dips. The geological structure at this point suits the purpose admirably. This shaft was sunk under the direction of the late S. A. Townes, superintendent of the Taylor mines.

The method of opening a mine therefore depends upon the geological structure, the position of the coal bed, transportation facilities, and numerous other conditions. Some mines have been handicapped throughout their period of production by the fact that the original openings were not properly selected.

SYSTEMS OF WORKING.

THE LONGWALL.

In thin beds that lie flat or nearly so a system of longwall mining is sometimes used. There are two methods of working longwall, called advancing and retreating.

In the longwall advancing, the face of the work is carried from the entrance of the mine outward toward the boundary. In retreating, the face of work is carried from the boundary toward the entrance. The retreating method is the least expensive and the one by which the greatest percentage of coal is removed. This latter method is also the better one as regards ventilation, but it requires greater initial cost than the advancing system.

Very little longwall mining has been done in King county. Such beds as the Gem and the Carbon at Bayne, or wherever beds dip at slight angles, they could probably be worked by this method.

CHUTES AND PILLARS.

In the chute and pillar method, narrow chutes are driven up the pitch from the gangway to the chain pillar which is left to support either the surface or the upper gangway. The chutes

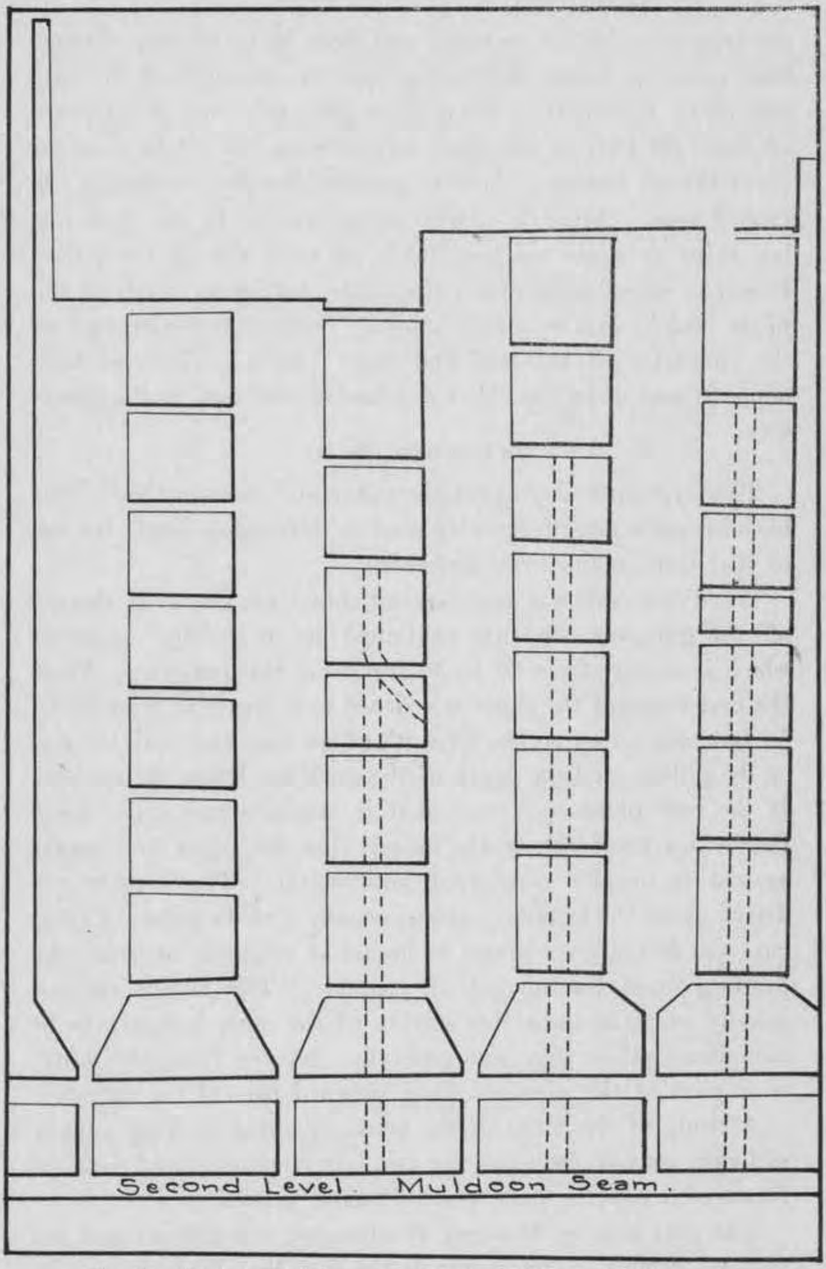

FIG. 53. System of Mining, second level of Muldoon Bed, Newcastle.

are from 8 to 12 feet in width and from 50 to 60 feet or more from center to center, depending upon the strength of the coal and roof. Crosscuts or break-throughs are driven at intervals of about 50 feet, as the chute advances up the pitch, so as to carry the air from one chute to another, thereby ventilating the face of work. After the chutes are worked up to the chain pillar, skips or slices are then taken off each side of the pillar, from the upper pillar down the chute, taking as much of the pillar coal as can be safetly mined. Such timbers are used as the character of the roof and floor require. The coal thus mined is sent down the chute and loaded into cars at the gangway.

PILLAR AND BREAST.

This system is also called the pillar and room method. The term breast is more frequently used in this region, hence the use of that term in this brief discussion.

When this system is used, narrow chutes are generally started off the gangway, and are continued up to the first crosscut, which is usually from 30 to 50 feet from the gangway. From the first crosscut the chute is widened to a breast of from 24 to 50 feet, depending on the strength of the roof and coal, the size of the pillars, and the depth of the workings below the surface. If the roof pressure is such that it necessitates a pillar more than twice the width of the breast, then the pillar and breast system is usually considered impractical. The breasts are driven up to the boundary above, usually a chain pillar. Crosscuts are driven from breast to breast at required intervals, depending upon the amount of gas, etc. The pillars are not usually removed until this section of the mine is ready to be abandoned; then they are generally removed from the innermost part of the mine, working outward toward the entrance.

A study of the maps of the mines operated in King county will soon convince one that the two latter methods, and modified forms of a panel system, are used most generally.

The coal beds of Western Washington are difficult and expensive to mine. This is due to the fact that the beds may be

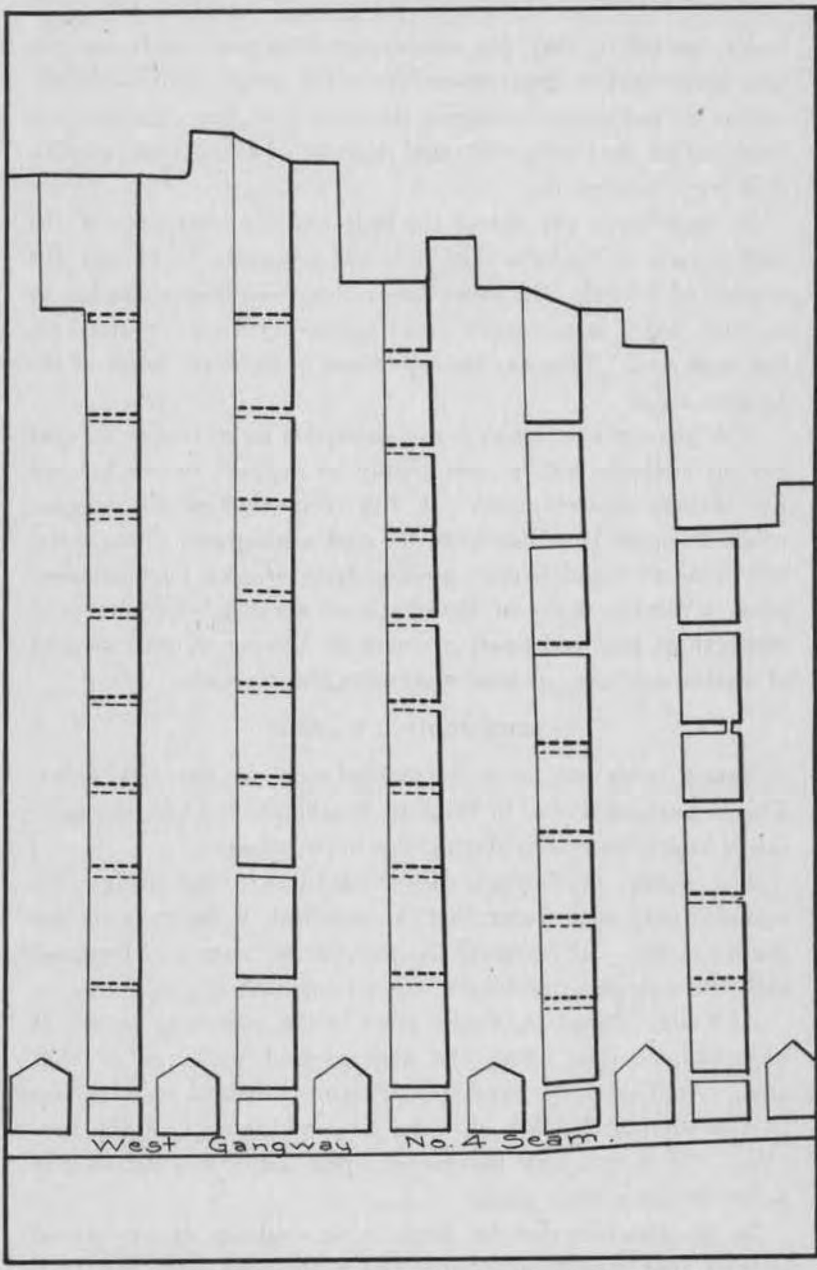

FIG. 54. System of Mining, west gangway, No. 4 seam, Newcastle.

badly faulted or may dip steeply, or have poor roofs, or gas may be present in great quantities. The above mentioned difficulties do not always occur in the same bed, but where such a combination does occur the coal must be of exceptional quality if it pays to mine it.

In some areas the dip of the beds and the character of the roof remain so uniform that it is not necessary to change the system of mining. In other areas these conditions change so rapidly that it is necessary sometimes to try several systems on the same level. This was the experience in the lower levels of the Lawson mine.

This part of the report is not presented as a treatise on coal mining methods, but is used simply to suggest to the layman the various systems used. A full discussion of the subject would no doubt be of benefit to the coal mining men of the state, but to do so would require a close study of each part of every mine, a careful study of the depth of working, character and strength of roof and floor, presence or absence of gas, amount of worked out area, general squeeze on the mine, etc.

UNDERGROUND WATERS.

Nearly every coal mine is troubled more or less with water. This is particularly so in Western Washington, where the rainfall is heavy, especially during the winter months.

The mines at Renton, Newcastle and grand Ridge are troubled only with water that is contained in the more or less porous strata. At Issaquah the pre-glacial channel in Issaquah valley is a serious problem in the development of this field.

At Cedar mountain, Cedar river is the principal source of water that might affect the underground workings of that area. At Taylor the synclinal structure will tend more or less to concentrate the flow of water toward the axis of the syncline. Of course, any fissures or open faults will deflect any water crossing their paths.

In the Danville district there is no evidence of pre-glacial erosion that would materially affect the area near the mine openings, but to the eastward a distance of one mile, in section

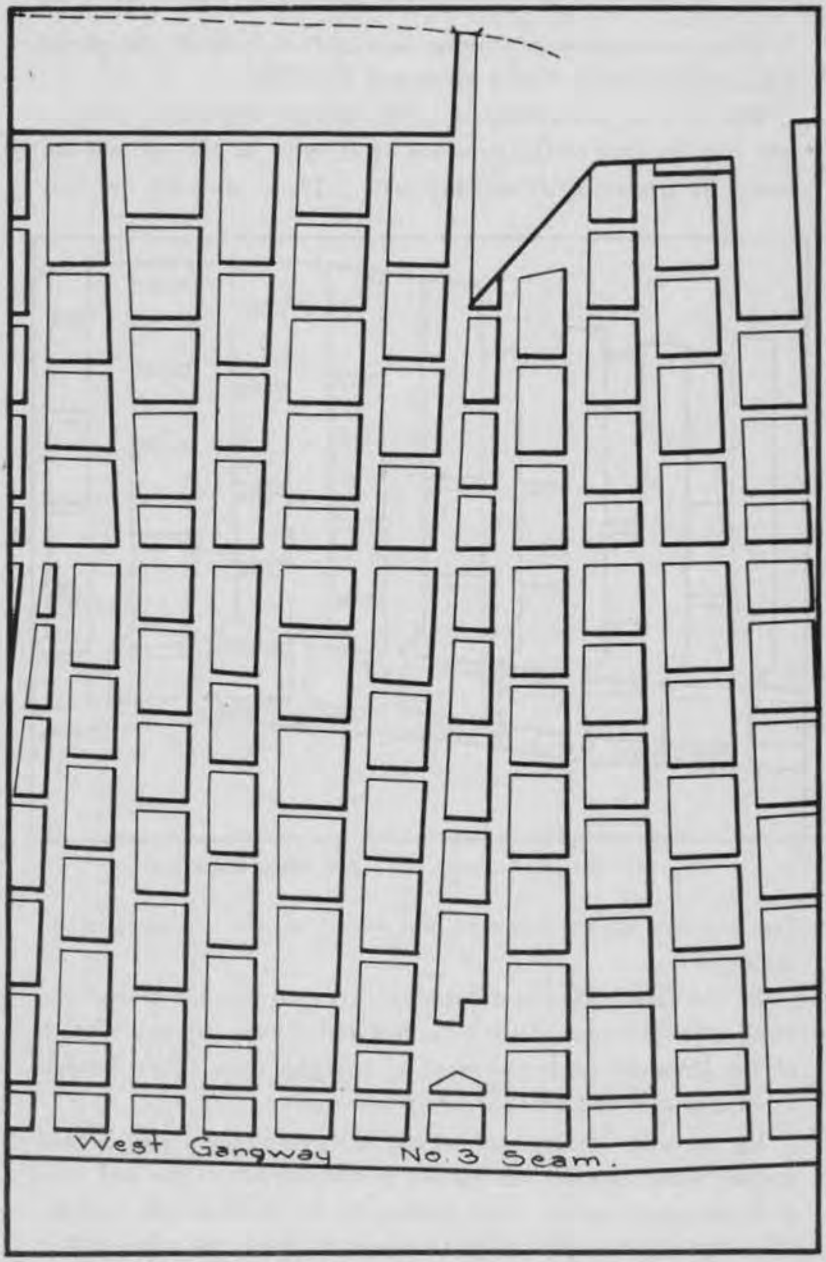

FIG. 55. System of Mining, west gangway, No. 3 seam, Newcastle.

19, there are numerous streams issuing from beneath the gravel plain lying between Cedar river and Fish lake.

The area to the northeast of Ravensdale will cause more or less trouble, due to the presence of streams at the contact between the glacial drift and bed rock. There are very few surface streams within this area and nearly all the drainage is underground.

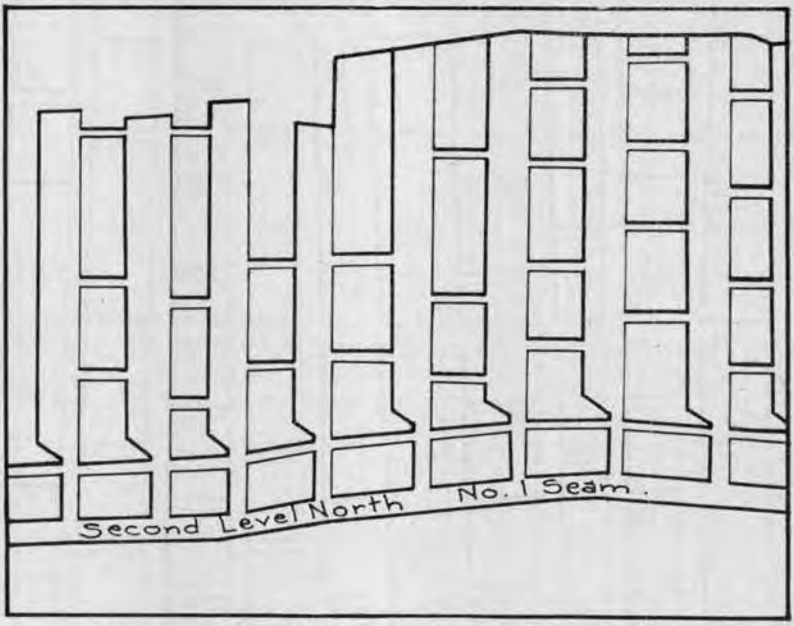

FIG. 56. System of Mining, No. 1 Bed, Grand Ridge Mine.

In the Black Diamond-Franklin area no trouble is encountered near the cores of the hills, but as the work advances south of the Franklin fault and west of Morgan slope, some trouble from underground water is likely to occur.

In the early development of the Morgan slope, a well defined underground channel was struck at the contact of the bed rock with the glacial drift, while driving an air chute to the surface. This stream was of sufficient volume to flood the mine and it remained flooded for some time. South of Black Diamond in

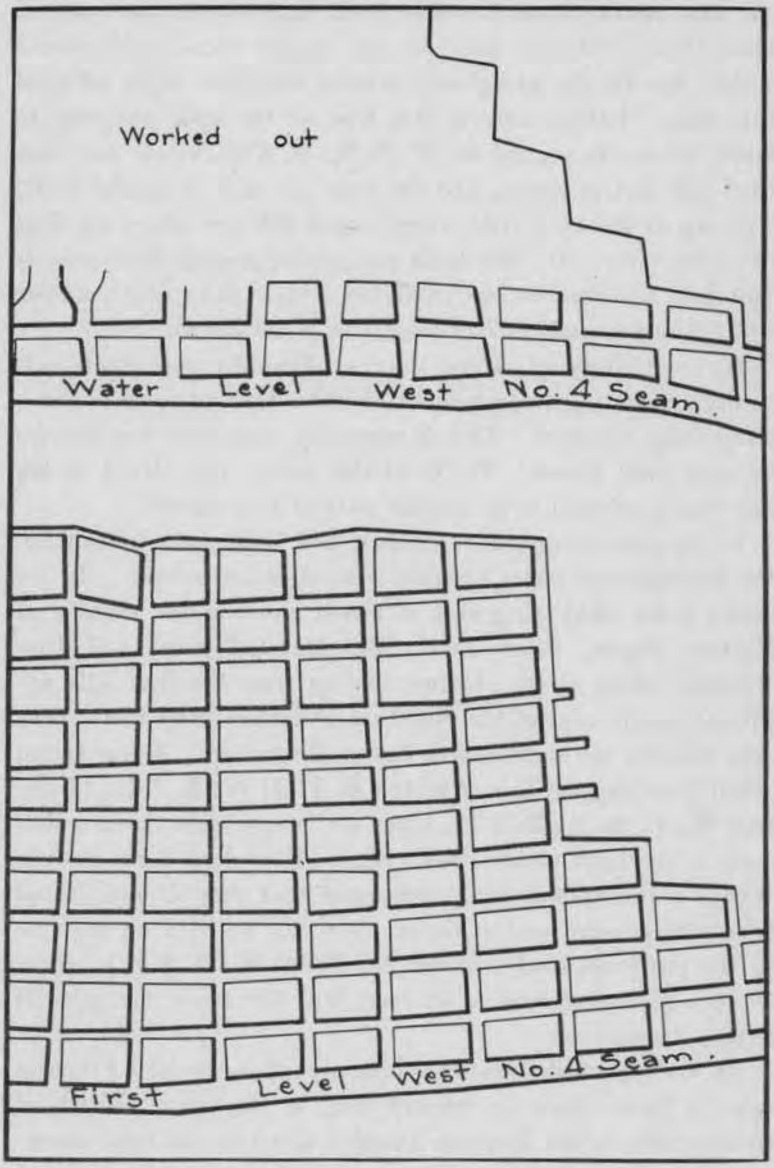

FIG. 57. System of Mining, No. 4 Bed, Ravensdale Mine.

the area south of the Franklin fault, and also to the south of Green river, there is more or less danger from underground water, due to the pre-glacial erosion that has likely affected this area. Particularly is this true of the area adjacent to Green river. In section 34, T. 21 N., R. 6 E., a hole was sunk over 500 feet in depth, and the hole was still in glacial drift. The top of this drill hole is only about 300 feet above the level of Green river. On this basis pre-glacial erosion here extends 200 feet beneath the bed of Green river. How much deeper this channel extends or how long it is, is not known.

In the vicinity of Green river at Franklin one would naturally expect a greater amount of water than at some distance away from the river. This is especially true near any fissures or open fault planes. Water of this nature was struck in the new shaft, referred to in another part of this report.

In the area lying east, southeast and northeast of Franklin, the underground water problem is more or less serious. In the entire water shed lying east of Green river, in the vicinity of Palmer, Bayne, Cumberland, Rose-Marshall mine and New Franklin mine, as the streams coming from the foot hills approach points west of the Northern Pacific railway track, they sink beneath the surface and flow underground. Along Green river, from the east line of section 9, T. 21 N., R. 7 E., to section 26, T. 20 N., R. 6 E., there are innumerable streams that come to daylight at the river's edge. How deep these streams extend is not known. It is presumed that they do not extend below the present level of Green river, but we have an example to the southwestward (section 34, T. 20 N., R. 6 E.), where the pre-glacial channel is at least 200 feet below the present level of Green river.

An underground stream has been struck in the New Franklin mine, a little above the present level of the river. North of Green river, in the Durham-Kangley district, the same condition prevails as south of the river. The streams flowing on the surface in the area east of the Northern Pacific railway sink west of the track, some of them flowing to the northward

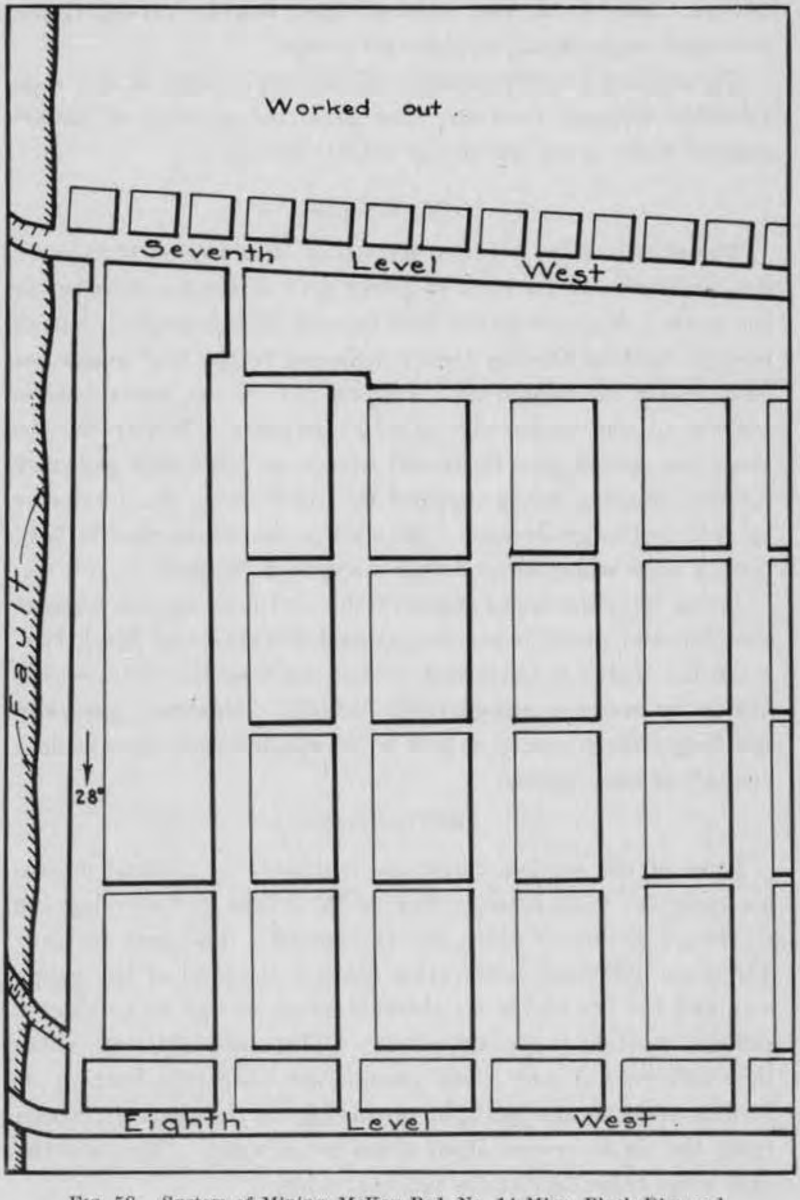

FIG. 58. System of Mining, McKay Bed, No. 14 Mine, Black Diamond.

toward Cedar river, but most of them flowing toward Green river and reappearing at the river's edge.

Throughout the development of this entire area, at any considerable distance from the rock hills, the problem of underground water is one worthy of serious attention.

MINE TIMBER.

Almost the entire western portion of Washington is more or less timbered. In parts of it grows some of the finest timber in the world. King county is well favored in this respect, but at present most of the big timber adjacent to the coal mines has been nearly all logged off. Only a few of the mines have a sawmill to cut timber for mining purposes. Nearly all the mines use second growth fir and spruce as props and gangway timbers, lagging being supplied by either using small trees or by splitting large fir trees. Hemlock is sometimes used in temporary work where other timber is expensive to get.

In the later developed parts of the coal field there is a great abundance of good timber, but around Franklin and Black Diamond the timber is quite well cleaned up near the mines and it has to be hauled a considerable distance. However, generally speaking, King county is still well supplied with an adequate amount of mine timber.

VENTILATION.

Some of the smaller mines are ventilated by natural means, by using the main haulage way as the intake and allowing the air to go up an air chute for the upcast. This may be done where the difference in elevation between the level of the gangway and the top of the air chute is great enough to produce a sufficient motion in the air column. There are instances where this difference is not great enough, or where the heating of certain areas in the sunlight or cooling in the shadows, would cause the air to reverse itself about twice a day. This was the case some years ago at the Kummer mine.

After the mine becomes extensive, particularly if there is considerable explosive gas in the workings, some means of arti-

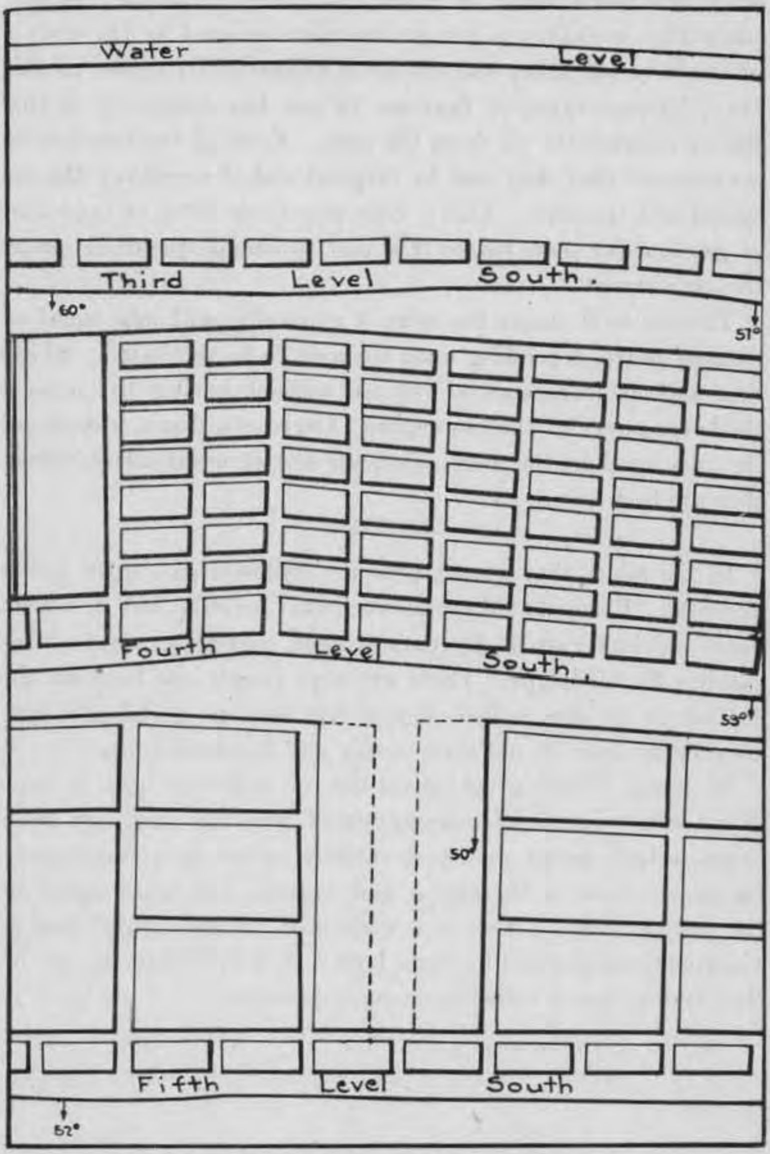

FIG. 59. System of Mining, McKay Bed, Lawson Mine.

ficial ventilation must be employed. This is usually accomplished by installing a fan at the place selected as the upcast or outlet to the mine, and the air is exhausted by means of this fan. Various types of fans are in use, but nearly all in this county exhaust the air from the mine. Some of the fans are so constructed that they can be reversed and if necessary the air forced into the mine. This is done sometimes after an explosion of gas and for some reason it is best to change the direction of the air current.

The air as it enters the mine is generally split into equal or unequal parts, depending upon the area to be ventilated. Splitting the air increases the volume, without having to increase the horse-power of the fan engine. Overcasts, doors, stoopings, etc., are used in the mine, whenever the superintendent thinks they are best suited.

LIGHTING.

In the mines that do not produce explosive gas, open lights are used. Formerly oil lamps were used entirely, but in recent years calcium carbide lamps are used, and they are fast replacing the oil lamps. There are some people who have an objection to the new carbide lamps, but they are gradually winning favor over the old style smoky and dirty oil lamp.

In mines where great quantities of explosive gas is produced safety lamps of some approved type are used. In some mines safety lamps are used entirely, while in others safety lamps are used in the chutes and breasts, and open lights in the haulage ways. This is a system of "mixed lights" and is vigorously condemned by some men. It is said that the use of this system has resulted in many explosions.

CHAPTER VII.

GENERAL CHARACTER OF KING COUNTY COAL.

GENERAL STATEMENT.

The coal of King county varies considerably in character because there are wide differences in moisture, volatile matter, fixed carbon, ash and all the other chemical subdivisions.

In the western part of the county, in the Renton, Newcastle, Issaquah and Grand Ridge areas, the moisture content ranges from 4.9 per cent. to 10.7 per cent. for air dried samples. The volatile matter ranges from 30.1 per cent. to 41.9 per cent., and the fixed carbon from 33.6 per cent to 50.6 per cent. The ash in the workable beds ranges from 6.38 per cent to 18 per cent. The calorific power, as represented by calories, varies from 5,275 to 6,600, and the B. T. U. (British Thermal Units) range from 9,500 to 11,880. These coals are nearly the same in character and they might perhaps be called lignitic bituminous. Some of the beds have coal with a cubical fracture, such as the Jones bed at Newcastle, the No. 6 bed at Issaquah, and the No. 7 bed at Grand Ridge. Most of these coals, however, have a conchoidal fracture, and lose considerable moisture on air drying; some of them weather very quickly on exposure. They will not stock very well, and are liable to spontaneous combustion. As a house coal for range use, they are very satisfactory, since they kindle quickly, produce a quick fire, but burn up equally rapidly. Their low price is a factor in their favor. For furnace use they are not as well suited as some of the bituminous coals. These coals, if used in producer gas engines or Parkinson furnaces, should prove very satisfactory. It is by using some special devices of this type that these lower grade coals will develop their greatest efficiency.

The coals at Taylor are lignitic bituminous coals that have lost part of their moisture probably by folding and by intrusions, and have really become bituminous in character. The moisture in the coals of this district ranges from 1.9 per cent. to 3.7 per cent., air dried samples. The volatile matter varies from 25.3 per cent. to 41.4 per cent. and the fixed carbon from 32.7 per cent. to 55.4 per cent. The ash runs from 8.9 per cent. to 39.8 per cent. The calories range from 4,400 to 7,095; the B. T. U. from 7,920 to 12,770.

These coals are usually so high in ash that they could not very well be sold in the domestic market. However, there are exceptions to this in some cases. Their best use is that to which the company places them, viz., burning the coal in the various kilns in the factories for the production of clay wares. In this work the ash constituent does not interfere so much as in other uses.

In the Ravensdale field the coals vary considerably. The moisture ranges from 4.5 per cent. to 8.9 per cent.; the volatile combustible matter from 35.5 per cent. to 42.1 per cent.; the fixed carbon from 39.1 per cent. to 48.0 per cent; the calories from 5,060 to 7,080, and the B. T. U. from 9,100 to 12,740; all from air dried samples. These coals are used entirely by the locomotives of the Northern Pacific railway.

At Black Diamond and Franklin the principal bed mined is the McKay. The Gem is also mined at Franklin. The McKay coal has a distinctly cubical fracture, and men who are thoroughly familiar with this coal can distinguish it from any other coal by its characteristic physical properties. The coal from this bed is popular for nearly all purposes. It is used extensively for domestic purposes and the clean mine run coal is used a great deal on Alaskan steamers. The moisture in this bed varies from 1.8 per cent. to 3.3 per cent.; the volatile matter from 37.8 per cent. to 43.2 per cent.; the fixed carbon from 45.4 per cent. to 51.7 per cent.; the calories from 6,615 to 7,540 and B. T. U. from 11,910 to 13,630; all air dried.

The other beds in the southeastern district vary very much in character. They represent beds that occur in the three separate series. In the Kummer series the beds have original moisture of 12.4 to 14.1 per cent. and from 9,420 to 11,900 B. T. U. They are lignitic bituminous coals.

The other beds in the Franklin series, besides the McKay, are the Harris, Gem, Nos. 12, 11 and 10. The McKay and Gem were the only beds sampled. The Gem bed has about 7.3 per cent. original moisture and air dries to 2.5 per cent., with volatile matter making 35.9 per cent., fixed carbon 50.2 per cent., and 12,010 B. T. U, on air dried samples.

The other beds occuring in the Franklin series and mined more or less in other part of the field very in moisture from 2.2 per cent. to 7 per cent.; volatile matter from 27.1 per cent. to 39.8 per cent.; fixed carbon from 30.9 per cent. to 48.8 per cent.; ash from 8.7 per cent. to 39.6 per cent.; calories from 4,555 to 7,215; B. T. U. from 8,200 to 12,990; air dried samples. These coals are all more or less impure and represent the other beds in the Franklin series aside from the McKay and Gem.

In the Bayne series the workable beds range in moisture from 1.5 to 7.0 per cent.; volatile matter from 31.8 to 38.2 per cent.; fixed carbon from 42.5 to 57.7 per cent.; ash from 8.36 to 21.8 per cent.; calories from 5,785 to 7,365, and B. T. U. from 10,410 to 13,260. Some of these beds make satisfactory domestic coal when properly cleaned, but their best use is for steam purposes. Nearly all the workable coal in this area can be classed as bituminous. All or nearly all of it has a cubical fracture and is jet black in color. Some of the beds of this series are supposed to be fairly well suited for gas making purposes. It is likely that the great amount of ash in most of it will prove a drawback for this purpose.

Summarizing, we find that King county has a variety of coal, ranging from lignitic bituminous, in the western part of the county, to a bituminous coal in the eastern part, coal that is suited for a great many purposes. It is true, that when compared with certain high grade Eastern coals, or with some of the coals in the Alaskan fields, our coals do not stand very high, but for ordinary purposes, where a comparatively cheap fuel is needed, King county coals do very well.

ANALYSES OF SAMPLES OF COAL FROM KING COUNTY MINES.

(WITH ANALYSES OF COAL FROM OTHER COUNTIES FOR PURPOSES OF COMPARISON.)

SAMPLES COLLECTED BY THE WASHINGTON GEOLOGICAL SURVEY IN CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY. THE ANALYSES WERE MADE IN THE FUEL-TESTING LABORATORY OF THE LATTER SURVEY. THE RESULTS AS GIVEN ARE FROM AIR-DRIED SAMPLES.

KING COUNTY.

NAME OF MINE OR FORM OF EXPOSURE	LOCATION				Air-drying loss	PROXIMATE			ULTIMATE						HEAT VALUE		Split Volatile ratio (a)	Carbon-Hyd. ratio (b)
	Quarter	Section	Township	Range		Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units		
Prospect, 3 mi. north of Issaquah	SW	13	24 N	6 E	9.7	8.7	34.5	42.7	14.14	.41	5.28	57.71	1.20	21.26	5,740	10,330	2.3	10.9
Grand Ridge, 3 mi. east of Issaquah, No. 1 bed.	NW	26	24 N	6 E	6.1	8.7	32.3	46.6	12.42	.39	5.42	60.38	1.13	20.26	5,940	10,690	2.5	11.1
Grand Ridge, 3 mi. east of Issaquah, No. 2 bed.	NW	26	24 N	6 E	3.8	10.4	33.7	37.5	18.40	.51	5.43	53.26	.99	21.41	5,275	9,500	2.0	9.9
Grand Ridge, 3 mi. east of Issaquah, No. 3 bed.	NE	26	24 N	6 E	9.0	7.6	39.6	42.3	10.5	.54	......	......	......	......	6,085	10,950	2.3	9.0
Grand Ridge, 3 mi. east of Issaquah, No. 4 bed.	NE	26	24 N	6 E	9.6	6.6	37.0	33.6	22.8	2.51	......	......	......	......	5,155	9,280	2.1	......
Grand Ridge, 3 mi. east of Issaquah, No. 7 bed.	NE	26	24 N	6 E	10.6	6.5	38.8	40.7	14.0	.42	......	......	......	......	5,955	10,720	2.3	......
Grand Ridge, 3 mi. east of Issaquah, washed coal	......	26	24 N	6 E	8.5	10.4	36.6	37.6	15.39	.41	5.47	56.55	1.13	21.05	5,515	9,920	2.0	10.3
Issaquah at Issaquah, No. 4 bed	NE	33	24 N	6 E	8.0	10.7	31.8	47.4	10.1	.38	......	......	......	......	5,925	10,660	2.4	......
Issaquah at Issaquah, No. 5 bed	SE	33	24 N	6 E	6.6	9.1	31.4	47.4	12.15	1.20	5.27	59.51	1.17	20.70	5,920	10,660	2.5	11.3
Superior, 1½ mi. s. w. of Issaquah, main bed	SE	32	24 N	6 E	5.3	7.9	30.1	46.0	15.96	.72	5.25	58.80	1.17	18.10	5,940	10,690	2.6	11.2
Superior, 1½ mi. s. w. of Issaquah, No. 0 bed	SE	32	24 N	6 E	4.3	8.5	31.0	43.7	16.8	1.68	......	......	......	......	5,725	10,310	2.5	......
Ford at Coal Creek, Muldoon bed	SE	25	24 N	5 E	9.7	5.1	34.9	47.0	13.01	.49	5.27	62.15	1.38	17.70	6,130	11,040	2.8	11.8
Ford at Coal Creek, Muldoon bed	SE	27	24 N	5 E	7.2	6.3	37.4	42.6	13.73	.76	5.34	60.83	1.45	17.89	5,965	10,730	2.4	11.4
Ford at Coal Creek, Muldoon bed	SE	26	24 N	5 E	7.1	6.2	38.5	44.0	11.28	.59	5.43	63.42	1.46	17.82	6,200	11,160	2.1	11.6
Ford at Coal Creek, No. 3 bed	SE	25	24 N	5 E	8.6	6.4	33.8	47.4	12.36	.39	5.30	61.52	1.18	19.25	6,090	10,960	2.8	11.6
Ford at Coal Creek, No. 3 bed	SE	25	24 N	5 E	9.7	5.2	36.0	50.6	8.16	.47	5.32	66.00	1.16	18.89	6,410	11,540	3.0	12.4
Ford at Coal Creek, No. 4 bed	SE	25	24 N	5 E	8.9	6.5	36.5	47.9	9.07	.41	5.53	64.19	1.47	19.33	6,240	11,240	2.7	11.6
Bagley at Coal Creek, Bagley No. 1 bed	SE	26	24 N	5 E	6.6	5.8	39.4	43.6	11.15	.36	5.38	62.26	1.47	19.38	6,195	11,150	2.5	11.6
Bagley at Coal Creek, Bagley No. 2 bed	NE	25	24 N	5 E	4.6	4.9	41.9	38.5	14.68	4.00	5.41	60.64	1.25	14.02	6,185	11,140	2.3	11.2
Bagley at Coal Creek, Bagley No. 2 bed	NE	25	24 N	5 E	....	5.2	39.7	43.0	12.07	.96	5.34	62.43	1.31	17.89	6,200	11,160	2.5	11.7
Denny-Renton at Renton, No. 1 bed	SW	17	23 N	5 E	8.1	8.9	35.0	42.9	13.23	.52	5.30	58.30	1.45	21.20	5,690	10,240	2.3	11.0
Denny-Renton at Renton, No. 1 bed	NW	20	23 N	5 E	8.9	8.7	35.4	42.9	13.02	.47	5.41	58.84	1.40	20.86	5,725	10,300	2.3	10.8
Renton at Renton, No. 2 bed	NE	20	23 N	5 E	7.2	7.9	34.3	41.8	16.00	.73	5.17	57.38	1.27	19.45	5,585	10,060	2.3	11.0
Renton at Renton, No. 3 bed	NE	20	23 N	5 E	7.2	8.0	36.6	44.7	10.7	.47	......	......	......	......	6,030	10,860	2.4	......
Renton at Renton, No. 3 bed	NE	20	23 N	5 E	8.1	6.9	39.2	45.7	8.2	.65	......	......	......	......	6,395	11,510	2.5	......
Renton at Renton, No. 3 bed	SE	17	23 N	5 E	7.5	7.8	35.9	43.8	12.53	.51	5.54	59.86	1.39	20.17	5,930	10,670	2.4	10.8
Renton at Renton, No. 3 bed	SE	17	23 N	5 E	7.2	7.5	38.3	46.0	8.17	.73	5.49	63.85	1.49	20.27	6,320	11,370	2.4	11.6
Renton at Renton, No. 3 bed	SE	19	23 N	5 E	10.0	7.0	35.5	48.2	9.35	.41	5.65	63.46	1.41	19.72	6,240	11,230	2.7	11.2
Renton at Renton, No. 3 bed	SE	20	23 N	5 E	9.5	6.1	39.1	48.4	6.38	.60	5.64	66.00	1.51	19.87	6,600	11,880	2.6	11.7
Renton at Renton, No. 3 bed	SE	20	23 N	5 E	9.9	7.0	39.6	43.6	9.8	.51	......	......	......	......	......	....	2.4	......

Renton at Renton, No. 3 bed	NE	20	23 N	5 E	12.9	5.8	40.4	44.9	8.9	.49	......	......	......	......	6,380	11,490	2.5	......
Renton at Renton, washed pea coal	......	20	23 N	5 E	10.7	6.0	35.1	46.0	12.91	.68	4.91	63.28	1.30	16.92	6,185	11,130	2.7	12.9
Renton at Renton, run-of-mine coal	......	20	23 N	5 E	9.6	5.2	36.6	45.6	12.58	.80	5.16	63.35	1.29	16.82	6,275	11,290	2.7	12.3
Danville at Danville	SW	24	22 N	6 E	10.9	8.1	36.5	46.4	9.0	.57	......	......	......	......	6,115	11,010	2.5	......
Ravensdale No. 1 at Ravensdale, No. 3 bed	NE	36	22 N	6 E	3.6	5.6	36.7	45.1	12.62	.99	5.16	64.21	1.45	15.57	6,425	11,570	2.6	12.4
Ravensdale No. 1 at Ravensdale, No. 4 bed	NE	36	22 N	6 E	3.0	4.5	38.6	45.3	11.59	.53	5.46	65.89	1.57	14.96	6,585	11,850	2.8	12.0
Ravensdale No. 1 at Ravensdale, No. 5 bed	NW	36	22 N	6 E	4.1	5.3	39.7	47.5	7.47	.37	5.33	69.48	1.60	15.75	6,845	12,320	2.7	13.0
Ravensdale No. 1 at Ravensdale, No. 5 bed	NE	36	22 N	6 E	2.9	5.4	38.3	44.0	12.32	.30	5.30	63.71	1.47	16.90	6,380	11,480	2.6	12.0
Ravensdale No. 1 at Ravensdale, No. 5 bed	NE	36	22 N	6 E	3.9	5.7	37.2	40.8	16.27	.73	5.10	60.18	1.59	16.13	6,005	10,810	2.4	12.1
Ravensdale No. 1 at Ravensdale, No. 5 bed	NE	36	22 N	6 E	3.6	5.7	36.4	40.6	17.26	1.29	5.04	58.60	1.59	16.22	5,895	10,610	2.4	11.7
Ravensdale No. 1 at Ravensdale, No. 5 bed	NE	36	22 N	6 E	4.0	6.0	38.1	41.6	14.28	.39	5.21	61.95	1.59	16.58	6,185	11,130	2.4	11.8
Ravensdale No. 1 at Ravensdale, No. 5 bed	......	36	22 N	6 E	6.3	5.2	35.5	46.3	13.0	.32	......	......	......	......	6,320	11,380	2.8	......
Ravensdale No. 1 at Ravensdale, No. 9 bed	NW	36	22 N	6 E	2.9	4.5	41.5	48.0	5.99	.65	5.72	70.32	1.81	15.51	7,080	12,740	2.7	12.3
McKay at Ravensdale, McKay bed	SE	36	22 N	6 E	4.9	8.9	42.1	45.7	3.34	.41	5.83	67.46	1.73	21.23	6,715	12,080	2.3	11.5
McKay at Ravensdale, McKay bed	NE	1	21 N	6 E	4.7	6.8	41.7	47.3	4.21	.55	5.83	69.14	1.82	18.45	6,860	12,350	2.5	11.8
McKay at Ravensdale, McKay bed	NE	1	21 N	6 E	5.0	7.1	41.7	47.3	3.9	.51	......	......	......	......	6,860	12,340	2.4	......
McKay at Ravensdale, McKay bed	NE	1	21 N	6 E	6.8	7.4	30.0	39.1	23.5	.62	......	......	......	......	5,060	9,100	2.4	......
McKay at Ravensdale, McKay bed	NE	1	21 N	6 E	5.5	6.6	36.7	50.7	5.97	.38	5.85	67.77	1.83	18.20	6,700	12,060	2.8	11.5
Morgan, 1 mi. n.w. of Bl'k Diamond, McKay bed	SW	11	21 N	6 E	4.6	2.3	41.9	50.2	5.60	1.41	5.50	70.93	1.98	14.58	7,180	12,920	3.1	12.9
Morgan, 1 mi. n. w. of Black Diamond, upper McKay bed	SW	11	21 N	6 E	5.4	2.5	40.1	47.7	9.68	.47	5.16	67.73	1.46	15.50	6,855	12,340	3.0	13.1
Black Diamond at Black Diamond, McKay bed	SE	14	21 N	6 E	4.8	2.7	41.3	51.7	4.28	1.34	5.28	71.69	2.02	15.39	7,295	13,130	3.1	13.5
Bl'k Diamond at Bl'k Diamond, upper McKay bed	SE	14	21 N	6 E	6.0	2.1	40.1	48.9	8.92	.48	5.24	68.93	1.80	14.63	6,935	12,480	3.1	13.2
Lawson, 1 mi. n.e. of Black Diamond, McKay bed	NW	13	21 N	6 E	3.2	1.8	43.2	50.3	4.66	.49	5.67	74.80	1.63	12.75	7,540	13,580	3.1	13.2
Lawson, 1 mi. n. e. of Black Diamond, upper McKay bed	NW	13	21 N	6 E	4.2	2.0	37.8	45.4	14.82	.58	4.96	65.11	1.61	12.92	6,615	11,910	3.1	13.1
Surface exposure at Franklin, McKay bed	NE	19	21 N	7 E	2.9	3.3	40.4	52.8	3.54	.49	5.82	74.89	1.68	13.58	7,570	13,630	3.1	12.9
Kummer at Kummer, No. 1 bed	NE	26	21 N	6 E	12.3	2.1	34.1	53.6	10.17	.49	5.05	66.58	1.51	16.20	6,610	11,900	3.7	13.2
Kummer at Kummer	NE	26	21 N	6 E	9.7	2.9	33.7	38.6	24.8	.65	......	......	......	......	5,235	9,420	2.8	......
Gem at Franklin, Gem bed	NE	19	21 N	7 E	4.9	2.5	35.9	50.2	11.36	.56	5.09	66.80	1.78	14.41	6,675	12,010	3.3	13.1
Surface exposure, ¾ mi. s. w. of Franklin, Gem(?) bed	SW	19	21 N	7 E	7.1	7.7	37.0	45.5	9.8	.61	......	......	......	......	6,145	11,060	2.4	......
Rose-Marshall, 1 mi. w. of Cumberland, Jno. Harris bed	NE	29	21 N	7 E	2.6	2.7	39.8	48.8	8.7	.48	......	......	......	......	7,215	12,990	3.0	......
Rose-Marshall, 1 mi. w. of Cumberland, Jno. Harris bed	NE	29	21 N	7 E	3.3	4.1	35.5	43.9	16.54	.60	5.12	63.25	1.48	13.01	6,375	11,480	2.8	12.3
Independent, 1 mi. south of Cumberland	SW	28	21 N	7 E	3.4	2.7	30.8	42.2	24.3	.67	......	......	......	......	5,780	10,400	3.2	......
Independent, 1 mi. south of Cumberland	SW	28	21 N	7 E	3.4	2.5	32.4	37.8	27.31	.49	4.58	54.63	1.35	11.64	5,480	9,860	2.9	11.9
Sunset, 1 mi. s. e. of Cumberland, No. 1 bed	SE	28	21 N	7 E	6.2	7.0	33.1	46.6	13.3	.96	......	......	......	......	5,855	10,540	2.7	......
Sunset, 1 mi. s. e. of Cumberland, No. 2 bed	SE	28	21 N	7 E	2.2	2.3	34.8	40.6	22.26	.70	4.77	60.56	.96	10.69	6,095	10,970	2.9	12.7
Sunset, 1 mi. s. e. of Cumberland, No. 3 bed	SE	28	21 N	7 E	2.8	2.9	35.4	46.3	15.44	2.48	4.96	65.63	.99	10.50	6,680	12,020	2.8	13.2
Sunset, 1 mi. s. e. of Cumberland, No. 7 bed	SE	28	21 N	7 E	2.6	2.4	27.1	30.9	39.6	.42	......	......	......	......	4,555	8,200	2.8	......
Naval at Cumberland	NW	28	21 N	7 E	2.8	2.8	33.2	42.4	21.64	.71	4.83	61.20	1.69	9.93	6,185	11,130	3.0	12.7
Naval at Cumberland	NW	28	21 N	7 E	4.0	2.3	31.2	39.1	27.4	.68	......	......	......	......	5,565	10,020	3.0	......
Naval at Cumberland	NW	28	21 N	7 E	2.7	2.2	36.6	48.7	12.50	.53	5.19	68.66	1.70	11.42	6,960	12,530	3.3	13.2

(a) Calculated by formula $\frac{\text{Fixed carbon} + \frac{1}{2}\text{ volatile combustible}}{\text{Moisture} + \frac{1}{2}\text{ volatile combustible}}$

(b) Calculated by formula $\frac{\text{Carbon}}{\text{Hydrogen}}$

NAME OF MINE OR FORM OF EXPOSURE	LOCATION				Air-drying loss	PROXIMATE			ULTIMATE						HEAT VALUE		Split Volatile ratio (a)	Carbon-Hyd. ratio (b)
	Quarter	Section	Township	Range		Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units		
Eureka, 1 mi. south of Bayne	NE	28	21 N	7 E	4.2	1.8	32.7	45.8	19.75	.49	4.81	63.00	1.18	10.77	6,345	11,420	3.4	13.1
Bayne at Bayne, No. 1 bed	NW	22	21 N	7 E	7.6	1.2	32.6	45.6	20.59	.52	4.70	62.02	1.21	10.96	6,245	11,240	3.5	13.2
Bayne at Bayne, No. 3 bed	NW	22	21 N	7 E	3.5	1.5	34.2	42.5	21.84	.56	4.92	61.50	1.29	9.89	6,180	11,120	3.2	12.5
Bayne at Bayne, No. 5 bed	NW	22	21 N	7 E	3.6	1.5	35.1	44.3	19.12	.65	4.88	62.36	1.52	11.47	6,380	11,480	3.2	12.7
Bayne at Bayne, No. 5 bed	NW	22	21 N	7 E	5.5	7.0	33.1	46.1	13.78	.49	4.85	60.07	1.46	19.35	5,785	10,410	2.7	12.5
Bayne at Bayne, No. 5 bed	NW	22	21 N	7 E	4.4	3.0	34.9	43.7	18.40	.59	4.93	62.15	1.51	12.42	6,255	11,260	3.0	12.6
Bayne at Bayne, No. 5 bed	NW	22	21 N	7 E	3.3	2.6	38.2	49.9	9.26	.65	5.46	71.36	1.78	11.49	7,210	12,980	3.2	13.0
Prospect at Bayne	NW	22	21 N	7 E	4.5	3.1	24.4	37.3	35.2	1.85	......	......	......	......	4,630	8,330	3.2	......
Carbon, ½ mi. n. e. of Bayne, No. 1 bed	SE	15	21 N	7 E	2.3	2.0	33.2	53.4	11.39	.46	5.11	70.62	1.44	10.98	7,145	12,860	3.2	13.7
Carbon, ½ mi. n. e. of Bayne, No. 1 bed, special sample	SE	15	21 N	7 E	1.5	2.3	34.2	54.1	9.4	.40	......	......	......	......	......	......	3.7	......
Carbon, ½ mi. n. e. of Bayne, composite sample	SE	15	21 N	7 E	1.9	2.3	33.4	53.8	10.54	.46	5.22	72.89	1.59	9.30	7,240	13,030	3.7	13.9
Carbon, ½ mi. n. e. of Bayne, No. 2 bed	SE	15	21 N	7 E	3.1	2.1	31.8	57.7	8.36	.37	5.01	74.80	1.18	10.28	7,365	13,260	4.0	14.9
Prospect, ¼ mi. west of Bayne	NE	21	21 N	7 E	3.5	2.6	32.3	45.1	20.05	.44	4.67	61.75	1.19	11.90	6,165	11,100	3.3	13.4
Occidental at Bayne, No. 1 bed	SE	16	21 N	7 E	2.4	2.8	35.3	48.7	13.25	.74	5.24	67.94	1.20	11.63	6,810	12,260	3.2	12.9
Occidental at Bayne, No. 2 bed	SE	16	21 N	7 E	2.5	2.9	33.9	48.3	14.88	.72	5.05	65.77	1.31	12.27	6,605	11,890	3.8	13.0
Occidental at Bayne, No. 3 bed	SE	16	21 N	7 E	2.1	2.7	35.1	49.5	12.69	1.14	5.49	68.30	1.14	11.24	6,925	12,460	3.3	12.4
Occidental at Bayne, No. 3 bed	SE	16	21 N	7 E	2.1	3.0	35.1	50.0	11.90	1.21	5.10	68.15	1.10	12.54	6,850	12,330	3.3	13.3
Occidental at Bayne, No. 6 bed	SE	16	21 N	7 E	2.8	2.9	32.7	42.0	22.43	.52	4.73	58.64	1.34	12.34	5,950	10,710	3.1	12.4
Occidental at Bayne, No. 14 bed	SE	16	21 N	7 E	1.8	2.4	33.8	46.3	17.5	.59	......	......	......	......	......	......	3.3	......
Occidental at Bayne, No. 14 bed	SE	16	21 N	7 E	1.6	2.5	37.3	53.5	6.7	.52	......	......	......	......	......	......	3.4	......
Occidental at Bayne, composite sample	SE	16	21 N	7 E	1.7	2.3	35.8	49.6	12.30	.50	5.45	68.67	1.73	11.35	6,975	12,560	3.3	12.6
Big Six, 1½ mi. e. of Bayne, Pocahontas bed	NE	23	21 N	7 E	3.1	1.5	32.0	53.9	12.63	.75	5.09	72.31	1.08	8.14	7,300	13,140	4.0	14.2
Prospect at Palmer Junction	NE	14	21 N	7 E	2.5	2.0	25.6	38.2	34.2	.59	......	......	......	......	5,100	9,180	3.5	......
Prospect at Palmer Junction	NE	14	21 N	7 E	2.9	1.9	24.4	40.3	33.4	.68	......	......	......	......	5,190	9,340	3.7	......
Prospect shaft, 3½ mi. east of Ravensdale	SE	28	22 N	7 E	5.7	5.0	37.3	45.0	12.65	.37	5.27	63.35	.93	17.43	6,305	11,350	2.7	12.0
Prospect near Barneston	NW	12	22 N	7 E	12.6	1.7	6.2	59.1	33.0	.49	......	......	......	......	5,095	9,170	3.0	......
Denny-Renton at Taylor, No. 2 bed	SW	3	22 N	7 E	4.0	2.5	38.2	43.2	16.1	1.39	......	......	......	......	6,450	11,610	2.8	......
Denny-Renton at Taylor, No. 3 bed	SW	3	22 N	7 E	2.6	2.4	37.1	34.9	25.6	1.97	......	......	......	......	5,705	10,270	2.5	......
Denny-Renton at Taylor, No. 4 bed	SE	3	22 N	7 E	2.6	2.2	37.4	50.1	10.32	.83	5.22	69.91	1.39	12.33	7,075	12,740	3.3	13.4
Denny-Renton at Taylor, No. 5 bed	SE	3	22 N	7 E	2.3	2.1	36.4	46.3	15.20	.76	5.06	66.67	1.64	10.67	6,750	12,150	3.2	13.2
Denny-Renton at Taylor, No. 5 bed	SW	3	22 N	7 E	3.5	2.8	41.4	39.1	16.7	1.05	......	......	......	......	......	......	2.5	......
Denny-Renton at Taylor, No. 5 bed	SW	3	22 N	7 E	2.2	1.9	36.7	44 5	16.9	.55	......	......	......	......	6,565	11,820	3.1	12.1
Denny-Renton at Taylor, No. 4 bed	SE	3	22 N	7 E	3.3	2.1	39.0	50.0	8.9	.65	......	......	......	......	7,095	12,770	3.1	12.8
Denny-Renton at Taylor, No. 6 bed	SE	3	22 N	7 E	3.1	2.5	37.1	45.6	14.84	.97	4.99	65.95	1.30	11.95	6,620	11,920	3.0	13.2
Denny-Renton at Taylor, No. 5 bed	......	3	22 N	7 E	3.3	2.2	25.3	32.7	39.8	.53	......	......	......	......	4,400	7,920	3.0	......
Denny-Renton at Taylor, run-of-mine coal, No. 4 bed	SE	3	22 N	7 E	2.6	3.7	35.1	42.5	18.72	.71	4.78	61.72	1.45	12.62	6,210	11,180	2.8	12.9
Denny-Renton at Taylor, run-of-mine coal, No. 5 bed	SW	3	22 N	7 E	2.3	3.1	35.0	38.7	23.20	.79	4.57	58.32	1.40	11.72	5,860	10,550	2.7	12.7

Prospect, 6 mi. s. e. of Issaquah	SW	12	23 N	6 E	8.9	2.7	30.1	55.4	11.8	.25	......	......	......	......	6,950	12,510	4.0	......
Prospect, 6 mi. s. e. of Issaquah	SW	12	23 N	6 E	8.5	4.4	30.6	49.8	15.2	2.50	......	......	......	......	6,230	11,220	3.3	......
Prospect, 1 mi. s. w. of Preston	SE	31	24 N	7 E	4.0	1.6	7.6	31.8	59.0	3.44	......	......	......	......	2,825	5,080	6.6	......
Niblock, 1½ mi. s. w. of Snoqualmie, No. 3 bed.	SE	1	23 N	7 E	7.3	1.0	29.3	58.2	11.53	.51	4.76	75.12	1.98	6.10	7,455	13,420	4.6	15.8
Niblock, 1½ mi. s. w. of Snoqualmie, No. 4 bed.	SE	1	23 N	7 E	4.1	2.1	23.7	61.3	12.9	.92	......	......	......	......	6,205	11,170	5.3	......
Niblock, 1½ mi. s. w. of Snoqualmie, No. 5 bed.	NW	1	23 N	7 E	3.7	1.2	28.3	45.2	25.28	1.54	4.68	60.08	1.43	6.99	6,100	10,980	3.9	13.0

(a) Calculated by formula $\dfrac{\text{Fixed carbon} + \frac{1}{2}\text{ volatile combustible}}{\text{Moisture} + \frac{1}{2}\text{ volatile combustible}}$

(b) Calculated by formula $\dfrac{\text{Carbon}}{\text{Hydrogen}}$

CLALLAM COUNTY.

Fuca, 6 mi. east of Clallam	......	25	32 N	12 W	3.4	8.1	41.4	37.5	13.01	5.28	5.79	58.70	.93	16.29	6,030	10,860	......	......

COWLITZ COUNTY.

Prospect, 12 mi. west of Kelso	......	......	9 N	4 W	......	15.24	36.28	29.54	18.94	4.39	......	......	......	......	......	......	......	......
Prospect, 12 mi. west of Kelso	......	......	9 N	4 W	......	22.22	33.30	27.11	17.37	4.08	......	......	......	......	......	......	......	......
Prospect, 12 mi. west of Kelso	......	......	9 N	4 W	......	16.26	36.33	30.05	17.36	4.61	......	......	......	......	......	......	......	......

KITTITAS COUNTY.

Prospect, 1¼ mi. n. w. of Beekman	NW	2	20 N	14 E	4.1	1.2	28.7	44.4	25.7	.40	......	......	......	......	......	......	......	......
Lakedale, 1 mi. n. w. of Beekman	SW	1	20 N	14 E	2.5	2.0	30.3	45.7	22.03	.36	4.86	63.03	1.21	8.51	6,395	11,510	......	......
Beekman at Beekman, Roslyn bed	NW	12	20 N	14 E	2.4	1.3	36.0	51.7	11.0	.33	......	......	......	......	......	......	......	......
Beekman at Beekman, Roslyn bed	SE	12	20 N	14 E	1.8	1.8	35.2	51.1	11.9	.39	......	......	......	......	......	......	......	......
Beekman at Beekman, Roslyn bed	SW	12	20 N	14 E	1.8	1.6	36.2	50.7	11.5	.38	......	......	......	......	......	......	......	......
Beekman at Beekman, Roslyn bed	NW	12	20 N	14 E	1.0	1.5	35.2	50.5	12.8	.33	......	......	......	......	......	......	......	......
Beekman at Beekman, Roslyn bed	SW	12	20 N	14 E	.8	1.8	35.0	49.3	13.9	.34	......	......	......	......	......	......	......	......
Beekman at Beekman, car sample	SW	12	20 N	14 E	2.7	1.7	34.1	50.9	13.30	.36	5.30	71.77	1.60	7.67	7,150	12,870	......	......
Beekman at Beekman, composite sample	......	12	20 N	14 E	1.8	1.5	34.7	51.4	12.37	.36	5.51	71.97	1.68	8.11	7,305	13,150	......	......
Beekman at Beekman, Roslyn bed	......	12	20 N	14 E	1.9	1.6	39.2	49.2	10.0	.42	......	......	......	......	7,490	13,480	......	......
Beekman at Beekman, Roslyn bed	......	12	20 N	14 E	7.5	1.5	39.2	49.8	9.5	.38	......	......	......	......	......	......	......	......
Beekman at Beekman, car sample	......	12	20 N	14 E	5.8	2.2	35.1	47.7	15.05	.48	5.14	68.65	1.50	9.18	7,020	12,630	......	......
Busy Bee, 2½ mi. n. w. of Roslyn, Roslyn bed	NE	12	20 N	14 E	1.4	1.9	36.7	52.3	9.1	.42	......	......	......	......	7,535	13,560	......	......
Patrick-McKay, 3¾ mi.n.w. of Roslyn, Roslyn bed	SW	6	20 N	15 E	1.1	3.2	36.3	49.4	12.1	.37	......	......	......	......	......	......	......	......
Patrick-McKay, 3¾ mi.n.w. of Roslyn, Roslyn bed	SW	6	20 N	15 E	1.1	1.9	37.4	50.1	10.6	.39	......	......	......	......	......	......	......	......
Patrick-McKay, 3¾ mi.n.w. of Roslyn, Roslyn bed	SW	6	20 N	15 E	1.1	1.9	36.6	49.9	11.6	.38	......	......	......	......	......	......	......	......
Patrick-McKay, 3¾ mi. n. w. of Roslyn, composite sample	......	6	20 N	15 E	1.1	2.0	36.0	50.6	11.40	.41	5.57	70.96	1.46	10.20	7,215	12,990	......	......

KITTITAS COUNTY—Concluded.

NAME OF MINE OR FORM OF EXPOSURE	LOCATION				Air-drying loss	PROXIMATE				ULTIMATE					HEAT VALUE			
	Quarter	Section	Township	Range		Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units		
Patrick-McKay, 3½ mi. n.w. of Roslyn, lower bed	NW	6	20 N	15 E	2.5	1.6	33.9	47.4	16.85	.81	5.14	66.76	1.25	9.19	6,745	12,140	......	......
Roslyn No. 3 at Ronald, Roslyn bed............	NW	7	20 N	15 E	1.3	2.2	36.8	50.2	10.8	.41	......	......	......	......	......	......	......	......
Roslyn No. 3 at Ronald, Roslyn bed............	NE	7	20 N	15 E	1.1	2.1	36.9	49.8	11.2	.37	......	......	......	......	......	......	......	......
Roslyn No. 3 at Ronald, Roslyn bed............	NW	7	20 N	15 E	1.0	2.2	36.8	50.3	10.7	.33	......	......	......	......	......	......	......	......
Roslyn No. 3 at Ronald, Roslyn bed............	SE	7	20 N	15 E	1.0	2.2	36.4	47.2	14.2	.39	......	......	......	......	......	......	......	......
Roslyn No. 3 at Ronald, Roslyn bed............	SW	7	20 N	15 E	1.1	2.2	35.6	51.7	10.5	.33	......	......	......	......	......	......	......	......
Roslyn No. 3 at Ronald, composite sample......	......	7	20 N	15 E	1.1	2.0	36.0	50.5	11.50	.40	5.47	71.07	1.56	10.00	7,225	13,010	......	......
Roslyn No. 2 slope at Roslyn, Roslyn bed.......	SE	18	20 N	15 E	0.9	2.0	36.1	49.2	12.7	.37	......	......	......	......	......	......	......	......
Roslyn No. 2 slope at Roslyn, Roslyn bed.......	NW	18	20 N	15 E	1.8	1.6	35.2	51.5	11.7	.37	......	......	......	......	......	......	......	......
Roslyn No. 2 slope at Roslyn, Roslyn bed.......	SW	17	20 N	15 E	1.8	1.6	36.6	49.3	12.5	.38	......	......	......	......	......	......	......	......
Roslyn No. 2 slope at Roslyn, Roslyn bed.......	SE	18	20 N	15 E	1.1	2.0	36.3	48.2	13.5	.31	......	......	......	......	......	......	......	......
Roslyn No. 2 slope at Roslyn, composite sample	......	.....	20 N	15 E	1.4	1.8	36.1	49.5	12.65	.35	5.39	70.06	1.55	10.00	7,125	12,820	......	......
Roslyn No. 2 at Roslyn, Roslyn bed.............	SW	9	20 N	15 E	1.9	2.6	37.7	47.5	12.2	.43	......	......	......	......	......	......	......	......
Roslyn No. 2 at Roslyn, Roslyn bed.............	NE	8	20 N	15 E	1.8	2.7	36.1	48.0	13.2	.42	......	......	......	......	......	......	......	......
Roslyn No. 2 at Roslyn, Roslyn bed.............	SE	9	20 N	15 E	2.2	3.3	37.3	47.2	12.2	.40	......	......	......	......	......	......	......	......
Roslyn No. 2 at Roslyn, composite sample......	......	.....	20 N	15 E	2.0	2.7	36.8	47.8	12.71	.39	5.77	68.22	1.37	11.54	6,940	12,490	......	......
Roslyn No. 2 at Roslyn, Roslyn bed.............	......	.....	20 N	15 E	.9	2.5	36.5	47.0	14.0	.36	......	......	......	......	......	......	......	......
Roslyn No. 2 at Roslyn, lump coal..............	......	.....	......	......	1.3	1.9	37.0	48.7	12.42	.38	5.08	70.26	1.26	10.60	7,085	12,750	......	......
A. & E. mine, 1 mi. n. e. of Roslyn, Roslyn bed	SW	10	20 N	15 E	2.5	3.3	37.9	45.8	13.02	.46	5.32	67.23	1.31	12.66	6,800	12,240	......	......
Roslyn No. 6 at Roslyn, Roslyn bed.............	NE	16	20 N	15 E	1.9	2.6	37.4	47.3	12.7	.42	......	......	......	......	......	......	......	......
Roslyn No. 6 at Roslyn, Roslyn bed.............	NE	16	20 N	15 E	1.8	2.7	37.1	47.4	12.8	.43	......	......	......	......	......	......	......	......
Roslyn No. 6 at Roslyn, Roslyn bed.............	NE	16	20 N	15 E	2.1	2.8	38.0	46.6	12.6	.39	......	......	......	......	......	......	......	......
Roslyn No. 6 at Roslyn, composite sample......	......	16	20 N	15 E	1.9	2.8	36.8	47.6	12.77	.40	5.26	68.73	1.33	11.51	6,885	12,390	......	......
Roslyn No. 4 at Roslyn, Roslyn bed.............	NW	20	20 N	15 E	2.2	1.6	34.6	49.0	14.8	.36	......	......	......	......	......	......	......	......
Roslyn No. 4 at Roslyn, Roslyn bed.............	NE	20	20 N	15 E	1.4	2.3	36.4	48.9	12.4	.38	......	......	......	......	......	......	......	......
Roslyn No. 4 at Roslyn, composite sample......	......	20	20 N	15 E	1.8	1.9	35.0	49.5	13.65	.37	5.33	68.81	1.30	10.54	6,935	12,480	......	......
Roslyn No. 4 at Roslyn, Roslyn bed.............	......	17	20 N	15 E	1.3	2.1	37.9	49.5	10.5	.33	......	......	......	......	7,230	13,020	......	......
Roslyn No. 5, 1½ mi. s.e. of Roslyn, Roslyn bed	SW	16	20 N	15 E	1.9	2.9	37.6	48.3	11.2	.36	......	......	......	......	......	......	......	......
Roslyn No. 5, 1½ mi. s.e. of Roslyn, Roslyn bed	SW	22	20 N	15 E	1.6	3.9	36.3	47.7	12.1	.37	......	......	......	......	......	......	......	......
Roslyn No. 5, 1½ mi. s.e. of Roslyn, Roslyn bed	NW	21	20 N	15 E	1.4	2.9	35.8	47.8	13.5	.38	......	......	......	......	......	......	......	......
Roslyn No. 5, 1½ mi. s.e. of Roslyn, Roslyn bed	SW	22	20 N	15 E	1.7	3.6	37.2	47.2	12.0	.39	......	......	......	......	......	......	......	......
Roslyn No. 5, 1½ mi. s.e. of Roslyn, Roslyn bed	SE	21	20 N	15 E	1.5	3.5	35.5	50.3	10.7	.40	......	......	......	......	......	......	......	......
Roslyn No. 5, 1½ mi. s.e. of Roslyn, composite sample	......	.....	20 N	15 E	1.6	3.4	36.5	48.1	11.97	.41	5.45	68.78	1.29	12.10	6,920	12,450	......	......
Roslyn No. 7, ½ mi. n.e. of Cle Elum, Roslyn bed	SE	22	20 N	15 E	1.5	4.1	36.8	47.2	11.9	.33	......	......	......	......	......	......	......	......
Roslyn No. 7, ½ mi. n.e. of Cle Elum, Roslyn bed	NW	26	20 N	15 E	2.0	5.1	35.2	45.8	13.9	.38	......	......	......	......	......	......	......	......

Roslyn No. 7, ½ mi. n.e. of Cle Elum, Roslyn bed	SE	22	20 N	15 E	2.4	4.0	36.6	47.5	11.9	.36	......	......	......	......	......	......	......	......
Roslyn No. 7, ½ mi. n.e. of Cle Elum, Roslyn bed	NE	27	20 N	15 E	2.0	4.1	35.7	48.1	12.1	.35	......	......	......	......	......	......	......	......
Roslyn No. 7, ½ mi. n.e. of Cle Elum, composite sample	......	......	20 N	15 E	2.0	3.0	36.8	47.8	12.40	.37	5.49	67.35	1.32	13.07	6,745	12,140	......	......
Summit, 1 mi. north of Cle Elum, Roslyn bed.	SW	14	20 N	15 E	2.6	5.2	36.1	46.4	12.33	.45	5.50	65.59	1.36	14.77	6,605	11,890	......	......
Cle Elum, No. 3 Extension, 1 mi. north of Cle Elum, Roslyn bed	NW	23	20 N	15 E	3.0	5.7	36.0	45.8	12.53	.48	5.36	64.62	1.53	15.48	6,500	11,700	......	......
Cle Elum, No. 2 Extension, 1 mi. north of Cle Elum, Roslyn bed	SE	23	20 N	15 E	2.8	5.9	36.0	45.8	12.28	.44	5.36	65.18	1.46	15.28	6,535	11,760	......	......
Cle Elum No. 2, ½ mi. n. of Cle Elum, Roslyn bed	NE	25	20 N	15 E	3.9	4.3	35.9	47.3	12.53	.47	5.28	66.22	1.45	14.05	6,620	11,920	......	......
Cle Elum No. 1 at Cle Elum, Roslyn bed	NW	26	20 N	15 E	2.7	4.0	36.9	45.6	13.5	.36	......	......	......	......	......	......	......	......
Cle Elum No. 1 at Cle Elum, Roslyn bed	SE	26	20 N	15 E	2.3	5.3	36.0	45.2	13.5	.43	......	......	......	......	......	......	......	......
Cle Elum No. 1 at Cle Elum, Roslyn bed	NE	25	20 N	15 E	5.1	5.1	35.3	47.2	12.4	.41	......	......	......	......	......	......	......	......
Cle Elum No. 1 at Cle Elum, composite sample.	......	......	20 N	15 E	3.4	4.7	35.8	46.4	13.13	.44	5.57	65.05	1.36	14.45	6,565	11,820	......	......
Ellensburg, mines 25 miles from N. P. and C., M. & St. P. R. R.	......	22	18 N	15 E	4.10	3.49	39.12	49.93	7.46	.67	......	......	......	......	6,988	12,578	......	......
Ellensburg, west, 25 miles from N. P. and C., M. & St. P. R. R.	......	16	18 N	15 E	6.70	3.99	32.51	39.04	24.46	1.21	......	......	......	......	5,346	9,623	......	......
Thorp, 10 miles west	......	33	19 N	16 E	3.10	4.74	40.90	37.67	16.69	.44	......	......	......	......	5,724	10,303	......	......

LEWIS COUNTY.

Prospect on Carlton Creek	NW	29	15 N	11 E	7.8	2.1	7.4	14.8	75.7	.27	......	......	......	......	1,205	2,170	......	......
Prospect on Carlton Creek	SE	1	14 N	10 E	3.5	.8	10.8	53.1	35.28	.50	2.79	55.55	.90	4.98	5,115	9,200	......	......
Prospect A on Summit Creek, Primrose bed	NW	13	14 N	10 E	2.8	.8	8.6	61.4	29.22	.68	2.94	61.73	1.02	4.41	5,740	10,340	......	......
Prospect A on Summit Creek, Primrose bed	NW	13	14 N	10 E	3.7	1.5	8.9	38.0	51.6	1.04	......	......	......	......	3,455	6,210	......	......
Prospect A on Summit Creek, Primrose bed	NW	13	14 N	10 E	3.0	.9	8.9	53.7	36.5	.68	......	......	......	......	4,970	8,950	......	......
Prospect A on Summit Creek, Primrose bed	NW	13	14 N	10 E	3.1	.9	7.6	73.4	18.09	.57	3.11	73.69	1.34	3.20	6,825	12,280	......	......
Prospect A on Summit Creek, Primrose bed	NW	13	14 N	10 E	2.0	.7	7.3	81.1	10.89	.63	3.33	80.84	1.35	2.96	7,570	13,620	......	......
Prospect B on Summit Creek	NW	13	14 N	10 E	2.9	.8	7.6	49.2	42.39	.72	2.39	49.06	.91	4.53	4,575	8,230	......	......
Prospect C on Sumit Creek	NW	13	14 N	10 E	2.1	.8	8.8	83.6	6.8	.80	......	......	......	......	7,805	14,050	......	......
Prospects east of Cowlitz river	SE	7	13 N	10 E	5.6	1.9	5.1	55.1	37.9	.78	......	......	......	......	4,825	8,690	......	......
Prospect near Ladd and Glenavon	SE	14	13 N	4 E	6.0	2.7	29.0	47.7	20.6	.29	......	......	......	......	6,205	11,170	......	......
Prospect near Ladd and Glenavon	NE	26	14 N	4 E	5.1	4.2	29.3	35.0	31.5	.66	......	......	......	......	4,715	8,480	......	......
Prospect near Ladd and Glenavon	NE	10	13 N	4 E	8.7	5.3	23.8	54.3	16.6	.38	......	......	......	......	5,845	10,530	......	......
Prospect near Ladd and Glenavon	SE	34	14 N	4 E	8.5	2.9	34.2	51.5	11.4	.61	......	......	......	......	6,775	12,200	......	......
Prospect near Ladd and Glenavon	NW	14	13 N	4 E	5.8	2.5	4.9	66.2	26.4	.32	......	......	......	......	5,795	10,420	......	......
East Creek-Ladd at Ladd, No. 2 bed	SW	13	14 N	4 E	2.7	1.4	27.7	53.1	17.79	1.29	4.70	68.36	1.35	6.51	6,770	12,190	......	......
East Creek-Ladd at Ladd, No. 3 bed	NW	13	14 N	4 E	3.3	3.1	35.8	38.9	22.2	.86	......	......	......	......	5,765	10,370	......	......
East Creek-Ladd at Ladd, No. 3 bed	NW	13	14 N	4 E	4.4	3.0	35.9	39.5	21.6	.55	......	......	......	......	5,875	10,570	......	......
East Creek-Ladd at Ladd, No. 4 bed	NW	13	14 N	4 E	5.2	3.6	34.3	36.3	25.8	.90	......	......	......	......	5,415	9,750	......	......
East Creek-Ladd at Ladd, No. 2 bed	SW	12	14 N	4 E	2.4	2.0	27.3	52.8	17.9	1.08	......	......	......	......	6,490	11,680	......	......
East Creek-Ladd at Ladd, No. 3 bed	NW	13	14 N	4 E	2.3	3.4	34.7	41.3	20.6	.62	......	......	......	......	5,910	10,630	......	......

LEWIS COUNTY—Concluded.

NAME OF MINE OR FORM OF EXPOSURE	LOCATION				Air-drying loss	PROXIMATE				ULTIMATE					HEAT VALUE			
	Quarter	Section	Township	Range		Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units		
East Creek-Ladd at Ladd, No. 4 bed	NW	13	14 N	4 E	2.9	3.6	32.1	41.3	23.0	.91	......	......	......	......	5,630	10,130	......	......
East Creek-Ladd at Ladd, washed coal from No. 2 bed	SW	12	14 N	4 E	8.9	2.0	28.4	51.7	17.9	.92	......	......	......	......	6,440	11,590	......	......
Mendota at Mendota	SW	3	14 N	1 W	11.5	10.2	37.8	38.1	13.91	1.45	5.61	55.27	.93	22.83	5,455	9,820	......	......
Mendota at Mendota	SW	3	14 N	1 W	9.6	10.7	37.4	37.9	13.96	1.29	5.44	55.31	.92	23.08	5,440	9,790	......	......
Richmond, 1½ mi. n. e. of Centralia	SW	34	15 N	2 W	14.9	13.9	38.5	37.7	9.88	1.79	5.80	53.88	.93	27.72	5,240	9,430	......	......
Superior No. 1, 1 mi. north of Chehalis	......	......	14 N	2 W	14.3	15.0	39.5	32.8	12.74	.38	5.46	51.20	.93	29.29	4,905	8,830	......	......
Superior No. 2 at Chehalis	......	......	14 N	2 W	17.1	16.2	42.1	35.7	5.97	1.51	6.02	54.86	.90	30.74	5,320	9,580	......	......
Twin City, 1 mi. n. e. of Chehalis	......	......	14 N	2 W	19.3	14.0	39.4	34.5	12.07	.34	5.47	51.82	.90	29.40	4,975	8,960	......	......
Chehalis, 2 mi. east of Chehalis	SE	28	14 N	2 W	15.7	16.0	41.1	33.8	9.10	2.10	5.87	53.71	.88	28.34	5,235	9,420	......	......
Sheldon, 3 mi. east of Chehalis	......	......	14 N	2 W	15.2	17.3	40.0	35.9	6.78	.68	6.24	53.65	1.00	31.65	5,195	9,350	......	......
Crescent, 4 mi. n. w. of Littell	......	......	14 N	3 W	19.1	16.1	39.4	33.8	10.7	3.66	......	......	......	......	......	......	......	......

PIERCE COUNTY.

NAME OF MINE OR FORM OF EXPOSURE	Quarter	Section	Township	Range	Air-drying loss	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units		
Burnett at Burnett, No. 2 bed	SE	21	19 N	6 E	2.4	1.3	37.0	53.4	8.33	.78	5.42	75.71	2.05	7.71	7,725	13,900	......	......
Burnett at Burnett, No. 3 bed	NW	21	19 N	6 E	1.3	1.9	35.5	50.0	12.62	.39	5.21	71.67	2.00	8.11	7,160	12,890	......	......
Burnett at Burnett, No. 3 bed	NW	21	19 N	6 E	1.8	1.8	37.5	46.3	14.35	.39	5.25	69.00	1.78	9.23	7,000	12,600	......	......
Burnett at Burnett, No. 3 bed	NW	21	19 N	6 E	2.7	2.0	36.2	48.2	13.56	.38	5.20	69.52	1.98	9.36	7,005	12,610	......	......
Burnett at Burnett, lump coal	......	16	19 N	6 E	1.4	1.9	37.3	47.5	13.34	.42	5.22	69.75	1.98	9.29	7,060	12,710	......	......
Burnett at Burnett, washed coal	......	16	19 N	6 E	6.1	1.7	36.6	49.6	12.09	.60	5.34	71.89	2.00	8.08	7,280	13,110	......	......
Black Carbon, ½ mi. west of Pittsburg, Black Carbon bed	NW	22	19 N	6 E	2.7	2.5	33.7	40.2	23.60	.55	4.58	58.92	1.75	10.60	5,960	10,730	......	......
Pittsburg at Pittsburg, Lady Wellington bed	......	14	19 N	6 E	3.5	3.3	33.9	43.7	19.14	.42	4.78	60.98	1.70	12.98	6,125	11,020	......	......
Pittsburg at Pittsburg, Pittsburg bed	......	14	19 N	6 E	2.2	2.6	33.4	43.2	20.84	.56	4.72	60.52	1.88	11.48	6,165	11,100	......	......
Pittsburg at Pittsburg, washed coal	......	14	19 N	6 E	4.7	3.3	32.8	42.5	21.42	.42	4.73	60.01	1.73	11.69	5,990	10,780	......	......
Wilkeson at Wilkeson, No. 2 bed	NW	3	18 N	6 E	2.8	.9	27.8	58.3	12.96	.46	4.91	74.63	2.25	4.79	7,420	13,350	......	......
Wilkeson at Wilkeson, No. 2 bed	SE	34	19 N	6 E	2.3	.8	18.9	56.2	24.1	.44	......	......	......	......	......	......	......	......
Wilkeson at Wilkeson, No. 2 bed	SE	34	19 N	6 E	2.8	.8	19.7	63.0	16.51	.50	4.22	72.55	2.00	4.22	7,040	12,670	......	......
Wilkeson at Wilkeson, No. 3 bed	NW	3	18 N	6 E	1.6	.9	28.1	62.3	8.67	.43	5.13	78.19	2.08	5.50	7,840	14,120	......	......
Wilkeson at Wilkeson, No. 3 bed	NW	3	18 N	6 E	1.2	1.1	24.8	56.0	18.1	.49	......	......	......	......	......	......	......	......
Wilkeson at Wilkeson, No. 3 bed	NE	34	19 N	6 E	4.3	1.1	21.4	61.9	15.62	.47	4.22	72.93	2.00	4.76	7,140	12,850	......	......
Wilkeson at Wilkeson, No. 7 bed	NW	34	19 N	6 E	4.9	1.1	24.3	64.3	10.26	.43	4.78	77.86	2.28	4.39	7,690	13,840	......	......
Wilkeson at Wilkeson, re-washed coal	......	27	19 N	6 E	5.5	1.1	24.7	59.8	14.36	.49	4.69	73.32	2.10	5.04	7,245	13,040	......	......
Gale Creek at Wilkeson, No. 1 bed	NE	28	19 N	6 E	3.4	2.2	37.7	51.8	8.34	.83	5.51	73.75	1.98	9.59	7,490	13,480	......	......

Gale Creek at Wilkeson, No. 2 bed	NE	28	19 N	6 E	2.4	1.6	35.9	56.4	6.13	.98	5.49	76.81	2.00	8.59	7,825	14,080	......	......
Gale Creek at Wilkeson, Queen bed	NE	28	19 N	6 E	1.4	1.4	34.3	54.6	9.70	1.02	5.36	74.93	2.03	6.96	7,580	13,640	......	......
Willis at So. Willis, Windsor bed	NE	22	19 N	6 E	1.4	1.8	30.6	46.1	21.48	.42	4.73	63.45	1.58	8.34	6,330	11,400	......	......
Willis at So. Willis, washed coal	......	22	19 N	6 E	5.0	2.2	29.9	44.2	23.69	.45	4.81	60.98	1.53	8.54	6,075	10,930	......	......
Brier Hill at Wilkeson	NW	28	19 N	6 E	2.3	2.4	30.5	37.9	29.17	1.18	4.13	53.65	1.78	10.09	5,425	9,760	......	......
Snell, 2 mi. s. e. of Wilkeson	NW	26	18 N	6 E	5.4	1.4	27.2	52.9	18.5	.82	......	......	......	......	6,790	12,220	......	......
Carbon Hill at Carbonado, No. 11 bed	SW	4	18 N	6 E	2.7	1.8	29.2	48.9	20.05	.40	4.68	64.07	1.83	8.97	6,435	11,580	......	......
Carbon Hill at Carbonado, No. 9 bed	SW	4	18 N	6 E	2.4	1.4	29.7	53.0	15.88	.53	4.93	69.03	2.18	7.45	6,905	12,430	......	......
Carbon Hill at Carbonado, No. 5 bed	NW	9	18 N	6 E	1.9	1.7	30.3	51.3	16.70	.57	4.82	66.79	2.14	8.98	6,630	11,930	......	......
Carbon Hill at Carbonado, No. 1 bed	NW	4	18 N	6 E	1.8	1.6	32.8	50.4	15.15	.46	5.22	68.47	2.04	8.66	6,930	12,470	......	......
Carbon Hill at Carbonado, No. 1 bed	NW	4	18 N	6 E	2.4	1.7	31.9	51.4	15.0	.36	......	......	......	......	......	......	......	......
Carbon Hill at Carbonado, No. 4 bed	NW	4	18 N	6 E	2.0	1.2	35.6	52.6	10.64	.33	5.37	74.02	1.93	7.71	7,490	13,480	......	......
Carbon Hill at Carbonado, No. 3 coking bed	NE	4	18 N	6 E	3.5	.7	31.1	54.3	13.93	.31	4.88	72.67	1.95	6.26	7,290	13,120	......	......
Carbon Hill at Carbonado, No. 3 coking bed	NE	4	18 N	6 E	3.0	.8	27.4	50.9	20.89	.40	4.82	65.82	1.99	6.08	6,595	11,870	......	......
Carbon Hill at Carbonado, No. 3 coking bed	SE	4	18 N	6 E	1.8	1.1	31.5	51.0	16.4	.47	......	......	......	......	7,085	12,660	......	......
Carbon Hill at Carbonado, run-of-mine coal	SE	4	18 N	6 E	3.3	1.3	30.1	52.0	16.6	.47	......	......	......	......	6,970	12,550	......	......
Carbon Hill at Carbonado, No. 2 coking bed	SE	4	18 N	6 E	2.8	1.1	27.8	55.3	15.81	.40	4.81	70.16	2.08	6.74	7,050	12,690	......	......
Carbon Hill at Carbonado, No. 1 coking bed	SE	4	18 N	6 E	2.2	.6	28.7	51.9	18.75	3.29	4.64	67.10	1.93	4.29	6,835	12,310	......	......
Carbon Hill at Carbonado, Wingate bed	SE	5	18 N	6 E	1.5	1.3	36.9	53.6	8.24	.50	5.72	75.20	2.13	8.21	7,635	13,740	......	......
Carbon Hill at Carbonado, Wingate bed	NE	5	18 N	6 E	2.0	2.1	37.6	53.8	6.54	.53	5.73	75.53	2.20	9.47	7,530	13,560	......	......
Carbon Hill at Carbonado, Wingate bed	SE	8	18 N	6 E	1.1	1.8	33.2	54.2	10.77	1.12	5.32	71.71	1.82	9.26	7,220	13,000	......	......
Carbon Hill at Carbonado, Wingate bed	......	5	18 N	6 E	1.4	2.1	40.5	51.1	6.3	.87	......	......	......	......	......	......	......	......
Carbon Hill at Carbonado, Wingate lump coal	......	5	18 N	6 E	1.7	1.5	35.1	52.5	10.93	.70	5.22	72.70	2.00	8.45	7,375	13,280	......	......
Carbon Hill at Carbonado, Wingate lump coal	......	5	18 N	6 E	1.8	1.3	37.8	52.8	8.1	.45	......	......	......	......	7,690	13,840	......	......
Carbon Hill at Carbonado, washed Wingate coal	......	5	18 N	6 E	4.7	1.4	32.3	53.6	12.66	.86	5.06	71 07	2.13	8.22	7,180	12,930	......	......
Carbon Hill at Carbonado, washed coal	......	5	18 N	6 E	2.5	1.2	33.2	52.8	12.77	.78	4.96	70.93	2.08	8.48	7,210	12,970	......	......
Carbon Hill at Carbonado, Douty washed coal	......	5	18 N	6 E	4.6	1.3	32.1	52.3	14.31	.44	5.06	69.75	2.01	8.43	7,030	12,650	......	......
Carbon Hill at Carbonado, Douty lump coal	......	5	18 N	6 E	2.3	......	......	......	......	......	......	......	......	......	......	......	......	......
Carbon Hill at Carbonado, coal dust	......	5	18 N	6 E	17.4	1.7	30.3	46.7	21.3	.72	......	......	......	......	6,310	11,350	......	......
Melmont at Melmont, No. 3 bed	NE	16	18 N	6 E	2.9	.8	24.3	61.0	13.87	.36	4.79	73.75	1.77	5.46	7,295	13,130	......	......
Melmont at Melmont, No. 3 bed	NW	15	18 N	6 E	2.3	.8	21.9	62.0	15.3	.32	......	......	......	......	7,055	12,700	......	......
Melmont at Melmont, No. 2 bed	SW	15	18 N	6 E	4.4	1.2	12.6	66.8	19.4	.40	......	......	......	......	6,740	12,130	......	......
Melmont at Melmont, No. 2 bed	SW	15	18 N	6 E	4.5	1.6	12.4	69.4	16.6	.45	......	......	......	......	6,940	12,490	......	......
Melmont at Melmont, washed coal	......	22	18 N	6 E	6.2	.9	21.8	57.3	20.00	.36	4.36	67.16	1.68	6.44	6,720	12,090	......	......
Melmont at Melmont, composite sample	......	15	18 N	6 E	4.5	1.4	13.1	67.7	17.85	.40	3.77	71.82	1.75	4.41	6,850	12,330	......	......
Melmont at Melmont, No. 1 bed	SE	16	18 N	6 E	7.8	1.5	10.2	69.1	19.2	.72	......	......	......	......	6,705	12,070	......	......
Fairfax at Fairfax, No. 3 bed	NW	26	18 N	6 E	1.3	.6	23.6	65.4	10.45	.54	4.92	78.20	2.16	3.73	7,725	13,900	......	......
Fairfax at Fairfax, No. 7 bed	NW	26	18 N	6 E	2.2	.6	18.9	46.5	34.01	.48	3.74	55.02	1.56	5.19	5,435	9,790	......	......
Fairfax at Fairfax, Blacksmith bed	NW	26	18 N	6 E	2.0	1.4	21.4	64.2	12.98	.69	4.77	74.63	1.93	5.00	7,400	13,320	......	......
Fairfax at Fairfax, washed coal	SW	26	18 N	6 E	2.9	.7	23.2	66.3	9.84	.45	4.84	78.45	2.11	4.31	7,735	13,920	......	......
Montezuma, 1 mi. s. of Fairfax, No. 1 bed	NW	2	17 N	6 E	5.0	.7	20.2	65.7	13.4	1.02	......	......	......	......	7,395	13,310	......	......
Montezuma, 1 mi. s. of Fairfax, No. 2 bed	NW	2	17 N	6 E	2.3	.7	18.5	57.5	23.3	.73	......	......	......	......	6,395	11,510	......	......
Montezuma, 1 mi. s. of Fairfax, washed coal from No. 2 bed	......	35	18 N	6 E	5.8	1.0	18.8	57.7	22.46	.78	4.18	65.73	1.88	4.97	6,510	11,720	......	......
Montezuma, 1 mi. s. of Fairfax, No. 3 bed	NW	2	17 N	6 E	3.3	.7	18.7	60.5	20.1	.51	......	......	......	......	6,790	12,220	......	......
Montezuma, 1 mi. s. of Fairfax, No. 4 bed	NW	2	17 N	6 E	2.0	.6	21.5	66.9	11.0	.57	......	......	......	......	7,605	13,690	......	......

PIERCE COUNTY—Concluded.

NAME OF MINE OR FORM OF EXPOSURE	LOCATION				Air-drying loss	PROXIMATE			ULTIMATE						HEAT VALUE			
	Quarter	Section	Township	Range		Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units		
Montezuma, 1 mi. s. of Fairfax, washed coal from 3 and 4 beds	......	35	18 N	6 E	4.7	.7	20.8	65.5	12.99	.54	4.64	75.33	2.13	4.37	7,510	13,520	......	......
Mashel at Ashford	SW	22	15 N	6 E	2.4	1.7	22.5	36.8	38.98	.70	3.50	48.10	1.30	7.42	4,785	8,610	......	......
Mashel at Ashford	SW	22	15 N	6 E	2.6	1.5	25.0	46.0	27.47	.45	4.13	59.71	1.43	6.81	5,870	10,570	......	......
Prospect, 7 mi. e. of Ashford	SW	20	15 N	7 E	7.0	2.6	13.7	55.2	28.5	.40	......	......	......	......	5,645	10,160	......	......
Prospect, ½ mi. s. of Fairfax, No. 1 bed	......	34	18 N	6 E	4.0	.78	27.5	63.3	8.40	1.18	......	......	......	......	7,890	14,202	......	......
Prospect, ½ mi. s. of Fairfax, No. 2 bed	......	34	18 N	6 E	1.7	.87	25.2	53.7	20.18	.69	......	......	......	......	6,700	12,060	......	......
Prospect, 2 mi. s. of Fairfax, Montezuma bed	......	2	17 N	6 E	2.3	1.3	21.1	42.9	34.7	.56	......	......	......	......	3,536	6,365	......	......
Nisqually Chief, Ashford	......	......	15 N	6 E	3.6	2.2	15.8	56.7	25.1	.43	......	......	......	......	5,998	10,796	......	......

THURSTON COUNTY.

NAME OF MINE OR FORM OF EXPOSURE	Quarter	Section	Township	Range	Air-drying loss	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	British thermal units		
Hannaford No. 1 at Tono	SE	20	15 N	1 W	16.0	5.9	39.5	43.7	10.9	.50	......	......	......	......	5,890	10,610	......	......
Hannaford No. 1 at Tono	SE	20	15 N	1 W	7.2	15.4	34.3	43.8	6.51	.46	5.97	56.69	1.20	29.17	5,490	9,880	......	......
Hannaford No. 1 at Tono	NE	20	15 N	1 W	17.4	7.4	37.6	45.2	9.84	.44	5.16	60.97	1.23	22.36	5,750	10,350	......	......
Hannaford No. 1 at Tono	SW	21	15 N	1 W	16.8	6.5	38.2	44.4	10.9	.42	......	......	......	......	5,720	10,290	......	......
Hannaford No. 1 at Tono	SW	21	15 N	1 W	16.7	7.2	37.3	45.9	9.63	.44	5.20	59.50	1.30	23.93	5,755	10,360	......	......
Hannaford No. 1 at Tono, car sample, run-of-mine coal	......	......	......	......	6.7	14.5	33.5	42.9	9.05	.56	5.56	56.29	1.14	27.40	5,520	9,940	......	......
Perth, 3 mi. north of Centralia	......	......	15 N	2 W	12.4	14.5	36.8	38.8	9.88	.94	5.70	53.95	1.04	28.49	5,180	9,330	......	......
Black Bear, 2 mi. s. e. of Tenino	SW	31	16 N	1 W	6.3	10.4	34.0	30.9	24.75	1.60	4.63	46.36	.78	21.88	4,625	8,330	......	......
King, 3 mi. s. w. of Tenino	SW	35	16 N	2 W	9.5	14.3	37.2	36.4	12.10	2.65	5.50	54.01	.80	24.94	5,385	9,690	......	......

CHAPTER VIII.

MARKETS FOR KING COUNTY COAL.

GENERAL STATEMENT.

A discussion of the markets for King county coals includes a general statement regarding nearly all fuels entering the markets of the Pacific Coast. It would require a market expert to collect and arrange the data for a complete report. At this time, only the data that are readily available are used and no attempt is made to formulate a thorough report covering the situation. The increasing use of California fuel oil has had a decided effect on the coal production of Washington, and it has been deemed advisable to include some information on that subject as well.

The following tables gives an idea of the volume of coal trade for a specified period of time:

FOR SIX MONTHS OF 1910.	*Tons.*
From railway company mines	733,104
From commercial mines for railway use	182,000
For vessel use	180,000
For domestic use, apartments, family hotels, etc.:	
East of Cascades	65,000
West of Cascades	110,000
For steam plants, gas works, etc	470,040
Total	1,740,144

Inasmuch as a certain percentage of lignite lump and nut coals are used in steam plants, it is impossible to determine accurately just what proportion of the coal used for domestic purposes is lump coal, but the following figures are approximately correct:

	Tons.
Bituminous lump coal, east of Cascades	65,000
Bituminous lump coal, west of Cascades	12,000
Lignite lump coal	48,000
Total	125,000

All the above figures are for six months of 1910.

VARIETIES OF COAL.

The coals of Washington are divided into four classes, viz., lignite, sub-bituminous, free-burning bituminous and coking bituminous.

LIGNITE.

In the lignite class are the coals found in Lewis and Thurston counties. These coals are of low grade, an average analysis showing from 18 to 25 per cent. moisture, and from 9 to 14 per cent. ash. They can be mined very cheaply, and this is their chief recommendation. They are not a strong factor in the market, taking the business that is close at hand, and they cannot compete in the large market, such as Seattle, Tacoma and Portland, except during times of coal shortage.

Mines producing lignites are as follows: Washington Union Company, Perth, Potlatch, Mendota and Wilson Company.

SUB-BITUMINOUS.

Coal of this character is mined at the Grand Ridge, Newcastle, Renton and Issaquah mines. The coal produced by these mines is sub-bituminous, very similar in structure to that obtained at Rock Springs. The best beds will class a little higher than Rocky Mountain or Almy, but the coal is higher in moisture and ash than Rock Springs, throwing considerable fire when used in a locomotive.

The above mines produce about 40 per cent. lump, 20 per cent. to 25 per cent. nut, and 35 to 40 per cent. pea coal. The nut and pea varieties are put through washers to eliminate the clay, bone, etc., and the lump is picked over picking tables. The nut coals are in demand during the summer, on account of quick ignition.

FREE-BURNING BITUMINOUS.

This coal is mined chiefly in the Roslyn and the Green river fields. The free-burning bituminous coals vary so in quality that it would be necessary to describe the coal from each mine separately, in order to do so properly. In the Roslyn field the coal secured in all mines is from the same bed, but on account of the greater folding to the westward, the character of the coal changes from a lower fixed carbon to a higher fixed carbon in the west end. For instance, at the east, or Cle Elum end, the coal is very little removed from a low grade sub-bituminous, while at the west end (Roslyn Fuel Company) it is almost a coking coal. The beds in this field lie at pitches ranging from 7 to 25 degrees, and it is the only field in the state, outside of the lignites, where a reasonable percentage of lump coal can be produced, the percentage ranging from 18 to 20 per cent. on the west end, to 45 per cent. at the east end. The Patrick & McKay mine and the Northwestern Improvement Company mines 2, 3, 4, and 6 produce about 40 per cent. lump.

The Roslyn production goes to the railways, with the exception of some 750 tons per day, which are sold east of the Cascade mountains for domestic purposes.

Of the mines in the Green river field, the Black Diamond No. 11, or Morgan slope, and the Black Diamond No. 14 of the Pacific Coast Company, on the McKay bed, are producing a superior grade of coal, low in ash, for steamship use. They produce, however, only about 18 per cent. of lump coal.

The other beds in the Green river field are, for the most part, rather impure and require washing, except the Carbon bed at Bayne. Some of them produce a small amount of lump coal, but on account of its bony nature the coal does not sell readily if Black Diamond, Roslyn or Carbonado coal can be bought.

COKING BITUMINOUS.

This coal is found only in the Carbonado and Wilkeson fields. The best steam coal bed is the Wingate, so-called, at Carbonado. This bed runs through the Gale Creek and South Prairie properties also, but it cokes heavier at those points and no lump can be obtained, except at Carbonado, where the bed seems harder. Even at Carbonado the Wingate bed produces but 15 per cent. of lump.

There are a number of beds in this field being worked, but they are, for the most part, poor steamship coals, and will not be used for such work, unless the McKay or Wingate coals are off the market.

The mines producing coking bituminous coals are located at Carbonado, Wilkeson, South Prairie and Fairfax.

COAL PRICES IN SEATTLE AND NEIGHBORING CITIES.

SEATTLE.

Lump Coal.

	At retail yards to dealers, 2,000 lbs. per ton.	*At mines in carloads, 2,240 lbs. per ton*
Carbonado	$6 50	$5 25
Black Diamond	6 50	5 00
Roslyn	6 25	5 00
Newcastle	4 25	3 25
Renton	4 25	3 25
Wellington	7 00	*6 50
Nanaimo	7 00	*6 50
Boat Harbor	7 00	....

Nut Coal.

Newcastle	$3 25	$2 50
Renton	3 25	2 50
Various bituminous	3 25	2 75
Wellington	6 00	....

Steam Coal.

	For vessels at Seattle per ton of 2,240 lbs.	*Carload shipments f. o. b. cars at mine per ton of 2,240 lbs.*
Carbonado, Wingate	$4 00	$3 50
Douty veins	3 40	2 75
Black Diamond	4 00	3 50
Other bitum. steam coals	3 25	2 50

PORTLAND.†

Japanese	$7 50
Washington	$7.00 to 7 50
Australian	10.00 to 10 50
Rock Springs, Wyo.	9.50 to 10 50
Diamond, Wyo.	10 00
Carbon Hill, Wash., lump	10 50
Carbon Hill, Wash., steam	7 50
Newcastle, Wash.	7 00
Beaver Hill, Ore.	$9.00 to 9 25
Blacksmith coal	17 00

*This is at Seattle for carload shipments to points outside of water-front teaming limits.

†Coal Age, November 25, 1911.

SPOKANE*

Grade.	November and December. Wholesale.	Retail.
Rock Springs	$7 20	$9 00
Owl Creek	7 20	9 00
Kirby	7 20	9 00
Carney	6 70	8 50
Bearcreek	6 35	8 25
Roslyn steam	5 25	6 25
Canadian steam	5 25	6 25

SAN FRANCISCO.

Wellington, clean	$8 00
Wellington, average	7 50
Australian, clean	8 00
Australian, average	7 50
Puget Sound, clean.......................	6 50
Puget Sound, steam................$5.00 &	5 50
Pennsylvania anthracite	15 00
Colorado anthracite	12 50
New Mexico anthracite....................	13 50
Anthracite briquets	10 00
Cumberland, smithing	12 50
Utah, Wyoming and New Mexico, clean, (for domestic use only).........$9.00 &	8 00

COMPETITIVE FUELS.

VANCOUVER ISLAND COAL.

The best average steam coal on the Pacific Coast is mined at Comox. It has a very large percentage of lump. In fact, only lump coal is sold for steamship contracts. This coal is not as desirable as some others for domestic use, due to its coking too heavily and containing too much sulphur.

The coals produced at Nanaimo, Ladysmith and Boat Harbor are from the same bed, except that Nanaimo also works a small bed which is put into their steam coal. The main bed, however, varies at the different points. It is generally conceded that the Ladysmith coal is the best for household purposes, being cleaner and freer from rock. Nanaimo is the next best, the Boat Harbor coal being high in sulphur and prone to

*Coal Age, November 25, 1911.

make an excessive amount of screenings. All three coals, though they coke slightly, can be classed as free-burning bituminous coals. It is almost impossible to obtain exact figures showing how much lump is produced but it is estimated that about 75 per cent. of the output is lump.

The principal markets for Comox coal are the steamships and railroads—White Pass & Yukon, and Canadian Pacific—the small coal being washed and made into coke. The principal markets for Ladysmith, Nanaimo and Boat Harbor coals are domestic purposes in British Columbia, California, Puget Sound and Alaska; steamships and steam purposes in British Columbia, Alaska and California. All of the nut and slack from these mines, with a possible exception of a few hundred tons per annum, is disposed of on Vancouver island and the Mainland of British Columbia.

Foreign markets controlled by British Columbia and Australian coal, average receipts:

	Receipts.	*Kind of Coal.*
San Francisco	333,000	Australian and Vancouver Island.
Guaymas	55,000	Comox.
Other points on West Coast of Mexico	15,000	Australian and Comox.
Alaska	65,000	Comox, Nanaimo and Ladysmith.
San Diego	2,500	Australian.
Columbia River	22,000	Australian.
Puget Sound	89,856	Ladysmith and Australian.

ANALYSES OF VANCOUVER ISLAND COAL.*

LOCALITIES	Moisture	Volatile matter	Fixed carbon	Ash	Sulphur	Calorific value in B. T. U.
Comox—						
Union colliery, upper seam	1.08	29.24	57.03	9.60	3.05	13,261
Union colliery, No. 4 slope, Comox seam	0.88	27.34	61.82	8.70	1.26	13,881
Nanaimo—						
Nanaimo colliery, No. 1 shaft, lower seam	2.86	35.84	54.79	5.5	1.01	12,951
Nanaimo colliery, No. 5, Southfield mine	2.08	35.78	56.26	5.60	0.28	13,261
Wellington mine	2.75	38.03	52.64	6.58	....	12,567

* Bulletin No. 1035, Canadian Geological Survey.

The following table gives an aggregate summary of the output of the Coast collieries (including Nicola valley) for the year 1910, and shows the dispositions made of such product:

SALES AND OUTPUT FOR YEAR	COAL	
(Tons of 2,240 pounds)	Tons	Tons
Sold for consumption in Canada	1,055,861	....
Sold for export to United States	363,722	....
Sold for export to other countries	60,290	....
Total sales	....	1,479,873
Used in making coke	4,670	....
Used under colliery boilers	124,548	....
Lost in washing	135,204	....
Total for colliery use	....	264,422
		1,744,295

EAST KOOTENAY COAL.

The gross output of the collieries of the East Kootenay district for the year 1910 was 1,365,119 tons (2,240 lbs.) of coal actually mined, of which 3,539 tons were put into stock, making the actual consumption of coal 1,361,580 tons. Of this gross consumption of coal 933,665 tons were sold as coal, 82,323 tons were consumed as fuel by the producing companies, 11,073 tons were lost in washing, while 334,519 tons were converted into coke, of which there was produced 215,696 tons, while 1,940 tons of coke were added to stock, and 79 tons were used under company's boilers, making the coke sales for the year 213,677 tons.

The East Kootenay collieries exported to the United States about 80 per cent. of the coal they sold and about 4 per cent. of the coke.

The following table gives an aggregate summary of the output of the East Kootenay collieries for the year 1910, and shows the disposition made of such product:

SALES AND OUTPUT FOR YEAR	COAL		COKE	
(Tons of 2,240 pounds)	Tons	Tons	Tons	Tons
Sold for consumption in Canada	182,578	....	204,947	....
Sold for export to United States	751,087	....	8,730	....
Sold for export to other countries	....	....	....	....
Total sales	....	933,665	....	213,677
Used in making coke	334,519	....	....	....
Used under colliery boilers, etc.	82,323	....	....	79
Lost in washing	11,073	....	....	....
Total for colliery use	....	427,915	....	....
Stock on hand first of year	1,538	....	269	....
Stock on hand last of year	5,077	....	2,209	....
Difference added to stock during year	....	3,539	....	1,940
Output of collieries for year	....	1,365,119	....	215,696

The following table shows, for the past four years, the output and the per capita production of the various districts in British Columbia.*

Year	DISTRICT	Gross tons of coal mined	Total number of employees at colliery	Tons of coal mined per employee	Number of men employed underground	Tons of coal mined per underground employee
1907.	East Kootenay District	876,731	2,290	383	1,527	574
	Coast District	1,342,877	3,769	356	2,862	469
	Whole Province	2,219,608	6,059	366	4,389	506
1908.	East Kootenay District	883,205	2,524	350	1,746	506
	Coast District	1,226,182	3,549	345	2,686	456
	Whole Province	2,109,387	6,073	347	4,432	476
1909.	East Kootenay District	923,865	2,427	380	1,737	532
	Coast District	1,476,735	3,991	370	2,976	496
	Whole Province	2,400,600	6,418	374	4,713	509
1910.	East Kootenay District	1,365,119	3,111	439	2,374	575
	Coast District	1,774,116	4,647	382	3,529	502
	Whole Province	3,139,235	7,758	404	5,903	532

* Annual report Minister of Mines for year ending 1910.

During the year 1910 about 51.3 per cent. of the coal, sold as such, by the collieries of the province was consumed in British Columbia; about 46.2 per cent. was exported to the United States, including Alaska; and 2.5 per cent. was exported to other countries, chiefly to Mexico. Of the coke sold, about 96 per cent was consumed in British Columbia, and the remainder was exported to the United States.

The distribution of this output of coal and coke is shown in the following table:

COAL AND COKE PRODUCED, EXPORTED, ETC., BY PROVINCE DURING YEAR 1910.

SALES AND OUTPUT FOR YEAR	COAL		COKE	
(Tons of 2,240 pounds)	Tons	Tons	Tons	Tons
Sold for consumption in Canada	1,238,439		213,274	
Sold for export to United States	1,114,809		8,730	
Sold for export to other countries	60,290			
Total sales		2,413,538		222,004
Used in making coke	339,189			
Used under colliery boilers, etc	206,871		79	
Lost in washing	146,277			
Total for colliery use		692,337		79
		3,105,875		222,083
Stock on hand first of year	36,290		17,109	
Stock on hand last of year	69,650		13,055	
Difference (*added to) (†taken from) stock during year		*33,360		†4,054
Output of collieries for year		3,139,235		218,029

APPENDIX.

GENERAL STATEMENT OF COAL MINING IN WASHINGTON.

Coal mining in this state began in 1848 when a small amount of lignite was mined from a bed outcropping on the banks of the Cowlitz river. In 1852 coal was found on the area where the city of Bellingham now stands, and it was here that the first real mining began. Shipments from this mine did not begin until 1860. A mine fire occurred at this mine in 1878 and no coal has been mined from it since that date.

King county began to ship coal to the outside world in 1871, but the coal had been used locally for many years previous to that time. On the banks of Black river, near the town of Renton, coal was discovered in 1859. This bed was not very clean and so was not mined extensively. In 1862 coal was discovered near what is now called Issaquah, and several small shipments were made to Seattle where the coal was sold for $22 per ton. A year afterward coal was discovered in Coal creek and a mine started at what later was called Newcastle. Arrangements were made to ship coal to Seattle, transporting it by wagons from the mine down to the shore of Lake Washington; then by barge around to Union bay; hauling it by teams across the portage to Lake Union; and from this point distributing it to the various parts of the then little sawmill town.

In 1876 and 1877, a railroad, now called the Columbia and Puget Sound, was built from Seattle to the mines at Newcastle and to the coal prospects which had been struck near Renton. After railroad connections were made, Seattle coal, as it was then called, became a strong competitor with the California coal on the San Francisco market.

In the early eighties, a higher grade coal than either the Newcastle or Renton coals, was discovered outcropping in Green river. The railroad was extended from Renton to Black Diamond and Franklin and the coal industry became important. While these discoveries were being made and new fields developed in King county, Pierce county was also becoming known as a prospective coal shipper. In 1875 coal was discovered in the Carbon river canyon, and on the banks of Gale creek. The Northern Pacific railway was extended from Tacoma to Wilkeson in 1876. These new mines operated in a small way for three or four years when they were abandoned until 1885, at which time they again began to ship coal and have been a factor in the coal industry ever since.

Producing mines were also opened in the Roslyn coal field between 1880 and 1885, and these mines continued to increase their production until in the past few years this county has at times led the state.

Lewis, Thurston and Cowlitz counties have produced more or less coal in the past ten or fifteen years. Lewis and Thurston especially have become important producers.

Clallam, Skagit and Whatcom counties have been rather irregular in their coal shipments. The mines of Clallam and Skagit counties are closed at present, and the Blue Canyon mine is the only one operating in Whatcom county.

Washington is the only state on the Pacific Coast that produces coal in any quantity. Oregon and California coals are of lower grade, and cannot compete with the very cheap fuel oil of California. The production of coal in the Washington mines has not increased nearly as rapidly as has the growth of the entire Pacific Coast. In fact, for the past ten years, the annual increase has not doubled itself, while the production of California oil has increased about twenty-seven times. Should the supply of California oil decrease suddenly, the coal areas of this state would develop by leaps and bounds.

PRODUCTION OF COAL IN WASHINGTON, 1860 TO 1911.
Given in short tons (2,000 pounds).

1860	5,374	1877	120,896	1894	1,131,660
1861	6,000	1878	131,660	1895	1,163,737
1862	7,000	1879	142,666	1896	1,202,534
1863	8,000	1880	145,015	1897	1,330,192
1864	10,000	1881	296,000	1898	1,775,257
1865	12,000	1882	177,340	1899	1,917,607
1866	13,000	1883	244,990	1900	2,418,034
1867	14,500	1884	166,936	1901	2,464,190
1868	15,000	1885	380,250	1902	2,690,789
1869	16,200	1886	423,525	1903	3,190,477
1870	17,844	1887	772,601	1904	2,905,689
1871	20,000	1888	1,215,750	1905	2,846,901
1872	23,000	1889	1,030,578	1906	3,290,523
1873	26,000	1890	1,263,689	1907	3,722,433.75
1874	30,352	1891	1,056,249	1908	2,977,490
1875	99,568	1892	1,140,575	1909	3,590,639.183
1876	110,342	1893	1,308,850	1910	3,979,569
				1911	3,546,322

Western Washington contains by far the largest percentage of coal land in the state. Clallam county has an area of fair coal of undetermined extent. A mine has been opened near East Clallam. Jefferson county has some coal outcrops at the western end of the county, along the Hoh river. It is not improbable that coal underlies Scow bay, near Port Townsend. Whatcom county has its low grade sub-bituminous coals underlying the city of Bellingham, and its high grade bituminous coals at Blue Canyon. This latter area has been worked extensively at the Blue Canyon mine. The coal at this point occurs more in the form of lenses than in a bed of uniform thickness. The anthracite of Whatcom county occurs near Glacier and has been advertised quite extensively. The coal is doubtless of very high grade but there is some question as to the amount of minable coal in that area. Coal has been known to exist in that vicinity for the past twelve or fifteen years and a great deal of money has been spent in prospecting but no shipments have been made from this field as yet.

Skagit county has some high grade coal. Mines have been opened at Cokedale and some prospects across the Skagit river from Hamilton partly developed. The Cokedale coal produced a very good coke but the coal beds or lenses were badly disturbed and the mines were finally closed. The Hamilton district never got beyond the prospecting stage.

Snohomish county has some thin beds of bony coal on the Pilchuck river. It is not improbable that thicker beds occur at some points in this vicinity. King county has several areas of coal that ranges from a sub-bituminous at the west end of the coal field to a bituminous coal at the eastern end. The Renton, Newcastle, Issaquah and Grand Ridge areas produce sub-bituminous coals of about equal merit and compare favorably with the Wyoming coal that enters the markets of Southeastern Washington and parts of Oregon. The Black Diamond-Franklin area produces the famous McKay coal which is considered a very satisfactory all-around coal. The remainder of the Green river field in the vicinity of Cumberland and Bayne produces steam coals and some house coal.

There are approximately eighty-two square miles of King county that are known to be underlaid with coal that can in all probability be mined economically. There are approximately fifty square miles of the county classed as probable coal. There are about twenty-four square miles in the Raging river district that contain coal but so badly disturbed by faults, folds and intrusions, as to be rendered practically valueless, at least for the present. In all there is sufficient known coal in this county to last the present market demands for a great number of years to come.

Pierce county coals are higher in fixed carbon than the King county coals. This area extends in a comparatively narrow and somewhat irregular belt from a point near Buckley on White river to the town of Ashford on the Nisqually river. The belt is from five to seven miles wide and occupies most of range 6 east for the entire length of the county, north and south. By far the best part of the field is at the north end and mines have been developed at Carbonado, Wilkeson, Burnett, Melmont, Spiketon and Fairfax, some of which produce high grade steam, domestic and coking coals. The area south of Evans creek is badly disturbed by folding, faulting, and igneous intrusions. While the coal is good in places there is much of that area that from a commercial standpoint is nearly worthless. The southern end of the field has been prospected rather extensively, and at Ashford much money has been spent with no great promise for future mining in this area.

In Lewis county there are some bituminous coals near the eastern end. They have been prospected and advertised extensively but no shipments have been made from this region. The beds are somewhat disturbed and the coal is high in ash. At Ladd, just east of the center of the county, are some mines producing sub-bituminous coals; to the westward they gradually change in character until at Centralia and Mendota the coals become lignites.

In Thurston county occurs an area of lignite coal similar in character to the Lewis county lignites. In Cowlitz county occurs lignites similar to the Lewis and Thurston county lignites. Up to the present time there has been a limited demand for these lignites, due to their low heating values. But of late more attention has been paid to their burning, and special furnaces and grates have been constructed so that greater efficiency is now to be had from their burning than was formerly possible. In fact, there appears to be a comparatively bright future for the most favored areas containing this grade of coal.

East of the Cascades, Kittitas county is the only one of importance as a coal county. The best area in that county is the one developed at Roslyn and Cle Elum. The Roslyn is the principal bed of this series and is a very satisfactory coal for steam and domestic purposes. Other areas occur in Kittitas county, such as those on the head waters of the Taneum and the Manastash; some outcrops at Table mountain; but the commercial value of these areas is indeed doubtful.

Yakima county contains some coal near the head waters of the Naches which is doubtless similar to the Manastash and Taneum areas.

A TEN-YEAR SUMMARY—COAL PRODUCTION OF WASHINGTON.*

Year	Total production in short tons........	Total value at mine in dollars........	Average value at mine, per ton........	Total production coke, tons..........	Total value at mine.................	Average value at mine, per ton........	Total number of inside employees.....	Total number of outside employees....	Total number of employees...........	Average tons produced per employee..
1900..	2,418,034	$4,425,002 00	$1 83	35,921	$176,012 00	$4 90	3,447	791	4,238	570
1901..	2,466,190	4,858,394 00	1 97	49,197	245,958 00	5 00	3,945	881	4,826	511
1902..	2,690,789	5,300,854 00	1 97	40,569	202,845 00	5 00	3,515	829	4,344	619
1903..	3,290,468	6,580,936 00	2 00	47,916	239,580 00	5 00	3,936	940	4,876	674
1904..	2,998,663	5,697,459 00	1 90	46,175	230,875 00	5 00	3,748	885	4,633	647
1905..	2,846,901	5,779,209 00	2 03	50,972	242,117 00	4 75	4,080	896	4,976	572
1906..	3,253,821	5,954,492 00	1 83	44,944	215,731 00	4 80	3,885	1,265	5,150	518
1907..	3,722,433	7,706,890 00	2 07	49,798	308,249 00	6 19	4,855	1,258	6,113	609
1908..	2,977,490	6,054,001 00	2 03	37,381	205,595 00	5 50	4,270	1,071	5,341	557
1909..	3,590,639	9,248,730 30	2 57½	42,335	232,937 00	5 50	4,420	1,305	5,725	627
1910..	3,979,569	10,266,399 64	2 57¾	50,715	322,932 50	5 50	4,579	1,435	6,014	661.71

* Report of the State Inspector of Coal Mines for the biennial period ending December 31, 1910.

INDEX.

PUBLICATIONS

OF THE

WASHINGTON GEOLOGICAL SURVEY.

Volume 1.—Annual Report for 1901. Part 1, Creation of the State Geological Survey, and An Outline of the Geology of Washington, by Henry Landes; part 2, The Metalliferous Resources of Washington, except Iron, by Henry Landes, William S. Thyng, D. A. Lyon and Milnor Roberts; part 3, The Non-Metalliferous Resources of Washington, Except Coal, by Henry Landes; part 4, The Iron Ores of Washington, by S. Shedd, and the Coal Deposits of Washington, by Henry Landes; part 5, The Water Resources of Washington, by H. G. Byers, C. A. Ruddy and R. E. Heine; part 6, Bibliography of the Literature Referring to the Geology of Washington, by Ralph Arnold. Out of print.

Volumne 2.—Annual Report for 1902. Part 1, The Building and Ornamental Stones of Washington, by S. Shedd; part 2, The Coal Deposits of Washington, by Henry Landes and C. A. Ruddy. Postage 20 cents. Address, State Librarian, Olympia, Washington.

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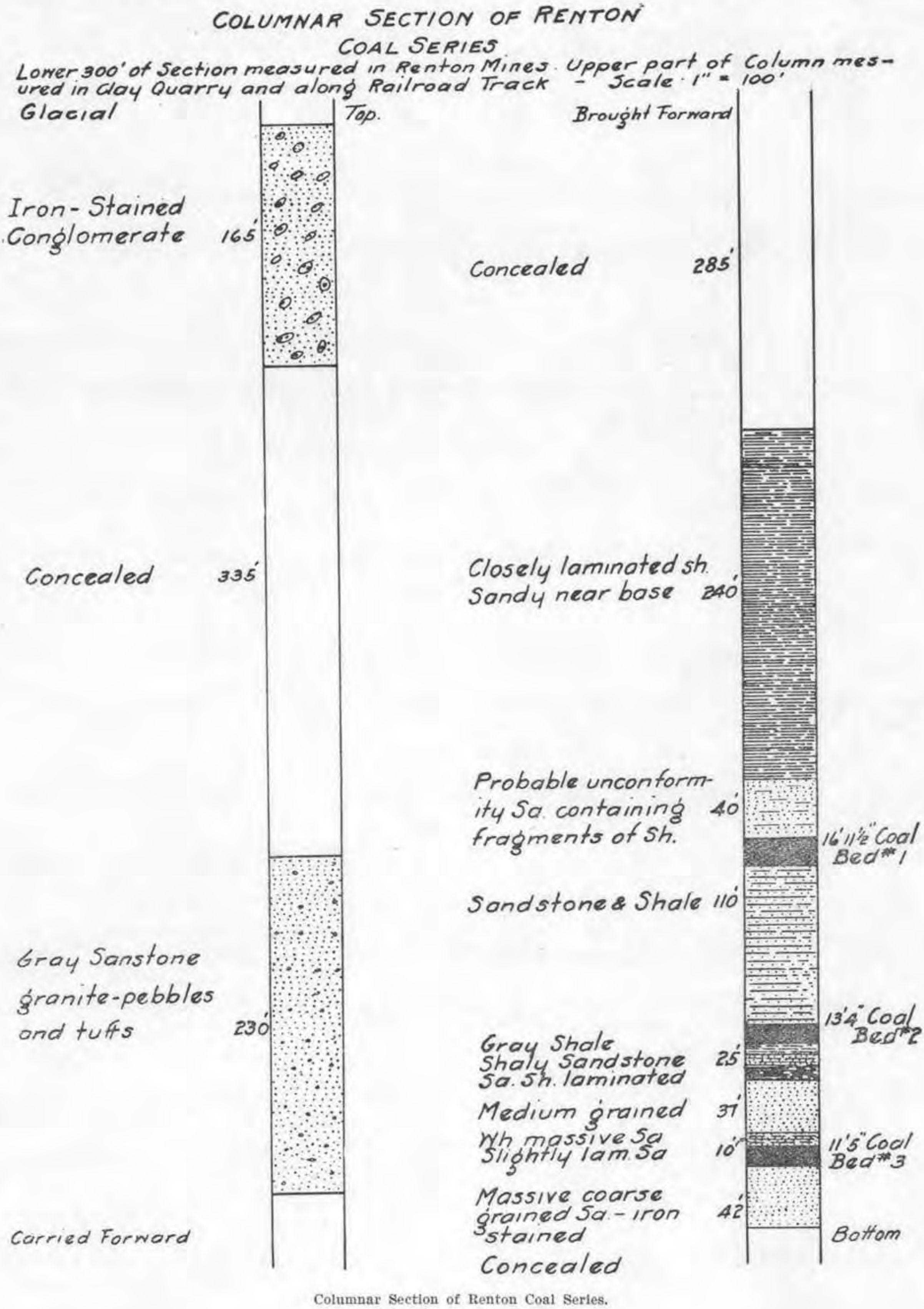
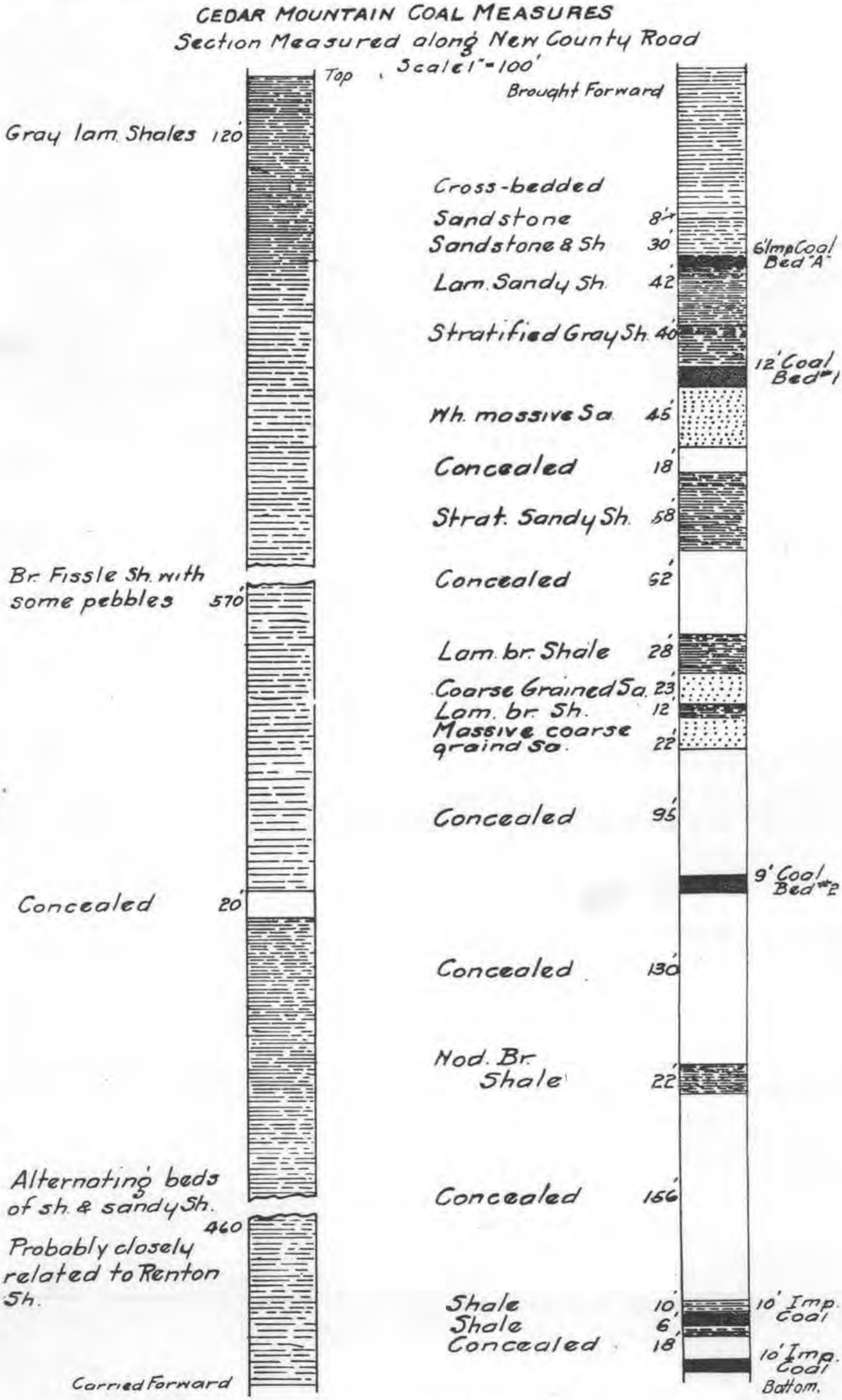
Reconnoissance Soil Survey of the Quincy Area. In preparation.

GEOLOGICAL AND CLASSIFICATION MAP
OF THE
COAL AREAS OF KING COUNTY, WASHINGTON
SHOWING THEIR POSITION AND EXTENT
Scale 1 in. = 1 mi.

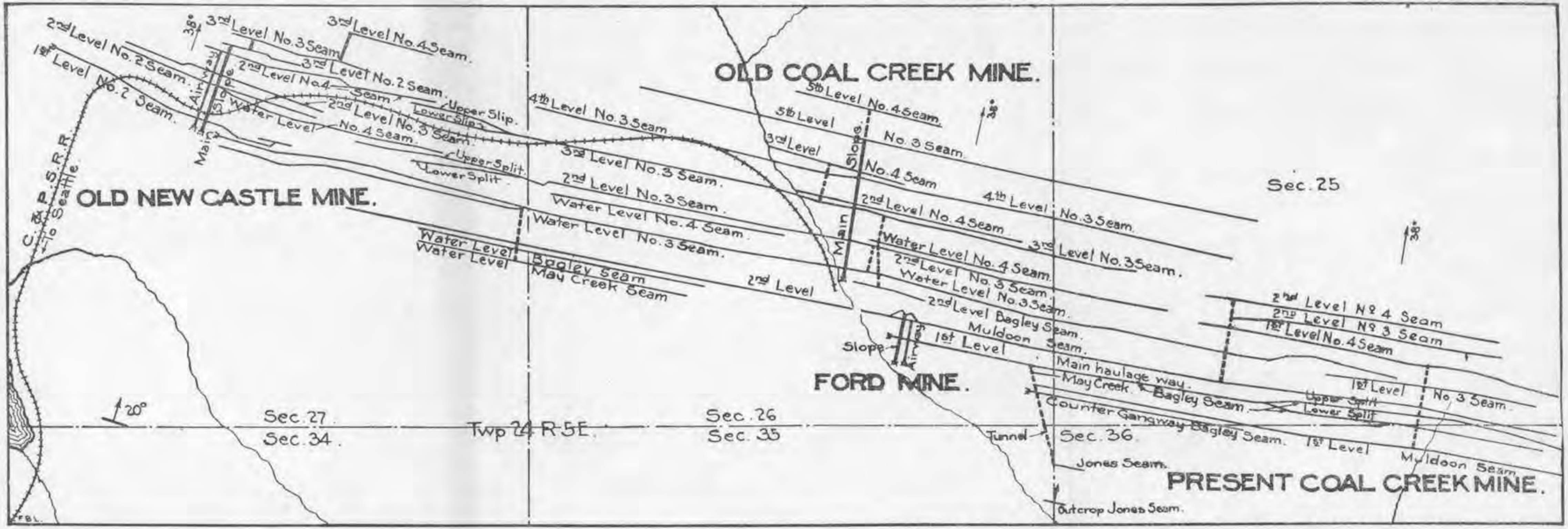
Geological Structure and Classification by Geo. Watkin Evans. Assisted in the field by C. E. Weaver, E. J. Saunders, H. E. Taylor and C. H. O'Conner. Surveyed during Summers of 1909 and 1910. January 18, 1912. Silena Brown, Draftsman.



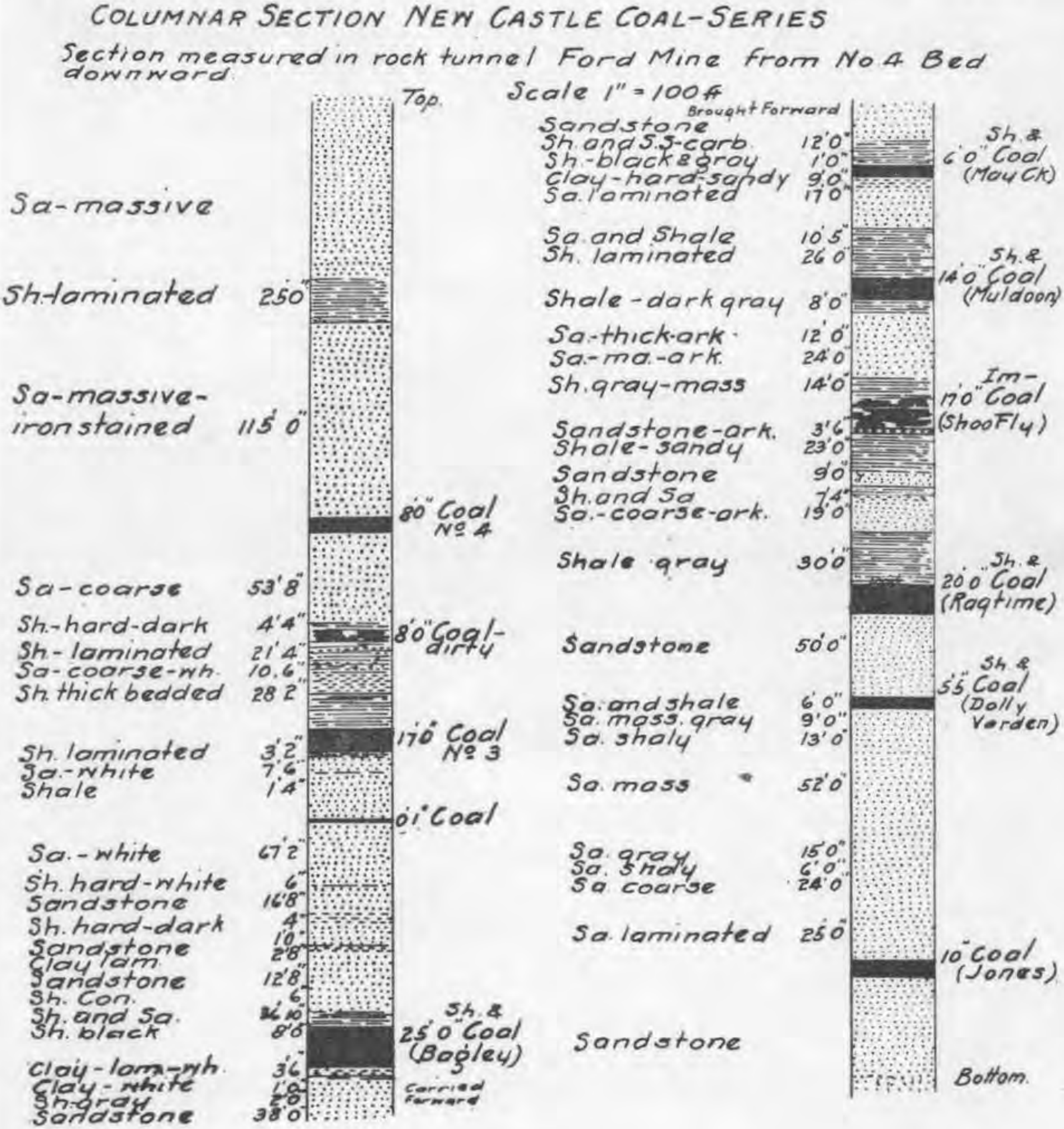
Columnar Section of Renton Coal Series.



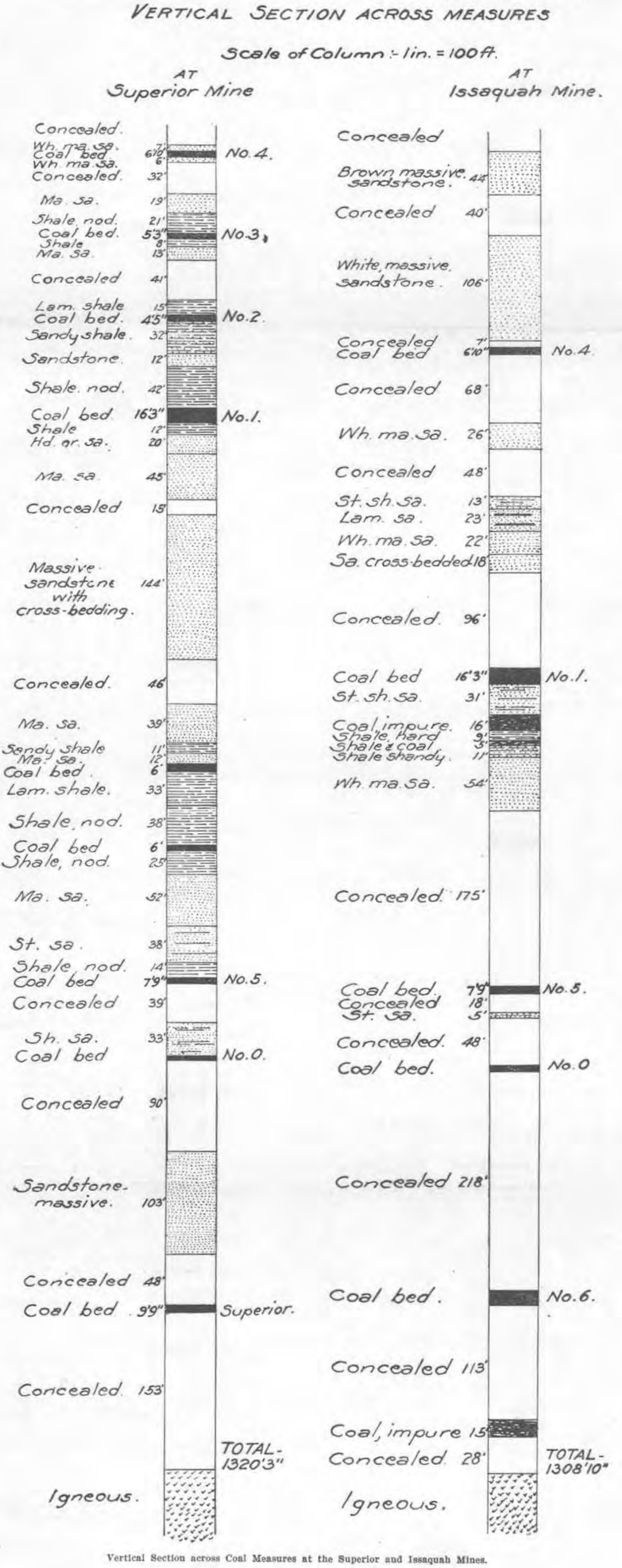
Cedar Mountain Coal Measures.



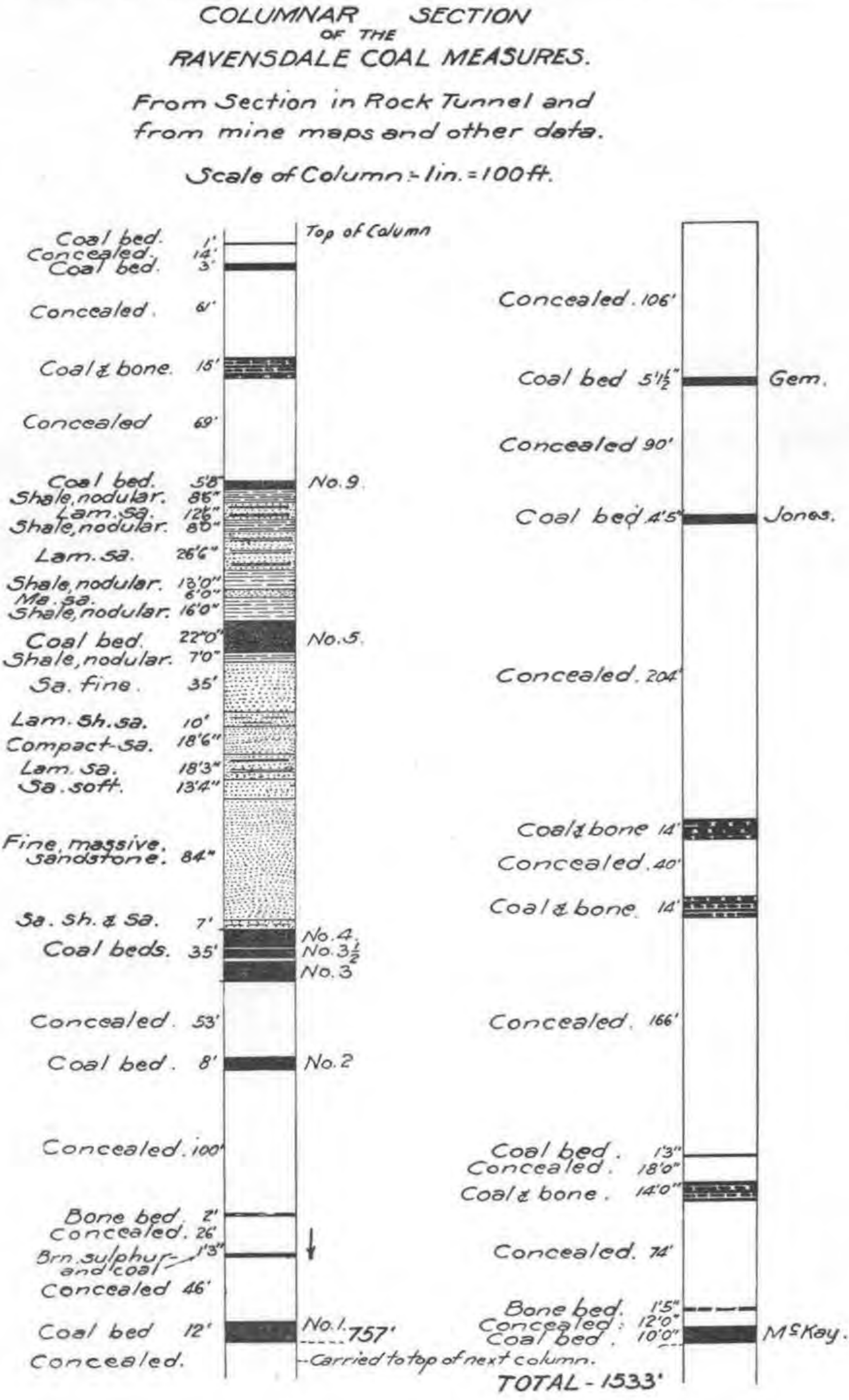
Map of Mines at Newcastle and Coal Creek.



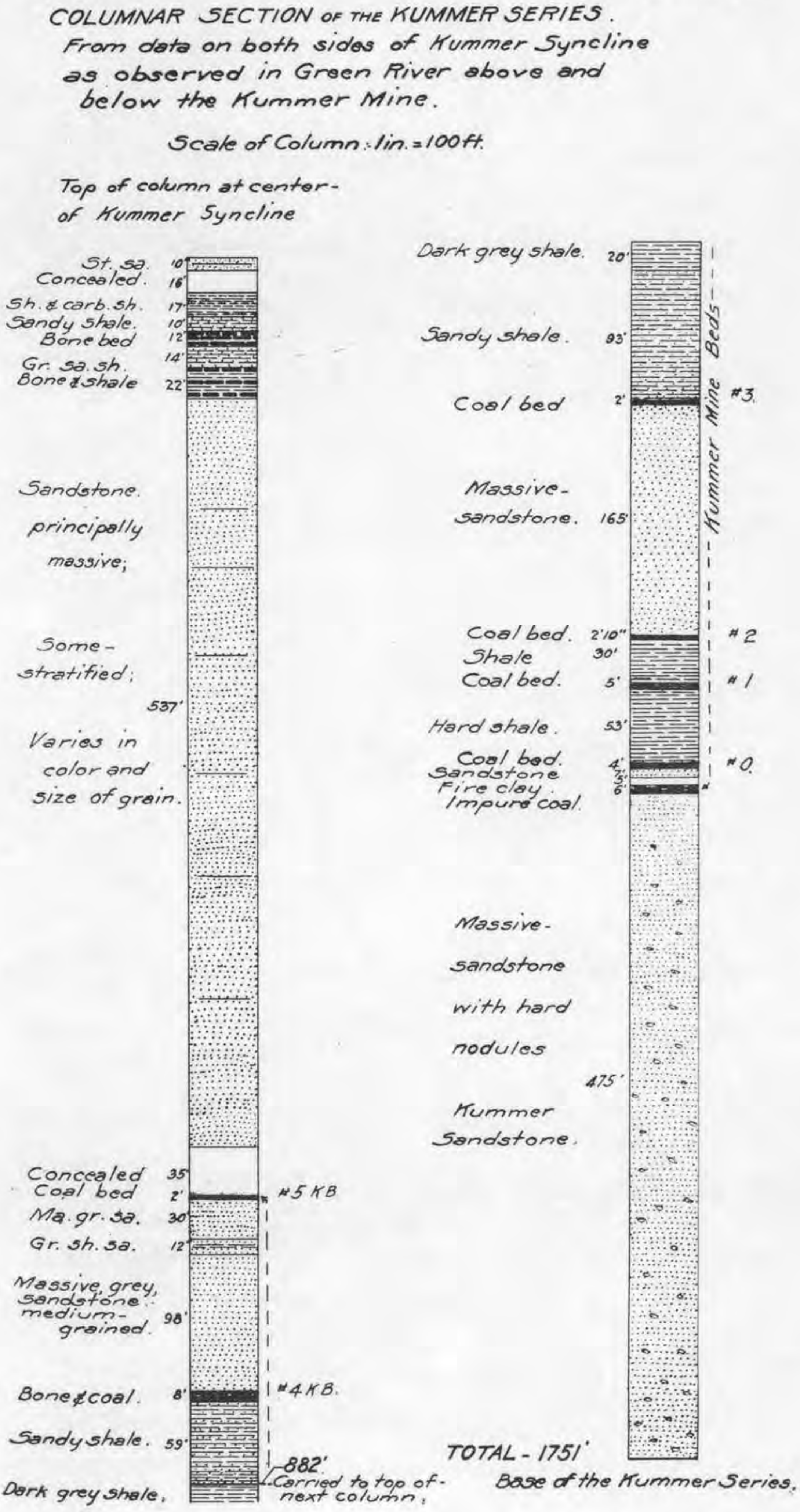
Columnar Section of Newcastle Coal Series.



Vertical Section across Coal Measures at the Superior and Issaquah Mines.



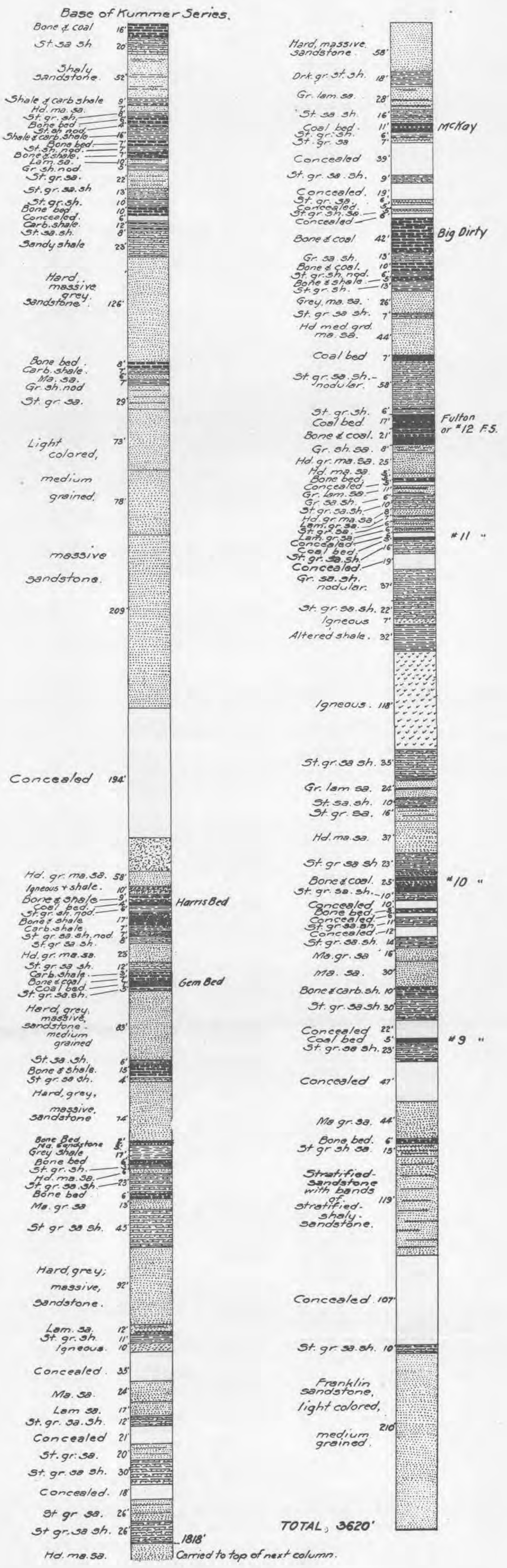
Columnar Section of the Ravensdale Coal Measures.



Columnar Section of the Kummer Series.

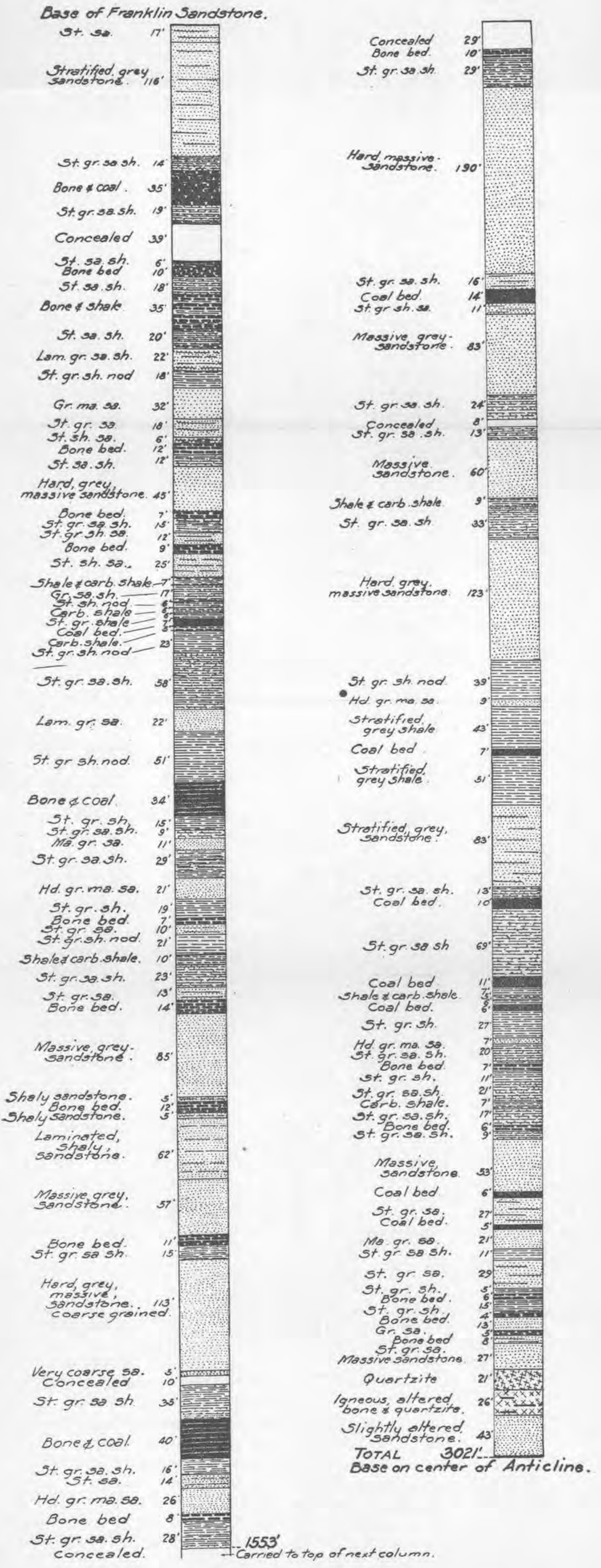
COLUMNAR SECTION OF THE FRANKLIN SERIES.
From data on Green River and along the C. & P.S. R.R.
between the old McKay Tunnel and the Harris Bed.

Scale of Column:-1in. = 100 ft.

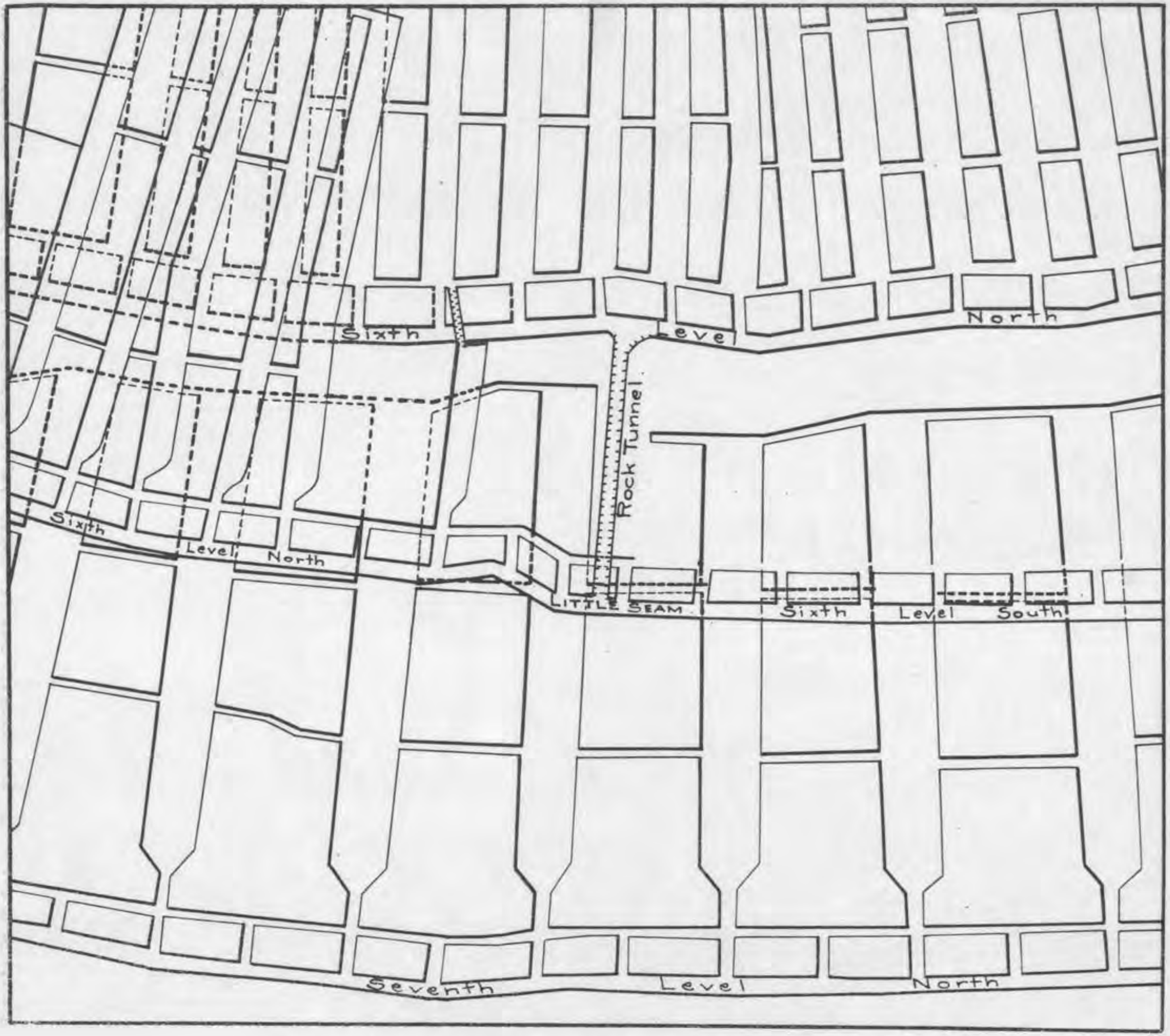


Columnar Section of the Franklin Series.

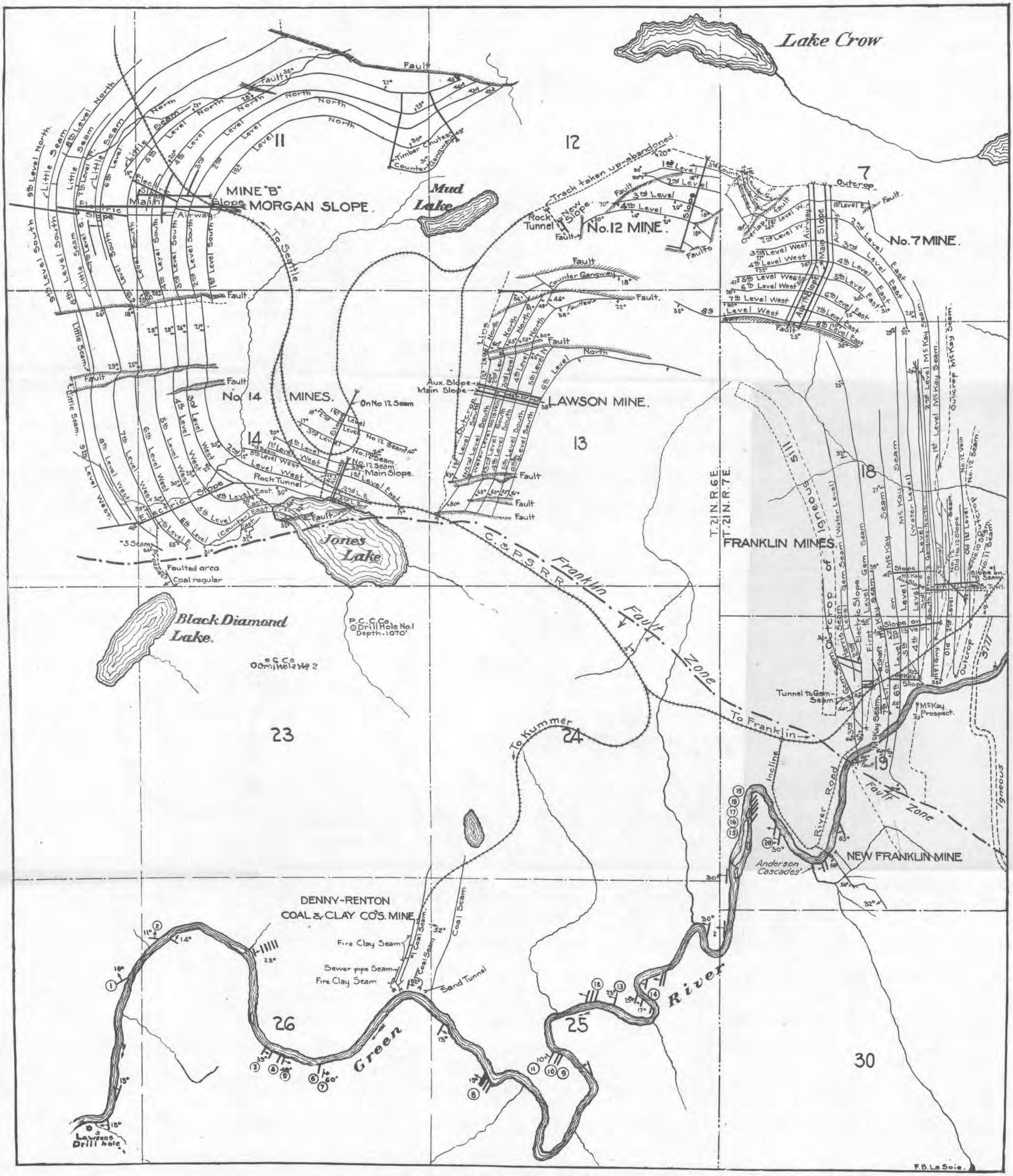
COLUMNAR SECTION OF THE BAYNE SERIES.
From detailed survey along Green River.
This section represents coal and bony beds that outcrop at Bayne and vicinity
Scale of Column:- 1 in. = 100 ft.



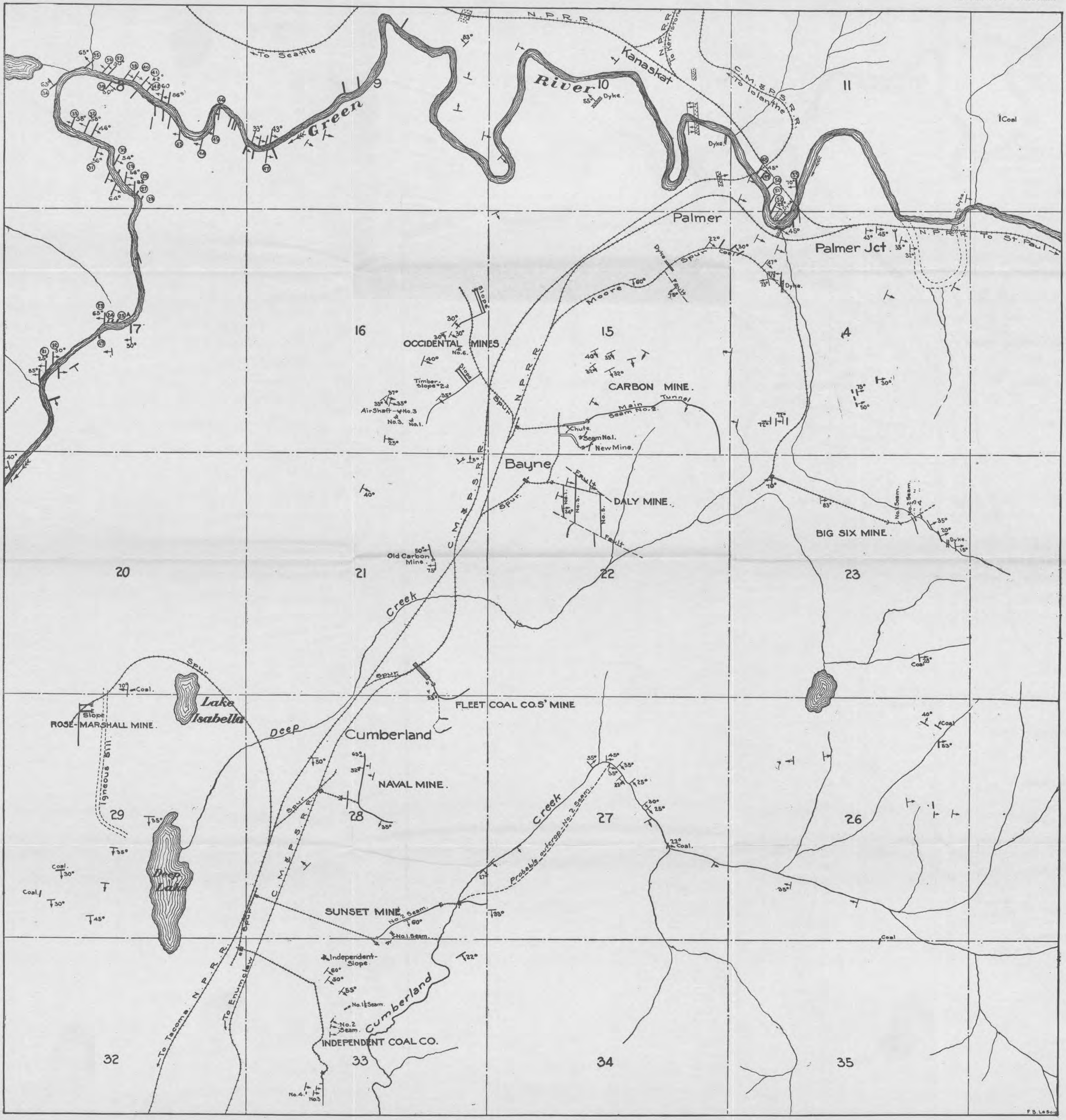
Columnar Section of the Bayne Series.



System of Mining, McKay Bed, Upper and Lower Benches, Black Diamond.



Map of the Mines and Coal Fields at Black Diamond and Franklin.



Map of the Coal Fields south of Green River, in the vicinity of Bayne and Cumberland.