

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

GEORGE OTIS SMITH, DIRECTOR

BULLETIN 474

COALS OF THE STATE OF WASHINGTON

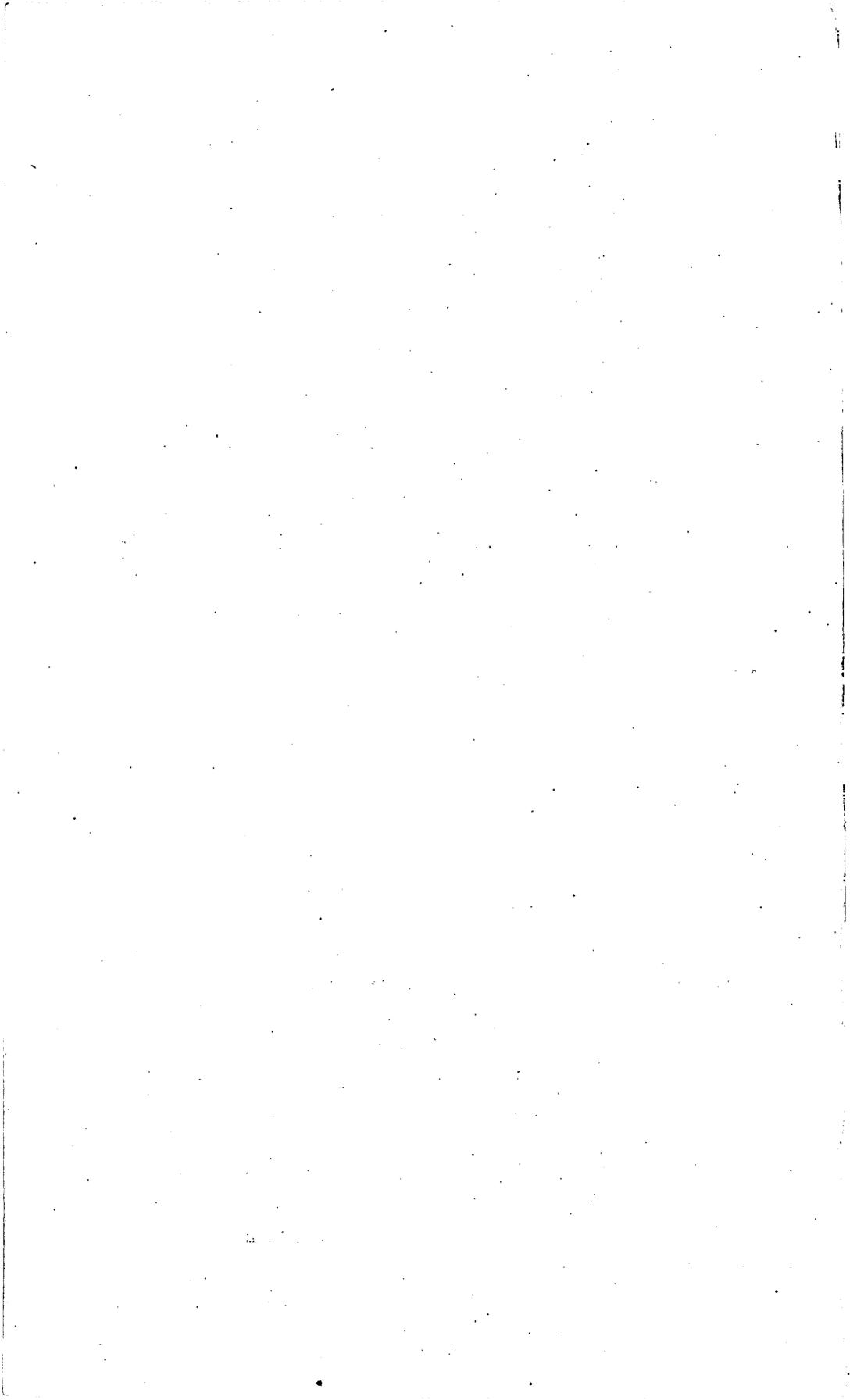
BY

E. EGGLESTON SMITH

WORK DONE IN COOPERATION WITH THE
GEOLOGICAL SURVEY OF WASHINGTON



WASHINGTON
GOVERNMENT PRINTING OFFICE
1911



CONTENTS.

	Page.
Introduction.....	7
Explanation of terms used in this report.....	7
Methods of sampling.....	10
Comparison of methods of sampling.....	10
Methods used in collecting samples.....	14
Preparation of sample for the laboratory.....	15
Character and quality of the coal.....	16
Introduction.....	16
Chemical properties.....	16
Methods of analysis.....	16
Analyses of the coals.....	17
Effect of different constituents of coal.....	19
Ease of ignition.....	21
Physical properties of the coals.....	22
Results of physical tests on coals sampled.....	22
Summary.....	27
Effect of exposure on moisture.....	28
Coking coals of Washington by Pishel test.....	31
Impurities.....	34
Sulphur.....	34
Moisture.....	34
Ash.....	34
Comparative quality and distribution of the coals.....	37
Commercial use of the coal.....	38
Detailed descriptions of mines, samples, and coals.....	76
Distribution of mines.....	76
Order of description.....	76
Clallam County.....	77
Fuca.....	77
Cowlitz County.....	79
King County.....	80
Prospect north of Issaquah.....	80
Grand Ridge.....	81
Issaquah.....	83
Superior.....	84
Ford and Bagley.....	85
Denny-Renton.....	89
Renton.....	90
Danville.....	93
Ravensdale No. 1.....	94
McKay.....	96
Morgan.....	98
Black Diamond No. 14.....	99
Lawson.....	101

Detailed descriptions of mines, samples, and coals—Continued.

King County—Continued.

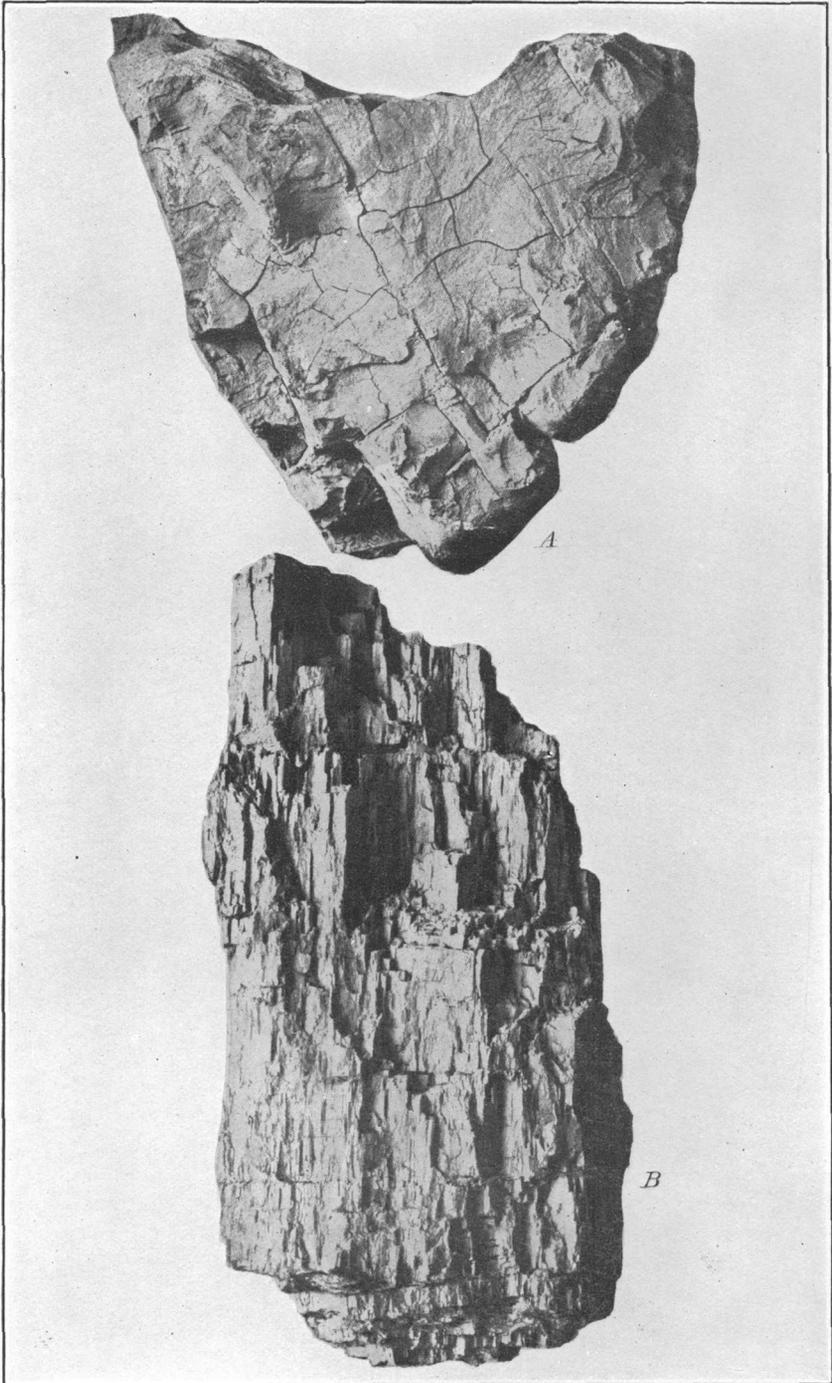
	Page.
Surface exposure at Franklin.....	102
Kummer.....	103
Gem.....	105
Surface exposure southwest of Franklin.....	105
Rose-Marshall.....	106
Independent.....	107
Sunset.....	108
Naval.....	110
Eureka.....	111
Bayne.....	112
Carbon.....	114
Prospect drift west of Bayne.....	116
Occidental.....	117
Big Six.....	119
Surface exposure at Palmer Junction.....	120
Prospect shaft east of Ravensdale.....	122
Prospect drift near Barneston.....	123
Denny-Renton.....	123
Prospects southeast of Issaquah.....	126
Prospect southwest of Preston.....	127
Niblock.....	128
Kittitas County.....	129
Prospect northwest of Beekman.....	131
Lakedale.....	131
Beekman.....	131
Busy Bee.....	135
Patrick-McKay.....	136
Roslyn No. 3.....	137
Roslyn No. 2 slope.....	139
Roslyn No. 2.....	140
K. & E.....	142
Roslyn No. 6.....	142
Roslyn No. 4.....	144
Roslyn No. 5.....	145
Roslyn No. 7.....	146
Summit.....	148
Cle Elum No. 3 extension.....	148
Cle Elum No. 2 extension.....	149
Cle Elum No. 2.....	150
Cle Elum No. 1.....	151
Lewis County.....	152
Prospect north of Carlton Creek.....	152
Prospect south of Carlton Creek.....	153
Prospect A, Summit Creek.....	154
Prospect B, Summit Creek.....	155
Prospect C, Summit Creek.....	156
Surface exposure east of Cowlitz River.....	156
Prospects near Ladd and Glenavon.....	157
East Creek-Ladd.....	158
Mendota.....	160
Richmond.....	162
Superior No. 1.....	162

Detailed descriptions of mines, samples, and coals—Continued.

	Page.
Lewis County—Continued.	
Superior No. 2	163
Twin City	164
Chehalis	165
Sheldon	165
Crescent	166
Pierce County	167
Burnett	168
Black Carbon	170
Pittsburg	171
Wilkeson	172
Gale Creek	175
Willis	177
Brier Hill	178
Snell	179
Carbon Hill	180
Melmont	186
Fairfax	188
Montezuma	190
Mashel	191
Prospect east of Ashford	192
Skagit County	193
Thurston County	193
Hannaford No. 1	194
Perth	196
Black Bear	197
King (Great Western)	198
Whatcom County	199
Index	201

ILLUSTRATIONS.

	Page.
PLATE I. <i>A</i> , Subbituminous coal from the Philippine Islands, showing characteristic weathering cracks; <i>B</i> , Pocahontas (West Virginia) coal, showing structure	7
II. <i>A</i> , Mortar and pestle showing adherence of powder of coal from the Roslyn bed at Clealum, Kittitas County; <i>B</i> , Mortar and pestle showing adherence of powder of coal from the Roslyn bed at Beekman, Kittitas County; <i>C</i> , Mortar and pestle showing poor adherence of the powder of noncoking bituminous coals; <i>D</i> , Mortar and pestle showing adherence of powder of the best coking coals of Washington; <i>E</i> , Mortar and pestle showing adherence of powder of the Pocahontas coal, from West Virginia.	30
III. Map of a portion of western Washington, showing distribution of coal mines and prospects discussed in this report	76
IV. <i>A</i> , Bunker of the Clallam Coal Co. at Fuca, Clallam County, at low tide; <i>B</i> , Exposures of beds of anthracite on Summit Creek, Lewis County	78
V. <i>A</i> , Forest undergrowth in the coal district near Bayne, King County; <i>B</i> , Typical forested area of the Puget Sound country, looking east from Lizard Mountain, near Bayne, King County.	80
VI. <i>A</i> , Glacial boulders on the south bank of Green River, near Franklin, King County, Wash.; <i>B</i> , Exposures of the Puget formation, in which the coal occurs, along Green River, near Franklin.	82
VII. <i>A</i> , Abandoned bunker of the Issaquah Coal Co. at Issaquah, King County; <i>B</i> , Washer and bunker of the Pacific Coast Coal Co. at Burnett, Pierce County	84
VIII. <i>A</i> , Town of Carbonado, Pierce County; <i>B</i> , New beehive coke ovens of the Carbon Hill Coal Co. at Carbonado, Pierce County	168



A. SUBBITUMINOUS COAL FROM THE PHILIPPINE ISLANDS.
Showing characteristic weathering cracks.

B. POCAHONTAS (WEST VIRGINIA) COAL.
Showing structure.

COALS OF THE STATE OF WASHINGTON.

By E. EGGLESTON SMITH.

INTRODUCTION.

The field work on which this report is based was done between the months of June, 1909, and March, 1910. The anthracite coal field at the head of Cowlitz River was examined for the purpose of classifying the coal land in the Rainier National Forest, the work being done entirely by the United States Geological Survey. The remainder of the work was designed to procure as complete data as the funds available would permit concerning the character, quality, and relative values of the coals of the State of Washington, and it was carried on in cooperation with the State Geological Survey. The field work was done under the administrative supervision of Henry Landes, State geologist of Washington, and M. R. Campbell, of the United States Geological Survey.

During the same period a party under the supervision of G. W. Evans, of the Geological Survey of Washington, mapped the surface geology of King County with special reference to coal, and investigated the underground geology as shown in coal mines, the mining conditions and methods, and the preparation of coal for the market. The writer spent parts of July, August, and September, 1909, assisting this party in field work. The results of this investigation will be published by the State.

The writer wishes to express his thanks to all the mine managers, superintendents, and foremen who kindly cooperated with him and assisted in collecting the samples and the geologic and other data used in preparing this report.

EXPLANATION OF TERMS.

In the descriptions of mines and samples in this report certain terms are used which have more or less definite local meanings and as these terms and their meanings may not be familiar to all readers they will be given. The term "water level" is applied to any gangway or drift which has natural drainage above the surface of the surrounding country, or in a general way to the workings lying above a water-level gangway or drift. The lowest water level in a series is spoken

of as the first water level, the next above as the second water level, etc. The term "level" is applied to gangways or drifts that lie below the natural drainage of the region and to workings above such gangways, from all of which water must be pumped. They are spoken of in descending order as first level, second level, third level, etc.

The terms "niggerheads," "sulphur" balls, and pyrite nodules are applied to masses of marcasite and pyrite which occur in much of the coal. The term "binder" is applied to any hard, black carbonaceous shale which resembles the coal and which is not easily separated from it either in mining the coal or in preparing it for the market.

In the mines of the Northwestern Improvement Co., in Kittitas County, the block-and-battery system of mining has been installed. The rooms are arranged in groups of ten each. As the gangway advances all the coal from the alternate groups is removed. These alternate groups are called batteries. The remaining groups are worked out as the gangway retreats. These groups are called blocks. The batteries and blocks are numbered independently of each other in consecutive order from the main slope.

For many years the need of a simple, consistent, and satisfactory scheme of classification for coal has been felt by all who have been in any way connected with the coal business, from the geologist and mining engineer to the dealer who places the coal on the market. Recently the United States Geological Survey has adopted a scheme¹ which seems in a way to answer the needs, and new names have been coined and old ones redefined in order to make the schemes suitable for practical use. The groups of coal recognized and the names applied to them are as follows: (1) Anthracite, (2) semianthracite, (3) semibituminous, (4) bituminous, (5) subbituminous, and (6) lignite. The higher grades (anthracite, semianthracite, semibituminous, and bituminous) are generally well known and need little or no description in this report. The type coals of the different groups are easily distinguished, but as there is a complete gradation between the groups the attempt to classify coals that belong in the dividing or debatable ground between the groups is difficult.

The generally accepted criterion for distinguishing the groups from bituminous upward is that of fuel ratio, or the quotient of the fixed carbon divided by the volatile matter, but it is questionable where one group shall end and another start. This question has not yet been settled by the United States Geological Survey and consequently the terms employed in this report will be used as they are used in the trade in the eastern fields of the United States, with the meanings indicated below:

1. Anthracite may be defined as a very hard, jet-black coal having a dense homogeneous texture, a bright irregular conchoidal fracture,

¹ Campbell, M. R., A practical classification for low-grade coals: Econ. Geology, vol. 3, No. 2, March-April, 1908.

burning with a short blue flame, and having a fuel ratio¹ of 10 or more. The coal from the Scranton-Wilkes-Barre district in Pennsylvania is typical anthracite.

2. Semianthracite is below the grade of anthracite, but its limits are not well defined. In general, it is fairly hard and bright, but it resembles bituminous coal in that it is more or less affected by minute jointing. It contains a considerably lower percentage of volatile matter than bituminous coal and has a fuel ratio of about 6 to 10. Coal from the Bernice Basin, Pa., and Spadra, Ark., is representative of this class.

3. Semibituminous coal is the next group below the semianthracite and above the bituminous. This group includes some of the best-known coal of the country, such as the Clearfield coal of Pennsylvania, the Georges Creek coal of Maryland, the New River and Pocahontas (Pl. I, B) coals of Virginia and West Virginia, and most of the coal of Arkansas. The fuel ratio of coal of this group ranges approximately from 3 to 6.

4. Bituminous coal includes all so-called "soft coal" which is lower in fuel ratio than semibituminous coal and which does not contain sufficient moisture to cause it to crumble (mechanical breaking down not being considered). In the State of Washington coal from the mines operating at present in Pierce and Kittitas counties and from the Black Diamond and many other mines in King County is typical bituminous coal. The coals of Iowa and Illinois and many of the coals of Ohio, Pennsylvania, West Virginia, Kentucky, and Alabama belong to this class.

5. Subbituminous coal has generally heretofore been called "black lignite." The criteria for the distinction of coal of the subbituminous group are in general (1) grayish black or black color; (2) almost universal absence of a distinct system of joints; (3) high percentage of moisture, which is given off readily on exposure to the sun or air, thus producing the peculiar irregular weathering (see Pl. I, A) spoken of as "slacking," and (4) the tendency of many of these coals to separate on weathering into thin plates parallel to the bedding. Of these features the color and the manner of weathering are the most characteristic. The color distinguishes the group from lignite; the manner of weathering separates it from bituminous coal. Fresh blocks of subbituminous coal, when exposed to the air or to the direct rays of the sun, tend to break up independently of the joint planes into smaller and smaller fragments having irregular faces. The fresh coal has a bright luster and an irregular conchoidal fracture; the resultant fragments are lusterless and their surfaces do not show an even fracture of any kind. Certain subbituminous coals have high heating value and will stand transportation in closed cars without

¹ Frazer, Persifor, jr., Classification of coals. Rept. MM, Second Geol. Survey Pennsylvania, 1879, pp. 128-158; Trans. Am. Inst. Min. Eng., vol. 6, 1879, pp. 430-451.

"slacking," but will check slightly when exposed to the direct rays of the sun in open cars. Such coal is evidently near the border line between the bituminous and subbituminous groups. In the State of Washington the coals of Issaquah, Coal Creek, Renton, and Tono are typical of this class.

6. Lignite is distinguished from subbituminous coal by its color, texture, and amount of moisture. It is brown in color or has a distinctly brownish cast. The texture is usually more or less distinctly woody, although some lignite, notably that of Texas, is amorphous. The amount of moisture is greater than that of subbituminous coal and ranges from 25 to nearly 45 per cent. The lignite of North Dakota is typical of this group. The name lignite is perhaps more loosely used at the present time than any other in the list. On the Pacific coast, especially in the State of Washington, this term is applied to all the coals commonly classed as "lignite," "brown lignite," "brown coal," "black lignite," "lignitic coal," and very frequently to a good grade of bituminous coal. The writer has often heard the coals from Black Diamond and Carbonado referred to as lignite, though they are among the best bituminous coals in the State. It is hoped that the classification, with the corresponding nomenclature just given and used throughout this report, will be adopted by the local operators and dealers, for its general features are already in use and it only prescribes, in addition to these features, certain fairly definite limits for the lower groups and introduces the term subbituminous to replace the many terms like "black lignite," "lignitic coal," and "brown coal."

METHODS OF SAMPLING.

COMPARISON OF METHODS.

In attempting to compare the coals of a region like the State of Washington, where the character of the coal is so different within short distances and where mining operations are in so widely different stages of development, it is evident that some standard method of sampling must be adopted. Of the three methods commonly employed—sampling at the place of consumption, sampling in carload lots, and sampling from the mine—the last seemed to be the only one that could be used economically under the present conditions of development.

Commercial samples are more nearly representative of the coal as it is placed in the market; but as different methods of preparation for market, varying length of exposure to the air, changing conditions in the different parts of the mine from which the coal is obtained, and other variable factors affect the character of the coal at the consumer's plant, this method of sampling is not very satisfactory, particularly for a low-grade coal.

Carload sampling, if carried on under the supervision of a man skilled in the work and preceded by a careful study of the condition of the bed, the character of the coal in the different parts of the mine, and the method employed for the preparation of the coal for the market, affords a means of obtaining better average results than can be obtained by sampling at the place of consumption. The coal can be so chosen as to be fairly representative of the average output of the whole mine or the sample can be made to represent the average of any particular part of the mine. Much, however, depends on the experience and personal equation of the sampler. This method also permits a choice of shipment, in either open or closed cars, which will place the sample at the laboratory in about the same condition that it would reach the consumer. On the other hand, the great cost of this method of sampling and the responsibility and judgment required of the sampler make it almost prohibitive under ordinary conditions and not so reliable in its general results as mine sampling.

Mine sampling can be applied to all kinds of operating mines, abandoned mines, and prospects in all stages of development to which access can be obtained. In fact, it is the only method that can be employed where the coal is not being used commercially. It costs much less than the shipment and testing of commercial or carload samples and for that reason is much better suited to ordinary requirements. Mine sampling provides a ready means of making a comparison of coal from different places in the same bed—a comparison which can be made by the other two methods only by the expenditure of a large amount of time and money.

Wherever car samples have been taken by the United States Geological Survey, mine samples have been taken at the same time from the working parts of the mine from which the coal came. This practice has been extremely valuable in giving data for comparing the merits of the two methods of sampling and in affording a means of estimating roughly the commercial quality of coals from prospects, developing mines, and other mines, from which carload samples can not be obtained.

Most of the following discussion of the value of coal-mine sampling as compared with carload sampling is taken from an article by M. R. Campbell.¹ In comparing these two methods of sampling the effect on the impurities in the coal is most important, although there is undoubtedly some effect on the other constituents. These impurities, named in the order of their importance, are moisture, ash, and sulphur.

Exposure to the atmosphere has different effects on the moisture in coal, the degree of change depending on the amount of initial moisture, the kind of exposure, and the length of exposure. The

¹ The value of coal-mine sampling: *Econ. Geology*, vol. 2, No. 1, January-February, 1907, pp. 48-57.

standard method of mine sampling as set forth by Campbell, supplemented by precautions to avoid certain difficulties, should reduce the variation in moisture in mine samples to a minimum. The ordinary method of car sampling is subject to all the conditions producing alteration in the moisture content. The comparison of a large number of mine samples with car samples has made it possible for Campbell to divide into four great groups the coals which have certain relations in their moisture content. The following is Campbell's statement¹ regarding coals tested at the Louisiana Purchase Exposition at St. Louis in 1904:

Group A: This group includes all coals in which the average moisture content of the car sample is less than 3 per cent. Of this group 18 samples show an excess of moisture in the coal from the mines and 6 samples show an excess in the coal from the car. The total excess in the mine samples is 9.47 per cent and in the car samples 5.48 per cent. The difference is 3.99 per cent. This divided by 24, the total number of samples, gives an average excess in the mine sample of 0.17 per cent.

Group B: In this group are included all samples having an average moisture content in the commercial coal of from 3 to 8 per cent. Of this group 18 samples show an excess of moisture in the commercial coal and the other 18 samples show an excess in the coal from the mine. The number of samples is the same in both cases, but the total amounts are quite different, the excess in the car samples being 24.60 and in the mine samples 10.23 per cent. The difference between these amounts, or 14.37, divided by 36, the total number of samples, gives 0.40 per cent, as the average excess in the car samples.

Group C: This group includes all samples having a moisture content in the average car sample of from 8 to 10 per cent. Of this group 4 samples show an excess in the commercial coal, and 11 samples an excess in coal from the mine. The total amount of excess in the car samples is 2.24 per cent and in the mine samples 10.69 per cent. The difference, 8.45 per cent, divided by 23, the number of samples, gives an average excess in the mine sample of 0.56 per cent.

Group D: This group includes all samples having a greater amount of moisture in the car sample than 10 per cent. The mine samples show an excess in moisture over the car samples, as in the previous group, but the excuse for considering it separately is that the average amount of excess is much greater than that of the preceding group. Of Group D 8 samples show an excess in coal from the car and 22 samples show an excess in coal direct from the mine. The total excess in the former case is 10.50 per cent and in the latter 48.56 per cent; the difference, 38.06 per cent, divided by 30, the number of samples, gives 1.27 per cent as the average excess in the mine samples.

Tabulated, the results are as follows:

Table of coal groups arranged according to the excess of moisture in mine and car samples.

Groups of coal.	Excess in mine samples.	Excess in car samples.
	<i>Per cent.</i>	<i>Per cent.</i>
A. Coals having less than 3 per cent in car samples.....	0.17	
B. Coals having from 3 to 8 per cent in car samples.....		0.40
C. Coals having from 8 to 10 per cent in car samples.....	.56	
D. Coals having over 10 per cent in car samples.....	1.27	

¹The value of coal-mine sampling: Econ. Geology, vol. 2, No. 1, January-February, 1907, pp. 50-55.

The meaning of the above-described groups is not well understood, especially the reason why an intermediate group, B, should show an excess of moisture in the car samples when coals of both larger and smaller content show less moisture in the car lot than in the mine samples. The reasons for Groups C and D are evident. They include coals having a high moisture content, and it is only reasonable to suppose that coal of this character would lose some of its moisture in transit, especially when the shipment occurred in midsummer, as was the case with most of these samples. It is possible that the coals of Class B were shipped in bad weather and hence gained moisture in transit, or it may be possible that coals of this intermediate grade are in such a condition that they will absorb moisture from the atmosphere more readily than those having either a higher or lower moisture content. It is possible also that Group B is not a natural group, but merely due to fortuitous circumstances. If that is the case, a larger series of tests would probably show that no such group exists.

The effect of the two methods on the amount of sulphur in the sample is slight. The following report is Campbell's statement¹ on this point:

Of the 105 samples analyzed during the two years, 75 show an excess of sulphur in the commercial coal, 28 show an excess in coal direct from the mines, and 2 show an equal amount in each. The total excess in car samples is 261.67 per cent, and in mine samples 246.25 per cent; 261.67 divided by 246.25 equals 1.06, the coefficient of excess of sulphur in the car samples over the mine samples. If, therefore, the amount of sulphur shown in any analysis of coal direct from the mines be multiplied by 1.06, the result will be approximately the amount of sulphur that may be expected in commercial coal from the same mines.

The amount of ash in the samples obtained by the two methods depends on the personal equation of the mine sampler and the car sampler, on the character of the roof and floor of the mine, on the methods of mining and hauling to the surface, and on the methods of preparation for market if the sample is taken after it has been cleaned. The results of the comparison of the ash as given by Campbell² are as follows:

The total excess in the car samples is 1,062.66 and in the mine samples 825.95 per cent; 1,062.66 divided by 825.95 equals 1.29. This may be called the coefficient of increase, and can be used in converting the ash in analyses of mine samples into analyses of commercial coal; thus, if the ash in the analysis of the mine sample be multiplied by the coefficient, 1.29, the result will be approximately the amount of ash that may be expected in commercial coal from the same mine.

The percentage of volatile combustible matter in a coal undoubtedly changes on exposure to the air, and the amount of change depends on the length of exposure, the size of the particles, and the amount of weathering. It has been shown by R. T. Chamberlin³ that fresh coal dust gives nearly four times as much volatile combustible as old dust. The rate of change is undoubtedly controlled by the size of the particles and the amount of air in circulation among them.

¹ The value of coal-mine sampling: *Econ. Geology*, vol. 2, No. 1, January-February, 1907, p. 52.

² *Idem*, p. 53.

³ Notes on explosive mine gases and dusts: *Bull. U. S. Geol. Survey* No. 383, 1909, p. 62.

The following conclusions may be drawn concerning the comparison of the standard methods of mine sampling and car sampling. First, no exact ratio can be established between the amounts of moisture in the two kinds of samples, because of the varying conditions of original moisture content, methods of transportation, and time of transportation. Second, a more or less definite ratio exists between the amount of sulphur in the two kinds of samples, which may be used as a possible basis for estimating the amount of sulphur in commercial coal from the analysis of a mine sample, although the variation of many of the samples from this ratio is great. Third, a more or less definite ratio exists between the amounts of ash in the samples, which may be used with considerable accuracy in determining from the mine sample the possible ash in a commercial sample.

METHODS USED.

In collecting samples from mines operating on one bed the writer took one sample from each mine having a daily output of 200 tons or less. An additional sample was taken for each additional 100 tons of output; that is, a mine producing 500 tons daily would have one sample for the first 200 tons and three samples for the additional 300 tons, or a total of four samples.

The following method was used in collecting such samples. After ascertaining the parts of the mine at which the coal bed was most nearly normal, points were selected for sampling in the center and the periphery of the active workings which would give samples representing very closely the present and the future output of the mine. At the place where each sample was taken a fresh face of coal was selected and cleaned of all coal dust, powder stains, and other impurities by removing from half an inch to 2 inches of the coal. In slightly dipping beds, where the floor of the mine was wet, a piece of oilcloth was spread so as to catch the coal as it was cut and to keep out impurities and moisture. In highly dipping beds the oilcloth was supplemented by a small canvas bag on a hooped stick which could be held immediately under the part of the bed being sampled and which caught most of the coal as it was cut from the face. The sample was obtained by cutting a channel across the face as nearly perpendicular to the floor as possible and of such a size as to yield about 5 pounds of coal to each foot of the bed sample. All material in the bed was included except partings, lenses, and binders more than three-eighths of an inch thick and lenses or concretions of "sulphur" or other impurities greater than 2 inches in maximum diameter and half an inch in thickness. In some places a layer of the foreign material resembled the surrounding coal so closely that it could not be separated in preparation for market and was therefore included in the sample. Some beds also contained thin partings which could not

be entirely separated from the coal by picking and washing. Several of these partings were also included in the sample, so that the amount of ash would be about the same as that contained in the commercial coal that had been carefully prepared for the market. In the sections of the beds which are given with the descriptions of the mines (see pp. 77-199) an asterisk (*) or dagger (†) indicates the parts which are included in the sample. Only half of some layers was included, and such layers are indicated by a dagger. Some samples were wet when they were taken from the mine. As most of the sampling was done in the winter or rainy season, it was not possible to dry all samples before being ground and sealed in the can. When the weather was so dry that the sample could be dried without being exposed to the air very long, it was air-dried until all visible moisture had disappeared before it was prepared for the laboratory.

The samples of washed coal, lump coal, and steam coal were taken from the surface of the storage bins and from the surface of railroad cars which had just been loaded. The coal was collected in small quantities at more or less regular intervals until 75 to 300 pounds was obtained.

PREPARATION OF SAMPLE FOR THE LABORATORY.

The mine sample was prepared for the laboratory either in the mine or in a protected place at the entrance to the mine where the atmospheric conditions were similar to those of the mine. Each sample was kept in an oilcloth bag until the sampler was ready to pulverize it. The coal was ground in a bone grinder to the size of a pea, or pulverized with a piece of flat steel and an iron pestle until it would pass through a sieve with a half-inch mesh. It was then thoroughly mixed and quartered. Opposite quarters were rejected, and the remaining quarters were thoroughly mixed and quartered as before. The operations of mixing and quartering were repeated until the final sample of about one quart was obtained. This was then placed in a screw-top galvanized-iron can made to hold about $3\frac{1}{2}$ pounds of coal, and was sealed and mailed to the Geological Survey's laboratory at Pittsburg for analysis.

The samples of washed coal, lump coal, and steam coal were thoroughly mixed. The pieces were then reduced to a diameter of three-fourths of an inch and mixed and quartered in the usual way until a sample of about 25 pounds was obtained. This was ground in a bone grinder to the size of a pea and then mixed and quartered until a final sample of about $3\frac{1}{2}$ pounds was obtained, which was sealed in a screw-top galvanized-iron can and sent to the laboratory.

If the exact location of the place from which a sample was taken is not known, its location with respect to a known land corner is given in the description of the individual mines and prospects, so

that its position can be readily determined. Mine maps were not available to determine some locations, and their exact position with regard to a Government land corner is not known. For such places the location of the mine is given as nearly as possible by distance and direction from the nearest town.

CHARACTER AND QUALITY OF THE COAL.

INTRODUCTION.

The character and quality of the coals of the State were ascertained by determining their chemical composition, calorific value, physical properties, and impurities. The relative heating and commercial values of coal depends largely on the character, relation, and proportion of its chemical constituents. Its ability to stand transportation, and hence to a considerable degree its commercial value, depends largely on its physical properties. Its relative heating value and its adaptability to special uses is strongly influenced by the impurities it contains, so that a knowledge of the character and amount of these impurities is all-important in determining the commercial value of the coal.

CHEMICAL PROPERTIES.

METHODS OF ANALYSIS.¹

Two kinds of analyses were made at the Survey's laboratory—the proximate analysis and the ultimate analysis. A proximate analysis determines by a conventionally standardized process the coal's percentage of moisture, volatile matter, fixed carbon, ash, and sulphur. An ultimate analysis determines the ultimate constituents—hydrogen, carbon, nitrogen, oxygen, sulphur, and ash. Calorific determinations were made when called for, and the heating value is expressed in both calories and British thermal units, the calorie being 1.8 times the British thermal unit. In mines that are working on the same bed it was customary to take the ordinary number of samples from each mine and make only a proximate analysis of each. If these analyses showed no considerable variation in the composition of the coal an ultimate analysis and a calorimeter determination were made of a composite sample consisting of equal amounts from each of the original samples. If the analyses showed marked differences in composition, ultimate analyses and calorific determinations were made of the samples showing the variations and a composite sample was made of the remaining samples. Various conditions determined whether a proximate or an ultimate analysis should be made of a particular sample. Generally speaking, a

¹ For a full discussion of the methods of analysis used at the Government laboratory see Prof. Paper U. S. Geol. Survey No. 48, 1906, pt. 1, pp. 174-195. Also Lord's paper on air-drying.

proximate analysis was made of a coal that was weathered or altered by volcanic action or that was believed to be high in ash, but an ultimate analysis was made of a coal that was not weathered or altered and was believed to be a good commercial coal. Ash determinations were made on samples which were believed to contain so much ash that it was doubtful whether or not the coal they represented had any economic value.

A large number of mine samples and many samples of washed and prepared coal contained much more moisture than was inherent in the coal. In order to compare the heating value of the coal from a wet part of a mine with that from a dry part, or with that from a dry mine, or the coal from a washer with dry coal from the mine, some system of drying the samples to a uniform condition must be adopted. By continued experiment it was found that proper comparisons can be made by weighing the coal in a shallow galvanized iron tray and drying it in an oven through which a gentle current of air heated from 10° to 20° above the temperature of the laboratory is passing until the weight becomes practically constant. The difference in weight between the original sample and the partly dried sample gives the amount of moisture driven off by air drying. This process is not intended to produce the same effect as the exposure of the coal to the air and sun during transportation. It simply appears to be the best method of determining roughly the amount of moisture loosely held by the coal.

In actual practice analysis is made of the air-dried sample. The figures given opposite the items "As received," "Dry coal," and "Pure coal" are calculated from the analysis of the air-dried sample and are included in the table for convenience in comparing and studying the analyses. The figures opposite "Dry coal" represent the analysis calculated for the coal when free from moisture; those opposite "Pure coal" represent the analysis calculated for the coal when free from moisture and ash. The term "pure coal" is somewhat misleading as the coal so designated includes sulphur, but the term is used simply on account of its brevity and convenience.

ANALYSES OF THE COALS.

Analyses of samples of coal collected by the writer in Washington were made at the laboratory of the United States Geological Survey at Pittsburg, and the results are given in the table on pages 41-75. Samples 6760 and 6761 were taken by J. S. Diller¹ in Cowlitz County in 1904. These were analyzed by W. T. Schaller in the laboratory of the United States Geological Survey at Washington, D. C. In

¹ Diller, J. S., Coal in Washington near Portland, Oreg.: Bull. U. S. Geol. Survey No. 260, 1905, pp. 411-412.

1905 M. R. Campbell¹ collected mine and carload samples from the Renton mine, in King County (Nos. 2455, 2456, 2686, 2687), and the Roslyn mines, in Kittitas County (Nos. 2457, 2458, 3098). Two mine samples (Nos. 2459 and 2460) were collected by M. R. Campbell at about the same time from the Carbon Hill mine at Carbonado, the results of which have not been published but which compare favorably with the analyses of samples collected by the writer from the same mines and from the same beds. Sample 6487 was collected in 1908 by J. B. Umpleby from the No. 5 bed at Ravensdale. Samples 6486, 6488, 6489, 6490, 6491, 6492, 6493, 6494, 6495, and 6496 were collected by J. B. Umpleby at the same time from prospects and mines in Lewis and Pierce counties. Samples 520-D and 6485 were collected from Taylor and samples 552-D, 787-D were obtained by K. M. Way from Carbonade. These samples, together with those collected by Umpleby, were analyzed at Pittsburg, Pa., and the results are given in the accompanying table. Samples 11736, 11737, and 11738 were collected by George W. Evans after the completion of the author's field work from mines that were not then in operation. Samples of coal from Whatcom and Skagit counties were analyzed by the Bureau of Naval Equipment,² Washington, D. C., and are given in the table on page 76 to afford a comparison of these coals with the other coals of the State.

In the table the locations of the samples are given by township, range, section, and quarter section. On account of the absence of accurate maps the locations by section or quarter section of some of the prospects sampled may be incorrect, but they are as near as could be determined with the means at hand and the knowledge of the legal subdivisions. Under the column headed "Thickness" the total bed as sampled, including the partings, is given under the heading "Coal bed." Coal which was either not exposed or of no commercial value, underlying or overlying the part sampled, is not included in the thickness given. This thickness minus the thickness of all the partings not included in the sample is given in the column headed "Part sampled."

The general opinion of the members of the laboratory staff is that the methods used for determining the values given in the proximate analysis are not sufficiently refined to warrant the use of the second decimal place in recording the results. Therefore those percentages which are not directly involved in the ultimate analysis are given to the nearest tenth. In like manner it is believed that the methods used in the determination of calorific values are not accurate enough

¹ Report of the United States fuel-testing plant at St. Louis, Mo.: Bull. U. S. Geol. Survey No. 332, 1908, pp. 272-277.

² Reports of the efficiency of various coals, 1896 to 1898, and expenses of equipment abroad, 1902-3, and recent chemical analyses of coal at the navy yard, Washington, D. C., 1906, pp. 5-7, 96-99, 119-121.

to justify the use of unit value and hence the amounts of calories are given to the nearest five and British thermal units are given to the nearest ten.

EFFECT OF DIFFERENT CONSTITUENTS OF COAL.

In the table under proximate analysis four constituents of the coal are given and under ultimate analysis five, with ash common to both. They are as follows: (1) Moisture, (2) volatile matter, (3) fixed carbon, (4) ash, (5) sulphur, (6) hydrogen, (7) oxygen, (8) nitrogen, and (9) carbon. The influence of each constituent is in general as follows:

The moisture in a sample of coal consists of (1) extraneous moisture, which occurs on the surface of the different particles or grains and which is the result of seepage from adjoining rocks, water from washing of the coal for market, precipitation on the coal when exposed to the open air, or sweating, which is a precipitation of moisture from warm saturated air coming in contact with relatively cooler coal; (2) moisture inherent in the coal—that is, residual water from the original organic matter, or water evolved by chemical change. Moisture is the constituent which has the greatest effect in reducing the heating value of the lower grades of coal. This reduction is due to the fact that moisture is inert and does not produce heat, and that it absorbs heat from the coal during its rise in temperature to the evaporation point and during its conversion into steam. It is evident also that for each unit or per cent of moisture contained in the coal there is one unit or 1 per cent less of combustible matter which might have been there if the moisture were absent. By considering this fact alone it becomes evident that each per cent of moisture decreases the efficiency of the coal 1 per cent or 20 pounds per ton. In addition to this it should be noted that the amount of heat required to raise the temperature of the water from the normal to the boiling point and then to convert it into steam is 620 calories of heat for each kilogram of water, or 282 calories per pound, which is equivalent to about 0.035 per cent of the heating value of a ton of pure coal for every per cent of moisture in the coal. In high grade coal the loss due to moisture is very small, but in low grade coal it is an important quantity. Other conditions being equal, coal containing 40 per cent of moisture will have about 41.4 per cent less heating value than one which is absolutely free from moisture. A relatively small percentage of moisture does not materially affect the adaptability of coal for many uses, but a large amount, such as that contained in subbituminous coal and lignite, causes the coal when placed upon a hot fire to swell and crumble to pieces, so that it can not be used with forced draft without great loss of fuel and great danger from fires from the hot cinders thrown out of the smokestack.

The volatile matter¹ of a coal consists of two parts—(1) combustible and (2) noncombustible. That part of the volatile matter which unites with oxygen and produces heat is composed chiefly of hydrocarbons, sulphur, and hydrogen.² The hydrocarbons have a heat of combustion ranging from about 1.3 to 4 times that of carbon, and therefore increase the efficiency of the coal. Other things being equal, the greater the percentage of combustible volatile matter in a coal the higher its heating value. The effect of the percentage of hydrocarbon on the heating value of coal is shown by the well-known fact that anthracite coal, which contains a relatively small amount of volatile combustible matter, has a markedly lower heating value than semibituminous coal (Pocahontas, New River, etc.), which contains a much higher percentage of volatile combustible matter.

In the coals of Washington sulphur usually occurs in small quantities, ranging from a fraction of 1 per cent to 3 per cent. When free it has a heating value much less than that of carbon, and would therefore tend to lower the efficiency of the coal. Free hydrogen has a heating value more than four times as great as that of carbon. The presence of this gas in the coal would raise its calorific value.

That part of the volatile matter which does not produce heat and which is regarded as "inert" consists of oxygen and nitrogen. The effect of these gases is to reduce the heating value of the coal, the principal effect of the oxygen being, according to Du Long's formula, to reduce the hydrogen available for heat by so much as is necessary to form water with the oxygen present ($H - \frac{O}{8}$). Nitrogen is believed

to have generally no effect other than to decrease in proportion to its amount the percentage of combustible matter in the coal, and therefore to decrease the total heating value. Oxygen in excess of the amount which may unite with hydrogen to form water reduces the heating value because it replaces an equal amount of combustible matter. (See p. 21.)

Carbon is the principal combustible in most coal. Other things being equal, the higher the amount of fixed carbon the higher the heating value of the coal up to a certain limit. Carbon has not, however, so high a heating value as hydrocarbons, and therefore some coals which have a relatively large amount of hydrocarbons have a higher efficiency than those which have a large amount of carbon. This appears to be true only of coals having a small amount only of incombustible volatile matter. Those containing less than 55 per cent of fixed carbon generally have a lower heating value, due to

¹ For discussion of the volatile matter in coal see the report of S. W. Parr, Bull. Illinois State Geol. Survey No. 3, 1906, pp. 31-49.

² The occurrence of free hydrogen in coals is believed to be very rare. R. T. Chamberlin (notes on explosive mine gases and dusts, Bull. U. S. Geol. Survey No. 383, 1909, p. 31) reports the finding of a small amount of free hydrogen in a gas issuing from a standpipe for anthracite coal near Wilkes Barre, Pa.

larger quantities of other volatile constituents, principally moisture or oxygen, otherwise combined in the coal.

Ash is one of the important factors that determine the heating value of the coal. It is generally inert and does not produce or absorb heat, so that in this respect its effect is negative. Each per cent of ash in the coal not only replaces 20 pounds per ton of combustible matter, but means just 20 more pounds of useless material to be handled, and if the ash is fusible it acts as a positive detriment to the coal.

The constituents of coal shown in an ultimate analysis have a more or less definite significance as to its heating value. As stated above, sulphur tends to decrease the calorific value of the coal, but if it exists as free sulphur it has a small heating value. The amount of available hydrogen above the ratio needed to satisfy the oxygen in the formation of water increases the heating value. The effect of oxygen, as already stated, is to reduce the heating value. David White¹ states that its effect in reducing the heating value is about the same as that of ash and that oxygen and ash are of nearly equal anti-calorific importance. Nitrogen is inert and as a diluent reduces the heating value in proportion to its amount. Carbon has a heat of combustion about equal to that of pure anthracite and when not in combination with oxygen is the principal heat-producing element of coal.

EASE OF IGNITION.

Many of the coals of the State of Washington ignite much more easily than coal from the eastern part of the United States. A splinter from almost any of the purer Washington coals can be burned readily with a match, but the flame produced is usually not self-sustaining. The coking coal of Pierce County swells and sputters in the flame and shoots out burning gases in the form of little jets. Coal samples from Black Diamond, Ravensdale, and Roslyn burn with a long flame while a match is burning under them, but the flame dies out very soon after the match is removed. The subbituminous coals can be burned, but not so readily as the other coals. The coal from Fuca, Clallam County, is easily ignited, and the flame is self-sustaining in still air. The low-grade coal from Chehalis will give off a very dense smoke, but will not burn independent of the match. The cannel-like coal which occurs in pockets in the Mendota mine burns very readily and the flame is self-sustaining. This coal gives a much larger flame and more soot than any other cannel coal with which the writer is familiar.

In general, those coals which have the larger percentage of volatile matter in the analysis of the moisture-free sample ignite the more

¹ The effect of oxygen in coal: Bull. U. S. Geol. Survey No. 382, 1909, p. 8.

readily. A small fragment of a coal containing about the same proportion of volatile matter as fixed carbon will sustain a flame after it has been ignited by the flame of a match. The coal from Clallam County has nearly 10 per cent more volatile matter than fixed carbon. The coal from Mendota, already referred to, is believed to have a still higher proportion of volatile matter. This appears to be the reason why these coals burn so readily. The coal occurring near Chehalis has much more volatile matter than fixed carbon, but the percentage of moisture is high, and this fact probably accounts for the difficulty encountered in igniting the gases from the coal. If the moisture could be driven off, the resulting coal would probably burn easily when ignited by a match.

PHYSICAL PROPERTIES OF THE COALS.

RESULTS OF PHYSICAL TESTS ON COALS SAMPLED.

The coal of the different groups has certain physical properties which, taken collectively, serve as a practical basis of considerable value for determining the character of the coal. The more important of these properties are as follows:¹ (*a*) Color: (1) of the coal, (2) of the streak, and (3) of the powder; (*b*) luster; (*c*) structure: (1) beds and (2) joints; (*d*) texture; (*e*) fracture; (*f*) coherence; (*g*) adherence of powder; (*h*) flexibility; (*i*) elasticity; (*j*) hardness; (*k*) impact; (*l*) specific gravity, and (*m*) mineral accessories. To these properties may be added those which result from combustion—kind of flame, odor of smoke, and character of ash. Tests for most of these physical properties were made by the writer on about 100 samples during the field season and on about 20 other samples while in the office.

The color of the coal ranges from pitch black to brownish black. Anthracite coal and the best grade of bituminous coal are pitch black. Impure bituminous coal, or bituminous coal with which a large amount of ash is intimately mixed, and subbituminous coals are grayish black, although fresh fractures of high-grade subbituminous coal are pitch black. Lignite has a distinctly brownish tinge. Coal from the vicinity of Centralia and Chehalis has only a faint touch of brown, and the classification of this coal is doubtful because it is very near the boundary line between low-grade subbituminous coal and high-grade lignite. No true brown lignite was observed by the writer.

The color of the streak on unglazed porcelain varies from black through dark brown and reddish brown to a light brown which is nearly yellow, and its relative blackness appears to indicate approximately the comparative value of the coal. Anthracite and the highest grade of bituminous coal have a black streak. Bituminous coal has

¹ This list of physical properties is taken from a table made by a committee of geologists of the United States Geological Survey after extended experimentation with coal from all parts of the United States. The table is issued in pamphlet form for the field use of the members of the Federal Survey.

a dark-brown streak—the darker the streak the better the coal. Subbituminous coal and high-grade lignite have a reddish-brown streak; the darker color is characteristic of subbituminous coal and the lighter color of high-grade lignite. The change of the reddish-brown streak from dark to light is approximately in proportion to the decrease in heating value and the increase in the moisture content of the coal. The only light-brown streak is given by the cannel-like coal which occurs in pockets and lenses in the low-grade subbituminous coal near Centralia. The streak of this coal is nearly yellow. In general a large amount of ash intimately mixed with coal will produce a lighter streak than that given by a sample of the same grade of coal which does not contain so much ash. The difference of intensity of color of the streak of bituminous coal in different parts of the same bed is possibly due to the presence of ash in varying proportions.

The color of the powder ranges from black to reddish brown. With the powder as with the streaks, the degree of blackness seems to indicate approximately the quality of the coal, and the same general range of color applies to about the same classes of coal, except that the color of the powder is never so intense as that of the streak. Ash affects the color of the powder of bituminous coal much as it affects the color of the streak.

The difference in luster does not seem to follow closely the change in quality of the coals, although it serves to distinguish certain classes. With few exceptions anthracite and high-grade coking coals have a vitreous luster. Low-grade bituminous coal or coals having a high ash content have a vitreous luster not nearly so bright as that of the better grades. Subbituminous coal may have a slightly vitreous luster when freshly fractured, but it becomes dull on weathering. Coal from the vicinity of Centralia and Chehalis, when freshly fractured, has a dull, slightly satiny luster, which becomes dull and earthy in a short time. The luster of a fresh surface resembles that of impure cannel coal.

The bedding does not vary with the character of the coal. The anthracite and bituminous coals of the State have a bedded and banded structure. Some of the bituminous coals have a foliated structure, but this foliation occurs only in regions of extreme folding. In many places, notably near Centralia and Chehalis, subbituminous coal has massive structure.

The joints of the coal of the different groups are similar within the group. In the anthracite beds only the major joints are visible. The coal is considerably crushed in places and has irregular diagonal slips. The joints of the coking coal are very prominently developed, and the minor joints are so prominent that it is difficult to distinguish a system of major joints except where they pass through bony layers

or extend into the roof or floor. In many places the coal is so badly broken that it can be easily crushed in the hand. The noncoking bituminous coal has well-developed major joints. The face cleats (joints), which frequently extend into the roof and floor, are usually either in the direction of the dip or at a small angle from it, and the butt cleats are nearly at right angles to the face cleats. The development of the major joints is more prominent in coal low in intrinsic ash—that is, ash intimately mixed with the coal—than in bony coal. The major joints range from an inch to about 2 feet apart. These are much more prominent in the purer coals, and they are scarcely developed at all in the very bony coals. The subbituminous coal is generally broken by major joints, but the joints are much farther apart than in bituminous coal having the same percentage of intrinsic ash. The face joints are the more perfectly developed and usually occur from 6 inches to a foot apart. The butt joints are generally very poorly developed, as are also the minor joints in the few places where they are present. The low-grade coal near Centralia and Chehalis has a system of major joints, in places well developed, corresponding approximately to the dip. The joints are usually a foot or more apart, but may be found only an inch or two apart. The butt joints are scarcely noticeable, so that the coal breaks with a splintery end between the face joints. So far as the writer observed, minor joints are absent.

The texture of the coal appears to change with the ash content, and the differences are probably due to the manner of the original deposition of the coal. Pure anthracite has a dense texture. Bony coal associated with anthracite consists of layers of pure coal and of bony shale which give the whole a laminated texture. Good coking coal is so minutely jointed that it is difficult to determine the texture, and noncoking bituminous coal is laminated in proportion to the amount of intrinsic ash. Subbituminous coal is generally laminated, although in places the lower grades show a woody texture. The texture of the coal in the vicinity of Centralia and Chehalis appears, at a casual glance, to be almost earthy, but close examination shows it to be slightly woody.

The fracture varies considerably, but is generally uniform in the same group. It appears to vary with the hardness, the amount of ash, and the amount of moisture. Anthracite has an irregular conchoidal fracture with very bright faces and sharp edges, which becomes splintery where there are bony layers. Bituminous coking coal has a cubical fracture, which is somewhat hackly where the joints are oblique. Bituminous noncoking coals have an irregular fracture which becomes progressively more splintery as the amount of intrinsic ash present in the coal increases. Subbituminous coals exhibit irregular conchoidal fracture, the amount of irregularity being

about in inverse proportion to the amount of moisture. The fracture of the coal near Chehalis and Centralia is somewhat conchoidal, but mostly splintery. This coal resembles cannel coal in physical appearance and this similarity probably explains the character of the fracture.

The coherence of the coal varies with the amount of ash and the degree of devolatilization or metamorphism. Coals high in ash are generally tough. Coals low in ash which have been altered to a good grade of bituminous or anthracite are generally brittle. Bituminous coking coal is as a rule very crumbly. Coal low in ash and high in moisture is generally, but not invariably, tough.

As explained on page 31, the adhesive power of the powder is in direct proportion to the coking quality of the coal. Anthracite coal does not adhere at all. The adhesive power of bituminous coking coal ranges from medium to good. Many bituminous coals show slight coking tendencies, and their powder adheres slightly, but they will not produce commercial coke. The other bituminous coals and the subbituminous coal give powders which do not adhere, but which pack to a greater or less degree between the mortar and the pestle.

The elasticity of coal appears to depend both on its hardness and on the amount of moisture it contains. Anthracite is fairly elastic. Medium-grade bituminous coal, notably that from Roslyn and the vicinity of Black Diamond and Bayne, is very elastic. The pick, if not properly sharpened and squared, will often rebound from a face of these coals without cutting at all, and sometimes the strength of the recoil is very noticeable. High-grade bituminous coal which is finely jointed does not show elasticity because of the closeness of the joints and the distribution of the force of impact they effect. The elasticity of subbituminous coal and lignite probably increases with the amount of moisture.

The hardness of the coal appears to vary directly with the amount of devolatilization or metamorphism, and inversely with the moisture content. As a rule the higher the percentage of fixed carbon and the lower the percentage of ash the harder is the coal; a notable exception among the Washington coals is that of the Fuca mine, Clallam County. This coal is somewhat high in moisture and very low in fixed carbon, which is only 90 per cent of the amount of volatile matter, but fresh samples compare favorably in hardness with the best grade of bituminous coal in the State.

The character of the impact depends on the hardness and the jointing of the coal. In general, the harder the coal the more metallic will be the impact, and the softer the coal and the more frequent the joints the duller will be the impact.

The specific gravity of the coal depends on the amount and kind of ash, the absence of moisture, the extent of devolatilization, and

consequently on the percentage of fixed carbon. Anthracite has a specific gravity at least 10 per cent greater than bituminous coal, and bituminous coal a somewhat higher specific gravity than subbituminous coal and lignite. The bituminous coals of the State which are high in ash have a high specific gravity, as is shown by the greater specific gravity of the bony layers that are separated from the purer coal by washing. Coal containing a large amount of moisture is low in specific gravity, because the moisture, which forms a definite part of the mass, has a lower specific gravity than the average of the other constituents of coal which it replaces.

The mineral accessories vary considerably, but none except resin indicate the character of the coal. Resin was not found in the State by the writer except in coal that is only slightly altered from its original state of deposition, such as the low-grade subbituminous coal of Thurston, Lewis, and Cowlitz counties, and to some extent the high-grade subbituminous coal of Lewis, Thurston, and King counties. Sulphur is found in coal of all kinds, from lignite to anthracite; the largest amount is found in the Fuca coal, which in the sample analyzed contains 5.97 per cent. In this bed the sulphur is disseminated through the coal, or occurs as thin lenses of marcasite or pyrite and as "nigger-heads" in places several feet in maximum diameter. In the other coals the sulphur usually occurs in "sulphur" balls and "nigger-heads" of varying sizes. The presence of mineral charcoal in the beds was not observed.

The character of the flame depends on the amount and character of the volatile combustible. Anthracite, which has a low percentage of volatile combustible, burns with a short blue flame, and oxidation of the combustible matter is practically complete. As a rule the bituminous coal of the State has a high percentage of volatile combustible. It burns with a long yellow flame and produces a large amount of smoke in an ordinary furnace. Under forced draft it produces a very high temperature in the uptake. Subbituminous coal and lignite also have a large percentage of volatile combustible and burn with a long yellow flame and the accompanying large amount of soot and smoke.

The odor of the gases resulting from the combustion of anthracite coal is mostly sulphurous. The prominence of this odor is probably due to the relatively small percentage of hydrocarbons in the coal. The odor of gases from bituminous and subbituminous coals is bituminous and is due to their large content of hydrocarbons, although sulphur frequently occurs in sufficient quantities to be distinctly noticeable. Lignite gives out, in combustion, an odor between bituminous and resinous.

The character and amount of ash depend on the amount of the original ash of the vegetable matter and on the amount of extraneous mineral matter represented by such impurities as partings, lenses,

“sulphur” balls, and roof and floor rock, which can not be readily separated in mining the coal and preparing it for market. Except in a very few of the high-grade bituminous coals and the low-grade coal in the vicinity of Chehalis, the amount of ash is generally medium or high. Coals having a white ash contain only a small amount of iron; a red ash indicates the presence of a larger quantity. The tendency of coal to clinker is believed to be due to the fusibility of the iron in the ash. Inasmuch as the use of coal for some purposes depends to a considerable extent on freedom from clinkers, coal having a white or light-colored ash is preferable to coal forming darker ashes. The fineness or coarseness of the ash depends to a considerable extent on the amount of intrinsic ash of the coal; those coals which have a low percentage of such ash burn completely, leaving a powder, and those which have a high percentage do not burn completely, but leave what is called a “core.”

SUMMARY.

Anthracite coal has the following characteristic physical properties: Black color, streak, and powder; pitch black, brilliant luster; massive or bedded structure with only major joints; dense texture; irregular conchoidal fracture with very bright faces and sharp edges; considerable elasticity; very hard, distinct, metallic ring on impact; high specific gravity; short blue flame with relatively little odor and no smoke on combustion.

Bituminous coal has the following characteristics: Black color and dark-brown streak and powder; bright vitreous or dull luster; structure generally banded by layers of slightly different character and more or less broken by joints; texture locally dense, but usually banded in proportion to the amount of intimately mixed ash; fracture varying from cubic through hackly and irregular to splintery; adherence of powder proportional to the coking quality of the coal; elasticity depending on the purity of the coal and the absence of joints; hardness variable but generally intermediate between that of anthracite and that of subbituminous coal; impact dependent on joints and less metallic than that of anthracite; specific gravity somewhat less than that of anthracite and greater than that of subbituminous coal; long flame and considerable smoke, with a distinctly bituminous odor on combustion.

Subbituminous coal exhibits the following characteristic physical properties: Black color, with a reddish-brown streak and powder; massive structure, in places slightly bedded and generally free from minor joints; laminated, woody, or earthy texture; fracture generally conchoidal, but in some varieties cubical; adherence of powder very slight; considerable elasticity; hardness in inverse ratio to the moisture content; dull impact; low specific gravity; occasional occurrence of resin; long yellow, smoky, resinous or bituminous flame on combustion

and "slacking" on exposure to the air through loss of moisture. In point of coherences the coal is generally tough, but it may occasionally be brittle.

Lignite has the following physical properties: Brown color, with reddish-brown streak and powder; dull, woody, or earthy luster, in places slightly satiny, resembling cannel, when freshly fractured; massive structure between partings; structure having only large joints; fracture generally conchoidal, but locally splintery, resembling cannel; coherence usually tough; no adherence of powder; elasticity noticeably high; dull impact; low specific gravity; frequent occurrence of resin; long yellow, very sooty and smoky flame on combustion.

EFFECT OF EXPOSURE ON MOISTURE.

Coal high in moisture gives up a small percentage of moisture on exposure to the air when not kept continually wet by precipitation or by artificial means. It is also believed that subbituminous coal and lignite, which have a very large percentage of moisture, give up a much larger amount if exposed immediately to dry air or the sun than they do after standing for some time exposed to mine air or moist air or after weathering when not exposed to excessive drying.

Two samples (Nos. 9089 and 9573) from the upper bench of the Hannaford mine at Tono were collected from the same face. Sample No. 9089 was perfectly fresh. It was obtained when the top coal was being drawn in a room of the lower bench. The can containing the sample was broken, however, in transit, exposing for only a few hours the sample to the atmosphere of a small mail sack which was not exposed to the sun. The coal was then transferred to a new can and sealed air tight. The work in this room of the mine was abandoned soon after the writer's visit. Nine weeks later a second visit was made to the mine to obtain another sample. The original channel from which the first sample was obtained was found intact. Two inches of the coal to the right of the channel was removed, after which the second sample (No. 9573) was cut by channeling across this face in the same manner as before. This sample was exposed to the mine air about nine weeks and was, therefore, presumably slightly weathered. The total moisture content, however, of the two samples was nearly the same, and is about the same as in other samples obtained in this mine. This indicates that very little moisture evaporated from the coal during its exposure to the mine atmosphere. A computation from the moisture content of the two samples shows that 23.8 per cent of the total moisture of the first sample (No. 9089) was retained after air drying, as compared with 66.5 per cent of the second sample (No. 9573). In the other samples the amount of moisture retained was as follows: No. 9095, 26.3 per cent; No. 9094, 24.3 per cent; No. 9096, 26.4 per cent. The average of the three is

25.7 per cent. In July two cars of run-of-mine coal from the lower bench were shipped from the mine to Pittsburg, Pa., and the analysis (No. 8752) of the coal as it reached the laboratory is given in the accompanying table (p. 75). This analysis shows that 71.9 per cent of the total moisture which reached the laboratory was retained on air drying, or 58.7 per cent of the total moisture which left the mine, which is about $2\frac{1}{2}$ times the average held by the mine samples.

M. R. Campbell referred the writer to a similar change which took place in a car sample of North Dakota lignite collected by him in 1905 and tested at the fuel-testing plant of the United States Geological Survey at St. Louis, Mo.¹ In two mine samples, No. 1971 retained 15.4 per cent of the total moisture on air drying and No. 1972 retained 20.8 per cent. A car sample contained 68.1 per cent of its total moisture after air drying, or about 47.3 per cent of the total moisture it contained before drying in transit and storage. Campbell reports that the coal was shipped in a closed car from the mine to St. Louis, but that all the storage bins were full when it arrived at the laboratory and the sample was dumped in a pile in the open air. It had stood exposed to the air for some time when it was finally analyzed and tested.

The effect of exposure during transportation on carload samples of the same kind of coal is shown by the test and analyses of the other samples from North Dakota in the same report. In a mine sample (No. 1730) 19.5 per cent of the original moisture was retained, but in the carload sample No. 2365 from the same mine 52.1 per cent of the moisture content of the coal on arrival at the laboratory, or 42.5 per cent of the content when the coal left the mine, was retained after air drying. Mine samples Nos. 1935 and 1938 and car sample No. 2243 were taken from another mine. Sample No. 1935 retained 20.3 per cent and No. 1938 held 20 per cent of the moisture after air drying. The car sample No. 2243 retained 64.7 per cent of the moisture that reached the laboratory or 53.5 per cent of the moisture that left the mine.

The result of these comparisons indicates that subbituminous coal and lignite which contain a large amount of moisture give up a greater percentage of their moisture in the laboratory process of air drying, if taken from a fresh face and sent immediately from the mine to the laboratory in air-tight cans, than they do if exposed to the circulation of air in the mine, or in transit to the laboratory, or in storage while awaiting analysis.

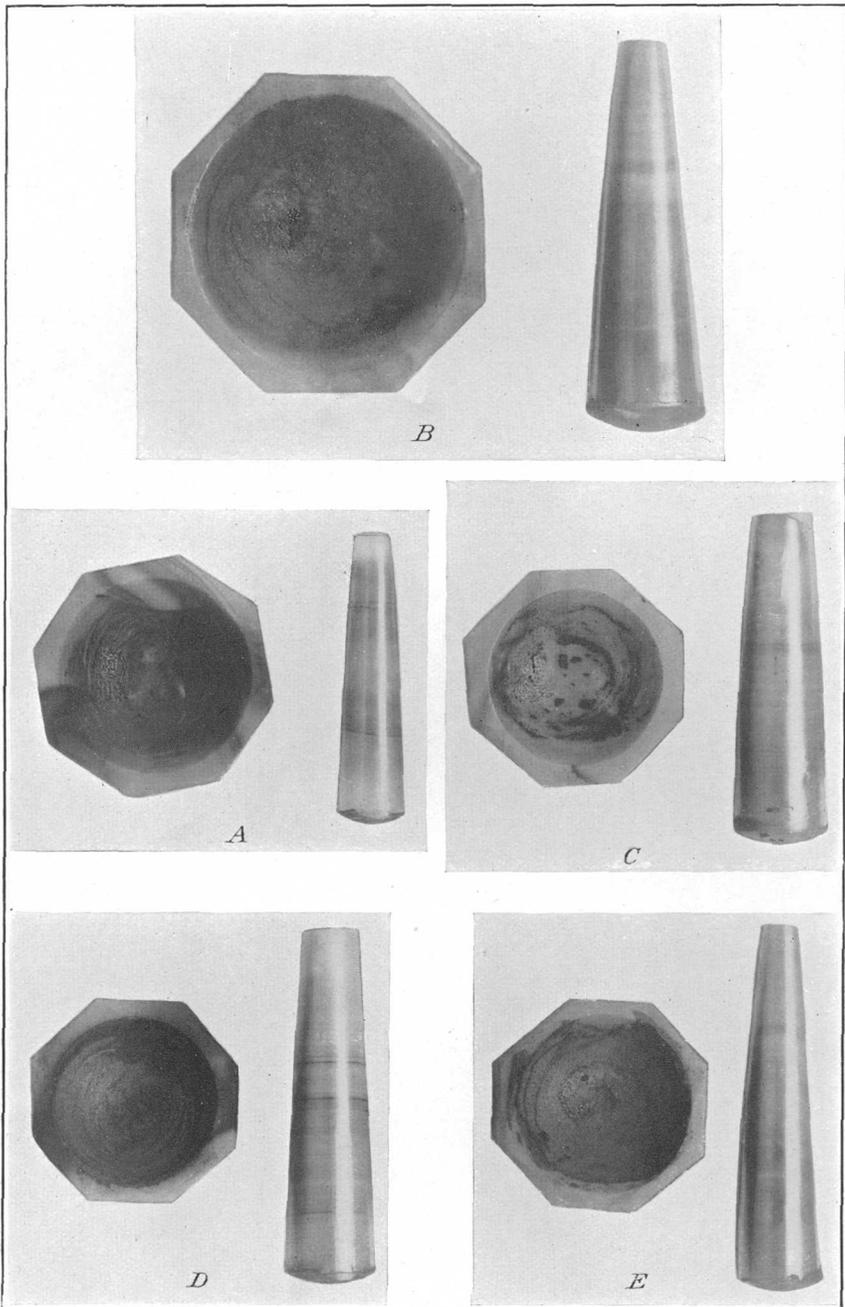
The conclusion is that upon exposure to the atmosphere in the mine, in transportation, or in storage, the relation to the coal of at least a part of the moisture content is so altered that it is not given up readily in the ordinary method of air drying. It is not known whether

¹ Preliminary report on the operations of the fuel-testing plant of the United States Geological Survey at St. Louis, Mo., 1905; Bull. U. S. Geol. Survey No. 290, 1906, p. 135.

this is a physical or a chemical change. It is hoped that experimentation will be carried on which will determine the character of this alteration.

Inasmuch as the amount of weathering and the amount of moisture retained by the weathered sample will vary with an innumerable combination of conditions, the only uniformity in the air-drying loss of low-grade coal will be found in samples from unweathered coal analyzed as soon as received at the laboratory. The air contained in the interstices of the coal in the can probably has some effect on the moisture, but if the sample is ground in the mine so as to pass through a $\frac{1}{4}$ -inch to $\frac{1}{2}$ -inch mesh and packed in the can the amount of air is reduced nearly to a minimum. A finer reduction of the fragments would probably allow the air in the pore spaces to affect the finer particles more readily, since the mass of a fragment is much smaller in proportion to its diameter and the surface exposed to the air is much greater in proportion to the mass in small pieces of coal than in large pieces. A mixture of large pieces with the spaces packed with smaller fragments would be the best way of reducing the effect of the air to a minimum, but this method would not produce a representative sample and consequently should not be used.

Samples of coal high in moisture, analyzed in commercial laboratories, show considerable variation in the amount of moisture from the same mine, due probably to different methods of sampling, to drying in transit, and to alteration of the relation of the moisture to the coal by exposure to the air—all causes which may be ultimately reduced to lack of uniformity in the methods of sampling and transportation to the laboratory. Discrepancies are generally due to the following circumstances: (1) Samples are not taken from fresh faces of unweathered coal; (2) samples are not cut uniformly from the face of the coal; (3) the coal is not ground and sealed in the mine or under atmospheric conditions similar to those existing at the face where the sample was taken; (4) the coal is not always ground and sealed immediately after being cut and is frequently exposed to the air for a considerable length of time; (5) the coal is not always pulverized to the same size and thoroughly mixed, quartered, and packed in an air-tight can; (6) the sample is not always sealed in an air-tight can packed full, but is frequently shipped to the laboratory in a box or sack which admits of more or less circulation of the atmosphere; (7) the sample is not always sent so as to reach the laboratory in the shortest possible time and is therefore exposed to the air for varying lengths of time; (8) the coal is not always analyzed as soon as it reaches the laboratory. It is hoped that in the future commercial samples will be taken by the method herein described, so that the results will be mutually comparable, as well as comparable with the Government work.



MORTARS AND PESTLES.

- A. Showing adherence of powder of coal from the Roslyn bed at Clealum, Kittitas County.
 B. Showing adherence of powder of coal from the Roslyn bed at Beekman, Kittitas County.
 C. Showing poor adherence of powder of noncoking bituminous coals.
 D. Showing adherence of powder of the best coking coals of Washington.
 E. Showing adherence of powder of Pocahontas (West Virginia) coal.

COKING COAL OF WASHINGTON BY PISHEL TEST.

M. A. Pishel¹ found by experimentation on a large number of samples of coal from different parts of the United States that the best coking coal, when finely pulverized in an agate mortar, adheres very strongly both to the mortar and to the pestle and can be removed only by rubbing or washing, and that noncoking coal does not adhere either to the mortar or to the pestle. This test was applied to nearly all the coals sampled by the writer. In making the test a dry sample is selected from each bench in the bed, or from each part of a bench if the bed is not uniform. A small quantity of the coal is pulverized in a mortar until it will pass through a 100-mesh sieve, and after the pulverized coal has been poured from the mortar the amount and character of the adhesion of the powder to the pestle and the mortar are observed. Stages of adhesion range from that of a deep covering of greasy or gummy powder, resembling iron filings clustered on the poles of a magnet, which adheres so strongly to the surface that it can be removed with difficulty, to that of thin films of powder which will scarcely soil the finger. Between these two extremes was found to be complete gradation. Coal which adhered fairly well was found to produce a fair grade of coke. Coal which adhered only slightly formed a poorer grade of coke and then only under the most favorable conditions for coking. The scale of adhesion given by Pishel in describing his test is used in Table 3 of this report. By this scale coking coals are graded in respect to coking qualities as poor, medium, good, and excellent.

The author experimented while in the field with mortars of different composition to ascertain if possible whether the coal would adhere to substances other than agate. Porcelain, glass, earthenware, and iron mortars were used, and the powder of coking coal adhered to all; the powder adhered to a piece of flat glass just as well as to the mortar, but it was more difficult to reduce the powder to the proper degree of fineness on the flat surface. It appears that a powder must be of a certain degree of fineness in order to show the property of adhesion. Pocahontas (W. Va.) coal, powdered both on smooth and rough surfaces, was found to adhere provided the surface was not too soft or too rough to admit of the reduction of the particles to the proper size. In general a hard smooth surface is preferable, because the use of such a surface insures a finer and more uniform powder. (See Pl. II.)

The following table shows the results of the tests on the bituminous coals of Washington examined and on a sample of Pocahontas coal from Virginia:

¹ A practical test for coking coals: *Econ. Geology*, vol. 3, 1908, pp. 265-275.

Do.	Do.	Do.	Upper McKay	Good	do.	do.	Has been coked.
Northwestern Improvement Co. No. 3.	Ronald	do.	Roslyn	Medium	do.	do.	Do.
Northwestern Improvement Co. No. 2.	Roslyn	do.	do.	do.	do.	do.	Do.
Northwestern Improvement Co. No. 4.	do.	do.	do.	Poor	do.	do.	Cokes slightly on forge.
Northwestern Improvement Co. No. 5.	do.	do.	do.	do.	do.	do.	Strong sinter.
Northwestern Improvement Co. No. 7.	Cleatun	do.	do.	do.	do.	do.	Weak sinter.
Northwestern Improvement Co. No. 1.	Ashford	do.	No. 1	Good	do.	do.	Has been coked.
Northwestern Iron & Steel Co.	Bayne	do.	No. 2	do.	do.	do.	Cokes on forge.
Occidental Colliery Co.	do.	do.	No. 3	do.	do.	do.	Do.
Do.	do.	do.	No. 6	Poor	do.	do.	Do.
Do.	do.	do.	No. 14, lower bench	Good	do.	do.	Do.
Do.	do.	do.	No. 14, upper bench	do.	do.	do.	Do.
Pacific Coal & Oil Co.	Wilkeson	do.	No. 2	do.	do.	do.	Do.
Pacific Coast Coal Co.	Burnett	do.	No. 3	Good	do.	do.	Do.
Do.	do.	do.	No. 3	do.	do.	do.	Do.
Do.	Franklin	do.	Gem	Poor	do.	do.	Has been coked.
Do.	do.	do.	McKay	do.	do.	do.	Do.
Do.	do.	do.	Upper McKay	do.	do.	do.	Do.
Rose-Marshall Coal Co.	Cumberland	do.	Harris	Medium	do.	do.	Do.
Roslyn Cascade Coal Co.	Ronald	do.	Roslyn	Good	do.	do.	Do.
Do.	do.	do.	Lower	do.	do.	do.	Do.
Roslyn Fuel Co.	Beekman	do.	Roslyn	do.	do.	do.	Do.
Sunset Coal Co.	Cumberland	do.	No. 1	Poor	do.	do.	Cokes on forge.
Do.	do.	do.	No. 2	do.	do.	do.	Do.
Do.	do.	do.	No. 3	Medium	do.	do.	Do.
Surface exposure	Palmer Junction	do.	No. 3	Poor	do.	do.	Cokes on forge.
Tacoma Smelting Co.	Fairfax	do.	No. 7	do.	do.	do.	Is coked.
Do.	do.	do.	Blacksmith	Good	do.	do.	Do.
Do.	do.	do.	do.	do.	do.	do.	Cokes on forge.
Tunnel, sec. 21, T. 21 N., R. 7 E.	Bayne	do.	No. 3	do.	do.	do.	Has been coked.
United Collieries Co.	Snoqualmie	do.	No. 4	do.	do.	do.	Do.
Do.	do.	do.	No. 5	do.	do.	do.	Do.
Do.	do.	do.	No. 2	do.	do.	do.	Is coked.
Wilkeson Coal & Coke Co.	Wilkeson	do.	No. 3	do.	do.	do.	Do.
Do.	do.	do.	No. 7	do.	do.	do.	Do.
Do.	do.	do.	do.	do.	do.	do.	Has been coked.

^a Semibituminous.

IMPURITIES.

The impurities which have the most important effect upon the quality and commercial value of the Washington coals are sulphur, moisture, and ash.

SULPHUR.

The amount of sulphur in the coal of this State is generally very small. Only a few samples show more than 2 per cent. The sulphur is either disseminated through the main mass of the coal, or occurs in the form of lenses, nodules, and irregular masses of marcasite or pyrite. In the latter form the marcasite or pyrite is associated with other minerals, such as silica and iron, and is considered as ash when its amount is too small to be easily removed in preparing the coal for the market.

MOISTURE.

Moisture is present in amounts depending on the metamorphism of the coal. Anthracite has very little moisture. Bituminous coal has from 2 to 12 per cent, about half of which is given up on air drying. Subbituminous coal has from 9 to 25 per cent of moisture; and gives up from one-third to three-fourths of this when air-dried. As a general rule coal that is high in moisture slacks on exposure to air and sparks readily under forced draft. It is therefore of much less commercial value than coal that is low in moisture.

ASH.

The amount of ash in a coal and its condition and origin have very great effects both on the preparation of the coal for use and on its market value, and accordingly the cost of reducing the amount of ash in a coal as it is mined is one of the most important factors in determining the economic value of a coal bed. Washington coal as it comes from the mine has a large amount of ash, due to varying combinations of inorganic material derived from the vegetable matter from which the coal was formed, extraneous material which became mixed more or less intimately with the carbonaceous material during accumulation, vein material deposited after the coal was formed, and broken or shaly roof or floor material that "slacks," scales off, or mixes with the coal in mining.

The ash derived from the vegetal material which formed the coal consists of the remains of the organisms contributory to the formation of the coal, and it may be termed "original" or "residual." Those plants which contain a large amount of inorganic material will tend to produce a coal of high ash content, other conditions being equal.

Addition to the residual ash is brought about by several processes and conditions. The rate of accumulation of the layers of peat from which the coal was formed is one of the factors. If a layer 1 inch thick accumulates in so short a time that the organic matter does not have a chance to decay, the resulting coal will be lower in ash than if the layer had resulted from a relatively long period of accumulation and far advanced decay.

Ash that is more or less intimately mixed with the coal but not derived from the original organic débris is either of eolian origin or has been laid down as sediment or deposited from solution. In some places ash of this kind has been deposited in the form of minute veins by precipitation from mineralized waters after the coal was formed. Many beds of peat, such as those of the northern part of Iowa and those of the salt marshes bordering the Atlantic coast, contain a large amount of ash in the form of dust or sand derived from the adjoining regions. The amount of meteoric material included in coal depends on the length of time required for the deposition of the organic material; on whether climatic, physiographic, and geologic conditions of the adjoining region were favorable to slow or rapid formation of dust or sand; and on whether meteoric conditions were favorable to the transportation of dust to the bog or marsh in which the coal measures were forming.

The intimately mixed ash resulting from sedimentation is brought from adjacent land areas by surface waters. This sediment is usually very fine and is deposited as silt in the interstices between the fragments of organic material as they accumulate in the bog or marsh. A very small amount of this extraneous matter is not visible in coal, but larger amounts produce the various stages of impure coal, bony coal, bone, carbonaceous shale, and the like.

Incoming water carries in solution varying quantities of mineral matter. If the water of the bog or marsh is not drained off, but is removed by evaporation, the minerals will sooner or later reach their saturation point and will be precipitated, forming minerals that mix with the particles of organic material and form a part of the ash.

The ash that is separate from the coal occurs as partings, lenses, nodules, concretions, and veins. It originates at the time of the formation of the coal, in part from eolian or meteoric dust or sand, but principally from mineral matter dissolved or suspended in water. It may also be formed in the bed after the organic material has been deposited during the different stages in the alteration of the coal.

If at any time in the formation of a coal bed conditions are such that the organic material in the bog or marsh decays completely, the ash of the bed will accumulate in a layer free from carbonaceous matter. This layer will be a parting in the bed if it is not removed before

the further deposition of the coal-forming substances. If conditions for a short time allow the carrying of extraneous material into the area of accumulation greatly in excess of the rate of formation of the coal, it will be deposited in a layer or lens in the coal.

In places small veins of calcite, selenite, quartz, or other minerals occur in the coal. These veins probably originate by deposition from mineralized water in the joints of the coal at some stage in its devolatilization or development. In the State of Washington veins of calcite up to half an inch in thickness occur in the lower part of the bed No. 2 at the Ladd mine (p. 160). Ash also occurs in the form of nodules, such as "niggerheads" and "sulphur" balls. The mode of origin of these nodules is not known, although it is believed that they were formed during the deposition or subsequent to the formation of the coal. They vary from a fraction of an inch to several feet in maximum diameter. Several layers of this material occur in the Roslyn bed as definite partings and extend for some distance. The great specific gravity of impurities of this kind, together with their other physical characteristics, makes it possible to separate them from the lighter coal by washing and from the lump coal by picking.

The amount of ash in commercial coal depends to a large extent on the character of the roof and floor and the amount and prominence of the joints. In some of the mines in the area of low-grade coal in Thurston, Lewis, and Cowlitz counties the rocks overlying and underlying the beds are very poorly indurated and are consequently mixed with the coal in mining. In some places the rocks are indurated, but they disintegrate on exposure and break off in slabs which mingle with the coal. Unless great care is taken to remove this extraneous material, the amount of ash is likely to be so large as to materially reduce the value of the commercial coal. In the areas of high-grade bituminous coking coals the coal is minutely jointed. The joints affect not only the coal, but many of the partings, and frequently the roof and floor, so that it requires the most refined methods of washing to remove the impurities that become mixed with the coal during the process of mining.

With very few exceptions, the Washington coal beds contain one or more partings of sand, shale, or clay, some of which material mixes with the coal in mining and therefore increases the ash in the commercial coal. The percentages of ash in the analyses accompanying this report are almost invariably higher than they would have been if clean coal had been taken. The partings are either too thin to be removed economically or they resemble the coal so closely in physical properties that they can not be completely separated by any method so far devised.

COMPARATIVE QUALITY AND DISTRIBUTION OF THE COALS.

The coal of the State ranges from low-grade subbituminous to anthracite. In general, variation in the character and quality of the coals is regional rather than local, although many of the beds are locally burned out or altered to coke. In his reports on Washington coal, Willis ¹ makes the following statement regarding the coal in the Green River district near Black Diamond: "Beyond the area of this mechanical influence the coal changes into lignite by transition within a single bed." The name of the bed concerning which this statement was made is not given. The writer looked for evidence to verify this statement while in the field, but was unable to find any. It seems possible from Willis's report that he considered that the subbituminous bed at Danville might be the continuation of the McKay bed at Black Diamond. The identity of these two beds has not been established, and at present all the evidence available points to the conclusion that they are different beds. In general, anthracite and bituminous coal occur nearer the main axis of the Cascade Mountains, and subbituminous coal occurs farther from the range and nearer the center of the Puget Sound depression. In the depression between Puget Sound and Columbia River the coal is subbituminous. None of the coals at the mines and prospects visited by the writer were typical brown lignite. The coal at the Union Coal Co.'s mine, near Littell, and that in Cowlitz County are brownish black in color, and probably they are nearest to true lignite. The coal at the Hannaford mine, at Tono, is the only distinctly subbituminous coal in the district. The Mendota coal is on the border line between the two groups, but should probably be classed as a low-grade subbituminous coal. It is slightly brownish black, contains much more moisture than the average subbituminous coal, and much less moisture than the lignite of North Dakota. In the western part of King County subbituminous coal occurs in an area lying between Renton, Danville, and sec. 13, T. 24 N., R. 6 E. This coal is grayish black, contains a large amount of moisture, and slacks when exposed to the direct rays of the sun. East of this area and south of Snoqualmie River, in King County, most of the coal is bituminous except where it is altered locally by igneous action to coke. At Kummer, south of Franklin, several beds contain a large amount of moisture and slack on exposure to the sun. The coal of Kittitas and Pierce counties is bituminous. In Pierce County the coal from the lower part of the formation carries less ash and has a greater heating value than that from beds higher in the formation. The bituminous coal

¹ Willis, Bailey, Some coal fields of Puget Sound: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 402, and Willis, Bailey, and Smith, G. O., Tacoma folio (No. 54), Geol. Atlas U. S., U. S. Geol. Survey, 1899.

at Ladd appears to be the southward continuation of the bituminous area of Pierce County. The coal of Clallam County has been described in previous reports as lignite, but the coal of that area with which the writer is familiar lacks the physical properties of lignite and should be classed as bituminous. It is possible, however, that coal from other beds in the district is subbituminous or even lignite. The coal of the Bellingham and Skagit River regions is reported much jointed, very friable, and so high in fixed carbon that it is considered a very good grade of bituminous or, possibly, semibituminous coal. Specimens of coal from Skagit County, which the writer saw at the Alaska-Yukon-Pacific Exposition, indicated that it was nearer semibituminous than any other coal seen in the State. The anthracite district at the head of Cowlitz River, in Lewis County, is the only one visited by the writer, although a second anthracite area is reported on Glacier Creek, near Mount Baker, in Whatcom County.

COMMERCIAL USE OF THE COAL.

The commercial value of the Washington coal depends chiefly on the composition of the particular coals and on the distance of the mine from markets.

The anthracite is not used at the present time for lack of transportation facilities. The demand for anthracite for domestic use is great, but the prevailing price is so high that the better grades of bituminous coal must be utilized instead.

The bituminous coal has various uses. The coals from the McKay field in King County, from Pittsburg and the easternmost beds at South Willis, from beds Nos. 3 and 4 at Ladd, and from the Roslyn bed at Clealum and Roslyn are free burning and noncoking. They burn rapidly and produce a very hot fire, but the fire must be fed more frequently and with smaller quantities of coal than when coking coal is used. Coals of this type that are not too high in ash have a good heating value, and are valuable for domestic use and for generating steam, and the Roslyn coal is used extensively in the eastern part of the State. The coals from the remainder of the eastern part of King County, from the rest of Pierce County, from bed No. 2 at Ladd, from Cokedale, in Skagit County, and from the west end of the Roslyn field coke to a greater or less degree. Coal from Cokedale, Snoqualmie, Burnett, Wilkeson, Carbonado, Fairfax, Montezuma, and bed No. 2 at Ladd have been used for coking, and at the present time practically the entire output of the Wilkeson, Fairfax, and Montezuma mines is being used in the manufacture of metallurgical and foundry coke. Coke of various grades has been made from the other coals, and those that have not been coked show fair coking tendencies by the Pishel test. (See p. 31.) All these coals are high in volatile matter and produce a hot fire; they ignite easily and, on

account of their coking tendencies, hold the fire much longer than the free-burning coals. They are used very generally for domestic purposes and for generating steam. The coal from Burnett, Wilkeson, Carbonado, the west end of the Roslyn field, and several other places in the region is used to a considerable extent in the manufacture of illuminating gas. Some of the coal, notably the washed coal from Wilkeson, Fairfax, and Montezuma, is used in blacksmithing, but the finer kinds of welding are done with coal imported from the Eastern States.

Experiments on both classes of bituminous coal, designed to test their suitability for naval use, indicate that their content of volatile combustible matter is too high to permit their use in the boilers now in service, because they produce too high temperature in the uptake and an excessive amount of soot. The introduction of furnaces that will consume the gases before they leave the combustion chamber might make possible the employment of many of these coals on naval vessels. They are now used by Pacific steamships whose requirements are not so exacting as those of the Navy, by railroads, and for domestic and commercial purposes.

Subbituminous coal is produced in the vicinity of Issaquah, Newcastle, Renton, Cedar Mountain, and Danville, in King County, and near Tono, in Thurston County. On account of the large amount of moisture in this kind of coal, it swells and crumbles readily when placed on a fire. With forced draft, the pieces resulting from the crumbling are blown out with the smoke in considerable quantities, so that much of the fuel is wasted and in inflammable structures considerable risk of fire is entailed. Owing to the high percentage of combustible volatile matter in the coal, a large amount of soot is formed and the temperature in the uptake is rather high. This coal is used mainly for domestic purposes, or by steam boilers having natural draft. A fire made with this coal in furnaces and stoves is very hot when there is sufficient natural draft but cools very rapidly when the supply of air is shut off. As a rule the coal does not hold a fire nearly so long as bituminous coal. Subbituminous coal is used by some of the steamships of the Pacific Coast Steamship Co., and to some extent by railroads, besides supplying the domestic and commercial needs of the cities and towns near Puget Sound.

The low-grade subbituminous coal from Thurston, Lewis, and Cowlitz counties is high in moisture and crumbles readily when exposed to the sun or air. It must be used within a short time after it is brought from the mine or it will crumble to pieces and fall through the grate. When placed upon a hot fire, it crumbles and swells very rapidly, and forms a great many sparks. Owing to the high percentage of volatile combustible matter contained in it a great deal of soot is formed unless proper precautions are taken to assure the complete

combustion of the gases. The great amount of moisture in this coal gives it a lower heating value than the other coals in the State, and consequently it is not in very great demand except where better coal is scarce and high in price. Most of this coal is used by the local trade or is shipped south, away from the centers of mining of the coal of better grades. It is used almost entirely for domestic purposes and for stationary boilers with natural draft.

The rapid growth in the utilization of producer gas for the generation of power is opening a way for the use of low-grade subbituminous coal and lignite. Campbell¹ sets forth the value of these low-grade coals in the production of producer gas, and points out as essential features the facts that low-grade coal yields practically double or more than double the amount of power in the producer that it will yield in a steam plant, and that low-grade fuels, such as North Dakota and Texas lignite and Florida peat, yield more power in the producer than the best West Virginia coal under the ordinary type of steam boiler. These experimental results make it hopeful that it will soon be possible to build and conduct producer plants satisfactorily on a commercial scale. Low-grade coal, which now is disposed of with difficulty, will then find a ready market.

¹ Campbell, M. R., Recent improvements in the utilization of coal: *Econ. Geology*, vol. 2, April-May, 1907.

Analyses of coal samples from the State of Washington.

[A. C. Fieldner, chemist in charge.]

Clallam County.

Name of mine or form of exposure.	Laboratory No.	Location.			Air-drying loss.	Page ^a	Form of analysis.	Proximate.				Ultimate.				Heat value.		
		Quarter.	Section.	Township.				Range.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Fuca, 6 miles east of Clallam.	10030		25	32 N.	12 W.	77	As received Air dried Dry coal Pure coal	11.2 8.1 45.0 52.5	40.0 41.4 40.8 47.5	36.2 37.5 40.8 47.5	12.57 13.01 14.16	5.10 5.28 5.75 6.70	5.97 5.79 5.33 6.21	56.70 58.70 63.88 74.42	0.90 .93 1.01 1.18	18.76 16.29 9.87 11.49	5,825 6,030 6,565 7,645	10,490 10,860 11,810 13,760

Cowlitz County.^b

Prospect 12 miles west of Kelso.	c 6760			9 N.	4 W.	79	As received Dry coal Pure coal	15.24 42.60 56.12	29.54 34.55 44.88	18.84 22.35	4.39 5.18								
Do.	d 6760			9 N.	4 W.	79	As received Dry coal Pure coal	22.22 42.81 56.12	33.30 34.86 44.88	17.87 22.33	4.03 5.18								
Do.	6761			9 N.	4 W.	79	As received Dry coal Pure coal	16.26 43.38 54.72	30.05 36.80 46.25	17.36 20.73	4.61 5.51								

King County.

Prospect 3 miles north of Issaquah.	9291	SW.	13	24 N.	6 E.	81	As received Air dried Dry coal Pure coal	17.5 8.7 44.7	31.2 34.5 44.7	38.5 42.7 55.3	12.77 14.14 15.48	0.37 .41 .53	5.85 5.28 5.60	52.11 57.71 63.17	1.08 1.31 1.55	21.72 21.26 17.58	5,185 5,740 6,285 7,435	9,330 10,330 11,310 13,380
-------------------------------------	------	-----	----	-------	------	----	---	---------------------	----------------------	----------------------	-------------------------	--------------------	----------------------	-------------------------	----------------------	-------------------------	----------------------------------	-------------------------------------

^a Section of coal bed and description of sample are given on the page indicated.
^b These analyses were not made in the fuel-testing laboratory of the Geological Survey.

^c Finely ground.
^d Coarsely ground.

Analyses of coal samples from the State of Washington—Continued.

King County—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.					Ultimate.					Heat value.	
		Quarter.	Section.	Township.				Range.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Grand Ridge, 3 miles east of Issaquah, No. 1 bed.	8544	NW.	26	24 N.	6 E.	81	As received	43.8	30.3	14.2	30.3	0.36	5.77	56.70	1.06	24.45	5.575	10,040	
								46.6	32.3	8.7	32.3	0.39	5.43	60.38	1.13	20.26	5.940	10,680	
								51.1	35.3	8.7	35.3	0.42	4.89	66.11	1.24	13.75	6,500	11,700	
Grand Ridge, 3 miles east of Issaquah, No. 2 bed.	8545	NW.	26	24 N.	6 E.	81	As received	36.1	32.4	13.8	32.4	0.49	5.64	51.24	0.95	23.98	5.075	9,140	
								37.5	33.7	10.4	33.7	0.51	5.43	53.26	0.99	21.41	5,275	9,500	
								41.9	37.6	10.4	37.6	0.57	4.77	59.43	1.10	13.60	5,885	10,600	
Grand Ridge, 3 miles east of Issaquah, No. 3 bed.	11736	NE.	26	24 N.	6 E.	81	As received	38.5	36.0	15.9	36.0	0.49	6.00	74.77	1.38	17.13	7,395	13,310	
								42.3	39.6	7.6	39.6	0.54	5.4	68.5	1.14	13.60	6,085	10,950	
								45.8	42.8	7.6	42.8	0.58	5.4	68.5	1.14	13.60	6,585	11,850	
Grand Ridge, 3 miles east of Issaquah, No. 4 bed.	11737	NE.	26	24 N.	6 E.	82	As received	30.4	33.4	15.6	33.4	0.27	5.95	51.74	1.03	26.82	5,045	9,080	
								33.6	37.0	6.6	37.0	0.51	5.15	56.15	1.13	21.05	5,515	9,920	
								36.0	39.6	6.6	39.6	0.56	5.25	63.12	1.26	13.16	6,155	11,080	
Grand Ridge, 3 miles east of Issaquah, No. 7 bed.	11738	NE.	26	24 N.	6 E.	82	As received	47.6	52.4	16.5	52.4	0.38	5.82	76.21	1.52	15.89	7,430	13,370	
								36.4	34.6	6.5	34.6	0.42	5.95	51.74	1.03	26.82	5,045	9,080	
								40.7	38.8	6.5	38.8	0.48	5.95	51.74	1.03	26.82	5,045	9,080	
Grand Ridge, 3 miles east of Issaquah, washed coal.	9883		26	24 N.	6 E.	82	As received	51.2	48.8	18.0	48.8	0.53	5.82	76.21	1.52	15.89	7,430	13,370	
								34.4	33.5	18.0	33.5	0.38	5.95	51.74	1.03	26.82	5,045	9,080	
								37.6	36.6	10.4	36.6	0.41	5.47	66.15	1.13	21.05	5,515	9,920	
Issaquah at Issaquah, No. 4 bed.	8542	NE.	33	24 N.	6 E.	83	As received	43.6	29.2	17.9	29.2	0.35	5.45	63.12	1.26	13.16	6,155	11,080	
								47.4	31.8	10.7	31.8	0.43	5.45	63.12	1.26	13.16	6,155	11,080	
								53.1	35.6	10.7	35.6	0.43	5.45	63.12	1.26	13.16	6,155	11,080	
							Pure coal	59.9	40.1	11.3	40.1	0.48	5.82	76.21	1.52	15.89	7,430	13,370	

Issaquah at Issaquah, No. 3 bed.	8543	SE.	33	24 N.	6 E.	83	6.6	As received Air dried Dry coal Pure coal	15.1 9.1	29.4 31.4 34.6 39.9	44.2 47.4 52.0 60.1	11.35 12.15 13.36	1.12 1.20 1.32 1.52	5.65 5.27 4.69 5.41	55.58 59.51 65.43 75.62	1.09 1.17 1.28 1.48	25.21 20.70 13.92 16.07	5,530 10,660 6,510 7,515
Superior, 1½ miles south-west of Issaquah, Main bed.	8548	SE.	32	24 N.	6 E.	84	5.3	As received Air dried Dry coal Pure coal	12.8 7.9	28.5 30.1 32.7 39.5	43.6 46.0 50.0 60.5	15.11 15.66 17.32	68 72 75 94	5.56 5.25 4.73 5.74	55.68 58.80 63.83 77.21	1.11 1.17 1.25 1.54	21.86 18.10 12.05 14.57	5,625 10,120 6,940 7,795
Superior, 1½ miles south-west of Issaquah, No. 0 bed.	8547	SE.	32	24 N.	6 E.	84	4.3	As received Air dried Dry coal Pure coal	12.4 8.5	29.7 31.0 33.9 41.5	41.8 43.7 47.7 58.5	16.1 16.8 18.4	1.61 1.63 1.84 2.25	5.480 5.725 6.255 7.665	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	9,820 10,310 11,260 13,800
Ford at Coal Creek, Mul- toon bed.	9163	SE.	25	24 N.	5 E.	86	9.7	As received Air dried Dry coal Pure coal	14.3 5.1	31.5 34.9 36.8 42.7	42.4 47.0 49.5 57.3	11.75 13.01 13.72 14.66	44 49 54 59	5.84 5.27 4.96 5.75	56.12 62.15 65.51 73.93	1.25 1.38 1.46 1.69	24.60 17.70 12.84 16.04	5,535 6,130 6,480 7,490
Do.....	9166	SE.	27	24 N.	5 E.	86	7.2	As received Air dried Dry coal Pure coal	13.1 6.3	34.7 37.4 39.9 46.8	39.5 42.6 45.4 53.2	12.74 13.73 14.66	71 76 82 96	5.76 5.34 4.90 5.81	56.45 60.83 64.94 76.10	1.35 1.45 1.55 1.82	22.99 17.89 12.87 13.31	5,535 5,965 6,265 7,460
Do.....	9165	SE.	26	24 N.	5 E.	86	7.1	As received Air dried Dry coal Pure coal	12.8 6.2	35.8 38.5 41.1 46.7	40.9 44.0 46.9 53.3	10.48 11.28 12.03	55 59 63 72	5.83 5.43 5.03 5.74	58.92 63.42 67.62 76.80	1.36 1.46 1.56 1.77	22.86 17.82 13.11 14.91	5,760 6,200 6,610 7,555
Ford at Coal Creek, No. 3 bed.	9168	SE.	25	24 N.	5 E.	86	8.6	As received Air dried Dry coal Pure coal	14.5 6.4	30.9 33.8 36.1 41.6	43.3 47.4 50.7 58.4	11.30 12.36 13.22	36 39 42 48	5.80 5.30 4.90 5.65	56.23 61.52 66.76 73.78	1.08 1.18 1.26 1.45	25.23 19.23 14.44 16.94	5,565 6,090 6,505 7,500
Do.....	9164	SE.	25	24 N.	5 E.	86	9.7	As received Air dried Dry coal Pure coal	14.5 5.2	32.5 35.0 38.0 41.6	45.6 50.6 53.4 58.4	7.37 8.16 8.61	42 47 49 54	5.88 5.32 4.98 5.46	59.60 66.00 73.67 82.23	1.05 1.16 1.23 1.36	25.68 18.89 13.01 16.41	5,790 6,410 6,765 7,500
Ford at Coal Creek, No. 4 bed.	9167	SE.	25	24 N.	5 E.	86	8.9	As received Air dried Dry coal Pure coal	14.8 6.5	33.3 36.5 39.1 43.3	43.6 47.9 51.2 56.7	8.26 9.07 9.70	37 41 44 49	6.03 5.53 5.14 5.69	58.48 64.19 68.64 76.01	1.34 1.47 1.57 1.74	25.52 19.35 14.51 16.97	5,685 6,240 6,675 7,380
Bagley at Coal Creek, Bag- ley No. 1 bed.	9170	SE.	26	24 N.	5 E.	87	6.6	As received Air dried Dry coal Pure coal	12.1 5.8	36.8 39.4 41.9 47.5	40.7 43.6 46.3 52.5	10.41 11.15 11.84	34 36 39 44	5.75 5.38 5.01 5.63	58.15 62.26 66.12 73.00	1.37 1.47 1.56 1.77	23.98 19.38 15.08 17.11	5,785 6,195 6,580 7,465

Analyses of coal samples from the State of Washington—Continued.
King County—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.						Heat value.			
		Quarter.	Section.	Township.				Range.	Moisture.	Volat-ile mat-ter.	Fixed car-bon.	Ash.	Sul-phur.	Hy-dro-gen.	Car-bon.	Nitro-gen.	Oxy-gen.	Calo-ries.	British thermal units.		
Bagley at Coal Creek, Bagley No. 2 bed.	9171	NE.	25	24 N.	5 E.	87	4.6	As received...	9.3	39.9	36.8	14.00	3.82	5.67	57.85	1.19	17.47	5,900	10,620		
								Air dried.....	4.9	41.9	38.5	14.68	4.00	5.41	60.64	1.25	14.02	6,185	11,140		
								Dry coal.....	44.0	40.6	15.43	4.21	5.11	63.76	1.31	10.18	6,505	11,710			
								Pure coal.....	52.1	47.9	.....	4.98	6.04	75.40	1.55	12.03	7,090	13,850		
Do.....	9169	NE.	25	24 N.	5 E.	87	7.5	As received...	12.3	36.8	39.7	11.16	89	5.77	57.75	1.21	23.22	5,735	10,320		
								Air dried.....	5.2	39.7	43.0	12.07	96	5.84	62.43	1.31	17.89	6,200	11,160		
								Dry coal.....	41.9	45.4	12.73	1.02	5.02	65.86	1.38	13.99	6,540	11,780			
								Pure coal.....	48.0	.....	.....	1.17	5.75	75.47	1.58	16.03	7,495	13,490	
Denny-Renton at Renton, No. 1 bed.	9154	SW.	17	23 N.	5 E.	89	8.1	As received...	16.3	32.1	39.4	12.16	48	5.77	53.58	1.33	26.68	5,230	9,410		
								Air dried.....	8.9	35.0	42.9	13.23	52	5.30	58.30	1.45	21.20	5,690	10,240		
								Dry coal.....	38.4	47.1	14.52	57	4.73	63.99	1.59	14.60	6,245	11,240			
								Pure coal.....	44.9	55.1	.....	67	5.53	74.86	1.86	17.08	6,730	13,150		
Do.....	9155	NW.	20	23 N.	5 E.	89	8.9	As received...	16.8	32.2	39.1	11.86	43	5.92	53.60	1.28	26.91	5,215	9,390		
								Air dried.....	8.7	35.4	42.9	13.02	47	5.41	58.84	1.40	20.86	5,725	10,300		
								Dry coal.....	38.7	47.0	14.25	52	4.87	64.42	1.54	14.40	6,265	11,280			
								Pure coal.....	45.2	54.8	.....	61	5.68	75.13	1.80	16.78	7,310	13,160		
Renton at Renton, No. 2 bed.	9158	NE.	20	23 N.	5 E.	90	7.2	As received...	14.5	31.8	38.8	14.85	68	5.60	53.24	1.18	24.45	5,185	9,330		
								Air dried.....	7.9	34.3	41.8	16.00	73	5.17	57.38	1.27	19.45	5,585	10,060		
								Dry coal.....	37.2	45.4	17.37	80	4.67	62.29	1.37	13.50	6,065	10,920			
								Pure coal.....	45.0	55.0	.....	97	5.65	75.39	1.66	16.33	7,340	13,210		
Renton at Renton, No. 3 bed.	9153	NE.	20	23 N.	5 E.	91	7.2	As received...	14.6	34.0	41.5	9.9	44	.....	.....	.....	.....	5,000	10,070
								Air dried.....	8.0	36.6	44.7	10.7	47	6,030	10,800
								Dry coal.....	39.8	48.6	11.6	52	6,555	11,800
								Pure coal.....	45.0	55.0	59	7,420	13,360
Do.....	9160	NE.	20	23 N.	5 E.	90	8.1	As received...	14.4	35.1	42.0	7.5	60	5,875	10,580	
								Air dried.....	6.9	39.2	45.7	8.2	65	6,395	11,510
								Dry coal.....	42.1	49.1	8.8	70	6,865	12,360
								Pure coal.....	46.2	53.8	77	7,525	13,540

ANALYSES.

Do.....	9157	SE.	17	23 N.	5 E.	91	7.5	As received... Air dried... Dry coal... Pure coal.....	14.7 7.8 38.9 47.5 45.0	40.5 11.59 12.53 12.53 55.0	47 51 55 64	5.95 5.54 5.05 5.84	55.37 59.56 64.93 75.14	1.20 1.39 1.51 1.75	25.33 20.17 14.37 16.63	5,485 5,930 6,430 7,440	9,870 10,670 11,570 13,390
Do.....	9156	SE.	17	23 N.	5 E.	90	7.2	As received... Air dried... Dry coal... Pure coal.....	14.2 7.5 38.3 46.0 45.4	42.7 35.5 38.3 46.0 54.6	68 73 79 87	5.89 5.49 5.02 5.51	59.25 63.55 69.07 75.77	1.33 1.49 1.61 1.77	25.22 20.27 14.67 16.08	5,865 6,320 6,835 7,500	10,550 11,370 12,300 13,500
Do.....	9151	S.E.	19	23 N.	5 E.	91	10.0	As received... Air dried... Dry coal... Pure coal.....	16.3 7.0 35.5 48.2 42.4	31.9 35.5 38.1 51.8 57.6	37 41 44 49	6.20 5.65 5.24 5.83	57.11 63.46 68.21 75.84	1.27 1.41 1.52 1.69	26.63 24.00 14.53 16.15	5,615 6,240 6,705 7,455	10,100 11,230 12,070 13,420
Do.....	9162	S.E.	20	23 N.	5 E.	90	9.5	As received... Air dried... Dry coal... Pure coal.....	15.0 6.1 39.1 48.4 44.7	43.8 48.4 51.6 55.3	54 60 64 69	6.16 5.64 5.28 5.66	59.73 66.90 70.27 75.39	1.37 1.51 1.61 1.73	26.43 19.87 14.67 16.53	5,975 6,600 7,030 7,540	10,750 11,880 12,650 13,570
Do.....	2455	S.E.	20	23 N.	5 E.	90	9.9	As received... Air dried... Dry coal... Pure coal.....	16.2 7.0 35.7 42.5 47.5	39.3 43.6 46.9 52.5	46 51 55 62	....................	....................	....................	....................	....................	....................
Do.....	2456	N.E.	20	23 N.	5 E.	91	12.9	As received... Air dried... Dry coal... Pure coal.....	18.0 5.8 40.4 47.7 47.3	39.1 44.9 49.9 52.7	43 49 52 57	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	5,560 6,380 6,775 7,485	10,010 11,490 12,200 13,480
Rennton at Rennton, washed pea coal.	2657	.....	20	23 N.	5 E.	92	10.7	As received... Air dried... Dry coal... Pure coal.....	16.0 6.0 37.4 43.3	41.4 46.0 48.9 56.7	61 68 73 84	5.57 4.91 4.51 5.23	56.51 63.28 67.31 78.02	1.16 1.30 1.38 1.60	24.62 16.92 12.34 14.31	5,520 6,185 6,575 7,625	9,940 11,130 11,840 13,730
Rennton at Rennton, run-of- mine coal.	2656	.....	20	23 N.	5 E.	92	9.6	As received... Air dried... Dry coal... Pure coal.....	14.3 5.2 38.5 44.4	41.3 45.6 48.2 55.6	72 80 84 97	5.73 5.16 4.82 5.57	57.27 63.35 66.82 77.05	1.17 1.29 1.37 1.57	23.74 16.82 12.86 14.84	5,670 6,275 6,615 7,630	10,210 11,290 11,910 13,730
Danville at Danville.....	9323	S.W.	24	22 N.	6 E.	93	10.9	As received... Air dried... Dry coal... Pure coal.....	18.1 8.1 36.5 44.1	32.6 46.4 50.4 55.9	51 60 62 69	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	5,450 6,115 6,650 7,375	9,810 11,010 11,970 13,280
Ravensdale No. 1 at Ra- vensdale, No. 3 bed.	9266	N.E.	36	22 N.	6 E.	94	3.6	As received... Air dried... Dry coal... Pure coal.....	9.0 5.6 38.8 44.9	43.5 45.1 47.8 55.1	95 99 104 120	5.37 5.16 4.80 5.54	61.90 64.21 68.02 78.52	1.40 1.45 1.54 1.78	18.21 15.57 11.23 12.96	6,195 6,425 6,810 7,860	11,150 12,250 12,570 14,140

Analyses of coal samples from the State of Washington—Continued.
King County—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.			
		Quarter.	Section.	Township.				Range.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorifics.	British thermal units.	
Ravensdale No. 1 at Ravensdale, No. 4 bed.	9267	NE.	36	22 N.	6 E.	91	3.0	As received....	37.4	44.0	11.24	0.51	5.63	63.91	1.52	17.19	6,390	11,500		
								Air dried.....	38.6	45.3	11.59	.53	5.46	65.89	1.57	14.96	6,585	11,550		
								Dry coal.....	40.4	47.5	12.14	.55	5.20	69.03	1.64	11.44	6,900	12,420		
								Pure coal.....	46.0	54.0	.....	.63	5.92	78.55	1.87	13.03	7,855	14,140
Ravensdale No. 1 at Ravensdale, No. 5 bed.	9279	NW.	36	22 N.	6 E.	94	4.1	As received....	38.0	45.6	7.16	.35	5.57	66.63	1.53	18.76	6,565	11,820		
								Air dried.....	39.7	47.5	7.47	.37	5.33	69.48	1.60	15.75	6,845	12,320		
								Dry coal.....	41.9	50.2	7.89	.39	5.00	73.41	1.69	11.62	7,235	13,020		
								Pure coal.....	45.5	54.5	.....	.42	5.43	79.70	1.83	12.62	7,850	14,130
Do.....	9274	NE.	36	22 N.	6 E.	94	2.9	As received....	37.2	42.7	11.96	.29	6.47	61.85	1.43	19.00	6,195	11,150		
								Air dried.....	38.3	44.0	12.32	.30	6.30	63.71	1.47	16.90	6,380	11,480		
								Dry coal.....	40.5	46.5	13.02	.32	4.97	67.33	1.56	12.80	6,745	12,140		
								Pure coal.....	46.5	53.5	.....	.37	5.69	77.41	1.79	14.74	7,750	13,950
Do.....	9271	NE.	36	22 N.	6 E.	94	3.9	As received....	35.7	39.2	15.63	.70	5.33	57.83	1.53	18.98	5,770	10,390		
								Air dried.....	37.2	40.8	16.27	.73	5.10	60.18	1.59	16.13	6,005	10,810		
								Dry coal.....	39.4	43.3	17.26	.77	4.73	63.56	1.69	11.69	6,370	11,470		
								Pure coal.....	47.7	52.3	.....	.93	5.72	77.18	2.04	14.13	7,700	13,860
Do.....	9272	NE.	36	22 N.	6 E.	95	3.6	As received....	35.1	39.2	16.64	1.24	5.26	56.49	1.53	18.84	5,685	10,230		
								Air dried.....	36.4	40.6	17.26	1.29	5.04	58.90	1.59	16.22	5,895	10,610		
								Dry coal.....	38.6	43.1	18.30	1.36	4.67	62.13	1.68	11.86	6,255	11,260		
								Pure coal.....	47.3	52.7	.....	1.66	5.72	76.05	2.06	14.51	7,655	13,780	
Do.....	9273	NE.	36	22 N.	6 E.	94	4.0	As received....	36.6	40.0	13.71	.37	5.44	59.47	1.53	19.48	5,940	10,690		
								Air dried.....	38.1	41.6	14.28	.39	5.21	61.95	1.59	16.58	6,185	11,130		
								Dry coal.....	40.5	44.3	15.19	.41	4.83	65.88	1.69	12.00	6,580	11,840		
								Pure coal.....	47.8	52.2	.....	.48	5.69	77.68	1.99	14.16	7,755	13,960
Do.....	6487	.....	36	22 N.	6 E.	96	6.3	As received....	33.3	43.4	12.2	.30	.....	.....	.....	.....	5,920	10,660
								Air dried.....	35.5	46.3	13.0	.32	6,320	11,380
								Dry coal.....	37.5	48.8	13.7	.34	6,660	11,990
								Pure coal.....	43.4	56.639	7,720	13,890

ANALYSES.

9277	NW.	36	22 N.	6 E.	95	2.9	As received..... Air dried..... Dry coal..... Pure coal.....	7.3 4.5 43.5 46.4	40.3 41.5 50.2 53.6	5.82 5.99 6.28 6.71	5.87 5.72 5.46 5.83	68.28 70.32 73.67 78.01	1.76 1.81 1.90 2.03	17.64 15.51 12.01 12.82	6,875 12,740 13,350 7,910 14,240
9279	SE.	36	22 N.	6 E.	97	4.9	As received..... Air dried..... Dry coal..... Pure coal.....	13.3 8.9 46.2 48.0	43.4 45.7 56.1 52.0	3.18 3.34 3.67 5.51	6.08 5.83 7.37 7.65	64.15 21.23 14.65 15.21	1.65 1.73 1.90 1.97	24.55 12,080 13,250 7,650 13,770	
9280	NE.	1	21 N.	6 E.	97	4.7	As received..... Air dried..... Dry coal..... Pure coal.....	11.2 6.8 44.7 46.8	39.7 41.7 50.8 53.2	4.00 4.21 4.51 5.71	6.08 5.83 5.45 5.71	65.89 69.14 74.16 77.67	1.73 1.82 1.96 2.04	6,540 12,350 13,334 7,705 13,870	
9281	NE.	1	21 N.	6 E.	97	5.0	As received..... Air dried..... Dry coal..... Pure coal.....	11.8 7.1 41.9 46.8	39.6 47.3 50.9 53.2	3.7 3.9 5.4 5.6	5.87 5.72 5.46 5.83	64.15 21.23 14.65 15.21	1.65 1.73 1.90 1.97	11,770 12,560 13,250 7,705 13,870	
9282	NE.	1	21 N.	6 E.	97	6.8	As received..... Air dried..... Dry coal..... Pure coal.....	13.7 7.4 32.4 43.5	28.0 30.0 42.2 43.5	21.9 23.5 25.4 36.5	5.87 5.72 5.46 5.83	64.15 21.23 14.65 15.21	1.65 1.73 1.90 1.97	11,730 8,800 12,840 7,385 13,200 7,710 13,870	
9283	NE.	1	21 N.	6 E.	97	5.5	As received..... Air dried..... Dry coal..... Pure coal.....	11.7 6.6 38.7 41.9	34.7 36.7 54.3 55.1	5.64 5.87 6.39 5.1	6.14 5.85 5.48 5.85	64.04 67.77 72.55 77.52	1.73 1.83 1.96 2.09	6,330 6,700 7,175 7,665 13,790	
9106	SW.	11	21 N.	6 E.	98	4.6	As received..... Air dried..... Dry coal..... Pure coal.....	6.8 2.3 42.5 43.5	40.0 41.9 50.2 51.4	5.34 5.60 5.73 5.73	5.76 5.50 5.37 5.70	67.67 69.93 72.57 76.98	1.89 1.88 2.03 2.13	17.99 14.58 12,850 13,630 14,020	
9108	SW.	11	21 N.	6 E.	98	5.4	As received..... Air dried..... Dry coal..... Pure coal.....	7.7 2.5 41.2 45.7	38.0 41.9 48.0 54.3	8.16 8.68 9.93 9.3	5.48 5.16 5.01 5.56	64.07 67.73 69.46 77.11	1.98 1.40 1.67 1.67	19.47 15.50 13.62 15.13	6,485 12,340 9,850 7,805 14,650
9105	SE.	14	21 N.	6 E.	100	4.8	As received..... Air dried..... Dry coal..... Pure coal.....	7.4 2.7 42.5 44.5	39.3 41.3 51.7 53.1	4.07 4.28 4.39 4.39	5.56 5.28 5.12 5.35	68.25 71.39 73.68 77.06	1.92 2.02 2.07 2.17	18.92 15.39 13.36 13.98	6,945 12,500 7,495 7,840 14,110
9114	SE.	14	21 N.	6 E.	100	6.0	As received..... Air dried..... Dry coal..... Pure coal.....	8.0 2.1 41.0 45.1	37.7 40.1 49.9 54.9	8.38 8.92 9.11 5.63	5.60 5.24 5.13 5.63	64.79 68.93 70.41 77.47	1.69 1.80 1.84 2.02	19.09 14.63 13.03 14.34	6,520 6,935 7,085 7,790 14,030

Analyses of coal samples from the State of Washington—Continued.

King County—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.			Ultimate.					Heat value.		
		Quarter.	Township.	Range.				Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calories.	British thermal units.
Lawson, 1 mile northeast of Black Diamond, McKay bed.	9104	NW.	21 N.	6 E.	101	3.2	As received....	4.9	41.8	48.8	4.51	0.47	5.85	72.41	1.58	15.18	7,300	13,140
							Air dried....	1.8	43.2	4.66	.49	5.67	74.80	1.63	12.75	7,540	13,580	
							Dry coal....	44.0	51.3	4.74	.49	5.58	76.17	1.66	11.36	7,680	13,820	
Lawson, 1 mile northeast of Black Diamond, upper McKay bed.	9107	NW.	21 N.	6 E.	101	4.2	As received....	6.1	36.2	43.5	14.20	.56	5.22	62.38	1.54	16.10	6,335	11,410
							Air dried....	2.0	37.8	45.4	14.82	.58	4.96	65.11	1.61	12.92	6,615	11,910
							Dry coal....	38.6	46.3	15.12	.60	4.84	66.41	1.64	11.39	6,745	12,140	
Surface exposure at Franklin, McKay bed.	9484	NE.	21 N.	7 E.	102	2.9	As received....	6.1	39.2	51.3	3.44	.48	5.97	72.72	1.63	15.76	7,350	13,230
							Air dried....	3.3	40.4	52.8	3.54	.49	5.82	74.89	1.68	13.58	7,570	13,630
							Dry coal....	41.8	54.5	3.66	.51	5.63	77.45	1.74	11.01	7,830	14,090	
Kummer at Kummer, No. 1 bed.	9113	NE.	21 N.	6 E.	103	12.3	As received....	14.1	29.9	47.1	8.92	.43	5.80	58.39	1.32	25.14	5,795	10,430
							Air dried....	2.1	34.1	53.6	10.17	.49	5.05	66.58	1.51	16.20	6,610	11,900
							Dry coal....	34.8	54.8	10.39	.50	4.93	68.01	1.54	14.63	6,750	12,150	
Kummer at Kummer.....	9115	NE.	21 N.	6 E.	105	9.7	As received....	12.4	30.4	34.8	22.4	.59	5.49	75.89	1.72	16.34	4,730	8,510
							Air dried....	2.9	33.7	38.6	24.8	.65	5.235	78.30	1.81	14.63	5,235	9,420
							Dry coal....	34.7	39.7	25.6	.67	5.395	80.39	1.81	11.01	5,710	10,960	
Gem at Franklin, Gem bed.	9103	NE.	21 N.	7 E.	105	4.9	As received....	7.3	34.2	47.7	10.80	.53	5.38	63.53	1.69	18.07	7,245	13,040
							Air dried....	2.5	35.9	50.2	11.36	.56	5.09	66.80	1.78	14.41	6,345	11,420
							Dry coal....	36.9	51.5	11.65	.57	4.93	68.53	1.82	12.50	6,845	12,320	
Surface exposure, $\frac{3}{4}$ mile southwest of Franklin, Gem (?) bed.	9487	SW.	21 N.	7 E.	106	7.1	As received....	14.3	34.4	42.2	9.1	.57	5.58	77.57	2.06	14.14	7,750	13,950
							Air dried....	7.7	40.1	49.3	9.8	.61	5.710	80.39	2.06	14.14	7,750	13,950
							Dry coal....	44.9	55.1	10.6	.64	5.710	80.39	2.06	14.14	7,750	13,950	

ANALYSES.

9293	Rose-Marshall, 1 mile west of Cumberland, John Harris bed.	NE.	29	21 N.	7 E.	107	2.6	As received.....	5.2	38.8	47.6	8.4	47	7.025	12,650			
								Air dried.....	2.7	39.8	46.8	8.7	48	7.215	12,990			
								Dry coal.....	40.9	50.2	8.9	50	7.415	13,330				
10312	Do.....	NE.	29	21 N.	7 E.	107	3.3	Pure coal.....	44.9	53.1	15.99	55	8.140	14,650				
								As received.....	7.2	34.4	42.4	15.99	58	5.32	61.16	1.43	15.52	11,100
								Air dried.....	4.1	35.5	43.9	16.54	60	5.12	63.25	1.48	13.01	6,375
9474	Independent, 1 mile south of Cumberland.	SW.	28	21 N.	7 E.	108	3.4	Dry coal.....	37.1	45.7	17.24	67	9.80	11,960				
								Pure coal.....	44.8	53.2	17.24	76	4.87	65.92	1.54	9.80	6,645	
								As received.....	6.0	29.7	40.8	23.5	65	5.88	79.65	1.86	11.55	8,030
9286	Do.....	SW.	28	21 N.	7 E.	108	3.4	Air dried.....	30.8	42.2	24.3	67	5.780	10,050				
								Dry coal.....	31.6	43.4	25.0	69	5.940	10,400				
								Pure coal.....	42.2	57.8	26.38	92	7.920	14,250				
9263	Sunset, 1 mile southeast of Cumberland, No. 1 bed.	SE.	28	21 N.	7 E.	108	6.2	As received.....	12.7	31.1	43.7	12.5	5.495	9,890				
								Air dried.....	7.0	33.1	46.6	13.3	96	4.58	54.63	1.35	11.64	5,285
								Dry coal.....	35.6	50.1	14.3	102	6.295	11,330				
9264	Sunset, 1 mile southeast of Cumberland, No. 2 bed.	SE.	28	21 N.	7 E.	109	2.2	Pure coal.....	41.5	58.5	22.79	119	7.345	13,220				
								As received.....	4.5	34.1	39.6	21.77	77	4.91	59.23	.91	12.41	5,960
								Air dried.....	2.3	34.8	40.6	22.26	79	4.77	60.56	.93	10.69	6,065
9265	Sunset, 1 mile southeast of Cumberland, No. 3 bed.	SE.	28	21 N.	7 E.	109	2.8	Dry coal.....	35.7	41.5	15.89	81	8.82	6,240				
								Pure coal.....	46.2	53.8	15.89	105	5.98	80.32	1.23	11.42	8,080	
								As received.....	5.6	34.4	45.0	15.01	2.41	5.13	63.79	.96	12.70	6,490
9276	Sunset, 1 mile southeast of Cumberland, No. 7 bed.	SE.	28	21 N.	7 E.	109	2.6	Air dried.....	2.9	35.4	46.3	15.44	2.48	4.96	65.63	.99	10.50	6,680
								Dry coal.....	36.4	47.7	15.89	81	4.62	62.01	.95	8.82	6,240	
								Pure coal.....	43.3	56.7	15.89	105	5.98	80.32	1.23	11.42	8,080	
9287	Naval at Cumberland.....	NW.	28	21 N.	7 E.	109	2.6	As received.....	5.0	26.4	30.1	38.5	41	4.440	7,990			
								Air dried.....	2.4	27.1	30.9	39.6	42	4.555	8,200			
								Dry coal.....	27.8	31.7	40.5	43	31.7	40.5	43	4.670	8,410	
9285	Do.....	NW.	28	21 N.	7 E.	110	4.0	Pure coal.....	46.8	53.2	53.2	72	7.855	14,140				
								As received.....	5.5	32.3	41.2	21.03	69	5.01	59.49	1.64	12.14	6,010
								Air dried.....	2.8	33.2	42.4	21.64	71	4.83	61.20	1.69	9.93	6,185
9285	Do.....	NW.	28	21 N.	7 E.	110	4.0	Dry coal.....	34.2	43.6	22.24	73	7.72	6,360				
								Pure coal.....	43.9	56.1	22.24	94	4.65	62.93	1.73	7.72	6,360	
								As received.....	6.2	30.0	37.5	26.3	65	5.98	80.93	2.22	9.93	8,180
9285	Do.....	NW.	28	21 N.	7 E.	110	4.0	Air dried.....	31.2	39.1	27.4	68	5.340	9,620				
								Dry coal.....	32.0	40.0	28.0	69	5.665	10,020				
								Pure coal.....	44.5	56.5	28.0	95	7.915	14,250				

Analyses of coal samples from the State of Washington—Continued.

King County—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.						Heat value.	
		Quarter.	Section.	Township.				Range.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorics.	British thermal units.
Naval at Cumberland....	9284	NW.	28	21 N.	7 E.	110	2.7	As received.... Air dried..... Dry coal..... Pure coal.....	4.8 2.2	35.6 30.6 37.4 42.9	47.4 48.7 49.8 57.1	12.16 12.90 13.71	0.52 .53 .63	5.35 5.19 5.06 5.80	66.81 88.66 70.18 80.45	1.65 1.70 1.73 1.98	13.51 11.42 9.71 11.14	6,775 6,969 7,119 8,153	12,190 12,530 12,800 14,680
Eureka, 1 mile south of Bayne.	9294	NE.	28	21 N.	7 E.	112	4.2	As received.... Air dried..... Dry coal..... Pure coal.....	5.9 1.8	31.3 32.7 33.3 41.6	43.9 43.8 46.0 53.4	18.92 19.75 20.11.....	.47 .49 .50 .63	5.08 4.81 4.0 5.88	60.35 63.00 64.10 80.31	1.13 1.18 1.20 1.50	14.95 10.77 9.33 11.68	6,075 6,345 6,469 8,085	10,940 11,450 11,630 14,500
Bayne at Bayne, No. 1 bed.	9112	NW.	22	21 N.	7 E.	113	7.6	As received.... Air dried..... Dry coal..... Pure coal.....	8.7 1.2	30.2 32.0 33.0 41.7	42.1 42.6 46.2 58.3	19.03 20.89 20.84.....	.48 .52 .53 .67	5.18 4.70 4.62 5.83	57.31 62.02 62.75 79.28	1.12 1.21 1.23 1.59	16.88 10.86 10.03 12.67	5,770 6,245 6,310 7,980	10,380 11,240 11,370 14,300
Bayne at Bayne, No. 3 bed.	9110	NW.	22	21 N.	7 E.	113	3.5	As received.... Air dried..... Dry coal..... Pure coal.....	4.9 1.5	33.0 34.2 34.7 41.0	41.0 42.5 43.1 55.4	21.08 20.84 21.84.....	.54 .56 .57 .73	5.13 4.92 4.83 6.21	59.35 62.40 62.44 80.23	1.24 1.29 1.20 1.67	12.68 10.86 8.68 11.10	5,965 6,180 6,275 8,060	10,730 11,130 11,260 14,510
Bayne at Bayne, No. 5 bed.	9109	NW.	22	21 N.	7 E.	113	3.6	As received.... Air dried..... Dry coal..... Pure coal.....	5.1 1.5	33.8 35.1 35.6 44.2	49.7 44.3 45.0 55.8	18.43 18.42 19.41.....	.63 .68 .66 .82	5.10 4.88 4.78 5.93	60.12 62.30 63.32 78.37	1.47 1.52 1.52 1.92	14.25 11.47 10.58 12.76	6,145 6,360 6,475 8,065	11,060 11,480 11,550 14,460
Do.....	9275	NW.	22	21 N.	7 E.	113	5.5	As received.... Air dried..... Dry coal..... Pure coal.....	12.1 7.0	31.3 33.1 35.6 41.8	43.6 43.6 46.6 58.2	13.02 13.76 14.81.....	.46 .49 .52 .61	5.20 4.82 4.77 5.13	56.70 60.07 64.59 73.81	1.28 1.48 1.57 1.84	23.19 19.93 16.78 16.61	5,465 5,785 6,260 7,300	9,840 10,410 11,260 13,140
Do.....	9268	NW.	22	21 N.	7 E.	113	4.4	As received.... Air dried..... Dry coal..... Pure coal.....	7.3 3.0	33.3 34.6 34.9 44.3	41.8 43.7 45.1 55.7	17.59 18.97 18.97.....	.56 .59 .70 .74	5.20 4.93 4.74 5.85	59.42 62.15 64.10 79.11	1.44 1.51 1.55 1.91	15.79 12.42 10.44 12.89	5,980 6,255 6,460 7,960	10,760 11,260 11,610 14,380

ANALYSES.

Do.....	9269	NW.	22	21 N.	7 E.	113	3.3	As received.....	5.8	37.0	48.3	8.93	63	5.46	69.01	1.73	14.04	6.970	12,550
								Air dried.....	2.6	38.2	49.9	9.26	.65	5.46	71.36	1.78	11.49	7.210	12,980
								Dry coal.....	30.2	30.2	51.3	9.50	.65	5.32	73.24	1.83	9.45	7,400	13,320
								Pure coal.....	43.4	43.4	56.6	.....	.72	5.88	80.94	2.02	10.44	8,175	14,720
Prospect at Bayne.....	9483	NW.	22	21 N.	7 E.	113	4.5	As received.....	7.5	23.3	35.6	33.6	1.77	.....	.....	.....	.....	4,420	7,960
								Air dried.....	3.1	21.4	37.3	35.2	1.85	.....	.....	.....	.....	4,630	8,330
								Dry coal.....	.....	21.2	38.2	36.3	1.91	.....	.....	.....	.....	4,780	8,600
								Pure coal.....	.....	39.5	60.3	.....	3.00	.....	.....	.....	.....	7,505	13,500
Carbon, 1/2 mile northeast of Bayne, No. 1 bed.	9485	SE.	15	21 N.	7 E.	115	2.3	As received.....	4.2	32.4	52.3	11.13	.46	5.25	69.00	1.44	12.76	6.980	12,870
								Air dried.....	2.0	33.2	53.4	11.33	.45	5.11	70.62	1.41	10.08	7,145	12,860
								Dry coal.....	.....	33.9	54.2	11.62	.47	4.00	72.05	1.47	9.40	7,290	13,190
								Pure coal.....	.....	38.3	61.7	.....	.53	5.65	81.52	1.66	10.64	8,250	14,850
Carbon, 1/2 mile northeast of Bayne, No. 1 bed, special sample.	9486	SE.	15	21 N.	7 E.	115	1.5	As received.....	3.8	33.7	53.3	9.2	.30	.....	.....	.....	.....	.....	.....
								Air dried.....	2.3	34.2	54.1	9.4	.40	.....	.....	.....	.....	.....	.....
								Dry coal.....	.....	35.3	55.3	9.6	.41	.....	.....	.....	.....	.....	.....
								Pure coal.....	.....	38.7	61.3	.....	.45	.....	.....	.....	.....	.....	.....
Carbon, 1/2 mile northeast of Bayne, composite sample.	9492	SE.	15	21 N.	7 E.	115	1.9	As received.....	4.1	32.8	52.8	10.34	.45	5.33	71.51	1.56	10.81	7,100	12,780
								Air dried.....	2.3	33.4	53.8	10.54	.47	5.22	72.89	1.59	9.30	7,240	13,090
								Dry coal.....	.....	34.2	55.0	10.79	.38	5.08	74.59	1.63	7.44	7,410	13,330
								Pure coal.....	.....	38.3	61.7	.....	.53	5.69	83.62	1.33	5.33	8,305	14,350
Carbon, 1/2 mile northeast of Bayne, No. 2 bed.	9489	SE.	15	21 N.	7 E.	115	3.1	As received.....	5.1	30.8	56.0	8.10	.36	5.19	72.48	1.14	12.73	7,140	12,850
								Air dried.....	2.1	31.8	57.7	8.36	.37	5.01	74.80	1.18	10.28	7,365	13,260
								Dry coal.....	.....	32.5	59.0	8.54	.38	4.87	76.40	1.20	8.61	7,525	13,840
								Pure coal.....	.....	35.5	64.5	.....	.42	5.32	83.54	1.31	9.41	8,230	14,810
Prospect 1/2 mile west of Bayne.	9488	NE.	21	21 N.	7 E.	116	3.5	As received.....	6.0	31.2	48.5	19.35	.42	4.90	59.59	1.15	14.59	5,950	10,710
								Air dried.....	2.6	32.3	48.1	20.05	.44	4.67	61.75	1.19	11.90	6,163	11,100
								Dry coal.....	.....	33.2	46.2	20.39	.45	4.30	63.40	1.22	9.84	6,330	11,390
								Pure coal.....	.....	41.8	58.2	.....	.57	5.66	79.85	1.54	12.38	7,970	14,350
Occidental at Bayne, No. 1 bed.	9479	SE.	16	21 N.	7 E.	117	2.4	As received.....	5.1	34.4	47.6	12.93	.72	5.38	66.31	1.17	13.49	6,645	11,900
								Air dried.....	2.8	35.3	48.7	13.25	.74	5.24	67.94	1.20	11.63	6,810	12,260
								Dry coal.....	.....	36.3	50.1	13.63	.76	5.07	69.90	1.22	9.42	7,005	12,610
								Pure coal.....	.....	42.0	58.0	.....	.88	5.86	80.93	1.41	10.92	8,110	14,600
Occidental at Bayne, No. 2 bed.	9480	SE.	16	21 N.	7 E.	117	2.5	As received.....	5.4	33.0	47.1	14.51	.70	5.20	64.12	1.28	14.19	6,440	11,580
								Air dried.....	2.9	33.9	48.3	14.88	.72	5.05	65.77	1.31	12.27	6,605	11,880
								Dry coal.....	.....	34.9	49.8	15.33	.74	4.87	67.74	1.35	9.97	6,800	12,240
								Pure coal.....	.....	41.2	58.8	.....	.87	5.75	80.01	1.59	11.78	8,085	14,460
Occidental at Bayne, No. 3 bed.	9478	SE.	16	21 N.	7 E.	117	2.1	As received.....	4.8	34.3	48.5	12.42	1.12	5.60	66.87	1.12	12.87	6,780	12,200
								Air dried.....	2.7	35.1	49.5	12.69	1.14	5.49	68.30	1.14	11.24	6,925	12,460
								Dry coal.....	.....	36.1	50.9	13.04	1.18	5.32	70.22	1.18	9.06	7,120	12,820
								Pure coal.....	.....	41.5	58.5	.....	1.36	6.12	80.75	1.36	10.41	8,190	14,740

Analyses of coal samples from the State of Washington—Continued.

King County—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.			Ultimate.					Heat value.			
		Quar-ter.	Sec-tion.	Town-ship.				Range.	Mois-ture.	Vola-tile mat-ter.	Fixed car-bon.	Ash.	Sul-phur.	Hy-dro-gen.	Car-bon.	Nitro-gen.	Oxy-gen.	Calo-ries.	British thermal units.
Occidental at Bayne, No. 3 bed.	9475	SE.	16	21 N.	7 E.	117	2.1	As received...	34.4	48.9	11.65	5.22	66.72	1.08	14.15	6,705	12,070		
								Air dried...	35.1	50.0	11.90	5.10	68.15	1.10	12.54	9,850	12,350		
								Dry coal...	36.2	51.5	12.27	4.90	70.28	1.14	10.17	7,060	12,710		
Occidental at Bayne, No. 6 bed.	9481	SE.	16	21 N.	7 E.	117	2.8	As received...	31.8	40.9	21.80	4.91	57.00	1.30	14.49	5,785	10,410		
								Air dried...	32.7	42.0	22.43	4.73	58.64	1.34	12.34	5,960	10,710		
								Dry coal...	33.7	43.2	23.08	4.54	60.35	1.38	10.12	9,120	11,020		
Occidental at Bayne, No. 14 bed.	9477	SE.	16	21 N.	7 E.	117	1.8	As received...	33.1	45.5	17.2	5.8	75.46	1.79	13.16	7,960	14,320		
								Air dried...	33.8	46.3	17.5	5.9	75.46	1.79	13.16	7,960	14,320		
								Dry coal...	34.6	47.4	18.0	5.1	75.46	1.79	13.16	7,960	14,320		
Do.....	9476	SE.	16	21 N.	7 E.	117	1.6	As received...	36.7	52.6	6.0	5.1	75.46	1.79	13.16	7,960	14,320		
								Air dried...	37.3	53.5	6.7	5.2	75.46	1.79	13.16	7,960	14,320		
								Dry coal...	38.3	54.8	6.9	5.7	75.46	1.79	13.16	7,960	14,320		
Occidental at Bayne, com-posite sample.	9491	SE.	16	21 N.	7 E.	119	1.7	As received...	41.1	58.9	12.09	4.9	67.50	1.70	12.67	6,825	12,340		
								Air dried...	35.2	48.7	12.30	4.9	67.50	1.70	12.67	6,825	12,340		
								Dry coal...	36.6	50.8	12.39	5.1	68.37	1.73	11.85	7,975	12,560		
Big Six, 1½ miles east of Bayne, Pochontas bed.	9278	NE.	23	21 N.	7 E.	119	3.1	As received...	41.9	58.1	12.88	5.8	80.41	2.02	10.90	8,170	14,700		
								Air dried...	31.0	52.2	12.94	7.3	70.07	1.05	10.64	7,075	12,730		
								Dry coal...	32.0	53.9	12.63	7.3	72.31	1.08	8.14	7,365	13,140		
Prospect at Palmer Junction.	9288	NE.	14	21 N.	7 E.	120	2.5	As received...	37.3	62.7	12.83	5.7	84.24	1.26	7.91	8,565	15,310		
								Air dried...	25.0	37.3	33.2	5.8	84.24	1.26	7.91	8,565	15,310		
								Dry coal...	26.1	38.2	34.2	5.9	84.24	1.26	7.91	8,565	15,310		
								Pure coal.....	40.1	59.9	34.9	5.4	7,990	14,380					

ANALYSES.

9482	NE.	14	21 N.	7 E.	120	2.9	As received...	4.8	23.7	39.1	32.4	66	5.040	9.070
							Air dried...	1.9	24.4	40.3	33.4	68	5.100	9.340
							Dry coal.....	37.7	24.9	41.1	34.0	69	5.200	9.520
							Pure coal.....	37.7	37.7	62.3	34.0	1.05	8,020	14,430
9292	SE.	28	22 N.	7 E.	122	5.7	As received...	10.5	35.2	42.4	11.93	35	5.945	10,700
							Air dried...	5.0	37.3	45.0	12.65	37	6.305	11,350
							Dry coal.....	39.3	39.3	47.4	13.32	39	6.640	11,950
							Pure coal.....	45.3	45.3	54.7	13.64	45	7,660	13,790
9111	NW.	12	22 N.	7 E.	123	12.6	As received...	14.0	5.5	51.7	28.8	43	4.500	8.010
							Air dried...	1.7	6.2	59.1	33.0	49	5.065	9.170
							Dry coal.....	6.4	6.4	60.1	33.5	50	5.180	9.320
							Pure coal.....	9.5	9.5	90.5	33.5	75	7,790	14,030
9173	SW.	3	22 N.	7 E.	124	4.0	As received...	6.4	36.7	41.4	15.5	1.33	6.190	11,140
							Air dried...	2.5	38.2	43.2	16.1	1.39	6.450	11,610
							Dry coal.....	39.2	39.2	44.3	16.5	1.42	6.610	11,900
							Pure coal.....	46.9	46.9	53.1	16.5	1.70	7,920	14,260
9176	SW.	3	22 N.	7 E.	124	2.6	As received...	5.0	36.1	34.0	24.9	1.92	5.555	10,000
							Air dried...	2.4	37.1	34.9	25.6	1.97	5.705	10,270
							Dry coal.....	38.0	38.0	35.8	26.2	2.02	5.845	10,520
							Pure coal.....	51.5	51.5	48.5	26.2	2.74	7,920	14,260
9172	SE.	3	22 N.	7 E.	124	2.6	As received...	4.8	36.4	48.7	10.05	81	6.890	12,410
							Air dried...	2.2	37.4	50.1	10.32	83	7.075	12,740
							Dry coal.....	38.3	38.3	51.2	10.55	85	7.235	13,030
							Pure coal.....	42.8	42.8	57.2	10.55	95	8,090	14,560
9174	SE.	3	22 N.	7 E.	124	2.3	As received...	4.3	35.6	45.2	14.85	74	6.585	11,870
							Air dried...	2.1	36.4	46.3	15.20	76	6.750	12,150
							Dry coal.....	37.2	37.2	47.3	15.52	77	6.890	12,400
							Pure coal.....	44.0	44.0	56.0	15.52	91	8,155	14,680
520-D	SW.	3	22 N.	7 E.	124	3.5	As received...	6.1	40.0	37.8	16.1	1.01	6.420	11,560
							Air dried...	2.8	41.4	39.1	16.7	1.05	6.565	11,820
							Dry coal.....	42.6	42.6	40.3	17.1	1.08	6.695	12,050
							Pure coal.....	51.4	51.4	48.6	17.1	1.28	8,085	14,550
518-D	SW.	3	22 N.	7 E.	124	2.2	As received...	4.1	35.9	43.5	16.5	54	6.420	11,560
							Air dried...	1.9	36.7	44.5	16.9	55	6.565	11,820
							Dry coal.....	37.4	37.4	45.4	17.2	55	6.695	12,050
							Pure coal.....	45.2	45.2	54.8	17.2	66	8,085	14,550
519-D	SE.	3	22 N.	7 E.	124	3.3	As received...	5.4	37.7	48.3	8.6	63	6.860	12,340
							Air dried...	2.1	39.0	50.0	8.9	65	7.065	12,770
							Dry coal.....	39.8	39.8	51.1	9.1	67	7.245	13,040
							Pure coal.....	43.8	43.8	56.2	9.1	74	7,970	14,350

Analyses of coal samples from the State of Washington—Continued.

King County—Continued.

Name of mine or form of exposure.	Labo- ratory No.	Location.			Page.	Air- drying loss.	Form of analysis.	Proximate.			Ultimate.					Heat value.			
		Quar- ter.	Sec- tion.	Town- ship.				Range.	Mois- ture.	Vola- tile mat- ter.	Fixed car- bon.	Ash.	Sul- phur.	Hy- dro- gen.	Car- bon.	Nitro- gen.	Oxy- gen.	Calo- ries.	British thermal units.
Denny-Renton at Taylor, No. 6 bed.	9175	SE.	3	22 N.	7 E.	124	3.1	As received... Air dried... Dry coal... Pure coal...	5.6 2.5 38.1 44.9	35.9 37.1 46.7 55.1	44.1 45.6 46.7 55.1	14.38 14.84 15.23 15.23	0.94 0.97 1.00 1.18	5.18 4.99 4.83 5.70	63.91 65.95 67.67 79.83	1.26 1.30 1.33 1.57	14.33 11.95 9.94 11.72	6,415 6,620 7,195 8,015	11,580 11,920 12,230 14,430
Denny-Renton at Taylor, No. 5 bed.	6485		3	22 N.	7 E.	125	3.3	As received... Air dried... Dry coal... Pure coal...	5.4 2.2 25.9 43.7	24.5 25.3 32.7 56.3	31.6 32.7 33.4 56.3	38.5 39.8 40.7 40.7	.51 .53 .54 .91	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	4,255 4,400 4,495 7,585	7,660 7,920 8,100 13,660	
Denny-Renton at Taylor, run-of-mine coal, No. 4 bed.	585-D	SE.	3	22 N.	7 E.	125	2.6	As received... Air dried... Dry coal... Pure coal...	6.2 3.7 36.5 45.3	34.2 35.1 42.5 45.3	41.4 42.5 44.1 54.7	18.23 18.72 19.44 19.44	.69 .71 .74 .92	4.95 4.78 4.54 5.63	60.12 61.72 64.09 79.56	1.41 1.45 1.50 1.86	14.60 12.62 9.69 12.03	6,050 6,210 6,450 8,005	10,890 11,180 11,610 14,410
Denny-Renton at Taylor, run-of-mine coal, No. 5 bed.	586-D	SW.	3	22 N.	7 E.	125	2.3	As received... Air dried... Dry coal... Pure coal...	5.3 3.1 36.1 47.5	34.2 35.0 42.5 47.5	37.8 38.7 39.9 52.5	22.67 23.20 23.95 23.95	.77 .79 .81 1.06	4.72 4.57 4.36 5.73	56.98 58.32 60.30 79.16	1.37 1.40 1.45 1.91	13.49 11.72 9.23 12.14	5,730 5,860 6,050 7,960	10,310 10,550 10,890 14,330
Prospect 6 miles south- east of Issaquah.	9290	SW.	12	23 N.	6 E.	126	8.9	As received... Air dried... Dry coal... Pure coal...	11.4 2.7 30.9 35.2	27.4 30.1 30.9 35.2	50.5 55.4 57.0 64.8	10.7 11.8 12.1 12.1	.23 .25 .26 .30	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	6,330 6,950 7,145 8,130	11,390 12,510 12,860 14,630	
Do.....	9289	SW.	12	23 N.	6 E.	126	8.5	As received... Air dried... Dry coal... Pure coal...	12.5 4.4 32.0 38.1	28.0 30.6 32.0 38.1	45.6 49.8 52.1 61.9	13.9 15.2 15.9 15.9	2.37 2.59 2.71 3.22	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	5,700 6,230 6,520 7,750	10,260 11,270 11,740 13,950	
Prospect 1 mile south- west of Preston.	8546	SE.	31	24 N.	7 E.	127	4.0	As received... Air dried... Dry coal... Pure coal...	5.5 1.6 7.7 19.3	7.3 7.6 31.8 80.7	30.5 31.8 32.3 80.7	56.7 59.0 60.0 60.0	3.30 3.44 3.49 3.72	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	2,710 2,825 2,870 7,165	4,880 5,080 5,160 12,890	

Niblock, 1 1/4 miles south-west of Snoqualmie, No. 3 bed.	10031	SE.	1	23 N.	7 E.	128	7.3	As received.....	8.2	27.2	53.9	10.69	.47	5.22	69.64	1.84	12.14	6,910	12,440
								Air dried.....	1.0	29.3	58.2	11.53	.51	4.76	75.12	1.98	6.10	7,485	13,470
								Dry coal.....	29.6	58.7	11.65	.51	4.69	75.89	2.01	5.25	7,630	13,600	
Niblock, 1 1/4 miles south-west of Snoqualmie, No. 4 bed.	10032	SE.	1	23 N.	7 E.	128	4.1	As received.....	6.1	22.7	58.8	12.4	.88	5.22	69.64	1.84	12.14	5,850	10,710
								Air dried.....	2.1	23.7	61.3	12.9	.92	4.92	75.89	2.01	5.25	7,630	13,600
								Dry coal.....	24.2	62.6	13.2	.94	4.92	75.89	2.01	5.25	7,630	13,600	
Niblock, 1 1/4 miles south-west of Snoqualmie, No. 5 bed.	10033	NW.	1	23 N.	7 E.	128	3.7	As received.....	4.8	27.3	43.6	24.84	1.48	4.92	57.86	1.38	10.02	5,875	10,380
								Air dried.....	1.2	28.3	45.2	25.28	1.54	4.68	60.08	1.43	6.99	6,100	10,680
								Dry coal.....	28.6	45.8	25.58	1.56	4.60	60.81	1.43	6.00	6,175	11,120	
								Pure coal.....	38.5	61.5	.....	2.10	6.18	81.71	1.95	8.06	8,300	14,940	

Kittitas County.

Prospect, 1 1/4 miles north-west of Beekman.	9404	NW.	2	20 N.	14 E.	131	4.1	As received.....	5.3	37.5	42.6	24.6	0.38	.....	.....	.....	.....	.....	5,860	10,550			
								Air dried.....	1.2	58.7	44.4	25.7	.40	6,110	11,000
								Dry coal.....	59.1	44.0	23.0	6,185	11,170
Lakedale, 1 mile north-west of Beekman.	9405	SW.	1	20 N.	14 E.	152	2.5	As received.....	4.5	39.5	44.5	21.48	.35	5.02	61.45	1.18	10.52	6,225	11,270					
								Air dried.....	2.0	30.3	45.7	22.63	.36	4.80	63.63	1.21	8.57	6,309	11,510					
								Dry coal.....	30.9	40.6	22.48	.37	4.74	65.31	1.23	8.87	6,323	11,510						
Beekman at Beekman, Roslyn bed.	9411	NW.	12	20 N.	14 E.	133	2.4	As received.....	3.7	35.1	50.5	10.7	.33	.....	.....	.....	.....	.....	.....
								Air dried.....	1.3	36.0	51.7	11.0	.33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
								Dry coal.....	36.5	52.4
Do	9412	SE.	12	20 N.	14 E.	133	1.8	As received.....	3.5	34.6	50.2	11.7	.38	.....	.....	.....	.....	.....	.....
								Air dried.....	1.8	35.2	51.1	11.9	.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
								Dry coal.....	35.9	52.0	12.1	.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Do	9413	SE.	12	20 N.	14 E.	133	1.8	As received.....	3.4	35.5	49.8	11.3	.37	.....	.....	.....	.....	.....	.....
								Air dried.....	1.6	36.2	50.7	11.5	.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
								Dry coal.....	36.8	51.5	11.7	.43	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Do	9414	NW.	12	20 N.	14 E.	133	1.0	As received.....	2.5	34.9	50.0	12.6	.33	.....	.....	.....	.....	.....	.....
								Air dried.....	1.5	35.2	50.5	12.8	.33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
								Dry coal.....	35.8	51.3	12.9	.34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Do	9415	SW.	12	20 N.	14 E.	133	.8	As received.....	2.6	34.7	48.9	13.8	.34	.....	.....	.....	.....	.....	.....
								Air dried.....	1.8	35.0	49.3	13.9	.34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
								Dry coal.....	35.6	50.2	14.2	.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
								Pure coal.....	41.5	63.5	.....	41	.....	.....	.....	.....	.....	.....

9444	SE.	9	20 N.	15 E.	141	2.2	As received. Air dried. Dry coal. Pure coal.	5.4 3.3 36.5 44.2	46.2 47.2 48.8 55.8	11.9 12.2 12.6	39 40 41 47							
9468			20 N.	15 E.	141	2.0	As received. Air dried. Dry coal. Pure coal.	4.7 2.7 36.0 43.4	46.8 47.8 49.1 56.6	12.46 12.71 13.07	38 39 40 46	1.34 1.37 1.41 1.62	6.800 6.940 7.335 8.205	12.240 12.490 12.840 14.770				
2457			20 N.	15 E.	141	.9	As received. Air dried. Dry coal. Pure coal.	3.4 2.5 36.1 43.7	46.6 47.0 48.2 56.3	13.9 14.0 14.4	36 36 37 43							
3098					141	1.3	As received. Air dried. Dry coal. Pure coal.	3.1 1.9 37.0 43.2	48.1 48.7 49.6 56.8	12.26 12.42 12.66	38 38 39 45	1.24 1.26 1.28 1.47	6.900 7.065 7.320 8.270	12.590 12.730 13.000 14.880				
9402	SW.	10	20 N.	15 E.	142	2.5	As received. Air dried. Dry coal. Pure coal.	5.7 3.3 37.9 45.3	44.7 45.8 47.2 54.7	12.69 13.02 13.46	45 46 48 55	1.28 1.31 1.36 1.57	6.630 6.800 7.080 8.125	11.930 12.300 12.650 14.620				
9439	NE.	16	20 N.	15 E.	143	1.9	As received. Air dried. Dry coal. Pure coal.	4.4 2.6 37.4 44.2	46.4 47.3 48.6 55.8	12.5 12.7 13.0	41 42 43 49							
9441	NE.	16	20 N.	15 E.	143	1.8	As received. Air dried. Dry coal. Pure coal.	4.5 2.7 38.1 45.9	46.5 47.3 48.7 56.1	12.6 12.8 13.2	42 43 44 51							
9440	NE.	16	20 N.	15 E.	143	2.1	As received. Air dried. Dry coal. Pure coal.	4.8 2.8 38.0 45.0	45.6 46.6 47.9 55.0	12.3 12.6 13.0	38 39 40 46							
9466			20 N.	15 E.	143	1.9	As received. Air dried. Dry coal. Pure coal.	4.6 2.8 37.9 43.6	46.8 47.6 49.0 56.4	12.53 12.77 13.14	40 42 48	1.30 1.33 1.36	6.755 6.885 7.085	12.150 12.300 12.750 14.680				
9438	NW.	20	20 N.	15 E.	144	2.2	As received. Air dried. Dry coal. Pure coal.	3.7 1.6 35.1 41.3	48.0 49.0 49.8 58.7	14.5 14.8 15.1	35 36 36 42							

ANALYSES.

61

9425	SE.	21	20 N.	15 E.	145	1.5	As received... Air dried... Dry coal... Pure coal...	5.0 3.5 30.8 41.3	49.6 50.3 52.1 58.7	10.5 10.7 11.1	39 40 41 46						
9462			20 N.	15 E.	146	1.6	As received... Air dried... Dry coal... Pure coal...	4.9 3.4 36.5 43.2	47.3 48.1 49.8 56.8	11.77 11.97 12.38	40 41 42 48	67.68 68.78 71.21 81.27	1.27 1.20 1.34 1.53	13.34 12.10 9.40 10.73	6,810 6,920 7,165 8,175	12,250 12,450 12,800 14,710	
9422	SE.	22	20 N.	15 E.	147	1.5	As received... Air dried... Dry coal... Pure coal...	5.5 4.1 38.3 43.8	46.5 47.2 49.2 56.2	11.8 11.9 12.5	33 33 35 40						
9421	NW.	26	20 N.	15 E.	147	2.0	As received... Air dried... Dry coal... Pure coal...	7.0 5.1 37.1 43.5	44.9 45.8 48.3 56.5	13.6 13.9 14.6	37 38 40 47						
9420	SE.	22	20 N.	15 E.	147	2.4	As received... Air dried... Dry coal... Pure coal...	6.3 4.0 38.2 43.6	46.3 47.5 49.4 56.4	11.6 11.9 12.4	35 36 37 42						
9419	NE.	27	20 N.	15 E.	147	2.0	As received... Air dried... Dry coal... Pure coal...	6.0 4.1 37.2 42.6	47.2 48.1 50.2 57.4	11.9 12.1 12.6	34 35 36 41						
9461			20 N.	15 E.	147	2.0	As received... Air dried... Dry coal... Pure coal...	5.0 3.0 38.0 43.5	46.8 47.8 49.2 56.5	12.15 12.40 12.79	36 37 38 44	66.00 67.35 69.46 79.65	1.29 1.32 1.36 1.56	14.60 13.07 10.70 12.26	6,610 6,745 6,955 7,975	11,900 12,140 12,520 14,360	
9403	SW.	14	20 N.	15 E.	148	2.6	As received... Air dried... Dry coal... Pure coal...	7.6 5.2 38.1 43.8	45.2 46.4 48.9 56.2	12.01 12.33 13.01	44 45 48 55	63.88 65.59 69.18 79.53	1.32 1.36 1.43 1.64	16.77 14.70 12.30	6,430 6,605 6,965 8,010	11,580 11,890 12,540 14,410	
9408	NW.	23	20 N.	15 E.	149	3.0	As received... Air dried... Dry coal... Pure coal...	8.5 5.7 38.1 44.0	44.5 45.8 48.6 56.0	12.15 12.53 13.28	47 48 51 59	62.68 64.62 68.52 79.01	1.48 1.53 1.62 1.87	17.69 15.48 11.06 12.75	6,305 6,500 6,890 7,945	11,340 11,700 12,400 14,300	
9409	SE.	23	20 N.	15 E.	150	2.8	As received... Air dried... Dry coal... Pure coal...	8.5 5.9 38.3 44.0	44.6 45.6 48.7 56.0	11.94 12.28 13.05	43 44 47 54	63.35 65.18 69.23 79.62	1.43 1.46 1.56 1.79	17.33 15.28 10.69 12.30	6,350 6,535 6,940 7,980	11,430 11,760 12,490 14,370	

ANALYSES.

63

Prospect A on Summit. Creek, Primrose bed.	9101	NW.	13	14 N.	10 E.	154	2.8	As received....	3.6	8.4	59.6	28.40	.66	3.17	60.00	.99	6.78	5,580	10,050
								Air dried.....	.8	8.6	61.4	29.22	.68	2.91	61.73	1.02	4.41	5,740	10,340
								Dry coal.....	.68	8.7	61.8	29.46	.68	2.87	62.23	1.03	3.73	5,790	10,420
								Pure coal.....	12.3	87.796	4.07	88.20	1.46	5.31	8,205	14,770
Do.....	9097	NW.	13	14 N.	10 E.	154	3.7	As received....	5.1	8.6	36.6	49.7	1.00	.....	.....	.....	3,325	5,980
								Air dried.....	1.5	8.9	38.0	51.6	1.04	.....	.....	.....	3,455	6,210
								Dry coal.....	.....	9.0	38.5	52.4	1.05	.....	.....	.....	3,505	6,310
								Pure coal.....	.....	19.0	81.0	2.21	.....	.....	.....	.....	7,370	13,260
Do.....	9102	NW.	13	14 N.	10 E.	154	3.0	As received....	3.9	8.6	52.1	35.4	.66	.....	.....	.....	4,820	8,860
								Air dried.....	.9	8.9	53.7	36.5	.68	.....	.....	.....	4,970	8,950
								Dry coal.....	.....	8.9	54.2	36.9	.69	.....	.....	.....	5,015	9,030
								Pure coal.....	.....	14.1	83.9	1.09	.....	.....	.....	.....	7,945	14,300
Do.....	9099	NW.	13	14 N.	10 E.	154	3.1	As received....	4.0	7.4	71.1	17.53	.55	3.35	71.41	1.30	5.86	6,615	11,900
								Air dried.....	.9	7.6	73.4	18.09	.57	3.11	73.69	1.34	3.20	6,825	12,280
								Dry coal.....	7.7	74.0	18.25	.57	3.03	74.33	1.35	2.47	6,885	12,390
								Pure coal.....	.....	9.4	90.6	.70	3.71	90.92	1.65	3.02	8,420	15,150
Do.....	9100	NW.	13	14 N.	10 E.	154	2.0	As received....	2.7	7.1	79.5	10.67	.62	3.48	79.22	1.32	4.69	7,420	13,350
								Air dried.....	.7	7.3	81.1	10.89	.63	3.33	80.84	1.35	2.96	7,570	13,620
								Dry coal.....	7.3	81.7	10.96	.64	3.27	81.39	1.36	2.38	7,620	13,720
								Pure coal.....	.....	8.2	91.8	.72	3.67	91.41	1.53	2.67	8,560	15,410
Prospect B on Summit. Creek.	9098	NW.	13	14 N.	10 E.	155	2.9	As received....	3.7	7.3	47.8	41.16	.70	2.64	47.64	.87	6.99	4,440	7,980
								Air dried.....	.8	7.0	49.2	42.39	.72	2.39	49.06	.91	4.53	4,575	8,230
								Dry coal.....	7.7	49.6	42.74	.73	2.31	49.47	.91	3.84	4,610	8,300
								Pure coal.....	.....	13.3	86.7	1.27	4.03	86.39	1.59	6.72	8,050	14,490
Prospect C on Summit Creek.	9092	NW.	13	14 N.	10 E.	156	2.1	As received....	2.9	8.6	81.9	6.6	.78	.....	.....	.....	7,640	13,750
								Air dried.....	.8	8.8	83.6	6.8	.80	.....	.....	.....	7,805	14,050
								Dry coal.....	.....	8.9	84.3	6.8	.80	.....	.....	.....	7,870	14,170
								Pure coal.....	.....	9.5	90.5	.80	.....	.....	.....	.....	8,440	15,200
Prospects east of Cowlitz River.	9090	SE.	7	13 N.	10 E.	156	5.6	As received....	7.4	4.8	52.0	35.8	.74	.....	.....	.....	4,555	8,200
								Air dried.....	1.9	5.1	56.2	35.9	.75	.....	.....	.....	4,695	8,600
								Dry coal.....	.....	5.2	56.2	36.6	.80	.....	.....	.....	4,850	8,850
								Pure coal.....	.....	8.4	91.0	1.30	.....	.....	.....	.....	8,010	14,420
Prospect near Ladd and Glenavon.	6488	SE.	14	13 N.	4 E.	157	6.0	As received....	8.5	27.3	44.8	19.4	.27	.....	.....	.....	5,830	10,500
								Air dried.....	2.7	29.0	47.7	20.6	.30	.....	.....	.....	6,205	11,170
								Dry coal.....	.....	29.0	49.0	21.1	.30	.....	.....	.....	6,375	11,470
								Pure coal.....	.....	37.9	62.1	.38	.....	.....	.....	.....	8,065	14,550
Do.....	6489	NE.	26	14 N.	4 E.	157	5.1	As received....	9.1	27.8	33.2	29.9	.63	.....	.....	.....	4,475	8,050
								Air dried.....	4.2	30.3	35.0	31.5	.66	.....	.....	.....	4,715	8,480
								Dry coal.....	.....	30.6	36.5	32.9	.69	.....	.....	.....	4,925	8,860
								Pure coal.....	.....	43.6	54.4	1.03	.....	.....	.....	.....	7,330	13,200

Analyses of coal samples from the State of Washington—Continued.

Lewis County—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.			Ultimate.						Heat value.		
		Quar-ter.	Sec-tion.	Town-ship.				Range.	Mois-ture.	Vole-tile mat-ter.	Fixed car-bon.	Ash.	Sul-phur.	Hy-dro-gen.	Car-bon.	Nitro-gen.	Oxy-gen.	Calo-ries.	British thermal units.
Chehalis, 2 miles east of Chehalis.	9944	SE.	28	14 N.	2 W.	165	15.7	As received... Air dried... Dry coal... Pure coal...	29.1 16.0 48.9 54.9	34.7 41.1 40.3 45.1	28.5 33.8 40.3 45.1	7.67 9.10 10.83	1.77 2.10 4.87 2.80	6.69 3.87 4.87 3.46	45.28 53.71 63.91 71.68	0.74 .88 1.04 1.17	37.85 28.34 16.85 18.89	4,415 3,235 6,230 6,985	7,940 9,420 11,210 12,580
Sheldon, 3 miles east of Chehalis.	9943	.....	.....	14 N.	2 W.	165	15.2	As received... Air dried... Dry coal... Pure coal...	29.9 17.3 48.4 52.7	34.0 40.0 48.4 52.7	30.4 35.9 43.4 47.3	5.75 6.78 8.19.....	.58 .68 .83 .90	6.98 6.24 3.22 3.69	45.50 53.65 64.89 70.68	.85 1.00 1.21 1.32	40.34 31.65 19.66 21.41	4,405 5,195 6,285 6,845	7,930 9,350 11,310 12,320
Crescent, 4 miles north-west of Littell.	9940	.....	.....	14 N.	3 W.	166	19.1	As received... Air dried... Dry coal... Pure coal...	32.1 16.1 47.0 53.9	31.9 39.4 40.2 46.1	27.3 33.8 40.2 46.1	8.7 10.7 12.8	2.97 3.66 4.36 5.00	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	3,970 4,905 5,850 6,705	7,140 8,830 10,530 12,070

Pierce County

Burnettat Burnett, No. 2 bed.	9891	SE.	21	19 N.	6 E.	168	2.4	As received... Air dried... Dry coal... Pure coal...	3.7 1.3 37.0 40.9	36.0 37.4 54.2 59.1	52.2 53.4 54.2 59.1	8.13 8.33 8.44	0.76 .78 .79 .86	5.56 5.42 5.35 5.84	73.89 75.71 76.72 83.79	2.00 2.05 2.08 2.27	9.68 7.71 6.62 7.24	7,540 7,725 7,830 8,550	13,570 13,900 14,090 15,390
Burnettat Burnett, No. 3 bed.	9890	NW.	21	19 N.	6 E.	168	1.3	As received... Air dried... Dry coal... Pure coal...	3.2 1.9 36.2 41.5	35.0 35.5 50.9 58.5	49.3 50.0 50.9 58.5	12.46 12.62 12.86.....	.38 .39 .39 .45	5.28 5.21 5.08 5.83	70.74 71.67 73.08 83.87	1.97 2.00 2.04 2.34	9.17 8.11 6.55 7.51	7,065 7,160 7,300 8,380	12,720 12,890 13,140 15,080
Do.....	9889	NW.	21	19 N.	6 E.	168	1.8	As received... Air dried... Dry coal... Pure coal...	3.6 1.8 38.2 44.8	36.8 37.5 47.2 55.2	45.5 46.3 47.2 55.2	14.09 14.35 14.62.....	.38 .39 .39 .46	5.36 5.25 5.15 6.03	67.76 69.00 70.29 82.32	1.75 1.78 1.82 2.13	10.68 7,000 7,130 9.06	6,870 7,000 7,130 8,350	12,370 12,600 12,830 15,030

9888	N.W.	21	19 N.	6 E.	168	2.7	As received..... Air dried..... Dry coal..... Pure coal.....	4.7 2.0 37.0 42.9	35.2 48.2 49.8 57.1	46.9 13.19 13.56 13.83 39.0 57.1	13.19 13.56 13.83 39.0 57.1	.37 .38 .39 .45	5.36 5.20 5.90 5.90	67.64 69.52 70.94 82.33	1.93 1.98 2.02 2.34	11.51 9.36 7.150 8.300	12,270 12,610 12,870 14,940	
9887		16	19 N.	6 E.	169	1.4	As received..... Air dried..... Dry coal..... Pure coal.....	3.3 1.9 38.0 44.0	36.8 47.5 48.4 56.0	46.8 13.15 13.34 13.59 48.4 56.0	13.15 13.34 13.59 48.4 56.0	.41 .42 .42 .49	5.31 5.22 5.12 5.93	68.77 69.75 71.08 82.25	1.95 1.98 2.02 2.34	10.41 9.29 7.195 8.325	12,530 12,710 12,950 14,990	
9886		16	19 N.	6 E.	169	6.1	As received..... Air dried..... Dry coal..... Pure coal.....	7.7 1.7 36.6 42.5	34.4 49.6 50.5 57.5	46.6 11.35 12.09 12.29	11.35 12.09 12.29	.56 .60 .61 .70	5.69 5.34 5.23 5.96	67.50 71.89 73.15 83.40	1.88 2.00 2.04 2.33	13.02 8.08 6.68 7.61	12,310 13,110 13,340 15,210	
9892	N.W.	22	19 N.	6 E.	170	2.7	As received..... Air dried..... Dry coal..... Pure coal.....	5.1 2.5 33.7 45.6	32.8 40.2 41.2 54.4	39.1 23.60 24.6 54.4	22.96 19.14 19.79	.54 .55 .57 .75	4.76 4.58 4.42 5.83	57.33 60.98 60.40 79.67	1.70 1.75 1.79 2.36	12.71 10.60 8.63 11.39	5,800 5,960 6,110 8,060	
9895		14	19 N.	6 E.	171	3.5	As received..... Air dried..... Dry coal..... Pure coal.....	6.7 3.3 33.9 43.8	32.7 42.1 43.7 56.2	42.1 18.47 19.14 56.2	18.47 19.14	.41 .42 .44 .55	5.00 4.78 4.56 5.08	58.85 60.98 63.06 78.63	1.64 1.70 1.76 2.19	15.63 12.98 10.39 12.95	5,910 6,125 6,335 7,895	
9894		14	19 N.	6 E.	171	2.2	As received..... Air dried..... Dry coal..... Pure coal.....	4.7 2.6 33.4 43.7	32.7 43.2 44.3 56.3	42.2 20.38 20.84 56.3	20.38 20.84 21.38	.55 .56 .58 .74	4.86 4.72 4.55 5.79	59.19 60.52 62.10 78.98	1.84 1.88 1.93 2.45	13.18 11.48 9.46 12.04	6,030 6,165 6,330 8,050	
9893		14	19 N.	6 E.	172	4.7	As received..... Air dried..... Dry coal..... Pure coal.....	7.8 3.3 33.9 43.6	31.3 42.5 44.0 56.4	40.5 20.41 21.42 56.4	20.41 21.42 22.13	.40 .42 .43 .55	5.03 4.73 4.51 5.79	57.19 60.01 62.02 79.65	1.65 1.73 1.79 2.30	15.32 11.69 9.12 11.71	5,710 5,990 6,190 7,945	
9905	N.W.	3	18 N.	6 E.	173	2.8	As received..... Air dried..... Dry coal..... Pure coal.....	3.7 .9 27.8 32.4	27.1 27.8 58.3 67.6	56.6 12.60 12.96 67.6	12.60 12.96 13.08	.45 .46 .47 .54	5.08 4.91 4.85 5.58	72.54 74.63 75.32 86.66	2.19 2.25 2.27 2.61	7.14 4.79 4.01 4.61	7,210 7,420 7,485 8,615	
9904	SE.	34	19 N.	6 E.	173	2.3	As received..... Air dried..... Dry coal..... Pure coal.....	3.1 .8 18.9 25.2	18.5 56.2 56.7 74.8	54.9 23.5 24.1 74.8	23.5 24.1 24.2	.43 .44 .44 .58	6.130 6.275 6.825 8.350	11,030 11,290 11,380 15,030
9903	SE.	34	19 N.	6 E.	174	2.8	As received..... Air dried..... Dry coal..... Pure coal.....	3.6 .8 19.1 23.8	19.1 19.7 63.0 76.2	16.3 16.05 16.51 76.2	16.05 16.51	.49 .50 .51 .61	4.41 4.22 4.16 4.99	70.82 72.55 73.12 87.71	1.94 2.00 2.01 2.41	6.59 4.22 3.56 4.28	12,320 12,670 12,770 15,330	

Burnett at Burnett, lump coal.

Burnett at Burnett, washed coal.

Black Carbon, 1/2 mile west of Pittsburg, Black Carbon bed.

Pittsburg at Pittsburg, Lady Wellington bed.

Pittsburg at Pittsburg, Pittsburg bed.

Pittsburg at Pittsburg, washed coal.

Wilkeson at Wilkeson, No. 2 bed.

Do.....

Do.....

Analyses of coal samples from the State of Washington—Continued.

Pierce County—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.	
		Quarter.	Section.	Township.				Range.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Hydrogen.	Carbon.	Nitrogen.	Oxygen.	Calorifics.	British thermal units.
Wilkeson at Wilkeson, No. 3 bed.	9902	NW.	3	18 N.	6 E.	173	1.6	As received... Air dried... Dry coal... Pure coal...	2.5 .9 28.1 31.1	61.3 62.3 62.8 68.9	8.53 8.67 8.75	0.42 .43 .43 .47	5.23 5.13 5.07 5.56	76.94 78.19 78.93 86.50	2.05 2.08 2.10 2.30	6.83 5.50 4.72 5.17	7,715 7,840 7,915 8,675	13,890 14,120 14,250 15,620
Do.....	9901	NW.	3	18 N.	6 E.	173	1.2	As received... Air dried... Dry coal... Pure coal...	2.4 1.1 24.8 30.7	55.3 56.0 56.6 69.3	17.8 18.1 18.3	.48 .49 .60	.....	.....	.....	.....	6,810 6,890 6,970 8,550	12,260 12,410 12,550 15,350
Do.....	9900	NE.	34	19 N.	6 E.	173	4.3	As received... Air dried... Dry coal... Pure coal...	5.3 1.1 21.4 25.6	59.3 61.9 62.6 74.4	14.95 15.62 15.79	.45 .47 .48 .57	4.52 4.22 4.15 4.93	69.79 72.93 73.73 87.55	1.91 2.00 2.02 2.40	8.38 4.76 3.83 4.55	7,315 7,140 7,220 8,570	12,300 12,850 12,990 15,430
Wilkeson at Wilkeson, No. 7 bed.	9899	NW.	34	19 N.	6 E.	173	4.9	As received... Air dried... Dry coal... Pure coal...	5.9 1.1 24.3 27.5	61.1 64.3 65.0 72.5	9.76 10.26 10.38	.41 .43 .44 .49	5.09 4.78 4.71 5.26	74.04 77.86 78.72 87.84	2.17 2.28 2.31 2.58	8.53 4.39 3.44 3.83	7,315 7,690 7,775 8,675	13,160 13,840 14,000 15,620
Wilkeson at Wilkeson, re-washed coal.	9898	.....	27	19 N.	6 E.	175	5.5	As received... Air dried... Dry coal... Pure coal...	6.6 1.1 25.0 29.2	56.5 59.8 60.5 70.8	13.57 14.36 14.53	.46 .49 .57	5.04 4.69 4.61 5.39	69.29 73.32 74.19 86.80	1.98 2.10 2.12 2.48	9.66 5.04 4.07 4.76	6,850 7,245 7,330 8,580	12,330 13,040 13,200 15,440
Gale Creek at Wilkeson, No. 1 bed.	9908	NE.	28	19 N.	6 E.	176	3.4	As received... Air dried... Dry coal... Pure coal...	5.5 2.2 36.4 42.1	50.0 51.8 53.0 57.9	8.06 8.34 8.53	.80 .83 .85 .93	5.70 5.51 5.39 5.89	71.24 73.75 75.38 82.41	1.91 1.98 2.02 2.21	12.29 9.59 7.83 8.56	7,235 7,490 7,655 8,370	13,020 13,480 13,780 15,060
Gale Creek at Wilkeson, No. 2 bed.	9909	NE.	28	19 N.	6 E.	176	2.4	As received... Air dried... Dry coal... Pure coal...	3.9 1.6 36.5 38.9	55.1 56.4 57.3 61.1	5.98 6.13 6.22	.96 .98 1.00 1.07	5.63 5.49 5.77	74.97 76.81 78.01 83.18	1.95 2.00 2.03 2.16	10.51 8.59 7.33 7.82	7,635 7,825 7,945 8,475	13,740 14,080 14,300 15,250

ANALYSES.

9910	NE.	28	19 N.	6 E.	176	1.4	As received. Air dried. Dry coal. Pure coal.	2.8 1.4	33.8 34.3 34.8 38.5	53.8 54.0 53.4 61.5	9.56 9.70 9.83 1.15	1.01 1.02 1.04 1.15	5.44 5.36 5.28 5.86	73.88 74.93 76.00 84.28	2.00 2.03 2.06 2.28	8.11, 6.46, 5.79, 6.43	7.475 7,580 7,885 8,525	13,450 13,640 13,840 15,340
9906	NE.	22	19 N.	6 E.	177	1.4	As received. Air dried. Dry coal. Pure coal.	3.1 1.8	30.2 30.6 31.1 39.9	45.5 46.1 47.0 60.1	21.18 21.48 21.87.....	.41 .42 .42 .54	4.82 4.73 4.62 5.91	62.56 63.45 64.59 82.67	1.56 1.58 1.61 2.06	9.47 8.84 6.89 8.82	6,245 6,330 6,445 8,240	11,240 11,400 11,600 14,850
9907	.....	22	19 N.	6 E.	177	5.0	As received. Air dried. Dry coal. Pure coal.	7.1 2.2	28.4 29.9 30.6 40.3	42.0 43.2 45.2 59.7	22.51 23.69 24.22.....	.45 .45 .46 .61	5.13 4.81 4.67 6.16	57.93 60.98 62.34 82.26	1.45 1.53 1.56 2.06	12.55 8.54 6.270 8.91	5,770 10,930 6,270 8,190	10,380 10,930 11,170 14,750
8997	NW.	28	19 N.	6 E.	178	2.3	As received. Air dried. Dry coal. Pure coal.	4.7 2.4	29.8 30.5 31.3 44.6	37.0 37.9 38.8 55.4	28.50 29.17 29.91	1.15 1.18 1.21 1.73	4.30 4.13 3.97 5.66	52.42 53.65 55.01 78.48	1.74 1.78 1.83 2.61	11.89 10.09 8.07 11.52	5,300 9,760 5,560 7,930	9,540 9,760 10,010 14,280
8996	NW.	26	18 N.	6 E.	179	5.4	As received. Air dried. Dry coal. Pure coal.	6.7 1.4	25.7 27.2 27.6 34.0	50.1 52.9 53.7 66.0	17.5 18.5 18.7.....	.78 .82 .84 1.03	..... ..... ..... .....	..... ..... ..... .....	..... ..... ..... .....	6.425 6,790 6,885 8,470	11,560 12,220 12,390 15,250	
9570	SW.	4	18 N.	6 E.	180	2.7	As received. Air dried. Dry coal. Pure coal.	4.4 1.8	28.5 29.2 29.8 37.4	47.6 48.9 49.8 62.6	19.51 20.05 20.42.....	.39 .40 .41 .52	4.85 4.68 4.56 5.73	62.34 64.07 65.25 81.99	1.78 1.83 1.86 2.34	11.13 8.97 7.50 9.42	6,260 6,435 6,555 8,235	11,270 11,580 11,790 14,820
9556	SW.	4	18 N.	6 E.	181	2.4	As received. Air dried. Dry coal. Pure coal.	3.7 1.4	29.0 29.7 30.1 35.9	51.8 53.0 53.8 64.1	15.50 15.88 16.10.....	.52 .53 .54 .64	5.08 4.93 4.84 5.77	67.37 69.03 70.99 83.42	2.13 2.18 2.21 2.63	9.40 7.45 6.32 7.54	6,740 6,905 7,000 8,345	12,130 12,430 12,600 15,020
9564	NW.	9	18 N.	6 E.	180	1.9	As received. Air dried. Dry coal. Pure coal.	3.6 1.7	29.7 30.3 30.8 37.1	50.3 51.3 52.2 62.9	16.38 16.70 16.99.....	.56 .57 .58 .70	4.94 4.82 4.71 5.67	65.52 66.79 67.96 81.87	2.10 2.14 2.18 2.63	10.50 8.98 7.45 9.13	6,505 6,630 6,745 8,130	11,710 11,930 12,140 14,680
9572	NW.	4	18 N.	6 E.	181	1.8	As received. Air dried. Dry coal. Pure coal.	3.4 1.6	32.2 32.8 33.3 39.4	49.5 50.4 51.3 60.6	14.88 15.15 15.40.....	.45 .46 .47 .56	5.33 5.22 5.12 6.05	67.24 68.47 69.59 82.26	2.00 2.04 2.07 2.45	10.10 8.66 7.53 8.68	6,805 6,930 7,040 8,325	12,250 12,470 12,680 14,880
2460	NW.	4	18 N.	6 E.	181	2.4	As received. Air dried. Dry coal. Pure coal.	4.1 1.7	31.1 31.9 32.5 38.3	50.2 51.4 52.3 61.7	14.6 15.0 15.2.....	.35 .36 .36.....	....................	....................	....................	....................	....................	....................

Gale Creek at Wilkeson,
Queen bed.

Willis at South Willis,
Windsor bed.

Willis at South Willis,
washed coal.

Brier Hill at Wilkeson.....

Snell, 2 miles southeast of
Wilkeson.

Carbon Hill at Carbonado,
No. 11 bed.

Carbon Hill at Carbonado,
No. 9 bed.

Carbon Hill at Carbonado,
No. 5 bed.

Carbon Hill at Carbonado,
No. 1 bed.

Do.....

Analyses of coal samples from the State of Washington—Continued.

Pierce County—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.						Heat value.	
		Quar-ter.	Sec-tion.	Town-ship.				Range.	Mois-ture.	Vola-tile mat-ter.	Fixed car-bon.	Ash.	Sul-phur.	Hy-dro-gen.	Car-bon.	Nitro-gen.	Oxy-gen.	Calo-ries.	British therma-units.
Carbon Hill at Carbonado, No. 4 bed.	9562	NW.	4	18 N.	6 E.	181	2.0	As received...	3.2	34.9	51.5	10.43	0.32	5.48	72.54	1.89	9.34	7,340	13,210
								Air dried.....	1.2	35.6	52.6	10.64	.33	5.37	74.02	1.93	7.71	7,490	13,480
								Dry coal.....	36.0	53.2	10.77	.33	5.30	74.93	1.95	6.72	7,580	13,650	
Carbon Hill at Carbonado, No. 3 Coking bed.	9565	NE.	4	18 N.	6 E.	181	3.5	As received...	4.2	30.0	52.4	13.44	.30	5.10	70.13	1.88	9.15	7,035	13,060
								Air dried.....	.7	31.1	54.3	13.93	.31	4.88	72.67	1.95	6.26	7,290	13,120
								Dry coal.....	31.3	54.7	14.03	.31	4.84	73.19	1.96	5.67	7,340	13,210	
Do.....	9555	NE.	4	18 N.	6 E.	181	3.0	As received...	3.8	26.6	49.3	20.26	.39	5.01	63.85	1.93	8.56	6,400	11,520
								Air dried.....	.8	27.4	50.9	20.89	.40	4.82	65.82	1.99	6.08	6,595	11,870
								Dry coal.....	27.6	51.3	21.06	.41	4.77	66.38	2.01	5.37	6,650	11,970	
Do.....	552-D	SE.	4	18 N.	6 E.	181	1.8	As received...	2.9	30.9	50.1	16.1	.46	4.7	61.8	1.93	6.905	12,430	
								Air dried.....	1.1	31.5	51.0	16.4	.47	4.7	61.8	1.93	6.905	12,430	
								Dry coal.....	31.9	51.6	16.5	.47	4.7	61.8	1.93	6.905	12,430		
Carbon Hill at Carbonado, run-of-mine coal.	787-D	SE.	4	18 N.	6 E.	184	3.3	As received...	4.6	29.1	50.3	16.0	.45	4.7	61.8	1.93	6.905	12,430	
								Air dried.....	1.3	30.5	52.8	16.7	.47	4.7	61.8	1.93	6.905	12,430	
								Dry coal.....	30.6	52.8	16.7	.47	4.7	61.8	1.93	6.905	12,430		
Carbon Hill at Carbonado, No. 2 Coking bed.	9557	SE.	4	18 N.	6 E.	181	2.8	As received...	3.8	27.1	53.7	15.37	.39	4.99	68.20	2.02	9.03	8,850	12,330
								Air dried.....	1.1	27.8	55.3	15.81	.40	4.81	70.16	2.08	6.74	9,050	12,690
								Dry coal.....	28.1	55.9	15.98	.41	4.74	70.92	2.10	6.85	7,135	12,820	
Carbon Hill at Carbonado, No. 1 Coking bed.	9569	SE.	4	18 N.	6 E.	182	2.2	As received...	2.8	28.1	50.9	18.93	.32	4.78	65.62	1.89	6.16	6,685	12,040
								Air dried.....	.6	28.7	51.9	18.75	.33	4.64	67.10	1.93	4.99	6,865	12,310
								Dry coal.....	28.9	52.2	18.86	.33	4.59	67.53	1.94	4.79	6,880	12,300	
								Pure coal.....	33.0	64.4	4.08	5.00	83.22	2.39	4.65	8,480	15,200		

COALS OF THE STATE OF WASHINGTON.

Pierce County—Continued.

Analyses of coal samples from the State of Washington—Continued.

Name of mine or form of exposure.	Laboratory No.	Location.			Page.	Air-drying loss.	Form of analysis.	Proximate.				Ultimate.					Heat value.			
		Quar-ter.	Sec-tion.	Town-ship.				Range.	Mois-ture.	Vola-tile mat-ter.	Fixed car-bon.	Ash.	Sul-phur.	Hy-dro-gen.	Car-bon.	Nitro-gen.	Oxy-gen.	Calo-ries.	British thermal units.	
Carbon Hill at Carbonado, coal dust.	9568		5	18 N.	6 E.	185	17.4	As received... Air dried... Dry coal... Pure coal...	18.8 1.7 30.8 39.3	25.0 30.3 30.8 39.3	38.6 46.7 47.5 60.7	17.6 21.3 21.7 .	0.59 .72 .73 .93						5,210 6,310 6,415 8,195	9,380 11,350 11,540 14,750
Melmont at Melmont, No. 3 bed.	9579		16	18 N.	6 E.	186	2.9	As received... Air dried... Dry coal... Pure coal...	3.6 .8 24.5 28.5	23.6 24.3 24.5 28.5	59.3 61.0 61.5 71.5	13.47 13.87 13.98 .	.35 .36 .36 .42	1.72 1.77 1.79 2.08	7.88 5.46 4.81 5.59	7.085 7,295 7,355 8,550	12,750 13,130 13,230 15,380			
Do.....	9578		15	18 N.	6 E.	186	2.3	As received... Air dried... Dry coal... Pure coal...	3.1 .8 22.1 26.1	21.4 21.9 22.1 26.1	60.6 62.0 62.5 73.9	14.9 15.3 15.4 .	.31 .32 .32 .38				6,890 7,055 7,115 8,410	12,400 12,700 12,800 15,140		
Melmont at Melmont, No. 2 bed.	9576		15	18 N.	6 E.	186	4.4	As received... Air dried... Dry coal... Pure coal...	5.6 1.2 12.7 15.8	12.0 12.6 12.7 15.8	63.9 66.8 67.6 84.2	18.5 19.4 19.7 .	.38 .40 .40 .50				6,440 6,740 6,825 8,490	11,600 12,130 12,280 15,290		
Do.....	9580		15	18 N.	6 E.	186	4.5	As received... Air dried... Dry coal... Pure coal...	6.0 1.6 12.6 15.1	11.8 12.4 12.6 15.1	66.3 69.4 70.5 84.9	15.9 16.6 16.9 .	.43 .45 .46 .55				6,625 6,940 7,055 8,490	11,930 12,490 12,700 15,280		
Melmont at Melmont, washed coal.	9575		22	18 N.	6 E.	187	6.2	As received... Air dried... Dry coal... Pure coal...	7.0 .9 22.0 27.6	20.5 21.8 22.0 27.6	53.7 57.3 57.8 72.4	18.76 20.00 20.18 .	.34 .36 .37 .46	1.58 1.68 1.70 2.13	11.54 6.44 5.67 7.11	6,300 6,720 6,780 8,495	11,340 12,090 12,200 15,290			
Melmont at Melmont, composite sample.	10412		15	18 N.	6 E.	187	4.5	As received... Air dried... Dry coal... Pure coal...	5.8 1.4 13.3 16.2	12.6 13.1 13.3 16.2	64.6 67.7 68.6 83.8	17.04 17.85 18.09 .	.38 .40 .40 .48	1.67 1.75 1.77 2.16	8.22 4.41 3.24 3.97	6,540 6,850 6,945 8,480	11,780 12,330 12,500 15,260			

Do.....	9094	SW.	21	15 N.	1 W.	194	16.8	As received.....	22.2	31.7	37.0	9.1	35	4,755	8,560
								Air dried.....	6.5	38.2	44.4	10.9	42	5,770	10,290
								Dry coal.....	40.8	47.5	53.8	11.7	45	6,115	11,000
								Pure coal.....	46.2	53.8	58.8	51	6,925	12,460
Do.....	9096	SW.	21	15 N.	1 W.	194	16.7	As received.....	22.7	31.0	38.3	8.02	37	6.19	49.56	1.08	34.78	4,795	8,630	
								Air dried.....	7.2	37.3	45.9	9.63	44	5.20	59.50	1.30	23.93	5,755	10,360	
								Dry coal.....	40.1	49.5	55.2	10.37	48	4.75	64.08	1.40	18.92	6,200	11,160	
								Pure coal.....	44.8	55.2	60.2	.....	54	5.30	71.49	1.56	21.11	6,915	12,340
Hannaford No. 1 at Tono, car sample, run-of-mine coal.	8752					195	6.7	As received.....	20.2	31.5	39.9	8.44	52	5.93	52.52	1.06	31.53	5,150	9,280	
								Air dried.....	14.5	33.5	42.9	9.03	56	5.56	56.29	1.14	27.40	5,520	9,940	
								Dry coal.....	39.5	49.9	56.0	10.58	65	4.61	65.83	1.33	17.00	6,460	11,630	
								Pure coal.....	44.0	56.0	61.0	.....	73	5.16	73.62	1.49	19.00	7,230	13,000
Perth, 3 miles north of Centralia.	9178			15 N.	2 W.	196	12.4	As received.....	25.1	32.3	34.0	8.65	82	6.37	47.26	.91	35.99	4,540	8,170	
								Air dried.....	14.5	36.8	38.8	9.88	94	5.70	53.95	1.04	28.49	5,180	9,330	
								Dry coal.....	43.1	45.4	51.3	11.55	109	4.77	63.08	1.21	18.30	6,060	10,910	
								Pure coal.....	48.7	51.3	56.0	.....	123	5.39	71.32	1.37	20.69	6,840	12,320
Black Bear, 2 miles south- east of Tenino.	9939	SW.	31	16 N.	1 W.	197	6.3	As received.....	16.0	31.9	28.9	23.19	150	5.04	43.44	.73	26.10	4,335	7,800	
								Air dried.....	10.4	34.0	30.9	24.75	160	4.63	46.36	.78	21.88	4,625	8,330	
								Dry coal.....	37.9	34.5	47.6	27.61	179	3.88	51.73	.87	14.12	5,160	9,290	
								Pure coal.....	52.4	47.6	53.0	.....	247	5.36	71.46	1.20	19.51	7,130	12,850
King, 3 miles southwest of Tenino.	9987	SW.	35	16 N.	2 W.	198	9.5	As received.....	22.4	33.6	33.0	10.95	240	6.04	48.88	.72	31.01	4,875	8,770	
								Air dried.....	14.3	37.2	36.4	12.10	265	5.50	54.01	.80	24.94	5,385	9,690	
								Dry coal.....	43.4	42.5	49.5	14.12	309	4.58	63.02	.93	14.26	6,285	11,310	
								Pure coal.....	50.5	49.5	53.0	.....	360	5.33	73.38	1.08	16.61	7,315	13,170

Proximate analyses of coal samples from Whatcom and Skagit counties, Wash.

[Analyzed by Bureau of Equipment of the Navy Department, Washington, D. C.]

Place.	Condition of sample.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.
Blue Canyon, T. 35 N., R. 5 E..	As received.....	0.310	22.265	62.395	14.885	0.145
Cokedale, Fairhaven:						
T. 35 N., R. 5 E.....	.....do.....	2.980	35.030	59.980	2.010	.202
T. 37 N., R. 4 E.....	.....do.....	1.790	31.479	62.744	3.679	.308

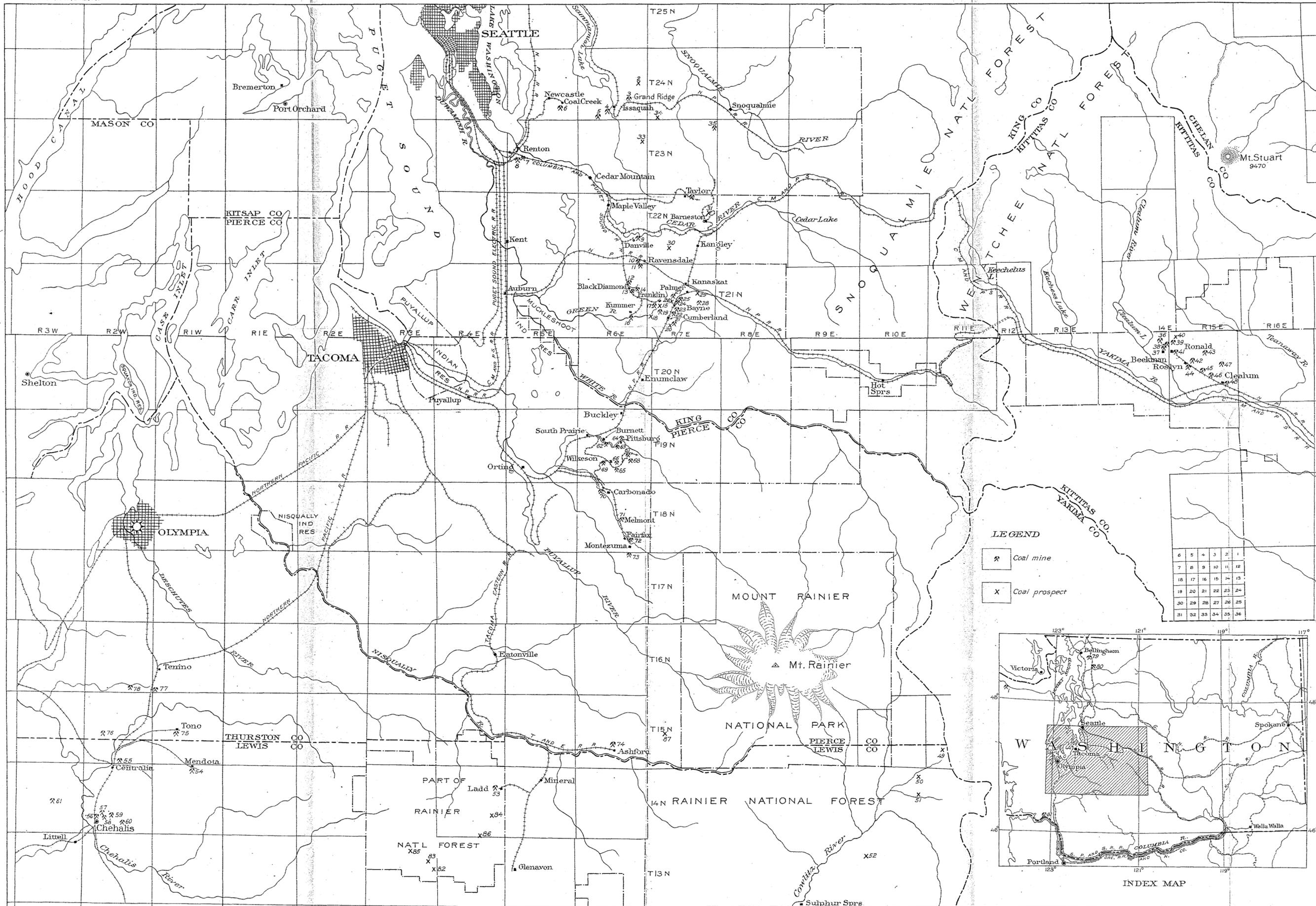
DETAILED DESCRIPTIONS OF MINES, SAMPLES, AND COALS.¹**DISTRIBUTION OF MINES.**

The general distribution of the mining districts and the locations of the mines and prospects from which samples were obtained are shown on the accompanying map (Pl. III), which is based on the General Land Office map of the State with corrections and additions from the topographic atlas sheets of the United States Geological Survey. The numbers of the mines and prospects refer to the numbers in the list of mines and prospects given at the edge of the map. The system of railroads shows the connections between mines, centers of consumption, and tidewater shipping points.

ORDER OF DESCRIPTION.

It has been the custom in reports on the coal of the State to group the mines according to the counties in which they occur, and the county will be the unit used in the publications contemplated by the State Geological Survey. Therefore the mines and the samples are here arranged and discussed in the same manner, the counties being considered in alphabetic order. The mines and prospects in Kittitas County have been discussed from west to east, in Pierce County from north to south, in Lewis County from east to west, and in Thurston County from south to north. Those in King County are arranged nearly in the order of a rude circle beginning near Grand Ridge and passing through Renton, Black Diamond, Bayne, and Taylor to Snoqualmie. The parts sampled are indicated in the section by an asterisk (*), a dagger (†), or by the insertion of the sample number.

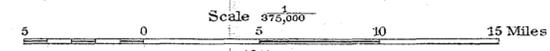
¹ Samples were taken from all the working mines in the State except those at Park, Whatcom County, and at Kopiah, Lewis County. The Blue Canyon mine of the Whatcom County Coal Co. at Park has been in operation for many years. This coal has been repeatedly analyzed and its character is well known. A visit to the mine of the Wilson Coal Co. at Kopiah was made by the writer, but admission to the mine was refused. In Cowlitz County there are several small mines which the writer was unable to visit and sample because the funds available for this investigation were exhausted. Considerable development work has been done at different periods in Skagit County, but no mines are at present in operation there because of the great number of faults and the lenticular character of the coal beds.



LIST OF MINES

- 1 FUCA
- 2 PROSPECT
- 3 GRAND RIDGE
- 4 ISSAQUAH
- 5 SUPERIOR
- 6 FORD AND BAGLEY
- 7 DENNY-RENTON
- 8 RENTON
- 9 DANVILLE
- 10 RAVENSDALE NO. 1
- 11 MCKAY
- 12 MORGAN
- 13 BLACK DIAMOND NO. 14
- 14 LAWSON
- 15 SURFACE EXPOSURE
- 16 KUMMER
- 17 GEM
- 18 SURFACE EXPOSURE
- 19 ROSE-MARSHALL
- 20 INDEPENDENT
- 21 SUNSET
- 22 NAVAL
- 23 EUREKA
- 24 BAYNE
- 25 CARBON
- 26 PROSPECT DRIFT
- 27 OCCIDENTAL
- 28 BIG SIX
- 29 SURFACE EXPOSURE
- 30 PROSPECT SHAFT
- 31 PROSPECT DRIFT
- 32 DENNY-RENTON
- 33 PROSPECT
- 34 PROSPECT
- 35 NIBLACK
- 36 LAKEDALE
- 37 BEEKMAN
- 38 BUSY BEE
- 39 PATRICK-MACKAY
- 40 SURFACE EXPOSURE
- 41 ROSLYN NO. 3
- 42 ROSLYN NO. 2
- 43 K. & E.
- 44 ROSLYN NO. 4
- 45 ROSLYN NO. 5
- 46 ROSLYN NO. 7
- 47 SUMMIT
- 48 CLE ELUM NO. 1
- 49 PROSPECT
- 50 PROSPECT
- 51 PROSPECT
- 52 SURFACE EXPOSURE
- 53 EAST CREEK-LADD
- 54 MENDOTA
- 55 RICHMOND
- 56 SUPERIOR NO. 1
- 57 SUPERIOR NO. 2
- 58 TWIN CITY
- 59 CHEHALIS
- 60 SHELDON
- 61 CRESCENT
- 62 BURNETT
- 63 BLACK CARBON
- 64 PITTSBURG
- 65 WILKESON
- 66 GALE CREEK
- 67 WILLIS
- 68 SNELL
- 69 BRIER HILL
- 70 CARBON HILL
- 71 MELMONT
- 72 FAIRFAX
- 73 MONTEZUMA
- 74 MASHEL
- 75 HANNAFORD
- 76 PERTH
- 77 BLACK BEAR
- 78 KING
- 79 BLUE CANYON
- 80 COKEDALE
- 81 ?
- 82, 83, 84 DRIFTS
- 85, 86, 87 PROSPECTS

SKETCH MAP OF A PORTION OF WESTERN WASHINGTON, SHOWING THE DISTRIBUTION OF COAL MINES AND PROSPECTS DISCUSSED IN THIS REPORT



CLALLAM COUNTY.

The coal fields of Clallam County were studied by Ralph Arnold in 1904 and are described by him in two reports.¹

The only mine at present operating is situated in the Clallam Bay field east of the town of Clallam. Most of the work being done at the time of the writer's visit was for the purpose of development. The analysis given by Arnold of the coal from Clallam was probably that of a sample taken from another bed than that which is mined at the present time. The sample collected by the writer was obtained in February, 1910.

FUCA.

Fuca, a drift mine 6 miles east of Clallam on the shore of the strait of San Juan de Fuca. No. 1.²

Operator: Clallam Coal Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal beds.—Several coal beds are reported as occurring in this vicinity, but only one is being developed. An exposure higher on the hill but on a bed underlying the one now being mined is reported, but it was not sampled. The beds strike nearly north and south and dip about 60° W. The bed now being mined, believed to be the middle one of the three referred to by Arnold in his reports, occurs in conglomerate containing pebbles up to 1 inch in diameter. The mine is situated on the face of a very steep sea cliff which rises sharply from the water's edge to a height of about 400 feet. The entrance to the mine is about 50 feet above low tide. The gangway has been driven on the strike of the bed to a distance of about 450 feet: A small fault was encountered which offset the bed a few feet. Practically all the coal between the level of the gangway and the surface has been worked out. The bed varies in thickness from 1 foot 6 inches to 2 feet 6 inches, the average being about 1 foot 10 inches. At several places in the mine lenses of coal from 5 to 50 feet long and varying up to 2 feet in thickness have been found beneath the main bed and separated from it by several inches of shale. The coal bed is so thin that a large amount of rock work is necessary. In the gangway about 4 feet of the roof is brushed down for head room. The following section was measured where the sample was obtained:

Section of coal bed in Fuca mine.

No. 10030.

Sandstone.	Ft. in.
Shale.....	2½±
*Coal.....	1 11
Shale.....	} to 2 7
Sandstone.	
Coal bed.....	1 11

¹ Coal in Clallam County, Wash.: Bull. U. S. Geol. Survey No. 260, 1905, pp. 413-421; Geological reconnaissance of the coast of the Olympic Peninsula, Washington: Bull. Geol. Soc. America, vol. 17, 1906, pp. 451-468, pls. 55-58.

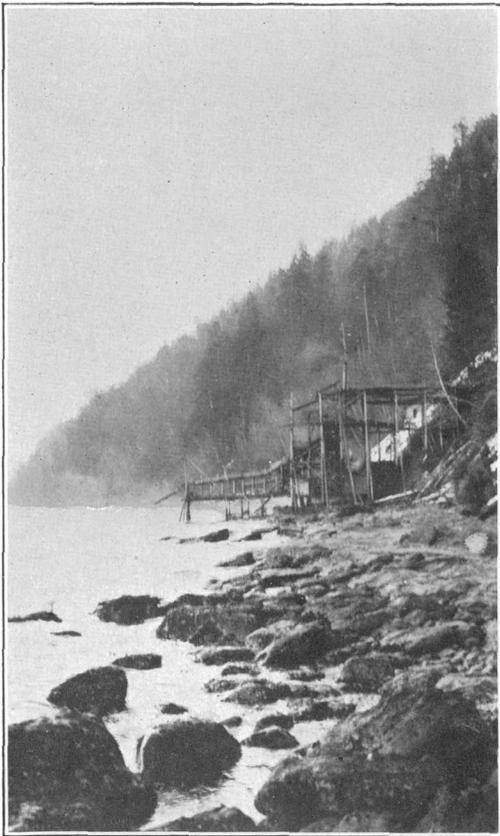
² Numbers refer to location on the map, Pl. III.

Preparation for market.—A bunker of 100 tons capacity has been erected at the entrance to the mine. (See Pl. IV, A.) It extends over the water at high tide about 40 feet, and the coal can be loaded from it into barges when the water is not too rough. The coal is passed over 1-inch and $\frac{1}{2}$ -inch bar screens. The oversize from the larger screen is hand-picked to remove "sulphur" balls and shale from the roof and floor, and the undersize is washed in a home-made jig to remove the fine shale produced in mining.

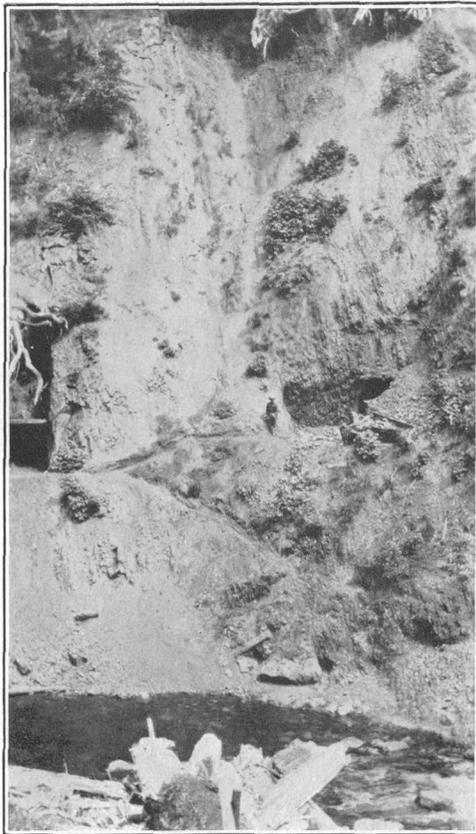
Sample for analysis.—Sample 10030 was taken at a point about 100 feet above the gangway in chute 6, about 400 feet from the entrance of the mine. The sandstone both above and below the coal bed is massive and very resistant and makes an excellent roof and floor. The shale immediately overlying the coal does not adhere to it and does not come down in mining; the shale underlying the coal is used as a "mining"¹ and must be separated from the fine coal by picking and washing. The analysis of this sample is given on page 41.

Character and quality of the coal.—The coal is pitch black, very hard, and brittle, and has a vitreous luster. It is massive and laminated and breaks with an irregular splintery and conchoidal fracture. Although it contains nearly as much moisture as subbituminous coal, it gives off little on exposure to the air and hence does not air slack. It contains about the same amount of ash as the subbituminous coal of Renton and Coal Creek. The percentage of sulphur is higher than in any of the other coals described in this report, owing to the occurrence of many minute lenses of marcasite or pyrite disseminated through the main mass of the coal. The bed contains many nodules of pyrite, from 1 inch to several feet in length, which can be readily separated from the coal by picking and washing. The amount of sulphur in the coal in different parts of the bed varies considerably, according to the relative abundance or scarcity of the larger pyrite nodules. In many places the amount of sulphur in the coal may be as low as 2 per cent, and elsewhere as high as 10 per cent. It will be noticed from the analysis that the percentage of fixed carbon is considerably less than that of the volatile matter, the actual ratio of the two being about 9 to 10, a proportion suggestive of that which characterizes cannel coal. A splinter of the coal can be ignited with a match about as readily as cannel from the eastern part of the United States. The coal is different in its characteristics from any other coal in the State or any other coal with which the writer is familiar. Although it resembles subbituminous coal in moisture content and heating value, it should be classed as bituminous coal on account of its ability to stand transportation without disintegration.

¹ "Mining" is a term used in coal mining to indicate a soft layer on which work is begun in opening a bed.



A. BUNKER OF THE CLALLAM COAL CO., AT FUCA,
CLALLAM COUNTY, AT LOW TIDE.



B. EXPOSURES OF BEDS OF ANTHRACITE ON SUMMIT
CREEK, LEWIS COUNTY.

COWLITZ COUNTY.

The coal fields of Cowlitz County are not very well known on account of the dense surface covering and the scanty outcrops. Coal has been reported at several places along the Northern Pacific Railway in the western part of the county, especially in the vicinity of Castle Rock and Kelso, and several small mines, opened to supply local trade, have been operated periodically for several years. The location of some mines and prospects and a short discussion of the geology of the district has been given by Henry Landes.¹

In 1904, J. S. Diller² visited a mine (No. 81) on Coal Creek 12 miles west of Kelso, a few miles from a slough leading to Columbia River. The following description is taken from his report:

The coal bed is 6 to 7 feet in thickness, with two small partings of sand. The top bench has 12 to 18 inches of bony coal, the middle bench 2½ feet of better quality, and the lower bench 18 inches of coal in part good. The coal bed is overlain by soft sandstone.

In the mine the coal looks bright, but on exposure it loses its luster, cracks somewhat, and partially slacks. Some part of it is well banded and contains small pieces of fossil resin.

Two specimens were taken for analysis, one from the middle (No. 6760) and the other (No. 6761) from the lower bench.

[The analyses of these samples as made in the United States Geological Survey laboratory by W. T. Schaller are given on page 41.]

Mr. Schaller reports that—

“The bottle containing No. 6761 was broken when received at the laboratory. A moisture determination of the coarsely ground sample gave 17.79 per cent, showing that the coal had lost moisture in transit, due to the bottle being broken. For this reason no data are given for the coarsely ground No. 6761 sample.

An aluminum sulphate occurs on the joint planes of 6761. The values for volatile combustible matter, fixed carbon, and ash in the coarsely ground No. 6760 are calculated from the corresponding figures of the finely ground sample.”

The high percentage of water, ash, and sulphur present are all against its utility. The coal was used in running the engine of the mine and appeared to burn well, but as to later developments in the mine no information is at hand.

The bed of coal is interstratified with a lot of shales and shaly sandstones well exposed along Coal Creek near the mine. The strike of these beds near the mine is northwest-southeast, with a dip of about 15° SW., and it seems probable that if the coal on trial proves of sufficient value to work it could be traced to higher ground where gravity would be of greater service in operating the mine. There are igneous rocks cutting the coal-bearing beds in that region and the strata are faulted locally, but neither igneous rocks nor faults were seen near the mine.

To judge from the above description of the coal it resembles the lower grade of coal in the vicinity of Centralia and Chehalis, in Lewis County, although it is considerably higher in its sulphur content.

¹ Landes, Henry: Ann. Rept. Washington Geol. Survey, vol. 1, 1901, pp. 279-281; vol. 2, 1902, pp. 255-257.

² Diller, J. S., Coal in Washington near Portland, Oreg.: Bull. U. S. Geol. Survey No. 260, 1905, pp. 411-412.

KING COUNTY.

GENERAL DESCRIPTION.

The extent of the coal fields of King County is not well known. The surface is covered by dense timber and undergrowth (Pl. V) and by gravel and glacial drift (Pl. VI, A) so that it is very difficult to trace the outcrops of the formations (Pl. VI, B), and the character of the rocks is so variable and the quality of the coal so different within short distances that it is almost impossible to correlate coal beds on these criteria. Variations in quality of the coal from subbituminous to bituminous are regional rather than local, except where the beds have been altered by volcanic action. No coal bed so far as known can be said to be subbituminous in one part of a field and bituminous in another part. Both bituminous and subbituminous beds are constant in character within the fields in which they are known to occur, but variations in the character of coal of adjoining fields believed to be closely associated are often very marked. It is believed that the detailed work performed by the State Geological Survey during the summer and autumn of 1909 will do much toward establishing the correlation of the beds in different parts of the county.

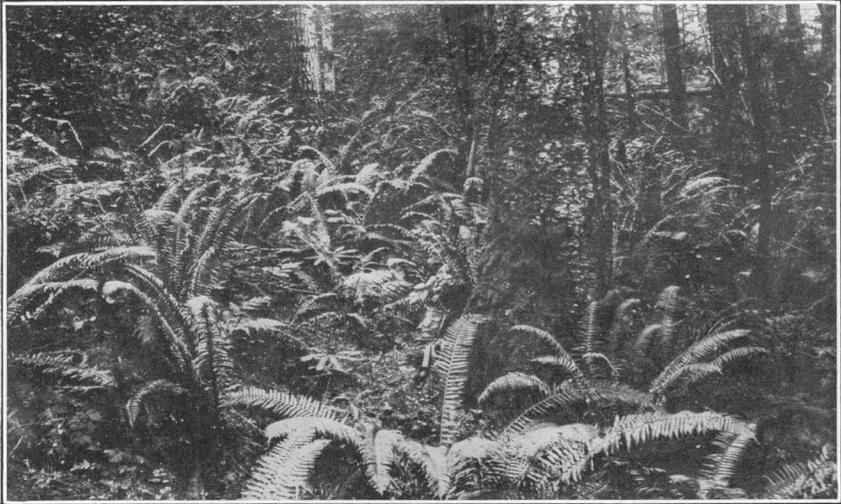
The samples taken from this county were collected at different times between July, 1909, and January, 1910, but mostly during the months of July, August, and September. Several samples obtained by other collectors from the mines at Renton, Taylor, and Ravensdale in the last few years have been analyzed by the United States Geological Survey, and the analyses of these samples are given as a means of comparison with those taken by the writer.

Gas is present in many of the mines of this county. In the mines at Black Diamond it is so abundant as to necessitate the use of safety lamps in all the workings. It occurs in small quantities in the subbituminous coal at Coal Creek, but chiefly in the bituminous coal nearer the main crest of the Cascade Mountains.

PROSPECT NORTH OF ISSAQUAH.

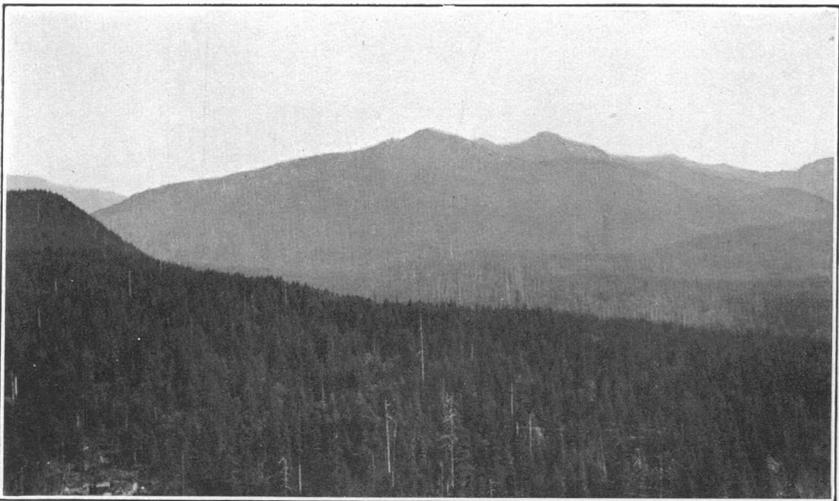
A prospect shaft 3 miles north of Issaquah. No. 2.
Opened by United States Coal Co., Seattle, Wash.
Kind of coal: Subbituminous.

Coal bed.—The coal bed probably belongs to the group of coal beds exposed at the Grand Ridge mine, to the south. It strikes N. 73° E. and dips 79° NW. A shaft has been sunk on the bed to a depth of 53 feet. The following section was measured at the bottom of the shaft.



A. FOREST UNDERGROWTH IN THE COAL DISTRICT NEAR BAYNE, KING COUNTY.

A factor which makes study of the coal-bearing formations of Washington very difficult.



B. TYPICAL FORESTED AREA OF THE PUGET SOUND COUNTRY.

Looking east from Lizard Mountain, near Bayne, King County.

Section of coal bed at United States Coal Co.'s prospect 3 miles north of Issaquah.

No. 9291.

Shale, carbonaceous.	Ft.	in.
*Coal.....	3	1
Clay, white, plastic.....		2
*Coal.....	2	9
Clay, yellowish, white, plastic.....		3
*Coal, bony.....		3½
Shale, slaty, carbonaceous.	6	6½

Sample for analysis.—Sample 9291 was taken at the bottom of the shaft. The two clay partings in the bed can be easily separated from the coal and were not included in the sample. The hanging wall and the foot wall of the bed, which are made up of carbonaceous shale, are firm and strong and do not mix with the coal. The analysis of the sample is given on page 41.

Character and quality of the coal.—The coal is grayish black and banded and has a splintery fracture. It contains a small amount of gas which could be heard escaping from the bottom of the shaft. The coal contains a large amount of moisture and probably weathers rapidly on exposure to the direct rays of the sun, but large blocks exposed to the air under the cover of trees for several months showed no signs of breaking down. The coal has about the same heating value as the coal from the mines at Grand Ridge and Issaquah.

GRAND RIDGE.

Grand Ridge slope mine, on the Northern Pacific Railway, 3 miles east of Issaquah. No. 3.

Operator: Central Coal Co., Seattle, Wash.

Kind of coal: Subbituminous.

Coal beds.—Five coal beds are being worked, ranging from No. 1, at the bottom, to No. 7, at the top. They strike N. 34° E. and dip 28° NW. Sections of beds Nos. 1, 2, 3, 4, and 7, where the samples were taken, are given below:

Sections of coal beds in Grand Ridge mine, 3 miles east of Issaquah.

No. 8544, bed No. 1.			No. 11736, bed No. 3.		
	Ft.	in.		Ft.	in.
Shale.			Sandstone, massive.		
*Coal.....	1	3½	*Coal.....	1	7
Shale.....		2½	Shale, carbonaceous.....		3
*Coal.....	1		Clay, white.....		6
Shale.....		½	*Coal.....	1	11
*Coal.....	1		Clay, white.....		5
Shale.....		1	Bone and coal.....	1	2
*Coal.....	1	8½	Shale.....		4
Shale.....		½	Sandstone, massive.		
*Coal.....	1	7			
Shale.					
	6	11½		6	2

Sections of coal beds in Grand Ridge mine, 3 miles east of Issaquah—Continued.

No. 8545, bed No. 2.		No. 11738, bed No. 7.	
Shale.	Ft. in.	Sandstone, massive.	Ft. in.
Shale and coal in streaks.....	5	Shale.....	2
*Coal.....	2	*Coal.....	1 6
*Coal, banded.....	2	Clay, white.....	1 5
Shale.		*Coal.....	1 7
	4 5	Clay, white.....	5
		*Coal.....	8
		Clay.....	5
		Coal, impure.....	6
		Shale, carbonaceous.....	11
		Shale.	
			9 5½

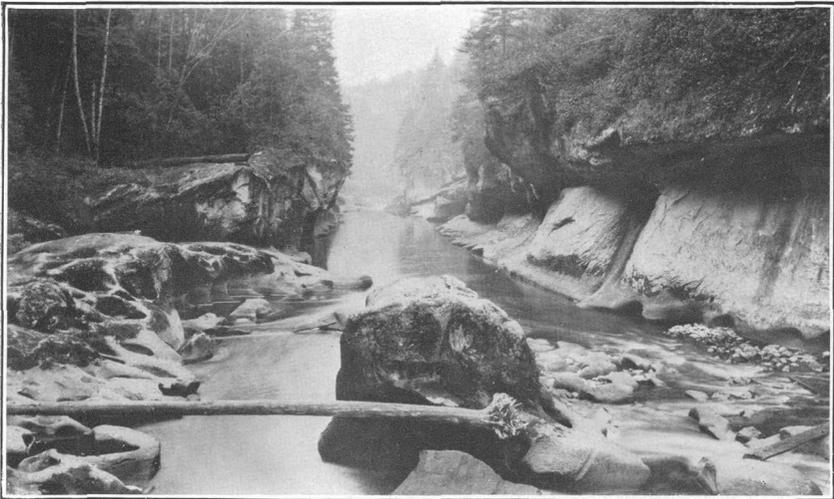
Preparation for market.—At the time this mine was examined by the writer beds Nos. 1 and 2 only were being worked on a commercial scale. The coal from both beds was mixed in the bunkers; that which passed over 1½-inch bar screens was hand picked and sold as lump, and that which passed through the screen was washed in a Jeffery-Robinson washer.

Samples for analysis.—Sample 8544, from bed No. 1, was taken from the north end of the north gangway on the first water level about 220 feet north of the rock tunnel to bed No. 2. At this point four distinct shale partings ranging from half an inch to 2½ inches are present. By careful picking and washing these bands may be separated from the coal, and they were therefore excluded from the sample. Both hanging and foot walls are fairly strong and do not mix with the coal in mining. Sample 8545, from bed No. 2, was taken from the north end of the north gangway on the first water level about 100 feet north of rock tunnel from bed No. 1. Both hanging and foot walls are firm and do not mix with the coal. Sample 11736, from bed No. 3, was taken from the left side of chute 4. Sample 11737, from bed No. 4, was taken on the north side of the rock tunnel. This sample was damp when it was sealed in the can. The location of sample 11738 is not given, but it is reputed as being wet when it was sealed in the can.

In preparing sample 9883, 40 pounds of coal which had just passed through the washer and was still wet was taken from the surface of a 50-ton bin. The fragments were reduced to a uniform size of about three-fourths of an inch and the sample was quartered, opposite quarters being rejected and the remainder ground in a bone grinder to the size of a pea. This was in turn quartered by the usual method until the final sample, about a quart, was obtained. This sample was sealed without drying in an air-tight can and mailed to the



A. GLACIAL BOWLERS ON THE SOUTH BANK OF GREEN RIVER NEAR FRANKLIN, KING COUNTY.



B. EXPOSURES OF THE PUGET FORMATION, IN WHICH THE COAL OCCURS, ALONG GREEN RIVER NEAR FRANKLIN.

chemical laboratory. The analyses of the samples are given on page 42.

Character and quality of the coal.—The coal is grayish black and has a reddish-brown streak. It is banded and laminated and breaks with an irregular splintery fracture. It slacks slightly when exposed to the direct rays of the sun, but does not contain enough moisture to cause it to slack noticeably when shipped in closed cars. Coal from bed No. 1 compares very favorably with that from Coal Creek and Renton. Coal from bed No. 2 is higher in ash than that from bed No. 1 because of the slightly bony nature of the lower portion of the bed, and hence has a lower heating value. The analysis of the washed coal (laboratory No. 9883) represents the quality of a mixture from the two beds. The great amount of moisture in the washed coal as received is due to water from the washing. The coal makes a good fire in stationary boilers without forced draft and is classed as sub-bituminous.

ISSAQUAH.

Issaquah slope and drift mine, at Issaquah, on the Northern Pacific Railway. No. 4.

Operator: Issaquah Coal Co., Seattle, Wash.

Kind of coal: Subbituminous.

Coal beds.—Only two of the numerous coal beds worked by this company were exposed so that samples could be taken. The company ceased operations at the mine several years ago (see Pl. VII, A), and most of the workings were flooded with water so that the samples had to be taken above the water level of the valley. The beds strike N. 74° E. and dip 26° NW. The following sections were taken where the samples were obtained:

Sections of coal beds in Issaquah mine.

No. 8542, bed No. 4.		No. 8543, bed No. 5.	
Shale.	Ft. in.	Sandstone.	Ft. in.
*Coal.....	11½	*Coal.....	1
Shale.....	½	Clay.....	5
*Coal.....	1	*Coal.....	2
Shale.....	½	Clay.....	2½
*Coal.....	5	*Coal.....	11
Shale with streaks of coal..	1	Shale, carbonaceous.....	7
*Coal.....	7	Sandstone, white.....	
Shale.....	½	Coal bed.....	4 6½
*Coal.....	1 9		
	4 11		

Preparation for market.—The coal from this mine was passed over bar screens, after which the lump coal was picked by hand and the screenings were washed in a Jeffery-Robinson tub washer.

Samples for analysis.—Sample 8542 was taken from the side of a small entry west of the main slope on bed No. 4, 50 feet down the

slope from the entrance to the mine. All the partings of the bed can be separated from the coal by careful picking and washing and were therefore not included in the sample. Although it had been exposed to the weather for a considerable length of time, the roof appeared to be firm and strong. The bottom of the bed was not exposed, and the character of the floor could not be determined. Mud carried down by water from the overlying rocks had filled the joints in the coal and in order to remove this mud the sample was thoroughly washed in a small stream before being ground and quartered. It was sealed in the can without being dried and for this reason the percentage of moisture in the sample as received is higher than it would be when mined under ordinary conditions. Sample 8543 was taken at the end of a 700-foot water-level gangway on bed No. 5. Both clay partings in the bed can be separated by picking and washing and consequently were not included in the sample. The sample which was taken near the surface and was wet by seepage from overlying rocks and soil was still moist when sealed in the can and the analysis of the sample as received shows moisture of more than ordinary amount. The analyses of these samples are given on pages 42-43.

Character and quality of the coal.—The coal is grayish brown, has a slightly banded structure, and breaks with a conchoidal fracture. It slacks slightly when exposed to the direct rays of the sun but does not contain enough moisture to cause it to weather when shipped in closed cars. Its heating value is about the same as that of the coal from the Grand Ridge mine but is slightly lower than that of the coal from Coal Creek. This coal is classed as subbituminous.

SUPERIOR.

Superior drift mine, $1\frac{1}{2}$ miles southwest of Issaquah, on a spur of the Northern Pacific Railway. No. 5.

Operator: Superior Coal & Improvement Co., Seattle, Wash.

Kind of coal: Subbituminous.

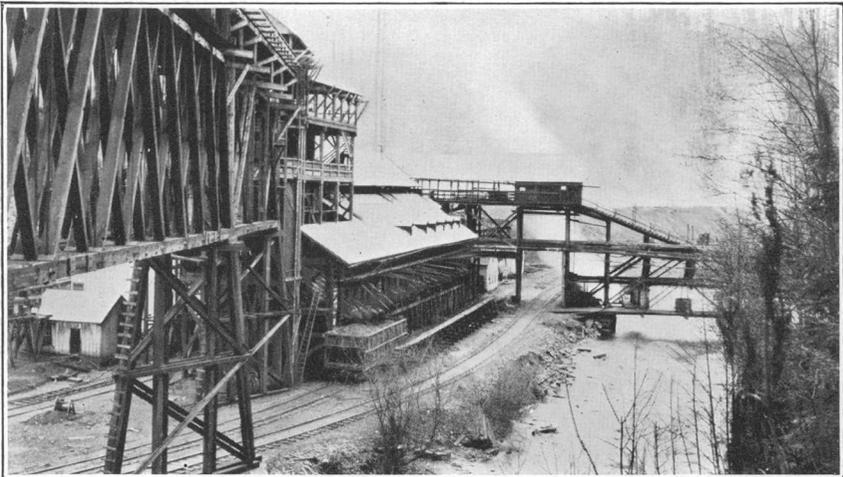
Coal beds.—One coal bed is worked in this mine. It strikes N. 70° E. and dips 30° NW. Another bed, about 300 feet to the north, is thought to be the same as the bed No. 0 at the Issaquah mine. The following sections were measured at the points from which the samples were taken:

Sections of coal beds at Superior mine, $1\frac{1}{2}$ miles southwest of Issaquah.

No. 8548, main bed.			No. 8547, bed No. 0.		
	Ft.	in.		Ft.	in.
Coal, roof.					
Clay (small lens).....		2½	*Coal.....	1	5
*Coal, poor.....	3	7	Clay, brown.....		1
Sandstone, shaly, very hard			*Coal.....	1	1
(varies 1" to 3½").....		2½	Clay, yellow.....		4
*Coal.....	3+		*Coal.....		8½
Coal, floor.					
Total worked.....	6	9½	Total worked.....	3	7½



A. ABANDONED BUNKER OF THE ISSAQUAH COAL CO., AT ISSAQUAH, KING COUNTY.



B. WASHER AND BUNKER OF THE PACIFIC COAST COAL CO., AT BURNETT, PIERCE COUNTY.

Preparation for market.—Temporary bunkers have been erected. The coal is being picked by hand, pending the further development of the mine.

Samples for analysis.—Sample 8548 was taken on the first water level 900 feet from the entrance to the mine and 60 feet up the rise on the west side of the last entry. A parting which occurs near the center can be removed by picking and washing and was therefore not included in the sample. The roof of the mine is coal, but it is separated from the bed at this particular place by small lenses of clay which come down in mining and which must be removed from the coal. The bottom of the bed was not exposed, and the floor at this point was in coal. The sample contained films of mud in the joints of the coal and these were removed by washing before the sample was ground and quartered. The sample was sealed in the can while wet and the analysis of the sample as received contains a slightly excessive amount of moisture. Sample 8547 was taken 60 feet from the entrance of the 75-foot drift on coal bed No. 0. Both partings can be separated from the coal by picking and they were not included in the sample. The coal was slightly moist when taken from the mine and sealed in the can, and for this reason the amount of moisture in the sample as received is a little too high. Analyses of these samples are given on page 43.

Character and quality of the coal.—The coal from these beds is grayish black, gives a brown streak, and is very slightly banded. It breaks with a conchoidal fracture. The upper bench of the main bed is considerably more banded than the others and probably contains a higher percentage of ash. Although the coal weathers slightly on exposure to the sun, it should stand transportation for some distance in closed cars. Its heating value is about the same as that of the coal from Issaquah and Grand Ridge and is somewhat lower than the average of that mined at Coal Creek.

FORD AND BAGLEY.

Ford slope mine and Bagley water-level drift, at Coal Creek, on the Columbia & Puget Sound Railroad. No. 6.

Operator: Pacific Coast Coal Co., Seattle, Wash.

Kind of coal: Subbituminous.

Coal beds.—Five coal beds are worked at present in these mines—the Muldoon, No. 3 and No. 4 beds, in the Ford mine, and the Bagley, Nos. 1 and 2 beds, in the Bagley mine. The beds strike N. 78° W. and dip 36° to 43° NE. The beds are very irregular and the thickness and number of the partings differ considerably in sections measured only a short distance apart. The distances between the beds or the benches in the beds are not at all similar in the opposite ends of the workings. The layer of bony coal overlying bed No. 3, about 700 feet east of the cross tunnel from the Muldoon, is 1 foot 5 inches thick.

Sections of coal beds in Bagley mine.

No. 9170, Bagley No. 1 bed.		No. 9171, upper bench of Bagley No. 2 bed.	
Shale, brown, carbonaceous.	Ft. in.	Sandstone, white (good roof).	Ft. in.
*Coal, banded.....	1 3	Shale, carbonaceous.....	$\frac{1}{2}$
Shale, brown, carbonaceous..	1	*Coal.....	7
*Coal, banded.....	1 $3\frac{1}{2}$	Shale, carbonaceous.....	6
Shale, yellow.....	$\frac{1}{2}$	*Coal.....	$3\frac{1}{2}$
*Coal.....	$6\frac{1}{2}$	*Coal, badly crushed.....	$1\frac{1}{2}$
Shale, brown.....	$\frac{1}{2}$	*Coal.....	$5\frac{1}{2}$
*Coal, bony.....	3	Shale, hard, nearly black....	1
Shale, brown.....	$\frac{1}{2}$	*Coal, bony.....	$2\frac{1}{2}$
*Coal.....	$11\frac{1}{2}$	Shale, sandy, "sulphur "	
Shale, brown, "sulphur"....	$\frac{1}{2}$	band.....	$\frac{1}{2}$
*Coal.....	$5\frac{1}{2}$	*Coal, bony, with streaks of	
Shale, hard.	5	shale.....	5
		Shale, brown to yellow.	
		Coal bed.	2 $7\frac{1}{2}$
No. 9169, lower bench of Bagley No. 2 bed.			
Shale, hard, carbonaceous.	Ft. in.		
*Coal.....	1 7		
†Shale, soft, very carbonaceous	1		
*Coal.....	2 5		
Shale, carbonaceous (fair bottom).	4 1		

Preparation for market.—The coal from all the beds is passed over a $2\frac{1}{2}$ -inch bar screen at the bunkers. The oversize is picked by hand for steam and domestic coal. The undersize is washed in a Jeffery tub washer.

Samples for analysis.—Sample 9163 was taken from the Muldoon bed at the east end of the first air course above the gangway on the first level, about 5,400 feet east of the slope. The bed contains three partings, which can be separated by careful picking and washing, and these partings were not included in the sample. A thin, soft layer of bony coal and shale between the upper bench of coal and the roof comes down with the coal in mining and is removed by the washer. A band of pyrite and a thin layer of soft shale at the bottom of the lower layer breaks away from the floor and is separated by the washer. Sample 9166 was taken from the first level gangway on the Muldoon bed 5,750 feet west of the slope. The bed contains numerous thin partings, of which only parts can be separated from the coal by picking and washing. In order to obtain a representative amount of ash, three of the partings were omitted from the sample. A thin layer of carbonaceous shale occurs between the coal and the roof and another between the coal and the floor. Both of these mix with the coal in mining and must be removed at the bunker. Sample 9165 was taken from the first level gangway on the Muldoon bed 1,400 feet west of the slope and 80 feet up chute 13 $\frac{1}{2}$. The bed contains several partings, which generally can be separated from the coal by picking and washing. Half of the upper parting and the

entire lowest parting were included in the sample. A thin layer of carbonaceous shale occurs between the top of the bed and the roof. This breaks from the roof in mining and mixes with the coal and must be picked out at the bunker. Sample 9168 was taken from the upper bench of bed No. 3 on the first level gangway 700 feet east of the cross tunnel from the Muldoon bed. The bed contains four partings, the upper three of which can be removed by picking and washing only with difficulty, and in order to obtain a representative amount of ash half of the upper parting and the entire parting next below were included in the sample. Sample 9164 was taken from the lower bench of bed No. 3 at the same location as No. 9168: The lower bench is separated from the upper by $8\frac{1}{2}$ inches of bone, and as both benches are worked together in this part of the mine, the bone separating them must be removed at the bunker. Sample 9167 was taken on the first level gangway on bed No. 4, about 650 feet east of the cross tunnel from the Muldoon. In the upper part of the bed are two partings which can be separated from the coal and were not included in the sample. A thin layer of carbonaceous shale between the coal and the roof and a portion of the floor mixes with the coal in mining and must be removed at the bunker. Sample 9170 was taken from Bagley No. 1 bed on the first water-level gangway at the entrance to the rock tunnel from the Bagley No. 2 to the Muldoon. The bed contains five partings which can be separated from the coal by careful picking and washing, and which were not included in the sample. It is not being worked at the present time. Sample 9171 was taken from the upper bench of the Bagley No. 2 bed, 36 feet up chute 24 of the first water level. Several partings can be separated from the coal, and these were not included in the sample; a thin layer of carbonaceous shale between the bed and the roof breaks down with the coal and must be removed at the bunker. Sample 9169 was taken from the lower bench of the Bagley No. 2 bed at the same place from which sample 9171 was taken. This bench is separated from the upper bench by about $5\frac{1}{2}$ inches of shale. Both benches are worked at the same time and the shale between them must be removed from the coal. A small band of soft shale occurs in the center of this bench. About half of it can be separated during preparation for market, and therefore only half was included in the sample. The analyses of these samples are given on pages 43-44.

Character and quality of the coal.—The coal is grayish-black, has a slightly banded structure, and breaks with an irregular conchoidal fracture. It contains about the same amount of moisture as the coal of Issaquah, Grand Ridge, and Renton. It slacks slightly when exposed to the direct rays of the sun, but will stand transportation for a considerable distance in closed cars. The coal is good for domestic purposes and for steam and stationary boilers without forced draft, and should be classed as a high-grade subbituminous coal.

DENNY-RENTON.

Denny-Renton drift mine, at Renton, on the Columbia & Puget Sound Railroad and Chicago, Milwaukee & Puget Sound Railway. No. 7.

Operator: Denny-Renton Clay & Coal Co., Seattle, Wash.

Kind of coal: Subbituminous.

Coal bed.—The coal bed worked at this mine is known as the Renton No. 1. It overlies the two beds worked by the Seattle Electric Co. at the Renton mine, strikes N. 32° E., and dips 14° SE. The bed is worked in two benches and a sample of each was taken. The following sections were measured at the places from which the samples were obtained:

Sections of Renton No. 1 coal bed in Denny-Renton mine.

No. 9154, upper bench.		No. 9155, lower bench.	
	Ft. In.		Ft. In.
Shale, sandy.		Clay, yellow.	
*Coal, slaty.....	1	*Coal.....	11
*Coal.....	1 1	Shale (clayey).....	3½
Shale.....	1	Coal, bony.....	5
*Coal.....	1	Coal, bony, shaly toward top.....	8½
Shale, hard, carbonaceous.....	1 6	*Coal.....	1 6
Coal bed.....	2 3	Clay.....	2½
		Coal, bony.....	3½
		Clay, sandy.....	½
		Coal.....	5
		Clay, sandy.....	1
		*Coal.....	2 1
		Clay, plastic, yellow.	6 11½

Preparation for market.—The layers between the coal are thick and are separated in the mine, where they are used as gob. The coal as it comes from the mine is picked at the bunker before using.

Samples for analysis.—Sample 9154 was taken from the gangway about 300 feet north of the south line of sec. 17. The upper layer of the bench consists of shaly coal that can be separated only with difficulty from the coal immediately underlying it; this layer and the shale separating the two coal beds were not included in the sample. Sample 9155 was taken at two places on the gangway near the north line of sec. 20. The sample from one part of the bed was taken 540 feet south and 160 feet west of the north quarter corner of sec. 20 and the sample of the other part was taken 120 feet due south of the same corner. This bench contains three good layers of coal, separated by layers of clay and by layers of coal too thin to be mined economically. The two benches of coal are separated by 2 feet 8½ inches of material, which must be removed; the three layers in the lower bench are separated by thick partings, which are thrown into the gob. Several of the layers of clay absorb moisture upon exposure to the air and swell to about 1½ times their original thick-

ness, making it very difficult to keep the gangways and rooms open. The samples of coal were moist when taken from the mine and prepared for the laboratory, and therefore the percentage of moisture in the sample as received is a little too large. Analyses of these samples are given on page 44.

Character and quality of the coal.—The color of the coal is grayish-black, the streak reddish-brown, and the structure laminated. It breaks with a splintery fracture, which is almost conchoidal. A considerable amount of moisture is present in it and it slacks slightly when exposed to the air. Its heating value is about the same as that of the coal from bed No. 2 and from the upper bench of bed No. 3 at Renton, but is slightly lower than that of the average coal from the lower bench of bed No. 3 and from the Coal Creek mines. It is classed as a subbituminous coal.

RENTON.

Renton slope mine, at Renton, on the Northern Pacific Railway, the Puget Sound Electric Railway, the Columbia & Puget Sound Railroad, and the Chicago, Milwaukee & Puget Sound Railway. No. 8.

Operator: Seattle Electric Co., Seattle, Wash.

Kind of coal: Subbituminous.

Coal beds.—Renton No. 2 and No. 3 coal beds are being worked in this mine. The older workings are on the lower or the No. 3 bed. The beds strike about N. 10° E. and dip 12° SE. The following sections were measured at the places where the samples were taken:

Sections of coal beds in Renton mine.

No. 9158, bed No. 2.		No. 9156, lower bench of bed No. 3.	
Shale, brown.	Ft. in.	Shale, black, carbonaceous.	Ft. in.
*Coal.....	2 4	*Coal.....	2 8½
Clay.....	2½	Shale, black, carbonaceous.	
*Coal.....	1 5	No. 9162, lower bench of bed No. 3.	
Shale, brown.....	7	Shale.	Ft. in.
Coal, bony.....	1 6	*Coal.....	10
Coal.....	1 1	Shale, hard, black.....	4
Clay.....	2	*Coal.....	1 10
Coal, bony.....	2	Shale, black, carbonaceous.	3
Clay.....	6	No. 2455, bed No. 3.	
Coal, bony.....	5		Ft. in.
	8 4½	*Coal.....	2 2
No. 9160, lower bench of bed No. 3.		Coal, bony.....	11½
Shale, brown (slightly carbonaceous).	Ft. in.	*Coal.....	8½
*Coal.....	9½	Shale.....	1½
Coal, bony, and carbonaceous shale.....	5	*Coal.....	6
*Coal.....	1 9½	Shale.....	1
Shale, black, carbonaceous.	3	Coal, bony.....	11
		*Coal.....	2 3
			7 8½

near the center a layer of bony coal and carbonaceous shale, which is separated in mining and in preparation for the market, and was therefore not included in the sample. The lower bench of the bed is separated from the upper bench by about 1 foot 5 inches of shale, which is separated from the coal and thrown into the gob. Sample 9157 was taken from the upper bench of bed No. 3 at the north end of the gangway of the ninth level north about 2,900 feet east and 1,300 feet north of the main portal of the mine. The bed contains one parting, which can be separated from the coal and was not included in the sample. This bench is separated from the roof by about 3½ inches of carbonaceous shale which comes down with the coal, and must be removed in preparation for the market. Sample 9156 was taken from the lower bench of bed No. 3 at the place where 9157 was taken. It is separated from the upper bench by 1 foot 5 inches of shale, which is removed from the coal during the mining, and is thrown into the gob. The coal in these two samples was slightly moist, owing to the seepage of water from the rocks above, and inasmuch as the samples were not dried before sealing in the cans, analyses show a slightly higher per cent of moisture in the "as received" determination than should be expected in average coal from this part of the mine. Sample 9161, taken from the upper bench of bed No. 3 about 600 feet above the sixth level south on plane No. 6 of the new workings, contains three shaly layers, which can be separated in mining and in preparation for market and which were therefore not included in the sample. A bed of soft shale between the upper bench and the roof absorbs moisture upon exposure to the air and swells to about 1¼ times its original thickness. Sample 9162 was taken from the lower bench of bed No. 3 at the location from which sample 9161 was taken. It contains one layer of bone, which can be removed from the coal and was not included in the sample. This bench is separated from the upper bench by about 3 feet of shale, the upper part of which absorbs moisture when exposed to the air and swells to about 1¼ times its original thickness. Analyses of these samples are given on pages 44-45. The samples noted below were also taken from this mine:¹ Sample 2455 was taken by M. R. Campbell October 9, 1905, from bed No. 3 in the sixth level gangway, 2,400 feet south of the slope. All the partings in the bed were separated from the sample. Sample 2456 was taken at the same time as No. 2455 from the seventh level gangway, 150 feet north of the slope. All the partings in the bed were excluded from the sample. Carload sample 2687 consisted of pea coal from the washer and No. 2686 was made up of run-of-mine coal. These carload lots were sent to the Geological Survey fuel-testing plant at St. Louis in 1905, and the analyses of the samples are included in the table on page 45.

¹ Bull. U. S. Geol. Survey No. 332, 1908, pp. 272-274.

Character and quality of the coal.—The coal is pitch black when freshly fractured, but turns grayish black in a very short time. It has a reddish-brown streak, is slightly banded and laminated, and breaks with a slightly conchoidal splintery fracture. It contains a considerable amount of moisture, and slacks slightly when exposed to the sun, but will stand transportation to a considerable distance when shipped in closed cars. Bed No. 2 and the upper bench of bed No. 3 have a heating value somewhat lower than that of the lower bench of bed No. 3, which is about the same as that of the better grades of coal obtained from the Coal Creek mines. This coal should be classed as high-grade subbituminous.

DANVILLE.

Danville, a water-level mine at Danville, on a spur of the Columbia & Puget Sound Railroad. No. 9.

Operator: North Coast Colliery Co., Seattle, Wash.

Kind of coal: Subbituminous.

Coal bed.—Only one bed is worked at this mine. It strikes N. 42° E. and dips 75° SE. The following section was measured where the sample was taken:

Section of coal bed in Danville mine.

No. 9323.

Shale, hard.		
Shale, rather soft.		
Coal, broken and apparently dirty.....	Ft.	in.
*Coal.....	1	11
*Coal, broken and apparently dirty.....	2	2½
Shale, yellow, slightly carbonaceous.	3	9
Coal bed worked.....	5	11½

Sample for analysis.—Sample 9323 was taken 20 feet to the southwest along the bed from the end of the rock tunnel from the fan. The mine had been abandoned for more than a year and the exposures of the coal along the gangway were very badly caved, so that it was difficult to obtain a good sample. Considerable movement has taken place along the bed, so that it would be difficult to prevent the impure coal overlying that part of the bed sampled from mixing with the better coal. About 7 inches of rather soft shale overlies the upper bench of coal, and a layer of carbonaceous shale underlies the bed. Where these were exposed in the mine they were soft and broken and would mix with the coal in mining. The analysis of this sample is given on page 45.

Character and quality of the coal.—The coal is grayish black, is slightly banded, and breaks with a splintery and conchoidal fracture. It has a relatively large amount of moisture and slacks slightly when exposed to the sun, but will hold up well for considerable length of time when shipped in closed cars. It is a subbituminous coal and has about the same heating value as the coal from the upper bench of bed No. 3 at Renton and the coal from Issaquah and Grand Ridge.

Sections of coal beds in Ravensdale No. 1 mine—Continued.

No. 9272, upper bench of bed No. 5.		No. 9277, bed No. 9.		Ft.	in.
Shale.	Ft. in.	Coal, bony.....	1	5	
*Coal.....	3 2½	*Coal.....	2	2½	
Coal, bony.		Bone, poor.....	1	7	
		Shale, very slightly carbonaceous.	1	7	
		Shale.	6	9½	

Preparation for market.—No attempt is made to separate the partings from the coal in the mine. At the bunker the run-of-mine coal is passed over a shaking screen having 2½-inch and ¾-inch perforations. That which passes through the holes is sorted in a revolving screen, and the different sizes are passed through a spiral dry washer, which has not been found very efficient in separating the impurities from the coal. The coal from the spiral separator and from the picking table are mixed in the bunker before shipment. The entire output of the mine is used by the Northern Pacific Railway.

Samples for analysis.—All the samples were collected on the second level. Sample 9266 was taken October 20, 1909, from the face of the east gangway of bed No. 3, 775 feet east and 400 feet north of the center of sec. 36, T. 22 N., R. 6 E. The bed contains three partings, which are nearly regular, and which may be separated from the coal by careful picking and washing. The roof of the mine is poor and in many places breaks down and mixes with the coal. The floor is fairly firm and does not mix very much with the coal. Sample 9267 was taken from bed No. 4 at a point 100 feet up chute 16 of the east gangway. The irregular layer of shale which occurs in the center of the bed and a considerable amount of shale from the roof is mixed with the coal in mining, but these impurities can be removed by careful picking and washing. Sample 9270 was taken from bed No. 5 about 15 feet east of the sump at the bottom of the slope. Only the upper part of the bed was exposed. Two thin partings near the top, which could only be partially separated from the coal by picking and washing, were included in the sample to offset the amount of ash which might be left in the coal from the other partings. Sample 9274 was taken from chute 31 about 20 feet up the rise from the east gangway on bed No. 5. The bed contains three partings, which can be separated from the coal and which were not included in the sample. About 7 inches of black clay overlies the coal and is mixed with it in mining. This clay must be removed in preparation for use. The sample represents the part of the bed being mined in the part of the workings from which the sample was taken. Sample 9271 was taken from bed No. 5, 150 feet up chute 59 on the east gangway. This section represents the entire thickness of the bed. The two shaly partings can be separated in preparation for use and are not included

in the sample. Sample 9272 was taken from the upper bench of good coal at the location at which sample 9271 was obtained. Sample 9273, which was taken from the same place, consists of the lower bench. The parting can be separated in preparation for use and was not included in the sample. Sample 6487 was taken in 1908 by J. B. Umpleby from bed No. 5. Only the lower part of the bed was sampled because the upper part was not exposed. Sample 9277 was taken from the east end of the gangway on bed No. 9, 100 feet from the rock tunnel from No. 5. The bench sampled lies between two layers of bony coal which are believed to contain too much ash to be of economic value. Analyses of the samples from this mine are given on pages 45-47.

Character and quality of the coal.—The coal is nearly pitch black, and has a dark brown streak and a slightly banded structure. It breaks with an irregular splintery fracture. It has a moderate amount of moisture, but does not crumble readily when exposed to the sun. Most of the benches of coal mined contain a rather high percentage of ash. The layer of crushed coal at the bottom of bed No. 5 contains small quantities of gas, which is liberated when the coal is shot down, and sometimes gives rise to small explosions. The coal is bituminous and compares in heating value with the subbituminous coal mined at Renton and Newcastle. The low heating value of this coal is due to the large amount of ash and the moderate amount of moisture.

M'KAY.

McKay, slope mine at Ravensdale, on the Northern Pacific Railway. No. 11.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—The bed worked at this mine is known as the McKay and is thought to be identical with the McKay bed of the Black Diamond mine. At the north end of the gangway the bed strikes N. 30° W. and dips 76° SW. Within a short distance to the south the bed changes in attitude, striking N. 50° W. and dipping about 40° SW. The bed is composed of two benches of clean coal separated by about 3 feet of shale and bony coal. The upper bench is nearly uniform in thickness where it is exposed in the mine. The parting between the benches is also uniform in thickness, but if this bed is the McKay bed exposed at Black Diamond the parting should increase in thickness toward the southwest. At the McKay mine the two beds could be worked as one and the parting separated from the coal. The lower bench of the bed varies in thickness from a little more than 5 feet to nearly 6 feet. In several parts of the mine this bench contains a layer of bony coal near the bottom which is mined with the rest of the

coal. The following sections were taken at the place from which the samples were obtained:

Sections of McKay coal bed in McKay mine.

No. 9279.			No. 9282.	
Shale, hard..	Ft. in.		Coal.....	Ft. in.
* Coal.....	4 8½		* Coal, bony.....	1 9½
Shale.			Shale.....	8½
No. 9280.			5 8½	
Shale, hard.	Feet.		No. 9283, upper bench.	
* Coal.....	5		Shale.	Ft. in.
Shale.			* Coal.....	3 2½
No. 9281.			Coal, bony.....	1 9½
Shale, carbonaceous, hard.	Ft. in.		Shale, yellow.....	8½
* Coal.....	5		Shale, hard, carbonaceous.....	5
† Shale, carbonaceous.....	2½			
Shale.				
	5 2½			6 1½

Preparation for market.—The main bed is so clean that it does not need special preparation for the market except when gangways are being driven. In order to make the gangway of sufficient width the upper bench of the coal is mined. The partings between these two benches could be separated by picking and washing.

Samples for analysis.—All samples for analysis were taken from the first level. Sample 9279 was taken from the north end of the north gangway about 300 feet north of the main slope. Both walls of the bed are fairly firm and not mixed with the coal in mining. Sample 9280 was taken at the north end of the south gangway about 500 feet north of the entrance on October 21, 1909. The entire bench is clean coal, and separates both from the roof and from the floor in mining. Sample 9281 was taken from the south end of the south gangway about 36 feet beyond chute 26. The bed contains about 2½ inches of carbonaceous shale at the bottom, which can not be entirely separated from the coal. About half of this was included in the sample. The coal was slightly moist, due to seepage of water through the joints, and was not dried before being sealed in the can and sent to the laboratory. Sample 9282, which came from the same place in the mine as No. 9281, represents a layer of bony coal lying between the two main benches of the bed, and was taken to determine whether it contained enough carbonaceous matter to be of value in the manufacture of gas if the entire bed was worked. Sample 9283 was taken from the upper bench at the place in the mine from which No. 9281 was taken. The bench is clean and separates freely from both the roof and floor, but it is not mined except along the gangway. This sample was very slightly moist when sealed in the can, but not sufficient to increase the percentage of moisture noticeably. The analyses of these samples are given on page 47.

Character and quality of the coal.—The coal of the lower bench is pitch black in color and has a dark-brown streak. It has a vitreous luster and is massive without any distinct banding. The fracture is irregular and, along the planes of the butt joints, somewhat conchoidal. The coal from the upper bench resembles that of the lower bench except that it is slightly banded. The McKay coal has a relatively small amount of moisture and does not crumble when exposed to the sun. It is noncoking bituminous coal of rather high grade, and compares favorably with many of the noncoking coals from the eastern part of the United States.

MORGAN.

Morgan, slope mine 1 mile northwest of Black Diamond, on the Columbia & Puget Sound Railroad. No. 12.

Operator: Pacific Coast Coal Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal beds.—Two beds, the lower of which is known as the McKay and the upper as the Little or Upper McKay, are being worked in this mine. Near the surface the two beds are separated by about 10 feet of shale and sandstone, but in the lower workings, which are about 3,000 feet down the dip from the surface, the sandstone increases in thickness to nearly 90 feet. The beds strike about north-south near slope, from which point northward the outcrop swings gradually to about N. 20° E. The dip is about 25° W. Both beds are uniform in thickness throughout the workings, and the partings are fairly regular for a considerable distance. The following sections were taken at the places from which the samples were obtained:

Sections of coal beds in Morgan slope.

No. 9106, McKay bed.		No. 9108, Upper McKay bed.	
Shale.	Ft. in.	Shale, black.	Ft. in.
* Coal, good, clean, bright....	6	* Coal.....	1 4
Coal, shaly and bone.....	1	Shale, lens.....	2
Coal.....	2½	* Coal.....	3 2½
Shale.	<hr/>	Shale.	<hr/>
	6 3½		4 8½

Preparation for market.—No attempt is made to separate any of the partings from the coal in the mine. At the bunker the coal from the two beds is picked over different sets of screens. It is not necessary to pick the coal from the lower bed except to remove pieces of mine timber and fragments which may have broken from the roof and floor; the upper bench is picked more carefully to remove the shale partings which in many places are present in the coal.

Samples for analysis.—Sample 9106 was taken from the McKay bed on the north side of chute 46 about 12 feet above the north gangway on the sixth level. At this point the bed has a very good roof which does not break or become mixed with the coal, but it is underlain by about $3\frac{1}{2}$ inches of shaly coal which sometimes breaks from the floor and must be separated at the bunker. Sample 9108 was taken from the Upper McKay bed on the south side of chute 11, about 15 feet above the north gangway on the sixth level. A lens of shale contained in the bed can be separated from the coal by picking, and was not included in the sample. Analyses of these coals are given on page 47.

Character and quality of the coal.—The coal of the McKay bed is pitch black, has a dark-brown streak, and breaks with an irregular, slightly conchoidal fracture along the lines of the butt joints. Elsewhere the fracture is irregular. It has a vitreous luster and massive structure. The coal contains a small amount of moisture and does not slack when exposed to the sun. Sulphur is present in it in somewhat higher amount than in the coal from the same bed farther east and north. A small amount of gas, which is given off from the coal very slowly, accumulates at the top of the working rooms and makes necessary the use of safety lamps. The McKay bed yields a noncoking bituminous coal which compares very favorably with the better grades of bituminous coal obtained in the Eastern States. The coal of the Upper McKay bed is pitch black and has a dark brown streak and a somewhat splintery fracture; it may be readily distinguished from the McKay coal by its slightly banded texture. It contains about the same amount of moisture as the McKay and does not slack when exposed to the sun, but its ash content is somewhat higher. Like the McKay, it is a noncoking bituminous coal of good quality.

BLACK DIAMOND NO. 14.

Black Diamond No. 14, slope mine at Black Diamond, on the Columbia & Puget Sound Railroad. No. 13.

Operator: Pacific Coast Coal Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal beds.—Two coal beds are being worked at this mine. The lower one is known as the McKay and the upper one as the Little McKay, or Upper McKay. At the surface these beds are separated by about 4 feet of shale and bony coal, but the distance between the two beds increases greatly toward the deeper part of the workings. At the ninth level, about 3,200 feet down the dip from the surface, the beds are separated by about 90 feet of sandstone. At the main slope the beds strike N. 75° W. and dip 30° SW.; beyond the electric slope in the west end of the workings the strike is nearly N. 25° W. and the dip is 30° SW. The beds are uniform in thickness throughout

the mine, and the partings and impurities in the beds are fairly continuous. The following sections were measured at the places from which the samples were obtained:

Sections of coal beds in Black Diamond No. 14 mine.

No. 9105, McKay bed.		No. 9114, Upper McKay bed.	
	Ft. in.		Ft. in.
Shale, brown, sandy.		Shale, brown.	
* Coal.....	5 ½	* Coal, bright, black.....	11½
* Coal, bony, soft.....	3	Shale, black, carbonaceous.	7
		* Coal.....	2 9½
	5 3½	Shale, black, carbonaceous.	4 4

Preparation for market.—No attempt is made to remove any of the partings from the coal in the mine. At the bunker the coal from the two beds is picked over separate screens. It is not necessary to pick the coal from the lower bed except to remove pieces of mine timber and fragments which may have broken from the roof and floor, but the upper bench is picked more carefully to remove the shale partings which in many places are present in the coal.

Samples for analysis.—Sample 9105 was taken from the McKay bed 70 feet from the gangway in chute 59 on the eighth level north. At this place the bed contains a layer of bony coal near the bottom, which is used as a “mining,” and which can not be readily separated from the coal without washing. It is believed to be so low in ash that it will not materially decrease the quality of the coal from the remaining part of the bed. Sample 9114 was taken from the Upper McKay bed 20 feet beyond chute 16 on the eighth level gangway north. The bed contains one shale parting which can be separated at the bunker and which was not, therefore, included in the sample. The shales which overlie and underlie this bed are mixed to some extent with the coal and must be removed at the bunker. The analyses of the samples are given on page 47.

Character and quality of the coal.—The coal of the McKay bed is pitch black, has a dark-brown streak, and breaks with a somewhat conchoidal fracture along the lines of minor joints. Except at the joints the fracture is irregular. It is massive and has a vitreous luster. It contains a small amount of moisture and does not slack when exposed to the sun. The amount of sulphur is somewhat higher than that of the same coal farther to the east and north. A small amount of gas is given off from the coal very slowly and accumulates in the abandoned rooms, making necessary the use of safety lamps. The coal is a noncoking bituminous coal and compares very favorably with the better grades of bituminous coal obtained in the Eastern States. The coal of the Upper McKay bed is pitch black, and has a dark-brown streak and a somewhat splintery fracture; it

may be readily distinguished from the coal of the McKay bed by its slightly banded texture. It contains about the same amount of moisture as the McKay and does not slack when exposed to the sun, but has a somewhat greater amount of ash. Like the McKay it is a noncoking bituminous coal of good quality.

LAWSON.

Lawson, a slope mine 1 mile northeast of the Black Diamond, on the Columbia & Puget Sound Railroad. No. 14.

Operator: Pacific Coast Coal Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal beds.—The Upper or Little McKay and the McKay proper occur as practically one bed of coal in this mine. Only the McKay is mined, however, except in the gangway, where the upper bed is taken out to give additional space in which to handle the cars. The beds are separated by about 10 inches of hard, black carbonaceous shale, which is used as a roof for the McKay bed throughout most of the workings. The beds strike N. 25° E. and dip 60° SE. at the west end of the workings, and strike N. 69° E. and dip 30° SE. at the east end. The McKay bed is uniform in thickness throughout the mine. The following sections were measured at the places from which the samples were taken:

Sections of coal beds in Lawson mine.

No. 9104, McKay bed.		No. 9107, Upper McKay bed.	
	Ft. in.	Shale.	Ft. in.
Shale, black, carbonaceous.....	11	*Coal with few layers of carbonaceous shale.....	2 2½
*Coal.....	4 9½	Shale, black, carbonaceous .	1
Shale, brown, carbonaceous.	5 8½	*Coal.....	1
		Shale, brown, sandy.....	1
		Coal, bony.....	2½
		*Coal.....	1 2½
		Shale, black, carbonaceous.....	11
		Coal bed.....	5 8½

Preparation for market.—No attempt is made to remove any of the partings from the coal in the mine. At the bunker the coal from the two beds is picked over separate screens. It is not necessary to pick the coal from the lower bed except to remove pieces of mine timber and fragments which may have broken from the roof and floor. The upper bench is picked more carefully to remove the shale partings which in many places are present in the coal.

Samples for analysis.—Sample 9104 was taken from the McKay bed on the side of the gangway between chutes 73 and 74 of the sixth level. The bed has a fairly good roof and floor and what impurities

break from them are separated at the bunker. Sample 9107 was taken from the Upper McKay bed at the place from which sample 9104 was taken. The bed contains several partings of shale and bony coal which can be separated from the good coal by very careful picking and washing, and these were not included in the sample. The analyses of these coals will be found on page 48.

Character and quality of the coal.—The coal of the McKay bed is pitch black, has a dark-brown streak, and breaks with a slightly conchoidal fracture along the lines of minor joints. In other directions the fracture is irregular. It is massive and has a vitreous luster. It contains a small amount of moisture and does not slack on exposure to the sun. A small amount of gas, which is given off from the coal very slowly and which accumulates at the top of the working rooms, makes necessary the use of safety lamps. The coal is noncoking, and compares very favorably with the better grades of bituminous coal obtained in the Eastern States. The coal of the Upper McKay bed is pitch black, and has a dark-brown streak and a somewhat splintery fracture. It may be readily distinguished from coal from the McKay bed by its slightly banded texture. It contains about the same amount of moisture as the McKay, and does not slack when exposed to the sun, but the amount of ash is much greater than in the McKay, owing to the presence of thin layers of carbonaceous shale in the upper layer of the coal. Like the McKay, it is a noncoking bituminous coal of good quality.

SURFACE EXPOSURE AT FRANKLIN.

Surface exposure at Franklin, on opposite side of Green River from the old Sullivan mine of the Pacific Coast Coal Co. No. 15.

Kind of coal: Bituminous.

Coal bed.—This coal bed is known as the McKay. The outcrop from which the sample was taken is the southeasternmost limit of the McKay bed as known at the present time. It strikes north and south and dips about 52° W. The bed is somewhat thinner at this point than to the northwest. The following section was taken where the sample was obtained:

Section of McKay coal bed at Franklin.

No. 9484.		Ft.	in.
*Coal.....	4	4	3½
Shale, carbonaceous.....			3½
Shale.....		4	7

Sample for analysis.—Sample 9484 was taken by removing about 2 inches of coal from the surface of the bed and channeling according

to the usual method. The bed had been exposed to the air for a considerable length of time, and portions of it were overgrown with moss. The coal is separated from the floor by about $3\frac{1}{2}$ inches of carbonaceous shale, which may break from the floor and mix with the coal in mining. The analysis of this sample is given on page 48.

Character and quality of the coal.—The coal is pitch black and has a dark-brown streak and a vitreous luster. It breaks with a somewhat conchoidal fracture along the lines of the minor joints. Elsewhere the fracture is irregular. It contains a small amount of moisture, and does not crumble when exposed to the sun. The heating value of this sample, though taken from a surface which had been exposed to the weather for a long time, is greater than that of any of the other samples taken from the McKay bed. The coal is noncoking and is classed as a high-grade bituminous coal.

KUMMER.

Kummer, water-level drift on north bank of Green River, about one-fourth mile south of Kummer, on the Columbia & Puget Sound Railroad. No. 16.

Operator: Denny-Renton Clay & Coal Co., Seattle, Wash.

Kind of coal: Subbituminous.

Coal beds.—Several beds of coal and carbonaceous matter are exposed, and the better beds of coal are worked in conjunction with several layers of clay, which are used in the manufacture of brick and terra cotta. The two coal beds from which samples were taken are very close together. They strike nearly north and south and dip about 40° E. The following sections were measured at the places from which the samples were obtained:

Sections of coal beds in Kummer mine.

No. 9113, bed No. 1.		No. 9115, lower bed.		
	Ft.	in.	Ft.	in.
Shale, black, carbonaceous.			*Coal, slightly bony.....	9
*Coal, bright.....	3	$8\frac{1}{2}$	*Shale, hard, black, carbonaceous.....	$\frac{1}{2}$
Shale, brown, soft.....		1	*Coal.....	$3\frac{1}{2}$
*Coal, bright.....		5	Shale, black, carbonaceous.	3
Shale.			*Coal, hard, containing some bony layers.....	2 $9\frac{1}{2}$
	4	$2\frac{1}{2}$	Shale, hard, black, carbonaceous.	3 $8\frac{1}{2}$
			Coal bed.....	4 $1\frac{1}{2}$

Preparation for market.—No attempt is made to separate the impurities from the coal in the mine. The coal is picked at the bunker to remove the shale that breaks from the roof and floor and

is mixed with the coal which is used by the company owning the mine for the manufacture of brick and is not cleaned as well as it would be if it were placed upon the open market.

Samples for analysis.—Sample 9113 was taken from the north side of the chute about 1,500 feet north of the entrance to the gangway on bed No. 1, and about 60 feet up the rise from the water level. The bed contains one shale parting, which can be separated by careful picking and washing and was therefore not included in the sample. The roof and floor are of shale, which breaks off to some extent and should be removed from the coal in preparing it for use. This bed is the only one worked at present. Sample 9115 was taken from the lower bed from the side of a cross tunnel about 100 feet south of the entrance to the gangway of bed No. 1. The bed contains thin layers of hard black shale and a large amount of bony coal that can be separated from the good coal only with difficulty. The 3-inch shale parting near the bottom of the bed, however, can be separated by careful picking, and this parting was not included in the sample. The coal is underlain by hard black carbonaceous shale containing stringers of coal. This shale does not part readily from the lower bench of the bed, but will have to be separated from the coal in preparation for the market. The analyses of these samples are given on page 48.

Character and quality of the coal.—The coal of bed No. 1 is pitch black, and has a dark-brown streak and a vitreous luster. It is massive and slightly laminated, and breaks with an irregular fracture. Although it contains a moderate amount of moisture and crumbles when exposed to the direct rays of the sun, it will stand shipment to considerable distances in closed cars. It is a high-grade subbituminous coal and has a heating value somewhat higher than that of any of the other subbituminous coals in the State. Its amount of fixed carbon is considerable higher than that of any other subbituminous coal in the State, and somewhat higher than the McKay coal, which is considered a high-grade bituminous coal. The coal from the other bed is nearly pitch black and has a dark-brown to reddish brown streak. It has a banded, shaly structure and breaks with an irregular fracture. It contains considerable moisture and weathers when exposed to the direct rays of the sun. Owing to its excessive amount of ash, the coal is at present of little commercial value. It was used at one time as fuel for the boiler which operates the bunker and hoisting machinery, but as it was found unsatisfactory its use has been discontinued. It is a high-grade subbituminous coal, but its great amount of ash reduces its heating value to a figure much lower than that of any other high-grade subbituminous coal of the State.

GEM.

Gem, water level and slope mine at Franklin, on the Columbia & Puget Sound Railroad. No. 17.

Operator: Pacific Coast Coal Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal bed.—The coal bed operated at this mine, known as the Gem, lies about 500 feet stratigraphically above the McKay bed at Franklin. It strikes N. 2° W. and dips from 53 to 55° W. The thickness of the bed varies from 2½ to 4 feet in different parts of the mine. The following section was taken at the place from which the sample was obtained:

Section of Gem coal bed in Gem mine.

No. 9103.

Shale, bony.		Ft.	in.
* Coal.....	3	6½	
Shale, bony.			

Preparation for market.—The bed is inclined at an angle too high to permit separation of impurities during mining. Bony coal and shale from the hanging and foot walls and “niggerheads,” which are frequent in some parts of the mine, are removed by picking at the bunker.

Sample for analysis.—Sample 9103 was taken 10 feet up chute 9 from the entrance to the lower water-level gangway. Both the hanging and foot walls are firm in this part of the mine, but in other parts they are mixed to some extent with the coal and must be separated from it in preparing it for the market. The analysis of this sample is given on page 48.

Character and quality of the coal.—The coal is pitch black and has a dark-brown streak and vitreous luster. It is somewhat banded and laminated and breaks with an irregular fracture. It contains a small amount of moisture and does not weather when exposed to the air. Ash is present in greater amount than in the McKay bed but to about the same extent as in the upper McKay bed. When loaded on cars for shipment, the lumps can not be distinguished from the lumps of the upper McKay. Like the coal from other mines in this immediate vicinity it is noncoking.

SURFACE EXPOSURE SOUTHWEST OF FRANKLIN.

Surface exposure on south bank of Green River, about three-fourths of a mile southwest of Franklin. No. 18.

Kind of coal: Bituminous (?).

Coal bed.—The coal bed is exposed in an open cut about 20 feet above the bed of the river. A drift has been driven on the strike for a

distance of about 70 feet in the lower part of the bed. The coal at the end of the drift was covered with mud and water which had seeped through from above. The coal at the surface when dressed for sampling appeared much more free from impurities than the coal in the drift, and the sample was therefore taken at the surface. The bed is believed to be the same as the Gem which is worked at Franklin. It strikes N. 22° W. and dips 60° SW. The following section was taken where the sample was obtained:

Section of Gem (?) coal bed in surface exposure three-fourths of a mile southwest of Franklin.

No. 9487.		Ft.	in.
Coal, minutely jointed.....		5	
Coal, cubic fracture.....		8½	
Coal, bony.....		1	
Bone with thin stringers of coal.....		5	
Shale with thin layers of bone and coal.....		8½	
Shale, black, with layers and stringers of coal.....	1.	2½	
Coal, bony.....	1	2½	
*Coal.....	2	8½	
Shale, black, carbonaceous:		7	5½

Sample for analysis.—Sample 9487 was taken from this bed. The layer sampled is overlain by bony coal and underlain by carbonaceous shale, both of which would probably adhere to some extent to the coal and should be separated from it in preparation for the market. The analysis is given on page 48.

Character and quality of the coal.—The coal is nearly pitch black and has a dark-brown streak. It is slightly banded and laminated and has an irregular fracture. The sample as received at the laboratory has a somewhat high percentage of moisture, but whether the coal will slack on exposure to the sun is not known. The surface of the exposure was kept moist continually by a spray from a small stream which falls down along the footwall of the bed, so that the coal was not exposed to the action of the air. The coal is noncoking and should be classed as either a very high-grade subbituminous or a low-grade bituminous. Its heating value is about the same as that of the better grades of subbituminous coal obtained in the State.

ROSE-MARSHALL.

Rose-Marshall, slope mine, about 1 mile west of Cumberland, Wash., on a proposed extension of the Northern Pacific Railway. No. 19.

Operator: Rose-Marshall Coal Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal bed.—The coal bed is known as the John Harris bed and is supposed to be one of a group mined at Franklin and Black Diamond.

The beds strike nearly north and south and dip about 60° W. The following section was measured where the sample was cut:

Section of John Harris coal bed in Rose-Marshall mine.

No. 10512.		Ft.	In.
Shale, roof.			
Coal, with layers of bone and clay.....	5		
*Coal.....	1	1	
Shale, carbonaceous.....			2
*Coal, cubical fracture.....	5		
Coal, bony.			
		11	3

Preparation for market.—No bunkers for cleaning and storing the coal had been erected at the time of the writer's visit.

Samples for analysis.—Sample 9293 was taken by cutting channels across the face of six lumps of coal stacked under a small cover near the entrance to the slope. The mine was filled with water above the point in the slope where the bed was first encountered. These lumps which were sampled had been exposed to the direct rays of the sun for at least a part of the day for about three months, but the coal was bright and fresh and showed no indications of weathering. Sample 10512 was obtained by G. W. Evans in April, 1910, after the mine had been reopened and placed in operation. It was taken 500 feet down the slope from the surface and on the left-hand side. A layer of carbonaceous shale in the bed, which can be separated from the coal by picking and washing, was not included in the sample. The coal was moist when taken from the mine and sealed in the can, and the analysis shows a slightly higher percentage of moisture than an analysis of a dry sample. The analyses of these samples are given on page 49.

Character and quality of the coal.—The coal is pitch black in color and has a dark-brown streak. It is banded and has either a slightly irregular conchoidal fracture or a somewhat cubical fracture. It contains a small amount of moisture and does not weather when exposed to the sun. In heating value it compares favorably with many of the bituminous coals of the east and with the McKay coal at Black Diamond and Franklin.

INDEPENDENT.

Independent, slope mine, about 1 mile south of Cumberland, Wash., No. 20.

Operator: Independent Coal Co.

Kind of coal: Bituminous.

Coal bed.—One coal bed, which strikes N. 30° E. and dips 55° SE., is exposed. The section given below was taken at the foot of the slope, which has been sunk to a depth of only about 20 feet.

Section of coal bed in Independent mine.

Shale, black, carbonaceous.	Ft.	in.
*Coal, bony (sample No. 9474).....	3	5
*Coal (sample No. 9286).....	2	2½
*Coal, bony (sample No. 9286).....	1	2½+
Covered.....	1	2½
Shale, carbonaceous, black.		
	8	½+

Samples for analysis.—Samples 9474 and 9286 were taken from the two benches of the bed at the foot of the slope. Sample 9474 was taken from the upper bench and sample 9286 from the lower bench of the bed. About 14 inches of the lower part of the lower bench was covered and could not be sampled, so that the character of this part of the bed is not known. Both hanging and foot walls are firm, and will probably not mix appreciably with the coal. The analyses of the samples are given on page 49.

Character and quality of the coal.—The coal from the upper bench is grayish black and has a brown streak. It is banded and breaks with a conchoidal fracture. The amount of moisture present in it is relatively small and the coal does not weather when exposed to the air. The amount of ash is very high, but the heating value is sufficient to make the coal marketable. It is a noncoking bituminous coal and resembles the coal from bed No. 5 at Ravensdale. The coal from the lower part of the lower bench resembles that from the upper bench but is higher in ash. The coal from the upper part of the lower bench is pitch black; has a dark-brown streak and a vitreous luster. It is only slightly banded, and breaks with an irregular splintery fracture. It appears to be much lower in ash and to have a much higher heating value than any of the other layers in the bed. The coal appears to be of high grade, and resembles that from bed No. 5 at the Green River Coal Co.'s mine. This portion of the bench, if worked with the upper bench, would give a product with only a moderate amount of ash.

SUNSET.

Sunset, water-level mine, about 1 mile southeast of Cumberland. Bunkers are located on the Northern Pacific Railway about 1 mile from the mine. No. 21.

Operator: Sunset Coal Co., Cumberland, Wash.

Kind of coal: Bituminous.

Coal beds.—Three coal beds have been worked. Bed No. 1, the highest in the group, was worked by a water-level gangway, which has been abandoned and closed up. Beds No. 2 and No. 3 are benches of a lower bed of coal, and are worked together in some parts of the mine. Bed No. 7 outcrops farther to the north on the hill and several hundred feet lower down in the formation. The

beds strike about N. 60° E. and dip from 42° to 60° SE. The thickness of beds No. 2 and No. 3 varies considerably within short distances, and the partings are somewhat irregular. No. 2 and No. 3 are the only beds worked at the present time. The following sections were measured at the places from which the samples were taken:

Sections of coal beds in Sunset mine.

No. 9263, bed No. 1.		No. 9264, bed No. 2.	
	Ft. in.		Ft. in.
Shale.		Shale, carbonaceous.	
Coal, bony.....	7	*Coal.....	1 6½
*Coal.....	4 8½	Shale.....	1
Coal, bony.		*Coal.....	8½
	5 3½	Shale, carbonaceous, soft, black.....	2½
		*Coal, bony.....	9½
			3 4
No. 9265, bed No. 3.		No. 9276, bed No. 7.	
	Ft. in.		Ft. in.
Shale, soft.		Bone (roof).	
*Coal.....	1 3½	*Coal, bony.....	2
Sand, brown.....	1	Shale, black, carbonaceous.	2½
*Coal.....	1	*Coal.....	6
Shale, carbonaceous.....	1½	*Coal, bony.....	11
Clay.....	3	*Coal, bony.....	2 5
Sandstone, carbonaceous....	3½	Bone, with some coal (floor).....	1
Coal.....	4		
Coal, bony.....	4		
	3 8½		7 ½

Preparation for market.—No attempt is made to separate the impurities at the mine. The partings are separated from the coal by picking and washing at the bunkers.

Samples for analysis.—Sample 9263 was taken from the side of an air chute on bed No. 1, about 30 feet down the dip from the surface. The air chute comes to the surface about 20 feet below the crest of the first ridge east of the entrance to the mine, and this was the only place where a sample from this bed could be obtained. The coal had been exposed to the atmosphere for a considerable length of time and was somewhat weathered. The bed lies between two layers of bony coal, which cling more or less to the coal and should be picked out at the bunkers. Sample 9264 was taken from bed No. 2 about 1,450 feet from the entrance to the mine. This bed contains two partings, which can be separated by picking and washing and were not included in the sample. Sample 9265 was taken at the same place as No. 9462, but from bed No. 3. It contains a parting of sand, which can be removed by washing and was not included in the sample. Between this bed and bed No. 2 is a layer of soft shale, of which a part can be removed in the mine and the rest separated at the bunkers. The bed is underlain by about 16 inches of shale and more or less impure coal which may be mixed to some extent with the coal in mining, but it can probably be removed

by careful picking and washing. Sample 9276 was taken from bed No. 7 about 30 feet from the entrance to the drift which is located on the hill about 300 feet due north from the bunk house. The bed contains some bony coal and one layer of black shale; the black shale can be separated and was not included in the sample. The roof and floor are both of bone and should not mix much with the coal. The analyses of these samples are given on page 49.

Character and quality of the coal.—The coal from beds Nos. 1, 2, and 3 is pitch black and has a dark-brown streak. The luster of most of the coal is vitreous, but some from bed No. 1 displays very beautiful peacock colors. The coal is banded and laminated and breaks with an irregular, splintery fracture. Considerable moisture was found in the sample taken from bed No. 1, but this moisture may be due to absorption during weathering. The coal from beds No. 2 and No. 3 contains a small amount of moisture and does not slack on exposure to the air, but that from No. 2 bed is rather high in ash, owing probably to the presence of a bony layer near the bottom of the bed. All three beds are bituminous, and the coal compares favorably with that taken from beds Nos. 1 and 3 at Bayne. Coal from beds No. 2 and No. 3 shows fair coking tendencies and is sometimes used in blacksmithing. The coal from bed No. 7 is grayish black and has a reddish-brown streak. It is banded and laminated and breaks with a splintery fracture. Inasmuch as its heating value is greatly reduced by the excessive amount of ash contained in it, this coal may be of little economic value until the better coals are exhausted.

NAVAL.

Naval, water-level and slope mine at Cumberland, on the Northern Pacific Railway. No. 22.

Operator: Naval Coal Co., Cumberland, Wash.

Kind of coal: Bituminous.

Coal bed.—Two beds of coal, No. 4 and No. 6, are worked at this mine. They are separated by about 12 feet of carbonaceous shale, which is left standing after the two beds are worked out. The following section was measured in the places where the samples were taken:

Section of coal beds in Naval mine.

	Ft.	in.
Clay shale.....		
Shale, white.....		3½
Bone.....		3½
*Coal (sample 9287).....		11
Shale.....		½
*Coal (sample 9287).....	1	6
Shale, carbonaceous.....	10	
Coal, hard, bony.....	2	
*Coal, fat, bony (sample 9285).....	1	7
*Coal (sample 9284).....	2	4

Preparation for market.—No attempt is made to separate any of the impurities in the mine. The coal is picked at the tippie over 2-inch bar screens.

Samples for analysis.—Sample 9287 was taken from bed No. 4 at the first crosscut above the water-level gangway in a chute 144 feet north of the rock tunnel. The bed contains one shale parting, which can be separated from the coal and was not included in the sample. Layers of shale and bone, in all about 7 inches in thickness, overlay the bed and mix to some extent with the coal. These impurities must be removed at the tippie. The shale floor is firm and does not mix with the coal. Sample 9285 was taken from the north water-level gangway, about 330 feet from the rock tunnel, from the upper bench of bed No. 6. Sample 9284 was taken from the same place as sample 9285, but from the lower bench of the bed. The bed is between two layers of bony coal, which appear to be firm and should not mix to any extent with the coal. The analyses of these samples are given on pages 49–50.

Character and quality of the coal.—The coal from bed No. 4 and the upper bench of bed No. 6 is grayish black and has a reddish-brown streak. It is banded and laminated, and breaks with a splintery fracture. It contains a small amount of moisture and does not weather when exposed to the air. The amount of ash in both beds is somewhat high, but the heating value is sufficient to make the coal of commercial value. The coal of the lower bench of bed No. 6 is pitch black and has a dark-brown streak and a vitreous luster. It is slightly banded and has an irregular splintery fracture. It contains a small amount of moisture and does not weather when exposed to the atmosphere. In ash content, which is moderate, the coal compares favorably with the best coal in bed No. 5 at Bayne and the coal from bed No. 3 at Occidental. The coal from bed No. 4 and from the upper bench of bed No. 6 shows a tendency to coke and that from the lower part of bed No. 6 should produce fairly good coke. This coal should be classed as a fair grade of bituminous coal.

EUREKA.

Eureka, abandoned water-level mine about 1 mile south of Bayne. No. 23.

Kind of coal: Bituminous.

Coal bed.—The coal bed belongs to the same group of beds as that exposed in the mine of the Green River Coal Co. at Bayne. It strikes N. 85° W. and dips 38° SW. The bed, as exposed in the gangway, contains a great number of partings of shale and bony coal, and only a portion of it is pure enough to be mined economically at the present time. The section following was measured.

Section of coal bed in Eureka (abandoned) mine.

No. 9294.		Ft.	in.
Shale, black, carbonaceous.....		1	1
*Coal.....		1	
Shale, brown.....			2½
*Coal.....		2	1
*Coal, crushed, and carbonaceous shale?.....		1	
“Sulphur” band and sandy shale.....			2½
*Coal.....			9½
Bone and shale.....			5
Coal.....			3½
Shale.....			2½
Coal.....			5
Shale.....			1
Coal.....			3½
Bone and shale.....			2½
Mixture bone and shale crushed.....	1		7
Bone.....			3½
Coal, crushed, bony.....			6
Shale, carbonaceous.....			2½+
		10	10½

Sample for analysis.—Sample 9294 was taken from the side of the gangway 174 feet from the entrance to the mine. Two partings which occur in the bed can be separated by careful picking and washing, and were not included in the sample. The analysis of the sample is given on page 50.

Character and quality of the coal.—The coal is pitch black and has a dark-brown streak and a vitreous luster. It is banded and breaks with an irregular fracture. It contains a small amount of moisture and does not weather when exposed to the air. Although the amount of ash in the sample is large, the heating value is high enough to make the coal of considerable commercial value. The coal is bituminous and of about the same quality as that from beds No. 1 and No. 2 at Bayne.

BAYNE.

Bayne, water-level tunnel and drift mine at Bayne, on the Northern Pacific Railway. No. 24.

Operator: Green River Coal Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal beds.—Three coal beds, Nos. 1, 3, and 5 in ascending order, are being worked in this mine. One is separated from another by several hundred feet of sandstone. The beds strike N. 30° W. and dip 34° NE. They are uniform in thickness and the partings are fairly continuous. The following sections were measured where the samples were obtained:

Sections of coal beds in Bayne mine.

No. 9112, bed No. 1.		No. 9110, bed No. 3.	
Shale, black.	Ft. in.	Shale, sandy.	Ft. in.
*Coal.....	10	*Coal.....	1 8½
*Shale, black, carbonaceous, hard.....	½	Shale, carbonaceous, very soft.....	2½
*Coal.....	1 9½	*Coal.....	9½
Shale, soft, carbonaceous...	3½	Shale, gray.....	1
*Coal.....	3½	*Coal.....	4
Shale, hard.....	1	Shale, gray.....	2
*Coal, with small "nigger- heads".....	1 1	*Coal.....	5
Shale, black, carbonaceous..	2	Shale, gray.....	2½
*Coal.....	3½	*Coal.....	1
Shale, carbonaceous.....	½	Shale, gray.....	1
*Coal.....	3½	*Coal.....	7
Shale, black.....	2	Shale, black, carbonaceous.	4 8
*Coal.....	1 2½	Nos. 9268, 9269, 9275, bed No. 5.	
Shale, brown, carbonaceous.	6 7	Shale, soft, carbonaceous.	Ft. in.
No. 9109, bed No. 5.		*Coal.....	2
Shale.	Ft. in.	Shale, carbonaceous.	
Shale, black.....	7	No. 9483, highest bed on hill.	
*Coal.....	2 2½	Shale.	Ft. in.
Shale, soft, brown, carbona- ceous.....	2½	*Coal.....	2
*Coal.....	2 7	Shale, carbonaceous.....	1
Shale, carbonaceous.	5 7	*Coal, slightly bony.....	1
		Sand.....	½
		*Coal, stringy and slightly bony.....	8
		Clay, yellowish.	1 11½

Preparation for market.—No attempt is made to separate the partings from the coal in the mine. At the bunker the coal is passed over a shaking screen having 2-inch perforations; the oversize is hand picked and the undersize washed twice through a new model of the Pittsburg jig, which is supposed to remove 95 per cent of the impurities.

Samples for analysis.—Sample 9112 was taken on the north side of the main rock tunnel where it crosses bed No. 1. The bed contains numerous partings, most of which have a higher specific gravity than the coal and can be separated by carefully adjusting the washers. The top parting only was included in the sample. Sample 9110 was taken from the face of the south gangway on bed No. 3, about 70 feet from the main tunnel. This bed also contains numerous shale partings, which can be separated from the coal by very careful picking and washing, which were not included in the sample. Sample 9109 was taken on bed No. 5, 55 feet above the gangway and 15 feet to the left of chute 9. The bed contains one shale parting that can be separated from the coal, and was not included in the sample. Both the roof and

the floor of the mine are very firm and do not mix with the coal in mining. Samples 9275, 9268, and 9269 were taken from the lower 2 feet of good coal from bed No. 5 in a small drift at the outcrop of the bed on the hill above the entrance to the mine, to show the effect of weathering upon this grade of coal. Sample 9275 was taken at the entrance to the drift 1 foot beyond the first set of timbers. The coal was weathered and much jointed, the joints being filled with mud and iron rust. Sample 9268 was taken 9 feet beyond the first set of timbers. The coal, which appears to be somewhat shaly at this point, was weathered, and the major joints were filled with mud and iron rust. Sample 9269 was taken 15 feet from the first set of timbers. The coal was bright and firm and represents about the best coal that could be obtained from bed No. 5 in the mine proper. Sample 9483 was taken from the highest bed on the hill above the Bayne mine. It was very poorly exposed in a small prospect, and appeared to be faulted out of its regular position in the group. It contains several partings which can be separated by careful picking and washing, and these partings were not included in the sample. The analyses of these samples are given on pages 50-51.

Character and quality of the coal.—The coal from beds Nos. 1, 3, and 5 is nearly pitch black and has a dark-brown streak and a vitreous luster. It is massive and laminated and breaks with an irregular fracture. It contains a small amount of moisture and does not crumble when exposed to the air. All the samples, except the one taken from the lower bench of bed No. 5, show a high percentage of ash. A small amount of gas is liberated after the coal is shot, and this accumulates in sufficient quantities to necessitate the use of safety lamps until the rooms can be tested and brushed out. This coal is bituminous and of good grade; the large amount of ash accounts for the low heating value. The coal shows coking tendencies, and is used at the mine as blacksmithing coal for rough work. Coal from the small prospect at the top of the hill contains little moisture, but the high percentage of ash makes it of little economic value at the present time.

Comparison of the analyses of the three samples from the drift on bed No. 5 shows a decrease in moisture and sulphur and an increase in volatile matter in the coal as the distance from the entrance increases. The increased amount of ash in the second sample is probably due to the greater thickness of the films of mud in the joints and to the more bony nature of the coal.

CARBON.

Carbon, a water-level mine about half a mile northeast of Bayne, on the Northern Pacific Railway. No. 25.

Operator: Carbon Coal Co., Bayne, Wash.

Kind of coal: Bituminous.

Coal bed.—The bed worked at this mine is believed to belong to the same group as that mined by the Green River Coal Co. at Bayne. It strikes N. 45° E. and dips about 10° SE. The upper bed, or bed No. 1, is the only one that is being worked. Bed No. 2 is separated from No. 1 by a parting that increases in thickness from a few feet at the far end of the gangway to about 25 feet at the entrance of the mine. The following sections were measured where the samples were taken:

Sections of coal beds in Carbon mine.

No. 9485, bed No. 1.		No. 9489, bed No. 2.	
Shale, clayey.	Ft. in.	Shale, brown, sandy.	Ft. in.
Coal, bony.....	1	*Coal.....	2 8½
*Coal.....	2 9½	Shale.	
Shale, sandy.....	2½		
*Coal.....	9½		
Shale, clayey.....	1		
*Coal.....	5 +		
Shale.			
	4 4½+		

Preparation for market.—The coal contains numerous “nigger-heads” varying in maximum diameter from 2 inches to several feet, most of which are separated from the coal in the mine. The coal is picked at the bunker and washed through a jig.

Sample for analysis.—Sample 9485 was taken from bed No. 1 at a point 630 feet west and 590 feet north of the southeast corner of sec. 15, T. 21 N., R. 7 E. The bed contains two partings, which, since they can be separated by careful picking and washing, were not included in the sample. About an inch of bony coal overlies the bed and is mixed with the coal to some extent in mining. It is necessary to remove this at the bunker. Sample 9486 was taken from spherical nodules of coal, which occur frequently throughout the bed and range from 2 inches to a foot in diameter. Coal of this character appears to be brighter and more nearly pure than the remainder of the bed. Analysis 9492 was made of a composite sample consisting of equal parts of the coals tested in samples 9485 and 9486. Sample 9489 was taken from bed No. 2 at a point 380 feet west and 844 feet north of the southeast corner of the same section. At this place the bed is separated from bed No. 1 by about 2 feet of coal, clay, and shale. The coal is worked only in the gangway, where the floor is taken up to give sufficient height for handling cars. The analyses of these samples are given on page 51.

Character and quality of the coal.—The coal from both beds is pitch black, and has a dark-brown streak and a vitreous luster. It is massive and slightly laminated, and breaks with an irregular hackly fracture. In general, the coal from these beds contains a small amount of moisture and does not weather on exposure to the sun,

and that obtained from the spherical nodules contains a smaller percentage of moisture and ash and a greater percentage of volatile matter and fixed carbon than the remaining coal of the bed. The coal forms fair coke and is a bituminous coal of about the same quality as that obtained from the best beds in the vicinity of this mine.

PROSPECT DRIFT WEST OF BAYNE.

Prospect drift about one-fourth mile west of Bayne and about 600 feet west and 140 feet south of the northeast corner of sec. 21, T. 21 N., R. 7 E. No. 26.

Kind of coal: Bituminous.

Coal bed.—This coal bed belongs to the same group as that exposed at Occidental and at Bayne. It is very nearly horizontal, and lies in the center of the syncline passing through Lizard Mountain. At the point in the drift where the sample was taken the bed strikes about N. 60° E. and dips nearly 8° NW. The partings in the bed are not uniform in thickness throughout the length of the bed exposed in the drift. The following section was measured where the sample was taken:

Section of coal bed in prospect drift west of Bayne.

No. 9488.		Ft. in.
Shale, carbonaceous.		
*Coal.....		8½
Shale, black, carbonaceous.....		½
*Coal.....	1	6
Shale, brown, sandy.....		2½
*Coal.....		8½
Shale, sandy.....		1
*Coal.....		11
Shale, sandy, carbonaceous.....		1
*Coal.....	1	3½
Shale.		5 6½

Sample for analysis.—Sample 9488 was taken 72 feet from entrance on the upper side of the gangway. The bed contains four partings, which can be separated by careful picking and washing and which were not included in the sample. The analysis of this sample is given on page 51.

Character and quality of the coal.—The coal is pitch black, and has a brown streak and a vitreous luster. It is massive and slightly laminated and breaks with an irregular hackly fracture. It contains a small amount of moisture and does not weather on exposure to the air. The analysis shows a rather high amount of ash, but the heating value is high enough to make the coal of commercial value, and it should compare favorably with the coal from other mines in the immediate neighborhood. Coking tendencies are apparent in coal taken from this prospect.

OCCIDENTAL.

Occidental, two slope mines and one drift, at Bayne, on a spur of the Northern Pacific Railway. No. 27.

Operator: Occidental Colliery Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal beds.—Sixteen beds of coal and carbonaceous material, numbered in descending order, are reported in this group. Beds Nos. 1, 2, 3, 4, 5, 6, and 14 have been developed at different times. At the time of the visit to the mine the openings on Nos. 4 and 5 were closed, and these beds could not be sampled. The beds strike N. 45° E. and dip about 38° SE.; both beds and partings are about uniform in thickness throughout the workings. The following sections were measured at the places where the samples were obtained:

Sections of coal beds in Occidental mine.

No. 9479, bed No. 1.		No. 9480, bed No. 2.	
Shale.	Ft. in.	Shale, black, carbonaceous.	Ft. in.
Clay and coal, irregular streaks...	1	*Coal, bright.....	1 1
*Coal.....	1 5	Shale, sandy, brown, varies up to 3½ inches.....	1
Shale, slightly bony, altered locally to "niggerheads"...	3½	*Coal.....	2
*Coal, bony.....	1	Clay, soft, pale yellow, varies from 1 to 5 inches.....	2½
*Coal, bright.....	4 1	*Coal.....	3
Coal, bony.	6 10½	Shale, brown, carbonaceous..	½
		*Coal, bright.....	1 5
		Shale, brown.....	½
		*Coal, bright.....	5½
			3 9
		No. 9475, bed No. 3.	
		Shale, black.	Ft. in.
		*Coal.....	11½
		Bone.....	½
		*Coal.....	8½
		Bone.....	½
		*Coal.....	1 9½
		Shale.....	2½
		*Coal.....	11
		Shale, sandy.....	½
		*Coal.....	5
		Shale, floor.	5 1½
		No. 9477, bed No. 14.	
		Shale, carbonaceous:	Ft. in.
		*Coal, hard, bony.....	1
		*Coal, soft, bony.....	½
		*Coal.....	2 9½
		*Coal, hard, bright.....	1 6
		Shale.....	1
		*Coal.....	8½
		Shale, carbonaceous.	6 1½
No. 9478, bed No. 3.			
Shale, carbonaceous.			
*Coal, slightly bony near cen- ter.....	Ft. in.		
Clay.....	1 5		
*Coal, hard, bright.....	1 11		
Shale.....	2½		
*Coal.....	1 5		
Shale, black.....	8½		
	5 9		
No. 9481, bed No. 6.			
Shale, black, carbonaceous.	Ft. in.		
*Coal.....	1 2½		
"Sulphur" band.....	1		
*Coal.....	1 5		
Shale, brown, sandy.....	3½		
*Coal.....	7		
Shale, brown, soft.			
Shale, smooth.	3 7		
No. 9476, bed No. 14.			
Coal, bony.	Ft. in.		
*Coal, hard, bright.....	1 6		
Shale.			

Preparation for market.—Coal from the beds No. 2 and No. 3 is picked, and then washed through a small jig at a dump house near the entrance to mine No. 3. Numerous “niggerheads” occur in bed No. 2; the largest of these are separated from the coal in the mine, and the others are removed at the bunker. Coal from bed No. 14 is hand picked at another dump house at the entrance to the slope of bed No. 14, or what is known as the new mine.

Samples for analysis.—Sample 9479 was taken from the abandoned workings on bed No. 1 on the side of an air course 550 feet from the entrance to the first water level and on the counter gangway 250 feet above the water level gangway. The bed contains a layer of bony shale, altered locally to “niggerheads,” which may be separated from the rest of the coal and was not included in the sample. The coal is overlain by about a foot of irregular bands of clay and coal, which will come down to some extent in the rooms and must be removed at the bunker. Sample 9480 was taken on bed No. 2, about 70 feet up a chute 310 feet from entrance to the gangway. The bed contains several partings, which can be separated by careful picking and washing and which were not included in the sample. The roof is of carbonaceous shale, and is not mixed to any extent with the coal in mining. Sample 9478 was taken from bed No. 3 about 100 feet above the first level on the manway 30 feet north-east of the slope. The bed contains two partings which can be removed by picking and washing and which were not included in the sample. Sample 9475 was taken from the same bed about 660 feet up the rise from the first level in chute 7. The bed contains four partings, which can be separated in preparation for market and were therefore not included in the sample. Both roof and floor are firm and do not mix with the coal in mining. Sample 9481 was taken from the south side of an old air course on bed No. 6, about 112 feet from the surface. The air course is located about 300 feet northeast from chute 7 on bed No. 3. Two partings which occur in the bed can be separated from the coal in preparation for the market, and were not included in the sample. The roof of the mine is firm and is not mixed with the coal in mining, but the bed is underlain by $2\frac{1}{2}$ inches of soft shale which parts from the floor with the coal and must be removed at the bunker. Sample 9477 was taken from bed No. 14 at the New mine about 200 feet down the slope and 30 feet to the west, where a small room had been opened to supply the boiler with fuel. A parting near the bottom of the bed can be separated and was not included in the sample. The roof and floor are firm and are not mixed to any extent with the coal. Farther west and southwest along the gangway the bed is badly crushed, and the roof and floor become mixed to a considerable extent with the coal, introducing impurities which must be removed at the bunker. Sample 9476 was taken from the same place as sample 9477, and is

composed of coal from the 1 foot 6 inch bench of good coal in the lower portion of the bed. Analysis 9491 was made of a composite sample containing equal parts of samples 9476 and 9477. The analyses of these samples are given on pages 51-52.

Character and quality of the coal.—The coal from beds Nos. 1, 2, and 3 and the lower part of bed No. 14 is pitch black and has a dark-brown streak and a vitreous luster. It is massive and very slightly laminated and breaks with an irregular fracture. It contains a small amount of moisture and does not crumble when exposed to the sun. This coal, except that from the lower bench of No. 14, contains about the same amount of ash as most of the coal in the vicinity of Bayne. Gas occurs in the coal in such quantities as to make necessary the use of safety lamps after shooting, or after the workings have stood vacant for some time. The coal is bituminous, and is used to some extent as blacksmith coal, as it will coke in the forge. It has about the same heating value as the better grades of coal from the immediate vicinity. The coal from bed No. 6 and from the upper bench of bed No. 14 is grayish black, and has a dark-brown streak and a dull luster. It is banded and laminated, and breaks with a splintery fracture. It contains a small amount of moisture and does not weather when exposed to the sun. More ash is present in it than in the other samples obtained at this mine, and its heating value is correspondingly lower. This coal is bituminous, shows good coking tendencies, and is of about the same value as that obtained from the beds of mine No. 1 at Ravensdale.

BIG SIX.

Big Six, a drift mine about 1½ miles east of Bayne, on a spur of the Northern Pacific Railway. No. 28.

Operator: Bix Six Coal Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal bed.—This mine, which has been closed for some time, is located on what has frequently been called the Pocahontas bed. The bed strikes N. 12° W. and dips about 31° E. The main rock tunnel to the bed is badly caved and was not considered safe at the time of the visit. The main bench of the bed could not be sampled, but a sample of the upper bench was obtained from a small drift made near the fan house on the outcrop of the bed, where the following section was taken:

Section of the Pocahontas bed in Big Six mine.

No. 9278.

	Ft.	in.
Shale, hard, carbonaceous.		
*Coal.....	1	5
Shale, brown.....		2
*Coal.....	1	1
Shale, brown.....		1
*Coal.....		4
Shale, carbonaceous, sandy.....		1
Shale, sandy.....		
	3	2

Sample for analysis.—Sample 9278 was taken about 30 feet from the entrance to the drift. The bed contains two partings of shale, which can be separated from the coal by careful picking and washing and were therefore not included in the sample. A foot or two of shale separates it from the main or lower bench of the bed. The analysis of this sample is given on page 52.

Character and quality of the coal.—The coal is pitch black, gives a dark-brown streak, and has a vitreous luster. It is massive and dense and breaks with an irregular fracture. It is low in moisture and does not crumble when exposed to the sun. The ash content is about the same as that of the average coal in the same region. The coal is bituminous, of fair grade, and is reported to make good coke. It has about the same heating value as the better grades of coal from the same region.

PROSPECT AT PALMER JUNCTION.

Prospect at Palmer Junction, on the Northern Pacific Railway. No. 29.

Kind of coal: Bituminous.

Coal bed.—The coal bed appears to belong to the group exposed at Durham on the north and at the Big Six mine on the south. It strikes S. 2° W. and dips 38° E. The total thickness of the bed between hanging and foot walls is 30 feet 3¼ inches. A drift has been driven on the strike in the upper part of the bed to a distance of about 160 feet. A section of the bed follows.

Section of coal bed in prospect at Palmer Junction.

	Ft.	in.
Shale, sandy (hanging wall)		
Shale, black, carbonaceous.....	2½	
Coal, bony.....	6	
Shale, brown.....	2½	
Shale, carbonaceous, with stringers of coal.....	7	
Coal, bony.....	6	
Shale, gray.....	7	
Shale, carbonaceous, with stringers of coal.....	5	
*Coal, bony (sample 9288).....	1	3½
Shale, hard, gray.....	1	
*Coal, bony (sample 9288).....	8½	
Shale, gray.....	1	
Bone.....	2	
Shale, gray.....	1	
Coal, bony.....	3½	
Shale, brown.....	½	
Coal, bony.....	5	
Shale, brown, carbonaceous.....	3	
Shale, carbonaceous, with stringers of bony coal and bright coal.....	1	
*Coal, bony, with stringers and lenses of good coal (sample 9482).....	1	4

	Ft.	in.
Shale, brown, carbonaceous.....		3½
Coal.....		1
Shale, brown.....		5
Sandstone, coarse.....		3½
Shale, carbonaceous, with lenses of coal.....	1	
Shale, brown.....		3½
Coal.....		2½
Shale, sandy.....		1
Coal.....		1
Sandstone, soft.....		7
Coal, poor.....		5
Coal.....		2½
Coal, poor.....		3½
Shale, sandy.....		3½
Shale, sandy.....		3½
Coal, crushed.....		8½
Coal.....		7
Shale, brown, with irregular lenses of coal.....		8½
Coal.....		2½
"Niggerhead".....		5
Coal.....		3½
Shale, carbonaceous, with stringers of coal.....		11
Coal, bony.....	1	
Shale, sandy.....		1
Coal, bony.....		3½
Shale, soft, brown.....		6
Coal.....		3½
Coal, bony.....		6
Coal, very poor, bony (coal in thin lenses).....	1	9½
Sandstone.....		3½
Shale, sandy black.....		3½
Shale, black, carbonaceous.....		1
Coal.....		1
Coal, bony.....		5
Coal.....		3½
Shale, carbonaceous, with stringers of coal.....		8½
Coal, poor.....		1
Shale, hard, sandy.....		3½
Shale, soft.....		1
Coal, lens about 2 feet long.....		1
Shale, carbonaceous, with lenses of coal.....		9½
Coal, very badly crushed.....		6
Shale, black, hard, carbonaceous.....		3½
Coal.....		5
Shale, carbonaceous, with irregular lenses of coal.....		4±
Shale (footwall).....		

30 7

Samples for analysis.—Samples 9288 and 9482 were taken from the surface of the bed just above the entrance to the drift, after about 6 inches of the coal had been removed. Sample 9288 was taken from the upper bench, which contains a small parting not included in the sample. Sample 9482 was taken from the lower bench. The analyses of these samples are given on pages 52–53.

Character and quality of the coal.—The coal from these two benches is pitch black, and has a dark-brown streak and vitreous luster. It is banded and laminated, and breaks with an irregular splintery fracture. It contains a small amount of moisture and does not weather when exposed to the sun. The amount of ash is very large, forming about one-third of the total weight of the coal, and the heating value of the coal is so greatly reduced in consequence that it is only about the same as that of the lowest grade of coal in the State.

PROSPECT SHAFT EAST OF RAVENSDALE.

Small prospect shaft about $3\frac{1}{2}$ miles east of Ravensdale. No. 30.

Kind of coal: Bituminous.

Coal bed.—About 5 feet of the coal bed is exposed in the bottom of the shaft. The bed has been disturbed by local movements so that the sections on both sides of the opening do not agree, and the dip and strike are somewhat uncertain; as near as could be determined from the present opening the bed strikes about N. 80° W. and dips from 80 to 85° S. The following section was taken on the west side of the opening:

Section in Prospect shaft $3\frac{1}{2}$ miles east of Ravensdale.

No. 9292.		Ft.	in.
Shale.			
*Coal.....	1	9	$\frac{1}{2}$
Shale, and carbonaceous shale.....		2	
*Coal.....		9	$\frac{1}{2}$
Clay, lens.....			$\frac{1}{4}$
*Coal.....		5	
Shale, carbonaceous.....		2	$\frac{1}{2}$
*Coal.....	1	5	
*Coal, bony.....		7	
Shale.			
		5	$4\frac{1}{4}$

Samples for analysis.—Sample 9292 was taken at the place where the section given above was measured. The bed contains three partings which can be separated from the coal, and these were not included in the sample. It is overlain by crushed shale, which will mix with the coal in mining. The analysis of this sample is given on page 53.

Character and quality of the coal.—The coal is pitch black, and has a dark-brown streak and a vitreous luster. It is slightly banded and has an irregular conchoidal fracture, resembling that of the McKay coal, and this circumstance, among others, has led to the belief that this may be the McKay bed. The coal contains a rather large amount of moisture and a moderate amount of ash, so that its fuel value is considerably lower than the McKay. It has about the same heating value as the average coal from the Ravensdale No. 1 mine, and may be a continuation of one of these beds.

PROSPECT DRIFT NEAR BARNESTON.

Prospect drift run 70 feet, near Barneston, on the Northern Pacific Railway. No. 31.

Kind of coal: Natural coke(?).

Coal bed.—The bed upon which this drift is run is one of a group of coal beds exposed in a small ravine west of the north end of the horse-shoe loop on the railroad. All the beds are more or less affected by igneous intrusions, and in some places they are almost completely burned out. The following section was taken about 10 feet from the entrance to the drift.

Section of coal bed in prospect drift near Barneston.

No. 9111.		
	Ft.	in.
Igneous rock.		
* Shale, black, with thin streaks of coal.....	1	2½
Igneous rock.....		6
* Shale, with streaks of coked coal.....	3	
	4	8½

Sample for analysis.—Sample 9111 was taken where the above section was measured. Both the hanging wall and footwall of the bed are of a porphyritic igneous rock which appears to be rhyolite or andesite. The parting in the middle of the bed appears to be of the same material, but it is much decayed and can be readily broken in the hand. This parting follows about the same position in the bed for a distance of 30 feet from the entrance. It then turns abruptly and lies immediately under the roof. The analysis of this sample is given on page 53.

Character and quality of the coal.—The coal has been altered by igneous action. The upper bench of the bed is changed almost entirely to natural coke, and the lower bench is partially altered. The analysis indicates a large amount of fixed carbon and a small amount of volatile matter. The coal contains a high percentage of moisture, nearly all of which is given off when exposed to the sun. This moisture appears to fill the pore spaces in the coked part of the bed, and has probably been absorbed from the adjoining rocks. Nearly one-third of the weight of the coal is ash. It has a low heating value, and considering the uncertain nature of the igneous intrusions in this vicinity the bed is of no economic importance.

DENNY-RENTON.

Denny-Renton, tunnel and drift mine at Taylor, on the Columbia & Puget Sound Railroad. No. 32.

Operator: Denny-Renton Clay & Coal Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal bed.—Five coal beds are exposed in this tunnel, which is being operated for several large shale beds that are of special value in the

manufacture of brick and terra cotta. The coal beds are worked in conjunction with the shale in order to supply fuel for burning the clay. In descending order the beds are known as Nos. 2, 3, 4, 5, and 6. They strike N. 70° W. and dip from 60 to 70° S. The formation is badly broken by igneous intrusions which follow the coal beds for some distance, parallel them in the shale, or cut across the coal at various angles. Wherever the igneous rock comes in contact with the coal it is altered more or less to natural coke. The igneous rock is either rhyolite or andesite, and is more or less decomposed. It makes excellent brick of delicate tints, and is used when encountered in the coal beds, so that the cost of mining the coal is not increased by its presence. The following sections were taken where the samples were obtained:

Sections of coal beds in Denny-Renton mine.

No. 9173, bed No. 2.		No. 9176, bed No. 3.	
Scale, carbonaceous.	Ft. in.	Shale, carbonaceous.	Ft. in.
* Coal.....	3 8½	* Coal, slightly bony.....	6
Coal, bony.		Shale, brown, hard.....	1
		* Coal, one-third badly squeezed.....	8½
No. 9172, bed No. 4.		Shale, hard.....	2½
Shale, black.	Ft. in.	* Coal, lime in joints.....	11
Shale, carbonaceous.....	2½	Shale, brown.....	1
* Coal.....	2 8½	* Coal.....	1 3½
Shale.	2 11	Shale, carbonaceous (poor floor).	3 9½
No. 9175, bed No. 6.		No. 9174, bed No. 5.	
Shale, carbonaceous.	Ft. in.	Shale, black, carbonaceous.	Ft. in.
* Coal, irregular streaks of "sulphur".....	2 2½	* Coal.....	1 11
Shale, brown.....	1	"Niggerhead".....	3
* Coal.....	2 5	* Coal.....	1 11
Shale, black, carbonaceous (poor floor).	4 8½	Shale, black, carbonaceous (poor floor).	4 1
No. 518-D, bed No. 5.¹		No. 519-D, bed No. 4.¹	
* Coal.....	Ft. in.		Ft. in.
Shale.....	5½	* Coal.....	2 3½
* Coal.....	1 1	Coal, bony.....	4
"Rash".....	1½		2 7½
* Coal.....	2 1	No. 520-D, bed No. 5.¹	
Coal, bony.	3 10		Ft. in.
		* Coal.....	5
		* Shale and sandstone.....	¼
		* Coal.....	5½
		Shale and sandstone.....	1
		* Coal.....	1½
		"Rash".....	2¼
		* Coal.....	1 11
			3 2¼

¹ Washing and coking tests of coal, Bull. Bureau of Mines No. 5, 1910, pp. 13-14.

Preparation for market.—The coal from all the beds is mixed at the bunker and picked by hand. The small coal is then washed through a Jeffery tub washer, so that most of the partings and all the "sulphur" balls are removed from the coal.

Samples for analysis.—Sample 9173 was taken from bed No. 2 in a small crosscut from bed No. 3 about 2,600 feet due north of the south quarter corner of sec. 3, T. 22 N., R. 7 E. It is overlain by carbonaceous shale and underlain by bony coal, both of which mix to some extent with the coal in mining and must be separated. Sample 9176 was taken from bed No. 3 about 50 feet west of the place where sample 9173 was obtained. The bed contains three layers of shale, which can be separated by careful picking and washing and which were not included in the sample. The roof and floor are of carbonaceous shale; both are more or less crushed and break off very readily. The floor of the mine is especially poor, and some places as much as a foot of the shale mixes with the coal, so that the output from this bed should be very carefully picked and washed. Sample 9172 was taken from bed No. 4 in chute 29 of the east gangway. The bed is overlain by about 2 inches of carbonaceous shale, which breaks with the coal and must be separated at the bunker. Sample 9174 was taken from chute 27, about 45 feet above the east gangway on bed No. 5. A layer of pyrite near the center of the bed can be separated at the bunker, and this impurity was not included in the sample. The bed also contains scattered through the coal small nodules of pyrite, which may be removed by washing. The roof of this mine is of strong carbonaceous shale, but the floor is badly broken carbonaceous shale, and this shale mixes with the coal in mining.

Samples 518-D, 519-D, and 520-D were taken in 1908 by Karl M. Way in connection with two cars of coal shipped from this mine to the United States Geological Survey for testing purposes. Sample 518-D was obtained from coal bed No. 5 at a point in the mine 2,400 feet northeast of the drift mouth. Sample 520-D represents the same bed of coal and was obtained at a point 3,000 feet northeast of the drift mouth. Sample 519-D was obtained from coal bed No. 4 at a point 1,500 feet northeast of the mouth of the mine. Sample 585-D represents a car of run-of-mine coal from bed No. 4, and 586-D represents a car of the same kind of coal from bed No. 5. Sample 6485 was taken from bed No. 5. Sample 9175 was taken from chute 5 about 25 feet above the east gangway on bed No. 6. The bed contains one shale parting and numerous small nodules of pyrite which can be separated by careful picking and washing and were not included in the sample. The roof of this bed is of carbonaceous shale, and is fairly firm. The bottom is of badly broken carbonaceous shale which slabs off to a depth of about 1 foot in places and must be separated from the coal. The analyses of the samples are given on pages 53-54.

Character and quality of the coal.—The coal from beds Nos. 4, 5, and 6 is pitch black, gives a dark brown streak, and has a vitreous luster. It is minutely jointed, banded, and laminated, and breaks with an irregular fracture. It contains a small amount of moisture, and does not weather on exposure to the air. It has a moderate amount of ash and the same heating value as the average coal from the vicinity of Bayne and Occidental. Coal from bed No. 3 resembles that from Nos. 4, 5, and 6. Owing to its higher amount of ash, it has a correspondingly lower heating value than other coals from the same mine. This coal has also a greater amount of sulphur than that found in the other beds. The coal from bed No. 2 is pitch black has a reddish-brown streak and a slightly vitreous luster. It is massive, banded, and laminated, and breaks with an irregular splintery fracture. It contains about the same amount of ash as the other beds and compares in heating value with coal from mine No. 1 at Ravensdale.

PROSPECTS SOUTHEAST OF ISSAQUAH.

Prospects in the Tiger Mountain district, about 6 miles southeast of the Northern Pacific Railway at Issaquah. No. 33.

Kind of coal: Bituminous.

Coal beds.—The beds are exposed on the north side of a ravine in a densely wooded country. Their relation to beds in other parts of the county is not definitely known, for they are more or less broken by faults and intrusions of igneous rock and the outcrops are very limited. The beds strike N. 43° E. and dip 44° NW. The following sections were measured where the samples were obtained:

Sections of coal beds in prospects in Tiger Mountain district.

No. 9290.		No. 9289.	
	Ft. in.		Ft. in.
Shale, compact.	6	Sandstone, massive, white.	
Shale, slaty.....	6	Shale, carbonaceous.....	5
*Coal.....	2 2	*Coal.....	4
Clay, dark, plastic.....	2	Shale, brown, soft.....	3
*Coal.....	1 8½	*Coal.....	2
Clay, white, plastic.....	11	Pyrite.....	1
Coal, dirty.....	11	*Coal.....	9
Clay, shaly.....	3	Clay, brown.....	2
Sandstone, massive, white.		*Coal.....	6
	6 7½	Clay.....	1
		*Coal.....	4
		Clay, sandy.....	2
		Coal.....	6
		Sandstone, massive, white.	
			3 9

Samples for analysis.—Sample 9290 was taken from the larger and better of the two beds. The coal is so badly crushed that it could be crumbled almost to a powder in the hand. A parting of clay which occurs near the center can be separated from the coal and was not included in the coal. Sample 9289 was taken a short distance down the stream from No. 9290 in the other bed. This bed contains several thin partings which can be separated from the coal, and they were not, therefore, included in the sample. The analyses of these samples are given on page 54.

Character and quality of the coal.—The coal from the prospect highest on the creek is pitch black, with a black streak and a vitreous luster. It is massive and dense, and breaks with an irregular fracture. It contains a moderate amount of moisture, probably absorbed from the overlying soil, which is given off readily on air drying. It has a moderate amount of ash and compares in heating value with the average bituminous coal of the State. The coal from the lowest prospect is pitch black and has a reddish-brown streak. It is banded and laminated, and breaks with an irregular splintery fracture. It contains about the same amount of moisture and a greater amount of ash than that of the other bed and a correspondingly lower heating value. The amount of sulphur in the coal is greater than that of most of the Washington coals. Both coals should be classed as bituminous.

PROSPECT SOUTHWEST OF PRESTON.

Prospect about 1 mile southwest of Preston. No. 34.

Coal bed.—The bed is very poorly exposed, and its relation to other beds in the vicinity is not known. The following section was taken at the end of a small drift run on the bed about 25 feet.

Section in prospect southwest of Preston.

No. 8546.

Coal and shale, mixed.	Ft.
*Coal, badly broken.....	3±
Coal and shale mixed.	

Sample for analysis.—Sample 8546 was taken from the bench of crushed coal here exposed. The joints of the coal were filled with mud from the overlying soil and the sample was washed to remove the mud. It was sealed in the can while still wet and the analysis should show a higher amount of moisture than if the sample had been dry. The analysis of the sample is given on page 54.

Character and quality of the coal.—The coal is so high in ash and sulphur that it is of no economic value. The relation of volatile matter to fixed carbon indicates that this is a semibituminous coal, but taken as a whole the bed can hardly be considered more than carbonaceous shale.

NIBLOCK.

Niblock, a series of water level drifts about $1\frac{1}{2}$ miles southwest of Snoqualmie, on a spur of the Northern Pacific Railway. No. 35.

Operator: United Collieries Co., Seattle, Wash.

Kind of coal: Bituminous (coking).

Coal beds.—Four coal beds have been worked at this mine at different times. The mine has not been in operation for several years, but it will probably be reopened in a short time. At the time of the writer's visit beds Nos. 3, 4, and 5 were the only ones from which samples could be obtained. The coal measures strike N. 13° E., and dip rather steeply to the west. Bed No. 4 lies about 100 feet stratigraphically above No. 3, and bed No. 5 about 60 feet above No. 4. The following sections were measured where the samples were obtained:

Sections of coal beds in Niblock mine.

No. 10031, bed No. 3.		No. 10033, bed No. 5.	
	Ft. in.		Ft. in.
Coal, very finely jointed.....	1	B one.....	2
Shale, soft.....	6	*Coal, bright.....	1 9
Shale and clay, mixed.....	8	Bone.....	1
*Coal, bright, clean.....	4	*Coal, clean, bright.....	10
Shale, carbonaceous.....	6 2	Shale, carbonaceous.....	2
		*Coal.....	2 5
		Coal, bony.....	4
		Coal, soft.....	1
			5 10
No. 10032, bed No. 4.			
	Ft. in.		
Sandstone, shaly.....			
*Coal, clean, bright.....	1 1 $\frac{1}{2}$		
Clay.....	$\frac{3}{4}$		
*Coal, clean.....	1 4		
Shale, carbonaceous.....	$\frac{3}{4}$		
*Coal.....	8 $\frac{1}{2}$		
Shale, black, carbonaceous, with 3 coal, bottom.....	3 3 $\frac{1}{2}$		

Preparation for market.—The beds are too highly inclined and the coal too finely jointed and broken to admit of the separation of impurities in the mine. The coal was picked and washed at the bunker, and the best washed coal was used at the coke ovens on the property. A new bunker and washer is being installed by the United Colliery Co. at Seattle, and to this bunker all the coal will be shipped for cleaning and preparation for the market after it has passed the picking table. Much of the coal will be manufactured into briquets.

Samples for analysis.—Sample 10031 was taken from bed No. 3 about 25 feet up a chute 500 feet from the entrance to the highest water level on this bed. The bed is overlain by soft shale mixed with clay, and by a layer of finely jointed coal. A good sample could not be obtained from this upper layer of coal, and therefore only the main bench of coal was sampled. The bed is overlain and underlain by soft carbonaceous shale, which mixes to a considerable extent with

the coal, and must be removed in preparing the coal for the market. Sample 10032 was taken from bed No. 4 on the middle water level where the rock tunnel from bed No. 5 to bed No. 3 crosses bed No. 4, at a point about 800 feet from the entrance to the tunnel on bed No. 5. The two partings in this bed can be separated by careful picking and washing, and were not included in the sample. Sample 10033 was taken from bed No. 5 at the junction of the main rock tunnel to No. 5 with the gangway on the coal, at a point about 160 feet from the entrance to the mine. The bed contains several partings, which can be separated from the coal by careful picking and washing and which were not included in the sample. The analyses of these samples are given on page 55.

Character and quality of the coal.—The coal from this mine is pitch black, with a nearly black streak and a vitreous luster. It is dense and breaks with an irregular cubical fracture, but owing to its minute joints it crumbles very readily, so that the proportion of lump coal is very small. The amount of moisture is small, and the coal does not slack when exposed to the air. Samples from bed No. 5 show a large amount of ash, but it is possible that much of this ash may be removed by very careful washing. The coal is considered one of the best coking coals in the State, and has also been used not only in making coke, but to some extent as blacksmith coal.

KITITAS COUNTY.

The extent of the Roslyn coal bed on the northeast side of the field is well known, for it has been worked nearly the full length of the field along this side of the syncline in the mines of the Northwestern Improvement Co., but the southwest edge of the field is covered by gravel, and the geology of the coal-bearing formation is therefore obscure. One bed of known workable thickness underlies the Roslyn bed, but its extent and value have not been determined. The structure of the northwest end of the field is believed to be complicated by faults and folds, but it is thought that a part of the structure can be worked out by careful field examination.

The principal coal bed of this field, the Roslyn, changes considerably in character and quality from the southeast end of the field, near Clealum, to the northwest end, near Beekman. Near Clealum the coal is banded and laminated, and breaks with an irregular splintery fracture, so that it resembles very closely some of the layers of bony coal which it contains. At the northwest end of the field the coal is either dense or only slightly laminated, breaks with an irregular cubical fracture, and is more jointed and more friable than that at the southeast end. The amount of ash in the clear coal at Clealum is considerably greater than at Beekman, and the heating value is correspondingly lower. A considerable difference in coking properties

is also reported; the coal at Clealum shows only slight coking tendencies, whereas that at Beekman makes a fair coke. Investigation indicates that this change in coking quality takes place between Clealum and Roslyn and coincides approximately with the change in the character of lamination of the coal. Of the change in the Roslyn bed, George Otis Smith¹ makes the following statement: "These analyses, which were furnished by L. S. Storrs and are given below, show the variation in this seam from a lignitic, noncoking coal to a fairly good coking coal." The term lignite as used in the preceding quotation was applied to almost all the western coals now known as subbituminous, and even to some of the lowest grades of true bituminous coal.

Gas occurs in considerable quantities in the coal and in the overlying rocks. It works out gradually as the gangways and rooms are being driven, or comes from the roof in the form of small blowers. Several small explosions and two large ones have resulted from the gas. In some of the mines the workings are very dry; the coal crumbles readily and makes a large amount of dust, which accumulates on the ribs and mine timbers. This dust, like the coal, is high in volatile matter, and very inflammable, and will explode with great violence when mixed with the proper proportion of air. In order to guard against such explosions, the gangways in most of the lower workings are sprinkled several times a week. A small gas explosion at a time when the mine is dry and filled with dust would probably produce very serious results. It is the belief of the investigators of the United States Geological Survey, the State inspector of mines, and the mine officials that the violent explosion at shaft No. 4, at Roslyn, on October 3, 1909, was brought about through those conditions.

The coal of the Roslyn field is low in moisture, and does not slack or crumble by weathering during transportation or storage. No preparation for market is given the coal beyond the separation of the thicker partings, and the "sulphur" balls in the mine and the picking of the lump coal at the tipple, but the percentage of ash would be much smaller if the coal could be thoroughly picked and washed after coming from the mine. The coal mined by the Northwestern Improvement Co. is not cleaned except in mining, and carload samples would doubtless show a percentage of ash considerably higher than those given in the analyses accompanying this report.

The samples collected from this county by the writer were obtained in November, 1909. Analyses of five samples collected from Roslyn and Beekman by other members of the Survey are included for the purpose of comparison.

¹ Mount Stuart folio (No. 106), Geol. Atlas U. S., U. S. Geol. Survey, 1904, p. 10; Snoqualmie folio (No. 139), Geol. Atlas U. S., U. S. Geol. Survey, 1906, p. 13.

PROSPECT, NORTHWEST OF BEEKMAN.

Prospect, about $1\frac{1}{4}$ miles northwest of Beekman.¹

Kind of coal: Bituminous (?).

Coal bed.—The bed strikes N. 55° E. and dips 12° SE. It is believed to underlie the principal bed of the Roslyn field. It is too thin to be of commercial importance. The following section was measured at the end of a 25-foot drift driven on this bed:

Section of coal bed in prospect $1\frac{1}{4}$ miles northwest of Beekman.

No. 9404.		Ft. in.
Shale, hard.....		1+
*Coal.....		1 2½
Shale.....		2½
Coal.....		2½
Shale, soft.....		7
		3 2½

Sample for analysis.—Sample 9404 was taken where the above section was measured. The layers of coal and shale associated with the main bed were so badly weathered that their behavior under average mine conditions could not be determined. The analysis of the coal is given on page 55.

Character and quality of the coal.—The sample collected was somewhat weathered. A sample of unweathered coal from this bed would probably show a higher grade of coal than that indicated by the analysis. The coal should probably be classed as low-grade bituminous.

LAKEDAILE.

Lakedale, a water-level mine 1 mile northwest of Beekman, on a spur of the Northern Pacific Railway. No. 36.

Operator: Consolidated Coal Co., Yakima, Wash.

Kind of coal: Bituminous.

Coal bed.—The coal bed worked in this mine strikes N. 80° E. and dips 10° S. Some investigators have thought this bed to be the Roslyn bed or the bed underlying the Roslyn, but comparison of the section with those of the Roslyn bed given in the following descriptions, or with that of the bed measured at the prospect on the property of the Roslyn-Cascade Coal Co. (p. 136) will show that this is probably a third bed. It is believed to underlie both the Roslyn beds exposed farther east. The section following was measured at the place where the sample was taken.

¹ Not represented on Pl. III.

Section of coal bed in Lakedale mine.

No. 9405.

Shale, carbonaceous, black.	Ft. in.
*Coal, bony near center.....	1
Shale.....	6½
*Coal.....	6½
*Shale, hard.....	1
*Coal.....	7½
*Coal, bony.....	¼
*Coal.....	9¼
Shale, hard, brown.	3 7

Preparation for market.—The partings can be removed to some extent in mining, but most of the remaining impurities is removed at the tippie by picking as the coal passes over bar screens.

Sample for analysis.—Sample 9405 was taken 10 feet above the gangway, about 150 feet from the entrance. The bed contains two bony layers in the lower part which can not be readily separated from the coal, and which were therefore included in the sample. The shale parting between the upper and the lower benches can be separated in preparation for market, and was, therefore, not included. Both the roof and the floor are firm and do not mix with the coal. The analysis of this sample is given on page 55.

Character and quality of the coal.—The coal is pitch black and has a dark-brown streak. It is massive and laminated and breaks with a cubical fracture. In general, the coal resembles that of the Roslyn bed at the west end of the field. It contains a small percentage of moisture and will not weather while being transported to market. The high percentage of ash is due to the presence of the two bony layers of the lower bench. The coal is classed as bituminous.

BEEKMAN.

Beekman, a slope at Beekman, about 3 miles northwest of Roslyn on the Northern Pacific Railway. No. 37.

Operator: Roslyn Fuel Co., Seattle, Wash.

Kind of coal: Bituminous.

Coal bed.—The Roslyn bed is the only one worked at this mine. In the eastern part of the workings it strikes N. 70° W. and dips 14° SW. Near the end of the west gangways the bed turns south, so that it strikes S. 75° W. and dips 8° SE. Several partings, which vary in character and position in different parts of the mine, are present in the bed. The roof and floor of the mine are very firm, and do not mix with the coal in mining. Shale occurs in a layer 1 or 2 inches thick between the coal and the roof and mixes to some extent with the coal, but can be separated in mining and in preparation for market.

The following sections were measured at the points where the samples were taken:

Sections of Roslyn coal bed in Beekman mine.

No. 9411.		Ft.	in.
Shale.....		2+	
Shale, soft.....		1	
*Coal.....	1	3	
*Shale, little "sulphur".....		$\frac{1}{4}$	
*Coal.....	1	$2\frac{1}{2}$	
Shale, hard.....		$\frac{1}{2}$	
*Coal.....		3	
*Shale, hard.....		$\frac{1}{4}$	
*Coal.....		$2\frac{1}{2}$	
Shale, hard.....		1	
*Coal.....	1	$8\frac{1}{2}$	
Shale, hard.....		1	
*Coal.....		$2\frac{1}{2}$	
Shale, sandy.....		7	$2+$

No. 9412.		Ft.	in.
Shale.....		1+	
*Coal.....	2	6	
*Shale, brown, carbonaceous		1	
*Coal.....		2	
*Coal, bony.....		$\frac{1}{2}$	
*Coal.....	1	$1\frac{1}{2}$	
*Shale.....		1	
*Coal.....		$5\frac{1}{2}$	
Shale, hard.....		4	$6\frac{1}{2}+$

No. 9413.		Ft.	in.
Shale.....		2+	
Shale, streak of coal.....		1	
*Coal.....	1	1	
*Coal, bony.....		$\frac{1}{2}$	
*Coal.....	3	1	
Shale, hard.....		1	
*Coal.....		2	
Shale, hard, carbonaceous.....		6	$6\frac{1}{2}+$

No. 9414.		Ft.	in.
Shale.....		1+	
Shale, soft.....		1	
*Coal.....	2	5	
*Shale, hard.....		$\frac{1}{2}$	
*Coal.....		$3\frac{1}{2}$	
*Shale, hard.....		$\frac{1}{2}$	
*Coal.....	1	$9\frac{1}{2}$	
Shale, hard.....		1	
*Coal.....		$2\frac{1}{2}$	
Shale, hard.....		3	$\frac{1}{2}$

No. 9415.		Ft.	in.
Shale.....		6	$3+$
Shale, soft.....		1	$\frac{1}{2}$
*Coal.....	1	$3\frac{1}{2}$	
*Shale, bony.....		$\frac{1}{2}$	
*Coal.....	1	$2\frac{1}{2}$	
*Shale, bony.....		$\frac{1}{2}$	
*Coal.....		3	
*Sandstone, "sulphur" band		$\frac{1}{4}$	
*Coal.....		5	
*Shale, bony.....		$\frac{1}{4}$	
*Coal.....	1	$9\frac{1}{2}$	
Shale, bony.....		4	

No. 550-D. ¹		Ft.	in.
Shale.....		5	$6\frac{1}{2}$
*Coal.....		1	
**"Mother coal".....		$\frac{1}{4}$	
*Coal.....	2	3	
Shale.....		1	
*Coal.....		4	
Shale.....		$\frac{3}{4}$	
*Coal.....		$6\frac{1}{2}$	
Shale.....		$\frac{3}{4}$	
*Coal.....	1	$1\frac{1}{2}$	
Shale.....		$\frac{1}{2}$	
*Coal.....		2	
Shale.....		4	9

No. 551-D. ¹		Ft.	in.
*Coal.....	2	$9\frac{1}{2}$	
Shale, hard.....		$\frac{3}{4}$	
*Coal.....	1	10	
Shale.....		$\frac{1}{2}$	
*Coal.....		$1\frac{1}{2}$	
Shale.....		4	$10\frac{1}{4}$

¹Washing and coking tests of coal: Bull. Bureau of Mines, No. 5, p. 16.

Preparation for market.—Only the larger “sulphur” balls and local enlargements of the partings are removed at the mine. At the tippie the coal is passed over shaking screens having $1\frac{3}{4}$ -inch and 3-inch perforations; the oversize is picked as it is loaded into the railroad cars, and the undersize from the $1\frac{3}{4}$ -inch and 3-inch screens are sold as steam coal and as egg coal, respectively.

Samples for analysis.—Sample 9411 was taken on the gangway of the second level west between rooms 26 and 27. At this place the bed contains five thin partings, three of which are over one-fourth inch in thickness and can be separated from the coal by picking. These three partings were therefore not included in the sample. Sample 9412 was collected at the end of the gangway on the second level east near the property line. Three thin partings were found at this place, but they resemble the coal so closely that they can not be readily separated, and were therefore included in the sample. Sample 9413 was collected 150 feet beyond room 21 on the gangway of the third level east. One parting of bony coal near the bottom of the bed was removed from the sample. Sample 9414 was obtained between rooms 17 and 18 on the gangway of the third level west. The three shale partings do not differ very materially from the coal, and it was thought that by removing the largest of these partings the resulting amount of ash in the sample would represent the amount of ash in the coal after picking. Sample 9415 was obtained at the foot of the slope, about 250 feet below the fourth level gangway. Several thin partings in the bed could not be separated readily by picking and were included in the sample. Sample 9410 was obtained from the surface of a railroad car after the coal had passed through the shaking screen with $1\frac{3}{4}$ -inch perforations. The best coal from the mine is much jointed and breaks very readily, so that a considerable percentage of the output passes through $1\frac{3}{4}$ -inch holes. The fragments of the partings as they come from the mine are too large to pass through these holes, and in consequence examination of the coal on the surface of the car shows almost clean coal and a very small percentage of shale or bone. It is believed that the shale partings can be better separated from the fine coal by the shaking screen than by washing or picking. Analysis 9459 represents a composite sample consisting of equal portions of all the samples collected by the writer from this mine. Samples 550-D, 551-D, and 693-D were taken by Karl M. Way, of the United States Geological Survey; sample 550-D from the face of the main slope, 1,000 feet southwest of the entrance to the mine, sample 551-D on the second level west, 1,300 feet southwest of the entrance, and sample 693-D from a car of coal shipped to Denver, Colo., for testing. The analyses of the samples are given on pages 55-56.

Character and quality of the coal.—The coal is pitch black and has a dark-brown streak. It is massive and slightly laminated and breaks

with a cubical fracture. If the coal is so carefully picked as to remove all nodules or lenses of pyrite over 2 inches in maximum diameter and one-half inch in thickness, the picked coal should contain a very low percentage of sulphur. It has a heating value nearly as high as that of the best coal of King and Pierce counties, and equals in this respect much of the Alabama and Kentucky coal.

BUSY BEE.

Busy Bee, strip pit $2\frac{1}{2}$ miles northwest of Roslyn. No. 38.

Operator: Busy Bee Coal & Improvement Co., Roslyn, Wash.

Kind of coal: Bituminous.

Coal bed.—The coal bed lies only a few feet beneath the surface throughout most of this property. A steel scraper, operated by wire cables from a logging engine, has replaced the ordinary horse scraper previously used in removing the material overlying the coal bed. A sample of the coal was taken and the following section of the coal bed measured where the cover had been about 6 feet thick:

Section of Roslyn coal bed in Busy Bee strip pit.

No. 9406.		Ft.	in.
Sandstone, yellow.			
Shale.....	3		$2\frac{1}{2}$
Coal (weathered).....			7
* Coal.....			$9\frac{1}{2}$
Coal, soft, with layers of shale.....			1
* Coal.....	1		3
Shale.....			1
* Coal.....			$3\frac{1}{2}$
Shale.....			$\frac{1}{2}$
* Coal.....			$9\frac{1}{2}$
Coal.....			7
Shale.....			
		7	$8\frac{1}{2}$

Preparation for market.—The coal is passed over a $2\frac{1}{2}$ -inch bar screen. The oversize is picked and sold as lump, and the undersize is sold as steam coal.

Sample for analysis.—Sample 9406 was taken where the section given above was measured. The three partings can be removed from the coal by picking and were not included in the sample. About 7 inches of the upper portion of the bed was weathered and was not included in the sample. The lower 7 inches of the bed was not exposed. The analysis of the sample is given on page 56.

Character and quality of the coal.—The coal is pitch black and has a dark-brown streak. It is massive and laminated and breaks with a cubical fracture. This sample is lower in ash and has a higher heating value than any sample collected from the Roslyn bed in other parts of the field, but this fact does not necessarily mean that the coal is better here than elsewhere, because the entire thickness of the bed was not sampled.

PATRICK-M'KAY.

Patrick-McKay, slope 2½ miles northwest of Roslyn on the Northern Pacific Railway. Nos. 39 and 40.

Operator: Roslyn-Cascade Coal Co., Bellingham, Wash.

Kind of coal: Bituminous.

Coal bed.—The Roslyn bed is the only one at present operated on this property. It strikes N. 75° W. and dips 9° SW. The lower 2 inches of a 3-foot layer of shale between the bed and the overlying sandstone breaks after the coal is removed and is thrown into the gob, but the rest forms a good roof throughout most of the mine. The floor is firm and does not mix with the coal. A second bed 3½ feet thick is exposed 260 feet vertically below the outcrop of the Roslyn bed on this property and in prospects to the east on the north side of the ridge northeast of Roslyn, but the prospects were caved and neither sections nor samples could be obtained. The following sections of the Roslyn bed were measured at the points from which the samples were taken:

Sections of Roslyn coal bed in Patrick-McKay mine.

No. 9418.		No. 9416.	
	Ft. in.		Ft. in.
Shale.		Shale.	
* Coal.....	1 3	Shale, soft.....	2½
* "Sulphur" band.....	¼	* Coal.....	1 2
* Coal.....	1 1	* "Sulphur" band.....	¼
* "Sulphur" band.....	Trace.	* Coal.....	1 3
* Coal.....	3	* Shale, hard.....	¼
Shale, hard.....	1	* Coal.....	2½
* Coal.....	1 10	Shale.....	1
Shale.		* Coal.....	1 3½
	4 6¼	Shale.	
No. 9417.			4 3
Shale (good roof).	Ft. in.	No. 9407, lower bed.	
Shale.....	2½	Sandstone, yellow, massive.	Ft. in.
* Coal.....	1 2	Shale.....	4
* "Sulphur".....	Trace.	Coal, bony.....	1 5½
* Coal.....	1 3½	Sandstone.....	1½
* Coal, bony.....	½	* Coal.....	8
* Coal.....	2	Shale, hard.....	½
Shale.....	1	* Coal.....	1 5½
* Coal.....	1 5½	Shale.....	3½
Shale, hard.....	1	Shale, hard.....	2
Shale.		* Coal.....	9
	4 6	Shale.	
			8 11

Preparation for market.—The coal is passed over bar screens with ⅞-inch and 1½-inch spaces. The oversize is picked and sold as lump coal, while the undersize is sold as steam coal.

Samples for analysis.—Sample 9418 was taken on the gangway of the first water level west at the entrance to room 18. Two "sulphur"

bands, too thin to be separated by picking, are present, but a parting of bony shale in the lower part of the bed can be readily removed by picking and was not, therefore, included in the sample. Sample 9416 was taken from the west side of the slope, 50 feet above the entrance to the first water level east. The lowest shale parting of the bed, which is the only one that can be readily separated in preparation for market, was not included in the sample. Sample 9417 was taken at the end of the gangway on the first water level east, about 1,000 feet from the rock tunnel to the main slope. The lowest shale parting is the only one which can be separated by picking, and this parting is therefore not included in the sample. Analysis 9460 was made of a composite sample consisting of equal parts from samples 9418, 9416, and 9417. Sample 9407 was taken from the lower bed on this property, about 1,300 feet north of the center of sec. 6. The coal occurs in two benches separated by $5\frac{1}{2}$ inches of shale, which can be used as a "mining." The bony coal overlying the upper bench has been considered to be of workable quality, but judging from its weathered appearance it probably contains more than 40 per cent of ash, and if mined and sold with the two other benches the coal from these benches would probably lose much of its commercial value. This bench may, however, prove to be of economic value in other parts of the field. The analyses of these samples are given on pages 56-57.

Character and quality of the coal.—The coal of the Roslyn bed is pitch black, massive, and very slightly laminated and breaks with an irregular fracture. It has about the same heating value as the coal from the same bed in the northwest end of the field. The coal of the lower bed is pitch black, massive, and slightly laminated and breaks with an irregular fracture. It contains a small amount of moisture and does not slack when exposed to the sun, but analysis of the coal shows a somewhat larger percentage of ash and sulphur than the average of the Roslyn coal. It resembles the best coal of the Roslyn bed in the western end of the field.

ROSLYN NO. 3.

Roslyn No. 3, incline, slope, and shaft mine at Ronald, $1\frac{1}{2}$ miles northwest of Roslyn, on the Northern Pacific Railway. No. 41.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—The Roslyn bed, which is the only one worked in this mine, has about the same thickness here as elsewhere in the field. About 3 feet of shale lies between the bed and the overlying sandstone. Of this layer the lower 2 to 6 inches breaks after the coal is removed and is thrown into the gob, but the remainder forms a good roof throughout most of the mine. The floor of the mine is firm and does not mix with the coal. The sections following were measured at places where the samples were obtained.

Preparation for market.—The partings which separate freely from the coal in the mine and the rock “falls” from the roof are thrown into the gob when the cars are loaded. The coal is not picked at the tipple, because it is clean enough for locomotive use.

Samples for analysis.—Sample 9433 was taken on the fifth level west from slope No. 2, about 250 feet up room 7 of the second block. Both shale partings of the bed can be separated by picking and were not included in the sample. Sample 9434 was taken on the sixth level west from slope 2 on the side of the barrier pillar separating this mine from mine No. 3, and 360 feet up the rise from the gangway. Only the lowest shale parting is of sufficient size to be separated by picking, and this parting was not included in the sample. Sample 9435 was collected on the sixth level west from slope 2 on the gangway between rooms 2 and 3. The bed contains five partings, and it would be difficult to remove more than half of the impurities resulting from these partings. In order to obtain a representative amount of ash the lowest parting and one-half of the first parting below the top were separated from the sample. Sample 9436 was taken from the side of the slope between the eighth and tenth levels, west from shaft 4, about 10 feet below the air course below the eighth level. The lower part of the bed was not exposed on account of rock “falls,” and the condition of the mine atmosphere was so poor that time could not be taken to obtain a full section. The lower parting, which is the only one of sufficient size to be separated by picking, was not included in the sample. Analysis 9464 was made of a composite sample consisting of equal parts of samples 9433, 9434, 9435, and 9436. The analyses of these samples are given on page 58.

Character and quality of the coal.—The coal is pitch black, massive, and slightly banded, and breaks with an irregular fracture. The coal in the upper part of the bed contains thin irregular lenses of “sulphur,” which could probably be easily separated from the coal by washing. These lenses were excluded from the samples, which, therefore, give small amounts of sulphur in the analyses. The coal has about the same heating value as that obtained from other mines in this part of the field.

ROSLYN NO. 2.

Roslyn No. 2, incline at Roslyn, on the Northern Pacific Railway. No. 42.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—This mine is operated on the Roslyn bed, which strikes N. 50° W. and dips about 12° S. About 3 feet of shale separates the bed from the overlying sandstone. The lower 2 inches of this shale breaks after the coal is removed and is thrown into the gob. The remainder forms a good roof throughout most of the mine. The floor of the mine is firm and does not mix with the coal. The following

A. & E.

A. & E., a drift and slope mine 1 mile northeast of Roslyn. No. 43.
Operator: Yakima-Roslyn Coal Co., Roslyn, Wash.

Kind of coal: Bituminous.

Coal bed.—The mine is on the Roslyn bed, which strikes N. 70° W. and dips 11° S. About 3 feet of shale lies between the coal bed and the overlying sandstone. The lower 2 inches of the shale breaks after the coal is removed and is thrown into the gob, but the rest forms a good roof throughout most of the mine. The floor of the mine is firm and does not mix with the coal. The following section was measured:

Section of Roslyn coal bed in A. & E. mine.

No. 9402.		Ft.	In.
Shale.			
Shale, soft.....			2½
*Coal.....	2		5
Clay.....			½
*Coal.....			2½
Shale, black.....			½
*Coal.....	1		8
Shale, dark.		4	7.

Preparation for market.—Partings, roof fragments, and other impurities which can be readily removed when the mine cars are loaded are thrown into the gob. At the tippie the coal is passed over a 3-inch bar screen, from which the oversize is sold as lump and the undersize as steam coal.

Sample for analysis.—Sample 9402 was taken 160 feet up the ninth room from the slope where the section given above was measured. Both the shale partings can be removed by careful picking, and were not included in the sample. The analysis of this sample is given on page 59.

Character and quality of the coal.—Most of the coal is pitch black, massive, and slightly laminated, and breaks with a cubical fracture. The remaining part is slightly banded and has a somewhat splintery fracture. It has about the same heating value as coal from the other mines in this vicinity.

ROSLYN NO. 6.

Roslyn No. 6, a series of drift mines at Roslyn, on the Northern Pacific Railway. No. 42.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—The mine is on the Roslyn bed, which strikes N. 65° W. and dips from 7 to 10° SW. About 3 feet of shale lies between the coal and the overlying sandstone; the lower 2 to 6 inches of this shale breaks after the coal is removed, and is thrown into the gob,

but the rest forms a good roof throughout the major part of the workings. The floor of the mine is firm and does not mix with the coal. The following sections were measured at the places where the samples were taken:

Sections of Roslyn coal bed in Roslyn No. 6 mine.

No. 9439.		No. 9441.	
	Ft.	in.	
Shale.			Sandstone.
Shale, soft.....		2½	Shale, slate-colored.....
*Coal.....	2	6½	*Coal, lenses of "sulphur" ..
†"Sulphur" band.....		¼	Shale.....
*Coal.....		1½	*Coal.....
Shale.....		½	Shale.....
†Coal.....		1½	*Coal, lenses of "sulphur" ..
Shale.....		1	Shale, sandy.
*Coal.....	1	1	
*"Sulphur" band.....		¼	
*Coal.....		6	
Shale, hard.....		6½	
		5	3½
No. 9440.			
	Ft.	in.	
Shale.			
Shale, soft.....		2½	
*Coal.....	2	3½	
Shale.....		1	
*Coal.....		2½	
*Shale, carbonaceous.....		¼	
*Coal.....		4	
Shale, hard.....		2	
*Coal.....	1	8	
Shale, hard.		4	11¼

Preparation for market.—The partings and impurities which separate readily from the coal are removed in the mine, and as all the coal is used for locomotives it needs no further picking at the tippie.

Samples for analysis.—Sample 9439 was taken from the stump pillar between rooms 1 and 2 on the seventh level. In order to remove an amount of impurities equivalent to that which could be separated by careful picking, the two center partings, half the coal between them, and half the upper parting were not included in the sample. Both the shale partings were removed from sample 9441, which was taken at the east end of the seventh level, and the top and bottom partings were removed from sample 9440, taken from the east end of the fifth level. Analysis 9466 was made of a composite sample containing equal parts of all of the samples collected from this mine. The analyses of these samples are given on page 59.

Character and quality of the coal.—Most of the coal is pitch black and massive, and breaks with a cubical fracture, although a part is slightly banded and has a somewhat splintery fracture. The coal has about the same heating value as that of the other mines in this part of the country.

ROSLYN NO. 4.

Roslyn No. 4, a shaft 640 feet deep at Roslyn, on the Northern Pacific Railway. No. 44.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—This mine is on the Roslyn bed, which strikes N. 70° W. and dips 15° SW. Fragments from the lower 2 to 6 inches of a layer of shale about 3 feet thick separating the coal from the overlying sandstone break off after the coal is removed and are thrown into the gob. The rest of the shale forms a good roof throughout the greater part of the workings, and the floor of the mine is firm and does not mix with the coal. The following sections were measured at the places from which the samples were taken:

Sections of Roslyn coal bed in Roslyn No. 4 mine.

No. 9437.		No. 9438.	
	Ft. in.		Ft. in.
Shale.		Shale, roof.	
Shale, gobbled.....	7	Shale, gobbled.....	9½
Coal, streaks of "sulphur"...	2½	*Coal.....	1 3½
*Coal, thin streaks of "sulphur".....	2 5½	Shale, containing "sulphur".....	1
Shale.....	1	*Coal.....	1 5½
*Coal.....	3	*"Sulphur" band.....	¼
Shale.....	½	*Coal.....	1½
*Coal.....	2	Shale.....	1
Shale.		*Coal.....	2
	5 7½	Shale.	
No. 2458.	Ft. in.		5 10¼
*Coal.....	1 4½		
"Sulphur" band.....	½		
*Coal.....	1 4		
Coal and shale.....	4		
*Coal.....	1 9½		
	4 10½		

Preparation for market.—The partings and impurities which separate readily from the coal are removed in the mine, and as all the coal is used for locomotives it does not need further picking at the tippie.

Samples for analysis.—Sample No. 9438 was taken from the gangway on the eleventh level west, near the center of the second battery; the top and bottom partings are not included in the sample. Sample 9437 was taken from the gangway on the eleventh level east, between rooms 3 and 4 of the second battery, both partings being removed. Analysis No. 9465 was made from a composite sample containing equal portions of these two samples. Sample 2458 was collected by M. R. Campbell in 1905 from room 3 of the second battery, on the ninth level west, about 2,000 feet from the bottom of the shaft. Two partings occurred in the bed at this place, neither of which was included in the sample. The analyses of the samples are given on pages 59–60.

Character and quality of the coal.—The coal is pitch black and massive and breaks with a cubical fracture. In the mine it is under considerable pressure from the roof and is worked without shooting. It has about the same heating value as coal from the other mines in this part of the field.

ROSLYN NO. 5.

Roslyn No. 5, a slope mine 1½ miles southeast of Roslyn, on a spur of the Northern Pacific Railway. No. 45.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—The mine is on the Roslyn bed, which strikes N. 45° W. and dips from 20 to 30° SW. The coal is separated from a massive overlying sandstone by about 3 feet of shale, of which fragments ranging up to a foot in thickness break off after the coal is mined and are thrown into the gob. Occasionally they break with the coal and must be separated from it before the mine cars are loaded. The floor is firm and does not mix with the coal. The following sections were measured at the places from which the samples were taken:

Sections of Roslyn coal bed in Roslyn No. 5 mine.

No. 9427.			No. 9423.	
Shale.	Ft. in.	Shale.	Ft. in.	
Shale, with streak of coal.....	1	*Coal.....	2	8
*Coal.....	2	*Bone.....		1
“Sulphur” band.....	1	*Coal.....		3
Coal, crushed.....	1	Clay, soft.....		½
Clay.....	1	*Coal.....	1	8½
*Coal.....	1	Shale.		4
Shale, hard.	11			9
	4	No. 9426.		
No. 9424.		Shale.	Ft. in.	
Shale.	Ft. in.	Shale, soft.....		3
*Coal.....	1	*Coal.....	1	2
*Sandstone and “sulphur”..	½	*Sandstone, “sulphur” band.		¼
*Coal (middle 3½ inches is high in sulphur).....	1	*Coal.....	1	6
Sandstone and “sulphur”..	½	*“Sulphur” band.....		¼
*Coal.....	1	*Coal.....		2
Shale.....	½	Clay, soft.....		1
*Coal.....	2	*Coal.....		2
Shale, carbonaceous.	5	*Coal, bony.....		¼
	3½	*Coal.....	1	7
No. 9425.		Shale, hard.....		5
Shale.	Ft. in.	Shale.		5
*Coal.....	1			4½
*“Sulphur” band, irregular.	Trace.			
*Coal.....	1			
*“Sulphur”.....	¼			
*Coal.....	1½			
Clay.....	½			
*Coal.....	2			
Shale, hard, carbonaceous.	4			
	11½			

Preparation for market.—The partings and impurities which separate readily from the coal are removed in the mine, and as all the coal is used for locomotives it needs no further picking at the tippie.

Samples for analysis.—Sample 9427 was taken from the barrier pillar between mine No. 5 and old mine No. 1, at Roslyn and on the gangway of the first level west of slope 5. A 3-inch parting of crushed coal, clay, and pyrite, which occurs in the center of the bed, was not included in the sample. Sample 9423 was taken from the barrier pillar between mines No. 5 and No. 7, about 10 feet above the second level gangway of mine No. 5. The lower parting in the bed can be separated by picking, and was not included in the sample. Sample 9424 was taken on the third level west at the entrance to room 50. The two lower partings in the bed can be easily separated from the coal and were therefore not included in the sample. Sample 9426 was taken on the third gangway east at entrance to room 42. The bed contains four partings, all but one of which would be difficult to separate from the coal by picking, and only the second parting from the bottom was removed in the sample. Sample 9425 was taken from the air course below the fourth level, about 30 feet west of the slope. Only the lower parting could be separated by picking and therefore was not included in the sample. Analysis 9462 was made of a composite sample containing equal parts of all the samples taken from this mine. The analyses of these samples are given on pages 60–61.

Character and quality of the coal.—The coal in this mine is pitch black, massive, and slightly banded. In general it breaks with an irregular fracture, though a part of it has a tendency toward a splintery fracture. It has about the same heating value as coal obtained from the mines at Roslyn.

ROSLYN NO. 7.

Roslyn No. 7, a slope mine one-half mile northwest of Clealum, on a spur from the Northern Pacific Railway. No. 46.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—The mine is located on the Roslyn bed, which strikes about N. 65° W. and dips from 20 to 30° SW. The overlying sandstone is separated from the coal by about 3 feet of shale, of which the lower 2 to 6 inches breaks after the coal is removed, and is thrown into the gob. The remaining shale, however, forms a good roof throughout most of the mine, and the floor is firm and does not mix with the coal. The following sections were measured at the places where the samples were taken:

Sections of Roslyn coal bed in Roslyn No. 7 mine.

No. 9422.		No. 9421.	
	Ft. in.		Ft. in.
Shale.		Shale.	
*Coal.....	1 2	*Coal.....	1 2
Shale.....	1/2	"Sulphur" band.....	1/2
*Coal, streaks of "sulphur".....	1 6 1/2	*Coal.....	1 2 1/2
*Shale.....	1/2	Shale.....	1
*Coal.....	2	*Coal.....	1 1/2
Shale.....	1	"Sulphur" band.....	1/4
*Coal.....	1 6	†Coal.....	1
Shale.	4 6 1/2	*Shale.....	1/2
		*Coal.....	4
		Shale.....	1/2
No. 9420.		*Coal.....	1 6 1/2
Shale.	Ft. in.	Shale.	4 8 1/2
Shale, soft.....	1 1/2		
*Coal, crushed.....	4	No. 9419.	
*Coal.....	10	Shale.	Ft. in.
Shale.....	1	Shale, carbonaceous streaks.....	1
*Coal, partly crushed.....	1 6 1/2	*Coal.....	2 1/2
Coal and shale streaks.....	2	Shale.....	1
*Coal.....	2	*Coal.....	1 1/2
*Shale.....	1/2	*Shale.....	1
*Coal.....	1 8 1/2	*Coal.....	4
Shale.	5	*Coal, banded.....	2
		*Coal.....	1 6 1/2
		Shale.	4 5 1/2

Preparation for market.—Partings and impurities which separate readily from the coal are removed in the mine, and as all the coal is used for locomotives it needs no further picking at the tippie.

Samples for analysis.—Sample 9422 was taken on the gangway of the second level west, 6 feet up room 40. The upper and the lower partings of the bed can be separated by picking and were not included in the sample. Sample 9421 was taken on the gangway of the second level east, 15 feet from the barrier between mine No. 7 and mine No. 1 at Clealum. The bed contains five partings, most of which can be separated from the coal by careful picking. A parting of shale, "sulphur" and coal occurs near the center of the bed. In picking, about half the coal in this parting will be thrown away, and, accordingly, in sampling, only half the coal and the layer immediately underlying it was included in the sample. Sample 9420 was taken in the air course below the gangway of the fourth level west, about 800 feet west of the slope. The two upper partings in the bed, which can be separated by careful picking, were not included in the sample. Sample 9419 was taken on the gangway of the fourth level east, 330 feet beyond the entrance to room 12. The upper parting, which is the only one that can be separated from the coal by picking, was not included in the sample. Analysis 9461 was made

of a composite sample containing equal parts of the samples taken at this mine. The analyses of the samples are given on page 61.

Character and quality of the coal.—The coal is grayish black, massive, and banded, and breaks with a splintery fracture. On account of the banding, it is difficult to distinguish some parts of the coal from bony layers containing a high percentage of carbon. The coal has a heating value a little lower than the coal obtained from this bed at the mines further to the northwest.

SUMMIT.

Summit, incline 1 mile north of Clealum. No. 47.

Operator: Summit Coal Mining Co., Portland, Oreg.

Kind of coal: Bituminous.

Coal bed.—The mine is on the Roslyn bed, which here strikes N. 75° W. and dips 11° S. The following section was measured at the point from which the sample was taken:

Section of Roslyn coal bed at Summit mine.

No. 9403.		Ft.	in.
Sandstone.			
Shale (5 inches to 1 foot 6 inches).....		11	
Shale with streaks of coal.....			5
*Coal.....	2		5½
Shale.....			½
*Coal.....			2
Shale.....			½
*Coal.....	1		9½
Shale.			
		5	10

Preparation for market.—The partings and impurities that can be separated readily at the mine are thrown into the gob. At the tippie the coal is passed over two 2-inch bar screens, the oversize, after picking, being marketed as lump coal, and the undersize as steam coal.

Sample for analysis.—Sample 9403 was taken down the gangway 50 feet from the new tunnel about 40 feet below the surface. Both shale partings of the bed were excluded from the sample. The analysis of the sample is given on page 61.

Character and quality of the coal.—The coal is grayish black, massive, and slightly banded, and has a splintery fracture. Its heating value is somewhat lower than that of the coal obtained from the same bed farther to the west.

CLE ELUM NO. 3 EXTENSION.

Cle Elum No. 3 Extension, incline and drift mine about 1 mile north of Clealum. No. 48.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—The mine is worked on the Roslyn bed, which strikes N. 70° W. and dips about 9° S. The coal is separated from massive sandstone by about 3 feet of shale, fragments of which, the largest a foot in thickness, break off after the coal is mined and are thrown into the gob. Occasionally it breaks with the coal, in which event it must be separated before the mine cars are loaded. The floor is firm and does not mix with the coal. The following section was measured where the sample was obtained:

Section of Roslyn coal bed at Cle Elum No. 3 Extension mine.

No. 9408.		Ft.	in.
Shale.			
Shale, carbonaceous, and bone.....	1		
*Coal.....	2	8½	
Shale.....			½
*Coal.....			4
*Shale, hard.....			1
*Coal.....	1	2½	
Shale.		5	4½

Preparation for market.—Partings and impurities which separate readily from the coal are removed in the mine, and as all the coal is used for locomotives it needs no further picking at the tippie.

Sample for analysis.—Sample 9408 was taken from the air course which parallels the incline, just below the sixth level, and does not include the upper parting of the bed. The analysis of the sample is given on page 61.

Character and quality of the coal.—The coal is grayish black, massive, and banded, and breaks with a splintery fracture. The bony layer in the bottom of the bed resembles the surrounding coal to such an extent that it was difficult to separate them and its presence does not seem to have materially increased the amount of ash in the sample. This coal has a heating value a little lower than that of coal obtained from the same bed in the vicinity of Roslyn.

CLE ELUM NO. 2 EXTENSION.

Cle Elum No. 2 Extension, incline and drift mine about 1 mile north of Clealum. No. 48.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—The mine is located on the Roslyn bed, which strikes N. 80° W. and dips 9° S. The coal is separated from massive sandstone by about 3 feet of shale, pieces of which ranging up to a foot in thickness break off after the coal is mined and are thrown into the gob. When they break with the coal, they must be separated from it before the mine cars are loaded. The floor is firm and does not mix with the coal. The section following was taken from the place where the sample was obtained.

Section of Roslyn coal bed in Cle Elum No. 2 Extension mine.

		No. 9409.	
	Ft.	in.	
Shale.		6	
Shale, slightly carbonaceous.....		6	
*Coal.....	1	2½	
†Shale, hard.....		1	
*Coal.....	1	3	
*Shale, hard.....		¼	
*Coal.....		1½	
Shale.....		¾	
Coal.....		1	
Shale.....		½	
*Coal.....		4	
*Shale, hard.....		½	
*Coal.....	1	5	
Shale, hard.....		5	2

Preparation for market.—Partings and impurities that separate readily from the coal are removed in the mine, and as all the coal is used for locomotives it needs no further picking at the tippie.

Sample for analysis.—Sample 9409 was taken on the gangway of the eighth level about 50 feet east from the rope slope. Half the upper parting and the entire bench near the center of the bed was excluded from the sample. The analysis of this sample is given on page 61.

Character and quality of the coal.—The coal is grayish black, massive, and banded, and has a splintery fracture. It has a lower heating value than coal obtained from the same bed farther northwest.

CLE ELUM NO. 2.

Cle Elum No. 2, one-half mile north of Clealum. No. 48.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—The mine is worked on the Roslyn bed, which strikes N. 55° W. and dips about 14° SW. The coal is separated from a massive sandstone by about 3 feet of shale, fragments of which ranging up to a foot in thickness break off after the coal is mined and are thrown into the gob. It occasionally breaks with the coal and must be separated before the mine cars are loaded. The floor is firm and does not mix with the coal. The following section was measured where the sample was obtained:

Section of Roslyn coal bed in Cle Elum No. 2 mine.

		No. 9472.	
	Ft.	in.	
Shale.		8½	
Shale, soft.....		8½	
*Coal.....	1	1	
“Sulphur” band and coal.....		1	
*Coal.....		6½	
*Coal, bony.....		½	
*Coal.....		7	
Shale and coal layers.....		3½	
*Coal.....	1	5½	
Shale.....		4	9½

Preparation for market.—Partings and impurities which separate readily from the coal are removed in the mine, and as all the coal is used for locomotives it needs no further picking at the tippie.

Sample for analysis.—Sample 9472 was taken at the face of the gangway of the sixth level east. The upper and the lower partings of the bed can be separated by careful picking and were not included in the sample. The analysis of the sample is given on page 62.

Character and quality of the coal.—The coal is grayish black, massive, and banded, and has a splintery fracture. Bony layers in the coal resemble the coal so much that they can be separated only with great care.

CLE ELUM NO. 1.

Cle Elum No. 1, a shaft mine 250 feet deep at Clealum, on the Northern Pacific Railway. No. 48.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—This mine is on the Roslyn bed, which strikes N. 65° W. and dips 24° S. in the west end of the workings, and strikes N. 55° W. and dips 31° S. in the east end of the workings. The coal is separated from a massive sandstone by about 3 feet of shale, of which fragments ranging up to a foot in thickness break off after the coal is mined and are thrown into the gob. Occasionally it breaks with the coal and must be separated before the mine cars are loaded. The floor is firm and does not mix with the coal. The following sections were measured at the points from which the samples were obtained:

Sections of Roslyn coal bed in Cle Elum No. 1 mine.

No. 9445.				No. 9446.			
Shale.	Ft.	in.		Shale.	Ft.	in.	
Shale (gobbed).....		9½		Shale (gobbed).....		5	
*Coal.....	2			*Coal.....	1	½	
Shale.....		¼		Shale.....		2½	
†Coal.....	1			*Coal.....	1	2½	
Shale.....		½		*Shale.....		½	
†Coal.....	2			*Coal.....		3	
Shale.....		½		Shale.....		1	
*Coal.....	5½			*Coal.....		5½	
*Shale, hard.....		½		Shale.....		1	
*Coal.....	1	4		*Coal.....	1	2½	
*Shale, hard.....		½		Shale.....		4	10
*Coal.....	2			No. 9447.			
*Shale.....		¼		Shale (poor roof).....	Ft.	in.	
*Coal.....	1			Clay, soft.....		1	
Shale.....	5	3½		*Coal.....	2	5½	
				Shale, upper part hard.....		1	
				*Coal.....		6	
				*Shale.....		1	
				*Coal.....	1		
				Shale.....	1	1	
					5	3½	

Preparation for market.—Partings and impurities which separate readily from the coal are removed in the mine, and as all the coal is used for locomotives it needs no further picking at the tippie.

Samples for analysis.—Sample 9445 was taken from the gangway on the first level southwest between rooms 32 and 33. Only about half of the coal between the three upper partings could be removed by careful picking, and therefore the partings, with the remaining half of the coal, were not included in the sample. Sample 9446 was taken from the gangway of the first level southwest, 100 feet from the slope. The upper and the two lower partings can be separated from the coal by picking, and were not included in the sample. Sample 9447 was taken at the east end of the gangway on the first level southeast. The upper parting can be separated by picking and was, therefore, not included in the sample. Analysis 9467 was made of a composite sample containing equal parts of the samples obtained from this mine. The analyses of these samples are given on page 62.

Character and quality of the coal.—The coal is grayish black, massive, and banded, and has a splintery fracture. The bed contains some partings of bony coal, which are banded and which can be separated only with difficulty from the coal. The heating value of the coal is lower than that of coal obtained from the mines on the same bed farther northwest.

LEWIS COUNTY.

The samples collected in Lewis County were obtained from three fields—the anthracite field on the headwaters of Cowlitz River, the bituminous field at Ladd, and the subbituminous field near Centralia and Chehalis. The geologic relations of these fields to one another has not yet been determined, except that the coal-bearing rocks in all three fields belong to the Puget formation of the Tertiary system.¹ The samples upon which this report is based were collected during August and September, 1909, and February, 1910. Several samples obtained during 1908 by J. B. Umpleby, of the United States Geological Survey, at Ladd and in the vicinity of Glenavon have also been included in this report.

Gas is said to occur in the Primrose bed along Summit Creek, in the anthracite district, and has been seen by the writer bubbling from some of the coal beds in the bottom of the creek. In the mine at Ladd the beds have been cut by igneous rocks in several places, and gas is especially abundant where these intrusions occur. In bed No. 2 gas is found in small quantities throughout the entire workings.

PROSPECT NORTH OF CARLTON CREEK.

Prospect on the north side of valley, about 500 feet vertically above Carlton Creek, in SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 29, T. 15 N., R. 11 E. No. 49.

Kind of coal: Carbonaceous shale.

¹ Willis, Bailey, Tacoma folio (No. 54), Geol. Atlas U. S., U. S. Geol. Survey, 1899.

Coal bed.—This coal bed occurs in the lower coal group of the Carlton Pass coal field. An open cut has been made across the face of the bed, exposing a total thickness between hanging and foot walls of about 9 feet. The bed is composed almost entirely of black shale containing very thin stringers of bright coal and several layers of very badly crushed graphitic shale. The following is a section of the bed:

Section of coal (?) bed in SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 29, T. 15 N., R. 11 E.

No 9093.		Ft.	in.
Shale, sandy, carbonaceous.			
*Shale, graphitic.....	1	6	
Shale, hard, black.....		7	
Shale, graphitic.....		3 $\frac{1}{2}$	
Shale, black, thin stringers of pure coal.....	2		
Shale, black, hard.....		8 $\frac{1}{2}$	
Shale, graphitic.....	1	7	
Shale, carbonaceous, with thin stringers of bright coal.....	1	11	
Sandstone and shale, with thin layers of carbonaceous shale.			
		8	7

Sample for analysis.—Sample 9093 was taken from the graphitic shale layer 1 foot 6 inches thick near the top of the bed.

Character and quality of the coal.—The material is badly broken and shows considerable movement in the bed. When wet, the slickensided faces are very bright and give the appearance of anthracite coal. This bench was thought by the writer to contain a high percentage of graphite, and has been considered generally by coal prospectors who visited this field to be a high-grade coal. The analysis in the accompanying table (p. 62) shows that the bench is hardly better than carbonaceous shale.

PROSPECT SOUTH OF CARLTON CREEK.

Prospect on hillside south of Carlton Creek in SE. $\frac{1}{4}$ sec. 1, T. 14 N., R. 10 E.; about 1,100 feet above the bed of the creek. No. 50.

Kind of coal: Semibituminous.

Coal bed.—A gangway 90 feet in length has been driven on this bed which strikes north and south and dips 60° W. At the end of the gangway the following section was measured:

Section of coal bed in prospect in SE. $\frac{1}{4}$ sec. 1, T. 14 N., R. 10 E.

No. 9091.		Ft.	in.
Shale.			
Shale, black.....	3	2 $\frac{1}{2}$	
Coal, partly graphitic.....		7	
Shale, black, carbonaceous.....	1		
*Coal.....	3	6	
Coal, impure.....	1	6	
Sandstone.			
		9	9 $\frac{1}{2}$

Sample for analysis.—Sample 9091 was taken from the bed of good coal 3 feet 6 inches thick, and its analysis is given in the table (p. 62).

Character and quality of the coal.—The coal is very hard and bright, but contains a few thin stringers of dull coal. It burns on a forge with a short blue flame and has the appearance of anthracite coal. Analysis shows that it is very high in ash. It is massive and banded, and breaks with a conchoidal fracture.

PROSPECT A, SUMMIT CREEK.

Prospect on Summit Creek in SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 14 N., R. 10 E. No. 51.

Kind of coal: Semibituminous and semianthracite.

Coal bed.—This bed, which is known as the Primrose bed, is about 20 feet in thickness between hanging and foot walls. A gangway has been driven about 50 feet in the lower part of the bed, which is slightly overturned, dipping 82° and striking north and south. The following section shows the details of the bed:

Section of Primrose coal bed in prospect in SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 14 N., R. 10 E.

Shale, hanging wall.	Ft.	in.
* (1) Coal, with thin layers of bone (sample 9101).....	2	8 $\frac{1}{2}$
(2) Coal, bony, with some graphitic shale.....	2	6
* (3) Shale, graphitic (sample 9097).....	1	5
(4) Shale, black.....		8 $\frac{1}{2}$
* (5) Coal and layers of bony coal (sample 9102).....	2	1
* (6) Coal (sample 9099).....	4	11
(7) Coal and graphitic shale in alternating layers.....	3	11
(8) Shale, black.....	2	
Sandstone, footwall.		

20 3

Samples for analysis.—The section was measured and the samples taken from the face of an open cut across the bed at the entrance to the gangway. Bench No. 1, from which sample 9101 was taken, contains a large percentage of hard, bright coal resembling that from bench No. 6, but the numerous thin layers of bony coal scattered through the bed can be separated from pure coal only with extreme difficulty, and will increase the percentage of ash in the bed very considerably. No sample of bench No. 2 was taken, but the coal resembles that sampled in bench No. 5. Sample 9097, taken from the graphitic shale of bench No. 3, shows on analysis that this bench is too high in ash to be of economic value. Sample 9102, taken from bench No. 5, contains a large amount of ash, and is too impure to be of commercial value at the present time. Sample 9099 was taken from bench No. 6, and represents the best coal in the bed. Sample 9100 was obtained from a layer of the best coal near the center of

bench No. 6, and represents the best picked coal from the bed. The analyses of these samples are given on page 63.

Character and quality of the coal.—The coal from bench No. 6 is pitch black, bright, and very hard. It is massive and breaks with an irregular conchoidal fracture. In the other benches the coal is not so pure, is banded and laminated, and breaks with an irregular, splintery fracture. The coal burns in an open fire with a short blue flame and, in general, leaves a fairly large amount of ash, though a sample taken from the best layer in the center of bench No. 6 has a fuel ratio of 11 and a relatively small percentage of ash. The analysis (No. 9100) of this sample compares favorably with the analyses of some of the anthracite coals of Pennsylvania. The percentage of volatile matter is somewhat higher than in the average Pennsylvania anthracite, but lower than that of the semianthracite coal of Sullivan County, Pa., which is sold in the market as anthracite.

PROSPECT B, SUMMIT CREEK.

Prospect on Summit Creek, in SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 14 N., R. 10 E. No. 51.

Kind of coal: Semianthracite.

Coal bed.—The bed is slightly overturned at this place, and has the same dip and strike as that given for the Primrose bed in the preceding description. It is separated from the Primrose by 25 feet of shale. The following section was measured at the face of a drift run along this bed 35 feet:

Section of coal bed in prospect in SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 14 N., R. 10 E.

		No. 9098.	
			Ft. in.
Shale.			
*Coal.	.....	2	9 $\frac{1}{2}$
Coal, poor.	.....		7
Shale, black.	.....	3	
Coal, bony.	.....	2	2 $\frac{1}{2}$
Shale.			<hr style="width: 100%; border: 0.5px solid black;"/>
			8 7

Sample for analysis.—Sample 9098 was taken from the best bench of coal in the section noted above. The coal was more or less crushed and mixed with carbonaceous shale. The analysis of this sample is given on page 63.

Character and quality of the coal.—The coal is pitch black, bright, and hard. It is massive and dense, and breaks with a conchoidal fracture. Analysis shows that the coal contains a very high percentage of ash, and although it is classed as a good grade of semianthracite, the percentage of ash in the entire bed is so high that it would be of little value commercially unless the carbonaceous shale could be separated thoroughly by crushing and washing.

PROSPECT C, SUMMIT CREEK.

Prospect on Summit Creek, in SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 14 N., R. 10 E., about 350 feet west of the opening on the Primrose bed previously described. No. 51.

Kind of coal: Anthracite.

Coal bed.—The coal bed, which belongs to the same group as the Primrose bed, outcrops very near the level of the creek, and only the middle of it was exposed in the prospect. It is slightly overturned, and has a dip and strike practically the same as that of the Primrose. The following section was measured:

Section of coal bed in prospect in SE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 13, T. 14 N., R. 10 E.

No. 9092.

	Feet.
Coal, bony.....	1+
*Coal.....	1
Coal, bony.....	1+
	3+

Sample for analysis.—Sample 9092 was taken from the 1-foot bench of good coal. The analysis is given on page 63.

Character and quality of the coal.—The coal, which is very bright, pitch black, and hard, is massive and dense, and breaks with a conchoidal fracture. It contains a low percentage of ash and has a high calorific value. The coal is an anthracite and compares favorably with much of the Pennsylvania anthracite.

SURFACE EXPOSURE EAST OF COWLITZ RIVER.

Surface exposure in SE. $\frac{1}{4}$ sec. 7, T. 13 N., R. 10 E., about 2 miles east of Cowlitz River. No. 52.

Kind of coal: Anthracite.

Coal bed.—The coal bed outcropping near the summit of the hill strikes N. 5° E. and dips 32° W. The bed has a total thickness of about 18 feet, only 3 feet of which was thought to be pure enough to be of any commercial value. The remainder of the bed is composed almost entirely of a hard black shale containing thin stringers of coal.

A drift was run about 20 years ago on a bed outcropping on the opposite side of the hill, about 200 feet below the outcrop described above, and it has always been supposed that the drift and the surface exposure are on the same bed. It was reported that a sample taken from the drift and analyzed at the New Orleans exposition showed 92 per cent of fixed carbon. It is very clear from the analysis and physical character of the coal from the surface exposure that the drift must be on a different bed.

Sample for analysis.—Sample 9090 was taken from the 3-foot bench of bony coal after removing about 6 inches of coal from the face of the exposure. The analysis of the coal is given on page 63.

Character and quality of the coal.—The small stringers of coal, which are very hard and jet black, and break with a conchoidal fracture, should probably be considered as anthracite. It would be impossible to separate them from the bony coal in which they are embedded, and the marketable coal would have about the same percentage of ash as that contained in this sample.

PROSPECTS NEAR LADD AND GLENAVON.

Prospects in the vicinity of Ladd and Glenavon, Washington. Nos. 82, 83, 84, 85, 86, and 87.

Kind of coal: Bituminous and anthracite.

Coal beds.—On account of the heavy forest covering, the exposures are very small and the relation of the beds in each part of the field can not be definitely worked out from the surface. J. B. Umpleby examined this area in 1908 and measured the following sections, from which he obtained the samples.

Sections of coal beds in the vicinity of Ladd and Glenavon.

No. 6488.		No. 6489.	
	Ft. in.		Ft. in.
Hanging wall:		Hanging wall.	
Coal, shaly.....	1 1	Coal, very bony.....	1 4
Parting.....	4½	Clay, sandy.....	5
*Coal.....	11	Coal, very bony.....	11
Parting.....	2	Clay.....	½
*Coal.....	5	Coal and bone in alternating bands.....	10
Parting.....	1	Clay.....	½
*Coal.....	1 7	*Coal, bony, dull layers.....	4½
Parting.....	1½	Clay.....	4½
*Coal.....	1 1	*Coal, hard, dull layers.....	8
Coal, slaty.....	9	Clay.....	1
Clay, plastic.....		*Coal, bony.....	8
Footwall.....	6 7	Footwall.....	5 9
No. 6490.		No. 6495.	
	Ft. in.		Ft. in.
Clay, hanging wall.		Clay, hanging wall.	
*Coal.....	1 6	*Coal.....	3 6
Volcanic ash.....	1	Parting.....	5½
*Coal.....	8½	*Coal.....	1 7
Parting.....	9½	Parting.....	3
*Coal.....	1	*Coal.....	8
Parting.....	1	Clay, footwall.....	6 5½
*Coal.....	3½		
Parting.....	1	No. 6496.	
*Coal.....	1	Clay, hanging wall.	Ft. in.
Parting.....	1	*Coal.....	1 1
*Coal.....	1 6	Parting.....	1 11
Shale, footwall.....	7 1½	*Coal.....	2 5
		Parting.....	1
		Coal, bony.....	2½
		Clay.....	
		Shale and coal, bony, footwall.....	6 7½

Samples for analysis.—Sample 6488 was taken from a drift 60 feet long in the SE. $\frac{1}{4}$ sec. 14, T. 13 N., R. 4 E. All the partings were removed in sampling. Sample 6489 was taken from a 33-foot drift in the northeast corner of the SW. $\frac{1}{4}$ NE. $\frac{1}{4}$ sec. 26, T. 14 N., R. 4 E. Sample 6490 was taken from an open cut 10 feet deep in the NE. $\frac{1}{4}$ sec. 10, T. 13 N., R. 4 E., all partings being excluded. Sample 6495 was taken from an open cut near some small faults in the SE. $\frac{1}{4}$ sec. 34, T. 14 N., R. 4 E. It is not certain that the bed is normal at this point. Both partings were excluded from the sample. Sample 6496 was obtained from a 26-foot drift in the NW. $\frac{1}{4}$ sec. 14, T. 13 N., R. 4 E. The part sampled contained one parting which was excluded from the sample. The analyses of these samples are given on pages 63-64.

Character and quality of the coal.—The physical character of the coal is not known to the writer. Analyses show moderate to very high amount of ash; the amount of moisture given off is somewhat high, due probably to moisture on the surface of the coal, which was not removed before the samples were sealed. The coal does not slack on exposure to the air. The percentage of fixed carbon is considerably higher than that of volatile matter, in which respect the coals compare with that from mine No. 1 at Ravensdale. Sample 6496 shows a remarkably small amount of volatile matter, and the analysis indicates either that the coal is anthracite or natural coke. With this exception, the samples indicate that this is an impure bituminous coal.

EAST CREEK-LADD.

East Creek-Ladd, a tunnel and drift mine at Ladd, on the Tacoma Eastern Railroad. No. 53.

Operator: East Creek Coal Co.; W. M. Ladd and J. Bagley, Ladd, Wash.

Kind of coal: Bituminous (coking and noncoking).

Coal beds.—Two coal beds, Nos. 2 and 3, were being developed commercially at the time of sampling and a third bed, lying above Nos. 2 and 3 and called No. 4, was being prospected. The beds strike N. 85° W. and dip 40° SW. Bed No. 2, the main commercial bed and the lowest in the group, is being worked on the property of the East Creek Coal Co., and coal is brought to the surface by a gangway and a rock tunnel through the property of W. M. Ladd and J. Bagley. Bed No. 3 lies 590 feet west of bed No. 2 and is being developed in the valley of a small creek southwest of the main entrance to No. 2. A gangway 250 feet long has been driven on this bed. A short gangway has been driven on bed No. 4, which is 160 feet west of bed No. 3, near the entrance to the gangway on No. 3. Sections of these coal beds at the places where the samples were taken are as follows:

Sections of coal beds in East Creek-Ladd mine.

No. 9882, bed No. 2.		No. 9881, upper bench of bed No. 3.	
Sandstone.	Ft. in.	Shale.	Ft. in.
Shale.....	6	*Coal.....	1 8
Shale, carbonaceous, soft.....	to 2	Shale and bony coal.....	6½
*Coal.....	10		2 2½
Shale, clayey.....	1	No. 9879, bed No. 4.	
*Coal, "sulphur" in joints... 1	9	Coal, bony, and shale.....	2 8½
Shale, carbonaceous.....	4	*Coal.....	1 8
*Coal, calcite veins.....	11	Shale.....	1
Coal bed.....	3 11	*Coal.....	1
		Shale.....	3
No. 9880, lower bench of bed No. 3.		Coal, bony.....	2½
Coal.	Ft. in.	Shale.....	½
Shale and bony coal.....	6½	*Coal.....	1
*Coal.....	3 6½	*Shale.....	½
Coal, bony.	4 1	*Coal.....	5
		Shale.	
		Shale, and coal, bony.	7 5

The following sections were measured in this mine by J. B. Umpleby in 1908:

Sections of coal beds in East Creek-Ladd mine.

No. 6493, bed No. 2.		No. 6494, bed No. 3.	
Clay.	Ft. in.	Coal.....	Ft. in.
*Coal.....	9½	Parting.....	1
Parting.....	1	Coal.....	8½
*Coal.....	1 11	Bone.....	3½
Parting.....	1	*Coal.....	4 1
*Coal.....	1 5	Parting.....	11
Clay.	4 3½	Coal.....	1 8½
		Shale.	9 3½
No. 6492, bed No. 4.			
Coal, bony.....	Ft. in.		
*Coal.....	1 11		
Bone.....	2½		
*Coal.....	2 3½		
Shale.	20 11		

Preparation for market.—The coal from bed No. 2 is picked at the bunker and washed through a Howe tub washer. The coal from No. 3 is picked at the entrance of the gangway and then flumed to the washer at the entrance to bed No. 2, where it is mixed with the coal from No. 2 and passed through the washer.

Samples for analysis.—A sample (No. 9882) of bed No. 2 was taken 60 feet up chute 62 from the first water-level gangway. The two shale partings given in the section can be separated from the bed

by careful picking and washing, and were not included in the sample. Two samples were taken at the face of the gangway on bed No. 3—No. 9881 from the upper bench and No. 9880 from the lower bench. These benches are separated by $6\frac{1}{2}$ inches of shale and bony coal which is removed from the coal by picking. Sample 9879 was obtained from the face of the gangway on bed No. 4. The bed contains several partings of shale and bony coal. It will probably be somewhat difficult to separate the bony coal from the commercial parts of the bed, but inasmuch as the lower shale parting in the bed was not removed in the sampling it was thought that by removing all the bony coal the resulting amount of ash in the sample would represent that obtained in the ordinary commercial coal from this bed. Sample 6493 was taken from bed No. 2, the two partings of which were not included in the sample. None of the partings were included in sample 6494, taken from bed No. 3. Sample 6492 was taken from the short drift on bed No. 4 where No. 9879 was taken. The parting was not included in the sample. Sample 6491, consisting of two samples of about 300 pounds each of washed coal from bed No. 2, was taken at the bunker as it came from the washer. Each sample was reduced and quartered in the usual manner until 100 pounds were obtained. The two samples were then mixed, ground, and quartered until the final sample was about 4 pounds. It was sealed in the can while still wet.

Analyses of the samples will be found on pages 64-65.

Character and quality of the coal.—The coal from bed No. 2 is bright, has a cubical fracture, and is of better quality than that from either bed No. 3 or No. 4. It is rather high in ash and produces coke of fairly good quality. The joints in the coal are very close together, and are, in the lower portion of the bed, filled with calcite, pyrite, and free sulphur. The coal from bed No. 3 is banded and is heavier than that from bed No. 2, but not nearly so bright or well jointed. Both benches of this bed contain coal of similar quality. The coal, though high in ash, is considered fairly good for railroad and domestic use. The coal from bed No. 4 resembles very much the coal from bed No. 3, but it is higher in ash and therefore lower in heating value. The coal from all three beds contains a small percentage of moisture, does not slack during transportation to the market, and may be classed as bituminous.

MENDOTA.

Mendota, a slope mine at Mendota, about 6 miles east of Centralia on the Centralia Eastern Railroad. No. 54.

Operator: Mendota Coal & Coke Co., Centralia, Wash.

Kind of coal: Subbituminous.

Coal bed.—Several coal beds are exposed on the property of the company, but only the one upon which the mine was working was sampled. The bed strikes north and south and dips 12° W. The following sections were measured at the places at which the samples were taken:

Sections of coal bed in Mendota mine.

No. 10324.		No. 10323.	
	Ft. in.		Ft. in.
*Coal.....	2 2½	*Coal.....	1 4
Shale, sandy.....	2½	†Shale, sandy.....	½
*Coal.....	1 1	*Coal.....	6½
Shale, sandy.....	½	†Shale, sandy.....	½
*Coal.....	2	*Coal.....	3 6
Shale, yellow-brown.....	1	Shale.....	1
*Coal.....	2½	*Coal.....	3
Shale.....	½	Shale.....	½
*Coal, little stringers of bone.....	9½	*Coal.....	4 2½
Shale, yellow-brown.....	½		
*Coal.....	3		
	<hr/>		<hr/>
	9 8½		10 ½

Preparation for market.—When the partings are large and separate easily from the coal they are removed in the mine. The coal is picked and sized at the tippie over a shaking screen with 2-inch perforations.

Samples for analysis.—Sample 10324 was collected 80 feet above the gangway at the first level north in room No. 2. At this place all of the partings in the bed can be separated by careful picking, and hence they were not included in the sample. Sample 10323 was taken at the foot of the slope, 850 feet from the entrance of the mine. The bed contains four partings. It would be difficult to separate all the material in upper two partings from the coal, and therefore about one-half of each was included in the sample. The analyses of these samples are given on page 65.

Character and quality of the coal.—The coal is grayish black and has a reddish-brown streak. It is massive and banded, and breaks with a conchoidal fracture. It slacks readily upon exposure to the air, owing to the large amount of moisture it contains—an amount about equal to that of the coal from the Hannaford mine. It has, however, less fixed carbon than this coal, a greater amount of ash and sulphur, and a lower heating value. It has considerably less moisture than the coal in the vicinity of Chehalis and will probably stand transportation better. It should be classed as low-grade sub-bituminous.

Irregular lenses of a soft cannel-like coal occur in places in this mine. When first exposed these lenses are black and give a yellowish brown streak, but they turn brown very soon. The percentage

of volatile matter in them is very high, for large pieces can be easily ignited in the hand with a match, and they burn much more readily than any cannel with which the writer is familiar, with a long, smoky, yellow flame.

RICHMOND.

Richmond, a slope mine $1\frac{1}{2}$ miles northeast of Centralia. No. 55.
Operator: Centralia Coal Co., Centralia, Wash.

Kind of coal: Subbituminous.

Coal bed.—Only one coal bed is developed at this mine. It strikes N. 40° W. and dips 40° SW. The following section was measured at the face of the north gangway, just beyond chute No. 10 on the first level:

Section of coal bed in Richmond mine.

No. 9177.		Ft.	in.
Coal.....		1	
Shale, hard.....			6
Coal (used as roof).....			$8\frac{1}{2}$
*Coal.....		7	$8\frac{1}{2}$
Coal and shale, carbonaceous.....			6
Coal.....		1+	
		11	5+

Preparation for market.—The coal is passed over a $\frac{3}{4}$ -inch screen and then picked. Only the lump coal is placed on the market.

Sample for analysis.—Sample 9177 was cut at the place where the above section was measured. The analysis of the coal is given on page 65.

Character and quality of the coal.—The coal is brownish black in color, and has a reddish-brown streak. It is massive and banded, and breaks with an irregular conchoidal fracture. It contains a very high percentage of moisture and weathers very readily on exposure to the air. It should be classed as a very low-grade subbituminous coal.

SUPERIOR NO. 1.

Superior No. 1, a water-level mine 1 mile northeast of Chehalis. No. 56.

Operator: Superior Coal Co., Chehalis, Wash.

Kind of coal: Subbituminous.

Coal bed.—This coal bed is about 11 feet in thickness. It strikes N. 70° W. and dips 40° SW. The entire bed of coal, which is the same bed as that mined in the Twin City mine of the Twin City Light & Traction Co. about one-fourth mile west, is mined, but as the sample from the Twin City mine was taken from the lower bench very near this mine it was considered that a sample from the upper bench to supplement the Twin City mine sample was all that was

necessary. The following is a section of the upper portion of the bed at this mine and that from which the sample was taken:

Section of upper part of coal bed in Superior No. 1 mine.

No. 9942.		Ft.	in.
Sandstone.			
*Coal.....		1	7
Shale, sandy.....			½
*Coal.....		3	
Shale, sandy.....			½
*Coal.....		2	
Shale.....			1
*Coal.....			6
Shale, hard.			
Shale.		4	6

Preparation for market.—The coal is passed over a 1-inch bar screen at the bunker, picked, and dumped into the bin.

Sample for analysis.—Sample 9942 was taken 10 feet east of the entrance to the tunnel to the bed. The analysis of the coal is given on page 65.

Character and quality of the coal.—The coal is brownish black and has a reddish-brown streak. It is massive and banded and breaks with an irregular conchoidal fracture. Owing to its high percentage of moisture, it slacks very readily upon exposure to the air. It is probably on the border line between low-grade subbituminous and high-grade lignite.

SUPERIOR NO. 2.

Superior No. 2, a slope mine one-fourth mile north of the station at Chehalis, on the main line of the Northern Pacific Railway. No. 57.

Operator: Superior Coal Co., Chehalis, Wash.

Kind of coal: Subbituminous.

Coal bed.—The coal bed is nearly 10 feet in thickness. It strikes N. 80° W. and dips 54° S. The following section was measured where the sample was taken:

Section of coal bed in Superior No. 2 mine.

No. 9941.		Ft.	in.
Sandstone, soft.			
*Coal.....		3	11
*Coal.....		4	6
*Coal, slightly bony and soft.....			5½
Shale, carbonaceous, soft.....			1
*Coal.....			9
Coal, bony.....			2
Sandstone.			
		9	10½

Preparation for market.—The coal is passed over a 1-inch bar screen at the bunkers and then picked.

Sample for analysis.—Sample 9941 was obtained in chute 5 about 50 feet above the first level gangway. The bed contains one carbonaceous shale parting near the bottom, which can be separated by picking, and was not therefore included in the sample. The analysis of the coal is given on page 65.

Character and quality of the coal.—The coal has a brownish-black color, a reddish-brown streak, massive and banded structure, and a conchoidal fracture. It contains a high percentage of moisture, slacks very easily upon exposure to the air, and is a very low-grade subbituminous coal.

TWIN CITY.

Twin City, a slope mine 1 mile northeast of Chehalis. No. 58.

Operator: Twin City Light & Traction Co., Chehalis, Wash.

Kind of coal: Subbituminous.

Coal bed.—The coal bed worked in this mine is the lower part of the bed worked at the Superior No. 1 mine about one-fourth mile east. (See p. —.) It strikes No. 70° W. and dips 40° SW. The following section was measured where the sample was taken:

Section of lower part of coal bed in Twin City mine.

No. 9945.		Ft.	in.
Shale.			
Coal, with thin irregular bands of shale	4		
Shale			6
* Coal	1		7
Shale			3½
* Coal	2		6
Shale			1
* Coal			7
* Shale, thin lens			½
* Coal			3½
Shale			½
* Coal			9½
Shale.		10	8½

Preparation for market.—The coal is passed over a bar screen and picked.

Sample for analysis.—Sample 9945 was taken at the east end of the first level gangway about 300 feet from the slope. The bed contains several shale partings which can be easily separated by picking and washing, and these were therefore not included in the sample. The analysis of the coal is given on page 65.

Character and quality of the coal.—The coal is brownish black and gives a reddish-brown streak. It is massive and banded, and breaks with an irregular conchoidal fracture. Its percentage of moisture is high and it slacks very readily upon exposure to the air. It is probably on the border line between low-grade subbituminous and high-grade lignite,

CHEHALIS.

Chehalis, a drift mine 2 miles east of Chehalis. No. 59.

Operator: Chehalis Coal Co., Chehalis, Wash.

Kind of coal: Subbituminous.

Coal bed.—The coal bed strikes N. 30° E. and dips 30° SE. The following section was measured at the place where the sample was obtained:

Section of coal bed in Chehalis mine.

No. 9944.		Ft. in.
Shale.		
* Coal.....		2 10
Shale, soft "mining".....		9½
* Coal.....		2 9½
Shale.		<hr style="width: 100%; border: 0.5px solid black;"/> 6 5

Preparation for market.—The coal is screened and picked at the bunker.

Sample for analysis.—Sample 9944 was obtained in the first water-level gangway 250 feet from the entrance of the mine from a stump pillar which was then being drawn and which had probably been exposed in the mine air for some time. A parting of soft shale near the center of the bed is used as "mining" and is separated from the coal by picking. The analysis is given on page 66.

Character and quality of the coal.—The coal is brownish black and has a reddish-brown streak. It is massive and banded, and breaks with an irregular conchoidal fracture. It contains a high percentage of moisture and slacks very readily on exposure to the air. This coal is on the border line between low-grade subbituminous and high-grade lignite.

SHELDON.

Sheldon, a slope mine 3 miles east of Chehalis, Wash. No. 60.

Operator: Sheldon Coal Co., Chehalis, Wash.

Kind of coal: Subbituminous.

Coal bed.—The coal bed worked at this slope is about 6 feet thick. The section measured is as follows:

Section of coal bed in Sheldon mine.

No. 9943.		Ft. in.
Coal.....		2+
* Coal.....		2
Shale, carbonaceous.....		2½
Coal.....		6
Shale, carbonaceous.....		2
* Coal.....		3 5½
Shale.		<hr style="width: 100%; border: 0.5px solid black;"/> 8 4

Preparation for market.—The coal is screened over a 1-inch bar screen and then picked.

Sample for analysis.—Sample 9943 was taken 250 feet east of the slope and 40 feet up the rise from the first level. The bed contains near the middle a parting of 10½ inches of carbonaceous shale and coal, which can be separated from the remainder of the bed by careful picking and washing, and this portion of the bed was not included in the sample. The analysis is given on page 66.

Character and quality of the coal.—The coal is brownish black and has a reddish-brown streak. The structure is massive and banded, and the fracture conchoidal. The high percentage of moisture causes the coal to slack very readily upon exposure to the air. The coal should be classed as low-grade subbituminous.

CRESCENT. |

Crescent, a water-level mine 4 miles northwest of Littell, on logging road. No. 61.

Operator: Union Coal Co., Seattle, Wash.

Kind of coal: Subbituminous.

Coal bed.—Several coal beds have been opened at this mine, but a sample could be obtained only from the main bed. This bed strikes N. 85° W. and dips 40° S. A bench of coal 1 foot 6 inches thick is left as a roof to support the sand overlying it. Wherever this roof is broken and the rocks are moist the sand flows into the mine in large quantities and makes the conditions of operating very unsafe. This mine was not being operated at the time it was visited. The following section was measured at chute 17, between chutes 18 and 19, and about 800 feet from the entrance to the first water-level gangway.

Section of coal bed in Crescent mine.

	No. 9940.	Ft.	in.
Sand.			
Coal.....		1	6
* Coal.....			9½
Shale, hard.....			4
* Coal.....		1	6
* Shale.....			1
* Coal.....			3½
Shale, hard.....			6
Shale, yellow.....		1	
Shale, carbonaceous.....			9½
* Coal.....		1	5
Shale.....			½
* Coal.....		1	3½
Shale, carbonaceous.			
		9	6½

Sample for analysis.—Sample 9940 was taken where the section given above was measured. The bench of shale 2 feet 3½ inches thick near the center and small partings of shale in both the upper and lower benches of the bed should be removed in preparation for the market, and these were not included in the sample. The large amount of foreign material included in the bed, together with that which mixes with the coal from the floor and the roof, will increase the amount of ash in the marketable coal above that shown in the analysis very greatly unless it is very carefully removed. The analysis of the sample is given on page 66.

Character and quality of the coal.—The coal is brownish black in color, and has a reddish-brown streak. It is massive and banded, and breaks with a conchoidal fracture. It contains a higher percentage of moisture than any other coal sampled in the State, and slacks very readily on exposure to the air. This coal should be classed as subbituminous.

PIERCE COUNTY.

The coal fields of Pierce County have been studied by Bailey Willis and George Otis Smith.¹ The beds of the north end of the field were correlated by them on the data available in 1899, and the extension of the mines since then has essentially borne out their conclusions. The field has been developed to some extent farther south, at Melmont and Fairfax, but the relation of the beds worked in these places to those in the other mines farther north have not been definitely established.

The work of sampling was done in this county during December, 1909, and January, 1910. Two samples were taken from the Carbon Hill mine by M. R. Campbell in 1905, and a mine sample and a car sample were taken from the same mine by K. M. Way in 1908. A sample was taken in 1908 by J. B. Umpleby from a prospect about 7 miles east of Ashford. Descriptions of these samples and their analyses are here given for purposes of comparison.

Gas is present in considerable quantities in some of the mines. At Burnett and Carbonado safety lamps are used in many of the workings. At the south end of the levels from slope No. 1 on the Wingate bed at Carbonado so much gas is encountered along a well-defined zone which cuts diagonally across the workings that operations must be discontinued when this zone is reached.

¹ Willis, Bailey, Report on the coal fields of Washington Territory: Mining industries, Tenth Census U. S., vol. 15, 1886, pp. 759-771.

Willis, Bailey, Some coal fields in Puget Sound (Wash.): Eighteenth Ann. Rept., U. S. Geol. Survey, pt. 3, 1898, pp. 399-436.

Willis, Bailey, and Smith, G. O., Tacoma folio (No. 54), Geol. Atlas U. S., U. S. Geol. Survey, 1899.



A. VIEW OF THE TOWN OF CARBONADO, PIERCE COUNTY.



B. NEW BEEHIVE COKE OVENS OF THE CARBON HILL COAL CO., AT CARBONADO, PIERCE COUNTY.

dumped into the bin. The undersize is washed in a Howe-Robinson tub washer.

Samples for analysis.—All the samples taken from the mine were obtained from the second level. Sample 9891 was taken from bed No. 2 on the first crosscut 2,200 feet south of the rock tunnel to bed No. 3. The bed contains a layer of soft carbonaceous shale which can be separated by careful picking and washing and was not included in the sample. The bed is overlain by 5 inches of carbonaceous shale which breaks with the coal and must be removed at the bunker. Sample 9890 was taken 15 feet above the gangway on bed No. 3 from the first manway south of the rock tunnel from bed No. 2. The bed contains six layers of shale, which can be separated from the coal by careful picking and washing and which were not included in the sample. It is overlain by about 6 inches of shale, more or less crushed, which mixes with the coal in mining and must be removed at the bunker. The lower part of the bed as exposed in this manway was still in the coal. Sample 9898 was taken from the north end of the gangway on bed No. 3 at a point 1,650 feet north of the rock tunnel from bed No. 2. The sample was taken on the upper bench of coal, which, together with the 5 inches of shale underlying it, is frequently left as a roof for the lower bench. This bench is overlain by badly broken carbonaceous shale, which makes a very poor roof, for it mixes with the coal and must be removed at the bunker. Sample 9888 was taken from the place where sample 9889 was obtained but from the lower bench. The bed contains irregular lenses of shale, most of which can be removed by careful picking and washing, and only a few of the thinnest were included in the sample. The shale underlying the bed is fairly firm and does not mix with the coal to any great extent.

Sample 9887 was taken from the surface of storage bins in the bunkers by selecting about 75 pounds of small lumps at random over the surface of the coal. The coal of this sample was reduced to about $\frac{3}{4}$ -inch mesh and then quartered. Opposite quarters were discarded and the remaining coal mixed and ground to the size of a pea. It was then quartered and reduced in the usual way until the final sample, about 4 pounds, was obtained. Sample 9886, which was taken from the surface of the bins and from a loaded 50-ton railroad car, consisted of wet coal direct from the washer; it was prepared for analysis in the same way as sample 9887, but was sealed in the can while still moist. The analyses of these samples are given on pages 66-67.

Character and quality of the coal.—The coal from bed No. 2 is pitch black, gives a dark-brown streak, and has a vitreous luster. It is massive and slightly banded, and breaks with an irregular, slightly

conchoidal fracture resembling that of the Wingate coal at Carbonado and the McKay coal at Black Diamond. The coal contains a small amount of moisture and does not slack when exposed to the sun. Its heating value is nearly as high as that of any coal obtained in the State, and it should be classed as a high-grade bituminous coal. The coal from bed No. 3 is pitch black, and has a dark-brown streak and a vitreous luster. It is massive and laminated, and breaks with an irregular splintery fracture. The amount of moisture present in it is small, and it does not weather on exposure to the sun, but its ash content is greater than that of the coal from bed No. 2, and its heating value is correspondingly lower. It is considered a good grade of bituminous coal. Both these coals are coking coals and are used in the manufacture of gas.

BLACK CARBON.

Black Carbon, a drift mine on the Northern Pacific Railway about one-half mile west of Pittsburg, Wash. No. 63.

Operator: Black Carbon Coal Co.

Kind of coal: Bituminous.

Coal bed.—Only one coal bed has been worked in this mine, and at the time of the visit the mine was not operating. The bed strikes N. 15° W. and dips 40° E. The following section was taken where the sample was obtained:

Section of Black Carbon coal bed in Black Carbon mine.

No. 9892.		Ft. in.
Shale.		
*Coal.....		11
*Shale.....		¼
*Coal.....		8½
Shale.....		¼
*Coal.....		5½
Shale, lens.....		½
*Coal.....	1	3½
Shale.....		½
*Coal.....		5
Shale.....		½
*Coal.....		9½
Coal, bony.....		7
Clay, yellow.....		3
Shale, black.....		5 7

Preparation for market.—No attempt was made in working this bed to separate any of the impurities from the coal in the mine. It was picked at the bunker over a 1½-inch bar screen.

Sample for analysis.—Sample 9892 was taken from chute 2½, about 6 feet above the gangway and 1,250 feet from the entrance

to the mine. The bed contains several shale partings, most of which can be separated by careful picking and washing; the upper parting, however, is too thin to be separated and was included in the sample, an analysis of which is given on page 67.

Character and quality of the coal.—The coal is pitch black, and has a dark-brown streak and a vitreous luster. The lower bench of the coal is massive and dense, and breaks with an irregular fracture; the other layers are banded and laminated, and break with an irregular splintery fracture. The coal contains a small amount of moisture and does not crumble when exposed to the sun. Although the percentage of ash contained in it is somewhat high, it has a sufficiently high heating value to make it a fair commercial coal.

PITTSBURG.

Pittsburg, two slope mines at Pittsburg, on the Northern Pacific Railway. No. 64.

Operator: Coast Coal Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal beds.—Two coal beds are worked in this mine, the Lady Wellington and the Pittsburg. They strike N. 15° W. and dip 58° to 60° SW. The following sections were taken from the places where the samples were obtained:

Sections of coal bed in Pittsburg mine.

No. 9895, Lady Wellington coal bed.		No. 9894, Pittsburg coal bed.	
	Ft. in.		Ft. in.
Shale.		Shale.	
*Coal	4 11	*Coal	10½
Shale.		*Bone	¼
		*Coal	1 2½
		Shale and bone.....	4
		*Coal	4
		Shale, lens	1
		*Coal	6½
		Shale.....	1½
		*Coal	1 2½
		Bone.....	1 6½
			6 3¼

Preparation for market.—No attempt is made to separate the impurities from the coal in the mine. Coal from the Pittsburg bed is hoisted and dumped immediately on a 1½-inch bar screen, from which the oversize is hand-picked and the undersize is conveyed by flume to a washer at the bunkers. Coal from the Lady Wellington bed is hauled directly to the bunkers, where the lump coal is picked by hand and the fine coal is washed through two Forrester jigs.

Samples for analysis.—Sample 9895 was taken from the first cross-cut between chutes 32½ and 33, on the first level of the Lady Wellington bed. Both roof and floor are firm and do not mix with the coal in mining. Sample 9894 was taken at the face of the gangway just beyond chute 13½ on the first level of the Pittsburg bed. It contains several partings of shale and bone, most of which can be separated from the coal in preparation for market. The upper parting of bone was included in the sample. Both roof and floor of the bed are firm and do not mix with the coal. Sample 9893 was obtained by picking small quantities at intervals from the surface of the washed coal in the bins and on one of the railroad cars. The coal was still moist when the sample was taken and sealed in the can. The sample, containing about 65 pounds, was reduced to about ¾-inch mesh and quartered. Opposite quarters were discarded and the remaining sample reduced to the size of a pea. This was again quartered and reduced in the usual way until about 4 pounds was left; this amount was sealed in the can and sent to the laboratory. The analyses of these samples are given on page 67.

Character and quality of the coal.—The coal from both of these beds is nearly pitch black, gives a dark-brown streak, and has a vitreous luster. It is massive, banded, and laminated, and breaks with an irregular, splintery fracture. It contains a small amount of moisture and does not crumble when exposed to the sun during transportation. Although it contains a large amount of ash, its heating value is high enough to make it a fair commercial coal. In almost every respect it resembles the coal from mine No. 1 at Ravensdale and the more mpure grades of coal in the vicinity of Bayne.

WILKESON.

Wilkeson, a water-level mine at Wilkeson, on the Northern Pacific Railway. No. 65.

Operator: Wilkeson Coal & Coke Co., Tacoma, Wash.

Kind of coal: Bituminous (coking).

Coal beds.—The coal beds worked in this mine are the same as beds Nos. 1, 2, and 3 (coking) at the Carbon Hill mine, Carbonado. The beds are folded along north-south axes so much that in some parts of the workings they dip to the east and in others to the west. They strike from due north-south to N. 30° W. and dip from 20° to 60° E. in the parts of the mine worked at the present time. They are fairly uniform in thickness in different parts of the mine, but the partings are somewhat irregular. The sections following were measured where the samples were obtained.

Sections of coal beds in Wilkerson mine.

No. 9905, bed No. 2.	
	Ft. in.
Coal.	
Shale.....	1½
*Coal.....	1
Shale.....	1
*Coal.....	9½
Shale, hard.....	½
*Coal.....	3
Shale, hard.....	1
*Coal.....	6
Shale, hard.....	3
*Coal.....	2 3
Shale, "mining," black.....	6 ±
Shale.	
	<hr/> 4 11½±

No. 9903, lower part of bed No. 2.	
	Ft. in.
Shale.	
Coal.....	1 7
Coal, bony.....	1 6
Coal, bony and streaks of coal.....	1 5
*Coal.....	9½
Coal, bony.....	½
*Coal.....	5
Shale, hard.....	1
*Coal.....	1 8½
Coal, bony.....	5
Shale, hard.	
	<hr/> 7 11½

No. 9901, lower part of bed No. 3.	
	Ft. in.
Shale, bony.	
Coal.....	1
Shale.....	6
Coal.....	1 6
Shale, hard.....	¼
Coal.....	8½
Shale, lense.....	1
Coal.....	4
*Coal, bony.....	2 5
Shale, hard.	
	<hr/> 6 6¼

No. 9904, upper part of bed No. 2.	
	Ft. in.
Shale.	
Coal.....	1 7
Coal, bony.....	1 6
*Coal, bony and streaks of coal.....	1 5
Coal.....	9½
Coal, bony.....	½
Coal.....	5
Shale, hard.....	1
Coal.....	1 8½
Coal, bony.....	5
Shale, hard.	
	<hr/> 7 11½

No. 9902, upper part of bed No. 3.	
	Ft. in.
Shale, bony.	
*Coal.....	1
Shale.....	6
*Coal.....	1 6
Shale, hard.....	¼
*Coal.....	8½
Shale, lense.....	1
*Coal.....	4
Coal, bony.....	2 5
Shale, hard.	
	<hr/> 6 6¼

No. 9900, bed No. 3.	
	Ft. in.
Shale, hard.	
*Coal.....	11
Shale.....	6
*Coal.....	1
Coal, bony.....	1
*Coal.....	6
Bone.....	½
*Coal.....	7
*Coal, impure.....	1 9½
Coal, bony.....	3½
	<hr/> 5 8½

No. 9899, bed No. 7.	
	Ft. in.
Coal.....	1 6
Shale, hard.....	6
*Coal.....	3 6
Coal, bony.....	7
Bone.	
	<hr/> 6 1

Preparation for market.—No attempt is made to separate the partings from the coal in the mine. At the bunkers the coal is passed over a shaking screen with $1\frac{1}{4}$ -inch perforations, after which the best lump coal is sent through a crusher and mixed with the washed coal from the first set of jigs, while the poorer grade of lump is stored in a separate bin and used for steam coal. The screenings are passed through five Forrester jigs, and are then rewashed through another set of jigs before being used for coke. The tailings from the second set of washers are stored in a separate bin and are used for the boilers. The equipment in use is capable of handling about 400 tons of coal a day. A new bunker, with a revolving dump and a Shannon jig, was being installed at the time the workings were visited. In this bunker the coal will be passed over a bar screen having $5\frac{1}{2}$ -inch spaces, from which the oversize will be picked and used for domestic coal and the undersize passed over a shaking screen with 3-inch perforations. The oversize from this second screen will be hand picked and conveyed to the bin for steam coal; the undersize will be again passed over a screen with $\frac{3}{4}$ -inch mesh. Oversize from the $\frac{3}{4}$ -inch screen is to be washed through a Shannon jig and the concentrates used for steam coal, and undersize will be washed through an improved Howe tub washer and used for coke. When the bunker is completed the capacity of the plant will be about 800 tons a day.

Samples for analysis.—Sample 9905 was taken from bed No. 2 about 50 feet up chute 105, on the southeast gangway. The bed contains several shale partings which can be separated at the bunkers, and these were not included in the sample. Soft shale, which breaks very readily, overlies the bed and necessitates the use of a fairly firm layer of coal as a roof. The bed is underlain by 6 inches of black shale, which is used as a "mining" and is removed by washing. Sample 9904 was taken from the upper part of bed No. 2, at the face of the gangway on the east water level, which, on the day the sample was taken, was 1,200 feet west and 1,500 feet north of the southeast corner of sec. 34, T. 19 N., R. 6 E. The bed is overlain by about 3 feet of bony coal and coal, which is badly crushed in this particular part of the mine and makes a very bad roof. Sample 9903 was taken from the bench underlying that from which No. 9904 was obtained, at the same place. This bed contains two layers of shale and bony coal that can be separated at the bunkers, and these were not included in the sample. It is underlain by 5 inches of bony coal, which mixes to some extent with the good coal in mining and must be removed at the bunkers. Sample 9902 was taken from the upper part of bed No. 3, about 50 feet up chute 19 on the southeast gangway. Three layers of shale are contained in the bed, but these impurities can be removed at the bunkers, and they were not included in the sample. Hard carbonaceous shale, which is crushed in some parts of the mine and mixes to some extent with the coal, overlies the bed. Sample 9901

was taken from the lower part of bed No. 3 at the place from which sample 9902 was obtained. The bed is underlain by hard shale, which is broken to some extent in parts of the workings and mixes with the coal. Sample 9900 was taken from the south end of the east gangway on bed No. 3, at a point about 3,000 feet north and 1,650 feet west of the southeast corner of sec. 34, T. 19 N., R. 6 E. The bed contains several layers of bone and shale which can be separated at the bunkers, and which were not included in the sample. Bony coal and shale, which mix to some extent with the coal and are removed at the bunkers, lie both above and below the bed. Sample 9899 was taken from a portion of bed No. 7 exposed in the roof of the gangway about 100 feet south of the rock tunnel from the west parting to the east gangways, and at a point about 650 feet west and 600 feet south of the north quarter corner of the section noted above. The bed is overlain by hard shale and coal, and underlain by bony coal, all of which are more or less crushed and mix with the coal in mining. The layer of coal next above the bed would probably be worked with this bed in mining. Sample 9898, consisting of about 100 pounds, was taken in small quantities and at random from the surface of the storage bins containing the reworked coal, which is used in the coke ovens. The coal in the sample was broken to about $\frac{3}{4}$ -inch mesh and reduced by the usual method of quartering to a sample of about 25 pounds, which was then ground to about the size of a pea and quartered by the usual method until the final sample of about 4 pounds was obtained. The coal was wet when sealed in the can. The analyses of these samples are given on pages 67-68.

Character and quality of the coal.—The coal from this mine is pitch black, gives a dark-brown streak, and has a vitreous luster. Most of the coal is minutely jointed and crumbles readily, so that the percentage of lump is very small. The texture of the coal is dense, and it breaks with a cubical fracture sometimes slightly irregular. It contains a small amount of moisture, and does not slack on exposure to the sun. Pure coal from the mine is probably low in ash and high in fixed carbon, and should have a very high heating value. Some of the benches, however, have considerably more ash than others and correspondingly lower heating value. The washed coal is used as a blacksmithing coal and is considered one of the best blacksmithing and coking coals in the State. The coal is fair bituminous, of about the same quality as that obtained from bed No. 3 at Burnett.

GALE CREEK.

Gale Creek, a slope mine at Wilkeson, on the Northern Pacific Railway. No. 66.

Operator: Gale Creek Coal & Coke Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal beds.—The three coal beds at this mine strike about N. 10° W. and dip from 26° to 60° SW., are uniform in thickness throughout the mine, and belong to the same group as that worked at Wilkeson and Carbonado. The mine had not been in operation for several months previous to the writer's visit. The following sections were taken where the samples were obtained:

Sections of coal beds in Gale Creek mine.

No. 9908, bed No. 1.		No. 9910, Queen coal bed.	
Shale.	Ft. in.	Shale, hard.	Ft. in.
Shale, slate-colored, fissile.....	1	*Coal.....	1 11
*Coal.....	1 9	Shale, carbonaceous.....	3
*Coal, soft.....	$\frac{1}{2}$	*Coal.....	1 4
*Coal.....	1 6	Shale.	<hr/>
Shale, hard, black.	<hr/>		3 6
	3 4 $\frac{1}{2}$		
No. 9909, bed No. 2.			
Shale.	Ft. in.		
Bone, soft.....	1		
*Coal.....	3		
Shale, carbonaceous, "mining".....	6		
Shale, with bands of shale and coal.	<hr/>		
	3 7		

Preparation for market.—No attempt was made when the mine was operated to separate impurities in the mine. The coal was passed over a 1 $\frac{1}{2}$ -inch bar screen at the bunkers, after which the lump coal was picked by hand and the screenings were washed in a Jeffery tub washer.

Samples for analysis.—Sample 9908 was taken from bed No. 1 about 10 feet south of the auxiliary slope to the old No. 1 opening and in the first-level air course. The bed has one parting of soft coal which can not be separated from the hard coal and was included in the sample. The bed is overlain by about an inch of fissile shale which loosens from the roof after the coal has been drawn and mixes to some extent with it. The floor of the mine is a hard black shale, which is firm and does not mix with the coal. Sample 9909 was taken on the second level gangway of bed No. 2 in the new mine, about 100 feet south of the rock tunnel from this bed to the Queen. The bed is overlain by 1-inch of soft bone, which mixes more or less with the coal, and is underlain by 6 inches of carbonaceous shale, used as a "mining" and separated from the coal in preparation for the market. This bed has been considered the same as bed No. 1, but the workings on the two beds have not been connected and the relations between them have not been definitely established. Sample 9910 was taken from the Queen bed on the pillar between chutes 3 and 4, on the second level gangway north. The bed contains a shale parting near the center which can be removed in preparing the coal for the market and which was not

included in the sample. Both the roof and the floor of the mine are firm and do not mix with the coal. Analyses of these samples are given on pages 68-69.

Character and quality of the coal.—The coal from these beds is pitch black, with a dark-brown streak and a vitreous luster. It is massive and laminated and breaks with a cubical fracture, occasionally slightly irregular. It contains a small amount of moisture and does not weather on exposure to the sun. All three beds have a fairly low percentage of moisture, but are somewhat higher in sulphur content than the best coal in this region. They have high heating values and should be classed as bituminous coal of high grade.

WILLIS.

Willis, a slope and water level mine at South Willis, on the Northern Pacific Railway, about 2 miles from Wilkeson. No. 67.

Operator: Commonwealth Coal Co., Wilkeson, Wash.

Kind of coal: Bituminous.

Coal beds.—These coal beds parallel the beds worked at the Wilkeson and Gale Creek mines, but are higher in the series. They strike about N. 10° W. and dip about 56° E. Two beds were being worked at the time the writer visited the mine, but the higher bed, which is known as No. 1, is not in its normal position and was not sampled. The following section was taken where the mine sample was obtained:

Section of Windsor coal bed in Willis mine:

No. 9906.		Ft.	in.
Shale.			
Shale, carbonaceous		4	3
* Coal		4	4
Coal, soft, impure			2½
Shale			9½
Shale, sandy		1	6
Sandstone.		7	1

Preparation for market.—The coal from both the Windsor bed and from bed No. 1 is passed over a 1½-inch bar screen at the bunker. The oversize is picked and used solely as lump coal. The undersize is washed in a Robinson-Howe tub washer.

Samples for analysis.—Sample 9906 was taken from the Windsor bed 25 feet beyond chute 11 on the lower water-level gangway. The bed is overlain by carbonaceous shale and underlain by soft impure coal, both of which mix more or less with the coal and must be separated at the bunkers. Sample 9907, which was taken from the bunker containing washed coal, was composed of about 60 pounds of coal taken in small quantities and at random from the surface of

the coal in the bins. The coal in the sample was reduced to $\frac{3}{4}$ -inch mesh and quartered. Opposite quarters were discarded, the remaining sample ground to the size of a pea, quartered, reduced in the usual way until the final sample of about 4 pounds was obtained. The analyses of these samples are given on page 69.

Character and quality of the coal.—The color of the coal is pitch black, the streak dark brown, and the luster vitreous. It is massive and somewhat banded, and breaks with an irregular fracture. Moisture is present only in small amount in this coal, which does not slack on exposure to the sun, but the ash content is high. In general, the coal has about the same heating value as that from Pittsburg, which appears to be on beds of the same group. It is classed as a rather impure bituminous coal.

BRIER HILL.

Brier Hill, a water-level mine, about one-fourth mile west of Wilkeson, on the Northern Pacific Railway. No. 69.

Operator: Brier Hill Coal & Coke Co., Wilkeson, Wash.

Kind of coal: Bituminous.

Coal bed.—The coal bed upon which this mine was worked belongs to the group which occurs at the Gale Creek workings, but lies near the crest of the anticline on the opposite side of the syncline. The bed strikes N. 5° E. and dips 20° W. No work was being done on it at the time it was visited by the writer. The following section was measured where the sample was obtained:

Section of coal bed in Brier Hill mine.

No. 9897.		Ft.	in.
Shale.			
Shale, hard.....			1½
* Coal, banded.....			6
* Bone.....			2
* Coal, banded.....			6
* Shale, hard.....			½
* Coal, banded.....			2
Shale, hard.....			1½
* Coal, banded.....	3		1½
Shale.			
		4	9

Preparation for market.—The bed has a low dip, and some of the impurities can be separated in the mine. In preparation for shipment the coal has been picked at the bunker.

Sample for analysis.—Sample 9897 was taken on the water-level gangway 500 feet south of the entrance of the mine. The bed contains several layers of hard shale and bony coal, much of which resembles the coal so closely that it can not be readily separated. Only the lowest parting in the bed was excluded from the sample. The analysis of this sample is given on page 69.

Character and quality of the coal.—The coal from this bed is grayish black and has a dark-brown streak and a dull luster. It is massive, distinctly banded, and laminated and breaks with a splintery fracture. It contains a small amount of moisture and does not slack when exposed to the sun. On account of the large amount of ash the heating value of the coal is about the same as that of an average subbituminous coal, but it should be classed as very impure bituminous coal.

SNELL.

Snell, a slope mine about 2 miles southeast of Wilkeson. No. 68.
Operator: Pacific Coal & Oil Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal bed.—One coal bed was worked at this mine when it was in operation. It had been closed for some time when the writer visited the place, and the slope was flooded nearly to the water level, and as most of the water-level gangway was caved in it was difficult to obtain a good sample. The bed strikes about N. 10° W. and dips 75° E., and is believed to underlie the beds worked at South Willis. The bed is somewhat disturbed where the sample was taken, and a full section could not be obtained. The section at this point is as follows:

Section of coal bed in Snell mine.

No. 9896.		Ft.	in.
Shale.			
Shale, carbonaceous.....			2½
* Coal.....			7
Clay.....			½
* Coal.....	1		5
Shale, black.....			1
Sandstone.			
		2	4

Sample for analysis.—Sample 9896 was taken from the roof of the first water-level gangway 75 feet from the entrance and about 10 feet beyond the slope. A layer of clay near the middle of the bed can be removed, and was not included in the sample. The bed is overlain by about 2 inches of carbonaceous shale, which mixes with the coal and must be separated from it in preparing it for the market. A thin parting of black shale separates the coal at this point from a bed of massive sandstone underlying it. This sandstone was reported to be a lens in the main coal bed which had increased from a thickness of a few inches in the northern part of the mine to several feet at this place so that only the upper bench could be worked. The analysis of the coal sample is given on page 69.

Character and quality of the coal.—The coal in this bed is pitch black, gives a brown streak, and has a vitreous luster. It is minutely jointed, and can be readily crushed in the hand. The structure is

slightly banded and laminated, and the fracture irregular. Analysis shows a slightly high percentage of ash, but this may be due to impurities which were mixed with the bed during the movement which crushed the coal. It contains a small amount of moisture and does not weather on exposure to the sun. It is reported to be one of the best blacksmithing coals in the State, and should be classed as a bituminous coal of fair quality.

CARBON HILL.

Carbon Hill, a series of drift and slope mines at Carbonado, on the Northern Pacific Railway. No. 70.

Operator: Carbon Hill Coal Co., San Francisco, Cal.

Kind of coal: Bituminous.

Coal beds.—More than a dozen coal beds have been worked at different times in this mine. Ten were being worked at the time of the writer's visit, and nine were sampled. Carbon River cuts diagonally across the beds, approximately along the line of a large fault which separates the more regular southern part of the formation from the folded part on the north. The strike of the beds on the south side of the river is fairly uniform, nearly north and south, and they dip from 60° near the north end to about 20° at the south end. North of the river the beds are somewhat closely folded, and locally they are offset by small faults. The beds were not numbered in reference to their position in the formation. Three slopes have been driven; one on the Wingate bed on the southwest side of the river, known as the No. 1 slope; another on the Wingate bed on the north side of the river, known as the No. 6 slope; and a third, called the Electric slope, on bed No. 1 at the end of a long rock tunnel, known as Mine No. 1 North. All the remaining openings are slightly above the river, and are spoken of as water levels. The beds and their partings are fairly continuous throughout the workings, but about one-half mile south of slope No. 1 the Wingate bed is offset by a diagonal dike and shows a different section south of the dike. The following sections were measured where the samples were obtained:

Sections of coal beds in Carbon Hill mines.

No. 9570, bed No. 11.			No. 9564, bed No. 5.		
Shale, black (poor roof).	Ft.	in.	Shale.	Ft.	in.
*Coal.....	1	1	*Coal.....	1	10
Shale.....		3½	Shale, irregular.....		2½
*Coal.....	1	½	Coal, impure.....		3½
Shale.....		2½	*Coal, crushed.....	2	2½
Shale, carbonaceous.....		2½	Shale, hard, and some coal.....	1	3½
*Coal.....	1				
Shale.....		4			5
Coal.....		3			10
Shale (poor floor).					
		4			5

No. 2460, bed No. 1.

	Ft.	in.
Coal, dirty.....	1	
Parting.....		$\frac{1}{2}$
*Coal.....	1	9
Parting.....		7
*Coal.....	1	8
Parting.....		$\frac{3}{4}$
*Coal.....		8
Parting.....		1
*Coal.....	1	2
	<hr/>	
	7	$\frac{1}{4}$

No. 9565, upper bench of coking bed No. 3.

	Ft.	in.
Shale, hard (poor roof).		
*Coal.....	1	5
Shale.....	1	
Coal.....	2	
Shale.....		$2\frac{1}{2}$
Coal.....	3	5
Coal, bony.....		7
Shale (poor floor).		
	<hr/>	
	8	$7\frac{1}{2}$

No. 552-D, coking bed No. 3.

	Ft.	in.
*Coal.....	1	10
Shale.....		4
*Coal.....	1	10
Shale.....		$1\frac{1}{4}$
*Coal.....		10
Shale.....	1	
*Coal.....	7	
Shale.....	2	
*Coal.....	2	4
	<hr/>	
	8	$1\frac{1}{4}$

No. 9557, coking bed No. 2.

	Ft.	in.
Shale (poor roof).		
*Coal.....	2	7
Shale, hard.....		$\frac{1}{2}$
*Coal.....	1	6
Shale.....		1
*Coal.....		3
*Coal, fine-grained metallic ...		$2\frac{1}{2}$
*Coal.....		$2\frac{1}{2}$
Shale, hard.....	1	
*Coal, bright, minutely jointed		$11\frac{1}{2}$
*Shale.....		$\frac{1}{4}$
*Coal, bright, minutely jointed		$6\frac{1}{2}$
Shale.....		1
*Coal.....	2	$2\frac{1}{2}$
Shale (poor floor).		
	<hr/>	
	8	$9\frac{1}{4}$

No. 9560, Wingate bed.

	Ft.	in.
Shale, hard.		
*Coal.....	4	6
Shale, hard and very smooth.		

No. 9558, Wingate bed.

	Ft.	in.
Shale, black.		
*Coal.....	5	1
Shale, black.		

No. 9556, bed No. 9.

	Ft.	in.
Shale, black.		
*Coal.....	3	7
Shale.		

No. 9572, bed No. 1.

	Ft.	in.
Shale, black.		
*Coal.....	2	$9\frac{1}{2}$
Shale and broken coal.....		$2\frac{1}{2}$
*Coal.....		$11\frac{1}{2}$
Shale.....		$\frac{1}{2}$
*Coal.....		5
Shale.....		$2\frac{1}{2}$
*Coal.....		3
Shale, hard.....		$\frac{1}{2}$
*Coal.....	2	
Coal, bony.....		5
Shale.		
	<hr/>	
	7	4

No. 9562, bed No. 4.

	Ft.	in.
Shale, carbonaceous.		
*Coal.....	1	7
Shale.....		$\frac{1}{2}$
*Coal, impure.....		3
Shale.....		$\frac{1}{2}$
*Coal.....	1	$5\frac{1}{2}$
Shale, "sulphur".....		$\frac{1}{2}$
*Coal.....		6
Shale, "sulphur".....		1
*Coal.....	1	7
Coal, bony.....	1	$3\frac{1}{2}$
	<hr/>	
	6	$10\frac{1}{2}$

No. 9555, lower bench of coking bed No. 3.

	Ft.	in.
Shale, hard (poor roof).		
Coal.....	1	5
Shale.....		1
*Coal.....		2
Shale.....		$2\frac{1}{2}$
*Coal.....		3
*Coal, bony.....		7
Shale.		
	<hr/>	
	8	$7\frac{1}{2}$

No. 9569, coking bed No. 1.		No. 9601, Wingate bed in slope No. 1.	
	Ft. in		Ft. in.
Shale.		Shale, hard.	
*Coal, impure.....	3	Shale, carbonaceous, thin streaks	10
*Coal, finely jointed and		of coal.....	
crushed.....	1 3½	*Coal.....	4 1
Shale, irregular.....	1	Shale, hard.	
*Coal, finely jointed and			4 11
crushed.....	9½		
Shale, black (poor floor).		No. 2459, Wingate bed.	
	2 5		Ft. in.
		*Coal.....	4 11

Preparation for market.—The coal from this mine is prepared for the market by three processes. The first method is applied only to dry coal from the Wingate bed, which is passed over a 3-inch bar screen, the oversize being picked and dumped into the bin for lump. The undersize is picked by hand to remove fragments of mine timber and occasional pieces of shale from the floor or roof, which may mix with the coal, and is either sold as unwashed Wingate or flumed to the washer which handles the small coal from the wet Wingate dump. Coal from mine No. 6 and wet coal from mine No. 1 on the Wingate bed are handled by the second process, by which the coal is washed from the mine cars and passed over a bar screen having 2¼-inch and 1¾-inch openings; the oversize is picked twice to remove fragments of mine timber and impurities of shale and bone, and the undersize passed through two Robinson-Howe tub washers. Concentrates from the washer are carried by drags over draining screens having slits about 0.06 inch in width into bunkers for the washed Wingate coal, and the fine coal which passes through the slits is collected in a special settling tank constructed for the purpose. This fine coal is drawn from the bottom of the settling tank and again carried by drags over a draining screen, having slits about 0.03 inch wide. The coal which passes over the end of the screen is called "birdseye," that which passes through the screen is separated in large settling tanks and is called coal dust. Both the coal dust and the birdseye are sold in Seattle and Tacoma for use in automatic stokers for large heating plants. About 50 tons a day of coal dust and birdseye are saved from a total output of 800 tons. The coal from the other beds, all of which is treated by the third method, is passed over bar screens having 2¼-inch and 1¾-inch spaces. The oversize is picked three times and the resulting lump is known as Douty lump. The undersize is passed through a Robinson-Howe washer and is treated in the same manner as the Wingate coal.

A special set of Forrester jigs has been installed for the purpose of cleaning the coal for coking, but they were not in use at the time of the visit. Plate VIII, A, shows the town of Carbonado and the new beehive coke ovens of this company.

Samples for analysis.—Sample 9570 was taken 500 feet from the entrance to the gangway on bed No. 11, and about 40 feet above the gangway in chute 10. The coal bed is disturbed and considerably broken at this place. It contains three shale partings, which can be separated by careful picking and washing, and these were not included in the sample, but both the roof and floor, and the coal and shale which separate the bed from the floor, are badly broken and mix with the coal to a considerable extent in mining, constituting impurities which must be removed from the coal in preparing it for the market. Sample 9556 was taken from the south end of the gangway about 400 feet from the entrance to the water level on bed No. 9. The bed is overlain by fairly firm black shale, which does not mix with the coal. Sample 9564 was taken at the south end of the water-level gangway of bed No. 5 about 3,200 feet from the entrance. The bed contains an irregular layer of shale and some impure coal near the center, but both can be fairly well separated in preparation for the market, and they were excluded in the sample. The bed is overlain by shale and underlain by hard shale and thin layers of coal, all of which are fairly firm and do not mix with the coal. Sample 9572 was taken from the first level on bed No. 1 about 100 feet up chute 13 and 600 feet north of the bottom of the Electric slope. The bed contains several partings which, as they can be separated in preparation for the market, were not included in the sample. The carbonaceous shale overlying the bed and the bony coal underlying it are fairly firm, although locally they break and mix with the coal to some extent. Sample 2460 was taken by M. R. Campbell from bed No. 1 on the east dip, halfway between the synclinal point and the anticlinal end. All four partings in the bed were removed in sampling. Sample 9562 was taken from bed No. 4 about 200 feet up chute 14, north of the entrance to the gangway. The bed contains several layers of shale, which can be separated from the coal in preparation for the market, and these were not included in the sample. The roof is of carbonaceous shale and the floor of bony coal, which mix only slightly with the coal and can be removed at the bunkers. Sample 9565 was taken at the south end of the gangway on coking bed No. 3, at a point about 1,900 feet south and 100 feet west of the northeast corner of sec. 4, T. 18 N., R. 6 E. It was taken from the upper bench of the bed, which is overlain by hard shale—a very poor roof, which, in mining, mixes with the coal to a very considerable extent. Sample 9555 was taken from the lower bench of coking bed No. 3 at the place from which sample 9565 was taken. The bed contains a layer of shale, but as this can be removed in preparing the coal for the market it was not included in the sample. The lower layer of the bench is somewhat bony, but is mined with it, and is included in the

sample. The coal in both samples from this bed was slightly moist, owing to seepage from the surrounding rocks, and the samples for analyses were sealed in the can while still wet. Samples 552-D and 787-D were taken by K. M. Way. The first-named sample was taken from the face of the gangway of coking bed No. 3 in the north workings, about 14,000 feet from the entrance to the No. 1 north tunnel. All the partings were separated from the sample. Analysis No. 787-D was made from a car of run-of-mine coal from bed No. 3 north (coking), after it had been shipped to Denver and before it had been put through the washer. Sample 9557 was taken from the north end of the gangway on coking bed No. 2, about 3,200 feet south and 100 feet west of the northeast corner of sec. 4, T. 18 N., R. 6 E. The bed contains several layers of shale, most of which can be separated when the coal is prepared for the market and were therefore not included in the sample. The second parting from the bottom, however, is very thin, and was included in the sample. Both roof and floor of the bed are of badly broken shale; they mix with the coal in mining to a considerable extent, and must be separated at the bunkers. Sample 9569 was taken from coking bed No. 1 at the end of the rock tunnel from coking bed No. 2. Coking bed No. 1 is believed to be one of the beds worked at the Wilkeson mine, but it is very much thinner at this place, probably on account of local movement along the bedding planes. The bed contains an irregular layer of shale near the bottom, which, as it can be removed in preparing the coal for the market, was not included in the sample; the upper part of the coal is somewhat impure, but was included in the sample. The coal in the two benches is finely jointed and crushed, indicating considerable movement, and is underlain by a very poor floor of black shale, also badly broken, which mixes with the coal in mining. Sample 9560 is a composite of two samples taken from the Wingate bed near slope No. 1. Half of the sample was taken from the third level at the south end of the gangway about 40 feet south of the main slope, and the other half from the same level at the end of the gangway 280 feet north of the slope. Both roof and floor are hard and firm and do not mix with the coal. Sample 9558 was taken from the third level in mine No. 6 on the Wingate bed, about 20 feet north of the slope in the first crosscut. Roof and floor are firm and do not mix with the coal except where there has been local disturbance. Sample 9601 was taken from slope No. 1 on the Wingate bed in the tenth crosscut between chutes 56 and 57 of the second level. The upper part of the coal bed in this part of the mine is replaced by soft carbonaceous shale containing thin streaks of coal, which breaks with the coal and must be separated at the bunkers. Along a definitely marked zone at the south end of the workings this shale contains a very large amount of gas, under enormous pressure, which frequently blows out great masses

of coal. Sample 2459 was taken by M. R. Campbell from the Wingate bed on the level 700 feet below the river, near a small fault.

The following samples were taken after the coal had been prepared for market by picking small lumps or small quantities at random from the surface of the bunkers or from the surface of railroad cars. In preparing each sample the coal was reduced to a $\frac{3}{4}$ -inch mesh and quartered until about 25 pounds was left, after which it was ground to the size of a pea and quartered in the usual manner until a final sample of about 4 pounds was obtained. Sample 9566 represents about 125 pounds of Wingate lump coal taken from the surface of a 30-ton car. It was still moist when sealed in the can. Sample 9563 consisted originally of 80 pounds of dry Wingate coal passed over a 3-inch bar screen, sample 9567 of about 245 pounds of washed Wingate coal taken from the surface of the bunkers and from several railroad cars, and sample 9561 of 150 pounds of washed coal taken from the surface of 12 loaded railroad cars. It was raining at the time sample 9561 was taken, and the coal was sealed in the can while still wet. This sample probably consists for the most part of coal from the Wingate bed, but it may contain some of the Douty coal. Sample 9559 represents about 215 pounds of Douty washed coal taken from the bunkers and the surface of several railroad cars, and sample 9571 about 172 pounds of Douty lump coal taken from the Douty bin and from several cars which were being loaded. The coal in both samples was moist when sealed in the cans. For sample 9568, about 95 pounds of coal dust was taken from the surface of a railroad car containing about equal proportions of "birdseye" coal and coal dust just after it had been loaded. The sample was thoroughly mixed and quartered in the usual manner. The sample contained a very high percentage of moisture, most of which was retained after passing through the washer and was given off in air drying. The analyses of the samples from this mine are given on pages 69-72.

Character and quality of the coal.—The coal from this mine is pitch black, gives a dark-brown to black streak, and has a vitreous luster. It is massive and dense, and breaks with an irregular, hackly fracture. The coal from the Wingate bed breaks with an irregular, slightly conchoidal fracture along the lines of minor joints, resembling in this respect the coal of the McKay bed. The coal has a small amount of moisture and does not slack when exposed to the sun. Coal from the Wingate bed has a fairly small amount of ash and a heating value nearly as high as that of any coal in the State; coal from the other beds contains generally a greater amount of ash and is somewhat lower in heating value. All the coals are bituminous and of good grade, comparing favorably with many of the bituminous coals of the eastern part of the United States.

MELMONT.

Melmont, a slope and drift mine at Melmont, on the Northern Pacific Railway. No. 71.

Operator: Northwestern Improvement Co., Tacoma, Wash.

Kind of coal: Bituminous.

Coal beds.—Three coal beds are exposed in the mine, and the lower two were being worked at the time the mine was visited. Bed No. 1, the highest in the group, is not now being worked. No. 2, the middle bed, is being mined on a short water-level gangway. No. 3, the main bed of the mine, is worked at the present time in the first level. The beds strike N. 30° W. and dip 42° SW. Bed No. 3 is fairly uniform in thickness throughout the mine. The rocks of the entire region in which this mine is situated are very badly broken; joints occur close together and extend through both roof and floor, so that the blocks between the joints slide upon each other and cause a very strong squeeze in all parts of the workings. The following sections were made where the samples were obtained:

Sections of coal beds in Melmont mine.

No. 9579, bed No. 3.		No. 9578, bed No. 3.	
Shale (poor roof).	Ft. in.	Sandstone.	Ft. in.
*Coal, broken except lower 1 foot 3½ inches.	5 5	Shale (poor roof).....	4±
*Shale.....	½	Shale, carbonaceous, soft.....	1 5±
*Coal.....	11½	*Coal.....	4
	6 5	Coal.....	2
		Shale.	11 5±
No. 9576, upper bench of bed No. 2.		No. 9580, lower bench of bed No. 2.	
Shale roof (poor).	Ft. in.	Shale roof (poor).	Ft. in.
Shale, carbonaceous, soft.....	4½	Shale, soft, carbonaceous.....	4½
*Coal.....	3 6	*Coal.....	3 6
Dirt, black.....	4	Dirt, black.....	4
Coal.....	5 3½	Coal.....	5 3½
Shale.....	2½±	Shale.....	2½±
Coal.	9 8½±	Coal.	9 8½±
No. 9577, bed No. 1.			
Shale, hard.	Ft. in.		
Shale, soft.....	1 1		
*Coal.....	7		
Shale.....	1		
*Coal.....	6½		
Shale.....	1 5		
*Coal.....	1 11		
Coal, soft, clayey.....	1		
*Coal.....	6		
Shale, with thin layers of bony coal.	6 2½		

Preparation for market.—No attempt is made to separate impurities from the coal in the mine. At the bunkers the coal is passed over a shaking screen having perforations 2 inches in diameter, from which the oversize is picked on a link-belt picking table and conveyed to the bunkers, and the undersize sorted through a set of revolving screens. The different sizes from these screens are washed through a Forrester feldspar jig.

Samples for analysis.—Sample 9579 was taken from bed No. 3 on the first level north 50 feet above the gangway in chute 73. The bed contains a thin parting of shale which can not be readily removed in preparing the coal for the market, and it was therefore included in the sample. Both roof and floor are badly jointed at this place and mix with the coal to a considerable extent. Sample 9578 was taken from bed No. 3 on the first level north about 200 feet up the rise in the pillar between chutes 56 and 57. The workings were subjected to a very heavy squeeze at this point and only part of the bed could be sampled. The bed is overlain by $1\frac{1}{2}$ feet of carbonaceous shale, very badly broken, which mixes to a considerable extent with the coal. The cap rock of shale which overlies this carbonaceous shale is also very badly broken, and makes a very poor roof. The floor of the mine is of shale and is probably broken like the roof. Sample 9576 was taken from the upper bench of bed No. 2 on the first water-level gangway north, 25 feet above the entrance to chute 2. The bed is overlain by an irregular layer of soft carbonaceous shale that mixes with the coal in mining and must be separated at the bunkers. The roof of the mine is also very poor and mixes to some extent with the coal. Sample 9580 was taken from the same place in the mine from which sample 9576 was obtained, from the lower bench of bed No. 2, which is separated from the upper bench by about 4 inches of black dirt that must be removed at the bunkers. The lower bench is underlain by a thin layer of shale which mixes to some extent with the coal. Analysis 10412 was made of a composite sample consisting of equal parts of the samples taken from bed No. 2. Sample 9575 represents about 200 pounds of coal taken from eight railroad cars, obtained by collecting small quantities at regular intervals from the surface of cars just loaded from the bunkers. The coal in this sample was reduced to $\frac{3}{4}$ -inch mesh, and then quartered and reduced in the usual manner until about 25 pounds remained. This was ground to the size of a pea and quartered and reduced until the final sample of 4 pounds was obtained. The coal was wet when taken from the surface of the cars, and was sealed in the cans while still moist. Sample 9577 was taken from the north end of the first water-level gangway on bed No. 1 about 100 feet from the main rock tunnel. The bed contains several partings of shale and impure coal which can be separated from the coal in preparation for the market, and which were not included in the sample. At this point the bed is overlain by about

a foot of soft shale, which makes a poor roof, inasmuch as it mixes to a considerable extent with the coal. The analyses of these samples are given on pages 72-73.

Character and quality of the coal.—The coal from bed No. 3 is pitch black, gives a black streak, and has a vitreous luster. It is dense and breaks with an irregular fracture. Joints break the bed very badly, so that it produces a very small amount of lump coal. The coal contains a small amount of moisture and does not weather on exposure to the air. It contains, however, a somewhat large amount of ash that can not be separated from the coal in preparation for the market. Coal from beds Nos. 2 and 3 is grayish black and dense, and breaks with an irregular fracture. It contains a greater amount of ash than bed No. 3 and a somewhat lower heating value. All these coals coke and are used as blacksmithing coal. They are of about the same quality as those at Carbonado, with the exception of the Wingate, and are regarded as a good grade of bituminous coal.

FAIRFAX.

Fairfax, a drift and slope mine at Fairfax, on the Northern Pacific Railway. No. 72.

Operator: Tacoma Smelting Co., Tacoma, Wash.

Kind of coal: Bituminous (coking).

Coal beds.—Three beds were examined in the mine and sampled. The lower bed, known as the blacksmith bed, was not being worked at that time. The middle, or bed No. 3, was being worked on the first level, and the upper, or bed No. 7, was being worked on the water level. The beds strike N. 30° W. and dip about 75° NE. Bed No. 3 is the only one at present worked to any considerable extent. Both the roof and floor of the bed are very firm, but they are not uniform. In some places the bed is only about a foot in thickness, and in other places it is nearly 4 feet. The following sections were taken where the samples were obtained:

Sections of coal beds in Fairfax mine.

No. 9607, bed No. 3.		No. 9609, blacksmith bed.	
	Ft. in.		Ft. in.
Shale, very hard.		[South end of gangway.]	
*Coal, slightly bony	3	Shale.	
*Coal	6	Shale, carbonaceous	2½
Shale, hard	1	*Coal	1 9
*Coal	2 11½	Shale.	1 11½
Coal, bony	3		
Shale, hard, flinty.	4 ½		
No. 9608, bed No. 7.			
Shale (poor roof).			
*Coal, broken	5 3½		
Shale, hard	4		
*Coal	2 8½		
Shale (poor floor).	8 4		

Preparation for market.—At the bunkers the coal is passed over a shaking screen having $1\frac{1}{2}$ -inch perforations. The oversize is hand picked to remove the shale partings and other impurities, then passed through a crusher, and thence conveyed to the washer. The undersize is washed through a Jeffery-Robinson washer and reworked through two jigs.

Samples for analysis.—Sample 9607 was taken from bed No. 3 80 feet below the north water level in chute 8. The bed contains one shale parting, which can be removed in preparation for market and which was not included in the sample. Both roof and floor are very hard and do not mix with the coal in mining. Sample 9608 was taken from bed No. 7 at the end of the water-level gangway, about 75 feet south of the rock tunnel from bed No. 3. It contains a parting of shale near the center, which can be removed and which was not included in the sample. Both roof and floor are very poor; they mix to considerable extent with the coal and must be removed at the bunkers. Sample 9609 was taken from the blacksmith bed at the south end of a short gangway from a rock tunnel about 500 feet along the main gangway from slope No. 3. The bed varies in thickness and the coal for the sample was taken in two places within a few feet of each other. Both roof and floor are hard and do not mix with the coal except where local lenses of shale occur under the roof. Sample 9574 was made up from about 75 pounds of washed coal from the bunkers, which had stood in them under cover for some time. Small quantities of coal, all in fragments less than three-fourths of an inch in diameter, were taken at irregular intervals from the surface of the coal. The coal was thoroughly mixed and quartered in the usual manner until about 20 pounds were left; this was ground to the size of a pea and quartered until the final sample of 4 pounds was obtained. The analyses of these samples are given on page 73.

Character and quality of the coal.—The coal from this mine is pitch black, and has a black streak and a vitreous luster. It is massive and dense, and has a hackly fracture. It is very much broken in the bed and crumbles readily in the hand. Owing to its good coking qualities, nearly the entire output is coked in the ovens at the mine. A small amount, however, is sold occasionally for blacksmithing coal, for which purpose it is considered one of the best coals mined in the State. All the Fairfax coal is low in moisture and does not slack when exposed to the air, but that from bed No. 7 contains so large an amount of ash that, unless it can be thoroughly removed by washing, the coal will be of little value in the manufacture of coke. The coal from the blacksmith bed and from bed No. 3, however, have heating values nearly as high as any coal in the State. These coals are considered to be very good bituminous coal.

MONTEZUMA.

Montezuma, a number of drifts about 1 mile south of Fairfax, near the Northern Pacific Railway. No. 73.

Operator: Evans Creek Coal & Coke Co., Seattle, Wash.

Kind of coal: Semibituminous (coking).

Coal beds.—The four coal beds exposed in this mine are numbered in descending order. No. 1 is not being worked at the present time. All the beds are very thin, and if it were not for the steepness of the dip it would be very difficult to mine them. The beds strike nearly north and south and dip from 65° to 70° W. Most of the beds are fairly regular where they are not offset by faults. In a few places beneath some of the beds occur small lenses of coal, which can be mined with the rest of the bed. The following sections were measured where the samples were taken:

Sections of coal beds in Montezuma mines.

No. 9602, bed No. 1.			No. 9603, bed No. 2.		
	Ft.	in.		Ft.	in.
Shale.			Sandstone.		
Shale, soft.....	3½		Shale, hard, with streaks of coal..	7	
*Coal.....	9½		Shale, soft, carbonaceous.....	2	
Shale, hard.....	3½		*Coal.....	1	4
*Coal.....	3	2½	Shale.....		1
Clay, yellow, soft.....	6		*Coal.....	1	1
Shale.			Shale, soft, carbonaceous..	2½	
	5	1	*Coal.....	2½	
No. 9605, bed No. 3.			No. 9606, bed No. 4.		
	Ft.	in.		Ft.	in.
Sandstone, flinty.			Shale, hard.	3	8
Shale, hard.....	1	6			
*Coal, bright.....	1	6			
*Coal, crushed.....	1		Shale, carbonaceous.....		5
*Coal, slightly bony.....	3½		*Coal, small "niggerhead"		
Shale.....	3½		near center (local).....	1	11
Coal and bone.....	1±		*Coal, slightly bony.....		8½
Sandstone.	5	7±	Shale.....	1	
			Coal.....	4	
				8	½

Preparation for market.—Coal from beds Nos. 3 and 4 is washed and stored apart from the coal from bed No. 2. All coal is passed over a shaking screen having 1½-inch perforations, from which the oversize is picked and used as domestic and steam coal, and the undersize washed through feldspar jigs and flumed to a bunker at the railroad track, where most of it is used in the manufacture of coke. A small percentage of the washed coal is sold for blacksmithing coal.

Samples for analysis.—Sample 9602 was taken from bed No. 1 at the entrance to chute 4, on the north water level. At this place the bed contains one shale parting which can be removed in actual mining, and this parting was not included in the sample. The bed is

overlain by soft shale and underlain by soft clay, both of which mix with the coal in mining and must be separated at the bunkers. Sample 9603 was taken from bed No. 2, 5 feet above the first counter in chute 36. The bed contains two layers of shale, which can be removed without much difficulty and which were not included in the sample. It is overlain by bony coal and soft carbonaceous shale that mixes with the coal and must be separated from it at the bunkers. Sample 9604 was made up from 165 pounds of coal from bed No. 2 collected in small quantities at random from the bunker at the railroad track. It was thoroughly mixed and quartered and reduced until about 25 pounds was obtained; this was then ground to the size of a pea and mixed, quartered, and reduced until the final sample of about 4 pounds was procured. Sample 9605 was taken from bed No. 3 about 5 feet above the gangway in chute 11. This bed contains a layer of slightly bony coal near the bottom which can not be separated, and the entire layer was included in the sample. The main bed at this place is separated by a parting of shale from a lower bench of coal and bone, which is mined in part of the workings. Sample 9606 was taken from bed No. 4 just above the second counter on chute 6, at which place the bed is underlain by a local pocket of coal about 4 feet thick, an enlargement of a layer normally about 6 inches thick. The pocket coal was not included in the sample. Sample 9613 represents about 140 pounds of washed coal collected in small quantities at random from the surface of a bunker in which the coal from beds No. 3 and No. 4 is stored. The sample was prepared for the laboratory in the same manner as sample 9604. Analyses of these samples are given on pages 73-74.

Character and quality of the coal.—The coal from all four beds is pitch black, gives a black streak, and has a vitreous luster. It is massive and dense, and breaks with a hackly fracture. Because of its minute jointing it produces a very small amount of lump. It contains a very small percentage of moisture and does not weather when exposed to the sun. Bed No. 2 contains more ash than the other beds, and the amount of ash in the washed sample shows that this can be removed only with difficulty. The coal is considered a good coking coal and is used to a large extent as blacksmithing coal. Bed No. 3 is considered to be the best blacksmithing coal in the mine, and is reported to equal any blacksmithing coal in the State. The coal has a fairly high heating value and should be classed as a good grade of bituminous coal.

MASHEL.

Mashel, a tunnel mine located at Ashford, on the Tacoma Eastern Railroad. No. 74.

Operator: Western Steel Corporation, Seattle, Wash.

Kind of coal: Bituminous (coking).

Coal bed.—One coal bed is worked in this mine at the end of a long rock tunnel, which was driven to intercept the lower part of a bed known to outcrop along the crest of the ridge north of Ashford. The bed strikes N. 5° W. and dips about 38° E.; it is disturbed by a fault and the workings have not reached its normal position. The following section was taken at the end of the gangway about 4,400 feet from the entrance to the mine:

<i>Section of coal bed in Mashel mine.</i>		Ft.	in.
Shale, crushed.			
*Coal (sample 9885)		9	½
Shale, black		5	
*Coal (sample 9885)	7	6	
*Coal, bony (sample 9885)		2	½
*Coal (sample 9885)	1	3	½
Shale		3	
*Coal, with few irregular layers of shale and bone (sample 9884)	5	1	
Bone.		15	6½

Samples for analysis.—Sample 9885 was taken from the upper bench of the bed, which contains one parting of black shale that can be removed by careful picking and washing and was not included in the sample, and a layer of bony coal that can not be easily separated and was included in the sample. The bed was overlain at this place by shale so badly crushed that several feet break during mining and mix with the coal. Sample 9884 was taken from the lower bench of the bed, which is separated from the upper bench by about 3 inches of bony shale that can be separated from the coal. The analyses of these samples are given on page 74.

Character and quality of the coal.—The coal is pitch black, has a brown streak, and a vitreous luster. It is massive, and, in some parts of the bed, slightly banded. Most of the coal breaks with an irregular bright fracture. Although it contains a percentage of ash so high that the heating value of these two samples was greatly reduced, this impurity may possibly be removed by very careful and refined methods of washing. The coal appears to be a very good bituminous coal, and if a large percentage of the ash could be removed it would make good coke.

PROSPECT EAST OF ASHFORD.

An open cut in the SW. ¼ sec. 20, T. 15 N., R. 7 E., about 7 miles east of Ashford, Wash.

Kind of coal: Semibituminous.

Coal beds.—The coal bed strikes N. 73° W. and dips 15° SW. The section measured by J. B. Umpleby is as follows:

Section of coal bed in SW. $\frac{1}{4}$ sec. 20, T. 15 N., R. 7 E.

		No. 6486.	
Shale.		Ft.	in.
*Coal.....		6	
Parting.....		2	
*Coal.....		8	
Parting.....		1	
*Coal.....		4	
Parting.....		10	
*Coal.....		1	9
Shale.....		2	6
		6	10

Sample for analysis.—Sample 6486 was taken by J. B. Umpleby in 1908 from the place where he measured the section given above. All the partings were separated from the sample, the analysis of which is given on page 74.

Character and quality of the coal.—The physical properties of the coal are not known by the writer. The ratio of volatile matter to fixed carbon, however, is higher than in any coal commercially developed in the State, and the amount of ash in the coal is so high as to reduce its heating value to that of a low-grade coal.

SKAGIT COUNTY.

Numerous coal prospects and several old mines occur in the vicinity of Cokedale and Hamilton, in Skagit County, but none are being developed commercially at the present time. Owing to the fact that funds for the investigation were limited, the writer was unable to visit this region to obtain samples. Two samples of the Fairhaven coal from Cokedale (No. 80) were analyzed by the Bureau of Equipment¹ of the Navy Department at Washington, D. C., and these analyses are given on page 76 of this report. Although the coal is reported to be a good cooking and steaming coal, the Cokedale mine has not been in operation for several years. Gas occurs in some of the beds and makes mining very dangerous.

THURSTON COUNTY.

The coals of Thurston County are either subbituminous or on the border between subbituminous and lignite. All the mines worked at present are in the southern part of the county, between Tenino and Centralia. The relief of the region is low, and the outcrops are obscured by gravel, soil, and dense undergrowth. The geology of the coal-bearing beds has not been worked out, and their extent and

¹ Reports of the efficiency of various coals, 1896-1898, sections relating to coal from the annual reports of the Chief of the Bureau, 1902-3, and recent chemical analyses of coal at the navy yard, Washington, D. C., 1906, pp. 97 and 98.

relations to each other are not known. Dips of the beds at all the mines in this county visited by the writer are very low. The samples were collected during July and September, 1909, and February, 1910.

HANNAFORD NO. 1.

Hannaford No. 1, a slope mine at Tono, Wash., on a spur of the Oregon-Washington Railroad and Navigation Co., off the main line near Centralia. No. 75.

Operator: Washington Union Coal Co., Centralia, Wash.

Kind of coal: Subbituminous.

Coal bed.—Only one of the several coal beds exposed is mined at the present time. The bed is nearly horizontal, dipping only 4° NE. A slope has been driven about 1,500 feet in the lower portion of the bed, and two levels have been run to the north and three to the south. The mine has thus far been worked almost entirely in the lower bench of the bed, but the upper bench has been taken down in one or two rooms on the second level south and the company intends eventually to mine the entire upper bench. The following sections were measured at the places where the samples were taken:

Sections of coal bed in Hannaford No. 1. mine.

Nos. 9089 and 9573, upper bench.		No. 9095, lower bench.	
Shale.	Ft. in.	Shale.	Ft. in.
*Coal.....	4 5	*Coal.....	1 3½
Shale.....	1	Shale, clayey.....	1
	4 6	*Coal.....	1 9
		*Clay, irregular layer.....	1
		*Coal.....	3 2½
			6 5
No. 9094, lower bench.		No. 9096, lower bench.	
Shale.	Ft. in.	Shale.....	Ft. in.
*Coal.....	1 3	*Coal.....	1 2½
Shale.....	½	Shale, brown.....	1
*Coal.....	1 8½	*Coal.....	1 11½
Clay.....	1	Shale, carbonaceous.....	½
*Coal.....	9½	*Coal.....	11½
*Shale, brown.....	½	*Shale.....	½
*Coal.....	1 8	*Coal.....	1 9½
*Shale.....	½	Shale.....	½
*Coal.....	3½	*Coal.....	4
	5 11		6 6½

Preparation for market.—The coal from this mine is shipped as run-of-mine, and no attempt is made to separate the shale unless it parts readily from the coal in the mine or is of greater thickness than at any point from which the samples were taken. The entire output,

aside from the coal consumed at the mine and in the company town, is used for steam coal by the Oregon-Washington Railroad & Navigation Co. and its connections.

Samples for analysis.—Samples 9089 and 9573 were taken from the upper bench, about 150 feet up the slope, in room No. 7 of the second level south. The 1-inch shale at the bottom of the bed forms a parting between this bench and the lower bench, which is the one worked in other parts of the mine. Sample 9095 was taken 200 feet from the gangway in room No. 12, on the first level south. The upper parting of this bench, which is the more regular, can be separated by picking, and was not included in the sample. Sample 9094 was collected at the entrance of room No. 12, on the first level north. The coal was slightly moist, owing to seepage from the overlying rocks, and was sealed in the can before it had a chance to dry; the analysis of this sample should therefore show a slightly higher percentage of moisture than the analysis of a sample in a normal condition. The bench at this place contains four partings, of which most of the upper two and part of the lower two can be separated from the coal by careful picking. In order to obtain a representative amount of ash, only the lower two partings were included in the sample. Sample 9096 was taken at the entrance to room No. 8, on the second level north, at which place the bed contains four distinct partings. In order to obtain a representative amount of ash in the sample, the third parting from the top was included. Analysis No. 8752 was made from a mixture of samples of run-of-mine coal from the lower bench of Hannaford No. 1 mine, taken at Pittsburg from two cars which had been on the road from three to five weeks. The analyses of these samples are given on pages 74-75.

Character and quality of the coal.—The coal is black in color and has a reddish-brown streak. It has a slightly banded structure and breaks with a conchoidal fracture. Because of its high moisture content, the coal weathers very readily when exposed to the sun, but it will stand transportation for some distance when shipped in closed cars. It should be classed as subbituminous coal.

Samples 9089 and 9057 were taken from the same place in the mine, but there is a very notable difference in the heating value and the amount of moisture of the air-dried samples. Sample 9089 was taken on July 21, when the coal was being mined from the upper bench in this room, and was exposed for a few hours during transportation to the office, but it was sealed immediately thereafter and was forwarded to the laboratory in an air-tight can. Sample 9573 was taken by removing the surface coal and cutting a fresh channel at the side of the old channel from which No. 9089 was taken. Previous to the time when it was obtained, September 29, it had been

exposed to the mine atmosphere for about nine weeks. A comparison of the amount of moisture in these two samples as received and in samples as received from the other parts of the mine indicates that only a little moisture evaporated from either sample 9089 or sample 9573 during exposure to the atmosphere. The moisture in these two coals, as shown in the samples as received and in the same samples air dried, indicates that, although the total amount of moisture was the same, its relation to the coal had been changed so that it could not be driven off at the ordinary temperature used in the regular method of air drying.

PERTH.

Perth, a slope mine about 3 miles north of Centralia, on a logging road. No. 76.

Operator: Perth Coal Mining Co., Centralia, Wash.

Kind of coal: Subbituminous.

Coal bed.—Although several coal beds are exposed at this mine, the bed now being worked is the only one from which a sample could be obtained. This bed strikes N. 35° W. and dips 20° SW. The section was measured at a point 120 feet north from the foot of the slope and 40 feet up the rise from the first level gangway.

Section of coal bed in Perth mine.

No. 9178.

	Ft.	in.
Shale, compact, slate colored.		
*Coal.....	10	
Clay, yellow.....	3½	
*Coal.....	3½	
Clay, yellow.....	3	
*Coal.....	7	
Clay, yellow.....	5	
*Coal.....	2	8½
Shale, black, sandy.	5	4½

Preparation for market.—Shale from the roof is separated from the coal in the mine, and the coal is screened and picked by hand at the tippie.

Sample for analysis.—Sample 9178 was taken where the section given above was measured.

Three partings of yellow clay, all of considerable thickness, occur in the bed and must be separated in mining. When exposed to the air for a short time they swell to about one and one-fourth times their original thickness and become very soft and spongy. All three partings were excluded from the sample. The roof is of compact shale, which breaks off in large irregular slabs and mixes with the coal. The analysis of the sample is given on page 75.

Character and quality of the coal.—The coal is brownish-black and has a reddish-brown streak; it is massive and banded, and breaks with a conchoidal fracture. Owing to its high moisture content, which causes it to slack readily when exposed to the air, this coal should be classed as low-grade subbituminous coal.

BLACK BEAR.

Black Bear, a slope mine about 2 miles southeast of Tenino, on a spur of the Northern Pacific Railway. No. 77.

Operator: Tenino Coal & Iron Co., Tenino, Wash.

Kind of coal: Subbituminous.

Coal bed.—The coal bed from which the sample was taken was exposed in an abandoned mine east of the present slope. It was taken about 30 feet up the first room on the first level west of a slope sunk about 150 feet from the portal of the old gangway. The face from which the coal was obtained had been exposed to the weather for several years. The section measured is as follows:

Section of coal bed in Black Bear mine.

No. 9939.		Ft.	in.
Shale.			
Shale, carbonaceous.....		3	½
*Coal.....	2	1	
Shale, spongy, varies from 1 to 2½ inches.....		1	
*Coal.....		8	½
Shale, spongy.....		2	
*Coal.....		5	
Shale.....			½
*Coal.....	2	5	
Shale.		6	2½

Preparation for market.—The coal from this mine is prepared for market by screening and hand picking.

Sample for analysis.—Sample 9939 was taken where the section given above was measured. All three shale partings can be separated from the coal and were therefore not included in the sample. The sample was taken from the old workings, because a fault had been encountered in the new slope. The section of the bed exposed there was not typical. The analysis of this sample is given on page 75.

Character and quality of the coal.—The coal is brownish black and has a reddish-brown streak. It is massive and laminated and breaks with a conchoidal fracture. It contains a high percentage of moisture, and weathers on exposure to the air; probably 4 or 5 per cent of moisture had been removed from the coal by the circulation of mine air at the time it was taken, for it appeared to be slightly weathered. Like sample 9573, taken at the Hannaford mine, the condition of the moisture contained in the coal had apparently been modified

in such a way that it could not be driven off by the usual method of air drying. This coal should probably be classed as low-grade subbituminous.

KING (GREAT WESTERN).

King, or Great Western, slope mine, 3 miles southwest of Tenino, on a branch of the Northern Pacific Railway. No. 78.

Operator: King Coal Co., Tenino, Wash.

Kind of coal: Subbituminous.

Coal bed.—The coal bed lies very nearly horizontal. At the entrance to the main gangway it dips very slightly (1° to 2°) to the east, while at the far end of the gangway the bed has about the same dip in the opposite direction, so that the gangway passes through a syncline near the center of the workings. The bed is thin, and is subjected to considerable pressure, so that a great deal of rock work is necessary in the gangways to keep them open. The following section was measured at the place where the sample was taken:

Section of coal bed in King mine.

		No. 9987.	
		Ft.	In.
Sandstone, white.			
Shale, hard.....			2½
*Coal.....			7
Shale, with irregular lenses of coal.....			3½
*Coal.....			4
Shale.....			1
*Coal.....	1		6
Shale, brown.....			1
*Coal.....	1		1
Clay, yellow, soft.....			4
Shale.....			
		4	6

Preparation for market.—Impurities are for the most part removed at the bunker, where the coal is picked and washed.

Sample for analysis.—Sample 9987 was taken in room 10, about 100 feet up the rise from the twenty-fifth level north. Several partings of shale which occur in the bed may be separated from the coal by careful picking and washing, and they were, therefore, excluded from the sample. The analysis of the sample is given on page 75.

Character and quality of the coal.—The coal is brownish-black, and has a reddish-brown streak. It is massive and banded, and breaks with a conchoidal fracture. Owing to its high percentage of moisture, it slacks on exposure to the air, although not so readily as some of the other coals from the same region. Minute lenses of pyrite are probably responsible for a percentage of sulphur somewhat higher than that of other coals of this locality. The coal should be classed as low-grade subbituminous.

WHATCOM COUNTY.

The coals of Whatcom County have been mined in the vicinity of Lake Whatcom for many years. The only mine of commercial importance operating at the present time is the Blue Canyon mine (No. 79) at Park, near the shore of Lake Whatcom, which was not visited by the writer on account of the limited appropriation. The coal from this mine has been analyzed by the Bureau of Equipment of the Navy Department at Washington, D. C., and is given on page 76 of this report. It has a fixed carbon content equal to that of any of the high grade bituminous coals of the State, and a small amount of ash and moisture. Unless it is too badly jointed, the coal should hold up well in transportation to market.



INDEX.

	Page.		Page.
A.		Page.	
A. & E. mine, coal at, character of.....	142	Big Six mine, coal at, character of.....	119-120
coal at, preparation of for market.....	142	coal at, coking test of.....	32
sample of, analysis of.....	59, 142	sample of, analysis of.....	52, 120
section of.....	142	section of.....	119
Acknowledgments to those aiding.....	7	Binder, definition of.....	8
Adherence of coals, plates showing.....	30, 32	Bituminous coal, characteristic features of...	9
Analyses, accuracy of.....	17-19	physical properties of.....	27
discrepancies in, causes of.....	30	Black Bear mine, coal of, character, section,	
methods of making.....	16-17	and preparation of.....	197-198
results of.....	41-76	coal of, sample of, analysis of.....	75, 197
Anthracite coal, characteristic features of.....	8-9	Black carbon mine, coal of, character, section,	
exposures of on Summit Creek, plate		and preparation of.....	170-171
showing.....	78	coal of, coking test of.....	32
physical properties of.....	27	sample of, analysis of.....	67, 170-171
Arrangement of mine descriptions, plan of.....	76	Black Diamond, coal near, analyses of.....	47-48
Ash, character, occurrence, and effect of.....	34-36	coal near, character of.....	98-102
effect of, on heating value.....	21	coking tests of.....	33
variations in character and amount of.....	26-27	Black Diamond mine, coal at, character of.....	99-101
Ashford, coal near, analyses of.....	74	coal at, preparation of for market.....	100
coal near, character and sections of.....	191-193	samples of, analyses of.....	47, 100
coking tests of.....	33	section of.....	100
prospect near, coal of, analysis of.....	74	Brier Hill mine, coal of, character, section,	
coal of, section and character of.....	192-193	and preparation of.....	178-179
Atmosphere, effect of, on coal.....	11-15	coal of, sample of, analysis of.....	69, 178
B.		Bunkers, plates showing.....	78, 84
Bagley drift, coal at, character of.....	85-88	Bureau of Naval Equipment, analyses by...	76
coal at, preparation of, for market.....	87	work of.....	18
samples of, analyses of.....	43-44, 87-88	Burnett, bunker at, plate showing.....	84
section of.....	86-87	coal at, analyses of.....	66-67
Barneston, prospect drift near, coal at, analy-		character and section of.....	168-170
sils of.....	53	coking tests of.....	33
prospect drift near, coal at, section and		Burnett mine, coal at, character of.....	168-170
character of.....	123	coal at, preparation of for market.....	168-169
Bayne, coal near, analyses of.....	50-52	samples of, analyses of.....	66-67, 169
coal near, character of.....	112-120	section of.....	168
coking tests of.....	32-33	Busy Bee mine, coal at, character of.....	135
forested area near, plate showing.....	80	coal at, preparation for market of.....	135
prospect drift near, coal at, analysis of...	51	sample of, analysis of.....	56, 135
coal at, section and character of.....	116	section of.....	135
undergrowth near, plate showing.....	80	C.	
Bayne mine, coal at, character of.....	112-114	Campbell, M. R., on carload sampling.....	11-13
coal at, preparation of for market.....	113	on coals at the St. Louis Exposition.....	12-13
samples of, analyses of.....	50-51, 113-114	work of.....	7-18
section of.....	113	Carbon, effect of, on heating value.....	20-21
Bedding, variations in.....	23	Carbonado, beehive coke ovens at, plate	
Beehive coke ovens, at Carbonado, plate		showing.....	168
showing.....	168	city, panoramic view of, plate showing..	168
Beekman, coal at, analyses of.....	55-56	coal near, analyses of.....	69-72
coal at, section and character of.....	131-135	character of.....	180-185
coal near, adherence of, plate showing...	30	coking tests of.....	32
coking tests of.....	33	Carbon Hill mine, coal at, character of.....	180-185
Beekman mine, coal at, character of.....	132-135	coal at, coking tests of.....	32
coal at, preparation of for market.....	134	preparation of for market.....	182
samples of, analyses of.....	55-56, 134	samples of, analyses of.....	69-72, 183-185
section of.....	133	section of.....	180-182

	Page.		Page.
Carbon mine, coal at, character of.....	114-116	Coal, constituents of, effects of.....	19-21
coal at, coking tests of.....	32	detailed descriptions of varieties of.....	76-199
preparation of for market.....	115	exposure, effect of, upon.....	11-13, 28-33
samples of, analyses of.....	51, 115	ignition of.....	21-22
section of.....	115	impurities of, effect of.....	34-36
Carload sampling, methods and advantages of	10-15	mineral ash of, effect of.....	34-36
Carlton Creek, prospects near, coal at, analyses of.....	62	moisture of, effect of.....	34
prospects near, coal at, section and character of.....	152-154	physical properties of.....	22-33
Central Coal Co., Grand Ridge mine of, coal of, analyses of.....	42	physical tests on, results of.....	22-27
Grand Ridge mine of, coal at, section and character of.....	81-83	sampling of, methods of.....	10-15
Centralia, coal near, analyses of.....	65, 75	sulphur of, effect of.....	34
coal near, sections and character of.....	160-162, 196-197	<i>See also particular mines, prospects, and localities.</i>	
Centralia Coal Co., Richmond mine of, coal at, analyses of.....	65	Coal Creek, coal near, analyses of.....	43-44
Richmond mine of, coal at, section and character of.....	162	coal near, character of.....	79, 85-88
Chehalis, coal near, analyses of.....	65-66	mine near, character of coal of.....	79
coal near, sections and character of.....	162-166	Coal mines, method of fixing location of.....	15-16
Chehalis mine, coal of, character, section, and preparation of.....	165	Coast Coal Co., Pittsburg mine of, coal at, analyses of.....	67
coal of, sample of, analysis of.....	66, 165	Pittsburg mine of, coal at, section and character of.....	171-172
Clallam Coal Co., bunker of, plate showing.....	78	Coherence, variation in degree of.....	25
Fuca mine of, coal of, character and section of.....	77-78	Coking, Pishel test for.....	31-33
coal of, chemical analysis of.....	41	Pishel test for, results of, tables showing.....	32-33
Clallam County, coal of, analyses of.....	41	results of, with particular coals, plates showing.....	30, 32
coal of, distribution and character of.....	77-78	Color, variations of.....	22
<i>See also particular mines, localities, etc.</i>		Commercial sampling, disadvantages of.....	10-12
Clealum, coal near, adherence of, plate showing.....	30	Commonwealth Coal Co., Willis mine of, coal of, analyses of.....	69
coal near, analyses of.....	61-62	Willis mine of, coal of, character and section of.....	177-178
coking, tests of.....	33	coal of, coking test of.....	32
sections and character of.....	146-152	Consolidated Coal Co., Lakedale mine of, coal at, analysis of.....	55
Cle Elum No. 1 mine, coal at, character of.....	151-152	Lakedale mine of, coal at, section and character of.....	131-132
coal at, preparation of, for market.....	152	Constituents, of coal, effect of, on heating value.....	19-21
samples of, analyses of.....	62, 152	Cooperation, plan of.....	7
section of.....	151	Cowlitz County, coal of, analyses of.....	41
Cle Elum No. 2 extension, coal at, character of.....	149-150	coal of, distribution and character of.....	79
coal at, preparation of, for market.....	150	Cowlitz River, surface exposure near, coal at, analysis of.....	63
sample of, analyses of.....	61, 150	surface exposure near, coal at, section and character of.....	156-157
section of.....	150	Crescent mine, coal of, character, section, and preparation of.....	166-167
Cle Elum No. 2 mine, coal at, character of.....	150-151	coal of, sample of, analysis of.....	66
coal at, preparation of, for market.....	151	Cumberland, coal at, analyses of.....	49-50
samples of, analyses of.....	62, 151	coal at, character and section of.....	106-111
section of.....	150	coking tests of.....	32-33
Cle Elum No. 3 extension, coal at, character of.....	148-149		
coal at, preparation of, for market.....	149	D.	
samples of, analyses of.....	61, 149	Danville, coal near, analyses of.....	45
section of.....	149	coal near, character of.....	93
Coal, character and quality of.....	16-40	Danville mine, coal at, character of.....	93
chemical analyses of, methods of.....	16-17	coal at, sample of, analyses of.....	45, 93
results of.....	17-19, 41-76	section of.....	93
tables showing.....	41-76	Denny-Renton Clay & Coal Co., coal of, coking tests of.....	32
chemical properties of.....	16-22	Kummer mine of, coal at, analyses of.....	48
classification of, Geological Survey methods of.....	8-10	coal at, character and section of.....	103-104
coking, results of Pishel test for.....	31-33	coal of, coking test of.....	32
commercial use of.....	38-40	Denny-Renton mine near Renton, coal at, character of.....	89-90
comparative quality and distribution of.....	37-38	coal at, preparation of, for market.....	89

	Page.
Denny-Renton mine near Renton, coal at,	
samples of, analyses of.....	44, 89-90
coal at, section of.....	89
Denny-Renton mine near Taylor, coal at,	
character of.....	123-126
coal at, coking tests of.....	32
preparation of, for market.....	125
samples of, analyses of.....	53-54, 125
section of.....	124
Description, order of.....	76
Diller, J. S., on coal of Cowlitz County.....	79
work of.....	17
Discrepancies, in analyses, causes of.....	30

E.

East Creek-Ladd mine, coal at, character of.....	153-160
coal at, coking tests of.....	32
preparation of, for market.....	159
samples of, analyses of.....	64-65, 159-160
section at, near.....	159
Elasticity, variations in degree of.....	25
Eureka mine, coal at, character of.....	111-112
coal at, sample of, analysis of.....	50, 112
section of.....	112
Evans Creek Coal & Coke Co., Montezuma	
mine of, coal of, analyses of.....	73-74
coal of, character and section of.....	190-191
coking tests of.....	32
Evans, G. W., work of.....	7, 18
Exposure, effect of, on coal.....	11-15, 28

F.

Fairfax, coal near, analyses of.....	73-74
coal near, character and section of.....	188-191
coking tests of.....	33
Fairfax mine, coal of, character, section, and	
preparation of.....	188-189
coal of, samples of, analyses of.....	73, 189
Flame, variations in character of.....	26
Ford mine, coal at, character of.....	85-88
coal at, preparation of, for market.....	87
samples of, analyses of.....	43, 87-88
section of.....	86-87
Fracture, variations of.....	24-25
Franklin, coal near, analyses of.....	48
coal near, character of.....	102-106
coking tests of.....	33
glacial boulders and exposures of Puget	
formation near, plates showing.....	82
surface exposures at, coal of, analyses of.....	48
coal of, character of.....	102-103, 105-106
Fuca, bunker at, plate showing.....	78
Fuca mine, coal at, character of.....	78
coal at, preparation of, for market.....	78
sample of, analysis of.....	41, 78
section of.....	77

G.

Gale Creek mine, coal of, character of.....	175-177
coal of, coking tests of.....	32
preparation of, for market.....	176
samples of, analyses of.....	68-69, 176-177
section of.....	176

	Page.
Gem mine, coal at, character of.....	105
coal at, preparation of, for market.....	105
sample of, analyses of.....	48, 105
section of.....	105
Glacial boulders near Franklin, plate show-	
ing.....	82
Glenavon, prospects near, coal at, analyses of.....	63-64
prospects near, coal at, character, and sec-	
tion of.....	157-158
Grand Ridge mine, coal at, character of.....	81-83
coal at, preparation of, for market.....	82
samples of, analyses of.....	42, 82
section of.....	81-82
Great Western mine, coal of, character, sec-	
tion and preparation of.....	198
coal of, sample of, analysis of.....	75, 198
Green River, glacial boulders and exposures	
of Puget formation near, plates	
showing.....	82
Green River Coal Co., Bayne mine of, analy-	
ses of.....	50-51
Bayne mine of, coal at, section and charac-	
ter of.....	112-114

H.

Hannaford No. 1 mine, coal at, character of.....	194-196
coal at, preparation of, for market.....	194-195
samples of, analyses of.....	74-75, 195
section of.....	194
Hardness, variations in.....	25
Heating value, effect of constituents of coal on.....	19-21
Hydrocarbons, effect of, on heating value.....	20
Hydrogen, effect of, on heating value.....	20

I.

Ignition, ease of.....	21-22
Impact, variations in character of.....	25
Independent mine, coal of, character of.....	107-108
coal of, coking tests of.....	32
samples of, analyses of.....	49, 108
section of.....	108
Issaquah, bunker at, plate showing.....	84
coal near, analyses of.....	41-43
character of.....	80-85
prospects near, coal of, analysis of.....	41, 54
coal of, character of.....	80-81, 127
Issaquah mine, coal at, character of.....	83-84
coal at, preparation of, for market.....	83
sample of, analysis of.....	42-43, 83-84
section of.....	83

J.

Jointing, variation in.....	23-24
-----------------------------	-------

K.

Kelso, coal near, character of.....	79
King Coal Co., King or Great Western mine	
of, coal at, analysis of.....	75
King or Great Western mine of, coal at,	
section and character of.....	198
King County, coal of, analyses of.....	41-55
coal of, distribution and character of.....	80-129
<i>See also particular mines, localities, etc.</i>	
King mine, coal of, character, section, and	
preparation of.....	198
coal of, sample of, analysis of.....	75, 198

	Page.		Page.
Kittitas County coal of, analyses of.....	55-62	Moisture of coal, extraneous, effect of, on heating value.....	19
coal of, distribution and character of.....	129-152	inherent, effect of, on heating value.....	19
<i>See also particular mines, localities, etc.</i>		Montezuma mine; coal of; character, section, and preparation of.....	190-191
Kummer, coal near; analyses of.....	48	coal of, coking tests of.....	32
coal near, character of.....	103-104	samples of, analyses of.....	73-74
coking test of.....	32	Morgan mine, coal at, character of.....	98-99
Kummer mine, coal at, character of.....	103-104	coal at, preparation of for market.....	98
coal at, coking test of.....	32	samples of, analyses of.....	47, 99
preparation of, for market.....	103-104	section of.....	98
samples of, analyses of.....	48, 104		
section of.....	103		
L.		N.	
Laboratory, preparation of samples for.....	15-16	Naval mine, coal at, character of.....	110-111
Ladd, coal near, analyses of.....	63-65	coal at, coking tests, of.....	32
coal near, character of.....	158-160	preparation of for market.....	111
coking tests of.....	32	samples of, analyses of.....	49-50, 111
prospects near, coal of, analyses of.....	63-64	section of.....	110
coal of, character of.....	157-158	Niblock mine, character of.....	128-129
Lakedale mine, coal at, character of.....	131-132	coal at, preparation of for market.....	128
coal at, preparation of for market.....	132	samples of, analyses of.....	55, 128-129
sample of, analyses of.....	55, 132	section of.....	128
section of.....	132	Niggerheads, definition of.....	8
Landes, Henry, State geologist of Washington, cooperation by.....	7	Nitrogen, effect of, on heating value.....	20
Lawson mine, coal at, character of.....	101-102	North Coast Colliery Co., Danville mine of, coal at, analyses of.....	45
coal at, preparation of for market.....	101	Danville mine of, coal at, section and character of.....	93
samples of, analyses of.....	48, 101-102	Northwestern Improvement Co., properties of coal from, analyses of.....	45-47, 57-62, 72-73
section of.....	101	properties of, coal from, character of.....	94-96, 137-152, 186-188
Lewis County, coal of, analyses of.....	62-66	coal from, coking tests of.....	32-33
coal of, distribution and character of.....	152-167	<i>See particular mines</i> —Melmont, Ravensdale, Cle Elum mine No. 1, No. 2, No. 2 extension, No. 3 extension, Roslyn mine No. 2, No. 2 slope, No. 3, No. 4, No. 5, No. 6, and No. 7.	
<i>See also particular mines, localities, etc.</i>		Occidental mines, coal at, character of.....	117-119
Lignite, characteristic features of.....	10	coal at, coking tests of.....	33
physical properties of.....	28	preparation of, for market.....	118
Lizard Mountain, forested area near, plate showing.....	80	samples of, analyses of.....	51-52, 118-119
Locations, of coal mines, method of fixing.....	15-16	section of.....	117
Luster, variations of.....	23	Odor, variations in.....	26
		Oxygen, effect of, on heating value.....	20
M.			
McKay mine, coal at, character of.....	96-98		
coal at, preparation of for market.....	97		
samples of, analyses of.....	47, 97		
section of.....	97		
Mashel mine, coal of, character, section, and preparation of.....	191-192		
coal of, samples of, analyses of.....	74, 192		
Melmont, coal at, analyses of.....	72-73		
coal at, character and section of.....	186-188		
coking tests of.....	32		
Melmont mine, coal of, character of.....	186-188		
coal of, coking test of.....	32		
preparation of for market.....	187		
samples of, analyses of.....	72-73, 187-188		
sections of.....	186		
Mendota mine, coal at, character of.....	160-162		
coal at, preparation of for market.....	161		
samples of, analyses of.....	65, 161		
section of.....	161		
Mineral accessories, occurrence of.....	26		
Mine sampling, methods of.....	10-15		
Mining terms, explanation of.....	7-10		
Moisture, occurrence of, in coal.....	34		
of coal, discrepancies in analyses of, causes of.....	30		
effect of exposure upon.....	28-33		
		P.	
		Pacific Coal & Oil Co., Snell mine of, coal at, analyses of.....	69
		Snell mine of, coal at, character and section of.....	179-180
		coal at, coking test of.....	33
		Pacific Coast Coal Co., Black Diamond mine of, coal at, analyses of.....	47
		Black Diamond mine of, coal at, section and character of.....	99-101
		Burnett mine of, coal at, analyses of.....	66-67
		coal at, character and section of.....	168-170
		Ford and Bagley mines of, coal at, analyses of.....	43-44
		coal at, character and section of.....	48
		Lawson mine of, coal at, analyses of.....	101-102

	Page.		Page.
Snoqualmie, coal at, analyses of.....	55	Terms, explanation of.....	7-10
coal at, character and section of.....	128-129	Texture, variations of.....	24
coking tests of.....	33	Thurston County, coal of, analyses of.....	74-75
South Willis, coal at, analyses of.....	69	coal of, distribution and character of... 193-198	
coal at, character and section of.....	177-178	<i>See also particular mines, locations, etc.</i>	
Specific gravity, variations in and properties		Tono, coal at, analyses of.....	74-75
determining.....	25-26	coal at, character and section of.....	194-196
Steamships, use of coal by.....	39	Twin City mine, coal of, character, section,	
Streak, variations of.....	22-23	and preparation of.....	164
Subbituminous coal, characteristic features of.	9-10	coal of, sample of, analysis of.....	65, 164
physical properties of.....	27-28	U.	
weathered, from Philippine Islands, plate		Umpleby, J. B., work of.....	18
showing.....	7	Undergrowth, in coal districts, plate show-	
Sulphur, occurrence of.....	34	ing.....	80
"Sulphur" ball, definition of.....	8	Union Coal Co., Crescent mine of, coal at,	
Summit Creek, exposures of anthracite on,		analyses of.....	66
plate showing.....	78	Crescent mine of, coal at, character and	
prospects on, coal of, analyses of.....	63	section of.....	166-167
coal of, character of.....	154-157	United Collieries Co., Niblock mine of, coal at,	
Summit mine, coal at, character of.....	148	analyses of.....	55
coal at, preparation of for market.....	148	Niblock mine of, coal at, character and	
samples of, analyses of.....	61, 148	section of.....	128-129
section of.....	148	coal at, coking tests of.....	33
Sunset mine, coal of, character of.....	108-110	United States Coal Co., Issaquah prospect,	
coal of, coking tests of.....	33	coal of, analysis of.....	41
preparation of for market.....	109	Issaquah prospect, coal of, character of..	80-81
samples of, analyses of.....	49, 109-110	V.	
section of.....	109	Volatile matter, composition of.....	20
Superior Coal Co. (Lewis County), mines of,		W.	
coal of, analyses of.....	65	Washington, State geological survey, coop-	
mines of, coal of, character and section of.	163	eration by.....	7
Superior Coal & Improvement Co. (King		western part of, map showing.....	76
County), Superior mine of, coal		Washington Union Coal Co., Hannaford mine	
at, analyses of.....	43	of, coal at, analyses of.....	74-75
Superior mine of, coal at, section and		Hannaford mine of, coal at, character and	
character of.....	84-85	sections of.....	194-196
Superior mine (King County), coal at, char-		Water level, definition of.....	7
acter of.....	84-85	Way, K. M., work of.....	18
coal at, preparation of, for market.....	85	Weathering, effect of, on Philippine coal, plate	
samples of, analyses of.....	43, 85	showing.....	7
section of.....	84	Western Steel Corporation, Mashel mine of,	
Superior No. 1 mine (Lewis County), coal of,		coal at, analyses of.....	74
character, section, and prepara-		Mashel mine of, coal at, character and sec-	
tion of.....	162-163	tion of.....	191-192
coal of, sample of, analysis of.....	65, 163	Whatcom County, coal of, analysis of.....	76
Superior No. 2 mine (Lewis County), coal of,		coal of, distribution and character of.....	199
character, section, and prepara-		Wilkeson, coal near, analyses of.....	67-69
tion of.....	163-164	coal near, character of.....	172-180
coal of, sample of, analysis of.....	65, 164	coking tests of.....	32-33
T.		Wilkeson mine, coal of, character of.....	172-173
Tacoma Smelting Co., Fairfax mine of, coal		coal of, coking tests of.....	33
of, analyses of.....	73	preparation of, for market.....	174
Fairfax mine of, coal of, character of... 188-189		samples of, analyses of.....	67-68, 175
coal of, coking tests of.....	33	sections of.....	173
Taylor, coal at, analyses of.....	53-54	Willis, Bailey, on Green River coal.....	37
coal at, character and section of.....	123-126	Willis mine, coal of, character, section, and	
coking tests of.....	32	preparation of.....	177-178
Technical terms, explanation of.....	7-10	coal of, samples of, analyses of.....	69, 177-178
Tenino, coal at, analyses of.....	75	Y.	
coal at, section and character of.....	197-198	Yakima-Roslyn Coal Co., A. & E. mine of,	
Tenino Coal & Iron Co., Black Bear mine of,		coal at, analysis of.....	59
coal at, analysis of.....	75	A. & E. mine of, coal at, character and	
Black Bear mine of, coal at, section and		section of.....	142
character of.....	197-198		