PART II.

COAL DEPOSITS OF WASHINGTON.

BY

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CHAPTER I.
INTRODUCTION.

GEOGRAPHIC RELATIONS.

The coal fields of Washington, as shown by the accompanying geological map, lie mostly in the western part of the state. They extend in a broken line from the Canadian boundary to the Columbia river, lying on the border between the foot hills of the Cascades and the Puget Sound basin, being entirely within the latter in two or three instances. In most cases the coal fields are within easy reach of tide water and all of them have excellent facilities for transportation. The cost of carrying the coal to market or at least to ports at which shipments may be made by vessel is comparatively small. In some instances special lines of railroad have been constructed for the purpose of connecting the coal fields with the Sound. In other instances the main lines of railway run directly through the coal fields.

In no case has the entire boundary of any coal field been accurately traced, and the exact area of the coal fields of the state is unknown. There are many reasons why detailed mapping of the coal areas has not been done and it will be many years before the exact boundaries of the deposits can be accurately defined. Reliable topographic maps of the coal fields have been prepared in but one or two instances. In addition to this the coal-bearing rocks as a rule are deeply covered, sometimes by an excessive growth of vegetation, sometimes by a thick mantle of glacial material which lies upon them, and in other cases by extensive lava flows which have come down from the Cascades adjoining. Not infrequently also the coal-bearing rocks disappear beneath the later sedimentary rocks which lie conformably upon them. In many instances

the coal-bearing rocks do not appear save where some vigorous stream has cut its way through the thick soil or other overlying material and has disclosed the coal seams along its canyon walls.

A reference to the map above mentioned shows a number of disconnected coal fields, both large and small. The suggestion at once comes to mind that beneath the overlying mantle some of these fields may be connected and therefore of much greater extent than appears at the surface. In other cases it is no doubt true that excessive erosion has removed large portions of what were once larger fields and that we now have only comparatively small isolated remnants remaining.

In addition to the coal fields noted above, which contain seams of coal merchantable in quality and quantity, there are found in the northeastern counties of the state, Chelan, Okanogan, Ferry and Stevens, many small remnants of coal measure areas which contain thin seams of coal. These coal deposits now lie far apart and long continued erosion has reduced them to diminutive sizes. In no case is coal of economic value now found within them.

TOPOGRAPHY.

The physical features of Washington are conspicuous because of their great diversity. The state abounds in alluvial valleys, low plains, high plateaus, deep gorges and lofty mountains. In making a classification of the physical features of the state six distinct provinces are easily recognized. Passing from the Pacific ocean to the eastward these divisions are: Olympic Mountains, Puget Sound Basin, Cascade Mountains, Okanogan Highlands, Columbia Plain, and Blue Mountains.

Of the above topographic regions the coal deposits have to do with two, namely, the Cascade Mountains and the Puget Sound Basin. A varied topography is therefore had passing from the low plains of the coast through plateaus and ridges to the rugged and deeply furrowed mountains. The coal fields of Whatcom county extend from the shores of Puget Sound to within a few miles of the snow-covered slopes of Mt. Baker. The coal fields of King county lie for the most part within the

limits of the Puget Sound Basin but in some cases the eastern limits of the fields extend into the foot hills of the Cascades. In Pierce county the coal fields or the major portion of them at least lie without the realm of the Puget Sound Basin and are within the confines of the Cascade Range. These coal fields, therefore, abound in sharp ridges and deep valleys and for the most part have a truly mountainous character. The Roslyn-Clealum field in Kittitas county lies within the Cascade province and abounds in mountain ridges and deep valleys. The fields of Thurston and Cowlitz counties and the western portion of Lewis county are well within the Puget Sound Basin. They are for that reason regions of low relief, composed of low hills or extended plains, in which the coal-bearing rocks rarely outcrop. In going from the westward toward the eastward in Lewis county the coal deposits attain elevations greater and greater until the last fields are reached when these are found to lie within the heart of the Cascades.

GEOLOGICAL FORMATIONS.

The coal measures of Washington belong to the early part of the Tertiary period or the Eocene epoch. In only a very few instances has the base of the coal measures been found. In the coal fields of Whatcom and Skagit counties the lowest strata of the coal measures lie upon a metamorphic rock, a mica schist of unknown age. At the Blue Canyon and Cokedale mines the largest coal seams lie but a few inches, or at the most but a few feet, above the schists. In general in the different fields the principal seams of coal lie well toward the bottom of the coal series and hence belong to the earlier portion of the epoch. In Washington, during Eocene time, the shore line was somewhere in the vicinity of the eastern border of Puget Sound, and extending southward beyond the present boundary of the state. The Olympic Mountains formed a large island immediately off the coast. The region of the Cascade Mountains was in general one of low relief.

In the northern portion of the state, however, the Cascades were doubtless of considerable height and the streams flowing from them possessed of great strength as shown by the coarse

character of the sediments deposited at that time. The hills were composed of granite rocks as shown by the character of the sediments derived from them. The fossil contents and character of the sediments of the coal fields of Roslyn-Clealum and those of Whatcom and Skagit counties show that these fields represent lake deposits. In the case of the Whatcom coal field the sediments reach an approximate thickness of 20,000 feet and are made up of massive sandstones and coarse conglomerates. In the remaining coal fields as far as known the coal swamps were in estuaries along the shore where brackish water conditions prevailed.

For the most part the coal seams of Washington occur interbedded in a series of light-colored sandstones and shales, with sandstones as the predominating rocks. The latter are usually bluish or grayish in color, but often weather into light buff owing to the oxidation of the iron carbonate which they contain. Carbonaceous matter is distributed in greater or less quantity throughout the rocks of the whole series. Small streaks of coal are found in most of the sandstones. The shales vary in color from light gray to black, according to the amount of carbonaceous matter present. All gradations are found between carbonaceous shale and pure coal. While the number of workable coal veins is small, being perhaps not more than ten or fifteen in any one district, the number of seams of more or less impure coal is very large, considerably over a hundred being known. All the veins thus far discovered which are clean enough to work, and with the coal in sufficient quantity to be of commercial value, are contained in the lowermost three thousand feet of the series. The upper two-thirds of the coal measures have thus far proven barren of workable seams, although rich in disseminated carbon.

During the whole of the long period in which these sediments were being deposited the region was undergoing a gradual but persistent sinking. The evidence of the coal seams in the lowest strata clearly shows that at that period the water at intervals was very shallow, and at the end of the period after sediments nearly two miles deep had been deposited the water still remained at about the same depth, showing that in

the meantime the bottom of the sea had sunk two miles. These nicely adjusted forces of nature permitted the accumulation of a practically unbroken series of sediments throughout the whole period.

Subsidence did not take place at a uniform rate. There were periods during which the process of sedimentation shoaled the waters faster than the sea floor sank, and this continued until the water was shallow enough to support a swamp vegetation, which thereupon spread over the broad lagoons and flourished with great luxuriance. In regard to the climate, Professor F. H. Knowlton* says: "The lower beds, on account of the abundance of ferns, gigantic palms, figs, and a number of genera now found in the West Indies and tropical South America, may be suposed to have enjoyed a much warmer, possibly a subtropical temperature, while the presence of sumacs, chestnuts, birches and sycamores in the upper beds, would seem to indicate an approach to the conditions prevailing at the present day."

Alternating with the periods of coal formation, there were long lapses of time during which the water was too deep to admit of swamp growth. These were the times when subsidence proceeded at a more rapid rate than sedimentation, or at least kept pace with it. Sand and clay were then deposited. The final results of this intermittent, long continued subsidence was that we now have a large number of coal seams and layers of more or less carbonaceous matter interstratified with beds of sandstone and shales.

Since the time of their deposition mountain making forces have been at work throughout the coal measure areas producing in most instances great deformation. The original position of the rocks has wholly changed and for the most part they are tilted at high angles. They have been thrown into extensive folds and as a rule the tops of these folds have been planed off by erosion. In most instances the folding has been accompanied by faulting and the continuity of the coal seams has been broken thereby. As a result of the folding and the

* Geological Atlas of the U. S., Tacoma Folio, U. S. Geological Survey.

faulting of the coal measures in most instances the coal has been greatly crushed and broken. Occasionally when the mechanical action has been greatest a large amount of earthy matter from the roof and floor of the seam has become mixed with the coal so that it is necessary to wash it before it is placed upon the market. As to the extent of deformation it may be said in a general way that it increases in intensity from the western to the eastern borders of the coal fields.

CHAPTER II.

DESCRIPTIONS OF THE COAL FIELDS.

WHATCOM COUNTY.

In the western part of Whatcom county, extending from the foot of Mt. Baker to the coast, there is an area of coal measures embracing over 250 square miles. These coal measures are composed mainly of massive sandstones and conglomerates, with occasional shales, and are exclusively of lake origin. They have a total thickness of many thousands of feet. Within them very much vegetal matter in the form of lignite or coal is to be found, often in irregular masses or pockets, but now and then in a well-defined seam. Occasionally these seams assume dimensions sufficiently large to afford workable coal, and they are then of economic importance. In all cases, as far as known, the beds of coal are not immediately underlaid by clay, but by conglomerate or sandstone, showing that the coal was not formed by the plants which grew upon that particular spot, but rather that it was formed from driftwood. As a result no individual seam of coal can be expected to extend throughout the coal basin, or even over a large part of it, but it is more local in its extent. It is also true that a coal seam will show considerable variability in thickness when followed in different directions.

Since their deposition the coal measures have been greatly folded and the strata are now inclined at high angles. Erosion has removed large portions of them, as may be seen in the wide valleys of the Nooksack and its tributaries, in the basin of Lake Whatcom, and elsewhere. In the eastern and central parts of the Whatcom coal field the strata outcrop everywhere and the coal beds may be easily found, but in the western part of the coal field the rocks pass under a heavy mantle of glacial drift and may only be studied or prospected by diamond drilling.

In the coal fields of Whatcom county, veins of workable coal have been found at a number of places. In some instances extensive mines have been opened and large quantities of coal produced. In a general way the coal may be said to improve in quality from west to east, as one passes from the region of least folded rocks to those that have suffered the greatest deformation. The coal vein now being developed on Cornell creek, within six miles of Mt. Baker, is of a better quality than any other so far found in the county.

The Bellingham bay coal vein is the uppermost one in the coal measures of Whatcom county. It is 14 feet thick, a lignite in quality, and was extensively worked 20 years ago. Its outcrop is north through the middle of the city of Whatcom and thence north-westerly, dipping west and southwest from 8 to 10 degrees.

Blue Canyon Field.

Blue Canyon Mine.—This mine is located on the southeastern shore of Lake Whatcom, on the line of the Whatcom branch of the Northern Pacific Railway. The vein of coal that is being worked varies much in thickness, but averages about 7 feet. It lies at the very base of the coal measures, being separated from the mica schist lying below by a layer of conglomerate which varies from six inches to three feet in thickness. Where the conglomerate is thinnest the coal vein is greatly broken and shattered, and is occasionally faulted. Lying as it does between the massive sandstones above and the metamorphic rocks below, the vein has suffered greatly in the deformation of the coal measures. The vein pitches to the northwestward at an angle of 50 to 60 degrees.

The Blue Canyon mine has been in operation for a number of years, but has done little more than supply the demand of the cities and towns of Bellingham Bay and thereabouts. The coal is very desirable for steaming and for domestic purposes. In 1901 the output of the mine was 8,200 tons, and 1902 it was 6,010 tons.

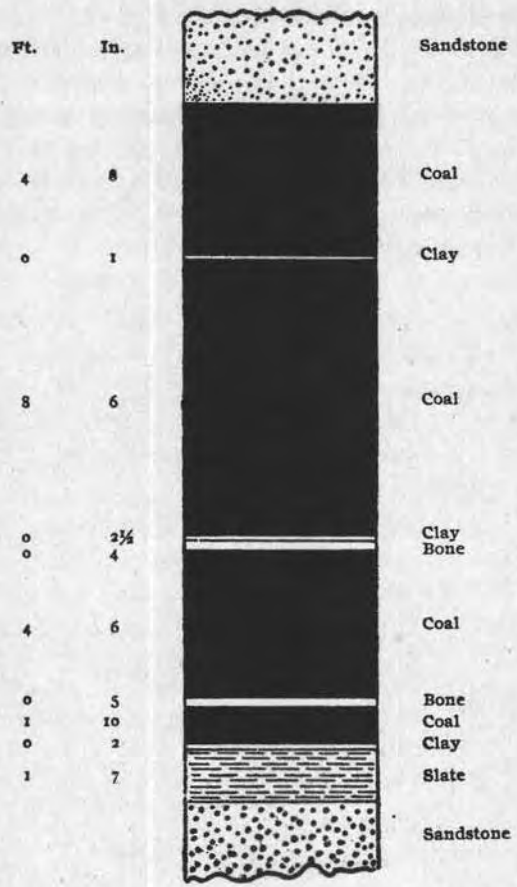


Fig. 1. Cross-section of Blue Canyon vein.

Cornell Creek Field.

On Cornell creek, a tributary of the North Fork of the Nooksack river, coal measures appear which have a thickness of not less than 20,000 feet. They are composed mainly of massive sandstone and conglomerate and are clearly continuations of the strata of the Blue Canyon field. In the coal measures are a number of veins of coal, one of them having a thickness varying from 2 to 14 feet. At one place in the south end of T. 29 N., R. 6 E., about $10,000 has been spent

in prospecting this coal vein, and 1,200 feet of tunnels have been driven. The vein has a strike about east and west and a dip of 70 degrees to the north. The coal is a semi-anthracite, or sometimes even an anthracite in character and contains from 78 to 92 per cent. in fixed carbon. While the coal vein is quite regular the coal itself is very much broken and in using it it may be necessary to feed it into the furnaces in the form of powder or else to make it into briquettes.

SKAGIT COUNTY.

In the western half of Skagit county coal measures outcrop at a number of places. Surrounding these outcrops, as a rule, there are small coal basins, which seemingly have never been connected but have always been separated one from another. In the northwestern part of the county the large coal field of Whatcom county extends into Skagit for a little way. A mile west of Thornwood, on Samish river, there is an outcrop of coal where a little development work has been done. Immediately east of Montborne there is a small area of coal measures with a few coal outcrops. Near Cokedale and Hamilton there is in each case a coal measure area in which well known veins of coal occur.

The coal-bearing rocks above mentioned are composed essentially of shale, sandstone, and conglomerate, with very much irregularly embedded vegetal matter in the form of lignite or coal. These deposits have been made in lakes which were enclosed in basins of metamorphic rocks, mainly schists and slates. After the lake sediments accumulated to a great thickness they were folded to such an extent that the strata are now often inclined at high angles. Since the disappearance of the lakes the lacustrine sediments have been largely removed by erosion, and it is possible that the removal has been so great in the cases of the smaller lake deposits that some of these may have been entirely eroded.

Cokedale Field.

Cokedale Mine.—At the town of Cokedale a coal mine has been in operation for a number of years. The mine is located

at the extreme northern limit of the coal basin, the lowest vein of coal being but a few feet from the schist which lies below. The coal measures of Cokedale outcrop along the northern boundaries of the district, but for the most part they

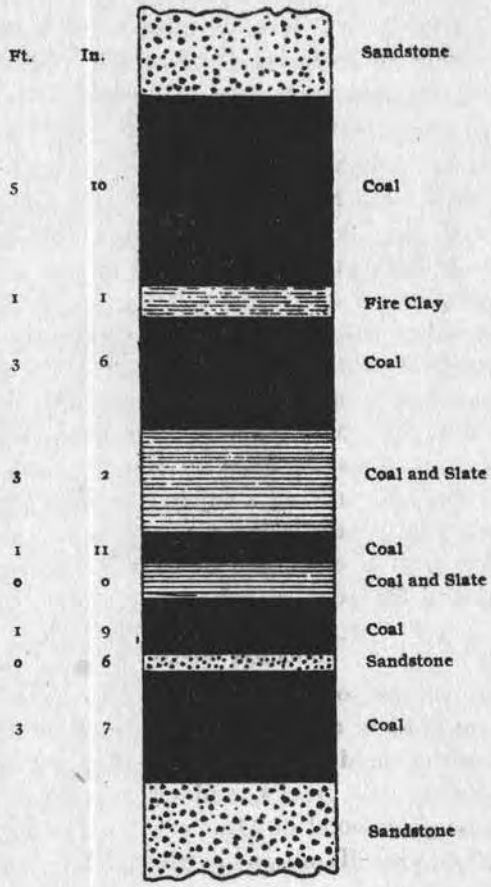


Fig. 2. Cross-section of Cokedale vein.

are covered by the alluvial deposits of the Skagit river. The district is not believed to be a large one, extending from Cokedale southward to the Skagit, and in an east and west direction from near Lyman to a point a little way beyond Sedro-Wooley.

At the Cokedale mine three veins of coal are found, viz.; the north or Klondike vein, the middle vein, and the south vein. The north vein is the lowest one in the series and has a thickness varying from 10 to 25 feet; the middle vein lies 140 feet above the north vein, stratigraphically, and has a thickness of from 4 to 8 feet, with an average of 6 feet; the south vein, lying 40 feet above the middle vein, has a thickness varying from 6 inches to 2½ feet. The north and middle veins only are worked at the present time.

The Cokedale coal veins at their outcrops stand about vertical, but in the lower mine workings they dip slightly to the southward. In the deformation of the coal measures the coal was so greatly broken that in mining it it is obtained only in small pieces, and never in large lumps. It is a good coking coal, and a large part of it is made into coke. The coal is all passed through washers after leaving the mine; the coarser part is then used for steaming and domestic purposes, while the finer part is taken directly to the coke ovens near by. Forty ovens are now in place. They are of the beehive pattern, each having a capacity of five tons. In 1901 the output of the Cokedale mine consisted of 12,643 tons of coal and 5,806 tons of coke, and in 1902 it consisted of 19,017 tons of coal and 601 tons of coke.

Hamilton Field.

A few miles east of the Cokedale district, and near the town of Hamilton, is a region of coal-bearing rocks known as the Hamilton field. This district lies chiefly between Cumberland and Day creeks, and extends from the Skagit river to the neighborhood of Deer creek. The rock outcrops of the Cokedale and Hamilton districts are separated by the broad alluvial plain of the Skagit, and it is not known at the present time whether the coal-bearing rocks extend from one district to the other.

At several places in the Hamilton district coal veins of commercial importance are known to outcrop. Upon some of these veins considerable development work has been done, and in times past some coal has been mined and sold. The

coal is of good quality, and of a variety that may be made into coke. As a rule the coal veins lie in such a position that they may be worked very readily.

On the property of the Skagit Cumberland Coal Company and on the lands of Mr. J. J. Conner, near the mouth of Cumberland creek, there are a number of outcropping coal veins. The first of these is located on the bank of Cumberland creek, not far from the contact of the coal measures with the underlying mica schist. This vein of coal has a strike of south 43 degrees east, and a southwest pitch of 55 degrees. It lies between sandstone walls, and has a thickness of about

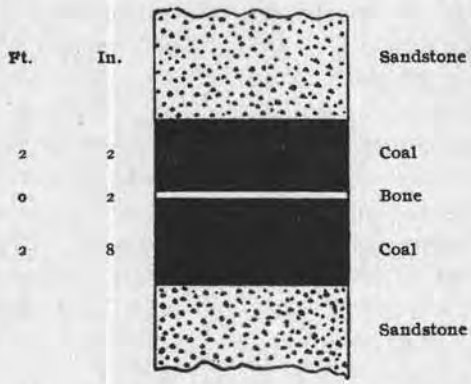


Fig. 3. Cross-section of Hamilton vein.

7 feet of clean coal. About a hundred feet stratigraphically above the vein just mentioned, is a second coal seam having approximately the same dip and strike, with a thickness of over 5 feet. Above the outcrop of the number two vein, at varying heights on the mountain side, are outcrops of several other veins of coal with thicknesses ranging from a few inches to 4 feet.

Toward the southern part of the Hamilton field, in the region about Day lake, coal outcrops at a number of places. In a few instances some development work has been done. In sections 13 and 24, T. 34 N., R. 6 E., the coal veins have a thickness varying from 8 to 12 feet.

KING COUNTY.

NEWCASTLE–ISSAQUAH FIELD.

Newcastle and Coal Creek Mines.—Newcastle is one of the oldest coal mining towns in the state, the mines having been in continuous operation for the last forty years. It is located about ten miles southeast of Seattle and about three miles from the eastern shore of Lake Washington. Most of the mining has been done in sections 25, 26, and 27, T. 24 N., R. 5 E. The mines are reached from Seattle by a branch of the Columbia and Puget Sound railroad, which runs around the southern end of the lake, by way of Renton. Both mines and railroad are the property of the Pacific Coast Company. The Newcastle mines are very favorably situated with regard to transportation facilities, being only about seventeen miles by rail from tide water.

The first discoveries of coal in this field were made in the valley of Coal creek, a small stream flowing into Lake Washington, and along which all the principal openings are located. The coal measures outcrop in the bed of the stream and on both sides of the valley. The prevailing rock is a fine grained light colored sandstone, having the bleached appearance characteristic of rocks associated with coal. Beds of shale all more or less darkened by carbonaceous matter occur interstratified with the sandstones. Immediately underlying the coal measures and at a distance below the lowest coal vein of not more than 150 feet is an older formation whose relation to the coal measures is not definitely known. It seems to be composed largely of volcanic rock, but in the vicinity of Newcastle contains scattered through it fossil leaves and stems. In the vicinity of Issaquah, along the valley of Tibbett's creek, a similar formation is seen underlying the coal measures but at this point the older rocks are evidently of true volcanic origin, being continuous with the mass of pyroxene andesite which forms Squak mountain nearby. To the northward of Newcastle the coal measures pass under a thick mantle of glacial drift which covers the whole surface of the country thereabouts. The structure of the field about Newcastle is that of a simple monocline, the strata dipping

northward at an angle of about 40 degrees. The strike of the measures is nearly due east and west.

The coal at Newcastle has been mined from a number of openings at various times. The last mine was opened in 1895, but it has not been working for the past two years. There are still about 100,000 tons of coal in this mine, and this will be taken out at some time in the future. At the present time active operations are confined to the new Coal Creek mine, located about one mile east of the town of Newcastle. Within this mine, and exposed along the creek, there are nine distinct seams of coal, but only four of them are being worked at the present time. The mine is opened by a double-track tunnel 5,800 feet long and 7 feet by 14 feet, in cross-section. Electric lighting and haulage are employed. It is about four years since work was begun on the main tunnel of the Coal Creek mine and the coal has been shipped from it for the last three years.

The main tunnel follows the course of the Bagley vein (known also as No. 1 and No. 2) for about 3,000 feet, or to a point where the Bagley vein splits into two parts. The tunnel then swings to the upper or northern bench and follows along that for the remainder of the way. The total width of the Bagley vein before it splits is 22 feet. The northern or upper bench, after splitting, is about 7 feet wide and the lower bench 12 feet wide. From the end of the main tunnel a crosscut has been driven southward to the lower bench of the Bagley vein, and gangways driven along the vein both east and west. Nearly all the coal in the lower Bagley bench between the crosscut and the mouth of the tunnel has been taken out. The crosscut tunnel has been extended northward to veins No. 3 and No. 4, both of which are being worked. The lower workings are connected underground with an upper tunnel 1800 feet long, which opens on the hillside above the town of Coal Creek. The coal is mined by the breast and pillar system where the roof is bad and by the panel system where the roof is good. In the breast and pillar system chutes ten feet wide are driven upward from the main gangway every forty feet. At a height of twenty-five feet they are widened

out to twenty or twenty-five feet with pillars between them twenty-five or thirty feet wide. The breasts are carried upward to the next gangway above or to the surface, or as near to the surface as it is safe to go. Crosscuts four feet wide are driven through the pillars every sixty feet to allow of a circulation of air through all the workings. Each pillar is then split from the bottom upward by a ten-foot chute. This is carried upward to the top and the narrow strip six or seven feet wide on each side drawn from the top downward. In this manner all the coal is extracted except a row of stump pillars left to prevent the gangways from caving. All the workings from which the coal has been extracted are allowed to cave. In the panel system breasts about fifty feet wide are driven and pillars thirty feet wide left between them. This system can only be employed when the roof is very solid. In veins No. 1, No. 2 and No. 3 the breast and pillar system is the only one that can be employed on account of the shaky condition of the roof. The panel system is employed in vein No. 4, which has a much more solid roof than the other. Modifications of the two systems are sometimes employed to suit the varying circumstances. On the character of the roof depends to a considerable extent the cost of mining.

A slope was sunk on a vein near the mouth of the new tunnel a number of years ago and a large amount of coal was taken out of it, but the mine caught fire about eight years ago and it was therefore abandoned and allowed to fill with water up to the water level. This vein splits in going westward and has been worked in the Newcastle mine as two distinct veins, separated from each other by about sixty feet of rock. In the new Coal Creek mine the same vein is known as No. 3, and when followed eastward it attains a width of about forty-two feet between walls, but of this width not more than two or three feet is clean coal. The remainder of it is composed of thin bands of clay, bone, and coal, alternating with one another.

In the old Newcastle mine the veins when followed westward were found to be involved in a fault which threw them

about one hundred feet to the northward. Another fault occurs between the Newcastle and Coal Creek workings which has served a useful purpose in preventing the spread of fire and water from one set of workings to the other. No faults of any importance have been encountered in the Coal Creek mine. The strike of the veins is nearly the same in all parts of the mine. The dip varies from 38° to 40°, but is usually about the latter. The coal from Newcastle has been tilted upward from its original horizontal position without undergoing any internal movement within the seams, and therefore has not

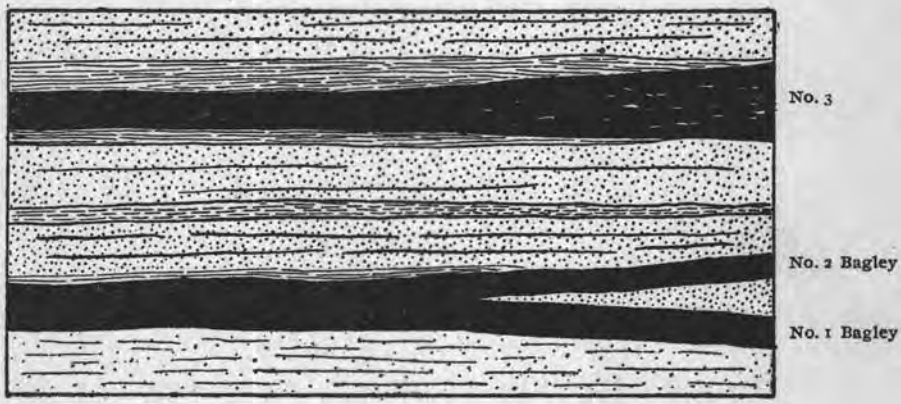


Fig 4. Cross-section in Coal Creek Mine, near Newcastle, showing splitting of vein.

lost its lignite character. It is a hard, compact coal with a bright lustre. It is used almost exclusively for steaming and for domestic purposes. None of the veins are of solid, clean coal, but all contain streaks of more or less bony coal, which must be hand picked and washed.

It is not customary for the veins in the Newcastle field to be followed until they pinch out. Usually when followed any considerable distance the coal forms a relatively small proportion of the total contents of the vein. Some of the largest veins known to occur in the coal measures are not worked because they have too high a percentage of ash. A layer of dirty coal or bone overhanging a workable seam detracts consid-

erably from its value on account of the difficulty of holding up such a roof. Sandstones make the best roof and impure coal and bone make the poorest. Care is taken in the mines not to leave very much coal behind in the abandoned workings. When brought into contact with air the coal left behind gradually heats and finally takes fire, owing to the oxidition of its volatile constituents. Some disastrous fires have arisen from this cause, notably the one started eight years ago in veins No. 1 and No. 2, which is still burning.

The outside equipment of the Coal Creek mine consists of a modern washing plant having a capacity of about 500 tons per day of ten hours. All of the coal from the mine is sent to the washers. About 1000 tons of coal are required to make 600 tons of clean, marketable coal. The coal cars are dumped onto screens which allow the fine coal to pass through them. The coarse coal goes onto sorting tables, where the bone and rock are picked out by hand. The fine coal goes to the washing machines. A strong current of water is forced in from below and the coal and dirt are kept in constant motion by revolving arms and by the upward current of water. The coal being lighter than the dirt accumulates at the top and is washed over the sides. The dirt is drawn off from the bottom at intervals of about ten minutes. The coal as it passes from the washing machine falls into revolving screens, which separate it into two grades, nut coal and pea coal. Nut coal is put on the market for domestic use. The pea coal is used for steam making and a large amount of it is used under the company's own boilers. A 265 H. P. engine and dynamo generate power to run the electric motor and furnish lights for the main tunnel. A subsidiary engine and dynamo furnish lights for the two towns of Coal Creek and Newcastle. Other engines run the fans and the washing plant.

The mines about Newcastle have produced in round numbers about five million tons of coal. The output for the year 1901 was 130,957 tons, and for the year 1902, 140,841 tons.

Issaquah Mines.—These mines are located two or three miles from the southern end of Lake Sammamish, at the northern base of Squak mountain, about six miles east of Newcastle.

Pacific Railway, which runs around the northern end of Lake Washington. The coal is a lignite similar to that of Newcastle and is used entirely for domestic purposes and for generating steam. It is sold on the market under the name of Grand Ridge coal, the name being taken from one of the company's mines on the eastern end of the property. Most of the coal has been taken out of section 33, T. 24 N., R. 6 E., but in some of the gangways the coal has been followed westward into section 32, the 800 foot level of No. 4 vein having been driven more than half way across that section.

Squak mountain forms the western part of a great mass of eruptive rock which is cut fairly in two by Issaquah creek, a They are reached by the Snoqualmie branch of the Northern comparatively insignificant stream which flows northward into Lake Sammamish. About two miles south of the town of Issaquah the stream leaves the narrow gorge by which it flows through the mountain and enters a wide, level valley which extends northward to Lake Sammamish. The coal measures lie upon the northern flank of Squak mountain and dip to the northward at an angle varying from twenty to forty degrees. The mines are opened by slopes and water level tunnels driven on the western edge of the valley at the base of the mountain.

There are five principal veins in the Issaquah series, varying in width from five to eighteen feet. The dip of the veins has been found to increase with depth; at the surface it is about twenty degrees, but in the lowest workings it is thirty-eight or forty degrees. Operations are now conducted on veins No. 4 and No. 5. No. 5 vein is worked by a water level tunnel which runs westward into the mountain. The coal is now nearly all worked out above this level. During the past year an upper tunnel was run on the vein for a distance of about two hundred feet and the coal sent down to the washers over a 1200-foot incline. In this upper tunnel the vein is five feet in thickness and contains two seams of clay having thicknesses of four inches and two inches respectively. Vein No. 1 was worked by a slope 800 feet long, from which gangways were driven east and west from the 400-foot and 800-foot levels. This vein has a total width of eighteen feet, but there is only

eight feet of it that is clean enough to work. The remainder of the vein contains thin streaks of coal and bone interstratified. Vein No. 4 is the principal producer at the present time. A rock tunnel was driven northward from the bottom of the slope on the 800-foot level of No. 1 vein to No. 4, and a large amount of coal has been taken out of No. 4 by this opening, and it is still producing a little coal. A new slope was sunk on No. 4 vein about a year and a half ago. It is now down a distance of twelve hundred feet and it is proposed to sink it still deeper. This vein has been worked extensively to the westward, having been followed for two miles on the 800-foot level,

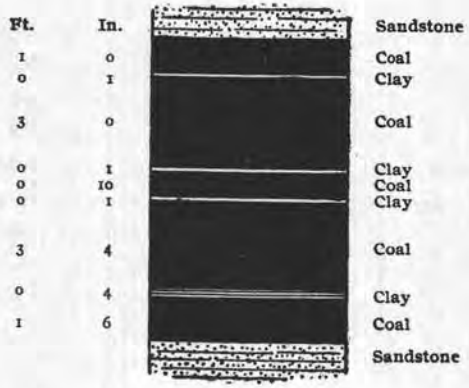


Fig. 5. Cross-section of No. 4 vein, Issaquah, in East gangway, 1200-foot level.

or beyond Tibbett's creek. It is said to become too bony in that direction to be worked with profit. This vein is only four and a half feet thick at the bottom of the slope, but when followed westward it widens to twelve feet, and at the point where work was stopped at the east end it is nine feet wide. On the 1200-foot level the west gangway is now in about 2000 feet. At the face of the gangway the vein contains seven feet six inches of coal, with only one or two small partings of clay. At the face of the 1200-foot level east the vein showed nine feet ten inches of good coal, with very little clay.

Thus far every attempt to drive the gangways eastward

under the valley of Issaquah creek has met with failure. The floor of the valley is composed of glacial sand and gravel to a depth of at least four or five hundred feet, and wherever this has been tapped by the gangways the miners have been driven out by floods of water and sand, and strong bulkheads of timand cement have had to be erected to prevent the mine being flooded. The last encounter of this kind was in the east gangway of the 1200-foot level of No. 4 vein. Water and gravel had previously been encountered in the 800-foot level of both No. 1 and No. 4. It was hoped that at the 1200-foot level it would be possible to get under the valley, but in the workings sand, gravel and clay of the old valley were again encountered and the miners were driven out.

The bottom of the ancient valley is considerably below sea level and it probably was occupied in pre-glacial times by an arm of Puget Sound, which at that time covered a much more extended area than at present. Lake Washington at that time constituted a part of the Sound, and beyond this lake a long arm of the sea occupied the basin of Lake Sammamish as far south as Issaquah. The debris left by the ice on its retreat has greatly modified the old topography and has completely filled up many of the old waterways. When the glacial material was encountered in the Issaquah mine it was found to be composed of clay, sand and gravel, with many large boulders scattered through it. It also contains a large amount of water under sufficient pressure to flood all of the tunnels which have been thus far driven into it.

The structure of the field about Issaquah is very similar to that about Newcastle. The general strike of the coal measures is N. 80° W., or within four degrees of that of Newcastle. This strike would carry the Issaquah veins to Newcastle, and it is probable that the veins of the two places, if not identical, are at least in the same geological horizon. There is a vein at Issaquah sometimes called the Bagley vein, but it is by no means certain that it is the same as the Newcastle vein of the same name. The gap between the two localities, Newcastle and Issaquah, has lately been bridged to some extent by the workings of the Consolidated Coal Company's mine on Tibbett's creek,

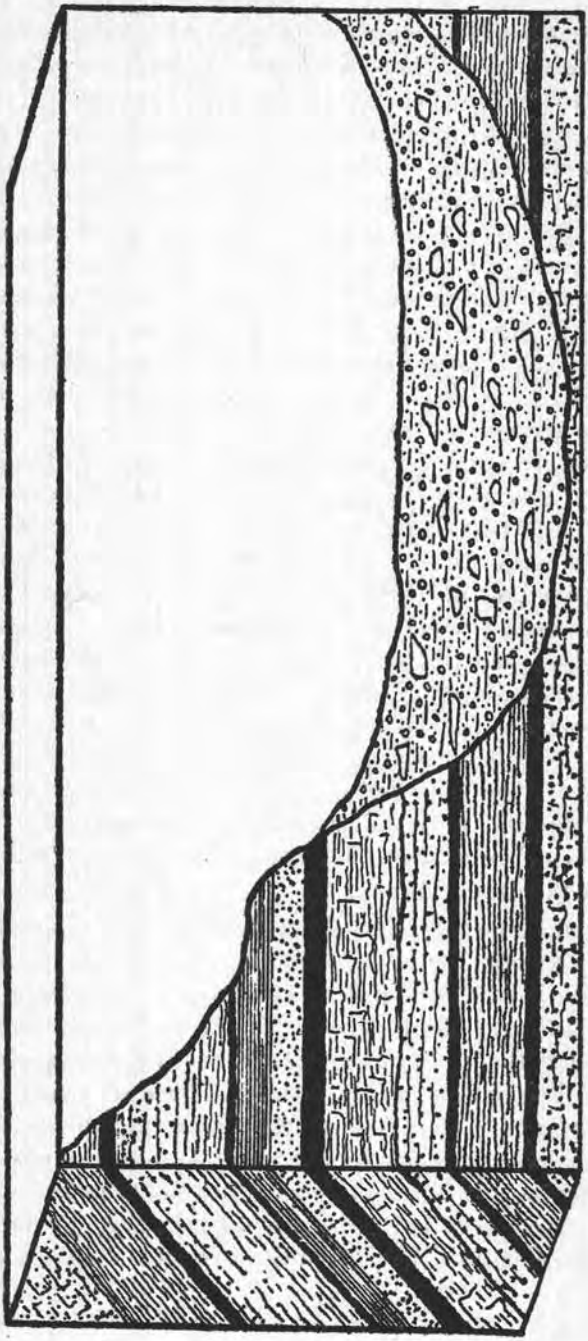


Fig. 6. Illustrating pre-glacial erosion in Issaquah Coal Field.

described below. It serves to further strengthen the theory that the coal field is continuous between the two places.

About two miles east of Issaquah the strike of the coal measures swings around to the northward and the veins dip westward. The Issaquah Coal Company has opened up some veins in Sec. 26, T. 24 N., R. 6 E., at a place known as Grand Ridge. Two slopes and a tunnel have been driven here, but no work is being done at present. It is the intention of the company to work out all of this coal by way of the Issaquah openings as soon as they find a way of tunneling under the Issaquah valley successfully. The veins at Grand Ridge are underlaid at a depth of about 250 feet by eruptive rocks, which may be seen outcropping along the railway. It is not likely that these rocks have been intruded into the coal measures, but probably constitute an older formation upon which the coal measures were laid down. Two veins have been worked at Grand Ridge, the upper one being four feet and the lower one seven feet in thickness. They pitch N. 68° W. at an angle of 25 or 30 degrees. The coal seams in this mine are underlaid with clay and considerable trouble has been experienced because of the clay floor squeezing up into the tunnels.

The Issaquah mines (formerly known as the Gilman mines) were opened by the Issaquah Coal and Iron Company in 1887. The holdings of the company embrace a tract of land five miles long by one and a quarter miles wide. Up to the present time about three hundred and twenty acres of coal have been worked out, and the mines have yielded about 1,500,000 tons of coal. The output for 1901 was 121,829 tons, and for 1902 it was 117,184 tons.

The Consolidated Coal Company of Seattle is opening a new mine on Tibbet's creek, between Issaquah and Newcastle. Two tunnels have been driven on the east side of the creek in the southern part of section 32. One tunnel is about 90 feet long, and the other 175 feet long, both on the same vein. This vein measures eight feet in width and contains only one two-inch streak of clay. It is probably the same vein as No. 6 of the Issaquah Coal Company, whose western gangways on the veins lying above No. 6 have passed under Tibbett's creek not

very far north of the Consolidated workings. The general strike of the veins on Tibbett's creek is the same as at Newcastle and Issaquah, and the dip is to the north. As soon as facilities are arranged the coal will be hauled from the mine to the washery, a distance of three and a half miles, by an electric motor. The washery and bunkers will be situated on the railroad, about a mile and a half below the town of Issaquah, where the company has acquired a site for its plant.

Renton–Cedar River Field.

The depression occupied by Lake Washington is continued southward first as Black river valley, and then as White river valley. Less than a mile from where Black river leaves Lake Washington, Cedar river enters the former from the eastward, flowing through a narrow, steep-sided valley for a number of miles and entering the broader valley at the town of Renton. Between the valleys of Cedar river and White river there is a plateau which from the surface indications seems to be composed entirely of glacial drift. It has an average elevation of about four hundred feet above the level of the bordering valleys. Along the steep-sided northern and western edges of this plateau, especially near the town of Renton, the coal measures outcrop from beneath the covering of glacial drift. Seven or eight miles farther up the valley of Cedar river the coal-bearing rocks are again exposed, where the Cedar mountain mine has been opened.

Renton Mine.—The Renton coal mine is located on the hill back of the town of Renton, at the southern end of Lake Washington, near the point where Cedar river enters the northern end of White river valley. The main tunnel of the mine runs in an easterly direction into the hillside about half a mile south of the town and not more than thirty or forty feet above the level floor of the valley.

Coal has been mined in the vicinity of Renton for the last thirty years. The old Talbot mine, located south of the present workings, was worked out many years ago and abandoned. The present mine is located between the old Talbot workings and Cedar river valley. While three veins are known to occur

here, only two are being worked at the present time. These veins are known as No. 2 and No. 3, the former overlying the latter at a distance across the strata of about eighty-seven feet. The veins dip eastward at an angle varying from fifteen degrees at the surface to ten degrees at the bottom of the slope. The strike of the veins in the present mine is nearly due north and south. In the south workings of the Talbot mine the measures swing around to the westward, the change in direction being much more pronounced in the upper levels of the mine than in the lower ones. To the northward of the main slope in the present mine the veins have been followed

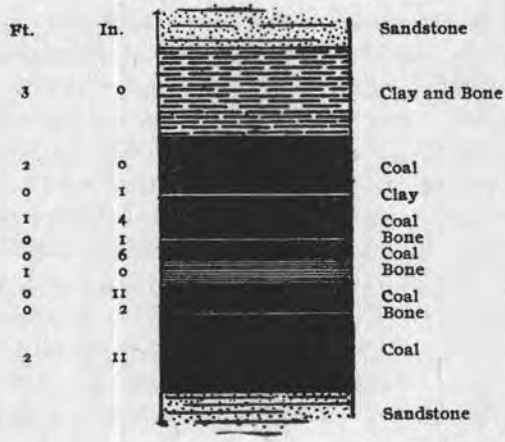


Fig. 7. Cross-section of vein No. 3, Renton Mine.

until the surface gravels were reached in the Cedar river valley, a distance of about 2500 feet. The veins do not outcrop anywhere on the surface, but are covered to a depth of twenty or thirty feet by glacial gravel.

In the development of the mine most of the work done thus far has been on No. 3 vein. On this vein a slope 1100 feet long has been sunk, through which until recently all of the coal mined was brought to the surface. The coal is now all taken out through a tunnel 400 feet long which enters the hill a little above the valley level and connects with the slope. Four levels have been driven north and south from the slope. Four

rock tunnel connects veins No. 2 and No. 3. No. 2 has only recently been opened, but it is rapidly being put in shape for extensive working.

No. 3 vein is about nine feet thick, nearly eight feet of which is good coal. In the northern part of the mine there is a three-foot layer of bone, shale and clay overlying the coal. These materials scale off and do not make a good roof. They are in turn overlaid by a thick bed of soft, white, incoherent sandstone. To the southward the bone, shale and clay thin out until the sandstone lies directly upon the coal. No. 2 is a sixteen-foot vein, only the upper seven feet of which is worked. The roof of this vein for several feet overhead is a hard shale which usually makes a good roof, but occasionally scales off. Everywhere in this roof of shale are found stumps of trees standing upright, with their roots still embedded in the ancient soil. Tree trunks lying prostrate also occur, some of them forty or more feet long. The soil on which this forest grew lies directly upon the topmost layer of coal. The soft vein matter which forms the floor of the workings on No. 2 vein keeps squeezing up so that the floor is continually rising and has to be lowered occasionally. There is another vein still higher in the series, known as No. 1. It outcrops on the hillside above No. 2, but not much known as to its value, since it has never been prospected to any extent.

A number of irregularities in the strata have been encountered in the mine. On the north side of the main slope a fault occurs, having a throw varying from fifty feet in the upper levels to 80 feet in the lowest level. This fault is a simple break in the strata whereby the rocks have been pushed past each other so that they overlap for a distance of forty or fifty feet. In the south level a similar fault occurs with the strata overlapping. This fault has a throw of forty-five feet. Apparently the large block forming the center of the mine has been forced down by lateral pressure and the two outer sides forced upwards on it. There are a number of minor irregularities in the vein but none of them have interfered seriously with the process of mining. A disturbance in the strata also occurs in the valley of Cedar river. This is shown by the fact

that extensive prospecting on the north side of the valley has failed to find the coal where it should occur if a break in the strata or a sudden change in the strike had not taken place.

The sandstone which forms the greater body of the enclosing rock is very soft and friable. When thrown on the dump it quickly crumbles into loose sand. Considerable trouble has been experienced on account of the walls squeezing together thereby necessitating constant retimbering. This crushing movement is due chiefly to the flatness of the vein and the unconsolidated character of the overlying rocks.

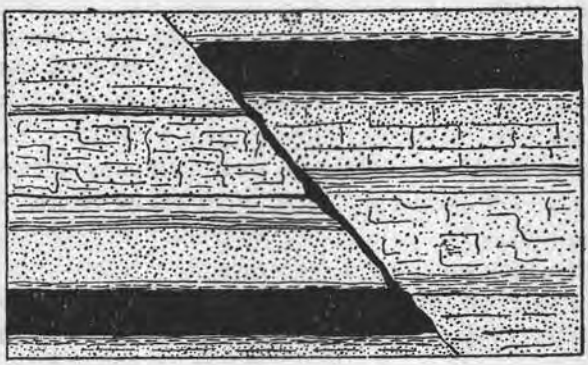


Fig. 8. Reverse Fault, No. 3 Vein, Renton Mine.

The Renton coal is a black lignite. At the present time about 400 tons per day are being taken out. The coal is hand picked and washed with Howe washers before being placed upon the market. The mine is now the property of the Seattle Electric Company, who use about half of the entire output in their own furnaces and the rest is placed upon the market as a domestic and steam coal. The total output of the mine for 1901 was 72,865 tons, and for 1902, 104,071 tons.

Cedar Mountain Mine.—Cedar Mountain is a station on the Columbia and Puget Sound Railway about twenty miles southeast of Seattle, and six miles east of Renton. Formerly it was an important coal shipping point but of late years it

has not been very active. At this place several seams of coal may be seen outcropping in the railroad cuts and in the bed of Cedar river. The most important vein is known as No. 1, which varies from eleven to fifteen feet in thickness, practically all of which is clean coal. This is the vein that was worked in the old Colman mine on both sides of Cedar river for a number of years and was a great producer in its day. The Colman mine was worked by a slope from which gangways were driven both north and south on vein No. 1. The north workings were continued until the gangways ran into an old pre-glacial stream channel which cut out the coal in that direction. Southward of the main slope the gangways were extended until they encountered a fault of unknown extent, beyond which the vein seemed to be lost. Surface prospecting for a long time failed to discover what had become of the lost vein and after all the coal had been worked out north of the fault the mine was closed down in 1892.

In 1898 the Cedar Mountain Coal Company opened a new mine on a vein known as No. 2, lying below No. 1. No. 2 is nine feet thick but contains a seam of dirt a foot or more in width which must be mined with the coal. Until a washing plant is built this coal cannot compete in the market with the washed coal of other mines. Nevertheless from No. 2 there was shipped 13,500 tons of coal in 1901, but active operations ceased in the spring of 1902 because of a change of ownership of the mine. The coal from No. 1 vein never required washing but was shipped just as it came from the mine.

More thorough prospecting has lately uncovered No. 1 vein on the other side of the fault from where it was abandoned in 1892. The surface of the country away from the river is heavily covered with brush and fallen timber and the solid rock lies beneath a mantle of gravel, sand, and soil many feet in thickness. This accounts for the delay in finding the vein. The coal is a hard black lignite and is a good domestic and steam coal. It contains a high per centage of moisture and volatile hydrocarbons but burns freely and when it was on the market was popular as a domestic coal.

The Cedar Mountain Coal Company own all of section thirty except the south half of the south half. They also own nearly all of section nineteen south of Cedar river. Several other veins of coal occur on their property, but beyond the fact of their existence little is known of them. It is probable, however, that some of them will yet prove to be valuable.

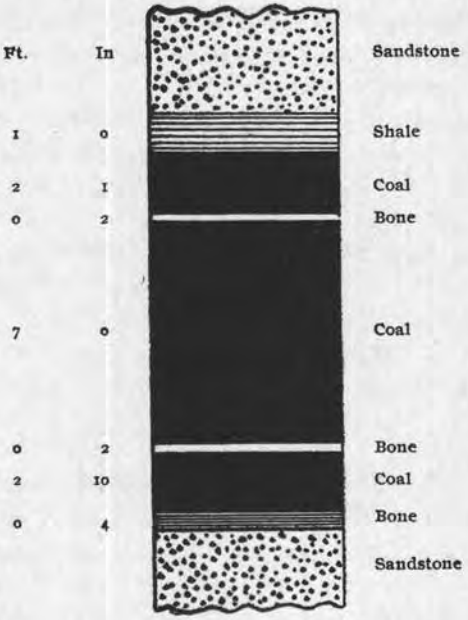


Fig. 9. Cross-section of vein, Cedar Mountain Mine.

Niblock Field.

The Niblock Coal Company own lands to the extent of 2,160 acres lying about two miles south of Snoqualmie Falls. A short branch railroad has just been completed to the mine from the Snoqualmie branch of the Northern Pacific Railway, connecting with the main line about half a mile above the Falls. The Green River Northern branch of the Northern Pacific Railway is also being extended into the same region and will make its terminus in the Niblock property. This latter road is being built primarily to take out the splendid

timber which covers all that region but it will also afford an outlet to the southward for the Niblock coal. The distance by rail to tide water in either direction is about fifty miles. The region in which the coal occurs is about nine miles east of Issaquah and well within the foot hills of the Cascade range. The strata are considerably more disturbed and broken than are those of Issaquah and Newcastle. The coal has lost its lignite character and has become a soft bituminous coking coal. The region is one of somewhat rugged topography. The coal lies upon the western side of a ridge about a thousand feet high which parallels Snoqualmie valley for several miles above the falls, and which is composed in large part of eruptive rocks. To the west and south of the Falls there

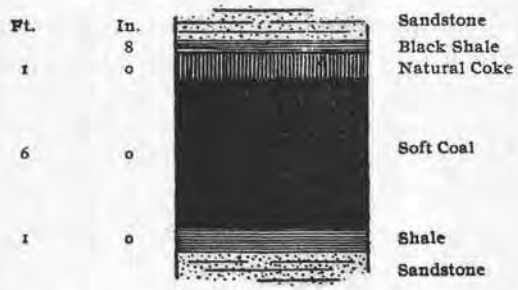


Fig. 10. Cross-section of No. 2 Vein, No. 8 Tunnel, Niblock Mine.

are a number of ridges and isolated hills composed of eruptive rocks which form conspicuous features of the landscape. Their relation in age to the coal measures has not been satisfactorily determined, but in the Niblock field it is evident that, in part at least, they are older than the coal measures.

There are eight veins of coal known to occur within the field, but only two of them have been prospected to any great extent. These are known in the series as No. 3 and No. 5. Vein No. 3 varies in width from seven to nine feet. It is a first class coking and blacksmithing coal, and has been extensively prospected by tunnels and test pits, the longest tunnel being about 700 feet. Vein No. 5 consists of two benches of coal, each about six feet thick and separated from each

other by eighteen inches of bone and shale. The upper bench is rather soft and dirty but the lower bench is good commercial coal. It consists of three or four layers separated from each other by thin partings of clay. Both veins are enclosed in sandstone walls.

The strike of the coal measures is north 12 degrees west and the dip is to the southwestward, at an angle of from forty-five to sixty degrees. The veins in places are pockety, i. e., they widen and contract quite rapidly. This in itself does not involve much loss of coal, since what is lost in one place is gained in another, but during the process of pinching in which the walls were slid along one another a considerable amount of the wall rock was mixed in with the coal thereby rendering some of it too dirty to be of any value.

The development work on the Niblock property has extended over a period of ten years or more and consists of several tunnels and a large number of test pits. About $25,000 in all has been spent in putting the mine in shape to ship coal. The lowest tunnel, through which it is intended to work the mine, has been driven a distance of four or five hundred feet. An inclined tramway leads from the mine mouth to the washing plant and bunkers situated on the railway track. A coking plant is also contemplated to treat the coal from vein No. 3. Some of the other veins will probably be found clean enough to work when they are developed. The region is all very heavily covered with thick underbrush making it difficult to explore, and this accounts in part for the slowness with which the mines are being opened.

Raging River Field.

The Raging River field lies a few miles to the southwest of the Niblock field and embraces a considerable portion of T. 23 N. R. 7 E., on the western side of Raging river. No mines have ever been developed in this district and little is known of the extent of the coal. Surface croppings have been found in many places over an area of eight or ten square miles, and in several instances prospect tunnels have been driven as far as 200 feet. The coal for the most part seems to be considerably

broken up and has been rendered bituminous. An eight-foot vein occurs on section 8, while the croppings of seven or eight veins have been found on sections 16 and 21. On section 26 much tunnel work has been done in times past but little of value has been found.

Fig. 11. Cross-section of vein, Raging River Field, Secs. 25 and 26, T. 23 N. R. R. 7 E.

In the region south of Raging river coal has been found north of Walsh lake in section four. In section 3 a coal vein shows in a deep gulch along the Columbia and Puget Sound Railroad, about half a mile above Sherwood Station. This vein stands perpendicular, with a north and south strike. A short tunnel has been driven on the vein but the coal did not prove to be of any value. The region is one of low relief and the surface is nearly everywhere covered by glacial drift. It is probable that the coal measures underlie all of it. From the occasional outcrops found it is evident that the rocks are thrown into a series of north and south folds which involve the Niblock and Raging river fields.

Green River Field.

This coal field is located about thirty miles southeast of Seattle, on the line of the Columbia & Puget Sound Railway. It includes most of T. 21 N. Ranges 6 and 7 E., with portions of the adjoining townships north and south. Green river flows along the southeastern edge of the field in a deep canyon cut in the coal bearing rocks. Away from the river the surface of the country is covered with glacial drift, in some places to a considerable depth, but usually with only a thin coating. Along the railroad between Black Diamond and Frank-

lin the coal bearing rocks appear in the cuts. They are mostly sandstones, weathered into light buff or brown tints by the oxidation of the iron. A large number of shale beds occur, more or less darkened by the carbonaceous matter which they contain, and associated with them are about forty beds of coal, bone and black shale, varying in width from a few inches to forty feet or more. Only three or four of the coal seams are clean enough to work. The McKay or Black Diamond vein is by far the most important of all, and varies in width from four feet six inches to seven feet, practically all of which is clean coal. The McKay vein has produced nearly all of the coal mined in the district. At the present time it is the only vein worked outside of the Franklin mine, where two other veins are being worked, viz., the Gem and the Fulton or No. 12 vein. The Fulton vein is about forty feet wide between walls but contains many streaks of bone, and only a small part of it can be worked. The Gem vein, lying above the McKay and Fulton veins, is three feet wide, without any partings of bone or clay in it. Other veins occur above and below these but it is not believed that any of them are clean enough to work.

The rocks of the district have been thrown into broad open irregular folds trending in a general way northeast and southwest and pitching to the southwest. Black Diamond is on the western edge of the field and Franklin on the eastern edge. The two mines of the Black Diamond Coal Company, No. 11 and No. 14, are located on the western side of an anticline and the Lawson mine and the old Light Ash mine are on the corresponding eastern side. Between Lawson and Franklin the strata form a basin on the eastern rim of which the Franklin mines are opened, the veins dipping westward at steep angles. The intermediate mines, Black Diamond No. 12, and Franklin No. 7, are located upon the northern rim of the basin.

Coal was first discovered along Green river in 1880 and the Black Diamond and Franklin collieries were opened two or three years later. At the present time there are seven mines in operation and the total output is not far from 1,500

tons per day. The coal is a high grade semi-bitumionous steam coal and used very largely for locomotives and steamers. It leaves only a small quantity of ash, with no clinkers. In composition it occupies an intermediate position between the lignites of Renton and Newcastle and the bituminous coking coal of the Wilkeson-Carbonado district.

Black Diamond Mines.—These mines, two in number, are located on the western edge of the field, in sections 11 and 14. The old slope, No. 14, is sunk on the Black Diamond vein in section 14. Three levels have been driven on the vein in both directions, from the main slope. From the third level a second slope has been sunk and two levels driven from it. The Black Diamond vein is the only one worked in this mine. It varies in width from five feet ten inches to six feet three inches. The coal is so clean that it does not require washing but is placed on the market just as it comes from the mine. The levels driven southward from the slopes ran into broken ground in the vicinity of Lake Jones and the vein was not followed any further in that direction. In the northern part of section 14 three minor faults were encountered in the workings. The third one near the line between mines No. 11 and No. 14, was not penetrated but was left to serve as a wall between the two sets of workings. In the north end of mine No. 14, the strike of the vein is almost due north and south, but when followed southward it swings to the eastward almost at right angles. The nature of the disturbance in the strata at Lake Jones is not definitely known, but it is supposed that there is a sharp synclinal axis accompanied by faulting. Whether or not the Black Diamond vein and the McKay vein are identical is still open to dispute. They are generally believed to be the same but until that part of the field around Lake Jones is explored underground the question can not be settled.

No.11 mine is opened by a slope one mile north of No. 14. There are two veins in the No. 11 mine, one known as the little vein and the other as the Black Diamond vein. The little vein lies above the Black Diamond vein about eighteen or twenty feet. It is rather dirty and is not being worked at

present because the coal would have to be washed. The main slope, 1,600 feet long, is sunk on the little vein. Another slope 400 feet long goes down to the fourth level, which is the deepest in the mine. From the two slopes gangways have been driven north and south, the south gangway going as far as the fault, which separates No. 11 from No.14. Northward the vein has been followed over 5,000 feet. It goes first north and then swings to the eastward into section 12 where it has an almost east and west strike.

Fig. 12. Cross section of Black Diamond vein, Black Diamond Mine.

Black Diamond mine No. 12 is on the opposite side of the anticline from the two other mines of the company. It is opened by a slope on the McKay vein near the eastern boundary of section 12. It is not being worked at the present time.

The Black Diamond mines are owned by the Black Diamond Coal Company. They produced in 1901, 227,000 tons and in 1902, 258,996 tons.

Franklin Mines.—The Franklin mines are owned by the Pacific Coast Company. The property of this company includes four sections of land directly east of the Black Diamond mines. At Franklin three veins are being worked, the

McKay, the Fulton or No. 12, and the Gem. The first two are operated by means of a slope, and the Gem by means of a tunnel, which is over a mile long. The opening of the Gem tunnel is in section 19, and it runs northward through most of section 18. A shaft is being sunk near the mouth of the Gem tunnel to open up the McKay vein, which it is expected will be found at a depth of about 1,350 feet. The McKay vein was formerly worked by way of the main slope of the old mine as far down as the seventh level, but at the time of the big explosion, several years ago, the mine took fire and had to be flooded.

Fig. 13. Cross-section of Gem vein, Franklin Mine.

The three Franklin mines, No. 1, No. 7, and Gem, produced in 1901, 129,171 tons, and in 1902, 190,080 tons.

Lawson Mine.—The Lawson mine is located on the western rim of the McKay basin, in the western part of section 13. It is the northward continuation of the old Light Ash mine. A slope 1,400 feet in length has been sunk on the McKay vein which is the only one worked in this mine. The vein averages in thickness about four feet four inches of clean coal. This mine makes considerable gas, and the safety lamps are used in nearly all the underground workings. The coal that is to be reached from this slope covers the space between the Light Ash mine on the south and Black Diamond No. 12 on the north. It is estimated that there are as yet 5,000,000 tons of coal within reaching distance of the Lawson slope. The output of the Lawson mine in 1901 was 97,329 tons, and in 1902, 107,750 tons.

Kummer Mine.—This mine, belonging to the Denny Clay Company, is located at Kummer, on Green river,

toward the western border of this field. Kummer is reached by a branch line of the Columbia & Puget Sound Railway. The mine is not worked extensively, the output being limited to the coal used in the works of the Denny Clay Company in Seattle. The number of tons mined in 1902 was 10,044.

Ravensdale Mines.—The Ravensdale or Leary mines are located on the Palmer cut-off in section 36, T. 22 N., R. 6 E.

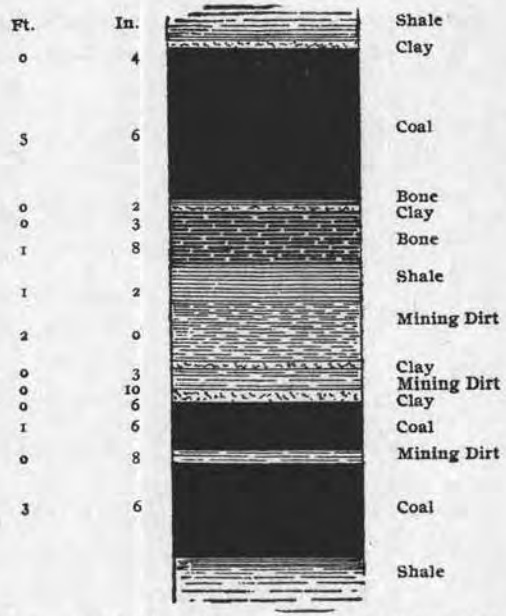


Fig. 14. Cross-section of No. 4 vein, East side, Ravensdale Mine.

They are the property of the Seattle & San Francisco Railway Company. The mines are located on a series of veins which outcrop about a mile and a half north of the most northern mines of the Black Diamond Company. Between Ravensdale and Black Diamond there are no rock outcrops, since the country is flat and swampy and is covered with glacial drift to an unknown depth. It seems probable that the Ravensdale veins occur considerable higher in the series than those of Black Diamond and Franklin. The end of the north gangways of Black Diamond mine No. 11 shows the strata dipping

northward, and at Ravensdale, a mile and a half further north, they are dipping in the same direction at angles varying from twenty-five to forty-five degrees. Unless there should be a fold in the intervening space, which is not impossible, the Ravensdale veins must be assigned to a considerably higher place in the coal-bearing series than those of Black Diamond.

Six veins of workable size occur in the Ravensdale series, the two extreme ones being about eighteen hundred feet apart, measured across the strata. Only three veins, No. 4, No. 5,

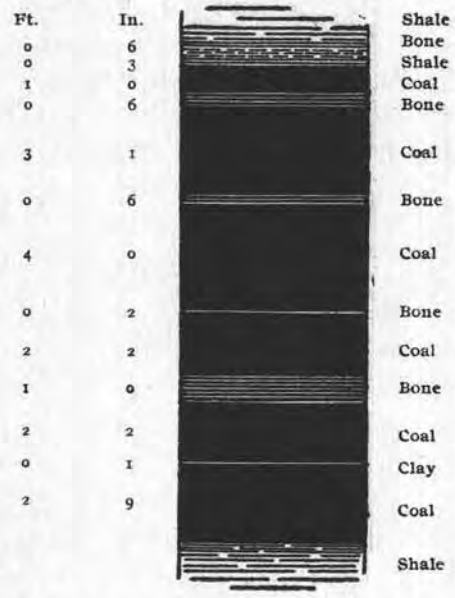


Fig. 15. Cross-section of No. 5 vein, east side, Ravensdale Mine.

and No. 9 are being worked at the present time. They outcrop on both sides of a small creek, and tunnels have been driven east and west on the outcrops. Those on the west side are being the most actively developed.

Vein No. 3 has been opened by tunnels on both sides of the creek. It contains five benches of coal varying in width from nine to twenty-nine inches and separated one from another by clay partings from two to six inches, in thickness. The vein contains too large a proportion of waste and is not

being worked. No 4 vein is over eighteen feet wide between walls and contains three benches of coal, with widths of one foot six inches, three feet six inches, and five feet six inches respectively. Tunnels have been driven on No. 4 vein on both sides of the creek, but only the west tunnel is now being worked. Vein No. 5 is over eighteen feet wide, fifteen feet of which is coal. The vein contains several partings of bone from an inch to a foot in width. It is worked on the west side of the creek by a tunnel now in a distance of 1,500 feet and a slope about 420 feet long. The next workable vein above No. 5 is known as No. 9. It contains a bench of about three feet of good coal in the middle of the vein. It is opened by tunnels on both sides of the creek. Two other veins, No. 1 and No. 2, have been uncovered but neither of them are considered clean enough to work.

An electric locomotive is used in hauling the coal from the mine mouth to the washery. All of the coal is hand picked and washed before being placed upon the market. The company has a well equipped washery capable of handling about four hundred tons per day. The coal is used for steam and domestic purposes. The output of the Ravensdale mine in 1901 was 63,578 tons, and in 1902 71,426 tons.

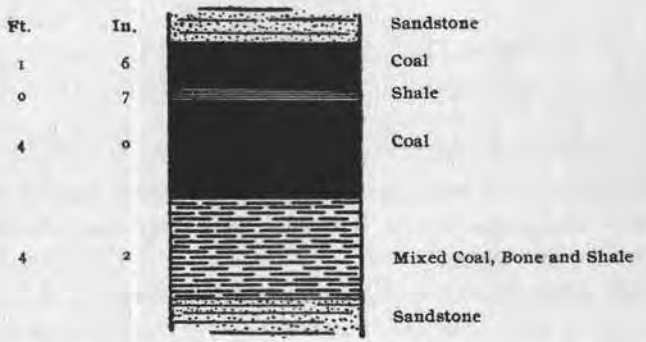


Fig. 16. Cross-section of vein, Kangley Mine. (W. J. Wood.)

Kangley Mine.—The Kangley mine has been shut down for the last four years, but for a number of years previous to that

date it was a good producer. It is situated on the Green River Northern branch of the Northern Pacific Railway, about four miles north of Palmer. It was worked by a slope twenty-three hundred feet long, and gangways three-fourths of a mile long. There was only one vein worked and this was so badly faulted that the mine was finally abandoned. The pitch of the vein is to the eastward at an angle of 35 to 40 degrees. The coal produced was bituminous and of good quality.

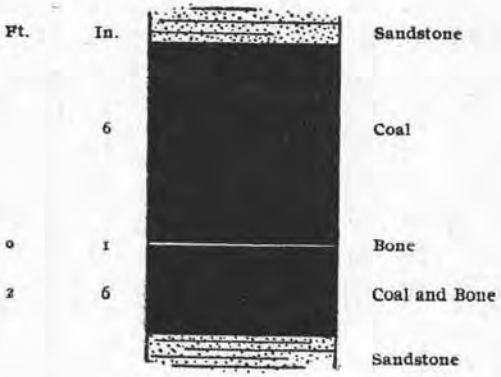


Fig. 17. Cross-section of vein, Alta Mine. (W. J. Wood.)

Alta Mine.—The Alta mine was worked on the extension of the Kangley vein, in section 36, but it was abandoned when a fault was encountered.

Durham Mine.—The Durham mine, belonging to Balfour, Guthrie & Company, is located on the railroad half way between Kangley and Palmer. It has never been worked to any great extent.

Coal veins are known to outcrop on Sugar Loaf Mountain, in section 34. Three veins have been uncovered and a tunnel fifty feet long driven on one of them. The title to the property is now in dispute and until it is settled not much development work will be done. The veins strike nearly east and west and dip to the northward at an angle of about 23 degrees.

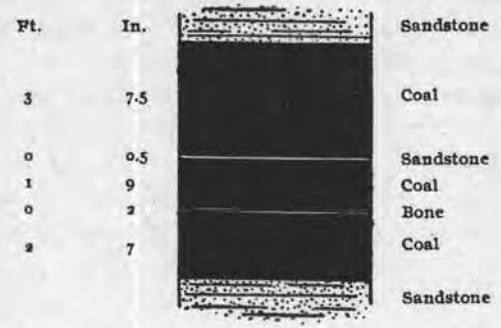


Fig. 18. Cross-section of vein near Sugar Loaf Mt. in Sec. 34, T. 22 N. R. 7 E.

Palmer Junction marks the eastern limit of the coal-bearing rocks in the Green River valley. East of this point the river flows in a deep valley or gorge cut entirely in eruptive rocks. A number of veins outcrop in the region south of Palmer in sections 14, 15, 22, 23 and 24, as well as at the Gibbon mine in section 16, and at the Carbon and Sunset mines in sections 21 and 28. A railroad spur two or three miles long runs to the Pocahontas mine, which is located in section 24. Along the line of this railroad a number of coal seams appear in the cuts, some of them ten or twelve feet wide.

Pocahontas Mine.—At the Pocahontas mine a rock tunnel twelve hundred feet long has been driven to crosscut the veins at right angles. Three veins were encountered in the tunnel and there are yet three or four lying above these which the tunnel will cut through when extended. The strike of the coal measures is north and south, and the veins dip eastward into the mountain side at an angle of thirty-five degrees. The coal is bituminous and of a good furnace quality. A great deal of gas was encountered in driving the tunnel and all the workings must be well ventilated. The bunker site is situated at the end of the railway track, about half a mile west of the mine mouth. A two-foot vein of dirty coal outcrops near the bunker site, dipping westward at a steep angle. At the mine half a mile east the veins dip in the opposite direction, showing that the arch of an anticline is located in

the intervening space. Work has been suspended for the present at the Pocahontas mine but it is expected that operations will be renewed early in the future.

Gibbons Mine.—The Gibbons mine (formerly the Occidental mine) is situated in the southeast quarter of section 16, about a mile from Palmer. A short spur connects it with the main line of the Northern Pacific Railway. It is situated at the eastern base of Lizard mountain and forms part of the Lizard mountain coal basin. The veins dip to the southeast at an angle of about 45 degrees. The strike is fairly regular but the veins are greatly crushed and brecciated. In some places large angular blocks of white sandstone are imbedded in the vein matter. Ten veins are known to occur on the

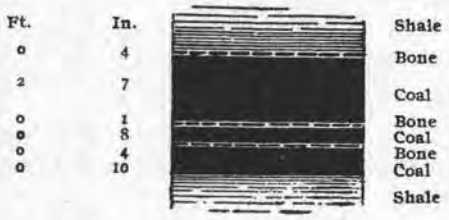


Fig. 19. Cross-section of No. 6 vein, Gibbons Mine.

property and of these eight have been worked more or less. A tunnel has been driven on vein No. 3 and the other veins have been worked by way of this tunnel. The veins are rather more broken up than is usual in the mines of this district and the irregularities have interferred seriously with the progress of development. The output is now from sixty to seventy tons per day. The coal is not washed but is shipped just as it comes from the mine. Considerable gas has been met with in some of the workings. All the development thus far has been above water level. The output in 1902 was 3,225 tons.

On section 21, which is the next section south of the one on which the Gibbons mine is located, the Carbon Coal Company opened a mine six or seven years ago. It was operated for three years and has been closed down since that time. The

mine is opened at the southeast base of Lizard mountain, the mouth of the tunnel being within a few hundred feet of the main line of the Northern Pacific Railway. A small washing plant and bunkers were installed alongside the railroad track. It is possible that this mine may again be put in operation sometime in the future.

There is a group of several mines around Cumberland station, all located in section 28. Of these the Sunset mine, located in the southern part of the section, is the only one in operation at the present time. Two veins are being worked in the Sunset mine, each of them containing about three feet

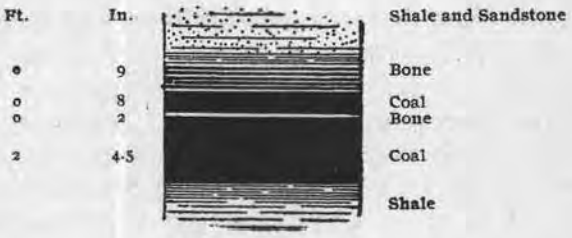


Fig. 20. Cross-section of No. 1 vein, Sunset Mine.

of coal. Vein No. 2 lies about two hundred and fifty feet above No. 1. The Navy mine is worked out, and the Eureka mine has been closed down for a long time.

PIERCE COUNTY.

Carbon River Field.

This field lies about midway between the city of Tacoma and Mount Rainier. All of the producing mines are in the northern part of the field and not far from the main line of the Northern Pacific Railway. A branch of the Northern Pacific Railway enters the district by way of South Prairie Junction and reaches all of the mines in this field. Another branch leaves the main line at Crocker Junction and runs up Carbon river canyon to the Carbonado mines. The field includes all the mines centered about the towns of Burnett, Wilkeson, Carbonado, Melmont, and Fairfax. All the mines are located

along Carbon river and its tributaries, South Prairie creek, Gale creek and Evans creek. Carbon river, which derives its name from the numerous outcroppings of coal along its course, flows for about eight miles through the district. Between Melmont and Carbonado and for two miles below the latter town the river flows through a deep and precipitous canyon, the upper part of which is cut in a hard eruptive rock and the lower part in the coal measures. The topography of the district is somewhat varied, being more rugged in the southern part where it approaches the mountains. Gale creek and South Prairie creek flow through shallow valleys cut for the most part in the coal measures. Away from the streams the surface is covered with glacial drift varying in depth from a few feet to nearly a thousand feet. Old stream channels filled with drift have been encountered in several places in the underground workings of the mines. Numerous potholes, some of them of great size, indent the surface of the region. The whole country was formerly entirely covered with a heavy growth of timber but in the vicinity of the older mines most of it has been removed for mine purposes. In the southern part much splendid timber still remains and forms a valuable asset to the resources of the district.

In the Carbon river canyon a section of the coal measures is exposed five thousand feet in thickness which dips to the westward at steep angles. All the workable seams are contained in the lowermost three thousand feet. Other sections of the coal measures are shown along Gale, South Prairie and Evans creeks.

The coal measures have been thrown into a series of north and south folds which extend from one end of the field to the other with scarcely any change in direction. In the northern end of the field there is one main anticline known as the Wilkeson arch. From Carbonado southward a number of smaller folds occur and the rocks are considerably more distorted. More or less connection may be traced between the veins of Burnett, Wilkeson and Carbonado but in the newer mines of Melmont and about Fairfax the relation between the veins of

the different mines is not so well known. In every mine in the district from half a dozen to a dozen veins of more or less value are know to occur.

The coal of the Carbon river district is a bituminous coking and steam coal. A considerable amount of it is also used for gas making and blacksmithing purposes. Not all the coal makes good coke, but that of Wilkeson and Fairfax is used very largely for this purpose. It is probable that as soon as the new mines of Melmont, Montezuma and Hillsboro get their coke ovens built the output of coke from the district will be more than doubled. In the southern end of the district, owing to the disturbed condition of the strata, the coal is richer in fixed carbon and its coking qualities are better. At the present time the total output of the district is about two thousand tons per day, about one-fourth of which is made into coke.

Burnett Mines.—These mines are opened along South Prairie creek in the most northerly part of the Carbon River field, the present opening being not more than half a mile from the main line of the Northern Pacific railway. The property belongs to the South Prairie Coal Company and consists of eleven hundred acres in sections 16, 21, and 22, T. 19 N. R. 6 E. The mines were opened twenty-one years ago by Mr. C. H. Burnett, the present superintendent and general manager. Up to the present time over one million tons of coal have been taken out and it is estimated that there are still nearly five million tons available. Operations have been conducted on both slopes of the great Wilkeson anticline which in this part of the field has a strike of N. 25 degrees W. and pitches to the northward. At the present time all the coal is being taken from two veins on the eastern dip. The good coal has not been found to extend northward more than a third of a mile beyond the town of Burnett. The coal measures in that direction pass under a heavy mantle of drift and the northward dip of the strata carry the veins downward to a considerable depth. Above the town the strata are exposed along both sides of the creek for several miles. Form-

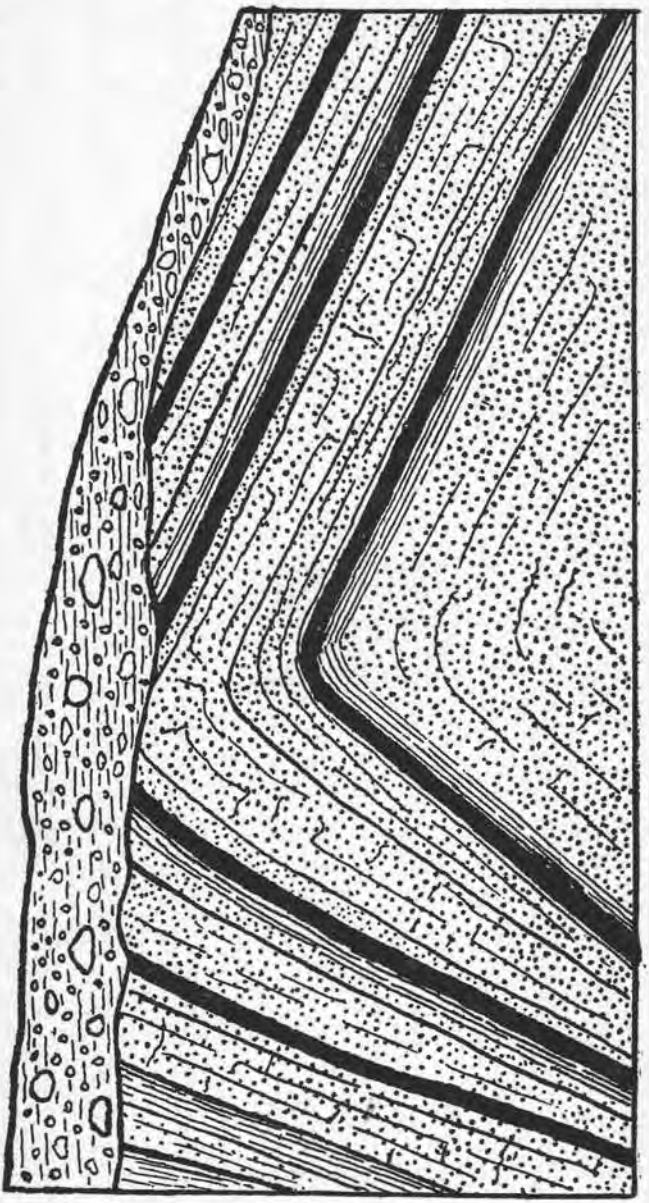


Fig. 21. Cross-section of the Coal Measures at Burnett.

erly there were large sandstone quarries located just above Burnett but they have not been working for several years.

The present Burnett mine is worked by means of a slope sunk in vein No. 1 on the eastern dip. It runs diagonally down the pitch of the vein to a vertical depth of six hundred and twenty-five feet. From a point on the slope four hundred feet from the entrance a rock tunnel was driven across the strata to veins No. 4 and No. 5. No. 5 vein does not outcrop on the surface and its existence was not suspected until it was encountered in the tunnel. Veins No. 2 and No. 3 were opened by water level tunnels on the western side of the anticline, No. 2 being followed for twenty-four hundred feet. On the western dip the veins stand at an angle of from fifty to eighty degrees, but on the eastern dip they are not so

Fig. 22. Cross-section of No. 4 vein, Burnett Mine.

steep. It is probable that vein No. 1 on the east side is identical with vein No. 2 on the west side, and that No. 4 corresponds to No. 3. No. 4 and No. 5 are the only veins being worked at the present time. No. 5 shows three feet eight inches of clear coal and has been opened up by a gangway over four hundred feet long. A chute was driven upwards on No. 5 from the main gangway and at a height of four hundred and eighty-five feet the vein turned over and started down on the western dip, having reached the top of the fold. The turn was made without breaking the vein or the enclosing rocks to any appreciable extent.

On vein No. 1 the gangways were driven a distance of ten thousand feet, the southern end of the gangway being directly

under the stone quarry at Wilkeson. Vein No. 4 contains three feet of coal with a clay band in the middle which varies in thickness from two to twelve inches. Old No. 1 is not being worked at the present time. It contains three and a half feet of coal. There is still a large amount of coal blocked out in the north gangway which is in a distance of fifteen hundred feet. On No. 4 the gangways have been driven southward eight thousand feet and there is still nine hundred feet to be driven in that direction.

Three pumps of a total capacity of three million gallons per day are employed to keep the mine free of water. All the coal is washed before being placed upon the market. A large amount of it is used in gas manufacture and for steam-making in the various cities about Puget Sound. The output of the mine in 1901 was 77,255 tons and in 1902, 32,003 tons.

Fig. 23. Cross-section of No. 5 vein, Burnett Mine.

Wilkeson Mine.—The Wilkeson mine is one of the most extensively developed properties in the Carbon River field. The underground workings extend in an approximately north and south direction through sections 27 and 34, T. 19 N. R. 6 E. and section 3, T. 18 N. R. 6 E. The main opening to the mine is on Gale creek, in section 27. All the present workings are above water level and it will be many years before sinking operations will become necessary. The mine is opened on both sides of the main Wilkeson arch, which is the chief structural feature of the locality. A water level tunnel driven on vein No. 2 on the western dip penetrates southward for two and a quarter miles. A rock tunnel driven eastward across the strata from the main tunnel has opened up three

workable veins on the eastern side of the anticline, known respectively as No. 1, No. 2, and No. 7. Vein No. 3 lies still further eastward and will be found by extending the crosscut tunnel in that direction. Four veins have been worked on the western dip, corresponding to those on the eastern dip. In the southern part of section 34 the gangways on the western dip encountered an overthrust fault which had thrown the measures to the westward four hundred feet. The veins were again picked up by a rock tunnel driven westward from the point where the veins were lost, and after being found they were followed southward until at the present time the furthest gangway is in the southwestern part of section 3. Besides the crosscut tunnel which leads to the veins on the eastern dip near the line between sections 27 and 34, another tunnel, a mile further south, has been driven from the west to the east veins to afford an outlet to the eastern veins at that point.

Vein No. 2 on the eastern dip has a gangway from the north opening two thousand feet long. The vein varies in width from four to eight feet and dips at an angle of sixty degrees. Vein No. 1 in the same set of workings contains about five feet of coal and is worked from a gangway sixteen hundred feet long. Not much coal is being taken out of No. 1 in this gangway at the present time. Where No. 1 is opened in the southern end of section 34 it contains two benches of coal each three feet wide and separated by a fourteen inch band of bone. Vein No. 7 is about seven feet nine inches wide. It contains two benches of coal separated by a parting of bone nine inches thick. The lower bench contains five feet of the best coal in the mine. The gangway on No. 7 is thirty-eight hundred feet long.

The mines are worked by the chute and pillar system, as being best suited to the conditions of roof and coal, Narrow chutes are driven upward from the main gangway and crosscuts driven from one chute to the ather every forty or fifty feet. The pillars are pulled beginning at the top and working downward. A row of stump pillars thirty feet

thick is left to protect the gangways. The coal is washed by means of Forrester jig washers which have been found to work very satisfactorily. Water for the washery is brought from Gale creek through a flume half a mile long. Two small steam locomotives are used to haul the coal from the mine, one of them working on the east side and the other on the west side.

The output of the mine averages five hundred tons per day, three hundred tons of which is made into coke and the remainder sold as steam and domestic coal. All the coal is coking and the product of the different veins is mixed indiscriminately before being sent to the coke ovens. There are one hundred ovens in constant operation. The mine was opened in 1879 and since that time has produced about 1,000,000 tons. The output in 1901 was 125,028 tons, and in 1902, 106,896 tons.

Gale Creek Mine.—The Gale Creek mine is located on the northeast quarter of section 28, T. 19 N. R. 6 E., on the northern outskirts of the town of Wilkeson. The principal opening is by a slope on vein No. 1, four hundred feet long, from the bottom of which a gangway has been driven northward on the vein six hundred and fifty feet. This vein contains three feet nine inches of clean coal. It is not a coking coal but is sold for steam and gas making. Vein No. 2 is not being worked at the present time. It was opened by a tunnel three hundred feet long driven across the strata to encounter it, after which a gangway five hundred and seventy feet long was driven south of the vein, and another shorter one north from the main tunnel. Vein No. 2 averages three feet eight inches of good coal. The opening on the Queen vein is about a quarter of a mile east of the opening above mentioned, and on the opposite hill from the Wilkeson mine opening. A tunnel runs into the hillside nine hundred feet along the vein, which averages about four and a half feet in width. The present output of the two veins, No. 1 and the Queen, is about one hundred and fifty tons per day. The coal is not washed but goes directly to the bunkers. New bunkers are being

erected, and it is expected that a washing plant will be added to the equipment in the near future.

In addition to the veins which are being worked a number of others are known to occur on the property. Between No. 1 and No. 2 there is a six-foot vein and a three-foot vein, neither of which, however, yield coal clean enough to put on the market without washing. A three and a half foot vein occurs about two hundred feet above No. 1 and there is a six-foot vein below the Queen vein. Several large veins of fire clay are interbedded with the coal which may prove to be valuable.

All the veins which have been opened in this quarter section dip westward at an angle of about seventy-five degrees. They occur on the western side of the Wilkeson anticline and lie higher in the series than the veins worked at the Wilkeson mine. They are probably the same as those worked at Burnett. From the Gale Creek mine in 1901 18,900 tons of coal were mined. The total output in 1902 was 29,640 tons.

Carbonado Mine.—This mine is, next to Roslyn, the largest in the state and when worked to its full capacity has a daily output of from twelve hundred to fifteen hundred tons. At the present time, owing to several causes, chief of which is the substitution of crude oil for coal in the locomotives of the California railways, the output is not more than four hundred tons per day. Heretofore all the coal which the mine produced was shipped to California and no attempt was made to find a market for it in this state, but at the present time much of the output is consumed in the home market. It is a first-class steam coal and is used very largely in locomotives. It gives an intense heat, cokes only to a slight extent in the furnace and leaves only a small amount of ash. When it becomes better known probably a large amount of it will be used for domestic purposes. Analyses of the coal from the different veins show a slight variation, especially in the percentage of ash, but they are all bituminous non-coking coals. The coal has none of the scaly appearance of the Fairfax and Melmont coal, probably due to the fact that it has not been

subjected to the same degree of crushing. A number of tests have been made of the coking qualities of the various veins but only with indifferent success. Thus far no good coking coal has been found in the Carbonado workings, but the Wilkeson coking veins have been followed in that company's gangways as far as the Carbonado company's line, so it is probable that coking veins will yet be found on the Carbonado property. A rock tunnel begun twenty years ago is now being extended eastward from Carbon river canyon, across the strata to find the Wilkeson vein. It is now in a distance of over 3,000 feet.

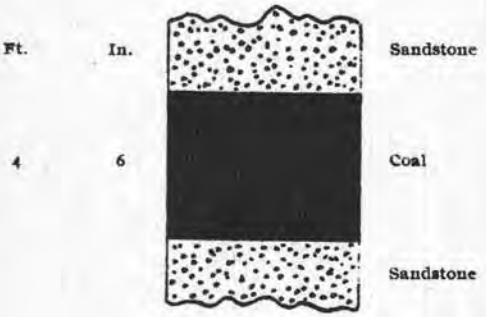


Fig. 24. Cross-section of vein, Carbonado Mine.

Carbon river at Carbonado flows through a steep sided canyon about 350 feet deep. The town is situated above the canyon on comparatively level ground. The mine openings are all at the bottom of the canyon. Operations have been conducted from a number of openings on both sides of the river. At the present time most of the coal is being taken from the Wingate vein on the west side of the river. A slope 450 feet long has been sunk on this vein, and gangways driven southward for about 9,000 feet. The vein is from five to seven feet in thickness and produces an excellent quality of coal. It has been mined extensively for many years and still contains a very large quantity of good coal within reaching distance. Two duplex Dow pumps of 1,000,000 gallons

per day capacity each, keep the mine clear of water. A small steam locomotive works along the main gangway at the bottom of the slope. In order to prevent too much smoke coke is used for fuel. On the same side of the river the Miller vein, which lies 600 feet above the Wingate vein, has been worked extensively in the past, but is not worked at the present time. Both of these veins have been involved in a fault which has thrown them about 1,000 feet out of line. The Wingate has been picked up on the northern side of the fault and followed for about a mile on the east side of the river, when the gangway turned back on its course and ran into some broken ground at which point the vein was abandoned. It is probable that if followed a little further it would again become regular. Two other veins, known as No. 4 and No. 9, have in the past been worked extensively on the west side of the river but the coal in them has deteriorated in quality and they are now abandoned. On the east side a rock tunnel crosscuts a number of veins of more or less value. On one of them, known as No. 1, a gangway has been driven southward over 1,900 feet and a considerable quantity of coal is being produced from it. This vein averages about nine feet in thickness, and is nearly all clean coal. It has been tested for coke making but has not proven altogether suitable. A smaller vein, No. 2, lies about 100 feet below No. 1. Where it is crosscut in the main tunnel it shows about twenty-eight inches of good clean coal next to the hanging wall, and a thick seam of dirty coal along the foot-wall. About 1,000 feet in on the No. 1 gangway a crosscut was driven to No. 2, and it was there found to be thirty-eight inches thick. A chute was driven upward 1,050 feet to the surface on No. 2, in the expectation that it would prove to be the same vein which outcrops along the canyon side just below the old wagon road. However, No. 2 proved to be not the same but a higher vein. The vein which is shown in the outcrop contains about six feet of good clean coal, and now that it has been definitely located in the underground workings develop-

ment will soon be commenced upon it. The south end of the gangway on vein No. 1 is not over a thousand feet distant from the southern end of the Wilkeson workings. The veins in the two sets of workings pitch towards each other and undoubtedly form a basin somewhere between the two places. It is the intention of the Carbon Hill Company to ascertain definitely the conditions in this part of their property.

All the veins at Carbonado are involved in a number of small northward pitching folds. They have a steep western dip but a much more gentle eastern one. On the west side of the river the Wingate and Miller veins dip westward at an angle varying from forty to sixty degrees, while in the eastern vein the dip is not more than twenty-five or thirty degrees.

The outside equipment of the mine is very complete. Eight steam locomotives are used in and about the mine for hauling the coal to the bunkers and bringing mining timber from the woods to the mine. About twenty or thirty horses and mules are employed in the mine and outside. A washing plant of 1,200 tons per day capacity is located a mile below the principal mine openings, and at the end of the standard gauge road. It contains three Robinson washers, each having a daily capacity of 400 tons. Power to run the washers is furnished by a little mountain stream which comes down the side of the canyon. The water after generating power to run the machinery is used in washing the coal.

The Carbonado mines have been very active producers for many years, and from them over 4,000,000 of tons of coal have been obtained. The output of the mines in 1902 was 169,733 tons.

Melmont Mine.—The Melmont mine was opened by the Northwestern Improvement Company about one year ago. It is situated on the eastern side of Carbon river canyon, about half way between Carbonado and Fairfax. A rock tunnel 1,500 feet long runs eastward directly across the coal measures and crosscuts seven veins, all of which have been

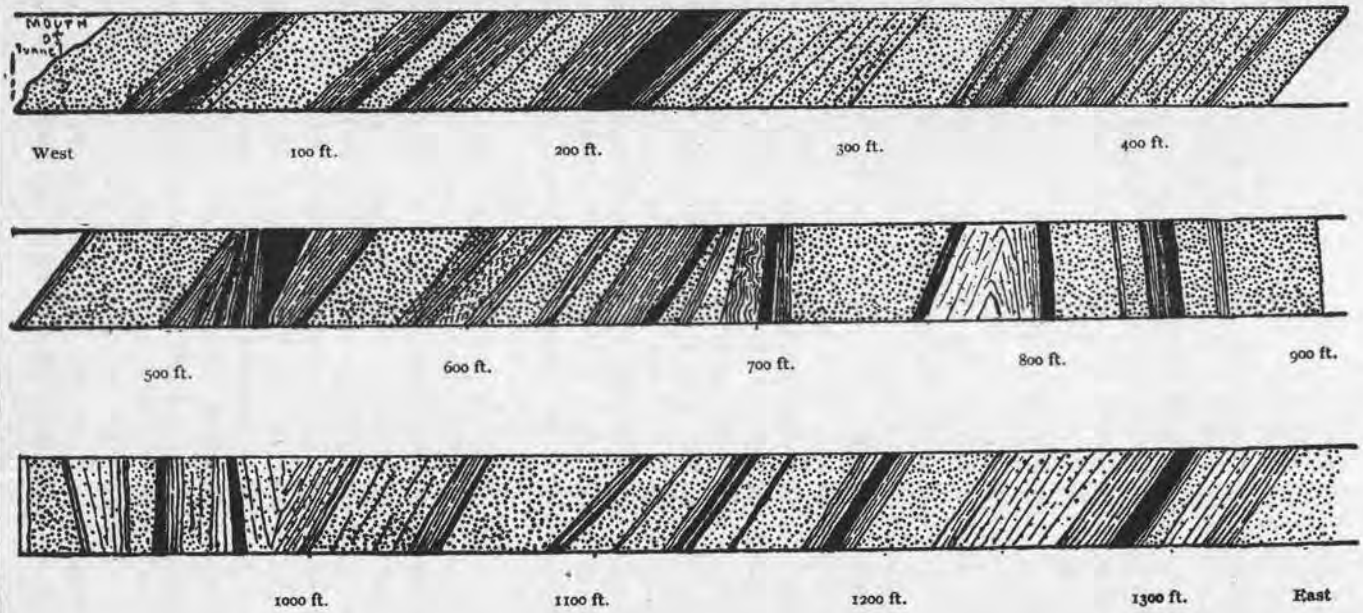


Fig. 25. Cross-section of coal measures, as shown in the Melmont tunnel.

opened by gangways driven northward from the main tunnel. The rock passed through in the tunnel is mostly massive sandstone interstratified with beds of carbonaceous shale. The strike of the measures is about North 10 degrees West and the dip of the veins varies from forty to ninety degrees, the general dip being about sixty degrees. At a distance of 800 feet from the mouth of the tunnel the arch of an anticline was encountered and beyond it for 200 feet the rocks dip to the eastward, or stand perpendicular. At this point the rocks were found to be considerably disturbed and dipping to the westward again, showing that a syncline was passed through. Several more veins besides those encountered in the tunnel are known to occur farther to the eastward, and will be cross-cut when the tunnel is entered.

Vein No. 1 carries about six feet of soft coking coal. It has been opened by a gangway driven several hundred feet northward from the main tunnel. It will not be worked until the company gets its coke ovens ready. Vein No. 2 is also a coking coal. It averages 14 feet in width and has been opened by a gangway 350 feet long. The gangway on No. 3 has been driven north over 1,400 feet. This coal will not coke but makes a first class steam coal and is being used under the company's own boilers. The vein varies in width from thirty feet down to a thin stringer. A layer of coal along the foot wall appears as though it had been partially converted into coke. It has something of the spongy grayish appearance characteristic of coke, and is said to approach it in composition. At the face of the gangway a horse of light gray shale, evidently forced up from below, cuts into the lower part of the vein.

A vein not numbered occurs between No. 4 and No. 5. It contains about three and a half feet of soft coking coal. Vein No. 5 is also a coking coal. A test lot was sent to the Fairfax ovens and it made a first class quality of coke. This vein averages about eight feet in width. A gangway is being driven in it northward from the main tunnel. No. 6 is the last vein encountered in the tunnel. Along it a gangway

has been driven in 800 feet. The width of the coal is irregular, varying from twenty feet down to almost nothing, but averaging about eleven feet of good coal. The relation of the Melmont veins to those of Carbonado and Fairfax is not definitely known but it is evident that if not identical they occur at least in the same general horizon.

At the Melmont mine a large washing plant has just been completed. It is located on a gravel terrace between the mine mouth and the river. It has a daily capacity of four or five hundred tons. The coal as it comes from the mine is dumped onto screens, which separate it into three or four different sizes. The coarse coal falls onto traveling picking tables and the bone and shale are picked out by hand as they pass along. The washing machines, known as the Luhrig washers, are the only ones of the kind used in the state. They are arranged in two batteries, one of four compartments and the other of eight, each compartment being four feet square. A screen is set in each compartment and covered with a three or four inch layer of angular feldspar. The pieces vary in size from a half inch to an inch and a half in diameter. A plunger operated by an eccentric attached to a shaft above forces a body of water up through the screen and rock layers. The force of the water is so adjusted that the coal is carried up through the feldspar but the heavier dirt and rock settles to the bottom and is drawn off at intervals from below. The different sizes of coal are washed in separate machines. From the washers the coal is taken by conveyors to the bunkers, situated above the railroad track, from whence it is loaded on the cars. Only steam coal is being mined at the present time.

Besides the various mine buildings and shops the company has a sawmill turning out 20,000 feet of lumber per day. A large hotel and boarding house furnish accomodations for the company's employes.

Western American Mines.—The mines of the Western American Company were the first to be opened in the vicinity of Fairfax. They began to ship coal about three years ago

and have been steady producers ever since. The company owns about 1,300 acres of land lying on both sides of Carbon river and including the town of Fairfax. The principal mine opening is on the north side of the river, in section 26, where a rock tunnel has been driven across the strata to crosscut the veins. At the point where the veins were encountered the rocks have been involved in several small sharp folds which have destroyed to some extent the regularity of the veins and have interfered seriously with the process of mining. The folds pitch downward at a considerable angle and the gangways driven along the veins have in two or three instances made a sharp backward turn. A number of small faults and slips have been encountered in the workings. The coal shows the effect of these displacements and it has the scaly, distorted appearance which characterizes most of the coking coals of the state, the distortions being much more noticeable in the face of the vein than in a hand specimen of the coal. The company is at present working five veins varying in thickness from two and a half to nine feet. Two veins have recently been opened by a tunnel on the south side of the river in section 34. These veins are probably the same as those being worked at the Montezuma mine a mile further south. The Montezuma gangways have been driven northward to the property line of the Western American Company, and the continuation of the veins on the same strike would carry them to the point where the Western American tunnel has been driven, unless faults should exist in the intervening space.

The structure of the field seems to be that of a main anticline with one or two small secondary folds near its crest. The folds trend about north ten degrees west and the main anticline is apparently the southern continuation of the Wilkeson arch. All the veins pitch downward at angles varying from sixty to seventy degrees. Where the gangways turn back upon themselves when passing around the crest of a pitching fold the veins frequently stand perpendicular.

One of the veins is a good blacksmith coal and about 500

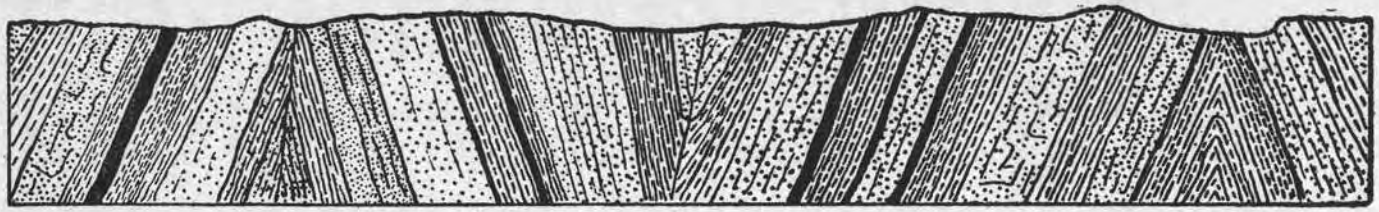


Fig. 26. Cross-section of portion of Fairfax Field.

Fig. 27. Cross-section of coal measures, Hillsboro Mine.

tons a month is sold for that purpose. An additional 500 tons is sold for steam coal, and about 2,000 tons is made into coke, making the average monthly output of coal for all purposes about 4,000 tons. The blacksmith coal is nearly all sent to the San Francisco market, and the steam coal is supplied to the Tacoma Eastern Railway for locomotive use.

The washing plant has a daily capacity of about 500 tons, a Howe-Jeffry washer being used. In this machine a powerful column of water forced up from below through the dirty coal carries up with it the pure coal and flows over the top, carrying the coal along with it. A set of revolving arms keeps the whole mass thoroughly stirred up and allows the coal and dirt to separate according to their different specific gravities. The rock particles being so much heavier than the coal gradually settle to the bottom and are drawn off through a spout at the bottom. These machines are probably the most satisfactory now in use, and are more generally used in this state than any other. A fifty H. P. motor is used to run the washing plant.

Power to run all the machinery of the mine is taken from the water of Carbon river. A flume three-fourths of a mile long brings the water to the power plant situated a short distance from the mine mouth. The total capacity of the plant is 600 H. P., but at the present time only 500 H. P. is being generated. The power is used to run the washer, the ventilating fans, electric locomotives, machine shop, blacksmith shop, and electric light machines. In addition to these, power is furnished during the dry summer months to the Montezuma mine to run their washing plant. A small flume leading off from the main flume supplies water to the washer. The electric light plant supplies the mine, the washer, and the town of Fairfax.

The Western American Company has sixty coke ovens in operation. The coal is sent from the washers to the ovens by means of a flume. At the lower end of the flume a conveyor hoists the coal from the flume to the hopper from which it is drawn into a dump car. The car runs on a track

between the two lines of ovens and dumps the coal into the ovens from above. The charge for each kiln varies from four to six tons of coal.

Two qualities of coke are produced, one for smelter use and the other for foundry use. The smelter coke is burned for forty-eight hours and the foundry coke for seventy-two hours. The seventy-two hour coke is firmer and stronger and of a better quality than the other. Most of the coal used for making coke comes from two veins opened on the north side of the river. This coke commands a ready sale and the company finds it impossible to fill all of the orders which come to it.

The output of the Western American mine in 1901 was 30,513 tons of coal, and in 1902, 32,117 tons.

Montezuma Mine.—This is the joint property of the Washington Co-Operative Mining Company and the Montezuma Mining Company. There is a mutual working agreement between the two companies by which the mine is operated under one management. Their property extends along Evans creek southward from its mouth for four miles, and embraces a total area of 2,120 acres of coal bearing land. The mine has been in operation for less than a year, the first coal being shipped in the spring of 1902. The daily output is still small and no attempt will be made to increase it until the coke ovens are ready for use. Twenty-five ovens are now being built, and will probably be finished by the beginning of 1903.

The principal openings of the Montezuma mine are located on Evans creek, about a mile above its mouth. Evans creek is a swift mountain stream entering Carbon river from the south about half a mile above the town of Fairfax. It drains part of the region between the headwaters of Carbon and Puyallup rivers, and flows for a considerable part of its length over coal measures. For the greater part of the year it carries a large volume of water but during the dry summer months it dwindles to a comparatively small stream. Where the Montezuma tunnels have been driven the veins cut diag-

onally across the creek, the general strike of the measures being North twelve degrees West. On the east side of the creek a water level tunnel was driven through the sandstone and shale for a distance of 350 feet, in order to reach a vein known as the east vein. After reaching the vein a gangway was driven on it some distance, and it was found to vary in thickness from two and a half to four feet. On the opposite side of the creek another tunnel 528 feet long crosscuts two veins, known respectively as the blacksmith vein and the

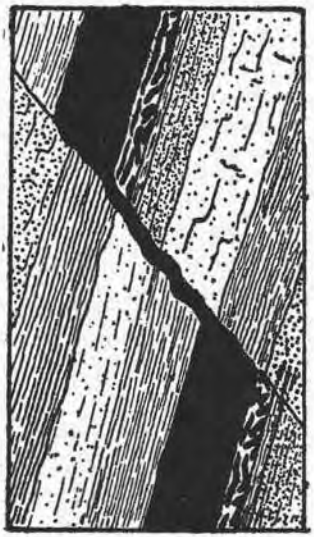


Fig. 28. Fault in the Montezuma Mine.

steam vein. The point where these veins were opened is not very far from the north line of the company's property, so that the gangway driven northward from the main tunnel on the blacksmith vein reached the boundary line at a distance of 580 feet and was stopped. The Western American Company owns the extension of these veins. Both veins are being worked only to a limited extent at the present time. There is a larger demand for the blacksmith coal than for the steam coal, and as it commands a much better price it is being worked more extensively than the steam vein. The coal

from both veins is extremely soft, and a large part of it reaches the market in the form of fine slack. The south gangway on the blacksmith vein is about1,050 feet in length (October, 1902). Near the main tunnel it encountered a small fault which displaced the vein fifteen feet. At a distance of seven hundred feet it ran into a much larger fault and the vein was lost completely for a distance of two hundred feet, when it was again picked up. When measured at the face of the gangway October 13th, 1902, the vein was sixteen feet wide, all clean coal except a band of dirt a foot or two wide near the middle of the seam. In the north gangway on the same vein about five feet of coal appears.

The steam vein was encountered 525 feet from the mouth of the tunnel. Gangways have been driven north 200 feet and south 550 feet. On the north face of the gangway the vein has a total width of eight feet ten inches, only five and a half feet of which is good coal. On the south end the total width is six feet ten inches, with a seam of coal four feet ten inches thick on the foot wall. The coal in this vein is overlaid by a band of shale from two to three feet thick.

Another vein eleven feet wide shows in the creek bottom just below the sawmill and has been prospected by a tunnel two hundred feet long. It is rather dirty and work on it has been abandoned. Two other veins appear in the creek between the eleven foot vein and the east vein, but have not yet been opened. A half dozen or more other veins are known to occur on the property, but beyond occasional outcrops nothing is known of them.

All the veins encountered in the tunnels dip to the westward at an angle of about seventy degrees. The line of strike would carry them to a point a mile north where the Western American Company have opened a tunnel on the south side of the railway track and where they crosscut two veins. Two or three hundred yards east of this place an anticline shows along the railway track. It is quite probable that this anticline extends southward and passes only a short distance to the eastward of the present Montezuma workings.

The outside equipment of the Montezuma mine consists

of a washing plant, sawmill, machine shop, blacksmith shop, and water-power plant, besides numerous small buildings. The power plant gets its water from Evans creek through a flume 800 feet long. The penstock is ninety feet high and is connected with a 350 H. P. Victor turbine. Additional power is also furnished by a small 15 H. P. Pelton wheel connected with the penstock by an eight-inch pipe. It is used only in dry weather when there is not enough water in the creek to run the big wheel.

The washing plant is capable of handling a considerably larger output than is being produced at present. The coal as it comes from the mine is first screened and the coarse coal hand picked. The fine coal is sent to the Forrester washing machines. These work in sets of two each, one machine being set a foot or two higher than the other in order that the coal after being washed in the first may pass to the second to complete the washing.

A double flume nearly a mile long runs from the mine to the lower camp, one side of it being used for coal and the other for lumber. The bunkers have a capacity of 800 tons. There are two compartments, one being used for blacksmith coal and the other for steam coal. The flume which carries the coal leads directly to the bunkers, so that they act as settling tanks and are built practically water tight. The sawmill has a daily capacity of ten to fifteen thousand feet and supplies all the lumber and shingles used by the company.

The town of Montezuma, which includes the company's store, boarding house, and cottages for the employes, is situated on a gravel terrace at an elevation of 100 feet or more above the river bottom and about half a mile below the mine. Twenty-five coke ovens are being erected on the river bottom near the point where Evans creek enters Carbon river. When completed the ovens will have a capacity of sixty-five tons of coke per day. All the coal from the steam vein and the fine slack from the blacksmith vein will be coked.

Hillsboro Mine.—The Hillsboro Coal Company is an allied organization of the Olympic Mining Company of Seattle.

Its property consists of 1280 acres of coal land, including section 36, T. 18 N., R. 6 E., and section 6, T. 17 N., R. 7 E., lying on both sides of Carbon river a mile or two above the town of Fairfax. The mine opening is in section 36, on the north side of the river. A rock tunnel was begun in January, 1902, and was driven eastward to crosscut the veins which were known to outcrop on the side of the mountain above the camp. The tunnel is now in a distance of 725 feet and there are six veins exposed, varying in width from one foot to eight feet. The last vein, known as No. 6, is eight feet wide and shows good coal nearly all of the way across its face. A chute has been begun on this vein and will be extended upward to the surface. An analysis of the coal in No. 6 made by Mr. Paul Hopkins gave the following percentages: Water, 1.00; volatile matter, 11.98; fixed carbon, 79.01; sulphur, .54; ash, 7.47.

This coal gave the highest percentage of fixed carbon and the lowest percentage of volatile matter of any from the vicinity of Fairfax, and shows that it possesses high heating power. The moisture and sulphur are quite low. Its coking qualities have not yet been tested, but from its similarity to the known coking coals of the district it is assumed that the Hillsboro coal will make good coke. A small amount of development work has been done on veins No. 2, No. 3 and No. 4 where they were crosscut in the tunnel. A further extension of the mine tunnel will encounter several more veins lying higher in the series whose outcrops have been found. The mountains to the north of the main tunnel rise steeply and the northern gangways will gain considerable depth on the veins.

A number of veins outcrop on the company's property on the south side of the river. Several of them have been uncovered, but not much work has been done upon them. All of th veins on the Hillsboro property lie to the eastward of those worked at Fairfax and Montezuma and probably occur higher in the series. The coal measures all dip at a steep angle and the numerous outcrops on the two sections, 6 and 36, probably represent a thickness of three or four thousand feet of strata.

The enclosing rocks are massive, light colored sandstone

and very dark carbonaceous shale. The veins all pitch eastward at a very steep angle and show the effects of great crushing. It is probable that the coal measures extend only a short distance eastward beyond the boundaries of the company's property. A short distance above, on Carbon river, the sedimentary strata are replaced by igneous rocks derived in large part from Mount Rainier, whose summit lies to the southeast about twenty miles away.

As soon as the mine can be put in shape for producing coal on a considerable scale the railway will be extended from Fairfax to the mines, and bunkers will be built. The railroad will pass along the south side of Carbon river past the Montezuma bunkers and cross the river about three-fourths of a mile below the Hillsboro camp. It is also the intention of the company to build coke ovens and go into the manufacture of coke. All the coal will be made into coke unless some of it should prove to be more valuable for blacksmithing purposes.

The company operates a sawmill having a daily capacity of 15,000 feet, in order to supply lumber for its own use. A small air compressor is also in use, furnishing power to run the Rand drills used in the rock tunnel. The camp, consisting of the company store, boarding house, blacksmith shop, offices and dwelling houses, is located near the mine mouth. A good wagon road extends from Fairfax to the mine.

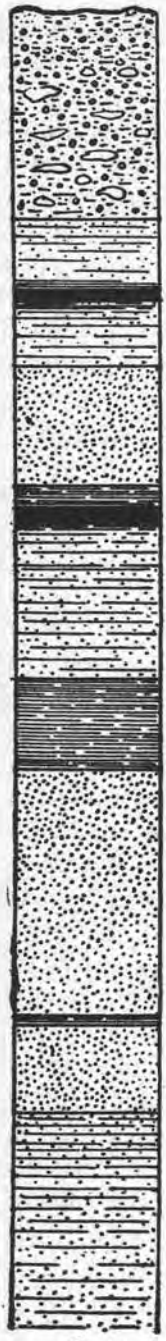
KITTITAS COUNTY.

Roslyn-Clealum Field.

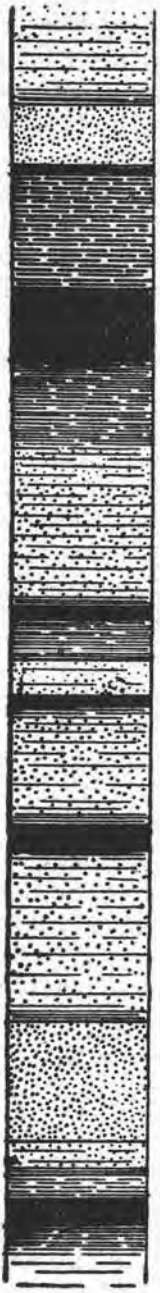
This coal field is on the main line of the Northern Pacific Railway, about fifteen miles east of the main divide of the Cascade mountains. It occupies the valley of the Yakima river near the point where the Yakima is joined by the Clealum. The coal seams occur in a massive, light colored sandstone of Eocene age, to which the name Roslyn sandstone has been applied. The Roslyn formation is a lake deposit of limited area and has a total thickness of not far from 3500 feet. The Roslyn coal basin is the most extensive and valuable in the state and at present has an output equal to all the others

combined. The two most important veins in the series are the Roslyn and Clealum veins, working respectively at Roslyn and Clealum. These two mines are three and a half miles apart and their underground working are not connected. It is still an open question whether or not the two veins are identical, and this problem has a most important bearing on the future of the field. It is generally believed, however, that the Clealum vein is a different one from the Roslyn and lies several hundred feet higher in the series. The strata dip to the southwest at an angle varying from ten to fifteen degrees. The outcrop of the Roslyn vein makes an exceedingly tortuous line along the mountain side northeast of the two towns of Roslyn and Clealum. Its general direction, however, is southeast and northwest. The rocks have not been greatly folded or faulted and the coal has been but little disturbed. It is a bituminous coking and steam coal. It is quite hard and compact and nearly all of it reaches the market as lump coal. It is used very largely as a steam coal for locomotives and steamships and supplies very much of the market of Eastern Washington, Idaho and Oregon for steam and domestic coal. Large quantities are shipped to Puget Sound, Portland, San Francisco, and even Honolulu. The Northern Pacific Railway uses it exclusively in its locomotives as far east as Helena, Montana. The Great Northern Railway heretofore has had a large standing order for Roslyn coal, but within the past few months it has completed a line of its own to the Crow's Nest coal field of British Columbia and is now using that coal chiefly on all its lines in Washington, Idaho and Montana.

The Roslyn and Clealum mines are operated under one management by the Northwestern Improvement Company. The company owns practically the entire coal basin. Several small, independent companies control small tracts within the coal area, but as a rule they are not able to compete with the big mines. One of them, the Ellensburg Coal Company, has a small mine two miles north of Clealum on a forty-acre tract. The vein upon which they are working is the same one as that being worked at Clealum. The coal is hauled in wagons to Clealum and sold about town for local use.



Ft.	In.	
50	6	Soil and Talus
18	0	Sandy Shale
2	8	Coal
16	0	Shale and Sandstone
31	0	Sandstone
5	0	Shale
3	8	Coal and Bone
40	0	Sandy Shale
24	0	Shale
56	0	Sandstone
4	0	Shale
22	0	Sandstone
74	0	Sandy Shale



Ft.	In.	
16	0	Sandstone
3	0	Black Shale
30	10	Dark Shale
19	0	No. 1 Coal "Big Dirty" vein
60	0	Sandy Shale
3	2	Bony Coal No. 2 vein
9	0	Shale
9	0	Sandy Shale
2	2	Bony Coal No. 3 vein
34	0	Sandy Shale
3	0	Shale
4	2	Bony Coal No. 4 vein
42	0	Sandy Shale
28	0	Sandstone
9	0	Sandy Shale
5	0	Shales
5	4	Roslyn vein Shales

Total 628 ft. 8 in.

Fig. 29. Cross-section of Coal Measures as shown in Roslyn Shaft.

Roslyn Mine.—This mine is at the head of a branch road three and a half miles long which runs to Clealum on the main line of the Northern Pacific Railway.

The Roslyn mine is opened on the northern rim of the coal basin at a point where the vein outcrops along the sides of a small gulch. Tunnels have been driven east and west on the vein from this point. The underground workings include a considerable part of five sections of land, and are being rapidly extended. Besides the tunnel entrances to the mine there is a shaft 625 feet deep which taps the vein about half a mile south of the tunnels. The Roslyn vein, which is the only one

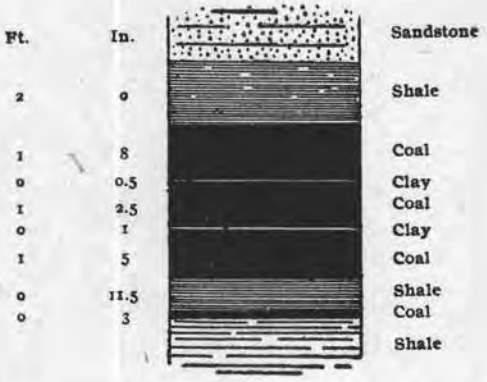


Fig. 30. Cross-section of Roslyn vein, Roslyn Mine.

worked in the mine, averages about four and a half feet in width and dips southeast at an angle varying from ten to twenty-five degrees. In nearly all parts of the mine the cars can be run up the breasts and loaded directly at the face of the workings. The tail-rope system of haulage is very largely employed in this mine. A system of wire cables stretches along the various gangways of the mine and are all connected with the engines on the outside. Some of the cables haul the cars from the inner workings to the gathering points, where they are made up into larger trips and hauled to the outside by another cable. Several small electric locomotives are also employed on the inside to gather the trips together. The

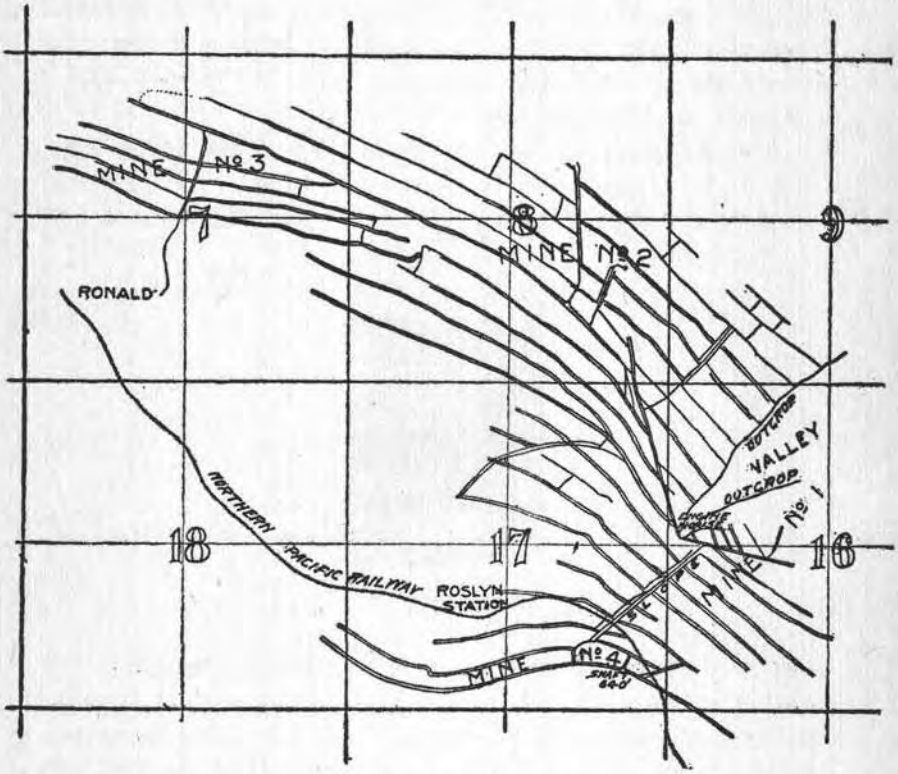


Fig. 31. Map showing the extent of the underground workings in the Roslyn Mine.

shaft is divided into two compartments, in each one of which is a double-deck hoist. The hoists work alternately with each other and each trip carries up two cars, or about 5000 pounds of coal. The daily output by way of the shaft is about 1800 or 2000 tons, and the total output of the mine at the present is not far from 3000 tons per day. The coal is not washed, but is shipped just as it comes from the mine. The vein is practically all clean coal, there being only two thin clay partings. The mines are well ventilated and very little trouble is experienced from gas.

The Roslyn mine was opened in 1885, and in all has produced over 7,000,000 tons of coal, taken from an area of about 1200 acres. The total output for 1901 was 1,005,027 tons, and for 1902, 1,039,870 tons.

Fig. 32. Cross-section of vein, Ellensburg Coal Co's Mine.

Clealum Mine.—The town of Clealum is on the mine line of the Northern Pacific Railway and has an elevation of 1900 feet above sea level. A branch line three and a half miles long runs to Roslyn, which is about 300 feet higher than Clealum. On the north side of the valley a ridge of sandstone parallels the river and rises about 1900 feet above the stream. On the south side of the valley a ridge of basalt rises 2500 feet above the valley floor. Several clearly marked gravel terraces occur on each side of the river, rising by steps to the base of the mountains. These heavy gravel deposits cover the coal

bearing rocks and serve to obscure the outlines of the coal basin.

The Clealum mine is opened by a shaft and a tunnel at the base of the mountain on the northern outskirts of the town. The shaft is 250 feet deep. The vein is four feet six inches wide and is practically all clean coal. The dip of the vein varies from twelve to twenty-three degrees to the southward. From the bottom of the slope four levels have been run, the longest of which is about 5000 feet. Only one fault has been encountered in the mine, a small overthrust between the first and second levels. The daily production at present is seven or eight hundred tons, and the mine is rapidly being put in shape for a more extensive output. The mine was opened in 1894. In 1902 the amount of coal mined was 212,584 tons.

THURSTON COUNTY.

Bucoda–Tenino Field.

The Bucoda-Tenino district lies in the southern portion of Thurston county. Its boundaries are not definitely fixed in any direction. A large part of its surface area is composed of flat river bottom and barren gravel plains, and it is only where the coal-bearing formation appears at the surface along the hillsides and on higher ground that it is possible to discover any outcroppings of coal.

Coal was first discovered in the valley of the Skookumchuck in 1855. It was mined in the vicinity of Bucoda in early territorial days, the convicts of the penitentiary being employed for that purpose. The early mines are now closed down and it is difficult to get definite information regarding them.

The Chehalis and Skookumchuck rivers flow through wide, level valleys. Hills of sedimentary rocks belonging to the coal-bearing series border the valleys and rise to heights of several hundred feet. During late glacial time the melting of the great ice mass which occupied the basin of Puget Sound caused a tremendous flood of water to sweep southward over this region. This great river was heavily loaded with sedi-

ments of all degrees of coarseness, which it dropped by the wayside as it passed along. In the northern part of the field in the vicinity of Tenino the gravel is quit coarse, and water-worn boulders are scattered everywhere. Traveling southward into Lewis county the material gets finer and finer until in the vicinity of Chehalis it is a fine, sandy loam with no gravel. South of Chehalis there are no signs of glacial action whatever.

The Seatco coal mine was opened in 1880 near the town of Seatco, the name of which was afterwards changed to Bucoda. It was operated with convict labor taken from the territorial penitentiary, which was at that time located at Seatco. Public sentiment was hostile to the enterprise, however, so that the convict system was soon discontinued and the mine closed down. Operations were conducted on an eight-foot vein of coal and altogether about 10,000 tons of coal were mined.

Fig. 33. Cross-section of vein, Great Western Mine, Tenino.

The Great Western Coal Company owns about 2100 acres of coal land two or three miles southwest of Tenino and has opened a small mine on its property. It has driven a tunnel for a distance of seven hundred feet on one of its veins where it outcrops at the base of a small hill. The vein lies nearly flat, with only very slight undulations, and is not more than three or four feet thick. There are only about half a dozen men employed in the mine and two or three cars of coal per week are being shipped. The coal is a typical brown lignite and carries a high percentage of moisture.

LEWIS COUNTY.

Lewis County contains coal at intervals throughout its whole length from east to west. The county is about ninety-six miles long and twenty-five miles wide, and stretches from the main divide of the Cascade mountains westward to the foot-hills of the low mountain range which borders the coast between Gray's Harbor and the Columbia river. The western part of the county forms part of the wide, level valley or plain which stretches from Puget Sound to the Columbia and which is continued southward into Oregon as the Willamette valley. From Chehalis eastward the land rises gradually into the Cascade range. It is along the principal river, the Cowlitz, and its tributary, the Tilton, that most of the coal prospects have been found. In the low, level country in the western part of the county nearly all of the rocks belong to the coal measures, and have in most places been folded only to a slight extent. Igneous intrusions are occasionally found traversing these rocks. To the eastward, as the mountains are approached, the country becomes more broken and the eruptive rocks form a more and more prominent feature until in the eastern end of the county they constitute practically the whole mass of the mountains, with only occasional small outcrops of sedimentary rock.

The coal of Lewis County offers a good example of the alterations brought about by folding and the intrusions of igneous rocks into the coal measures. From the low,level country in the western part of the county to the mountainous country to the eastward the coal shows a gradual transition from lignite to semi-anthracite. The brown lignite of Chehalis and Centralia and the semi-anthracite of Verndale occupy extreme positions on the scale. They are both of the same age and probably have both had approximately the same load of overlying sediment. The main difference has been that in the Verndale region the coal has been folded, broken across and overflowed by great bodies of eruptive rocks, while at Chehalis and Centralia the rocks have been tilted only to a slight degree from their original horizontal position, without under-

going any great degree of crushing or folding and without much loss of their volatile constituents. Many intermediate types of coal are represented in the valleys of the Cowlitz and Tilton rivers at Alpha, Cinebar, Morton, and Sulphur Springs.

The lignite field of Lewis county may be said to extend from the western end of the county as far east as Alpha, where a number of veins of this character have been prospected. Bituminous coal occurs at Cinebar, about ten miles east of Alpha, in a region where the strata have been broken by dikes and considerably crushed and folded. Still further eastward, in the Morton and Verndale regions, the surface rock is nearly all of igneous origin and the coal has been reduced to anthracite or semi-anthracite. The coal of the Packwood and Davis prospects in the Cowlitz pass region is of this same type.

Chehalis–Centralia Field.

Lignite of a rather inferior quality occurs in the region about Chehalis and Centralia, and has been mined on a small scale for the local trade for several years. It is sold in these two towns chiefly as a domestic coal, but is used to a limited extent for making steam. It is so situated as to be mined very cheaply and its low price enables it to compete in the local market with outside coals of much superior quality.

The general aspect of the region is that of a level plain with low rounded hills rising at intervals above the surrounding country. The coal measures appear along the hillsides and coal outcrops are known to occur at many places. A number of attempts have been made in the past to open up some of the numerous coal veins and place the product on the market, but at the present time there are only two mines in active operation, and neither of these produce more than a few tons per day.

Rosenthal Mine.—A small mine is being worked in section 29, just outside of Chehalis, on the Rosenthal property. Four veins show along the hillside, varying in thickness from two and a half to twelve feet. The only vein being worked at present is about four feet thick. A tunnel has been driven into the

base of the hill for a distance of 250 feet and the coal above it is being worked out. Only two or three men are regularly employed in the mine and all the coal is sold in Chehalis. Some of the other veins on the same property have been

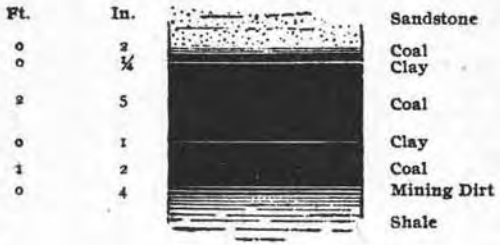


Fig. 34. Cross-section of vein, Rosenthal Mine, Chehalis.

worked in the past. All of the coal carries high percentages of ash and moisture and a correspondingly low percentage of fixed carbon.

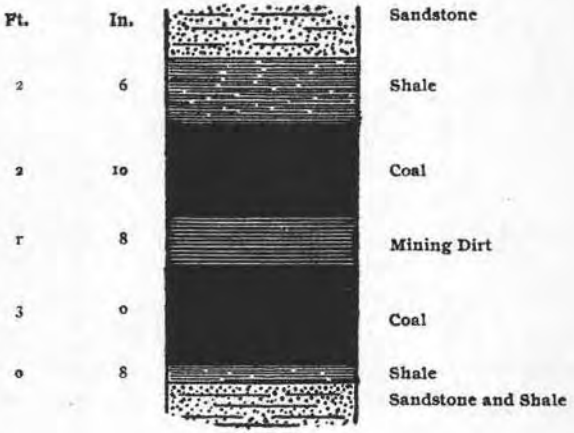


Fig. 35. Cross-section of vein, Salzer Valley Mine, Secs. 22 and 23, T. 14 N. R. 2 W.

Salzer Valley Mine.—The town of Centralia is supplied by the Salzer valley coal mine, situated about four miles east of the town in sections 22 and 23. There is only about forty-five acres in the property and the output is very limited. Three

veins are known to occur, all lying nearly flat, and dipping only about four degrees. The lowest vein, which is the only one being worked at present, is about seven feet wide and contains two benches of coal two feet and three feet wide respectively, and separated from each other by about twenty inches of clay. Another vein ten feet wide lies 200 feet above the first one. A tunnel 400 feet long was driven on this vein and about 1500 tons of coal taken out, but nothing has been done on it for the past three years. A third vein occurs about fifty feet higher in the series, but has never been prospected.

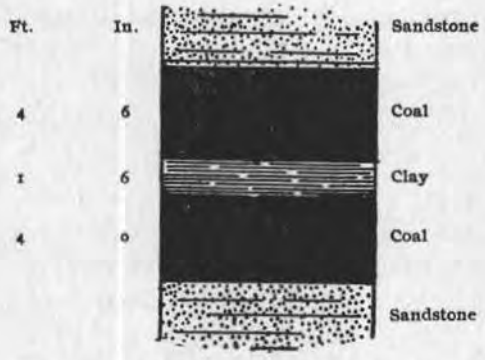


Fig. 36. Cross-section of No. 8 vein, Crescent Mine, Claquato.

Claquato Mine.—A new prospect has lately been opened up near Claquato by the Crescent Coal Company. Three veins have been found, ranging in width from five to eleven feet. A tunnel is being driven on the middle one, which contains two benches of coal, each about four feet wide, with a layer of clay eighteen inches wide in the middle. The veins dip to the southward at angles varying from twenty to forty-five degrees.

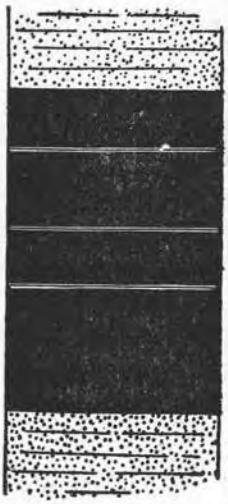


Fig. 37. Cross-section of No. 10 vein, Crescent Mine, Claquato.

Alpha Field.

A lignite field of limited extent occurs near Alpha post office, about eighteen miles east of Chehalis, in townships 13 and 14 N., R. 1 E. The region is one of low relief and there are very few exposures of rock in place, consequently it is impossible to define the actual limits of the area that is underlaid with coal. Some prospecting has been done in sections

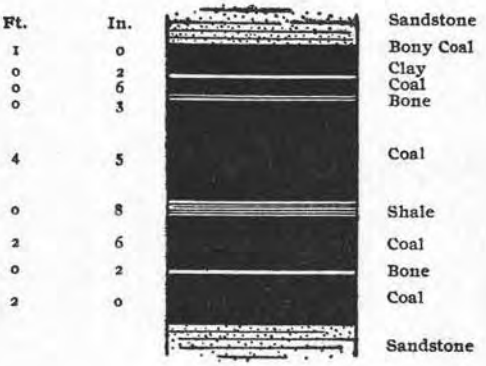


Fig. 38 Cross-section of vein, Hannaford Creek, S. W. ¼ sec. 32 T. 15 N. R 1 E.

2, 4, 8, 9, 10, and 11, T. 13 N., R. 1 E., and in sections 32 and 34, T. 14 N., R. 1 E. It is said that the coal was not found of sufficient value to encourage further work and it was therefore suspended. Four tunnels varying in length from thirty-five to ninety feet were driven, besides a number of open cuts and test pits. Several veins were exposed, varying in width from five to ten feet, and dipping to the southwest at an angle of about 45 degrees. They were traced for about two and a half miles. The coal is said to be traversed in places by dikes, which have caused a local change from lignite to bituminous coal. No work is being done at present in this field.

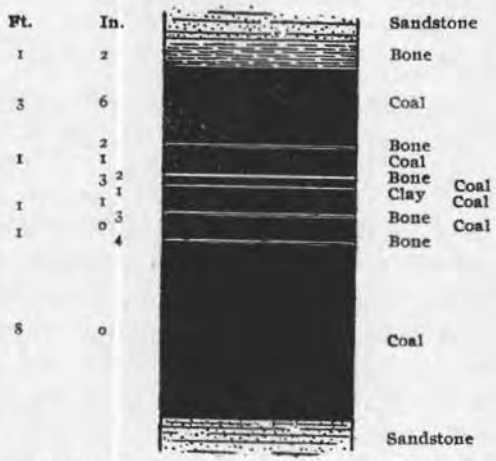


Fig. 39. Section of vein, Hannaford Creek, N. W. ¼ sec. 32 T. 15 N. R. 1 E. (W. J. Wood.)

CINEBAR FIELD.

Cinebar Mines.—The Cinebar coal mines, owned by the Columbia Coal and Coke Company, are opened on a little stream known as Sherman creek, which flows into Tilton river about a mile south of Cinebar post-office. The coal-bearing rocks lie along the southern base of a range of hills which parallels Tilton river for twelve or fifteen miles. In this part of its course Tilton river flows in a deep, narrow gorge, above which is a comparatively level valley, largely under cultivation. The mines are opened along the northern edge of the

valley just where the hill begins to rise. The hills are covered with thick timber and the soil is quite deep, so that surface prospecting cannot be carried on except in some of the stream beds, and consequently the extent of the coal-bearing rocks is not definitely known. Coal croppings have been found on Bear creek, which parallels Sherman creek, about a mile to the eastward, and on Cinebar creek about the same distance to the westward. The coal veins on Cinebar creek and its tributary, Coal creek, has been quite extensively prospected and are supposed to be identical with those now being opened up on Sherman creek.

There are about a dozen veins outcropping on Sherman creek, and all of them have been prospected more or less by a number of short tunnels which have been driven on the different veins, the longest being 256 feet on vein No. 5. A crosscut tunnel 1900 feet long runs at right angles to the strata and brings to view a number of veins, on some of which gangways have been driven. Vein No. 5 is about nine feet thick and shows at its mouth clean, hard coal, but further along in the tunnel the coal becomes dirty in places and near the end of the tunnel is involved in a small fault. The coal in all the tunnels makes a little gas, so that safety lamps have to be used to some extent.

All of the veins thus far developed show signs of crushing and sliding whereby the wall rock has become mixed with the coal to such an extent as to render a large amount of it too dirty to be of any commercial value. This loss in part is the price which it seems must be paid for bituminous coal in rocks so recent as the Eocene. The forces which changed it from lignite to bituminous have caused a more or less serious loss in the quantity of clean coal. Where the dirt partings in the veins are clearly defined the task of separating the dirt from the coal is comparatively easy, but in such veins as those of Cinebar, where the whole contents of the vein and part of the wall have ben formed into an intimate mixture, it is a difficult undertaking to separate them. The process of rolling to which the veins have been subjected has reduced most of the coal to a powder, so that it crumbles at the touch,

and a very large percentage of it will reach the market in the form of slack. This difficulty may be obviated by making it into coke at the mine, and probably the most of it will be treated in this way.

It is planned to build a railroad into the Cinebar field by way of the Cowlitz valley so as to give as short and easy a route as possible to the Columbia river. The nearest railroad point at present is Chehalis, twenty-five miles away. On account of the abundance of good coal tributary to Puget Sound cities, and its almost entire absence in the region immediately tributary to Portland, it is thought advisable to market all of the coal in the latter city and thereabouts.

Morton Field.

The Morton coal prospects lie about fourteen miles east of Cinebar, and forty miles east of Chehalis, the nearest railroad point. A wagon road leads from Chehalis to Morton by way of Alpha and Cinebar, and all the travel to and from the district is over this route.

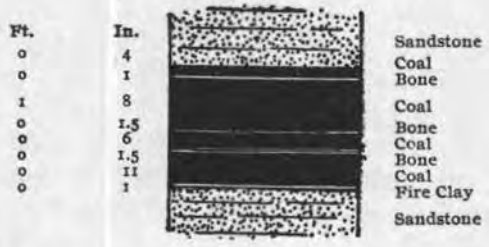


Fig. 40. Cross-section of No. 2 vein, sec. 30, T. 13 N. R. 5 E. (Morton Field.)

The coal outcrops in the Morton field occur in a number of isolated localities separated from each other by bodies of igneous rock, which in this region appear to have overflowed the coal measures. The region is one of high mountains, composed almost entirely of igneous rock, the small areas of coal measures forming comparatively insignificant features of the landscape. Their boundaries have never been traced out, so that the actual extent of country underlaid with coal is quite

unknown. A considerable variation is found in the analyses of the coal from different prospects, the dissimilarity being probably due to the greater intensity of volcanic action in some localities than in others. The coal is quite hard and does not show evidence of having been subjected to much internal movement, its bituminous character being due rather to the close proximity of large passes of igneous rocks. Nearly all the other bituminous coals of the state except those of Roslyn are quite soft and mine very small, but a large percentage of the Morton coal can be placed upon the market as lump and nut coal. The coking qualities of the Morton coal have not yet been tested.

Fig. 41. Cross-section of vein, sec. 6, T. 12 N. R. 5 E. (Morton Field.)

There is one prospect upon which considerable work has been done and which shows better quality of coal than that found elsewhere in this field. This is in section 6, T. 12 N., R. 5 E., near Davis lake, where a slope 350 feet long has been sunk on a vein which outcrops along the hillside northeast of the lake. The vein is from three and a half to four feet wide and is fairly regular all the way down the slope. Short gangways have been driven in both directions from the slope and some of the coal has been taken out for use in the boiler which supplied the hoisting engine at the top of the slope. An analysis of the coal gave the following percentages: Water, 1.57; volatile matter, 7.87; fixed carbon, 84.82; sulphur, 1.70; ash, 4.04. The heating power of this coal is very high and it has been found to work well in the furnace. Its composition

places it in the semi-anthracite class. There are six other veins lying at short intervals from the main vein and a number of short prospect tunnels have been driven upon them.

The prospect described above is the most promising one in the Morton field, owing to the regularity of the veins and the high character of the coal. More development work, however, will have to be done upon it before the mine will be in shape to make extensive shipments, even if transportation facilities were at hand. It is forty miles to the nearest railroad point, and for this reason development work has been necessarily slow. The Cowlitz and Tilton river valleys offer an easy railroad grade all the way to the mines and the construction of a railroad does not present any serious engineering difficulties.

Fig. 42. Cross-section of No. 1 Vein, sec. 30 T. 13 N. R. 5 E. (Morton Field.)

In section 12, T. 12 N., R. 4 E., on the opposite side of Davis lake from section 6, Mr. E. E. Edmond has driven a small tunnel on a coal vein which he says is nine feet thick. Several veins are said to outcrop on the mountain side south of this place.

Three or four miles north of Davis lake, at the forks of Tilton river, there is a coal area covering about six sections of land. Some development work has been done on sections 24 and 30. Six veins are said to occur, varying in width from

three and a half to eight and a half feet. An analysis of the coal from section 24, T. 13 N., R. 4 E., gave the following percentages: Water, 3.71; volatile matter, 35.03; fixed carbon, 59.01; sulphur, 1.24; ash, 1.01. A sample from section 30, which adjoins 24, gave somewhat similar percentages: Water, 1.80; volatile matter, 34.27; fixed carbon, 58.93; sulphur, 1.34; ash, 3.66.

Another prospect is located on Connolly creek in section 26, T. 13 N., R. 4 E. The vein is six feet wide and has been opened by a tunnel sixty feet long, from the end of which a slope was sunk on the vein sixty feet. Nothing is being done on it at the present time.

North of Verndale some work has been done in section 20, T. 13 N., R. 6 E. This location is at the very headwaters of the east fork of Tilton river. The coal outcrops in the bed of the stream at the bottom of a deep gulch. The seams of clean coal are only a few inches thick and the whole formation has been greatly distorted by the intrusion of eruptive rocks, which constitute practically all the surface rocks of the region. An analysis of the coal shows the following percentages: Water, 2.67; volatile matter, 4.86; fixed carbon, 88.66; sulphur, 1.22; ash, 2.59. The coal has a steel-gray appearance and is extremely hard and compact.

Packwood Field.

The Packwood coal field is the name locally applied to a region on the headwaters of the Cowlitz river, in the Mt. Rainier Forest Reserve. The coal beds to which the name of Packwood has been definitely applied outcrop on the south side of the Cowlitz, just north of Lake creek, about twelve miles northeast of the post-office of Sulphur Springs.

The valley of the Cowlitz river from Cora post-office, twenty-three miles due south of Mt. Rainier, to the junction of the Clear and Muddy forks, about seventeen miles up-stream to the northeast, has a width varying from one-half to two miles. Spurs of the Tatoosh and Sawtooth ranges form the northwestern walls of the valley. The ridges bordering it on the southeast extend back to the main divide of the Cascade range

and culminate in Goat mountain, at an elevation of 5000 feet. The broad, alluvial floor of the Cowlitz valley has a very even rise from about 800 feet at Cora to 1500 feet at the mouth of the Muddy fork.

The coal-bearing shales and sandstones outcrop along the banks of the main river in a few places, but there are more numerous and clearer exposures in the gorges cut by the streams entering the valley from each side, and on the intervening ridges. The strata lie mostly within a few degrees of the horizontal. They appear to be free from faults and abrupt folds, but observations made at a number of different points in the region show the direction of dip to vary greatly.

The chief prospects in the Packwood field are located three miles southeast of the Cowlitz river and two miles north of Lake creek, at an elevation of 2600 feet. The workings have a total length of 600 feet. Clean coal lies in thin layers interbedded with shale, which in some cases is highly carbonaceous. The thickness of these layers is most commonly from one to three inches, along with a number of vein-like streaks about one-fourth inch thick, and a few layers from eight to ten inches thick. Some are continuous for several hundred feet, but the majority are short and taper very gradually at the ends. The beds are overlaid by an igneous rock, which at other points near by shows evidence of intrusive origin. At several points in the workings the contact of the igneous mass with the coal shales is plainly shown.

All of the coal exposed in the tunnels is slacked and crumbles readily, due to its exposure to the atmosphere for several years. Fresh coal, taken a few feet from the face, ignites with difficulty, burns with a short, blue flame, gives intense heat, and leaves a small amount of gray ash. No pyrites of iron is visible in any of the coal.

Three-eighths of a mile east of the Packwood prospects, just north of the divide between Lake and Coal creeks, two short tunnels have been driven in coal-bearing shales which seem to belong to the same series as those just described and which may be identical with them, although the cannection

cannot be traced accurately. Several feet below the coal a layer of sandy shale contains petrified wood in the form of roots, twigs and stumps. Most of the woody matter has been replaced, but enough carbonaceous material remains to give the specimens a black color, which can be removed by heating.

Pure coal interbedded with carbonaceous shale and sandstone occurs at a number of places in the beds of Coal and Lake creeks, on the high, steep ridge between them, and along the smaller creeks to the north and south. The hard, firm texture of the coal accounts for the amount of it found as float in all the creeks of the region.

Davis Field.

The first main trail crossing the Cascades south of Mt. Rainier is known as the Cowlitz, starting from Sulphur Springs on the western side of the range, and ending in the Tieton basin. The trail follows the Cowlitz river up to its main fork, thereafter following the east or Clear fork for several miles, then turning east to the broad summit, which it crosses at an elevation of 5,190 feet. Five miles west of the summit, at an elevation of 3,700 feet, the trail follows Coal or Summit creek, which here cuts through a thick series of shales, sandstones and conglomerates on which the Davis claims are located.

These sedimentaries have been upturned to high angles, in some cases standing vertical, and their strike is somewhat east of north. Summit creek flowing west has worn through the beds a canyon with precipitous walls from one to three hundred feet high, in which a cross-section of the bedding is well shown for several thousand feet. Scattered through the series are a number of so-called "veins" of coal and carbonaceous shale, varying in thickness from two to twenty feet. Most of these veins are conformable with the under and overlying layers of sediment, and are distinguished by their dark color, which is due to the carbonaceous matter present. The shale within the veins is finely bedded and contains some bone. Considerable crushing and slipping has occurred in certain places, forming slickensides and false walls, and mak-

ing a resulting mass of soft, loose coal and shale. Faults and folds are small and of rare occurrence, so far as the present surface shows. The "veins" of black shale and coal appear to maintain their proper widths and positions in the series, but observations on this point can hardly be made with exactness.

The streams north and south of Summit creek at the Davis claims run in a general westerly direction parallel to them. The strike of the coal-bearing shales may be traced nearly to the top of the ridge south of Summit creek, where the edges of the upturned beds are covered by a lava sheet, and the shales outcrop in several streams to the south. About two miles

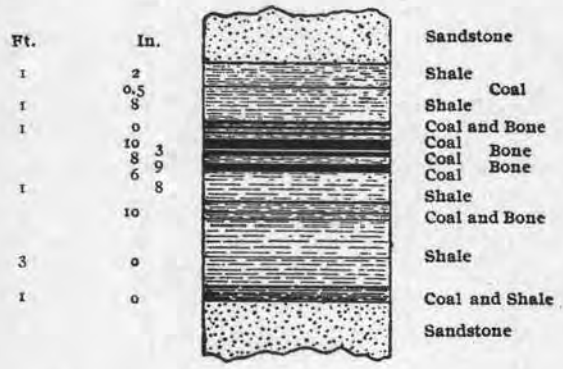


Fig. 43. Cross-section of Coal Measures on Summit Creek, Davis Field. Dip 11° N. 22° E.

north of the Davis claims, on the ridge which forms the divide between Summit and Carlton creeks, several coal prospects have been opened. Tunnels have been driven near the top of the ridge, on the Carlton slope, and also on the north side of Carlton creek. The occurrence of the coal is quite similar to that on Summit creek and the direction of the beds would indicate that they are identical or else nearly in the same geological horizon. Other claims have been located near Fish lake, three or four miles to the northeast of Carlton creek. One of the seams already exposed shows fourteen inches of clean, solid coal, while others show as much as eight or ten inches.

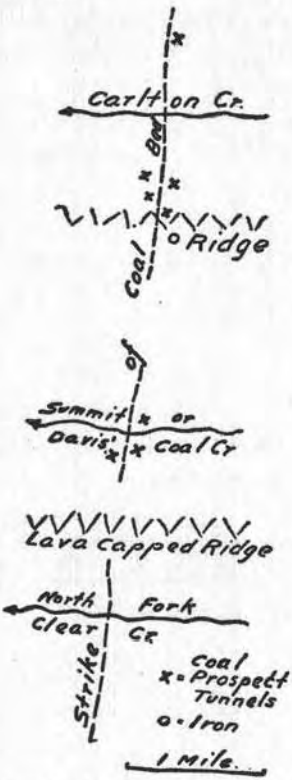


Fig. 44. Map showing Coal Prospects in Davis Field.

The following section appears on the north bank of Summit creek, below the Davis claims. Dip of beds nearly vertical. Downstream, for east to west. Distances by pacing:

	Feet.
Carbonaceous shale with very thin streaks of coal.....	5
Fine laminated sandstone and shale	20
Coal-bearing black shale	16
Soft and hard gray shale	35
Carbonaceous shale (one seam of clean coal 6 inches, one 3 inches, several ½ to 2 inches thick).....	12
Shale and sandstone	20
Carbonaceous shale, with clean coal in streaks from ¼ to 3 inches thick	3

Shale and sandstone, with 6 "veins" of carbonaceous shale from 3 to 12 feet thick, each containing thin streaks of clean coal	300
Carbonaceous shale with coal	25
Sandstone	60
Carbonaceous shale	12-20

COWLITZ COUNTY.

Kelso-Castle Rock Field.

The coal of the Kelso-Castle Rock field is not of very great commercial importance at the present time. There is a large extent of territory on both sides of the lower Cowlitz river that is underlaid with coal. At a large number of places prospecting has been done, but in no case thus far has a large body of first class coal been found. The coal is a low grade lignite, quite high in moisture and in ash. The quality of the coal in the different prospects is variable, being much better in some places than in others. The country is for the most part very heavily timbered and the hills are worn into low, rounded forms, so that the solid rock does not show in many places. The soft coal-bearing rocks have been much decomposed and a residual soil many feet in thickness has been formed. Because of the heavy mantle of soil it is not easy to state the exact boundaries of the coal-bearing territory. It is probable that as the district becomes better known the boundaries of the area of productive coal measures will be greatly extended.

Throughout its lower course the Cowlitz river flows through a flat, alluvial valley a mile or two in width, bordered by low hills, which gradually increase in height as they recede from the river. The tide flows up the river several miles above Kelso. At Rocky Point and at Castle Rock bold bluffs of hard, basaltic lava extend out into the valley. In the vicinity of Kelso and farther up the river there are remnants of a rocky bench or terrace about fifty feet above the level floor of the valley.

The coal-bearing rocks are shale and impure sandstone, probably of Eocene age. They have been upturned only to a

slight degree. Along the Cowlitz river the rocks may be seen in places dipping at low angles. The basalts are of later age than the sandstones and evidently are dikes which have broken through the older formation.

The Coal Creek Development Company of The Dalles, Oregon, is operating a small coal mine on Coal creek about eight miles west of Kelso. The coal is a lignite rather high in moisture, but suitable for domestic use. Portland is the market for this coal.

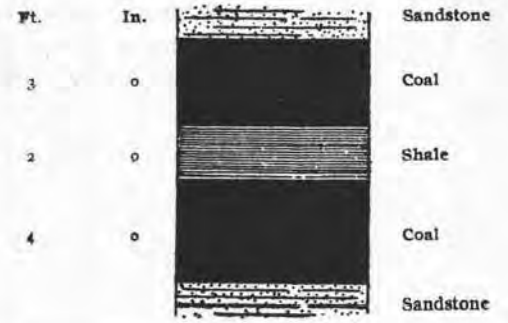


Fig. 45. Cross-section of vein, Coal Creek Development Co's Mine, near Kelso.

The Oregon Coal and Timber Company, of Portland, Oregon, has been endeavoring to open up the old Idleman mine, situated in sections 12 and 13, T. 9 N., R. 2 W., about a mile and a half east of Castle Rock. The mine was operated by Mr. C. M. Idleman a number of years ago. It was worked in a small way until 1893, when it was closed down on account of litigation. The present company began operations late in the fall of 1901. There are three veins having widths of four feet six inches, four feet one inch, and six feet, respectively. Still other veins of unknown thickness outcrop below these.

Another mine, known as the Red Ash, was opened up several years ago on Arkansas creek, about two or three miles west of Castle Rock. A considerable amount of coal was shipped to Portland and other places, where it is said to have given good satisfaction. The mine was closed down about three years ago and nothing has been done with it since. The

vein is said to have been several feet in thickness and to be composed of good, clean coal.

The Anchor mine is another old mine that was worked for awhile and then abandoned. It is situated in section 13, T. 8 N., R. 2 W., about three miles northeast of Kelso. Two veins were worked, one four feet and the other five feet in thickness. The mine was operated for several years prior to 1898, but has not been working since that time.

The Carbondale mine, three miles southeast of Castle Rock, in section 24, T. 9 N., R. 1 W., has been developed to some extent, but has not yet been put on a shipping basis. Other prospects have been opened in the N. W. ¼ of section 24, T. 10 N., R. 1 W.; in section 24, T. 9 N., R. 1 W., and in sections 8 and 18, T. 10 N., R. 1 E.

CHAPTER III.

THE COAL SEAMS.

NUMBER AND CHARACTER.

Carbonaceous matter occurs practically throughout the whole extent of the Eocene beds in Washington, either disseminated through the rocks or concentrated into coal veins. The shale owes its dark color to the fine particles of carbon which it contains and all gradations are found between shale and clean coal. The sandstones generally contain little streaks of coal. Much of the carbon of both the shale and sandstone is held in the form of iron carbonate.

Conditions favorable for the formation of coal beds occurred repeatedly throughout the long period during which the Eocene sediments were being laid down. In some fields over one hundred distinct coal seams have been observed. Of these, however, only a small proportion are clean enough and large enough to be of value, the number of workable veins in the different mines varying from one to seven or eight. Few veins are worked whose thickness of coal is less than three feet. It seldom or never happens that a vein is made entirely of clean coal; there are nearly always present one or more distinct layers of shale, sand, or impure coal varying in width from a fraction of an inch to several feet. Some of the largest veins attain a thickness of forty or fifty feet. In these veins only a small portion, if any, is workable coal and the remainder of the veins is made up of more or less impure coal, bone, shale, and clay occuring in distinct layers. From this it will be seen that the contents of a vein may vary rapidly in quality in a cross-section of the vein but longitudinally its contents will be quite uniform over large areas; that is to say, each layer within the vein differs from those above and below it, but maintains its own characteristics of composition and structure for long distances. It

usually happens that one or more of the impure seams must be mined with the coal and this requires washing and hand picking. In the lignite mines where the danger of spontaneous combustion is great, all the coal contents of the vein whether pure or impure must be removed.

In addition to the impurities which occur in more or less well defined layers there is always a certain amount of dirt in the coal which cannot be removed by washing, because it is too intimately mixed with the coal itself. The ash which is contained in coal is derived from two sources. In the first place, there is the wood ash which was contained in the vegetal matter from which the coal was formed, and in the second place there is the sand and mud which was washed into the coal swamp at the time of the deposition of the vegetal matter. The latter constitutes by far the greater portion of ash in nearly all coal veins. In a very few cases, however, notably that of the Black Diamond vein, the percentage of ash is very little more than a calculation based on the amount of wood ash in the original plants would indicate. The ash in Washington coals varies from one per cent up to fifteen or eighteen, at which point the coal ceases to be of any commercial value.

It is the ash percentage which in nearly every case determines whether or not a coal can be marketed. There are few lignite veins in the state whose percentages of moisture and other volatile constituents are so high as to render them of no value commercially. A large amount of ash, besides being totally inert so far as heat producing is concerned, is a positive injury on account of its clinging to the grate bars of furnaces and requiring frequent cleaning of the fires.

VARIETIES OF COAL.

The physical appearance of coal is to a considerable extent an index to its composition and to the conditions under which it has existed. The lignite occurs in rocks which have undergone only a moderate amount of tilting without any shearing movement having taken place within the coal beds and their hard consolidated condition is due to the

superincumbent weight of sediments. The soft coking coals indicate a much greater degree of folding and shearing. The walls of the coal veins have been rolled one upon another until the coal has been ground into powder. Nearly all the moisture has been expelled and the percentage of volatile combustible material greatly reduced, with a conseqeunt increase in the percentage of fixed carbon.

Few coals have been found in the state whose percentage of carbon both fixed and volatile is over ninety per cent. and which, therefore, could properly be classed as anthracite. In certain limited areas in Lewis county and elsewhere in the near neighborhood of igneous masses the coal has been reduced to anthracite. The coal in this condition is steel-gray in appearance and is quite hard and compact. It ignites with great difficulty. No large amount of it has ever been taken out so that no satisfactory boiler tests have been made.

There are certain characteristics which mark the coal of the different fields. These are due in part to the different conditions under which the coal was originally formed and in part to the subsequent history of the field. The coals of the state fall naturally into three classes, viz., lignite, semi-bituminous, or steam coals and bituminous coking coals. A fourth class might be added, that of anthracite, but up to the present time the anthracite fields have not been developed and little is known as to their commercial value. The dividing line between the different classes is to a certain extent indeterminate, but as a rule the different kinds of coal are confined within well marked geographical boundaries. Each field produces a certain quality of coal which is fairly uniform within the limits of that province. The classification is based upon the relative percentages of fixed carbon, volatile hydrocarbon, and moisture. The volatile constituents are highest in the lignite and lowest in the anthracite.

The Renton-Cedar mountain and Newcastle-Gilman fields are the most important lignite fields and the only ones which are producing on an extensive scale. The coal of Cowlitz and Thurston counties and western Lewis county is lignite and of an inferior quality as far as it has been opened up. Lignite

has a representative analysis of moisture 8 to 12 per cent., volatile hydrocarbons 35 to 45 per cent., fixed carbon 30 to 45 per cent., and varying amounts of ash. The coal is hard and breaks with a cubical fracture.

The semi-bituminous steam coals have a representative analysis of moisture 3 to 5 per cent, volatile hydrocarbon 30 to 40 per cent, and fixed carbon 40 to 50 per cent. This coal is best represented in the Green River field of King county. Chemically it is only one step removed from lignite, which it resembles in many respects. It has a higher heating capacity and is an excellent coal for locomotive and steamboat use. It is a free-burning coal and does not coke in the furnace. Nearly all of it is used for steam-making.

The bituminous coking-coal of the Wilkeson-Carbonado and Cokedale fields is still another step removed from lignite. A representative analysis of this coal is as follows: Moisture 1 to 3 per cent, volatile hydrocarbons 25 to 35 per cent, fixed carbon 50 to 60 per cent. Frequently the percentage of fixed carbon is considerably higher than this, especially in the Fairfax district and some of the coal might properly be classed as semi-anthracite. Most of the coking veins are greatly crushed and their contents have undergone considerable chemical change. The coal comes from the mine mostly in the form of fine slack. Where it is destined to be made into coke no attempt is made to mine the coal in large sizes, but where the coal is intended for the market care is taken not to break it finer than necessary. It is a good steam and domestic coal and a large amount of it is used for steamboats and locomotives. It cakes to a certain extent in the furnace and requires frequent working but it makes an intense heat. Most of this coal carries a considerable percentage of ash, usually more than the other coals. This is due largely to the fact that a certain amount of the wall rock has been mixed with the coal during the process of rolling to which the veins have been subjected. The dirt partings in the veins have in many cases become obliterated and so intimately mixed with the coal that it is impossible to wash it thoroughly.

The Roslyn coal belongs to the bituminous coking group but unlike the others it is very hard, and shows no tendency to crumble. A very large percentage of it reaches the market as lump coal. A 25-ton block of Roslyn coal was exhibited at the Chicago World's Fair. The Roslyn coal has not been subjected to the same degree of close folding as the other bituminous coals of the state, and very little mechanical change has taken place within the veins since they were formed.

Normally the Roslyn coal with its gentle folds would not have passed beyond the lignite stage were it not for some other cause which has hastened the process of distillation. This cause may be sought in the great sheets of basaltic lava which are known to underlie the Roslyn formation. They outflowed only a short time prior to the deposition of the Roslyn sediments and the buried sediments in comparatively close contact with the heated lavas undoubtedly reached a higher temperature than coal veins under normal conditions. It is well known that destructive distillation of the volatile elements of coal will take place at a comparatively low temperature, and the higher the temperature the more rapidly will distillation proceed. The conditions under which the Roslyn coal was originally formed probably differ considerably from those obtained in the Puget Sound region, and distillation of the volatile hydrocarbons may have reached an advanced stage before the carbonaceous matter forming the veins was finally buried by the succeeding sediments.

Anthracite has been formed only in the vicinity of dikes or masses of eruptive rocks. The intense heating of the coal where it has come in contact with the molten mass of intrusive rock has in several instances caused nearly all the volatile matter to be dissipated and only the ash and fixed carbon remain. The anthracite areas occur usually high in the mountains where the volcanic action has been severe. The coal measures have been broken across by numerous dikes, and sheets of lava have been forced in between the beds for long distances.

It is possible for coal to pass through all the stages from

lignite to anthracite without undergoing any great disturbance of the strata, providing the superincumbent mass of rock is sufficiently great and the time during which the pressure has been acting is long enough. The bituminous coal veins of the states of the middle west still remain nearly all in their original horizontal position. They are of Carboniferous age and the very long period during which they have been subjected to the pressure of the rocks lying upon them has gradually driven off the volatile matter to such an extent as to render the coal bituminous. The coal of Washington is very much younger and normally would still be in the lignite stage, but some of it has taken what may be called a short cut to the bituminous class. This result has been brought about by a sharp folding of the rocks and the intrusion of dikes into the strata. Thus the same result has been arrived at in a fraction of the time required for the eastern bituminous coal fields but it has been accomplished only at the cost of destroying to a large extent the regularity of the strata. It has improved the quality of the coal so far as an increase in the percentage of fixed carbon is concerned, but it has usually increased the percentage of ash and in a number of cases rendered the veins so dirty as to destroy entirely their commercial value.

The introduction of washeries in recent years has served greatly to increase the supply of marketable coal. Only the finer coal is washed but in most of the mines this forms a large percentage of the whole. All of the larger mines except Roslyn and Black Diamond have washeries in operation whose capacity is from three hundred to fifteen hundred tons per day.

COMPOSITION AND HEATING POWER OF THE COAL.

The volatile combustible constituents of coal are composed of members of the hydrocarbon group of compounds. They differ from the so-called fixed carbon by reason of the greater ease with which they volatilize under moderate heat. When coal high in volatile matter is thrown into the furnace great volumes of dense black or brown smoke immediately pour

forth. This is an indication of imperfect combustion and consequently great loss of heat-producing power. The dark color of the smoke is due to finely disseminated particles of carbon of which it is composed. The ordinary type of furnace does not give sufficient ventilation to oxidize the volatile hydrocarbon and it requires some type of so-called smoke consumer to utilize all the heat producing qualities of these coals. The great value of anthracite lies in the fact that it contains only a small percentage of volatile constituents and practically all its heating qualities can be utilized.

The exact chemical combination in which the various elements in the coal are held together is not definitely known so that when we speak of fixed carbon the term must be understood only in a relative sense. The percentage of fixed carbon is lowest in lignite and highest in anthracite and the heating power of the different varieties of coal is in a general way in direct ratio to the amount of fixed carbon.

None of the Washington coal carries a very high percentage of sulphur and in most of it the amount is very low. While sulphur oxidizes under heat and produces considerable heat a certain amount of it reacts with the other constituents of the coal to form sulphuric acid which attacks the iron of the grate bars and boiler tubes. Where coal is used for coke making the presence of sulphur detracts from the value of the coke, especially for foundry use. Nearly all of the coke made in the state is for foundry and smelter use. In that which is used in smelters the amount of sulphur in the coke is of no consequence but for foundry use if the coke contain more than a very small percentage of sulphur the iron is injured thereby.

The moisture in Washington coal varies from less than one per cent up to nearly twenty per cent. It is smallest in the soft bituminous coking coals and greatest in the brown lignites of Lewis and Cowlitz counties. The moisture is not only entirely inert as far as heat producing is concerned but works a positive injury, because a considerable amount of heat is consumed in vaporizing the moisture before any of it is available for heating outside objects. For this reason

a coal high in moisture makes a very inferior steam coal and finds its greatest use in domestic purposes where the heat requirements are not so great.

So closely is the chemical composition of the coal related to the structure of the field that a chemical analysis is a good index to the amount of movement which the strata have suffered. The greater the degree of disturbance the greater the percentage of fixed carbon and the smaller the percentage of volatile constituents.

The Bureau of Naval Equipment at Washington, D. C., has made a large number of tests on different coals including some from this state. The Bureau undertakes to furnish a free analysis to any one who will forward a sample of at least four pounds weight. Evaporative tests are made at the New York and Mare Island Navy yards for any one who will furnish free of charge a lot of twelve tons.

The following table shows the result of the analyses made on some of the Washington coal:

NAME	Moisture	Phosphorus	Volatile matter	Fixed Carbon	Ash	Sulphur
Blue Canyon	1.790	.006	31.479	62.744	3.679	.308
Fairhaven	2.980	.....	35.030	59.980	2.010	.202
Wilkeson	.700	.009	23.545	56.895	18.715	.145
Franklin (McKay Vein)	1.300	.007	39.254	56.400	2.884	.162
Roslyn	1 450	.008	32.794	53.656	11.944	.156
Newcastle No. 4 Vein	13.590	.....	32.310	48.320	5.780	.164
Black Diamond	3.040	.023	36.566	56.084	4.166	.144
Fairhaven	.310	.245	22.265	62.395	14.885	.145
Gilman	10.240	.004	32.640	51.321	5.714	.085
Franklin	3.260	.....	35.360	57.580	3.800	.097
Roslyn	2.050	.....	33.550	54.550	6.850	.106
Roslyn	2.718	.....	34.275	50.109	12.753	.145
Franklin	4.559	.....	33.501	46.668	15.080	.192

"The amount of moisture shown in the first column indicates to some extent the liability of the coal to spontaneous combustion since the presence of moisture is necessary to the generation of heat."

"The amount of fixed carbon indicates heat-giving properties. The amount of combustible volatile matter is of value

in determining the rapidity of combustion. A coal rich in combustible gases usually burns rapidly."

The following boiler tests made on the U. S. S. Yorktown indicate the comparative heating power of some of the Washington coals:

Name of Coal	Coal burned per hour	Burned per H. P. per hour	Refuse	Knots per ton of coal	H. P.
	Pounds	Pounds	Percentage		
Comox B. C.	2,288	2.70	34	11.3	845
Black Diamond	2,478	3.51	14	9.6	706
Black Diamond	2,164	4.45	14	9.4	486
Fairhaven	2,575	3.40	20	9.4	756
Blue Canyon	2,599	2.53	16	10.2	1025
Blue Canyon	2,336	2.50	27	9.3	934

The following tests of coal from various mines made at the Mare Island Navy yard will serve as a basis of comparison between the Washington coals and those from other sources:

Name of Coal	Coal consumed per hour per sq. ft. of grate surface	Water evaporated per pound of coal	Equivalent evaporations from and at 212° per lb. of coal	Refuse
	Pounds	Pounds	Pounds	Per cent.
Albion Cardiff (Wales)	10.00	9.07	10.69	10.00
Comox B. C.	12.77	7.689	9.027	14.70
Wellington B. C.	13.48	7.146	8.389	11.87
Castle Gate (Utah)	12.296	6.934	8.123	12.049
Franklin	14.33	6.78	7.94	13.33
Nanaimo B. C.	14.35	6.5077	7.6315	15.45
Roslyn	14.24	6.243	7.315	16.20
Newcastle	15.14	5.965	6.996	10.50
Fairhaven	11.178	6.853	8.05	19.95
Roslyn	13.387	6.827	7.09	11.66

Steaming tests have been made by vessels of the United States navy on the coal from a number of Washington mines with results as follows: On the U. S. S. Mohican the following coals were tested:

Coal from Franklin (McKay vein) was tested and found to be free burning coal, the fires requiring very little working, firing lightly every twelve or fifteen minutes. The fires

required cleaning once in eight hours. There is a very little clinker of a brittle character and does not adhere to the grate bars. When fresh coal is thrown on the fires there is a dense smoke of a grayish black color. The tubes did not require sweeping during the run in either the low speed or the high speed tests. There was very little soot to sweep out at the end of the test.

Roslyn. The coal from the Roslyn mine received aboard the Mohican at Tacoma was found to be a free burning coal; the fires required little working, firing lightly about every fifteen minutes. The fires required cleaning once in eight hours. Only a small quantity of clinker was found, which was easily broken, and did not adhere to the grate-bars. There is a considerable volume of grayish colored smoke when fresh coal is thrown on the fire. Tests were made at low and high speed under natural draft. Sweeping of the tubes was not found necessary after either of the tests. The ashes are of a reddish color.

Wilkeson. The coal from this mine was in the form of very small lump and slack. It ignites quickly. There is a little gray smoke at first which ceases as the coal cakes so there is hardly any smoke when the fires are not being worked. The coal cakes in the furnace and requires considerable working of the fires. While it ignites readily it requires a strong draft. Under a high speed test the coal worked well for three hours, when it became necessary to clean the grates. The tubes did not require cleaning during either of the trial trips.

Blue Canyon. This is a free-burning coal requiring very little work at the fires. There is no clinker and the fires did not require cleaning during either of the trial tests. It is a good steaming coal and cakes very little in the furnace. There is considerable smoke of a grayish black color when the coal is first thrown in the furnace, thinning out after the coal is thoroughly ignited. The consignment used in these tests was nearly all small lump coal with only a small percentage of slack.

Fairhaven. (Cokedale). This coal gave a high percentage of ash of a light cream color. In the furnace the coal caked and coked very readily and required a great deal of working. After a trial of four hours a large amount of hard brittle clinkers remained, which however did not adhere to the grates and were easily removed. During the low speed tests no difficulty was found in maintaining sufficient steam pressure but in the high speed tests steam could not be made fast enough to fulfil the requirements. The smoke is light gray in color, and thins out when not firing until it is almost invisible.

Navy Mine. This coal is very inflammable and burns freely, leaving a small quantity of cream colored ash. It does not coke or cake and makes only a small quantity of clinkers which do not adhere to the grate bars. The best results were obtained by firing lightly at short intervals. In the thirty revolution test it was frequently necessary to check the draft in order to reduce the steam pressure. In the forty revolution test the fires were clinkered, and in the fifty revolution test the fires were kept in good condition only by running the bar through the fires to shake them clear of ashes to admit air for combustion. It was not necessary to sweep the tubes during the tests. The smoke was of a dark gray color when first firing, thinning out in volume and becoming lighter in color when combustion was going on. During the intervals that the fires were not worked no smoke at all was visible.

Black Diamond. Scarcely any injurious results were observed from the use of this coal. It showed a remarkably low percentage of ash, and did not cake or coke in the furnace. This coal ignites immediately upon being fired and is consumed with great rapidity, giving forth an intense heat but soon burning out. The coal made no body in the fire and on this account considerable care was necessary in cleaning and shaking fires. It was rapidly broken into small fragments as soon as brought into contact with the fires and some loss was incurred from the dropping of unburnt fuel through the grate bars. A light thin clinker was formed which did not

adhere to the grate bars and was easily removed, but in any long distance steaming the removal of the clinker would practically mean the removal of almost all the fire in the furnace. Steam was maintained with ease at the thirty revolution test, in fact it became necessary frequently to retard the combustion. At forty revolutions the coal burned up rapidly in keeping up the required steam pressure. At fifty revolutions with six boilers difficulty was experienced in keeping the steam pressure to the required point as the coal burned up almost as fast as it was fired. At thirty revolutions no cleaning of the grates was necessary; at forty revolutions the fires were cleaned of clinkers after eight hours, and at fifty revolutions it was necessary to clinker the fires after three hours. The smoke was of a grayish brown color rather dense at first and rapidly thinning out during combustion.

Table of Coal Analyses.

Locality	Water	Volatile matter	Fixed carbon	Sulphur	Ash	Analyst or authority
Whatcom County—						
Blue Canyon	2.73	36.59	57.71	.76	2.21	1.
Blue Canyon	1.79	31.48	62.74	.308	3 68	3.
Cornell Creek	0.37	17.10	78.27	.74	3.52	1.
Cornell Creek, T. 39, N. R. 3. E	0.13	4.89	92.48	.....	2.50	6.
Skagit County—						
Hamilton	1.19	18.80	71.66	.....	8.35	4.
Cokedale	.53	26.67	64.51	.68	8.29	2.
King County—						
Newcastle, No. 4 Vein	6.64	36.91	53.80	.....	2.65	4.
Newcastle, No. 2 Vein	2.12	46.57	43.90	.13	7.28	4.
Newcastle, Bagley Vein	7.22	42.36	44.86	.....	5.56	4.
Gilman, No. 2 Vein	4.80	47.04	37.19	.....	10.06	4.
Gilman, No. 4 vein	2.05	32.64	53.49	.....	11.40	4.
Gilman, No. 6 Vein	12.36	31.91	52.65	.....	3.08	4.
Renton, No. 2 Vein	3.44	37.38	53.60	.73	5.58	2.
Cedar Mountain	13.00	41.40	37.20	.....	8.40	4.
Snoqualmie	3.92	14.99	79.66	.33	1.10	3.
Black Diamond	3.04	36.56	56.08	.144	4.16	3.
Franklin, No. 10 Vein	3.33	33.92	57.68	.....	5.07	4.
Franklin, No. 12 Vein	3.66	34.63	50.78	.....	10.93	4.
Franklin, No. 14 or McKay	1.30	39.25	56.40	.162	2.88	3.
Kangley	1.00	45.50	52.00	.....	1.50	4.
Pierce County—						
Burnett	2.59	34.49	59.89	.....	3.03	4.
Wilkeson	1.87	25.56	62.87	.....	9.70	4.
Wilkeson (coke)	.20	1.82	80.57	.66	16.75	1.
Carbonado, Miller Vein	1 69	41.00	48.95	.. ..	8.35	5.
Carbonado, Wingate Vein	1.80	42.27	52.11	.....	3.82	5.
Carbonado, Average nine veins	1.74	30.70	58.30	.....	9.26	4.
Melmont, No. 3 vein	1.03	21.15	66.55	.46	10.81	1.
Fairfax, No. 5 vein	.51	23.46	70.72	.62	4.69	1.
Fairfax (coke)	.00	.55	81.79	.54	17.12	1.
Montezuma, Blacksmith vein	.49	25.97	70.11	.60	2.83	1.
Hillsboro, No. 6 vein	1.00	11.98	79.01	.54	7.47	1.
Kittitas County—						
Roslyn	2.05	33.55	54.55	.106	6.85	3.
Roslyn	3.35	30.29	59.31	.12	6.93	4.
Thurston County—						
Bucoda	2.55	35.40	49.75	.....	12.30	4.
Tenino, Great Western Mine	15.59	33.73	46.64	1.18	2.86	1.
Lewis County—						
Chehalis, Rosenthal Mine	15.46	40.86	35.48	2.06	6.14	1.
Centralia, Salzer Valley Mine	20.04	38.83	33.32	1.90	5.91	1.
Claquato, Crescent Mine	19.79	42.02	34.27	0.34	3.58	1.
Cinebar, Big Betsy Vein	1.78	28.85	65.40	0.54	3.43	1.
Morton, S. 6 T. 12 N. R. 5 E	1.57	7.87	84.82	1.70	4 04	1.
Morton, S. 30 T. 13 N. R. 5 E	1.80	34.27	58.93	1.34	3.66	1.
Morton, S. 24 T. 13 N. R. 4 E	3.71	35.03	59.01	1.24	1.01	1.
Verndale, S. 20 T. 13 N. R. 6 E	2.67	4.86	88.66	1.22	2.59	1.
Cowlitz Pass, Davis Mine	1.09	6.79	86.18	.74	5.20	1.
Cowlitz County—						
Coal Creek	9.57	43.93	41.84	0.72	3.94	1.

ANALYST OR AUTHORITY.

1. Paul Hopkins, University of Washington.
2. Edward H. Young. Washiugton Agricultural College and School of Science.
3. United States Navy Yard, Washington, D. C.
4. Second Annual Report, Coal Mine Inspector of Washington.
5. Volume 15, Tenth Census.
6. Thomas Price and Son, San Francisco.

CHAPTER IV.

EXTENT OF COAL INDUSTRY.

PRODUCTION OF COAL AND COKE.

The total output of the various mines of the state for the year 1902, as given by the State Mine Inspector, Mr. C. F. Owen, is given in the table below. In this table the output of a few mines where only a small number of men are employed is not given. The combined product of these mines amounts to only a few hundred tons per year.

NAME OF COMPANY	LOCATION OF MINE	Output of Coal (short tons)	Output of Coke (short tons)
Northwestern Imp. Co.	Roslyn	1,039,870	.....
Black Diamond Coal Mining Co.	Black Diamond	258,996	.....
Northwestern Imp. Co.	Clealum	212,584	.....
Carbon Hill Coal Co.	Carbonado	169,733	.....
Pacific Coast Co.	Newcastle	140,841	.....
Issaquah Coal Co.	Issaquah	117,184	.....
Pacific Coast Co.	Lawson	107,750	.....
Wilkeson Coal and Coke Co.	Wilkeson	106,896	22,800
Seattle Electric Co.	Renton	104,071	.....
Pacific Coast Co.	Franklin No. 7	72,238	.....
The S. & S. Ry. & Nav. Co.	Ravensdale	71,426	.....
Pacific Coast Co.	Franklin No. 1	65,107	.....
Pacific Coast Co.	Franklin Gem	52.735	.....
Western American Co.	Fairfax	32,117	17,168
South Prairie Coal Co.	Burnett	32,003	.....
Gale Creek Coal Co.	Wilkeson	29,640	.....
Northwestern Imp. Co.	Melmont	24,000	.....
Skagit Coal & Coke Co.	Cokedale	19,017	601
Denny Clay Co.	Kummer	10,044	.....
Fred Nolte Co.	Cumberland	8,600	.....
Wash. Co-op. Mining Co.	Montezuma	6,702	.....
Blue Canyon Coal Co.	Blue Canyon	6.010	.....
P. Gibbons	Palmer	3.225	.....
Totals		2,690,789	40,569

COAL OUTPUT BY COUNTIES, 1902.

Kittitas	1,252,454
King	1,012,217
Pierce	401,091
Skagit	19,017
Whatcom	6,010

STATISTICS CONCERNING COKE PRODUCTION SINCE 1884.

Years	Establishments	Number of Ovens in operation	Coal used (short tons)	Coke produced (short tons)	Total value of coke at ovens	Value of coke at ovens per ton	Yield of coal in coke per cent.
1884	1	0	700	400	$ 1,900	$ 4.75	57.5
1885	1	2	544	311	1,477	4.75	57
1886	1	11	1,400	825	4,125	5.00	58.9
1887	1	30	22,500	14,625	102,375	7.00	65
1888	3	30	.....	.....	.....	.....	.....
1889	1	30	6,983	3,841	30,728	8.00	55
1890	2	30	9,120	5,837	46,696	8.00	64
1891	2	80	10,000	6,000	42,000	7.00	60
1892	3	84	12,372	7,177	50,446	7.03	58
1893	3	84	11,374	6,731	34,207	5.08	59
1894	3	84	8,563	5,245	18,249	3.48	61.2
1895	3	110	22,973	15,129	64,632	4.27	65.9
1896	3	120	38,685	25,949	104,894	4.04	67
1897	3	120	39,124	26,189	115,754	4.42	67
1898	2	90	48,559	30,197	128,933	4.27	62.2
1899	2	90	50,813	30,372	151,216	4.98	59.8
1900	3	90	57,756	35,921	178,012	4.90	65
1901	3	150	.....	49,197	245,985	5.00	.....
1902	3	.....	.....	40,569	202,845	5.00	.....

STATISTICS CONCERNING COAL PRODUCTION SINCE 1870.

YEAR	Total Product (short tons)	Total Value	Average price per ton at the mine	Average number of days active	Total number of employes
1870	17,844	$.....	$.....	.....	.....
1871	20,000	.....	.....	.....	.....
1872	23,000	.....	.....	.....	.....
1873	26,000	.....	.....	.....	.....
1874	30,352	.....	.....	.....	.....
1875	99,568	.....	.....	.....	.....
1876	110,342	.....	.....	.....	.....
1877	120,896	.....	.....	.....	.....
1878	131,660	.....	.....	.....	.....
1879	142,666	.....	.....	.....	.....
1880	144,315	389,046	2.70	.....	168
1881	167,554	.....	.....	.....	.....
1882	177,340	.....	.....	.....	.....
1883	244,990	.....	.....	.....	.....
1884	166,936	.....	.....	.....	.....
1885	380,250	.....	.....	.....	.....
1886	423,525	952,931	2.25	.....	.....
1887	772,601	1,699,746	2.19	.....	1571
1888	1,215,750	3,647,250	3.00	.....	.....
1889	1,030,578	2,393,238	2.32	.....	2657
1890	1,263,689	3,426,590	2.71	270	2006
1891	1,056,249	2,437,270	2.31	211	2447
1892	1,213,427	2,763,547	2.28	247	2564
1893	1,264,877	2,920,876	2.31	241	2757
1894	1,106,470	2,578,441	2.33	207	2662
1895	1,191,410	2,577,958	2.16	224	2840
1896	1,195,504	2,396,078	2.00	221	2622
1897	1,434,112	2,777,687	1.94	236	2739
1898	1,884,571	3,352,798	1.78	270	3145
1899	2,029,881	3,603,989	1.78	259	3330
1902	2,418,034	4,425 002	1.83	260	4338
1901	2,466,190	4,586,327	1.83	273	4826
1902	2,690,789	5,300,854	1.97	266	4342

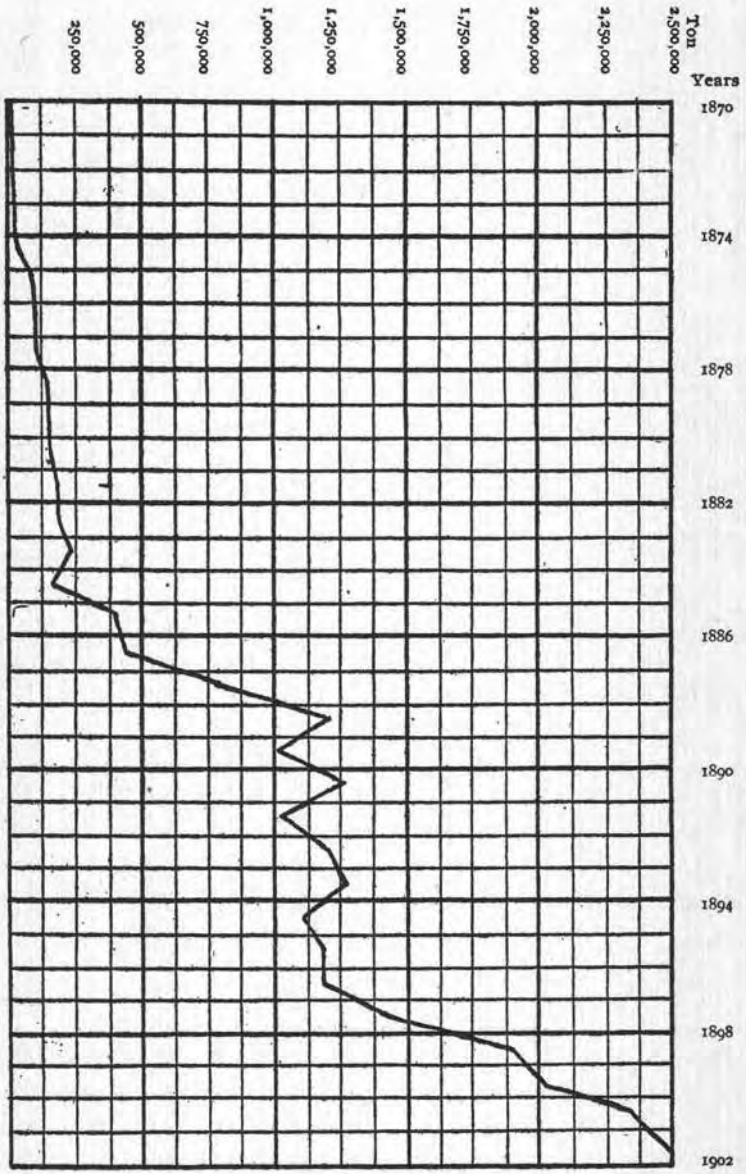


Fig. 46. Production of Washington Coal Mines from 1870 to 1902.

MARKETS.

San Francisco has always been the most important market for Washington coal outside of the state. The first regular shipments to San Francisco were made from the old Bellingham Bay mine in Whatcom county. In the year 1860 the shipments amounted to 5,490 tons. For the years 1869, 1871, 1873, and 1876 the San Francisco shipments exceeded 20,000 tons. The total amount for the nineteen years in which the mine was in operation was 233,043 tons.

Shipments from Seattle to San Francisco began in 1871 when 4,918 tons were shipped. In 1880 the shipments increased to 123,741 tons, in 1890 to 216,760 tons, and in 1899 to 349,813 tons. The mines tributary to Seattle and whose outputs are included in these figures are those of Renton, Newcastle, Issaquah, Cedar Mountain, Black Diamond, and Franklin. A considerable amount of Roslyn coal is also included.

The mines of the Carbonado-Wilkeson field are tributary to Tacoma and ship their product from that port. Shipments of coal from Tacoma to San Francisco began in 1879 in which year a few hundred tons were shipped. By 1890 the shipments had increased to 191,109 tons and in 1899 to 355,756 tons.

The coal receipts and shipments at Seattle for the years 1896-1901, inclusive, are shown by the following figures collected by Mr. Lovett M. Wood of the Seattle Trade Register:

Year.	Receipts (Short Tons.)	Shipments (Short Tons.)
1896	425,103	194,771
1897	472,311	287,883
1898	662,342	376,342
1899	806,029	435,624
1900	909,322	478,562
1901	991,788	482,679

According to the above table the increase of coal receipts from year to year is much greater than the increase of shipments. Thus the increase in receipts for 1901 over 1900 was 82,466 tons as against an increase in shipments of 4,117 tons. The difference between the increase in receipts and the increase in shipments is due to the growth in population and

rapid development of manufactures in Seattle. In the year 1900 Seattle consumed 430,760 tons and in 1901, 509,109 tons, an increase in consumption in one year of 78,349 tons.

The receipts at Tacoma for 1901 were 680,980 short tons, made up of shipments from Roslyn and the various mines of Pierce county. The total output of the Carbonado mine has heretofore been shipped to San Francisco by way of Tacoma for the use of the Southern Pacific Railway, but since the partial substitution of oil for fuel in their locomotives these shipments have fallen off, and much of the coal from this mine is being distributed among the various Sound cities for local consumption.

The great bulk of all the coal shipped from Seattle and Tacoma goes to San Francisco, but during the year 1901 a number of cargoes were sent to Hawaii as well as to Alaskan ports. Washington's chief competitor in the Alaskan coal trade is British Columbia. It is not unlikely that before many years, with theopening of her well known coal deposits, Alaska herself will become an exporter of coal and will enter into competition with the Washington mines for the export trade.

Most of the coal output is consumed within the borders of the state and as time goes on and the population of the state increases the proportion of coal consumed will be greater and greater. The largest single use to which coal is put is in the making of steam in locomotives, steam boats, and stationary boilers. Wood is used to a very large extent as a fuel in western Washington, but as the most accessible timber is being gradually exhausted we may expect to see a gradual substitution of coal for wood, especially in the larger towns and cities.

In the timberless region of eastern Washington, coal is very largely used for all purposes, even in the rural districts. Roslyn coal supplies nearly all of this part of the state. Along the lines of the O. R. and N. Company Roslyn coal is brought into competition with that from Rock Springs, Wyoming, and in the north eastern part of the state with British Columbia and Montana coal. In the city of Spokane 80 per cent of the coal used is from Roslyn.

The following table* shows the disposition of the coal output for 1900. It does not include the amount used at the mines for steam purposes.

Disposition of the coal output of Washington in 1900:

	Tons of 2,000 lbs.
Consumed by railroads in Washington, Idaho, Oregon, and Montana	611,728
Exported to California	783,481
Exported to Hawaiian Islands	70,894
Exported to Alaska	13,436
Consumed by steamers in foreign trade (plying between Puget Sound ports and the Orient)	43,452
Consumed by steamers in domestic trade	218,114
Consumed by United States vessels (naval vessels, revenue cutters and army transports).	42,715
Manufactured into coke	57,010
Consumed in Washington, Idaho and Oregon for domestic and steam purposes	577,204
Total output	2,418,034

* 22nd Annual Report U. S. Geological Survey Part III., p. 496. Pacific Coast Coal Fields. George Otis Smith.

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