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Department of Conservation and Development
D. A. SCOTT, Director

DIVISION OF GEOLOGY
S. SHEDD, Supervisor

BULLETIN No. 29
(Geological Series)

Geological Investigation

OF THE

Coal Fields of Skagit County Washington

BY
OLAF P. JENKINS

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LETTER OF TRANSMITTAL

Hon. D. A. Scott, Director, Department of Conservation and Development, Olympia, Washington:

SIR: I have the honor to submit herewith the manuscript of a report on a Geological Investigation of the Coal Fields of Skagit County, Washington, by Olaf P. Jenkins and recommend that it be published as a Bulletin of the Department of Conservation and Development and designated as Geological Series No. 29.

Very respectfully,

S. SHEDD,
Supervisor, Division of Geology.

College Station,
Pullman, Washington.
June 16, 1924.

TABLE OF CONTENTS

	Page
INTRODUCTION	9–13
Purpose	9
Area covered	9
Results	9
Acknowledgements	10
Maps used in the work	11
Significance of Skagit County as a coal district	12
Production of coal and coke from Skagit County	13
GEOGRAPHIC FEATURES OF SKAGIT COUNTY	14–17
Location and general features	14
Topography	14
Transportation lines	16
Population and industry	17
GEOLOGIC FEATURES OF WESTERN SKAGIT COUNTY	18–25
General statement	18
Description of the formations	19
Rocks older than the coal measures	19
The coal measures	20
Rocks younger than the coal measures	21
Igneous rocks	23
Structure and stratigraphy of the coal measures	23
DESCRIPTION OF THE COAL AREAS IN SKAGIT COUNTY	26–56
Cokedale area	26
General features	26
The Cokedale mine	29
Coal area south of Hamilton	32
General features	32
Cumberland Creek coal area	33
Conner coal area	38
Loretta Creek area	39
Day Creek coal area	40
Alger-Chuckanut area	43
Mount Vernon—Big Lake—McMurray area	43
General features	43
Coal prospects near Mount Vernon	45
Coal prospects in Walker Valley	46
Coal outcrops near McMurray	50
Area east of McMurray	52
Coal prospect on Pilchuck Creek	52
Rick Creek coal area	54
Island area	54
CONCLUSIONS AND RECOMMENDATIONS	57–58
BIBLIOGRAPHY	59–60
INDEX	61–63

ILLUSTRATIONS

Plates *Page*

I. Geologic map of the coal fields of Skagit County, showing the areas underlain with coal measures, the structural features of these rocks, the location of coal mines and prospects, and, in general, the character of the surrounding formations. Also an areal geologic map, on a smaller scale, of both western Whatcom and Skagit Counties, together with a columnar stratigraphic section .....In pocket

II. (In four colors, including black.)
Map of the Cokedale mine, taken from reports of the Skagit Coal and Coke Company, dated August 1, 1901, also from data on the Klondike vein up to July 1, 1919.....In pocket

III. (a) Lake McMurray, looking southwestward. The hills in the background are of the coal measures, which dip toward the southwest. A few thin seams of coal are exposed in the outcrop .....facing 14

(b) View of the north side of the Skagit Valley from a hill above the Northern State Hospital buildings, looking eastward. The old Cokedale Mine is located in the low distant hills to the left, while the high hills beyond are of metamorphic rocks .....facing 14

IV. (a) Exposure beside the pavement by Minkler Lake. The dipping beds represent the sandstones and shaly beds of the coal measures. The dark hole is in a three-foot coaly bed. Overlying unconformably these consolidated sedimentary rocks is a mantle layer of gravel, clay, and sand deposited by glacial action .....facing 20

(b) Exposure of slaty schists in railroad cut between the Skagit River and Clear Lake. This metamorphic series of rocks underlies the coal measures of the district.....facing 20

V. (a) Abandoned coke ovens of the old Cokedale mine....facing 30

(b) The tipple of the old Cokedale mine. The entrance of the mine is not in view; it is to the right. In the background to the left are the coke ovens.....facing 30

VI. (a) Main entrance to the tunnel of the Cokedale Mine. The thick foliage is characteristic of the region.....facing 40

(b) The Blumont mine. Inclined shaft is on the right..facing 40

VII. (a) Exposure on Jack Island, typical of the old metamorphic series of slaty schists, filled with white veins and stringers of quartz .....facing 56

(b) Exposure on the southwest shore of Guemes Island, northwest of Anacortes, of white clayey sand overlain unconformably with cross-bedded gravels of glacial origin. At the top of the lower whitish formation is a two foot layer of lignite, appearing in the picture as a dark horizontal line. This lignite is full of black fossil seeds..facing 56

Figures *Page*

1. Index map. The area covered by the accompanying detailed map (Plate I) is shaded. The positions of the government topographic maps of the district are given with explanatory numbers as follows: (1) U. S. Coast and Geodetic chart No. 6380; U. S. Geological Survey topographic quadrangles; (2) Samish Lake, (3) Wickersham, (4) Mt. Vernon, (5) Stilaguamish, and (6) Mt. Baker district.... 11
2. Geologic cross-section through Powell (Camp) Creek, in the Cokedale area, showing the relative postions of the coal seams and the general structure of the rocks..... 27
3. Geologic section through Coal Creek, near Cokedale, showing the relative positions of the coal seams exposed in the creek and the general structure of the rocks found there.. 29
4. Map of the Cumberland Creek coal fields, located across the river and south of Hamilton, showing the contact between the coal measures and the older metamorphic rocks, and also the structural conditions and their relation to the coal prospects. The presence of these features have led to the recommendation of areas to be test drilled. The base of this topographic map was contributed by Mr. J. H. Smith of Hamilton and from a private report of the property.... 34
5. Map of the Blumont coal mine, located two miles east of Montborne, in Walker Valley..... 46

INTRODUCTION

PURPOSE

An investigation of the coal fields of western Skagit County was made by the writer in the summer of 1923. This was a continuation of the work done the year before in Whatcom County, the results of which have already been published[1].

The object of this present report is to record the results of the field examination in Skagit County and to bring together all the information available on this district. Although no coal mines are, at this present writing, actually producing any coal on a commercial scale in Skagit County, there are several places where coal may some time in the future be produced. The old Cokedale mine was formerly quite an important factor, especially as a contributor to the coke industry of the State.

AREA COVERED

A large area in western Skagit County was carefully studied and many parts of it eliminated from consideration because they are barren of the rocks which contain the coal seams. Those areas which are underlain by the Eocene sandstones, which are the coal measures, were determined and mapped. Some of the principal structural features were recorded and all available data on coal seams were procured. The map (Plate I) included in this report, covers practically all the coal fields of importance in the county.

RESULTS

The coking quality of the coals in Skagit County, especially in the Cokedale and Cumberland Creek areas, is of considerable significance, for coals of that quality are limited in extent in the State of Washington.

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[1]Olaf P. Jenkins; Geological Investigation of the Coal Fields of Western Whatcom County, Washington, Department of Conservation and Development, Division of Geology, Bull. 28, 1923.

The thickest seams of coal were found in the Cokedale mine and in the Cumberland Creek prospects. Further development at Cokedale could now only be done with much deeper mining, unless examination through diamond drilling would disclose a more favorable way of entering the seam from the surface. The Cumberland Creek area deserves investigation with the drill and with other methods of prospecting. It would not be worth while, however, in either case to go ahead without careful consideration of geologic conditions.

The Cokedale and Cumberland areas at present appear to be the most deserving of development of any in the county. The Blumont district does not at present indicate many good features for finding coal of considerable extent, although some pockets may be found if further prospecting is carried on. The area about McMurray has not been sufficiently tested to disclose any coal seams of importance. The outcrops show only thin seams. Possibly drilling might cut seams of consequence.

If any coal mines should be developed in the county, the transportation facilities would be found to be unusually good, for railroads enter nearly every district where coal measures lie.

ACKNOWLEDGEMENTS

The writer was assisted in the field during part of the summer by Cedric E. Denman. In the preparation of the report Mr. Denman assisted very materially, for he drew the maps and sections included herein, and made some of the coal analyses.

A private report by George Watkin Evans, coal mining engineer, on the McMurray district was used, supplementary to the present examination.

The officials of the lumber companies gave much assistance through their generous contributions of information, maps, transportation, and hospitality in their

camps. Mr. J. H. Smith of Hamilton provided guides and maps of the Cumberland Creek area. Mr. Sam Arnold of McMurray conducted an excursion into Deer Creek, and guided the writer to places about McMurray and Pilchuck Creek.

To these persons and to many others the writer is greatly indebted for courtesies.

MAPS USED IN THE WORK

No one base map was found to cover the area completely. Several topographic quadrangles issued by the United States Geological Survey were constantly em-

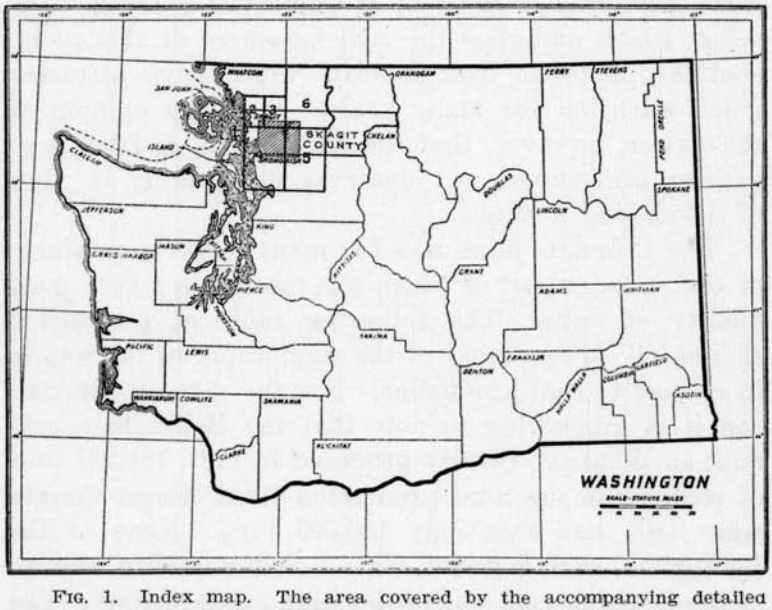


FIG. 1. Index map. The area covered by the accompanying detailed map (Plate I) is shaded. The positions of the government topographic maps of the district are given with explanatory numbers as follows: (1) U. S. Coast and Geodetic chart No. 6380; U. S. Geological Survey topographic quadrangles; (2) Samish Lake, (3) Wickersham, (4) Mt. Vernon, (5) Stilaguamish, and (6) Mt. Baker district.

ployed in this work. The areas covered by these are shown in the index map, Figure 1. For the island country of Puget Sound, the United States Coast and Geodetic Survey charts were found to be the best maps

available. Several railroad maps and logging road maps were used to advantage, such as those of the following companies: Puget Sound and Cascade Railway, Clearlake Lumber Company, English Lumber Company, Skagit Mill Company, etc. Other maps such as the Road Map of Skagit County made by the County Engineer, R. E. L. Knapp, were found quite useful.

SIGNIFICANCE OF SKAGIT COUNTY AS A COAL DISTRICT

Thirty years ago it was hoped by many that Hamilton would be the center of a great coal and iron industry because the iron deposits of that region were located in close proximity to the coal of Cumberland Creek. The schist which underlies the coal measures at this point, contains magnetic iron deposits which have attracted much attention for many years. It is the opinion of the writer, however, that the coal of this district is of greater importance and deserves prospecting in view of developing a mine.

The Cokedale mine was for many years a producer of coal, a large part of which was made into a very good quality of coke. The following table of production should tell its own story of the significance of the county in respect to coal production. For the sake of comparison it is interesting to note that the Bellingham coal mine in Whatcom County produced in 1921, 186,237 tons of coal, while the total production from Skagit County since 1891 has been only 180,693 tons. None of the Bellingham coal, however, was of coking quality, and all of the Cokedale coal was of this high grade variety. The Cokedale coal resembles more closely the coal produced at the Blue Canyon mine in Whatcom County. Both mines are located on seams at the base of the coal measures, while the Bellingham seam is at a much higher stratigraphic horizon.

PRODUCTION OF COAL AND COKE FROM SKAGIT COUNTY
(Practically all of which came from the Cokedale mine)

	Year	Total Production of Coal (Short Tons)	Coal Used for Coke (Short Tons)	Production of Coke (Short Tons)
Coal produced for first time	1891	1,400	300	*
First coke ovens, four in number	1892	4,703	920	*
	1893	2,905	400	*
	†1894	7,537	*	*
Skagit Coal & Transportation Co. (30 ovens)	1895	20,764	Nearly all	*
Skagit Coal & Transportation Co. (40 ovens)	1896	18,000	*	*
Skagit Coal & Transportation Co	1897	15,192	*	*
Skagit Coal & Transportation Co	1898	16,500	*	*
Skagit Coal and Coke Co	1899	6,558	*	*
Skagit Coal and Coke Co	1900	10,430	4,107	6,385
Skagit Coal and Coke Co	1901	12,643	*	*
Skagit Coal and Coke Co	1902	19,017	*	*
Skagit Coal and Coke Co	1903	19,256	*	*
Skagit Coal and Coke Co	1904	10,650	*	*
Mine was not operating during these years	1905 to 1916	.....	.....	.....
Cokedale Coke Co	1917	1,000	.....	.....
Cokedale Coke Co	1918	5,897	.....	.....
Cokedale Coke Co	1919	3,820	.....	.....
Cokedale Coke Co	1920	2,988	502	290
Tieg-Tennent Coal Co	1921	1,433	752	401
Mine ceased operating	1922	.....	.....	.....
Total	.....	180,693	6,981	7,076

* Not found listed in any reports.

† Production figures taken from U. S. Geological Survey, Mineral Resources, from 1891 to 1894, inclusive. The others are taken from the reports of the State Mine Inspector.

GEOGRAPHIC FEATURES OF SKAGIT COUNTY

LOCATION AND GENERAL FEATURES

Skagit County is located in the northwestern part of the State of Washington, just south of Whatcom County, which is in the extreme northwestern corner. Skagit County extends eastward from the islands of Puget Sound, for nearly 100 miles to the summit of the Cascade Mountains, although it is only 24 miles wide. Its western side is bounded by San Juan, and Island Counties; its eastern boundary divides it from Okanogan and from Chelan Counties; while Snohomish County lies to the South.

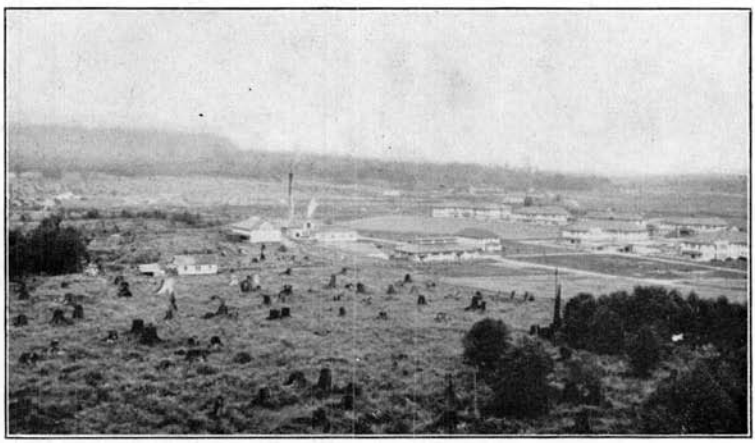
The Skagit River is a great stream which rises in British Columbia, crosses the eastern mountainous part of Whatcom County, entering Skagit County also in its eastern section, and flows westward through a broad valley. Finally, through many diverse courses of a delta, the river reaches the Sound by way of Skagit Bay, the water of which lies on the southwestern border of the county. The eastern part of the county is wild and mountainous and so also are parts of the northern and southern boundary areas, while the broad Skagit Valley and the western flat delta lands are rich agricultural districts populated by industrious people.

The precipitation in Skagit County increases from west to east, towards the mountains. At Anacortes it averages for the year about 28 inches, at Sedro Woolley 46 inches, and at Baker, 64 inches.

TOPOGRAPHY

The mountainous sections are very rugged and stand out in great contrast with the flat valley country. The lower lands and hills are covered with a mantle of unconsolidated gravel, sand, and clay, left largely through the action of the great ice sheet of the past. These covering materials, together with intensely thick vegetation

(a) Lake McMurray, looking southwestward. The hills in the background are of the coal measures, which dip toward the southwest. A few thin seams of coal are exposed in the outcrop.



(b) View of the north side of the Skagit Valley from a hill above the Northern State Hospital buildings, looking eastward. The old Cokedale Mine is located in the low distant hills to the left, while the high hills beyond are of metamorphic rocks.

and forests, make geological work quite unsatisfactory in the majority of districts. The cleared lands are usually the alluvial flats. The logged-off hillsides may contain a few rock outcrops, but these must be reached by following old grown-over logging roads and by struggling over wind-falls, through underbrush, etc. Nearly every bit of geological data that is not acquired on a beaten path must be obtained through great physical effort and with a sacrifice of very much time.

The mountains within the coal area rise to a height of over 4,000 feet. Most of the hills containing the sandstones of the coal measures are much lower, however, and are located within a few miles of transportation and of towns. There are some regions where coal seams are reported to occur, as those on the upper courses of Deer Creek east of Cavanaugh Lake, that were not studied in detail because of their almost inaccessible location. In some remote time in the future these deposits may deserve further examination.

The extreme western part of Skagit County is an island area and no Eocene coal measures of any consequence were found to occur there. Most of the islands represent tops of old mountain peaks which now stand nearly submerged in the waters of Puget Sound. With the exception of a few outcrops of sandstones and conglomerates, and one lignite seam, these islands are composed of slates, schists, and serpentine, invariably found to be filled with numerous little quartz veins and stringers. The rocks stand up very well under erosion and form rugged island peaks.

A number of fresh water lakes occur in the county, most of which are the result of glaciation. In general, the topography of Skagit County is very much affected by glaciation. The presence of old channels of prehistoric streams are very confusing to a newcomer who is trying to adjust himself to the general geographic surroundings.

TRANSPORTATION LINES

Skagit County is well provided with railroads, logging railroads, pavements, dirt roads, old logging grades, trails, skid roads, etc. The Great Northern Railway has one road running north and south from Seattle through Conway, Mount Vernon and Burlington, towards Bellingham in Whatcom County. Another one of its lines extends from Anacortes on the extreme west, to Mount Vernon, then eastward to Sedro Woolley, Lyman, Hamilton, Concrete, and Rockport. Here the City of Seattle Railroad begins and follows up the river to the Seattle power plant which is located in southeastern Whatcom County. A branch of the Great Northern Railway, just east of Sedro Woolley, extends to the Cokedale mine. The Northern Pacific Railway, on the other hand, extends from the south to McMurray, through Sedro Woolley, and northward to Bellingham by way of Lake Whatcom. It also passes through Montborne and Big Lake, and its location here is significant in view of the coal deposits in that area. The Puget Sound and Cascade line extends from Mount Vernon to Clear Lake and eastward to a point on the opposite, or south side of the river from Hamilton, beyond which the road is under construction. This is an especially significant feature in view of the coal prospects in Cumberland Creek, on the south side of the Skagit, as it is only in the last few years that there has been a railroad on this side of the river. This road is a common carrier, although its principal purpose is to reach lumber camps which connect with it by logging railroads. The Clear Lake Lumber Company's logging roads which run up Day Creek are of particular significance in consideration of the old abandoned coal prospects of that district.

The railroad of the English Lumber Company, which extends from Conway to McMurray and eastward toward Lake Cavanaugh, should be of service if any prospecting

were done on the Deer Creek coal area. The road is under construction to Deer Creek and should be completed soon.

An electric interurban line runs from Bellingham to Mount Vernon and also to Sedro Woolley from Burlington. This is called the Northwest Traction.

Many old railroad grades, over stump-covered hill lands, give ways of approach into places otherwise difficult of access. In some cases, maps of these old grades may be procured which give a basis on which geologic data may be placed.

Concrete pavements and other good roads connect the important towns in Skagit County. Many of the secondary roads are, however, rather difficult to traverse in an automobile. There are many trails, but some of them have been ruined through logging operations.

POPULATION AND INDUSTRY

The principal industries of Skagit County are farming and dairying. Next comes lumbering. Salmon fishing is especially important at Anacortes. At the town of Concrete, cement is manufactured. In the eastern section of the county, there are some small metal mines. Coal mining and the production of coke in the Cokedale mine was in the past an important item. At the present writing this is not a productive industry. Undoubtedly coal mining will be revived at another time. Water power must also be considered a great resource for future development.

According to the 1920 census, the population of the principal towns was as follows:

Anacortes	5,284
Mount Vernon (county seat)	3,341
Sedro Woolley	3,389
Burlington	1,360
Concrete	924
La Conner	516
Lyman	492
Hamilton	462
McMurray	243

GEOLOGIC FEATURES OF WESTERN SKAGIT COUNTY

GENERAL STATEMENT

The coal measures of Skagit County are undoubtedly of the same series of sandstone which occurs in Whatcom County. The beds which comprise them are lithologically similar; the same kinds of fossil leaves are found in the coal measures of both counties; and a coal horizon occurs rather persistently at the base of the series above the underlying schist in both areas. The age of the coal measures has been placed as Eocene[1], and the formation is generally referred to as the Puget.

It is quite probable that, during the deposition of the sedimentary beds which comprise the coal measures, the body of water which received the sediments was more or less continuous throughout the whole of this northwestern region. In consideration of the land plants (palms, willows, ferns, sequoia, poplars, etc.) now represented in the rocks as fossils, the natural conclusion is that the body of water was not marine but a lake or series of more or less connected lakes and marshes. The sea must have been situated much farther to the west than now. The surface upon which the coal measures were laid down was the eroded face of the old metamorphosed series of rocks now found underlying the coal measures and exposed in many places. The metamorphic rocks consist largely of serpentine, schist, and slate, all filled with numerous quartz veins and stringers.

Since strata are deposited originally in horizontal layers deformation of the beds must have taken place subsequent to the original deposition. The most profound deformation of the rocks took place in the form of a great rise in a direction more or less east and west through the center of Skagit County. Later erosion

[1]Smith and Calkins; U. S. Geol. Survey, Bull. 235, 1904, pp. 34, 97.

removed a vast quantity of the sediments, leaving remnants of the strata flanking the sides of this great upheaval. To the north the coal measures of Whatcom County plunge northwestward. To the south, about Big Lake and McMurray, the rocks of this same series, for the greater part, dip southwestward. The uprise was not without complications, and wrinkles were formed across the great raised area. A narrow strip of the coal measures stretching from Cokedale to Hamilton and southeastward to Deer Creek was left folded in, and in places faulted down, forming a sort of narrow synclinal trough which was thus preserved from the destructive effects of erosion. It is in this synclinal area that the most important coal deposits lie.

At a time later than this deformation period was the glacial epoch. The advance and retreat of the ice sheet over the country and the resulting deposition of sand and gravel made marked changes in the topography. The peculiar glacial topography and the glacial mantle covering are both significant in relation to the coal fields. The sandstones of the coal measures are in some cases exposed through glacial erosion, but more often completely covered from sight by glacial debris.

DESCRIPTION OF THE FORMATIONS

Rocks Older than the Coal Measures. The floor upon which the coal measures rest was found to be made up of various kinds of metamorphic rocks. If one were mapping these older rocks in detail, differentiation might possibly be attempted, but it would be found very difficult to carry it far owing to the complexity of structure.

The schist south of Hamilton, which underlies the coal bearing sandstones of that area, contains much glaucophane and magnetite. It is slaty and undoubtedly of sedimentary origin. Talc schists are exposed near Cokedale. A railroad cut north of Clear Lake exposes slaty schists. Some of the prominent dome-like hills

between Clear Lake and Big Lake are composed of slaty schists and also a basic igneous rock resembling peridotite. In Walker Valley there are several hills in which quartzite is exposed. This rock is filled with veins and stringers of banded quartz and chalcedony. In the islands to the west, schist, slate, and serpentine are exposed.

Many of the slates throughout the whole series are graphitic. In every case the metamorphic rocks are filled with characteristic quartz veins. The whole formation has been intensely crumpled and plicated.

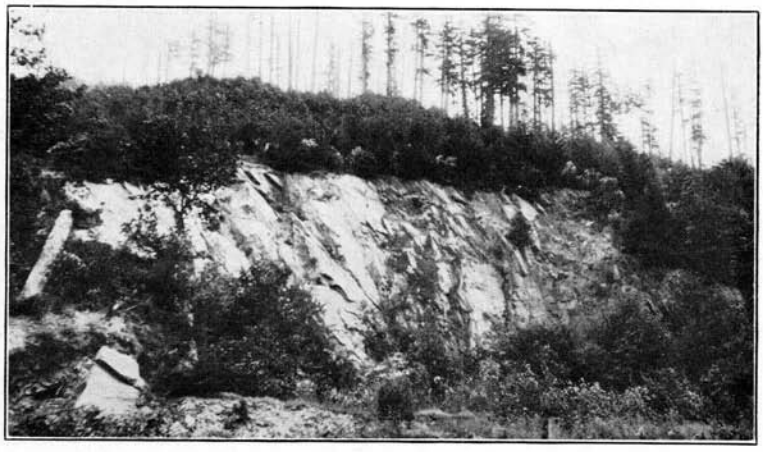
The Coal Measures. Sandstone is the most common rock of the coal measures. On exposure the surface color is a dirty gray or buff gray. A fresh fracture tends to give a more greenish tinge to the grayness. Cross-bedding in the formation is a prominent characteristic.

Conglomerates in some localities are very prevalent. In the hills between Big Lake and Mount Vernon conglomerates are especially noticeable. The size of the pebbles varies from very small ones up to boulders several inches in diameter. The material of which they are made may be of igneous and metamorphic rocks or quartz vein matter, but usually the characteristics of the older schist formation are present in them.

In some areas, especially in association with coal layers, shale is the more prominent rock of the measures, but it is usually a sandy variety of shale. This is especially true in the stream exposures about Cokedale. Here fossil imprints of leaves are abundant, and the carbonaceous material associated is coaly. Likewise in the other coal-bearing areas the same condition is found. Fossil vegetation is a characteristic feature of the coal measures wherever coal seams are present.

The gravel forming the conglomerates of the coal measures, and that of glacial origin may be distinguished because the older formation is more consolidated and the

(*a*) Exposure beside the pavement by Minkler Lake. The dipping beds represent the sandstones and shaly beds of the coal measures. The dark hole is in a three foot coaly bed. Overlying unconformably these consolidated sedimentary rocks is a mantle layer of gravel, clay, and sand deposited by glacial action.



(*b*) Exposure of slaty schists in railroad cut between the Skagit River and Clear Lake. This metamorphic series of rocks underlies the coal measures of the district.

beds usually are structurally deformed. Besides, the individual layers of rock of the coal measures are much more widespread and the outcrops are more persistent. These individual layers are not easily correlated, one to another, however, for their appearance is much the same. Though local variations occur in the beds there are no particular outstanding characteristics, such as interbedded prominent shales or limestones.

On Pilchuck Creek there is one locality where a few specimens of marine fossils were collected from a shale underlying coal bearing sands and shales and apparently overlying quartzite. This shell-bearing material is a bluish clay shale filled with shells and concretions. One fossil limb of a tree was found within a concretion.

Rocks Younger than the Coal Measures. On the southwest side of Guemes Island, unconformably underlying glacial outwash gravel and exposed in a tide-cut cliff, there is an exposure of horizontal layers of unconsolidated shale and sandstone with a two-foot lignite bed resting at the top very near the contact. The lignite bed apparently is more resistant than the other material, which fell easily under the pick. The lignite is woody and checks so easily that when dried it falls all to pieces. Some of the lignite was found to grade into carbonaceous clay. The formation is probably much younger than the coal measures although it is not in contact with them. The characteristic Eocene coal measures are not present in this particular region. It is more likely that these softer beds represent Pliocene Age. The lignite contains many black fossil seeds which were collected but have not yet been identified.

Throughout the Skagit Valley there are many clay patches located above the level of the alluvial plains, and in the sides of the hills about one hundred feet above the river level. These clays show distinct stratification as

if formed in the quiet waters of lakes. Glacial gravels lie above the clay layers unconformably.

There are many places where the glacial sands and gravels are well exposed. These materials are used in road building. Sand and gravel quarries may be found at several places such as above Minkler Lake; on the road between Clear Lake and Mount Vernon; in the hills south of Mount Vernon; and in the hills south of Milltown. In these exposures the gravels and sand lie rudely sorted.

The southern extent of the coal measures in the Cokedale area is concealed from view owing to the glacial gravel covering. Walker Valley and the valley of the Pilchuck are both strewn with this material which is very distracting in a geological study concentrated on the study of the underlying coal measures. Southwest of McMurray are hills composed of coal measures but so covered with glacial gravel that very little data may be had except along the edge of the hills near the town and in a few spots in some of the stream cuts.

At one stage in the glacial history of the region the drainage of the south fork of the Nooksack was turned southward through the valley now occupied by Samish River[1]. The river thus joined the Skagit and the two formed a great delta which covered nearly the whole of the western part of the county.

The valley now partly occupied by Big Lake and Lake McMurray was filled with a glacial lake which emptied to the south by way of Pilchuck Creek. Now the drainage of those lakes is northward into the Skagit River. These incidents in the glacial history show some of the changes which have taken place in the topography. They are confusing to a person the object of whose search is for the older underlying rocks rather than the glacial history of the region. Interpretation of glacial geology

[1]J. Harlen Bretz; Glaciation of the Puget Sound Region, Wash. Geol. Survey, Bull. 8, 1913, pp. 168-171.

is, nevertheless, necessary before an understanding is to be gained of the geology of the older features.

Igneous Rocks. A white felsitic rock, probably a rhyolite, occurs about Devils Lake in a strip lying just east of the lake. This volcanic rock is in places very fine grained and in others porphyritic. A clearly exposed contact with the coal measures was not seen, but the rock appeared to be intruded into the sandstone and is, therefore, of later age.

As noted previously, basic igneous rocks of an age much earlier than that of the coal measures occur as intrusives in the metamorphic series.

STRUCTURE AND STRATIGRAPHY OF THE COAL MEASURES

The structure of the coal measures of Skagit County is complicated in the extreme. Besides being complicated by folding and faulting, much of the record is broken through intense erosion. In addition to these features, the covering of glacial materials has hidden from view the detail necessary for the study of the complete geological section. For that reason the geological column accompanying the map (Plate I) presented with this report is largely drawn from work in Whatcom County.

At the base of the coal measure series, there are several coal layers, one of which lies very near or directly upon the underlying schist. The other seams of consequence are at higher stratigraphic positions, but all within a few hundred feet of the base. Throughout the rest of the coal measures there are other thin seams of coal, but no thick seams above this lower geological horizon have been found.

In Whatcom County, the Bellingham coal seam, which is about fourteen feet thick, lies at a stratigraphic horizon of some 10,000 feet above the base of the measures. It would appear to the writer that this same coal seam would not necessarily be found in Skagit County, for its

original extent was in all probability not great enough for such widespread occurrence. The upper layers of the coal measures in Skagit County occur southwest of McMurray. If any coal seams of consequence occur in these upper layers, corresponding to the Bellingham seam, they will probably be discovered through core drilling in that locality, for only thin seams have so far been uncovered in the exposures about McMurray.

The Cokedale, Cumberland Creek, Day Creek, and Rick Creek areas described in this report all lie in a more or less continuous belt of steeply dipping sandstones which are in contact with the metamorphic series on either side. In some places this contact is an unconformity, but in others it is probably a fault. The structure of the sandstones within this narrow belt is apparently synclinal, or trough-like. It would seem that this strip represents a folded-in layer, and on either side the measures have been removed through upheavel followed by erosion.

The area east of Mount Vernon to Walker Valley and southward is covered largely with sandstones and conglomerates. The geologic structure, especially in the northern portion of this area is very complicated. Faults and vertical beds are common in Walker Valley, but the region south of Ehrlick is one of continuous southwest dip. This dip gradually diminishes towards the southwest until it is lost from sight by the mantle covering of sand and gravel. A pronounced dip-slope may be recognized in the sections which lie southwest of McMurray, and east of Milltown. The region east of McMurray, however, is very complicated in structure.

In the region between Big Lake and Mount Vernon the sandstones dip northeastward, which is opposite in direction to those near Devils Lake southward. The metamorphic series extends through Lake Ten, and at Devils Lake there are large hills composed of porphyritic

rhyolite, probably intrusive into the coal measures. The interpretation which should be made of these data is that a great eroded anticline passes through the hills between Lake Ten, Devils Lake to Erhlich and beyond. The region to the north is a structural basin, but complicated in structure especially on the northeastern side. The intrusion of the rhyolite apparently was associated in some way with the uprising of the anticlinal area. Coal has been reported near Devils Lake, but it was not found by the writer. If coal exists there it is probably of the lower series which lies at the base of the measures. The coal of Walker Valley may be correlated in this same general horizon. The coal seams about McMurray, however, should be placed as occurring farther up in the geological column of the measures.

DESCRIPTION OF THE COAL AREAS IN SKAGIT COUNTY

COKEDALE AREA

General Features. Although the Cokedale mine is not in operation today, it has in the past been a very important property because much of the coal produced there was made into a good quality of coke. This good coking property is not at all common among the coals of Washington.

The mine is situated a little over four miles in a straight line northeast of Sedro Woolley. The buildings of the Northern State Hospital are located half way between the town and the mine. A wagon road to the mine passes the hospital. The Great Northern Railway has a branch railroad built from Cokedale siding to the mine. The Skagit Mill Company also has a logging railroad extending from the Puget Sound and Baker River Railroad to a point within one-half mile of the mine.

The coal measures of this area are partially exposed in a strip of territory which runs northwestward from Minkler Lake to the Northern Pacific Railroad. East of Minkler Lake the formation dips under the alluvium of the Skagit River valley, but appears again in the area south of Hamilton as described elsewhere in this report. Northwest of the Northern Pacific Railroad the formation is covered with glacial drift for two or three miles. Beyond that covered region the old metamorphic rocks are found exposed again at the surface. The rocks in the mountain side to the north of this coal measure strip are of the old metamorphic series—schists, etc. To the south the sandstones disappear beneath glacial drift and alluvium. The hills west of the Northern State Hospital are of the metamorphic series and so are those on the south side of the Skagit River. Apparently, then, this coal measure area about Cokedale is limited in extent in

every direction unless it passes under the alluvium of the Skagit River reappearing in the Cumberland Creek district.

There are several places where the coal measures are exposed on the surface. In a road cut beside the pavement which passes Minkler Lake there is a good exposure of dipping beds of sandstone and shale containing a bed of coal. These are overlain unconformably by clay and glacial gravel. The coal seam exposed dips N. 75° W., 40° and is about three feet thick. The following is a section measured across this coal seam:

	Feet	Inches
Sandstone above		
Coal and bone		10
Coal, weathered	1	4
Bone and coal		6
Coal, bone, and shale		6
Sandstone at base		

This seam has never been prospected. It may be the same as one of those found in the Cokedale mine, but the covering of glacial drift in the region does not allow one to determine from surface evidence its exact stratigraphic horizon.

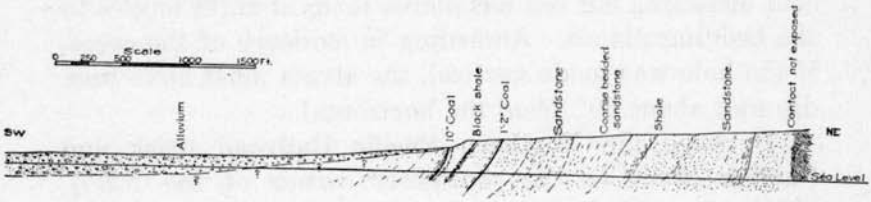


FIG. 2. Geologic cross-section through Powell (Camp) Creek, in the Cokedale area, showing the relative positions of the coal seams and the general structure of the rocks.

Both Powell Creek (also known as Camp Creek) and Coal Creek are streams which cut through the coal measures of this area and expose not only the sandstones and shales of the formation but some of the coal seams themselves. The beds exposed in Powell Creek dip very steeply, and all in a southwesterly direction. In Coal Creek some of the beds are standing in a vertical position

and some even dip towards the northeast, but the majority dip towards the southwest. Those which dip towards the northeast probably represent a reversal of position due to an overturned thrust and not to anticlinal folding. This interpretation is also borne out by evidence reported in the Cokedale mine. At depth the beds turn and dip southwestward. Since the covered area to the south is completely concealed, it is not known whether the beds are faulted off or whether they change in dip again to form a syncline. The rocks of the hills in the region of the Northern State Hospital are of the underlying metamorphic series, which proves the discontinuing of the coal measures toward the south near this point.

There is so much debris—boulders, etc., washed down from the mountain side, together with a large covering of glacial drift—that outcrops are very scarce in the region. A diamond drill hole was once put down in the SW¼, NE¼, Sec. 9, T. 35 N., R. 10 E. The log of this hole was not secured. The drill cores which lay on the ground beside the hole, however, contain fossil leaves showing that the drill cut through sandstones and shales of the coal measures but did not pierce them at right angles to the bedding planes. According to evidence of the cores, if the hole was made vertical, the strata must have been dipping about 60° from the horizontal.

Between the Northern Pacific Railroad track and Samish River in the southwest corner of the NE¼, NW¼, Sec. 36, T. 36 N., R. 4 E., one and a half miles southeast of Samish River there are two old prospect holes. The holes were filled with water at the time of my examination, but on the dump were a few small fragments of coal and some remains of fossil leaves. The dip of the nearby sandstones and shales in place was found to be S. 40° W., 70°. The coal seam prospected here was thought by the prospectors to be one of the seams encountered in the Cokedale mine. The seam is said to have been opened up about 25 years ago.

The Cokedale Mine. The Cokedale mine was once known as the Sedro mine and also as the Bennett mine. This last name was taken from the man who discovered the coal. The mine is situated largely in the SE¼, Sec. 4, and the NE¼, Sec. 9, T. 35 N., R. 5 E., at an elevation of 550 feet above sea level. It first became a producer in 1891 and in 1892 four coke ovens were built. The number of coke ovens was later increased to fifty. In these early years the mine was operated by C. X. Larabee and J. J. Hill through the superintendency of William Mackay. After eleven years it was sold to the Great Northern Railway Company. The property has been leased to several different companies since then. During the years from

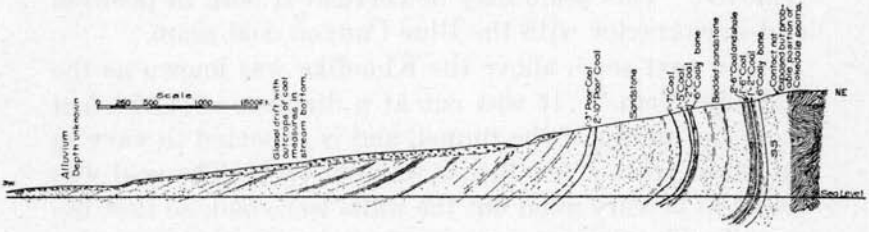


FIG. 3. Geologic section through Coal Creek, near Cokedale, showing the relative positions of the coal seams exposed in the Creek and the general structure of the rocks found there.

1905 to 1916 the mine was inactive. The last production was made in 1921, and since that time the mine has been abandoned.

Since it was impossible to enter the mine at the time of my examination the following data have of necessity been gathered from various sources, both published and unpublished.

The strike of the formation and of the coal seams is about N. 70° W. The dip is in general towards the southwest, though in many cases the beds stand in a perpendicular attitude. In the lower beds, however, the formation dips to the southwest.

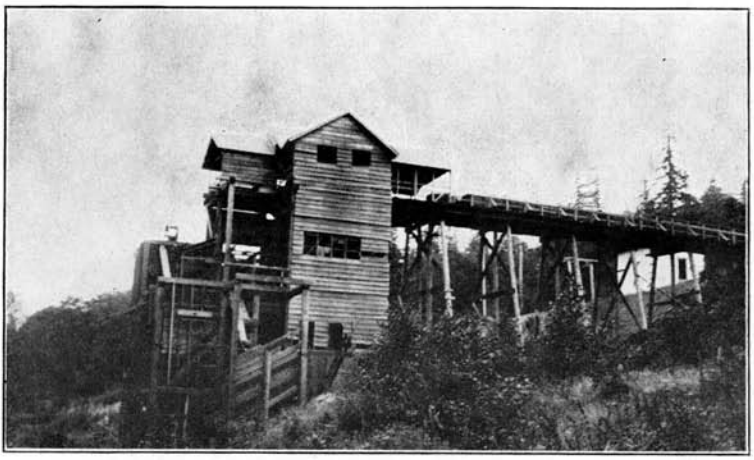
The first tunnel was driven into the hill against the dip, cross-cutting the formation, and reached a length

of 1,267 feet. It intersected seven coal seams, the last three of which proved to be of economic interest. The most northerly of the coal seams cut was reached at a distance of 1,200 feet from the mouth of the tunnel and at a depth of 275 feet below the surface. This seam was called the "Klondike" and varied from 10 to 30 feet in thickness, containing about half coal. Geologically it occurs at the very base of the coal measures lying against or nearly upon the schist. The walls of the lowest vein are reported to be very poor and the coal very soft, with water in great abundance so that a gangway could not stand up for any great distance. It is even said that the walls had a tendency to press together after the coal was removed. This seam may be correlated both in position and in character with the Blue Canyon coal seam.

The next seam above the Klondike was known as the "Middle Vein." It was cut at a distance of 1,050 feet from the mouth of the tunnel, and is reported to vary in thickness from a few inches to eight feet. The coal was found to be very good but the walls were bad, so that the cost of maintaining a gangway in it was very high.

The upper seam, cut at a distance of 1,000 feet from the mouth of the tunnel, varied in thickness from a few inches to two feet of coal. Its hanging wall proved to be solid. A slope of 30° was sunk on this seam for 240 feet to a vertical depth of 120 feet below the water level, and a gangway was driven on the vein with cross-cut tunnels to the Middle and Klondike seams. On this slope level the Middle and Klondike seams were mined.

(a) Abandoned coke ovens of the old Cokedale mine.



(b) The tipple of the old Cokedale mine. The entrance of the mine is not in view; it is to the right. In the background to the left are the coke ovens.

SECTION OF COAL AT COKEDALE

(As given by Henry Landes, Wash. Geol. Surv., Ann. Rept., Vol. I, 1901, pl. XXVII; also in Vol. II, Fig. 2, p. 177.)

	Feet	Inches
Sandstone		
Coal	5	10
Fire Clay	1	1
Coal	3	6
Coal and slate	3	2
Coal	0	11
Coal and slate	1	0
Coal	1	9
Sandstone	0	6
Coal	3	7
Total stratigraphic thickness of vein* (Dip 64°)	21	4
Coal	15	7

ANALYSIS OF COKEDALE COAL

(Made by Henry H. Young, reported by Henry Landes in his second annual report, p. 270.)

	Percentage
Moisture	0.53
Ash	8.29
Vol. Com. M.	26.67
Fixed carbon	64.51
Total	100.00

ANALYSIS OF COAL OF THE SKAGIT COAL AND TRANSPORTATION CO. OF FAIR HAVEN,[1] WASHINGTON

(Coke made of unwashed coal.)

	Per cent
Moisture	0.44
Fixed carbon	86.76
Sulphur	0.84
Ash	11.22
Total	99.26

ANALYSIS[2] OF COKE FROM COKEDALE, WASHINGTON

	Per cent
Moisture	0.30
Vol. Mat.	3.80
Fixed carbon	86.38
Sulphur	0.62
Phosphorous	0.30
Ash	8.60
Total	100.00

*It is not definitely stated which vein this represents but it is probably the Klondike.

[1]U. S. Geol. Sur., Min. Res., 1892, p. 594. Fair Haven is now a part of Bellingham. The coal used to make the coke probably came from the company's mine at Cokedale.

[2]U. S. Geol. Sur. Min. Res., 1893, p. 453. Analysis made by Department of Mines and Mining at World's Columbian Exposition.

ANALYSIS OF FRAGMENTS OF COAL FROM THE OLD COAL BUNKERS OF THE COKEDALE MINE
(Collected in 1923 and analyzed by C. E. Denman.)

	As Received	Moisture Free	Ash and Moisture Free
Moisture	1.04	.....	.....
Volatile matter	30.80	31.11	34.19
Fixed carbon	59.28	59.89	65.82
Ash	8.90	8.99	.....
Total	100.02% 13,850 B.T.U.	99.99%	100.01%

COAL AREA SOUTH OF HAMILTON

General Features. Exposures of coal measures occur between the creeks of Cumberland and Loretta, in the hills south of the town of Hamilton, across the Skagit River and across the railroad now under construction. The strata apparently rest in a general but disrupted synclinal trough and extend southward to Coal Mountain towards Day Lake and beyond. These exposures represent in all probability the continuation of the coal measures from the Cokedale area, the intervening area being covered by the alluvium of the Skagit River. The eastern contact between the coal measures and the underlying schist follows, in general, along the bed of Cumberland Creek. The western contact lies along Loretta Creek. Land-slide material, glacial drift, and a dense forest cover the areas examined to such an extent that accurate geological data in places cannot be gathered.

East of Cumberland Creek the schist contains layers of magnetite in such quantity that a considerable amount of prospecting has been done on it from time to time. Iron Mountain stands but a few miles from Coal Mountain and both rise in elevation over 4,000 feet above the town, which is about 100 feet above sea level.

In about 1891 there was a coal and iron boom in Hamilton and this district was written up in some of the early journals as the future Pittsburgh of the Pacific slope. This boom quieted down and not much work further than

prospecting was done on the coal deposits. Now definite information concerning the property is scarce. At the time of my investigation most of the old tunnels and holes were in such bad condition that it was not possible to get very far back into them.

At this early period there was no railroad on the south side of the Skagit River, but now the newly constructed Puget Sound and Cascade Railway runs along the bank of the river only a short distance from these old coal properties. This railroad connects with the Great Northern Railway at Mount Vernon and the Northern Pacific at Clear Lake. Transportation would, therefore, be an easy matter should these mines be opened up and put on a commercial basis.

The coal properties in the immediate vicinity of Cumberland Creek were first owned by the Cumberland Coal Company. Later on they went into the hands of the Hamilton Coal and Development Company. A short distance to the west of the creek there are other coal properties once owned by J. J. Conner.

At a point several miles to the south there are some old abandoned coal properties on Coal Creek, an east tributary of Day Creek flowing from Coal Mountain. The coal measures are apparently continuous from the Cumberland Creek area to Coal Mountain. It is not, however, definitely known whether or not the formation is continuous in outcrop from Coal Mountain southward to Rick Creek. Coal has been found in several places in this rugged country. Rick Creek is on the other side of a topographic divide from Day Lake. It is tributary of Deer Creek which flows southward to the north fork of the Stilaguamish River.

Cumberland Creek Coal Area. The property of the old Cumberland Coal Company is located in Sec. 23, T. 35 N., R. 6 E. In going up Cumberland Creek, a group of old buildings is encountered about 500 feet from the

railroad. These once constituted part of the old Cumberland mine office buildings, etc. Fifteen hundred feet upstream there is an old dam across the creek where water was flumed for power. Below this dam are two tunnels (SW¼, NE¼, Sec. 23) both of which enter schist. The

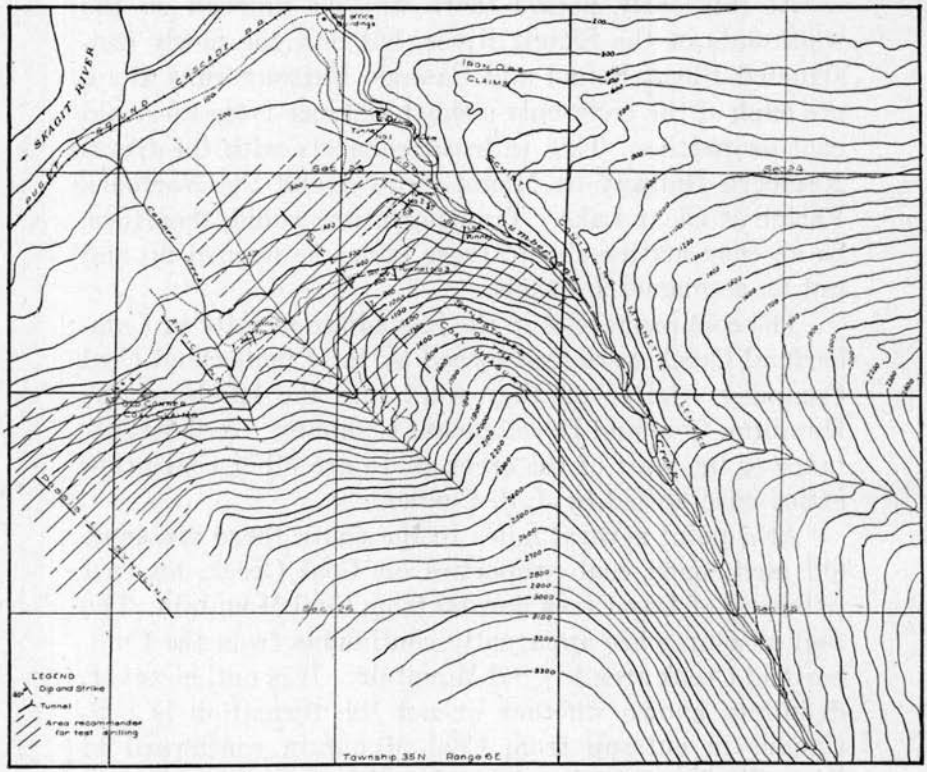


FIG. 4. Map of the Cumberland Creek coal fields, located across the river and south of Hamilton, showing the contact between the coal measures and the older metamorphic rocks, and also the structural conditions and their relation to the coal prospects. The presence of these features have led to the recommendation of areas to be test drilled. The base of this topographic map was contributed by Mr. J. H. Smith of Hamilton and from a private report of the property.

first is directed S. 45° W., and was found to be caved 75 feet from the entrance. The second was found to be about 35 feet long. It is not known whether the first of these workings ever encountered any of the coal measures.

Probably the most significant opening is tunnel No. 2 (NW¼, SE¼, Sec. 23) located 600 feet upstream from the dam and about 250 feet in elevation above the Skagit River. This was driven into the hill in the direction of the dip of the coal measures, which are exposed all the way. Evidently the contact between the schist and the coal measures occurs between this tunnel and the dam. The dip of the sandstone and shale beds is S. 53° W., at an angle of 55° to 74° from the horizontal. Entries were turned 250 feet from the portal on a coal vein said to vary from eight to ten feet in width. The right entry is said to have reached 200 feet in length, while the left is said to have extended 400 or 500 feet. Two small shaly coal layers occur stratigraphically below this large seam. Since the mine was not in shape for further exploration I could not see what was beyond. It is said that the tunnel reached 900 feet in total length, and that one or two other good sized seams occurred in it. One at least is recorded to be eight feet thick occurring 422 feet from the entrance. It was intended that the tunnel would be driven much farther so as to encounter all the six seams which the prospectors believed to be present in the area. A personal measurement of the first large coal seam found in the tunnel No. 2 gave the following results:

	Feet	Inches
Hanging wall solid, but slickensided....		
Coal	0	6
Shale and coal, bony	1	9
Good coal	2	5
Shale and bony coal	1	7
Coal	2	9
Foot wall, solid slaty shale		
Total	9	0

The coal is said to have been proved to be a medium grade of coking coal. Two analyses are recorded: I, by Henry Wurtz of New York; II, by T. Rice of San Francisco.

	I	II
Fixed carbon	79.66	68.30
Vol. matter	9.00	19.38
Water	0.33	0.47
Sulphur	0.39	0.65
Ash	11.01	not recorded
Sp. Gr.	1.33	not recorded
Evaporative power 9¾ lbs. of water to 1 lb. coal		not recorded

Tunnel No. 3 (S½, NW¼, SE¼, Sec. 23) is situated on a hillside 400 feet higher than tunnel No. 2. It was driven about 200 feet on a vein which dips S. 30° W., about 10°. The tunnel branches near the end. The coal seam varies in thickness from two to four feet, and is reported to be five and a half feet in places. The hanging wall is solid. The foot wall is shaly and the coal is mashed and not at all regular. It has been thought by some that this tunnel is only in slide material, but that is questionable. It is more likely to be in the trough of a syncline in the formation.

Tunnel No. 4 (SE¼, SW¼, Sec. 23) is located farther around the nose of the hill and about 100 feet lower in elevation than tunnel No. 3. It was driven on the strike of a coal seam which dips N. 66° E., 76° to 80°. Both hanging and foot walls are firm. The face of the tunnel was not seen, for caving and water did not permit examination. The total length of the tunnel is 250 feet. It is reported that the face showed eight inches of coal on the top, then eight inches of rock, followed by 32 inches of coal beneath.

Tunnel No. 4 is located one-half mile southwest of tunnel No. 2 and tunnel No. 3 is nearly halfway between. The dip in tunnel No. 4 is opposite to that in tunnel No. 2 and in tunnel No. 3 the dip is approaching the horizontal. This in itself is a fairly good proof that a syncline is present. It is quite possible that the seam found in tunnel No. 4 is the same as one of the other seams encountered in tunnel No. 2. That is, it may form a structural trough rather than occurring as an upper layer of a regu-

lar continuous stratigraphic series as formerly thought. With this interpretation there would not be so many seams present. A structural feature would exist, however, which should prove easier to handle from a mining standpoint, if the openings were made on the axis of the syncline. Features of this sort can only be satisfactorily determined through intelligent core drilling.

The "Lost Tunnel" (NE¼, SE¼, Sec. 23) is a name applied to a tunnel which was driven over 100 feet into the hillside, 800 feet upstream from tunnel No. 2 and later was hidden from view by a great mountain land slide covering. It is said that the same seam as encountered in tunnel No. 2 was found here and the coal was of good quality.

Above the former position of the Lost Tunnel is a surface opening on the outcrop of coal. The rocks are here rather distorted owing to surface movement. In one place the coal seam was fairly distinct and measured three feet ten inches in width.

It is interesting to note that the lowest seam of coal found in the area is generally called No. 2 seam, but No. 1 seam has never been found. It was expected that No. 1 seam would be found, and would lie at the very base of the coal measures in a similar position to that of the Klondike vein at Cokedale. This is not poor reasoning, for the principal seam at Blue Canyon and also Discovery Tunnel vein in the Glacier coal field are located at the base of the coal measures next to the schist. So far, a seam at that position has not been encountered in the Cumberland Creek area. As a suggestion it might be said that drilling across the contact of the coal measures and the schist might prove its existence, unless the contact is a fault contact.

Landes[1] describes the coal of the Hamilton district. He speaks of the Skagit Cumberland Coal Company and

[1]Wash. Geol. Sur., Vol. I, pp. 266, 267.

of the property of J. J. Conner. On Cumberland Creek he says the first coal seam strikes S. 43° E., and dips SW. 55°, and lies between sandstone walls with a thickness of seven feet of clear coal. About 100 feet stratigraphically above this seam is vein No. 2, with the same strike and dip and with a thickness of over five feet.

Bailey Willis, in a report of the coal fields of Washington Territory, published in the Tenth Census of the United States, 1882, presents a geological sketch map of this coal district.

SECTION OF COAL AT HAMILTON

(As given by Henry Landes, Wash. Geol. Surv. Ann. Rept. Vol. I, 1901, Plate XXVI).

	Feet	Inches
Sandstone, hanging wall		
Coal	2	2
Bone	0	2
Coal	2	8
Sandstone, footwall (Dip 55°)		

ANALYSIS

	Per cent
Fixed carbon	68.38
Vol. Mat.	19.30
Moisture	0.47
Ash	11.85
Total	100.00

ANALYSIS

(As given in Vol. II, p. 270)

	Per cent
Fixed carbon	71.66
Vol. Mat.	18.80
Water	1.19
Ash	8.35
Total	100.00

Conner Coal Area. Still farther around the nose of the hill from tunnel No. 4 of the Cumberland Creek properties and above a little creek known as Conner Creek is the old J. J. Conner coal property. All the workings are abandoned and practically obliterated. The principal workings could not be found at the time of this examination.

The main tunnel (NW¼, NW¼, Sec. 26) is recorded as being about 300 feet higher in elevation than tunnel No. 4 and was driven some 300 feet in length. The coal is reported to be of unusually good grade. There evidently are several other good openings one of which (southwest corner of the SW¼, Sec. 23) was found during the examination. This occurred at an elevation of about 100 feet lower than tunnel No. 4. The seam was found to be enclosed in solid hanging and foot walls, exposed by surface trenching in an opening 30 feet long and 8 feet deep. The coal is black powdery material with a thickness of one foot four inches. Its dip is S. 37° W. 61°. This dip is opposite to that found in tunnel No. 4 and shows that an anticline exists between these two properties which are only 1600 to 2000 feet apart. It shows the intense folding of the coal measures and the necessity of intensive detailed work, even though it should have to be done by drilling. Many more dips should be taken in order thoroughly to establish these structural features. It would take months of intensive geological work supplemented with careful prospecting confined to a few square miles to count for much as far as mine locations are concerned, but the job is not an impossible one to perform.

ANALYSIS OF COAL FROM THE CONNER MINE, SKAGIT COUNTY, WASHINGTON.[1]

	Vein No.1†	Vein No. 2‡
Fixed carbon	70.24	80.20
Vol. Mat.	18.68	12.05
Sulphur	0.95	
Phosphorous	0.01	
Water	0.52	0.45
Ash	9.59	7.30
Total	99.99	100.00

Loretta Creek Area. Still farther westward on the east side of Loretta Creek beside a logging railroad switchback it was found that the sandstones of the coal

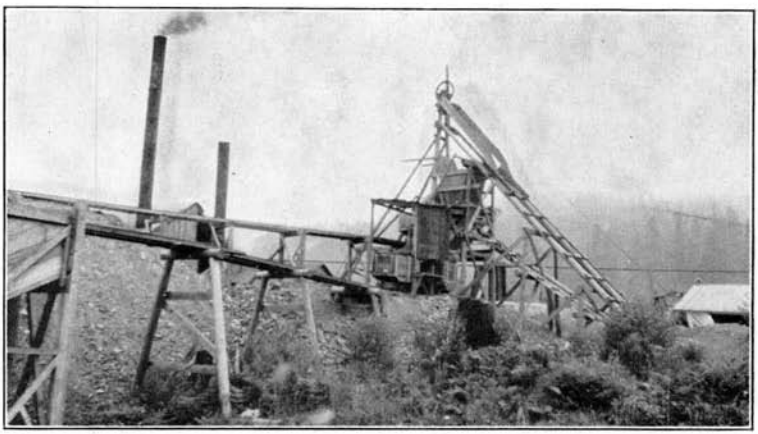
[1]U. S. G. S., Min. Res., 1891, p. 334.
†Made by Otto Worth, Pittsburgh, Pa.
‡Made by D. I. Davis, Wilkeson, Wash.

measures dipped N. 40° W., 50°. This again is a change in dip and would indicate another syncline between Loretta Creek and the Conner property. On the west side of Loretta Creek schist is again exposed. This would indicate that the sandstone was overlying the schist here as well as in Cumberland Creek and that between the two creeks were two synclines and one anticline, in the distance of one and one half miles.

Day Creek Area. The property of the old Day Creek Coal Company (Sec. 13, T. 34 N., R. 6 E.) is located near Coal Creek, a tributary of Day Creek. At the time of the prospecting from 1891 to 1910 the property was a long way from railroad transportation, but now the Clearlake Lumber Company has a logging railroad built within a half mile of the property. This logging railroad runs to Potts on the newly constructed Puget Sound and Cascade Railway which in turn connects with the Northern Pacific at Clear Lake and the Great Northern at Mount Vernon. Even with this present transportation facility the prospects remain abandoned and are now practically destroyed.

The coal measures of this area are apparently a continuation of those exposed between Cumberland and Loretta Creeks. The surface of the mountainside is covered with land slides of varying magnitude. This condition together with a dense forest growth does not always allow very accurate data to be gathered. The contact between the schists and the coal measures is apparently high along this mountain side, and the coal seams found were evidently those which occur at the base of the coal measures. Fossil leaves similar to those found elsewhere in this formation, and also some small layers of coal were found in the general locality, but the prospects themselves were not all located during this examination. The prospects have been abandoned so many years that undoubtedly they are pretty well

(a) Main entrance to the tunnel of the Cokedale Mine. The thick foliage is characteristic of the region.



(b) The Blumont mine. Inclined shaft is on the right.

destroyed. The following description is taken from a report by Ernest G. Locke, coal mining engineer, made to the Day Creek Coal Company in May, 1894.

Three principal seams were found on the property. No. 1 vein was discovered on the SE¼, SW¼, Sec. 13, but no work other than the uncovering of it was done. It was found to occur at an elevation of over 2140 feet above Hamilton and 1040 feet above Day Creek. The seam is recorded as dipping N. 28° W., 14°.

CROSS SECTION OF NO. 1 VEIN

	Feet	Inches
Sandstone, hanging wall		
Slate	1	0
Coal	4	2
Shale, clay and coal	3	5
Slaty clay	0	8
Coal	1	10
Fire clay, footwall		

No. 2 vein was recorded by W. H. Brown in 1901 as outcropping at the surface in a small continuous bed of clean coal of good quality but no development work was done on the seam. No description is given by Locke of vein No. 2.

No. 3 vein is described, however, as occurring in a slide, located in the SW¼, SE¼, Sec. 13 and lying 2225 feet above Hamilton and 1125 feet above Day Creek. Apparently the seam consists of three "benches" of coal separated by layers of clay, the total thickness of coal being 7 or 8 feet. It is reported also that a piece of coke was made of this coal at the Cokedale furnaces.

W. H. Brown in a later report gives the following section for No. 3 vein which was taken by a Mr. Derwent:

	Inches
Sandstone, hanging wall	
Coal	48
Bone	18
Coal	72
Bone	2
Coal	36
Fire Clay	12
Sandstone, footwall	

No. 4 vein was found in the SE¼, SE¼, Sec. 13. It was found to dip to the west at an angle of 32°, lying at an elevation of 2680 feet above Hamilton and 1580 feet above Day Creek. The coal found in vein No. 4 appeared to be of good quality.

CROSS SECTION OF NO. 4 VEIN

	Feet	Inches
Sandstone, hanging wall		
Coal	0	3
Clay	0	7
Coal	2	11
Shaly clay	3	6
Coal	0	11
Slaty clay, footwall		

The interpretation that Locke makes in regard to the general structure, is that a syncline runs through the property whose axis is approximately N. 30° W. and S. 30° E. This same condition was found to be present through a measurement of the coal measures along Coal Creek. It is quite possible that it is a condition which persists from the area near Loretta Creek as previously described.

The following coal analyses are recorded in a report accompanying that of Locke and signed by J. B. Champlain, assayer:

SAMPLE NO. 2 VEIN NO. 2

	Per cent
Moisture, 100° C.	2.00
Vol. Mat.	33.00
Fixed carbon	63.25
Ash (white)	1.75
Total	100.00
Percentage of coke	65.00

SAMPLE NO. 3 VEIN NO. 4

	Per cent
Moisture	2.25
Vol. Mat.	40.50
Fixed carbon	55.25
Ash (slightly reddish)	2.00
Total	100.00
Percentage of coke	55.00

ALGER-CHUCKANUT AREA

In the northwestern part of Skagit County there are two small areas covered by the coal measures. One of these is along Chuckanut Drive and the other is north of Alger. Both areas have been described and mapped previously by the author and published in Bulletin 28 by the Department of Conservation and Development. Both areas are really a part of the district which connects with that of Whatcom County. The base of the coal measures is present in these localities. It is the same geological horizon as represented in Blue Canyon mine located at the southern end of Lake Whatcom.

MOUNT VERNON-BIG LAKE-McMURRAY AREA

General Features. The hill region southeast of Mount Vernon extending to Big Lake, McMurray, and Pilchuck in Snohomish County, is largely composed of the folded beds of sandstone, conglomerate and shale that make up the coal measures. In a few places seams of coal have been found in this formation. In Walker Valley, two miles east of Mountborne, is situated a property generally known as the Blumont coal mine. This mine is in reality a prospect, for no coal has ever been shipped from it. A few coal outcrops have been found in the region about McMurray and also about Pilchuck Creek. One coal outcrop was reported as occurring near Devils Lake.

The rocks underlying the coal measures are schist, serpentine and quartzite. In the region of Devils Lake a form of rhyolite was found which is apparently intrusive into the coal measures.

Structural deformation of the sedimentary rocks is especially prominent in this area. Faulting is present on the east side of Walker Valley only a short distance from the Blumont mine. The sandstones in the hills between Big Lake and McMurray are folded but the general dip is towards the southwest. This dip dimin-

ishes gradually towards the southwest so that beyond McMurray the rocks dip gently under the glacial drift and are then lost from sight. Thin coal seams may be dug from between outcrops in the narrow valley which passes from McMurray westward towards Fir, and southeastward toward Pilchuck. The lower layers of the coal measures are apparently exposed in the region about Big Lake. The geological horizon about McMurray is towards the top of this series and a few miles farther southwestward the uppermost beds probably could be reached by drilling. It is reported that a local oil company expects to drill in this region and if it does, a log of their well would be helpful in the further study of the formation.

The region southwest of Mount Vernon is practically all covered with alluvium, the ancient delta of the Skagit River. A few hills, however, stand up out of this flat area. Cedar Hill, located on Fir Island is very small but prominent, composed of conglomerate and sandstone layers which contain fossil coaly leaf imprints showing that the formation is the same as that which contains the coal seams elsewhere. Farther westward towards the town of La Conner there are several other prominent hills, which were little islands before the region became filled with silt. Those in the immediate vicinity of the town are composed of metamorphic rocks, while those farther south in a line directly west of Cedar Hill are of sandstone and conglomerate, apparently of the coal measure formation. One low lying hill is of glacial and outwash gravel.

It is quite possible, however, that under the alluvium and glacial gravels, between these island-like hills and those to the east of Fir lie continuous beds of the coal measures. North of a line from La Conner to Mount Vernon and eastward the older metamorphic series would be found to underlie the delta and glacial material which

fills the old valley of the Skagit. Prominent island-like hills northeast of Burlington are largely composed of rocks of this series—schists, slates, and serpentine—and the presence of these would bear out this supposition. It would appear, therefore, from this and from further geological evidence on the north side of the Skagit Valley and further north in Whatcom County that this lower Skagit Valley region is an eroded upwarp in the earth's crust. The lowest and oldest rocks are found here and the younger sedimentaries flank the sides, to the north, towards Bellingham, and to the south from Big Lake to the Snohomish County line. Although the coal measure formation was once probably connected throughout the whole region, it is now disconnected by subsequent erosion so that this southern district referred to here as the Mount Vernon-Big Lake-McMurray area is now totally cut off from the Cokedale and Hamilton areas. All these areas in Skagit County are cut off by erosion from the northern coal area which largely lies in Whatcom County, only two corners of which extend into Skagit County; one by Alger and the other on Chuckanut Mountain.

Coal Prospects near Mount Vernon. In driving from Conway to Mount Vernon one may see in the hills to the east the sedimentary beds of the coal measures dipping southwestward. The dip on the north slope of the farthest north of these hills is, however, in the opposite direction, N. 30° E., 68°. One half mile northeast of this point there is a small coal prospect known as the Blasingame prospect. It is located in SW¼, NE¼, Sec. 28, T. 34 N., R. 4 E. The prospect hole, said to have been about 50 feet deep, was filled with water so that an examination could not be made of it. It is reported that coal was discovered in a ten foot well here and the prospect disclosed a seam a few inches wide. Judging from the angle of the inclined shaft the dip was about N. 25° E., 75° to 85°.

No other outcrops of bed rock are found towards the northeast of this prospect until the metamorphics are encountered in the hills about the Nookachamps Creek where the pavement crosses it.

Coal Prospects in Walker Valley. It is said that 30 or 40 years ago prospectors made openings on coal seams in Walker Valley east of Mount Vernon and Big Lake. Very scanty remnants of these prospects can be found today, although they are now very near logging railroads which traverse the area and are therefore easy of access. There is one prospect which has recently been

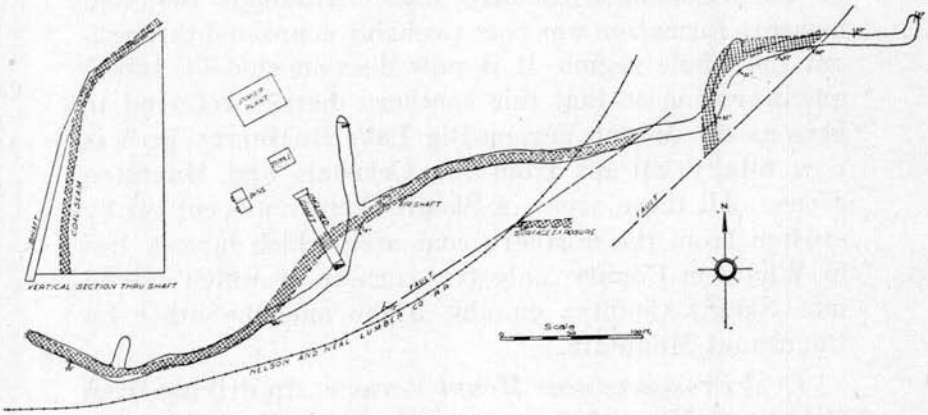


FIG. 5. Map of the Blumont coal mine, located two miles east of Montborne, in Walker Valley.

worked, known as the Blumont mine, now owned by the Sedro Woolley Coal Company. The mine is located beside the track of the Nelson Neal Lumber Company, formerly owned by the Day Lumber Company.

The geology of Walker Valley and the surrounding hills is complicated from a structural standpoint. The mountains to the east are composed of metamorphic rocks and serpentine. The hills between the valley and Big Lake are largely composed of quartzite which is filled with crustified banded veins of quartz and chalcedony. Other isolated hills of this quartzite occur scattered here and there in the valley. The main part of

Walker Valley is covered with an irregular mantle of glacial drift. The coal measures outcrop along the flank of the mountain on the east and south sides. The sandstone, conglomerate, and shaly beds of this formation are badly contorted, folded and faulted. Although glacial drift conceals it from view, the formation probably connects to the south with the coal measures at the southern end of Big Lake and with those of the Pilchuck Creek. The exact extent of the coal measures farther to the south and east was not completely worked out.

The Blumont Coal Mine is located in SW¼, SW¼, Sec. 33, T. 34 N, R. 5 E. on the land of John B. Peterson. A coal seam was first discovered here in 1916 in a railroad cut by the Day Lumber Company. Later a coal company was formed and began to sink an incline shaft, supposedly on the coal outcrop. At the time of my examination the shaft was found to be over 200 feet long. The slope started at an angle of 35° for the first 60 feet, then at an angle of 65° for 45 feet while the last 100 feet stood at an angle of 75°. The coaly layers which the shaft started on, attained such a steep dip that the shaft was obliged to cross them and entries below were driven back at angles to cut the seam again. To the west in the mine the coal seam was followed in a curved tunnel for some 240 feet. To the east it followed for the same distance until it disappeared because of faulting, but reappeared some 60 feet beyond the fault and was followed for 100 feet in a zigzag line until it disappeared against another fault. The rest of the tunnel, some 40 feet, was in rock. A cross-cut was extended from near the base of the shaft for about 60 feet towards the north but encountered no appreciable amount of coal. The general dip of the formation may be said to be towards the southeast at an angle of 35° to 75°. The rock layers and the coal in the mine all seem to have been squeezed badly and distorted in many ways. The mine is only a short distance from a great fault which is exposed at the sur-

face in a small creek lying in the N. ½ of Sec. 33, on the side of the mountain to the northeast. Although good coal pockets may possibly be found in future prospecting, none so far has been disclosed. Coal mining in this locality is likely to be uncertain owing to the distorted condition of the formation. The coal seams in the mine vary in thickness from a few inches to about two feet, and all contain a considerable amount of shale. It has been expected that better coal would be reached at greater depth. The following section was measured in the east entry where a little stoping had been done. The dip at this point was S. 50° E., 35°. (See following analysis, II):

	Feet	Inches
Hanging wall, sandstone		
Coal	1	9
Shale, coal and bone	3	0
Clay, black shale and bone.....	3	2
Coal seam	0	6
Footwall, sandstone		

A section at the face of the west entry gave the following results:

	Feet	Inches
Hanging wall, sandstone		
Bone, shale and coal	2	2
Clay, shale and bone	1	10
Footwall, sandstone		

(Dip was S. 70° E. 37°; the formation was badly crushed)

ANALYSES OF COAL COLLECTED FROM BLUMONT MINE OF THE SEDRO WOOLLEY COAL COMPANY, 1923.

(Analyst, C. E. Denman.)

I. Sample of lump coal collected underground in the northeast corner of the mine, 1923.

II. Sample taken from across seam underground in the northeast corner of the mine, 1923. (See section)

A. As received.
B. Moisture free.
C. Ash and moisture free.

SAMPLE		Moisture	Volatile Matter	Fixed Carbon	Ash	B. T. U.
I	A.....	4.00	42.70	35.60	17.70	9,830
	B.....	.....	44.50	37.08	18.43	.....
	C.....	.....	54.53	45.46	.....	.....
II	A.....	1.04	30.80	59.28	8.90	13,850
	B.....	.....	31.11	59.89	8.99	.....
	C.....	.....	34.19	65.82	.....	.....

Due east of the Blumont Mine, on the Toverey property in the SE¼, of Sec. 33, there are several coal prospects. Since these prospects were made in the form of vertical shafts and shallow drill holes, and since the coal was not found in the outcrop, no very definite field notes could be taken on the geology of that area. One shaft is said to have reached 70 feet in depth and struck coal at the bottom. Two drill holes are said to have reached 225 feet and 275 feet respectively. In each hole, coal is said to have been found near the bottom. The dip was not visible near the surface, but is said to be towards the northeast or nearly opposite in direction to that of the Blumont Mine. The coal seams encountered are said to have been from 6 to 10 feet thick. North of these prospects, in the same section, there are outcrops of serpentine in the creek bed. Evidently the contact between the coal measures and the serpentine lies, for the most part, to the south of this creek, but crosses the lower end of the creek where exposure shows there is unmistakably a fault contact, located very near the property of the Blumont mine.

It is said that the Pacific Coast Coal Company thirty-five or forty years ago, opened up a seam of coal a mile and a half southeast of Big Lake. Its location is probably not far from the Day Lumber Company's railroad.

There is an old prospect tunnel in the SW¼, NW¼, Sec. 10, T. 33 N., R. 5 E. which undoubtedly struck some coal. The prospecting is said to have been done by the Pacific Coast Steamship Company in the early years. It is now located beside the logging railroad of the Day Lumber Company. It is also reported that coal was uncovered in many of the ravines in the sides of the hills to the south of this old prospect in the course of logging off this land. These locations are not far from the contact of the coal measures with the metamorphics and it is likely that the geological horizon encountered is near the base. Faulting and intense folding are prominent in the area.

It is reported that coal was found near Devils Lake on the logging railroad of Nelson and Neal Lumber Company. The road has since been torn up and the location of the coal could not be found during this examination. It is also said that other small seams have been observed in the hills of this region southwest of Big Lake.

Coal Outcrops Near McMurray. Although active prospecting has never been done to amount to anything in the region about McMurray, there has been some interest in the past aroused among the people as to the possibility of finding coal in this area.

McMurray, situated on the southwest side of a lake by that name, is located in a peculiar old glacial valley. In fact three rather narrow valleys join at this point. To the north a valley extends to Big Lake. To the southeast another valley reaches to Pilchuck in Snohomish County. While to the west a narrow opening in the hills extends to the more flat open country in the Skagit delta region. The sandstones which largely make up the coal measures dip towards the southwest leaving their upturned edges exposed in the bluffs back of the town. In these bluffs and also in the bottom of the valley a few little seams of coal have been superficially opened in the past but very few of them were to be seen at the time of my investigation. If prospecting were done in this region coal seams of some consequence might be disclosed, but at present very little can be seen.

In the bluffs above and back of the town of McMurray in the SW¼, SE¼, Sec. 25, T. 33 N., R. 4 E. on the property of J. E. Baker there is an outcrop which exposes a few inches of coal. The section exposed is as follows:

	Inches
Conglomerate beds in overhanging bluff.....	
Coal	1
Shale	2
Coal	5
Shale, covered below	

A coal outcrop is exposed in a railroad cut (NE¼, NW¼, Sec. 26, T. 33 N., R. 4 E.) one and a half miles northwest of McMurray, where the railroad passes through the property of John Abrahamson. The coal occurs in decomposed material but apparently dips S. 17° W. about 45°. Beyond this outcrop in a ravine in the hillside there are some old shallow prospects now practically destroyed. It is reported that several sacks of coal were removed from a three foot seam in this hole during 1913 and burned in stoves. The dip in the nearby shale outcrop was S. 20° W., 27°.

In the valley bottom just north of the town of McMurray (near center Sec. 25, T. 33 N., R. 4 E.) known as the LeClair place, below a sharp bend in the road to Big Lake, coal is reported to have been found in two different wells about 15 and 20 feet deep. The following section from the deeper well has been reported as follows:

	Feet	Inches
Roof—shale, sandy, bluish color.....		
Bone and shale	0	8
Bony coal	0	6
Carbonaceous matter, bony	1	0
Floor—shale		

A prospect occurs in the SE¼, Sec. 24, T. 33, R. 4 E. one mile north of McMurray on a small creek. A section which contains little or no coal has been reported as follows:

	Feet	Inches
Roof—sandstone, bluish color.....		
Carbonaceous matter	2	10
Floor—shaly sandstone		

Coal is reported to occur three miles southeast of McMurray on the Bass ranch (Sec. 5, T. 32 N., R. 5 E.) in a little creek which crosses the road. The outcrop was covered at the time of my investigation but the following section was reported to have been measured there:

	Feet	Inches
Roof—loose shale overlain with conglomerate		
Carbonaceous shale and bone.....	1	10
Floor—shale		

A prospect is said to occur at the west end of an old skid road which runs to the old Bass Mill. The following section has been reported:

	Feet	Inches
Roof—blue shale overlain with a conglomerate		
Coal, bony		4
Shale, gray, soft		6
Bone and coal	2	2
Floor—shale		

Another prospect is said to occur a short distance to the southeast, along the strike, from this last prospect, and is an outcrop on the same coal seam. The following section was reported:

	Feet	Inches
Roof—sandstone, bluish color overlain with conglomerate		
Coal		3
Shale		10
Coal, good	1	2
Shale		3
Coal		3
Floor—shale		

It was found that two miles southeast of McMurray on the boundary line between Skagit and Snohomish counties at a point overlooking the Bass ranch in a railroad cut of the English Logging Company there is clearly exposed to view a sharp anticline in the sandstones of the coal measures. The axis of this fold runs N. 30° W. Most of this country is so completely covered with glacial material and forest thickets that outcrops are not common. This exposure of a complete anticline within a very small area shows that the crumpled condition of the formation is intense. It also shows the impossibility of doing very complete, accurate or satisfactory structural geology in the coal measures throughout this region, for many folds similar to this one probably occur but are concealed from view, and no record can be made of them.

AREA EAST OF McMURRAY

Coal Prospect on Pilchuck Creek. About three miles in a straight line east of McMurray there is an old coal

prospect in the east bank of Pilchuck Creek located in the NW¼, Sec. 34, T. 33 N., R. 5 E. The prospect was originally opened in 1894 by Sam Arnold of McMurray who says that the tunnel was driven 355 feet into the bank and followed a coal seam, which was about 6 feet thick though variable and pockety. It was composed of layers of coal and shale. He said he had the coal tested and it was determined to be a semi-anthracite. The tunnel, directed N. 70° E. was completely caved at the time of my investigation, but some weathered coal was found exposed in a bank near the mouth of the hole. The dip on the sandstone, shale and conglomerate beds was found to be S. 20° W. 5° to 7°. Beneath the coal seam there were a few feet of sandstone and conglomerate, but beneath those beds were layers of sandy clay filled with marine fossil shells. This same shell formation Mr. Arnold says is found on the floor of the tunnel in a "swell" which was encountered during his work. The strata containing these fossil shells were only a few feet thick, for beneath them in the bed of the creek was an exposure of quartzite. Also it was found that the sandstone of the coal measures rested directly on the quartzite farther down stream. It would appear therefore that the fossil shell beds form a wedge at this point with unconformity both above and below them. A section was measured from the creek to top of the bluff, through the mouth of the tunnel with the following results:

	Feet
Conglomerate and sandstone, top covered.....	9
Shaly sandstone	1
Coarse sandstone	1½
Coarse conglomerate	1
Shaly sandstone	4
Shale and coal	1
Covered portion (where tunnel is located).....	6
Conglomerate (below level of tunnel).....	2
Shale with marine shells, mussels, etc.....	0 to 5
Quartzite, somewhat faulted, beneath.....	

Although many interesting features probably would have been found here, time did not permit further detailed geological work in the area. Above the settlement of Pilchuck in Snohomish County, however, the rocks were examined where a dam was being constructed. The rocks were found to be of the coal measures, sandstone, conglomerates and shale with a few coaly streaks, all dipping towards the southwest at an angle of about 56°. At the bend in the stream just above the damsite a basic igneous rock apparently a hornblende gabbro is exposed. The structural relationship between the sandstone and the igneous rock appeared to be contact by faulting rather than intrusion.

Rick Creek Coal Area. It is reported that prospecting for coal was carried on by the Deer Creek Coal Company on Rick Creek, in Sec. 15, 16, 9 and 10, T. 33 N., R. 7 E., from 1891 to 1900. The coal is reported to have been of good quality, but very little work was done on the properties which were later given up as mining claims. The region may be reached by trail from the end of the English Lumber Company's logging railroad, situated on Lake Cavanaugh. The trail also extends from Day Creek through Day Lake and over the pass to Deer Creek. It is expected that the logging railroad from Lake Cavanaugh will soon reach Deer Creek for it is being constructed today. The whole region is of deep canyons all very thickly forested.

The coal measures found in this area are quite likely a continuation from the Day Creek region which lies to the northwest. At the time of the examination no prospecting was being carried on. A few thin coal seams found in the sandstones were of good quality.

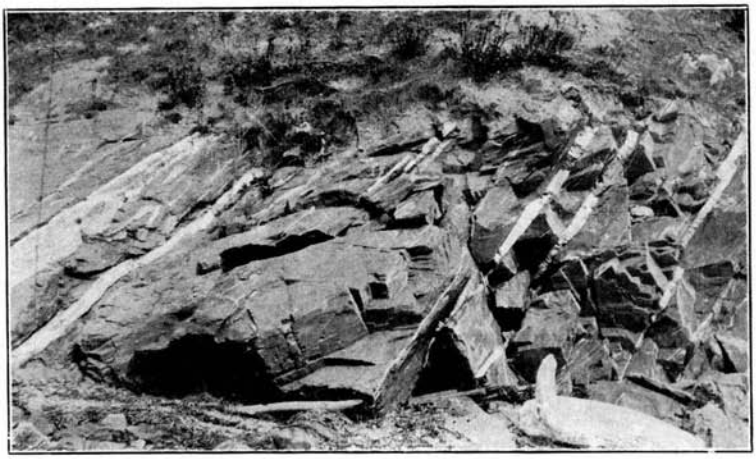
ISLAND AREA

Nearly all the islands which occur in the western end of Skagit County were examined to see what rocks composed them. They were found to consist for the

most part of the old metamorphic series—schists, and slates filled with quartz veins, and basic igneous rocks such as peridotites and serpentines. Most of the islands were covered in part at least by glacial drift and outwash gravel and in some cases with what appeared to be lake deposits. A buff-white sedimentary deposit occurring on the southwest end of Guemes Island a mile and a quarter northwest of Anacortes, and across the water from that city, contains a black layer of lignite. This deposit is the only coal-like material found in the islands of Skagit County.

This lignitic formation is exposed in a high bluff along the shore for one-half mile. It is composed of loosely consolidated sands and clays overlain unconformably by cross-bedded gravels and coarse sands which probably represent the outwash material from an old glacier front. About thirty feet from the base of the bluff, which supported a loose talus slope extending to the shore, there is a two foot black layer of lignite. This lignite is composed of compressed woody material and other different sorts of fossil vegetation which cracked and checked, breaking all to pieces when left standing in the air. Fossil seeds were very abundant in the lignite. Above it, the glacial gravels were found to be very nearly in contact with it. Below it clay layers occur containing many leaf imprints which fell to pieces readily when dug into. The rest of the formation consists of sandy clay with lenses of sand running through it. In one place the lignite was measured and found to be a foot and a half thick, overlain with gravel and underlain with sand and sandy clay. A white film of iron sulphate was found on the surface of some of the lignitic clays and sands. The northern end of the exposure is worn off and the gravels, resting unconformably above, were found to extend down to the shore. The bed of lignite was apparently the most resistent of any of the

strata in the bluff and shrubs were growing on it where they could not stick to the shifting and falling sands, gravels and clays of the rest of the bluff. This lignitic formation did not look like the Eocene coal measures and does not contain the same kind of fossil vegetation found in those layers. It is probably a much younger formation but not as young as the Pleistocene.



(a) Exposure on Jack Island, typical of the old metamorphic series of slaty schists, filled with white veins and stringers of quartz.

(b) Exposure on the southwest shore of Guemes Island, northwest of Anacortes, of white clayey sand overlain unconformably with cross-bedded gravels of glacial origin. At the top of the lower whitish formation is a two foot layer of lignite, appearing in the picture as a dark horizontal line. This lignite is full of black fossil seeds.

CONCLUSIONS AND RECOMMENDATIONS

There are two principal areas in Skagit County covered by the coal measures. One lies as a long narrow strip extending from Cokedale to Minkler Lake, from Cumberland Creek to Coal Mountain, and southeastward towards Deer Creek. The other extends from Walker Valley and Mount Vernon to McMurray and southward. These areas are best shown on the accompanying map.

The most significant coal property of the district was the Cokedale mine, which was once a producer of a good quality of coking coal, but is now abandoned. The coal seam mined stood in practically a vertical position so that after the upper part was worked out, much deeper mining would have been necessary to continue the production. The principal seam, the Klondike, varied in thickness from 10 to 30 feet, being about half coal. Two other seams were opened up which occurred within 200 feet stratigraphically above the Klondike. These were not as thick as the main seam and only a small amount of coal was extracted from them.

In the Cumberland Creek area, the lowest seam corresponding to the Klondike was apparently never found. The coal seams which occur in the Cumberland Creek district may be the representatives of the upper seams found in the Cokedale mine. This correlation cannot be definitely stated, though. There is one principal seam which apparently occurs about 300 feet above the contact with the underlying schist formation. This seam is about eight feet wide in tunnel No. 2. The coal is of good quality. Other prospects in the region have disclosed other coal seams. It would appear, judging from the attitude of the formation in this region, that a syncline occurs between Conner and Cumberland Creeks into which the outcropping coal seams dip. The conclusion would be, therefore, that a coal basin is present which has never been properly prospected. The best method of prospecting would be by drilling in the syncline until

schist is reached, thus testing out the measures for all seams present, including the lowest one corresponding to the Klondike vein of Cokedale.

Nothing very definite is known about the Day Creek coal area, which lies several miles south of Cumberland Creek, for the prospecting was abandoned many years ago. Since the region is now more accessible it would be interesting to see it opened up again.

The Rick Creek area is still too remote to interest most coal prospectors at the present time.

Something more definite in the way of a good coal seam should be brought to light in the Walker Valley region to consider that a coal mining district. The same is true of the region about McMurray.

The uppermost strata of the coal measures are not exposed to view in many places. They may be reached, however, by drilling in the area which lies a few miles southwest of McMurray. Whether or not a coal seam of consequence occurs there is the question. The geological horizon which would be encountered, however, would be close to the same horizon of Whatcom County which carries the Bellingham coal seam.

In summing up the conclusions thus reached it would appear that prospecting in the Cumberland Creek area might be carried on profitably if due consideration were given to the existing geological conditions. Further mining at Cokedale should be preceded by examination with the core drill.

The extent of the coal measures in Skagit County is not great. The outcrops of coal seams are few in number, but the quality of the coal in most instances is good. At present, the only coal seams of consequence are located stratigraphically near the base of the coal measures. Much difficulty may always be expected in the mining of a coal seam at the base of the measures where the underlying formation is schist.

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Topographic quadrangles, covering parts of Skagit County, Washington, U. S. Geol. Survey:

QUADRANGLE	Scale
Mount Vernon	1:125,000
Wickersham	1:62,500
Samish Lake	1:62,500
Stilaguamish	1:125,000
Mt. Baker	1:250,000
Glacier Peak	1:125,000

INDEX

	Page
Abrahamson, John	51
Age of coal measures	18
Alger	43
Anacortes, lignite near	55
Analyses of coal from	
Blumont mine	46
Cokedale	31
Conner property	38
Cumberland Creek	36-38
Day Creek area	42
Anticline	25
Arnold, Sam	53
Bass ranch prospects	51
Bellingham coal	12-23
Bennett mine	29
Bibliography	59
Big Lake, coal near	46
Blue Canyon coal seam	30
Blumont mine	46
Brown, W. H.	41
Burlington, rocks near	45
Camp Creek	27
Cavanaugh Lake	15
Clear Lake Lumber Company, logging railroad	16
Climate	14
Coal Creek	27
Coal measures	20
Coal Mountain	30
Coal, production of	13
Cokedale Coal Co	13
Cokedale mine, production of coal and coke from	13
Cokedale mine, description of	26
Coke, production of	13
Conclusions	57
Conglomerates	20
Conner coal area	38
Conner, J. J.	33
Cumberland Coal Co	33
Cumberland Creek coal area	33
Day Creek area	40
Day Creek Coal Co	41-54
Day Lake	32
Day Lumber Co	46
Deer Creek	15
Devil's Lake, coal near	50
Dip-slope	24
Ehrlich	24
English Lumber Co., logging railroad	16
Eocene	18
Evans, George Watkin	10

Page

Fault 24
Fir 44
Formations, description of 19
Fossil leaves 18
Fossil seeds 55
Fossil shells 21

Glacial history 22
Gravel 20-22
Great Northern Railway 16-29
Guemes Island 54

Hamilton, coal south of 32
Hamilton Coal & Development Co 33
History 12

Igneous rocks 23
Industry 17
Iron Mountain 32
Iron ore near Hamilton 32

Klondike coal seam 30

La Conner 43
Lake Cavanaugh 54
Lake Ten 24
Larabee, C. X. 29
Landes, Henry 31
Le Clair coal prospect 51
Lignite 21
Lignite on Guemes Island 55
Locke, Ernest G. 41
Loretta Creek area 39
Loretta Creek 32

Mackay, William 29
McMurray, coal near 50
Maps 11-60
Middle Vein at Cokedale 30
Mines and prospects near
- Alger 43
- Anacortes 54
- Bass ranch 51
- Big Lake 46
- Cavanaugh Lake 54
- Conner Creek 38
- Cumberland Creek 32
- Day Creek 40
- Deer Creek 54
- Hamilton 32
- Loretta Creek 39
- McMurray 50
- Montborne 46
- Mt. Vernon 45
- Pilchuck Creek 52
- Sedro Woolley 26
- Winkler Lake, exposure near 27

Montborne, coal near 46
Mount Vernon, coal near 45

Page

Nelson & Neal Lumber Co. 46
Nookachamps Creek 46
Northern Pacific Railway 16
Northern State Hospital 26
Northwest Traction Railroad 16

Pacific Coast Coal Co. 49
Pacific Coast Steamship Co. 49
Peterson, John B. 47
Pilchuck Creek coal area 52
Pliocene 21
Population of towns 17
Powell Creek 27
Production of coal 13
Production of coke 13
Puget Sound & Cascade Railway 16-40

Quartzite 20

Railroads 16
Recommendations 57
Results 9
Rhyolite 23
Rice, T. 35
Rick Creek coal area 54

Sand 22
Sandstone 20
Schist 19
Serpentine 20
Sedro mine 29
Sedro Woolley Coal Co. 46
Shale 20
Skagit Coal & Transportation Co. 13
Skagit Coal & Coke Co. 13
Skagit County production of coal and coke 13
Skagit County coal, significance of 12
Skagit Cumberland Coal Co. 37
Skagit Mill Co., logging railroad 26
Skagit River 14
Slate 20
Smith, J. H. 11
Stilaguamish River 33
Stratigraphy 23
Structure 23
Synclinal area 24

Thickness of coal measures 23
Tieg-Tennent Coal Co. 13
Topography 14
Toverey property 49
Towns, population of 17
Transportation 16

Walker Valley, coal in 46
Whatcom County coal 12
Willis, Bailey 38
Wurtz, Henry 35

Young, Henry H. 31

MAP OF THE COAL MEASURES OF SKAGIT COUNTY

LEGEND

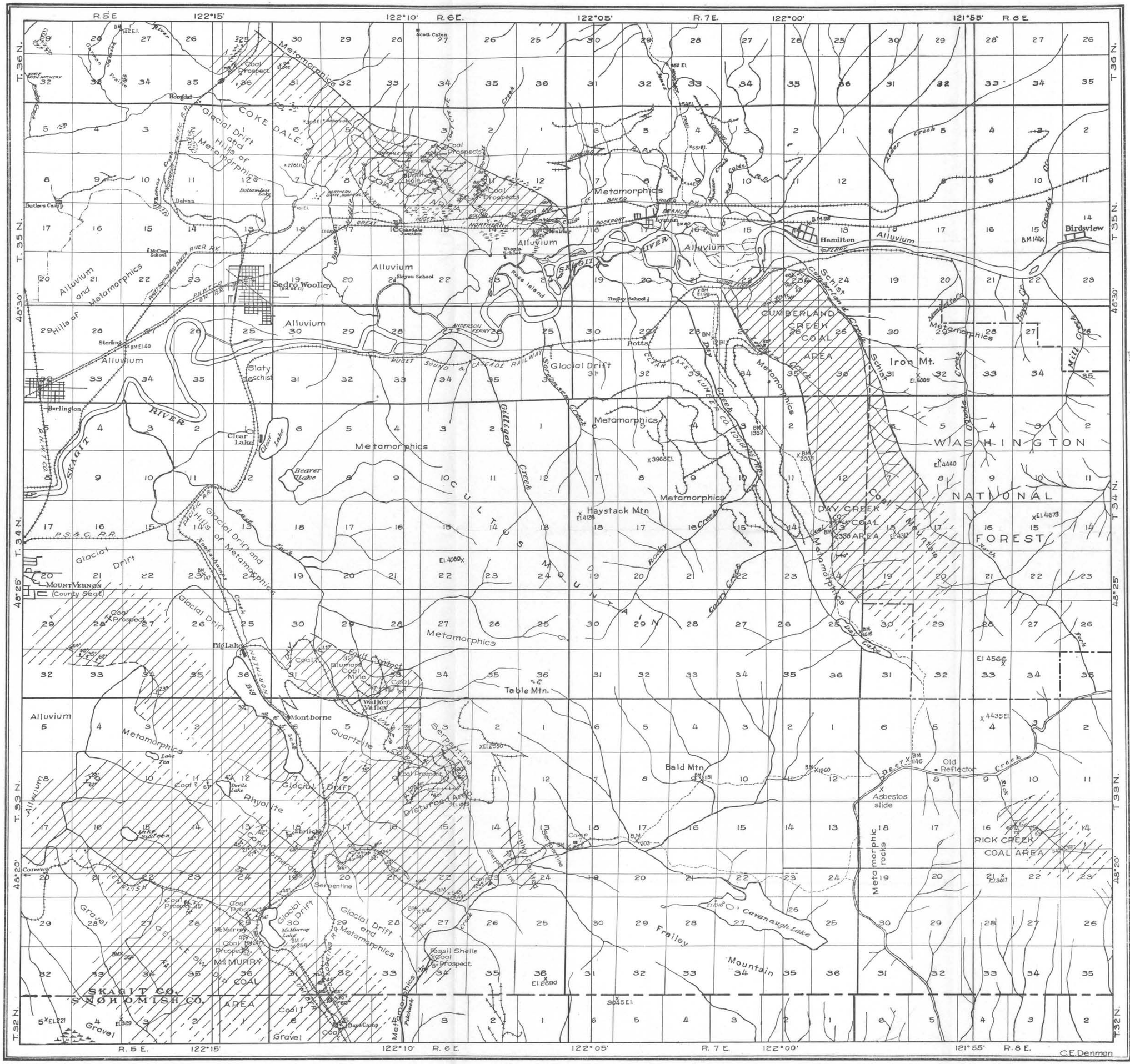
- Town or city
- 85 x BM Bench Mark
- Coal Prospect
- Coal Mine
- Dip and strike
- Area underlain by coal measures

BY
Olaf P. Jenkins

Scale
0 ½ ½ 1 2 3 miles

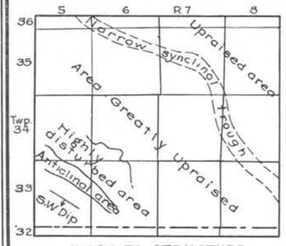
1924

Base maps from U.S.G.S. and railroads

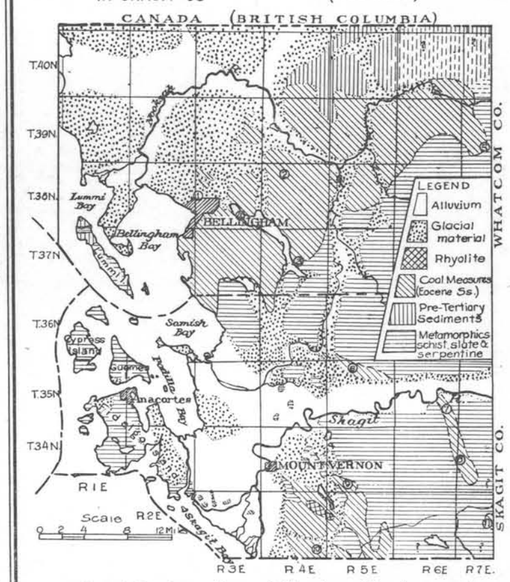


Coal Properties and Districts

1. Bellingham
2. Glen Echo
3. Blue Canyon
4. Lake Whatcom
5. Glacier
6. Cokedale
7. Hamilton
8. Day Creek
9. Blumont
10. McMurray
11. Rick Creek (See below)

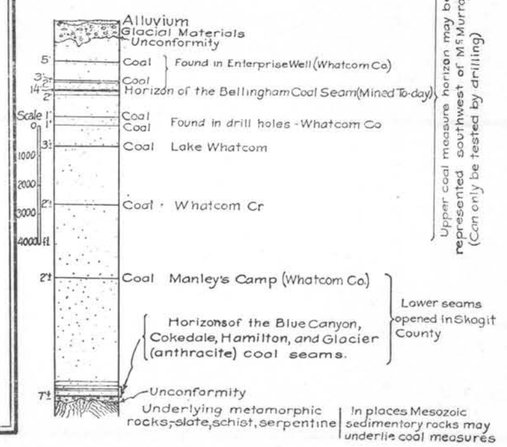


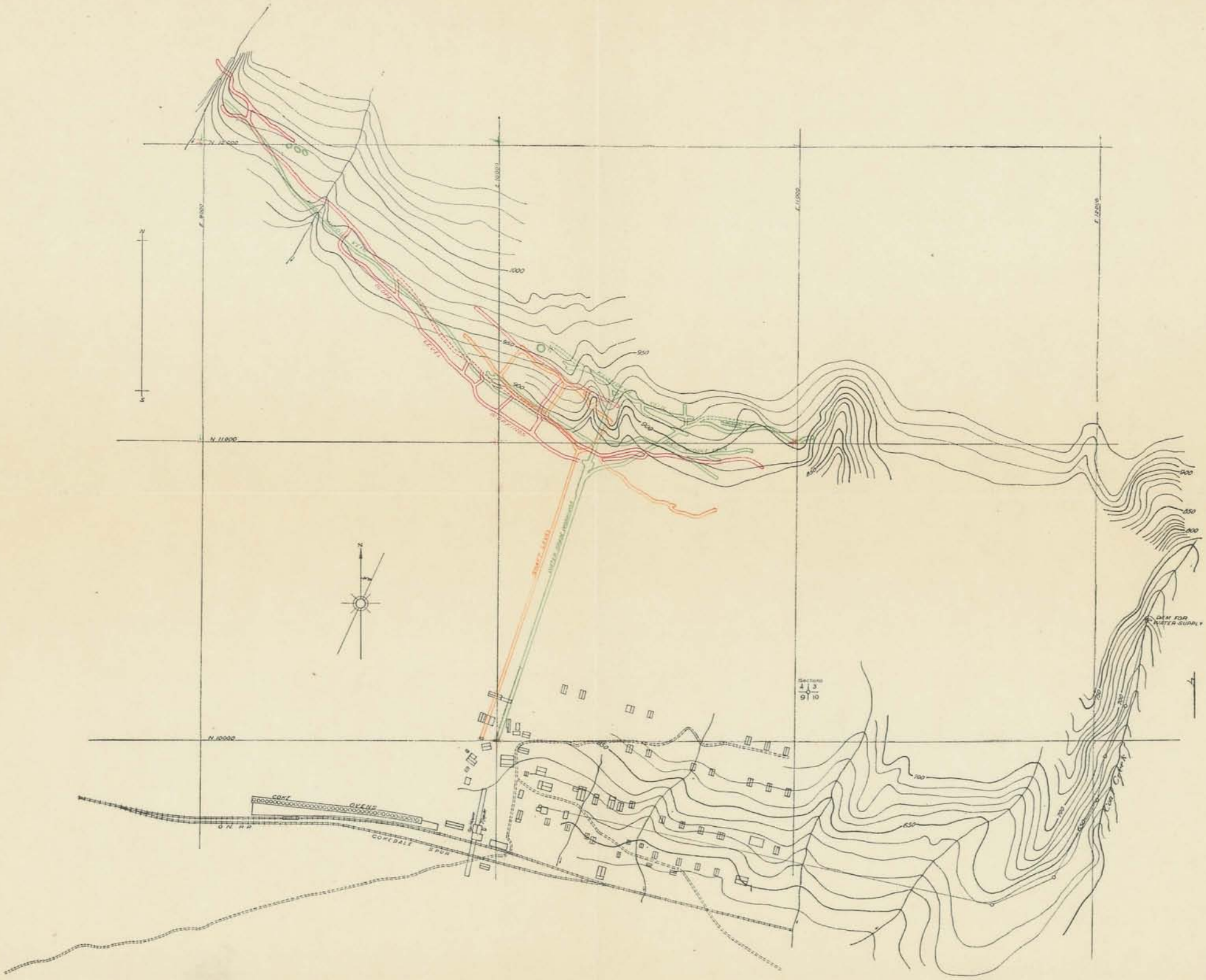
INDEX TO STRUCTURE IN SKAGIT CO



Areal Geologic Map of Western Whatcom and Skagit Counties

Columnar Section of the Coal Measures of Whatcom and Skagit Counties





Map of the Cokedale mine, taken from reports of the Skagit Coal and Coke Company, dated August 1, 1901, also from data on the Klondike vein up to July 1, 1919.