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Geology and Coal Resources of the Coos Bay Quadrangle, Oregon

by

John Eliot Allen and Ewart M. Baldwin

State of Oregon—Coos County
Coal Survey

1944



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Air view of coastal section looking east. Lighthouse Point
in the foreground, Yokam Point (Mussell Reef) and Coos Head in the middle distance
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FOREWORD

The State Department of Geology and Mineral Industries presents the ensuing report in accordance with the directive of the forty-second regular session of the Oregon legislative assembly, as set forth in chapter 350, page 470, of the 1943 Session Laws.

The purpose of the investigation described in the report was to make available information, both geologic and economic, which would encourage, promote, and increase commercial production of Coos Bay coal.

To this end, exploration by drilling of shallow coal was carried out and a detailed study of the geology was made, supplementing the pioneer work of J. S. Diller of the U. S. Geological Survey and later workers. Deep drilling to test continuity of coal beds was not attempted because the U. S. Bureau of Mines was engaged in that type of exploration. This work by the Bureau is being continued in November 1944.

The value of exploration work in the form of drilling and sampling is understandable to everybody. The value of regional geologic study in relation to exploration work is not so generally appreciated. Coal fields are usually of considerable areal extent and the coal may occur in several beds. Thus to understand characteristics of any local area in the coal field, all possible evidence must be gathered in a study of the regional geology in order to recognize structural relationships; to project strike and dip of beds and faults, and to determine areal extent of coal-bearing horizons.

This report represents a large amount of work, both in the field and office. It is believed that results of the study will be of much tangible value not only to Coos County but to the state as a whole. In addition, it is believed that the report is an important contribution to knowledge of the geology of the state.

F. W. LIBBEY, Director.

November 4, 1944.

GEOLOGY AND COAL RESOURCES OF THE COOS BAY QUADRANGLE OREGON

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GEOLOGY AND COAL RESOURCES OF THE COOS BAY QUADRANGLE, OREGON

by

John Eliot Allen and Ewart M. Baldwin

Abstract

The Coos Bay coal field is situated on the coast of southwest Oregon, readily accessible to railroad and to the harbor of Coos Bay. It lies within a roughly elliptical structural basin measuring 35 miles north and south by 11 miles east and west.

Mesozoic sediments, schists, and volcanics, tentatively correlated with the Franciscan-Knoxville group of California, are exposed in the southern part of the quadrangle and are overlain unconformably by the middle Eocene Umpqua formation, consisting of more than 1,800 feet of tuffaceous sandstone and shale with thick lenticular basalts and pyroclastics. The Tyee massive feldspathic sandstone, about 2,000 feet thick, overlies the Umpqua and occupies the northeastern corner of the quadrangle.

About 6,000 feet of upper Eocene Coaledo sediments are confined to a complex structural basin occupying the central portion of the quadrangle. The lower and upper Coaledo members consist of medium-bedded tuffaceous sandstones made up largely of basaltic glass, separated by the middle Coaledo member consisting of as much as 2,300 feet of dark tuffaceous shale of more acidic composition. The principal coal beds occur in the upper and lower sandstone members of the Coaledo formation.

The Bastendorf shale and Tunnel Point sandstone represent uppermost Eocene strata and Oligocene strata, and they crop out mainly on the western edge of the basin, although remnants of the Bastendorf are also found farther eastward. The Bastendorf, 2,900 feet thick, is composed predominantly of basaltic glass, and the Tunnel Point, with a minimum thickness of 850 feet, is composed of basaltic, with lesser amounts of andesitic, glass.

The Coaledo and the later Oligocene formations in the major basin were compressed during the Miocene into north-trending folds, and faulted by north-trending faults and by more numerous transverse faults. The Pliocene Empire formation, comprising about 2,000 feet of poorly bedded sandstone, unconformably overlies the Oligocene and Eocene strata in the South Slough syncline and has been folded along the same axis as the older formations but to a lesser degree. Pleistocene terrace and estuarine deposits cover the coastal plain and major valley bottoms.

Coal was first mined in 1854, and production reached 100,000 tons a year during the early part of the century but, since the use of fuel oil

increased during the twenties, coal has been mined only for local needs. The total production of the field is probably of the order of 3 million tons.

✓ Detailed mapping and drilling on four properties have resulted in developing 541,000 tons of measured coal; an additional 800,000 tons was indicated and 3,200,000 tons was inferred. Coos Bay coal is subbituminous in rank, with a heating value of 9,000 to 10,000 B. t. u. per pound as received, with a low sulphur content, moderate percentage of ash, and a relatively high moisture content.

The coals of the upper Coaledo have been designated as the upper coal group and those of the lower Coaledo the lower coal group. Coals in undifferentiated parts of the Coaledo formation have not been classified according to age.

The Beaver Hill bed, lowest coal of the upper group, has been mined more extensively than any other bed. With a few exceptions, other beds of the Coaledo formations have not yielded great tonnages, as these beds are usually higher in ash and contain more numerous partings. The coals of the lower group have a higher heating value but have a higher ash content, and mining conditions are relatively unfavorable.

INTRODUCTION

Purpose and Scope of Survey

The importance of the reserves of the Coos Bay coal field has been emphasized by the Department of Geology and Mineral Industries ever since its inception in 1937. Bulletin No. 2 (Libbey, 1938) is a progress report on the Coos Bay coal field; Bulletin No. 20, *Analyses and other properties of Oregon coals*, (Yancey and Geer, 1940) was prepared in cooperation with the U. S. Bureau of Mines.

Early in 1942 it became evident that manpower and transportation stringencies might result in a fuel shortage in the Northwest. Coos County officials and individuals requested the Department to undertake a survey of the Coos Bay coal field, and for this purpose the 1943 State Legislature appropriated \$20,000 which was matched by an equal amount of Coos County funds.

Plans were drawn up early in 1943 for a survey which would have a dual purpose: first, to determine whether economic tonnages of strip-ping coal could be indicated, because of the facility and minimum of manpower with which such coal may be put on the market; and, second, to revise and map, in detail, structure and stratigraphy of the area, primarily to provide basic information of value in coal and oil exploration. The pioneer work by Dillar had been the primary source of information on the geology of the field, both structural and economic, for 45 years; and, in the light of present-day conditions, it appeared desirable to make further studies along those lines.

Work was started in April 1943 with John Eliot Allen, geologist in charge, and Ralph S. Mason, mining engineer. In June, Ewart M. Baldwin became assistant geologist; in October, Mason was transferred to the Portland office of the Department, and J. Francis Cleaver became engineer. Coal analyses were made by L. L. Hoagland, assayer and chemist for the State Department of Geology and Mineral Industries.

Search for new coal projects was conducted by the geological staff, while the engineering staff supervised drilling, sampling, and open-cut prospecting in selected areas. Geologic work in the Coos Bay area is difficult because of dense underbrush, thick soil mantle, slumping, and the extensive cover of Pleistocene marine terrace de-

posits along the coast and remnant river terrace deposits along many of the streams.

Some 160 coal prospects were examined, and 15 were tentatively chosen for further exploration in order to determine whether or not they were suitable for strip mining. Some of the prospects were eliminated without intensive drilling because of faulting, thinning of the coals, or low grade. Work was concentrated on four projects: namely, Riverton, Southport, Englewood, and South Slough.

The geology of the Coos Bay quadrangle is described in Part I, and the mines, prospects, and outcrops are discussed in Part II.

Acknowledgments

Without the initiative and foresight of the Coos County Court, comprised of Judge E. L. Peterson, and, later, Judge L. D. Felsheim, and County Commissioners Lars P. Peterson and P. W. Culver, the coal survey would not have been effective.

The work of the survey has at all times been facilitated by the cooperation of residents in the area who have given generously of their time and information. It is difficult to list all individually, although special mention should be made of the valuable maps and other data supplied by James H. Flanagan and D. L. Buckingham. The survey wishes also to acknowledge the assistance of the following: W. H. Kay, Oscar Larson, Clarence Coe, A. V. Carlson, W. S. Chiene, James R. Wall, E. R. Lyons, W. G. Robertson, Evor Rudberg, Charles Sneddon, William and James Yates, Claude Elliott, Clifford Anderson, Leonard Gibbs, John Thomas, Bob Geaney, Sam Flint, and many others.

The advice and counsel of Mr. Earl K. Nixon is gratefully acknowledged, and the editorial assistance of Mr. F. W. Libbey and Mrs. J. B. Priestaf in the final revision of the manuscript has been invaluable. Dr. W. D. Lowry did the petrographic work on the thin sections, and Mr. John Dinkel and Miss Jo Anne Lehman made the final drafts of the plates.

Dr. W. D. Smith and Dr. E. L. Packard, heads of the departments of geology at the University of Oregon and at Oregon State College respectively, and Mr. Donald Duncan of the U. S. Geological

Survey have rendered valuable assistance by discussion with the writers of the regional structure and stratigraphy.

Principal Conclusions

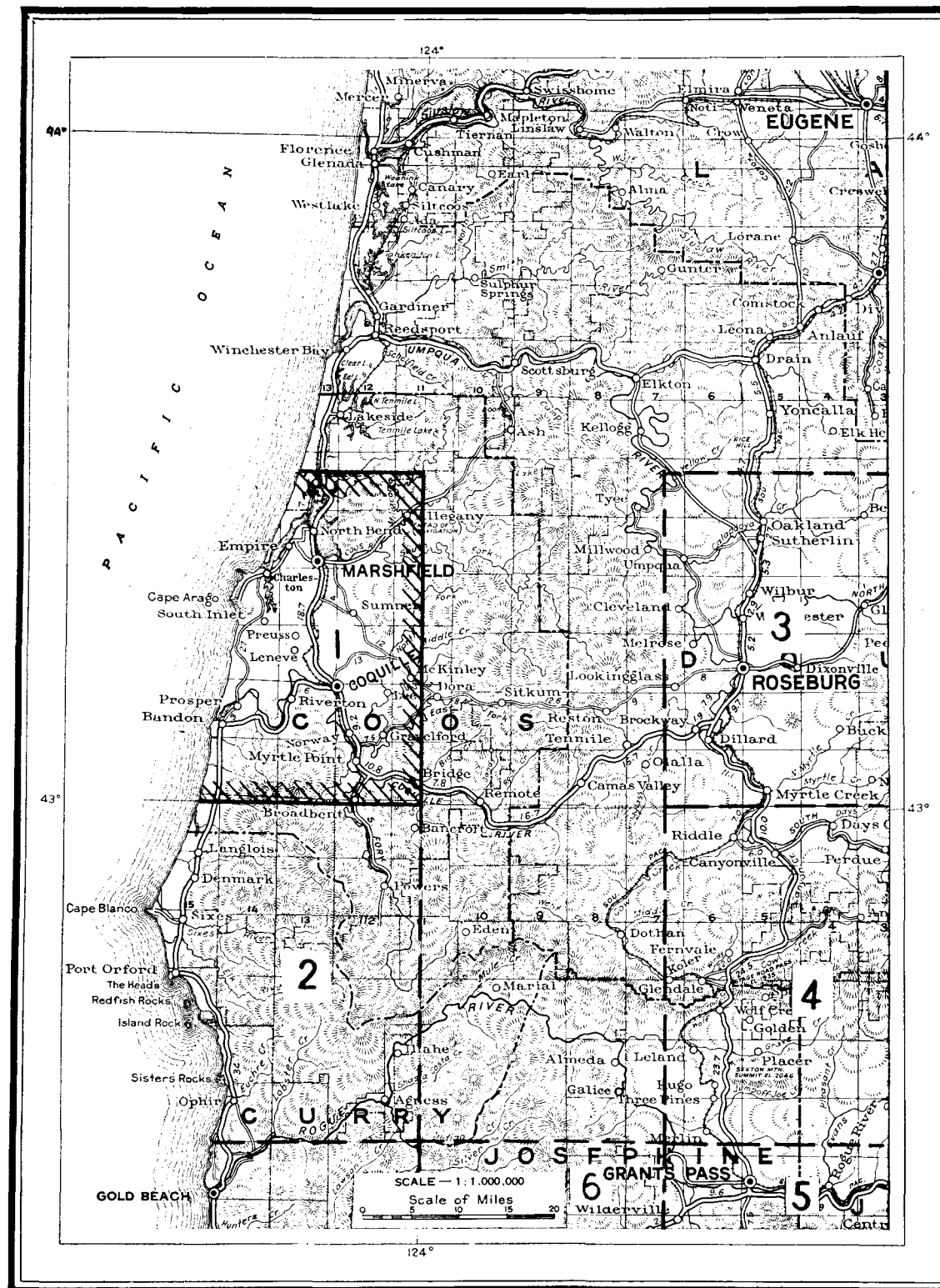
The minable reserves in the Coos Bay coal field are many times that of the recorded production of 2½ million tons. The Beaver Hill coal bed, from which most of this production has been derived, has seldom been mined below 500 feet down the dip, and only the Beaver Hill mine has approached the maximum practicable depth of mining.

Campbell (1913) estimated that the coal reserves of the Coos Bay area were a billion tons. Results of the present survey would not alter this estimate, but qualifications concerning economical grade should be made. Two major coal groups, the upper and lower Coaledo coals, have been mapped.

The lower Coaledo coals have an advantage in being slightly higher in rank although they are

generally bonier and the ash is in such a form that it is inherent in the coal and difficult to separate. With improved mining methods, coupled with adequate washing and sorting, selected portions of the thick lower Coaledo and undifferentiated coals could produce a product equal to the more desirable upper coals. As the better and more available coal of the upper coal group is exhausted, and as the need for coal for by-products becomes greater, the vast reserve of the lower Coaledo and undifferentiated coals may be utilized.

There are a few areas in which stripping might be feasible. In other parts of the Coos Bay field, stripping operations would be hampered by timber, by steep dips, and by weathering, which sometimes affects the coal to a depth of 20 to 30 feet. The Beaver Hill bed is overlain by a fairly thick sandstone. Where this sandstone has been removed by erosion, the coal is generally missing except for very small strips. Thus most stripping areas are relatively small.



Index Map of Southwest Oregon

- | | |
|---------------------------|-------------------------------|
| 1. Coos Bay quadrangle | 4. Riddle quadrangle |
| 2. Port Orford quadrangle | 5. Grants Pass quadrangle |
| 3. Roseburg quadrangle | 6. Kerby quadrangle (in mss.) |

Part I

General Geology

INTRODUCTION

Location and Accessibility

The Coos Bay quadrangle is between parallels 43° and 43°30' north latitude, and between meridian 124° west longitude and the Pacific Ocean. The quadrangle is located near the southern end of the Coast Range where the range merges into the Klamath or Siskiyou mountains. Coos Bay is about 200 miles south of the mouth of the Columbia River.

U. S. highway 101 runs north and south through the quadrangle and connects with State highway 42 at Coquille, which runs east to U. S. highway 99 near Roseburg. The Southern Pacific railroad, a branch from the main line at Eugene, parallels the highway 101 south through the quadrangle to Myrtle Point.

Coos Bay is an adequate port for ships as large as those of the Victory and Liberty classes which load lumber at Bunker Hill, just south of Marshfield. In early mining days, coal was shipped to San Francisco by coastal vessel directly from bunkers along the inlets.

Relief and Drainage

The Coos Bay quadrangle may be divided topographically into the coastal plains and terraces, the lowest and broadest of which range in elevation from sea level to 120 feet; the central hills which are flat-topped remnants of coastal plains ranging from 300 to 600 feet in elevation; and the hills and mountains around the southern and eastern border which range from 1,000 to 1,575 feet in elevation and include such prominent features as Blue Mountain and Bill Peak.

Coos River and its tributaries drain most of the north half of the quadrangle. Coos Bay, the drowned mouth of Coos River, is the outstanding topographic feature. The branches and tributaries of the Coquille River drain the southern half of the quadrangle. A few short streams run directly into the bay and the ocean.

Climate and Vegetation

The climate of Coos Bay is humid with a dry period in summer. The annual rainfall varies from less than 40 inches to nearly 100 inches, depending

upon year and locality. The January mean precipitation is three times that of August. The long "rainy season" enables most of the abundant moisture to seep in, resulting in dense growth of vegetation. Fog is common along the coast even in the summer months.

The January mean temperature is around 50° F., and the July mean temperature somewhat above 60° F. The maximum temperature occurs in August, but no summer month has an average temperature above 74.4° F. June is cooler than July, thereby differing from the California fog belt, where June is often warmer than July (Stovall & Hopson, 1940:89).

A large portion of the area has been logged off at least once, and is now covered with second and third growth timber and a dense undergrowth of berry vines, ferns, and brush, along with fallen timber, making geologic exploration very difficult. Coos County still has about 900,000 acres of commercial timber, with a volume of about 20 billion board feet (Mason, 1940:226). Of this amount, Douglas fir is by far the most important, although substantial amounts of Port Orford cedar, western hemlock, Sitka spruce, and western red cedar are logged every year.

Population and Industry

The population is largely concentrated around Coos Bay and along the broad river valleys. Coos County, an area about twice that of the quadrangle, had a total population of 32,466 in 1940, half of which lived in seven towns within the quadrangle; there are no communities of more than a few hundred inhabitants elsewhere in the county. The center of population is on Coos Bay. Marshfield and adjoining North Bend, Englewood, Bunker Hill, and Eastside had a total population of more than 10,000 in 1940. This is the principal shipping point and center of trade. Coquille is the county seat.

An interesting feature of the distribution of population is related to the physiographic history of the region. Most of the houses and farm buildings in the quadrangle are built upon remnant

river terraces which are widespread along the streams and inlets. Large portions of the towns of Coquille, Myrtle Point, and Marshfield lie upon such terraces, which are out of reach of floodwaters yet are adjacent to the wide fertile valley bottoms.

The most important industry is lumbering, with production of recent years exceeding half a million board feet annually, from over 30 sawmills in Coos County. The value of the various products from processing plants which include lumber, venetian blinds, battery separators, plywood, pre-

fabricated houses, shingles, veneer, sash and door material, wood culverts, myrtlewood novelties, and others, approaches \$10,000,000 a year¹. Farming, largely dairying, is next in importance. Other industries are: commercial deep-sea fishing, coal mining (at present not as important a part of the local economy as formerly), the gathering of greens and herbs, shipbuilding, tourist trade, the raising of cranberries, etc.

¹ Paul M. Dunn, dean, School of Forestry, Oregon State College, personal communication.

STRATIGRAPHIC GEOLOGY

Previous Work

Most of the early geological work in the Coos Bay area was done by J. S. Diller of the U. S. Geological Survey, who devoted many years to mapping this and other areas in western Oregon and northern California. The Coos Bay coal field was first described by Diller in 1896, and a more complete report was published in the 19th Annual Report of the U. S. Geological Survey (1899). The Coos Bay folio (Diller, 1901) included areal and geologic maps, and structural cross sections. Information gathered by Diller and Pishel was published in 1911 and by Diller in 1914.

Other reports on the coal field have been confined to descriptions of individual mines or groups of mines. Paleontological studies were made by Dall (1909), Arnold and Hannibal (1913), Howe (1922), Schenck (1927, 1928), Turner (1938), and Weaver (1942). Diller's *Topographic Development of the Klamath Mountains* (1902) was the first comprehensive discussion of the physiographic history of southwestern Oregon. A general discussion of the stratigraphy of western Oregon is given by Smith and Packard (1919), Harrison and Eaton (1920), Washburne (1914), Hertlein and Crickmay (1925), and Weaver (1937).

Valuable information has been obtained by the writers in discussions with geologists of oil companies, and from private reports on this area by coal and oil geologists.

Contributions of the Mesozoic stratigraphy of southwestern Oregon which have aided in clarifying the extent of the formations have been published by Louderback (1905), Knowlton (1910), Crickmay (1931), Anderson (1938), Wells et al. (1939, 1940, 1941), and Taliaferro (1942, 1943).

Diller (1896:462) first applied the name "Arago beds" (later called formation) to the thick section of sediments lying stratigraphically between the pre-Tertiary rocks and the "Miocene sandstones" (Empire formation) near Cape Arago. As originally defined this formation included sediments as far north as Astoria. The Arago was subdivided by Diller (1899:320) according to the following:

For convenience and clearness, however, in describing the coal field it is necessary to consider the coal-bearing strata apart from the other portion of the Arago formation. For this purpose the coal-bearing strata will be designated the Coaledo formation, because it is well exposed in the vicinity of Coaledo. The other portion of the Arago formation will be designated the Pulaski formation, because it forms the hills about the head of Pulaski Creek and the Pulaski arch, which separates the Beaver Slough and Coquille coal basins.

"Foraminiferal shales" at Bastendorf¹ Beach and the overlying Tunnel Point sandstone were also included in the upper portion of the Coaledo formation. More recent work has further subdivided the stratigraphic section in the Coos Bay area. The "Pulaski" formation has been abandoned as a formational name because it has been preoccupied and also because it is believed to be equivalent to the Umpqua and Tyee formations of the Roseburg area (Wilmarth, 1938:1744). Additional evidence is supplied in this report supporting the correlation of "Pulaski" sediments with the Umpqua and Tyee section in the Roseburg quadrangle.

The name "Arago" should be abandoned as a formational name although it might be retained

¹ The correct spelling of the family name from which the beach derived its name, and the locally accepted name of the beach.

as a group name to include the Eocene formations of the Cape Arago region. There is good evidence of a break in deposition and unconformable relations between the Coaledo formation and the underlying Umpqua and Tyee beds which Diller included in his Pulaski formation. The original division of the Arago formation was based upon the prevalence of coal beds, and not on paleontologic or stratigraphic evidence. It is now known that the Umpqua includes coal deposits in several places, and the stratigraphic boundaries of the Coaledo cannot be based upon such criteria.

Turner (1938) divided the Coaledo into three members, the lower, middle, and upper, on the basis of fauna and lithology. These subdivisions have been used in this report.

The fauna of the lower Coaledo has been described and illustrated by Turner (1938), and it is included in a more recent publication by Weaver (1942). These publications were particularly valuable in correlating the strata found inland with the standard sections along the coast and in the Roseburg quadrangle.

Schenck (1927) proposed the name "Bassendorf shale" for the beds found at Bastendorf Beach.

The lithologic unit, the "Tunnel Point beds" described by Dall (1898:340), was called the Tunnel Point sandstone by Schenck (1927).

The Empire formation was named the "Empire beds" by Diller (1896:475). It has received much geological and paleontological study because of its abundant fauna. The Coos conglomerate has been included as a member of the Empire formation in this report. The recognized areal extent of the Empire has been enlarged by the writers to cover a large part of the South Slough basin.

The study of Pleistocene stratigraphy in the area had been neglected until recently. The physiographic study of the Klamath Mountains by Diller (1902) included a summary of the Late Cenozoic coastal movements and related deposits. Smith (1933) discussed some of these deposits in relation to coastal physiographic events. Economic studies of beach and terrace placers have been made by Pardee (1934), Twenhofel (1943), and Griggs (1944). Late Cenozoic history and stratigraphy have been discussed by Baldwin (1945).

Pre-Tertiary Rocks

Introduction

A complex series of pre-Tertiary sediments, schists, and basic igneous rock is exposed in the southern part of the Coos Bay quadrangle, and extends southward into the Port Orford quadrangle where the series is more extensively exposed. Diller (1901) mapped the sediments of this series as a part of the Myrtle formation which he named and described (1898) in the Roseburg folio. The cherts, schists, and igneous rocks were mapped separately. Diller (1903, 1907, 1908, . . . and Kay, 1924) further defined and clarified stratigraphic units of the Mesozoic of southwestern Oregon. The "Myrtle" was assigned by Diller to the Lower Cretaceous and was correlated with the Knoxville of California.

Several revisions of the complex Mesozoic stratigraphy of California and of southwestern Oregon have changed earlier correlations and have limited the scope of these formations. In order to revise and map the pre-Tertiary stratigraphy of the Coos Bay quadrangle, a more complete knowledge of the surrounding Mesozoic area would be necessary. The writers have not undertaken this study and, with a few designated changes, Diller's boundaries of the pre-Tertiary units have been accepted.

Although the fauna in the Myrtle which Diller collected and correlated with the Knoxville of California was then thought to be Lower Cretaceous, revision of the California stratigraphy as reviewed by Taliaferro (1942:75, 76) indicates that the lower Knoxville part of the original Myrtle must be placed in the Upper Jurassic. Taliaferro (1942:76, 77) further states:

The Myrtle formation, as mapped and defined, is a heterogeneous assemblage ranging from Upper Jurassic to late Lower Cretaceous and including at least one important unconformity. In the Port Orford quadrangle, Oregon, both Dothan and Galice, as well as Franciscan, Knoxville, Paskenta, and Horsetown are included in the Myrtle; in the Roseburg quadrangle, Oregon, the Myrtle, as mapped, includes Franciscan, Knoxville, and Horsetown; in the Coos Bay quadrangle, Oregon, the Myrtle appears to be largely, if not entirely, Franciscan. The inclusion of so many heterogeneous elements in the Myrtle is not surprising when the nature of the exposure, the intricate folding and faulting, the nature of the base maps, and the rapidity of the mapping are considered. In

the field the separation of these units over wide areas could only be accomplished by slow and detailed mapping on much better base maps than now exist. . . . Therefore, the name Myrtle either should be redefined or abandoned.

Peridotite

A small area of peridotite which is nearly altered to serpentine is exposed southwest of Gravelford where good exposures of sheared serpentine are found in a quarry. The outline of unaltered coarse-grained peridotite may be seen in the center of some of the larger fragments. Diller (1901:4) described this exposure as follows:

It has the mesh structure characteristic of serpentine derived from olivine, which once formed by far the greater part of the rock. Some of the serpentine has the fibrous structure of bastite, like that derived from enstatite, so that the original rock was apparently an olivine-enstatite rock or saxonite.

The serpentine is more sheared and slickensided than the adjacent Umpqua sediments. Structurally there is little evidence to indicate that this occurrence is at the base of the Tertiary section as it appears to be on the eastern limb of an anticline. The age of the serpentine masses of the Coast Range has been given by Taliaferro (1942:95) as Upper Jurassic. Although this locality is farther north than other serpentine masses of the coastal area, it probably should be correlated with them in age.

It is difficult to explain the presence of a small body of serpentine surrounded by steeply dipping sediments, without recognized fault relationships, contact metamorphism, or position in the center of an anticline. It seems entirely probable that the serpentine is older than the Umpqua, and its method of emplacement may have been similar to the "cold intrusions" of serpentine described by Taliaferro (1943:205) in which plastic masses of serpentine are squeezed into place when overlying younger rocks are closely folded.

Sediments

Sediments of the pre-Tertiary formations in the Coos Bay quadrangle are composed of some chert and conglomerate, with larger amounts of sandstone and shale. A prominent ridge of pre-Tertiary sandstone exposed in Bill Peak extends southeastward into the Port Orford quadrangle. This medium-grained sandstone is greenish in

color and includes lenses of grit composed of chert pebbles. These may have been reworked from the Franciscan cherts. The sandstone unconformably overlies cherty sediments elsewhere in the quadrangle and is possibly a part of the Lower Cretaceous series.

Massive sandstone lenses stand out as isolated knobs above rolling terrane which is underlain by more highly deformed shaly material. The more flaggy sandstone and dark shale which surround these sandstone projections are exposed along the Coquille-Roseburg highway. The sandstone is highly sheared in places, and the pulverized mass tends to slump, endangering the highway. No evidence of general regional metamorphism was noted; the massive sandstone is jointed but does not show any change in mineral content. Some quartz veins are present along the joints.

Some areas of sediments included by Diller in the "Myrtle" formation and checked by the writers were believed to be Tertiary in age and were so mapped. They crop out along the highway north of Broadbent to the mouth of Rhoda Creek, and along the north side of Twomile Creek which is just south of Bill Creek. Steeply dipping sandstone with minor amounts of intercalated sandy shale more closely resemble Tertiary sediments than pre-Tertiary although no faunal evidence was found.

Cribbins Hill, south of Myrtle Point, is mapped as "Myrtle" by Diller. The topography is rolling with few outcrops. Many boulders of chert are scattered over the surface; they are well-rounded and of medium size, seldom more than 10 inches in diameter. A vertical bed of sandstone and conglomerate which strikes north may be seen in a small stream about 600 feet west of the road near the northeast corner of sec. 28, T. 29 S., R. 12 W., on Cribbins Hill. In the conglomerate portion it contains many boulders of chert and sandstone similar to those scattered over the surface. The numerous boulders upon the hill probably are derived from the breakdown of this conglomerate, believed to be the basal part of the Tertiary section in this part of the quadrangle. This massive conglomerate and sandstone bed probably corresponds to similar exposures near the mouth of Ward Creek, also to the prominent knobs

between Bill Creek and Bear Creek, and possibly also to the conglomerate along the west bank road of the North Fork of the Coquille about 3 miles northeast of Myrtle Point.

Basalt

Most of the basaltic volcanics of the Coos Bay quadrangle are extrusive and are discussed with the Tertiary stratigraphic units. The remainder of the basalts occur as dikes and plugs, some of which appear to be pre-Tertiary in age although it is difficult to distinguish between these and the feeders of the Tertiary volcanics.

Many of the basalt dikes and plugs have small bodies of schist along their edges, and are surrounded by pre-Tertiary sediments. Similar schists resulting from contact metamorphism of Mesozoic sediments are found in many places in California and southern Oregon (Taliaferro, 1943:159-169).

In several puzzling instances, the basalt masses and accompanying bodies of schists are surrounded by Tertiary sediments. It could not be determined whether the basalt and schists are pre-Tertiary and exposed by fensters or whether they are Tertiary basalts that have metamorphosed Tertiary sediments.

Schists

Schists are generally associated with the pre-Tertiary rocks and, according to Diller (1901) and Taliaferro (1943), probably originated from contact metamorphism by intrusives, thus accounting for their scattered occurrence. Diller (1901:2) describes the schists as follows:

The most important varieties of these crystalline rocks found in the Coos Bay quadrangle are amphibolite, amphibole-schist, mica-schist, and chlorite-schist The blue amphibole of Tupper Rock and the other similar crystalline rocks of the region is probably not all the same, but most of it appears to be of the variety known as glaucophane, so that the schists may be appropriately called glaucophane-schists.

Besides glaucophane, the blue schists frequently contain other minerals, among which epidote, garnet, muscovite, zoisite, and albite are most common and important.

Many small outcrops of schist were mapped by Diller, and their occurrence has been noted without change on the geologic map accompanying this report. They are universally small in area with indistinct border relations, and they usually occur adjacent to basalts. The schists may be pre-Tertiary in age. In several places they protrude above Tertiary sediments as if they were either peaks on the pre-Tertiary surface or were pushed up during folding. The schists are more resistant than the Tertiary sediments and are easily distinguished from them.

A sample of gray-colored schist collected near the contact between the Tertiary and the pre-Tertiary east of Myrtle Point in sec. 14, T. 28 S., R. 12 W., is characterized by crenulate streaks of pink garnet. The following petrographic description as well as those cited ahead are by W. D. Lowry of the Oregon Department of Geology and Mineral Industries.

Petrographic examination shows it to be a quartz-garnet schist. Interlocked, in part strained quartz grains with sutured, jigsaw-like outlines constitute about 70 percent of the rock. Dodecahedral garnets have an average diameter of about 0.015 mm and for the most part are aligned in rows several grains wide. They have a pink color and an index of $1.735 \pm .004$, and form about 20 percent of the rock. Anhedral grains and aggregate masses of actinolite as much as 1 mm in size, and flakes of muscovite about 0.25 mm in diameter each make up about 5 percent of the section. Small anhedral grains of magnetite, pyrite, and chalcopyrite (?) are minor constituents.

The rock described is not necessarily typical of the pre-Tertiary schists, and is but one of the many types associated with the "Myrtle," described by Diller (1901).

Classification used by Clark, Durham, Grant, Putnam, Taliaferro, and Weaver (1944)		Diller 1896-462	Diller 1899-1902	Dall 1909	Schenck 1927-1928	Turner 1938	Weaver 1944	Allen and Baldwin 1944	EPOCH
TERTIARY	Quaternary	Terrace mtrl.	Marine terraces	Marine terraces			Marine terraces	Elk River beds	Pleistocene
	Pleistocene	Tulare						Coquille	
	Pliocene	San Joaquin clay		Coos cgl.					
		Etchegoin			Empire fm.		Empire Coos cgl. fm.	Empire Coos cgl. fm.	Pliocene
		Jacalitos							
	Miocene	Neroly	Empire beds	Empire fm.	Empire fm.	NOT DISCUSSED			Miocene
		Cierbo							
		"Briones"							
		"Temblor"							
		"Vaqueros"							
	Oligocene	"Blakeley"							Oligocene
		"Lincoln"		Tunnel Point sandstone	Tunnel Point sandstone	Tunnel Point sandstone	Tunnel Point sandstone	Tunnel Point sandstone	
	Eocene	Keasey		Coaledo fm.	Transition	Bassendorf shale	Bassendorf shale	Bassendorf shale	Eocene
		"Tejon"	Arago beds	Arago fm.	Coaledo fm.	Coaledo fm.	Arago fm.	Upper Coaledo fm.	
		"Transition beds"						Middle Coaledo fm.	
		"Domengine"		Pulaski fm.	Pulaski fm.	Pulaski fm.		Lower Coaledo fm.	
		"Capay"							
		"Meganos"							
		"Martinez"							
	Paleocene						Metchisin volcanics ?	Tye sandstone Umpqua fm. Volcanics	Paleocene

Historical review of the Tertiary stratigraphy of the Coos Bay area.

TERTIARY FORMATIONS

Umpqua formation (middle Eocene)

The Umpqua formation was named and described by Diller (1898) in the Roseburg folio. The presence of strata of Umpqua age in the Coos Bay quadrangle had been suggested by several early writers although a supporting fauna had not been previously collected in the lower portion of the Arago formation, called "Pulaski" by Diller. Poor exposures of "Pulaski" sediments along the coastal section have retarded correlation.

Dall (1898:323-358) observed that the Arago along the coast appeared to be younger than beds near the junction of the Little and the North Umpqua rivers. These beds are a part of the Umpqua formation of the Roseburg quadrangle. This observation is substantiated in general by collections from the abundantly fossiliferous Coal-Edo portion of the Arago, but fauna collected in 1943 and 1944 in the hitherto uncorrelated "Pulaski" showed its Umpqua age.

The dark shale and flaggy sandstone series exposed in the valley of Sandy Creek near Remote has been correlated with the upper Umpqua by Turner (1938). This member of the Umpqua together with the overlying Tyee sandstone has been traced northward to the valley of the East Fork of the Coquille River between Dora and Sitkum, and to the north end of Blue Mountain near Fairview. The areal extent of the Umpqua sediments is confined for the most part to the southern half of the quadrangle where it is in contact with pre-Tertiary rocks.

Umpqua sediments exposed in the Coos Bay quadrangle are thin-bedded dark tuffaceous sandy shales with intercalated flaggy sandstone beds. The massive tuffaceous sandstone members which are present in the section along the Middle Fork of the Coquille River (Turner, 1938) appear to be missing in the quadrangle, or are present as more shaly material resulting from a facies change. A few thin lenses of massive sandstone and conglomerate are present but they are of minor importance quantitatively.

Several rock samples were taken in widely separated places and their petrographic descriptions are by W. D. Lowry. The rocks described were taken from the more sandy facies.

A dark - gray medium - grained sandstone was sampled in a road cut in the NE¼ sec. 29, T. 29 S., R. 11 W., about 1 mile west of Bridge, Oregon.

Under the microscope the grains in the thin section are mainly less than 0.25 mm in size and about 75 percent are rock fragments. They are angular to subrounded in shape. Chert and other siliceous rock grains form about 45 percent of the rock. Shale and other lithic fragments including colorless basic glass, with incipient plagioclase laths and magnetite grains, and quartz schist make up a total of some 25-30 percent. Grains of quartz, including vein quartz, are in part strained and constitute about 10 percent.

Dirty and altered grains of oligoclase-andesine, of about composition Ab_7An_3 , add up to 15 percent whereas fresh grains of andesine, Ab_6An_4 , total only 1 or 2 percent. Grains of epidote, hornblende, actinolite, chlorite, pyrite, calcite, and flakes of biotite, in part sharply folded, are minor constituents. Part or all of the calcite and chlorite may be secondary and calcite may be distributed sparsely throughout the rock as a cement.

A brown massive medium - to coarse - grained sandstone member is exposed along Catching Creek in sec. 30, T. 29 S., R. 12 W.

Petrographic examination of the thin section shows that it is made up of a variety of angular to subrounded mineral and lithic fragments, mainly less than 0.5 mm in size. Angular to subrounded grains of quartz, in part displaying strain shadows and sutured outlines, include vein quartz and form about 20 percent of the rock. Subangular dirty and altered grains of oligoclase-andesine make up a total of 20 percent whereas fresh angular grains of plagioclase, at least as basic as Ab_6An_4 , constitute only about 2 percent. Grains of hornblende, magnetite, epidote, and flakes of muscovite and biotite, in part sharply folded, each form about 1 percent of the section. Some of the grains of brown basaltic glass, in part devitrified and with an index greater than balsam, contain laths of plagioclase and grains of magnetite. Together they make up a total of about 5 percent. Other lithic fragments include chert, which forms about 15 percent; quartz schists, about 5 percent; and various others, largely shale or slate, 20 percent. The grains are poorly cemented with limonitic material which composes 5 percent of the rock.

The average grain size of the sandstone lens from which the specimen was taken is coarser than that of the above described representative. The sediments are thought to have been laid down near the old shore line as the subrounded shapes

of some of the grains and the assortment of mineral and rock fragments suggest mixing and reworking of older sediments whereas the large size of some of the grains suggests lack of transportation.

A medium-gray, thinly bedded and cross-bedded, fine-grained sandstone underlies the unconformity at the base of the Coaledo in North Cove in sec. 20, T. 26 S., R. 14 W.

Under the microscope the matrix of the thin section is seen to be calcite and it composes 35 percent of the rock. Nearly all the clastic particles are subangular to angular in shape and less than 0.25 mm in size. Quartz grains, in part strained, make up about 45 percent of the section. Gray and grayish brown grains of basaltic glass have an index greater than balsam and form about 10 percent of the rock. They contain magnetite and laths of plagioclase and are in part devitrified. Fresh grains of andesine as basic as Ab_5An_5 and dirty and altered ones of less basic plagioclase constitute respectively about 5 and 1 percent of the rock. Minor constituents are microcline, sharply folded flakes of biotite and muscovite, magnetite, and lithic fragments which include chert and quartz schist and quartz-mica schist.

A fossiliferous dark-gray fine-grained sandstone contains an Umpqua fauna at the mouth of Steel Creek in sec. 12, T. 28 S., R. 11 W.

Under the microscope the rock displays a matrix of calcite which forms about 55 percent of the rock. Nearly all the clastic grains are less than 0.25 mm in size. For the most part the grains are subangular to angular in outline, and some of the lithic fragments and quartz tend to be subrounded. Mineral grains compose 25-30 percent of the rock and include about 15 percent quartz, 5 percent hornblende, 2 percent labradorite (Ab_5An_7), 2 percent magnetite, 2 percent muscovite and biotite together, 1 percent epidote, 1 percent augite, and 1 percent oligoclase-andesine (Ab_7An_3). Some of the quartz grains are strained. The labradorite tends to be fresh whereas the oligoclase-andesine tends to be dirty and altered. Lithic fragments include about 10 percent basic brown glass, partially devitrified, with an index greater than balsam. Some grains contain inclusions of magnetite. Other lithic fragments total about 7 percent, most of which are chert though grains of hornblende schist, mica schist, and quartz schist are present.

This rock, as well as others described from the Umpqua formation, differs from the Tyee sandstone in that it contains more lithic fragments.

Traces of coal are reported in the Umpqua in the Coos Bay quadrangle, and several beds of marginal quality coal occurring in the upper part of a massive sandstone in the upper Umpqua were examined near Remote and Bridge. Coal is reported to have been found in the massive and flaggy sandstone series which forms the constriction in the Coquille River between Myrtle Point and Coquille. Also coal was reportedly found in the highway cut west of Bear Creek near Bandon, and coal encountered in prospect holes just southeast of the town of Bandon is believed to be in strata of Umpqua age although the formations are covered by a veneer of terrace material.

The Umpqua strata in the southern part of the Coos Bay quadrangle are closely folded. Minor structures seem to be superimposed upon broader anticlines and synclines. Contacts with igneous and pre-Tertiary rocks are generally obscure. The beds near the contact usually have very steep dips, but there seems to be no reason to conclude that they are fault contacts, as the pre-Tertiary rock is not known to be in contact with sediments younger than the Umpqua, and outliers of Umpqua sediments rest upon the pre-Tertiary in the Port Orford quadrangle to the south.

In the valley of Fourmile Creek at the southern edge of the quadrangle, the Umpqua appears to overlie the pre-Tertiary with depositional contacts. About 2,000 feet of dark tuffaceous shale containing an abundant fauna is exposed in the creek bed. The following fauna was collected, part as float but most of it in place¹:

Venericardia aragonia Arnold and Hannibal
Barbatia landesi (Weaver and Palmer)
Ostrea idriaensis Gabb
Volsella (*Brachidontes*) *cowlitzensis* (Weaver and Palmer)
Gari hornii subsp. *umpquaensis* Turner
Eomeretrix martini (Dickerson)
Loxocardium brewerii (Gabb)
Anomia mcgoniglenensis Hanna
Acila decisa (Conrad)
Nuculana 2 sp.
Pitar sp.
Calyptrea diegoana (Conrad)
 cf. *Potamides carbonicola* Cooper
Turritella uvasana Conrad cf. subsp. *hendoni* Merriam

¹ The Eocene faunas were compared with collections by F. E. Turner and others now located at Oregon State College. The writers wish to express their appreciation to Dr. E. L. Packard for many courtesies extended during the course of their determination.

Turner (1938:5) discusses the division of the formation into the upper and lower Umpqua as follows:

"The paleontologic evidence for this division is largely negative—for example, the restriction of *Turritella uvasana hendoni* Merriam ss. to the beds of the upper Umpqua at Glide; *Turritella bramkampii* Merriam and Turner, and *Surculites* n. sp. A to the lower Umpqua beds on the Coquille River and west of Roseburg; and the restriction of *Corbula torreyensis* Hanna, *Ampullina andersoni* Dickerson, *Barbatia morsei* Gabb, and *Potamides carbonicola* Cooper to the upper beds at Glide and the upper Umpqua beds on the Coquille River."

The Fourmile Creek fauna contains *Barbatia landesi*¹ and a form referred to *Potamides carbonicola*. Other species common to the upper Umpqua are also present. This fauna occurs in a type of sediment common in the Umpqua elsewhere in the Coos Bay quadrangle. Because there seems to be little room for intervening sediments between these upper Umpqua and "Myrtle" beds, it is believed that lower Umpqua sediments are either missing or very thin. This condition indicates an overlap of the Umpqua upon the pre-Tertiary highland to the west of the main basin of deposition.

About 200 yards south of the Gravelford bridge the following forms were collected:

Turritella uvasana Conrad cf. subsp. *hendoni* Merriam
Nitidavenus tejonensis (Waring)
Crassatellites sp.
Dentalium

Mr. Edwin Abernethy kindly showed the writers the following fauna near the bridge at the mouth of Steel Creek, 1½ miles east of Dora, and donated several good specimens:

Microcallista (*Costacallista*) *conradiana* (Gabb)
VolSELLA (*Brachidontes*) *cowlitzensis* (Weaver and Palmer)
Pitar uvasanus (Conrad) cf. subsp. *coquillensis* Turner
Loxocardium brewerii (Gabb)
Nemocardium linteum (Conrad)
Glycymeris sagittata (Gabb)
Glycymeris cf. *perrini* Dickerson
Gari hornii subsp. *umpquaensis* Turner
Pitar cf. *eocenica* (Weaver and Palmer)
Anomia mcgoniglenensis Hanna
Solena coosensis Turner

Pelecypora sp.
Nuculana sp.
Turritella uvasana Conrad cf. subsp. *hendoni* Merriam
Ectinochilus (*Macilentos*) *macilenta* White subsp. *oregonensis* Hendon
Whitneyella cf. *sinuata* (Gabb) var. *aragoensis* Turner
Amaurellina hendoni Turner
Cylichnina tantilla (Anderson and Hanna)
Ficopsis sp.
Dentalium.
 Crabs in concretions

Near the mouth of Daniels Creek in a small quarry in the SE¼ sec. 26, T. 25 S., R. 12 W., more than 100 feet of coarse conglomerate composed of reworked volcanics overlies the basalt. Above this, dark friable sandstone which yielded the following fauna lies beneath another thin bed of conglomerate which is in turn overlain by a thin bed of limestone.

The fauna consisted of the following forms:

Nemocardium linteum (Conrad)
Marcia (*Mercimonia*) *bunkeri* (Hanna)
Glycymeris perrini Dickerson
Anomia mcgoniglenensis Hanna
Solen sp.
Microcallista conradiana (Gabb) var. *meganosensis* (Clark and Woodford)
Nuculana cf. *fresnoensis* (Dickerson)
Gari sp.
Tivelina vaderensis (Dickerson)
Pachydesma weaveri (Dickerson)
Ectinochilus (*Macilentos*) *macilenta* White subsp. *oregonensis* Hendon
Ficopsis cf. *remondii* (Gabb)
Amaurellina hendoni Turner
Pseudoliva dilleri Dickerson
Turritella uvasana Conrad cf. subsp. *hendoni* var. Merriam
Whitneyella sp.
Polinices (*Neverita*) *globosa* (Gabb)
Cylichnina tantilla (Anderson and Hanna)
Dentalium sp.

This fauna contains many pre-Coaledo forms; in some aspects it resembles an Umpqua fauna. As its stratigraphic position is uncertain, it is difficult to determine whether the conglomerate represents a local erosional break during deposition of the Umpqua, or whether the conglomerate is a phase of the basal Tyee where it lies upon the basalt.

Diller mapped the coastal strip between Five-mile Creek and Whiskey Run as Empire which Dall (1909:14) described as follows:

After the uplifts which closed the Arago epoch a general process of erosion was initiated, which, in the submerged portion of the Coos Bay basin and in a region on the outer sea-

¹ Reinhart (1943:31) indicates that forms identified as *Barbatia morsei* by Turner more closely resemble *Barbatia landesi* (Weaver and Palmer).

coast south of Fivemile Creek, deposited a series of marine sandstones and shales containing a Miocene fauna, which has been named by Diller, the Empire formation.

If an Empire fauna were found in this strip, it would indicate that at least a portion of it could be correlated with the Empire formation. However, the only fauna collected by the writers came from a point about midway between Twomile and Threemile creeks; it contains an Eocene form of *Venericardia*. The sediments do not resemble the Empire in lithology, and the deformation is much more pronounced than that of the Empire at South Slough. It seems probable that the above citation by Dall is in error, and this area has been mapped as Umpqua by the writers.

The actual contact with the overlying Tyee has not been found but the strata seem to be conformable in dip. The rapid change to massive Tyee sandstone from thin-bedded Umpqua shale suggests diastrophic changes which may have resulted in uplift and rapid erosion of the adjacent land masses. Some of the Umpqua sediments may have been eroded during this stage of uplift.

Volcanic series (intercalated with the Umpqua formation)

Volcanic material crops out in a discontinuous belt of variable width around the northern and eastern edge of the Coaledo basin, and in irregular masses in the southeastern portion of the quadrangle. The volcanics are largely confined to areas underlain by Umpqua or older strata. North of Blue Mountain, they appear to form the center of an anticline on whose limbs the Tyee dips eastward and the Coaledo dips westward. The belt of volcanics which crops out in and north of Blue Mountain would appear to be more resistant basalt rising above the less resistant Umpqua sediments along the crest of the anticline.

Diller (1901) refers to these masses as intrusives, but their predominantly clastic texture and their stratigraphic position indicate they are for the most part extrusive and possibly submarine in origin. The fragments making up the pyroclastics, agglomerates, flow-breccias, and flows are usually fine-grained, in many places amygdaloidal and without definite structure. Many of the outcrops are weathered to a yellow clay. The basalt is greenish-gray in color and has been universally altered. Medium-to fine-grained tuffs alternate

with flow-breccias, mud flows, and coarse agglomerates. A few masses, most of them coarse flow-breccias, are quarried for road and jetty material on Kentuck and Willanch sloughs, Coos River, Blue Mountain, and east of Coquille.

A compact dark-colored coarsely jointed diabasic-appearing rock is exposed in the county quarry on Kentuck Slough in sec. 34, T. 24 S., R. 12 W., at an elevation of about 300 feet.

In the thin section the rock is seen to be a coarse-grained zeolitized basalt with a nearly holocrystalline seriate texture. Unaltered subhedral grains of plagioclase with an average size of 0.8 mm are characterized by albite twinning which indicates a composition as basic as Ab_5An_5 . The plagioclase forms only about 10 percent of the rock, the remaining 40 percent or more of the original plagioclase has been converted to an undetermined zeolite which forms radiating fibrous aggregates as much as 2 mm long. Subhedral to anhedral grains of magnetite as much as 1.7 mm long constitute about 5 percent of the rock. Euhedral and subhedral grains and clusters of augite and as much as 2 mm in length form a total of 15-20 percent. In places they are cut into by laths of plagioclase and some of the augite grains are slightly pleochroic.

Masses of dirty grayish material make up about 10 percent of the section and may be largely zeolitic in composition but contain some chloritic matter.

Opal and acicular grains of natrolite (?) are minor constituents. Chlorite forms 5 percent or more of the section and may be an alteration from augite.

The undetermined zeolite, which forms about 40 percent of the rock, resembles in certain ways both thomsonite and stilbite but also differs in some ways from both. Spectroscopic examination shows that the zeolite contains both calcium and sodium. Its hardness is about 5-5.5. It fuses with difficulty to a colorless blebby glass, and gelatinizes with hydrochloric acid. Its index is variable; in one specimen it was both greater and less than 1.50 and in another, both greater and less than 1.51, being greater than 1.50 and less than 1.52. Its birefringence is high first order and it is both length fast and slow, similar in that respect to thomsonite. Unlike thomsonite, the birefringence of the cross sections of the fibers is lower than that of the longitudinal sections, and the index seems a little too low for thomsonite. No amygdules are present in the rock and zeolitization seems to have been a late magmatic process.

This type of basalt is not typical of the Coos Bay region. However, it may point to a sub-

marine origin for it and much of other basalts that contain zeolites and hydrothermal secondary minerals. Lindgren (1933:516) stated as follows:

That zeolitization is far from being simply an effect of the leaching by surface waters is shown by the absence of the zeolites from large areas of basic flows, many of them full of vacuoles or blow-holes. . . . It is probable that their development would be greatly furthered if the eruption of the effusive rock took place under water; the sea water would cool the surface of the flow and a slow downward movement would be caused in the porous rock. Besides, these conditions would give rise to a system, cool at one end, hot at the other, in which the circulation competent to effect concentration would be initiated.

The basaltic material which crops out between the Coos River and Mart Davis Creek is composed of large broken fragments of fairly hard basalt in a matrix of softer altered green material. A sample from this belt of volcanics was collected in the Enegrin quarry in sec. 27, T. 25 S., R. 12 W. It is a dark-gray fine-grained porphyritic basalt.

The rock as shown in the thin section has a porphyritic intersertal texture which tends to be seriate. Euhedral to subhedral phenocrysts originally of olivine are now made up of a mixture of chlorite and serpentine, including both antigorite and chrysotile, with inclusions of residual magnetite, surrounded by a border of iddingsite. In a few cases, iddingsite forms nearly half the mass. The center of some grains is made up largely of chlorite which grades outward into iddingsite. This suggests that the chlorite may have a similar composition. The grains are as much as 1 mm in size and constitute about 20 percent of the basalt. Subhedral to anhedral phenocrysts of augite as much as 0.7 mm in length with inclusions of magnetite, and euhedral grains of magnetite about 0.4 mm in size make up respectively 10 and 5 percent of the rock. Laths of labradorite with a composition Ab_4An_6 and an average length of about 0.2 mm make up much of the groundmass and 40 percent of the entire rock. Somewhat smaller anhedral grains of augite and grayish-brown glass compose respectively about 20 and 5 percent of the section. The tendency of the texture to be seriate suggests nearly continuous crystallization of the parent lava.

In some places limestone forms the matrix for the basalt fragments. The limestone is in irregular lenses, generally less than 6 feet thick. Near the mouth of Daniels Creek in a quarry in sec. 35,

T. 25 S., R. 12 W., the lenses overlies basaltic conglomerate and fossil-bearing sandstone. The pebbles of the conglomerate are encrusted with limy material. A sample pebble from this conglomerate in the quarry is a well-rounded dark-gray fine-grained basalt. Pyrite and silica fill fractures within the pebbles. The petrographic description of volcanics within the conglomerate is as follows:

The basaltic pebble sectioned has a nearly even-grained, though slightly seriate, hyalopilitic texture. Light grayish-brown glass, in part devitrified and in part spherulitic, composes nearly half of the rock. Laths of labradorite having a composition Ab_4An_6 - Ab_3An_7 are as much as 0.5 mm in length but average about 0.1 mm. They constitute nearly 30 percent of the basalt. Subhedral and euhedral grains of augite about 0.02 mm in length, make up a total of approximately 15 percent. Individual magnetite grains averaging 0.01 mm in size are in part aligned in strings, and comprise 5 percent of the section.

Numerous margarites are present in much of the glass. Fibrous aggregates of chlorite make up less than 5 percent of the section and may be the result of alteration of large grains originally of augite. Amygdules of calcite are a minor constituent.

These well-rounded basalt pebbles were probably eroded from nearby Umpqua basalts, but they may have been derived from basalt outside of the quadrangle.

The volcanics are best exposed in road cuts and in a quarry on the Summer-Fairview road at Blue Mountain in sec. 9 or 10, T. 27 S., R. 12 W., where palagonitic material, produced by hydrothermal alteration of fragmental basalt, appears to be interbedded with shaly material (pl. 8-C). The more massive basalt in the quarry is amygdaloidal and has been altered to such an extent that it breaks down rapidly. A sample from this quarry shows the following characteristics:

Under the microscope the basalt is seen to have a porphyritic intersertal texture. The labradorite phenocrysts have corroded subhedral and anhedral outlines and an average size of about 1.5 mm. They exhibit both albite and combined Carlsbad-albite twinning, and form 15-20 percent of the basalt. Phenocrysts of augite, ranging in size from 0.4-1.3 mm, have euhedral and anhedral shapes and constitute about 3 percent of the rock. Subhedral and anhedral phenocrysts of magnetite, about 0.15

mm in size, are a minor constituent. Altered phenocrysts are euhedral and anhedral grains made up of a mixture of calcite and limonite; one contains residual augite. They have an average size of 1.2-1.5 mm and total about 5 percent. The groundmass is composed of augite, magnetite, and glass. The augite grains, which are about 0.02 mm in size, are larger than those of magnetite. These minerals form 25 percent and 2.5 percent of the rock respectively. The glass, with an index greater than balsam, constitutes about 20 percent of the basalt.

Nearly all the amygdules are calcite, and they are as much as 1 mm in diameter. The calcite has a radial-like extinction and is surrounded by rims of brown glass. Amygdules of zeolite as much as 0.7 mm in diameter are a minor constituent. The amygdules constitute about 20 percent of the rock. Calcite veinlets and opal (?), possibly somewhat dehydrated and with an index between 1.48 and 1.49, together make up about 5 percent of the section. Both are present as crack fillings in the labradorite phenocrysts.

The rims of brown glass surrounding the calcite indicate that the calcite is a cavity filling, and the radial-like extinction of the calcite suggests that it replaced a zeolite. Thus zeolitization is believed to have been followed by alteration which may have converted the augite to calcite and limonite, and liberated silica.

A dark-gray porphyritic basalt with large phenocrysts of plagioclase crops out at the falls of Steinon Creek in the center of the E½ sec. 10, T. 27 S., R. 12 W. This specimen has the largest phenocrysts of any rock yet found in the area. They are as much as 20 mm in length. At this locality the basalt has a well-developed pillow structure characterized by a markedly increased vesicularity, decreased grain size, and change in color toward the surface of the pillows, which suggest rapid cooling probably during submarine extrusion.

Under the microscope the rock displays a porphyritic intersertal texture. The phenocrysts of plagioclase are euhedral crystals of labradorite of Ab_4An_6 composition. They show slight zoning and both albite and combined Carlsbad-albite twinning as well as some pericline twinning. Euhedral phenocrysts of olivine, as much as 4 mm in size, constitute less than 5 percent of the rock. The groundmass is made up of subhedral acicular grains of augite about 0.3 mm in length, somewhat smaller laths of labradorite (Ab_4An_6), spear-like aggregates and irregular masses of magnetite, and glass, in part devitrified. These form respectively about 20, 10, 5, and 15 percent of the basalt. Calcite in

the form of amygdules and crack fillings in the labradorite phenocrysts constitutes a small percentage of the section.

A dark-gray dense basalt crops out as a dike-like body along the road about half a mile south of Gravelford on the west side of the North Fork in the NW¼ sec. 36, T. 28 S., R. 12 W., at an elevation of about 100 feet.

As shown in the thin section the basalt has a glomeroporphyrhic intersertal texture. The phenocrysts, which form about 10 percent of the rock, consist of subhedral needle-like laths of labradorite, of composition Ab_4An_6 , that range in size from 0.4-1.0 mm, and anhedral to subhedral grains of augite, about 0.2 mm in size. They constitute respectively about 6 and 4 percent of the rock. The groundmass is composed of laths of plagioclase, possibly slightly more acid than that in the phenocrysts, and anhedral to subhedral grains both of augite and magnetite set in a base of brown glass. The glass is partially devitrified and has an index greater than balsam. These groundmass constituents are mainly less than 0.1 mm in size and form respectively about 30, 25, 5, and 35 percent of the rock. A cavity filling of opal surrounded by a rim of brown glass is a minor constituent.

Recent drilling operations on the Westport arch by the Phillips Petroleum Company disclosed a thickness of nearly 5,000 feet of sheared serpentinized basalt with some reportedly intercalated shale beds. This basalt was encountered at the base of the Coaledo formation, and its presence indicates that the Tyee is missing in this area. The Tyee is not known to be present in the adjacent area to the southwest.

The thickness and structure within the igneous masses are difficult to determine. Where exposed in broad areas such as Blue Mountain, the dip of the volcanics is evidently low and no great thickness is necessarily indicated. The volcanic masses do not seem to be continuous throughout the area for they are missing in the section along the Middle Fork of the Coquille River. It may be that the extrusives piled up near the vents, especially if submarine in origin, thus attaining considerable thickness locally, and interfinger with Umpqua sediments along the margins. Although conglomerate composed of igneous pebbles overlies volcanic masses such as near the mouth of Daniels Creek, it seems unlikely that erosion during the time of Umpqua deposition removed them entirely in the areas in which they are now missing. It is

more likely that post-Tyee erosion removed part of the volcanics.

Wells and Waters (1935:963-966) and Turner (1938:10-11) described similar volcanics associated with and intercalated in the Umpqua formation in the Roseburg area. Wells and Waters concluded that these volcanics, which had been described by Diller as intrusive diabase, were in reality mostly of extrusive origin, and at least in part submarine. The volcanics in the Coos Bay quadrangle are believed by the writers to be generally equivalent, both in composition and in stratigraphic position, to those in the Roseburg area. Features that support an extrusive origin for the volcanics in the Coos Bay region are pillow structure, erosional contacts with overlying Umpqua sediments, absence of contact effect on overlying sediments, palagonite, glass in matrix, and associated conglomerate composed of similar basaltic pebbles. The olivine crystals tend to be euhedral, more like those found in extrusive volcanics than in intrusives.

Although the border relationships between the volcanics and the Umpqua sediments are usually steep and indeterminate, they exhibit structural and textural features which indicate submarine extrusion. Definite flows are absent. Palagonite, pillow structure, zeolitization, and alteration of olivine to serpentine, chlorite, and iddingsite indicate hydrothermal alteration, probably owing to extrusion beneath water. According to Ross and Shannon, iddingsite is a deuteric or hydrothermal mineral and is not formed by weathering.

Many of the basaltic masses directly underlie the base of the lower Coaledo, both around the periphery of the basin and in the Phillips Petroleum Company well. It also appears possible that the volcanics overlie Tyee sediments along Mart Davis Creek near the forks of the Coos River. At this place, the sediments along the Millicoma River strike nearly at right angles to the belt of exposed volcanics. This leads to a tentative conclusion that the volcanics were erosional remnants of extrusions laid down upon a post-Tyee erosion surface and might be a correlative of the Calapooya volcanics farther east. However, the Calapooya volcanics, although similar in some respects, are predominantly andesitic in composition and contain abundant hypersthene, a mineral absent or rare in the Coos Bay basalts. No remnants of basalt unquestionably overlying Tyee were found

and dikes and plugs seem to be rare or absent in nearby areas overlain by Tyee sandstone. It seems more likely that the basalts are older than the Tyee and are associated with the Umpqua.

Some of the igneous rock of the Coos Bay quadrangle has been discussed under the heading "Pre-Tertiary basalt." It is difficult to segregate the small plugs and dikes of supposed pre-Tertiary age. Some of the basalt is surrounded by pre-Tertiary rock and associated with schist masses, yet these may have been feeder dikes for the Tertiary volcanics. No dikes, flows, or sills are known to penetrate or be associated with the Tyee or younger sediments in the Coos Bay quadrangle.

Tyee sandstone (middle Eocene)

The Tyee sandstone was the name given by Diller (1898) to the type section at Tyee Mountain in the Roseburg quadrangle where the section overlies the Umpqua with undetermined structural relationship. The Tyee is a massive gray micaceous sandstone with some thin dark shale beds. The sandstone is feldspathic and contains some tuffaceous material. The shale beds in many places are only a few inches thick and are sharply divided from the much thicker sandstone beds. Elsewhere in the Coast Range, a sparse Tyee fauna has been found in shaly facies as much as 100 feet thick, but few Tyee fossils were found in the Coos Bay quadrangle. Correlation of the Tyee with other massive sandstones occurring throughout much of western Oregon has been based largely upon their micaceous nature.

Two specimens of Tyee sandstone collected near the cataract on the East Fork of the Coquille River east of the quadrangle border were examined in detail.

One gray medium-grained sandstone with visible flakes of mica was obtained in sec. 9, T. 28 S., R. 10 W., along the old stage road from Coquille to Roseburg. A petrographic description of the rock is as follows:

Subangular, in part strained grains of quartz make up about 40 percent of the thin section. Subangular and angular grains of both clear and weathered plagioclase, in part at least as basic as Ab_6An_4 , are present in nearly equal amount and together constitute about 20 percent of the rock. The more acid plagioclase (Ab_3An_7) grains are more weathered and some are altered, in part, to sericite. Subangular to angular lithic fragments, which are largely basic glassy volcanic rock, with a few laths of

plagioclase, and chert, form about 35 percent of the sandstone. Some of the glass in the fragments is colored and has an index greater than balsam. The remainder is muscovite, biotite, magnetite, epidote, perthite, orthoclase, and chloritic (?) matter. Most of the mica flakes are sharply folded or bent.

Another massive gray medium-grained micaceous sandstone was collected in the same general area along the East Fork road, but, unlike the above, it was quite calcareous. The thin section of the rock is described as follows:

The rock contains 30 percent calcite which is present both in veinlets and in the matrix. Clastic fragments compose the remaining 70 percent. Subangular grains of quartz, in part strained, have an average size of about 0.4 mm and constitute about 25 percent of the rock.

Labradorite (Ab_5An_5) and less basic angular to subangular grains of plagioclase form some 20 percent of the rock. Both fresh and in part incipiently fractured and badly weathered grains are present; the weathered grains have a composition of about Ab_7An_3 . Sharply folded flakes of biotite and muscovite together make up some 3 percent of the rock; magnetite and microcline are minor constituents. Lithic fragments include about 7 percent each of chert and glassy basic lava fragments with a few laths of plagioclase, and about 5 percent of other rock grains including quartz-mica schist and quartz schist and perthite.

The massively bedded nature of the Tyee sandstone, together with the presence of schist and chert fragments, indicates rapid erosion of the pre-Tertiary highlands. The sharply bent mica flakes and grains made up of similarly bent mica interlocked with strained quartz may have been derived in part from the May Creek schists now found in the Roseburg and Butte Falls quadrangles to the east and southeast.

Harrison and Eaton (1920:7) suggested that the Tyee of the Florence and Newport areas included the same horizon as the Coaledo of Coos Bay. A comparison of faunas as listed by Turner (1938:33-37) shows that the Tyee is much more closely related to the Umpqua than to the Coaledo.

A section of the Tyee, preserved as a broad shallow basin, appears along the Middle Fork of the Coquille River, and has been correlated with the Roseburg section by Turner (1938:16). The escarpment along the western limb of this basin represents the outcrop of the more resistant Tyee sandstone where it overlies the Umpqua shales. This escarpment was traced up the valley of Sandy

Creek from Remote to the valley of the East Fork of the Coquille River east of Dora, and into the valley of the North Fork a few miles north of Fairview. Gently undulating beds of Tyee sandstone cover most of the northeastern part of the Coos Bay quadrangle.

Between the Millicoma River and the volcanic mass on Mart Davis Creek, sandstone assigned to the Tyee strikes N. 60°-80° E., approximately at right angles to the trend of the volcanics. This suggests an unconformity between the Tyee and the volcanics, but at this place their relationship is difficult to determine.

The faunal evidence concerning the Tyee comes from outside the quadrangle. At the top of the hill on the Johnson Creek road southwest of Shutters Landing, a few miles north of the quadrangle, a poorly preserved fauna was collected from a sandy shale lens which overlies massive micaceous sandstone. The sandstone appears to be an extension of the Tyee. The fauna contained the following:

Marcia (Mercimonia) bunker (Hanna)
 Volsella (Brachidontes) cowlitzensis (Weaver and Palmer)
 Acila decisa (Conrad)
 Turritella uvasana Conrad cf. subsp. hendoni Merriam
 Ectinochilus (Macilentos) macilenta White subsp. oregonensis Hendon
 Cerithiopsis sp.
 Conus sp.
 Dentalium

Several indeterminate forms were also present.

Another location 1½ miles from the highway on the same road also yielded poorly preserved fossils from a similar, weathered sandy shale.

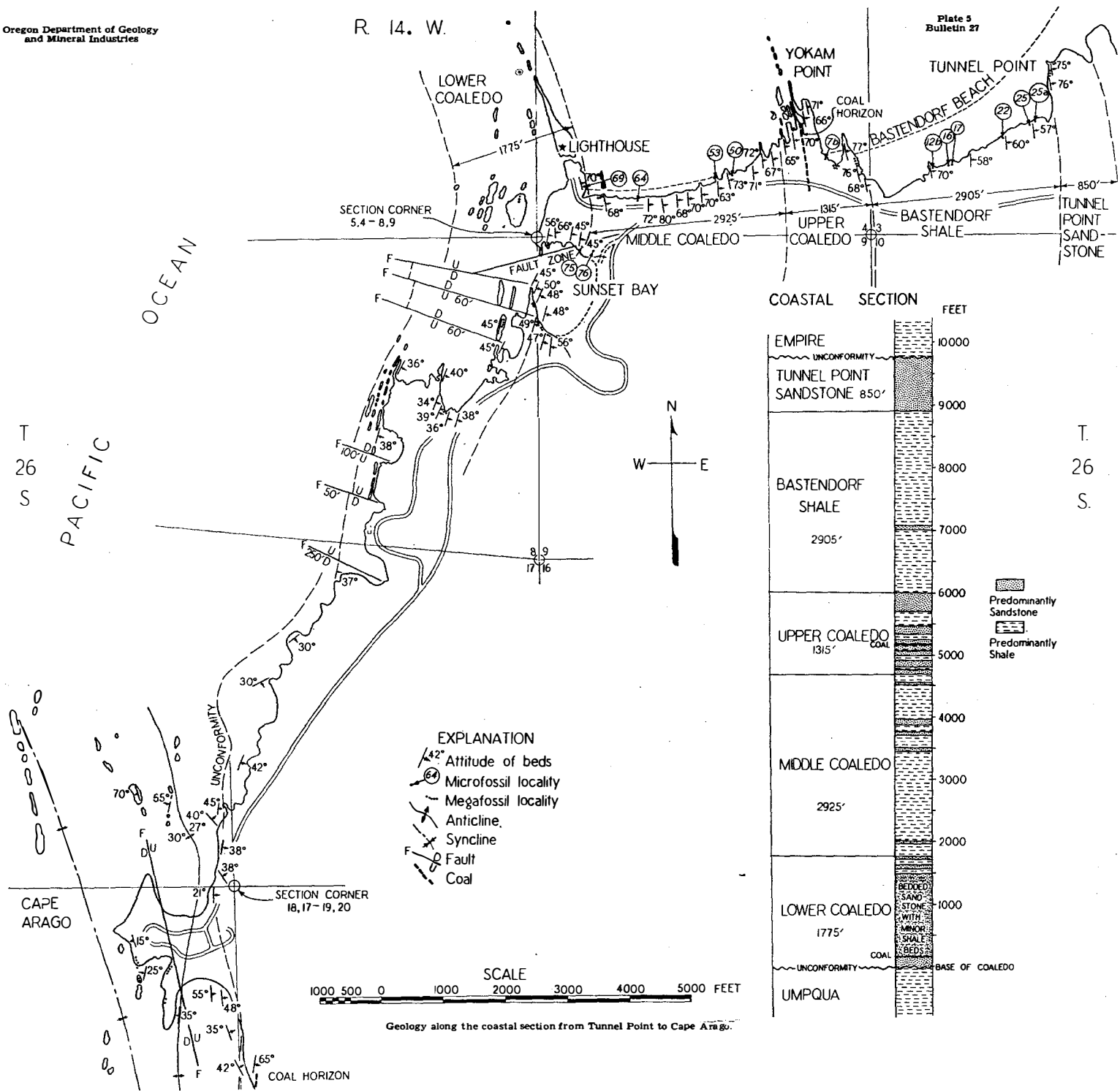
Although the above collection is not determinative, it resembles pre-Coaledo faunas and it is therefore correlated with the Tyee because of underlying massive micaceous sandstone.

Large oysters identified as *Ostrea idriaensis* Gabb are present in the Tyee at a quarry on Camas Creek near Sitkum which is east of the Coos Bay quadrangle on the East Fork of the Coquille River.

Small coal beds, indicating some nonmarine deposition, were noted in the Tyee sandstone east of Sitkum. Mud cracks in a quarry near Deton Creek also indicate shallow-water to strand-line conditions. Evidently the amount of sediments being deposited in the basin of sedimentation increased greatly in volume, keeping pace with subsidence of the basin. There is no definite evi-

R 14. W.

Plate 5
Bulletin 27



dence that folding or marked erosion took place between the time of deposition of the Umpqua and the Tyee. The coarser sediments of the Tyee represent an abrupt change in sedimentation possibly resulting from uplift.

Lower Coaledo (upper Eocene)

The lower member of the Coaledo formation is best exposed in the coastal section in the promontory beneath Cape Arago lighthouse and along the shore as far south as Fivemile Creek (pl. 7-B). The lower Coaledo is predominantly sandy. Its base was tentatively placed by Turner (1938:28) at the shale conglomerate which overlies an unconformity at Cape Arago (pl. 6).

Blue-gray medium-to coarse-grained nodular sandstone predominates, with some grit and intercalated fine-grained sandy shale beds which are usually darker in color than the sands (pl. 8-A, B). The sandstone, which weathers to a characteristic buff color, is tuffaceous, and many of the pebbles in the few conglomerate lenses are of fine-grained basaltic material. Mud cracks, coal beds, and coarse cross-bedded sand lenses indicate shallow-water to nonmarine conditions at the time of deposition.

Three samples were collected at Jordan Point, believed to be a part of the lower Coaledo, and along the shore to the west. The coarse clastic dark-greenish rock which forms the east side of Jordan Point in sec. 12, T. 25 S., R. 13 W., is a basaltic tuffaceous grit with a calcareous matrix.

As shown in the thin section, calcite cements the various basaltic constituents and forms about one-third of the rock. All of the fragments are angular in outline and are mainly less than 2 mm in size. About 55-60 percent of the rock consists of fragments of brown glass with various percentages of magnetite grains and plagioclase laths some of which are as basic as Ab_3An_7 . The glass has an index greater than balsam and some grains contain spherulitic structures and a little included augite. Grains of labradorite constitute about 2 percent; augite, 2 percent; and magnetite, 1 percent of the rock. Several small grains of hornblende are present in the section.

The fragments are similar to those in a thin section of a rock collected from the Calapooya formation at the Cottage Grove damsite, 7 miles south of Cottage Grove, and they suggest a pyroclastic origin.

Another specimen associated with fossil lenses is a fine-grained calcareous tuffaceous sandstone

which overlies the above described bed at Jordan Point.

In the thin section the matrix is seen to be calcite which forms about half of the rock. Most of the clastic fragments have angular or subangular outlines and are less than 0.25 mm in size. Grains of basaltic glass, which is mainly brown in color and has an index greater than balsam, and basaltic fragments, which contain grains of magnetite and laths of plagioclase, together constitute 35-40 percent of the sandstone. Grains of labradorite as basic as Ab_4An_6 - Ab_3An_7 make up about 10 percent. Quartz, hornblende, magnetite, and microcline are minor constituents.

Although the percentage of calcite is greater than usual, this sample contains the characteristic fragments of basaltic composition found in other samples from the lower Coaledo.

Another sample collected still higher in the section at Jordan Point is a fine-grained basaltic sandstone with a calcareous matrix.

Under the microscope the thin section displays a matrix of calcite which contains a number of foraminifera. The calcareous matrix forms a little more than half of the rock. The clastic fragments have angular shapes and are mainly less than 0.25 mm in size. Grains of labradorite (Ab_4An_6 - Ab_3An_7) and grains of augite are present in nearly equal amounts and compose about 10 percent of the sandstone.

Brown and green basaltic fragments and brown glass, in part devitrified and in part altered to greenish chlorite, together compose some 25 percent of the section. Magnetite, hornblende, and biotite are minor constituents.

The coastal section of 1,775 feet was plotted on a scale of 200 feet to the inch (pl. 5). A section measured along the highway west of Lampa Creek is at least 1,900 feet thick, although the base could not be accurately determined.

The coal group designated by Diller as the Sevenmile Creek group and the coals at Lampa are in the lower Coaledo member. Only a few thin coal beds crop out in the coastal area. Eastward toward the center of the Coaledo basin, many coal beds were penetrated in the Phillips Petroleum Company well, and to the south at least six beds are found in the Lampa Creek area.

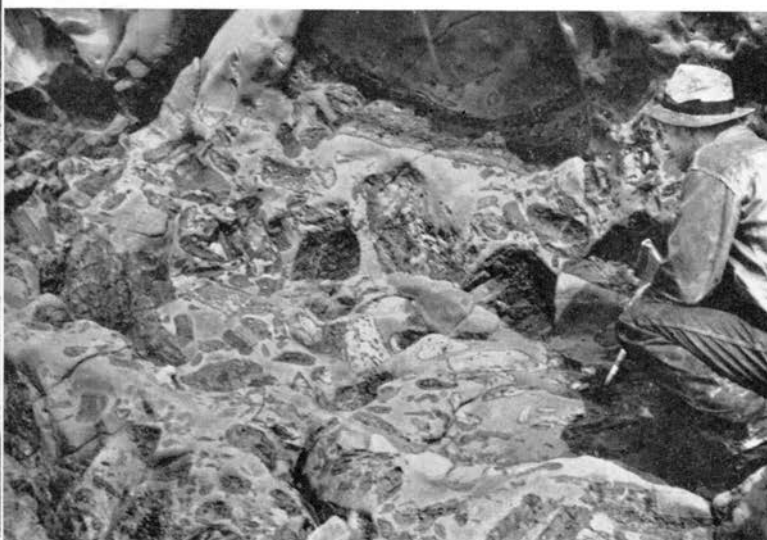
Buff-colored tuffaceous sandstone at the base of the lower Coaledo is in unconformable contact with dark fine-grained thin-bedded sandstone and shaly sandstone along the coast both north and south of Cape Arago (pl. 6-A, B). As tentatively proposed by Turner, there is a shale conglomerate



A—Looking north toward Cape Arago.



B—Closeup of A.

C—Large shale boulders in sandstone
near unconformity near D.

D—Shale breccia near unconformity.

Unconformity at base of Coaledo formation south of Cape Arago.

at the base of the Coaledo (pl. 6-C, D) just above the angular unconformity. The strike of the beds below and above has a discordance of 40°-50° in places.

The writers have accepted the base of the lower Coaledo as suggested by Turner. The relationship between the Coaledo and beds assigned to the Umpqua is well shown at Cape Arago, along the beach near the mouth of Fivemile Creek, and along Randleman and Bear creeks. Massive buff sandstone and basal shale conglomerate, just north of the mouth of Fivemile Creek, are evidently a continuation of the basal beds at Cape Arago designated by Turner. They overlie thin-bedded flaggy sandstone and shale. These beds in turn overlie a dark shale in the center of the anticline the axis of which lies to the south of Fivemile Creek. The sandstone and the shale conglomerate also appear in the point south of Fivemile Creek on the south limb of the anticline. The dark shale is correlated with similar Umpqua shale along Bear Creek on the basis of lithology and stratigraphic position.

Thin-bedded flaggy gray sandstone and thin shale beds which form the neck of Cape Arago are believed to be the equivalent of the upper portion of the beds assigned to the Umpqua just north of the mouth of Fivemile Creek as both underlie the shale conglomerate. There is a similarity, however, between the beds in the Cape and those of lower Coaledo age lying between the lighthouse and Squaw Island, but this similarity seems to be coincidental.

The massive sandstone which contains an abundant lower Coaledo fauna, downfaulted to form the tip of Cape Arago, appears to be the equivalent of the strata in Squaw Island which is the lowest known fossiliferous horizon of the lower Coaledo in the beach section. Upon this assumption the displacement of the fault through the cape would be approximately 800-1,000 feet.

Field relations in other parts of the quadrangle indicate that the unconformity beneath the shale conglomerate is of major importance, for the Tyee sandstone is missing, and the sediments beneath the unconformity correspond to similar sediments containing an upper Umpqua fauna.

The unconformity between the Coaledo and underlying formations is difficult to locate in most parts of the quadrangle because of thick covers of soil and brush. Along the northern and north-

eastern edge of the Coaledo basin, the base of the Coaledo overlies the volcanics, but where the volcanics are missing it is extremely difficult to locate the contact because of the low dip of the strata and the somewhat similar lithology of the lower Coaledo and the Tyee sandstone.

The contact is easier to follow south of Coquille and around the western edge of the basin along Bear Creek, because the lower Coaledo sandstone dips steeply enough to form a prominent ridge, and the underlying Umpqua shales are less resistant than the Tyee found in the northern part of the quadrangle.

The fauna of the lower Coaledo has been described and illustrated by Turner (1938) so it is not repeated here.

A fossil locality a third of a mile south of Lone Rock along the eastern edge of Haynes Slough contains *Ectinochilus macilenta* subsp. *oregonensis* Hendon and *Cerithiopsis* sp. and appears to be stratigraphically above the Hardy coal bed, unless unrecognized faulting complicates its position. These forms have not been reported previously from the Coaledo.

Middle Coaledo (upper Eocene)

The predominantly shaly middle member of the Coaledo formation is best exposed at the type locality between Mussel Reef (Yokam Point) and the lighthouse (pl. 7-A). The coastal section consists of the following series:

(East)	
Sandy shale	130 feet
Sandstone	40
Shale	550
Sandstone	90
Shale	100
Sandstone	50
Shale	210
Tuffaceous sandstone	60
Predominantly shale	1,445
Sandstone	50
Sandy shale	200
(West)	

Total 2,925 feet

In the highway section north of the mouth of Lampa Creek, the middle Coaledo is about 2,100 feet thick.

The middle Coaledo thins noticeably in the area between Coquille and Coaledo and is thought to be thin over portions of the Westport arch and north of Coos Bay near Glasgow. Along the Dean-Minard road which lies just west of Cunningham Creek, it is about 400 feet thick. If it were not



A—Lighthouse Point from Yokam Point (Mussel Reef). Upper Coaledo member in foreground, middle Coaledo member in cliffs, lower Coaledo member in promontory on skyline.



B—Looking south across mouth of Sunset Bay. Lower Coaledo sandstones and shales dipping steeply east (left). Coastal section.

for the gentle dip, its presence would be difficult to detect. In the eastern part of the Coaledo basin the middle Coaledo is not recognized and the Coaledo strata are undifferentiated.

The middle Coaledo is a medium-gray tuffaceous shale with some sandy lenses. Fossils are not common. Well-indurated tuff forms a resistant light-gray bed 2-3 feet thick lying between less resistant tuffaceous beds where exposed on the north bank along the Coquille River just north of the mouth of Hatchett Slough; it is also found to the west of the lookout on the Krome road in secs. 24 and 25, T. 26 S., R. 13 W., and in the valley of Big Creek.

The thin bed of light-gray tuff that crops out in the upper portion of the middle Coaledo west of the lookout on the Krome road in secs. 24 and 25, T. 27 S., R. 14 W., weathers on the surface to a buff to light-brownish orange. It is very well indurated, almost flinty in character.

In the thin section it displays a very fine-grained texture and is largely composed of partially devitrified glass shards about 0.02 mm in size which form 80-85 percent of the rock. The glass has an index less than balsam. Mineral grains of somewhat larger dimensions include biotite, muscovite, quartz, feldspar, and zircon, and constitute the remaining 15 percent of the rock.

The relatively uniform size of the glass fragments and the presence of biotite, muscovite, and zircon indicate the tuff was water-laid.

A similar tuff was collected from an old railroad cut on the ridge between Brown and Sengstacken sloughs in sec. 6, T. 37 S., R. 13 W. It is believed to occupy approximately the same stratigraphic horizon as that which crops out along the Krome road.

The rock is a rudely stratified light-gray fine-grained indurated tuff with an appreciable amount of fragmentary organic material, much of which may be plant remains. Part of the weathered surface is stained buff and the rock has a strong earthy odor.

The thin section is made up of angular grains averaging about 0.15 mm in size. About 85 percent of the rock is light-brown partially devitrified glass which has an index of about 1.51. Angular grains of basic andesine (Ab_5An_5) constitute about 10 percent of the section and sharply bent flakes of biotite and muscovite, and a minor amount of chert form the rest of the rock.

The two sections probably represent the most tuffaceous phase of the middle Coaledo and indicate somewhat the andesitic composition of the glass contributed by vulcanism in neighboring regions. Tuffs in the Calapooya are similar in composition and may be of equivalent age, as both are the oldest known andesitic rocks in their respective areas. Similar appearing tuffs are present in both the Bastendorf shale and the Tunnel Point sandstone, but both contain more basic glass. The igneous fragments in the lower and upper Coaledo are likewise basaltic in composition.

Upper Coaledo (upper Eocene)

The type locality of the upper member of the Coaledo formation is the promontory at Yokam Point (pl. 8-D). Apparently, the Bastendorf shale conformably overlies this predominantly sandy member, although the valley fill of Miner Creek obscures the relationship, and evidence elsewhere suggests disconformity. The base of the member has been placed at the base of the lower (western) lens of massive sandstone, although three minor sandstone lenses occur in the middle Coaledo along the beach.

The detailed section of the upper Coaledo along the coast was measured as follows:

(East)	
Coarse sandstone	310 feet
Shale	250
Sandstone, grit at top	120
Shale and sandstone	85
Sandstone, coal at top	75
Sandstone and shale	90
Sandstone	80
Shale	80
Sandstone	100
Shale	55
Sandstone	70
(West)	
Total	1,350 feet

The sandstone is a gray medium to fine-grained tuffaceous sandstone which contains less indurated carbonaceous sandstone members, sandy shales, carbonaceous shales, and coal. Concretions, as well as coarse sandstone, grit, and coarse grit lenses, occur in places. Although the measured thickness of the coastal section is 1,350 feet with one coal bed, the thickness in the Riverton district is 2,770 feet with many included coal beds.

A section of the drill core from the Bureau of Mines test hole in the W $\frac{1}{2}$ sec. 23, T. 26 S., R. 13 W., near the bridge over Isthmus Slough, is a light-gray medium to coarse-grained sandstone.

Petrographic examination of the thin section shows it has a calcareous matrix which makes

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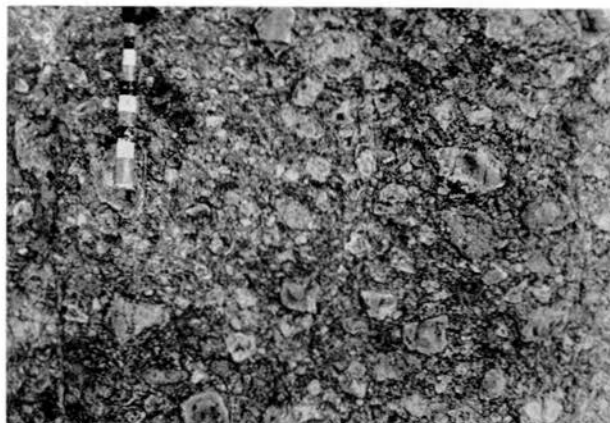
Plate 8
Bulletin 27



A—Coaledo sandstone at mouth of Catching Slough.



B—Closeup of A showing channeling.



C—Coarse tuff-breccia a quarter of a mile north
of Blue Mountain quarry.

D—Resistant upper Coaledo sandstone at Yokam Point
(Mussel Reef).



Rock types in the Coos Bay quadrangle.

up about 15 percent of the rock. The grain size of the elastic fragments ranges from 0.8 mm to less than 0.1 mm. Angular and subangular grains of fresh labradorite, as basic as Ab_4An_6 , are in part zoned and corroded and form about 25 percent of the section. Angular and subangular grains of quartz, in part strained, constitute 15 percent of the rock. Elongate angular and subangular grains of hornblende total about 8 percent. Subangular grains of basic glass, in part devitrified, contain plagioclase laths, magnetite grains, and crystals of hornblende which is very similar to that forming grains entirely of hornblende. These grains of basic lava compose about 35 percent of the rock. Grains of epidote, microcline, magnetite, and augite, crenulated flakes of biotite, and lithic fragments including chert, quartz schist, and shale are minor constituents. One grain of an undetermined zeolite is also present.

The hornblende in the basic lava fragments suggests that the almost total absence of grains of augite and the presence of a considerable number of grains of hornblende in sediments derived largely from basic volcanic rocks may be explained possibly by the conversion of the augite to hornblende in a late magmatic stage. The hornblende was probably not derived from schistose rocks forming old highlands, as the assemblage and percentages of other mineral and rock fragments suggest their derivation largely from other rocks such as basalts.

Another sample of the drill core from the same drill hole is a dark-gray and brownish shale with a veinlet of calcite.

A thin section shows the shale is composed of about 65 percent clay, perhaps beidellite. Bent flakes of biotite, about 0.1 mm in diameter, and of muscovite, about 0.1 mm in diameter, make up about 5 percent and 1 percent of the rock respectively. Angular to subangular grains of plagioclase as basic as Ab_5An_5 have an average size less than 0.1 mm and constitute approximately 15 percent of the rock. Very small grains of magnetite and grains of quartz as large as 0.35 mm form several percent. Calcite forms a small veinlet in the section. Organic matter totals about 15 percent.

Unlike other upper Coaledo sediments this shale does not contain hornblende but the absence may be due to sorting.

The Beaver Hill coal bed is an excellent stratigraphic marker in the western part of the the upper Coaledo. It may be recognized in the Newport basin and southward along the west side of the Beaver Slough basin to the Riverton district, as well as in the South Slough basin.

Several coal beds above the Beaver Hill horizon have been mined in the Riverton district but they are evidently missing in the western part of the Coaledo basin as a result of erosion or pinching. Only one bony coal bed has been recorded beneath the Beaver Hill bed in the upper coal group.

The massive sandstone below the Beaver Hill coal bed forms a prominent ridge along the western and southern part of the Beaver Slough basin. East of Isthmus Slough, the upper Coaledo has not been differentiated although it presumably underlies the area between the Sumner basin and Isthmus Slough.

The fauna of the Coaledo has been described and illustrated by Turner (1938), and correlated with the Tejon of California and the Cowlitz of Washington. Few fossils were restricted to either the upper or lower Coaledo. *Venericardia hornii* subsp. *clarki* Weaver and Palmer, common in the lower Coaledo but generally not reported in upper Coaledo strata, was found in the cove just east of the most prominent tip of Yokam Point. Brackish-water fossils are commonly associated with the coal beds. The identification of the upper Coaledo sandstone is aided by its position between the Bastendorf and the middle Coaledo shale series. Intense deformation makes the stratigraphic position of the formations along the western edge of the Westport arch difficult to determine, and in the area south and east of Empire a veneer of sand covers much of the structure.

A flora was collected from the upper Coaledo at Riverton by Diller (1899:341) and the following identifications were given by F. H. Knowlton:

Magnolia lanceolata Lesquereux
Magnolia californica ? Lesquereux
Laurus californica ? Lesquereux
Sobolites californicus ? Lesquereux
Rhamnus sp.
Juglans ? sp.
Ficus ? sp.

A more complete flora collected in the Riddle, Roseburg, and Coos Bay quadrangles and given by Diller (1907:405) includes many of the above forms.

Bastendorf shale (uppermost Eocene, and possibly lower Oligocene in part)

The "foraminiferal shales" of the Arago group are best exposed at Bastendorf Beach between Mussel Reef (Yokam Point) and Tunnel Point (see frontispiece). Dall (1909) indicated a probable Oligocene age, and Schenck (1927:454) proposed

the name "Bastendorf shale" for thinly laminated, blue to steel-gray shale with some thin strata of carbonaceous sandy shale and feldspathic sandstone.

Sandstone is rare in the Bastendorf formation. The most prominent member is a light-gray medium-to coarse-grained sandstone exposed just east of Miner Creek along the beach in the W $\frac{1}{2}$ sec. 4, T. 26 S., R. 14 W. It weathers to a rusty brown color.

Petrographic examination of the thin section shows the matrix is calcareous and forms about 20 percent of the rock. The grain size of the clastic particles ranges from 0.7 mm to less than 0.1 mm. Mainly subangular grains of colored basaltic glass with magnetite inclusions and plagioclase laths as basic as Ab₄An₆ make up about 45 percent of the sandstone. Grains of labradorite, as basic as Ab₃An₇, have angular outlines for the most part, and some show slight zoning. Together they total about 20 percent. Other important constituents include angular grains of hornblende, some of which appear to have formed from augite, and subangular to subrounded grains of quartz, in part strained. They constitute about 5 and 10 percent of the rock, respectively. Grains of magnetite, augite, sericitized feldspar, chlorite, crenulated flakes of muscovite and biotite, and other lithic fragments, mainly chert, are minor constituents.

The hornblende may have been derived largely from basaltic rocks in which the augite was converted to hornblende. Some grains have two extinction positions in one direction and apparently are composed of both hornblende and unaltered augite. This rock corresponds to some of the upper Coaledo sediments in the amount of hornblende that the sample contains. The source of the hornblende is unknown but it was evidently derived largely from a volcanic rock rather than from a schist. The basaltic character of the sandstone also seems to bear out this conclusion.

A light-gray well-indurated, almost flint-like tuff was collected from the SE $\frac{1}{4}$ sec. 19, T. 26 S., R. 13 W., on the Sengstacken place at an elevation of about 100 feet. Although it resembles in appearance the tuffs described from the middle Coaledo, it occurs in an area mapped on the basis of inferred stratigraphic position as Bastendorf shale.

In the thin section the tuff is shown to be very fine-grained and to be made up of angular grains averaging about 0.03 mm in size. Light-colored partially devitrified grains of basic

glass with an index less than balsam and greater than 1.53 form about 90 percent of the rock. Flakes of biotite and a lesser number of muscovite constitute 5-10 percent of the section, and plagioclase with an index greater than 1.54, clay, and other mineral grains including zircon are minor constituents.

The presence of muscovite and biotite and the uniformity of size of the tuff fragments indicate the tuff was water-laid.

The chief difference between this tuff and that of the middle Coaledo lies in the more basic composition of the glass in the Bastendorf sample.

Neither of the sections examined from the Bastendorf are typical, the largest percentage of the formation being soft shales which contain very fine-grained tuffaceous material.

Megafossils are not plentiful but a microfauna is abundant. Cushman and Schenck (1928) proposed a lower Oligocene age. Later work by Schenck and Kleinpell (1935) on the microfauna of the Gaviota formation in California indicated that it was for the most part of Eocene age, and they correlated the Bastendorf formation of Oregon with it. The foraminifera have been studied by Riechers (appendix B) and the diatoms have been studied by Schenck (1927a).

Studies of the Bastendorf have been confined largely to the beach section where the lower part is not exposed. Measurement here shows a thickness of 1,845 feet of shale and 60 feet of sandstone, plus a covered thickness of 1,000 feet which to the south along the creek appears to be shale, giving a total of 2,095 feet, from top to bottom. The contact between the Bastendorf and upper Coaledo is recognized at three places in the Coquille River Valley: on the highway 2 miles north of Riverton; just south of China Camp Creek; and in the railroad cut at Beaver Hill. The outcrops consist of a deep red, poorly sorted, but bedded and cross bedded shale conglomerate. It is composed of fragments and pebbles of shale and some chert, argillite, and quartzite in a matrix of medium-grained tuffaceous sand. No disconformable relationship could be established, but the clastic nature and maroon color of the basal beds suggest a depositional break.

Tunnel Point sandstone (middle Oligocene)

Dall (1898:340) first named and recognized the "Tunnel Point beds" and their Oligocene age. This massive sandstone formation overlies the Bastendorf with apparent conformity and is overlain

in turn by the Empire formation with an angular unconformity of at least 30° Schenck (1928:19) described the formation as follows:

At the base of the formation, on the west side of Tunnel Point, is a massive concretionary bed composed chiefly of quartz and feldspar with an admixture of tuffaceous material and glauconite. Near the top, the sandstone is interbedded with brittle shale and a thin bed of tuff, in which glass shards are conspicuous.

One specimen collected on the sea cliff midway in the coastal section is a light-gray fine-grained and finely bedded sandstone, interbedded with a similar but lighter-colored sandstone. It is somewhat porous, has an earthy odor, and is unevenly stained a buff color on the weathered surfaces.

Examination of the thin section shows that the rock is a fine-grained tuffaceous sandstone made up mainly of angular to subangular fragments averaging 0.1 mm in size. Grains of brown basaltic glass with n about 1.535 constitute about 50 percent of the section, and grains of colorless, probably andesitic glass with n about 1.515 make up about 40 percent. The basaltic glass is partially devitrified and a few grains contain laths of labradorite. Angular and subangular grains of both andesine and labradorite total 5-10 percent. Lesser constituents are flakes of biotite and muscovite which are in part bent.

The Bastendorf sediments contain predominantly basaltic tuffs and fragments, and basalt is common as a constituent in the Tunnel Point sandstone, possibly both derived from erosion of a common source. However, the presence of andesitic material in the Tunnel Point sandstone may indicate extrusions of pyroclastics of this composition to the east or south as volcanic material of this composition is not common in the Coos Bay area.

About 800 feet of sandstone is exposed in the beach section; no other outcrops are known. Inland, the Tunnel Point sandstone is covered with Pleistocene deposits. Weaver (1942:1824) suggested the presence of a slight unconformity at the base of the Tunnel Point. The fauna and stratigraphic relations have been discussed by Dall (1909), Arnold and Hannibal (1913), Howe (1922), Schenck (1928), and Weaver (1937).

The contact of the Tunnel Point with the overlying Empire formation is in a small ravine and is not visible. However the Tunnel Point beds dip 70° eastward whereas the Empire dips 40° or

less, a condition which has generally been interpreted as an angular unconformity although Arnold and Hannibal proposed a fault contact. Howe (1922:89) likewise suggested a fault, concluding that the "large dip of the Empire beds can hardly be explained without a fault being placed at Gold-washer's Gully, for from there on the dip is gradually less—from 25° to 18°."

Regional mapping shows that the Empire formation does unconformably overlap the Tunnel Point, Bastendorf, and part of the upper Coaledo in the southwestern part of the South Slough basin (pl. 1). The additional evidence secured in tracing the contact southward shows that faulting is minor.

Empire formation (late lower and middle Pliocene)

Thick-bedded sandstone which contains an abundant fauna in its lower portion occupies the center of the South Slough basin near Charleston. This formation was first named the "Empire beds" by Diller (1896:475) for the neighboring town of Empire. The formation is divided by a fossiliferous conglomerate lens which was named the Coos conglomerate by Dall (1898:336), illustrated in plate 9-C, D. The sandstone underlying the conglomerate contains an abundant fauna whereas fossils are scarce in the upper part of the Empire. The age of the Coos conglomerate has been questioned; it formerly was considered to be a separate formation but more recent workers have generally followed Howe (1922) in assigning it to the Empire formation.

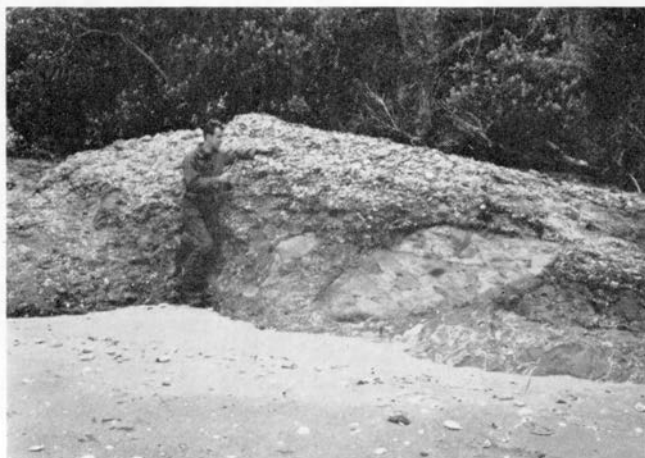
Early paleontological work by Dall (1909) pointed to a Miocene age for the Empire, but he assigned the Coos conglomerate to the Pleistocene. Unfortunately, much of Dall's collection was not gathered in place, thus causing confusion. Arnold and Hannibal (1913) likewise placed the Empire in the Miocene but assigned the Coos conglomerate to the Pliocene. Howe (1922) re-examined the fauna and concluded that the Empire was lower Pliocene and that the Coos conglomerate was a part of the formation, as a result of a minor erosional break. Howe (1922:88) gave Merriam and Lawson credit for recognizing the Pliocene age of the Coos conglomerate. A Pliocene age for the Empire has gradually become accepted although Hertlein and Crickmay (1925) reviewed the faunal lists and decided that the Empire was Miocene. Gale (Grant and Gale, 1931:22) assigned



A—(1) Wave-cut bench. (2) Subaerial bench, (3) Lowest wave-cut terrace, (4) Terrace surface (Elk River beds).



B—Subaerial bench at mean tide, cut in Empire formation.



C—Sandstone block in fossil conglomerate.



D—Detail of fossil conglomerate, showing *Crepidulas*.

Fossil Point (Empire Formation)

the Empire to the upper Miocene; Weaver (1944: chart) proposed an upper lower and middle Pliocene age.

Weaver (1942:1824) records a thickness of 1,540 feet of Empire beds. There is the possibility that farther south in the basin it is more than 2,500 feet thick, if the dip remains consistent. Bedding planes are difficult to determine but dips of 30° were recorded along the ridge in the north-east corner of sec. 27, T. 26 S., R. 14 W. The sediments are well exposed to the southwest across sec. 27 and in logging roads which connect the Seven Devils road with the Big Creek drainage. The dip could not be determined accurately, but a much greater thickness is indicated for the Empire than formerly reported.

Diller is the only writer who has mapped the areal extent in both the Coos Bay folio (1901) and the Port Orford folio (1903). The boundaries of the Empire formation have been extended by mapping by the writers to cover almost all of the South Slough basin—about three times the area mapped as Empire by Diller.

The Empire overlaps older formations along the western edge of the basin.

Rocks exposed on the coast between Fivemile Creek and Whiskey Run were mapped as Empire by Diller (1901). These are mapped (pl. 1) as Umpqua on the basis of lithology, deformation, and included Eocene fauna. Diller mapped a small area along the coast about 3 miles south of Bandon as Empire but these sediments are assigned by the writers to the Port Orford formation. Thus the only known Empire in the Coos Bay quadrangle is confined to the South Slough basin. Sediments south of Floras Lake and at Cape Blanco in the Port Orford quadrangle are correlated with this formation.

Port Orford formation (middle Pliocene)

The Port Orford formation has been named and described by Baldwin (1945). These sediments at Cape Blanco had been included with the Pleistocene terrace deposits which unconformably overlie them and had been called the Elk River beds (or formation) by Arnold and Hannibal (1913), Martin (1916), and other workers who referred to this section.

Diller (1902:30-31) described the "Cape Blanco beds" which included the Empire and the sediments now assigned to the Port Orford formation. He evidently failed to recognize the break in the

Cape Blanco beds but correlated all with the Empire of Coos Bay. He named the Pleistocene terrace deposits the Elk River beds. Arnold and Hannibal (1913:604) did recognize the erosional break in the Pliocene beds but they included the younger Pliocene strata (Port Orford) with the overlying Pleistocene Elk River beds, and included both in their Elk River formation. Martin (1916:246) recognized the distinct lithologic and faunal break in the Elk River formation as defined by Arnold and Hannibal but concluded that the series was not separated by a stratigraphic break.

Bandy (1941) studied the Cape Blanco section and concluded that the sediments now designated as the Port Orford formation were middle Pliocene instead of late Pliocene, as thought by Arnold and Hannibal and by Martin.

A definite unconformity separates the Pliocene and Pleistocene strata at the plane of a wave-cut platform which was formed when the sea removed much of the middle Pliocene and deposited the terrace material. Thus Baldwin (1945) proposed that the name Elk River beds be restricted to the Pleistocene terrace deposits as originally applied by Diller, and that the name Port Orford formation be given the middle Pliocene sediments.

A small area of sediments south of Bandon between China and Crooked creeks was mapped as Empire by Diller (1901) presumably because he failed to differentiate between sediments of the Port Orford formation and the Empire. This section consists of about 20 feet of coarse, iron-stained, friable sandstone which may be traced about 2 miles along the coastal strip. It has been truncated by the sea, and the overlying terrace sands have been stripped off and piled farther inland as dunes. Although no fauna was found in this section, it is considered to be a northern extension of the Port Orford formation, a correlation based upon lithology and stratigraphic position.

Quaternary Formations

Coquille formation (late Pleistocene)

The Coquille formation has been named and described by Baldwin (1945). This type section is exposed in the sea cliff between Whiskey Run and Cut Creek to the north of the mouth of the Coquille River. The following continuous section is overlain by the Elk River beds:

Conglomerate, containing woody material	24 feet
---	---------

Beds of stumps and peaty material....	2-3
Cross-bedded sands and grit (some- what indurated)	18
Sand containing wood material and a local unconformity	10
Cross-bedded sand, woody material, and in places pebble lenses	30
Thin-bedded clay, bottom unexposed..	9 plus
93 feet	

A much thicker section is exposed here, but intervening slumped areas and a flattening of the dip made it impossible to determine whether the strata were repeated. Undoubtedly the formation is more than 200 feet thick. The series is characterized by its included woody material and coarse sediments showing rapid lateral and vertical change in grain size. The sediments here apparently represent the filling of a previous valley of the Coquille River, cut during a prior uplift.

Several feet of clay and peat are exposed at low tide in the point which separates Brown Slough from the south end of South Slough. These beds occupy a stratigraphic position similar to the Coquille formation beneath sands correlated with the Elk River beds. They seem to fill an erosional channel in the Empire formation.

The age of the Coquille formation was inferred from a study of the entire Pleistocene history with associated changes in sea level. Both are discussed more fully in the section on geologic history. The Coquille formation was concluded by Baldwin to be late Pleistocene in age.

Elk River beds (late Pleistocene or Recent)

The term Elk River beds as originally defined by Diller (1902) and used by Baldwin (1945) includes terrace sands and gravels of the broad lower terrace which are well exposed at Cape Blanco. This lower terrace is also exposed for several miles north and south of Bandon, and north of Cape Arago (see pl. 9-A). Similar strata with intermittent breaks may be found in places along the coast of Oregon. The sediments are spread like a veneer upon the wave-cut platform; they appear to be well sorted and are probably of marine origin. Marine fossils, however, are rare; the only known occurrence is just south of Cape Blanco.

Recent work on the age of the marine terraces of California by Putnam (1942) and Bailey (1943)

and identifications of faunas by Grant (in Putnam, 1942:700) indicate a late to post-Pleistocene age even for some of the higher terraces. It seems likely that the series of terraces along the Oregon and California coasts are contemporaneous.

Depositional river terraces corresponding in elevation with the Elk River beds on the marine terrace are prominent in the inland valleys (pl. 11-A). Notable stretches occur at Coquille, beneath the village of Arago in the Coquille River Valley, and near Cooston and Eastside on Coos Bay. A later change of sea level, responsible for the downcutting which excavated the present bays, has removed much of the terrace material of this age.

Alluvium (Recent)

Large areas in the quadrangle are covered by alluvial deposits, resulting from the Recent submergence and filling of the broad valleys of the Coos and Coquille rivers and their tributaries (pl. 11-B).

The river flood plains rise in elevation up the tidal streams. At the forks of the Coos River, the flood plain lies at high tide level, but gradually rises above tide level when traced upstream. At Dellwood 14 miles up the Coos River, the alluvial terrace is 25 feet above the river, which still shows tidal variations. This gradual rise in elevation of the alluvium is equally well shown for some distance above tidewater on the Coquille River and its tributaries. The North Fork of the Coquille flows on bedrock lying from 15 to 20 feet below the flood-plain level. On Catching Creek south of Myrtle Point, the stream is cut even deeper below this terrace surface.

Extremely well-developed natural levees occur on a number of the forks of the Coquille River, especially on the North Fork. In places where the flood plain is 400-600 feet wide, the natural levee bordering the deeply cut, meandering channel of the stream may stand as much as 10 feet above the alluvial level. On the Coquille River west of Coquille the levees are perceptible but not as well developed. Along all these drainages, no matter how deeply the stream is incised in the alluvium, flooding of the entire plain is not uncommon, and most of the habitations are built upon the well-developed first terrace, remnants of which occur throughout the quadrangle at about 25 feet above the flood plain.

STRUCTURAL GEOLOGY

General Features

Structures in the Coos Bay area cannot be determined on the basis of plotted dips and strikes alone. Minor and even large-scale landsliding and slumping result in abrupt changes in attitude within short distances. Outcrops are scarce, owing to a thick soil mantle and forest and underbrush cover. Fresh rock exposures are found only along the sea cliffs, in new road cuts, in cliffs along major streams, and in the beds of a few of the more youthful streams. Pleistocene terrace deposits along the coast and in the major valleys along many of the roads and highways mask the structure of the underlying beds in many critical areas. Low dips in these sands and clays are easy to mistake for weathered bedrock structures.

The rock-type sequences observed along the coastal section could be traced inland only by a study of the stratigraphic relations.

The dips and strikes measured and plotted by Diller, together with more than 500 additional attitudes recorded by the survey, are shown on plate 1.

Three major periods of folding in the Tertiary have been recognized in the Coos Bay area. The first apparently took place in post-Tyee time, and affected the Umpqua and Tyee sediments; the second occurred during the Miocene, and may have included more than one movement; and the third took place during middle or late Pliocene or early Pleistocene. Minor post-Pleistocene faulting and warping also took place.

Two general sets of faults are recognized: the strike faults which generally trend north; and the dip faults which generally strike a little north of west, and range in throw from a few feet to an estimated 600 to 1,000 feet.

A major structural basin which will be referred to as the Coaledo basin occupies the center of the Coos Bay quadrangle, and is filled by Coaledo and later sediments. It is folded into minor arches and basins which are described in detail because of their effect upon the coal beds (pl. 10, pocket).

The remaining Tertiary portion of the quadrangle may be divided into two parts: the northeast corner which is underlain by massive, gently undulating Tyee sandstone; and the southern half which contains the closely folded, thin-bedded Umpqua shales with minor sandstone lenses and

included volcanics. Pre-Tertiary rocks, which are found along the southern edge of the quadrangle, have not been studied in detail.

The dominant structural feature of the Coast Range to the east of the Coos Bay quadrangle is a broad syncline made up largely of Umpqua sandstone, with massive Tyee sandstone occupying the central part of the syncline. This structure, which generally has low dips, is shown in the section on the Middle Fork of the Coquille River described by Turner (1938:16). Post-Tyee erosion removed the Tyee from a large portion of the Coos Bay quadrangle prior to the deposition of the Coaledo formation. Thus the stratigraphic column in the central and southern portions of the quadrangle includes only the less competent, tuffaceous post-Tyee sediments, and the upper shaly portion of the Umpqua with associated volcanics. The more massive sandstone of the lower portion of the Umpqua is evidently missing either because of a westward overlap of the Umpqua upon the pre-Tertiary or because of a facies change.

Folding

No attempt was made to determine details of structural attitudes within the pre-Tertiary sediments. Tertiary deformation of the Coos Bay area resulted in folds diverging to the north, evidently owing to the control of the basement rock and the shape of the Coaledo basin. The diverging character of the axes of the folds is shown on the structural map (pl. 10). Along the western edge of the Coaledo basin, the folds trend due north, whereas folds on the eastern side trend from N. 30°–50° E., and the divergence is even more accentuated in the Umpqua sediments north of Myrtle Point. The tendency for the sediments to wrap around the north end of the pre-Tertiary and the igneous area east of Myrtle Point may have resulted from the controlling influence of the pre-Tertiary basement.

The axes of the Umpqua folds generally trend northeast. They apparently blend northward into the northwestward structural trends of the Tyee. The nature of the contact between the Umpqua and Tyee could not be determined, but the attitudes seem to be close to parallel. The pre-Coaledo folding of the Umpqua sediments as shown at Cape Arago may be pre-Tyee in age, but, in the absence of more definite proof, it could be attributed to

gentle deformation prior to the formation of the post-Tyee unconformity. This deformation is comparable to that believed to have occurred in the eastern part of the quadrangle during a post-Tyee time of diastrophism.

For the purpose of clarity, those names used by Diller for the folds will be employed in the description of the principal structures, with qualifications when necessary. This accounts for the interchangeable usage of the terms anticline and arch, and of syncline and basin.

Cape Arago anticline

An anticlinal fold which trends north through Cape Arago reappears in the coastal section south of the mouth of Fivemile Creek, and its eastern limb may be traced still farther southward to the head of Bear Creek. The western limb of this portion of the fold is obscured beneath terrace deposits. At Cape Arago this anticline is broken by a north-trending fault, and is complicated by minor sharp crenulations well exposed in a wave-cut platform, and by the presence of the unconformity between the lower Coaledo and beds assigned to the Umpqua. At Fivemile Creek its axis lies within the Umpqua shales, and farther south the location of its main axis is obscured by close secondary folding and crushing within the shales along Bear Creek and Bill Creek.

South Slough basin

The western limb of the South Slough syncline is especially well shown in the coastal section between Charleston and Sunset Bay. This area has received most of the attention of earlier geologists and paleontologists. Nearly 10,000 feet of Eocene, Oligocene, and Pliocene sediments are exposed in this major structure. The axis of folding of the Eocene and Oligocene sediments trends north. Any Miocene sediments which might have been deposited, as well as a possible younger part of the Tunnel Point sandstone, would occupy the central portion of the basin beneath the Pliocene Empire foundation. The structure of the western portion of the basin seems to be simple, but that of the eastern limb is obscure. Some of the beds along the eastern edge of the basin may be slightly overturned. Upper Coaledo sediments apparently bridge or nearly bridge the Westport arch between the southern end of the basin and the Beaver Slough basin in the vicinity of Beaverton (see pl. 1). The Beaverton fault

apparently complicates the structure in this area. The outline of the toe of the syncline may be accurately traced by means of the outcrop of the Beaver Hill coal bed near the South Slough (Schetter) mine.

The South Slough basin is a synclinal structure which was folded largely during the Miocene, was further folded in the upper Pliocene after deposition of the Empire formation, and again was gently warped during the Pleistocene.

Westport arch

The Westport arch of Diller seems to consist of a single arch only in the area between Beaverton just west of the Beaver Hill mine and the south end of South Slough. Even in this area there may be minor multiple folding. To the north, the structure is divided from west to east into the following superimposed basins and minor arches.

(1) *Empire basin*: The Empire basin is inferred from the attitude of coal beds near Empire. The beds dip steeply on both limbs. South of the Mill Slough fault, the upraised basin probably continues southward as a structure even though the coal marker-beds have been eroded and cannot be followed. The structures mapped in the area just west of Beaver Hill are largely inferred from relatively few dips.

(2) *Western fork of the Westport arch*: An anticlinal fold, whose limbs evidently dip steeply on the west and dip gently on the east beneath the shallow Newport basin, extends from west of The Buttes northward toward Pony Slough. Between the Empire basin and the northern end of the Newport basin, this structure is probably complicated by further divergence of the fold or by longitudinal faulting, as there is a westward dip in coals, believed to be upper Coaledo, in the NE $\frac{1}{4}$ sec. 29, T. 25 S., R. 13 W.

(3) *Newport basin*: The structure of the shallow Newport basin, which occupies the crest of the ridge west of Marshfield and Coalbank Slough, has been relatively well explored because of the extensive mining operations. Numerous transverse faults were encountered in mining and have been described by Diller (1899:324; 1911: pl. 9). The largest of these, the Mill Slough fault, cuts the basin near its northern end.

(4) *North Bend basin*: In a broad sense, the North Bend basin appears to be a northern extension

sion of the Newport basin from which it may be separated by the westward continuation of the Lillian fault. It is a shallow basin which trends northeast beneath the city of North Bend, and in its center contains upper Coaledo sediments. This structure should be traceable to the north side of the bay near Glasgow, but a detailed survey of the very good exposures along the shore failed to correlate it with any of the structures found there. The area between Coos Bay and Empire is almost everywhere covered by terrace sediments and sand dunes which obscure the underlying structure.

(5) *Eastern fork of the Westport arch:* This fork of the Westport arch parallels Isthmus Slough and extends northward toward Marshfield from The Buttes. Upper Coaledo beds probably extend across the arch west of the Southport mine; the middle Coaledo is exposed in Shinglehouse and Coalbank sloughs. Although the Beaver Hill bed has not been definitely identified north of Southport along the eastern limb, other coals which are believed to be upper Coaledo coals may be traced north to Bunker Hill.

Beaver Slough basin

The Beaver Slough basin (including the southern end, known as the Riverton basin) is one of the major structural features of the Coos Bay quadrangle. The Isthmus Slough fault, which parallels the axis of the syncline for some of its length, apparently has upfaulted the west side of the basin between the "Thirty-Six" coals and Isthmus Slough. Furthermore, several northwest-trending normal faults have resulted in offsets in the areal pattern of beds. The faulting is discussed farther on in the report. The basin extends from Coos Bay on the north to a point 2 miles south of Riverton, a total distance of more than 20 miles. Along Isthmus Slough the dips on both flanks are gentle, generally less than 25°. Exceptions are probably caused by faulting. Farther south along Beaver Slough the dips are as much as 45°, although they average less.

The basin is a flat-bottomed structure with minor folds causing a reversal of dip in places. An example of this is the structure cited by Diller (1899:335) which was shown by drilling southeast of the Beaver Hill mine. The broadest part of the basin between Beaverton and Coquille is covered by gently undulating Bastendorf shale,

remnants of which may be noted along the edge of the broad erosional bend of the Coquille River.

Near Riverton, the southern end of the Beaver Slough basin is a simple syncline which plunges gently northward (pl. 26). The broad portion of the basin near the bend of the Coquille River is caused by more than the plunging structure. The Catching Slough arch and the Sumner basin smooth out southward into gentle undulations. This change in structure marks the position of a gentle crosswarp, which trends through a basin on the western limb of the structure near Beaverton, and through a sag still farther west in the Westport arch (see pl. 1).

Near Coaledo, the Beaver Slough basin narrows and the belt of Bastendorf shale has been removed by erosion. The basin plunges gently both north and south from Coaledo. To the north the syncline widens, and a broad topographic basin has been eroded in shale at the head of Isthmus Slough. This topographic basin could have extended farther northward along Isthmus Slough if it were not for the more resistant sandstone of the Coaledo which was apparently upfaulted along the east side of the Isthmus Slough fault. The axis of the Beaver Slough basin curves eastward and runs between the "Thirty-Six" coals and the Catching Slough arch, thence north to a point just west of the mouth of Catching Slough.

The Beaver Hill coal group of the upper Coaledo can be traced along the west flank of the Beaver Slough basin south from Marshfield to the Riverton district, and then northeast through the Fat Elk Creek area through Cedar Point. The Beaver Hill bed is unrecognized north of the Peart mine, and the eastern part of the basin contains undifferentiated coal beds of the Coaledo formation.

Catching Slough-Coaledo arch

The Catching Slough-Coaledo arch was first recognized by Diller and Pishel (1911:204) who stated that:

The east limb of a (Beaver Slough) syncline runs through the whole western tier of sections (T. 26 S., R. 12 W.). This syncline in the southern half of the township (west of Sumner) is joined by an anticline that is overturned and faulted to such an extent that the coal beds of both sides are brought within a short distance of each other. Another syncline (Sumner basin) adjoins this anticline on the east, and thence eastward the dips are to

the west for an unknown distance. The axis of the anticline and the fault line run parallel to each other or perhaps coincide with each other at places.

The words in parentheses are those of the present authors.

Half a mile west of Sumner the anticline and associated fault trend north; 2 miles to the north the anticline crosses Catching Slough and was not recognizable in the Stock Slough section. The fault may continue north parallel to Catching Slough. South of Sumner in sec. 31 the coals on the west flank of the anticline make an abrupt bend to the west, which may represent an offset on the eastward continuation of the Davis Slough fault but appears to be just a change in strike. The anticline widens southward and the dips lessen so that in T. 27 S., R. 13 W., few dips are more than 40°, and most of them are between 15° and 25°. The arch abruptly ends a mile southeast of the town of Coaledo, where the coal beds appear to swing around the end of the anticline with southeast, south, and southwest dips. There is the possibility that the distribution and varying thickness of the Umpqua volcanics believed to be beneath the Coaledo basin influenced this structure. The absence of close folding in the bend of the Coquille River west of Coquille indicates a slackening of compressive stresses near the southern end of the arch.

Sumner basin

The outline of the Sumner basin corresponds generally with the areal extent of the Bastendorf shales which occupy the valley of Catching Slough and extend southward to Noble Creek. The beds along the northern end of the basin near the site of the abandoned Newcastle mine dip gently southward. In the vicinity of Sumner, the dips are quite steep and the axial plane dips steeply westward, generally paralleling that of the narrow Catching Slough arch. The southern end terminates north of the Coquille Valley in a cross fold with southward dipping beds.

Pulaski arch

The Pulaski arch received its name from Pulaski Creek which parallels the axis of the anticline. It extends northward across the broad valley of the Coquille along Cunningham Creek, and into the Umpqua sediments between the mass

of volcanics at Blue Mountain and the volcanics east of Coquille. The Coquille basin, which lies to the east of the arch, is shallow and its base is much higher than that of the Beaver Slough basin, the arch being a minor fold on the eastern limb of the greater Beaver Slough basin.

Diller (1899:365) described the relationship between the Coquille and Beaver Slough basins near Riverton as follows:

The two (basins) are separated by an arch near the head of Pulaski Creek, which for convenience may be called the Pulaski arch. Although numerous outcrops of coal are known west of Fat Elk Creek and east of Pulaski Creek, none are known in the intermediate region. The reason is that the Pulaski arch brings up strata of the Pulaski formation which lie below the coal.

More recent investigations disclose coal outcrops at the head of Pulaski Creek and at the upper end of Fishtrap Creek, approximately at the center of the Pulaski arch. The lower portion of the upper Coaledo nearly bridges across, particularly at the southern end where the fold blends into the broader structure of the Beaver Slough basin. The strata exposed in the center of the arch, the type section of Diller's "Pulaski" formation (1899:320), has been identified as middle Coaledo.

The middle Coaledo beds are comparatively thin west of Coquille along the Dean-Minard road where they are approximately 400 feet thick.

Coquille basin

The Coquille basin as mapped by the authors is different from that described by Diller (1899:363). The coals at Coquille are lower Coaledo, whereas those at Harlocker Hill are upper Coaledo in age, preserved by crosswarping of the Coquille basin by the northwest-trending downwarp which parallels the Coquille Valley to Beaverton and extends into the southern tip of South Slough.

The southern end of the Coquille basin dies out against the east flank of the Cape Arago anticline at a point south of the southern toe of the Beaver Slough basin. The coals on Hall Creek, formerly included in the Coquille basin by Diller, are an extension of the lower Coaledo coals and occupy separate folds paralleling the Coquille basin to the east along Hall Creek.

The southern portion of the Coquille basin plunges gently northward to Harlocker Hill, and rises again northward through Coquille to the

valley of the North Fork of the Coquille River. Middle Coaledo strata are covered by the flood plain of the river between Coquille and Harlocker Hill. They should occur between Cedar Point and Coquille, as the west-dipping Cedar Point sediments are upper Coaledo and the sandstone underlying Coquille is lower Coaledo. There is little room for the middle Coaledo, on the basis of dip of the strata, either south or west of Coquille, and it appears that the middle Coaledo is much thinner here than to the west.

Norway anticline

A broad arch is well exposed by the Coquille River between Myrtle Point and Coquille. The axis trends in a northeast direction through the vicinity of Norway. The eastern limb is composed of flaggy Umpqua sandstone and fine-bedded tuffaceous shales. Scour channels may be seen at the base of several of the sandstone members (pl. 11-D). The eastern limb of the structure forms the prominent ridge on the western side of the North Fork Valley and runs southward from the Coquille River along Catching Creek. The Coquille Valley is constricted where it cuts through this ridge. The center of the anticline is composed of shaly members which have low dips. The resistant sandstone which may be seen on the eastern limb does not appear on the western limb, where it is overlapped and covered by the lower Coaledo as well as by Umpqua volcanics north of the river. This structure is traceable from the pre-Tertiary highland on the south to the North Fork of the Coquille River near Lee.

Hall Creek folds

These structures consist of a small anticline and syncline in lower Coaledo rocks. They plunge northward, trending about N. 20° E. and dying out rapidly both to the north and south of Hall Creek. They are superimposed upon the broad western limb of the Norway anticline.

Myrtle Point folds

Several small folds in Umpqua strata trend northeast through Myrtle Point up the valley of the North Fork of the Coquille River. On a large scale, these folds make up a general synclinal structure, lying between the Norway anticline and pre-Tertiary rocks. The strata are so broken that it is difficult to determine the true dips of the beds, but most of the strikes are northeast.

It seems probable that the conglomerate and massive sandstone at Cribbins Hill is the same as that at the mouth of Ward Creek.

Bill Peak anticline

Pre-Tertiary sandstone is exposed in the center of an anticline which trends southeast from Bill Peak into the northeast corner of the Port Orford quadrangle. Umpqua strata dip very steeply away from the older rock on the northeastern limb, but outliers of Umpqua on Fourmile Creek dip more gently southward.

Small patches of Umpqua rest upon the pre-Tertiary farther south where the base of the Umpqua is higher than in the Coaledo basin, owing to differential uplift and submergence.

Tyee folds

Gentle folds in the Tyee in the northeastern corner of the quadrangle seem to trend northwest. East of the quadrangle a broad gentle syncline strikes northward.

The Tyee strata, between the Coos River and the North Fork of the Coquille, dip gently to the southeast. Along the Millicoma drainage farther north, there are slight undulations in strata. Evidently the massive Tyee sandstone was more resistant to deformation than the less competent strata in the Coaledo basin.

Strike Faults

Strike faults in the Coos Bay quadrangle, which are more or less parallel to the coal marker-beds as well as to the physiographic trends, are obscured and have been proved only by determining stratigraphic displacements. With one exception they were not mapped by Diller. The presence of several unmapped north-trending faults is suggested by anomalous dips and dislocation of coal beds. One such fault may parallel the east limb of the South Slough basin.

Isthmus Slough fault

A fault is tentatively placed between the "Thirty-Six" coals and Isthmus Slough. This fault generally parallels Isthmus Slough and is therefore termed the Isthmus Slough fault.

Diller and Pishel (1911:214-215) believed that the "Thirty-Six" coals were 2,500 feet above the Beaver Hill bed and suggested the presence of unknown faults or folds. A fault is believed to explain best the implied stratigraphic distance

between the Beaver Hill bed and the coals exposed on the east side.

The presence of a fault is suggested by the drainage alignment of tributaries of Isthmus Slough between its headwaters and the Sumner-Isthmus Slough road. The isolated occurrence of coals exposed in sec. 36 and the areal distribution of the Bastendorf shale and the Coaledo sandstone likewise seem best explained by upfaulting and duplicating of strata of the upper Coaledo along the western limb of the Beaver Slough basin. There seems to be no indication of a reversal of dip to explain their position by ordinary folding.

As the fault generally parallels other north-trending faults and also coincides with the place of maximum shortening in the Coos Bay quadrangle, it is probably a high-angle reverse fault formed during maximum deformation of the region. The fault probably dies out within a short distance to the north and south. Movement may be distributed over a relatively broad fault zone.

Cape Arago fault

The lower Coaledo is downfaulted on the west against pre-Coaledo sediments assigned to the Umpqua. Because the Tyee is missing here, the displacement would be at least 200 to 300 feet, even if the Coaledo strata on the west represented the lower portion of the lower Coaledo. Fauna, similar to that found in the downfaulted part at Cape Arago, occurs throughout the upper half of the lower Coaledo. The lower portion is the equivalent of the coal series and is largely nonmarine in origin. Because the fauna occurs in the upper portion, a displacement of at least 1,000 feet is indicated along this fault.

The strata on both sides of Cape Arago are badly broken with rapid changes in strike in small rotated blocks. There is the possibility of a horizontal component in the movement.

The Cape Arago anticline turns sharply eastward near the mouth of Fivemile Creek. Here the fault which parallels its axis at Cape Arago seems to be missing. There is an apparent break along the southern flank of the fold along Threemile Creek which will be described under "Transverse faults."

Blue Mountain fault

The volcanics along the eastern edge of Blue Mountain have a very steep contact with the Umpqua shale which is demonstrated by topographic

changes in the valley of Steinnon Creek and to the north along the edge of the volcanic mass. A fault has been tentatively shown in the stratigraphic cross sections as a means of interpreting this relationship. Such faulting, if present, could be pre-Coaledo in age. It would generally parallel the longitudinal faults in the Coos Bay area.

Sumner fault

The Sumner fault was recognized by Diller and Pishel (1911:204) who reported that:

This syncline in the southern half of the township (T. 23 S., R. 12 W.) is joined by an anticline that is overturned and faulted to such an extent that the coal beds of both sides are brought within a short distance of each other. . . . The axis of the anticline and the fault line run parallel to each other or perhaps coincide with each other at places.

The fault dips westward and parallels the west side of the north-trending Sumner basin, which is steepest on the west. This is a reverse fault, the west side having moved up. As the coal beds on both sides of the fault are nearly parallel, the amount of offset cannot be determined. A continuation of the fault northward may explain the anomalous presence of coal on both sides of Catching Slough in the N $\frac{1}{2}$ sec. 17, T. 26 S., R. 12 W.

China Camp Creek fault

This fault is considered to be essentially parallel to the structural trends of the Sumner basin and the Catching Slough arch although it trends northeast. A displacement of at least 600 feet causes a repetition of the Bastendorf shale and the upper Coaledo series along the highway near the mouth of China Camp Creek, 3 to 4 miles west of Coquille, and probably resulted from stresses caused by the changes in structural trend at the southern end of the Catching Slough arch and the Sumner basin.

Transverse Faults

The major faults which cut across the general structural trends and which strike a few degrees north of west are the Beaverton, Davis Slough, Mill Slough, and Lillian. Numerous other small faults with transverse trends have also been mapped.

Beaverton fault

The Beaverton fault cuts the Westport arch in the vicinity of Beaverton (now deserted). Diller and Pishel (1911:219, 220) suggested a fault and a shallow basin in this vicinity, based upon the dislocation of the coal beds. The Beaver Hill bed appears to be offset, with the northern side of the fault upthrown. This fault is further indicated by the jumbled structure in the saddle between Beaverton and the South Slough drainage, which could be interpreted as a fault zone. A continuation of the strike of this fault to the southeast would carry it into the Coquille River Valley beneath the alluvium. West of Coquille the basin plunges to the south instead of being faulted as it is near Beaverton.

Davis Slough fault

The Davis Slough fault was named by Diller and Pishel (1911:210) who recognized the offset in the Beaver Hill bed. The south side is upthrown an estimated distance of at least 700 feet. There seems to be little evidence of an extension of this fault east of the Isthmus Slough fault. The Catching Slough arch narrows abruptly near the projection of the strike of the Davis Slough fault, but there seems to be no break in the course of the coals.

Mill Slough fault

The Mill Slough fault was described by Diller (1899:327) and mapped by Diller and Pishel (1911:196) as running due east along the north lines of the southernmost tier of sections in T. 25 S., R. 13 W., through the city of Marshfield, as follows:

The Mill Slough fault marked as separating the Newport and the Flanagan coal basins is not exposed to view, but its existence is inferred from the positions and dissimilarity of the coal beds in the two basins. The Reservoir coal bed is not considered to be the northern extension of the Newport coal, although there is some correspondence between them. The Mill Slough fault is believed to be not very large, having a downthrow of less than a thousand feet on the north side; . . . If, however, the Reservoir coal is the same as the Newport, the Mill Slough fault has a throw of only a few hundred feet.

The upper and middle benches of the Newport coal bed are much thinner in the Englewood area than farther south, and the middle parting is considerably thicker. At the extreme west edge of the Englewood project just west of Marshfield, the

middle parting widens to 5 feet of coarse sandstone, and the upper benches are even thinner than those farther east at the Englewood mine. Half a mile north at the Reservoir mine the single bench of dirty coal exposed is overlain by 9 feet of sandstone followed by four very thin seams of coal totaling only 3½ inches. It is suggested that these seams represent the upper benches of the Newport bed on the extreme west edge of the coal basin, and that the two areas can be correlated as suggested by Diller, assuming a throw of only a few hundred feet.

Lillian fault

This tentative fault is named for the mine at the southern end of the Steva coal bed just east of the Coos River. The bed evidently terminates against a fault although further prospecting might uncover this bed to the south. This suggested fault fits the transverse pattern of faulting.

Threemile Creek fault

At the mouth of Threemile Creek south of Cape Arago, the lower Coaledo on the south limb of the Fivemile Creek anticline has been faulted down against Umpqua strata. The south side is upraised. This fault is parallel to the transverse set of faults but, like the Lillian fault, it is locally parallel to the structure.

Minor faulting

Minor faulting is common in the Coos Bay quadrangle as shown by mine workings and detailed mapping along the coast between Sunset Bay and Cape Arago. The fault pattern along the coast and the relative movement along the faults is shown in plate 5. They seem to be normal faults with vertical displacements ranging from 50 to 100 feet, with a few more than 200 feet.

Nearly all of the faults in the coal mines have a throw of a few feet and they hinder mining only slightly. Only a few larger faults have been encountered in mining operations. In the Southport and Overland mines, they are generally small dip faults, but a few strike faults, parallel to the rolls, have been encountered.

The southern end of the Newport coal basin is cut off by two faults recorded and illustrated by Diller (1899:324). The northern of these two east-trending faults, dipping 65° N., displaced the coal 50 feet up on the south; the second displaced it above the surface of Yokam Hill. Diller and

Pishel also reported faults which have offset the coal in Boatman Gulch. These faults were mapped (1911: pl. 9, opp. p. 218) as striking N. 75°—80° E. The block, 800 feet in width, that lies between the two faults has dropped 40 feet with respect to the area to the north and 10 feet with respect to the area to the south. These are all normal faults.

Drilling during the survey of the Englewood project showed that at least two faults cut the coals in this area. They strike northwest, and the southwest side of each fault has been dropped about 30 feet. A north-trending fault zone immediately adjoins the project on the east, with the east side thrown up with the result that the coal is now missing.

Two faults which limited the operations were encountered in the Delmar or old Coos Bay Coal Company mine (pl. 22). The southern extension of the coal was cut off and downfaulted. The strike of the fault was N. 50° E., whereas to the north the coal was upthrown by a fault with a strike of N. 20° W. Most of the coal within this triangular block was mined out. The dip of the faults and the amount of throw are not shown on the mine maps.

Three faults appear on the maps of the Beaver Hill mine, striking N. 30°—60° W. and dipping north, with the downthrow side of each on the northeast (pl. 25). The amount of displacement on these faults is usually less than 20 feet.

Several faults are figured and described by Diller and Pishel (1911:207-8) near the Newcastle mine north of Sumner. These strike west or a little north of west, and all have the north side dropped. Diller also reports that:

At the Equality prospect . . . (just west of the Newcastle) the crinkling and duplication of the coal bed at one place indicate a thrust fault.

The minor faulting described represents only those faults that have been observed in the field, recorded on the maps of old mines, and inferred on stratigraphic evidence. Undoubtedly there are even a few major faults which have not been recognized. The coal horizons will be found by future mining to be faulted on a minor scale, but the throw, except along major fault zones, should not exceed more than a few feet. Diller (1899:333) has remarked that:

The association of ravines or sloughs and faults, both at Beaver Hill and Newport

strongly indicates that the presence of faults determines the places of the ravines.

That this is not always so is shown by the workings at the Delmar mine, where the coal is continuous beneath the main ravine, although a northern tributary does parallel a small fault.

Pleistocene or later faulting has, at least at two places along the coastal section, offset the wave-cut platform and formed low ridges in the overlying sands. A steep reverse fault which parallels the coal bed in Yokam Point, with the southwest side down about 10 feet, causes a distinct difference in elevation on the top of the terrace. A similar fault located in the sea cliff 2,500 feet to the southwest has also formed a ridge on the sand, and has displaced the wave-cut platform a few feet.

Summary of Age and Origin of Structural Features

Pre-Tertiary structural trends have not been mapped in the Coos Bay quadrangle.

It has not been determined whether a slight deformation, with an accompanying period of erosion which modified the Umpqua surface, preceded the deposition of the Tyee. A post-Tyee erosion period is indicated by the absence of the Tyee at the base of the lower Coaledo in the southwest part of the quadrangle, and by a discordance in strike of as much as 40° between the Coaledo and the underlying Umpqua at Cape Arago (pl. 5).

Folding of the Coaledo did not take place until the late Oligocene or Miocene. The Bastendorf shale and the Tunnel Point sandstone may be disconformable upon their underlying formations but there is little evidence of deformation. Slight folding in the Newport area of Yaquina Bay may have occurred prior to the deposition of the Astoria during the Miocene, and another period of deformation at the end of the Miocene is recognized in many parts of Oregon and California. It does not seem possible to differentiate between Miocene movements in the Coos Bay area. Thrusting along the axis of folding of the Catching Slough arch probably occurred during the Miocene period of folding. Later folding has been gentle. Along the western border of the Empire formation in the South Slough basin, post-Empire deformation has caused dips of approximately 20° to 30°; a few dips of 40° were found; elsewhere in the basin dips in the Empire are low. Some of the post-Empire warping probably occurred during the Pleistocene.

All major faulting evidently occurred prior to the wave planation of much of the western Coos Bay quadrangle, for no scarps were recognized in this area.

The structural map (pl. 10) shows a northward divergence of the axes of folds in the Coos Bay quadrangle. The Coaledo basin includes most of the closely folded region, yet the area south of Coquille through Myrtle Point which has also been closely folded lies outside of the present outlines of the basin.

The Coaledo basin lies between two buffers: the pre-Tertiary highland to the south, which presumably also extended northward along the western edge of the basin; and the Tyee sandstone and underlying massive sandstone and sandy shale of the Umpqua to the north and east. The Tyee lies in a broad shallow syncline, which is the dominant structural feature of the Coast Range between Coos Bay and the Umpqua Valley. Evidently the Tyee inherited its structure from pre-Coaledo time as its preservation in the center of the basin indicates shallow folding. Near the forks of the Coos River, the truncated western limb of the basin appears to underlie the Coaledo at an angle.

The pattern of folding in the Coaledo basin seems to be governed by its original outline instead of by rotational stresses and en échelon folding. The basin was apparently diamond-shaped, and stresses acted approximately in N. 70° W. and S. 70° E. directions. The resulting folds seem to have been formed parallel to the borders of the basin. Toward the center, where shortening was much more pronounced, folds were formed which die out along their strike. The more active stress seems to have come from the west, as most of the folds are arcuate toward the east, and, as in the case of the Catching Slough arch, there was a tendency to overturn and thrust in that direction. The maximum shortening of the basin occurred between Cape Arago and Sumner. Shortening in the southern part of the area was evidently less, for here the basin is not as closely folded. The compressive stresses in an area between Coquille and Beaverton seem to have been relatively weak.

The north-trending faults coincide with the area of maximum shortening and probably die out rapidly. This supports the belief that they are high-angle reverse faults formed during maximum compression.

A gentle downwarp seems to exist along an axis trending nearly at right angles to the main structural axes, northwest from Coquille through Beaverton to the south end of South Slough. This axis of crosswarping may have been established during maximum folding, as the small, faulted basin at Beaverton and a sag in the Westport arch coincide with this axis. However, relative uplift accompanying the differential movement of the Coaledo basin with respect to the Siskiyou highland has tilted the southern end of the basin northward. The Catching Slough arch and the Sumner basin presumably die out at their southern end because of a lack of compressive stresses. There is also a northwest-trending cross-arch which caused a slight broadening of the blunt end of the Catching Slough arch, and an uplift at the southern end of the Sumner basin. These structures suggest some compression from the south. Some of this warping probably occurred after the main period of folding, possibly along with transverse faulting and differential uplift.

It is not surprising that during the deformation of an irregular basin stresses should be more intense in certain areas than in others. These differences would probably be relieved by minor faulting which would die out a short distance along the strike.

There are no other areas in western Oregon in which the fault pattern has been described in sufficient detail so that analogies can be made concerning the faulting in the Coos Bay field. Specific faults give little evidence of the forces involved which must be deduced from a study of the results of larger scale deformation.

Glover¹ has found both normal and reverse faulting in the complex deformations of the Olympic Peninsula of Washington. Deformation of the Tertiary basins of California has produced many high-angle reverse faults paralleling the axes of folding. Although the Cape Arago and the Isthmus Slough faults appear to be high-angle reverse faults, it may be shown in the future that they are normal faults. Both of these faults are downthrown on the west.

Post-Miocene movement seems to have consisted of gentle warping and isostatic adjustment, some of which probably resulted in transverse faulting. Some warping and small-scale faulting occurred during the late Pleistocene and Recent.

¹ S. L. Glover, personal communication.

As a general rule the east-trending faults are much more likely to have physiographic expression than those trending north, as the former cut across the strike of the beds and break up as well as offset the massive sandstone strata forming the

ridges, tending to make them more easily eroded. Davis Slough in its lower course, Threemile Creek, and the coves in the cliffs south of Sunset Bay, all are caused by erosion along transverse or dip faults.

PHYSIOGRAPHY

Topographic Divisions

The Coos Bay quadrangle can be divided into three natural topographic divisions: the coastal plain and terraces, the central region of low hills, and the peripheral region of higher relief around the southern and eastern borders of the quadrangle.

The coastal plain north of the mouth of Coos Bay consists in part of the long spit which protects the lower bay, and which is covered with sand dunes standing just above tide, and in part of a series of higher terraces covered with sand dunes along the eastern side of the lower bay between North Bend and Charleston.

South of the bay mouth the Cape Arago-Seven Devils prominence rises to 700 feet or more above sea level, with steep cliffs to the shore line on the west.

The southern coastal plain extends south from the Seven Devils to the border of the quadrangle as a series of wide, gently rolling or relatively flat terraces which rise by steps from sea level to an elevation of more than 300 feet, and extend inland a distance of from 2 to 4 miles. Short westerly streams with steep canyon walls and flat valley bottoms drain this region.

The central region is roughly bounded on the north by Coos Bay and on the south by the Coquille River; Catching Slough marks its approximate eastern border. The drainage basins of South Slough on the west and Isthmus and Beaver sloughs on the east are the most important. The lower courses of most of the streams and sloughs have flat-bottomed valleys lying below or just above hightide level. The present inner stream-channels usually have meandering courses. The maximum relief is slightly more than 800 feet, with an average relief of less than 500 feet. The ridges generally extend northerly and have rather wide, gently sloping or flat summits. The valley walls are more commonly steep than gently sloping.

The peripheral region, which is from 5 to 7 miles wide around the eastern and southern borders of the quadrangle, is the rugged portion of the area, with an average relief of more than 1,000 feet, and with numerous peaks reaching heights greater than 1,500 feet. It is cut by the meandering steep-walled canyons of the Coos and Coquille rivers and their tributaries, and in portions of the area the cliffed canyon walls make access difficult.

Relation of Topography to Lithology and Structure

The lithology and structure of the formations of the Coos Bay quadrangle have markedly affected the topographic forms, a fact which has been of considerable value in tracing the formations inland from the well-exposed coastal section. The ridges are usually underlain by steeply dipping massive or flaggy sandstone. Softer and less resistant shale generally erodes to form valleys or wide basins, depending upon the attitude or thickness. The more steeply dipping strata usually form the more prominent ridges. The peripheral mountainous region is largely underlain by the massive pre-Tertiary rocks or relatively flat lying Tyee sandstone.

Davis Slough, Hatchett Slough, Lampa Creek, and the Coquille River between Hatchett Slough and Lampa Creek are subsequent streams flowing in the belts of middle Coaledo shale. The east branch of Big Creek heads in the Bastendorf shale; the west branch heads in middle Coaledo shale. The larger rivers cut across the regional structure more commonly than do the tributary streams, but they also are locally adjusted to structure as is well shown by the Coquille River.

The North Fork of the Coquille River rises in the highland of massive flat-lying Tyee sandstone, where the river has a narrow deep valley, but near Fairview the river has excavated a broad basin in the soft Umpqua shale. A few miles south of Fairview where the river cuts through a basalt

mass, the valley is constricted but widens again in a flaggy shale, which differs little from that near Fairview except that it dips more steeply. Where the North Fork joins the main Coquille River near Myrtle Point, erosion in the Umpqua shale has resulted in a broad valley. Just to the north of the junction of these streams, the valley is narrower than at any other place downstream to the sea; this condition is caused by resistant sandstone beds dipping upstream about 45° . Between this constriction and the broad bend just west of Coquille, the river cuts gently dipping strata of less resistant rock, resulting in a broad valley. Between Coquille and Harlocker Hill, the valley is cut in middle Coaledo strata, and the more resistant upper Coaledo forms promontories at Cedar Point and to the southwest near the mouth of Fat Elk Creek. The broadest portion of the valley is in the bend just west of Coquille, where it is cut in a basin of gently undulating Bastendorf shale. The valley narrows at Riverton where the river cuts through the upper Coaledo sandstone into the middle Coaledo shale belt. Between Lampa Creek and Bear Creek, the river cuts through the lower Coaledo and broadens out in the Umpqua flaggy sediments near the coast.

The fairly steep narrow valley between Riverton and Bandon, which Twenhofel (1943) interpreted as being younger than the valley as a whole, and the low pass between Beaver and Isthmus sloughs are the chief arguments for postulating a former course of the Coquille River through Isthmus Slough into Coos Bay. Twenhofel (1943:13) stated that "the major streams antedate the submergence of the land to the level of the 1,500-foot terrace and thus their valleys were probably full of sediments when the sea stood that high." The former valley of the Coquille between Randolph and the sea contains the Coquille formation and is believed by the writers to post-date the formation of the 1,500-foot terrace, for it would be difficult to explain such great and rapid fluctuations of the coast. Twenhofel further states: (1943:20):

It is believed that when the submergence of the coast of southwest Oregon began, the Coquille River flowed through the lowland extending from the town of Coquille through Isthmus Slough to Coos Bay and had its entrance into the sea in the vicinity of Coos Bay. The present valley of the Coquille River into the Bandon area did not then exist.

Detailed field work in the Coos Bay quadrangle has shown that the "isthmus" near Coaledo probably has no relation to the drainage history of the Coquille River. Twenhofel proposed that the valley of the Coquille River through this pass was filled with sediments during submergence, and that the Coquille wandered upon the fill and established a shorter course to the sea at Bandon. No evidence of residual fill was noted; there are no gravels of chert or other resistant rocks, typical of Coquille drainage, that would not be destroyed by weathering or entirely removed by erosion. Then, too, with such filling of the stream channels, changes in drainage should have resulted in many filled valleys. The Coquille River is very crooked and only by coincidence would it return to its old valley. Absence of such fill can hardly be ascribed to later erosion, as the shale members are only slightly more resistant than the fill, and selective erosion would not explain its absence. Headward erosion of Beaver Slough and Isthmus Slough when the gradient was steeper caused the low pass between the drainages. Had recent submergence been approximately 100 feet greater, the valley alluvium of the two drainages would have connected and the apparent shift in drainage would have been even more coincidental.

Secondary drainage within the Coaledo basin has been strongly affected by the north-trending folds, which have resulted in orientation of the streams with the axial trends of the folds. Outside of the Coaledo basin, Bear Creek and Bill Creek are also aligned with the folding.

An offset in the coal bed at the mouth of Davis Slough coincides with the abrupt bend in the slough. This is probably the most striking physiographic expression of faulting. Along the coast near Sunset Bay erosion along minor fault zones has resulted in embayments.

The broad crosswarp which trends northwestward through Coquille may have governed the course of the river as far west as Leneve. Streams such as Haynes, Kentuck, and Willanch Sloughs run approximately across the strike of the gently dipping Coaledo strata, as do some of the other minor streams.

Effects of Sea Level Changes Upon Topography

The coastal and river terraces in the Coos Bay quadrangles have been discussed by Diller (1902),

Smith (1933), Pardee (1934), Twenhofel (1943), and Baldwin (1945). Diller (1902:26) sectioned the terraces 12 miles north of Port Orford, giving their elevations as 50-100, 500, 1,000, and 1,500 feet.

The "1,500-foot terrace" is represented in the Coos Bay quadrangle by gravel and boulder deposits around the base of a prominent knob which forms the top of Bill Peak in the southwestern part of the quadrangle. The "1,000-foot terrace" is well defined along the ridge a mile north of Bill Peak and elsewhere farther inland. "The 500-foot terrace," the most extensive of the upper terraces in the quadrangle, ranges from 400 to 600 feet in elevation. It occupies a large part of the highland west of the Coquille River Valley and Beaver Slough. This "plateau" is well developed along the Krome road west of Beaver Hill (pl. 11-C), but is less distinct to the north where it has been apparently downwarped along the South Slough axis. Near Bandon there is a less distinct series of terraces rising from approximately 50 feet at the coast to 400 feet in the ridges west of Bear, Bill, and Sevenmile creeks. These terraces were not differentiated in the field, as a report describing them in connection with a study of the black sands is being prepared by A. B. Griggs (in manuscript, U. S. Geological Survey). Evidence which supports warping of the lowest terrace has been presented by Baldwin (1945). This warping as well as probable earlier warping makes correlation of the higher terraces more difficult.

The lowest and broadest of the marine terraces is particularly well developed along the coast south of Seven Devils. The bedded terrace deposits rest upon the smoothly truncated older rock. At Cape Blanco in the Port Orford quadrangle, the plane of unconformity slopes perceptibly in both directions. It drops below sea level near Floras Lake, then gradually rises from sea level north of Fourmile Creek to a crest of 80 feet at Bandon. It then slopes down to 25 feet in elevation between Cut Creek and Fivemile Point. Although it is largely missing in the Seven Devils area, it is 100 feet in elevation at Cape Arago. North of the cape, it slopes gently to sea level near Empire. The plane of unconformity is below sea level north of Coos Bay where the terrace deposits have been reworked as dunes.

In the beach section, some of this warping may be apparent rather than real, for in some places

the old shore line is several miles inland, and a slight initial slope of the wave-cut platform may cause some of the variation in elevation. Study of the old shore line as a whole, however, shows that warping is the most important factor. Terraces which have been called by earlier writers the 50-, the 100-, and the 150-foot terraces can in many cases be considered the same terrace, depending upon the portion of coast line where they occur. River terraces formed during the same time may be found in the major river valleys and in many of their tributaries (pl. 11-A). The river terraces are generally constructional. They are especially well displayed at the towns of Coquille and Arago. Some erosional terraces, capped by alluvium, occur at nearly the same elevation along Catching Creek, south of Myrtle Point.

These lowest constructional or erosional terraces are a convenient elevation above sea level or river flood plain for human habitation, and many of the towns and farmhouses are located upon them. The north-trending spit upon which North Bend is situated was formed during this terrace stage when the bay emptied into the ocean very near the present highway bridge. The spit points northward as is the tendency along the Oregon coast except where headlands prevent northward growth.

Several well-displayed erosional terraces capped by gravels may be seen at Myrtle Point, both in the business district and under a schoolhouse farther up the hill. The main terrace upon which the business district rests seems to be too high to coincide with the Arago terrace, but differential warping which is present along the coast may account for the apparent discrepancy.

The sequence of shore line movements resulting in the formation of these terraces is outlined more fully under "Geologic history."

Flood Plains

Aside from the obvious drowning which has affected the river valleys, natural levees are common in the broad valleys of the Coquille and Coos rivers and their tributaries. This seems to indicate the establishment of a state of equilibrium in which the stream, which is normally entrenched in a narrow inner valley, occasionally builds up the broader portion of the valley during periodic flooding, while keeping the inner channel very near

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base level, or even within the range of tide water.

Near Dellwood on the Coos River and along the North Fork of the Coquille River, the levees and

flood plains are from 10 to 20 feet above the river, and lateral erosion within this frequently meandering inner channel is almost absent.

GEOLOGIC HISTORY

Pre-Tertiary

In the Coos Bay quadrangle there are no formations known to have been affected by the Nevadan revolution, although Paleozoic and early Mesozoic formations are present to the south and southeast. The Knoxville sediments included by Diller in his

Cretaceous are missing and orogeny near the close of the Cretaceous formed highlands which existed well into the Eocene.

Tertiary

Eocene

Southwestern Oregon evidently remained an area of erosion throughout the Meganos and Mar-

	European Stages	California	Southwestern Oregon
Lower Cretaceous	Lower Albian Aptian Barremian Hauterivian Valanginian	Shasta group Horsetown stage Paskenta stage	Shasta group (restricted Myrtle) Horsetown stage Paskenta stage
Upper Jurassic	Unconformity		
	Diablan orogeny		
	Tithonian and Portlandian	Knoxville and Franciscan	Dillard (restricted) Knoxville and Franciscan
	Profound Unconformity		
	Nevadan Revolution		
	Lower Kimmeridgian and Upper Oxfordian	Mariposa group	Galice group
	Older than Upper Oxfordian, may extend downward into Middle Jurassic	Amador group Monte de Oro beds	Dothan group Plant beds of Douglas County, Oregon

Myrtle formation, as well as Cretaceous sandstone of the Port Orford quadrangle to the south, are probably present.

A proposed correlation of the Jurassic and Lower Cretaceous of southwestern Oregon with that of California and Europe is given by Taliaferro (1942:107) as follows:

Jurassic or Cretaceous granite is not known to crop out in the Coos Bay or adjacent quadrangles, although the "dacite-porphry" dikes mapped by Diller in the Port Orford quadrangle may be related to this period of intrusion. Chico sediments found in the Riddle quadrangle may have been deposited over part of the Coos Bay quadrangle, but, so far as is known, sediments of the Upper

tinez stages of the Eocene. Although some basic igneous flows preceded the Umpqua sediments in the Roseburg area, known Eocene sediments are of the Capay stage or younger. The old Siskiyou highland probably extended north of Bandon, west of the present coast line. The basin of deposition lay to the north and east, and trended northward paralleling the axis of the Coast Range into northwestern Oregon where Eocene sediments are generally covered by later Tertiary deposits. Volcanics of basic composition, possibly coinciding with some of the eastern Oregon Clarno volcanism, accompanied Umpqua deposition as shown by the tuffaceous nature of the sediments and intercalated flows. Coal deposition during Umpqua

time indicates fluctuation of the shore line during the sandy facies but thick tuffaceous shale indicates deeper marine facies. The environment conditions responsible for coal formation are more completely discussed under the section on the Coaledo formation.

The Umpqua sediments contain a large percentage of lithic material, which includes chert and some fragments of schists, evidently derived from a nearby land mass. They contain a considerable amount of partially altered oligoclase-andesine which may have been derived from diorites, granodiorites, etc., such as are now found in the Grants Pass quadrangle. Glass fragments generally have an index higher than balsam both in the tuffaceous material and in glass within the Umpqua volcanics.

The volcanics which are associated with the Umpqua are largely extrusives of submarine origin. They may have been piled in thick lens-like masses upon the sea bottom for their areal extent is limited to small areas of a few square miles. Flows are absent but pillow structure, hydrothermal alteration, and palagonite characteristic of submarine extrusives are common.

The massive, thickly bedded, coarse-grained sandstone of the Tyee suggests rapid deposition of coarser material than that of the underlying tuffaceous Umpqua sandy shales. Although it was not determined whether there was an erosional break between the Umpqua and the Tyee, the change in lithology suggests regional uplift and more rapid erosion and deposition.

Mud cracks, small coal beds, abundant plant material, and brackish-water oysters indicate shallow water deposition, possibly continental in part.

The sediments contain quartz, weathered oligoclase-andesine, fragments of schists with sharply bent micas, flakes of sharply folded micas, and some chert, as well as comparatively fresh labradorite ($Ab_{75}An_{25}$) and some basic glass fragments. The quartz and weathered feldspar may be derived from reworked pre-Tertiary sediments or granitic masses such as the Ashland granite. Some of the basic glass may have been derived from uplift and erosion of Umpqua volcanics. The fragments of schist indicate erosion of pre-Tertiary rocks of the Klamath highland and that is probably the source of the abundant mica characteristic of the Tyee.

The dominant structural feature of the Coast Range east of Coos Bay is a broad gentle syncline

which contains a thick section of Tyee sediments in the center. Post-Tyee erosion has truncated the edges of the syncline prior to deposition of the Coaledo formation. This erosion period resulted in a greater faunal change between the Tyee and Coaledo formations than occurred between deposition of the Umpqua and the Tyee.

The lower Coaledo is tuffaceous with some volcanic sand and conglomerate that were probably derived in part from pyroclastics (which may have coincided with the Calapooya stage of volcanism) and in part from the erosion of the Umpqua volcanics. The Umpqua volcanics contain abundant augite, but hornblende is rare or absent; however, the Coaledo sediments contain an appreciable percentage of hornblende, the source of which was not determined. Possibly part or much of it was derived from the erosion of basalts in which augite had been converted to hornblende. Numerous coal beds as well as coarse cross-bedded sandstone point to a continental origin for much of the lower Coaledo, but abundant marine fossils in the upper half of the lower Coaledo and the shaly sediments of the middle Coaledo indicate a transition from continental to marine environment.

The middle Coaledo, which apparently was deposited in a shallow marine basin, is a thin-bedded shale containing a few microfossils. It thins toward the east and northeast. The thinning of the middle Coaledo may have resulted from lack of deposition at the edge of the basin, from later erosion before the deposition of the upper Coaledo (which is doubtful), or from a facies change eastward. Several hundred feet of coarse reworked volcanic material is found in strata believed to be the uppermost lower or lowermost middle Coaledo near Jordan Point. No doubt the apparent change in thickness of the middle Coaledo is due to a facies change in lithology rather than actual nondeposition or erosion before deposition of the upper Coaledo. The top of the middle Coaledo is difficult to determine even in the type section along the coast. The volcanic glass present in the tuffaceous lenses of the middle Coaledo has an andesitic composition whereas more basic glass is present in the older formations. The source of the tuff may be to the east where andesitic flows and tuffs are associated with the Calapooya volcanics.

The upper Coaledo coarse sandy sediments and coals indicate a change from marine to continental conditions with an accompanying retreat of the sea. In contrast to the middle Coaledo, both the lower and upper Coaledo contain mud cracks, channeling, cross-bedding, unrounded grains, and poor sorting of the sediments. Peculiar shale fragments and shale conglomerates as shown by Davis (1918:37) were probably formed during the dry seasons as follows:

In the dry season the rivers retire into small channels and leave large bodies of water, charged with fine mud, in the river bottoms. As the water evaporates, the mud becomes hardened, cracks, and breaks into blocks. A sudden influx of water in a freshet may cause the shale beds thus formed to be broken up and their fragments embedded in the newly deposited sand.

The coal swamps were widespread, and many of the coal beds maintained a remarkably uniform thickness over large areas. Individual coal beds of the lower Coaledo group are thickest and most numerous in the south-central part of the coal basin; there are sometimes as many as eight beds in a stratigraphic distance of 1,000 feet, whereas in the coastal section only small seams of coal have been found. The upper Coaledo coals are also thick in the southern toe of the basin where there are six or more beds in the section.

Interfingering of nonmarine sediments with strata containing marine fossils shows the oscillation of the shore line. This seems to be more applicable to the upper Coaledo than to the lower, as the latter contains few fossils in the lower 1,000 feet. The coal swamps probably spread over the broad outwash plains of rivers. An absence of coarse conglomerate would point to moderate relief. In the sands, fragments of wood, both carbonized and petrified, show the presence of forests other than the coal forests. Diller (1907:405-406) reported cottonwood or poplar, magnolia, fig, walnut, elm, and laurel in the Eocene of southwestern Oregon. The formation in which these occurred is not specified, but it is probable that these forms ranged through the upper Eocene. A fairly warm climate in the Northwest during the Eocene is indicated by a semitropical fauna (Chaney, 1940:483).

Chaney (1938:635) summarizes the Eocene climate of Oregon as follows:

Modern forests differ greatly from east to west, owing to the topographic and climatic

influence of the Cascade Range, but in the Eocene time the vegetation across the state was essentially uniform. The avocado, cinnamon, fig, and persimmon found in the Goshen flora near Eugene or in the Comstock flora to the south are identical with those which lived in the John Day Basin. Of more than forty species of trees, shrubs, and vines which make up the Clarno flora, there are only four or five which have not been found in older Tertiary rocks along the Pacific slope from Washington to California. The conclusion is inescapable that the mild and humid climate of the coastal borders extended inland to the John Day Basin of eastern Oregon, over the area now occupied by the Cascade Range. For if a mountain barrier had divided Oregon during the Eocene, the fossil flora would have been as different as they are across the state today.

The Bastendorf shale, now assigned in part or wholly to the Eocene, overlies the Coaledo with apparent conformity, although evidence obtained in the Coquille River Valley indicates a slight break between them. A sample of Bastendorf shale was analyzed by Schenck (1928:18) who reports:

The analysis points to deposition in quiet water where only weak currents and no strong wave action prevailed; it resembles a histogram of silt deposited in harbors.

The restricted areal extent of this formation makes it difficult to determine the source of sediments or the outline of the basin of deposition. The inclusion of considerable tuffaceous material points to volcanic action in neighboring areas while deposition was taking place. The volcanic glass is predominantly basaltic, and the source is probably the same as that which contributed to the Coaledo sandstone; there is a similarity in composition.

Oligocene

The contact between the Bastendorf and Tunnel Point formations appears to be conformable, although there is a sharp break in lithology, and possibly a faunal break. The Tunnel Point contains coarser material and abundant tuffaceous products of nearby volcanism. There is glass of basaltic and andesitic composition; the latter may be pyroclastic in origin. If the upper Oligocene sediments were deposited, they either were removed by erosion or are covered by the Empire in the center of the South Slough syncline.

Miocene

So far as is known, the Miocene was a time of deformation and erosion in the Coos Bay quad-

range. Near Newport, Oregon, middle Miocene Astoria sediments lie upon the Nye shale with a slight angular discordance, thus indicating some deformation during the lower Miocene in that region. In other parts of the Pacific Coast the upper Miocene was also a time of deformation. It is not definitely known whether the major deformation of the Coos Bay region occurred during the lower Miocene or the upper, but the truncation of the older folded strata beneath the Empire indicates a long period of erosion prior to deposition of the Empire.

Pliocene

The Empire formation in the South Slough basin was evidently derived from Tertiary rocks to the east and from pre-Tertiary highlands to the south. The older Tertiary sediments surrounding the Empire basin of deposition were eroded nearly to base level as shown by the overlap of Empire upon the truncated Tunnel Point, Bastendorf, and Coaledo formations.

The Empire sediments are thickly bedded, and in places poorly sorted, indicating rapid deposition. The chert pebbles in the Coos conglomerate member of the Empire are similar to those derived from the Siskiyou highland.

The coarser sediments of the Coos conglomerate may indicate a slight erosional break within the Empire formation. Fossils are very scarce above the conglomerate. Deformation of the Empire at Cape Blanco preceded deposition of the Port Orford formation which was dated as middle Pliocene by Bandy (1941). According to Weaver (1944:chart), deposition of the Empire at South Slough took place during the upper lower and the greater part of middle Pliocene. If the major deformation of the Empire at South Slough coincided with that at Cape Blanco, there is a possibility that the Port Orford is upper middle or upper Pliocene. However, deformation within the Pliocene basins may not have coincided, and warping of the terraces at South Slough indicates that intermittent deformation continued to the late Pleistocene. Deformation of the Empire at South Slough may be late Pliocene or even early Pleistocene.

Upper Pliocene deposits are apparently missing along the southern Oregon coast. This was evidently a time of erosion which accompanied uplift of the Coast Range continuing well into the Pleistocene.

Quaternary

Pleistocene and Recent

The early and middle Pleistocene was a time of erosion, following the uplift of the Coast Range. Some of the broad upper valleys in the Coos Bay area may have been formed during this time.

Late Pleistocene events seem to have taken place with remarkable rapidity. Many marine terraces were formed; some of the upper terraces spread over broad areas in the Coos Bay quadrangle. The succession of marine terraces from sea level to 1,500 feet indicates a general uplift of the coast, as the upper terraces seem too high to be explained by eustatic changes in sea level. Such changes in sea level undoubtedly accompanied glaciation and deglaciation (Daly, 1934) but, instead of accounting for the higher terraces, they probably were superimposed upon the regional uplift. Thus, instead of a continuous repetition of uplift with successive terraces, there were undoubtedly oscillations and slight reversals of relative sea level.

The following summary of the late Pleistocene history of the southern Oregon coast as outlined by Baldwin (1945) indicates two stages of emergence higher than present sea level. The first of these occurred prior to the formation of the lowest and best developed of the upraised marine terraces. The second was relatively recent and antedates formation of this terrace. Quite recent drowning followed the later emergence, resulting in the formation of bays and lakes along the coast.

The two stages of emergence with resultant valleys are shown best near the mouth of the Coquille river where the Coquille formation occupies the valley formed during the earlier uplift. It is difficult to determine how far below sea level the bottom of this valley now lies. Sediments of the Coquille formation were truncated by a later advance of the sea which preceded the formation of the present broad lower terrace. Near Denmark, south of Bandon, the terrace is about 4 miles in width and displays a very low seaward gradient. Along other parts of the coast much of this terrace has been destroyed by the sea at its present level.

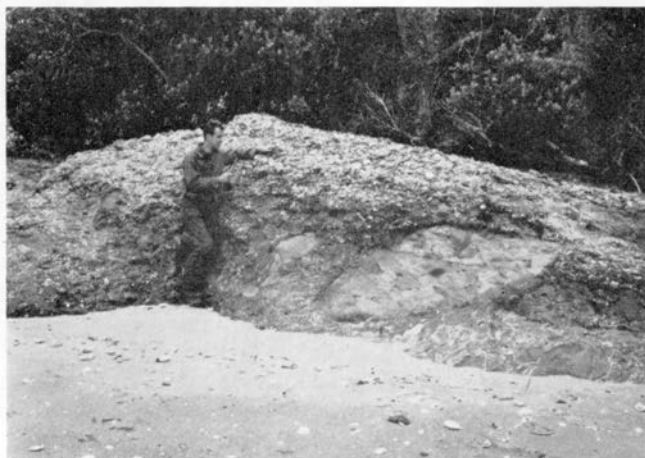
The terrace was uplifted or the sea withdrew, possibly coinciding with the latest glacial stage, and the rivers incised their valleys at least 200 feet below sea level and probably more. In most places this later uplift removed the sediments of



A—(1) Wave-cut bench, (2) Subaerial bench, (3) Lowest wave-cut terrace, (4) Terrace surface (Elk River beds).



B—Subaerial bench at mean tide, cut in Empire formation.



C—Sandstone block in fossil conglomerate.



D—Detail of fossil conglomerate, showing Crepidulas.

Fossil Point (Empire Formation)

the Coquille formation, and it was only at river mouths, such as that of the Coquille, that a slight shift of the course of the river allowed this formation to be preserved.

A summary of the sequence of Pleistocene events is tentatively suggested as follows:

1. Late Pliocene or early Pleistocene arching of the Klamath erosion surface, followed by or accompanying uplift of the Coast Range.

2. Lower and middle Pleistocene erosion of the Coast Range, accompanying the uplift.

3. Intermittent regional uplift and the formation of the higher coastal terraces, with development of broad valleys along master streams inland.

4. Emergence above present sea level, and erosion of deep valleys, such as the old course of the Coquille between Whiskey Run and Cut Creek.

5. Relative subsidence and deposition to considerable depth of the Coquille formation.

6. Slight emergence followed by still-stand while the broad lower coastal terrace and the valley terraces were formed. The Elk River beds were deposited at this time, accompanied and followed by warping.

7. Relative uplift of at least 200 feet and downcutting by the rivers. Erosion during this stage removed sediments of the Coquille formation in most places. The present lower valley of the Coquille River was established.

8. Recent relative submergence and resultant filling of the broad river valleys.

Recent warping of the coast has been gentle, and a study of elevations of the lowest terrace along the old shore line indicates no great differential drowning of the coast. Diller and most later writers have suggested that the coast north of the

mouth of the Coquille River has been submerged to a greater extent than the rivers to the south. Relative elevations of the terrace do not support this conclusion, and the apparent difference in drowning might be explained better by the state of aggradation of the valley. The Coquille and rivers to the north have been incised in softer Tertiary sediments thus forming broad valleys. The Rogue River and rivers in its vicinity have narrower valleys cut in pre-Tertiary rock. In addition, they drain more rugged highlands and carry a greater load. This results in quicker filling and aggradation of the narrow valleys, so that the tidal currents are not effective far upstream. Rivers such as the Coos, Siltcoos, Alsea, and Yaquina have not even filled their former valleys.

The chronological sequence of events and the age of the Pleistocene sediments depend largely upon correlation with other regions in which criteria for dating are better displayed. The same trend toward regional uplift has been recognized along the California coast. Determinations by Grant and Gale (1931), Putnam (1942), Bailey (1943), and others indicate a very late to post-Pleistocene age for some of the younger terraces. Faunas collected on terraces at 400 and 600 feet along the Ventura coast were identified by Grant (in Putnam, 1942:700) who suggested a late to post-Pleistocene age. Although correlation of the specific terraces cannot be made, the regional uplift probably was contemporaneous. The terrace displayed at Cape Blanco and Cape Arago, the youngest of the uplifted terraces along the Oregon coast, is probably very late Pleistocene or post-Pleistocene in age. Dating of these Pleistocene and Recent events can only be tentative because of the incomplete state of knowledge and lack of agreement concerning late Cenozoic history.

Part II

Coal Resources

Introduction

Coos Bay coal should have an important position in Oregon's economic future. Wartime over-taxing of transportation facilities with resultant fuel shortage should encourage larger scale production, and it is hoped that this shortage will be an incentive to establish steady production. Perhaps fuel oil will never again be used on the prewar scale for domestic heating. Certainly with the tremendous increase in aviation, our oil reserves will be strained to the utmost to supply high-test gasoline, even after the war. It is not unreasonable to presume that liquifaction and distillation processes (for which Coos Bay is well adapted) may some day add to the gasoline and fuel oil supplies of the nation, as well as to supply some of the many other coal derivatives which are rapidly increasing in use in the chemical and plastic industries. Economic methods of low-temperature carbonization might be applied to Coos Bay coal to produce a high-grade smokeless char or briquet that could better compete with other western coals than the raw product, as well as to produce large amounts of by-products. (See appendix A.)

A substantial tonnage of coal will be needed for production of alumina from Oregon clays, even for the pilot plant now being built at Salem. If Oregon's vast reserves of clays are to be used in developing refractory industries, with application to all the varied fields of ceramics such as porcelains, pottery, pipe, and brick, Coos Bay coal certainly should come into the picture.

The new foundry-sand plant at Eugene (Silica Products, Oreg., Ltd.) is designed to use coal in substantial amounts for drying.

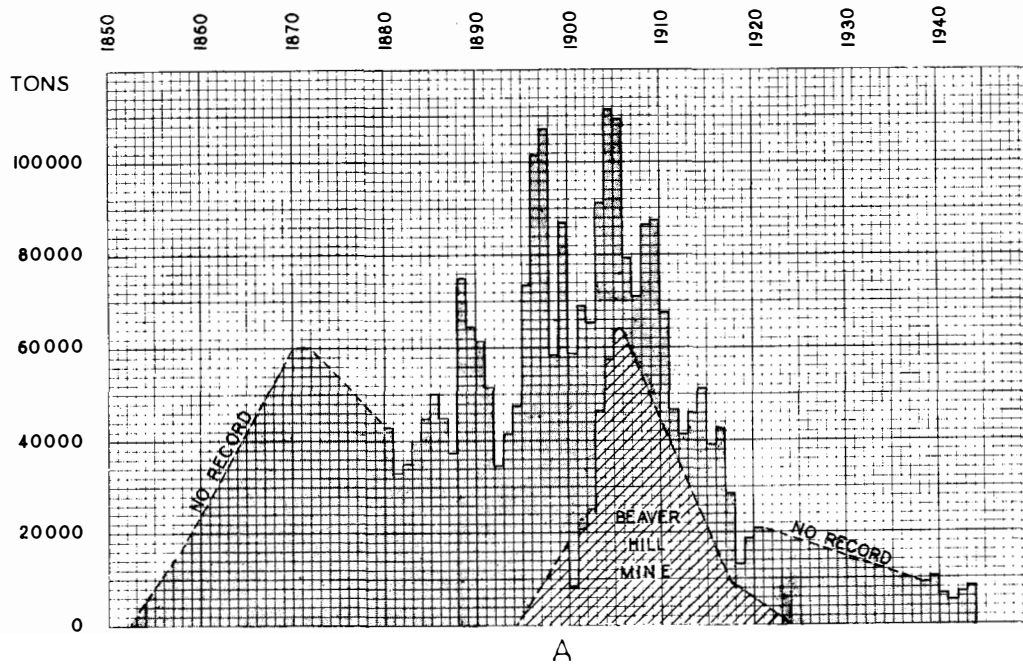
The rapid depletion of the lumber reserves of Coos County has become a matter of concern. It is becoming apparent that the giant lumber industry which has been the mainstay of the local economy for many years will not last forever. Coal production was an important part of the pioneer economy of the last half of the 19th century. It is to be hoped that it may be re-established to supplement the dwindling lumber reserve.

History of Coal Production

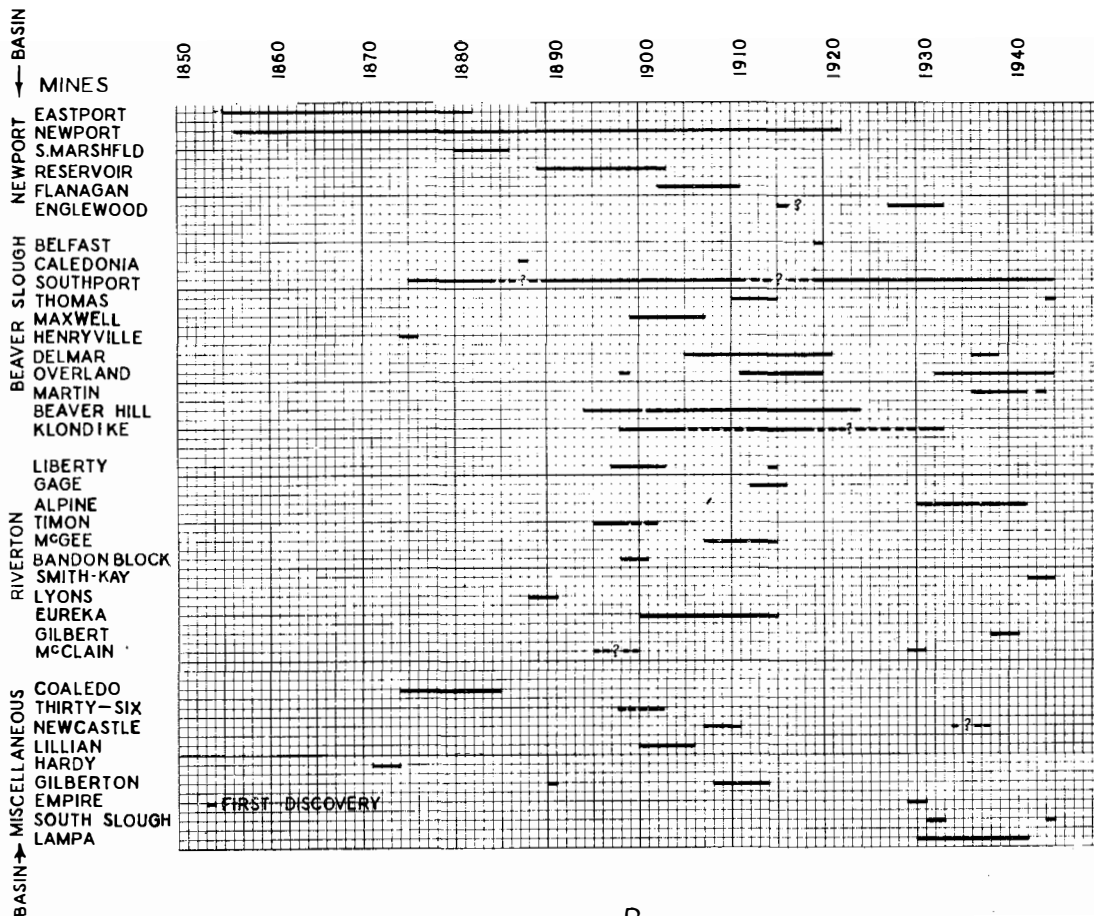
Mining in the coal field which surrounds Coos Bay and extends south for more than 30 miles to a point beyond Coquille began soon after the region was settled in the early 1850's. Coal was discovered near Empire in 1854, and the mines just southwest of Marshfield first operated in 1855. By 1880, when records were first kept, production was about 40,000 tons a year, and for 15 years annual production ranged between 30,000 and 75,000 tons (pl. 12-A). In 1896 and 1897 the production mostly from the Eastport and Newport mines exceeded 100,000 tons a year, a figure not reached again until 1904, the year of maximum production, when 111,540 tons of coal was shipped. The coal was often loaded for shipment to the San Francisco Bay region on coastwise steamers which came far up the sloughs, in some cases almost to the mine portals. Since 1905 there has been a general decrease in production, attributable in part to the decline of the California market, and because in the 1920's oil began to replace coal in railroad operation and in domestic heating. From 1903 to 1920 at least half the total production came from the Beaver Hill mine, which was owned and operated by the Southern Pacific Company. When it closed down in 1923, it had reached a depth of 1,400 feet below sea level and a distance of 3,030 feet down the dip of the coal. Since that time coal has been produced largely for local consumption, at a rate varying from 7,000 to 15,000 tons a year. The largest production in the Coos Bay district has been from the Newport basin, which includes the Eastport, the Newport or Libby, and the Englewood mines (pl. 12-B). This basin is a shallow canoe-shaped syncline located from 2 to 3 miles southwest and west of Marshfield. It has produced over a million tons, but is now practically mined out. The recorded production of the Coos Bay field from 1880 to 1920 was 2,380,000 tons. Probably the total production is in the order of 3,000,000 tons.

Past Investigations

The first detailed survey of the coals in the Coos Bay field was made in 1896 for the U. S. Geological Survey by J. S. Diller. The survey was



A, Annual production of Coos Bay coal, 1854-1943.



B, Period of operation of mines in the Coos Bay coal field.

continued and the results were published in 1899, 1901, and 1911. Other early reports dealing with Coos Bay coal were made by Newberry (1857), Goodyear (1877), Rockwell (1902), Smith (1902), and Stovall (1905). Since then many publications have referred to Coos Bay coal, only a few of which contained further original work. In 1938 Libbey made a progress report, and in 1940 Yancey and Geer sampled and made analyses of the coals. Portions of this latter report are reprinted in the section on character of the coals.

Present Investigations and Summary of Work Done

The geologic work by the authors began late in April 1943, and the field work was completed by April 1944. Many references were checked before beginning the project. Some 130 different publications mention Coos Bay coal, but only 15 were abstracted, and only 3 were found to be of constant value. These were the Coos Bay folio; the 19th Annual Report of 1897-1898; and Bulletin 431, 1911, all of the U. S. Geological Survey. All three of these were by J. S. Diller, the pioneer survey geologist, with M. A. Pishel as the junior author of the 1911 publication.

Historical information concerning past production of old mines was collected to supplement data given on the old mine maps available. Where there are no maps of old mines, total tonnage produced may sometimes be inferred from a knowledge of the period of operation and rate of production. Wherever old workings were still open they were examined and mapped. There are still a few old-time miners in the Coos Bay area who have astonishingly good memories as to "how long the slope was," or "how many rooms were taken off the gangway."

Coal prospects were reopened where practicable, new road cuts were examined, and the sea-cliff exposures were studied in detail. Several stratigraphic sections were measured to establish a guide to the main coal horizons and intervals between them. The study of the coastal section (pl. 5) proved to be of utmost value in correlating the coal horizons inland. It is in part on the basis of this stratigraphic data that some revisions in the structure of the area and the tonnage of economic coal reserves have been made.

Where outcrops of coal were exposed, they were carefully measured as they were sampled. These

sections occasionally show characteristics that can be correlated for miles. The Beaver Hill coal bed is typified by three benches of coal: a 6-inch upper bench, a 2- to 3-foot middle bench, and a 2-foot lower bench, each being separated by clay partings 6 to 10 inches thick. When there are several beds of coal in a group, the thickness of the intervening sands and shales is of value in correlation.

One of the duties of the geologist was to select coal-bearing areas for exploration. If the preliminary prospecting proved to be favorable, the area was mapped in detail. This mapped area was then drilled on coordinates, drill logs were plotted, and cross sections made.

During the preliminary exploration about 150 coal localities were examined. Of these, 53 had previously had some production and could be classified as "mines"; 62 were prospects; and the rest were undeveloped outcrops.

During the detailed examination of the selected projects, areas totaling 980 acres were mapped on a scale of 200 feet to the inch with a 10-foot contour interval. A total of nearly 9,000 feet in 322 holes was drilled by hand and power drill. Coal was faced, measured, and sampled in 107 places, and coal outcrops on the eight projects were traced by shallow drilling and open cuts for a total distance of 18,500 feet.

The coal exploration work was handled by the engineers, Mr. R. S. Mason and Mr. J. F. Cleaver. This involved hiring the crews, calculation of the payrolls, laying out the daily work for the crews, who might be working in separate localities, transportation of crews to and from work, operation and maintenance of the hand and power drills, location of the holes to be drilled, supervision of the drilling and other exploration, keeping the drill-log and section records, and finally the calculation of the tonnage per acre and the overburden above the coal.

As is usual with any large-scale exploration program, not every project "hits the mark." Eight areas were prospected in detail, but only four of these resulted in the delimitation of substantial tonnages of coal. The work of the survey was, first, to estimate the largest amount of economically minable coal with the funds available and, secondly, to have a complete record of the exploration which could be presented to any concern which might wish to begin mining coal in the Coos

Bay area. Much of this record, in the form of individual well logs, summary sheets of well-log data for the different projects, cross section sheets showing thickness, depth, and attitude of the coals, and large-scale topographic sheets, is too detailed to be included in this report.

Subbituminous coal weighs about 80 pounds to the cubic foot or 25 cubic feet to the ton (Moore, 1940:267). A bed 1 foot thick weighs approximately 1,700 tons to the acre. If the bed were 3 feet thick, the weight would be 5,100 tons, and so on. Underground mining gives a 60-70 percent recovery of coal, because in most places pillars must be left to support the roof. In underground mining, the narrow top or bottom benches of coal are often left for a roof or a floor. In the Englewood mine, for instance, only the middle of three benches was mined. In strip mining, all the coal can be recovered. In past years, the ratio of overburden to coal which could be economically stripped was from 4 to 6 feet to 1 foot of coal. The introduction of giant dirt-movers has increased this ratio, so that one operator in southeast Kansas now strips 50 feet of overburden for 22 inches of coal, giving a ratio of over 27 to 1. This is an exception, however, where an extensive horizontal bituminous coal bed is mined by a giant electric shovel with a 34-cubic yard capacity.

Most of the coal beds in the Coos Bay field are tilted, some of them steeply, and in only a very few localities is there possibility of stripping coal. Two such areas have been explored: one of them at Riverton contains about 50,000 tons of coal in a bed from 3 to 4 feet thick which lies from 12 to 20 feet below the surface; another at Englewood contains 150,000 tons of coal in a 5-foot bed lying from 30 to 60 feet below the surface. In the first of these properties the ratio of stripping is from 4 to 7:1 and in the second from 6 to 12:1.

The tonnages of measured, indicated, and inferred coal in the projects explored by the survey are as follows:

FOUR CHIEF PROJECTS

	Measured	Indicated	Inferred
Southport project	272,000*	433,500	900,000
South Slough project		263,500	2,362,000
Englewood project	219,000*	85,000*	
Riverton project	50,000†	15,200†	
Totals	541,000	797,200	3,262,000

SMALLER PROJECTS

	Measured	Indicated	Inferred
Beaver Slough		145,000	290,000
Lillian			132,000
Thomas		20,000†	75,000
Totals		165,000	497,000

* Coal about half available to stripping.

† Stripping coal.

CHARACTER OF THE COALS

During the summer of 1939, large samples of coal from 11 mines and prospects in the Coos Bay area were taken by engineers of the U. S. Bureau of Mines in cooperation with the State Department of Geology and Mineral Industries. The mines were described and the coals subjected to comprehensive analytical study. Not only were the usual proximate and ultimate analyses made, but the indices of friability and slacking were determined. Stoker-burning as well as hydrogenation and low-temperature carbonization tests were made.

The results of these tests were published as Bulletin 20 of the Department, which is now out of print. They are therefore reprinted in part here (Yancey and Geer, 1940:18-38):

Analyses of Samples

Coal analyses have little value unless the type of sample they represent is known. Two kinds of samples are in common use—mine or

face samples and samples of delivered coal. As most of the analyses presented in this report are of mine samples and these often must be interpreted in terms of delivered coal, it is well to establish the relationship between the two types of samples. Mine or face samples are taken in the mine by cutting a uniform channel 4 to 6 inches wide and 2 or 3 inches deep from the roof to the floor of the seam, as described in detail in Technical Paper 1, Federal Bureau of Mines. In so doing all partings or bands of impurity three eighths inch or thicker and all roof and floor materials are carefully excluded from the sample. A mine sample therefore tends to represent the best quality of coal that can be produced. In fact, the sampler is more careful than the miner in excluding impurities and even more exacting than some mechanical cleaning plants. Consequently, mine samples usually contain a lower percentage of ash than can be attained in commercial shipments. This fact must be borne in mind when analyses of mine samples are interpreted in terms of delivered coal. The

relationship of mine and tippie samples is discussed in the various coal-analysis technical papers of the Federal Bureau of Mines.

Samples of delivered coal, as differentiated from mine samples, are taken as cars or trucks are loaded for shipment at the mine or unloaded at their destination. They therefore represent the commercial product as shipped and hence contain any impurities that are not removed in preparing the coal. Samples of delivered coal frequently contain 2 or 3 percent more ash than face samples. Rarely, however, one or more sizes of delivered coal contain as low or even lower percentages of ash than the mine samples, due to a segregation of coal from the cleanest portion of the bed in those particular sizes.

Only mine or face samples were taken in this investigation. Sampling of delivered coal was not feasible, for some of the mines were not producing and others were producing only

very little coal as the sampling was carried out in the late spring. However, analyses of delivered coal from one mine sampled in 1933 are included in this report.

The analyses of mine samples are given in table 2, which is arranged geographically with respect to counties and towns. Each analysis is given for three conditions, as follows: (1) As received, (2) moisture free, and (3) moisture and ash free. The as-received condition represents the sample as received at the laboratory. The sample was put into an air-tight can in the mine, and hence it contained all of the moisture, both that inherent and characteristic of the particular coal and any extraneous water present on the coal face at the point of sampling. The moisture-free condition represents the composition and heating value of the moisture-free or dry coal, that is, excluding all of the inherent and extraneous moisture removed by drying at 105° C. The moisture-and ash-free condition

Table 2
Analyses of Mine Samples

Location	Mine	Bed	Location in Mine	Sample	
				Condi- tion ¹	Labora- tory No.
1	2	3	4	5	6
Coquille, 2½ miles west of	Gilbert	Unnamed	1 south entry, 40 feet south of slope	1 2 3	B-40026
Marshfield, 6 miles south of	Southport	Southport	Morrisoul room, upper works, 2300 feet north of portal	1 2 3	A-90058
do	do	do	9 room pillar, 1 north entry, 2400 feet north of portal	1 2 3	B-40027
10 miles south of	Thomas ²	Beaver Hill	13 room, 60 feet above entry, 600 feet north of portal	1 2 3	B-40028
11 miles south of	Overland	do	1 room, 100 feet above 1 south entry, 95 feet south of slope	1 2 3	B-40064
do	do	do	4 room neck, 1 south entry 250 feet south of slope	1 2 3	B-40065
do	do	do	Composite of B-40064 and B-40065	1 2 3	B-40066
Riverton, ½ mile west of	Alpine	Riverton	Crosscut off slope between 4 and 5 south entries	1 2 3	B-40029
do	do	do	Face of slope, 750 feet from portal	1 2 3	B-40030
do	do	do	Composite of B-40029 and B-40030	1 2 3	B-40031
2 miles west of	Riverton prospect	Unnamed	Face of drift, 50 feet south of portal	1 2 3	B-43482

¹ — 1, sample as received; 2, dried at a temperature of 105° C.; 3, moisture and ash free.

² The Thomas Mine listed here is not the mine referred to by the writers as the Thomas Mine, which is now operated by Mr. W. J. Thomas, but it is instead the same as the Martin Mine or The Beaver Coal Company Mine located west of Coaledo.

represents approximately the composition and calorific value of the coal substance itself, free of moisture and all associated ash-forming constituents. Thus, conditions 2 and 3 do not represent the coal as it occurs naturally in the bed and hence are useful only for comparative purposes. Condition 1, or the as-received analysis, represents the natural coal in the bed and therefore is the most useful of the three in judging the quality of commercial shipments, allowance being made, of course, for the lower ash content of mine samples compared with that of delivered coal.

In the table, columns 7 to 11 give the proximate analysis and columns 11 to 16 the ultimate analysis. The calorific value or heat of combustion, in British thermal units per pound, is given in column 18. Column 19 shows the ash-softening temperature, which represents the temperature at which a cone of coal ash fuses to a spherical lump when heated in a furnace in a slightly reducing atmosphere. This determination is a rough indication of the clinkering tendencies of a coal. The agglomerating index and rank of coal, shown in columns 20 and 21,

respectively, will be discussed under Rank of Coal.

A noticeable feature of the table of analyses is the similarity in the composition of the Coos Bay coals. Except for the coal from the River-ton prospect, which is lower in moisture and somewhat higher in ash and sulfur content, these coals are similar in composition, in heating value, and in the softening temperature of their ash. An analysis typifying the Coos Bay coals would show 17 percent moisture, 8 percent ash, less than 1 percent sulfur, an ash-softening temperature of 2,200° F., and a heating value of 9,700 B. t. u. per pound, on the as-received basis.

Table 3 gives the analyses of delivered lump, nut, and slack coal sampled at the Southport mine, Marshfield, Oregon, in 1933 by S. H. Ash of the Federal Bureau of Mines. These analyses, when compared with those for the corresponding mine samples shown in table 2, illustrate the relationship between the two types of samples. The nut and slack sizes of delivered coal contain particles of impurity excluded from the mine samples and hence are higher in ash

Sample laboratory No.	Proximate percent				Ultimate percent						Air-dry loss, percent	B. t. u.	Ash softening temperature, ° F.	Agglomerating index	Subbituminous rank of lignite
	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen						
7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
A-90058	17.2	33.6	40.8	8.4	.6	6.2	56.1	1.2	27.5	3.3	9880	2080		B	
		40.6	49.2	10.2	.8	5.1	67.8	1.5	14.6	.....	11940	.....	.....		
		45.2	54.8	.....	.8	5.7	75.4	1.6	16.5	.....	13290	.....	.....		
B-40027	16.7	33.4	40.4	4.5	.5	6.0	55.6	1.3	27.1	7.7	9720	2100	NAa	B	
		40.2	48.3	11.5	.6	4.9	66.8	1.6	14.6	.....	11670	.....	.....		
		45.3	54.7	.....	.7	5.5	75.5	1.8	16.5	.....	13180	.....	.....		
B-40028	16.9	34.6	42.8	5.7	.5	6.2	57.5	1.4	28.7	9.1	10080	2340	NAa	B	
		41.7	51.5	6.8	.6	5.2	69.3	1.6	16.5	.....	12140	.....	.....		
		44.8	55.2	.....	.7	5.6	74.3	1.8	17.6	.....	13030	.....	.....		
B-40064	16.7	35.7	42.2	5.4	.7					6.4	10150	2330	NAa	B	
		42.8	50.7	6.5	.9	.....	.....	.....	.....	.....	12190	.....	.....		
		45.8	54.2	.....	.9	.....	.....	.....	.....	.....	13030	.....	.....		
B-40065	18.5	33.4	41.2	6.9	.7					7.6	9760	1990	NAa	B	
		41.0	50.6	8.4	.8	.....	.....	.....	.....	.....	11970	.....	.....		
		44.8	55.2	.....	.9	.....	.....	.....	.....	.....	13070	.....	.....		
B-40066	17.9	34.4	41.5	6.2	.7	6.3	57.0	1.3	28.5	7.0	9960		NAa	B	
		41.8	50.7	7.5	.9	5.2	69.4	1.5	15.5	.....	12130	.....	.....		
		45.2	54.8	.....	.9	5.6	75.1	1.7	16.7	.....	13120	.....	.....		
B-40029	19.3	32.8	40.3	7.6	.7					9.4	9250	2320	NAa	B	
		40.6	50.0	9.4	.8	.....	.....	.....	.....	.....	11460	.....	.....		
		44.8	55.2	.....	.9	.....	.....	.....	.....	.....	12650	.....	.....		
B-40030	19.6	32.6	40.9	6.9	.6					10.1	9310	2340	NAa	B	
		40.5	50.9	8.6	.7	.....	.....	.....	.....	.....	11580	.....	.....		
		44.3	55.7	.....	.8	.....	.....	.....	.....	.....	12670	.....	.....		
B-40031	19.3	32.6	40.9	7.2	.6	6.1	53.8	1.4	30.9	9.8	9280		NAa	B	
		40.4	50.6	9.0	.7	4.8	66.7	1.7	17.1	.....	11500	.....	.....		
		44.4	55.6	.....	.8	5.3	73.3	1.9	18.7	.....	12640	.....	.....		
B-43482	10.1	36.1	37.8	16.0	4.3	5.5	55.1	.9	18.2	3.5	10080	2070	NAb	A	
		40.1	42.1	17.8	4.8	4.9	61.3	1.0	10.2	.....	11220	.....	.....		
		48.8	51.2	.....	5.9	5.9	74.6	1.2	12.4	.....	13650	.....	.....		

content, but the lump coal is derived largely from the cleanest coal in the bed and therefore contains a lower percentage of ash than that shown by the mine samples.

All of the Coos Bay coals are associated with friable impurities, such as shale and clay, which tend to break up in mining and contaminate the finer sizes of coal; hence these sizes are generally higher in ash content, and correspondingly lower in heating value, than the coarse coal. Washing of the coal would of course, remedy this condition. A washability examination of coal from the Beaver Hill bed was made by the Northwest Experiment Station of the Federal Bureau of Mines in cooperation with the University of Washington in an earlier investigation.¹⁰

¹⁰ McMillan, E. R., and Bird, B. M., Coal-Washing Problems of the Pacific Northwest: University of Washington Eng. Exp. Sta. Bull. 28, 1924, pp. 221-228.

Table 3
Proximate Analyses of Delivered Coal
From Southport Mine, Marshfield, Oregon

Size of coal	Condition	Moisture, percent	Volatile matter, percent	Fixed carbon, percent	Ash, percent	Sulfur, percent	B. t. u. per pound	Ash softening temperature, °F.
Lump ²	1	16.3	34.6	41.1	8.0	0.6	9,990	2130
	2	.....	41.3	49.2	9.5	.7	11,950	.....
	3	.....	45.7	54.3	.....	.8	13,210	.....
Nut ²	1	16.0	32.8	39.5	11.7	.6	9,600	2130
	2	.....	39.1	46.9	14.0	.7	11,440	.....
	3	.....	45.4	54.6	.....	.8	13,290	.....
Slack ²	1	20.2	29.9	33.9	16.0	.5	8,320	2190
	2	.....	37.4	42.5	20.1	.6	10,430	.....
	3	.....	46.8	53.2	.....	.8	13,050	.....

¹—1, sample as received; 2, moisture-free; 3, moisture and ash free.

² Lump, over 1½-inch round-hole screen; nut, through 1½-inch round-hole and over ¾-inch square-hole screens; slack, through ¾-inch square-hole screen.

Rank of Coal

All of the coals sampled are of subbituminous or lignitic rank. The designation of rank shown in column 21 of table 2 is in accordance with the system of classification of coals by rank adopted by the American Society for Testing Materials¹¹. Briefly, the classification of subbituminous and lignitic coals is based upon their heating value and their weathering and agglomerating properties. Coals of these ranks weather or slack on exposure to the air after mining. They do not agglomerate (that is, they do not form a coherent button in the volatile-matter determination of the proximate analysis), and they have a heating value of less than 13,000 B. t. u., on the moist mineral-matter-free basis. The moist mineral-matter-free B. t. u. of subbituminous A coals is 13,000 to 11,000, of subbituminous B coals 11,000 to 9,500 and of lignites less than 8,300.

¹¹ A. S. T. M. Standards on Coal and Coke, 1938, p. 104; 1938 Supplement to Book of A. S. T. M. Standards, p. 157.

Weathering properties are discussed more fully in a following portion of this report. Agglomerating indices are given in column 20 of table 2. The symbols NAa and NAb both indicate a nonagglomerating coal.

Friability

Friability, as the term is applied to coal, refers to the tendency of a coal to be broken or suffer degradation in size during the handling incident to mining, transportation, and use. It is a composite physical property embracing the over-all effects of hardness, cleavage, fracture, and elasticity. The larger sizes of coal still command a premium on the domestic market, hence the friability of a coal—its tendency toward reduction in size on handling—is a factor of economic importance to producers and jobbers of coal. Only recently has it been possible to assign numerical values to relative degrees of friability by means of a laboratory test.

A sample for friability tests was obtained in each mine at the same localities as were selected for taking analysis samples. If one sample for analysis was taken, the friability sample came entirely from that one place; if two analysis samples were taken, the friability sample was made up of equal amounts of material from the two sampling locations. In either instance, the sample was composed of about 5 pounds of pieces 1½ inches to 1 inch in size, screened from material representing the full minable thickness of the bed, and it was sealed in a can until tested.

The friability test employed is a tentative standard method of the American Society for Testing Materials¹². Briefly, the test is designed to simulate in the laboratory the forces of impact and attrition experienced by coal in actual handling. A 1,000-gram sample of coal carefully screened between 1½ and 1-inch square-hole screens is tumbled for 2,400 revolutions in a special jar mill fitted with lifters that alternately lift and drop the coal. After tumbling, the coal is removed from the mill and screened with six screens ranging from 1 inch to 48 mesh in size. From the screen analysis, the friability index is calculated as the percentage reduction in average particle size caused by tumbling in the jar mill. Thus coals that break up readily in the mill are greatly reduced in average particle size and yield a high friability index, but tougher coals that resist degradation in size come from the mill with nearly the same average size of particle as the original feed coal and hence give a low friability index.

Table 4 gives the friability indices of the coals tested; . . . Values in this range are typical of the subbituminous coals of the

¹² American Society for Testing Materials, Tentative Method of Tumbler Test for Coal Proc.: vol. 37, part 1, 1937, pp. 827-831.

West. They are similar to the friability indices of anthracite, commonly called "hard coal" because of its ability to withstand breakage, and decidedly lower than those for the friable low-volatile bituminous coals, some of which have friability indices up to 90 percent. The friability indices of the Oregon coals indicate that they will, under ordinary conditions, withstand breakage well in mining and preparation and consequently yield a relatively large proportion of the coarser sizes of coals.

Table 4
Friability Indices of Oregon Coals, Averages
of Four Determinations

Mine	Bed	Friability, percent
Gilbert	Unnamed	21.2
Southport	Southport	27.6
Thomas	Beaver Hill	27.3
Overland	do	32.0
Alpine	Riverton	29.9
Riverton Prospect	Unnamed	37.6

Purely from the standpoint of the external forces that cause degradation in size on handling—the forces simulated in the friability test—these coals also would withstand handling in the operations that follow after a coal is prepared, such as storage, transportation, and use. However, the degradation in size that occurs in these subsequent operations is, with subbituminous coals, determined more by their weathering or slacking properties than by their friability.

Slacking Characteristics

Subbituminous coals and lignites show a pronounced tendency to disintegrate or slack on exposure to the weather, particularly when alternately wetted and dried or subjected to hot sunshine. This troublesome property of low-rank coals is attributable to their high moisture content. When they are exposed to dry atmosphere after removal from the mine they lose moisture rapidly. As the moisture is lost from surface layers, shrinkage causes stresses that result in cracking and disintegration. Slacking, like the handling of a friable coal, causes the formation of excessive amounts of fine material at the expense of the coarser sizes, thus decreasing the value of the coal for some uses. Storage of coals that slack readily is unsatisfactory not only because of the loss of the more valuable coarse sizes but also because slacking greatly increases the tendency of coal to ignite spontaneously, owing to the increased surface area exposed.

A laboratory test developed by the Federal Bureau of Mines¹³, in which natural slacking

is accelerated to permit laboratory determination of slacking characteristics, was applied to the Oregon coals. Samples for this test were obtained at each location in the mine chosen for taking the analysis sample, the coal being obtained in the form of pieces approximating 1¼-inch cubes selected from material representing the full minable thickness of the seam. Essentially, the test consists in drying 500 to 1,000 grams of the sample for 24 hours under controlled conditions of temperature and humidity. The sample is then immersed in water for 1 hour and again dried for 24 hours. After the second drying period the coal is sieved on a 3-mesh Tyler standard sieve to determine the amount of degradation in size caused by slacking. The percentage of material passing the 3-mesh sieve, adjusted for the amount of under-size due to normal breakage during screening, is the slacking index.

Table 5
Average Slacking Indices of Oregon Coals

Mine	Bed	Slacking index, ¹ percent
Gilbert	Unnamed	29.4
Southport	Southport	24.9
Thomas	Beaver Hill	50.1
Overland	do	37.7
Alpine	Riverton	66.8
Riverton Prospect	Unnamed	6.4

¹ Average of 2 to 4 determinations.

Slacking indices for the Oregon coals, shown in table 5, range from a low of 6.4 percent for the Riverton prospect to a maximum of 66.8 percent for coal from the Alpine mine. Coals having slacking indices of less than 5 percent are considered nonslacking, and indices of 5 to 15 percent represent coals that slack slightly. Moderate slacking is indicated by indices from 15 to 35 percent, and coals having indices of over 35 percent are strongly slacking.

Experience with subbituminous coals that are strongly slacking indicates that they cannot be stored without excessive degradation in size owing to slacking unless the loss of moisture can be prevented during dry weather. When the relative humidity is high, as during the winter months in western Oregon, storage of these high-moisture coals is more satisfactory. The resistance of a coal to the forces causing degradation in size during mining, transportation, and storage is, in general, well-defined by the laboratory friability and slacking tests.

Low-Temperature Carbonization Assay

A laboratory study of the low-temperature carbonization of Oregon coal was undertaken

¹³ Fieldner, A. C., Selvig, W. A., and Frederic, W. H., Accelerated Laboratory Test for Determination of Slacking Characteristics of Coal: Bureau of Mines Rept. of Investigations 3055, 1930, 24 pp.

to provide information on this method of processing low-rank coals to obtain premium fuel. Duplicates of each analysis sample were retained for this work. Where more than one analysis sample was taken the duplicates were combined in equal proportions to obtain an average sample for the mine.

Low-temperature carbonization of coal may be defined as the heat treatment of coal in the absence of air at temperatures of 450° to 700° C. as distinguished from the usual high-temperature carbonization at temperatures of 900° to 1200° C. The principal aim of the process is to produce a smokeless, easily ignitable solid fuel for domestic use and at the same time to recover a maximum yield of liquid by-products. The solid fuel obtained from coking coals is a coke containing 7 to 15 percent volatile matter and from coals that do not coke a char of similar volatile content. Ordinarily the char, or a major portion of it, depending on the size of the coal originally charged, must be briquetted to convert it into a form suited to domestic use. The usual by-products of gas, tar, and light oil are recovered, but the yield of tar is about twice as high as is obtained in normal by-product coking.

Low-temperature carbonization has been considered an ideal means of converting high-moisture subbituminous and lignitic coals into premium fuels for domestic use; however, much of the cost of the process must be borne by the coke, as the value of the tar and oil is determined largely by the price of fuel oil. Enough inducement to warrant general application of the process on a commercial scale must await possible future changes in the value of the products, both solid and liquid. Only two plants surrounded by especially favorable conditions are now being operated in this country. One is operated by the Pittsburgh Coal Carbonization Co. of Pittsburgh, Pa., and the other is the plant of the Lehigh Briquetting Co. at Dickinson, N. Dak. A detailed discussion of the technical and economic aspects of commercial low-temperature carbonization is not included in this report because these factors have been described in a previous publication of the Federal Bureau of Mines¹⁴.

Details of the low-temperature assay procedure used will be found in a previous publication¹⁵. Briefly, 250 grams of coal crushed to pass 10 mesh is placed in a specially designed aluminum retort, to which are connected in series an ice-cooled tar receiver, a condenser, a glass tube filled with activated charcoal to entrap any tar and light oil mists escaping the condenser, and a gas receiver. The retort is heated to a maximum temperature of 550° C.

and maintained at that temperature for 2½ hours. The distillation products pass from the retort, the oils, tar, and water being caught in the condensing system or the activated charcoal and the gas collected in the gas receiver. Later the water is separated from the oils and tar so that the quantity of the four products of the assay (namely, char, tar and oils, gas, and water) can be measured. The gas is analyzed to determine the constituents present and to enable its calorific value to be calculated.

Table 6 presents the results of the low-temperature assays. The figures for each mine are averages of duplicate assays. The results were calculated to the as-received basis from the air-dry basis on which the laboratory determinations were made.

Agglutinating tests on the original samples indicated that all of the coals are noncoking. This finding was borne out by the assays, for all of the coals produced noncoherent granular chars rather than cokes. In fact, visual examination revealed no difference in appearance between the carbonized char and the original coal. Analysis, however, showed that carbonization effects a decided change in chemical properties. As an illustration, the analysis and heating value of the char produced from the coal from the Thomas mine are shown in the following tabulation, in comparison with corresponding figures for the original coal:

Analyses and Heating Values of Thomas Mine Coal and Resulting Char, As-Received Basis

	Coal percent	Char percent
Moisture	16.9	1.1
Volatile matter	34.6	11.6
Fixed carbon	42.8	77.8
Ash	5.7	9.5
Sulfur	.5	.4
B. t. u. per pound	10,080	13,200

¹⁴Yancey, H. F., Johnson, K. A., and Selvig, W. A., Friability, Slacking Characteristics, Low-Temperature Carbonization Assay, and Agglutinating Value of Washington and Other Coals: Tech. Paper 512, Bureau of Mines, 1932, pp. 61-84.

Table 6
Results of Low-Temperature Carbonization Assay, Calculated to As-Received Basis

Product	Gilbert	Southport	Thomas	Overland	Alpine	Riverton prospect
Moisture in coal, percent	16.4	16.7	16.9	17.9	19.3	10.1
Yield, percent						
Char	55.3	57.3	55.3	55.4	55.0	60.4
Gas	9.1	9.1	9.3	9.7	10.3	10.8
Tar and Oil	11.9	10.9	10.7	8.4	5.8	11.7
Water	24.1	23.0	25.0	27.0	29.0	17.6
Total	100.4	100.3	100.3	100.5	100.1	100.5
Yield, per net ton of coal						
Char, pounds	1106	1146	1106	1108	1100	1208
Gas, cubic feet (wet) ¹	2982	3110	3048	3195	3179	3236
Tar and oil, gallons	28.4	26.1	25.7	20.2	13.8	28.2
Gas analysis, volume, percent ²						
CO ₂	26.4	25.4	23.7	25.7	29.5	30.2
Illuminants	2.5	1.4	3.7	2.5	2.6	3.8
CO	10.3	9.2	11.5	9.8	10.8	6.7

¹⁴Fieldner, A. C., Low-Temperature Carbonization of Coal: Tech. Paper 396, Bureau of Mines, 1926, 46 pp.

Table 6—Continued

Product	Gilbert	Southport	Thomas	Overland	Alpine	Riverton prospect
H ₂	17.7	20.3	15.8	17.9	15.5	13.3
CH ₄	35.1	36.1	36.6	36.0	33.0	33.7
C ₂ H ₆	7.0	5.1	6.6	6.7	6.7	11.1
N ₂	1.0	2.5	2.1	1.4	1.9	1.2
Gross B. t. u. of gas ¹ , ² cu. ft....	609	572	633	611	578	662

¹ At 60° F. and 29.92 inches of mercury.² Calculated to air-free basis.³ Calculated from analysis.

(For other tests, see appendix A.)

A low-temperature carbonization assay of a large sample of coal from the Southport mine, submitted by the State Department to the American Lurgi Corporation in March 1944, gave the following results:

Char —From coal as received	54.4 %
Pitch required to briquette 1 ton Char	82.0 Lbs.
Coal necessary to form 1 ton briquettes	1.84 Tons
Tar Oil—From coal as received	17.00 Gal.
	140.00 Lbs.
	7.00 %
Pitch—(Low Yield)	1.33 Gal.
From coal as received	0.55 %
Oil —From coal as received	15.67 Gal.
	129.00 Lbs.
	6.45 %
Phenolics—(High Yield)	4.30 Gal.
% of Tar Oil	25.30 %
From coal as received	1.77 %
Neutral Oil	11.37 Gal.
From coal as received	4.68 %
Gas—From coal as received	240.00 Lbs.
@ 600 B. t. u. per cu. ft.	6,000.00 Cu. Ft.
	12.00 %
Water and ash	26.6 %

Further quotation from Yancey and Geer is as follows:

As the foregoing results indicate, carbonization eliminates the moisture and much of the volatile matter and in consequence increases the proportion of fixed carbon and ash and materially benefits the heating value. The char, which contains only hygroscopic moisture, is thus a high-quality fuel, easily ignitable, smokeless, and high in heating value. . . . It should be stressed that since all of the coals yield chars rather than cokes, a commercial low-temperature carbonization operation would necessarily have to include provision for briquetting most if not all of the char to render it suitable for domestic use.

Hydrogenation of Coal

By means of hydrogenation—a process in which coal is treated with hydrogen under high temperature and pressure—the products now obtained from petroleum can be produced from coal. Gasoline and fuel oil are being produced on a commercial scale by coal hydrogenation in Germany and England. The hydrogenation process is expensive, however, and liquid fuels obtained from coal are more costly than those derived from petroleum. Consequently, com-

mercial application of the process in this country must await the time when our reserves of petroleum approach exhaustion, thus necessitating a supplementary source for the more expensive liquid fuels. Nevertheless, in anticipation of the time when the hydrogenation of our coals may be required, the Bureau of Mines is testing various ranks and types of American coals to determine their amenability to the hydrogenation process.

A 40-pound sample of coal from the Thomas mine was sent to the Central Experiment Station of the Bureau, Pittsburgh, Pa., for a small-scale hydrogenation test. The coal was hydrogenated for 3 hours in a 1-liter rotating bomb at a temperature of 430° C. and an initial (cold) pressure of 1,500 pounds per square inch of hydrogen. Eighty-eight percent of the coal, on the moisture-free basis, was liquefied, and 12 percent remained as an unliquefied residue. Of this residue, about 5 percent was ash and 7 percent unliquefied coal. Of the 7 percent of unliquefied coal, 5 percent was of such a nature that it probably could have been liquefied had a higher pressure of hydrogen been employed. These tests indicate that this coal would be satisfactory for full-scale commercial hydrogenation.

More detailed information on the hydrogenation of coal and on the procedure employed in this test will be found in previous publications of the Federal Bureau of Mines¹⁶.

¹⁶ Storch, H. H., Hirst, L. L., Golden, P. L., and others; Coal Hydrogenation: U. S. Bureau of Mines Experimental Plant: Jour. Ind. Eng. Chem., vol. 29, 1937, pp. 1377-1380. Fieldner, A. C., Annual Report of Research and Technologic Work on Coal, Fiscal Year 1937; Bureau of Mines, Inf. Circ. 6992, 1938, pp. 37-39. Annual Report of Research and Technologic Work on Coal, Fiscal Year 1938; Bureau of Mines, Inf. Circ. 7052, 1939, pp. 38-44.

Burning Tests

In May 1938, 1-ton samples of coal from Southport and Alpine mines were sent to the Northwest Experiment Station of the Bureau of Mines, Seattle, Wash., for burning tests. These tests were made on an overfeed-type domestic stoker installed in a vertical, six-section, hot-water boiler, such as is used for heating residences. The stoker and boiler, as well as the test procedure, are described in Bureau of Mines Report of Investigations 3379¹⁷.

Two tests were made on each coal, one with the stoker feed-gate set for intermediate rate and the other at maximum rate; however, owing to the coarseness of the two coals, the intermediate rate test on each coal corresponded to the minimum feed rate with other coals previously tested that had been crushed to a smaller screen size.

¹⁷ Yancey, H. F., Johnson, K. A., Lewis, A. A., and Cordiner, J. B. Jr., Burning of Various Coals Continuously and Intermittently on a Domestic Overfeed Stoker: Bureau of Mines, Dept. of Investigations 3379, 1938, 30 pp.

The appearance of the retort and the flame condition in the boiler were about the same with either coal. Both burned with a rather long, yellow, sootless flame, without visible smoke. Smoke-density readings taken during the tests, at the top of the chimney, showed an absence of smoke in all but test 59, during which too small an amount of air was supplied. Even under this condition the smoke density was only 4 percent.

The chief difference in the behavior of the two coals was in the character of the ashes produced. The coal from the Southport mine had an ash-softening temperature of 2170° F. and that from the Alpine mine softened at 2600° F. This difference was shown in the character of the ashes obtained in the tests. The Southport coal formed larger clinkers, which were more completely fused, than did the Alpine coal. The ashes obtained in the test on the Alpine coal were more friable and porous; such clinker as was formed was friable rather than glassy and occurred in smaller pieces than that from the Southport coal.

Inspection of the heat-balance statement shown in table 9 reveals that a rather high recovery of useful heat was obtained with both coals despite their low heating values. An over-all efficiency of 78.2 percent was obtained with the Southport coal when 12.1 pounds was burned per hour. At the maximum burning rate (21.5 pounds per hour) the efficiency of the stoker and boiler was 69.5 percent. These efficiencies do not differ greatly from the corresponding values of 74.9 and 71.3 percent obtained with the Alpine coal.

Substantially the same efficiency could be obtained with either coal. Although the low heating value of these coals naturally limits the rate of heat output obtainable on burning them, they can be used satisfactorily and efficiently for house-heating purposes with equipment similar to that employed in conducting these tests.

No tests of the Oregon coals to determine directly their suitability for use as industrial steam coals were included in this investigation, for this would entail large-scale burning tests in an industrial boiler installation. However, the generalization can be made that similar coals are used successfully in Washington and elsewhere as steam coals. In many instances these coals compete directly with bituminous coals mined in the same or adjacent localities. Tests of 13 Washington coals, including one very similar in character to the Coos Bay coals, in a powdered-coal boiler plant¹⁸ demon-

strated that even coals high in moisture and low in heating value can be utilized successfully with reasonably high efficiency as pulverized fuel. Thus, the properties of the Coos Bay coals and the experience in burning similar coals elsewhere indicate that they probably would be suitable for industrial use as steam coals. Their principal limitation would be their lower rate of heat output, a factor of prime importance only when burning capacity is limited.

Table 9

Principal Results of Burning Tests of Southport and Alpine Coals, Using an Overfeed Domestic Stoker Installed in a Hot-Water Boiler

Coal Test No.	Southport		Alpine	
	58	59	60	61
Feed rate, pounds per hour	12.1	21.5	12.6	21.7
Output, B. t. u. per hour	88,400	137,200	77,900	124,900
Analysis of coal, as fired				
Moisture, percent	17.2	17.1	17.7	18.7
Ash, percent	11.7	12.9	16.4	16.8
B. t. u., per pound	9,350	9,210	8,250	8,080
Ash-softening temperature, °F.	2,170	2,170	2,600	2,600
Heat balance, percent				
Efficiency	78.2	69.5	74.9	71.3
Losses:				
Combustible in ashes	4.6	9.4	7.0	7.2
Combustible in soot	.3	.4	.2	.2
Heat in dry flue gases	7.7	6.7	7.5	10.3
Combustible in flue gases	.0	4.4	.0	.0
Moisture and hydrogen in coal	6.6	6.7	7.0	7.5
Radiation and unaccounted for	2.6	2.9	3.4	3.5
Total	100.0	100.0	100.0	100.0
Excess air, percent:				
Coal fired	73	.3	79	64
Coal burned	82	12	93	77

Summary

This report presents the results of analyses, friability tests, slacking tests, and low-temperature carbonization assays of coals from nine mines and prospects in the state of Oregon. Other laboratory work described includes a washability examination of one coal, a hydrogenation test of one coal, and the burning of two of the coals on an overfeed-type domestic stoker.

... the coals examined are subbituminous in rank. ... None of the coals has coking properties. The Coos Bay coals ... are characterized by a relatively high moisture content, a moderate percentage of ash, low sulfur content, and a heating value of 9,260 to 10,080 B. t. u. per pound, as received.

All of the coals have low friability indices, thus indicating that they will withstand well the forces of impact and attrition that produce breakage and degradation in size during handling.

Slacking tests showed that all of the coals will weather or slack to some extent when exposed to the elements after mining. Most of the coals are classed as strongly slacking and therefore will not withstand storage during dry weather unless the loss of moisture can be prevented.

¹⁸ Wilson, George Samuel, Yancey, H. F., and Daniels, Joseph. Preliminary Tests of Thirteen Washington Coals in a Powdered-Coal Boiler Plant at the University of Washington: Univ. of Washington Eng. Exp. Sta. Bull. 58, 1931, 27 pp.

On low-temperature carbonization in the laboratory the coals yield 16 to 37 percent water, 4 to 12 percent tar and oil, 6 to 11 percent gas having a heating value of 450 to 730 B. t. u. per cubic foot, and 47 to 70 percent char. The char is low in moisture and volatile matter, contains a moderate percentage of ash in most cases, and in general has a high heating value, namely, over 13,000 B. t. u. per pound. In short, it is a high-quality, smokeless fuel. . . .

Under laboratory conditions, 88 percent or more of the dry Thomas coal can be liquefied by hydrogenation, indicating that this coal would be technically suitable for full-scale commercial hydrogenation.

Burning tests of the Southport and Alpine coals on an overfeed-type domestic stoker and hot-water boiler demonstrated that the Coos Bay coals can be burned satisfactorily and with high efficiency on equipment of this type.

Conclusions

The laboratory tests recorded in this report have shown that the Oregon coals, particularly those of the Coos Bay field, are suited to both low-temperature carbonization and hydrogenation processes; however, these methods of utilization, although technically sound, probably are not economically feasible at the present. Their commercial application is reserved for the day when liquid fuels and carbonization by-products will bring a substantially higher price on the market. Thus, Oregon coals, in common with virtually all other noncoking coals, must turn for immediate markets to combustion in their natural form.

The Coos Bay coals are typical subbituminous coals. As such, and as shown by laboratory tests, they are subject to the limitations imposed by their rank. These limitations are principally their relatively low heating value and their tendency to weather or slack if stored during dry weather. They have the advantage, however, of being relatively nonfriable and hence yielding a large proportion of the coarser sizes, which still command a premium in price on the domestic market.

Despite their natural disadvantages, subbituminous coals are mined in considerable quantities in the United States. Moreover, in many instances these coals are marketed successfully in the face of competition from higher-rank coals mined in the same or adjacent localities. In Washington, about 370,000 tons of subbituminous coal were mined in 1938. This coal, much of which is similar in character to the Coos Bay coals, not only supplied local markets but moved into the highly competitive Seattle market where it met competition from bituminous coals. In Colorado, the Denver

region produces over 2½ million tons of subbituminous coal annually. This coal is similar in character to the Coos Bay coals and finds a ready market for domestic heating and steam coal.

Thus, the actual use of similar coals in other parts of the country bears out the conclusion based upon the results of laboratory tests that the Coos Bay coals are suitable for both domestic heating and industrial uses.

Factors Affecting Minability of Coals

Many factors enter into the problem of determining whether a coal prospect may be developed into a mine. Only the physical factors can properly be discussed here; the human problem enters the field of economics, and is discussed in part in a report by M. D. Curran, appendix A. Some of these physical factors are: the character of the coal; the thickness of the coal; the number and thickness of the partings of either clay or bony material; the attitude or dip of the coal; and the competency of the roof and floor rock as well as the cost and availability of timber. Still other physical factors affect the mining costs, such as the cleavage or size of the blocks into which the coal breaks, the amount and distance water must be pumped (drainage), the amount of gas encountered (ventilation), availability of power, the type of mining equipment which may be used, and the distance and difficulty of transportation to the nearest or principal market.

The *thickness* of the coal beds in the Coos Bay area ranges from less than an inch to more than 19 feet, but only the Beaver Hill and Riverton beds have been extensively mined. The Beaver Hill bed has a fairly uniform thickness over an outcrop distance of about 7 miles from the Southport on the north to the Klondike mine on the south. The thickness of minable coal is rarely less than 4 feet and usually is more than 5 feet. In the Newport basin, the thickness was usually over 5 feet in the Libby, Eastport, and Englewood mines. The Riverton bed averages between 3 and 4 feet in thickness.

Attempts to mine coal in thinner beds have been numerous (Wilcox, Belfast, Reservoir, and other mines) but the additional expense of brushing out the roof or floor in order to permit access for miners and equipment has restricted such mining. Attempts to mine thicker beds (Sevenmile, Gilbert, Gibbs) have been unsuccessful because of the steep attitude or bony nature of the coal.

Numerous *partings* in the coal raise production costs, as larger tonnages must be handled to produce a finished, hand-sorted, or washed product. The Steva and Hardy beds on the east side of Coos Bay have adequate thicknesses but they have several bony and clayey partings which make washing and sorting a prerequisite to the production of marketable coal. The Beaver Hill bed contains two partings, one of which must either be left in the roof (with the abandonment of the upper seam of coal) or must be gobbled inside the mine. In portions of the Beaver Hill bed (Overland, and parts of Beaver Hill mines) the lower part of the lower seam is bony and was left as floor. At the northern end of the Newport basin in the Libby, Englewood, and South Marshfield mines, the lower parting thickens appreciably, and in portions of the South Marshfield mine became so thick that it could not be gobbled, and the thick lower bench was left in place.

The *attitude* of the coal beds in the Coos Bay field varies widely. Horizontal or gently dipping beds are present in the Libby, Englewood, Eastport, and South Marshfield mines; dips of 8°-15° are present in the Southport and Smith-Kay mines; 15°-30° in the Alpine and Thomas mines; and 30°-45° in the Delmar, Overland, Martin, Beaver Hill, and Klondike mines.

Almost no mining has been attempted on beds dipping more than 45°, although there are many miles of outcrop of the Beaver Hill bed in the South Slough basin where the coal dips from 50° to 80°. The greatest success in mining appears to have been in the Newport basin where the mine haulage-ways ran along the axis of a relatively flat bottomed basin. In the Beaver Hill mine the dip at the surface was 45°, which decreased gently to 26° at a point 3,000 feet down the dip. The 19-foot bed in Sevenmile Creek dips more than 50°.

The *roof and floor* conditions have frequently determined the minability of the coal. The Beaver Hill and Riverton beds generally have a hard sandstone roof which stands up well. Some of the workings in the old Southport mine have stood for over 50 years with very little timbering and only small amounts of cavings. On the other hand mining on the Steva bed of the lower coal group has been handicapped by the hard-to-hold clay roof commonly encountered. In some mines it has been found advisable to leave the upper bench of coal as a roof. In other mines it has been neces-

sary to gob the upper coal together with the upper parting (South Slough, Panther). The floor usually furnishes little difficulty except at depth. In the lower workings of the Beaver Hill mine it is reported that one of the reasons the mine was abandoned was because of the swelling of the clay floor, which, within an 8-hour shift, often rose 2 or even 3 feet. As a rule it has not been difficult to timber rooms in mines on the Beaver Hill bed, although in the steeper portions of the bed, as at Overland and Martin, light timbering has had to be fairly closely spaced, and the rooms are seldom more than 25-35 feet in width. Mine timbers are readily procurable in the Coos Bay area.

The *cleavage* of the Coos Bay coals is such that at any appreciable depth from the surface the coal usually breaks into large chunks which are relatively resistant to further mechanical breakdown (Yancey and Geer, 1940:25). The ratio between the size splits in mining and sorting as previously done in the Coos Bay area varies greatly, depending upon treatment of the coal. Average limits are probably:

Lump	50-80%
Nut	15-25%
Pea and slack	2-30%

Between 1900 and 1905 the Beaver Hill mine produced 224,517 tons, averaging over 40,000 tons a year for the last three years. During this time about one-third of the minerun was burned for fuel, but the rest was classified, with average size percentage as follows:

	Lump	Nut	Pea	Annual Production
1900	54.5	18.7	26.8	8,603
1901	75.4	21.2	3.4	20,415
1902	69.5	25.2	5.3	25,229
1903	75.5	19.0	5.5	46,399
1904	75.6	15.7	8.7	57,873
1905	80.2	17.7	2.1	63,962
Average	76.5%	18.1%	5.4%	224,517 tons

The *drainage* problem in the Coos Bay area has been unimportant in the past. There is usually adequate surface water for steam plants and for washing coal. The rocks of the region are relatively impervious so that small pumps can take care of the daily inflow in a few hours' operation. Even in the deep Beaver Hill mine beneath Beaver Slough, water was a minor problem. Faults in the mine workings are generally sealed with impervious clays.

Gas in mine workings is not a serious problem. Open flame lamps have always been used in the

Coos Bay mines, and safety lamps have only been used for testing. Explosions have occurred several times in some of the mines but have usually been due to negligence. Gas has been known to collect in the deeper mines which had insufficient ventilation. In the Overland mine it has been customary to keep two or three pipes driven into fissures with flames burning at the ends of the pipes. Adequate ventilation can handle any amounts of gas likely to be encountered.

Transportation conditions are unusually favorable. The Beaver Hill bed, where mining has been most extensive, parallels the highway and railroad from Marshfield south for more than 10 miles, rarely being farther than a mile distant. In the early days the coal in the mines on the northern part of this bed was brought to tide-water on Isthmus Slough and on Coos Bay itself,

and was loaded directly into coastal steamers for shipment to San Francisco. The Beaver Hill and Klondike mines were reached by branch railroads about two miles in length. In more recent years the coal has been trucked to the Coos Bay and other markets, over distances seldom more than 1½ miles from the main paved highway, and two to ten miles on the highway. The building of the Krome road in 1942 to a point within 1½ miles of the South Slough mine may make possible the development of another large body of coal, although it is located nearly nine miles by graveled road from the highway and railroad siding. The mines at the southern end of the basin around Riverton now rely largely upon a local market at Bandon and Coquille, although in the past coastal steamers came up the river to load close to the mine portals.

DESCRIPTION OF COAL MINES AND PROSPECTS

Introduction

The coal mines and prospects are discussed in this section according to their location in the coal basin to which they belong, and are taken up in order, so far as is possible, moving in a counter-clockwise direction around each basin. In this way the relationships between adjacent properties are best brought out and described. For convenient reference purposes, the names of all mines and prospects, including names used in the past but not now current, may be found in the alphabetical index. The term "mine" is applied to those properties which have had some commercial production; the term "prospect" to those which have had no production, although some development work may have been done; and the terms "coal" or "coals" to undeveloped outcrops on a particular bed or groups of beds.

These mines are numbered on plate 1 and are discussed in the following order:

Upper Coal Group

North Bend basin coals

1. Wilcox mine

Newport basin coals

2. Libby mines
3. Englewood mines and project
4. Reservoir mine
5. Flanagan mine

Beaver Slough basin coals (west side)

6. Southport mine and project
7. Thomas mine
8. Maxwell mine
9. Henryville mine
10. Delmar mines
11. Overland mine
12. Martin mine
13. Beaver Hill mine
14. Klondike mine
15. Fahy-Muir coals

Riverton basin coals (south end of Beaver Slough basin)

16. Riverton mine and project
17. Smith-Kay mine
18. Panter mine
19. Lyons mine
20. Sell coal
21. Eureka mine
22. Scorby-McGinity mine
23. Fat Elk Creek coals
24. Cedar Point coal
25. McClain mine
26. Bituminous Coal Company

South Slough basin coals (including Empire)

27. Yokam Point coal
28. Big Creek mine and prospect
29. South Slough project
30. Oldlands mine
31. Vey prospect
32. Empire mines

Coquille basin coals

33. Marsters prospects
34. Lyons mine
35. Albee mine

Undifferentiated Coal Group**East Side coals (Steva and Hardy beds)**

- 36. Hanson coal
- 37. Black Diamond tunnel
- 38. Lone Rock prospects
- 39. Glasgow mine
- 40. Gilbertson mine
- 41. Carlson coals
- 42. Willanch Slough coals
- 43. Ward prospect
- 44. Worth prospect
- 45. Smith mine
- 46. Lillian mine

Catching Slough coals to Coaledo

- 47. Gunnell coals
- 48. Messerle coal
- 49. Huntley coals
- 50. West prospect
- 51. Smith-Powers mine
- 52. Coaledo mines

Sumner basin coals

- 53. Standley coals
- 54. Noble Creek prospects
- 55. Newcastle mines

- 56. Sumner coals
- 57. Ferberish prospect

Lower Coal Group**Sevenmile Creek coals**

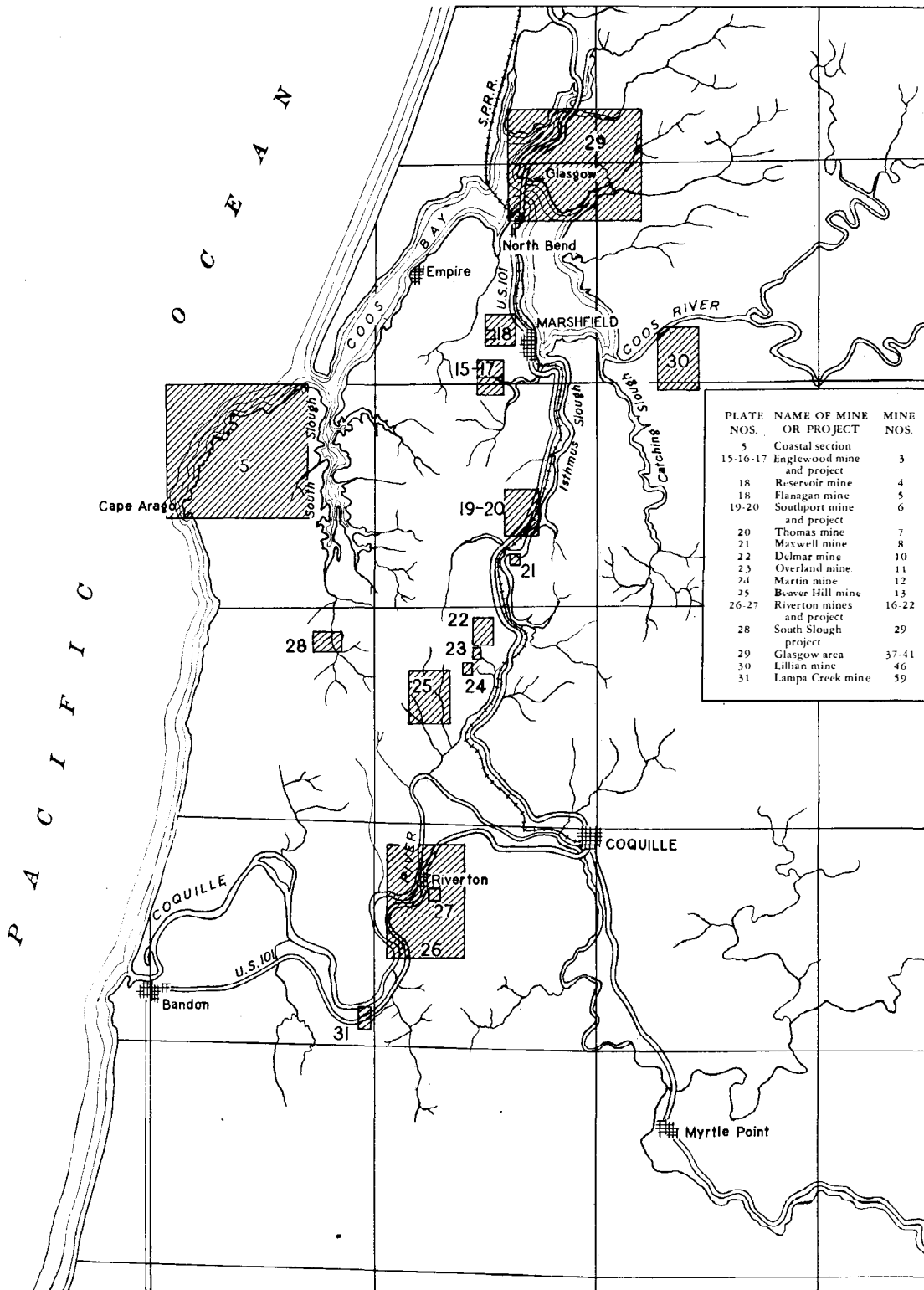
- 58. Hall Creek mine
- 59. Lampa Creek mine
- 60. Donaldson prospect
- 61. Woomer coal
- 62. Sevenmile Creek coals
- 63. Seven Devils coals

Undifferentiated Coal Group

- 64. Archer and Sengstacken coals
- 65. Bunker Hill mine
- 66. Belfast mine
- 67. Caledonia mine
- 68. Davis Slough coals
- 69. "Thirty-Six Coal" mine
- 70. Brown Slough coals
- 71. Stainbeck coal

Other Coals

- 72. Bandon coals
- 73. Lakeside coals
- 74. Remote coals

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Location of detail maps of mines, projects, and areas in the Coos Bay quadrangle.

UPPER COAL GROUP

The coals within the upper member of the Coaledo formation are known as the upper coal group. Of these coals, the Beaver Hill bed is the most prominent. This bed lies at or near the base of the coal group; only one thin bed is known to underlie it in the Newport basin and west of Beaver Hill. Attempts to mine other beds (Henryville, Empire, Gibbs) have in most cases been unsuccessful, the beds being either too thin or too dirty. However, the Riverton or Timon bed which lies several hundred feet above the Beaver Hill has been mined for many years. The upper coal group consists of as many as six or seven coals in a stratigraphic distance of from 600 to 1,000 feet.

The Beaver Hill bed is characterized by three benches of coal, which are about 6, 20 (top), and 30 (bottom) inches thick, although these vary considerably. The lower bench is generally bony in its lower portion. The roof is usually firm, which is not generally true of other upper coals.

Toward the southern end of the Beaver Slough basin, the Beaver Hill bed becomes dirty, although it maintains its thickness (Panter, Lyons). Toward the north end of the basin it splits and the benches are widely separated (Englewood, Reservoir).

North Bend Basin Coals

Wilcox Mine (I)

The old Wilcox mine is located in the face of the bluff just west of Mill B in the town of North Bend, 50 feet west of the highway, in sec. 15, T. 25 S., R. 13 W. The beds dip 35° northwest. Exposures today are much poorer than they were when the property was examined by Diller and Pishel (1911:197) who made the following section of the bluff:

	Feet	Inches
Soil and soft sandstone	12	.....
Shale, coaly	1	6
† Coal, upper bed, mined	1	6
Shale, gray, with shells and leaves	5	.....
Shale, dark gray	4	6
Sandstone, massive	12	.....
Shale .....	.....	4
* Coal, lower bed, mined	1	4
Shale	1	.....
Sandstone, massive	20	11
Coal	2	.....
Shale, gray, nodular	4	.....
Coal, blocked	8	.....
Coal, shaly	2	.....
Shale, dark gray	3	.....
Sandstone	15	.....
Coal, flinty	4	.....
Shale, dark gray	10	.....
Sandstone	6	.....
Total thickness of section	94	10
Total coal in six beds	4	2
Total coal mined in two beds	2	10

† Analysis No. 9126.

* Analysis No. 9125.

The samples No. 9126 and No. 9125 (Diller and Pishel, 1911:225) are as follows:

Lab. No. 9126				
Coal bed (upper coal)	1 ft. 6 in.			
Part sampled	1 ft. 6 in.			
Air-drying loss	17.1			
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	22.5	6.5	.....	.....
Volatile matter	29.5	35.5	38.0	46.0
Fixed carbon	35.2	42.5	45.5	54.0
Ash	12.8	15.5	16.5	.....
Sulphur	2.79	3.36	3.60	4.30
Calories	4,340	5,235	5,595	6,705
B. t. u.	7,810	9,420	10,070	12,070

Lab. No. 9125				
Coal bed (lower coal)	1 ft. 9 in.			
Part sampled	1 ft. 4 in.			
Air-drying loss	14.8			
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	19.6	5.6	.....	.....
Volatile matter	30.0	35.0	37.0	47.5
Fixed carbon	32.6	38.5	40.9	52.5
Ash	17.8	20.9	22.1	.....
Sulphur	5.45	6.40	6.75	8.65
Calories	4,230	4,965	5,260	6,750
B. t. u.	7,610	8,940	9,470	12,150

Diller and Pishel (p. 197) reported that:

The upper coal is 18 inches thick and the lower 16 inches thick. They are 21 feet, 10 inches apart and both are mined from the same opening. The main entry along the coal bed at a point over 400 feet from the entrance has turned somewhat toward the west as if nearing the end of the basin. This structure is also suggested by the position of some of the strata in the hill containing the coal. Samples were taken across the whole of each bed of coal in the mine and the analyses are given in the table, No. 9125 representing the lower coal and No. 9126 the upper coal. The coal is mined with but little waste, and is used for domestic purposes and for generating steam.

The outlines drawn for the North Bend coal field are based on a very small amount of visible data and should be regarded only as suggestive and problematical.

A section was taken by the survey on the coal in one of the open rooms of the Wilcox mine near the surface, where the bed strikes N. 50° E. and dips 30° NW. The section is as follows:

	Feet	Inches
Sandstone	50 feet	.....
Shale	40 feet	.....
Sandstone, coarse	30 feet	.....
Coal, bony .....	.....	1
Coal .....	.....	2
Clay .....	.....	½
Coal, bony		5
Coal	1	6
Shale		
Total thickness of coal	1	8
Total thickness of bed	2	2½

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Plate 14
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A. Two benches of coal at head of Boatman Gulch, Libby.



B. Three benches of coal in Cut No. 56. Englewood project (note sampling channels).



C. Beaver Hill bed at Yokam Point (between men).



D. Power drill at Englewood project.

Newport Basin Coals

Libby Mines (2) (including Newport, Eastport, etc.)

The portal of the old Eastport mine, which was opened in 1855 and was mined extensively until 1881, is located near the section line between the NW $\frac{1}{4}$ sec. 3 and the NE $\frac{1}{4}$ sec. 4, T. 26 S., R. 13 W., at a point about 600 feet south of the section corner at an elevation of about 180 feet (see pl. 15, accompanying Englewood mine report). The workings of this mine adjoin those of the Libby or Newport mine to the south and west, and the Englewood mine to the north. The outcrop has been traced about 3,200 feet around the hillside to the main portal of the Englewood, an airline distance of about 2,300 feet.

An old tunnel of the Eastport mine runs N. 80° W., sloping about 14° on the dip of the coal. A section of the coal bed as exposed at the mouth of the tunnel is as follows:

	Feet	Inches
Sandstone, fine-grained		
Coal		4
Clay parting		6
Coal	4	10
Covered		

According to Goodyear (1877), the workings of the mine at that time extended through the NE $\frac{1}{4}$ sec. 4 into the SE $\frac{1}{4}$ sec. 30 of the next tier of townships. The main entry is reported to have gone in below the outcrop in a westerly direction for 700 feet to the coal, which dips 8° W. Gangways ran north and south from this point. Five or six hundred feet south of the tunnel a slope ran 900 feet west, the coal being almost flat at this point. A number of gangways ran north and south from this slope a distance of 2,000 feet or more. In May 1876, the westernmost gangways ran 250 feet north and 350 feet south of the slope. Later this slope was extended another 700 feet up the west side of the basin.

The Newport mine, later known as the Libby, opened on the south side of Boatman Gulch soon after the Eastport started operation. Goodyear reported that in 1877 a tunnel from the gulch in the north part of sec. 9 ran south for 2,000 feet to daylight, with the lifts of coal nearly 1,500 feet to the east being mostly mined out. In later years the coal on the west side of the basin and north of Boatman Gulch was largely worked out. Diller visited the mines in 1897 and describes both of them as follows (1899:322-328):

The Newport Basin is named from its principal mine, the Newport, at Libby. Its length

north and south from Yokam Hill to the neighborhood of Marshfield is about 3 miles. Excepting the trace of coal at North Bend, no coal has been found north of the ravine containing the Marshfield waterworks, although it is probable that the Newport Basin extends somewhat farther in that direction. The average breadth of the basin is about a mile, and it occupies the greater part of secs. 4 and 9, T. 26, as well as sec. 33, T. 25, besides small portions of several adjoining sections, so that the total area of the coal basin is nearly 3 square miles.

The Newport Basin has only one bed of coal extensively worked. The bed is generally known throughout the region as the Newport bed. It contains about 6 feet of coal in three benches, yielding 5 feet of workable coal. The basin originally contained over 6,000,000 tons of coal, a large part of which was available.

The Newport Basin is well defined, and the outcrop of its coal has been traced more carefully than that of any other portion of the field. It is the most conveniently situated with reference to coal shipment of all the productive portions of the coal field, and the attitude of the strata is such as greatly to facilitate mining. The basin is shallow, with gentle dips on both sides. It lies in a ridge so high above local drainage that the mine not only drains itself, but the coal is readily carried out of the mine by gravity alone. Three mines have been worked in the basin, but only one, the Newport, is now in operation. The Eastport was closed some years ago.

The most complete section of the strata involved in the Newport Basin is furnished by the borings made at Libby in prospecting for coal near the mouth of the Newport mine. One of the borings penetrated 800 feet. . . . Overlying the Newport coal there is about 100 feet of sandstone, in which occurs a small bed of carbonaceous shale containing about 1 foot of coal. This is the only bed of coal known in the southern portion of the basin besides the Newport bed. Fifty feet below the Newport coal is a 5-foot bed of shale containing traces of coal. The deep boring was started at the bottom of the ravine, near the bunkers, about 100 feet below the Newport coal. According to Mr. Campbell, who was superintendent of the Newport mine when the boring was made, it penetrated 300 feet of sandstone and 500 feet of shale without finding any coal. This disclosed the fact that in the Newport Basin it is certain that there is no bed of coal within 900 feet below the Newport.

The Newport mine is operated by Goodall, Perkins & Co., of San Francisco, with Mr. P. Hennessey as superintendent, to whom I am much indebted for assistance while examining the mine. The opening of the mine is in Boat-

man Gulch, which cuts into the coal basin far enough to expose the coal at its lowest point, about 100 feet above sea level. The main entry of the mine may follow the coal along the bottom of the basin, and branching gangways lead from the main entry up the gently sloping (8°) sides of the basin. A stationary engine upon the coal outcropping at the edge of the basin draws the empty cars into the mine, and the loaded cars return to the surface by gravity, arriving at a sufficient elevation to allow for screening and storage before reaching the level of the railroad cars, in which it is taken down a gentle grade to the bunkers on the bay. . . . The mine is so situated as to be operated very cheaply.

The southern end of the basin, under Yokam Hill, has been almost completely mined out. In that direction the bottom of the basin rises and the coal approaches the surface, but does not reach it to form a continuous outcrop of coal around the southern end of the basin. Mr. William Campbell was superintendent of the Newport mine when this portion was worked. He furnished me interesting data concerning the displacements found there . . . the coal runs out against a fault which is inclined to the north at an angle of 65° . On the south side of the fault the coal was found 50 feet higher than on the north side. At the time the faulting took place the coal on the north side slid downward upon the fault plane with reference to that on the south side, . . . The plane of the fault . . . inclines (hades) toward the downthrow, and the fault is a normal one. Before reaching the surface at the southern end of Yokam Hill, the coal is cut off again by another fault. It was probably thrown up as before and is now washed away. The faults of the Coos Bay coal field are generally of the normal type—i. e., they hade to the downthrow, and this rule may be taken as a guide in searching for the continuation of a bed of coal cut off by a fault.

A series of similar faults occurs about the limit between the old and the new portions of the Newport mine, near Boatman Gulch. The largest has a displacement of 50 feet, but the downthrow is on the southern side. The fault hade in the same direction. . . Although the strike of all the faults is approximately the same, lying between $S. 60^{\circ}$ and 90° W., they hade in different directions, and the displacement is generally small. The 50-foot faults already noted are among the largest found in the Coos Bay coal field. This group of faults is closely associated with the principal ravine, and in fact their presence may be taken as the feature which probably determined the development of the ravine at that point. The faults break up the strata and render them

more easily eroded. It has been found to be generally true that near the ravines the coal beds are faulted.

. . . The roof is generally sandstone, but locally shale, and requires comparatively little timbering. Where shale occurs in the roof it is usually full of brackish-water fossils. The top bench is usually left up with the upper parting to form the roof. It occasionally contains small veins of pitch coal, . . . The middle bench contains, within a few inches of its top, a red streak that is quite characteristic of the Newport bed, and is used by some as a means of identifying the Newport bed in various portions of the coal field. The bottom bench is regarded as the best coal at Newport, although it contains a little bony coal at the base. The different benches vary somewhat in thickness, but the triple arrangement extends throughout the Newport Basin, and even a considerable distance beyond, for it is possible to recognize the Newport bed over a wider area than any other one in the Coos Bay coal field, and it is found of much importance in working out the structure of the field . . .

In the Newport mine the main entry is being extended northward along the bottom of the basin into the lowest underground openings of the Eastport mine, which has not been worked since 1881. Eastport mine was operated from the side of the basin through a tunnel of nearly 1,000 feet and an incline of 1,600 feet, reaching not only the bottom of the basin, but ascending the western side a short distance. The incline runs westward, following the coal, first at an angle of 8° , but near the middle of the basin the coal lies flat, with small rolls and faults which render mining more expensive. Gangways were run north and south from the incline, in some cases for nearly 2,000 feet. The coal at the bottom of the basin is softer and not so good as that higher up on the slope. The coal was hauled up the incline, but the water was drained from near the bottom of the basin by a tunnel reaching the surface in Boatman Gulch. To the north the mine was limited by a fault running northwest and southeast, cutting the strata near the mouth of the tunnel, but crossing the bottom of the basin a considerable distance north of the foot of the incline. It is said that the downthrow is on the southern side; but as the tunnel has caved in, evidence concerning this matter could not be obtained. The coal has not been found immediately north of the fault. The Eastport was operated from 1855 to 1881. The property has lately passed into the hands of the company operated at Newport, from which side the mine can be worked most conveniently and cheaply. Although most of the coal has been removed from the southern half of the field, a large part of that in

the northern half yet remains. The bottom of the basin appears to rise gently to the north, giving easy drainage in the opposite direction and forming the most natural outlet for the coal along the same line.

The outcrop of the coal about the northern end of the basin has not been traced so continuously, especially upon the slope of Pony Slough, as around the southern and eastern side. North of the Eastport mine the Newport bed outcrops at the head of Galloway Gulch and swings around to the South Marshfield mine, which is at an elevation of about 200 feet above tide and scarcely a mile from Marshfield. The mine has been worked only for about a year, to supply local demand. One gangway is about 300 feet in length and another 100 feet, and over 600 tons of coal are said to have been removed. The dip is very gentle to the northwest, and the coal rises and falls in low wrinkles about a foot in height, so as to render the mining somewhat more difficult and expensive. The bed is evidently the same as that mined at Newport and Eastport, although on the whole somewhat larger, . . . The three benches are well marked, and in the overlying shales, as at Newport, brackish-water fossils are very abundant. The parting between the middle and lower benches varies in this small mine from 4 to 18 inches in thickness, and contains a thin layer of coal. The middle and lower benches of coal are somewhat thicker than at Newport. The middle bench in places, especially at the head of Galloway Gulch, contains a thin layer of shale about 6 inches above its base. The coming in of this bit of shale in the coal suggests that in the South Marshfield region we approach the limit of the swamp in which the Newport bed was formed. . . .

The only coal bed of considerable size yet found in the Newport Basin as far north as the waterworks west of Marshfield is the one close to the pipe line where it descends the rocky bluff about a quarter of a mile from the reservoir. This coal was long since prospected by two tunnels, one 60 and the other 300 feet in length. For convenience of description this coal is called the Reservoir coal. It strikes a few degrees east of north and dips very gently northwest. . . . The upper bench may be nearly 3 feet thick in places, and contains several thin layers of clay. It has recently been prospected by James Flanagan, . . . The relation of this bed to the Newport bed is important.

At Newport, . . . there is a small coal-bearing stratum 60 feet above the Newport bed, and another containing only a trace of coal 50 feet below the Newport bed. Which of these beds, if either, does the Reservoir coal represent? Judging from its location and position it would appear to lie below the Newport, but

it is quite unlike the shale with a trace of coal found in a similar position at Newport. The distance between the two exposures at Newport and the Reservoir is only about 2 miles, and so great a change in the character of the bed, with the coal increasing away from the center of the coal field, would hardly be expected. No outcrop of coal below the Newport mine has been found between the two exposures, and the borings which are said to have been made on the hill half a mile east of the South Marshfield mine show no coal in that part of the basin for a distance of over 100 feet below the Newport. All these facts tend to show that the Reservoir coal is not below the Newport, but above it, and that there is an east-west fault along one of the ravines between the waterworks and the South Marshfield mine. Although only one small bed occurs, in the Newport Basin overlying the Newport bed, in the Beaver Basin, to be noted later, there are a number of coals within a few hundred feet above the Newport bed, and it is probable that the Reservoir coal is one of these. The reason why the other coals are not found throughout the Newport Basin south of the South Marshfield mine is because they have been washed away from the surface. The basin is too shallow to contain them.

If, as supposed, the Reservoir coal is one of the beds belonging above the Newport bed, then the Newport bed must extend somewhat farther north than Marshfield. The basin and a trace of coal also appear as far north as North Bend, but the thick covering of sand north of Marshfield renders prospecting especially difficult, and it is not surprising that so little coal has been discovered. Valuable information concerning the northern extension of the Newport coal and its relation to the Reservoir coal could be obtained by drilling a few hundred feet near the outcrop of the Reservoir coal.

A glance at the structure map will show that the Newport Basin is the smallest and shallowest basin of the coal field, and is the only one whose bottom lies above the tide level, thus affording a facility for economic mining which none of the other portions of the field enjoy. The reason for this exceptional position is due to its relation to the Westport arch, which is a board one lying between the deeper basins of Beaver and South Sloughs. The broad arch continues southwestward by the head of Davis Slough, where the strata are considerably disturbed. It is possible, but not probable, that there is another small basin, an extension of the Newport, in that region.

Two sections in the Libby mine were taken by M. R. Campbell in 1905: section A was taken from the third gangway west of the bottom of

the basin, and section B from the first gangway west of the bottom of the basin, 900 feet from the bottom of the slope:

	A		B	
	Feet	Inches	Feet	Inches
Coal .....	.....	6	.....	7
Shale .....	.....	9	.....	10
Coal	2	8	2	5
Shale .....	.....	8	.....	8
Coal	2	9	2	4
Total thickness of coal ..	5	11	5	4
Total thickness of bed ..	7	4	6	10

Diller and Pishel (1911:225) gave analyses of these coals as follows:

Lab. No. 2461				
Coal bed at A				
Part sampled				
Air-drying loss				
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	20.8	10.8	.....	.....
Volatile matter	34.0	38.4	43.0	48.1
Fixed carbon	36.8	41.4	46.4	51.9
Ash	8.4	9.4	10.6	.....
Sulphur	1.17	1.32	1.48	2.86
Calories	5,750	6,480	7,260	8,120
B. t. u.	10,350	11,670	13,070	14,620

Lab. No. 2462				
Coal bed at B				
Part sampled				
Air-drying loss				
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	24.9	16.8	.....	.....
Volatile matter	39.8	44.1	53.0	59.3
Fixed carbon	27.3	30.2	36.3	40.7
Ash	8.0	8.9	10.7	.....
Sulphur	.75	.83	1.00	1.12
Calories	4,715	5,225	6,280	7,035
B. t. u.	8,490	9,400	11,310	12,660

The survey made one opening on the Libby bed near some of the old workings in the center of the SW $\frac{1}{4}$ sec. 4, T. 26 S., R. 13 W. The coal crops out in a small creek about 200 feet south of the Libby road just below the summit (pl. 14-A).

The section is as follows:

	Feet	Inches
Sandstone		
Coal .....	.....	10
Parting .....	.....	6
Coal	2	10
Parting .....	.....	4
Coal	2	8
Clay		
Total thickness of coal	6	4
Total thickness of bed	7	2

Undoubtedly there remain some unmined areas in the Newport basin. The extensive nature of the old workings, however, and the lack of any maps or records of old mining operations would make the development of such areas extremely difficult.

Englewood Mines & Project (3) (including South Marshfield)

The Englewood and South Marshfield mine workings are located almost entirely within the SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34, T. 25 S., R. 13 W., just west

and south of the Marshfield city limits, at an elevation of from 90 to 200 feet. The property is owned by the Reynolds Development Company, which mined the Englewood from 1927 to 1932 at a rate reportedly about 40 tons a day. This would give a total production of about 50,000 tons, which agrees closely enough with the 75 acres mined, at 60 percent recovery. The extent of workings and the location of the portals of the old Eastport and South Marshfield mines are shown on plate 15.

The project includes the area lying north of the old Englewood mine which at one time was mined to a small extent from the South Marshfield mine portal. It is located within the NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 34, T. 25 S., R. 13 W., at an elevation of about 200 feet. This is only half a mile west of the end of Elrod Street in southwestern Marshfield. The property is bounded on the north by Mill Slough (or Blossom Gulch) and on the south by the Englewood workings.

The South Marshfield mine began operation in the early 1880's, and when visited by Diller in 1909 little more than an acre of coal had been removed. Although the workings are now caved, it is probable that less than two acres were mined out.

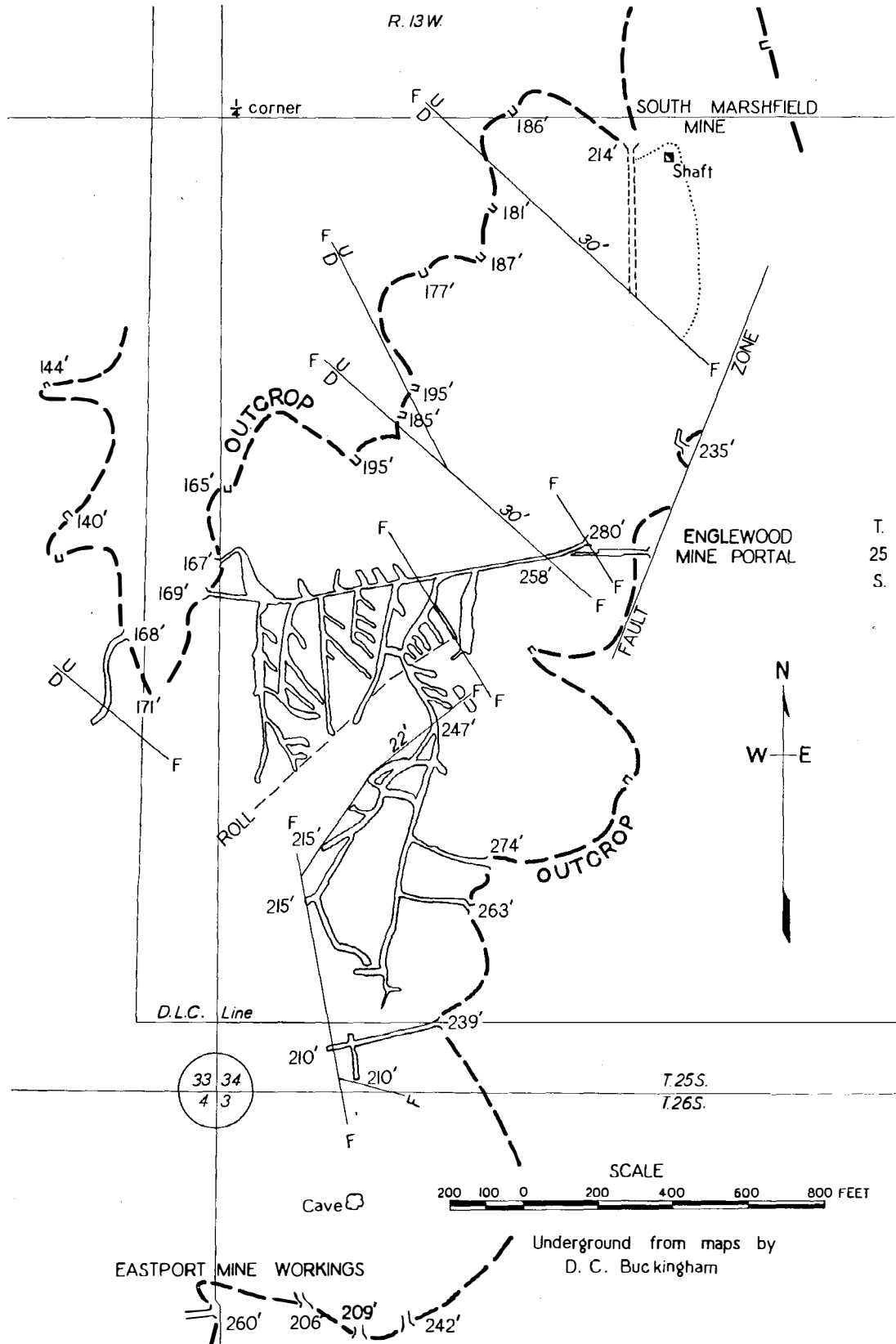
A section of the coal was measured by Diller and Pishel (1911:195) 500 feet in on the main gangway as follows:

	Feet	Inches
Roof, sandstone		
Shale, dark	1	5
Coal, hard, shaly .....	.....	10
Shale, soft, gray, with shells .....	.....	8
Coal, hard .....	.....	2
Shale .....	.....	1
*Coal, good	1	8
Bone .....	.....	1½
*Coal, good .....	.....	5
Shale	1	.....
*Coal	2	.....
Floor, shale, firm, sandy		
Total thickness of coal	5	1
Total thickness of bed	8	4½

He gave a chemical analysis of the sample (*) as follows (p. 225):

Lab. No. 9124				
Coal bed				
Part sampled				
Air-drying loss				
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	20.2	6.3	.....	.....
Volatile matter	33.5	39.5	42.0	48.0
Fixed carbon	36.5	42.6	45.7	52.0
Ash	9.8	11.6	12.3	.....
Sulphur	2.15	2.55	2.70	3.10
Calories	4,865	5,710	6,095	6,955
B. t. u.	8,760	10,280	10,970	12,520

Diller and Pishel (p. 195) also reported a bed of coal exposed in the wagon road near the South



Englewood mine workings and course of outcrop of coal. Old Eastport mine portals at lower left;
South Marshfield mine, upper right.

Marshfield mine, 50 feet stratigraphically below the Newport coal bed, and gave the following section:

In SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 34, T. 25 S., R. 13 W.

	Feet	Inches
Roof, shale		
Coal, bright, lustrous, with conchoidal fracture	10	
Shale	8	
Coal, good	2	
Floor shale		
Total thickness of coal	2	10
Total thickness of bed	3	6

They reported that the extent of this bed is not great; at the Libby mine it is present 50 feet below the Beaver Hill bed, but there it consists of 5 feet of shale with a trace of coal. This is probably the same shaly bed as that examined in the Empire district, which lies about 50 feet below what is believed to be the Beaver Hill bed.

Coal underlies a northeast-trending, relatively flat topped ridge at a depth of 0-70 feet below the crest of the ridge. Twenty open cuts have exposed the coal along the northwest flank. Nine power-drill holes totaling 702 feet, and 66 hand-drill holes totaling 1,200 feet, show the extent of the coal within this area. The ridge has steep sides and is covered with first and second growth timber. It is accessible by dirt road in summer from the end of Elrod Street. A topographic map (pl. 16) indicates the trend of the ridge and gives the elevations of the workings.

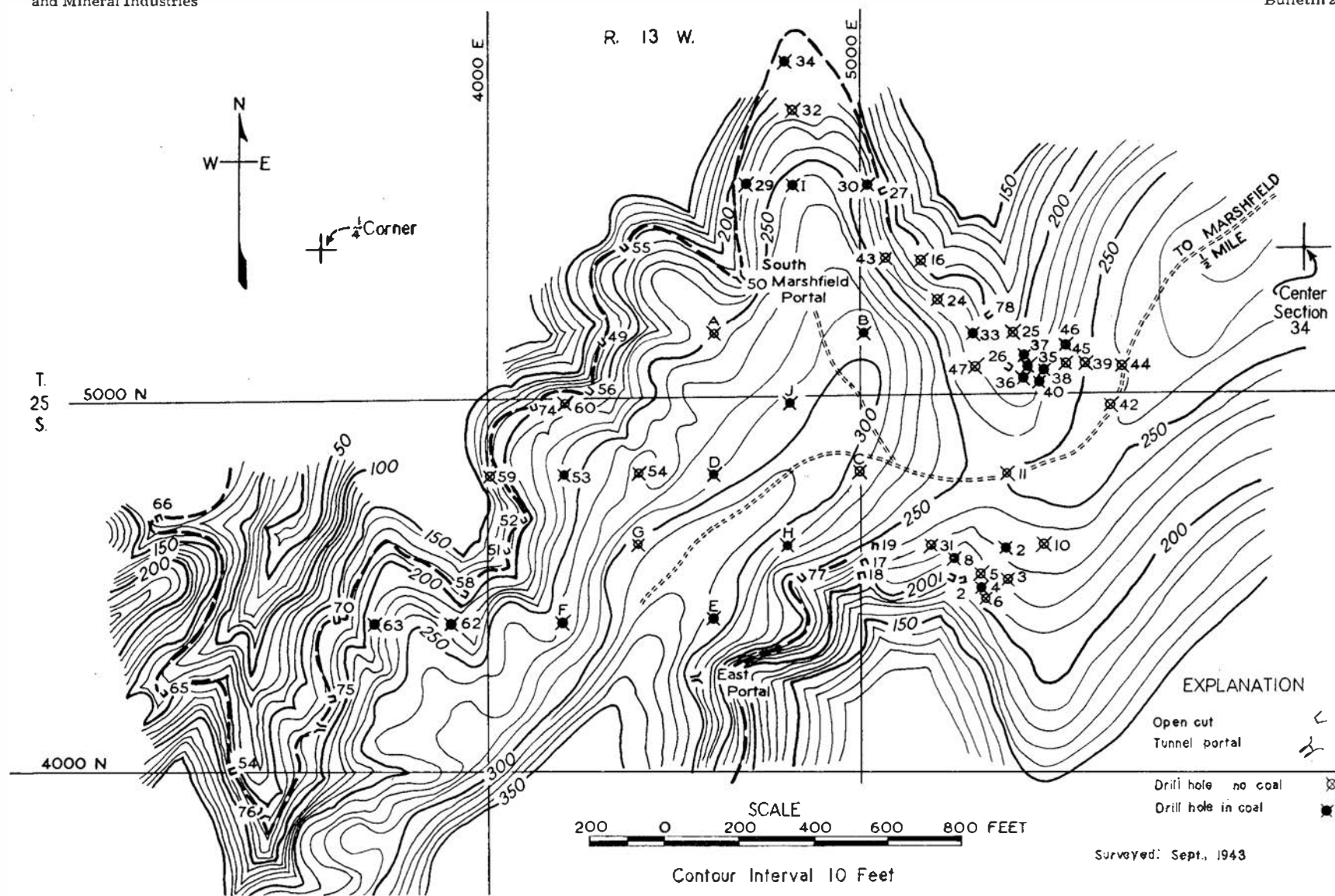
The coal is overlain by hard coarse-grained sandstone which, in a 35-foot shaft at the South Marshfield mine, has stood up well for many years. The coal bed dips 2° -5° to the northwest (see pl. 17-A) and is cut by at least two northwest-trending faults whose southwest sides have dropped 20-35 feet. The eastern border of the coal is limited by a north-trending fault zone which forms a saddle in the ridge. Small patches of coal in this zone are badly disturbed, and, in spite of considerable drilling done, no coal could be measured there. The area east of the fault zone has apparently moved up and the coal has been eroded.

The coal bed ranges in thickness from 5 feet 4 inches to more than 11 feet, and consists of three and in places four benches of coal. The top bench, from 4 to 10 inches thick, was not mined. The main upper bench averages 1 foot 11 inches in thickness and is separated from the lower bench by 10-22 inches of sandy clay which in a few places contains 3-10 inches of coal. The bottom bench averages 2 feet 1 inch in thickness. The total

thickness of coal is about 4 feet for the two main benches or more than 5 feet for all benches.

Sections were measured and sampled in 13 localities and are summarized below, the sections being listed counter-clockwise around the area, commencing at the South Marshfield shaft. Locations are by numbered holes (pl. 16) and by coordinates.

No. 79—5300N.—4750E.		No. 50—5325N.—4650E.	
	Feet Inches		Feet Inches
Sandstone		Clay, sandy	
Shale, carb.	10	Coal	9
Coal, bony	7	Clay, sandy	2
Coal	8	*Coal	1 7
Shale, white	7	Shale, carb.	5½
*Coal	4	Coal	4
Clay	1	Clay, sandy	5
*Coal	2 11	Shale, carb.	4
Shale, carb.	1 4	Clay, sandy	5½
*Coal	2 4	*Coal	2 4
Clay, blue		Clay, gray	
Total thickness		Total thickness	
of coal	6 10	of coal	5
Total thickness		Total thickness	
of bed	8 10	of bed	7 8
No. 55—5475N.—4375E.		No. 56—5650N.—4250E. (See pl. 14-B)	
	Feet Inches		Feet Inches
Clay and peat		Clay, sandy	
*Coal, soft	1 4	Clay, gray	8
Coal, bony	3	*Coal	10
Shale, carb.	10	Clay	4
Coal, bony	2	Shale and coal, broken	6
Shale, carb.	2	*Coal	1 11
Clay, sandy	3 1	Clay	1 3
*Coal	2	*Coal	8
		Clay	11
		*Coal	2 2
Total thickness		Clay	
of coal	3 9	Total thickness	
Total thickness		of coal	5 7
of bed	7 10	Total thickness	
		of bed	9 3
No. 52—4700N.—4095E.		No. 51—4600N.—4043E.	
	Feet Inches		Feet Inches
Clay, sandy		Clay, sandy	
*Coal	10	*Coal	3
Clay	1 4	Clay	1 2
*Coal	1 11	*Coal, soft	4
Shale, carb.	5	*Coal, hard	1 10
*Coal	5	Shale, carb.	9
Clay	1 2	*Coal	5
*Coal	1 10	Clay	1 3
		*Coal	2 2
Clay		Clay	
Total thickness		Total thickness	
of coal	5	of coal	5
Total thickness		Total thickness	
of bed	7 11	of bed	8 2
No. 58—4475N.—4375E.		No. 70—4400N.—3600E.	
	Feet Inches		Feet Inches
Clay, sandy		Sandstone	
*Coal	11	*Coal	2
Clay	1	Clay	9
*Coal	1 11	*Coal	9
Shale, carb.	7	Clay	5
*Coal	5	*Coal	1 4
Shale, carb.	3	Shale and coal, broken	2 3
Clay	1	*Coal, soft	1 1
*Coal	2	*Coal, hard	1 1
Shale, carb.	2		
*Coal	2		
Clay		Clay	
Total thickness		Total thickness	
of coal	5 7	of coal	4 5
Total thickness		Total thickness	
of bed	8 7	of bed	7 10



Englewood project: topography and location of drill holes.

No. 75—4200N.—3600E.

	Feet	Inches
Sandstone		
*Coal	10	
Clay	10	
*Coal	2	
Shale, carb.	2	
*Coal	1	8
Shale, carb.	4	
Clay	8	
Coal, bony	6	
Clay	11	
*Coal	9	
Coal, bony	4	
*Coal	1	7

Total thickness	
of coal	5
Total thickness	
of bed	8 9

No. 76—3890N.—3390E.

	Feet	Inches
Clay		
*Coal, soft	10	
*Coal	6	
Shale, carb.	8	
*Coal	4	
Clay	10	
*Coal	2	2

Total thickness	
of coal	3
Total thickness	
of bed	5 4

No. 64—4000N.—3300E.

	Feet	Inches
Sandstone		
*Coal	9	
Clay	6	
*Coal	10	
Coal, bony	2	
*Coal	1	

No. 65—4420N.—3220E.

	Feet	Inches
Sandstone		
Clay		
*Coal	3	
Coal, bony	8	
*Coal	5	
Shale, carb.	3	

Feet Inches

Shale, carb.	1	3
*Coal	4	
Clay	2	
Shale, carb.	3	
Clay	8	
*Coal	2	4

Total thickness	
of coal	5 5
Total thickness	
of bed	8 3

Feet Inches

Clay, sandy	5	
*Coal, soft	9	
*Coal	1	2

Total thickness	
of coal	2 7
Total thickness	
of bed	8 6

No. 77—4490N.—4830E.

	Feet	Inches
Coal	Not seen	
Clay, sandy	11 1/2	
Coal	2	3
Clay, sandy	8	
Coal	2	2

Clay

Total thickness of coal	4	5+
Total thickness of bed	6	1 1/2+

The analyses of the coals sampled (*) in the foregoing sections are as follows:

Location	Thickness		Analysis			Field No.	Lab. No.
	Sample	Bed	Asa	Moisture	B. t. u.		
Shaft, 5300 N.-4750 E., Elev. 225'	2' 11"		8.4	20.40	(As Rec'd.)	39	
Upper bench.		6' 7"	9.10	7.8	(Air Dried)		
Shaft, Lower bench.	2' 4"		10.8	22.30	(As Rec'd.)	40	
			12.10	11.1	(Air Dried)		
Cut No. 50, 5325 N.-4650 E., Elev. 216'	1' 7"		7.40	19.20	(As Rec'd.)	36	
Upper bench.		6' 9"	8.10	7.7	(Air Dried)		
Cut No. 50, Lower bench.	2' 4"		9.7	19.10	(As Rec'd.)	37	
			10.65	8.8	(Air Dried)		
Cut No. 55, 5475 N.-4375 E., Elev. 186'; (two benches).	3' 4"	7' 10"	13.71	26.24	(As Rec'd.)	46	P-2063
			18.59	15.03	(Air Dried)		
Cut No. 56, 5050 N.-4250 E., Elev. 187'	1' 11"		13.0	21.3	(As Rec'd.)	31	1904
Upper bench.		6' 11"	14.8	11.8	(Air Dried)		
Cut No. 56, Lower bench.	2' 2"		9.9	19.4	(As Rec'd.)	30	1903
			11.0	9.5	(Air Dried)		
Cut No. 56, (four benches.)	5' 7"	9' 9"	11.8	22.5	(As Rec'd.)	23	1898
			13.6	12.5	(Air Dried)		
Cut No. 52, 4700 N.-4095 E., Elev. 195'	1' 11"		7.7	23.6	(As Rec'd.)	26	1900
Upper bench.		5' 9"	9.0	14.1	(Air Dried)		
Cut No. 52, Lower bench.	1' 10"		11.3	20.2	(As Rec'd.)	25	1899
			12.7	10.8	(Air Dried)		
Cut No. 52, (four benches).	5'	7' 11"	8.6	24.3	(As Rec'd.)	28	1902
			10.0	14.8	(Air Dried)		
Cut No. 51, 4600 N.-4043 E.,	1' 9"		6.6	26.7	(As Rec'd.)	33	1906
Upper bench.		6' 5"	7.9	17.4	(Air Dried)		
Cut No. 51, Lower bench.	1' 11"		10.3	20.3	(As Rec'd.)	32	1905
			11.6	10.9	(Air Dried)		
Cut No. 51, (five benches).	5'	8' 2"	11.4	23.5	(As Rec'd.)	27	1901
			13.0	12.9	(Air Dried)		
Cut No. 58, 4475 N.-4375 E., Elev. 195', (five benches.)	5' 7"	8' 7"	7.32	27.7	(As Rec'd.)	29	P-2057
			10.13	17.4	(Air Dried)		
Cut No. 70, 4400 N.-3600 E., Elev. 165', (five benches.)	4' 5"	7' 10"	10.57	31.07	(As Rec'd.)	35	P-2059
			15.42	14.6	(Air Dried)		
Portal No. 75, 4200 N.-3600 E., (five benches.)	5'	8' 9"	7.12	23.64	(As Rec'd.)	34	P-2058
			9.41	10.7	(Air Dried)		
Portal No. 76, 3890 N.-3390 E., (four benches.)	3' 10"	5' 4"	11.92	28.13	(As Rec'd.)	45	P-2062
			16.58	15.4	(Air Dried)		
Cut No. 64, 4000 N.-3300 E., Elev. 168', (five benches.)	5' 5"	8' 3"	7.34	24.85	(As Rec'd.)	43	P-2060
			9.77	13.6	(Air Dried)		
Cut No. 65, 4220 N.-3220 E., (four benches.)	2' 7"	8' 6"	9.03	29.49	(As Rec'd.)	44	P-2061
			12.81	16.8	(Air Dried)		
Tunnel No. 77, 4500 N.-4825 E., Elev. 235';	2' 3"		10.0	16.50	(As Rec'd.)	41	
Upper bench.		5' 1"	10.7	6.0	(Air Dried)		
Tunnel No. 77, Lower bench.	2' 2"		10.9	18.40	(As Rec'd.)	42	
			12.0	9.2	(Air Dried)		
Cut No. 2, 4500 N.-5275 E., Elev. 198'; (one bench.)	2' 1"		7.7	25.20	(As Rec'd.)	38	
			9.20	16.3	(Air Dried)		

The area underlain by coal and proved by drilling totals 26 acres, which should yield over 200,000 tons of coal (pl. 17-B). Ten or twelve acres lying on the southwesterly extension of the outcrop might yield an additional 75,000 tons (inferred coal). On the western edge of the project, the coal was measured in two localities and the upper two benches are separated from the lower bench by 4 or 5 feet of blue sandy clay. It is apparent that this parting is widening rapidly to the north and west, and it is suggested that the coal in the Reservoir mine could be correlated with the lower bench of the Englewood project.

Reservoir Mine (4)

The Reservoir mine was opened in 1889 by James H. Flanagan, in order to supply coal for the city water supply pumping plant, which is located across the hill to the north on Pony Creek. It operated for about 14 years. Two portals of the mine are located just east of the center of the S $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 27, T. 25 S., R. 13 W., on land now owned by the Peoples Water Company, at an elevation of about 125 feet in the north fork of Blossom Gulch.

The two tunnels, about 200 feet apart, were started still earlier by C. A. Merchant, the southern tunnel being about 400 feet long, and the northern 300 feet long (Diller, 1899:326-7). On plate 18 these are located by the coordinates 750 N.-1350 E. of the southwest corner of sec. 27. The block of coal between the tunnels was mined, reportedly producing about 400 tons of coal in the 2 years that the mine was operated by Merchant. The coal is said to have pinched out in both directions, and, as the Flanagan mine (5) was discovered on the opposite side of the ridge to the north, operations were transferred in 1902.

At the north tunnel (800 N.-1400 E.), 30 feet in on the east side, the coal strikes N. 20° E., and dips 20° W. The following section is found:

	Feet	Inches
Shale, gray		
Coal, bony	1½	
Clay, sandy	1	
*Coal, hard	7	
Shale, carbonaceous	1½	
*Coal, hard	1½	
Shale, carbonaceous	1½	
*Coal, hard	1	6
Coal, bony		1
*Coal, hard		6
Clay, gray		5½
*Coal, hard		6
Total thickness of coal sampled	3	2½
Total thickness of bed	4	2½

The analysis of this sample (*) is as follows:

Field No. 47.		
Lab. No. P-2064.		
Location, 30 ft. in north portal; Blossom Gulch.		
Thickness		
Sample	3 ft. 2½ in.	
Bed	4 ft. 2½ in.	
Analysis	As Rec'd.	Air Dried
Moisture	23.59	9.10
B. t. u.	7,981	10,446
Ash	11.45	14.98

In the south tunnel portal (750 N.-1350 E.) on the right side of the cut, striking N. 20° E. and dipping 20° W., the following section is found:

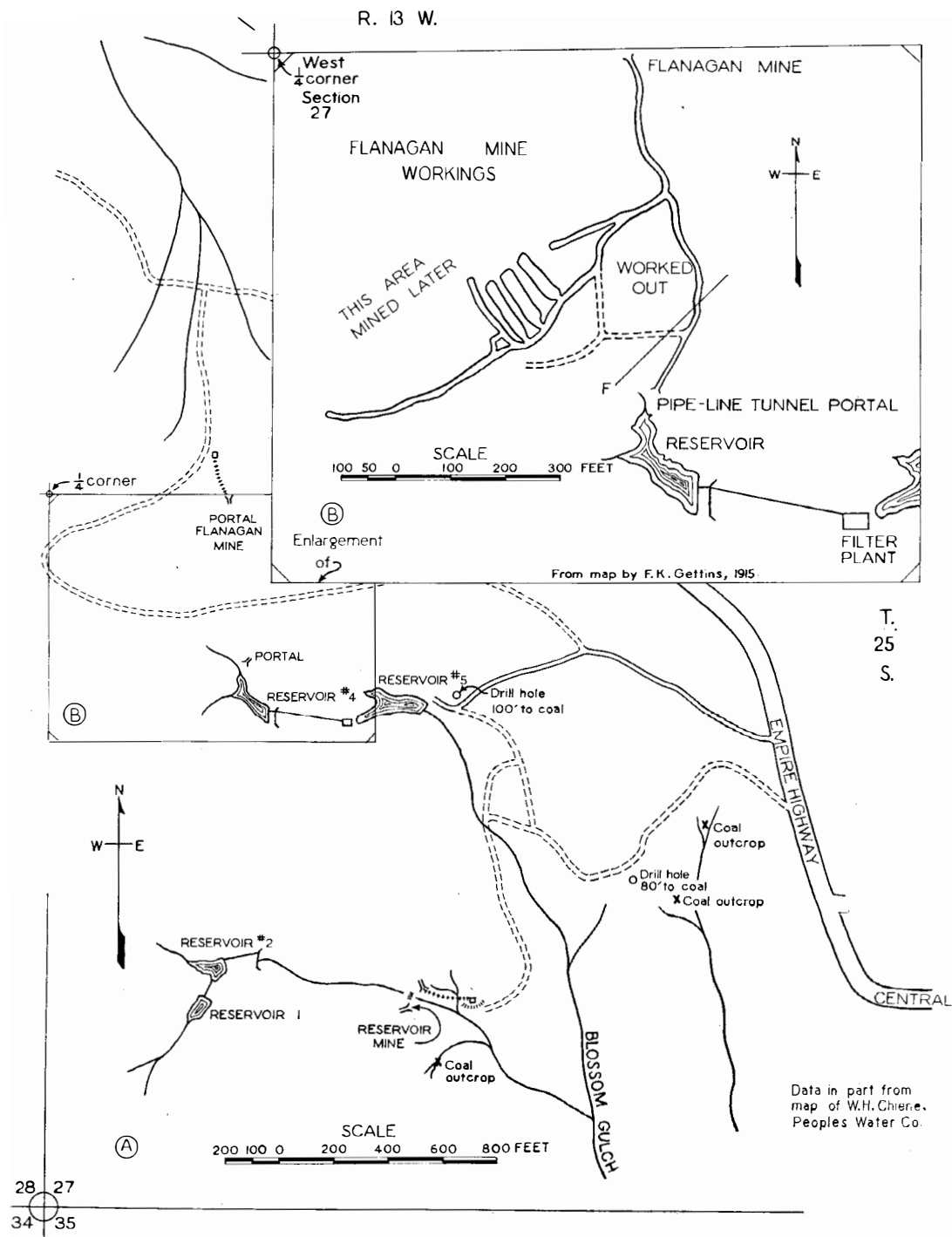
	Feet	Inches
Clay, yellow, sandy		
Coal, bony		1½
Clay, light		2
*Coal, soft		1
Clay, light sandy		2
*Coal		6
Clay, light yellow, sandy		2
*Coal		2
Coal, bony		2
*Coal		6½
Shale, carbonaceous		½
*Coal		11
Shale, carbonaceous		1
*Coal		6
Clay, sandy		5
*Coal		6
Clay, gray		
Total thickness of coal samples	3	2½
Total thickness of parting	1	4
Total thickness of bed	4	6½

Analysis of the coal (*) is as follows:

Field No. 48.		
Lab. No. P-2065.		
Location, South portal, Reservoir mine, Blossom Gulch.		
Thickness		
Sample	3 ft. 2½ in.	
Bed	4 ft. 6½ in.	
Analysis	As Rec'd.	Air Dried
Moisture	25.65	10.87
B. t. u.	7,389	9,538
Ash	10.62	14.28

Another coal bed 2 feet thick exposed in the Flanagan prospect No. 3 in the SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 27 was reported by Diller and Pishel (1911:196) to lie 50 feet below the Reservoir coal. Probably this is the old tunnel which was reopened and sampled by the survey at a point in the gulch 300 feet west of the highway just north of the end of Central Avenue (about 1150 N.-2300 E.). The bed strikes N. 20° E. and dips 20° W., and the section and analysis are as follows:

	Feet	Inches
Sandstone		
Clay		2
Coal and clay		7
*Coal, soft		6
Shale, carbonaceous		3
Coal, bony		4
*Coal	1	1
Clay		2
*Coal		½
Clay		1
*Coal		½
Shale, carbonaceous		
Total thickness of coal	1	8
Total thickness of bed	3	3



Coal mines west of Marshfield on Peoples Water Company property: A, location of Flanagan and Reservoir mines; B, Inset of underground workings of Flanagan mine.

Analysis of this sample (*) is as follows:

Field No. 55.		
Lab. No. P-2070B.		
Analysis	As Rec'd.	Air Dried
Moisture	25.57	10.00
B. t. u.	6,951	9,340
Ash	14.31	15.90

Flanagan Mine (5)

The Flanagan mine operated for about 10 years, from 1902 to 1911, producing coal for the city water supply pumping plant. It is on land owned by the Peoples Water Company, the portal being located 660 feet east of the west quarter-corner of sec. 27, T. 25 S., R. 13 W., at an elevation of about 225 feet (see pl. 18).

According to J. H. Flanagan, after the water company ceased mining, the mine was leased by a Mr. Swanson who continued to mine up the dip to the west, taking the coal remaining between the old workings and the outcrop. The mine has probably produced a total of from 20,000 to 25,000 tons, judging from the area mined, the thickness of the coal, and information supplied by Mr. Flanagan. No coal has been mined below the tunnel level.

The coal strikes almost due north and dips 8° E. A section measured near the portal is as follows:

	Feet	Inches
Clay, sandy		
*Coal, soft	4	
Clay	4	
*Coal, soft	2	
Shale, carbonaceous	3	
*Coal	1	3
Clay		1
*Coal		8
Shale, carbonaceous		1
Clay		2
Shale, carbonaceous		1
*Coal		6
Shale, carbonaceous		1
*Coal		1½
Clay		
Total thickness of coal	2	11½
Total thickness of bed	4	1½

The analysis of the above sample (*) is as follows:

Field No. 49.		
Lab. No. P-2066.		
Analysis	As Rec'd.	Air Dried
Moisture	26.69	11.76
B. t. u.	7,596	10,376
Ash	8.21	11.22

A section given of the coal at the Flanagan mine by Diller and Pishel (1911:196), in the face of the main entry, 700 feet from the entrance, is as follows:

	Feet	Inches
Sandstone		
Shale, firm	4	
*Coal		7
Sand, fine		2
Coal		2
Sand, fine		2
*Coal, good	2	

	Feet	Inches
Sand		3
*Coal, good, hard		6
Sandstone		
Total thickness of coal	3	1
Total thickness of bed	7	10

The analysis of coal (*) from the Flanagan mine is as follows:

Lab. No. 9123				
Coal bed			3 ft. 10 in.	
Part sampled			3 ft. 1 in.	
Air-drying loss			15.3	
Analysis	As Rec'd.	Air Dried	Dry Coal	Pure Coal
Moisture	20.3	5.9		
Volatile matter	34.1	40.3	42.8	51.4
Fixed carbon	32.2	38.0	40.4	48.6
Ash	13.4	15.8	16.8	
Sulphur	1.02	1.20	1.28	1.54
Calories	4,765	5,625	5,975	7,180
B. t. u.	8,580	10,120	10,760	12,920

In an attempt to determine the northern extension of this coal bed, a hole was drilled just north of the main highway at a point a few hundred feet west of the summit in the NW¼ sec. 27. The hole was all in shale and was abandoned owing to caving at 51 feet.

Beaver Slough Basin Coals (West Side)

Southport Mine and Project (6)

The Southport Land and Commercial Company of San Francisco owns about 2,700 acres in T. 26 S., R. 13 W., about 5 miles south of Marshfield on the west side of Isthmus Slough. Of this property about 600 acres in secs. 14, 15, 22, and 23 leased to James H. Flanagan of Marshfield for a number of years, and formerly subleased to Oscar Larson of Coquille, is now operated by the Coast Fuel Corporation.

The two main portals to the mine are located half a mile northwest of the highway and Southern Pacific R. R., about 2,300 feet north and 600 feet west of the section corner between secs. 22, 23, 26, and 27, at elevations of 70 and 95 feet (pl. 20).

The mine was first opened in 1875 on a bed believed by Diller to be higher than the Beaver Hill bed. In March 1877, the main tunnel, then known as the "new mine," had extended N. 18° E. for 600 feet, on the coal bed which here dips about 8° E. This tunnel, which now extends 2,000 feet through the hill, is still open, and until recently was in use (pl. 19). Later the New Southport (Thomas, 7) was opened upon the same bed across the creek to the south, but at this point it resembled the Beaver Hill bed.

For several years the Southport mine maintained a fairly large production, much of which was sent to San Francisco by water from a dock

located half a mile from the mine on Isthmus Slough. It is estimated that about 55 acres has been mined with a total production of about 250,000 tons, assuming a 60 percent recovery of the coal. No adequate production records have been kept.

The mine is located on the east side of a tributary to Isthmus Slough which runs a little east of south. The walls of this valley rise rather steeply to an elevation of about 300 feet, where they level out to form a wide, gently east-sloping surface cut by similar steep-walled valleys which run directly east to join Isthmus Slough. The area has been logged more than once, and most of the timber now standing consists of second- or third-growth fir and alder. The main stream contains adequate water for a small operation at most times of the year and, because it is at tide level, water would be available from the slough to supply a much larger operation. A good gravel road was built in 1943 from the highway to the mine portals by the access roads division of P. R. A.

The main tunnel from which most of the coal has been mined runs 2,000 feet a little west of north from an elevation of about 95 feet at the south portal, coming out in a gulch at an elevation of 255 feet at the north portal (pl. 19). One hundred feet in from the portal a slope was sunk 300 feet northeasterly to a now-caved north gangway, which on the old maps is 1,000 feet long, but which is believed to be closer to 2,000 feet. Fifty feet farther in, another gangway runs northerly for a mapped distance of 1,000 feet although it is also believed to have been approximately 2,000 feet long. Several other gangways have been run off in a northerly direction from the main tunnel. The ground to the west of the southern 1,000 feet of the main tunnel has been mined out to a gulch 300-400 feet to the west. Along the northerly 1,000 feet of its length it has been mined for a distance of about 800 feet to the west of the main tunnel. The old mine has six main gangways with connecting slopes.

During the summer of 1943 Larson began operations on a new slope which is located 250 feet due south of the old portal. This slope runs easterly down the dip for about 200 feet, where one gangway has been turned off. The mouths of two old tunnels are located 450 feet south of this new portal at elevations of 20 and 30 feet. Two attempts were made here to drive in a north-

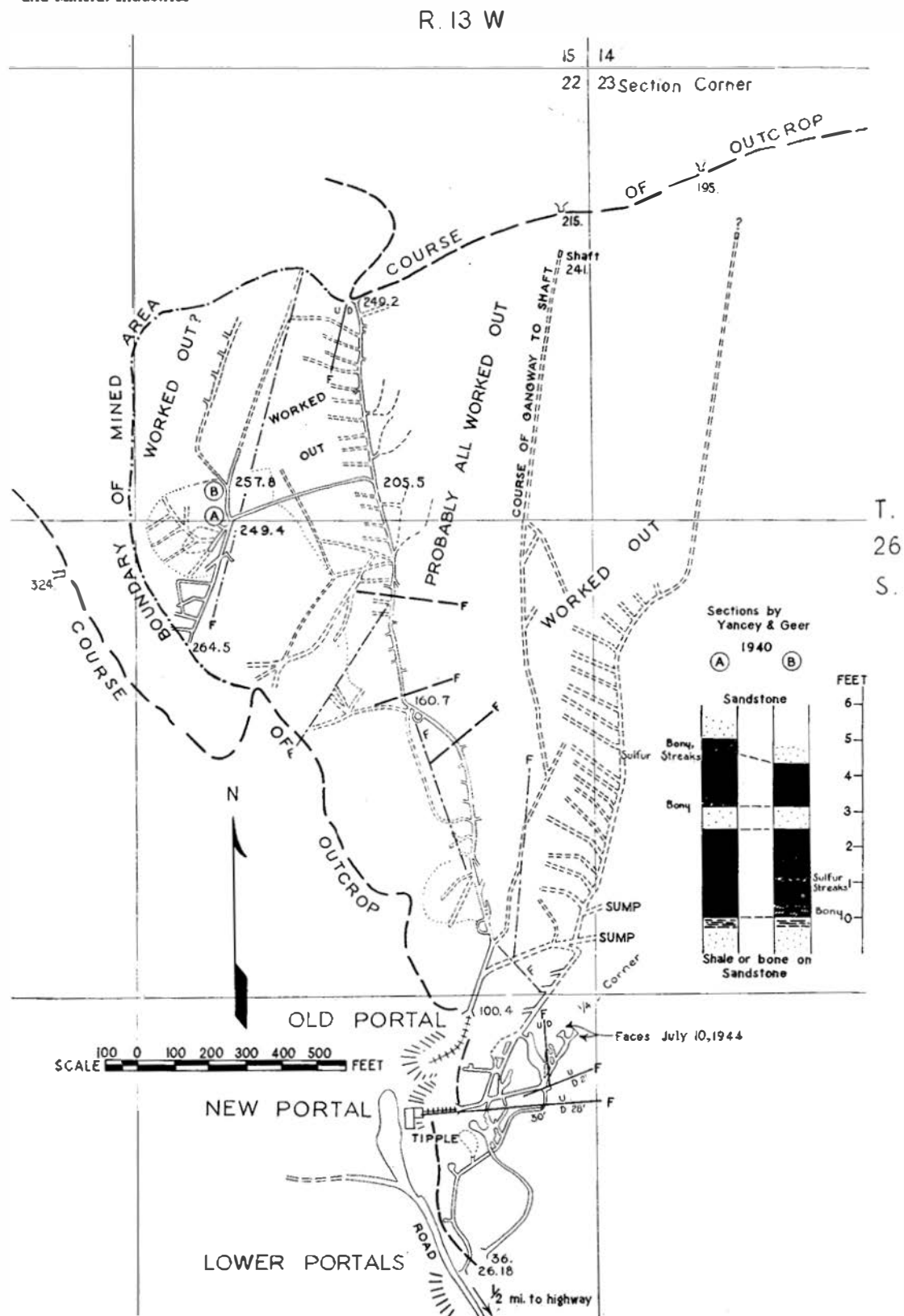
erly direction to hit the coal at a lower level, but an east-trending fault with about 28 feet of displacement was struck and the attempts were abandoned, after some coal south of the fault had been mined. This old tunnel has been tapped through the new slope and is now used for drainage.

On the Thomas property, across the slough slightly west of south, a distance of 600 feet, there is the portal of an old tunnel described later. The coal at the Thomas mine has the full three benches typical of the Beaver Hill bed.

Mining on the Southport property has in the past been done by turning rooms about 35 feet wide with pillars about 20 feet wide between and a wider stump on the gangway. Stulls are occasionally used in the rooms but the roof is strong and relatively few are necessary. Black powder is now being used for breaking the coal but much of the mining has been done with explosives. During past operations trains of two 1-ton cars were taken out through the main entry by two mules. At the present time a small hoist pulls the cars up the new slope. During the last 20 years, production has seldom exceeded 20 tons a day but the present operators plan to raise this to 200 tons a day.

The Southport coal bed is the same as the Newport or Beaver Hill bed. In most of the mine the coal consists of only two benches, the upper 28 to 32 inches thick, being separated from the lower 20 to 30 inches of coal by 6 to 10 inches of clay. Drill logs up the dip to the west show the full three benches. The roof is usually hard coarse-grained sandstone grading into shaly bedded sandstone with a thin 18-inch fossiliferous bed of coal about 25 feet above the main coal. Another thin 6-inch coal bed lies 25 feet above this one. In the westernmost workings the roof was shale.

In the mine workings the coal dips from 6°-15° to the east and southeast. At the south portal the strike is almost north, but farther north it swings gently toward the east, so that the strike is N. 50° E. at the north portal. Minor rolls in the coal do not materially affect mining. There are also small faults with displacement varying from a few inches to 6 or 7 feet. The north-trending faults usually are dropped on the east. There are also a number of small faults trending in an easterly direction. One of these located south of the new slope has a displacement of about 28 feet with the south side down.



Southport mine workings.

The grade of the coal is shown by the following analysis (Libbey, 1938:4):

Lab. No. A90058
Can. No. D896

136

Location in mine: Upper works—in counter or Morrisoul room
2,300 feet from portal (old entry).
(See section A, pl. 19)

Air-dry loss 3.3

Analysis	Air-dried	As received	Moisture free	Moisture and ash free
Moisture	14.4	17.2		
Volatile Matter	34.8	33.6	40.6	45.2
Fixed Carbon	42.1	40.8	49.2	54.8
Ash	8.7	8.4	10.2	
	100.0	100.0	100.0	100.0
Hydrogen	6.0	6.2	5.1	5.7
Carbon	58.0	56.1	67.8	75.4
Nitrogen	1.3	1.2	1.5	1.6
Oxygen	25.3	27.5	14.6	16.5
Sulphur	0.7	0.6	0.8	0.8
Ash	8.7	8.4	10.2	
	100.0	100.0	100.0	100.0

Calorific Value	Cal. B. t. u.	5,678	5,489	6,633	7,383
		10,220	9,880	11,940	13,290

Softening temperature of ash 2,080° F.

Date 6-9-33

It is reported that in the lower workings the coal was still harder and more solid than in the upper workings from which these samples were obtained.

Total reserves of coal from this property are in the order of 1,605,500 tons, of which 272,000 tons consists of the coal west of the old workings which has been drilled on 200-foot centers by the present survey. To the east of the old workings where the outcrop has been traced by hand and power drilling east toward the highway, 433,500 tons is indicated and an additional 900,000 tons is inferred to the south of this block between the old workings and the highway.

A vertical shaft was put down about the turn of the century by the Crescent Coal Company, at that time operating the Maxwell mine. This shaft is located east of the Southport mine and across Isthmus Slough, a few hundred yards north of the Sumner road bridge, near the center of the E $\frac{1}{2}$ sec. 23, T. 26 S., R $\frac{1}{2}$, 13 W., a few hundred feet from the bank of the slough and only a few tens of feet above tide level.

According to Rockwell (1902) this shaft passed through six coal beds; the lowest and best was at a depth of 760 feet. The bed was reported to strike north and dip 12° E. However, reports are at great variance as to whether coal actually was ever struck in this shaft, upon which \$30,000 is reported to have been spent. No coal was ever

mined, and no coal could be found in the dump. Another shallower shaft lies 100 yards farther north.

Thomas Mine (7) (New Southport)

This property, consisting of about 160 acres located in the SE $\frac{1}{4}$ sec. 22, T. 26 S., R. 13 W., across the gulch from the Southport mine, was operated by the Southern Pacific Company about 1914. It is now owned by W. J. Thomas, who was operating on a small scale near the surface in 1943-1944. Coal was originally mined from a 17°-slope running S. 55° E. for 700 feet, with an adit from the gulch below joining the slope at an angle from the east. Other development work on this property consists of a long tunnel driven only a few feet above slough level from the north; a second tunnel trending S. 30° E. from the gulch north of the slope; and a shaft a hundred feet east of the slope, which bottomed before the coal was reached, although it is said that an 18-foot drill hole in the bottom of the shaft reached coal. The Thomas mine is included in the Southport project map (see pl. 20).

The coal, as exposed in recent work by Mr. Thomas, and as determined by shallow drilling, strikes N. 30°-45° E. and dips 13°-16° SE. Near the surface it has a section which may be thickened by slumping, as follows:

Shale, sandy	Feet	Inches
Coal, bony	1	8
Clay		5
Coal, good	2	6
Clay		5
Coal	3	
Clay		9
Coal	1	11
Coal, bony		6
Total thickness of coal	9	7
Total thickness of partings	1	7
Total thickness of bed	11	2

A section of the coal at the Thomas mine (then called the "New Southport") is given by Diller and Pishel (1911:213) as follows:

In SW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 22, T. 26 S., R. 13 W.

Sandstone	Feet	Inches
Coal	1	1 $\frac{1}{2}$
Clay		10
Coal	2	8
Clay		10
Coal	2	7
Sandy clay		
Total thickness of coal	6	4 $\frac{1}{2}$
Total thickness of partings	1	8
Total thickness of bed	8	$\frac{1}{2}$

According to miners who worked in the mine in 1914, the coal is rather badly faulted at depth. A drill hole in the SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 27, near the high-

way, is said to have struck the coal at 800 feet. The U. S. Bureau of Mines hole, located near the section corner 2,000 feet to the east of the main workings, reached a depth of 569 feet without passing through any coal. The attitude of the coal at the mine should carry it to a depth of about 550 feet at this point. It is possible, as is discussed in the section on structure, that faulting has displaced the coal near the highway.

The coal outcrop on the Thomas property was traced by shallow hand drilling of the survey for about 2,300 feet, from the slough on the north to and beyond the crest of the ridge on the south. Farther south it appears to be cut off by the Davis Slough fault. Two thin upper beds were encountered in the 60 feet above the main coal bed. Although the dip of the coal rapidly increases the overburden, it was shown that several tens of thousands of tons might be developed by stripping along this outcrop.

Maxwell Mine (8)

The mine is located in the SW $\frac{1}{4}$ sec. 27, T. 26 S., R. 13 W., on the east side of Isthmus Slough, just half a mile southeast of the mouth of the Davis Slough. The old mine bunkers still stand on the shore, and the mouth of the crosscut tunnel lies in the creek 300 feet to the southwest. The property is now owned by Al Pierce, Marshfield logging operator.

The mine was opened by James Wall before 1900, and operations started during that year and closed down in 1906. In 1902 it was operated by the Crescent Coal Company, with W. H. Maxwell, superintendent. The tunnel at this time was reported by Rockwell (1902) to be 500 feet long. A 300-foot crosscut tunnel trends N. 73° W. to the coal, which strikes N. 15° E. and dips 24° SE. A 300-foot drift trends south along the coal to the main slope from which two gangways were run, one below and one on the haulage tunnel level. The accompanying map (pl. 21) is a composite compiled from information supplied by Evor Rudberg and James Wall, both of whom were familiar with the mine during its operation. The only part now open is the main tunnel in as far as the coal, which was measured as follows:

	Feet	Inches
Shale		
Bone	2	
Shale	7	
Coal, bony	1	1
Coal, clean, blocky	1	3
Clay parting		6
Coal, good	2	7+

Not observed	Feet	Inches
Thickness of coal visible	4	11
Thickness of parting	1	3
Thickness of bed	6	2

This is the Beaver Hill bed, similar to that at the Thomas mine across the slough. In the lower levels, it is reported that the 1 foot 1 inch of bony coal becomes good coal, and that the two benches total over 5 feet in thickness.

At the mouth of the tunnel, about 95 feet stratigraphically above the main coal, is an upper bed consisting of:

	Feet	Inches
Shale		
Coal		10
Clay parting		8
Bone	1	4
Sandstone		
Total thickness of coal		10
Total thickness of parting	2	
Total thickness of bed	2	10

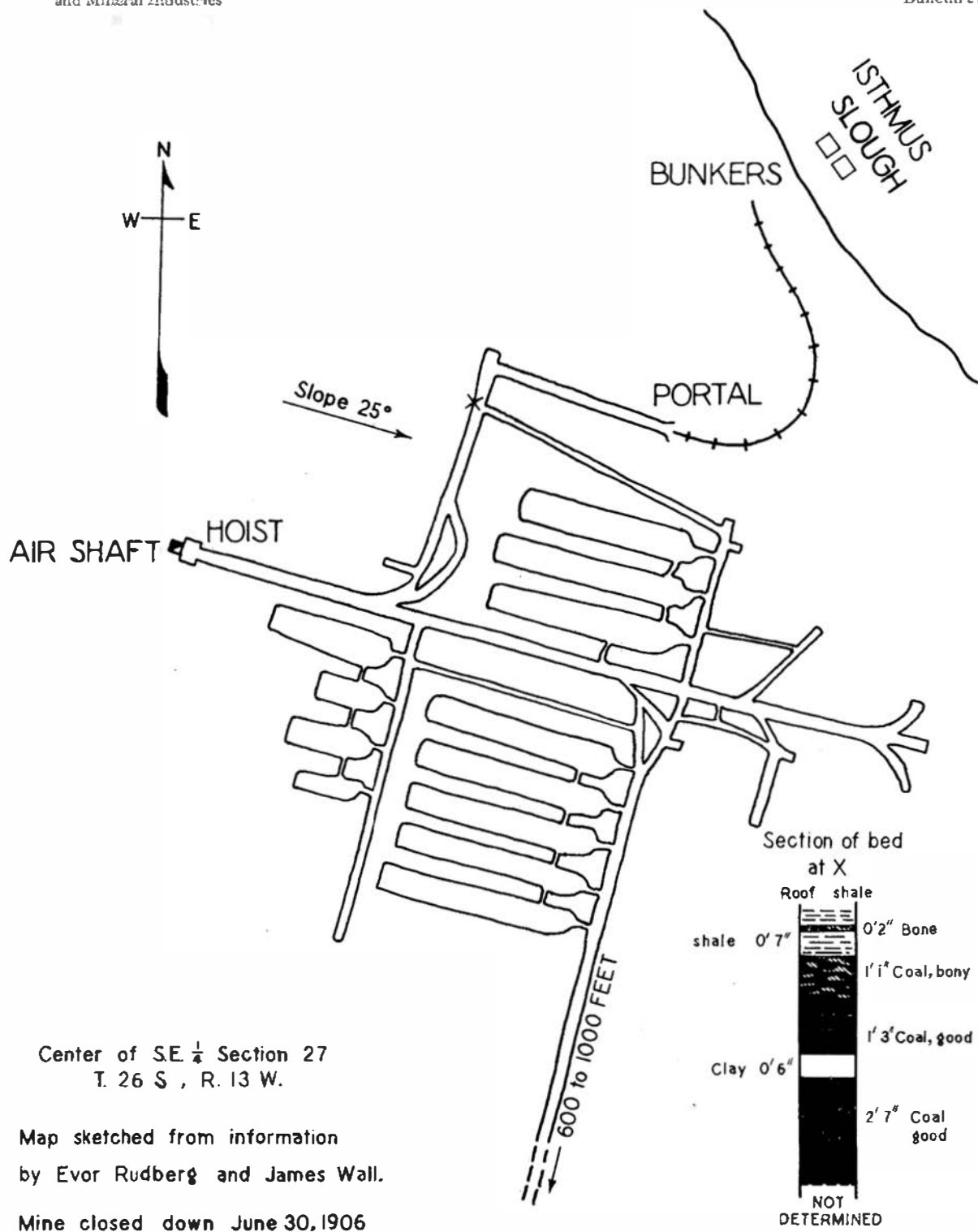
According to Charles Sneddon, who worked in the mine, only 1,000 tons was mined, but other reports state that all the coal was mined above the water level tunnel, and the maps drawn by Rudberg and Wall indicate that the production must have been at least four or five times this amount. Reports vary as to the reason for closing down. Very heavy ground was certainly encountered as the bed was mined southward. The slope was then extended to 300 or 400 feet. The ground was reported to stand well at these depths, requiring no timber. Reports, while not consistent, indicate that the mine may have closed on account of water difficulties. Other reports say that the difficulties were legal and not natural.

The Beaver Hill bed is not certainly known north of the Maxwell mine on the east side of Isthmus Slough. It is believed to have been faulted down about 700 feet by the northwest-trending Davis Slough fault, and the displaced outcrop appears on the Thomas property. Southward the coal trends across the slough toward the outcrops in Poage Gulch, although the Beaver Hill bed was probably reached at depth in the Henryville shaft.

Henryville Mine (9)

The old Henryville mine is located on the east bank of Isthmus Slough near the center of the E $\frac{1}{2}$ sec. 34, T. 26 S., R. 13 W., about 500 feet from the shore line at an elevation of about 40 feet. All openings were caved in 1943. According to Diller (1899:349):

At Henryville, along the eastern bank of Isthmus Slough, in sec. 34, T. 26, R. 13, there



SCALE

100 50 0 100 200 300 400 500 FEET

Maxwell mine workings.

were once extensive mining operations and several coals were discovered, but none are now open to investigation. The works consist of an incline run down upon the coal, but not quite in the line of its dip, for 1,750 feet. The coal being of poor quality, a better bed was sought by sinking a shaft at the mouth of the incline to the depth of 375 feet, and from this point a boring is said to have been made 180 feet farther. Several additional beds of coal were thus found, and some coal was removed from them by means of the shaft. . . . The mine has long since been closed and there are no exposures of the coal now accessible. The top bed, No. 1, in which the incline was opened, is a large one, but contains little coal of value as compared with the amount of waste material necessary to be removed to obtain it. The coal is reported upon good authority to be about 9 feet in thickness and has the character of what is called the "Big Dirty vein," like the top bed at Dean's. . . . and Beaver creek. . . .

Coal No. 2 in the shaft, 110 feet below the surface, is said to contain 3 feet 6 inches of clean coal without partings. Coal No. 3 appears 265 feet below No. 2 in the shaft, with a reported thickness of 6 feet 4 inches. It contains a 3-inch clay parting 2 feet 4 inches from the top. This bed is regarded by Mr. Campbell and others who saw it as the Newport bed. The still lower bed, reported by Mr. Bowron to be 5 feet 8 inches in thickness, may represent a bed lower than the Newport, but this does not seem probable, for the bed below the Newport, so far as known, is always small. The thickness of the section, as calculated from these measurements, is much less than that determined at Dean's.

The coal is reported to strike north and to dip 10° - 12° E., whereas the slope was sunk obliquely down the dip in a N. 53° E. direction.

According to old-time miners there was only $2\frac{1}{2}$ -3 feet of good coal. Bad faults were struck on both sides of the old slope.

This development is one of the two outstanding examples in the Coos Bay area (the other being the Glasgow or Hardy mine) in which large sums were spent upon uneconomic coal beds. It is reliably reported (Rockwell, 1877) that a total of \$200,000 was expended on this property.

Delmar Mines (10)

(New Henryville, Coos Bay, and Noah Mines)

The Coos Bay mine on the south side of Manning Gulch half a mile west of Delmar was operated intermittently between 1905 and 1920. It is located in the SE $\frac{1}{4}$ sec. 4, T. 27 S., R. 13 W. Plate 22 shows the rather extensive workings, which con-

sist of a 400-foot rock tunnel, a slope more than 1,000 feet long, and gangways on three levels. The coal mined prior to 1916 probably totaled well over 75,000 tons. The lower gangways terminate against faults on both sides of the slope, which limited the operation.

This property was operated as the New Henryville mine (according to a report by G. A. Sielaff made in 1921) from 1914 to 1916 by the Smith and Powers Lumber Company.

The Noah mine, on the north side of the gulch, was active between 1936 and 1938. Several acres of coal was mined by means of a 50-foot rock tunnel which started slightly above creek level and about 1,000 feet of gangway. The production was probably 5,000 to 6,000 tons.

All the above-mentioned workings were inaccessible in 1943. The coal strikes N. 10° E. and dips 30° - 35° E. in the Coos Bay mine, and strikes N. 30° E. and dips 8° SE. in the Noah mine.

Diller and Pishel (1911:212) sectioned an outcrop in Manning Gulch near the Delmar mine, which was mapped as striking N. 45° E. and dipping 30° SE.:

Near west line of sec. 3, T. 27 S., R. 13 W.

	Feet	Inches
Sandstone		
Coal		7
Sandstone		2
Coal	3	2
Clay		6
Coal	1	6
Total thickness of coal	5	3
Total thickness of bed	5	11

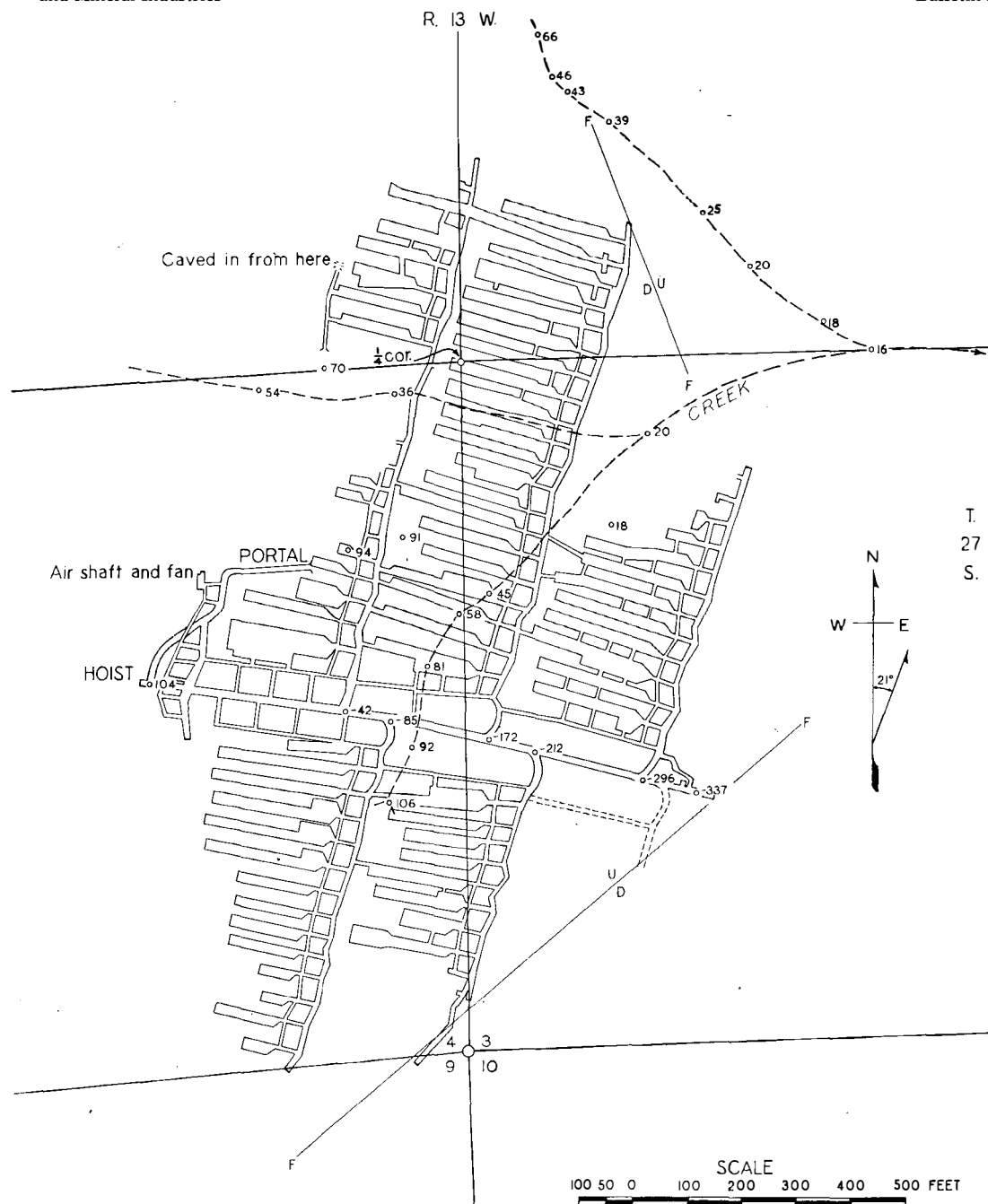
At this place there are two openings on coal beds above the Newport. The lower of these beds has a thickness of 2 feet 8 inches; the upper, known as the Big Dirty coal, shows the following section:

In NW $\frac{1}{4}$, sec. 3, T. 27 S., R. 13 W.

	Feet	Inches
Coal, dirty	1	4
Coal		5
Dirt and coal mixture	1	4
Clay		2
Coal	1	
Clay		1 $\frac{1}{2}$
Coal		6
Total thickness of coal seen	3	3
Total thickness of bed	4	10 $\frac{1}{2}$

The upper bed is called the Big Dirty on account of the numerous dirt seams it contains.

The Big Dirty bed is mapped as striking N. 40° E., dipping 25° SE.

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From map by H.G. Butler, Jan. 1, 1916

Underground survey by L.A. Whereat, 1915

Delmar (Coos Bay Coal Company) mine workings.

A section given for the New Henryville coal in the Sielaff report is as follows:

	Feet	Inches
Sandstone, gray, carbonaceous		
Shale, sandy, dark, carbonaceous	2	
Coal	1	6
Sandstone, yellow, clayey		8
Coal	2	6
Sandstone, yellow		8
Coal	2	
Bony coal, hard, flinty		2
Sandstone, dark, carbonaceous		
Total thickness of coal	6	
Total thickness of parting	1	4
Total thickness of bed	7	8

In 1943 Jess Annis faced up coal 1,000 feet east of the Delmar mine on the north side of the gulch, 200 feet above the road. The coal, undoubtedly an upper bed, is so broken no section could be taken. Analysis of a sample follows:

Field No.	10		
Lab. No.	1606		
Analysis		As Rec'd.	Air Dried
Moisture		32.8%	23.2%
Ash		24.8	

Over the ridge to the north in Poage Gulch a tunnel, now caved, was driven in a southerly direction many years ago by a Mr. Sharp. Farther north the coal appears to cross Isthmus Slough toward the Maxwell mine. The Delmar mine adjoins the Overland to the south.

Overland Mine (II)

The Overland mine in Dunham Gulch lies in the NE $\frac{1}{4}$ sec. 9, T. 27 S., R. 13 W. It is reached by the way of U. S. Highway 101 south from Marshfield 10 miles to a concrete viaduct over the railroad. The mine is 1.8 miles southwest of the highway on a gravel road and 1.3 miles from the railroad near Coaledo.

The mine, owned and operated by Evor Rudberg, Adolph Rudberg, George Chard, and John Anderson, was opened up in June 1932 and has had an average production of 1,800 tons per year since that time. In 1941 and 1942 the production was more than 2,300 tons a year. A fault was encountered in 1944 and development was stopped; operations now consist of robbing pillars and re-treating. The total production is probably close to 20,000 tons.

The old mine workings on the north side of the gulch consisted of an adit 400 feet long, with rooms from 50 to 180 feet up the dip. A still older drift mine, said to have been driven by Dunham, lies farther up the hill.

The present mine workings are 300 yards south, on the south side of the gulch, and consist of a 700-foot slope with two gangways to the south

at 400 and 700 feet down the slope. The lower gangway is at least 2,000 feet long, at about 40 feet below sea level (see pl. 23).

The mine is on the Beaver Hill bed, which here strikes N. 20° E. and dips 30° S. The bed was measured and sampled at two points by M. R. Geer and J. E. Morrison on May 8, 1939, as tabulated below (Yancey and Geer, 1940:9):

	Section A Laboratory No. B-40064		Section B Laboratory No. B-40065	
Roof, soft shale, underlain by 8 in. of bone				
	Ft.	In.	Ft.	In.
Bone (immediate roof)	7	8	7	8
Clay parting, firm	7	6-1/2	7	6
Bone	7	2	7	2
Clay parting, firm	7	1-3/4	7	2
Coal, hard, bright	2	5-1/2	10-1/2	
Nigger head			7	2-1/2
Coal, hard, bright			1	5
Bone, soft	7	2		
Clay mining, firm	7	9	7	10
Bone, soft	7	1		
Coal, some bony	1	3		
Coal, dull				9
Bone				7
Bone (immediate floor)	7	10		7
Floor, shale, overlain by 10 in. of bone				
Thickness of bed	7	3/4	7	1
Thickness in sample	3	8-1/2	3	1/2

⁷ Not included in sample.

Section A was taken at the face of No. 1 room, 100 feet above the first south entry and 95 feet south of the slope; cover at this point was 150 feet. Section B was taken in No. 4 room neck, first south entry, 250 feet south of the slope; cover here was 225 feet. The analysis of a composite sample made by combining samples B-40064 (section A) and B-40065 (section B) is given under laboratory No. B-40066.

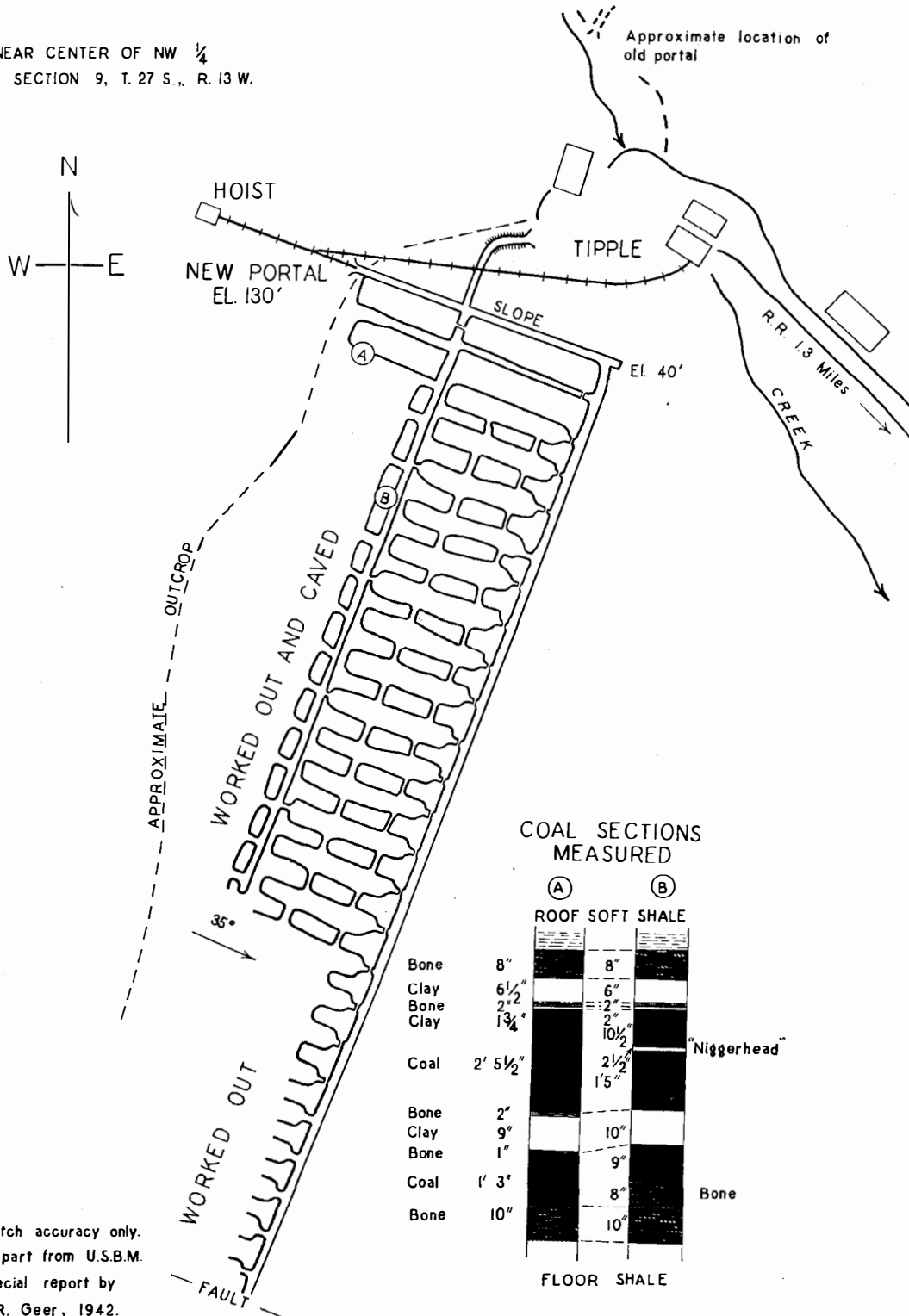
Lab. No. B-40064	As Received	Dried at 105°	Moisture and Ash free
Moisture	16.7		
Volatile matter	35.7	42.8	45.8
Fixed carbon	42.2	50.7	54.2
Ash	5.4	6.5	
Sulfur	.7	.9	.9
Hydrogen			
Carbon			
Nitrogen			
Oxygen			
Air dry loss %	6.4		
B. t. u.	10,150	12,190	13,030
Ash softening temperature	2330° F.		
Agglomerating index	NAa		

Lab. No. B-40065	As Received	Dried at 105°	Moisture and Ash free
Moisture	18.5		
Volatile matter	33.4	41.0	44.8
Fixed carbon	41.2	50.6	55.2
Ash	6.9	8.4	
Sulfur	.7	.8	.9
Hydrogen			
Carbon			
Nitrogen			
Oxygen			
Air dry loss %	7.6		
B. t. u.	9,760	11,970	13,070
Ash softening temperature	1990° F.		
Agglomerating index	NAa		

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NEAR CENTER OF NW $\frac{1}{4}$
SECTION 9, T. 27 S., R. 13 W.



Lab. No. B-40066	As Received	Dried at 105° C	Moisture and Ash free
Moisture	17.9		
Volatile matter	34.4	41.8	45.2
Fixed carbon	41.5	50.7	54.8
Ash	6.2	7.5	
Sulfur	.7	.9	.9
Hydrogen	6.3	5.2	5.6
Carbon	57.0	69.4	75.1
Nitrogen	1.3	1.5	1.7
Oxygen	28.5	15.5	16.7
Air dry loss %	7.0		
B. t. u.	9,960	12,130	13,120
Ash softening temperature			
Agglomerating index	NAA		

Martin Mine (12)

(Thomas Coal Company, Beaver Coal Company)

This mine is located in Garden Gulch, 1 mile from the highway and railroad, in the SE $\frac{1}{4}$ sec. 9, T. 27 S., R. 13 W., at an elevation of about 200 feet. It is about 10 miles south of Marshfield on land referred to by Diller as "Dean and Company's land" (pl. 24).

The coal at the mine strikes N. 40° E. and dips 30° E., on the west limb of the Beaver Slough basin and on the Beaver Hill bed. It lies between the Beaver Hill mine located in sec. 17 to the southwest and the Overland mine in the NE $\frac{1}{4}$ sec. 9 to the north. The mine was operated from 1936 to 1941 by Mr. Zeph Thomas.

According to Yancey and Geer (1940:9):

Room-and-pillar mining is practiced, with rooms turned up the pitch from a drift 650 feet in length driven northeasterly along the strike of the bed. The dip of the bed, 30°, is adequate to allow the use of chutes lined with sheet iron to convey coal from the room face to the gangway. The soft shale roof of the bed must be protected by leaving up about 1 foot of roof coal; and, similarly, bony coal is left as the immediate floor. The remainder of the bed is mined by cutting out by hand and gobbing the center mining seam of bone and clay and then removing the upper and lower benches of coal by pick. Only a little stumping powder is used. From 6 to 10 inches of bony coal and clay underlying the roof coal is taken down with the upper bench and gobbed.

At the tippie the production of the mine, which averaged 10 tons per day in 1938, is passed over 3-inch bar, 1 $\frac{1}{2}$ -inch round-hole and $\frac{3}{8}$ -inch round-hole stationary screens to produce lump, nut, pea, and slack sizes for the market.

The coal was measured and sampled by Geer (Yancey and Geer, 1940:8) at the face of 13 room,

60 feet above the gangway and 600 feet north of the portal:

	Feet	Inches
Shale, soft		
Coal	1	
Clay, firm		4
Coal, bony		1 $\frac{1}{2}$
Clay		1 $\frac{1}{4}$
*Coal	2	10
Bone, soft		2
Clay, firm		8
Bone, soft		2
*Coal, some bony	1	6
Bone		8
Shale		
Thickness of sample	4	4
Thickness of bed	7	6 $\frac{3}{4}$

The analysis given of this sample is as follows (p. 20):

Lab. No. B-40028	As Received	Dried at 105° C	Moisture and Ash free
Moisture	16.9		
Volatile matter	34.6	41.7	44.8
Fixed carbon	42.8	51.5	55.2
Ash	5.7	6.8	
Sulfur	.5	.6	.7
Hydrogen	6.2	5.2	5.6
Carbon	57.5	69.3	74.3
Nitrogen	1.4	1.6	1.8
Oxygen	28.7	16.5	17.6
Air dry loss %	9.1		
B. t. u.	10,080	12,140	13,030
Ash softening temperature	2340° F.		
Agglomerating index	NAA		

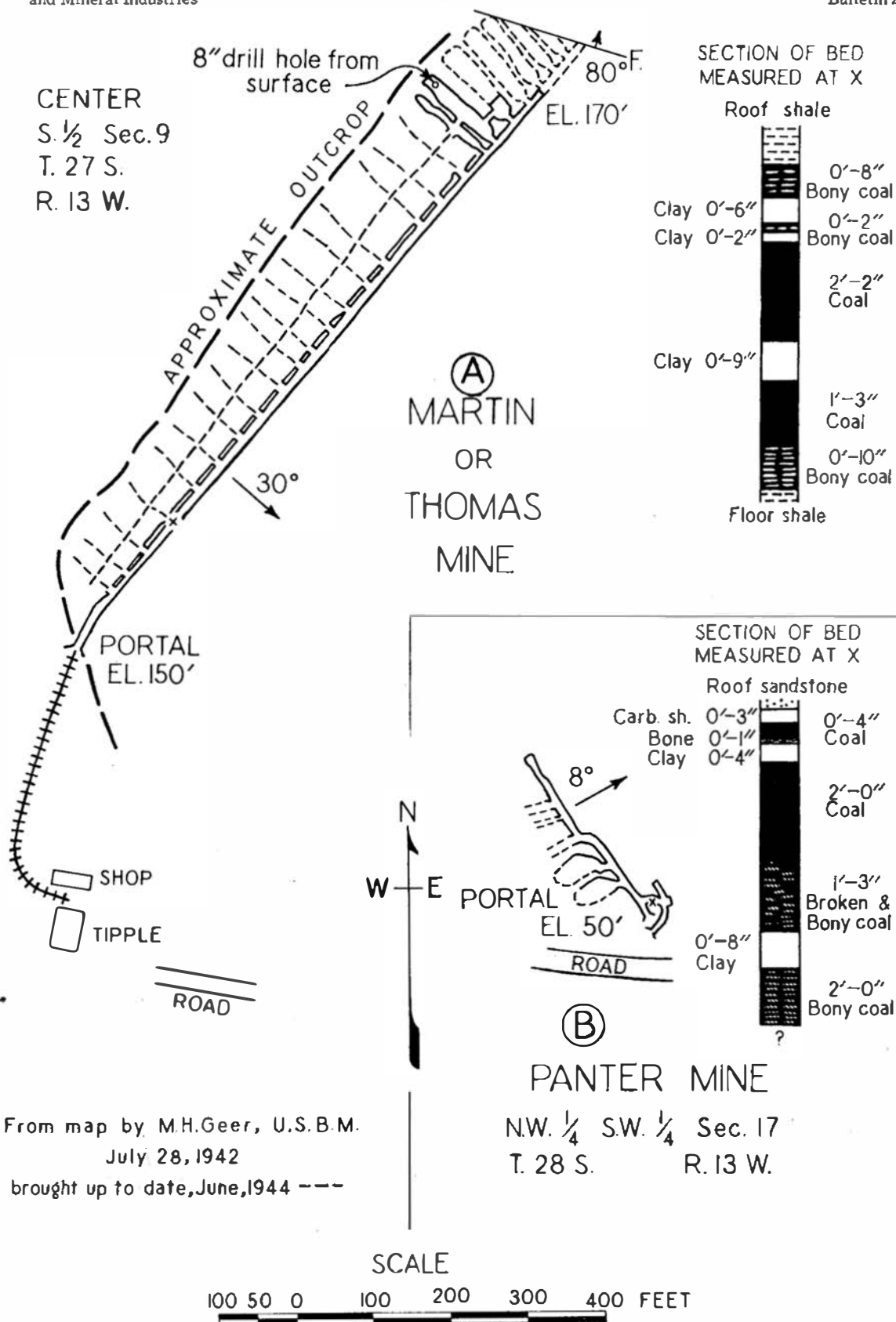
There are six main coal beds exposed in Garden Gulch within a stratigraphic distance of 600 feet, according to Diller (1899:328), who says that, at the time the section was made, "the property had just been thoroughly prospected for Mr. R. A. Graham by a number of miners from Beaver Hill, and the coals opened for inspection." The section of these coals as reported by Diller (p. 329) is as follows:

Section of coals and associated rocks, sec. 9 T. 27 S., R. 13 W.

	Feet	Inches
Sandstone	16	
Shale, carbonaceous	2	2
Sandstone	19	
Carbonaceous shale		5
Shale	23	
Sandstone and shale	1	
Coal	1	2
Shale	3	
Shale and coal seams	2	
No. 6		
12'8"	Coal, slaty	1 3
	Clay, yellow	3
	Coal	3
	Clay	2
	Coal	1 6
	Clay	10
	Shale and coal	1 3
	Sandstone and shale	154
	Coal, shaly	3
No. 5		
3'9"	Sand, shaly	6
	Coal	5
	Shale and coal	7½
	Coal, shaly at base	2
	Sandstone	34
No. 4, 2'	Coal	2
	Shales and sandstones	22
No. 3		
4'9"	Coal	2 3
	Shale and coal, shale at base	2 6
	Sandstone	110

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A, Martin mine workings and coal section; B, Inset. Panter mine workings and coal sections.

	Feet	Inches
No. 2, 1'6" Coal	1	6
Sandstone	44	...
Shale and traces of coal	2	6
Sandstone	51	...
Coal	1	2
No. 1 Clay	...	8
7'5" Coal	2	4
Clay	...	8
Coal, shale at base	2	7
Sandstone	...	...
Total thickness of section	610	2

The No. 1 bed is the Beaver Hill bed; all others lie above it, with the exception of a trace of coal reported some distance below on this property, and also appearing in the Libby and the Beaver Hill mine sections. The Overland and Martin coals were described by Diller (1899:328) as follows:

The section of coal beds most conveniently exposed for examination and measurement is on the land of Dean & Co., in the eastern part of sec. 9, T. 27, R. 13. . . The total thickness of strata is 608 feet, containing 21 feet of coal in six beds, ranging from 1 to 6 feet of coal each, besides three beds of carbonaceous shale containing only traces of coal. Sections of the coal exposed on this property have been made by a number of other individuals, and a much larger number of coals have been reported. At the time the section . . . was made, the property had just been thoroughly prospected for Mr. R. A. Graham by a number of miners from Beaver Hill, and the coals opened for inspection. Detailed sections of the coal beds, on a larger scale, are given on the left of the complete section. Mr. L. A. Whereat, who has more carefully measured from the bottom of the Beaver Hill bed to the bottom of No. 2, found the distance 108 feet or about 5 more than that given in the section.

The most important coal bed is the one at the bottom, which has over 6 feet of coal in three benches, with two small partings. Its general character at once suggests that it is the Newport bed, sections of which have been noted in various parts of the Newport Basin. The reasons for regarding it as the Newport bed are as follows:

(1) It has the same composition, structure, and size, and is unlike any other coal of the same series. The similarity in detail is marked, even to the red streak which occurs 3 inches below the top of the middle bench and the bony coal which occurs at the bottom of the lower bench. Not only the coal but the partings between the beds are quite alike.

(2) It is practically the bottom of the coal series exposed in the two basins. A trace of coal has been found below it on Dean & Co.'s land, as well as at Newport, but no workable bed has been found below it in either basin.

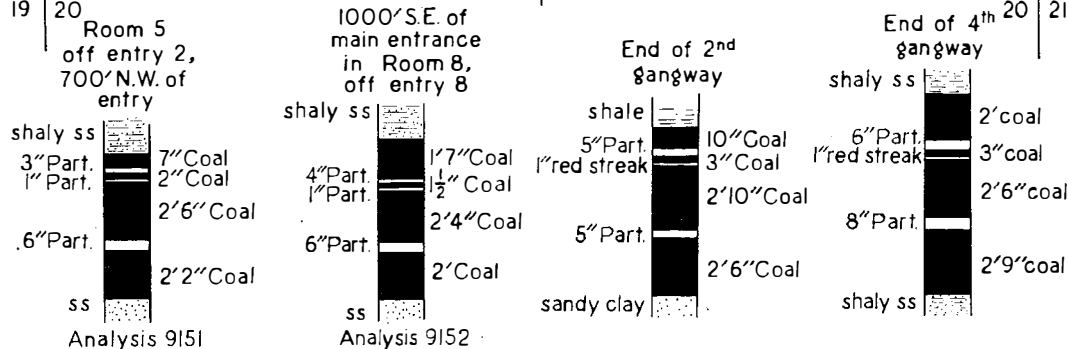
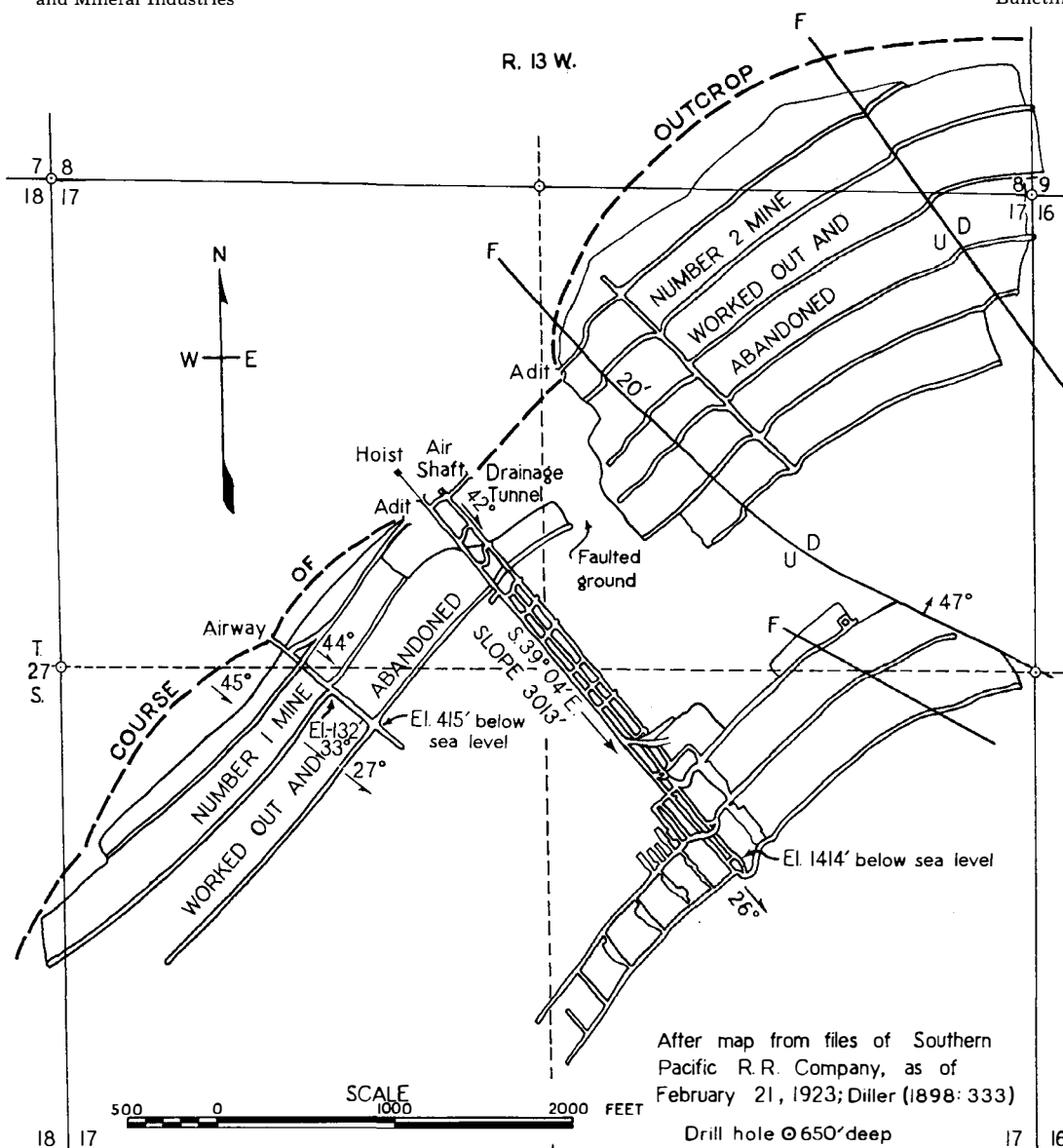
(3) It is in places immediately overlain by a layer of shale containing a multitude of brackish-water shells like those at Newport. This shell bed is not present everywhere in either basin, but is locally present in both.

(4) The general structural relations are such as to show them to be the same bed of coal. The Newport Basin and the Beaver Slough Basin are separated by an arch of the sandstone below the Newport bed. It may be considered as practically certain that the Newport coal bed occurs near the bottom of both basins. It is the bed which is mined at Beaver Hill and Beaverton, where it is locally known as the Beaver Hill bed. It should be remembered that the Newport coal, Beaver Hill coal, and coal No. 1 on Dean & Co.'s property are all the same bed. The overlying coals are sometimes referred to by number with respect to the Beaver Hill.

Beaver Hill Mine (13)

The Beaver Hill mine was opened in the fall of 1894 and operated continuously, except for a short period about 1900 (owing to differences among owners of the property) until it was closed in 1923. At this time increasingly difficult mining conditions in the lower level of the mine coupled with the increased use of oil for locomotives of the Southern Pacific Company, which was operating the mine, led to its shutdown.

The openings to the three Beaver Hill mines are located about a quarter of a mile north and west of the center of sec. 17, T. 27 S., R. 13 W., near the upper end of Caulfield Marsh (see pl. 25). The oldest mine workings, known as the Beaver Hill No. 1 or Graham mine, consisted of a water-level tunnel and two lower-level gangways which extended southwest to the edge of sec. 17. The water-level tunnel goes completely through the ridge to the valley opposite the Klondike mine. Beaver Hill No. 2 consists of water-level gangways that run northeast to the edge of sec. 17. The three upper gangways extend through the southeast corner of sec. 8. Beaver Hill No. 3 lies below the other two mines. The workings consist of gangways running northeast and southwest from a 3,013-foot slope. At the time the mine was closed down there were three north gangways, the lowest extending to the section line, and two south gangways extending to within 1,000 feet of the southern edge of sec. 17. A considerable block of coal remains below the old workings of the No. 1 and No. 2 mines.

Oregon Department of Geology
and Mineral IndustriesPlate 25
Bulletin 27

Beaver Hill mine workings and coal sections.

The Beaver Hill bed strikes N. 40°–60° E., and in the northeast corner of the section it swings around still farther to N. 75° E. The dip at the surface varies from 40° to 45° and gradually flattens downward along the main gangway to 26° in the lowest workings of the mine, some 1,400 feet below sea level.

The roof above the coal consisted of a fairly hard sandy clay which showed some disposition to crumble, but which gave little trouble. The floor in the upper mines was a hard tenacious sandstone but in the lower workings this changed to shale overlain by soft clay, which had a tendency to "swell" and make mining difficult and expensive.

According to Diller (1899:333) there was considerable faulting in the old No. 1 mine; one fault had a throw of 20 feet. Two faults appeared in the No. 2 mine, both striking almost at right angles to the strike of the coal. In the No. 3 mine operations continued northward to one of these faults.

A second bed 200 feet above the Beaver Hill bed was developed by a crosscut tunnel from the slope. This bed was found also near the Klondike mine. It was reported to be 4 feet thick and of good quality in the Beaver Hill mine, but of poorer quality near the Klondike.

The Beaver Hill mine had a large output of coal, probably averaging about 200 tons per day throughout its life. The production was maintained at 500 tons per day for 20 days during March 1905, and one day it reached 600 tons. A record of production between 1900 and 1905, taken from the report of the manager, is as follows:

Date	Lump	Nut	Pea	Fuel	Total
1900	709	244	350	7,300	8,603
1901	4,413	1,237	201	14,600	20,451
1902	7,398	2,665	566	14,600	25,229
1903	25,465	6,420	1,914	14,600	48,399
1904	32,786	6,688	3,799	14,600	57,873
1905	39,570	8,735	1,017	14,640	63,962
	110,341	25,989	7,847	80,340	224,517

At the time of the survey the Beaver Hill mine No. 1 was active, and Diller (1899:331-335) wrote as follows:

Beaver Hill until recently was the point of greatest activity on the Beaver Slough coal basin. I am much indebted to Mr. R. A. Graham, formerly the manager of the Beaver Hill Coal Company, and to Mr. L. A. Whereat, his civil engineer, for assistance while working in that region. The mine is on a branch of Beaver Slough in sec. 17, only 1½ miles southwest of the locality where the section shown in fig. 27 is so well exposed.

(The column in fig. 27 is given as follows:)

	Feet	Inches
Clay		
Coaly shale	1	
Coal	1	2
Clay		1
Coal	1	
Bone		2
Sandstone and shale	32	
Clay and sand		3
Coal	2	1
Bone		5
Sandstone and shale	103	
Coal	2	9
Clay		3
Shale, bone and coal	1	9
Sandstone	200	
Coal	1	5
Parting		6
Coal	2	11
Clay, sandy		6
Coal, shaly sand at base	2	6
Sandstone	180	
Coal	1	6
Sandstone		
Total thickness of section	535	3

Section of coals and associated rocks at Beaver Hill.

The exposures are few, but the prospecting in connection with the development of the Beaver Hill mine has brought to light the series shown in fig. 29. All of the members of the series shown in fig. 27 have not been discovered at Beaver Hill, and exposures are not such in this densely wooded region as to allow their relative position to be readily measured. The entire section of rocks immediately associated with the coal here appears to be about 550 feet, although this may be too high an estimate. It includes 15 feet of coal in five beds, ranging from 1 to 7 feet of coal each. The coal beds have been carefully measured, and sections of them are given in connection with the general section, fig. 29. At the bottom is an 18-inch coal, which is well exposed on the edge of the marsh nearly opposite the bunkers of the Beaver Hill mine. This small coal may represent the trace of coal reported below the Beaver Hill bed on Dean & Co.'s property, and also the trace of coal found in the 5-foot shale below the Newport bed at Newport. There can be no doubt as to its position with reference to the Beaver Hill bed at Beaver Hill, for both are exposed near together on the same side of the marsh.

None of the beds indicated in fig. 29 overlying the Beaver Hill bed are mined at Beaver Hill. Their outcrops occur within a mile southwest of the Beaver Hill mine, and their correlation with beds 3, 4 and 5 of the Dean & Co's coals (fig. 27) is probable.

The only coal mined at Beaver Hill is No. 1, and it is regarded as one of the best coals in the whole field. The Beaver Hill bed, as already indicated, is the same as the Newport bed. . . . An adit . . . runs in upon the coal, and at a distance of 980 feet from the mouth an incline follows the coal, dipping southeast toward the

basin. The incline has a length of 732 feet, and reaches to a depth of 415 feet below sea level. From the incline there are two sets of gangways; one at 132 feet, another at 415 feet below sea level. The dip of the bed of coal near the surface is 45°, but decreases as the depth increases. In gangway No. 2 it is 44°. In the upper part of the chute, between the second and fourth gangways, it is 35°, and in the lower part of the chute it is only 31°, while along the fourth gangway, 415 feet below the surface, it averages about 27°. The associated rocks are rather soft, and as the pressure upon them rapidly increases with the depth, the pillaring and timbering of the mine are matters requiring much attention.

There is comparatively little variation in the Beaver Hill bed as it appears in the mine. . . . At some points upon the last level gas appeared, so that safety lamps had to be used. . . .

The gangways extending northeast from the incline encounter faults as they approach the Caulfield marsh. The faults produce so much disturbance that it is not economical to follow the coal through under the marsh to the hills beyond. Judging from the position of the Beaver Hill bed upon the northeast side of Caulfield marsh, according to Mr. Whereat's measurements, there must be a displacement of about 200 feet in this branch of the marsh, which leads up to Caulfield Gulch. Probably there are several faults, rather than one of so great a throw. On the northeast side of the Caulfield marsh a tunnel is run in upon the Beaver Hill bed for 1,000 feet, and in its course two faults were encountered, the first a normal fault of 20 feet with the downthrow on the northeast side, while succeeding that there was a jump up of 6 feet. Both these were quite near the marsh. After leaving the marsh by a considerable distance the faults seem to disappear. The association of ravines or sloughs and faults, both at Beaver Hill and Newport, strongly indicates that the presence of faults determines the places of the ravines. . . .

As all of the readily available coal from the Beaver Hill incline has been removed, that portion of the mine, being badly squeezed, has been abandoned, and a new tunnel run in nearly 1,000 feet on the northeastern side of the marsh. Work has lately ceased at this point also.

In prospecting to determine the position of the coals nearer the axis of the Beaver Slough Basin, two drill holes were sunk near the border of the marsh; one about three-fourths of a mile and the other 1½ miles, southeast of the mine. Both were close to the marsh but upon opposite sides. The sections reported by Mr. Whereat are given below:

Section A.—Record of drilling at a point 1,400

feet west and 210 feet north of corner of secs. 16, 17, 20, 21.

	Feet
Sandy clay, surface deposit	48
Coarse sand	3
Gray shale	15
Gray sandy shale	27
Gray sandstone	2
Gray sandy shale	84
Gray lime shale	11
Gray limestone and fossils	3
Gray lime shale	10
Dark-gray lime shale	15
Dark-gray shale	32
Gray soapstone	22
Gray shale	170
Gray shale and "nigger-heads"	14
Gray limestone	2
Gray shale	59
Conglomerate	11
Sandstone	48
Gray shale	34
Very coarse sandstone	5
Coarse sandstone and partings of coal	5
Sandstone and partings of coal	30
Total	650

Section B.—Record of drilling at a point 1,500 feet south and 370 feet east of same corner.

	Feet
Yellow clay shale	14½
Blue shale	5½
Blue shale and fossils	20
Hard sandstone	1
Blue shale	1
Blue shale and fossils	24
Limestone and fossils	2
Blue shale	139
Sandstone	44
Conglomerate	30
Brown shale	4
Conglomerate	15
Sandstone upper 27 feet very soft, with little or no core	65
Sandstone with sandy shale mixed	17
Sandy shale	81
Gray slate	62
Gray shale and fossils	15
Soft limestone	1
Hard, gray, fine-grained sandy shale	2
Total	543

The strata passed through are similar to those exposed along the railroad between Beaver Hill at the Junction, as well as along the main line from near Marshfield to Coquille.

Judging from the position of the coal in the Beaver Hill mine, it is probably at least 650 feet below the bottom of Section A and but little greater distance below Section B, because, although half a mile farther away from the mine, an arch of the strata brings it toward the surface. These sections show conclusively that overlying the group of coal beds . . . there is an extensive series of light-colored shales and sandstones, the upper part of the Coaledo formation, among which there are no coal beds of economic importance. These strata, so well exposed along the railroad and wagon road from Coquille to Beaver Hill and Marshfield, vary greatly in position, especially in the middle portion of the basin from Cedar Point to the divide, a mile beyond Coaledo. They have doubtless been thrown into small folds or wrinkles by being compressed within the arms of the larger

basin. If the coals were near the surface in the basin they would be much affected by these wrinkles, but as they lie beneath a considerable thickness of beds, their position is, in all probability, less variable.

Two sections and analyses of the coal in the Beaver Hill mine were later given by Diller and Pishel (1911:220):

No. 9151—NE $\frac{1}{4}$ sec. 17, T. 27 S., R. 13 W.

	Feet	Inches
Shale, sandy		
*Coal	7	
Parting	3	
*Coal	2	
Parting	1	
*Coal	2	6
Parting	6	
*Coal	2	2
Sandstone		
Total thickness of coal	5	5
Total thickness of bed	6	3

Sample 9151 (*) was analyzed as follows (Diller and Pishel, 1911:226):

Lab. No. 9151				
Coal bed			6 ft. 3 in.	
Part sampled			5 ft. 5 in.	
Air-drying loss			7.0	
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	14.3	7.8		
Volatile matter	34.4	37.0	40.2	44.4
Fixed carbon	43.2	46.5	50.4	55.6
Ash	8.1	8.7	9.4	
Sulphur	.74	.80	.86	.96
Calories	5,350	5,750	6,240	6,885
B. t. u.	9,630	10,350	11,230	12,400

No. 9152—NE $\frac{1}{4}$ sec. 17, T. 27 S., R. 13 W.

	Feet	Inches
Shale, sandy		
*Coal	1	7
Parting		4
*Coal		1½
Parting		1
*Coal	2	4
Parting		6
*Coal	2	
Sandstone		
Total thickness of coal	6	½
Total thickness of bed	6	11½

Sample 9152 (*) was analyzed as follows (Diller and Pishel, 1911:226):

Lab. No. 9152				
Coal bed			6 ft. 11½ in.	
Part sampled			6 ft. 1½ in.	
Air-drying loss			8.1	
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	16.1	8.7		
Volatile matter	31.1	33.8	37.1	44.0
Fixed carbon	39.6	43.2	47.2	56.0
Ash	13.17	14.33	15.70	
Sulphur	.81	.88	.97	1.15
Hydrogen	5.53	5.04	4.46	5.29
Carbon	51.07	55.57	60.87	72.20
Nitrogen	1.19	1.30	1.42	1.68
Oxygen	28.23	22.88	16.58	19.68
Calories	5,015	5,460	5,980	7,095
B. t. u.	9,030	9,830	10,760	12,770

Klondike Mine (14) (Beaverton, Swanson)

The Klondike mine was first opened and operated during 1898 and 1899. It is located 1,600 feet west and 500 feet north of the southeast corner

of sec. 18, T. 27 S., R. 13 W., a few feet above sea level and about 1 mile up the slough from the road along the north bank of the Coquille River, and a mile west of the Beaver Hill road junction.

The Klondike, on the south side of the slough, is said to have been worked out above sea level for 1,000 feet to the southwest. No reliable records of the workings in this mine are available but it is said to have been worked last in 1932 when the coal caught fire and the pillars were pulled. According to a report by G. J. Sielaff,* dated October 1921, the Klondike was operated extensively at the turn of the century, although when visited by him it was being mined at a rate of 5 tons a day on coal left above the water level. There was one slope 400 feet long with two gangways from which the coal was mined for 500 feet to the northeast and southwest. On the north side of the slough across from the Klondike mine there are several old workings, one of which, the R. A. Graham tunnel, is said to connect the workings of the No. 1 Beaver Hill or Graham mine; the other workings were dug in an attempt to connect with this tunnel.

The "Swanson mine," located across the slough about 900 feet northwest of the Klondike, was operated for the U. S. Government during World War I. Sielaff reports:

Here a tunnel, said to be 180 feet, exposes a coal bed striking N. 60°-70° W. and dipping 17° SW.

A section shows:

	Feet	Inches
Sandstone, yellow		
Coal	2	
Sandstone		8
Coal	1	6
Shale, dark, carbonaceous		

The Swanson mine coal bed is probably the upper portion of the Klondike bed faulted down. It now lies 200 feet stratigraphically below the Klondike bed, which strikes N. 40° E., and dips 11° to the southeast. Half a mile north of the Klondike machine shop, the rocks have been considerably crushed and faulted.

According to Diller (1899:336-339) the conditions were then as follows:

At Beaverton, a short distance southwest of the Beaver Hill mine, a new mine has recently been opened upon the Beaver Hill coal. Like Beaver Hill, it lies on the border of Beaver Slough, and is reached by a branch of the Coos Bay, Roseburg and Eastern Railroad. An adit has been run in the coal on the northeast side of the ravine and a slope upon the southwest side. Most of the coal is below

* Unpublished report from files of Southern Pacific Company.

sea level, although there may be much above. The slope is down about 700 feet, at an inclination of from 27° to 30°. Four gangways extend from it for a considerable distance on both sides, and the mine being thoroughly opened, the removal of coal has begun. The mine is favorably situated, and it is hoped that this effort will demonstrate the possibility of mining Coos Bay coal at a fair profit, notwithstanding the expense of lifting and pumping. The comparatively low price of Coos Bay coal in the market renders this a difficult problem, and the final outcome of Beaver Hill and Beaverton is watched with much interest.

North and west of Beaverton, in the same section (18), there is a series of coal exposures with strike ranging from N. 88° E. to N. 65° W., dipping in all cases southerly. The coal beds exposed are the Beaver Hill bed and those nearest it, and indicate that at this point the lower coals of the Beaver Hill and South Slough basins are continuous across the southern end of the Westport arch.

Southwest of the Beaver Hill and Beaverton mines, along the border of the Beaver Slough Basin, a remarkable change in the position of the coal beds is found in the western half of sec. 19. Crossing secs. 9, 17, 18 and into 19, the whole series of coal beds has a somewhat variable position, with an average strike approximately S. 45° W. and dip 24° to 45° SE. The strike becomes more southerly toward the southwest. The gangways at Beaverton, in the NE¼ of sec. 19, according to Mr. Whereat, run S. 31° W. Near the western border of sec. 19 the whole series quite abruptly swings around so as to strike S. 12° E. and dip 20° NE. This sudden change in strike is due to the fact that the arch of strata which bounds the Beaver Slough Basin upon the west, from East Marshfield to beyond Beaver Hill, here pitches to the southwest and runs out, allowing the coal beds to adjust themselves to the position of the strata in the South Slough Basin. The new strike of the beds points directly to Riverton, which lies close to the southern end of the basin. . . . The thickness of the rocks exposed, including the three lower coals, is about 336 feet. The upper coal may lie a hundred feet or more above the next lower one.

The lowest coal has three benches, and is regarded by miners and prospectors generally as the Beaver Hill coal, although its bottom bench is smaller than is usually the case and the middle bench is considerably larger. . . . About 200 feet above this there is a small bed having two exposures showing some variation in the coal. At some distance southeast of the other exposures, in sec. 30, is the Doyle outcrop, which has recently been opened for Mr. Graham. It resembles the Beaver Hill coal in

some particulars, but in others differs widely. The middle bench is nearly 6 feet thick and contains considerable shale in its upper portion.

Fahy-Muir Coals (15)

Several coal outcrops in the N½ sec. 30, T. 27 S., R. 13 W., on the north side of the slough opposite the Krome road, were faced up, measured, and sampled.

These coals lie in two and possibly three beds; they strike N. 10°–45° W. and dip 9°–22° NE.

Six coal outcrops (located by coordinates from the southwest corner of sec. 30) were measured and sampled by the survey; the results are as follows:

Cut No. 1 (3000 N.–3150 E.)

Sample No. 82. Strike N. 10° W.—dip 29° E.

	Feet	Inches
Sandstone, yellow		
Clay, yellow, sandy	1	1
Clay, yellow	1	1
Clay, dark gray	1	11
*Coal, hard	2	7
Shale, carbonaceous		1
*Coal, soft		4
Shale, carbonaceous		6
Coal, bony		3
Clay, dark gray		3
Coal, bony		7
Clay, dark gray		
Total thickness of coal sampled	2	11
Total thickness of bed	8	8

Analysis:

Field No. 82

Lab. No. P-2193

	Thickness
Sample	2 ft. 11 in.
Bed	7 ft.

Analysis	As Received	Air Dried
Ash	9.60	10.48
Moisture	18.89	8.30
B. t. u.	8,847	10,907

Cut No. 2 (3650 N.–3450 E.)

Not sampled. Strike N. 50° W.—dip 18° N. E.

	Feet	Inches
Clay, yellow		
Clay, dark		6
Coal, bony	1	4
Coal, hard		5
Shale, carbonaceous		2
Clay, dark gray		
Total thickness of coal	1	9
Total thickness of bed	2	5

Cut No. 3 (3500 N.–1250 E.)

Sample No. 87. Strike N. 20° W.—dip 15° NE.

	Feet	Inches
Clay, dark, sandy		
*Coal, hard	1	6
Coal, bony		4
Shale, carbonaceous		8
Clay, dark, sandy		
Total thickness of coal sampled	1	6
Total thickness of bed	2	6

Analysis:

Field No. 87
Lab. No. P-2198

	Thickness	
Sample	1 ft. 6 in.	
Bed	2 ft. 6 in.	
Analysis	As Received	Air Dried
Ash	9.48	10.25
Moisture	16.16	7.50
B. t. u.	9,132	10,892

Cut No. 4 (3850 N.-1400 E.)

Samples No. 85 and No. 86. Strike N. 65° W.—
dip 9° NE.

	Feet	Inches
Clay, yellow, sandy		
Coal, bony	2	1
Clay, gray, sandy		10
Shale, carbonaceous		4
Coal, bony		4
*Coal, hard	2	3
Clay, gray, sandy		8
*Coal, hard	1	10
Shale, carbonaceous		4
Clay, gray, sandy		
Total thickness of coal sampled	4	1
Total thickness of bed	8	8

Analysis:

Field No. 86
Lab. No. P-2197

	Thickness	
Sample (upper bench)	2 ft. 3 in.	
Bed	8 ft. 8 in.	
Analysis	As Received	Air Dried
Ash	11.72	12.80
Moisture	16.64	8.40
B. t. u.	8,701	10,438

Field No. 85
Lab. No. P-2196

	Thickness	
Sample (lower bench)	1 ft. 10 in.	
Bed	8 ft. 8 in.	
Analysis	As Received	Air Dried
Ash	25.58	27.72
Moisture	15.05	7.70
B. t. u.	7,157	8,425

Cut No. 5 (Location missing)

Sample No. 84. Strike N. 50° W.—dip 10° NE.

	Feet	Inches
Coal, bony		
*Coal	3	...
Clay, gray, sandy		10
*Coal	1	4
Clay, dark		4
Clay, gray, sandy		
Total thickness of coal	4	4
Total thickness of bed	5	6

Field No. 84
Lab. No. P-2195

	As Received	Air Dried
Analysis		
Ash	15.14	16.77
Moisture	18.03	9.70
B. t. u.	8,127	9,915

Cut No. 6 (3050 N.-2150 E.)—Not sampled.

	Feet	Inches
Top soil		
Clay, blue, sandy	2	...
Coal	2	6
Clay, dark	1	6
Clay, dark		
Total thickness of coal	2	6
Total thickness of bed	6	...

The coal was traced up several canyons, and, if projected through the ridges, would underlie an area in excess of 40 acres. Portals of caved tunnels were discovered at 4200 N.-1050 E., and at 2350 N.-2500 E. of the southwest corner of sec. 30.

A thin bed of coal was reported by Diller and Pishel (1911:219) to be located south of the present Krome road junction with the North Bank road, in the NE $\frac{1}{4}$ sec. 31, but this coal could not be located. The section given is as follows:

	Feet	Inches
Coaly shale	3	...
Coal		6
Coaly shale	1	4

The coal as mapped strikes N. 5° W. and dips 33° E.

Diller and Pishel visited two coal outcrops in sec. 30, which they believed represented the Newport or Beaver Hill coal. One section located in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ was given as follows:

	Feet	Inches
Shale		
Coal, shaly		6
Shale and coaly shale		8
Clay		1
Coal, shaly	2	2
Coal	2	6
Shale		9
Coal, shaly	2	6
Shale		
Total thickness of coal	7	8
Total thickness of bed	9	2

Another section along the strike still farther to the north in the eastern part of sec. 24, T. 27 S., R. 14 W., was given as (p. 220):

	Feet	Inches
Coal		8
Parting		1
Coal	1	1
Parting		5
Coal, shaly	3	...
Parting	1	...
Coal	3	6
Coal, shaly		8
Total thickness of coal	8	11
Total thickness of bed	10	5

Here the coal as mapped strikes north and dips 20° E.

Between this point and the Klondike mine to the north, Diller was uncertain whether the obscure relations were due to a fault or to a sharp fold, although he finally mapped a fault with a considerable downthrow on the south. Recent work by the survey has not changed this conclusion.

Riverton Basin Coals (South End of Beaver Slough Basin)

Riverton Mines and Project (16)

(Alpine, Timon, Gage, McGee, Rouse, Urquhart, Kight)

The Riverton district (see pl. 26) has produced coal for more than 50 years, mostly from the Riverton or Timon bed, which Diller (1899:338) reported to be 300 feet stratigraphically above the Urquhart bed, now believed to be the equivalent of the Beaver Hill bed. Plane-table mapping by the survey indicates that the interval may be nearer 700 feet.

The *Alpine* is one of the most recently operated mines near Riverton. It is located about 100 yards east of the highway on the southern edge of Riverton, in the NW $\frac{1}{4}$ sec. 17, T. 28 S., R. 13 W. It was operated from 1930 to 1941 by W. T. Alpine, the production during this time being about 100,000 tons. The mine averaged about 20 tons a day in 1938.

In early days the coal was shipped from the Riverton district directly to San Francisco by steamers from bunkers on the bank of the Coquille River only a few hundred feet from the mine portals.

The first mine in operation, according to Diller (1896:496), was the *Timon*, opened in 1895; the *Liberty* mine was opened by Joseph Ferrey in 1897 near the edge of the river. The slope of the Liberty mine is said to have gone down 1,300 feet on a 20° dip with three or four gangways driven mostly to the north. It is said to have produced from 50 to 75 tons a day until 1902, and, although it was flooded for 10 or 12 years before being reopened, the last work was done about 1914.

The *Gage* mine is located very close to the present highway, between the Liberty and the Alpine on the line between secs. 17 and 19. The slope started in the hanging wall and was sunk at a steep angle for 300 feet until it hit the coal. One gangway trended north toward the Liberty workings; another trended south for 200 feet. The mine operated from 1912 to 1915 and had a possible production of 25 or 30 thousand tons.

The two mines lying immediately south of the Alpine on the same bed were operated by J. H. Timon. The No. 2 mine, only a few hundred feet south of the Alpine, had a crosscut 200 feet to the coal, and a slope 200 feet long, with gangways a short distance in both directions from the bottom

of the slope. The No. 1 mine, another 500 feet to the south, followed the coal southeasterly 400 feet from the outcrop, and mining extended to the surface.

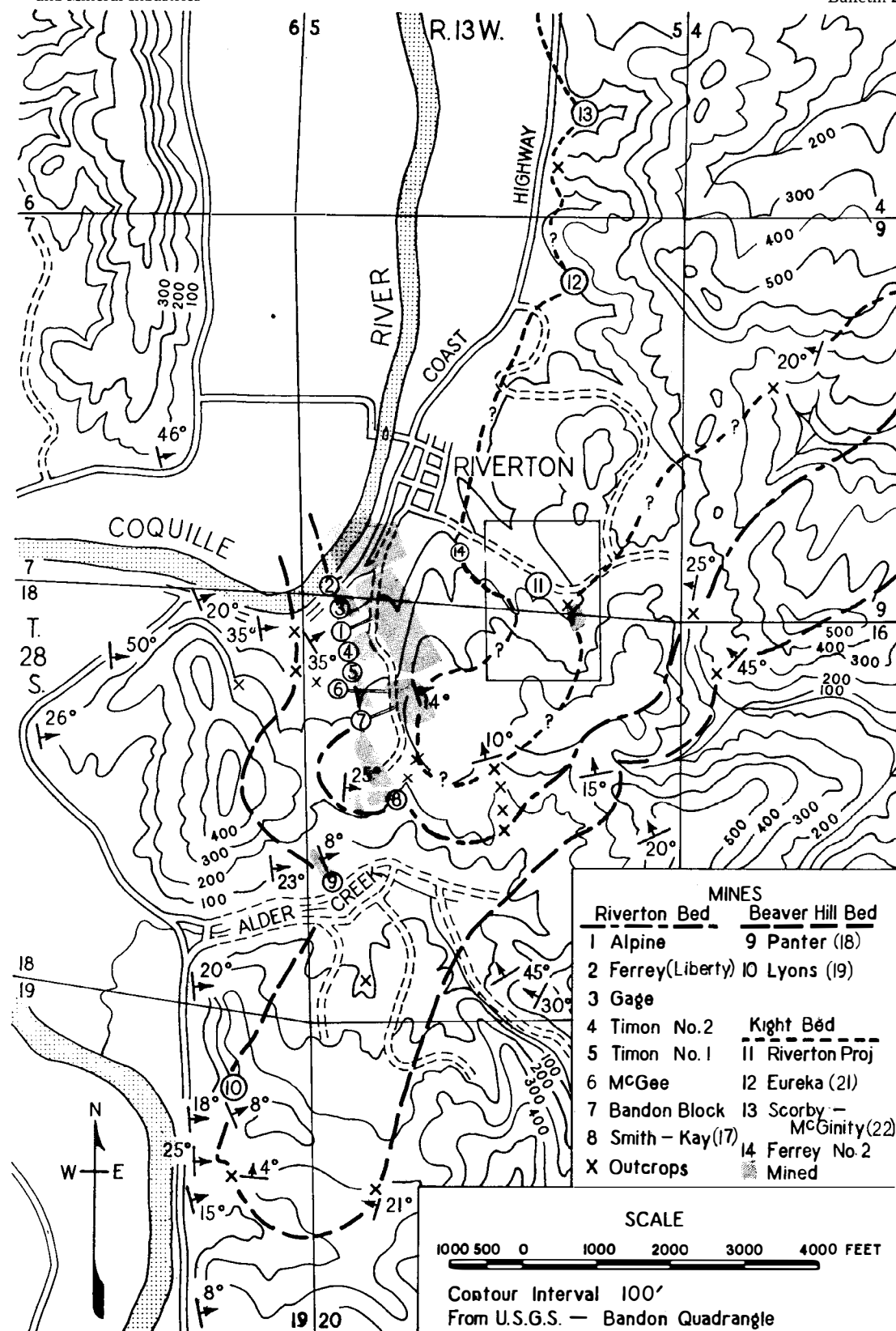
The McGee mine, which was opened still farther south in 1907, had a crosscut trending due east for 800 feet to the coal. Gangways extended at least 300 feet to the north and 500 feet to the south. A slope about 300 feet long opened up two lower levels. The mine closed in 1914, and may have produced as much as 90,000 tons.

The *Bandon Block* mine, which operated from 1898 to 1900, is the next mine to the south on the Riverton bed. It is discussed with the Smith-Kay mine (which see).

The *Alpine* mine was opened in 1930 at a point between the Gage and Timon No. 2 workings. When it closed down in 1941, it had been mined out for more than 1,000 feet down the dip and for 1,200 feet south, and had connected with the old McGee mine workings. It also removed the coal below the Timon mines. When visited in 1937 by Libbey (1938:7) the 15° incline which trended a little south of east was 500 feet long, with a 1,000-foot entry to the south. In 1939 Yancey and Geer (1940:11) reported the slope to be 750 feet long, with five entries to the south in that distance:

Entries driven both north and south from the slope and aggregating 4,000 feet in length have developed the property. From the entries rooms 25 to 40 feet wide on 65-foot centers are driven up the pitch to a depth of 200 feet. A small electric hoist on the entry, from which a rope is carried around a sheave at the room face, provides power for pulling empty cars up the rooms. Cars holding 1,500 pounds of coal are gathered on the entry by mules, hauled to the slope, and hoisted in two-car trips. Pillar recovery is limited to about 50 percent by the nature of the roof, which is a massive but somewhat loosely consolidated sandstone that caves badly during pillar extraction. The seam is mined by cutting out by hand the center 7-inch bench of coal with its enclosing bone bands; the upper and lower benches of coal can then be picked out without shooting.

At the tippie the coal is sprayed with water as it is passed over improvised vibrating screens having 3-inch round-hole, 1-inch square-hole, and $\frac{1}{8}$ -inch square-hole openings to produce lump (which is hand-picked on the screen) nut, pea, and buckwheat sizes. The mine averaged 20 tons per day in 1938.

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Riverton area: Location of mines and extent of mining, topography, course of outcrop of the Urquhart, Timon, and Kight coal beds.

Two samples were taken by Yancey and Geer (1940:11) from the Alpine mine.

Section A was taken in the crosscut connecting the slope and aircourse between the 4th and 5th south entries, 650 feet from the portal. Section B was taken at the face of the slope, 750 feet from the portal. Cover at these points was about 140 feet.

	Section A Lab. No. B-40029		Section B Lab. No. B-40030	
Roof, soft to firm sandstone, underlain by 1 to 20 inches of shale and bone:				
	Feet	Inches	Feet	Inches
Shale, brown†	1		1	3
Bone, coal streaks†				5
*Coal, bone streaks	4-½			
*Coal	7		7	
Bone	2		2	
*Coal	3		7	
Bone	1			
Shale, firm			1	
*Coal	2	1	1	6
Floor, 10 inches of smooth shale underlain by sandstone.				
Thickness of bed	3	7-½	4	7
Thickness in sample	3	3-½	2	8

* Sampled.

† Immediate roof in section A.

‡ Immediate roof in section B.

Analyses of these two samples were made as follows (p. 20):

Section A Lab. No. B-40029	As Received	Dried at 105° C.	Moisture and ash free
Moisture	19.3		
Volatile matter	32.8	40.6	44.8
Fixed carbon	40.3	50.0	55.2
Ash	7.6	9.4	
Sulfur	.7	.8	.9
Air dry loss %	9.4		
B. t. u.	9,250	11,460	12,650
Ash softening temperature	2320° F.		
Agglomerating index	NAa		

Section B Lab. No. B-40030	As Received	Dried at 105° C.	Moisture and ash free
Moisture	19.6		
Volatile matter	32.6	40.5	44.3
Fixed carbon	40.9	50.9	55.7
Ash	6.9	8.6	
Sulfur	.6	.7	.8
Air dry loss %	10.1		
B. t. u.	9,310	11,580	12,670
Ash softening temperature	2340° F.		
Agglomerating index	NAa		

Analysis of the bed at the old Gage mine, 450 feet from the mouth of the mine, is given by Diller and Pishel (1911:226):

Lab. No. 9312				
Coal bed			4 ft. 5 in.	
Part sampled			4 ft.	
Air-drying loss			5.8	
	Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	16.0	10.8		
Volatile matter	32.8	34.8	39.0	48.2
Fixed carbon	35.2	37.4	41.9	51.8
Ash	16.0	17.0	19.1	
Sulphur	1.28	1.36	1.52	1.88
Calories	4,785	5,080	5,700	7,040
B. t. u.	8,620	9,150	10,260	12,670

Mining on beds other than the Riverton has not been successful. Tunnels were driven many years ago on the Urquhart or Beaver Hill bed a few

hundred yards southwest of the Alpine mine, but the coal proved to be too dirty. A section in the highway cut where the coal strikes N. 20° W. and dips 35° E. illustrates the character of this bed in the Riverton district:

Shale	Feet	Inches
Bone	1	4
Clay		5½
Coal, bony		11
Coal, soft, broken		5½
Shale, red-brown		1½
Coal	3	2
Clay		7
Coal, fair	1	11
Shale, bony	1	6
Coal, bony		8
Total thickness of coal	7	1½
Total thickness of bed	11	1½

An attempt to mine the 28-inch bed lying between the Urquhart and Riverton was made by Rouse in 1908, and the 400-foot slope is located about 300 feet east of the highway.

Lord (1913:692) lists a section taken by Pishel in the Rouse mine at a point 100 feet from the mouth of the mine in room 1 of entry 1 as follows:

Roof, shale	Feet	Inches
*Coal	2	3
Bone		1
Floor, sandy shale		
Thickness of bed	2	4
Thickness of coal sampled	2	3

The analysis (*) is as follows (Diller and Pishel, 1911:227):

Lab. No. 9311				
Coal bed			2 ft. 4 in.	
Part sampled			2 ft. 3 in.	
Air-drying loss			6.2	
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	16.0	10.4		
Volatile matter	36.1	38.5	43.0	47.3
Fixed carbon	40.2	42.9	47.8	52.7
Ash	7.7	8.2	9.2	
Sulphur	2.47	2.63	2.94	3.24
Calories	5,410	5,765	6,440	7,085
B. t. u.	9,740	10,380	11,590	12,760

The coal strikes N. 3° W. and dips 19° E. At the time of Pishel's visit (October 1909) the mine was producing only 2 tons a day. This coal was in greater demand than any other mined in this area, because it was comparatively low in ash and deteriorated very little in storage. Pishel reported that the shale roof was firm; the sandy shale floor heaved somewhat.

A section of a coaly bed apparently lying several hundred feet below the Urquhart (Beaver Hill) bed was measured by the survey in the bed of a small creek about 1,000 feet south of the highway, half a mile southwest of Riverton. The bed

strikes about N. 10° W. and dips 35° to the east, and has the following section:

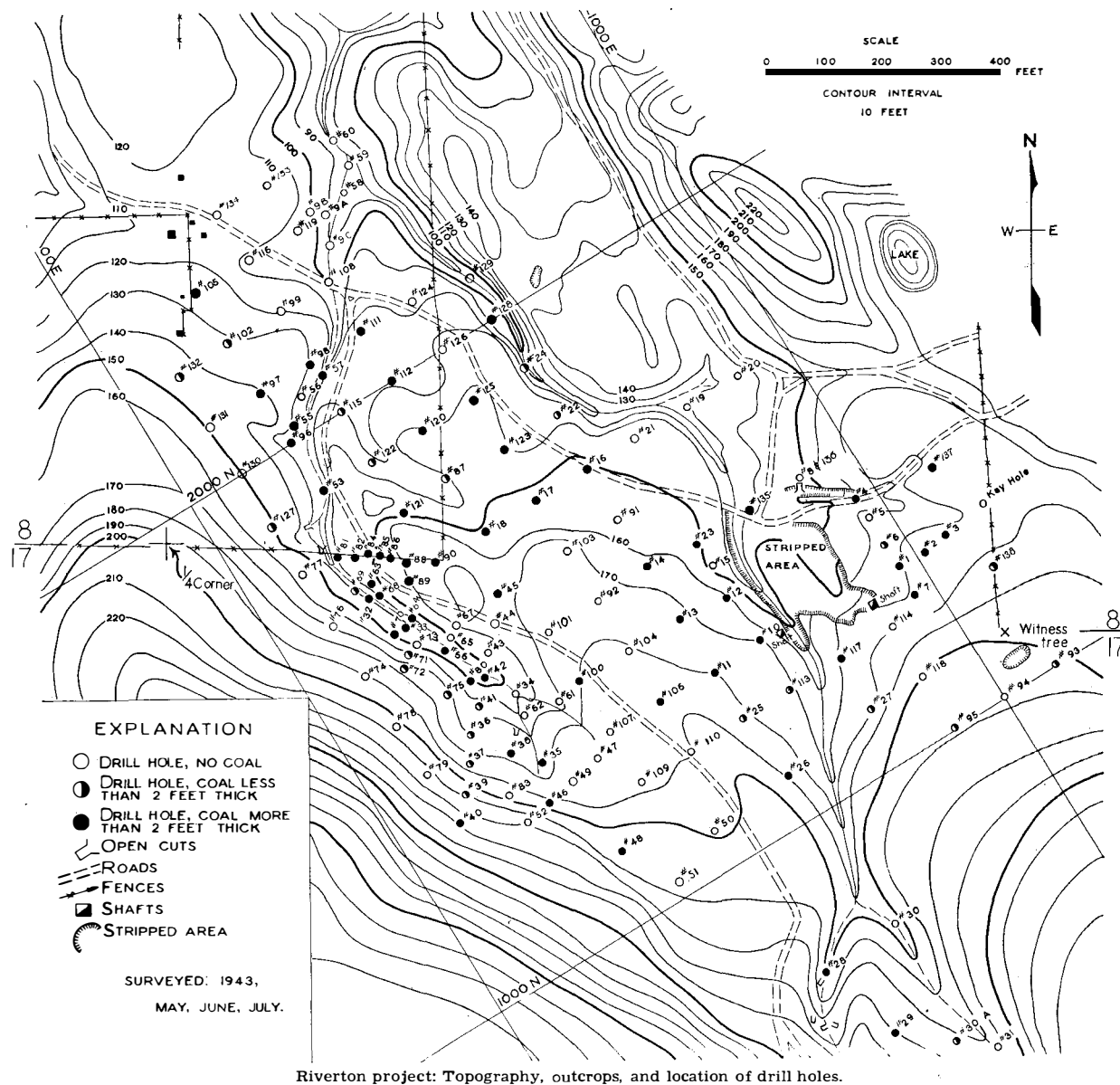
Soil	Feet	Inches
Coal "blossom"		3
Clay, blue	1	2
Bone	2	6
Sandstone		8
Bone		6
Clay	—	—
Total thickness of bone and coal "blossom"	3	3
Total thickness of bed	5	1

The *stripping coal project* is located in the SE $\frac{1}{4}$ sec. 8 and the NE $\frac{1}{4}$ sec. 17, T. 28 S., R. 13 W. (pl. 26). It is a quarter of a mile east of the town of Riverton. Owners of portions of the area mapped (pl. 27) are Walter D. Kight, Riverton; Verne M. Fonner, Tigard; Beulah Fahy estate, $\frac{1}{2}$ Webb Fahy, Los Gatos, California; and R. E. V. Johnson, Riverton (coal rights owned by Kight).

A bed conservatively estimated to contain 50 thousand tons of coal underlies an area of about

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8 acres lying at an elevation of 200 feet. The coal averages a little more than 4 feet in thickness, and lies at an average depth of 19 feet below the surface, giving a stripping ratio of 4.4:1. The coal is of subbituminous rank, with 12 to 20 percent ash, 10 to 20 percent moisture, and a heating value of 6,400 to 9,200 B. t. u. as received. It is believed that this area can be economically stripped and the coal sold locally at a profit, although the deposit is too small for large scale operation.

Shallow coal of the so-called "Kight bed" has long been known to occur immediately back of the town of Riverton. According to Diller (1899-342):

The Kight coal overlies the Timon coal (now called the "Riverton vein") by about 200 feet, and the two are separated chiefly by soft sandstones. It is the uppermost of the coals well exposed at Riverton, and has been mined chiefly by Mr. Ferrey, who ran an entry 500 feet upon the strike of the coal. Some water was encountered, but the mine drains itself. The bed contains 32 inches of coal, with a parting 8 inches from the top. . . . The coal is much fractured perpendicular to the bedding, and at intervals is associated with pitch coal. . . . The occurrence of soft, shaly rocks above and below renders it necessary to timber the mine fully. The overlying shale is sometimes composed chiefly of brackish-water shells. The Ferrey mine on the Kight coal was operated successfully for some time, but as the mine proceeded the coal bent more to the east, becoming irregular and was finally pinched out by an extensive landslide which reached the river at the northern edge of Riverton. The landslide covers many acres and fills the little valley that heads three-fourths of a mile southeast of the town. Kight's coal has been prospected on the surface near the head of this slide, and irregular portions of the coal occur at several points in the slide. The road from Riverton to Fat Elk Creek crosses the lower part of the slide, where its irregular hummocky surface clearly tells the character of the material beneath. Tunnels have been run into it at several places, in prospecting for coal, but without encouraging results.

The coal at the head of the "landslide" was called to the attention of the department by Mr. William H. Kay, who has done considerable prospecting around Riverton. Two old open cuts exposing 3½ to 4 feet of coal were cleaned out and sampled. An area of about 1 acre, which had been stripped and mined several years ago, was examined and hand drilling was begun June 4, 1943, immediately adjacent to the area where coal

of good grade had been proved to be present. The area was mapped (pl. 27) and holes were located at the intersections of a 100-foot grid-network. As the lines of drill holes were completed, cross sections were constructed showing the thickness of this coal, and the thickness and type of overburden. Ninety holes, which ranged in depth from 3 to 34 feet, with an average of 19.4 feet, were drilled with 3-inch hand augers. Of these holes 37 showed no coal, and in 11 the coal found was less than 2 feet in thickness. The average thickness (omitting 6 holes with anomalous thicknesses of over 8 feet of coal) was 44 inches. About 8 acres, definitely underlain by coal, was drilled on 100-foot centers or closer.

A composite drill-hole section on the Riverton project (Kight coal) would be as follows:

Soil	Feet	Inches
Yellow-brown sandstone		
(sometimes admixed with clay) . . .	17	....
Dense dark gray to blue shale or clay . .	10	....
Carbonaceous shale		4-13
Bone		3
Coal		5
Carbonaceous shale parting		1
Coal	1	6
Bony coal		5
Coal		11
Shale	10	....
Dark gray hard sandstone	10-1	....
Total thickness of coal	3	3

A section of the coal taken at the head of the old stripping pit (1250 N.-910 E.) is as follows (sample P-1841):

	Feet	Inches
Sandstone, 10 feet	10	....
Clay, gray, 10 feet	10	....
Broken coal	3	....
Clay, gray	1	7
Shale, carbonaceous		1
*Coal, good		6
Shale, carbonaceous		1½
*Coal, good	1	9½
Bone		5
Clay, gray		
Total thickness of coal	5	3½
Total thickness of bed	7	5

Another typical section of the coal is exposed in a cut at 1870 N.-150 E. (sample 1605) as follows:

	Feet	Inches
Sandstone, soft and shaly		
Shale, carbonaceous	1	1
Bone		3
Clay		1
Coal	1	5
Shale, carbonaceous		1
Coal	1	6
Clay		1½
Coal	1	3
Shale		
Total thickness of coal	4	2
Total thickness of bed	5	8½

Analyses of these coals and three others from other parts of the area are as follows:

Lab. No. 1601			
Location: 1380 N—170 E			
Bed	Thickness		
Sample	10 in.		
Analysis	As	Air	
Ash	Received	Dried	
Moisture	14.31		
B. t. u.	22.95		15.8
	6,678		8,667
Lab. No. 1602			
Location: 1380 N—270 E			
Bed	Thickness		
Sample	38 in.		
	18 in.		
Analysis	As	Air	
Ash	Received	Dried	
Moisture	20.83		
B. t. u.	20.1		7.9
	6,743		8,439
Lab. No. 1603			
Location: 760 N—500 E			
Bed	Thickness		
Sample	13 ft. 4½ in.		
	9 ft. 6 in.		
Analysis	As	Air	
Ash	Received	Dried	
Moisture	19.94		
B. t. u.	10.89		6.2
	9,161		10,281
Lab. No. 1605			
Location: 1870 N—150 E			
Bed	Thickness		
Sample	5 ft. 8½ in.		
	4 ft. 2 in.		
Analysis	As	Air	
Ash	Received	Dried	
Moisture	27.2		
B. t. u.	20.2		8.4
	6,365		7,976
Lab. No. P-1841			
Location: 1250 N—910 E			
Bed	Thickness		
Sample	4 ft. 5 in.		
	2 ft. 3½ in.		
Analysis	As	Air	
Ash	Received	Dried	
Moisture	12.23		13.73
B. t. u.	21.81		10.9
	7,988		10,216

Certain portions of the seam, as shown in the sections, may be bony. Some of the coal is quite soft and crumbly. The 1,000-1,500 tons of coal that was stripped several years ago for use in the local schoolhouse is said to have been satisfactory.

The Kight coal is the uppermost in the area, lying 200 feet above the "Timon" or Riverton coal which has been most extensively mined. The generalized section uses measurements given by Diller (1899:338) as follows:

	Feet	Inches
Shale		
Kight coal	2	8
Sandstones and shales	200	
Timon coal or Riverton coal bed	4	9
Sandstone	1	6
Carbonaceous shale (leaf bed)	3	
Sandy shale	12	
Carbonaceous shale	3	
Sandstone and some shales	87	
Rouse coal ("Bunker")	2	
Sandstone (shale at top)	50	
Carbonaceous shale	2	
Sandstone	140	
Urquhart coal	7	1
Sandstone	70	
Carbonaceous shale and coal		
Sandstone		
Total	601	6

The section as described correlates very closely with the section of the coals at the Beaver Hill mine (Diller, 1899:332) if the Urquhart coal is taken to be the Beaver Hill bed. The "Rouse" coal then compares with the 33 inches of coal lying 200 feet above the Beaver Hill; the "leaf bed" correlates with the bed of coal 103 feet farther up the section; and the Timon bed correlates with the 3 feet 5 inches of coal (with one parting) which lies 32 feet above the coal correlated with the leaf bed.

The Riverton stripping area lies within a north-facing amphitheater-shaped basin which encloses the headwaters of the two branches of "Johnson Creek." The floor of the "basin" is relatively flat, although it slopes gently to the north. It is interrupted here and there by hummocks and swales, and is incised to a depth of from 10 to 25 feet by the two forks of the creek.

The preliminary impression (and one reached by Diller) is that the basin was formed by land-sliding, but a more detailed study of the physiography, aided by a knowledge of the structure of the rocks and coal gained by drilling, indicates that such is not the case, although there may have been small-scale landsliding in one or two localities. Instead the hummocks are erosional features in shale, presumably the basal portion of the Bastendorf.

The elevation of the basin rises from about 200 feet on the northwest to nearly 300 feet on the south. Northeasterly behind a group of small hills it connects with the headwaters of a small creek which flows into the Coquille half a mile above Riverton. This "wind gap" is part of the same bench-like flat, which widens again farther to the northeast. Thick beds of peat near the surface of the flat have been found in drill holes at several localities. It is believed that the Riverton stripping area represents a meander terrace of the Coquille or of a tributary to the Coquille River, formed when the river stood at the level near 200-300 feet, a level which may be correlated with the ocean terrace, 200-300 feet in elevation, which is so well preserved along the coast both north and south of Bandon.

It has been reported that, in the area which was stripped several years ago, the coal was absent in places and that the same overlying clay appeared in contact with the sandstone which normally underlies the coal. This condition strongly suggests that the coal in this basin was in places

eroded by the stream which formed the terrace. The presence of the terrace level on both sides of "Johnson Creek" and its presence in the headwaters of the next creek to the east is corroborative evidence of terrace formation.

Structurally, the Riverton stripping area lies in the toe of an asymmetrical, gently north-plunging syncline, whose axis strikes N. 35° W., with the east limb (east of the edge of the area mapped) striking N. 20° E. and dipping 25° NW., and the west limb striking N. 40°-60° W. and dipping 10°-17° NE. On the relatively flat bottom of the syncline the beds strike about N. 55° E., and dip an average of 6° NW. The absence of coal in some of the holes immediately west of the west branch of the creek (and the excessive thickness in other holes) cannot be entirely explained by this simple structure. There apparently have been some bedding-plane landslides down the dip slope of the west ridge, eliminating the coal in some spots and duplicating it in others. Duplication appears to have taken place along the 1700 N. coordinate between 200 and 300 E., and the coal appears to be missing up the hill west of the 100 E. coordinate. Flexures other than the main one seem to be relatively minor, although a few anomalies and local rolls are present.

Profitable stripping operation postulated on the basis of the "measured" and "indicated" coal tonnage rests not only on these tonnages, but upon a number of other factors of perhaps equal importance.

Although not as favorably located as some of the coal mines in the area with regard to nearness to local points of consumption or to the railroad, the Riverton area is within half a mile of paved U. S. Highway 101, at a point 6 miles from Coquille (the nearest railroad loading point) and 24 miles from Marshfield. A road, partly graveled, to the property could be made an all-year road with the addition of only a small amount of road metal.

The overburden in nearly all the holes is composed of 6 to 10 feet of dark clay shale, overlain by about 10 feet of soft clayey sandstone. The consistency of the sandstone is such that it could be removed quite easily by power shovel or dragline; the shale might in some places have to be blasted. There is usually a layer of carbonaceous shale overlying the coal, which might serve as a stripping floor. Only that part of the area with less than 35 feet of overburden was considered

in the tonnage calculations for "measured" ore, although the "indicated" ore includes some coal at greater depth. The area to be mined is incised throughout its length by the two forks of "Johnson Creek" to a depth ranging from 10 to nearly 30 feet. The coal, however, underlies the bed of these forks in their upper courses, so that casting of overburden into the creek would be possible only on the north end of the property. The 6° slope of the coal, which roughly corresponds to the surface slope, will probably permit bench stripping and casting to advance southward up the hill.

Smith-Kay Mine (17) (Bandon Block)

This property was purchased in 1941 by William H. Kay, and was leased in 1942 to J. D. Kay and E. M. Smith, of Riverton, who produced from 5 to 15 tons of coal a day during 1942 and 1943. It is located on the old Bandon Block property. One entry is near the center of the S $\frac{1}{2}$ NW $\frac{1}{4}$ sec. 17, T. 28 S., R. 13 W. (pl. 26). The mine is reached by a gravel road over the hill from Riverton, less than 1 mile to the north.

The Bandon Block workings on the Riverton bed consist of a 600-foot entry driven about the year 1900. They extend from the north side of the ridge to the surface on the south side at a point about 60 feet east of the lower Smith-Kay entry.

Rooms 150 feet long were turned off this tunnel, and the Smith-Kay operation has removed the coal from the area above and to the west of these rooms. The entry runs N. 60° W., and exposes a section of the Riverton bed which dips 10°-15° E., and has a hard coarse-grained sandstone roof and about 3 feet of good coal in two benches, with one thin bone parting. The lower bench is of better grade than the upper. Faulting is minor, usually less than a foot of displacement.

The Riverton bed has been traced to the east, and early in 1944 a new entry was being driven 200 feet to the east of the first entry, to open up coal down the dip from the Bandon Block tunnel. Farther around the hill to the east, the bed crops out in a narrow gulch, approximately in the center of the toe of the Beaver Slough basin, where the coal dips gently to the north.

A bed of coal, which may be correlated with the "Kight" bed, crops out in a gulch directly above and north of the Smith-Kay mine. The measured section is as follows:

	Feet	Inches
Clay, blue		
Coal		1
Clay		1
Coal, broken		7
Clay		$\frac{1}{2}$
Coal, hard	2	7
Clay		4
Coal		5
Clay, carbonaceous		
Total thickness of coal	3	8
Total thickness of bed	4	$1\frac{1}{2}$

Panther Mine (18)

The Panther mine on the Urquhart coal bed lies a quarter of a mile from the highway on the north side of Alder Creek in the NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 17, T. 28 S., R. 13 W. (pl. 26).

A tunnel has been driven approximately N. 35° W. a distance of 500 feet and at least 5 rooms have been mined up the dip to the southwest (pl. 24). The coal at this point strikes approximately N. 20° W. and dips 8° NE.

Sections of the coal were measured in two different localities and are given as follows:

Section A (in south wall of crosscut)

	Feet	Inches
Sand roof		
Shale, carbonaceous		3
Coal		4
Bone		1
Clay parting		$4\frac{1}{2}$
†*Coal	2	
† Coal, broken, clayey		3
† Coal, broken		3
†*Coal, hard		9
Clay parting		8
Coal, bony	2	
Total thickness of coal	5	7
Total thickness of bed	6	$11\frac{1}{2}$
Thickness of coal mined	3	3

Section B (300 feet from portal, old gangway)

	Feet	Inches
Sandstone		
Bone		5
Shale, carbonaceous		2
Bone		4
Parting		6
Bone		4
†Coal	2	
†Coal, broken		8
†Coal, hard		8
Parting		9
Coal, bony	2	
Bone, coaly	2	
Total thickness of coal	5	4
Total thickness of bed	9	10
Thickness of coal mined	3	4

† Coal bench mined.

* Coal sample No. 18, analysis as follows:

Location: 70 feet from portal in crosscut.

	Thickness	As Received	Air Dried
Sample	2 ft. 9 in.		
Bed	6 ft. $11\frac{1}{2}$ in.		
Analysis			
Moisture		16.82	5.6
Ash		13.73	14.65

This coal is said to have a high (8 percent) sulphur content, which, together with the high ash, has made mining uneconomic.

Lyons Mine near Alder Creek (19)

This mine is located in the NE $\frac{1}{4}$ sec. 19, T. 28 S., R. 13 W., on the W. A. Panter estate, about 200 feet above the Coquille Valley a short distance south of the mouth of Alder Creek (pl. 26.) The mine was worked for 2 years in 1898-1900, and the coal was transported by aerial tramway to bunkers by the river. According to Mr. Lyons, numerous faults made mining unprofitable. Where examined, the strike was N. 15° W., with a dip 7° NE. along the southwestern edge of the toe of the Riverton basin, opposite the coal described in the Sell prospect. This bed is believed to be the Urquhart bed, as at the Panther mine. Although the coal sections do not correspond, a projection of the bed indicates they are the same. The following section at the Lyons mine was measured:

Sandstone, massive, with a few inches of shale.

	Feet	Inches
*Coal	1	2
Clay, dark		2
Coal, broken (not sampled)		1
Clay, dark		2
*Coal, slightly bony	1	2
Clay, light		10
Coal		11+
Total thickness of coal	3	4+
Total thickness of parting	1	2
Total thickness of bed	4	6+

In this mine only the coals above the 10-inch parting were mined. The bottom bench, which was evidently bony, was left. The analysis of the upper two benches is as follows:

Field No. 59
Lab. No. P-2074

	Thickness	As Received	Air Dried
Sample	2 ft. 4 in.		
Bed	4 ft. 6 in.		
Analysis			
Moisture		32.64	13.00
B. t. u.		6,360	9,443
Ash		10.03	11.53

Sell Coal (20)

This prospect is located 1 mile south of the Panther mine in the northern part of the SE $\frac{1}{4}$ sec. 20, T. 28 S., R. 13 W., on land owned by F. E. Sell (pl. 26). The coal crops out in the headwaters of a stream which enters the Coquille River south of Alder Creek. This coal bed is apparently beneath the Urquhart bed (Beaver Hill) a fact which should be mentioned because few beds have definitely been identified below the Beaver Hill. The coal strikes N. 20° E. and dips 21° NW. along the southeastern toe of the basin. The coal section is as follows:

	Feet	Inches
*Coal, bony	1	2
Shale, carbonaceous		4
*Coal, bony		$5\frac{1}{2}$
Shale, carbonaceous		3

	Feet	Inches
*Coal, hard with "sulphur" nodules	4	3
Clay, blue	2	.....
*Coal with streaks of bone and "sulphur" .....	.....	.....
Clay .....	.....	.....
Total thickness of bony coal	3	11½
Total thickness of parting .....	.....	10
Total thickness of bed	4	9½

Analysis of the four benches gave the following:

Field No.	64		
Lab. No.	P-2078		
Sample	4 ft.	Thickness	
Bed	4 ft. 9½ in.		
Analysis	As Received	Air Dried	
Moisture	19.90	8.42	
B. t. u.	7,054	8,807	
Ash	20.93	23.86	

Eureka Mine (21)

Between 1900 and 1914, coal is reported to have been mined at the Eureka mine located about a quarter of a mile east of the highway and a little over half a mile north of Riverton in the NE¼, sec. 8, T. 28 S., R. 13 W., on land owned by Joseph Nilsen. The location of this old mine, the dump of which may still be seen from the highway, is shown on plate 26. The coal, which dips very gently to the north, was mined from a slope said to have been 500 or 600 feet long, and was run over a long trestle to the river's edge, where it was loaded on board ship. The coal is in a thick bed said to be stratigraphically above the Kight, with the only good coal in the uppermost 4 feet.

The mine workings are now completely inaccessible. Lord (1913:691) lists a section from the Eureka mine "in sec. 9," taken in an air course about 250 feet east of the mouth of the mine, as follows:

	Feet	Inches
Roof, sandstone .....	.....	.....
Bone	2	.....
Dirt	1	.....
Bone	2	.....
*Coal, good	2	.....
*Coal, with some bone	2	.....
Floor, bone (about 14 feet thick) .....	.....	.....
Thickness of bed	4	5
Thickness of coal sampled	4	.....

The analysis (*) is as follows:

Lab. No. 9313 (Diller and Pishel, 1911:227-28)				
Coal bed	4 ft. 1½ in.			
Part sampled	3 ft. 3½ in.			
Air-drying loss	6.3			
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	17.7	12.2	.....	.....
Volatile matter	31.9	34.1	38.8	43.3
Fixed carbon	41.9	44.7	50.9	56.7
Ash	8.5	9.0	10.3	.....
Sulphur	.78	.83	.95	1.06
Calories	5,175	5,525	6,295	7,015
B. t. u.	9,320	9,950	11,330	12,630

Scorby and McGinity Mine (22)

A coal bed, probably the same as that at the Eureka, was opened up in a small gulch, on land

owned by Joseph Nilsen, just east of the highway, three-quarters of a mile north of Riverton in the SE¼ sec. 5, T. 28 S., R. 13 W. (pl. 26).

According to William Kay, it was mined on a small scale by Jack Scorby and Pat McGinity from 1931 to 1935. The slope is on the north side of the gulch and is filled with water so that the coal could not be measured. The track crossed the gulch and the coal was hoisted to bunkers on the south slope of the gulch next to the highway.

Fat Elk Creek Coals (23) (Gibbs, Gilbert)

At least five coal beds of the upper coal group crop west of Fat Elk Creek in secs. 3, 9, and 10, and farther south. They were described by Diller (1899:343-345) who also measured them and gave a section. Portions of this section were measured by means of a plane-table survey, and the thickness of rock between the coals were found to be much greater than Diller indicated. Comparative sections given are as follows:

Diller (1899:344)

	Feet	Inches
Shale .....	.....	.....
Coaly shale	5	.....
Clay .....	.....	3
Bed No. 5	2	6
15'7" (Gilbert?) .....	.....	4
Coal	2	6
Shale	3	.....
Coal, bony	2	.....
Shale	50	.....
Bed No. 4 .....	.....	9
5'9"	2	6
Shale	2	6
Coal and coaly shale	100	.....
Shale	5	.....
Bed No. 3	3	.....
10'	2	.....
Coal, bony	60	.....
Shale .....	.....	4
Bed No. 2	5	.....
7'10" (Gibbs?)	1	.....
Coal, shaly	1	6
Shale	100?	.....
Coal	2	7
Bed No. 1 .....	.....	1
4'6"	1	10
Coal .....	.....	.....
Sandstone	150?	.....
	503	8?

Survey (1944)

	Feet
Shale .....	.....
Bedded sandstone and shale	160
Massive sandstone	50+
Shale and sandstone (may contain upper coals)	440
Gilbert bed	11*
Shale	269
Gibbs bed	6
Shale	865
Bogard bed	5
Massive sandstone	50
	1,856+

There are several coals which were not measured, lying above the Gibbs bed, exposed up

the creek to the west. One of these is undoubtedly the Gilbert bed.

A prospect was opened up by Leonard Gibbs during the summer of 1943 on a bed a quarter of a mile south of the schoolhouse on Fat Elk Creek in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 3, T. 28 S., R. 13 W., about half a mile south of the highway. This bed lies 275 feet below the Gilbert bed.

Gibbs sunk a slope on the coal a distance of about 150 feet; 30 feet down the slope the coal dips 25°; 40 feet down, 30°; and 50 feet down, 35°. The strike is N. 50° E. This prospect was abandoned because of the poor quality of the coal as shown in the following sections:

Section 1, taken 50 feet from portal on right side:

	Feet	Inches
"Slate"		
*Coal	3	
Dirt	1½	
*Coal	6	
Dirt	1	
Coal	1	
Dirt	¾	
*Coal	10½	
Dirt	1½	
*Coal	2	
*Dirt	1½	
*Coal	4½	
Broken coal and dirt	½	
Mining	5	
*Bone	2	
*Coal	5	
Bone	1	
Clay	1	
Clay and bone	6	
Coal	½	
Clay	1	
Coal	¾	
Clay	2	
Bone	5	
Clay		
Total thickness of coal sampled	2	10½
Total thickness of parting	2	5½
Total thickness of bed	5	4

* Clean sample (34½ inches) No. 61; total thickness (5 ft. 4 in.) sample, No. 60.

Field No. 60
Lab. No. P-2075

	Thickness	
Sample	5 ft. 4 in.	
Bed	5 ft. 4 in.	
Analysis	As Received	Air Dried
Moisture	20.27	8.82
B. t. u.	5,803	7,278
Ash	29.36	32.20

Field No. 61
Lab. No. P-2076

	Thickness	
Sample	2 ft. 10½ in.	
Bed	5 ft. 4 in.	
Analysis	As Received	Air Dried
Moisture	19.95	8.70
B. t. u.	7,579	9,469
Ash	16.94	18.56

Another section was measured 75 feet in, as follows:

	Feet	Inches
Shale, sandy		
Coal	1	7
Bone		1
Coal		9
Bone		3
Coal		2
Clay		¾
Coal		4
Bone		3
Bony clay		4
Coal		4
Carb. shale		2
Coal, bony		5
Clay		1
Coal		1½
Carb. shale		6
Coal		3½
Coal, bony		4
Shale, 3 ft. 7 in. plus		
Total thickness of coal	4	1
Total thickness of parting	1	11
Total thickness of bed	6	...

The same bed of coal is exposed over the ridge a quarter of a mile to the southwest in the bed of a small creek. The coal strikes N. 50° E. and dips 29° NW. The section is as follows:

	Feet	Inches
Sandstone, shaly		
Bone		6
Coal, bony		8
Coal	1	1
Clay		2
Coal		9
Bone		1
Coal	1	1
Shale, carbonaceous		1
Coal		11
Clay		5
Bone	1	...
Clay		
Total thickness of coal	3	10
Total thickness of parting	2	11
Total thickness of bed	6	9

Farther up this creek, at least three other outcrops were found in a vertical distance of 300 feet. All the coal appeared to be dirty although the beds were of considerable thickness.

The Gilbert mine is located near the mouth of Fat Elk Creek 3 miles west of Coquille, in the NW $\frac{1}{4}$, SW $\frac{1}{4}$ sec. 3, T. 28 S., R. 13 W., at an elevation of about 150 feet. It lies up a small gulch, a hundred yards west of the Fat Elk Creek road, less than half a mile south of its junction with the highway.

When the mine was visited by Geer in 1939 (see Yancey and Geer, 1940:12) it was under development. The mine was not operating in 1943.

The bed is thick and dirty, and lies 275 feet above the coal developed in the Gibbs prospect. The outcrop was measured in the road cut, where it strikes N. 50° E. and dips 29° NW.

The section in the mine given by Geer is as follows:

	Feet	Inches
Sandstone, smooth		
Bone, coal streaks		4
Shale, firm		2
*Coal, friable		4½
Shale, gray, hard		1
*Coal, hard	2	10
Shale, soft carbonaceous		
Bone, shale, coal, interstratified, 10 ft.		
Total thickness of bench	3	9½
Total thickness in sample	3	2½

The analysis (*) of this coal is given as follows (p. 20):

Lab. No. B-40026			
Analysis	As Received	Dried at 105° C.	Moisture and ash free
Moisture	16.4		
Volatile matter	35.0	41.9	48.7
Fixed carbon	36.9	44.1	51.3
Ash	11.7	14.0	
Sulfur	.6	.7	.8
Hydrogen	6.0	5.0	5.8
Carbon	52.7	63.1	73.3
Nitrogen	1.2	1.4	1.7
Oxygen	27.8	15.8	18.4
B. t. u.	9,260	11,080	12,880
Air dry loss		8.1%	
Ash softening temperature		2370° F.	
Agglomerating index		NAa	

The bed, although nowhere completely exposed, is thought to be about 14 feet thick, but only the upper 4 feet is being worked. At the time of sampling the mine was under development, and some 50 feet of slope and 60 feet of entry had been driven. The production was being sold as run-of-mine coal.

The lowest exposed coal of the Fat Elk Creek group appears in the road cut on the point east of Fat Elk Creek on the section line between 3 and 10, in the NE¼ NW¼ sec. 3, T. 28 S., R. 13 W. This coal has been correlated with the Beaver Hill or Urquhart bed of the upper coal group. It lies more than 800 feet stratigraphically below the Gibbs bed. The measured section is as follows:

	Feet	Inches
Sandstone, medium-grained, massive		
Bone		11
Coal		2
Bone, coaly		8
Clay		1
Bone		2½
Coal, fair		7½
Shale, carbonaceous		6
Bone	2	
Sandstone, massive		
Total thickness of coal and bone	4	7
Total thickness of bed	5	2

The coal at this point strikes N. 40° E. towards Cedar Point and dips 17° W.

Cedar Point Coal (24)

The coal at Cedar Point 2 miles west of Coquille is believed by Diller and Pishel (1911:221) to be the bed below the Beaver Hill or Newport, "unless

faulting took place in the SW¼ SW¼ sec. 35." Diller's section is as follows:

	Feet	Inches
Shale		
Coal		3
Parting		1
Coal	2	8
Shale, coaly		8
Shale		8
Coal, shaly	1	
Sandstone		
Total thickness of coal	3	11
Total thickness of bed	5	4

A short tunnel near the railroad was visited by the survey. The strike of the coal here is N. 50° E. and the dip 35° NW. The incomplete section obtained is as follows:

	Feet	Inches
Shale, paper (several feet)		
Coal and bone in thin layers	3	10
Shale, brown	1	2
Shale, carbonaceous (base not exposed)		

It could not be determined whether or not this was the same bed measured by Diller.

McClain Mine (25)

The McClain mine is located northwest of Coquille in the SE¼ sec. 35, T. 27 S., R. 13 W. Coal was mined in 1929-1930 from a slope on a bed which is probably the Beaver Hill. The coal strikes N. 20° E. and dips 24° NW.

The old Peart and the new Peart mines mentioned by Diller and Pishel (1911:221-22) and Lord (1913:684) are presumably upon the same bed northeast of the McClain mine. At the old Peart mine the bed is reported to strike N. 55° E. and dip 26° NW.; at the new Peart the strike is N. 20° E. and dip 16°-18° NW.

The old Peart mine was located in the SW¼ NE¼ sec. 35, and, near the northeast corner of this section, five coals are reported by Diller and Pishel (1911:221) to be exposed. It was operated in 1908 and 1909 at a rate of 10 to 20 tons a day. The new Peart mine is in the NW¼ NW¼ sec. 36. The section at the new Peart mine, measured 140 feet west of the main slope and 480 feet down, is given by Lord as follows:

	Feet	Inches
Roof sandstone		
Sandy shale		6
Jointed coal		4
Sandy clay		6
*Good coal		3½
Sandy gray clay		1
*Good coal	3	4
Very sandy clay		8
Bony coal	1	
Coaly bone	1	11
Thickness of bed	8	7½
Thickness of coal sampled	3	7½

The analysis (*) is as follows (Diller and Pishel, 1911:226):

Lab. No. 9188				
Coal bed	8 ft. 7½ in.			
Part sampled	3 ft. 7½ in.			
Air-drying loss	6.8			
	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	18.0	12.0		
Volatile matter	31.8	34.1	38.7	44.4
Fixed carbon	39.7	42.6	48.4	55.6
Asn	10.5	11.3	12.9	
Sulphur	2.27	2.44	2.77	3.18
Calories	4,950	5,310	6,035	6,925
B. t. u.	8,910	9,560	10,860	12,470

According to Diller and Pishel (1911:222):

One bed of this group was found by Mr. Diller on Budd Creek, near the north quarter corner of sec. 36, and its section was taken. No other outcrops were found in this township on this limb of the syncline northeast of the point last mentioned.

The above-mentioned section (Diller, 1899:345) is as follows:

	Feet	Inches
Coal, shaly	1	6
Coal, good	1	2
Coal, bony		10
Parting		3
Coal, shaly	1	10
Sandstone, shaly		
Thickness of bed	5	7

In this reference this coal is reported to be in sec. 25, and it possibly is the same as that at the Bituminous Coal Company mine.

The upper Coaledo plunges southward from the Catching Slough arch and the southern toe of the Sumner basin, and the middle Coaledo is greatly thinned, pinching to about 400 feet along Dean-Minard road which parallels the coal from the McCain mine to the Bituminous Coal Company mine.

Bituminous Coal Company Mine (26)

A small coal mine was operated in about 1926 on land now belonging to Lester Brown in the SW¼ sec. 25, T. 27 S., R. 13 W. The complete history of this mine is not known but William W. Elmer* reports that it was mined by the Bituminous Coal Company which held this property under lease. Mr. Elmer described the operation as follows:

In sec. 25 a road and bunkers have been constructed and are now in good working order. A cross-cut tunnel has been run 192 feet as shown by records of the company.

The vein on which drifting has been done is cut at 105 feet from the tunnel portal and beyond this point the cross-cut is caved and

cannot be examined. This cross-cut was doubtless continued beyond the first vein in order to cut the second vein called upper bed on the company map . . .

A drift south from the cross-cut is caved and cannot be examined. North from the cross-cut the drift is open. At the face, 40 feet from the cross-cut, a room has been taken out above the level and an incline put down 200 feet (according to Mr. Thos. Keller) with rooms from drifts at various elevations. This incline is full of water . . . at this time.

Three outcrops were inspected on this section and it is certain that two veins exist while a third is reported as cropping beneath the dump at the mouth of the tunnel.

(Analysis No. 1 was taken from a cross-cut and No. 2 from the same bed 200 feet westerly.)

	No. 1	No. 2
Water @ 220° F.	16.69	17.69
Vol. combustion	22.64	26.00
Fixed carbon	50.51	45.29
Ash	10.16	11.02
Sulphur	0.30	0.63

The old mine opening is now caved but the following section was taken near the entrance:

	Feet	Inches
Shale, sandy		
Coal, platy	1	2
Clay parting		3
Coal	3	3
Coal, bony	1	1
Carbonaceous shale		

The coal has been faced recently about 50 feet higher up the hill to the north in a small ravine. The following section was taken on what appears to be a higher bed:

	Feet	Inches
Sandstone		
Platy coal, some bone	3	3
Bottom undetermined		

Most of the mining has been on the lower beds. The strike is N. 10° W. and the dip 12° W. From their stratigraphic position, these are the basal beds of the upper coal group. The lower bed is probably the equivalent of that in the McClain and Peart mines to the south along the strike. The coal north of here swings around toward the west on a southward plunging structure.

South Slough Basin Coals (Including Empire)

Yokam Point Coal (27)

On the west side of Yokam Point (Mussel Reef) a coal bed is exposed which may be the Beaver Hill bed, (pl. 14-C). This outcrop, near the center of the E½ sec. 4, T. 26 S., R. 14 W., on the sea cliff, is the only coal exposed in the upper Coaledo

* Private report.

coastal section. The following section was measured:

	Feet	Inches
Sandstone, medium-bedded		
Shale, gray, sandy	3	.....
Shale, gray, fine-bedded	4	.....
Marl, shaly, oyster bed	3	.....
Coal, bony	1	6
Sandstone, massive		
Total thickness of coal	1	6
Total thickness of section	11	6

No other coal of the upper group appears as far north and west, although the rock exposures in the coastal section are continuous. Possibly the sea was advancing during upper Coaledo time and the coal swamps in which the coals above the Beaver Hill bed were formed were farther inland; possibly the basin was becoming smaller, so that only the lowermost and earliest coal (the Beaver Hill bed) was deposited in this area.

Big Creek Mine and Prospect (28)

The Big Creek mine is located along the south side of Big Creek near the center of sec. 16, T. 26 S., R. 14 W. It was operated by Mr. L. Simpson. The coal was taken from the portal across a small creek to a low bunker, the remains of which still stand. From there it was taken by horse-drawn vehicles to the local market. Mr. Simpson estimates about 3,000-4,000 tons was removed.

The coal strikes N. 13° E. and dips an average of about 48° E. The following section was measured:

	Feet	Inches
Massive sandstone		
Shale, light colored		4
Coal	1	11
Coal, soft dirty		5
Clay parting, brown		7
Coal, soft dirty		7
Sandstone		
Total thickness of coal	2	13
Total thickness of bed	3	10

It is doubtful if this is the Beaver Hill bed. The coal is relatively high in the upper Coaledo, and it does not correspond with other sections of the Beaver Hill coal. According to Diller and Pishel (1911:218) the Beaver Hill bed was not found between sec. 28 and Yokam Point.

An outcrop of coal which strikes N. 15° W. and dips 46° E. is located near the head of Big Creek in the SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 28, T. 26 S., R. 14 W. It was sectioned by Diller and Pishel as follows:

	Feet	Inches
Sandstone, shaly		
Coal	2	6
Shale, sandy		6
Coal	1	8
Clay		1
Coal		2

	Feet	Inches
Clay		$\frac{1}{2}$
Coal, bony	1	.....
Shale		
Total thickness of coal	5	4
Total thickness of bed	5	11 $\frac{1}{2}$

South Slough Project (29) (Schetter or McKenna mine)

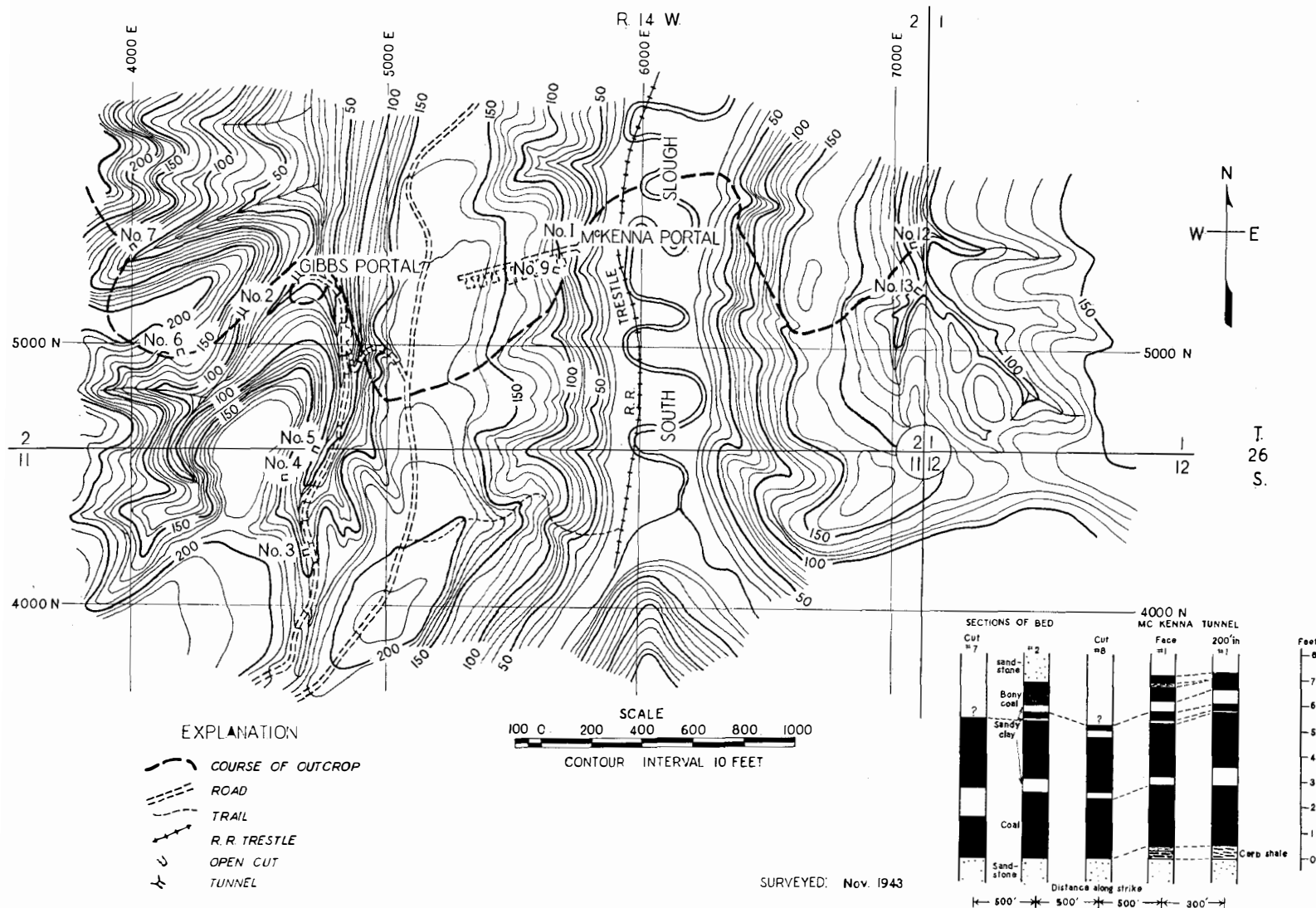
The Beaver Hill coal bed crops out in the S $\frac{1}{2}$ sec. 2, T. 27 S., R. 14 W., and was mined in 1932 at the Schetter or McKenna mine whose portal is located 1,300 feet west and 800 feet north of the southeast corner of the section. An area of 250 acres along the southern boundary of the section was mapped by the survey on a scale of 200 feet to the inch and a contour interval of 10 feet (pl. 28), and the course of outcrop of the coal was traced for over 5,000 feet by means of open cuts, short tunnels, and hand auger holes.

Early in 1944 the property was being operated by Leonard H. Gibbs on lease from the owners, H. G. Kern, Mrs. Otto Schetter, Groth, and J. S. and M. C. Getty. Mr. Gibbs built a road to the outcrop down the first gulch to the west of South Slough proper, and is driving on the coal both to the east and to the west at a point near the junction of the forks of the gulch.

Both the McKenna and Gibbs mines are most easily reached at the present time by way of the Krome road from the highway and railroad siding at Beaver Hill, a distance of 8 miles by surfaced road and 1.1 miles by dirt road.

The McKenna or Schetter mine workings lie approximately on the axis of a north-plunging syncline. The strike swings both to the northeast and to the northwest when followed from the mine. The portal of the mine lies on the west side of South Slough at an elevation of about 50 feet. The gangway extends into the ridge for 500 feet in a S. 70° W. direction. Eight rooms were turned to the south, and it is reported that about 2,000 tons was mined for local use including logging operations. The coal dips from 17° to 25° N. The roof is firm; the tunnel and rooms have remained open since the mine was in operation in 1932 and 1933 except for a small amount of caving from the small upper bench of coal. Sections in the mine and to the west are given on plate 28, and analyses of the coal at localities listed are as follows:

Field No.	57
Lab. No.	P-2072
Location:	Cut No. 7, 1800' W. of McKenna; 5°3'N 40°35'E, Elevation 71'.
	Thickness
Sample	4 ft. 4 in.
Bed	5 ft. 4 in.



South Slough project: Topography, McKenna or Schetter mine workings and coal sections, and course of outcrop of the Beaver Hill bed.

Analysis	As Received	Air Dried
Ash	7.70	8.53
Moisture	21.80	9.60
B. t. u.	8,743	11,181

Field No. 67
 Lab. No. P-2080
 Location: Cut No. 2, old tunnel W. of McKenna; 5170N-4485E. Elevation 86'.

Sample	Thickness
.....	5 ft. 4½ in.
Bed	7 ft. 4 in.

Analysis	As Received	Air Dried
Ash	7.11	7.55
Moisture	29.83	5.80
B. t. u.	9,078	11,481

Field No. 0
 Lab. No. P-2056
 Location: Cut No. 8 (now covered by new road), 5000N-4953E. Elevation 50'.

Sample	Thickness
.....	4 ft. 6 in.
Bed	5 ft. 2 in.

Analysis	As Received	Air Dried
Ash	5.72	7.44
Moisture	23.15	12.8
B. t. u.	8,423	10,960

Field No. 54
 Lab. No. P-2070
 Location: McKenna tunnel No. 1, left side of face, end of gangway.

Sample	Thickness
.....	5 ft. 6 in.
Bed	6 ft. 4 in.

Analysis	As Received	Air Dried
Ash	8.98	9.66
Moisture	20.05	7.00
B. t. u.	8,747	10,941

Field No. 56
 Lab. No. P-2071
 Location: McKenna tunnel No. 1, 200' from portal, 5435N-5800E. Elevation 49'.

Sample	Thickness
.....	5 ft. 6 in.
Bed	7 ft. 5½ in.

Analysis	As Received	Air Dried
Ash	9.12	9.96
Moisture	21.74	8.38
B. t. u.	8,611	11,003

Field No. 53
 Lab. No. P-2069
 Location: Cut No. 9, 150' South of McKenna; 5345N-5720E. Elevation 92'.

Sample	Thickness
.....	7 ft. 10 in.
Bed	9 ft. 1 in.

Analysis	As Received	Air Dried
Ash	7.20	7.92
Moisture	22.59	10.32
B. t. u.	8,704	11,243

Coal was also found several hundred feet south of the main bed at several points in the west gulch and in a gulch still farther to the west. The dip and strike of this coal is approximately the same as that of the main bed but the section shows only two benches. Either this is a coal lower than the Beaver Hill bed, which is improbable, or it is a thinner portion of the Beaver Hill bed lying in a down-dropped fault block. Landslide pockets suggest a northwest-trending fault zone between the coal outcrops. It is unlikely that this bed is the

equivalent of that which underlies the Beaver Hill at an interval of 70 feet, east of Empire and west of Beaver Hill.

One mile northeast of the McKenna mine, in the NW¼ sec. 1, T. 27 S., R. 14 W., an old tunnel has been driven on a bed of coal which strikes N. 20° E. and dips 82° W. This tunnel is located on an eastern branch of South Slough. The section of coal is as follows:

	Feet	Inches
Sandstone, hard		
Carbonaceous shale		3
*Coal, soft		6
Coal, bony		5
*Coal, soft		11
Clay		2
*Coal, soft		11½
Clay		1
*Coal, soft		7
Shale, carbonaceous		3
*Coal, hard		4
Sandstone, hard, blue		
Total thickness of coal sample	3	3½
Total thickness of bed	4	5½

Analysis of the above sample (*) is as follows:

Field No. 68
 Lab. No. P-2080B
 Location: Tunnel 1 mile NE of McKenna; NW¼ sec. 1, T. 27 S., R. 14 W.

Sample	Thickness
.....	3 ft. 3½ in.
Bed	4 ft. 5½ in.

Analysis	As Received	Air Dried
Ash	6.01	7.20
Moisture	25.84	10.55
B. t. u.	8,183	11,034

A section on the Beaver Hill bed mentioned by Diller and Pishel (1911:217) in the NW¼ sec. 1, T. 27 S., R. 14 W., is as follows:

	Feet	Inches
Sandstone		
Coal		8
Shale, sandy		5
Coal		4
Clay		1
Coal		3
Sandstone		6
Coal		8
Sandstone		2
Thickness of coal	7	
Thickness of bed	8	2

Another adjacent outcrop is reported by Diller and Pishel (1911:211) to strike N. 22° E. and dip 62° W. The section is as follows:

	Feet	Inches
Sandstone		
Coal		10
Clay		5
Coal		3
Clay		1
Coal		6
Clay		10
Coal		6
Sandstone		
Total thickness of coal	7	1
Total thickness of bed	8	5

On following the strike northeastward from this point into sec. 36, T. 26 S., R. 14 W., coal was found in a ravine about 260 feet south-east of a shaly sandstone outcrop of similar

strike. About 1,500 feet north of Mr. Sengstacken's house in sec. 19, T. 26 S., R. 13 W., a pile of coal was found on the creek bank. This may have been taken out of the bottom of the creek, but the outcrop could not be found. Up the same creek, in the NE $\frac{1}{4}$, NE $\frac{1}{4}$ sec. 19, an outcrop of coal was observed, but a section of the bed could not be obtained. Mr. Diller also reported in the Coos Bay folio a coal outcrop at this point, but gave no section. Farther north, near the west line of sec. 17, a coal opening on the Newport bed was located and the section measured as follows:

	Feet	Inches
Sandstone		
Coal	.....	5
Clay	.....	6
Coal	.....	2
Clay	.....	3
Coal	.....	2
Total thickness of coal	4	5
Total thickness of bed	5	2

This coal is mapped as striking N. 20° E. and dipping 42° W.

Oldlands Mine (30)

The Oldlands mine on the Newport or Beaver Hill bed of the upper coal group is located on the east side of Joe Ney Slough, in the center of the W $\frac{1}{2}$ SW $\frac{1}{4}$ sec. 8, T. 26 S., R. 13 W. A tunnel runs N. 75° E. for 65 feet to the coal, then turns to the left on the coal, which strikes N. 15° E., for another 65 feet to the face. The coal dips 65° to the west, and a measured section (possibly somewhat disturbed by faulting) is as follows:

	Feet	Inches
Sandstone		
Coal	.....	4
Clay, sandy	.....	6
Coal	.....	1½
Clay	.....	1
*Coal (to fault)	2	5
*Coal, pulverized (across fault)	2	3
Clay	.....	3
*Coal, bony	2	6
Sandstone		
Total thickness of coal	7	7½
Total thickness of parting	.....	10
Total thickness of bed	8	5½

Analysis (*) of the three lower benches is as follows (half the lower bench was omitted):

Field No.	17		
Location:	Face of 130 ft. tunnel.	Center of W½ SW¼	
	sec. 8, T. 26 S., R. 13 W.		
Sample	6 ft.	Thickness	
Bed	8 ft. 5 in.		
Analysis	As Received	Air Dried	
Moisture	23.8	12.3	
Ash	7.88	8.99	

In the SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 7, Diller and Pishel (1911:211) reported a bed of coal higher than the Newport bed, with a thickness of 1 foot 10 inches of coal, striking north and dipping 70° W.

Vey Prospect (31)

A coal outcrop was examined on the Vey property on the north fork of Joe Ney Slough in the SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 5, T. 26 S., R. 13 W. The outcrop is in a narrow gulch running south from the main gulch where the Vey ranch is located. The coal strikes N. 10° W. and dips 70° W., and has the following section.

	Feet	Inches
Roof, sandstone		
Coal	2	8
Clay parting	.....	3
Coal	2	4
Floor, blue clay		
Total thickness of coal	5	.....
Total thickness of bed	5	3

Empire Mines (32)

According to Diller and Pishel (1911:197-198), the Empire basin furnished one of the first cargoes of coal shipped from Coos Bay to San Francisco. The coal was mined near the southwest corner of sec. 20, where the bed strikes N. 15° W. and dips 70° E. in three openings all of which appear to be on the same bed. Diller gives a section as follows:

	Feet	Inches
Sandstone		
Coal	1	6
Sandstone	.....	6
Coal	1	8
Sandstone		
Total thickness of coal	3	2
Total thickness of bed	3	8

The survey investigated three outcrops of coals along the southwest edge of sec. 20, within a north-south distance of 3,000 feet. The bed seems to be badly broken by small faults ranging in throw from a few inches to more than a foot. The high angle of dip and the faulting would probably make the coal unprofitable to mine.

The northern cut is located just west of Camas Road in the south bank of a small creek; the coal strikes N. 45° E. and dips 61° SE. The section and analysis are as follows:

	Feet	Inches
Sandstone		
*Coal	.....	6
Clay	.....	2
*Coal	.....	7
Clay	.....	1
*Coal	2	4
Clay	.....	3
*Coal	.....	10
Clay		
Total thickness of coal	4	3
Total thickness of bed	4	9

Field No.	83		
Lab. No.	P-2194		
Analysis	As Received	Air Dried	
Moisture	24.75	13.50	
B. t. u.	7,224	8,342	
Ash	14.76	17.07	

The southern cut is located in the bank of another creek half a mile farther south. A section showed 2 feet 5 inches of hard coal between sandstone and clay, standing almost vertically and striking almost north. Analysis is as follows:

	Field No.	81		
	Lab. No.	P-2192		
Analysis			As Received	Air Dried
Moisture			24.29	8.50
B. t. u.			8,460	11,175
Ash			7.94	8.68

Diller and Pishel (1911:198) reported an outcrop on the east side of the basin in the northeast corner of sec. 29, with a strike of N. 35° W. and a dip of 65° SW. The section is as follows:

	Feet	Inches
Sandstone, thin-bedded		
Coal	1	3
Clay		2
Coal	1	6
Sandstone		
Total thickness of coal	2	9
Total thickness of bed	2	11

The dip of the coal bed is steep to the southwest, as if it belonged to the eastern arm of a basin whose western arm contains the coal bed near Empire. The basin is deep and the belt of coal within 2,000 feet of the surface is narrow. The outline of the basin based on these two exposures is largely conjectural and as represented has only a suggestive value; it indicates nearly 350 acres within the probable coal belt.

One quarter of a mile to the south of this outcrop, Diller mapped a north-striking vertical bed of coal.

A coal locality, possibly the same as reported by Diller, situated along the section line between secs. 20 and 21 and between secs. 28 and 29, was investigated by the survey. This locality is reached by a road leading through the cemetery. Coal was mined just back of the cemetery by Mr. W. G. Robertson during 1932 and 1933 with an average production of 10 tons per day. Two beds of coal at this locality strike about N. 20° E. and dip 14° W. The mine was in the lower bed which is also the thinner coal. The upper or "7-foot bed," as it is locally referred to, is believed to be the Beaver Hill bed. This is an exceptional instance in which a coal has been worked beneath the Beaver Hill bed in the upper Coaledo series. The upper bed is exposed in a short tunnel just west of the main portal. There is a covering of sand which makes prospecting difficult. However, the surface slope and the dip of the bed seem to coincide generally and there is a possibility of a coal stripping area in this locality.

South of the mine in the northeast corner of sec. 29, and near the head of drainage into Pony Slough, the same coal beds crop out but they dip steeply (45°-60°) to the east. The structure here appears to be that of an asymmetrical anticline, lying east of the Empire basin.

There seems to be some evidence of numerous faults in this area. On the western slope toward Empire, the covering of sand prevents examination of the strata. In the Robertson mine, which is reported to have reached 600 feet down a dip of 14° and to have extended nearly 1,000 feet southward, no extensive faulting is said to have been encountered.

Coquille Basin Coals

Marsters Prospects (33)

Two prospects owned by the Marsters estate have been developed, one toward the head of Pulaski Creek, in the NE $\frac{1}{4}$ sec. 21, T. 28 S., R. 13 W., and the other in the SE $\frac{1}{4}$ of the same section, over the divide to the west.

The prospect in upper Pulaski Creek was opened up many years ago when the area was being logged. Coal was hoisted to the top of the hill by donkey and skyline, then brought down to the Fishtrap Creek road. Operation was soon discontinued because of distance from good roads. The coal in the upper Pulaski Creek strikes N. 5° W. and dips 24° SW. beneath a very steep, high hill. Sixty inches of coal in one bench is exposed in the tunnel portal. One or two dirt partings of about an inch occur in this bed.

The prospect in the SE $\frac{1}{4}$ sec. 21 was opened in about 1937 or 1938. The tunnel is in good condition but little coal was removed. Another prospect in the SE $\frac{1}{4}$ of the section strikes N. 70° E. and dips 4°-5° W. The section is as follows:

	Feet	Inches
Sandstone		
Coaly material		4
Clay		5
Coal and bony coal	2	11
Total thickness of coal	3	3
Total thickness of parting		5
Total thickness of bed	3	8

Both of these coals belong to the upper coal group, and there is a possibility that they represent variations of the same bed. The Pulaski Creek coal appears to be good coal in a fairly thick bed.

Lyons Mine on Harlocker Hill (34)

The Lyons mine is located in the SE $\frac{1}{4}$ sec. 23, T. 28 S., R. 13 W., about 300 feet above the Coquille

River in a small ravine. According to information from Mr. Lyons, the slope was sunk 80 feet west-erly to a vertical fault where the coal dropped 12 feet. Gangways were run 300 feet north and 300 feet south. The mine produced coal for one year during 1904 and 1905 at a rate of approxi-mately 10 to 15 tons per day.

The opening was entirely caved when visited. The section of coal as remembered by Mr. Lyons consisted of the following:

	Feet	Inches
Coal .....	.....	3½
Mining .....	.....	8
Coal	1	6

The coal lies on the east limb of the Coquille basin. The dip of surrounding strata is gentle, about 20° W. This is one of the upper Coaledo coals although its correlation with the Riverton group is uncertain. Mr. Lyons suggests that it is the equivalent of the Riverton bed.

Other coal prospects were visited in the vicinity of Harlocker Hill. Several coal croppings, pre-sumably on the western limb of the basin, are reported in the small gulches which drain through Mr. Theo. Scheil's farm. Coal located in the gulch about 200 yards west of the road in the SW¼, sec. 23, T. 28 S., R. 13 W., dips 35° SW., but the thickness was undetermined.

In the road cut along the river just north of the Lyons property, 40 inches of bony coal crops out at the top of the road cut. It strikes N. 40° E. and dips 24° NW.

Diller (1899:364) gives a section of the coals exposed in the cliff at Harlocker Hill as follows:

	Feet	Inches
Shale		
Coaly shale	3	6
Shale?	30?	
Coal	1	
Bed 5'10"		
Parting	6	
Coal	3	
Parting	7	
Coal	6	
Sandstone? (massive towards base) ..	100	
Coal, shaly	2	
Sandstone	50	
Bed 3'7"		
Coal, shale	8	
Coal, good	1	
Coal, dull	1	
Sandstone? (shaly at base)	185	
Shaly coal	6	
Coal	3	
Shale?	44	
Bed 8'9"		
Coal and coaly shale	6	
Shale	3	
Coal and coaly shale	2	
Shaly sandstone	25?	
Coaly in part shaly	1	
Shaly sandstone?	100	
Total thickness of section	537	6?

Albee Mine (35)

Lord (1913:686) describes the Albee mine, lo-cated in the NE¼ sec. 4, T. 29 S., R. 13 W., on a branch of Fishtrap Creek 4 miles from the mouth of the creek.

The coal was mined on a small scale in 1909. It dips 22° SE. and has the following section:

	Feet	Inches
Roof, massive sandstone		
*Coal, hard	1	
Parting		4
*Coal, block, hard	2	
Coal, bony	1	
Floor, shale		
Thickness of bed	4	4
Thickness of coal sampled	3	

The analysis (*) is as follows (Diller and Pishel, 1911:226):

Lab. No. 9245	
Coal bed	4 ft. 4 in.
Part sampled	3 ft.
Air-drying loss	1.6

	As Rec'd	Air Dried	Dry Coal	Pure Coal
Moisture	12.8	11.4		
Volatile matter	34.8	35.4	39.9	47.7
Fixed carbon	38.2	38.8	43.8	52.3
Ash	14.2	14.4	16.3	
Sulphur	1.13	1.15	1.30	1.55
Calories	4,990	5,070	5,720	6,835
B. t. u.	8,980	9,130	10,300	12,310

UNDIFFERENTIATED COAL GROUP

In many instances, it is not known definitely whether the coals belong to the upper or lower group. The coals exposed on the north side of Coos Bay and on the east side of Isthmus Slough are among those of undetermined age. Faulting has displaced the strata, and the structure is un-certain in several places.

The northeast strike of the coal in the northern part of the Southport mine, and several other northeast and easterly strikes on both sides of Shinglehouse Slough suggest that the upper Coal-edo strata may not extend northward to Bunker Hill. As the middle Coaledo was not found be-tween Caledonia and Southport, however, it seems more probable that the strata at Caledonia and Bunker Hill are in reality upper Coaledo in age.

East Side Coals (Steve and Hardy Beds)

Hanson Prospect (36)

Coal appears 200 yards west of the Haynes Slough road, behind the Hanson farmhouse in sec. 13, T. 24 S., R. 13 W. It strikes N. 8° W. and dips 70° W. The following section was measured:

	Feet	Inches
Sandstone		
Coal, good	8	
Clay, brown	2	
Coal, dirty	7	
Clay, brown	3	
Coal, good	6	
Clay, brown	4	
Coal, dirty	8	
Clay, blue	5	
Coal, poor	3½	
Clay, brown	2	
Coal, dirty	10	
Clay		
Total thickness of coal	3	6
Total thickness of bed	4	5

This coal has not been traced to connect with any known bed, but it probably belongs to the lower group.

Black Diamond Tunnel (37)

A tunnel driven 30 feet on coal is located on the shore just above high tide on the point between North Slough and Haynes Slough in the northwest corner of sec. 34, T. 24 S., R. 13 W. (pl. 29). The coal strikes N. 17° E. and dips 29° W. The section given by Diller and Pishel (1911:-203) is as follows:

	Feet	Inches
Sandstone		
Coal, bony	2	...
Sandstone	9	
Coal, bony	1	
Coal	2½	
Coal, bony	2	
Shale	8	
Coal, bony	2	
Sandstone		
Total thickness of coal (bony)	7	2½
Total thickness of parting	1	5
Total thickness of coal bed	8	7½

The section taken by the survey is as follows:

	Feet	Inches
Sandstone, massive, gritty, and pebbly		
Bone, platy	6	
Coal	4	
Clay	1½	
Coal	5	
Clay	1½	
Coal (broken)	4	
Shale	6	
Bone, with coaly streaks	2	4
Clay	4	
Bone	6	
Sandstone, massive		
Total thickness of coal and bone	4	7
Total thickness of parting	1	1
Total thickness of coal bed	5	8

Lone Rock Prospects (38)

The Steva bed crops out in the highway road cut just 0.2 mile north of Lone Rock, in the center of the SW¼ sec. 25, T. 24 S., R. 13 W., (pl. 29, No. 38-A). The rocks here strike N. 50° W. and dip 30° W. A dark-colored coarse-grained basaltic sandstone underlies the coal a few hundred feet to the south.

Two tunnels on the south side of the Ingersoll Gulch, east of Lone Rock, in the NW¼ sec. 36,

T. 24 S., R. 13 W., were driven in 1938 and 1939 by Zeph Thomas. One tunnel on the Hardy bed (pl. 29, No. 38-B) lies 700 feet east of the highway and 25 feet above sea level, having been driven 150 feet S. 20° E. on the coal, which dips 15° SW. The other tunnel (pl. 29, No. 38-C) lies 1,500 feet east of the highway in a small branch on the south side of the main gulch, and is said to be about 50 feet long. The coal is cut off by a fault at the face. At the mouth of the tunnel the coal strikes N. 20° E. and dips 33° NW.

In tunnel No. 38-C the following section was disclosed:

	Feet	Inches
Sandstone		
Clay		3
*Coal	1	9
Clay, light		½
*Coal		2
Parting		1½
*Coal		5
Parting		4
*Coal, soft	1	8
Clay		
Total thickness of coal	4	
Total thickness of parting		9
Total thickness of bed	4	9

The analysis (*) is as follows:

Field No.	96		
Lab. No.	P-2216		
Sample		Thickness	
Bed		4 ft.	
		4 ft. 9 in.	
Analysis		As Received	Air Dried
Moisture		20.69	11.20
B. t. u.		7,716	9,730
Ash		15.09	17.08

A 50-foot drift exposes the Hardy bed at the Oscar Larson prospect, east of the Shell station, a quarter of a mile south of Ingersoll Gulch in the NE¼ sec. 36 (pl. 29, No. 38-D). The coal here strikes N. 40° W. and dips 22° SW. The following section is found:

	Feet	Inches
Sandstone, coarse, friable		
Coal, fair quality	1	3
Coal, bony		7
Bone		2½
Clay, dark		3
Bone		1
Clay, light		½
Coal		½
Shale, carbonaceous		1
Coal, bony		3
Clay		1
Bone and clay, alternating	1	
Clay, hard		4
Shale, carbonaceous		6
Coal, fair quality		1½
Coal, bony		4
Shale and bone		3½
Coal		4½
Clay		
Total thickness of coal and bony coal	2	2½
Total thickness of parting		½
Total thickness of bed	6	3

The Steva bed is reported by Diller (1911:203) to crop out in the NE¼ NW¼ sec. 36, T. 24 S.,

R. 13 W., where it strikes N. 7° E., dips 35° W., and has the following section:

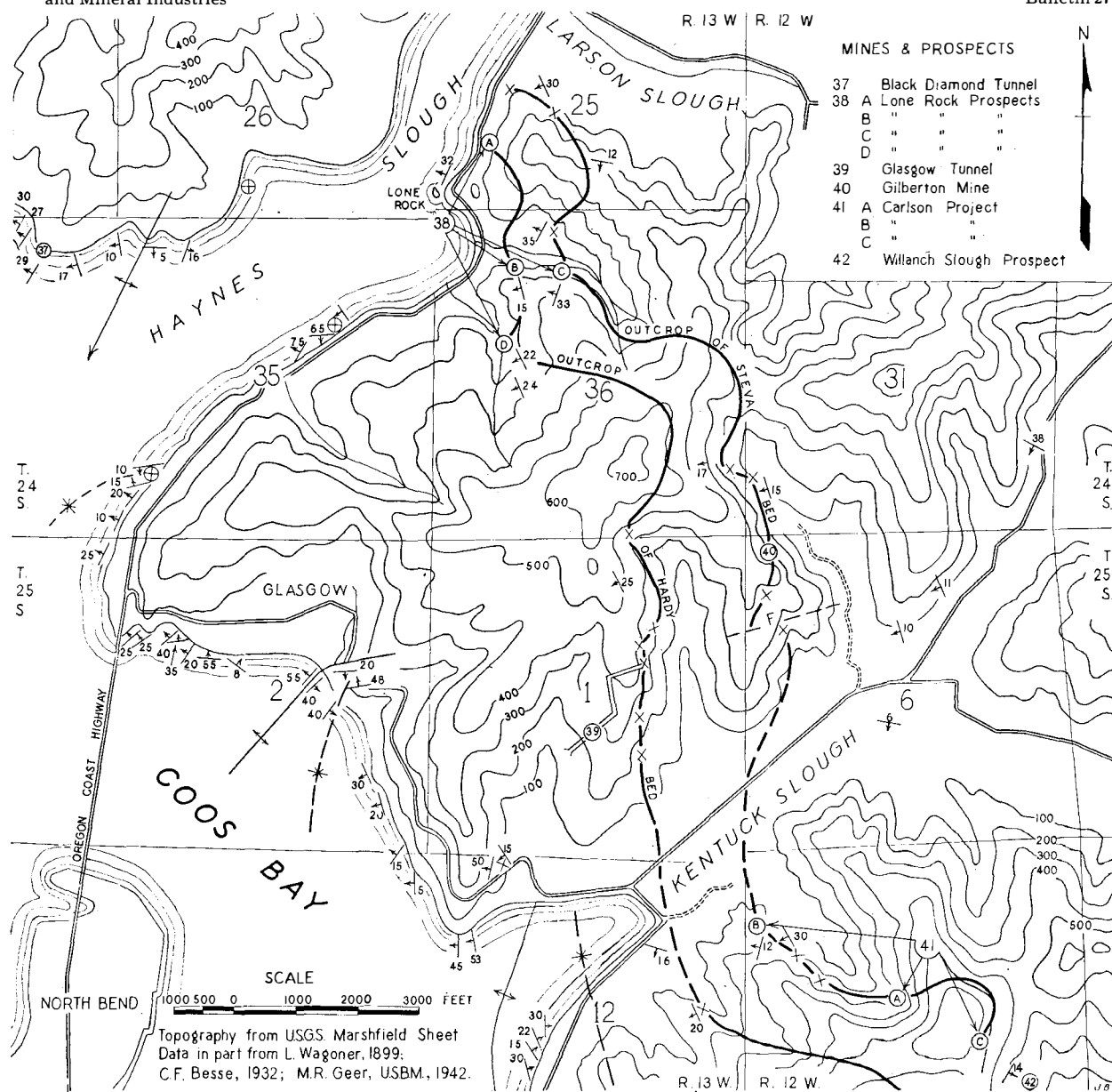
	Feet	Inches
Sandstone		
Coal, fair	1	10
Shale, soft gray	1	10
Coal, some bony, but mostly fair	2	9
Sandstone, fine	1	9
Coal, some good	1	4
Shale		
Three layers of coal	4	11
Two partings	2	7
Total coal bed	7	6

The Hardy bed, which strikes N. 35° W. and dips 24° SW., was reported by Diller and Pishel (1911:203) to crop out in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 36, T. 24 S., R. 13 W. The coal at this place lies 725 feet above the Steva bed. A massive sandstone roof preserved the drift and permitted Diller access to the coal. It has the following section:

	Feet	Inches
Sandstone		
Coal	2	...

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and Mineral Industries

Plate 29
Bulletin 27



Glasgow area: Location of mines and prospects, topography, structure, and coal sections.

	Feet	Inches
Clay and coal	8	8
Coal	1	6
Parting	7	7
Coal	1	.....
Sandstone .....	.....	.....
Three layers of coal	4	6
Two partings	1	3
Total coal bed	5	9

Glasgow Mine (39) (Hardy mine)

A rock tunnel whose portal is located in the NE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 1, T. 25 S., R. 13 W., was driven in the early 1870's for a distance of about 850 feet in a northeasterly direction to intersect the Hardy bed at depth (pl. 29, No. 39). According to maps by L. Wagoner (1889) and C. F. Besse (1932) a 700-foot drift ran north along the bed to an air shaft which extended to the surface in coal. The coal strikes nearly north and dips about 20° W. Abandonment of the project was due to the relatively low quality of the coal, as well as to the soft and weak nature of the roof. The tunnel, which was large enough for a double track, is now caved part of the way in.

According to Diller and Pishel (1911:194), a section, taken in the old workings, was as follows:

	Feet	Inches
Roof, shale, fairly firm	1	.....
Coal .....	.....	1
Clay	2	4
Coal .....	.....	8
Sandstone, shaly	1	.....
Coal	2	.....
Shale, carbonaceous .....	.....	.....
Floor, sandstone .....	.....	.....
Total thickness of coal	4	4
Total thickness of bed	7	1

The Hardy coal is reported to decrease in thickness and possibly to pinch out before reaching Willanch Slough to the south. It lies 840 feet stratigraphically above the Steva coal bed.

Gilbertson Mine (40) (also known as Gilberton)

A caved tunnel on the Steva bed is located in the NW $\frac{1}{4}$ sec. 6, T. 25 S., R. 12 W. (pl. 29, No. 40). There are also other openings to the northwest, where the coal outcrop crosses a few hundred feet east of the township corner into sec. 36. According to Mr. D. L. Buckingham, most of the coal in sec. 6 has been mined out to the property line (west edge of sec. 6). The first operation is said to have commenced about 1891, and the mine was operated from 1908 to 1913. According to a survey by Buckingham, the coal crops out in the successive creek beds at elevations of 127, 227, 236, and 217 feet from the Kentuck Slough road on the south of the township corner on the north, and dips 10°-15° W. in this same stretch of about half a mile. The total tonnage mined is not known, but was probably not large.

A section of the Steva coal bed at the Gilbertson mine at a point in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 6, where the coal strikes N. 30° W. and dips 15° SW., is given by Diller and Pishel (1911:201) and by Lord (1913:690):

	Feet	Inches
Sandstone .....	.....	.....
*Coal, platy, with rusty joints	1	4
Shale .....	.....	7
*Coal	1	1
Sandy layer .....	.....	3
*Coal, finely jointed in pencils	1	6
Clay, sandy .....	.....	6
*Coal, part hard, some shaly	2	9
Clay, sandy .....	.....	4
*Coal (best) bright, conchoidal fracture	1	8
Sandstone, fine .....	.....	.....
Five layers of coal	8	4
Total coal bed	10	.....

A chemical analysis of the five benches of coal exposed here is also given (Diller and Pishel, 1911:226) as No. 9128. The mine had just started production when it was visited in 1909; only 50 tons had been removed.

Lab. No. 9128	10 ft.
Coal bed	8 ft. 4 in.
Part sampled	16.5
Air-drying loss .....	.....
Moisture	As Rec'd. 23.2 Air Dried 7.7 Dry Coal 41.0 Pure Coal 49.8
Volatile matter	31.5 37.8 41.0 49.8
Fixed carbon	31.8 38.2 41.4 50.2
Ash	13.5 16.3 17.6
Sulphur	2.35 2.83 3.06 3.71
Calories	4,455 5,355 5,800 7,040
B. t. u.	8,020 9,640 10,440 12,670

The coal is now exposed to the south of the mine for a distance of about 500 feet along the strike in at least three different gulches. It appears to be of fair quality but the middle bench contains numerous thin dirt seams which give the coal a platy appearance. The coal in one cut about a mile northwest of Kentuck Slough strikes north and dips 15° W., and has the following section:

	Feet	Inches
Sandstone .....	.....	.....
Coal	1	3
Clay, brown .....	.....	8
Clay, alternating with fine seams of coal .....	.....	10
Coal	1	5
Clay, brown .....	.....	9½
Coal	2	6
Clay .....	.....	9½
Coal	1	.....
Slate, blue .....	.....	.....
Total thickness of coal	6	2
Total thickness of bed	9	3

Carlson Coals (41)

Coal was found in the bed of a west-flowing creek at an elevation of about 200 feet just west of the center of sec. 7, T. 25 S., R. 12 W., on the south side of Kentuck Slough, on land owned by A. V. and A. S. Carlson (pl. 29, No. 41-A).

The Steva coal bed was recognized at the "Hearst prospect" by Diller and Pishel (1911:201) near the center of sec. 7, where it is said to strike N. 57° E., and dip 15° S., with a section given as follows:

	Feet	Inches
Sandstone		
Coal, good, blocked	.....	8
Shale and clay	2	6
Coal and shale mixed; not much		
coal	2	9
Shale	1	6
Coal, hard	1	1
Sandstone, fine		
Three layers of coal	4	6
Two partings	4	.....
Total coal bed	8	6

Just north of the creek, the ridge is wide and gently sloping. An area along the creek and on this ridge of about 12 acres was mapped, and partially explored by 13 auger holes. Coal was proved to be present in the bed of the creek for at least 350 feet with an average thickness of 2-3 feet. Fifty feet north of the creek, however, the coal was not present in any appreciable thickness in the sections drilled. South of the creek the bank rises so steeply that drilling was not attempted. Some coal in thin seams was found in one hole 75 feet north of the creek, but no coal appeared in holes 100 and 120 feet north of the creek. Apparently the coal is broken and faulted down to the north to such an extent that it does not appear at shallow depth, and a possible area of shallow stripping coal is not present.

Coal outcrops were found both to the east of the Carlson project area, over the ridge, and to the west extending for at least half a mile. A 120-foot tunnel is located about 300 feet above the valley floor in the NW¼ sec. 7 (pl. 29, No. 41-B). This tunnel, which was driven in 1938 by Gilbertson, runs S. 12° W. for 45 feet, S. 15° E. for 40 feet, and S. 45° W. for 25 feet to the face. It started in on one bed, then crosscut to another 9 feet below, which dips 12° to the west, and has the following section 60 feet in from the portal:

	Feet	Inches
Sandstone, gray, micaceous		
Coal, bony	.....	3
Coal, shaly	.....	2
Clay	.....	1
Coal, bony	.....	4
Coal, good	.....	3
Clay	.....	2
Clay, carbonaceous	.....	1
Coal, broken	.....	2
Clay	.....	1½
Coal, broken	1	2
Sandstone		
Total thickness of coal and bony		
coal	2	4
Total thickness of bed	2	8½

The bed on which the tunnel started shows about 3 feet of solid coal, but the roof did not hold, so an attempt was made to mine the lower coal, which is irregular in thickness, pinching and swelling from 2 to 4 feet.

Another outcrop 200 yards to the east in the bed of another gulch strikes N. 45° W. and dips 30° SW.

An outcrop over the ridge to the east of the Carlson project (pl. 29, No. 41-C) lies at an elevation of about 570 feet, or 250 feet below the crest of the hill, and a distance of 200 yards down the hill from the ridge road. It may be the same coal as the Buzzard prospect (see Willanch Slough prospects) which is located not far to the south. In the old cut 8 inches of bony coal overlies clay, and is overlain by at least 1 foot of broken coal of good quality.

Willanch Slough Coals (42)

An outcrop of coal is located 2,000 feet northwest of Vernon Buzzard's ranch house in the center of the E½ sec. 7, T. 25 S., R. 13 W., at an elevation of approximately 400 feet, at the head of the deep gulch that trends northwesterly from Willanch Slough (pl. 29, No. 42). Coal has been mined by the ranch owner for the last 2 or 3 years. The outcrop is high on the hill and the coal is dug from an open pit and hauled down the hill on sleds. The strike is N. 30° E. and dip 14° SE. A section is as follows:

	Feet	Inches
Roof, light brown clay		
Coal, bony	.....	6
Coal	.....	24
Bone	.....	4
Floor, gray clay		
Total thickness of coal	2	6
Total thickness of bed	2	10

An outcrop of coal located on land owned by Nils Ostling, near Willanch Slough, 300 feet south of the quarter corner between secs. 17 and 18, T. 25 S., R. 12 W., and about 100 feet west of the section line, strikes N. 25° W. and dips 10° W.; it was measured as follows:

	Feet	Inches
Clay-shale, massive gray		
Shale, carbonaceous	.....	1
Bone	.....	1
*Coal, bony	.....	2
Clay-shale		
Total thickness of coal	2	.....
Total thickness of bed	3	1

Analysis of the 2 feet of coal (*) gave:

Field No. 14		
Lab. No. 1607		
Sample		Thickness
Bed		3 ft.
		3 ft.
Analysis		As Received
Moisture		22.0
Ash		13.05
		Air Dried
		10.0

Ward Prospect (43)

Several coal beds are exposed, according to Diller and Pishel (1911:200-201), in the eastern part of sec. 19, T. 25 S., R. 12 W. The principal one, near Mr. Ward's house, in the NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 19, strikes north, dips 30° W., and has the following section:

	Feet	Inches
Shale, dark		
Coal		6
Shale, few films of coal	3	
Coal		5
Clay, sandy		2
Coal		4
Shale, dark, with few films of coal		
Three layers of coal	1	3
Two partings	3	2
Total coal bed	4	5

What appears to be the same bed is partly exposed in sec. 17, where it turns strongly to the east and then extends westward around the end of a syncline to a point near the center of sec. 7, where at Mrs. Hearst's prospect it is recognized as the Steva coal bed.

Worth Prospect (44)

The Worth prospect, according to Diller and Pishel (1911:200), is located in the NW $\frac{1}{4}$ sec. 29, T. 25 S., R. 12 W., 1 $\frac{1}{2}$ miles north of the Lillian mine on a bed correlated with the Steva. The coal strikes N. 15° E., dips 23° NW., and the section given is as follows:

	Feet	Inches
Shale, sandy		
Coal		6
Shale		1
Coal, shaly		6
Sand		1
Coal, shaly, with clay parting		6
Parting		1
Coal		9
Shale, hard		2
Coal, shaly		8
Coal, hard, lustrous	1	6
Coal, shaly		6
Shale, gray		3
Shale, dark, carbonaceous		6
Shale, gray		6
Shale, carbonaceous, with little coal	1	2
Shale, dark gray		
Five layers of coal	4	11
Five partings	2	10
Total coal bed	7	9

A coal outcrop in the road 1 mile north of the mouth of Coos River in the NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 30, T. 25 S., R. 12 W., is probably the Hardy bed. The coal strikes N. 5° W., dips 6° W., and has the following section:

	Feet	Inches
Sandstone		
Bone		4
Shale, carbonaceous	1	
Clay		2
Coal, bony		9
Clay		1
Bone		10
Coal, poor		10
Clay		6
Coal, poor		9

	Feet	Inches
Clay		5
Bone		6
Clay		
Total thickness of coal and bone	4	4
Total thickness of bed	6	6

Smith Mine (45)

A bed of coal, reported by Diller and Pishel (1911:201-202) to strike north and dip 15° NW., lies about 450 feet stratigraphically below the Steva or Worth coal. It crops out in a sandstone bluff on the north bank of the Coos River, in the SW $\frac{1}{4}$ sec. 29, T. 25 S., R. 12 W. It was known as the Smith mine when in production in the early 1900's. A section was given by Diller and Pishel as follows:

	Feet	Inches
Sandstone, massive		
Coal, good		6
Sandstone, fine		1 $\frac{1}{2}$
Coal, well blocked, but dull	1	9
Clay		1
Coal		5
Clay		1
Sandstone, massive		
Three layers of coal	2	8
Three partings		3 $\frac{1}{2}$
Total coal bed	2	11 $\frac{1}{2}$

This bed, though thin and somewhat faulted, has an excellent roof and floor and is so conveniently located with reference to transportation that it has been successfully mined in a small way for several years.

A small coal bed occurs near the eastern line of sec. 19, about 100 feet below the horizon of the Worth (or Steva) coal bed. It has a sandstone roof and floor and about 3 feet of shaly and bony coal.

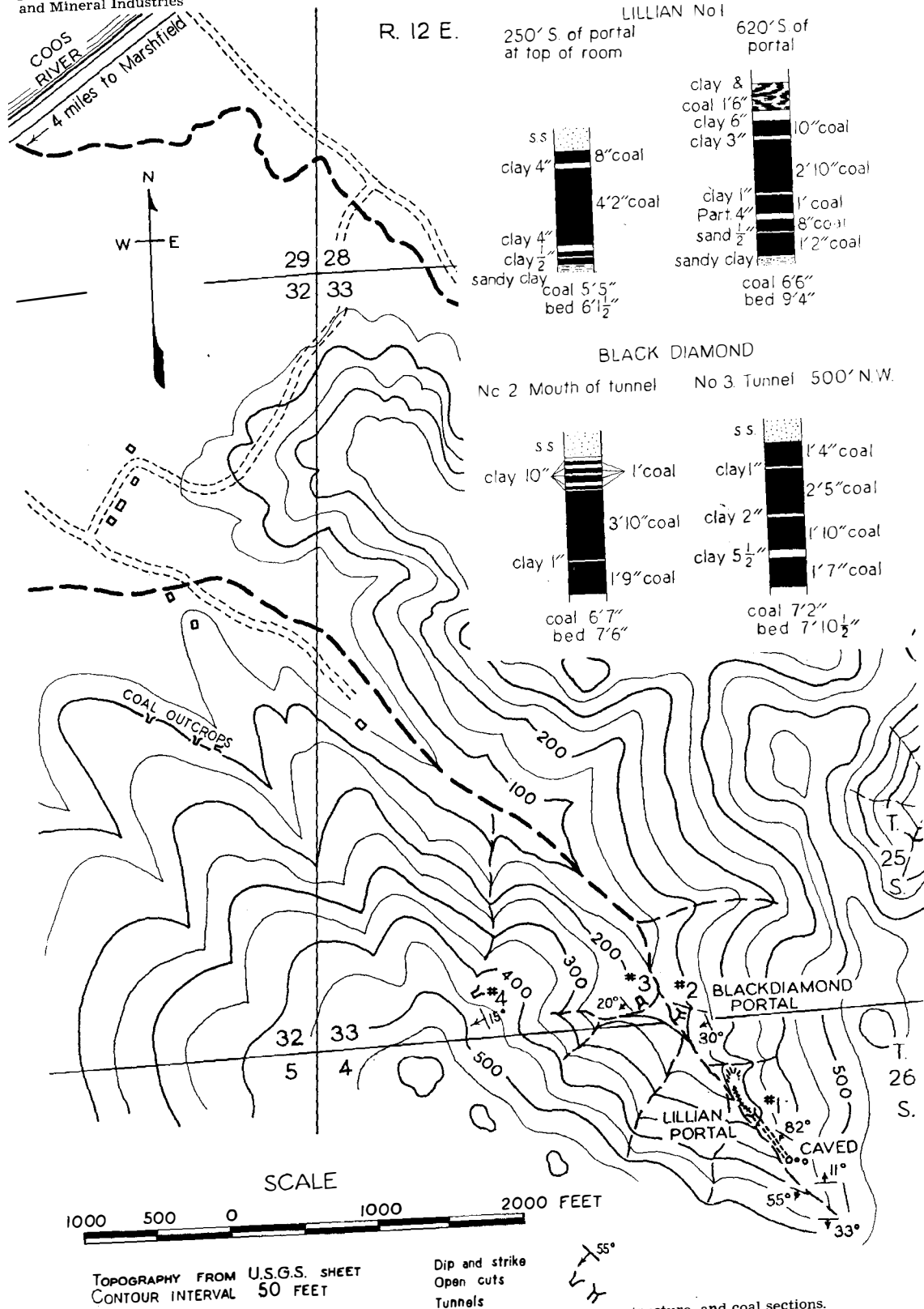
This property was not visited by the survey.

Lillian Mine (46) (also Black Diamond)

The Lillian mine is located 700 feet south of the section line between 4 and 33, Tps. 25 and 26 S., R. 12 W. The Black Diamond mine is located 800 feet down the creek to the north (see pl. 30).

The Lillian was operated by Louis Simpson between 1900 and 1905, when about 4,000 tons of coal was produced. Coal was run out on a track for several hundred feet to the loading bunkers and then transported 1 mile to Coos River on a narrow gauge railway.

The coal bed, although assigned to the Steva bed, does not particularly resemble other coals in the immediate area, as it is unusually thick here. The outcrop has been traced from a point just south of the Coos River flood plain for nearly a mile to the headwaters of Lillian Creek near the center of the N $\frac{1}{2}$ sec. 4. No coal has been found south of this point and the coal in this vicinity is

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Lillian and Black Diamond mines and prospects: topography, structure, and coal sections.

so broken that it is believed to be cut off by a fault of considerable throw (see Lillian fault).

The mine workings consist of the Lillian tunnel, which runs from a point near the creek level in a S. 30° E. direction for at least 450 feet, and rooms which surface at several points. The coal dips steeply (up to 75°) to the southwest. In the upper part of one of the caved rooms, 250 feet south of the portal, the coal strikes N. 48° W. and dips 45° SW., and the following section was observed:

	Feet	Inches
Sandstone, solid		
*Coal, solid	8	
Clay	4	
*Coal, solid	4	2
Clay	4	
*Coal, solid	3	
Clay	1½	
*Coal, solid	4	
Clay, gray, sandy		
Total thickness of coal	5	5
Total thickness of parting		8½
Total thickness of bed	6	1½

The analysis (*) is as follows:

Field No.	90		
Lab. No.	P-2201		
		Thickness	
Sample	5 ft. 5 in.		
Bed	6 ft. 1½ in.		
Analysis	As Received	Air Dried	
Moisture	18.16	4.15	
B. t. u.	8,469	10,349	
Ash	13.32	13.90	

Diller and Pishel (1911:199) cited three sections of the coal at the Lillian mine, in the SW¼ sec. 33, T. 25 S., R. 12 W., which were copied from a detailed survey of the property by L. A. Whereat, Southern Pacific mining engineer:

Feet	Inches	Feet	Inches
Sandstone		Sandstone	
Coal	1	Coal	8
Clay, etc.	2	Clay	1
Coal	9	Coal	5
Clay	2	Clay	2
Coal	7	Coal	5
Clay	1	Clay	1
Coal	1	Coal	3
Clay	1	Shale	10
Coal	5	Sandstone	4
Clay	1	Sandstone and shale	6
Sandstone	6	Coal	4
Sand, gravelly	11	Sandstone	1
Coal	5	Coal	1
Shale, hard		Sandstone	1
Six layers of coal	6	Coal	3
Five partings	7	Clay	1
Total bed	13	Coal	2
		Shale, hard	
		Eight layers of coal	6
		Seven partings	3
		Total bed	11
Sandstone	Feet	Inches	
Coal		4	
Clay		1	
Coal	1	10	
Clay		1	
Coal	4	1	
Bone		1	
Coal		4	

	Feet	Inches
Clay		9
Coal	3	
Shale, hard		
Five layers of coal	9	7
Four partings	1	
Total bed	10	7

Lord (1913:688) also gave a section of the Lillian coal exposed in the mine, 620 feet from the entrance:

	Feet	Inches
Roof, sandstone		
Coal and coaly shale, mixed	1	6
Clay, squeezed		6
*Coal, good		10
Clay		3
*Coal, bright and shiny	2	10
Sandstone		1
*Coal, good	1	
Irregular parting		4
*Coal		8
Sandy parting		2
*Coal, good	1	2
Floor, soft, shaly clay		
Total thickness of coal sampled	6	6
Total thickness of bed	9	4

The analysis (*) is as follows (Diller and Pishel, 1911:225):

Lab. No. 9127				
			Thickness	
Coal bed			9 ft. 4 in.	
Part sampled			6 ft. 6 in.	
Air-drying loss			13.6	
	As Rec'd.	Air Dried	Dry Coal	Pure Coal
re	19.7	7.0		
e matter	31.5	36.5	39.5	47.5
carbon	35.0	40.5	43.3	52.5
.....	13.8	16.0	17.2	
r	.79	.92	1.00	1.20
.....	4,665	5,400	5,810	7,015
.....	8,400	9,720	10,460	12,630

Eight hundred feet downstream north of the Lillian, a tunnel (No. 2, pl. 30) known as the "Black Diamond" trends southeasterly into a spur between two creek branches. This bed is reported to lie 140 feet stratigraphically below the Lillian bed. A section of the coal near the mouth of this tunnel where it strikes N. 29° W. and dips 29° SW. is as follows:

	Feet	Inches
Sandstone		
Clay, brown		2
*Coal		2
Clay, brown		2
*Coal		3
Clay		2
*Coal		4
Clay		3
*Coal		3
Clay		1
*Coal	3	10
Clay, brown		1
*Coal	1	9
Clay, gray		
Total thickness of coal sampled	6	7
Total thickness of parting		11
Total thickness of bed	7	6

Analysis of this coal (*) is as follows:

Field No.	91		
Lab. No.	P-2202		
		Thickness	
Sample		6 ft. 7 in.	
Bed		7 ft. 6 in.	
Analysis		As Received	Air Dried
Moisture		21.22	9.04
B. t. u.		8,321	10,563
Ash		12.80	14.07

On the north side of a gulch about 500 feet north and west of the Black Diamond, the following section of coal, striking N. 45° W. and dipping 20° SW., is disclosed 4 feet from the mouth of a small tunnel:

	Feet	Inches
Sandstone		
*Coal	1	4
Clay, brown		1
*Coal	2	5
Clay, brown		2
*Coal	1	10
Clay, brown		5½
*Coal	1	7
Total thickness of coal	7	2
Total thickness of parting		8½
Total thickness of bed	7	10½

Analysis of this coal (*) is as follows:

Field No.	92		
Lab. No.	P-2203		
		Thickness	
Sample		7 ft. 2 in.	
Bed		7 ft. 10½ in.	
Analysis		As Received	Air Dried
Moisture		20.80	8.3
B. t. u.		8,119	

Cut No. 4 (pl. 30) is located at the head of a small gully where the coal strikes S. 20° E. and dips 15° SW. The following section is disclosed:

	Feet	Inches
Clay, brown, sandy		
Coal crop	2	
Coal, soft		9
Clay, brown		2
Coal	1	2
Clay, brown		3
Coal		1½
Clay, brown		1½
Coal		5
Clay, brown		1
Clay, brown, mixed with coal		5½
Coal	1	2
Clay, sandy		
Total thickness of coal	5	7½
Total thickness of parting	1	1
Total thickness of bed	6	8½

Catching Slough Coals to Coaledo

Gunnell Coals (47)

An outcrop of coal in the NE¼, NE¼, sec. 6, T. 26 S., R. 12 W., on the narrow point east of the mouth of Catching Slough, was opened up 300 feet S. 20° E. of Mr. Alfred Gunnell's house at an elevation of about 60 feet. The coal strikes N.

10° E. and dips 15° W. and has the following section:

	Feet	Inches
Sandstone, coarse and friable		
Shale, white	1	6
Coal, bony	1	4
Clay	1	1
Coal, bony		10
Total thickness of coal	2	2
Total thickness of bed	4	9

A coal tunnel was said to have been driven 350 feet S. 40° E. of the house. This was completely caved but it probably is the coal mentioned by Diller and Pishel (1911:205) from notes taken in 1897. Diller reported that the coal strikes N. 80° E., dips 10° S., and has the following section: Coal bed in NE¼, NE¼ sec. 6, T. 26 S., R. 12 W.

	Feet	Inches
Sandstone		
Coal	1	
Dirt		1
Coal	1	
Dirt		1
Coal		10
Dirt		1½
Coal	1	6
Total thickness of coal	4	4
Total thickness of bed	4	6½

Another bed, known as "Nortons coal," which strikes N. 50° E. and dips 30° SE., is reported to be located in the SW¼, NW¼ sec. 5. The section here is:

	Feet	Inches
Sandstone		
Coal		1
Dirt		1½
Coal		3
Dirt		1½
Coal	1	6
Shale		
Total thickness of coal	1	10
Total thickness of bed	1	11

In a gulch half a mile to the east and 200 yards south of Gunnell's coal outcrop, a bed of coal on property owned by George A. Blake has the following section:

	Feet	Inches
Sandstone		
Coal and sandy clay		10
*Coal (in part bony coal)	1	7
Sandy clay		

The analysis (*) is as follows:

Field No.	62		
Location:	Open cut, NW¼ sec. 5, T. 26 S., R. 12 W.		
		Thickness	
Sample		1 ft. 7 in.	
Bed		2 ft. 5 in.	
Analysis		As Received	Air Dried
Moisture		19.79	7.47
B. t. u.		8,493	10,589
Ash		11.59	12.53

Messerle Coal (48)

A thin bed of coal was measured near the center of the S½ sec. 5, T. 26 S., R. 12 W., on land owned by J. R. Messerle. It lies in the first

gulch north of Stock Slough on the east side of Catching Slough, at an elevation about 200 feet.

The coal strikes north, dips 17° W., and has the following section:

	Feet	Inches
Sandstone		
Coal	1	2
Bone		7
Shale, carbonaceous		6+
Total thickness of coal	1	2
Total thickness of bed	2	3+

Huntley Coals (49)

Two sections were taken on coals in the center of the N $\frac{1}{2}$ sec. 17, T. 26 S., R. 12 W., on land owned by C. J. Huntley.

The first coal is located on the south branch of the gulch north of Mr. Huntley's house where the coal strikes N. 15° E. and dips 35° W. The following section was obtained:

	Feet	Inches
Sandstone, fine grained		
*Coal, good	2	6
Clay, sandy		6
*Coal		6
Sandstone		5
Clay		3
Shale, carbonaceous		3
Shale, massive		
Total thickness of coal	3	
Total thickness of bed	4	5

The two beds of coal (*) were analyzed as follows:

Field No. 24
Lab. No. 1897
Location: Elev. 40 ft., 300 ft. up creek above meadow.

Sample Thickness
Bed 3 ft. 1 in.
..... 4 ft. 5 in.

Analysis	As Received	Air Dried
Moisture	18.7	9.2
Ash	15.8	17.4

Across the meadow 2,000 feet to the north, another section on a bed which strikes N. 5° E. and dips 38° W. is as follows:

	Feet	Inches
Sandstone, fine, gray		
Coal, broken		3
Bone, coaly		3
Clay		4
Coal, broken		4
Shale, carbonaceous		8
Sandstone, blue		
Total thickness of coal		7
Total thickness of bed	1	10

Diller and Pishel (1911:205) reported a section of coal farther south in the NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 17, as follows:

	Feet	Inches
Shale		
Coal	2	2
Sandstone, shaly near coal	32	
Coal		4
Clay		$\frac{1}{2}$
Coal		2
Clay		$\frac{1}{2}$
Coal	1	2
Sandstone		
Total thickness of coal	3	10
Total thickness of beds	35	11

West Prospect (50)

An outcrop was measured on the Dave West property, in the center of sec. 31, T. 26 S., R. 12 W.

The coal is fairly well exposed in the small gully in which it has been faced, and has the following section in strata striking N. 60° E. and dipping 30° NW.:

	Feet	Inches
Shale		
Coaly material		4
Clay	1	1
Bone		3
Clay		4
Coal, bony		11
Small thrust fault		
Clay		2
Bone and carbonaceous clay	1	11
Coal	1	
Clay bottom?		
Total thickness of coal	1	11
Total thickness of bed	6	

The roof is weak and there are thick clay partings which would make mining difficult.

The coal bed presumably extends southwestward toward the old Smith-Powers mine on Noble Creek from the Dave West property. It is not known whether this is the same bed as that in the Smith-Powers mine.

Smith-Powers Mine (51)

At least two beds of west-dipping coal crop out on Noble Creek in the SE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 36, T. 26 S., R. 13 W., less than 500 feet from the section corner, on land owned by Sam Flint. The easternmost bed was mined on a small scale (4 tons a day) in 1909 by the Smith-Powers Lumber Company. It was measured and sampled in the third room, 150 feet northeast of the mouth of the mine, by Pishel (Lord, 1913:689) who gives the following section:

	Feet	Inches
Roof, shale		
*Coal	1	3
Dirt		2
*Coal		3
Dirt		2
*Coal (best)	1	5
Clay		3
Bone		3
Clay		2 $\frac{1}{2}$
Coaly bone		3-7
Floor, shale		
Total thickness of coal sampled	3	1
Total thickness of bed	4	6 $\frac{1}{2}$

The analysis (*) is as follows (Diller and Pishel, 1911:226):

	Lab. No. 9187				
Coal bed		3 ft. 3 in.			
Part sampled		2 ft. 11 in.			
Air-drying loss		8.6			
	As Rec'd.	Air Dried	Dry Coal	Pure Coal	
Moisture	18.9	11.3			
Volatile matter	28.6	31.2	35.2	44.6	
Fixed carbon	35.4	38.8	43.7	55.4	
Ash	17.1	18.7	21.1		
Sulphur	.54	.59	.67	.85	
Calories	4,315	4,720	5,325	6,750	
B. t. u.	7,770	8,500	9,590	12,150	

The strike is N. 30° E. and dip 40° NW. The mine was in operation during Pishel's examination. The shale roof was very poor and required much timbering.

Three sections of coal were measured by the survey. A prospect shaft 200 feet northeast of the old portal (which lies about 300 feet north of Noble Creek up a small tributary gulch) has the following section on coal which strikes N. 45° E. and dips 28° NW.:

	Feet	Inches
Clay shale		
Coal		6
Shale, bony		10
Clay, pale yellow		10
Coal, platy		7*
Shale, carbonaceous		1*
Coal, platy		9*
Coal, blocky		7*
Coal, platy	1	2*
Clay		3
Sandstone, yellow		10
Sandstone, blue		3
Shale, with "niggerheads"		6
Sandstone, blue		4
Coal		2
Sandstone, blue		
Total thickness of coal	3	9
Total thickness of bed	7	8
*Thickness mined	3	2

Two air shafts lie 60 feet to the south and 135 feet to the northeast of this prospect shaft, indicating that probably at least 2 acres of coal was mined.

Two hundred yards west of this old mine, Sam Flint has recently opened another coal bed in the next gulch to the west, perhaps 300 feet north of the main creek. The coal strikes N. 15° E. and dips 45° W. A section of the bed is as follows:

	Feet	Inches
Shale, gray, blocky		
Bone	1	1
Coal		6
Bone		4
Coal, bony	1	
Shale	1	1
Shale, carbonaceous		7
Shale, blocky	2	9
Shale, carbonaceous	1	1
Coal		1½
Bone		7
Shale, carbonaceous		7
Bone	1	1
Coal, bony		7
Coal, good		7
Coal, bony		3
Coal, good		5
Clay		3
Coal, good	1	10
Bone		7
Shale	3	3
Bone		2
Shale		4
Bone		2
Shale, carbonaceous, and bone	1	6
Shale (12 feet)		
Sandstone, coarse		
Total thickness of bone and coal	9	3½
Total thickness of bed	20	8½

In the next gulch, about 200 feet farther west, a 50-foot tunnel was driven in 1942 by Sam Flint, in a N. 25° E. direction on coal which dips 38° W. The section of coal in the face of the tunnel is as follows:

	Feet	Inches
Shale, clay		
Shale, bony		4
Clay		2½
Coal, platy	1	10
Clay		3
Coal	1	
Clay		6
Coal, bony		3
Shale		
Total thickness of coal	3	1
Total thickness of bed	4	4½

This westernmost coal appears to have been faulted. It is possible that all three exposures may belong to the same bed, which has been duplicated by this large-scale landsliding. There is a similarity to the sections which suggests this.

Half a mile south of the Smith-Powers mine, in the SE¼ NE¼ sec. 1, Diller and Pishel (1911: 222) sectioned a bed which strikes north and dips 35° W. They suggest that this bed resembles the Big Dirty in sec. 9.

	Feet	Inches
Coal		2
Parting		3
Coal		7
Parting		5
Coal, shaly		3
Parting		6
Coal		2
Parting		1
Coal	1	6
Parting		5
Coal	1	
Total thickness of coal	3	8
Total thickness of bed	5	4

Coaledo Mines (52) (Utter, Carbondale, Ojeda, Beaver Creek mines, Coos Bay Union Coal Co., North Pacific Coal Co.)

Some of the oldest mines in the Coos Bay district were located near the corner of secs. 14, 15, 22, and 23, T. 27 S., R. 13 W., just east of Coaledo. Coal from these mines was transported by narrow gauge railroad to Isthmus Slough where it was loaded for shipment.

Little first-hand information can be found concerning development of this district, for the portals were caved even prior to Diller's survey, and now even the dumps are hard to locate.

According to an undated and unsigned report, furnished by J. H. Flanagan, the mine was first known as "Beaver coal mine," later as "Blue Mountain mine," then as "Utter mines." Coal was first mined in 1874 by William Utter and the North Pacific Coal Co. Three tunnels were driven in

the NW $\frac{1}{4}$ sec. 23, and a third, a 400-foot tunnel, was opened by Capt. D. R. Dale.

According to Diller (1896:500):

The Utter mine was operated about 20 years ago, and produced, according to Mr. Utter, about 10,000 tons of coal.

The bed was reported to be 6 feet thick, with a clay parting in the middle, the lower coal being soft and of little value. The bed dips 17° S.

Another report of unknown origin (*) gives the following:

The lower tunnel runs south 450 feet where it cuts a vein of coal 6 feet thick; the east gangway runs 1,100 feet on this 6-foot vein, where it diverged south 80 feet and cut a 3-foot 6-inch vein 200 feet or more. The west gangway was extended through an unbroken 6-foot vein 1,200 feet to the face, and the quality of the coal was said to be excellent. The other tunnel was about 100 feet above the first one, and runs south 200 feet where it struck a vein that was named the Pelican, 3 feet 8 inches thick. From here the gangways ran east and met with 3 feet 8 inches of good coal at the face of each. Both mines have good roofs. Three distinct veins were worked upon in these mines, and the outcrops of these distinct veins were visible. Bunkers at these mines in 1875 held 500 tons.

Diller (1899:345-347) briefly mentions these coals and gives a stratigraphic section of the series as follows:

Section $\frac{3}{4}$ of a mile southeast of Coaledo.

	Feet	Inches
Shale		
Bed "e" 6'6"	Coal	1
	Parting	2
	Coal	1
	Parting	4
	Coal, bony	3
Bed "d" 2'7"	Shale	Unknown
	Coal	6
	Parting	1
	Coal, partly bony	2
Bed "c" 5'4"	Shale	Unknown
	Coal	3
	Clay	2
	Coal, shaly	2
	Shales and sandstones, sandstone toward base	45
	Coal	4
	Parting	3
	Coal	1
	Sandstone	12
	Shale	7
	Coal	1
	Sandstone	36
Bed "b" 6'4"	Shale	18
	Coal	2
	Parting	6
	Coal, in part shaly	3
	Sandstones and shales, sandstone at base	180
	Coaly, shale	6
	Clay	2
Bed "a" 7'1"	Coaly shale	8
	Parting	2

* Furnished by Claude Elliott, August, 1943.

	Feet	Inches
Coaly shale	1	8
Parting		3
Coaly shale	3	8
Shale		

Diller and Pishel (1911:223) give a section of a coal at the Utter mine in sec. 23 as follows:

	Feet	Inches
Shale		
Coal		1
Parting		5
Coal		9
Parting		1
Coal	1	
Shale	1	
Coal		3
Sandstone		
Total thickness of coal	2	1
Total thickness of bed	3	7

The coals are here mapped as striking N. 20°-70° W. and dipping 20°-22° SW.

The main openings of the Utter mines were situated near the prominent forks in the valley, although it is now difficult to find their exact location. The coals visited by the survey may be located by coordinates, taken from the section corner of 14-15, 22-23. A cave-in of one of the old rooms, in a small tributary east of the forks (coordinates 1,300 E.-800 S.) exposes the following section:

	Feet	Inches
Shale, carbonaceous		
Coal, broken		6
Clay, light gray		3
Coal		10
Dirt		$\frac{1}{2}$
Coal	2	6
Clay		3
Coal, bony		5
Shale, sandy		
Total thickness of coal	4	3
Total thickness of bed	4	$9\frac{1}{2}$

The coal strikes N. 77° W. and dips 30° S.

Two openings south of the slough in the southeast corner of sec. 15 (300 W.-700 N.) were driven on a rather large dirty vein probably the same as the "a" bed of Diller. This is presumably also the same bed which crops out in the point opposite Coaledo. The coal strikes N. 10° W. and dips 5° W., although it is possibly disturbed. The following section is exposed:

	Feet	Inches
Coal, bony		6
Clay, yellow		2
Coal, bone		5
Clay, yellow		$1\frac{1}{2}$
Coal, fairly good	1	6
Dirt indicating minor fault or unconformity		
Coal, bony, hard	2	1
Coal, fair		9
Total thickness of coal and bone	5	3
Total thickness of bed	5	$6\frac{1}{2}$

Another attitude of the coal a few feet away was N. 15° W., with a dip of 6°-8° W. The relation between this bed and those at the Utter mines to

the southeast is undetermined, although it strikes toward the mines.

A prospect in the northeast corner of sec. 22 near the headwaters of a small stream which enters Beaver Slough south of Coaledo (1,300 W.-700 S.) was shown to the writers by George Elliott. This prospect is on one of the uppermost beds in the series possibly equivalent to Diller's "e" bed. The following section is exposed in a tunnel about 60 feet long. The strike is east and the dip 10° S. No information was obtained concerning early operations.

	Feet	Inches
Sandstone		
Shale, carbonaceous		4
*Coal, hard		10
Shale		1½
*Coal, bright containing some "sulphur"	2	5
Shale		4
Coal, bony	1	3
Total thickness of coal	4	6
Total thickness of bed	5	3½

The coal seems to be of fair quality although the lower portion is bony. Analysis of the upper two benches (*) is as follows:

Field No.	98		
Lab. No.	P-2218		
Location:	Prospect tunnel about 50 feet long, NE¼ sec. 22, T. 27 S., R. 13 W.		
		Thickness	
Sample	.....	3 ft. 3 in.	
Bed	.....	4 ft. 11½ in.	
Analysis		As Received	Air Dried
Moisture	.....	24.27	16.20
B. t. u.	.....	6,833	10,948
Ash	.....	15.86	18.93

An unsuccessful attempt was made to trace the coal southward where it should be found along the hillside near the Coaledo schoolhouse.

An old mine formerly operated by Sharp, situated in the northwest corner of sec. 23 (400 W.-900 S.), is now caved. Considerable coal was mined but tonnage figures were unobtainable. The coal strikes N. 50° W. and dips 12° S. A section of the coal has been exposed in the creek just below the old portal and was measured as follows:

	Feet	Inches
Sandstone		
Shale, carbonaceous		1½
Coal, bright	2	8

The bed seems to be of fair quality. About 30 feet stratigraphically above this opening 25 inches of bony coal and carbonaceous shale crops out in the bed of the creek beneath a massive sandstone. The coal exposed in the Sharp tunnel may be one of the three beds mined farther east in the Utter Mines.

The coals of the Utter mines crop out on the toe of an arch plunging to the southward. This

series is believed to be the same as that farther north on Noble Creek.

Sumner Basin Coals

Standley Coal (53)

An outcrop of coal was examined on the E. C. Standley property near the center of the NW¼ sec. 13, T. 27 S., R. 13 W., on the ridge between two forks of Beaver Creek 2 miles east of Coaledo. The coal strikes N. 30° E. and dips about 20° SE. This coal is on the east flank of the Catching Slough arch. A section of the coal exposed is as follows:

	Feet	Inches
Shale		
Bone		6
Coal, bony		8
Coal		8
Shale, carbonaceous and bone		10
Carbonaceous shale		10+
Shale		
Total thickness of coal	1	4
Total thickness of bed	3	8+

Noble Creek Prospects (54)

A coal prospect is on the land of Della Jones in the SE¼ sec. 12, T. 27 S., R. 13 E. It may be reached by following the old railroad grade up Noble Creek. The coal strikes N. 65° E. and dips 23° SE. It is evidently one of the upper coal beds in the undifferentiated Coaledo strata. It is located on the eastern limb of the arch that trends northeastward from Coaledo. The following section was obtained:

	Feet	Inches
Shale		
*Coal, bony		10
Clay		1
*Coal, bony		7½
*Coal, very bony	1	1
Shale, carbonaceous	2	4
*Coal, bony		3
Shale, carbonaceous		2
*Coal	2	10
Coaly shale with bottom undetermined		
Total thickness of coal sampled	5	7½
Total thickness of parting	2	7
Total thickness of bed	8	2½

This coal bed contains only one bench which might be mined. The roof is soft and the locality inaccessible.

Analysis (*) shows the high percentage of ash:

Field No.	88		
Lab. No.	P-2199		
Sample		Thickness	
Bed		5 ft. 7½ in.	
		8 ft. 2½ in.	
Analysis		As Received	Air Dried
Moisture		23.15	13.50
B. t. u.		5.939	7.728
Ash		24.62	28.46

Diller and Pishel (1911:224) sectioned an outcrop of coal in the eastern part of sec. 12, as follows:

	Feet	Inches
Shale		
Coal		6
Parting		1
Coal	1	10
Parting		8
Coal	2	
Shale		
Total thickness of coal	4	4
Total thickness of bed	5	1

The coal bed mentioned and sectioned by Diller and Pishel (1911:223) in the NW $\frac{1}{4}$ of sec. 12 on Noble Creek could not be found. Their section is as follows:

	Feet	Inches
Shale		
Coal		4
Parting		1
Coal		6
Parting		1
Coal		11
Parting		2
Coal	2	
Parting		6
Coal	1	2
Parting		6
Coal, shaly		3
Shale		
Total thickness of coal	5	2
Total thickness of bed	6	6

They report that this bed is perhaps 350 feet below the coal in the NE $\frac{1}{4}$ sec. 1.

Newcastle Mine (55)

The Newcastle mine, which was first operated in 1907-8, is located in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 21, T. 26 S., R. 12 W., on the northern end of the Sumner basin, on beds which strike N. 30° W. and dip 9° SW. The entrance was entirely caved when visited. In 1909-1910 the mine produced about 40 tons a day. Diller and Pishel (1911:207) gave the following section taken at the face of the entry 150 feet southeast of the mouth of the mine:

	Feet	Inches
Shale		
*Coal	2	2
Clay		8
*Coal		9
Sandstone		
Total thickness of coal	2	11
Total thickness of bed	3	7

The analysis (*) is as follows (Diller and Pishel, 1911:226):

Lab. No. 9189				
Coal bed		3 ft. 7 in.		
Part sampled		2 ft. 11 in.		
Air-drying loss		11.4		
	As Rec'd.	Air Dried	Dry Coal	Pure Coal
Moisture	22.8	12.8		
Volatile matter	31.4	35.5	40.7	47.7
Fixed carbon	34.4	38.9	44.6	52.3
Ash	11.4	12.8	14.7	
Sulphur	1.92	2.17	2.49	2.92
Calories	4,480	5,060	5,805	6,805
B. t. u.	8,070	9,110	10,450	12,250

The section at the Equality prospect, half a mile to the northwest, is also given (Diller and Pishel, 1911:207):

	Feet	Inches
Shale		
Coal		8
Clay		1
Coal	1	4
Dirt		1
Coal, lower portion bony		11
Total thickness of coal	2	11
Total thickness of bed	3	1

At another point 40 feet southwest of the mouth of the prospect, a normal fault was encountered by the prospector. At 260 feet farther southwest a coal bed is exposed, striking S. 82° W. and dipping 16° SE.; another in the NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 20 strikes S 70° W. Both of these outcrops clearly indicate the end of a rising syncline in this vicinity.

A mine operated by Vaughan to supply coal for logging operations is located in the SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 20, very near to Diller's "Equality prospect" and probably on the same bed as that of the Newcastle.

Three openings have been made in a small gulch about 30 feet above slough level. The northward-flowing stream cuts directly across the bed, so that two of the openings face each other. The strike is N. 80° W. and dips 5° S. into the hill. The tunnels are still open, and the following section is exposed in the eastern one:

	Feet	Inches
Roof, sandstone but rather soft		
Shale, carbonaceous		8
Coal	2	4
Parting		2
Coal		10
Floor not determined		
Total thickness of coal	3	2
Total thickness of bed	4	

An upper opening a few feet upstream and about 20 feet higher is now caved.

These coals are evidently high in the Coaledo because of their stratigraphic position near the Bastendorf shale in the Sumner Basin.

Sumner Coals (56)

Two outcrops of coal are located on property owned by Clifford Osborn in the SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 32, T. 26 S., R. 12 W. These outcrops are exposed in the north and south forks of a west-flowing creek, 2 miles south of Sumner and half a mile east up the creek.

The coals strike N. 10° W. and dip 50° W. In the south gulch an old tunnel is completely caved

and the coal could not be seen. In the north gulch the section of coal exposed is as follows:

	Feet	Inches
Shale		
Bone	1	1
Coal, bony	1	6
Clay		8
Coal, bony		8
Shale, carbonaceous		6
Coal	1	4
Sandstone		
Total thickness of coal	3	6
Total thickness of parting	2	3
Total thickness of bed	5	9

A small bed of coal, according to Diller and Pishel (1911:208), crops out in the NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 29, T. 26 S., R. 12 W., where it strikes north and dips 40° E. The next outcrop to the south is said to dip 50°, and just south of the north line of sec. 32, dips from 55° to 65° W. The upper of the two beds is reported to resemble somewhat the one near the south line of sec. 32 on the other side of the syncline, carrying similar fossil shells in the floor of the coal and also having a similar parting near its base. Sections are given as follows:

Sections of coal beds in the NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 32, T. 26 S., R. 12 W.

Upper Bed		Lower Bed	
	Ft.	In.	
Sandstone			Coal
Coal	1	4	Coal, dirty
Coal with bone	10		Coal
Clay	7		Clay
Coal	6		Coal
Shale			Dirt
			Coal
Total thickness			Clay
of coal	2	8	Coal
Total thickness			Clay
of bed	3	3	Coal
			Clay
			Total thickness
			of coal
			Total thickness
			of bed

It must be borne in mind that in this locality the beds are overturned. Although no coal was found for over 2 miles to the south along the strike, it seems only logical to join these coal beds with those outcropping near the east line of sec. 12, T. 27 S., R. 13 W.

A coal outcrop was examined by Diller in 1897 (Diller and Pishel, 1911:205), located in the NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 17, on the west side of Catching Slough just north of the point where the road turns west towards Ross Slough. The coal is said to strike about N. 25° E. and dip 25° W. A section on the coal is given as follows:

	Feet	Inches
Shale		
Coal	2	2
Sandstone, shaly near coal	32	
Coal		4
Clay		1 $\frac{1}{2}$
Coal		2

	Feet	Inches
Clay		1 $\frac{1}{2}$
Coal	1	2
Sandstone		
Total thickness of coal	3	10
Total thickness of beds	35	11

Three more outcrops were found in the same section farther south along the strike. The next outcrop to the south is in sec. 19, near the east line. This can not be correlated with anything in sec. 17, but it is thought to be part of the same group of coal beds. Other coals were reported in this gulch by Mr. Frank Batter, who prospected here about nine years ago, but further information could not be obtained. No coals were found farther south on this limb of the syncline that could be definitely identified with the coal beds to the north. A coal was reported by a miner near the east line of sec. 30 and was said to dip at a comparatively low angle to the west. It could not be found, but it is indicated on the map about as reported. A coal outcrop in the NW $\frac{1}{4}$ sec. 32, near the west line, very poorly exposed, contains at least 9 inches of coal. The strike here is north and south and the dip from 15° to 25° W. Near the center of sec. 31 two outcrops were found on Mr. Boone's place striking directly toward both the outcrop last named and the coal in sec. 36, T. 26 S., R. 13 W. The dip here is very slight.

Near the south line of the SE $\frac{1}{4}$ sec. 32 a coal is exposed which resembles somewhat the Newport bed as it is found in sec. 11, T. 26 S., R. 13 W.

	Feet	Inches
Shale		
Coal		11
Clay		6
Coal		11
Dirt		1
Coal	1	9
Sandstone		
Total thickness of coal	3	7
Total thickness of bed	4	2

The next outcrop to the north does not resemble anything found heretofore, and the outcrop near the north line of this section is so covered that the dip and strike could not be measured.

Section of coal bed in SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 32, T. 26 S., R. 12 W.

	Feet	Inches
Coal, dirty	1	
Dirt		1
Coal		1
Dirt		2
Coal	1	6
Shale	3	
Coal	1	6
Bone and dirt	3	4
Total thickness of coal	5	
Total thickness of bed	11	7

The next exposure to the north is in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 28. One bed is only partly exposed, and superficial rock rests directly on the lower bench of this bed. The other bed exposed is different from any other bed seen

up to this point. The outcrop near the southwest corner of sec. 21 resembles the one in the SW $\frac{1}{4}$, NW $\frac{1}{4}$, sec. 28, but here the strike is N. 70° W., indicating some irregularity.

Section of coal bed in SW $\frac{1}{4}$, NW $\frac{1}{4}$ sec. 28, T. 26 S., R. 12 W.

	Feet	Inches
Shale, bituminous		
Coal	1	2
Dirt		11
Coal		2
Dirt		9
Coal		7
Clay		2
Coal		
Total thickness of coal	2	10
Total thickness of bed	3	9

Ferberish Project (57)

The coal prospects in sec. 18, T. 27 S., R. 12 W., were shown the writers by Mr. Bob Geaney. A series of coal beds strikes N. 20° E. and has an average dip of 45° W. These beds were prospected during 1928 and information furnished by Wm. W. Elmer, consulting engineer, indicates the presence of five beds ranging in thickness from 3.4 to 6.1 feet. These were exposed by short prospect tunnels and open cuts.

These coal beds should be equivalent to the series just east of Coaledo. The following section was obtained from a bed presumably one of the lower beds of the series:

	Feet	Inches
Shale		
Bone with an occasional streak of coal	2	2
*Coal, bony		10
Shale, black		5
*Coal	1	2
Shale, light gray		4
Bone, shale	1	8
Total thickness of coal	2	
Thickness of bed	6	7

Analysis (*) is as follows:

Field No.	58	
Lab. No.	P-2073	
Sample	Thickness	
Bed	2 ft.	
	6 ft. 7 in.	
Analysis	As Received	Air Dried
Moisture	26.0	10.27
B. t. u.	4,499	6,122
Ash	23.76	26.51

LOWER COAL GROUP

The coals occurring within the lower Coaledo member are known as the lower coal group and lie stratigraphically far below the Beaver Hill bed of the upper group, being separated by the middle Coaledo shale and much of the lower Coaledo formation. At least seven coals are known but only a few of these have ever been mined successfully, and these only on a limited scale. Several attempts have been made to mine

these coals, especially in the Lampa Creek area. The thickest coal measured in the Coos Bay area appears on the northernmost branch of Sevenmile Creek (see Sevenmile coal) where 9 feet of coal was measured in a 21-foot bed.

The coals of the lower group have numerous and thick shaly partings and "niggerheads" and a high content of bone. Their B. t. u. content and rank, when a clean sample is analyzed, are usually higher than those of the upper coals. Most of the beds have shaly or otherwise unfavorable roof conditions. The cleavage of these coals is more likely to be platy than blocky.

Sevenmile Creek Coals

Hall Creek Mine (58)

An attempt was made to mine a coal bed in a gulch on the north side of Hall Creek, about 100 yards from the road behind an old sawmill in the NW $\frac{1}{4}$, sec. 11, T. 29 S., R. 13 W., about 3 miles southwest of the town of Arago.

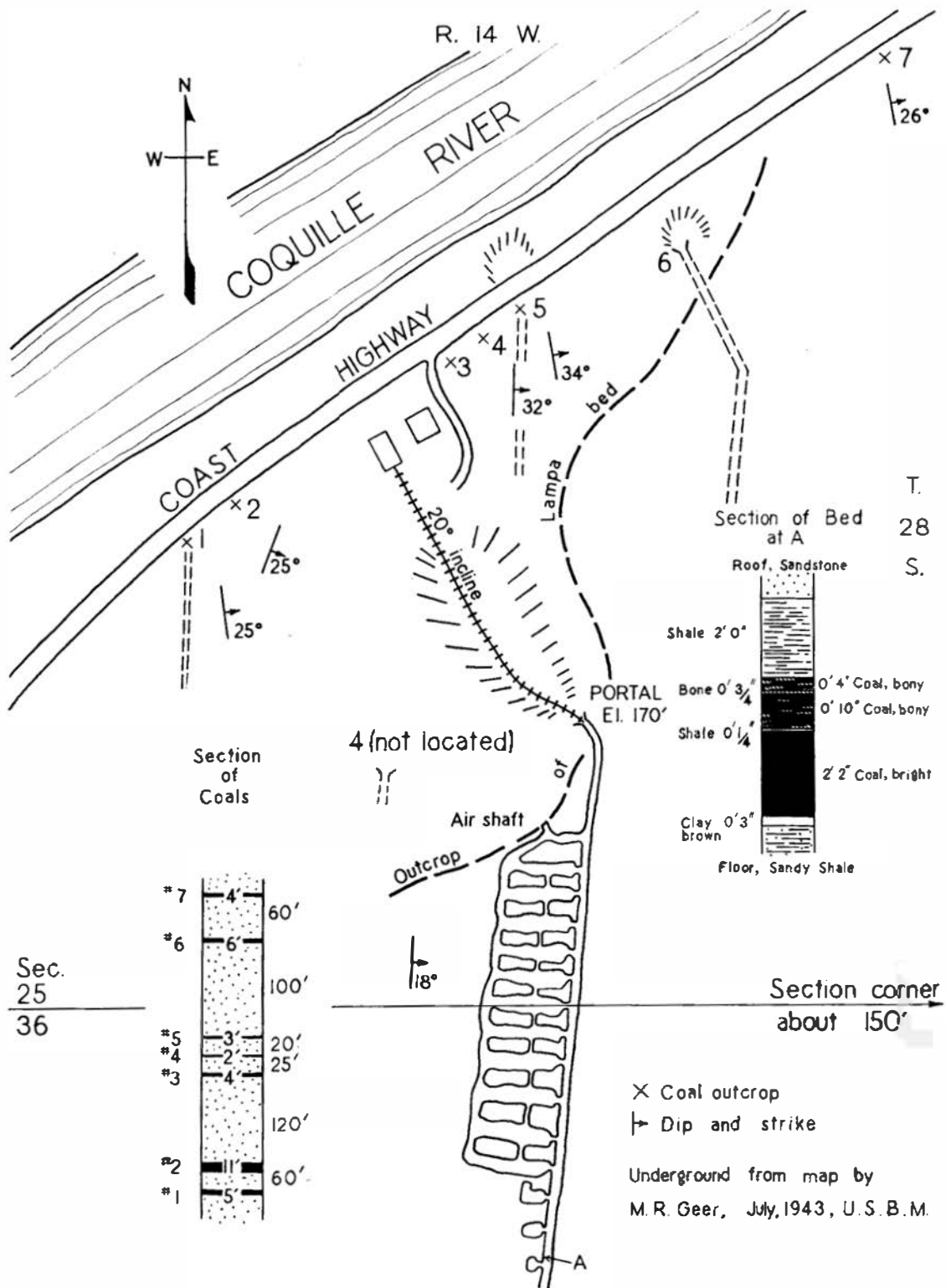
The coal is underlain by a massive ridge of sandstone of lower Coaledo age, striking N. 30° E. and dipping 45° W. A section obtained near the face of the 150-foot tunnel driven along this strike is as follows:

	Feet	Inches
Sandstone		
Bone and coal, platy		3
Sandstone		$\frac{1}{2}$
Coal, bony		5
Shale, carbonaceous		$\frac{1}{2}$
Bone		8
Clay		3
Coal, dull		9
Clay		$\frac{1}{2}$
Coal, hard, dull		6
Clay		3
Shale, carbonaceous		5
Clay, soft		2
Shale		
Total thickness of bone and coal	2	7
Total thickness of bed	3	$9\frac{1}{2}$

Lampa Creek (59)

Mining operations in the Lampa Creek district started later than most of the other mining districts and continued intermittently until 1942, when the Lampa Coal Company mine operated by Mr. Leonard Gibbs ceased operation. The mine is located in the NE $\frac{1}{4}$ sec. 36 and the SE $\frac{1}{4}$ sec. 25, T. 28 S., R. 14 W., on the highway 11 miles west of Coquille. At least seven beds of coal have been prospected within a stratigraphic distance of 400 feet, and several smaller beds are known to be present.

Plate 31 shows the location of the outcrops along the highway and a section of seven coals. A bed

Oregon Department of Geology
and Mineral IndustriesPlate 31
Bulletin 27

Lampa Creek mine workings, outcrops, and sections of coal beds.

believed to be lower than No. 1 crops out farther west in a small creek south of the highway. It may be a continuation along the strike of one of the lower beds.

No. 1. This bed is reported to be 5 feet thick. At one time, considerable mining was done and several rooms were opened with airshafts which surface farther up the hill.

No. 2. The bed locally known as the "Big Dirty" coal, lies 23 feet stratigraphically above the No. 1 bed. It corresponds to a bed exposed in the North Bank road across the Coquille River where the bed has the following section:

	Feet	Inches
Sandstone		
Coal, platy micaceous	10	
Sandstone, carbonaceous, micaceous	8	
Coal, soft bony	7	
Shale, carbonaceous	5	
Coal, bony	3	
Shale, carbonaceous	6	
Coal, bony	6	
Sandstone, soft, friable, white		

No. 3. About 120 feet above No. 2 bed is a 4-foot dirty bed which has not been mined extensively.

No. 4. A bed of coal 22 inches thick which Mr. Gibbs mined farther up the hill is believed to be the same bed as one which crops out along the highway 25 feet above No. 3. A tunnel driven 400 feet along the strike with several rooms yielded good coal. The section on the highway is as follows:

	Feet	Inches
Sandstone		
Coal	5	
Sandstone	6	
Coal	11	
Shale		

No. 5. A 3-foot bed of coal was opened 20 feet above No. 4 by Mr. Timon, and a tunnel was driven along the strike for some distance. The dump which is still visible between the highway and river indicates considerable mining. The coal is reported to be of fair quality. Until recently, the opening could be entered from the highway ditch.

No. 6. An opening just above the highway is the mouth of the tunnel which McGurty drove 160 feet before reaching the coal. The bed which he mined is the "Lampa," mined by Mr. Gibbs during the last few years. It lies about 100 feet above No. 5. The section in the Lampa Coal Company mine taken by M. R. Geer* is as follows:

	Feet	Inches
Sandstone		
Shale	2	
Coal, bony	4	
Bone		3 $\frac{3}{4}$
Coal, bony	10	

* Special report for the U. S. Bureau of Mines, July 27, 1942.

	Feet	Inches
Shale		$\frac{1}{4}$
Coal, bright	2	2
Clay, brown		3
Shale, sandy		
Total thickness of bone and coal	3	4
Total thickness of bed	5	8

Production in 1941 is listed as 665 tons.

No. 7. This bed, about 60 feet above the Lampa bed, was prospected by Gibbs who drove along the strike of the coal until it was faulted a short distance from the portal. There is a possibility that the same fault cuts the McGurty tunnel on bed No. 6. The following section was reported:

	Feet	Inches
Coal		4
Parting		1
Coal, fair quality	4	

Lord (1913:685) gives a section and analysis from the Happy Hooligan mine in sec. 36, T. 28 S., R. 14 W. This is probably the Lampa coal bed which is reported to strike N. 9° W. and dip 30° E.

The section in this prospect is given as follows:

	Feet	Inches
Roof, sandstone		
Bone	1	
*Coal		3
*Dirt		$\frac{1}{2}$
*Coal		5
*Dirt		$\frac{1}{2}$
*Coal	1	6
*Dirt		$\frac{1}{2}$
*Coal	1	8
Black clay		6
Floor, sandstone		
Thickness of bed	5	5 $\frac{1}{2}$
Thickness of coal sampled	3	11 $\frac{1}{2}$

The analysis (*) is as follows (Diller and Pishel, 1911:227):

Lab. No. 9322	
Coal bed	5 ft. 5 $\frac{1}{2}$ in.
Part sampled	3 ft. 11 $\frac{1}{2}$ in.
Air-drying loss	7.8

	As Rec'd.	Air Dried	Dry Coal	Pure Coal
Moisture	13.8	6.5		
Volatile matter	32.0	34.7	37.2	40.7
Fixed carbon	46.7	50.7	54.2	59.3
Ash	7.5	8.1	8.6	
Sulphur	4.35	4.72	5.04	5.52
Calories	5,030	5,455	5,835	6,385
B. t. u.	9,050	9,820	10,500	11,490

Over the ridge to the south in the Randleman Creek drainage, several of these coals could be seen in the cuts along the old logging road, but the outcrops were too poorly exposed to be measured.

Donaldson Prospect (60)

It is reported that a long tunnel was driven on land owned by J. D. Donaldson, west of the mouth of Hatchett Slough, probably in the SE $\frac{1}{4}$ sec. 12, T. 28 S., R. 14 W. The tunnel is supposed to have been driven across the strike to inter-

sect the coal. It is now inaccessible, and this property was not visited.

The same or another nearby prospect was visited and examined in 1939 by Yancey and Geer (1940:13), who described it as follows:

An abandoned prospect in the Coos Bay field 2 miles northwest of Riverton, Coos County, in NE $\frac{1}{4}$ sec. 12, T. 28 S., R. 14 W., was sampled by M. R. Geer and J. E. Morrison on September 14, 1939. The bed, which is unnamed, strikes N.-S. and dips 50° E.; it is opened by a drift driven 50 feet in a southerly direction at an elevation of about 75 feet. A section of the bed is given below:

	Feet	Inches
Roof, sandstone		
Coal, bony, hard		8
Coal, hard		5
Bone, hard		$\frac{1}{4}$
Coal, friable, bright	1	7
Floor, sandstone		
Thickness of bed	2	8 $\frac{1}{4}$
Thickness in sample	2	8 $\frac{1}{4}$

The analysis (pp. 19-20) is as follows:

Analysis	As Received	Dried at 105° C.	Moisture and Ash free
Moisture	10.1		
Volatile matter	36.1	40.1	48.8
Fixed carbon	37.8	42.1	51.2
Ash	16.0	17.8	
Sulfur	4.3	4.8	5.9
Hydrogen	5.5	4.9	5.9
Carbon	55.1	61.3	74.6
Nitrogen	.9	1.0	1.2
Oxygen	18.2	10.2	12.4
B. t. u.	10,080	11,220	13,650
Air-dry loss	3.5%		
Ash softening temperature	2070° F		
Agglomerating index	NAb		
Subbituminous rank	A		

This is the only coal with an A rank reported by Yancey and Geer.

Woomer Coal (61)

This outcrop is on land owned by Mr. C. S. Woomer on the west side of Hatchett Slough in the SE $\frac{1}{4}$ sec 36, T. 27 S., R. 14 W., near the township line. This dirty coal bed strikes north and dips 45° E. It is apparently one of the uppermost beds in the lower Coaledo series. The following section was measured and sampled:

	Feet	Inches
Sandstone, soft		
Bone		1
*Coal		5
Shale, carbonaceous	1	8
Bone with coal streaks	1	6
Shale		3
*Bone and coal		5
*Coal		8
Bone with streaks of coal		10
*Coal	2	
Clay	2	
*Coal		1
Clay		3
*Coal		3

	Feet	Inches
*Bone		3
*Coal		1
Clay base		
Total thickness of sample	2	4
Total thickness of bed	7	1

The analysis (*) of the better class material gave over 30 percent ash:

Field No.	63	
Lab. No.	P-2077	
	Thickness	
Sample	2 ft. 4 in.	
Bed	7 ft. 1 in.	
Analysis	As Received	Air Dried
Moisture	15.76	6.22
B. t. u.	5,938	7,050
Ash	32.91	35.10

Sevenmile Creek Coals (62)

Two beds of coal, the lower one totaling a thickness of 17 feet, are exposed on the north bank of Sevenmile Creek in the center of the S $\frac{1}{2}$ sec. 23, T. 27 S., R. 14 W., half a mile south of the Krome road. The coal strikes N. 20° W. and dips 60°-70° E. One outcrop occurs in the bottom of a small slide just above the creek level where the section is as follows:

	Feet	Inches
Sandstone, coarse		
Roof, fine conglomerate (50 feet)		
Bone	1	
Clay, gray	1	5
Shale, carbonaceous	1	
Shale, sandstone lenses		3
Shale, carb.		4
Coal		8
Clay, gray		4
Coal	1	7 $\frac{1}{2}$
Clay, gray		9 $\frac{1}{2}$
Bone, hard, coaly		7
Coal, few dirt stringers	1	3
Coal, bony	1	8 $\frac{1}{2}$
Clay, white		1 $\frac{1}{2}$
Coal	1	2 $\frac{1}{2}$
Clay and bone		9 $\frac{1}{2}$
Coal, bony	1	6 $\frac{1}{2}$
Bone		10
Coal	3	8
Clay, white		1
Coal	1	3 $\frac{1}{2}$
Coal, bony		8 $\frac{1}{2}$
Clay, yellow, and bone	1	4 $\frac{1}{2}$
Bone		9 $\frac{1}{2}$
Floor, clay, yellow		
Total thickness of coal and bone	16	10 $\frac{1}{2}$
Total thickness of parting	6	6
Total thickness of bed	23	4 $\frac{1}{2}$

Another outcrop occurs a quarter of a mile to the northwest just below the edge of the flat where the section is as follows:

	Feet	Inches
Sandstone, light brown		
Coal, bony	3	
Shale, light brown	3	
Coal, bony	2	
Shale, light brown	12	6
*Coal, hard		11
Clay, dark		5
*Coal	1	10
Coal, bony	2	10
Clay		1
*Coal		4
Clay, light		2
*Coal		7
Clay, brown		1

	Feet	Inches
*Coal	3	4
Coal, soft	1	7
*Coal	1	2
Coal, bony	2	4
Shale, carbonaceous	5	.....
Coal, soft	6	.....
Sandstone, brown		
Total thickness of coal	25	11
Total thickness of coal sampled	8	2
Total thickness of parting	21	3
Total section measured	47	2

Analysis (*) is as follows:

Field No. 99
Lab. No. P-2219
Location: Open cut on slide N. 61° W. of lookout. NE 1/4 sec. 23, T. 26 S., R. 14 W.

Sample Thickness
Bed 8 ft. 2 in.
..... 21 ft. 3 in.

Analysis	As Received	Air Dried
Moisture	18.17	9.95
B. t. u.	9,086	11,104
Ash	5.90	6.56

This analysis is unusual considering the fact that the sample was close to the surface and appeared very badly weathered. This prospect was the last one examined by the survey and may well bear further investigation.

Coal is reported to crop out in the road cut just below the crest of the hill immediately east of the Krome Corporation plant, near the center of the S 1/2 sec. 10, T. 26 S., R. 14 W.

Seven Devils Coal (63)

Two thin beds of coal and coaly material appear high on the sea cliff about half a mile north of the mouth of Fivemile Creek in sec. 32, T. 26 S., R. 14 W., where they strike N. 50° W. and dip about 42° NE. The section was measured as follows:

	Feet	Inches
Sandstone		
Carbonaceous shale		6
Sandstone	40	
Coal, good		8
Clay		3
Coal, broken	1	.....
Shale, bony	1	4
Shale, carbonaceous	1	.....
Shale		6
Sandstone, massive, nodular		
Total thickness of coal	1	8
Total thickness of lower bed	4	9

This coal belongs to the lower coal or Seven-mile group.

An outcrop of about 4 feet of broken coaly material appears in a road cut on the Seven Devils road at a point a little more than a mile due east of the coal on the shore, just 1.34 miles north of the Fivemile Creek crossing. This coal strikes N. 80° W. and dips 64° N. It is undoubtedly one of the lower coal group.

Coaly material was also seen in the face of the cliff about half a mile south of Cape Arago, but

it could not be reached for measurement. Here the sandstone beds in which the coal occurs lie just above the unconformity between the lower Coaledo and the Umpqua, and strike N. 10° E. and dip 65° E.

UNDIFFERENTIATED COAL GROUP

Other coals of uncertain age occur in the following mines and prospects.

Archer and Sengstacken Coals (64)

Three prospect tunnels, on land owned by D. L. Buckingham, two of which trend south and one north, lie approximately 1,000 feet east of the Eastside bridge in the SW 1/4 sec. 36, T. 25 S., R. 13 W. Some coal is said to have been mined for local consumption within the past 10 years, but very little tonnage was removed. The strike in the west tunnel south of the creek is N. 30° E. and the dip 14° NW. The tunnel is approximately 100 feet long. The eastern tunnel on the south side of the creek is approximately 100 feet from the first tunnel, and the coal appears to dip 14° SE. The 5 feet of coal exposed is very dirty. The roof and floor are sandstone. The tunnel was full of water and could not be examined fully. A rock tunnel north of the creek is approximately 100 feet long. No coal was found but the bedding appeared to strike north and dip 10° E.

Diller and Pishel (1911:214) projected the coals at the Caledonia mine northward, and calculated that the Archer should lie 390 feet stratigraphically above them; hence it belongs to a zone higher than the "Big Dirty" coal bed. He gives a section of the Archer coal striking north and dipping 5°-15° E., in sec. 1, T. 26 S., R. 13 W., as follows:

	Feet	Inches
Coal	3	10
Clay		6
Coal		6
Total thickness of coal	4	4
Total thickness of bed	4	10

Two and possibly more beds of coal are reported by Diller and Pishel (1911:194) from secs. 35 and 36, T. 25 S., R. 13 W., on the southern border of Coos Bay. The "Sengstacken bed" is said to be exposed in the SE 1/4 NE 1/4 sec. 36, with a section as follows:

	Feet	Inches
Shale, dark		
Coal, fair, jointed		8
Sand, fine		3
Coal, some good, mostly shaly	2	.....
Shale		
Total thickness of coal	2	8
Total thickness of bed	2	11

This bed is said to curve to the east as it is followed south, and it reaches Catching Slough at a locality where there are several coal beds which dip westward.

The Sengstacken coal bed is also reported by Diller and Pishel (1911:202) to occur in sec. 31, T. 25 S., R. 12 W., where it strikes N. 45° E. and dips 24° NW., with a section given as follows:

	Feet	Inches
Shale		
Coal		8
Clay		2
Coal, some good, but mostly shaly	2	
Shale		
Two layers of coal	2	8
Total coal bed	2	10

Bunker Hill Mine (65)

During recent years, coal was mined from an open cut on the north side of Bunker Hill at an elevation of about 200 feet, about 1,000 feet south of the highway, in the SE $\frac{1}{4}$ sec. 35, T. 25 S., R. 13 W.

Only the top bench was uncovered, so a complete section was not obtained. The bed strikes N. 37° E. and dips 14° SE.

Belfast Mine (66)

This mine is located a quarter of a mile due west of the Sunset cemetery, near the center of the SE $\frac{1}{4}$ sec. 2, T. 26 S., R. 13 W., at an elevation of about 100 feet.

It was operated by J. H. Flanagan soon after World War I and is reported to have yielded not more than 300 tons from one gangway between 300 and 400 feet long. The coal is said to strike north and dip 4°-5° E. It was badly broken, the miners encountering one "jump" after another in the workings. Later a few more tons of tons were taken out from short tunnels farther east down the dip.

A section of coal was taken about 200 feet northwest of the mouth of the main tunnel, where the coal appears to strike N. 30° E. and dip 10° N.

	Feet	Inches
Shale		
*Coal	1	2
Clay, hard		4
*Coal, sulphur bands	2	7
Bone		8
Clay		
Total thickness of coal	3	9
Total thickness of bed	4	9

Analysis of the two benches (*) sampled is as follows:

Field No.	97
Lab. No.	P-2217
Sample	Thickness
Bed	3 ft. 9 in.
	4 ft. 9 in.

Analysis	As Received	Air Dried
Moisture	20.22	10.05
B. t. u.	8,734	10,948
Ash	8.94	9.94

At the junction of the southern cemetery road and the main highway, a coal outcrop, striking N. 30° E. and dipping 25° N., has the following section:

	Feet	Inches
Roof, sandstone, 15 feet plus		
Shale		8
Shale, carbonaceous		4
Coal		$\frac{1}{2}$
Shale		1
Coal		$\frac{1}{2}$
Shale		3
Bony coal		8 $\frac{1}{2}$
Clay		1 $\frac{1}{2}$
Coal		$\frac{1}{2}$
Clay		$\frac{1}{2}$
Coal, bony		1
Floor, brown clay		
Total thickness of coal		11
Total thickness of parting	1	6
Total thickness of bed	2	5

Although the Belfast coal is not similar to the Southport or Libby beds, it is probably a member of the upper coal group and in general equivalent to the Caledonia coals.

Caledonia Mine (67)

The Caledonia mine operated for about a year in 1887 (Diller, 1899:352). The old mine workings are located just south of the center of sec. 11, T. 26 S., R. 13 W., half a mile northwest of the Shinglehouse Slough highway bridge. The old mine workings located by the survey were so badly caved as to be hardly discernible. An airshaft was cleaned out to a depth of 60 feet without revealing any coal. A topographic map covering some 25 acres was made. Holes were drilled to the south and west of the airshaft. Two cuts were made near the old workings showing about 30 inches of coal. In all, 16 holes were drilled to depths of 20-30 feet without encountering coal. Inasmuch as the property was investigated to determine stripping possibilities, and the drilling proved the coal to be too deep for stripping, further work on the project was considered inadvisable.

Three beds of coal are reported by Diller and Pishel (1911:213) to occur in a hole drilled near the mine. One bed near the surface is a foot thick, the second is 30 feet below the surface 1 foot 8 inches thick, and the lowest or Caledonia bed is

30 feet below the second. They give a section of the Caledonia bed as:

	Feet	Inches
Shale		
Coal		10
Clay		6
Coal	2	3
Total thickness of coal	3	1
Total thickness of bed	3	7

Davis Slough Coals (68)

Coaly material shows in a small stream which enters a large tributary of Davis Slough in the NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 21, T. 26 S., R. 13 W. A small dump nearby indicated some prospecting, although no opening could be detected. The following section was measured:

	Feet	Inches
Shale roof		
Coal, dull		6
Bone	2	6
Coal, dull		3
Clay		10
Coal, dull		3
Shale		
Total thickness of coal	1	
Total thickness of bed	4	4

According to Diller and Pishel (1911:210) an outcrop of coal in the SE $\frac{1}{4}$ sec. 21, presumably in the vicinity of that measured above, is 2,400–3,000 feet stratigraphically below the Beaver Hill coal group and gives the following section:

	Feet	Inches
Coal and dirt in alternating bands	1	6
Clay		1
Coal, soft		4
Shale		

The coal in sec. 21 in all probability belongs to the lower coal group, and there is a strong suggestion that the middle Coaledo is much thinner here than in the coastal section. This coal is about 1 mile north along the Westport arch from the site of the Phillips Petroleum Company well, which encountered coals at depths from 450 to 1,500 feet, undoubtedly of the lower coal group. Another outcrop in the NW $\frac{1}{4}$ sec. 31 was reported by Mr. Paul Bartram, geologist for the company, but was not visited by the survey.

Diller and Pishel (1911:216) summarized the coal groups in T. 26 S., R. 14 W., as follows:

The Beaver Hill group of coal beds, so named because they are mined extensively at Beaver Hill, is the only group exposed in this township. The Big Hill coal group, 2,400 feet lower, and the Sevenmile Creek coal group, 5,000 feet lower than the Beaver Hill coals, should outcrop in this area.

The writers recognize only two major groups of coal, the upper coal group and the lower coal group that includes the Sevenmile Creek coals.

The usage of the term "Big Hill coal group" is confusing as Bill Hill cannot be located on the map. Presumably the "Big Hill group" is a part of the lower Coaledo series.

"Thirty-Six Coal" Mine (69)

The mine is located in the SW $\frac{1}{4}$ sec. 25, T. 26 S., R. 13 W., between elevation 100 and 150 feet. At one time, probably about 1900, it was operated as part of the Maxwell mine. Judging from the size of the dump, several thousand tons of coal was mined. One gangway was driven S. 70° W. at least 75 feet (judging from airshaft opening) on a bed of coal which strikes in the same direction and dips about 20° SE. An east-trending fault, which dips 55° S. cuts off the coal north of the mouth of the tunnel. A section of the upper part of the coal (not all of it may be seen) was measured as follows:

	Feet	Inches
Shale, fossiliferous		
Bone	1	2
Clay		7
Bone		1
Coal	2	6+
Not observed		
Total thickness of coal	2	6
Total thickness of parting	1	10
Total thickness of bed	4	4

Coal was also found cropping out in a gulch 500 feet east of the old mine opening, striking N. 40° E. and dipping 20° SE. as follows:

	Feet	Inches
Shale		
Shale, carbonaceous	1	
Bone		5
Clay		6
Shale, carbonaceous	1	1
Shale	1	
Coal, broken		2
Shale, carbonaceous		3
Shale		7
Coal (some bony)	2	10
Shale, carbonaceous		6
Shale		
Total thickness of coal	3	
Total thickness of parting	5	4
Total thickness of bed	8	4

There are also several thin beds of dirty coal 20 to 30 feet up the creek to the southeast.

Diller and Pishel (1911:215) believed that a series of four coal beds in this locality lies 2,500 feet above the Newport bed, and that these beds

have no resemblance whatever to the coal beds of the Newport group, as thought by some people. There may be unknown faults or folds in the neighborhood, but these beds appear to occupy a small basin in secs. 36 and 25 and perhaps reach over into sec. 30, T. 26 S., R. 12 W. No coal beds were reported at this horizon from any other place in the field, but it is doubtful if rocks as high as these in the stratigraphic

column outcrop anywhere except in the South Slough Basin.

It seems more probable that these coals are in reality a part of the upper coal group and owe their position to uplift along the eastern side of the Isthmus Slough fault (see discussion under "Structure").

The four sections are given (p. 214) as follows:

Sections of coal beds in SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 25, T. 26 S., R. 13 W.

	Feet	Inches		Feet	Inches
Shale			Shale, bituminous		
Coal	2		Coal, dirty	8	
Dirt	4		Clay	8	
Coal, dirty	1		Coal	1	6
Shale	4		Bone	1	1
Coal	3		Coal	1	5
Clay	1 $\frac{1}{2}$		Shale		
Coal	1	6			
Bone	1		Total thickness		
Coal	10		of coal	3	7
Shale	8		Total thickness		
Coal	9		of bed	4	4
Clay					
Total thickness					
of coal	4	6			
Total thickness					
of bed	6	$\frac{1}{2}$			

Sections of coal beds in NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 36, T. 26 S., R. 13 W.

	Feet	Inches		Feet	Inches
Shale			Shale		
Coal	3		Coal, dirty	5	
Clay	1		Coal	9	
Coal	9		Clay	1	
Clay	2		Coal	5	
Coal	5		Clay	1	
Sandstone			Coal	1	10
Total thickness			Clay	1	1
of coal	1	5	Coal	1	3
Total thickness			Clay		6
of bed	1	8	Sandstone		
			Total thickness		
			of coal	4	8
			Total thickness		
			of bed	5	5

Diller and Pishel mapped three attitudes on these beds as N. 10°–45° E., with dips of 17°–18° SE.

Brown Slough Coals (70)

Diller and Pishel (1911:210) report three outcrops of coal in the headwaters of Brown Slough in sec. 31, T. 26 S., R. 13 W. These are tentatively referred by the survey to the Sevenmile Creek coal group. In the SE $\frac{1}{4}$ sec. 31 a coal bed striking N. 3° W. and dipping 70° W. has the following section:

	Feet	Inches
Sandstone		
Coal, dirty		6
Coal	1	
Bone		3
Coal		3
Shale		
Total thickness of coal	1	9
Total thickness of bed	2	

The attitude of the rocks in this section is anomalous; they have been much disturbed, either by faulting or by intense folding or both.

Stainbeck Coal (71)

A mine formerly operated by Martin Stainbeck is located near the center of the N $\frac{1}{2}$ sec. 31, T. 27 S., R. 12 W. The mine was connected with the county road north of Coquille by a short road planked with railroad ties across the valley of Cunningham Creek.

A tunnel was examined for a distance of 150 feet but caving prevented further access. The tunnel parallels horizontal strata, but no coal could be seen. Evidently the coal was intercepted farther underground. The amount of coal slack on the dump suggests a production of at least several hundred tons. The bed at this property is believed to be one of the lower Coaledo coals.

OTHER COALS

Coals within the Umpqua formation generally have a high ash content, owing to the intimate interbedding of thin platy layers of coal and bone. The coal itself is likely to be of a higher rank than coals of the Coaledo formation and they may even be bituminous, but generally the ash content is more than 20 per cent. East of Myrtle Point along the Middle Fork of the Coquille River, there are several beds exposed, some of them as much as 14 feet in thickness. Most of this thickness, however, (see Rookard coals) is bone and shale, and it would probably be impossible to make a marketable separation. Coals at Lakeside and near Bandon are probably of pre-Coaledo age.

Bandon Coals (72)

Coal crops out in a small creek which runs through Bandon in the NE $\frac{1}{4}$ sec. 31, T. 28 S., R. 14 W. This coal was shown the writers by Mr. L. S. Klineman, who had done considerable prospecting in this area and encountered coal in several test pits which went through the surficial terrace sands into bedrock.

One attitude shows a strike of N. 60° E. and a dip of 40° SE. The belt of coal as encountered in the pits seems to run N. 40° W., although there is the possibility that several beds were encountered so that this cannot be depended upon for the strike.

The coal as observed on the dump seemed to be of good quality, and the reported thickness and quality indicate the feasibility of small scale mining operations. Water would be one of the chief problems encountered in mining operations.

The significance of this coal lies in its probable Umpqua age. Although the structure of this area is masked by terrace deposits, it seems probable that these strata are Umpqua in age because of their proximity to pre-Tertiary rock near Bandon, and because the Coaledo sediments seem to be generally limited to the eastern limb of the structure. The closest known Umpqua coals of prominence are found near Remote and Bridge. Some Umpqua coal was reported just east of the highway about 2 miles north of Myrtle Point. Coal was reportedly encountered in the highway cuts along the hill west of Bear Creek near Bandon.

Lakeside Coals (73)

Several outcrops of coal appear near the shore of Tenmile Lake in T. 23 S., R. 12 W.

One of these is located in sec. 19 under the pipe line between the house of Dr. Melvin Johnson and the reservoir. The exposure in the creek bottom shows 1 foot 6 inches of bone and carbonaceous shale striking east and dipping 6°–10° N. The country rock is a buff-colored, soft, and rather massive sandstone.

Two other coal outcrops have been reported by Mr. D. L. Buckingham. One of these lies on the south side of a northeasterly inlet of Tenmile Lake in the S½ NE¼ SE¼ sec. 17. Another outcrop is reported to occur on the west side of the south inlet near the southwest corner of sec. 20. Neither of these was visited.

Remote Coals (74)

Coal crops out in the Coquille-Roseburg highway half a mile west of the Sandy Creek bridge. The strike is N. 55° E. and dip is about 20° SE. The section was measured as follows:

	Feet	Inches
Sandstone, shaly		
Coal, bony	2	4
Clay	1	10
Coal, bony		7
Clay		8
Coal		10
Total thickness of coal	3	9
Total thickness of bed	6	3

About 1.1 miles west of Sandy Creek bridge, the coal crops out in three or four beds in a bluff on the south side of the Middle Fork of the Coquille. The strike is N. 50° E. and dip 25° SE.

Because the river could not be forded, the prospects on the south side of the river were not visited. A sample from the dump was furnished by Mr. C. E. Dick and was analyzed as follows:

Field No.	89		
Lab. No.	P-2200		
Location:	Dump of Dick mine. NE¼ sec. 31, T. 29 S., R. 10 W.		
Analysis		As Received	Air Dried
Moisture		5.15	2.80
B. t. u.		8,744	9,219
Ash		29.19	30.03

A section of carbonaceous material and coal is exposed in the highway cut 1.75 miles west of the Sandy Creek bridge. It strikes N. 40° E. and dips 35° SE., and has the following section:

	Feet	Inches
Sandstone, massive, conglomeratic		
Shale, paper, carbonaceous		2
Clay, soft		11
Shale, carbonaceous		5
Shale, coaly	1	1
Clay		5
Coal, dirty		7
Shale, gray	6	
Coal, bony		6
Clay		3
Coal, bony		3
Clay		2
Coal		1
Clay, carbonaceous	1	9
Sandstone, soft	1	2
Shale		4
Sandstone, massive, conglomeratic		
Total thickness of section	14	1

The Rookard prospect, thought to be on the line between secs. 5 and 6, T. 29 S., R. 10 W., about 6 miles northeast of the town of Bridge, is just off the eastern edge of the quadrangle. The prospect consists of an open cut beneath the massive sandstone, 100–150 feet thick, which caps a high mountain overlooking Big Creek Valley and the town of Bridge. The coal strikes N. 40° W. and dips 16° NE. The section is as follows:

	Feet	Inches
Sandstone, massive		
Shale, carbonaceous	3	
Bone	1	6
Shale, carbonaceous	2	6
*Coal, bony		6
Shale, carbonaceous	2	8
*Coal, bony		4
Clay, light gray		4½
*Coal and shale, intercalated	2	6
Clay, hard		
Total thickness of coal	3	4
Total thickness of parting	10	½
Total thickness of bed	13	4½

Considerable coaly material occurs in this thick bed but it is too impure to be of commercial importance under present conditions. The following analysis shows the high ash content:

Field No.	7 and 13		
Lab. No.	1604		
Location:	East of Big Creek. Secs. 5-6, T. 29 S., R. 10 W.		
Analysis		As Received	Air Dried
Moisture		8.40	4.1
Ash		39.85	

These coals are interstratified with the upper massive sandstone beds of the upper Umpqua and are platy and extremely high in ash. The massive sandstone near Remote forms a dip slope from

which the softer Umpqua shales have been eroded. The Rookard coal prospect near Bridge is believed to occur in much the same stratigraphic position below the top of the massive sandstone.

APPENDIX A

Introductory Note

In order to obtain the opinion of an experienced coal mine engineer and operator on the practical as well as theoretical problems connected with production of coal in the Coos Bay field, the department retained Mr. M. D. Curran

of the M. D. Curran and Company, St. Louis, Missouri, to make a report with particular attention to economic possibilities of coal by-products. Mr. Curran's report is reproduced in the following pages.

REPORT OF INVESTIGATION CONCERNING THE DEVELOPMENT OF COAL PRODUCTION IN THE COOS BAY REGION OF OREGON

by

M. D. Curran

Introduction

Large reserves of subbituminous coal located convenient to cheap water transportation in the Coos Bay district of Oregon constitute an important mineral resource which is available for development and utilization by domestic and industrial consumers in Pacific Coast markets. Mining of coal in the Coos Bay area was begun almost a century ago, and, prior to the development of large petroleum reserves in California and Texas, mining was carried on profitably. During the past twenty years, however, mining operations have been limited to extremely small tonnages for local use due to the replacement of coal by oil and waste wood material.

Fuel requirements to meet wartime demands in the Pacific Northwest have reached a new peak. Emergency regulations are being applied to the use of fuel oil, and the supply of waste wood material to the larger cities is not sufficient to permit its substitution for fuel oil to any greater extent. Coal supplies are being rationed. The occurrence of unusually cold weather during the war period would, undoubtedly, cause considerable suffering due to the general fuel shortage. In view of this situation and the anticipated postwar conditions with respect to the supply of fuel oil and waste wood products, it is obvious that serious consideration should be given to the production of coal from the Coos Bay district.

Summary

Reserves of minable coal in the predominant Beaver Hill seam which occurs generally in the Coos Bay district are indicated to be adequate to supply a substantial mining industry for a great many years. Evidence of the extent and character of the seam is provided by drill holes, surface cuts and operating and abandoned mines.

A fair appraisal of mining conditions can be made from the many exposures and workings, which permits the assumption that very little timbering will be required with room widths of thirty feet and that the coal required for pillars will be no more than average.

A rock parting occurs at about the middle of the seam, which varies from about eight inches to two feet, thus creating upper and lower benches which run from one and one-half to three feet thick. There appears to be four feet or more of minable coal throughout the area. This rock band must be removed from the coal before loading, but it does not present an obstacle to mining operations.

The coal is subbituminous in quality and runs about 10,000 B.t.u. per pound as mined. It has moderate slacking characteristics which limit its storage to some extent, but it has good burning qualities. It runs 18% to 20% in moisture and contains moderate amounts of ash and sulphur which can be reduced to a very satisfactory level by washing.

The trade territory and the kind of markets which can be served are only limited by the low heating value of the coal. Beneficiation to raise the heating value is indicated and low-temperature carbonization suggested. Research along this line is recommended.

Purpose and Scope

The investigation herein recorded was undertaken with the objective of determining pertinent data on the coal bodies, mining conditions, present-day competitive position with respect to other available coal, and possible means of beneficiating the coal to develop the greatest possible competitive advantage.

At the present time there is a shortage of all fuels in the Pacific Northwest which has been occasioned by higher wartime fuel consumption and restriction of the volume of the fuel oil supply to approximately two-thirds of the amount desired by oil users. This present acute fuel shortage is expected to continue throughout the period of the war, and, accordingly, attention is being given to the production of coal from local sources for replacement of fuel oil for domestic and industrial use.

Emphasis has been given in this study to mining development on the reserves of coal comprising the Beaver Hill seam in the immediate

vicinity of the City of Marshfield, which is located on Coos Bay. Since this particular locality has provided practically all of the coal mined in this district in the past, and since the reserves are known to be adequate to support a sizeable mining industry, and due to the fact that mines can be located on tidewater, it seems apparent that any new mining development would naturally be undertaken in this district. Accordingly, the opinions and recommendations made herein pertain to the Coos Bay field.

Historical

Production of coal in the Coos Bay field is recorded as having been started in 1855. There are no records to show the tonnage mined and sold during the early years. Since the year 1880, however, records have been kept, and annual production records indicate a production of from 40,000 to 75,000 tons per year during the interval between 1880 and 1890. During the next ten-year period the production increased to as much as 107,000 tons in the year 1897. Between 1900 and 1910 the production ranged from 60,000 to 111,000 tons and thereafter began to drop rapidly to a low tonnage of 13,000 tons in the year 1918. Generally speaking, this record of operations shows very clearly the story of the replacement of coal by fuel oil in the West Coast markets. At the turn of the century considerable tonnages were being sold in the San Francisco area which moved via coastwise vessels, and this business, of course, was lost to fuel oil shortly after it became available in this market. Records indicate that more than 2,000,000 tons of coal were mined and shipped prior to 1920. During the last twenty years mining operations have practically ceased.

Reserves

The Coos Bay coal field is a pumpkin-seed shaped area, 30 miles long north and south, by 12 miles wide east and west. Coos Bay, with its harbors at Marshfield and North Bend, is in the north central part of the productive coal area; Coquille is in the southern part of the coal area. The Coast Highway U. S. 101 and also the Coos Bay branch of the Southern Pacific Railroad run the length of the field. The coal lies in broad folds or basins where the coal seam extends almost horizontally at the bottoms and tops. On the flanks of the basins the veins dip anywhere from 10° to 40°.

Various estimates are available touching on the minable coal in the Coos Bay district. Campbell, in 1913, gave a figure of 1,000,000,000 tons. The tonnage that can be mined profitably must be considered to be substantially less than Campbell's figure. Geologists of the Oregon State Department of Geology and Mineral Industries believe that the Coos Bay district can supply 100,000,000 tons or more. The work done by this department in recent months through drilling and other explorations, which I had occasion to review, shows beyond any reasonable doubt that there is an abundance of minable coal to support substantial mining operations for many years to come.

Geology

The coal seams are substantially interrupted by faulting. The position of large faults has been confirmed as a result of intensive work recently done by the Oregon State Department of Geology. The various exposures which were examined show a variation in thickness of the coal and the impurity bands, but throughout the area there appears to be an average of about 4 feet of minable coal excluding the rock and shale partings. There are, of course, frequent horsebacks and pinched zones, but these do not appear to be of the type which cause undue hardship in mining.

Mining operations now carried on at two mines show clearly the variation in dip of the seam. The Southport mine operates on a 10° dip and the Overland mine on a 30° dip. The elevation of the Beaver Hill seam in the Coos Bay district varies above and below sea level, and mining operations which I witnessed in the Overland mine below sea level did not indicate any difficulty due to water seepage.

Outcrop cuts show clearly the banding of the coal and impurities as they occur in this seam of coal. Upper and lower benches of coal are separated by a rock parting which varies in thickness from about 8 inches to 2 feet. Explorations were made on a small island-like area at Englewood on the outskirts of Marshfield which would offer an immediate opportunity for strip mining were it not for the forest of large trees on the surface.

Mining

The faulted condition of the Coos Bay district more or less governs the size of individual mine operations. Generally speaking, we feel that mines laid out to produce from 200 to 300 tons of coal

per day could be made to pay out more readily than mines geared for larger scale operations. In some locations mines of even smaller capacity would undoubtedly produce coal at a competitive cost with a profit. On the other hand, there may be one or more areas, when properly explored, which will indicate the advisability of carrying on operations at a somewhat larger scale. The foregoing statement is intended to indicate a general classification rather than to in any way indicate a definite limit to the scale of mining.

The Beaver Hill seam is distinctly separated into two minable parts by a rock band which, at some locations, seems to be too hard to be cut out successfully with mining machines. Generally speaking, it appears that the rock band may be mined with the two layers of coal, and the rock gobbled or loaded separately as it is mined. This rock band appears to have a fairly rapid slacking quality, with the result that upon exposure to air and moisture it disintegrates into a clay-like substance. Due to this characteristic, the separation of this rock at the face will always be helpful, and particularly so in the event the coal is washed before shipment. On all exposures noted, both underground and at the various outcrops, I observed that slacking of the rock band was much more rapid than the coal surrounding it.

The top and bottom conditions for mining would be classified as good. A thick layer of sandstone covers the Beaver Hill seam generally throughout the area, and its character is such as to require only a limited amount of timbering.

The two mines now in operation are each producing in the neighborhood of 15 to 20 tons of coal daily which, of course, is too small a tonnage to give any indication of the probable mining cost upon a reasonable scale of operations. The room and pillar method of mining is commonly employed, the room necks generally being 8 feet to 10 feet in width and opening up to a room width of 20 to 30 feet. The rooms in the Overland mine run up to 300 feet in length; these rooms extend up the dip of the seam, thus permitting the coal to be chuted to the gangway. The Southport mine is just being opened up, and the coal produced up to the present time has come almost entirely from the main haulageway, although at the time of my visit the first room had been necked off at a point about 400 feet in from the mine portal. The dip of the seam at the room neck was indicated to

be approximately 10°. The working force at each of these mines consisted of two to four men and all mining was being done by hand.

At the Southport mine the tippie and bins are constructed of wood and hoisting of the coal is accomplished by a Diesel engine driven cable-drum located at the tippie entrance. Electric power is not now available at either mine.

The water made in the Southport mine is handled by a small pump operating part time. The mine water largely comes from accumulations in abandoned workings of an old mine lying farther up the dip. The operators have installed a 2-inch siphon which is rapidly lowering the water level in the abandoned mine, and, in due course, is expected to remove the water from the adjacent workings so that there will be very little water to pump. In this connection, it should be mentioned that a substantial water reserve can be retained in these old workings in the event it should be needed for coal washing.

As mentioned above, the mining cost under present working conditions cannot possibly indicate the probable cost if coal were mined with the help of mechanical equipment and at the rate of 200 to 300 tons per day. Mining cost records were not available, but the cost at both these mines is estimated to be in the neighborhood of \$6 or more per ton. In attempting to estimate the probable mining cost, we conclude that the most accurate method of determination will be arrived at by comparison of mining conditions with other mine operations where years of experience have conclusively demonstrated the practical mining cost. On this basis of reasoning, we conclude that, with the present-day wage scales and materials costs and the requisite number of good local miners, coal should be mined from the Beaver Hill seam at a cost ranging from \$3 to \$4 per ton and probably averaging \$3.50 per ton. This cost figure we believe can be established, assuming, of course, that electric power will be made available and that a limited amount of mechanical equipment be employed in mining operations.

Mining Development

It would seem that the quickest relief could be provided in the present fuel shortage emergency by expanding the operations of either one or both of the existing mines because of their proximity to rail and water transportation and because they

are partially developed and have a certain amount of equipment which can be used. Detailed studies should, however, be made in connection with the development of an enlarged plan of operations to determine the practicability of expanding operations, the availability of labor, the cost of providing electric current and the kind and extent to which mechanical equipment could be utilized.

In connection with the use of mechanical equipment, there is no doubt but that a considerable saving in cost can be obtained by the use of electric drills and electric haulage. In view of the unusually good top conditions and the difficulty in handling machines on a dipping seam, the use of undercutting machines should be carefully studied, as there would seem to be some doubt about the extent of their usefulness. It appears likely that shooting on the solid may be practiced to good advantage under conditions which appear to exist. The use of conveyors for delivery of the coal from the face to the gangways would appear to be desirable, particularly where the dip of the seam is not sufficient to permit chuting. In the case of the Overland mine, the dip is quite adequate to allow the coal to be chuted to the main haulage-way and, accordingly, the use of conveyors would be limited to the movement of coal along the gangway. However, mine car haulage on the gangway can be carried on to good advantage and at a reasonable cost where the grades are not too steep. Neither of the existing mines have adequate facilities at the bottom or the top for handling coal at the rate of 200 or 300 tons per 8-hour shift, and, accordingly, there would be some expenditure necessary to move the coal to the tippie on a reasonable basis of cost. Consideration should also be given to the problem of disposing of the coal after it passes over the tippie. The present small truck loading bins will not provide adequate storage for one day's run, but they may be made to serve if the coal is trucked away as produced. If this is not done, larger bins or railroad loading facilities would be required. These features should be carefully examined to see if the necessary facilities may be advantageously installed at existing mines.

A sample of coal was taken from each of the two mines and sent to the United States Bureau of Mines laboratory at Seattle for washability tests. The results of these tests were as follows:

Sample	Specific Gravity	Weight, percent	Ash, 1 percent	Cumulative Weight, percent	Ash, 1 percent
Southport-Larsen Mine Under	1.60	90.1	12.5	90.1	12.5
3-inch to 0 ² Over	1.60	9.9	83.2	100.0	19.5
Overland-Rudberg Mine Under	1.60	98.1	7.6	98.1	7.6
1-inch to 0 ³ Over	1.60	1.9	61.6	100.0	8.6

¹ Moisture-free basis.

² Weight of lot, 9,660 gms.

³ Weight of lot, 8,745 gms.

It will be noted that the sample from the Overland mine was fairly low in ash which probably indicates a good job of cleaning at the face. The sample from the Southport mine was taken from coal produced from the room neck where a horse-back was observed and very likely contained a large amount of bone coal, thus accounting for the higher ash. There seems little doubt but that a worthwhile improvement in the coal quality can be obtained by washing the coal, particularly the smaller sizes.

By means of a series of washability tests where the coal is examined under various specific gravity conditions, a correct understanding may be had of the washing characteristics and the feasibility of installing washing facilities. Offhand, it would seem that a single jig of the Baum type might do a satisfactory job. Since present-day local markets will absorb any coal production which can possibly be obtained, there appears to be plenty of time available for making a careful study to determine the desirability of installing washing facilities and the particular equipment which will be best suited for the job. Washing the coal is, however, stressed in this report for the reason that an enlarged program of mining to provide coal for the Portland and other markets will require the use of any practical means of beneficiation which will permit the coal to compete in such markets.

Every possible encouragement should be given to mines now operating towards increasing production, and studies should be made to determine the practicability of using mechanized equipment. We believe that the best results may be obtained by installing only that kind of equipment first by means of which an assured profit will result. If electric power rates are attractive, it would seem that electric drills would prove profitable at both mines. The use of other mechanical equipment must depend upon its merit.

In connection with the work at the face, it might be well to give some thought to the use of puncher-type undercutting machines on account of their small size and weight and the convenience

with which they may be used on dipping seams. This type of undercutting is sometimes used in gasey mines because the machines can be operated with compressed air. In flat seams the cost of undercutting with chain-type machines is somewhat lower than with the puncher type, but I suggest that consideration be given to the latter in this case on account of the difficulties which are apparent in connection with handling a heavy chain-type machine on steeply dipping seams. The opening of a new mine where the coal lies in a horizontal plane would have the advantage of undercutting with a chain machine and certain other advantages which would develop lower-cost mining. Furthermore, the long wall system of mining might be advantageously employed.

Investment Cost

The greatest obstacle to be overcome at the present time is that of procuring capital from the right source to develop additional coal production. In the case at hand the capital risks involved are substantially greater than would be anticipated if the business were established and if the mining problems were thoroughly understood.

The present Federal income tax law, as applied to corporations, does not permit the accumulation of a suitable reserve for exploratory work nor does it provide for short-term amortization of investment which is required to attract capital in such a new development. In other words, even though satisfactory marketing could be developed for the production of the coal with a substantial operating profit, the tax requirement is so great as to prevent any accumulation of working capital and disallowance of sound amortization and depletion charges might easily absorb all profit after paying taxes. To clarify this statement it should be realized that the actual working life of certain parts of the plant equipment might well be substantially less than the period allowed by taxing authorities. This particular item ought to be cleared up before any funds are expended for mine development and a ruling secured from the Treasury Department. If an exception can be made to the usual practice, it might be that conditions can be established which will permit private initiative and capital to go ahead with the development.

The other course open would be the supplying of public money from the state or Federal treasury.

Due to the fact that many developments have been undertaken during the present wartime period with such funds, I would like to submit that in this instance there should be a substantial part of the necessary capital supplied from individuals who have the will and the courage to overcome the many obstacles which will inevitably arise in connection with production and marketing. A substantial local financial interest is the best means of assuring good management and markets to take care of the coal production at times when normal competitive forces begin to make themselves felt.

Markets

The fuel markets in the local communities have been almost entirely served with waste wood products and fuel oil. Lumber operations, at the present time, are working at maximum capacity and, accordingly, are producing more than a normal amount of waste wood products. There seems to be a fair supply of hog fuel available to take care of the domestic heating requirements, but some of the industrial plants require and use oil in substantial amounts. Certain new industries which are projected for the area will need either coal, oil, or gas. Since there is no natural gas available at the present time, their gas requirements may be met by the gasification of coal, and they have, accordingly, the choice of either using fuel oil or gas from coal. Increased activity in the Coos Bay harbor may very well provide an outlet for steam coal for vessels. At the present time, some coal is being shipped into local communities from western states and sells at prices well above those which would be profitable if local mining operations were increased. This is true even with present mining costs.

Consideration should be given to the possible location of other industrial activity in the Coos Bay harbor area which would be practical if a low-cost coal were available for processing work. Oregon is rich in minerals, and it is entirely possible that processing plants to bring these minerals into use could be established advantageously on the shores of Coos Bay because of its exceptional tide-water location. It should be remembered that revolutionary changes are taking place in the utilization of wood and wood products and that industrial operations dealing with the processing of wood may be expected to come into being in connection with the lumber industry in and around

Coos Bay. Prospects for the utilization of some of the by-products of coal, together with wood and its by-products, seem very good and appear to be on the not too far distant horizon.

The Coos Bay harbor provides an excellent opportunity for handling tidewater shipments to points all along the Pacific Coast. Coal destined for the San Francisco-Los Angeles market would have considerable advantage moving out of Coos Bay in comparison to other West Coast sources of coal which require a substantial rail haul between the mine and tidewater loading points. This is particularly true if the thermal value of the Coos Bay coal can be increased by some means of beneficiation.

Following our investigation in the Coos Bay district, we spent some time looking into possible markets for the coal at Seattle, Tacoma, San Francisco, and Los Angeles. Briefly, the distinct impression was obtained at all these large industrial centers that coal would have to be supplied to replace increasing amounts of fuel oil during the immediate future. While the opportunity for movement of Coos Bay coal into Tacoma and Seattle is more or less prohibited on account of the nearness of an abundant supply of Washington coal, we nevertheless developed assurances that there is great apprehension among industrial users of fuel that they shall need to make provision for replacing oil with coal even though the investment required in some cases will be burdensome. In San Francisco and Los Angeles we found solid-fuel distributors making plans for the importation of coal from the East Coast via the Panama Canal and from the more distant sources of supply such as Australia and Indo-China. Considerable discussion was had with members of the petroleum industry while in San Francisco and Los Angeles, and their attitude as to future supplies of fuel oil substantially confirmed the feeling expressed by large industrial managers and solid-fuel distributors. We noted some apprehension on the part of certain citizens with whom we talked about the shortage of oil and the probability of a dirty atmosphere which would result from the utilization of coal by their industries. These observations are noted in this report because they will be of interest at this time in regard to the mining of Coos Bay coal on a commercial scale for the reason that favorable transportation facilities surrounding the Coos Bay district would give this coal a

preferred marketing position in these large cities to the south.

It will be noted that coal for markets in neighboring small communities can be advantageously delivered by trucks. The total volume of business developed in these markets may be expected to absorb the immediate production.

Competitive Position

Coal now being supplied to Portland comes largely from Wyoming, Montana, Utah, and Washington. Table No. 1 is presented to show the relative costs of various coals to the domestic consumer in Portland, from which it will be noted that the established F.O.B. mine prices vary considerably. In all cases a dealer's charge of \$5 per ton for handling and delivering the coal is allowed and is based upon the information that this sum is the going charge for such service.

It should be pointed out that a handling charge of \$5 per ton by the dealer is unusually high and will have the effect of curtailing the use of coal when competing with other fuels. The dealer's charge is expected to cover handling charges, inventory expense, degradation losses and delivery cost which generally, in mid-western cities, run less than one-half of the amount shown as dealer's charge in this table. Both inventory expense and degradation loss will be substantially decreased when coal is supplied from a local source, and some saving in cost to the consumer should result if these items are given their full consideration. It may even prove desirable for the mine operators to establish retail yards in cities where a substantial movement of coal can be developed. This practice has occasionally been carried out where competitive forces made it necessary.

Table No. 1

	●PA Ceiling Price	Calc. Mine Price	Rail Freight	Dealer's Charge	Delivered Price	BTU as Received Basis	Cost per Million BTU
Colorado (District 17)	\$ 5.25	\$	\$ 7.85	\$ 5.00	\$18.10	12,900	\$0.70
Colorado (District 17) ....	.....	6.15	7.85	5.00	19.00	12,900	0.74
Montana (District 22)	4.40	.....	4.91	5.00	14.31	11,010	0.65
Montana (District 22) ....	.....	5.00	4.91	5.00	14.91	11,180	0.67
Wyoming (District 19)	4.45	.....	5.50	5.00	14.95	11,610	0.64
Wyoming (District 19) ....	.....	4.30	5.50	5.00	14.80	12,360	0.60
New Mexico (District 18)	5.65	.....	12.60	5.00	23.25	11,000	1.06
Utah (District 20)	3.95	.....	5.50	5.00	14.44	12,870	0.56
Utah (District 20) ....	.....	4.15	5.50	5.00	14.65	13,500	0.54
Washington (District 23) Roslyn Field....	5.85	.....	2.45	5.00	13.30	12,195	0.54

Table No. 1—Continued

	OPA Celling Price	Calc. Mine Price	Rail Freight	Dealer's Charge	Delivered Price	BTU as Received Basis	Cost per Million BTU
Washington (District 23) Pierce County (Fairfax)	5.85	.....	1.71	5.00	12.56	12,390	0.51
Washington (District 23) Southwest (Centralia- Chehalis- "Tono")	4.85	.....	1.22	5.00	11.07	9,180	0.60
Washington (District 23) Bellingham	5.45	.....	2.36	5.00	12.81	10,390	0.62
Washington (District 23) McKay Lawson (“Black Dia- mond”-Bayne)	7.20	.....	1.71	5.00	13.91	12,270	0.57
Washington (District 23) Renton Field....	5.85	.....	1.71	5.00	12.56	11,350	0.55
Washington (District 23) Cumberland (Palmer)	5.65	.....	1.71	5.00	12.36	10,995	0.56
Oregon (District 23) Riverton	5.20	.....	2.50	5.00	12.70	10,000	0.63
Oregon (District 23) Marshfield	5.20	.....	2.50	5.00	12.70	10,000	0.63

Referring again to Table No. 1, attention is directed to the cost per million BTU to the consumer in Portland of the various grades and kinds of coal reaching this market. While some of the Washington coals appear to offer the lowest cost, it is quite possible that domestic sales are limited due to the friable character of certain of these coals. It will be noted that a freight rate of \$2.50 per ton has been established on coal from Marshfield to Portland, which seems out of line with the rates now applying from other coal fields. It is possible that if coal were to move from Coos Bay by water, the transportation cost might be reduced by about one-half. Under present conditions, and due to the low heating value of the coal, the cost per million BTU on the coal from Marshfield will be seen to be somewhat higher than the cost from several other sources of supply. If, however, the BTU value of the coal can be increased to 12,500 or 13,000 by some practical method of beneficiation, then the Coos Bay coal can compete favorably with any of the present sources of supply.

The slacking tendency of Coos Bay coal will always affect its salability for storage. This property is characteristic of high-moisture, subbituminous coals which, when exposed to dry atmosphere, lose their moisture rapidly. Shrinkage due to loss of moisture causes cracking and disintegration with the result that excessive amounts of fines are produced while the coal lies in storage. Aside

from the loss of the larger and more valuable sizes through disintegration, the presence of fines greatly increases the danger of spontaneous combustion.

The slacking tendency of Coos Bay coal is not so rapid as to cause any difficulty in its regular marketing and use but must be reckoned with when storage is necessary.

Beneficiation

The desirability of producing a higher grade fuel from the Coos Bay coal is obvious. If consideration be given to the cost breakdown in Table No. 1, it will be noted that the selling price at the mine comprises less than one-half the price paid by the consumer. Accordingly, a small increase in cost at the mine will create only a small percentage of increase in the price paid by the consumer. While it should be possible to effect some decrease in the cost of transportation and dealer's charge, the saving reflected in the retail price may not be large. If a mine be established on a fundamentally sound basis it must not only meet competitive fuel costs but it must also bring to the consumer a decrease in the cost per million BTU. Therefore, beneficiation of Coos Bay coal is a subject of primary importance and should be explored.

Various methods of raising the heating value of coal have heretofore been employed and suggest themselves for use on this coal. To illustrate the problem, a typical analysis of coal from the Beaver Hill seam may be taken as follows:

Moisture	18.0%
Volatile Matter	33.0%
Fixed Carbon	41.0%
Ash	8.0%
Sulphur	0.7%
BTU	9,900

If the moisture be completely removed from this coal, the heating value can be raised to approximately 12,000 BTU. Any practical reduction in the ash would not substantially affect the heating value. The application of drying processes to lignite or subbituminous coals for the removal of about one-half of the moisture has sometimes proved practical, but the total elimination of water has not only been too costly but has caused serious degradation. It is, therefore, quite evident that drying this coal would yield, at best, a product containing approximately 11,500 BTU. The prac-

ticability of using such kind of beneficiation will depend upon the character of the resulting product and its cost.

Moisture eliminating processes have been employed in Europe, and one of the most successful European processes has been tried out on North Dakota lignites which contain 35% to 40% moisture. This process, developed by Prof. Hans Fleissner of Austria, employs saturated steam at pressures up to 400 lbs. per square inch to remove moisture from lignite. The material to be dried is charged into large autoclaves into which high-pressure, saturated steam is admitted for a period of 1½ to 2½ hours, then the pressure slowly reduced to atmospheric and vacuum applied. This latter operation requires 30 minutes to one hour. The moisture given up by the coal and from condensation of steam is trapped off into receivers. Lignite containing 37% moisture can be dried to about 15% moisture on a two-hour cycle. Likewise, subbituminous coal running 23% moisture can be reduced to 5% to 8% moisture. The steam requirements run about ¾ lbs. of steam per pound of water removed. The cost of drying is estimated at \$0.50 to \$1.00 per ton of material charged and depends to some extent, on the character and size of the raw coal and the manner in which it reacts to the process. The experimental work indicated that subbituminous coal disintegrates considerably more than lignite and that the dried coal would require briquetting if sold for domestic use. The cost of a drying plant, including a steam power plant and reacting chambers capable of handling sizeable charges of coal at high pressure, must, necessarily, be substantial. Beneficiations of Coos Bay coal utilizing such a process in combination with a briquetting process would create a final production cost which would undoubtedly be so high as to make the use of such a system uneconomic. It is, therefore, not recommended.

Various low-temperature carbonizing processes suggest themselves, all of which provide for carbonizing the coal in a temperature range of 900° F. to 1100° F. for the production of a char. In these processes all the moisture would be removed and probably about one-half the volatile matter, thus requiring a condensation plant for the recovery of coal tars contained in the gas. Such processes commonly produce between 2,000 and 3,000 cubic feet of non-condensable coal gas of 500 to 600 BTU quality per ton of coal, which gas is used to furnish

the heat for carbonization. Generally speaking, such low-temperature processes use all the gas produced and occasionally require additional fuel for carrying on operations. The products of such a plant, therefore, consist of a smokeless char and low-temperature tar oils. Usually during the process of carbonization in the low-temperature processes employed in Europe there is considerable disintegration of subbituminous coal which is caused by shrinkage resulting from the loss of moisture in the coal. Therefore, the char produced generally requires briquetting to make it marketable for domestic and many industrial uses. There is a possibility, however, of burning the unbriquetted char, after the fines have been removed by screening, in industrial stokers for the production of steam or for other plant purposes. The beneficiation of Coos Bay coal based upon the use of such low-temperature processes would unquestionably require briquetting of the char and thus again present the problem of employing a two-stage process. Generally speaking, low-temperature carbonization treatment has the better chance of providing an economic method of beneficiation because of the high BTU value of the char and the by-product value which may be realized from the low-temperature tar oils produced.

As to the value of low-temperature tar, it may be pointed out that progress has been made in the treatment of such low-temperature tar so that the various components can now be used to advantage. This was not true a few years ago, but with increasing interest in the utilization of low-temperature tars it is safe to assume that continued progress will be made so that such tar may have an increasing value.

One important point to remember is that a heating value of 13,000 BTU per pound can be developed if the Coos Bay coal is carbonized to char. In other words, the upper limit of heating value may be as much as 2,000 BTU higher, if the coal is carbonized in the low-temperature range, than can be obtained by drying.

In connection with the experiments carried on with the Fleissner process for the steam drying of lignite, we observe that the average moisture reduction is from 37% to approximately 15%. This simply means that in order to develop plant capacity and practical drying costs the material cannot be allowed to stay in the reacting chambers to completely free it from water because the cost

of removing the last of the moisture is very much greater than the cost of removing that portion which comes off first. This point is mentioned to show that if such a drying process were employed on Coos Bay coal the practical range of drying might very well be from 18% to 8% or 10% moisture, in which event the heating value of the coal would not be increased through drying to 12,000 BTU but would more likely run in the neighborhood of 11,000 to 11,500 BTU. Thus, it can be said that from a practical standpoint, carbonization of the coal may be expected to increase the heating value 30% as compared to a possible increase of 12% by drying.

As stated above, there are several commercial low-temperature processes operating in Europe on subbituminous and lignitic coals where the type of process employed in each particular case is governed by the inherent characteristics of the coal or some particular use for which the coal is being made. In this country there is only one successful commercial low-temperature plant operating which is employed in making Disco balls from a high-grade coking coal. Just how this process might be adapted to subbituminous noncoking coals of the Coos Bay quality is not known. The thing to be desired is a single-stage process by means of which a finished product can be made at the lowest cost. The Disco process would not eliminate briquetting because the subbituminous coal does not develop bonding elements such as those obtained from the high-grade coking coal now employed. If this process were employed for carbonization of Coos Bay coal the end product would consist largely of fines.

In view of the fact that there is no known experience by which to be guided on the low-temperature treatment of Coos Bay coal, and in view of the fact that the costs of transportation and distribution constitute such a large part of the cost to the ultimate consumer, a study of the reaction of the coal to low-temperature carbonization seems to be thoroughly justified.

Summary and Conclusions

This investigation included inspection of coal mines now in operation in the Coos Bay district, an examination of geological explorations which were in progress by the Oregon State Department of Geology and Mineral Industries, and a market survey of the fuel supply to the principal cities along the Pacific Coast. Our findings support the following general conclusions:

1. The Beaver Hill seam in the vicinity of Coos Bay provides adequate minable coal to justify substantial mining operations at a moderate rate for many years. Potential reserves are an important asset to the West Coast fuel supply.
2. The coal, when mined carefully with hand picking of the rock impurities, will enjoy a preferred position in local markets as compared to competitive coals. Through the utilization of water transportation it may also compete favorably in industrial markets in Portland.
3. Beneficiation to raise the heating value of the coal should be considered as a necessary step in the preparation of the coal to meet competition in distant markets and to satisfy the requirements of domestic and many industrial users in all markets.
4. The use of simple and relatively inexpensive coal-washing equipment is indicated as the best and cheapest method of eliminating excessive ash-forming material.
5. Encouragement should be given to present mining operations by making electric power available and by lending aid in the establishment of a taxing policy which will encourage the investment of local private capital.
6. The greatest stimulation to mining development may possibly be obtained by encouraging a new mining venture based upon a larger scale operation, provided detailed studies indicate all fundamental factors favorable for such a development.
7. A research program to determine the response of this coal to low-temperature carbonization is recommended as the most practical approach to beneficiation.

APPENDIX B
DISTRIBUTION OF FORAMINIFERA IN THE COASTAL SECTION
by
Mildred Riechers*

NAME ^a		Lower Coaledo			Middle Coaledo			U C	Bastendorf									Occurrence				
		69	75	76	64	53	50		B-76	A-12b	C-14	C-16	C-17	D-22	25	30' NE. 25	28	D-28	L. Coaledo	M. Coaledo	U. Coaledo	Bastendorf	Total
25	Bolivina cf. jacksonensis C. & A.			X														1				1
26	Bulimina cuneata C. of B.	X																1				1
31	Buliminella sp.							X														2
	Cassidulina globosa Hantken				X											X	X	1	1	1	1	2
35	Cibicides? aff. baileyi B.	X	X			X		X					X		X	X		2	1	1	3	7
37	Cibicides? hodgei C. & Sc.																					
38	Cibicides? pseudowuellerstorfi Cole																					
6	Cyclammina pacifica B.							X											1			1
10	Dentalina consobrina d'Orbigny of C. & Sc.									X						X				2		2
	Ellipsoidina sp.									X									1			1
11	Nodosaria adolphina (d'Orbigny)			X										X	X	X		1		3		4
	Elphidium sp.											X								1		1
33	Globigerina triloculinoides Plummer										X	X				X				3		3
30	Gyroidina cf. soldanii of C. & Si.	X	X		X									X		X		2	1	2		5
18	Guttulina byramensis (C.) of C. & Sc.																					
19	Guttulina problema d'Orbigny of C. & Sc.															X	X			2		2
	Lagena sp.															X	X			2		2
	Lagenonodosaria sp.															X	X			3		3
21	Nonion sp.	X	X								X	X				X		2		1		3
34	Planulina haydoni C. & Sc.															X	X			2		2
39	Planulina sp. of C. & Si?																					
40a	Plectofrondicularia packardi C. & Sc.		X											X	X	X	X	1		5		6
40b	Plectofrondicularia p. multilineata C. & Si.																					
20	Pseudoglandulina sp. C. & Si.?															X				1		1
2	Quinqueloculina minuta B.																					
4	Quinqueloculina sp.				X			X										1	1			2
9	Robulus inornatus (d'Orbigny)	X	X	X		X		X			X		X	X	X	X		3	1	1	4	9
15	Saracenaria hantkeni C. of B.							X												1		1
	Siphononodosaria sp.											X								1		1
5	Spiroloculina wilcoxensis C. & G. of C. & Si.										X	X								2		2
3	Triloculina gilboei B.							X											1			1
	Trochammina sp.																					
	Turrilina sp.													X				1		1		1
27a	Uvigerina cf. glabrans C.																					
27b	Uvigerina cocoaensis? C.																					
27c	Uvigerina cocoaensis? C. of C. & Sc.							X		X	X	X	X	X	X	X		1	6			7
29	Uvigerina aff. garzaensis C. & S.																					
	Uvigerinella sp.																			1		1
	Valvulinaria sp.				X													1				1
28	Virgulina cf. hobsoni B.							X											1			1

* Numbered samples have been checked and identified by R. Stanley Beck; other determinations are tentative and subject to late alterations.

Distance of Samples Above Base
of Lower Coaledo:

	Feet
Bastendorf	
D-28	8920
28	8920
30' NE. 25	8620
25	8590
D-22	8290
C-17	7090
C-16	7065
C-14	7040
A-12	6130
Upper Coaledo	
B-76	5820
Middle Coaledo	
50	4105
53	3905
64	2400
Lower Coaledo	
76	2050
75	2000
69	1800

Key to Authors:

A—Applin	S—Siegfus
B—Beck	Si—Simonson
C—Cushman	Sc—Schenck
G—Garret	

Genera occurring once	15
Genera occurring twice	8
Genera occurring 3 times	3
Genera occurring 4 times	1
Genera occurring 5 or more times	5

Appendix C

FOSSIL LOCALITIES

Umpqua Formation

Creek bed about 200 feet upstream from the mouth of Steel Creek, 1½ miles east of Dora along the East Fork of the Coquille River; T. 28 S., R. 11 W.

Creek bed of Fourmile Creek, south of Bandon, between 3 and 4 miles from highway 101; in secs. 3 and 4, T. 30 S., R. 14 W.

Road cut opposite service station about ½ mile south of Gravelford; sec. 36, T. 28 S., R. 12 W.

Small quarry west of the mouth of Daniels Creek beneath a limestone lens and above conglomerate, all of which overlies basalt; NE¼ sec. 35, T. 25 S., R. 13 W.

Tyee Formation

Road to Shutters Landing on Tenmile Lake. Road cut just east of creek in the E½ sec. 1. T. 24 S., R. 13 W., and at the top of the hill southwest of the landing.

Coaledo Formation

Jordan Point and cliff along edge of the bay to the northwest; in sec. 2 and the NW¼ sec. 12, T. 25 S., R. 13 W.

Near the mouth of Catching Slough in cliff along the Coos River road in the northwest corner of sec. 31, T. 25 S., R. 13 W.

Sunset Bay, both the north and south sides.

South Cove, just south of the tip of Cape Arago.

In bank at the junction of the Lampa Creek road and highway 101; sec. 30, T. 28 S., R. 13 W.

Along the North Bank road (Coquille River) about 1 mile south of the mouth of Hatchett Slough in sec. 13, T. 28 S., R. 14 W.

Vacant lot in Marshfield on Tenth Avenue, just north of Mingus city park tennis courts.

Along edge of the bay about ¼ mile south of Lone Rock; NE¼ sec. 35, T. 24 S., R. 13 W.

Deep highway cut just north of the mouth of Lampa Creek; sec. 30, T. 28 S., R. 13 W.

Yokam Point (Mussel Reef) along coast.

High road cut near the mouth of Fat Elk Creek west of Coquille; in northeast corner sec. 3, T. 28 S., R. 13 W.

Bastendorf Shale

A few feet below the base of the Tunnel Point sandstone in the beach section.

Tunnel Point Sandstone

At Tunnel Point in the beach section.

Empire Formation

Fossil Point; sec. 36, T. 25 S., R. 13 W.

Coos Head; northwest corner sec. 2, T. 26 S., R. 14 W.

In the excavation for the Krome Corporation pumping plant at the south end of South Slough; S½ sec. 35, T. 26 S., R. 14 W.

Along logging road; in sec. 27, T. 26 S., R. 14 W.

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PUBLICATIONS

State Department of Geology and Mineral Industries, 702 Woodlark Building, Portland 5, Oregon.

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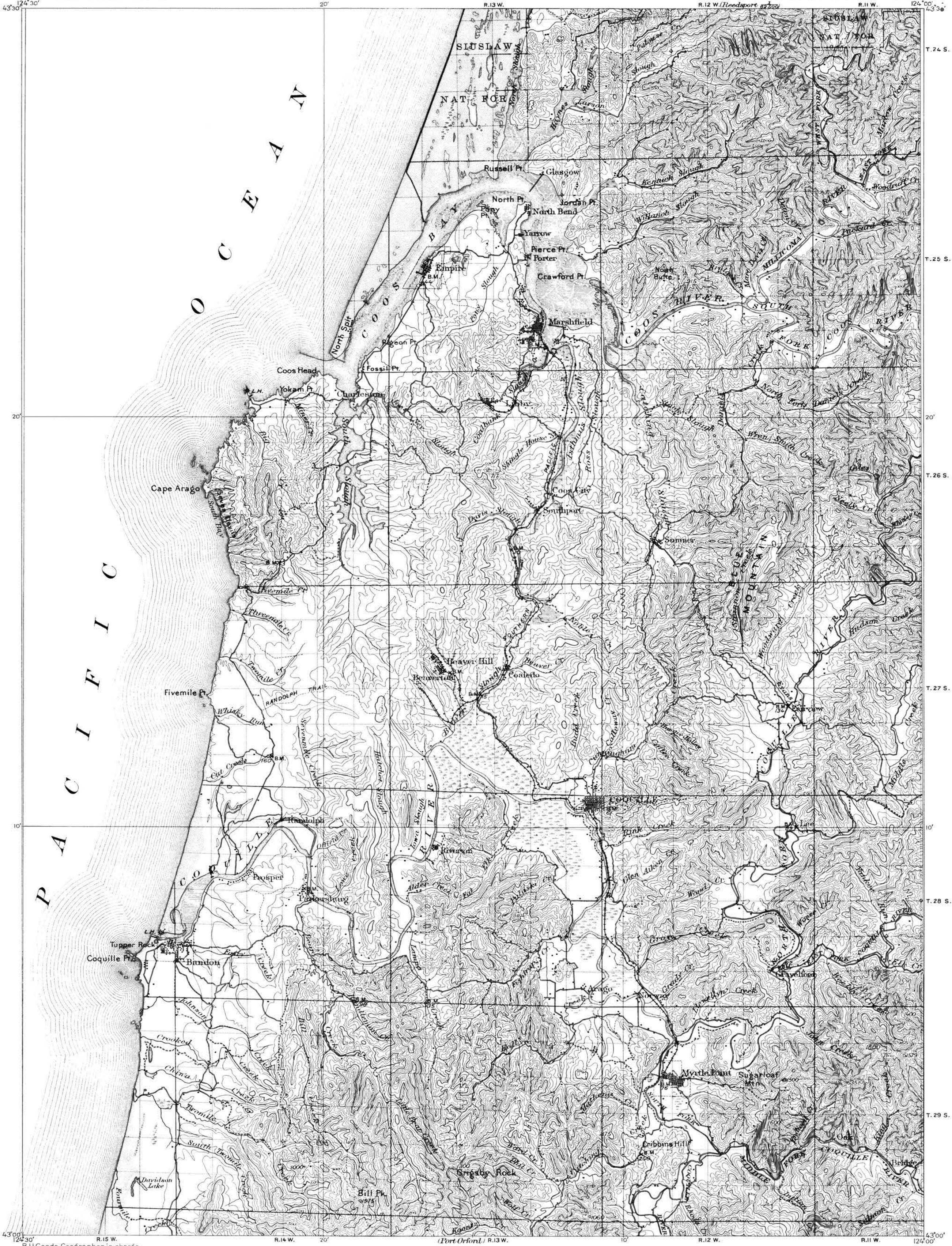
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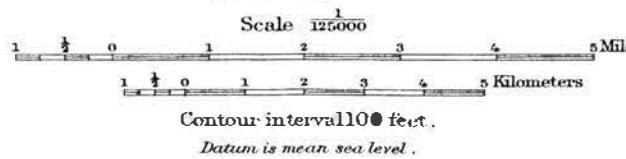
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DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
SURVEYED 1943-1944

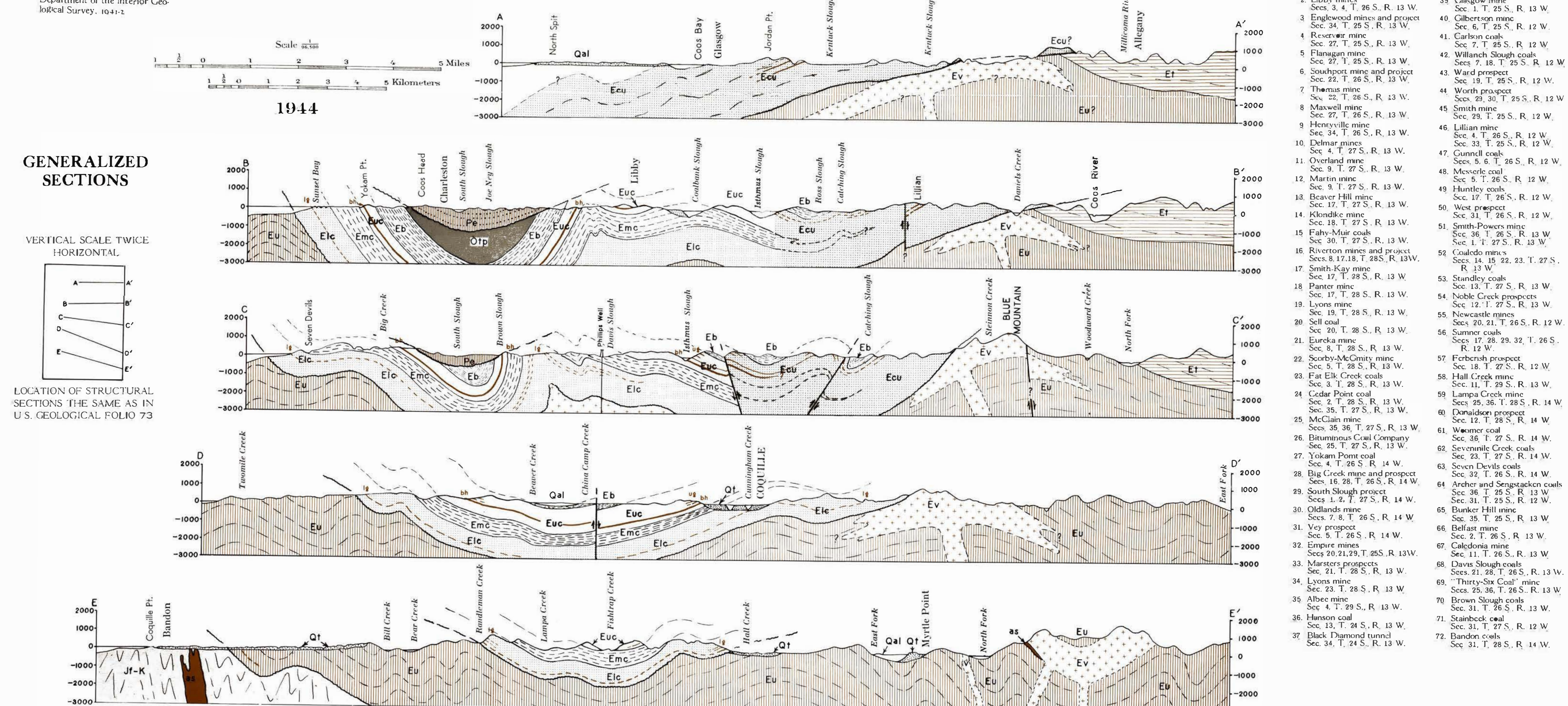
PLATE I
BULLETIN 27



VERTICAL SCALE TWICE
HORIZONTAL.

A diagram of a rectangular box. Inside the box, there is a horizontal line segment. The left endpoint of this segment is labeled 'A' and the right endpoint is labeled 'A'.

LOCATION OF STRUCTURAL
SECTIONS THE SAME AS IN
U.S. GEOLOGICAL FOLIO 73



COAL MINES AND PROSPECTS

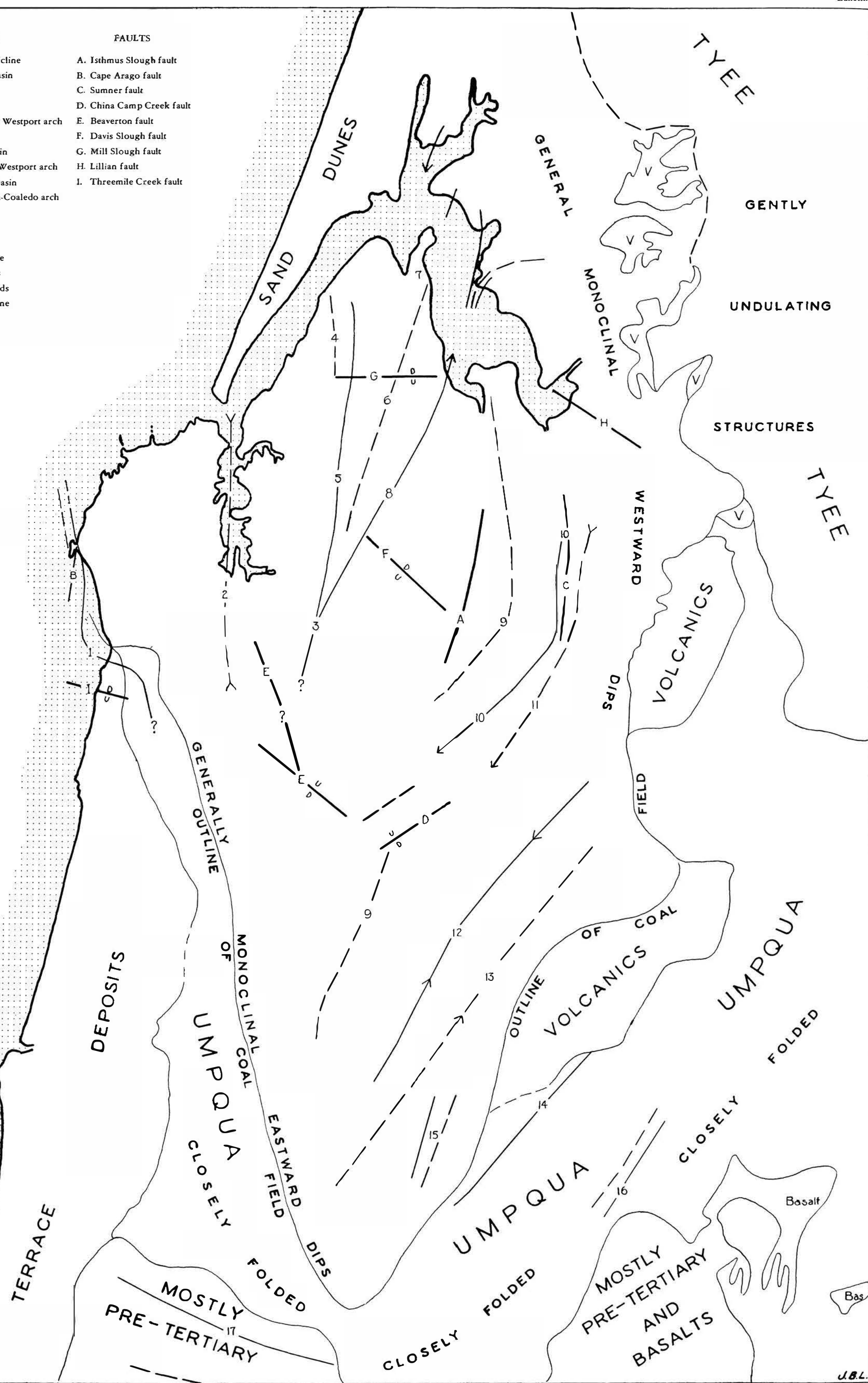
- | | |
|--|---|
| Wilson mine
Sec. 17, 25 S., R. 13 W. | 38. Lone Rock prospects
Secs. 25, 26 T. 24 S., R. 13 W. |
| 2. Libby mines
Secs. 21, 26 S., R. 13 W. | 39. Glasgow mine
Secs. 11, 26 S., R. 13 W. |
| 3. Englewood mines and prospect
Sec. 17, 25 S., R. 13 W. | 40. Gilberston mine
Sec. 6, 25 S., R. 12 W. |
| 4. Reynolds mine
Sec. 17, 25 S., R. 13 W. | 41. Carlson coal
Secs. 2, 7 T. 25 S., R. 12 W. |
| 5. Flanagan mine
Secs. 21, 26 S., R. 13 W. | 42. Willanish Slough coals
Secs. 7, 18 T. 25 S., R. 12 W. |
| 6. Southport mine and prospect
Sec. 22, 27 S., R. 13 W. | 43. Wagon Creek
Secs. 19, 25 S., R. 12 W. |
| 7. Thomas mine
Sec. 21, 26 S., R. 13 W. | 44. Worth prospect
Sec. 20, 27 S., R. 12 W. |
| 8. Maxwell mine
Sec. 17, 25 S., R. 13 W. | 45. Smith mine
Secs. 29, 25 S., R. 13 W. |
| 9. Harville mine
Sec. 34, 27 S., R. 13 W. | 46. Lillian mine
Secs. 4, 7 T. 26 S., R. 12 W. |
| 10. Delmar mines
Sec. 22, 27 S., R. 13 W. | 47. Gunnell coal
Sec. 3, 26 S., R. 12 W. |
| 11. Overland mine
Sec. 9, 27 S., R. 13 W. | 48. Murrell creek
Sec. 5, 26 S., R. 12 W. |
| 12. Martin mine
Sec. 3, 27 S., R. 13 W. | 49. Huntley coals
Secs. 17, 26 S., R. 12 W. |
| 13. Beaver Hill mine
Secs. 22, 27 S., R. 13 W. | 50. West prospect
Sec. 31, 27 S., R. 12 W. |
| 14. Klondike mine
Secs. 18, 27 S., R. 13 W. | 51. Smith-Powers mine
Sec. 36, 26 S., R. 13 W. |
| 15. Fifty-Mur coals
Sec. 27, 27 S., R. 13 W. | 52. Caledonia mine
Secs. 14, 22, 23 T. 27 S., R. 13 W. |
| 16. Fairview mines and prospect
Secs. 17, 18 T. 28 S., R. 13 W. | 53. Standley coals
Sec. 13, 27 S., R. 13 W. |
| 17. Searcy mine
Sec. 17, 28 S., R. 13 W. | 54. Noble Creek prospects
Secs. 12, 27 S., R. 13 W. |
| 18. Planter mine
Sec. 27, 28 S., R. 13 W. | 55. Newcastle mines
Secs. 5, 11 T. 26 S., R. 12 W. |
| 19. Safford mine
Sec. 20, 28 S., R. 13 W. | 56. Summer coals
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| 20. Eureka mine
Sec. 27, 28 S., R. 13 W. | 57. Fernbach prospect
Sec. 18, 27 S., R. 12 W. |
| 21. Scobey-Ab-Gmitz mine
Sec. 5, 28 S., R. 13 W. | 58. Hall Creek mine
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| 22. Fiat Earth Creek coals
Sec. 2, 28 S., R. 13 W. | 59. Lampas Creek mine
Secs. 25, 26 T. 30 S., R. 14 W. |
| 23. Cedar point coal
Sec. 2, 28 S., R. 13 W. | 60. Odenburg prospect
Sec. 12, 28 S., R. 14 W. |
| 24. McClain mine
Secs. 35, 36 S., R. 13 W. | 61. Woomer coal
Secs. 12, 28 S., R. 14 W. |
| 25. Bituminous coal Company
Secs. 25, 27 S., R. 13 W. | 62. Sevinville Creek coals
Secs. 23, 27 S., R. 14 W. |
| 26. Yokum point coal
Sec. 2, 28 S., R. 13 W. | 63. Smith-Cecil coals
Sec. 32, 27 S., R. 14 W. |
| 27. Big Creek mine and prospect
Secs. 16, 26 T. 28 S., R. 14 W. | 64. Archer and Senegatchak coals
Secs. 31, 32 S., R. 13 W. |
| 28. Searcy Slough mine
Secs. 1, 2 T. 27 S., R. 14 W. | 65. Dunker Hill mine
Secs. 11, 28 S., R. 12 W. |
| 29. Oldlands mine
Secs. 27, 28 S., R. 14 W. | 66. Belfast mine
Sec. 2, 28 S., R. 13 W. |
| 30. Vay prospect
Sec. 5, 26 S., R. 14 W. | 67. Caledonia mine
Secs. 11, 28 S., R. 13 W. |
| 31. Emory mine
Secs. 49, 21, 29 S., R. 13 W. | 68. Daves Slough coals
Secs. 21, 28 T. 26 S., R. 13 W. |
| 32. Marsters prospects
Secs. 2, 28 S., R. 13 W. | 69. Daves Slough mine
Secs. 25, 26 T. 26 S., R. 13 W. |
| 33. Lyons mine
Sec. 23, 28 S., R. 13 W. | 70. Brown Slough coals
Sec. 17, 28 S., R. 13 W. |
| 34. Albee mine
Sec. 33, 28 S., R. 13 W. | 71. Stainbeck coal
Sec. 31, 27 S., R. 12 W. |
| 35. Hanson coal
Sec. 33, 24 S., R. 13 W. | 72. ...
Sec. 31, 28 S., R. 14 W. |
| 36. Black Diamond
Sec. 34, 24 S., R. 13 W. | |

FOLDS

1. Cape Arago anticline
2. South Slough basin
3. Westport arch
4. Empire basin
5. Western fork of Westport arch
6. Newport basin
7. North Bend basin
8. Eastern fork of Westport arch
9. Beaver Slough basin
10. Catching Slough-Coaledo arch
11. Sumner basin
12. Pulaski arch
13. Coquille basin
14. Norway anticline
15. Hall Creek folds
16. Myrtle Point folds
17. Bill Peak anticline

FAULTS

- A. Isthmus Slough fault
- B. Cape Arago fault
- C. Sumner fault
- D. China Camp Creek fault
- E. Beaverton fault
- F. Davis Slough fault
- G. Mill Slough fault
- H. Lillian fault
- I. Threemile Creek fault



A—Major structures in the Coos Bay quadrangle

