DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

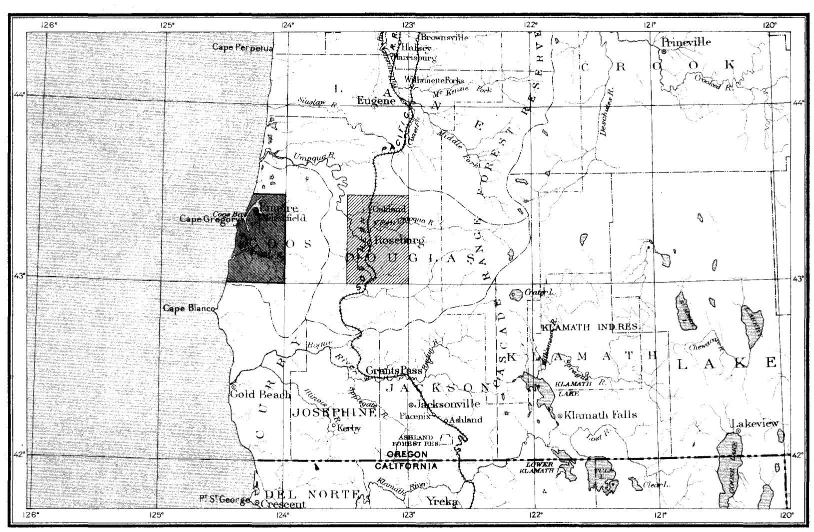
OF THE

UNITED STATES

COOS BAY FOLIO

OREGON

INDEX MAP



SCALE: 40 MILES - 1 INCH

AREA OF THE COOS BAY FOLIO

AREA OF OTHER PUBLISHED FOLIOS

LIST OF SHEETS

DESCRIPTION | TOPOGRAPHY | HISTORICAL GEOLOGY | ECONOMIC GEOLOGY | STRUCTURE SECTIONS

COAL SECTIONS

FOLIO 73 | FIELD EDITION | COOS BAY

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS   S. J. KUBEL, CHIEF ENGRAVER

1901

EXPLANATION.

The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea-level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the horizontal outline, or contour, of all slopes, and to indicate their grade or degree of steepness. This is done by lines connecting points of equal elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called *contours*, and the uniform vertical space between each two contours is called the *contour interval*. Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map:

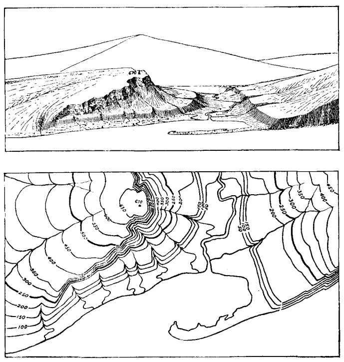


Fig. 1.—Ideal sketch and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand-bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply in a precipice. Contrasted with this precipice is the gentle descent of the left-hand slope. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates approximately a certain height above sea-level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, 200 feet, and so on, above sea-level. Along the contour at 250 feet lie all points of the surface 250 feet above sea; and similarly with any other contour. In the space between any two contours are found all elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration nearly all the contours are numbered. Where this is not possible, certain contours—say every fifth one—are accentuated and numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conforming to the surface of the ground, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. The relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The vertical space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If the stream flows the year round the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, and towns, together with boundaries of townships, counties, and States, and artificial details, are printed in black.

Scales.—The area of the United States (excluding Alaska) is about 3,025,000 square miles. On a map with the scale of 1 mile to the inch this would cover 3,025,000 square inches, and to accommodate it the paper dimensions would need to be about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the scale of the map. In this case it is "1 mile to an inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to an inch" is expressed by $\frac{1}{63,360}$. Both of these methods are used on the maps of the Geological Survey.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents and corresponds nearly to 1 square mile; on the scale $\frac{1}{125,000}$, to about 4 square miles; and on the scale $\frac{1}{250,000}$, to about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three different ways, one being a graduated line representing miles and parts of miles in English inches, another indicating distance in the metric system, and a third giving the fractional scale.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The corresponding four-cornered portions of territory are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree, i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-quarter of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, respectively.

The atlas sheets, being only parts of one map of the United States, are laid out without regard to the boundary lines of the States, counties, or townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet the names of adjacent sheets, if published, are printed.

Uses of the topographic sheet.—Within the limits of scale the topographic sheet is an accurate and characteristic delineation of the relief, drainage, and culture of the district represented. Viewing the landscape, map in hand, every characteristic feature of sufficient magnitude should be recognizable. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold; save the engineer preliminary surveys in locating roads, railways, and irrigation ditches; provide educational material for schools and homes; and serve many of the purposes of a map for local reference.

THE GEOLOGIC MAP.

The maps representing areal geology show by colors and conventional signs, on the topographic base map, the distribution of rock formations on the surface of the earth, and the structure-section map shows their underground relations, as far as known, and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. The original crust of the earth was probably composed of *igneous rocks*, and all other rocks have been derived from them in one way or another.

Atmospheric agencies gradually break up igneous rocks, forming superficial, or *surficial*, deposits of clay, sand, and gravel. Deposits of this class have been formed on land surfaces since the earliest geologic time. Through the transporting agencies of streams the surficial materials of all ages and origins are carried to the sea, where, along with material derived from the land by the action of the waves on the coast, they form *sedimentary rocks*. These are usually hardened into conglomerate, sandstone, shale, and limestone, but they may remain unconsolidated and still be called "rocks" by the geologist, though popularly known as gravel, sand, and clay.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried, consolidated, and raised again above the surface of the water. In these processes, through the agencies of pressure, movement, and chemical action, they are often greatly altered, and in this condition they are called *metamorphic rocks*.

Igneous rocks.—These are rocks which have cooled and consolidated from a liquid state. As has been explained, sedimentary rocks were deposited on the original igneous rocks. Through the igneous and sedimentary rocks of all ages molten material has from time to time been forced upward to or near the surface, and there consolidated. When the channels or vents into which this molten material is forced do not reach the surface, it either consolidates in cracks or fissures crossing the bedding planes, thus forming dikes, or else spreads out between the strata in large bodies, called sills or laccoliths. Such rocks are called *intrusive*. Within their rock enclosures they cool slowly, and hence are generally of crystalline texture. When the channels reach the surface the lavas often flow out and build up volcanoes. These lavas cool rapidly in the air, acquiring a glassy or, more often, a partially crystalline condition. They are usually more or less porous. The igneous rocks thus formed upon the surface are called *extrusive*. Explosive action often accompanies volcanic eruptions, causing ejections of dust or ash and larger fragments. These materials when consolidated constitute breccias, agglomerates, and tuffs. The ash when carried into lakes or seas may become stratified, so as to have the structure of sedimentary rocks.

The age of an igneous rock is often difficult or impossible to determine. When it cuts across a sedimentary rock, it is younger than that rock, and when a sedimentary rock is deposited over it, the igneous rock is the older.

Under the influence of dynamic and chemical forces an igneous rock may be metamorphosed. The alteration may involve only a rearrangement of its minute particles or it may be accompanied by a change in chemical and mineralogic composition. Further, the structure of the rock may be changed by the development of planes of division, so that it splits in one direction more easily than in others. Thus a granite may pass into a gneiss, and from that into a mica-schist.

Sedimentary rocks.—These comprise all rocks which have been deposited under water, whether in sea, lake, or stream. They form a very large part of the dry land.

When the materials of which sedimentary rocks are composed are carried as solid particles by water and deposited as gravel, sand, or mud, the deposit is called a mechanical sediment. These may become hardened into conglomerate, sandstone, or shale. When the material is carried in solution by the water and is deposited without the aid of life, it is called a chemical sediment; if deposited with the aid of life, it is called an organic sediment. The more important rocks formed from chemical and organic deposits are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the above sedimentary deposits may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in successive layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks over wide expanses, and as it rises or subsides the shore-lines of the ocean are changed: areas of deposition may rise above the water and become land areas, and land areas may sink below the water and become areas of deposition. If North America were gradually to sink a thousand feet the sea would flow over the Atlantic coast and the Mississippi and Ohio valleys from the Gulf of Mexico to the Great Lakes; the Appalachian Mountains would become an archipelago, and the ocean's shore would traverse Wisconsin, Iowa, and Kansas, and extend thence to Texas. More extensive changes than this have repeatedly occurred in the past.

The character of the original sediments may be changed by chemical and dynamic action so as to produce metamorphic rocks. In the metamorphism of a sedimentary rock, just as in the metamorphism of an igneous rock, the substances of which it is composed may enter into new combinations, or new substances may be added. When these processes are complete the sedimentary rock becomes crystalline. Such changes transform sandstone to quartzite, limestone to marble, and modify other rocks according to their composition. A system of parallel division planes is often produced, which may cross the original beds or strata at any angle. Rocks divided by such planes are called slates or schists.

Rocks of any period of the earth's history may be more or less altered, but the younger formations have generally escaped marked metamorphism, and the oldest sediments known, though generally the most altered, in some localities remain essentially unchanged.

Surficial rocks.—These embrace the soils, clays, sands, gravels, and bowlders that cover the surface, whether derived from the breaking up or disintegration of the underlying rocks by atmospheric agencies or from glacial action. Surficial rocks that are due to disintegration are produced chiefly by the action of air, water, frost, animals, and plants. They consist mainly of the least soluble parts of the rocks, which remain after the more soluble parts have been leached out, and hence are known as residual products. Soils and subsoils are the most important. Residual accumulations are often washed or blown into valleys or other depressions, where they lodge and form deposits that grade into the sedimentary class. Surficial rocks that are due to glacial action are formed of the products of disintegration, together with bowlders and fragments of rock rubbed from the surface and ground together. These are spread irregularly over the territory occupied by the ice, and form a mixture of clay, pebbles, and bowlders which is known as till. It may occur as a sheet or be bunched into hills and ridges, forming moraines, drumlins, and other special forms. Much of this mixed material was washed away from the ice, assorted by water, and redeposited as beds or trains of sand and clay, thus forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as osars, or eskers, and kames. The material deposited by the ice is called glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice deposit.

AGES OF ROCKS.

Rocks are further distinguished according to their relative ages, for they were not formed all at one time, but from age to age in the earth's history. Classification by age is independent of origin; igneous, sedimentary, and surficial rocks may be of the same age.

When the predominant material of a rock mass is essentially the same, and it is bounded by rocks of different materials, it is convenient to call the mass throughout its extent a *formation*, and such a formation is the unit of geologic mapping.

Several formations considered together are designated a *system*. The time taken for the deposition of a formation is called an *epoch*, and the time taken for that of a system, or some larger fraction of a system, a *period*. The rocks are mapped by formations, and the formations are classified into systems. The rocks composing a system and the time taken for its deposition are given the same name, as, for instance, Cambrian system, Cambrian period.

As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be discovered by observing their relative positions. This relationship holds except in regions of intense disturbance; sometimes in such regions the disturbance of the beds has been so great that their position is reversed, and it is often difficult to determine the relative ages of the beds from their positions; then *fossils*, or the remains of plants and animals, are guides to show which of two or more formations is the oldest.

Strata often contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas or were buried in surficial deposits on the land. Rocks that contain the remains of life are called fossiliferous. By studying these remains, or fossils, it has been found that the species of each period of the earth's history have to a great extent differed from those of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are characteristic types, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present.

When two formations are remote one from the other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first.

Fossil remains found in the rocks of different areas, provinces, and continents, afford the most important means for combining local histories into a general earth history.

Colors and patterns.—To show the relative ages of strata, the history of the sedimentary rocks is divided into periods. The names of the periods in proper order (from new to old), with the color or colors and symbol assigned to each, are given in the table in the next column. The names of certain subdivisions of the periods, frequently used in geologic writings, are bracketed against the appropriate period name.

To distinguish the sedimentary formations of any one period from those of another the patterns for the formations of each period are printed in the appropriate period-color, with the exception of the first (Pleistocene) and the last (Archean). The formations of any one period, excepting the Pleistocene and the Archean, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the period-color are used: a pale tint (the underprint) is printed evenly over the whole surface representing the period; a dark tint (the overprint) brings out the different patterns representing formations.

PERIOD.	SYMBOL.	COLOR.
Pleistocene	P	Any colors.
Neocene { Pliocene / Miocene }	N	Buffs.
Eocene (including Oligocene)	E	Olive-browns.
Cretaceous	K	Olive-greens.
Juratrias { Jurassic / Triassic }	J	Blue-greens.
Carboniferous (including Permian) . .	C	Blues.
Devonian	D	Blue-purples.
Silurian (including Ordovician)	S	Red-purples.
Cambrian	Є	Pinks.
Algonkian	A	Orange-browns.
Archean	AR	Any colors.

Each formation is furthermore given a letter-symbol of the period. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period to which the formation is supposed to belong, the letter-symbol of the period being omitted.

The number and extent of surficial formations of the Pleistocene render them so important that, to distinguish them from those of other periods and from the igneous rocks, patterns of dots and circles, printed in any colors, are used.

The origin of the Archean rocks is not fully settled. Many of them are certainly igneous. Whether sedimentary rocks are also included is not determined. The Archean rocks, and all metamorphic rocks of unknown origin, of whatever age, are represented on the maps by patterns consisting of short dashes irregularly placed. These are printed in any color, and may be darker or lighter than the background. If the rock is a schist the dashes or hachures may be arranged in wavy parallel lines. If the rock is known to be of sedimentary origin the hachure patterns may be combined with the parallel-line patterns of sedimentary formations. If the metamorphic rock is recognized as having been originally igneous, the hachures may be combined with the igneous pattern.

Known igneous formations are represented by patterns of triangles or rhombs printed in any brilliant color. If the formation is of known age the letter-symbol of the formation is preceded by the capital letter-symbol of the proper period. If the age of the formation is unknown the letter-symbol consists of small letters which suggest the name of the rocks.

THE VARIOUS GEOLOGIC SHEETS.

Historical geology sheet.—This sheet shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any particular colored pattern and its letter-symbol on the map the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any given formation, its name should be sought in the legend and its color and pattern noted, when the areas on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. In it the symbols and names are arranged, in columnar form, according to the origin of the formations—surficial, sedimentary, and igneous—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology sheet.—This sheet represents the distribution of useful minerals, the occurrence of artesian water, or other facts of economic interest, showing their relations to the features of topography and to the geologic formations. All the formations which appear on the historical geology sheet are shown on this sheet by fainter color-patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A symbol for mines is introduced at each occurrence, accompanied by the name of the principal mineral mined or of the stone quarried.

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface. In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits those relations is called a *section*, and the same name is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of the formation of rocks, and having traced out the relations among beds on the surface, he can infer their relative positions after they pass beneath the surface, draw sections which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

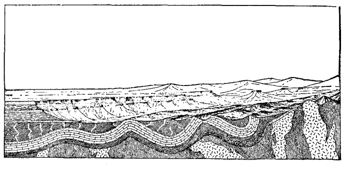


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane that cuts a section so as to show the underground relations of the rocks.

The kinds of rock are indicated in the section by appropriate symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock:

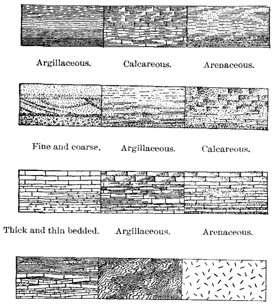


Fig. 3.—Symbols used to represent different kinds of rock.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section.

The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to beds of sandstone that rise to the surface. The upturned edges of these beds form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shales.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred.

When strata which are thus inclined are traced underground in mining, or by inference, it is frequently observed that they form troughs or arches, such as the section shows. But these sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets. That they are now bent and folded is regarded as proof that forces exist which have from time to time caused the earth's surface to wrinkle along certain zones.

On the right of the sketch the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

In fig. 2 there are three sets of formations, distinguished by their underground relations. The first of these, seen at the left of the section, is the set of sandstones and shales, which lie in a horizontal position. These sedimentary strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has swelled upward from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata which form arches and troughs. These strata were once continuous, but the crests of the arches have been removed by degradation. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger strata thus rest upon an eroded surface of older strata the relation between the two is an *unconformable* one, and their surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were plicated by pressure and traversed by eruptions of molten rock. But this pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that an interval of considerable duration elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered metamorphism; they were the scene of eruptive activity; and they were deeply eroded. The contact between the second and third sets, marking a time interval between two periods of rock formation, is another unconformity.

The section and landscape in fig. 2 are ideal, but they illustrate relations which actually occur. The sections in the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profiles of the surface in the section correspond to the actual slopes of the ground along the section line, and the depth of any mineral-producing or water-bearing stratum which appears in the section may be measured from the surface by using the scale of the map.

Columnar-section sheet.—This sheet contains a concise description of the rock formations which occur in the quadrangle. The diagrams and verbal statements form a summary of the facts relating to the character of the rocks, to the thicknesses of the formations, and to the order of accumulation of successive deposits.

The rocks are described under the corresponding heading, and their characters are indicated in the columnar diagrams by appropriate symbols. The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest measurements. The average thickness of each formation is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement: the oldest formation is placed at the bottom of the column, the youngest at the top, and igneous rocks or other formations, when present, are indicated in their proper relations.

The formations are combined into systems which correspond with the periods of geologic history. Thus the ages of the rocks are shown, and also the total thickness of each system.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition of sediments may be indicated graphically or by the word "unconformity," printed in the columnar section.

Each formation shown in the columnar section is accompanied by its name, a description of its character, and its letter-symbol as used in the maps and their legends.

CHARLES D. WALCOTT,
Director.

Revised June, 1897.

DESCRIPTION OF THE COOS BAY QUADRANGLE.

By J. S. Diller.

TOPOGRAPHY.

TOPOGRAPHY OF THE PACIFIC COAST.

Mountain ranges and great valleys of the Pacific coast.

The portion of the United States bordering the Pacific Ocean is mountainous, containing three ranges, the Coast, Cascade, and Sierra Nevada. In California the Coast and the inlying range are separated by the Great Valley; farther north, by the valleys of the Willamette and Puget Sound. Between the heads of these great valleys is a complex group of uplands, the Klamath Mountains, in which the three ranges appear to join, and it is only upon geological grounds that their limits can be determined.

The Cascade Range is composed almost wholly of volcanic material and is thus distinguished from the Sierra Nevada, which is composed largely of metamorphosed sediments and old eruptives. Mount Shasta is usually regarded as the southern end of the Cascade Range, but in reality the range extends about 75 miles farther southeast and ends a short distance beyond Lassen Peak, which fills a depression between the northern end of the Sierra Nevada and the Coast Range.

Klamath Mountains.

The Klamath Mountains, although composed largely of old rocks like those of the Sierra Nevada, belong to the Coast Range. They extend from the western base of Mount Shasta to the ocean, and from near the fortieth parallel in California to the forty-third in Oregon, embracing the Salmon, Trinity, Scott, Siskiyou, and Rogue River mountains, and many other ridges and peaks known by local names only. Although a unit geologically, the Klamath Mountain mass appears to have many distinct parts, owing to the cross drainage of the Klamath and Rogue rivers, as well as that of the Trinity and Sacramento. North of the Klamath Mountains the Coast Range of Oregon lies between the Great Valley and the coast.

TOPOGRAPHY OF THE COOS BAY QUADRANGLE.

Location and area.—For convenience, the four-sided tract of country represented by any of the maps of the Geologic Atlas of the United States, is called a quadrangle. The Coos Bay quadrangle lies at the northern edge of the Klamath Mountains, between parallels 43° and 43° 30′ north latitude and meridian 124° west longitude and the Pacific Ocean, among the foothills at the western base of the Coast Range of Oregon. It embraces about 640 square miles.

Flat-topped hills, terraced slopes, and broad valleys.

General features.—A general view of the country from one of its elevations shows it to be a dissected platform in which the flat-topped hills are the remnants of what were originally more extensive plains. The streams have cut into the plain so extensively that from the valleys the country seems hilly. The hilltops, although flat, are rarely broad, and the slopes toward the valleys are steep. In some cases they are well terraced. The valleys of the principal streamways are wide and characterized by comparatively broad flood plains. The flat-topped hills, terraced slopes, and broad alluvial plains are all features which will be readily understood as results of geologic processes now at work when we consider the later stages of the geological history of the region.

Drainage.—The northern half of the quadrangle is drained by the Coos River and the southern half by the Coquille. Both of these streams have cut deep canyons in the Coast Range and take the water from its eastern crest. Crooked courses constitute one of the most striking features of the principal and subordinate streams. There seems to be no agreement in the stream courses except in meandering. The North Fork of the Coquille, rising only a few miles from the South Fork of the Coos and scarcely more than 25 miles from the ocean, flows south for over 25 miles to near Myrtle Point, where it joins the South Fork of the Coquille and turns seaward, having yet over 30 miles to travel to its mouth.

Valley of Coos River.

The Coos River Valley is remarkable for its fertile plains, which rise in places 15 feet above low-tide level and are devoted largely to dairying, the traffic for which is wholly by small steamers on the river. The tide ascends the South Fork to a point about a mile beyond the eastern limit of the quadrangle and ascends the North Fork or Millicoma River nearly to the junction of the East and West forks. The continuous flood plains do not extend upstream beyond the tide limit, to which point the river is navigable. Above this point the stream is shallow and flows in a rocky or pebbly bed in a narrow valley, presenting a strong contrast with its lower course. In both cases, however, the sides of the valley are steep and occasionally terraced. The course of the river is in places deeply curved, and this is due not to the swinging of the river in its present flood plain but to some earlier condition, which may appear in considering the origin of the topographic features of the region. In the southwest part of T. 25 S., R. 12 W., the character of the drainage changes and the river enters Coos Bay, which differs from the river especially in the greater extent of its tidal flats and in having tidal branches or sloughs. The bay itself may be considered in two parts, one extending southeast from North Bend, the other extending southwest. Of these the southeastern has the greater expanse of tidal flats and several sloughs; the other arm has but a small margin of tidal flats and one slough. This difference is due chiefly to the mode of development, the one arm of the bay being very much older than the other.

The Coquille River is ascended by the tide nearly to Myrtle Point, a distance of about 34 miles from the mouth, although only 15 miles in a direct line from the ocean. In the Coos River the tide ascends about 30 miles by the river and reaches a point 17 miles in a direct line from the beach. This difference between the two rivers is due to the greater crookedness in the course of the Coquille. In all its meanderings the Coquille follows the general course of the valley, except, notably, between Norway and the mouth of Glen Aiken Creek, where the river wanders in its own flood plain. Another excepted stretch occurs on the South Fork 4 miles south of Myrtle Point.

Valley of Coquille River.

From Riverton to the mouth of the Coquille the river is bordered most of the way by arable flood plains from one-fourth to nearly one-half mile wide. They are rarely swampy and are generally cultivated. Between Riverton and Norway these flood plains expand to a mile or a mile and a half in width. They are largely marshy and are covered with a dense growth of small trees and vines. Some of these marshes have been cleared and cultivated. Most of the remainder could be made valuable in the same manner, so as greatly to increase the productive agricultural land of the region. The Coquille is navigable for small steamers to the head of tide water. A short distance above that point the river becomes shallow, full of pebbly rapids, and occasionally rocky. The flood plains extend 5 miles up the river beyond the present limit of high tide, and mark a point to which the tide once ascended.

Relief.—As the streams are irregular in their courses, so the hills, which are carved out by them, are irregular in outline. The rainfall is heavy and the rocks are generally so soft that erosion would proceed rapidly but for the protective influence of the dense vegetation, which breaks the dash of the rain.

The highest point in the quadrangle is between the forks of Coos River, where the elevation reaches 1700 feet. The next highest point is on Sugarloaf Ridge, directly east of Myrtle Point. The most prominent upland in the quadrangle, on account of its mass, and the only one commonly called a mountain in that region, is Blue Mountain, which for nearly 3 miles has an elevation of 1500 feet. Near the southern border of the quadrangle is Bill Peak, rising to over 1500 feet within 8 miles of the coast. The tops of the highest hills and the crests of the highest ridges are generally somewhat flat, although rather narrow, and the slopes are usually steep. The arrangement of the hills is digitate and they closely approximate a general altitude, but this feature is much more prominent at an elevation of from 500 to 700 feet in the region between Coos Bay and the Coquille, where there is a broad tableland incised by various sloughs.

Elevated sea beaches.

This is the region, too, of elevated terraces or elevated beaches. They are well displayed about the mouth of Coos Bay and the hill of Seven Devils, especially upon its seaward slope. The first terrace, about 60 feet above the present sea level, is well displayed between Yokam Point and Cape Arago. The slope of the hill north of Cape Arago is like a giant staircase. The sea cliff, at the foot of which the present beach now lies, is at that point about 30 feet in height, and is capped by a terrace at least 200 yards in width. At its eastern limit rises a steep slope, an ancient sea cliff, which is capped by a second terrace, and so upward a succession of steps and terraces of ancient beaches extend to the top of the hill. Above 800 feet elevation the beaches are less distinct, although they may be detected about the summits of the highest peaks near the sea. On the southwest side of Bill Peak, at an altitude of about 1500 feet, a terrace is cut in the fissured sandstone of the peak. That this terrace is an ancient beach is shown by the presence of occasional pebbles and cobblestones upon its surface. Upon the eastern side of Seven Devils Hill, terraces are well developed, but are somewhat broader. Terraces may be seen also at points on the road from South Slough to Bandon.

Coastal plain.

A well-marked coastal plain, 2½ to 4 miles in width, borders the coast south of Fivemile Creek. Generally it terminates along the sea in a cliff, whereas to the landward it rises by occasional terraces (old sea beaches) to an altitude of several hundred feet before abutting against the low hills. The black auriferous sand, which has attracted so much attention along the Oregon coast, is found locally not only along the present beach but also along the elevated beaches.

The Seven Devils.

An old trail to the Randolph mines at the mouth of Whiskey Run followed the coast south from the mouth of Coos Bay. Travel to Cape Arago was easy on the first broad terrace of the elevated beaches, but below that point for 2 miles the coast is cut by numerous deep ravines on a steep slope, and the sea dashes against the high cliffs. The name of this rugged feature, the Seven Devils, arose from the difficulties it imposed upon the early traveler.

Dunes and sand spits.

From Coos Bay northward the coast is bordered by a waste of drifting sand, in places over 2 miles in width, which is thrown by the waves upon the beach and carried inland by the winds. The irregular hills, ridges, and dunes of sand usually have their largest diameters approximately parallel to the coast and frequently inclose lakes, like those west of North Slough, which appear to have no outlet to the sea save through the barrier of sand. A similar sand area, but one of much smaller size, extends north from the mouth of the Coquille for about 4 miles, with a maximum width of nearly a mile. The landward portion of this area, as well as some of that north of the Coos, is well covered with timber, showing that it assumed its present form long ago. Another sand stretch occurs along the coast near the mouth of Fourmile Creek, shutting in Davidson Lake.

Rock stacks.

Tupper Rock is an excellent example of a conspicuous rocky, stack-shaped ledge rising out of a level plain. It is composed of hard rocks and withstood the force of the erosive agents which carved away the softer surrounding rocks. Other rock stacks, somewhat less conspicuous, occur in the northern part of sec. 20, T. 28 S., R. 14 W., and on the western line of sec. 7, T. 29 S., R. 14 W. More pronounced examples occur farther south along the coast.

GEOLOGY.

The geological maps of this folio exhibit the distribution of eleven formations, of which nine are sedimentary and two igneous. In the legend the formations are arranged in the order of geological age, with the oldest at the base. The sedimentary rocks, beginning with the oldest, will be considered first, and then the igneous rocks.

SEDIMENTARY ROCKS.

CRETACEOUS PERIOD.

Chert.—The chert of this quadrangle, which is doubtfully assigned to the Cretaceous period, is compact, hard, and highly siliceous. It closely resembles some forms of flint and jasper, and has a wide range of color—from white and gray to yellow, green, and red. There are eleven outcrops of this rock which are shown on the map, some of them too small to be represented without exaggeration. They all lie in the southern portion of the quadrangle.

Radiolarian remains in the chert.

One of the most accessible areas is on Indian Creek, where the red and gray cherts are exposed. Although full of minute veins of quartz, the red chert contains a multitude of small round specks that clearly represent organisms, radiolaria, which lived in the water at the time the deposit was formed. Some of the ledges in this area are clearly but irregularly banded.

The small area in the NE. ¼ of sec. 3, T. 30 S., R. 12 W., contains dull-red chert in which the fossils are well preserved. To the naked eye the largest of these forms are scarcely visible, but with the aid of a small lens they appear as minute white spots, and when magnified in thin section their organic nature is evident. Similar areas of the rock occur in the neighborhood of Bill Peak, and in some of them the organic nature is evident, but in others the alteration is so great that the structure is obscured. A small area occurs at the China Creek bridge, and one also in the cliff west of Tupper Rock, too small to appear on the map. The material is reddish brown, veined with quartz and calcite, and contains numerous radiolaria.

Origin of the chert containing radiolaria.

The chert occurs only in small masses, showing that the conditions under which it formed must have been local and not general. The character of the contained fossils indicates that one of the peculiarities of the local conditions must have been the abundance of siliceous organisms. On Johnson Creek, in the Port Orford quadrangle, chert full of radiolarian remains is interstratified with fine sandstone composed almost wholly of volcanic material. The minute forms associated with volcanic deposits, both in lakes and in the sea, are most frequently highly siliceous. Among the lacustrine deposits of the great volcanic region of northern California and Oregon, diatomaceous earth composed almost wholly of silica is not uncommon. The marine equivalent of such deposits appears to be radiolarian chert.

Age of the chert.

Radiolaria are of little value in determining closely the geological age of the strata containing them. No other fossils are associated with them. As the sandstones and shales with which the chert appears to be interstratified are known in the Port Orford quadrangle to be of Cretaceous age, it is reasonable to regard a part of the chert as of the same age. In other cases, however, it is equally evident that the chert is of greater antiquity, for well-rounded pebbles of chert in which the radiolaria are distinct occur in the basal conglomerate of the Cretaceous.

Myrtle formation.—The Myrtle formation received its name from Myrtle Creek, Douglas County, in the Roseburg quadrangle, where it is well exposed and characterized by definite fossils. In the Coos Bay quadrangle the exposures, although much larger than those of the radiolarian chert, are not of great extent. The area south of Myrtle Point, which is the largest, occupies scarcely 6 square miles.

The most prominent rock in this formation is gray sandstone, moderately hard and in general so greatly fissured as to break into small pieces. It has evidently been much affected by pressure, for it is so crushed as to obliterate the bedding. It is frequently schistose, and within the quadrangle the attitude of bedding can rarely be determined. Fine conglomerates and shales also occur. The sandstone is well exposed in a ledge near the forks of the river in the southern part of sec. 22, T. 29 S., R. 12 W., and also at a few places by the river road around the hill of diabase in sec. 26. It is well exposed also near the southeast corner of sec. 28 in the same township, where it contains some fine conglomerate. Farther south thin beds of shale and sandstone are interstratified.

There is another small area, embracing about 3 square miles, southeast of Bill Peak. The peak itself is composed of much-fissured sandstone.

Age of the Myrtle formation.

As to the age of this formation no conclusive evidence has been found. That it is older than the relatively soft, yellowish, unaltered fossiliferous sandstone appears to be evident, although the contact has not been found within the quadrangle. In the Port Orford quadrangle, which lies next southward, rocks which appear to belong to the same formation as those under consideration contain *Aucella piochii*, which is a characteristic Cretaceous fossil.

Amphibole-schist.—Under this head are included certain crystalline rocks which are closely related in structure, mode of occurrence, and origin, although they differ widely in composition and general appearance. Their outcrops are usually prominent, standing out in conspicuous ledges, of which Tupper Rock, near Bandon, is one of the best examples.

Distribution of amphibole-schist.

Like the radiolarian chert, the schists have small outcrops and are confined to the southern third of the quadrangle. The largest area is scarcely 50 acres in extent, and the smallest contains less than that number of square feet. Toward the southeast corner of the quadrangle there are at least fourteen outcrops, and in the southwest corner an equal number, some of which are well exposed along the beach.

The most important varieties of these crystalline rocks found in the Coos Bay quadrangle are amphibolite, amphibole-schist, mica-schist, and chlorite-schist.

Amphibolite and amphibole-schist are characterized by an abundance of amphibole, which may be either blue or green. When the schistose structure is evident the rock is amphibole-schist; otherwise it is amphibolite. Amphibole-schist is more abundant, although amphibolite usually forms the larger exposures. There is no sharp distinction between them and they frequently occur in the same outcrop, as, for example, Tupper Rock. In portions of the mass the rock splits readily in one direction and is amphibole-schist, but in other parts it is amphibolite. 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 schist may be appropriately called *glaucophane-schist.*

Glaucophane-schist.

Besides glaucophane, the blue schists frequently contain other minerals, among which epidote, garnet, muscovite, zoisite, and albite are most common and important. Epidote that is usually of a faint yellowish color may be scattered rather regularly through the whole mass or arranged in bands alternating with the blue amphibole, producing epidote-glaucophane-schist. A finely crumpled epidote-glaucophane-schist occurs on Johnson Creek 3 miles southeast of Bandon, where it contains small quantities of other minerals also.

Garnets are rarely conspicuous. In some outcrops there are well-defined crystals, but more frequently the garnet appears as round, reddish to purplish grains. The so-called black sand, which in some places contains considerable gold is composed largely of garnets derived from these rocks. One of the best garnet localities in the Coos Bay quadrangle is in the small area one mile northeast of Bandon, but even there they are not abundant.

Muscovite-mica is a common constituent of the glaucophane-schists and sometimes becomes so abundant that the rock passes into regular mica-schist. Zoisite, although somewhat widely distributed, is rarely abundant, but feldspar, which is generally if not always albite, becomes important in places and forms many small veins. With quartz it occasionally forms light-colored bands alternating with those of glaucophane. The best observed examples of albite veins occur with greenish amphibole-schist near Crooked Creek, about 3¼ miles directly south of Bandon, while the alternating bands of albite and glaucophane occur near Mr. Peter Axes's, on Big Creek, just east of the quadrangle. Many of the amphibolites and amphibole-schists are characterized by green amphibole, which is almost as abundant as the blue. The blue and green amphiboles are generally not intermingled in the same rock. They appear to be in a measure mutually exclusive, and yet they occur abundantly in adjacent masses and are closely related in origin. One of the best examples of green amphibole-schist occurs about 3⅓ miles south of Myrtle Point, where the fibrous green amphibole is prominent and forms practically the whole mass. Another occurs 1 mile southeast of Bill Peak, where the green rock is an amphibolite rather than a schist.

Green amphibole-schist.

With the green amphibole is commonly found considerable chlorite, and it may become so abundant as to form the principal portion of the rock. As it contains alumina, one would expect it to be associated with glaucophone, but its most common association is with green amphibole, which is not aluminous. A fine example of chlorite-amphibole-schist occurs near the road up Big Creek three-fourths of a mile above Bridge. Chlorite occurs also in the greenish schist one mile northeast of Gravelford and on the spur above Weaklys, near the mouth of Elk Creek.

A green schist in which chlorite is so abundant as to become one of the most important constituents, occurs 4 miles southeast of Myrtle Point. Chlorite in small green scales is most conspicuous. The mass is penetrated by many bluish-green blade-like crystals of amphibole, and in thin section numerous small crystals of sphene may be seen. A short distance west of Tupper Rock, on the beach, is a chlorite-schist containing much muscovite and considerable quartz.

Quartzite containing amphibole.

An exceptional form of rock which may be considered in this place occurs at Bandon, on the mud flat near the mouth of Fairy Creek. It is composed chiefly of moderately fine granular quartz, penetrated by a multitude of acicular and hair-like crystals of a blue and green pleochroic mineral that appears to be amphibole, so that the rock may be considered quartzite containing amphibole, or, more likely, a form of chert.

Origin of the schists.

The sporadic distribution of the amphibole and associated schists shows that their origin is not due to regional metamorphism, but is to be ascribed rather to some form of local metamorphism. Their intimate association with igneous rocks on the one hand and with sedimentary rocks on the other points emphatically to some form of contact metamorphism as their source. Further than this the evidence is less specific. The parent rock from which they were derived and the peculiar conditions under which the changes were effected are not clearly understood, although in a few cases there are suggestions as to the course of events. The associated sedimentary rocks of the Myrtle formation are not infrequently much affected by pressure, and shearing has rendered them fissile, but in such cases they clearly retain their fragmentary character, and among the new minerals formed no trace of blue amphibole was observed within the quadrangle. This is surprising when we remember that in the neighborhood of San Francisco blue amphibole occurs not only in slightly altered sandstones but also in rocks exhibiting intermediate stages of metamorphism and, finally, in those showing complete alteration to amphibole-schist. The apparent absence of a transition phase in the Coos Bay quadrangle is due possibly to lack of contact exposures. The only sedimentary rock of that region containing a suggestion of its alteration to amphibole-schist by the intruded rock is the chert, and in this case the evidence furnished by the small ledge on the flat near the mouth of Fairy Creek at Bandon is very meager.

On the other hand, the contemporaneous or subsequent changes which occurred within the intruded masses are more clearly in the direction of producing the peculiar amphibole-schists. It is evident that the wide range in mineral composition of the metamorphic rocks must indicate either their derivation from rocks differing widely in chemical composition or else a mode of alteration that permits the transfer of much chemical matter.

Interval between Myrtle and Pulaski formations.—There was a long interval between the completion of the Myrtle formation and the beginning of Eocene deposition in the Pulaski formation. This interval is represented in other parts of Oregon and California by 5000 feet or more of marine sediments, known to geologists as the Chico formation. The absence of the Chico from the Coos Bay region indicates that some time after the Myrtle formation was laid down the Coos Bay region was raised above the sea and exposed to extensive erosion, but it again subsided beneath the ocean to receive the deposits of the Arago formation.

Late Cretaceous erosion.

The topmost portion of the Myrtle formation was removed during this epoch of erosion, and possibly also strata equivalent to a part of the Chico formation of California, for the beds now exposed in the Coos Bay quadrangle are those which should immediately underlie the Chico. Study of the structure of the region demonstrates that much has been washed away.

Within the interval between the Myrtle and the Arago epochs, probably in connection with the uplifting of the region, the molten igneous masses of older basalt and perhaps also of saxonite were intruded from below into and through the Myrtle formation. Along portions of their contacts with the sedimentary rocks the peculiar metamorphic rocks already described were in some way developed.

EOCENE PERIOD.

The rocks of the Eocene period in this region have been called the Arago formation, but in this quadrangle they are grouped into two formations: the Pulaski and the Coaledo. These formations occupy almost the whole of the Coos Bay region. They are composed generally of sandstones and shales, which are especially well exposed near the mouth of Coos Bay and at Cape Arago, where they contain *Cardita planicosta* and numerous other characteristic Eocene fossils. Heavy-bedded sandstones prevail in the eastern part of the area, toward the Coast Range, where the Eocene rocks have a wide distribution, and shales become abundantly interstratified with the sandstones in the western part near the coast. In the eastern part of the quadrangle the sandstones are penetrated and separated by dark, heavy intrusions of igneous rock, basalt, and the overlying sandstone nearby generally contains much sediment derived from it.

The strata among which the coal beds are found contain at a number of places the fossils which characterize the Arago formation, and it is therefore evident that the coal-bearing strata are of the same age as that formation and form part of it. 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 they are well exposed in the vicinity of Coaledo. The other portion of the Arago formation, which is older and lies beneath the Coaledo formation, will be designated the Pulaski, because it forms the hills about the head of Pulaski Creek and makes the Pulaski arch, which separates the Beaver Slough and the Coquille coal basins. The distribution of both the Pulaski and Coaledo formations is shown upon the Historical Geology sheet. Their combined area is that of the Arago formation.

Pulaski formation.—The Pulaski formation embraces all the Eocene strata of the Coos Bay quadrangle not included in the coal field. In the northern portion of the quadrangle, along the forks of the Coos River near the junction, are massive sandstones which have been quarried for building jetties. Toward the south the sandstones are less massive and locally shales become extensive, but the prevailing rock nearly everywhere within the area occupied by the Pulaski formation is rather soft, yellowish sandstone, contrasting strongly with the sandstone of the Myrtle formation in its color and freedom from the multitude of cracks which traverse the latter. Along the coast the beds of Pulaski sandstone are thinner and more frequently interstratified with thin beds of shale.

Limestone composed of microscopic fossils indicating marine conditions.

Traces of limestone have been found at a number of places within the Coos Bay quadrangle, but the masses are too small to be indicated upon the map. They are of scarcely any economic importance. On the East Fork of Kentuck Slough, in sec. 3, T. 25 S., R. 12 W., several bowlders of limestone were observed. The rock is composed almost wholly of microscopic fossils of many varieties. On Denton Creek in sec. 13, T. 25 S., R. 12 W., and also in sec. 27, T. 25 S., R. 12 W., one-fourth mile southwest of the forks of Coos River, there are similar rocks full of minute fossils, which, according to Dr. G. H. Girty, are calcareous algæ and foraminifera of marine origin. On Daniels Creek, near its mouth, concretions of limestone occur in Pulaski shales. No traces of fossils have been found at that point. The nodules are so abundant that some years ago they were burned to furnish the lime used in constructing a neighboring building. All of the outcrops of limestone are close to the diabase and in some cases contain lapilli, suggesting that the eruption of the igneous material was submarine.

At the close of the long interval of erosion following the deposition of the Myrtle formation the Pulaski epoch was initiated by a subsidence which brought in the sea from the northwest over the land, and the Coos Bay quadrangle and the adjacent region was completely submerged beneath the ocean. The shore from which the sediments were then derived lay only a short distance away to the south. The tilted strata of the Myrtle formation then formed the sea bottom in the Coos Bay region, and the Pulaski beds were laid down unconformably upon their upturned edges.

Volcanic tuff interbedded with the sediments.

During the earlier portion of the Pulaski epoch there were but slight changes in the relative elevation of the land and sea, and they had but little effect upon the character of the material deposited, but near the end of that epoch there occurred in the eastern portion of the quadrangle eruptions of large masses of basalt. The eruptions were in some measure explosive, for fragmental volcanic material was thrown out and formed tuff beds near the border of the igneous rocks. The amount of this fragmental material is insignificant when compared with that of the sandstones of the Pulaski formation.

During the Pulaski epoch there were doubtless many slight oscillations of the land and the sea floor, but the sea appears to have almost entirely covered the quadrangle throughout the whole of the epoch, for the fossils found are everywhere purely marine except at a place a few miles south of Myrtle Point, where some brackish and fresh-water shells have been discovered. After the volcanic eruptions, however, changes of sea level became frequent and led to the development of the Coaledo beds.

Fresh- and brackish-water fossils associated with coal beds.

Coaledo formation.—The Coaledo formation, besides bearing coal, is found to have characteristics by which it may be distinguished from the Pulaski formation. One of its especially interesting features is the occurrence of fresh- or brackish-water fossils in immediate connection with the coal, while between the coals, and sometimes close to them, purely marine fossils are occasionally found. The fresh- or brackish-water fossils most frequently occur in the roofs of coal beds, as at Newport, Beaver Hill, and Riverton, but may be found at some distance from the coal in the associated strata. They evidently indicate variations in saltness of the estuary, variations probably due to irregular subsidence accompanied by sedimentation, which now inclosed lagoons of brackish water, and now admitted the sea. When the lagoons were long maintained they became fresh-water marshes in which the peaty vegetation accumulated to form beds of coal.

The Coaledo formation is characterized not only by the presence of coal, but also by the relatively large proportion of beds containing brackish-water fossils, which have been found in rocks outside of the coal field at only a few places, although they are common within it. In the Pulaski formation of the Coos Bay quadrangle mere traces of coal occur, and strata containing brackish-water fossils are rare.

Upon the Historical Geology sheet is shown the area of the coal field, i. e., the region over which the Coaledo formation is exposed. Besides coal the rocks of the Coaledo formation are varied sandstones and shales. In the lower portion sandstones predominate; then comes the portion where the workable coal beds occur, and the associated rocks consist of about equal thicknesses of sandstones and rather dark-colored shales. In the upper portion light-colored shales are most abundant and characteristic, none like them occurring outside of the coal field in the Coos Bay quadrangle. This fine, white shale of the Coaledo formation is well exposed by the roadside at a number of points between Coquille and Marshfield. When examined under a microscope it is found to contain numerous minute flakes of biotite-mica, with much clear, glassy material which looks like volcanic dust. A somewhat similar white shale occurs in the Empire formation on South Slough near the ferry, but under the microscope this is readily distinguished from the white shale of the Coaledo formation by means of the multitude of peculiar minute fossils which the Empire shale contains.

Development and structure of the coal field.—In its early stages of development the surface of the coal field was flat and the strata deposited were nearly level. The swamp in which the vegetation accumulated to form beds of coal extended more or less continuously over the whole field. It bordered upon the sea and was but little above the sea level. When the associated sandstones and shales containing fresh- or brackish-water shells were laid down the field was covered by fresh water or a brackish-water estuary, but when the sediments containing purely marine shells were deposited it was invaded by the open sea.

During the deposition of the Arago formation the whole area receiving such deposits was subsiding irregularly. Slight subsidences alternated with episodes of constant level, and accumulations of sand or shale succeeded those of peaty vegetation. In the coal field the movements were repeated many times, resulting in the alternate deposition of many beds of coal, sandstone, and shale over the same area. They were so slight that the strata were laid upon one another in parallel positions. Later, after the Arago epoch came to a close and when the Coast Range was formed, there came a change. The rocks, originally horizontal, were then compressed laterally and thrown into folds, i. e., into upward and downward flexures. On opposite sides of an upward flexure the strata incline away from each other, forming an anticline or arch, while on opposite sides of a downward flexure the strata incline toward each other, forming a syncline or basin. When such compression continues far enough folds may be pressed close, and the strata may be driven into a vertical position, or beyond the vertical into an overturned attitude. During such folding the rocks are generally broken and may be displaced or faulted along lines of fracture. The Arago formation has been both folded and faulted, but was most affected by the folding. The faulting, so far as known, is of minor importance, and the displacement is small.

Folding of the coal-bearing rocks.

Considering the folds of the coal-bearing rocks—the Coaledo formation—the coal field may be divided into six portions, four basins and two arches, all of which are marked upon the Structure Section sheet. The basins contain the coal; the arches bring to the surface the underlying strata of the Pulaski formation, which are generally without coal beds. The basins are the Newport, the Beaver Slough, the Coquille, and the South Slough. These are separated by the Westport and Pulaski arches. Upon the Structure Section sheet the attitude of the strata upon the surface is indicated by the strike and dip symbol, and beneath the surface by a series of structure sections. The dark color used to represent the lower portion of the Coaledo formation, where coal occurs, makes the coal basins conspicuous, in contrast with the anticlines between them. It is possible, however, that the Westport arch is made up of coal-bearing strata. Upon the west the South Slough Basin appears in sections B–B, C–C, and D–D. The Newport Basin appears in B–B only, and the Coquille in D–D only, while the Beaver Slough Basin appears in all the sections.

Four basins and two arches in the Coaledo beds.

The folding of the strata was doubtless accompanied by the raising of a large tract of sea bottom to make dry land of part if not the whole of the Coast Range of Oregon, and before the beginning of the next epoch (the Empire) the country was subjected to much erosion.

Along the coast for 2 miles east of Coos Bay light-house the Coaledo beds dip eastward at an angle of about 70°, and afford an excellent opportunity to measure their thickness. At a few points heavy sandstones occur, but generally the strata are comparatively thin beds of sandstone and shale. The total thickness of strata measured at this place is over 7000 feet, and there are probably several thousand feet of underlying strata exposed along the coast from the light-house to Cape Arago. Eastward from the light-house there is also a considerable thickness of strata which could not be accurately measured, so that the total thickness of the Arago beds must be at least 10,000 feet. The measured section includes foraminiferal and other shales (2200 feet) and the sandstones of Tunnel Point (850 feet), which are paleontologically distinguished from the Arago formation by Dr. Dall (Eighteenth Ann. Rept., Pt. II, 1898, pp. 340-343). The Tunnel Point sandstones and the foraminiferal shales are conformable with each other and are apparently conformable with the underlying Arago beds, with which they are herein combined on lithologic grounds. As far as known, these upper beds have a very limited distribution and occur only in the middle portion of the South Slough syncline.

Thickness of the Arago formation.

NEOCENE PERIOD.

Empire formation.—The Empire epoch was initiated by the general erosion which followed the uplift at the close of the Arago epoch. A narrow tract about South Slough and along the coast south from Seven Devils, however, was still submerged, and received deposits of sand and silt which contained numerous marine fossils characteristic of the Miocene. Coos Head is composed of massive sandstones belonging to this formation, and northeast of the mouth of South Slough, as far as Pigeon Point, there is a mass of darker, somewhat shaly, and highly fossiliferous sandstone containing concretions.

The Miocene strata upon the opposite sides of South Slough at its mouth incline gently toward each other, as if forming a syncline. In fact, these strata lie in the South Slough Basin, and it is probable that the South Slough syncline continued as an axis of down-folding after the close of the Arago epoch and its terminating upheaval. A white shale lies in the middle of the syncline and rests upon the sandstones and darker shales which form the lower portion of the Empire formation. This whitish shale appears to be closely related in its general appearance and composition to that which occurs at Mist, on the Nehalem River, in Oregon, and to the Monterey shale of California. Upon the bank of South Slough near the ferry the whitish shale contains a multitude of microscopic fossils. Shale of the same sort occurs by the road upon the grade above the west end of South Slough bridge, and the syncline in which these beds are contained evidently rises southward. Similar beds occur on the coast 3 miles south of Bandon. The whitish Miocene shale closely resembles that found in the Coaledo formation associated with the coal, but it may be readily distinguished by the fact that the latter does not contain microscopic fossils. The whole thickness of the Miocene in the Coos Bay region can scarcely be as much as 500 feet.

Miocene white shale similar to the Monterey shale of California.

The Empire formation rests unconformably upon the Arago, which had previously been folded and eroded. The unconformity may be seen on the shore a short distance west of Coos Head.

SURFICIAL ROCKS.

PLEISTOCENE PERIOD.

At the time the Empire beds were laid down along the coast the region of the Coast Range had been reduced by long-continued erosion to a lowland of very gentle relief, from which the fine sediments of the Empire formation were derived. This formation was afterwards bent and in part raised above sea level. In the Coast Range region the uplifting was greater than along the shore, and as the region rose by intervals the ocean cut terraces upon the western slope of the range at each halt, the terraces varying in breadth according to the duration of the pause and the hardness of the rocks covered. Although the movement was generally upward it was occasionally downward, submerging the wave-cut terraces to receive a thick deposit of marine sediments.

Coos conglomerate.—The Pleistocene deposits, which were formed mainly during the epoch of uprising, are almost wholly unconsolidated, but at the east side of the mouth of South Slough there is a conglomerate which is a remarkable exception. It has been named by Dr. Dall (Eighteenth Ann. Rept., Part II, 1898, p. 336) the Coos conglomerate, but is generally known as "Fossil Rock" on account of the large number of conspicuous fossil shells it contains. Some of the shells represent species still living in the adjacent waters, but the larger part were derived by erosion directly from the fossiliferous Empire beds, upon the eroded surface of which the Coos conglomerate rests unconformably. According to Dr. Dall this conglomerate is probably Pleistocene. Its thickness is not over 30 feet and it contains cross-bedding dipping to the southwest. Some of the fossiliferous fragments from the adjacent Empire beds are a foot in diameter. Most of the pebbles are of sandstone, but the small, smooth ones, which appear to have traveled a long distance, are of igneous rocks and chert, like those associated with the Myrtle formation. This Coos conglomerate is completely lithified, so that it is as ancient in appearance as the Miocene and presents a strong contrast to all the unlithified Pleistocene deposits of that region.

A consolidated conglomerate.

The exposed extent of the Coos conglomerate is very limited, covering less than an acre, and is therefore not represented on the map. At one time it had a much more extensive distribution along the coast. Much of it may have been removed by erosion, for after its deposition there was an upward movement of the land which raised it at least 200 feet above its present level and exposed the Coos conglomerate to igneous erosion. It has since been covered by over 20 feet of marine sands and gravels.

Marine sand.—The unconsolidated Pleistocene deposits are almost wholly sand, although local accumulations of pebbles have been observed which look much younger than the Coos conglomerate. The highest deposit of this sort noted is upon the wave-cut terrace about the summit of Bill Peak, at an elevation of 1500 feet. The neighboring hilltops are generally flattish, and many of the slopes, where not abrupt, have a covering of sand ranging in thickness from a few feet to over 100 feet. As would be expected, the thickest deposits are near sea level. At Empire is a prominent bluff, 100 feet in height, of clearly stratified sand of this epoch, and similar deposits occur in South Slough near the bridge. At both of these points the base of the deposit lies below sea level. The sand is white in places, as on the road at the head of Big Creek and also upon a branch of Bill Nye Slough near its mouth.

Pleistocene marine sand 1500 feet above sea level.

The largest mass of this deposit in the Coos Bay quadrangle occurs upon the coastal plain stretching along the coast southward from Seven Devils. This plain becomes a prominent feature south of Threemile Creek. In the vicinity of Bandon it is 4 miles in width, and rises to over 200 feet above sea level along its eastern border, where it terminates in a series of more or less well-defined terraces which mark ancient coast lines. Sections of the Pleistocene sands and gravels of this plain are well exposed in some of the black sand mines and ravines to a depth of nearly 100 feet. This is the only area of "Pleistocene marine sands" represented on the map, partly because it is better defined than any of the other areas, but largely also for the reason that to represent the areas about South Slough and Coos Bay would in a measure obscure the general features of the coal field, which are of much greater importance.

Canyon erosion.—The evidence of uplift after the close of the Empire epoch (Miocene) is found not only in the elevated beaches but also in the canyons carved in the land by the streams. As the land was raised the streams acquired greater slope to the sea, and consequently greater power to carry away sediment and deepen their valleys. The Coos and Coquille rivers and their tributaries then cut deep valleys, with steep slopes that extend far below the level not only of their present flood plains but of the sea. This feature was discovered by borings made near the edge of the flood plains at Newport and Kentuck Slough.

Fig. 1 illustrates the borings made a few years ago by Mr. Campbell while prospecting for coal below the Newport vein near Newport. The boring was started in sandstone at the foot of a steep slope near the edge of the marsh. As reported by Mr. Campbell, it passed through about 20 feet of sandstone and then struck the marsh deposits,

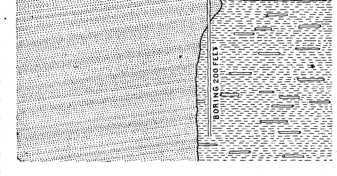


FIG. 1.—Section of bluff and marsh near Newport (Libby) mine, showing buried cliff revealed by boring.

which it penetrated to a depth of 200 feet without reaching solid rock. The deposit contains logs in the mud, which is so soft that the boring could not be kept open and had to be abandoned. The outline of the valley below the surface of the flood plain, as indicated in the figure, must be a cliff.

From evidence which is not displayed in the Coos Bay region but is abundant on the slopes of the Sierra Nevada in California, the epoch of canyon cutting belonged to the earlier portion of the Pleistocene, lately called by Professor Le Conte the Sierran. It preceded the Glacial epoch. The large glaciers, which sculptured more or less deeply the upper valleys of the Cascade Range, the Sierra Nevada, and the Klamath Mountains, did not reach the Coos Bay region, and the streams there continued their activity through the Glacial epoch.

Canyon cutting is of Sierran age.

River terraces.—The rise of the land recorded in the elevated beaches also affected the rivers. Their courses were extended in the valleys which they had carved out during their period of previous elevation. They found the valleys to some extent filled by marine deposits which had accumulated during submergence. This material was worked over by the streams and augmented by the large amount of loose marine sediments spread over the surface during the submergence, which at first overloaded the streams. However, they soon gained control and swept their narrow valleys, leaving only a few terraces here and there in protected places to mark their original gorged condition.

The best-marked terraces of the Coquille are those on which the town of Myrtle Point is situated. They are near the junction of the North and South forks of the Coquille. The river at that place enters a narrow gap through a sandstone ridge. Farther downstream terraces occur in protected places near the mouths of tributaries and rise occasionally to a height of over 200 feet. The higher terraces appear to be cut in sandstone and capped by a comparatively thin layer of sand and gravel.

On the Coos River the river terraces are in general lower. At about 25 feet above sea there is one well developed near the forks of the river, as well as others at many points along the east side of the bay between the mouth of the river and Jordan Point.

Tusk of mastodon in river bank.

Some years ago the Harrison brothers discovered the tusk of a mastodon in the river bank along the North Fork of the Coquille about 1¼ miles east of Myrtle Point. The bone, although not waterworn, was found close to the stream about 5 feet above low water, resting on a terrace of sandstones and shales and covered by a thin layer of alluvium. A fragment of this tusk was examined by F. A. Lucas, of the National Museum, who reports it to contain bands of enamel which are characteristic of a mastodon that lived probably during the Pliocene. If the tusk had not been transported, it would indicate that the canyon may have been cut as early as the Pliocene.

Alluvium.—This formation includes the material deposited by the larger streams along their borders and forming their present flood plains. It is generally fine silt and is deposited by the highest floods. When the plains are sufficiently dry to be arable the soil is found to be very fertile. The fertility is renewed with every flood. The same material is carried by Coos River into the bay and its many slough branches, where it forms mud flats. The tidal motion of the water is so gentle as not to remove it, excepting in the channels, so that the sloughs and the bay are gradually filling up. On approaching the mouth of the bay, where the tidal motions are stronger and the force of the waves is felt more fully, the fine material is removed and carried out to sea, leaving the flats and beaches composed of sand. At this point the alluvium merges into the dune sand which results from the combined action of the sea and the winds. The sand carried out by the water of the bay, joined with that thrown up by the waves of the sea and drifting along the coast, makes the bar at the mouth of the bay which is such an obstruction to navigation.

Sand dunes.—The sea shore is one of nature's greatest mills for grinding rocks to furnish the sediments spread over the sea floor. The waves are unceasingly pounding the shore and knocking the rocks against one another, breaking them to pieces, and if this action is continued long enough the fragments are ground to sand and mud. The sand is in some cases thrown upon the beach and under favorable circumstances is gradually carried inland by the strong winds, forming irregular hills and ridges called dunes. The drifting sand destroys vegetation, and the dunes are barren wastes so long as the moving sand prevents vegetation from gaining a foothold. However, the plants soon take root and hold the sand in places, reclaiming the dune tracts. The largest dune area is along the shore north of Coos Bay, where the dune belt has a width of about 2 miles. The landward portion of the belt is partly covered with trees. There are numerous ridges parallel to the coast and numerous lakes inclosed behind them by bars thrown up by the wind.

Sand dunes occur along the coast north of the mouth of the Coquille and about the mouth of Fourmile Creek, and there is evidence that sand dunes of long ago, now covered with vegetation and in places thickly forested, extend inland in some cases over a mile.

IGNEOUS ROCKS.

In the Coos Bay quadrangle igneous rocks are much less abundant than sedimentary rocks, and are of two types, serpentine and basalt.

Serpentine.—Only one small mass of serpentine was observed in the quadrangle, and that occurs by the road one-fourth mile southeast of Gravelford. 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.

South and southeast of this area serpentine occurs in large masses throughout the Klamath Mountains. The Gravelford outcrop is the most northern exposure of serpentine known in the Coast Range of Oregon. It is only about 200 feet in diameter and is surrounded by sandstone of the Pulaski formation, with no trace of metamorphic rocks upon its borders. It is most likely, therefore, that it was intruded before the surrounding rocks were deposited. It appears to be an irregular hill projecting up through the Eocene beds and exposed by erosion.

Basalt.—Along the eastern portion of the quadrangle, in range 12, extending from the head of Kentuck Slough to the Middle Fork of the Coquille, there are four igneous masses which are generally basaltic in character. They are all composed essentially of plagioclase feldspar (anorthite or labradorite) and augite, with more or less olivine and magnetite, and differ chiefly in crystallization and structure.

North of Coos River are a half dozen apparently separate outcrops, which are in all probability connected beneath the adjacent sandstone. The basalt is well exposed about the head of Kentuck and Willanch sloughs and along Coos River below the forks, but the intermediate divides are capped by sandstone belonging to the Pulaski formation. Where unaltered the rock is in many places rich in olivine and pyroxene, but upon the surface it is generally weathered, the olivine being replaced by serpentine, oxide of iron, and carbonate of lime, and the augite chiefly by chlorite.

In places the basalt is rather coarse grained. The grains of feldspar have crystallographic boundaries and the augite occupies the irregular spaces between them, giving rise to the ophitic structure which characterizes diabase, but generally the structure of the rock when wholly crystalline is granulitic. The largest grains are olivine, sometimes in well-defined crystals, surrounded by many small grains of augite and small lath-shaped crystals of feldspar. Generally the rock is holocrystalline, but in places some of the matter is amorphous and the rock has the appearance of a lava which flowed out upon the surface. This view is supported by the fact that the basalt is not infrequently amygdaloidal and is associated with fragmental volcanic rocks, tuff, due to explosive eruptions upon the surface. The fragmental material may be regularly stratified and interbedded in the sandstones of the Arago formation. Strata of this character occur at Jordan Point and in the road a short distance east of Glasgow, where they are within the Coaledo beds of the coal field. This is the only place in which igneous material was seen in the coal field. Where the relation of the Pulaski formation and the basalt are best exposed the sheets of basalt either lie conformably between the beds of Pulaski sandstone or break through them. It is evident from these facts that the eruption of the basalt occurred during the Pulaski epoch and before the deposition of the coal beds in the Coos Bay region. The igneous material of the Glasgow locality may possibly indicate a later eruption at that place, although the sediments may have been derived from such material farther east.

Amygdaloidal lava and tuff.

Age of the eruption.

In the region immediately north of Coos River the basalt is chiefly exposed in the valleys, while the adjacent hills are made of the overlying sandstone. In the Blue Mountain, however, the basalt occurs at a greater altitude and forms a prominent elevation, from which the overlying sandstone has been removed. The basalt is in all respects like that in the masses farther north.

The third large area of basalt lies southeast of Coquille, forming the prominent hills about the head of Glen Aiken Creek. The rock is generally of the normal type, but occasionally it is coarse grained, with a structure somewhat like that of granite, and is especially rich in olivine and augite. This, however, is only a local variation from the typical rock. It was seen best developed on the North Fork of Coquille River just below the bridge near Lee, where the mass of basalt is bordered by tuff.

The fourth large area is about Sugarloaf, a few miles east of Myrtle Point. Along the Middle Fork of the Coquille the relation of the basalt to the sandstones is well exposed. In some places it lies conformably between the beds of sandstone and at others it breaks through them. A number of small outcrops occur along the coast south of Bandon, especially near the mouth of Crooked Creek. In the valley of Twomile Creek there are a few areas of considerable size. The rocks are basaltic, but more highly altered than those already noted, and are associated with the Myrtle formation. They are probably of greater age than those found in the Pulaski formation and are the product of eruptions occurring at the close of the Cretaceous. In some of these altered rocks the feldspar is largely oligoclase, and such varieties should probably be separated from the rocks in which the feldspar is nearer the basic end of the series. One of these, 2 miles northwest of Bill Peak, is quite rich in ilmenite partly altered to leucoxene.

ECONOMIC GEOLOGY.

COAL.

The Coos Bay coal field is the only productive field yet discovered in Oregon. It is described in greater detail than is here possible in a paper entitled "The Coos Bay Coal Field," in the Nineteenth Annual Report of the Geological Survey, Part III.

Newport Basin.—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 S., R. 13 W., as well as sec. 33, T. 25 S., R. 13 W., besides small portions of several adjoining sections, so that the total area of the coal basin is nearly 3 square miles.

The Newport Basin is well defined, and in it the outcrop of coal has been traced more carefully than in 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 brought out by gravity. Three mines have been worked in this 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. The section revealed, together with that afforded by the exposures near the mine, is shown in fig. 34 on the Coal Section sheet.

The Newport bed.

The Newport Basin has only one bed of coal that is 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.

Fig. 2 illustrates a section of the Newport bed in the Newport mine. The roof is generally sandstone but locally shale, and requires very

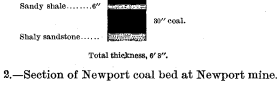


Fig. 2.—Section of Newport coal bed at Newport mine.

little timbering. Where shale occurs in the roof it is often full of brackish-water fossils. The top bench is usually left with the upper parting to form the roof. It occasionally contains small veins of pitch coal which intersect the other coals. The middle bench within a few inches of its top contains a red streak that is 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 in working out the structure of the field it is found to be of much importance.

The only coal bed of considerable size 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. It has been recently prospected again by James Flanagan, and a section of it is shown in fig. 3. This coal is supposed

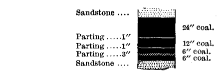


Fig. 3.—Section of coal near conduit of Marshfield waterworks.

to overlie the Newport coal and to have been dropped by a fault in the strata between the reservoir and the South Marshfield mine.

The outcrop of the coal about the northern end of the Newport Basin, especially upon the slope of Pony Slough, has not been traced so continuously as around the southern end and eastern side of the basin. North of the Eastport mine the Newport bed outcrops at the head of Galloway Gulch and swings around to the South Marshfield

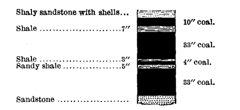


Fig. 4.—Section of Newport coal at South Marshfield mine.

mine, which is at an elevation of about 200 feet above tide and scarcely a mile from Marshfield. The mine was operated for some time to supply local demand. Fig. 4 shows the section of the Newport bed at that point.

Beaver Slough Basin.—The Beaver Slough coal basin takes its name from Beaver Slough, which lies near the middle of the most important portion of the basin. The basin has a length of over 20 miles, extending from the neighborhood of Riverton northeast between Isthmus and Catching sloughs to the northern limit of Coos Bay. Its widest part is in the Coquille Valley, where it is about 5 miles across. To the north it narrows as it approaches Coos Bay. A short distance beyond Glasgow it joins the South Slough Basin. Its position, shape and relation to the Newport Basin can be best seen upon the Economic Geology sheet.

Beaver Slough Basin, although many times as large as the Newport Basin and containing much more coal, has not yet yielded so great an output, for the reason that it is not so conveniently located for economical mining. The basin is deep, extending far below sea level, so that the removal of the coal to the surface, as well as the drainage and ventilation of the mine, is in general considerably more expensive than at Newport. Many mines have been started in this basin. The Timon and Liberty (Ferrey) mines at Riverton, and the Beaver Hill and several others farther northeast, are yet active, while the Glasgow, Southport, Henryville, and Utter mines are among those which have ceased operations. Only the lower portion of the Coaledo formation contains coal beds worthy of consideration. These crop out close to the border of the basin, or farther within the basin where brought to the surface by an upward bend of the strata. The coal-bearing series of the Beaver Slough Basin is nearly 600 feet in thickness and contains about six beds of coal. One of the best sections occurs in sec. 9, T. 27 S., R. 13 W., and is illustrated in fig. 8 of the Coal Section sheet. The coal beds are shown at the side of the principal section on an enlarged scale. The position, association, composition, structure, and size of the lowest coal bed of this section tend to show that it is the Newport bed. If so, the bed of coal mined at Beaver Hill and Beaverton is the same as that mined at Newport. The section measured in that region is shown in fig. 9. At this point a coal bed of considerable size appears beneath the Newport. The Newport bed has not yet been traced with certainty much farther southwest than Beaverton, nor farther northeast than the vicinity of Henryville. A coal bed resembling it to a considerable extent, as illustrated in fig. 14, occurs near the western edge of sec. 19, T. 27 S., R. 13 W. The coal mined at Riverton is called the Timon bed and has the

The Newport bed at Beaverton.

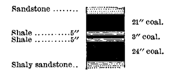


FIG. 5.—Section of Timon coal in Timon's mine, Riverton.

section shown in fig. 5. It is also shown as the second coal bed from the top in fig. 10. Both the Timon and the Liberty (Ferrey) mines are operating upon this bed.

The structure, size, and general relations of the Urquhart coal at Riverton (fig. 6) suggest that it corresponds to the Newport coal mined at Beaverton, but of this correlation there is as yet no completely satisfactory evidence. This is especially true since the reported discovery by J. H. Timon of promising coal west of Lamprey Creek.

Newport bed possibly at Riverton.

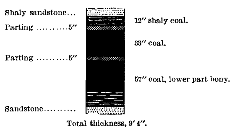


FIG. 6.—Section of Urquhart coal at Riverton.

The Beaver Slough Basin joins the South Slough Basin a short distance south of Riverton, where the coals swing around and strike northwest, as shown on the Structure Section sheet. A columnar section of the coals and associated rocks on Fat Elk Creek is shown in fig. 13, while that of the old Utter mines on a branch of Beaver Creek is shown in fig. 15, and that of the Glasgow region in fig. 11, on the Coal Section sheet.

Many prospects have been opened in the Beaver Slough Basin and some of the sections exposed are given in figs. 16 to 33. Individual beds can not be traced for any considerable distance. They change rather rapidly, and generally near the eastern borders of the basin contain much sediment. The best coal of this basin is near the western side, especially in the Beaverton and Beaver Hill region, where, all things considered, the outlook appears more promising for successful mining than in any other portion of the basin, excepting, perhaps, Riverton, where the coals are of smaller size.

On December 16, 1900, Beaverton was practically closed, but development continued at Beaver Hill under the direction of W. S. Chandler. Since the report on the Coos Bay coal field was published (Nineteenth Ann. Rept., Part III, 1899, p. 333), the openings northeast of Caulfield Marsh have been extended. A slope is down 400 feet from the adit, with gangways at 340 feet, and the mine will evidently soon be in condition to yield a good output.

Mr. Chandler reports that north of Beaver Hill, in sec. 26, T. 26 S., R. 13 W., a drill hole was sunk 550 feet, showing a disturbed condition of the rocks and no coal. The Southport coal was opened at several promising points in sec. 22, and if the coal is found where drilling was going on, as is expected, this portion of the coal field will be opened up.

Near Coos City, W. A. Maxwell was sinking a prospecting shaft, which was down about 250 feet, and it was expected that the Henryville coals would be reached.

A promising prospect has been recently opened along the eastern border of the Beaver Slough Basin near the mouth of Coos River, in sec. 4, T. 26 S., R. 12 W. Three beds are exposed, but the middle one is of most importance. It is known as the Lillian and has the section shown in fig. 7. Coal from this mine is well spoken of by local users in Marshfield. It is supposed to be the same coal as that at Nortons, which cokes.

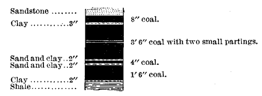


FIG. 7.—Section of Lillian coal (sec. 4, T. 26 S., R. 12 W.) 2 miles southeast of mouth of Coos River.

The following analyses show the composition of the coal in the three benches. The analyses were made by Dr. W. F. Hillebrand, who reports as follows concerning them:

When heated in the usual manner for the determination of fixed and volatile combustible matter—that is, by applying suddenly the full heat of a burner—it became manifest at once that the results, especially in the case of 5329, could not be at all exact, because of the ejection of much undecomposed coal by the force of the escaping gases. In order to correct for this error, separate ash determinations were made in such a manner as to preclude any mechanical loss, and with the data thus obtained, were calculated the values for volatile and fixed combustible matter given under the heading for recalculated values.

Results actually obtained by analyses.

	No. 5327. (*Top.*)	*No. 5328.* (*Middle.*)	*No. 5329.* (*Bottom.*)
Moisture in vacuo over sulphuric acid	7.84	8.34	8.82
Volatile combustible........	43.64	43.08	46.11
Fixed carbon........................	41.47	37.58	38.22
Ash	7.05	11.00	6.85
	100.00	100.00	100.00
Sulphur............................	.54	.44	.42

Coke sandy, hardly sintered at all. Ash buff colored.

Analyses recalculated on basis of separate ash determinations.

	No. 5327.	*No. 5328.*	*No. 5329.*
Moisture	7.84	8.34	8.82
Volatile combustible................	42.40	41.23	39.93
Fixed carbon........................	42.53	39.01	43.46
Ash	7.23	11.42	7.79
	100.00	100.00	100.00

The application of corrections made as above seems theoretically justifiable for all coals which give off quantities of sparks on sudden heating—a sure indication of mechanical loss—for in the analyst's opinion the results for volatile combustible matter and fixed carbon thus obtained will be more strictly comparable with those for non-sparking coals than if they were determined directly by slow application of heat, as is sometimes done. It is well known that in practically all coals the values for these two components differ largely according as they are determined by rapid or by slow heating.

South Slough Basin.—The South Slough Basin has the South Slough for its central topographic feature, and lies to the west of the Newport and Beaver Slough basins, from which it is separated by the Westport arch. Except at the southern end, where it joins the Beaver Slough Basin, the limits of the South Slough drainage mark approximately the outline of the basin. The coal exposed at several localities near Empire, as well as farther southwest in secs. 8, 17, and 18, T. 26 S., R. 13 W., and sec. 1, T. 27 S., R. 14 W., belongs to the eastern arm of the basin. In sec. 2 the coals turn and extend west, then northwest, cropping out at several points, and reach the coast near the mouth of Big Creek. This basin extends south to Hatchet Slough, where it swings across the end of the Westport arch and joins Beaver Slough Basin.

In sec. 2, T. 27 S., R. 14 W., near South Slough, the principal coal is evidently the Newport bed. It is well developed and crops out with gentle dip under conditions favorable for mining. In the surrounding territory, however, the rocks are highly tilted, and it is probable that the area promising the most favorable conditions for mining is less than a square mile in extent. The same coal occurs farther south, and in that part of the basin there is a larger bed lower in the section, which has been traced northwest and southeast for about 6 miles. Part of the coal in this latter bed is of good quality, but, like the associated strata, it is generally soft and inclined at a high angle. At first this coal was regarded as the probable equivalent of the Newport coal, but later investigations tend to show that it lies far below the Newport bed. These two large beds occur nearest together in sec. 10, T. 27 S., R. 14 W., where their outcrops are about a mile apart and each has a dip of 80° E. On this basis, if the beds are not faulted, about 5000 feet of strata lie between them. If it is so far below the Newport bed and widely developed, it may underlie the whole of the Westport arch. It has not been definitely recognized in any other part of the coal field beyond that already noted, although it is probable that it may yet be positively identified farther south. This basin was extensively prospected in 1897, and a number of the sections then exposed are shown in figs. 35 to 44.

Newport bed in South Slough Basin.

Coquille Basin.—The Coquille Basin embraces the coal beds extending from the town of Coquille southward past Harlocker Hill to the upper portion of Hall Creek. The complete outline of this basin is shown on the Economic Geology sheet.

The coals of the Coquille Basin have been prospected at Coquille and Harlocker Hill near the river, but they have not yet proved of sufficient value to be worked. Sections of the coals and their associated rocks in the basin at Coquille and Harlocker Hill are shown in figs. 45 and 46.

"*Pitch coal.*"—In the mine at Newport and in the Old Ferrey mine at Riverton, a dark-brown coaly substance, commonly known in that region as "pitch coal," occurs associated with the lignite. It is brittle, and readily ignites from a match, yielding an odor like that of burning asphalt. At Newport, according to P. Hennessey, the superintendent of the mine, it forms vertical seams and sometimes passes directly through portions of the coal bed. In chemical composition as well as in its other properties it appears to be asphalt rather than coal. Investigations tend to show that it has been derived from petroleum. While the presence of "pitch coal" in Oregon offers interesting suggestions with reference to the occurrence of petroleum, too little is known of the facts to warrant any predictions.

BUILDING STONE.

Sandstone.—Sandstone occurs in both the Myrtle and Pulaski formations. In the former it is generally too much fissured to furnish stones of sufficient size for building, and in the latter the rock is generally too soft to stand great pressure and resist weathering. On the forks of Coos River quarries have been opened to obtain stones for making the jetties at the mouth of the bay. The rock is a micaceous sandstone, and when fresh is bluish in color, but weathers yellowish owing to the oxidation of its contained iron. No buildings have been made of this stone so far as known. From one of the quarries on the North Fork of Coos River much stone has been taken for the jetties, although it is far less durable material than is desired for such purpose. The beds are thick, but easily quarried, and very conveniently located for transportation on the river. A large amount of such stone may be obtained in that locality.

On the Coquille the sandstone of the Pulaski formation is not quarried, but some years ago one of the sandstones in the Coaledo formation 2 miles southwest of Riverton was quarried for building the Light House at Bandon. The stone has not proved to be sufficiently durable.

Basalt.—A far more durable stone is the basalt, although it is much harder to quarry. It is one of the best stones that could be obtained for building the jetties, but on account of its hardness, toughness, and lack of good planes of separation it would be much more expensive to quarry than the sandstone so commonly used in the jetties. Basalt occurs upon both banks of Coos River a short distance below the forks, where it could be conveniently obtained for any purpose. Although basalt is abundant at many points in the quadrangle, the locality on Coos River is the only one conveniently situated for quarrying.

Amphibole-schist.—Amphibole-schist occurs at a number of points in the southern part of the quadrangle, but Bandon is the only point where it is quarried for any purpose. Tupper Rock, at Bandon, is a prominent ledge which once reached nearly 100 feet above the general level of the plain on which the upper part of Bandon is located. It was an attractive feature, affording a fine outlook along the coast, but now it has been largely blasted away and removed to build the jetties at the mouth of the Coquille. Although the loss of this prominent ledge is to be greatly deplored, no better rock for the jetties could be found.

CLAY.

Clay is more or less abundant at many points in the alluvium, but appears to be used only at Myrtle Point, where it is employed in the manufacture of tiles and brick.

GOLD.

The Pleistocene marine deposits at a number of points contain auriferous black sand and have been washed for gold. Wave action upon a beach results in separating the heavier and lighter materials when there is a wide range in specific gravities, and the gold, when present, is found with the magnetite and other heavy black minerals. The output of gold in Oregon has steadily increased from year to year, until in 1897 it reached $1,354,593.43. Although the greater part of this was obtained among the Blue Mountains of eastern Oregon, nearly one-fifth of the whole amount was obtained chiefly in placer mines among the Klamath Mountains, in the southwestern portion of the State.

Coos County is not an important factor in this production, and yet there is more or less active gold mining carried on all the time in the Pleistocene "black sands" within the Coos Bay quadrangle. These mines are confined to the present beach and the ancient beaches raised only a few hundred feet above the present ocean level. Many years ago the mines were of much importance, especially those near the mouth of Whiskey Run, but the gold is so fine that it is saved only with great difficulty. There has been more or less mining along the beach from Coos Bay southward, and it is the belief of miners that the deposits are renewed from year to year by the winter storms. These mines generally have paid but little. In a few cases, however, the yield has been more encouraging. For a short time in the summer of 1897, three men took out nearly a hundred dollars a day a short distance south of the mouth of Whiskey Run.

The most extensive elevated beach mining in the Coos Bay quadrangle has been carried on at the foot of a bluff extending from Threemile Creek to the head of the lagoons. The plain at the base of the sea cliff is about 200 feet above sea level, and the black sand lies about 30 feet below the level of the plain—that is, at an elevation of about 170 feet above the present sea level. The only mines of this kind that have been worked recently are the Rose mine, in sec. 21, T. 27 S., R. 14 W., and the Pioneer, at the head of the lagoons near the northeast corner of sec. 33 in the same township. The Rose mine has been worked during the season of high water for a number of years. The bedrock shale has been laid bare and the black sand is well exposed. The latter generally lies next to the bed rock and stretches along the foot of the bluff for several miles. The belt of black sand is about 150 feet in width. In cross section it is lenticular in shape; about 4 feet thick in the middle, tapering to an edge upon each side, with the coarsest material, including gold, near the landward border, where it is highest and represents the most vigorous wave action. On account of the thick coating (30 feet) of sand and gravel which overlies the black sand, an attempt has been made in some of the mines, especially in the Eagle, to remove the auriferous sand by means of tunnels. Logs and bowlders of various sizes, especially bowlders of the harder rocks of the Klamath Mountains, are found occasionally in the black sand.

Elevated beach gold mines.

The black sand is composed chiefly of garnet, magnetite, ilmenite, and chromite, with a smaller amount of zircon, epidote, and a few other minerals. Gold is generally found more or less abundantly, and platinum with iridosmine is locally found in recognizable quantities among the heavy concentrates. These metals should be looked for. In some cases they may be so abundant as to pay for saving.

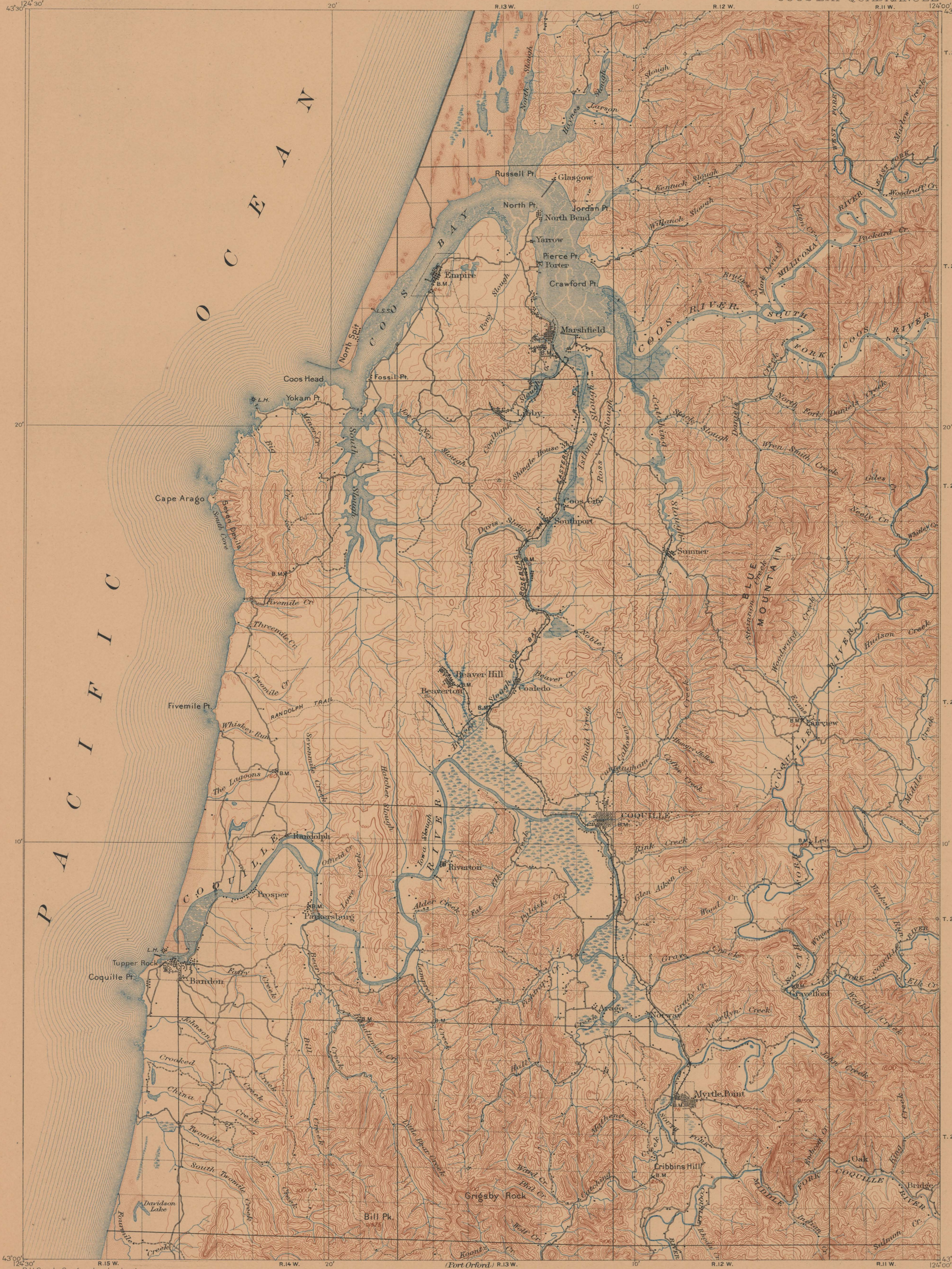
The gold in the black sand is derived immediately from the Eocene shales and sandstones by the concentrating action of the streams and waves, and originally it was derived from the older rocks of the Klamath Mountains. Garnets and epidote, usually so abundant in the black sand, are contained mainly in the amphibole-schist, such as that of Tupper Rock, and it is possible that more or less gold also occurs in these masses, although no well-defined auriferous veins have as yet been discovered in them.

January, 1901.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
DIRECTOR

TOPOGRAPHIC SHEET

OREGON
(COOS CO.)
COOS BAY QUADRANGLE



LEGEND

RELIEF (printed in brown.)

Figures (showing height above mean sea level instrumentally determined)

Contours (showing height above sea, horizontal form, and steepness of slope of the surface)

Sand dunes

DRAINAGE (printed in blue.)

Streams

Intermittent streams

Lakes and ponds

Salt marshes

Fresh marshes

Tidal flats

CULTURE (printed in black.)

Roads and buildings

Private and secondary roads

Trails

Railroads

Bridges

City and town boundary lines

U.S. township and section lines

Located township and section corners

Triangulation stations

Bench marks

R.U. Goode, Geographer in charge.
Triangulation by W.T. Griswold.
Topography by E.C. Barnard.
Surveyed in 1895-96.

Scale $\frac{1}{125000}$

Miles

Kilometers

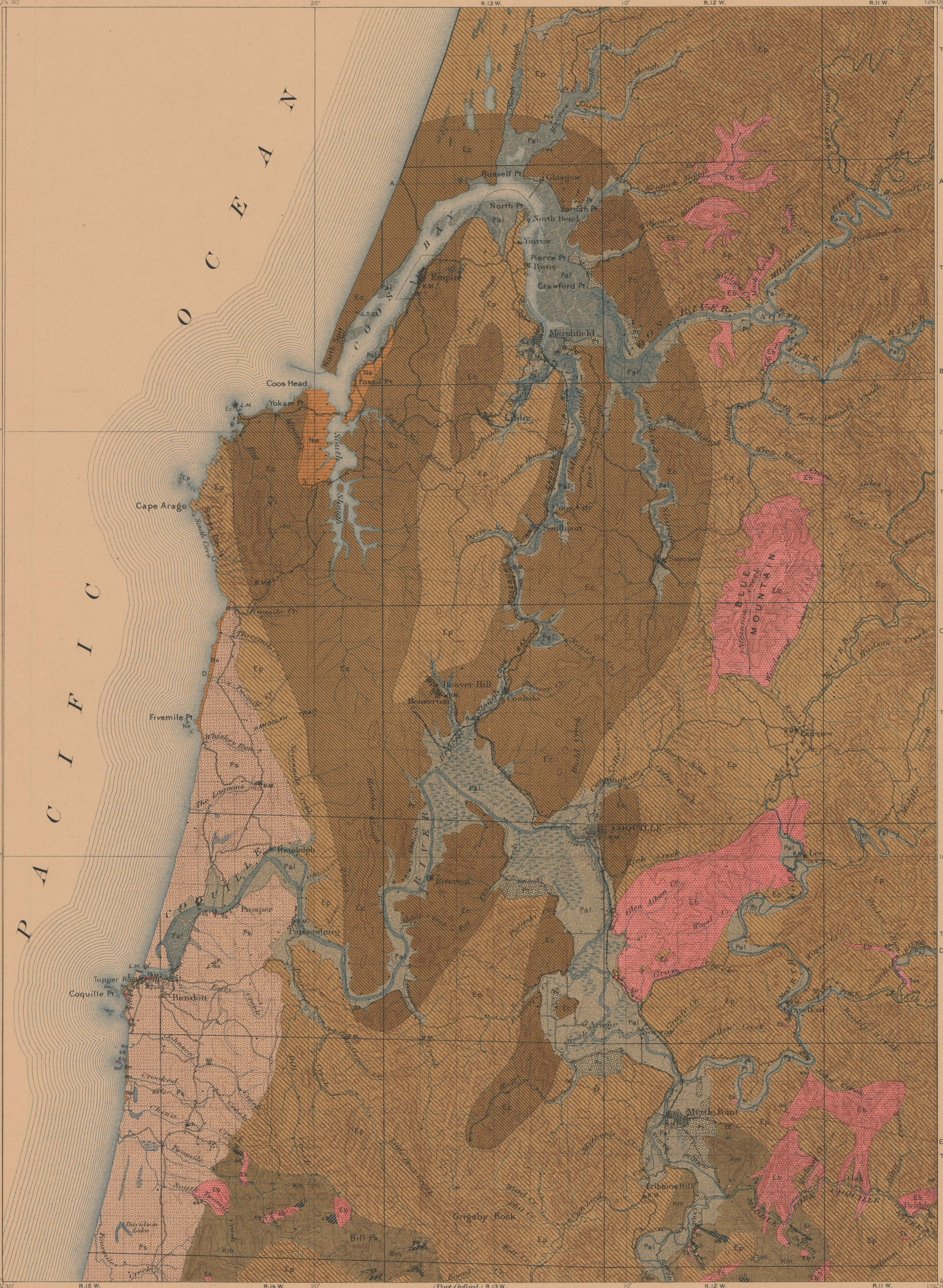
Contour interval 100 feet.
Datum is mean sea level.

Edition of Nov. 1900.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
DIRECTOR

HISTORICAL GEOLOGY SHEET

OREGON
(COOS CO.)
COOS BAY QUADRANGLE



LEGEND

SURFICIAL ROCKS
(Areas of Surficial rocks are shown by patterns of dots and circles.)

PLEISTOCENE
- Pal — Alluvium
- Pt — River terraces *(sand, generally capped by gravel)*
- Ps — Marine sands *(generally gray, with some gravel; along beaches sometimes black and auriferous)*

SEDIMENTARY ROCKS
(Areas of Sedimentary rocks are shown by patterns of parallel lines. Metamorphism is indicated by short dashes combined with the parallel lines.)

NEOCENE
- Ne — Empire formation *(sandstone and dark and whitish shales)*

EOCENE — *Subdivisions of Arago formation*
- Ec — Coaledo formation *(sandstone and shale, in part light colored; contains several beds of workable coal)*
- Ep — Pulaski formation *(sandstone and shale)*

CRETACEOUS
- Km — Myrtle formation *(conglomerate, sandstone, and shale)*

CRETACEOUS?
- ch — Chert *(siliceous shale and gray and red jaspery rocks; "radiolarian chert")*
- as — Amphibole-schist *(blue and green amphibole-schist with some mica-schist and other schists, derived probably from Cretaceous formations by contact metamorphism)*

IGNEOUS ROCKS
(Areas of Igneous rocks are shown by patterns of triangles and rhombs.)

EOCENE
- Eb — Basalt *(including diabase flows and intrusives)*

- sp — Serpentine *(derived probably from saxonite)*

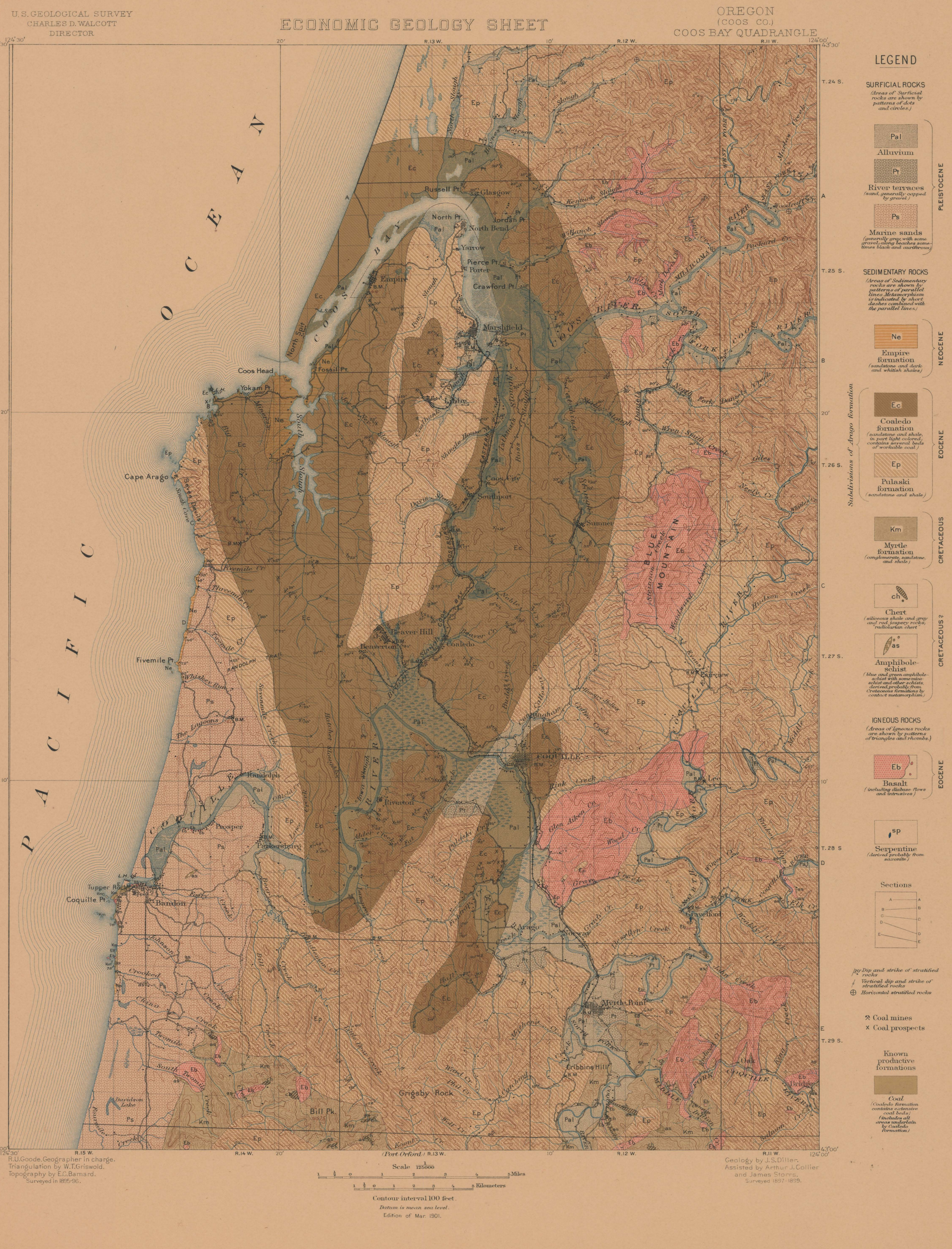
Sections

R.U. Goode, Geographer in charge.
Triangulation by W.T. Griswold.
Topography by E.C. Barnard.
Surveyed in 1895-96.

Scale $\frac{1}{125000}$
Miles
Kilometers

Contour interval 100 feet.
Datum is mean sea level.
Edition of Mar. 1901.

Geology by J.S. Diller,
Assisted by Arthur J. Collier
and James Storrs.
Surveyed 1897-1899.

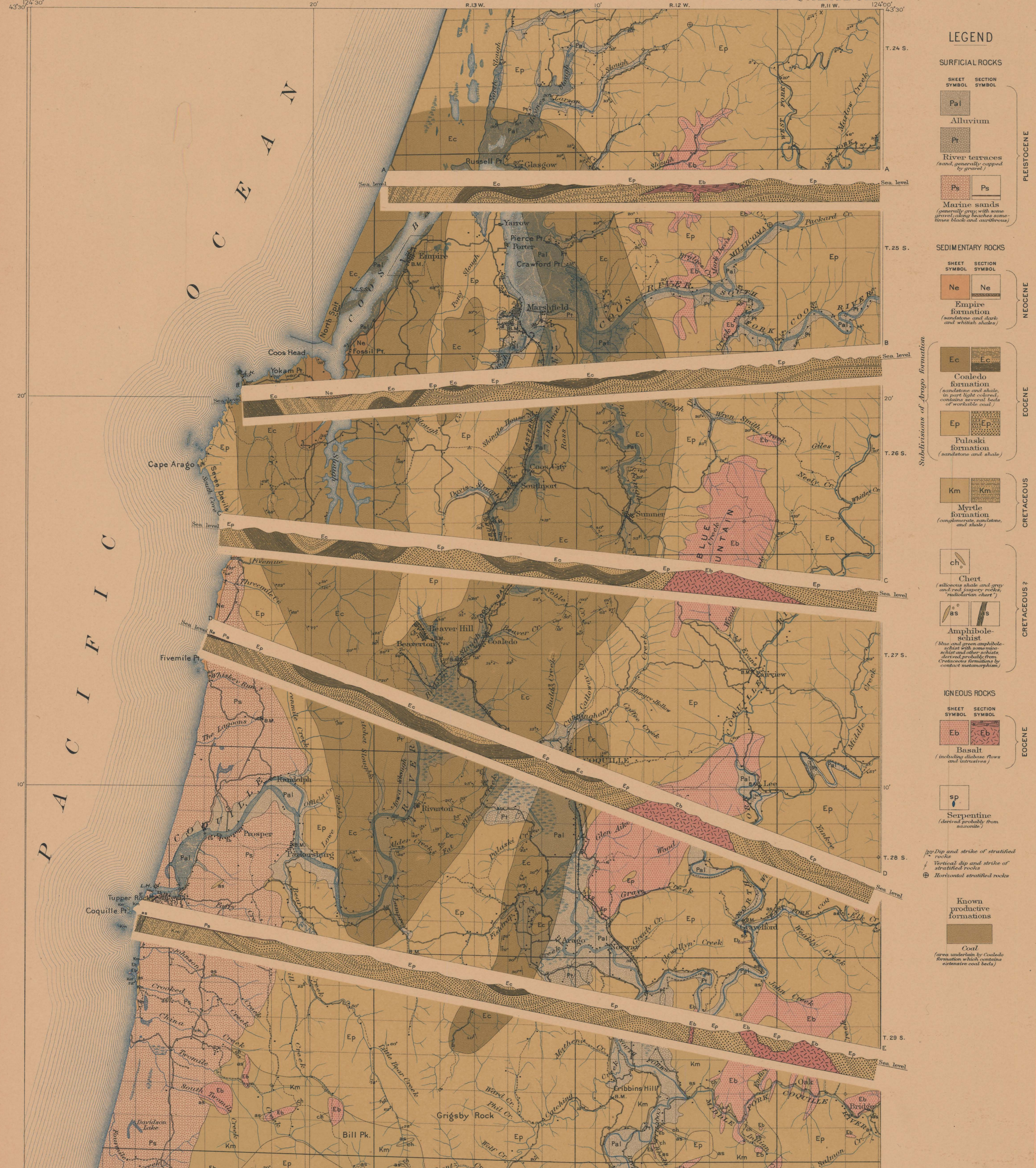


U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
DIRECTOR
ECONOMIC GEOLOGY SHEET
OREGON
(COOS CO.)
COOS BAY QUADRANGLE
PACIFIC OCEAN
COOS BAY
Coos Head
Yokam Pt.
Cape Arago
Fivemile Pt.
Tupper Rock
Coquille Pt.
Bandon
Prosper
Parkersburg
Randolph
Russell Pt.
Glasgow
North Pt.
North Bend
Jordan Pt.
Yarrow
Pierce Pt.
Porter
Crawford Pt.
Empire
Fossil Pt.
Marshfield
Libby
Coos City
Southport
Sumner
Beaver Hill
Beaverton
Coaledo
Riverton
Coquille
Lee
Fairview
Myrtle Point
Arago
Gribbins Hill
Grigsby Rock
Bill Pk.
Davidson Lake
Bridge
BLUE MOUNTAIN
LEGEND
SURFICIAL ROCKS
(Areas of Surficial rocks are shown by patterns of dots and circles.)
Pal Alluvium
Pt River terraces (sand, generally capped by gravel)
Ps Marine sands (generally gray, with some gravel; along beaches sometimes black and auriferous)
PLEISTOCENE
SEDIMENTARY ROCKS
(Areas of Sedimentary rocks are shown by patterns of parallel lines. Metamorphism is indicated by short dashes combined with the parallel lines.)
Ne Empire formation (sandstone and dark and whitish shales)
NEOCENE
Subdivisions of Arago formation
Ec Coaledo formation (sandstone and shale, in part light colored; contains several beds of workable coal)
Ep Pulaski formation (sandstone and shale)
EOCENE
Km Myrtle formation (conglomerate, sandstone, and shale)
CRETACEOUS
ch Chert (siliceous shale and gray and red jaspery rocks; "radiolarian chert")
as Amphibole-schist (blue and green amphibole-schist with some mica-schist and other schists, derived probably from Cretaceous formations by contact metamorphism)
CRETACEOUS ?
IGNEOUS ROCKS
(Areas of Igneous rocks are shown by patterns of triangles and rhombs.)
Eb Basalt (including diabase flows and intrusives)
EOCENE
sp Serpentine (derived probably from saxonite)
Sections
20° Dip and strike of stratified rocks
Vertical dip and strike of stratified rocks
Horizontal stratified rocks
Coal mines
Coal prospects
Known productive formations
Coal (Coaledo formation contains extensive coal beds) (includes all areas underlain by Coaledo formation)
R.U. Goode, Geographer in charge.
Triangulation by W.T. Griswold.
Topography by E.C. Barnard.
Surveyed in 1895-96.
(Port Orford)
Scale 1/125000
Miles
Kilometers
Contour interval 100 feet.
Datum is mean sea level.
Edition of Mar. 1901.
Geology by J.S. Diller.
Assisted by Arthur J. Collier
and James Storrs.
Surveyed 1897-1899.

U. S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
DIRECTOR

STRUCTURE-SECTION SHEET

OREGON
(COOS CO.)
COOS BAY QUADRANGLE



Scale $\frac{1}{125000}$

R. U. Goode, Geographer in charge.
Triangulation by W. T. Griswold.
Topography by E. C. Barnard.
Surveyed in 1895-96.

Geology by J. S. Diller.
Assisted by Arthur J. Collier
and James Storrs.
Surveyed 1897-1899.

Edition of May 1901.

COAL-SECTION SHEET 1

SECTIONS OF COAL-BEARING ROCKS IN COOS BAY QUADRANGLE.

SCALE OF GENERAL SECTIONS: 1 INCH = 100 FEET.
SCALE OF DETAILED COAL SECTIONS: 1 INCH = 10 FEET.

BEAVER SLOUGH BASIN.

FIG. 8.—SECTION OF COAL-BEARING ROCKS ON DEAN & CO.'S PROPERTY, SEC. 9, T. 27 S., R. 13 W.

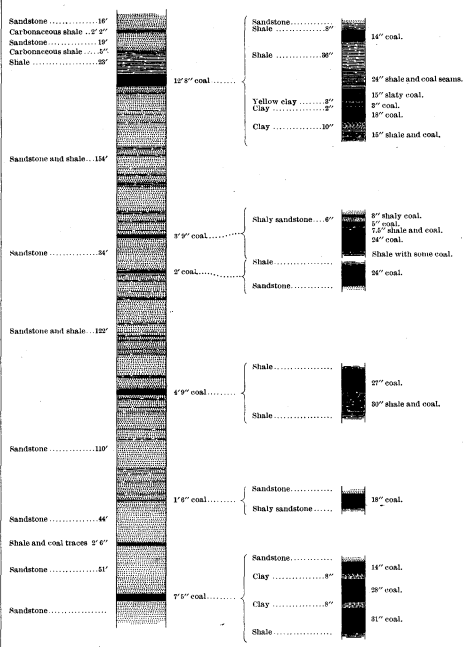


FIG. 9.—SECTION OF COAL-BEARING ROCKS AT BEAVER HILL.

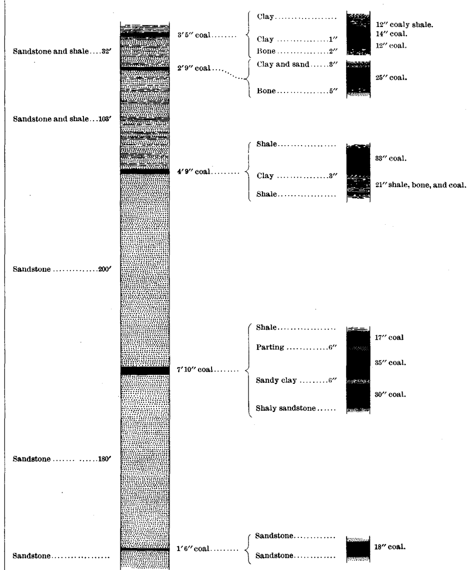


FIG. 10.—SECTION OF COAL-BEARING ROCKS AT RIVERTON.

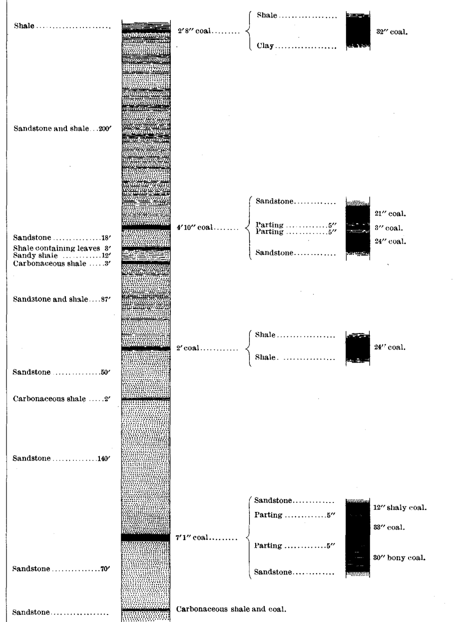


FIG. 11.—SECTION OF HARDY AND STEVA COALS NEAR GLASGOW.

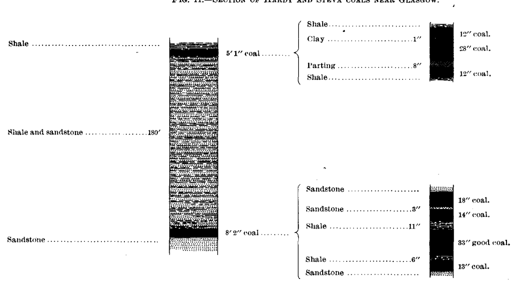


FIG. 12.—SECTION OF COAL-BEARING ROCKS 2½ MILES NORTHEAST OF COALEDO, NEAR LINE BETWEEN SECS. 12 AND 13, T. 27 S., R. 13 W.

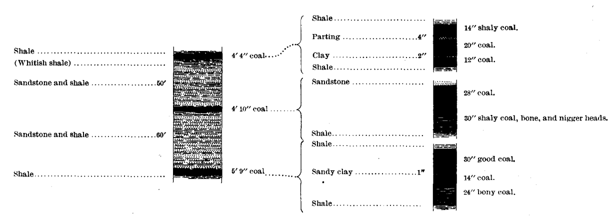


FIG. 13.—SECTION OF COAL-BEARING ROCKS IN FATELK CREEK REGION.

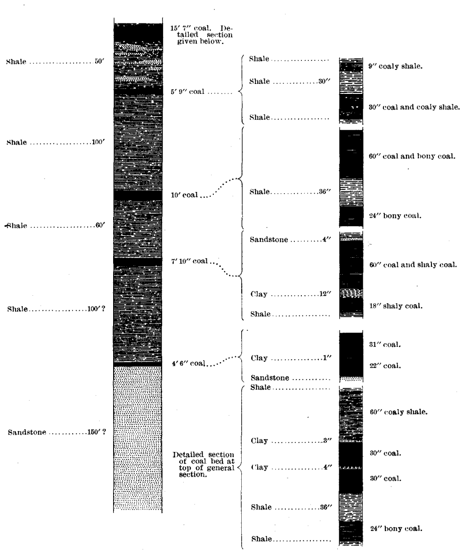


FIG. 14.—SECTION OF COAL-BEARING ROCKS NEAR WESTERN EDGE OF SEC. 19, T. 27 S., R. 13 W.

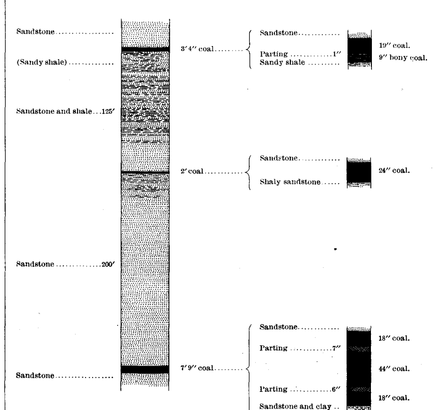
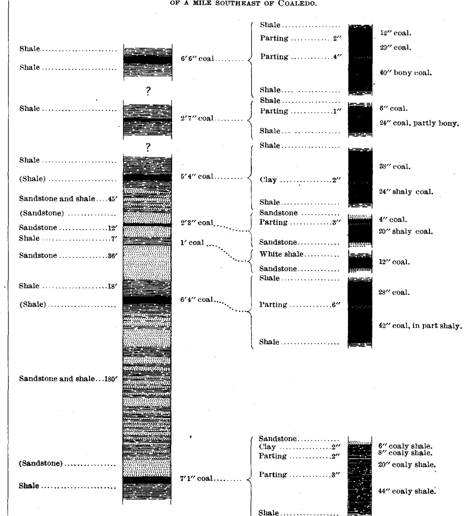


FIG. 15.—SECTION OF COAL-BEARING ROCKS AT BEAVER CREEK MINE (UTTER MINES) THREE-FOURTHS OF A MILE SOUTHEAST OF COALEDO.



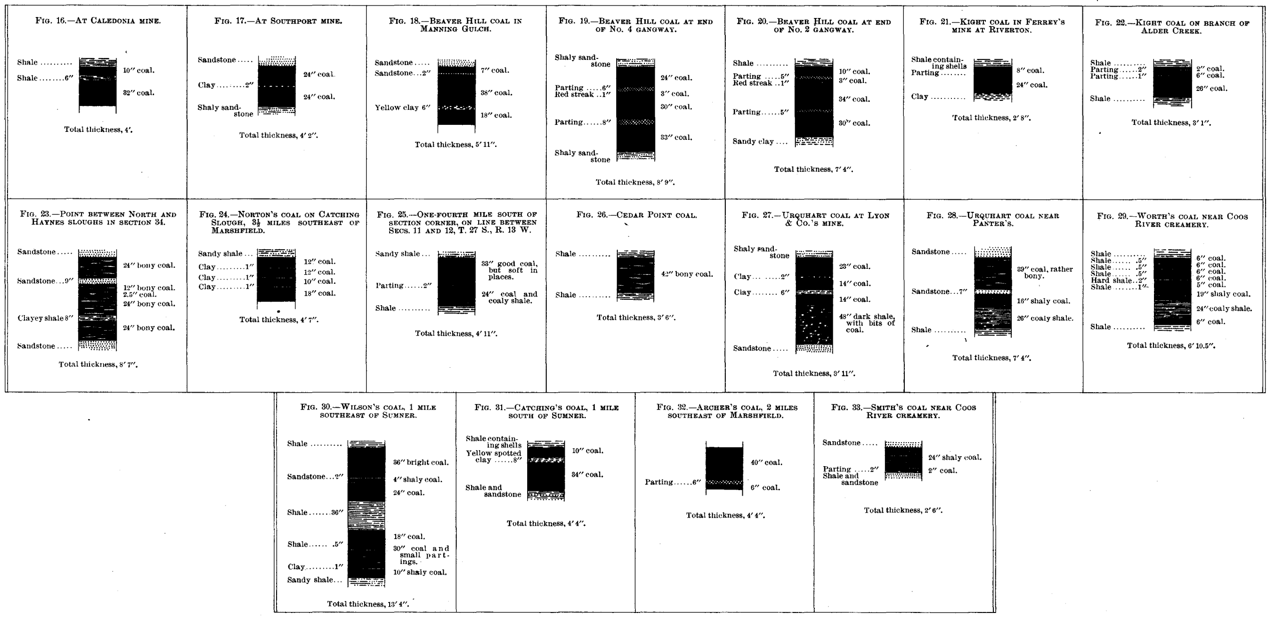
COAL-SECTION SHEET 2

SECTIONS OF COAL-BEARING ROCKS IN COOS BAY QUADRANGLE.

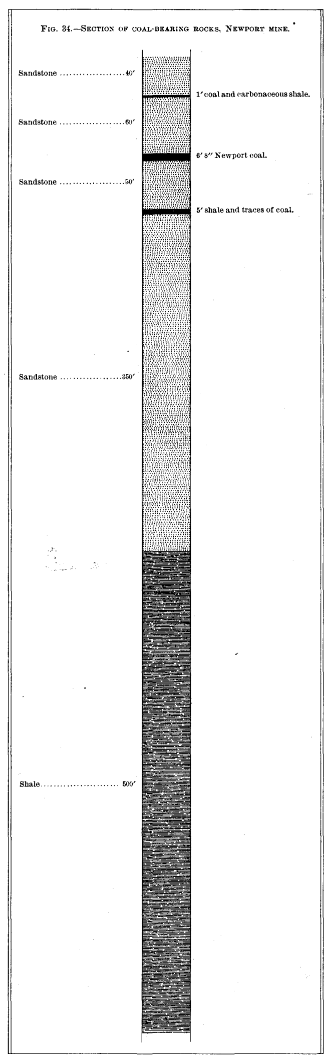
SCALE OF GENERAL SECTIONS: 1 INCH = 100 FEET.

SCALE OF DETAILED COAL SECTIONS: 1 INCH = 10 FEET.

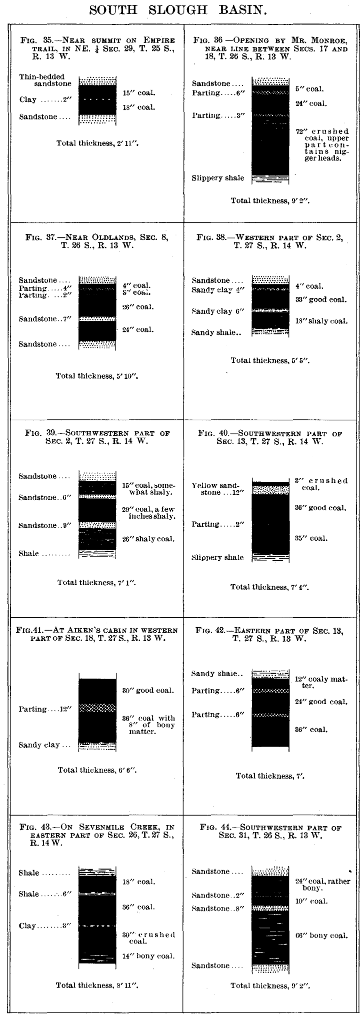
BEAVER SLOUGH BASIN (CONTINUED).



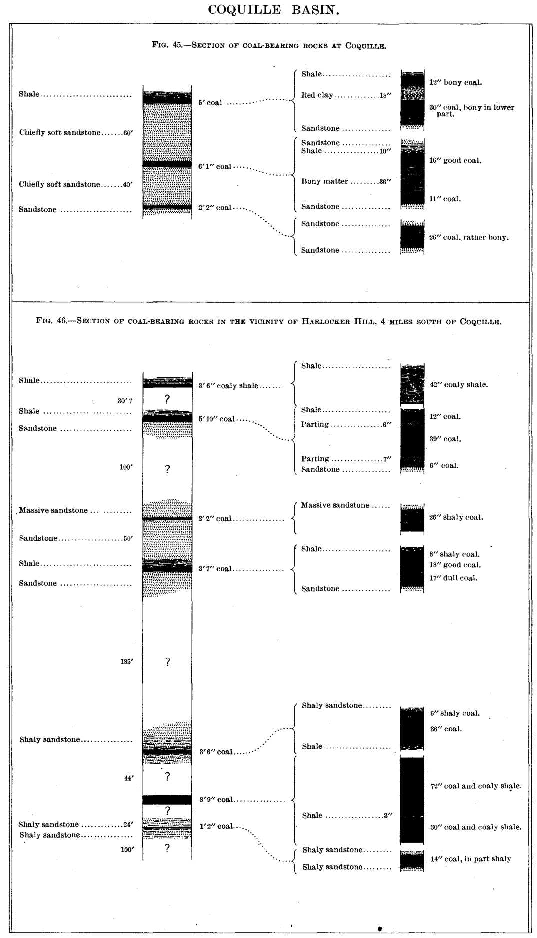
NEWPORT BASIN.



SOUTH SLOUGH BASIN.



COQUILLE BASIN.



J. S. DILLER,
Geologist.

INFORMATION CONCERNING

TOPOGRAPHIC AND GEOLOGIC MAPS AND FOLIOS

AND OTHER PUBLICATIONS OF THE GEOLOGICAL SURVEY

CAN BE HAD ON APPLICATION TO

THE DIRECTOR, U. S. GEOLOGICAL SURVEY,

WASHINGTON, D. C.