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DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

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The Geology and Mineral Resources of Lane County, Oregon

by

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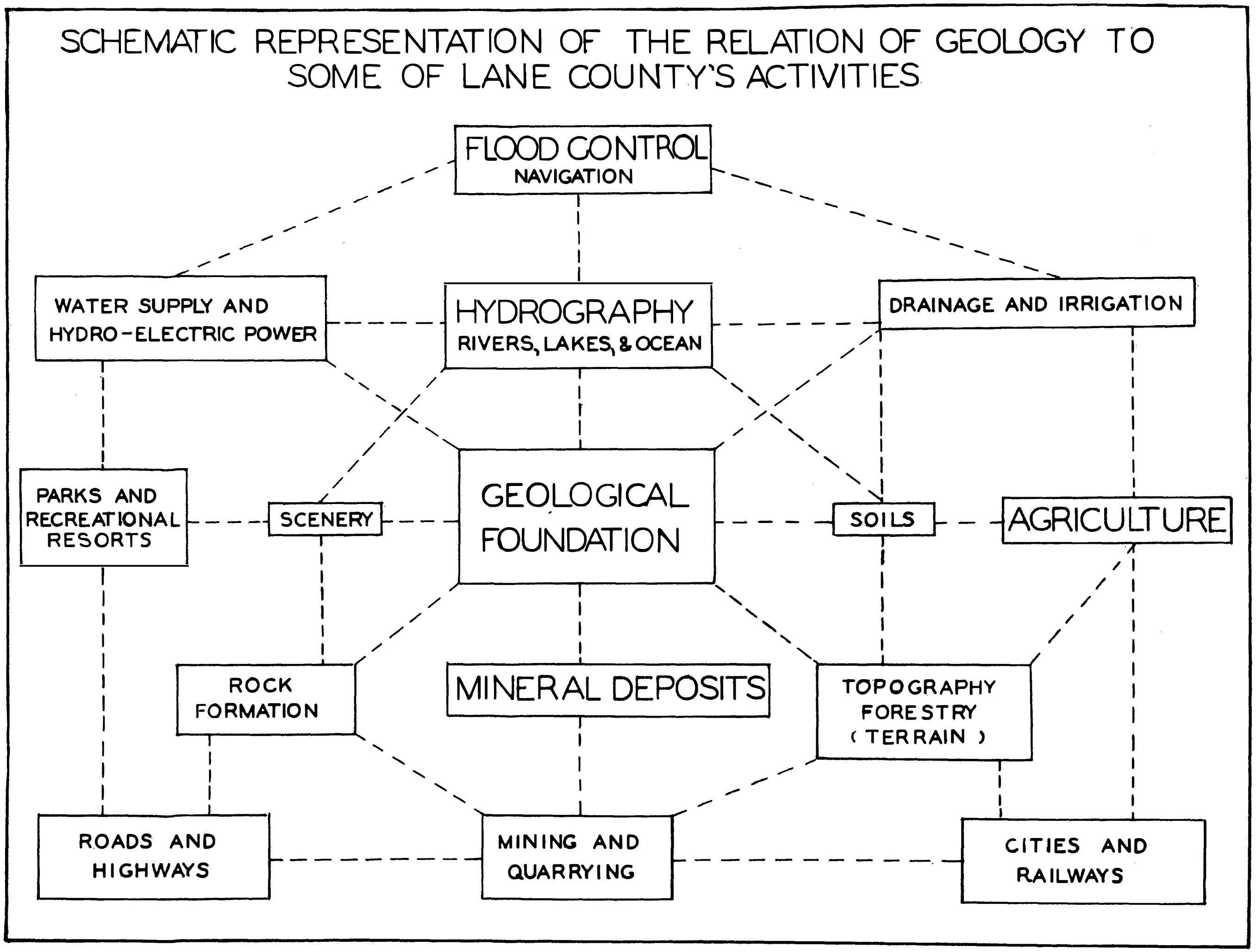

Figure 1—GEOLOGY AND LANE COUNTY ACTIVITIES

This bulletin is dedicated to the memory of

Ellen Condon McCornack

in grateful recognition of her helpfulness in the early years of the author's work in the University of Oregon.

FOREWORD

THIS BULLETIN on the Geology and Mineral Resources of Lane County is the first of a series of reports which the Department intends to make covering the counties of the state. Making the county the unit of area covered by each of these reports is not an innovation; the plan has been carried out in other states, and has been found to be practical and to have several advantages.

Lane County was chosen as a subject for the first of these reports, partly because Dr. Warren D. Smith, head of the Department of Geology, University of Oregon, had in his files much geologic information on the area. Under the circumstances duplication of effort would have occurred had anyone else undertaken preparation of the report.

Dr. Smith's unquestioned ability as a geologist together with his intimate knowledge of Lane County made him especially well-fitted to prepare this study.

Particular attention is drawn to the author's discussion of the Bohemia mining district.

EARL K. NIXON, Director.

Portland, Oregon,
February, 1939.

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INTRODUCTION

Lane county has been selected for one of the first bulletins descriptive of Oregon counties for several reasons; among these being, its importance in the mineral industry; its critical place in the great reclamation program known as the Willamette Valley Project; its great variety of geologic terrain spanning the physiographic gamut from the sea coast to the high Cascades, with its exceptional scenic features; and also because of the availability of much geologic information relating to the county largely from workers in the department of geology of the University from the time of Thomas Condon to the present.

Among features of interest in this county we may call attention in passing (to be described in succeeding pages) to the following of special interest:

1. Black Butte Quicksilver mine, the second largest producer in the state.
2. Bohemia and Blue River Mining Districts, with their gold, silver, copper, lead and zinc.
3. The Hobart Butte arsenic and clay deposits.
4. Belknap, Foley, and McCredie hot springs.
5. A coast line of striking beauty, the interesting Sea Lion caves, and dunes.
6. The remarkable "braided" course of the Willamette river between Eugene and Junction City.
7. The Goshen Flora locality with its assemblage of tropical leaves.
8. The "Lava Beds" on the summit of the McKenzie Pass.
9. The cluster of 10,000-foot volcanic peaks known as "The Three Sisters".
10. Collier Glacier, the largest in Oregon.
11. The Salt Creek Falls, one of the beauty spots of the state.
12. The Coast lakes.
13. The McKenzie river.

Investigators in this Field

The earliest worker in this county was, of course, the pioneer geologist of the Oregon Country, the late Dr. Thomas Condon, who was the first professor of this subject in the University of Oregon. Condon was the originator of the so-called "Willamette Sound" theory. With him was associated for many happy years his daughter, Ellen Condon McCornack, who prepared the first general geological map of the state for student use.

Next we should mention the veteran U. S. Geological Survey geologist, Joseph S. Diller, whose principal studies however were carried on outside this county.

With Condon (as a student) and Diller (as a field assistant) was a young man, Chester W. Washburne, later to become eminent as an authority in petroleum geology. The present writer is particularly indebted to Washburne for much assistance in the field and for voluminous notes on Lane County geology.

One of the earliest reports made of the Bohemia Mining district was contributed by Donald F. McDonald who was working with Diller for the U. S. Geological Survey. A complete report on Bohemia and Blue River districts by Eugene Callaghan and A. F. Buddington has just been issued as Bulletin 893 of the U. S. Geological Survey.

Next we should mention especially Edwin T. Hodge and E. L. Packard, former professors in the department at the University (now at Oregon State College), and the following students who worked on various problems under their and the author's direction:

Hubert Schenck (now at Stanford University), whose master's thesis on the geology of Eugene and vicinity has been freely drawn upon.

Ian Campbell's (now at California Institute of Technology) study of the McKenzie river section is especially important.

Eugene Callaghan (now geologist on the U. S. Geological Survey), for his description of the Sea Lion caves and his studies in the High Cascades are very valuable.

Hodge's own work in the Three Sisters region makes one of the most complete studies we have in this part of the state.

Ralph Tuck, Donald Fraser and Donald Zimmerman have reported on the Blue River mining district, geology of the Oakridge section of the Willamette river, and the Long Tom area respectively in master's theses. All of these have proved to be valuable contributions to the geology of this county.

Francis Wells and Aaron Waters, U. S. Geological Survey, have made valuable contributions to Lane County geology in their study of the "Quicksilver Deposits of Southwestern Oregon" in which publication they cover quite completely the geology of the Black Butte district in southern Lane.

Ira S. Allison, Oregon State College, in his studies of the Pleistocene geology of the valley, has contributed most valuable data and constructive interpretations of the later history of this part of the county.

Harold Stearns, U. S. Geological Survey, is one of the latest contributors to the geology of the McKenzie Valley in his study of proposed reservoir sites on that stream.

For notes on Hobart Butte clay and arsenic deposits, we are indebted to Wilson and Treasher who prepared a bulletin on refractory clays recently issued by the State Department of Geology and Mineral Industries.

And finally, though by no means least in importance, we have the paleobotanical studies of Ethel Sanborn and Ralph Chaney, especially relating to the Goshen Flora. Sanborn began her studies some years ago while she was at the University of Oregon. Chaney is head of the Paleontology department, University of California.

My own work has been chiefly along the Oregon Coast, but in the course of over twenty years of teaching in the University of Oregon and in consulting work I have visited nearly every corner of the county and in the company of many of the persons just named.

My present colleagues, James C. Stovall and Lloyd Ruff, instructors in geography and geology respectively, have been freely consulted and have contributed many important data. Fred Hoffstaed, Wilbur Greenup, Joseph Sallee, and James Weber have all assisted very considerably in making sections and maps, and collecting miscellaneous data. To all of these grateful acknowledgement is made.

George S. Barton, Fred Getchell, Kenneth Watkins, and F. S. Day have furnished valuable assistance and data to the writer during his visits to the Bohemia district.

The present bulletin is in part a selection of the literature already published, or in thesis form, which really is considerable, data supplied from private sources and the present writer's interpretations of this mass of data in the light of his own personal investigations.

The text of this bulletin has been written mainly by the senior author, while Ruff's contribution has been largely the supplying of field data and much assistance in preparing maps and illustrations.

E. L. Packard has given invaluable assistance in the preparation of the short paleontological chapter.

Much still remains to be done in the matter of detail, especially in areal mapping, but this will have to wait until funds for field work are provided.

GEOGRAPHY

LOCATION

Lane county is one of the very few in the United States which extends from the crest of a great mountain range at 10,000 feet elevation, down to the sea. One other county in this state, Douglas county, is similarly situated, but these two are practically unique in this respect in the entire United States.

This county is located about midway down the Oregon Coast. On the north it is bounded by Benton, Lincoln and Linn counties, on the east by Deschutes and Klamath, and on the south by Douglas. It embraces within its boundaries portions of three quite distinct physiographic regions of the state. In the eastern portion there is the Cascade lava plateau, in the central portion the upper end of the Willamette Valley, and in the western portion the Coast Range. More precisely it lies between 43° 27′ and 44° 18′ N. Lat. and 121° 45′ and 124° 09′ W. Longitude.

The area of this county is approximately 4,612 square miles—120 miles in length east and west, and varying from 30 to 50 miles in width.

TOPOGRAPHY

Even a casual examination of the portion of the relief map of the State reproduced in Fig. 2 will indicate the very considerable diversity in topography. There is a very great variety of topographic form and variation in relief. In fact, this diversity in topography is the outstanding single physical feature of this county. As indicated above, the elevations extend from sea level to slightly over 10,000 feet, but these figures do not begin to reveal the complete story. If we merely talk about plains and hills and mountains we give only a superficial picture. This empirical description is not enough and therefore in later paragraphs we shall describe the topography and interpret it under the general head of physiography. Suffice it to say in this portion of our general statement that we have on the Coast an exceedingly narrow coastal strip—at the most, only a mile or two in width, and very close to sea level. From here the surface rises rather gradually to the elevation of between two and three thousand feet at the crest of the Coast Range, not in a simple sloping surface but in a surface which is sharply dissected, with steep ridges alternating with deeply entrenched stream valleys.

Farther east toward the central part of the county, the relief becomes somewhat less, and elevations also less at the head of the Willamette Valley. Here the relief is marked, as in the case of Spencer Butte, by rather abrupt elevations as high as 2,065 feet above sea level. These extend some 1,500 feet, or slightly more, above the Willamette Valley which at Eugene is between 400 and 450 feet above sea level (B. M. 449′ U. of O.). From this point eastward the elevations increase until they reach 10,354 feet in the culminating peaks of the Cascade Range known as the Three Sisters. Here again this is not a gently sloping plateau surface but a very considerably dissected surface, giving us great variety of topographic forms and differences in relief.

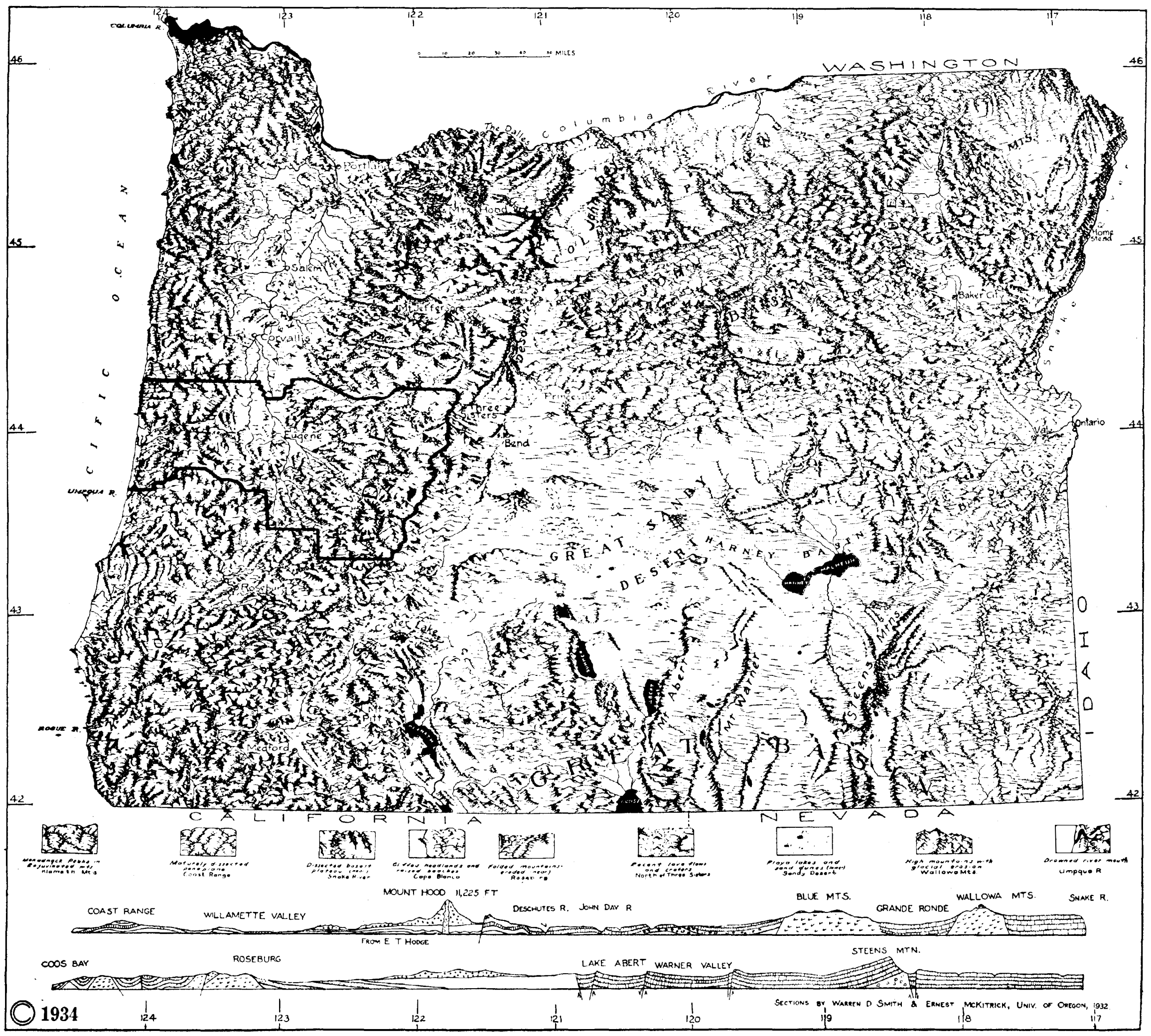


Figure 2—KEY LOCATION MAP (Physiographic Diagram, Geographical Press, Columbia University)

Extending from the Coast Range to the Cascades we have a fairly rugged connecting link of small mountains known as the Calapooyas. These lie at the southern end of the Willamette Valley.

HYDROGRAPHY

Under hydrography we consider all forms of water whether natural or due to man's handiwork. These include the ocean, rivers, lakes and ponds, canals and ditches. The ocean is the principal hydrographic feature of the county, with a frontage of approximately thirty miles on the Pacific. This western coast line is one of the county's important physical assets which will be reverted to later.

Off the western coast there is a submerged shelf which is of varying width. Opposite Florence the shelf extends seaward about fifty miles. This is an area of fairly shallow water, with depths up to about a hundred fathoms; beyond this the bottom drops off rapidly to much greater depths.

Lane county is well supplied with rivers. The principal one is the Willamette, the head waters of which rise for the main part in this county. Of the several tributaries that feed this river, the principal one is the McKenzie. It is possible that an ancestor of one of the forks of the Willamette or the McKenzie may have extended much farther to the west and emptied into the Pacific, but through process of capture the waters have been diverted north to the Columbia. As these streams rise very close to the summit of the Cascade Lava plateau and fairly well up on the sides of some of the volcanoes on top of the plateau, they have steep gradients, averaging 37 feet per mile. Naturally with such gradients these streams are not navigable for other than small boats. They are marked by rapids and waterfalls. As they flow through heavily forested areas they are generally swift and clear, in great contrast to the Willamette after it reaches the valley floor. Naturally streams of this type afford excellent power sites.

In the western part of the county the chief stream is the Siuslaw, which in its lower portion is a partially drowned river, permitting navigation of small boats to Mapleton, some fifteen miles from the Coast. Above Mapleton the stream is navigable only in limited reaches with small craft.

Lane county has an abundance of lakes marked by great diversity in type. Near the summit of the Cascade Range there is the lava plateau type lake, Waldo Lake, the waters of which occupy an irregular depression in the lava surface. Farther westward toward the coast is Triangle Lake, caused by a hard rock obstruction in the river valley and by possible structural dislocations. On the Coast are several low-level lakes due, in the main, to the damming of river valleys by sand dunes. Lakes Whoahink and Siltcoos are examples of this type. The latter is the largest lake in the county, with a circumference of approximately thirty miles. In addition to these four lakes mentioned there are many small lakes, some little more than ponds. Oxbow lakes, a particularly interesting type, are found along the Willamette river on the main floor of the valley. They are generally crescent-shaped but only a few hundred feet in length and generally less than a hundred feet in width. They are merely old meanders of the river that have been cut off by the deposition of debris. A few small lakes of another type are found in the High Cascades which are connected with the past glacial history of the region. These generally occupy *cirque** basins near the heads of old glacial valleys. And there is also one small crater lake, little more than a pond, in the crater of the South Sister peak.

Therefore, it can be seen that in this one feature, lakes, the county has a very considerable variety which adds greatly to the scenic, recreational, and even the economic life of the area.

Just a word concerning ponds: In the sand dune area near the Coast there are many small ponds which are peat bogs in the making, and may be of potential importance.

Under canals and ditches all that can be said at present is that with the growing interest in irrigation we shall see the county more and more lined with canals and ditches, but at the present time these are relatively unimportant.†

Under hydrography should be included some mention of the proposed Willamette Valley Flood Control Project inasmuch as Lane county is more directly concerned with this than any other valley county. Briefly, the plans (there being an initial and a larger coordinated plan), as proposed by the U. S. Army Enginers, provide for the building of seven large storage dams on tributaries of the Willamette river. Five of these will be located in Lane county. The particular locations are:

1. Near the junction of Quartz Creek and McKenzie river.

* Cirque, a glacial amphitheatre.
† The Leaburg Power Canal is 5 miles long and the Walterville Canal 4 miles.

2. At Lookout Point on the Middle Fork of the Willamette river.
3. On the Coast Fork (R. 3 W., T. 21 S., sec. 29).
4. At Fern Ridge on the Long Tom river.
5. At Dorena on Row river.

The "initial plan" contemplates neither power development nor irrigation program, these being taken care of in the larger "coordinated plan".

The principal objectives of the larger plan are:

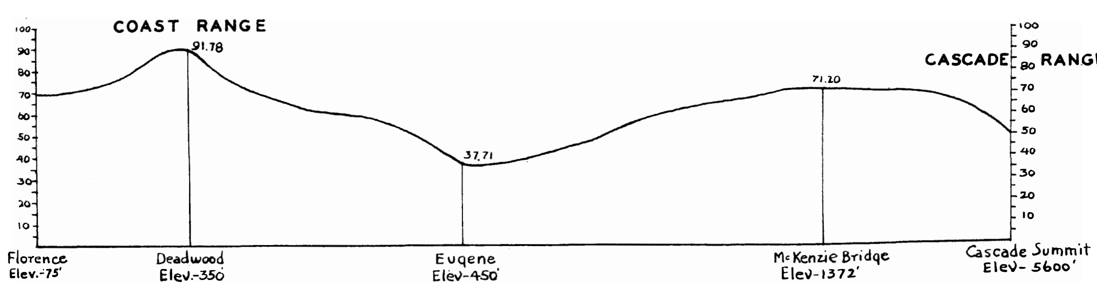
1. Flood control.
2. Navigation.
3. Purification of the river.
4. Irrigation and drainage.
5. Power development.

The survey for this project required two years and cost $300,000. While the entire economic picture of the valley and particularly of Lane county will be changed very materially by this great construction program, only two of the above named items will have a direct effect on mining developments, namely navigation and power.

CLIMATE

For this portion of the report the present writer is greatly indebted to Miss Ruth E. Hopson,* geography teacher in the Wilson Junior High School, Eugene, Oregon, and a former graduate student of the University. In general the climate is of the Mediterranean type, i. e. with rainy winter months and dry summers. More precisely we may recognize five distinct climatic types, all belonging to the humid climates, as the county lies entirely west of the summit of the Cascades. Beginning with the coast and continuing a short distance east of a small place called Deadwood on the Siuslaw, is the so-called fog belt, the climate of which, in the classification used by Miss Hopson based upon the German climatologist, Köppen, is designated by the symbols "C sn." The "C" stands for humid, the month of January having a mean temperature of more than 32 degrees Fahrenheit, and no summer month with a mean of more than 64.4 degrees Fahrenheit. The letter "s" stands for summer drought, and the "n" stands for fog belt. The next belt east of the fog belt which extends to a point a few miles east of Vida on the McKenzie is designated with the symbols "C S b"; that is, humid, summer drought, and the "b" standing for a July mean temperature less than 71 degrees Fahrenheit. From this point to about the beginning of the Deadhorse grade on the McKenzie highway we have a belt designated with the symbols "C s f", the "C" standing for humid, "s" again for summer drought, but "s-f" indicating that each of the three summer months has not less than .75 inches precipitation. Directly east of this belt, designated by the symbols "D s", humid conditions prevail, but with a January mean temperature less than 32 degrees Fahrenheit. This belt completely surrounds the Three Sisters region. However, in the upper portion of these peaks, above 7,000 feet elevation, there is another type of climate called the "E" climate or tundra, with extremely low temperatures most of the year so that glaciers are found on these mountains.

* Hopson, Ruth E., Climatic Map of Oregon, Masters Thesis, University of Oregon.



CROSS SECTION OF PRECIPITATION IN LANE COUNTY

Figure 3—PRECIPITATION PROFILE

Figure 3 shows a cross section from the coast to the high mountains, giving the approximate precipitation for each of these belts mentioned above. It will be seen that on the west side of both the Coast Range and the Cascades the precipitation is greatest with much less on the lee side of these ranges. This is due to the particular type of rainfall in the region of the westerly winds. This rainfall is called "adiabatic"; that is to say, the precipitation is produced by the warm winds from the Pacific being forced to rise and therefore expand and cool as they ascend these mountains. As these winds come down on the lee side of the mountains the air is being condensed and therefore warmed, and so instead of precipitating moisture they are more apt to gather moisture. This is especially pronounced on the lee or eastern side of the Cascades, and east of the mountains we have the typical "B" or dry climate. As the coast ranges are not very high, with numerous low passes, there is not as great a difference between the east and west sides of these mountains as between the east and west sides of the Cascades. It is seen that the widest climatic belt (C s b) takes in the central part of the county which includes the upper end of the Willamette Valley. The most favorable conditions climatically of the whole county are present here and so we find here the principal cities and the greatest activities.

Other important features of Lane County's climate might be discussed but as they are not particularly pertinent to the present discussion they are omitted.

In conclusion, one may have almost any climate he desires by merely going from sea level eastward to the extreme eastern boundary of this county. Within a few miles over excellent roads one can travel from the climate of the perpetual frost region to the relatively warm climate of the coast.

Meteorological data for several stations in the county are given in figure 4.

Figure 4—Meteorological Data of Lane County for 1937

(U. S. Weather Bureau)

Station	Elevation at Station	Age of Station	Temperature in Degrees F. Annual Mean	Highest	Date	Lowest	Date	Precipitation in Inches Total for Year	Greatest Month	Month	Least Month	Month	Total Snow	Rainy Days	Sky Cloudy	Partly	Clear	Prevailing Wind
Canary (near Florence)	50	6	51.7	92	June 4	15	Jan. 8	104.61	20.36	Nov.	.17	July	9.2	187	148	73	144	NW.
Cottage Grove	650	22	51.3	97	Sept. 14	3	Jan. 8	62.21	9.83	Nov.	.09	July	13.7	157	127	83	155	SW.
Eugene ..	450	48	52.4	93	Sept. 14	6	Jan. 8	55.21	7.73	Nov.	.09	July	8.0	173	107	128	130	S.
McKenzie Bridge ..	1372	19	50.3	103	Sept. 14	—3	Jan. 7	80.45	13.23	Nov.	.24	July	97.2	158	168	56	141	W.
Oakridge	1313	21	52.5	108	Sept. 14	0	Jan. 8	50.53	9.74	Nov.	.50	Aug.	43.3	......	118	75	172	......

Snowfall at Cascade Summit

(Data supplied by Southern Pacific R. R.)

1928	185.0 inches
1932	371.5 inches
1933	548.0 inches
1934	200.6 inches

TRANSPORTATION

Lane county is well served in the matter of rail transportation. Eugene is the junction point of the Willamette Pacific branch line to the coast with the main line of the Southern Pacific. The Cascade main line and the Shasta route come together at this city. In addition there is another branch line up the Mohawk valley to Wendling and one to Brownsville. The Oregon Electric Railway has a line between Eugene and Portland, but has suspended passenger operations.

The county is well supplied with paved highways, being traversed by the Pacific Highway U. S. No. 99 and the McKenzie U. S. No. 28. Other main highways under construction are the Willamette Highway No. 58 and the so-called "Route

F" shortcut to the coast. Another route to the coast is State Highway No. 36, which is oiled macadam throughout its length. At Junction City the Pacific Highway forks, giving a west side and an east side highway north to Portland. Last is the portion of the famous Oregon Coast Highway which parallels the coast on the western margin of the county. These highways are all paved or in the process of being paved. The Pacific Highway is paved throughout. A system of graveled, secondary roads crisscrosses the county in almost every direction. Fair, hard-surfaced roads lead into the two mining districts, Bohemia and Blue River.

GEOLOGY

GENERAL STATEMENT

Of the three great groups of rocks, igneous, sedimentary and metamorphic, the first two are dominantly represented in Lane county, while the third apparently is almost entirely lacking, save for small areas showing some minor contact metamorphism near the granitic and dioritic intrusives. In the eastern part of the county, from the edge of the Cascades to the summit and beyond the limits of the county, the rocks are practically all igneous and of the extrusive type, i. e. volcanic. In the higher part of the Cascades they are dominantly andesites, while in the lower part they are basalts and agglomerates. There is present, however, a third type of formation, which is igneous but *intrusive* in nature with a texture more like that of a granite. This type is found in certain parts of the Cascades where the streams have cut down sufficiently through the overlying lavas to reach it.

In the western part of the county the rocks are dominantly sedimentary. In a recent trip along the new proposed Route F to the Coast, we traveled along canyons or valleys cut in sandstone or shale, and saw only one or two outcrops of hard igneous formation.

In the central part of the county in the Willamette Valley bottom the formations are sedimentary as well, but consist in the main of relatively unconsolidated alluvial materials like sands and gravels overlying shales. And then on the Coast there is another type of sedimentary formation, sand dunes which are for the most part of wind origin (aeolian).

Now for the purposes of the geologist who may be looking for coal, oil, or other minerals of economic importance, it has been found necessary to study the rock formations to determine their *stratigraphic* position,—that is to say, their order of superposition. In parts of the Coast Range they are practically undisturbed, but as we travel through the valleys we sometimes find them faulted and folded. In general, in northwestern Oregon, at least where Lane county is situated, nothing as yet has been identified as being older than the formations dating from that period known as the Eocene. Farther to the south are formations which have been referred to the Cretaceous, and to still older rocks than that, but the presence of these older rocks anywhere within the limits of Lane county is something at present merely to be inferred and to be revealed, if at all, by deep drilling below the present surface formations.

One of the oldest and most widely distributed formations in Lane county that the present writer correlates with certainty is a great mass of sandstone locally called "The Tyee". This sandstone, from fossils contained in it, can be dated definitely as belonging to the Eocene period. The careful, technical, geological student will need to make closer distinctions than we do in this particular report, and so we shall merely say here that in the upper Eocene period there is present a group of formations consisting of conglomerates, sandstone, shales, limestone lenses and tuffs, with intrusions of diabase. These can all be grouped into one general body of rocks called the Arago-Umpqua group. Altogether this group of rocks has been estimated to be about 20,000 feet, or, roughly, four miles, thick. No one section is known to be that thick and these rocks are not always piled one on top of the other but are standing in places more or less on end, and can be studied where the streams cut across them.

Above the Eocene is another group of shales and tuffaceous materials with basaltic intrusions which can be referred to the Oligocene. This series was formerly called the Astoria Shales, but recent work has further subdivided the formation and we have some other names to deal with. These have been estimated to be at least a thousand feet thick and the total thickness of Oligocene sediments is several thousand feet.

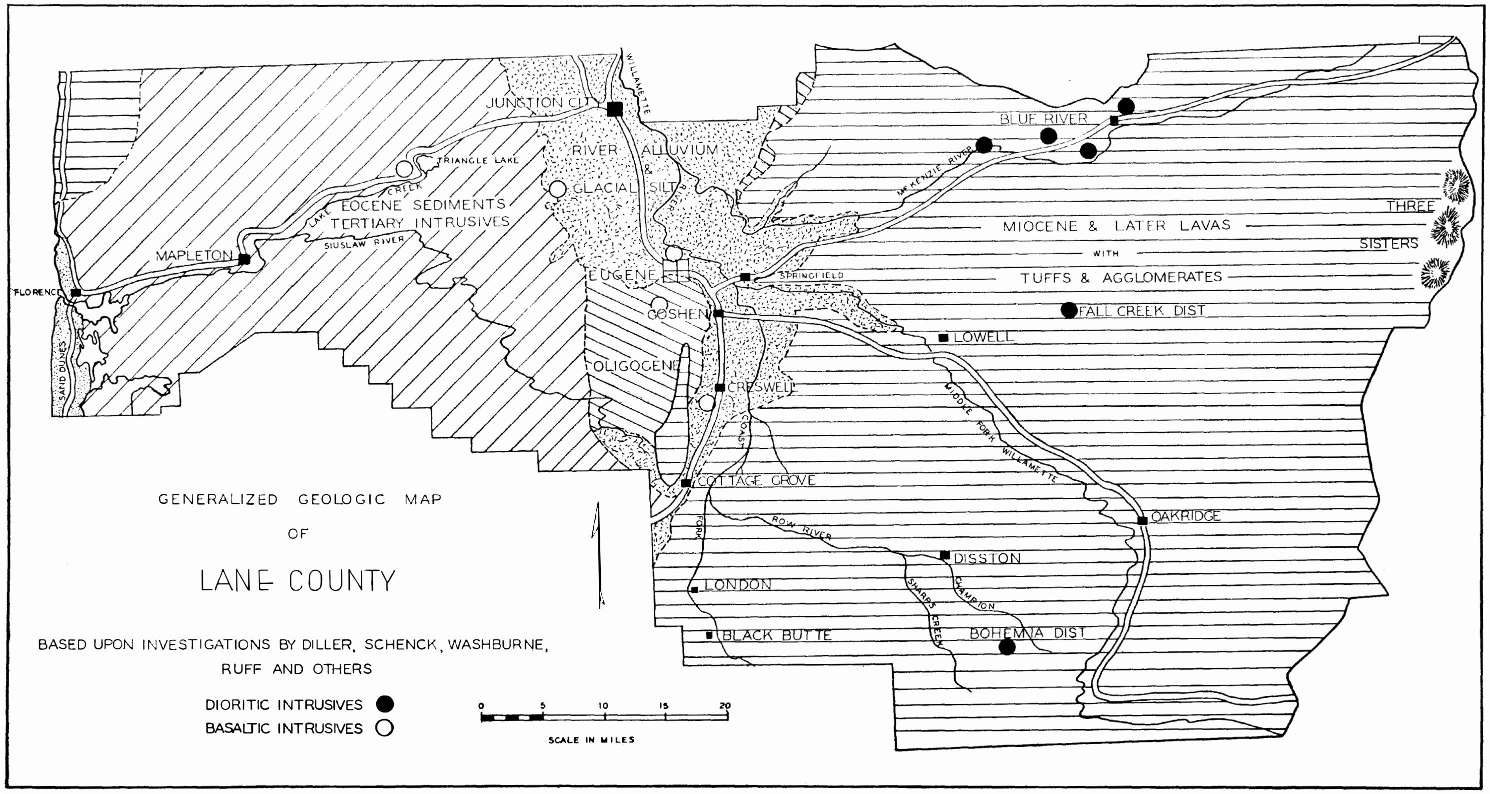


Figure 11—GENERALIZED GEOLOGIC MAP

Beginning probably with the upper Miocene and running on through to the present there is in the eastern part of the county the great series of lava flows and beds of fragmental material blown out during violent volcanic eruptions. Then, the most recent of all is the alluvium of the main valley floor of the Willamette and the McKenzie.

Figure 6 is a columnar section based upon the work of many students of the geology of Lane county, but particularly upon the work of H. G. Schenck. It shows the main formations, gives the estimated thicknesses, the physical characteristics of the rocks and some of the index fossils. In other parts of the county the columnar section would be somewhat different, but in general the sequence is the oldest to the west and the youngest formations to the east. The principal rock types are next described in somewhat more detail.

Geologic Formations

The reader is expected to refer to the stratigraphic column as shown in figure 6 while reading the following more or less technical descriptions of the formations occurring in Lane county. It should be understood that, as stated above, at no place in the county do we find all those formations piled up one on the other as shown here. This is a composite graphic representation of the entire geologic column in this region as it is now known from a study of many localities. The formations are considered from the oldest (lowest stratigraphically) to the youngest (highest stratigraphically).

Umpqua Formation:

The oldest formation known in this county is the Umpqua, named from the Umpqua river in Douglas county where it is particularly well represented. It comes into the Lane County geological picture especially in the Black Butte district where it has been studied by several geologists. The description of the type localities on the Umpqua will be found in Diller's Roseburg Folio*, but most complete description of it as it occurs in Lane county (The Black Butte area) is that of Wells and Waters.† This formation lies below the Tyee sandstone but this writer has never seen the contact of the two in Lane county.

In general the Umpqua in Lane county consists of alternating sandstone and shale beds intercalated with which are basalt flows, palagonite tuff and breccia, conglomerates, etc. The sandstones are characteristically thinner than the more massive Tyee. No accurate estimate of the thickness of the Umpqua in Lane county can be given at this time, though it is safe to say that it amounts to many hundred feet. While some of the sandstone members are beds approximately as thick as those of the Tyee, they are not usually as coarse-grained and are not so definitely characterized by the mica flakes, which are so conspicuous in the Tyee.

The shales of the Umpqua are exceedingly thin-bedded and generally quite dark-colored. They are characterized by very thin, paper-like laminae in contrast to the coarser stratification of the sandstones.

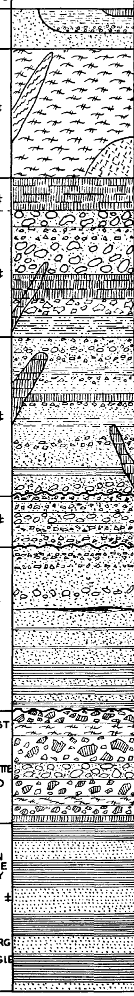
The pyroclastic (fire-broken) rocks intercalated in the Umpqua "when studied under the microscope are seen to be composed largely of *palagonite*, a tuff derived by hydration, through the agency of water or water vapor of exotic origin, and of clear, pale-colored basaltic glass which has been produced by drastic chilling of basalt magma." (Wells and Waters). †

Calapooya Formation:

Next above, stratigraphically, comes the Calapooya Formation, the lower part of which is dominantly sedimentary, while the upper part is dominantly igneous. This formation lies unconformably (i. e. resting on truncated folding) upon the Umpqua. Detailed stratigraphic work to the north and west of this area may indicate that the Calapooya should be placed higher in the geologic column; the unconformity may represent the time of the Tyee which is missing in the Black Butte area. The formation gets its name from the Calapooya Mountains, a sort of subsidiary connecting range between the Cascades and the Coast Range at the head of the Willamette Valley.

The lower or sedimentary phase of the Calapooya is dominantly made up of pyroclastics or coarse breccias and agglomerates, all of these being different facies of volcanic materials of more or less explosive origin. Mud flows are also present. The upper or igneous phase consists largely

* Diller, J. S., Folio No. 49, U. S. G. S. (1898).
† Wells, Francis A., and Waters, Aaron C., Quicksilver Deposits of Southwestern Oregon, Bulletin 850, U. S. G. S. (1934).

AGE	FORMATION	LOCATION OF OUTCROPS	THICK-NESS	COLUMN	DESCRIPTION	REFERENCES	FOSSILS	CORRELATIVES	ECONOMIC DEPOSITS
PLEIST-OCENE & RECENT	BELKNAP LAVA BEDS WILLAMETTE VALLEY FILL RECENT COAST DUNES OLDER " "	McKENZIE PASS VALLEY FLOOR COAST AREA	100' ± 350' ± 400' ±		RECENT LAVA FLOW ALLUVIUM, GRAVELS, GLACIAL OUTWASH, BOULDERS " " DUNE SAND, PEAT,	ALLISON	ELEPHANT TEETH & TUSKS	WISCONSIN	VALUABLE SOILS & GROUND WATER, SAND & GRAVEL
PLIOCENE & PLEISTOCENE	CASCADE	HIGH CASCADES	4000' ±		ANDESITIC LAVAS; SOME QUARTZ VEINS; INTRUSION OF NIMROD GRANITE	HODGE CALLAGHAN CAMPBELL			GOLD AND SILVER IN VEINS
MIOCENE	COLUMBIA R. LAVA	McKENZIE AND WILLAMETTE RIVERS	1000' ±		BASALT FLOWS	CAMPBELL		YAKIMA BASALT (WASH)	ROAD METAL
MIOCENE	HECETA HEAD BEDS	COAST (HECETA HEAD AREA)	3900' ±		HEAVY CONGLOMERATE; TUFF AND CONGLOMERATE; BASALT FLOWS; AGGLOMERATE; AND SANDY SHALE.	CALLAGHAN	PECTEN NEVADANUS CONRAD " WASHBURNEI ARNOLD " PECKHAMI GABB FISH SCALES		
OLIGOCENE	GOSHEN BEDS EUGENE	NEAR GOSHEN OUTCROPS IN AND AROUND EUGENE	5000' ±		FINE GRAINED TUFFS SANDSTONES, SANDY SHALES, SHALES CONGLOMERATE TUFFACEOUS MATERIAL, BASALT DIKES AND SILLS. PREVAILING DIP 10° N.E.	SCHENCK TURNER	FOSSIL LEAVES FIG MAGNOLIA ATURIA ANGUSTATA EPITONIUM OREGONENSE " CONDONI TELLINA EUGENIA THRACIA CONDONI MOLOPOPHORUS GABBI	SAN LORENZO (CALIF.)	BUILDING STONE
OLIGOCENE	FISHER	COYOTE CREEK	1500' ±		TERRESTRIAL MATERIAL TUFFS, AGGLOMERATE; CLAYS SANDS AND GRAVEL	SCHENCK ZIMMERMAN	LEAF FRAGMENTS CARBONIZED WOOD		
EOCENE	SPENCER TYEE	THROUGHOUT MUCH OF COAST RANGE	5000-6000'		SANDSTONE, CALCAREOUS TUFF, CONGLOMERATE; THIN COAL PARTINGS; SHALE.	DILLER SCHENCK ZIMMERMAN TURNER	VENERICARDIA IONENSIS FORAMINIFERA PLANT FRAGMENTS	TEJON (CALIF.)	JETTY ROCK
EOCENE	CALAPOOYA	CALAPOOYA MTS.	AT LEAST 3500' IN BLACKBUTTE ELKHEAD AREA		TUFFS, LAVA FLOWS; CONGLOMERATES; MUD FLOWS	WELLS AND WATERS	FOSSIL LEAVES ARALIA WHITNEYI PLATANUS (SYCAMORE) POPULUS (POPLAR)		QUICKSILVER ARSENIC FIRE CLAY
EOCENE	UMPQUA	WESTERN HALF OF BLACKBUTTE ELKHEAD AREA	TOTAL DEPTH NOT KNOWN IN LANE COUNTY 12000' ± IN ROSEBURG QUAD-RANGLE		SHALE; SANDSTONE SOME CONGLOMERATE	DILLER WELLS AND WATERS TURNER	CARDITA PLANICOSTA TURRITELLA UVASANA FORAMINIFERA	(DOMENGINE (?)) (CALIF.)	

COMPILED BY WARREN D SMITH ASSISTED BY WILBUR GREENUP

Figure 6—STRATIGRAPHIC (geologic) COLUMN

of different types of andesitic, dacitic and basaltic flows.

In some of the stratified tuffs of the lower part of the Calapooya formation, fossil leaves of the Aralia have been studied by Sanborn and Chaney, who have also described a rather considerable flora from Comstock on the Pacific Highway. On the basis of this flora they refer the beds to the Eocene.

Tyee Sandstone—Eocene:

This sandstone, named by Diller* from Tyee Mountain in Douglas county, is the dominant formation in western Lane county. It is heavily bedded and fairly indurated and may be several thousand feet thick in the aggregate, though no one section known to the writer exhibits any such thickness. In Lane county it is best seen and studied along Lake creek and the Siuslaw river where it can be seen for many miles relatively little folded or faulted. On exposed faces weathering has given it a dirty buff to gray color, but on fresh faces it inclines to bluish gray. It is fairly coarse-grained and is made up of detritus from earlier basic or even medium acid igneous rocks. Much lime feldspar and some quartz are present, but the darker ferromagnesian minerals predominate. The rock is particularly marked by numerous flakes of yellowish mica.

Of this formation Diller* says: "The Tyee sandstone is the principal sandstone of the Roseburg quadrangle and occupies about 28 square miles. At its northwest corner it immediately overlies the Umpqua formation from whose sandstone it differs chiefly in being heavier bedded and in containing more conspicuous scales of mica. It forms the prominent eastern escarpment of the Coast Range from Tyee Mountain to Camas Valley, as illustrated in the farthest distance of fig. 1 on the sheet of special illustrations (Folio 49). Where well exposed midway of this course it is a massive sandstone having a thickness of about 1000 feet. Near its middle is a thin layer which locally contains leaf impressions. At Basket Point, on the Umpqua river, just beyond the limits of the map, *Cardita planicosta* and other characteristic Eocene fossils are abundant."

Typical Eocene fossils found in this sandstone are Venericardia c. f. *merriami* Dickerson, *Glycimeris major* (Stanton), *Turritella* sp., which indicate that this formation in Oregon is to be correlated with the Tejon Eocene of California.

Coyote Creek or Fisher Formation (Eocene or transitional to the Oligocene):

Next higher in the stratigraphic column is the series of tuffs, breccias, etc., called the *Coyote Creek Formation* by Schenck,† who described it in fair detail in his study of the Eugene quadrangle. According to Schenck, it consists of "non-marine beds, perhaps 1000 feet in thickness, made up of agglomerate, volcanic breccia, tuff, rhyolite, terrestrial clays, sands and gravels. . . . .

"A characteristic volcanic breccia belonging to this formation outcrops at a locality one mile west of Bailey Hill, where it has an approximate dip of 15 degrees to the northeast. It is composed of angular rhyolitic and basaltic fragments averaging 10 mm. in size, though some of the size of a hen's egg, embedded in a tuffaceous matrix, badly weathered to a buff color. This bed weathers to a gravelly red soil in which rhyolitic boulders are often conspicuous. . . . .

"Another characteristic rock in this non-marine formation is a tuff that outcrops typically in the southwest quarter of section 6, T. 18 S., R. 4 W. It is a bluish-gray, fine-grained, dense rock, meagre to the touch, a few flakes of muscovite (white mica) and pyrite phenocrysts are present, but is so fine-grained that no crystal fragments can be seen without magnification. This tuff in places contains leaves."

Since this formation of terrestrial materials is underlain by marine beds, we have here a record of a change of position of the shoreline, in this case due to a general upwarp movement.

Eugene Formation (Oligocene):

This formation occurring typically in the immediate vicinity of the city of Eugene (see cross-section, figure 7) consists of at least four thousand feet of easterly-dipping sediments which Schenck† describes as being made up of "heavy bedded blue-gray fine-to-coarse-grained fossiliferous tuffaceous sandstone, with sandy shales and some conglomerates; interbedded and intrusive basalt; fine-grained tuff containing leaves; black coarse-grained sandstone; laminated fine-grained clay-shale; conglomeratic sandstone".

* U. S. G. S. Roseburg Folio No. 49.
* Loc. cit.
† Master's thesis, University of Oregon (1923).

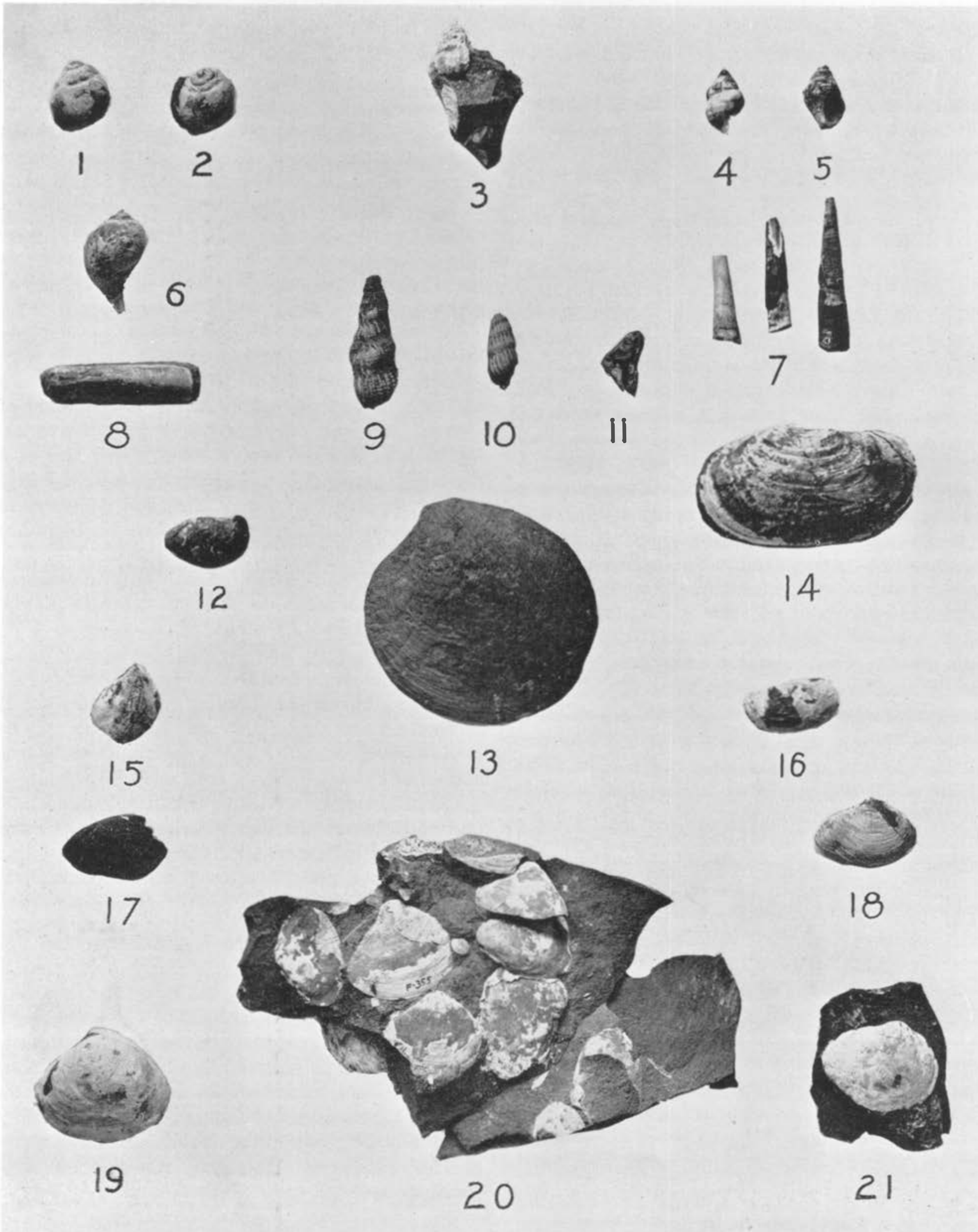


Figure 24—LANE COUNTY INVERTEBRATE FOSSILS (Apprx. ½ Nat. size)

Some of the characteristic fossils in this series are:

Aturia angustata Conrad
Agasoma gravidum Gabb
Solen curtus Conrad
Spisula ramonensis Packard
Tellina eugenia Dall
Epitonium condoni Dall
Mulinia eugenensis Clark

Several of these are shown on figure 24. Most of these figured here were found in the material recently excavated for the basement of the new library on the University of Oregon campus or in the new tunnels of the campus heating plant. Some years before Schenck made his studies, a suite of these fossils was collected by the present writer from the city reservoir excavation on College Crest, and submitted to Professor B. L. Clark, paleontologist of the University of California, who pronounced the fauna as typical Oligocene*.

From the fine-grained tuff horizon near Goshen, Sanborn and Chaney have described a fine flora which is particularly interesting in that it has affinities with that of Panama today.

There has been more or less controversy between the paleobotanists and the stratigraphers concerning the position of the Goshen beds. However, from field work it seems certain that these beds overlie the Eocene and most of what Schenck includes in his Eugene formation, and therefore they are referred to the Oligocene.

A group of excellent specimens from the Goshen type locality collected by Lloyd Ruff and identified by Sanborn is shown in figure 25.

This Eugene formation has another interest in Lane county, since some years ago an attempt to find oil in it was made at a point just southeast of the University. This will be discussed in the economic chapter of this report.

Columbia River Basalt (Miocene):

On the eastern side of the Willamette Valley floor at Coburg bridge, the valley wall rises rather abruptly into the foothills of the Cascades. The sudden change in topography is due to the westward extension of the Cascade lavas which are distinctly harder than the valley sediments. At the old Matthews quarry nearby, the contact between the underlying easterly-dipping sediments and the overlying basalts can be plainly seen after clearing away the talus and brush on the steep slopes.

From this point on eastward there are in general three broad bands of lavas. The first Callaghan† has designated as the black lavas, the second, gray andesitic lavas, and, the third, olivine basalt and other lavas. The first corresponds to the Columbia River lava at the bottom of the Cascade lava series. The second is the Cascade formation and makes up a broad intermediate zone, while the third is the highest and occupies a broad strip on the crest and on both sides of the crest of the range.

A typical specimen of this lowest or "black lava" studied by Campbell§, is porphyritic with large tabular phenocrysts of labradorite feldspar in a finer black ground-mass of olivine, pyroxene and magnetite. The rock is holocrystalline and porphyritic in texture, and is classed as an olivine-basalt porphyry.

From here on up to Blue river, except for the Nimrod Granite to be referred to later, the dominant formation is basalt in massive flows often exhibiting fine columnar jointing. An especial example of this latter is at a point one mile above Hayden's bridge. This formation here shows evidence of later folding similar to that shown in exposures in the Columbia Gorge.

Associated with the basalts are some andesites and tuffaceous beds indicating eruptions of a more acid and sometimes violent type.

Spencer's Butte Diabase:

This conspicuous landmark at the head of the Willamette Valley is a large intrusive mass of igneous rock technically called a diabase sill-dike. This is probably of Miocene age as it appears to have intruded Oligocene sediments which lie on its flanks. The presumption is that this mass of material intruded and domed up the overlying sediments which have since been removed by erosion.

In thin section this rock is seen to be a typical diabase with lath-shaped feldspars interlaced so as to give an ophitic texture. Had this material come through to the surface as an extrusive rock it would have formed either a basalt or andesite. Because it is an exceedingly tough, resistant rock,

* Smith, W. D.: Geology of the Oregon Cascades, University of Oregon Bulletin, New Series, Vol. XIV, No. 16 (1917).
† Callaghan, Eugene. Some Features of the Volcanic Sequence in the Cascade Range in Oregon. Trans. Am. Geophys. Union, 14 Ann. Meetings (1933).
§ Campbell, Ian, A Geological Reconnaissance of the McKenzie River Section, University of Oregon Master's Thesis (1923).

it has resisted erosion and stands up as a monadnock in the otherwise maturely dissected country.

Cascade Formation:

As in the Columbia Gorge section the next higher part of the McKenzie section is predominantly andesitic. This is well exhibited along Blue river, a tributary of the McKenzie. The rock is hard, dense and greenish-blue. Probably it is due to the rock's color that this stream received its name.

A typical andesite from the Lucky Boy mine is described by Campbell* as fine-granular and holocrystalline, containing about 60 per cent of plagioclase feldspar (andesine), augite, biotite, and about 5 per cent of quartz, with magnetite and apatite as accessory minerals. Some secondary chlorite, calcite and epidote are noted in partly decomposed specimens.

Nimrod Granite:

Near Nimrod on the McKenzie river and Indian creek, a tributary of that river, are exposures of a rock of granitic texture which the present writer at first called a granodiorite, but which Campbell* has definitely determined on microscopic examination to be granite. It is an intrusive rock which the present writer believed to be probably much older than the surrounding and overlying lavas, perhaps post-Jurassic and pre-Tertiary.

Campbell* believed it to be later than the Miocene lavas and correlated it with the quartz-monzonite intrusives at Shell Rock and Wind Mountain along the Columbia Gorge. This latter rock appears to be intrusive in the Columbia Basalts.

According to Campbell*, "It is a medium-grained, light-colored rock, often containing numerous small veins of pyrite. It possesses a rhombohedral fracture due to sets of intersecting joints, which results in flattened angular pieces making up the typical talus slopes of the hills formed by this granite. This gives the rock its local name of 'shell-rock' ".

In thin section under the microscope the Nimrod granite is seen to be composed of 60 per cent quartz, 30 per cent orthoclase and oligoclase feldspar with subordinate amounts of muscovite mica, magnetite, zircon, sericite, kaolin, chlorite, etc.

Buddington and Callaghan† investigated several similar intrusives in the Cascades and proved quite clearly that these were all later than the Miocene basalts of the range. These were referred to by them as dioritic intrusives, though they noted several variations from true diorite. The following is an analysis of a "porphyritic augite-quartz diorite" from the Bohemia district:

SiO_2	59.70
Al_2O_3	15.53
Fe_2O_3	3.57
MgO	3.16
FeO	4.07
CaO	6.17
Na_2O	3.65
K_2O	1.34
H_2O+	.98
H_2O-	.03
CO_2	–
TiO_2	1.13
P_2O_5	.25
MnO	.17
	99.75

These writers believe that these intrusives have had an important influence upon the mineralization of the older Cascade lavas and in this opinion we fully concur.

Quaternary Extrusives:

The superstructure of the Cascades is, according to Callaghan made up of "olivine basalts and other lavas", while, according to Campbell the later lavas are predominantly andesitic in the region in which we are here concerned. The present writer's own observations in this territory are in general agreement with Campbell's* statement. On this subject we quote Campbell as follows:

> "Not all the elevation of the Cascades is due to lava extrusions during the Miocene. Recent volcanic activity has contributed considerably to the height of the range. Such peaks as the Three Sisters, Mt. Jefferson, and Mt. Hood, stand up conspicuously as the high points of the range and they are without doubt volcanoes but recently dead—perhaps, who can tell? only dormant. The lava beds around the Three Sisters, and more especially those around Belknap Crater, look as though they had just cooled. The lava extruded from Belknap cannot be more than three hundred years old. The only vegetation which has had time to gain a foothold is tiny lichens. A few junipers have started to grow in pockets where ash and soil have collected, but these are at best no more than 50 or 75 years old."

* Loc. cit., pp. 17-20.
* Loc. cit., pp. 20-22.
† Dioritic Intrusive Rocks and Contact Metamorphism in the Cascade Range of Oregon: American Journal of Science, June, 1936.

"It is not alone these outstanding features which prove the recentness of vulcanism in this region. The hot springs at Foley and Belknap, the topography of the country near the summit which is rolling, dotted with lakes and marshes, interspersed with cinder cones and upon which drainage has not yet had time to thoroughly establish itself, and the masses of cinders and ash seen everywhere, all testify to mighty volcanic forces in the not very distant past."

"In this region the predominating rock is a light gray, usually highly vesicular andesite locally basic and acidic lavas are found—often in streams which can be traced for miles. One remarkable occurrence of an acid flow rock is at the Obsidian Cliffs. These cliffs stand up some 300 feet above the surrounding country, and are perhaps a mile and a half long. They are composed almost entirely of obsidian. Sometimes it is the almost pure black glass that is found, more often it is intercalated with layers of a very fine grained rhyclite, in which the minor foldings and contortions of the flow can be traced. Again, much of the obsidian is becoming spherulitic, and small lithophysae are developing. This occurrence is remarkable, for such an extremely acid glassy rock is not often found in such masses as are here exposed".

Pleistocene and Recent Formations:

In this group we may include the valley fill or alluvium in the main valley of the Willamette, the river gravels on the several terraces of the tributary streams, glacial moraines, glacial outwash, talus and landslide materials and the still unconsolidated beach materials and sand dunes on the coast; also many of the volcanic flows on the summit of the Cascades.

From the work of Ira S. Allison of the State College we now have a fairly complete "picture" of these valley formations, which is given in the chapter on Physiography.

Geologic Structure

In the entire distance from the coast to the western edge of the Cascade lavas the writer has neither noted any conspicuous faults (save the one at the Sea Lion Caves), nor any overturned folding, which is in striking contrast to conditions in the Coast Range of California.

There are a few basalt dikes and sills, but on the whole the Coast Range in Lane county is not particularly marked by such intrusive bodies. Five miles south of Eugene there is a notable monadnock of diabase (Spencer Butte), which Washburne* has called a sill-dike, and near the Southern Pacific depot in Eugene is a basalt laccolith with typical columnar jointing.

Many of the "riffles" or rapids in the Willamette river are caused by dikes of basalt which cut through the older Oligocene sediments. These dikes are presumably Miocene in age.

A conspicuous and quite important structure to be noted in all of the more indurated rocks is that of jointing. This consists of large and small fractures or rifts which cut through many of the formations along more or less definite planes which in many places occur in definite sets, some at right angles to each other, others at oblique angles. Within a given formation, joint fractures may assume a very definite pattern, as in the columnar jointing of some of the basalts, resulting in pentagonal or hexagonal columns.

Figure 7 is a greatly generalized geologic structural section from the summit of the Cascades west to the coast at Florence. This section may not be accurate as to details; some of it has been inferred. The reader will find this generalized and idealized section of considerable help in getting a geological "lay of the land." One outstanding feature is revealed by this section; that is, the general easterly dip or inclination of the sedimentary formations. Except on the coast, they all dip, gen-

* Personal Communication.

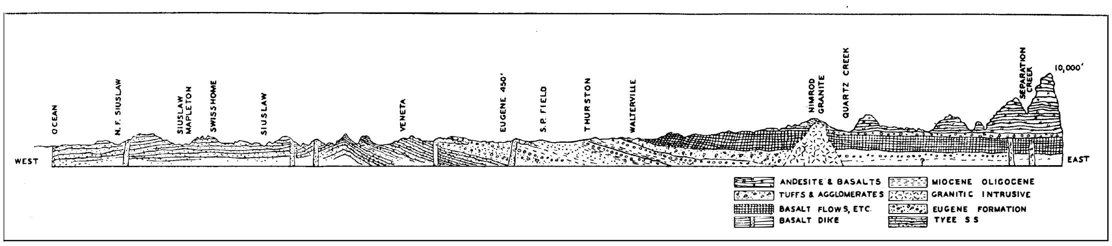


Figure 7—GEOLOGIC CROSS SECTION

erally to the eastward, and plunge beneath the Cascade lavas (fig. 8). From this it is plain that the sediments were here first and that the lavas poured out on top of them. Later the country was subjected to mountain-making movements with compression and wrinkling, thus tilting the beds in various positions, but in the main to the eastward. In the center of the Coast Range, however, they are in places almost flat-lying; and on the coast, not everywhere but in certain parts, they dip to the westward into the ocean. At the summit of the Coast Range on the Triangle Lake road north of the section referred to, is an anticlinal crest and this is the reason for the relatively high elevation of the pass where the road crosses over the range.

Geologic structure is often of extreme economic importance both in mining and in the oil business. In the latter connection, had certain citizens of Lane and adjacent counties a few years ago had a strictly technical and scientific study made of geologic structure around Eugene, they would almost surely have saved themselves some $300,000,—sunk in an unwarranted oil exploration. They refused to heed the cautions of local geologists familiar with the structure, but preferred to follow the advice of so-called "practical" oil men. There is little excuse for such losses of private fortunes.

A careful study of the igneous part of the section, that is in the Cascade region, reveals that the great lava pile has been both folded and faulted. In fact, Hodge* concluded from his studies that a major north-south fracture near the summit of the range was responsible for the alignment of volcanic extrusions that caused the string of magnificent volcanic peaks we see there today.

The present writer considers the structure in the Coast Range as a moderately folded anticlinorium (where smaller folds are superimposed upon a larger arch-like structure) and that when the sediments pass beneath the Cascade lavas we have a broad synclinorium or great down-warped structure, the eastern part of which is concealed beneath the lavas.

As the final details have not been worked out in the structure of this region, the subject may rest with these broad generalizations.

In the metalliferous districts there are structural features such as faults that are of major importance that have to be worked out by laborious underground studies. Deformation may be said to be the control of mineralization at the various

* Hodge, E. T., Mount Multnomah, Ancient Ancestor of the Three Sisters. University of Oregon, 1925, p. 6.

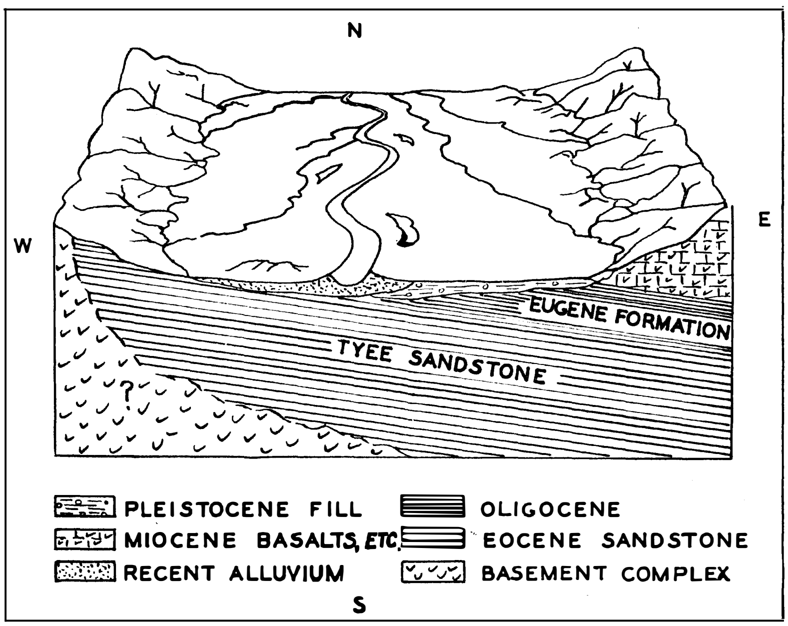


Figure 8—BLOCK DIAGRAM ILLUSTRATING WILLAMETTE VALLEY STRUCTURE

mines. In the Black Butte mine, for instance, the ore body is located along one of these fractures.

Another feature of the general structure of this, and most regions, is the secondary structure known as jointing. This, as described previously, consists of fracture planes which occur often in definite sets, cutting through all kinds of formations, often with one pattern or arrangement in the sediments and quite different ones in the lavas. Jointing in sedimentary formations is usually of great assistance to the quarry-man in excavating building stone.

One of the most characteristic of these igneous rock features is the columnar jointing in Skinner's Butte in the basalt exposed at the western end of that hill. These columns were formed during cooling of the material and the planes are commonly at 120-degree angles. Adjacent shrinkage cracks of this kind produce six-sided columns.

The structure at the west end of Skinner's Butte in Eugene is well shown in figure 9a, and the explanation of this is represented diagrammatically in figure 9b. As this is such a prominent feature of the Lane county landscape and its structure so interesting to many visitors, although exhibiting a structure quite common to many parts of the world, we shall explain it briefly.

Washburne and the writer have studied it together, and we agree (1) that this butte represents a monadnock of hard rock which has resisted erosion; (2) that it is what we call a laccolith which may be represented diagrammatically as in figure 9—a sort of mushroom-shaped body of basalt. This laccolith or sill-dike is about 700 feet long and 400 feet wide. Presumably it intruded Oligocene sediments and arched them as in the case of such structures. However, erosion has removed all the cover of sediments and only remnants are left on the flanks as at the northwestern end where they can be seen in the road cuts.

Another important and interesting detail of structure is to be noted at Judkins Point. The situation is shown in figure 10. At low water one can note that the tongue of igneous rock which is the core of Fairmount Ridge appears to have been sheared off to the eastward. Washburne's tentative interpretation, which has not been published but was left with the writer in the form of notes, is that of faulting along a general east-west line. While Washburne's hypothesis is not to be taken as fully established—and he has not claimed for it anything more than hypothesis—it does explain very acceptably the anomalous course of the river in the vicinity of Eugene. If this fault condition

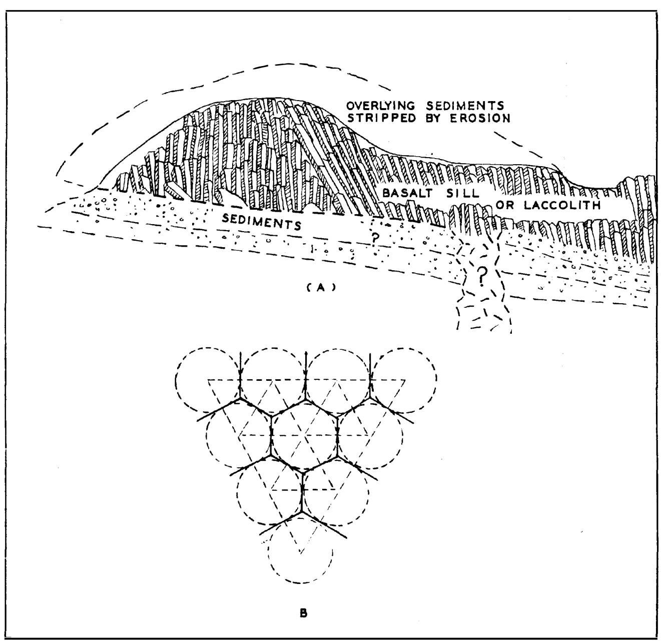


Figure 9—SKINNER'S BUTTE LACCOLITH

is correct, it would appear that the territory north of the river has been shifted eastward with reference to the part south of the river.

An extremely important matter is that of the structure of the rocks and particularly of the veins that cut through the rocks in the mineral bearing areas. (See Economic chapter).

This matter of structure is all-important in mountain formation, in the delineation of stream patterns, in the deposition of ore bodies, in quarry operations, and in the localization of volcanic vents.

PALEONTOLOGY

Fossils are the petrifactions and imprints of pre-historic organisms and are of great significance and utility in the study of the geologic history and of some mineral deposits of a region. First of all they tell us much of past fauna and flora. They tell us where seas and lands were in past ages and what sorts of climates prevailed.

They are indispensable in the study of economic mineral deposits, especially those in sedimentary formations such as petroleum and coal. In metal mining regions where igneous rocks predominate they, naturally, are of less importance.

How Fossils Are Formed:

A fossil is literally some ancient form of life dug up—the word is derived from "fossa" (Latin for ditch). Fossils may be preserved as:

1. Petrifactions—in which the organic matter of the organism, bone or shell is replaced by mineral matter, molecule for molecule.
2. Molds or casts—in which merely an impression of the form of the organism is preserved; for example, the filling of the interior of a shell with sand or other material.
3. Hard parts, such as bone or teeth, but not necessarily petrified.
4. Carbonized impression of leaves, wood, etc.
5. The entire body, or its parts, such as bones or flesh, preserved in frozen ground, asphaltum, etc.

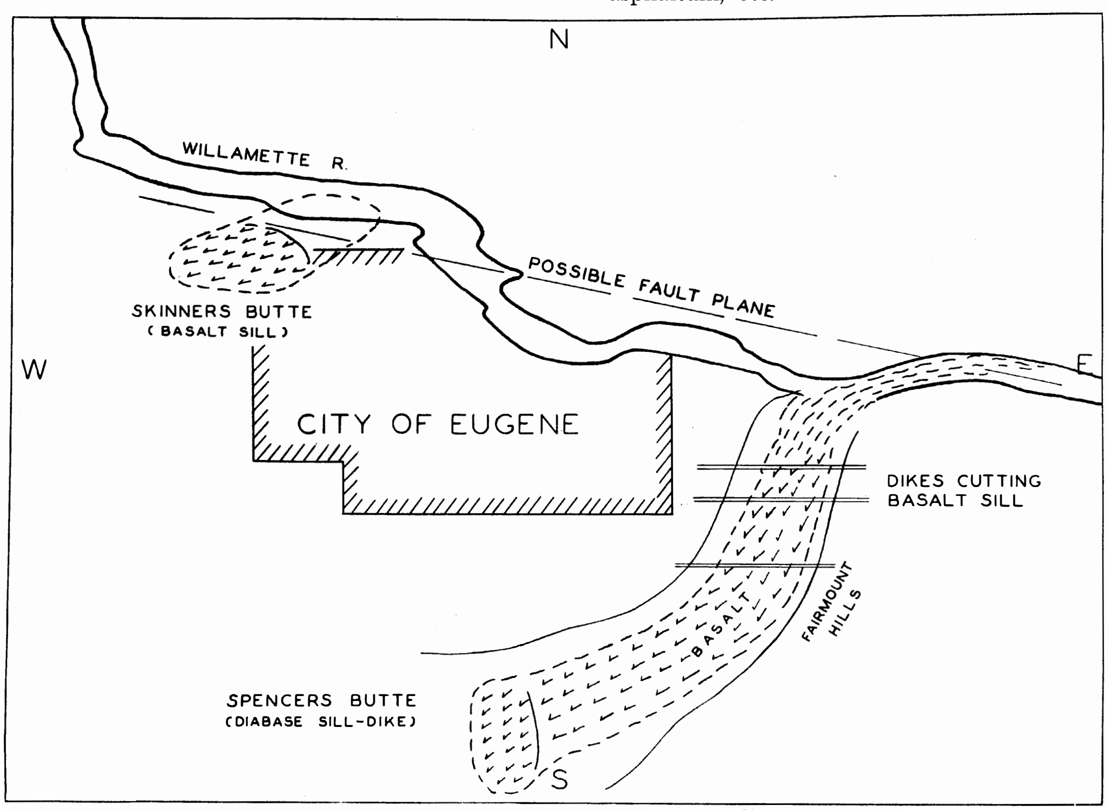


Figure 10—STRUCTURAL DETAIL NEAR EUGENE

It should be remembered that fossilization of animal and plant remains is more or less an accident and only a very small percentage of the organisms of a given period are preserved for future study and a still smaller percentage may be found, since such discoveries are for the most part a matter of chance. By far the commonest fossils are of (1) the invertebrates, such as sea shells, next (2) fossil leaves and (3) hard parts of vertebrates, fragments of bone, teeth, etc.

In Lane county are fossil remains representative of all three groups, vertebrate and invertebrate animals, and plants, but of the first group, the vertebrates, relatively few specimens have been found. These include the teeth and tusks of the elephant family, and a few sharks' teeth.

Below are given abbreviated descriptions of a few common genera and species from rocks of this area. Those who would like to have detailed descriptions of individual species are referred to the scientific papers by Bruce Clark, Ralph Arnold and others describing many identical species or similar forms from California and Vancouver Island where the Oligocene and Eocene have been studied in great detail.*

Very few good fossils of Eocene† age from this county have been determined owing to their poor preservation and general scarcity, but Schenck‡ found the following near the confluence of Coyote and Spencer creeks in sec. 11, T. 18 S., R. 5 W.:

Venericardia merriami Dickerson.
Glycimeris major (Stanton).
Turritella sp.
Tellina eugenia Dall.

A nearly perfect specimen of *Venericardia planicosta* var. *merriami*, which is the same as the one Schenck refers to, was found at the overhead crossing of the Pacific Highway near Comstock just across the line in Douglas county. This is shown in figure 24. As this is an index fossil of the Pacific Coast Eocene it is very important for students of Lane County geology to recognize it.

Turner*, a former student of the University of Oregon, has recently completed a rather exhaustive study of the Eocene of Western Oregon, in which he lists a number of species from the Spencer formation, and reviews Schenck's previous work. The serious student of the paleontology of this part of Oregon should by all means consult Turner's paper.

The technical student of the subject is referred to the original descriptions in previously published literature or to actual specimens in the collections of the University of Oregon and of Oregon State College.

Description of Species

Venericardia planicosta var. *merriami Dickerson* (fig. 24, No. 13):

This large, excellent specimen is a very important Eocene index fossil which was found in the cut on the north side of the overhead crossing near Comstock, just over the line in Douglas county. But other specimens not so well preserved have been found in the Eocene rocks of Lane county southwest of Eugene. This specimen measures 4½ inches in length and almost the same in height. It is a bivalve shell with strong radial ribs rounded or cordate. The lateral teeth are either absent or obsolete but in this specimen cannot be seen at all. It has very prominent anterior beaks, is also characterized by rather prominent growth lines, particularly near the outer edge of the shell. An end view of the shell gives the typical heart-shaped cross section so characteristic of the *cardium*. This is the only Eocene fossil figured in this particular plate of specimens.

Faunules of foraminifera, microscopic protozoans, have been found in the Umpqua and Tyee formations by investigators of the type localities, but no one, as far as known, has described any of these minute fossils from the rocks of Lane county. There is no good reason, apparently, why search for them in our local rocks should not yield many such forms.

Oligocene Period:

When Washburne published his bulletin on "Geology and Oil Prospects of Northwestern Oregon"§ twenty-four years ago, the Oligocene Period was not then generally recognized on the Pacific Coast and what he called Miocene then has since been fairly well established as being Oligocene. However that may be (and in some quarters there is still some controversy over the exact stratigraphic position of these formations), he collected extensively in the rocks of Lane county.

* University of California Publications in Geology.
† Turner, F. E., Stratigraphy and Mollusca of the Eocene of Western Oregon, Geol. Soc. of Am., Special Papers No. 10, 1938.
‡ Master's Thesis, University of Oregon.
§ U. S. G. S. Bulletin 590.

Some years later the present writer collected a suite of fossils from Smith's (not the writer's) quarry at the east entrance to Eugene and submitted them to Dr. Bruce L. Clark* of the University of California, who determined the following:

Amiantis mathewsonii, Gabb
Chione mathewsonii, Gabb
Sanguinolaria n. sp.
Panope astrellana, Conrad
Mesodesma sp. (?)
Spisula ramonensis, Packard
Spisula n. sp.
Solen n. sp.
Thracia condoni, Dall
Diplodonta n. sp. (?)
Tellina oregonensis, Conrad
Agasoma gravidum Gabb
Tellina eugenia
Natica n. sp.
Natica recluziana var., listed by Dall as inezana

Some of these are also found in the collection made by the writer at the city reservoir, College Crest, Eugene. It seems quite clear, then, that much that has been referred to the Miocene must be reclassified as Oligocene, if the California and Washington faunas are Oligocene. Quoting from the writer's earlier bulletin:†

"It will be noted that the genus *Solen* occurs in this list. Dr. Thomas Condon grouped quite a number of horizons, apparently, and called them 'solen beds'. According to Arnold's table, these so-called 'solen beds' ranged from San Lorenzo (Oligocene) to the Empire (Miocene). Of course, at the time Dr. Condon did his work, no great refinement and exactness was possible."

"A typical exposure of a similar sandstone, which is probably equivalent to that of the Smith quarry, is found on Reservoir hill, Eugene (the excavation for a new city reservoir on College Crest in the southern part of the city of Eugene). This locality has, perhaps, yielded the most perfect specimens of invertebrate fossils from this horizon anywhere in the state. Unfortunately, the opportunity to collect from this locality will not soon return. The writer was there at the time of the excavating (1915), and, with the assistance of school children, secured an excellent series of very perfect specimens, part of which was placed in the Condon Geological Museum at the State University. At the time a report for the press was issued by Prof. G. J. Mitchell and the writer, in the hope of counteracting foolish statements by ill-informed persons, and we repeat some of the report as then issued.

" 'The principal formations seen in our examination of the excavation for the new reservoir on College Crest are as follows:

" '(1) A soft, though fairly tough, tuff formation, formed by material blown out from some volcanic vent and later water-sorted.

(2) A much harder, blue sandstone, characterized by small, hard concretions about the size of large glass marbles, and containing many genera of "clams", which are listed below.

(3) Layers of finer material, a sort of shale. This is buff-colored, and contains harder concretions, which are more or less rounded, and shaped something like coal balls. There are plenty of iron stains, particularly along cracks and weathered surfaces, *but no sign of iron ore*, as stated in earlier press reports, anywhere around the workings.

" 'The deposit is of general and scientific interest because of the varieties of formations shown in a small area, the abundance of well-preserved fossils, and the fact that much interesting light is thrown on the past history of this part of Oregon. In the Miocene (or Oligocene), this part of the valley was under the sea. There were also active volcanoes either close to the shore or beneath the sea. There was subsequent upheaval, with folding and hardening of the sands and muds, making sandstones and shales, respectively, and then followed the undetermined hundreds of thousands of years of erosion; how many years, no man knows, and all estimates are, and can be, only guesses; certainly long before the earliest recorded history, which would still be comparatively recent, geologically speaking. More than this, we can not say.' "

"The following is a partial list of the forms found in the coarse bluish-gray sandstone:

Solen curtus, Dall
Dentalium substriatum, Conrad
Crepidula praerupta, Conrad
Spisula ramonensis, Packard
Spisula albaria, Conrad
Mactra
Saxidomus
Callista
Tivela
Cytherea
Caryatis (?)
Macoma molinana, Dall
Dosinia merriami (?) Clark
Natica
Fusus hecoxi (?) Arnold"

A suite of similar forms was collected by some of the writer's students in 1936 during the excavation for the new library building and heating tunnels on the University of Oregon campus. These

* Personal Communication.
† Salient Features of the Oregon Cascades.

are shown in figure 24. Below is a description of a few representative species:

Panope (Glycimeris) major Stanton, figure 24, No. 14:

This is a moderately large bivalve with the shells gaping considerably behind and to a lesser extent in front; surface concentrically sculptured with heavy growth lines. There is an obscure tooth in each valve which is usually not seen unless the shells are cleaned out or sectioned. This specimen, as well as most of those shown on this plate, was found during the excavation for the new library building, University of Oregon campus. The enclosing matrix in practically all of these shells is sandstone. The age of this shell as well as most of the rest of those to be described here are of Oligocene age. Compare with modern "geoduck"—*panope generosa* Gould.

Panope, sp. (figure 24, No. 16):

The writer has not found anything exactly like this form figured in the literature. It resembles somewhat some of the figured species of the genus Panope. It measures 1¾ inches in height. The specimen is not perfect but on portions of the shell still preserved shows fairly strong growth lines.

Lima sp. Clark (figure 24, No. 15):

The shell is moderate to large in size, equivalved with moderately convex beaks which are fairly prominent and overhang the ligamental pit. The anterior ear is about twice the size of the posterior ear in perfect specimens. When the shell covering is present it is smooth except that the dorsal marginal area is radially striated or ribbed. This specimen measures 1½ inches in height and about 1¼ inches from the posterior to the anterior margins.

The type of this species was collected by Packard about ten miles from Buxton, near Tillamook, and described by Clark in the University of California Publication, vol. 15, p. 84, plate 14, figs. 3 and 4. The specimen figured here came from the University of Oregon library excavation.

Solen eugenensis Clark (figure 24, No. 8):

There are many of these razor clams in the Eugene formation as well as at lower and higher horizons. The specimen figured here seems to correspond rather well to the one named above. It is long and narrow with a straight hinge line. The anterior end is somewhat rounded. The shells are generally thin. The length of this specimen is 2½ inches and the height or width, ¾ inch. The type form was collected near Eugene by H. V. Howe and described by Clark, University of California Publications, vol. 15, page 98, plate 22, fig. 1. This particular specimen also came from the new library excavation.

Cast of Bivalve (figure 24, No. 17):

This is a cast and therefore indeterminable, but is included here to show the preservation of many of these fossils. The genus can only be guessed at and perhaps is *Macrocallista.* This shell measures approximately two inches in length and 1⅛ inches in height at the beaks. This came from the heating tunnel excavation, University of Oregon campus.

Spisula hanniballi Clark (figure 24, No. 19):

There are many varieties of these bivalves. The shells are fairly large and somewhat triangular in shape. The surface of the shell is generally smooth except for some development of growth lines. These are quite common forms in the Eugene Oligocene. The length of this specimen is 2½ inches, the height 2 inches. Some of these attain 4 inches in height. This came from the library excavation, University campus.

Mulinea eugenensis Clark (figure 24, No. 21):

The shell is moderately large with fairly heavy beaks, anterior to the median line and only moderately prominent. The posterior end of the shell is rounded. The anterior end more acute. The surface is smooth except for heavy irregular growth lines. The length of this shell is 2⅛ inches and the height 1⅝ inches. The type specimen was collected by H. V. Howe about three miles south of Eugene, and described by Clark, University of California Publications, vol. 15, plate 14, page 104, figures 1 and 2. This specimen came from the library excavation, University campus.

Macoma (?) sp. (figure 24, No. 18):

This is a rather thin-shelled bivalve which is marked by delicate concentric growth lines and a prominent diagonal wrinkling of the shell forward from the beaks which produces a very definite groove. A form very close to the one shown here is figured by Dall under the name *Macoma molinana* from the Oligocene (?) at Miller's Beach, Oregon, south of the entrance to Coos Bay. Our specimen measures 1¾ inches by 1 3/16 inches. It was found in the library excavation, University of Oregon campus. This form also resembles fairly closely *M. andersoni* Clark figured by B. L. Clark from the California San Pablo group.

Agasoma gravidum Gabb (figure 24, Nos. 4 and 5):

This is one of the Buccinidae family. The body whorl is globose, the spire not very acuminate but higher than in Natica. The sculpture is featured by a series of nodes or low tubercules and spiral ribs and growth lines. The height is ½ inch and the width of the bottom whorl ¾ inch. This is a common form in the Lane county Oligocene. This species was originally described by Gabb in 1866 but has been refigured by Clark in the University of California Publications, vol. 11, page 182, plate 19, figures 1, 3 and 5. Our form was found in the library excavation, University campus.

Natica sp. (figure 24, Nos. 1 and 2):

Several species of this gastropod (snail) are found in the marine sediments of this region. These are typically globose, ovate or pyramidal in shape consisting of several whorls, sometimes with an acute spire but often depressed with the lowest whorl quite large. It is generally smooth shelled but in some specimens very finely striated. The specimens shown here are on the average 1 inch in height and 1½ inches wide in the bottom whorl. The shell has an unusually large aperture or mouth opening which is semi-circular or oval. Found in the library excavation, University campus.

Pyrula or Ficus (figure 24, No. 6):

This is a thin ovate to subglobular shell with low spire and swollen body whorl with elongated canal at the base. It has fine spiral growth lines with somewhat stronger longitudinal ribs. This species may have been described, but so far the writer has not been able to identify it more closely with any other forms figured in the literature available. The height of this specimen is 2 inches and the width 1⅜ inches. It was found in the library excavations, University campus. A form known as Pyrula papyratia (?), not greatly different from this, is found living today on the southeast Atlantic coast. Its common name there is the "paper fig shell".

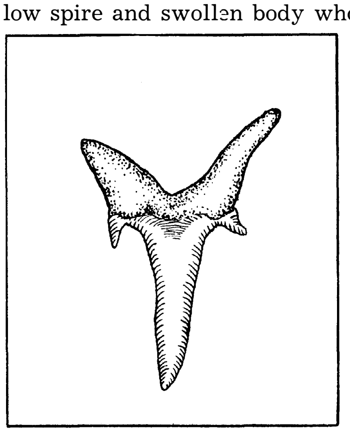


Figure 14—SHARK'S TOOTH (Approx. twice Nat. size)

Epitonium (Scalaria) condoni Dall (figure 24, Nos. 9 and 10 (?)):

This is a high, turreted shell with the whorls strongly arched and transversely ribbed. The aperture is oval. The height of the larger of the two specimens is 2½ inches and the width of the bottom whorl ⅞ inch. This specimen, which may reach a height of 4 inches, was found by Lloyd Ruff at Springfield, up-stream from the old wagon bridge about ¼ mile.

Crepidula sookensis Clark and Arnold (figure 24, No. 12):

This is the so-called "slipper shell", but rarely in the fossil specimens can the slipper-like arrangement of the internal shell be seen because the shell is generally filled with matrix. The shell is elongate oval, flat or arched. The aperture, or mouth opening, is greatly elongated. The form figured here is in general shape like *C. sookensis* of Clark-Arnold but somewhat smoother perhaps due to the fact that the outer nacreous coating of the shell is missing. This specimen measures 1¾ inches by 1 inch. The genus is long-lived, ranging from the Cretaceous to Recent.

Dentalium (figure 24, No. 7):

There are several varieties of these and they are quite common in Lane county sediments. They belong to the group known as the scaphopods, which is a special class of Mollusca. They are tubular, somewhat curved and regularly tapering throughout. They may be sculptured with longitudinal flutings or perfectly smooth, and are rarely found unbroken. The largest of the three specimens figured here measures 2¾ inches in length and has a diameter at the larger end or mouth end of ½ inch.

Some fragments of crustaceans (crabs) have been found in sandstone concretions, but those that have come under our notice have been usually too unsatisfactory for accurate determination. Rathbun*, of the National Museum, has, however, identified several specimens such as *Portunites alaskensis, Callianassa oregonensis,* and *Ranoides eugenensis.*

Vertebrates:

A few shark's teeth, referable to the genus *Odontaspis* or *Lamna* have been found in the sandstones in the vicinity of Springfield. One of these, about ½ inch long, is shown in figure 24.

Odontaspis, sp. (figure 24, No. 11):

This is a very fine, clean-cut little shark-tooth. The photograph, however, does not do it justice. A pen-drawing of this is given in figure 14. It is marked by two tiny lateral teeth or prongs scarcely ⅛ inch high. The central part of the tooth is ⅝ inch in length and width is ¼ inch at the base. This was found in the Oligocene sediments near Springfield Junction by David Drager. Another shark's tooth of this period, Notidanus primigenius ag., was found at the base of Springfield Butte by M. Doty.

Proboscidian:

Teeth, and fragments of elephant tusks, have been found in the vicinity of Spencer Creek and elsewhere in the Willamette valley fill. These probably belong to Elephas columbi which was plentiful in this area during the Wisconsin epoch of the Pleistocene. A tooth is shown in figure 26. These came from that portion of the fill referred to the Wisconsin by Allison. *

Fossil Plants:

Some excellent leaf impressions in Oligocene and Miocene tuffs, of a fairly compact, fine-grained, cream-colored variety have been found in several localities in this county as follows:

1. At Rujada, on Laying Creek, branch of Row river, ½ mile above the Ranger station. Miocene.
2. Goshen—1½ miles south on Pacific highway. Oligocene.
3. Jasper, in the railroad cut just north of the station. Oligocene.
4. Springfield Butte, in the saddle about ½ mile east. Oligocene.

The Goshen locality, through the work of Sanborn and Chaney, has become well known. Some of the species found here, figured and described by these investigators†, are the following:

Ficus goshenensis	Tetracera oregana
Magnolia hilgardiana	Cordia rotunda
Meliosma goshenensis	Anona prereticulata
Sapium standleyi	Quercus howei etc.
Inga oregana	

All of these have close affinities with living forms in the southern United States or Central America. Of this flora the authors† of the monograph cited have this interesting comment:

> "When the Goshen flora was first collected by the senior author in 1921, it was at once apparent that the species in it were unlike those in any of the previously described fossil floras from the western United States. A comparison of the Goshen leaves with those in the living forests of temperate North America and of northeastern Asia emphasized an equally wide difference between the fossil species and those now living in the higher latitudes of the northern hemisphere. In the course of a short trip into southern China and the Philippines in 1925, the general resemblance of the Goshen leaves to those of many paleotropical species was at once noted; the modern forests visited were made up dominantly of trees with firm-textured leaves of comparatively large size, and a facial similarity was apparent even though no great number of generic relationships were evident. With this suggestion as to a possible relation between the Goshen flora and the modern paleotropical forests, there was implied a corresponding resemblance to the modern low latitude forests of the Americas, and to the Eocene floras, described by Berry from the southeastern United States, which have their principal affinities with these neotropical forests."

A few similar forms from Goshen, recently collected by Lloyd Ruff, are shown on figure 25.

How to Collect and Preserve Fossils.

If one is collecting fossil invertebrates or leaves he should have a good prospector's pick, one or two moils or cold chisels, one with a flat edge, a stiff flat trowel, a light-weight sledge hammer, a light-weight crowbar, and an ordinary carpenter's saw or hack saw. If the specimens seem to be quite friable, enough rock enclosing the desired specimen should be removed and taken to the laboratory or work shop where with finer tools, such as some old dental tools, more careful removal from the matrix can be effected. It is well to coat with white shellac, or, better still, gum arabic, very fragile specimens, and wrap in cloth before removal.

Elephant teeth and tusk fragments are usually quite friable from weathering, or would soon become so if uncovered, and these should be treated with liberal applications of the above-named preservatives. In the case of extremely fragile speci-

* Science, Vol. 83, No. 2158, p. 442.
† Chaney, Ralph W., and Sanborn, Ethel I.: The Goshen Flora of West Central Oregon: Contributions to Paleontology, Carnegie Institution, Washington, 1933.
† Loc. cit.

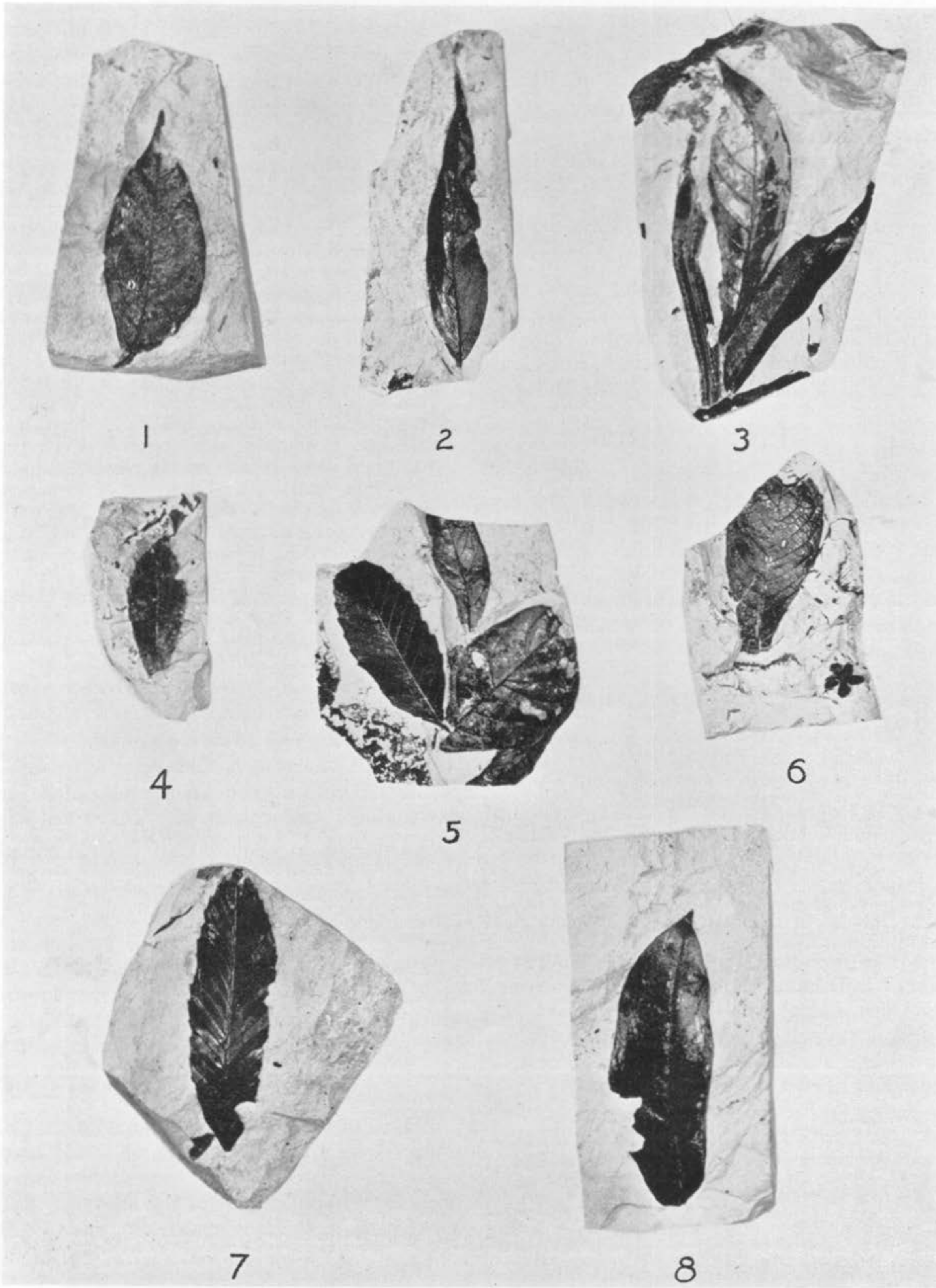


Figure 25—LANE COUNTY FOSSIL PLANTS (Approx. ½ Nat. size)

mens they may be swathed in wrappings of cloth dipped in flour paste. These will harden, but can easily be removed later by soaking in water. Plaster of Paris may also be used.

Careful notes of the exact locality and local conditions of enclosing formations should be made and as soon as practicable contact should be made with someone in the department of geology of the University or Oregon State College. Professor E. L. Packard, head of the Department of Geology at the latter institution, is the chief paleontology specialist in Oregon and has visited many of Lane county's fossil localities.

GOSHEN PLANTS, COLLECTED BY LLOYD RUFF AND FIELD GEOLOGY CLASS

Determined by Dr. Ethel Sanborn, Oregon State College.
Figure 25

			Family	Common Name
a.	F-1184.	Allophylus wilsoni	Sapindaceae	Buckeye Family
b.	F-1179.	Nectandra praesanguinea	Lauraceae	Laurel
c.	F-1180.	a. Laurophyllum merrillii	"	"
		b. Nectandra praesanguinea	"	"
		c. Fern with sori. Asplenium?	....	Fern
d.	F-1185.	Anona prereticulata?	Anonaceae	Custard apple
e.	F-1182.	a. Tetracera oregona (leaf on left)	Dilleniaceae	Fig
		b. Ficus goshenensis (largest leaf)	Moraceae	
		c. Chrysobalanus ellipticus (fragment)	Rosaceae	Rose
f.	F-1191.	a. Viburnum plamatum (flower)	Viburnum or arrowood	....
		b. Meliosma aesculiforlia	Sabiaceae	....
g.	F-1178.	Tetracera oregona	Dillenaceae	....
h.	F-1183.	Inga oregona	Leguminosae	Pea

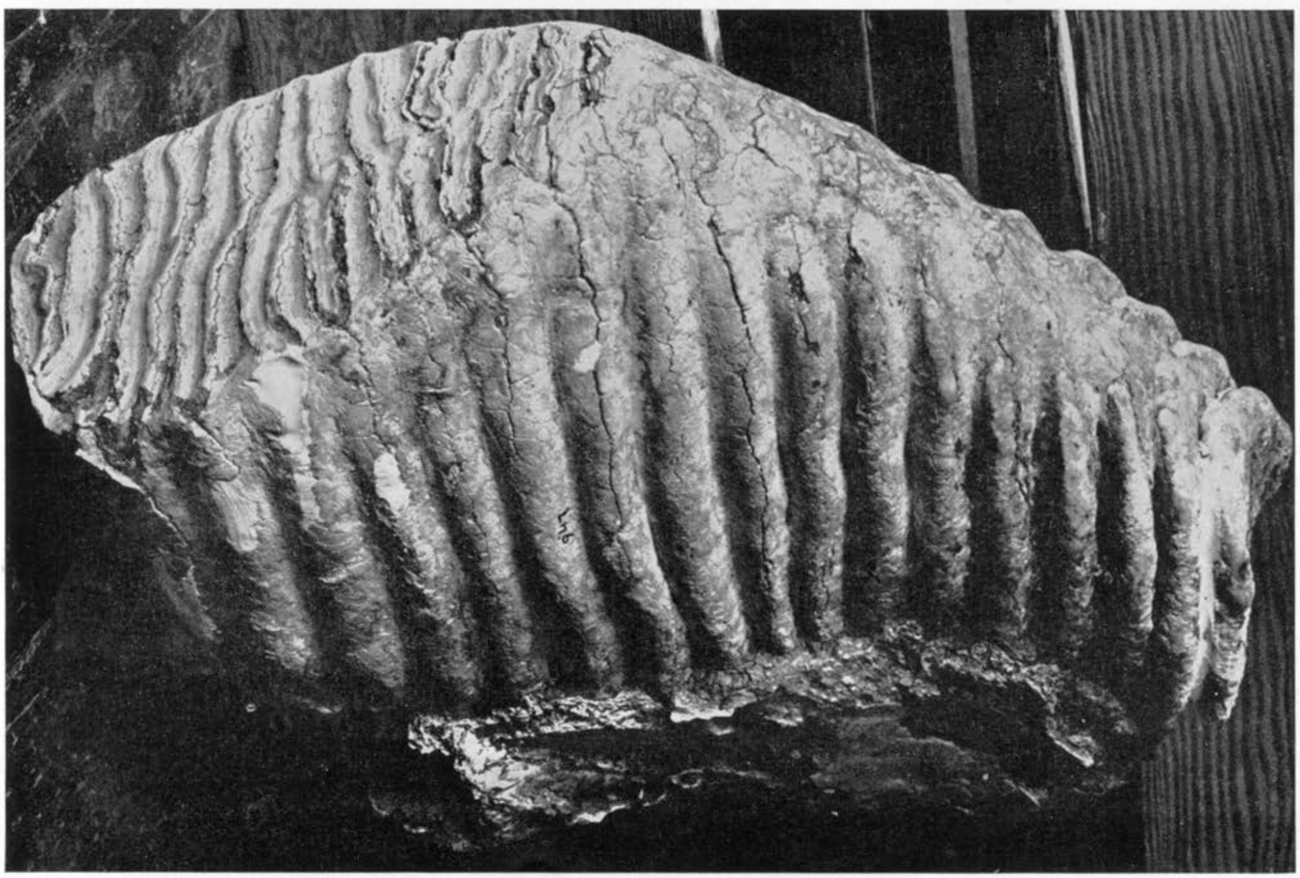


Figure 27—PLEISTOCENE ELEPHANT TOOTH (Approx. ½ Nat. size) (Photo by Dotson)

GEOLOGIC HISTORY

We have no knowledge of rocks exposed in Lane county which are older than those of the Tertiary period. Presumably they are concealed either by the younger sediments or the Cascade lava flows. As yet no stream has cut through the overlying rocks nor has the drill penetrated that far down. So there is no means of knowing the character of these underlying rocks. Somewhat to the south in Douglas county such older rocks are exposed, and by inference they should be found, although deeply buried, in Lane county.

Now as to the Tertiary, in the western part of Lane county and extending some distance east of Roseburg in Douglas county on the Umpqua, and as far east at least as Comstock in Lane county, Eocene sandstone is present with typical Eocene fossils of marine variety which indicate that at that time the seacoast was that much farther east than it is at present.

During the following period, known as the Oligocene, there was a shore-line running through the present city of Eugene, and along the east side of the valley at least as far as Brownsville in Linn county. These early sediments have more or less volcanic ash material intermingled with them, indicating vulcanism in the region to the eastward.

During the Oligocene there are indications of dry-land conditions near Eugene because there are in certain rocks very abundant remains of trees in the form of leaves and stems. Excellent specimens are found, particularly near Springfield, Jasper, and Goshen. Some very interesting work has been done on these fossil leaves by Sanborn*, who, in collaboration with Chaney, has concluded that the Goshen flora is tropical or subtropical. The close relatives of the Goshen flora are represented by trees growing today in Central America.

Beginning probably with the late Eocene, continuing through the Oligocene and very prominently in the Miocene, there were volcanic eruptions. At times these were violent explosions, that threw out great quantities of fragmental material, particularly in the Oligocene, to be followed by a more quiet welling out of lava flows in the Miocene. In fact, these have continued through the Pliocene and Pleistocene to recent times, building up the great superstructure of the Cascades.

Sometime during the Miocene presumably, or perhaps later, ore deposition occurred through the filling up of fractures in the rocks—gold-silver-copper-lead-zinc deposits in quartz veins in the high Cascades, and quicksilver deposits in the older lavas of the lower Cascades. With the upfolding of the rocks resulting in the raising of the Coast Range and the elevation of the Cascades, the sea withdrew to a position much to the west of where it now is, and later by submergence of the land has come back to its present position as it is today. The Pliocene was undoubtedly a period of more or less continuous vulcanism, and the area of this county was probably entirely above the sea.

In the Pleistocene the two dominant activities were *vulcanism* with very active volcanoes going full steam along the Cascade crest line, and *glaciation.* The periods of volcanic activity and periods of glaciation unquestionably alternated in the high Cascades of Lane county, as this story is rather complete in other parts of the range as, for instance, at Crater Lake. During all this time material was being eroded from the highlands and deposited in the valleys and on the continental shelf. This was a period of valley-cutting and valley-filling, sometimes one activity in excess of the other.

During the late Pleistocene there was presumably a backing up of water due to an ice jam in the lower Columbia, which caused rafting of boulders brought down probably from eastern Washington, for these erratics or wanderers are now found here and there on the Willamette Valley floor. Several hundred of them have been located, a number in Lane county. The history of these has been very thoroughly worked out by Allison†, and a few paragraphs from his report are quoted herewith:

> ". . . . What then were the circumstances which enabled the Columbia River to carry boulder-bearing icebergs and discharge them in the Willamette Valley and other tributaries? This question becomes particularly pertinent in the face of the fact that the erratics in Wil-

* Chaney, Ralph W., and Sanborn, Ethel I.: The Goshen Flora of West Central Oregon. Carnegie Institution Contributions to Paleontology, 1933.

† Allison, Ira S.: Glacial Erratics in the Willamette Valley, Bull. Geol. Soc. Am. 46, No. 4, pp. 625 and 626, 1935.

lamette Valley occur as much as 250 feet above the filling on the valley floor, in Hood River valley at least 125 and perhaps 275 feet, and to similarly great heights above the valley fillings in Umatilla, Walla Walla, Yakima, and other valleys tributary to the Columbia River. The explanation of these deep waters in these tributaries is thought to furnish the clue to the distribution of icebergs and erratics. . . . ."

"Apparently, flood waters, thus dammed up in the Columbia River Gorge to depths of 50 to 400 feet or more, poured out occasionally in sufficient volume to sweep across the Portland gravels and to rush back into the Willamette Valley through the gaps at Oswego and Oregon City, carrying gravel, silt, sand and icebergs along with them. This entrance into Willamette Valley was facilitated by the slope, the Portland gravels adjacent to the Columbia River lying mostly 200 to 300 feet above seal level whereas the Willamette Valley floor has been aggraded only to about 200 feet above sea level just south of the Oregon City gap and to about 150 feet above sea level near McMinnville, Oregon, 25 miles farther southwest. An equally important factor in reversing the drainage into the Willamette Valley (instead of out of it) and in producing unusually high backwaters probably was the presence of icejams (of icebergs and river ice) in the Columbia River Valley below Portland, Oregon. Such icejams and the water-ice-mixture released from Columbia River Gorge would impede the drainage and divert it into the tributary basin. Willamette Valley thus would serve as a sort of surge-basin, analagous to the surge-tanks commonly installed on penstocks to offset water hammer, so that periodic failures of the icejams in Columbia River Gorge would cause repeated flooding† sufficient to float icebergs into the valley. Glacial Columbia River would then furnish both the erratics and the impetus needed to get them through the gaps and past other obstacles into Willamette Valley . . . ."

The late Cenozoic history of this region is best seen on the coast where evidences of alternating submergences and emergences are plain. At an earlier time in the Miocene and Pliocene periods there was considerable submergence of the coast but in the Pleistocene apparently the dominant activity was emergence or elevation. But presumably, though there is no definite record of it, the coast in general is still rising very slowly. As evidence of the submergences we have the partial drownings of the lower portions of some of the rivers like the Siuslaw and the Alsea. In Coos Bay, Coos county, there is a more striking example—that of a drowned river valley, causing what is called a *ria* coast. As evidence of emergence or elevation there are several terraces which are now found well above sea level.

At the present time stream erosion is the dominant feature in the highlands of the county, but in the Willamette Valley proper sedimentation is the principal feature. Now, man is producing more rapid changes in the geology of the county than these agencies because he is removing hills, changing stream beds, making dams, stripping off the timber, and doing a number of things which speed up the work of the natural agencies.

Such in brief is the bare outline of the geological history of this region. Those desiring further details are referred especially to the Master's theses by Schenck and Campbell listed in the bibliography.

† This conception of the flooding of Willamette Valley by backwaters from glacial Columbia river so differs from Condon's theory of a Willamette Sound that in the writer's opinion the term Willamette Sound is misleading and should not be used for it. Further consideration of Willamette Sound is deferred to another paper. According to this interpretation the valley-fill is of river channel, flood-plain and lacustrine origin.

PHYSIOGRAPHY

WILLAMETTE VALLEY SECTION

From Eugene northward the Willamette Valley is a fairly wide, flat-floored valley in which the Willamette and McKenzie rivers meander through deposits of alluvium of varying thickness. On either side of these streams are typical *yazoo* tributaries (Long Tom, etc.), which have even more meandering courses. On the margin of the valley are buttes, such as Skinner's Butte, standing somewhat isolated from the higher lands to the eastward and westward, and typical foothills which are a part of the mountain ranges on either side. Owing to the obstruction of lava at the falls of the Willamette (Oregon City) the Willamette river has been halted in its down cutting, is at a temporary base-level, and has many of the characteristics of an old-age stream.

The finding of glacial erratics widely scattered over the valley floor and its quite level surface between Eugene and Harrisburg early led Dr. Thomas Condon to the theory of a Willamette Sound during the Pleistocene period. Later modifications of this theory were discussed in the preceding chapter.

One of the most conspicuous features of the Valley physiography within Lane county limits is the braided or anastomosing channel of the main stream.

From the focal point of Eugene can be noted several other features of interest and importance. First, and perhaps most important, is the junction of several tributaries near this point: the Coast Fork, Middle Fork, McKenzie and Mohawk, all of which streams come into the master stream within relatively short distances. This fingering out of the main valley near where Eugene is today is that city's chief asset, for it has made this place a natural distributing point for commerce.

Second, it will be noted on the map that the river, which has in general a south-north course, assumes an east-west direction at Eugene. This may be due to some structural control, perhaps an east-west fault from Eugene to Springfield.

The third notable feature is the rather abrupt difference in gradient in the eastern tributaries as compared with that of the main stream north of Eugene. This last is of particular importance in the local flood problem, since by the sudden

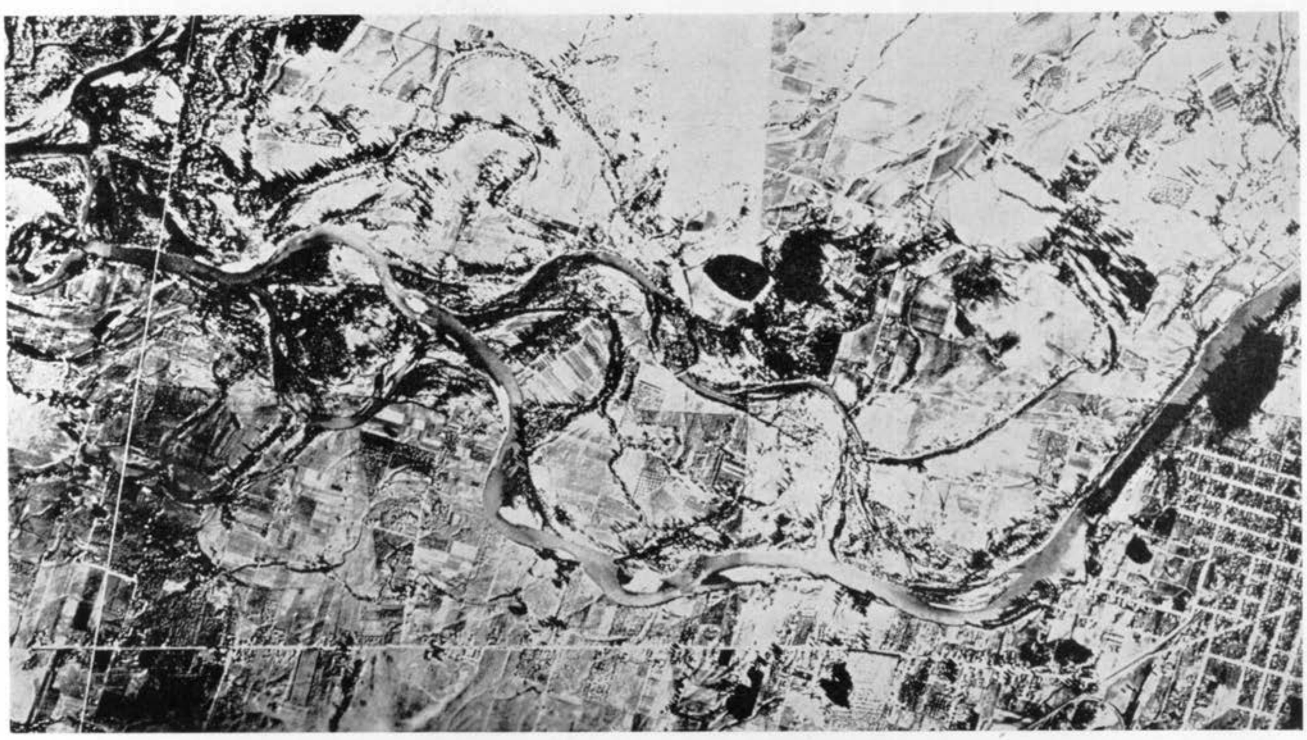


Figure 16—WILLAMETTE RIVER (Brubaker Aerial View)

checking of stream velocities it causes the deposition of the coarsest debris, such as gravels and boulders over good farm lands.

On the margins of the valleys in places we note one or more well-defined terraces and alluvial fans, the soils of which differ in age so that there results considerable differences in their value for agricultural purposes.

The valley, as it is today, is the result in part of structural features, easterly-dipping monoclinal beds with lava flows on the eastern side forming abrupt slopes to the west. This structural trough was widened and deepened by normal river erosion. Later filling of this trough by ordinary river alluvium and glacial silts causes the present general condition of the valley.

The present facial expression of the valley is due in great degree to the events of the Pleistocene and Recent, which may be considered under two heads: (a) The normal aggrading of the river in which deposition of detritus from the adjacent mountains was dominant, and (b) glacial filling.

These two types of material constitute the valley fill. All of this material is relatively loose and unconsolidated as compared with the more compact and older sedimentary beds constituting the foundation of the valley.

On the basis of his quite thorough study of the Pleistocene history of the valley, Allison* furnished the following notes concerning the Pleistocene physiography and history of the valley:

> ". . . . The main elements of the topography of Willamette Valley had been developed by early Pleistocene or Glacial time. Let us continue the history from that time. The Pleistocene may be characterized as a time of multiple glaciation with several ages of glacial advance separated by long intervals of relatively mild climate. Probably the semilateritic hill soils were formed mainly during the interglacial ages under conditions of comparative warmth and moisture even more favorable than the present. Oregon was not invaded by ice sheets from the north as the Puget Sound glaciers did not reach farther south than Chehalis, Washington. The only glaciers in Oregon were confined to mountain valleys. Although the ice tongues in the upper ends of McKenzie, Santiam, Molalla and Clackamas valleys were 20 to 30 miles or more long and one in Sandy River valley reached almost to Troutdale, Oregon, the ice did not reach the open lowland of Willamette Valley. Instead, the principal effect of these glaciers was to cause the outflowing streams of melt water to be so heavily laden with boulders, gravel and sand that they partly filled the lower ends of these valleys with gravel to depths of hundreds of feet. These valley fillings extended out onto the Willamette lowland and merged with one another as a great sheet of alluvium. When the ice disappeared the streams set to work again to remove the gravel deposits and to erode their valleys still deeper. Fortunately for our record, the task was still unfinished when glaciation set in again and interrupted the process, so that some of the earlier gravels were left as benches or terraces. Then this sequence of events was repeated. As the intervals between glacial stages became shorter and the glaciers became successively weaker, the deposits of glacial outwash (with one exception) form successively lower terraces that reach farther upvalley, and the soils developed upon these alluvial deposits show less and less weathering with decreasing age.
>
> Alluvium corresponding to the first glacial age, commonly called the Nebraskan age, has not been identified in Willamette Valley with certainty, but from analogy to the later deposits, a deeply weathered gravel deposit as, for example, on the hilltops in T. 6 S., R. 6 W., Polk county, is tentatively assigned to that age. On the soil map the area is shown as Salkum soils series. The comparative maturity of the soil is a testimony to the great length of time the material has lain in its present position—time enough for the surrounding areas to be lowered by erosion about 200 feet.
>
> Gravel deposits of the second or Kansan glacial age form well-defined terraces along the valleys coming out of the Cascade Mountains and benches along the margins of Willamette Valley lowland at elevations of about 300 feet above sea level. Presumably the whole lowland was once filled to that level with similar materials that were eroded away during the subsequent interglacial age. The deposits remaining lie mostly on resistant rock or in protected places where streams could not readily undercut and destroy them. Examples of these deposits on the east side of Willamette Valley occur on Sand Ridge near Lebanon, at Gilkey, above Lyons, on Cemetery Hill at Jefferson, near Aumsville and near Molalla. Those on the west side of the valley include several square miles immediately northeast of Dallas, the high bench along Mill Creek near Buell and a small patch in the Yamhill river basin about three miles northwest of Yamhill. On the county soil maps these areas are shown

* Personal Communication—excerpts from Proc. 22d Ann. Mtg. Western Nut Growers Association, December, 1936.

mostly as Salkum soil series. Along the edges of the terraces these gravels have been oxidized to depth of 20 to 30 feet and pebbles of basalt and andesite have been softened to clayey consistency to depths of as much as 10 feet and those from greater depths can be broken readily in the fingers.

Deposits of the third or Illinoian glacial age are young enough to be well preserved. They include extensive, well-developed gravel terraces which spread out as they leave the canyons and coalesce as large alluvial fans on the floor of the Willamette Valley lowland, such as the fans of Molalla river near Molalla, North Santiam river west of Stayton, of South Santiam river between Lebanon and Albany, and of Willamette river proper north of Eugene. Equivalent fans of Rickreall creek, Luckiamute, South Yamhill, and North Yamhill rivers and Gales creek were much smaller and are now largely concealed by a later deposit on top. The gravels of this age are oxidized to red and brown colors to depths of 10 to 15 feet or more or about half as much as the Kansan. In the soil zone the pebbles are entirely decomposed; only resistant pieces of chert, agate, etc., remain. The pebbles are softened and crumbling at depths of several feet and the fine material between the pebbles has rotted sufficiently to prevent free flow of groundwater. In wet areas a clay pan two to three feet thick has developed in the subsoil. Typical soils are the Clackamas and Holcomb soil series.

The time interval between the third and fourth glacial ages was not long enough to permit the streams to remove much of these gravels. Before erosion had gone very far the trend was reversed and deposition began again. The deposit of the Wisconsin or fourth glacial age is thickest in the northern part of the Willamette Valley where its surface is 150 to 200 feet above sea level as at Hillsboro, McMinnville, Dayton, Woodburn, etc. Toward the south and about the edges of the valley it overlaps older rocks to elevations between 350 and 400 feet above sea level. The bulk of the material is silt and fine sand, but it also includes blocks and smaller fragments of foreign rocks such as granite and quartzite that evidently came down glacial Columbia river, which apparently built up its bed and spilled back to Tualatin valley through the gap at Oswego Lake and into the main part of Willamette Valley through the gap at Oregon City as shown by the type of material and the foreset bedding oriented away from these gaps.

On the lower slopes of the hills near Lafayette and Dundee these gray silts with a comparatively youthful soil developed on top may be seen to overlie the older, deeply decomposed basalts. Near Forest Grove, Silverton, Sheridan, Albany, and Harrisburg a buried soil zone separates these silts from the underlying older gravels.

Typical soils on these silts are the Willamette, Amity and Dayton soil series—the Willamette in well-aerated soils which are brown to depths of 4 to 5 feet, and the Dayton in waterlogged areas which have developed a subsoil claypan one to one and a half feet thick. The moderate weathering of these deposits indicates

Figure 26—PLEISTOCENE GRAVELS (McKenzie River)

that they are not very old as compared with the other alluvial deposits.

Since the fourth glacial age the streams have cut valleys generally a half mile to two miles wide through the alluvium on the valley floor. Within these valleys occur one or two levels of so-called 'bottom land'. These bottom lands carry Chehalis and Newberg soils principally. These soils are so young as to show little effect of weathering in place. What weathering is shown was accomplished before the materials were washed into their present positions. . . . ."

With this comparatively young deposit or series of Pleistocene glacial deposits covering the older valley alluvium the old-age base-level features are modified by a youthful stage of the river which is now in process of reworking and moving away these younger deposits.

Since these detrital materials of whatever origin are relatively loose and little indurated the river, even in stages much below flood stage, finds it easy to erode whether it be by scour or lateral wear.

There are especial features of the valley floor which arise from the kinds of materials constituting the valley fill and the geological stage which have a particular bearing upon the flood problem of this river. They are:

1. The flat-floored condition of the upper valley due to temporary base-levelling.
2. The intricate network of channels and abandoned water courses resulting in the braided or anastomosing type of stream.
3. Natural levees along the river bank which make for poor drainage and in turn cause features under 4 and 5.
4. "Yazoo" streams such as the Long Tom, Muddy, and others.
5. Meanders and "ox-bow" lakes.

THE COAST RANGE SECTION

From Cheshire westward one leaves the flat-floored valley and passes quickly into the foothill section of rolling mature slopes. Within a few miles, the road westward leads into more rugged terrain and very shortly into mountains of rather moderate height. The main road (Junction City to Florence) follows up several valleys, those of Long Tom and Bear creek, to the summit at 1,142 feet. From this point it descends Lake creek, thence via the Siuslaw to the coast. The Coast Range consists of the peneplaned and uplifted, moderately folded, Tertiary sediments in which these streams have been deeply entrenched. If one stands upon one of the many ridge tops he will note that all but a few come up to a general level and they are referred to as *accordant ridge tops.* Another important physiographic feature in this connection may be noted which has significance, namely, the valley-in-valley profile. The upper and wider cross section is a mature valley profile produced in an earlier cycle. The lower and more V-shaped cross section is due to the uplift of the region as a whole which has resulted in rejuvenated streams. Standing above the general level of the Coast Range ridges are a few monadnocks of harder rocks like Mary's Peak, lying just to the north of Lane county. The relation between the structure of the folded sediments of the Coast Range and topography is well shown as one crosses the mountains along the road mentioned above. At the summit one finds the rocks tilted at a comparatively high angle, while on either side of the Range the sediments show progressively decreasing dips with the distance from the crest. Though not a high barrier the Coast Range is high enough to have an important effect upon rainfall, the heaviest precipitation being upon the western slopes.

THE COAST SECTION

The Oregon coast in general and Lane county's portion of it in particular present five features worthy of especial note, though they are by no means unique.

First, the almost entire absence of a coastal plain. In a few stretches a very narrow interrupted plain not more than a mile or two in width can be found. This is in great contrast to the extensive coastal plain on the Atlantic side of the continent.

Second, a few wave-cut terraces, though better examples of these are to be found on sections of the coast outside of Lane county.

Third, the bold headlands composed of hard, resistant igneous rock, as at Heceta Head and the broad sweeping beaches between these due to marine erosion of less resistant rocks.

Fourth, the dunes which are of at least two generations, the older Pleistocene dunes, rather well covered with vegetation, and fairly stationary, and the younger dunes of the Recent Period which are comparatively bare of vegetation and are constantly shifting in position and shape. Some of these latter are close to two hundred feet in height. The best examples along the Lane county coast are just south of the mouth of the Siuslaw river.

Fifth, the picturesque coast lakes which are for the most part either stream valleys which have been dammed by dunes or are irregular depressions in the dune country.

The Oregon coast in general, and this applies to the Lane county portion of it as well, is seen to be a *composite* coast, when certain features of an emerging coast are added to those of a formerly submerged coast, for we have both partly drowned river mouths and terraces. The former indicates subsidence while the latter point to elevation. In some places the coast is being retrograded (cut back on the headlands) and in other prograded (built up) by spits and bars.

THE CALAPOOYA MOUNTAIN SECTION

Calapooya mountains form a connecting link between the Coast Range and the Cascades and cannot be sharply differentiated from either. Made up for the most part of Tertiary sediments and related intrusive igneous rocks, basalts, and andesites, they are the result of folding and faulting, peneplanation and later dissection by rejuvenated streams. They do not seem to present any definitely regular pattern. The topography is in that stage usually designated as maturity.

THE CASCADE MOUNTAIN SECTION

The eastern part of the county is made up almost entirely of lavas and associated pyroclastics which extend for about eighty miles from near Eugene to the eastern boundary of the county on the summit of the Cascades. This eastern half of the county is a well-dissected lava plateau in the stage of late youth or early maturity. The streams flowing down the western slopes of the Cascades are generally deeply incised in valleys which in their lower courses are V-shaped, while in their upper reaches they occupy broad U-shaped valleys due to glacial action. They have for the most part quite steep gradients and are characterized by rapids and some waterfalls.

The eastern border of the county comprises the High Cascade country where such erosion as has taken place is mainly due to ice. This high country is characterized by volcanic flows and volcanic cones of relatively recent origin. The volcanic peaks rise as quite prominent superstructures upon a general constructional plateau surface. Many beautiful lakes occupy irregular depressions on this high level surface. Some of the volcanic cones show relatively little dissection, others are in advanced stages of erosion.

The largest glacier in Oregon, Collier, about 1½ miles long, is found on the west side of the North Sister peak. In all there are 15 glacier remnants in this area.

Beginning at Eugene and following up the McKenzie to the summit of the highest peaks, one would pass through four quite different kinds of physiography. In the lowermost section is a normal river valley in volcanic formations with dendritic drainage pattern. Next there is the upper valley section formerly occupied by glaciers with their characteristic U-shaped cross sections. Third, there is the plateau surface characterized by relatively old lava flows and lakes. The fourth section is that dominated by volcanic peaks and glaciers.

In this highest section, in the region of the Three Sisters and neighboring peaks, Hodge* found evidence of a former ancestral volcanic mountain of stupendous proportions, much larger than any peak now found anywhere in the entire Cascade range. This he thinks was destroyed by a gigantic explosion of krakatoan magnitude and in the caldera of which the later Three Sisters peaks were built up. To this ancestral mountain he gave the name Multnomah. The evidences for this explanation of events in that area cannot be given in this paper, and the reader is referred to Hodge's* very interesting monograph on the subject. It must be kept in mind that Hodge has studied this area more intimately than anyone else and, until we have done as much work in the field on this problem, any contrary view cannot be given as much weight as if it were backed by more study. The present writer, from his own many trips into that region and from a view of this area from two of the highest peaks, is inclined to differ somewhat with Hodge in his interpretation. It is hoped that students who come after us will eventually find more facts upon which we may base a final and conclusive verdict. However we may differ in some of

* Loc. Cit.

these interpretations of the physiographic history of this summit area, we are deeply indebted to Hodge for much detailed study of the glacial features and the rocks found there. His is a most valuable contribution.

From our rapid survey of the physiography of the entire county it is plain that there is a rich variety of terrain from the coast section to the lofty volcanic peaks on the eastern boundary of the county affording a tremendous range of topographic forms and some exceptional scenic features.

In a subsequent chapter we shall discuss the outstanding scenic features which result from these diverse land forms.

In closing this chapter the importance of three things in the devlopment of land forms should be emphasized:

a. The kinds of formations, hard and soft rocks.

b. The structure or attitude of these formations.

c. The geologic stage in which we find them at a given period in their geologic history.

From this it can be seen readily how much more comprehensive is the physiographic interpretation of a given area than a mere empirical description of its topography and hydrography. If this is clearly understood it can be seen that our land forms today are the result of *continual* transformations of landscapes of earlier epochs, and that with the passage of time still other land forms will appear. Of course this process is relatively slow. In a single human lifetime little change will be noticed. Only one with some geological training will be able fully to appreciate this evolutionary process. The geologist can see not only the present landscape but in his mind's eye he can reconstruct and restore long vanished landscapes. This makes his work the more interesting.

SOILS

The subject of Soils can be thoroughly understood only upon the background of the geology and climate of a region and therefore we are in a position now to discuss this, the most important topic in this treatise. First and last and all the time soils are the most important geologic product. Neither gold nor silver, iron nor diamonds, nor for that matter any other mineral substance, is so important. Once our soils are depleted or washed away our civilization will completely change or disappear.

Lane county has a great variety of soils as can be seen by a glance at the Bureau of Soils map of this county. However, this soil map, excellent as it is for purposes of the agriculturist, is of limited use to the geologist because he first considers the parent rock from which the soil may be derived, and he likes to refer to soils by such names as will show the connection between the two. But many of the names on the Bureau of Soils soil map are merely local, and without a good memory they tell one little.

However, another consideration other than the parent rock comes into this subject of soils which is of great importance, and that is climate. The Russian pedologists, or soil experts, claim that the parent rock has little to do with the type of soil and that climate is the main factor. This writer believes that both should be taken into consideration. Certainly we find some soils in Lane county that are directly connected with the rock mantle; that is, they are *residual* soils due to the decay of the underlying rock. Others are *transported* soils brought down by the streams, such as the sandy loams in the river bottoms. Other soils are in part of glacial origin such as those in the high meadows of the Cascades, and even some of the materials in the alluvium of the main valley floor have been derived from distant glacial sources, erratic material brought down by ice rafting during the time of the damming of the Columbia and the Willamette.

Age and climate, both affecting the maturity of the soil, are of vital consequence as can be shown in a study of the various soil types in the Willamette valley floor.

The following general scheme of soil types in Lane county is based partly upon parent rock, partly upon climate, and with, as far as possible, the Bureau of Soils terminology for the guidance of those who may be more familiar with the soil map. (Fig. 5).

As one studies the soils of this region several things should be noted. First is the spotty character of the soil pattern with quite different types of soil within short distances of each other. This points conclusively to the great necessity for diversification in crops to make the best use of the greatly diversified soil types.

A second feature which has economic importance is the maturity of the soils in different locations. For instance, the soils only recently deposited on the lowest level of the valley floor are less mature, and therefore not as good as the older soils on the higher benches along the sides of the valley.

A third point to note is that certain soil ingredients, such as lime, are deficient locally, and this goes back primarily to the geology of the region. For a more detailed discussion of soils of this region the reader is referred to the Soil Survey of the Eugene Area.*

Still another feature of the soils not only of Lane county but of Western Oregon in general, which is of much importance to geologists and miners, is its considerable depth in places. This is due to deep weathering of the rocks under conditions of humidity prevailing in the region. This heavy deep soil mantle often conceals the rocks below and thus impedes the work of the men who are primarily concerned with a study of the rock formations in a comparatively unaltered condition.

Figure 5—SOIL SCHEME OF LANE COUNTY

A. Simplified soil classification primarily based upon geological considerations.		B. Local soil types.
I. Residual (in situ) soils ...	a. Derived from the weathering of sandstones and shales	Carlton, Melbourne and Sites.
	b. Derived from the weathering of lavas	Aiken, Olympic, Polk and Viola.
II. Transported Soils	a. Deposited by streams eroding formations of interfluvial areas ..	Amity, Clackamas, Concord, Dayton.
	b. Derived from glacial materials.... 1. Outwash morainal. 2. Glacial silts in old "Willamette Sound"	Holcomb, Salem, Salkum, Veneta and Willamette.
	c. Lacustrine (lake) or paludal (swamp) soils	Cove and Wapato.

ECONOMIC GEOLOGY

Lane county's premier industry is lumbering, second comes agriculture, and third is mining. Among the minerals mined quicksilver at present easily leads. The Black Butte mine is the second producer of the state and Oregon ranks second only to California in the United States in the production of this metal. Besides quicksilver there are deposits of gold, silver, lead, copper and zinc of which at times there has been fair production, especially in gold. Copper has never been produced in any considerable quantities. An arsenic deposit of problematical value, owing to lack of a nearby market for this substance, has been discovered recently, but there is no production as yet.

Among the non-metals are clay deposits, which have been worked only to a limited extent. The annual production of sand, gravel and crushed stone is rather large, but no accurate statistics are available at this time.

There are in the county several mineral springs which have economic value.

It seems likely that there will be some increase in quicksilver production if the demand for this metal continues and there should be an increase also in gold and base metal production, although at the present time it is not prospering for reasons to be discussed later on in this report.

The clay deposits, especially refractory clays, apparently hold some promise for early development.

Hopes for both oil and gas were entertained some years ago by persons having little knowledge of the requisite conditions for the accumulations of such substances. At present there seems little justification for thinking that these substances will ever be found in this part of the state in commercial quantities.

From time to time coal deposits have been reported but investigation has always shown that the seams were too thin to have any value.

* U. S. Dept. of Agr. Bur. Chem. & Soils, No. 33, series 1925, E. J. Carpenter in charge (Map).

THE METALS

Quicksilver

The only producing quicksilver mine in the county is at Black Butte near the southern limit of the county. It is in a small mountain of altered andesite lying between the east and west forks of Garoutte creek about five miles almost due south from London Springs in NW¼ sec. 16, T. 23 S. R. 3 W. (15 miles south of Cottage Grove). It is well described by Wells and Waters* and by C. N. Schuette.†

First, to quote Elmer§ on the history:

> "The principal vein in the district was discovered in the early nineties. Prior to 1900 only a small amount of development work was done on the property, and the equipment for the reduction of the ores consisted of a 40-ton Scott-Hutner furnace with series chamber condensers operated by natural draft. In 1898 the property passed into the hands of W. B. Dennis, who, in succeeding years up to 1908, extended the workings of the former holders and opened new levels. A total of 15,000 feet of development work was done. The property lay idle until 1916, when, due to the high price of quicksilver, it was operated by a substantial mining organization under lease and bond until April, 1919. During this active period the Scott-Hutner furnace was rehabilitated and the natural draft altered to an artificial down draft furnished by two 42-inch suction fans, increasing the capacity about 25 per cent. An improved dust chamber, an intermediate water-cooled cast-iron pipe condenser, an elaborate supplementary condenser constructed of brick and concrete, and 18-inch clay pipes, water-sprayed, were also added.
>
> Due to the fall in the price of quicksilver at the close of the World War, the property was closed down in 1919 and remained idle until 1927. Operations were resumed in the fall of 1927 under the management and ownership of the Quicksilver Syndicate. The old Scott-Hutner furnace has been dismantled and replaced by two rotary furnaces, each 60 feet in length and 4 feet outside diameter, having a normal combined capacity of 150 tons per 24 hours."

This property is in full operation at the present time and there is every indication that it will continue to do so for some years to come.

Geology of the Deposit:

The predominant rocks of the district are andesitic lavas, presumably of late Eocene or even later age, but quite distinct from the later andesites of the Cascades. In the region of Black Butte and the nearby Elkhead Mine (across the line in Douglas county) this andesite has been extensively and profoundly altered by hydrothermal action probably at the same time as the deposition of the cinnabar. So completely has this alteration been in some localities, as in Hobart Butte (about three miles to the NW.), that it is difficult at times to recognize the original rock. According to the report of Wells and Waters:*

> ". . . . Silica-carbonate veins, weathered at the surface to brown iron-ribs, are of almost universal occurrence. They are thickly massed in the brecciated and locally silicified andesite adjacent to a well-defined fault that strikes (trends) approximately S. 69° E. . . . . . . Rock containing sufficient amounts of cinnabar to constitute ore occurs in a zone adjacent to this fault. . . . . Oxidization and leaching by surface waters have affected the silica-carbonate gangue of the Black Butte deposit more or less to a depth of nearly 1,000 feet and very noticeable changes in the appearance of the rock have been produced. . . . . The vertical extent of the quicksilver deposit at Black Butte is noteworthy. Mining operations have disclosed the presence of workable material at a depth of 1200 feet along the dip of the fault, though this ore has not yet been proved to be continuous with the ore at higher levels."

An interesting feature of the geology of this deposit is the 30-foot thick body of calcite vein material exposed in the Dennis Creek tunnel 666 feet below the "China stope". This calcite was formed through the agency of solutions during and after the deposition of the cinnabar, derived from adjacent though concealed limestones.

The principal minerals in these deposits are cinnabar, siderite, chalcedony, calcite with minor amounts of sericite, marcasite, chlorite, very rarely metacinnabarite and native quicksilver. In the oxidized upper workings secondary limonite is common.

Tenor of the Ore:

Few of the ore bodies run over five pounds to the ton and on the average about four. Under prevailing conditions less than 3½ pounds per ton can hardly be mined with profit.

The present writer visited the Black Butte mine on May 21, 1938. There is little to add in the

* Wells, F. G., and Waters, A. C.: Quicksilver Deposits of Southwestern Oregon: Bulletin 850, U. S. G. S., Wash. (1934), pp. 26-33.
† Schuette, C. N.: Quicksilver in Oregon. Bulletin No. 4, Oregon State Dept. of Geology & Mineral Industries (1938), pp. 137-145.
§ Elmer, W. W.: Mining Methods and Costs at the Black Butte Quicksilver Mine, Lane County, Oregon: U. S. Bureau of Mines Information Circular 6276 (1930).
* Loc. Cit., pp. 29-31.

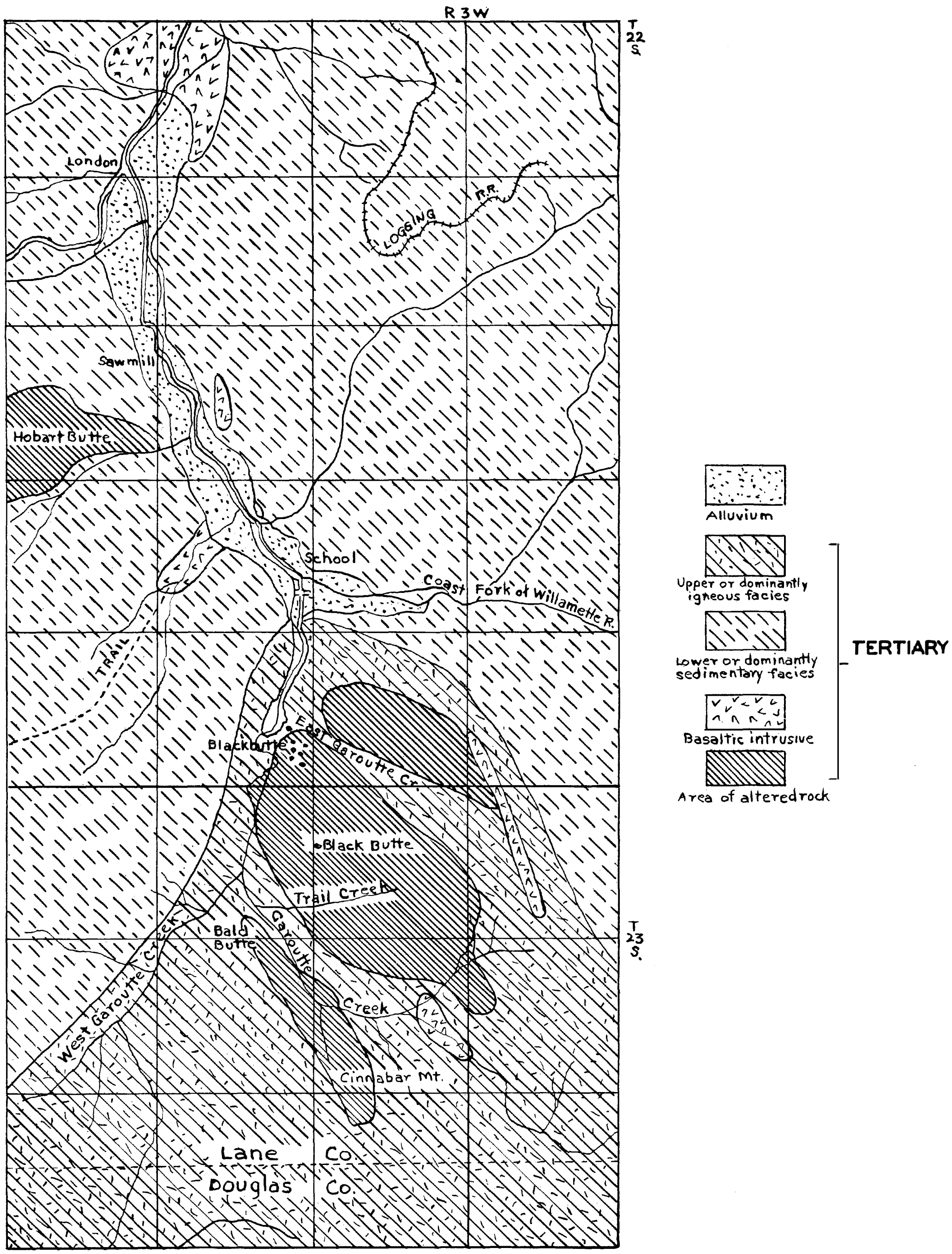


Figure 12—GEOLOGIC MAP OF BLACK BUTTE DISTRICT (from U. S. G. S. Bull. 850)

matter of detail to the observations made by Wells and Waters or Schuette. At present the work is being carried on on the 900-foot level and between the 600 and 400-foot levels in the main workings. However, on Dennis creek near the entrance to the Dennis Creek tunnel, there is some new work on a rich stringer just across the creek. It is too early as yet to say how this will turn out.

The economic situation with reference to this mine is very important and interesting, and it may throw light upon other quicksilver operations in the state. Owing to competition from the Italians who practically control the market, this mine has, as this is written, seven months' production unsold. At present the price varies from $69.50 to $72 per flask* (76 pounds to the flask). The price in 1929 went as high as $121 a flask. In 1932 in the worst of the depression, it dropped to $55 a flask. The superintendent, Mr. Mills, thinks the price should be at least $100 to enable investors to get returns upon their investment.

Gold and Silver

Gold and silver have been mined more or less profitably in two districts: at Bohemia and Blue River, with extensive prospecting and some development in three other localities: Windberry, Oakridge, and McKenzie Pass. At the present time there is practically no gold or silver production from any of these districts though some development work is going forward on the Champion property in the Bohemia district.

This district was first studied systematically by the U. S. G. S. by Diller† in the late 1890's, and again about 1908 by Donald MacDonald and again by Buddington and Callaghan in 1930. While many private engineers and geologists have been in the district very few of their reports, if any, have been published. The present writer has visited the district for short periods on four different occasions, the last being in June of this year (1938).

Diller's‡ statement:

> "The Bohemia mining region was discovered, according to Dr. W. W. Oglesby, of Junction City, Oregon, by himself and Frank Brass, in August, 1858. The region was named from James Johnson, also called Bohemia Johnson, who, with George Ramsey, reached it in 1863 from Roseburg by way of the North Fork of Umpqua river and Steamboat and City creeks. Free gold was found in a small vein near the headwaters of City creek, but gave out at a depth of 6 feet. This discovery brought many prospectors. Bird Farrier discovered what, by purchase, became later the Knott claim, where a 5-stamp mill was put up in 1875. It shut down in 1877, and the Bohemia region was almost forgotten until interest in it was revived by Dr. W. W. Oglesby, O. P. Adams, and others, in 1891. The first ledge of importance, located the same year, was the Musick, which has been running a 5-stamp mill almost continuously ever since. In 1892 the Annie (since called the Noonday) was opened. The Champion put in a 10-stamp mill in 1895 and the Noonday a 20-stamp mill in 1896. Over a hundred claims have been located in the district."

In Diller's early report he calls attention to the following points which seem to have especial value:

1. The veins seem to be clearly of the fissure type.
2. They vary from "a mere film to sheets 12 feet thick". They may be simple or compound.
3. They trend in general from N. 15° to 80° W.
4. They follow definite sets of joint planes of which there are two — they follow more generally the N. W. trending joints.
5. The principal gangue mineral is quartz.
6. The ore minerals are pyrite, sphalerite, galenite, chalcopyrite, oxide of iron and cerussite.

The principal mines of the district are:

The Musick
The Noonday
The Champion
The Vesuvius
The Helena

Quoting Buddington and Callaghan§ of the U. S. Geological Survey (1931) we have a summary of the district up to that time:

> "The maps resulting from the survey of the Bohemia district accurately show the position of about 75 veins and 200 adits and, in addition, the form of the surface and the relations of the underlying rocks. This survey has brought out the facts that the veins are related in origin to dikes and stocks of intrusive rocks and that the strongest veins occur where the intrusives are most abundant. Several of the developed ore shoots are definitely known to be located at the intersection of two veins, and this is doubtless a valuable guide for exploration, even though the intersection of veins does not uniformly determine the localization of an ore shoot.

* As this goes to press the price has advanced to $84, nominal.
† Diller, J. S.: Twentieth Annual Report of the U. S. G. S., Part III, Precious-Metal Mining Districts, p. 7 (1898-99).
‡ Bohemia Mining Region of Western Oregon, U. S. G. S. 20th Ann. Rep't, p. 7 (1898-99).
§ Press Bulletin March 2, 1931, p. 5. See also U. S. G. S. Bull. 893.

Although the Bohemia district is said to have been discovered as early as 1858, the principal period of mining activity was from 1891 to 1908. Since then only a little work, mostly superficial development, has been done. In 1930 there was practically no work going on in the district except that necessary to the holding of unpatented claims.

The prevailing formations of the district are lavas and tuffs, chiefly andesitic but including considerable felsite, that occur in horizontal or gently inclined beds and aggregate a great thickness. They are cut by intrusive porphyries which vary in composition from diorite to quartz diorite. Near these intrusives large masses of the volcanic rocks are altered, as is

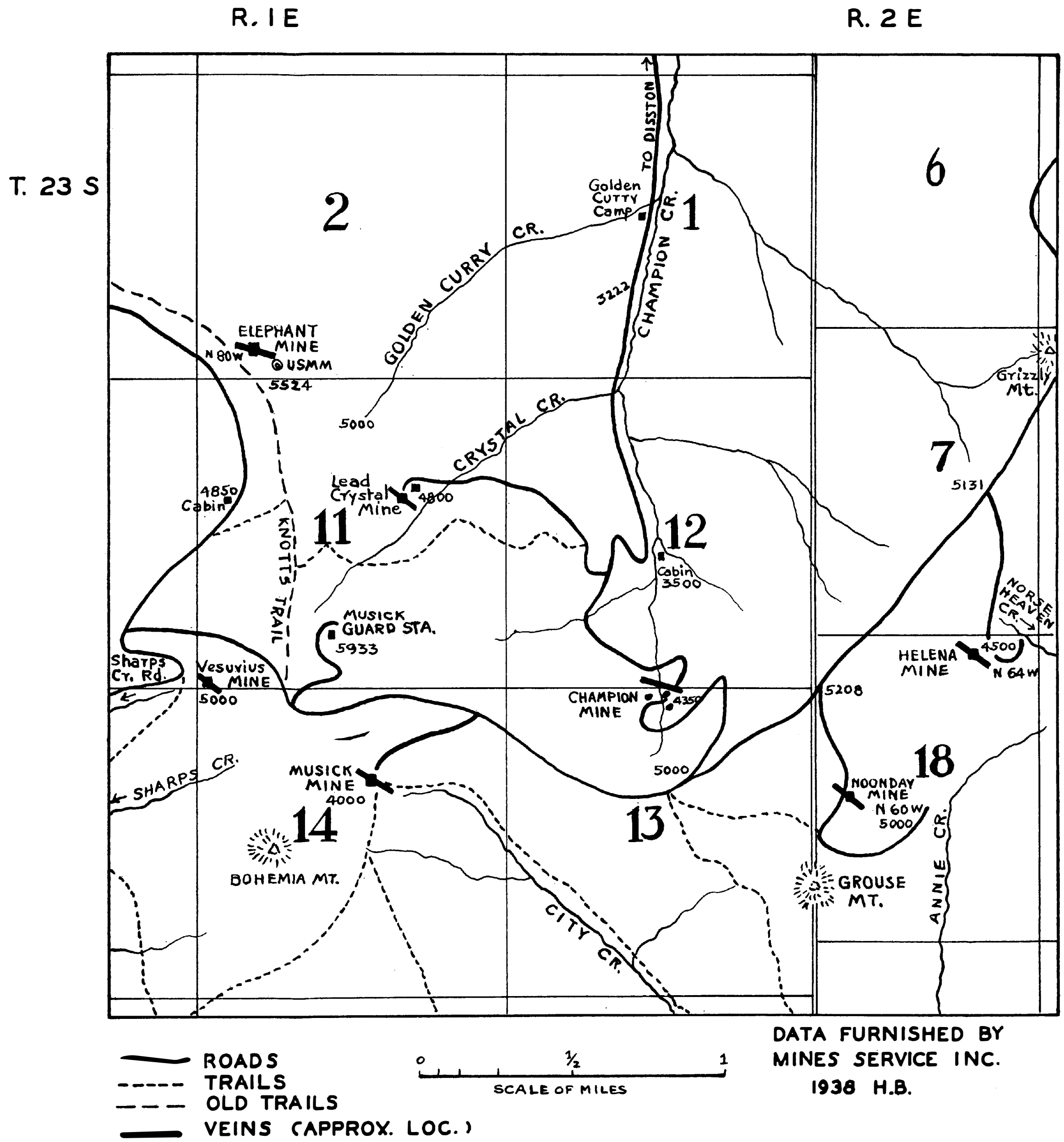


Figure 13—GENERAL LOCATION MAP OF BOHEMIA DISTRICT

shown by bleaching, impregnation with pyrite, and other less noticeable but equally characteristic changes.

The veins were deposited in steeply dipping fractures that in general trend northwestward. Many of them are continuous for hundreds or thousands of feet, some for a mile or more. Workable ore, however, is confined to local shoots within the veins, and many of the veins are of low value. For veins of such length, a considerable persistence in depth may reasonably be inferred. Most of them are 2 or 3 feet or more wide; some are as much as 10 or 12 feet. Exploitation has been confined largely to the upper or oxidized portions of the veins, 100 to 300 feet in depth, which have yielded mainly gold to an amount estimated variously from $500,000 to $1,000,000. Below the oxidized zone at least some of the veins contain ore that in addition to more or less gold carries one or more of the sulphides of lead, zinc, and copper. These complex sulphide ores form the bulk of the reserves within the district. They consist of sphalerite and pyrite with variable amounts of galena, chalcopyrite, and fine native gold in a gangue consisting mainly of quartz and altered country rock.

The value of the ores in gold has ranged between wide limits, and satisfactory data for averages are not available. For the oxidized ores, amounts ranging from $7 to $85 a ton, but generally from $10 to $30 a ton, are reported from several of the mines. The fresh sulphide ores from some of the veins are reported to contain about the same amounts of gold as the oxidized ores. Smelter returns for concentrates and assays of crude fresh sulphide ore from several of the shoots show in round figures from 1 to 3 per cent of copper, 1 to 10 per cent lead, 5 to 15 per cent of zinc, and 2 to 4 ounces of silver and $7 to $13 a ton in gold. Base metal ore from some of the veins, however, carries but little gold, though this low-grade gold ore may run higher than the averages in copper, lead, zinc, or silver.

At the time when most of the production was made from oxidized free-milling ores near the surface the sulphide ores could not be cheaply treated, because of the necessity for concentration and special treatment, such as cyaniding or smelting. Crude ore containing less than $25 a ton could not be shipped at a profit, owing to the high cost of freight. Furthermore, all the base metal in the ore would not be paid for by smelters, as there was no commercial method of separating the different sulphides such as is now available in the flotation process; in addition, zinc, which is abundant in most of the veins, was penalized by the smelters. For the most part, the known free-milling ores have worked out, and the future of the district must depend upon profitable exploitation of the fresh sulphide ores in depth.

The deeply dissected topography is favorable to development of the veins in depth by tunnels. The country rock in general is strong and stands up well in the workings. Even in the older adits it is as a rule only the entrance which is caved, and that is due to the intensive action of frost on the rock there. Timbering in general is necessary only in working the ore from the levels upward.

In view of the advances made in metallurgy during recent years the future of the district appears promising for operations on a moderate scale. Much additional sulphide ore is probably to be found with further exploration. It goes without saying, however, that the profitable working of the deposits will depend more than ever on careful management."

On a recent trip to the Bohemia district (June, 1938) all the important properties were visited. Little mining activity was noted and no ore was being milled. With the exception of work on No. 12 cross-cut tunnel at the Champion Mine, whose portal is nearest the mill, practically no development work was going on anywhere in the district. This tunnel has cut a small vein and has penetrated the hillside about 1,000 feet, with as yet no large ore body visible, though the last few rounds of shots showed encouraging indications.

The Champion 50-ton flotation mill was in good condition but shut down. (Figure 17).

The Musick mill was badly wrecked by last winter's snows.

The Noonday mill was also badly wrecked and all work suspended.

The Helena mill (40-ton capacity), one of the most compact seen by this writer in years, was in excellent condition, but shut down. No plans were being made for early resumption of operations.

Some good surface showings were found on the Elephant Mountain property. It is expected that work will be resumed there this summer.

The same observation holds for the Day properties near Fairview Mountain. On this last group of claims observations were impeded by a new fall of snow (in the middle of June).

It is very clear to this observer that there is little to be expected in the way of results from the present small operations and that unless some large, well-financed and more experienced company takes an interest in the district we need not expect a mine of any note to be developed here.

Figure 17—CHAMPION FLOTATION MILL

It appears from information derived from the most experienced men in the district and our own observations during several visits, that a cross-cut lower down on Champion creek might produce a real mine. Although near surface operations everywhere have shown that the ore bodies are quite irregular and discontinuous, this writer believes that conditions will improve with depth. Of course there are considerable risks involved and for this reason only a large concern with considerable capital and experience should be encouraged to go ahead on such an ambitious program.

In a recent Bulletin* issued after this Bulletin was practically completed, Callaghan and Buddington have the following to say concerning the Bohemia veins:

> "Many of the veins as a whole, as distinguished from ore shoots, have been shown to be persistent over lengths of more than half a mile, and some contain several ore shoots. The fact that the difference in altitude between the lowest and highest veins within the productive part of the district is 2,800 feet is encouraging for deeper exploration on the larger veins. It may be expected that sulphide ores will persist to depths of several hundred feet at least in the large veins, though there are no data on which to base predictions of possible metal content of the ore. The veins outside of the main productive area previously outlined may be expected to include shoots containing some gold but very little sulphide ore, and they should be worked in only a very small way with a minimum of overhead."

The Blue River mining district is situated on the river of the same name, a tributary of the McKenzie, about 4½ miles north of the town of Blue River and some forty miles north of Bohemia.

This district, like Bohemia, has had a checkered career and at present is comparatively inactive.

It has been studied by various geologists, chief among them being those of the U. S. Geological Survey and by Ralph Tuck†, a former geological student at the University of Oregon.

In their press statements of March 2, 1931, the U. S. G. S. men‡ have the following statement summarizing conditions in this district at that time:

> "An examination of part of the Blue River district, which contains a score or more of mines and prospects shows the geology to be in general similar to that of the Bohemia district. The prevailing rocks are andesite tuffs and flows. There is in addition an overlying basalt flow. All these rocks are intruded by dikes of granodriorite or a related rock. Alteration of the lavas in the vicinity of the dikes is not as strong as at Bohemia nor as extensive but is in general of the same type.
>
> Several veins of workable dimensions have been formed along persistent fractures that trend northwestward. The ore bodies are generally found in or near the zones of rock alteration produced by the intrusive grandiorite. At times in the past considerable development work has been done, and a production of more than $100,000, chiefly in gold, is reported from one mine, The Lucky Boy. Most of this output

* "Metalliferous Mineral Deposits of the Cascade Range in Oregon", by Callaghan and Buddington (Extract from page 50. U. S. G. S. Bulletin 893).

† Tuck, Ralph: Geology and Ore Deposits of the Blue River District. University of Oregon Master's Thesis. 1927.

‡ Loc. cit. p. 7.

came from the upper and oxidized parts of the lode. Below a depth of 100 to 200 feet the lode is characterized by sulphide minerals such as pyrite, galena, and sphalerite. Mill returns on some of the oxidized ore show that it yielded an average of $6.12 a ton, chiefly in gold. The value of the sulphide ore is not known, but its appearance shows clearly that it contains noteworthy amounts of zinc and lead."

In the bulletin by Callaghan and Buddington* referred to above, there is the following interesting summary statement:

"The veins in the Blue River district are smaller and less persisent than those in the Bohemia district. The only large ore shoot was that at the intersection of the Lucky Boy and Daisy Creek veins, a favorable location for weathering. The sulphides appear to have a low content of the precious metals. The Lucky Boy vein has been explored by drifts for more than 1,100 feet, and the drift on the Union vein is 700 feet long. According to Parks and Swartley† the main drift in the Treasure mine followed the vein for 1,800 feet.

Possibly some pockets or small shoots of gold ore from the weathered parts of the veins may be found, though considerable prospecting was done in the early days of the camp. Probably moderate quantities of sulphides with a low gold content remain in the Lucky Boy mine and might be extracted when prices of base metals become sufficiently high. The discovery of large ore bodies is not anticipated, and any newly developed ore should be blocked out prior to selection and installation of milling equipment."

The present writer visited the Lucky Boy, the principal property in this district, in May, 1938, and found the main tunnel padlocked and no operations under way.

Winberry:

The so-called Winberry "mining district" is located for the greater part on the north and south forks of Winberry creek, in the east central part of Lane county. Winberry creek is a branch of Big Fall creek which is in turn a branch of the Middle Fork of the Willamette river. Most of the area lies within the boundaries of the Willamette National Forest and the original discovery site as well as the places of greatest activity are found in Township 19 S., R. 2 E., Willamette Meridian.

The area is approximately thirty miles southeast of Eugene and may be reached either via Springfield and Jasper or via Goshen and Lowell. The roads (except for the last few miles) are gravel or macadam and are passable at all seasons. The last few miles are little improved and the road terminates at the Winberry Guard Station and Forest Camp within the west boundary of the National Forest.

For the past six years there has been considerable interest in this district and scores of mining claims have been located there, and some abortive attempts at mining and milling. The writer made a private report in 1933 for certain persons in Eugene and came to the conclusion at that time that this district offered little promise of becoming a real mining field.

Recently Lloyd Ruff, instructor in the geology department at the University, has made a further study of the area and the results of his investigations substantiate the earlier conclusions. A more complete report on this district is being submitted by him to the director of the State Department of Geology and Mineral Industries. The main formation in the region is a very thick deposit or series of deposits, mainly of tuffaceous material with some lava flows. This material contains some leaf impressions and some fossilized wood specimens. These leaf impressions seem to be of the same general types as noted by Chaney and Sanborn in the Goshen locality. This tuffaceous agglomerate with associated lavas seems to be rather persistent throughout the Cascade Range in Oregon at least below the Columbia basalts. It is important to note that reports have been received that gold has been recovered from similar rock in the Cascades to the east of Mount Angel (Marion county) and therefore it is rather important to know more about the true situation here. A more detailed description of the formation and structure is given verbatim in the next few paragraphs from Ruff's report:‡

"The rocks in the Winberry formation so far observed consist of the tuffaceous agglomerate, intrusive basalts, and a tachylite flow. The basalt and tachylite have been identified in thin section by Mr. Jacobsen. The agglomerate is so called because of the many fragments of various volcanic rocks found in the matrix of volcanic ash. The included fragments range from basalt and scoria to material almost pumice-like in nature. W. D. Smith has classed this type of rock in other areas as andesitic

* U. S. G. S. Bulletin 893, pp. 116-117, by Callaghan and Buddington.
† Parks, H. M., and Swartley, A. M.: Vol. 2, No. 4, p. 224, 1916.
‡ Report made to Director State Dept. Geology and Mineral Industries, unpublished.

tuff. Ernest McKitrick in his work for the U. S. Army Engineers encountered similar or identical formations from the Santiam to the Coast Fork. His classification as a tuffaceous agglomerate seems the most adequate to describe the Winberry rock.

The identifiable mineral content includes a fair amount of quartz in doubly terminated crystals, some magnetite and ilmenite, pyroxene or amphibole and sanadine, the glassy feldspar which is also present in the formations at Jasper and Springfield."

Structure:

"The structure of the rocks in the area examined seems only slightly disturbed. Many dikes of basalt as aforementioned cut through the agglomerate and range from a few feet to over a hundred feet in width. Only slight unconformity is noticeable below the flow of tachylite which covered an ancient forest when it came down some volcanic slope.

The agglomerate is massive with joint cracks widely spaced and shows little variation except for color in either vertical or lateral extent. On steep slopes the material weathers unequally and at times gives rise to isolated stacks and to small caves. It is for the most part highly impervious as shown by cuts and tunnels. Unaltered rock is generally found from a few inches to 4 or 5 feet below the surface depending on the steepness of the slope.

The tunnel of the original Winberry discovery site which is about 50 feet long is perfectly dry from the face to within a few feet of the opening where rain and snow may blow in. Where weathered in place the material shows considerable oxidization of iron minerals and the presence of limonite. This material may be easily removed with a pick to a depth of 2 or 3 feet.

Aside from weathering of the country rock we are unable to find any evidence of mineralization either on a large scale or in the form of mineralized veins or stringers. The question then arises what is the source of the gold as has been repeatedly reported from dozens of assays from an equal number of claims in the area?"

A great many samples have been taken from this area by a number of people including the present writer, but perhaps the most complete sampling was done by Ruff and Jacobsen, whose samples were assayed at the Grants Pass laboratory of the state department, and at the University of Washington. These gave very low returns and in most cases only traces. For instance, in a suite of 10 samples assayed by Mr. Albert A. Lewis of the State Assay Laboratory only one sample showed as much as 70 cents per ton.

Ruff's general conclusions are as follows:

"1. There is a small gold content in Winberry rock but nothing comparable to the results shown by early assays. The so-called ore does not carry consistent values and cannot be expected to average more than a few cents to the ton.

2. Early assays and mill tests are believed to be unreliable. Later results by private individuals and by the State Assay Office seem to bear out this conclusion.

3. Small operators and limited capital should be discouraged since large mining concerns fail to become interested in the area."

McKenzie Pass or Noonchester District:

The only reason for giving any attention to this locality is by way of a bit of history.

Through misplaced zeal and ignorance of geology a considerable number of people were attracted to an alleged "strike" near the McKenzie Pass and a great many claims were staked and some buildings erected. As the formation here is relatively recent andesite and no veins visible anywhere in the vicinity, all hopes were soon frustrated and the camp abandoned.

Oakridge District:

Some placer operations have been attempted from time to time on the Middle Fork of the Willamette and its tributaries but nothing substantial has ever come of these operations and at present there is no activity.

In summing up the gold and silver mining situation in the county we can make the following very definite statements:

1. A few pockets of relatively rich gold ore were found near the surface in the early days.

2. The ore in the Blue River and Bohemia districts is low grade sulphides and will have to be concentrated and smelted.

3. The tonnage developed in these two districts does not now warrant the erection of a local smelter.

4. Over-enthusiasm and unwise promotions have characterized both these districts in the past.

5. There are grounds for expecting the bringing in of paying mines in this Cascade region if large-scale development along conservative lines precedes the erection of mills.

Copper, Lead and Zinc

In some of the mines in the Bohemia district, notably in the Musick and Champion, these metals are found in commercial quantities in the lower levels and may be recovered as valuable by-products.

Antimony

On Peters creek, a branch of the Row river west of the Bohemia district, some good specimens of stibnite, antimony sulphide, have been found. It is too early to say whether or not the deposit is of commercial grade.

Arsenic

Recently some realgar and orpiment, the two sulphides of arsenic, have been discovered at Hobart Butte along joint cracks in an altered andesitic tuff, undoubtedly produced under similar conditions as were the cinnabar deposits only a few miles away. As the market demand for arsenic on the Pacific Coast is limited and this can be met by arsenic produced as a by-product of the smelters, there is no immediate prospect for the commercialization of this deposit.

NON-METALLIC DEPOSITS

Clays

There are at least two deposits of commercial clays or near clays in this county which merit our attention. One of these is the altered andesitic tuff of Hobart Butte referred to above which is called in the trade a fire-clay, but which is not clay in the usual form. This rock will withstand a temperature of about 3,200° F. before fusing. This material is owned and quarried by the Willamina Clay Products Co. and has produced some excellent fire brick. It is cream colored save where carbonaceous material discolors it. It is estimated by the State Department of Geology and Mineral Industries* that some 46,200,000 tons of this material are available.

About three miles due west of Eugene on the West 11th Street road on the old Cook place at the west end of Wallace Butte, is a pit of very siliceous sandy clay, belonging to the Eugene Clay Products Co. This material has produced a fair fire brick. These are cream white. This same clay has also been used in small quantities as a moulding sand in foundry work.

At Monroe just across the line, a red building brick of medium grade is being made, so it is not unreasonable to look for similar clay deposits within Lane county in that vicinity. In fact, clay deposits in the vicinity of Elmira in western Lane county have recently attracted attention in connection with the tests made as to their suitability for bricks for the new post office at Eugene. The deposits are said to be at least 27 feet thick. They are found on the property of a farmer, Mr. I. A. Inman, and on neighboring tracts. This clay is a bluish white and yields a buff to reddish product on burning. A fair grade of pottery has been made from it. It is hoped it will satisfy the government specifications as to color for the new post office brick which calls for a light color. However, for ordinary purposes it should make quite a satisfactory brick.

For more detailed information on clays the reader is referred to Bulletin No. 6, mentioned above.

Crushed Rock

Lane county has a number of outcrops of hard igneous rocks such as basalts and andesites or diabase which are often lumped under the commercial term of "trap rock". These are dark or black, often times very dense, fine-grained; sometimes, however, coarse-grained and vesicular. These rocks make a very fair grade of road ballast. Of the three, diabase is the best. This is the rock which makes up Spencer's Butte, the highest point in the central part of the county. In the Cascades the rocks in Lane county are both andesite and basalt. In the buttes around the head of the Willamette Valley and in parts of the Coast Range the rock is basalt. The basalts are generally finer-grained than the other two rocks, sometimes even glassy in texture and quite brittle. The very fine-grained rocks because of their brittleness are easily abraded and crushed down into mud. On the other hand, the diabases (Spencer's Butte) when studied in thin sections with a microscope show a texture which makes for toughness; that is, the component grains or mineral crystals are generally interlocking, giving a typical diabasic texture. Such rock has a higher abrasion strength than the other two rocks. These igneous rocks of whichever variety form a very important resource of the county as witness the numerous crushed

* Wilson, Hewitt, and Treasher, Ray: Preliminary Report of Some of the Refractory Clays of Western Oregon. Bulletin No. 6, p. 74, State Dept. Geology and Mineral Industries, 1938.

rock and gravel plants where these rocks or gravels derived from them are prepared for the market to be used as road ballast and for concrete mixtures. The output of these materials is valued in tens of thousands of dollars a year for this county.

Sand and Gravel

Such streams as the McKenzie and the Willamette, particularly in the vicinity of Eugene, furnish enormous quantities of these materials. The gravels are usually the remnants of larger fragments of hard, igneous rock which have been eroded to a certain extent in the higher mountain areas. Owing to the abrupt change in gradient of the McKenzie and the Willamette rivers, where they debouch on the valley floor, the bulk of these gravels is deposited between Springfield and Eugene. Here there are some large sand and gravel plants. In the lower reaches of streams like the lower Siuslaw it is often very difficult to find good gravel.

Tuff

Beneath the lavas at various localities on the McKenzie and other streams are tuff (volcanic fragments) deposits, which on experimentation some years ago by Prof. E. H. McAlister* proved to be suitable for mixing with cement in making concrete. This material also could be used as a building material as similar rocks in other parts of Oregon, as at Mount Angel, have so been used.

Coal

Coal is mentioned here not because of any known commercial deposits, but because of the possibility of finding them in this county. There is coal both to the north and to the south in rocks of the same general age as those in the western part of the county, and in a few places, such as Comstock, thin seams of as much as three and four inches of coal have been opened. Why coal is present in one place and not in another depends upon the local conditions at the time the coal was forming, and these conditions apparently did not exist over a long enough time within the boundaries of this county to produce a commercial thickness of coal. It is possible that with further prospecting coal seams of commercial thickness may be found; that is, not less than two and one-half feet of fair grade, though the writer is not sanguine of such results. If such seams exist they probably will be encountered at some depth by drilling.

Lime and Calcite

There is very little limestone outcropping anywhere in Lane county though there is some just to the south in Douglas county. However, in the Dennis creek tunnel at the Black Butte quicksilver mine in the lower part of Black Butte, when the miners were crosscutting to reach the lower part of the quicksilver veins they cut a deposit of calcite vein material of considerable thickness, sufficient in quantity to be of some commercial value. Some of this has been taken out and shipped for use on acid farm lands. If a large deposit of this substance, calcium carbonate, either in the form of limestone or the pure calcite, could be located nearer the main valley, this would be quite valuable. This is one of the most essential mineral substances for our agricultural lands in western Oregon. The Willamette Valley in general is very deficient in lime, but the transportation, either from southern or eastern Oregon, retards its use.

Gas and Oil

Efforts have been directed for a number of years by many persons, most of whom have been acting in good faith, but with little knowledge, in an attempt to secure supplies of gas and oil, but without success. In spite of all assertions to the contrary the writer knows of not a single barrel of oil that has been obtained naturally from the rocks of Lane county. Of the many alleged oil seeps which the writer has examined, not one has proved to be genuine. The nearest to an oil seep known to the writer is one reported by Chester Washburne,† petroleum geologist, where about a teacup of oil was seen by him in a vug or cavity, in a basalt dike cutting some shales on the Johnson ranch on the north fork of the Siuslaw near Florence.

Many other seeps have been reported but in every instance on examination they have turned out to be either pure "fakes" or merely the iridescent vegetable scum on marshy stagnant waters. In view of the great interest in this subject, and of the thousands of dollars that have been spent in seeking petroleum in this region, it is pertinent to state some of the requisite conditions before one can expect to find petroleum. These are three:

* McAlister, E. H.: University of Oregon Bulletin, New Series,vol. X, no. 5 (1913).
† Washburne, Chester W.: Reconnaissance of the Geology and Oil Prospects of Northwestern Oregon. U. S. G. S. Bulletin 590, p. 100, 1914.

First: There must be a source of oil, which is generally organic shales, for it is through the decay of the organisms that petroleum is produced. There are other theories for the origin of petroleum but we may dismiss them since practically no competent geologist accepts them.

Second: There must be a suitable container for the petroleum after it is formed. This may be a porous sandstone or limestone or even a loose sand.

Third: A suitable structure must be present, such as an arched or domed condition of the formations with impervious beds or strata as confining members.

These conditions, with a few possible exceptions, must be present; otherwise, we cannot expect to find commercial petroleum deposits. The few exceptional conditions we need not discuss in this place.

The prospecting for petroleum that has been done in Lane county has been within the vicinity of the city of Eugene on what was supposed to be an oil dome just southeast of the city. This particular structure is not a dome at all, and practically no conditions which competent geologists look for are to be found in this locality. A sum of between $200,000 and $300,000 was collected for this development work but apparently only a portion of it actually went into the drilling operations. The persons in charge of this work, outside of the driller, were evidently unqualified.

Another unfortunate venture which came to naught was a well located on a basalt ridge near Cottage Grove!

As natural gas, generally in the form of marsh gas (CH_4) has been found frequently in the state of Oregon there might be in Lane county accumulations in commercial quantities, and therefore the writer would not discourage drilling in suitable areas for gas, provided all necessary structural and other geological conditions can be demonstrated.

It would be advisable for persons intending in the future to prospect for either natural gas or oil in Lane county to consult the geologists either of the State Department of Geology and Mineral Industries, the State College, or the University, before beginning operations. Practically all the large oil companies who have come into this state have done so.

Mineral Hot Springs

It would be natural to expect hot springs in a region of comparatively recent vulcanism like the Cascades. There are several in this county, but only five localities that are well known for their hot springs; at three of these are well-established recreational and health resorts. These as listed by the U. S. Geological Survey in its recent bulletin on "Thermal Springs" are:*

The two best known are Foley and Belknap, both on the McKenzie river.

Location	Name	Geology	Temperature °F.	Approx. Discharge (Gallons a Minute)	Remarks
Six miles east of McKenzie Bridge, sec. 11, T. 16 S., R. 6 E.	Belknap Hot Springs.	Late Tertiary Lava.	150–188	75	3 main springs; resort.
4½ miles SE. of McKenzie Bridge, sec. 28, T. 16 S., R. 6 E.	Foley Springs	Late Tertiary Lava.	162-174	25	4 springs; resort.
South Fork of McKenzie River, 8 mi. SW. of McKenzie Bridge, SE¼ sec. 7, T. 17 S., R. 5 E. Cascade Nat'l Forest.		Columbia River Basalt.	130	60	4 springs; not used.
10½ mi. NE. of Oakridge, NW¼ sec. 26, T. 20 S., R. 4 E., Cascade Nat'l Forest.	Wall Creek Hot Springs.	Columbia River Basalt.	98	3	3 springs; local use.
11 mi. E. of Oakridge, SE¼ sec. 36, T. 21 S., R. 4 E, Cascade Nat'l.	Winino Springs	Columbia River Basalt.	Hot	20	Group of 15 springs covering 1 acre; resort. Also called McCredie Springs.
8 mi. SE. of Oakridge, sec. 6, T. 22 S., R. 4 E., Cascade Nat'l Forest.	Kitson Springs	Columbia River Basalt.	114	35	2 main springs; resort.

* Stearns and Waring: Thermal Springs in the United States, Water Supply Paper 679-B, U. S. G. S., Washington (1937).

Analyses of Belknap Springs water* is given below:

Ca SO_4	0.2386
Na Cl	.9250
K Cl	.1318
Mg Cl_2	.0498
Ca Cl_2	1.0669
Si O_2	.0809
Fe & Al oxides	.0030
Mn Cl_2	trace
	2.5060
Oxygen set free in making chloride	.1622
	2.6682 (parts per million)

Ground Water

The three principal kinds of ground water are (1) the deep-seated waters such as those mentioned in connection with hot springs in a previous paragraph; (2) the waters in the stratified formations beneath the valley floor or in the joint fractures of the lavas; and (3) the water contained in the alluvial filling in the valley bottoms. The most important of the sources in Lane county, as far as agriculture is concerned, is the last named, since most of the farm wells of the Willamette Valley obtain their water from the valley fill. This valley fill varies from 0 to 300 feet or more, and covers hundreds of square miles in area, so that millions of gallons of water are available. However, with increased draft on this ground water reservoir we shall in time be obliged to turn to one or both of two other sources of water. One of these is the deeper water in the Eocene and Oligocene sediments below the valley fill, which supply is entirely problematical as to quantity, or to storage water which may be provided if the Willamette Valley Flood Control project goes into operation.

The subject of ground water resources of the Willamette Valley has been treated in a short bulletin by A. M. Piper.*

FACTORS AFFECTING MINING DEVELOPMENT IN LANE COUNTY

Character of the Ores:

In the early days of mining in this county there were some fairly rich pockets of free gold, but these first found have long since been exhausted and now the ore bodies for the most part consist of base ore which requires smelter treatment. Furthermore, the ores are not high grade. The lack of sufficiently large ore bodies as known at present precludes the building of a smelter nearby, which means that the concentrates must be shipped.

Difficulty in Prospecting:

Heavy forests, undergrowth and deep soils have retarded prospecting and made it difficult to explore such lodes as may exist.

Unwise Promotion:

Some unwise promotion, some poor management, and some downright swindling have made the investing public cautious about backing mining enterprises here, so that even when a perfectly legitimate undertaking is put forward the public is reluctant to invest.

Lack of Proper Development Work Before Beginning Milling Operations has led to some fiascos which have given the public just cause for conservatism. Some of these operations have been in the hands of unqualified persons.

Lack of Capital:

Very few mining enterprises in Lane county have been sufficiently financed. This in part is due to the above named factors, which have scared away real mining men who might properly develop some properties here.

Transportation Difficulties:

A factor is the dependence upon a single railroad after the ore has been trucked a considerable distance. This makes freight rates upon low grade ores a critical consideration.

Labor:

While labor is plentiful in Lane county good miners are not to be had in very large numbers. The necessity of importing experienced miners in the event of the beginning of substantial mining operations would be a handicap.

Markets:

With the exception of gold all metallic minerals of this county must be marketed or smelted at some distant point. The non-metallic products are slightly more fortunate.

* U. S. G. S.

Research:

Development and advance in any industry depends much upon research. In the past Oregon has spent too little for research in the fields of geology and mining; and the so-called "practical miner" has sometimes scoffed at the idea of what he often styles "high-brow" investigations. Mining in Lane county, and for that matter nearly everywhere, has become increasingly difficult and needs the assistance of highly trained geologists and engineers. Because of conditions enumerated in paragraph 2, geophysical methods may have to be resorted to in the search for new ore bodies or the extensions of those already known. In this field much research needs to be done to enable one to know the best method to employ.

POWER AND TIMBER RESOURCES

Power:

Any regional economic report of a mining area should pay especial attention to power and timber resources.

In Lane county the potential power resources from hydroelectric plants are very great because of the McKenzie and Willamette rivers with their many tributaries. The high gradient of these streams affords many power sites.

At the present time there is in the Leaburg Project (Eugene Municipal Power Plant) 7,300 KW. of developed electric power. The rates for power are the second lowest on the Pacific Coast.

The California Power Company's main power lines also pass through Lane county.

Adequate power from Bonneville on a kilowatt-year basis will soon be available also.

With the completion of the "Coordinated" plant of the U. S. Engineers' Willamette Valley Flood Control Project, additional power from five dams in Lane county will insure abundant power for all purposes in the future.

Timber:

It has been estimated that Lane county has fifty-five billion board feet of merchantable timber, mainly Douglas fir. With the hills and mountains, especially in the mining districts, heavily timbered with large trees and the many valley mills in operation (50-75) there will probably never be any dearth of timber for mine use or lumber for construction.

The cost of lumber at the Lane county mills is about as given in the table:

Douglas Fir—$17-$18 per thousand.
Cedar—$20-$22 per thousand.
Oak—None available except as firewood.

A square-set of mine timbers (Black Butte Mine) costs delivered at the mine about $2.25.

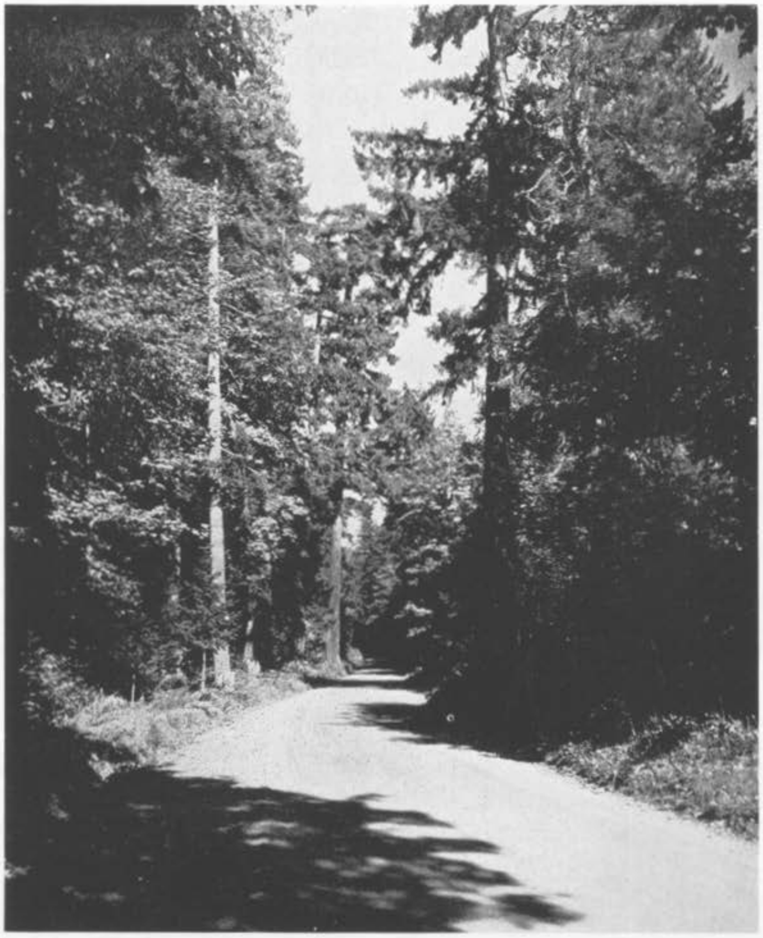


Figure 19—LANE COUNTY FOREST SCENE
(Oregon State Hwy. Dept.)

Figure 20—THREE SISTERS (Jiro Harada)

SCENIC RESOURCES

Lane county, extending as it does from the High Cascades to the coast, would be expected to have a great variety of scenic features. Here is a resource which residents have long been aware of but which they have not yet capitalized to the fullest extent. The general public is not fully aware of the great variety and magnificence of some of the scenery in this county.

THREE SISTERS AREA AND LAVA BEDS

The Three Sisters Primitive Area has been well studied and described by Dr. E. T. Hodge.* His description is contained in a completely illustrated brochure entitled "Mount Multnomah, Ancient Ancestor of the Three Sisters."

The tourist can leave Eugene and in less than two hours leave his car at Frog Camp on the Skyline Trail. Then on foot or by skiis, depending upon the season of the year, he can make his way across White Branch, then eastward to its headwaters where he comes to an area lying just to the north of the Middle Sister and northwest of the North Sister, where he will find the lower end of Collier Glacier, the largest glacier in Oregon. Just at the end of this glacier is a rather recent looking cinder cone. After exploring this region he can traverse the surface of the glacier to its head and see many more interesting geologic features. And then, if he is very agile, he may climb the Middle Sister and by making a long day of it get back to his car late in the evening.

We do not propose to describe this region in detail in this report, but merely tell some of the outstanding features and refer the reader to Hodge's publication.*

The North Sister is very rugged with an exceedingly precipitous wall on the west side. This side was scaled over fifty years ago by a man who is still a member of the faculty of the University of Oregon, Louis F. Henderson, the eminent botanist and curator of the University Herbarium. A part of this precipitous wall which he climbed at that time has since crumbled away and so no one can repeat the feat. This, perhaps, is the first ascent of this mountain. It is now climbed from other points but with some risk, and is a favorite of the Obsidian Club members who frequently visit the region.

* Loc. Cit., Univ. Ore., 1925.

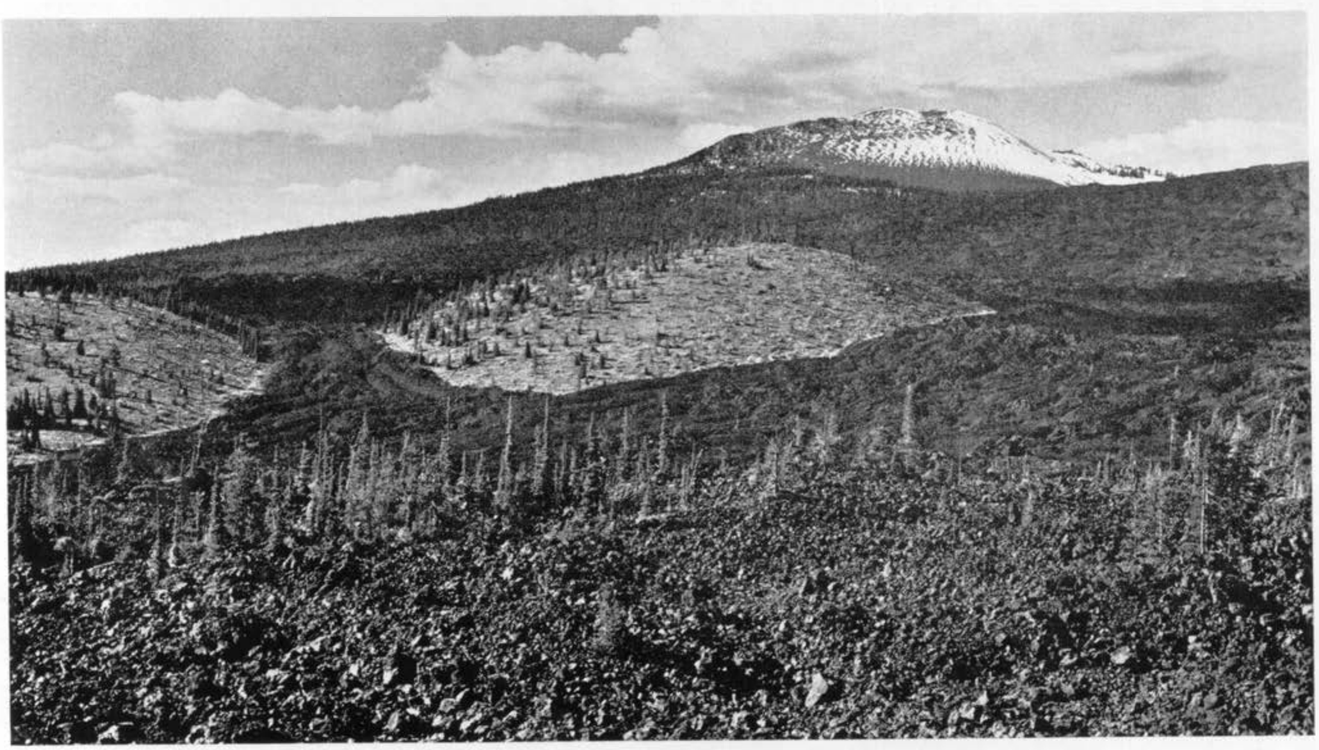


Figure 21—McKENZIE "LAVA BEDS" (Oregon State Hwy. Photo)

The Middle Sister is much easier of ascent, has no precipitous walls but has a gently rounded cone-like top.

The South Sister, some five or six miles to the south, has a well defined crater in the top with a small crater lake.

Lava flows of different ages and degrees of weathering can be studied in this area. Just to the north of the main highway is Belknap Crater with very spectacular black lava flows extending down from it. These can be seen along the highway. These lava flows, probably not over 500 years old, are exceedingly rough and have very little vegetation on them. They are of the type known in Hawaii as "a-a" in contradistinction to the smooth, glassy lava flows which are called "pahoi-hoi".

In this same region are numbers of other mountains, showing various degrees of erosion and disintegration, with such intriguing names as Broken Top, the Husband, the Wife, and the Brother. Somewhat to the east of these mountains there is a nest of small lakes which afford not only pleasing scenery but excellent fishing.

With its ice-covered mountains, lava flows, forest-encircled lakes and high alpine meadows, this region is a very remarkable one and has been set aside as a Primitive Area. The geological student is able in this region to study vulcanism in many of its phases, glaciation, erosion by streams, weathering, and many other geologic processes and features. It is also a paradise in the spring and early summer for the botanist. In time there should be erected here a fine mountain chalet to be used as a base for exploring this beautiful country.

THE HIGH LEVEL LAKES

At various places on or near the summit of the range there are lakes of varying size and depth occupying the many irregular depressions in the uneven lava surface. Waldo lake is the largest, covering many square miles, while scme are little more than millponds. In most cases completely surrounded by forest, they are concealed from general view and often afford a delightful surprise to the tourist who sees them for the first time.

THE McKENZIE AND WILLAMETTE RIVERS

These two rivers rise high up on the western side of the Cascades and have cut deep canyons in the lava plateau. The canyon-cutting has been due both to river work and ice work. When one reaches the upper end of these valleys, above McKenzie Bridge on the McKenzie, and above Oak Ridge on the Willamette, he is aware of a striking change in the topography. The valleys become somewhat wider and more U-shaped, the result of glaciation. All of the erosion is being done by running water. In the very steep walls of these valleys, the outcrops of rugged lava rock, and the high gradient of the stream beds with the excessive forest growth on all sides, and the very clear water of the streams carrying very little silt, give these two very remarkable rivers exceptional beauty. The McKenzie is far-famed as a fishing stream, the chief fish being trout. Some of the forest trees in the upper reaches of these valleys are only exceeded in size by the redwoods in the southwestern corner of the state. These upper forests are great game refuges, abounding in deer, some elk, cougar, bobcats, et cetera. It is not an

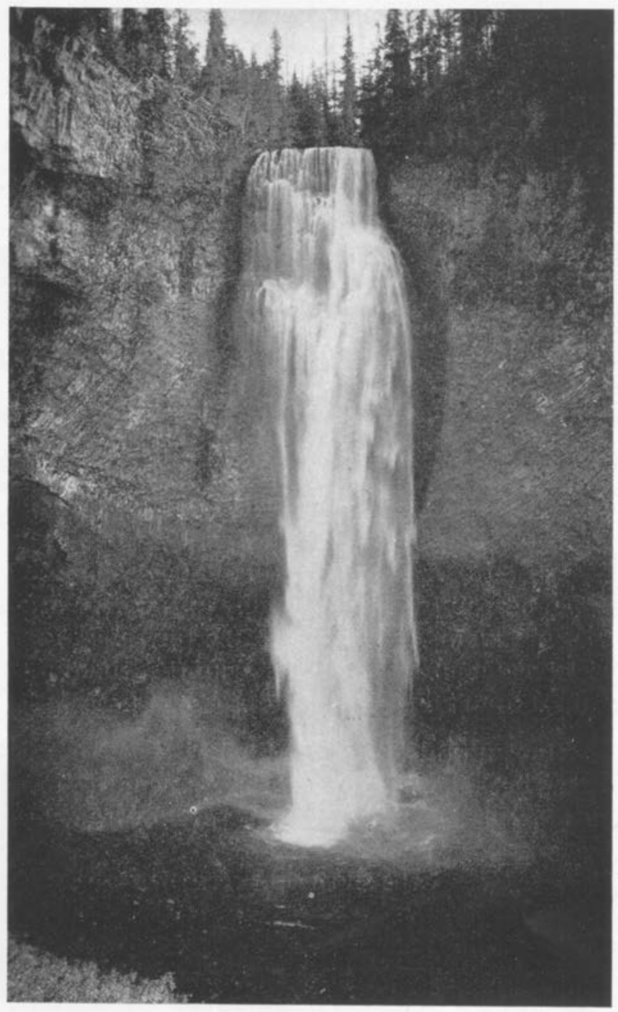


Figure 18—SALT CREEK FALLS (U. S. Forest Service)

unusual thing to be motoring through the forest and see deer ahead on the road, particularly in the early morning or early evening.

A word of caution should be given here. Tourists unacquainted with the country should not leave the main roads very far as they may easily become lost in these forests, due to the very heavy undergrowth. As most of this upper region is in national forest, anyone traveling through here, and particularly, making a camp, is obliged to obtain permits from the nearest forest rangers.

Space does not permit the discussion or even mention of but few of the many spots in this county, but we wish to call attention to one feature in the country just to the northwest of Oakridge, called Hell Hole. Unfortunately, this is not accessible to the automobile tourist. To reach it one turns off the main highway at Oakridge onto the High Prairie forest road to the holdings of the Western Timber Company, where he takes the Christy Creek trail, crossing the North Fork of the Willamette. Within a couple of miles beyond this crossing he will come upon a great gash in the mountain side, some two hundred yards long, 100 to 200 feet deep and 20 to 25 feet wide where the mountain side has literally split open. The round trip on foot is close to ten miles, but well worth the effort.

SALK CREEK FALLS

About two-thirds of the way down from the High Cascades to the main valley of the Willamette on Salt creek is a very beautiful falls named after the creek. The stream drops over a ledge or flow of basalt 286 feet high. A new road has been completed to the falls and a forest camp erected here by the Forest Service. This is a spot of idyllic beauty and well worth visiting.

THE WILLAMETTE VALLEY AND THE VALLEY BUTTES

In the central portion of the county are two striking features—the flat valley floor itself and Spencer Butte. The former lies just to the north of Eugene with its remarkable "braided" channels of the Willamette river with great meander curves, ox-bow lakes, gravel bars, et cetera. This portion of the Willamette river is of exceptional interest to the geologist, and this flat-floored valley with its fertile top soil of loam is also one of the garden spots of the United States. The valley has an east wall consisting of the ends of the Cascade lava flows, which in places are fairly steep. On the

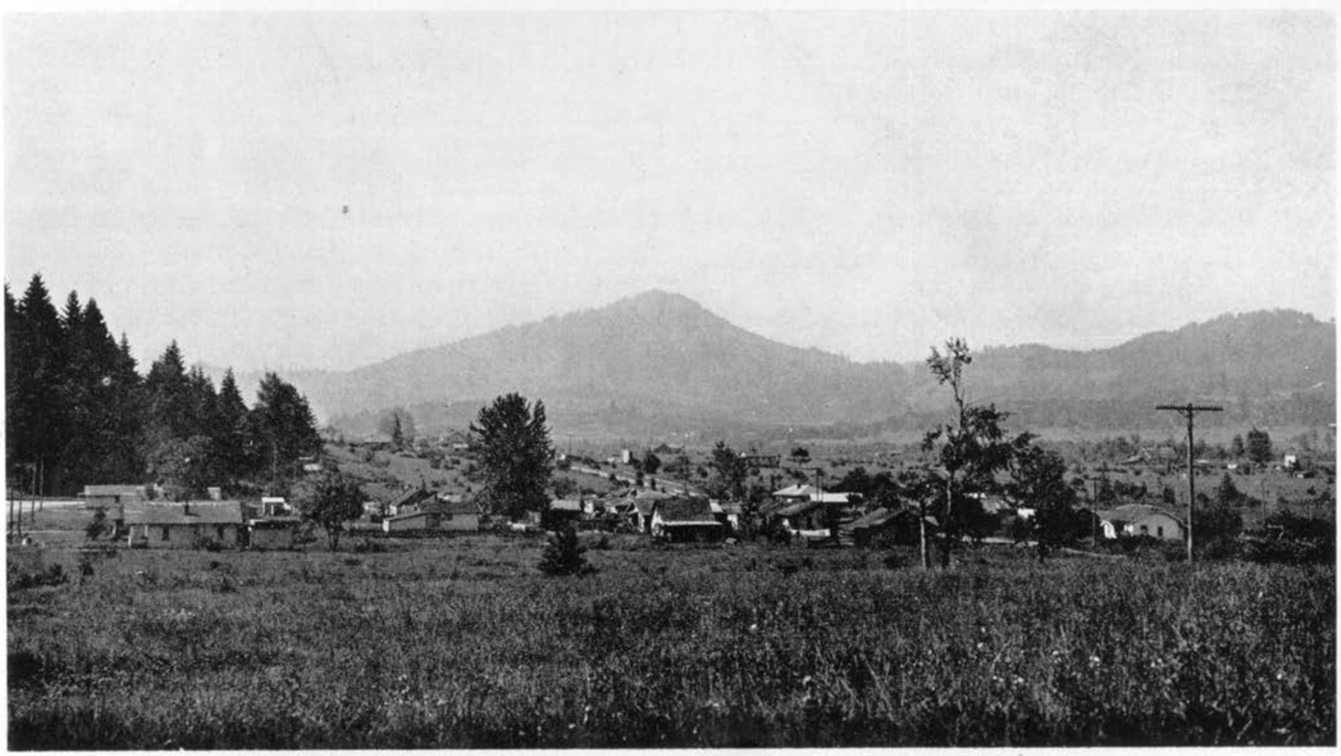


Figure 15—SPENCER'S BUTTE

west side the slopes are much gentler, owing to the different kind of rocks on the west side of the valley, these being in the main of sedimentary origin. At the south end of the valley, five miles due south of Eugene, is Spencer Butte. It is 2,065 feet above sea level. Viewed from the north it appears somewhat conical in shape, but in reality it is a long, north-south ridge consisting of a hard igneous rock technically known as a diabase sill-dike. Other buttes around the valley are not so high but stand out prominently from the flat valley floor. Invariably these buttes are due to a core of hard rock which has resisted erosion.

Just north of the Southern Pacific Railroad tracks in the city of Eugene is a smaller hill known as Skinner's Butte. An excavation in the west end of this reveals the nature of the rock of which it is formed. This consists of basalt with characteristic columnar jointing—great columns 30 to 40 feet in height and two to three feet in diameter, all either five or six sided. This structure is due to the cooling and contraction of the igneous material. (See chapter on Structure).

THE COAST RANGE AREA

The Coast Range is not as high as the Cascades by several thousand feet. In fact, the highest point in the entire Coast Range is little over 4,000 feet—Mary's Peak in Benton county immediately to the north. In the Lane county Coast Range section the highest point is well under 4,000 feet. These Coast Range mountains consist largely of sedimentary rocks which have been folded and to a certain extent intruded by igneous formations. However, due to the erosive work of the streams, they have been very sharply dissected and present a very rugged appearance, softened, however, by the heavy forest cover. The streams are deeply incised, giving the appearance of entrenched *meanders* which one would expect, knowing that this region has in late geologic times undergone considerable elevation.

About forty miles from Eugene, roughly, half way to the coast, is a very pretty little lake called Triangle Lake, about a mile long. It is the remnant of a much larger lake. The former extension of this lake can be traced upstream to a point beyond Blachly. The outlet of Triangle Lake is Lake creek which has to flow over a rather hard, rocky ledge. When this is cut through, ultimately the lake will drain out and disappear as happens in the case of many lakes. They either fill up, drain themselves, or do both. The fate of Triangle Lake is certain. This is one of the attractive fishing and boating resorts within easy access of Eugene.

There are other small lakes within the Coast Range but the one described is the largest and perhaps the most attractive.

THE COASTAL LAKES

On the narrow coastal strip, almost within sight of the sea in some cases, there is a string of very attractive lakes ranging in size down to little more than ponds. Of these Siltcoos is the largest, with a shoreline of roughly thirty miles. Practically all of these occupy old river valleys dammed up by debris of one kind or another, or by sand dunes. Ten Mile Lake is one of the most interesting of these. It is about ten miles long, has a width averaging not much over a quarter of a mile, in some places much narrower, and is clearly occupying a damned-up river channel. Surrounded, as most of these lakes are, by large fir, cedar and spruce trees, with rhododendron and small shrubs abounding, they are exceedingly picturesque features of the landscape. Siltcoos Lake is a year-round resort for boating, swimming and fishing, and a number of cottages and camps are located on its margin. One of the most interesting of all these coast lakes is Lake Cleawox. On the west it is confined entirely by large sand dunes, some of them nearly 300 feet high. The east shores are low and sandy. This lake is said to be of exceptional depth in places but we have no definite figures at hand. This is the site of the Lane County Girl Scout Camp. It makes an ideal place for their program, inasmuch as the lake never gets rough and the water is generally warm.

THE SEASHORE

And now we have come to the farthest point west in our county—to the seashore, that part of any country which to the geologist is always interesting,—for at the seashore there is the interminable conflict between the atmosphere, hydrosphere and the lithosphere—the never-ending struggle between the winds, the waves and the land. There are many features of interest along the coast included between the north and south ends of this county. There are long sandy beaches, perfectly flat or nearly so, as is the case north of Florence, and the exceptional dune area to the south of the Siuslaw river, and the rocky headlands of which Heceta Head is the most famous. This is a paradise not only for the tourist but for the geologist as well.

One of the most interesting features of this part of the coast is the Sea Lion Caves just south of Heceta Head. These have been well described by Callaghan,* of the United States Geological Survey, in a Master's thesis:

> "The most interesting of these sea caverns are the famous Sea Lion caves at Sea Lion point. They are doubtless the most extensive sea-caves found on the Oregon coast. They consist of four great entrances, three of which lead into a main cavern which is a huge dome-shaped room 150 feet high and 200 feet wide. The north half has a steep beach of huge boulders, some 30 feet thick, which have been smoothed by the movements of the sea lions over them. The main entrance, which is about 100 feet wide and 75 feet high, and 200 feet long, approaches the main cavern from a west-northwest direction. The south entrance which is about 50 feet wide, 75 feet high, and 1,200 feet long, approaches from the mouth of Norse creek in a direction of south 20° east. Another cave about half as long, roughly parallels this one, but it enters the main entrance rather than the cavern. The north entrance which is about 40 feet wide, 60 feet high, and 200 feet long, enters the main cavern from a direction of north 15° west. It differs from the others in being almost filled with rock debris, allowing a dry land entrance to the main cavern as all the others have water in them. It is rather a difficult matter to get into this entrance, involving as it does climbing across the face of an almost perpendicular wall which tries the courage of a novice. The caves are cut in agglomerate, and a well defined red layer practically encircles the main cavern."

Since Callaghan's visit to these caves extensive improvements have been made by a company† which has made this scenic feature more accessible to the general public. By means of trails down the steep cliffs and a shaft through the roof of the cavern, one can go down to the bottom of the cave with comparative ease and comfort. If the visitor is lucky he will encounter hundreds of sea lions swimming around or climbing on the rocks. There are three main entrances to this large cave, one to the south, one straight in from the west, and the one by which the tourist enters from above.

* Callaghan, Eugene: Geology of the Heceta Head District, Univ. Ore., 1927.
† Sea Lion Caves, Inc., Florence, Oregon.

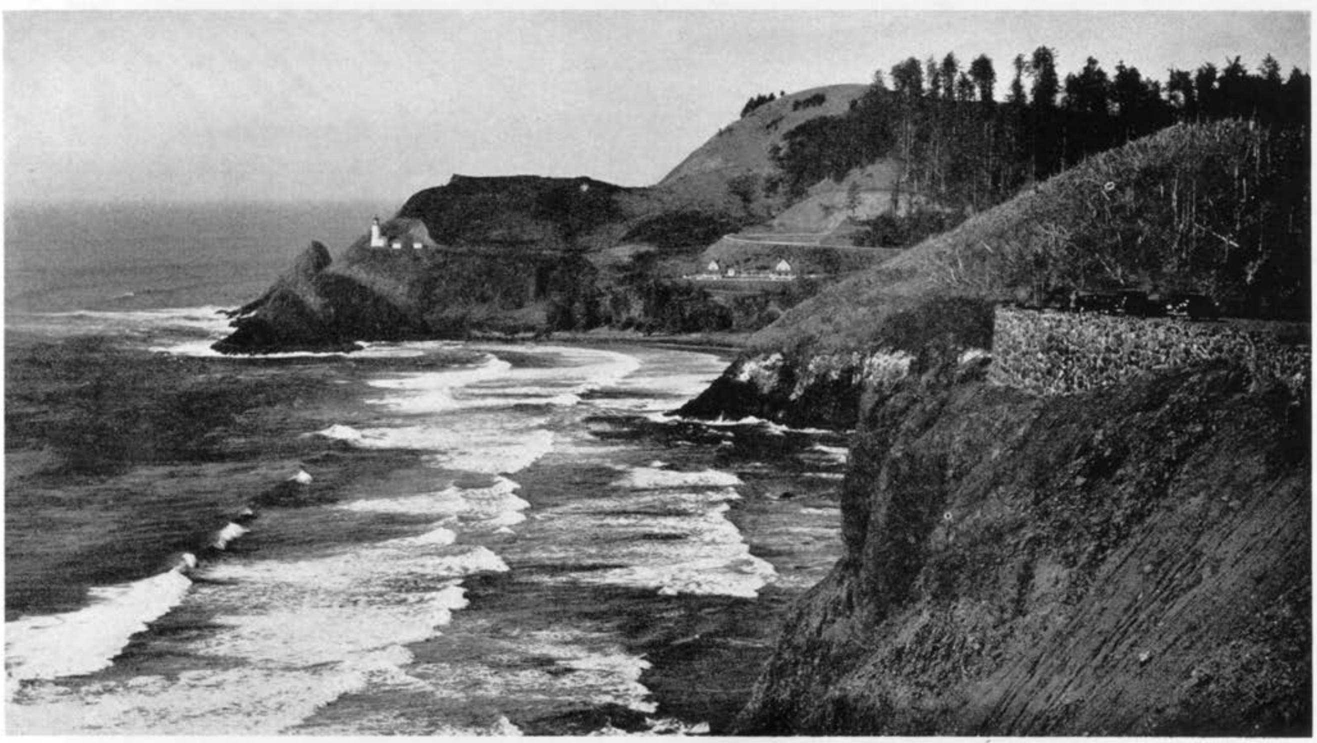


Figure 22—HECETA HEAD (Oregon State Hwy. Photo)

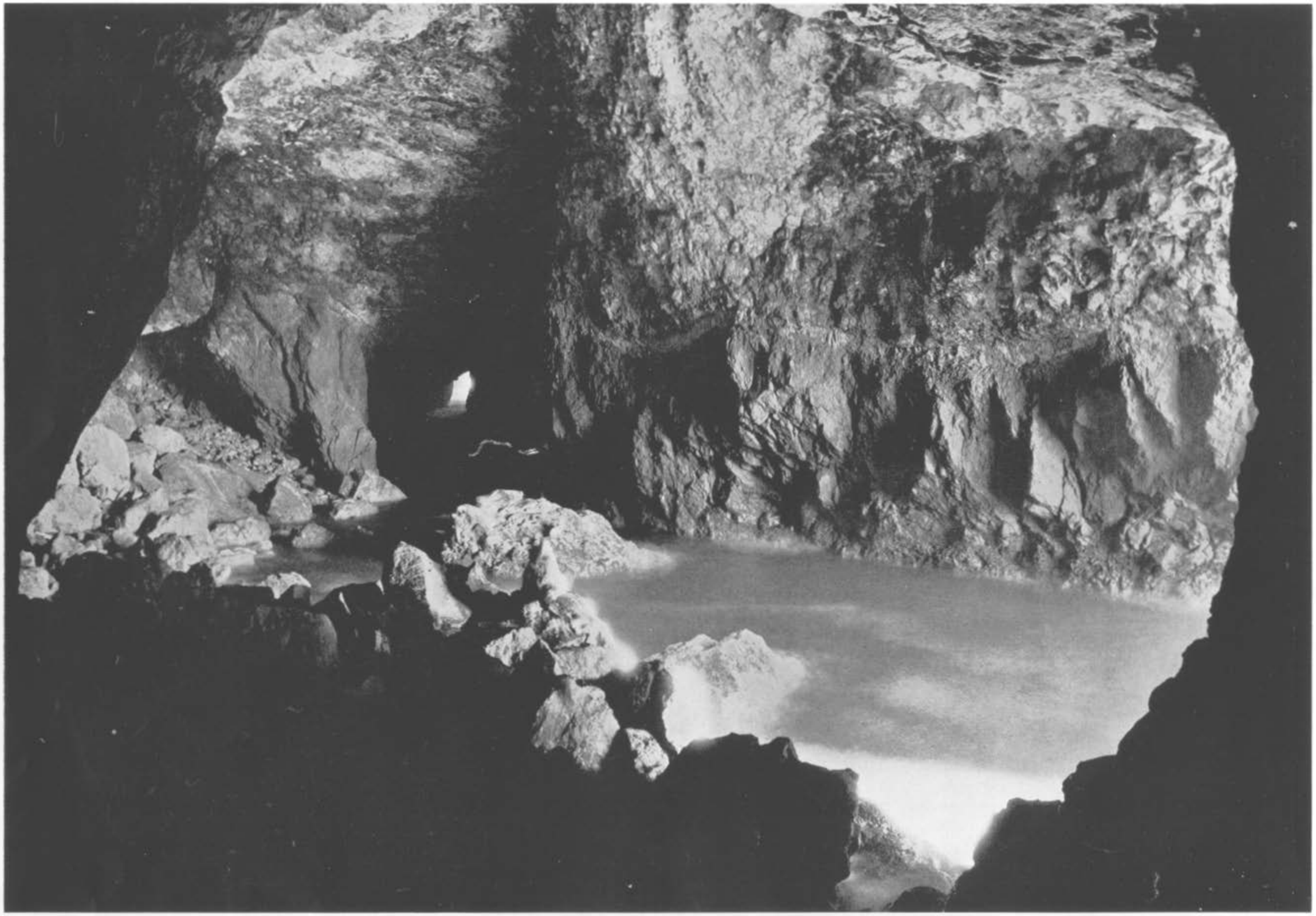


Figure 23—SEA LION CAVES (Sawyer Photo)

SUMMARY AND CONCLUSIONS

Lane county embraces 4,612 square miles of territory (almost the size of Connecticut) lying between the crest of the Cascades and the Pacific ocean. The county is quite diversified topographically and includes parts of three physiographic provinces; the Coast Range, Willamette Valley, and the Cascades. Topographic relief, with elevations from sea level to 10,354 feet, is naturally quite varied, and, in portions of the area, very rugged.

Geologically the formations are, as far as we now know, all of Tertiary age and later, with marine sediments of Eocene age in the western portion, terrestrial in the middle, and Miocene to Recent igneous extrusives dominating in the eastern part.

During the upper Eocene or lower Oligocene, a tropical climate prevailed in this region, as evidenced by fossil leaves of trees whose affinities now exist in Central America and the Philippines.

Both mastodons and elephants grazed in the Willamette Valley during the Pleistocene Period.

During one epoch of this period the Willamette Valley was flooded so that water completely submerged the present site of Eugene and was several hundred feet deep where Portland stands today. The greatest flood in historic times was that of 1861. The annual discharge of the Willamette is twice that of the Sacramento or Tennessee rivers.

The entire region has been subjected to folding and faulting. Such faults as exist are not conspicuous, and are doubtless relatively inactive.

No serious earthquakes have been felt in the county in historic times, and little apprehension on this score need be felt. Minor earthquakes at long intervals, however, have been recorded.

The Willamette Valley is a temporarily baselevelled valley, in which alluvial material of both stream and glacial origin is predominant.

While the industries of the county are predominantly agriculture and lumbering, there has been considerable mining here in the past and there are fair prospects for a substantial mining industry in the future if systematic work is done and metallurgy improved so that marketing costs will be reduced.

Gold (with some silver), copper, zinc, lead, quicksilver, and arsenic deposits occur here, but, of these, quicksilver is at present the metal of especial importance. The gold ores are base except near the surface, as this metal is associated with zinc, lead, copper, and iron sulphides.

Of the non-metallic substances sand, gravel and crushed rock are the most important (leaving out of account ground water and the soils).

Some good fire-clay, pottery and ordinary brick clays exist.

As Lane county has suffered in the past from over-enthusiasm and unwise practices in exploration of its mineral resources, especial attention is given to a discussion of some of the reasons for unsuccessful operations and suggestions for the future.

The scenic resources, largely dependent upon geologic conditions, will in time become a great activity in the county and for this reason are given especial treatment.

This county has a magnificent range of scenic features, coast, lakes, beautiful rivers, waterfalls, volcanoes and glaciers. In this respect it is, perhaps, the most scenically diversified county in the entire United States.

RECOMMENDATIONS CONCERNING THE GEOLOGY AND MINERAL RESOURCES OF LANE COUNTY, OREGON

From a reading of the foregoing chapters of this report it will be clear to the geologist or mining engineer, especially if he has any field experience in the county, that much detailed information remains to be acquired. Some of the desiderata as this writer views the "picture" are the following:

General

1. Completion of the topographic mapping either by the older plane table method or by aerial surveys, especially the area east of Eugene.

2. Beginning detailed areal geologic mapping of the entire county, starting in a metal mining quadrangle.

3. Study of landslide areas especially in the territory of Hell Hole north of Oakridge.

4. A detailed section of the Middle Fork of the Willamette river to the summit of the Cascades.

5. Study of recent changes in the Willamette river channels between Eugene and Junction City.

6. Physiographic studies in the Coast Range, especially in the vicinity of Triangle Lake.

7. Further studies along the summit of the Cascades, especially the summit lakes.

8. Detailed studies to ascertain changes taking place along the coast and studies of the coastal lakes.

Economic

1. More detailed study of the two metalliferous districts, Bohemia and Blue River, especially the latter. Geophysical surveys would probably be of great value in the heavily wooded portions.

2. If possible an adequately financed mining company should tunnel at considerable depths in the Bohemia district to ascertain two things especially: (1) the downward extension and probable tonnage of the ore veins and (2) the tenor and character of the ore bodies with increased depth.

3. Examination of all possible clay deposits and road cuts to ascertain if commercial clays, other than those now known, exist. This is well under way.

4. Continuation of ground water studies, especially recording all available data with the sinking of one or more deep wells to explore the possibilities of artesian water *beneath* the valley fill.

APPENDIX A

ELEVATIONS OF SOME IMPORTANT POINTS IN LANE COUNTY

		Feet
1.	Belknap Crater	6,877
2.	Belknap Springs	1,650
3.	Bohemia Mountain	5,967
4.	Cottage Grove	640
5.	Diamond Peak	8,750
6.	Eugene (Villard Hall)	449
7.	Foley Springs	700
8.	Junction City	324
9.	Linton Lake	3,550
10.	McKenzie Summit	5,324
11.	Oakridge	1,313
12.	Scott Mountain	6,125
13.	Sister (Middle)	10,053
14.	" (North)	10,094
15.	" (South)	10,354
16.	Skinner's Butte	681
17.	Spencer's Butte	2,065
18.	Springfield	450
19.	Triangle Lake Pass (Low Pass)	1,174

APPENDIX B

METEOROLOGICAL DATA FOR LANE COUNTY

(U. S. Weather Bureau)

1. The average annual mean temperature for Lane county is approximately 50.3 degrees F.
2. The average number of rainy days in Lane county is 153 per year.
3. The average number of clear days is 147.
4. The average annual precipitation for the county is 56.74 inches.

   The above figures are averages taken over several years from the following stations:

   Canary
   Cottage Grove
   Cascade Summit
   Deadwood
   Eugene
   Florence
   McKenzie Bridge
   Oakridge
   Leaburg

5. The average mean annual snowfall is 12.4 inches. This figure was computed from reports from the following stations:

Canary	Eugene
Cottage Grove	Florence
Deadwood	Leaburg

   Annual snowfall at Cascade Summit, Oregon:

   1928—185 inches (this year was driest on record in Eastern Oregon)
   1929—292 inches
   1931—264 inches
   1932—371.5 inches
   1934—200.6 inches

In 1907 Eugene had 205 days without any rain and 73 days when it rained less than 1/10 of an inch.

APPENDIX C

CHECK LIST OF LANE COUNTY MINERALS

Economic Minerals

	Name	Locality	Authority
1.	Agate		
2.	Ankerite	Bohemia	
3.	Barite	Bohemia	Mitchell
4.	Bornite	Bohemia	
5.	Calcite	Black Butte	Betts
6.	Cerussite	Bohemia	Mitchell
7.	Chalcedony	Willamette River Gravels	
8.	Chalcopyrite	Bohemia and Blue River Districts	Mitchell
9.	Chrysotile	Meadow	Mitchell
10.	Cinnabar	Black Butte	Mitchell
11.	Coal	Spencer Creek	Smith, W. D.
12.	Galena	Bohemia and Blue River Districts	Mitchell
13.	Gold	Bohemia and Blue River Districts	Mitchell
14.	Hematite	Bohemia and Blue River Districts	Mitchell
15.	Kaolinite		
16.	Limonite	Widespread as alteration product	Smith, W. D.
17.	Magnetite	Cottage Grove, etc.	Mitchell
18.	Marcasite	Black Butte, etc.	Smith, W. D.
19.	Melanterite	Black Butte, etc.	Ruff, Lloyd
20.	Mercury (native)	Black Butte, etc.	Smith, W. D.
21.	Metacinnabar	Black Butte, etc.	Wells and Waters
22.	Opal		
23.	Orpiment	Hobart Butte	Treasher
24.	Pyrite	Bohemia and Blue River Districts	Mitchell
25.	Quartz	Bohemia and Blue River Districts	Mitchell
26.	Realgar	Hobart Butte	Treasher
27.	Silver (with gold)	Bohemia and Blue River Districts	Mitchell
28.	Siderite	Black Butte	Wells and Waters
29.	Sphalerite	Bohemia and Blue River Districts	Mitchell
30.	Soda nitre	Mount June	Mitchell
31.	Stibnite	Peter's Creek	Smith, W. D.

Rock Making Minerals

(A. In the Lavas and Tuffs of the Cascades)

	Name	Locality	Authority
1.	Analcite		
2.	Apatite		Campbell, Hodge, Frazer
3.	Andesine		and others
4.	Augite		
5.	Bytownite		
6.	Chabazite		
7.	Chlorite		
8.	Epidote		
9.	Heulandite		
10.	Hypersthene		
11.	Iddingsite		
12.	Ilmenite		
13.	Labradorite		
14.	Magnetite		
15.	Olivine		
16.	Palagonite	Southern Lane County	Wells and Waters
17.	Stilbite		
18.	Thomsonite		

APPENDIX C—Continued

(B. In Granitic Intrusives)

Name	Locality	Authority
1. Biotite		Various Investigators:
2. Hornblende		
3. Kaolinite	(Generally Widespread)	Diller,
4. Muscovite	" "	Washburne,
5. Oligoclase	" "	Hodge,
6. Orthoclase	" "	Campbell,
7. Quartz	" "	etc.
8. Sericite	" "	
9. Titanite	" "	
10. Tourmaline	" "	
11. Zircon	Bohemia	Buddington and Callaghan

(C. In Dioritic Intrusives)

Name	Locality	Authority
1. Apatite		Buddington and Callaghan
2. Augite		
3. Hypersthene		
4. Labradorite		
5. Magnetite		

(D. In Sedimentary Rocks)

Name	Locality	Authority
1. Sericite	Eugene and vicinity	Ruff
2. Calcite		
3. Gypsum		
4. Garnet		
5. Quartz		
6. Sanidine	Eugene and vicinity	Ruff
7. Muscovite		
8. Biotite		
9. Pyrite		

APPENDIX D

LIST OF PRINCIPAL FOSSIL LOCALITIES

1. Springfield Junction (RR. Junction).
2. Springfield Butte (upstream from highway bridge 125 yards, along river).
3. Goshen (1½ miles south on Highway 99).
4. Rujada (Laying Creek Ranger Station).
5. University of Oregon Excavations for new library and heating tunnels.
6. Fir Butte (S. slope; sec. 24, T. 17 S., R. 5 W.).
7. Kelley Butte (sec. 34, T. 17 S., R. 3 W.).
8. West Point Hill (sec. 3, T. 17 S., R. 3 W.).
9. Coryell Pass (sec. 10, T. 17 S., R. 3 W.).
10. Oak Hill School (½ mile west sec. 31, T. 17 S., R. 4 W.).
11. Lower Hendricks Park Road, Eugene.
12. Smith's Quarry (near eastern edge of Eugene city limits between highway 99 and mill race).
13. Crabtree Hill (sec. 19, T. 17 S., R. 4 W.).
14. One-half mile south of Masonic Cemetery on Dillard Road near Springfield; sec. 8, T. 17 S., R. 3 W.
15. On Loraine Highway (0.6 miles southwest of Loraine; sec. 14, T. 19 S., R. 5 W.).

APPENDIX E

BIBLIOGRAPHY OF MORE IMPORTANT SOURCES OF INFORMATION ON THE GEOLOGY OF LANE COUNTY

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APPENDIX F

MAPS DEALING WITH LANE COUNTY

United States Geological Survey Topographic Maps:

Siltcoos Lake	15′ Quadrangle
Heceta Head	15′ Quadrangle
Mapleton (advance sheet)	15′ Quadrangle (south half completed)
Waldport	15′ Quadrangle
Monroe	15′ Quadrangle (in part)
Halsey	15′ Quadrangle
Earl (advance sheet)	15′ Quadrangle
Elmira	15′ Quadrangle (in part)
Eugene	15′ Quadrangle
Cottage Grove	15′ Quadrangle
Waldo Lake	30′ Quadrangle
Maiden Peak	30′ Quadrangle
Three Sisters	30′ Quadrangle
Diamond Lake	30′ Quadrangle
Lowell (advance sheet)	30′ Quadrangle
McKenzie Bridge (advance sheet)	30′ Quadrangle

Willamette River survey
Separation Creek survey
McKenzie River survey

United States Coast and Geodetic Survey Hydrographic Maps:
Siuslaw River, No. 6023 1/20,000
Cape Blanco to Yaquina Head No. 5892 1/197,000 (approximate)

United States Department of Commerce Airway Maps:
Sectional
Portland
Klamath Falls
Strip
Medford to Vancouver

United States Forest Service Forest Maps:
Siuslaw National Forest
Willamette National Forest

Lane County:
General County Map

State Highway Commission:
General Highway map of the state

United States Department of Agriculture—Bureau of Chem. and Soils:
Soil Survey of the Eugene Area

Brubaker Company (Portland):
Aerial photographs of Willamette River.

APPENDIX G

GLOSSARY

Adiabatic rainfall—caused by a rise or fall in temperature over a land area causing condensation of moisture in the air.

Agglomerate—coarse and irregularly shaped fragmental volcanic material.

Alluvial—pertaining to material deposited by flowing water.

Andesite—a volcanic, effusive or intrusive rock.

Anticline—fold in strata in the shape of an arch.

Basalt—a fine-grained intrusive or extrusive igneous rock, black or gray in color.

Batholith—a deep-seated igneous mass.

Biotite—a mineral composed of iron, magnesium and silica, brown or black in color; generally occurring in small flakes, rarely in sheets.

Bombs—pear-shaped "blobs" of viscous lava blown out of active volcanoes.

Butte—a detached hill or small mountain with steep sides, often capped by a lava flow or relatively hard formation. In this region it generally has a core of hard, igneous rock.

Cast—imprint or form of a disintegrated fossil left in a rock.

Cirque—topographic feature produced by mountain glaciers. Generally is in the shape of an amphitheater.

Conglomerate—aggregate of gravel or pebbles with a matrix of sand and mud more or less well cemented.

Cyclonic storm—storms characterized by a high wind of a circular nature.

Diabase—a basic igneous rock consisting mainly of plagioclase feldspar laths and pyroxene, with typical interlocking texture.

Diatomaceous earth or Diatomite—sediments composed mainly of fossil remains of diatoms found in fresh and salt water.

Dike—tongue or intrusive mass of igneous rock which cuts across or invades other rock bodies.

Dip—the angle of inclination which the bedding plane makes with a horizontal plane. Often confused with pitch.

Drowned river—a river that has been inundated by a submergence of the coast line or a raising of the water level.

Erosion—a general term referring to the lowering of the land surface toward sea level by the various agencies as weathering, stream, glacial, and wind action.

APPENDIX G—Glossary—Continued

Extrusive—molten lava which has been poured out on the surface of the earth from a vent or fissure in the earth. Fragmental igneous material may also be extrusive.

Fault—a break on either side of which there has been relative displacement of the formerly continuous beds.

Fauna—animal population of a region.

Flora—plant population of a region.

Generic—pertaining to a genus or class of related things.

Genus—a classificatory group of animals or plants.

Gradient—refers to the slope of stream beds—whether gentle, steep, or in terms of so many feet per mile.

Hydrography—description of bodies of water of a region.

Igneous rocks—rocks formed from molten magma.

Intrusion—molten material forced into or between other rocks from below.

Laccolith—igneous rock body roughly mushroom shaped formed below the surface of the earth.

Lava—molten material which has been poured out on the surface of the earth, and due to relief of pressure may have lost much of its gas and water during its consolidation. The term lava is used both for the liquid and the solidified state of the substance.

Meanders—curves in the bed of a stream caused by a very low gradient.

Metamorphic rocks—igneous or sedimentary rocks that have been altered or changed by mineralogical or structural agencies.

Meteor—extra-terrestrial body, known as a "shooting star", which upon entering the earth's atmosphere becomes luminous.

Meteorite—the stony or metallic body of the meteor after it has reached the earth.

Monadnock—a residual hill or similar local topographic feature rising above a peneplain.

Moraine—debris of all sorts that has been transported and deposited by a glacier or ice sheet.

Necks—volcanic conduits or plug-like characters consisting of lava or other volcanic products which have been exposed to erosion.

Nonconformity—condition where a younger formation has been deposited upon an erosion or folded surface of older rocks.

Obsidian—volcanic glass. Pure obsidian is hard with conchoidal fracture and a vitreous luster.

Oxbow Lakes—bodies of water occupying old meanders that have been isolated by a change in the channel of a river.

Paleontology—study of fossils, or remains of ancient life.

Peneplain—meaning "nearly a plain", a broad flat erosional plain.

Pedologist—soil expert.

Physiography—the delineation and interpretation of the relief (topographical features) of the surface of the earth.

Piracy (stream)—diversion of part of a stream by the headward growth of another stream.

Plateau—an extensive stretch of elevated and comparatively level land.

Rejuvenation—development of youthful topographic features, usually by uplift of an old valley or river bed, causing increase in erosion.

Relief—difference in altitude in a specific area.

Schist—a metamorphic rock sometimes banded, or foliated, chiefly notable for the preponderance of the lamellar minerals such as the micas, chlorite, talc, hornblende, graphite, etc. The word schist is derived from the Greek word meaning to split.

Sedimentary rocks—rocks formed from the decomposition products of other rocks, chemical precipiates, organic material, and deposited by various geologic agencies.

Seismology—study of the earth's crustal movements and earthquakes resulting therefrom.

Sill-dike—an intrusion of igneous material along the bedding planes of sediments.

Slickensides—smoothed or polished surfaces on rocks due to earth movements.

Talus—loose, broken-rock debris which flanks the lower sides of mountains or hill slopes. This rock is broken from the higher slopes by weathering.

Tombolo—shore-tied island—island tied to mainland by spits or bars of sand.

Ventral—pertaining to the lower or abdominal surface; opposed to dorsal, or upper surface.

Wave-built terrace—zone where the material acquired from a wave-cut terrace is being deposited.

Wave-cut terrace—concave section on shore line where the bottom is being eroded by waves.

Weathering—chemical and mechanical action of air, moisture, frost, temperature, animal and plant life that cause rocks to disintegrate.