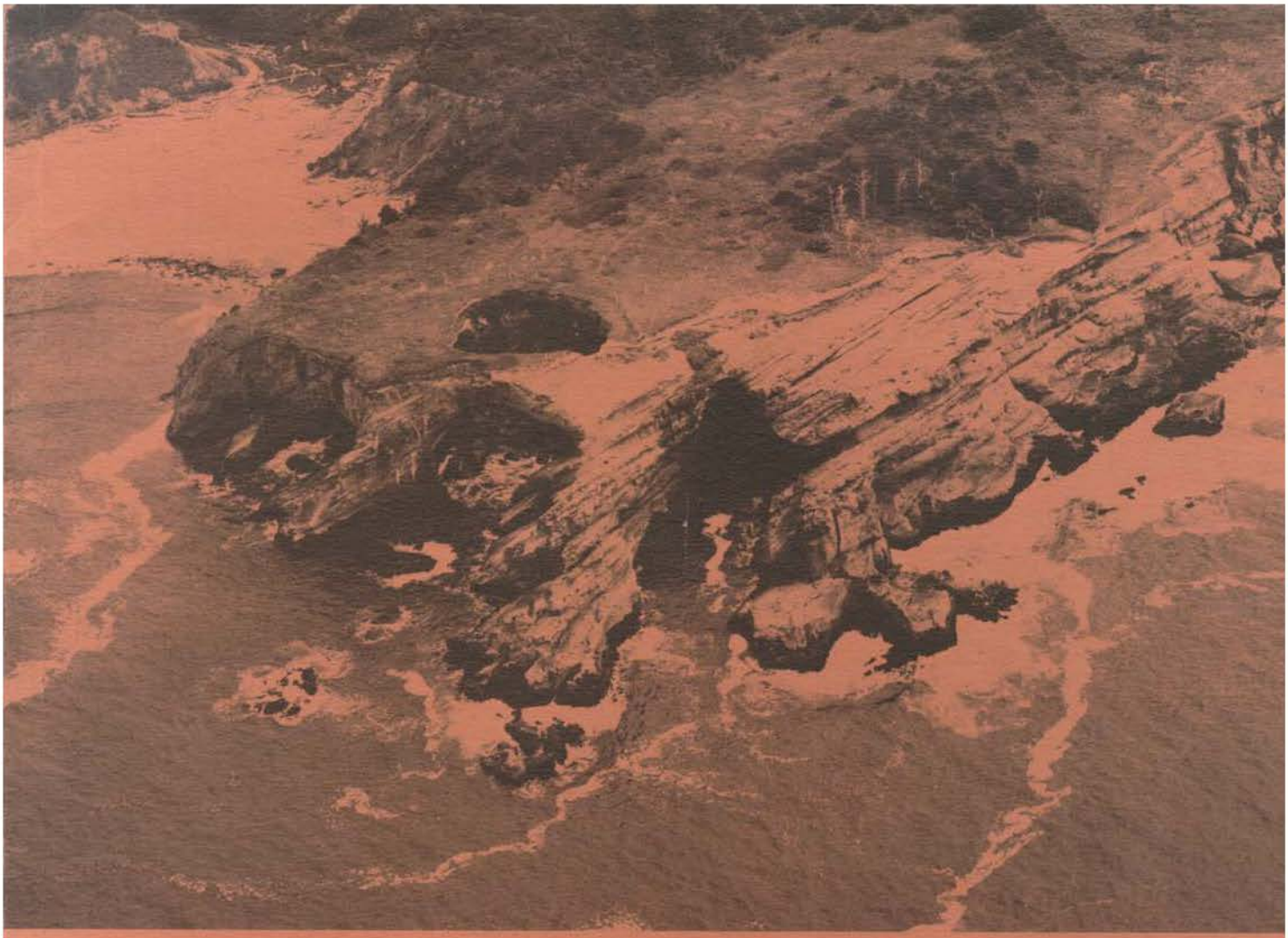
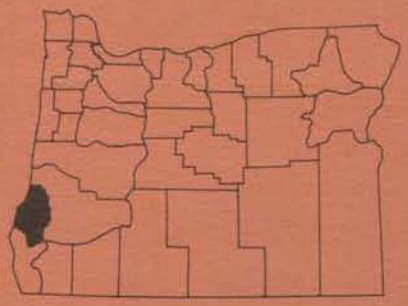


GEOLOGY & MINERAL RESOURCES *of* COOS COUNTY, OREGON



STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

1973

BULLETIN 80

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 State Office Building
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GEOLOGY AND MINERAL RESOURCES *of* COOS COUNTY, OREGON

Sections on Geology and Geography
by
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and
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Sections on Mineral and Fuel Resources
by
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Oregon Department of Geology and Mineral Industries

The preparation of this report was aided financially by a grant from
Coos County

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STATE GEOLOGIST
R. E. Corcoran

Aerial view of the mouth of Coos Bay and hinterland. Sunset Bay and Cape Arogo lighthouse in foreground. (Delano Photographics 57045)

FOREWORD

Although portions of Coos County were geologically mapped as early as 1901, the first comprehensive survey was begun in the late 1950's by Prof. E. M. Baldwin and graduate students in the Department of Geology at the University of Oregon. The Coos County Commission, recognizing the need for a report that would provide the basic scientific information needed for future planning, assisted the project through financial grants.

Gold was discovered on the southern Oregon beaches in 1852 and mining was carried on sporadically for many years. The coastal black sands south of Coos Bay and near Bandon contain, in addition to gold, undetermined quantities of chromite, iron, platinum, and titanium. Coal mining at Coos Bay began in 1855 and continued until soon after World War II. Oil and gas discoveries in California during the early 1900's eventually replaced coal as a prime energy source in the west. Probably an additional 50 million tons of recoverable coal in the Coos Bay area is available if coal once again should occupy a competitive economic position.

This report, the second in a series of county reports being published by the Oregon Department of Geology and Mineral Industries, represents the combined efforts of many people to show clearly for the first time the geology of the whole of Coos County and its mineral potential. It should serve as a useful guide in the development of intelligent land-use planning and zoning ordinances in this region during the coming years.

R. E. Corcoran
Oregon State Geologist

June 1973

CONTENTS

INTRODUCTION ---------- 1
Purpose ---------- 1
Previous work ---------- 1
Authorship and acknowledgments ---------- 2

GEOGRAPHY ---------- 3
Location ---------- 3
Population and transportation ---------- 3
Climate and vegetation ---------- 3
Relief and drainage ---------- 5
Industry ---------- 5

GEOLOGY ---------- 9
Description of geologic units ---------- 9
Rogue Formation ---------- 9
Galice Formation ---------- 10
Serpentinite ---------- 11
Diorite intrusions ---------- 12
Otter Point Formation ---------- 13
Dothan Formation ---------- 16
Myrtle Group ---------- 16
Umpqua Formation ---------- 18
Roseburg Formation ---------- 18
Lookingglass Formation ---------- 20
Fluornoy Formation ---------- 23
Tyee Formation ---------- 24
Elkton Siltstone ---------- 26
Bateman Formation ---------- 26
Coaledo Formation ---------- 27
Bastendorff Formation ---------- 31
Tunnel Point Formation ---------- 32
Miocene beds ---------- 32
Empire Formation ---------- 33
Coquille Formation ---------- 33
Terrace deposits ---------- 35
Alluvium ---------- 36
Tectonic history ---------- 36
Geologic history ---------- 37

METALLIC MINERAL RESOURCES ---------- 41
Black sands ---------- 41
Origin and distribution ---------- 41
Reserves ---------- 41
History and production ---------- 43
Mines and deposits ---------- 43

METALLIC MINERAL RESOURCES (continued)
Lode chromite ---------- 52
Copper ---------- 53
Gold and silver ---------- 55
Manganese ---------- 59
Mercury ---------- 61
Nickel ---------- 61
Platinum, titanium, and zirconium ---------- 62

INDUSTRIAL MINERALS AND ROCKS ---------- 63
Aggregate ---------- 63
Crushed and broken rock ---------- 63
Sand and gravel ---------- 65
Sand ---------- 65
Asbestos, talc, and soapstone ---------- 66
Building stone ---------- 66
Blueschist ---------- 66
Sandstone ---------- 67
Basalt ---------- 67
Clay ---------- 67
Garnet ---------- 68
Gem stones ---------- 68
Limestone ---------- 68

MINERAL FUELS ---------- 69
Oil and gas possibilities ---------- 69
Drilling history ---------- 69
Geologic conditions ---------- 71
Specific prospects ---------- 72
Coal ---------- 73

BIBLIOGRAPHY ---------- 77

ILLUSTRATIONS

Frontispiece - Aerial view of the mouth of Coos Bay and hinterland. Sunset Bay and Cape Arago lighthouse in foreground.

Figures

1. Index map of Coos County showing location of main geographic features ---------- 4
2. Marine terrace at Bandon formed at time of higher sea level ---------- 6
3. Jagged shoreline near Shore Acres, Cape Arago ---------- 6
4. Stratigraphic chart for southern Oregon coastal region ---------- 8
5. Large road cut along Oregon Highway 42 north of Myrtle Point exposes Roseburg Formation 21
6. Sole markings on base of a sandstone bed of the Flournoy Formation ---------- 21
7. Silver Falls drops over resistant Tyee Formation ---------- 25
8. Aerial view looking east across loops of the lower Coquille River ---------- 28
9. Mudstone clasts in sandstone associated with the Elkton Siltstone at Agate Beach ----- 30
10. Aerial view of Sunset Bay showing lower Coaledo strata in foreground ---------- 30
11. Cliff face south of Whiskey Run ---------- 34
12. Wave-cut platform at Fivemile Point ---------- 34
13. Gold mining in the early 1900's at Whiskey Run ---------- 42
14. Gold mining in 1918 at the Eagle mine ---------- 42
15. Locations of off-shore grab samples, southern Coos County and northern Curry County -- 44
16. Black sand deposits of Coos County ---------- 46
17. Seven Devils property and mill of Krome Corp. ---------- 49
18. Humphreys spirals during construction of gravity concentration plant at The Lagoons --- 49
19. Warren and Associates oil test hole near Beaver Hill ---------- 69
20. Annual production of Coos Bay coal, 1854-1943 ---------- 74
21. Period of operation of mines in the Coos Bay coal field ---------- 74
22. Beaver Hill coal mine about 1895, Coos County ---------- 75
23. Libby (Newport) mine about 1905 ---------- 75

Tables

1. Crushed rock, sand and gravel, and sand operations in Coos County ---------- 64
2. Holes drilled for oil and gas in Coos County ---------- 70
3. Gas analyses from wells in Coos County ---------- 71
4. Tonnage estimates, Coos Bay coal field ---------- 76

Plates (in pocket)

1. Geologic map of Coos County - northern section
2. Geologic map of Coos County - middle section
3. Geologic map of Coos County - southern section (with explanation and cross sections)
4. Mineral resource map of Coos County

INTRODUCTION

Purpose

The purpose of this report is to provide a geologic map and a discussion of the geology and mineral resources of Coos County, Oregon. Such basic data are essential for long-range planning.

The geology section describes the surficial deposits and bedrock units of the county. Together with the geologic map it provides a comprehensive picture of the basic geology of the area. The sections dealing with coal, oil and gas and mineral wealth outline in more detail the natural resources of the county.

Previous work

Much of the early geologic work in Coos County was done by J. S. Diller, who first discussed the Coos Bay coal field in 1896 and more completely described it in 1899. The Coos Bay folio (Diller, 1901) and the Port Orford folio (1903) included areal and geologic maps and structural cross sections of parts of the county. Later information on coal and metal mining in this area was published by Diller and Pishel (1911) and by Diller (1914).

The Fossil Point fauna was studied by Dall (1909). Arnold and Hannibal (1913), Howe (1922), Schenck (1927, 1928), Turner (1938), and Weaver (1942) discussed the Cenozoic faunas and ages of strata in Coos County. Broader studies of western Oregon by Smith and Packard (1919), Harrison and Eaton (1920), Washburne (1914), Hertlein and Crickmay (1925) and Weaver (1937) indirectly discuss the Cenozoic stratigraphy of Coos County.

Studies by Diller (1907), Louderback (1905), Knowlton (1910), Anderson (1938), Wells and others (1949), Wells and Walker (1953) deal in part with the older rocks in the southern part of the county.

During World War II considerable attention was paid to the chromite in the beach sands (Griggs, 1945) and the coal deposits (Allen and Baldwin, 1944 , and Duncan 1953).

In later studies Wells (1955) and Wells and Peck (1961) included Coos County in geologic maps. Dott (1966-b) discussed the petrography and mode of deposition of the Coaledo Formation and Koch (1966) discussed some of the broader aspects of Mesozoic sedimentation. Baldwin (1966) discussed various aspects of Coos Bay geology, and Snavely, Wagner and MacLeod (1969) developed a regional picture for the Cenozoic basins of deposition. Dott (1971) mapped and discussed the complex geology of an adjacent area immediately to the south. Baldwin (1969-a) mapped the Myrtle Point area and Baldwin and Hess (1971) mapped the Powers quadrangle.

Geology students at the University of Oregon mapped segments of Coos County in a series of mapping projects which were supported in part by Coos County and were directed by the senior writer of this report. They include Stephen Born (1963), L. K. Burns (1964), J. Ehlen (1969), R.W. Fairchild (1966), P. D. Hess (1967), N. P. Johannesen (1972), R. C. Kent (1972), M. L. Klohn (1967), A. E. B. Krans (1970), L. B. Magoon (1966), E. B. Nelson (1966), R. L. Phillips (1968), J. O. Rud (1971), and J. K. Trigger (1966). The present study represents a culmination of their work and additional work by the senior author.

Authorship and acknowledgments

This bulletin is the product of almost 30 years of geologic mapping in southwestern Oregon by the senior author, Professor Ewart M. Baldwin, Department of Geology, University of Oregon. It also incorporates a great deal of information accumulated by numerous graduate students working under his direction. Their contributions are appreciated; their works are cited in the text and listed in the bibliography.

The text was written as a joint effort between Professor Baldwin and various members of the Oregon Department of Geology and Mineral Industries. Geology was written by Ewart Baldwin and John D. Beaulieu; metallic and industrial mineral sections were written by Len Ramp; aggregate and crushed stone by Jerry J. Gray; oil and gas by Vernon C. Newton, Jr.; and the section on coal by Ralph S. Mason.

The editing and revising of this collective effort, together with typing and preparation of the camera-ready copy for publication, are the work of Margaret Steere, Carol Brookhyser, and Ruth Pavlat. Cartography was by Steven Renoud and M. E. Lawson.

GEOGRAPHY

Location

Coos County covers approximately 1,600 square miles of rugged to moderate terrain along the southwest Oregon coast (Figure 1). It lies between latitudes 42°40' and 43°35' and longitudes 123°40' and 124°30'. The county is situated partly in the northern Klamath Mountains, a complex region of Mesozoic rocks, and partly in the southern Coast Range, a region of less deformed early Cenozoic flows and sedimentary rocks.

Population and transportation

According to the census, the 1970 population of Coos County was 56,515. This compares to a total population of 54,000 in 1960 and reflects an overall increase of 2.8 percent in that ten year period. The population is centered around the Coos Bay area where the major communities include Coos Bay (13,446), Coquille (4,437), and North Bend (8,553). The community of Coos Bay experienced a 90 percent gain in population between the years 1960 and 1970 largely as the result of the annexation of Empire and Englewood. Communities elsewhere in the county have undergone losses of population in recent years, including Bandon (1,832), Myrtle Point (2,511), Eastside (1,380) and Powers (842).

The Southern Pacific Railroad connects the ports of Coos Bay and North Bend and the communities of Coquille and Myrtle Point to the railroad network to the east. Coos Bay and North Bend are major ports specializing in the shipping of timber products. U. S. Highway 101 traverses the length of the county close to and parallel to the coast except in the area between North Bend and Bandon, where it lies a short distance inland. Highway 42 extends eastward from Coquille, the county seat, and a minor highway connects the central part of the county with the community of Powers situated in the southern part of the county.

A network of county roads, generally restricted to the stream valleys, serves the inhabited parts of the county and private logging roads penetrate the large sections of timberland that are concentrated primarily along the eastern edge of the county. The Coos Bay Wagon Road is of historical interest, for it was the pioneer route which lead from Coos Bay inland through Sumner, Fairview, McKinley, Dora, and Sitkum to the Roseburg area when most other transportation was limited to boat and barge traffic to the head of tidewater in the various estuaries. The history of the development of Coos County is given by Dodge (1898) and by Peterson and Powers (1952).

Climate and vegetation

Owing largely to the moderating influence of the Pacific Ocean, the climate of Coos County is moist, marine, and temperate. The winters are cool and wet, and the summers are characterized by dry periods and intermittent rain. The annual rainfall ranges from approximately 60 inches to 100 inches, depending upon specific location and the particular year. The annual rainfall for North Bend is 62 inches with greater than 10 inches falling in both December and January.

The abundant rainfall supports a dense growth of forest and brush on the gentle to moderate slopes throughout much of the county. On some of the steeper slopes in the southern part of the county, certain types of oaks and shrubs are more able to tolerate the shifting water table characteristic of those areas. Some of the more barren slopes are underlain by active slides or by exposures of certain types of infertile rock such as serpentinite.

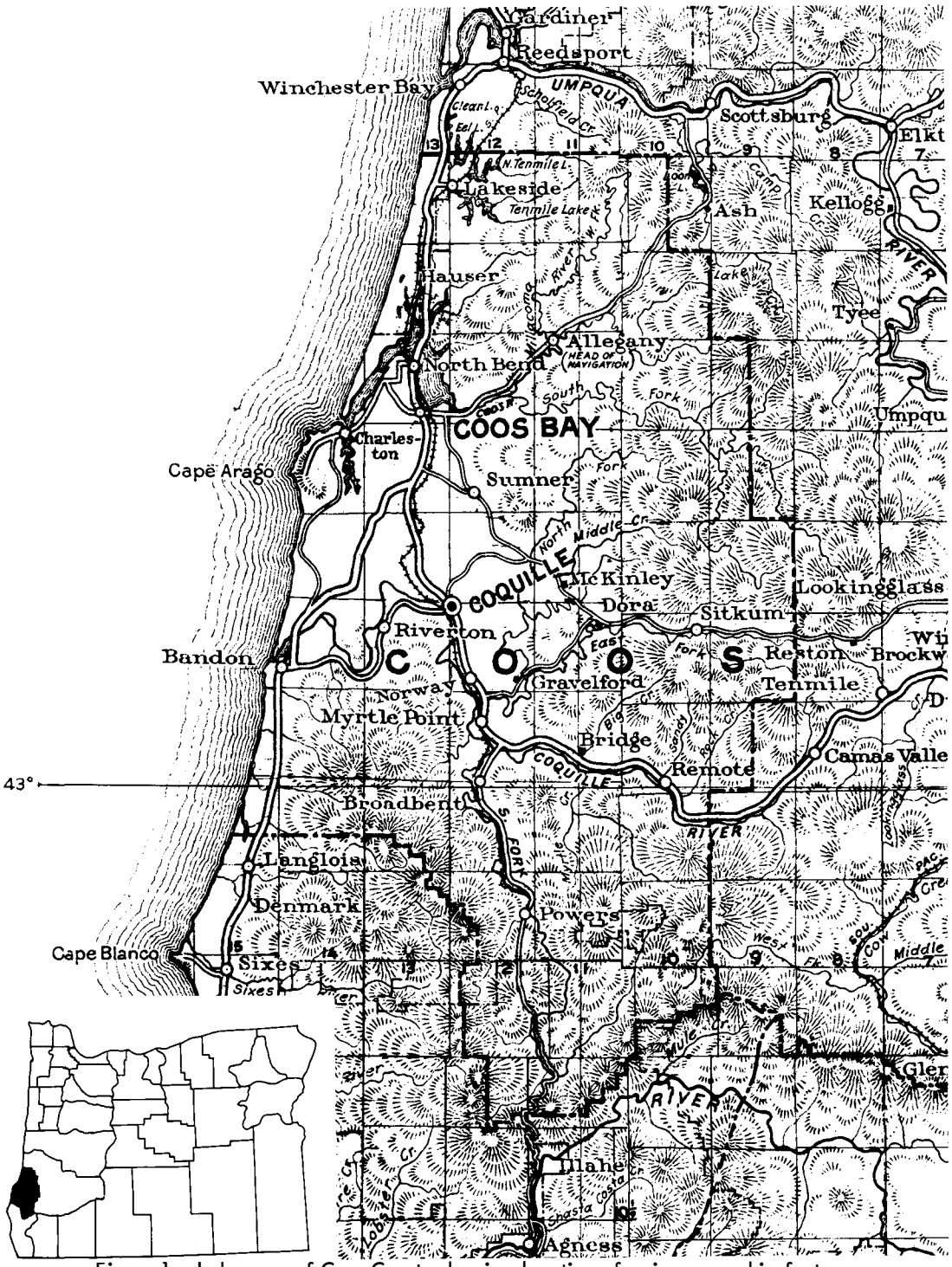


Figure 1. Index map of Coos County showing location of main geographic features.

Relief and drainage

The terrain of Coos County rises from sea level along the coast to 4,319 feet on Mt. Bolivar in the rugged Klamath Mountains Province in the southern part of the county. Elevations along the western edge of the Coast Range to the north are somewhat lower, averaging 1,600 feet in the Blue Ridge area and peaking at elevations of 3,661 feet at Bone Mountain, 3,294 feet at Kenyon Mountain, and 2,241 feet at Coos Mountain.

The slopes are steep and the ridge tops are characteristically narrow and sinuous. Near tidewater, the valleys are broad and flat owing to the rise in sea level and consequent valley flooding and sedimentation which accompanied the melting of the continental ice at the close of the Ice Age. Were it not for these events the valley bottoms would be exposed, revealing a terrain much like that observed above sea level today.

The southern part of the county is drained by the Coquille River and its principal tributaries, which include the South Fork which rises in Eden Valley, the Middle Fork which rises east of the county border in Camas Valley, and the North and East Forks which rise along the eastern margin of the Coast Range. The northern part of the county is drained by the Coos River and its tributaries, including the Millicoma River and several smaller streams such as Haynes, Larsen, Tenmile, and Eel Creeks.

The coastal plain is as much as 4 miles in width and consists of low marine terraces (Figure 2). North of Coos Bay the terraces are largely covered by sand dunes; the smaller dunes are active, but the older dunes are stabilized by protective vegetation. The terraces south of Coos Bay generally are higher than those to the north and are free of dunes. Logging operations have removed much of the forest cover.

Along the valleys many of the tidal flats are protected by tidal gates in the levees. During the rainy season, however, broad valleys such as that of the Coquille River are flooded by local runoff and the accumulation of rainwater.

In many of the low-lying areas, natural levees have developed where the swifter sediment-laden floodwaters of the channel spill onto the relatively quiet water of the flood plains and drop their sediment. The levees are marked by the rows of trees and shrubs which line the edge of the channels. Because of their relatively high elevation within the flood plain natural levees are commonly used for homesights.

Where alluviation has not completely filled all of the drowned valleys, swamps and marshes, as those near Myrtle Point and elsewhere, occupy significant portions of the valleys. North of Coos Bay, large lakes such as Tenmile and Eel Lakes occupy drowned stream valleys that are still alluviating. The principal difference between large lakes such as these and the bays lies in the volume of water delivered by the entering streams. The flow of the Coos River is sufficient to maintain a channel to the sea at Coos Bay whereas the flow of Tenmile Creek, which empties into Tenmile Lake, is insufficient to maintain such a channel.

Elsewhere in low coastal areas, shifting dunes border small bodies of water which represent trapped runoff or the intersection of local topography with the water table.

The jagged coastline at Cape Arago was produced by wave erosion of tilted sedimentary rocks. Hard sandstone beds form steep cliffs or project into the sea in long parallel ribs. Less resistant layers have been gouged out to form small bays. Arches and sea caves are some of the other erosional features that have developed in this part of the coast (Figure 3).

Industry

Coos County, with its expanses of wooded hills and numerous coastal and inland attractions, relies on the timber and tourist industries for its economic livelihood. Of significance also is the production of agricultural products.

Forestry: Approximately 900,000 acres of Coos County, 87 percent of the total land area, are devoted to commercial forests. The acreage is equally divided among public, small private, and forest industry ownership. The majority of the standing saw timber in the county (55 percent) is located on public lands as opposed to 29 percent on forest industry lands and 16 percent on small private plots. The increasing dependence of the forestry industry on public lands in the future is evident.

Figure 2. Morine terrace at Bandon was formed at time of higher sea level. Bedrock was planed off by wove erosion and sand was deposited over the surface.

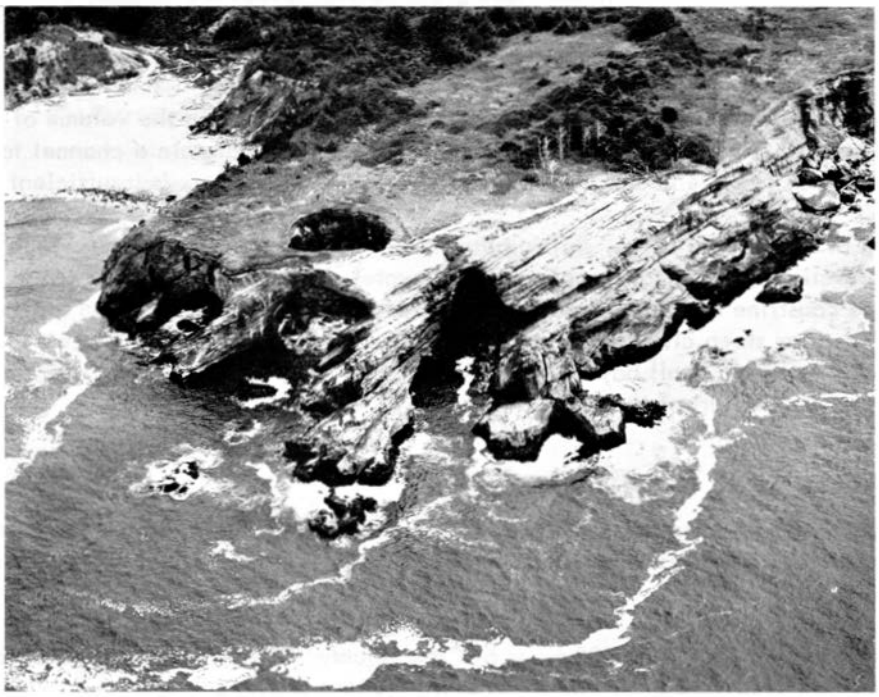


Figure 3. Jogged shoreline near Shore Acres, Cope Arogo. Arch and collapsed sea-cove roof ore in lower Coaledo Formation. (Photo by Word Robertson)

The average annual timber production for Coos County is 585 million board feet; the average annual value of manufactured timber products is $60 million. More than 6,000 persons are employed in the timber industry, and the increasing demand for wood products around the world insures the health of the industry in the future.

Tourism and recreation: With its scenic coastal stretches and abundant streams ond lakes Coos County is among the more popular recreation areas of the state. Tourism is the second largest ond fastest growing industry in the county. More than 45 miles of the shoreline are devoted to state and county parks and waysides.

Much of the tourist industry is indirectly the result of the fishing potential of the area. Salmon fishing draws 37,000 anglers to the county annually. Auxilliary boat equipment, fishing gear, gas and oil account for annual expenditures of $2 million.

In recent years, thousands of sightseers have been turned away for lack of adequate overnight facilities, causing considerable loss of input to the economy. With the continuation of national trends in income, leisure time, and desire to travel, the further growth of the tourist industry in Coos County is assured.

Agriculture: Approximately 24 percent of the land area of Coos County is devoted to farm ownership, chiefly farm woodlots and pastures. In 1964 there were 1,058 farms in the county, a decrease from previous years, which was in keeping with national trends.

Dairy products accounted for half the agricultural income, bringing in $3.5 million in wages. Livestock marketing, including cattle, calves, sheep, wool, and poultry, accounted for an additional $2 million in 1967. Crops include cranberries, fruits, hay, nursery and greenhouse products, and farm forest products. The cranberry industry grossed $822,000 in 1967.

Fisheries: Coos Bay produced 16,666,174 pounds of fish and shell fish in 1967 to rank second to Astoria in that industry in the state of Oregon. The major types of fish include coho and chinook salmon, crab, shrimp, tuna, and bottom fish. There are 450 commercial fishermen and 700 fish processors employed in the county. Available for future harvesting are significant quantities of saury, hake, anchovy, tanner crab, and black cod which remain untapped owing to the present lack of adequate markets and adequate harvesting techniques.

Mineral resources: Some of the earliest considerations of the geology of Coos County came as a result of interest in gold and coal. Gold was discovered on the southern Oregon beaches in 1852, and the earliest beach mining on record was at Whiskey Run, a few miles north of the mouth of the Coquille River (Diller, 1903). Gold was discovered in Johnson Creek, a tributary of the South Fork of the Coquille River, in 1856 (Diller, 1903), and mining continued for many years. On a trip into the Johnson Creek mines, John Evans supposedly discovered the famous Port Orford meteorite (see Henderson and Dole, 1964).

In addition to gold, the coastal black sands deposits south of Coos Bay and near Bandon also contain undetermined quantities of chromite, iron, platinum, and titanium. Eventual production, however, must successfully meet the problems posed by overburden, land use policies, and littoral hazards such as wind, waves, and tides.

Coal was discovered near Empire in 1854 and in 1855 a mine was opened immediately southwest of the town of Coos Bay in the now largely abandoned Coos Bay coal field. Demand for the coal in the foreseeable future appears minimal in view of the excellent port facilities and consequent ready availability of oil. However, with the depletion of other energy sources, coal may once again occupy a position of economic importance. There are probably an additional 50 million tons of recoverable subbituminous coal in the field as compared to the total production to date of 2.5 million tons.

Nine exploratory oil wells have been drilled in the Coos Bay area. Three of the wells penetrated to depths in excess of 5,000 feet. Although there were a few minor shows, there has been no production.

A substantial supply of fresh ground water was discovered in the sand-dune area north of Coos Bay (Brown and Newcomb, 1963). The ground-water body extends throughout the area of the sand deposit and saturates the sand from the water table down to the underlying impermeable bedrock of the Coaledo Formation.

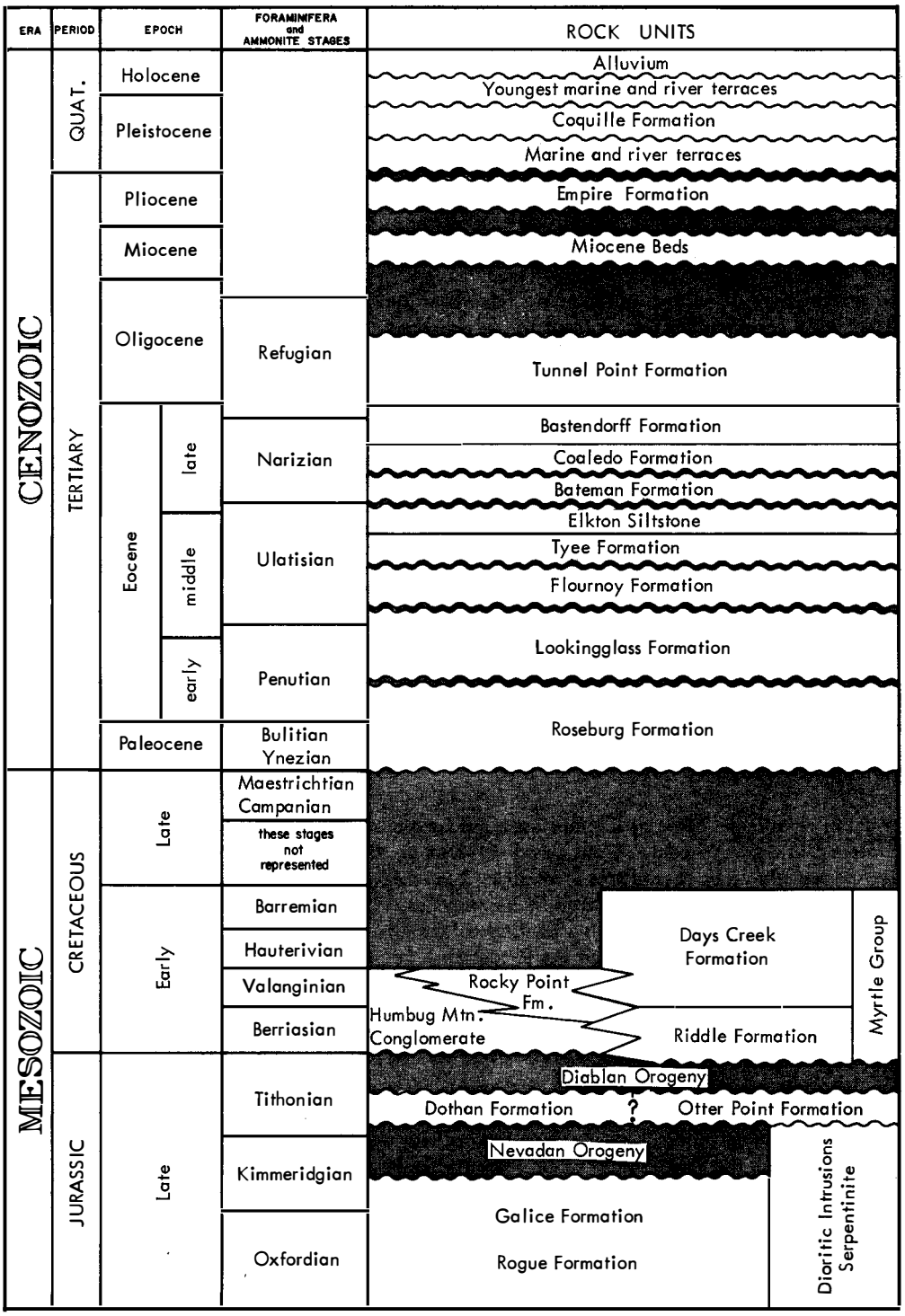


Figure 4. Stratigraphic chart for the southern Oregon coastal region.

GEOLOGY

by E. M. Baldwin and J. D. Beaulieu

Description of Geologic Units

A wide variety of bedrock units ranging in age from Mesozoic through Pliocene underlies Coos County (Figure 4 and Plates 1, 2, and 3). The Mesozoic units include altered basalts, eugeosynclinal turbidites, shelf deposits of conglomerate, sandstone, and siltstone, and a variety of intrusions. In order of decreasing age, the following units are recognized: Rogue Formation, Galice Formation, serpentinite, diorite intrusions, Otter Point and Dothan Formation, Riddle Formation and Humbug Mountain Conglomerate, and Days Creek Formation. Composite thickness for the Mesozoic units is approximately 10 miles.

The Eocene units consist primarily of turbidite sandstone and siltstone assigned to the Roseburg, Lookingglass, Flournoy, and Tyee Formations and the Elkton Siltstone. Basalt makes up the lower part of the Roseburg Formation. The late Eocene and early Oligocene shallower water deposits include the Bateman, Coaledo, Bastendorff, and Tunnel Point Formations. Exposures of unnamed Miocene beds and the Pliocene Empire Formation are present locally in the south Coos Bay area. Total composite thickness for the Tertiary units also approximates 10 miles.

Rogue Formation

The Rogue Formation is composed of altered Mesozoic volcanic rock and is exposed as a thrust sheet in the area between Mt. Bolivar and Saddle Peaks near Eden Valley (Baldwin and Rud 1972). Wells and others (1949) originally mapped similar appearing rocks as Galice Formation in the Kerby quadrangle to the south. Later Wells and Walker (1953) assigned 15,000 feet of equivalent volcanic strata to the Rogue Formation in the Rogue River Canyon west of the community of Galice. Wells and Peck (1961) assigned the volcanic rocks in Mt. Bolivar to the Dothan Formation.

The overall sequence of strata making up the Galice and Rogue Formations probably constitutes part of an ophiolite assemblage in which volcanic and intrusive rocks dominate low in the section and sedimentary rocks dominate high in the section. In a broad sense the smaller bodies of volcanic rock which are interfingered with the sediments of the Galice Formation are probably analogous to the Rogue Formation, but are best treated stratigraphically as part of the Galice Formation. As discussed by Irwin (1960, 1964), Baldwin (1969), and Hotz (1969) the Rogue Formation and associated intrusive and sedimentary rocks probably were thrust westward relative to the younger underlying Dothan Formation.

Greenstone associated with the Galice Formation and mapped by Baldwin and Hess (1971) near Johnson Mountain may be equivalent to the Rogue Formation. At Rusty Butte about six miles west of Johnson Mountain the volcanic rock occupies the center of a syncline in the Galice Formation, a relationship which appears to place it near the top of the formation, however. In contrast, the type Rogue Formation along the Rogue River appears to lie at the base of the Galice Formation; both units dip eastward and the Galice exposures lie east of the Rogue Formation.

According to Rud (1971),

> "The Rogue Formation in the Saddle Peaks area is made up of basaltic flows and breccias that have been hydrothermally altered. These metavolcanic rocks are called greenstone because of the abundance of green minerals, mostly chlorite. Vesicular and amygdaloidal structures are present along the top of flows. The fresh surfaces of the rocks exhibit a greenish-gray color and conspicuous phenocrysts of augite and plagioclase in a microcystalline groundmass. Epidote occurs in veins and amygdule below Saddle Peaks.
>
> "The feldspar ranges in composition from An_{25} to An_{36} and is distinctly zoned. The plagioclase, ranging in size up to 4 mm in length, has a tendency to occur as glomerocrysts and microlites. Composition of the microlites was not determined, due to their small size, lack of twinning, and alteration. An effect of the hydrothermal alteration can be observed by the sericitization of approximately 50 percent of the plagioclase.

"The mafic constituent in the specimens examined was a pyroxene that was identified as augite. The subhedral augite occurs as phenocrysts ranging in size up to $2\frac{1}{2}$ mm in length and as constituents in the groundmass. Approximately 90 percent of the pyroxenes contain magnetite inclusions. Subhedral magnetite is also scattered rather evenly throughout the samples and occurs both as phenocrysts and in the groundmass.

"The groundmass of these rocks includes plagioclase feldspar, clinopyroxene, glass, chlorite, and magnetite. Approximately 40 percent of the groundmass is plagioclase and approximately 15 percent is composed of magnetite. The clinopyroxene has been chloritized, so it is difficult to estimate the percentage of these constituents in the groundmass."

The above assignment of the volcanic exposures between Mt. Bolivar and Saddle Peaks to the Rogue Formation represents a refinement of earlier mapping. On the geologic map of western Oregon, Wells and Peck (1961) map the above exposures as part of the Dothan Formation. Baldwin (1969b), Rud (1971), and Baldwin and Rud (1972) show, however, that the above exposures are probably part of a thrust sheet composed of the Rogue Formation which was thrust westward relative to the underlying Dothan Formation and Myrtle Group. Subsequent faulting and erosion has obscured the relationship with the Rogue exposures to the east.

The Rogue Formation is Late Jurassic in age and presumably is in part age equivalent to the Galice Formation of late Oxfordian and Kimmeridgian age. Recent mapping reveals also that the unit locally contains dioritic and gabbroic intrusions, a feature which suggests a subjacent and pre-Nevadan origin. Because the Rogue Formation overlies the Cretaceous Myrtle Group in the west, thrusting must have occurred in the Late Cretaceous or later. Baldwin and Lent (1972) present evidence that some major thrusting occurred near the end of the early Eocene. It is uncertain, however, when the actual bulk of the thrusting took place; there may have been several stages of thrusting.

Galice Formation

The Galice Formation consists of rhythmically bedded sandstone and siltstone and associated volcanic rock; it crops out in the area surrounding Johnson and Bray Mountains south of Powers. The name was defined by Diller (1907) in reference to exposures of dark gray slaty argillite along Galice Creek and the Rogue River near the community of Galice.

The sedimentary part of the Galice Formation is composed of steeply dipping, dark gray, partly fissile mudstone and siltstone interbedded with thin beds of fine-grained sandstone. In most places dark gray argillite is the predominate rock type. Wells and Walker (1953) estimate a total thickness of approximately 15,000 feet for the unit in the type area along the Rogue River. It is difficult to measure the thickness of the strata south of Powers, but 5,000 feet of sedimentary rock is probably exposed there. In addition, 2,000 to 3,000 feet of volcanic rock apparently intercalated with the sedimentary rock is also included in the unit.

The Galice beds are extensively fractured and faulted and are riddled with vein deposits of quartz and calcite. Diorite intrusions are widespread and are treated in the literature (Lund and Baldwin, 1969). Some of the sedimentary strata along the Iron Mountain road and along the South Fork of Elk River consist of rhythmically bedded sandstone which in some respects is similar to that of the Dothan Formation.

Bodies of altered volcanic flow rock, breccias, and tuffs are associated with the sedimentary rocks of the Galice Formation at various locations including Johnson Mountain, Bray Mountain, and the area along the east slopes of Iron Mountain. At Johnson Mountain the volcanic rocks approach 2,500 feet in thickness and are separated from the sedimentary rocks of the Galice Formation by a body of serpentinite and possibly by faults of considerable magnitude. Elsewhere to the east smaller bodies of volcanic rock appear to be interbedded with the sedimentary rocks.

At Rusty Butte six miles west of Johnson Mountain the volcanic rocks occupy the center of a syncline in the Galice Formation and appear to be relatively high in the section. Although some of the volcanic rocks here and elsewhere may be equivalent to the Rogue Formation, they are assumed to be interbedded with the Galice Formation and are treated as a part of that unit. The complex stratigraphic relationships of the two lithologies constitute a feature to be expected if the exposures represent a sea floor ophiolitic assemblage.

Lent (1969) described the volcanic rocks in the Galice Formation along the South Fork of the Sixes River as follows:

> "Various shades of green typify the altered flow and pyroclastic rock. Flow rocks present uniform weathering surfaces which may or may not exhibit large plagioclase phenocrysts.... Galice flowrock is fine-grained to porphyritic. Extremely altered plagioclase phenocrysts (to $2\frac{1}{2}$ mm) are dominately calcic oligoclase (An_{25}), but the presence of granular albite is suggestive of a more calcic parent. Plagioclase occurs in an intersertal to intergranular texture. Clinopyroxene is almost entirely replaced by nematoblastic actinolite and fibrous chlorite. In some of the larger grains, pyroxene has been replaced by hornblende. Epidote and iron oxides occur as interstitial minerals. Chlorite, albite, quartz, and twinned calcite appear in scattered patches closely resembling amygdules. Basaltic hornblende in trace amounts is found as a brown pleochroic core surrounding a cloudy alteration zone."

The Galice Formation, like the Rogue Formation, is intruded by numerous dioritic dikes and stocks (Lund and Baldwin, 1969), a feature characteristic of subjacent rocks but not present in post-Nevadan strata. A Late Jurassic age is inferred for the unit. Dott (1966-a) reported the discovery of Buchia concentrica of Late Oxfordian to middle Kimmeridgian age in Galice strata along Sucker Creek, a tributary of Johnson Creek.

The Galice Formation was evidently laid down in a rapidly filling trough as part of a thick section of sedimentary and volcanic rock. Subsequently the rocks were severely deformed and intruded during various pulses of the Nevadan Orogeny. According to present thought, the tectonism may have occurred within a subduction zone separating the ancestral Pacific Plate from the Klamath Mountain block of the ancestral North American Plate.

Serpentinite

Exposures of serpentinite are restricted primarily to the southern part of Coos County and occur as large flat-lying bodies and as narrow bands that apparently were squeezed up along steep faults. The largest body crops out at Iron Mountain, the eastern slope of which lies in the extreme southwestern corner of Coos County. To the east a linear body crops out along the Powers-Agness fault, which parallels the South Fork of the Coquille River. Other exposures of serpentinite occur in Baker Creek north of Powers and at Johnson Mountain. A relatively small body of serpentinite crops out east of Bridge along Highway 42, and another is located at Gravelford along the North Fork of the Coquille River. The latter body is unusual in that it appears to be entirely surrounded by Cenozoic rocks.

Serpentinite is a green to blue rock composed primarily of minerals of the serpentine group including antigorite, chrysotile, and lizardite. It is formed by the alteration of ultramafic rocks such as peridotite and commonly has preserved within it relict crystals of olivine and pyroxene. The degree and type of alteration varies with tectonic setting, a feature which is informative to the experienced geologist. For instance, blue-green serpentine is usually associated with shearing and is indicative of nearby high-angle faults.

Present theory maintains that the peridotite from which the serpentinite of southwestern Oregon was derived, represents upper mantle material which emerged at the sea floor along an ancestral sea floor rise and which was rafted eastward and emplaced along the west edge of the Cordillera during one or more episodes of late Mesozoic subduction (Coleman, 1971a, 1971b; Medaris, 1972).

Hydration concurrent with rafting or thrusting altered the peridotite to serpentine. In later tectonism the serpentine, owing to its incompetence, served as "tectonic carpets" over which thrust plates developed. In a regional sense many of the thrust faults of southwestern Oregon are associated with significant exposures of serpentinite; the broader sheets of serpentinite probably are soles of thrusts.

In some areas where serpentinization was fairly complete, later tectonic stresses remobilized the serpentinite along steeply dipping faults. In these instances (i.e. along the Powers-Agness fault) the serpentinite crops out in linear bands. The original relationship of the serpentinite to the other bedrock is obscure and synthesis of the local tectonic history is correspondingly difficult.

In southwestern Oregon the first emplacement of the serpentinite apparently was during the Late Jurassic Nevadan Orogeny. Some of the larger bodies are intruded by masses of diorite, also of Nevadan age. Later stages of orogeny in the late Mesozoic Era and probably in the early Tertiary remobilized some of the serpentinite along steeply dipping faults. In the project area some of the serpentinite is in contact with beds as young as middle Eocene (Lookingglass Formation) along the Powers-Agness fault near the South Fork of the Coquille River.

Diorite intrusions

Stocks, dikes, and sills generally of dioritic composition crop out in southwestern Oregon and have been described by Koch (1966), Dott (1971) and Lund and Baldwin (1969). In south central Coos County, a small stock is exposed about three miles from the mouth of Johnson Creek, and a broad dike makes up the summit of Granite Mountain and extends across Granite Creek into the south slope of Bray Mountain (Baldwin and Hess, 1971). Larger bodies lie to the west in the Elk River drainage and in the Upper Sixes River. Lund and Baldwin (1969, p. 197) describe the Granite Peak pluton as follows:

> "In hand sample the rock of the Granite Peak pluton closely resembles that of Pearse Peak. One small difference is in the color of the orthoclase, which in the rock of Granite Peak is pale pink and readily identifiable because of its contrast with the gray plagioclase. The most significant difference in the rock is the extent of hydrothermal alteration. The biotite has been almost completely converted to chlorite and epidote, and the plagioclase has been considerably sericitized, except for a thin, clear outer zone in most grains. Hornblende is generally fresh looking, but parts of some grains have been altered to chlorite. The orthoclase has not been significantly changed. The rock is cut by small veinlets consisting mainly of quartz, and the presence of these veinlets offers a clue to the reason why this rock is more intensely altered than rock in the other plutons of the Pearse Peak type."

Several bedrock and placer gold mines are clustered around the Granite Peak intrusive and are discussed by Diller (1903 and 1914). Mineralization presumably accompanied emplacement of the pluton.

The Johnson Creek pluton was described by Lund and Baldwin (1969, p. 197) as follows:

> "The rock of the Johnson Creek pluton is similar to that of Pearse Peak in both texture and mineral composition, but certain variations were noted. The most significant difference is in its much higher content of hornblende--30 percent in the one sample examined in contrast to a maximum of 17 percent in the other samples of this rock type. It is correspondingly lower in all the other essential minerals. And, in addition, the hornblende has more of a tendency to form euhedral grains than it does in the rocks of the other plutons."

The Pearse Peak diorite with which the above pluton is compared is described by Koch (1966, p. 510) as "hornblende-biotite quartz diorite (as defined by Williams et al, 1954)."

Where Iron Mountain road crosses the head of Rock Creek a small nearly white dike crops out and appears to be high in silica. A similar dike of dacite porphyry crops out at the head of Ragsdale Creek (NW½ sec. 21, T. 32 S., R. 12 W.), a tributary of Johnson Creek. The rock was described by Lund and Baldwin (1969, p. 203) as follows:

> "a light-colored, fine-grained porphyry with plagioclase and some quartz phenocrysts in a groundmass of quartz, plagioclase, and the secondary minerals epidote and zoisite; no hornblende is present."

In summary, the intrusive rocks of southern Coos County are intermediate to dacitic in composition. The smaller intrusions and dikes are fine grained compared to the more deep-seated larger plutons such as those at Johnson Creek or Granite Peak. Hornblende is present in the large plutons but is lacking in the smaller intrusions in which water pressure was probably significantly lower.

The intrusions are restricted to pre-Nevadan terrain and occur within the Rogue and Galice Formations. As mentioned above, diorite intrudes serpentinite locally. Emplacement occurred in the Late Jurassic.

Otter Point Formation

The name Otter Point Formation was applied by Koch (1966) to a varied assemblage of primarily eugeosynclinal rocks exposed along the southern Oregon Coast. The name was derived from Otter Point, a small headland situated three miles north of the mouth of the Rogue River in Curry County. The formation consists of a thick assemblage of sandstone, siltstone, conglomerate, chert, and volcanic rock. In addition, it contains scattered blocks of blueschist and random stringers of serpentinite. Rock now assigned to the Otter Point Formation was originally included in the Myrtle Formation by Diller (1903). That formation, now called the Myrtle Group, has subsequently been restricted by Imlay and others (1959) to rocks of slightly younger age inland in the vicinity of Myrtle Creek in Douglas County.

In Coos County, outcrops of the Otter Point Formation occur primarily along the South Fork of the Coquille River drainage between Broadbent and Salmon Creek southwest of Powers. One small infaulted block lies immediately west of China Flats (Baldwin and Hess, 1971). Small exposures also occur along the Middle Fork of the Coquille River east of Bridge and at the Kincheloe quarry. The formation presumably underlies Cenozoic formations to the north.

The formation is subdivided into two members by Lent (1969) and Baldwin and Hess (1971). The older unit is the more variable of the two and consists of sheared, virtually structureless and incompetent siltstone and thin-bedded sandstone with rootless masses of sandstone, greenstone, chert, and blueschist. Much of the unit is highly disordered and conforms to the concept of mélange as advanced by Hsu (1968).

The upper unit consists of massive feldspathic sandstone and is well exposed at Sugarloaf Mountain, a few miles west of the county boundary. This massive sandstone extends eastward into parts of Salmon Creek Valley and Bingham Mountain near Powers. Both units are discussed in more detail below.

Lower member: The lower member of the Otter Point Formation consists primarily of highly sheared mélanged sedimentary and associated volcanic rock. Hess (1967) suggests that the lower member of the Otter Point Formation is made up of approximately 80 percent sandstone, 15 percent siltstone, 3 percent conglomerate, 1 percent volcanic rock, and less than 1 percent bedded chert in the Powers area. Elsewhere volcanic rock is more abundant.

Much of the sandstone occupies large sheared areas in which alteration makes adequate sampling difficult. Some of the massive sandstone forms rootless knobs or "islands" that rest in a matrix of sheared siltstone and sandstone. The knobs generally consist of massive beds of medium-gray to yellowish-gray sandstone, but several are composed of volcanic rock, schist, and chert. Diapiric masses of sheared Otter Point sedimentary rocks crop out along the North Fork of the Coquille River, either in center of folds or squeezed up along faults. Included blocks of greenstone at the Kasper quarry near the mouth of Elk Creek and near the bridge over the North Fork of the Coquille a few miles east of Myrtle Point have been large enough to quarry.

A multitude of hairline joints, many of which are filled by thin quartz veinlets, cut sandstone of the lower unit of the Otter Point Formation. Small angular blebs of dark-gray mudstone are scattered through the lighter yellowish-gray sandstone. The sandstone is distinctly more indurated than that of the Cretaceous or younger units. When broken it frequently fractures into angular fragments with sharp edges defined by the acute intersections of the numerous fracture surfaces.

On the basis of 15 thin sections of sandstone of the lower unit, Hess (1967) classified the sandstone as wackes (according to the terminology of Williams, Turner, and Gilbert, 1954). Quartz varies in abundance from 35 to 55 percent, except where chert or other lithic fragments predominate. Plagioclase commonly makes up 5 to 15 percent of the rock and lithic fragments and matrix make up the remainder. Stain tests for potassium revealed potassium feldspar in abundances varying from 1 to 3 percent.

Red, green, pink, and nearly white bedded chert is widespread in terrain of the lower unit of the Otter Point Formation. The red cherts contain radiolaria (Lent, 1969) and are commonly veined by white quartz to make an attractive ornamental stone. Boulders of the various types of chert are present in the South Fork of the Coquille River. Nonbedded chert has been observed in the interstices of pillow lavas at

Bandon and may be related to the submarine extrusion of the associated volcanic rock.

Although common elsewhere, volcanic flows, dikes, and sills are rare in the Otter Point Formation in Coos County. Fragmental volcanic material may be more abundant than is presently suspected, however. Specifically, the remnants of flows and dikes crop out near Bandon, Two Mile Creek, along Dement Creek, at Hood Mountain, and in the vicinity of the Kincheloe quarry east of Bridge. The more solid masses are quarried for road and construction rock.

Basaltic pillow lavas crop out in the county quarry on South Two Mile Creek and on the Bandon Beach. Ehlen (1969) describes the rock in the South Two Mile Creek as follows:

> "The rock is cut by calcite veins, and some tiny anhedral grains of aragonite and/or calcite occur in the groundmass near the veins. The rock is composed primarily of plagioclase, pyroxene, and some clinozoisite. Plagioclase crystals are up to 0.5 mm in length and 0.1 mm in width. The crystals are twinned, but are so highly albitized that it was impossible to determine the anorthite content."

Remnant exposures of basic volcanic breccia, presumably of submarine origin, near the top of Hood Mountain are about 150 feet thick and cover approximately one-half square mile. Angular rock fragments up to 3 inches in diameter make up the unit. The rock was described by Hess (1967) as follows:

> "a fine-grained spilite composed of acicular laths of oligoclase (40 percent), granular clinopyroxene (35 percent), and partially devitrified brown glass (25 percent). Alteration effects are abundant: vesicles have been filled with chlorite, oligoclase laths are cloudy, and fractures are filled with secondary minerals, mostly calcite."

The term blueschist refers to the wide variety of glaucophane-bearing foliate bodies that occur throughout the mélanged parts of the lower member. The pods vary in size from those that can be carried away by hand to large bodies that cover up to one-eighth square mile. The blocks of blueschist occasionally are clustered in small groups as in upper Catching Creek. Blueschist exposures north and west of Powers are discussed by Hess (1967) and Lent (1969) respectively.

Blueschists are composed of varying proportions of quartz, mica, white feldspar (albite), bluish glaucophane, garnet, and pyrite. The composition and relict original structures indicate that the schists were derived from associations of greenstone, graywacke, and chert. In no instances are there gradational contacts between the blueschists and the surrounding country rock. This suggests an origin independent of that of the enclosing mélange. In addition, the blueschist bodies are often partially rounded and encased in a thin mantle of actinolite schist.

Samples of the blueschist collected at the Tupper Rock quarry were dated at approximately 150 million years (phengitic mica, 147 $\pm$ 4 million years, and glaucophane, 145 $\pm$ 8 million years) by Coleman and Lanphere (1971, p. 2406). This age corresponds favorably with that of the high-grade blueschists present within the nearby Colebrooke Schist. By contrast the lower-grade blueschists of the Colebrooke Schist are dated at approximately 130 million years (Coleman, 1972).

The origin of the blueschists is discussed by Coleman and Lee (1963), Coleman and Lanphere (1971), and Coleman (1972). It is proposed that the blueschist pods of the Otter Point Formation formed approximately 150 million years ago (Rogue times) within a subduction zone during a period of active plate collision. In a later period of tectonic activity, the deposits were fragmented and introduced tectonically into the Otter Point Formation. Because the Otter Point Formation may represent fossil trench and arc material it is conceivable that the subduction responsible for the formation and deformation of the Otter Point Formation was also instrumental in the tectonic emplacement of the blueschist pods within that unit.

In some specific instances, the blueschist bodies are associated with serpentinite and may have been brought up from the depths during reintrusion of the serpentine or scraped in during periods of thrusting. Also, in a few areas of adequate relief and geology the present precise location of the blueschist pods may be explained in part by landsliding from previous positions. In most cases, however, it is difficult to account for the random distribution of the blueschists within the mélanged country rock of the Otter Point Formation with any mechanism other than tectonic emplacement.

Blake, Irwin, and Coleman (1967) proposed the formation of blueschists and schists in a pattern of upside-down metamorphic zonation in the bedrock underlying the thrust sheet. In their scheme the blueschist facies would be best developed at the thrust plane and would pass downward into less intense

metamorphic facies. Although this model may have application in parts of northern California, no systematic pattern of reverse zonation is recognized in southern Oregon and the mechanism may not apply to either the Otter Point Formation or the Colebrooke Schist.

The blueschists are dense rocks admirably suited for jetty construction and are commonly used for that purpose. One large exposure in upper Baker Creek furnished rock for the Coos Bay jetty. Perhaps the best known body of blueschist in the county was that which made up Tupper Rock at Bandon. This point, which rose as a seastack above the old marine terrace, now has been almost completely removed and used as jettystone along the south jetty at Bandon. The remnants of Tupper Rock are described by Ehlen (1969).

Upper member: The upper member of the Otter Point Formation is made up almost entirely of indurated, light-gray, massive sandstone which weathers to a light yellowish brown. The unit is described by Lent (1969) and Baldwin and Hess (1971). Bedding planes are generally indistinct and the unit appears massive in outcrop, such as at Sugarloaf Mountain along the north side of the Sixes River in Curry County a few miles west of the Coos County line. Exposures of massive sandstone extend eastward to Bingham Mountain near Powers, through the lower parts of Salmon Creek, and as far east as Whobrey Mountain between Gaylord and Broadbent.

A unique feature of the sandstone is the presence of disseminated angular dark-gray siltstone fragments scattered throughout the medium-grained parts of the unit. The resulting speckled appearance is characteristic of the upper member of the Otter Point Formation. Jointing is universal and the cracks are commonly filled with vein quartz. The indurated sandstone maintains sharp angular edges when broken, unlike the younger sandstone units in this part of Oregon.

Thin beds of conglomerate and pebbly sandstone are present locally. Conglomerate composed of pebbles of greenstone, sandstone, blueschist, quartz, and some gabbro overlies an outcrop of Colebrooke Schist two miles north of the Dement Ranch a short distance west of the Coos County line. Lenses of similar pebbles, including the well-rounded pebbles of blueschist, crop out high on the south slope of Sugarloaf Mountain (Baldwin and Hess, 1971) far above the base of the unit. The relative abundances of the various pebble types within individual lenses are somewhat provincial; Hess (1967) counted 83 chert pebbles, 11 volcanic pebbles, and 6 siltstone pebbles in a 100-pebble sample near the top of Bingham Mountain.

As suggested by the presence of the blueschist pebbles in the pebbly lenses, the upper member of the Otter Point Formation may have been partly derived from the lower member. The inferred unconformity, of course, warrants treatment of the upper and lower members as distinct stratigraphic entities. However, the areas underlain by the upper member are sufficiently difficult to work with that adequate boundaries between the two units cannot be delineated at the present time. Both units are therefore treated as part of the Otter Point Formation.

In terms of environment of deposition, the massive sandstone making up the upper unit is distinctly different from the eugeosynclinal mélange of the lower unit. It is proposed as one working hypothesis that the upper member was laid down concurrently with the lower member and that it was thrust over the lower unit for considerable distances at a later time. Alternatively, the upper member may represent yet another sequence of post-Otter Point deposition that presently is unrecognized elsewhere in southwestern Oregon.

Age and correlation: *Buchia piochii* and fragmentary ammonites dominate the scattered fossil remains that have been recovered from the lower member of the Otter Point Formation. The assemblages have been assigned to the Tithonian stage of the latest Jurassic (Jones, 1969). The upper unit of the Otter Point Formation has yielded no fossils and its age is uncertain. It is probably older than the Humbug Mountain Conglomerate, however.

Considerable evidence suggests that subduction occurred during the actual deposition of the lower Otter Point Formation. The overlying Humbug Mountain Conglomerate of lowermost Cretaceous age is much less deformed and clearly postdates the deformation. Moreover, the composition of the Otter Point Formation is indicative of a trench and island arc origin, which in turn implies the presence of an active Benioff zone. Finally, the mélanged structure of the lower unit of the Otter Point Formation is suggestive of intense deformation prior to lithification, a feature which implies deformation nearly concurrent with deposition.

The lower unit of the Otter Point Formation is clearly a tectonic unit as well as a stratigraphic one. Consistent with this interpretation is the seemingly tectonic emplacement of the numerous blueschist pods and serpentine bodies described above. Although thrusting in southwest Oregon continued into the Eocene, it seems most probably that at least some of the larger blueschist pods were incorporated into the unit during the period of Late Jurassic subduction.

Dothan Formation

The Dothan Formation was defined by Diller (1907) and is typically exposed along Cow Creek in the southwestern corner of Douglas County. In Coos County exposures of the Dothan Formation are restricted to a small area covering approximately one square mile east of Mount Bolivar in the extreme southeastern corner of the county.

The Dothan Formation consists of thick-bedded, well-indurated, medium-grained, poorly to moderately sorted, lithic graywacke and minor amounts of intercalated dark gray siltstone and shale. The overall thickness of the unit is uncertain but must be on the order of several miles.

The recent discovery of Buchia piochii (Ramp, 1969) in the Dothan Formation indicates a Tithonian (Late Jurassic) age for the unit. Nowhere is it known to be intruded and it is post-Nevadan. The Dothan Formation is in fault contact with the Rogue Formation and underlies the Riddle Formation south of Riddle in Douglas County.

The Dothan Formation appears to be correlative with the Otter Point Formation from which Buchia piochii also has been reported and for which similar stratigraphic relationships are interpreted. The Dothan Formation may represent shelf and fan deposits, whereas the Otter Point Formation probably represents offshore trench and island arc accumulations (Coleman, 1972). In southwestern Oregon, units transitional in lithology between the Dothan Formation and the Otter Point Formation are unknown, and it is postulated that the two units were brought into juxtaposition by eastward underthrusting of the Otter Point Formation. As discussed above, there is considerable evidence to support subduction of the Otter Point Formation.

Myrtle Group

Pre-Tertiary exposures in the southern part of the Roseburg quadrangle were assigned to the Myrtle Formation by Diller (1898), and similar exposures in the Port Orford and Coos Bay quadrangles were included in the unit a short time later (Diller, 1901). Louderback (1905) restricted the Myrtle to beds of Cretaceous age and reassigned older strata to the Dillard Series (the Dothan, Otter Point, Galice and Rogue Formations of present usage). Imlay and others (1959) subdivided the type Myrtle Group into the Riddle and Days Creeks Formations in the southern Roseburg quadrangle.

To the west, exposures of the Myrtle Group have been traced intermittently along the northwestern edge of the Klamath Mountains as far south as the lower Illinois River near Agness. The Riddle Formation consists of chert pebble conglomerate, medium-grained lithic subgraywackes, and siltstone. Its lateral equivalent, the Humbug Mountain Conglomerate, crops out in the western part of Coos County. The Riddle Formation is overlain by the rhythmically bedded sandstone and siltstone of the Days Creek Formation.

Humbug Mountain Conglomerate: The Humbug Mountain Conglomerate was defined by Koch (1966) for exposures at Humbug Mountain a short distance south of Port Orford in Curry County. The unit and the overlying Rocky Point Formation are generally age equivalent to the Riddle and Days Creeks Formations inland but are distinguished from them on the basis of subtle lithologic differences and geographic separation. The exposures of Humbug Mountain Conglomerate in Coos County are geographically isolated from exposures of that unit at the type locality. Equivalence is established on the basis of lithology, stratigraphic position, and fossil content.

The Humbug Mountain Conglomerate consists of several thousand feet of thickly bedded, well-indurated conglomerate which contains boulders low in the section and which grades upsection into dark-gray veined sandstone. Clasts within the conglomerate consist of chert, schist, diorite, greenstone, sandstone, and quartz.

In southwestern Coos County, beds mapped as Humbug Mountain Conglomerate overlie the Otter Point Formation along the west slopes of Johnson Mountain and older strata on the north end of the peak. The basal conglomerate, predictable stratigraphic order, and unsheared character of the unit rule out the possibility that the unit is in thrust contact with the underlying units.

The Humbug Mountain Conglomerate apparently rests unconformably over older strata and was laid down in an onlapping sea. This is the first instance known to the writers in which shelf deposits similar to the Great Valley Sequence of the Sacramento Valley are found in what appears to be a depositional contact over deeper water rocks of Franciscan type.

Robust, moderately to coarsely ribbed specimens of Buchia similar to what has been called Buchia crassicollis elsewhere (Imlay, written communication, 1968) have been recovered from the west bank of Salmon Creek about 100 yards south of the bridge near the east edge of sec. 4, T. 32 S., R. 12 W. Similar fossils have also been recovered from the north side of Johnson Mountain. Buchia crassicollis is indicative of a Berriasian to Valanginian age (Early Cretaceous) and has also been recovered from the type locality of the Humbug Mountain Conglomerate (Koch, 1966).

Dott (1966) reported the discovery of Late Jurassic specimens of Buchia piochii at Barklow Mountain, but more recent work by Jones, Bailey, and Imlay (1969) and Jones (1969) reveals that many of the Buchia specimens identified as Buchia piochii are instead, Buchia uncitoides, an Early Cretaceous species. Thus all fossil-bearing exposures included in the Humbug Mountain Conglomerate in Coos County are probably Early Cretaceous in age.

Riddle Formation: Although the Riddle Formation is similar to the Humbug Mountain Conglomerate in terms of general composition and environment of deposition, it differs from that unit in terms of some of the subtler aspects of lithology. The pebbles of the Riddle Formation are smaller and better rounded than those of the Humbug Mountain Conglomerate and they are much more uniform in composition. Chert clasts predominate and there are no significant local variations in pebble composition.

The Riddle Formation probably was deposited farther from its source areas than was the more provincial Humbug Mountain Conglomerate. It is also possible that the two units were derived in part from the same sources and that they grade imperceptibly into each other. There is no evidence to support the alternative possibility that the two units were deposited in separated basins and were brought to their present proximity by later thrusting.

The Riddle Formation is largely of Early Cretaceous age (Jones, Bailey, and Imlay, 1969; and Jones, 1969). Originally the entire Riddle section was regarded as Late Jurassic; now, however, much of the section is considered Berriasian (Early Cretaceous) on the basis of the tentative reassignment of the Buchia specimens to the Early Cretaceous species Buchia uncitoides. Species of Buchia low in the section have not been definitely identified, but a probable Late Jurassic age is indicated by the associated ammonites (Imlay to Beaulieu, written communication, 1970).

Days Creek Formation: The Days Creek Formation was defined by Imlay and others (1959) after exposures in the South Fork of the Umpqua River and was named after the nearby community of Days Creek. To the west the unit has been mapped along the north edge of the Klamath Mountains and it is exposed south of Agness and in Eden Valley. Particularly good exposures are situated along Foggy Creek in the upper reaches of the South Fork of the Coquille River (Rud, 1971).

The Days Creek Formation consists of rhythmically bedded dark-gray, sandy siltstone and light-gray, fine-grained sandstone. The sandstone, a lithic subgraywacke, dominates the upper part of the section. The unit is distinguished from the Riddle Formation on the basis of its higher sand content and the absence or near absence of conglomerate.

The Days Creek Formation contains abundant specimens of Buchia crassicollis and several species of ammonites indicative of a middle Valanginian through Hauterivian age. Popenoe and others (1960) report the following from the Foggy Creek locality:

Buchia crassicollis	Simberskites
Wellsia oregonensis	Hoplocrioceras
Hannaites riddlensis	Spitidiscus

The Days Creek is considered to be equivalent to the Rocky Point Formation of Koch (1966) and may have been laid down in the same seaway. The type locality for the Rocky Point Formation is on the coast south of Port Orford where it interfingers with Humbug Mountain Conglomerate. No outcrops of Rocky Point are known in Coos County.

The mutual concordance of the Days Creek Formation and the underlying Riddle Formation suggests a conformable relationship between the two units. The absence of lower Valanginian strata between the two units may be attributable to local faulting or incomplete sampling.

Umpqua Formation

The Umpqua Formation was defined by Diller (1898) in the southern Roseburg quadrangle. The formation consists of a thick series of submarine basalt and rhythmically bedded sandstones and siltstones. It is exposed over much of the southern Coast Range of Oregon. On the basis of excellent exposures such as those in the Camas Valley and Tyee quadrangles the unit has been subdivided in recent years to give three unconformity-bounded sequences, the lower member, the middle member, and the upper member. In a forthcoming publication Baldwin elevates the three units to formational status; the terminology of that report is incorporated into this briefer discussion. Hence the Roseburg Formation, Lookingglass Formation and Flournoy Formation of this report refer respectively to the lower, middle, and upper members of the Umpqua Formation of Baldwin (1965).

Roseburg Formation

The Roseburg Formation is named and defined by Baldwin (in preparation) and is equivalent to the lower member of the Umpqua Formation. It makes up the lower part of the Umpqua Formation of Diller (1898) and is composed of basalt low in the section and rhythmically bedded sandstone and siltstone high in the section. The base is rarely, if ever, exposed and the unit is unconformable beneath younger formations. The most continuous section in Coos County crops out along Highway 42 between the volcanic ridge near Norway and the North Fork of the Coquille River. There, basalt of undetermined thickness is overlain by nearly 8,000 feet of tuffaceous siltstone and interbedded sandstone and siltstone.

Basalt: North of Roseburg along U. S. Highway I-5 basaltic flows at the southwest end of the Red Hill anticline (Hoover, 1963) are overlain by approximately 8,000 feet of tuffaceous siltstone and sandstone interbeds which dip southward toward a synclinal axis near Calapooya Creek. From this and other similar exposures, a consistent pattern emerges in which the basalt occupies a stratigraphic position beneath the bulk of the sedimentary rocks of the Roseburg Formation.

Basalt masses low in the section are also exposed at Blue Ridge, near the forks of the Coos River, in Willanch and Kentuck Creeks, at Sugarloaf Mountain, and along the Middle Fork of the Coquille River. The bodies occupy the axes of northeast-trending anticlines and are faulted with high angle or reverse faults on the northwest edges. The basalt is presumed to be extensive in the subsurface and was encountered in a thickness of at least 5,000 feet in the Phillips Petroleum Co. well in Davis Slough.

The basaltic rock is fine-grained and characteristically pillowed or brecciated, indicating a submarine origin. Compositionally the flows are calc-alkalic and comparable to the early Eocene Siletz River Volcanics to the north, the present day sea-floor basalts of the Pacific Ocean, and basalts of the Hawaiian Islands. It is inferred that at the time of Roseburg deposition the western coastline of the North American continent was situated farther east than today.

In discussing the detailed petrography of the basalts Klohn (1967) states:

> "The typical massive flow basalts have a holocrystalline, fine-grained (less than 1 mm in size) groundmass consisting of minute plagioclase laths arranged in a felted to pilotaxitic texture. Small euhedral to subhedral grains of pyroxene and magnetite commonly occupy the interstices. Interstitial glass may be present in small amounts. Phenocrysts of plagioclase, pyroxene and magnetite, and olivine are from 0.2 to 4.0 mm in size. Plagioclase and pyroxene phenocrysts are commonly arranged in glomeroporphyritic clots. Plagioclase (composition An_{48-54}) is mainly labradorite and makes up 30 to 50 percent of the rock. Plagioclase shows minor alteration to chlorite in the groundmass of all thin sections studied.

The pyroxene is augite and is generally as abundant as plagioclase. Olivine is a relatively minor constituent, occurring as phenocrysts partly or wholly replaced by a greenish mixture of chlorite and antigorite surrounded by a reddish-brown border of iddingsite, hematite, and magnetite. Small subhedral grains of magnetite form 4 to 10 percent of most rocks."

Alteration, although widespread, is not pervasive. The groundmass is chloritized and cavity-filling zeolites are present. Serpentine replaces much of the original olivine. In contrast to the basalts of the Pre-Teriary units, there is little evidence of dynamic metamorphism. Some of the volcanic rock in the Hillstrom quarry along Kentuck Creek is coarser-grained than most flows and may represent localized intrusive activity contemporaneous with the basaltic extrusion.

The basalt probably was extruded at least in part from localized centers of volcanism producing a section of markedly variable thickness and complex detailed stratigraphy. Interfingering with sedimentary rocks is postulated at several localities including Sugarloaf Mountain, where a thick mass of basalt containing a few sedimentary interbeds passes abruptly northeastward into a much thinner section in Johns and Weakley Creeks. Only one or two flows are present within the predominately sedimentary section exposed along Elk Creek. The volcanic rocks terminate rather abruptly to the southwest as well and the formation contains very little basaltic rock in the north end of the Powers quadrangle (Baldwin and Hess, 1971). Lateral facies changes as well as local faulting are required to explain the regional variations in the thickness and abundance of the basalt.

Sedimentary rocks: Sedimentary rocks within the Roseburg Formation include thick sections of rhythmically bedded sandstone and siltstone, which are well exposed in Catching Creek, and minor amounts of conglomerate and pebbly sandstone, which are exposed along the road at the mouth of Ward Creek, a tributary of Catching Creek. One of the thickest sedimentary sections is exposed along State Highway 42 from Gray Creek southeastward to the North Fork of the Coquille River (Figure 5). The strata, nearly 8,000 feet thick, overlie the basaltic core of an anticline and dip to the southeast. The lower beds immediately overlying the basalt consist of dark gray, tuffaceous siltstone which weathers rusty red and produces a characteristic low, rolling, and subdued topography.

The abundance of sandstone increases upsection and a prominent ridge is developed immediately north of the North Fork Bridge. Strata forming the section south of the North Fork Valley are more severely deformed than those to the north, and it is possible that the river valley represents a structural weakness such as a fault.

Locally, sedimentary strata assigned to the Roseburg Formation are exposed which may be older than the basaltic unit. Several down-faulted blocks southwest of the head of Catching Creek in the Powers quadrangle (Baldwin and Hess, 1971) rest directly upon the Otter Point Formation and represent one of the few places in which the base of the Roseburg Formation may be exposed. Possibly the beds were thrust into the area prior to downfaulting, but it is also possible that the beds represent the actual stratigraphic base of the Roseburg Formation. Popenoe and others (1960) report the discovery of a Late Cretaceous ammonite from Dement Creek in an area where no potential source other than the Roseburg Formation is recognized. It is inferred that the ammonite may have been derived from exposures of the basal Roseburg Formation at the south end of one of the fault slivers. Possibly, however, assignment to the Dement Creek drainage may be erroneous.

Strata consisting of massive pebbly sandstone and thin-bedded conglomerate crop out along the North Fork of the Coquille River (sec. 2, T. 29 S., R. 11 W.). Although the significance of the conglomerate is not fully understood, thin-bedded crumpled strata south and east of it have yielded Late Cretaceous foraminifers (Baldwin, 1965). The beds contain less volcanic material than does the Roseburg Formation, but since they are difficult to distinguish from that unit the exposures are tentatively treated as part of the Roseburg Formation. It is noted, however, that the strata occupy a severely deformed zone.

In Rhoda Creek and at Robbins Butte near Broadbent, the Roseburg Formation directly overlies the Otter Point Formation and consists of thin sections of basalt interbedded with sedimentary rocks. Again it is not known whether the exposures represent the stratigraphic base of the Roseburg Formation or the structural base of a thrust sheet.

Age: On the basis of a few scattered foraminiferal samples and stratigraphic position, a Paleocene through early Eocene age is inferred for most beds here included in the Roseburg Formation. Although late Cretaceous foraminifers have been recovered from the North Fork of the Coquille River in sections 2, 10 and 11, T. 29, S., R. 11 W. (Baldwin, 1965), more detailed mapping may exclude them from the Roseburg Formation. Paleocene foraminifers have been recovered from sedimentary strata interbedded with the basalt flows at the south end of Sugarloaf Mountain east of Myrtle Point (Baldwin, 1965). Penutian (early Eocene and C zones of Laiming) foraminiferal assemblages are common in some of the younger sedimentary rocks (Thoms, 1964).

There is little evidence for a break in sedimentation at the end of the Cretaceous in northern California (Hackel, 1966, p. 223), and present evidence suggests that the same may be true for southwestern Oregon. Further detailed mapping, however, may reveal disconformities or slight angular unconformities within the unit.

Structure and origin: Baldwin (1964) proposed thrusting of the lower basaltic member of the Roseburg Formation over the sedimentary unit at the close of Roseburg deposition in early Eocene times. Similarly the basalt and massive sandstone at Sugarloaf Mountain and on Johns and Weekly Creeks near Myrtle Point appears to be thrust northwestward over the severely deformed strata along the North Fork of the Coquille River. Possibly this fault is a continuation of the thrust fault to the northeast in the Roseburg area.

The Roseburg Formation is isoclinally folded along northeast-trending fold axes and generally speaking is severely deformed relative to the younger units which unconformably overlie its beveled upper surface. The structural trends developed in the unit parallel those of the older units in the Klamath Mountains Province and are unrelated to the more gently folded, north-trending structures of the younger Tertiary units.

Present theories would suggest that the tight deformation and telescoping of the Roseburg Formation was related to active collision of the oceanic plate with the continental plate at the close of early Eocene times. Baldwin and Lent (1972) proposed that the Colebrooke Schist to the south was thrust into the area during this period of deformation.

The interpretation that the Roseburg Formation was deposited on deep oceanic sea floor is consistent with the results of geophysical surveys which reveal that the edge of the continental crust is situated to the east at the edge of the Cascades Range (Blank, oral communication). Also, the reconstructions of Atwater (1970) reveal the presence of a southeasterly spreading sea-floor rise system off the coast of Oregon during Eocene times.

Lookingglass Formation

The Lookingglass Formation was named and described by Baldwin (in preparation) and is equivalent to the middle member of the Umpqua Formation as defined by Baldwin (1965). The name is derived from the Lookingglass Valley in Douglas County where a representative, although incomplete, section is exposed. The type section is also in Douglas County and is situated along Tenmile Creek. It includes the exposures of basal conglomerate at Bushnell Rock and the overlying sequence of rhythmites which extends eastward to Tenmile Butte.

The Lookingglass Formation crops out as an arcuate series of exposures located at the southern edge of the Oregon Coast Range. In Coos County it extends as far north as the North Fork of the Coquille River. Isolated blocks of the Lookingglass Formation downfaulted into older strata are preserved along Catching Creek and Bear Creek in southwestern Coos County, near the head of the Sixes River in southern Coos County, at Gaylord, and in the vicinity of Powers along the South Fork of the Coquille River. Structurally the unit cuts across all the axial trends of the underlying Roseburg Formation and clearly overlies that unit with angular unconformity.

Lithology: The Lookingglass Formation consists of a thick marine sequence of rhythmically bedded fine-grained sandstone and siltstone and a prominent basal near-shore sequence of conglomerate and massive sandstone. Maximum total thickness for the unit is estimated to be 7,000 feet.

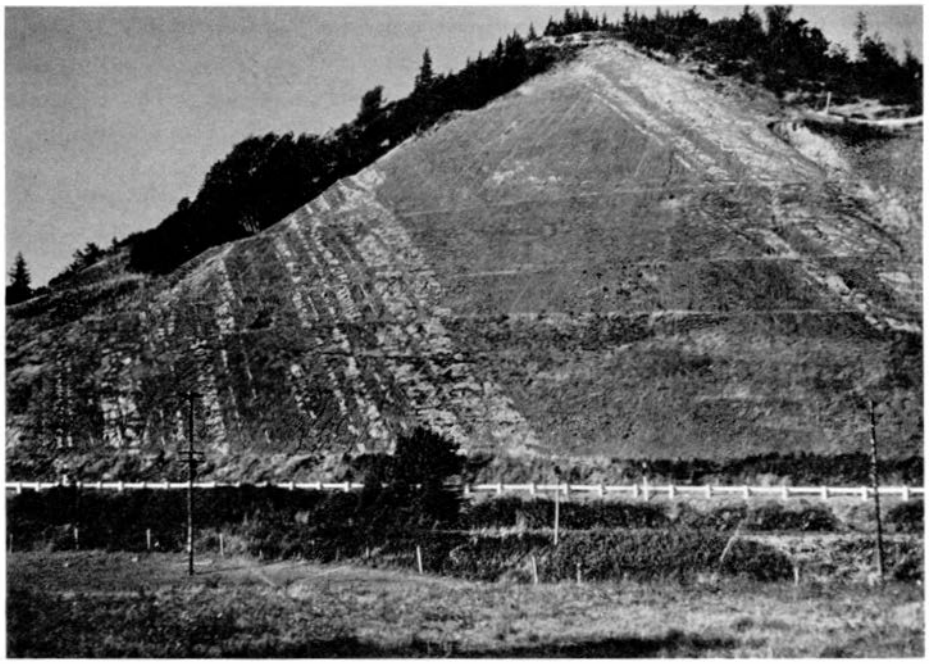


Figure 5. Large road cut along Oregon Highway 42 a mile north of Myrtle Point exposes tilted beds of the Roseburg Formation.

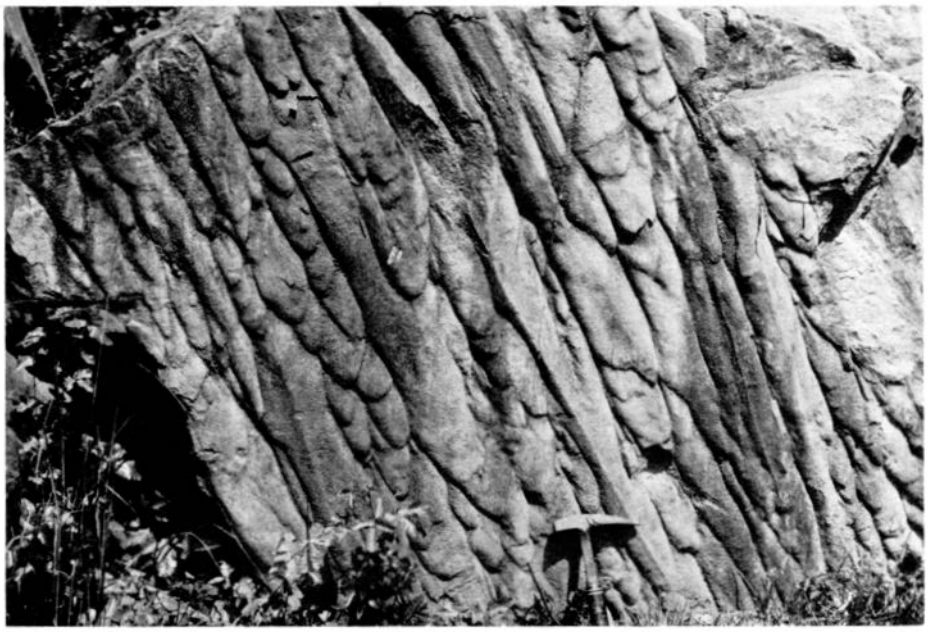


Figure 6. Sole markings on base of a sandstone bed of the Flournoy Formation along Middle Creek east of Coquille.

Along the western margin of the exposures the rhythmites range from a few inches to perhaps a foot in thickness. The siltstone is exposed in Sandy Creek near the community of Remote in southeastern Coos County northward to the North Fork of the Coquille River. The exposures are composed primarily of dark-gray massive siltstone with relatively little fine-grained sandstone. The characteristic indistinct bedding and spheroidal weathering of these exposures commonly make the determination of attitudes difficult.

The basal conglomerate of the Lookingglass Formation is thickest at the type locality at Bushnell Rock in adjacent Douglas County where a thickness of 700 feet is reported. The conglomerate is also well-developed in southern Coos County where thicknesses as great as 400 feet are present locally along Catching Creek. At Bear Creek a few miles to the northwest the conglomerate is 50 feet thick, and at Gaylord, an equal distance to the southeast, the massive pebbly sandstone is present in thicknesses of up to 200 feet. Farther south at the head of the Sixes River and near Powers the basal conglomerate and massive sandstone ranges from 100 to 200 feet in thickness.

Nonmarine deposition for part of the lower Lookingglass Formation in southern Coos County is indicated by the presence of coal low in the section in the Middle Fork of the Sixes River (Diller and Pishel, 1911). Coaly beds are also exposed near the mouth of Frenchie Creek, which drains into the Middle Fork of the Coquille River immediately west of the community of Remote in eastern Coos County.

Along the Middle Fork of the Coquille River, Burns (1964) recognized a dominately pebbly and sandy basal member and an upper mudstone member in strata here assigned to the Lookingglass Formation. His studies revealed that the lower member was made up of 75 percent medium- to course-grained sandstone, 15 percent mudstone, shale, and coal, and 10 percent conglomerate. He noted that well-rounded pebbles derived from the underlying Roseburg Formation occurred both as discrete beds of conglomerate and as isolated clasts scattered throughout the finer-grained strata. He also noted the absence of graded bedding and the higher degree of sorting relative to the Roseburg Formation. As at the Middle Fork of the Sixes River the observed sedimentary structures include crossbedding, cut-and-fill features, and thin lamellae of coal, and suggest a strandline environment of deposition.

The composition of the pebbles in the basal conglomerate of the Lookingglass Formation varies with the nature of the underlying rock units and with the distance from the Klamath Mountains Province. Near the Klamath Mountains, for instance, the pebbles consist of a wide variety of greenstone, chert, quartz, basalt, and sedimentary rock, which can be related to the older units in the area. Farther to the north the clasts consist primarily of basalt which is traceable to the underlying Roseburg Formation.

Present evidence suggests that the shoreline during the deposition of the lower Lookingglass Formation extended northeasterly through the southern part of what is now Coos County. Grain size and relative abundance of conglomerate decrease to the northwest as the unit grades laterally into a sequence of rhythmites. In the south, coal-bearing beds and other shallow-water features define a northeast-trending boundary within the lower part of the Lookingglass Formation.

Age: Megafossils recovered along the Middle Fork of the Coquille River (Turner, 1938) and well-shaped specimens of the species, *Venericardia aragona* recovered from exposures near Powers indicate a Capay to Domengine age (early to middle Eocene) for the unit. Foraminifers also recovered from the unit are representative of the Middle B zones of Laiming and the upper Penutian (upper early Eocene) or the lower Ulatisian (lower middle Eocene) stages of Mallory (1959) (Thoms, 1964; Rau, written communication). The presence of Penutian foraminifers both in the upper part of the Roseburg Formation and in the Lookingglass Formation indicates that the Roseburg Formation was deformed in a relatively short period of time, probably not exceeding a few million years.

Structure: The Lookingglass Formation is gently to moderately folded regionally and is faulted in places. Dips within the unit are seldom steep and, with the exception of those in the Bear Creek Valley, average considerably less than 45 degrees.

A major fault extends between the communities of Powers and Agness and is invaded in places by re-intruded and sheared serpentinite. North of Powers several northeasterly trending faults of lesser magnitude are mapped. In southwestern Coos County the Lookingglass Formation has been downdropped along the Sixes River Fault near the Powers Ranch. An unnamed fault bounds the southern edge of an exposure of the unit along Catching Creek. The precise age of the faulting is uncertain but probably pre-Tyee.

Flournoy Formation

The Flournoy Formation was named and described by Baldwin (in preparation) and is equivalent to the upper member of the Umpqua Formation as defined by Baldwin (1965). The type section is situated in Flournoy Valley along the upper part of Lookingglass Creek in west-central Douglas County. An equally representative, although less well exposed, section paralleling the type section is present in Camas Valley, also in Douglas County.

In eastern Coos County the Flournoy Formation is exposed on Bone Mountain (Johannesen, 1972) and north of the Middle Fork of the Coquille River (Trigger, 1966). In western Coos County beds originally mapped as Tyee Formation by Baldwin (1969a) between the Coquille River and Bear Creek east of Bandon are now recognized as Flournoy Formation. To the south a small outcrop situated between Little and Fourmile Creeks is also assigned to the Flournoy Formation.

The Flournoy Formation consists chiefly of massive, rhythmically bedded, micaceous lithic sandstone and siltstone which are very similar in gross aspect to the overlying Tyee Formation. Large exposures west of Sitkum, Coos Mountain, and Golden and Silver Falls previously mapped as Tyee Formation (Allen and Baldwin, 1944 ; Wells and Peck, 1961) are now included in the Flournoy Formation. In this area distinction between the Tyee and the Flournoy is based largely on the truncation of siltstone interbeds assigned to the Flournoy Formation and by massive beds of sandstone assigned to the Tyee Formation.

Exposures of conglomerate and pebbly sandstone at Moon Mountain and Avery Peak along the south side of the Sixes River in northwestern Curry County are also assigned to the Flournoy Formation as are exposures of similar rock which transect the Rogue River north of Illahee in north-central Curry County (Baldwin, in preparation).

Although dips are low and sections are difficult to measure, a total thickness of several thousand feet is inferred for the Flournoy Formation east of Coos Bay along the upper Coos River. In western Douglas County the unit is approximately 3,000 feet thick. There is about 1,500 feet of sandstone at White Tail Ridge above Flournoy Valley and about 1,500 feet of siltstone in the valley. Other good exposures are present in Camas Valley. Southward in the southern end of the basin the unit is considerably thinner. The basal sandstone member of the Flournoy Formation is 600 to 700 feet thick in the Middle Fork of the Coquille River (Trigger, 1966), but is considerably thicker north of Sitkum and probably exceeds 5,000 feet east of the forks of Coos River.

The basal part of the Flournoy Formation is composed of thickly-bedded locally pebbly sandstone very similar in aspect to the Tyee Formation. Conglomerates similar to those of the basal Lookingglass Formation are not present. The sandstone is light greenish-gray, well-indurated, micaceous, fine- to coarse-grained lithic wacke. Individual beds are generally 3 to 10 feet in thickness and are separated by thin layers of dark siltstone. Sole markings, cross bedding, and ripple marks are preserved in places (Figure 6).

Trigger (1966, p. 54) described the sandstone as follows:

> "Angular to rounded lithic fragments make up approximately 36 percent of the rock. The majority of these fragments are igneous, mainly andesite. Other types of fragments present, in approximate order of abundance, include schists, unidentifiable fragments, quartzite, and chert. The matrix, which makes up about 17 percent of the rock, is composed mainly of chlorite and calcite with subordinate amounts of finely divided quartz, feldspar, iron oxide, and lithic fragments.
>
> "Angular to subangular quartz grains make up approximately 19 percent of the rock. Angular to subangular feldspar makes up less than 18 percent of the rock, and plagioclase is about three times more abundant than potassium feldspar. Although fresh grains of potassium feldspar and plagioclase are present, many feldspar grains are partly altered to sericite and a few to calcite. Accessory minerals, which compose about 8 percent of the rock, include biotite, muscovite, zircon, garnet, opaque minerals, and detrital chlorite. Biotite is commonly altered to chlorite."

The Flournoy Formation is unconformable over the Lookingglass Formation and it is unconformable beneath the Tyee Formation. All three units are apparently middle Eocene in age. Microfossils recovered from the Flournoy Formation are indicative of the Ulatisian (lower middle Eocene) stage of Mallory (Thoms, 1964).

Megafossils recovered from the unit conform best with Domengine (early to middle Eocene) fossils elsewhere. Most of the fossils discussed by Turner (1938), however, were taken from exposures along the Middle Fork of the Coquille River which are now assigned to the underlying Lookingglass Formation.

Tyee Formation

The Tyee Formation was defined by Diller (1898) after exposures in the Roseburg 30' quadrangle. The name was derived from Tyee Mountain located northwest of Roseburg. No type section was specifically designated, but the exposures at Tyee Mountain are generally regarded as representative of the unit.

The Tyee Formation occupies the synclinal axis of the Oregon Coast Range in southwestern and west-central Oregon. Exposures of the Tyee Formation are restricted to the eastern edge of Coos County where the unit forms parts of Bone Mountain, Thomas Mountain, Brewster Rock, Ivers Peak, Coos Ridge, and the escarpment at Golden and Silver Falls (Figure 7). As discussed below, exposures formerly mapped as Tyee along the lower Coos and Millicoma Rivers and along Bear Creek near Bandon are now considered part of the Flournoy Formation.

The Tyee Formation in Coos County is composed of up to 5,000 feet of primarily massive, greenish-gray, coarse- to fine-grained, lithic wacke and rhythmically bedded sandstone and siltstone. Although there is much variation, individual beds of sandstone are commonly 5 to 10 feet in thickness and are prominent ridge-formers. Fossil plant remains are common on some bedding planes in places and the nearly universal abundance of mica provides a ready contrast to the sandstone of the Roseburg and Lookingglass Formations.

According to petrographic examinations conducted by Trigger (1966) on sandstone taken from the lower part of the Tyee Formation, the unit is very similar to the sandstone of the underlying Flournoy Formation. He states:

> "Angular to subrounded quartz grains make up about 20 percent of the Tyee sandstone. Angular to rounded feldspar make up 17 percent of the rock, and plagioclase approximates potassium feldspar in abundance. Although fresh grains of feldspar are present, most are partly altered to sericite and a few to calcite. Accessory minerals compose about 10 percent of the rock and include biotite, muscovite, zircon, garnet, opaque minerals and detrital chlorite. Angular to rounded lithic fragments make up approximately 32 percent of the rock. The majority of these fragments are igneous, mainly andesite. Noteworthy is the fact that andesite is also the most abundant lithic fragment in the sandstone of the upper Umpqua (Flournoy) member. Other types of fragments present in approximate order of abundance are quartzite, schist, unidentifiable fragments and chert. They range in size from less than 0.3 mm to about 4 mm in diameter. Ferromagnesian minerals present in some of the lithic fragments are completely or partly altered to chlorite."

Numerous lateral variations of lithology are evident within the Tyee Formation on a regional basis. Conglomerate and pebbly sandstone are present low in the section in Eden Valley, but north of the Middle Fork of the Coquille River conglomerate is virtually absent. Coal, fossil wood, and cross-bedding are also common in the south, whereas deeper-water turbidites and a greater abundance of siltstone is characteristic of more northerly exposures. Snavely and Wagner (1963) and Snavely, Wagner, and MacLeod (1969) and Lovell (1969) outline the extent of the probable Tyee Basin and propose a northerly direction of transport of sediments derived primarily from a Klamath high.

The Tyee Formation is unconformable over the Roseburg, Lookingglass, and Flournoy Formations. Originally all the exposures of massive sandstone north and west of Sitkum were included in the Tyee Formation (Allen and Baldwin, 1944). More recent mapping, however, has revealed that two sandstone units are present and that the lower unit is part of the Flournoy Formation (Trigger, 1966). On the ridge south of Sitkum, exposures of the Tyee Formation truncate those of the Flournoy Formation, revealing the unconformable relationship between the two units.

On the basis of stratigraphic position and meager megafunal collections, a middle Eocene age is interpreted for the Tyee Formation. Turner (1938) inferred a Domengine age for collections taken from exposures now assigned to the lower part of the overlying Elkton Siltstone. Similar fossils collected along

Figure 7. Silver Falls drops over resistant Tyee Formation in Golden and Silver Falls State Park northeast of Allegany. (Oregon Highway Division photo)

strike in the Elkton area by Baldwin (1961) are also suggestive of a middle Eocene age. Foraminiferal collections taken from beds immediately overlying the Tyee Formation have been assigned to the Ulatisian Stage of Mallory and the B-1 zone of Laiming (both middle Eocene).

Elkton Siltstone

The Elkton Siltstone was designated as a member of the Tyee Formation by Baldwin (1961). Subsequently Bird (1967) and Thoms (1964) proposed elevating the unit to formational status in their respective doctoral theses. On his time chart, Lovell (1969) treated the Elkton Siltstone as a formation and suggested that the exposures at Sacchi Beach also be included in the unit. The writers concur that formal elevation of the unit to formational status is probably in order. However, until such treatment is forthcoming, the unit is technically a member of the Tyee Formation according to the rules set forth by the American Commission of Stratigraphic Nomenclature (1970).

The Elkton Siltstone crops out at two localities in Coos County. The largest exposure covers approximately 50 square miles in the northeastern part of the county and comprises the edge of more extensive exposures of the unit to the east in adjacent Douglas County. At the mouth of Fivemile Creek near Sacchi Beach south of Cape Arago approximately 1,800 feet of micaceous siltstone is assigned to the unit. Maximum thickness for the unit is approximately 3,000 feet in the Elkton and Tyee quadrangles in Douglas County.

With the exception of fresh cuts and beach sections, exposures of the Elkton Siltstone are generally poor owing to the pervasive weathering and characteristic landslide topography. In the type area the unit consists of indistinctly bedded, micaceous siltstone with intermittent beds of massive sandstone. In eastern Coos County, however, sandstone interbeds are rare, perhaps indicating greater distance from contributing streams or a different stratigraphic position. The Elkton Siltstone was deposited in relatively deep or quiet water at the close of Tyee sedimentation when the hinterland may have been topographically reduced and probably was contributing finer material to the eroding streams.

The Elkton Siltstone overlies the Tyee Formation along a poorly defined gradational contact and underlies younger units with probable slight unconformity in most areas. At the Sacchi Beach locality, Baldwin interprets an unconformity between the Elkton and the Coaledo along the south limb of an anticline and is reasonably certain that an unconformity is present along the north limb also. Dott (1966-b), however, suggests a gradational contact between the two units. Possibly the lowermost part of the Coaledo Formation contains a high proportion of silt derived from reworking of the underlying Elkton Siltstone, a feature which would give the impression of a gradational contact. Also the lower contact may occur within the siltstone beneath the sandstone. At no other place is the Coaledo known to be gradational with the Elkton Siltstone.

Megafossils are abundant locally near the base of the Elkton Siltstone. Fossils collected from exposures at Basket Point along the Umpqua River are listed by Turner (1938), and similar fossils collected a short distance from Elkton in laterally equivalent strata are listed by Baldwin (1961). A middle Eocene, perhaps upper middle Eocene, age is interpreted.

Microfossils also are abundant and are treated by Stewart (in Baldwin, 1961). The lower part of the unit contains a B-1 Ulatisian fauna and the upper, more argillaceous, part of the unit contains a fauna indicative of the B-1A zone of Laiming. Rau (written communication, 1959) recognized both B-1 and B-1A assemblages in samples taken from high in the section in the Coos Ridge area. Possibly the B-1A zone of Laiming is facies controlled in part and is not an accurate age indicator.

Bateman Formation

The Bateman Formation was defined by Baldwin (in preparation) and consists of the massive sandstone which caps the ridges and forms many of the higher peaks in eastern Coos County and western Douglas County including Old Blue, Soup Mountain, and Rainy Peak. Other exposures make up part of the ridge which extends from the vicinity of Bateman Lookout (from which the name is derived) southward to Green Mountain and westward to Kelly Butte. Prior to recognition of this unit as a distinct stratigraphic entity it was mapped as Coaledo (?) by Baldwin (1961).

In the center of the basin in western Douglas County the unit is approximately 1,500 feet thick. Probably not more than a thousand feet of strata is present at Kelly Butte immediately east of the Coos County line, and even less is present on the ridges within the county.

The Bateman Formation is a medium-gray, medium-grained, micaceous, deltaic sandstone composed of lithic fragments, quartz, and feldspar, in order of abundance. The unit is thickly bedded to cross-bedded and contains coaly beds and leaf-bearing beds in the upper part of the section indicative of near-shore deposition. It is concluded that the Bateman Formation was laid down under offlap conditions immediately following deposition of the Elkton Siltstone, and that it represents the end of sedimentation in the Tyee Basin.

Bedding is generally parallel to that of the underlying Elkton Siltstone, but regionally the Bateman Formation onlaps a thinner section of Elkton on the western margin of the basin. This suggests gentle uplift about the edges of the basin during deposition or erosion of the Elkton prior to the deposition of the Bateman Formation. Locally on the east side of the basin the two units appear to be gradational, but in other places such as along the North Fork of Bottom Creek the massive sandstone of the Bateman Formation appears to be disconformable over the Elkton Siltstone.

Megafossils are sparse in the Bateman Formation. The senior author, however, did find specimens of Venericardia cf. califia along the North Fork of Bottom Creek in the basal beds of the unit. This species is more related to the Tyee Formation than to the Coaledo Formation. Bird (written communication, 1967) found upper Ulatisian foraminifers along the ridge east of Ivers Peak in strata which he concluded were deposited at shelf depths, probably between 200 and 600 feet.

Brown (in Baldwin, 1961) lists the plants associated with the coal-bearing strata near the top of the Bateman Formation; many of the ferns are suggestive of a warm subtropical to tropical climate. Hopkins (1967) presents a list of plants associated with the Coaledo Formation on the basis of spore and seed floras. A comparison of the lists of Hopkins and Brown shows little in common. Brown's flora consisted mainly of large ferns and that of Hopkins consisted chiefly of broadleafed shrubs and trees.

The evidence at hand suggests that the Bateman Formation is early late Eocene in age, and is somewhat older than the Coaledo Formation. Nowhere are the Bateman Formation and the Coaledo Formation in direct contact.

Coaledo Formation

As originally defined by Diller(1899), the Coaledo Formation was made up of the coal-bearing part of the Arago Formation. Although the term Pulaski, which he assigned to the non-coal-bearing beds, was later pre-empted, the name Coaledo has survived and has surplanted the name Arago Formation.

Turner (1938) divided the Coaledo Formation into lower and upper members, composed primarily of sandstone, and a middle member, composed primarily of argillaceous and silty material. Allen and Baldwin (1944) showed that the non-coal-bearing beds along Pulaski Creek were not a separate formation but were assignable to the middle member of the Coaledo Formation, and that coal occurred in both the upper and the lower members. Allen and Baldwin (1944) and Baldwin (1969a) mapped the three members throughout most of the Coos Bay coal field.

The Coaledo Formation occupies a north-plunging basin surrounding Coos Bay. The south end lies at the head of Lampa Creek where the basin is a simple syncline; additional folds occupy the basin immediately to the north, however. The outer margin of the basin is rimmed by the lower member of the Coaledo Formation, and some of the hills near the center are capped by sandstone assigned to the upper member. Many of the streams occupy the areas underlain by the softer exposures of the middle member of the Coaledo Formation. They include Lampa Creek and the Coquille River between the mouths of Hatchett Slough and Lampa Creek (Figure 8).

Thickness: The Coaledo Formation consists of a maximum of 6,000 feet of lower and upper sandstone separated by a mudstone member of variable thickness that is thickest in the northwest. The sequence typifies a transgressive-regressive cycle of deposition in which the middle fine-grained member represents the deeper water conditions resulting from maximum transgression.

Thicknesses of 1,775 and 1,900 feet of Lower Coaledo Formation are present in the coastal section and along the highway west of Lampa Creek, respectively, according to Allen and Baldwin (1944).

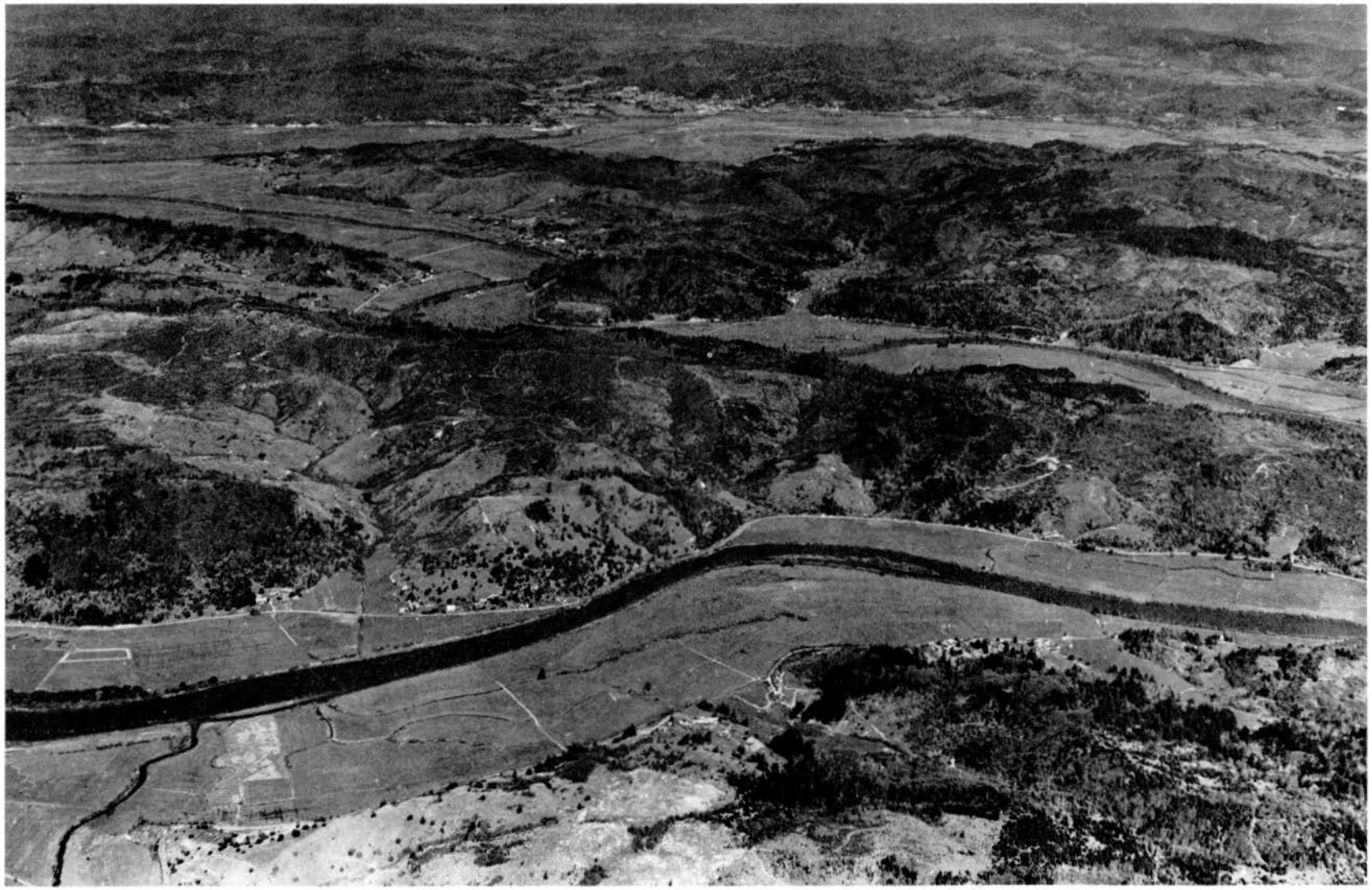


Figure 8. Aerial view looking east across loops of the lower Coquille River where it crosses lower, middle, and upper Coaledo Formation. Central valley in photo is in middle Coaledo. Town of Coquille in distance. (Delano Photographics 62073)

They reported a thickness of 2,925 feet for the middle member of the Coaledo Formation and a thickness of 1,350 feet for the upper member of the Coaledo Formation in the coastal section.

Later work shows that several prominent sandstone points near the top of their middle member in the coastal section should probably be considered as the basal part of the upper member of the Coaledo Formation. Elsewhere, as well, the gradational contacts between the member preclude consistent and rigorous measurements of the thicknesses of the units. Thus, although Allen and Baldwin (1944, p. 25) found 2,770 feet of upper Coaledo in the Riverton district, the thickness may in part be a result of the somewhat arbitrary position of the lower contact of the unit. Adjusted figures of 2,000 feet for the middle Coaledo and 2,300 feet for the upper Coaledo in the coastal section are more likely.

Lithology: The lower member of the Coaledo Formation is made up of cross-bedded tuffaceous sandstone and subordinate amounts of conglomerate and pebbly sandstone. The bedding includes channelling, cross-bedding, and flame structures. Intraformational conglomerates composed of mudstone pebbles and poorly rounded mudstone blocks (Figure 9) and interbedded coal and coaly layers are indicative of deposition on a prograding deltaic front. The coal beds were probably deposited on the margin of the basin and between distributaries.

The middle member of the Coaledo Formation is made up of thin-bedded siltstone with minor thin sandstone and minor light-yellowish-gray tuff beds. It is easily eroded and is generally occupied by valleys and coastal indentations (Figure 10). Small megafossils are present locally, and microfossils are abundant in places. Quiet, fairly deep-water deposition is generally indicated. Although it is postulated that the middle member was laid down during maximum transgression of the sea, the unit may also represent a time during which coarser detrital was not being deposited for other reasons.

The rather sudden reappearance of the near-shore coal-bearing sandstone of the upper Coaledo Formation points to a recession of the sea and possibly to rejuvenation of the source area. It represents an offlapping phase of sedimentation. Primary structures within the upper member are similar to those of the lower member, and petrographically the two units cannot be distinguished.

The sandstone of the upper and lower members of the Coaledo Formation is medium-gray, coarse- to fine-grained, feldspathic and lithic arenite. Bedding, laminations, and flame structures within the units are characteristic of sediments sorted by lateral bypassing near the profile of aggradation. The sedimentary rock was examined by Dott (1966-b), who states:

> "Most of the Coaledo sandstones are texturally submature to immature; feldspathic, micaceous, and carbonaceous lithic (volcanic) arenites: more poorly sorted ones are lithic (volcanic) wackes.... Feldspar comprises 14 to 32 percent of most sections. Sodic plagioclase, chiefly andesine, predominates as relatively large, rather angular, but more or less equant grains, some of which are prominently zoned.... Accessory minerals include universal biotite, and some muscovite flakes, which may amount to several percent in most sections. Amphibole, opaque, and other less common heavy minerals are present. Schist, sandstone, 'granitic' and serpentine grains occur sporadically. Detrital calcite grains, notably foraminiferal tests, are also present as very minor constituents."

Rottman (1970, p. 105) examined bedrock samples from the lower member of the Coaledo Formation south of Sunset Bay. A summary of 8 thin sections shows approximately 30 to 45 percent quartz, 4 to 16 percent feldspar (mostly plagioclase), 7 to 20 percent lithic fragments, and 25 percent matrix with biotite, opaque minerals, and cement making up the remainder. Although her samples are from only the lower part of the Coaledo Formation, it may be noteworthy that she reported significantly more quartz and less feldspar than did Dott. Heavy minerals in the lower member include epidote, hornblende, zircon, and garnet.

Much of the pyroclastic material of the Coaledo Formation could have been swept in from exposures of late Eocene volcanic rocks in the Western Cascades which include the Colestin Formation of Wells (1956), the Calapooya Formation of Wells and Waters (1934), and the Fisher Formation of Hoover (1963). On the basis of the heavy mineral suite it is inferred that much of the sediments also were derived from exposures of pre-Tertiary rocks in the area of the present-day Klamath Mountains.

Most of the minable coal of the Coaledo Formation occurs in the upper sandy member, although some deposits near Lampa Creek and along Sevenmile Creek are in the lower member. The Hardy and Steva

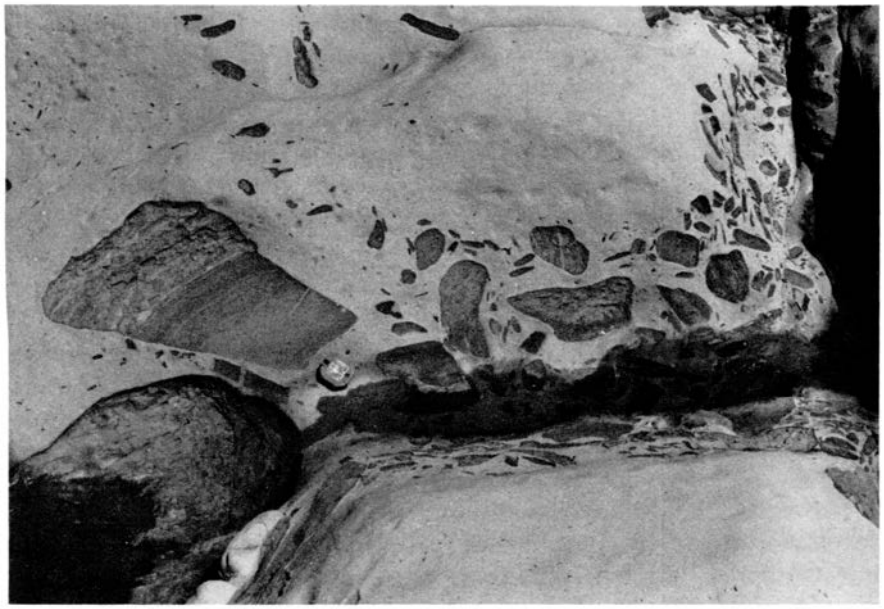


Figure 9. Mudstone clasts in sandstone associated with the Elkton Siltstone at Agate Beach. Compass near center for scale.

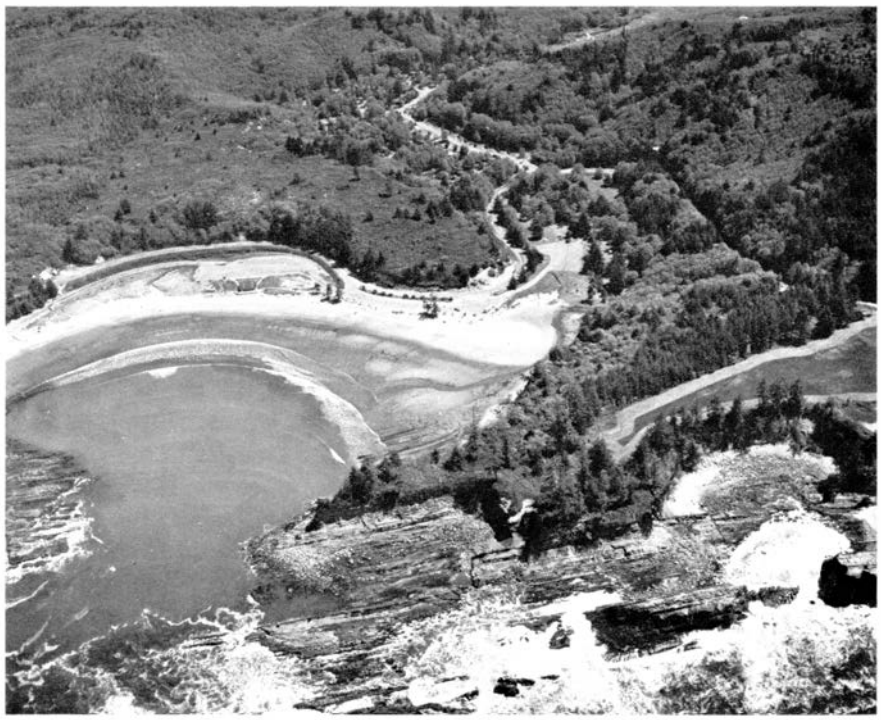


Figure 10. Aerial view of Sunset Bay showing lower Cooledo strata in foreground truncated by marine terrace. Bay lies in easily eroded middle Cooledo. (Oregon Highway Division photo)

coal beds in the Glasgow area also appear to be in the basal member of the Coaledo Formation. Allen and Baldwin (1944) and Mason (1969) discuss the location of the coal mines and prospects and the thickness and quality of the coal. A summary of information on the coal mines is given in this bulletin.

Stratigraphy and age: The Coaledo Formation is unconformable over the Roseburg, Lookingglass, and Flournoy Formations, but is not known to be in contact with the Tyee Formation. Beds assigned to the Elkton Siltstone infaulted against the Roseburg Formation north of Fivemile Point are overlain by the Coaledo. Although relationships are somewhat obscure, it is not likely that the Coaledo would be conformable upon the Elkton Siltstone at the north end of Sacchi Beach as proposed by Dott (1966b) and yet overlie faults involving the Elkton Siltstone on the south.

Earlier references to an unconformable contact of the Coaledo Formation with the Tyee are no longer thought to be valid in that the underlying micaceous sandstones involved have subsequently been reassigned to the Flournoy Formation. The Coaledo Formation grades abruptly upward into the Bastendorff Formation.

Fossils from the Coaledo Formation were collected by many early workers including Dall (in Diller, 1899, 1901) and Turner (1938), who made the most extensive study of the fauna and concluded that it was late Eocene in age and generally equivalent to the Tejon Stage of California. Weaver (1942) listed and illustrated the megafauna of the Coaledo Formation and also inferred a late Eocene age.

Abundant foraminifers contained in the more argillaceous beds were studied by Detling (1946), Cushman, Stewart, and Stewart (1947) and by Stewart (1957). Both A-1 and A-2 stages of Laiming and the Narizian Stage of Mallory (1959) are represented. All are late Eocene. Plant spores, pollen, and seeds examined by Hopkins (1967) and leaf imprints associated with the coal also suggest a late Eocene age for the Coaledo Formation.

Bastendorff Formation

The Bastendorff Formation was originally termed the "Bastendorf shale" by Schenck (1927), who designated exposures at Bastendorff Beach south of Coos Bay as the type locality. The original spelling was incorrect and apparently was taken from a Coast and Geodetic marine chart in use at the time. The spelling was later corrected by Allen and Baldwin (1944) to conform to the spelling of the Bastendorff family name.

The Bastendorff Formation is confined to the center of the South Slough syncline, the Sumner syncline, and the Riverton syncline south of Beaver Hill. North of Miner Creek the unit consists of 1,845 feet of shale, a 60-foot sandstone member, and approximately 1,000 feet of apparently fine-grained strata that is covered in the beach section. Total thickness for the Bastendorff Formation is therefore about 2,900 feet.

The bulk of the Bastendorff Formation is made up of fine-grained shale and consists of thin beds of dark-gray shale and occasional thin beds of light-yellowish-gray tuff. The beds are easily eroded and give rise to a characteristic low-lying subdued topography. The sandstone member near Miner Creek, described by Lowry (in Allen and Baldwin, 1944, p. 28), is not unlike that of the upper Coaledo Formation. Both show derivation in part from volcanic rock. Tuff from the Bastendorff Formation, however, contains more basic glass than does that of the middle member of the Coaledo Formation.

Bedding of the Bastendorff Formation appears to be parallel to that of the underlying Coaledo Formation and the overlying Tunnel Point Formation and conformable relationships are inferred. The environment of deposition changed rather abruptly, however, as is indicated by the sharp upper and lower contacts of the unit.

A latest Eocene and early Oligocene age is interpreted for the Bastendorff Formation on the basis of contained microfossils. Foraminifers were first examined by Cushman and Schenck (1928), who postulated an early Oligocene age. Subsequently Schenck and Kleinpell (1936) proposed age equivalence with the Eocene Gaviota Formation of California. More recently Stewart (1957) assigned the upper third of the unit to the early Oligocene and the lower two-thirds of the unit to the late Eocene.

Duncan (1953) suggested that the similarities between the lower and upper Coaledo and between the middle Coaledo and Bastendorff Formation might be explained by repetition of a sandstone-shale couplet through thrust faulting. He did not present cross-sections to show how this might be accomplished, and field relationships do not support such a conclusion. Moreover, the Bastendorff Formation, being finer grained

and somewhat chalky in appearance in weathered outcrops, is lithologically quite distinct from the middle Coaledo.

A regional study of the distribution of the four units leaves little doubt regarding their true geologic relationships. A section along the Coquille River shows all four units in stratigraphic succession with no evidence of thrusting. Along Isthmus Slough and near Sumner the Bastendorff appears above the Coaledo without duplication. Any similarity in apparent age of the units is due to the short time span involved in their deposition relative to the time span represented by the foraminiferal stages.

Tunnel Point Formation

The Tunnel Point Formation was originally defined by Dall (1898) and is restricted to exposures near Tunnel Point, one-half mile southwest of Coos Head adjacent to Coos Bay. Allen and Baldwin (1944) measured 800 feet of sandstone assigned to the unit in the beach section. No other exposures of the Tunnel Point Formation are known. The sandstone, however, is probably more widespread beneath exposures of the Empire Formation farther south in the South Slough Syncline.

The sandstone is made up primarily of medium-gray, coarse- to fine-grained current-sorted sandstone. Occasional pebbly and fossiliferous layers are present in the basal part of the section. Where weathered the sandstone is light yellowish brown. According to Schenck (1928, p. 19), the sandstone consists chiefly of quartz and feldspar with an admixture of subordinate tuffaceous material and glauconite. Lowry (in Allen and Baldwin, 1944 p. 29) states:

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

Basaltic tuffs and clastic fragments are common in the Bastendorff and upper Coaledo Formations, and similar rock in the Tunnel Point Formation may point to erosion of a common source. The appearance of andesitic material probably results from erosion of the contemporaneous Little Butte Volcanics in the Western Cascades.

The Tunnel Point Formation is apparently conformable over the Bastendorff Formation and is overlain by the Empire Formation with marked angular unconformity. A pronounced disparity of dip between the two units is evident even though the actual contact is largely obscured by local slumping and vegetation.

A meager megafossil fauna recovered primarily from basal beds of the unit indicate a middle Oligocene age similar to that of the upper half of the Eugene Formation in the Willamette Valley.

Regional studies show that the sea invaded several coastal embayments as well as the Willamette Valley in Oligocene times. It is not known for certain whether the sea was continuous from Coos Bay to the Willamette Valley at that time or whether the Coast Range was starting to rise, possibly isolating the Coos Bay embayment.

Marked facies changes within the Oligocene units of much of western Oregon, the presence of numerous Oligocene intrusives in the central Coast Range, and the limited extent of the Oligocene units in the Coos Bay area suggest a very complex regional paleogeography in Oligocene times. The apparent concordance of the Coaledo, Bastendorff, and Tunnel Point Formations in southwestern Oregon, however, indicate that in southwestern Oregon at least, deformation occurred after middle Oligocene times.

Miocene beds

Beds of Miocene age were unknown in the Coos Bay area until 1949 when the U.S. Army Corps of Engineers dredged the bay and piled the dredgings on both sides of the harbor. The dredgings on the edge of the spit to the west were by far the more fossiliferous and included fossils from both the Miocene

beds and the Pliocene Empire Formation. Mollusks were abundant in the Miocene dredgings and have been studied subsequently by James (1950), Moore (1963), and Armentrout (1967).

The beds most commonly represented in the dredgings consist of medium-grained, medium-gray sandstone cemented with calcite. Finer-grained strata may have been present originally but were broken up during the dredging process.

Armentrout (1967) was the first to find a Miocene outcrop on land. Between Pigeon Point and the Cape Arago Pulp Mill 26 feet of section is exposed at low tide. Armentrout (1967, p. 34) describes the beds as follows:

> "The lower half of the section is a concretionary massive lithic graywacke that is highly fossiliferous. The upper half of the section is a poorly consolidated lithic graywacke only sparsely fossiliferous."

Barring the presence of faults, a thicker section is undoubtedly present along strike in the bay adjacent to the pulp mill. Projected dips show there is room for a thousand feet or more of Miocene strata in the center of the South Slough Syncline. Both Moore (1963) and Armentrout (1967) consider the mollusks to be middle Miocene and generally equivalent in age to the Temblor Formation of California and a part of the type Astoria Formation of Oregon. Older beds equivalent to the Nye Formation may be present in the center of the South Slough Syncline.

Empire Formation

The term Empire Formation was first applied to the sandstones and siltstones which occupy the center of the South Slough Syncline in the western Coos Bay area by Diller (1896). The name was derived from the early settlement of Empire, now a part of Coos Bay. The Empire Formation is limited in extent, but equivalent beds probably crop out along the shore south of Bandon (Orr and Weinstein, 1970).

A highly fossiliferous conglomeratic lens exposed at Fossil Point along the east side of the bay was termed the "Coos Conglomerate" by Dall (1909). He described and illustrated the fauna and considered the unit to be a distinct stratigraphic entity. Howe (1922), however, showed that the conglomerate lies within the Empire Formation and that it is, therefore, a member of that formation. Weaver (1942) identified and illustrated the fauna of the Empire Formation and Allen and Baldwin (1944) summarized the local geology. A detailed study of the formation and its fauna was undertaken by Armentrout (1967).

Weaver (1945) recorded a thickness of 1,540 feet for the formation along the coastal section, and Armentrout (1967) measured a thickness of 1,630 feet. If dips along the western limb of the South Slough Syncline are uniform, it is possible that the unit is more than 2,500 feet thick farther south in the basin.

The Empire Formation is made up of massive sandstone beds with little siltstone. Bedding is difficult to define in places, although limy concretions roughly depict stratification. The sandstone is medium gray where fresh and rusty brown where weathered. Borings by submarine organisms are common and are indicative of slow deposition. Armentrout (1967, p. 80) discusses the petrography as follows:

> "Based on 300 grain counts of 11 thin sections, the sandstone of the Empire Formation is a feldspathic graywacke (Pettijohn's classification, 1957). The light-gray rock has angular quartz and feldspar grains and a preponderance of matrix. The components of the sandstone are randomly oriented."

The Empire Formation contains an abundant molluscan fauna, especially in the conglomeratic lens noted above. Dall (1909) described many of the forms and suggested an early Pleistocene or late Pliocene age. Weaver (1942) re-examined the fauna and interpreted a late early to middle Pliocene age. Microfossils are scarce. The Empire Formation is markedly unconformable over the Tunnel Point Formation and onlaps progressively older units to the south.

Coquille Formation

The Coquille Formation was named and defined by Baldwin (1945). The type section is located between the mouths of Cut Creek and Whiskey Run north of the mouth of the Coquille River. The unit is not mapped separately but is included with the terraces owing to small areas of outcrops (Figure 11).

Figure 11. Cliff face south of Whiskey Run exposes Coquille Formation below and terrace sands and gravels above.

Figure 12. Wave-cut platform at Fivemile Point. Vertical to slightly overturned strata of the Roseburg Formation with pholad-bored knob and overlying terrace sands.

The unit consists of poorly indurated conglomerate, sandstone, mudstone, and clay. Stumps and logs are present in places. Because little more than 40 feet of the unit is exposed at any one cliff face, it is difficult to estimate the total thickness of the unit. However, the base of the unit is inferred to be several hundred feet below sea level. Also, beds assigned to the Coquille Formation are exposed at an elevation of 160 feet in the excavations of the Pioneer mine along Cut Creek. Total thickness for the unit may therefore approach 500 feet.

Although megafossils are scarce in the Coquille Formation of Coos County, collections taken from beds assigned to the Coquille Formation near Newport (Baldwin, 1950) are late Pleistocene in age. Also, a log from the base of the terrace which overlies the Coquille exposures at the Pioneer mine was determined by carbon-14 radiometric dating techniques to be greater than 50,000 years old. This minimum age for the terraces overlying the beveled upper surface of the Coquille Formation suggests an age significantly greater than 50,000 years for the Coquille Formation.

A more precise post-Illinoian and pre-Wisconsin age is inferred for the Coquille Formation on the basis of the known Pleistocene eustatic history of the West Coast and the probable geomorphic history of the Coquille River area. Briefly, the Coquille beds are estuarine deposits which are thought to fill an ancestral mouth of the Coquille River. Because the Coquille River now flows through a valley cut during the last (Wisconsin) glaciation, the Coquille beds are thought to fill a valley cut during an earlier stage of glaciation and low sea level, possibly the Illinoian Stage. Thus, the Coquille Formation is probably post-Illinoian and pre-Wisconsin (Sangoman Interglacial) in age.

Elsewhere in western Oregon additional evidence for alluviation contemporaneous with that of the Coquille Formation in Coos County has been recognized. Beds analogous to the type Coquille Formation have been found at the mouths of many of the streams along the Oregon coast and have been assigned to that unit. In addition, Lowry and Baldwin (1952) propose that much of the alluvial fill of the Portland area is contemporaneous with the Coquille Formation along the coast.

Terrace deposits

Terrace deposits in addition to the Coquille Formation mantle many of the marine benches present at various elevations within the western part of Coos County and consist of loosely compacted, rudely bedded sand with pebbly horizons near the base. Burrows of marine rock-boring clams in places in the underlying bedrock indicate at least a partial marine origin for some of the terrace deposits (Figure 12). The uppermost layers of the terraces, however, occasionally consist of black, organic, nonmarine, or brackish soil.

Formational names have not been applied to the deposits of the individual marine terraces. Rather, they are treated as physiographic entities (Griggs, 1945). Generally speaking, the terraces form easily recognized flat benches, but locally recent alluvial fans or tree-covered dunes modify the topography.

Tectonic processes also have affected the terraces. The higher terraces, for which possible late Pliocene ages are inferred, are present at elevations of up to 1,500 and 1,600 feet and obviously owe their position in large part to regional uplift rather than eustasis alone. According to Baldwin (1945), the lower lying terraces also are warped, although to lesser degrees, and it is often difficult to define individual terraces solely in terms of elevations.

Most of the terrace deposits range in thickness from 10 to 50 feet and appear to have been deposited during recessions of the sea. The variable thickness is a function of paleogeography and slight warping during deposition, relative position to the shoreline during deposition, and mass wasting and erosive processes after deposition. Lithology also varies as a function of the depositional conditions. For instance, gravels and black sands are developed low in the sections during times of moderately intense current action. Quartz- and feldspar-rich beds high in the section record deposition under less extreme conditions when these lighter grains were not winnowed out.

In contrast to the recessional terraces so common in much of coastal Coos County, the terrace deposits developed at the Seven Devils chrome mine (sec. 10, T. 27 S., R. 14 W.) are quite thick and are thought to have been laid down during an advance of the sea. Within the terrace the richest deposits of black sand are situated near the old channel of the Coquille River (Coquille Formation) and the most productive mines, the Pioneer and Eagle, are in terrace material immediately overlying the Coquille Formation. Evidently the gold, chromite, and magnetite were partially concentrated at the time of deposition of the

Coquille Formation and were further winnowed and concentrated as the terrace deposits immediately overlying the Coquille Formation were developed.

Alluvium

Alluvium occurs in all the major river valleys and bays and consists of variable amounts of unconsolidated clay, silt, sand, and gravel. As sea level rose at the end of the Ice Age, deposition within the estuaries developed broad, flat valleys which now are present near tidewater. The net result is that the larger bays are filled with alluvium which is believed to extend to depths as great as 400 to 450 feet.

In the low-lying areas of the flood plains, especially along the North Fork of the Coquille River, tree-covered natural levees are well developed. They formed as floodwaters spilled over established channels and deposited sediments along the edges of the rivers. During flood stage the levees continue to grow and are observed as two parallel rows of vegetation marking the banks of the river channel within the inundated flood plain.

Mappable deposits of alluvium inland are present along portions of the major streams, commonly on the inner corners of meanders. They were laid down as the meanders migrated laterally, cutting into the outer bank and depositing sediments along the inner bank. Other deposits of inland alluvium owe their origin to damming of streams by large landslides. Behind the obstructions sediments being transported downstream were deposited in the slack water. Ultimately a new flood plain was developed as the temporary lake was filled with alluvium.

Coastal Coos County is characterized by numerous large dune fields of differing ages and varying degrees of stability. In places the older dunes are stabilized by mature forests; in others the forest cover has not had the time to develop. In still others, large quantities of sand continue to blow inland and the dune fields continue to be active. This is particularly true north of the Coquille River, a stream which contributes much sand to this part of coastal Oregon.

In swampy and marshy lowlands within the flood plains and parts of the dune fields, fine-grained sediments with high contents of organic material are common at the surface and may be widespread in the subsurface. Organic soils such as these characteristically form in areas of high ground water. Such soils pose many problems in terms of stability and should be extensively investigated if construction upon them is contemplated.

Tectonic History

In addition to the deposition of great thicknesses of sedimentary rock and the extrusion of prodigious quantities of volcanic rock, the geologic history of Coos County has included significant episodes of active tectonism and erosion. During these times little or no sediments were laid down, and the pre-existing rocks were severely deformed, eroded, and in some cases intruded with igneous rock. Present thought relates the tectonic processes responsible for both the deposition and tectonism to movements of large plates making up the crust and upper mantle of the earth. In the western United States and Oregon interaction between the North American Plate and various ancestral plates of the Pacific Ocean has been particularly pronounced since the middle of the Mesozoic era.

The Rogue Formation and the overlying Galice Formation were deposited in middle Late Jurassic times and were severely deformed shortly thereafter during the Nevadan Orogeny. Thrusting, folding, faulting, intrusion and metamorphism occurred at this time. A short distance to the south in California the Sierra Nevada Batholith was implaced during a series of intrusive episodes assigned to the Nevadan Orogeny. Collectively the compressive processes of this orogeny undoubtedly shortened the crust of the earth considerably in the western United States.

In latest Jurassic times the Dothan and Otter Point Formations were laid down as abyssal fan and deep sea-floor deposits respectively. The varied rock types of the Otter Point Formation were possibly deposited over an active zone of subduction as is suggested by the widespread distribution of pre-lithification mélange features within the unit. With increased tectonism both the Otter Point and the Dothan Formations were uplifted so that a surface of erosion now separates these units from the overlying Early Cretaceous units. To the inferred period of short-lived tectonism the term Diablan Orogeny is assigned

in California. It differs from the Nevadan Orogeny in that no intrusions are associated with it. More than one pulse of deformation may hove been involved in this orogeny; clasts of blueschist in the upper member of the Otter Point Formation apparently were derived from the lower member, a feature which indicates erosion of the lower Otter Point prior to deposition of the upper Otter Point.

In earliest Cretaceous time, continental seas spread across the Klamath Mountain region to deposit the Myrtle Group and correlative units. During the middle of the Cretaceous Period, Early Cretaceous units were folded and faulted and no deposition occurred in western Oregon. Isolated exposures of marine sedimentary rock of Late Cretaceous age in southwestern Oregon indicate reinvasion of the sea following the Cretaceous tectonism.

The Roseburg Formation was deposited in early Eocene, Paleocene, and possibly latest Cretaceous times. There is no evidence to suggest a break in deposition at the close of the Cretaceous Period. Near the close of early Eocene times, however, the Roseburg Formation underwent severe compression and was isoclinally folded and locally overthrust to the northwest. Crests of anticlines within the unit are truncated and it is thought that a land mass was formed at this time. During this time also the Colebrooke Schist may have been thrust into the area (Baldwin and Lent, 1972) from a westerly source (Coleman, 1972). A metamorphic age of 130 $\pm$ million years has been assigned to the Colebrooke Schist, and geochemical affinities to the Galice Formation have been recognized (Coleman, 1972).

With the close of the post-Roseburg tectonic episode, the regional pattern of deformation in the Coos County area and western Oregon in general changed significantly in terms of intensity and orientation. Most later folds are gentle in comparison to the Klamath structures, and structures generally trend north rather than northeasterly. Active Klamath Mountain tectonism apparently ceased at or near the close of the early Eocene. To the north in Washington a similar pattern is recognized by Miller and Misch (1963), who describe gently folded middle and late Eocene rocks overlying much more severely deformed strata of Cretaceous through Paleocene age.

The Lookingglass, Flournoy, and Tyee Formations indicate near-shore conditions in the southeast and deeper water turbidite deposition towards the northwest. Although unconformities separate the three formations, actual deformation is gentle except along major faults. The overlying Elkton and Bateman Formations respectively represent post-Tyee deepening and offlap conditions.

Along the coast the Coaledo Formation represents deltaic deposition indicative of a large Klamath landmass to the southeast in late Eocene times. The overlying Bastendorff and Tunnel Point Formations represent continued deposition in a localized basin and, collectively with the Coaledo Formation, are the most severely deformed units of post early Eocene age in Coos County. Dips within the Coos Bay area approach 70 degrees, whereas dips within the Tyee, Elkton, and Bateman Formations in the Coast Range seldom exceed 20 degrees. It is inferred that the basement rocks beneath the Coos Bay area may occupy a zone of crustal weakness. Progressive folding has occurred in that area intermittently throughout much of the Tertiary (Baldwin, 1966). Angular unconformities separate the Tunnel Point Formation, Miocene beds, and Empire Formation.

Regional uplift continues to the present day. The high terrace on Blue Ridge at elevations of 1,500 and 1,600 feet is probably no older than latest Pliocene and assuredly owes much of its elevation to regional uplift. The gentle decline of the youngest terrace from Cape Arago to Charleston is indicative of local uplift within the late Pleistocene. A fifteen foot dislocation of the terrace surface at Mussel Reef near Cape Arago and regional tilting of various other terrace surfaces towards the axis of the South Slough Syncline are consistent with continued compression within the South Slough Syncline.

Geologic History

Coos County is located along the western margin of the North American continent, a region which has been characterized by the complex interaction of the oceanic and continental plates of the earth's crust for much of geologic time. Shortening of the crust in southwestern Oregon is attributed to underthrusting (subduction) and overthrusting (obduction) of the oceanic plate in relation to the continental plate. Associated with much of Late Mesozoic subduction was the development of the large batholithic intrusions, which now are widespread in the Klamath Mountains Province. Tectonism in most of Tertiary times has been much less severe. In Pleistocene times regional uplift has produced a series of marine terraces along the coast.

In Late Jurassic times thick accumulations of volcanic rock (Rogue Formation) and monotonous sequences of siltstone and graywacke (Galice Formation) were deposited in that order on the sea floor west of what was then the North American continent. The andesitic breccias of the Rogue Formation suggest that it may have been part of a volcanic chain, and one can envisage a growing island arc similar to that of the Aleutian Islands or parts of Indonesia today.

With the close of Galice sedimentation in Kimmeridgian times the region was subjected to the intense deformation and plutonism of the Nevadan Orogeny (see stratigraphic chart, Figure 4). Slabs of rock of regional dimensions were thrust over one another and severely deformed. At depth partial melting of the subducting plate gave rise to the large batholiths which intruded pre-Nevadan strata. At this time also large sheets of serpentinite and related rocks representing Mesozoic upper mantle material probably served as tectonic carpets, thus facilitating the regional thrusting and crustal shortening.

Later the uplifted mountains resulting from the Nevadan Orogeny contributed more sediments to the sea. Near the continental margin, sedimentation was in the form of rapidly deposited, thick sequences of sandstone (Dothan Formation); farther out to sea, fine-grained, thinner-bedded sandstone, siltstone, volcanic rocks and related sediments accumulated (Otter Point Formation). Blocks of blueschist, pods of serpentine, and a variety of mélange features within the Otter Point Formation as seen today indicate deformation prior to lithification, a feature which in turn suggests deposition in a tectonically active terrain. Possibly the Otter Point Formation was thrust beneath part of the continental crust as it was being deposited.

Near the close of Jurassic times the sea evidently withdrew from this part of Oregon, but an almost immediate reinvasion is indicated by the deposition of sand, silt, and conglomerate (Myrtle Group and Humbug Mountain Conglomerate) in latest Jurassic and earliest Cretaceous times. Island or peninsular sources for part of these rocks are suggested by the facies changes within the basal conglomeratic beds of the Humbug Mountain Conglomerate. Although this unit is situated to the west of the Myrtle Group, its clasts are characteristically larger, more locally derived, and less well rounded than those of the Riddle Formation situated farther to the southeast.

Structures within the Myrtle Group, but absent in younger strata, suggest folding and possible thrusting in the middle part of the Cretaceous Period. A Late Cretaceous reinvasion of the sea-laid down strata which are now exposed at Cape Sebastian and along the North Fork of the Coquille River. No significant orogenesis occurred at the end of the Cretaceous period. Possibly invasion of the Late Cretaceous sea continued uninterrupted into early Eocene times to give the more widespread deposits of the lower part of the Roseburg Formation.

Within the Roseburg Formation thick sections of basaltic pillow lavas and breccias petrographically similar to the floor of the Pacific Ocean and Hawaiian Islands today are widespread and may be continuous with correlative volcanic units farther north in western Oregon and Washington. Little is known of the specific origin of the rocks, but their extent points to a volcanic episode of regional dimensions. Perhaps an abyssal fan of Roseburg sediments interfingered seaward with the products of early Eocene subsea volcanism.

A brief pulse of relatively intense deformation produced isoclinal folds and thrusting in the Roseburg Formation at the close of early Eocene times. At this time basaltic units were thrust above overlying sedimentary strata; the enigmatic Colebrooke Schist may have been thrust eastward into the area from a yet undefined source; and a northeast trending structural style quite similar to that of the older Klamath rocks was imparted to the Roseburg Formation. Active collision of the oceanic and continental plates is inferred. In spite of its brevity, this period of deformation is regarded as a major orogenic pulse in southwestern Oregon. Products of succeeding deformations are gentle in comparison to it.

The presence of Penutian foraminifera in both the steeply dipping strata of the Roseburg Formation and the less deformed strata of the overlying and less extensive Lookingglass Formation attest to the short period of time involved in the post-Roseburg deformation. With continued transgression of the sea the basal conglomeratic beds of the Lookingglass Formation passed upwards into the deposition of finer-grained sandstone and siltstone.

A middle Eocene retreat and readvance of the sea is indicated by the angular unconformity between the middle Eocene Lookingglass Formation and the overlying Flournoy, which consists of relatively coarse near-shore deposits low in the section and finer-grained rhythmically bedded deeper water deposits high in the section.

In addition to the Lookingglass and Flournoy Formations, a third sequence of rhythmically bedded sandstone and siltstone (Tyee Formation) was deposited in middle Eocene times. The Tyee Formation is more extensive than either the Flournoy or the Lookingglass Formation, and it rests unconformably on all older Tertiary units. As shown by the absence of reworked local material in the unit, it must have been derived primarily from sources outside the immediate basin. Coal beds, channeling, and cross-bedding are restricted to the southerly exposures. Rhythmites and other deeper water features are dominant in the north, and paleocurrent indicators suggest a northerly direction of transport. The Tyee Formation may have been deposited in an end-filling basin that was open on the north, bounded on the south by ancestral Klamath Mountains, and bounded on the west by a peninsula along what is now the coastal part of Coos County.

With continued transgression, progressively finer-grained deposits were laid down so that the sandstones of the Tyee Formation passed upward into a finer-grained series of sediments dominated by siltstone (Elkton Siltstone). Subsequently, as the sea withdrew in latest middle Eocene times, a blanket of offlapping sandstone (Bateman Formation) was laid down. The unit is still preserved in the central part of the basin in eastern Coos County and western Douglas County. The distribution of the coal beds, cross-bedding, and channeling in the Bateman Formation point to a prograding delta characteristic of a shallow retreating sea.

Although evidence of an unconformity between the Elkton Siltstone and the overlying Coaledo Formation is not present at the one common locality of the two units at Sacchi Beach, it is likely that a period of slight deformation separates the two units. Apparently the late Eocene Coaledo sea was fairly restricted, and exposures of the Coaledo Formation are now preserved only in the central and western parts of Coos County. Originally, however, the unit may have lapped farther inland over older strata. Late Eocene beds of similar rock type are present south of Eugene, but no concrete evidence exists to suggest that a late Eocene seaway directly connected the two localities: the Eugene beds may be a part of the Cowlitz-Nestucca seaway.

The upper and lower sandstone members of the Coaledo Formation were deposited in shallow-water environments as sediment-laden distributaries shifted back and forth on a deltaic front. Much of the sand was derived from the ancestral Klamath Mountains, and tuffaceous material was contributed by streams draining the volcanic terrain of the ancestral Western Cascades to the east. Coal beds common in the units probably were derived from the vegetative matter which no doubt thrived along the margins of the late Eocene embayment and in the backwaters between the distributaries.

Overall, the Coaledo Formation represents a cycle of marine transgression and regression; the siltstone middle member, which is thickest along the coast and tapers to a feather edge inland, presumably was laid down during maximum transgression and deepest water conditions.

A probable shift to deeper water conditions in latest Eocene and early Oligocene times ushered in the deposition of the Bastendorff Formation conformable above the Coaledo Formation. A relatively sudden influx of coarser tuffaceous material in middle Oligocene times produced the sediments of the present day Tunnel Point Formation, a unit which also is largely restricted to the center of the South Slough Syncline. The grain size and present distribution of the unit suggest that it probably was more restricted in original distribution than either the Coaledo or the Bastendorff Formations.

Folding and erosion followed Tunnel Point deposition. It was not until middle Miocene times that sedimentation was again reinitiated in the Coos Bay area, as indicated by dredgings and small outcrops of middle Miocene rock. Older Miocene strata of Nye age may be present, however, in the center of the South Slough Syncline.

Renewed folding continued into the Pliocene at which time massive beds of sandstone were laid down to form the Empire Formation, a unit which is unconformable over many of the older units. Beds of Empire age evidently are more or less continuous offshore as far south as Cape Blanco. Fossiliferous boulders of Pliocene age are present on the beach near Bandon, and Pliocene beds crop out a short distance south of Bandon.

Long-term regional uplift since the late Pliocene and glacially induced fluctuations of sea level in the Pleistocene have resulted in the formation of a series of well-preserved marine terraces in southwestern Oregon. During stillstands of the sea, beveling by wave action produced the flat-lying surfaces which later were uplifted to give a series of terraces in which the successively older benches are situated at progressively higher elevations.

The highest terrace truncates Blue Ridge at an elevation of 1,500 to 1,600 feet. Whether entirely of marine origin or not, the erosion surface was governed in large part by the level of the nearby sea and significant later uplift is indicated. Among the lower terraces are small remnants to the south in Curry County at an elevation of about 1,200 feet, a terrace southeast of Cape Arago at 700 feet above sea level, and several other terraces at lower elevations in the Empire quadrangle. The terrace at the Seven Devils chrome mine along the coast is 300 to 350 feet high, and the prominent terrace at the Cape Arago Lighthouse and at Bandon is 80 to 100 feet above sea level.

Most of the terraces consist of a thin veneer of sand overlying a wavecut bench in bedrock. They probably represent recessional terraces formed when the land was rising relative to the sea. In contrast, the terrace deposits at the Seven Devils mine are much thicker and may represent aggradation during a relative rise of sea level.

The prominent terrace at Cape Arago has been incised by downcutting streams and is therefore older than the drowned bays of the present day. Because the bays were probably excavated during the low stand of sea level associated with the Wisconsin stage of glaciation, it is inferred that the Cape Arago terrace is pre-Wisconsin in age and that the sedimentary fill of the bays is post-Wisconsin in age. One can envisage pre-Wisconsin beveling and uplift to give the surface of the terrace, Wisconsin downcutting to give the present bays, and post-Wisconsin deposition to give the present-day bay fill.

A similar sequence of events that took place during and after an earlier stage of glaciation is recorded in the rocks between the mouth of the Coquille River and Whiskey Run. There, a valley cut during either the Illinoian or early Wisconsin glacial stage, when sea level was low, was subsequently buried by sediments. Apparently the valley was occupied by the Coquille River when it was situated north of its present course. During the last interglacial stage when sea level was high, the valley was clogged with sediments to give a series of valley-fill materials which form the present-day Coquille Formation. In Wisconsin times the river shifted southward to incise different bedrock, and the Coquille Formation was fortuitously preserved.

Although long-range uplift of the land is the prevailing tectonic process at the present time, the bays remain drowned today owing to large and rapid rise in sea level which accompanied the abrupt termination of Wisconsin glaciation in the recent geologic past. Sediments being deposited in the bays today are analogous in terms of origin to the Coquille Formation, which was deposited in the last interglacial epoch.

METALLIC MINERAL RESOURCES

by Len Ramp

Black Sands

Several potentially valuable minerals occur in black sands along the southern Oregon coast. Gold, platinum, and chromite have been produced from these sands in the past. Other black sand minerals include magnetite, feldspar, quartz, zircon, garnet, ilmenite, olivine, pyroxene, epidote, and minor rutile. Interest has been mainly in the relatively thin black sand layers which contain a natural concentration of these heavy minerals in both onshore and offshore deposits. Figures 13 and 14 show two of the early-day gold-mining operations in the black sands.

Workers reporting on the gold and chromite resources in these sands include Diller (1901), Day and Richards (1906), Diller (1914), Horner (1918), Pardee (1934), Twenhofel (1943), Griggs (1945), Clifton (1968), and Clifton and Mason (1969).

Origin and distribution

The black sands are derived from sediments of nearby rivers and creeks which drain into the ocean and are then reworked by the waves. The principal source stream which drains most of the southern half of Coos County is the Coquille River. Other less important sources of the black sand include the Coos River, Twomile Creek, Fourmile Creek, and Floras Creek and the Sixes River to the south in Curry County. Some long-shore drift of sand from these streams to the south is believed to have contributed to the Coos County deposits. Fluctuation of sea level during Pleistocene (Ice Age) time has given rise to several elevated wave-cut terraces. Gradual uplift of the region with a number of still-stand periods has allowed erosion by small coastal streams to re-work portions of the deposits on the upper terraces so that the succeeding lower terraces are somewhat richer in the more weather-resistant minerals such as gold, platinum, chromite, zircon, quartz and garnet. The winnowing action of the waves has concentrated the heavy mineral deposits in thin tapering layers or stringers mainly along the back beaches.

Griggs (1945) divides the black sand deposits into two general types: those formed on the beaches and those which were deposited in the offshore zone. The beach deposits are found next to old sea cliffs and are elongated parallel to the former coast line. These deposits are usually lenticular, thinning rapidly on the landward side, but usually with poorly defined boundaries on the seaward side.

The offshore type deposits were formed in depressions in the sea floor and do not necessarily lie parallel to the coastline. Griggs (1945, p. 119) states "the black-sand bodies range from less than a foot to 42 feet in thickness usually averaging between 5 and 10 feet. The width ranges from several tens of feet to more than 1,000 feet, and the length from several hundred feet to over a mile."

Black sand deposits that have been explored and worked to a limited extent for chromite, gold, and platinum are situated on the broad coastal plane from the Seven Devils, about 10 miles north of Bandon, to Port Orford in Curry County. This gently-sloping plane includes three lower terraces named the Whisky Run, Pioneer, and Seven Devils. These terraces, mapped by Griggs (1945) lie between about 300 feet (upper levels of the Seven Devils terrace) and about 20 feet (lower portion of the Whisky Run terrace) above sea level.

Reserves

Griggs (1945) estimated that black-sand reserves amounted to 1,913,000 long tons of measurable and indicated ore containing more than 5 percent Cr_2O_3 and 1,212,000 long tons of sand averaging between 3 and 5 percent Cr_2O_3. These total estimated reserves were reported to be capable of yielding 456,000 long tons of chromite and concentrates containing 40 percent Cr_2O_3. Griggs further estimated

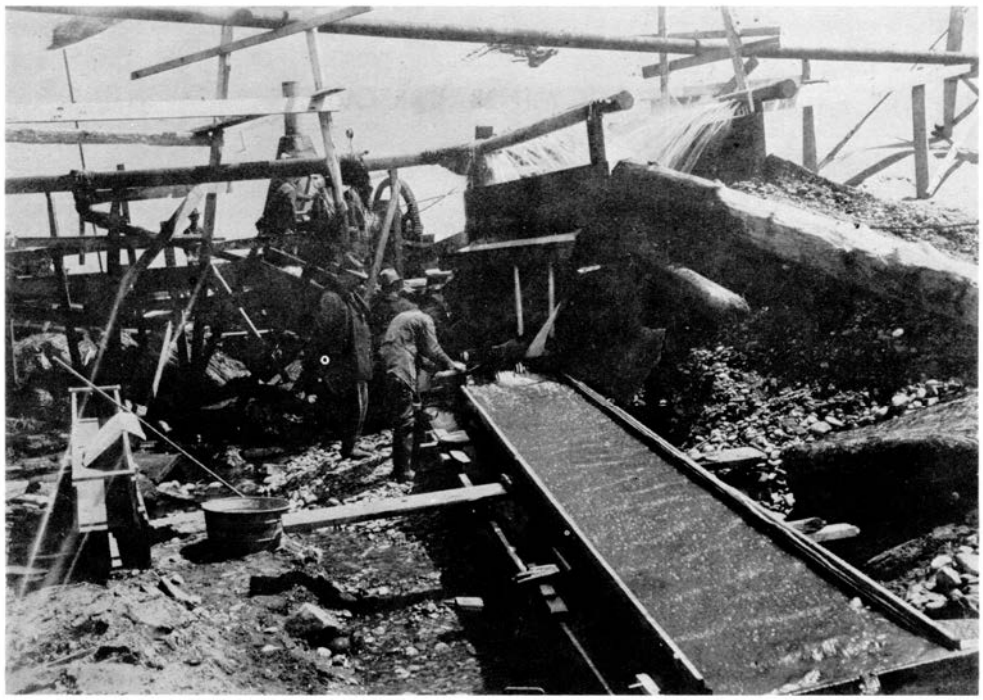


Figure 13. Gold mining in the early 1900's at Whiskey Run. (Photo courtesy of Melvin McKinney)

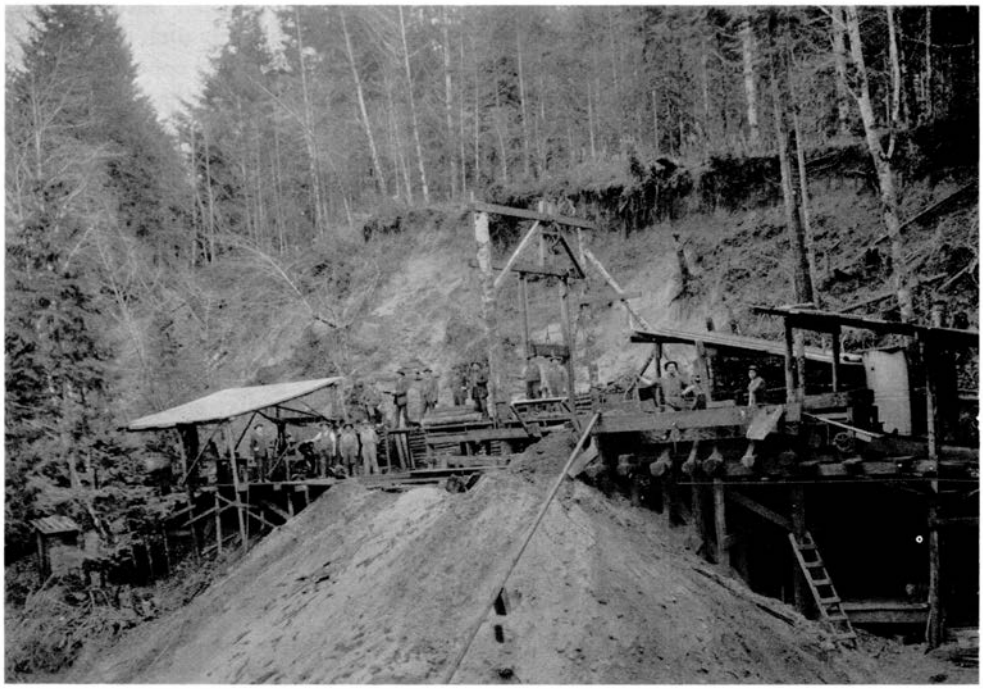


Figure 14. Gold mining in 1918 at the Eagle mine. (Photo courtesy of Melvin McKinney)

that an additional 100,000 long tons of sand in the present beaches contain 5 percent or more Cr_2O_3, and that known reserves in many of the deposits can be substantially increased by more detailed exploration.

During recent years there has been interest in off-shore black-sand deposits, and oceanographers have done fairly extensive sampling of the continental shelf sediments off the southern Oregon coast. A few anomalous areas of heavy mineral concentration and gold values are reported by Kulm and others (1968) and Clifton (1968). Anomalies containing 5 parts per billion and greater gold are shown in Figure 15 and represent only surface sampling of the sea floor. Further sampling by drilling is necessary to evaluate areas of heavy mineral concentrates on the continental shelf.

History and production

The earliest gold mining on the Oregon beaches was at Whisky Run, about 7 miles north of Bandon, in 1852. Reports of success resulted in the usual gold rush into the area and the community of Randolph was established near the mouth of Whisky Run. The nearby black sands were mined with feverish activity between 1853 and 1855 (McArthur, 1952). The mining activity soon subsided and Randolph became a ghost town. It was later re-established on the north bank of the Coquille River about 4½ miles from Bandon. There have been occasional flurries of activity at Whisky Run ever since the initial productive period. Records of gold production from beach mining and from the black sand horizons in the elevated terraces are incomplete. Pardee (1934) reported Bureau of Mines production statistics from 1903 to 1929 in the Whisky Run-Bullards area to be 804 ounces of gold and $1,707 worth of platinum or a total value of $18,269 for the period. Spreen (1939, p. 11) estimated production from the Whisky Run claim and reported "during the fifties and sixties more than one hundred thousand dollars were taken from this one claim."

During World War II (1943) a total of 46,500 tons of semi-finished chromite concentrates was produced and purchased by the government. These concentrates, which were stockpiled near Coquille for about 10 years, contained about 35 percent Cr_2O_3. They were subsequently up-graded in 1955 and 1956 by Pacific Northwest Alloys, Inc., under a contract with General Services Admin., to about 40 percent Cr_2O_3 and then shipped to a smelter at Mead, Washington for use in the manufacture of ferrochromium.

By-product concentrates of zircon were also made and utilized by the U.S. Bureau of Mines in Albany for metallurgical research. Some by-product garnet-rich concentrates suitable for sand blasting were also obtained.

Mines and deposits

Black sand properties of Coos County occur in four general areas: South Slough area, terraces north of Coquille River, terraces south of Coquille River, and present-day beaches. The more significant occurrences are described below and their locations shown on Figure 16.

South Slough Area

CHICKAMIN MINE (No. 2, Figure 16)

Location: S½ sec. 25, T. 26 S., R. 14 W., at the head of South Slough on the east side of John B Creek, at about 60 feet elevation.

Description: Griggs (1945 p. 128-129) describes the occurrence as follows: "A 6-inch to 3-foot layer of brown sand with black laminae, the basal part of which is mostly gravel, is exposed in the pit at an altitude of 65 feet. This rather lean material is covered by about 10 feet of barren sand and underlain by at least 40 feet of similar sand."

Across John B Creek from the Chickamin pit "a 14-foot bed of cemented brown- and black-stained sand is exposed at the portal of a short tunnel on the west side of John B Creek, just across

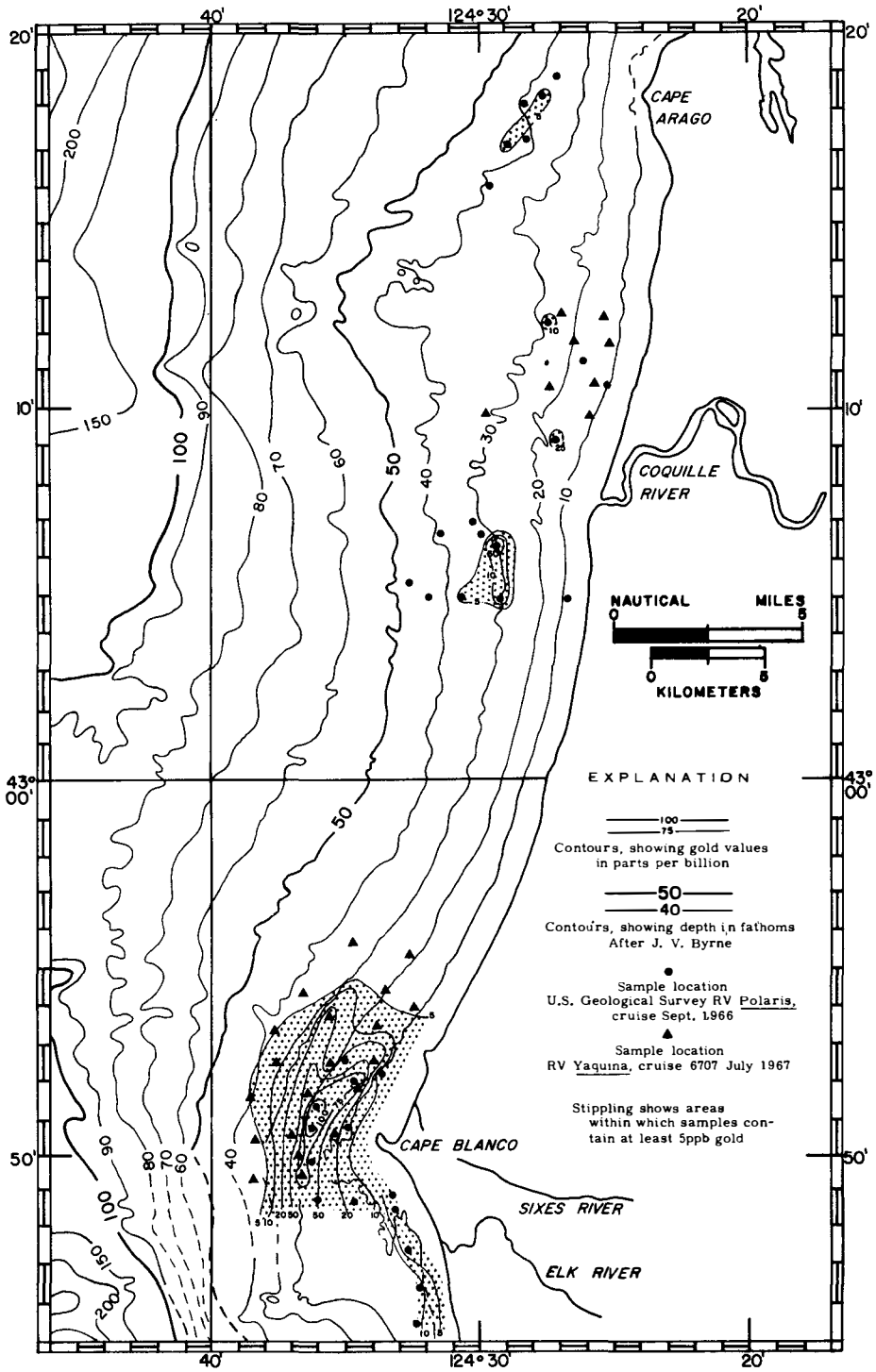


Figure 15. Locations of off-shore surface grab samples that have been analyzed for gold, southern Coos County and northern Curry County. (From Clifton, 1968)

from the Chickamin mine and at about the same elevation, in the S½ sec. 25, T. 26 S., R. 14 W. Black mineral grains are concentrated only in the lower 6 feet of the layer. A sample taken across this lower part assayed 6.53 percent Cr_2O_3."

OTHER SOUTH SLOUGH OCCURRENCES

Several other small pits and prospects exposing layers of black sand in terrace deposits of the South Slough area were mapped by Griggs (1945). Most of these deposits lie within an area 2 miles south of the Chickamin mine. One deposit in the SW¼ sec. 36, T. 26 S., R. 14 W., on the east side of Cox Creek was drilled and sampled for its chromite content. The exploration, using a 2.5 percent Cr_2O_3 cut-off, indicated a roughly triangular bed of iron-stained cemented sand which ranges from 1.5 to 24 feet thick and averages 9.7 feet thick. On the southwestern margin the bed is about 600 feet wide, the northeastern end is about 100 feet wide, and the length about 650 feet. Average thickness of overlying barren sand is about 6 feet. The deposit is relatively high in magnetite and ilmenite with an average Cr_2O_3 content of 3.6 percent.

A small amount of gold occurs in black sands of South Slough but reliable assays have not been reported, according to Pardee (1934), and the limited developments indicate that there have been no successfull mining operations in the area.

Pardee (1934) stated that sands of the South Slough area were deposited in an offshore environment.

Terraces north of Coquille River

Griggs (1945) mapped and described 29 mines and prospects in black sand on the three terraces between the Seven Devils and Coquille River. The area is about 7 miles long and 3 miles wide. A few of the more important deposits are described below from north to south.

UNNAMED DEPOSIT (No. 10, Figure 16)

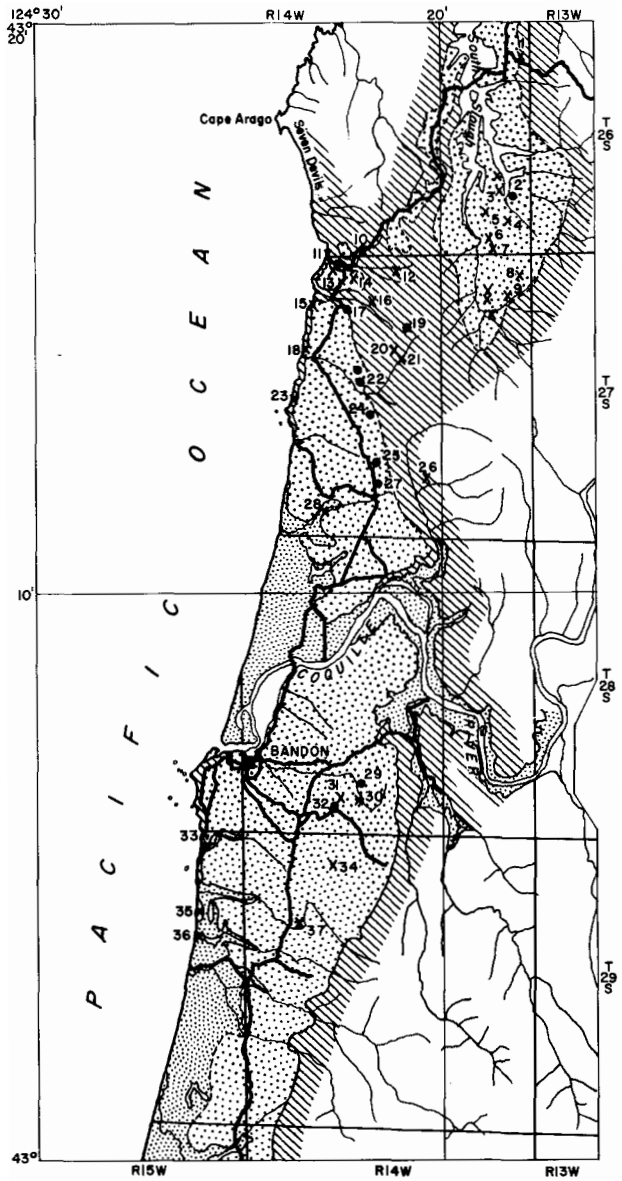
Location: S½ sec. 33, T. 26 S., R. 14 W. and extending into the N. edge sec. 4, T. 27 S., R. 14 W.

Exploration and development: In 1942 the Humphreys Gold Corp. put down 53 hand-auger holes and dug 7 test pits. During 1943 and 1944 the U.S. Bureau of Mines drilled 86 holes and dug 7 bulldozer trenches and cuts.

Geologic description: The deposit is at the back of the Seven Devils terrace next to the old sea cliff, which at this location trends nearly east. The terrace deposit has been dissected by erosion into three segments by south-flowing tributaries of Fivemile Creek. These segments are elongate in a northerly direction. The central and western segments are the largest bodies and each measures about 2,000 feet long by 600 feet wide. The eastern, smaller body measures about 1,200 feet long and 280 feet wide. The chromiferous sand layer in the three segments is lenticular in cross section with a thin edge on the northern side near the sea cliff, a maximum thickness of 26.5 feet near the center, and a thickness of 2 or 3 feet on the southern side. The average thickness is 12.5 feet. The average thickness of overburden is 5.5 feet and the average grade of the chromiferous layer is 4.2 percent Cr_2O_3 with a 1.5 percent Cr_2O_3 cut-off used to mark the top and bottom of the layer.

Production: None is reported.

Reference: Griggs (1945, p. 130-132)



EXPLANATION

Holocene beach sand, stream alluvium and sand dunes

Pleistocene marine beach and offshore deposits

Tertiary rocks

• x Placer mines and prospects

MINES AND PROSPECTS

1. NE¼NE¼ sec. 13, T. 26 S., R. 14 W.
2. Chickamin mine
3. S½ sec. 25, T. 26 S., R. 14 W.
4. SW¼NE¼ sec. 36, T. 26 S., R. 14 W.
5. NW¼ sec. 36, T. 26 S., R. 14 W.
6. N½SW¼ sec. 36, T. 26 S., R. 14 W.
7. S½SW¼ sec. 36, T. 26 S., R. 14 W.
8., 9. NE¼sec. 1, T. 27 S., R. 14 W.
10. Section 33 deposit
11. Beach at mouth of Fivemile Creek
12. W½ sec. 3 and NE¼ sec. 4, T. 27 S., R. 14 W.
13. NE¼ sec. 5, T. 27 S., R. 14 W.
14. Section 4 deposit
15. Beach at mouth of Threemile Creek
16. SE¼ sec. 4, NE¼ sec. 9, NW¼ sec. 10, T. 27 S., R. 14 W.
17. Kendall mine
18. Beach at mouth of Twomile Creek
19. Seven Devils (Last Chance) mine
20. SW¼ sec. 10 and NW¼ sec. 15, T. 27 S., R. 14 W.
21. Near center sec. 15, T. 27 S., R. 14 W.
22. Shepard mine
23. Fivemile Point
24. Rose mine
25. Coquille (Norman) mine
26. SE¼ sec. 27, T. 27 S., R. 14 W.
27. Eagle and Pioneer mines
28. The Lagoons
29. Iowa mine
30. Prospect 2,000 feet south of Iowa mine
31. N½SE¼ sec. 32, T. 28 S., R. 14 W.
32. Geiger (Little) mine
33. Beach at mouth of Johnson Creek
34. NW¼ sec. 9, T. 29 S., R. 14 W.
35., 36. Beach near mouth of China Creek
37. Pits on Crooked Creek

Figure 16. Black sand deposits of Coos County. (Adapted from Pardee, 1934, and Griggs, 1945)

UNNAMED DEPOSIT (No. 14, Figure 16)

Location: Sec. 4, T. 27 S., R. 14 W., on the Seven Devils terrace at about 310 feet elevation.

Exploration and development: The property was leased in 1942 by the Humphreys Gold Corp. and explored by a large number of shallow drill holes.

Geologic description: The deposit consists of a relatively flat-lying thin layer of chromiferous black sand on the northeast side of a low northwest-trending ridge of the dissected Seven Devils terrace. The deposit extends for more than a mile in length through section 4 southeastward into sections 3 and 10. It ranges in width from about 100 feet near the $\frac{1}{4}$ corner of sections 4 and 5 to more than 18,000 feet near the center of section 4 at the east side of the explored ground and averages about 700 feet wide. The chromiferous layer in the area of detailed exploration averages 3.1 feet thick and the overburden of sand and clay averages 3.8 feet thick.

Production: None reported.

Reference: Griggs (1945, p. 132)

SEVEN DEVILS (LAST CHANCE) MINE (No. 19, Figure 16)

Location: S$\frac{1}{2}$ sec. 10, T. 27 S., R. 14 W., at the back of the Seven Devils terrace at about 300 feet elevation.

Exploration and development: In 1940 the U.S. Geological Survey drilled 16 hand-auger holes. The Krome Corp. acquired the property in 1942 and in 1942 and 1943 drilled 112 holes and dug 17 pits. During the same period they erected a gravity concentration plant capable of handling 2,000 tons daily. (Figure 17). Mining was done from February to December 1943.

Geologic description: The black sand deposit is divided into north and south ore bodies which are about 800 feet apart and lie along the base of an ancient sea cliff. The north ore body is about 1,900 feet long and 600 feet wide and the south ore body is 2,200 feet long and averages 350 feet in width. The north ore body averages about 14 feet thick and the southern ore body 20 feet. Thickness of overburden on the north ore body averages about 35 feet and south ore body about 16 feet. The average Cr_2O_3 content of the north ore body is 6.7 percent and that of the south ore body 5.8 percent. Griggs (1945, p. 135) states that "although the deposit was laid down next to the sea cliff, it was undoubtedly formed under water, for the bedrock surface on the western side is as much as 65 feet above the top of the deposit, which precludes the possibility of its being a beach deposit."

Production: About a third of the south ore body was mined out during 1943.

References: Griggs (1945, p. 132-135)
Mining World (January 1944, p. 7-12)

SHEPARD MINE (No. 22, Figure 16)

Location: W$\frac{1}{2}$ sec. 16, T. 27 S., R. 14 W., near the east edge of the Pioneer terrace at about 160 feet elevation.

Exploration and development: Two pits, one 140 by 60 feet and about 30 feet deep and the other about half as large and a 100-foot tunnel a quarter of a mile south of the pits which entered in an east-northeast direction and is now caved were evidence of early gold mining activity. A number of hand-dug pits and drill holes explored the deposit for chromite during 1941-1943.

Geologic description: The deposit is an elongate flat-lying layer of black sand about half a mile long and 100 yards wide. The average thickness of the black sand layer is 7 feet. It underlies sand and clay at an average depth of about 30 feet and is underlain by sandstone. The average Cr_2O_3 content is 6.8 percent. The deposit lies at the foot of an ancient sea cliff at the east edge of the Pioneer terrace.

Production: A small amount of gold and platinum were probably produced from the early workings, but there are no records.

Reference: Griggs (1945, p. 137-138)

ROSE MINE (No. 24, Figure 16)

Location: NW¼ sec. 21, T. 27 S., R. 14 W., at about 150 feet elevation.

Development: A pit 800 feet long, 150 to 350 feet wide, and 30 to 50 feet deep along the west bank of Twomile Creek.

Geologic description: There were two small north-trending bodies of black sand separated by 150 to 300 feet of barren or low-grade sand. The east body is nearly mined out. The west body is 50 to 200 feet wide, at least 1,100 feet long, and has an average thickness of 3 feet with an average Cr_2O_3 content of 7.1 percent. Griggs (1945, p. 138) states that "the relatively small size of the deposit and the disproportionate thickness of overburden, which averages 40 feet, make the deposit of scientific interest only."

Production: Horner (1918, p. 24) reported that Abraham Rose, owner-operator of the mine, is said to have recovered a considerable amount of gold and platinum by ground sluicing.

References: Griggs (1945)
Horner (1918)

EAGLE AND PIONEER MINES (No. 27, Figure 16)

Location: Secs. 28 and 33, T. 27 S., R. 14 W., between 150 and 200 feet elevation at the head of Cut Creek.

Development: The Pioneer pit as described by Griggs (1945) was 450 feet long, 250 feet wide, and 50 feet deep with about 2,000 feet of tunnels. The Eagle mine pit was 250 feet long, 120 feet wide and 55 feet deep with about 435 feet in two tunnels. Some enlargement of the pits has been done during a more recent operation, and the deposit has been drilled fairly extensively.

Description of the deposit: The black sand deposit is a very long, narrow, and relatively thin layer that is lenticular in cross section. It trends north and has been explored by drilling, which shows that the layer extends at least 1,250 feet south of the Pioneer pit and 2,400 feet north of the Eagle pit. Neither end has been determined by exploration.

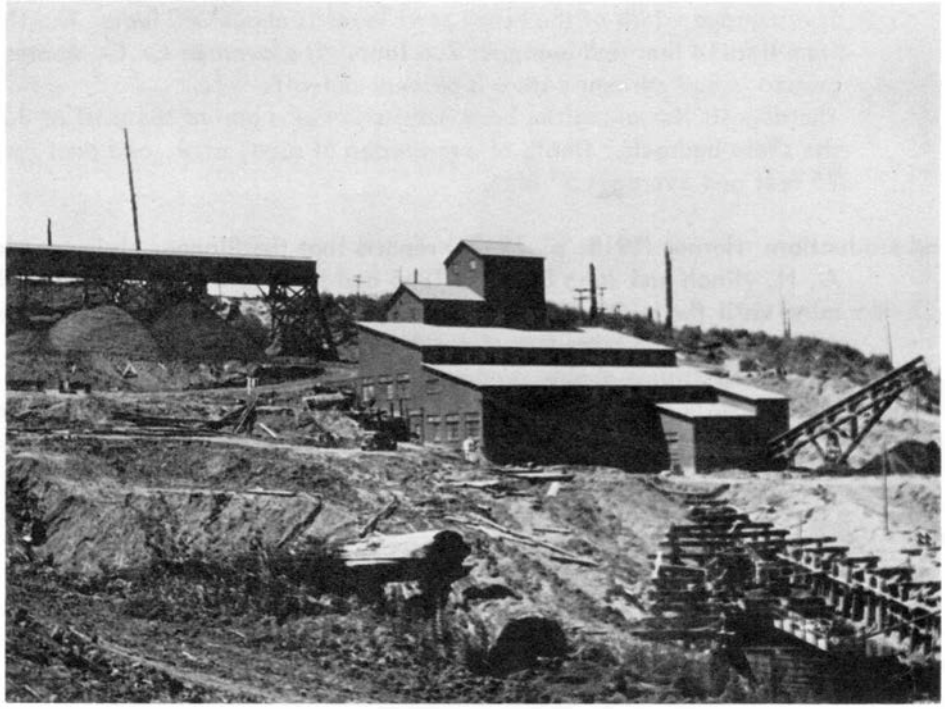


Figure 17. Seven Devils property and mill of Krome Corp. in 1943. Black sands were processed by gravity concentration.

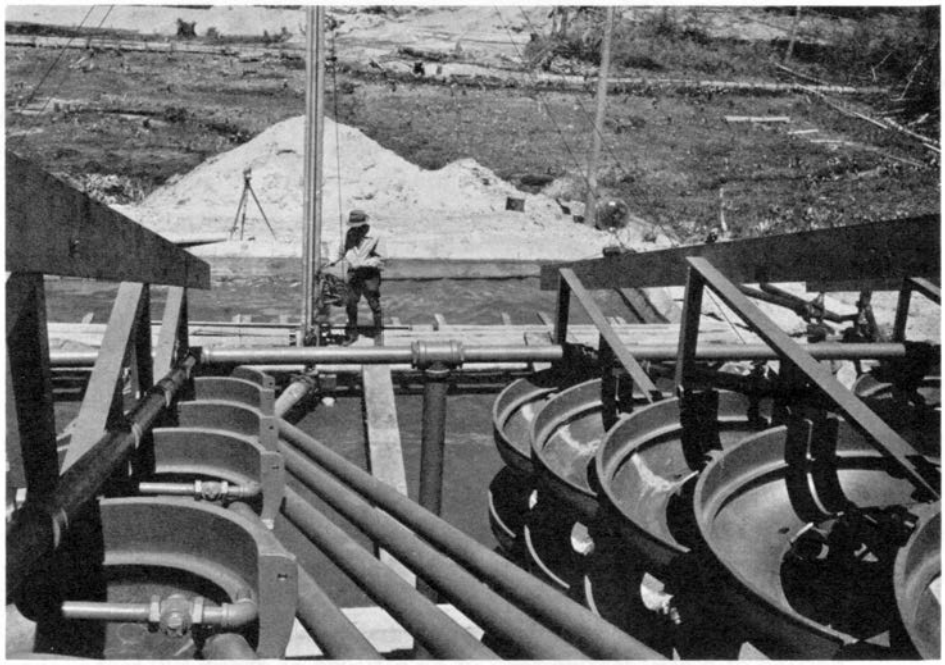


Figure 18. Humphreys spirals during construction of gravity concentration plant by Humphreys Gold Corp. at The Lagoons in 1943.

The average width of the black sand layer is about 300 feet. The thickness ranges from 0 to 14 feet and averages 7.8 feet. The average Cr_2O_3 content of the explored ground is 8.0 percent with a 3 percent cut-off.
The deposit lies along the base (west side) of a buried sea cliff of 30 to 40 feet in the shale bedrock. Depth of overburden of sand, clay, and peat ranges from 45 to 75 feet and averages 57 feet.

History and production: Horner (1918, p. 18-21) reports that the Pioneer claim was located by A. H. Hinch and John Dame in 1866 and later sold to Simon Lane, who worked the mine until the middle 1870's, when it was shut down. The claim was patented in 1872. The Eagle mine was also active from the late 1860's to 1873. Together these properties probably produced more gold and platinum than any of the other black sand operations in the area. A number of attempts have been made to reactivate the properties to produce gold, but there is no record as to whether or not these operations were profitable.

References: Griggs (1945)
Horner (1918)
Pardee (1934)

THE LAGOONS (No. 28, Figure 16)

Location: Near the center of sec. 32, T. 27 S., R. 14 W., at about 50 feet elevation.

Description: The Lagoons was a small lake about 2,500 feet long and a little more than 200 feet wide that was filled with black sand tailings from sluice boxes on Cut Creek fed by the Pioneer and Eagle mines. The black sand tailings ranged in thickness from a few feet at the eastern end of the lake, where it averaged 5.8 feet, to a maximum of 32 feet at the western end, where it averaged 14.0 feet. The average Cr_2O_3 content was about 11 percent.

Mining activity: Several unsuccessful attempts were made to reprocess the tailings to extract the remaining gold and platinum. The Humphreys Gold Corp. leased the deposit and set up a gravity concentration plant in the spring of 1943 to make chromite concentrates under a contract with Metals Reserve Co. (Figure 18). By December 1943 nearly all the deposit had been processed.

Terraces south of Coquille River

IOWA MINE (No. 29, Figure 16)

Location: S½ sec. 28, T. 28 S., R. 14 W., near the head of the north fork of Ferry Creek about 2 miles east of Bandon.

Development: A pit 250 feet by 150 feet and about 40 feet deep had a short tunnel (45 feet) in the northern end of the pit.

The deposit: Two thin streaks of very fine black sand 6 and 12 inches thick occur in the lower portion of a gray marine sand at an altitude of about 120 feet. The marine sand section is overlain by about 30 feet of overburden.

Production: Some mining was done in the early days to recover gold and platinum alloys. It is apparent that the operation did not pay well.

References: Griggs (1945)
Pardee (1934)

GEIGER (LITTLE) MINE (No. 32, Figure 16)

Location: SE$\frac{1}{4}$ sec. 32, T. 28 S., R. 14 W., on the south fork of Ferry Creek.

Development: A pit from early-day placer mining 700 feet long, 200 feet wide, and 20 to 40 feet deep was sluiced out along the creek. In 1942 the Pacific Co. drilled 19 holes exploring for chromite sand.

Geology: Drilling disclosed a buried north-trending sea cliff and some associated black sand concentrated near the shale bedrock but the Cr_2O_3 content was too low to be of economic interest. A few holes encountered a layer of brown and black sand 4.3 feet thick under 45 feet of overburden which averaged 3.1 percent Cr_2O_3.

Production: Probably a small amount of gold and platinum as at the Iowa mine.

References: Griggs (1945, p. 142)

Beach Deposits

The following black sand deposits described by Griggs (1945) occur on the present beaches of Coos County:

Beach at mouth of Fivemile Creek (No. 11, Figure 16), in secs. 32 and 5, Ts. 26 and 27 S., R. 14 W. According to Griggs, a 3-foot vertical channel sample at a point about 50 feet west of the sea cliff assayed 7.8 percent Cr_2O_3. The deposit consists of a 2- to 3-foot section of alternating thin layers of gray and black sand which lies along the base of the sea cliff for a distance of about 1,200 feet and is 50 to 75 feet wide.

Beach at mouth of Threemile Creek (No. 15, Figure 16), in SW$\frac{1}{4}$ sec. 5, T. 27 S., R. 14 W. The deposit is adjacent to the sea cliff and extends about 400 feet north and 1,200 feet south of the mouth of the creek. It is 2 to 3 feet thick, 50 to 75 feet wide, and made up of alternating thin layers of black and gray sand. A vertical channel sample 2.5 feet in depth taken 1,000 feet south of the mouth of the creek and 20 feet west of the sea cliff assayed 7.7 percent Cr_2O_3.

Beach at the mouth of Twomile Creek (No. 18, Figure 16), in secs. 8 and 17, T. 27 S., R. 14 W. A strip 800 feet long and 50 to 75 feet wide, lying next to the sea cliff near the north end of the beach about 300 feet north of the mouth of the creek, is underlain by thin layers of black and gray sand which assayed 6.7 percent Cr_2O_3 in a 2.5-foot vertical channel.

Beach at mouth of Johnson Creek (No. 33, Figure 16), in secs. 36 and 1, Ts. 28 and 29 S., R. 15 W. A layer of black sand about 1 foot thick and 100 feet or more in width extends along the base of the sea cliff for almost 2,500 feet north from the mouth of the creek. Five vertical samples of 2.8 feet in average thickness contained an average of 7.6 percent Cr_2O_3.

Beach near mouth of China Creek (Nos. 35 and 36, Figure 16), in sec. 11, T. 29 S., R. 15 W. Griggs (1945) sampled black sands of the backshore where China Creek cuts through the beach. A 7.5-foot channel sample taken at the thickest part of the 250-foot-wide deposit assayed 4.7 percent Cr_2O_3. Another 1-foot layer of black sand 2,500 feet north of China Creek appeared to have very limited extent, and a 3.5-foot channel sample assayed 9.6 percent Cr_2O_3.

Lode Chromite

A few small lode chromite occurrences have been reported in southern Coos County in the Powers district. The deposits are characterized by small pod-like lenses of massive chromite in highly sheared serpentinite. The production has been small and there are no known reserves. Brief summary descriptions of the occurrences are given below; numbers refer to locations on Plate 4.

INDEPENDENCE MINE (No. 1)

Location: Secs. 19 and 30, T. 33 S., R. 11 W., and secs. 23 and 24, T. 33 S., R. 12 W. 45 lode claims in 1938.

Development: Two adits, the lower 425 feet long and upper, 25 feet higher, about 50 feet long and a number of surface cuts. The precise location of these workings are not described.

Geology: Chromite occurs as small pods in serpentinite with associated gabbro. Some gold reportedly occurs in quartz veins along the contacts of serpentinite and gabbro. A sample of chromite from SW¼ sec. 23 assayed 44.5 percent Cr_2O_3, 11.7 percent Fe, and 11.2 percent SiO_2.

History and production: Production reports are confusing and were apparently somewhere between 75 and 200 tons. The first mining was in 1916 and later mining activity was in 1938.

References: Oreg. Dept. Geol. (1940, p. 41-42)
Ramp (1961, p. 112)

LAST CHANCE CLAIM (No. 2)

Location: On line of secs. 24 and 25, T. 33 S., R. 12 W., at about 2,200 feet elevation.

Development: Bulldozer excavations and trenching over about an acre.

Geology: The chromite occurs as small pods in a highly sheared serpentinite. Assays indicate from 40 to 48 percent Cr_2O_3 with a 2.2 Cr:Fe ratio.

Production: This occurrence was part of the old Independence mine group. Early production from this and nearby claims was reported to be about 150 tons. In 1953 about 15 tons of 45 percent Cr_2O_3, 2.6 Cr:Fe ratio, ore was shipped and a few small batches of mill-concentrated ore were shipped during 1956 and 1957.

References: Department mine file report, unpublished, (1939)
Ramp (1961, p. 112-113)

ROCK CREEK (BLACK BIRD) MINE (No. 3)

Location: SW¼ NE¼ sec. 33, T. 33 S., R. 12 W., on the southeast slope of Iron Mtn. at 3,160 feet elevation.

Development: In 1956, workings consisted of a shallow bulldozer cut 180 feet wide and 200 feet long.

Geology: Crushed chromite occurs in a flat-lying irregular zone in a serpentinite landslide area. The chromite-bearing zone exposed in the cut was about 1 foot thick and 50 feet long. Abundant 1/2 inch pieces of chromite float were found below the cut.

Production: A small amount of concentrated ore was shipped in 1956.

References: Department mine file reports, unpublished (1942)
Ramp (1961)

WHITE ROCK (CHROME FLOAT GROUP) MINE (No. 4)

Location: S½ sec. 15 and N½ sec. 21, T. 32 S., R. 12 W., between 2,400 and 2,800 feet elevation, on the south flank of Johnson Mountain.

Development: In 1954 there were two open cuts. The northern cut is in the south edge of sec. 15. It is about 200 feet in diameter and shallow. The southern cut, in sec. 21, lies about 100 yards to the south. It is a 200-foot bulldozer trench with a maximum depth of 20 feet.

Geology: The northern cut is in sheared serpentinite near the contact with metagabbro and phyllite to the north. The southern cut is near the center of a 250-foot-wide sheared serpentinite body which appears to widen to the south. The main direction of shearing is N. 30° E. parallel to the direction of the cut. Although no chromite was seen in place, it apparently occurs as discrete lenses in the highly sheared serpentinite. Most of the production was derived from surface float which had accumulated by erosion processes. A few large blocks, some weighing 5 tons, were reportedly found.

Production: During 1917 between 80 and 100 tons were reportedly hauled out by pack animals. There may have been additional small production in the 1940's. The ore reportedly assayed as high as 50 percent Cr_2O_3.

References: Department mine file report, unpublished, (1942)
Ramp (1961, p. 112)

Copper

There are four reported copper occurrences in Coos County. Only one, the Bolivar mine, has had any production. The Bolivar mine also appears to be the only occurrence which has potential of developing important tonnage reserves. At present, however, only very small reserves are known. Further exploration might be justified also in the vicinity of the Coos Copper and Magnabonus prospects.

The occurrences are described below; numbers refer to locations on Plate 4.

BOLIVAR (THOMPSON) MINE (No. 5)

Location: Secs. 10 and 15, T. 32 S., R. 10 W., between 2,600 and 3,300 feet elevation.

Development: The lower, No. 1 adit is about 700 feet long; the No. 2 adit, 150 feet higher, is a little more than 200 feet long; and the No. 3 adit, which is about 50 feet higher, is only about 40 feet long. In addition there are a shaft and a stope in No. 2 adit, a caved, inclined shaft about 200 feet southwest of No. 2 adit, extensive trenching and some drilling.

Geology: The rocks are altered volcanics, largely basalt, which are mapped as Dothan Formation by Wells and Peck (1961), and Rogue Formation by Baldwin (1972), and Rud and Utterback (1973). The "basalt" appears to be of submarine origin. Mineralization consists of scattered disseminations and streaks of bornite, chalcopyrite, and minor chalcocite; secondary malachite, azurite and chrysocolla; and minor cuprite, tenorite, and native copper near the surface. Gangue minerals accompanying the copper mineralization include sparse quantities of quartz, calcite, and barite. The mineralization appears to occur as irregular bunches and masses with no clear-cut vein structure in areas of multiple small fractures within the altered basalt; areas that appear to be ore shoots terminate abruptly in barren rock. Exploration to date has indicated relatively small tonnages of low-grade ore.

Production: Several attempts have been made to put the mine into production. Small shipments of ore and concentrates have been made by various operators since the early 1900's but none have met with success. Total production is not reported but probably does not exceed 300 tons of ore, which may have averaged about 5 percent copper.

References: Department mine files reports and maps, unpublished (1941, 1944, 1957)
Diller (1914, p. 86)
Oreg. Dept. Geol. (1940)
Utterback (1973)

COOS COPPER (No. 6)

Location: SE$\frac{1}{4}$ sec. 29, T. 32 S., R. 12 W. Two mining claims were patented in 1922 (M. P. # 916506)

Development: Four small open cuts and two short tunnels are situated near Granite Creek. The discovery cuts are about 50 feet northeast of Granite Creek. The tunnels and other cuts lie to the southwest across the stream and within about 250 feet of it.

Geology: A narrow north-trending dacite dike intrudes sediments and volcanic rocks of the Galice Formation. Small serpentinite bodies and diorite or gabbro intrusives are mapped nearby. The deposit is reported as probably consisting of disseminated sulfides associated with the contact zone of the dacite dike.

Production: None reported.

References: Baldwin (1971)
Department mine file report, unpublished (1942)
Diller (1903)
U. S. Mineral Survey No. 811 (1921)

COPPER KING CLAIMS (No. 7)

Location: Sec. 33, T. 33 S., R. 12 W. Three lode claims (precise location not reported).

Development: "A large number of open cuts tracing the vein for the full length of the three claims."

Geology: A lens of quartz in serpentinite lies about 100 feet east of a big outcrop of dacite-porphyry. Veinlets of chalcopyrite and associated malachite and azurite are reported in the quartz. A composite sample assayed 2.23 percent copper, 0.05 oz./ton gold and 0.08 oz./ ton silver.

Production: None reported.

Reference: Oreg. Dept. Geol (1940, p. 40)

MAGNABONUS PROSPECT (No .8)

Location: Sec. 29, T. 32 S., R. 12 W., north of Coos Copper, on a small creek just north of Granite Creek and Poverty Gulch at about 1,700 feet elevation.

Development: Several cuts and trenches and a small amount of underground work.

Geology: Workings expose a heavy siliceous gossan underlain by a silicified "meta-igneous" rock. The area is mapped by Baldwin and Hess (1971) as Galice Formation metavolcanics that are intruded by dacite and serpentinite. The siliceous rock underlying the gossan is impregnated with pyrite, chalcopyrite, and arsenopyrite (?).

History: The prospect was opened first for gold in the early days since Poverty Gulch and Johnson Creek were famous for their placer gold production. The sulfides were sampled for their copper content in the 1940's. There are no records of production, and development is not sufficient to evaluate the potential of the deposit.

References: Baldwin and Hess (1971)
Department mine file report, unpublished (1942)

Gold and Silver

There are a number of gold mines and prospects in the Powers area in southern Coos County. The principal production has been from placers on Johnson Creek and its tributaries, Poverty Gulch and Sucker Creek. A minor amount of placer mining was also done on Rock Creek, the head of Salmon Creek, and the head of West Fork Cow Creek in the southeastern corner of the county. Placer mining for gold in the beach and terrace deposits has been discussed under the heading of "Black Sands". There are no records of total gold production for the county.

Geologically the area of gold mineralization south of Powers is underlain by the Galice Formation, composed of indurated sediments and volcanics that have been intruded by dioritic dikes and stocks, and serpentinite (Baldwin and Hess 1971). The mineralization appears to be related to the dioritic or dacitic intrusives and is generally accompanied by sulfide minerals including pyrite, pyrrhotite, chalcopyrite, sphalerite, galena, and arsenopyrite. The sulfides are usually found in quartz fissure veins and in sheared rocks without quartz.

None of the lode prospects have had much production. The placer deposits were probably concentrated by weathering and erosion of a large number of small lode occurrences. Some of them may have been relatively rich, near-surface, pocket-type deposits.

Deposits that have been reported are briefly described below; numbers refer to locations on Plate 4.

DIVELBISS (COARSE GOLD) MINE (No. 9)

Location: NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 32, T. 32 S., R. 12 W., between 2,000 and 2,150 feet elevation.

Development: Three short adits: the longest 200 feet, a second 95 feet, and the third caved; plus other caved workings, the dumps of which are visible across the canyon to the southeast.

Geology: Ore minerals, mainly pyrrhotite, with some sphalerite, pyrite, and minor chalcopyrite and galena, occur with quartz and calcite gangue concentrated along the

southwest contact zone of a northwest-striking dacite porphyry dike with slaty siltstone of the Galice Formation. Maximum exposed zone of alteration is 10 feet wide. Assay samples are generally low, but a few selected samples with more abundant sulfides assayed as high as 0.28 ounce per ton gold and 10.66 percent zinc. Where galena is present fair silver assays are obtained.

Production: There was small production from a 5-stamp mill about 1900. The operation was short-lived.

References: Oregon Dept. of Geol. (1940, p. 39-40)
Department mine file reports, unpublished (1942, 1971)
Diller (1903)

GOLD BACK (FULLER) PLACER (No. 10)

Location: N½ N½ sec. 10, T. 32 S., R. 10 W., along the head of the West Fork Cow Creek both above and below the mouth of Fuller Creek.

Development: A pit about 200 feet in diameter.

Geology: Gravel worked was a low bench deposit from 10 to 75 feet thick with about 3 feet of clay at the surface. The bedrock is slate similar to the Galice Formation and minor conglomerate.

History: The area was being worked by hydraulic methods during the late 1930's and early 1940's. No production records are given.

References: Brooks and Ramp (1968, p. 188-189)
Department mine file report, unpublished (1941)

INDEPENDENCE MINE (see Chromite)

JOHNSON CREEK PLACERS (No. 11)

Some placer mining has been done along most of the length of Johnson Creek. According to Diller (1903), "Placer mines were once active along Johnson Creek throughout the greater part of its course, and paid moderately, but in the severe weather of the spring of 1890 landslides so filled up the stream bed that mining since has been unprofitable." He further reported that the most successful mines were near the head of the stream near the belt of dacite porphyry which crosses the Sixes River divide toward the Salmon Mtn. mine.
In recent years the Big Slide placer near the NE corner of sec. 34, T. 32 S., R. 12 W. has been worked on a seasonal basis. No estimates of overall production are available.

JUPITER GROUP (LITTLE JUPITER) (No. 12)

Location: West edge of NW¼ sec. 11, T. 33 S., R. 12 W., at about 1,600 feet elevation on the point of a north-trending ridge between tributaries of Sucker Creek known locally as Nickel Creek and Twobit Creek.

Development: A shallow open cut on the northwest side and a 30-foot drift on the steep east side of the topographic knob. Other workings may be present in sec. 10, but were not examined.

Geology: The country rocks are metavolcanics (greenstone) probably belonging to the Galice Formation. Gold mineralization occurs in small quartz veins with pyrite, chalcopyrite, minor galena, and free gold.

Production: Sucker Creek and its tributaries have produced small amounts of placer gold, but no significant production has been reported from these prospects.

References: Department mine file report, unpublished (1963)
Oregon Dept. of Geol. (1940, p. 42)

MAGNABONUS (see Copper)

NICOLI GROUP (No. 13)

Location: E½ sec. 23, T. 33 S., R. 12 W., at about 2,600 feet elevation.

Development: Three tunnels, 250 feet, 150 feet, and 25 feet in length and an open cut 50 feet deep (in 1937).

Geology: Work has been done on two quartz veins containing some calcite, pyrite, and free gold. The veins 1 to 5 feet wide contain spotty values - some high grade.

Production: There may have been a small amount of gold recovered by milling but no records are given in the reports.

References: Department mine file report, unpublished, (1937)
Oregon Dept. Geol. (1940, p. 43)

POVERTY GULCH PLACERS (No. 14)

Several brief mentions of placer mining on Poverty Gulch are made in other reports of gold mining in the area but none give specific information as to periods of mining activity, size of area worked, values per yard, or production statistics. Diller (1903) reported that the stream was worked a short distance up from Johnson Creek. Department mine file reports indicate some placer mining at a point near the mouth of Granite Creek which is about 1 mile from Johnson Creek. Most of the placer mining in the area was probably done between 1860 and 1900.

REYNO CLAIM (No. 15)

Location: SE¼ sec. 30, T. 32 S., R. 12 W., on the ridge between Barklow and Bray Mountains, at about 3,050 feet elevation and 2,500 feet southwest of the top of Bray Mtn.

Development: A small discovery cut lying 255 feet south of a shallow 15-foot adit and a caved adit about 1,700 feet west down the gully. (Not visited)

Geology: Workings on the ridge expose two narrow, nearly parallel mineralized seams about 250 feet apart in gabbro. The south zone strikes N. 75° W. and dips 75° S. It contains lenses of dark-gray massive, sheared arsenopyrite in sheared iron-stained gabbro. The zone varies from a trace to 10 inches thick with occasional 6-inch lenses of arsenopyrite. The north zone strikes N. 75° W, is vertical, and appears to follow the contact of gabbro with slaty siltstone of Galice Formation to the north. It is about 14 inches wide and also contains lenses of fine-grained, massive, gray arsenopyrite. Assays indicate interesting gold values in the arsenopyrite.

Production: None reported.

Reference: Department mine file report, unpublished (1971)

ROCK CREEK PLACERS (No. 16)

A small amount of placer mining and sniping has been done in the headwaters of Rock Creek, probably including portions of the stream in sections 26, 27, 33, and 34, T. 33 S., R. 12 W. Periods of work were during the late 1800's to about 1940. No significant operations are reported and production is believed to have been small.

Reference: Oregon Dept. Geol. (1940, p. 44)

SALMON MOUNTAIN MINE (No. 17)

Location: E½ sec. 19, T. 32 S., R. 12 W., at about 2,100 feet elevation on the northeast flank of Salmon Mtn.

Development: In 1937 there was a hydraulic cut about 50 feet wide, 50 feet deep, and 500 feet long extending up the slope, and four caved tunnels with a reported aggregate length of about 1,000 feet.

Geology: The mine area is a landslide and the rocks consist largely of brecciated metavolcanics (altered basalts) and sediments of the Galice Formation lying downslope from a major west-trending fault. Small dioritic intrusives and serpentinite are also nearby. Gold is fairly coarse and was mined by hydraulic methods. Some placering was also done on a tributary of Salmon Creek (Dude Creek) a short distance down the slope north of the mine.

History and production: Operated from 1885 to 1936 intermittently as a hydraulic mine when sufficient water was available. Total production was estimated at between $75,000 to $100,000.

References: Baldwin and Hess (1971)
Brooks and Ramp (1968, p. 184 and 186)
Department mine file report, unpublished (1937 and 1942)
Diller (1903)
Oregon Dept. of Geol (1940)

SUCKER CREEK PLACERS (No. 18)

Sucker Creek, a main tributary from the south, enters Johnson Creek at a point about 2 miles up from its mouth. No principal mines are reported, but there are brief mentions in the literature of placer mining on the lower end of Sucker Creek, probably in the area down stream from the Jupiter Group lode gold prospects. Total production is probably small and most of the mining was done in the late 1800's.

Reference: Diller (1903)

Manganese

A few small manganese prospects, one of which has had some production, are reported in Coos County. Most of the deposits occur in small chert bodies associated with marine sediments and volcanics which belong to the Late Jurassic Otter Point Formation. The manganese oxides have been concentrated at the surface by weathering processes which tend to leach out the other materials, such as the silica, and leave residual concentrations of manganese and iron oxides. None of the deposits are believed to contain significant reserves. They are described briefly below; numbers refer to locations on Plate 4.

DEMENT CREEK PROSPECT (No. 19)

Location: On private land near the section line of 18 and 19, T. 30 S., R. 12 W., about 100 feet west of Dement Creek Road and 500 feet east of Dement Creek at a point about 4 miles south of Broadbent.

Development: One small discovery cut.

Geology: Manganese oxides occur on weathered surface and fractures of a red, green, and white banded chert. The layers of red chert appear to contain the greater amount of manganese oxides. The chert lens appears from float to be about 150 to 200 feet long. Grab samples of the better looking material assayed about 10 percent Mn.

Production: None

Reference: Department mine file report, unpublished (1950)

FITZGERALD PROSPECT (No. 20)

Location: About 100 yards north of Rock Creek in sec. 26, T. 33 S., R. 12 W.

Development: One 30-foot-deep bulldozer trench.

Geology: The prospect is in a lens of green chert lying in a black shale that strikes N. 10° E. and dips 60° W. The lens is exposed in the cut for a width of 7 feet and length of 30 feet. Manganese and iron oxides have formed to a thickness of about 3 inches on the exposed weathered chert surfaces. A grab sample reportedly assayed 7.25 percent Mn.

Production: None

Reference: Appling (1958, p. 7)

GUERIN PROSPECT (No. 21)

Location: On private land in the center of sec. 22, T. 29 S., R. 12 W., about 3 miles southeast of Myrtle Point along a southwest-trending ridge from about 500 to 900 feet elevation.

Development: One tunnel 130 feet long, caved at portal, a narrow trench above the tunnel about 20 feet long and 10 feet at the deepest end, and many shallow pits along the ridge.

Geology: Superficial manganese oxides occur in a banded multicolored chert. Thin manganiferous bands are interlayered with nonmanganiferous bands. Manganese-stained chert float indicates an area about 230 feet long and 100 feet wide. The chert body appears to strike N. 20° E. and dip nearly vertical. A sample across the face of the cut assayed 10.9 percent Mn and 70.6 percent insoluble.

History: The tunnel, driven sometime in the 1930's to explore the deposit, encountered no ore and the exploration was discontinued.

References: Appling (1958, p. 9)
Department mine file report, unpublished (1941)

LEEP PROSPECT (No. 22) (formerly Iron Mtn. Manganese)

Location: West edge NW¼ sec. 24, T. 33 S., R. 12 W., at about 2,500 feet elevation.

Development: A 50-foot adit completed in 1918 by gold prospectors is now caved; road cuts and two long bulldozer trenches.

Geology: Two low-grade manganese oxide-bearing chert zones in sandstone lying about 500 feet apart strike about N. 20° W. and dip about 65° W. The smaller, eastern zone is about 85 feet long and 25 feet wide. The larger, west zone composed of several chert lenses is exposed for more than 900 feet in length and is about 80 feet wide. The lenses are 5 to 15 feet wide, with manganese-stained chert layers 1 to 4 inches thick. Manganese oxides also occur as fracture fillings in the sandstone and chert. An 85-foot chip sample assayed 1.75 percent Mn and a composite sample representative of a 600-foot bulldozer trench assayed 21 percent Mn and 11.8 percent Fe.

Production: None

References: Appling (1958, p. 9-11)
Oregon Dept. Geol. (1940, p. 42)

McADAMS MINE (No. 23)

Location: NW¼ sec. 20, T. 30 S., R. 14 W., private land on a small tributary of Bethel Creek, at the Coos-Curry County line.

Development: Three bulldozed benches, each about 100 feet long and up to 15 feet deep, were cut across the slope at right angles to the ore zone.

Geology: Massive manganese oxides and rhodonite are associated with chert lenses with occasional basalt knobs and schist lenses in sandstone of the Otter Point Formation. The rhodonite occurs as small pods erratically distributed in the chert lenses. There is evidence of landsliding in the area of the deposit.
A representative sample of float assayed 63.84 percent MnO, 4.97 percent Fe_2O_3, and 14.07 percent SiO_2.

Production: It is reported that 50 to 100 tons of 47 percent ore were shipped during World War I and about 50 tons (mostly float) were shipped during World War II.

References: Appling (1958, p. 12-14)
Department mine file report, unpublished,(1941)

ROOKARD PROSPECT (No. 24)

Location: NE¼ sec. 33, T. 29 S., R. 11 W., on private land.

Development: Not reported, probably road-cut exposures only.

Geology: Minor concentrations of manganese oxides occur in fractures of chert at this locality. Other details are lacking.

Reference: Appling (1958, p. 13)

Mercury

Although no mercury occurrences have been reported in Coos County, a few samples have been submitted to the Department for assay that showed some mercury content. Brooks (1963) reported on the Harmony prospect in sec. 35, T. 32 S., R. 13 W., in Curry County about 2 miles from the Coos County line. This occurrence lies along a northeast-striking and steep northwest-dipping fault contact of Cretaceous Humbug Mountain Conglomerate to the south with Galice Formation slaty shale. Cinnabar occurs as disseminations and pebble-coatings in the conglomerate under the shale hanging wall and has been traced for more than 1,000 feet along the contact. A 5-foot channel sample assayed 3.05 pounds of mercury per ton. Mercury assays from Coos County are as follows:

Assay No.	Location			Date	Description	lbs./ton Hg
	Sec.	Twps.	R. W.	Assayed		
BG-1095	10	32	10	Sept. 1941	Fuller Mine	0.10
EG-50	28	29	11	Sept. 1944	Not described	0.40
P-24107	8	30	14	May 1959	Weathered sandstone	0.15
P-24536	8	26	14	Sept. 1959	Weathered conglomerate	0.3

Nickel

Nickel, like aluminum, is enriched in soils by weathering processes and leaching of more soluable elements such as magnesium from ultramafic rocks (peridotite and serpentinite). These rocks normally contain about 0.2 percent nickel when fresh. Weathered rocks (saprolite) and lateritic soils derived from them may contain about 1 percent nickel. Appling (1955, p. 16) described an occurrence on Iron Mountain, sec. 33, T. 33 S.,R. 12 W., as follows:

> "The west slope of the mountain is steep and apparently has little possibility as a source of laterite. The crest and eastern side are more gently sloping and are occasionally benched. The brief ground reconnaissance indicated a possible deposit on the southeast slope between the road and crest of the ridge in an area 1 mile long and 1/3 mile wide. Assays from various locations in this area are as follows:

Sample No.	Type	Depth in feet From	Depth in feet To	Ni%
NR 1-9	Channel	0	8.0	0.69
NR 1-10	Channel	0	6.0	.28
NR 1-11	Chip	0	14.0	.85
NR 1-13	Channel	0	4.0	.58
NR 1-14	Channel	0	6.0	.61

"Another possible deposit, about 40 or 50 acres in extent, was noted on the road following the crest of the ridge less than 1 mile southwest of a small lake at the north end of the ridge. A three-foot chip sample of representative material assayed 0.62 percent nickel. Northeast of the lake a gently sloping area was noted that appeared rocky, but should be examined in the future. No samples were taken."

More detailed prospecting of Iron Mountain is warranted and could result in finding new nickel reserves. Particular attention should be given areas of more gentle topography such as benches, ridgetops, and slumped areas where soil may be more highly developed. Preliminary sampling is generally done by hand augering. Nickel values generally increase a short distance below the surface and then taper off at greater depth as fresh unweathered rock is encountered.

For more detailed descriptions of other nickel deposits in southwestern Oregon, refer to Hundhausen and others (1954), Hotz and Ramp (1969), and Ramp (1972).

Platinum, Titanium, and Zirconium

Platinum group metals occur in very small amounts in the black sands in coastal terrace, beach, and submarine deposits associated with gold and other heavy minerals. The relative abundance of gold to platinum-group metals in black sands was estimated by Pardee (1934, p. 33) to be about 100 to 1 in samples of high-chromite sands from Port Orford and Cape Blanco in Curry County. The platinum metals appear to increase somewhat with an increase of chromite content in the sand.

The relative abundance of individual metals of the platinum group is apparently not reported for the black sands; but Wells and others (1949, p. 21), in their study of the Kerby area, state:

"Precise analytical data for these metals in the 'platinum' from southwestern Oregon are scanty, but apparently it runs about 30 percent platinum, 32 percent iridium, 25 percent osmium, 13 percent ruthenium, and little or no rhodium or palladium."

Diller (1901, p. 5) reports platinum with iridosmine among the heavy concentrates from the black sands.

Titanium minerals, ilmenite ($FeTiO_3$) and rutile (TiO_2) are also present in the black sands. Ilmenite is a common to abundant mineral in the black sands, and in concentrates it probably increases with a decrease of chromite. Rutile is relatively rare and probably has no economic importance in Oregon coastal sands. Ilmenite may have some potential value as a by-product of chromite mining should it ever be produced from the sands in the future.

Zircon ($ZrSiO_4$) is the most important commercial mineral source of zirconium and a fairly common constituent of the black sands. An unweighted average of 24 samples of black sand from terraces and beaches of Coos County contains about 14 percent chromite, 4.5 percent ilmenite, and 1.4 percent zircon (calculated from Griggs, 1945, p. 124, table 10).

Pardee (1934, p. 39) reported an analysis of gravity concentrates from the Eagle mine as follows:

	Percent
Chromite, containing 50 percent of Cr_2O_3	44.20
Magnetite	18.90
Ilmenite, containing 50 percent of TiO_2	15.00
Zircon, containing 95 percent of $ZrSiO_4$	13.70
	91.80

In addition the concentrate reportedly assayed 0.10 ounce per ton gold and 0.01 ounce per ton platinum.

A small tonnage of zircon concentrates, a by-product of the chromite concentrated from black sands in 1943, was used by the U. S. Bureau of Mines at Albany for metallurgical research (Kauffman and Baber, 1956, p. 12). Kauffman and Holt (1965, p. 21) estimate the total zircon reserves in Coos County to exceed 90,000 short tons.

INDUSTRIAL MINERALS AND ROCKS

by Jerry Gray and Len Ramp

Aggregate*
(Crushed and broken rock, sand and gravel, and sand)

Compared to other parts of the State, Coos County is deficient in both gravel resources and high-quality rock for concrete aggregate. The county is self-sufficient, however, in rock suitable for road fill, base, and surfacing and is rich in sand. Probably more than 1 million tons of aggregate and fill is used annually in Coos County, comprising 680,000 tons of crushed and broken stone and 390,000 tons of sand and gravel.

Coos County sand and gravel deficiency is apparent from its consumption statistics which show that over half of the gravel used as well as small quantities of rock are imported from Douglas County. In some cases the gravel is trucked all the way from Reedsport to Bandon, a distance of 50 miles. The high transportation cost for the imported gravel and the small size of the local resources of sand and gravel has given the competitive edge to stone almost 2 to 1. Sand and gravel and rock can be interchangeable sources for fill and aggregate, but material from a rock quarry usually costs more to produce than from a sand and gravel quarry.

Crushed and broken rock

In 1969 the U. S. Bureau of Mines reported that 309,000 tons of stone was produced in Coos County; however, the Department's Mined Land Reclamation survey in 1973 recorded a total of 680,000 tons. Several of the firms canvassed by the Department had not been reporting production to the U.S. Bureau of Mines.

Eleven of the 17 rock quarries listed in Table 1 and plotted on Plate 4 are in marine basalt. Of the remainder, one is in serpentine, four are in blueschist, and two are in metavolcanic rock. The marine basalt quarries appear to contain good-grade road metal. The material is used for road fill, base, and surfacing. Jetty rock can be obtained from the marine basalts by saving and stockpiling those boulders and larger unfractured blocks that qualify. Probably more jetty rock could be produced from the quarries if the blasting and other mining techniques were slanted toward jetty-rock production. The rock is not utilized to a great extent as an aggregate for asphalt or cement concrete on Federal road construction sites. One operator stated that Federal specifications are so high he and other operators do not try to bid Federal jobs.

Material from the one serpentine quarry (pit number 15) can be used for road metal if the quarry-run fines are screened out and only the over-size saved for crushing. An operator of this quarry stated that 10 to 40 percent of quarry-run material could be lost as fines.

The blueschist deposit on Baker Creek (No. 16) was used to produce 100,000 tons of jetty rock in 1962-63 for the Coos Bay south jetty.

A great number of small sandstone quarries exist in the northeast part of the county. The sandstone was used mainly for fill material for adjacent road construction. Most of these quarries have been abandoned because aggregate for road surfacing and maintenance must meet higher specifications today than in the past. For these uses and in this part of Coos County some crushed rock is imported from Douglas County.

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*Sand and gravel is treated as a single commodity because both sand- and gravel-size fractions usually occur in the same deposit. Although Coos County has sand deposits that contain no gravel-size fractions, production from these deposits is included in the sand and gravel total.

Table 1. Crushed rock, sand and gravel, and sand operations in Coos County

CRUSHED ROCK	Type of Deposit
1. Coos Bay Timber operators	marine basalt
2. Coos County Highway Dept.	marine basalt
3. Johnson Rock Products	marine basalt
4. Coos Bay Timber operators	marine basalt
5. R. E. Baker	marine basalt
6. Coos County Highway Dept.	marine basalt
7. Coos Bay Timber operators	marine basalt
8. Coos County Highway Dept.	marine basalt
9. G. W. Woodward, Inc.	marine basalt
10. Coos County Highway Dept. and Parkerson	marine basalt
11. Oregon Highway Dept.	marine basalt
12. Martin Kincheloe	blueschist
13. Oregon Highway Dept.	blueschist
14. Unknown (Birdwell owner)	blueschist
15. F. Gross	serpentine
16. Peter Kiewit Sons Co. (BLM owner)	blueschist
17. Bureau of Public Roads Nos. 1 and 2	metavolcanics
SAND AND GRAVEL	
1. Harold Gates	marine terrace
2. Oregon Highway Dept.	marine terrace
3. Bullards Sand & Gravel, Inc.	marine terrace
4. Coos County Highway Dept.	marine terrace
5. G. W. Woodward, Inc.	marine terrace
6. Robertson's Inc.	stream bar
7. Benham Concrete, Inc.	stream bar
8. Coos County Highway Dept.	stream bar
9. Merchen and Reed Gravel Co.	stream bar
10. Oregon Highway Dept.	stream bar
11. Merchen & Reed Gravel Co.	stream bar
12. Merchen & Reed Gravel Co.	stream bar
13. Merchen & Reed Gravel Co.	stream bar
SAND	
14. Coos Sand Corp.	
15. John Backhoe Service	

Basalt of road metal grade may be covered by 10 to 40 feet of overburden; if it were in the Willamette Valley it would usually find a ready market as a fill material, but the overburden in Coos County does not have an equivalent market value because of the availability of fill sand. Consequently the operator must pay both to remove it and to dispose of it. Because of the capital that must be invested to strip overburden, the operator tries to get maximum output for the amount of area stripped, which results in steep-walled pits. The Federal Metal and Nonmetallic Mine Safety Law now prohibits the bench height that results from this type of mining system, and the State Mined Land Reclamation Law will probably also restrict bench height, not for the miner's safety as much as for the public's safety. Because of these new restrictions, two of Coos County quarries may already have been abandoned.

The outlook for substantial increases in rock supply for Coos County is not good. The limited areal distribution of the marine basalts, the deep overburden, the Federal and State regulations which will add to the costs and the selling price of imported gravel will tend to impose a ceiling on the amount of rock produced in Coos County. However, that ceiling can be raised by higher prices. For the near future, prices should hold steady; but for the long term, prices can only rise.

Sand and Gravel

A major portion of the 390,000 tons of gravel used in Coos County is imported from Reedsport, Douglas County. Of the gravel extracted there from the bed of the Umpqua River an estimated 250,000 tons has been trucked into Coos County to as far south as Bandon. The U. S. Bureau of Mines reported that 140,000 tons of sand and gravel was produced from Coos County during 1969. This figure checks closely with that obtained by the Department during a Mined Land Reclamation inventory in 1973.

Sand and gravel in Coos County is mined from two types of deposits: from the bed of the Coquille River and its tributaries and from a marine terrace near Bandon. The South Fork Coquille River and its tributaries drain a few rock types which form hard durable gravels. Other rivers in Coos County cross mainly sandstones which normally do not form good gravels. Most of the sand and gravel produced from the Coquille River is from bars located between Myrtle Point and Powers. This sand and gravel is cropped from the bars annually during low water and the stockpiled material is then drawn upon for the rest of the year.

The sand and gravel deposit on the marine terrace near Bandon is 18 to 20 feet thick and is covered with 10 to 20 feet of sand overburden. The largest gravel found in the terrace deposits is a minus 2 inch and most is a minus 1/2 inch. Because of its mean small size, the gravel has limited utilization, and its use is further restricted by aggregate (asphalt or cement) specifications which call for faced gravel. To get faced gravel the gravel must be crushed in such a way that the fragments have two fracture faces. The 10 to 20 feet of sand overburden must also be marketed for the total deposit to be economical. Since the market area is largely covered by minable sand resources, the availability and marketability of the gravel may be restricted more by the lack of a market for fill-sand than by the small size of the gravel.

The outlook for county production of sand and gravel to keep pace with the population growth of Coos County does not appear possible because of the limited resources; probably as the county's needs grow, imports will increase. County production may reach 200,000 tons per year, but that would seem to be a maximum.

Sand

Many sand pits exist or have existed in Coos County coastal area. The pits range from very small to very large; however, they all tend to be temporary. Sand mining requires little capital equipment. The mining can and does take place in the middle of the urban areas. In many cases the object of the mining is to use the final pit site for an urban development such as a shopping center. The mined sand is in turn used for a fill which may also be used for an urban development. Only two sand pits are plotted on Plate 4. Most sand production goes unreported since the operators consider the activity more construction excavation than mining;however, that reported is included in the county's total sand and gravel production.

Sand from pit number 14 (Plate 4) is mined as a silica sand and is used for industrial purposes such as foundary sand and air-blast abrasive. Pit number 15 fronts on a highway and has nearly reached the size projected for use in urban development. The floor has been mined to about highway level, and the back and side walls have been trimmed to allow for construction.

Coos County is not in danger of runing out of sand; what will happen is that as the urban area develops mining will be forced to move with the outward growth of the suburbs. As the pressure for stronger planning grows, so will the restrictions increase on sand removal. In turn these restrictions will cause higher prices for the sand as a fill material.

Beneficiation studies were conducted on Oregon coastal dune sands for use as silica glass sand by the U. S. Bureau of Mines (Carter and others, 1964). They obtained a high-alumina product suitable for blending with low-alumina sand for various types of glass and as an alumina source for amber, flat, and colorless container glass. Dune sand deposits between the Umpqua River and Coos Bay were found to be larger, contain fewer impurities, and are more susceptible to simple beneficiation than other sands investigated.

Asbestos, Talc, and Soapstone

Asbestos is an important industrial mineral with more than 2,000 uses. All uses call for processed fiber and most are based on its high strength-to-weight ratio and resistance to high temperatures. The two principal types of asbestos are chrysotile and amphibole.

Because of its superior strength and flexibility, chrysotile is the more important variety. It generally occurs as cross-fiber veinlets in blocky serpentinite, but it may also occur as matted or slip fibers in highly sheared serpentinite.

The more common variety of amphibole asbestos is tremolite. Tremolite is generally less flexible than chrysotile and lacks strength. It often has the appearance of light-colored rotten wood fibers. Tremolite occurs mainly in serpentinite and is most likely to be found in zones of shearing associated with talc.

Talc is a soft, hydrous magnesium silicate mineral, and soapstone is a commercial term for massive impure talcose rock. Pulverized talc is used as a filler in various items, for ceramics, cosmetics, and pharmaceuticals; block talc is used for insulators, marking pencils, and sculpture.

There are no reported occurrences of asbestos or talc in Coos County; but there are a large number of exposures of serpentinite and zones of intense shearing which represent potential areas to prospect for these minerals.

Building Stone

A few rock types in Coos County are suitable for use as building stone, but to date very little use has been made of this native material. The following are believed to be suitable for use in some types of building.

Blueschist

This rock is a tough, compact, and heavy glaucophane-bearing schist that occurs in small bodies at various locations in the county associated with the Otter Point Formation. It has been quarried at a location at the head of Baker Creek, near the north edge of sec. 17, T. 31 S., R. 12 W., and used for jetty rock. Another quarry (No. 12, Plate 4) located east of Bridge on the south side of the Middle Fork Coquille River in sec. 36, T. 29 S., R. 11 W., provides this type of rock for road aggregate. The old abandoned quarry at Tupper Rock in Bandon produced blueschist that was used mainly for jetty blocks with minor amounts being adapted to landscaping and rubble stone work. Diller (1901) stated:

> "Tupper Rock, at Bandon, is a prominent ledge which once reached nearly 100 feet above the general level of the plain on which the upper part of Bandon is located. It was an

> attractive feature, affording a fine outlook along the coast, but now it has been largely blasted away and removed to build the jetties at the mouth of the Coquille. Although the loss of this prominent ledge is to be greatly deplored, no better rock for the jetties could be found."

Sandstone

Massive and layered sandstone in the Tyee Formation and selected sandstone layers in the Umpqua and Coaledo Formations may be usable as building stone but no formal testing for suitability has been conducted. Sandstone of the Tyee Formation has been taken in the past from a quarry on the Millicoma River in the NW$\frac{1}{4}$ sec. 18, T. 25 S., R. 11 W. Diller (1901) reported:

> "On the forks of Coos River quarries have been opened to obtain stones for making the jetties at the mouth of the bay. The rock is a micaceous sandstone, and when fresh is bluish in color, but weathers yellowish owing to the oxidation of its contained iron. No buildings have been made of this stone so far as known. From one of the quarries on the North Fork of Coos River much stone has been taken for the jetties, although it is far less durable material than is desired for such purpose. The beds are thick, but easily quarried, and very conveniently located for transportation on the river. A large amount of such stone may be obtained in that locality.
>
> "On the Coquille the sandstone of the Pulaski formation is not quarried, but some years ago one of the sandstones in the Coaledo formation 2 miles southwest of Riverton was quarried for building the Light House at Bandon. The stone has not proved to be sufficiently durable."

Basalt

Basalt largely of the submarine pillow variety, is present in fairly large, intermittent exposures extending in a northerly line from the vicinity of Bridge to the drainage of Kentuck Slough. A number of quarries have been established in the more convenient sites for use as road rock, riprap, fill, and a minor source of jetty stone. Select chunks derived from quarrying basalt for other purposes could be utilized for building stone.

Clay

Very little research has been conducted on clays of Coos County, but limited observations appear to indicate fairly abundant supply. Both alluvial clay deposits and residual deposits in areas of deeply weathered sedimentary rocks are present in many parts of the county.

Allen and Mason (1949) analyzed a single sample from Coos County near Coquille. The results showed a buff to reddish-buff firing clay with moderate shrinkage. Diller (1901) reported that clay was more or less abundant at many points in the alluvium of the area and that it was being used in manufacture of brick and tile at Myrtle Point.

Information from Department files includes brief notes to the effect that possibly the first brick plant in Coos County was located at Norway in sec. 32, T. 28 S., R. 12 W., and that the Coos Bay Brick and Clay manufacturing company was operating in Marshfield in 1930. Additional information has not been obtained.

Garnet

Some garnet occurs in the coastal black sand deposits and any mining and processing of the sands for other products, such as chromite, ilmenite, zircon, gold, etc., could also obtain a by-product of garnet sand suitable for abrasives. The small grain-size would, however, be a limiting factor in the usefulness of this product. Griggs (1945, p. 122) identified the varieties almandite and spessartite in black sand concentrates from the terrace area north of the Coquille River. Calculated abundance of garnet minerals in these black sands will average about 23 percent by weight. Twenhofel (1943, p. 4) reports that "garnet is extremely abundant in some beds and places."

Some impure garnet-bearing black sand concentrates have been marketed for sand blasting purposes but accurate records of this production have not been obtained.

Gem Stones

Semi-precious gem stones including agates, jasper, and petrified wood can be found from time to time along the beaches of Coos County. Collecting, shaping, and polishing these stones is a fascinating hobby of many persons in the area and sale of jewelry and ornamental stones is a small but growing business. The principal source of varicolored jaspers is the banded chert of the Dothan-Otter Point Formation. Petrified woods including agatized myrtle wood found on the beaches were probably formed by burial in porous Tertiary sandstones where they gradually became impregnated by silica. Some grossularite suitable for polishing may be derived from rodingite dikes found in serpentinites. Another mineral often gathered for polishing is rhodonite. It is associated with some of the manganese-rich cherts and underlies some of the surface deposits of manganese oxides (see manganese chapter).

Hobbyists have organized the Coos County Mineral and Gem Club of North Bend and the Coquille Valley Gem and Mineral Club of Coquille.

Limestone

Coos County has only one reported limestone occurrence. It is the Morgan Limestone located in the NE$\frac{1}{4}$ sec. 35, T. 25 S., R. 12 W., on the hillside west of the south fork of Coos River, 250 feet above the highway. The Oregon Dept. of Geology and Mineral Industries (1940, p. 32-33) reports a small deposit of impure limestone which assays between 76 and 79 percent $CaCO_3$, about 10 percent SiO_2, 5 to 7 percent iron and aluminum oxides, and 2 to 4 percent $MgCO_3$. Limited excavation indicated that the deposit is quite small; estimated reserves are 80,000 tons (Hodge, 1938). The deposit is reported to be 10 to 25 feet wide and traceable along the strike (N. 65 to 70° E.) for about 750 feet. A small amount of this rock has reportedly been used locally for mortar.

MINERAL FUELS

by V. C. Newton, Jr., and R. S. Moson

Oil and Gas Possibilities

Drilling history

The first oil and gas drilling in Coos County was done by the West Shore Oil Company in 1919 near the town of Bandon (Table 2). No production was found in this well or the 10 wildcat holes drilled over the following 40 years in Coos County. Coast Oil Company reportedly encountered strong gas shows in two of its holes drilled 2½ miles southwest of Coquille along Fat Elk Creek. Reported attempts to finance a commercial gas system from the well apparently failed. A hole drilled near Bandon by Pacific Petroleum Company in 1941 found enough gas to fire the engine boiler (see gas analysis in Table 3).

Petroleum resources became a national defense item during World War II so major oil companies began exploring in non-productive regions of the United States that had favorable geology. Phillips Petroleum Company put down a deep hole south of Coos Bay during this period of activity but were discouraged when submarine basalt was hit at 2,300 feet. The electric log indicated the presence of a 10-foot gas sand at 1,040 feet but it was not tested by Phillips. E. M. Warren & Associates drilled a deep wildcat 3½ miles southwest from the Phillips hole in 1963 (Figure 19). The hole was in Coaledo Formation from top to bottom, 6,337 feet (W. W. Rau, written communication, 1971). Several gas and oil shows were found in the Warren hole but sediments were too fine grained to produce commercial amounts of petroleum.

The State Land Board leased two of 18 submerged-lands tracts offered at a bidding sale in December 1964. Shell Oil Company and Standard Oil Company of California each acquired a tract at this lease-sale. The 3- by 3-mile tracts were located just south of Florence. A month earlier Federal Shelf lands along the northwest coast were leased to 11 oil companies. However, only one small lease block was offered off the southwest coast by the U. S. Bureau of Land Management in its lease-sale. This area,

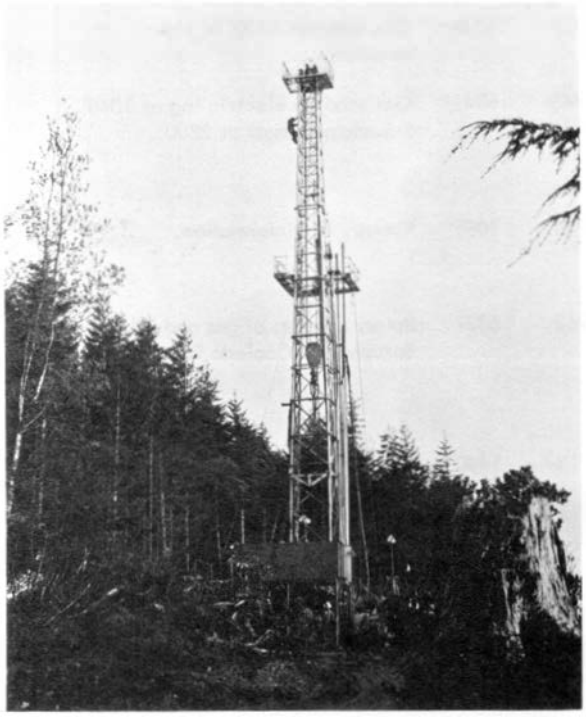

Figure 19. Warren and Associates oil test hole drilled near Beaver Hill in 1963 penetrated 6,337 feet of Coaledo Formation. Gas shows and numerous coal seams were found in the interval 3,000-4,800 feet. Oil fluorescence was obtained from drill samples at 4,860 feet and at 5,230 feet.

Table 2. Holes drilled for oil and gas in Coos County

Company	Well Name	Location	Date	Depth Drilled	Remarks
Coast Oil Co. (deepened by Fat Elk Oil Co.)	Well No. 1	Coquille area NE¼SE¼ sec.10, T.28S., 13 W.	1929-1934	2526'	Cable tools. A thin oil-bearing sand reported at 1585' and gassy salt water at 1745'.
Coast Oil Co.	Well No. 2	Coquille area NE¼SW¼ sec.10, T.28S., 13 W.	1939	2255'	Cable tools. A good gas flow reported at 1170'.
Coast Oil Co.	Well No. 3	Coquille area SW¼SE¼ sec. 10, T.28S., 13 W.	1939	1640'	Cable tools. Reported to be a small gas well.
Coast Oil Co.	Well No. 4	Coquille area SW¼SE¼ sec. 10, T. 28S., 13 W.	1939	1640'	Cable tools. Hit flowing salt water.
Coast Oil Co.	Rhoades-Menasha No. 1	Westport Arch NE¼SE¼ sec. 32, T.26S., 13 W.	1938	1365'	Cable tools. Reported shows of gas and numerous coal layers.
Libby Mine area	Pitch Coal occurrence	Westport Arch Approx.sec. 3 or 4, T.26S., 13 W.	1920	--	Pitch coal found in fractures of coal. This is a form of asphalt.
Oregon Coastal Corp.	J.Coy No. 1	Bandon area NW¼ sec. 4, T.29S., 14W. 330' S.of N.line & 330' E.of W. line	1953	1894'	Rotary. No oil or gas shows reported.
Pacific Petrol Co. (J.B.Ewell)	Morrison No. 1	Bandon area S½NW¼ sec. 28, T.28S., 14 W.	1936-1937	2282'	Claimed enough gas was encountered to fire the boiler.
Pan American Petroleum Corp.	OCS P-0112	Bandon area Tract 102	1967	6146'	Gas show at 5400' in tight sandstone.
Phillips Petrol.Co.	Dobbyns No. 1	Coos Bay area SW¼ sec.28, T.26S., 13 W. 330'S.&330' E.from W¼ cor.	1943-1944	6941'	Gas sand on electric log at 1040'. Submarine basalt at 2300'.
Sunset Oil Co. (J.B.Ewell)	Bandon	Bandon area Sec.4, T.29S., 14 W.	1944	1089'	Rotary. No information.
Warren, E.M.	Coos County No. 1-7	Coquille area SE¼sec.7, T.27S., 13 W. 450'N. of S. line &2200' W. of E. line	1963	6337'	Rotary. Traces of gas and oil. Bottomed in Coaledo Formation.
West Shore Oil Co.	?	Bandon area NW¼ sec. 23, T.30 S., 14W.	1913-1919	1400'+	No information.

Table 3 - Gas analyses from wells in Coos County

Company	Well	Location	Methane	Ethane	Heavy Fract.	Nitrogen	Carbon Dioxide	Hydrogen	Oxygen
Pacific Power & Light Co.	Water Well	SE¼ sec. 15, T.25S.,R.13W.	97.2%	0.2%	0.2%	2.4%	----	----	----
Pacific Petroleum Co.	Morrison #1	NW¼ sec. 28, T.28S.,R.14W.	99.4%	0.5%	0.1%	----	0.0%	----	----
Pacific Petroleum Co.	Morrison #1	Same	94.9%	0.4%	0.2%	4.3%	----	----	0.2%

referred to as the "Bandon Block", included 11 tracts; only four tracts were leased. Pan American Petroleum and its partners drilled Bandon Tract 102 in 1967, located about 10 miles off the coast northwest of Bandon. The well reached a depth of 6,146 feet and bottomed in the Tyee Formation. A good gas show was encountered at 5,400 feet in a 60-foot sandstone but the zone was too tight to yield commercial amounts.

Approximately 1,100 square miles of shelf lands offshore from Coos County remain to be explored for oil and gas. Prospects are still considered to be very good in this area. Most of the shelf off Coos County was not offered for lease in the 1964 Federal lease-sale because it was withdrawn by the U.S. Navy for national defense purposes in 1964. This strip of shelf land remains as one of the best prospects for petroleum exploration in western Oregon.

Geologic conditions

Coos Basin is a relatively small structural feature measuring 11 miles in width by 25 miles in length, covering an area of 275 square miles. Post-early-Eocene rocks within the basin have been subjected to much more deformation than similar strata elsewhere in the county. It has been suggested earlier in this report that structures in the Coos Basin are related to a zone of weakness in underlying crustal rocks. In the central portion of Coos Basin, Tertiary sedimentary formations probably have a thickness of at least 10,000 feet. More intensely deformed pre-Tertiary sedimentary rocks extend to an estimated depth of 15,000 or 20,000 feet. The three main periods of deformation in southwestern Oregon occurred near the end of Jurassic time, at the close of early Eocene time, and in late Oligocene time. Rocks, therefore, become progressively more deformed the lower in the stratigraphic section they occur.

Southwestern Oregon was involved in successive emergences beginning late in Oligocene time until the present. Much of the sedimentary rock has been eroded off the margin of the Klamath highlands leaving only remnants in structurally low areas. Late Tertiary rocks have been preserved in the central portion of the Coos synclinorium and only in this area are these formations prospective for oil and gas.

Seas that encroached upon the continent in late Mesozoic and for much of Cenozoic time washed against a northeasterly trending shore. The area which now is occupied by the Coos Basin was a part of the bordering ocean shelf during these geologic eras. Consequently, sedimentary rocks in this region consist of coarse delta-plain types exibiting channeling, cross-bedding and rhythmite sequences (Dott, 1966). Within the delta-type deposits are numerous coal strata and abundant organic debris which may be residual products of hydrocarbon generation. Nearly 50,000 feet of sediments derived from the Klamath highland at the south end of the basin and from the ancestral Cascades to the east were deposited on the ocean floor.

Ancient deltas are well known for their association with petroleum accumulations. Rapid deposition of sediments, reducing conditions, and abundant organic debris provide an excellent environment for synthesis of hydrocarbons. Cretaceous Athabasca sands of delta origin in northern Alberta hold an estimated 700 billion barrels of heavy oil (Carrigy, 1971). Delta deposits ranging in age from Pennsylvanian to Pliocene in the United States contain millions of barrels of oil. Coos Basin, however, is quite small volumetrically compared to many of the large delta fields.

Conditions favoring entrapment of hydrocarbons in the delta environment require periods of marine transgression to provide enclosing deep-water shale deposits over-capping coarse hydrocarbon-bearing sediments. Extensive shale bodies of this type are not known to exist in Coos County. Confining beds in southwestern Oregon are limited to thin siltstone and shale beds laid down during short-term marine encroachments. Significant periods of deep water onlap apparently did not take place in this area. Shale members are found in the Bastendorff, Coaledo, Tyee, Flournoy, Lookingglass, and Galice Formations. Thicker, more massive shale deposits probably occur on the present continental shelf bordering Coos County.

Specific prospects

Several unconformity prospects have been described in southwestern Oregon. However, unconformity traps in rocks older than middle Eocene are not good prospects because of the intensity of deformation involving rocks of this age. Where coarse sediments are overlain by impervious shales, unconformities are very good prospects for accumulations of petroleum. Such possibilities in Coos County appear to be at contacts between Miocene and Oligocene rocks and at the less pronounced unconformities within the middle Eocene rocks.

Drilling for unconformity traps in the middle Eocene rocks would probably be best located in the northern half of the county. Testing of the Miocene-Oligocene contact is limited to the central basin where the younger rocks exist.

Traps formed by lenticularity of coarse sediments within impervious shale sections are a very limited possibility in Coos Basin because of the scarcity of shale strata. This type of stratigraphic closure may be present in the northwestern part of the basin and most probably exists offshore from Coos County.

Structural traps may be present in Coos Basin where there are anticlinal structures with updip closure. The arch between South Slough and Isthmus Slough appears to have fault closure updip. Middle Coaledo is exposed at the crest of this structure. Phillips Petroleum Company drilled at the south end of the fold and hit submarine basalt at 2,300 feet. This discouraged further exploration of the structure for the next 20 years. A 10-foot gas sand was indicated on the electric log at 1,040 feet but Phillips did not test the zone. In 1963, Warren and Associates, San Antonio, Texas, drilled another wildcat on this structure, $3\frac{1}{2}$ miles south of the Phillips well. Warren's well was located between two faults which cut transversely across the fold crest. The hole was in the Coaledo Formation from ground level to 6,337 feet (W. W. Rau, written communication, 1971). Several shows of gas and oil were obtained during the drilling but the rocks were too impermeable to produce oil or gas. Several other drilling locations may be found on the northern half of this anticline but they would be down structure from the two holes already drilled. However, closure southward may be formed by a permeability barrier.

A narrow anticline is shown by geologic mapping between Isthmus Slough and Catching Slough. Upper Coaledo is exposed in the crest of this fold so that more section is available here than in the anticline to the west. No drilling has been done to date on this structure. Fault closure is shown up dip to the south and closure is also indicated in this direction by a gentle plunge of the fold axis. The prospective structure extends for a distance of at least 7 miles and has a width of 1 or 2 miles.

Thrusting and deformation of the Roseburg Formation into isoclinal folds discourages the search for oil and gas trapped structurally in rocks of this age or older in Coos County. Prospecting for hydrocarbons in rocks of middle and lower Eocene age in this region could best be done in the eastern half of the county where the younger units have been removed by erosion. Folds cut by large northeast-trending faults offer closure and the upthrown or overthrust side of the fault is the best location to drill the first test holes. (Levorsen, 1954, p. 71). Sands in the Flournoy and Lookingglass Formations can be explored at the east county location as well as at the main lower Eocene unconformity. Depths for reaching these objectives should not be more than 10,000 feet.

A 15,000-foot test hole is needed in the north portion of Coos Basin to define stratigraphic conditions in the region. Such a hole would cost as much as $500,000 but a great deal could be learned from it. Group participation would cut costs for any one company. Results could be very helpful in bidding on future parcels within the approximate 1,000 square miles of unexplored shelf lands offshore from Coos County.

Coal

The history of coal production in Coos County extends back to 1854 when coal was discovered near Empire. Production increased rapidly with many fluctuations, until 1904 when 111,540 tons were mined. The discovery of oil and gas in California in 1898 signalled the eventual downturn in the use of Coos coals and production slumped steadily after 1905, approaching the vanishing point following World War II. Figure 20 shows graphically the production history of the district. Figure 21 shows the operating periods for 36 of the principal mines.

Considerable quantities of coal were shipped to the San Francisco Bay area around the turn of the century. Sailing vessels pushed far up the various sloughs feeding into Coos Bay and often were able to load almost directly from the mine tipples. Southern Pacific locomotives used large quantities of the local coals until the diesel replaced steam. The Beaver Hill mine (Figure 22), owned and operated by Southern Pacific, was driven to a depth of 1,400 feet below sea level and extended more than 3,000 feet down the dip of the coal seam.

Most of the mines had good sandstone roofs, were reasonably dry, and only a few were gassy. Characteristically, the coal pitched from a few degrees to 45 degrees or more. Minor faulting, or "jumps" as the Bay miners referred to them, rarely proved to be more than a slight inconvenience. The lower workings of the Beaver Hill mine were plagued with heaving floors.

Despite the removal of an estimated 3,000,000 tons of coal from the mines over a 90-year span, few if any traces of the operations remain today (Figure 23). Heavy rainfall and equally dense vegetative cover have combined to effectively obscure the portals and spoil banks.

Estimates of reserves in the Coos Bay field vary widely due to various methods and criteria applied. A total of 3,700,000 tons of inferred coal was estimated by Allen and Baldwin (1944) following a mapping, sampling, and drilling program conducted by the State Department of Geology and Mineral Industries in cooperation with Coos County. This figure represents only the reserves determined as a result of work performed in four project areas. In 1953 the State Department of Geology and Mineral Industries made a further inventory of the Coos Bay field, using available data, but doing no additional field work. The Department calculated a total of 51.36 million tons of minable coal. Coal lying east of the Bay was excluded from this study and various fringe areas were also eliminated. Other estimates of reserves have been made over the years and are summarized in Mason and Erwin (1955). Despite the wide differences in the estimates of the reserves it is apparent that a large amount of minable coal remains in the Coos Bay field.

The quality of the Coos coals is remarkably similar throughout the field. Typically the coals contain 17 percent moisture, 8 percent ash, less than 1 percent sulfur, an ash softening temperature of 2,200°F., and a heating value of 9,700 B.t.u. per pound on an as-received basis. Additional information on the analysis of coals from the various mines in the Coos Bay field has been published in Allen and Baldwin (1944).

The various coal seams of the Coos Bay field underlie lands owned in part by private interests and also by city, county, state, and federal governments. The ownership of the coal is vested principally in the surface owner but access to the coals might in some cases be difficult due to severed surface rights, county zoning, and environmental considerations. Very little Coos coal has been mined in the past 25 years, but the steadily increasing demand for energy both locally and nationally would indicate that this resource may be needed in the future. In anticipation of this, long range plans should be made for economical utilization of this resource based on nature and extent of reserves, the regional geology, hydrology, urban development, and the environmental requirements for the future of the area.

The coals situated in the Eden Ridge area of southeastern Coos County are separate and distinct from the Coos coals discussed above. Here the coal seams are characterized by relatively flat dips, larger fault displacements, generally thicker seams, and somewhat higher calorific value. The remote nature of the Eden Ridge area has so far precluded any exploitation. In 1956 Pacific Power & Light Company began an intensive exploration program at Eden Ridge. The company announced plans for a combined fossil fuel fired steam plant for base load power and a high head hydro plant for peaking periods. Reserves of 50,000,000 tons or more are indicated.

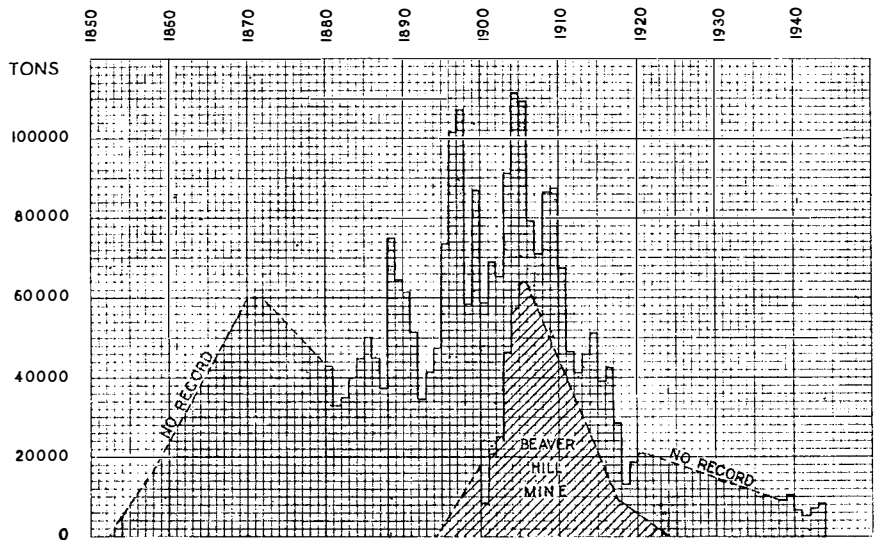

Figure 20. Annual production of Coos Bay coal, 1854–1943.

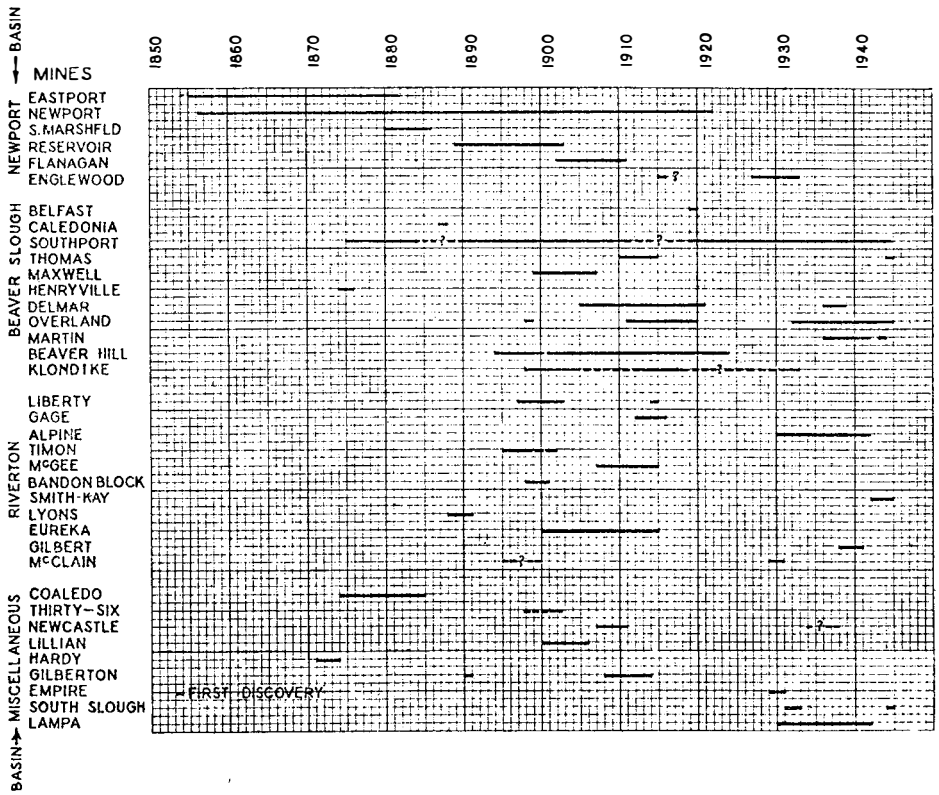

Figure 21. Period of operation of mines in the Coos Bay coal field.

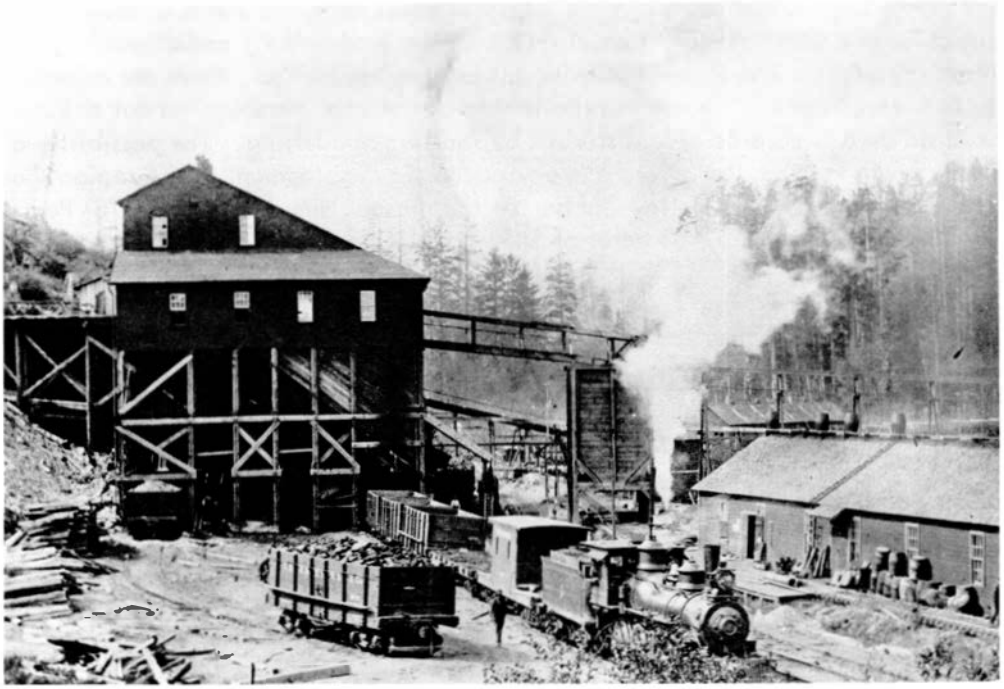

Figure 22. Beaver Hill coal mine about 1895. It was located in center of sec. 17, T. 27 S., R. 13 W., Coos County. (Jack's Photo Service, Coos Bay)

Figure 23. Libby (Newport) mine about 1905. Few traces are left of this enterprise in secs. 3 and 4, T. 26 S., R. 13 W. (Jack's Photo Service, Coos Bay)

Studies of the Eden Ridge coals and the adjacent coals in Squaw Basin have been made by Lesher (1914), Campbell and Clark (1916), Daniels (1920), Wayland (1964), and others.

Although Eden Ridge and Squaw Basin lie adjacent to each other, there are substantial geologic differences between them and the exact relationship of the coal members has not as yet been determined. The Squaw Basin area is considerably disturbed by faulting and tilting. The possibility of rather large reserves in the basin is good, however, and any economic development of the region should consider both the Eden Ridge and Squaw Valley Coals. At the present time (February 1973) Pacific Power & Light Company holds coal leases on 5,403 acres of Siskiyou National Forest land.

Table 4. Tonnage estimates, Coos Bay coal field (for Oregon Development Commission)

Area		Acreage	Average Thickness	Tonnage	Dip of bed
Englewood, stripping		27	5'	200,000[1] (100%)	2-5°
Southport	Block #1	390	5'	1,989,000 (60%)	7-17°
	Stripping	18	5'	153,000[2] (100%)	7-17°
Thomas	Block #1	510	6'	3,121,200 (60%)	17°
	Stripping	2	6'	20,000 (100%)	17°
Maxwell		270	5'	1,377,000 (60%)	25°
Delmar		1,730	5'	8,823,000 (60%)	10-24°
Beaver Hill		11,420	5' and 6'	64,851,000 (60%) 32,426,000 (30%) *	26°
Riverton	Block #1	206	3'	630,000 (60%)	15°
	Stripping	8	4'	50,000[3] (100%)	6°
South Slough		506	5'	2,580,000 (60%)	16-25° (1/3) Over 25° (2/3)
Total estimated minable		15,087	5'	51,369,000	- - -

1 Stripping ratio 10:1
2 " " 8:1
3 " " 4.4:1

* This figure used to obtain total estimated tonnage because large factor of safety required.

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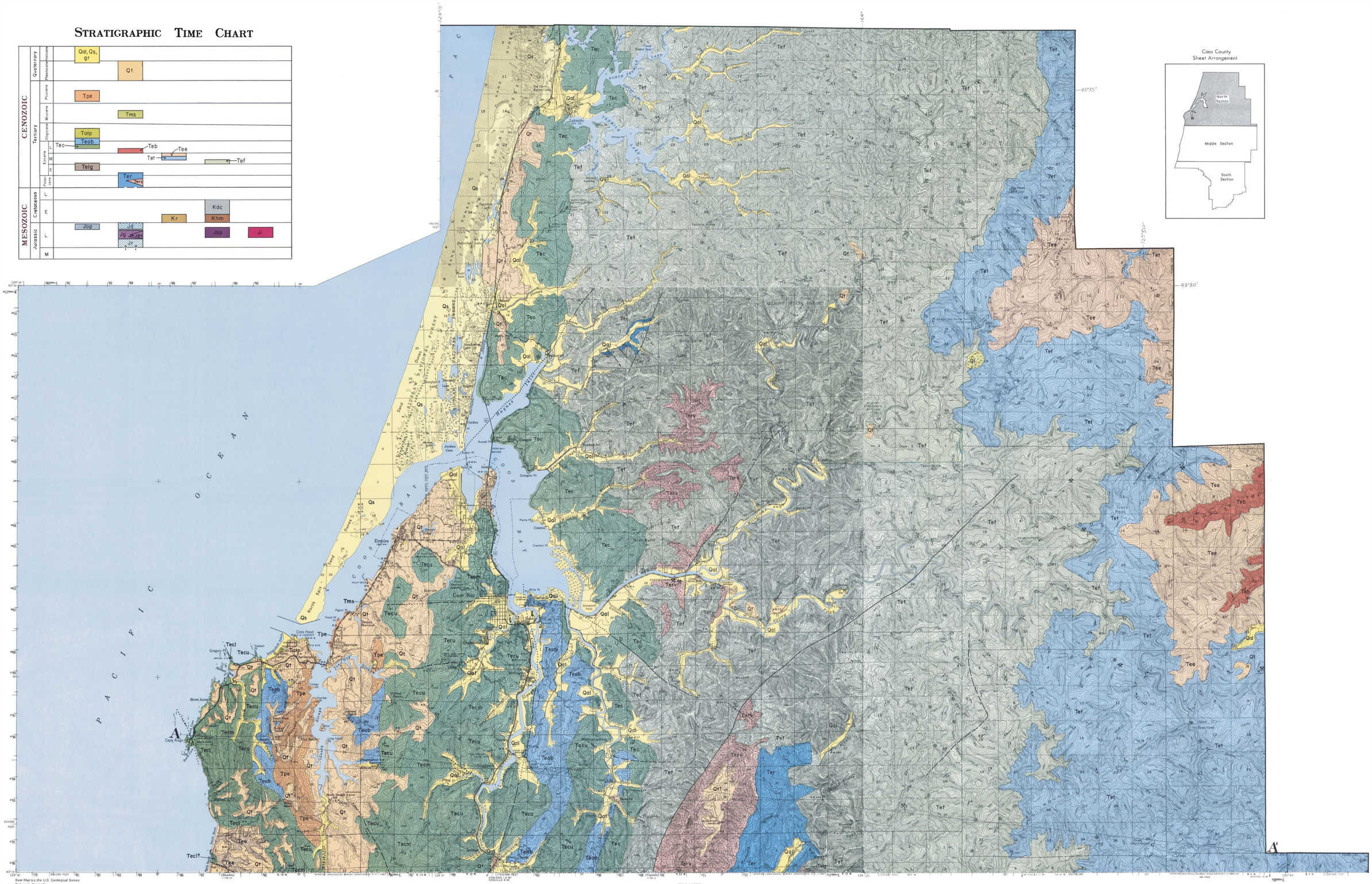
Geologic Map of Coos County, Oregon

Map prepared by
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST

Stratigraphic Time Chart



Coos County
Sheet Arrangement

Base Map by the U.S. Geological Survey
Polyconic Projection
1927 North American Datum

SCALE 1:62500

CONTOUR INTERVAL 50 FEET WEST AND
80 FEET EAST OF 124°00'

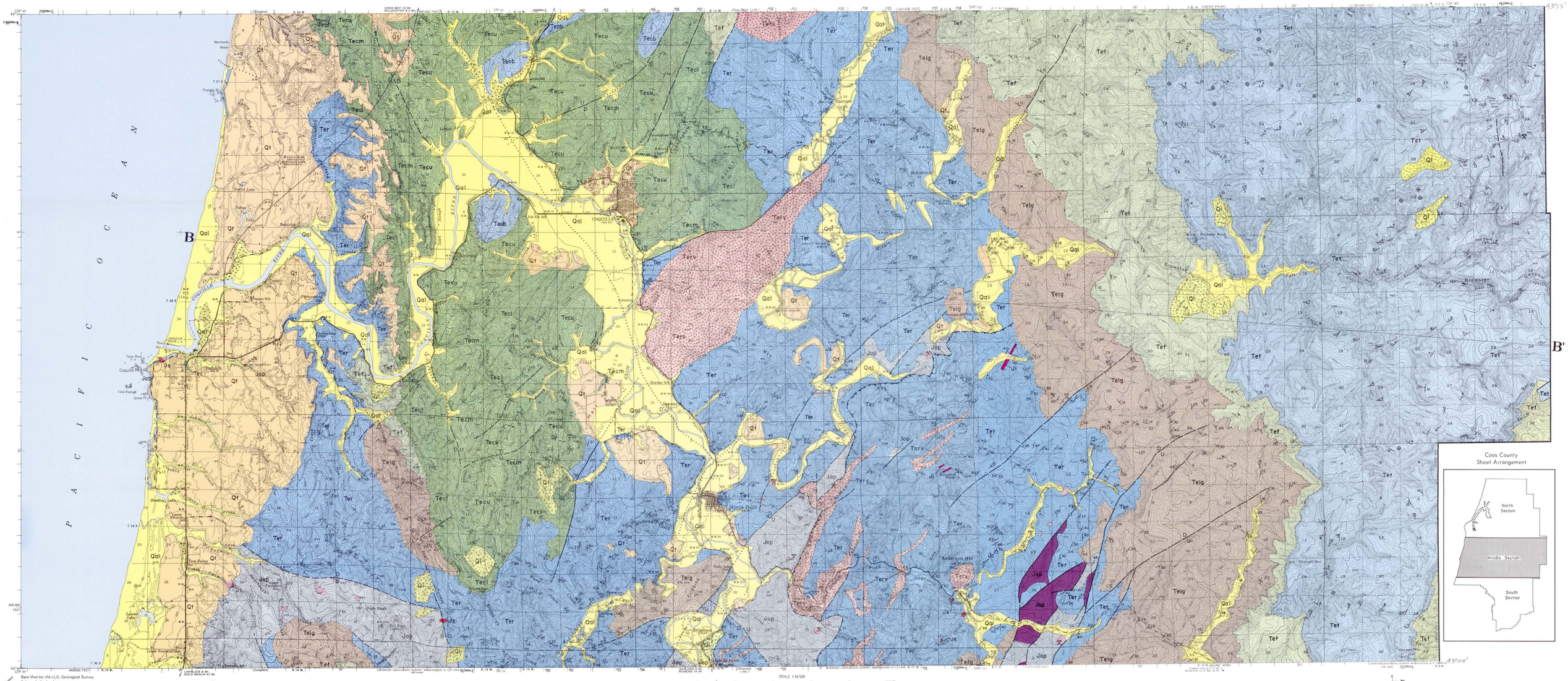
Geology by E. M. Baldwin

Cartography by S. R. Renoud and M. E. Lawson
1973

North Section

GEOLOGIC MAP OF THE MIDDLE SECTION OF COOS COUNTY, OREGON

Map prepared by
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES



Base Map by the U.S. Geological Survey
Polyconic Projection
1927 North American Datum

SCALE 1:62500

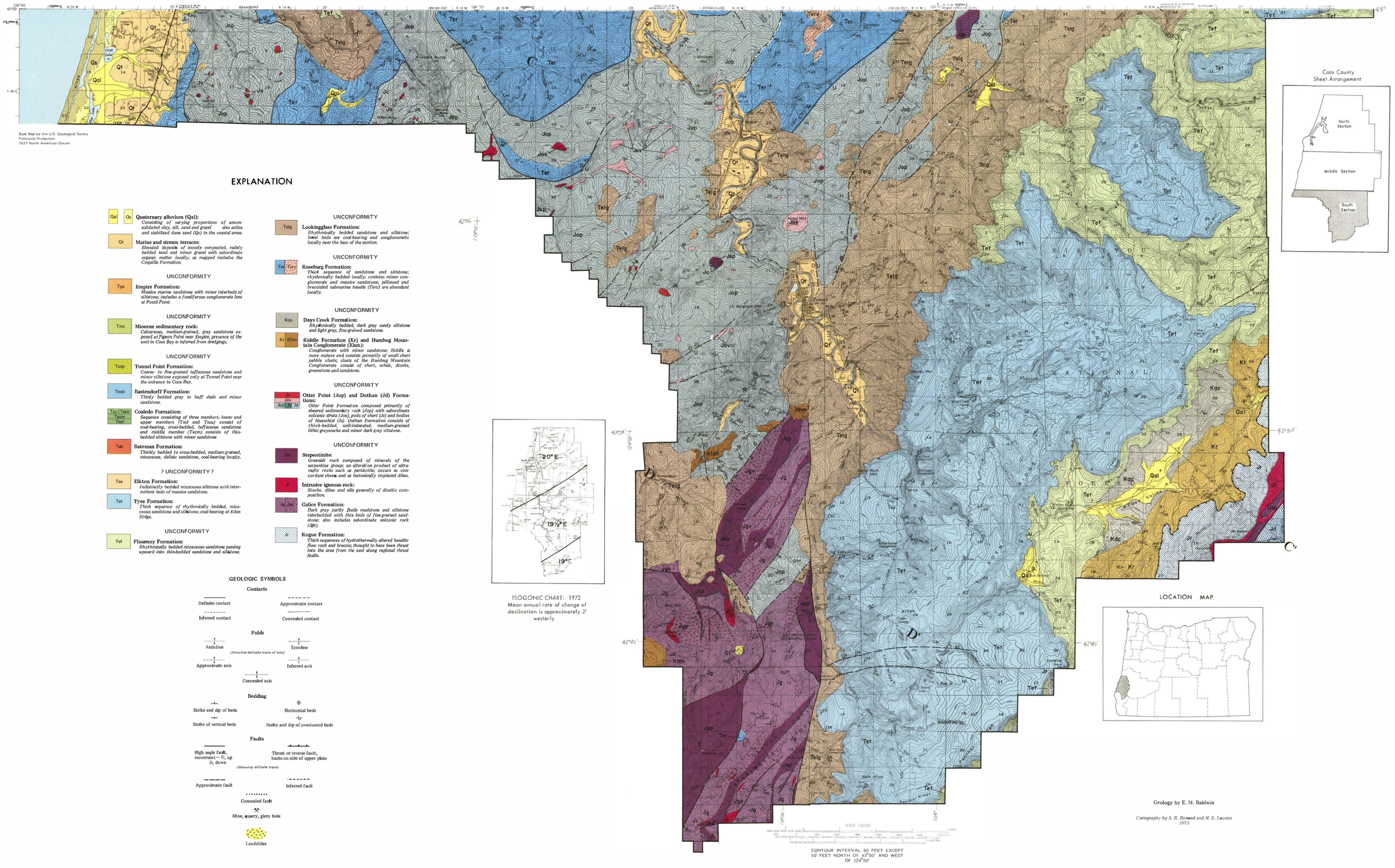
CONTOUR INTERVAL 50 FEET WEST AND 80 FEET EAST OF 124°00'

Geology by E. M. Baldwin

Cartography by S. R. Renoud and M. E. Lawson
1973

GEOLOGIC MAP OF THE SOUTH SECTION OF COOS COUNTY, OREGON

Map prepared by
STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES



EXPLANATION

Qal, Qs — Quaternary alluvium (Qal): *Consisting of varying proportions of unconsolidated clay, silt, sand and gravel also active and stabilized dune sand (Qs) in the coastal areas.*

Qt — Marine and stream terraces: *Elevated deposits of loosely compacted, rudely bedded sand and minor gravel with subordinate organic matter locally; as mapped includes the Coquille Formation.*

UNCONFORMITY

Tpe — Empire Formation: *Massive marine sandstone with minor interbeds of siltstone; includes a fossiferous conglomerate lens at Fossil Point.*

UNCONFORMITY

Tms — Miocene sedimentary rock: *Calcareous, medium-grained, gray sandstone exposed at Pigeon Point near Empire; presence of the unit in Coos Bay is inferred from dredgings.*

UNCONFORMITY

Totp — Tunnel Point Formation: *Coarse- to fine-grained tuffaceous sandstone and minor siltstone exposed only at Tunnel Point near the entrance to Coos Bay.*

Teob — Bastendorff Formation: *Thinly bedded gray to buff shale and minor sandstone.*

Tec, Tecu, Tecm, Teci — Coaledo Formation: *Sequence consisting of three members; lower and upper members (Teci and Tecu) consist of coal-bearing, cross-bedded, tuffaceous sandstone and middle member (Tecm) consists of thin-bedded siltstone with minor sandstone.*

Teb — Bateman Formation: *Thickly bedded to cross-bedded, medium-grained, micaceous, dellaic sandstone, coal-bearing locally.*

? UNCONFORMITY ?

Tee — Elkton Formation: *Indistinctly bedded micaceous siltstone with intermittent beds of massive sandstone.*

Tet — Tyee Formation: *Thick sequence of rhythmically bedded, micaceous sandstone and siltstone; coal-bearing at Eden Ridge.*

UNCONFORMITY

Tef — Flournoy Formation: *Rhythmically bedded micaceous sandstone passing upward into thin-bedded sandstone and siltstone.*

Telg — Lookingglass Formation: *Rhythmically bedded sandstone and siltstone; basal beds are coal-bearing and conglomeratic locally near the base of the section.*

UNCONFORMITY

Ter, Terv — Roseburg Formation: *Thick sequence of sandstone and siltstone; rhythmically bedded locally; contains minor conglomerate and massive sandstone; pillowed and brecciated submarine basalts (Terv) are abundant locally.*

UNCONFORMITY

Kdc — Days Creek Formation: *Rhythmically bedded, dark gray sandy siltstone and light gray, fine-grained sandstone.*

Kr, Khm — Riddle Formation (Kr) and Humbug Mountain Conglomerate (Khm): *Conglomerate with minor sandstone; Riddle is more mature and consists primarily of small chert pebble clasts; clasts of the Humbug Mountain Conglomerate consist of chert, schist, diorite, greenstone and sandstone.*

UNCONFORMITY

Jo, Jov, Jop, Jg, Jd — Otter Point (Jop) and Dothan (Jd) Formations: *Otter Point Formation composed primarily of sheared sedimentary rock (Jop) with subordinate volcanic strata (Jov), pods of chert (Jc) and bodies of blueschist (Js). Dothan Formation consists of thick-bedded, well-indurated, medium-grained lithic graywacke and minor dark gray siltstone.*

UNCONFORMITY

Jsp — Serpentinite: *Greenish rock composed of minerals of the serpentine group; an alteration product of ultramafic rocks such as peridotite; occurs as concordant sheets and as tectonically implaced dikes.*

Ji — Intrusive igneous rock: *Stocks, dikes and sills generally of dioritic composition.*

Jg, Jgv — Galice Formation: *Dark gray partly fissile mudstone and siltstone interbedded with thin beds of fine-grained sandstone; also includes subordinate volcanic rock (Jgv).*

Jr — Rogue Formation: *Thick sequences of hydrothermally altered basaltic flow rock and breccia; thought to have been thrust into the area from the east along regional thrust faults.*

GEOLOGIC SYMBOLS

Contacts

Definite contact — Approximate contact
Inferred contact — Concealed contact

Folds

Anticline — Syncline
(Showing definite trace of axis)
Approximate axis — Inferred axis
Concealed axis

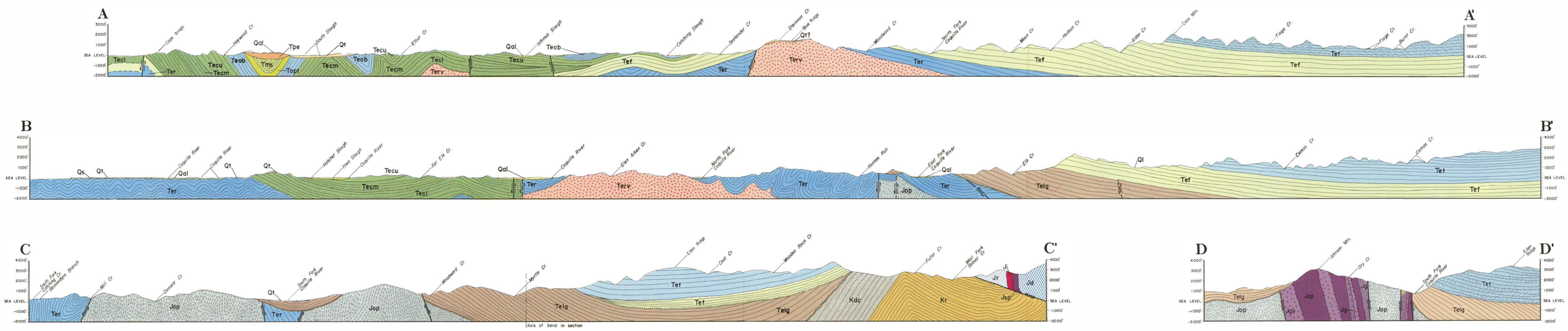
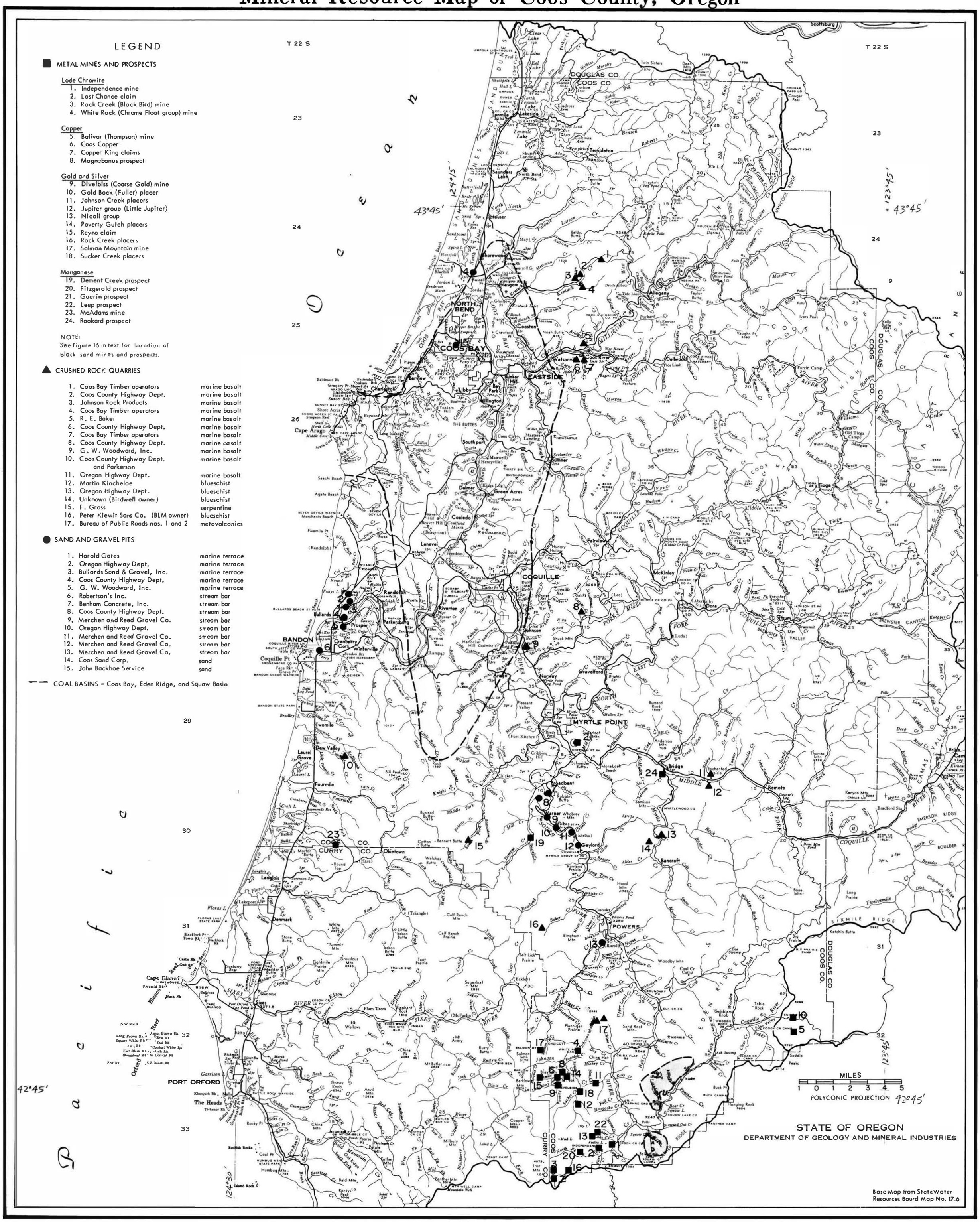
Bedding

Strike and dip of beds — Horizontal beds
Strike of vertical beds — Strike and dip of overturned beds

Faults

High angle fault, movement — U, up D, down — Thrust or reverse fault, barbs on side of upper plate
(Showing definite trace)
Approximate fault — Inferred fault
Concealed fault
Mine, quarry, glory hole
Landslides

Geologic Cross Sections



Mineral Resource Map of Coos County, Oregon