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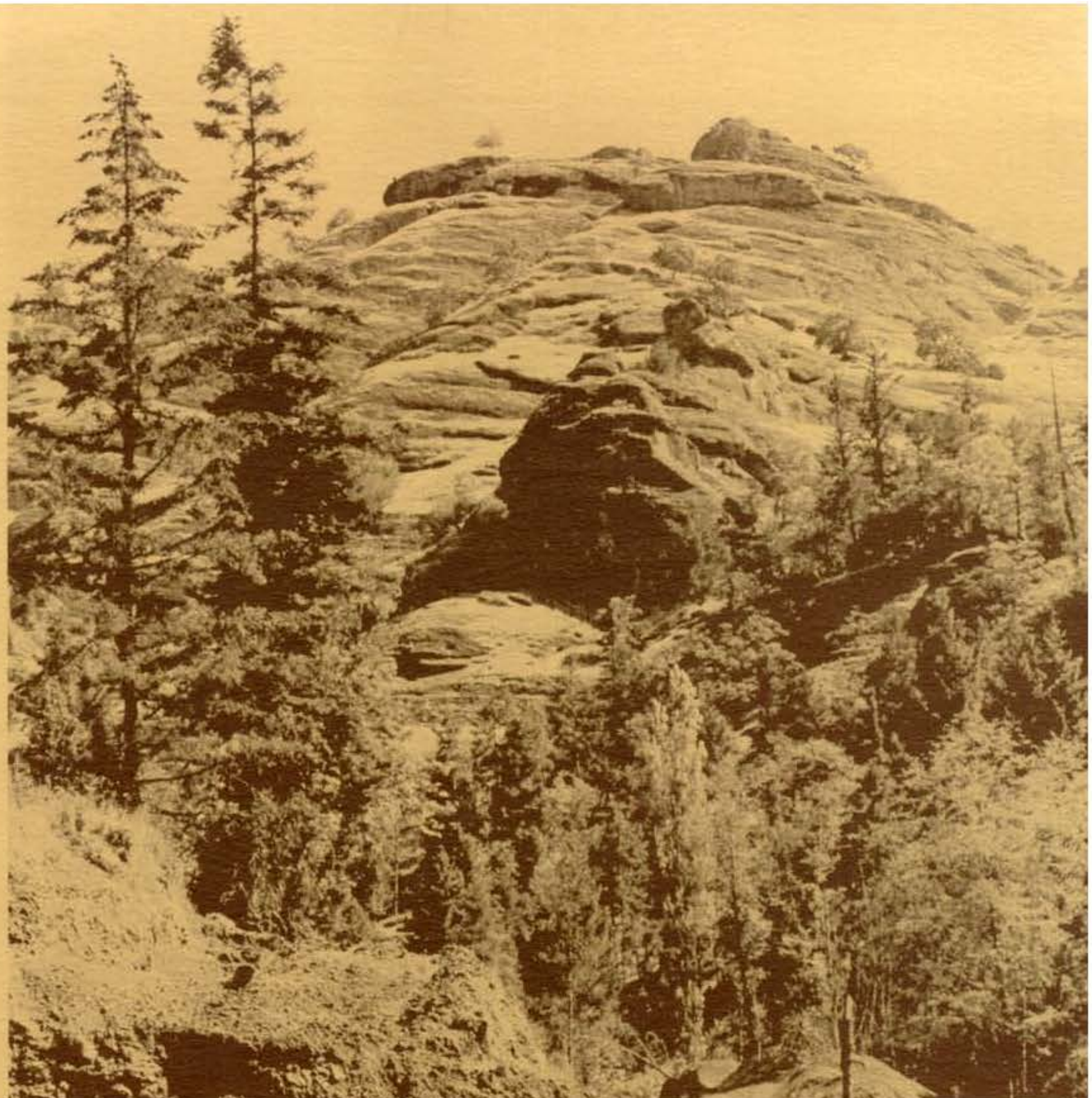

EOCENE STRATIGRAPHY OF SOUTHWESTERN OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
R. E. CORCORAN, STATE GEOLOGIST

1974

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STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 State Office Building, Portland, Oregon 97201

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FOREWORD

Southwestern Oregon has had a long history of mineral production dating back to the 1850's. Coal was discovered in Eocene marine sediments of the southern Coast Range near Coos Bay in 1854. By 1880, when records were first kept, production was about 40,000 tons a year, and for 15 years annual production ranged between 30,000 and 75,000 tons. Shortly after the turn of the century, petroleum discoveries in California caused most railroad and steamship lines on the West Coast to switch to fuel oil,and coalmining at Coos Bay declined rapidly.

The first detailed survey of the Coos County coals was made in 1896 for the U.S. Geological Survey by J. S. Diller. In the course of his studies, Diller compiled several geologic maps and reports showing the extent of the Eocene rocks and named and described many of the stratigraphic units. His work forms the basis of all subsequent investigations on the Tertiary stratigraphy of the Coast Range and encouraged subsequent search for oil and gas in western Oregon.

In more recent years, Dr. E. M. Baldwin and several of his graduate students in the Department of Geology at the University of Oregon have remapped in greater detail most of Coos County and adjoining parts of Douglas, Josephine, and Curry Counties. The original formations proposed by Diller have been revised and redefined so as to provide a clearer understanding of the Cenozoic structure and stratigraphy of the southern Coast Range. Their report comes at an especially appropriate time now that there is renewed interest in the Coos Bay coals and the petroleum potential of these marine sediments.

R. E. Corcoran
State Geologist

July 1974

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EOCENE STRATIGRAPHY OF SOUTHWESTERN OREGON

Ewart M. Baldwin

INTRODUCTION

Geologic interest in southwestern Oregon stemmed from early discoveries of gold and other metals in lode and placer deposits in and along the northern margin of the Klamath Mountains. Coal was discovered in the Coos Bay area about 1854, and later a search for commercial deposits of oil and gas focused interest on the early Cenozoic strata. Geologic mapping accompanied by studies of the mega- and microfaunas aided in determining the distribution and age of the stratigraphic units. The process of refining our knowledge of the geology of the area has continued and the revised stratigraphy presented here is a further attempt to explain geologic events.

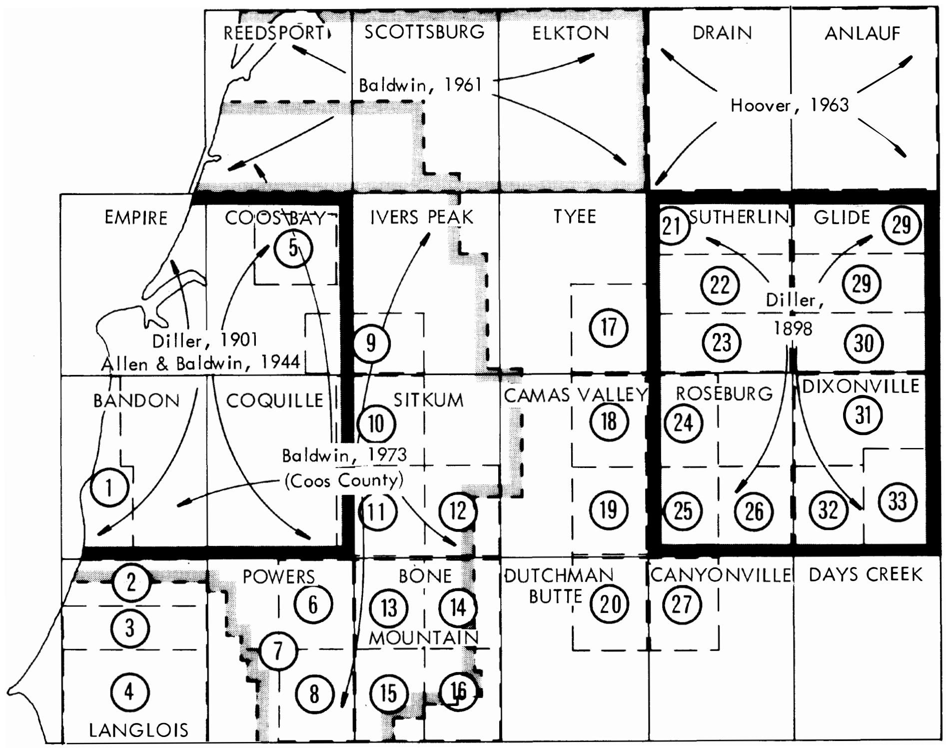
Location and Access

The area mapped lies largely at the south end of the Oregon Coast Range, where it borders the pre-Tertiary formations of the Klamath Mountains and, in addition, the broad Umpqua Valley to the foothills of the Cascade Range. Although the Klamath pre-Tertiary strata occupy only a small part of the area (see Geologic Map), they acted as a major source of sediments, and their Cenozoic tectonic history is interwoven with that of the sedimentary basins that reached northward from the Klamath Mountains into Washington.

Exposures in the Coast Range are largely along government and private timber access roads and along the streams. Exposures vary in accessibility and usefulness. The region is covered in most places by brush and a thick mantle of weathered rock. Annual rainfall ranges from an average of 55 inches at Coos Bay to more than 100 inches in parts of the Coast Range and then diminishes to approximately 32 inches at Roseburg.

Previous Work

Pioneer geologic work was done in this area by Diller (1898, 1899, 1901, 1903), who named and described many of the stratigraphic units. Turner (1938) described selected stratigraphic sections and the Eocene megafaunas. His work has been very useful in this study. Allen and Baldwin (1944) mapped the Coos Bay coal field. Weaver and others (1944) zoned the West Coast Cenozoic formations, and Weaver (1945) described the coastal exposures and listed megafaunas. Microfaunas of the Coaledo Formation were described by Detling (1946) and Cushman, Stewart and Stewart (1947). Other microfaunas have been identified by Stewart (1957), Thoms (1965), Bird (1967), and Rau (written communication). Hoover (1963) described the geology of the Drain and Anlauf quadrangles in the northeast corner of the area mapped. His contacts are little changed but the Umpqua strata are reassigned. Baldwin (1964, 1965, and 1966) discussed aspects of early Cenozoic revisions leading up to this report. Previous mapping in the area includes studies on the Elkton, Scottsburg, and Reedsport quadrangles in the northern edge (Baldwin 1961), the Myrtle Point, Coos County area (Baldwin 1969), and the Powers quadrangle (Baldwin and Hess 1971). Dott (1965) discussed the tectonic history of the Klamath Mountains, and Dott (1966) described the Coaledo Formation, its petrography and environment of deposition. Dott (1971) summarized the results of a University of Wisconsin mapping project that covered the southernmost part of the area discussed in this report. (See Figure 1 for areas geologically mapped.)

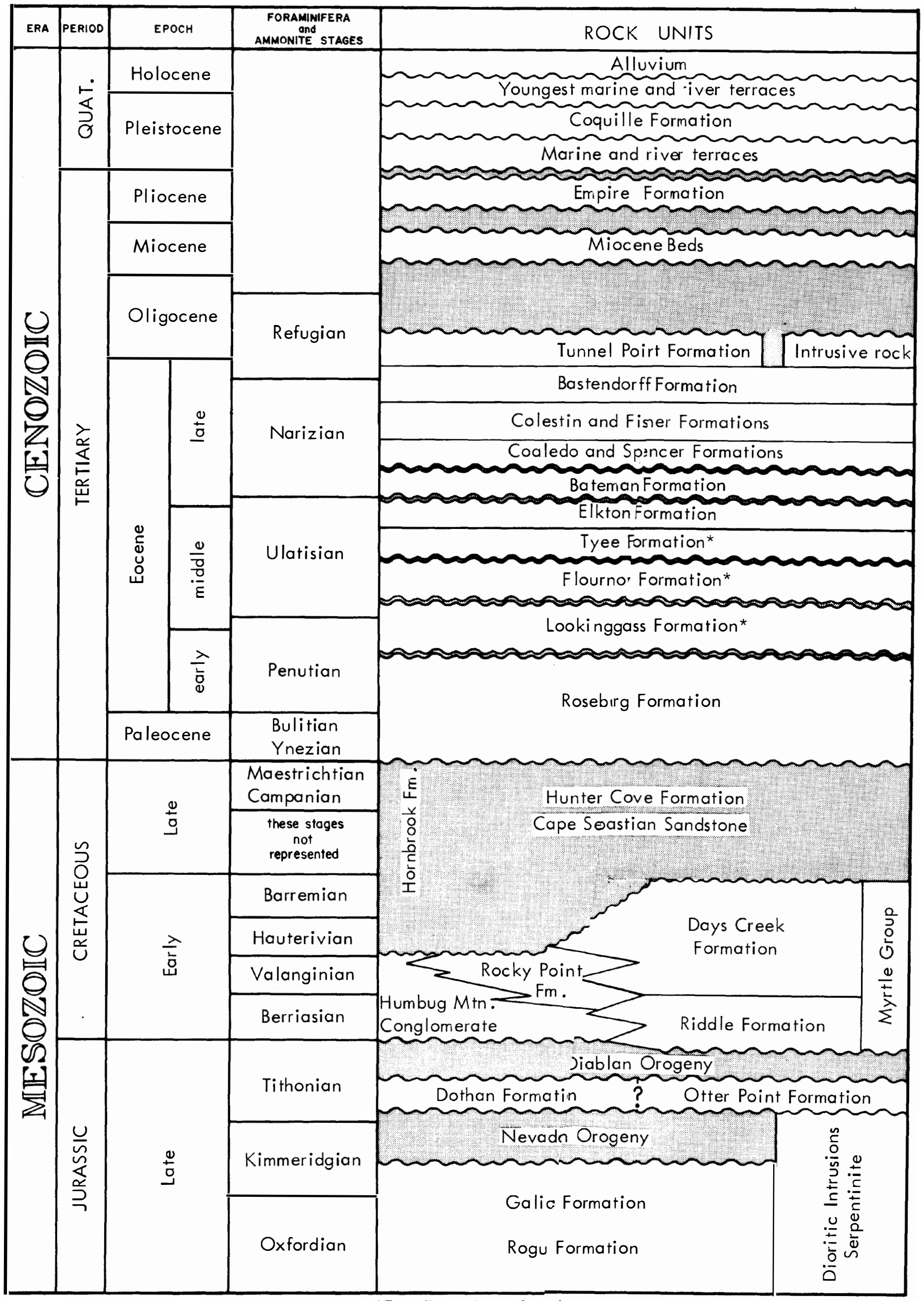


1. Ehlen, 1969
2. Phillips, 1968
3. Brownfield, 1972
4. Lent, 1969
5. Klohn, 1967
6. Hess, 1967
7. Baldwin & Hess, 1971
8. Born, 1963
9. Nelson, 1966
10. Magoon, 1966
11. Fairchild, 1966
12. Trigger, 1966
13. Krans, 1970
14. Johannesen, 1972
15. Rud, 1971
16. Kent, 1972
17. Hampton, 1958
18. Moore, 1957
19. Peterson, 1957
    Harms, 1957
20. Perttu, in prep.
21. Westhusing, 1959
22. Payton, 1961
23. Lawrence, 1960
24. Haq, in prep.
25. Hicks, 1964
26. Johnson, 1965
27. Cornell, 1971
28. Patterson, 1961
29. Thompson, 1968
30. Elphic, 1968
31. Champ, 1969
32. Hixon, 1965
33. Seeley, 1974

Figure 1. Index map of areas geologically mapped.

Acknowledgments

The writer spent many field seasons, beginning in 1943, in the Coos Bay coal field for the Oregon Department of Geology and Mineral Industries. Later work in the central and southern parts of the Coast Range was supported by the U. S. Geological Survey and some support came from University of Oregon Faculty Research Grants. He is indebted to all of these organizations for field support. He has gained a much better understanding of Oregon geology through discussion with colleagues. He is particularly indebted to Parke D. Snavely, Jr., H. E. Clifton, and Russell Wayland of the U. S. Geological Survey, and H. M. Dole and R. E. Corcoran of the State Department of Geology and Mineral Industries. E. H. Lund of the University of Oregon and John Beaulieu, Margaret Steere and Carol Brookhyser of the State Department of Geology read the manuscript. In the area mapped, the following students at the University of Oregon completed mapping projects for doctoral and master's degrees, most of whom were directed by the writer: Stephen Born, 1963; Michael Brownfield, 1972; Lary K. Burns, 1964; John Champ, 1969; Josiah H. Cornell, 1971; Judy Ehlen, 1969; Lance Elphic, 1969; Roy Fairchild, 1966; William Girard, 1962; Paul D. Hess, 1967; Donald Hicks, 1964; Harry Hixon, 1965; Wallace Johnson, 1965; Nils Johannesen, 1972; Melvin Klohn, 1967; Ainslie Krans, 1970; John Lawrence, 1961; Robert L. Lent, 1969; Leslie B. Magoon, 1966; Eric B. Nelson, 1966; Peter V. Patterson, 1961; Charles C. Payton, 1961; Robert L. Phillips, 1968; Norman V. Peterson, 1957; John O. Rud, 1971; Richard Thompson, 1968; William Seeley, 1974; James Trigger, 1966; James K. Westhusing, 1959; and Bobby J. Witt, 1964. Richard Kent (1972) and Rauno Perttu (in prep.), students at Portland State University, also contributed.



*For discussion of members see text

Figure 2. Stratigraphic chart for southwestern Oregon.

STRATIGRAPHY

General Discussion

The pre-Tertiary strata of the northern Klamath Mountains are a major source for the sediments that filled early Cenozoic basins in western Oregon. Volcanic flows and breccias were contributed during the Paleocene and early Eocene, and fragmental volcanic material from nearby late Eocene volcanism may have been incorporated in contemporary marine units. Younger Cenozoic strata may contain reworked material from earlier Cenozoic formations.

Cenozoic units were named and described by Diller (1898, 1899) in ascending order as the Umpqua, Tyee, and Arago Formations. Diller later divided the Arago into the Pulaski and Coaledo Formations. The name Pulaski was preempted and Coaledo has superceded Arago as a formational name. Diller showed no contact between the Tyee and Coaledo Formations, but the Coaledo has since been found to be the younger. The section assigned to the Umpqua Formation is thick and diverse. Baldwin (1964, 1965) recognized unconformities within the Umpqua Formation and proposed subdivisions which he tentatively called lower, middle, and upper members but which are herein named in ascending order, the Roseburg, Lookingglass, and Flournoy Formations (Figure 2). From the historical viewpoint these formations would be a part of the Umpqua Group; however, the major unconformity between the Roseburg and the Lookingglass Formations may not be in accord with the group concept.

A thick section of volcanic rock in the lower part of the Roseburg Formation is in general equivalent in age to the Siletz River Volcanics that crop out farther north in the Coast Range. However, in places the sedimentary and volcanic rocks are so intimately interfingered that it seems best to include them in the same formation.

The Lookingglass Formation is divisible into three members: the basal conglomerate is called the Bushnell Rock Member; the siltstone of Tenmile Valley is the Tenmile Member; and the conglomerate and sandstone of the upper part is the Olalla Creek Member.

The Flournoy Formation is divisible into a basal sandstone member, called the White Tail Ridge Member, and the overlying siltstone, which is called the Camas Valley Member.

The Tyee Formation is divisible along the eastern margin of the Coast Range into three members. The sandstone of Tyee Mountain is called the Tyee Mountain Member, the siltstone that parallels Hubbard Creek is called the Hubbard Creek Member, and the upper sandstone that crops out at Baughman Lookout is called the Baughman Member. None of the members listed above are shown in the geologic map but are shown in the cross sections. They are mapped by Baldwin and Peterson (in prep.) in the Camas Valley and Tyee quadrangles.

The siltstone in the upper part of the Tyee Formation was named the Elkton Siltstone Member by Baldwin (1961). It has been considered a separate formation by Thoms (1965), Bird (1967), and Lovell (1969), and the writer concurs, although contacts are difficult to establish because of gradation.

Strata south of Elkton questionably assigned to the Coaledo Formation (Baldwin, 1961) are herein named the Bateman Formation and considered to be deposited as offlapping beds at the end of the Tyee cycle of deposition and thus pre-Coaledo in age.

Even though not differentiated on the geologic map, the writer considers valid the lower, middle, and upper Coaledo members as proposed by Turner (1938) and mapped by Allen and Baldwin (1944) and Baldwin (1969, 1973). Post-Coaledo sedimentary formations are located in the Coos Bay area and are incidental to the study. They are mapped and described in more detail by Allen and Baldwin (1944), Baldwin (1973), and Baldwin and Beaulieu (1973).

Pre-Tertiary Formations

The Cenozoic rocks are underlain by thick Triassic, Jurassic, and Cretaceous sedimentary and volcanic units. The Triassic strata of the Applegate Group crop out in the southeast part of the Oregon Klamath Mountains near Grants Pass. The pre-Nevadan Late Jurassic Rogue and Galice Formations occupy a northeasterly trending belt west of the Triassic rocks, and both of them are in a thrust sheet that overlies the Late Jurassic Dothan Formation even further to the west. The Rogue Formation was intruded by gabbroic and dioritic rocks during the Nevadan Orogeny. The Dothan Formation is made up of rhythmically bedded sandstone and siltstone with occasional deposits of basalt and chert, whereas beds along the coast of similar age but of different facies have been named the Otter Point Formation by Koch (1966). The Otter Point Formation is made up of less competent material and is often in the form of a mélange. It contains thinner bedded clastic rocks, basalt, chert and minor amounts of limestone, and tectonically emplaced pods of blue schist and serpentinite. Narrow bands of serpentinite have been squeezed into high-angle fault zones and in other places the broader expanses of serpentinite may represent "tectonic carpets" along the soles of thrust plates. The Colebrooke Schist, which may be derived from the Galice Formation, has a metamorphic age of approximately 130 m.y. (Coleman, 1972). Baldwin and Lent (1972) suggest that it was thrust into its present position near the end of early Eocene.

The Myrtle Group (Imlay and others, 1959) includes the latest Jurassic and Early Cretaceous conglomeratic Riddle Formation and the Early Cretaceous more rhythmically bedded sandstone and siltstone of the Days Creek Formation, both of which crop out in the South Fork of the Umpqua River near the town of Days Creek. The Myrtle Group is exposed intermittently along the northern edge of the Klamath Mountains. The Myrtle Group along the coast between the Sixes and Rogue Rivers is represented by the Humbug Mountain Conglomerate and the Rocky Point Formation, which may be generally equivalent to the Riddle Formation and Days Creek Formation. Mid- and Late-Cretaceous beds are present in the Hornbrook Formation along Grave Creek (Peck and others, 1956) and the Cape Sebastian Sandstone and the Hunters Cove Formation at Cape Sebastian described by Dott (1971).

Roseburg Formation

Description

The Roseburg Formation is herein named for Roseburg, the county seat of Douglas County. The formation includes much of that designated as Umpqua Formation by Diller (1898) and that mapped as "lower Umpqua" by Baldwin (1965, 1969). It includes all of the basalt and interbedded sedimentary beds along the North Fork of the Umpqua River between the Frear bridge, three miles west of Glide, to its confluence with the South Fork and in addition a thick post-basalt section that overlies the basalt core in the Red Hill anticline along U. S. Highway I-5 from Turkey Hill to the center of a syncline along Calapooya Creek near Oakland (Figure 3). The thickness of the basaltic North Fork section is difficult to determine because of possible duplication by close folding or imbrication during faulting. Nearly 8,000 feet of post-basalt strata has been computed for the section overlying the basalt along U.S. Highway I-5. The basalt and post-basalt section could easily total 12,000 to 15,000 feet and neither the bottom nor the uneroded top is known. The basaltic section along the North Fork of the Umpqua River is thought to be thrust northwesterly over the sedimentary section (Baldwin, 1964-b).

Another thick but incomplete section of Roseburg strata is present along Highway 42 between Coquille and Myrtle Point. Approximately 8,000 feet of sedimentary rock rests on a basaltic core of unknown thickness. The upper part of the section may be faulted along the North Fork of the Coquille River but the trace is covered by alluvium of that valley. The base of the Roseburg Formation is nearly everywhere concealed; most visible contacts are faults. In the Robbin Hill area south of Myrtle Point, it may be resting depositionally upon the Otter Point Formation, but the possibility of thrusting is not ruled out. Where the base of the Umpqua Formation has been recorded, it is in nearly all instances the basal Lookingglass conglomerate. Of the few places where the base of the Roseburg is visible, one is along the West Fork of Cow Creek, and another is around the south rim of Elk Valley. Both locations are in the Dutchman Butte quadrangle.

Figure 3. Roseburg Formation. Low-dipping beds near axis of syncline exposed along Highway I-5 south of Sutherlin. (Photo by Leslie Magoon)

Poorly rounded fragments of locally derived slaty sedimentary rocks are abundant in the basal Roseburg Formation at these places.

Lithologically, the lower part of the Roseburg Formation is predominantly basalt flows, pillow lavas, or breccias interfingered with conglomerate and tuffaceous sandstone. The basalt has been described by Hoover (1963, p. D-11, D-12) in the Drain and Anlauf area as follows:

> Microscopic study shows that the basalt is hypocrystalline to holocrystalline with an intersertal, intergranular, or, in places, a trachytic texture. Labradorite (about An 52-62) and augite are present as phenocrysts and in the groundmass and together constitute 55 to 75 percent of the rock; generally plagioclase is nearly twice as abundant as augite. Many of the labradorite phenocrysts, which are as much as 3.5 mm long, have an outer zone of more sodic plagioclase and few are poikilitic, with inclusions of clinopyroxene and serpentinite. In a few thin sections the plagioclase and pyroxene phenocrysts form glomeroporphyritic clots. Olivine, which once constituted from 5 to 15 percent of the rock, is generally represented by pseudomorphs of serpentine or of a clear golden-yellow slightly pleochroic alteration product rimmed with antigorite and of associate hematite and magnetite. Unaltered olivine is rare. Small subhedral crystals of magnetite form as much as 12 percent of the basalt, and skeletal crystals of ilmenite were seen in some thin sections. Hypersthene is present in a few samples and apatite generally is a minor constituent. The mesostasis of the intersertal basalt is colorless to nearly opaque dark-brown glass, commonly altered to chloritic material and palagonite. The amygdaloidal basalt also contains cavity fillings of zeolites and fibrous chalcedony. Some amygdules are composed partly of zeolites and partly of magnetite, and most of them have a thin jacket of chloritic material. Calcite occurs in vesicles and in fractures, and in at least one thin section it is pseudomorphous after plagioclase. Secondary alteration has affected

not only the olivine and basaltic glass, but also some of the plagioclase, which now appears as saussurite. Only the plagioclase in the groundmass is thus changed; the labradorite phenocrysts are fresh and clear.

Other descriptions are given by Wells and Waters (1934) for the basalts in the Roseburg Formation north and east of Roseburg. The basalt in the Coos Bay area has been described by Lowry (in Allen and Baldwin, 1944, p. 16-18) and by Klohn (1967, p. 7-18). Most exposures of Roseburg basalt contain pillows, often in abundance. Some of the best places to observe the pillow structure are along the Glide to Wilbur road and along U. S. Highway I-5 in the southern part of Roseburg. Near Enegrin Ferry at the forks of Coos River, and in Blue Ridge, the basalt is brecciated; the interstices are commonly filled with pink iron-stained calcite, chalcedony, and zeolite minerals and other alteration products. In other places, the rocks are vesicular with cavities lined or sometimes filled with zeolite minerals.

In Sugarloaf Mountain east of Myrtle Point the flows are interlayered with bedded sedimentary rocks. Pillows are common along the Middle Fork of the Coquille in a large quarry at the junction with the McMillan Creek Road. The basalt evidently poured out on the sea floor, intertonguing with tuffaceous sediments. In places such as just east of Wilbur, a local conglomerate made up entirely of basaltic pebbles appears within the Roseburg Formation. The Wilbur tuff lentil of Diller (1898) is made up of tuff contemporaneous with a late phase of extrusion and is associated with the nearby basalts.

Tuffaceous sedimentary rocks associated with the volcanic part of the Roseburg Formation were examined microscopically by Hoover (1963, p. D-13 - D-16), who gives its constituents and concludes that the tuffaceous beds do not occupy the same stratigraphic position everywhere. The beds are not mapped separately and the name "Wilbur tuff lentil" is probably best abandoned as a formal unit.

The Oakland Limestone Lentil of Diller is interbedded in the sedimentary upper part of the Roseburg Formation. It is made up of a few thin fossiliferous beds of limestone, but the name is probably not justified and should be abandoned because similar thin beds of limestone occur as a part of the Roseburg Formation in other places.

The two most continuous sedimentary sections are those along U. S. Highway I-5 between Turkey Hill (the westernmost exposure of basalt in the Red Hill anticline) and the center of the syncline near Calapooya Creek and those along State Highway 42 between Coquille and Myrtle Point. Both sections have approximately 8,000 feet of sedimentary beds composed of dark-gray tuffaceous siltstone grading upward into more rhythmically bedded sandstone and interbedded siltstone. Megafossils are rare.

Centers of volcanism may have existed. Volcanics of this general age are widespread farther north in the Coast Range in the Siletz River Volcanics (Snavely and Baldwin, 1948). Although the basalt in the Roseburg Formation is recognized as being generally equivalent to the Siletz River Volcanics, it is not mapped as a separate formation in the southern part of the state because of the intimate interfingering and varying proportions of volcanic and sedimentary rocks. The basalt is confined to the lower part of the Roseburg Formation. It crops out in structural highs such as the centers of anticlines and the up-thrust side of faults, and it may be continuous at depth beneath synclines.

Age and correlation

Beds that contain Late Cretaceous microfossils and are lithologically indistinguishable from the Roseburg beds crop out along the North Fork of the Coquille River 2 miles northeast of Myrtle Point in the NE $\frac{1}{4}$ sec. 10, SW $\frac{1}{4}$ sec. 11, T. 29 S., R. 12 W. These beds may have been tectonically introduced into the Roseburg Formation, and their extent is unknown. They are not mapped separately.

In the Ashland area, beds assigned to the Umpqua Formation (Wells, 1956) are parallel to the upper part of the Late Cretaceous Hornbrook Formation. The correlation was based on similar lithology and incorporated coal beds. Elliott (1971) examined these beds in the Ashland area along the Bear Creek Valley and southward into California and assigned a Late Cretaceous age based on megafossils and paleobotanical data. Whether or not they are correlative with Late Cretaceous beds cited from the North Fork of the Coquille River is uncertain, but they do appear to be older than the bulk of the Roseburg Formation.

Hackel (1966) states that in both the northern San Joaquin and Sacramento Valleys deposition appears to be continuous from Cretaceous into Paleocene time. It is entirely possible that sedimentation was relatively continuous in Oregon. At the present time, no Cretaceous beds are definitely known to be a part of the Roseburg Formation.

Several areas of sedimentary rock along the coast are separated from the main bodies and occupy a debatable stratigraphic position. Dott (1962) mapped beds at Blacklock Point near Cape Blanco that he assigned to the Late Cretaceous on the basis of a meager fauna. Lent (1969) mapped beds along Edson Creek in the Langlois quadrangle that he also assigned to the Late Cretaceous. Lithologically both of these sections are difficult to distinguish from beds mapped in other places as Roseburg, and they are included in the Roseburg Formation although later information may lead to separation into another stratigraphic unit. Bandy (1944) assigned severely deformed beds at Cape Blanco to the middle Eocene; however, many of the Eocene foraminifera are long range. The writer, therefore, includes these strata within the Roseburg Formation on the basis of lithology and stratigraphic position.

Beds at Five Mile Point north of Bandon and at the mouth of Johnson Creek south of Bandon are in the debatable category. Foraminifera from Five Mile Point north of Bandon contain a small number of species that range from the Cretaceous to the Eocene in age. However, the nannofossil, Tribrachiatus orthostylus, found by D. Bukry (written communication, March, 1972), indicates an early Eocene age. A sample from a point on the new road north from Agness to Powers in the SE ¼ of sec. 13, T. 34 S., R. 12 W. was also examined by Bukry, who found a much larger assemblage of fossil forms that he assigned to the Tribrachiatus orthostylus zone or Discoaster lodoensis zone of early Eocene age.

Beds considered to be a part of the Roseburg Formation by the writer and mapped as lower Umpqua by Brownfield (1972) at the junction of the West Fork of Floras Creek and the main creek contain pollen and spores which were studied by Donald W. Engelhardt (written communication, Feb., 1972). He reports the following:

> Dinoflagellates and hystrichosphaerids were found in the sample. The sample contained the following taxa which have been reported from the Dos Palos shale in California:
>
> | | |
> |---|---|
> | Hystrichosphaera cf. furcata | Appendicisporites cf. perplexus |
> | Hystrichosphaeridium complex | Gleicheniidites |
> | Cordosphaeridium cf. inodes | Abietineaepollenites |
> | Membranosphaera sp. | Podocarpidites |
> | Stereisporites antiquasporites | Taxodiaceaepollenites hiatus |
> | Cyathidites cf. australis | Alnipollenites verus |
> | Cicatricosisporites dorogensis | |
>
> Many of the common lower Tertiary palynomorphs were not present, probably due to the environment. Pteridophyte spores were common to abundant. The environment of deposition is interpreted as brackish water with restricted circulation which is adjacent or in close proximity to freshwater swamp conditions. Many of the pollen grains have been distorted by probable pyrite crystal formation. This may be caused during deposition under conditions of restricted circulation.
>
> Palynologic evidence indicates a probable Lower Tertiary (Danian or Paleocene) age for the sample.

According to Popenoe, Imlay, and Murphy (1960, p. 1529), fossils of Late Cretaceous age, similar to some found near the mouth of Pistol River in the Hunters Cove Formation (Dott, 1971), were collected from the south edge of sec. 25, T. 30 S., R. 13 W. in Dement Creek southwest of Myrtle Point by Diller and his party many years ago. Dement Creek drains only beds assigned by Baldwin and Hess (1971) to the Late Jurassic Otter Point Formation or the lower Umpqua Formation (Roseburg Formation). This fossil locality has puzzled nearly all who have tried to find it. Either the location must be in error or these fossils were derived from the Roseburg Formation or a tectonically emplaced block of unmapped Late Cretaceous rock. This is one of the few places that basal Roseburg appears to be exposed in a thin fault sliver. No Cretaceous megafossils are known from other Roseburg localities.

Thoms (1965) made a study of the rocks formerly mapped as Umpqua and noted that the ranges of many of the foraminifera previously used to zone the West Coast early Cenozoic rocks had been extended. Thus it is difficult if not impossible at this time to zone more than roughly the Paleocene and early Eocene beds.

A Paleocene microfauna was found interbedded with the basaltic unit east of Myrtle Point (Baldwin, 1965). Both Thoms (1965) and Rau (in Baldwin, 1969) assigned the sedimentary part of the Roseburg Formation overlying the basaltic part to the C and lower B zones of Laiming (1940) or the Penutian stage of Mallory (1959). However, the Lookingglass Formation, although usually lacking in C zone fossils, is also assigned to the lower B zones and may be Penutian.

McKeel (1972) states that lower Umpqua is dominated by Globorotalia aequa and other species indicative of the lower Eocene. McKeel and Lipps (1972) note that sparse Oregon planktonic foraminifera suggest deposition beneath offshore oceanic water masses in lower and middle Eocene times in depositional sites isolated from lower latitude provinces by southward-flowing currents much as we have today.

Turner (1938) divided the Umpqua Formation of Diller into a lower and an upper part on the basis of megafauna. Although megafossils are generally lacking in the Roseburg Formation, they are present along the North Fork of the Umpqua River and in the western part of the Middle Fork of the Coquille River in beds that coincide with Turner's lower part of the Umpqua. The upper part of Turner's Umpqua includes the Glide section and the upper part of the Middle Fork of the Coquille section, including both the Lookingglass and Flournoy Formations.

Thoms (1965) assigns the Roseburg Formation as defined largely to the Penutian, but he also assigns the Lookingglass in the Glide section to the Penutian, perhaps the upper part. Yet the writer places a major hiatus (see deformation below) between the Roseburg and the Lookingglass Formations. Either the mollusks and foraminifera had longer ranges than originally supposed, or deposition and the erosional break occurred rapidly. The Roseburg Formation is closely folded and thrust. No doubt it formed mountains that were eroded before deposition by Lookingglass seas. Yet these events must have taken place rapidly to be spanned by the Penutian stage.

A summary of the age of the Roseburg Formation shows that, although beds of Late Cretaceous age may be tectonically infolded or faulted, more or less continuous deposition from Late Cretaceous to early Eocene time cannot be ruled out even though it has not been proven. Basaltic extrusion, with intertonguing sedimentation, probably started during the Paleocene but the bulk of the formation was deposited during the early Eocene (Baldwin 1965, p. 97).

Deformation

One explanation for the rapidity of events may be found in the movement of crustal plates. At the end of early Eocene time, the edge of the continent may have impinged upon the east Pacific plate, with subduction beneath the edge of the continent and a telescoping of the Roseburg strata. If this is true, movement evidently subsided before the Lookingglass beds were deposited, for subsequent deformation has been relatively minor and along different trends. It should be noted that the closely folded Roseburg Formation arcs around the Klamath Mountains, maintaining easterly trends near Roseburg whereas the later Eocene strata are folded gently along a more northerly axis (Figures 4 and 5). Thus this stage of deformation may be considered the culmination of Klamath Mountain orogenies. Not only were there minor thrusts of the lower basaltic part of the Roseburg over the upper sedimentary part near Roseburg (Baldwin, 1964-b), but there appears to be a continuation of the thrust beneath the central part of the Coast Range to the western edge of Sugarloaf Mountain near Myrtle Point (geologic map in pocket).

Tertiary strata, presumably a part of the Roseburg Formation but possibly Lookingglass, are tectonically emplaced within greenstone on the northwest side of Salmon Mountain in the Powers quadrangle (Baldwin and Hess, 1971), and similar beds are engulfed in serpentinite at the mouth of Sucker Creek and then again farther up Sucker Creek next to the big slide about a mile from its junction with Johnson Creek along the north margin of the Agness quadrangle. The tectonic inclusion of Tertiary beds in this manner supports an age for significant thrusting as late as the end of early Eocene.

Probably at this time, plates of Colebrooke Schist were emplaced in the Edson Butte area of the Langlois quadrangle and along the lower Rogue River. Blake, Irwin, and Coleman (1967) note that the plate along the lower Rogue overrode beds of Early Cretaceous age. However, in the Langlois quadrangle Lent (1969) and Brownfield (1972) show a warped plate of Colebrooke Schist capping the Edson Butte area, a slight projection of which overlies steep beds of either Late Cretaceous or early Tertiary age in Edson Creek to the south and beds assigned to the Paleocene in Floras Creek to the north. An isolated, detached plate of Colebrooke caps Calf Ranch Mountain across Floras Creek from the main body on Edson Butte.

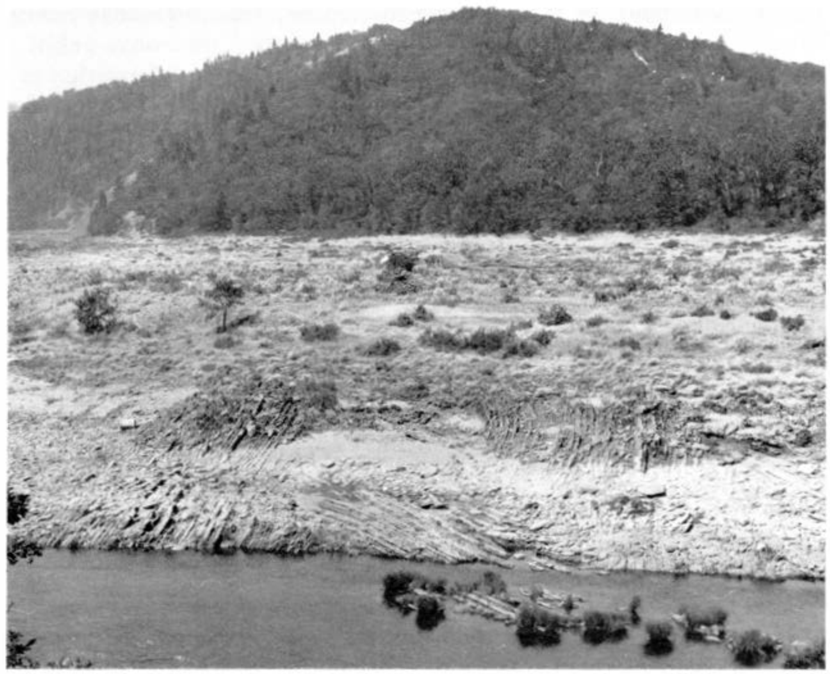


Figure 4. Contorted beds of Roseburg Formation along Umpqua River near Woodruff Mountain.

Figure 5. Steeply tilted Roseburg strata at junction of Coos Bay Wagon Road and Burnt Ridge Road, 12 miles west of Reston Road junction. (Photo by Leslie Magoon)

If once continuous, as is reasonable to suppose, the Colebrooke Schist must have overlain the early Tertiary beds in Floras Creek. The superior position of the Colebrooke Schist, plus known thrusting and isoclinal folding within the Roseburg Formation, points to major deformation at the end of the early Eocene (Baldwin and Lent, 1972).

The source of the Colebrooke Schist is not known, but Coleman (1972) proposes that it was obducted from the Pacific plate during impingement of the oceanic and continental plates.

Size and shape of the basin

The approximate shape of the Paleocene to early Eocene seaway in which the Roseburg Formation was deposited is shown in Figure 6. Beds formerly assigned to this age near Medford and Ashland are now considered to be Late Cretaceous and thus are excluded even though it is not known where the margin of the early Tertiary lies in this direction. The eastern margin disappears beneath the Cascade Range and may reach into eastern Oregon beneath younger formations; however, geophysical work (R. Blank, personal communication) shows that the crust thickens rapidly east of the Western Cascades front, whereas to the west it is more typical of oceanic basin. The basin reached northward into Washington, probably to Vancouver Island, and volcanic and sedimentary rocks of the Crescent Formation may be correlative.

There is no need to postulate a western barrier. Local areas of extrusion may have formed islands, but nearly all of the basalt appears to be submarine. Thoms (1965) suggests that the seas were warm and at times shallow where orbitoid foraminifera were present. Other foraminifera in other parts of the formation point to surface connections with the open ocean. In places, deposition may have been in the neritic and upper bathyal zones. The sediments are tuffaceous and may have been derived from nearby volcanic centers. Conglomerate at Wilbur may represent nearshore deposits around an island and thus may be locally derived. Conglomerates are relatively rare elsewhere. Angular fragments of basalt in poorly sorted conglomerates point to locally derived material downslope near volcanic extrusions.

Lookingglass Formation

Description

The Lookingglass Formation unconformably overlies the Roseburg Formation and oversteps upon the pre-Tertiary formations around the periphery of the basin. Notable examples of this are along Cow Creek west of Riddle, in the Bone Mountain and Powers quadrangles, in isolated outcrops near Bobs Garden in the Marial quadrangle, and at the junction of Boulder Creek and South Fork of Lobster Creek in the Agness quadrangle.

The formation derives its name from the Lookingglass Valley, the south wall of which is made up of the basal conglomerate and the floor of which is largely underlain by siltstone. The Lookingglass Formation is better exposed along Tenmile Creek from Bushnell Rock southward to Tenmile Butte, and this is designated as the type section. The formation is herein divided into three members: the basal Bushnell Rock Member, the Tenmile Member, and the Olalla Creek Member. The northern end of the Lookingglass Formation disappears beneath the Tyee Formation a short distance north of Melrose, wraps around the south end of the Coast Range syncline, and is traceable northward along the west limb of the Coast Range syncline as far as the northeast end of Blue Ridge, where it is covered by the Flournoy Formation.

Bushnell Rock Member

The Bushnell Rock Member is best displayed in the ridge extending from Tenmile Creek eastward across Porter Creek to Alexander Butte, where it is abruptly truncated by a fault. The member attains a thickness of from 800 to 1,000 feet but may be thinner or grade into finer beds in places. Basal beds contain some boulders, but most of the conglomerate at Bushnell Rock is made of pebbles 1 to 2 inches in diameter with a medium to coarse sandstone matrix (Figure 7). The beds are thick and poorly stratified. Many of the pebbles are sandstone, basalt, or greenstone, but some are quartz, chert, and medium-grained intrusive rocks typical of the Klamath Mountain terrain. The conglomerate grades upward into massive sandstone which gives way rapidly to the thin-bedded, rhythmically bedded Tenmile Member.

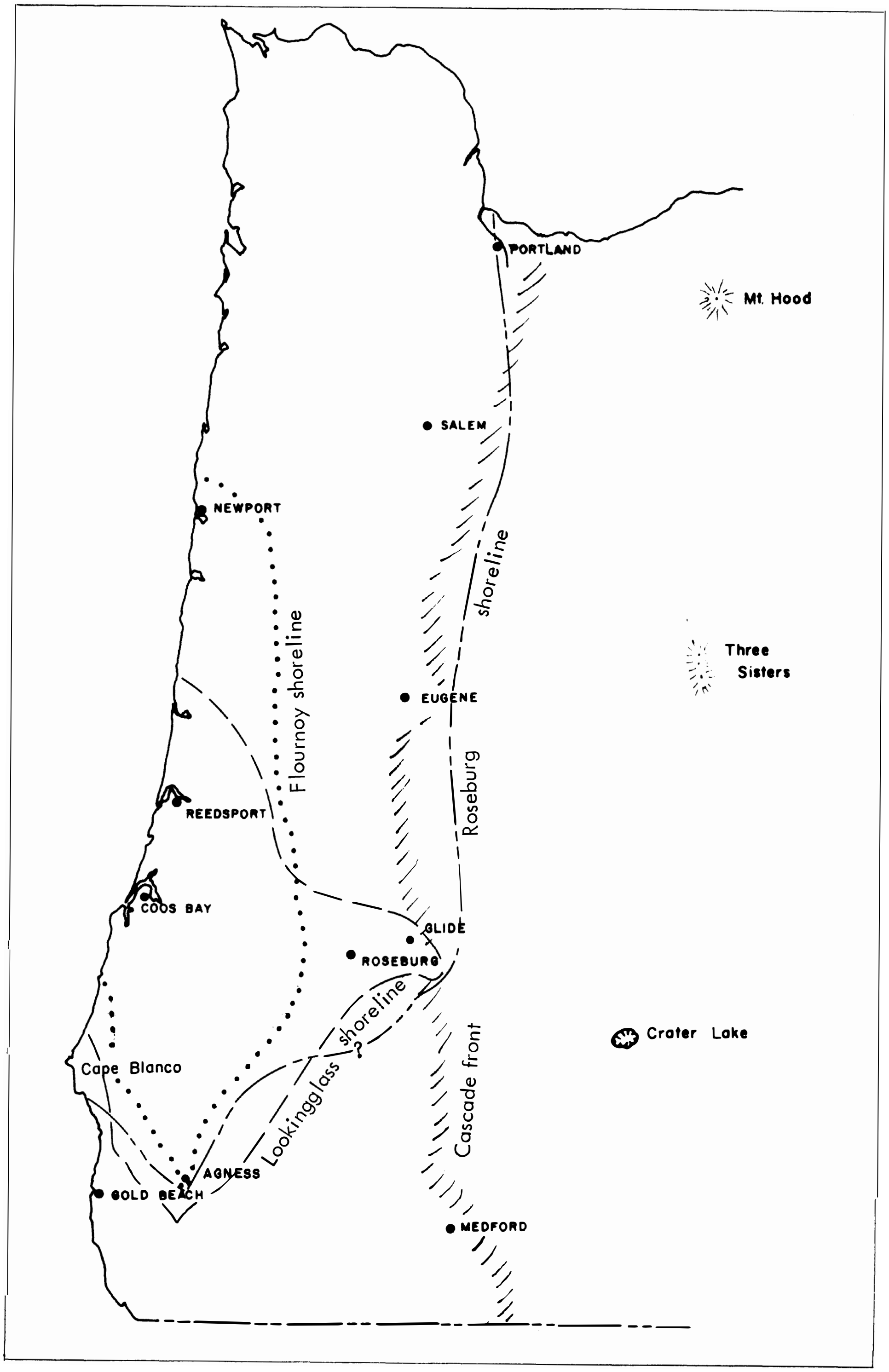


Figure 6. Paleogeographic map of Roseburg, Lookingglass, and Flournoy Formations.

The Bushnell Rock Member is infaulted in Cow Creek west of Riddle. It is present as numerous outliers on the pre-Tertiary rocks and as a thinner basal unit rimming the basin around Powers, the upper Sixes River in the Powers quadrangle, and along Bear Creek in the Bandon quadrangle. The conglomerate interfingers locally with coal-bearing massive sandstone along the Middle Fork of the Coquille River west of Remote in the Sitkum and Bone Mountain quadrangles. The base along the Middle Fork of the Coquille is placed at about 200 yards west of Frenchie Creek (Figure 8). Northward the amount of conglomerate is relatively thin along the North Fork of the Umpqua River west of Glide. It crops out in the river about 100 yards west of the Frear Bridge. Woodruff Mountain, north of Melrose, contains conglomerate which is mapped as basal Lookingglass.

The Bushnell Rock conglomerate represents the basal beds of an onlapping sea. Coal beds west of Remote and along the upper Sixes River in the Eckley field, referred to by Diller (1903), point to nearshore flood-plain deposition. Most of the conglomerate clasts are well rounded and include a more varied assemblage of rock types than do those in the basal Roseburg Formation. Conglomerates of the latter formation have more locally derived constituents.

Tenmile Member

The Tenmile Member is best displayed in the Camas Valley quadrangle in the broad east-trending Tenmile Valley from the community of Tenmile to Olalla Creek. It crops out also at Remote in lower Sandy Creek Valley, along Bear Creek in the Bandon quadrangle, along the East Fork of the Coquille near Dora, and along Rock Creek on the road south of Powers to Agness (Figure 9).

The member is composed of thin rhythmically bedded sandstone and siltstone. Peterson (1957) measured approximately 3,200 feet of the Tenmile Member at Tenmile. The siltstone steepens appreciably along the Tenmile fault southwest of Tenmile Butte along the Berry Creek Road. In one of the quarries near the center of sec. 12, T. 29 S., R. 8 W., steep, thin, rhythmically bedded strata are particularly well exposed. Peterson (1957, p. 62) describes a piece of sandstone from this locality as follows:

> It is a well indurated rock with a dark gray-brown color. Petrographic examination of the thin section shows that it is made up of 75 percent angular to sub-rounded grains mainly less than 0.2 mm that tend to be aligned with their long dimension parallel to the bedding. Angular to sub-rounded quartz makes up 15 percent of the rock. Clear to cloudy angular plagioclase feldspar near andesine (An_{40}) showing excellent twinning forms 15 percent of the total. Rock fragments include sandstone, schist, slate, and chert and make up 30 percent of the rock. Magnetite, biotite, and epidote are minor constituents.

The fine-grained sandstone and siltstone indicate deposition in quiet water not close to shore, perhaps the product of relatively weak turbidity currents. The coarse sand and conglomerate of the generally parallel but overlying Olalla Creek Member indicates rather sudden changes in depositional environment with shallowing water and uplift of source. Sedimentation became more rapid as coarser material was laid in a retreating sea.

Olalla Creek Member

The Olalla Creek Member caps Tenmile Butte and lies in a southwesterly plunging syncline in which perhaps 1,000 feet of strata are present along the northwest side of the Tenmile fault. It also occupies the center of a syncline along Olalla Creek in the Camas Valley and Dutchman Butte quadrangles. The member is made up of conglomerate and pebbly sandstone with thinner bedded sandstone and silt in other places. It is difficult to distinguish from the Bushnell Rock Member where the intervening siltstone is thin or absent.

The Olalla Creek Member is best developed at the south end of the basin where it borders the tectonically active Klamath Mountain terrain. The Olalla Creek Member may be seen in the center of the syncline along Olalla Creek, the source of its name, and also intermittently southwest of Tenmile Butte to Buck Springs, to Live Oak Mountain, and on to Dutchman Butte, then through Chipmunk Ridge to

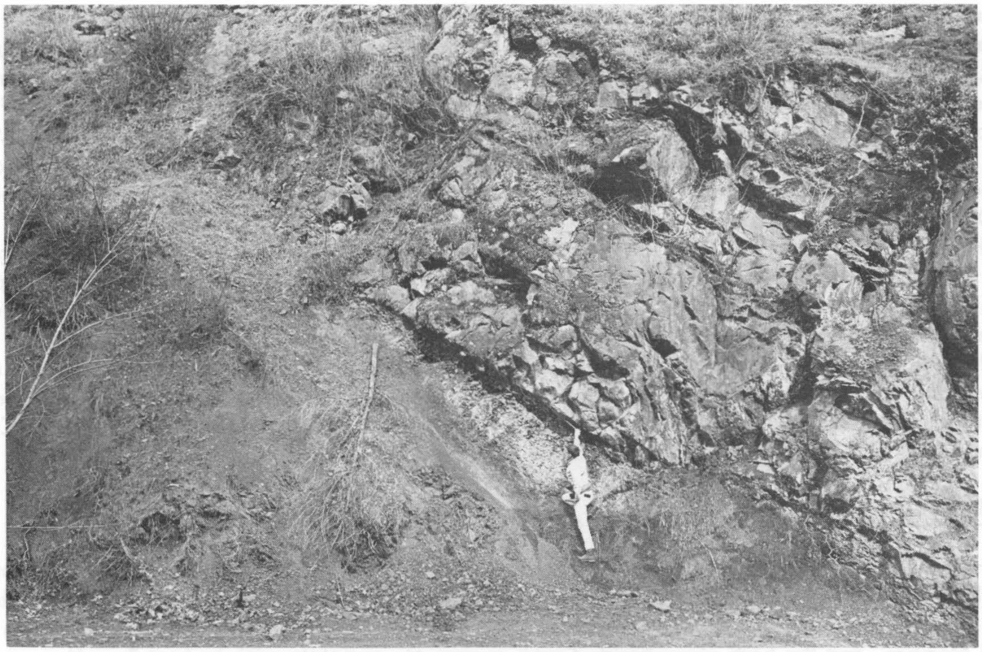


Figure 7. Contact between Roseburg and Lookingglass Formations 200 yards west of Frenchie Creek along Middle Fork of Coquille River. (Photo by Leslie Magoon)

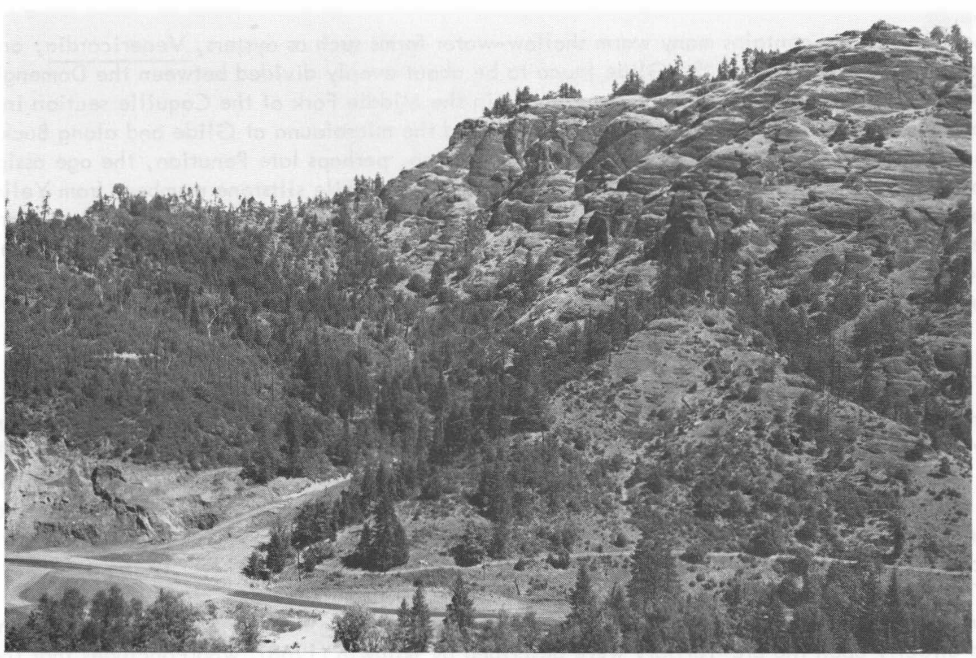


Figure 8. Bushnell Rock Member unconformably overlying Roseburg strata along Tenmile Creek. (Photo by Leslie Magoon)

Twelvemile Creek, and into the Bone Mountain quadrangle. There the Tenmile siltstone is either missing or grades into coarser beds, making the Olalla and Bushnell conglomerates appear to be a continuous section. Siltstone in Twelvemile drainage above the mouth of Boulder Creek in the northwest quarter of the Dutchman Butte quadrangle may be a remnant of the Tenmile siltstone which reappears east of Live Oak Mountain. Johannesen (1972) mapped the basal Lookingglass conglomerate (Bushnell Rock Member) in Long Prairie and eastward to Twelvemile Creek where it extends eastward past the mouth of Dice Creek. It reappears along Mansanita Creek (a tributary of Union Creek) and along Union, Table, and Smith Creeks in the Dutchman Butte quadrangle.

The variable thickness of the Olalla Creek Member and the local absence of the underlying Tenmile Member at Buck Rock, Table Mountain, and Dutchman Butte suggests slight warping with overlapping of the Olalla Creek Member upon the Bushnell Rock Member. The prominent fault zones extending westward from the Riddle area to Union Creek may have been active at this time.

The Olalla Creek Member appears to be missing along the western limb of the Coast Range syncline. Conglomerates and massive sandstone beds in the Rogue River a short distance upstream from Illahe near the mouth of Watson Creek are considered to be basal Flournoy. The composition of the Olalla Creek conglomerate differs little from the Bushnell Rock conglomerate.

Age and correlation

The base of the Lookingglass Formation is exposed about 200 yards west of the mouth of Frenchie Creek along the North Fork of the Coquille River. This point tends to coincide with the division between Turner's "lower" and "upper" Umpqua (Turner, 1938). The beds above the contact correlate with the Bushnell Member, and the beds along Sandy Creek apparently correlate with beds at Tenmile and Glide. No beds comparable to the Olalla Creek Member are found along the Middle Fork of the Coquille.

Baldwin (1964-b) originally considered the section at Glide to be an eastern extension of the Flournoy Formation but herein assigns the Glide beds and fauna to the Lookingglass. The thin conglomerate just west of the Frear Bridge about 3 miles west of Glide is therefore generally equivalent to the Bushnell Rock Member and the overlying sandstone and siltstone beds are generally equivalent to the Tenmile Member.

The Glide fauna contains many warm shallow-water forms such as oysters, Venericardia, and Turritella. Turner (1938) found the Glide fauna to be about evenly divided between the Domengine and Capay stages. Many of the Glide forms are present in the Middle Fork of the Coquille section in what is now regarded as Lookingglass. Thoms (1965) examined the microfauna at Glide and along Buckhorn Creek in the same unit and concludes that both are Penutian, perhaps late Penutian, the age assigned to most of the Lookingglass Formation. Microfossils from the Tenmile siltstone member, from Yellow Creek in the Powers quadrangle, and from Fourmile Creek south of Bandon,also examined by Thoms, were assigned to the Penutian, perhaps late Penutian, stage. Rau (written communication) assigns beds from the Tenmile section to the lower B zones of Laiming, which is equivalent to the late Penutian and perhaps the early Ulatisian.

Size and shape of the basin

The basin during the time of Lookingglass deposition onlapped part of the Klamath Mountains where outliers now rest on the pre-Tertiary rock (Figure 6). It presumably reached its easternmost point a short distance east of Glide. The northwest margin swings past Melrose to a point where it plunges beneath the Tyee Formation. Although no beds of the Lookingglass Formation are known to crop out north of Woodruff Mountain in the Sutherlin quadrangle, conglomerate of probable Lookingglass equivalent was encountered above the Roseburg Formation in the General Petroleum well on Smith River at the mouth of Spencer Creek. The shoreline on the paleogeographic map (Figure 6) is extended to include this area.

A narrow estuary, in part infaulted, lies south of Agness along the Illinois River. Black sands deposited directly upon the pre-Tertiary were described by Baldwin (1968), who concludes that they are middle Umpqua (Lookingglass) and were deposited by streams that drained magnetite-bearing pre-Tertiary strata. Beds higher in the section east of Agness seem to transgress the faults that border the Lookingglass strata. Although contacts have not been traced, the coarser textured beds capping Raspberry Mountain

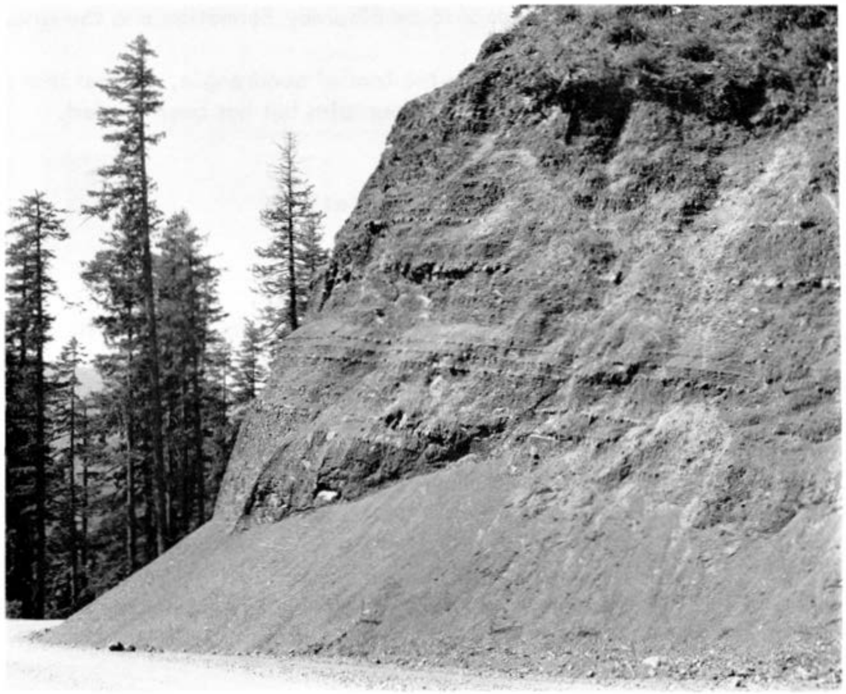


Figure 9. Lookinggloss strata of the Tenmile Member along Rock Creek Road between South Fork of the Coquille River and the Iron Mountain-Agness Road junction. (Photo by Wm. Holser)

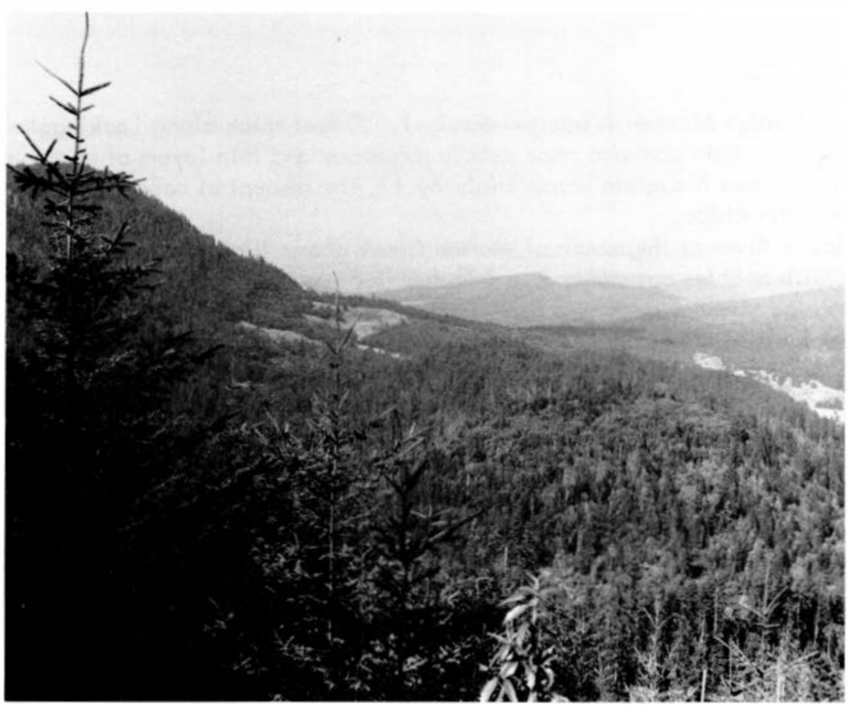


Figure 10. Tyee escarpment at left, with Camas Valley Member of Flournoy Formation in more gentle slope below it; White Tail Ridge Member of Flournoy Formation forms dip slope in middle distance.

and onlapping the Dothan across the fault appear to be Flournoy Formation and the infaulted beds along the Illinois, the Lookingglass Formation.

Outliers, such as the one at Bobs Garden in the Marial quadrangle, suggest that a shallow margin of the basin at one time extended onto the Klamath Mountains but has been eroded.

Flournoy Formation

Description

The Flournoy Formation is herein named for the section of sandstone and siltstone along upper Lookingglass Creek in Flournoy Valley in the Camas Valley quadrangle. Its type section lies between the north edge of Lookingglass Valley and the Tyee escarpment (Figure 10).

The Formation is divisible throughout the entire area into two members. The basal onlapping sandstone and pebbly sandstone making up White Tail Ridge and Sugar Pine Ridge in the Camas Valley quadrangle are included in the White Tail Ridge Member. The overlying siltstone and thin-bedded sandstone in Flournoy Valley and Camas Valley are designated the Camas Valley Member.

The Flournoy Formation is continuous northward to Coles Valley but the outcrop area narrows because of progressive overlap by the Tyee Formation. South of Flournoy Valley and Camas Valley, where the formation is best exposed, only the sandstone of the White Tail Ridge Member is exposed beneath Bone Mountain and Eden Ridge. The beds get coarser in texture to the south along the margin of the Klamath Mountains.

A nearly continous section of the Flournoy Formation is exposed along the Middle Fork of the Coquille River from a point near the east line of sec. 14, T. 30 S., R. 10 W. westward to the mouth of Rock Creek near Remote. Another well-exposed section is situated along a second Rock Creek, which lies south of Bone Mountain and is a tributary to Myrtle Creek. Both of these sections may be regarded as reference sections. No Flournoy Formation is exposed along the western side of the basin in the Coquille drainage south of the Middle Fork.

White Tail Ridge Member

The White Tail Ridge Member is approximately 1,500 feet thick along Lookingglass Creek. In White Tail Ridge the basal sandstone contains some pebbly sandstone and thin layers of conglomerate. However, when traced south of Camas Mountain across Highway 42, the amount of conglomerate increases beneath Bone Mountain and Eden Ridge.

Along the Rogue River at the mouth of Watson Creek above Illahe the basal White Tail Ridge Member is a conglomerate with pebbles commonly 2 to 4 inches in diameter. Conglomerate and pebbly sandstone of the White Tail Ridge Member continues southward to Raspberry Mountain, east of Agness, and overlaps eastward across the fault between the Lookingglass and Dothan Formations. Little if any movement has taken place since deposition of the Flournoy in this area.

North of Remote along the west slope of Thomas Mountain, the White Tail Ridge Member is disconformably overlain by the Tyee sandstone and is very difficult to distinguish from it. Trigger (1966) traced the contact between the two formations. The White Tail Ridge Member thickens and turns westward along the south rim of Brewster Valley south of Sitkum. It crops out along Steel Creek, Cherry Creek, the North Fork of Coquille River, and in Coos River drainage. The sandstone section is 4,000 to 5,000 feet thick along Coos River, although measurable sections are difficult to find. All of the sandstone formerly mapped as Tyee along the Coos and Millacoma Rivers west of Coos Mountain, Golden and Silver Falls, and Elk Peak is now assigned to the White Tail Ridge Member of the Flournoy Formation. The similarity in lithology is striking. It was not until detailed mapping had been done that the unconformable relationship between the Flournoy and Tyee Formations was discovered.

The White Tail Ridge Member along the west side of the basin in Coos River drainage is much thicker than along the eastern edge. This may be due to a western source with greater subsidence to the west and also to facies changes in which the top of the member was deposited higher in the section to the west.

The small remnant of Flournoy sandstone (Tyee of Baldwin, 1969) on the divide between Twomile and Fourmile Creeks south of Bandon, equivalent to the White Tail Ridge Member, shows that the formation extended to or west of the present coast.

Petrographic studies of the Flournoy (White Tail Ridge Member) sandstone along the West Fork of Millicoma River were made by Klohn (1967, p. 25-41). More mica is present than in underlying formations. In this respect the Flournoy Formation is similar to the overlying Tyee and may be derived in large part from the same source.

Camas Valley Member

The Camas Valley Member is best displayed in Camas Valley, where approximately 1,500 feet of the unit is exposed. Similar thicknesses are present in Flournoy Valley. The unit is made up of thin, rhythmically bedded, fine-grained sandstone and siltstone with some thin limestone layers or beds of limestone concretions. Erosion of this member produces rounded hills, relatively smooth slopes, and few outcrops. However, exposures do occur in logging roads and some creek beds. Warping evidently took place prior to deposition of the overlying Tyee Formation for the Tyee rests in places on the White Tail Ridge Member without the Camas Valley Member present. The Tyee also onlaps across the Flournoy onto the Lookingglass and Roseburg Formations so that beds of the Camas Valley Member outside of Camas and Flournoy Valleys make up a small percent of the exposed Flournoy Formation. North of Flournoy Valley the Camas Valley Member is overlapped by the Tyee Formation but is presumably thicker beneath the Tyee to the west.

The Camas Valley Member thins abruptly just south of the Signal Tree Lookout on Kenyon Mountain west of Camas Valley. It thickens in the heart of the syncline to about 500 feet beneath Bone Mountain and may be seen in both the Middle Fork of the Coquille and Rock Creek south of Bone Mountain.

The Camas Valley Member is present at Sitkum, along Steel Creek, Cherry Creek, and the North Fork of the Coquille River. The presence of the Camas Valley Member in places demonstrates an unconformity between the Flournoy and Tyee Formations; thus the thick sandstone section along Coos and Millicoma Rivers is Flournoy and not Tyee as previously mapped.

Age and correlation

The Flournoy Formation is middle Eocene in age. Microfossils from a well in Camas Valley and siltstone beneath the Tyee capping Bone Mountain were assigned by W. W. Rau (written communication, 1957) to the upper B zones (below B-1a) of Laiming (1940) or the Ulatisian of Mallory (1959). The position of the Flournoy Formation between the Lookingglass and Tyee Formations also of middle Eocene age supports this age assignment.

Shape and size of the basin

The Flournoy seaway was one of the most restricted of the Eocene seaways (Figure 6). There is no evidence that it reached east of Roseburg or north of Coles Valley on the east side of the Coast Range although some erosion may have occurred along the margin of the basin. Its northern extent is unknown beneath the Tyee Formation but on the western side of the Coast Range the formation appears to extend northward into and beyond Siuslaw drainage. Beds at the surface and in the upper part of the General Petroleum well at the mouth of Spencer Creek along Smith River are probably Flournoy. Rau (1973-a) has identified microfossils from the well cuttings. They do not confirm or deny the presence of Flournoy beds. The southern extent may be in Raspberry Mountain east of Agness.

Coal was reported by Treasher (1942) from the Melrose and Camas Mountain areas in the White Tail Ridge Member. The conglomerate, pebbly sandstone, and coal were evidently laid in shallow seas with interfingering nonmarine deltaic beds. The thinner upper beds imply deposition in quieter, perhaps deeper neritic water that may have been open to the sea without a barrier.

The source of the Flournoy beds is open to speculation. They may have come from the Klamath Mountains as end-filling a north-trending basin. However, the presence of beds assigned to the Flournoy Formation south of Bandon, and beds at Sacchi Beach that might be Flournoy, suggests a possible barrier farther to the west. The greater thickness of the White Tail Member near Coos Bay suggests that the center of the basin during Flournoy time may have been west of the axis of the Coast Range. If so, post-Flournoy uplift may have caused erosion in the vicinity of the coastline with that area acting as a local source of Tyee beds to the east.

Tyee Formation

Description

The Tyee Formation was named after Tyee Mountain (Diller, 1898) northwest of Roseburg; beds along the Umpqua River including Tyee Mountain are generally considered the type section. Another parallel and well-exposed section is present along Oregon Highway 38 between Elkton and a point 6 miles west of Drain (Baldwin, 1961, Hoover, 1963). The thickness is 5,000 to 6,000 feet to the top of the massive sandstone at Elkton (Baldwin, 1961).

Sandstone of the Tyee Formation is bluish-gray to gray, rhythmically bedded, micaceous, and arkosic. It is firmly cemented and is characterized by abundant flakes of muscovite and bleached biotite, and by fragments of plants along the bedding planes. Most beds in the northern part of the area are composed of medium-grained sandstone and grade upward into fine-grained sandstone and siltstone. The base of each bed is sharply defined and commonly contains groove casts which impart a ropy appearance to the undersides of the sandstone beds. Beds are commonly 2 to 10 feet thick in the southern end of the basin but thin toward the north.

Petrographic studies of the Tyee Formation have been made by Hoover (1963, p. 25-26), and Dott (1966). Special studies of the formation by Snavely and others (1964, p. 461-480) and by Lovell (1969) review the work of others and present far more data concerning mineralogy and rock types than can be given here. These papers should be consulted by those studying the formation. In both of the latter two studies the authors postulate that the sediments came from the south in the Klamath province and that to the north the beds were laid as turbidites by north-flowing currents.

Lovell (1969, p. 12) points to the uniformity of mineralogy of the sandstone, noting that the principal differences lie in the varying percentages of rock fragments and feldspar. He divides the Tyee basin of deposition into the shallow-water nonturbidite southern facies and the northern turbidite facies with a relatively broad transitional zone extending from Coos Bay easterly to where the formation plunges beneath the Cascade Mountains northeast of Roseburg.

The Tyee Formation unconformably overlies the Roseburg, Lookingglass, and Flournoy Formations (Figures 10 and 11). The basal beds rest on all of the older Cenozoic units with a conspicuous absence of basal conglomerate, particularly north of the Middle Fork of the Coquille River.

The general lack of conglomerate where it might otherwise be expected is illustrated in several places. In the Valsetz area, feldspathic micaceous Tyee rests on basalt of the Siletz River Volcanics, and and on Marys Peak it rests on the Kings Valley Siltstone Member of the Siletz River Volcanics with only a few mudstone clasts. Along the South Fork of the Coquille River south of Powers, at a point half a mile north of the mouth of Coal Creek, where the Tyee lies with slight angular relationship on siltstone of the Lookingglass Formation, only a few siltstone clasts occur in the basal few feet (Figure 11). Even near the southern tip of the Tyee basin where the formation comes closest to lapping onto the pre-Tertiary strata (at Hanging Rock overlooking the Rogue River), the massive, coarse sandstone contains only small, randomly dispersed pebbles of quartz and chert. A few beds of conglomerate are prominent locally near Eden Valley south of Powers.

These observations further indicate that the source area was not adjacent to the basin and that the sediments were delivered by rivers bearing mostly sands and silts, perhaps from the granitic parts of the Klamath Mountains. The sediments were apparently swept in from the south and covered a subdued terrane already reduced by erosion. Very little locally derived material is incorporated in the Tyee.

The Tyee as restricted is herein divided into three members, which are mappable along the eastern edge of the Coast Range but have not been traced into the western part (Figure 12).

The Tyee Mountain Member, which makes up Tyee Mountain, is composed of approximately 1,500 feet of massively bedded rhythmites which give way upward with little gradation into the Hubbard Creek Member, a siltstone and thin-bedded sandstone totalling nearly 400 feet in thickness. Hubbard Creek joins the Umpqua River just west of Tyee Mountain, and its valley follows the belt of softer sedimentary rock.

Figure 11. Base of the Tyee Formation upon Lookingglass strata south of Powers near the mouth of Coal Creek. (Photo by Wm. Holser)

Figure 12. Tyee Formation at Golden Falls, East Branch of Millacoma River. (Oregon Highway Div. Photo)

The Hubbard Creek Member is overlain without notable gradation by approximately 2,000 to 2,500 feet of thick-bedded sandstone which greatly resembles the Tyee Mountain Member. The upper unit is named the Baughman Member and is well exposed at Baughman Lookout near the head of Hubbard Creek.

A three-fold division is well shown between Woodby Mountain and Coal Creek Camp near Powers, but it is not known whether it is the same three members that are exposed west of Roseburg.

Tyee Mountain Member

Tyee Mountain lies north of Coles Valley near the upstream entrance of the Umpqua River Canyon through the Coast Range. The beds of the Tyee Mountain Member dip westerly 10 to 15 degrees,with the western slope of the mountain a dip slope. The unit has been traced both north and south from this point. It overlies Roseburg strata and cuts across structural trends to Scott Valley. From there it wraps around and may be traced southward along the foothills of the Cascades to Glide. This member at one time may have covered the entire Roseburg area but was later stripped off.

The Tyee Mountain Member extends south of Tyee Mountain to Mount Gurney in the Camas Valley quadrangle. It terminates against a high of Roseburg sedimentary rock and is absent across the Coos Bay Wagon Road. The Hubbard Creek siltstone member also pinches out at this locality and only the Baughman Member crosses the Wagon Road and extends southward. The Bureau of Land Management Burnt Ridge Road, which leaves the older Wagon Road west of Reston in steeply dipping Roseburg sedimentary rock (Figure 5), soon enters the basal Flournoy with the Lookingglass Formation missing. The narrow part of the valley is in the White Tail Ridge Member of the Flournoy which gives way upward into the Camas Valley Member of the Flournoy. Near the pass at the top of the hill, channeled sandstone and siltstone evidently represent the basal Tyee, although the beds are not nearly as massive as those in Mount Gurney a short distance to the north. Since neither the Flournoy below the basal Tyee nor the Baughman Member above appear to be displaced by faulting, it is concluded that the Tyee Mountain Member dies out abruptly. The Tyee south of Reston along the eastern and southern margin of the basin is apparently the Baughman Member. It is not known whether the Tyee Mountain Member is represented along the western margin between Sitkum and the Umpqua River.

Hubbard Creek Member

The Hubbard Creek Member consists of thin-bedded sandstone and siltstone which is less resistant to erosion than the two sandstone members of the Tyee Formation. Hubbard Creek follows this less resistant band, and erosion of the softer material is evident in topography. The member is traceable from the Burnt Ridge Road near Reston northward to Yellow Mountain in the Drain quadrangle. No effort has been made to trace it farther north. It may lose its identity outside the Tyee and Camas Valley quadrangles and thus be useful only locally.

Baughman Member

The massively bedded sandstone in the Baughman Member is well exposed in the ridge west of Hubbard Creek on which the Baughman Lookout is situated. The beds resemble those of the Tyee Mountain Member and could not be differentiated in the field without the presence of the intervening Hubbard Creek Member. Southward the member crosses the Burnt Ridge Road, where the lower members of the Tyee die out. Farther southward the Baughman Member appears to rest directly upon the Flournoy Formation.

A thin siltstone member between Buzzard Peak and Bear Mountain extends southward at a higher level than the Hubbard Creek Member and caps the slopes on either side of the Coos Bay Wagon Road in the Camas Valley quadrangle. The Tyee Formation is not readily divisible into members along the west side or north of the Umpqua River.

Age and correlation

Megafaunas just above the top of the massive Tyee in sandstone and siltstone beds of the Elkton Formation have been used to date the Tyee in the past and still bear on its age. The Elkton faunas occur at Basket Point along the Umpqua River, at Comstock south of Cottage Grove (Turner, 1938), and a short distance west of Elkton (Baldwin, 1961). Turner assigned the Comstock and Basket Point faunas to the Domengine stage.

Both the Flournoy Formation below the Tyee and the basal faunas above the Tyee are Ulatisian or B-1 of Laiming (1940), and the intervening Tyee is assigned to that microfaunal stage.

Although fossils are relatively scarce in the massive Tyee, the writer has collected relatively large faunas from a sandstone quarry along Matson Creek a short distance above the String of Pearl Falls and in the banks of the South Fork of the Coquille River about 1/4 mile south of the bridge on the Power-Agness Road. Specimens of Venericardia califia are prominent in both faunas. Turritella were found between Golden Falls and Silver Falls along the old Coos Bay-Loon Lake Road; other fossils were found along the banks of Coos River just opposite the mouth of Mink Creek.

Microfossils collected from within the siltier layers of the Tyee, largely in the central Coast Range, confirm the B-1 (Ulatisian) age. Some fossils formerly assigned to the Tyee are now considered to be from the Flournoy Formation.

Snavely and others (1969) list forms, most of them benthonic, from the Newport area and assign a middle Eocene Ulatisian age. McKeel and Lipps (1972) collected principally planktonic forms from the Pioneer Summit area each of Newport, and consider them to be in the upper part of the Tyee and of middle Eocene (Lutetian) age. In comparing the paleoecology of the early Tertiary formations, they note that in modern seas, high-latitude water-masses usually contain fewer species of planktonic forms but in greater numbers than lower-latitude tropical water-masses. They state that the Oregon mid-Tertiary planktonic foraminiferal assemblages are most similar to modern high-latitude assemblages and conclude that during the Eocene and Oligocene a cool water-mass, analogous to the modern transition water-masses, lay off the Oregon Coast, and that circulation patterns within the North Pacific were similar to modern times.

The intermittent and sparse occurrence of calcareous plankton in Oregon rocks are not indicative of truly oceanic water-masses. In modern cool water-masses, planktonic foraminifera are unusually abundant in offshore waters but decrease or are absent in nearshore ones. The reasons for this decrease are not clear although it appears to be related to runoff of terrestrial water. McKeel and Lipps (1972) infer that during the upper Eocene and Oligocene there was significant runoff from land, restricting the oceanic plankton from nearshore deep-water basins.

Size and shape of the basin

Exposures of the Tyee Formation lie in a trough bordered by older rocks, including pre-Tertiary formations along the west side at least as far north as Bandon. The pre-Tertiary barrier appears to have been uplifted during the post-Roseburg hiatus, and it may have remained a high. Snavely and Wagner (1963) postulate a western barrier along the south coast, giving way to perhaps a shallow sill farther north. They show that the dominant current direction was northward as far as 45 degrees north latitude. The Tyee basin was probably an end-filling basin with sediments furnished by streams draining the Klamath Mountain area. Late in Tyee time there was an offlap of the shoreline towards the north as shown by the increased coal content in the upper part of the unit at Eden Ridge and by the shallow-water and coal-bearing sediments of the younger Bateman Formation even farther north (Figure 13).

Since no Tyee is known along the southern coast, a reduction in size of the basin is advocated by Lovell (1969). It is difficult, however, to explain the position of Elkton-age siltstone beds at Sacchi Beach; if they do not represent a western extension of the Tyee-Elkton seas, they may be a phase of Flournoy deposition. The Camas Valley Member of the Flournoy Formation could be confused with the Elkton Formation, for both are largely B-1 in age. The Tyee seas may have extended somewhat farther west than the present scarp, for we see now an eastward retreating erosional scarp. Possibly middle Eocene uplift along the western side caused the massive sandstone of the Flournoy Formation to be a local source of the Tyee beds.

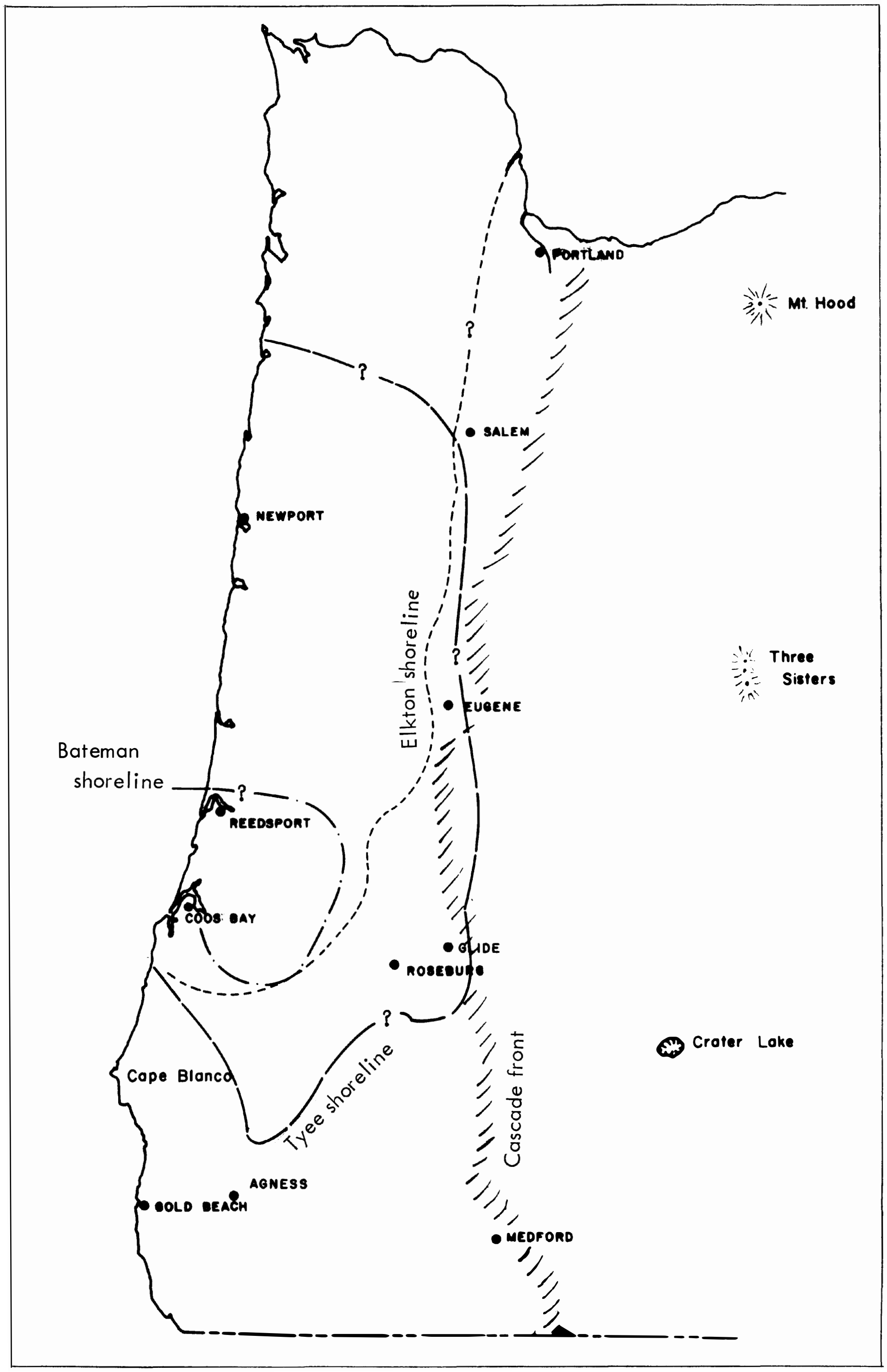


Figure 13. Paleogeographic map of Tyee, Elkton, and Bateman Formations.

Elkton Formation

Description

The Elkton Formation, named for Elkton, Oregon by Baldwin (1961), is made up of siltstone and intertongued lenses of sandstone that occupy a basin reaching southward from Elkton to Green Peak. It is best exposed in a semicircular erosional depression around the more resistant Bateman Formation in the center of the Coast Range. The Elkton Formation was considered to be a member of the Tyee Formation when named by Baldwin (1961). However, Thoms (1965), Bird (1967), and Lovell (1969) consider it to be a formation and the writer concurs.

The Elkton Formation reaches its maximum thickness of nearly 3,000 feet south of Elkton, thins southward, and pinches out near Green Mountain. It is well displayed along upper Lake Creek south of Loon Lake on the west, and from Elkton to Kellogg along the Umpqua River. When originally studied, the Lutsinger Creek Road exposures in the southern part of the Elkton quadrangle were its type section. However, since that time roads along Rader and Waggoner Creeks give a much more continuous section and are recommended as reference sections.

The Elkton is generally parallel with and evidently gradational above the Tyee Formation. Although mudstone and siltstone predominate, lenses of sandstone are intertongued. Where present, they resemble the Tyee beds lithologically and indicate that the sediments were still being derived from the same source. Near the upper part of the Elkton Formation the rhythmic bedding is replaced by cross-bedded, laterally sorted sandstone. The top of the Elkton Formation is difficult to determine in many places. However, in the Lutsinger, Waggoner, and Rader Creek sections the beds become notably thicker and coarser upward over a thin transition zone into the overlying Bateman Formation. South and west of Old Blue along upper Camp Creek the contact is abrupt where a massive bed of sandstone rests disconformably upon the Elkton.

The regional distribution of the Elkton indicates thinning along the margins to the south and west. This may be due to slight adjustments in the basin during deposition, an hypothesis favored by the writer, or to local removal of Elkton beds during a partial withdrawal of the sea. The Elkton Formation evidently represents fine-grained deposition in the Tyee seas at a time the vigor of the streams was diminished. The overlying Bateman Formation may represent offlapping deposition as the sea withdrew.

The siltstone beds at Sacchi Beach south of Cape Arago were called the Sacchi Beach Member of the Tyee by Baldwin (1964-a) and considered equivalent to those of the Elkton, but this name can be abandoned in favor of the name Elkton (Figure 14). A question still exists as to the correlation of the beds at Sacchi Beach. Their downfaulted position and the absence of known Tyee or Elkton beds in the vicinity suggests that the beds may be Flournoy and similar to beds along Cherry Creek east of McKinley.

The Coaledo Formation overlies the siltstone at Sacchi Beach that occupies the center of an anticline. On the southern limb the two units are clearly unconformable, but on the north limb no apparent break is discernible. Dott (1966) suggests that this contact is gradational; however, the writer believes that on the basis of regional distribution the two units are disconformable at this place and angularly unconformably at most other places.

Just south of Sacchi Beach at Threemile Creek there is a fault, south of which the silty beds attributed to the Elkton are overlain by sandstone beds which contain many angular pieces of mudstone. The sandstone may be a local lens within the siltstone and not mappable as a separate unit.

Age and correlation

The Elkton Formation contains megafaunas in places near its base and abundant microfaunas scattered throughout. The Basket Point fauna of Turner (1938) (sec. 30, T. 24 S., R. 7 W.) occurs in basal beds of the Elkton a short distance above the top of the massively bedded Tyee. He assigns this fauna as well as one at Comstock, also at the base of an argillaceous section, to the Domengine stage of California. A large fauna was collected by Baldwin (1961) along Henderer Road along the south bank of the Umpqua River $1\frac{1}{2}$ miles west of Elkton in a similar stratigraphic position to that of the Basket Point fauna and another high in the section along Lutsinger Creek Road. These have been identified (in Baldwin, 1961) and correlated with the Domengine of California. The microfossils were studied by Rau (in Baldwin, 1961), who concludes

Figure 14. Saachi Beach and valley of Fivemile Creek underlain by Elkton Formation. Cliffs at either end of beach composed of Coaledo sandstone, which is down-faulted against Elkton strata to right of photo. (Oregon Highway Div. photo)

that the faunas suggest a shallow, worm-water environment of deposition. Most of the assemblages compore favorably with those referred to Loiming's B-1 zone of California (Loiming, 1940), but o few collections from the uppermost part of the siltstone member best compare with faunas of Loiming's B-1A zone. Both the B-1 and B-1A zones ore considered to be in the Domengine stage of the standard West Coast Eocene (Weaver and others, 1944). Rou (in Baldwin, 1961) found similar foraminiferal assemblages in the Lorane shale member of the Tyee near Eugene, from the Comstock locality, and from Sacchi Beach south of Cope Arogo.

Microfossils from Socchi Beach hove been studied by Stewart (1957), who considers them to be late middle or upper Eocene and equivalent to the Yamhill Formation along Mill Creek in Polk County and the lower port of the McIntosh Formation of Washington, all of which fall within the upper Domengine B-1 to B-1A zones of Loiming (1940) in California or the upper part of the Ulotisian zone of Mallory (1959).

According to McKeel (1972), planktonic foraminifera from the northern port of Agate Beach (just south of Socchi Beach) contained species reported from the middle Eocene elsewhere.

Size and shape of the basin

The transition from massively bedded Tyee sandstone to more argillaceous beds must have come from less vigorous streams and basin currents rather than from notable deepening of the water and advancing shorelines. This conclusion is based on paleoecological data by Durham (Baldwin, 1961), who identified corals from the Henderer Road locality and suggested that they lived in water about 300 feet in depth. Coal in the uppermost Tyee at Eden Ridge suggests a northward offlap of the shoreline to a point somewhat north of Powers. The advent of the Elkton argillaceous beds may indicate a slight advance of the sea, although the Elkton beds are not present around the rim of the basin. It may be that the Elkton beds are offshore facies of the quiet deltaic coal-swamp deposits laid farther south in the basin. This period of lowered source area and less vigorous streams would have continued throughout Elkton deposition. The sandy lenses within the Elkton Formation may have been deposited close to the shifting channels.

The present exposures of Elkton Formation indicate a restriction of the Tyee embayment without withdrawal of the sea. Although the beds may have extended farther, only to be eroded back to their present distribution, the peripheral thinning of the beds to the south and west suggests that the basin may not have been much larger than what we see today. The presence of planktonic foraminifera and the exposure at Sacchi Beach, if truly a part of the Elkton, suggest that the basin was open to the west even though a barrier may have reached as far north as Bandon. Beds of similar age at Lorane and in the Yamhill Valley point to other embayments or a continuous shallow sea over much of western Oregon.

Bateman Formation

Description

Approximately 1,500 feet of shallow marine and continental coal-bearing beds are present in the center of a circular shallow basin surrounded by the more easily eroded Elkton Formation at the south end of the Elkton and Scottsburg quadrangles. Old Blue Lookout, Rainy Peak, and Soup Mountain are situated along the rim. Another outcrop area underlies Bateman Lookout and extends southward to Green Peak and along western ridges to Kelley Butte in the Tyee quadrangle.

Baldwin (1961) mapped these beds near Old Blue Lookout as Coaledo(?) for they resemble the Coaledo lithologically and are above the Tyee Formation. However, later work suggests that the beds are older than the Coaledo Formation.

The Bateman Formation is herein named for the Bateman Lookout in the Tyee quadrangle. The type sections are to the north along the Rader Creek and Waggoner Creek roads where these roads climb the east face of the mountain between Old Blue Lookout and Rainy Peak in the southern part of the Elkton quadrangle.

The Bateman Formation is generally parallel to the underlying Elkton Formation. In some places the contact may be gradational but in others a slight break is inferred. The Bateman lies close to the top of the Tyee Formation in places like Green Peak, and the Elkton Formation thins noticeably near Ivers Peak to the west. In the upper part of Camp Creek a prominent thick basal bed of sandstone containing random boulders as much as a foot in diameter appears to rest with slight angular relation on the thin-bedded Elkton beds. The abrupt change in lithology suggests a slight withdrawal of the sea in this part of the basin. In the Rader Creek section the change in lithology is not as abrupt and the contact is placed at the base of the more massive sandstone. The lithologic breaks indicate little more than regional warping and short time lapse.

The Bateman Formation is made up mostly of crossbedded and current-sorted sandstone. Some silty sandstone and siltstone interbedded with coal beds occur in its upper part. The rock is medium gray when fresh, micaceous, and contains abundant plant fragments including broad-leaf plants and ferns. The coal beds contain appreciable silty material and few are potentially commercial.

The Bateman Formation appears to represent the final deposits of the offlapping Tyee seas. Channelling, crossbedding, and current sorting without a preponderance of rhythmic bedding point to a shallow-water environment, and the abundance of coal beds in the upper part denote interfingering of the nonmarine and marine beds, perhaps on broad prograding deltas. Uplift and erosion is thought to have occurred in the Coast Range prior to the encroachment of the Coaledo seas, for at all other places the Coaledo appears to rest unconformably upon older formations.

Age and correlation

Megafossils are present in the Bateman Formation but no large assemblage has been collected. The writer found a well preserved specimen of *Venericardia califia* in the basal sandstone bed along the North Fork of Bottom Creek in sec. 13, T. 25 S., R. 9 W., a species related to the Tyee and not reported from the Coaledo. Microfossils are present and Bird (written communication, June 20, 1967) examined two samples from the ridge east of Ivers Peak. These samples yielded abundant foraminifera which indicate an upper Ulatisian age for the strata and deposition at shelf depths, probably between 200 and 600 feet deep. His age determination seems to corroborate the writer's conclusion that the Bateman Formation is somewhat older than the Coaledo Formation.

Brown (Baldwin, 1961) lists the plants associated with the coal-bearing strata at the top of the Bateman Formation. He found many ferns typical of a warm subtropical to tropical climate. Hopkins (1967) lists the plants associated with the Coaledo Formation as determined largely from spores and seeds. A comparison of Brown's and Hopkins' lists does not show much in common, although the environment in and near the swamps should be similar. The difference may be more apparent than real because of comparison of leaves with spores and pollen; however, it may also support the somewhat younger age of the Coaledo beds.

Size and shape of the basin

The only younger strata generally conformable with the Tyee and Elkton strata are confined to the southern part of the Coast Range. It is difficult to determine whether such offlapping strata reached farther to the north, only to be eroded later. The basin appears to have shrunk after Tyee onlap, and, as the coal of the upper part of the Bateman was laid down, the sea evidently withdrew from the Coast Range (Figure 13).

Coaledo Formation

Description:

Diller (1901) designated the coal-bearing part of his Arago Formation as the Coaledo Formation. The noncoal-bearing part was originally named the Pulaski Formation, but because this name was preempted elsewhere, it was abandoned. Allen and Baldwin (1944) noted that the Pulaski Formation, as applied by Diller (1901), included beds now recognized as Coaledo. Thus the name Arago duplicated that of the Coaledo and the name Coaledo has survived. The Coaledo Formation is found only in the Coos Bay area, extending as far north as Eel Lake near the Coos County line.

Turner (1938) divided the Coaledo Formation into a lower sandstone member, a middle siltstone member, and an upper sandstone member and described their faunas (Figure 15). Allen and Baldwin (1944) and Baldwin (1969, 1973) extended the three units throughout the Coos Bay coal field. They found that the middle Coaledo thinned along the eastern margin of the basin where it probably in part interfingered with more sandy facies. The beds east of the Summer basin and north of the Coos River to Tenmile Lake cannot be differentiated so were mapped by Baldwin (1973) as Coaledo undifferentiated.

The Coaledo Formation is made up of light- to medium-gray nonrhythmically bedded sandstone with thin, dark-gray beds of siltstone and mudstone commonly bearing carbonaceous material. In places, the sandstone contains thin beds of conglomerate and layers of pebbly sandstone. Primary sedimentary features such as slump structures, ripple marks, and intraformational conglomerates composed of mudstone clasts are abundant. These features, as well as the physical setting and petrography of the Coaledo Formation, have been discussed by Dott (1966). Dott suggested that the Klamath provenance for the Coos Bay Eocene comprised approximately 50 percent volcanic, 30 percent sedimentary, and 20 percent metamorphic rock. Rottman (1970) discusses the composition of the Coaledo sandstone near Cape Arago. The Coos Bay area has been mapped in much more detail by Baldwin (1973) than can be shown here, and the stratigraphy of the Coaledo Formation is discussed by Baldwin and Beaulieu (1973).

Figure 15. Cooledo Formation crops out from Cape Arago Lighthouse in foreground to Cape Arago in distance. Middle member exposed in Sunset Bay to left; lower member forms Lighthouse Point and offshore rocks. (Photo by Ward Robertson)

Age and correlation

Megafaunas are abundant in the lower and upper Coaledo members, and microfaunas occur in the middle Coaledo mudstone and in mudstone layers in both the upper and lower Coaledo. Turner (1938) identified and listed the megafauna of the Coaledo and concluded that it was late Eocene and generally equivalent to the Tejon of California. Allen and Baldwin (1944) added a few species but noted that the fauna of the lower and upper members differed very little and thus represented rapid deposition. Weaver (1945) listed the fauna and also correlated it with the Cowlitz Formation of Washington and the Tejon of California.

Microfaunas have been studied by Detling (1946), Cushman and others (1947), and Stewart (1957). Microfaunas generally fall in the A-1 zone of Laiming (1940) and the Narizian of Mallory (1959).

The Coaledo Formation apparently formed in warm shallow seas into which deltaic sediments, commonly coal bearing, were being deposited. The unit correlates with the Spencer, upper Nestucca, and Cowlitz Formations in northwestern Oregon and Washington, and all were probably deposited during the Tejon stage of California. Temperature differences may cause the correlation with the California section to be less sure.

Size and shape of the basin

Weaver (1945) believed that the "Arago" beds were deposited as a gulf with a western barrier, either a peninsula or islands, and that it may have been coextensive with the Cowlitz gulf to the north. He believed that there was some evidence that a portion of the "Arago Formation" received its sediments from west of the present coast.

Snavely and Wagner (1963) show a slight western barrier for the late Eocene. Dott (1966) shows an open embayment with no western barrier but perhaps an occasional volcanic island farther northward. The writer's work points to a slight barrier much as suggested by Snavely and Wagner (1963) (Figure 16). Pre-Tertiary rock is present along the coast as far north as Bandon. Coaledo strata lap against older formations to the west along the southern part of the depositional area and apparently overstep all of the older Tertiary formations to rest upon or next to the Jurassic strata in Bandon (Baldwin, 1965). According to Wagner and Newton (1969, p. 291), the Pan American Petroleum Co. well drilled in the Cape Arago Block several miles off Cape Arago penetrated 6,146 feet of strata and is thought to have encountered pre-Tertiary rock. The overlying strata would probably be Coaledo near the top and possibly lower Eocene (Roseburg Formation) near the base. The northernmost Coaledo strata along the coast reaches nearly to Clear Lake south of Reedsport. It is not known whether the Coaledo embayment was continuous and widespread farther north in the Coast Range or whether local deposits in minor gulfs were laid down intermittently northward into Washington.

Spencer Formation

The Spencer Formation was named and described by Turner (1938). It crops out in the Anlauf quadrangle and northward along the east edge of the Coast Range. The beds in the area mapped are shallow-water marine, interfinger with continental coal-bearing strata near Comstock, and pinch out south of Comstock. The beds have been mapped and described by Hoover (1963). The fauna of the Spencer Formation is comparable to that of the Coaledo, and it has been included in the discussion of the Coaledo seaways.

Colestin Formation

The only wholly Eocene nonmarine formation exposed within the map area is a series of flows, breccias, tuffs, and tuffaceous sandstones and conglomerates (Figure 17) that crop out along the western edge of the Cascade Range. These strata have been mapped and described by Hoover (1963) as the Fisher Formation in the Anlauf quadrangle. Wells and Waters (1934) referred to them as the Calapooya Formation and Peck and others (1964) as the Colestin Formation.

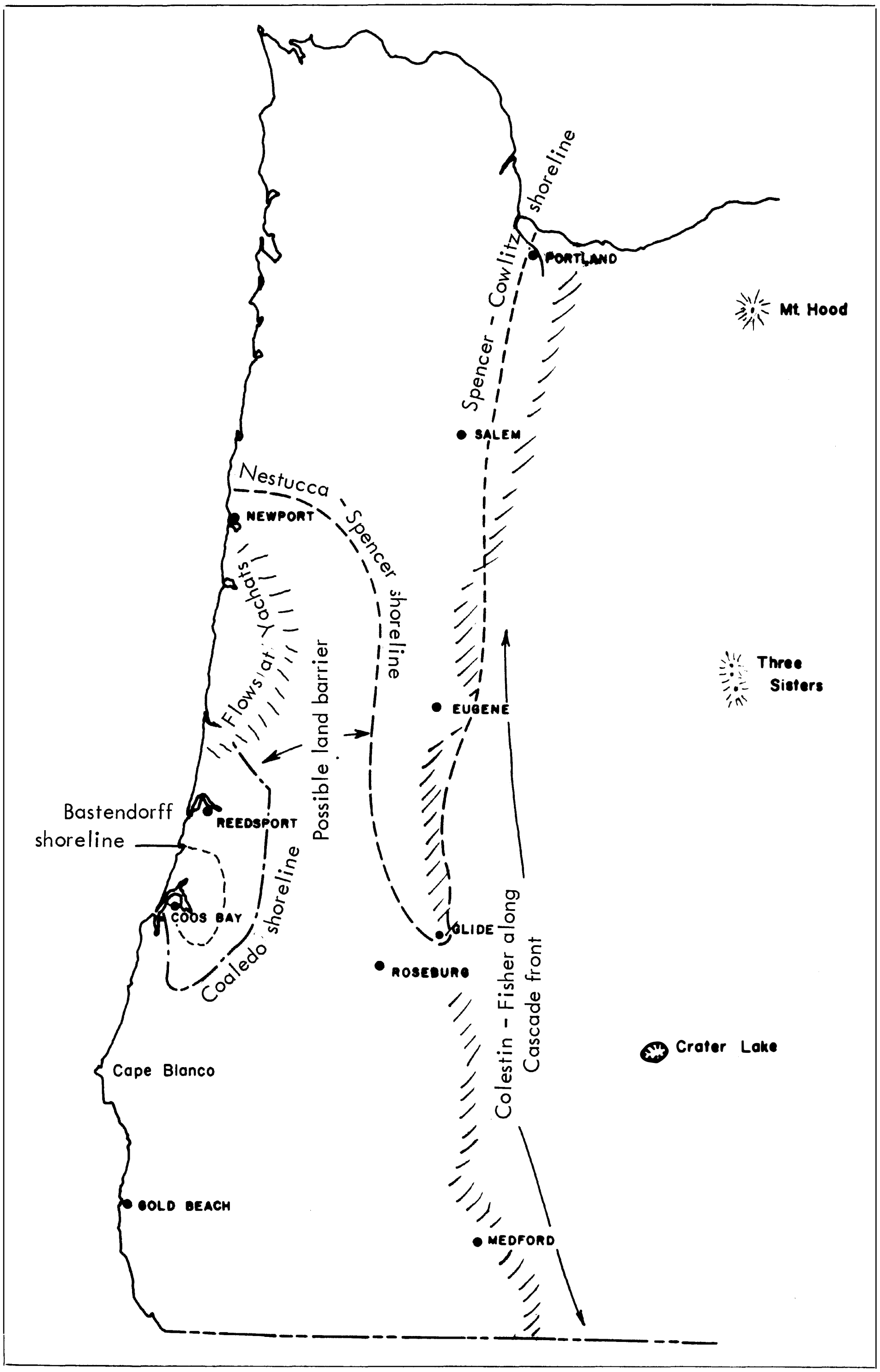


Figure 16. Paleogeographic map of Coaledo, Colestin, Spencer, and Bastendorff Formations.

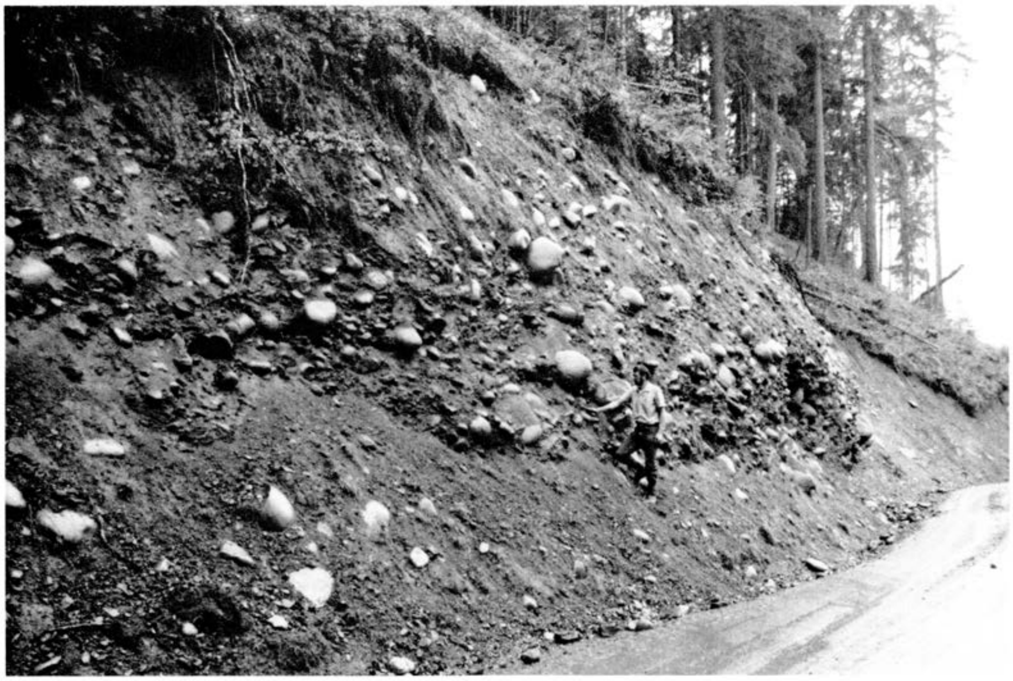


Figure 17. Conglomerate in Colestin Formation on Whiterock Road, southeast quarter of the Dixonville quadrangle.

The Colestin Formation covers the eastern margin of older marine Eocene strata and dips eastward beneath the younger volcanic rocks of the Cascade Range. These relationships obscure the easternmost extensions of the earlier Eocene seaways. The Colestin may have been marginal to the late Eocene marine Coaledo strata.

Tuffaceous conglomerates and sandstone beneath White Rock in the southeastern corner of the Dixonville quadrangle have been traced northward along Cavitt Creek as far as Little River by Seeley (1974) and Champ (1969). At Glide and northward, Elphic (1969) and Thompson (1968) also found nearly all sedimentary rock. However, in the Anlauf quadrangle, where the section is much thicker, Hoover (1963) found interfingered flows, tuffs and breccias, and sedimentary rocks.

In this report the name Colestin is used, although Fisher is probably appropriate for the formation in the Anlauf quadrangle northward to the Eugene area.

Brown (in Hoover, 1963) assigns the Fisher (Colestin) Formation largely to the late Eocene on the basis of plant fossils. It rests upon the upper Eocene marine Spencer Formation and may be in part early Oligocene in age.

Bastendorff Formation

Description

The Bastendorff Formation was named by Schenck (1927) for the outcrops in the coastal section along Bastendorff Beach, where 2,900 feet of shale with one sandy member perhaps 50 feet thick crops out. The narrow valley of Miner Creek obscures the lower part of the section but examination of the hills to the south reveals the continuity of the argillaceous beds and their parallel and apparently conformable relationship to the underlying upper Coaledo.

The Bastendorff Formation occupies the South Slough syncline but is best shown along the western limb primarily in the beach section. It also crops out in the center of the Isthmus Slough syncline at Eastside, near Green Acres south of Delmar, and in Beaver Hill at the north edge of the Coquille Valley. The beds weather to a light shade of tan or gray. Diller (1901) referred to these beds as diatomaceous although he did not separate them from his Arago Formation.

The Bastendorff beds are made of dark-gray to medium-gray shale and siltstone with some thin, white tuffaceous layers. Considerable organic material is present, including abundant well-preserved foraminifera.

Age and correlation

Microfossils were studied first by Cushman and Schenck (1928). Later studies by Detling (1946) and Stewart (1957) indicate that the basal Bastendorff is of late Eocene age and the upper part is early Oligocene, Refugian in age. McKeel (1972) suggests that the entire Bastendorff may be late Eocene.

Size and shape of the basin

The shale of the Bastendorff Formation was laid down in a sea open to the ocean; shoreline deposits are not known. Thus the margins may be considerably east of the outcrop area that is limited to the Isthmus and South Slough synclines. The Keasey Formation of northwest Oregon is comparable in age. Coarser nearshore beds at Looney Butte south of Salem contain a Keasey fauna. It is possible that similar marginal beds were deposited around the eastern edge of the Bastendorff basin.

Intrusive Igneous Rocks

Sills and dikes of basic to intermediate composition are present east of Roseburg near the junction of Little River and the North Fork of the Umpqua River, in Scott Mountain, Ben Moore Mountain, and in other places nearby. They intrude rocks as young as late Eocene but may be related to volcanic activity that took place during late Eocene or post-Eocene time. These intrusive rocks have been discussed by Hoover (1963), who concluded that they were post-Fisher and therefore Oligocene or younger in age.

Post-Eocene Formations

Oligocene and younger strata crop out along the coast mainly in the center of the South Slough syncline in the Coos Bay area and along the beach south of Bandon. These have been mapped by Baldwin (1973) and discussed by Baldwin and Beaulieu (1973). Miocene and Pliocene formations are present at Cape Blanco. None of the post-Eocene formations are mapped separately. They represent shallow embayments upon the older strata, none of which apparently lapped far onto the older rocks.

Plio-Pleistocene marine and river terraces parallel the coastline and occur intermittently along the valleys.

TECTONIC HISTORY

Much of southwestern Oregon was a part of the open ocean during the early Cenozoic. The western edge of the continental plate lies under the western foothills of the Cascade Range, from which point the crust thickens eastward (H.R. Blank, verbal communication).

During the Paleocene and early Eocene, volcanic extrusions on the sea floor interfingered with continentally derived sediments. Islands may have formed offshore. Relative movement between the oceanic plates and the continental plate near the end of early Eocene crumpled the sedimentary and volcanic rock, and in places induced thrusting. Volcanic masses that may have been a considerable distance offshore now occupy a thickened edge of the continent.

Subduction and underthrusting of the oceanic plate caused asymmetrical folds and reverse faults with relative movement of the overriding block toward the west-northwest. At the end of early Eocene (Penutian) northeast – east structural trends formed in the Roseburg and older formations parallel to the northern edge of the Klamath Range. This was probably a continuation of an earlier structural pattern in the Klamath Mountains. In contrast, gentler structural trends following this relatively brief but intense orogeny are more northerly and not related to the Klamath Mountain orogenies. The post-early Eocene orogeny was the culmination of Klamath Mountain orogenies.

Serpentinite and diapiric masses of Otter Point mélange were squeezed along faults into Roseburg strata during early Eocene deformation. Mountains undoubtedly formed, only to be worn down before the onlapping basal conglomerate of the Lookingglass Formation was laid on both the older Cenozoic rocks and the Mesozoic rocks of the Klamath Mountains.

Dott (1966) considers many aspects of Eocene deposition of southwestern Oregon. His descriptions of sedimentary structures and sedimentary petrology and petrography are useful in determining the environment and mode of deposition. However, his distribution of stratigraphic units differs greatly from that of this report. Dott (1966) envisions a continuous deltaic type of deposition in open-sea environment throughout Eocene time. In contrast, detailed regional field mapping prompts the writer to recognize regional unconformities and multiple incursions of the seas, with attendant nearshore and more open-ocean facies with each invasion. The Eocene picture as portrayed here is far more rigorous than that outlined by earlier writers. Dott, in his Figure 16, shows only one prominent age for the pillow lavas rather than separate and widely scattered bodies of lava as shown on his Figures 12 and 13. The writer recognizes only one stage of volcanism in the early Eocene and one in the late Eocene in the Colestin and Fisher Formations as well as at Heceta Head north of the area mapped.

The early Eocene seas evidently were aligned with pronounced northeasterly structural trends of the Klamath Mountains, and the shoreline may have extended beneath the Cascade Range into eastern Oregon, where early Eocene strata may be buried beneath younger formations. Dott (1966) shows the northeasterly trend of the shorelines, a trend that he carries throughout the Eocene. However, in the opinion of the writer, the trends swung more northerly with advance of the Lookingglass sea and paralleled the axis of the Cascade Range. Post-Roseburg structural trends continued to be more northerly.

The Lookingglass conglomerate is thickest near the Klamath Mountains and thins or is missing to the north. As onlap continued, the beds passed upward to sandstone then to thin-bedded sandstone and siltstone. However, on the southeastern side of the basin near Camas Valley and Dutchman Butte, the upper part of the Lookingglass is made up of conglomerate, indicating an offlapping sea.

The sea withdrew from western Oregon as warping and normal faulting occurred. Then the basal Flournoy sandstone and pebbly sandstone was laid by an incoming sea that reached Melrose and Lookingglass and possibly at one time as far as Roseburg. In the Coos Bay area, the basal sandstone thickens and makes up most of the formation although silts of the upper part may be in part eroded.

Some warping and faulting accompanied uplift and withdrawal of the Flournoy seaway. The Flournoy and Lookingglass were removed from some of the elevated parts so that the oncoming Tyee sea overlapped all of the older Cenozoic formations. At Hanging Rock near the south end of the Tyee basin it onlapped upon the Jurassic Rogue Formation.

The Roseburg, Lookingglass, and Flournoy seas, even though shallow at times, were generally open to the west, but the Tyee basin may have had a western barrier as far north as Bandon or even farther (Figures 6 and 13). Current indicators show a northerly trend, suggesting an end-filling basin with sediments derived from the Klamath Mountains to the south. It is possible that uplift of the western barrier furnished sediments locally for the Flournoy and Lookingglass.

Late Tyee deposition gave way to siltstone deposition of the Elkton Formation in the central part of the Coast Range. Meanwhile, offlapping shorelines were accompanied by deposition of coal-forming plant material near Eden Ridge. Offlap continued as a blanket of shallow-water Bateman sandstone spread northward over the siltstone of the Elkton Formation in the central part of the Coast Range. The Tyee-Elkton-Bateman sea withdrew from the Coast Range. These formations are gently folded but only slightly faulted compared to the Flournoy and older formations.

The Coaledo basin of deposition was apparently local and restricted, although equivalent sedimentary rocks are found near Eugene and southward towards Roseburg (Figure 15). It is not known whether the basin of deposition was continuous across the Coast Range or whether a separate basin extended into the southern Willamette Valley from the northwest.

The Coaledo Formation was deposited along prograding deltas during lower and upper Coaledo time. Advancing shorelines with deeper and quieter waters prevailed during middle Coaledo and Bastendorff time. Regional mapping shows that the resulting sandstone and siltstone are distinct units not duplicated by thrusting, as postulated by Duncan (1953).

The western peninsular barrier probably existed during Coaledo time. A thin deposit of Coaledo in Bandon, resting on either folded Roseburg or Jurassic Otter Point or both, shows that this had been a positive area with either nondeposition or removal of many of the pre-Coaledo formations.

The eastern limb of the South Slough syncline, although largely obscured by terrace deposits, is evidently steep to slightly overturned toward the west. The orogenic movement that compressed this syncline evidently had little effect upon the Coast Range to the east.

Although the tuffaceous Oligocene Tunnel Point beds appear to be conformable upon the Bastendorff shales, a rather sudden change in sediment type and source is indicated. Perhaps contemporaneous volcanism in the ancestral Cascade Range was the chief source. The Coaledo, Bastendorff, and Tunnel Point Formations were folded during the late Oligocene or early Miocene. Miocene sediments were deposited in the South Slough syncline. Deformation and erosion near the end of the Miocene was followed by an onlap of the Pliocene Empire Formation across the eroded edge of Miocene beds onto the older formations. The Empire Formation was also folded along the axis of the South Slough syncline later in the Pliocene and early Pleistocene. Baldwin (1966) has postulated that folding of the South Slough syncline has continued intermittently from Tunnel Point times to the present, for even the low terraces dip gently toward the axis. Post-Empire faulting took place near Cape Blanco, and warping of the Pleistocene terraces evidently continues today.

Eustatic movements of sea level accompanying the glacial stages produced terraces and alluviated stream valleys.

SOME REMAINING PROBLEMS

Although the major stratigraphic units have been traced and major structural features mapped, many problems still exist that require further work. A report of this magnitude brings to light some of the problems that still need additional attention.

The base of the Roseburg Formation has been located in very few places. It would be helpful if a more complete section could be found, measured, and dated. Members and local unconformities within the Roseburg Formation need to be traced. The contact between beds mapped as Roseburg and beds bearing Cretaceous fossils needs to be determined. In some places Cretaceous beds may have been included inadvertently within the Roseburg owing to inclusion of tectonic blocks or questionable assignment of outlying outcrops that contain insufficient fossils for dating. Along the Rogue River north of Agness, beds near Twomile Creek are mapped as Roseburg Formation on the basis of lithology, fauna, and flora. But the basal contact of these beds with Cretaceous strata near Waters Creek and the upper contact with Lookingglass Formation near Illahe are uncertain.

The Lookingglass Formation exposed along the South Fork of the Coquille and into Foster Creek lacks members, and nearly all is thin-bedded sandstone and siltstone, with the siltstone the more evident in many places. The contact between the Lookingglass and Flournoy Formations in the infaulted blocks along the Illinois River is obscure. The Lookingglass seems to be infaulted in grabens, whereas the Flournoy, as at Raspberry Mountain, onlaps across the faults bordering the Lookingglass.

The Flournoy Formation crops out over a large area east of Coos Bay and northward into Umpqua and Siuslaw River drainages. The Flournoy sandstone is so similar to that of the Tyee that it was formerly considered to be Tyee. Now the problem of differentiating becomes increasingly difficult when the contact is traced to the north. The contact may be placed with fair confidence from the Middle Fork of the Coquille to Elk Peak in upper Millacoma River drainage, with less certainty to the Umpqua River, and from there only tentatively. Nearly all of the strata along the Siuslaw west of Mapleton and all that in North Fork of the Siuslaw drainage is more likely to be Flournoy. It is probable that beds as far north as Pioneer Summit, as well as much if not all of the Burpee Formation of Schenck (1927), are in reality Flournoy. Baldwin (1956) shows that most of the dips in the Mapleton area are southward. Thus the Tyee between the Umpqua and Siuslaw Rivers may plunge to the south. It has already been noted that the center of the Tyee basin lies closer to the east side of the Coast Range. Thus the rock along the lower Siuslaw may be Flournoy, whereas the massive sandstone in the cliffs between Route F tunnel and Wildcat Creek eastward to Noti may be Tyee. The relationship is yet to be determined.

Additional structure data is needed. The extent of lower Eocene thrusting needs to be determined. Gravity faults, which are difficult to recognize within formations, have probably been overlooked within the broad expanses of Flournoy and Tyee sandstones.

Continued work is needed on current trends, source of sediments, and mineral identification. A study of nannoplankton, spores, and pollen, using techniques as yet unexploited, should lead to a better understanding of the age, distribution, and history of the southern Coast Range.

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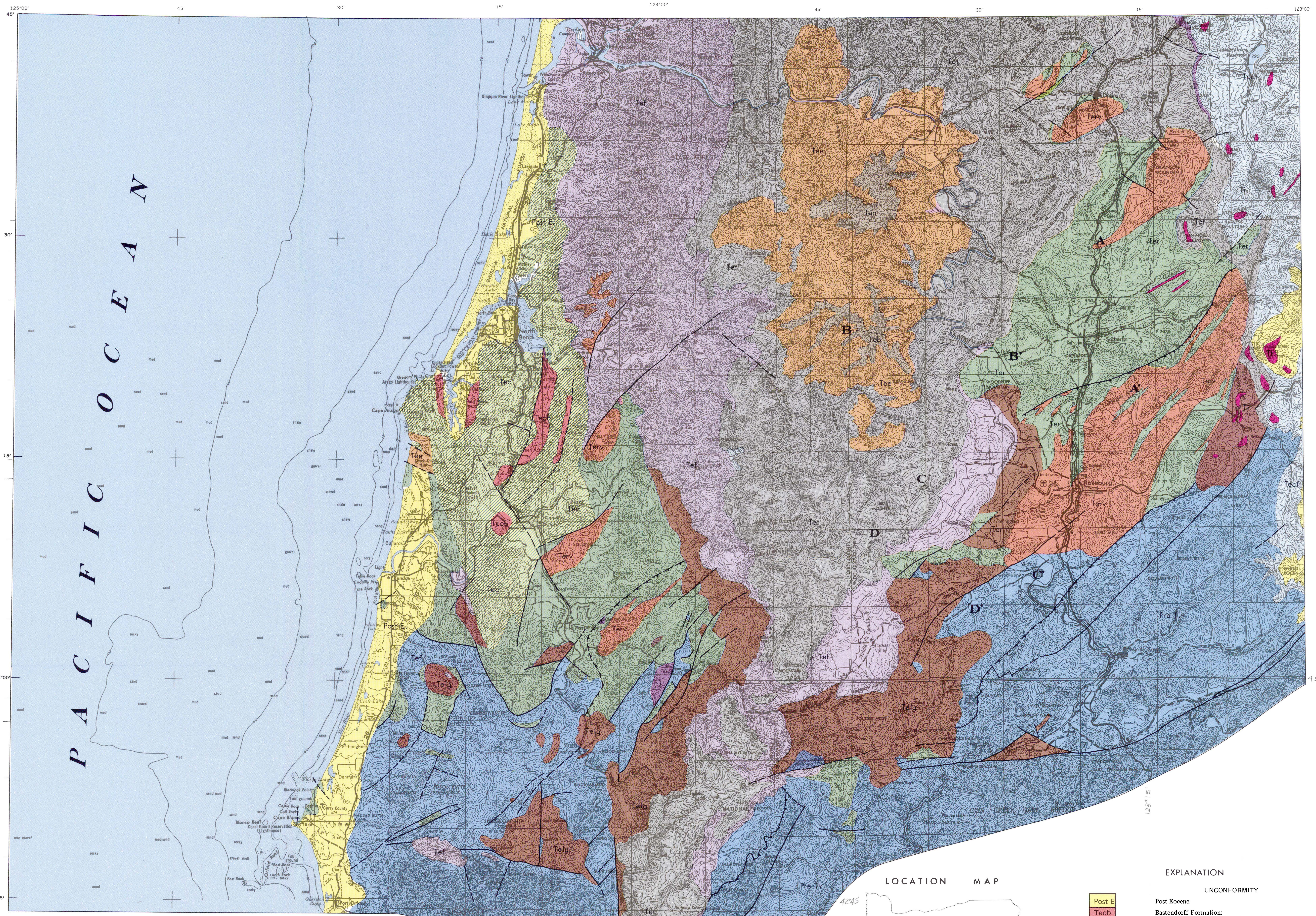
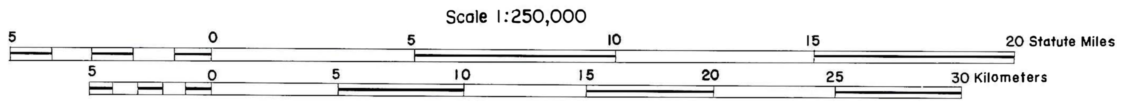
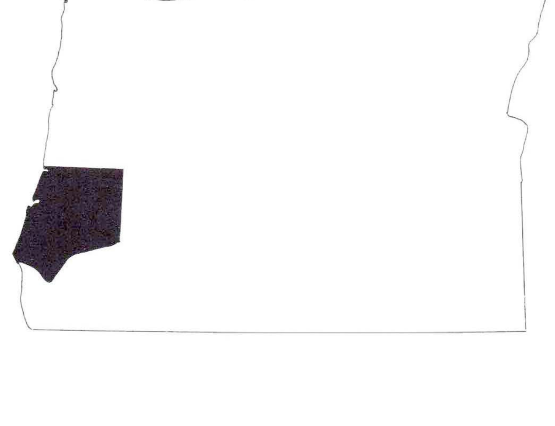
Eocene Stratigraphy of Southwest Oregon





Contour interval 200 feet

Base map from Army Map Service topographic series maps 1:250,000 scale (Coos Bay 1958, Medford 1963, Roseburg 1966), joined by Oregon Department of Geology and Mineral Industries Cartographic Section



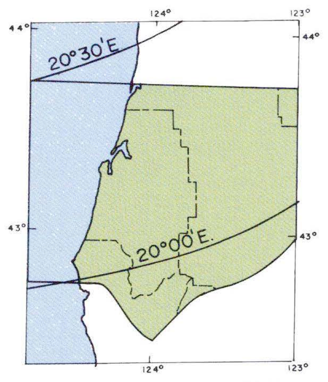
Geology by E. M. Baldwin

Cartography by *S. R. Renoud and W. H. Pokorny*

1974

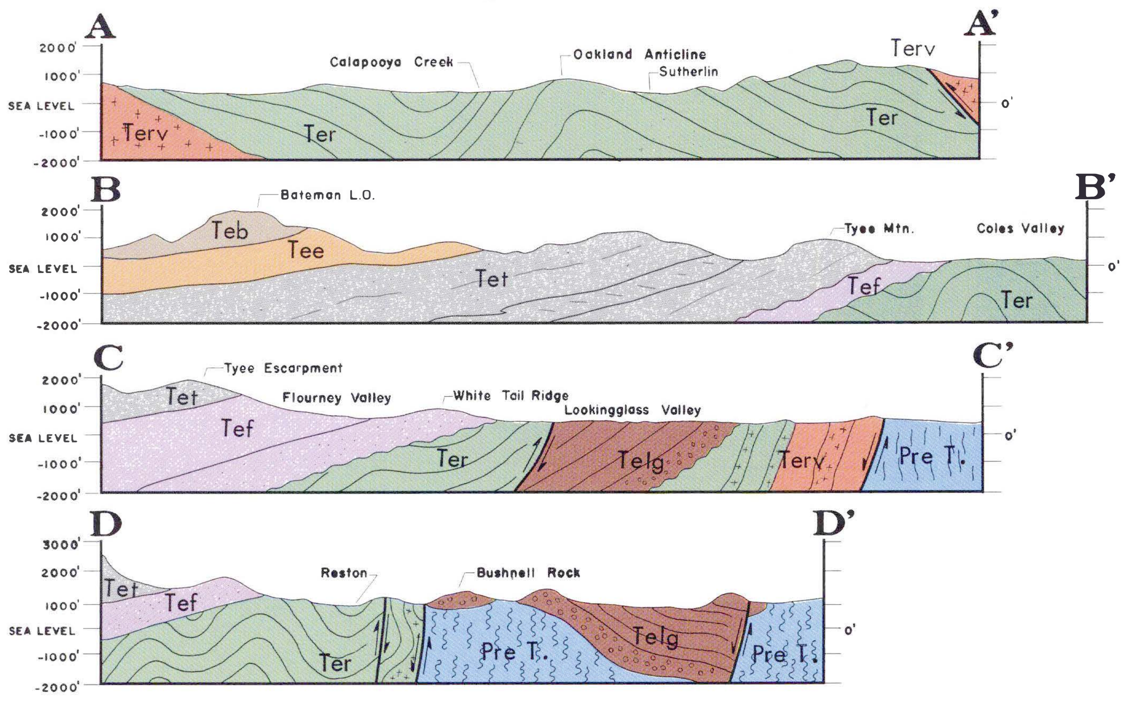
Drain and Anlauf quadrangles after Hoover, 1963

(See text)

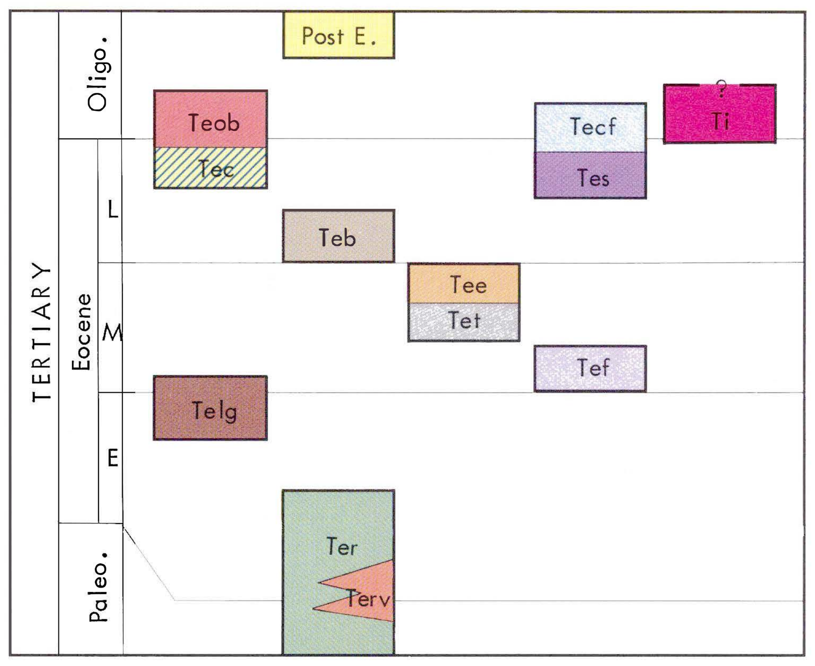


ISOGONIC CHART: 1965

Geologic Cross Sections



Stratigraphic Time Chart



EXPLANATION

UNCONFORMITY

Post E	Post Eocene
Teob	Bastendorff Formation: *Thinly bedded gray to buff shale and minor sandstone.*
Tecf	Colestin and Fisher Formations: *Flows and volcaniclastic beds, conglomerate and tuffaceous sandstone*
Tec	Coaledo Formation: *Sequence consisting of three members; lower and upper members consist of coal-bearing, cross-bedded, tuffaceous sandstone, and middle member consists of thin-bedded siltstone with minor sandstone.*
Tes	Spencer Formation: *Sandstone with some coaly beds.*
Teb	Bateman Formation: *Thickly bedded to cross-bedded, medium-grained, micaceous, deltaic 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.*

UNCONFORMITY

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

UNCONFORMITY

Terv / Ter	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.*
Ti	Tertiary intrusive rock: *Sills and dikes of basic to intermediate composition.*
Pre T.	Pretertiary

GEOLOGIC SYMBOLS

Contacts solid where definite, dashed where approximate

Faults solid where definite, dashed where approximate

Thrust faults solid where definite, dashed where approximate

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