

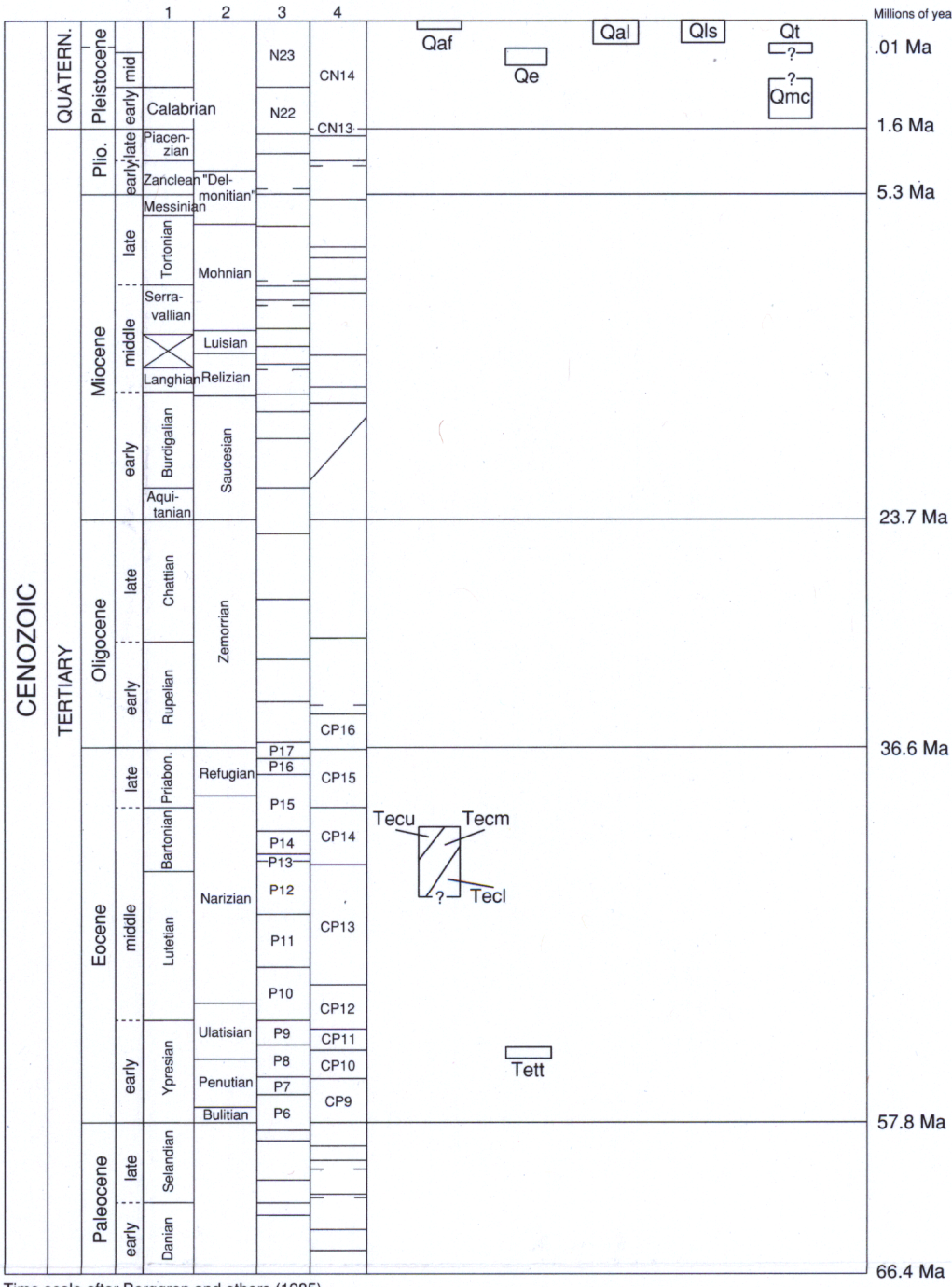
Geologic Map of the Coos Bay Quadrangle, Coos County, Oregon

1995

GMS-97
Geologic Map of the Coos Bay Quadrangle, Coos County, Oregon
By G.L. Black and I.P. Madin

Research was supported in part by the U.S. Geological Survey (USGS), Department of the Interior, under USGS award 14-08-001-A0012 and U.S. Department of Interior, Minerals Management Service, Cooperative Agreement 14-35-0001-30731. Contract management was provided by the University of Texas Bureau of Economic Geology.

TIME ROCK CHART



EXPLANATION OF MAP UNITS

(See accompanying text for complete geologic explanation)

Quaternary Deposits

- Qal Artificial fill (recent)
- Qal Quaternary alluvium and estuarine sediments (Holocene)
- Qls Landslide deposits (Holocene)
- Qe Quaternary estuarine terrace deposits (Pleistocene)
- Qt Quaternary terrace deposits (Pleistocene)
- Qmc Metcalc marine terrace (Pleistocene)

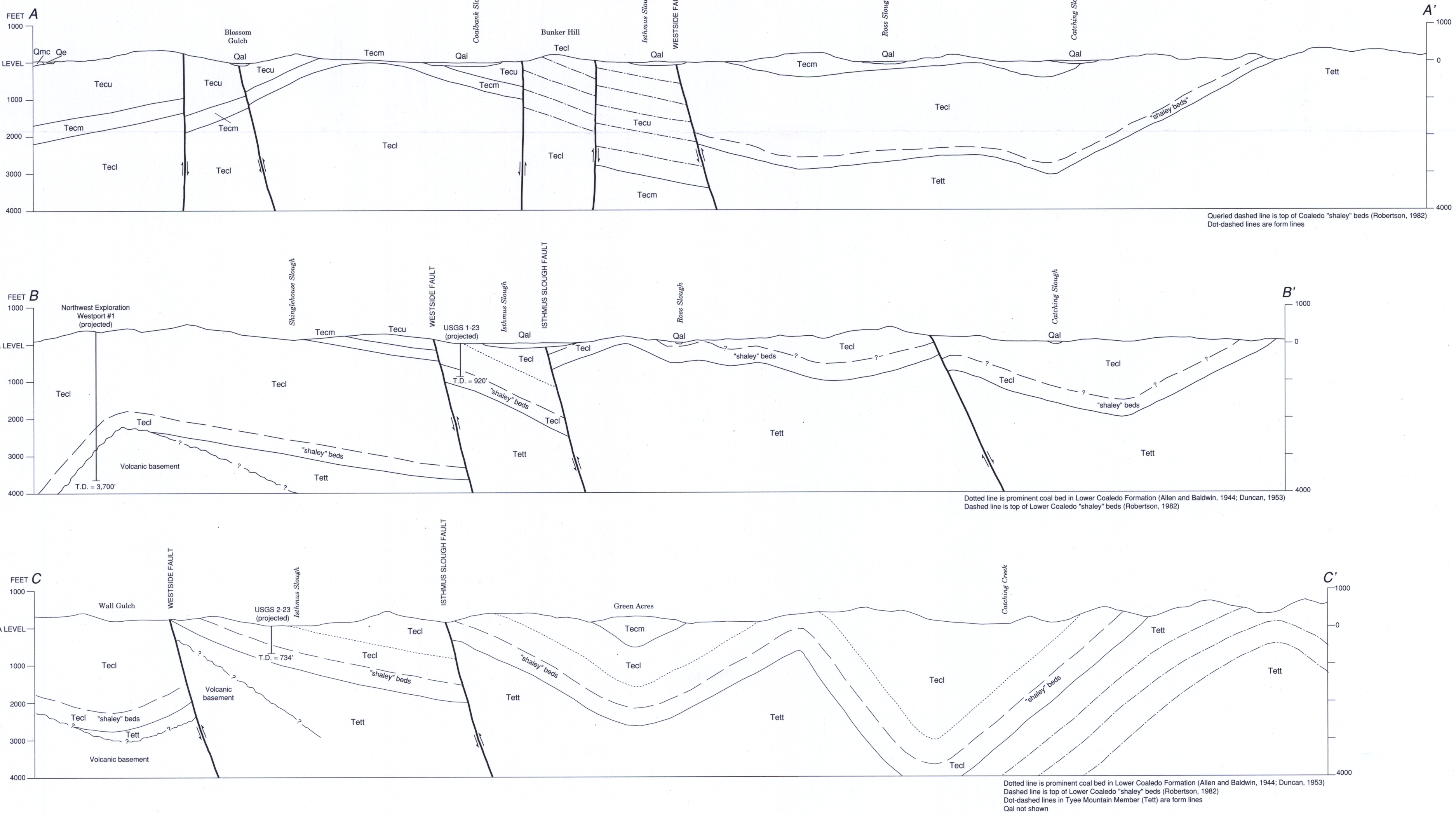
Tertiary Sedimentary Rocks

- Tecu Coaledo Formation (upper to middle Eocene; Narizian)
Upper Member of the Coaledo Formation (upper to middle Eocene; Narizian)
- Tecm Middle Member of the Coaledo Formation (upper to middle Eocene; Narizian)
- Tecd Lower Member of the Coaledo Formation (upper to middle Eocene; Narizian)
- Tett Tyee Mountain Member of the Tyee Formation of Baldwin (1974) (middle Eocene; Ulatisian)

MAP SYMBOLS

- Contact -- Approximately located
- Fault -- Dashed where inferred; dotted where concealed; queried where uncertain; ball and bar on downthrown side
- Anticline axis -- Dashed where inferred; dotted where concealed.
- Syncline axis -- Dashed where inferred; dotted where concealed.
- Strike and dip of bedding
- Strike and dip of horizontal bedding
- Strike and dip of vertical bedding
- Oil and gas exploration well
- Drill hole for coal exploration

GEOLOGIC CROSS SECTIONS



Geologic Map of the Coos Bay Quadrangle, Coos County, Oregon

1995

By Gerald L. Black and Ian P. Madin, Oregon Department of Geology and Mineral Industries

EXPLANATION OF MAP UNITS

Quaternary Deposits

- Qaf** **Artificial fill (recent)**—Sand, silt, and rock fill adjacent to Coos Bay and Isthmus Slough. Strikes and dips in unit Qaf were compiled from Allen and Baldwin (1944), and represent bedrock attitudes measured prior to emplacement of the fill
- Qal** **Quaternary alluvium and estuarine sediments (Holocene)**—Sand, silt, peat, and clay deposited in sloughs and valley bottoms. Generally restricted to elevations below 6 to 9 m above mean sea level. Attitudes depicted in alluvium are from exposures of underlying bedrock too small to be shown at the map scale
- Qls** **Landslide deposits (Holocene)**—Clay, silt, sand, and gravel chaotically mixed with angular blocks of weathered bedrock

ANGULAR UNCONFORMITY

- Qe** **Quaternary estuarine terrace deposits (Pleistocene)**—Weakly consolidated clay, silt, peaty mud, and pebbly mud located in a series of uplifted terraces along Davis Slough and the west margin of Isthmus Slough. Possibly associated with the Whiskey Run marine terraces (Madin and others, 1995)
- Qt** **Quaternary terrace deposits (Pleistocene)**—Weakly consolidated to unconsolidated sand occurring in two terraces at Graveyard Point. Sands are feldspathic, medium to coarse grained, subrounded and moderately to well sorted. Terraces in the Coos Bay area were originally mapped as "Elk River Beds" by Diller (1902) and Allen and Baldwin (1944). Five distinct terraces were mapped by Griggs (1945). These five terraces have been correlated west of South Slough (in the Charleston quadrangle, due west of the map area) on the basis of relative elevation and soil development (McInelly and Kelsey, 1990). Bockheim and others (1992) describe a soil chronosequence for the marine terraces west of South Slough. The terraces at Graveyard Point probably correlate with the Whiskey Run marine terraces, which have been dated southwest of the map area at 83.5 ka B.P. (Muhs and others, 1990)
- Qmc** **Metcalf marine terrace (Pleistocene)**—Weakly consolidated to unconsolidated sand occurring in the extreme northwest corner of the quadrangle. Sands are feldspathic, medium to coarse grained, subrounded and moderately to well sorted. Mica is locally common. Sediments average 3–16 m in thickness. Age speculatively estimated as 200 ka B.P. (McInelly and Kelsey, 1990)

ANGULAR UNCONFORMITY

Tertiary Sedimentary Rocks

Coaledo Formation (upper to middle Eocene; Narizian)—Sandstone, siltstone, and mudstone with minor subbituminous coal and conglomerate. Originally defined by Diller (1899) and divided by Turner (1938) into upper and lower coal-bearing sandstone members and a middle deep-marine siltstone and mudstone member (Baldwin and others, 1973). Dott (1966) reported that the sandstones are "texturally submature to immature: feldspathic, micaceous, and carbonaceous lithic (volcanic) arenites and lithic (volcanic) wackes." Dott (1966) and Ryberg (1978) interpreted the Coaledo as a prograding, wave-dominated deltaic complex deposited on an open coastline, with a sediment source to the southeast. The Coaledo Formation is divided into:

- Tecu** **Upper Member of the Coaledo Formation (upper to middle Eocene; Narizian)**—Fine- to coarse-grained lithic feldspathic micaceous sandstone with siltstone, mudstone, coal, and minor conglomerate. Ryberg (1978) and Chan and Dott (1986) reported six to eight upward-coarsening sequences from prodelta-shelf facies through delta-front facies, culminating in either delta-distributary channel facies or delta-margin facies. Common sedimentary structures include planar bedding; hummocky cross-stratification; trough, ripple, low-angle, and planar-tabular cross stratification; contorted cross beds; liquefaction dikes; intraformational mudstone clasts; burrows; flaser bedding; concretions; flame structures; coquina lags; slumped bedding; and scour-and-fill. Allen and Baldwin (1944) measured a thickness of 400 m along the coastline west of the quadrangle. Rooth (1974) reported Narizian foraminifera

- Tecm Middle Member of the Coaledo Formation (upper to middle Eocene; Narizian)**—Mudstone, siltstone, and minor sandstone and tuff. Allen and Baldwin (1944) measured a thickness of 890 m along the shoreline west of this quadrangle. Sedimentary structures are less abundant than in the Upper and Lower Members of the Coaledo Formation and include plane laminated beds and complete to partial Bouma sequences in sandstone beds. Bioturbation is common. Chan and Dott (1986) interpreted the Middle Member of the Coaledo Formation to be prodelta-shelf facies with some shelf to slope deposits. Rooth (1974) reported Narizian upper bathyal to lower neritic foraminiferal assemblages. The Middle Member of the Coaledo Formation pinches out in the eastern part of the quadrangle. For example, east of Green Acres, the Middle Member of the Coaledo Formation is absent, juxtaposing the Upper and Lower Members. Because the lithologically similar, sandstone-dominated Upper and Lower Members of the formation cannot be readily differentiated in the field, the result is a greater apparent thickness of the Lower Member (see cross-section C-C')
- TecL Lower Member of the Coaledo Formation (upper to middle Eocene; Narizian)**—Fine- to coarse-grained lithic feldspathic sandstone with siltstone, mudstone, coal, and minor conglomerate. Chan and Dott (1986) and Ryberg (1978) reported ten upward-coarsening sequences from prodelta-shelf facies through delta-front facies, culminating in either delta-distributary facies or delta-margin facies in the Cape Arago area. Common sedimentary structures include parallel stratification; hummocky stratification; trough, ripple, low-angle and planar cross-stratification; convolute bedding; clastic dikes; intraformational mudstone rip-up clasts; burrows; flaser bedding; calcareous and pyrite concretions; flame structures; coquina lags; slumped bedding; and scour-and-fill. Robertson (1982), on the basis of drill hole information, informally subdivided the Lower Coaledo Member into three facies: upper "sandy" beds, middle "coaly" beds, and lower "shaly" beds. These facies were not mapped as separate units in the Coos Bay quadrangle, but the lower "shaly" beds, which were encountered in the Northwest Exploration Westport #1 (SW¼SE¼ sec. 16, T. 26 S., R. 13 W.) oil and gas test and U.S. Geological Survey drill holes 1–23 (SE¼NE¼ sec. 23, T., 26 S. R. 13 W.) and 2–23 (SW¼SW¼ sec. 23, T. 26 S., R. 13 W.) (Duncan, 1953) are shown in the cross sections. Mudstone outcrops in Lexstrom Gulch (secs. 4, 9, T. 26 S., R. 12 W.) and a north-northeast-trending drainage in sec. 33, T. 26 S., R. 12 W., and secs. 4, 5, T. 27 S., R. 13 E.) represent these same beds. These "shaly" beds probably correlate with the Sacchi Beach beds described by Madin and others (1995). Allen and Baldwin (1944) measured a thickness of 540 m along the coastline west of the quadrangle. Rooth (1974) reported Narizian foraminifera

UNCONFORMITY

- Tett Tyee Mountain Member of the Tyee Formation of Baldwin (1974) (middle Eocene; Ulatisian)**—Light-gray to bluish-gray, brown-weathered sandstone beds up to 20 m thick with thin (<15-cm) mudstone interbeds. Sandstone is fine- to medium-grained lithic arkose, which is poorly sorted and well indurated, and contains ubiquitous coarse sand-sized flakes of biotite and muscovite. Porosity is low, owing to the degree of induration and amount of clay matrix (typically 20 to 40 percent). Beds are locally graded and amalgamated. Flute, groove, and load casts are present, and mudstone rip-up clasts are abundant in the upper parts of some sandstone beds. Carbonized wood and plant debris are common. Sandstones are deep-marine turbidite deposits. The Tyee Formation is unconformably overlain by the Coaledo Formation. At the type section, on the east flank of the Coast Range, the Tyee Mountain Member was interpreted by Chan and Dott (1983) as a sandy inner-submarine fan facies. They noted, however, that there appeared to be a line source for the deposits rather than a single large submarine canyon. Heller and Dickinson (1985) called this facies a submarine ramp turbidite complex

INTRODUCTION

The primary goal of this study was to map bedrock structure and identify Quaternary deformation. No new stratigraphic or paleontologic investigation of bedrock units was done. The ages and characteristics of the bedrock units on this map are drawn largely from the literature and field observations. Geologic maps that include all or parts of the Coos Bay quadrangle have been published at smaller scales several times in the past. Previous studies include those of Diller (1901), Allen and Baldwin (1944), Baldwin (1966), Baldwin and others (1973), Beaulieu and Hughes (1975), and Newton and others (1980).

STRUCTURE

The complex structure of the Coos Bay quadrangle results from roughly east-west compression that began in the late middle Miocene (Wells and Peck, 1961) and continues to the present day. This deformation has produced

many north-south-trending folds, north-south-trending reverse and thrust faults, and west-northwest-trending steeply dipping reverse (?) and strike-slip (tear) faults. The style of deformation is similar to that depicted for the active Cascadia Subduction Zone fold and thrust belt in Goldfinger and others (1992) and by Madin and others (1995) in the adjacent Charleston quadrangle.

FOLDS

Minor anticlines and synclines occur throughout the quadrangle. Many are associated with drag on adjacent faults. While strike and dip data are locally plentiful, attitudes are sparse throughout much of the area due to thick soils and vegetative cover. Thus it is difficult to trace individual fold axes for any significant distance in the complex structural terrane.

An exception is in the southern part of the quadrangle, where a series of north-northeast-trending folds can be traced for over 6 km. The syncline that is the western-

most of these folds is responsible for the preservation of the Middle Coaledo Member in the axis of the fold near Green Acres (secs. 35, 36, T. 26 S., R. 13 W., and secs. 1, 2, T. 27 S., R. 13 W.). The axes of these folds are offset dextrally along a northeast-trending tear (?) fault. North of this fault, adjacent to the Goat Creek fault, a series of northeast-trending shallow folds probably owes its existence to movement on the Goat Creek fault. Most of these folds cannot be traced much farther north than the central part of the quadrangle, owing to absence of data.

In the north-central part of the quadrangle, near the community of Eastside, a north-northwest-trending syncline axis is offset dextrally along a pair of northeast-trending tear (?) faults. This syncline is responsible for the presence of the Middle Coaledo Member in this area.

FAULTS

Most faults in the Coos Bay quadrangle can be assigned to one of two classes, (1) generally north-south-trending reverse faults or (2) one of a conjugate pair of west-northwest-trending and east-northeast-trending thrust (?) and/or strike-slip (tear) (?) faults. Some faults identified in this study had been mapped previously by Allen and Baldwin (1944) and Duncan (1953). Others were identified by direct observation in natural and man-made exposures (rare), or offsets, scarps, and lineaments observed on aerial photographs. Modern satellite imagery available from the U.S. Geological Survey EROS Data Center shows numerous lineations in the Coos Bay area, which were used to aid in mapping faults. It is likely that only a small percentage of the faults actually present in the quadrangle have been mapped. Many of the anomalous steep dips and strikes on the map (when compared to regional trends) may be related to drag along small, unexposed faults and/or landslides.

North-trending reverse faults

Two north-northeast-trending high-angle reverse faults (the Westside fault and the Isthmus Slough fault) are mapped in the west-central part of the quadrangle. The Isthmus Slough fault was named by Allen and Baldwin (1944). The Westside fault is named in this report. The Isthmus Slough fault was previously mapped by both Allen and Baldwin (1944) and Duncan (1953). The southern end of the Westside fault was mapped by Duncan (1953). Duncan (1953) assigned down-to-the-west throws to both faults, which is consistent with the compressional tectonic regime. Based on displacement of Lower Coaledo Member "shaly" beds, there is as much as 2,600 ft of vertical displacement on the Westside fault and 1,600 ft of vertical displacement on the Isthmus Slough fault.

The Westside fault appears to have late Quaternary movement, based on the presence of uplifted Pleistocene (?) estuarine sediments west of Isthmus Slough. These sediments dip as much as 15° to the east near the Coos City Bridge. Uplifted estuarine sediments are also present along the north bank of Davis Slough. The reason for the uplift there is uncertain, although the northeast-trending reverse (?) fault mapped in sec. 21, T. 26 S., R. 13 W., is a possible explanation.

West-northwest-trending faults

The Joe Ney fault (secs. 14, 15, 16, T. 26 S., R. 13 W.) was originally mapped by Madin and others (1995) in the Charleston quadrangle, where it juxtaposes the Upper and Middle Coaledo Members. They found several hundred meters of down-to-the-north displacement of

Coaledo strata. They also found that this fault displaces late Quaternary marine terrace sediments.

The two west-trending faults in the southwest part of the quadrangle (sec. 22, T. 26 S., R. 13 W., and sec. 3, T. 27 S., R. 13 W.) were mapped previously by Duncan (1953). He showed down-to-the-south displacement on both faults. They probably represent tears accommodating differential compression on either side of the faults.

The queried northwest-trending fault in sec. 7, T. 26 S., R. 12 W., is based on (1) a satellite image lineation; (2) the change from a strong strike-ridge controlled topography to the south to a more subdued, more homoclinal topography to the north; and (3) a change in fold axis trend to a more northeasterly course.

The north-northwest-trending down-to-the-north faults in secs. 4, 21, T. 26 S., R. 12 W., were mapped by Allen and Baldwin (1944), and both are consistent with high-angle reverse faults.

Northeast-trending faults

The queried northeast-trending fault in the central part of the quadrangle was discussed briefly in the section on folding. It is apparent as a satellite-image lineament and appears to offset the axes of a series of large folds.

South of the community of Eastside, a pair of northeast-trending faults offset a synclinal axis. These faults are also prominent satellite-image lineaments, and they appear to offset coal seams of the Coaledo Formation mapped by Allen and Baldwin (1944). They probably represent dextral tear faults.

GEOLOGIC HISTORY

The sedimentary rocks exposed in the Coos Bay quadrangle represent a fraction of the Tertiary history of the southern Oregon Coast Range. This history is discussed in more detail in Ryu and others (1992) and Black (1994). Major events in the geologic history of the quadrangle include (1) gradual filling of a middle Eocene forearc basin with sedimentary rocks representing several marine transgressions and regressions; (2) deposition of sedimentary rocks of the Coos Basin (Coaledo Formation and younger rocks); (3) a period of nondeposition during the Oligocene and early Miocene; (4) the commencement of deformation in the late middle Miocene; (5) continuing clockwise tectonic rotation during the Tertiary; (6) continuing east-west compressional deformation resulting from oblique subduction on the Cascadia Subduction Zone; (7) a series of Pleistocene marine transgressions; and (8) Holocene erosion, alluvial and estuarine deposition, landsliding, and possibly minor active faulting (?).

A forearc basin formed at the location of the southern Oregon Coast Range during the middle Eocene, a result of subduction initiated offshore from the modern coastline. Pillow basalt encountered in the Northwest Exploration Westport #1 well represents Coast Range basement docked during subduction prior to formation of the forearc basin. Forearc basin development was mostly complete about 52 Ma (Heller and Ryberg, 1983), when the basin started to fill. The Tyee Mountain Member of the Tyee Formation is part of a submarine fan complex that represents an early stage in the filling of the basin. East of the quadrangle, younger members of the Tyee Formation (the slope mudstones of the Hubbard Creek Member and the fluvial Baughman Member) represent further filling of the basin in progressively shallower water. There followed a marine transgression, represented

by the deeper water siltstones of the Elkton Formation, before the final depositional event of the basin began. Rocks of these units are not exposed in the Coos Bay quadrangle. It is probable that they were never deposited in the quadrangle.

Subsidence of the Coos Basin began in the late Eocene. The deep-marine beds of Sacchi Beach represent initial deposition in this basin. These beds, which occur along the coast in the adjacent Charleston quadrangle, have not been mapped in the Coos Bay quadrangle. A thin "shaly" facies present at the base of the Lower Coaledo Member may, however, be equivalent to the beds at Sacchi Beach (see Explanation of Map Units).

The beds of Sacchi Beach were subsequently buried by a northward-prograding sandy, wave-dominated deltaic complex (Coaledo Formation) fed by rivers draining the Klamath terrane to the southeast (Dott, 1966). The Upper and Lower Members of the Coaledo Formation represent progradational deltaic episodes, and the deeper water Middle Coaledo Member represents a marine transgression. A second marine transgression is represented by the deeper water Bastendorff Shale (Madin and others, 1995). Following this second transgression, a regressive episode culminated in the deposition of the shallow marine Tunnel Point Formation in the Charleston quadrangle to the west (Madin and others, 1995). The Bastendorff Shale and the Tunnel Point Formation do not occur in the Coos Bay quadrangle. If they were ever present, they have been stripped away by erosion. The generally conformable nature of the Coaledo, Bastendorff and Tunnel Point Formations indicates a tectonically stable environment (Madin and others, 1995).

The remainder of the Tertiary was a period of nondeposition in the Coos Bay quadrangle, although deposition of lower and middle Miocene units did occur to the west in the Charleston quadrangle. Starting in the late middle Miocene, the Oregon Coast Range was uplifted and deformed in response to subduction along the Cascadia Subduction Zone. It was during this period that the folds and thrust faults mapped in the quadrangle began to form.

Coast Range basement rocks (e.g., the lower Eocene Siletz River Volcanics) have been rotated as much as 80° in a clockwise sense since approximately 50 Ma (Wells and Heller, 1988). The overlying rocks, including the Tyee Formation, have been rotated nearly as much (Wells and Heller, 1988). Dextral shear associated with oblique subduction along the Oregon continental margin since the middle Eocene (mostly post-middle Miocene) may be responsible for approximately half of the total rotation. The remainder may be due to Basin and Range extension and small-block rotation that began in the late middle Miocene (Wells and Heller, 1988) and continues to the present time.

In the Quaternary, two geologic processes have been dominant: (1) continued east-west compression resulting from oblique subduction on the Cascadia Subduction Zone and (2) repeated episodes of marine transgression related to continental glaciation and local tectonic uplift of Pleistocene terraces.

During the Holocene, alluvial and estuarine deposits filled coastal valleys. Although Holocene faulting cannot be conclusively demonstrated in the quadrangle, uplifted estuarine terrace deposits adjacent to Isthmus Slough suggest that some faulting may have occurred during the Holocene.

RESOURCE GEOLOGY

The Coos Bay area has a long history of mineral resource production. Coal mining in the Upper and Lower Coaledo Members began in 1854 and continued for about 100 years. Over 3,000,000 tons were produced (Baldwin and others, 1973) from the Coos Bay region. Detailed studies of the coal occurrences and workings are available in Allen and Baldwin (1944), and Duncan (1953). A history of coal mining in the area is given by Beckham (1995).

Several oil and gas exploration wells have been drilled in or adjacent to the Coos Bay quadrangle over the years, most recently in 1993 (Steve Pappajohn, Carbon Energy International, personal communication, 1993). Only one well, the Northwest Exploration Company Westport #1, is located in the Coos Bay quadrangle. No oil or gas shows were reported (Olmstead, 1989). A second well, the Phillips Petroleum Company Dobbys 1, was drilled in the Charleston quadrangle, 5.5 km west of the quadrangle boundary (SW¼ sec. 28, T. 26 S., R. 13 W.). Gas sand was encountered at 1,040 ft, but no oil or gas shows were reported (Newton and others, 1980; Olmstead, 1989). Newton and others (1980) summarized oil and gas prospects in the Coos Bay area. Olmstead (1989) summarized the results from commercial oil and gas drilling through 1989. No commercial deposits of gas or oil have been found.

There are no significant gravel or rock resources in the Coos Bay quadrangle, largely because the sedimentary rocks present are too weathered or poorly consolidated for use as aggregate, road metal, or rip-rap.

Ground-water resources are likely to be highly variable in both quantity and quality in the Coos Bay quadrangle. The Coaledo Formation as a whole is poorly permeable (Brown and Newcomb, 1963; Newton and others, 1980), and where moderate permeability might be encountered in thick sandstone beds, the intense folding and faulting and interbedded mudstones might limit production. The Middle Member of the Coaledo Formation would be expected to be a poor aquifer because it is composed largely of mudstone, which results in poor permeability, and because it is areally restricted.

Alluvial units in the quadrangle will have the best porosity and permeability; but when near sea level, they may have water quality problems due to brackish water intrusion during pumping. Water quality in the Coaledo Formation may be impacted by the presence of numerous coal beds and carbonaceous sands.

GEOLOGIC HAZARDS

Geologic hazards and engineering geology of the Coos Bay quadrangle were described and mapped by Beaulieu and Hughes (1975). The major geologic hazards in the area are landslides, flooding, tsunamis, and earthquakes.

Minor surficial landslides and slumps occur on steep slopes, regardless of the underlying bedrock unit. These small landslides were not mapped. Because the sandstones in the area are fairly well indurated, there are relatively few large or deep-seated landslides, in spite of the many steep slopes cut parallel to bedding.

Flooding of low-lying alluvial floodplains and swamps is clearly a risk, and care should be taken to site structures above flood-prone areas.

In the adjacent Charleston quadrangle, there is a serious risk of tsunami inundation. In the Coos Bay quadrangle, the risk is less serious but still not trivial. Pre-

dicted runup elevations at the open coast from distant earthquakes that occur on average every 100 or 500 years are 8 ft and 16 ft, respectively, for North Bend-Coos Bay (Charland and Priest, 1995). The predicted runup elevation for a moment magnitude (M_w) 8.8 Cascadia Subduction Zone earthquake is between 12 and 22 ft at the open coast immediately to the west of the quadrangle (G.R. Priest, Oregon Department of Geology and Mineral Industries, unpublished data). These hypothesized numbers are the result of a reconnaissance-level assessment of the tsunami hazards along the Oregon coast, and apply only to the open coast. The barrier spit and bay will greatly reduce the runup height of any tsunami. The actual runup elevations will therefore be less than those cited above, but still significant. Local tsunamis originating from subduction zone earthquakes immediately offshore may arrive within minutes of the earthquake. When combined with coseismic subsidence (Briggs, 1994) in the bay, the tsunami effects may be significant. Residents and visitors to the area should consider a strong earthquake to be their only tsunami warning and should seek high ground immediately.

The earthquake risk in the Coos Bay quadrangle is significant. Local earthquakes of at least M_w 5.5 are possible, based on minimum mapped fault lengths of up to 6 km and empirical relationships between fault length and magnitude (Wells and Coppersmith, 1994). In addition, the Coos Bay quadrangle, like all of coastal Oregon, would experience damaging shaking from subduction earthquakes occurring immediately offshore along the Cascadia Subduction Zone (Atwater, 1987, 1992; Darienzo and Peterson, 1990, 1995; Atwater and Yamaguchi, 1991; Nelson and Personius, 1991; Savage and Lisowski, 1991; Adams, 1990; Clarke and Carver, 1992). Liquefaction of units Qal and Qaf is likely in either local or subduction earthquakes. Landslides and rock falls created by seismic shaking are likely.

To emphasize further the earthquake and tsunami risk in the Coos Bay quadrangle, Charland and Priest (1995) found that 19 of a total of 24 critical facilities (hospitals, fire and police stations, emergency vehicle shelters, communications centers, hazardous sites, major structures, and schools) are at risk from either ground shaking or tsunamis during a M_w 8.8 event on the Cascadia Subduction Zone. In North Bend, 16 of a total of 19 critical facilities are at risk. These numbers are typical for the Oregon coast. Since the chance of a great subduction zone earthquake in the next 50 years (Darienzo and Peterson, 1995) is between 10 and 20 percent, it is probable that the earthquake threat is the most serious geologic hazard facing the residents in the Coos Bay quadrangle.

ACKNOWLEDGMENTS

Thanks are due to Menasha Corporation and the residents of the area for providing access to private lands. Some strikes and dips were compiled from previous geologic studies in the area, including Allen and Baldwin (1944), Duncan (1953), Baldwin and others (1973), Beaulieu and Hughes (1975), and Newton and others (1980).

Research was supported in part by the U.S. Geological Survey (USGS), Department of Interior, under USGS award 14-08-001-AO512 and U.S. Department of Interior, Minerals Management Service, Cooperative Agreement 14-35-0001-30731. Contract Management was provided by the University of Texas Bureau of Economic Geology. The views and conclusions contained in this

document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Government.

REFERENCES CITED

- Adams, J., 1990, Paleoseismicity of the Cascadia subduction zone: Evidence from turbidites off the Oregon-Washington margin: *Tectonics*, v. 9, p. 569-583.
- Allen, J.E., and Baldwin, E.M., 1944, Geology and coal resources of the Coos Bay quadrangle, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 27, 160 p.
- Almgren, A.A., Filewicz, M.V., and Heitman, H.L., 1988, Lower Tertiary foraminiferal and calcareous nannofossil zonation of California: An overview and recommendation, in Filewicz, M.V., and Squires, R.L., eds., *Paleogene stratigraphy, West Coast of North America: Society for Sedimentary Geology (SEPM), Pacific Section, Publication 58*, p. 83-105.
- Armentrout, J.M., Hull, D.A., Beaulieu, J.D., and Rau, W.W., 1983, Correlation of Cenozoic stratigraphic units of western Oregon and Washington: Oregon Department of Geology and Mineral Industries Oil and Gas Investigation 7, 98 p.
- Atwater, B.F., 1987, Evidence for great Holocene earthquakes along the outer coast of Washington State: *Science*, v. 236, p. 942-944.
- 1992, Geologic evidence for earthquakes during the past 2,000 years along the Copalis River, southern coastal Washington: *Journal of Geophysical Research*, v. 97, p. 1901-1919.
- Atwater, B.F., and Yamaguchi, D.K., 1991, Sudden, probably coseismic submergence of Holocene trees and grass in coastal Washington State: *Geology*, v. 19, p. 706-709.
- Baldwin, E.M., 1966, Some revisions of the geology of the Coos Bay area, Oregon: Oregon Department of Geology and Mineral Industries, Ore Bin, v. 28, no. 11, p. 189-203.
- 1974, Eocene stratigraphy of southwestern Oregon: Oregon Department of Geology and Mineral Industries Bulletin 83, 40 p.
- Baldwin, E.M., Beaulieu, J.D., Ramp, L., Gray, J., Newton, V.C., Jr., and Mason, R.S., 1973, Geology and Mineral Resources of Coos County, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 80, 82 p.
- Beaulieu, J.D., and Hughes, P.W., 1975, Environmental geology of western Coos and Douglas Counties, Oregon: Oregon Department of Geology and Mineral Industries Bulletin 87, 147 p.
- Beckham, D., 1995, Stars in the dark: Coal mines of southwestern Oregon: Coos Bay, Oregon, Arago Books, 226 p.
- Berggren, W.A., Kent, D.V., Flynn, J.J., and Van Couvering, J.A., 1985, Cenozoic geochronology: *Geological Society of America Bulletin*, v. 96, no. 11, p. 1407-1418.
- Black, G.L., 1992, Offshore-onshore geologic cross section from the Pan American Corporation well (continental shelf) to the Umpqua River (southern Oregon Coast Range): Oregon Department of Geology and Mineral Industries unpublished report to U.S. Minerals Management Service under Cooperative Agreement 14-35-0001-30534.
- Black, G.L., 1994, Geologic map of the Remote quadrangle, Coos County, Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-84, scale 1:24,000.
- Bockheim, J.G., Kelsey, H.M., and Marshall, J.G., III, 1992, Soil development, relative dating, and correlations of late Quaternary marine terraces in southwestern Oregon: *Quaternary Research*, v. 37, p. 60-74.
- Briggs, G.G., 1994, Coastal crossing of the elastic strain zero-isobase, Cascadia margin, south-central Oregon coast: Portland, Ore., Portland State University master's thesis, 251 p.
- Brown, S.G., and Newcomb, R.C., 1963, Ground-water resources of the coastal sand-dune area north of Coos Bay, Oregon: U.S. Geological Survey Water-Supply Paper 1619-D, 32 p.
- Bukry, D., and Snively, P.D., Jr., 1988, Coccolith zonation for Paleogene strata in the Oregon Coast Range, in Filewicz, M.V., and Squires, R.L., eds., *Paleogene stratigraphy, West Coast of North America: Society for Sedimentary Geology (SEPM), Pacific Section, Publication 58*, p. 251-263.
- Chan, M.A., and Dott, R.H., Jr., 1983, Shelf and deep-sea sedimentation in Eocene forearc basin, western Oregon—fan or non-fan? *AAPG Bulletin*, v. 67, no. 11, p. 2100-2116.

- 1986, Depositional facies and progradational sequences in Eocene wave-dominated deltaic complexes, southwestern Oregon: AAPG Bulletin, v. 70, no. 4, p. 415–429.
- Charland, J.W., and Priest, G.R., 1995, Inventory of critical and essential facilities vulnerable to earthquake or tsunami hazards on the Oregon coast: Oregon Department of Geology and Mineral Industries Open-File Report O-95-2, 52 p., 1 diskette.
- Clarke, S.H., Jr., and Carver, G.A., 1992, Late Holocene tectonics and paleoseismicity, southern Cascadia Subduction Zone: Science, v. 255, p. 188–192.
- Cushman, J.A., and Schenk, H.G., 1928, Two foraminiferal faunules from the Oregon Tertiary: Berkeley, Calif., University of California Publications, Bulletin of the Department of Geological Sciences, v. 17, no. 9, p. 305–324.
- Dall, W.H., 1909, The Miocene of Astoria and Coos Bay, Oregon: U.S. Geological Survey Professional Paper 59, 278 p.
- Dariento, M.E., and Peterson, C.D., 1990, Episodic tectonic subsidence of late Holocene salt marshes, northern Oregon, central Cascadia margin: Tectonics, v. 9, p. 1–22.
- 1995, Magnitude and frequency of subduction-zone earthquakes along the northern Oregon coast in the past 3,000 years: Oregon Geology, v. 57, no. 1, p. 3–12.
- Diller, J.S., 1899, The Coos Bay coal field, Oregon: U.S. Geological Survey 19th Annual Report, pt. 3, p. 309–376.
- 1901, Description of the Coos Bay quadrangle: U.S. Geological Survey Geologic Atlas, Folio 89.
- 1902, Topographic development of the Klamath Mountains: U.S. Geological Survey Bulletin 196, 69 p.
- Dott, R.H., Jr., 1966, Eocene deltaic sedimentation at Coos Bay, Oregon: Journal of Geology, v. 74, no. 4, p. 373–420.
- Duncan, D.C., 1953, Geology and coal deposits in part of the Coos Bay coal field, Oregon: U.S. Geological Survey Bulletin 982-B, 73 p.
- Goldfinger, C., Kulm, L.D., Yeats, R.S., Mitchell, C., Weldon, R.J., Peterson, C.P., Dariento, M., Grant, W., and Priest, G.R., 1992, Neotectonic map of the Oregon continental margin and adjacent abyssal plain: Oregon Department of Geology and Mineral Industries Open-File Report O-92-4, 17 p., 2 pl.
- Griggs, A.B., 1945, Chromite-bearing sands of the southern part of the coast of Oregon: U.S. Geological Survey Bulletin 945-E, p. 113–150.
- Heller, P.L., and Dickinson, W.R., 1985, Submarine ramp facies model for delta-fed, sand-rich turbidite systems: AAPG Bulletin, v. 69, no. 6, p. 960–976.
- Heller, P.L., and Ryberg, P.T., 1983, Sedimentary record of subduction to forearc transition in the rotated Eocene basin of western Oregon: Geology, v. 11, no. 7, p. 380–383.
- Madin, I.P., McInelly, G.W., and Kelsey, H.M., 1995, Geologic map of the Charleston quadrangle, Coos County, Oregon: Oregon Department of Geology and Mineral Industries Geological Map Series GMS-94, scale 1:24,000.
- Mallory, V.S., 1959, Lower Tertiary biostratigraphy of the California Coast Ranges: Tulsa, Okla., American Association of Petroleum Geologists, 416 p.
- McInelly, G.W., and Kelsey, H.M., 1990, Late Quaternary tectonic deformation in the Cape Arago-Bandon region of coastal Oregon as deduced from wave-cut platforms: Journal of Geophysical Research, v. 95, no. B5, p. 6699–6713.
- Muhs, D.R., Kelsey, H.M., Miller, G.H., Kennedy, G.L., Whelan, J.F., and McInelly, G.W., 1990, Age estimates and uplift rates for late Pleistocene marine terraces: Southern Oregon portion of the Cascadia forearc: Journal of Geophysical Research, v. 95, no. B5, p. 6685–6698.
- Nelson, A.R., and Personius, S.P., 1991, The potential for great earthquakes in Oregon and Washington: An overview of recent coastal geologic studies and their bearing on segmentation of Holocene ruptures, central Cascadia Subduction Zone: U.S. Geological Survey Open-File Report 91-441-A, 29 p.
- Newton, V.C., Jr., Kulm, L.D., Couch, R.W., Braman, D., Pitts, G.S., Van Atta, R.O., and McKeel, D.R., 1980, Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane Counties, Oregon: Oregon Department of Geology and Mineral Industries Oil and Gas Investigation 6, 74 p.
- Olmstead, D.L., 1989, Hydrocarbon exploration and occurrences in Oregon: Oregon Department of Geology and Mineral Industries Oil and Gas Investigation 15, 78 p.
- Robertson, R.D., 1982, Subsurface stratigraphic correlations of the Eocene Coaledo Formation, Coos Bay basin, Oregon: Oregon Geology, v. 44, no. 7, p. 75–82.
- Rooth, G.H., 1974, Biostratigraphy and paleoecology of the Coaledo and Bastendorff Formations, southwestern Oregon: Corvallis, Oreg., Oregon State University doctoral dissertation, 270 p.
- Ryberg, P.T., 1978, Lithofacies and depositional environments of the Coaledo Formation, Coos County, Oregon: Eugene, Oreg., University of Oregon master's thesis, 159 p.
- Ryu, I., Niem, A.R., and Niem, W.A., 1992, Schematic fence diagram of the southern Tyee basin, Oregon Coast Range, showing stratigraphic relationships of exploration wells to surface measured sections: Oregon Department of Geology and Mineral Industries Oil and Gas Investigation 18, 40 p., 1 pl.
- Savage, J.C., and Lisowski, M., 1991, Strain measurements and potential for a great subduction earthquake off Oregon and Washington: Science, v. 252, p. 101–103.
- Tipton, A., 1975, Foraminiferal biostratigraphy of the late Eocene to early Oligocene type Bastendorff Formation near Coos Bay, Oregon, in Weaver, D.W., Hornaday, G.R., and Tipton, A., eds., Paleogene symposium and selected technical papers. Conference on Future Energy Horizons of the Pacific Coast, Long Beach, Calif.: Pacific Sections, AAPG-SEPM-SEG, p. 563–585.
- Turner, F.E., 1938, Stratigraphy and mollusca of the Eocene of western Oregon: Geological Society of America Special Paper 10, 130 p.
- Warren, A.D., and Newell, J.H., 1981, Calcareous plankton biostratigraphy of the type Bastendorff Formation, southwest Oregon, in Armentrout, J.M., ed., Pacific Northwest Cenozoic biostratigraphy: Geological Society of America Special Paper 184, p. 105–112.
- Wells, D.L., and Coppersmith, K.J., 1994, New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement: Seismological Society of America Bulletin, v. 84, no. 4, p. 974–1002.
- Wells, F.G., and Peck, D.L., 1961, Geologic map of Oregon west of the 121st meridian: U.S. Geological Survey Miscellaneous Investigations Series Map I-325, scale 1:500,000.
- Wells, R.E., and Heller, P.L., 1988, The relative contribution of accretion, shear, and extension to Cenozoic tectonic rotation in the Pacific Northwest: Geological Society of America Bulletin, v. 100, p. 325–338.