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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE STATE OF WASHINGTON
DEPARTMENT OF NATURAL RESOURCES DIVISION OF GEOLOGY AND EARTH RESOURCES

OPEN FILE REPORT 81-674

DESCRIPTION OF MAP UNITS

Qal ALLUVIAL DEPOSITS (Holocene) - Silt, sand, and gravel along Rivers and streams; include some low lying river terrace deposits, thick colluvium, and tidal flat mud and beach sand along the Columbia River

Qls LANDSLIDE DEBRIS (Holocene and Pleistocene) - Landslides very abundant in all rock units; only the largest are shown on the map

Qlh LOGAN HILL FORMATION (Snavely and others, 1958), (Pleistocene) - Partly weathered gravel and sand

Tsmp SADDLE MTS. BASALT OF THE COLUMBIA RIVER BASALT GROUP; POMONA MEMBER - (middle Miocene) - One basalt flow, up to 100 meters thick west of Mill Creek; exhibits characteristic wavy, irregular columnar jointing and contains up to 20 per cent stubby plagioclase phenocrysts, some with clinopyroxene inclusions; magnetic polarity is reversed (Simpson and others, 1980); Chemistry[1] is equivalent to that of the Pomona flow (Swanson and others 1979); basalt is overlain by deeply weathered basalt conglomerate containing ferruginous bauxite deposits (Livingston, 1966)

Tnm MON MARINE SEDIMENTARY ROCKS of Snavely and others (1958); (middle Miocene) - Poorly consolidated siltstone, sandstone, and conglomerate; contains fossil plants

Tau ASTORIA(?) FORMATION, UPPER MEMBER (middle Miocene) - Thick to thin bedded; friable, very fine to medium grained, micaceous, arkosic sandstone and silty sandstone; plane laminated thin bedded micaceous siltstone, some with large, low-angle cross bedding sets; large channels in siltstone filled with very coarse sand and transported blocks of siltstone; Convolute bedding and slump structures common; fossils not yet found in this unit

Timb BASALT INTRUSIVE ROCKS (Middle Miocene) - dikes and sills of dark gray, aphanitic, aphyric to sparsely plagioclase-phyric basalt intruding Lincoln Creek and Cowlitz Formations; could be invasive Grande Ronde Basalt or Wanapum Basalt related to the nearby flows (see Beeson and others, 1979, and Snavely and others, 1973).

Twfs WANAPUM BASALT OF THE COLUMBIA RIVER BASALT GROUP; FRENCHMAN SPRINGS MEMBER (Middle Miocene) - At least two flows of fine grained basal and associated flow breccia with total thickness of 100 meters, flows have well developed colonnades, with straight-sided columns up to 2 m in diameter; flows very sparsely plagioclase-phyric with phenocrysts up to 1.5 cm long; magnetic polarity is normal and chemistry[1] is equivalent to Frenchman Springs flows of the Columbia Plateau (Swanson and others, 1979)

Tgr GRANDE RONDE BASALT OF THE COLUMBIA RIVER BASALT GROUP (middle-Miocene) - One or more flows of dark gray aphanitic, aphyric basalt with well developed entablature; overlain by three or four flows of light gray, sugary, fine grained aphyric basalt with well developed colonnades; flows locally pillowed at base; hyaloclastite abundant west of Skamokawa; magnetic polarity is normal, and chemistry[1] of the upper three flows is similar to High Mg Grande Ronde basalt of the plateau (Swanson and others 1979); chemistry of lower flows is similar to Low-Mg Grande Ronde basalt; flows are separated by basaltic conglomerate, basaltic to arkosic fine to very coarse sandstone and siltstone; Grande Ronde Basalt separated from overlying Frenchman Springs Basalt by discontinuous arkosic sandstone containing carbonized logs; maximum thickness of Grande Ronde Basalt is 75 meters

Tal ASTORIA(?) FORMATION, LOWER MEMBER (early and middle Miocene) - Thick to thin bedded, very fine to medium grained, plane laminated, carbonaceous, micaceous friable sandstone; basalt and quartzite conglomerate lenses locally common, bioturbation and slump structures in places; molluscan fauna referred to Newportian or Pillarian Stages of Addicott (1976)

Tlc LINCOLN CREEK FORMATION (upper Eocene and Oligocene) - Tuffaceous siltstone and very fine sandstone; massive to thick bedded, concretionary, bioturbated, with interbeds of glauconitic sandstone and tuff; thin bedded, laminated siltstone in southwestermost exposures; Molluscan fauna referred to Blakely Stage of Weaver (1944); foraminifera referred to Refugian and Zemorrian Stages of Kleinpell (1938)

Tlcs Sandstone at base of Lincoln Creek Formation (upper Eocene) - Massive to thick bedded, moderately well sorted and indurated, fossiliferous, dark gray, fine grained arkosic to basaltic sandstone. Molluscan fauna referred to Galvinian Stage of Armentrout (1975) and Lincoln Stage of Weaver (1944)

Tsc SILTSTONE OF SKAMOKAWA CREEK (upper Eocene) - Thin bedded, laminated burrowed, concretionary, tuffaceous siltstone; contains thin tuff beds in places; abundant foraminifera are referred to the upper part of the Narizian stage of Mallory (1959)

Tiqm Quartz monzonite stock (Late Eocene to Oligocene?) - light gray to tan, quartz monzonite to granidiorite with blocky jointing, contains inclusions of Goble Volcanics; hypidiomorphic granular, granophyric and porphyritic texture; see Livingston (1966) for chemical analysis

Tgv GOBLE VOLCANICS (upper Eocene) - subaerial basalt flows and interbedded siltstone and sandstone; flows show columnar and platy jointing, weathered flow tops, and oxidized red basal flow breccias over baked and altered sedimentary interbeds; basalts are aphyric to densely porphyritic, contain phenocrysts of plagioclase, clinopyroxene, and olivine; foraminifera from siltstones beneath the basalt and immediately overlying it are referred to the upper Narizian Stage of Mallory (1959)

Tib Basalt intrusive rocks (Eocene) - dikes and sills of medium to fine grained aphyric to extremely porphyritic basalt; many related to Goble Volcanics but some may be older

Tc COWLITZ FORMATION (Weaver, 1937) (upper middle and upper Eocene) - massive to thin bedded, plane laminated and cross bedded, friable, very fine to coarse-grained, micaceous, arkosic sandstone; interbedded laminated micaceous, carbonaceous siltstone, tuffaceous siltstone, and very coarse-grained basaltic, andesitic, and tuffaceous sandstone; thin sub-bituminous coal up to 30 cm thick north of Abernathy Mt.; see Livingston (1966) for additional coal localities; Forminifera are referred to the upper Narizian Stage of Mallory (1959)

Tcv Basalt Breccia and Flows - basalt breccia, massive flows and intrusive rock interbedded in the Cowlitz Formation along Columbia River

Tmu MCINTOSH FORMATION, UPPER MEMBER (middle and upper Eocene) - dark gray massive to laminated, thin bedded, tuffaceous siltstone, silty sandstone and arkosic sandstones; basalt cobble conglomerate and slump breccias occur locally; upper part of unit equivalent in age to Cowlitz Formation in west half of map area, Rau (1958); Foraminifera are referred to the Narizian Stage of Mallory (1959); equivalent to the upper part of Henriksens (1956) Stillwater Creek member of the Cowlitz Fm

Tmus Sandstone - massive to thick bedded, plane laminated to cross bedded, friable, fine to medium grained, arkosic sandstone interbedded at the base of the upper member of the McIntosh Formation

Tig GABBRO AND BASALT INTRUSIVE ROCKS (early or middle Eocene) massive to blocky jointed and columnar jointed, fine to very coarse grained gabbro sill complex; marginal facies are basalt and have well developed columnar jointing, while interiors are very coarse-grained to pegmatitic; gabbro and basalt are vesicular and typically flow banded, a result of planar concentrations of vesicles and/or crystal sorting; interstitial glass is generally altered to green clays and vesicles are filled with clay, calcite, or zeolite; gabbros intrude the upper Crescent Formation and along the contact between Crescent Fm. and lower member of the McIntosh Fm; some gabbro and basalt intruding Crescent Fm. may be part of Crescent Fm. volcanics; some may be younger and related to Goble Volcanics

Tml MCINTOSH FORMATION, LOWER MEMBER (lower and middle Eocene) - massive to thin bedded and laminated very fine grained to coarse grained basaltic sandstone, arkosic sandstone and laminated tuffaceous siltstone; sandstone commonly shows graded bedding; sandstones are less common on east flank of the Willapa Hills; interbedded in lower part are pillow basalt flows of the Crescent Formation; foraminifera are referred to the upper Slatlatan and lower Narizian Stages of Mallory (1959); equivalent to the lower part of Henriksen's (1956) Stillwater Creek member of the Cowlitz Fm.

Tcbs Basalt breccia and sandstone - massive to well bedded basalt lapilli tuff, tuff breccia, basaltic sandstone, siltstone and conglomerate; lapilli tuff consists of palagonitic vesicular basaltic glass and altered glass shards commonly cemented by calcite and zeolite; graded bedding is common; form thick sequences interbedded with lower McIntosh and upper part of Crescent Formations

Tcb CRESCENT FORMATION (lower and lower middle Eocene) - pillow flows, massive and columnar jointed flow interiors, pillow breccia, lapilli tuff breccia, and filled lava tubes of tholeiitic and alkalic basalt, basalt groundmass altered to green and brown clays; zeolite and calcite fracture fillings are ubiquitous; contains minor amounts of mudflow breccia, basaltic sandstone, and interbedded laminated siltstone; includes a few dikes and sills not differentiated on the map; this assemblage is interpreted as a seamount built on oceanic crust, similar to the Siletz River Volcanics of Snavely and others (1968); foraminifera from interbedded siltstones are referred to the upper Penutian or Ulatisian Stages of Mallory (1959)

Tcs Siltstone - thin bedded laminated tuffaceous siltstone interbedded with pillow basalt of the Crescent Formation

Tcsb Subaerial basalt - massive to very vesicular, platy, plagioclase phyric basalt flows and flow breccias with weathered tops and baked and oxidized bottom contacts; interbedded with basalt boulder conglomerate; basalt groundmass is in part altered to clays, and vesicles are filled with calcite and zeolite

1/ Chemical Analysis of the Columbia River Basalt samples by P. R. Hooper
Identification of Foraminifera by Weldon W. Rau
Identification of Mollusean fauna by Ellen James Moore

Contact approximately located or inferred, ? where questionable, dotted where concealed

Fault, approximately located or inferred, dotted where concealed; dip shown where known, arrows show inferred horizontal motions; D is on downthrown side

Thrust Fault, teeth on upper plate

Fault inferred from Side-Looking Radar Imagery, not field checked

Horizontal slickensides on fault plane

Azimuth and plunge of slickensides on fault plane

Folds, showing trace of axial plane and direction of plunge

anticline

synoclinc

Strike and dip of beds

inclined

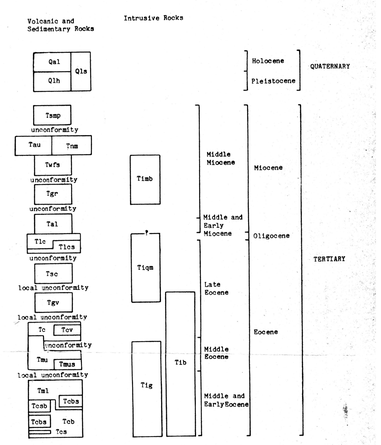
overturned

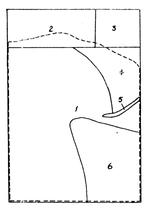
vertical

horizontal

Water well with gas show

CORRELATION OF MAP UNITS





Sources of Data

1. R. E. Wells, field mapping 1978-1980; assisted by R. Miyacka, B. Cope, and T. Plake
2. MODified from M. H. Pease and L. Hoover, 1957
3. Snavely and others, 1958
4. Modified from Henriksen, 1956
5. Modified from W. W. Rau, unpublished map, 1952
6. Modified from W. E. Livingston, 1966

OIL AND GAS POTENTIAL

Commercial quantities of natural gas were discovered at Mist, Oregon, about ten miles south of the map area, while this mapping project was in progress. As a result, the eastern Willapa Hills are now a prime target for oil and gas exploration. The Mist gas field and the southern Willapa Hills face one another across a broad synclinal trough trending east-west across a low point in the "Coast Range Anticlinorium".

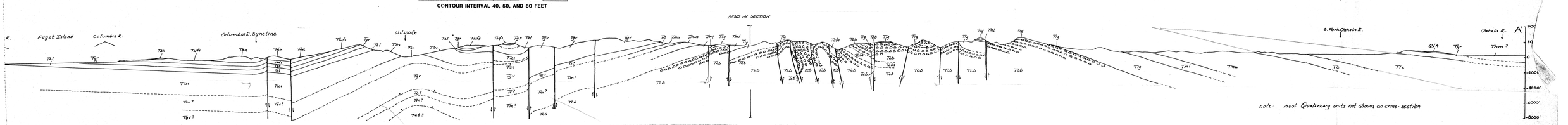
The stratigraphic section is similar on both sides, but facies relationships may be more complex on the Washington side of the river. The thick Cowlitz deltaic and shallow marine sediments of the type area (Weaver, 1937) lap unconformably across older strata and apparently thin rapidly to the west. Where they are replaced by laminated siltstones of the same age. This rapid facies change occurs across the gently south plunging nose of the eastern Willapa Hills uplift, which is coincident with the axis of the Coast Range gravity high. This structural high may have been an active tectonic feature through most of Tertiary time and it may have controlled the basin geometry and sediment dispersal patterns. The Cowlitz sequence lies beneath subaerial Goble Volcanics of latest Narizian age, which are in turn overlain by more deep water siltstones in the western part of the map area. Cowlitz sandstones above the Goble Volcanics are not exposed, but they may occur in the eastern part of the map area beneath the Lincoln Creek Formation.

The thick, friable arkoses of the Cowlitz Formation and the basal arkoses of the upper member of the McIntosh Formation have good reservoir potential, and they are the most likely reservoir rocks to be found at depth. Siltstones of the McIntosh and Cowlitz Formations may be suitable source rocks, but they have not been tested for source potential. In general, source rocks in the Coast Range have marginal to inadequate organic richness, but they are commonly thermally immature (Snavely and others, 1977). However, source rocks in the southern Willapa Hills may have been subjected to higher heat flow during late Eocene volcanism and plutonism associated with the Goble Volcanics. The McIntosh and Cowlitz Formations have in them abundant herbaceous material that may have provided a source for natural gas.

A series of en echelon northwest trending folds occur on the southern flank of the Willapa Hills uplift. Their structure is complex; the fold axes are typically offset by numerous cross-faults. Some of these structures are worth further investigation for their petroleum potential. The Wilson Creek uplift may have closure, and several cross-faults may have created local traps across the plunging structure. "Marsh gas" has been reported from a 1401' water well drilled near the axis of this structure (Wash. State Dept. Natural Resources well log 69-591), but the gas may be the result of decaying organic material beneath a relatively impermeable cover of landslide debris. The Arkansas Creek uplift is another complexly faulted anticline which may have a thick Eocene section beneath it. Other possible traps may occur in structures beneath the relatively flat lying Columbia River basalts, or where Cowlitz sandstones are faulted updip against impermeable strata. Stratigraphic traps may occur where Cowlitz or McIntosh sandstones pinch out or become channelized in the western facies deeper water siltstones.

REFERENCES CITED

Addicott, W. O., 1976, Neogene Molluscan Stages of Oregon and Washington, in Neogene Symposium: Soc. Econ. Paleontologists and Mineralogists, Pacific Section San Francisco, Calif., p. 95-115.
Armentrout, J. M., 1975, Molluscan biostratigraphy of the Lincoln Creek Formation, southwest Washington, in Weaver, D. W., and others, eds., Paleogene Symposium and Selected technical papers: AAPG/SEPM/SEG Pacific sections, 1975 Annual Mtg., Long Beach, Calif., p. 14-48.
Beeson, M. H., Perttu, R., and Perttu, Janice, 1979, The origin of the Miocene basalts of coastal Oregon and Washington: an alternative hypothesis: Oregon Geology, v. 41, no. 10, p. 159-166.
Henriksen, D. A., 1956, Eocene stratigraphy of the lower Cowlitz River Eastern Willapa Hills area, southwestern Washington: State of Washington Division of Mines and Geology Bulletin 43, 122 p.
Kleinpell, R. M., 1938, Miocene stratigraphy of California: Tulsa, Okla., Am. Assoc. Petroleum Geologists, 350 p.
Livingston, V. E., Jr., 1966, Geology and mineral resources of the Kelso-Cathlamet area, Cowlitz and Wahkiakum Counties, Washington: State of Washington Division of Mines and Geology Bulletin 54, 110 p.
Mallory, V. S., 1959, Lower Tertiary biostratigraphy of the California Coast Ranges: Tulsa, Okla., Am. Assoc. Petroleum Geologists, 416 p.
Pease, M. H., and Hoover, L., 1957, Geology of the Doty-Minot Peak area, Washington: U. S. Geol. Survey Oil and Gas Invest. Map OM 188, Scale 1:62,500.
Rau, W. W., 1958, Stratigraphy and Foraminiferal Zonation in some of the Tertiary rocks of southwestern Washington: U. S. Geol. Survey Oil and Gas Invest. Chart OC 57.
Simpson, R., Magill, J., Wells, R., and Cox. A., 1980, Post 12 m. y. rotation of southwestern Washington: EOS, Transactions Am. Geophysical Union, V. 61, No. 46, p. 949.
Snavely, P. D., Jr., Brown, R. D., Jr., Roberts, A. E., and Rau, W. W., 1958, Geology and coal resources of the Centralia - Chehalis district, Washington: U. S. Geol. Survey Bull. 1053, 159 p.
Snavely, P. D., Jr., MacLeod, N. S., and Wagner, H. C., 1968, Tholeiitic and alkalic basalts of the Eocene Siletz River Volcanics Oregon Coast Range: Am. Jour. Sci., V. 266, p. 454-481.
Snavely, P. D., Jr., MacLeod, N. S., and Wagner, H. C., 1973, Miocene tholeiitic basalts of coastal Oregon and Washington and their relationship to coeval basalts of the Columbia Plateau: Geol. Soc. America Bull. v. 84, p. 387-424.
Snavely, P. D., Jr., Pearl J. E., and Lander, D. L., 1977, Interim report on petroleum resources potential and geologic hazards in the outer continental shelf - Oregon and Washington Tertiary Province: U. S. Geol. Survey Open-File Report 77-282, 64 p.
Swanson, D. A., Wright, T. L., Hooper, P. R., Bentley, R. D., 1979, Revisions in Stratigraphic nomenclature of the Columbia River Basalt Group: U. S. Geol. Survey Bull. 1457 G, 59 p.
Weaver, C. E., 1937, Tertiary stratigraphy of Western Washington and northwestern Oregon: Washington Univ. (Seattle) Pubs. in Geology, v. 4, 266 p.
Weaver, C. E., and others. 1944, Correlation of the marine Cenozoic formations of western North America (Chart II): Geol. Soc. America Bull. v. 55, no. 5, p. 569-598.



GEOLOGIC MAP OF THE EASTERN WILLAPA HILLS
COWLITZ, LEWIS, PACIFIC, AND WAHKIAKUM COUNTIES, WASHINGTON

By
Ray E. Wells
1981

APPROXIMATE MEAN DECLINATION, 1981

QUADRANGLE LOCATION

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.