STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
DONALD A. HULL, STATE GEOLOGIST

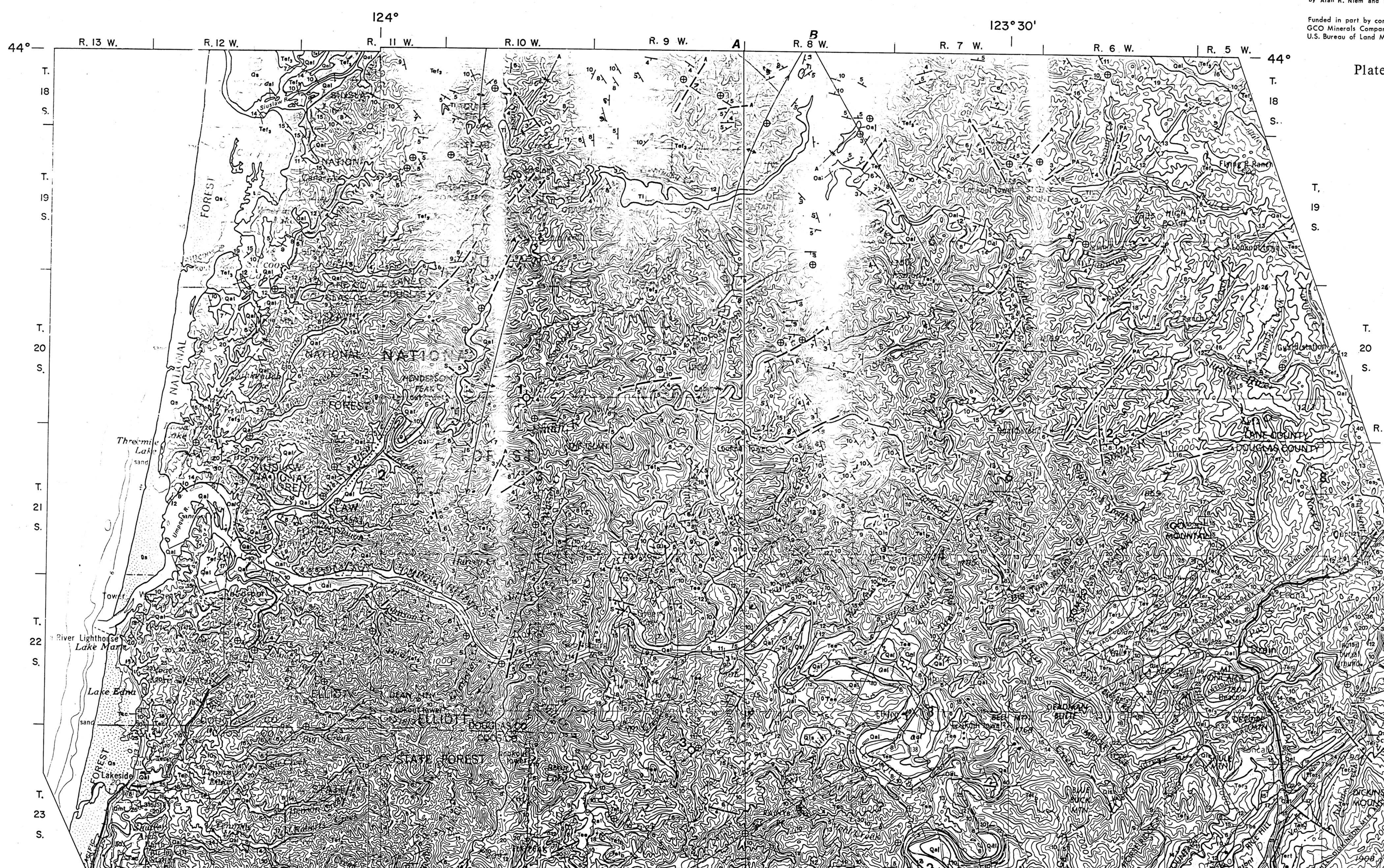
OPEN FILE REPORT O-89-3

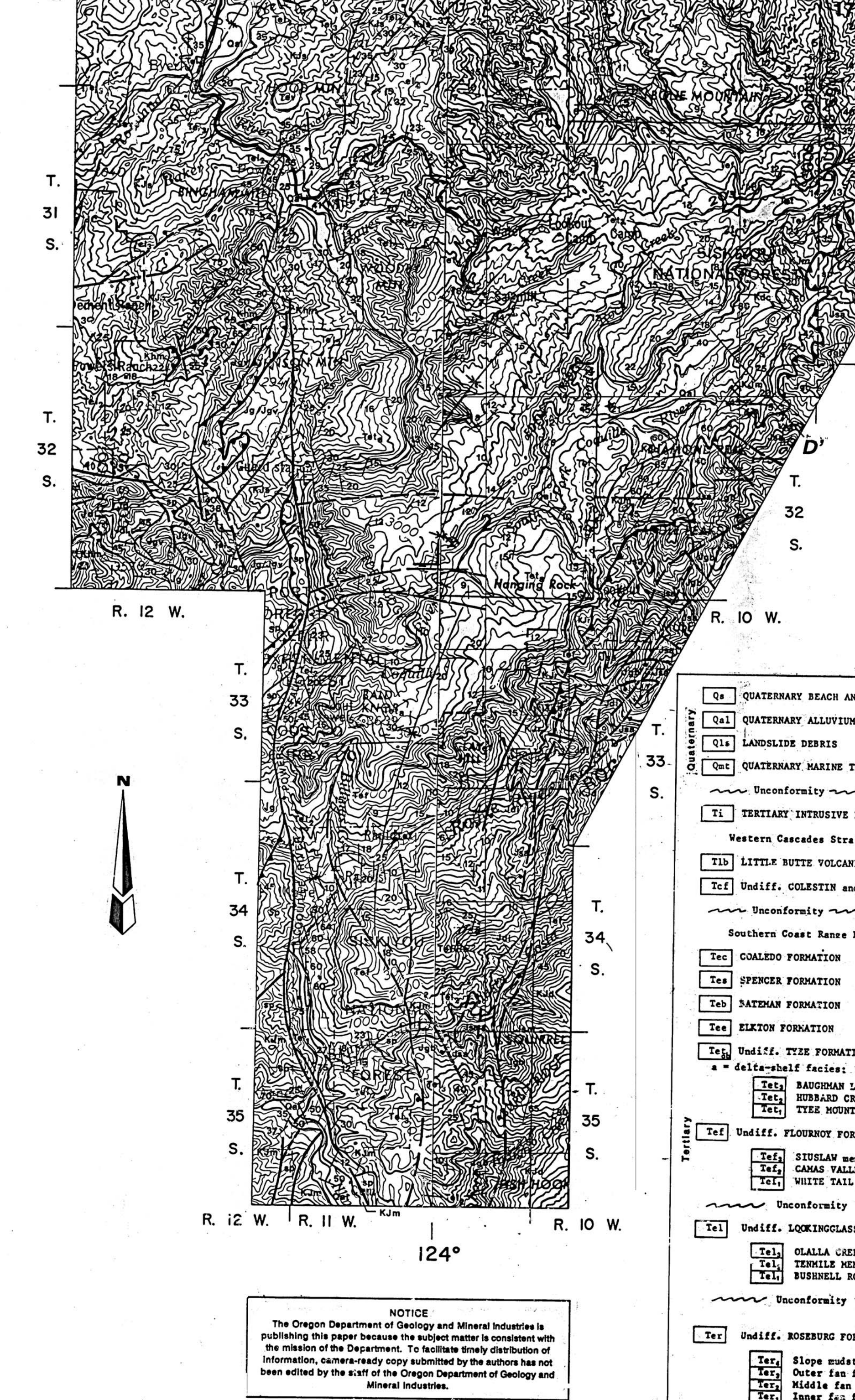
Geology and Oil, Gas, and Coal Resources, Southern Tyee Basin, Southern Coast Range, Oregon

by Alan R. Niem and Wendy A. Niem

Funded in part by contributions from the Douglas County Industrial Development Board GCO Minerals Company, Oregon Department of State Lands, Menasha Corporation U.S. Bureau of Land Management, U.S.D.A. Forest Service, and the Weyerhaeuser Corporation.

Plate 1





R. 7 W.

A'

123° 30'

R. 6 W.

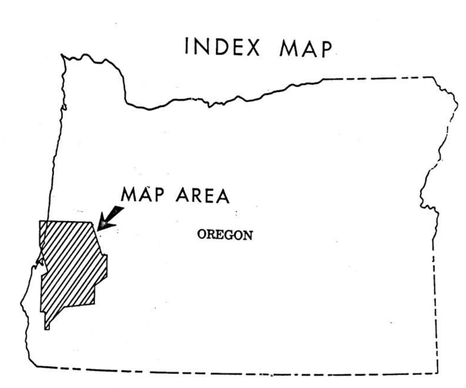
R. 5 W.

MAP SCALE 1:125,000
CONTOUR INTERVAL 200 feet

Base map enlarged from parts of U.S. Geological Survey 1:250,000 Coos Bay, Medford, and Roseburg, Oreg. quadrangles

Miles 1 ½ 0 1 2 3 4 5

INDEX MAP



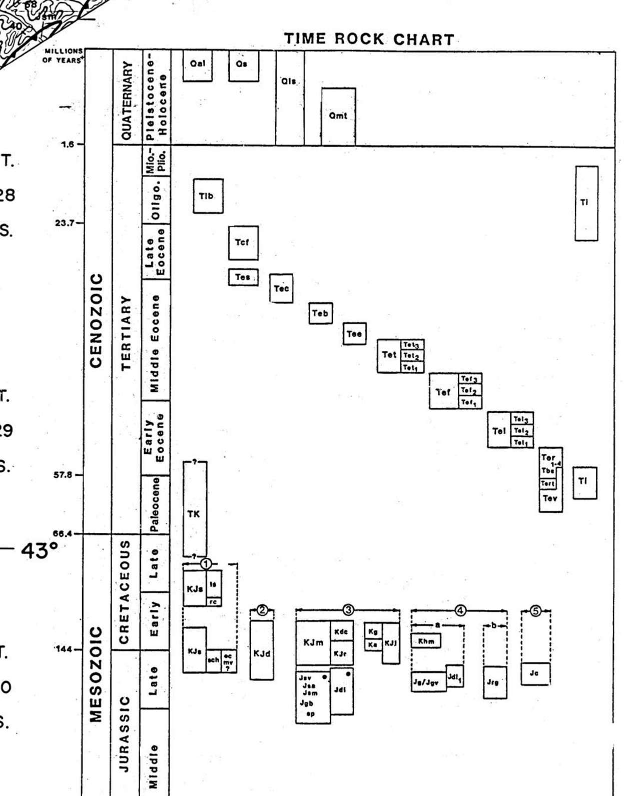
GEOLOGIC SYMBOLS

- Contact; dashed where inferred beneath alluvium
- Strike and dip of bedding
- Horizontal beds
- Overturned beds
- Vertical beds
- Axis of anticline
- Axis of syncline
- Axis of overturned syncline
- Zone of drag folds with trend and plunge of representative single fold
- Fault, dashed where inferred; ball and bar on downthrown block. A = based on attitudes P = based on air photo interpretation S = based on seismic reflection records
- Thrust fault, teeth on upper plate
- Oblique-slip fault; arrows indicate relative strike-slip movement
- Oil and gas exploration hole (identification numbers explained on Plate 2)
- Lake
- Indicates same unit on both ends of arrow

Reviewed by:

Parke D. Snavely, U.S. Geological Survey
Ray E. Wells, U.S. Geological Survey
Peter O. Hales, Weyerhaeuser Company

TIME ROCK CHART



* Absolute ages based on G.S.A.'s DNAG 1983 Geologic Time Scale
Klamath Mts. Tectonostratigraphic Terranes: 1 - Sixes River; 2 - Yolla Bolly; 3 - Snow Camp; units marked • = Coast Range ophiolite, 4 - Western Klamath: a - Elk subterrane; b - Rogue Valley subterrane; 5 - Pickett Peak (after Blake and others, 1985)
Age of Tertiary units based on Armentrout and others (1983), age of Mesozoic units after Blake (1984)

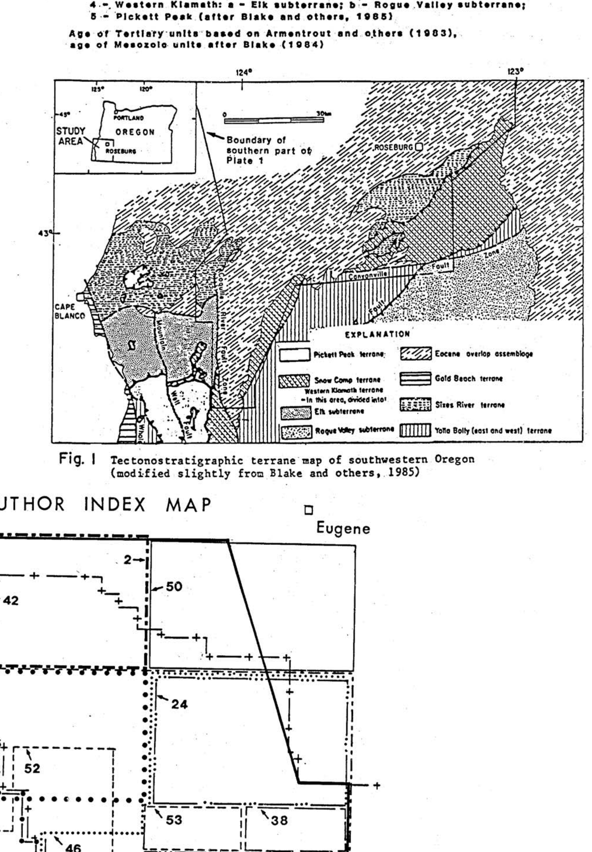


Fig. 1 Tectonostratigraphic terrane map of southwestern Oregon (modified slightly from Blake and others, 1985)

Compilation Geologic Map of Southern Tyee Basin, Southern Coast Range, Oregon

by

Alan R. Niem and Wendy A. Niem (Oregon State University)
with major contributions from Ewart M. Baldwin (University of Oregon)

1990

ABBREVIATED EXPLANATION

(see "Explanation of Geologic Units")

Quaternary

- Qs QUATERNARY BEACH AND DUNE SANDS
- Qal QUATERNARY ALLUVIUM
- Qls LANDSLIDE DEBRIS
- Qmt QUATERNARY MARINE TERRACE

Unconformity

Tertiary

- Ti TERTIARY INTRUSIVE ROCKS

Western Cascades Stratigraphy

- Tlb LITTLE BUTTE VOLCANIC SERIES
- Tcf Undiff. COLESTIN and FISHER FORMATIONS

Unconformity

Southern Coast Range Eocene Stratigraphy

- Tec COALEDO FORMATION
- Tes SPENCER FORMATION
- Teb BATEMAN FORMATION
- Tee ELKTON FORMATION
- Tet Undiff. TYEE FORMATION of Baldwin (1974) a = delta-shelf facies; b = turbidite facies
  - Tet_3 BAUGHMAN LOOKOUT MEMBER
  - Tet_2 HUBBARD CREEK MEMBER
  - Tet_1 TYEE MOUNTAIN MEMBER
- Tef Undiff. FLOURNOY FORMATION (Baldwin, 1974)
  - Tef_3 SIUSLAW member (informal)
  - Tef_2 CAMAS VALLEY MEMBER
  - Tef_1 WHITE TAIL RIDGE MEMBER

Unconformity

- Tel Undiff. LOOKINGGLASS FORMATION
  - Tel_3 OLALLA CREEK MEMBER
  - Tel_2 TENMILE MEMBER
  - Tel_1 BUSHNELL ROCK MEMBER

Unconformity

- Ter Undiff. ROSEBURG FORMATION (Baldwin, 1974)
  - Ter_4 Slope mudstones (Ryberg, 1984)
  - Ter_3 Outer fan facies (Ryberg, 1984)
  - Ter_2 Middle fan facies (Ryberg, 1984)
  - Ter_1 Inner fan facies (Ryberg, 1984)
  - Tbs Basaltic sandtone (Hoover, 1963)
  - Tert Tuffs
- Tev ROSEBURG VOLCANICS of Baldwin (1974) Pillow basalts, flows, and breccias

Pre-Tertiary

Klamath Mountains Tectonostratigraphic Terranes (after Blake, 1984; Blake and others, 1985)

- TK UNNAMED SANDSTONE (lower Eocene? to Cretaceous?)

Sixes River Terrane

- KJs MELANGE AND BROKEN FORMATION; contains tectonic blocks of:
  - ls Whitsett Limestone (Middle Cretaceous)
  - sch Blueschist
  - ec Eclogite
  - mv Metabasalt (greenstone)
  - rc Radiolarian chert

Yolla Bolly Terrane (east)

- KJd DOTHAN FORMATION

Snow Camp Terrane

- KJm Undiff. MYRTLE GROUP
  - Kdc DAYS CREEK FORMATION
  - KJr RIDDLE FORMATION

Unconformity

- Ka AMPHIBOLE GNEISS
- Kg GRANODIORITE
- KJi HORNBLENDE DIORITE

Snow Camp Terrane
Coast Range Ophiolite

- Jsv Undiff. VOLCANIC ROCKS
- Jsa ANDESITE, DACITE, and SHEETED DIKES
- Jgb GABBRO
- Jsm MAFIC VOLCANICS
- sp SERPENTINIZED PERIDOTITE
- Jdi DIORITE STOCKS AND DIKES

Western Klamath Terrane in this area divided into:

a) Elk Subterrane

- Khm HUMBUG MOUNTAIN CONGLOMERATE

Unconformity

- Jg GALICE FORMATION
- Jgv Volcanic rocks in Galice Formation
- Jdi_1 DIORITE STOCKS AND DIKES

b) Rogue Valley Subterrane

- Jrg Undiff. ROGUE/GALICE FORMATIONS

Pickett Peak Terrane

- Jc COLEBROOKE SCHIST

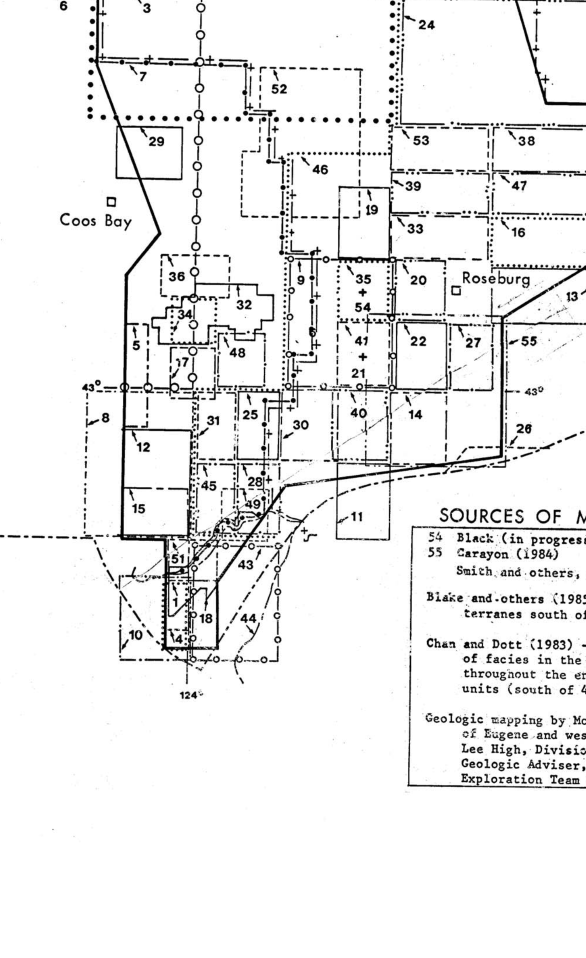
SOURCES OF MAPPING

(see References Cited)

1 Ahmad (1981)
2 Baldwin (1956)
3 Baldwin (1961)
4 Baldwin (1968)
5 Baldwin (1969)
6 Baldwin (1974)
7 Baldwin and Beaulieu (1973)
8 Baldwin and Hess (1971)
9 Baldwin and Perttu (1989)
10 Beaulieu and Hughes (1976)
11 Black (1979)
12 Born (1963)
13 Champ (1969)
14 Cornell (1971)
15 Dott (1971)
16 Elphic (1969)
17 Fairchild (1966)
18 Gray and others (1982)
19 Hampton (1958)
20 Haq (1975)
21 Harms (1957)
22 Hicks (1964)
23 Hixson (1965)
24 Hoover (1963)
25 Johannesen (1972)
26 Johnson and Page (1979)
27 Johnson (1965)
28 Kent (1972)
29 Klohn (1967)
30 Koler (1979)
31 Krans (1970)
32 Lane (1988)
33 Lawrence (1961)
34 Magoon (1966)
35 Moore (1957)
36 Nelson (1966)
37 Newton (1980)
38 Patterson (1961)
39 Payton (1961)
40 Perttu (1976)
41 Peterson (1957)
42 Ramp (1972)
43 Ramp and Moring (1986)
44 Ramp and others (1977)
45 Rud (1971)
46 Ryberg (1984)
47 Thompson (1968)
48 Trigger (1966)
49 Utterback (1973)
50 Vokes and others (1951)
51 Wayland (1964)
52 Weatherby, in progress
53 Westhusing (1959)

and unpublished mapping by Ewart Baldwin in the Bone Mtn, Elkton, Ivers Peak, Sitkum, and Tyee quadrangles

AUTHOR INDEX MAP



SOURCES OF MAPPING (cont'd)

54 Black (in progress)
55 Carayon (1984)
Smith and others, 1982

Blake and others (1985) - for tectonostratigraphic terranes south of 43°15' N and west of 123°

Chan and Dott (1983) - for approximate boundaries of facies in the Flournoy and Tyee formations throughout the entire outcrop area of those units (south of 45° N and west of 123° W.).

Geologic mapping by Mobil Oil Corporation south of Eugene and west of 123° W; courtesy of Lee High, Division Geologist, William Seely, Geologic Adviser, and Neal R. Goins, Exploration Team Leader.

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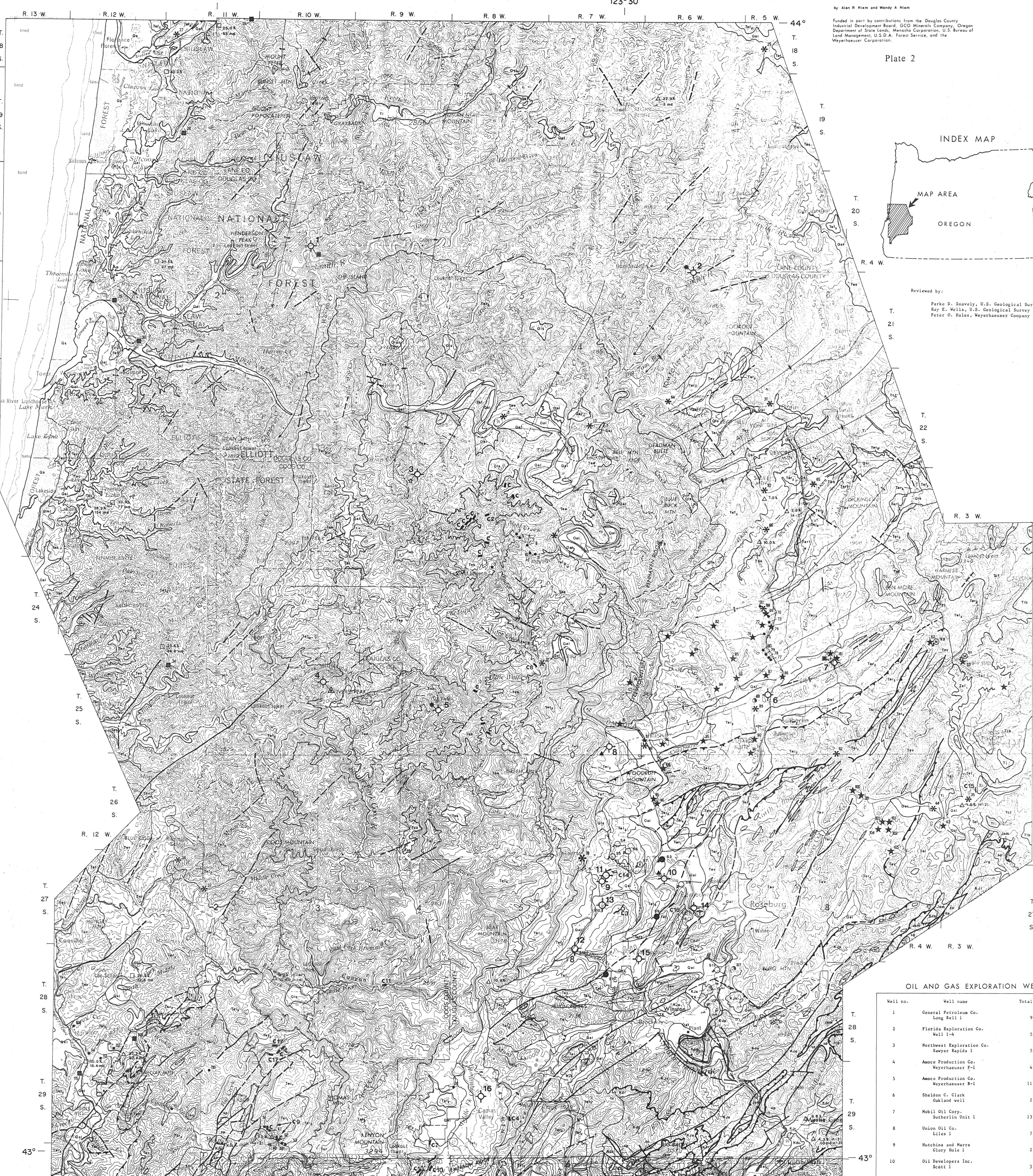
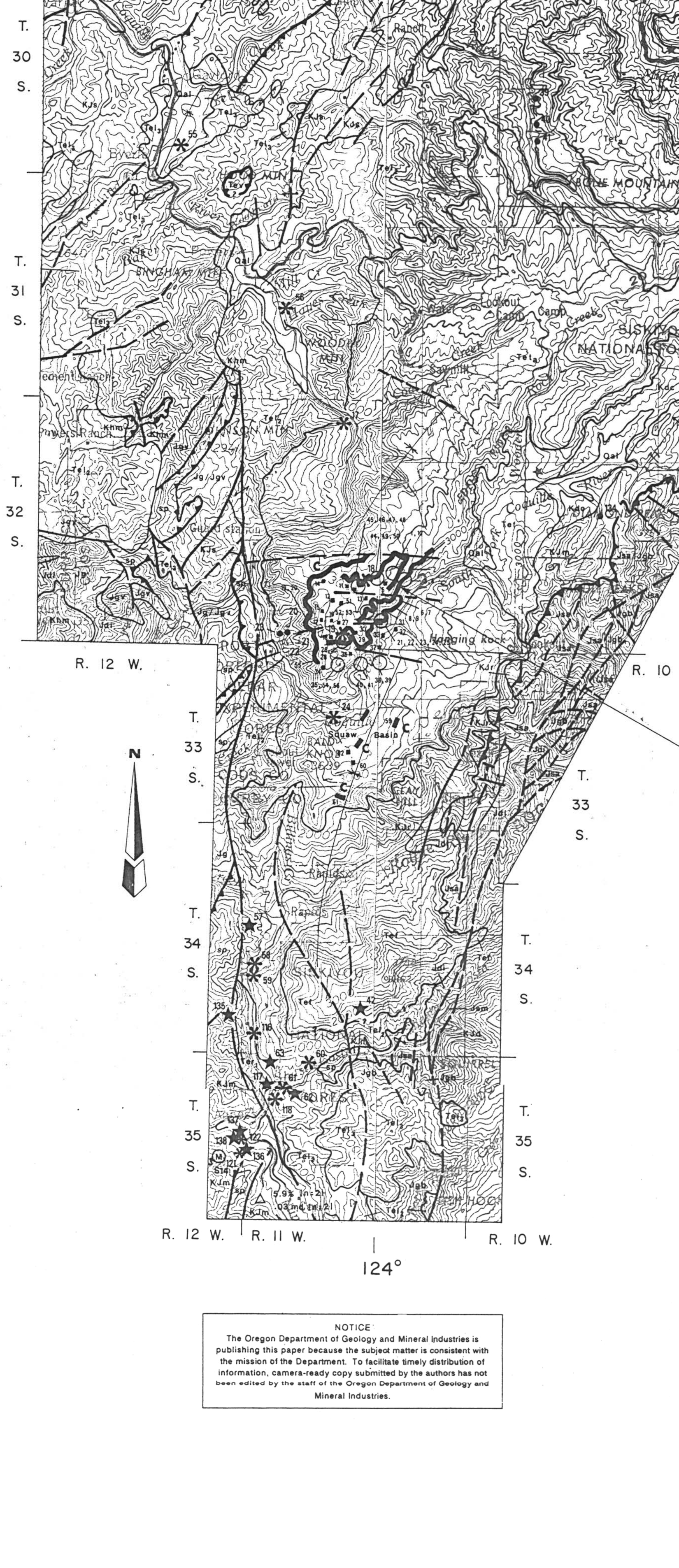
Plate 2





Reviewed by:
Parke D. Snavely, U.S. Geological Survey
Ray E. Wells, U.S. Geological Survey
Peter O. Hales, Weyerhaeuser Company

OIL AND GAS EXPLORATION WELLS

Well no.	Well name	Total depth (ft)
1	General Petroleum Co. Long Bell 1	9,004
2	Florida Exploration Co. Well 1-4	5,962
3	Northwest Exploration Co. Sawyer Rapids 1	5,562
4	Amoco Production Co. Weyerhaeuser F-1	6,401
5	Amoco Production Co. Weyerhaeuser B-1	11,330
6	Sheldon C. Clark Oakland well	2,235
7	Mobil Oil Corp. Sutherlin Unit 1	13,177
8	Union Oil Co. Liles 1	7,002
9	Hutchins and Marrs Glory Hole 1	2,987
10	Oil Developers Inc. Scott 1	3,693
11	Diamond Drill Contracting Co. Hamilton Ranch Well 3	545
12	Diamond Drill Contracting Co. Hamilton Ranch Well 1	628
13	Diamond Drill Contracting Co. Hamilton Ranch Well 2	1,109
14	W. F. Kernin Well No. 1	3,900
15	F. W. Dillard well in Lookingglass area	700
16	Uranium Oil and Gas Co. Ziedrich 1	4,368
17	Hutchins and Marrs Great Discovery 2	3,510
18	Riddle Gas and Oil Producers, Ltd. Wollenberg 1	1,100
19	Riddle Gas and Oil Producers, Ltd. Aikins 1	480
20	Riddle Gas and Oil Producers, Ltd. Dayton 1	1,370

Distribution of Oil, Gas, and Coal Resource Data, Southern Tyee Basin, Southern Coast Range, Oregon

by
Alan R. Niem and Wendy A. Niem
Oregon State University

1990

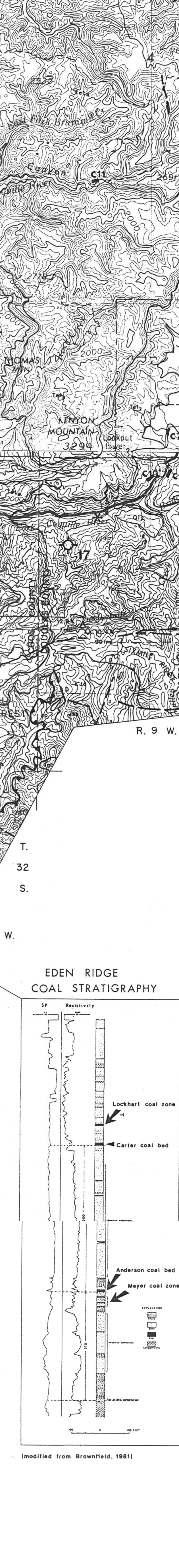
MAP SCALE 1:125,000
CONTOUR INTERVAL 200 ft

Abbreviated explanation of geologic map units appears on Plate 1. Expanded discussion of units is provided in accompanying "Explanation of Geologic Units".

For discussion of resources, see "Oil, Gas, and Coal Potential of the Southern Tyee Basin" report that accompanies this map.

Miles
0 1 2 3 4 5

EDEN RIDGE COAL STRATIGRAPHY



(modified from Brownfield, 1981)

EXPLANATION OF SYMBOLS

ORGANIC GEOCHEMISTRY (principally total organic carbon and vitrinite reflectance)

- ● data from Browning and Flanagan (1979)
- ✳ data from Law and others (1984)
- ■ data from Newton (1980)
- ◑ data from P.D. Snavely, Jr. (U.S. Geological Survey)
- ✸ unpublished data, courtesy of Weyerhaeuser Co.
- ▣ unpublished data from Brown and Ruth Laboratories (1983), courtesy of DOGAMI
- ⚠ unpublished data from Brown and Ruth Laboratories, courtesy of Weyerhaeuser Co.
- ★ unpublished data from Mobil, courtesy of Mobil Corp.
- ☆ unpublished data from Geochem Laboratories (1980), courtesy of R. D. Robertson
- ▲ unpublished data from Geochem Laboratories (1983) for Ogle Petroleum Corp.; courtesy of DOGAMI
- 140 Numbers next to symbols are sample analysis identification numbers; refer to Table 1a.

POROSITY

- □ data from Newton (1980)
- △ unpublished data from Mobil

Refer also to Table 2

SEEPS AND SHOWS

- Oil seep
- Gas seep
- Gas sample analyzed by Mobil
- Gas sample analyzed by K. Kvenvolden (1983)
- 8H Number refers to sample in Table 3.

COALS

- /c coal bed(s) in outcrop
- ◦ Coal sample analysis; refer to Tables 4a, 4b, and 4c.
- C2 coal sample number, refer to Table 4c
- 8 oil or gas exploration well, identification numbers explained in table on this plate; for further information also consult DOGAMI Oil and Gas Investigation Nos. 15 and 16

SOURCES OF DATA

Amoco Production Company Research Center, 1985, Source rock evaluation, Eocene cuttings, Amoco No. B-1 Weyerhaeuser, Douglas County, Western Oregon; courtesy of Weyerhaeuser Co.

Brown and Ruth Laboratories, Inc., 1983, Pacific Northwest, Regional petroleum geochemistry of the onshore and offshore sediments of Washington and Oregon, Mobil Oil Company Sutherlin Unit No. 1; courtesy of DOGAMI.

Brown and Ruth Laboratories, Inc., 1983, Pacific Northwest, Regional petroleum geochemistry of the onshore and offshore sediments of Washington and Oregon, General Petroleum Corporation Long Bell No. 1; courtesy of DOGAMI.

Brown and Ruth Laboratories, Inc., no date, Geochemical Report, Amoco Weyerhaeuser F-1; courtesy of Weyerhaeuser Co.

Brownfield, M. E., 1981, Oregon's coal and its economic future: Oregon Geology, v. 43, no. 5, p. 59-67.

Browning, J. L. and Flanagan, T. M., 1979, Source rock study of the lower Tertiary formations of southwestern Oregon: Source Rock Consultants report, 96 p.

Kvenvolden, K. A. (Geochemist, U.S. Geological Survey, Menlo Park, Calif.), 1983, Letter of June 3, 1983, to Alan R. Niem.

Law, B. E., Anders, D. E., Fouch, T. D., Pawlewicz, M. J., Lickus, M. R., and Molenaar, C. M., 1984, Petroleum source rock evaluations of outcrop samples from Oregon and northern California: Oregon Geology, v. 46, no. 7, p. 77-81.

Mobil Oil Corp., Lee High, Division Geologist, Bakersfield, Calif.

Newton, V. C., Jr., 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.

Ogle Petroleum Corp., 1983, Total organic carbon values and maturation analysis of selected wells, Oregon; unpublished report on file at DOGAMI (DOGAMI Oil and Gas Contract #2), Geochem Laboratories (1983).

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., (Consulting Geologist, Lakewood, Colorado), 1989, Letter of August 22, 1989, to Alan Niem.

Snavely, P. D., Jr. (Senior Research Geologist, U.S. Geological Survey, Menlo Park, Calif.), 1989, Letter to Alan Niem.

U.S. Bureau of Land Management, Roseburg, Oregon and Portland, Oregon offices.

Weyerhaeuser Co., Peter Hales, Oil and Gas Exploration Manager, Tacoma, Washington.

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Geologic Cross Sections

by

Alan R. Niem and Wendy A. Niem
Oregon State University

1990

Thin deposits of unit Qal are not shown.

On strike-slip faults, "A" and "T" indicate movement "away" and "toward" the reader.

Jagged line (~~~~~~) indicates unconformity.

Thin dashed lines within units (------------) are form lines to depict structure more clearly.

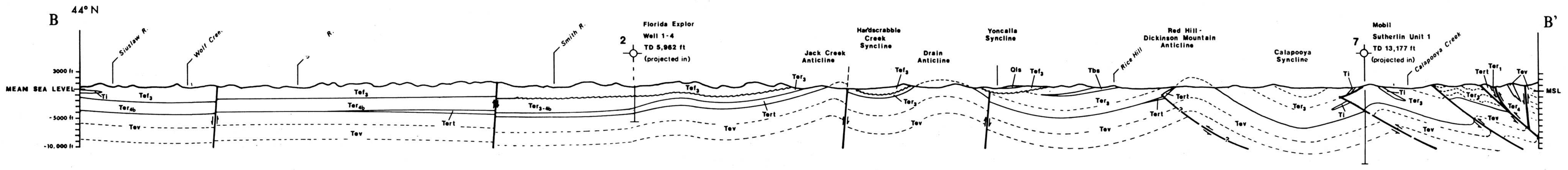
<?> Lateral facies change

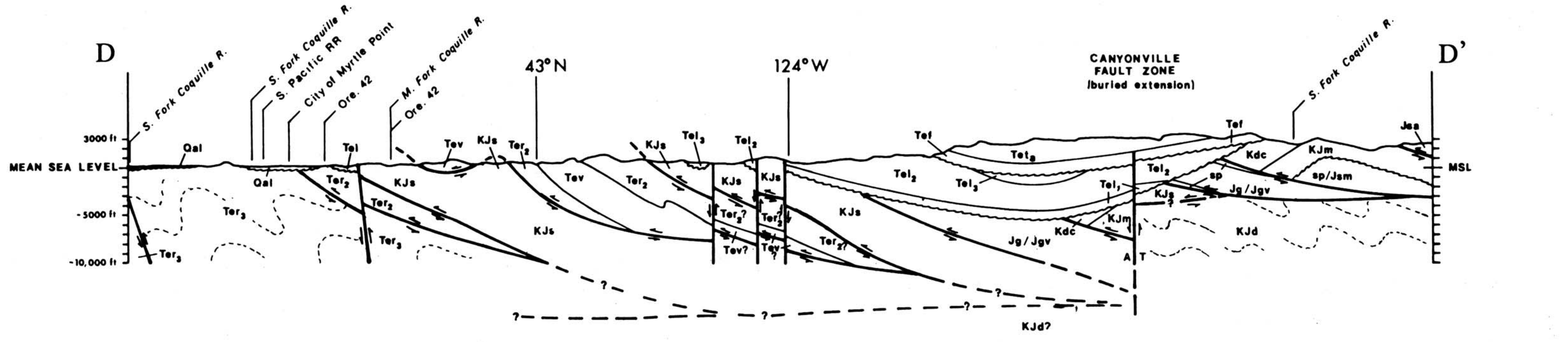
Plate 3

Reviewed by:

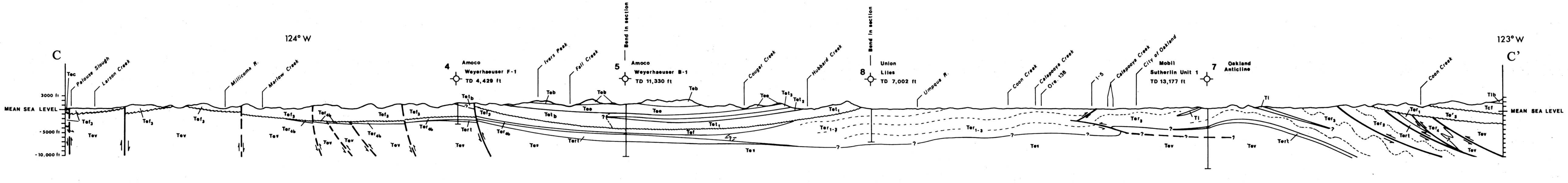
Parke D. Snavely, U.S. Geological Survey
Ray E. Wells, U.S. Geological Survey
Peter O. Hales, Weyerhaeuser Company

No Vertical Exaggeration





These cross sections are preliminary and are not balanced. The authors acknowledge help from Pete Hales, Weyerhaeuser and Mobil for seismic and well information in preparation of cross sections AA′, BB′, and CC′. Bob Lawrence, Oregon State University, helped in the structural interpretation of cross sections.



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DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
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Portland, Oregon 97201

OPEN-FILE REPORT O-89-3

GEOLOGY AND OIL, GAS, AND COAL RESOURCES, SOUTHERN TYEE BASIN, SOUTHERN COAST RANGE, OREGON

by Alan R. Niem and Wendy A. Niem
Oregon State University

EXPLANATION OF GEOLOGIC UNITS
(Plates 1, 2, and 3)

for the

Compilation Geologic Map of the Southern Tyee Basin, Southern Coast Range, Oregon

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EXPLANATION OF GEOLOGIC UNITS
(Plates 1, 2, and 3)

| Qs | QUATERNARY BEACH AND DUNE SANDS (Holocene)--Modern sediments along coastline, includes beach and dune sands and interdune silt, clay, and peat.

| Qal | QUATERNARY ALLUVIUM (Holocene and Pleistocene)--Floodplain and stream channel sediments composed of clay, silt, sand, and gravel, includes tidal flat sediments near mouths of Siuslaw and Umpqua rivers and fluvial terrace deposits; near Sitkum includes lacustrine sediments that filled an ancient lake created by a large landslide (Qls).

| Qls | LANDSLIDE DEBRIS (Holocene and Pleistocene)--Chaotic mixture of gravel, sand, silt, and clay with blocks of weathered bedrock of varying composition (mostly sandstone and mudstone). Only areas of approximately 1 sq mi or larger are shown due to scale of map.

| Qmt | QUATERNARY MARINE TERRACE (Pleistocene)--Elevated deposits of loosely compacted sand and gravel; mapped west of Tenmile Lake on the coast.

Unconformity

| Ti | TERTIARY INTRUSIVE ROCKS (Paleocene to lower Eocene and upper Eocene to Oligocene?)--Sills and dikes, predominantly basalt in composition. Paleocene to lower Eocene intrusive rocks related to Roseburg basalts; upper Eocene to Oligocene intrusive rocks related to western Cascade volcanism.

Western Cascade Stratigraphy

| Tlb | LITTLE BUTTE VOLCANIC SERIES (Oligocene)--Nonmarine volcanic rocks, including flows of olivine basalt to pyroxene andesite near the base of the unit and massive andesitic to dacitic pyroclastic rocks in the upper part of the unit (Ramp, 1972).

Tcf — Undifferentiated COLESTIN and FISHER FORMATIONS (upper Eocene)--Nonmarine volcanic strata (2200 m) including massive to poorly bedded tuffs, tuffaceous sandstone and siltstone, and some conglomerate and debris flows (Ramp, 1972). Unit contains some intercalated subaerial flows and breccias of andesite to basaltic andesite.

Southern Coast Range Stratigraphy
(refer also to "Discussion of Southern Tyee Basin-Coast Range Stratigraphic Problems" that follows this explanation)

Tes — SPENCER FORMATION (upper Eocene; upper Narizian)--Massive to poorly bedded micaceous arkosic sandstone interbedded with thin siltstone and some fine tuff. Sandstone is fine- to coarse-grained. Deltaic to shallow-marine unit contains a few thin impure coals, mollusks, and pebble conglomerate (Hoover, 1963).

Tec — Undifferentiated COALEDO FORMATION (middle Eocene; Narizian)--Deltaic sequence consisting of laminated to cross-bedded fine-grained feldspathic sandstone and thin-bedded siltstone with minor thin beds of subbituminous coal.

Teb — BATEMAN FORMATION (middle Eocene; lower Narizian)--Thick-bedded to cross-bedded, medium-grained micaceous arkosic sandstone and minor siltstone; locally bearing subbituminous coal and carbonaceous siltstone. Many sandstone beds massive to cross-bedded. Some are laminated to ripple cross-laminated and bioturbated. Deltaic and shallow marine unit, approx. 1500 ft thick (Baldwin, 1974; Weatherby, in progress).

Tee — ELKTON FORMATION (middle Eocene; Ulatisian)-- Micaceous siltstone with thin to thick sandstone lenses and rhythmically interbedded thin graded micaceous sandstone and siltstone. Siltstone contains bathyal microfossils. Unit is approximately 3,000 ft thick. May interfinger with upper part of Tyee Formation. Some thicker bedded to cross-bedded better sorted sandstone near top of formation (Baldwin, 1974).

Tet_{ab} — Undifferentiated TYEE FORMATION of Baldwin (1974) (middle Eocene; Ulatisian)--Five to six thousand feet of well-indurated, thick to very thick-bedded cliff-forming, micaceous arkosic sandstone and thin-bedded siltstone. In south, unit includes thick, cross-bedded medium- to coarse-grained sandstone with rare pebble conglomerate, thick coal, carbonaceous siltstone, and thinner beds of mudstone and mollusk-bearing bioturbated sandstone (shown on map as Tet_a; delta-shelf facies of Chan and Dott, 1983). In north, unit consists of fine- to medium-grained, micaceous (biotite and muscovite), lithic arkosic sandstone beds with load, flute, and groove marks, minor beds of siltstone, and thin to medium beds of graded sandstone (shown on map as Tet_b; inner to middle fan and slope facies of Chan and Dott, 1983 or proximal turbidite ramp-slope facies of Heller and Dickinson, 1985). Queried contact between the two facies is approximated on Plates 1 and 2 and in cross sections based on studies by Chan and Dott (1983) and Heller and Dickinson (1985). Queried contact between the Tyee and Flournoy formations in northern part of outcrop area is from unpublished mapping by Baldwin. Molenaar (1985) maintains that Flournoy and Tyee formations can not be differentiated in the northern part of the map area and that the two units should be mapped together as Tyee. Three members are mapped in the Camas Valley quadrangle (Baldwin and Perttu, 1989).

Tet_3 BAUGHMAN LOOKOUT MEMBER of Baldwin (1974) and Baldwin and Perttu (1989). Very thick-bedded to massive micaceous lithic-arkosic sandstone; medium- to very coarse-grained; rarely cross-bedded; minor interbedded siltstone; cliff-former; 2500 ft thick. May interfinger with Elkton siltstone to the north; interpreted as deltaic facies (Molenaar, 1985).

Tet_2 HUBBARD CREEK MEMBER of Baldwin (1974) and Baldwin and Perttu (1989). Mainly dark gray, parallel laminated mudstone and siltstone with minor thin to medium beds of fine-grained micaceous sandstone; 400-ft thick slope-former. Interpreted as a slope facies (Molenaar, 1985).

Tet_1 TYEE MOUNTAIN MEMBER of Baldwin (1974) and Baldwin and Perttu (1989). Fifteen hundred feet of thick-bedded, fine- to medium-grained locally graded to massive micaceous lithic-arkosic sandstone and thin layers of siltstone; cliff-former; grades upward into Hubbard Creek Member. Interpreted as a turbidite facies (Molenaar, 1985).

Unconformity (?)

Tef Undifferentiated FLOURNOY FORMATION of Baldwin (1974) (lower to middle Eocene; Ulatisian)--Thick-bedded fine- to coarse-grained mica-bearing lithic-feldspathic sandstone and thick sequence of mudstone-siltstone. Unit includes deltaic to shelf facies (Tef_1) in the south, bathyal slope facies (Tef_2), and turbidite facies (Tef_3) to the north.

Tef_3 SIUSLAW member (informal). Four to five thousand feet of very thick-bedded, massive to graded fine-grained micaceous amalgamated lithic-feldspathic sandstone with minor sequence of thin-bedded siltstone and fine- to very fine-grained graded sandstone beds and some very thick-bedded channelized sandstone. Some sandstone beds contain numerous groove, flute, and load casts; a few are slump folded. Siltstone contains bathyal microfossils. Informal unit suggested by maps by Mobil (Seely, 1989, personal communication). Formerly included in White Tail Ridge Member of Flournoy Formation of Baldwin (1974) and Tyee Formation of Molenaar (1985). Unit may be lateral facies of both Tyee and Flournoy to the south.

Tef_2 CAMAS VALLEY MEMBER of Baldwin and Perttu (1989). Rhythmically thin-bedded siltstone and fine-grained mica-bearing feldspathic graded sandstone; 1500 feet thick; some slump folded beds and horizons of calcareous concretions. Deep-marine slope facies(?).

Tef_1 WHITE TAIL RIDGE MEMBER of Baldwin and Perttu (1989). Thick-bedded, medium- to coarse-grained, mica-bearing lithic-feldspathic sandstone with minor interbedded mudstone; mollusk-bearing; some coal and carbonaceous siltstone layers. Unit is approximately 1500 ft thick. Some sandstone beds display hummocky cross-bedding. Some basal thin conglomerate beds and pebbly sandstone near Bone Mountain and Eden Ridge in southern part of map area (Baldwin, 1974). Delta-shelf facies.

Unconformity(?)

Tel Undifferentiated LOOKINGGLASS FORMATION of Baldwin (1974) (lower Eocene; Penutian to lower Ulatisian)--Coarse- to fine-grained cross-bedded, locally coal-bearing, quartzose lithic (metamorphic-volcanic) sandstones and thick lithic pebble-cobble conglomerates intercalated with thick mudstone with minor thin graded sandstone beds.

Tel_3 OLALLA CREEK MEMBER of Baldwin (1974). One thousand feet of thick-bedded pebbly quartzose lithic pebbly sandstone and polymict pebble-cobble conglomerate in type area along Olalla Creek. In other areas (e.g., along Oregon Highway 42) includes medium- to thick-bedded medium- to coarse-grained quartzose lithic sandstone, subbituminous coal, and thin beds of very fine-grained sandstone and carbonaceous siltstone and mudstone with shallow-water foraminifers and pelecypods; also some beds of thick massive bioturbated sandstone. Sandstone beds are locally trough to planar cross-bedded, lenticular to channelized with basal pebble lags. Molenaar (1985) would combine the Olalla Creek Member and the White Tail Ridge Member. Member is interpreted as non-marine fan delta at type section by Baldwin and Perttu (1989) to a fluvial braided stream deposit that interfingers with deltaic-coastal plain facies to the northwest (Kugler, 1979; Ryberg, 1984).

Tel_2 TENMILE MEMBER of Baldwin (1974). Well-indurated, dark gray mudstone interstratified with thin beds of fine-grained turbidite lithic arkosic sandstone. A rare submarine channel fill composed of olistostromal blocks is exposed near Agness (Ryberg, 1984). Upper part contains mollusk-bearing mudstones (Ryu, 1989, field observation). Unit is approximately 3,200 ft thick. Mainly a bathyal slope facies (Ryberg, 1984).

Tel_1 BUSHNELL ROCK MEMBER of Baldwin (1974). Eight hundred feet of well-indurated, very thick- to thick-bedded lithic disorganized pebble-cobble conglomerate and some thick-bedded very coarse-grained lithic sandstone; cross-bedded to channelized; fan delta of Kugler (1979) and braided stream deposit of Ryberg (1984);

possible submarine canyon facies at Cleveland Hill (Molenaar, 1985). Near Remote, on the west flank of the Coast Range syncline, the unit is finer grained and includes medium- to thin-bedded laminated to cross-bedded lithic feldspathic sandstone, subbituminous coals, carbonaceous siltstone, claystone, and some thick-bedded bioturbated to massive fine-grained sandstone to very coarse-grained sandstone lenses. Some ripples, tabular cross-bedding, and groove casts are present. Turritella and thin-shelled pelecypods in a few siltstone layers. Unit fines northwestward from the type section (Ryberg, 1984; Molenaar, 1985). Coastal plain-shallow marine-deltaic facies; Kugler, 1979; Ryberg, 1984).

Angular Unconformity

Ter/Tev — ROSEBURG FORMATION of Baldwin (1974) (Paleoecene to lower Eocene)--Thick sequence (8,000+ ft) of indurated lithic turbidite sandstones and mudstones with bathyal microfossils. Lower part of unit is pillow basalts (Tev) that are intertongued with minor amounts of sedimentary rocks (Ter). Locally overlain by tuffs and tuffaceous siltstone (Tert). The basalts are, in part, equivalent in age and petrology to the Siletz River Volcanics of the central Coast Range (Snavely and others, 1968); named Roseburg Volcanics by Baldwin (1974); renamed Siletz River Volcanics by Molenaar (1985). Sedimentary section is interpreted as an accreted submarine fan deposited in a trench/slope setting (Ryberg, 1984; Perttu and Benson, 1980).

Lithofacies associations within the Roseburg (informal subdivisions of Ter combined after Ryberg, 1984) are shown generalized to emphasize distribution of submarine fan depositional environments of this lower slope-submarine fan-trench complex formed in a subduction zone (Heller and Ryberg, 1983; Perttu and Benson, 1980).

Ter_4 — SLOPE (Ter_4) and BASINAL (Ter_{4b}) MUDSTONES; massive to laminated mudstone, channeled mudstone, and minor rhythmically interbedded siltstone and claystone; some slumped strata. Unit Ter_{4b} deposited in a basin plain environment and on seamount highs as hemipelagic muds; upper and lower slope mudstone and siltstone in upper slope channels; after Ryberg (1984). Basinal unit is mostly thick mudstone in the subsurface in the northern part of the map area.

Ter_3 — OUTER FAN and FAN FRINGE FACIES; thin, even-bedded very fine-grained to medium-grained graded lithic sandstone and siltstone; sandstone/mudstone ratio is 1/1 to 2/1; Bouma bcd, cde, and abcde sequences common in turbidite sandstone beds as a a few groove, flute, and load casts and sand-filled burrows at base of beds; mudstone calcareous nannoplankton, and bathyal benthic and planktonic foraminifers; some thickening-upward sequences; after Ryberg (1984).

Ter_2 MIDDLE FAN FACIES; thick-bedded, fine- to coarse-grained graded amalgamated lithic sandstone, locally lenticular with thin gray siltstone interbeds containing bathyal foraminifers; some thinning- and fining-upward sequences; sandstone/mudstone ratio is 4/1 to 6/1. Associated with a few sequences of very thick-bedded, amalgamated, massive lenticular medium-grained sandstone beds with thin discontinuous mudstone interbeds; some groove and flute casts at base of beds and burrowed in upper part of beds. Minor sequence of thin fine-grained graded lenticular sandstone and siltstone. Mudstone with some burrows and planktonic and benthic bathyal foraminifers. Bouma abde, abe, and ae sequences prevail; facies after Ryberg (1984).

Ter_1 INNER FAN to LOWER SLOPE CHANNEL FACIES; massive channelized disorganized conglomerate to inverse and normal graded polymict conglomerates and very thick-bedded, coarse-grained, pebbly, graded to massive lithic sandstone; minor sequences of interbedded mudstone and thin, fine-grained lenticular sandstone beds; facies after Ryberg (1984).

Tbs BASALTIC SANDSTONE (lower Eocene)--Tongue of basaltic sandstone in Roseburg outer fan strata (unit Ter3) and derived from unit Tev; mapped separately by Hoover (1963).

Tert TUFFS; thick sequence of palagonite tuff and deep-marine tuffaceous siltstone interbedded with pillow basalts in upper part of unit Tev; mapped separately by Hoover (1963). Hoover (1963) also recognized water-laid vitric tuff and lapilli crystal tuff.

Tev ROSEBURG VOLCANICS. Tholeiitic pillow basalts, breccias, and some massive subaerial flows (near Drain) interbedded with minor conglomerate and basaltic sandstone. Duncan (1982) and Snavely and Wells (1984) have published K/Ar dates of 59 to 62 Ma (early Eocene to Paleocene) for this unit. Carayon (1984) reported a K/Ar age of 69 Ma(?) (latest Maestrichtian) for Roseburg basalt sampled near Bushnell Rock. Microfossils (foraminifers and coccoliths) in sedimentary interbeds in the unit indicate Paleocene to lower Eocene (Armentrout and others, 1983; Miles, 1981; Ryberg, 1984; McKeel and Lipps, 1975; McKeel, 1983; Bukry and Snavely, 1988). These tholeiitic to alkalic basalts are interpreted to have formed at an oceanic ridge, forming a seamount terrane. Alternatively, the basalt may have formed *in situ* along a rifted continental margin (Snavely and Wells, 1984; Snavely, 1984, 1987; Wells and Snavely, 1989). Unit was accreted to the Klamath Mountains terrane in the early middle Eocene (Snavely, 1987).

Klamath Mountains Stratigraphy

TK — UNNAMED SANDSTONE (Lower Eocene? to Upper Cretaceous?)--A well-indurated to locally friable, pebbly, cross-bedded to massive medium- to coarse-grained micaceous arkosic sandstone of unknown age. This sandstone occurs as small isolated outliers unconformably(?) overlying the melange of Sixes River terrane which is Late Cretaceous in age (Blake, 1984; Carayon, 1984). The unit was assigned to Tertiary-pre-Tertiary by Peterson (1957) and Baldwin and Perttu (1989) and to Paleocene to Upper Cretaceous by Ryberg (1984) based on stratigraphic position. Carayon (1984) reported Eocene palynomorphs in the unnamed sandstone from an outcrop near Hoover Hill (T. 29 S., R. 7 W.). These sandstones may be an Upper Cretaceous (Campanian to Maestrichtian) equivalent of the Cape Sebastian sandstone of Bourgeois (1984) on the southwest Oregon coast. Baldwin (1989, personal communication) believes Late Cretaceous foraminifers have been identified from an outlier of friable cross-bedded pebbly arkosic sandstone in this unit in T. 29 S., R. 12 W.

The following explanation of rock units for the Klamath Mountains part of the map is organized by tectonostratigraphic terrane after Blake (1984) and Blake and others (1985). Within each terrane, the rock units are organized by age and stratigraphic position (see Fig. 1 and Time-Rock Chart on Plate 1). A brief discussion "Nomenclature of the Tectonostratigraphic Terranes of the Klamath Mountains" follows "Discussion of Southern Tyee Basin-Coast Range Stratigraphic Problems" at the end of this explanation.

Sixes River Terrane of Blake (1984) and Blake and others (1985)

KJs — SIXES RIVER MELANGE AND BROKEN FORMATION (Lower Cretaceous-Upper Jurassic; Hauterivian to Tithonian and Middle to Upper Cretaceous; Albian to Cenomanian)--Predominantly well-indurated, tightly cemented turbidite sandstone, thick sheared mudstone, and minor conglomerate. Sandstones are micaceous quartzo-feldspathic (Lent, 1969) to lithic graywacke. These rocks are well-indurated and metamorphosed (laumontite zeolite facies). Unit contains exotic tectonic blocks of metabasalt or greenstone (mv), red and white radiolarian chert (rc), blueschist (sch), metatuff, eclogite (ec), and Middle to Upper Cretaceous (Aptian to Upper Cenomanian) limestone (ls). Limestone blocks were named Whitsett limestone lentils by Diller (1898) and consist of shallow-marine algal boundstone, pelecypod-bearing grainstone, and deep-marine globigerinid micritic limestone with interbedded radiolarian chert. This unit formerly had been mapped south of Roseburg as Dothan Formation by Diller (1898), Ramp (1972), and Johnson (1965) and as Franciscan terrane by Carayon (1984). On the southwestern flank of the basin (generally south of Myrtle Point), the unit has been mapped as Jurassic Otter Point Formation by Baldwin and Hess (1971), Dott (1971), Lent (1969), and Beaulieu and Hughes (1976).

Yolla Bolly (east) Terrane of Blake (1984) and Blake and others (1985)

Upper Jurassic and Lower Cretaceous (Tithonian to Hauterivian) sedimentary and minor volcanic rocks of the Dothan Formation (KJd).

KJd — DOTHAN FORMATION (Lower Cretaceous-Upper Jurassic; Tithonian to Hauterivian)--Thick sequence of well-indurated, medium-grained, thin- to thick-bedded turbidite sandstone and thin- to thick-bedded mudstone with minor lenses of chert conglomerate, radiolarian chert, and local pillow lava (Blake and others, 1985). These moderately to poorly sorted graywacke sandstones are micaceous volcano-quartzo-feldspathic and contain detrital K-feldspar, phrenite, pumpellyite (Blake, 1984), and local laumontite veins. The Dothan is probably a post-Nevadan highly folded deep marginal basinal sequence that was accreted to the North American plate during the Middle Cretaceous (Black, 1979). Unit crops out mostly south of the Canyonville Fault Zone and in a small sliver north of the Canyonville Fault zone east of the town of Canyonville.

Snow Camp Terrane of Blake (1984) and Blake and others (1985)

A dismembered Jurassic (Callovian to Tithonian) ophiolite complex (Coast Range ophiolite) with unconformably overlying folded and faulted sedimentary rocks of the Lower Cretaceous to Upper Jurassic Myrtle Group (KJm, Kdc, KJr). The Coast Range ophiolite, according to Blake (1984), includes serpentinized peridotite (sp)(as at Nickel Mountain, Ramp, 1978) with mafic volcanics (unit Jsm), minor granodiorite and diorite intrusions, thick sequence of dioritic to andesitic intrusive and extrusive rocks (Jsa), gabbro (Jgb) along the Rogue River (Gray and others, 1982), and sheeted dikes which Saleeby (1984) dated at 164 Ma +/- 2 Ma). Near Marial, the ophiolite complex also contains spilitized pillow basalt, altered diabase, gabbro, and diorite (Gullixson and others, 1980). Extensive thrusting of these units is postulated in the Middle Cretaceous (Carayon, 1984; Roure and others, 1986). North of the Canyonville Fault Zone and east of the town of Canyonville, this terrane includes undifferentiated Jurassic volcanic rocks (Jsv). Along the southeast margin of this map, this terrane also includes amphibole gneiss (Ka) and Cretaceous-Jurassic hornblende diorite (KJi).

KJm — Undifferentiated MYRTLE GROUP (Lower Cretaceous-Upper Jurassic)--Sandstone and conglomerate of the Days Creek and Riddle formations.

Kdc — DAYS CREEK FORMATION (Lower Cretaceous)--Dark gray sandy siltstone with subordinate amounts of light-gray fine-grained sandstone overlain by thick- to medium-bedded fine- to medium-grained gray sandstone.

KJr — RIDDLE FORMATION (Lower Cretaceous-Upper Jurassic)--Massive chert-pebble conglomerate in the lower part of the unit overlain by thin- to medium-bedded, well-indurated lithic graywacke, siltstone, and conglomerate. Abundant fossil mollusks (*Buchia*) indicate a dominantly shallow-marine depositional environment (Perttu, 1976).

Ka

AMPHIBOLE GNEISS (Cretaceous?)--Banded, medium-crystalline rock consisting of alternating dark (hornblende-rich) and light (quartz- and plagioclase-rich) bands. This rock appears to be hornblende diorite (described below, KJi) that has undergone cataclasis (Champ, 1969). Unit is exposed in small fault slice in southeast corner of map (T. 27 S., R. 3 and 4 W.). Although this unit occurs within the Snow Camp Terrane on Blake's (1984) generalized tectonostratigraphic terrane map of southwest Oregon (Fig. 1 on Plate 1), it may represent a separate subterrane within the Snow Camp or may be an entirely separate terrane (such as Dry Butte subterrane of Western Klamath Terrane of Blake, 1984).

Kg

GRANODIORITE (Lower Cretaceous)--Intrusive igneous rocks of granitic texture and composition.

KJi

HORNBLENDE DIORITE (Lower Cretaceous-Upper Jurassic)--Coarsely crystalline intrusive hornblende diorite; mineral composition includes plagioclase (andesine), hornblende, minor quartz, and accessory magnetite, epidote, and chlorite.

Jsv

VOLCANIC ROCKS OF SNOW CAMP TERRANE (Jurassic)--Extrusive igneous rocks including tuff breccia, massive greenstone, massive tuffs and agglomerates (basalt to andesite in composition), and rhyodacite flows and bedded tuffs. Mapped by Johnson and Page (1979), Ramp (1972), and Ryberg (1984) as undifferentiated Rogue and Galice formations intruded by Cretaceous granodiorite (Kg) and as the Louis Creek klippe by Carayon (1984).

Coast Range Ophiolite of Blake and others (1985)

Jsa

ANDESITE, DACITE, AND SHEETED DIKES OF SNOW CAMP TERRANE (Middle and Upper Jurassic)--Suite of volcanic rocks of intermediate to felsic composition. Unit includes andesitic to dacitic agglomerates, tuffs, flows, flow breccias, sheeted dikes, and pillow lavas. Mapped by Gray and others (1982) as Rogue Formation.

Jgb

GABBRO (Jurassic)--Medium to coarsely crystalline gabbro. Mapped unit includes intrusions of diorite and metagabbro that are too small or complexly interrelated to be mapped separately. Unit occurs east of Powers Fault in T. 31 to 35 S.

Jsm

MAFIC VOLCANICS OF SNOW CAMP TERRANE (Jurassic)--Basalts

sp

SERPENTINITE (Jurassic)--Serpentinite and serpentinite-peridotite; sheared serpentinite along fault zones.

Jdi

DIORITE (Jurassic)--Diorite stocks and dikes.

Western Klamath Terrane of Blake (1984) and Blake and others (1985)

The Western Klamath Terrane represents a disrupted and dismembered continental marginal basin-volcanic arc sequence of metasedimentary and rare metavolcanic rocks (Blake, 1984). It consists of highly deformed Middle and Upper Jurassic rocks along the western margin of the Klamath Mountains. This complex terrane has been subdivided by Blake and others (1985) into five subterranes with slightly different substrate although most contain shaly flysch-like Galice Formation. Two of the subterranes, the Elk subterrane and the Rogue Valley subterrane, occur on the southern margin of the Tyee Basin south of the Canyonville Fault Zone and east of the Vallen Lake Thrust (Fig. 1 on Plate 1). Common in both subterranes is undifferentiated Rogue and Galice formations.

Elk Subterrane

Undifferentiated small blocks of Lower Cretaceous (Valanginian) well-indurated turbidite sandstone, mudstone, and conglomerate of the Humbug Mountain Conglomerate (Khm) and Rocky Point Formation of Koch (1966) and Dott (1971). These lithologies unconformably overlie widespread Middle to Upper Jurassic (Oxfordian to Kimmeridgian) undifferentiated metasedimentary (Jg) and scattered metavolcanic (Jgv) rocks of the Galice Formation which is intruded by Late Jurassic diorite plutons (Jdi) and serpentinite-peridotite (sp).

Khm — Undifferentiated HUMBUG MOUNTAIN CONGLOMERATE and ROCKY POINT FORMATION (Lower Cretaceous)--Well-indurated, normal to inversely graded polymict chert-volcanic-metamorphic conglomerate and overlying thin-bedded turbidite graywacke sandstone siltstone of Koch (1966) and Dott (1971). Aalto and Dott (1970) interpreted the depositional environment of these units as deep-marine turbidites and debris flows.

Jg — GALICE FORMATION (Upper Jurassic)--Dark gray to black partly fissile, highly sheared mudstone and siltstone interbedded with dark gray fine-grained graywacke turbidite sandstone with minor chert conglomerate. Mapped unit includes areas of Galice volcanics (Jgv) too small or complexly interrelated to be mapped separately.

Jgv — VOLCANIC ROCKS in the upper part of the Galice Formation (Upper Jurassic)--Volcanic breccias, pillow lavas, and tuffs, possibly with some intrusive basalt.

Jdi_1 — DIORITE (Jurassic)--Diorite stocks and dikes.

Rogue Valley Subterrane

Middle and Upper Jurassic (Oxfordian-Tithonian) calcalkaline volcanic rocks (Johnson, 1980; Garcia, 1982) and associated volcanolithic sandstone and shale).

| Jrg | Undifferentiated ROGUE and GALICE FORMATIONS (Jurassic)--Extrusive volcanic rocks, including tuff breccia, greenstone, massive tuffs and agglomerates (basalt to andesite in composition), and rhyodacite flows and bedded tuffs.

Pickett Peak Terrane of Blake (1984) and Blake and others (1985)

This terrane is represented by a small sliver of outcrop of Colebrooke Schist at the western edge of the map in T. 31 S. The terrane is, however, much more extensive west of the map area in the Klamath Mountains where it includes an underlying serpentinite melange and contains greenstone "knockers".

| Jc | COLEBROOKE SCHIST (Upper Jurassic; Oxfordian to Tithonian?)--Dark gray mica schist, carbonaceous phyllite, metagraywacke, minor metatuff and greenstone, and rare chert (Coleman, 1972). Greenschist to blueschist metamorphic minerals in the metagraywacke beds include quartz-albite-chlorite and phengite +/- lawsonite and +/- calcite (Blake and others, 1985). In the metabasalts, the minerals include albite-chlorite-epidote-actinolite +/- crossite (Coleman, 1972). An Early Cretaceous age (125 to 138 Ma) of metamorphism has been determined for the schist in Oregon and in California (Dott, 1971; Lanphere and others, 1978).

Discussion of Southern Tyee Basin - Coast Range Stratigraphic Problems

Diller (1898) was the first to map and define the Umpqua and Tyee formations in the southern Oregon Coast Range and pre-Tertiary rock units of the northern Klamath Mountains in the area of investigation. Ewart Baldwin and his thirty-two M.S. students at the University of Oregon did detailed pioneering work in the 1960's and 1970's in developing the Eocene stratigraphy, sedimentology, and mapping of the Coos Bay and Tyee basins (see Author Index Map on Plate 1 and "References Cited"). Baldwin synthesized this work into a series of geologic maps and reports (Baldwin, 1974; Baldwin and Beaulieu, 1973; Baldwin and Perttu, 1989) in which the Eocene stratigraphy of the area was defined (Fig. 1). In these reports, he divided the Umpqua Group into three formations: Roseburg (volcanics and sedimentary rocks), Lookingglass, and Flournoy. He further distinguished several members within these formations.

Some disagreement on the interpretation of the stratigraphy of the Tyee Basin developed with a publication by Molenaar (1985). He is of the opinion that the Roseburg volcanics should be called Siletz River Volcanics, a separate volcanic unit from the Umpqua Group (Fig. 1). In addition, he questions the regional unconformity between the Tyee and Flournoy formations and suggests abandoning the Lookingglass and Flournoy formations, downgrading the rank of the Umpqua Group to formation. He would retain four of the five member names but would combine the Olalla Creek Member of the Lookingglass Formation and the White Tail Ridge Member of the Flournoy Formation into one member (the White Tail Ridge Member)(Fig. 1).

The stratigraphic relationship and map pattern of the Flournoy and Tyee formations in the north-central and western part of the basin is also a subject of disagreement. On Plate 1, the contact between the Tyee and Flournoy in the northern part of the map area is queried because it has never been formally mapped in detail; it is sketched from discussions with Baldwin. Baldwin (1974) and Baldwin and Perttu (1989) show that there are two lithologically similar formations in the type area in Flournoy Valley, with an unconformity and a thick mudstone unit (Camas Valley Member) separating the thick sandstones of the two units. Molenaar (1985), on the other hand, believes that the two lithologically similar formations cannot be differentiated in the western and northern parts of this map area. He thinks the two units should be mapped as Tyee Formation as depicted by Wells and Peck (1961 and Snavely and others, 1964). This would significantly change the map pattern on Plate 1 (see cross-hatched pattern on Fig. 2). We could not resolve this stratigraphic problem within the 1-year scope of this compilation study; instead we elected to use Baldwin's interpretation because of the wealth of detailed geologic mapping (e.g., thesis maps) in the southern part of the basin that utilize his nomenclature (see Author Index Map on Plate 1 and "References Cited").

Recent studies of facies and depositional models in the Tyee Basin, using Baldwin's (1974) stratigraphic nomenclature, have been conducted by Chan and Dott (1983) and by Heller and Dickinson (1985). These contemporaneous studies proposed different deltaic-submarine fan models and different depositional positions on the fan for the same rock units. Chan and Dott (1983) concluded that the Tyee-Flournoy is a sandy submarine fan

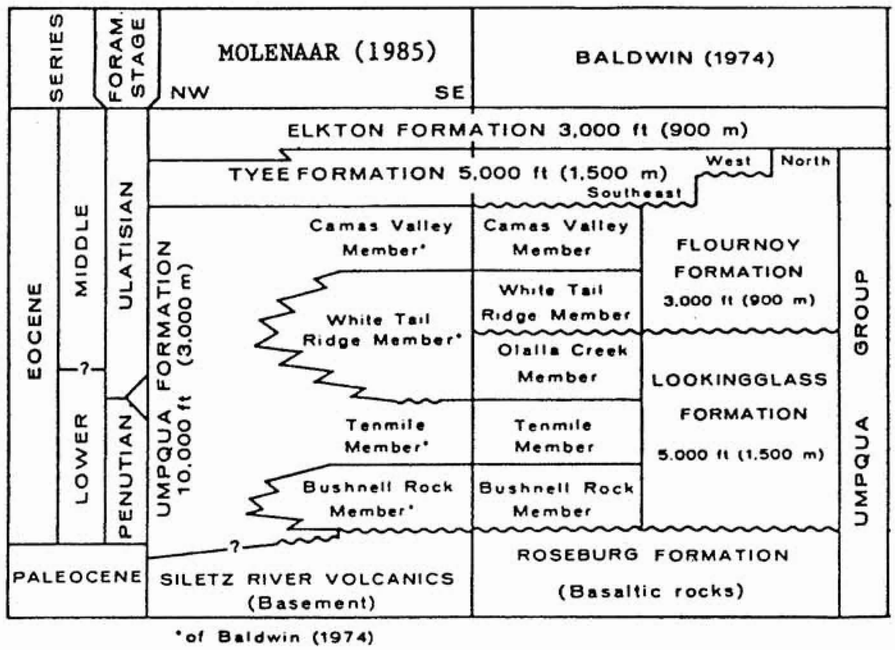

Fig. 1 Stratigraphic nomenclature in the Tyee Basin, comparing usage proposed by Molenaar (1985) with usage by Baldwin (1974). Diagram slightly modified from Molenaar (1985).

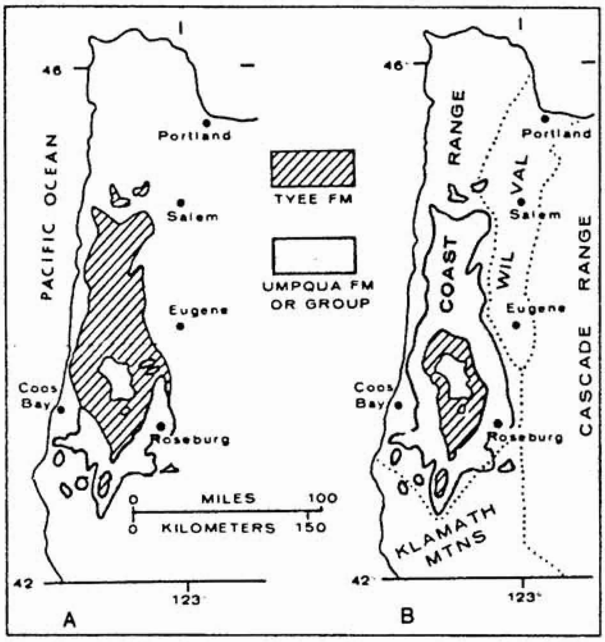

Fig. 2 Index map of western Oregon showing different interpretations of the distribution of Umpqua Formation (or Group)(including Siletz River Volcanics in southwestern Oregon) and Tyee Formation. Map A shows interpretation used by Wells and Peck (1961) and favored by Molenaar (1985). Map B shows interpretation of Baldwin (1974). Flournoy Formation of Baldwin (1974) is part of Umpqua Group. Map and caption slightly modified from Molenaar (1985).

system whereas Heller and Dickinson (1985) maintained that this sequence was deposited as a submarine ramp. We have added tentative boundaries between the dominantly delta-shelf sandstone-coaly facies of the Flournoy (Tef) and Tyee (Tet_a) and the turbidite fan or submarine ramp facies of the Tyee (Tet_b) and Flournoy (Tef_3) on Plate 1, using the boundaries of Chan and Dott (1983)(Fig. 3). For the turbidite facies of the Flournoy (Tef_3), we have used the informal name Siuslaw member (from unpublished mapping by Mobil Oil Corp., Bill Seely, 1989, personal communication). The type section of the informal Siuslaw member of the Flournoy Formation is very thick-bedded to massive amalgamated turbidite sandstones along the Siuslaw River.

If the queried stratigraphic break in the north between the turbidite facies of the Flournoy Formation (Siuslaw member) and the turbidite facies of the Tyee is not definable through more mapping in the future, then perhaps the informal Siuslaw and Tyee turbidite facies should be raised eventually to formation status as a turbidite fan lithofacies equivalent to the delta-shelf facies of both the Tyee and Flournoy; or, perhaps, the Flournoy nomenclature should be dropped from the northern and western part of the map area entirely. Only ongoing detailed mapping of lithofacies and subsurface study, age control, and section measuring can better define the depositional lithofacies and thereby resolve this problem. The second year of this project is addressing the subsurface distribution of these units through a well correlation diagram which will also be correlated to measured sections in the type area. Detailed mapping by members of the DOGAMI staff and graduate students at the University of Oregon and Oregon State University will also address this problem.

Another area of stratigraphic disagreement is the presence of a regional unconformity between the White Tail Ridge Member of the Flournoy Formation and the Olalla Creek Member of the Lookingglass Formation postulated by Baldwin (1974)(Fig. 1). Baldwin believes that the unconformity at the base of the Flournoy locally removed the entire thickness of the Lookingglass (Fig. 4B). Molenaar (1985), in his redefinition of units, believes that the White Tail Ridge Member (which includes Baldwin's Olalla Creek Member) gradationally overlies and locally scours into the Tenmile Member (Fig. 4A).

Baldwin and University of Oregon graduate students (e.g., Kugler, 1979) mapped the sequence of shallow-marine sandstones and deltaic coaly facies west of Remote and along the Middle Fork of the Coquille River as a finer grained delta-shelf facies of the Bushnell Rock Member of the Lookingglass Formation (Fig. 4B); this is the interpretation we used on Plate 1. Molenaar (1985) contends, on the other hand, that the Bushnell Rock conglomerate facies does not fine to this coaly shelf facies near Remote but rather that these rocks are a lithofacies of the White Tail Ridge Member (Fig. 4A). He prefers the model that the Bushnell Rock Member is a conglomeratic fan delta lithofacies that pinches out to the northwest along with the pinchout of the shallow-marine and deltaic sandstones of the White Tail Ridge Member into a 10,000-ft thick slope mudstone facies of Molenaar's Umpqua Formation (Fig. 1). An additional complication is that mapping by Baldwin and his students show a major angular unconformity between highly deformed Roseburg strata (part of Molenaar's Umpqua Formation) and the overlying Lookingglass Formation (also part of Molenaar's Umpqua Formation). Perhaps this stratigraphic disagreement

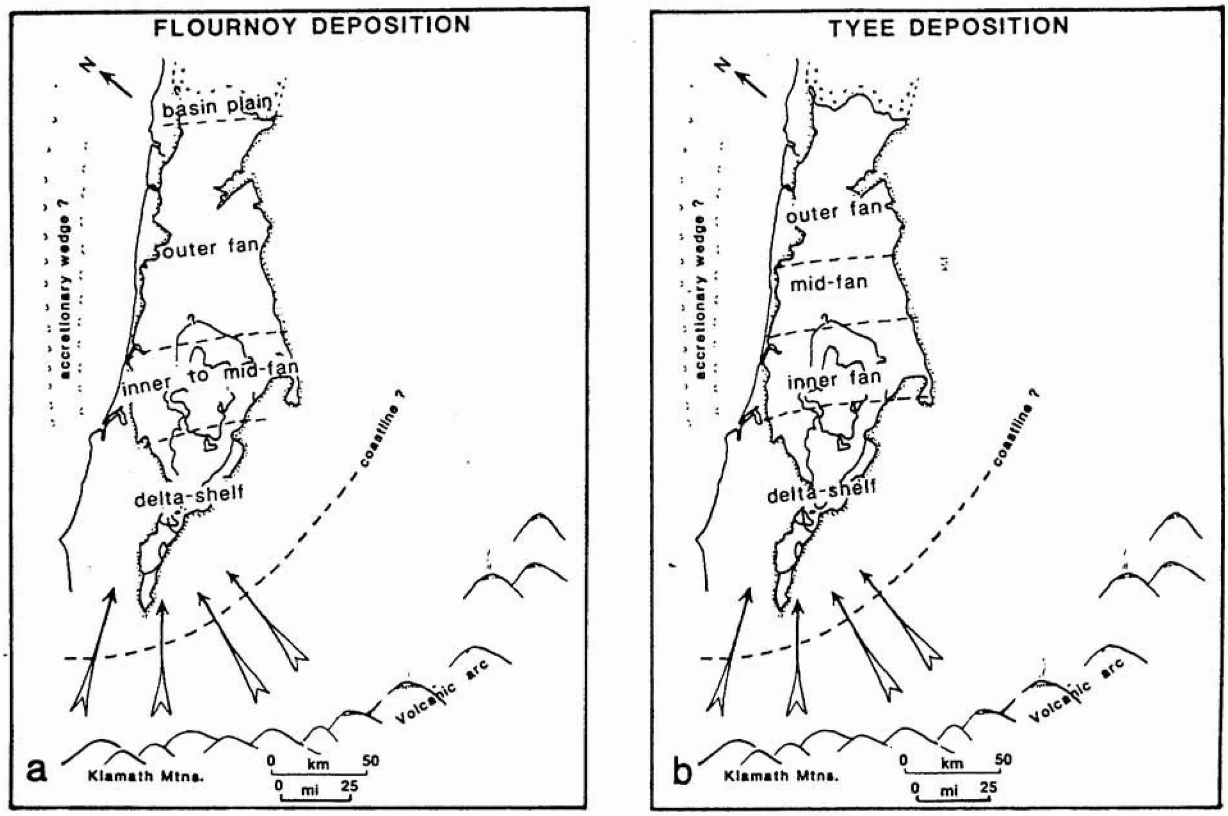

Fig. 3 Facies distribution and paleogeography of Flournoy Formation (panel a) and Tyee Formation (panel b), showing northward progradation of delta facies from early Ulatisian to late Ulatisian (from Chan and Dott, 1983).

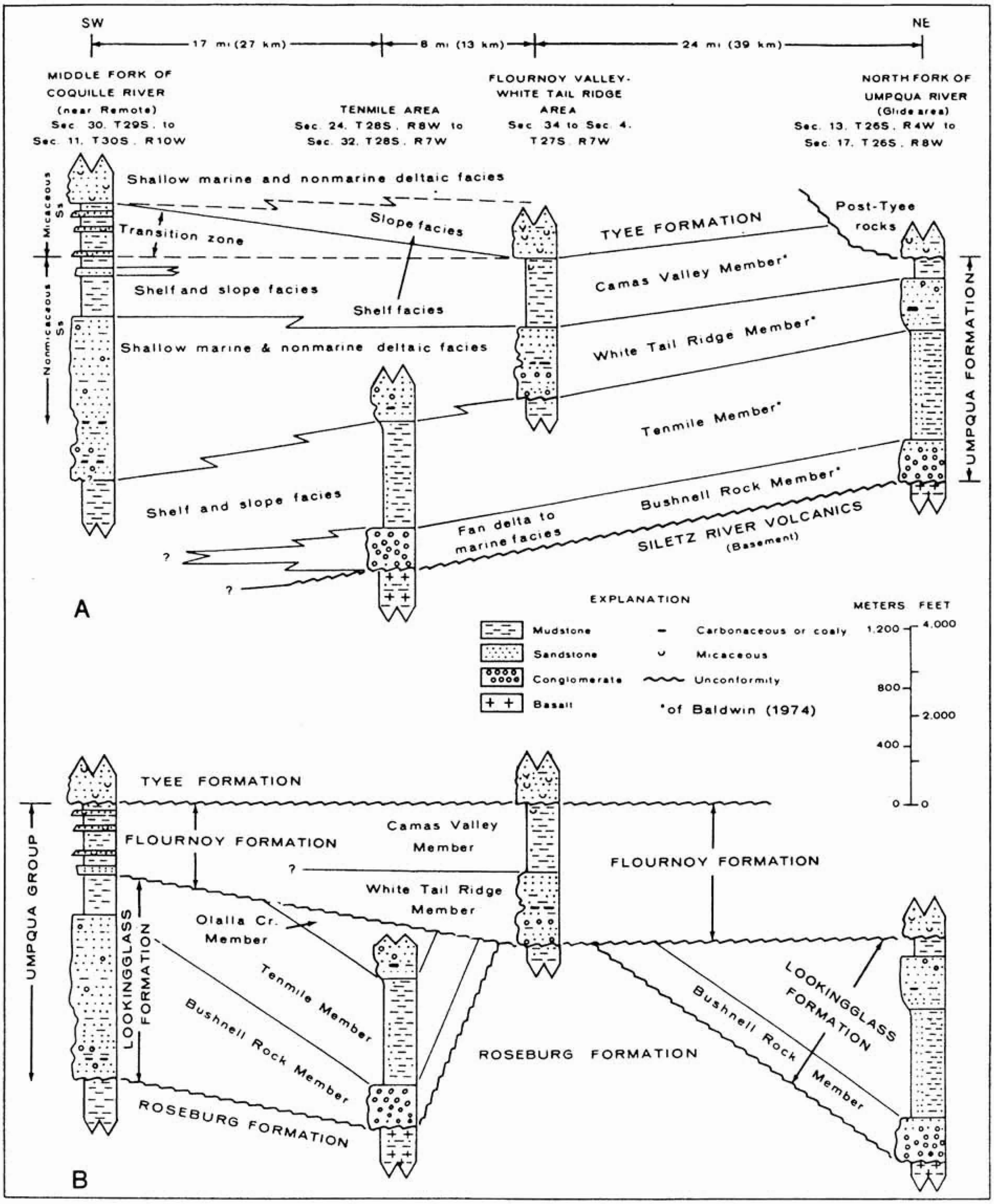

Fig. 4 Stratigraphic sections of Umpqua Formation (or Group) along southern margin of outcrop, showing correlations of Molenaar (1985) in A and correlations by Baldwin (1974) in B. Lithology of sections is generalized. Tenmile and Flournoy Valley-White Tail Ridge sections are type sections of Baldwin's Lookingglass and Flournoy formations. Diagrams and caption slightly modified from Molenaar (1985).

could be resolved by mapping lithofacies and temporarily abandoning the established nomenclature; that is, mapping from the type sections of the units and defining them strictly on lithology and stratigraphic position. For example, Ryberg (1984) recognized eight lithofacies within the Roseburg and Lookingglass strata. Using lithofacies associations, he then mapped the fan facies of the Roseburg which we incorporated on Plate 1 in order to show the distribution of the principal facies such as deep-sea conglomerates and sandstone in contrast to thin-bedded mudstone and sandstone. This lithofacies association mapping is generalized on Plate 1.

Another area of concern is the stratigraphic age assignment for these Eocene units. We followed utilized the age assignments of Armentrout and others (1983) and Miles (1981). Miles (1981) showed that, based on planktonic foraminifers, the Roseburg and Lookingglass formations were deposited during early Eocene time (Zone P7-8), the Flournoy was deposited during early middle Eocene time (Zone P10), and an unconformity representing 1 to 2 million years occurs between the two units. This conclusion agrees with Baldwin's (1974) field mapping interpretation. Bukry and Snavely (1988), however, reported that coccoliths from the Roseburg, Lookingglass (Tenmile Member), and Flournoy are all from Zone CP-11 (i.e., late early Eocene), suggesting age equivalency among the three units as Molenaar (1985; Fig. 1) maintained. This apparent age disparity between planktonic and coccolith zones in these units needs to be addressed through sampling the same outcrops for both foraminifers and coccoliths.

These differences in interpretation of the Eocene stratigraphy hopefully will be resolved through ongoing subsurface studies, detailed surface mapping of lithofacies, age dating, and section measuring by DOGAMI, U.S. Geological Survey, University of Oregon, and Oregon State University geologists. The resulting stratigraphic framework will direct future drilling, defining which are the target units in the subsurface. It will also effect interpretation of the reservoir and source-rock facies discussed in this preliminary report.

NOMENCLATURE OF THE TECTONOSTRATIGRAPHIC TERRANES OF THE KLAMATH MOUNTAINS

The Mesozoic rocks of the Klamath Mountain province of southwestern Oregon and northern California have had a long and complicated geologic and structural history. These rocks form the southern margin of the Tertiary Tyee Basin. A brief discussion of these rocks and tectonostratigraphic nomenclature is included here because of the need to evaluate the oil and gas potential of the Lower Cretaceous Myrtle Group and the implications of the regional structural setting of these rocks for maturation and structural traps in the southern part of the Tyee Basin.

Coleman (1972), Dott (1971), and more recently Blake (1984), Blake and others (1985), Roure (1984), Roure and others (1986), Roure and Blanchet (1983), Carayon (1984), and Carayon and others (1984) have recognized that the northern Klamath Mountains of Oregon are composed of a series of westward and northwestward oriented nappes or imbricate thrust sheets. Some are cut by and have been moved long distances by transcurrent faults as a result of plate collision and accretion. Deformation occurred in the Jurassic, early and late Cretaceous, and possibly as late as the early to middle Eocene as plate collision caused overthrusting of some Mesozoic rocks (e.g., Sixes River terrane) over the Roseburg volcanics and sedimentary strata (Carayon, 1984; Carayon and others, 1984).

These investigators have reorganized, and in some cases redefined, traditionally mapped Klamath Mountain rock units into tectonostratigraphic terranes, resulting in a different understanding of the complicated geologic history of the Klamath Mountains. Howell and others (1985) defined a tectonostratigraphic terrane as "a fault-bounded package of rocks of regional extent characterized by a geologic history which differs from that of neighboring terranes". Blake (1984) and Blake and others (1985) have applied this terrane concept to the complicated Mesozoic geology of the Klamath Mountains of southwestern Oregon. They have recognized eleven terranes, six of which form the southern margin of the Tyee Basin (Fig. 1 on Plate 1). These terranes are: Sixes River, Yolla Bolly, Pickett Peak, Snow Camp, and Western Klamath (Elk subterrane and Rogue Valley subterrane). The Time-Rock Chart on Plate 1 illustrates the stratigraphic and age relationships between the units that comprise each terrane and between terranes. Most of the rock unit names within each terrane are the formational names that have been traditionally used in geologic mapping of the Klamath Mountains. Traditional rock unit names are used on most of the maps listed in "Sources of Mapping" on Plate 1, particularly in theses. The reader is referred to these traditional names in Ramp (1972), Baldwin (1974), and Ryberg (1984).

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GEOLOGY AND OIL, GAS, AND COAL RESOURCES, SOUTHERN TYEE BASIN, SOUTHERN COAST RANGE, OREGON

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TEXT

Oil, Gas, and Coal Potential of the Southern Tyee Basin: A Preliminary Assessment

by
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1990

NOTICE

The Oregon Department of Geology and Mineral Industries is publishing this report because the subject matter is consistent with the mission of the Department. To facilitate timely distribution of information, camera-ready copy submitted by the authors has not been edited by the staff of the Oregon Department of Geology and Mineral Industries.

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OIL, GAS, AND COAL POTENTIAL OF THE SOUTHERN TYEE BASIN - A Preliminary Assessment

by
Alan R. Niem

OIL AND GAS POTENTIAL

Summary

Preliminary analysis through compilation of the geologic map, brief study of seismic reflection lines, and gathering source rock, maturation, and porosity and permeability data from industry and government agencies suggests that the oil potential of the lower Tertiary marine rocks of the southern Tyee Basin is low while the potential for gas is low to moderate. The potential for gas is best in the south-central part of the basin in terms of favorable source rock (e.g., coals), seals, maturation, reservoirs, and structural and stratigraphic traps. This area is where most of the known gas and oil seeps occur (Plate 2). The occurrence of many oil and gas shows in exploration wells throughout the Tyee Basin indicates that the potential of this basin still needs to be further investigated and that commercial quantities of hydrocarbons may exist in the subsurface.

The adjacent Mesozoic rocks of the northern Klamath Mountain Province that flanks the basin to the south have low potential for reservoirs and structural traps due to the intense deformation, and indurated nature of the sedimentary units and abundance of volcanic and igneous units (Blake, 1984; Roure and others, 1986; Carayon, 1984). It is possible that Tertiary Roseburg turbidite strata may be locally matured and fractured by deep underthrusting beneath the margin of the Klamath terrane (cross sections C-C′ and D-D′, Plate 3).

The northern part of the basin appears to be underlain by thick Paleocene to lower Eocene oceanic basalt basement (Siletz River-Roseburg volcanics) and thick lower Eocene mudstone (unit Ter_4) that is laterally equivalent to the Roseburg turbidite fan strata to the south. Overlying these units are thick, tightly cemented non-reservoir lower to middle Eocene micaceous lithic-feldspathic turbidite fan sandstones of the Tyee and Flournoy formations) which have low to moderate porosities and permeabilities. Overlying the turbidite sequences are indurated deep-marine channelized slope turbidite sandstones and slope mudstones of the middle Eocene Elkton Formation (unit Tee) and more friable, cleaner (more permeable?) arkosic deltaic sandstone of the middle Eocene Bateman Formation (unit Teb). Unfortunately, both of these younger units have been breached by erosion. However, broad (more open) north-south and northeast-southwest trending folds occur to the north (Plate 1). Evaluation of the 14 exploration wells that have been drilled in the basin is in progress and may provide further insight to the potential of the area. In addition, more data are needed in the south-central part of the area (both seismic and

field mapping) on potential source and reservoir rocks, sedimentary facies, and favorable structural and stratigraphic traps.

The following is a preliminary evaluation of the southern Tyee Basin in terms of source rocks, maturation, cap rocks or seals, potential reservoir rocks, structural and stratigraphic traps, timing of hydrocarbon accumulation, results of past exploration drilling (20 wells), oil and gas seeps, and coal resources. The reader should refer to the oil, gas, and coal resource map (Plate 2), the geologic map (Plate 1), and the cross sections (Plate 3). This report also includes data tables of source rock and maturation data, porosity and permeability measurements, and coal analyses and reserves estimates. Sample locations are indicated and numbered on Plate 2 and correspond to the sample numbers used in the data tables. Values for porosity and permeability are shown on Plate 2 and listed in Table 2. This array of data has been contributed by industry, academia, and government agencies and has been gleaned from published and unpublished sources; a list of the sources of the data appears on Plate 2 and in "References Cited". The author appreciates permission to publish these data. This interpretation of the data is only preliminary and comes from a compilation of the data at hand. A final evaluation will be prepared at the end of the 5-year study of the basin by DOGAMI.

SOURCE ROCK

Distribution:

More than 1,365 source rock analyses from 139 surface localities (Plate 2 and Table 1a) have been performed on most of the Paleogene rock units in the basin and on some of the Upper Jurassic to Lower Cretaceous rock units in the adjacent Klamath Mountains. The types of analyses include total organic carbon (TOC), Rock-Eval pyrolysis, some C15 soxhlet extraction, and liquid chromatography, and some visual kerogen typing (see Table 1). Most source rock analyses (TOC) were performed by Mobil Oil Corp. (unpublished) and the U.S. Geological Survey (Law and others, 1984). Sampling was concentrated in the oldest units (Upper Jurassic-Lower Cretaceous Myrtle Group and Paleocene to lower Eocene Roseburg strata), representing 1,310 samples, in the southern part of the map area (southeast of Roseburg, in the Canyonville-Myrtle Creek-Riddle area, and in the Agness area) (Plate 2). Fewer analyses are available for the lower to middle Eocene units (Tyee, Flournoy, and Lookingglass formations) and even fewer for the youngest units (middle Eocene Bateman and Elkton formations) in the north-central part of the map area (Fig. 1). Virtually no analyses are available for the other, intensely deformed, Jurassic-Cretaceous sedimentary units of the Klamath Mountain tectonostratigraphic terranes (e.g., Sixes River terrane [unit KJs], Galice Formation [unit Jg]). Further analysis of surface samples of units other than the Roseburg and Myrtle Group is warranted.

Source rock data for outcrop samples are listed by locality number and summarized by formation in Table 1a. Several hundred source rock analyses (e.g., TOC, Rock-Eval, C15 extraction) for samples from eight wells in the northern and central part of the basin provide additional information on the source rock potential of the Eocene units (i.e., Elkton to Roseburg). The subsurface data are presented as an average for each well in Table 1b.

Fig. 1 Summary of Rock Units

Total Organic Carbon and Vitrinite Reflectance

Age	Formation	Organic Carbon (% of rock) T.O.C. (x/no. of samples)	Vitrinite Reflectance Ro (x/no. of samples)
Outcrops:			
Eocene	Elkton	.56/10	.59/3
Eocene	Tyee	.90/27	.79/8
Eocene	Tyee coals	45.79/2	.59/2
Eocene	Flournoy	.58/17	.52/7
Eocene	Lookingglass	.59/19	.63/9
Eocene	Lookingglass carb. shale	19.20/1	.48/1
Paleocene-Eocene	Roseburg	.48/651	.59/282
Jur.-Cretaceous	Myrtle Group	.87/20	.74/2
Cretaceous	Days Creek	.78/617	1.01/43
Jur.-Cretaceous	Riddle	.79/22	.56/2

Results:

Most published and unpublished reports by consultants, industry, and government agencies indicate that the source rock potential of the Lower Cretaceous and lower Tertiary marine rocks is low to marginal (more than 95% of the samples analyzed contain <1.0% TOC [see Table 1a and Fig. 1]; which is typical of lean source rocks; Tissot and Welte, 1978)(Law and others, 1984; Newton, 1980). Dickey and Hunt (1972) showed that a minimum of 0.50 wt % TOC is necessary for a rock to be an effective hydrocarbon source. Many of the surface samples are below or barely exceed that value (Table 1a).

Outcrop samples of the middle Eocene Tyee Formation have the highest percentage of T.O.C. (0.90% for 5 samples, excluding one anomalously high value of 11% and coals). The next highest values of TOC occur in Upper Jurassic-Lower Cretaceous Myrtle Group samples (0.87% for 20 samples), in the Cretaceous Days Creek Formation (0.78% for 617 samples), Upper Jurassic-Lower Cretaceous Riddle conglomerate (0.77% for 22 samples), lower Eocene Lookingglass mudstones (0.59% for 19 samples), lower and middle Eocene Flournoy shales (0.58% for 17 samples)(Fig. 1). The lowest values are in the middle Eocene Elkton mudstone (0.56% for 10 samples) and the Paleocene-lower Eocene Roseburg mudstone (0.48% for 651 samples)(Fig. 1). Law and others (1984)(Table 1c) showed that the highest values of TOC in this lower Tertiary sequence are in coals, carbonaceous shales, and mudstones. The Tyee average is anomalously higher than expected, possibly due to high-grading of three samples (Browning and Flanagan, 1980). The TOC values for more than 300 samples of fresh cuttings from eight widely spaced oil and gas exploration wells also are indicative of low to marginal source rocks (Table 1b), suggesting that surface weathering and degradation of organic matter is not the reason for the low values of TOC in these rocks. However, a low to marginal source rock rating is not sufficient to condemn a Tertiary forearc basin in western Oregon. The Mist Gas Field produces from middle to upper Eocene strata that are similarly low to marginal source rocks (i.e., most TOC values <1%; Niem and Niem, 1985; Armentrout and Suek, 1985) yet it is a commercial field, producing since 1979 (Olmstead, 1989a).

There are some notable exceptions to the generalization that the Tyee Basin has poor to lean source rocks. One is the abundant and potentially very widespread subbituminous to bituminous coals in the deltaic facies of the Tyee Formation (unit Tet_a), Lookingglass Formation (Olalla Creek Member [unit Tel_3] on the east flank; Bushnell Rock Member [unit Tel_1] on the west flank), and Flournoy Formation (Tef) in the southern part of the basin. Plate 2 illustrates the distribution of coal outcrops (and samples number 18 and 19 for Tyee Formation in Table 1a). These coal beds are locally several feet thick, potentially underlie tens of square miles (e.g., Eden Ridge field), and contain sufficient volatile organic matter to generate dry and/or biogenic gas (e.g., 45% TOC in Tyee coals, Fig. 1, and 27 to 33% volatile matter for hundreds of coal analyses from the Tyee Eden Ridge coal field, Tables 4a and 4d). These widespread coals are associated with a locus of reported methane gas seeps in the basin (see "Coal Resources" discussion and Plate 2). Buried coals and marginal to lean upper Cowlitz mudstone associated with the upper Eocene deltaic Cowlitz Formation in the Tualatin and/or Nehalem basins east of the Mist

Gas Field may be the source of the partially thermogenic gas produced in the field (Armentrout and Suek, 1985; Fortier, 1989, ARCO, personal communication).

Other types of source rock analyses (e.g., visual kerogen typing, C15 extract, Rock-Eval pyrolysis) substantiate the TOC analyses that most Eocene turbidites, slope mudstones, and deltaic and shelf formations in the basin are limited (poor) to marginal source rocks. These other types of analyses have been conducted on much fewer samples. For example, microscopic inspection of kerogen types from outcrop and well cuttings samples (Brown and Ruth, 1983; Browning and Flanagan, 1980; Tybor in Newton, 1980) suggests that most kerogen in the samples is dominated by terrestrially derived herbaceous pollen and woody material (i.e., carbonaceous plant debris). There are only minor to trace amounts of amorphous material and alginite (see Flournoy in Table 1a). This dominant type of kerogen tends to be gas-prone (Tissot and Welte, 1978; Tybor in Newton, 1980). Low extractable bitumen levels in a few samples (e.g., 188 ppm) and C15 extract (total estimated hydrocarbon) of a few surface samples and dozens of subsurface samples also suggest that these lower to middle Eocene units have poor to very poor oil source rock rating (Tybor in Newton, 1980; Brown and Ruth, 1983).

Law and others (1984) and Tybor (in Newton, 1980) showed that low hydrogen indices (H index = S2/TOC) and high oxygen indices (O2 index = S3/TOC) from Rock-Eval pyrolysis of a dozen outcrop samples of these lower Tertiary formations (Table 1c) plot in the field of Type III hydrogen-deficient organic matter on a binary graph of oxygen index versus hydrogen index (Van Krevelen diagram Fig. 2), thus reconfirming the terrestrial gas-prone (non-oil or low oil potential) nature of the kerogen (Fig. 2; Table 1c). Further confirmation of this conclusion is provided by similar Rock-Eval pyrolysis analyses of many well cuttings of these Eocene units by Brown and Ruth (1983) and Amoco (1985). Law and others (1984) warned that the low TOC in these samples also can lead to artificially low hydrogen index values due to adsorption of pyrolysis products by clays (like smectites) and other mineral matter. The only exceptions to the poor to lean source rock evaluations are the two coal samples from the Tyee Formation (sample nos. 25 and 26). These coals also have high hydrogen indices and could serve as gas and minor oil sources (if matured); they plot as Type I and Type II oil- and gas-rich source rocks, according to Law and others (1984).

The genetic potential (S1 + S2 in Table 1c from Law and others, 1984) from source rock pyrolysis analysis is a measure of the source rock generation capability of a rock expressed in milligrams of hydrocarbon per gram (mg/g) or kilograms of hydrogen per ton of rock. Rocks with less than 2 kg/ton genetic potential have low hydrocarbon potential whereas samples with greater than 6 kg/ton genetic potential have good source rock values. For the few outcrop samples of Tyee, Flournoy, Lookingglass, and Roseburg strata that were analyzed, the genetic potential is <0.6 kg/ton; for the Elkton, it is <1.15 kg/ton. Thus, the genetic potential also indicates that the lower Tertiary strata of the Tyee Basin are lean source rocks. The important exceptions being the two coals in the Tyee and the carbonaceous shale in the Lookingglass Formation (nos. 21, 26, and 27, Table 1c) which have genetic potentials of 148 kg/ton, 61 kg/ton, and 11 kg/ton. These data reaffirm the importance of coals as potential source

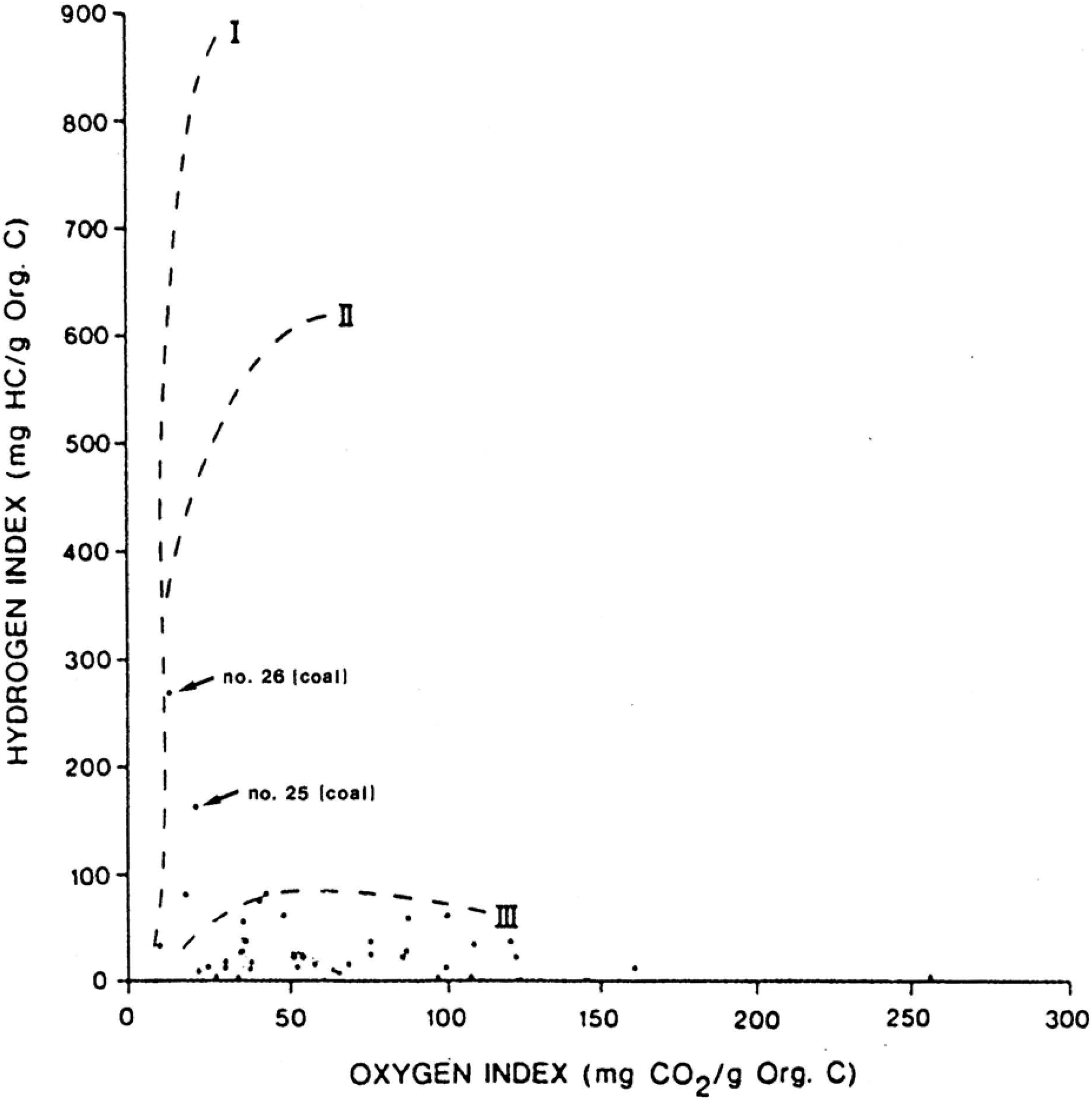


Fig. 2 Modified Van Krevelen diagram (Tissot and Welte, 1978) of hydrogen and oxygen indices of samples from southern Tyee Basin (adapted from Law and others, 1984).

rocks for gas in the Tyee Basin. Rare traces of oil are recognized in some wells that penetrated the coals (see oil and gas seep section and Table 4c).

Similarly, visual kerogen typing, Rock-Eval pyrolysis (for generation potential), chromatography, and C15 extraction characterization of dozens of well cuttings samples also confirm the gas-prone, non-oil or low oil source potential of these Paleocene-Eocene units (Brown and Ruth, 1983; Amoco, 1985). Brown and Ruth (no date, report on Amoco Weyerhaeuser F-1 well) suggested that these hydrogen-depleted, highly oxidized woody kerogens with high pristane/phytane ratios in the Paleocene to upper Eocene units in the Tyee Basin were probably subjected to degradation during transport and soon after shallow burial, perhaps by oxygenated waters. Most kerogen formed *in situ* and has not migrated after burial.

These preliminary analyses, however, should not condemn this basin of over 15,000 feet of Eocene strata as a non-oil gas-prone province because this sampling (particularly in the younger units) may not be entirely representative. The reports of several natural "oil seeps" and shows in wells in older non-coal-bearing units, like the Roseburg, suggest that some unsampled oil-prone source may exist, perhaps at depth.

More systematic outcrop sampling and field mapping of potential source rock mudtone units such as the Tenmile Member, coals in the Lookingglass, Tyee, and Flournoy (White Tail Ridge Member), and the melanged Sixes River terrane rocks (especially in the southwestern part of the map area) should be done in order to evaluate more fully the source rock potential of the area.

MATURATION

Distribution of Samples:

The distribution of surface samples of the early Tertiary and some of the Upper Jurassic-Lower Cretaceous strata (i.e., Myrtle Group) across the basin for which thermal maturation data (vitrinite reflectance, Rock-Eval - S1, S2, S3 and transformation ratios, TAI, and C15 extract chromatography) are available is also skewed. The majority of data is for samples in Paleocene-lower Eocene Roseburg turbidite fan strata in the Roseburg-Sutherlin area and for Upper Jurassic-Lower Cretaceous Myrtle Group in the Myrtle Creek-Canyonville-Riddle area (Plate 2). Scattered outcrop samples of Tyee, Flournoy, and Lookingglass in the southern and central part of the map area have been analyzed for maturation; and there are few samples for the youngest units (Bateman and Elkton formations) in the central part of the basin (Fig. 1; Table 1a; Plate 2).

Continuous downhole samples (cuttings) for vitrinite reflectance, Rock-Eval, and C15 extract are averaged for six wells scattered across the central and northern part of the basin (Table 1b and Plate 2). A summary of the average vitrinite reflectance value for the Eocene section in each well is presented in Table 1b. Additional outcrop samples of the lower Tertiary units in the southwestern part of the map area and perhaps from the older Jurassic-Cretaceous sedimentary units (such as the highly sheared marine mudstone in the Sixes River terrane) should be analyzed.

Results:

Preliminary interpretation of the maturation data suggests that most Tertiary and some Upper Jurassic-Lower Cretaceous units analyzed are too thermally immature for generation of thermogenic dry gas and are marginally mature to immature for oil. Most samples (>80%) give vitrinite reflectance values (Ro) <0.66% (Fig. 1), just below the major window of oil generation and significantly below the levels of dry and wet gas generation (Fig. 3). The top of the oil window varies with the kind of organic matter from 0.5 to 0.7% Ro, and the bottom of the window is 1.3% Ro (Tissot and Welte, 1978)(Fig. 3). Most Tyee Basin samples cluster around 0.55 to 0.66% Ro (Tables 1a and 1b). Thermogenic gas is thought to be generated at vitrinite reflectance values above 0.70% Ro for woody or terrestrial Type III kerogen. Therefore, the vitrinite reflectance values of many of the Tyee, Flournoy, Lookingglass, Roseburg, and Myrtle Group samples which contain principally Type III kerogen are insufficient to generate thermogenic dry gas (Law and others, 1984). For example, one Bateman coal sample has a vitrinite reflectance of 0.45% (correlates to subbituminous rank, Fig. 3). Three Elkton outcrop samples from near the top of the section average 0.59% Ro; the average of seven Flournoy samples is 0.50% Ro. The vitrinite reflectance of 19 Lookingglass outcrop samples is 0.59% Ro, and the average for 165 outcrop samples from the Roseburg is 0.59% Ro. Upper Jurassic to Lower Cretaceous Riddle Formation samples average 0.56% Ro (2 samples)(Fig. 1).

The Tyee average is higher than expected at 0.66% Ro which puts these rocks close to the center of the oil generation window. This average is anomalous because the vitrinite reflectance values of more deeply buried Eocene units (e.g., Roseburg, Lookingglass, and Flournoy) that underlie the Tyee are lower (Fig. 1). In addition, the average values of vitrinite reflectance for hundreds of cuttings samples from several oil and gas exploration wells that penetrated the Tyee and underlying Eocene units (e.g., Amoco Weyerhaeuser F-1 and Weyerhaeuser B-1) are nearly the same as the values for outcrop samples (e.g., 0.49 to 0.66% Ro, Table 1b)(Brown and Ruth, no date; Amoco, 1985). Vitrinite reflectance values for the Tyee coals in outcrop are probably more typical of the formation and vary from 0.63% (sample 18, Table 1a) to 0.55% (sample 19, Table 1a) which corresponds to subbituminous to high volatile "C" bituminous coal (Demshur, Core Lab, 1979, letter in Browning and Flanagan, 1980)(Fig. 3).

Only the older, more deformed Lower Cretaceous Days Creek Formation of the Myrtle Group are in the major zone of the oil generation window, averaging 1.01% Ro for 43 outcrop samples and 0.74% Ro for two samples (Fig. 1). Unfortunately, this unit is breached by erosion in the Myrtle Creek area. Also based upon plate tectonic reconstruction, this unit would not likely underlie much, if any, of the Tyee Basin. The Paleocene to Eocene formations, e.g., Roseburg Formation and Roseburg Volcanics, are thought to have been subducted beneath the Klamath Mesozoic terranes including the Myrtle Group (Snow Camp terrane; see Plate 3, cross section A-A′). An exception is in T. 31 and 32 S., R. 10 W. where Myrtle Group strata appear to dip northwestward beneath the Tyee and Flournoy forearc strata that unconformably overlie these Klamath terranes (Plate 1 and cross section D-D′ on Plate 3).

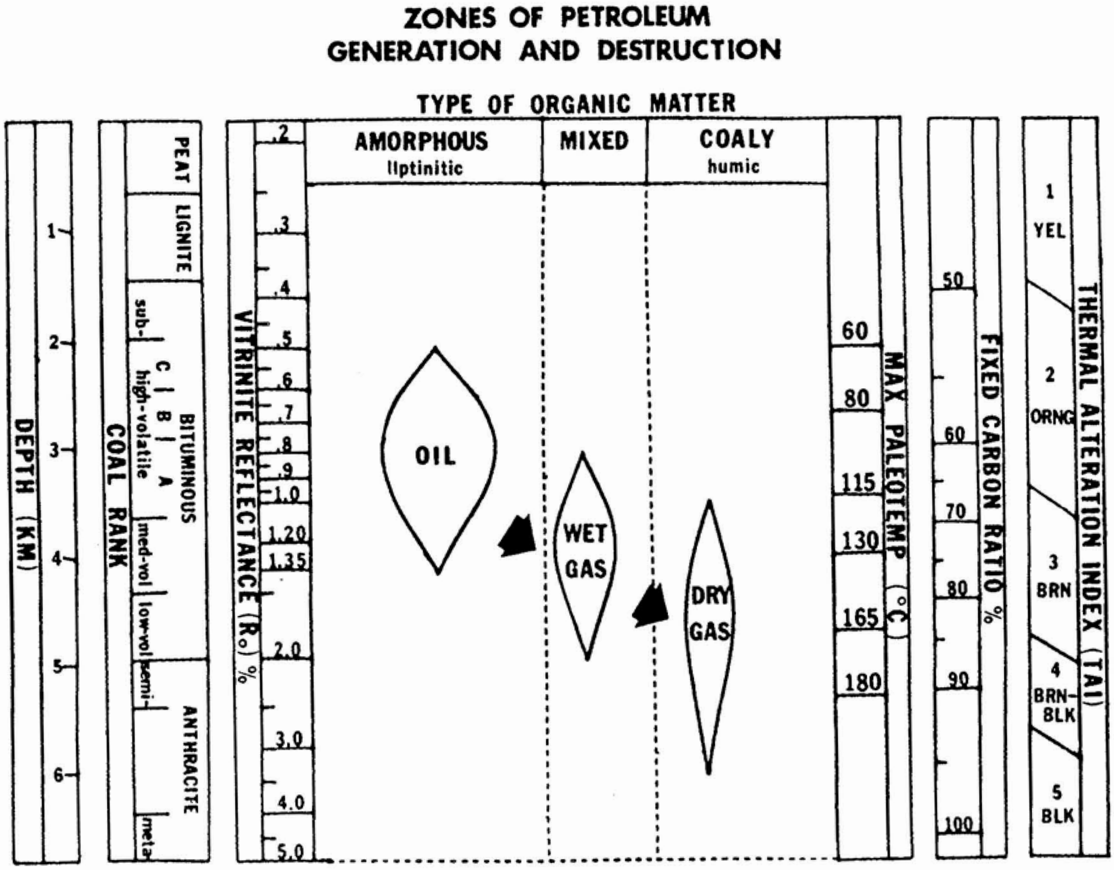


Fig. 3 Correlation of maturation indices (Dow, 1977)(from Newton, 1980).

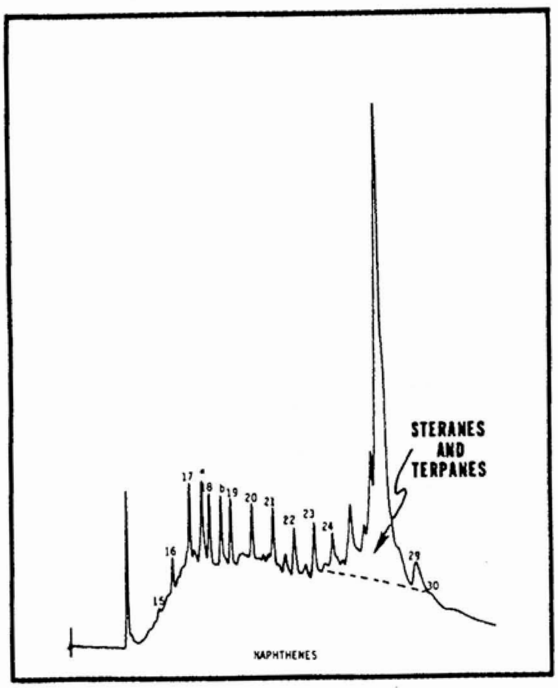


Fig. 4 Naphthenes, sample locality 109, Roseburg mudstone. (from Tybor, in Newton, 1980).

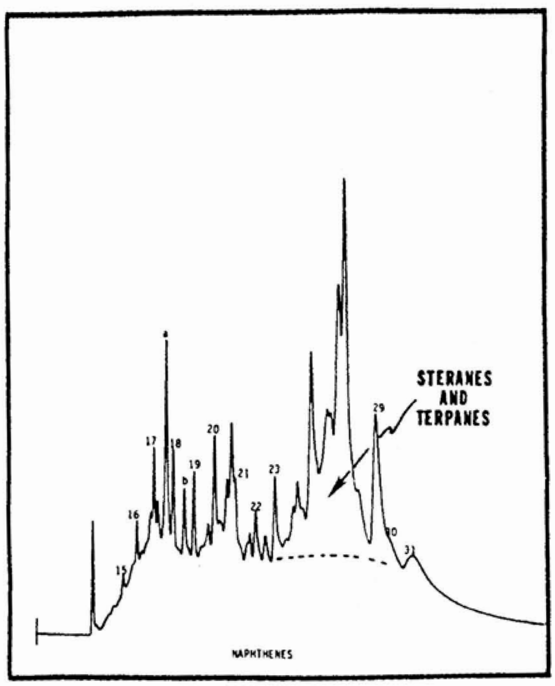


Fig. 5 Naphthenes, sample locality 30, Flournoy mudstone (from Tybor, in Newton, 1980).

Limited analyses suggest that the kerogen in these Upper Jurassic-Lower Cretaceous and Paleocene to Eocene units is probably dominated by gas-prone woody or coaly (humic) types (see "Source Rock" section). This type of kerogen and the low to marginal amount of total organic carbon in these rocks (except for coals) is more likely to produce quantities of dry thermogenic gas rather than large quantities of oil (see Fig. 3). The dry gas window occurs at much higher values of vitrinite reflectance (Ro >1.0 to 3.5%) than have been measured in these surface and subsurface samples (Fig. 3). It is, therefore, unlikely that significant quantities of dry thermogenic gas would be generated although some wet thermogenic gas and immature oil may have been generated at 0.6% or above. This does not exclude the possibility of generation of commercial quantities of biogenic gas in thermally immature strata particularly from the coals (see "Oil and Natural Gas Seeps and Shows in Water Wells" section).

Other types of geochemical tests for maturation (although more limited in number of samples) confirm the thermal immaturity of the Eocene and Upper Jurassic-Lower Cretaceous units broadly indicated by the vitrinite reflectance values. For example, thermal alteration index (TAI) and level of maturation index (LOM) determined by microscopic inspection of kerogen and coloration of spores are typical of low level of maturation (i.e., immature to marginally mature if TAI = -2 to 2.32; Haykus in Newton, 1980, and LOM of 6-7 according to Browning and Flanagan, 1980)(Table 1a). However, Browning and Flanagan (1980) noted some reworked thermally mature Cretaceous pollen (LOM = 11-12) in all the Eocene units as well as in the Coaledo Formation of the Coaledo Basin. This is strong evidence of reworking of Upper Cretaceous strata, possibly of a younger Maestrichtian age (Browning and Flanagan, 1980) unknown in most of the Oregon Klamath Mountains except at Cape Sebastian (Bourgeois, 1984). Browning and Flanagan (1980) analyzed only a few surface samples from the Sixes River terrane (Otter Point and Dothan formations in their report). In those, all the pollen are entirely carbonized; and, therefore, the rocks are thermally overmature (i.e., beyond the oil window).

Another geochemical indicator of thermal maturity is the transformation ratio (S1/(S1 + S2)(Table 1c); S1, S2, and S3 are measured during Rock-Eval pyrolysis. According to Law and others (1984), S1 "represents the quantity of volatile hydrocarbon (HC) expelled from rocks held at 250 degrees C for 5 minutes; S2 measures the quantity of hydrocarbons (HC) released from the rock samples upon pyrolysis of the kerogen at 250 to 550 degrees C programmed at 25 degrees C per minutes. S3 is a measure of the amount of pyrolitic carbon dioxide evolved during the heating interval from 250 to 390 degrees C" (see also Tissot and Welte, 1978; Espitalie and others, 1977, for more details). Some Eocene rock samples from the Tyee Basin are within the oil generation window according to their transformation ratios (i.e., 0.1 to 0.4), but most samples are not (Table 1c). In addition, the Tmax temperature (Table 1c), determined from Rock-Eval pyrolysis, corresponds to temperatures typical of immature source rocks (i.e., in the range of 400 to 435 degrees C; Law and others, 1984).

Similar results of Rock-Eval analysis have been obtained on hundreds of cuttings samples from exploration wells scattered across the basin (Brown and Ruth, 1983; Amoco, 1985). C15 extracts and gas chromatography also indicate low yields and immature source rocks (Brown and Ruth, 1983).

Detailed C15 soxhlet extraction and chromatography reveal that the organic matter in a few Roseburg and Tyee outcrop samples is mainly steranes and terpanes which are also typical of recent and thermally immature sedimentary strata (Haykus in Newton, 1980)(Figs. 4 and 5).

However, these preliminary indications of low maturity and source rock potential should not condemn the basin from further exploration for oil and gas. Some coal-rich deltaic units could produce commercial quantities of biogenic gas (see "Oil and Natural Gas Seeps and Shows in Water Wells" section and Table 3a). For example, similar thermally immature to marginally mature rocks with low source rock potential (woody kerogen, some coals) also occur in middle Eocene strata in the Astoria and Nehalem basins and in the Mist Gas Field in northwestern Oregon (Niem and Niem, 1985; Armentrout and Suek, 1985; Alger, 1985). The middle to upper Eocene Cowlitz Formation has produced over 35.8 billion cubic feet of methane gas since 1979 (Olmstead, 1989a).

In addition, the scattered reports of "gas" and "oil" seeps in the southern part of the basin suggest that some source rocks have been locally matured (Plate 2). Local maturation mechanisms should be evaluated: (1) flash maturation by heat generated from thick Tertiary intrusions (unit Ti on Plate 1) in potential deep-marine mudstone and coaly source rocks (e.g., east of Sutherlin and Roseburg), deeper burial of deltaic-marine lower Tertiary rocks (e.g., Flournoy) that dip eastward beneath the western Cascade province where higher geothermal gradients should have been present; note Fisher [unit Tcf] and Little Butte Volcanics [unit Tlb] on Plate 1; cross section C-C′ on Plate 3), and (2) possible deeper burial due to postulated underthrusting of the Paleocene to Eocene Roseburg strata beneath the northern Klamath province (cross sections A-A′ and D-D′, Plate 3).

Local heating by intrusions of thermally immature mudstones in the Astoria and Nehalem basins of northwestern Oregon may be the source of the thermogenic gas in the Mist Gas Field (Niem and Niem, 1985). This mechanism appears to be limited in the Tyee Basin because there are relatively few intrusions (unit Ti on Plates 1 and 2), and most are close to the Cascades in the southeastern part of the basin. Deep burial of strata due to underthrusting and seepage up along thrust faults and other faults (e.g., strike-slip faults) also appears to be a local mechanism, and it may explain the occurrence of some of the gas and oil seeps (e.g., along the Reston Fault) (Plate 2)(see further discussion in "Oil and Natural Gas Seeps and Shows in Water Wells"). Some oil shows even occur in the northern part of the basin in the basement volcanics (e.g., Florida Exploration well) hinting that potential source rocks may exist within or beneath the volcanics (Table 3a). Structural models and seismic reflection data indicate that potential reservoir strata in the Tyee, Flournoy, and Lookingglass overlie thrusted Roseburg volcanics and potential sedimentary source rocks (see "Structural Traps and Regional Structure" section).

RESERVOIR ROCKS

Very limited data on porosity and permeability (fewer than 35 analyses from 22 localities, Table 2) are presently available on potential sandstone reservoir rocks of the basin. These analyses are shown on Plate 2 and are listed by formation and averaged in Table 2. They are widely scattered across the basin and are far too few in number to make thorough conclusions about the reservoir potential in the basin. However, from limited diagenesis studies (Burns and Ethridge, 1979; Ryberg, 1984; Chan, 1985) and cursory field and well measurements of porosity and permeability (Newton, 1980), the reservoir potential of most Coast Range Paleocene to upper Eocene units and Upper Jurassic-Lower Cretaceous units (e.g., Myrtle Group) of the northern Klamaths appears to be generally low with some exceptions. The low porosity and permeability can be attributed to extensive post-burial diagenesis which formed pore-filling cements and clay minerals through chemical alteration of the unstable volcanolithic, micaceous quartzo-feldspathic and lithic (metamorphic detritus-rich) graywacke sandstones.

Porosities are highest in fine- to coarse-grained micaceous feldspathic-lithic sandstones of the Flournoy Formation (range 1.8 to 38.2%, av. 17.7% for 14 samples)(Table 2). Porosities in the other units from highest to lowest are: Roseburg fine-grained turbidite sandstones: 13.3% for 9 samples; Lookingglass: 7.0% (only 1 sample); Myrtle Group graywackes: 6.7% for 12 samples (range 4.3 to 12.9%). No data are available for the Bateman and Elkton formations.

Permeabilities are highest in the Flournoy Formation (range 0.17 to 154.0 md; av. 34.9 md for 12 samples). The next most permeable units are Roseburg Formation: range 15.6 to 53.4 md; av. 33.8 md for 3 samples; Myrtle Group: range 0.03 to 90.0 md; av. 8.1 md for 12 samples. No permeability data are available for the Lookingglass, Elkton, or Bateman sandstones.

Generally, the units with the highest porosity also have the highest permeability although there are exceptions (Table 2).

In studying outcrop samples of Tyee and Flournoy micaceous feldspathic and lithic sandstones in thin section, scanning electron microscope (SEM), and microprobe, Chan (1985) reported that major reduction of primary intergranular porosity has occurred through: (1) some compaction of ductile grains such as micas; (2) chemical alteration and compaction of "softer" volcanic grains to form clayey pseudomatrix; (3) precipitation of smectite/chlorite clay rim cements in primary interparticle pores and pore throats, (4) filling much of the remaining interparticle pore space with zeolites (laumontite and heulandite/clinoptilolite); and (5) local early calcite concretions followed by breaking of clay rim cements during continued compaction and final formation of late-stage calcite cement.

Burns and Ethridge (1979) also described similar extensive alteration and cementation in the Paleocene Roseburg lithic sandstones and in the Lookingglass and Flournoy sandstones. In addition, they discovered minor iron oxide cement and some late-stage pore-filling quartz and radiating chlorite cements in these largely lithic sandstones. Burns and Ethridge suggest that zeolites are more abundant in the Roseburg sandstones.

Chan (1985) found that secondary porosity, developed from dissolution of calcic palgioclase, is rare and that different facies within the middle Eocene Flournoy and Tyee formations have undergone varied diagenetic histories. For example, outer fan fine-grained turbidites tend to be more enriched in clay matrix whereas "cleaner" and coarser grained delta-shelf and inner fan sandstones are better cemented with zeolites, mixed layer chlorite/smectite clays, and calcite (in the form of larger concretions). These studies are from limited sampling of outcrops. Subsurface samples have not been studied.

These diagenetic studies and quantitative analyses of porosity and permeability are too few in number and too widely spaced to be necessarily diagnostic of the reservoir potential of all 10,000 to 15,000 ft of lower Tertiary strata in the basin.

In reconnaissance examination of outcrops, most potential reservoir units in the Tyee Basin appear to be well-indurated and tightly cemented. For example, deep-marine, polymict conglomerates of the Roseburg Formation, micaceous feldspathic lithic turbidite sandstone (sandy submarine fan and turbidite trench deposits) of the Tyee and Flournoy formations (units Tef_3 and Tet_b), and polymict conglomerates of the Bushnell Rock Member (a fan delta of the Lookingglass Formation)(Ryberg, 1984; Kugler, 1979) appear to have more limited reservoir potential (Bill Seely, Mobil Oil Corp., 1989, personal communication; Terry Mitchell, Amoco, 1985, personal communication). However, a more permeable, previously unreported deltaic(?) to shelfal(?) sequence in Roseburg strata that occurs immediately south of the Sutherlin well (T. 25 S., R. 4 W.) was a target of exploration in that well (Bill Seely, Mobil Oil Corp., 1989, personal communication). Other such facies may exist in the basin. Ongoing field studies by DOGAMI (e.g., Black), I. Ryu, and A. Niem have generally suggested that potential friable "permeable" sandstones are best developed in the shelfal-deltaic facies and more quartzo-feldspathic units such as the coal-bearing White Tail Ridge Member of the Flournoy Formation (unit Tef_1), the arkosic-quartzo-feldspathic southern facies of the Tyee (unit Tet_a), and the coarse-grained quartzose distributary channel sandstones in the Olalla Creek Member of the Lookingglass Formation (unit Tel_3) and Bushnell Rock coal-bearing sandstone facies near Remote. The deltaic and shelf sandstones of the Tyee, Flournoy, and Lookingglass (e.g., Olalla Creek Member) are concentrated in the southern part of the basin; these units rapidly wedge out, are erosionally cut out, or undergo rapid facies change to slope mudstones and thick deep-marine well-indurated turbidite fan or ramp sandstone facies to the north (cross section A-A′, Plate 3)(Heller and Dickinson, 1985; Chan and Dott, 1983)(Fig. 4). Some friable porous sandstones in these units in Camas Valley and along Oregon Highway 42 in T. 29 and 30 S., R. 8 and 9 W. should be studied further (Niem observation; Bill Seely, 1989, personal communication; Jerry Black, personal communication, 1989; Paul Ryberg, personal communication, 1989).

Other than the Upper Jurassic-Lower Cretaceous Myrtle Group (Days Creek and Riddle formations of the Snow Camp terrane), there is a lack of measurements of porosity and permeability for the Jurassic-Cretaceous feldspathic lithic sandstones, conglomerates, and turbidite sandstones (e.g., the Dothan or Sixes River terrane). Thin section descriptions of these units indicate that in addition to being intensely deformed (isoclinally folded and faulted), extensive cementation and diagenetic alteration severely limits the reservoir potential of these turbidite units (Hicks, 1964; Cornell, 1971; M.C. Blake, 1989, USGS, personal communication). There are, however, some local blocks of unnamed clean, friable arkosic micaceous to pebbly cross-bedded sandstone (Upper Cretaceous, Paleocene, or Eocene, unit TK on Plate 1) on top of the Sixes River terrane (as at Hoover Hill; Peterson, 1957) at the southern margin of the Tyee Basin and tectonically adjacent to lower Eocene Roseburg strata (northeast of Myrtle Point in T. 29 S., R. 12 W.). New mapping may show that this lower Tertiary-Cretaceous(?) sandstone is more widespread and could act as a reservoir. Deciphering the distribution, age, and tectonic position of this Tertiary-Cretaceous arkosic micaceous sandtone is important to future reservoir assessment of this basin.

Experience in other convergent margin basins (e.g., California) shows that commercial quantities of gas can be produced from apparently tightly cemented lithic graywackes and quartzo-feldspathic sandstones such as these Paleocene to Eocene and Upper Jurassic-Lower Cretaceous sandstones (Myrtle Group). In addition, secondary fracture porosity, produced by tectonism particularly on thrust related structures (such as in crests of fault-propagation anticlinal folds), could locally produce fractured and jointed reservoirs in these lower to middle Eocene sandstones that have such low primary porosity and permeability in hand specimen. For example, a reservoir in highly fractured but normally tightly cemented Eocene shelf limestones is producing commercial quantities of oil in the Durnal Field of Pakistan (Potwar Plateau) in a fault-bend fold below a surface syncline in the convergent margin setting of the Himalayas (Jaswal, 1989, personal communication).

There is definitely need for longer term field mapping of potential sandstone facies (members), analysis of fractures and joints related to structures, systematic outcrop sampling for porosity and permeability in the different facies of the Cretaceous and Paleocene to Eocene formations, and microscopic analysis of sandstone diagenesis and electric log analysis of porosity and permeability in the existing wells. The few outcrop samples collected by Chan (1985) and by Burns and Ethridge (1979) may not be entirely representative due to deep surface weathering effects.

CAP ROCKS AND SEALS

Many overlying and/or up-dip faulted thick mudstone members could act as seal or cap rock to these potential Eocene sandstone reservoirs. The very thick (>3,000 ft) Tenmile Member (unit Tel_2), thinner Camas Valley Member (unit Tef_2), and Hubbard Creek Member (unit Tet_2) could be seals to the deltaic sandstone members (i.e., Bushnell Rock Member, White Tail Ridge Member, Tyee Mountain Member) in the Lookingglass, Flournoy, and Tyee formations, respectively (Plate 1). In the Roseburg Formation, slope and basin mudstone facies (Ter_4) updip from turbidite sandstones could also act as seals (Plates 1 and 3). In addition, some sandstones (particularly in the turbidite fan facies of the Tyee and Flournoy formations) appear to be very tight due to extensive clay rim and zeolite pore-clogging cements. For example, outer fan sandstones of the Tyee Formation have very poor yield of groundwater (dry to < 5 gpm) west of Corvallis (Penoyer and Niem, 1975); they could act as a seal. Overthrusted Klamath terranes such as the melanged mudstone of the Sixes River terrane (unit KJs) and possibly Dothan Formation (KJd) Plate 1 and cross sections A-A′ and D-D′ on Plate 3) could also act as seals and source beds at depth.

STRUCTURAL TRAPS AND REGIONAL STRUCTURE

Structural and stratigraphic traps abound in the basin. There are numerous untested anticlines and fault-bounded blocks within the basin that could act as structural traps (Plates 1 and 2). However, some dry wells (e.g., nos. 3, 6, 7, and 8 on Plate 1) have been drilled on top of or near these anticlinal or faulted structures. This compilation, using attitudes from numerous sources, aerial photographic analysis, and preliminary study of seismic lines has tentatively recognized additional northeast and northwest trending faults (on Plate 1 labeled A where interpreted from aerial photographs and AS where interpreted from aerial photographs and study of seismic lines) and folds that should receive further field investigation. Preliminary reconnaissance in the Tyee, Flournoy, and Roseburg suggests that some of these faults may have some oblique slip. Conjugate oblique-slip faults with subhorizontal slickensides are abundant throughout the central Coast Range (Snavely and others, 1976a, 1976b, 1976c), in the Tillamook area (Wells and others, 1983), and in the Astoria Basin (Niem and Niem, 1985) as well as in southwestern Washington (Wells, 1981, 1989). For example, this compilation and Duell (1957) show faults with a component of left-lateral strike-slip that offset the axis of the north-south trending Coast Range synclinal axis in the Eden Ridge coal field area (Plate 1). Subhorizontal slickensides are well preserved in a basalt quarry on the north side of Oregon Highway 42 about 2 miles west of Bridge, Oregon (T. 29 S., R. 12 W.).

The major transcurrent structures in the southern part of the map area are the east-west Canyonville and Wildlife Safari faults and possibly the Coquille River-Powers Fault (Diller, 1898; Perttu, 1976; Ryberg, 1984; Ramp and Moring, 1986). The Wildlife Safari Fault separates the early Tertiary (Paleocene to lower Eocene) subduction zone-submarine fan sequence (Roseburg Formation, Ter, and Roseburg Volcanics, Tev) on the north from the Mesozoic terranes of the Klamath Mountains on the south (Baldwin, 1974; Ryberg, 1984; Carayon, 1984). Presumably this fault was initiated during oblique convergence of the Eocene Coast Range trench sediments and oceanic seamount province with the North American continental plate, represented by the northern Klamath terranes. This oblique-slip reverse fault has an estimated 5 km of right-lateral separation (Ryberg, 1984). Carayon (1984) suggested that the northeastern segment of this fault may be an underthrust boundary with the overlying Upper Cretaceous Sixes River melange of the Klamath Mountains (Plates 1 and 3).

The nearly east-west Canyonville Fault Zone (transcurrent) offsets various Cretaceous and Jurassic tectonostratigraphic terranes of the Klamath Mountains (Blake, 1984; Fig. 1 on Plate 1). Ryberg (1984) estimated 30 km of right-lateral motion. The 1 km wide fault zone contains sheared serpentinite (unit sp) and slivers of Riddle Formation and other Snow Camp terrane rocks. Latest motion on this fault may have involved members of the Lookingglass and Flournoy formations before deposition of the deltaic facies of the middle Eocene Tyee Formation (unit Tet). The fault may have been sufficiently active in the early Eocene to produce

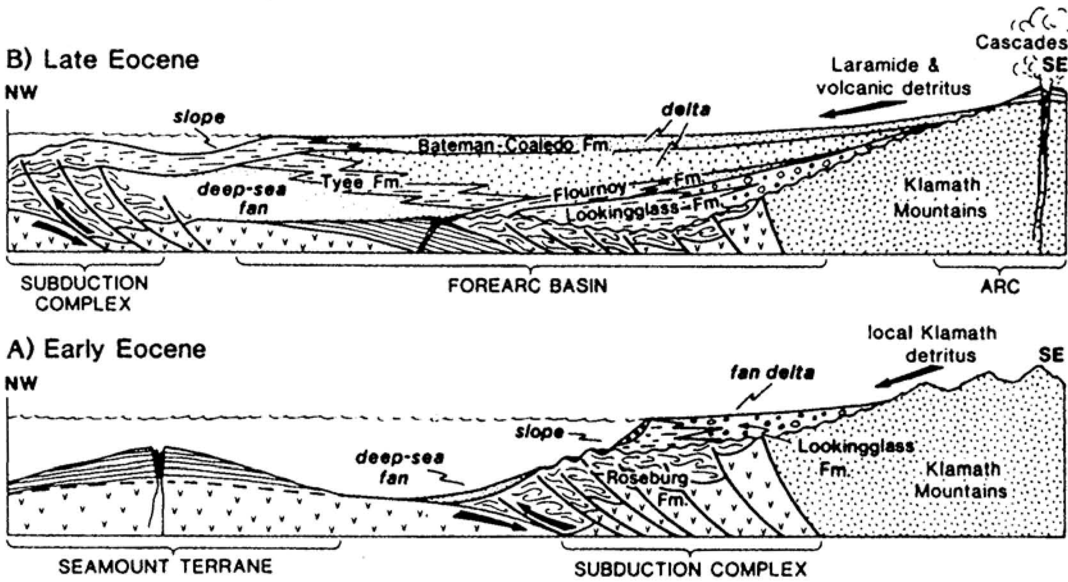


Fig. 6 Depotectonic setting of Eocene rock units in southern Tyee Basin (from Heller and Ryberg, 1983). Lithic Roseburg and Lookingglass formations were deposited in the subduction zone; arkosic Tyee and Bateman deltas were deposited in the subsequent forearc basin.

scarps in the Klamath Mountains which could have been point sources during syntectonic deposition of the Lookingglass (e.g., fan deltas of the Bushnell Rock Member) (Perttu, 1976; Heller and Ryberg, 1983; Ryberg, 1984; Kugler, 1979)(Fig. 6A).

Ryberg (1984), Baldwin and Hess (1971), and Ahmad (1981) report that the north-south-trending Coquille River-Powers Fault displays mainly reverse separation with as much as 1500 m of offset, uplifting Klamath terranes on the west against Tyee-Flournoy and Lookingglass strata on the east. It may be related to a major right-lateral northwest-trending fault in the Coaledo Basin that can be extended into the southwestern Tyee Basin in T. 28 S., R. 12 W., offsetting Roseburg basalts against Roseburg strata (Baldwin, 1974) and may extend offshore as the Fulmar Fault (Snavely, 1989, personal communication).

Other major structural features in the southern part of the basin include northeast-southwest striking imbricate thrust faults and high-angle reverse faults (e.g., Bonanza Fault Zone, Reston Fault) that involve Paleocene to lower Eocene Roseburg basalts and various subparallel northeast-southwest trending folds (e.g., Oakland anticline, Calapooya syncline, Red Hill-Dickinson Mountain anticline, Drain anticline, Jack Creek anticline, Hardscrabble Creek syncline, and Yoncalla syncline) (Hoover, 1963; Baldwin and Perttu, 1980). The intensity of imbricate thrust faulting and asymmetrical folding increases toward the Wildlife Safari Fault with broad, more open anticlines cored by Roseburg basalt and synclines to the northwest (cross section B-B′, Plate 3). Fault vergence is to the northwest. Mobil Oil Corporation drilled the core of one of these anticlines (Sutherlin Unit No. 1) in 1977. These thrust and high-angle reverse fault zones are significant because many gas and oil seeps (e.g., along the Reston Fault) appear to be associated with these structures (Plate 2).

The imbricate thrust boundary and strike-slip faults of the southern Tyee Basin have been interpreted as a collision boundary or suture zone between the obliquely underthrusted Siletz River oceanic crust (Farallon and Kula plates; represented by the Roseburg and Lookingglass formations) and the Klamath Mountains hinterland (North American plate)(Heller and Ryberg, 1983; Ryberg, 1984; Carayon, 1984)(Fig. 6A). Suturing occurred in the early middle Eocene prior to Tyee-Flournoy forearc deposition (Bukry and Snavely, 1988). The overall pattern of fault splays suggested to Ryberg (1984) that some right-lateral strike-slip motion may also have occurred on the Bonanza Fault as a result of this oblique underthrusting event. This thrust faulting is complex, with local back thrusts and isoclinal folding of thin-bedded Roseburg strata as seen along the Umpqua River in T. 26 S., R. 6 W. The early Tertiary thrust faults in the southeastern part of the Tyee Basin are unconformably overlain by Flournoy Formation and upper Eocene tuffs and flows of the western Cascades calcalkaline volcanic arc (e.g., Fisher Formation, unit Tcf and Little Butte Volcanics (unit Tlb, Plate 1). Less deformed middle Eocene siliciclastic deltaic and turbidite strata of the Flournoy, Tyee, Elkton, and Bateman formations occupy most of the central and northern parts of the map (Plate 1).

Preliminary study of seismic lines in the central and northern part of the map area suggests that many of the thrusts and the volcanic-basement-cored folds extend beneath the relatively undeformed forearc strata of the Flournoy-Tyee formations (Pete Hales, Weyerhaeuser, 1989, personal communication)(cross sections A-A′ and C-C′, Plate 3). Seismically, some of the fault zones in the subsurface appear to form fault-propagation folds. In addition, tip points and triangle zones as described by Jones (1982) and passive roof thrusts and near-surface synclinal sag structures are recognizable (Suppe, 1985; Pennock and others, 1989) (Plate 3, cross section A-A′). Some faults related to these structures may come to the surface in the Williams Canyon area. On the Potwar Plateau of Pakistan, normally tightly cemented sedimentary sequences produce petroleum from highly fractured fault-propagation anticlinal folded reservoirs associated with former active floor thrusts beneath synclinally folded passive roof thrusts (Jaswal, 1989, Oil and Gas Development Corporation, Pakistan, personal communication). Fault-propagation folds have also been recognized in multichannel seismic profiles on the central Oregon continental shelf (Snavely, personal communication, 1989).

The northeast-southwest trending thrusts and high-angle reverse faults in the Roseburg submarine fan strata and volcanics in the southwestern part of the basin in the Remote-Coquille area are probably the exposed continuation of the Bonanza, Reston, and other northeast-southwest trending faults and basement-cored folds. However, many of these faults juxtapose Middle and Upper Cretaceous Sixes River melange and broken formation and serpentinite against Paleocene to lower Eocene Roseburg volcanics and turbidite fan strata (cross section D-D′, Plate 3). Baldwin and Beaulieu (1973) and Baldwin (1974) originally interpreted these faults as high-angle reverse and normal, and some thrust faults in which Roseburg strata and volcanics form the upper block or hanging wall and the Sixes River terrane (formerly Otter Point Formation of Dott, 1971) forms the uplifted lower block or foot wall. An alternative explanation is that much of the Cretaceous Sixes River terrane (KJs) forms a major overthrust sheet (or nappe) with serpentinite over Roseburg strata and volcanics (cross section D-D′, Plate 3). Subsequent uplift and erosion have left klippen of Sixes River melange (i.e., blocks of blueschist and greenstone) over Eocene Roseburg strata and volcanics in this area.

A similar explanation was first proposed and mapped by Carayon (1984) and Carayon and others (1984) in the Bushnell Rock-Reston area (T. 29 S., R. 7 W.) where she showed an overthrust relationship north of the Wildlife Safari Fault with a small klippe of pre-Tertiary Sixes River tectonic melange (KJs) thrust over Roseburg strata (Plate 1). Baldwin′s (1984) alternative explanation for the geologic relationships in this poorly exposed area is that exposed exotic boulders of pre-Tertiary strata, blueschist, and greenstone are small olistostromal blocks that slid or slumped into the Roseburg flysch basin during the Eocene from uplifted Klamath terranes to the south. Some channel-shaped olistostromal deposits with exotic pre-Tertiary blocks near Agness are in mud matrix support and may be debris flow deposits in a submarine canyon head in the Lookingglass Formation (Ryberg, 1984). Ryberg found that some of the tectonic melange wedges with exotic blocks of blueschist and disrupted Mesozoic rocks, formerly mapped as pre-Tertiary Otter Point melange by Baldwin and Beaulieu (1973), also contain blocks of mudstone with Paleocene microfossils, suggesting that the tectonic melange formed in the latest Cretaceous to early Tertiary.

South of the Wildlife Safari Fault, Carayon (1984) showed this Cretaceous melange and broken formation (Sixes River terrane) thrust over Roseburg strata. Carayon (1984) was the first to map in detail the overthrusting of Snow Camp terrane ophiolite over the Sixes River terrane. On Plate 1, we have extended this pattern to include possible klippen of Lower Cretaceous Days Creek and Riddle formations and Jurassic ophiolite sequences on the Upper Cretaceous Sixes River terrane, following Blake's (1984) general pattern. Earlier mapping (e.g., by Cornell, 1971, and Hicks, 1964) interpeted these as depositional relationships and/or high-angle normal and reverse faulting. Additional field study is needed to clarify these relationships.

Therefore, the underthrust early Tertiary Roseburg strata may extend beneath the Klamath terranes (cross sections A-A′ and D-D′ on Plate 3) and may have important implications for oil and gas exploration. For example, thermally immature Roseburg strata when deeply underthrusted could have been matured and fractured. An exploration strategy could drill through the upper Sixes River thrust plate (or nappe), if it is thin, into the Paleocene-Eocene Roseburg strata and the unnamed Tertiary-pre-Tertiary sandstones below. This concept of Sixes River terrane thrust over Paleocene-lower Eocene units is consistent with oblique subduction and accretion of Eocene strata beneath the North American continent during the early middle Eocene (Fig. 6A).

A LITHOPROBE geophysical study by Clowes and others (1987) and other studies (e.g., Snavely and Wagner, 1981; Snavely, 1987) have shown that early Tertiary Roseburg-equivalent Crescent Basalt and early Tertiary turbidite core rocks of the Olympic Mountains were also partly underplated beneath the leading edge of the North American plate represented by Vancouver Island (also composed of Mesozoic igneous and sedimentary accreted terranes) at the northern end of the Oregon-Washington marginal basin during the early Tertiary. The idea of northwestward and westward overthrusting of the Sixes River terrane in the early Tertiary is also consistent with the earlier northwestward and westward overthrusting of nappes of other Klamath Mountain terranes (such as the Elk subterrane over the Sixes River, Snow Camp terrane over Sixes River, and Yolla Bolly terrane over the Snow Camp terrane)(cross sections A-A′ and D-D′, Plate 3). The complex overthrusting of various Klamath Mountain terranes has been suggested Coleman (1972), Dott (1971), Carayon (1984), Blake (1984), Blake and others (1985), Roure and others (1986), and Roure and Blanchet (1983). The northeast-southwest striking and north-south trending overthrust and transcurrent faults on Plate 1 formed as older forearc terranes, calcalkaline arcs, and ophiolite sequences were accreted in the late Jurassic, early Cretaceous, late Cretaceous, and late middle Eocene (Carayon, 1984; Roure and others, 1986; Roure and Blanchet, 1983). Ryberg (1984) presents an alternative structural interpretation with cross sections in which lower Eocene Roseburg strata and thickened buoyant Roseburg oceanic crust does not extend beneath the Sixes River terrane but rather are abruptly terminated by the oblique-slip Wildlife Safari Fault. If the reader prefers the Ryberg model, then there are no lower Eocene Roseburg strata as a target for exploration beneath the Sixes River terrane within a reasonable drilling depth. The exact nature of the suture zone between the Roseburg Formation of the southern Tyee Basin and the northern Klamath Mountains will be the subject of field and geophysical investigations by the U.S. Geological Survey (R. Wells and M. C. Blake, 1989, personal communications), by DOGAMI, and by the University of Oregon and Oregon State University.

Soon after accretion of the Roseburg volcanics and fan strata in the early middle Eocene, the subduction zone was re-established along the present continental slope and outer shelf, and middle Eocene Tyee-Flournoy forearc strata were deposited in the Tyee Basin (Heller and Ryberg, 1983; Ryberg, 1984)(Fig. 7). In the late middle Miocene to the present, renewed underthrusting and subduction of the Juan de Fuca plate beneath the North American plate (now represented by the accreted Oregon and Washington forearc basin and Olympic Mountains Hoh melange of Rau, 1973, and Tabor and Cady, 1978) created east-west compression and produced the broad, open north-south trending folds and faults in the Flournoy and Tyee turbidites and Elkton Formation in the northwestern part of the map area and in the adjacent upper Eocene Coaledo Basin (Newton, 1980; Snavely, 1987; Wells and others, 1984; Niem and Niem, 1984; Niem and others, in press). Some of these folds and fault blocks have been drilled (e.g., General Petroleum Long Bell No. 1, Florida Exploration Well 1-4, Northwest Exploration Sawyer Rapids). On this compilation the trends of the broad fold axes in the Tyee-Flournoy strata appear to change orientation from northeast to northerly, probably reflecting the influence of late middle Miocene reactivation of older structures in the underlying subduction zone-trench fan sequence of the Roseburg Formation and volcanics in the southeastern part of the map. From the pattern of strikes and dips and from preliminary study of seismic reflection lines, it appears that some older structures have been reactivated as high-angle faults up into the younger strata (for example, in the Williams Canyon area, T. 26 and 27 S., R. 9 W.; cross section A-A′, Plate 3). These folds and fault blocks may be additional structural targets for exploration.

On the geologic map of western Oregon, Wells and Peck (1961) showed a broad north-trending synclinal axis in the Tyee Basin forearc strata, roughly bisecting the middle Eocene Bateman and Elkton formations. This compilation confirms that broad outcrop pattern (Plate 1; cross section C-C′, Plate 3). However, many smaller reactivated basement structures have gently deformed the younger Elkton and Bateman strata into northeast- and north-trending folds (Plate 1). This preliminary study suggests that numerous small faults have disrupted the Tyee, Elkton, and Bateman strata into small fault blocks with many opposing attitudes (Plate 1) such that no single major north-south fold axis can be drawn through the area.

A similarly complex fault pattern is present in northwestern Oregon (Niem and Niem, 1985; Wells and others, 1983) and in the central Coast Range (Snavely and others, 1976a, 1976b, 1976c). These small fault-bounded blocks have created many structural traps in the Mist Gas Field in northwestern Oregon (Alger, 1985; Bruer and others, 1984). Only detailed mapping in the Tyee-Flournoy, Bateman, and older strata will determine if this intense late middle Miocene fault pattern exists in the southern Tyee Basin as well.

STRATIGRAPHIC TRAPS

Stratigraphic traps may occur in the Tyee Basin by northward pinch out of conglomeratic and sandstone facies to deep-marine mudstone facies and by channelized sandstone and conglomerate geometries. There seems to be some control of the depositional facies by the Roseburg Volcanics and by tectonics (Perttu and Benson, 1980). Plate 1 shows the different submarine fan facies of the lower Eocene Roseburg Formation Ter_{1-4}) generalized from Ryberg (1984). The Roseburg Formation is thought to represent an early Eocene trench fill and subduction complex (Fig. 6A). Thick amalgamated inner fan turbidite sandstones and conglomerates and thick-bedded middle fan channelized facies grade northward to deep-marine, largely very thin-bedded outer fan turbidite sandstones and thick basinal mudstone facies in the northeastern part of the basin. This wedge of overlapping fans (a former trench fill) rapidly thins against thin-bedded Paleocene-lower Eocene slope and basin mudstone (Ter_4) deposited on older highs (seamounts?) of Roseburg basalt north of the Bonanza Fault Zone (Seely, 1989, personal communication) and the Red Hill-Dickinson Mountain anticline (cross section B-B′, Plate 3)(Fig. 6A). These deep-water mudstones are exposed on the flanks of the Drain and Jack Creek anticlines (Hoover, 1963), are thicker in wells in the northern part of the map area, and thin over a Roseburg high in Amoco′s B-1 and F-1 wells (Pete Hales, 1989, personal communication)(cross sections A-A′ and B-B′, Plate 3). In addition, Perttu and Benson (1980) measured paleocurrent indicators that show deflection of flow around the highs, suggesting that the folds were growing as the sediments were being deposited and accreted in the early Eocene. Therefore, subsurface pinchouts of the lower Eocene strata over old highs are possible. The synorogenic Lookingglass Formation displays a number of facies ranging from coarse conglomerate fan deltas of the Bushnell Rock Member to the thick slope mudtone and thin turbidite sandstones (Fig. 6A) of the Tenmile Member (a possible seal) to the thick "permeable" shelf and thinner deltaic coal-bearing sandstones of the Olalla Creek Member and Bushnell Rock Member near Remote (Kugler, 1979). The deltaic and fan delta units rapidly thin and wedge out to the north and northwest in outcrop and in the subsurface (Plates 1 and 3, cross section A-A′).

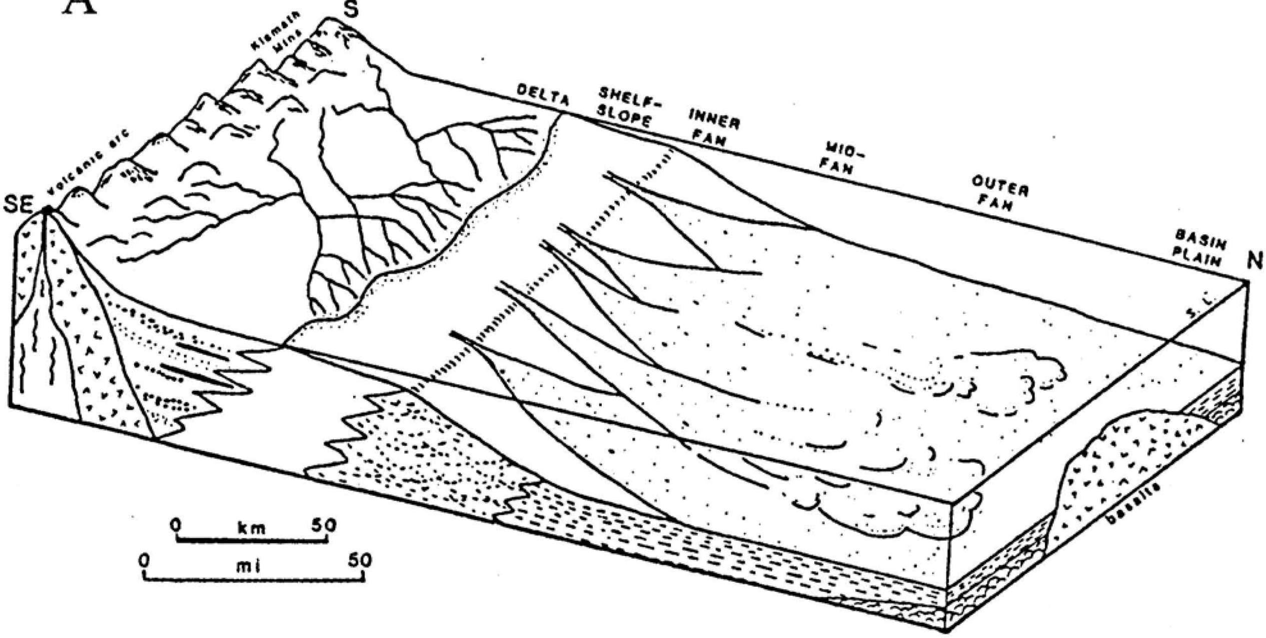
The forearc Tyee and Flournoy formations which unconformably overlie both the Klamath Mountain terranes and southern Coast Range Roseburg and Lookingglass strata have been broadly subdivided into several facies, including a delta-shelf facies at the south, slope channels and mudstone, inner to outer turbidite ramp (Heller and Dickinson, 1985) and/or a sandy fan facies to the north (Chan and Dott, 1983)(Figs. 6B and 7). It appears that the type Flournoy Formation consists of coal-bearing deltaic clean channel and shelf sandstone (White Tail Ridge Member) and the overlying thick Camas Valley mudstone which could act as a seal in the subsurface.

Many biogenic methane gas seeps and shows in the Melrose area (T. 27 S., R. 7 W.) appear to be associated with coals in the Olalla Creek Member of the Lookingglass Formation and White Tail Ridge Member of the Flournoy Formation.

In the Camas Valley quadrangle, Baldwin and Perttu (1989) recently mapped and defined three members of the Tyee Formation, the sandstone-rich Tyee Mountain Member and the Baughman Lookout Member separated by mudstones

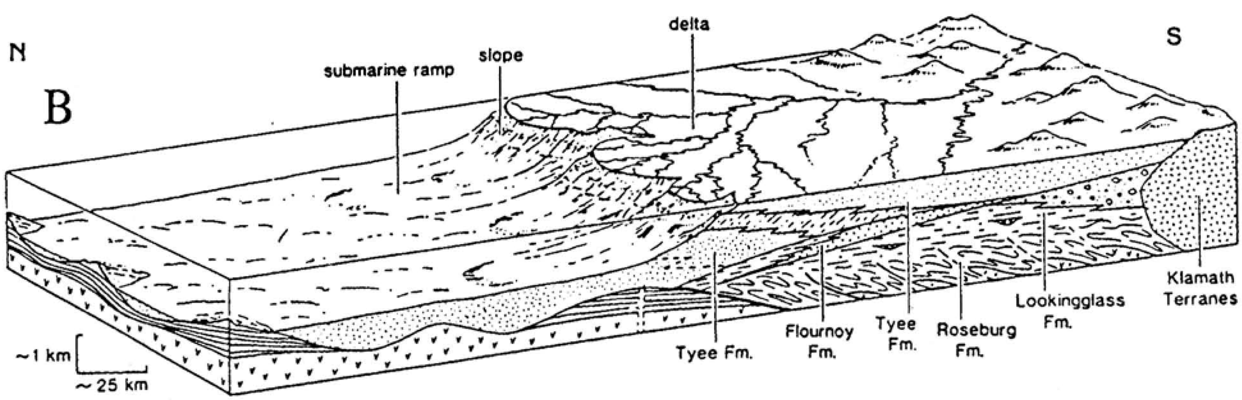
Fig. 7 Comparison of depositional models recently proposed for the Tyee-Flournoy formations of the Tyee Basin. A is the sand-rich submarine fan model of Chan and Dott (1983); B is the submarine ramp model of Heller and Dickinson (1985).

A



—Early Eocene Tyee-Flournoy model for shelf sandstones in a line source cascading into deep water to form sand-rich fan deposits.

B



—Paleogeographic reconstruction of southern part of Oregon Coast Range during Eocene deposition of Tyee Formation of the Hubbard Creek Member. In this compilation, we have extended these three members northward into the Tyee quadrangle based on Baldwin's unpublished mapping of that quadrangle. The Hubbard Creek Member could act as a seal. The lateral extent of these members and their appearance in the subsurface remains the subject of future studies, but they have been tentatively recognized in some wells (cross section A-A', Plate 3). The thick deltaic conglomeratic and coal-bearing facies of the Flournoy and Tyee formations should be mapped as members beyond the type areas in the Tyee and Camas Valley 15-minute quadrangles.

The overlying middle Eocene Elkton Formation (unit Tee) in the center of the map has been interpreted to be deep-marine slope facies with nested channelized turbidites and grain flow deposits in outcrop in sea cliffs south of Coos Bay (Dott and Bird, 1979). Whether this interpretation applies to the Elkton in the Tyee Basin remains to be proven. The middle Eocene Bateman Formation (unit Teb) which caps the sequence is the youngest Tertiary formation in the basin. It consists of three to four thickening-upward coal-bearing deltaic sequences of friable arkosic sandstone in distributary channels and shelf sandstones (Weatherby, in progress; Baldwin, 1974). Unfortunately, the Bateman, like the underlying Elkton, is breached by erosion and, therefore, has limited reservoir potential for hydrocarbons.

Well-indurated shallow-marine sandstones of the Cretaceous Days Creek Formation and conglomerates and sandstones of the Upper Jurassic-Lower Cretaceous Riddle Formation dip beneath the southern outcrop of Tyee-Flournoy forearc strata in T. 31 and 32 S., R. 10 W. and may have limited exploration value (cross section D-D', Plate 3). In addition, small isolated outcrops of slightly deformed massive friable to well-indurated clean arkosic micaceous to pebbly and cross-bedded sandstone of unknown age (TK on Plate 1; early Eocene, Paleocene, or Cretaceous) occur just south of the Wildlife Safari Fault in the Hoover Hill area (Peterson, 1957) and east of Winston (Baldwin, 1988, 1989, personal communication; Carayon, 1984) unconformably resting on top of the Upper Cretaceous Sixes River melange (Ryberg, 1984). Carayon (1984) determined a tentative age of the sandstone in the Hoover Hill outcrop as Eocene ("Roseburg equivalent") based on palynomorphs. Similar, though pebbly, friable arkosic fluvial or shelf cross-bedded sandstone crops out 2 miles northeast of the town of Myrtle Point (unit TK on Plate 1). This arkosic sandstone is surrounded by much more indurated lithic graywackes mapped as Roseburg turbidite strata (sec. 2, T. 29 S., R. 11 W.). Baldwin (1989, personal communication) says that these sandstones contain Cretaceous foraminifers identified by Weldon Rau of the Washington Department of Natural Resources. The age and origin of these sandstones should be determined because these clean sandstones represent potential subsurface targets beneath or associated with the Sixes River terrane or Roseburg Formation.

OIL AND GAS EXPLORATION WELLS AND OIL AND GAS SHOWS

Twenty oil and gas exploration wells have been drilled in the map area (Plates 1 and 2). Seventeen were in the early Tertiary strata of the southern Tyee Basin, and three were shallow wells (<1,400 ft) in the Upper Jurassic-Lower Cretaceous Myrtle Group in the northern margin of the Klamath Mountains province. All the wells were dry or not commercially productive. Many had shows of gas and traces of oil (Olmstead, 1989b) (Table 3a). Several widely spaced wells have been drilled in the central and northern parts of the map (wells no. 1, 2, 3, 4, and 5). Depths of these wells range from 4,428 ft to 11,330 ft. The wells were spudded in the middle Eocene forearc turbidite fan facies of the Tyee and Flournoy, deltaic Bateman, and Elkton slope strata. Many wells bottomed in basement highs of Roseburg Volcanics (Pete Hales, 1989, personal communication) (cross section C-C′, Plate 3). Three wells (Clark′s "Oakland well" [no. 6], Mobil Sutherlin Unit No. 1 [no. 7], and Union Liles No. 1 [no. 8]) were located on the southwest-plunging axis of the Oakland anticline (Plates 1 and 2). These wells were spudded in more highly deformed Paleocene-lower Eocene Roseburg flysch strata (cross sections B-B′ and C-C′, Plate 3). Well depths range from 2,235 ft to 13,177 ft. Some wells (e.g., Sutherlin Unit No. 1) penetrated thick sequences of Roseburg basalt (cross section B-B′, Plate 3).

A number of older shallow dry wells (545 ft to 3,693 ft) (nos. 10, 11, 12, 13, 14, 15, and 16) were drilled in the early 1900′s to 1950′s. More recently (1980′s) Hutchins and Marrs drilled Glory Hole 1 (2,987 ft) in Flournoy Valley near Melrose where there is a locus of reports of gas and oil seeps in water wells and natural seeps (Plate 2). Many of these wells were spudded in the deltaic quartzo-feldspathic sandstones and coals of the Lookingglass (Olalla Creek Member, unit Tel) and Flournoy (White Tail Ridge Member, Unit Tef) formations. Although commercially unsuccessful, some wells had shows of gas and traces of oil (Olmstead, 1989b)(Table 3a). Favorable areas for further exploration exist in this area and west to southwest of this area (especially west of the Tyee escarpment; e.g., R. 7 to 10 W., T. 30 S., T. 26 S.) in the thick Tyee-Flournoy strata. The stratigraphic target would be potential Olalla Creek deltaic-shelfal and/or White Tail Ridge distributary channel or shelf sandstone reservoir facies below (Plate 3, cross section A-A′). The overlying Tenmile and Camas Valley mudstones as well as thick Tyee/Flournoy mudstone beds and impermeable graywacke sandstone could act as seals.

No wells have been drilled in the southwest part of the basin except no. 17 (Hutchins and Marrs Great Discovery No. 2, 3,510 ft) south of Oregon Highway 42 which spudded in Olalla Creek deltaic-shelfal facies.

The northern and central parts of the southern Tyee Basin appear to have more limited exploration interest because of the apparent pinch out of the cleaner more permeable delta-shelf sandstone facies, and thick sandstones of the Roseburg submarine fan facies rapidly change to thick basinal mudstones (Ter_4) to the north (cross section A-A′). However, oil and gas shows reported in the basement volcanics (e.g., Florida Exploration well) indicate the possibility of source rocks beneath conventional basin reservoirs that should be further investigated. In addition, several shows of oil and gas were noted in the Northwest Exploration Sawyer Rapids well and in Amoco′s Weyerhaeuser F-1 and B-1 wells (in Flournoy/Tyee turbidite strata), pointing out that the oil and gas potential of these units can not be dismissed.

Future Studies:

Twenty widespread wells are not a true test of the oil and gas potential of this area, and many potential reservoir sandstone facies need to be defined better both in the surface and subsurface (e.g., electric log characteristics). Structural and stratigraphic traps in the subsurface and surface should be more clearly delineated through surface mapping, seismic, gravity and magnetics analysis, and well log analysis. A fence diagram through the exploration wells of the southern Tyee Basin is now in progress (Niem, Niem, and Ryu, in progress), and detailed mapping in the Camas Valley area is proceeding (Black, in progress).

OIL AND NATURAL GAS SEEPS AND SHOWS IN WATER WELLS

Preliminary study shows that 12 natural gas and oil seeps and shows in water wells (some with strong flows) and five oil and natural gas surface seeps have been reported in the southern Tyee Basin (Plate 2; Table 3b). Undoubtedly, more occur. Most of these seeps occur in the rural populated area around Melrose, Lookingglass, and Edenbower and in the Flournoy valley (T. 26 and 27 S., R. 6 and 7 W.). The gas seeps in water wells and in test wells issue from the deltaic Olalla Creek Member of the Lookingglass Formation and the deltaic facies (White Tail Ridge Member) of the Flournoy Formation. A few geochemical analyses (localities S4, S5, S7, and S13, Table 3b) show that these gases are mostly methane (C1) and have high traces of C2 and C3. Negative (depleted) carbon isotopic values of -64.3 o/oo for gas in a dry water well northwest of Melrose sampled by Alan Niem indicate a biogenic origin for the gas (Kvenvolden, 1983, U.S. Geological Survey, written communication)(Table 3b). Shallow buried coal beds in these members could be the source for this methane and other gas shows in wells, such as those in the Flournoy valley (e.g., locality S11).

Possibly as a result of these natural and water well seeps, several shallow oil and gas exploration wells were drilled in the Lookingglass, Flournoy, and Camas valleys in the early 1900's (Plate 2 and Table 3a). For example, the Kernin #1 well southeast of Melrose (no. 14 on Plate 2) reported had gas shows. This area merits further exploration as well as the area beneath the Tyee escarpment to the west (i.e., T. 28 and 29 S., R. 8 to 10 W.) where the Flournoy and Lookingglass formations are more deeply buried beneath the Tyee Formation (Plate 3, cross section A-A'). Mudstones of the Hubbard Creek Member, Camas Valley Member, and Tenmile Member could act as seals for these more deeply buried strata.

Not all the seeps are located in the deltaic units. Some gas seeps (e.g., S2 and S8) and three unconfirmed "oil" seeps (e.g., S3 and S13) have been reported in areas mapped as or underlain by more intensely deformed and thrusted deep-marine Roseburg fan strata (Plate 2, Table 3b). It is important to note that several oil and gas seeps occur along or between the Reston and Bonanza (thrust) faults (Plates 1 and 2, localities S2, S3, S8, S9, and S13). Some field chromatographic analyses (no record) indicate that a few of these gases are more thermogenic in origin (abundant C2 and C3 as well as C1; Bill Seely, 1989, Mobil Oil Corp., personal communication). The oil from the 60-ft deep water well (locality S13) tested as a high gravity oil similar to Union's Grays River well no. 1 in southwestern Washington (Dole, 1953). Additional source-rock and maturation analyses and field work should be conducted in the areas around these reported seeps, and the existence of the seeps should be confirmed.

The thermal maturity of the fractured and deformed strata adjacent to seeps should be tested. Frictional heating along faults of the Roseburg turbidite lithic sandstone and mudstone beds may have matured these generally immature rocks. It is more likely, however, that the oil and "thermogenic" gas seeps in the lower Eocene Roseburg turbidite strata are associated with seepage up thrusts and other faults from more deeply buried and melanged, partly subducted, Paleocene Roseburg turbidite strata. For example, Ryberg (1984) showed in a paleogeographic reconstruction older Paleocene melange with exotic Mesozoic blocks and slope mudstone underthrusted beneath Roseburg and Lookingglass strata. Deeper burial by subduction of the turbidite fan strata as well as heat associated with frictional shearing and disruption during the melanging process may have thermally matured these older strata. A similar situation occurs in Tertiary rocks of the Olympic Mountains of northwestern Washington where thermally immature middle Miocene Hoh melange contains several natural oil and "thermogenic" gas seeps (e.g., Garfield gas mound). Snavely and Kvenvolden (1988) and Snavely (1987) attributed the source of the oil and thermogenic gas to leakage up thrust faults from older, more deeply buried Eocene Ozette melange below. Preliminary analysis of seismic reflection lines suggests that thrust faults (e.g., Bonanza Fault Zone) in the Tyee Basin which involve older Paleocene-lower Eocene Roseburg strata can be traced beneath the middle Eocene Tyee-Flournoy forearc basin sequence (Flournoy-Tyee, Bateman, and upper Lookingglass formations; Plate 1; cross section A-A′ on Plate 3). In addition, these deep-seated faults could also act as conduits for oil and gas seepage from more deeply subducted and matured Roseburg strata and Paleocene or Sixes River melange. For example, one "oil" seep (S9) appears to lie along the Reston fault where it cuts the overlying Lookingglass. The coincidence of faults and "seeps" in the Tyee Basin should be investigated further.

Projecting the Reston and Bonanza faults in Roseburg strata beneath the Tyee and Flournoy forearc strata also suggests that further exploration should be done in the Melrose area, in Lookingglass and Flournoy valleys, and west of the Tyee escarpment (cross section A-A′, Plate 3). Faulted Roseburg strata may be the source for the many "biogenic" gas and oil seeps in the overlying Lookingglass and Flournoy strata near Melrose and in the Lookingglass and Flournoy valleys. In addition, folded and thrusted "mature" fractured Roseburg strata may be more deeply subducted beneath the Sixes River melange south of the Wildlife Safari Fault (cross sections A-A′ and D-D′, Plate 3). The melange itself appears to be "organic" black shale in the field adjacent to and interbedded with the Sixes River limestone blocks (e.g., Portland cement quarry in T. 28 S., R. 5 W.). The maturation, T.O.C., and kerogen type of the melange should be tested in order to evaluate the source rock potential of this unit.

Mobil sampled one gas seep in the Upper Jurassic-Lower Cretaceous Myrtle Group south of Agness in the extreme southwest corner of the map area (T. 35 S., R. 12 W.; locality S14 on Plate 2). Little exploration has been conducted in these units because they have been severely deformed. Gas shows were reported in the Lower Cretaceous Days Creek sandstone in exploration wells drilled in the Riddle area (Plate 2, wells no. 18 and 20)(Table 3b). These units probably occur below the deltaic facies of the

Tyee, Flournoy, and Lookingglass formations south of Oregon Highway 42 (e.g., in T. 31 and 32 S., R. 10 and 11 W.)(cross section D-D′, Plate 3). The potential of these units as source rocks for oil and gas should be further investigated.

COAL RESOURCES

Plate 2 depicts the locations of outcrops of coals and cores that have encountered coals. Tables 4a, 4b, 4c, 4d, and 4e which accompany this report, list the following information for the coals: geologic formation, name of coal seam, data source, coal bed thickness, moisture content, percentages of volatile matter and fixed carbon, ash content, sulfur content, and British thermal unit (Btu)/lb values for 62 localities. The values listed for each locality represent either a single sample or an average of several samples. When the value is an average, the number of samples "n" is listed in the Comments column. A total of 671 samples were analyzed.

Most coals are located in the central and southern part of the basin (i.e., south of T. 22 S.). Coals occur in the deltaic facies of the Tyee (unit Tet_a), Flournoy (White Tail Ridge Member, unit Tef_1), Lookingglass (Olalla Creek and Bushnell Rock members, units Tel_3 and Tel_1), and Bateman (unit Teb) formations.

The most extensively explored coal field in the basin occurs in the Tyee Formation at Eden Ridge in the southwest corner of the map area (T. 32 S., R. 11 W., Plate 2), south of Powers in Coos County (Brownfield, 1981; Mason, 1956). The elliptical shaped coal field lies in a slightly asymmetrical synclinal fold (Lesher, 1914). The fold axis appears to be offset several hundred feet by three east-west trending left-lateral folds (Duell, 1957) and/or vertical normal faults with 80 to 600 feet of throw (NERCO, 1981; USBLM, 1983). Early field and laboratory studies of the Eden Ridge coals and coals from the adjacent Squaw Basin were made by Diller (1898), Lesher (1914), Campbell and Clark (1916), and Daniels (1920).

Coal occurs in four principal beds called the Lockhart, Carter, Anderson, and Meyer coals (see Eden Ridge coal stratigraphy column on Plate 2). The coals are interbedded in a 1000-ft sequence of sandstone, mudstone, and local conglomerate. Of the four coal seams, only the Anderson and Carter are considered to be economically important (USBLM, 1983). These two seams have been extensively cored (29 cores) and analyzed (e.g., Tables 4a and 4b). Numerous outcrop sections have been measured (Lesher, 1914; Duell, 1957). The coals have been mapped on the surface and subsurface, and isopach maps have been constructed (NERCO, 1981). The Anderson bed averages 6.2 ft thick; the Carter coal averages 6.9 ft thick. Total reserves for the two coal seams are estimated at more than 50 million tons (Duell, 1957; USBLM, 1983; Table 4d). Btu/lb values (moisture free) for the Anderson bed range from 3,883 to 10,325 (av. 8,443 for 332 samples) and from 3,190 to 9,160 (av. 6,473 for 337 samples) for the Carter coal. Average percentages of volatile matter and fixed carbon (F.C.) in the two seams are quite close (Table 4d). These average values for Btu, F.C., and percentage volatile matter indicate that these coals range from lignitic to subbituminous in rank (Brownfield, 1981). Recalculating the coal analyses ash free produces values for Btu, F.C., and % volatile matter that are considered medium to high volatile bituminous C rank (ASTM standards) according to Erwin (1953).

The wide range of Btu values for both the Carter and Anderson coal seams appears to reflect the variable amount of interlayered bone coal and shaly layers in the coal seams (Woomer and others, 1957). Ash, moisture, and sulfur contents average 45.2%, 4.1%, and 0.8% in the Carter coal and 35.0%, 3.7%, and 1.9% in the Anderson coal. Therefore, these coals are considered to be low moisture, high ash, low sulfur coals (Table 4d)(Brownfield, 1981). Lesher (1914) suggested that a washing separatory technique could be designed to remove part of the ash from the crushed raw coal in order to upgrade the Btu quality.

The Lockhart coal seam at the top of the section is discontinuous and shaly. It ranges from 0 to 12 ft thick. This seam may represent as much as 16 million tons of in-place reserves (USBLM, 1983)(Table 4c). No analyses are available for this seam. The least known seam is the Meyer coal zone which occurs at the base of the coal-bearing section (Plate 2). This coaly layer ranges from 0 to 19 ft thick (USBLM, 1983)(Table 4c). Btu/lb averages 10,385; moisture content is 3.7%; volatile matter is 38.5%; fixed carbon is 36.3%; ash content is 25.3%; and sulfur is 1.68%. However, because these values are based on only two samples, the averages may not be representative of this seam which is generally more shaly than the Anderson and Carter coals.

Other coal seams are reported in the deltaic facies of the Tyee Formation in Squaw Basin (T. 33 S., R. 11 W.) in the vicinity of Bald Knob, approximately 2 miles south of the Eden Ridge coal field (Plate 2, Table 4e)(Lesher, 1914; Williams, 1914; Wayland, 1964). These coals appear to be lower in the stratigraphic section than the coals of Eden Ridge (Erwin, 1953) and have not been as extensively explored. Analyses of five samples indicate that values of Btu/lb range from 7,670 to 11,410 (av. 11,174), ash content varies from 7.2% to 30.9% (av. 16.55%), and the amount of sulfur ranges from 0.98% to 1.53% (av. 1.30%)(Table 4e). Wayland (1964) and Lesher (1914) reported that the Squaw Basin coals consist of one or possibly two beds called the Donnell coal and the 7-foot bed. These coal seams are 6 to 10 feet thick (Table 4e). Williams (1914) ranked these coals as subbituminous and estimated the reserves of the "7-foot vein" at 8 million tons. The coals in the Tyee Formation at Eden Ridge and possibly in the Squaw Basin are a potential reserve although mining may not be economical at present due to the cost of removing overburden, underground mining, transportation distance, and a possible mining problem of flooding by groundwater (Duell, 1957; Brownfield, 1981).

A 2- to 3-ft thick coal with several feet of carbonaceous mudstone occurs in the deltaic facies of the Tyee Formation in rock exposures along the Coos Bay wagon road, 4 miles east of Sitkum (Baldwin, 1989, personal communication) and 31 miles north of the Eden Ridge coal field (Locality C-11, Plate 2). Thus, coals are widespread in the southern deltaic facies of the Tyee Formation.

Trigger (1966) noted 4- to 6-foot thick beds of subbituminous coal and interbedded carbonaceous shales in the deltaic phase of the Bushnell Rock Member of the Lookingglass Formation in scattered road exposures immediately west of Remote along Oregon Highway 42 (locality C-9, T. 29 S., R. 10 W.). He also mapped more extensive 6- to 12-ft thick beds of coal interbedded with carbonaceous mudstone in the same member 6 miles north of Remote (locality C-8, Plate 2) on the west limb of the Coast Range syncline.

Scattered 1 to 3-ft thick beds of coal associated with thick overbank carbonaceous mudstone and cross-bedded distributary channel quartzo-feldspathic sandstones were noted by A. Niem (summer, 1989) in new roadcut exposures on the east flank of the Coast Range syncline. These rocks have been mapped as Olalla Creek Member of the Lookingglass Formation and the overlying deltaic facies (White Tail Ridge Member) of the Flournoy Formation (Tef_1) along Oregon Highway 42 (locality C-10, T. 30 S., R. 9 W.). Coal is also reported in these rocks in Camas valley (locality C-3 on Plate 2; Krogel coal prospect; Ramp, 1972).

Outcrops of coal in the Olalla Creek Member (Black, 1989, personal communication; locality C-14 on Plate 2) and possibly related seeps of "biogenic" methane gas in water wells and oil and gas exploration wells have been reported in coal-bearing Lookingglass strata in the Melrose area, 9 miles west of Roseburg (localities C-14, S7, S5, and S4, Plate 2). Coal gas also was noted in one core hole in Pacific Power and Light's Eden Ridge core drilling program in 1957 (Newton, 1980). In the late 1800's and early 1900's, more than 400 tons of coal were excavated from the Callahan Mine adits in a ridge of White Tail Ridge Member (Flournoy Formation), 3 miles southwest of Melrose (locality C-3)(Ramp, 1972; Treasher, 1942; USBLM, 1989). In Flournoy valley, several exploration holes (nos. 11, 12, and 13; Table 4e) penetrated up to four coals (2 to 4 ft thick) at a depth of several hundred feet and reported a show of gas in the White Tail Ridge Member according to Treasher (1942). This suggests that coal is widespread in this area as well.

New mapping and core drilling in all these areas probably will show that these coals in the deltaic facies of the White Tail Ridge Member (Flournoy Formation) and Olalla Creek Member (Lookingglass Formation) are also more areally widespread (e.g., south of T. 26 S.). Further laboratory analysis of these scattered coals also will be necessary to evaluate their rank, Btu, and ash and sulfur content before they can be considered as a potential resource.

Baldwin (1974) and Weatherby (1989, written communication and U. of Oregon MS thesis in progress) reported four or five thin (3 inches to 4 feet) discontinuous subbituminous coals in the middle Eocene deltaic Bateman Formation (unit Teb) at several localities in the central part of the southern Tyee Basin (T. 22 to 25 S., R. 8 and 9 W.; e.g., locality C-2 on Plate 2). Treasher (1942) estimated that the thickest (14 ft) and uppermost seam may underlie 125 acres. Weatherby believes that the coals cap several cycles of fining-upward sequences of meandering river/channelized distributary sandstone and overbank mudstone. Unfortunately, the unit has limited potential both as a coal resource and as source beds for methane because the coals are thin, silty, and discontinuous and have largely been eroded (Baldwin, 1974; Weatherby, 1989, personal communication).

These scattered, isolated outcrops of coal in the deltaic (nonmarine and brackish water swamp) facies and deltaic members of the Tyee, Flournoy, and Lookingglass formations are but a few occurrences. Many others probably exist. However, due to thick forest and soil cover and low resistance to weathering, these organically formed rocks are not noticed or have not been reported. These preliminary data suggest that coal seams are extensive and widespread throughout the southern part of the Tyee Basin shown on Plate 2. Methane may have been produced from these organic-rich deltaic-brackish water swamp deposits during the coalification process after burial.

In addition, if biogenic methane or coal gas is the principal component of the many gas seeps and is sourced in the coals of the Tyee, Flournoy, and Lookingglass formations (e.g., as in the Melrose area), then it is possible that this gas could be explored with coal degasification techniques, drilling into the fractured methane-bearing coal seams (Pappajohn, 1984). Such coal degasification exploration is presently commercially economic in the Cretaceous coals in the San Juan Basin of Colorado (Pappajohn, 1984).

Alternatively, if the coals are sufficiently thick and widespread, they could act as a source for biogenic methane in overlying fractured lower to middle Eocene sandstone reservoirs beneath Tyee forearc strata (e.g., in the area of T. 26 S. to 31 S. and R. 7 W. to 11 W.). Biogenic methane associated with coals in the non-marine Tertiary forearc basin of the Cook Inlet (Alaska) is a major source for the large gas reservoir there (Rice and Claypool, 1981). Fracturing or jointing could be related to local intense folding and thrusting or regional tectonism. There is some geochemical and field evidence that methane gas in the Mist Gas Field of northwest Oregon may be derived in part from coals in the middle to upper Eocene deltaic Cowlitz Formation that are buried in deeper parts of the adjacent Nehalem and Tualatin basins (Armentrout and Suek, 1985). Therefore, the possibility that the coals in the Tyee Basin are widespread is important for gas exploration in the southern part of the basin because those coals could also act as source rocks for potentially commercial quantities of natural biogenic or coal gas in these thermally immature formations.

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Geology and Oil, Gas, and Coal Resources of the Southern Tyee Basin, Southern Coast Range, Oregon

by

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GEOLOGY AND OIL, GAS, AND COAL RESOURCES, SOUTHERN TYÈE BASIN, SOUTHERN COAST RANGE, OREGON

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DATA TABLES

1990

NOTICE

The Oregon Department of Geology and Mineral Industries is publishing this report because the subject matter is consistent with the mission of the Department. To facilitate timely distribution of information, camera-ready copy submitted by the authors has not been edited by the staff of the Oregon Department of Geology and Mineral Industries.

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Sample Number	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Organic Carbon (% of rock)	Vitrinite Reflectance Ro (%)	Visual Kerogen Type*	Alteration (1-5 scale)	L.O.M.	Comments
1	Bateman	N1/2	4	24	8	B&F (1980)	---	0.45 (subbit. coal)	---	---	6-7	(L.O.M. = av. of 5 samples)
2	Fisher	NE	10	25	3	Mobil (1980)	0.80	---	---	---	---	
3	Elkton	NW	22	22	8	Law & others (1984)	0.63	0.59	---	---	---	
4	Elkton	NW	30	23	7	Law & others (1984)	1.35	0.59	---	---	---	
5	Elkton	NW	26	23	8	B&F (1980)	---	---	---	---	7-8	(L.O.M. = av. of 3 samples)
6	Elkton	SE	26	23	8	B&F (1980)	0.15	---	---	---	7-8	(2 samples)
7	Elkton	SE	26	23	8	B&F (1980)	0.41	---	---	---	8-9	(2 samples)
8	Elkton	SE	26	23	8	B&F (1980)	0.40	---	---	---	6-7	(2 samples)
9	Elkton	NE	27	23	8	B&F (1980)	---	---	---	---	6-8	(L.O.M. = av. of 3 samples)
10	Elkton	NE	35	23	8	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
11	Elkton	NW	36	23	8	B&F (1980)	---	---	---	---	6-7	
12	Elkton	SE	36	24	8	Law & others (1984)	0.91	0.59	---	---	---	
						average =	0.56 (n = 10)	0.56 (n = 4)				
13	Tyee		21	22	7	Law & others (1984)	1.41	0.60	---	---	---	
14	Tyee	SW	1	25	7	Mobil (1980)	---	0.60	---	---	---	
15	Tyee	ctr	23	25	7	Mobil (1980)	0.82	0.68	---	---	---	av. of 22 samples
16	Tyee	SW	33	26	7	Law & others (1984)	1.02	0.58	---	---	---	
17	Tyee	NW	5	32	11	Law & others (1984)	0.66	0.58	---	---	---	
18	Tyee	NE	29	32	11	Law & others (1984)	36.61 (coal)	0.63	---	---	---	

Table 1a. Source Rock and Maturation Data for Surface Samples, Southern Tyee Basin, Southern Coast Range, Oregon (continued)

Sample Number	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Organic Carbon (% of rock)	Vitrinite Reflectance Ro (%)	Visual Kerogen Type*	Alteration (1-5 scale)	L.O.M.	Comments
19	Tyee	SW	32	32	11	Law & others (1984)	54.97 (coal)	0.55	---	---	---	
	Tyee	sample Ty-2000, unknown				B&F (1980)	---	0.48	---	---	---	subbituminous coal, (letter from Dave Demshur, 12/3/79)
	Tyee	sample Ty-3092, unknown				B&F (1980)	---	0.59	---	---	---	high volatile "C" bituminous coal (Demshur, 12/3/79)
20	Tyee	SE	36	32	12	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 4 samples)
21	Tyee	SE	36	32	12	B&F (1980)	11.09	---	---	---	6-7	coal?
22	Tyee	SE	36	32	12	B&F (1980)	2.38	---	---	---	6-7	
23	Tyee	SW	36	32	12	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
24	Tyee	NW	21	33	11	Law & others (1984)	0.84	0.86	---	---	---	
						average	0.90 (n = 27)	0.66 (n = 29)				
25	Flournoy	W1/2	29	18	5	Law & others (1984)	0.62	0.49	---	---	---	
26	Flournoy	S1/2	13	18	11	Newton (1980)	0.31	---	W;H;Al	1+ to 2-	Immature, poor methane gas source, biogenic	
27	Flournoy	SE	19	18	11	Law & others (1984)	0.87	0.38	---	---	---	
28	Flournoy	NW	29	19	11	Newton (1980)	0.83	---	H-W;-;-	1+	Immature, methane gas source biogenic	
29	Flournoy	NW	15	21	12	Newton (1980)	0.52	---	W;H;-	1+	Immature, methane gas source, biogenic	
30	Flournoy	E1/2	26	21	12	Newton (1980)	0.88	---	H;W;-	2- to 2		
31	Flournoy	N1/2	17	22	5	Law & others (1984)	0.32	0.65	---	---	---	
32	Flournoy	NW	8	23	5	Law & others (1984)	0.65	0.59	---	---	---	
33	Flournoy	SW	32	24	3	Mobil (1980)	0.90	---	---	---	---	

Table 1a. Source Rock and Maturation Data for Surface Samples, Southern Tyee Basin, Southern Coast Range, Oregon (continued)

Sample Number	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Organic Carbon (% of rock)	Vitrinite Reflectance Ro (%)	Visual Kerogen Type*	Visual Kerogen Alteration (1-5 scale)	L.O.M.	Comments
34	Flournoy	E1/2	6	25	11	Newton (1980)	0.38	---	H-W;-;-	2- to 2		
35	Flournoy	N1/2	17	26	3	Law & others (1984)	0.22	0.52	---	---	---	
36	Flournoy	SE	5	27	11	Law & others (1984)	1.47	0.53	---	---	---	
37	Flournoy	W1/2	15	27	11	Law & others (1984)	0.66	0.51	---	---	---	
38	Flournoy	W1/2	7	29	8	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
39	Flournoy	NE	19	30	10	B&F (1980)	0.19	---	---	---	6-7	(L.O.M. = av. of 2 samples)
40	Flournoy	SE	19	30	10	B&F (1980)	0.61	---	---	---	6-7	
41	Flournoy	NE	30	30	10	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
42	Flournoy	SW	27	34	11	Mobil (1980)	0.29	---		TAI = 2.5-3.0; TOC = av. of 4 samples		
						average	0.58 (n = 17)	0.52 (n = 7)				
43	Lookingglass	W1/2	19	26	3	Mobil (1980)	0.92	---	---	---	---	av. of 5 samples
44	Lookingglass	ctr	13	26	4	Law & others (1984)	0.37	0.53	---	---	---	
45	Lookingglass	SE	7	26	6	Mobil (1980)	0.65	0.68	---	---	---	av. of 3 samples
46	Lookingglass	NE	18	26	6	Mobil (1980)	0.71	---	---	---	---	av. of 30 samples
47	Lookingglass	NW	29	29	10	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
48	Lookingglass	SE	29	29	10	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
49	Lookingglass	SE	29	29	10	B&F (1980)	0.69	---	---	---	6-7	
50	Lookingglass	SE	29	29	10	B&F (1980)	0.86	---	---	---	6-7	
51	Lookingglass	NE	30	29	10	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
52	Lookingglass	NE	32	29	10	B&F (1980)	---	---	---	---	6-7	
53	Lookingglass	NW	33	29	10	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)

Table 1a. Source Rock and Maturation Data for Surface Samples, Southern Tyee Basin, Southern Coast Range, Oregon (continued)

Sample Number	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Organic Carbon (% of rock)	Vitrinite Reflectance Ro (%)	Visual Kerogen Type*	Visual Kerogen Alteration (1-5 scale)	L.O.M.	Comments
54	Lookingglass	NW	16	30	9	Law & others (1984)	19.20	0.48	---	---	---	carbonaceous shale?
55	Lookingglass	NE	34	30	12	Law & others (1984)	0.89	0.46	---	---	---	
56	Lookingglass	ctr	19	31	11	Law & others (1984)	0.61	0.61	---	---	---	
57	Lookingglass	SW	18	34	11	Mobil (1980)	0.50	---	---	---	---	
58	Lookingglass	SW	19	34	11	Law & others (1984)	0.35	0.63	---	---	---	
59	Lookingglass	SW	19	34	11	Law & others (1984)	0.41	0.64	---	---	---	
60	Lookingglass	NE	5	35	11	Law & others (1984)	0.77	0.75	---	---	---	
61	Lookingglass	SW	5	35	11	Law & others (1984)	0.48	0.63	---	---	---	
62	Lookingglass	S1/2	5	35	11	Mobil (1980)	0.15	---	---	---	---	
63	Lookingglass	NE	6	35	11	Mobil (1980)	0.51	---	---	---	---	av. of 3 samples
						average	0.59 (n = 19)	0.63 (n = 11)				
64	Roseburg	SW	8	22	6	Law & others (1984)	0.41	0.76	---	---	---	
65	Roseburg	SW	2	23	5	Law & others (1984)	0.43	0.60	---	---	---	
66	Roseburg	SW	20	23	5	Law & others (1984)	0.31	0.61	---	---	---	
67	Roseburg	ctr	25	24	4	Mobil (1980)	0.60	---	---	---	---	
68	Roseburg	NW	17	24	5	Law & others (1984)	0.84	0.64	---	---	---	
69	Roseburg	SW	17	24	5	Mobil	0.42	0.57		TAI = 1.8 TOC = av. of 205 samples from measured section along I-5		
70	Roseburg	SW	17	24	5	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 4 samples)

Table 1a. Source Rock and Maturation Data for Surface Samples, Southern Tyee Basin, Southern Coast Range, Oregon (continued)

Sample Number	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Organic Carbon (% of rock)	Vitrinite Reflectance Ro (%)	Visual Kerogen Type*	Visual Kerogen Alteration (1-5 scale)	L.O.M.	Comments
71	Roseburg	NE	18	24	5	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
72	Roseburg	E1/2	19	24	5	Mobil (1980)	0.62	---	---	---	---	av. of 18 samples
73	Roseburg	N1/2	20	24	5	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
74	Roseburg	S1/2	20	24	5	Mobil (1980)	0.61	---	---	---	---	av. of 22 samples
75	Roseburg	NW	29	24	5	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 2 samples)
76	Roseburg	N1/2	30	24	5	Mobil (1980)	0.51	0.57		TAI = 1.8		TOC = av. of 139 samples from measured section
77	Roseburg	ctr	32	24	5	B&F (1980)	---	---	---	---	6-7	
78	Roseburg	NW	32	24	5	B&F (1980)	0.29	---	---	---	6-7	
79	Roseburg	NW	32	24	5	B&F (1980)	---	---	---	---	6-7	(L.O.M. = av. of 3 samples)
80	Roseburg	NW	32	24	5	B&F (1980)	0.28	---	---	---	6-7	
81	Roseburg	ctr	36	24	5	Mobil (1980)	0.66	---	---			av. of 15 samples from measured section along Calapooya Creek
82	Roseburg	W1/2	23	24	6	Mobil (1980)	0.61	---	---	---	---	av. of 2 samples
83	Roseburg	NW	29	24	6	Mobil (1980)	0.86	---	---	---	---	av. of 2 samples
84	Roseburg	NE	33	24	6	Mobil (1980)	0.60	---	---	---	---	av. of 2 samples
85	Roseburg	W1/2	36	24	6	Mobil (1980)	0.56	---	---	---	---	av. of 2 samples
86	Roseburg	SW	4	25	5	Mobil (1980)	0.60	0.60	---	---	---	av. of 11 samples
87	Roseburg	ctr	5	25	5	Mobil (1980)	0.62	0.62		TAI = 1.8		TOC = av. of 6 samples
88	Roseburg	S1/2	7	25	5	Snavely (p. comm.)	0.69	0.51	---	2.5	---	
89	Roseburg		18	25	5	Law & others (1984)	0.34	0.56	---	---	---	
90	Roseburg	NE	30	25	5	Mobil (1980)	0.63	---	---	---	---	av. of 8 samples
91	Roseburg	NW	31	25	5	Mobil (1980)	0.56	0.69	---	---	---	av. of 11 samples
92	Roseburg	SW	36	25	5	Law & others (1984)	0.81	0.54	---	---	---	

Table 1a. Source Rock and Maturation Data for Surface Samples, Southern Tyee Basin, Southern Coast Range, Oregon (continued)

Sample Number	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Organic Carbon (% of rock)	Vitrinite Reflectance Ro (%)	Visual Kerogen Type*	Visual Kerogen Alteration (1-5 scale)	L.O.M.	Comments
93	Roseburg	ctr	1&12	25	6	Mobil (1980)	0.47	---	---	---	---	av. of 7 samples from Williams Canyon measured section
94	Roseburg	NW	11	25	6	Mobil (1980)	0.41	---	---	---	---	av. of 19 samples
95	Roseburg	ctr	27	25	6	Mobil (1980)	0.29	---	---	---	---	av. of 26 samples
96	Roseburg	S1/2	30&29	25	6	Mobil (1980)	0.57	---	---	---	---	av. of 24 samples
97	Roseburg	SE	25	25	7	Mobil (1980)	0.47	---	---	---	---	av. of 5 samples
98	Roseburg	SE	25	25	7	Law & others (1984)	0.63	0.59	---	---	---	
99	Roseburg	SW	8	26	4	Mobil (1980)	0.57	0.66	---	---	---	av. of 5 samples (TOC) av. of 2 samples (Ro)
100	Roseburg	ctr	7	26	4	Mobil (1980)	0.45	---	---	---	---	av. of 5 samples
101	Roseburg	NE	21	26	4	Mobil (1980)	0.39	0.53	---	---	---	av. of 42 samples (TOC) av. of 2 samples (Ro)
102	Roseburg	NW	21	26	4	Mobil (1980)	0.94	---	---	---	---	av. of 17 samples
103	Roseburg	SE	21	26	4	Mobil (1980)	0.58	0.50	---	---	---	av. of 6 samples
104	Roseburg	SW	21	26	4	Mobil (1980)	0.51	---	---	---	---	av. of 6 samples
105	Roseburg	NE	33	26	4	Mobil (1980)	0.55	---	---	---	---	av. of 5 samples
106	Roseburg	NW	5	26	6	Mobil (1980)	0.65	0.67	---	---	---	av. of 26 samples
107	Roseburg	ctr	1	28	6	Snavely (p. comm.)	0.26	0.59	---	2.5	---	
108	Roseburg	SW	29	28	12	B&F (1980)	---	---	---	---	6-7	
109	Roseburg	W1/2	36	28	12	Newton (1980)	0.46	---	H-W;-;Am	2- to 2	---	
110	Roseburg?	?	10	29	11	B&F (1980)	---	---	---	---	6-7	(contains good Cretaceous microflora)
111	Roseburg	SW	20	29	11	B&F (1980)	---	---	---	---	6-7	
112	Roseburg	NE	3	29	12	B&F (1980)	---	---	---	---	6-7	
113	Roseburg	SW	3	29	12	B&F (1980)	---	---	---	---	6-7	

Table 1a. Source Rock and Maturation Data for Surface Samples, Southern Tyee Basin, Southern Coast Range, Oregon (continued)

Sample Number	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Organic Carbon (% of rock)	Vitrinite Reflectance Ro (%)	Visual Kerogen Type*	Visual Kerogen Alteration (1-5 scale)	L.O.M.	Comments
114	Roseburg	W1/2	4	29	12	B&F (1980)	---	---	---	---	6-7	
115	Roseburg	SE	8	29	12	Newton (1980)	0.41	---	W;H;-	2- to 2	---	
116	Roseburg	NW	31	34	11	Law & others (1984)	0.42	0.60	---	---	---	
117	Roseburg	SE	6	35	11	Mobil (1980)	0.56	---	---	---	---	av. of 3 samples
118	Roseburg	NE	7	35	11	Law & others (1984)	0.13	1.75	---	---	---	
						average	0.48 (n = 651)	0.59 (n = 282)				
----Pre-Tertiary----									----Pre-Tertiary----			
119	Myrtle Gp.	NE	25	30	6	Mobil (1980)	0.78	---	---	---	---	av. of 10 samples
120	Myrtle Gp.	SE & W1/2	25 & 36	30	6	Mobil (1980)	0.58	---	---	---	---	av. of 8 samples
121	Myrtle Gp.	NW	18	35	11	Law & others (1984)	2.42	0.75	---	---	---	
122	Myrtle Gp.	NE	13	35	12	Law & others (1984)	2.48	0.72	---	---	---	
						average	0.87 (n = 20)	0.74 (n = 2)				
123	Myrtle Gp. (Days Creek)	W1/2	18	30	5	Mobil (1980)	0.80	0.62				TAI = 2.0; TOC = av. of 499 samples Ro = av. of 3 samples
124	Days Creek	ctr	27	30	5	Mobil (1980)	0.92	---	---	---	---	av. of 4 samples
125	Days Creek	N1/2	32	30	5	Mobil (1980)	0.56	---	---	---	---	av. of 5 samples
126	Days Creek	ctr	33	30	5	Mobil (1980)	0.58	0.99	---	---	---	av. of 7 samples
127	Days Creek	W1/2	13	30	6	Mobil (1980)	0.53	1.05	---	---	---	av. of 33 samples
128	Days Creek	SE	22	30	6	Mobil (1980)	0.89	---	---	---	---	av. of 3 samples
129	Days Creek	NW	23	30	6	Mobil (1980)	0.61	---	---	---	---	av. of 10 samples
130	Days Creek	NE	26	30	6	Mobil (1980)	0.63	---	---	---	---	av. of 33 samples)
131	Days Creek	S1/2	29	30	6	Mobil (1980)	0.79	---	---	---	---	av. of 8 samples

Table 1a. Source Rock and Maturation Data for Surface Samples, Southern Tyee Basin, Southern Coast Range, Oregon (continued)

Sample Number	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Organic Carbon (% of rock)	Vitrinite Reflectance Ro (%)	Visual Kerogen Type*	Visual Kerogen Alteration (1-5 scale)	L.O.M.	Comments
132	Days Creek	SW	33	30	6	Mobil (1980)	0.26	---	---	---	---	
133	Days Creek	SE	33	30	6	Mobil (1980)	0.58	---	---	---	---	av. of 2 samples
134	Days Creek	W1/2	16?	32	10	B&F (1980)	---	---	---	---	6-7	(2 samples; one contained reworked pollen LOM = 11-12)
135	Days Creek	SE	25	34	12	Mobil (1980)	---	---	---	TAI = 2.7		
136	Days Creek	W1/2	18	35	11	Mobil (1980)	0.93	---	---	---	---	av. of 4 samples
137	Days Creek	NE	13	35	12	Mobil (1980)	1.8	---	---	---	---	av. of 6 samples
138	Days Creek	NE	13	35	12	Mobil (1980)	1.02	---	---	---	---	av. of 2 samples
						average	0.78 (n = 617)	1.01 (n = 43)				
139	Myrtle Gp. (Riddle)	E1/2	30	30	5	Mobil (1980)	0.79	0.56		TOC = av. of 22 samples Ro = av. of 2 samples		

*Al = algal
Am = amorphous sapropel
H = herbaceous spore cuticle
W = woody

L.O.M. = Level of Organic Maturity as indicated by the color of fossil pollen
L.O.M. of 10 or higher indicates organic maturity

--- = not measured

Sources of Data:

B&F (1980) = Browning, J. L. and Flanagan, T., 1980, Source rock study of the lower Tertiary formations of southwestern Oregon: Consultants' Report, 96 pages + figures, tables, and references.

Ogle Petroleum Corp., 1983, Total organic carbon values and maturation analysis of selected wells, Oregon; unpublished report on file at DOGAMI (DOGAMI Oil and Gas Contract #2), Geochem Laboratories (1983).

Table 1b. Weighted Averages of Source-Rock and Maturation Data for Eocene Sedimentary Samples in Oil and Gas Exploration Wells

Well Number and Name and Geol. Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Organic Carbon (% of rock)	Vitrinite Reflectance Ro (%)	Visual Kerogen Alteration (1-5 scale)
1 General Petrol. Long Bell #1 (Flournoy and Roseburg)	SW	27	20	10	B&R (1983)	0.44 (n = 176)	0.64 (n = 16)	TAI = 1.85 (n = 35)
2 Florida Explor. Well No. 1-4 (Flournoy and Roseburg)	NE	4	21	6	Amoco (1983)	0.8 (n = 39)	0.45 (n = 7)	
3 Northwest Explor. Sawyer Rapids 1 (Flournoy and Roseburg)	NE	3	23	9	Robertson (1989)	0.64 (n = 4)	---	
4 Amoco Weyerhaeuser F-1 (Elkton, Flournoy, and Roseburg)	NE	10	25	10	B&R (no date)	0.49 (n = 16)	0.66 (n = 16)	TAI = 2.32 (n = 15)
5 Amoco Weyerhaeuser B-1 (Tyee, Flournoy, and Roseburg)	SE	13	25	9	Amoco (1985)	0.69 (n = 10)	0.58 (n = 3)	
7 Mobil Sutherlin Unit 1 (Roseburg)	SW	36	24	5	B&R (1983)	0.60 (n = 63)	0.52 (n = 9)	TAI = 1.97 (n = 15)
8 Union Oil Co. Liles 1 (Roseburg)	SW	27	25	7	Ogle (1983)	0.85 (n = 1?)	---	
10 Oil Developers Scott #1 (Roseburg)	SW	5	27	6	Ogle (1983)	0.17 (n = 1?)	---	

--- = not measured

References:

Amoco Production Company, Research Center, 1985, Source rock evaluation: Eocene cuttings, Amoco No. B-1, Weyerhaeuser, Douglas County, Western Oregon, 2 p. + tables.

B&R = Brown and Ruth Laboratories, Inc., no date, Geochemical report: Amoco Weyerhaeuser F-1.

Ogle Petroleum Corp., 1983, Total organic carbon values and maturation analysis of selected wells, Oregon: unpublished report on file at DOGAMI (DOGAMI Oil and Gas Contract #2), Geochem Laboratories (1983).

Robertson, R. D., 1989, Letter of August 22, 1989 to Alan Niem.

Table 1c.--Source-rock analytical data for surface samples from Southern Tyee basin Oregon (slightly modified from Law & others, 1984)

(K, Cretaceous; T, Tertiary; argl, argillite; carb, carbonaceous; clyst, claystone; ms, mudstone; ss, sandstone; sdy, sandy; sh, shale; shy, shaly; sltst, siltstone; slty, silty; -- no data)

Plate 2

Location No.	Sample No.	Age	Stratigraphic unit	Lithology	R_o (percent)*[1]	organic carbon (Wt %)	S_1 (mgHC/g)	S_2 (mgHC/g)	S_3 (mgCO_2/g)	T_{max} (°C)	Genetic potential (S_1+S_2)	H_2 index (mgHC/gC)	O_2 index (mgCO_2/gC)	(S_1/S_1+S_2)*[2]
10	081M-3	T	Elkton Formation-----------	sltst, slty sh	.59	1.35	.026	1.09	.24	436	1.12	81	18	.02
6	081TF-95	T	------do------------------	slty sh	.59	.63	.016	.17	.32	420	.19	27	51	.09
12	081TF-120	T	Elkton Formation-----------	sh	.59	.91	.018	.51	.33	431	.53	56	36	.03
1	081TF-91	T	Tyee Formation (upper part)	sltst, ss	.49	.62	.051	---	.59	---	.051	--	95	1
5	081TF-94	T	------do------------------	sltst	.60	1.41	.046	.87	.68	436	.92	62	48	.05
2	081TF-89	T	Tyee Formation-------------	sh	.38	.87	.012	.12	.56	427	.13	14	65	.09
27	081TF-104	T	------do------------------	sh	.86	.84	.024	.08	.18	435	.10	10	22	.22
26	081TF-106	T	------do------------------	coal	.55	54.97	.285	147.71	7.03	423	148.00	269	13	.002
25	081TF-109	T	------do------------------	coal	.63	36.61	.999	59.69	7.70	416	60.69	163	21	.02
18	081TF-119	T	Tyee Formation (lower part)	sh	.58	1.02	.019	.76	.42	435	.78	75	41	.02
8	081TF-127	T	------do------------------	sh	.59	.65	.020	.12	.26	430	.14	19	39	.14
16	081TF-117	T	Umpqua Gp., Flournoy Fm.---	clyst	.52	.22	.008	.05	.27	432	.06	22	122	.15
20	081M-16	T	Umpqua Gp., Flournoy Fm.---	slty sh	.51	.66	.016	.16	.38	427	.18	24	57	.09
9	081TF-126	T	------do--, Roseburg Fm.---	slty sh	.61	.31	.019	.02	.75	440	.04	5	243	.54
24	081TF-102	T	Tyee Formation-------------	sh	.58	.66	.025	.18	.23	431	.21	27	35	.12
22	081TF-100	T	Umpqua Group--------------- (Lookingglass Formation)	sh	.46	.89	.019	.11	.47	431	.13	13	52	.14
23	081TF-101	T	------do------------------	sltst	.61	.61	.017	.13	.33	426	.15	22	54	.12
31	BELO 2082	T	Umpqua Group--------------- (Lookingglass Formation)	slty sh	.75	.77	.016	.09	.23	428	.11	12	30	.14
32	BELO 2182	T	------do---Lookingglass----	slty sh	.63	.48	.017	.11	.41	440	.13	23	85	.13
29	BELO 2382	T	------do---Lookingglass----	slty sh	.63	.35	.015	.01	.34	439	.03	3	96	.60
28	BELO 2482	T	------do---Lookingglass----	shy sltst	.64	.41	.029	.152	.31	439	.181	37	75	.16
17	081TF-116	T	Umpqua Gp., Lookingglass--- (Lower part of Lookingglass Formation)	slty sh	.53	.37	.015	.04	.37	428	.06	12	99	.26
3	081M-2	T	Umpqua Group---------------	sh, clyst	.65	.32	.016	.12	.38	422	.14	37	120	.12
14	081M-15	T	------do---Roseburg? Fm.---	slty sh	.53	1.47	.010	.05	.40	428	.06	3	27	.18
30	BELO 2282	T	Umpqua Gp., Roseburg Fm.---	slty sh	.60	.42	.013	.09	.22	441	.10	22	52	.12
33	BELO 2582	T	------do------------------	carb shy sltst	1.75	.13	.024	---	.23	---	.024	--	57	1
7	081M-1	T	Umpqua Gp., Roseburg Fm.---	slty sh	.60	.43	.009	.007	.46	426	.016	2	107	.56
4	081TF-92	T	------do---Roseburg? Fm.---	sh	.76	.41	.021	.05	.66	422	.07	13	161	.27
21	081TF-113	T	------do---Lookingglass----	carb sltst	.48	19.20	.037	11.05	16.66	425	11.09	58	87	.003
15	081TF-121	T	------do---Roseburg Fm.----	slty sh	.59	.63	.028	.24	.24	428	.27	38	38	.10
14	081TF-122	T	------do---Roseburg Fm.----	sh	.54	.81	.018	.003	.87	442	.021	33	108	.87
13	081TF-124	T	------do---Roseburg Fm.----	sh	.56	.34	.011	.06	.23	431	.07	16	68	.17
11	081TF-125	T	------do---Roseburg Fm.----	sh	.64	.84	.015	.14	.25	426	.16	17	30	1
88	585-133*	T	Umpqua Gp., Roseburg Fm.---	sltst	.51	.69	---	---	---	441	---	59	14	---
107	585-134*	T	Umpqua Gp., Roseburg Fm.--- (Interbed in basalts)	sltst	.59	.26	---	---	---	356	---	50	100	---
35	BELO 2682	K	Unnamed Cretaceous rocks--- (Myrtle Group)	slty sh	.75	2.42	.067	.79	.24	448	.86	33	10	.08
34	BELO 2782	K	------do----Myrtle Group---	slty sh	.72	2.48	.040	.36	.62	454	.40	14	25	.10

*Courtesy of Parke D. Snavely (1989); *[1]Vitrinite reflectance; *[2]Transformation ratio

Table 2. Porosity and Permeability of Outcrop Samples, Southern Tyee Basin

Geologic Unit	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Porosity (% volume)	Permeability (millidarcies)		Lithology
Flournoy	N1/2	22	18	11	Newton (1980)	25.0	63.0		litharenite, silty, fine- to medium-grained
Flournoy	ctr	7	19	6	Mobil (1980)	22.3	3.0		---
Flournoy	E	36	20	12	Newton (1980)	31.1	37.0		micaceous litharenite, firm to friable, massive fine- to medium-grained
Flournoy	SW	15	23	12	Newton (1980)	38.2	154.0		micaceous litharenite, thin-bedded, fine- to medium-grained
Flournoy	SW	15	23	12	Newton (1980)	33.9	77.0		micaceous litharenite, fine- to medium-grained
Flournoy	ctr	31	24	11	Newton (1980)	33.6	24.8		feldspathic litharenite
Flournoy	NW	17	26	3	Mobil (1980)	1.8	---	n = 2	---
Flournoy	NW	9	28	8	Mobil (1980)	10.9	0.17	n = 2	---
Flournoy	N 1/2	8	28	10	Mobil (1980)	9.0	15.0	n = 4	---
					average	17.7 (n = 14)	34.9 (n = 12)		
Lookingglass	S 1/2	29	29	10	Mobil (1980)	7.0	---	n = 2	---
Roseburg	SW	8	23	5	Mobil (1980)	1.0	---		---
Roseburg	ctr	16	23	5	Mobil (1980)	3.0	---	n = 2	---
Roseburg	ctr	30	23	5	Mobil (1980)	10.0	---		---
Roseburg	SE	11	28	12	Newton (1980)	28.3	32.6		feldspathic litharenite silty, hard, massive, fine-grained

Table 2. Porosity and Permeability of Outcrop Samples, Southern Tyee Basin (continued)

Geologic Unit	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Porosity (% volume)	Permeability (millidarcies)		Lithology
Roseburg	ctr	2	29	12	Mobil (1980)	23.2	53.4		---
Roseburg	SW	4	29	12	Newton (1980)	10.0	15.4		feldspathic litharenite minor mica, hard, fine-grained
					average	13.3 (n = 9)	33.8 (n = 3)		
------------------------------- pre-Tertiary -------------------------------									
Myrtle Gp. undiff.	NE	5	31	9	Mobil (1980)	12.9	7.0		---
Myrtle Gp. undiff.	E 1/2	5	31	9	Mobil (1980)	10.4	90.0		---
Myrtle Gp.	S 1/2	19	35	11	Mobil (1980)	5.9	0.03	n = 2	---
Days Creek	SE	22	29	5	Mobil (1980)	9.8	0.09		---
Days Creek	NE	18	30	5	Mobil (1980)	5.4	0.04	n = 5	---
Riddle	SW	26	29	5	Mobil (1980)	4.3	0.03	n = 2	---
					average	6.7 (n = 12)	8.1 (n = 12)		

--- = no data

Sources of Data:

Mobil Oil Corporation, 1980, Source rock data on map of southwest Oregon, courtesy of Lee High, Division Geologist

Newton, V.C., Jr., 1980, Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane counties, Oregon: Oregon Dept. of Geology and Mineral Industries, Oil and Gas Investigation 6, 74 p.

Table 3a. Oil and Gas Shows in Oil and Gas Exploration Wells

Well No.	Well Operator	Well Name	Depth (ft)	Comments	Date Drilled
1	General Petroleum	Long Bell #1	4200	Brown stain, fluorescence	1957
			5345	Slight gas	"
			5590	Trace, hydrocarbon cut in core	"
			6040	Trace, hydrocarbon cut in core	"
			6900	Tar stain, fluorescence	"
2	Florida Exploration	Well No. 1-4	5962 TD	Gas shows and several heavy oil shows in sandstones and in volcanics (lith log)	1982
3	Northwest Exploration	Sawyer Rapids #1	850	Minor oil in transitional sandstones between Tyee and Elkton formations (Robertson, 1980)	1980
			959	Trace of gold fluorescence; very slow milky cut; (side wall core description; Robertson, 1980)	"
			1050	Minor oil in transitional sandstones between Tyee and Elkton formations (Robertson, 1980)	"
4	Amoco	Weyerhaeuser F-1	1000	Oil in mud; slow yellow cut (lith log)	1985
5	Amoco	Weyerhaeuser B-1	1400	Oil stain, slight yellow cut fluorescence	1985
			2100	Oil stain	"
			2900	Oil stain, 5-35 unit gas increase, 90ppm C3	"
			5300	Trace crude oil in mud	"
			11204 TD	Oil (micro show) (in volcanics)	"
6	Clark, Sheldon C.	"Oakland well"	2200	Trace of oil (Stewart, 1954)	1926
			2234	Considerable gas (Stewart, 1954)	"
7	Mobil Oil Corp.	Sutherlin Unit 1	13,177 TD	Tested 28 mcfd at 3,000 ft (Olmstead, 1989)	1979
9	Hutchins & Marrs	Glory Hole #1	2980 TD	Pale yellow cut and fluorescence common	1983

Table 3a. Oil and Gas Shows in Oil and Gas Exploration Wells (continued)

Well No.	Well Operator	Well Name	Depth (ft)	Comments	Date Drilled
10	Community Oil & Gas	Scott No. 1	1,500 to 3,520	Oil shows in cores (Olmstead, 1989)	1954
10	Community Oil & Gas	Scott No. 1	3792 TD	Some oil colors under fluorescent lamp (Stewart, 1954)	1954
14	Kernin, W. F.	Well 1	3900 TD	Gas & oil shows (Olmstead, 1989)	1931-48
15	Dillard, F. W.	Unnamed	700 TD	Oil in shale reported (Olmstead, 1989)	1910
16	Uranium Oil & Gas	Ziedrich 1	1640-55	Gas, 8-10 mcf; oil shows; bright to pale yellow fluorescence CCl4 cut at 3640-3700 ft, 4020-4030 ft 4040-4050 ft	1955
			4368 TD	Some gas found at 1900 ft (Olmstead, 1989)	1955
18	Riddle Gas & Oil	Wollenberg 1	1100 TD	Gas shows below 700 ft; saltwater at 755 ft (Olmstead, 1989)	1956-65
20	Riddle Gas & Oil	Dayton 1	1370 TD	Small flow of gas found below 1,000 ft (Olmstead, 1989)	1955-58

References:

Olmstead, D. L., 1989, Hydrocarbon exploration and occurrences in Oregon: Oregon Dept. of Geology and Mineral Industries Oil and Gas Investigation 15, 78 p.

Robertson, R. D., 1980, Well Summary of Northwest Exploration Sawyer Rapids No. 1, 1 page.

Stewart, R. E., 1954, Oil and gas exploration in Oregon: Oregon Dept. of Geology and Mineral Industries Miscellaneous Paper 6, 53 p.

Table 3b. Oil and Gas Shows in Water Wells and Natural Seeps

Locality No.	Legal Location 1/4	sec.	T.S.	R.W.	Source of Data		Comments
S1	W 1/2	32	24	3	Mobil (1980)	NE of Sutherlin	7.14 ppm flammable gas in air
S2	E 1/2	25	24	4	Mobil (1980)	NE of Sutherlin	7.86 ppm flammable gas in air
S3	?	21	26	6	Olmstead (1989)	Melrose seep	Light oil seen rising on gas bubbles in South Umpqua River (Melrose seep)
S4	SW	26	26	7	Olmstead (1989)	John Graves	Water well; strong flow of petroleum gas
S5	SW	35	26	7	Newton (1980)	John Graves	Water well; gas
S6	NW	36	26	7	BLM (11/89)	Ed Bagwell	Dry water well; abundant gas (3 pounds pressure)
S7	SE	36	26	7	A. R. Niem	Kvenvolden analysis	Water well with strong flow of gas (unpublished observation, 1983)
S8	NW	9	27	6	Stewart (1954)	1 mile east of Scott #1	Gas at 75 ft
S9	NE	19	27	6	BLM (1989)	Stockel Creek	Numerous oil seeps reported in headwaters of Stockel Creek; in water wells and on the surface of ponds
S10	?	21	27	7	Olmstead (1989)	Diamond Drill Contract Co.	Coal prospect hole; gas at 605 ft (1109 ft TD) drilled in 1910
S11	NE	32	27	7	Treasher (1942)	Core Hole #1	Strong flow of gas in core hole
not shown	?	36	27	7	Stewart (1954)	T. L. Lee farm	110 ft water well, scum of oil Along trace of Reston Fault
S12	ctr	2	28	6	Mobil (1980)	NE of Winston	Gas sample; active methane generation from host rock
S13		3	28	7	Olmstead (1989)	Wilson Farm	60-ft water well drilled in 1945; small amount of light oil and gas in well water; high gravity (40) similar to Union's Grays Harbor No. 1 well
not shown	SW	21	33	11	Newton (1980)	Pacific Power & Light Co.	Coal core hole, gas reported; approx. coal locality #62

Table 3b. Oil and Gas Shows in Water Wells and Natural Seeps (continued)

Locality No.	Legal Location 1/4	sec.	T.S.	R.W.	Source of Data		Comments
S14	ctr	13	35	12	Mobil (1980)	SW of Agness	Gas sample; 11.79 ppm flammable gas in air

ANALYSES OF NATURAL GAS SAMPLES

S4 (J. Graves) CO_2 = 0.24% N_2 = 65.17% methane = 34.36% ethane = 0.18% (Source = Olmstead, 1989)

S5 (J. Graves) CO_2 = 0.11% N_2 = 54.9% C1 = 44.6% C2 = 0.23% C3 = 0.43% (Source = Newton, 1980)

S7 (Kvenvolden) CO_2 = 0.27% Air = 4.13% CH_4 = 95.6% C_2H_6 (ethane) = trace Del 13 CH_4 = -64.3 o/oo (= biogenic) (Source = Kvenvolden, 1983)

S13 (Wilson Farm) CO_2 = 0.40% N_2 = 24.70% O_2 = 1.20% methane = 73.70%

References:

BLM (1989) = Kalvels, John F., BLM Mining Engineer, Letter of November 15, 1989, to Alan Niem

Kvenvolden, K. A., 1983, Letter of June 3, 1983 to Alan R. Niem

Mobil Oil Corp., 1980, unpublished source rock maps, released by Lee High, Division Geologist and Neal R. Goins, Exploration Team Leader (Bakersfield)

Newton, V. C., Jr., 1980, Prospects for oil and gas in the Coos Basin, western Coos, Douglas, and Lane counties, Oregon: Oregon Dept. of Geology and Mineral Industries Oil and Gas Investigation 6, 74 p.

Olmstead, D. L., 1989, Hydrocarbon exploration and occurrences in Oregon: Oregon Dept. of Geology and Mineral Industries Oil and Gas Investigation 15, 78 p.

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Stewart, R. E., 1954, Oil and gas exploration in Oregon: Oregon Dept. of Geology and Mineral Industries Miscellaneous Paper 6, 53 p.

Treasher, R. C., 1942, Camas Valley and Flournoy Valley (west of Roseburg): unpublished report on file at DOGAMI, Portland, 8 p.

Table 4a. Coal Analyses for Samples from the Eden Ridge Coal Field - ANDERSON COAL

Sample Locality	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Moisture	Proximate analyses Volatile matter	Fixed carbon	Ash	S	Btu
1	Tyee	SE	21	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #20		2.6	---	---	---	---	---
							(n = 8) (moisture free)		---	23.8	16.3	59.9	0.9	4,256
2	Tyee	SW	22	32	11	Duell	Eden Ridge, Anderson coal bed							
						(1957)	Prospect "B"		3.9	---	---	---	---	---
							(n = 4) (moisture free)		---	31.0	28.4	40.6	1.6	7,628
3	Tyee	NE	28	32	11	Duell	Eden Ridge, Anderson coal bed							
						(1957)	No. 4 Prospect		6.6	---	---	---	---	---
							(n = 12) (moisture free)		---	33.0	30.0	37.1	1.4	7,842
4	Tyee	NE	28	32	11	Lesher	Eden Ridge	5´6"	4.2	33.4	26.5	35.9	1.2	7,960
						(1914)	J. H. Flanigan Prospect (moisture free)		---	34.8	27.7	37.5	1.2	8,310
							(moisture & ash free)		---	55.7	44.3	---	2.0	13,280
5	Tyee	NW	28	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #18		2.8	---	---	---	---	---
							(n = 8) (moisture free)		---	32.4	29.6	38.0	2.8	8,203
6	Tyee	SE	28	32	11	Duell	Eden Ridge, Anderson coal bed							
						(1957)	No. 2 Prospect, sample 0+0		9.1	---	---	---	---	---
							(n = 7) (moisture free)		---	32.0	33.2	34.8	0.8	8,264
							No. 2 Prospect, sample 0+20		5.0	---	---	---	---	---
							(n = 6) (moisture free)		---	32.8	38.3	28.9	1.2	9,100
							No. 2 Prospect, sample 0+40		4.1	---	---	---	---	---
							(n = 6) (moisture free)		---	33.9	38.0	28.2	1.3	9,450
							No. 2 Prospect, sample 0+60		4.1	---	---	---	---	---
							(n = 6) (moisture free)		---	34.7	38.9	26.4	1.7	10,142
							No. 2 Prospect, sample 0+80		4.3	---	---	---	---	---
							(n = 6) (moisture free)		---	34.4	37.6	28.0	2.0	9,142
							No. 2 Prospect, sample 0+100		3.8	---	---	---	---	---
							(n = 6) (moisture free)		---	33.3	32.3	34.4	1.9	8,567
7	Tyee	SE	28	32	11	Duell	Eden Ridge, Anderson coal bed							
						(1957)	Open Cut		3.8	---	---	---	---	---
							(n = 6) (moisture free)		---	32.9	32.2	34.9	2.3	9,225
8	Tyee	SE	28	32	11	Lesher	Eden Ridge	5´10"	3.9	34.7	27.1	34.3	2.6	8,460
						(1914)	Gant (moisture free)		---	36.1	28.2	35.7	2.7	8,800
							(moisture & ash free)		---	56.2	43.8	---	4.2	13,690

Table 4a. Coal Analyses for Samples from the Eden Ridge Coal Field - ANDERSON COAL (continued)

Sample Locality	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments		Thickness	Proximate analyses Moisture	Volatile matter	Fixed carbon	Ash	S	Btu
9	Tyee	SE	28	32	11	Lesher	Eden Ridge		5´10"	4.2	35.5	27.6	32.7	1.2	8,610
						(1914)	Gant	(moisture free)		---	37.0	28.9	34.1	1.2	8,990
								(moisture & ash free)		---	56.2	43.8	---	1.9	13,640
10	Tyee	N 1/2	28	32	11	Duell	Eden Ridge								
						(1957)	Drill Hole #26			2.3	---	---	---	---	---
							(n = 12)	(moisture free)		---	29.4	26.2	44.3	2.2	6,817
11	Tyee	NW	29	32	11	Duell	Eden Ridge								
						(1957)	Drill Hole #16			3.1	---	---	---	---	---
							(n = 7)	(moisture free)		---	28.7	24.6	46.7	2.2	6,350
12	Tyee	SW	29	32	11	Duell	Eden Ridge								
						(1957)	Drill Hole #9A			3.1	---	---	---	---	---
							(n = 6)	(moisture free)		---	35.7	32.6	31.7	3.6	9,042
13	Tyee	SE	29	32	11	Duell	Eden Ridge								
						(1957)	Drill Hole #17			3.1	---	---	---	---	---
							(n = 10)	(moisture free)		---	30.2	26.6	43.8	1.9	7,060
14	Tyee	NE	30	32	11	Lesher	Eden Ridge		5´10.5"	4.1	38.9	28.5	28.5	2.7	9,150
						(1914)	Vanderpool	(moisture free)		---	40.6	29.7	29.7	2.8	9,550
								(moisture & ash free)		---	57.7	42.3	---	4.0	13,580
15	Tyee	SE	30	32	11	Duell	Eden Ridge								
						(1957)	Drill Hole #8			3.4	---	---	---	---	---
							(n = 3)	(moisture free)		---	31.0	30.3	38.7	2.6	7,783
16	Tyee	NE	31	32	11	Duell	Eden Ridge								
						(1957)	Drill Hole #7			4.6	---	---	---	---	---
							(n = 8)	(moisture free)		---	32.3	32.9	34.7	3.2	8,725
17	Tyee	NE	31	32	11	Duell	Eden Ridge								
						(1957)	Drill Hole #15			3.7	---	---	---	---	---
							(n = 7)	(moisture free)		---	30.7	26.2	43.1	2.7	7,371
18	Tyee	SE	31	32	11	Duell	Eden Ridge								
						(1957)	Drill Hole #14			3.7	---	---	---	---	---
							(n = 17)	(moisture free)		---	35.9	34.6	29.5	1.8	9,344
19	Tyee	N 1/2	31	32	11	Duell	Eden Ridge, Anderson coal bed								
						(1957)	NW Outcrop No. 1			1.4	---	---	---	---	---
							(n = 4)	(moisture free)		---	33.5	38.4	28.2	1.6	8,938
20	Tyee	N 1/2	31	32	11	Duell	Eden Ridge, Anderson coal bed								
						(1957)	NW Outcrop No. 2			3.4	---	---	---	---	---
							(n = 5)	(moisture free)		---	34.1	38.7	27.2	1.2	9,150

Table 4a. Coal Analyses for Samples from the Eden Ridge Coal Field - ANDERSON COAL (continued)

Sample Locality	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Proximate analyses Moisture	Volatile matter	Fixed carbon	Ash	S	Btu
21	Tyee	NE	32	32	11	Wayland	Eden Ridge, Anderson coal	6´3"	7.6	36.0	25.8	30.6	1.24	8,460
						(1964)	Prospect 18 (moisture & ash free)		-	58.2	41.8	-	2.00	13,690
								6´10"	10.0	38.5	36.3	15.2	0.63	10,530
							(moisture & ash free)		-	51.4	48.6	-	0.84	14,070
								6´6"	6.9	35.0	35.7	22.4	1.5	9,790
22	Tyee	NE	32	32	11	Duell	Eden Ridge, Anderson coal bed							
						(1957)	No. 1 Adit, sample 0+0		6.6	---	---	---	---	---
							(n = 7) (moisture free)		---	33.4	32.5	34.2	1.1	8,500
							No. 1 Adit, sample 0+20		5.0	---	---	---	---	---
							(n = 6) (moisture free)		---	36.0	35.3	28.7	2.6	9,500
							No. 1 Adit, sample 0+40		5.1	---	---	---	---	---
							(n = 6) (moisture free)		---	36.3	37.6	26.1	1.9	9,950
							No. 1 Adit, sample 0+60		4.2	---	---	---	---	---
							(n = 7) (moisture free)		---	34.5	32.7	32.8	1.7	9,057
							No. 1 Adit, sample 0+75		3.7	---	---	---	---	---
							(n = 6) (moisture free)		---	35.1	36.2	28.7	1.5	9,600
							No. 1 Adit, samples 0+85 to 0+135		3.1	---	---	---	---	---
							(n = 6) (moisture free)		---	37.6	28.5	33.9	2.2	8,850
23	Tyee	NE	32	32	11	Lesher	Eden Ridge	6´3"	4.0	37.3	26.8	31.9	1.29	8,780
						(1914)	O.L. Hillis (moisture free)		---	38.9	27.9	33.2	1.34	9,150
							(moisture & ash free)		---	58.2	41.8	---	2.00	13,690
24	Tyee	NE	32	32	11	Lesher	Eden Ridge	6´10"	3.5	41.2	39.0	16.3	0.68	11,280
						(1914)	O.L. Hillis (moisture free)		---	42.7	40.4	16.9	0.70	11,690
							(moisture & ash free)		---	51.4	48.6	---	0.84	14,070
25	Tyee	NE	32	32	11	Lesher	Eden Ridge	6´10"	3.5	36.7	28.4	31.4	2.3	8,840
						(1914)	O.L. Hillis (moisture free)		---	38.1	29.4	32.5	2.4	9,170
							(moisture & ash free)		---	56.4	43.6	---	3.5	13,590
26	Tyee	SW	32	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #5		3.6	---	---	---	---	---
							(n = 10) (moisture free)		---	33.1	31.9	35.0	1.9	8,650
27	Tyee	SW	32	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #6		4.9	---	---	---	---	---
							(n = 3) (moisture free)		---	29.6	34.3	36.1	0.9	8,450

Table 4a. Coal Analyses for Samples from the Eden Ridge Coal Field - ANDERSON COAL (continued)

Sample Locality	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Moisture	Proximate analyses Volatile matter	Fixed carbon	Ash	S	Btu
28	Tyee	SW	32	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #27		1.5	---	---	---	---	---
							(n = 2) (moisture free)		---	36.6	35.8	27.7	1.8	9,721
29	Tyee	SE	32	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #40		1.9	---	---	---	---	---
							(n = 7) (moisture free)		---	32.8	28.8	22.4	3.4	8,193
30	Tyee	SE	32	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #41		2.8	---	---	---	---	---
							(n = 10) (moisture free)		---	33.9	30.6	35.5	2.9	8,745
31	Tyee	NW	33	32	11	Duell	Eden Ridge, Anderson coal bed							
						(1957)	Prospect "A"		5.0	---	---	---	---	---
							(n = 6) (moisture free)		---	33.9	33.5	32.7	1.9	8,617
32	Tyee	NW	33	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #28		1.5	---	---	---	---	---
							(n = 6) (moisture free)		---	26.8	23.1	50.1	0.6	6,042
33	Tyee	W 1/2	33	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #22		3.0	---	---	---	---	---
							(n = 10) (moisture free)		---	32.7	31.1	36.2	2.2	8,405
34	Tyee	SW	8	33	11	Duell	Eden Ridge							
						(1957)	Drill Hole #11		3.1	---	---	---	---	---
							(n = 2) (moisture free)		---	35.3	45.5	19.3	2.8	10,325
35	Tyee	SE	8	33	11	Duell	Eden Ridge							
						(1957)	Drill Hole #13		4.0	---	---	---	---	---
							(n = 19) (moisture free)		---	33.9	36.8	29.3	3.0	9,742
36	Tyee	NW	9	33	11	Duell	Eden Ridge							
						(1957)	Drill Hole #3		2.4	---	---	---	---	---
							(n = 11) (moisture free)		---	35.9	37.2	26.8	1.4	9,841
37	Tyee	NE	9	33	11	Duell	Eden Ridge							
						(1957)	Drill Hole #23		2.5	---	---	---	---	---
							(n = 10) (moisture free)		---	31.2	28.8	40.0	1.7	7,810
38	Tyee	NE	9	33	11	Duell	Eden Ridge							
						(1957)	Drill Hole #24A		2.9	---	---	---	---	---
							(n = 6) (moisture free)		---	23.2	15.1	61.8	0.4	3,883
39	Tyee	NE	9	33	11	Duell	Eden Ridge							
						(1957)	Drill Hole #21		4.2	---	---	---	---	---
							(n = 8) (moisture free)		---	29.7	31.0	39.3	0.7	7,791

Table 4a. Coal Analyses for Samples from the Eden Ridge Coal Field - ANDERSON COAL (continued)

Sample Locality	Geologic Formation	1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Moisture	Volatile matter	Fixed carbon	Ash	S	Btu
									Proximate analyses					
40	Tyee	NW	9	33	11	Duell	Eden Ridge							
						(1957)	Damsite #1		3.3	---	---	---	---	---
							(n = 17) (moisture free)		---	34.0	33.5	32.5	1.9	8,759
41	Tyee	SW	9	33	11	Duell	Eden Ridge							
						(1957)	Drill Hole #25		3.0	---	---	---	---	---
							(n = 4) (moisture free)		---	37.2	36.2	26.6	2.5	10,075
42	Tyee	?	?	32 or 33	11	Williams	Eden Ridge	---	4.6	37.0	36.8	21.6	---	9,600
						(1914)	(moisture free)		---	38.8	38.5	22.7	---	10,070
							(moisture & ash free)		---	50.2	49.8	---	---	13,020
43	Tyee	?	?	32 or 33	11	Williams	Eden Ridge	---	5.4	34.0	35.1	25.5	---	8,800
						(1914)	(moisture free)		---	35.9	37.1	22.7	---	9,300
							(moisture & ash free)		---	49.2	50.8	---	---	12,730
								average	3.7	32.9	31.8	35.0	1.9	8,443
									(n = 332)				(n=330)	(n = 332)

Estimated Reserves:

Proven Reserves: 23,568,500 tons (Duell, 1957)
Indicated Reserves: 11,134,700 tons (Duell, 1957)
Total Reserves: 34,703,200 tons (Duell, 1957)

Coal Reserve Base: 43,276,800 tons (USBLM, 1983)
Mineable Reserve Base: 37,470,000 tons (USBLM, 1983)
Recoverable Reserves Base: 22,482,000 tons (USBLM, 1983)

Coal Reserve Base = "In-place tonnage of subbituminous coal 28 inches thick to a depth of 500 feet and subbituminous coal 48 inches thick to depths of 500-3,000 ft" (USBLM, 1983)

Mineable Reserve Base = "In-place coal which is commercially minable with no deductions for coal to be left in pillars, fenders, property barriers and other lands where mining is not permissible" (USBLM, 1983)

Recoverable Reserve = "Commercially minable coal after deductions for pillars, fenders, property barriers and other land wher mining is not permissible" (USBLM, 1983)

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Table 4b. Coal Analyses for Samples from the Eden Ridge Coal Field - CARTER COAL

Sample Locality	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Moisture	Proximate analyses Volatile matter	Fixed carbon	Ash	S	Btu
1	Tyee	NW	28	32	11	Lesher (1914)	Eden Ridge	8´1"	5.6	27.5	28.5	38.4	0.59	7,230
							Reeves (moisture free)		---	29.2	30.1	40.7	0.62	7,660
							(moisture & ash free)		---	49.2	50.8	---	1.05	12,910
5	Tyee	NW	28	32	11	Duell (1957)	Eden Ridge							
							Drill Hole #18		3.5	---	---	---	---	---
							(n = 4) (moisture free)		---	25.5	31.1	48.4	0.7	6,144
10	Tyee	N 1/2	28	32	11	Duell (1957)	Eden Ridge							
							Drill Hole #26		3.1	---	---	---	---	---
							(n = 10) (moisture free)		---	25.2	25.6	49.2	1.1	6,000
45	Tyee	ctr	29	32	11	Duell (1957)	Eden Ridge							
							Drill Hole #2		3.6	---	---	---	---	---
							(n = 14) (moisture free)		---	25.7	26.1	48.2	0.6	6,071
46	Tyee	NE	29	32	11	Duell (1957)	Eden Ridge, Carter coal bed							
							Delta Creek Prospect, sample 0+20		5.7	---	---	---	---	---
							(n = 7) (moisture free)		---	33.9	39.1	27.1	0.7	9,293
							Delta Creek Prospect, sample 0+40		4.0	---	---	---	---	---
							(n = 6) (moisture free)		---	37.8	41.2	21.0	0.8	9,492
							Delta Creek Prospect, sample 0+60		3.4	---	---	---	---	---
							(n = 6) (moisture free)		---	35.8	42.1	22.1	0.8	9,592
							Delta Creek Prospect, sample 0+80		5.3	---	---	---	---	---
							(n = 7) (moisture free)		---	33.0	42.9	24.1	0.8	9,586
							Delta Creek Prospect, sample 0+100		5.8	---	---	---	---	---
							(n = 7) (moisture free)		---	31.5	42.2	26.3	0.8	9,107
47	Tyee	NE	29	32	11	Lesher (1914)	Eden Ridge	7´6"	5.0	33.6	30.2	31.2	0.36	8,580
							Hammond (moisture free)		---	35.4	31.8	32.8	0.38	9,030
							(moisture & ash free)		---	52.7	47.3	---	0.57	13,440
48	Tyee	NE	29	32	11	Lesher (1914)	Eden Ridge	6´	4.5	36.3	38.6	20.6	0.60	10,210
							Hammond (moisture free)		---	38.0	40.4	21.6	0.63	10,690
							(moisture & ash free)		---	48.5	51.5	---	0.80	13,630
49	Tyee	NE	29	32	11	Duell (1957)	Eden Ridge							
							Carter No. 2 Prospect		0.3	---	---	---	---	---
							(n = 6) (moisture free)		---	25.9	28.6	45.6	0.8	6,358
50	Tyee	NW	29	32	11	Duell (1957)	Eden Ridge							
							Carter No. 3 Prospect, sample 0+0		1.7	---	---	---	---	---
							(n = 6) (moisture free)		---	29.4	31.8	38.9	1.3	7,208

Table 4b. Coal Analyses for Samples from the Eden Ridge Coal Field - CARTER COAL (continued)

Sample Locality	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Moisture	Proximate analyses Volatile matter	Fixed carbon	Ash	S	Btu
							Carter No. 3 Prospect, sample 0+10		2.2	---	---	---	---	---
							(n = 6) (moisture free)		---	28.4	27.8	43.8	1.0	6,617
							Carter No. 3 Prospect, sample 0+20		3.6	---	---	---	---	---
							(n = 6) (moisture free)		---	28.8	33.4	37.9	1.3	7,392
							Carter No. 3 Prospect, sample 0+30		3.0	---	---	---	---	---
							(n = 6) (moisture free)		---	26.6	25.1	48.3	0.8	5,650
11	Tyee	NW	29	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #16		4.3	---	---	---	---	---
							(n = 2) (moisture free)		---	34.4	33.5	32.2	1.5	8,675
51	Tyee	SW	29	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #6		3.6	---	---	---	---	---
							(n = 5) (moisture free)		---	26.1	27.7	46.2	0.5	6,690
12	Tyee	SW	29	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #9A		3.9	---	---	---	---	---
							(n = 15) (moisture free)		---	28.1	30.8	41.1	0.7	7,237
52	Tyee	SE	29	32	11	Duell	Eden Ridge							
						(1957)	Carter No. 1 Prospect, sample 0+0		10.4	---	---	---	---	---
							(n = 7) (moisture free)		---	30.4	25.1	44.5	0.3	5,871
							Carter No. 1 Prospect, sample 0+20		6.2	---	---	---	---	---
							(n = 6) (moisture free)		---	30.7	29.5	39.8	1.0	7,433
							Carter No. 1 Prospect, sample 0+40		6.3	---	---	---	---	---
							(n = 6) (moisture free)		---	29.4	25.2	45.4	0.6	6,575
							Carter No. 1 Prospect, sample 0+60		5.7	---	---	---	---	---
							(n = 5) (moisture free)		---	31.8	27.8	40.4	0.7	7,320
							Carter No. 1 Prospect, sample 0+80		5.6	---	---	---	---	---
							(n = 6) (moisture free)		---	31.8	29.6	38.7	0.8	7,700
							Carter No. 1 Prospect, sample 0+90		4.5	---	---	---	---	---
							(n = 5) (moisture free)		---	30.6	28.7	40.7	0.9	7,560
13	Tyee	SE	29	32	11	Duell	Eden Ridge							
						(1957)	Drill Hole #17		3.6	---	---	---	---	---
							(n = 9) (moisture free)		---	22.9	18.7	58.4	0.8	4,522
53	Tyee	SE	29	32	11	Lesher	Eden Ridge	6'1.5"	4.8	34.9	29.7	30.6	0.83	8,720
						(1914)	Johnson (moisture free)		---	36.7	31.2	32.1	0.87	9,160
							(moisture & ash free)		---	54.1	45.9	---	1.28	13,500

Table 4b. Coal Analyses for Samples from the Eden Ridge Coal Field - CARTER COAL (continued)

Sample Locality	Geologic Formation	1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Moisture	Proximate analyses Volatile matter	Fixed carbon	Ash	S	Btu
18	Tyee	SE	31	32	11	Duell (1957)	Eden Ridge Drill Hole #14		4.4	---	---	---	---	---
							(n = 33) (moisture free)		---	25.0	24.5	50.5	0.8	5,715
28	Tyee	SW	32	32	11	Duell (1957)	Eden Ridge Drill Hole #27		3.6	---	---	---	---	---
							(n = 47) (moisture free)		---	25.7	25.9	48.5	0.9	6,002
29	Tyee	SE	32	32	11	Duell (1957)	Eden Ridge Drill Hole #40		3.6	---	---	---	---	---
							(n = 4) (moisture free)		---	22.5	16.6	60.9	1.0	4,100
30	Tyee	SE	32	32	11	Duell (1957)	Eden Ridge Drill Hole #41		2.7	---	---	---	---	---
							(n = 15) (moisture free)		---	30.1	28.2	41.7	1.4	7,270
54	Tyee	ctr	8	33	11	Duell (1957)	Eden Ridge Drill Hole #12		3.6	---	---	---	---	---
							(n = 2) (moisture free)		---	31.2	31.2	37.7	1.5	7,950
55	Tyee	SW	8	33	11	Duell (1957)	Eden Ridge, Carter coal bed PP&L Prospect "C", sample 0+0		9.1	---	---	---	---	---
							(n = 6) (moisture free)		---	28.2	28.0	43.8	0.5	6,590
							PP&L Prospect "C", sample 0+5		7.6	---	---	---	---	---
							(n = 5) (moisture free)		---	28.4	29.4	42.4	0.5	6,470
							PP&L Prospect "C", sample 0+10		4.1	---	---	---	---	---
							(n = 5) (moisture free)		---	27.3	30.1	42.6	0.6	6,950
							PP&L Prospect "C", sample 0+15		3.3	---	---	---	---	---
							(n = 3) (moisture free)		---	26.9	27.8	45.3	0.4	6,717
							PP&L Prospect "C", sample 0+20		3.8	---	---	---	---	---
							(n = 2) (moisture free)		---	27.9	28.3	43.8	0.5	6,850
							PP&L Prospect "C", sample 0+25		4.5	---	---	---	---	---
							(n = 2) (moisture free)		---	30.3	32.6	37.2	0.6	7,800
							PP&L Prospect "C", sample 0+30		5.0	---	---	---	---	---
							(n = 2) (moisture free)		---	27.8	32.5	39.7	0.5	7,550
							PP&L Prospect "C", sample 0+35		3.5	---	---	---	---	---
							(n = 7) (moisture free)		---	24.5	24.8	50.7	0.9	5,671
							PP&L Prospect "C", sample 0+40		5.3	---	---	---	---	---
							(n = 2) (moisture free)		---	25.6	29.3	45.2	0.6	6,825

Table 4b. Coal Analyses for Samples from the Eden Ridge Coal Field - CARTER COAL (continued)

Sample Locality	Geologic Formation	1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Moisture	Proximate analyses: Volatile matter	Fixed carbon	Ash	S	Btu
Sample Locality 55 continued							PP&L Prospect "C", sample 0+45		3.4	---	---	---	---	---
							(n = 6) (moisture free)		---	21.1	17.4	61.5	0.5	3,742
							PP&L Prospect "C", sample 0+50		3.4	---	---	---	---	---
							(n = 4) (moisture free)		---	20.3	16.7	63.0	1.1	3,225
							PP&L Prospect "C", sample 0+52		3.8	---	---	---	---	---
							(n = 4) (moisture free)		---	22.3	19.8	57.9	0.6	4,488
34	Tyee	SW	8	33	11	Duell (1957)	Eden Ridge Drill Hole #11		5.2	---	---	---	---	---
							(moisture free)		---	23.0	29.3	47.7	0.8	6,950
56	Tyee	SE	8	33	11	Duell (1957)	Eden Ridge Drill Hole #10		3.4	---	---	---	---	---
							(n = 9) (moisture free)		---	27.5	26.4	46.1	0.6	6,261
35	Tyee	SE	8	33	11	Duell (1957)	Eden Ridge Drill Hole #13		2.8	---	---	---	---	---
							(n = 10) (moisture free)		---	21.3	19.5	59.2	1.1	4,440
36	Tyee	NW	9	33	11	Duell (1957)	Eden Ridge Drill Hole #3		3.7	---	---	---	---	---
							(n = 7) (moisture free)		---	22.2	20.7	64.3	0.4	3,190
								average	4.1	27.4	27.7 (n = 337)	45.2	0.8	6,473

Estimated Reserves:

Indicated Reserves: 5,892,000 tons (Duell, 1957)
Inferred Reserves: 9,824,500 tons (Duell, 1957)
Total: 15,716,500 tons (Duell, 1957)

Coal Reserve Base*: 26,378,000 tons (USBLM, 1983)
Mineable Reserve Base*: 23,900,000 tons (USBLM, 1983)
Recoverable Reserves Base*: 14,340,000 tons (USBLM, 1983)

*Defined at foot of Table 4a.

References:

Duell, G. A., 1957, The Eden Ridge coal field, Coos County, Oregon-A preliminary study: consulting report prepared for Pacific Power and Light Company, 24 p. + tables and lithology logs; courtesy of U.S. Bureau of Land Management, Portland.

Lesher, C. E., 1914, The Eden Ridge coal field, Coos County, Oregon: U.S. Geological Survey Bulletin 541, p. 399-418.

Table 4c. Coal Analyses for Samples from the Eden Ridge Coal Field - MEYER COAL

Sample Locality	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Moisture	Proximate analyses Volatile matter	Fixed carbon	Ash	S	Btu
57	Tyee	?	?	33	11	Lesher	Eden Ridge	5´11"	3.5	37.8	35.6	23.1	1.47	10,270
						(1914)	Everett Assn (moisture free)		---	39.2	36.9	23.9	1.52	10,640
							(moisture & ash free)		---	51.4	48.6	---	2.00	13,990
58	Tyee	?	?	33	11	Lesher	Eden Ridge	8´9"	4.0	36.2	34.2	25.6	1.78	9,720
						(1914)	W.B. Meyers (moisture free)		---	37.7	35.6	26.7	1.85	10,130
							(moisture & ash free)		---	51.5	48.5	---	2.52	13,810
								average	3.7	38.5	36.3	25.3	1.68	10,385
											(n = 2)			

Estimated Reserves:

Coal Reserve Base*: 56,030,000 tons (USBLM, 1983)
Mineable Reserve Base*: ---
Recoverable Reserves Base*: ---

*Definitions are at foot of Table 4a.

Eden Ridge Coal Field - LOCKHART COAL

No Published Analyses Available

Estimated Reserves:

Coal Reserve Base*: 16,000,000 tons (USBLM, 1983)
Mineable Reserve Base*: ---
Recoverable Reserves Base*: ---

*Definitions are at foot of Table 4a.

References:

Lesher, C. E., 1914, The Eden Ridge coal field, Coos County, Oregon: U.S. Geological Survey Bulletin 541, p. 399-418.

Table 4d. Summary of Reserves and Quality of Two Principal Coal Seams in the Eden Ridge Coal Field.

Coal Bed	Carter*	Anderson*	Combined
Thickness (ft)	6.9	6.2	N/A
Btu/lb (moisture free)	6,473	8,443	7,458
Volatiles (%)	27.4	32.9	30.2
Fixed Carbon (%)	27.7	31.8	29.7
Ash (%)	45.2	35.0	40.1
Sulfur (%)	0.8	1.9	1.4
Moisture (%)	4.1	3.7	3.9
Reserves (tons in place) (Duell, 1957)	15,716,500	34,703,200	50,419,700

* weighted averages: Carter coal = 337 samples (Table 4b)
Anderson coal = 332 samples (Table 4a)

Table 4e. Other Coal Occurrences in Southern Tyee Basin

Plate 2 Loca-tion No.	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Proximate analyses Moisture	Volatile matter	Fixed carbon	Ash	S	Btu
59	Tyee	NW	22	33	11	Williams	Squaw Basin	10′	11.0	29.5	28.6	30.9	0.98	7,670
						(1914)	Donnell claim (moisture free)		---	33.2	32.2	34.6	1.10	8,620
							(moisture & ash free)		---	50.8	49.2	---	1.68	13,200
60	Tyee	NW	28	33	11	Lesher	Squaw Basin	6′	3.6	38.7	41.5	16.2	1.4	11,410
						(1914)	Squaw Creek (moisture free)		---	40.0	43.1	16.9	1.5	11,830
							(moisture & ash free)		---	48.2	51.8	---	1.8	14,230
							Wayland (1964) says this sample from same bed and locality as Williams (1914) Seven-Foot Vein							
60	Tyee	NW	28	33	11	Williams	Squaw Basin	7′	10.8	35.5	35.7	18.0	1.53	9,550
						(1914)	Seven-Foot Vein (moisture free)		---	39.7	40.1	20.2	1.72	10,700
							(moisture & ash free)		---	49.7	50.3	---	2.15	13,400
							Wayland (1964) says this sample from same bed and locality as Lesher (1914) Squaw Creek sample							
61	Tyee	NE	32	33	11	Williams	Squaw Basin	8′						
						(1914)	Outcrop - S. side Coal Butte		12.8	42.8	37.2	7.2	---	---
							(moisture free)		---	49.1	42.6	8.3	---	---
							(moisture & ash free)		---	53.6	46.4	---	---	---
							Analyses may reflect "high-grading" sampling (Wayland, 1964)							
62	Tyee	NE	29	33	11	Williams	Squaw Basin							
	or	SE	20	33	11	(1914)	M.J. Anderson claim		2.53	45.08	41.96	10.44	---	---
								average	8.15	38.3	28.70	16.55	1.30	9,543
								number of samples "n"	(n = 5)	(n = 5)	(n = 5)		(n = 3)	(n = 3)

REPORTED COALS (No Analyses)

Plate 2 Location No.	Geologic Formation	1/4	sec.	T.S.	R.W.	Source of Data	Comments	
C-2	Bateman	NW	28	23	8	DOGAMI report 6/13/41 R.C. Treasher & Weatherby (1989, writ. commun.)	Umpqua Coal Co. head of Mehl Creek 7 mi SW of Elkton 60-ft adit	4 subbituminous seams: youngest = 14′ (includes carbonaceous mudstone) 24" 30" oldest = 48"
		all	16	23	8			
C-8	Tyee-Elkton	SE	1	25	8	BLM (1989)	thin coal seams, possibly just carbonized limbs	

Table 4e. Other Coal Occurrences in Southern Tyee Basin (Continued)

Plate 2 Location No.	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Proximate analyses Moisture	Volatile matter	Fixed carbon	Ash	S	Btu
C-11	Tyee	SW	9	28	9	Baldwin field trips 1988 & 1989	4 miles east of Sitkum	2´ - 3´						
	Tyee	NW	21	33	11	Wayland (1964)	thin coal seam in road cut Squaw Basin	1´						
	Tyee	NW	22	33	11	Wayland (1964)	Squaw Basin							
	Tyee	NW	28	33	11	Wayland (1964)	Squaw Basin							
	Tyee	NE	32	33	11	Wayland (1964)	Coal Butte, Squaw Basin							
C-14	Flournoy	E1/2	3	27	7	Black (DOGAMI) (1989, verbal commun.)	coal bed in outcrop							
Well No. 11	Flournoy	S1/2	3	27	7	DOGAMI report 11/17/42 R.C. Treasher	Flournoy Valley coal core hole #3, drilled on order of J.W. Perkins (1910)							
C-3	Flournoy	S1/2	14	27	7	DOGAMI report 11/18/42 R.C. Treasher Ramp (1972)	Callahan Mine (coal) 400 tons mined in early 1900´s	20" - 48" bituminous						
Well No. 13	Flournoy	ctr	15	27	7	DOGAMI report 11/17/42 R.C. Treasher	Flournoy Valley coal core hole #2, drilled in 1910; produced a flowing artesian sulfur spring	4 seams, 6" 2´, 4´, 2´						
Well No. 12	Flournoy	NE	32	27	7	DOGAMI report 11/17/42 R.C. Treasher	Flournoy Valley coal core hole #1, drilled in 1910; strong flow of gas at 615 ft	6" - 4´ all 3 holes hit coal at 350 ft below the surface						>13,000
C-7	Flournoy	SE	26?	29	9	DOGAMI report 11/17/42 R.C. Treasher	Camas Valley coal on Holmes Creek	6"						

Table 4e. Other Coal Occurrences in Southern Tyee Basin (Continued)

Plate 2 Location No.	Geologic Formation	Sample Location 1/4	sec.	T.S.	R.W.	Source of Data	Comments	Thickness	Proximate analyses Moisture	Volatile matter	Fixed carbon	Ash	S	Btu
C-15	Flournoy		9	26	3	Ramp (1972)	Thin coals reported by Diller (1898); also in Flournoy near confluence of Little River and Cavitt Creek (off map)							
C-16	Lookingglass	ctr	17	27	6	BLM (1989)	coal was mined along Stockel Creek at one time							
C-17	Lookingglass	SW & NE	32	28	10	Trigger (1966)	6 miles north of Remote	6′ - 12′						
C-4	Lookingglass	SE	22	29	8	DOGAMI report 11/17/42 R.C. Treasher Ramp (1972)	Camas Valley coal (Albert H. Krogel)	3′						
C-9	Lookingglass	S1/2	29	29	10	Trigger (1966)	Coal near Remote, OR	4′ - 5′						
C-9	Lookingglass	NE	30	29	10	Trigger (1966)	Coal northwest of Remote	6′(?)						
C-18	Lookingglass	NE	11	31	8	Perttu (1976)	Minor coal lens in Bushnell Rock Member							
C-10	Lookingglass (Olalla Ck. Mbr) & Flournoy (White Tail Ridge Member)		2	30	9	Niem (1989, field work)	Subbituminous coals and carbonaceous shales in recent roadcut along Oregon Highway 42	1′ - 3′						

Estimated Reserves:

Squaw Basin:
Seven-Foot Vein = 8 million tons (4.8 million tons recoverable) (Williams, 1914)

References:

Duell, G. A., 1957, The Eden Ridge coal field, Coos County, Oregon-A preliminary study: consulting report prepared for Pacific Power and Light Company, 24 p. + tables and lithology logs; courtesy of U.S. Bureau of Land Management, Portland.

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Williams, I. A., 1914, The occurrence of coal in Squaw Creek Basin, Coos County, Oregon: Oregon Bureau of Mines and Geology, The Mineral Resources of Oregon, v. 1, no. 1, p. 28-48.