COAST RANGE

2. Saddle Mtn (3300 ft), Trask Mt (3400), and Sugarloaf Mtn 3400 ft are among highest peaks
3. western slope erosion dominant
    a. summits of passes east of axis of range
4. 100 in rain to 30 in on east
5. Coast
    a. pocket beaches
    b. headlands
    c. terraces
6. west and east flowing rivers

B. Geologic Overview
1. Paleocene-Eocene (66 my)
    a. volcanic seamounts / submarine rift volcanism
        (1) pillow basalts, sed. interbeds
    b. Eocene accretion of oceanic basalts
2. Eocene forearc sedimentation
    a. Klamath-Idaho Bath source terranes
    b. Cascade arc develops in late Eocene, supplies sediments
3. Oligocene intrusives
    a. resistant / support crests of Coast Range
4. Miocene
    a. Uplift of Coast Range block in Miocene, shift of sea westward
    b. CRB's make it to northern coast, via Columbia River drainage
5. Pleistocene
    a. coastal uplift and terrace development
    b. landslide lakes
    c. coastal dune complexes
6. Holocene
    a. earthquake / tsunami cycles

C. Bedrock Geology
1. early Eocene (60-65 m.y.) (siletzia volcanics form core of coast range)
    a. rifting / spreading center volcanism results in seafloor volcanics / basalts
        (1) pillow lavas and sed. interbeds (breccias, silstones)
    b. Seafloor volcanics: varying names and terminology of WA / OR coast geology, form north to south
        (1) Metchosin, Crescent, Grays Harbor, Tillamook, Siletz River, Roseburg
            (a) pillow basalts
    c. marine volcanics up to 10,000 ft(?) thick
    d. accreted onto western convergent zone in late Eocene
        (1) clockwise rotation and docking onto western NAM (51 deg. rotation since eocene)
        (2) Miocene-Pliocene basin and range extension rotated / pushed Coast Range rocks out to their present position in OR
2. middle to late Eocene (Tyee Time)
    a. siletzia accreted, forms forearc basin (in ascending order)
        (1) Roseburg, Lookinglass, Fluornoy, Tyee, fm deposition
        (2) marine, turbidite / submarine fan facies

(a) sed. source: Klamaths for Roseburg / Lookinglass, prior to good establishment of western Cascades in Oligocene

(b) Orr suggests

i) Tyee source from Idaho batholith (arkosic sands)

3. Late Eocene - Oligocene - western Cascades were developed
   a. forearc received seds. from western Cascades
   b. Klamath terranes eroded to low-relief surface
   c. to north - deeper water and/or shelf sediments of Yamhill, spencer
   d. by 38 my, intrusion of dikes and sills, gabbroic

4. Miocene - uplift of Coast Range proper
   a. deposition / sea shifted to west
   b. local miocene CRB lava flows made it to coast
      (1) invasive / sinking into coastal sediments, down to Yaquina head, and as far south as Seal Rock

5. Pliocene
   a. localized Troutdale gravels, ancestral columbia river gravels

6. Pleistocene / neotectonics
   a. north coast range and south coast range = uplift, tilting eastward
   b. terraces in souther Oregon
      (1) 80 - 200 ka terraces
7. Dunes / coastal lakes
8. local landslide dam lakes in "Tyee country"

D. structure
   1. northern coast range = anticlinorium (WA to central coast) (Nehalem arch)
   2. southern coast range = synclinorium to Klamath area (Elkton syncline)

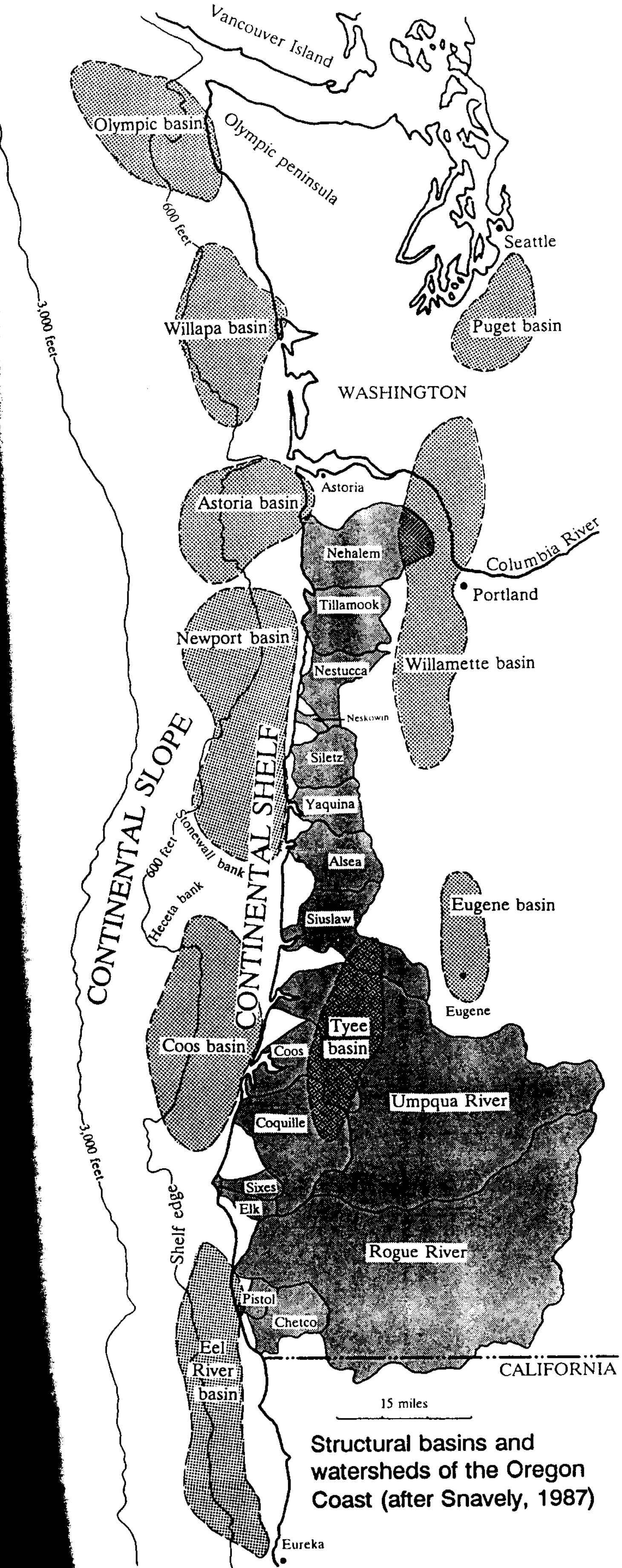
E. Holocene Earthquake - Tsunami cycles

F. Mining
   1. black sands / heavy minerals
   2. Coos Bay Eocene coal beds in Coaledo fm

G. Oil and Gas
   1. limited exploration in Oregon
   2. limited shows of oil and gas in Coos Bay, Willamette Valley near Lebanon, tyee
   3. Mist Region of Columbia County
      a. Cowlitz fm, fault traps, gas production

4. Petroleum potential
    a. low in Oregon due to high volume of volcanics
    b. potential reservoir rocks in coastal region
        (1) requirement
            (a) sand-dominated
            (b) low volcanic content (volcanics alter to clay - plug porosity)
        (2) Cowlitz, Coaledo, Spencer, Eugene, Yaquina, Astoria Fm

H. Offshore Geology
1. Coast Range stratigraphy extends offshore (structure, rocks, etc.)
2. Shelf-Slope system extends offshore 40-70 miles
    a. punctuated by Juan de Fuca trench, rises, fracture system, ridge system
    b. Cont. slope represents underthrusting at convergent boundary
        (1) landward-dipping thrusts
        (2) accretionary wedge / melange
        (3) high rates of slope sedimentation obscure / subdue topography on Juan de Fuca trench
    c. submarine canyon
        (1) Astoria Canyon - Columbia river
            (a) Astoria fan
        (2) Rogue Canyon - Rogue river



Structural basins and watersheds of the Oregon Coast (after Snavely, 1987)

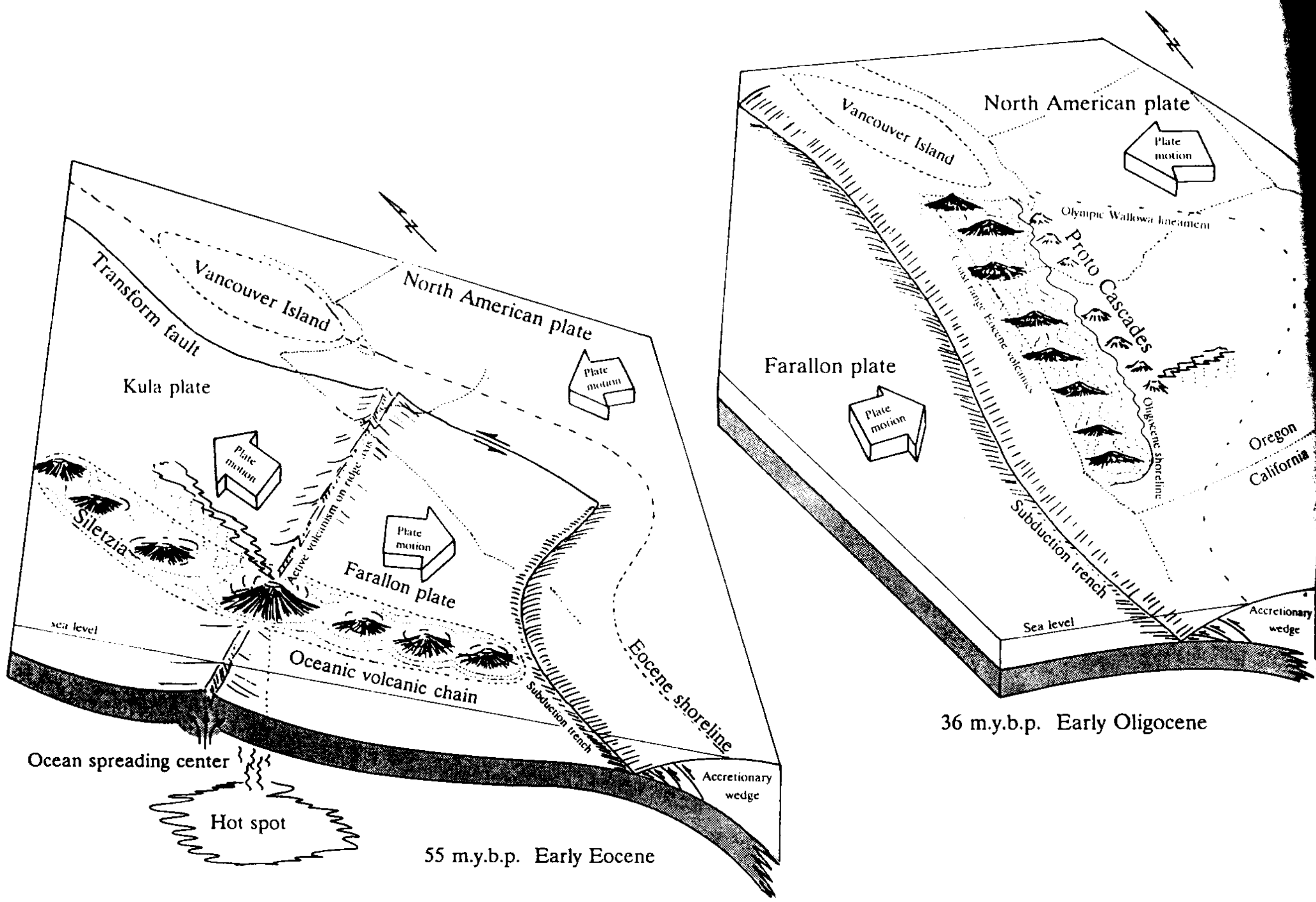
between two moving plates. Around each volcanic center pillow lavas and breccias built low islands where the vents continued to eject lava and ash. Riding atop the moving Kula and Juan de Fuca plates, the island volcanic chain collided with and was swept up by the oncoming westbound North American plate.

As the island chain began to subside and a proto-Cascade volcanic arc was established east of the block, sediments poured into the newly created forearc basin. A thick sequence of Eocene through Miocene marine clastics accumulated in the subsiding basin atop the platform of older basalts. Eocene sediments in the basin are derived from several sources. Initially the Klamath Mountains contributed detritus to the newly formed basin, but as watersheds extended further east the primary source of sediments was the Idaho batholith. Finally, volumes of pyroclastics and ash from the newly formed ancestral Cascade volcanoes covered earlier sands, silts, and muds in the adjoining basin.

Oligocene seas extended over the northern Coast Range block, but with uplift of the range during the Miocene the ocean retreated to the west. As the western edge of the North American plate was wrinkled by pressure from the subducting Juan de Fuca slab, lava flows from fissures in eastern Oregon reached the coast where they invaded layers of the softer sediments. Once the shoreline had withdrawn to the western edge of the coastal block, the older Cenozoic formations were shaped by erosion, and river valleys assumed their present positions. The rivers cut through many of the later formations laying bare the resistant Oligocene sills and dikes making up nearly all the prominent peaks of the central range.

Continued uplift and tilting of the coastal mountains combined with Pleistocene sea level changes created raised terraces in the vicinity of Cape Blanco and Cape Arago. Because rates of uplift vary along the coast, different sections of a terrace may have elevations that vary by hundreds of feet. Deeply eroded, one million year old terraces are inland at the highest levels, while the younger surfaces are near the coast at lower elevations.

Pleistocene landslide lakes of the inland mountains and freshwater dunal lakes along the coast are among the more ephemeral features of the region. Abundant sand along the shore dams streams creating lakes of varying sizes and depths. A fragile boundary between fresh and saltwater within the poorly consolidated dunal sands exists beneath the coastal lakes. Inland from the coast, massive water-saturated sandstones that are susceptible to landsliding move as blocks to dam stream valleys and back up waters into lakes.



Accretionary island arc model for formation of the Oregon-Washington coast block (after Duncan, 1982)

More than half of the Oregon Coast is bordered by sands resulting from the erosion of sea cliffs or transported and deposited by rivers. While winter beaches are stripped of sand by stormy conditions, the summer months are the period when sands are redeposited. Sand builds up as dunes or spits when it is trapped behind prominent headlands or man-made projections. In spite of the transitory nature of dunes and spits, houses, roads, and even entire towns have been constructed here only to be threatened or destroyed by severe winter erosion.

In the past the coastline has been subject to effects of earthquakes and tidal waves or tsumanis. At many coastal sites in Oregon sediments record land subsidance as buried forests and mud-covered bogs that resulted from powerful earthquakes. Similarly periodic scouring of bays and coast areas by tsunamis is part of the coastal erosion process. A final sculpting of the land took place as the ocean eroded headlands and filled bays creating a variety of spits, bay mouth bars, islands, tunnels, and offshore sea stacks.

Geology

The foundation block of coastal Oregon and Washington mountains began as a volcanic island chain that collided with the North American plate. Some distance to the west of Oregon and far beneath the ocean crust, a hot spot generated deep sea lavas 64 million years ago. This volcanic source was situated beneath an ocean spreading center straddling two active tectonic plates. The Kula plate was being pulled north to collide and slide below North America along Washington and British Columbia. The Farallon plate to the south was being overridden by southern Oregon and California. As these two plates continued spreading or pulling apart, a chain of undersea mountains, strung out to the north and south. Forming a prominent ridge on the sea floor, the line of volcanoes occasionally projected above the water as low volcanic islands. Close to the end of early Eocene time the North American plate, moving westward, collided with the recently formed islands and seamounts. With the capture of the new landmass, North America had grown about 50 miles in width. Volcanic rocks of this island chain today form the backbone of the Oregon and Washington coastal mountains and are the oldest known rocks in the range.

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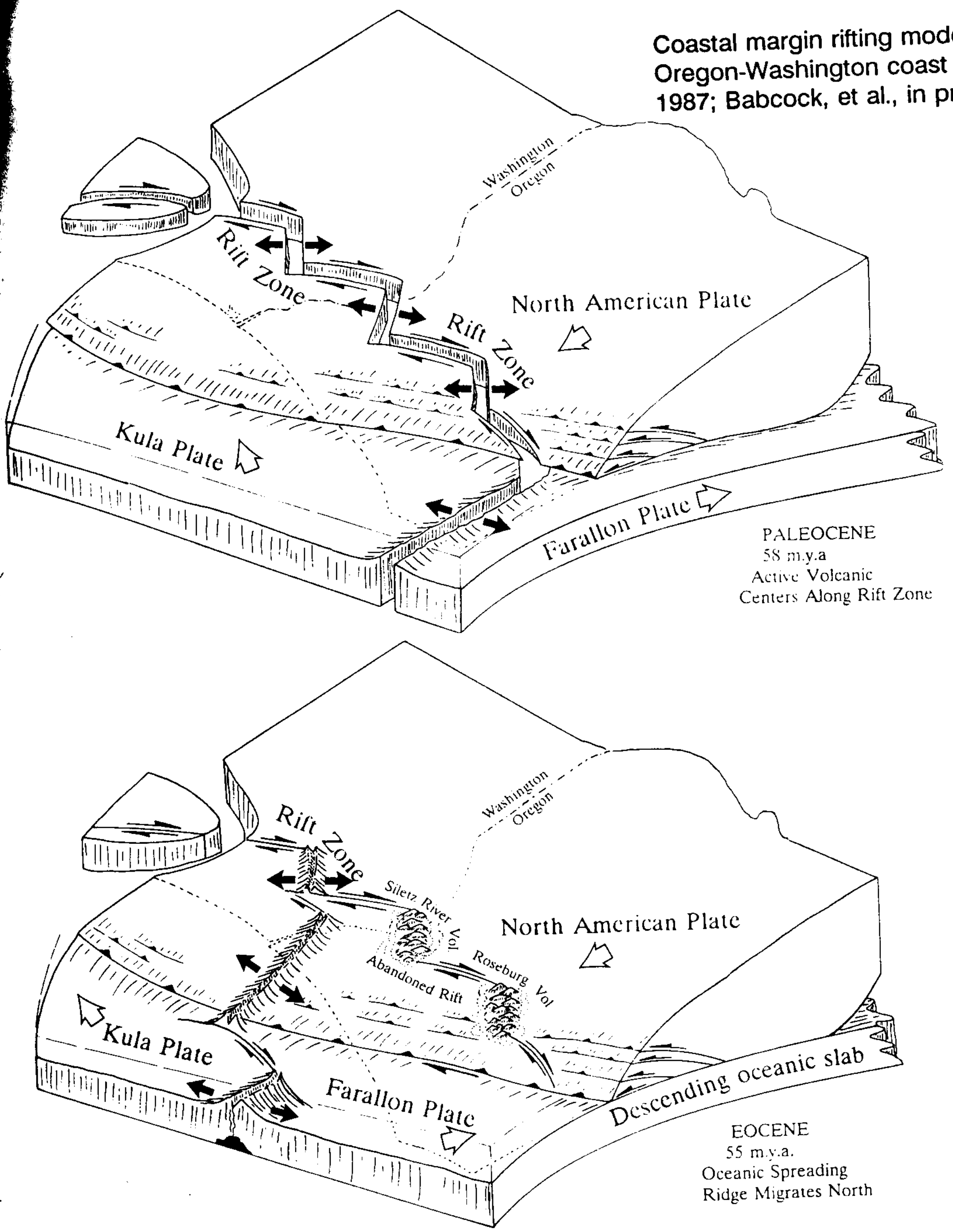
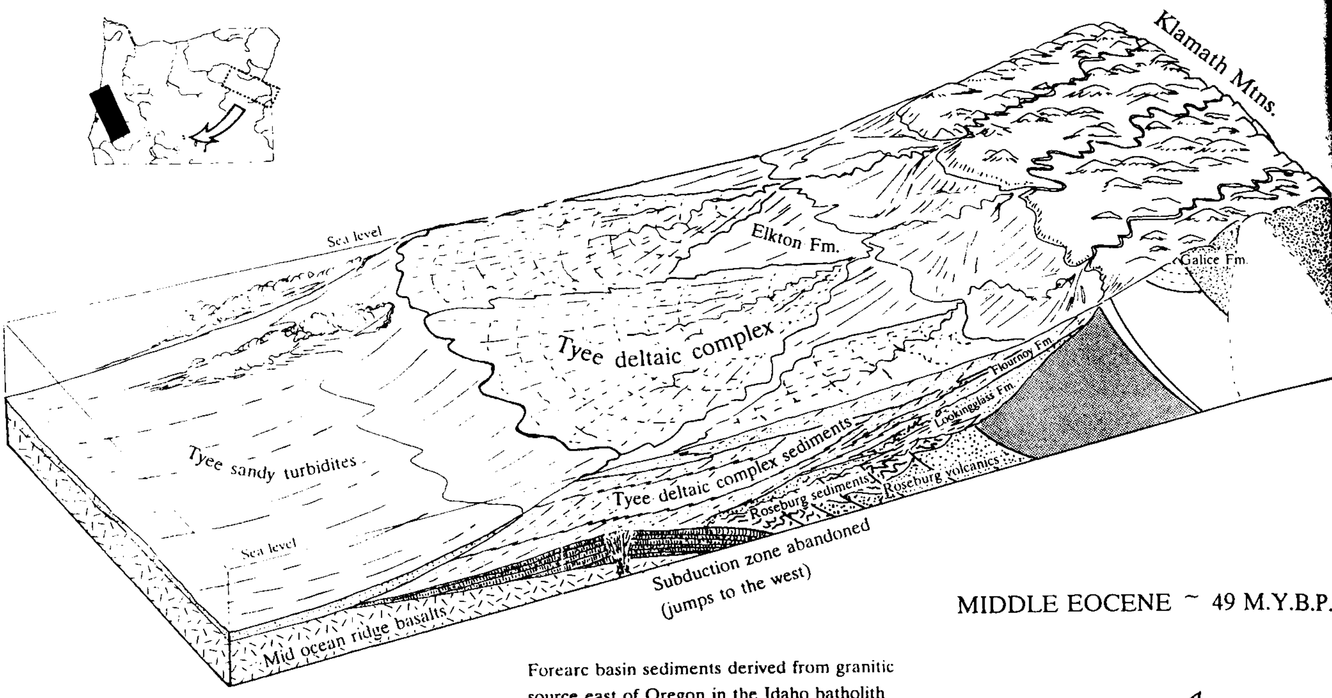
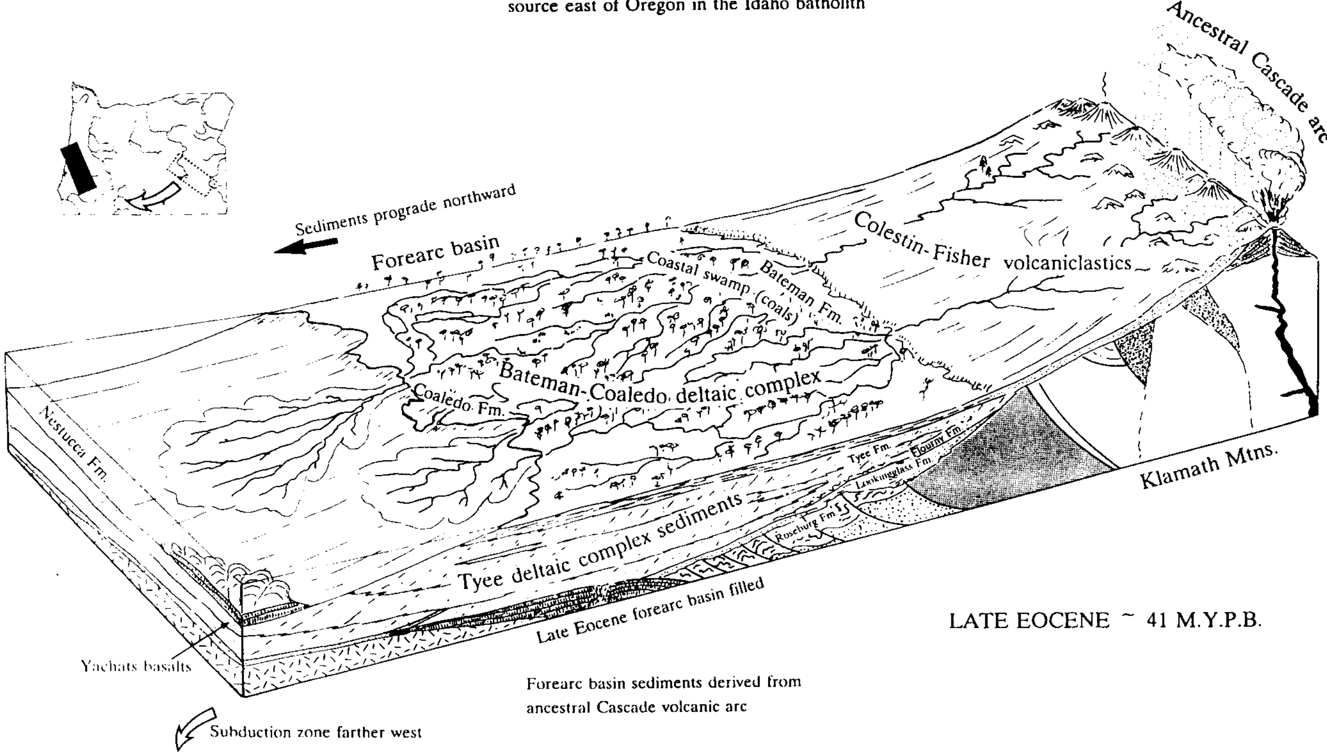
Coastal margin rifting model for formation of the Oregon-Washington coast volcanics (after Snavely, 1987; Babcock, et al., in press)



Another possible explanation for the formation of the Coast Range block is that the volcanics developed above a series of rifts or crustal rips along the coastal margin. Differential movement of large-scale blocks would have created a line of overlapping tears releasing lavas that became the base of the Coast Range. Alternately, the rifting could have been caused by a hot spot below the crust. With coastal margin rifting, the Coast block would have been formed in place and not accreted.

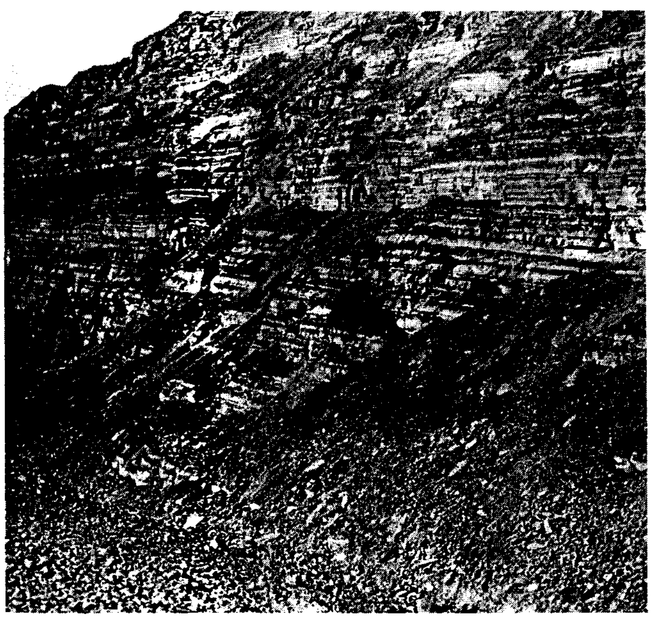
Differences in age, texture, and mineralogy of the core Coast Range volcanic rocks have caused them to receive different formation names. From the nc to south, they include the Metchosin, Crescent, Bl Hills, and Grays Harbor volcanics in Washington, Tillamook volcanics in the northern Oregon C Range, the Siletz River volcanics in the central par the Coast Range, and the Roseburg volcanics in south. The oldest volcanic rocks in the range are tl of the 64 million year old Roseburg and Metch formations at the southern and northern extre while the youngest are the 44 million year old G River Formation in the central region. Common t of these volcanics are elliptical bodies called "pillo



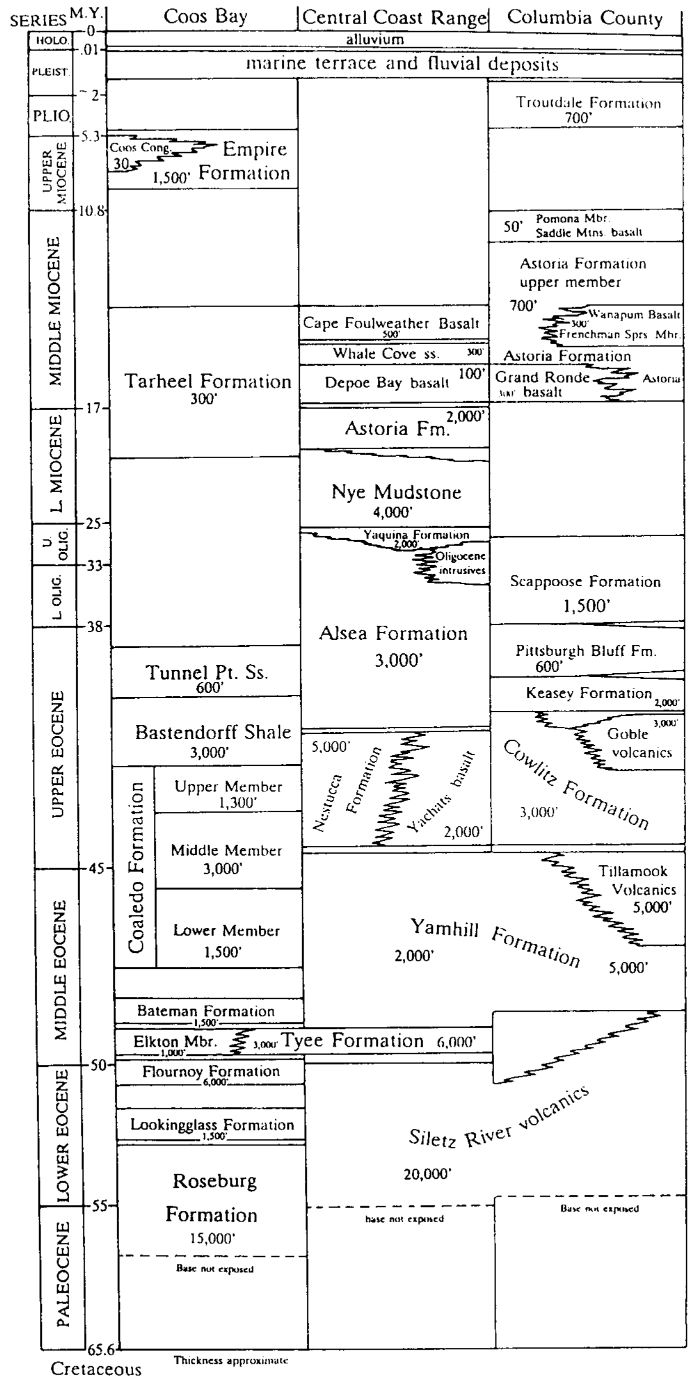


Sand bars were deposited in shallow waters high on the continental shelf and slope in the southern basin. Deep water currents spread sediments in a broad alluvial pattern across the middle of the basin, while fine-grained sediments were carried farthest from the source and into the deepest region of the seaway to the north. In the Roseburg Formation, there is evidence that large cohesive blocks of mud and rocks slumped from a steep upper shelf onto the deep sea fan. In this ancient submarine setting, the huge blocks or "olistoliths" are found imbedded in chaotic masses of rock indicating they slid down steep submerged oceanic slopes after breaking off an escarpment.

After Flournoy time, the end of Coast Range collision and renewed subsidance of the forearc basin marked a new phase of deposition. White mica, potassium feldspar, and quartz, carried into the basin during the Tyee interval, reflect a major change in the source of sediments as well as the depositional environment in the middle to late Eocene. By late Eocene time rivers feeding the basin had matured extending their watersheds well beyond the Klamaths into the interior of Idaho. White micas and potassium feldspar minerals that make up the Tyee Formation are identical to minerals of the Idaho batholith. In the southern part of the basin, sands transported by rivers created deltas and shallow marine sandbars on the shelf before cascading into the deeper basin where they were carried on turbidity currents to form Tyee submarine fans. The meager fossil record of this interval is due to overwhelming amounts of sand and silt diluting the marine faunas. In localized areas Tyee, Elkton, and Bateman deposits accumulated up to a mile in thickness. Approximately 1,500 feet of Bateman sediments typify a shallow delta in the Tyee seas, while the 2,500 feet of Elkton sands with abundant, shallow water molluscs and microfossils were the last to fill the southern basin.



Roseburg Formation south of Sutherlin on Interstate 5 displays deep water turbidite deposits (photo courtesy Leslie Magoon).



Stratigraphy of the Coast Range (after Correlation of Stratigraphic Units of North America [COSUNA], 1983) the heavy fluid lavas forced them downward into the underlying soft watersaturated sediments. Once the lavas invaded the unconsolidated sediments, they intruded a variety of Eocene and Oligocene rocks in the central and northern Coastal Range as dikes and sills. After cutting across the incipient Coast Range, the lavas terminated as far south as Seal Rocks. Geophysical transects across these coastal basalt exposures reveal that the dikes and sills are "rootless", which further supports an invasive origin rather than a local volcanic source.

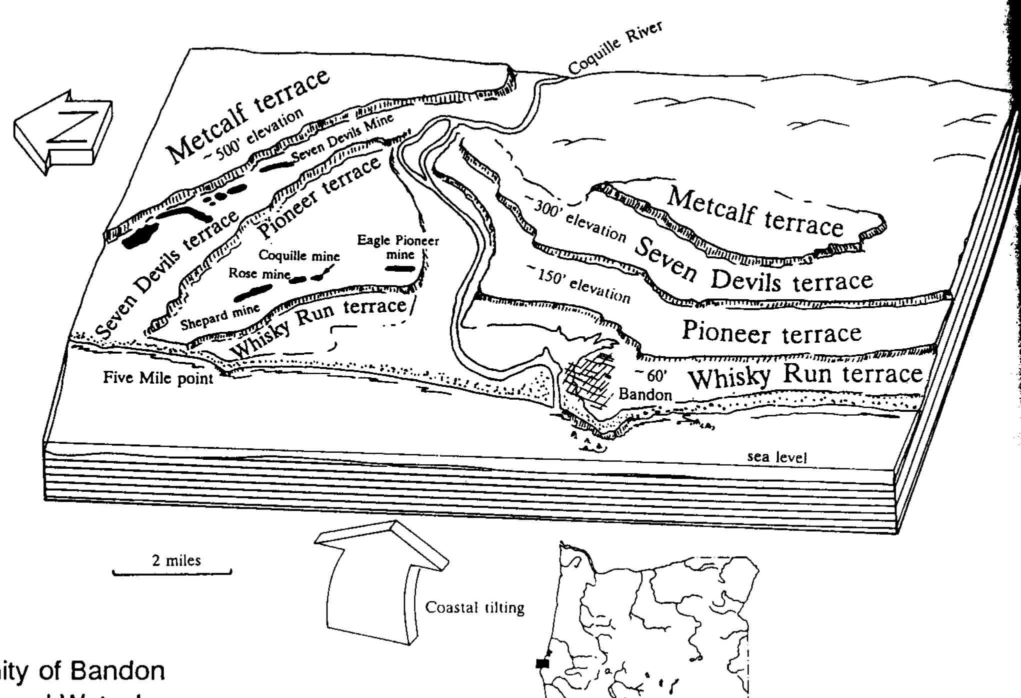
At Cape Blanco and Coos Bay sandstones of the Empire Formation are late Miocene. Molluscs, echinoids, and barnacles suggest a shallow water temperate marine environment. Many of the shells show wear and abrasion from action of the waves close to shore.

Pliocene

Few marine sediments record the Pliocene in western Oregon indicating this was a time of erosion when the area was above sea level and the coastline lay approximately in its present position. Pliocene muds, sands, and silts were carried to the shelf and slope where they form vast sheets of poorly consolidated sediments. Up to 1,000 feet of gravels of the Troutdale Formation acçumulated along the Columbia River in the St. Helens area and intermittently all the way to the mouth of the river.

Pleistocene

Subduction of the Juan de Fuca plate North America and continued growth of the wed accreted sediments on the leading edge of the N American plate at a rate of about 1 inch per year pushed the Coast Range upward. Areas offshore cl to the subduction trench have been subject to m uplift than areas farther inland. In a regional sense, varying uplift produces a tilting effect since the west edge of the coastal mountains are rising, while eastern margin as well as the Willamette Valley either subsiding or only rising at a minimal rate. In early 1980s a Cornell University team conducted v accurate east-west leveling surveys across Coast Ran highways in Oregon and Washington repeating me surements which had been taken over 50 years pre ously. The striking results showed a seesaw effect every transect, where western coastal areas had ris with respect to the eastern part of the range. Cons quently Cape Blanco, only 35 miles from the subdu tion zone, has the fastest uplift anywhere on the coa at 35 inches vertically every century or 1 inch every years. As Neah Bay along the Washington coast ris at the rate of about 1 inch every 15 years, Seattle an Vancouver on the inland side are sinking at 1 inc every 11 years and 1 inch every 40 years respectively. I Oregon, Astoria rises at the rate of 1 inch in 36 yea as Rainier to the east is proportionally depressed.

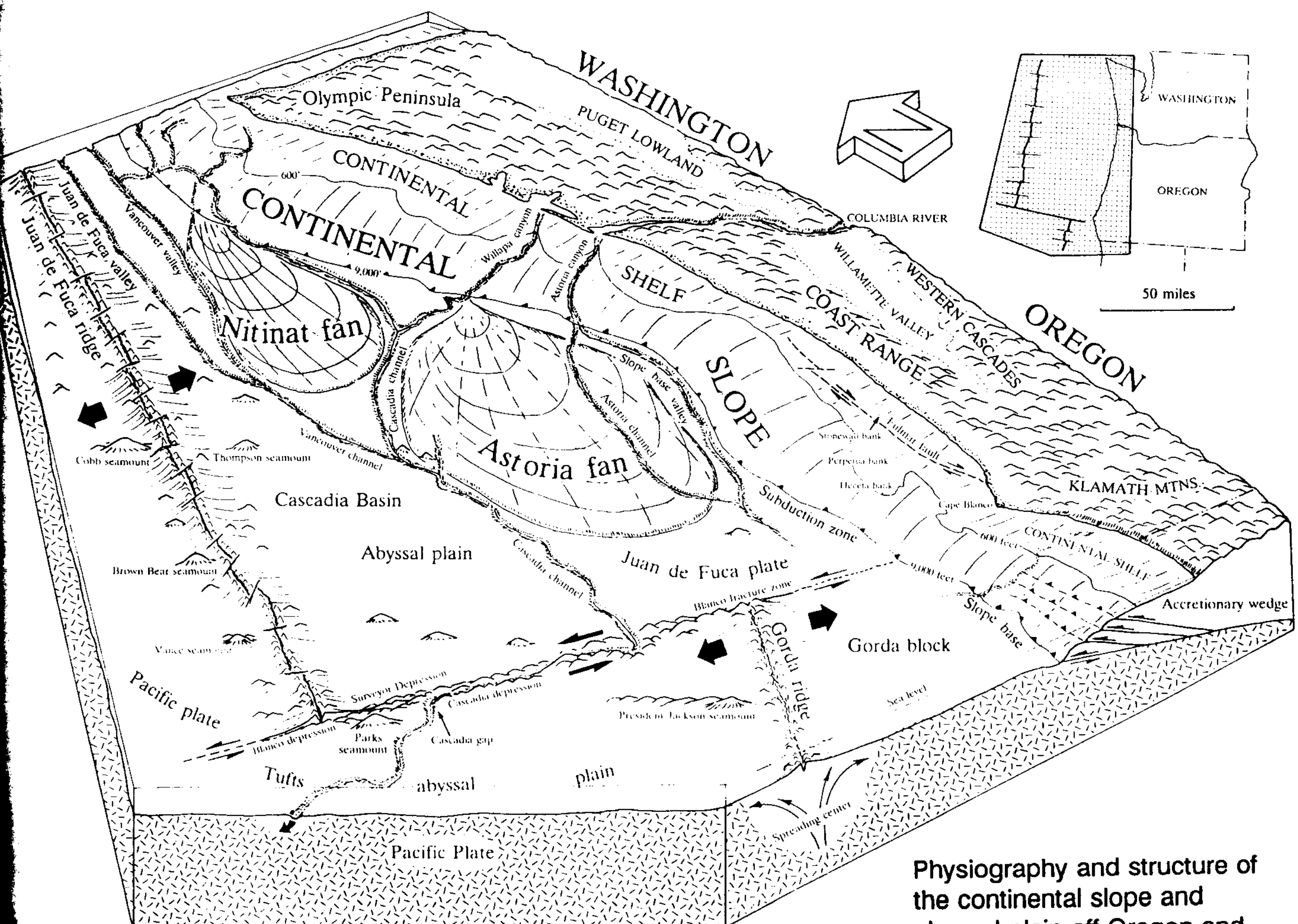


Terrace levels in the vicinity of Bandon (after Peterson, Gleeson, and Wetzel, 1987; McInelly and Kelsey, 1990) during 1983, and within 5 weeks the opening to Alsea Bay had widened to over 1,900 feet by shifting erosional patterns. Houses on the the spit as well as the city of Waldport were threatened. At Netarts Bay, the long narrow sand bar jutting northward from Cape Lookout is forested in the central section, but the north end is bare and subject to erosion.

Offshore Continental Shelf and Slope

The continental shelf and slope are of increasing importance as available technology makes exploration and exploitation easier, and the search for food, fossil fuels, and metals expands into the ocean basins. The edge of the continent does not stop at the beach but extends to the shelf that dips gently seaward to a depth of 600 feet. The steeper continental slope descends to abyssal seafloor depths of 9,000 feet below sea level. The combined width of the shelf and slope is approximately 70 miles off Astoria and 40 miles off Cape Blanco. Shelf and slope geology adjacent to continents are linked directly to onshore geologic systems, and the Oregon coastal margin is no exception. Sedimentary formations ranging from Eocene through Pleistocene exposed in the Coast Range can be traced offshore where the oldest sediments on the continental shelf grade into younger deposits on the slope.

The continental margin of the offshore shelf, slope, and abyssal plain are broken by features as banks, ridges and basins, canyons, and channels. On the outer edge of the shelf, prominent submarine fault-bounded escarpments as Nehalem, Stonewall, Perpetua, Heceta, and Coquille banks are exposed Miocene through Pliocene mudstones, sandstones, and clays that project as much as 200 feet above the surrounding seafloor. The steep escarpment at Stonewall Bank is situated approximately 19 miles off Yaquina and Alsea bays in water less than 120 feet deep. Another submarine projection, Heceta Bank lies about 35 miles west of the mouth of the Siuslaw River and rises within 360 feet of the surface, while Coquille bank, a shoal approximately 3 miles wide and 8 miles long between Coos Bay and Cape Blanco, exhibits 198 feet of relief.



Physiography and structure of the continental slope and abyssal plain off Oregon and Washington.

X. Willamette Valley

A. Physiography
1. Willamette-Puget Lowlands
a. N-S trending alluvial plains
b. Willamette River
(1) el. ~ 400 ft at Eugene to near Sea Level at Portland (avg. 3 ft/mi gradient)
2. Mid-Valley Topography
a. Salem Hills, Eola Hills (CRB's)
b. Tualitin Mtns near Portland
3. 70% of Oregon's population, agricultural and Urban center

B. Geologic Overview
1. Eocene-Oligocene
a. WV was part of continental shelf that extended from Cascades to present Coast (remember Coast Range not uplifted until Miocene and later)
2. Foundation Rocks
a. Eocene volcanic basalts (Siletz), accreted
b. Eocene forearc sediments (pre-western Cascades into Cascades)
c. Miocene - CRB's invaded northern portions of valley, as far south as Salem
3. Valley Structure
a. Combination of Coast Range uplift, and westward tilting of western Cascades
4. Pliocene-Pleistocene
a. Troutdale gravels
b. Boring lavas / basalts from > 100 small eruptive centers near Oregon City
c. late Pleistocene Missoula floods
d. ongoing earthquake activity

C. Eocene Basement
1. Siletz and related marine basalts form foundation of Valley
a. Siletz River Volcanics - up to 10,000 ft of basalts, accreted
(1) accretion and clockwise rotation
2. early-mid Eocene
a. Coast Range not in existence, western Cascades not in existence
b. valley forms part of forearc basin
(1) Coastal / offshore sedimentation from Klamath Block to SE and Idaho batholith (Roseburg - Tyee sediments)
c. middle to late Eocene
(1) shallow shelf sedimentation
(a) Yamhill siltstone / mudstones
(b) Ricreall / Buell limestones
(c) Spencer Fm- in part deriving volcaniclastics from growing w. Cascades
(d) Eugene Fm - in part deriving volcaniclastics from growing w. Cascades
(2) non-marine sediments over Spencer = Fisher Fm
3. Oligocene
a. local marine sediments in Salem / Scotts Mills area
b. Little Butte volcanics, input from western Cascades

c. intrusive dikes and sills in Coast Range (prior to uplift)

4. Miocene
   a. begin uplift of Coast Range, regression of sea to west
      (1) deformation and tilting of WV sediments to east
   b. Middle-Late Miocene
      (1) invasion of "CRBs" via Columbia Gorge
      (2) Eola / Salem hills, Amith hills, Portland Hills
   c. Portland Basin / Tualatin Basin = lake sedimentation
      (1) Sandy River mudstone
5. Pliocene
   a. continued uplift and tilting of Coast Range
      (1) total uplift of 3000-4000 ft in Coast
      (2) out shelf sediments (1000-2000 ft depth) uplifted to 3000 ft above sea level
   b. folding and tilting of WV rocks
   c. Boring Lavas erupted in northern WV (from eruptive centers = "buttes" west of Portland)
   d. Troutdale gravels
      (1) Pliocene ancestral Columbia River gravels

6. Pleistocene (from oldest to youngest)
   a. Rowland Formation
      (1) gravels from glacial outwash in western Cascades (Santiam, McKenzie)
         (a) coalesced alluvial fans at mid to southern end of valley
      (2) northern Willamette Valley was constricted at Oregon City by CRB's
         (a) Willamette cut through to form Willamette fass at Oregon City, established modern drainage

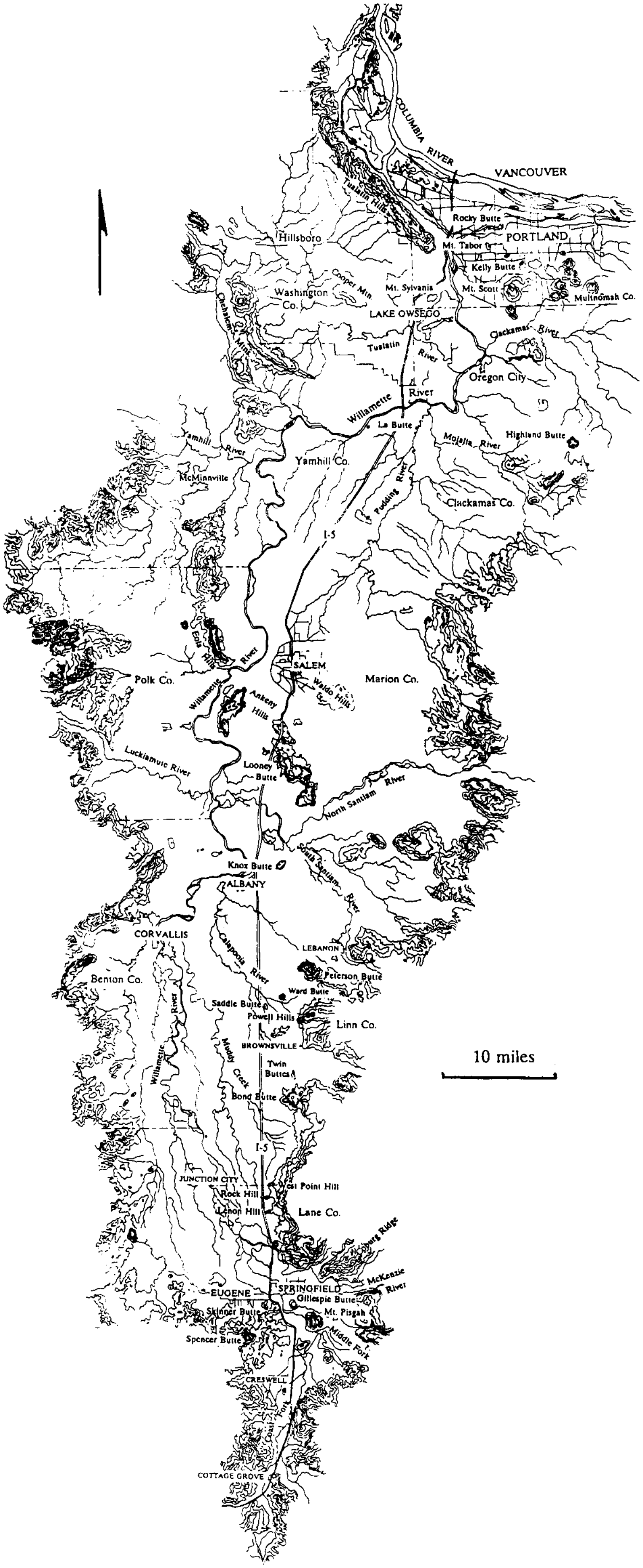
   b. Willamette Formation (15,000 to 12,000 yr ago)
      (1) Missoula floods
         (a) Cordilleran ice sheet, lake Missoula, catastrophic outburst floods
         (b) over 20 outburst floods recorded
            i) single flood released over 400 cu. mi of water, more than the annual flow of all rivers in the world
      (2) Channeled Scablands, mega bed forms, erosional scour / steepening of Columbia Rive gorge
      (3) backflow into WV, slackwater, Lake Allison
         (a) erratics / ice rafted debris
         (b) Willamette Silt deposits
7. Holocene
   a. continued terrace development / inset of floodplains and terraces into late Pleistocene surfaces

D. Structure
   1. WV gently folded, in concert with uplift and tilting of Coast Range
   2. faulting in valley (notable)
      a. Corvallis fault (NE strike)
         (1) early Tertiary activity
      b. Mt Angel faulte (NW strike)

c. Portland Hills fault (NW strike)
   (1) aligns with Brothers Fault zone on other side of Cascades

E. Earthquake ideas
   1. lack of historic seismicity
      a. warm crust, near ridge, bouyant
      b. subduction zone locked
      c. seismic strain accumulation and release
   2. Some Historic activity
      a. Mt. Hood seismicity
      b. 1990's - Mt Angel Fault
   3. types of earthquakes
      a. megathrust (at subduction zone / trench) - most widespread
      b. crustal / upper plate (shallower crustal quakes in over-riding plate)
      c. lower plate quakes / intraplate - in subducting slab (deep focus)
   4. Hazards
      a. ground shaking, liquefaction, landslides

F. Mining in Valley
   1. aggregate / channel gravel mining
   2. Bauxite - local residuum
   3. Iron -residual / weathering



Miocene, and Pliocene reflect shallowing as the ocean shoreline retreated northwestward. These marine sediments were covered in turn by Columbia River lavas that poured through the gorge from eastern Oregon during the middle and late Miocene to invade as far south as Salem.

Uplift and tilting of the Coast Range block and Western Cascades brought about the trough-like configuration of the Willamette Valley and the formation of a number of closed basins on the continental shelf. During the Pliocene and Pleistocene in the northern part of the province, a large lake received silts, muds, and gravels from the Willamette and Columbia rivers. The eruption of the Boring lavas from over 100 small volcanoes near Oregon City as well as east and west of Portland covered these earlier lake sediments, and today the vents project as small buttes.

The dominant signature on Willamette Valley geology resulted from a number of large-scale Pleistocene floods that scoured eastern Washington and the Columbia River gorge leaving deposits throughout the province. Enormous glacial lakes formed in Montana when the Clark Fork River was dammed by ice and debris. Once the ice blockage was breached, rushing flood waters carrying icebergs cascaded across Idaho, southeastern Washington, and down the Columbia gorge. Water backed up into the Willamette Valley creating temporary lakes and strewing a field of boulders in its wake. An unknown number of floods took place during a 2,500 year interval until the climate warmed, and glaciers retreated northward.

Because of its position close to the offshore subduction zone between Pacific Northwest plates, Oregon experiences a continual number of seismic events, and in the future the state could be the site of catastrophic earthquakes although details of time and place are uncertain. The coastal regions and Willamette Valley would be particularly vulnerable should a strong quake occur.

Geology

Geologically part of the eastern margin of the Coast Range block, foundation rocks of the Willamette Valley have played something of a passive role against the backdrop of moving tectonic plates. In Eocene time an undersea chain of volcanoes atop the Kula and Farallon plates collided with the westward moving North American plate where they were accreted. With a thickness of more than 2 miles, the volcanic rocks of the island chain form the basement of the Coast Range and Willamette Valley. After docking or making initial contact with North America, the island archipelago was rotated clockwise beginning in the early Eocene. With accretion, the old subduction zone east of the volcanic

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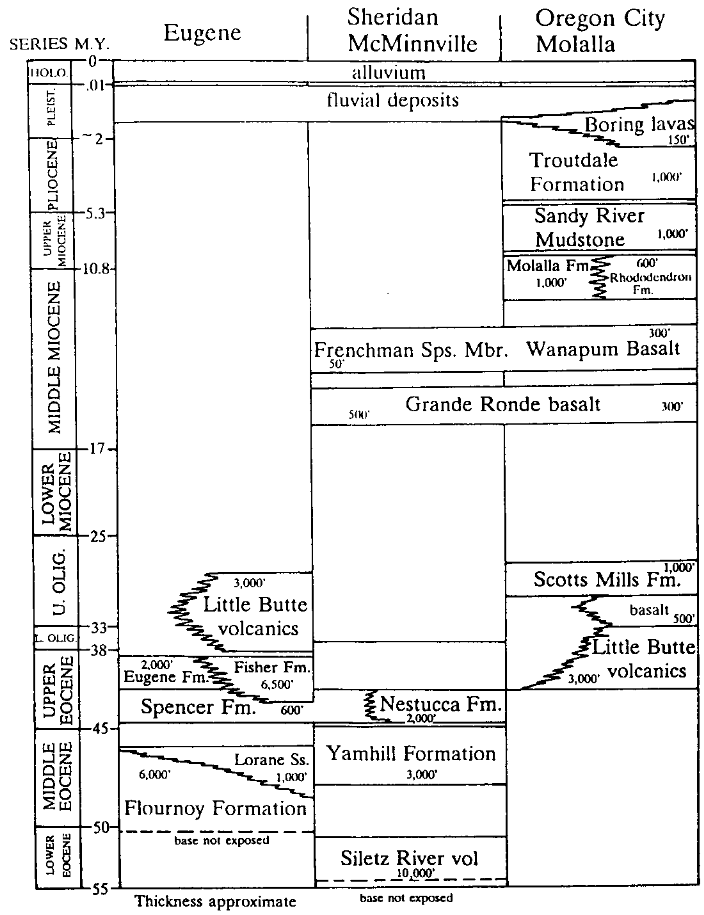
block was abandoned and a new one activated offshore to the west where it is today.

The slow subsidence of the block created a broad forearc trough along the western margin of North America. From Eocene through Pliocene time the basin was the recipient of deposits that blanketed the earlier volcanic platform. Rivers draining the Klamath Mountains and later the Idaho batholith provided abundant sediments that accumulated in the newly formed basin. During the early Eocene the eastern edge of the subsiding coastal block that was to become the Willamette Valley collected sandstones and siltstones of the Flournoy Formation near Lorane, Philomath, Falls City, the low hills around Camp Adair, and in the southern valley. Where Eocene rocks are exposed in the area north of Corvallis, rolling hills contrast sharply with the flat valley floor elsewhere that is covered with Pleistocene fill.

In the northern part of the valley these deposits were followed by middle Eocene Yamhill muds, sands, and silts, mixed with ash and lavas from the ancestral Cascades that were carried into the shallow seaway. Within the Yamhill, shoals of limestones around offshore banks formed the Rickreall and Buell limestones containing broken mollusc shells, foraminifera, and calcareous algae intermixed with volcanic debris. In the northern valley 2,000 feet of Nestucca Formation deposited in a deep water setting extended westward from McMinnville, while near-shore sands, silts, and muds of the shallow marine Spencer Formation produced deltas along the margin. Found along the western side of the valley from Eugene north to Gales Creek in Washington County, Spencer sands are covered by nonmarine tuffs and conglomerates of the late Eocene Fisher Formation. Fossil plants from the Fisher Formation southwest of Cottage Grove indicate a warm, moist tropical climate where broad leaf plants as the Aralia grew close to the shoreline. Beneath Eugene almost a mile of upper Eocene silts and sands of the Eugene Formation extend northward toward the Salem hills. Marine molluscs, crabs, and sharks in this formation suggest warm, semitropical seas. Sediments of the Spencer, Fisher, and Eugene formations were derived from the rapidly growing volcanics of the Western Cascades.



Willamette Valley stratigraphy (after COSUNA, 1983)

Oligocene

The Oligocene ocean in the Willamette Valley reached only as far south as Salem. The high-water mark on the western shoreline is recorded by marine sediments in the vicinity of Silverton and Scotts Mills in Marion and Clackamas counties. In the Scotts Mills Formation a transgressive, advancing seaway followed by a regressive, retreating ocean chronicles storm conditions, shallow water, and coastal swamps that gave rise to thin layers of low-grade coal. Coal beds at Wilhoit Springs and Butte Creek were deposited along the margins of the sea as it retreated. Prior to the arrival of the Columbia River lavas in the middle Miocene, the Scotts Mills sediments were tilted eastward and severely eroded.

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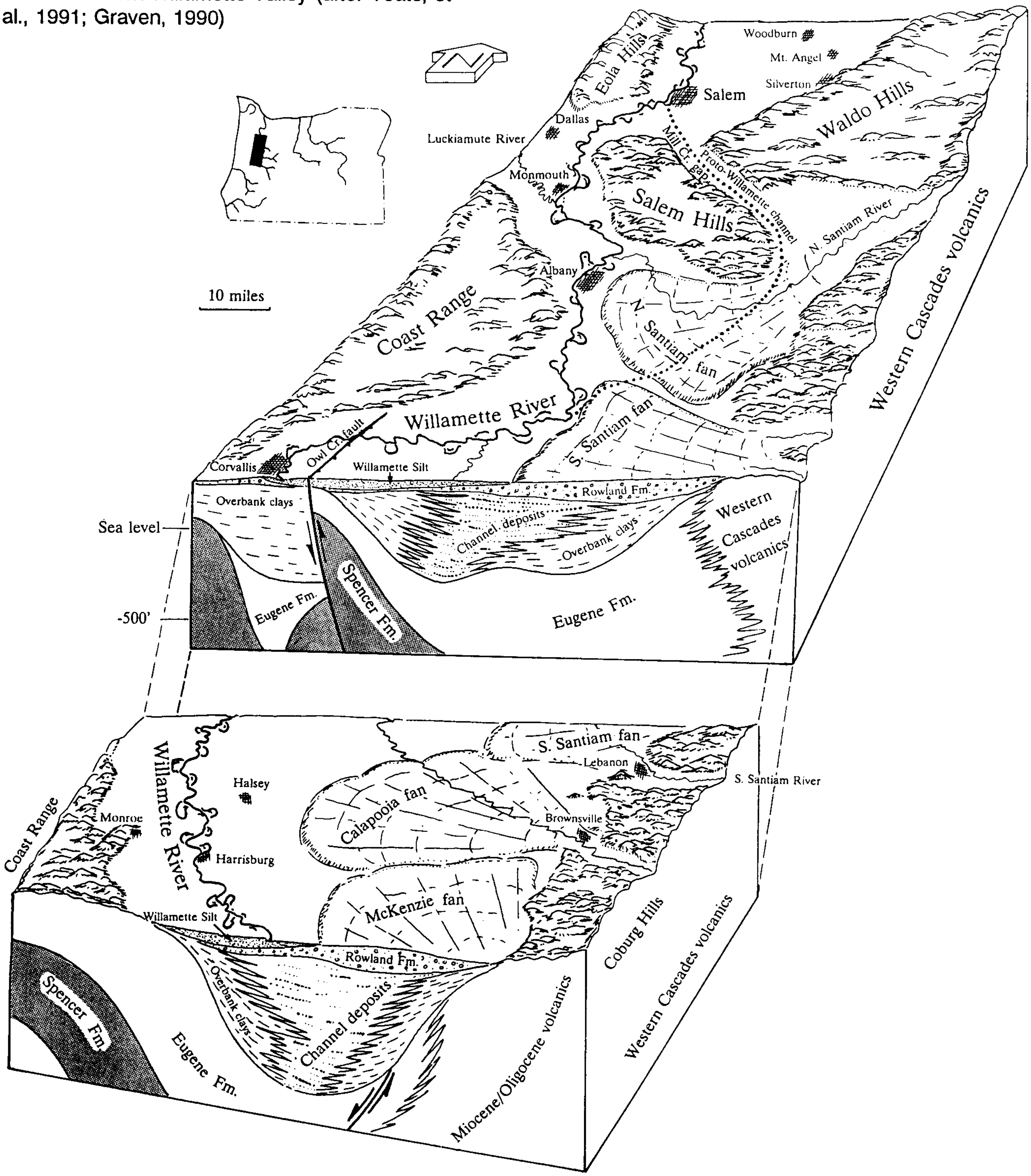
Pleistocene fluvial and flood deposits and structure of the southern Willamette Valley (after Yeats, et al., 1991; Graven, 1990)



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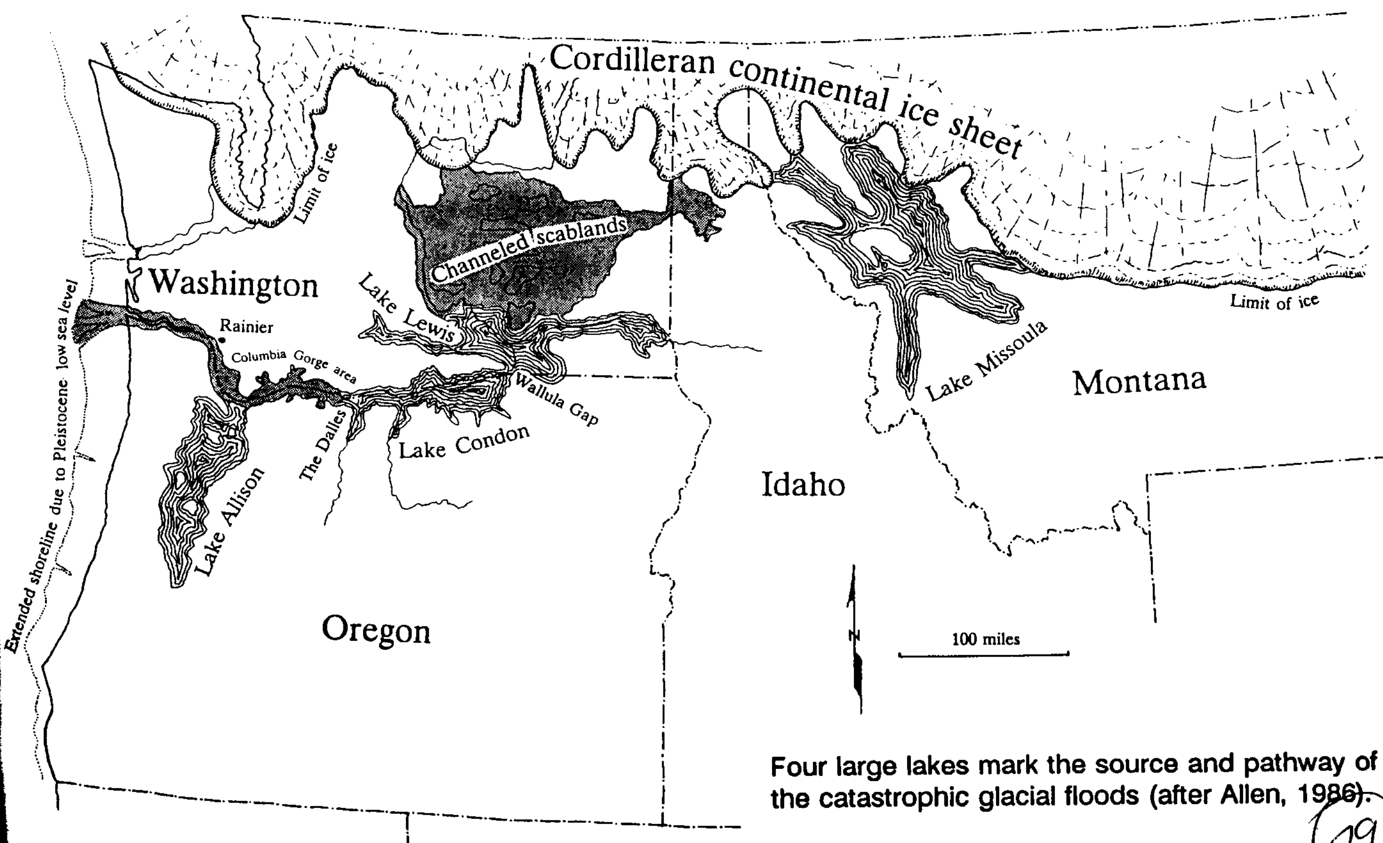
debris to become a marsh. Thick peat deposits in the old lake reflect a long period as a swamp and bog. In this organic layer, bones of Ice Age mammals such as mammoths, mastodon, giant sloth, and bison are frequently found. Unlike the Pleistocene LaBrea tar pits of Los Angeles, the animals were probably not mired in the peat, but carcasses were washed in and covered allowing the remains to be preserved in the oxygen-poor bog away from the attentions of scavengers. Today the fertile soils of Lake Labish support a thriving onion industry.

Pleistocene

Covering the Boring lavas and Troutdale gravels, a gritty, structureless, yellowish-brown sediment called the Portland Hills Silt was deposited within the last 700,000 years. Commonly 25 to 100 feet thick, the layer mantles much of the Portland area from the Tualatin and Chehalem mountains on the west all the way to the Gresham Hills and Ross Mountain on the east. Microscopically the silt is remarkably uniform, and the identified minerals include many which must have been derived from terrains as far north as Canada. This unique formation has long been something of a geologic puzzle and has been designated as both a wind-blown and water-laid deposit. The physical characteristics of the silt are similar to the palouse strata in southwest Washington indicating that the sediments are wind blown in origin. The Yellow River in China derives its name from comparable Pleistocene loess deposits that blanket vast areas in the northern part of the country. Ground up rock flour, produced by the crushing and milling action of glacial ice, was transported by water to be deposited along flood plains of the Columbia River. Strong Pleistocene winds, collecting the fine dust, carried it aloft in enormous clouds to cover the Portland Hills. Four different layers of silt are separated by three soil horizons. Interglacial, warm intervals are represented by the silt deposits, whereas soil horizons reflect times of glacial advance.

Ice Age Floods

Beginning about 2 million years in the past, the Ice Ages mark the advance and retreat of continental glaciers, an event that triggered one of the most catastrophic episodes in Oregon's geologic history. When first proposed in the 1920s by J. Harlen Bretz, the theory of an enormous flood washing across Washington and through the Columbia River gorge was not readily accepted. Careful work by Bretz, however, built up a body of evidence that could not be ignored. Between 15,500 and 13,000 years ago, the Columbia River drainage experienced a series of spectacular floods from ruptured ice dams along its



Four large lakes mark the source and pathway of the catastrophic glacial floods (after Allen, 1986).

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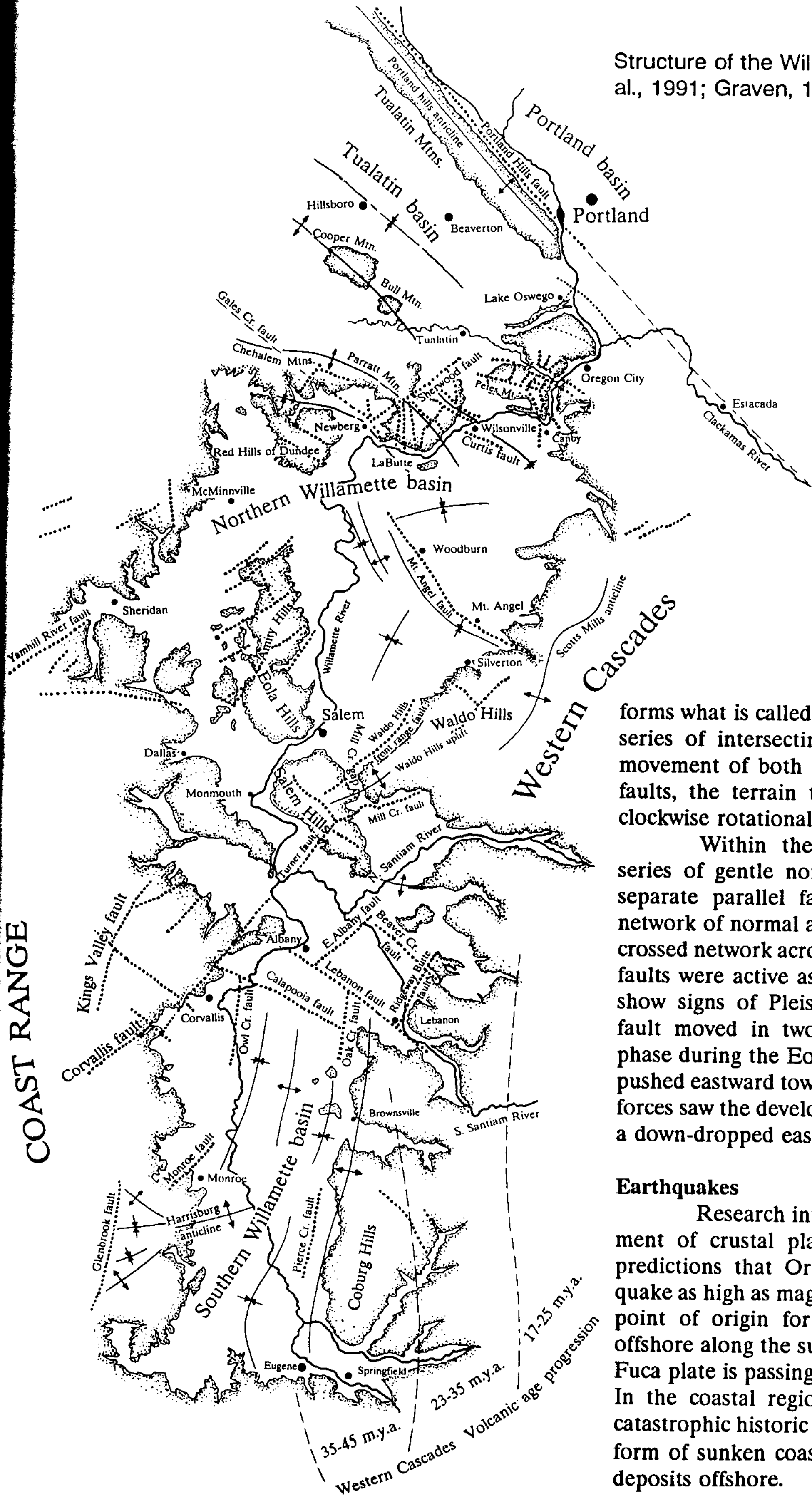

Structure of the Willamette Valley (after Yeats, et al., 1991; Graven, 1990; Werner, 1990).

forms what is called a fault "pop-up" caught between a series of intersecting fault blocks. With continuous movement of both the Portland Hills and Mt. Angel faults, the terrain trapped between them displays a clockwise rotational movement.

Within the southern Willamette Valley, a series of gentle north-south folds in the subsurface separate parallel faults. Eastward from Corvallis a network of normal and thrust faults extends in a criss-crossed network across to the Western Cascades. These faults were active as far back as Oligocene, but some show signs of Pleistocene movement. The Corvallis fault moved in two phases. In an earlier thrusting phase during the Eocene, the western upper plate was pushed eastward toward the valley while later tensional forces saw the development of a normal fault here with a down-dropped eastern block.

Earthquakes

Research into the relationship between movement of crustal plates and earthquakes has led to predictions that Oregon could experience an earthquake as high as magnitude 8 on the Richter scale. The point of origin for such massive quakes would be offshore along the subduction zone where the Juan de Fuca plate is passing under the North American plate. In the coastal region of Oregon good evidence for catastrophic historic earthquake activity is found in the form of sunken coastal bogs and distinctive turbidite deposits offshore.

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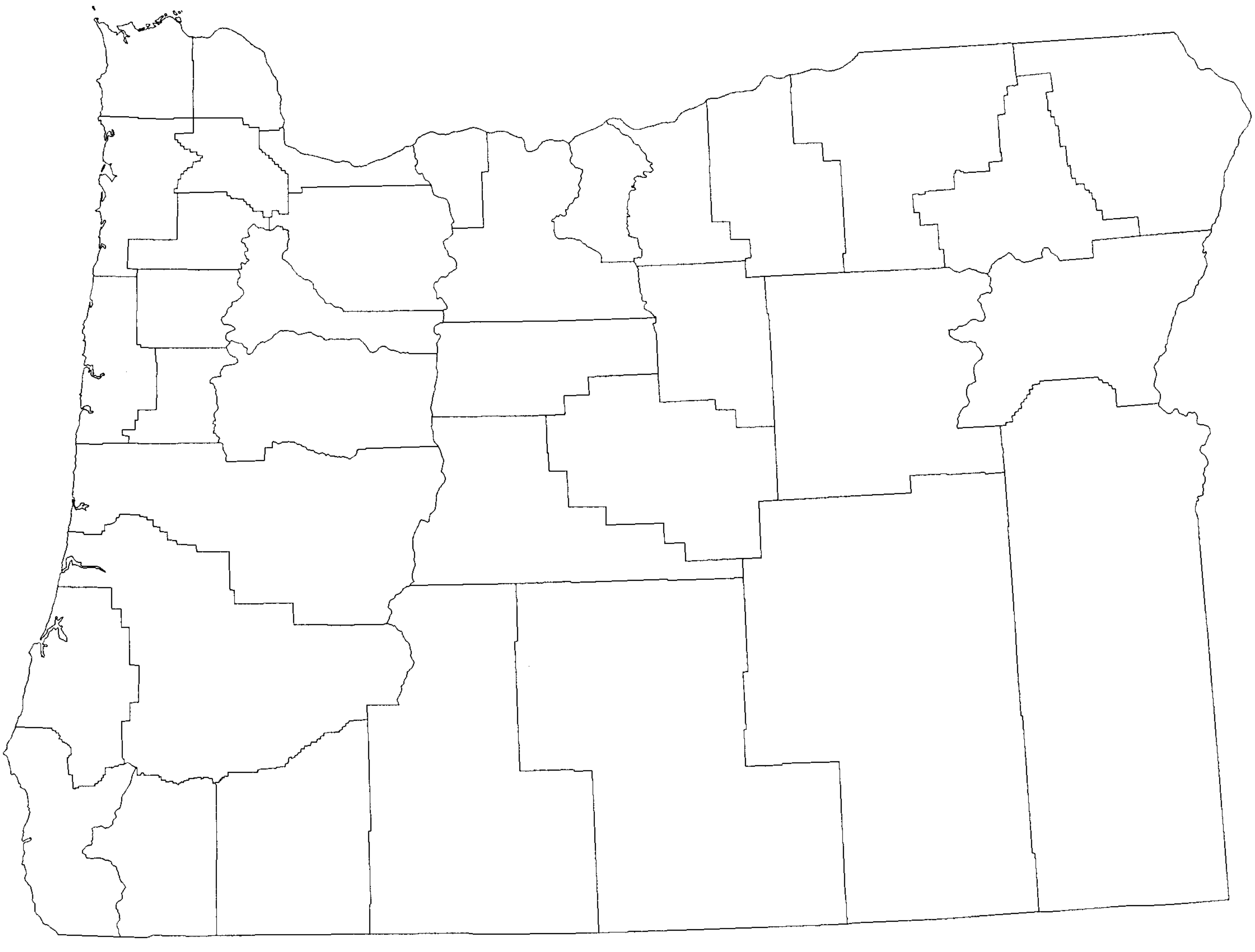

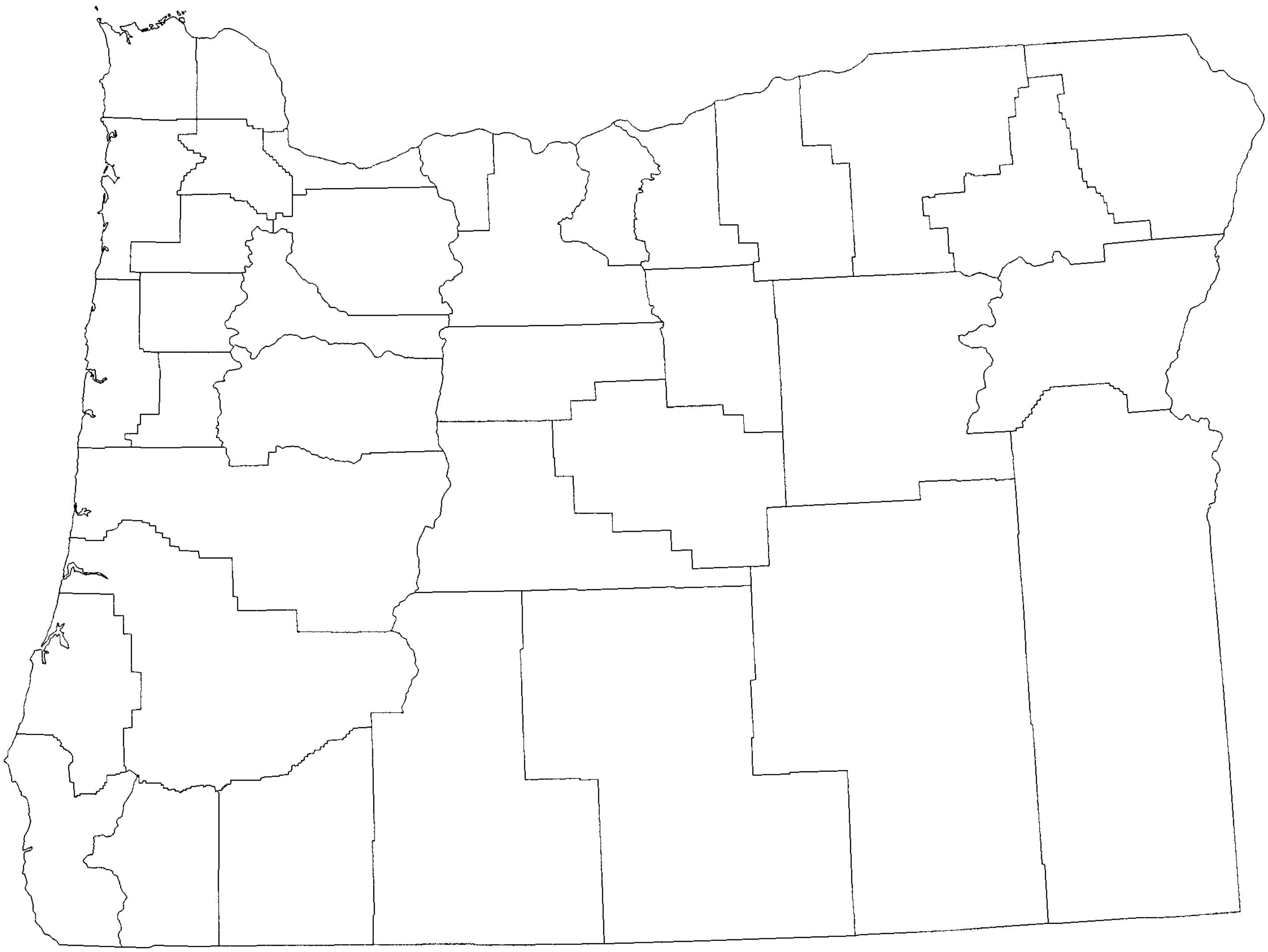

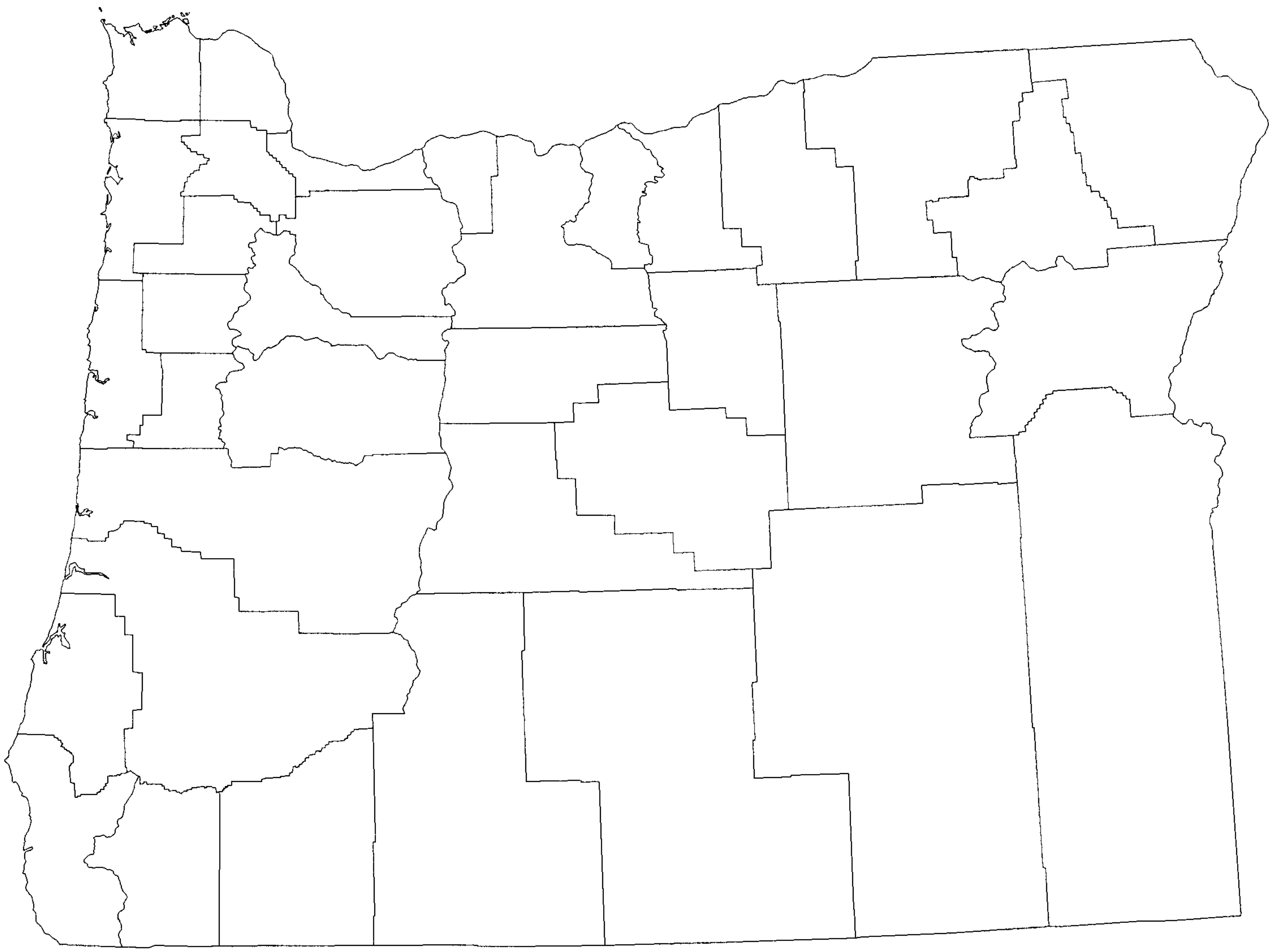

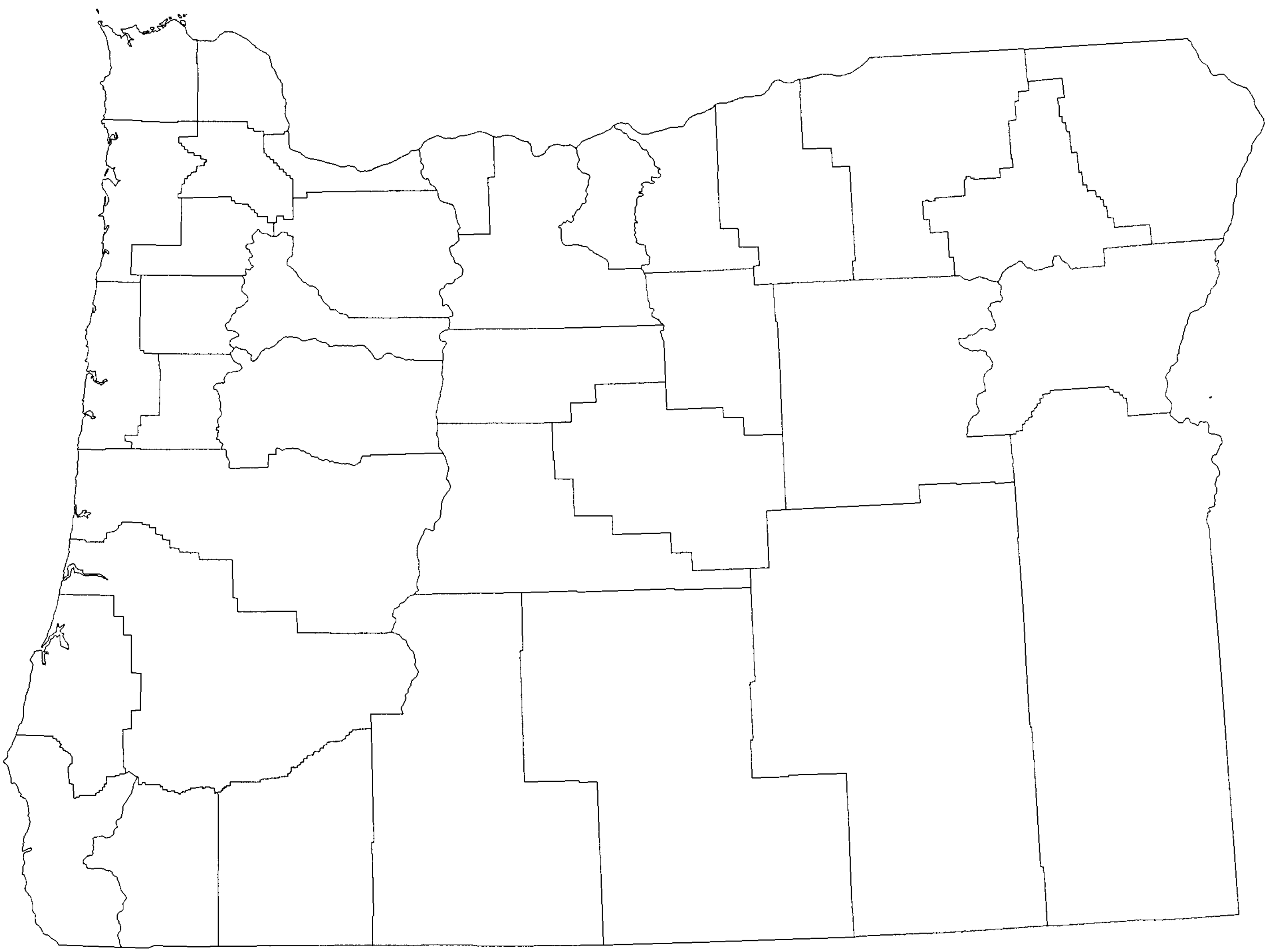

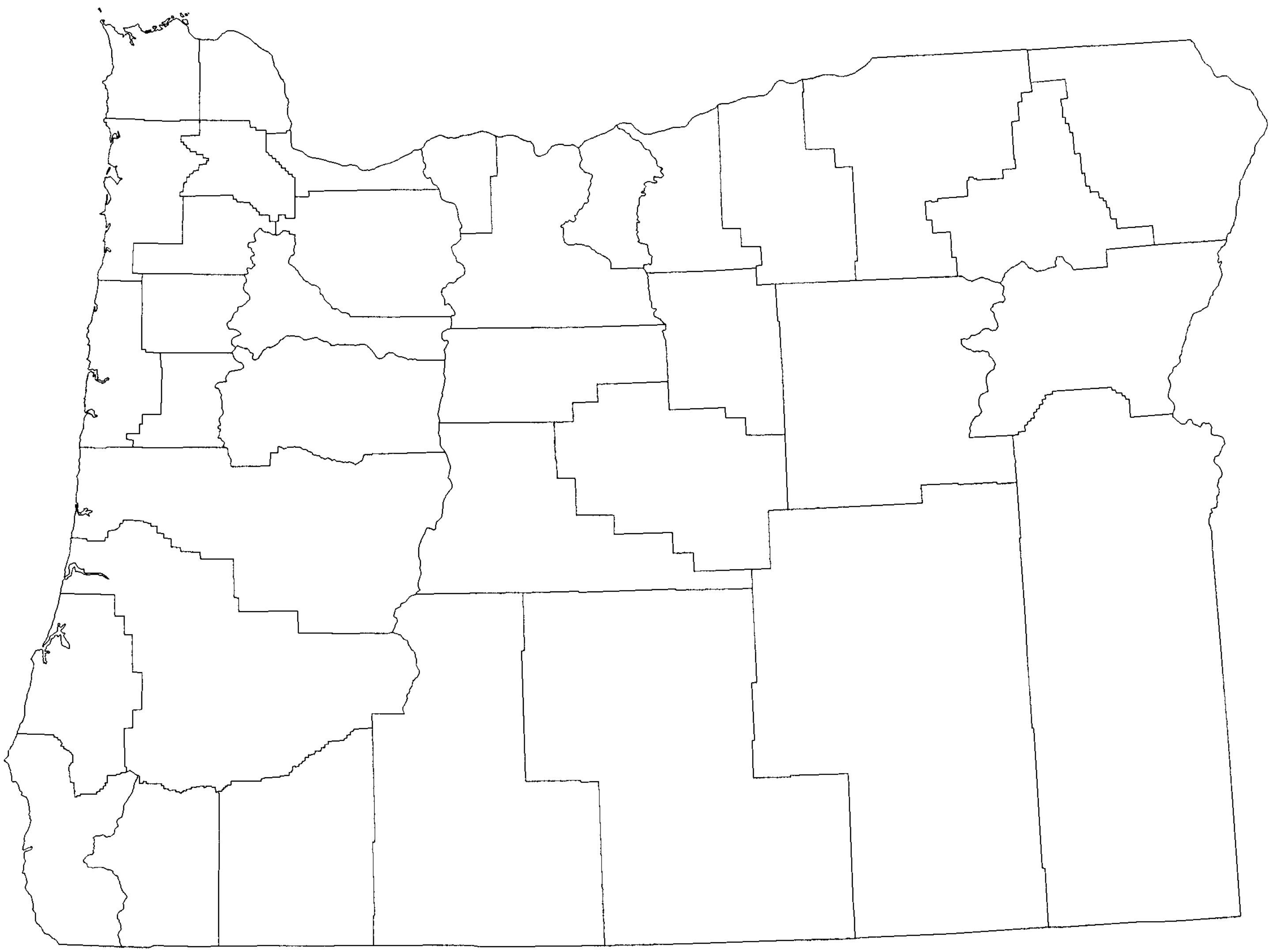

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