The Yakima Basalt and Ellensburg Formation of South-Central Washington

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CONTRIBUTIONS TO STRATIGRAPHY

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By James W. Bingham and Maurice J. Grolier

ABSTRACT

The uppermost part of the Yakima Basalt—herein assigned to the Columbia River Group—has the following largely conformable units (from oldest to youngest): lower basalt flows; the Vantage Sandstone Member; the Frenchman Springs Member, which locally includes the Squaw Creek Diatomite Bed; the Roza Member; the Priest Rapids Member, which locally includes the Quincy Diatomite Bed; and the Saddle Mountains Member. Sedimentary deposits of the Ellensburg Formation interfinger with basalt flows of the youngest member of the Yakima Basalt.

The maximum thickness of the Yakima Basalt is not known, but the formation is about 4,500 feet thick at a test well drilled in the Odessa area, and is probably much thicker toward the center of the Columbia Plateau. The part described herein has a composite thickness of about 1,200 feet above the Vantage Sandstone Member. The overlying and interfingering Ellensburg Formation is as thick as 2,000 feet in the type area, and the Beverly Member, which represents the lower part of the Ellensburg in the Sentinel Gap area, is as thick as 300 feet.

The Yakima Basalt is late Miocene and early Pliocene in age, as determined from the flora and fauna in the underlying Mascall Formation in Oregon, the intrabedded sedimentary rocks and the interbedded and overlying Ellensburg Formation.

INTRODUCTION

The stratigraphy of a thick series of outwardly monotonous basalt flows in the Columbia Plateau has been studied in the past to determine the geologic structure as it affects engineering and ground-water projects. Whether the project is an areal ground-water study or a relatively localized engineering investigation, the presence or absence of anticlines, synclines, faults, unconformities, interbedded sedimentary deposits, and other features must be known before sound geologic interpretations can be made. U.S. Bureau of Reclamation geologists and consultants noted about 1940 that some basalt flows in the Columbia Basin Irrigation Project area had distinctive characteristics which enabled them to be mapped. Grolier and Foxworthy (1961) mapped two basalt units in the Moses Lake North quadrangle. The names for units in the upper 1,200 feet of the Yakima Basalt and the overlying and interbedded Ellensburg Formation are herein briefly described in an effort to summarize the stratigraphic nomenclature. A résumé of the nomenclature used in this paper is given in figure 1.

COLUMBIA RIVER GROUP

Only the upper formation of the Columbia River Group, the Yakima Basalt, is exposed in south-central Washington (fig. 2). In northeastern Oregon the group also includes older rocks assigned to the Picture Gorge Basalt by Waters (1961, p. 607).

YAKIMA BASALT

The Yakima Basalt was named and defined by Smith (1901, p. 15) to describe "the great series of [flood] lavas * * * which covered the vast area between what is now the crest of the Cascade Mountains on the west and the mountains of Idaho on the east, and between the mountains of northeastern Washington on the north and the Blue Mountains of Oregon on the south." Smith restricted the name to that part of Russell's Columbia Lava (1893, p. 21; 1897, p. 40) which is of Miocene age. The name Yakima Basalt has been subsequently used by Calkins (1905), Waring (1913), and Schwennesen and Meinzer (1918), and many others.

In 1961, Waters (p. 607) considered the Yakima Basalt to be the upper formation of the Columbia River Group. He also confirmed (p. 606) the validity of Smith's definition of the formation but extended the time of eruption of the Yakima Basalt flows to early Pliocene (p. 608), an age indicated by flora and fauna preserved in continental sedimentary deposits of the Ellensburg Formation and in beds which interfinger with or overlie Yakima flows near the margin of the Plateau. The age of the Yakima Basalt is late Miocene and early Pliocene (Fiske and others, 1963, p. 63).

The Yakima Basalt includes individual lava flows, many of which are of great lateral extent. The general appearance is monotonous, but several flows have characteristics that make them distinctive. Among these characteristics are chemical composition; mineralogy; color; texture; degree of crystallization; hardness; porosity; number, shape, and size of vesicules; thickness; breakage habits; type and spacing of joints; alteration; permeability; and the presence of spiracles and pillow zones. Taken separately, no single feature permits the lateral tracing of individual flows, but the consistent association of several of the characteristics in one flow, when considered in relation

SYSTEM	SERIES	GROUP	FORMATION	MEMBER AND BED	LITHOLOGY AND THICKNESS
TERTIARY	Pliocene		Ellensburg Formation	Ellensburg Formation undifferentiated	Ellensburg Formation undifferentiated: 1800 ft of pebble conglomerate, sand, and mudflows; upper 500 ft basaltic and contains coarse brown sand; remainder andesitic, with beds of fine ash in lower part
	Miocene or Pliocene			Beverly Member	Beverly Member: As much as 300 ft of pumicite, quartzite-bearing conglomerate, and tuffaceous sand, silt, and clay
		Columbia River Group	Yakima Basalt	Saddle Mountains Member	COLUMBIA RIVER GROUP Yakima Basalt: Saddle Mountains Member: One or more basalt flows; total thickness as great as about 400 ft. Basalt is black to light gray, dense, fine to very fine grained; some flows are sparsely porphyritic. Small columns or hackly jointing are common, but some flows are composed of agglomerate or pillows in places
	Miocene			Priest Rapids Member	Priest Rapids Member: Four basalt flows; total thickness as great as 220 ft. Basalt is grayish black where fresh, mottled greenish brown where weathered; coarse grained and nonporphyritic. Very large columns as much as 10 ft in diameter are common
				Quincy Diatomite Bed	Quincy Diatomite Bed: Diatomite as thick as 35 ft; contains a few lenses of silt and clay
				Roza Member	Roza Member: Two basalt flows; total thickness as great as 200 ft. Basalt is dark blue gray or dark reddish gray where fresh; weathers deep red brown; coarse grained and porphyritic. Phenocrysts are not numerous but are present in nearly all outcrops. Phenocrysts are lath shaped and average 1 cm in length. Large columns which break into plates and chips are common
				Frenchman Springs Member	Frenchman Springs Member: As many as six flows; total thickness as great as 375 ft. Basalt is dark gray to black, medium to fine grained, and sparsely porphyritic. Phenocrysts are roughly equidimensional, shattered, yellowish white, and average 1 cm in diameter. Some large columns are present, but irregular jointing is common. Pillow zones are common in lowermost flow
				Squaw Creek Diatomite Bed	Squaw Creek Diatomite Bed: Diatomite as thick as 17 ft; grades westward to sandstone, fine conglomerate, siltstone, or clay
				Vantage Sandstone Member	Vantage Sandstone Member: Sandstone, as thick as 35 ft. Blue or green where fresh, pale yellow where weathered. Consists of medium-grained quartz-feldspar-mica sand, or a tuffaceous sand, silt, and clay
				Lower basalt flows	Lower basalt flows: Total thickness generally more than 1000 ft. Basalt is dark gray, fine grained, and well jointed. Columns 1-2 ft in diameter are common. Pillows and spiracles more common than in overlying basalt members

FIGURE 1.—Composite stratigraphic sequence in the northwestern Columbia Plateau.

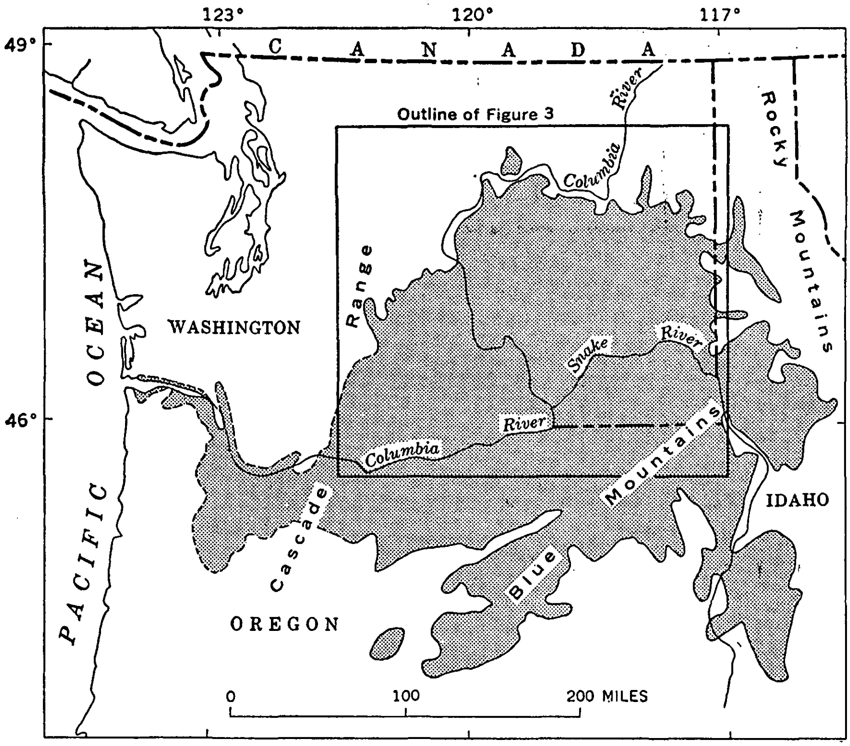

FIGURE 2.—Areal extent (stippled) of the Columbia River Group in the northern part of the Columbia Plateau. (After Waters, 1961.)

to those of the overlying and underlying flows, is sufficient for stratigraphic identification of some flows over many tens of miles.

The maximum thickness of the Yakima Basalt is not known because the base of the formation is exposed only in scattered outcrops near the margin of the Columbia Plateau. About 40 miles from the margin of the plateau, in the Odessa area, however, an oil test well has penetrated 4,465 feet of basalt, 202 feet of sand and shale, and 15 feet of granite. Smith (1901, p. 15–16) stated that "more than 2,500 feet [of basalt] is exposed in vertical section in the canyon of the Yakima River, and as the section [there] includes neither the top nor the base of the lava series, the real thickness may possibly approximate that along Snake River * * * Canyon, where 3,000 feet of lava is exposed * * *."

The exposures of Yakima Basalt in the Yakima River canyon between Ellensburg and Selah (fig. 3) are generally considered typical, and that area has been designated the type area (Mackin, 1961, p. 4, from Smith, 1901, p. 15) even though the complete sequence of flows is not present. Only the upper 1,200 feet of the Yakima Basalt has

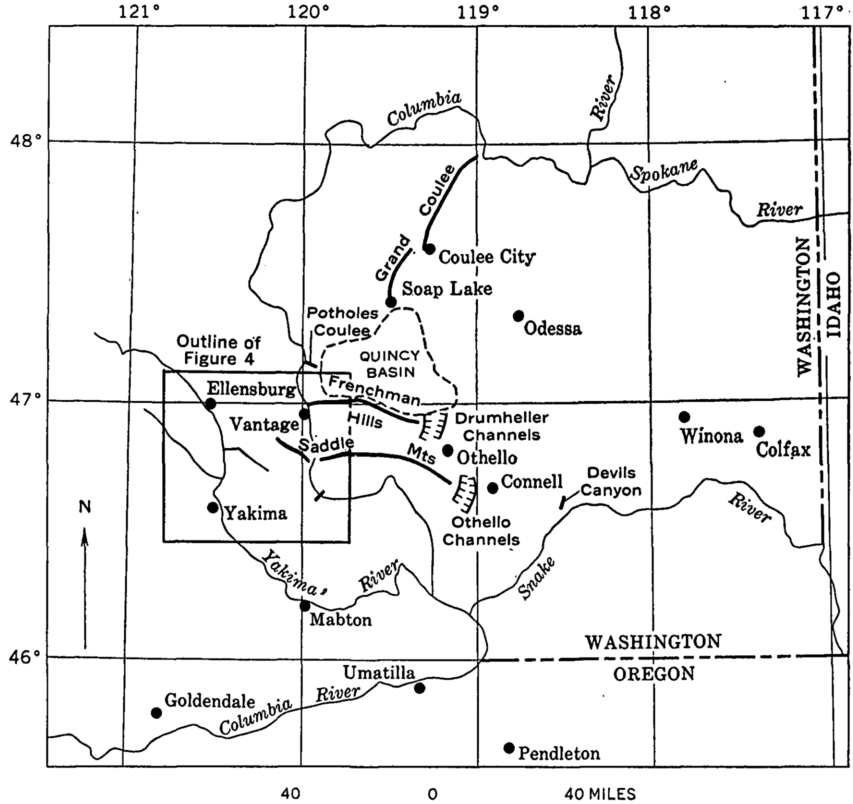

FIGURE 3.—Location of towns and physiographic features.

been extensively mapped and formally named. This paper describes only the Vantage Sandstone Member and the overlying members, as well as the lower part of the Ellensburg Formation, which is interbedded with the uppermost basalt member. The thick sequence of largely unnamed flows below the Vantage Sandstone Member is exposed only in the deepest gorges. The first few flows below the Vantage appear to be at least as extensive as the upper sequence. The flows have characteristics that make them distinguishable from the overlying sequence. Among these characteristics are smaller columns, different shape and type of vesicles, more spiracles, and more pillow zones.

The thickness and number of flows within the basalt members overlying the Vantage Sandstone Member differ from place to place. One of the reasons for the differences is the accumulation of more flows near the center of the plateau, where subsidence continued during ex-

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trusion of the basalt. The individual members have been mapped in only part of the Columbia Plateau; so, their total extent is not known. The members that constitute the upper 1,200 feet of Yakima Basalt are briefly described in the pages that follow:

VANTAGE SANDSTONE MEMBER

The Vantage Sandstone Member was named by Mackin (1961, p. 12) from exposures in roadcuts along old U.S. Highway 10, at the mouth of Schnebly Coulee in the SE¼NW¼ sec. 19, T. 17 N., R. 23 E., 1 mile west of the old Vantage bridge (fig. 4). The member consists of a distinctive medium, friable, quartz-feldspar-mica sand, or of a weakly cemented tuffaceous sand, silt, or clay containing hornblende. At most places, the arkosic sand is overlain by tuffaceous sedimentary rocks. Poorly preserved carbonized twigs and plant impressions commonly occur in a black earthy zone near the top of the tuffaceous unit. The member is oxidized to pale yellow where exposed and is reported as blue or green in the subsurface by water-well drillers.

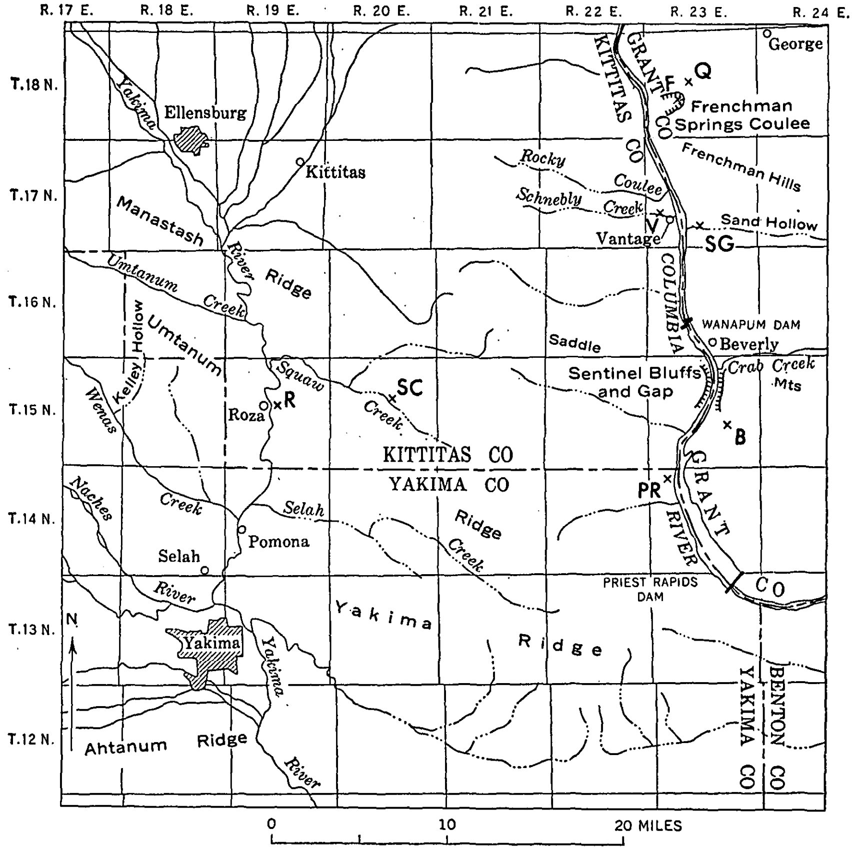
The Vantage Sandstone Member is about 35 feet thick in the Vantage–Priest Rapids area and thins northeastward to about 2 feet near the Bacon siding, approximately 10 miles northeast of Soap Lake.

FRENCHMAN SPRINGS MEMBER

Mackin (1961, p. 12–21) named and described the Frenchman Springs Member from excellent exposures in Frenchman Springs Coulee (fig. 4), where two flows and the Squaw Creek Diatomite Bed are present.

BASALT FLOWS

The Frenchman Springs Member contains two to six basalt flows. Of these, the three flows comprising the member in the Vantage–Sentinel Gap area were named for nearby localities. The lowermost flow, the Gingko, was named by Mackin (1961, p. 13–14) after the Gingko Petrified Forest; its type locality is in the lower part of Schnebly Coulee west of Vantage (fig. 4). The overlying Sand Hollow flow was named (Mackin, 1961, p. 15–17) for a tributary valley on the east side of the Columbia River valley nearly opposite Vantage; its type locality is in the cliff exposures just north and south of the tributary mouth (fig. 4). The uppermost flow in this area is the Sentinel Gap flow (Mackin, 1961, p. 17–21), named for the water gap through the Saddle Mountains. Its type locality is immediately south of the mouth of Sand Hollow. This flow terminates about 2 miles north of Sand Hollow and therefore is not present in Frenchman Springs Coulee. The three flows and additional unnamed flows exposed east of Connell make up the member within central Washington.



TYPE SECTIONS

B	Beverly and Saddle Mountains Members	SC	Squaw Creek Diatomite Bed
PR	Priest Rapids Member	SG	Sand Hollow and Sentinel Gap flows
Q	Quincy Diatomite Bed	V	Vantage Sandstone Member and Gingko flow
R	Roza Member		
F	Frenchman Springs Member		

FIGURE 4.—Location of type sections (x) of Yakima Basalt.

The Frenchman Springs basalt is dark gray to black, medium to fine grained, and sparsely porphyritic; it consists of plagioclase, monoclinic pyroxene, olivine, opaque minerals, and a large quantity of glass (Waters, 1961, p. 602, sample 10). The plagioclase phenocrysts occur as single crystals or in clusters and are usually equidimensional, ¼–½ inch in diameter. These phenocrysts are unevenly distributed—accumulations may occur anywhere in the flow. The concentration of crystals ranges from several per square foot to one in several square yards.

At Frenchman Springs Coulee, the Frenchman Springs Member is about 250 feet thick; it is thinner to the north and northeast. South of Vantage, where the Sentinel Gap flow is present, the total thickness increases to about 375 feet, and this thickness appears to be consistent eastward.

The basal part of the Frenchman Springs Member consists of a widespread zone of pillows and palagonite that is 50–75 feet thick in the Vantage–Priest Rapids area. This part of the member is best exposed in a highway cut at the junction of Sand Hollow and the Columbia River valley. The pillow-palagonite zone has been traced northeast into lower Grand Coulee, 4 miles north of Soap Lake, where it is 20 or 30 feet thick. In places the zone contains much petrified wood that occurs as logs lying partly or entirely embedded between pillows or in palagonite. Nearly everywhere the zone is buried under talus.

SQUAW CREEK DIATOMITE BED

A bed of diatomite, which rests on the basalt of the Frenchman Springs Member, was named the Squaw Creek diatomite by Mackin (1961, p. 21) for exposures in the Squaw Creek drainage basin (fig. 4). He interpreted the diatomite as having been "deposited in a lake impounded by the Sentinel Gap flow * * *"; on this basis he considered it equivalent to a part of the Frenchman Springs Member. This classification is used herein, and the unit is designated the Squaw Creek Diatomite Bed.

The easternmost known exposure of the Squaw Creek Diatomite Bed is in Frenchman Springs Coulee. In the Squaw Creek drainage basin, the bed is 5–17 feet thick; it grades westward into sandstone and pebble conglomerate composed partly of tuffaceous and partly of granitic detritus (Mackin, 1961, p. 21). In places where the Squaw Creek is not present, silicified wood or odd-shaped siliceous concretions mark the contact between the Frenchman Springs Member and the overlying Roza Member.

ROZA MEMBER

The Roza Member consists of two unnamed flows. The lower flow apparently is continuous over an area of thousands of square miles. This flow constitutes the Roza Member as defined by Mackin (1961, p. 21–23) in the Columbia River valley near Sentinel Gap and in the Yakima River canyon where he chose its type locality as "a scarp on the east side of the Yakima River opposite Roza Station * * *." (Roza station is a railroad siding in the canyon of the Yakima River between Ellensburg and Yakima (fig. 4).) This flow is a key stratigraphic marker throughout the Columbia Basin Irrigation Project area.

The lower flow of the Roza Member is relatively uniform in thickness and composition; it has been identified as far north as Coulee City in the Grand Coulee, as far south as Pendleton, Oreg., as far west as the vicinity of Goldendale, and as far east as Colfax, an area of over 20,000 square miles. The basalt is dark blue gray and weathers to a deep red brown, is medium to coarse grained and porphyritic, and contains plagioclase, monoclinic pyroxene, iron-rich olivine, opaque minerals, and glass (Waters, 1961, p. 602, sample 8). The phenocrysts are light-yellow or transparent plagioclase crystals that are lath shaped and average about 1 cm in length and 0.5 cm in thickness. The phenocrysts are uniformly distributed throughout the flow, averaging about five crystals per square foot.

The key lower flow is columnar through most of its thickness. The columns are 5–10 feet in diameter and tend to break into slabs and chips along platy joints normal to the columns. In many places these horizontal platy zones grade upward into a zone of swirling plates which characterize the upper part of the columns. Wherever the platy parting is well developed, the basalt is coarser grained than average, and plagioclase phenocrysts appear dark in the groundmass.

Overlying the lower flow from the Drumheller Channels and Connell eastward into most of Whitman County as far as Colfax is a dark-reddish-gray porphyritic flow. This overlying flow contains feldspar phenocrysts similar to those in the underlying flow; therefore, it is considered a part of the Roza Member (Bingham and Walters, 1965, p. 89). The reddish-gray flow ranges in thickness from 55 to about 100 feet and is well exposed in Washtucna Coulee east and west of Devils Canyon.

In central Whitman County near Winona, many outcrops expose porphyritic cinders that have thin stringers of the upper Roza flow interbedded with them. These outcrops of cinders are considered to represent cones formed around multiple vents that provided lava for the upper Roza flow. In the floor of a scabland channel in the NW¼SE¼ sec. 10, T. 17 N., R. 39 E., the flow dips radially from a central cinder area.

The average thickness of the Roza Member on the east wall of the Columbia River canyon, where only the key flow is present, is 110 feet. The flow thins abruptly north of Potholes Coulee and gently along Upper Crab Creek valley. The member is over 200 feet thick in the Drumheller Channels, where both flows are present.

PRIEST RAPIDS MEMBER

Mackin (1961, p. 23–26) recognized four flows overlying the Roza Member at Priest Rapids Dam and named them the Priest Rapids Basalt Member. He designated the area upstream from the Priest

Rapids Dam (fig. 4) the type area and stated that flows occur there "in a south-dipping homocline on the west side of the reservoir." The Priest Rapids Member consists of the Quincy Diatomite Bed and four basalt flows.

QUINCY DIATOMITE BED

In part of the area, a bed of diatomite separates the Roza Member from the basalt of the overlying Priest Rapids Member. This diatomite was designated the Quincy diatomite by Mackin (1961, p. 25–26), because of its many exposures in the southwestern part of the Quincy Basin (fig. 3), near Frenchman Springs Coulee (fig. 4). Mackin (1961, p. 26), stated "On the assumption that the Quincy lake [in which the Quincy diatomite was deposited] was impounded by one Priest Rapids flow and destroyed by another, the Quincy diatomite is considered to be a part of the Priest Rapids Basalt Member." It is herein designated the Quincy Diatomite Bed of the Priest Rapids Member. The area of many quarry exposures in the southwestern part of the Quincy Basin near the head of Frenchman Springs Coulee (S½ sec. 16; SE¼ sec. 17; NE¼ sec. 20; and N½ sec. 21, T. 18 N., R. 23 E.) is designated the type area.

The Quincy Diatomite Bed is as much as 25 feet thick in the southwestern part of the Quincy Basin and as much as 35 feet thick on the south slope of the Frenchman Hills. The Quincy varies laterally, not only in the thickness of the diatomite, but also in the occurrence of silt and clay lenses, layers of banded opal, and pieces of opalized wood. Northward and eastward from the type area the Quincy generally thins and may range locally from a few inches to about 6 feet.

The lake or lakes in which the Quincy Diatomite Bed accumulated must have been extensive. Even in areas where diatomite is absent at the base of the Priest Rapids Member, a zone of pillows and palagonite breccia as much as 10 feet thick is present. Many trees growing along the shore or floating in Lake Quincy were engulfed by the first flow of the Priest Rapids Member. These trees are now petrified logs or stumps, some in an upright position, within the pillow-palagonite zone.

BASALT FLOWS

Basalt of the Priest Rapids Member is grayish black, medium to coarse grained, and nonporphyritic, although some flows contain small phenocrysts easily noted in thin sections. Owing to a slightly diktytaxitic texture (Mackin, 1961, p. 23), basalt of the Priest Rapids Member weathers easily. Where freshly broken, a sample has a distinctive greenish cast, caused by altered saponite and chlorophaeite; where weathering has advanced, the basalt is mottled brown, and the outer surface is a distinctive red brown. Spheroidal weathering appears to be more common in the Priest Rapids than in other members.

According to Waters (1961, p. 602, sample 9), this basalt contains plagioclase, monoclinic pyroxene, olivine, glass, opaque minerals, and various decomposition products. The olivine-saponite content (12.5 percent) is the largest of all samples from the Yakima Basalt reported by Waters. The percentage of glass (5.5 percent) is less than one-third that in the Roza Member and less than one-fifth that in the Frenchman Springs Member.

The four flows of the Priest Rapids Member numbered by Mackin (1961, p. 23) at the Priest Rapids damsite have a total thickness of 220±25 feet there. The member appears to thin northward and eastward and thickens to the south near Mabton.

SADDLE MOUNTAINS MEMBER

In the Ellensburg quadrangle, Smith (1903) originally named the basalt flow intertongued with the Ellensburg Formation the Wenas Basalt. More recently, Waters (1955, p. 673) found that "The Wenas basalt continues eastward from Smith's area [in the southeastern part of the Ellensburg quadrangle] into the Yakima East quadrangle." Waters (p. 673) also identified two other flows, the Elephant Mountain flow and the Selah Butte flow, that were interstratified with the Ellensburg Formation at higher stratigraphic levels than the Wenas Basalt.

On the basis of general lithologic similarity, the name Wenas Basalt, used by Smith (1903, p. 4) for flows in his Ellensburg Formation, was used for similar rocks in the Sentinel Gap–Saddle Mountains area by Taylor (1948, pl. 1) in his open-file report on the Columbia Basin Irrigation Project area. Because the formations are not mapped across the intervening distance, the Vantage–Priest Rapids area is considered separate from the Yakima River valley, and the name Saddle Mountains Member of the Yakima Basalt is hereby assigned to all the basalt flows overlying the Priest Rapids Member in the Sentinel Gap area. At the type locality of the Saddle Mountains Member, southeast of Sentinel Gap (fig. 4), it consists of one flow (Mackin, 1961, p. 26).

One of the Saddle Mountains flows (the Pomona flow) and the underlying vitric tuff (a part of the Beverly Member) exposed on the Saddle Mountains have recently been correlated by Schmincke (1965, p. 275) with the basalt and sedimentary rocks mapped by Smith (1903, 1904) in the Ellensburg and Mount Stuart quadrangles, and by Waters (1955) in the Yakima East quadrangle. Also, reconnaissance observations along Wenas Valley have revealed that in Kelley Hollow, Smith

(1903) included basalt of the Frenchman Springs Member with that mapped as Wenas Basalt. For these reasons, the name Wenas Basalt is abandoned, and the name Saddle Mountains Member is substituted for all flows above the Priest Rapids Member in the Yakima River valley.

Field reconnaissance, eastward and southward from Sentinel Gap, suggests that the Saddle Mountains Member includes several previously unrecognized flows, rather than a single flow overlying the Beverly Member of the Ellensburg Formation as in the type section. Well drillers' logs also show that the Beverly Member is discontinuous laterally so that the Saddle Mountains Member rests disconformably on the Priest Rapids or Roza Member rather than on the Beverly Member in parts of south-central Washington. The basalt of the Saddle Mountains Member is petrochemically similar to the basalt of the Priest Rapids Member and is probably a continuation of the same great outpouring of basaltic lava as the rest of the Yakima Basalt (Waters, written commun., 1963). For this reason, the Saddle Mountains Basalt Member of Mackin (1961, p. 31), considered by him to be a part of the Ellensburg Formation, is herein renamed the Saddle Mountains Member and is reassigned to the Yakima Basalt, regardless of whether it overlies or is intercalated in the Beverly Member of the Ellensburg Formation.

At its type locality the single Saddle Mountains basalt flow is black, dense, very fine grained, and sparsely prophyritic. The flow is characterized by narrow, splintery columns and by hackly jointing in the entablature of the flow, and these characteristics may be so well formed that the colonnade is almost absent.

Much of the basalt is vesicular, the small spherical vesicles being 1–2 mm in diameter. Most of the Saddle Mountains basalt flows range from black and hackly to light or dark gray and columnar. In some places, however, a flow may consist of an agglomerate of reddish subangular pebble- and cobble-size fragments.

Apparently at least one of the flows contains sparse large phenocrysts similar in appearance to those in the Frenchman Springs Member. Also, several flows have distinctive small transparent lath-shaped plagioclase phenocrysts 2–4 mm long that are uniformly distributed through the flow six or more per square inch.

Flows of the Saddle Mountains Member have been identified north to the Frenchman Hills, eastward almost to Connell, southward to Umatilla, and westward to the Yakima area. In the central part of this area as many as four flows have been identified.

ELLENSBURG FORMATION

The Ellensburg Formation (Smith, 1901, p. 17–22; 1903, p. 2–3; 1904, p. 7; Waring, 1913, p. 19–21; Axelrod, 1950, p. 239–243; Waters, 1955, p. 670–673; Mackin, 1961, p. 26–36; Smiley, 1963, p. 169) is composed of 2,000± feet of continental pyroclastic and sedimentary deposits that interfinger with the uppermost part of the Columbia River Group—the Saddle Mountains Member of the Yakima Basalt—in the northwestern part of the Columbia Plateau. In a report describing the geologic features of a part of Yakima County, Smith (1901, p. 17) said that "Lying directly upon the [Yakima] basalt is the sedimentary series to which the name Ellensburg formation has been given." Smith was following a usage introduced earlier by Russell (1900, p. 127), who said that the Ellensburg sandstone of the Kittitas Valley "rests on a sheet of lava." Smith, however, qualified his statement by adding that "in the larger part of the North Yakima area * * * some of these sediments were laid down before the eruption of the last flow of the basaltic lava * * *."

According to Foxworthy (1962, p. 19), the age of the mollusks and vertebrates indicates that "the main body of the Ellensburg formation probably was deposited entirely during the Pliocene epoch * * * [and] the uppermost flows of the main body of the Yakima basalt probably are of early Pliocene age." On the basis of fossil evidence, Smiley (1963, p. 206) has determined the age of the Ellensburg Formation to range from late Miocene to early Pliocene.

BEVERLY MEMBER

The Beverly Member at the type locality southeast of Sentinel Gap (fig. 4) in the NW¼ sec. 23, T. 15 N., R. 23 E. (Mackin, 1961, p. 26) consists of beds of quartzite-bearing conglomerate, pumicite, and tuffaceous sand, silt, and clay. At Sentinel Gap, the quartzite-bearing conglomerate and the pumicite compose about 160 feet of the total 300 feet. The member is known to extend eastward as far as the Drumheller and Othello channels and southward as far as Umatilla. In the scattered outcrops the member may include basaltic fanglomerate, as well as conglomerate, pumicite, tuffaceous sand, silt, and clay. The Beverly Member may be considered a lithosome (Wheeler and Mallory, 1954, p. 929), consisting of mutually intertonguing lithostratigraphic units, any one of which may predominate or be present to the exclusion of the others at one locality. The time-stratigraphic significance of these lithostratigraphic units to one another has not been determined.

The 200± feet (Smiley, 1963, p. 169) of sedimentary deposits underlying the Saddle Mountains Member in the Yakima area was named the Selah Tuff Member of the Ellensburg Formation by Mackin (1947, p. 33). In 1961, Mackin (p. 26–31) named the 300± feet of sedimentary deposits and basalt flows under the Saddle Mountains

Member at Sentinel Gap the Beverly Member of the Ellensburg Formation. The name Beverly Member is here given to the sedimentary deposits below the top of the uppermost Saddle Mountains flow and above the Priest Rapids Member. The name Selah Tuff Member is abandoned.

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