SURFICIAL GEOLOGY, STRUCTURE, AND THICKNESS OF SELECTED GEOHYDROLOGIC UNITS IN THE COLUMBIA PLATEAU, WASHINGTON

By B. W. Drost and K. J. Whiteman

ABSTRACT

This report describes the geologic framework for the ground-water flow system in the Washington State part of the Columbia Plateau. Thickness and structure of the Grande Ronde, Wanapum, and Saddle Mountains Basalts, thickness of the interbeds between the Grande Ronde and Wanapum, and the Wanapum and Saddle Mountains Basalts, and thickness of the overburden were mapped at a scale of 1:500,000. Interpretations were based on information from about 2,500 well records using chemical analyses of core or drill chips, geophysical or geologist's logs, or driller's logs, in decreasing order of reliability. Surficial geology and surficial expression of structural features were simplified from published maps to provide maps with this information at the 1:500,000 scale.

INTRODUCTION

The Columbia River Basalt Group underlies about 25,000 square miles of Washington State. In much of the area, generally referred to as the Columbia Plateau, basalt aquifers are the principal source of water for irrigation, stock, rural domestic, and municipal use. The economy of the area is dependent, in large measure, on irrigated agriculture. In parts of the Columbia Plateau in Washington State, water users report excessive mineral deposits and a concurrent decrease in soil permeabilities in irrigated fields. In many places, this problem is attributed to the use of water that has a high sodium content relative to the calcium and magnesium content (high sodium-adsorption ratio, SAR). If the SAR is high, sodium in the water replaces calcium and magnesium in clays in the soil. As a result, soil structure is damaged and soil permeability is decreased, impeding the movement of irrigation water to plant roots.

In March 1982, the U.S. Geological Survey, in cooperation with the Washington State Department of Ecology, began a 2 1/2-year study of the Washington part of the Columbia Plateau to define spatial and temporal variations in dissolved sodium in Columbia River basalt aquifers and to relate these variations to the ground-water flow system and its geologic framework. This report describes the geologic framework, including the vertical and areal extent of the major basalt units, interbeds, and overlying materials. It is intended to serve as a base for evaluating the distribution of dissolved sodium in basalt aquifers and as a base for future water-resource studies. This work was done from the viewpoint of the hydrologist, giving consideration to the geologic information necessary to formulate a conceptual model of the ground-water flow system.

This report contains 11 sheets;

Sheet No.	Title
1	Introduction and text
2	Surficial geology
3	Structural features
4	Altitude of the top of the Grande Ronde Basalt and combined thickness of Grande Ronde Basalt and older basalts
5	Thickness of the interbed between the Grande Ronde Basalt and Wanapum Basalt
6	Thickness of the Wanapum Basalt
7	Altitude of the top of the Wanapum Basalt
8	Thickness of the interbed between the Wanapum Basalt and Saddle Mountains Basalt
9	Thickness of the Saddle Mountains Basalt
10	Altitude of the top of the Saddle Mountains Basalt
11	Thickness of the overburden

ACKNOWLEDGMENTS

The cooperation of many well owners, tenants, and well drillers who supplied information and allowed access to wells is gratefully acknowledged. Geophysical logs and associated well information for several hundred wells and drill cuttings from about 20 wells were supplied by the Geohydrology Section of the Engineering College of Washington State University. Rockwell International (Rockwell Hanford Operations) supplied information about wells on the Hanford Reservation.

PREVIOUS STUDIES

A detailed accounting of previous geologic studies of the Washington part of the Columbia Plateau was given by Myers and Price (1979). Studies that contributed directly to this study, and specific contributions are: Swanson and others (1979c), stratigraphic relationships and nomenclature for the Columbia River Basalt Group; Swanson and others (1979a and 1980) surficial geology and structural features; Caggiano and Duncan (1983) and Newcomb (1970), structural features; Swanson and others (1979b) and Myers and Price (1979 and 1981), altitudes of the tops of the Wanapum and Grande Ronde Basalts.

METHODS OF INVESTIGATION AND DATA ACCURACY

More than 20,000 well records were examined during this study, and about 2,500 were selected to make the interpretations shown in this report. Wells were chosen using the following criteria: (1) ideal minimum well density of 1 well per basalt formation per township (36 square miles), (2) inclusion of all wells with geophysical logs, geologist's logs, or chemical analyses of core or drill chips, (3) inclusion of all wells used in the Washington part of the water-level network for the U.S. Geological Survey's Regional Aquifer System Analysis of the Columbia Plateau, and (4) inclusion of all wells sampled for the sodium analysis part of this study.

The accuracy of identification of geologic units is dependent primarily on the method of identification. Where rock analyses are available, identifications are generally excellent. Designations made from geologist's lithologic logs or geophysical logs are generally good, but vary according to the complexity of the geology. Identifications made from by driller's logs are the least accurate, particularly in structurally complex areas. Geologic units in parts of Yakima County were identified by Biggane (1982) using geophysical logs.

The accuracy of altitudes of tops of geologic units depends not only on unit identification, but also on assigned land surface altitudes. Altitudes estimated for field-checked wells (those visited and plotted on topographic maps by U.S. Geological Survey personnel) are generally accurate within 10-20 feet. Land surface altitudes of surveyed wells are accurate to about 1 foot. The accuracy of land surface altitudes of non-field-checked wells varies greatly, but is generally within about 30 feet of the actual value.

Locations of field-checked data points are generally accurate to within a radius of several hundred feet of their actual location. Non-field-checked wells are generally accurate to within a radius of 1/4 mile of their actual location.

On the accompanying sheets, data-point symbols have been selected to show the level of confidence at each site regarding the site location, its land surface altitude, and the method of identification of geologic units.

GLOSSARY

Andesite - a dark-colored, fine-grained extrusive rock composed primarily of plagioclase and one or more minerals composed primarily of iron and magnesium.

Anticline - a fold, the core of which contains stratigraphically older rocks; convex upward.

Aphyric - the texture of a fine-grained igneous rock lacking phenocrysts.

Aquifer - a formation, part of a formation, or group of formations that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Basalt - a dark- to medium-dark-colored, usually extrusive, igneous rock composed chiefly of calcium-rich plagioclase, clinopyroxene, and minerals high in iron and magnesium.

Clinker - rough, jagged rock fragments formed by spalling off of partly solidified flow crusts as a flow advances or by volcanic explosions.

Clinopyroxene - a group of dark silicate minerals generally high in calcium and magnesium, iron, or aluminum, and having similar symmetry in crystal structure.

Dip - the angle that a structural surface makes with the horizontal, perpendicular to the trend of the structure.

Eolian - formed by the wind.

Fault - a surface or zone of rock fracture along which the rocks on opposite sides have moved relative to each other. A thrust (or reverse) fault is generally a compressional fault in which older material has moved upward relative to younger material.

Fluvial - produced by the action of flowing water.

Fold - a curve or bend in rock strata, usually a product of deformation.

Geophysical log - a record of some physical property of the rock material or fluid in a well.

Glaciofluvial - formed by the action of glaciers and moving water.

Holocene Epoch - geologic time extending from about 10,000 years ago to the present.

Joint - a fracture in rock strata without any displacement of the strata. A hackly joint is one with a jagged surface.

Lacustrine - formed in a lake.

Lava - molten extrusive rock-forming material.

Mesozoic Era - geologic time extending from about 225 million years ago to about 65 million years ago.

Metamorphosed - altered by heat and pressure.

Miocene Epoch - geologic time extending from about 23.5 million years ago to about 5.3 million years ago.

Olivine - an olive-green, grayish-green, or brown silicate mineral composed primarily of iron and magnesium.

Paleozoic Era - geologic time extending from about 570 million years ago to about 225 million years ago.

Permeability - the measure of the relative ease with which water can move through rock material. A property of the rock material dependent upon the shape, size, and interconnections of the openings in the material.

Phenocryst - a relatively large, conspicuous crystal in a finer grained groundmass. A microphenocryst is a phenocryst visible only under magnification, but is still relatively large compared to crystals composing the groundmass.

Phyric - containing phenocrysts.

Plagioclase - a silicate mineral composed primarily of aluminum, sodium, and calcium.

Pliocene Epoch - geologic time extending from about 5.3 million years ago to about 2-3 million years ago.

Quaternary Period - geologic time extending from about 2-3 million years ago to the present.

Shear zone - a tabular zone of rock that has been crushed, resulting in many parallel fractures due to shear strain.

Syncline - a fold, the core of which contains stratigraphically younger rocks; concave upward.

Vesicular - a rock texture characterized by abundant holes (vesicles) formed by the expansion of gases during the fluid stage of a lava.

Volcaniclastic - fragmented rock materials formed by volcanic explosion.

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Swanson, D. A., Brown, J. C., Anderson, J. L., Bentley, R. D., Byerly, G. R., Gardner, J.N., and Wright, T.L., 1979b, Preliminary structure contour maps on the top of the Grande Ronde and Wanapum Basalts, eastern Washington and northern Idaho: U.S. Geological Survey Open-file Report 79-1364, scale 1:500,000, 2 sheets.

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SURFICIAL GEOLOGY

The Columbia Plateau is that area underlain by the Columbia River Basalt Group in southeast Washington and adjacent parts of northeast Oregon and western Idaho (figure 1). It is both a structural and topographic basin with its deepest point near Pasco, Washington. The rocks that make up the plateau are primarily Miocene basalts (Columbia River Basalt Group), with minor amounts of sediments interbedded with and overlain by Miocene to Holocene sediments. Along the borders of the plateau, the basalts are underlain by Precambrian to lower Tertiary sedimentary, metamorphic, and granitic rocks. In the central part of the plateau the nature of the rocks underlying the basalts is not well known. The generalized stratigraphy of the Washington part of the Columbia Plateau, hereafter referred to as the study area, is shown in figure 2, and figure 3 on sheet 2. The surficial geology shown on sheet 2 is simplified from Swanson and others (1979a and 1980).

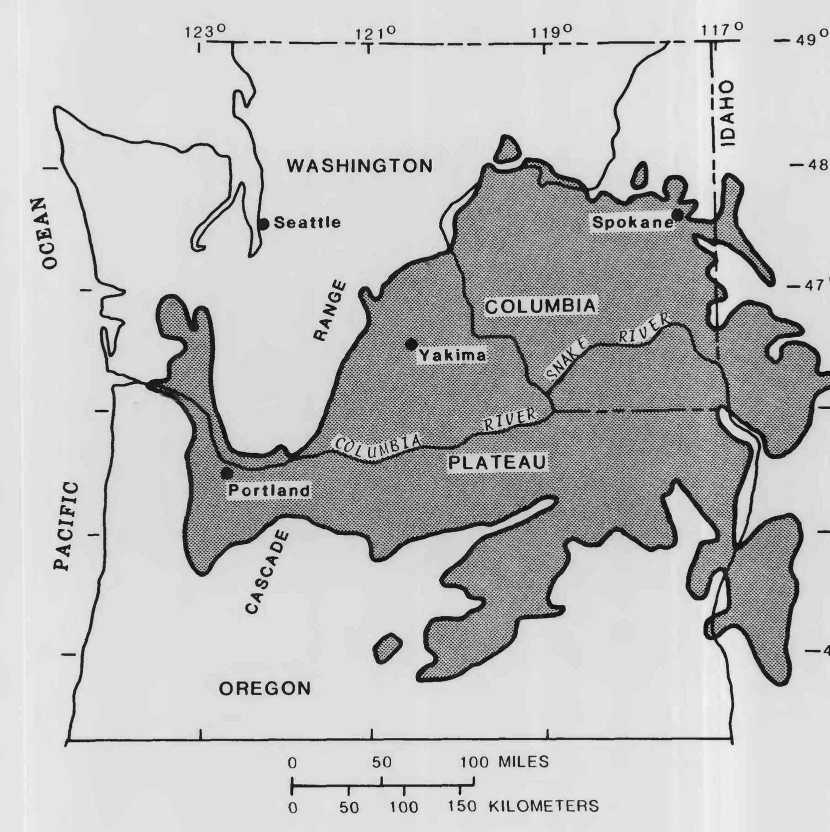


FIGURE 1.—Extent of the Columbia Plateau (After Swanson and others, 1979).

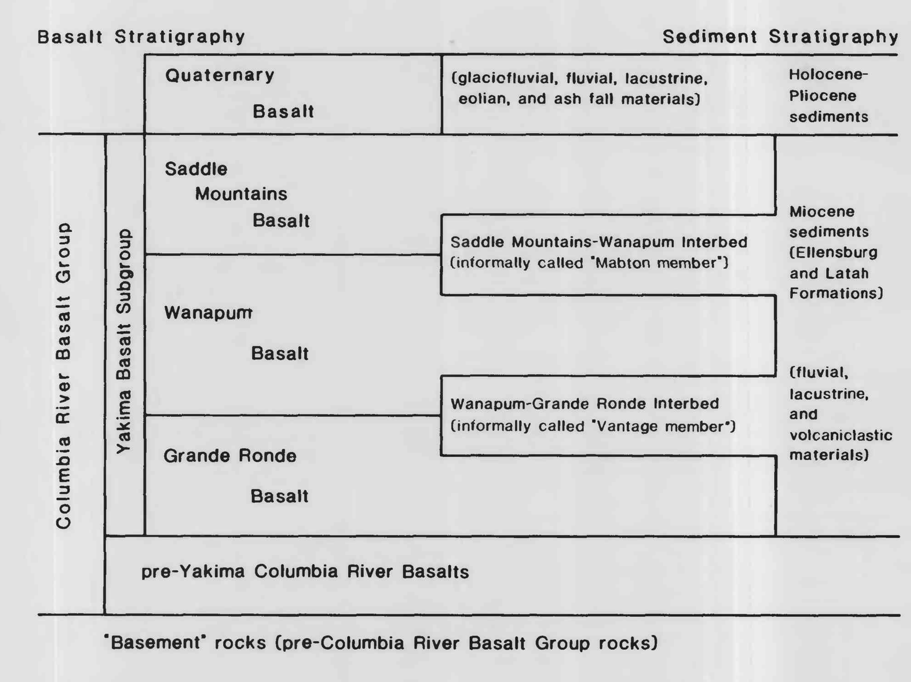


FIGURE 2.—Generalized stratigraphy of the Columbia Plateau.

The Columbia Plateau was formed from 6 to 17.5 million years ago when large volumes of lava were extruded from a system of northwest-trending linear vents in southeastern Washington, northeastern Oregon, and western Idaho. Units of hydrologic interest in the Columbia River Basalt Group are the Grande Ronde, Wanapum, and Saddle Mountains Basalts. The Grande Ronde Basalt is the oldest, underlies virtually all the study area, and is exposed along the margins of the study area and in a few deeply-incised stream channels in the central part of the area. Thickness ranges from a few feet along the northern margin, where it pinches out against "basement" rocks, to at least 4,000 feet and perhaps as much as 15,000 feet in the central and southwestern parts of the plateau.

The Grande Ronde Basalt is composed of at least 30 and perhaps as many as several hundred individual flows. Most Grande Ronde flows are aphyric with microphenocrysts of plagioclase and clinopyroxene. Olivine is generally present only in the groundmass, and generally totals less than 0.5 percent of the flow volume. Sedimentary interbeds within the Grande Ronde Basalt are rare and are generally only a few feet thick. These interbeds, and generally all interbeds in the Columbia River Basalt Group, range in composition from clay to sand and gravel. A sedimentary interbed between the Grande Ronde Basalt and the overlying Wanapum Basalt occurs in much of the study area, and is informally called the Vantage Member of the Ellensburg Formation. Where present, the Vantage Member averages about 25 feet in thickness, ranging from 0 to more than 100 feet.

The Wanapum Basalt underlies most of the study area. It is exposed, or is covered by a veneer of sediments, throughout most of the northern, eastern, and central parts of the study area. In the south-central part of the study area it is generally covered by thick sequences of sediments or by the Saddle Mountains Basalt. The Wanapum Basalt averages about 600 feet in thickness, ranging from a few feet where it pinches out against exposures of the Grande Ronde Basalt to more than 1,200 feet in the central part of the study area. The Wanapum Basalt may contain as many as 10 flows. Most Wanapum Basalt flows are medium-grained, slightly to moderately plagioclase-phyric, olivine bearing, and relatively high in iron and titanium oxides. Sedimentary interbeds in the Wanapum Basalt are more common than in the Grande Ronde Basalt, but are still rare and only a few feet thick. A sedimentary interbed between the Wanapum Basalt and the overlying Saddle Mountains Basalt occurs in some parts of the study area and is informally called the Mabton Member of the Ellensburg Formation. The Mabton Member averages about 50 feet in thickness, ranging from 0 to more than 150 feet.

The Saddle Mountains Basalt underlies the south-central part of the study area and small areas in the southeastern and east-central parts. The Saddle Mountains Basalt averages about 600 feet in thickness in the south-central part of the study area, ranging from a few feet where it pinches out against exposures of the Wanapum Basalt to more than 800 feet. In the rest of the study area it averages less than 200 feet in thickness. The Saddle Mountains Basalt flows differ greatly in texture and composition. Sedimentary interbeds in the Saddle Mountains Basalt are common and relatively thick, commonly 50 feet or greater, especially in the western part of the study area.

Individual flows within the three major basalt units range in thickness from a few inches to more than 300 feet, and generally include 2 to 6 cubic miles of basalt. The structure of an individual flow generally consists of three sections: the colonnade, the entablature, and the flow top (fig. 4). The colonnade consists of nearly vertical three- to eight-sided columns that average about 3 feet in diameter and about 25 feet in length. The columns are commonly cross-cut by systems of joints, and a vesicular zone is generally present at the base of the colonnade. The entablature consists of small-diameter (averaging less than a foot) columns in fan-shaped arrangements. Hackly joints are common, and the upper part of the entablature is commonly vesicular. The flow top (sometimes called the interflow) generally consists of vesicular basalt and clinker.

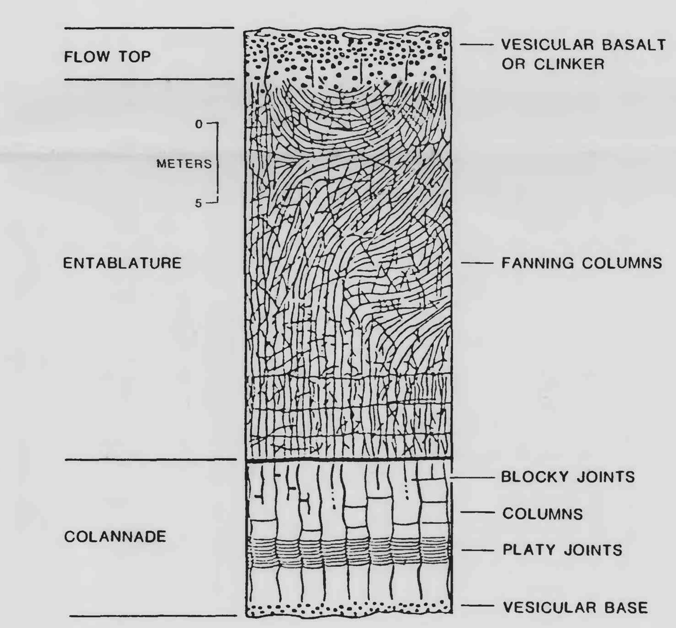
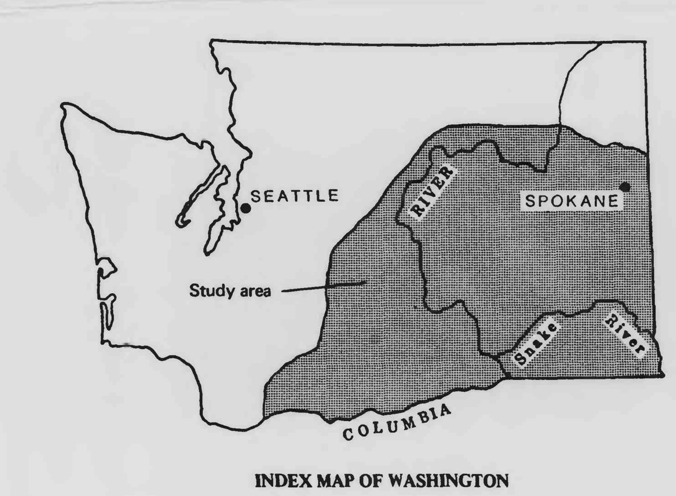


FIGURE 4.--Idealized basalt intraflow structures.

METRIC (SI) CONVERSION FACTORS

Multiply	By	To obtain
feet (ft)-------------	0.3048	meters (m)
miles (mi)------------	1.609	kilometers (km)
square miles (mi2)----	2.590	square kilometers (km2)

National Geodetic Vertical Datum of 1929 (NGVD of 1929): The reference to which relief features and altitude data of the conterminous United States and Alaska are related is the National Geodetic Vertical Datum of 1929, a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level." NGVD of 1929 is referred to as sea level in this report.



INDEX MAP OF WASHINGTON

Introduction and text

SURFICIAL GEOLOGY, STRUCTURE, AND THICKNESS OF SELECTED GEOHYDROLOGIC UNITS IN THE COLUMBIA PLATEAU, WASHINGTON

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1986

EXPLANATION

- Quaternary Sediments
- Quaternary Basalt
- Ellensburg Formation (sediments)
- Saddle Mountains Basalt
- Wanapum Basalt
- Grande Ronde Basalt
- Rocks older than Grande Ronde (primarily sedimentary and granitic rocks)

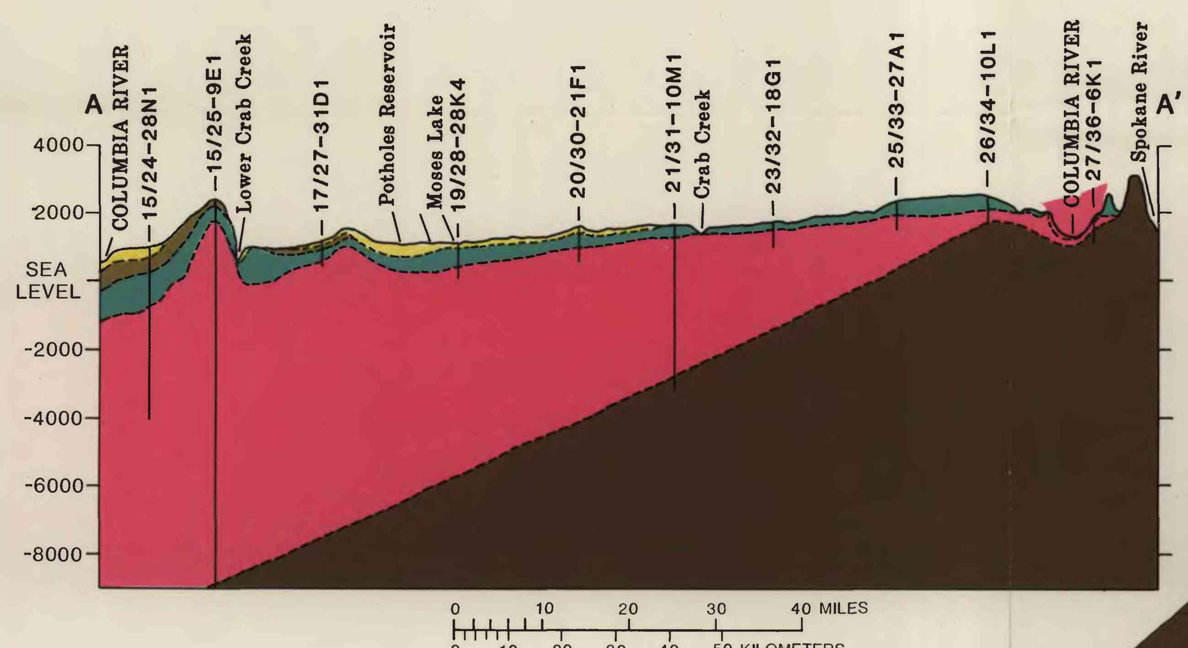
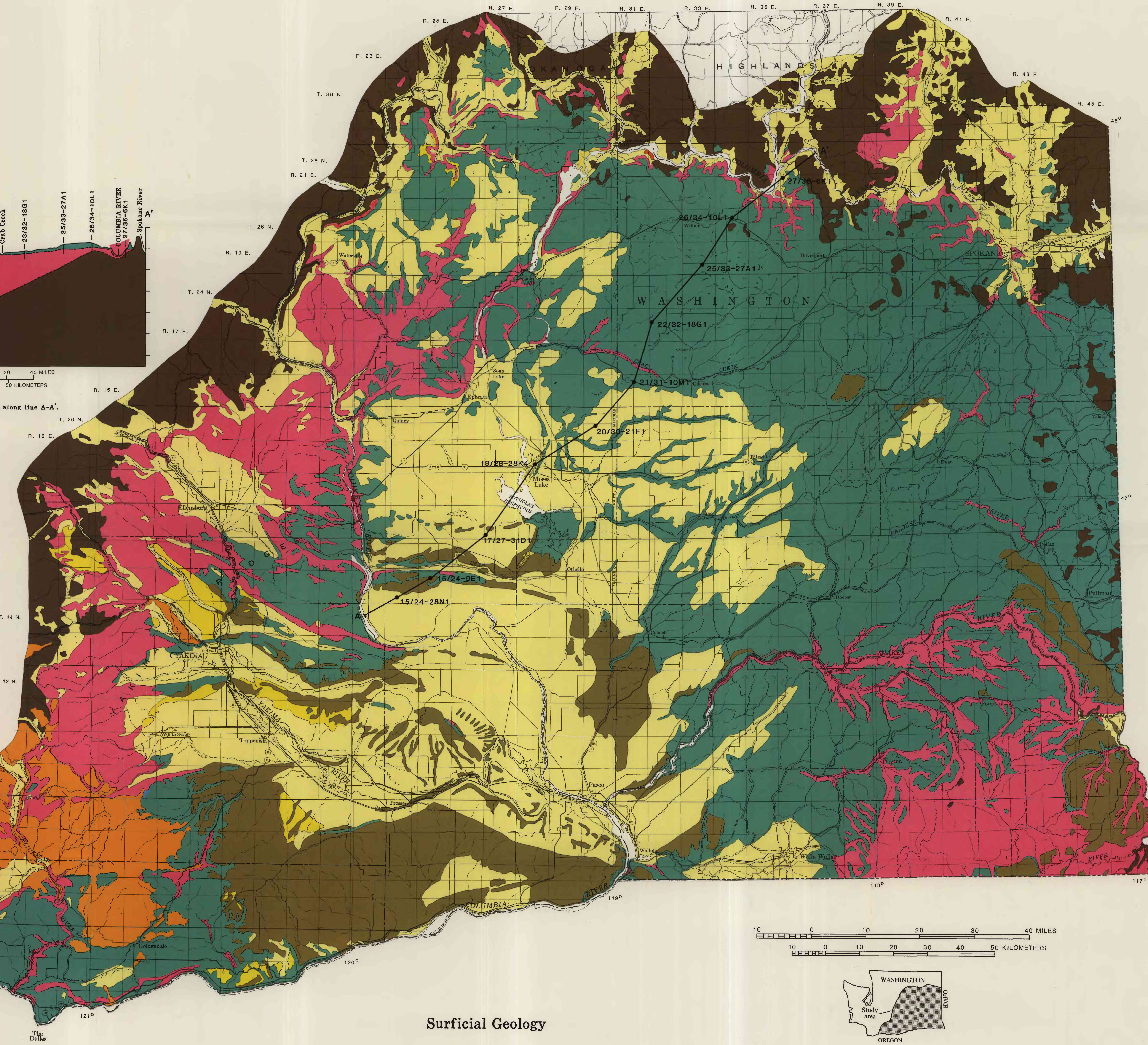


FIGURE 3.--Geologic section along line A-A'.



Surficial Geology

Base from U.S. Geological Survey
State base map, 1:500,000, 1982

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- Grande Ronde Basalt
- Rocks older than Grande Ronde (primarily sedimentary and granitic rocks)

- High-angle fault; bar and ball on downthrown side
- Thrust fault; sawteeth on upper plate
- Strike-slip fault; showing relative horizontal movement
- Anticline crestline; arrow shows direction of plunge
- Syncline troughline; arrow shows direction of plunge
- Monocline; abrupt decrease in dip in direction of arrows
- Monocline; abrupt increase in dip in direction of arrows
- Prominent regional joints
- Boundary of subprovince

STRUCTURAL FEATURES

The Washington part of the Columbia Plateau can be divided into three informally named geologic subprovinces: the Yakima Fold Belt, the Palouse, and the Blue Mountains. Descriptions of individual structural features in each subprovince can be found in Myers and Price (1979). Features shown on the map are primarily from Swanson and others (1979b), with modifications and additions from Caggiano and Duncan (1983), Tabor and others (1982), and Newcomb (1970).

Yakima Fold Belt Subprovince

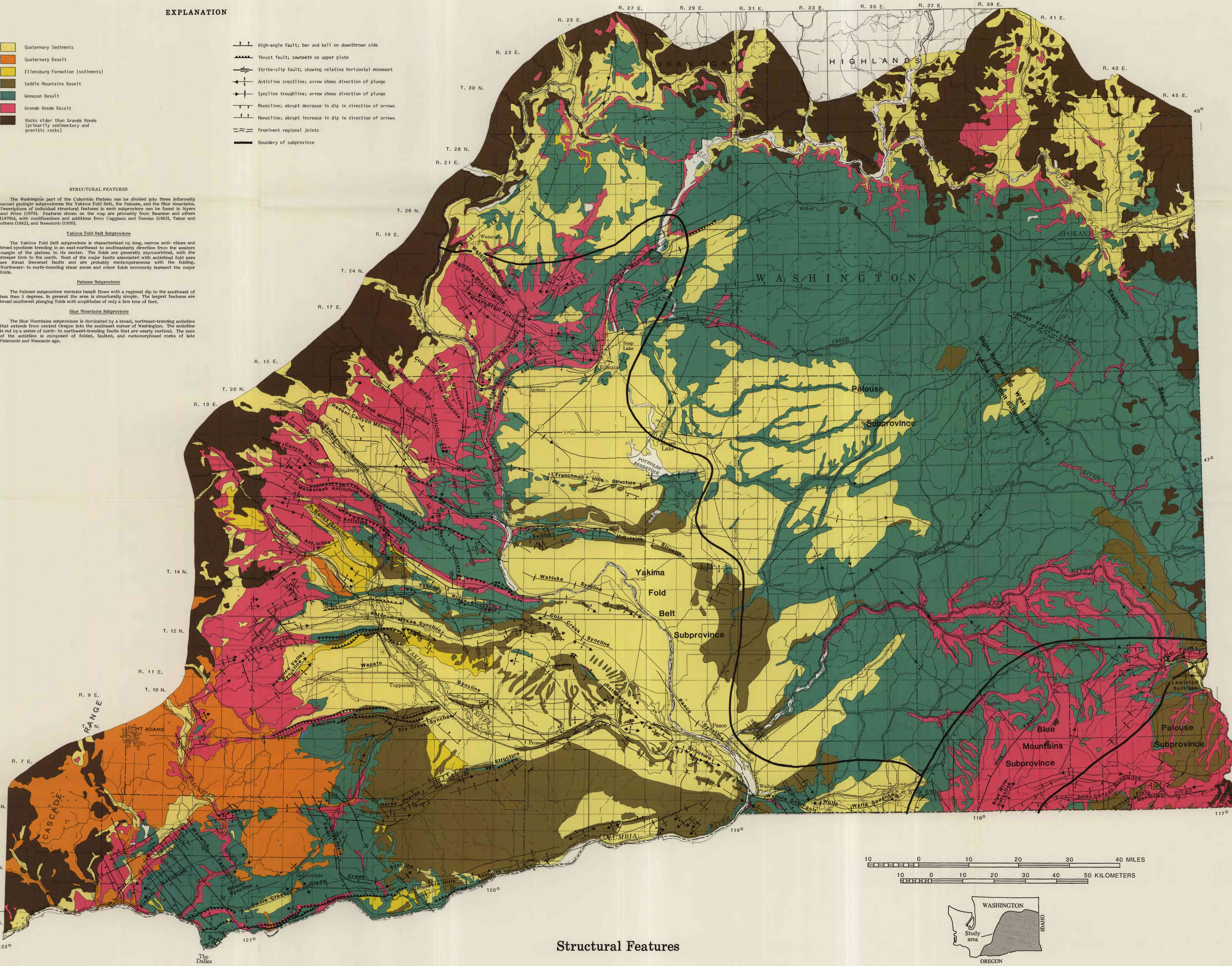
The Yakima Fold Belt subprovince is characterized by long, narrow anti- clines and broad synclines trending in an east-northeast to southeasterly direction from the western margin of the plateau to its center. The folds are generally asymmetrical, with the steeper limb to the north. Most of the major faults associated with anticlinal fold axes are thrust (reverse) faults and are probably contemporaneous with the folding. Northwest- to north-trending shear zones and minor folds commonly transect the major folds.

Palouse Subprovince

The Palouse subprovince contains basalt flows with a regional dip to the southwest of less than 5 degrees. In general the area is structurally simple. The largest features are broad southwest plunging folds with amplitudes of only a few tens of feet.

Blue Mountains Subprovince

The Blue Mountains subprovince is dominated by a broad, northeast-trending anticline that extends from central Oregon into the southeast corner of Washington. The anticline is cut by a series of north- to northwest-trending faults that are nearly vertical. The core of the anticline is composed of folded, faulted, and metamorphosed rocks of late Paleozoic and Mesozoic age.



Structural Features

Base from U.S. Geological Survey
State base map, 1:500,000, 1982

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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WATER-RESOURCES INVESTIGATIONS
REPORT 84-4326

EXPLANATION

- Quaternary Sediments
- Quaternary Basalt
- Ellensburg Formation (sediments)
- Saddle Mountains Basalt
- Wanapum Basalt

(Quaternary Basalt through Wanapum Basalt:) Grande Ronde at depth; rocks younger than Grande Ronde at land surface

- Grande Ronde Basalt — Grande Ronde Basalt at land surface
- Rocks older than Grande Ronde (primarily sedimentary and granitic rocks) — No Grande Ronde Basalt present; rocks older than Grande Ronde at land surface

Structure contours--shows altitude of top of Grande Ronde Basalt, in feet. Contour interval varies. National Geodetic Vertical Datum of 1929

Interpretation based on

- Chemical analysis of surface rock
- Chemical analysis of core or drill chips, field-checked well
- Chemical analysis of core or drill chips, non-field-checked well
- Geophysical or geologist's log, field-checked well
- Geophysical or geologist's log, non-field-checked well
- Driller's log, field-checked well
- Driller's log, non-field-checked well
- Well does not reach top of Grande Ronde Basalt

TOP OF THE GRANDE RONDE BASALT, AND COMBINED THICKNESS OF THE GRANDE RONDE BASALT AND OLDER BASALTS

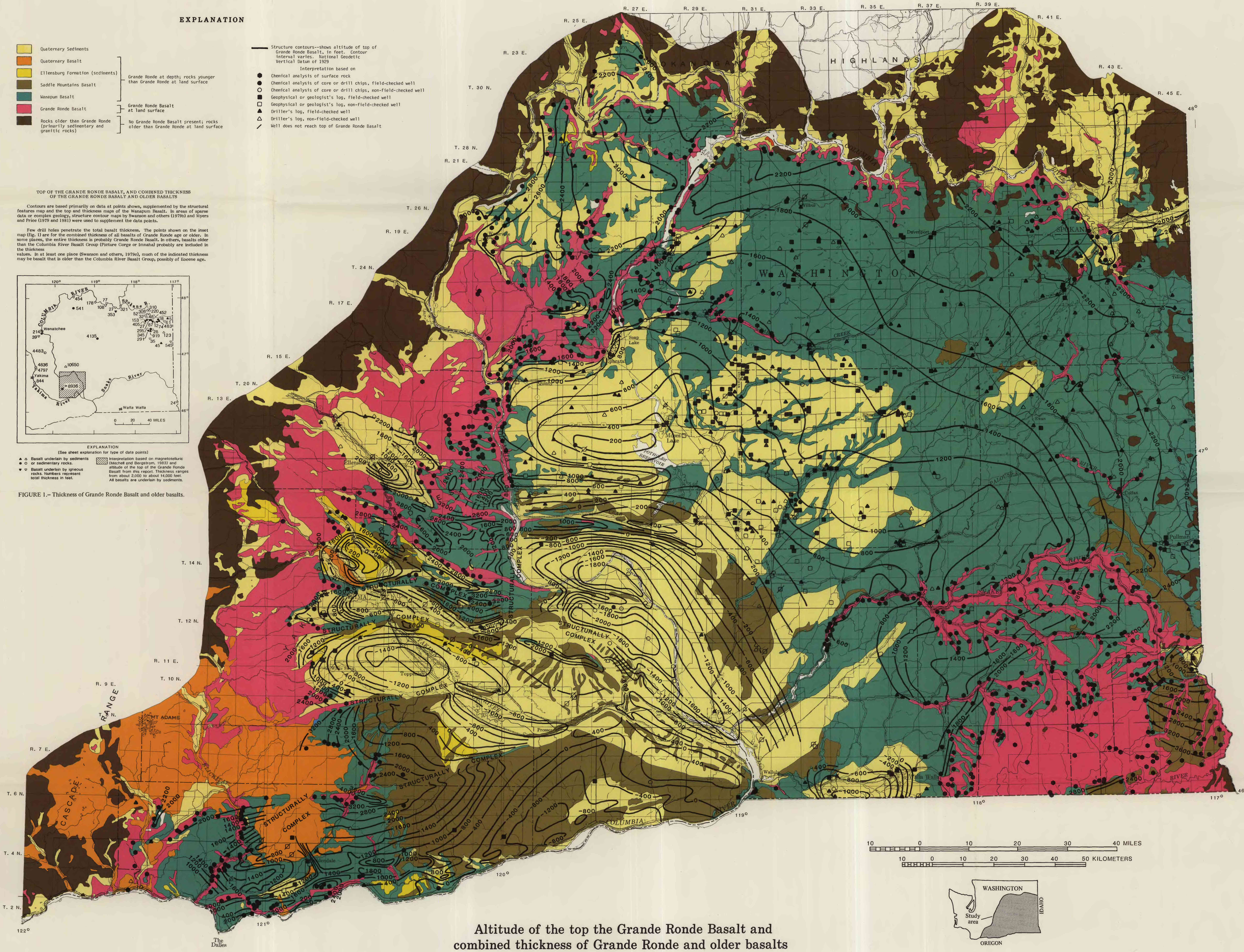
Contours are based primarily on data at points shown, supplemented by the structural features map and the top and thickness maps of the Wanapum Basalt. In areas of sparse data or complex geology, structure contour maps by Swanson and others (1979b) and Myers and Price (1979 and 1981) were used to supplement the data points.

Few drill holes penetrate the total basalt thickness. The points shown on the inset map (fig. 1) are for the combined thickness of all basalts of Grande Ronde age or older. In some places, the entire thickness is probably Grande Ronde Basalt. In others, basalts older than the Columbia River Basalt Group (Picture Gorge or Imnaha) probably are included in the thickness values. In at least one place (Swanson and others, 1979c), much of the indicated thickness may be basalt that is older than the Columbia River Basalt Group, possibly of Eocene age.

EXPLANATION
(See sheet explanation for type of data points)

- ▲ △ ● ○ Basalt underlain by sediments or sedimentary rocks.
- ▼ ▽ Basalt underlain by igneous rocks. Numbers represent total thickness in feet.
- Interpretation based on magnetotelluric (Mitchell and Bergstrom, 1983) and altitude of the top of the Grande Ronde Basalt from this report. Thickness ranges from about 2,000 to about 14,000 feet. All basalts are underlain by sediments.

FIGURE 1.– Thickness of Grande Ronde Basalt and older basalts.



10 0 10 20 30 40 MILES
10 0 10 20 30 40 50 KILOMETERS

Altitude of the top the Grande Ronde Basalt and combined thickness of Grande Ronde and older basalts

Base from U.S. Geological Survey State base map, 1:500,000, 1982

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- Wanapum Basalt

Rocks younger than Grande Ronde Basalt-Wanapum Basalt interbed at land surface

- Grande Ronde Basalt
- Rocks older than Grande Ronde (primarily sedimentary and granitic rocks)

No Grande Ronde Basalt-Wanapum Basalt interbed present; rocks older than interbed at land surface

Line of equal thickness of the Grande Ronde-Wanapum Basalt Interbed--in feet. Contour interval varies. National Geodetic Vertical Datum of 1929.

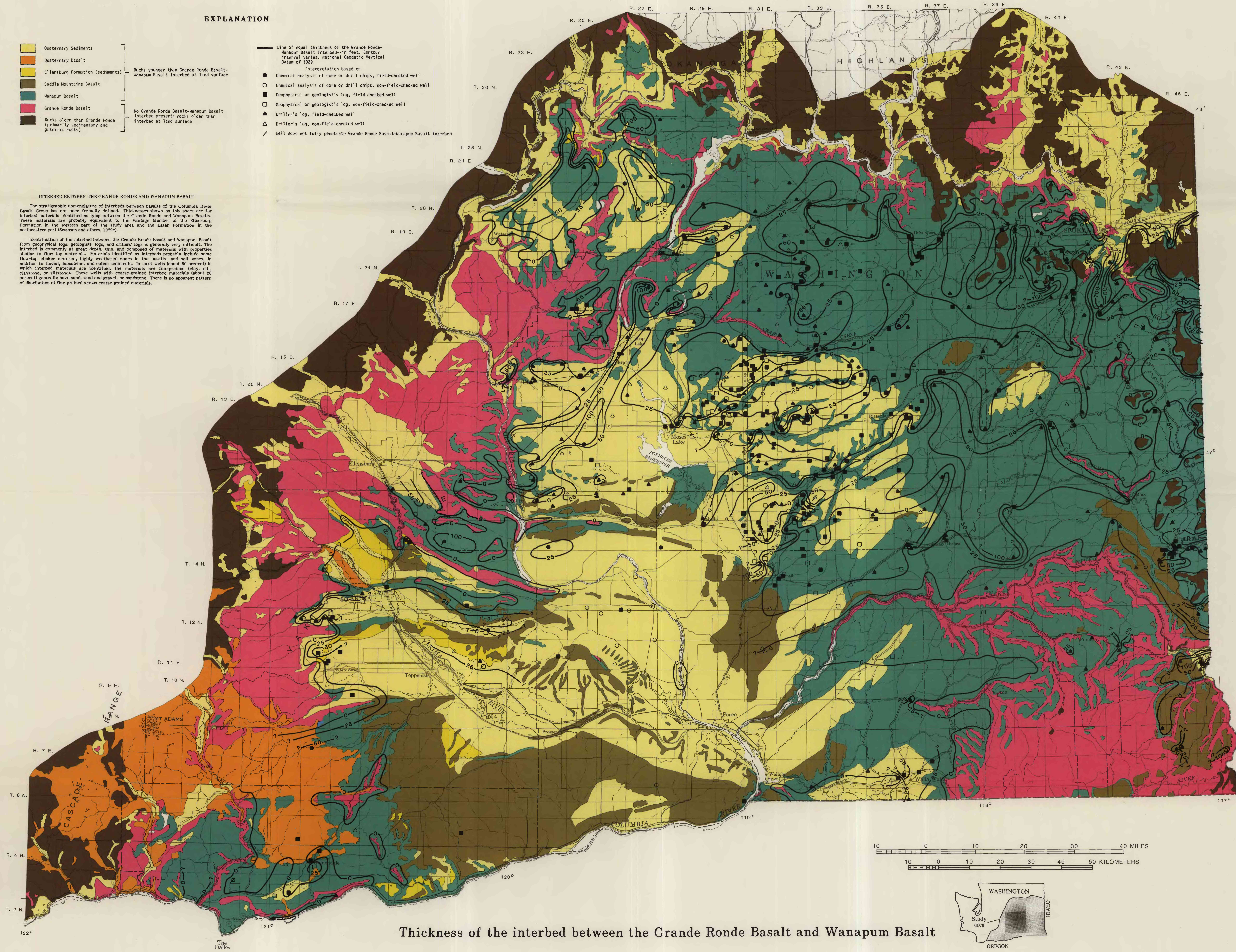
Interpretation based on

- ● Chemical analysis of core or drill chips, field-checked well
- ○ Chemical analysis of core or drill chips, non-field-checked well
- ■ Geophysical or geologist's log, field-checked well
- □ Geophysical or geologist's log, non-field-checked well
- ▲ Driller's log, field-checked well
- △ Driller's log, non-field-checked well
- / Well does not fully penetrate Grande Ronde Basalt-Wanapum Basalt interbed

INTERBED BETWEEN THE GRANDE RONDE AND WANAPUM BASALT

The stratigraphic nomenclature of interbeds between basalts of the Columbia River Basalt Group has not been formally defined. Thicknesses shown on this sheet are for interbed materials identified as lying between the Grande Ronde and Wanapum Basalts. These materials are probably equivalent to the Vantage Member of the Ellensburg Formation in the western part of the study area and the Latah Formation in the northeastern part (Swanson and others, 1979c).

Identification of the interbed between the Grande Ronde Basalt and Wanapum Basalt from geophysical logs, geologists' logs, and drillers' logs is generally very difficult. The interbed is commonly at great depth, thin, and composed of materials with properties similar to flow top materials. Materials identified as interbeds probably include some flow-top clinker material, highly weathered zones in the basalts, and soil zones, in addition to fluvial, lacustrine, and eolian sediments. In most wells (about 80 percent) in which interbed materials are identified, the materials are fine-grained (clay, silt, claystone, or siltstone). Those wells with coarse-grained interbed materials (about 20 percent) generally have sand, sand and gravel, or sandstone. There is no apparent pattern of distribution of fine-grained versus coarse-grained materials.



Thickness of the interbed between the Grande Ronde Basalt and Wanapum Basalt

Base from U.S. Geological Survey
State base map, 1:500,000, 1982

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EXPLANATION

Quaternary Sediments	Rocks younger than Wanapum Basalt at land surfce	
Quaternary Basalt		
Ellensburg Formation (sediments)		
Saddle Mountains Basalt		
Wanapum Basalt	Wanapum Basalt at land surface	
Grande Ronde Basalt	No Wanapum Basalt present; rocks older than Wanapum at land surface	
Rocks older than Grande Ronde (primarily sedimentary and granitic rocks)		

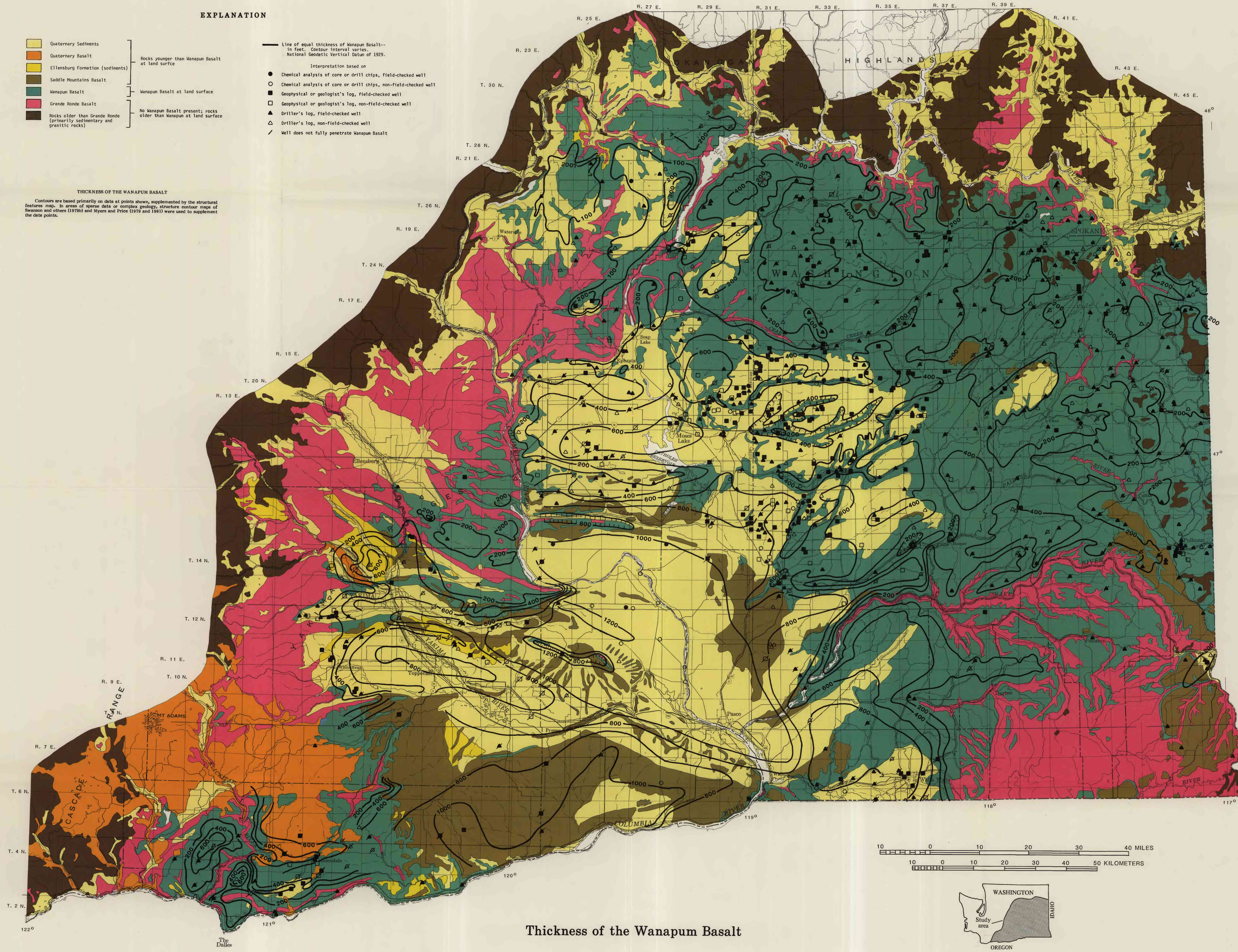
Line of equal thickness of Wanapum Basalt-- in feet. Contour interval varies. National Geodetic Vertical Datum of 1929.

Interpretation based on

- ● Chemical analysis of core or drill chips, field-checked well
- ○ Chemical analysis of core or drill chips, non-field-checked well
- ■ Geophysical or geologist's log, field-checked well
- □ Geophysical or geologist's log, non-field-checked well
- ▲ Driller's log, field-checked well
- △ Driller's log, non-field-checked well
- / Well does not fully penetrate Wanapum Basalt

THICKNESS OF THE WANAPUM BASALT

Contours are based primarily on data at points shown, supplemented by the structural features map. In areas of sparse data or complex geology, structure contour maps of Swanson and others (1979b) and Myers and Price (1979 and 1981) were used to supplement the data points.



Thickness of the Wanapum Basalt

Base from U.S. Geological Survey
State base map, 1:500,000, 1982

SURFICIAL GEOLOGY, STRUCTURE, AND THICKNESS OF SELECTED GEOHYDROLOGIC UNITS IN THE COLUMBIA PLATEAU, WASHINGTON

By
B.W. Drost and K.J. Whiteman

1986

EXPLANATION

- Quaternary Sediments
- Quaternary Basalt
- Ellensburg Formation (sediments)
- Saddle Mountains Basalt

} Rocks younger than Wanapum Basalt at land surface

- Wanapum Basalt

} Wanapum Basalt at land surface

- Grande Ronde Basalt
- Rocks older than Grande Ronde (primarily sedimentary and granitic rocks)

} No Wanapum Basalt present; rocks older than Wanapum at land surface

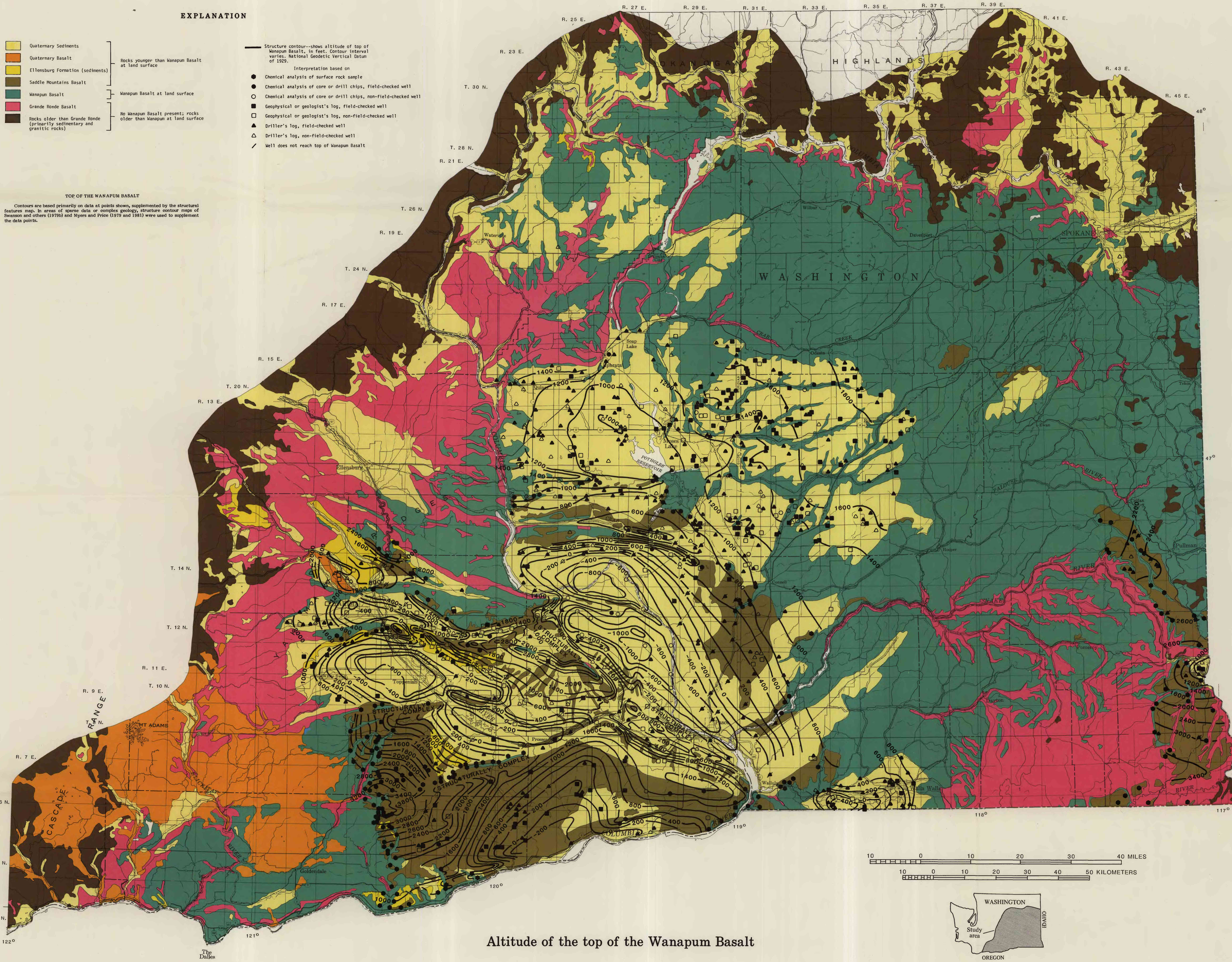
Structure contour--shows altitude of top of Wanapum Basalt, in feet. Contour interval varies. National Geodetic Vertical Datum of 1929.

Interpretation based on

- Chemical analysis of surface rock sample
- Chemical analysis of core or drill chips, field-checked well
- Chemical analysis of core or drill chips, non-field-checked well
- Geophysical or geologist's log, field-checked well
- Geophysical or geologist's log, non-field-checked well
- Driller's log, field-checked well
- Driller's log, non-field-checked well
- Well does not reach top of Wanapum Basalt

TOP OF THE WANAPUM BASALT

Contours are based primarily on data at points shown, supplemented by the structural features map. In areas of sparse data or complex geology, structure contour maps of Swanson and others (1979b) and Myers and Price (1979 and 1981) were used to supplement the data points.



Altitude of the top of the Wanapum Basalt

Base from U.S. Geological Survey
State base map, 1:500,000, 1982

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EXPLANATION

Quaternary Sediments	Rocks younger than Wanapum Basalt-Saddle Mountains Basalt interbed at land surface	
Quaternary Basalt		
Ellensburg Formation (sediments)		
Saddle Mountains Basalt		
Wanapum Basalt	No Wanapum Basalt-Saddle Mountains Basalt interbed present; rocks older than interbed at land surface	
Grande Ronde Basalt		
Rocks older than Grande Ronde (primarily sedimentary and granitic rocks)		

Line of equal thickness of the Wanapum Basalt-Saddle Mountains Basalt Interbed--in feet. Contour interval varies. National Geodoetic Vertical Datum of 1929.

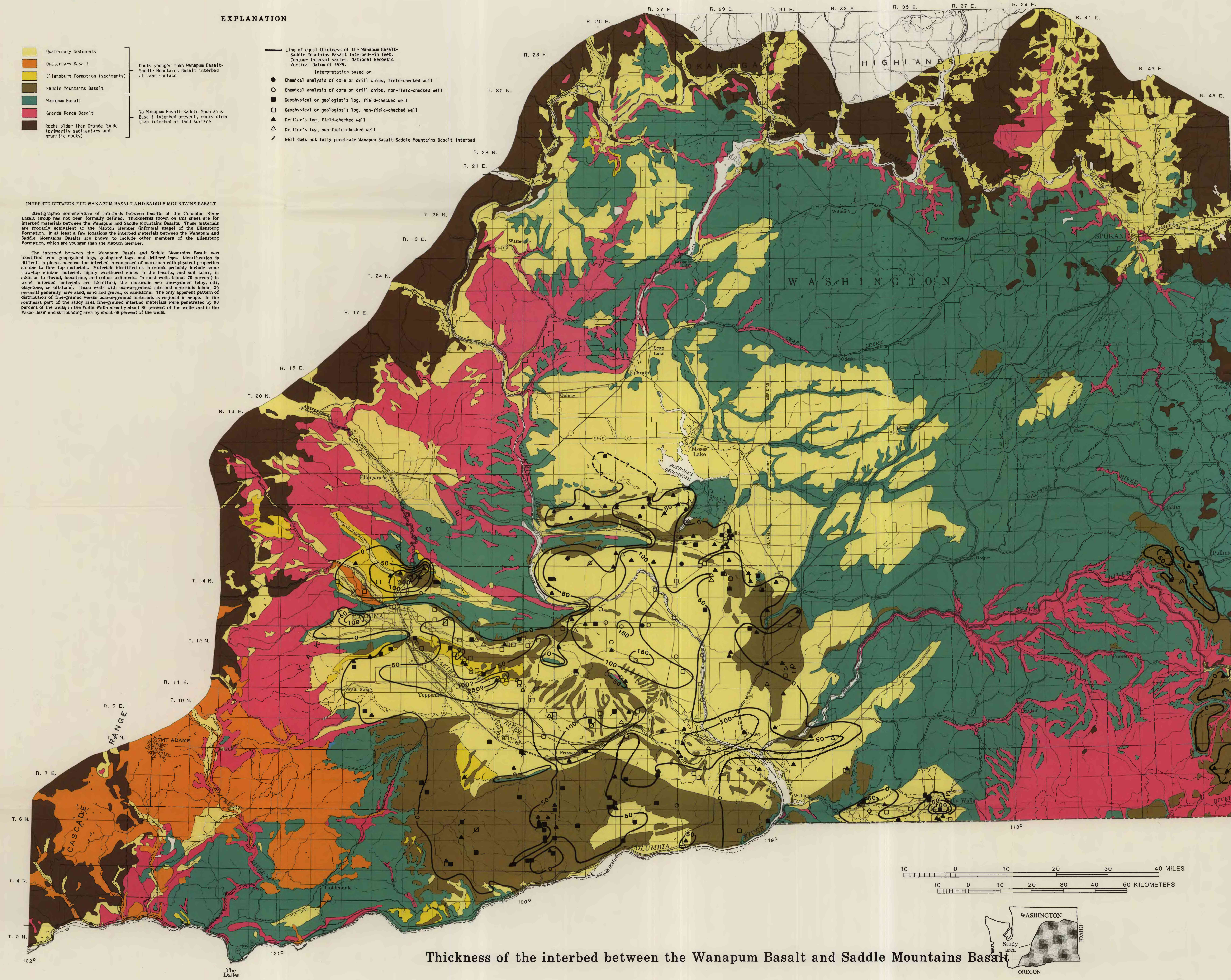
Interpretation based on

- ● Chemical analysis of core or drill chips, field-checked well
- ○ Chemical analysis of core or drill chips, non-field-checked well
- ■ Geophysical or geologist's log, field-checked well
- □ Geophysical or geologist's log, non-field-checked well
- ▲ Driller's log, field-checked well
- △ Driller's log, non-field-checked well
- / Well does not fully penetrate Wanapum Basalt-Saddle Mountains Basalt interbed

INTERBED BETWEEN THE WANAPUM BASALT AND SADDLE MOUNTAINS BASALT

Stratigraphic nomenclature of interbeds between basalts of the Columbia River Basalt Group has not been formally defined. Thicknesses shown on this sheet are for interbed materials between the Wanapum and Saddle Mountains Basalts. These materials are probably equivalent to the Mabton Member (informal usage) of the Ellensburg Formation. In at least a few locations the interbed materials between the Wanapum and Saddle Mountains Basalts are known to include other members of the Ellensburg Formation, which are younger than the Mabton Member.

The interbed between the Wanapum Basalt and Saddle Mountains Basalt was identified from geophysical logs, geologists' logs, and drillers' logs. Identification is difficult in places because the interbed is composed of materials with physical properties similar to flow top materials. Materials identified as interbeds probably include some flow-top clinker material, highly weathered zones in the basalts, and soil zones, in addition to fluvial, lacustrine, and eolian sediments. In most wells (about 70 percent) in which interbed materials are identified, the materials are fine-grained (clay, silt, claystone, or siltstone). Those wells with coarse-grained interbed materials (about 30 percent) generally have sand, sand and gravel, or sandstone. The only apparent pattern of distribution of fine-grained versus coarse-grained materials is regional in scope. In the southeast part of the study area fine-grained interbed materials were penetrated by 90 percent of the wells; in the Walla Walla area by about 86 percent of the wells; and in the Pasco Basin and surrounding area by about 68 percent of the wells.



Thickness of the interbed between the Wanapum Basalt and Saddle Mountains Basalt

Base from U.S. Geological Survey
State base map, 1:500,000, 1982

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EXPLANATION

Quaternary Sediments	Rocks younger than Saddle Mountains Basalt at land surface	
Quaternary Basalt		
Ellensburg Formation (sediments)		
Saddle Mountains Basalt	Saddle Mountains Basalt at land surface	
Wanapum Basalt	No Saddle Mountains Basalt present; rocks older than Saddle Mountains at land surface	
Grande Ronde Basalt		
Rocks older than Grande Ronde (primarily sedimentary and granitic rocks)		

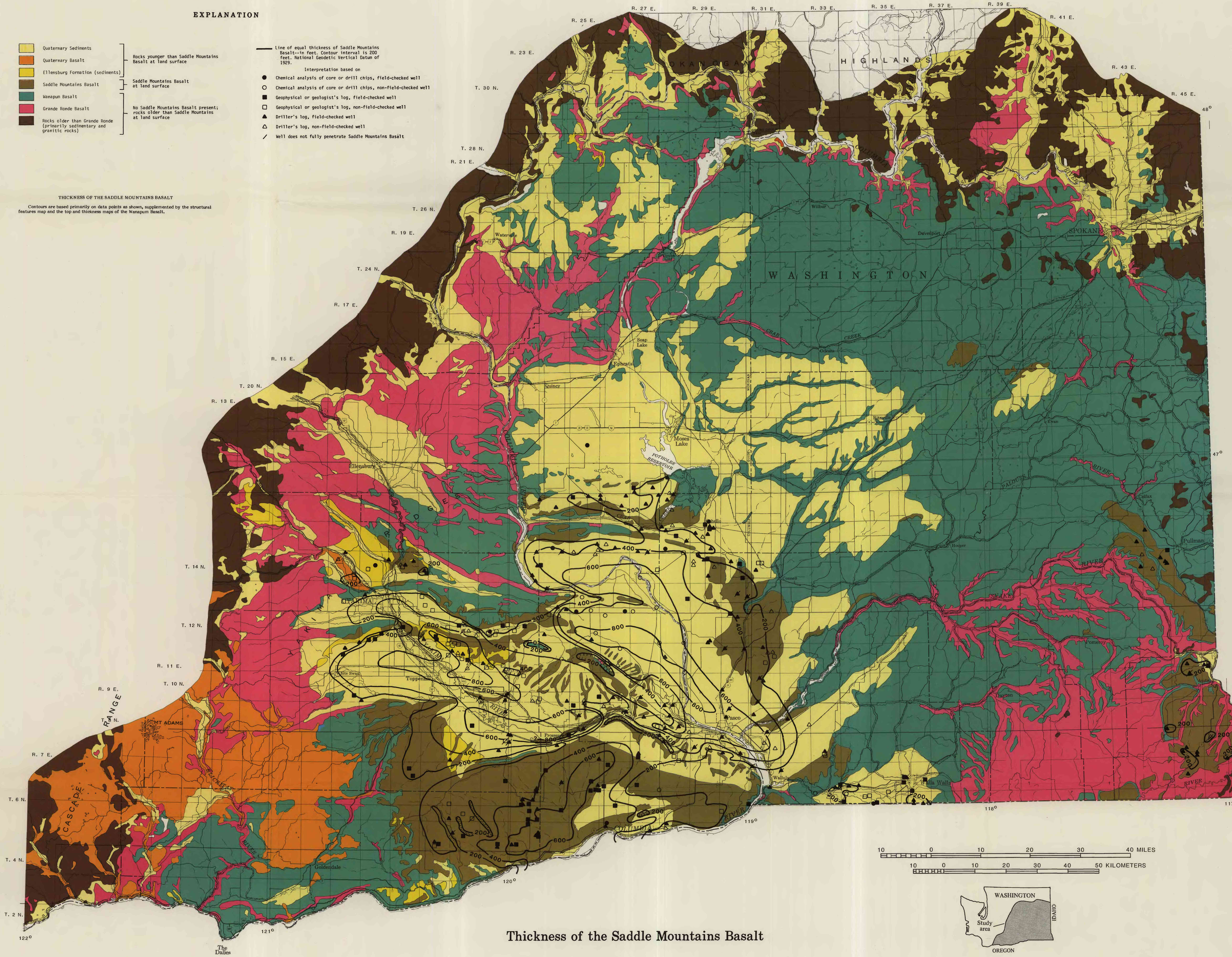
Line of equal thickness of Saddle Mountains Basalt--in feet. Contour interval is 200 feet. National Geodetic Vertical Datum of 1929.

Interpretation based on

- ● Chemical analysis of core or drill chips, field-checked well
- ○ Chemical analysis of core or drill chips, non-field-checked well
- ■ Geophysical or geologist's log, field-checked well
- □ Geophysical or geologist's log, non-field-checked well
- ▲ Driller's log, field-checked well
- △ Driller's log, non-field-checked well
- / Well does not fully penetrate Saddle Mountains Basalt

THICKNESS OF THE SADDLE MOUNTAINS BASALT

Contours are based primarily on data points as shown, supplemented by the structural features map and the top and thickness maps of the Wanapum Basalt.



Thickness of the Saddle Mountains Basalt

Base from U.S. Geological Survey
State base map, 1:500,000, 1982

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Prepared in cooperation with the
STATE OF WASHINGTON DEPARTMENT OF ECOLOGY

EXPLANATION

Quaternary Sediments	Rocks younger than Saddle Mountains Basalt at land surface	
Quaternary Basalt		
Ellensburg Formation (sediments)		
Saddle Mountains Basalt	Saddle Mountains Basalt at land surface	
Wanapum Basalt	No Saddle Mountains Basalt present; rocks older than Saddle Mountains at land surface	
Grande Ronde Basalt		
Rocks older than Grande Ronde (primarily sedimentary and granitic rocks)		

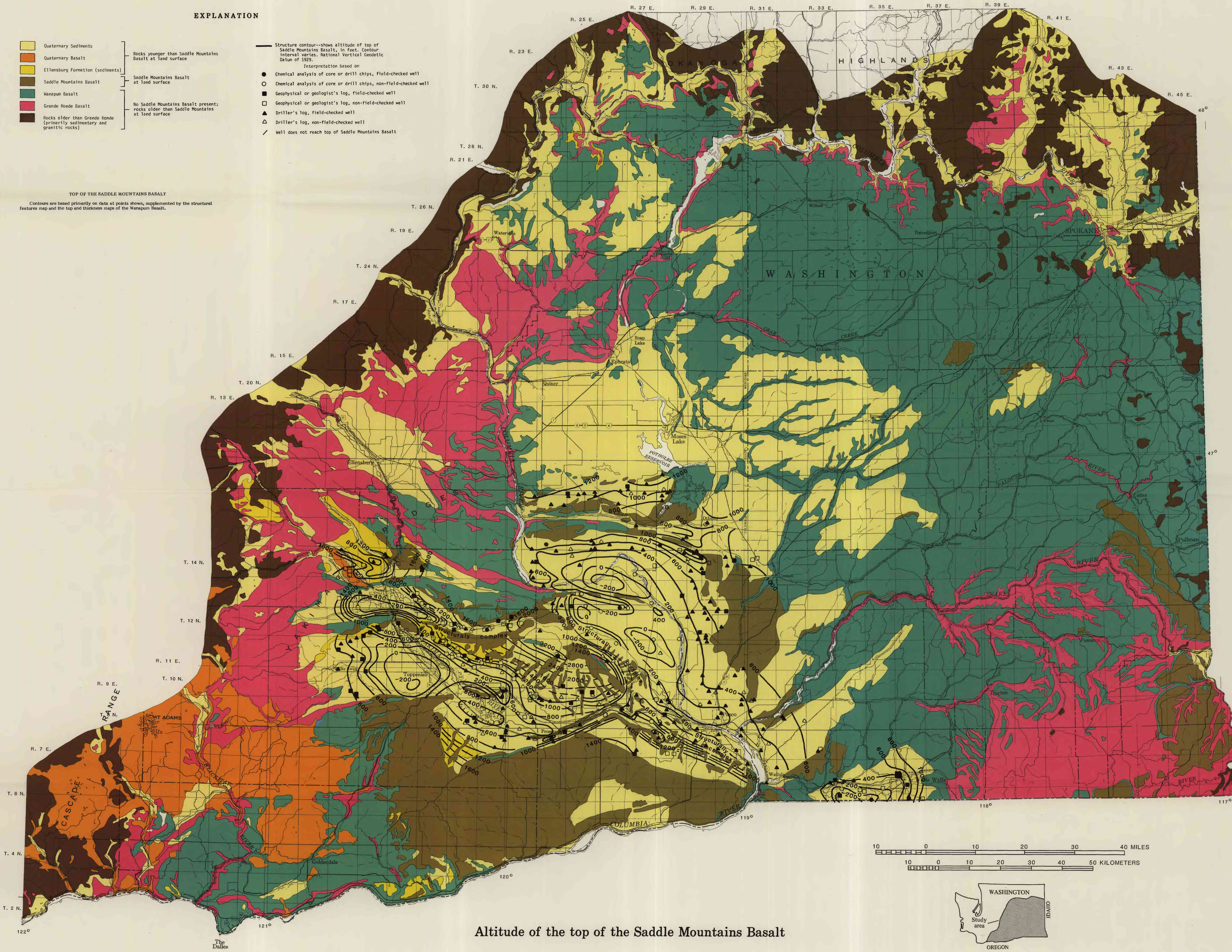
— Structure contour--shows altitude of top of Saddle Mountains Basalt, in feet. Contour interval varies. National Vertical Geodetic Datum of 1929.

Interpretation based on

- ● Chemical analysis of core or drill chips, field-checked well
- ○ Chemical analysis of core or drill chips, non-field-checked well
- ■ Geophysical or geologist's log, field-checked well
- □ Geophysical or geologist's log, non-field-checked well
- ▲ Driller's log, field-checked well
- △ Driller's log, non-field-checked well
- / Well does not reach top of Saddle Mountains Basalt

TOP OF THE SADDLE MOUNTAINS BASALT

Contours are based primarily on data at points shown, supplemented by the structural features map and the top and thickness maps of the Wanapum Basalt.



Altitude of the top of the Saddle Mountains Basalt

Base from U.S. Geological Survey
State base map, 1:500,000, 1982

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EXPLANATION

- Quaternary Sediments
- Quaternary Basalt
- Ellensburg Formation (sediments)

Overburden generally greater than 50 feet thick

- Saddle Mountains Basalt
- Wanapum Basalt
- Grande Ronde Basalt
- Rocks older than Grande Ronde (primarily sedimentary and granitic rocks)

Overburden generally less than 50 feet thick

Line of equal thickness of overburden--in feet. Contour interval is 200 feet. National Geodetic Vertical Datum of 1929

● Overburden thickness less than 50 feet

Interpretation based on

■ Geophysical or geologist's log, field-checked well

□ Geophysical or geologist's log, non-field-checked well

▲ Driller's log, field-checked well

△ Driller's log, non-field-checked well

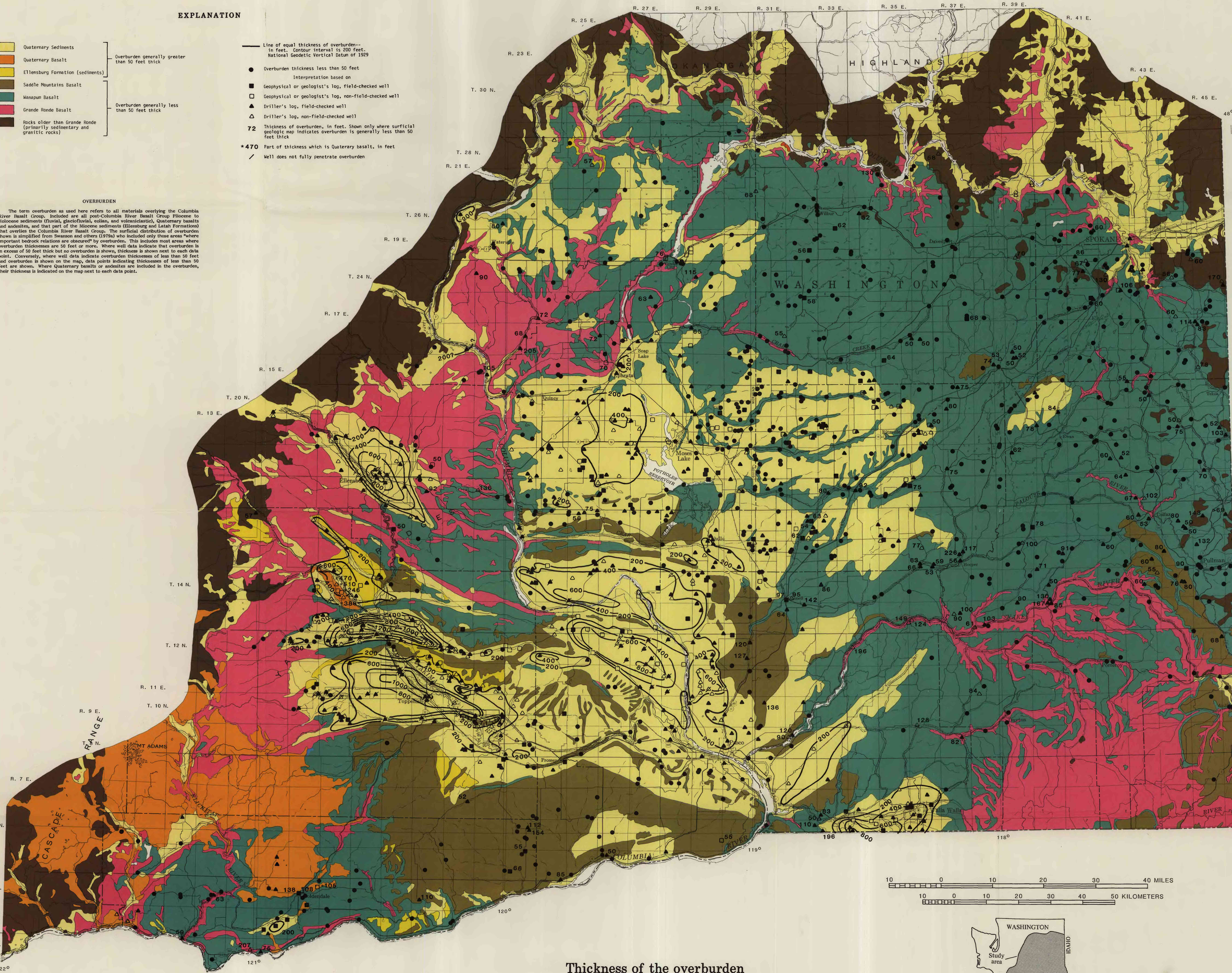
72 Thickness of overburden, in feet. Shown only where surficial geologic map indicates overburden is generally less than 50 feet thick

*470 Part of thickness which is Quaterary basalt, in feet

/ Well does not fully penetrate overburden

OVERBURDEN

The term overburden as used here refers to all materials overlying the Columbia River Basalt Group. Included are all post-Columbia River Basalt Group Pliocene to Holocene sediments (fluvial, glaciofluvial, eolian, and volcaniclastic), Quaternary basalts and andesites, and that part of the Miocene sediments (Ellensburg and Latah Formations) that overlies the Columbia River Basalt Group. The surficial distribution of overburden shown is simplified from Swanson and others (1979a) who included only those areas "where important bedrock relations are obscured" by overburden. This includes most areas where overburden thicknesses are 50 feet or more. Where well data indicate that overburden is in excess of 50 feet thick but *no overburden is shown*, thickness is shown next to each data point. Conversely, where well data indicate overburden thicknesses of less than 50 feet and overburden is shown on the map, data points indicating thicknesses of less than 50 feet are shown. Where Quaternary basalts or andesites are included in the overburden, their thickness is indicated on the map next to each data point.



Thickness of the overburden

Base from U.S. Geological Survey
State base map, 1:500,000, 1982

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