

**Geologic Framework of the Columbia Plateau Aquifer System,
Washington, Oregon, and Idaho**

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

**U.S. GEOLOGICAL SURVEY
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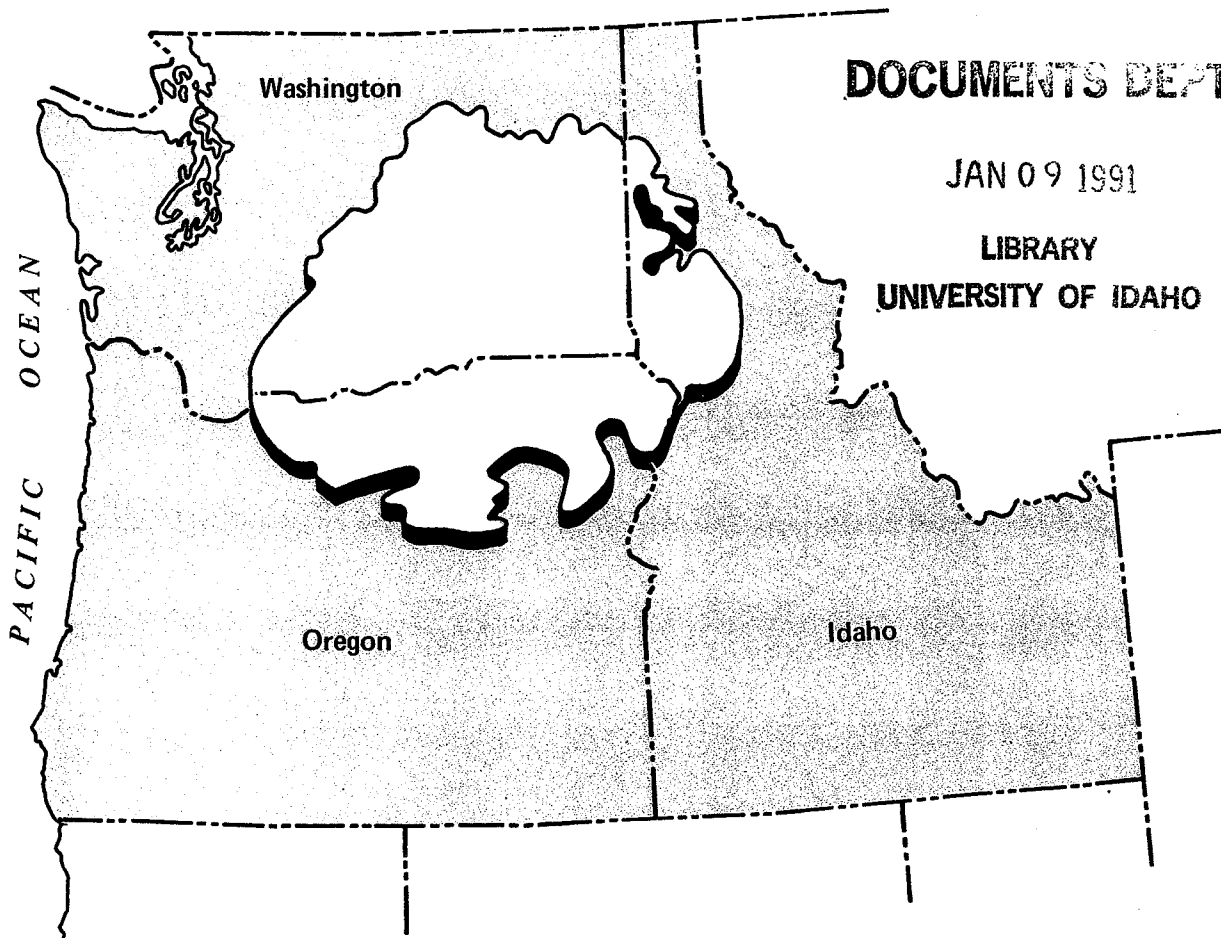
Geologic Framework of the Columbia Plateau Aquifer System, Washington, Oregon, and Idaho

A contribution of the Regional Aquifer-System Analysis Program

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CONVERSION FACTORS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
foot (ft)	0.3048	meter (m)
inch (in.)	25.4	millimeter (mm)
square mile (mi ²)	2.59	square kilometer (km ²)

GEOLOGIC FRAMEWORK OF THE COLUMBIA PLATEAU AQUIFER SYSTEM,
WASHINGTON, OREGON, AND IDAHO

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

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ABSTRACT

The Columbia Plateau in eastern Washington, north-central and northeastern Oregon, and western Idaho covers more than 70,000 square miles underlain chiefly by basalt belonging to the Columbia River Basalt Group. The Plateau is a large structural basin whose deepest part lies near Pasco, Washington, where the total thickness of basalt may exceed 14,000 feet. The Columbia Plateau regional aquifer system is a major aquifer system that consists chiefly of a great thickness of basalt belonging to the Columbia River Basalt Group, of minor interbedded sedimentary materials, and of overlying undivided consolidated and unconsolidated sediments. For hydrologic purposes, these rocks have been subdivided along stratigraphic boundaries into four hydrogeologic units. These hydrogeologic units are from oldest to youngest: the Grande Ronde, Wanapum, Saddle Mountains, and overburden units. Structure contour and thickness maps have been prepared for each unit and for selected sedimentary interbeds in this study.

The Grande Ronde is the thickest most extensive hydrogeologic unit; each of the overlying younger units in turn cover less area and is less voluminous. Thicknesses of each unit range from a minimum of zero to a maximum of about 14,000 feet for the Grande Ronde, 1,200 feet for the Wanapum, and 800 feet for the Saddle Mountain hydrogeologic unit. The maximum thicknesses for each of the hydrogeologic units occur near the deepest part of the structural basin near Pasco, Washington. The thickest overburden, 2,000 feet, occurs in the Grande Ronde Valley near La Grande, Oregon, but is generally much thinner elsewhere.

Dominant geologic structures in the Yakima Fold Belt in the western part of the Plateau are long, narrow, east-west to east-southeasterly trending anticlinal ridges, that are sharply folded and faulted, with intervening broad synclinal basins. Basalt units in the Palouse subprovince are gently inclined toward the southwest, but are gently warped in places by broad northwest and southwest trending low amplitude folds. The Blue Mountains province in the southeast part of the Plateau is a broad, deeply dissected, uplifted region crossed by northeast trending folds and by north to northwest trending normal faults and lineaments.

INTRODUCTION

The Columbia Plateau regional aquifer system is in the Columbia Plateau of central and eastern Washington, north-central and eastern Oregon, and a small part of western Idaho (fig. 1). The aquifer system underlies 70,000 mi² and is the major source of ground water for municipal, industrial, domestic, and irrigation uses. Concurrent with ground-water usage, imported surface water is used for irrigation in several areas of the Plateau. This surface water is almost fully allocated, and the demand for more irrigation water is increasing.

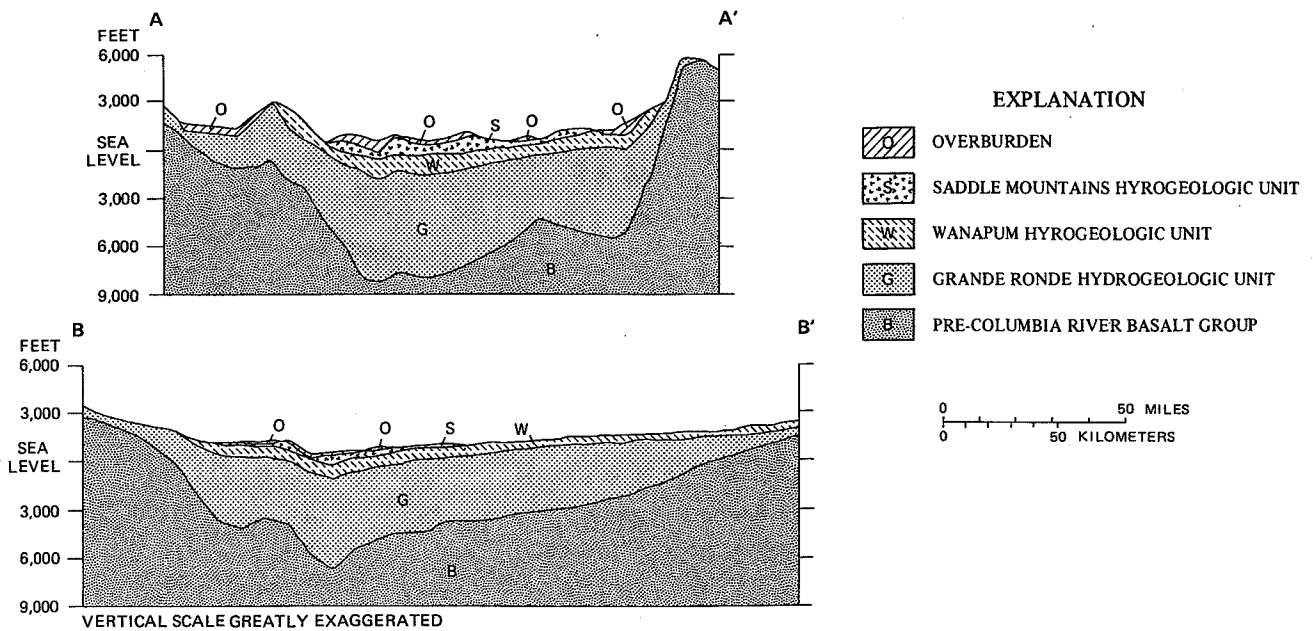
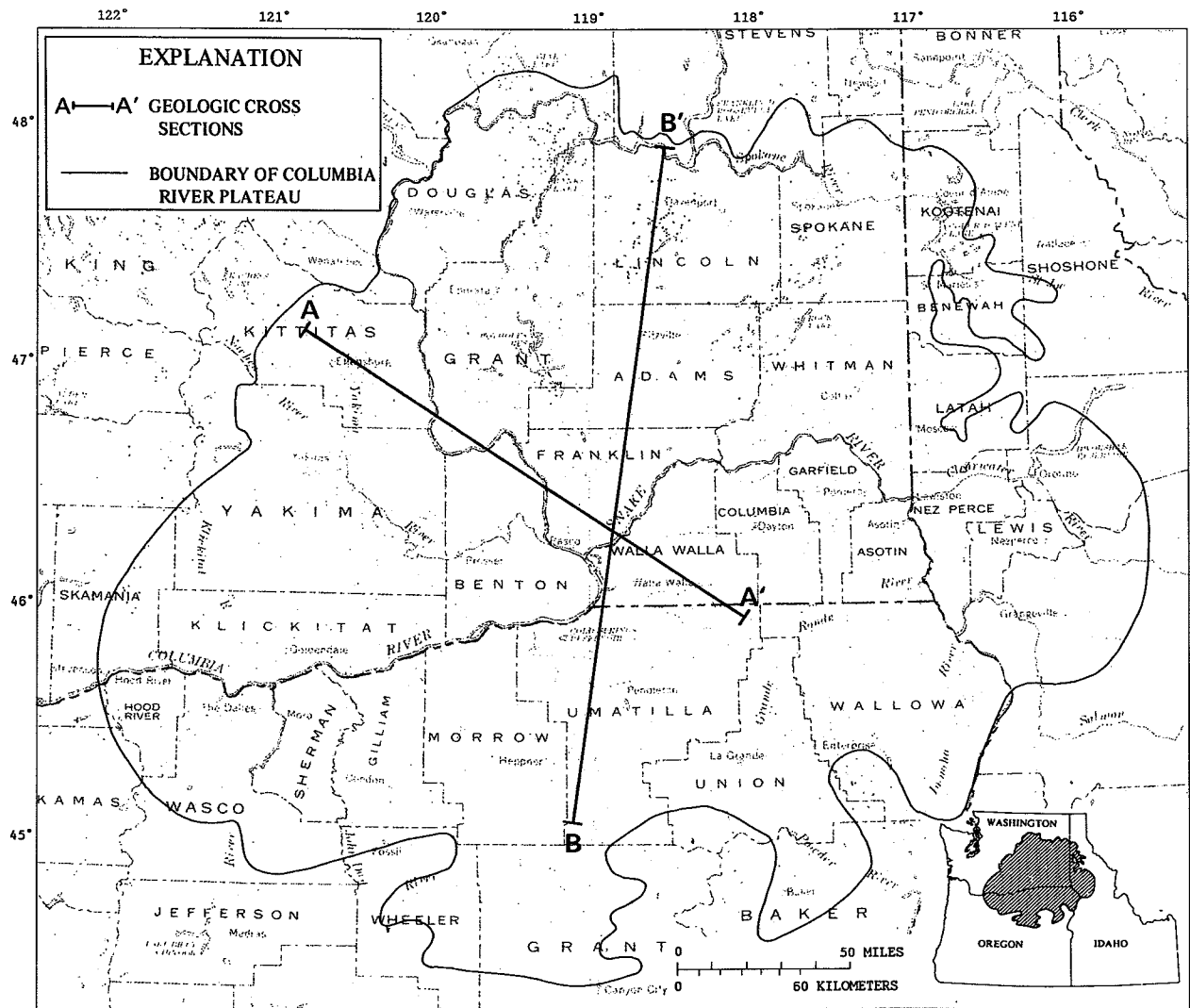


Figure 1.--Location of Columbia Plateau and geologic sections.

Use of water for irrigation has resulted in rises in ground-water levels in areas of surface-water importation, declines of as much as 100 feet in ground-water levels in areas of ground-water pumpage, and changes in the chemical quality of ground water in irrigated areas. The basalts that underlie the Plateau are being considered as the national site for a high-level nuclear waste repository. A better understanding of the regional aquifer system, especially in regard to the movement and direction of ground-water flow, is needed to evaluate this system.

The U.S. Geological Survey began a Regional Aquifer System Analysis (RASA) program in 1978 as a result of national concern for ground-water use, availability, and water quality. The Columbia Plateau aquifer system was chosen as one of the regional aquifers to be studied. The purpose of the RASA program is to aid in the effective management of the Nation's important ground-water resources by providing information on the geohydrology and geochemistry of regional aquifer systems, as well as on the analytical capabilities necessary to assess management alternatives. These objectives are met by this project through description of (1) the geologic framework; (2) the hydraulic characteristics; (3) the area water budget; (4) the flow system; (5) description of water-quality characteristics and water-rock interactions that occur in this regional aquifer system; and (6) provision of analytical capability for simulation, projection, and evaluation of ground-water management alternatives.

This report describes the geologic framework of the Columbia Plateau regional aquifer system and represents a first step in the development of a conceptual model of the flow system. Maps provided in this report are needed to determine hydraulic characteristics and define hydrologic boundaries of hydrogeologic units that compose the aquifer system. The aquifer system consists of a large thickness of basalt made of numerous flows with minor interbedded sediments. The basalt, known as the Columbia River Basalt Group, is overlain by sediments and sedimentary rock of varying thickness and origin, referred to herein as overburden. Formal stratigraphic nomenclature excludes non-basaltic formations from the Columbia River Basalt Group (Swanson and others, 1979). This fact has resulted in a minor nomenclature problem because some of the hydrogeologic units of the Columbia Plateau regional aquifer system by definition include basalt as well as minor sedimentary rock interbedded with the basalt. To overcome this problem in this report, the formal stratigraphic name will be used; for example, "Saddle Mountains Basalt" will be used when referring only to the basalt, whereas the term Saddle Mountains hydrogeologic unit, or more briefly the "Saddle Mountains unit," when referring to the basalt of the Saddle Mountains Basalt and the sedimentary rocks that are interbedded with it.

This report contains ten separate sheets. Each sheet describes in greater detail that part of the geologic framework that it represents.

<u>Sheet number</u>	<u>Title</u>
1	Geologic map
2	Structural features
3	Altitude of top of Grande Ronde Basalt and thickness of Grande Ronde hydrogeologic unit
4	Thickness of Wanapum-Grande Ronde interbed
5	Thickness of Wanapum hydrogeologic unit
6	Altitude of top of Wanapum Basalt
7	Thickness of Saddle Mountains-Wanapum interbed
8	Thickness of Saddle Mountains hydrogeologic unit
9	Altitude of top of Saddle Mountains Basalt
10	Thickness of overburden

These maps were compiled from several existing reports. Maps describing the geology, structure, and thickness of selected hydrogeologic units in the regional aquifer system in Washington (Drost and Whiteman, 1984) were combined with a similar set of maps developed for Oregon (Gonthier, in press). A report on the tectonic structure of the Columbia River Basalt Group (Newcomb, 1970) was used to delineate the southern extent of the basalt in Oregon. Maps developed by Swanson and others (1979a, 1979b, and 1980), which were the foundation for the work done by Drost and Whiteman (1984) and Gonthier (in press), also provided information for the occurrence of the basalt in Idaho. In addition, geologic maps published by the Idaho State Geological Survey provided surficial geology and structure data for the Clearwater Basin.

Sheets 1 and 2 show information for the entire Columbia Plateau. Sheets 3-10, however, present information for Washington and Oregon only. The exclusion of Idaho on these sheets reflects the fact that necessary data were lacking or not readily available.

In Washington and Oregon, respectively, more than 20,000 and 9,000 well records were examined; of these wells, about 2,500 and 1,200 wells, respectively were selected according to the following broad criteria: (1) ideal minimum well density of one well per formation per township (36 square miles); (2) availability of chemical analyses of core or drill chips, geophysical logs or geologists logs; (3) wells that were part of a water-level network for the Columbia Plateau (RASA) project; and (4) wells sampled as part of a project to determine the occurrence and geochemistry of sodium in the basalt. For Oregon there were no wells with chemical analysis data for core or drill chips, nor were there any with usable geophysical logs, and only a few wells had geologist logs. Therefore, in Oregon, interpretations were based almost entirely on well drillers' logs and the reconnaissance geologic maps by Swanson and others (1981).

Maps in this report were compiled at a scale of 1:500,000 for Washington and 1:250,000 scale for Oregon. At these large compilation scales and the relatively low well density, geologic structures tend to be very generalized, and smaller structures can be missed entirely. Earlier reports by Drost and Whiteman (1986) and Gonthier (in press) show locations of data points for Washington and Oregon.

GLOSSARY

- andesite -- a dark-colored, fine-grained volcanic rock composed primarily of plagioclase and one or more minerals high in iron and magnesium.
- anticline -- a fold, the core of which contains the stratigraphically older rock; it is convex upward.
- aphyric -- the texture of a fine-grained igneous rock lacking phenocrysts.
- aquifer -- formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.
- basalt -- a dark- to medium-dark-colored, generally extrusive, igneous rock composed chiefly of calcium-rich plagioclase, clinopyroxene and minerals high in iron and magnesium.
- clinker -- rough, jagged rock fragments formed by volcanic explosions or on the top or bottom of a lava flow.
- clinopyroxene -- a group of dark silicate minerals generally high in calcium and magnesium, iron, or aluminum, and having a similar symmetry in their crystal structure.
- dip -- the angle between an inclined plane and the horizontal.
- eolian -- pertaining to the wind.
- fanglomerate -- a sedimentary rock consisting of slightly waterworn fragments of all sizes, originally deposited in an alluvial fan and subsequently cemented into a firm rock.
- 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 one in which the upper plate has moved upward and over the lower plate.
- fluvial -- produced by the action of moving 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.
- graben -- an elongate, depressed part of the earth's crust that is bounded by faults on its long sides.
- glaciofluvial -- formed by the action of glaciers and moving melt water.
- Holocene -- an epoch of 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 material.

Mesozoic -- an era of geologic time extending from about 240 million years ago to about 63 million years ago.

metamorphosed -- altered by heat and pressure.

Miocene -- an epoch of geologic time extending from about 24 million years ago to about 5 million years ago.

olivine -- an olive-green, grayish-green, or brown silicate mineral high in iron and magnesium.

Paleozoic -- an era of geologic time extending from about 570 million years ago to about 240 million years ago.

permeability -- the measure of the relative ease with which water can move through rock material. It is a property of the rock material dependent on the shape, size, and interconnection of the openings in the material.

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

phyric -- texture of fine-grained igneous rock, containing phenocrysts.

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

Pliocene -- an epoch of geologic time extending from about 5 million years ago to about 2 million years ago.

Plutonic -- igneous rock formed at great depth.

Quaternary -- a period of geologic time extending from about 2 million years ago to the present.

shear zone -- a tabular zone of rock that has been crushed and brecciated by many parallel fractures due to shear strain.

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

Tertiary -- a period of geologic time extending from about 63 to about 2 million years before present.

vesicular -- a rock texture characterized by abundant holes (vesicles) formed by the expansion of gases in fluid lava.

volcaniclastic -- fragmented volcanic rock material, formed by explosion or erosion.

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