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

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

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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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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 hydrologeologic 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 mi^2 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.

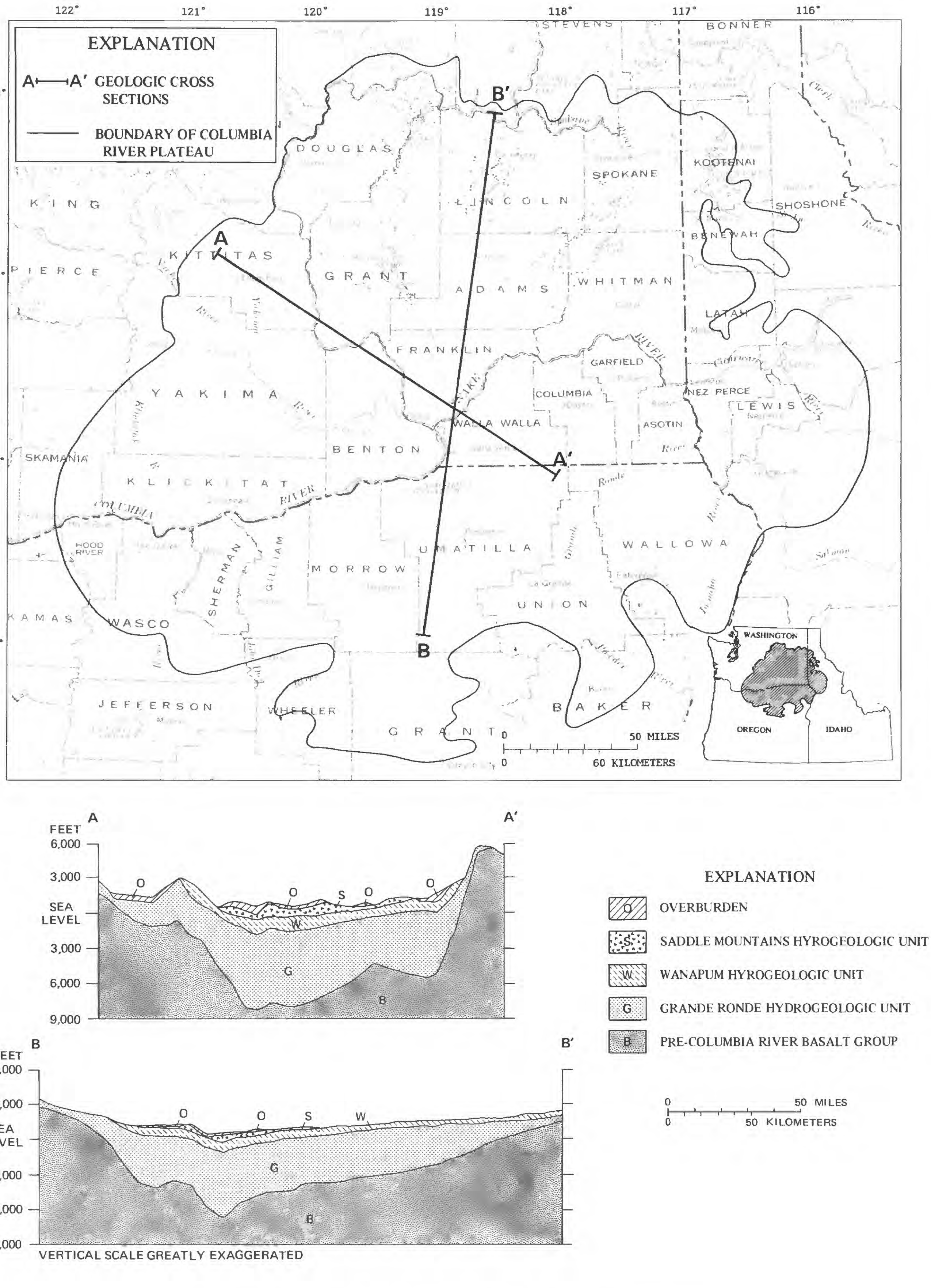

Figure 1.--Location of Columbia Plateau and geologic sections.

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.

Sheet number	Title
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.

SELECTED REFERENCES

Anderson, J.L., 1980, Pomona member of the Columbia River Basalt Group: An intracanyon flow in the Columbia River Gorge, Oregon: Oregon Department of Geology and Mineral Industries, Oregon Geology v. 42, no. 12, p. 195-199.

Barash, W., Bond, J.E., Kauffman, J.D., and Vekatakrishnan, R., 1980, Geology of the La Grande area, Oregon: State of Oregon Department of Geology and Mineral Industries, Special Paper 6, 47 p.

Bela, J.L., 1982, Geologic and neotectonic evaluation of north-central Oregon: The Dalles 1°x2° Quadrangle: State of Oregon Department of Geology and Mineral Industries, Geological Map Series 27, scale 1:250,000.

Bennett, G.D., 1979, Regional ground water systems analysis: U.S. Army Corps of Engineers Water Spectrum, v. 11, no. 4, p. 36-42.

Biggane, John, 1982, The low-temperature geothermal resource and stratigraphy of portions of Yakima County, Washington: Washington Division of Geology and Earth Resources, Open-File Report 82-6, 128 p.

Bonnichsen, B., and Breckenridge, R.M., 1982, Cenozoic geology of Idaho: Idaho Bureau of Mines and Geology Bulletin 26, 725 p.

Brown, J.C., 1978, Discussion of geology and ground-water hydrology of the Columbia Plateau, with specific analysis of the Horse Heaven, Sagebrush Flat, and Odessa-Lind areas, Washington: Washington State University, College of Engineering Research Report 78/15-23. 51 p.

_____1979, Investigation of stratigraphy and ground-water hydrology, Columbia River Basalt Group, Washington: Washington State University, College of Engineering Research Report 79/15-37, 61 p. Prepared for Rockwell-Hanford Operations under subcontract no. SA-920.

_____1980, Stratigraphy and ground-water hydrology of selected areas, Columbia Plateau, Washington: Washington State University, College of Engineering Research Report 80/15-39, 20 p. Prepared for Washington Department of Ecology under contract 80-061.

Caggiano, J.A., and Duncan, D.W., eds., 1983, Preliminary interpretation of tectonic stability of the reference repository location, Cold Creek Syncline, Hanford Site: Rockwell International, Rockwell Hanford Operations, RHO-BWI-ST-19P, 176 p.

Davies-Smith, A., Collins, C.A., and Olson, L.J., 1983, Selected ground-water data in parts of Gilliam, Morrow, and Umatilla Counties, Oregon: U.S. Geological Survey Open-File Report 83-34, 43 p.

Dicken, S.N., 1965, Oregon geography, the people, the place and the time: Edwards Brothers, Inc., Ann Arbor Michigan, 4th Edition, 127 p.

Drost, B.W. and Whiteman, K.J., 1986, Surficial geology, structural features, and thickness and tops of selected geohydrologic units in the Columbia Plateau, Washington: U.S. Geological Survey Water-Resources Investigations Report 84-4326, 11 sheets.

Farooqui, S.M., Clayton, D.C., Bunker, R.C., Bela, J.L., and Thoms, R.E., 1981, Post Columbia River Basalt Group stratigraphy and map compilation of the Columbia Plateau, Oregon: Oregon Department of Geology and Mineral Industries Open-File Report 0-81-10, 79 p., scale 1:250,000.

Farooqui, S.M., Beaulieu, J.B., Bunker, R.C., Stensland, D.E., and Thoms, R.E., 1981, Dalles Group: Neogene formations overlying the Columbia River Basalt Group in north-central Oregon: Oregon Department of Geology and Mineral Industries, Oregon Geology, v. 43, no. 10, p. 131-140.

Fenneman, N.M., 1931, Physiography of western United States: New York, McGraw-Hill, 534 p.

Gaston, M.P., and Bennett, E.H., 1979, Geologic map of the Grangeville quadrangle, Idaho: Idaho Bureau of Mines and Geology, Geologic Map Series (2° quadrangle), scale 1:250,000, 1 sheet.

Gonthier, J.B., in press, Geology, structure and thickness of selected hydrogeologic units in part of the Columbia Plateau, Oregon: U.S. Geological Survey Water-Resources Investigations Report 86-4001, 6 sheets.

Griggs, A.B., 1973, Geologic map of the Spokane quadrangle, Washington, Idaho, and Montana: U.S. Geological Survey Miscellaneous Investigations Series, Map I-768, scale 1:250,000, 1 sheet.

Hogenson, G.M., 1964, Geology and ground water of the Umatilla River basin, Oregon: U.S. Geological Survey Water-Supply Paper 1620, 162 p.

Huntting, M.T., 1961, Geologic map of Washington: State of Washington, Department of Natural Resources, scale 1:500,000, 2 sheets.

MacNish, R.D., and Barker, R.A., 1976, Digital simulation of a basalt aquifer system, Walla Walla River basin, Washington-Oregon: Washington Department of Ecology Water-Supply Bulletin 44, 51 p.

McKee, E.H., Swanson, D.A., and Wright, T.L., 1977, Duration and volume of Columbia River basalt volcanism, Washington, Oregon, and Idaho: Geological Society of America Abstracts with Programs, v. 9, no. 4, p. 463-464.

Mitchell, T.H., and Bergstrom, K.A., 1983, Pre-Columbia River Basalt Group Stratigraphy and structure in the central Pasco Basin, in Caggiano, J.A., and Duncan, D.W., 1983, Preliminary interpretation of tectonic stability of the reference repository location, Cold Creek Syncline, Hanford Site: Rockwell International, Rockwell Hanford Operations, RHO-BWI-ST-19P, p. 4-1 through 4-18.

Mitchell, V.E., and Bennett, E.H., 1979, Geologic map of the Elk City quadrangle, Idaho: Idaho Bureau of Mines and Geology, Geologic Map Series (2° quadrangle), 1 sheet.

Myers, C.W., and Price, S.M., 1979, Geologic studies of the Columbia Plateau, a status report: Rockwell International, Rockwell Hanford Operations RHO-BWI-ST-4, 520 p.

_____1981, Subsurface geology of the Cold Creek Syncline: Rockwell International, Rockwell Hanford Operations, RHO-BWI-ST-14, 380 p.

Newcomb, R.C., 1961, Storage of ground water behind subsurface dams in the Columbia River basalt Washington, Oregon, and Idaho: U.S. Geological Survey Professional Paper 383-A, 15 p.

_____1965, Geology and ground-water resources of the Walla Walla River basin, Washington-Oregon: Washington Division of Water Resources Water-Supply Bulletin no. 21, 151 p.

_____1969, Effect of tectonic structure on the occurrence of ground water in the basalt of the Columbia River Group of the Dalles area Oregon and Washington: U.S. Geological Survey Professional Paper 383-C, 33 p.

_____1970, Tectonic structure of the main part of the basalt of the Columbia River Group, Washington, Oregon and Idaho: U.S. Geological Survey Miscellaneous Geologic Investigation Map I-587, 1 sheet.

_____1972, Quality of the ground water in basalt of the Columbia River Group, Washington, Oregon, and Idaho: U.S. Geological Survey Water-Supply Paper 199-N, 71 p.

Peck, D.L., 1961, Geologic map of Oregon west of the 121st meridian: U.S. Geological Survey Miscellaneous Investigations Series, Map I-325, 2 sheets.

Rember, W.C., and Bennett, E.H., 1979a, Geologic map of the Hamilton quadrangle, Idaho: Idaho Bureau of Mines and Geology, Geologic Map Series (2° quadrangle), 1 sheet.

_____1979b, Geologic map of the Pullman quadrangle, Idaho: Idaho Bureau of Mines and Geology, Geologic map Series (2° quadrangle), 1 sheet.

Shannon and Wilson Inc., 1972, Geologic and subsurface investigation--proposed mid-Columbia thermal powerplant sites, Morrow, Gilliam and Umatilla Counties, Oregon: Report to Portland General Electric Company, Portland, Oregon.

_____1973a, Geologic studies of Columbia River Basalt structures and age of deformation, The Dalles-Umatilla region, Washington and Oregon Boardman Nuclear Project: Report to Portland General Electric Company.

_____1973b, Supplemental studies, Robison "fault" investigation, Boardman nuclear project, Morrow County, Oregon: Report to Portland General Electric Company, Portland, Oregon.

Stanley, W.D., 1984, Tectonic study of Cascade Range and Columbia Plateau in Washington State based up on magnetotelluric soundings: Journal of Geophysical Research, v. 89, no. B6, p. 4447-4460.

Swanson, D.A., Wright, T.L., and Helz, R.T., 1975, Linear vent systems and estimated rates of magma production and eruption for the Yakima Basalt on the Columbia Plateau: American Journal of Science, v. 275, p. 877-905.

Swanson, D.A., Anderson, J.L., Bently, R.D., Byerly, G.R., Camp, B.E., Gardner, J.N., and Wright, T.L., 1979a, Reconnaissance geologic map of the Columbia River Basalt Group in eastern Washington and northern Idaho: U.S. Geological Survey Open-File Report 79-1363, 26 p., scale 1:250,000, 12 sheets.

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.

Swanson, D.A., Wright, T.L., Hooper, P.R., and Bentley, R.D., 1979c, Revisions in stratigraphic nomenclature of the Columbia River Basalt Group: U.S. Geological Survey Bulletin 1457-G, 59 p.

Swanson, D.A., Wright, T.L., and Zeitz, I., 1979d, Aeromagnetic map and geologic interpretation of the west-central Columbia Plateau, Washington and adjacent Oregon: U.S. Geological Survey, Map GP-917.

Swanson, D.A., Wright, T.L., Camp, V.E. Gardner, J.N., Helz, R.T., Price, S.M., Reidel, S.P., and Ross, M.E., 1980, Reconnaissance geologic map of the Columbia River Basalt Group, Pullman and Walla Walla quadrangles, southeast Washington and adjacent Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1139, scale 1:250,000, 2 sheets.

Swanson, D.A., Anderson, J.L., Camp, V.E., Hooper, P.R., Taubeneck, W.H., and Wright, T. L., 1981, Reconnaissance geologic map of the Columbia River Basalt Group, northern Oregon and western Idaho: U.S. Geological Survey Open-File Report 81-797, 35 p.

Tabor, R.W., Waitt, R.B., Jr., Frizzell, V.A., Jr., Swanson, D.A., Byerly, G.R., and Bentley, R.D., 1982, Geologic map of the Wenatchee 1:100,000 quadrangle, Central Washington: U.S. Geological Survey Miscellaneous Investigations Map I-1311, scale 1:100,000, 26 p., 1 sheet.

Walker, G.W., 1977, Geologic map of Oregon east of the 121st meridian: U.S. Geological Survey Miscellaneous Investigations Series, Map I-902, 2 sheets.