COLUMBIA PLATEAU BASALT REGIONAL AQUIFER-SYSTEM STUDY

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INTRODUCTION

The basaltic rocks that comprise the regional aquifer system underlying the Columbia Plateau are located in central and eastern Washington, northern Oregon, and a small part of northwestern Idaho (fig. 85). The Plateau covers about 70,000 mi^2 entirely within the drainage of the Columbia River and is bordered on the west by the Cascade Range, on the north and east by the Rocky Mountains, and on the south by the Blue Mountains. Major tributaries to the Columbia River on the Plateau are the Snake, Spokane, John Day, Yakima, Palouse, and Deschutes Rivers. The topography of the Plateau is varied and includes: (1) major mountains consisting of a geologically young folded region of large anticlines and synclines, and (2) low relief features.

Rocks of the Columbia River Basalt Group underlie the Columbia Plateau and compose a multilayered aquifer system which, for study purposes, has been conceptualized as a three-layered aquifer system. The three aquifer layers correspond to three basalt formations—the Saddle Mountains, Wanapum, and Grande Ronde Basalts (Swanson and others, 1979) (fig. 86). The Saddle Mountains Basalt, less extensive than the other basalts, is the youngest formation, and is unconfined where it is not overlain by saturated unconsolidated deposits. The Wanapum Basalt underlies most of the study area and is loosely confined where it is overlain either by the Saddle Mountains Basalt or unconsolidated sediments. The Grande Ronde Basalt underlies the entire study area and is loosely confined where it is overlain by younger basalts or by sediments of Holocene and Pliocene age. Both the Wanapum and Grande Ronde Basalts are unconfined near their respective margins. All basalts are connected hydraulically either directly or through sedimentary interbeds.

These three major aquifers form the regional ground-water flow system that provides water for most municipal, industrial, and domestic needs and for most of the irrigated lands outside of the Columbia Basin Irrigation Project and the Yakima River Basin.

The predominant economic activity in the study area is agriculture, and the importance of this activity to the economy of Washington and Oregon underlines the need to better understand the ground-water flow system.

The Columbia Plateau Basalt regional aquifer system study was started in 1982 and is scheduled for completion in 1986. The study was designed to address some of the hydrologic problems currently being encountered on the plateau. These problems include: (1) declining water levels of as much as 20 ft/yr (Cline, 1984), (2) the occurrence of sodium-enriched water, (3) the need for additional ground water for expanding irrigated land, (4) the lack of knowledge of the effects of increased development of the aquifer system, (5) the lack of knowledge of the interaction between ground water and surface water, and (6) the potentiality of using the low-permeability zones of the deep basalts as a national repository site for solidified high-level nuclear wastes near Richland, WA.

HYDROGEOLOGIC FRAMEWORK

Rocks that comprise the Columbia River Basalt Group were emplaced through extrusion of numerous individual lava flows through fissure eruptions. These individual lava flows range in thickness from a few inches to more than 300 feet, and average about 110 feet (Swanson and Wright,

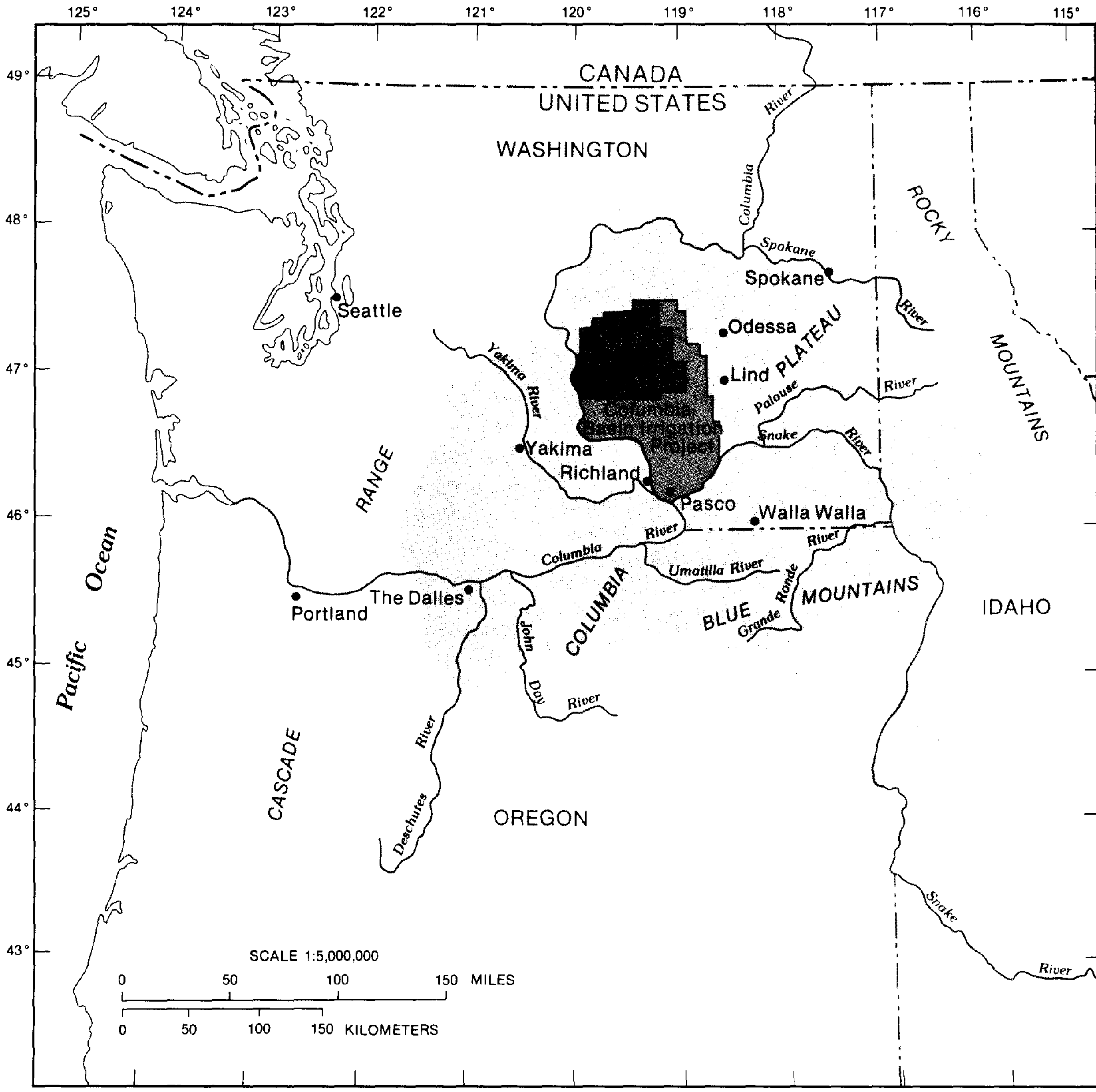

Figure 85.—Study area (shaded) of the Columbia Plateau basalt regional aquifer system.

1978). The structure of a lava flow generally consists of three units (fig. 87): the flow top, the entablature, and the colonnade. The flow tops may also include the basal part of the overlying flow that consists of pillow-palagonite complexes (Swanson and Wright, 1978). Ground-water flow is predominantly horizontal and occurs in the flow tops, which average about 5 to 30 percent of the total flow thickness. In general, the entablature and colonnade are denser than the flow tops. Because fractures are generally oriented vertically, flow through fractures in the entablature and colonnade is predominantly in the vertical direction.

The basalt flows are locally interbedded with sediments that function either as confining units or aquifers. The lithology of the interbeds varies from shalelike material to sand and gravel with fine-grained materials predominating. There are generally more interbeds in the younger basalt formation than in the older basalt. Basalt flows underlying the Columbia Plateau have been grouped into three major aquifers in this study. Movement of ground water in each aquifer is con-

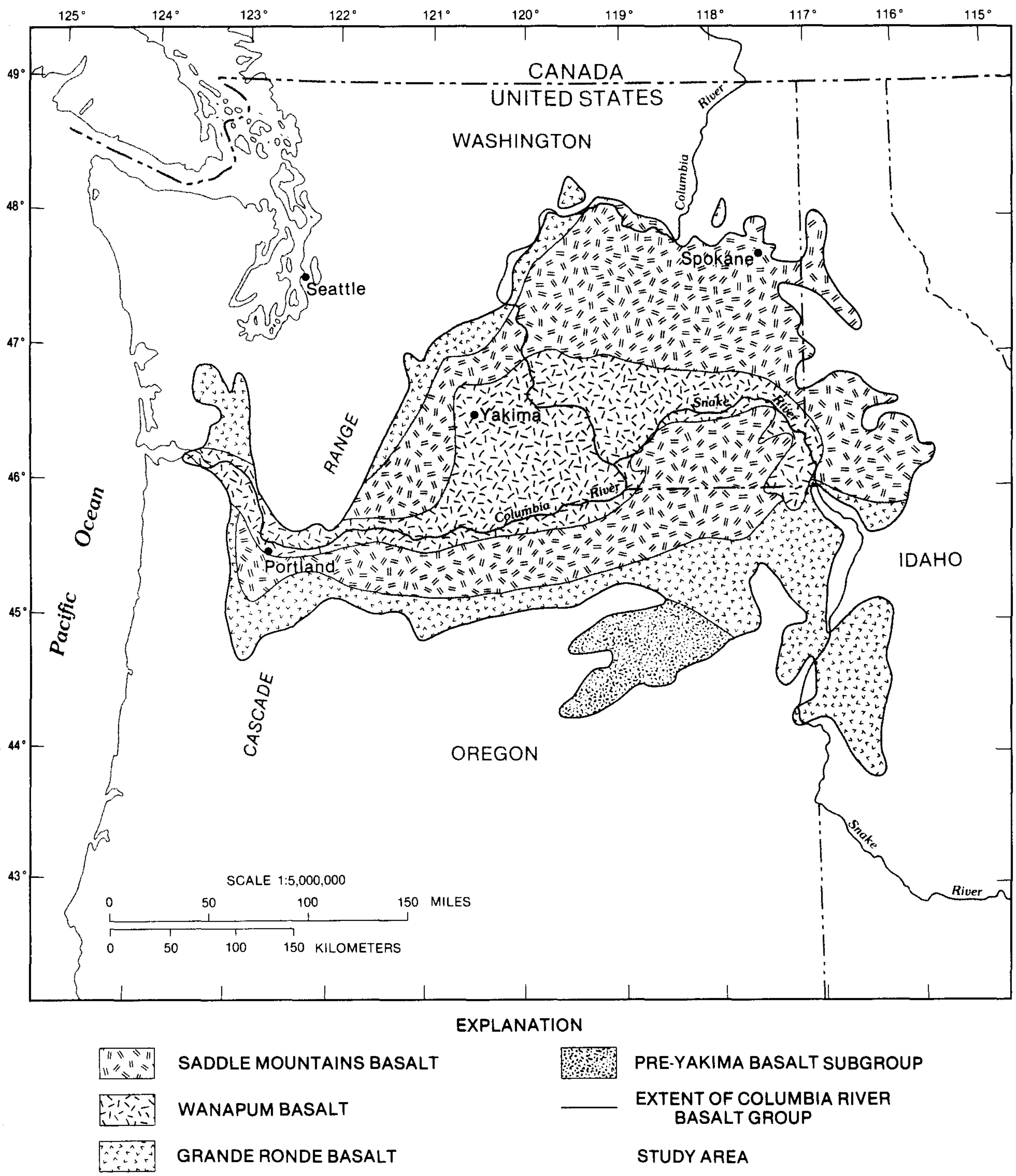

Figure 86.—Extent of the Columbia River Basalt Group.

sidered to be lateral with some vertical flow through sedimentary interbeds and fractures.

The hydrogeologic framework and generalized pattern of regional ground-water flow is depicted in figure 87. On a regional scale, water levels measured in the spring of 1983 indicate that the ground-water flow reasonably agrees with the conceptualized flow pattern shown in figure 87. Because of pumping, local geologic structures, and the inhomogeneity and anisotropy of the aquifer system, local variations in ground-water flow are common. For example, the regional water-level data show that in some areas ground-water flow is downward and that gradual,

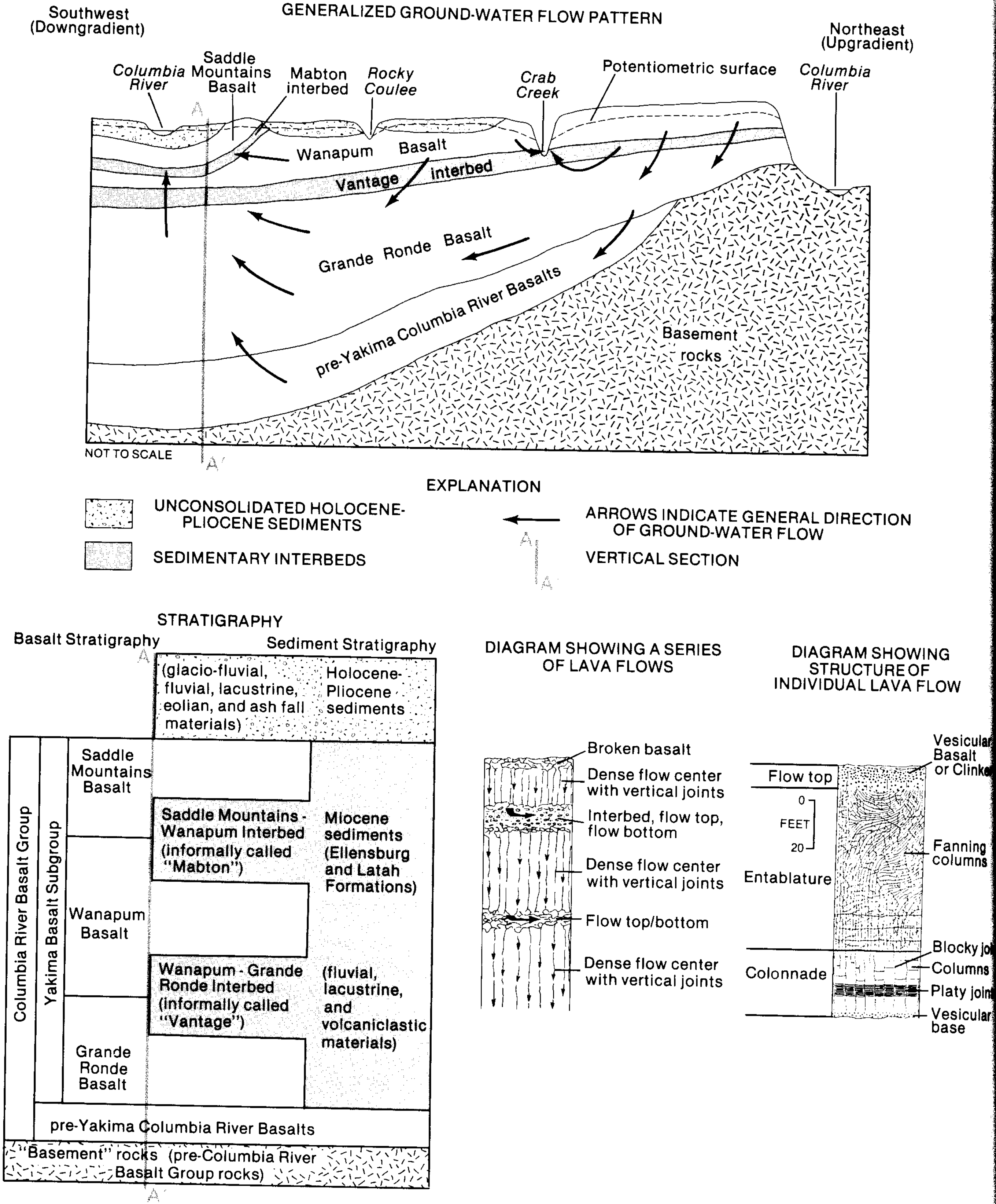

Figure 87.—Generalized ground-water flow pattern in the Columbia River basalt regional aquifer system and idealized vertical sections showing basalt interflow structures.

almost linear, changes of head occur with depth. Locally, however, changes of head with depth may be small within the basalt unit but quite large, up to 200 feet, at or near the boundaries between two basalt units.

RESULTS AND SCHEDULED WORK

As of 1984, the following work had been completed:

•The hydrogeologic framework for Washington State has been defined. This includes areal extent, thickness, tops and bottoms, and structural features for the three aquifers and the two major sedimentary interbeds.

•An observation well network was set up and two mass water-level measurements were made in the spring of 1983 and 1984.

•Potentiometric surface maps were prepared for the three basalt aquifers and the overlying sedimentary deposits for the spring of 1983.

•Conceptualization and development of a computer program of a recharge model was made.

•The first draft of a report documenting the recharge model was completed.

•The meteorological data base such as temperature, wind velocity, radiation, and others for input to the recharge model was established.

•Average annual runoff and precipitation maps were constructed.

•Computer programs for plotting, manipulating, and retrieving the hydrogeologic data were completed.

•Files of more than 4,000 wells in the U.S. Geological Survey's GWSI data base were revised.

The following work is in progress:

•Estimating ground-water pumpage and recharge rates.

•Developing a regional ground-water flow model.

•Preparing soil maps.

•Developing computer programs to estimate horizontal hydraulic conductivity values on the basis of specific-capacity test data.

•Determining boundary conditions for model simulations.

•Determining the location and altitude of surface-water bodies and identifying underlying geohydrologic units.

•Establishing rainfall-runoff relations.

•Generating land-use data for 1979 and 1983 on half-mile blocks through Landsat imagery.

•Estimating irrigation acreage associated with crop types.

•Using a model to estimate evapotranspiration.

•Developing the hydrogeologic framework for the Oregon and Idaho part of the study area.

•Completion of the 1984 potentiometric map.

Scheduled future work includes the following items:

•Complete maps for water levels, average annual precipitation, basalt-unit thickness, hydraulic conductivity, irrigation rates, and average annual runoff.

•Complete a computerized data base which will contain land-use data, model-node locations, locations and altitudes of water levels of the surface-water bodies, thickness of hydrogeologic units, and recharge and discharge rates.

•Construct pumpage maps, which will show location and average annual pumping rates.

•Calibrate the regional ground-water flow model, which will be used to evaluate current, predevelopment, and projected future conditions.

PUBLISHED REPORT

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