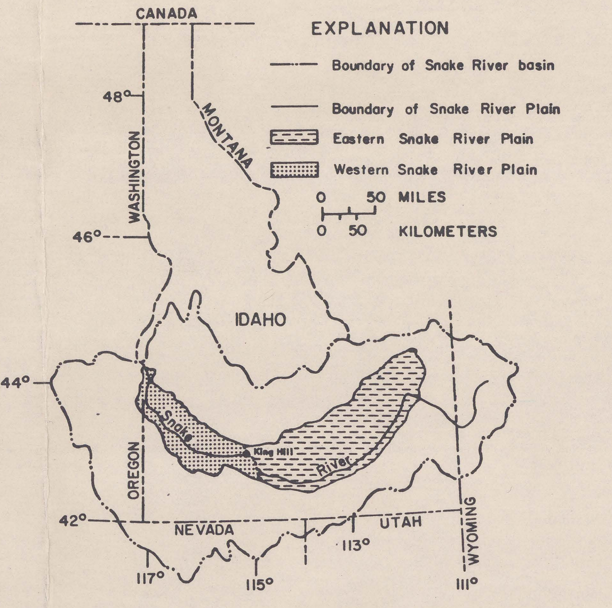
SURFACE GEOLOGY

INTRODUCTION

This report is one in a series resulting from the U.S. Geological Survey's Snake River Plain RASA (Regional Aquifer System Analysis) study that was initiated in October 1979.

As stated by Lindholm (1981), the purpose of the study was to (1) refine knowledge of the regional ground-water flow system, (2) determine effects of conjunctive use of ground and surface water, and (3) describe water chemistry.

The purpose of this report is to summarize knowledge concerning the geohydrologic framework of the Snake River Plain. Definition of the framework is based on preexisting geologic and hydrologic data and new data collected during this study.



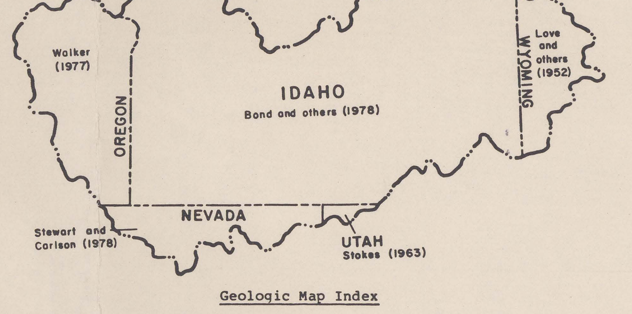
THE SNAKE RIVER PLAIN IS AN ARCUATE AREA OF ABOUT 15,600 SQUARE MILES THAT EXTENDS ACROSS SOUTHERN IDAHO INTO EASTERN OREGON. The plain ranges from about 30 to 70 mi in width and from 2,100 to 6,000 ft in altitude above sea level. Its relatively flat surface slopes generally westward and is surrounded by high mountains. Mountains in the 69,200-mi² Snake River drainage basin above Weiser, Idaho, range from about 7,000 to 12,000 ft in altitude. The Snake River is one of North America's steepest large rivers (Malde, 1968, p. 6) and in some reaches is entrenched as much as 700 ft below the plain.

Agriculture and its related activities dominate the economy of the plain. More than 3 million acres were irrigated in 1980, of which nearly 1 million were supplied by ground water (Lindholm, 1981). Ground water is also the source for most municipal, industrial, and domestic needs.

The areal extent of the Snake River Plain, as defined in this study, is based on geology and topography. Generally, the plain's boundary is the contact between Quaternary sedimentary and volcanic rocks and the surrounding Tertiary and older rocks. Where rocks equivalent in age to those in the plain extend beyond the plain's boundary (for example, where the boundary crosses the mouth of a tributary valley), a topographic contour was chosen to arbitrarily define the boundary.

The Snake River Plain is best studied and discussed in two parts, herein referred to as the eastern plain and the western plain. The line separating the two parts follows a drainage divide from the northern boundary of the plain to the Snake River at King Hill, follows the Snake River to Salmon Falls Creek, and follows Salmon Falls Creek to the southern boundary of the plain. Distinct changes in geology and hydrology that occur along the dividing line make a geohydrologic division feasible.

A geologic reconnaissance in part of the Snake River basin was first made by Hayden (1883). The first information on ground water was reported by Lindgren (1898), followed by Russell (1902, 1903), and Lindgren and Drake (1904a, 1904b). Additional ground-water studies of the Snake River Plain were made by Piper (1923, 1924, 1925); Mansfield (1920, 1927, 1929); Stearns and Bryan (1925); Stearns, Bryan, and Crandall (1939); Stearns, Crandall, and Steward (1938); and Mundorff, Crosthwaite, and Kilburn (1964). Numerous local studies have been conducted in parts of the plain, most of which are listed in the references on sheet 3.



Geologic Map Index

GEOLOGY SHOWN ON THE MAP AT RIGHT IS MODIFIED FROM MAPS REFERENCED ABOVE.

CONVERSION FACTORS

For readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
acre	4,047	square meter (m²)
foot (ft)	0.3048	meter (m)
gallon per minute (gal/min)	0.06309	cubic meter per second (m³/s)
gallon per minute per foot [(gal/min)/ft]	0.2070	cubic meter per second per meter [(m³/s)/m]
inch (in.)	2.540	centimeter (cm)
mile (mi)	1.609	kilometer (km)
pound per cubic foot (lb/ft³)	0.016	gram per cubic centimeter (g/cm³)
square foot per day (ft²/d)	0.09290	square meter per day (m²/d)
square mile (mi²)	2.590	square kilometer (km²)

NGVD of 1929 (National Geodetic Vertical Datum of 1929): The term "National Geodetic Vertical Datum of 1929" replaces the formerly used term "mean sea level" to describe the datum for altitude measurements. The geodetic datum is derived from a general adjustment of the first-order leveling networks in both the United States and Canada. For convenience in this report, the datum also is referred to as "sea level."

Base compiled from U.S. Geological Survey State base maps, 1:500,000

10 0 10 20 30 40 MILES

10 0 10 20 30 40 50 60 KILOMETERS

VOLCANIC ROCKS OF QUATERNARY AND TERTIARY AGE CHARACTERIZE THE SNAKE RIVER PLAIN. Rock types have varying effects on water yield and on amounts and types of solutes in water that recharges aquifers underlying the plain. For this reason, geology of that part of the Snake River drainage contributing water to the plain is shown.

The eastern plain (10,800 mi²) is characterized by widespread occurrence of basaltic rocks, some of which have little or no soil cover. Adjoining much of the eastern plain and structurally perpendicular to its axis are ranges of pre-Cretaceous rocks (chiefly limestone, sandstone, and shale) that are part of the Basin and Range physiographic province (Fenneman, 1931).

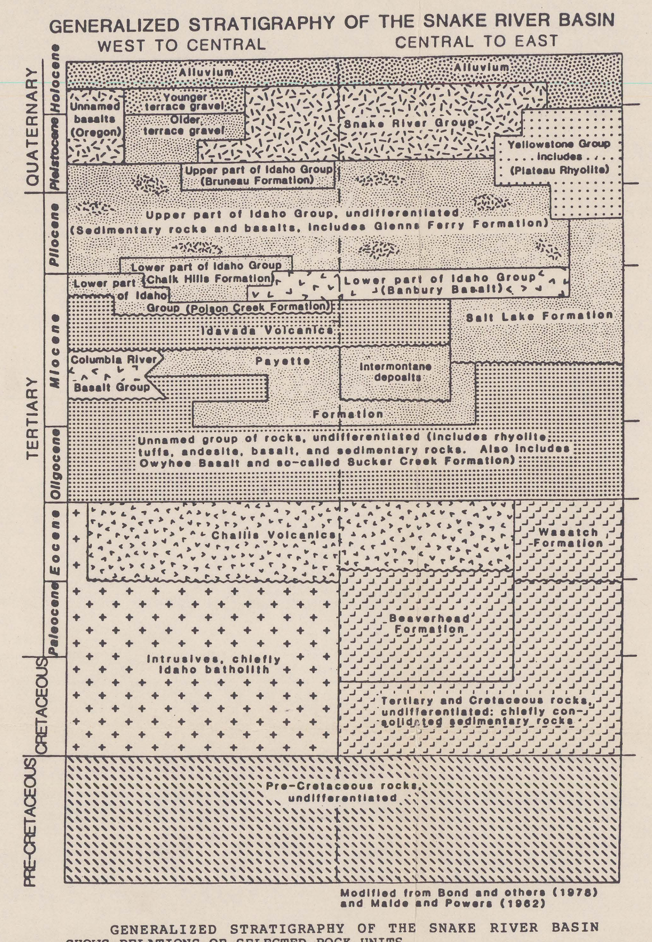
The western plain (4,800 mi²) is characterized by unconsolidated rocks of fluvial and lacustrine origin, except in the eastern part where Holocene basalts common to the eastern plain are prevalent. Older volcanic rocks (chiefly Tertiary age) and granitic rocks of the Idaho batholith adjoin the western plain. Granitic rocks predominate north of and crop out locally south of the plain.

Delineation of major rock types underlying the plain is shown in maps and geologic sections on sheet 2.

THE SNAKE RIVER PLAIN IS BOUNDED LARGELY BY HIGH-ANGLE FAULTS THAT ARE DOWNTHROWN PREDOMINANTLY ON THE VALLEY SIDE. On the basis of geophysical studies, Hill (1963, p. 5010) and Wood and Anderson (1981, p. 14) described the western plain as a graben. Wood and Anderson (1981) indicated deep-seated faulting in the central part of the western plain, as well as along the boundaries (see section J-J', lower right of sheet 2). Boundary faults are not as well defined in the eastern plain and therefore are not shown on the map above. However, their presence is suggested from seismic studies made by Braile and others (1982, obs.). They indicated that vertical displacement is greatest (at least 13,000 ft) along the northwestern boundary. According to Robertson, Schoen, and Barraclough (1974, p. 37), vertical displacement on faults bounding the eastern plain may be from 10,000 to 35,000 ft. Faulting associated with the adjacent Basin and Range province is evidenced into the eastern plain (Kuntz, 1978, p. 9). The Great Rift zone and other rift zones shown on the map above may be indicative of such deep-seated faulting. If so, most of the Rift zone faults are approximately perpendicular to the boundary faults of the plain.

Basalts underlying the plain are highly fractured; however, few major faults are mapped because they are obscured by Holocene basalts and sedimentary rocks that mantle much of the plain.

Faults may provide avenues for vertical movement of water, as reported by Lewis and Young (1982, p. 22) and by Chapman and Ralston (1970, p. 6). Faults also may impede or change the direction of horizontal movement of ground water (Lewis and Young, 1982, p. 6; Lewis and Goldstein, 1982, p. 39).



GENERALIZED STRATIGRAPHY OF THE SNAKE RIVER BASIN SHOWS RELATIONS OF SELECTED ROCK UNITS.

EXPLANATION

Volcanic rift zone (Kuntz, 1978)

Overthrust plate. Tooth on upper plate

Fault. Dashed where approximately located. Dotted where concealed. Bar and ball on downthrown side

Geologic contact

Boundary of Snake River Plain

Boundary of Snake River basin

		Rock unit and map symbol	Physical characteristics and areal distribution	Water-yielding characteristics	Greatest known thickness (ft)
QUATERNARY	Holocene	Alluvium Qa	Chiefly flood-plain deposits. May contain some glacial deposits and colluvium in the uplands. Clay, silt, sand, gravel, and boulders; unconsolidated to well compacted; unstratified to well stratified. Alluvium floors the tributary valleys and flood plains of the main streams and forms fans at mouths of some valleys.	Hydraulic conductivity variable, moderately high in coarse-grained deposits. Sandy and gravelly alluvium yields moderate to large quantities of water to wells. Specific capacities commonly range from 20 to 100 (gal/min)/ft. An important aquifer.	<200 (?)
		Windblown deposits Qw	Chiefly windblown deposits, include some lake and glacial-flood deposits; mantle much of the lowland areas; include active sand dunes in places, generally in northern Owyhee County and in northern part of eastern plain.	Generally above the water table.	<100 (?)
		Younger basalt Qb	Olivine basalt, dense to vesicular, aphanitic to porphyritic; irregular to columnar jointing; thickness of individual flows variable. Includes Snake River Group of Malde and Powers (1962). Includes beds of basaltic cinders, rubbly basalt, and interflow sedimentary rocks. Chiefly rocks of the Snake River Group. Crops out in much of Snake River Plain; mantled in many places with alluvium, terrace gravel, and windblown deposits.	Hydraulic conductivity variable but extremely high in places; formational conductivity high because of jointing between flows; rock conductivity low. Unit constitutes the Snake Plain aquifer east of King Hill (Mundorff and others, 1964, p. 8). Specific capacities of 500–1,000 (gal/min)/ft are common. Transmissivity determined from pumping tests in the eastern Snake River Plain averaged 6.7 x 10⁵ ft²/d (Mundorff and others, 1964, p. 159).	>4,000 Includes QTb below
	Pleistocene	Younger silicic volcanic rocks Qsv	Rhyolitic ash-flow tuff, occurs as thick flows and blankets of welded tuff with associated flow- to coarse-grained ash and pumice beds. Include rocks of upper part of the Yellowstone Group (Plateau Rhyolite). Mantle much of Yellowstone Plateau in northeastern part of basin.	Hydraulic conductivity generally unknown but may be high as indicated by rapid percolation of surface runoff (Whitehead 1978, p. 10). Tightly welded in places. Specific capacities range from 8 to 60 (gal/min)/ft. An important aquifer locally.	>3,000
QUATERNARY AND TERTIARY	Pleistocene, Pliocene and Miocene	Basalt QTb	Olivine basalt similar to Qb above. Included as part of the Snake Plain aquifer. Tentatively assigned to upper part of Idaho Group. Exposures generally have well developed soil cover.	Hydraulic conductivity similar to Qb above but decreases with age.	Included with Qb above
		Older alluvium QTs	Subaerial and lake deposits of clay, silt, sand, and gravel. Compacted to poorly consolidated, poorly to well stratified; beds somewhat lenticular and interbedded; contains beds of ash and interstratified basalt. Widespread tuffaceous sedimentary rocks and tuff in western part of basin. Includes Idaho Group and Payette and Salt Lake Formations and lower part of Yellowstone Group. In places, underlies the older basalt (Tb).	Hydraulic conductivity highly variable; generally contains water under confined conditions; yields to wells range from a few gallons per minute to as much as several hundred gallons per minute from sand and gravel. Specific capacities range from 5 to 60 (gal/min)/ft. In places, an important aquifer.	>5,500
TERTIARY	Miocene	Older basalt Tb	Flood-type basalt, dense, columnar jointing in many places; folded and faulted (except for the Banbury Basalt); yields to wells from fractures, some flows are vesicular. Olivine basalt (Banbury); interbedded locally with minor amounts of stream and lake deposits. Includes basalt of Columbia River Basalt Group, Owyhee Basalt Group, and Banbury Basalt of the Idaho Group.	Hydraulic conductivity variable, may be high in places. Locally yields small to moderate amounts of water to wells. Upper parts of the older basalt are part of Idaho Group, sand and gravel still yield good supplies of water under confined or unconfined conditions. Specific capacities range from 3 to 900 (gal/min)/ft. An important aquifer.	>3,000 (the Banbury Basalt is generally <1,000. The older basalt may be >7,000 in the western plain)
	Pliocene to Oligocene	Older silicic volcanic rocks Tsv	Rhyolitic, latitic, and andesitic rocks, mainly ash-flow tuff; jointed or platy to columnar; occur as thick flows and blankets of welded tuff with associated fine- to coarse-grained ash and pumice beds (commonly reworked by flowing water) and clay, silt, sand, and gravel; locally folded, tilted, and faulted. Include Idavada Volcanics.	Hydraulic conductivity highly variable. Joints and fault zones in flows and welded tuff and interbeds in coarse-grained ash, sand, and gravel yield small to moderate, and rarely large, amounts of water to wells. Commonly contain thermal water under confined conditions. Specific capacities range from 1 to >1,000 (gal/min)/ft and are generally less than 400 (gal/min)/ft. An important aquifer.	>3,000
	Eocene and Paleocene	Volcanic rocks, undifferentiated Tov	Extrusive rocks range in composition from rhyolite to basalt; include welded tuff, pyroclastics, tuffaceous, and other clastic and sedimentary rocks. Chiefly Challis Volcanics; mainly crop out in mountains and foothills north of the eastern plain; may include some intrusive rocks.	Hydraulic conductivity generally low. Little information available on yields to wells. May be an important aquifer locally for domestic and stock use.	>5,000
TERTIARY AND CRETACEOUS		Sedimentary rocks, undifferentiated TKs	Undifferentiated shale, siltstone, sandstone, and freshwater limestone of Tertiary and Cretaceous age. Younger rocks composed chiefly of breccia, conglomerate, and sandstone. Exposed in eastern part of basin. May include rocks of Jurassic age.	Hydraulic conductivity generally low. Little information available on yields to wells; weathered zones and fractures may yield moderate quantities of water to wells; large yields may be obtained in places. May be an important local aquifer.	>10,000
		Intrusive rocks TKi	Chiefly granitic rocks of the Idaho batholith; include older and younger crystalline rocks; crop out in a few places south of Snake River in Idaho and northern Nevada.	Hydraulic conductivity generally low. Fractures and weathered zones may yield small quantities of water to wells. Not an important aquifer.	Unknown
PRE-CRETACEOUS		Pre-Cretaceous rocks, undifferentiated pK	Well-indurated sedimentary and metamorphic rocks that have been folded, faulted, and intruded by igneous rocks. Crop out in mountainous areas. Include extrusive rocks of Permian and Triassic age in western part of basin. May include Cretaceous or younger sedimentary rocks.	Hydraulic conductivity low. Faults, fractures, and weathered zones may yield small quantities of water to wells. Little information available on yields to wells. Not an important aquifer.	>12,000

PHYSICAL CHARACTERISTICS OF ROCKS ARE SUCH THAT MUCH OF THE SNAKE RIVER PLAIN IS A HIGHLY PRODUCTIVE SOURCE OF GROUND WATER. Geologic units that have similar hydrologic characteristics, but which are shown separately on more detailed maps, are grouped and shown above as single units. Estimates of rock thicknesses are compiled from various published reports, which are included in the references.

GEOHYDROLOGIC FRAMEWORK OF THE SNAKE RIVER PLAIN, IDAHO AND EASTERN OREGON

By
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1984