Tuck, L.K., and others, 1996, Geologic history and hydrogeologic units of intermontane basins of the Northern Rocky Mountains, Montana and Idaho

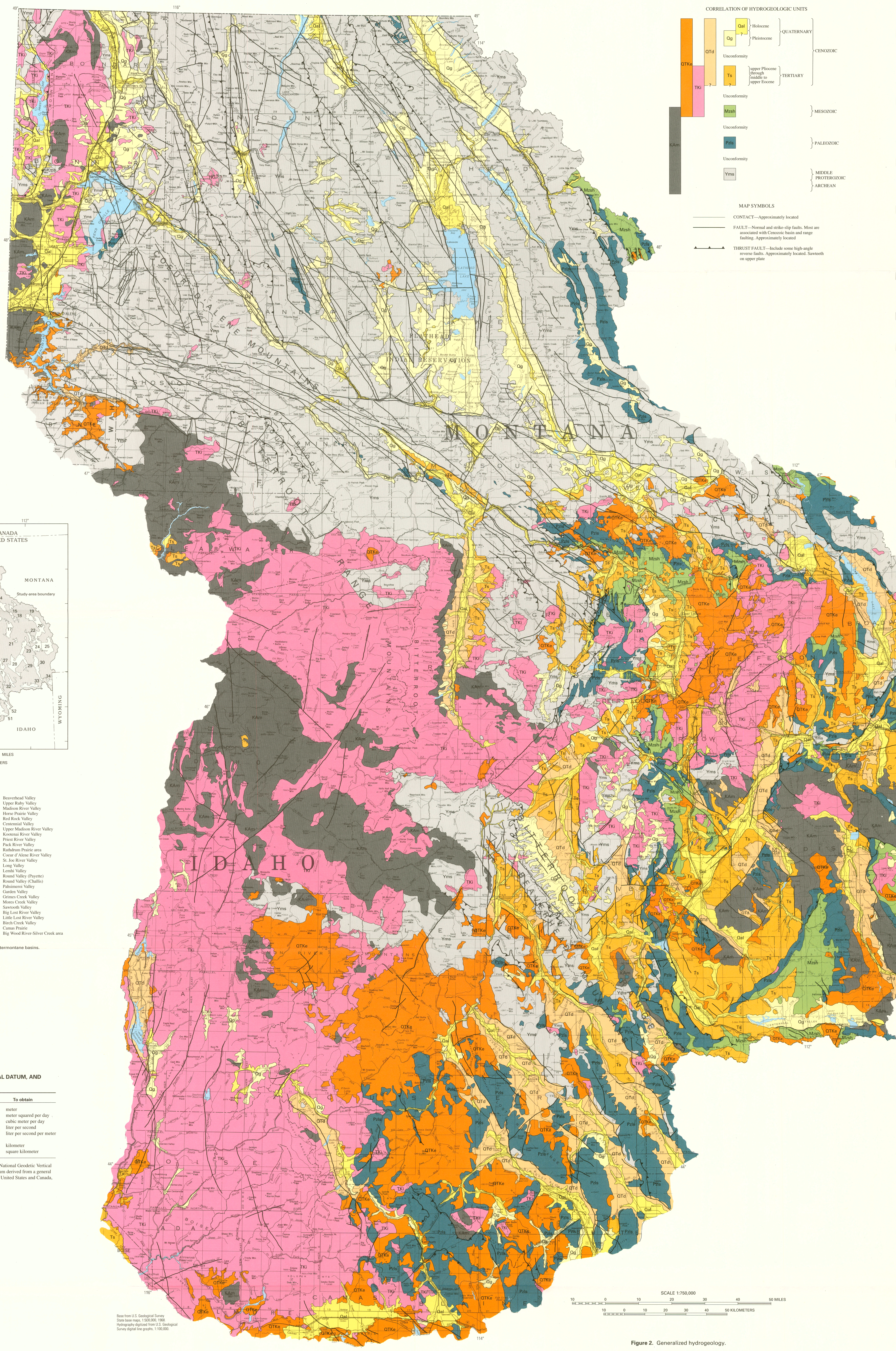
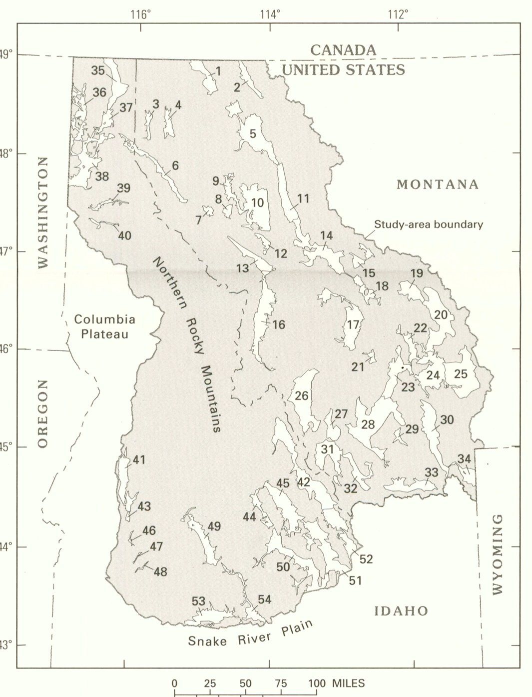


Figure 2. Generalized hydrogeology.

DESCRIPTION OF HYDROGEOLOGIC UNITS

	MAJOR LITHOLOGY	AREAL EXTENT OF OUTCROPS	WATER-YIELDING PROPERTIES
Qal	ALLUVIAL DEPOSITS (Holocene and Pleistocene)—Unconsolidated stream-laid gravel, sand, silt, and clay, that is poorly to moderately well sorted. Includes some talus, colluvium, landslide and placer deposits, mine tailings, and Pleistocene glacial outwash	Mainly present along present-day stream channels, flood plains and low-level terraces near rivers in larger basins and as smaller deposits near perennial and ephemeral streams. In mountainous areas, Qal is found in narrow deposits that are not laterally or vertically extensive. In most mountainous regions these deposits are not shown on figure 2	Deposits yield abundant water to wells throughout the study area.
Qg	GLACIAL DEPOSITS (Pleistocene)—Unconsolidated gravel, sand, silt, and clay, that is very poorly to moderately well sorted. Includes less permeable deposits from the Cordilleran ice sheet and mountain glaciers such as moraines, drumlins, broad areas of hummocky deposits, glacial debris, and lakebed deposits	Extensive deposits are present in the northern half of the study area where the Cordilleran ice sheet and mountain glaciers covered a large part of the study area.	Generally, a limited source of water to wells owing to the fine-grained material and very poor sorting of some deposits.
QTd	UNDIFFERENTIATED DEPOSITS (Quaternary and Tertiary)—Unconsolidated to semiconsolidated gravel, sand, silt, clay, ash, ash-fall tuff and locally contains lignite and limestone. Includes alluvium and landslide deposits, extensive alluvial-fan deposits within and outside of basins, alluvium on some alluvial fans, Tertiary deposits and rocks with a veneer of Quaternary deposits. Includes areas where Quaternary and Tertiary deposits are indistinct	Extensive deposits are present in central Idaho where QTd covers most basins from the present-day stream channels, flood plains, and low-level terraces near streams and rivers to the basin margins.	Yields are variable and might depend on hydraulic interconnection with more permeable units and extent of interbedded gravel.
Ts	SEDIMENTARY DEPOSITS AND ROCKS (upper Pliocene through middle to upper Eocene)—Unconsolidated to consolidated gravel, sand, silt, clay, ash, ash-fall tuff, and bentonite that is poorly to moderately well sorted. Locally includes massive conglomerate, sandstone, siltstone, shale, and interbedded volcanic and volcaniclastic rocks, lignite, and limestone	Deposits and rocks crop out only in the southern two-thirds of the study area. Ts is mainly found near basin margins, as erosional remnants within the basins, and as isolated outcrops on uplifted fault-bounded blocks within form mountains	Yields are variable and might depend on hydraulic interconnection with more permeable units and extent of interbedded gravel.
QTKe	EXTRUSIVE ROCKS (Quaternary through Cretaceous)—Pyroclastic rocks, lava flows, ash-flow tuffs, welded tuffs, and breccia that range in composition from rhyolite to basalt. Includes water-lain, well-bedded volcaniclastic rocks such as tuffaceous conglomerate, coarse-grained sandstone, and mudstone	Most outcrops are found in four general areas	Yields are variable and depend on the occurrence and extent of fractures, faults, breccia, and permeable zones between lava flows.
TKi	INTRUSIVE ROCKS (Tertiary through Cretaceous)—Primarily granite and rocks of granitic composition related to the Idaho and Boulder Batholiths, smaller plutons, stocks, dikes, and sills	The most extensive outcrops, present in central Idaho and west-central Montana, are part of the Idaho Batholith. Outcrops also are found in northern Idaho. In Montana, outcrops between Helena and Divide are part of the Boulder Batholith	Yields are variable and depend on the occurrence and extent of fractures and joints.
Mzsh	CLASTIC AND CARBONATE ROCKS, UNDIFFERENTIATED (Mesozoic)—Primarily marine shale with interbedded marine sandstone, siltstone, mudstone, and marine limestone	Most of these rocks are present as isolated outcrops	Generally consists of low permeability shale. Water-yielding zones depend on occurrence and extent of more permeable conglomerate and sandstone.
Pzls	CARBONATE AND CLASTIC ROCKS, UNDIFFERENTIATED (Paleozoic)—Primarily massive and thick- to thin-bedded limestone with dolomite, interbedded phosphatic sandstone, quartzite, siltstone, mudstone, and shale	Paleozoic rocks are generally present in uplifted fault-bounded blocks	Yields are variable and depend on the occurrence and extent of fractures, caverns, and breccia.
Yms	METASEDIMENTARY ROCKS, UNDIFFERENTIATED (Primarily Middle Proterozoic)—Primarily argillaceous limestone, dolomite, siltstone, argillite, and quartzite	Metasedimentary rocks primarily crop out in the northern half of the study area.	Yields are variable and depend on the occurrence and extent of fractures.
KAm	METAMORPHIC ROCKS, UNDIFFERENTIATED (Cretaceous through Archean)—Metamorphosed granitic plutons, sills, dikes, and metasedimentary rocks. Includes schist, dolomitic marble, quartzite, and iron formation	Metamorphic rocks primarily crop out in southwestern Montana between Yellowstone National Park, Wyo., and Missoula, Mont. Large outcrops are present in central Idaho and are associated with TKi of the Idaho Batholith. Scattered outcrops are also present in northern Idaho	Generally a barrier to ground-water flow. Might yield water locally, but generally water-yielding characteristics are unknown.



EXPLANATION

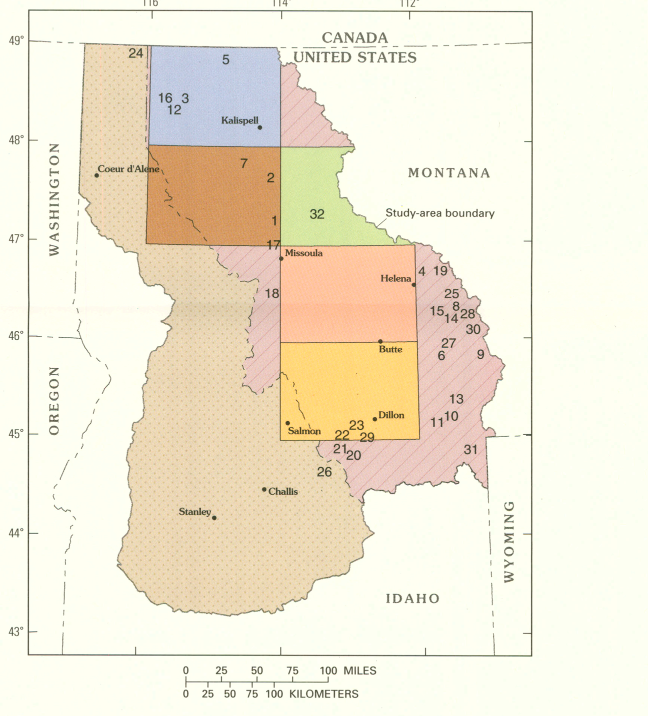
BASIN NAMES

1. Tobacco Valley
2. North Fork Flathead River Valley
3. Lake Creek Valley
4. Libby Creek Valley
5. Kalispell Valley
6. Lower Clark Fork Valley
7. Plains Valley
8. Camas Prairie Basin
9. Little Bitterroot Valley
10. Mission Valley
11. Swan Valley
12. Jocko River Valley
13. Missoula Valley
14. Blackfoot-Clearwater Valley
15. Upper Blackfoot River Valley
16. Bitterroot Valley
17. Upper Clark Fork Valley
18. Avon Valley
19. Helena Valley
20. Townsend Valley
21. Silver Bow Creek Valley
22. Boulder Valley
23. Jefferson River Valley
24. Western Three Forks Valley
25. Gallatin Valley
26. Big Hole Basin
27. Grasshopper Valley
28. Beaverhead Valley
29. Upper Ruby Valley
30. Madison River Valley
31. Horse Prairie Valley
32. Red Rock Valley
33. Centennial Valley
34. Upper Madison River Valley
35. Kootenai River Valley
36. Priest River Valley
37. Pack River Valley
38. Rathdrum Prairie area
39. Coeur d'Alene River Valley
40. St. Joe River Valley
41. Long Valley
42. Lemhi Valley
43. Round Valley (Payette)
44. Round Valley (Challis)
45. Pahsimeroi Valley
46. Garden Valley
47. Grimes Creek Valley
48. Mores Creek Valley
49. Sawtooth Valley
50. Big Lost River Valley
51. Little Lost River Valley
52. Birch Creek Valley
53. Camas Prairie
54. Big Wood River-Silver Creek area

Figure 1. Location of study area and intermontane basins.

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATION

Multiply	By	To obtain
foot (ft)	0.3048	meter
foot squared per day (ft^2/d)	0.0929	meter squared per day
gallon per day (gal/d)	0.003785	cubic meter per day
gallon per minute (gal/min)	0.06309	liter per second
gallon per minute per foot [(gal/min)/ft]	0.207	liter per second per meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.59	square kilometer



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INTRODUCTION

The Regional Aquifer-System Analysis (RASA) Program is a series of studies by the U.S. Geological Survey (USGS) to analyze regional ground-water systems that compose a major portion of the Nation's water supply (Sun, 1986). The Northern Rocky Mountains Intermontane Basins is one of the study regions in this national program. The main objectives of the RASA studies are to: (1) describe the ground-water systems as they exist today, (2) analyze the known changes that have led to the system's present conditions, (3) combine results of previous studies in a regional analysis, where possible, and (4) provide means by which effects of future ground-water development can be estimated.

The purpose of this study, which began in 1990, was to increase understanding of the hydrogeology of the intermontane basins of the Northern Rocky Mountains area. This report is Chapter A of a three-part series and describes the geologic history and the general hydrogeologic units of the Northern Rocky Mountains area. Chapter B (Briar and others, 1996) shows the general distribution of ground-water levels in the basin-fill deposits. Chapter C (Clark and Dutton, 1996) describes the quality of ground water and surface water in the study area.

This atlas provides a brief overview of the geologic history from early Precambrian time to the present and describes major tectonic events, depositional environments, and structural features in the study area. This atlas also describes the lithology, areal extent of outcrops, and water-yielding properties of the hydrogeologic units, with an emphasis on Tertiary to Quaternary basin-fill deposits.

Geologic units within the Northern Rocky Mountains RASA study area is subdivided into 10 hydrogeologic units. These subdivisions generally are based on major lithology, geologic age, and water-yielding properties. Hydrogeologic units in the study area consist of unconsolidated to consolidated basin-fill deposits and consolidated bedrock. Basin-fill deposits that are aquifers include Holocene and Pleistocene alluvial deposits (Qal), Pleistocene glacial deposits (Qg), Quaternary and Tertiary undifferentiated deposits (QTd), and Tertiary sedimentary deposits and rocks (Ts). Bedrock units that are aquifers in the study area include Quaternary through Cretaceous extrusive rocks (QTKe), Tertiary through Cretaceous intrusive rocks (TKi), Mesozoic clastic and carbonate rocks (Mzsh), Paleozoic carbonate and clastic rocks (Pzls), Middle Proterozoic metasedimentary rocks (Yms) and Cretaceous through Archean metamorphic rocks (KAm). Clastic and carbonate rocks (Mzsh) and metamorphic rocks (KAm) can yield water locally, but generally their water-yielding properties are unknown.

LOCATION AND GENERAL FEATURES

The Northern Rocky Mountains Intermontane Basins study area encompasses about 77,500 mi^2 in western Montana and central and northern Idaho (fig. 1). The study area extends from near the eastern front of the Rocky Mountains in Montana westward to the basalt plains of the Columbia Plateau in western Idaho. In the south, the study area extends from the Snake River Plain in Idaho northward to the United States-Canada border. The Continental Divide separates the study area into two major drainage systems—the Missouri River drainage to the east and the Columbia River drainage to the west. Major tributaries of the Missouri River drainage in the study area include the Beaverhead, Ruby, Big Hole, Jefferson, Madison, and Gallatin Rivers. Major tributaries of the Columbia River drainage in the study area include the Kootenai, Blackfoot, Bitterroot, Flathead, Clark Fork/Pend Oreille, Spokane, Salmon, Selway, Lochsa, South Fork Clearwater, and North Fork Clearwater Rivers.

Topography in the study area is varied. Land surface altitudes range from about 2,000 ft in the Kootenai River Valley in the northwestern part of the study area to more than 12,000 ft in the Lost River Range in the south-central part of the study area. In northwestern Montana and central Idaho, mountain ranges typically are separated by narrow, steep-sided valleys that have little or no basin-fill deposits. In contrast, the ranges of southwestern Montana and east-central and northern Idaho are separated by wide, relatively level valleys that are deeply filled with basin-fill deposits. Valley floor altitudes range from about 2,000 ft in the Kootenai River Valley to about 7,000 ft in the Sawtooth Valley in south-central Idaho.

The climate is characterized by cold winters and mild summers. Annual precipitation ranges from about 8 in. for basins of east-central Idaho to about 100 in. for some mountainous parts of Montana. Most valleys receive about 10 to 30 in. of precipitation per year, with more than one-half falling in winter and spring. Large winter snowpacks in the mountains gradually release their water content as snowmelt that maintains streamflow well into summer.

Major physiographic features in the study area include 54 generally north-south trending intermontane basins (or valleys) (fig. 1). For the purpose of this study, "basin" refers to topographic as well as geologic structural basins. The perimeters of the basins are approximated from topography, geologic structure, extent of basin fill, and results of previous studies. The intermontane basins range in area from less than 10 mi^2 to more than 700 mi^2 and are filled with unconsolidated to consolidated Tertiary to Quaternary continental deposits. Intermontane basins compose about 16 percent of the study area. All basins have through-flowing perennial streams with recent flood plains. In most southern basins, these flood plains are adjacent to older river terraces which grade into pediments or alluvial fans that meet mountain fronts with an abrupt change in slope. In northern basins, recent flood plains are adjacent to glacial deposits which extend to mountain fronts; in some areas, the glacial deposits reach an altitude of as much as 6,000 ft above sea level. Mountain fronts commonly coincide with faults or fault systems along which the basins have been down dropped relative to the mountains.

GEOLOGIC HISTORY

The early geologic history of the study area involved several episodes of tectonism and regional metamorphism, erosion, and deposition. Major tectonic events probably occurred about 3,000; 2,750; 1,600; 1,400–1,300; and 800 m.y. (James and Hedge, 1980; James, 1990) producing granitic plutons, gneiss, amphibolite, schist, dolomitic marble, quartzite, and banded iron (fig. 2, KAm). The oldest sedimentary rocks in the study area might be as old as 1,700 m.y. (Ruppel, 1986). These Early to Middle Proterozoic rocks (Yms) form a thick sequence of argillite, siltstone, and sandstone with some volcanic tuffs, which were deposited as turbidites (Hahn and Hughes, 1984). In Middle Proterozoic time, central Idaho was uplifted to form a highland area that created two areas of deposition which persisted through the remainder of the Proterozoic. Sediments from this highland were deposited southward into a deep-ocean basin along the western margin of North America in west-central Idaho (Ruppel, 1986) and northward into a basin in western Montana now called the Belt Basin.

GEOLOGIC HISTORY AND HYDROGEOLOGIC UNITS OF INTERMONTANE BASINS OF THE NORTHERN ROCKY MOUNTAINS, MONTANA AND IDAHO

By
L.K. Tuck, David W. Briar, and David W. Clark
1996

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