Hydrogeologic Framework of the Southern Part of the Flathead Lake area, Flathead, Lake, Missoula, and Sanders Counties, Montana

by

Larry Smith

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Hydrogeologic Framework of the Southern Flathead, Lake, Missoula, and Deerlakes Basins

by

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Introduction

The southern part of the Flathead Lake area, generally within the Flathead Indian Reservation, includes several intermontane valleys, including the Mission, Little Bitterroot River, Camas Prairie Basin, Swan, and Jocko valleys, and many smaller tributary valleys along the Flathead River, such as Irvine Flats (fig. 1). Elevations range from greater than 9,000 ft in the Mission Range to about 2,500 ft above sea level along the Flathead River where it exits the Flathead Indian Reservation in Sanders County.

Geologic units exposed in the mountains surrounding the valleys include Proterozoic Belt Supergroup rocks, Tertiary igneous rocks, Tertiary conglomerate, sandstone, and siltstone, and Quaternary glacial and post-glacial sediments (fig. 2; Mudge and others, 1982; Harrison and others, 1986; Ostenas and others, 1990; Smith and others, 2000). Belt Supergroup rocks core many ranges, with Tertiary volcano and intrusive rocks common only in the Hog Heaven Range at the northern end of the Little Bitterroot River valley (Lange and Zehner, 1992). Sedimentary rocks and loosely consolidated sediment of Tertiary age have been incompletely mapped in the area. However, reconnaissance work suggests that the upper parts of many small tributary valleys in the Salish Mountains are composed of Tertiary strata (P. C. Ryan, written comm., 1999).

Intermontane valleys between the bedrock-covered mountains are filled by Tertiary sediments and sedimentary rocks, local accumulations of pre-glacial sand and gravel, a variety of glacial sediments, and post-glacial alluvium and minor eolian accumulations (fig. 3). Glacial sediments mantle bedrock in the mountains north of the Polson moraine, where the last glacial advance of the Flathead Lobe of the Cordilleran ice sheet ended, and along many drainages in the Mission Range, which were once occupied by valley glaciers (figs. 1, 2).

The maps included here show the depths to, thicknesses of, and proportions of sand and gravel in sediments that contain basin-fill aquifers in the southern part of the Flathead Lake area. Data were gathered from descriptive water-well logs, surface exposures of sediments (Levish, 1997), and some previously published geophysical studies (LaPoint, 1971; Boeticher, 1982). Hydrogeologic units were defined based on surficial geologic map units, stratigraphic position, and drillers' log data (fig. 4). The maps include:

- Figure 5—depth below ground surface to a locally mappable deep alluvial unit in the Mission and Little Bitterroot River valley;
- Figure 6—thickness of Glacial Lake Missoula sediments above the deep alluvial unit; and
- Figure 7—relative coarseness of Glacial Lake Missoula sediments above the valley (Stagle, 1988; P. C. Ryan, written comm., 2000). The bottom portions of the deepest boreholes in the Jocko Valley penetrated reddish-colored clayey and silty conglomerates that may be correlative to a section of Tertiary sedimentary rocks that are at land surface in the northwestern part of that valley.

In most areas of the Mission and Little Bitterroot River valleys, the deep alluvium (probably of Quaternary age) rests on either Tertiary sedimentary rocks or bedrock. This unit, which is not known to be exposed at the surface and is recognized only in well bores, consists of gravel, sand, and minor silts and can produce large volumes of water where it is greater than 20 ft thick. Reported yields from about 700 water wells completed in this unit range from 2 to 2,500 gallons per minute (gpm) with an average of 100 gpm and a median of 40 gpm. The deep alluvium is known as the Lonepine aquifer in the Little Bitterroot River valley. Locally in T. 19, 20, and 21 N. in the Mission valley, a few wells have been drilled entirely through the deep alluvium into bedrock. In these wells the deep alluvium is as much as 77 ft thick. However, most wells are completed between 10 and 20 ft below the top of the unit.

The deep alluvium in the Little Bitterroot River valley (the Lonepine aquifer) represents a pre-glacial or early stream channel filled with continuous stream deposits of the Jocko River modified by pre-glacial or glacial sediments. The unit is overlain in many areas by lake sediments deposited in Glacial Lake Missoula, which covered many valleys in western Montana during the last glacial period (Pardoe, 1910; Alt, 2001).

The deep alluvium is generally overlain by beds of silty and clayey gravel and thick beds of silt and clay with minor silty sand and gravel, which are referred to here as Glacial Lake Missoula sediments (fig. 4; Levish, 1997). In the Little Bitterroot River valley, the deep alluvium is directly overlain by a thick sequence of Glacial Lake Missoula silt and clay that generally is not an aquifer. In the Mission valley, determining the contact between deep alluvium and the Glacial Lake Missoula sediments from water-well drillers is not always possible. Interfering between units makes correlations between wells difficult, especially in the northern and southwestern parts of the valley where wells do not reach into bedrock. Reported yields from about 1,200 water wells completed in the Glacial Lake Missoula sediments range from 1 to 1,500 gpm with an average of 45 gpm and a median of 20 gpm. Glacial Lake Missoula sediments correlate to the sequence that overlies the deep alluvium and is well exposed along the canyon walls of the Flathead River downstream of the Kerr Dam (fig. 1).

Silt and clay were deposited in Glacial Lake Missoula above the deep alluvium in the Little Bitterroot River valley and Camas Prairie Basin. In the Valley View Hills area of the Mission valley, exposures suggest that till (silty and clayey gravel deposited directly by glacial ice) may overlie the deep alluvium locally in the subsurface. However, the well data are insufficient to make a distinction between till and gravelly glacial-lake deposits. The glacial-lake deposits, which fill much of the valleys, are overlain by shallow alluvium along river valleys, glacial-meltwater stream deposits (outwash), and eolian sand. The shallow alluvium can contain shallow ground water (fig. 4). Reported yields from about 750 water wells completed in the shallow alluvium range from 1 to 1,000 gpm with an average of 55 gpm and median of 30 gpm.

VARIATION IN THE DEPTH TO THE DEEP ALLUVIUM

Erosion and deposition at the bottom and land-surface topography cause the deep alluvium to thin laterally. The top of the deep alluvium is poorly exposed and is shown by dashed lines on figure 5. The margins of the deep alluvium are greatest where the land surface is higher than the Polson moraine and thickest along the unit is similar to the unit is similar to the unit.

The evolution of bedrock and sand and gravel interpret the positions of the deep alluvium southeast of Crow Creek to Mission Creek. Well data show that the lower bedrock and alluvium between Johnson and the area west of Moise Hills. Topography influences the contact between upper bedrock and the incised Flathead River valley south of Flathead River.

GLACIAL LAKE MISSOULA SEDIMENTS

Glacial Lake Missoula sediments strata include surficial sand and gravel deposits (Smith, 2002). In the southern part of the Flathead Lake area (fig. 6), Glacial Lake Missoula sediments are broad areas of which extend beyond the known limits of the Glacial Lake Missoula sediments. Figure 7 shows the lateral limits of the Glacial Lake Missoula sediments on the Rock Creek and the Valley View Mesosills. The Flathead River where the water is cut a cut is insufficient to map the Glacial Lake Missoula sediments in the valley and Camas Prairie Basin.

Greater amounts of sand and gravel are deposited in the eastern Mission Valley than in the nearby Missouri River valley (fig. 7). This is likely because the Mission Valley is incised by the Flathead River. The isopach map of the ice sheet and valley was covered by the Mission valley is incised by the Flathead River. The isopach map of the ice sheet and valley was covered by the Mission valley.
northern part of the Flathead Lake area, Sanders counties, Montana

Smith

The thin alluvial fills (generally <50 ft thick) of the Missouri River, Madison Creek, Little Bitterroot River, and ecotone sand. The areas of shallow sand

sediments of the Mission valley are drilling targets. The positions of the deep alluvium (fig. 5) and the relative coarseness of Glacial Lake Missoula sediments (fig. 7) are useful for

Alluvium

top of the deep alluvium and variation in t to be at different depths. In many areas constrained by well data; its approximate

MAP CONSTRUCTION

Lithologic logs for the wells used in the mapping were retrieved from the Ground-Water Information Center (GWIC) databases in 1996, incorporating data for most wells

Land-surface altitudes at well locations were obtained from U.S. Geological Survey digital elevation models (DEMs) using ArcInfo™ computer software for determining the

DATA SOURCES


La Fest, J. I., 2002, Gleniometry surface map of the southern part of the Flathead Lake area Flathead, Lake, Sanders, and Missoula Counties, Montana: Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2; part B, map 4, scale 1:100,000.


Smith, L. N., 2002a, Altitude of and depth to the bedrock surface in the Flathead Lake Area, Flathead and Lake counties, Montana: Montana Bureau of Mines and Geology Ground-Water Assessment Atlas 2; part B, map 7, scale 1:150,000.

Smith, L. N., 2002b, Thickness of surficial sand and gravel deposits, Flathead Lake area:

nally above the deep alluvium and below b average about 250 ft in thickness the "deposits are made up of predominantly b the deep alluvium (figs. 5, 6). The Glacial Lake Missoula moraine and between the Flathade, the thicknesses decrease significantly along nongen through the basin fill. Well data were sediments in the Jocko Valley, Swan River sediments in Glacial Lake Missoula sediments the Flathead River or in the Little Bitterroot sediment was transported into the valleys key glaciers in the Mission Range. Sediment emerging from beneath the ice and by s of coarser sediment in the Polson moraine geat that much of the sediment carried from

continued to the present day. The main features remain as the well is drilled deeper, the

The use of coarser materials in the top of the alluvium layer is indicated by the generally

Early in the development of the well, the top of the alluvium layer is typically described as

The use of the alluvium layer top to determine the approximate depth to bedrock is

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Sufficient hydraulic continuity between the deep alluvium, permeable zones in much of the Glacial Lake Missoula sediment, and shallow alluvium (figs. 3, 4), allow the entire sequence to be considered a single, regional, ground-water flow entity. The ground-water flow system for the Glacial Lake Missoula sediments, deep alluvium, and fractured bedrock, and some tertiary sedimentary rocks, based on wells completed at depths greater than 75 ft below ground surface, is presented in LaFave (2002). Inset into the Glacial Lake Missoula sediments are surficial sand and gravel deposits which may be aquifers. The location of those deposits is shown as “Qal” on figure 2. Thickness of this shallow alluvium are up to 150 ft near the Polson moraine but generally are less than 50 ft in other areas (Smith, 2002b).

BASIN-FILL STRATIGRAPHY

The intermontane valleys in southern part of the Flathead Lake area are structurally down-dropped relative to the uplifted Salish, Mission, Swan, and Jocko mountain ranges. Bedrock is about 2,000 ft below the surface in the structurally deepest parts of the Mission valley, near the Polson moraine (Smith, 2002a), however the depth to bedrock is shallower in the southern and central parts of the valley. Depths to bedrock in the Jocko, Camas Prairie Basin, and Little Bitterroot River, and southern Mission valleys are poorly known. In these valleys, consolidated silt, clay, sandstone, and conglomerate of probable tertiary age were penetrated in the bottom of well bores, especially in the Camas Prairie Basin, Irvine Flats, tributary valleys along the Little Bitterroot River, and in the southern Mission valley, and Polson moraine (Alden, 1953) and from near it.

The sequence of unconsolidated geologic units (from older to younger–deep alluvium, local till deposits, glacial-lake deposits, and sand and gravel at the land surface) represents deposition during one or more glacial-age and glacial-lake advance and retreat cycles. The deep alluvium likely deposited before and during glacial advance. The uppermost beds of the deep alluvium most likely were deposited as outwash by meltwater streams in front of the glacier that advanced southward (Smith and others, 2000). Thick till was deposited by earlier advances of the Flathead glacier that extended south of the Polson moraine (Olson, 1998), but the distributions and ages of these deposits are poorly known.

Glacial-lake deposits of Glacial Lake Missoula were deposited south of, and possibly locally north of, the Polson moraine and within the Little Bitterroot River, Camas Prairie Basin, and Jocko valleys and their tributaries. Some silty and clayey glacial-lake sediments north of the Polson moraine were deposited in a lake in front of the retreating glacier as the glacier receded from the moraine. This lake was impounded by the Polson moraine and by bedrock along the Flathead River near Kerr Dam. Glacial-lake deposits and underlying compact till may form local confining units that extend across parts of the Mission valley. The stratigraphy of the sequence is complex because of interbedding of sand, gravel, silt, and clay deposited by different processes in the lake. These processes include settling out of fine sediment in the glacial lake, stream delta progradation into the lake, subaqueous debris-flow sedimentation at the bottom of the lake, and transportation of sediment by the Flathead River into the Mission valley and Polson moraine (Alden, 1953) and from near it.

The greater quantity of fine-grained glacial-lake sediments in the Flathead River basin and Irvine Flats than in other areas suggests a sediment supply to these valleys. These two areas, along with uplift sites where sedimentation mostly consisted of water, suggests the Missoula water column.

The relative abundance of sand and gravel in the eastern Mission valley, compared with other areas, suggests that sand and gravel lenses or beds exist in this area. Intervals of differing grain size within the predominantly silty Glacial Lake Missoula sediments in water wells. In the Little Bitterroot River valley, the relative abundance of sand and gravel reduces the possibility of sand and gravel lenses or beds in the Glacial Lake Missoula sediments. Boreholes in the Little Bitterroot River valley may not penetrate saturated sand beds in the Glacial Lake Missoula sediments. These maps can be used to help determine water wells where the deep alluvium or sand are.
Water-well driller logs and well locations are stored in the Ground-Water Information Center database at Montana Bureau of Mines and Geology (http://mtnbgwic.mtech.edu). Ground-surface topographic data are from the 1:24,000-scale U.S. Geological Survey DEMs for western Montana. Public Land Survey data, hydrography, and roads were obtained from Montana’s Natural Resources Information System, Helena (http://mriss.state.mt.us/).

ACKNOWLEDGEMENTS

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REFERENCES


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General drilling and completion depths for gravel beds in Glacial Lake Missoula sediments in areas, means that it is more likely that sandbars of water-permeable sand and gravel sediments are locally productive intervals and Irvine Flats areas the lower percentage successfully completing a well in the Glacial Lake Bitterroot River valley occasionally. The Missoula sediments, called “heaving” or rare aquifers. Productive wells will be on valley, but people constructing wells could complete a well at a shallower run.

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Interlayered Aquifer and Non-Aquifer (Confining Unit) Materials
- lake deposits (aquifer materials)
- till (aquifer materials)
- Tertiary sedimentary rocks (generally non-aquifer materials)
- lake deposits (non-aquifer materials)

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General view of the topography and thicknesses of geologic formations and directions of movement along basin-bounding fault.
Figure 2. Generalized map of the distribution of geologic units in the southern part of the Flathead Lake area. Mountain areas are underlain by bedrock of the Proterozoic Belt Supergroup (Ybe) and Tertiary intrusive rocks (Ti). The uppers of many valleys in the southwestern half of the area contain Tertiary sedimentary rocks (Ts), the distributions of which were mapped only approximately because the unit was not distinguished on previous maps. Valleys are covered by glacial deposits (Qgt), sediments that accumulated in Glacial Lake Missoula (Qgl and Qgls), and post-glacial (mostly stream) deposits (Qol).

Figure 3. Contour line, dashed with a dash indicates approximate elevation.

- Major roads
- Principal streams and water bodies
- Township boundaries
- Cross-section location

Explanation (for all figures):

1. Glacial Lake Missoula sediments
2. Quaternary glacial lake deposits (coarse-grained)
3. Tertiary glacial lake deposits (fine-grained)
4. Quaternary alluvium
5. Tertiary till
6. Proterozoic Belt Supergroup
7. bedrock
8. at land surface or buried by other units
9. not exposed on land surface
10. Tertiary sedimentary rocks
11. Tertiary intrusive rocks
12. Proterozoic Belt Supergroup
- Scattered gravel mixed in tan gray clay; clayey sand
- Gravel in tan silt matrix
- Fine to medium sand seeps of water
- Gravel in silt matrix with clay stringers
- Gravel in tan silt matrix
- Clayey gravel embedded in clay
- Mixed gravel in sand
- Mixed gravel in coarse sand, water
- Light green and brown claystone
- Green and brown siltstone, clay, and coal
- Greenish hard conglomerate
- Volcanic bedrock
- Broken gray rock with tan seams-water
- Blue-gray, tan, or green argillite
- Hard gray rock w/ a few fractures
- Fractured brown rock & some water

Comparison of descriptive drillers' logs of water wells with unit are permeable to ground water, but the greater limitations make that unit somewhat less productive of water bodies.

Figure 5. Depth to the deep alluvium. The deep alluvium is the main aquifer in the Little Bitterroot River valley and an important aquifer along the Flathead River and in the Mission valley. Reported yields of water wells completed in the unit are the greatest of any unit in the area, averaging 100 gallons per minute (gpm). Existence of the unit in the south of its mapped extent is unknown due to few deep wells in these areas.
Figure 6. Thickness of Glacial Lake Missoula sediments that overlie the deep alluvium or bedrock, and underlie the shallow alluvium in the Mission and Little Bitterroot River valleys. The Glacial Lake Missoula sediments are dominated by silty and clayey beds, but where sandy and gravelly beds occur the unit can produce significant quantities of water (fig. 4).

Figure 1. The southern part of the Flathead Lake area includes the Flathead Indian Reservation and part of the Swan River valley. Locations of geographic features discussed in the text are labeled.
Figure 7. Percent of sandy and gravelly beds in the silty and clayey Glacial Lake Missoula sediments in the Mission and Little Bitterroot River valleys. Few of the sands and gravels are described as being well-sorted, most of the beds contain mixtures of silt and clay in with sand and/or gravel (fig. 4). All of the water wells completed in the Glacial Lake Missoula sediments are in the Mission valley where a greater proportion of the sequence is composed of sand and gravel. However, not all beds containing sand and gravel are aquifers (produce water to wells).