

GEOLOGIC MAP OF THE EAST BAY 7.5' QUADRANGLE NORTHWEST MONTANA

Michael H. Hofmann and Marc S. Hendrix

Montana Bureau of Mines and Geology Open File Report MBMG 496

2004

This report has been reviewed for conformity with Montana Bureau of Mines and Geology's technical and editorial standards.

Partial support has been provided by the EDMAP component of the National Cooperative Geologic Mapping Program of the U. S. Geological Survey under Contract Number 02HQAG0096.

GEOLOGIC MAP OF THE EAST BAY 7.5' QUADRANGLE NORTHWEST MONTANA

Michael H. Hofmann and Marc S. Hendrix

Introduction

This project focused on mapping the distribution of Pleistocene and Holocene sediments along the northeastern Mission Valley in western Montana (USGS East Bay 7.5' quadrangle). Holocene and Pleistocene sediments are most common in the area south of Flathead Lake, whereas Precambrian rocks of the Belt Supergroup crop out in the easternmost part of the map area. Pleistocene sediments in the map area are dominated by till and glacial outwash related to advances of the Flathead Lobe of the Cordilleran Ice Sheet and advances of smaller alpine glaciers flowing down west-facing valleys of the Mission Range. Pleistocene sediments also include sub-lacustrine sediments related to glacial Lake Missoula. Holocene sediments in the map area consist of a complex suite of eolian, alluvial, fluvial, and colluvial sediments.

Early studies of Pleistocene deposits from the Mission Valley describe evidence for three major advances of the Flathead lobe of the Cordilleran ice sheet, including at least one major advance to the southern part of the Mission Valley, about 45 km south of the mapping area (Elrod, 1903; Davis, 1920; Nobles, 1952; Alden, 1953; Richmond and others, 1965; Richmond, 1986; Ostenaar and others, 1990). In contrast, Ostenaar and others (1995) and Levish (1997) interpreted most of the diamictite in the Mission Valley south of the Polson Moraine as sub-lacustrine deposits related to glacial Lake Missoula. The results of our mapping suggest that the Flathead lobe of the Cordilleran Ice Sheet did not advance south of the Polson Moraine, although there may have been two different advances of the Flathead lobe, both terminating at the position of the Polson Moraine.

Structure

The Mission Fault is the dominant geologic structure of the mapping area and consists of several synthetic down-to-west normal faults that drop the Mission Valley relative to the Mission Range. In the southern Mission Valley, Ostenaar and others (1990, 1995) described a single trace of the Mission Fault and conducted trenching studies of the fault in which they documented a major seismic event at about 7,700 cal. yr. BP* and an older event with poorly constrained chronology (~15,000 cal. yr. BP). In the map area, the Mission Fault splits into multiple north-south strands that locally offset Quaternary deposits. Two ~10m-high fault scarps offset glacial lateral moraines but do not offset younger sediments in the central part of the map area, suggesting fault activity between 16,000 and 10,000 cal. yr. BP. Evidence of pre-Pleistocene faults is present in the form of offset Precambrian Belt Supergroup rocks overlain by undeformed Pleistocene sediment. All mapped normal fault scarps are down to the west. In addition, a single southwest-northeast striking transform fault is present in the northeastern part of the map area.

* Dates given as calendar years before present (Cal. Yr. BP) are calibrated dates. Calibrated results are usually older than conventional radiocarbon dates.

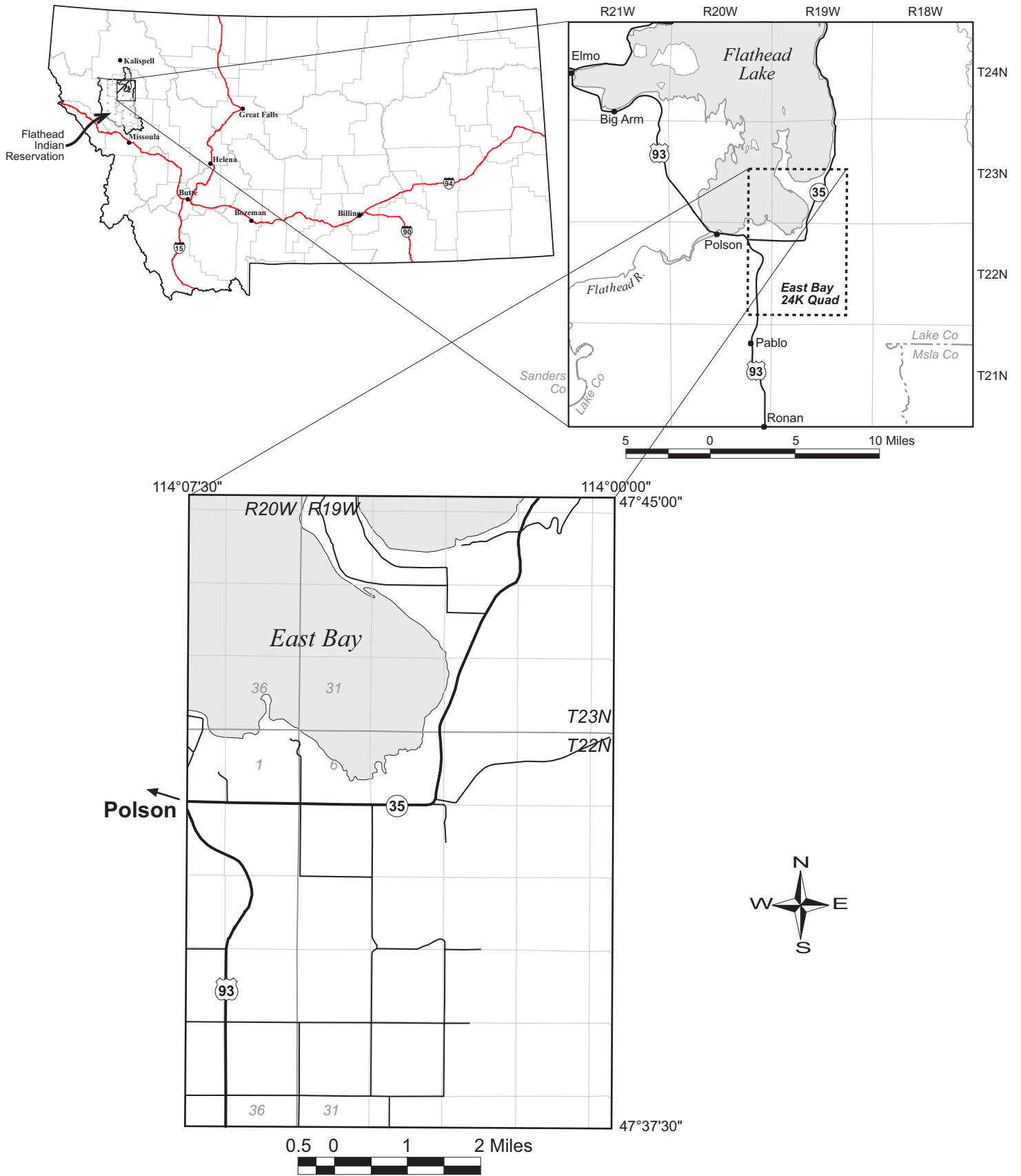
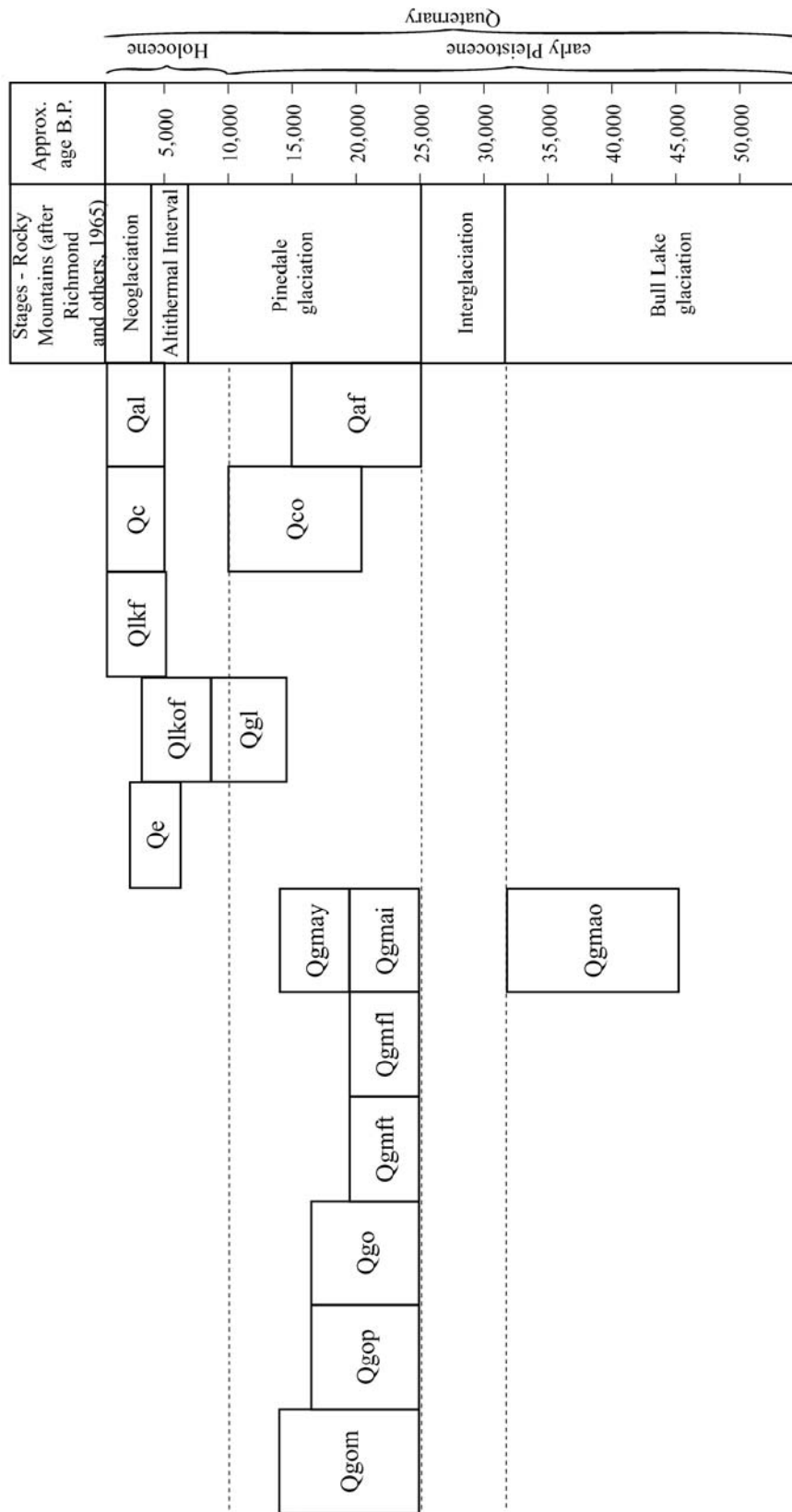
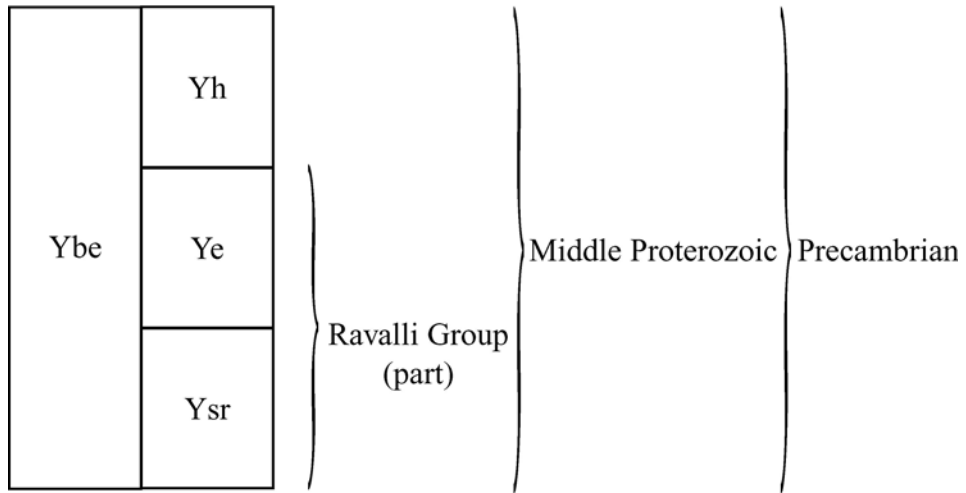


Figure 1. Location of the East Bay 7.5' quadrangle.

**CORRELATION OF QUATERNARY MAP UNITS
EAST BAY 7.5' QUADRANGLE**



**CORRELATION OF PRECAMBRIAN MAP UNITS
EAST BAY 7.5' QUADRANGLE**



DESCRIPTION OF MAP UNITS

EAST BAY 7.5' QUADRANGLE

Qal Alluvium of modern streams (latest Holocene to present) – Stream alluvium within active stream channels and flood plains. Includes reworked older coarse-grained deposits within active channels and fine-grained overbank sediments. Contains localized colluvium from oversteepened banks and creek walls.

Qc Colluvium (latest Holocene to present) – Poor to moderately sorted slope wash colluvium. Includes localized slumps and rockfall deposits. Angular to sub-angular clasts, poorly sorted.

Qlkf Lake deposits of Flathead Lake (latest Holocene to present) – Formed as marginal or flood related deposits around modern Flathead Lake. South and north of Polson Bay, contains organic-rich, fine-grained sand and silt. Usually contains swampy vegetation and is flooded during certain times of the year.

Qlkof Lake deposits of ancestral Flathead Lake (late Holocene) – Well-sorted fine sand with silt and clay. Probably deposited in an ancestral Flathead Lake dammed by the Polson moraine. Includes terraces at an elevation of 902 m that can be traced north of the Polson moraine and on Finley Point. Terraces are interpreted to be wave-cut and indicate a higher lake level for ancestral Flathead Lake.

Qe Eolian deposits (early Holocene) – Characterized by wind-blown, well-sorted, brown, fine- to medium-grained unconsolidated sand with minor silt. Forms hummocky like topography in the southern part of the map area and between Hwy. 93 and Turtle Lake. Soil color is light brown to tan.

Qgl Glacial lake deposits, undivided (late Pleistocene and Holocene) – Well-sorted fine sand with minor silt and local small pebbles. Sediments cover the terraces at 902-m elevation north of the Polson moraine and represent beach sand deposits along the shores of ancestral Flathead Lake. Similar sediments around Turtle Lake might be beach deposits of glacial Lake Missoula. Equivalent sediments also underlie thin gravel beds on Finley Point.

Qco Colluvium, older, undivided (Pleistocene) – Poor to moderately sorted slope deposits in the southeastern part of the map area. Predominantly angular boulders of Belt rock along slope between Minesinger Ridge and Ashley Creek. Forms gradual slope with no distinguishing morphology. Considered to be late Pleistocene in age. Overlain by Qgom deposits.

Qgmay Youngest alpine moraine (late Pleistocene) – Unconsolidated, poorly sorted, sandy and silty cobbles and gravel; angular to sub-angular deposits related to the range front of the Mission Mountains at Hell Roaring Creek, Bisson Creek, Dubay Creek, and Big Creek. Forms high, prominent, sharp-crested lateral moraines and less common and/or less pronounced terminal moraines. Occurs usually between lateral moraines of Qgmai and inferred to be late Wisconsin in age, about 16,000-13,000 cal. y.b.p. (Ostenaa and others, 1990). Alternatively, could be recessional to a Qgmai advance.

Qaf **Alluvial fan deposit (Pleistocene)** – Moderately to well-sorted, rounded clasts of cobble and pebble size. Deposition in high-energy stream flow or debris flow in alluvial fans at the mouths of Hell Roaring Creek and Skidoo/Holmes Creeks. Contains exclusively clasts of Belt sedimentary rocks and shows large-scale foresets.

Qgom **Glacial outwash from Mission Range glaciers (Pleistocene?)** – Clast-supported, silty and sandy cobble gravel. Very similar to Qgop but contains only local Belt sedimentary rocks and no igneous rocks. More than 200 m thick south of Blumenhagen Spring.

Qgop **Glacial outwash deposits south of Polson moraine (Pleistocene?)** – Clast-supported, silty and sandy cobble-bearing gravel. Deposits a broad south-sloping plain south of the Polson moraine. Contains well-rounded cobbles of Belt sedimentary rock, Precambrian igneous, and Tertiary igneous rocks. Sublacustrine fan delta deposits, more distal from the ice margin of a Flathead lobe than Qgo.

Qgo **Outwash and sublacustrine fan sediments, undivided (Pleistocene)** – Alternating beds of cross-bedded sand and gravel. Sand is moderately sorted with minor silt and occasional small pebbles. Erosional contacts at the base of gravel layers are common along north side of Polson moraine, on top of Polson moraine and on Finley Point. Probably deposited as a sublacustrine fan delta from subglacial meltwater flows proximal to the ice margin of a Flathead lobe of the Cordilleran Ice Sheet.

Qgmft **Flathead lobe terminal moraine (late Pleistocene)** – Clast-supported, rounded to sub-rounded, moderately sorted, massive deposit. Constitutes most of the surface of the Polson moraine. Includes higher sand content in southern parts of the moraine. Long axes of clasts are mostly parallel to the glacial front.

Qgmfl **Flathead lobe lateral moraine (late Pleistocene)** – Unconsolidated, moderately sorted, silt- to boulder-sized deposits with sub-angular to sub-rounded clasts. Exposed along the east side of the map area. Covers bedrock and is between 3 and 20 m thick. Contains clasts of Belt sedimentary rock, late Proterozoic igneous rock and Tertiary igneous rocks.

Qgmai **Intermediate alpine moraine (late Pleistocene)** – Characterized by high, sharp-crested lateral moraines (e.g. Minesinger Ridge) and less common and/or less pronounced terminal moraines at the mouths of Mud Creek, Bisson Creek, and Big Creek. Contains unconsolidated, poorly sorted, silt- to boulder-sized, angular to sub-angular deposits, exclusively consisting of local Belt sedimentary rock. Considered late Pleistocene in age and correlative with Pinedale glaciation of the Rocky Mountains.

Qgmao **Oldest alpine moraine (Pleistocene)** – Forms moderately high, round-crested lateral moraines near Ashley Creek, Minesinger Ridge, and Minesinger Creek. Terminal moraines are not developed or not very well pronounced. Moraines of Qgmai crosscut lateral moraines. Characterized by matrix-supported, sandy and silty cobble and boulder gravel of local Belt rocks. Considered to be late Pleistocene in age (Bull Lake glaciation equivalent, >35,000 cal. y.b.p.).

Ybe **Belt Supergroup rocks, undivided (Middle Proterozoic)** – Metasedimentary rocks of the Belt Supergroup. Unit includes red and green argillite,

fine-grained quartzite, carbonaceous argillite, and siltite of the middle Proterozoic Saint Regis, Empire, and Helena Formations.

Yh **Helena Formation of the Belt Supergroup** – Mostly gray to greenish-gray limestone locally containing stromatolites and interbedded with dolomite, dolomitic siltite, siltite, and argillite. Characteristic are beds with intraclasts containing molar-tooth structure.

Ye **Empire Formation of the Belt Supergroup** – Grayish-green argillite and locally slightly dolomitic siltite. Characteristic are mudcracks within the green argillite, ripple marks, and sub-horizontal calcite-filled voids. Pyrite is common.

Ysr **Saint Regis Formation of the Belt Supergroup** – Dark-purple to dark-green argillite and siltite. Mud cracks, mud chips, and ripple marks are common.

MAP SYMBOLS



Contact – dashed where inferred, dotted where concealed; most contacts within the Quaternary map units are approximate.



Faults – dashed where inferred, dotted where concealed; relative motion uncertain.



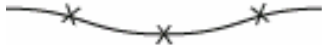
Normal faults – dashed where inferred, dotted where concealed; bar and ball on downthrown side. The positions of the faults are based on changes of bedrock lithology, changes in strike and dip, and offset of bedrock and surficial Quaternary sediments.



Fault scarps – surficial offset of Quaternary sediments. North of Skidoo Creek a fault scarp offsets Qgmfl sediments; the best developed fault scarp, south of Hell Roaring Creek, also offsets Qgmfl. Near Blumenhagen Spring a fault scarp offsets Qgom.



Lake terraces – wave-cut terraces related to an ancestral Flathead Lake. Terraces can be traced throughout the mapping area at an elevation of 902 m.



Moraine crest – several moraine crests exist within the mapping area. Very pronounced, sharp crests are related to younger moraines, probably of Pinedale age; more rounded, less pronounced crests are inferred to be Bull Lake equivalent moraines.



Strike/dip - strike and dip direction and angle of dip of middle Proterozoic Belt rocks.

ACKNOWLEDGEMENTS

We greatly appreciate the assistance of Winfield Wilson, Matt Affolter, and Tony Berthelote with field work, and discussions with Larry Smith, Don Winston and Michael Sperazza. Technical reviews by Montana Bureau of Mines and Geology are also appreciated. We are grateful to the Confederated Salish and Kootenai tribes for providing land access to accomplish this study. We gratefully acknowledge financial support provided by USGS-EDMAP grant #02HQAG0096.

CITED REFERENCES

- Alden, W.C., 1953, Physiography and glacial geology of western Montana: U.S. Geological Survey, Professional Paper 231, 190 p.
- Davis, W.M., 1920, Features of glacial origin in Montana and Idaho: Annals of the Association of American Geographers, v. 10, p. 75-148.
- Elrod, M.J., 1903, The physiography of the Flathead Lake region, *in* Lectures at Flathead Lake: Bulletin of the University of Montana No. 16, Biological Series No.5, p. 197-203.
- Levish, D.R., 1997, Late Pleistocene sedimentation in Glacial Lake Missoula and revised glacial history of the Flathead lobe of the Cordilleran Ice Sheet, Mission Valley, Montana: Boulder, University of Colorado, Ph.D. dissertation, 191 p.
- Nobles, L.H., 1952, Glacial Geology of the Mission Valley, western Montana: Cambridge, Harvard University, Ph.D. dissertation, 125 p.
- Ostenaar, D.A., Manley, W., Gilbert, J., LaForge, R., Wood, C., and Weisenberg, C.W., 1990, Flathead Reservation regional seismotectonic study: an evaluation for dam safety: U.S. Bureau of Reclamation, Seismotectonic Report 90-8, 161 p.
- Ostenaar, D.A., Levish, D.R., and Klinger, R.E., 1995, Mission fault study: U.S. Bureau of Reclamation, Seismotectonic Report 94-8, 111 p.
- Richmond, G.M., Fryxell, R., Neff, G.E., and Weis, P.L., 1965, The Cordilleran Ice Sheet of the northern Rocky Mountains, and related Quaternary history of the Columbia Plateau, *in* Wright, H.E., and Frey, D.G., eds., The Quaternary of the United States, Princeton University Press, p. 231-242.
- Richmond, G.M., 1986, Tentative correlation of deposits of the Cordilleran Ice Sheet: Quaternary Science Reviews, v. 5, p. 129-144.

SELECTED ADDITIONAL REFERENCES

- Harrison, J.E., Griggs, A.B., and Wells, J.D., 1986, Geologic and structure maps of the Wallace 1°x 2° quadrangle, Montana and Idaho: Montana Bureau of Mines and Geology, Montana Atlas Series MA 4-A, scale 1:250,000.
- La Fave, J.I., 2000, Potentiometric surface map of the deep aquifer, Kalispell Valley: Flathead County, Montana: Montana Bureau of Mines and Geology, Montana Ground-Water Assessment Atlas No.2, Part B, Map 2, scale 1:63,360.
- Mudge, M.R., Earhart, R.L., Whipple, J.W., and Harrison, J.E., 1982, Geologic and structure map of the Choteau 1°x 2° quadrangle, western Montana: Montana Bureau of Mines and Geology, Montana Atlas Series MA 3-A, scale 1:250,000.
- Qamar, A.I., Kogan, J., and Stickney, M.C., 1982, Tectonics and recent seismicity near Flathead Lake, Montana: Bulletin of Seismological Society of America, v. 71, p. 1591-1599.

- Smith, D.G., 1966, Glacial and fluvial land forms adjacent to the Big Arm Embayment, Flathead Lake, western Montana: Missoula, University of Montana, Master's thesis, 74 p.
- Smith, L.N., 2001, Hydrogeologic Framework of the southern part of the Flathead lake Area, Flathead, Lake, Missoula, and Sanders Counties, Montana: Montana Bureau of Mines and Geology, Montana Ground-Water Assessment Atlas No.2, Part B, Map 10, scale 1:300,000.
- Smith, L.N., Blood, L., and La Fave, J.I., 2000, Quaternary geology, geomorphology, and hydrogeology of the upper Flathead River valley area, Flathead County, Montana, *in* Roberts, S., and Winston, D., eds., Geologic field trips, western Montana and adjacent areas: The University of Montana, Missoula, p. 41-63.
- Smith, L.N., La Fave, J.I., Carstarphen, C., Mason, D., and Richter, M., 2000, Data for water wells visited during the Flathead Lake Area Groundwater characterization study: Flathead, Lake, Sanders, and Missoula Counties: Montana Bureau of Mines and Geology, Montana Ground-Water Assessment Atlas No.2, Part B, Map 1, scale 1:250,000.
- Stickney, M.C., 1980, Seismicity and gravity studies of faulting in the Kalispell Valley, Northwest Montana: Missoula, University of Montana, Master's thesis, 82 p.
- Stoffel, K., 1980, Glacial Geology of the southern Flathead Valley, Lake County, Montana: Missoula, University of Montana, Master's thesis, 149 p.