DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–1508–B (SHEET 1 OF 2)

Base from U.S. Geological Survey
Glacier National Park 1:100,000, 1968

APPROXIMATE MEAN DECLINATION, 1989

CONTOUR INTERVAL 80 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Strike and dip data supplemented from Ross, 1960

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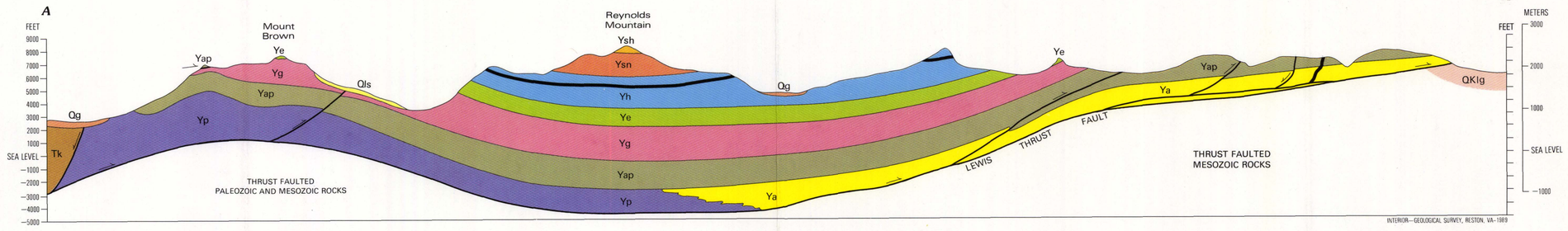
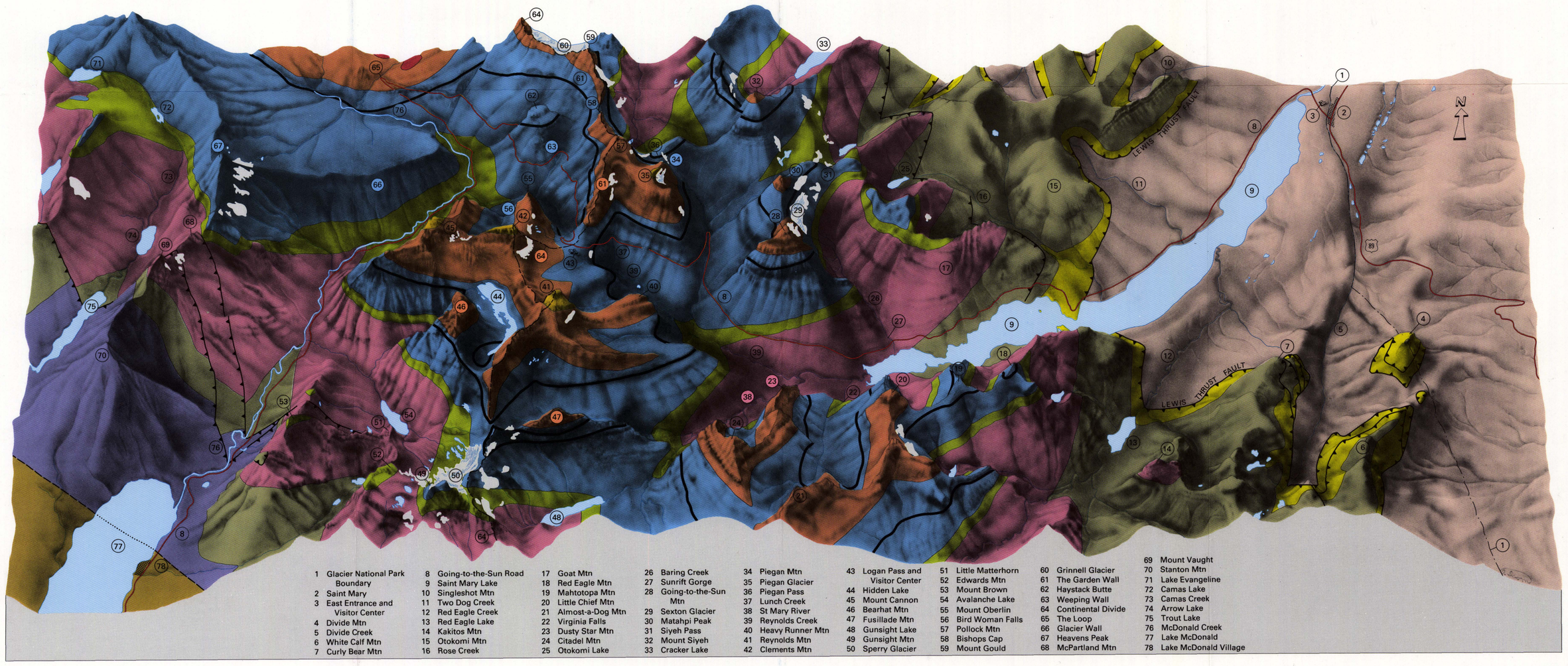
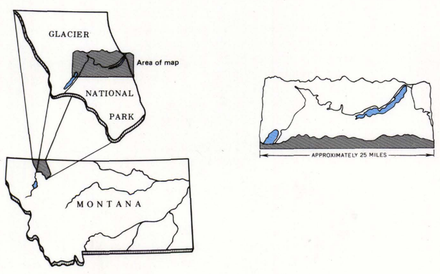


Map *A*. Geologic map and cross section



Map *B*. Shaded relief, oblique view geologic map

Generalized from planimetric geologic map above
Qls and Qg deposits not shown



DESCRIPTION OF MAP UNITS

Qls **Landslide deposits (Holocene and Pleistocene)**—Colluvium, predominantly in large slumps within glacial deposits. Many have well-defined headward scarps, some have ponds or bogs at the toe regions. Largest landslides cover several square kilometers and are more than 50 m thick

Qg **Glacial deposits (Pleistocene)**—Predominantly glacial till; unsorted material that ranges in size from clay to boulders. Thickness commonly ranges from 10 to 30 m

QKlg **Landslide and glacial deposits, and sedimentary rocks, undivided (Holocene, Pleistocene, and Cretaceous)**—Landslide and glacial deposits of Quaternary age underlain by shale, mudstone, siltstone, and sandstone of Early to Late Cretaceous age. Forms hummocky terrain on lower plate of the Lewis thrust fault

Tk **Kishenehn Formation (Oligocene and Eocene)**—Shown on geologic cross section only. Consists of two informal members. Upper member is red, brown, and gray, variegated calcareous claystone, mudstone, and siltstone interstratified with silver-gray to gray, calcareous, sandy pebble-cobble conglomerate; minor lignite and light-gray marlstone. Thickness as much as 3,000 m. Lower member is sandstone, siltstone, montmorillonitic mudstone-claystone, pebble conglomerate, oil shale, marlstone, and lignite seams. Thickness is 3,000–4,000 m

Zd **Dioritic intrusive rocks (Late Proterozoic)**—Mostly diorite and quartz diorite in sills and dikes as thick as 80 m. Sills intrude dolomite and dolomitic limestone of the upper part of the Helena Formation. Sills and dikes in the mapped area have not been dated, but sills of similar composition south of Glacier National Park have been dated by potassium-argon methods by J. D. Obradovich (oral commun., 1966) as 750±25 m.y. old

BELT SUPERGROUP

Metasedimentary and metavolcanic rocks of lower to upper parts of Belt Supergroup are widely distributed throughout the mapped area and are as much as 4,200 m thick.

Ysh **Shepard Formation (Middle Proterozoic)**—Yellowish-gray to greenish-gray dolomitic argillite and siltite and lesser amounts of pale-green argillite, light-gray quartzite, calcarenite, limestone, and dolomite. Contains numerous beds of stromatolites, particularly in the vicinity of Reynolds Mountain in the central part of the mapped area. Thickness is at least 300 m, although the top is not exposed

Ypu **Purcell Lava (Middle Proterozoic)**—Dark-gray to dark-greenish-gray basaltic lava with pillow and pahoehoe flow structures; locally shattered into small angular fragments. Parts of it contain numerous gas bubbles. Unit is in the upper part of the Snowslip Formation and is present only in the northwest part of this mapped area. Unit is about 20 m thick in the mapped area, but it thickens to more than 100 m thick to the north

Ysn **Snowslip Formation (Middle Proterozoic)**—Primarily argillite and siltite beds of various colors ranging from green to greenish-gray to mostly red. Many of the colors are pastel. Numerous beds of dolomitic siltite, dolomite, and stromatolites and gray to greenish-gray, very fine grained quartzite beds are in the upper part. Dolomite is more abundant in the upper part of the formation where it is transitional with the overlying Shepard Formation and oolites and stromatolites are common near the base. Thickness is about 460 m

Yh **Helena Formation (Middle Proterozoic)**—Thin to thick beds of gray to dark-gray argillaceous dolomite, gray limestone, and, in the lower part calcarenite and quartzite. Most beds weather tan to buff. Thick stromatolitic units in the upper part commonly form conspicuous, very thick ribs in otherwise thinly bedded rocks. The middle part is more thickly bedded, less argillaceous, and forms cliffs. The lower part is thinly bedded and increasingly argillaceous near the lower contact. A crinkled texture, called molar-tooth structure, is common on weathered outcrops. Beds of stromatolites and oolites occur throughout and are most numerous in the upper part. Most stromatolites are in the form of "cabbage heads" and are as large as 2–3 m in diameter. A stromatolite form, called *Conophyton*, unique to the Helena Formation, forms beds as much as 15 m thick in the upper part. Thickness is as much as 750 m thick in the mapped area

Ye **Empire Formation (Middle Proterozoic)**—Mostly green argillite and siltite. Many beds, particularly in the upper part, are dolomitic. Some are calcareous and stromatolitic. Carbonate-bearing beds weather buff and are commonly interstratified with green argillite and siltite; therefore, outcrops appear banded. At most places, the formation contains two sequences of red argillite and siltite near the middle part, each about 3 m thick, separated by green argillite and siltite. Formation locally contains thin beds of quartzite and calcarenite. Contacts with the overlying Helena Formation and the underlying Grinnell Formation are gradational. Thickness is 200–300 m

Yg **Grinnell Formation (Middle Proterozoic)**—Consists of two highly contrasting lithofacies—a quartz-rich facies in the southeastern part of the mapped area and an argillaceous facies in the northern part. The quartz-rich facies is interlayered red argillite and siltite characterized by mudcracks and interstratified with abundant white, crossbedded quartzite and sandstone. The quartzite is typically coarse grained and contains abundant red argillite clasts. The argillaceous facies is dominantly red, purple, and green argillite and siltite, but contains small amount of quartzite, mostly in the upper half of the formation. Thickness is about 750 m.

Yap **Appekunny Formation (Middle Proterozoic)**—In the eastern part of the area, this formation is mostly green argillite and siltite and moderate amounts of light-gray quartzite and medium-red argillite and siltite. In the western part of the area, the upper part of the formation is similar, but contains very minor quartzite and no red beds. The lower part, in the west area, also contains beds of carbonate, some of which are stromatolitic, and some carbonate pods of possible algal origin. Thickness is approximately 1,165 m

Ya **Altyn Formation (Middle Proterozoic)**—Buff, light-gray, dark-gray, and orange dolomite, argillaceous dolomite, and stromatolitic limestone and a few thin beds of red argillite exposed only on east side of park. The upper part is thin bedded, argillaceous, and forms slopes. Middle part contains thick resistant beds that form cliffs. The carbonate rocks contain abundant, coarse, subangular to subrounded, clastic quartz and feldspar. This is the lowermost unit in the upper plate of the Lewis thrust fault in the map area, and its base is not exposed. Thickness is at least 300 m in the mapped area

Yp **Prichard Formation (Middle Proterozoic)**—Mostly laminated to thin-bedded, medium-dark-gray and light-gray argillite and siltite exposed only on west side of park. Outcrops are characteristically rust-colored from oxidation of iron sulfide minerals in the rocks. In the mapped area, the upper part of the formation contains beds of calcareous and silty argillite that are inferred to be lateral, western facies of Altyn Formation. Contact with overlying Appekunny Formation is gradational over several hundred meters. Exposed thickness in mapped area is as much as 1,220 m

Contact—Dashed where approximately located; dotted where concealed

Normal Fault—Dashed where approximately located; dotted where concealed. Bar and ball on downthrown side

Thrust fault—Dashed where approximately located; dotted where concealed. Sawteeth on upper plate

Anticline—Showing trace of crestal plane. Dashed where approximately located

Syncline—Showing trace of trough plane. Dashed where approximately located

Monocline—Dashed where approximately located

10 **Strike and dip of beds**

GEOLOGIC SETTING

The area of this map is the middle part of Glacier National Park, Montana. It contains sedimentary rocks of Middle Proterozoic, Cretaceous, and Tertiary age, local lava flows of the Purcell Lava of Middle Proterozoic age, and diorite sills and dikes of probable Late Proterozoic age. Unconsolidated deposits of Pleistocene and Holocene age cover much of the foothills country east and southwest of the mountains and the bottoms of some of the mountain valleys.

Sedimentary rocks of the Belt Supergroup cover most of the mapped area. These rocks were deposited more than a billion years ago near the margin of a Middle Proterozoic sea. Now weakly metamorphosed, they were deposited mostly in fluvial and shallow-marine settings where they acquired the rapid lateral lithologic variations that characterize deposits of contrasting environments. Several formations contain red and green interbanded sequences that indicate alternating oxidizing and reducing environments typical of some sea margins. The shallow-water origin of the Belt Supergroup through a thickness of about 4,200 m suggests a near balance of downwarping and sedimentation in the Proterozoic basin over a period of perhaps 600 million years. Basaltic lavas in the upper part of the Belt Supergroup crop out near the north boundary of the mapped area. Many of these lavas have pillow structures that indicate eruption on the sea floor. Very late Proterozoic diorite sills have been injected into limestone and dolomite in the middle of the Belt Supergroup throughout much of the mapped area. Strata adjacent to these sills are metamorphosed and bleached to marble and calc-silicate rock. Mafic dikes intrude the lower and middle Belt rocks in the eastern part of the area. These dikes are perhaps related in time and origin to the sills. The sedimentary and igneous rocks of the mapped area are described in greater detail under "Description of Map Units."

The principal structural feature of Glacier National Park is the Lewis thrust fault, the trace of which zigzags northwesterly across the eastern part of the area. Middle Proterozoic rocks in the upper plate of the Lewis thrust were translated eastward more tha 65 km, where they now rest on Cretaceous rocks of the lower plate. The Lewis thrust formed between 56 and 72 million years ago. Numerous smaller thrust faults, normal faults, and folds are closely related to the emplacement of the Lewis. The Flathead normal fault, which crosses the southwest corner of the mapped area, bounds the east side of a Tertiary basin. Sedimentary rocks in the basin are as old as 42 million years—Eocene. Recurrent rotational movement on the Flathead fault has tilted these rocks eastward.

Alpine glaciers covered Glacier Park as recently as 20,000 years ago. As a result, the area abounds with features resulting from erosion by ice, such as U-shaped valleys, hanging valleys, cirques, aretes, tarns, and matterhorns. Grinnell and Sperry Glaciers, the largest ice bodies remaining in the Park, are in the north and south parts of the mapped area, respectively. Many of the high cirques contain small perennial snowfields that are remnants of former glaciers.

GEOLOGIC MAPS, CROSS SECTION, AND PHOTOGRAPHS OF THE CENTRAL PART OF GLACIER NATIONAL PARK, MONTANA

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