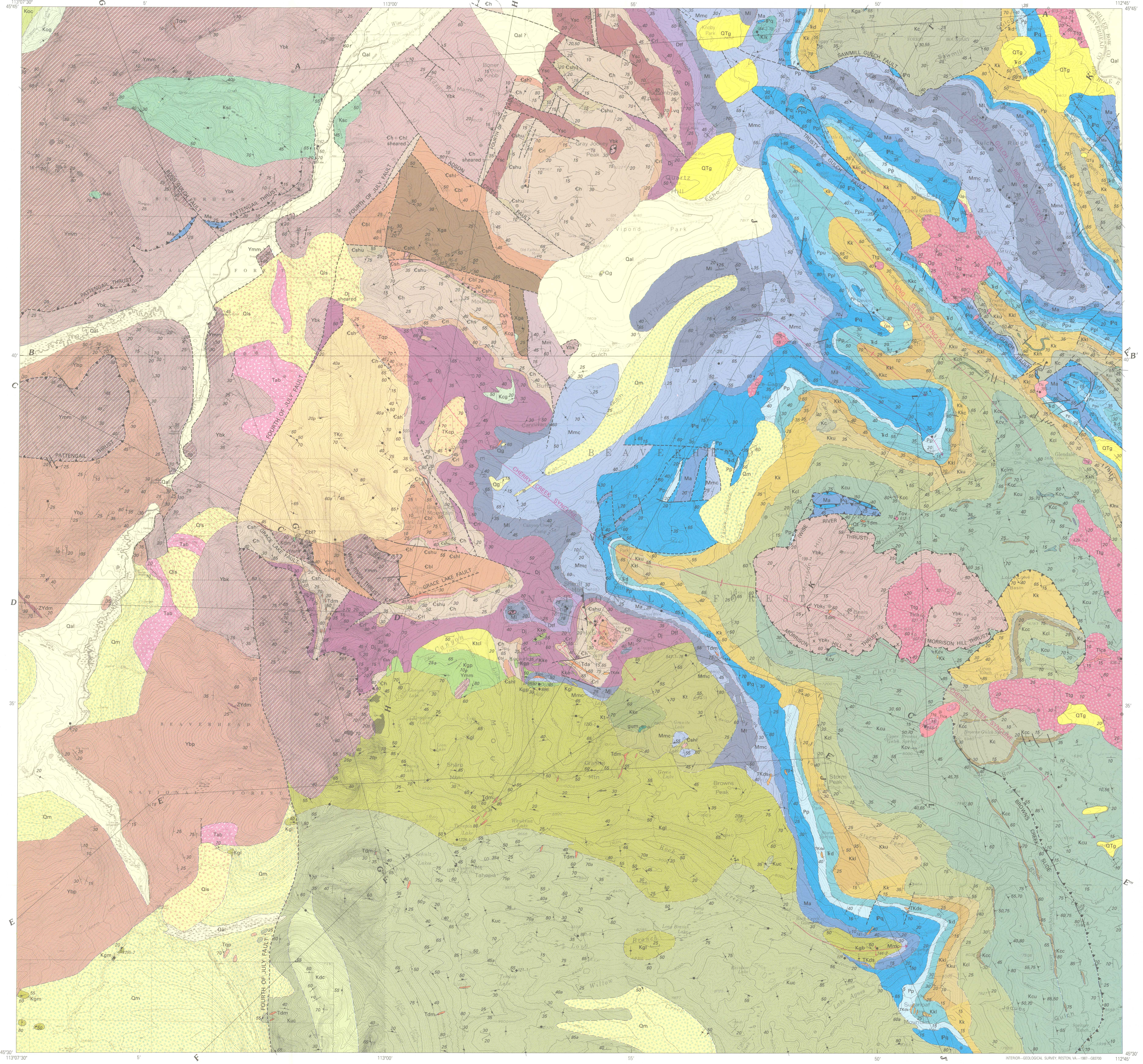
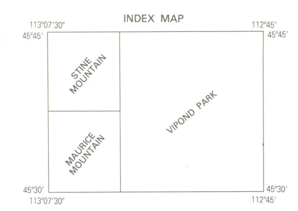
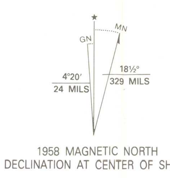
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY



Base from U.S. Geological Survey Vipond Park, 1:62,500, 1958 and Maurice Mountain and Stine Mountain, 1:24,000, 1978





1958 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:48 000

1 0 1 2 3 MILES

1 0 1 2 3 4 5 KILOMETERS

CONTOUR INTERVAL 80 FEET IN VIPOND PARK QUADRANGLE, 40 FEET IN MAURICE MOUNTAIN AND STINE MOUNTAIN QUADRANGLES
DATUM IS MEAN SEA LEVEL

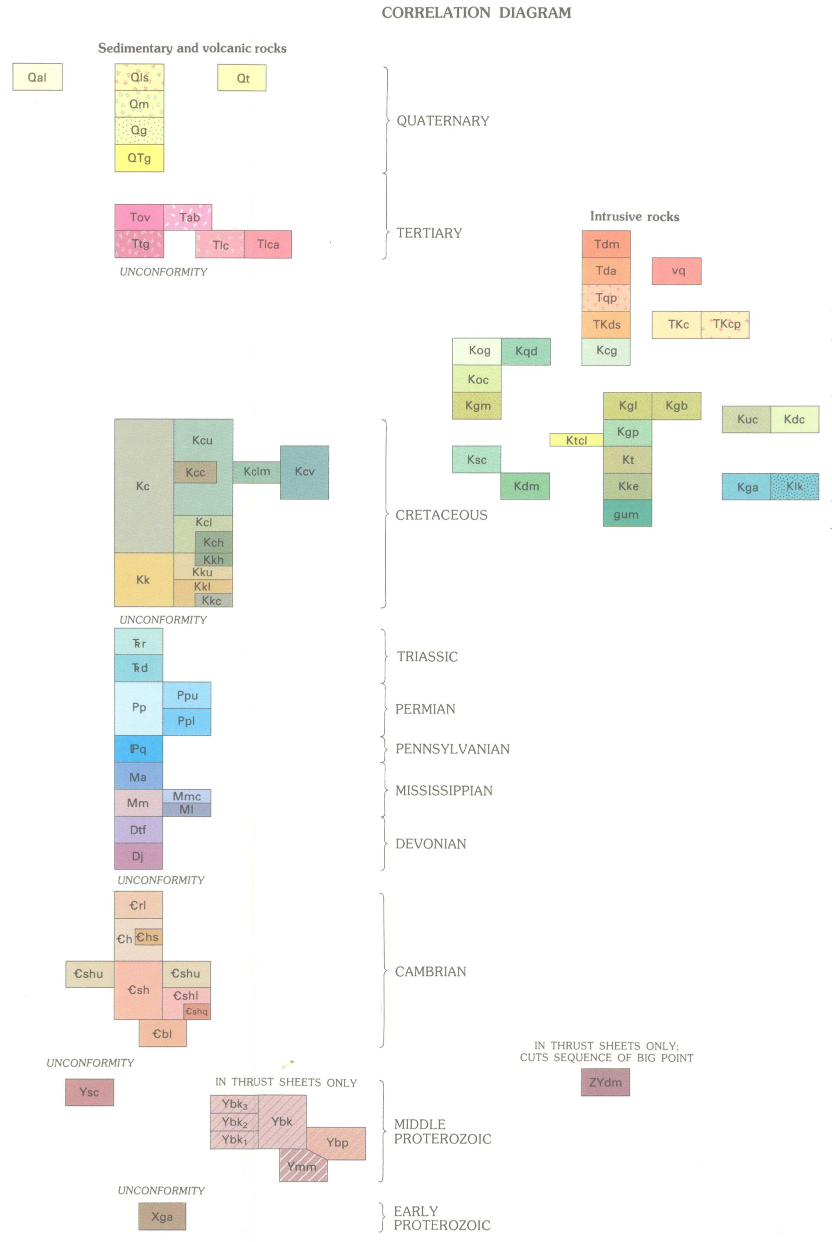
MONTANA

Geology by E-an Zen, 1970–80, in collaboration with R. I. Tilling, 1970 and J. S. Huebner, 1971. Assisted by C. S. Zen, 1970, 1971, 1973, 1974; J. M. Hammarstrom, 1978; Donald E. Deem, 1970; Charles Wm. Harris, Jr., 1971; Frederick J. Ketter, 1973; Lawrence W. Snee, 1974; Craig B. Davis, 1975; Melvin P. Dickenson III, 1978; J. Thomas Eggert, 1979; Martin K. Bijak, 1980; Wuling Zhao, 1981. Maurice Mountain quadrangle mapped in part by R. C. Pearson, 1978–81

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1987—G83700

MAP SHOWING BEDROCK GEOLOGY OF THE VIPOND PARK, STINE MOUNTAIN, AND MAURICE MOUNTAIN QUADRANGLES, PIONEER MOUNTAINS, BEAVERHEAD COUNTY, MONTANA

CORRELATION DIAGRAM



DESCRIPTION OF MAP UNITS

SEDIMENTARY AND VOLCANIC ROCKS

Qal ALLUVIUM (QUATERNARY)—Mostly valley floor deposits, but includes some slope wash and colluvium. Includes rare beds of the Mazama ash. May include some Quaternary glacial lake deposits. Only large areas are shown

Qls LANDSLIDE MATERIAL (QUATERNARY)—Mainly associated with ash and boulder beds (Tab)

Qt TUFA (QUATERNARY)—Deposit on the north slope of Morrison Hill

Qm MORAINE DEPOSITS (QUATERNARY)—Where extensively and prominently developed

Qg GRAVEL (QUATERNARY)—Indurated and faintly layered, mostly calcite cemented, perched on or surrounded by other Quaternary rocks; in isolated patches only

QTg HIGH-LEVEL STREAM GRAVEL (QUATERNARY AND(OR) UPPER TERTIARY)—Commonly consists of cobbles and boulders as much as 30 cm across, well-rounded, mainly of quartzite and conglomerate assignable to Middle Proterozoic sedimentary rocks now occurring mostly in drainage system of Wise River

Tov RHYODACITE FLOW (OLIGOCENE)—Similar to Trusty Gulch Volcanics, Ttg, exposed north of Morrison Hill

Tab ASH AND BOULDER BEDS (OLIGOCENE)—Siliceous, pumiceous ash deposits interbedded with ash-dominated boulder beds. Conspicuous from a distance because of distinct, bright-yellow color. Boulder-free layers are interpreted to be air-fall ash beds. Boulder beds are interpreted to be locally derived landslide material associated with explosive volcanism. Total thickness of sequence is at least 100 m

Ttg TRUSTY GULCH VOLCANICS (EOCENE)—Flows of basaltic andesite, andesite, dacite, and rhyodacite. Brown, grayish-brown, and lilac-brown, showing variably developed fracture cleavage. Individual flows range from less than 5 to as much as 50 m in thickness. Small, isolated patches of Ttg on map are loose rubble blocks of volcanic rocks assigned to unit

Tlc LOWLAND CREEK VOLCANICS (EOCENE)—Light-tan-gray to light-lilac-gray vitrophyre; contains sodic plagioclase, sanidine, and quartz phenocrysts; under microscope these minerals show resorption. Oxidized biotite phenocrysts are prominent. Groundmass is glassy and perlitic; orientations of phenocrysts and perlitic patches in outcrop are variable; may be orifice of an eruptive center, giving rise to volcanic ash (Tlca)

Tlca Volcanic ash (Eocene)—Interbedded with Eocene flows (Trusty Gulch Volcanics, Ttg). Dominantly pumiceous, but some layers are pebbly and contain variable amounts of volcanic blocks and boulders to chips of nearby sedimentary rocks. Interpreted to be the eruptive equivalent of Lowland Creek Volcanics (Tlc) on the basis of similar mineralogy. Some appear to be water-lain

Kc COLORADO GROUP (CRETACEOUS)—Graywackes, sandstones, argillites, and other minor rock types. Composite thickness estimated at 2 km

Kcu Upper part—Dominantly olive-drab and olive-gray siltstone and shale, and minor beds of impure sandstone in beds a few meters thick. Dark-gray, silty shale is locally a major component

Kcv Volcanic ash, indurated—Light-celadon-green or tan where fresh; weathers to dull white, in layers a few centimeters to .5 m thick, and breaks with conchoidal fracture. Mostly in upper part of Colorado Group

Kcc Conglomerate—Where separately mappable, chiefly in the upper member. Ledge-forming beds as much as 5 m thick in packets as much as 50 m thick, with minor crossbedded sandstone lenses. Conglomerate beds are lensoid and rapidly thin to feather edges. Cobbles and boulders are as much as 15 cm across, poorly to moderately rounded, set in a sandstone matrix and form a clast-supported framework. Clasts are dominantly light-colored quartzite and sandstone; gray, brownish-gray, and dark-gray chert; and rare silicified limestone. Clasts also include shale and pale-grayish-green volcanic ash resembling Kcv. Craggy outcrops of Kcc are common habitat of rattlesnakes

Kclm Limestone beds—Mapped only south of Trapper Creek (NW¼ Sec. 25, T. 2 S., R. 10 W.) in the upper part, bluish-gray-weathering, detrital limestone that may have been derived from detritus of Madison Group (Mm)

Kcl Lower part—Dominantly thick-bedded (individual beds as much as 8 m), impure, feldspathic sandstone and graywacke with slightly calcareous cement, and some volcanogenic sandstone, and intercalated argillite. Tan, olive, and gray; weathers to dark brown-gray. Sand-sized clasts are moderately rounded and sorted, and beds show tabular to tangential crossbedding on a scale of decimeters, defined by heavy-mineral concentration. Light-quartz and dark-chert sand grains give rock a "salt-and-pepper" appearance. Dark-gray, silty shales a few meters thick are found locally. On and near Storm Peak, basal beds are olive-drab, calcareous argillite. Thin (1–3 cm), light-gray, micritic limestone occurs in argillite. Limestone is broken up into intraformational chips, but could include original lenses. Talus of sandstone beds typically consists of subequant, angular blocks several decimeters across covered by lichen *Dimelaena oreina*

Kch Hornblende-bearing volcanic rocks (Cretaceous)—Interlayered with the Colorado Group, highly altered; found in Sec. 14, T. 2 S., R. 10 W.

Kk KOOTENAI FORMATION (LOWER CRETACEOUS)—Graywacke, impure sandstone, marl, limestone, limestone-chip conglomerate, argillite. Aggregate thickness about 200 m. Generally mappable as an upper member (Kku) and a lower member (Kkl)

Kku Upper member—Dominantly bright-red, sea-green, maroon, purple, and bluish-green marl and argillite, and rare interbeds of sandstone and light-gray, yellowish-ochre-weathering, silty limestone and limestone-chip, silty, limestone-matrix conglomerate. Massive, light- to dark-gray, tan-gray to bluish-gray-weathering limestone in beds 1–3 m thick and aggregating as much as 30 m in upper half of upper member. Beds contain gastropods; uppermost "gastropod bed" bears *Reesidella montanensis*

Kkh Hornblende-bearing volcanic rocks (Cretaceous)—Interlayered with upper member of Kootenai Formation, much altered

Kkl Lower member—Interbedded sandstone, conglomerate, and argillite. Sandstone, medium- to coarse-grained, well- to moderately well sorted, consists mainly of polycrystalline quartz and chert grains which gives rock a speckled ("salt-and-pepper") appearance; beds 1–10 m thick. Lowest bed in formation commonly conglomerate. Sandstone and conglomerate beds form ledges and comprise somewhat less than half of lower member. Bluish-green, gray, and olive-green argillite with bedding fissility separates sandstone and conglomerate beds in layers a few tens of meters thick; rarely calcareous in contrast to upper member. Limestone beds are rare to absent

Kkc Basal conglomerate—Where traceable. Pebbles and cobbles of conglomerate well sorted and rounded, as much as 10 cm across, and clast-supported with minimal interclast sand

Ŧr LIMESTONE (TRIASSIC)—Maroon-red. Apparently conformably overlies typical Dinwoody Formation (Ŧd), found only in small area south of Canyon Creek near Siria Ranch. Many dark-maroon stylolites throughout outcrop. Estimated 10 m of thickness preserved

Ŧd DINWOODY FORMATION (LOWER TRIASSIC)—Upper part massive beds of chocolate-brown-weathering, limy, silty, ripple-marked sandstone as much as 1 m thick. Shaley beds locally display flame structure against overlying sandstone beds. Massive gray, pinkish-gray-weathering limestone as much as 1 m thick is major component in upper part of formation. These beds pass downward into mainly olive-drab, chippy-weathering, hard shale showing planar bedding fissility, with interbedded, chocolate-brown-weathering, silty limestone in beds 10 cm or thinner. Upper contact is erosional unconformity at base of Kootenai Formation (Kk). Formation about 150 m thick

Pp PHOSPHORIA FORMATION (PERMIAN)—Several lithic types are recognizable in areas of abundant outcrop; these are locally mappable into an upper cherty and a lower dolomitic member. Thickness varies, ranging up to about 100 m; lower contact with the Quadrant Quartzite (ℙq) is gradational (visible on cliffs along boundary Secs. 9–10, T. 2 S., R. 10 W.); upper contact against the Dinwoody (Ŧd) is a sharp lithologic boundary but shows no evidence of a hiatus

Ppu Upper member—Where separately mappable. Dominantly massive brownish-gray to dark-gray chert; subsidiary beds of dark-olive-brown, phosphatic sandstone and phosphate-bloom-coated, dark-gray, pink-weathering, fissile shale. A favored habitat for rattlesnakes

Ppl Lower member—Where separately mappable. Dominantly light-tan-gray, massive dolostone containing tubular to nodular, yellow and brown chert and bedded, brown to gray-tan chert. Some decimeter-size chert nodules formed by replacement because sedimentary features, such as bedding, found in adjacent carbonate beds are preserved in the nodules. Some dolostone has quartz-sand layers defining laminations and cross laminations and indicating clastic origin. Lower contact against Quadrant Quartzite (ℙq) at least locally gradational; upper contact placed at top of last significant dolostone bed. Olive-brown, phosphatic sandstone locally interbedded with dolostone in upper part of member. Black, oolitic phosphate beds and fish-bone-bearing phosphate beds, never more than .5 m thick altogether, occur near upper contact

ℙq QUADRANT QUARTZITE (PENNSYLVANIAN)—Massive, cliff-forming, light-tan to light-gray quartzite and, much rarer, quartz-sandstone. Composed of well-sorted, washed, and rounded, medium-fine quartz grains; minor heavy minerals; and little or no feldspar. Generally cemented by quartz overgrowths on detrital grains. Bedding is rarely visible and is best seen as indistinct ridges and depressions on weathered surfaces. Rock weathers deep ochre to reddish yellow; shows characteristic concentric bands and rings of red iron-oxide stain on millimeter- to centimeter-scale fracture surfaces. Commonly 150–200 m thick, but apparent thickness variable owing to faulting and difficulty of deciphering internal structure. Rock fractures easily into blocky breccia along minor faults. Upper contact against Phosphoria (Pp) gradational where exposed. Abrupt lower contact. Rock typically covered by lichens of genera *Umbilicuria*, *Acarospora*, *Lecanora*, *Rhizocarpon* sp. and *R. geographicum*

Ma AMSDEN FORMATION (MISSISSIPPIAN)—Lithologically heterogeneous and laterally variable unit, consisting, at any given place, of combinations of following rock types: gray quartzite and calcareous sandstone beds as much as 1 m thick (especially conspicuous in lower part); grayish-purple-maroon marl and shale, characteristically containing light-green to tan, rounded "reduction" spots a few millimeters across; gray dolostone; gray and yellow, silty to clean limestone; thin beds of carbonate and marly shale; red limestone, weathering green to red, locally containing deep-maroon chert; dark-gray, fetid limestone; limestone-matrix limestone conglomerate. Carbonate becomes increasingly important toward the south. Both upper and lower contacts are abrupt. Thickness about 100 m. Generally crops out poorly; mapping by float and soil color is aided by characteristic development of grass-covered gentle slopes and benches. May also be Early Pennsylvanian in age

Mm MADISON GROUP (MISSISSIPPIAN)—Undifferentiated Mission Canyon (Mmc) and Lodgepole (Ml). Limestones where not separately mappable owing to deformation or metamorphism

Mmc Mission Canyon Limestone (Upper and Lower Mississippian)—Massive, cliff-forming limestone. Sugary to micritic, fossiliferous, light- to dark-bluish to tannish-gray limestone; weathers bluish gray to pale dove gray. Nodular to bedded dark-gray chert is locally abundant, for instance on cliffs above Cleve Mine near Hecla. Limestone conglomerate, much of which is solution breccia containing interclastic *terra rosa*, is locally abundant, for example on the cliffs south of Canyon Creek near Vipond Park. Upper contact is abrupt; lower contact is sharp to gradational through interbedding of massive limestone and thin-bedded limestone typical of the Lodgepole Limestone (Ml). About 300 m thick

Ml Lodgepole Limestone (Lower Mississippian)—Thin-bedded (typically 10 cm), dark-gray, silty, fine-grained limestone weathering to dark gray. Interbedded, dark, siliceous layers (south ridge of Lion Mountain) or, more typically, micaceous, silty layers weathering rose pink; silicate layers become, in skarn zones, layers of honey-brown grossular that weather out in positive relief, surrounded by white marble. Locally cliff-forming (above Canyon Creek Ranch), especially where protected by higher cliffs of Mission Canyon Limestone (Mmc), but more likely forming very steep slopes. Sharp lower contact; sharp to transitional upper contact. Thickness 100–150 m but highly variable, in part because of solution of beds

Dtf THREE FORKS FORMATION (UPPER DEVONIAN)—Thin-bedded, yellow, silty limestone, weathering to ochre, or a rock consisting of yellow limestone matrix surrounding gray dolostone blocks weathering into spongy masses. Former rock type may be equivalent to Trident Member of southwest Montana. Discontinuous, and not always separately mappable from underlying Jefferson Dolomite (Dj). Thickness, 30 m or less. Best shown in area west-southwest of Lion Mountain; also near Quartz Hill Gulch Road. Sharp upper contact

Dj JEFFERSON DOLOMITE (UPPER DEVONIAN)—Two facies may be distinguished in area: (1) Thick-bedded, very dark gray, fetid, sugary dolostone; (2) thick-bedded, interbedded, cream-white, locally quartz sand-bearing dolostone and minor dark-gray, fetid dolostone, mostly calcite-cemented and thus reacts to HCl test with varying vigor. Crossbedding defined by detrital quartz, on 1–2-cm scale, rarely present. Dark-gray, sugary facies found in northern part of map area, and interbedded white-and-gray facies found in central part. Where subjected to contact metamorphism, for instance near Hecla, large blades of white tremolite may be prominent in quartzose dolostone. Such contact-metamorphosed rocks weather to apparent thin-beddedness and a light, creamy color. Even dark-gray beds lose their fetidness. Upper contact against thin-bedded variety of Three Forks (Dtf) or (where latter is absent) the Lodgepole (Ml) is sharp; against the spongy-weathering variety of Three Forks, contact may be gradational owing to solution of Jefferson. Sharp lower contact against Red Lion (Ꞓrl); where latter is absent, contact against Hasmark (Ꞓh) in contact-metamorphosed areas may be difficult to determine because both become bleached white and have tremolite clusters. Thickness about 150–200 m. Intraformational solution breccia in area around Cannivan Gulch; thickness in such areas much reduced and variable

Ꞓrl RED LION FORMATION (UPPER CAMBRIAN)—Thin, discontinuous unit containing several rock types: (1) Red dolostone containing anastomosing maroon, shaley seams and thin, maroon shale beds and crossbeds a few meter thick, but laterally persistent for at least tens of meters; best seen east of Black Lion Mountain and near Gray Jockey Peak; (2) marly matrix, limestone-and-marl-chip conglomerate; chips are yellow, ochre, and red, less than 1 cm across, and sub-rounded; conglomerate several meters thick and best seen on the south slope of Sheep Mountain; (3) reddish-gray, calcareous, silty shale less than 1 m thick and laterally discontinuous; seen on ridge southeast of Sheep Mountain; (4) calcareous quartzite and sandstone, ledge-forming and supporting relatively modest flora on otherwise barren cliffs and slopes; some cross bedding; several meters thick and traceable for hundreds of meters; exposed near Hecla and northeast of Black Lion Mountain. These varieties locally contact-metamorphosed to green-and-white, calc-silicate rocks containing actinolite, epidote, and chlorite. Sharp upper contact; abrupt lower contact against Hasmark Dolomite (Ꞓh), though local interbedding is found on cliff face southwest of Gray Jockey Peak and above Adson Creek. Thickness 0–20 m

Ꞓh HASMARK DOLOMITE (UPPER AND MIDDLE CAMBRIAN)—Massive, gray dolostone predominates. In undeformed and little-metamorphosed rocks in northern part of quadrangle, basal part is peloidal dolostone, succeeded upward by oolitic and pisolitic dolostone in fine-grained matrix. Features seen suggest algal mounds, algal mats, and ripped-up algal mats. Local crossbeds and erosional channels in algal material. Common cross-bedded, detrital carbonate, now dolomite. Beds commonly several decimeters thick. Intraformational conglomerate is locally found (west ridge of Gray Jockey Peak). Replacement chert nodules and seams, some preserving outlines of pisolites, and bedded chert, a few centimeters to decimeters thick, distinguish unit from Jefferson (Dj). Sharp upper contact except where obscured by metamorphism, lower contact against upper member of the Silver Hill Formation (Ꞓsh) gradational in less metamorphosed rocks but sharp (white, massive dolostone against impure, calc-silicate rock) in metamorphosed terrane. Thickness 200–300 m. Dolostone outcrops typically encrusted with the red to orange lichen, *Caloplaca saxicola*.

Ꞓhs Dolostone—Silty, yellow weathering, a few meters thick about half way into Hasmark, found on ridge southeast of Sheep Mountain

Ꞓsh SILVER HILL FORMATION (MIDDLE CAMBRIAN)—Two members recognized and mapped, wherever practicable

Ꞓshu Upper member—Heterogeneous, interbedded sequence of nodular carbonate, some in disrupted beds a few centimeters thick, in sandstone matrix; ochre-yellow, silty limestone; carbonate-matrix siltstone showing crossbedding, slumping, and load casts; carbonate beds with anastomosing, silty seams; dark-gray limestone showing anastomosing seams of golden-yellow, dolomitic silt ("black and gold"), and massive-bedded siltstone and sandstone similar to those dominating the lower member. "Black and gold" rock locally as much as 15 m thick and found at top of member; assigned as a member here rather than to otherwise homogeneous Hasmark Dolomite (Ꞓh) because of its discontinuous nature. Upper contact at base of typical massive Hasmark; lower contact gradational. Thickness about 50 m

Ꞓshl Lower member—Quartzite and argillite. Rocks include: (1) thin-bedded (1–5 cm) dark-brownish-gray, olive-gray-weathering mudstone, near top of unit, yielding many worm tracks, rare pelmatozoan columnals, trace fossils, and a single trilobite; (2) thin-bedded and dark-gray, noncalcareous argillite; bedding defined by white, sandy layers 1 mm thick in sets of 5 cm or less; crossbedding, groove marks, ripple marks, slumps, and load casts locally abundant totalling a few m thick; (3) interbedded quartzite, some crossbedded, and dark-gray silty argillite, in decimeter-thick beds and meter-thick packets; bioturbation evident; best seen at Hecla and transitional from underlying Black Lion Conglomerate (Ꞓbl); (4) red-weathering, banded (1–3 cm), iron-oxide-rich quartzite; (5) coarse conglomerate lenses, with clast-supported, well-rounded, and well-sorted pebbles of vein quartz, quartzite (including green quartzite containing chrome-rich mica), and jasper, in sandy matrix; lenses as much as 5 m thick but taper laterally and rapidly to zero; found at Hecla about one-third way up in member; (6) lenses of quartzite showing sand grains as much as .5 mm, similar to quartzite beds found in underlying Black Lion Conglomerate (Ꞓbl), near lower part of member (includes quartzite lenses (Ꞓshq) of map;(7) one bed of green argillite, 1 m thick, found at base of member at Sheep Mountain. Upper contact gradational through addition of carbonate to mudstone; lower contact sharp at Sheep Mountain and at Black Lion Mountain-Grace Lake area. At Hecla, quartzite beds interbedded with dark shale, rock type (3), are nearly indentical with the quartzite in Ꞓbl and show similar types of trough crossbedding and scanty, matrix-supported pebbles; contact gradational. Thickness about 50 m

Ꞓshq Quartzite lenses—Similar to those in lower member of Silver Hill Formation (Ꞓshl, type (6)), where separately mappable

Ꞓbl BLACK LION CONGLOMERATE (CAMBRIAN? TO CAMBRIAN)—Conglomerate, well-bedded, small-pebble, and minor interbedded quartzite. Conglomerate typically occurs in beds about 1 m thick, consisting of trough-crossbedded sets about 10 cm thick. Main bedding defined by green, argillaceous layers a few cm thick; crossbedding defined by heavy minerals and grain-size changes in both conglomerate and quartzite. Clasts are mainly matrix-supported, well- to poorly sorted, medium to poorly rounded, and commonly several millimeters to 3 cm across. Dominant among clasts are massive quartz, mainly milky but including amythestine, rose, and smoky; bright-scarlet jasper, both massive and showing parallel laminations of clear quartz a fraction of a millimeter thick; all these together constitute about 80 percent of clasts. White and maroon, silty quartzite, resembling Middle Proterozoic rocks, constitute a small percentage of clasts. Single feldspar crystals constitute about 10 percent and tend to be concentrated in specific layers. Rare clasts are muscovite crystals, gneiss, and schist. Quartzite matrix of conglomerate has lithic and mineral components similar to pebbles. Gradations range from very matrix poor to very matrix rich rocks, latter merges into quartzites similar to those in the lower member of the Silver Hill Formation. Crossbedding almost always present in conglomerate. Pale-greenish-gray when fresh, except for other colors imparted by clasts; in some outcrops resemblance to a bright fruitcake is strong. Pale-greenish-gray argillite contains chlorite and white mica, some of which may be detrital, as is mica that spangles bedding surfaces of coarser grained rocks. Dark-reddish-brown coloring due to oxidation of iron-bearing minerals in slightly weathered rock. Conglomerate weathers to roughly equant blocks and forms frost-heaved, typically unstable piles in higher elevations. Quartzite beds range from white to maroon, show crossbedding similar to and on same scale as conglomerate beds. Quartzite beds occur in packets as much as 10 m in thickness; occur interbedded with conglomerate or at top of conglomerate sequence; best place to examine interbedded relations is on cliffs between two couloirs south of jeep track on north face of Sheep Mountain. Thickness of formation as much as 500 m. Typical lichen *Aspicilia unerea*

Ysc SEQUENCE OF SWAMP CREEK (MIDDLE PROTEROZOIC)—Muddy siltstone, quartzite, and argillite. Scattered outcrops; generally thin bedded (less than .5 m); weathers into small chips; siltstone dominates. Greenish-gray when fresh (rarely observed; 7,800 ft elevation in small ravine north of Ponsonby Peak, SW¼ SW¼ Sec. 24, T. 1 S., R. 11 W.) but pale-tan, brown, and reddish-tan when weathered. Age and thickness of section not known; exposed section a few tens of meters thick only

Ybk SEQUENCE OF BONER KNOB (MIDDLE PROTEROZOIC)—West of Fourth of July fault: Pink, lilac, red, and purple feldspathic quartzite. Well-sorted and rounded detrital quartz grains commonly overprinted with new growth resulting in mosaic texture. Beds commonly several decimeters thick, include packets of tangential and tabular crossbed sets on decimeter scale. Interbedded, polymictic conglomerates in beds as much as 3 m thick; jasper and vein quartz dominate well-rounded clasts in sandstone matrix (best seen at Eagle Rock or at 7,200 ft, south rim of 7,240-foot knoll, east center Sec. 28, T. 1 S., R. 11 W.); outcrops marked by crosses (x) on map. Maroon and dark-gray argillite beds a few cm thick and ripped-up beds and mudchips of similar lithology are characteristic. (May be correlative of member 3 of Mount Shields Formation or Bonner Quartzite of Missoula Group.) Estimated exposed section is about 1 km thick. East of Fourth of July fault (mainly the Morrison Hill klippe): quartzite, predominantly purple, red, pink, lilac, feldspathic, and massively bedded (meter scale); crossbedding in 10 cm sets indicated by heavy-mineral concentrations; dark-reddish-gray to maroon argillite partings; many have been broken into mud chips. Lesser quantities of white to light-gray quartzite and quartz-clast (up to 15 cm across) conglomerate in quartzite matrix are marked by crosses (x). Largely fractured and frost-heaved; large outcrops uncommon. Thickness of preserved section about 500 m; neither top nor bottom exposed; lowest strata in thrust contact against underlying rocks. Where possible, three units mapped separately in Morrison Hill klippe, largely on basis of color of quartzite:

Ybk3 Unit 3—quartzite, pale-lilac to flesh-pink, feldspathic, where separable from unit 2 (Ybk2). Typical lichen is *Lecidea atrobrunnea*

Ybk2 Unit 2—quartzite, maroon and purple, feldspathic,

Ybk1 Unit 1—quartzite and conglomerate, white to gray; latter several meters thick, marked by crosses (x); some conglomerate cobbles

Ybp SEQUENCE OF BIG POINT (MIDDLE PROTEROZOIC)—Quartzite, siltstone, and argillite. Fine- to medium-grained, heterogeneous unit. Pale-pinkish-gray to pale-greenish-gray quartzite. Maroon, flesh-pink, yellowish-tan, greenish-gray siltstone and argillite. In general, reddish-tinted strata occur in western part of the area, and greenish-tinted strata occur in eastern part; difference may be one of slightly higher metamorphic grade in eastern areas. Quartzite beds range from a few centimeters to .5 m in thickness; finer grained strata range from a few millimeters to several centimeters. Moderate to low feldspar content in sandstone beds evident; detrital mica for all strata and spangles bedding surfaces. Abundant sedimentary features including: wave-ripple marks (including flat-topped, beheaded ripples); current ripple marks (including some climbing ripples); tangential and tabular crossbeds in sets of 5–10 cm especially common in sandstone; mudcracks and more irregular desiccation features that may be water-escape channels; depressions having shapes suggestive of salt casts or gypsum casts; small round depressions on bedding surfaces having mudcracks, typical "rain drop" impressions. Rip-up features of argillaceous beds, re-incorporated into the overlying sedimentary layers, exceedingly common. Small-scale load casts are locally present. (May be correlative of member 2 of Mount Shields Formation of the Missoula Group). Estimated thickness 1 km

Ymm SEQUENCE OF MAURICE MOUNTAIN (MIDDLE PROTEROZOIC)—Quartz sandstone and quartzite. Light-gray to white, medium-to-coarse grained, with variable amount, but generally low content, of feldspar. Tangential crossbedding, shown by dark-gray-green laminae defined by slightly micaceous millimeter-thick layers and heavy-mineral concentrations, forms 10–cm sets. Rare ripple marks in thin, rare, greenish-gray argillite beds, best seen on undersurfaces of quartzite beds. Beds typically massive, 1 m or more thick; intrastratal slumps common, forming cyclic sequence of laminar bedding-crossbedding-slump bedding-cross bedding-laminar bedding (best seen on cliffs southeast of Grouse Lakes). White quartzite and vein-quartz-pebble conglomerate beds rare and only a few decimeters thick; marked by crosses (x). Beds weather pale brick red. Different lithic types recognized in upper part of sequence in two areas: (1) Stine Mountain and Grouse Lakes area, upper beds consist of massive-bedded clean, well-sorted, medium-grained, pink quartzite, poor in feldspar, contain some tangential crossbeds, interbedded with decimeter-thick, maroon, argillaceous siltstone beds. Contact with typical sequence of Maurice Mountain by interbedding; and (2) Maurice Mountain summit, strata consist of bluish-gray to steel-gray, poorly sorted, medium- to fine-grained silty sandstone in beds less than 1 m thick, interbedded with gray, argillaceous siltstone. Subordinate feldspar readily visible in sandstone. Upper beds estimated to be about 100 m thick at both localities. Main differences with typical Maurice Mountain sequence are: (1) latter mainly pale gray to greenish gray, containing green laminations; weathering gives beds an orange-red patina; (2) latter typically shows intrastratal slumps; (3) latter more massively bedded and has fewer silty interbeds. (May be correlative of member 1 of Mount Shields Formation of the Missoula Group). Thickness of sequence estimated at a minimum of 1–2 km. Typical lichens include *Umbilicaria* and *Rhizocarpon geographicum*

Xga GNEISS AND AMPHIBOLITE (EARLY PROTEROZOIC)—Foliated plagioclase gneiss, augen gneiss, banded fine-grained and coarse-grained gneiss and amphibolite sequence north and east of Sheep Mountain. Very rare quartzose, slightly calcareous layers. Various lithic units not separated on map. Mineral assemblage of gneiss typically quartz-plagioclase-biotite (partly altered to chlorite)-epidote-microcline-ilmenite (partly altered to sphene)-carbonate-zircon-apatite-muscovite (rare)-tourmaline. Mineral assemblage of amphibolite is typically brown hornblende (with and without actinolite overgrowth)-biotite-plagioclase (with simple twins)-epidote-chlorite-tourmaline-quartz (rare). All rocks show metamorphic textural relation of minerals. Thickness of unit not determinable. Rocks commonly have two, and rarely three, sets of planar fabric, oldest defined by mineral foliation (alinement of platy minerals and habits of more equant crystals); these are axial surfaces to isoclinal, recumbent folds that pass into surfaces of strain discontinuity

INTRUSIVE ROCKS

Mineral composition data are based on microprobe studies (Hammarstrom, 1982)

Tdm MAFIC DIKES (TERTIARY, at least in part EOCENE)—Generally a few meters across. Dark-brownish-gray, containing phenocrysts of forsteritic olivine and(or) augite as much as 1 mm across, some altered, in matrix of lath-shaped feldspar, pyroxene, and opaque minerals. Contact aureole negligible except northeast of Morrison Hill where pipe-like body that may have been a volcanic conduit altered country rock for several meters to tactite, and south of Morrison Hill where host quartzite was brecciated by dike intrusion and breccia fragments are rimmed by orthopyroxene. Dikes interpreted to be feeders to Eocene volcanic rocks. In granitic rocks of Pioneer batholith, these dikes often cause sharp saddles in ridge line and weather to deep-brown soil. Swarms of dikes locally observed, for example, on south wall of cirque due west of Green Lake

Tda APLITIC DIKE (TERTIARY?)—Fine-grained, two-mica granite containing microcline, plagioclase, quartz, biotite, and rare muscovite, some of which may be magmatic. Composition: 72 percent SiO_2, 13 percent Al_2O_3, 1.6 percent CaO, 8 percent total alkali oxide, 3 percent FeO+MgO

Tqp LEUCOGRANITE OF BOBS LAKE AREA AND SOUTH OF JACOBSON MEADOW (PALEOCENE)—Rounded, smoky-quartz phenocrysts about 1 cm in a medium-fine-grained, pinkish-gray matrix of quartz, feldspar, biotite, euhedral sphene and apatite. Plagioclase somewhat altered; large anhedral potassium feldspar with myrmekite rims; biotite partly altered to chlorite. Many small (±1 cm) dark-mineral clusters that may be inclusions. Leucogranite apparently related to late vein quartz containing muscovite found in coarse granite, one of which yielded 64 Ma by $^{40}Ar/^{39}Ar$ dating method. Molybdenite locally associated with quartz-sericite veins. Cuts Clifford Creek Granite (TKc) southwest of Bobs Lake; cuts Uphill Creek Granodiorite (Kuc) in Jacobson Meadow area

vq VEIN QUARTZ (TERTIARY?)—Massive crosscutting. Separately mapped only in the Ponsonby area. Age uncertain, probably related to later stages of the Pioneer batholith

TKds SILICIC DIKES AND SILLS (PALEOCENE TO CRETACEOUS)—Each a few meters wide. Light-gray, massive, containing altered phenocrysts of plagioclase and biotite (saussurite and chlorite, respectively), in fine groundmass of quartz, feldspar, and muscovite. Composition: 71 percent SiO_2, 15 percent Al_2O_3, 1 percent FeO+MgO, 1.2 percent CaO, 7 percent total alkalis. Presumably related to Paleocene two-mica granite

TKc CLIFFORD CREEK GRANITE (PALEOCENE AND UPPER CRETACEOUS)—Two-mica, massive, coarse granite and porphyritic coarse granite. Coarse granite, light-gray, medium-grained (2 mm or less), uniform-textured, without obvious foliation; but weak foliation, defined mainly by biotite alinement, locally measurable. Ab-rich oligoclase. Perthitic microcline (Or=86–92) forms large, inclusion-poor euhedral phenocrysts. Biotite has Fe/(Fe+Mg)=0.45–0.60; muscovite forms euhedral intergrowths with biotite, presumed to be magmatic, and also occurs as large to small single crystals and alteration products. Rare, anhedral sphene closely associated with biotite. Mn-rich ilmenite found only as inclusions in other minerals. Composition: about 74 percent SiO_2, 14 percent Al_2O_3, 1 percent FeO+MgO, less than 2 percent CaO, 8–9 percent total alkali oxides. Porphyritic phase has similar mineralogy and chemistry, with additional euhedral, white, twinned, potassium feldspar phenocrysts, largely inclusion free, as much as 3 cm long. Many small dikes of aplite and rare pegmatite, both pink (apparently older) and gray (apparently younger), presumably related to intrusion of leucogranite of Bob's Lake and characterized by large (1 cm or less) smoky, rounded quartz phenocrysts; dikes in general not separately mapped

TKcp Porphyritic phase of Clifford Creek Granite (TKc)—Where separately mapped

Kog GRANITE (CRETACEOUS)—Very coarse, porphyritic, with biotite. Potassium feldspar occurs as pink, euhedral phenocrysts as much as 2 cm across. Found only at one outcrop in northwest corner of map; relation to surrounding rock units unknown. Most closely resembles potassium-feldspar-phenocryst-rich portions of Grayling Lake Granite (Kgl)

Kqd HORNBLENDE QUARTZ-DIORITE PLUG OF DRY HOLLOW GULCH (CRETACEOUS)—Mottled, gray, coarse-textured, consisting of euhedral hornblende as much as 1 cm long, and plagioclase. Plagioclase strongly saussuritized; biotite largely altered to chlorite; fresh hornblende. Quartz. Opaque oxides. Epidote crystals probably secondary

Kcg GRANODIORITE OF CANNIVAN GULCH (CRETACEOUS)—Medium- to fine-grained. Light-gray, much altered and impregnated by pyrite and cut by quartz-molybdenite veins. Biotite only locally fresh; in most samples only limonite stain remains. Poorly exposed. K–Ar age on biotite, 68.0±2.5 Ma (Schmidt and others, 1979)

Koc PORPHYRY AND TONALITE WEST OF OSBORNE CREEK (CRETACEOUS)—Undifferentiated medium-gray, medium-grained, quartz-feldspar porphyry and dark-gray, fine-grained hornblende-biotite tonalite in Stine Mountain quadrangle

Kgl GRAYLING LAKE GRANITE (UPPER CRETACEOUS)—Medium to coarse, pinkish-gray granite to granodiorite, color becoming paler when slightly weathered. Fresh rock shows large (1 cm) euhedral, nearly inclusion-free, twinned, pink potassium feldspar set in matrix of 2–3-mm-size white plagioclase, smoky-lilac quartz, biotite, and rare hornblende. Thin section shows plagioclase to be euhedral, zoned and twinned, with some rafted clusters (Ab=72–55); potassium feldspar (Or=83–93) poorly perthitic; sphene; epidote as alteration of feldspar and as anhedral to subhedral grains associated with biotite; large, twinned allanite (some having epidote overgrowths); magnetite; apatite; secondary muscovite and rare magmatic muscovite in hornblende-free rocks; zircon producing pleochroic halo in biotite. Myrmekite common. Foliation commonly evident, defined by alinement of biotite books and long dimensions of feldspar; false foliation caused by close-spaced fracture that sheared feldspar into aligned crystal slivers is common. Foliation orientation closely associated with orientation of principal joints which split rock into slabs several meters thick. Inclusions are mainly dark, subrounded schlieren of hornblende, biotite, and feldspar of same composition as bulk of rock; inclusions of sedimentary rocks rare. Sharp, chilled contact zone, where exposed, only a few centimeters wide. Uniform texture from border inward. Some associated aplites and pegmatites invariably pink. Composition: 73 percent SiO_2, 15 percent Al_2O_3, 2 percent FeO+MgO, 2 percent CaO, 3 percent Na_2O, 3.5 percent K_2O. Cuts Keokirk Quartz Diorite (Kkc), Trapper Tonalite (Kt), and porphyritic border phase (Kgp) of Grayling Lake Granite

Kgb Granite (Upper Cretaceous)—Very similar to Grayling Lake Granite (Kgl) that occurs northwest of Browne's Lake. Composition: 72 percent SiO_2, 14 percent Al_2O_3, 4 percent FeO+MgO, 2.7 percent CaO, 3 percent Na_2O, 3.6 percent K_2O. Cuts flow-foliated Uphill Creek Granodiorite (Kuc)

Ktcl Tonalite of the Canyon Lake area (Upper Cretaceous)—Gray, "salt-and-pepper"-textured, fine-grained (1 mm) massive rock showing conspicuous cleavage reflections from biotite and hornblende. Interpreted to be a border phase of Grayling Lake Granite (Kgl) but no contact relation found

Kgp Porphyritic granodiorite, a border facies of Grayling Lake Granite (Upper Cretaceous)—Light-pinkish-gray, fine-grained (1 mm), containing phenocrysts (1 cm) of white potassium feldspar. Prominent foliation caused by alinement of hornblende laths and biotite books. Plagioclase Ab=75–62, zoned and twinned; potassium feldspar Or=86–91. Hornblende and biotite equally abundant; some biotite altered to chlorite. Minor magnetite as well as anhedral and euhedral sphene. Contact with Grayling Lake Granite (Kgl) gradational over less than 1 m, best seen on cliffs west and below summit of Barbour Hill. Composition: 65 percent SiO_2, 16 percent Al_2O_3, 5 percent total FeO, 2 percent MgO, 4 percent CaO, 3 percent each K_2O and Na_2O. Contains xenoliths of Trapper Tonalite (Kt)

Kuc UPHILL CREEK GRANODIORITE (UPPER CRETACEOUS)—Medium- to coarse-grained gray, massive, constitutes largest pluton of Pioneer batholith. White, euhedral plagioclase about 3 mm long, gray quartz, and books of biotite and prisms of hornblende 1–2 mm long. Honey-yellow sphene conspicuous. Most rocks characterized by megacrysts of potassium feldspar seen only by light reflection from cleavage planes; these crystals, as much as 3 cm across and always anhedral, include other minerals of normal texture but slightly smaller size. Inclusion-free phenocrysts of pink potassium feldspar locally found but very rare. Euhedral to subhedral hornblende and biotite about equally abundant. Zoned, twinned plagioclase (Ab 76–52) shows much rafted clustering. Sphene euhedral and less commonly anhedral. Magnetite and allanite subsidiary. Epidote occurs as alteration product, as discrete grains especially associated with biotite and anhedral sphene, and as overgrowth on allanite. Megacrystic potassium feldspar nonperthitic (Or 80–90); development of myrmekite pronounced especially at plagioclase contacts that are not inclusions in megacrysts. Foliation, defined by alined mafic minerals, poor to moderately developed; pseudofoliation due to shearing locally conspicuous especially along saddles of ridge lines. Dark, subrounded schlieren consist of hornblende, biotite, and lesser phenocrystic feldspar occur individually and in large clusters, locally paralleling intrusive contacts. Biotite compositional layering locally conspicuous (for example, rock basin south of Tendoy Lake); each layer appears to grade upward from biotite-rich to feldspar-rich parts a few centimeters thick; some layers convoluted. Biotite same size in the biotite-rich and biotite-poor layers. Sharp contact against country rock with little or no chilled margin; rock texture uniform from contact inward to main body except for local schlieren. Jointing conspicuous and commonly at 1–2-m spacing. Pegmatite and aplite locally abundant (for example, south of Rock Creek on ridge) and always contain pink feldspar. Miarolitic cavities lined with pink potassium feldspar, biotite and quartz locally found. Contact against Grayling Lake Granite (Kgl) may be difficult to map and is seemingly gradational from Grayling Lake (Kgl) to Kuc by loss of pink, euhedral potassium feldspar and gain of megacrysts. Contact against granite (Kgb) at Browne's Lake is sharp; Kuc older. Composition: about 66 percent SiO_2, 16 percent Al_2O_3, 2–3 percent FeO, 1.5 percent MgO, 4.5 percent CaO, 3 percent Na_2O, and 2.5 percent K_2O

Kdc GRANODIORITE OF DAVID CREEK (CRETACEOUS)—Medium-fine-grained, light- to medium-gray, slightly porphyritic. Contains hornblende and biotite in addition to two feldspars and quartz. Cuts Uphill Creek Granodiorite (Kuc) at places, but locally seems to grade into it. May be same as medium-fine-grained granodiorite of Birch Creek, "BC", of Zen and others, (1975)

Kgm BIOTITE GRANITE OF MONO PARK AREA (CRETACEOUS)—Resembles Grayling Lake Granite (Kgl), but contains a few megacrysts. Mafic minerals include biotite and minor hornblende, sphene, and monazite. Interpreted to be of the "mixed" zone between Grayling Lake Granite (Kgl) and Uphill Creek Granodiorite (Kuc) such as those occurring on ridge north of Tahepia Creek. As rock is in downdropped block west of the Fourth of July fault, it may correspond to a higher level of intrusion than exposed east of the fault

Ksc GRANITIC ROCKS OF STINE CREEK (CRETACEOUS)—Main body on Stine Creek medium-gray, medium-grained biotite granite. Muscovite rare; epidote and anhedral sphene rare and most probably secondary. Cuts dark-gray, medium- to fine-grained hornblende-biotite tonalite at extreme west end of Stine Creek pluton. Small body in Grouse Lake drainage area consists of medium to coarse, gray granodiorite containing hornblende, biotite, and euhedral sphene

Kdm MAFIC DIABASIC DIKE (CRETACEOUS OR OLDER)—North of Maurice Mountain, dike is truncated by Clifford Creek Granite (TKc) intrusive contact

Kt TRAPPER TONALITE (UPPER CRETACEOUS)—Medium-grained (2 mm), dark-gray tonalite, exhibiting weak foliation caused by alinement of mafic minerals. Euhedral hornblende dominates biotite; some crystals contain cores of relict pyroxene (weakly pleochroic in pink). Euhedral to subhedral laths of plagioclase (Ab 71–35) zoned and weakly twinned. Quartz interstitial and potassium feldspar rare. Clusters of magnetite abundant; euhedral sphene present. Epidote appears as alteration mineral associated with mafic phases. Composition: 61 percent SiO_2, 16 percent Al_2O_3, 2.4 percent Fe_2O_3, 3.6 percent FeO, 2.5 percent MgO, 5.5 percent CaO, 3.3 percent Na_2O, 3 percent K_2O, 0.5 percent TiO_2. Near contact with Grayling Lake Granite (Kgl), mafic minerals have become partially hydrated, altered, and "smeared out" into elongate patches; these altered mafic patches, plus alteration of feldspar to give that mineral a dull, clayey luster, lead to outcrops of striking, spotted "leopard" rock. Cuts Keokirk Quartz Diorite (Kke)

Kke KEOKIRK QUARTZ DIORITE (UPPER CRETACEOUS)—Fine-grained (1 mm or less) dark-gray, uniform-textured. Near contact with Grayling Lake Granite (Kgl), partly altered and shows blotches of intergrowth of white feldspar and bronze sheaves of biotite. Plagioclase (Ab 70–21) zoned, some twinned, subhedral to euhedral subequant grains. Potassium feldspar rare and interstitial. Hornblende dominates over biotite, some with pyroxene core. Quartz interstitial. Sphene, mostly anhedral, rare. Allanite, some with epidote overgrowth. Magnetite common. Composition: 52 percent SiO_2, 18 percent Al_2O_3, 5 percent Fe_2O_3, 5.5 percent FeO, 4 percent MgO, 9 percent CaO, 3 percent Na_2O, 1.3 percent K_2O, 1.2 percent TiO_2. Outcrop pattern at Keokirk Mountain generalized

Kga GABBRO OF NEZ PERCE RIDGE (CRETACEOUS)—Medium to coarse (2 mm to 2 cm) only a single outcrop within quadrangle. Euhedral plagioclase and pyroxene, latter rimmed by hornblende. Some primary biotite altered partly to chlorite. Apparently a border facies to tonalitic intrusive body centered northeast of Dewey

Klk TONALITE OF LIME KILN GULCH (CRETACEOUS)— Dark-gray, "salt-and-pepper"-textured, medium-fine grained (about 1 mm), showing conspicuous cleavages of hornblende and biotite. Euhedral, zoned plagioclase (Ab 70-37), euhedral to subhedral hornblende, anhedral to interstitial biotite, and interstitial quartz. Mafic minerals partly altered to chlorite; plagioclase saussuritized. Discrete anhedral epidote, euhedral magnetite. Composition: 56 percent SiO_2, 18 percent Al_2O_3, 3 percent Fe_2O_3, 4.5 percent FeO, 3 percent MgO, 6 percent CaO, 3.5 percent Na_2O, 2 percent K_2O, 1 percent TiO_2. Affinity of pluton to Pioneer batholith not obvious. Crops out poorly, no contact relation observed. May be related to large pluton in Dewey quadrangle just north

gum GABBRO AND ULTRAMAFIC ROCKS (probably Cretaceous or Archean)—Form large (as much as 300 m) inclusions in Trapper Tonalite (Kt) and Keokirk Quartz Diorite (Kke), on cliffs west of Granite Lake. Coarse (1 cm) bronzite-pyroxenite showing cumulate texture and minor interstitial plagioclase, layered gabbro, and massive gabbro, in masses and layers that locally suggest cross-stratification. Partly altered to talc-chlorite-actinolite rocks; borders of coarse (3–5 cm), hornbende-bearing rock against enclosing diorite and tonalite. Best exposed on ledges north of rock chute north of main cliff west of Granite Lake

ZYdm MAFIC DIKES OF LACY AND ELK CREEKS (LATE AND MIDDLE PROTEROZOIC)—Fine-grained, green-gray greenstone and medium-gray, medium-grained diabasic rocks. Some intensely sheared into mylonite. Cuts sequence of Big Point (Ybp); an argon release spectrum on whole rock gives a disturbed pattern but indicates a minimum age of about 660 Ma

EXPLANATION OF SYMBOLS

STRATIGRAPHIC CONTACTS—Dashed where concealed or inferred

FAULTS—Dashed where concealed or inferred
- Thrust fault, teeth on upper plate
- Normal fault, known relative displacement, hachure on downthrown side
- High-angle fault, either strike-slip or uncertain movement

FOLDS
- Trend of syncline; direction of plunge
- Trend of anticline; direction of plunge

STRUCTURAL DATA

Sedimentary and volcanic rocks
- 50 Bedding, strike and dip
- Bedding, horizontal
- Bedding, vertical
- 40 Bedding, overturned
- 25 Cleavage, strike and dip
- Cleavage, horizontal
- Cleavage, vertical
- 60 Bedding and cleavage parallel in strike and dip
- 10,55 Bedding and cleavage parallel in strike but not dip; first figure refers to bedding
- 10 75 Bedding and cleavage not parallel in strike; point of observation is where the two half-symbols join
- 15 Direction of current based on channel, square pointing downstream
- 20 Direction of current based on ripples, square pointing downstream
- 55 Joint, strike and dip
- Joint, vertical
- 40 20 Axial plane of folds, direction, dip. Direction and plunge of axis, where known, shown by attached arrow
- 65 Axial plane of folds, vertical, and dip of axial plunge
- 80 f Strike and dip of faults
- f Strike of faults, where dip not known

Intrusive rocks
- 60 Strike and dip of composition banding; attitude of contact
- 80a Attitude of aplite (a)
- 50p Attitude of pegmatite (p)
- 35vq Attitude of quartz veins (vq)
- Composition banding, horizontal
- Composition banding, vertical
- 25 Primary mineral foliation, strike and dip
- Primary mineral foliation, vertical
- 15 Fracture cleavage, strike and dip
- Fracture cleavage, horizontal
- Fracture cleavage, vertical
- 15 Lineation of minerals, plunge and dip amount
- Lineation of minerals, vertical
- 40 Joint, strike and dip
- Joint, vertical
- Intrusive breccia

SAMPLE LOCALITIES
- F Fossils found
- F Fossils found and studied, this report
- 121-1 Age-dated samples (table 3)
- 287-1 Age-dated and initial strontium samples (table 4)