GEOLOGIC MAP OF THE

SWEET GRASS HILLS 30' x 60' QUADRANGLE

NORTH-CENTRAL MONTANA

by

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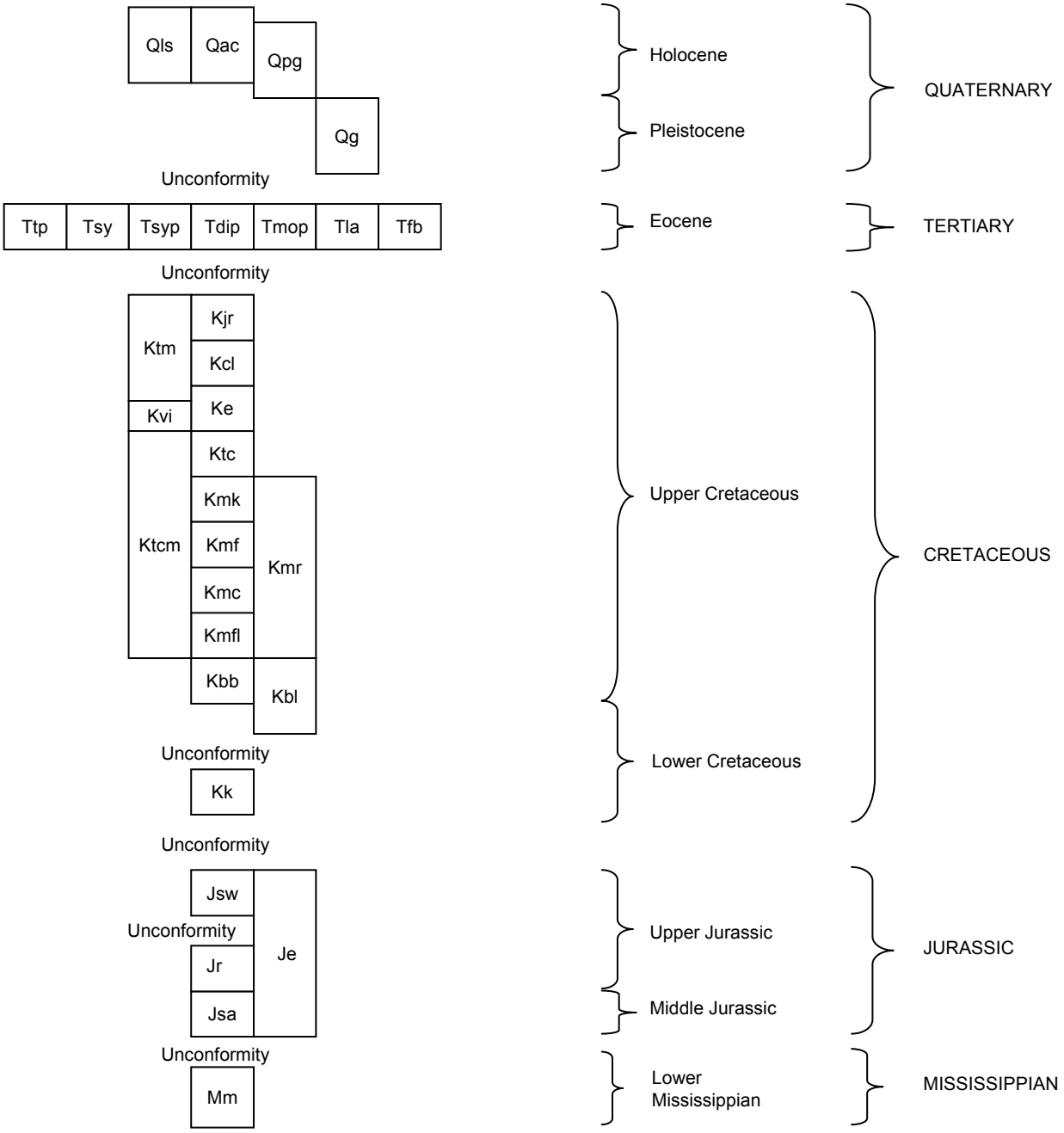
INTRODUCTION AND DISCUSSION

The area of the Sweet Grass Hills 30' X 60' quadrangle lies within the area covered by Pleistocene continental glaciers. Thus, glacial deposits cover much of the bedrock in the lower elevations surrounding the Sweet Grass Hills. Glacial deposits are depicted by a stippled pattern, and buried bedrock units are identified by letter symbols in parentheses (see map symbol explanation). The bedrock geology depicted here is based on limited exposure and on oil and gas drill-hole data. Because of the lack of sufficient data, buried contacts beneath glacial deposits are approximate. The stylized appearance of the Kevin—Sunburst Dome in the southwestern part of the quadrangle is due to this lack of data.

The northeast-trending, Great Falls Tectonic Zone is a broad zone that passes roughly through the southeastern half of the quadrangle (Lopez, 1995). Its effect on bedrock geology in this area could not be determined because of the limited amount of bedrock exposure. As can be seen in the exposed area in the Sweet Grass Hills, the structure in the area is complex. In the areas covered by glacial deposits, the bedrock structure must be much more complicated than shown on this map. Limited available gravity and aeromagnetic data, as well as unpublished proprietary data, shows the structure in the area is dominated by a northeast-striking basement fault system that is part of the Great Falls Tectonic Zone, and is known to affect the Paleozoic and Mesozoic rocks in the area (Lopez, 1995; O'Neil and Lopez, 1985).

This map is a digital, color version of Plate 1, Geologic map of the Sweet Grass Hills 30’ X 60’ quadrangle that is part of Montana Bureau of Mines and Geology Memoir 68 (Lopez, 1995).

CORRELATION OF MAP UNITS
SWEET GRASS HILLS 30'X 60' QUADRANGLE



DESCRIPTION OF MAP UNITS
SWEET GRASS HILLS 30' X 60' QUADRANGLE

Qac **Alluvium and colluvium, undivided (Holocene)** –
Alluvial deposits in active streams and rivers, consisting mainly of locally derived sand and gravel and reworked material from glacial till. Coarser material, as large as boulder size, is present close to mountainous areas. Locally may include colluvium, glacial outwash, and glacial lake deposits.

Qls **Landslide Deposits (Holocene)** – Deposits emplaced mainly down steep slopes by the force of gravity, consisting mainly of tumbled masses and blocks of local bedrock mixed with soil. Many are associated with steep slopes underlain by intrusive rocks or shales. Toes of these deposits display characteristic swells and swales arranged in a pattern concentric to the outer limit of the slide.

Qpg **Pediment Gravels (Holocene)** – Gravel deposits on smooth surfaces sloping away from the main summits of the Sweet Grass Hills. Composed exclusively of locally derived angular and subangular clasts of cobble and smaller sizes. Intrusive igneous rocks exposed in the Sweet Grass Hills are the predominant rock types present.

Qg **Glacial deposits, undivided (Pleistocene) —** Unsorted deposits of clay- to boulder-size material. Clast composition is anomalous relative to local bedrock, predominantly pink granite, quartz-biotite schist, granite gneiss, and quartzite. Locally cobbles and boulders of ultramafic rocks are present. Areas underlain by these deposits display characteristic hummocky topography. Locally may include colluvium and glacial outwash and glacial lake deposits. Roger Colton (written communication, 1994), on unpublished mapping of Quaternary deposits, divided these deposits in greater detail, but this detail is not included here because of the bedrock emphasis of this map.

Tsy **Syenite (Eocene) —** Medium-gray to light-brownish gray. Fine- to medium-grained, composed mainly of potassic feldspar with subordinate grains of pyroxene and biotite. Biotite content can be as much as 10%. Potassic feldspar as much as 0.25 inch long, biotite as much as 0.1 inch long, pyroxene as much as 0.05 inch in diameter. Makes up part of the stock of Mount Royal.

Tsyp **Syenite Porphyry (Eocene) —** Like the syenite of Mount Royal but is porphyritic with phenocrysts of sanidine(?) as much as 0.5 inch long. Locally contains phenocrysts of pyroxene and biotite. Makes up part of the stock of Mount Royal and of Mount Brown. It also occurs as thick sills at Mount Lebanon and Black Jack Butte and as thin sills and dikes throughout East Butte.

Ttp **Trachyte Porphyry (Eocene) —** Porphyritic, with greenish gray to medium-gray aphanitic groundmass. Phenocrysts of sanidine are euhedral and as large as 1 inch long; pyroxene is euhedral to subhedral and 0.05 to 0.1 inch in diameter. Groundmass trachytic, composed mainly of potassic feldspar needles, pyroxene, and opaque grains. Occurs as dikes and sills in East Butte.

Tdip **Diorite Porphyry (Eocene) —** Mostly medium-dark-gray diorite with phenocrysts of plagioclase and of pyroxene and/or hornblende in varying proportions. Phenocrysts euhedral to subhedral. Plagioclase in andesine compositional range and as much as 0.25 inch long. Other phenocrysts generally smaller. Occurs as stocks, laccoliths, sills, and dikes at Middle and West Buttes.

Tmop **Monzonite Porphyry (Eocene) —** Light-brownish gray to pale brown monzonite with phenocrysts of potassic feldspar, plagioclase, and minor pyroxene and hornblende. Potassic feldspar blocky, euhedral as much as 1.25 inches across, plagioclase lath shaped, euhedral, as much as 0.1 inch long. Anhedral grains of quartz are present in amounts less than 5%. Occurs in a thick sill in West Butte.

Tla **Lamprophyre (Eocene) —** Dark-gray dikes, thin sills, and plugs of mafic porphyritic rocks. Phenocryst proportions range from 100% biotite to varying combinations of biotite and hornblende. No feldspar phenocrysts are present. Matrix is aphanitic and is made up predominantly of potassic feldspar. Biotite-rich variety is called minette, biotite-hornblende varieties have been referred to as vogesite. Mount Lilly and Haystack Butte are composed of vogesite. Minette occurs mainly as thin sills and dikes at East Butte. Minette locally contains such a large proportion of biotite that the rock is easily weathered and becomes friable.

Tfb **Felsite Breccia (Eocene) –**Yellow to light-brown breccia. Abundant fragments of Eagle Sandstone and some shale. Vesicular to scoriaceous, aphanitic, hydrothermally altered, and highly brecciated. Composed of quartz, potassic feldspar and amorphous material that is predominately composed of goethite, jarosite, and unidentified clay minerals. Occurs only at Grassy Butte.

Kjr **Judith River Formation (Upper Cretaceous) –**
Interbedded deposits of fluvial sandstone, shale, mudstone, siltstone, and coal. Forms rounded light-colored outcrops. Sandstones are lenticular, trough cross-bedded, fine- to coarse-grained, light-gray to yellow-brown, and nearly white to brown weathering. Mudstones are commonly carbonaceous. Fossil plant debris is common. A complete section is not exposed in the area, but the total thickness in the area is reported to be about 750 ft (Erdmann, 1942).

Kcl **Claggett Shale (Upper Cretaceous**) **–** Brownish gray, silty, and sandy shale with thin interbeds of argillaceous and calcareous sandstone. Brown septarian concretions and *Inoceramus* prisms are common. The lower part contains beds of bentonite. The Claggett is typically very poorly exposed. Cobban (1955) reported a thickness of 420 ft at Goosebill Butte, 30 miles south of Chester.

Ke **Eagle Sandstone (Upper Cretaceous) –** Upper part is generally poorly exposed and is characterized by thin sandstone beds interbedded with brown and olive mudstones and less abundant bentonite, bentonitic mudstone, carbonaceous shale, and coal. Fossilized plant debris is common in this part of the section. The lower part is light-brown- to buff-weathering thick-bedded to massive sandstone that forms rounded rims and bluffs. Sandstones are fine-grained, light-gray to light-brownish gray, limonite speckled, and well indurated to friable. Ripples, low-angle cross-bedding and burrowing are common. This lower part of the section is commonly referred to as the Virgelle Member. The Eagle Sandstone is about 350 ft in total thickness in this area.

Ktm **Two Medicine Formation (Upper Cretaceous) –** Occurs only west of the axis of the Sweet Grass Arch in the northwest corner of the map area. Equivalent to the Judith River Formation, Claggett Shale, and the upper part of the Eagle Sandstone. Consists mainly of gray, greenish gray, and purplish gray mudstones and siltstones with interbedded lenticular, fine- to very coarse grained, locally calcareous sandstone. Exposures in the map area are very limited but the total thickness of the formation in the region ranges from 1,650 ft to 1,950 ft (Zimmerman, 1967).

Kvi **Virgelle Sandstone (Upper Cretaceous) –** Name used west of the axis of the Sweet Grass Arch. Appears only in northwest corner of the map area where it underlies the Two Medicine Formation. Lithologically the same as, and stratigraphically continuous with, the lower part of the Eagle Sandstone on the east side of the Arch, where it is commonly called the Virgelle Member.

Ktc **Telegraph Creek Formation (Upper Cretaceous) —** Interbedded medium-brownish gray sandy shale and brown, fine-grained, thin-bedded, argillaceous sandstone. Proportion of sandstone relative to shale increases upward. Total thickness in the area is about 150 ft.

Kmr **Marias River Formation, undivided (Lower Cretaceous) —** Members of the formation described individually below. Undivided in the Sweet Grass Hills where outcrop width does not allow separation at map scale of this report.

Kmk **Kevin Member (Upper Cretaceous) –** Medium-dark-gray to brownish gray, calcareous, fissile shale. In the subsurface the informal name, First White Specks, is commonly applied because of the characteristic white specks (calcite) visible on shale partings. Thin, light-gray bentonite beds, gray limestone septarian concretions, and *Inoceramus* prisms are common in this member. The Kevin is about 560 ft thick in the map area. At the type section on the Kevin-Sunburst Dome, it is 620 ft thick (Cobban and others, 1976).

Kmf **Ferdig Member (Upper Cretaceous) –** Dark-gray, fissile shale, with scattered lamina and very thin beds of sandstone and siltstone in the lower part. Reddish brown, gray, and brownish gray septarian concretions usually less than 1 ft in diameter are common. In the Sweet Grass Hills area, the Ferdig is 200-225 ft thick. At the type section on the Kevin-Sunburst Dome it is 224 ft thick (Cobban and others, 1976).

Kmc **Cone Member (Upper Cretaceous) –** Very dark gray, fissile, calcareous, white-specked shale with petroliferous odor. A thin, buff, calcareous sandstone with abundant shell fragments and fish teeth and bones occurs at the base. Commonly called the Second White Specks in the subsurface. The Cone is about 60 ft thick in the Sweet Grass Hills area. It maintains a similar thickness of 50 to 60 ft over the Sweetgrass Arch (Cobban and others, 1976).

Kmfl **Floweree Member (Upper Cretaceous) –** Dark-bluish gray, fissile to blocky and brittle noncalcareous shale and medium-gray sandy and silty shale. Thin beds of argillaceous sandstone and bentonite are common. Orange-brown, calcareous concretions 1 to 3 ft in diameter are characteristic of this member. Outcrops are commonly littered with chips of limonite-stained siltstone. The thickness of the Floweree is variable; in the Sweet Grass Hills the Floweree is about 175 ft thick; on the Kevin-Sunburst Dome it is 75 to 100 ft thick (Cobban and others, 1976).

Ktcm **Marias River Formation and Telegraph Creek Formation, undivided (Upper Cretaceous) —** Map unit used only in part of the Sweet Grass Hills area of map.

Kbl **Blackleaf Formation, undivided (Lower Cretaceous) —** Alternating beds of dark-gray fissile shale and brownish gray and gray, brown-weathering sandstone, organized in as many as seven upward-coarsening parasequences. Sandstones are generally fine-grained, quartzose, and burrowed to bioturbated. Sandstone beds are typically 5 to 20 ft thick. The upper 100 ft are siliceous claystone, siltstone and very fine grained sandstone interbedded with dark-gray fissile shale. Fish scales and some fish bones are common in this interval. The Blackleaf is 600 to 700 ft thick in the area (Cobban and others, 1976).

Kbb **Bootlegger Member** (**Upper Cretaceous) —** Uppermost member of the Blackleaf Formation. Differentiated only on the crest of the Kevin-Sunburst Dome. Siliceous claystone, siltstone and very fine grained sandstone interbedded with dark-gray fissile shale. Fish scales and some fish bones are characteristic of this member. The Bootlegger Member is approximately 100 ft thick (Cobban and others, 1976).

Kk **Kootenai Formation (Lower Cretaceous) —** Drab olive-gray and Reddish gray to maroon mudstones interbedded with fine- to coarse- grained, feldspathic, argillaceous sandstones. Sandstones become finer upward, are locally conglomeratic, are generally gray and weather brown, and are characterized by white, chalky detrital feldspar. The Kootenai is about 350 ft thick.

Jsw **Swift Formation (Upper Jurassic) –** Interbedded and interlaminated dark-gray fissile shale and thin beds and laminae of light-gray, brown-weathering, siltstone and very fine-grained sandstone. Referred to as the "ribbon sands" in the subsurface. In several localities the Swift is thinned or removed by pre-Kootenai erosion. Preserved thickness is as much as 30 ft.

Jr **Rierdon Formation (Middle Jurassic) –** Medium- to dark-gray, fissile to blocky, calcareous and noncalcareous shale with thin interbeds of siltstone, very fine grained sandstone, and dark-gray fossiliferous limestones. Siltstone and sandstone occur mainly in lower part. Limestones most common in upper part. Shales weather light-gray to light-greenish gray. Total thickness is about 200 ft.

Jsa **Sawtooth Formation (Middle Jurassic) –** Light-gray calcareous, thin-bedded, quartzose, brown-weathering sandstone. Near the middle is a sequence of about 30 ft of interbedded dark-gray shale and dark-gray limestone. A thin lag gravel composed of chert pebbles and shell fragments of *Gryphea* and *Ostrea* is present at the top. The Sawtooth is about 110 ft thick in the map area. Not shown separately but mapped with Je.

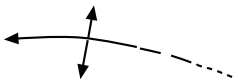
Je **Ellis Group, undivided (Middle and Upper Jurassic) –** Includes Swift, Rierdon, and Sawtooth Formations. Used in the Sweet Grass Hills where outcrop width does not allow division at the map scale of this report.

Mm **Madison Limestone (Lower Mississippian) –** Medium-gray to light-gray, medium- to thick-bedded, cherty limestone. Chert is nodular, not bedded. Argillaceous interbeds and partings are absent to very thin. Fossil crinoid stems, corals, and bryzoans are common. Forms prominent, nearly white ledges and rugged hogbacks. Thickness of the Madison varies across the region; in the Sweet Grass Hills it is about 1000 ft.

Map Symbols

Contact; dashed where approximate, dotted where concealed.

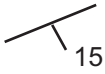
Fault; Dashed where approximately located, dotted where concealed; bar and ball on down-thrown side. Arrows indicate directon of strike-slip movement. On cross section, relative vertical displacement is indicated by “A”(away from the viewer and “t” (toward viewer).



Anticline; arrow denotes dirction of plunge, dashed where approximately located, dotted where concealed.

Syncline; arrow denotes direction of plunge, dashed where approximately located, dotted where concealed.

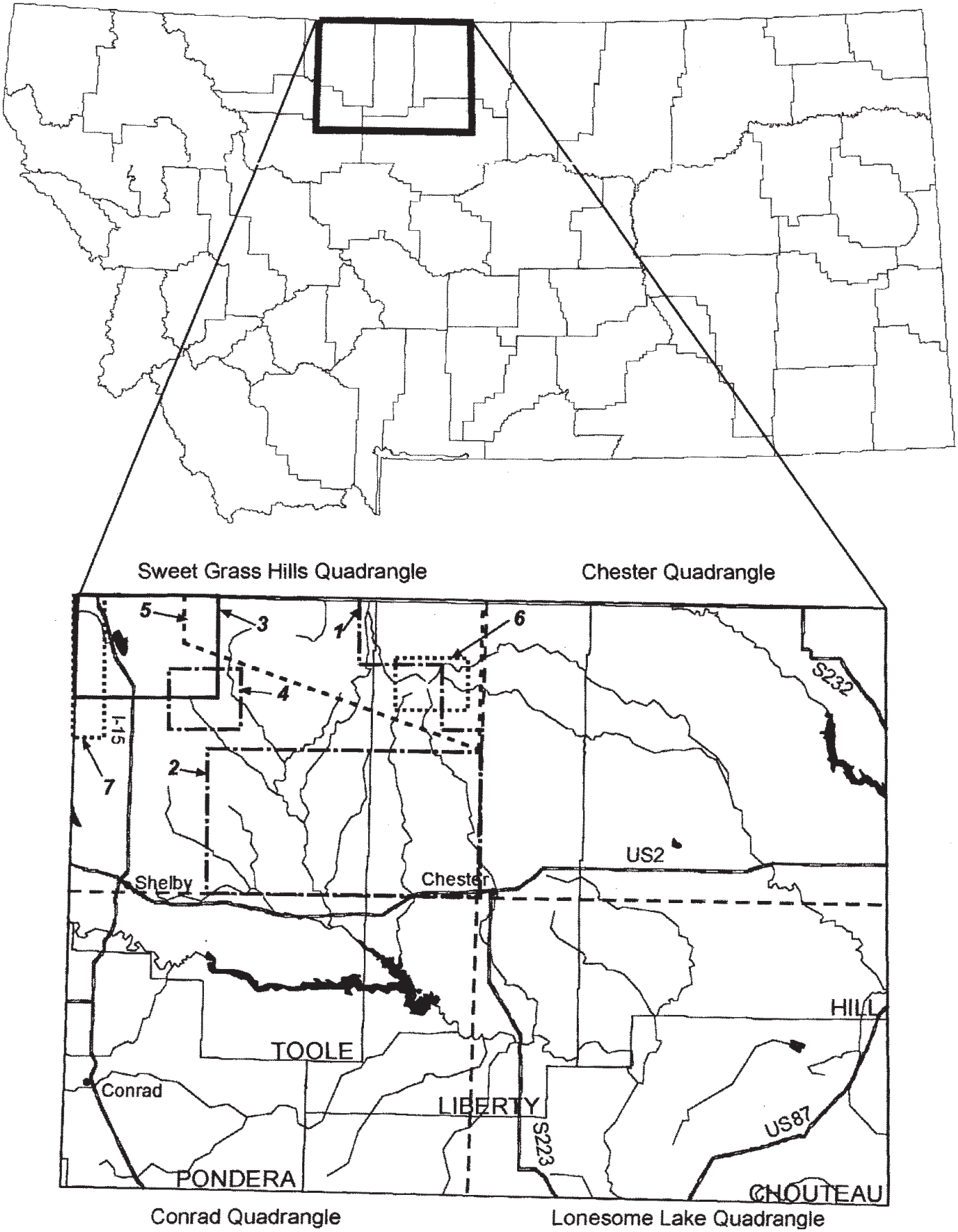
Dikes and sills (red on map)



Strike and dip of bedding

(Kjr)

Unit symbol in parentheses denotes that the unit is concealed by glacial deposits



Index map and soruces of geologic mapping in the Sweet Grass Hills 30' x60' quadrangle.

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Bold map numbers at end of citations correspond to numbered areas on index map

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