GEOLOGIC MAP OF THE HAVRE 30' x 60' QUADRANGLE

NORTH-CENTRAL MONTANA

by

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Introduction

This geologic quadrangle map is an updated and digitally produced version of MBMG Open-File 325, Preliminary Geologic Map of the Havre 30x60-minute Quadrangle, published by the Montana Bureau of Mines and Geology in 1994. Revisions are primarily focused on more detailed work in the northern Bears Paw Mountains along the southern map area, following the work of Hearn, Jr. (1976).

Glacial drift of varying thickness and multiple origins masks the bedrock over most of the quadrangle. Most map unit contacts, even where shown as a solid line, should be taken as concealed or approximate. Because this map, like its earlier version, is intended as a bedrock map, almost no delineation of the glacial deposits has been included. Nonetheless, the authors recognize this predominant Pleistocene history in the region, and anticipate that future mapping of these deposits would be a significant contribution to understanding the geology of Montana's north-central plains.

Geologic structure shown in the southern part of the map, along the Milk River in the vicinity of the city of Havre, Montana, is taken from the work of Hearn, Jr. (1976) in the Bears Paw Mountains. Other faults shown on the map are taken from the 1955 Geologic Map of Montana and remain to be field checked. These latter are primarily small faults observed in bedrock exposures along the Milk River's principal tributaries, and are considered to be distal occurrences of the extensive gravity-slide fault blocks that dominate the foothills surrounding the Bears Paw Mountains south of Havre (Hearn, Jr., 1976). No new field investigation of these faults was conducted for this map.

Plate 2 of this report is a structure contour map drawn on the top of the Claggett Shale, based on available petroleum and ground-water wells in the area. Contours are necessarily generalized in many areas, but can serve as a first approximation for estimating drilling depths for new wells.

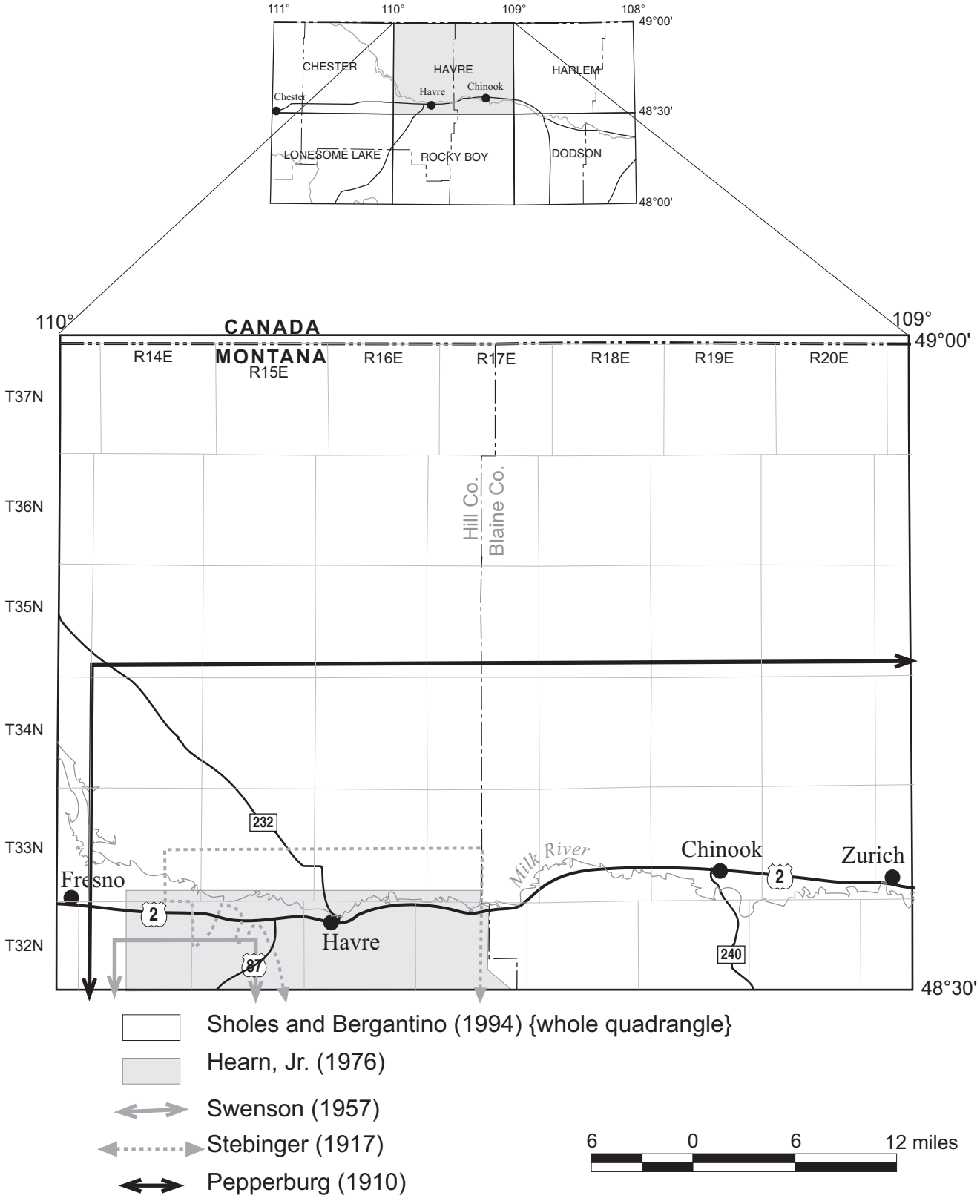

Figure 1. Location map for Havre 30'x60' quadrangle showing areas covered by older geologic maps within the quadrangle (see Sources of Previous Geologic Mapping), and location of adjacent geologic maps published by MBMG.

Correlation Chart of Map Units
Havre 30' x 60' Quadrangle

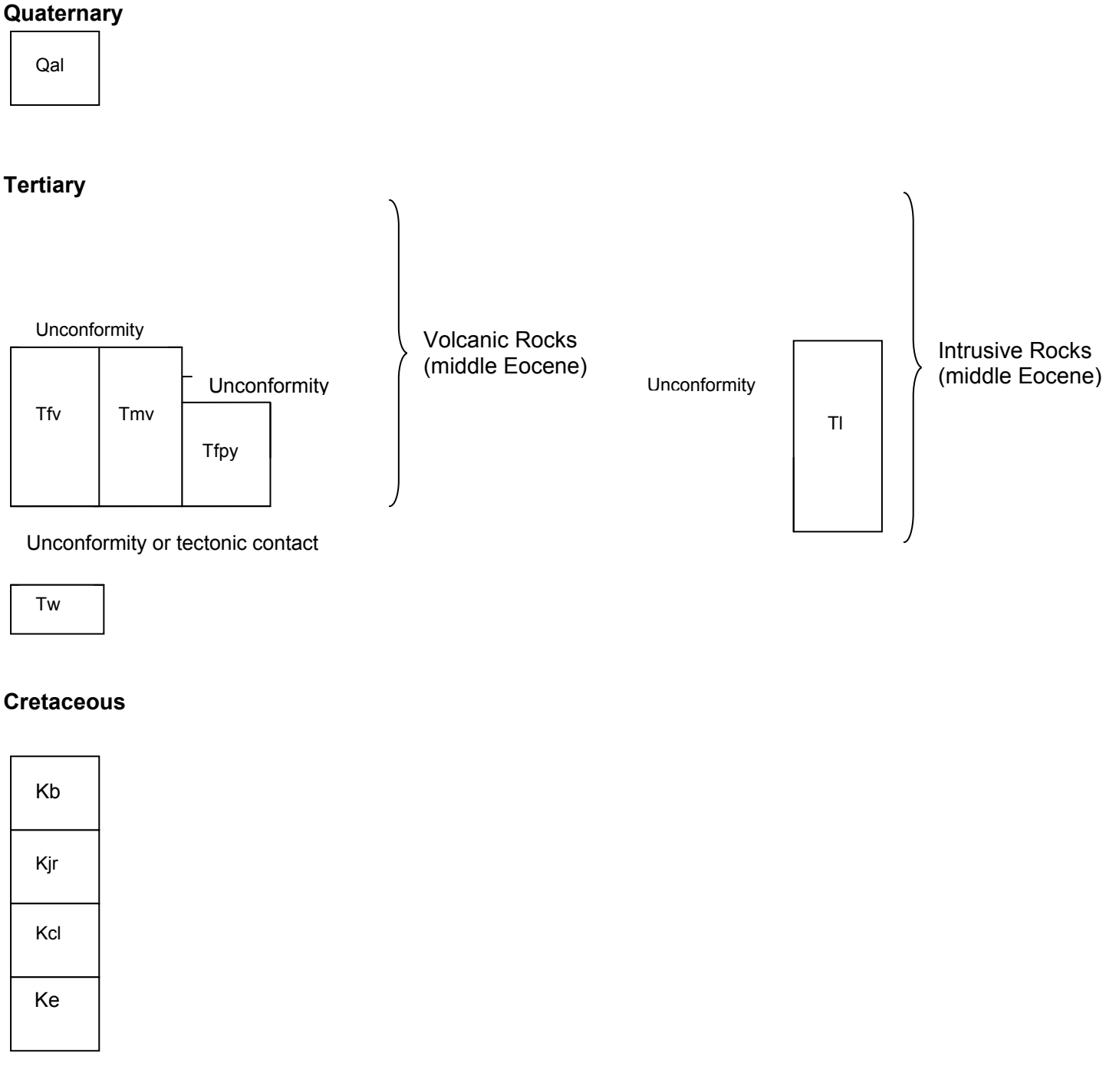

Figure 2. Correlation chart of map units.

Map Units

QUATERNARY

Qal ALLUVIUM — Deposits of modern streams and associated flood plains; includes colluvium, and modern terrace deposits; locally includes some slightly older Holocene terrace alluvium. Thickness not measured.

TERTIARY

Volcanic rocks (middle Eocene)

Tfv FELSIC VOLCANIC FLOW ROCKS, UNDIVIDED (MIDDLE EOCENE) — (from Hearn, 1976) Flows and flow breccias of porphyritic latite and quartz latite; light-gray, gray, and brown; green celadonitic alteration is common; phenocrysts of potassium feldspar, plagioclase, augite, hornblende, and biotite; quartz in groundmass only; interlayered with mafic and felsic pyroclastic rocks and mafic flows; as mapped includes some felsic pyroclastic rocks; extrusive equivalent of porphyritic latite (Tl). Maximum thickness about 5,000 ft [1,500 m].

Tfpy FELSIC PYROCLASTIC ROCKS (MIDDLE EOCENE) — (from Hearn, 1976) Agglomerate, tuff-breccia, lapilli tuff, tuff, water-laid volcanic sediments, and coarse mudflow deposits; contains more than 50 percent fragments of felsic volcanic rocks; inclusions of biotite pyroxenite and Precambrian basement rocks locally abundant; commonly forms lowermost volcanic unit, particularly in northwestern part of Bears Paw Mountains; in part deposited in local early collapse basins; fossil plants and fish indicate middle Eocene age. Maximum thickness about 3,000 ft [900 m].

Tmv MAFIC VOLCANIC ROCKS (MIDDLE EOCENE) — (from Hearn, 1976) Flows and flow breccias of phonolite and mafic phonolite; brown, red, and purple; phenocrysts of olivine, augite, biotite, analcime, and rare leucite in groundmass of augite, potassium feldspar, and analcime; natrolite, analcime, and calcite are common alteration products; interlayered with felsic flows and felsic and mafic pyroclastic rocks; as mapped includes some mafic pyroclastic rocks; extrusive equivalents of shonkinite and syenite, and possibly of monzonite. Maximum thickness about 5,000 ft [1,500 m].

Intrusive rocks (middle Eocene)

Tl LATITE, PORPHYRITIC — (from Hearn,1976) Occurs as dikes, sills, laccoliths and stocks; light gray to brown; fine grained, felsic,

porphyritic; most contains less than 20 percent mafic minerals; phenocrysts of augite ubiquitous; phenocrysts of potassium feldspar, plagioclase, biotite, and hornblende in varying amounts characterize separate varieties; groundmass of feldspar, augite, and quartz.

Sedimentary rocks (lower Eocene through Paleocene)

Tw WASATCH FORMATION (LOWER EOCENE) — (modified from Hearn, 1976) Variegated red, pink, lavender, light-green, yellow-gray, and white shale, bentonitic claystone, and siltstone with small calcareous concretions; interbedded light-gray, brown and green, fine- to coarse-grained, cross-bedded sandstones with lenses of boulder conglomerate in upper part of formation containing clasts derived from mountain uplifts to the west or southwest including argillite and quartzite from Proterozoic Belt Supergroup rocks, porphyritic igneous rocks, and limestone and dolomite; clasts locally crushed, fractured, and re-cemented; nonmarine; fossil plants and vertebrates indicate early Eocene age; top of formation missing due to pre-volcanic erosion or tectonic disruption or both. Maximum measured thickness 800 ft [240 m]; original maximum thickness probably exceeded 1,000 ft [300 m]. In the Havre quadrangle, only one small, fault-bounded outcrop of Wasatch Formation is present, mapped by Hearn, Jr. (1976) in the southwest area of the map.

UPPER CRETACEOUS

Note: The Upper Cretaceous Fox Hills and Hell Creek Formations are recognized and mapped in the Bears Paw Mountains immediately south of this quadrangle (Hearn, Jr., 1976). North of the mountains, and north of the numerous associated gravity-slide structural blocks, erosion has removed all formations younger than the Bearpaw Shale.

Kb BEARPAW SHALE (UPPER CRETACEOUS) — (modified from Hearn, 1976) Medium-gray, fissile shale and silty shale weathering to steel gray or rarely brownish-gray; light-gray to cream-colored bentonite beds prominent in lower one-third; numerous horizons of ovoid, gray, massive or septarian, commonly fossiliferous, limestone concretions; also several horizons of reddish-brown iron-manganese-rich claystone concretions; diagnostic species of *Baculites* define 5 faunal zones; upper 70 to 200 ft [20 to 60 m] are brown to brownish-gray, thin-bedded sandstone, siltstone, and dark shale, transitional into overlying Fox Hills Sandstone; bentonite beds in lower one-third allow good subsurface correlation of resistivity well logs, but general absence of bentonites and occurrence of tectonic disruption make well-log correlation of upper two-thirds less reliable. Total thickness approximately 1,000 to 1,200 ft [300 to 370 m].

Kjr JUDITH RIVER FORMATION (UPPER CRETACEOUS) — (modified from Hearn, 1976) Light-brown to yellow sandstone, locally gas-bearing, siltstone, and white, yellow, greenish, and light-gray claystone and shale; near top commonly are one or more horizons of oyster-shell coquina in dark shale, and several carbonaceous shales and thin coals that have been locally mined; locally, uppermost beds are white, clay-rich marine sandstone; locally, lowermost sandstone is burrowed by marine organisms (Parkman Sandstone of subsurface usage); vertebrate fossils locally common; on resistivity well logs correlation of nonmarine sandstones is uncertain because of lateral lensing. Thickness 540 to 670 ft [160 to 200 m].

Kcl CLAGGETT SHALE (UPPER CRETACEOUS) — (modified from Hearn, 1976) Dark gray or grayish-brown on fresh surfaces, commonly weathered to soft brown; blocky to fissile; characteristic dull-orange-weathering, smooth, ovoid, calcareous concretions in middle and upper part of unit; concretions commonly contain yellow calcite vein filling and are commonly highly fractured, forming mounds of small, sharp-edged orange-brown fragments; numerous grayish-white bentonite layers (1 to 5 inches thick [2.5 to 12.5 cm]) in lower 80 ft [20 m] of unit; upper 30 to 200 ft [10 to 60 m] contain laterally persistent sandstone beds forming transitional contact with overlying Judith River Formation. In quadrangle area, Claggett is involved in extensive landsliding beneath benches formed on lower Judith Rover Formation. Total thickness 400 to 680 ft [120 to 200 m].

Ke EAGLE SANDSTONE (UPPER CRETACEOUS) — (modified from Hearn, 1976) Light-brown to white sandstone with interbedded gray shale, siltstone, and carbonaceous mudstone and shale; contains as many as 3 massive sandstones, some or all of which may be gas-bearing; lowest sandstone (Virgelle Sandstone) is 70 to 170 ft [20 to 50 m] thick in southwest part of map area; upper 20 to 130 ft [6 to 40 m] are alternating thin glauconitic sandstone, chert-pebble conglomerate, siltstone, and shale. In Havre quadrangle, Eagle beds are only exposed in one small outcrop along the south margin of the map area. Total thickness 140 to 300 ft [40 to 90 m].

GEOLOGIC MAP SYMBOLS

Contact: dashed where approximate, dotted where concealed

Fault: dashed where approximately , dotted where concealed; ball and bar on downthrown side

Strike and dip of beds

Strike and dip of vertical beds

References

Sources of Previous Geologic Mapping within Quadrangle

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Additional References

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