



- TERTIARY**
- PALEOCENE**
- 9 PORCUPINE HILLS FORMATION: thick, crossbedded, medium- to coarse-grained, buff-weathering, grey sandstone; friable, grey, silty shale (non-marine)
- TERTIARY AND CRETACEOUS**
- PALEOCENE AND UPPER CRETACEOUS**
- 8 WILLOW CREEK FORMATION: soft, medium-grained, grey sandstone; clayey, grey, green and pink shale; abundant white-weathering, calcareous concretions in shale; grey fossiliferous limestone; massive, crossbedded, buff-weathering, grey sandstone in upper part (non-marine)
- CRETACEOUS**
- UPPER CRETACEOUS**
- 7 KNEEHILLS TUFF ZONE: light-green to grey, white-weathering, clayey sandstone (Whitemud equivalent); overlain by massive-weathering, dark purplish grey, bentonitic shale; siliceous tuff (Battle equivalent) (non-marine)
- 6 ST. MARY RIVER FORMATION: hard, green, grey, and buff-weathering, grey, fine-grained, calcareous sandstone; friable, green and grey, silty shale; fissile, grey shale, coal, and coquinoid limestone occurs in basal part (non-marine)
- 5 BLOOD RESERVE FORMATION: massive, buff- to yellow-weathering, grey or greenish grey sandstone (marine and non-marine)
- 4 BEARPAW FORMATION: dark grey and brownish-grey, rubby and flaky shale; silty shale; grey, argillaceous sandstone; ironstone concretionary bands; bentonite layers (marine)
- 3 OLDMAN FORMATION: massive, crossbedded, medium- to coarse-grained, light-grey weathering sandstone; grey, clayey siltstone; grey and light-grey weathering, green and grey shale; dark grey and brown, carbonaceous shale; ironstone concretionary beds (non-marine)
- 2 FOREMOST FORMATION: green and grey shale; dark carbonaceous shale; grey and green siltstone; grey and pale brown sandstone; ironstone; coal seams (non-marine)
- 1 PAKOWKI FORMATION: dark grey shale and sandy shale; grey sandstone; thin chert pebble conglomerate at base (marine)

- Geological boundary (approximate) x
- Rock outcrop x
- Fault (position approximate) x
- Anticline (approximate) x
- Syncline (approximate) x
- Coal mine x
- Oil and gas fields x

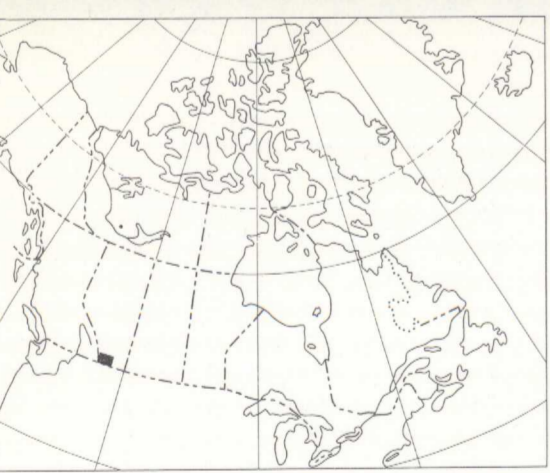
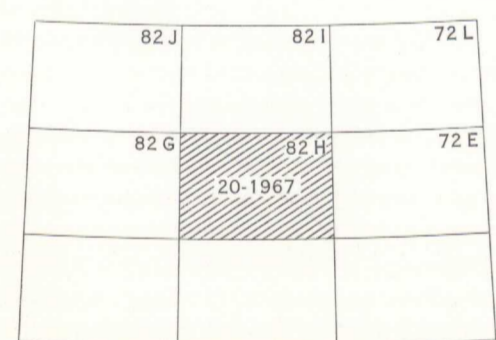
Geology by E. J. W. Irish, 1965, 1966, 1967

Geological cartography by the Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada, 1967

Base-map compiled and drawn by the Surveys and Mapping Branch, 1955

Magnetic declination 1968 varies from 19°54' easterly at the centre of the east edge to 20°40' easterly at the centre of the west edge. Mean annual change decreasing 3.2°

All elevations in feet above mean sea level



DESCRIPTIVE NOTES

The southwest corner of this map-area is occupied by mountains and foothills and is, therefore, topographically and structurally distinct from the plains. The geology of this region has not been included with this map.

The plains part of the map-area is mantled with glacial and glacio-fluvial deposits of clay, silt, sand, gravel and till so that bedrock exposures are rare except along parts of the major stream valleys and in the Porcupine Hills in the northwestern part of the area.

The geological formations that outcrop or occur immediately below the unconsolidated deposits are of Upper Cretaceous and Tertiary ages. Isolated outcrops are shown on the map but, at most places, the outcrop symbols indicate only the relative amount of rock exposure rather than specific outcrops.

The oldest strata are those of the Pakowki Formation (1). Shales of this formation underlie a small, northeasterly trending band in the southeast corner of the map-area south and southwest of the town of Milk River. Another small area underlain by these rocks is thought to occur in Verdigris Coulee in Twp. 3, Rge. 16W4. The formation consists of dark grey shale and sandy shale with some interbedded grey sandstone.

Pakowki shales are conformably and gradually overlain by strata of the Foremost Formation (2). These strata underlie a band extending from south to north along the eastern border of the map-area. Good exposures of part of the formation occur along Oldman River valley north of the town of Taber. Scattered outcrops occur southwest of Milk River town and in Verdigris and Chin coulees.

The exposed strata consist of green and grey shale; dark grey to black, carbonaceous shale; grey and brown siltstone; grey to pale brown sandstone; and thin discontinuous ironstone beds. The carbonaceous shales, in some places, grade into good coal seams. The sandstones are mainly soft and argillaceous, although thin, hard layers and concretionary masses of calcareous buff- to brown-weathering sandstone occur throughout. The individual units are thin lenses and do not extend far in any direction. Brackish and fresh water fossils are common in some beds.

Both upper and lower contacts of the Foremost Formation are gradational and are placed arbitrarily. At some localities in southern Alberta a massive, buff-weathering, sandstone unit is used to mark the base of the overlying Oldman Formation. Where this sandstone is missing or does not outcrop it is difficult to assign a contact with any degree of accuracy.

Beds of the Foremost Formation are overlain conformably and gradually by the Oldman Formation (3). The latter underlies a north-south trending area adjacent to and west of the region underlain by Foremost strata. Outcrops are few and widely scattered throughout the region. Beds near the top of the formation are fairly well exposed in the valley of Oldman River north and east of the city of Lethbridge and in the valley of North Milk River in Secs. 10, 13, and 14 of Twp. 2, Rge. 21W4.

The formation consists of interbedded and interlensed green, grey and light grey shale; silty shale; soft, grey and light-grey weathering, argillaceous sandstone. Some thin concretionary ironstone bands occur and thin limestone beds are present at some localities. Hard, grey, calcareous sandstone beds occur at some horizons and thick, crossbedded, light-grey weathering, lenticular sandstone units are typical of the upper part of the formation. Plant impressions and carbonized wood are present in some strata though the formation as a whole is not very carbonaceous except for the Lethbridge coal member at the top. This carbonaceous zone marks the approximate top of the Oldman Formation throughout southern Alberta and contains mineable coal at several localities. Fragments of vertebrate remains are common and shells, principally of *Gastrea*, occur at several horizons.

The Bearpaw Formation (4) rests conformably, though relatively abruptly, upon the Oldman beds. It underlies a narrow, north-south trending band adjacent to and west of the area underlain by the Oldman Formation. Excellent exposures of Bearpaw strata occur along the valley of St. Mary River from about the middle of township 6 to its confluence with Oldman River in township 8 and, in the valley of Oldman River from township 9 downstream to a point about 5 miles north of the city of Lethbridge. Small exposures occur, also, in Twp. 1, Rges. 21 and 22W4.

The formation consists of grey-weathering, dark grey or brownish grey shale and silty shale; spheroidal ironstone concretions; fine-grained, clayey sandstone; and bentonite beds. Most of the shale weathers to small angular fragments but fine flakes are produced in some zones. The entire formation, about 720 feet thick, is exposed on St. Mary River. There three sandy members, 6 feet, 28 feet, and 27 feet occur about 240 feet, 365 feet, and 640 feet respectively above the base of the formation. The section on Oldman River is incompletely exposed but, there also, sandstone is present. The upper 20 feet approximately of the Bearpaw Formation contains numerous intercalated, thin, sandstone beds, and forms a transitional zone into the overlying Blood Reserve Formation.

The Blood Reserve Formation (5) conformably overlies the Bearpaw beds. It extends through the centre of the map-area in a northerly direction from the International Boundary to just north of Oldman River. It is not known beyond this point. The formation consists of massive, buff- to yellow-weathering, light grey or light buff, medium-grained sandstone. The rock is hard and resistant where the cementing material is calcareous but is soft where the cement is clay. Crossbedding and irregular concretions occur and, at most places, the uppermost beds are indurated and ledge-forming marking a distinct contact with the overlying softer beds of the St. Mary River Formation.

Good exposures of the formation occur along North Milk River in Secs. 2, 3, and 4, Twp. 2, Rge. 22W4, and in Sec. 33, Twp. 1, Rge. 22W4. On the north side of Milk River Ridge the formation outcrops in Sec. 19, Twp. 5, Rge. 21W4, and, again, on St. Mary River in Sec. 24, Twp. 6, Rge. 23W4. The formation is about 100 feet thick just north of the International Boundary but thins to 40 feet on Oldman River where the unit is involved in the Monarch fault zone.

The St. Mary River Formation (6) underlies an area that forms a north-south trending band across the central part of the map-area. Outcrops are scarce except where these strata are exposed in the valleys of Oldman and St. Mary Rivers and in the valley of North Milk River near the east end of Whiskey Gap in Twp. 1, Rge. 23W4. The most complete section is that exposed along Oldman River Valley where the formation is approximately 1,500 feet thick. On Oldman River the St. Mary River Formation is overlain by equivalents of the Whitemud and Battle Formations but, elsewhere within the map-area, St. Mary River beds are conformably overlain by the Willow Creek Formation.

St. Mary River strata consist of hard, green-, grey- and buff-weathering, grey, fine-grained, calcareous sandstone; friable, green and grey, sandy shale; fissile, grey shale; carbonaceous shale; coal; and coquinoid limestone beds in the basal part of the formation. All sandstone and, to some extent, the shale units, are lenticular. The repeated alteration of hard sandstone and soft shale, and the prevailing light color of the sediments give a characteristic appearance to outcrops of St. Mary River beds. Brackish water molluscs occur abundantly in the basal zone of the formation, but throughout the greater part the shells are of fresh water and land habitat.

The "Kneehills Tuff zone" (7), a conspicuous marker between Red Deer and Bow Rivers farther north, was found within this map-area only in the valley of Oldman River. The zone comprises a white-weathering, greenish grey, argillaceous sandstone unit about 5 feet thick overlain by about 12 feet of massive-grey weathering, purplish black, bentonitic, silty shale. The shale unit includes, near the top, a light-grey weathering, brownish grey, siliceous tuff bed. These lithologic units are considered to be equivalents of the Whitemud Formation, Battle Formation, and Kneehills Tuff respectively.

The Willow Creek Formation (8) overlies the Battle equivalent on Oldman River but elsewhere throughout the map-area, overlies conformably St. Mary River strata. These beds underlie large areas immediately east and south of the Porcupine Hills but outcrops are widely scattered. The best exposure is that on Mokowan Butte in Twp. 4, Rge. 23W4, though the strata are well exposed on Oldman River, St. Mary River and Waterton River.

This succession of strata comprises interbedded, soft, grey-weathering, medium-grained, argillaceous sandstone and grey-, maroon-, and light brick red-weathering clay with some thin, grey, fossiliferous limestone beds. The presence, in most of the shale units, of numerous small, irregularly shaped, calcareous concretions is characteristic of the formation. Crossbedding, buff-weathering, grey sandstone beds occur toward the top of the formation and these become progressively more numerous upward forming a transition zone with the overlying Porcupine Hills Formation.

Brilliant colour banding distinguishes these beds from the rather similar Oldman Formation. The general colour of Willow Creek outcrops is pink throughout most of the map-area but, in places near the northern border, the colours are not as well developed and the beds are greyish. Fresh water fossils occur in the upper part of the formation.

The upper contact of the Willow Creek Formation is placed arbitrarily where thick, hard sandstone units of the Porcupine Hills Formation comprise the major part of the rock. The section on Mokowan Butte is about 700 feet thick with neither the top nor the base exposed. On Oldman River the formation is estimated to be between 1,000 and 1,300 feet thick.

Willow Creek strata are overlain gradationally and conformably by the Porcupine Hills Formation (9). These strata cap the Porcupine Hills region in the northwest part of the map-area and outcrop, also, on the Peigan Indian Reserve south and east of Brocket. Good sections are rare but the formation is exposed in most of the creeks that traverse the hills and outcrops of ledge-forming sandstone units are conspicuous on the sides of the hills.

The formation consists mainly of crossbedded, buff-weathering, grey sandstone with interbedded grey and dark grey clay shale. Pellets of clay and sandstone are present in some sandstone beds and ripple-marks and macrolenticles are common. A few fresh-water fossils occur. The formation occurs within part of the Alberta Syncline and is at least 2,500 feet thick.

The exposed formations are progressively younger from east to west because of their position on the west flank of the Sweetgrass arch. All strata dip westerly or southwesterly at low angles as far west as the axis of the Alberta Syncline. This downdip is a major structural feature along the western margin of the plains and extends approximately southeast from the northwest corner of the map-area to and beyond the International Boundary. In the northern part of the map-area the syncline is an open fold with gently dipping beds on both limbs but, south of 49°30' N., the southwest limb is compressed because of the change in strike of the mountains and foothills in this region that has resulted in a marked salient to the northeast. Thus, in the southern part of the map-area the western limb of the syncline is narrow and composed of steeply dipping strata that are repeated by numerous thrust faults.

An intricate zone, the so-called "Monarch fault zone", is known on Oldman River in Secs. 31 and 32 of Twp. 9, Rge. 23W4. At this locality the uppermost beds of the Bearpaw, the Blood Reserve, and the lower beds of the St. Mary River Formations are disturbed by several east-dipping thrust faults of small displacement. The structure there has not been shown because the lateral extent of the faults is not, as yet, known and because the folds and faults are too small and numerous to show on the map.

Another small thrust fault is known to cross Oldman River in the southeast corner of Twp. 8, Rge. 23W4. This fault involves the lower beds of the Bearpaw Formation and the upper part of the Oldman Formation and is thought to dip to the west. The lateral extent of the fault is unknown.

A shallow anticline and syncline can be mapped in St. Mary River strata where they cross St. Mary River. These folds are thought to be the northern extensions of the anticline and syncline occurring near Del Bonita in Twp. 1, Rge. 21W4.

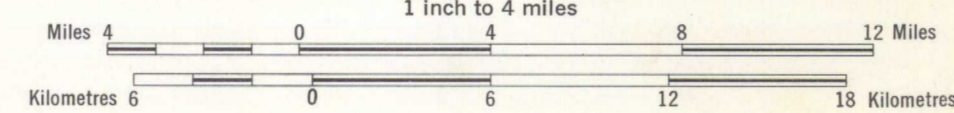
Coal was mined at Lethbridge and vicinity for many years but production is now either sporadic or has ceased entirely. The seams mined occur in the Lethbridge coal member at the top of the Oldman Formation. Small mines were once operated north and south of Taber where coal was mined from seams within the Foremost Formation. There is now little or no production from these mines.

Both oil and natural gas are recovered from the area and the established fields are indicated within the area mapped.

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Copies of this map may be obtained from the Director, Geological Survey of Canada, Ottawa

GSC/CGC OTTAWA
OOG 02578375

MAP 20-1967
GEOLOGY
LETHBRIDGE
WEST OF FOURTH MERIDIAN
ALBERTA
Scale 1:253,440
1 inch to 4 miles



LIBRARY
AHC 13 1968
GEOLOGICAL SURVEY

20-1967
C.2

G
3401
C5
1956
G4
omsc

MAP 20-1967
LETHBRIDGE
ALBERTA
82 H