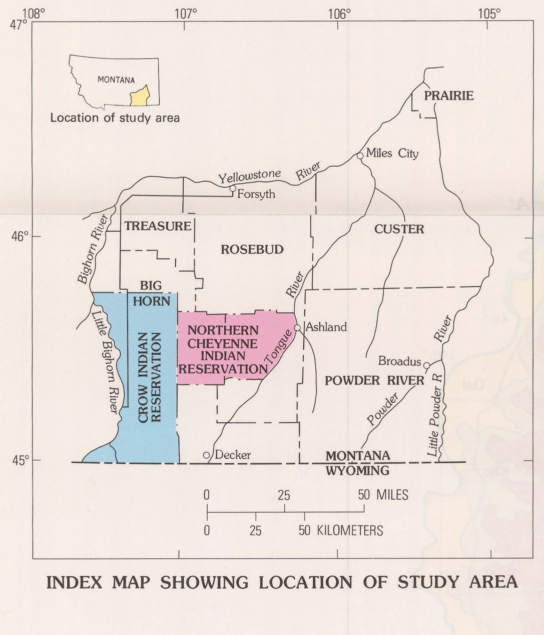
INTRODUCTION

PURPOSE AND SCOPE



INDEX MAP SHOWING LOCATION OF STUDY AREA

PREVIOUS INVESTIGATIONS

Acknowledgments

Residents of the area were very cooperative in allowing access to and providing information about their property.

Construction of the structure contours and geologic sections was facilitated by information obtained from various types of geophysical logs on file at the Montana Oil and Gas Conservation Commission in Billings.

DEVELOPMENT OF POWDER RIVER BASIN

Geologic units within the study area consist of marine deposits of the Parkman Sandstone, Bearpaw Shale, and Fox Hills Sandstone of Late Cretaceous age and continental deposits of the Hell Creek Formation, Fort Union Formation, Wasatch Formation, terrace deposits, and alluvium of Late Cretaceous to Holocene age (see geologic map). Gill and Cobban (1973) indicate that the marine units consist of eastward-thinning wedges of regressive deposits of the Parkman and Fox Hills Sandstones that enclose westward-thinning wedges of fine-grained predominantly transgressive deposits of the Bearpaw Shale.

The Parkman Sandstone is composed of fine- to coarse-grained massive sandstone interbedded with silty to carbonaceous shale on the west side of the basin. The Parkman is representative of a brackish to fresh-water near-shore depositional environment associated with a withdrawing sea (Balster, 1971). Lower Parkman beach, sandbar, and distributary-channel sediments were deposited in deltas. The upper beds of these sediments were subsequently reworked during later Parkman deposition into a successive series of bars and shoreline sands (Glaze and Keller, 1965).

The Bearpaw Shale is represented in the western part of the basin by silty sandstone and thin interbedded shale resulting from numerous transgressive and regressive periods of deposition. To the east, however, the Bearpaw is composed of dark shaly claystone and shale deposited in an extensive stable sea.

Permanent withdrawal of marine water from the basin area began after deposition of sediments forming the Bearpaw Shale (Gill and Cobban, 1973). This final withdrawal of the Late Cretacous sea is represented by the fine- to medium-grained sandstone deposits of the Fox Hills Sandstone. Many geophysical logs within the study area depict upper and lower parts of the unit separated by thin shale. The Fox Hills Sandstone, then, represents two separate regressive phases. Gill and Cobban (1973) believe that these regressive phases represent an initial slow and regular withdrawal of the sea, an intervening small advance, and a final rapid withdrawal.

Some geologists have considered the repeated transgressions and regressions of the sea during Late Cretaceous time to be related to the beginning of the Laramide orogeny. However, the absence of coarse clastics in any of the units fails to support a theory of any marked uplift in the western cordillera. Broad regional uplift in central Montana is believed to have been the cause of the final withdrawal of the sea (Gill and Cobban, 1973). Vast amounts of continental deposits identified as the Hell Creek Formation were subsequently deposited in the Powder River Basin. These continental deposits are indicative of various fluvial and lacustrine depositional environments.

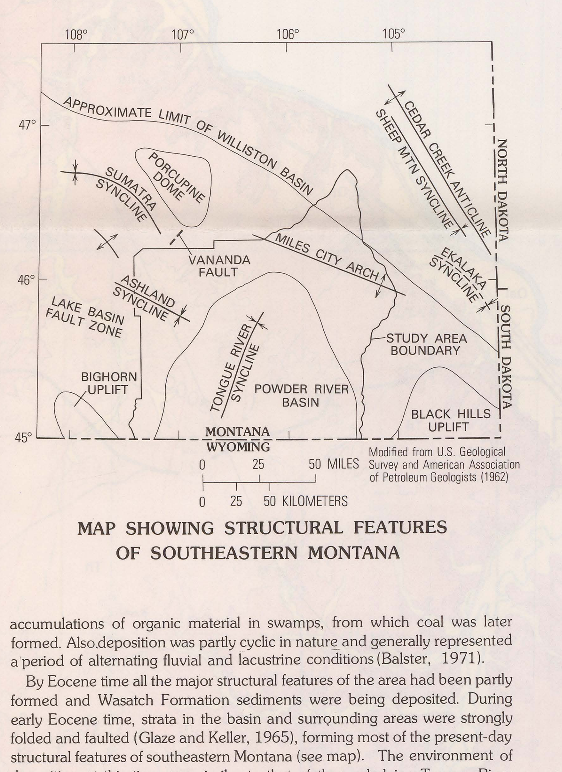
Existing at various periods throughout Late Cretaceous to Eocene time were extensive swamps, which are now represented by many coal beds of various thicknesses and lateral extent in the Hell Creek, Fort Union, and Wasatch Formations. The thickest and most extensive coal units, however, occur in the Tongue River Member of the Fort Union Formation. Interbedded with the coal beds of these formations are deposits consisting primarily of heterogeneous, discontinuous mixtures of fine lenticular sand, silty sandstone, siltstone, silty shale, and shale deposited in fluvial and lacustrine environments (Balster, 1971).

The Hell Creek Formation was deposited in the Powder River Basin in environments of coastal plains, meandering streams, and flood plains. These deposits are probably unconformable with the underlying shale and sandstone. During Hell Creek deposition, relatively strong subsidence of the basin area was the first indication of the Laramide orogeny. During this time, a primary trough of deposition existed in the southern part of the Powder River Basin in Wyoming (Glaze and Keller, 1965). The formation contains very little coarse-grained material, which suggests that adjacent uplifts were relatively inactive at this time.

Tectonic events that occurred from Late Cretaceous through Pliocene time shaped the Powder River Basin into its present structure. During deposition of the Fort Union and Wasatch Formations, the Laramide orogeny was most pronounced.

Fort Union sediments were being deposited during the Paleocene as the Bighorn Mountains (Bighorn uplift) and the Black Hills (Black Hills uplift) began to rise, and large volumes of sediment were being transported into the swampy flood-plain environment of the newly formed Powder River Basin (see structural features map). This age of basin formation and local uplift is supported by Beikman (1962), Mapel (1958), and Robinson, Mapel, and Bergendahl (1964). Parker and Andrews (1939) state that the Tullock and Lebo Shale Members of the Fort Union Formation were deposited along stream courses and in temporary ponds and marshes over an area of low topographic relief. Locally, however, outcrops of the Tullock and Lebo Shale Members of the Fort Union Formation exhibit a varved character in the northeast part of the basin, which is indicative of lacustrine deposition. Deposition was irregular and probably in none of the area was deposition continuous. The intervals of nondeposition allowed erosion of a limited amount of sediments and transportation elsewhere for redeposition. Such conditions are inferred from the lenticularity of the beds, the abrupt truncation of crossbedding, and the channel depressions filled with sandstone that cut across coal and shale beds.

The upper Paleocene is represented in the depositional sequence in the basin by the Tongue River Member of the Fort Union Formation. This unit is alternating sandstone, siltstone, carbonaceous shale, coal, and clinker. Deposition was in an environment similar to that of the other members of the Fort Union Formation. Continental conditions prevailed with abundant



MAP SHOWING STRUCTURAL FEATURES OF SOUTHEASTERN MONTANA

Member of the Fort Union Formation, with sediments that later formed shale, sandstone, and coal of the Wasatch being deposited in an environment of fresh-water lakes, stream channels, and swamps. During late Eocene time uplift was renewed in the Black Hills (Robinson and others, 1964) and the basin was tilted westward, creating an asymmetrical structure with the deepest part on the west side adjacent to the Bighorn uplift near the Montana-Wyoming border.

Following the Black Hills uplift, erosion created a mature landscape of reduced relief over much of the area. During Oligocene and Miocene time, the area is thought to have been buried by tuffaceous debris from increased volcanic activity to the west (Glaze and Keller, 1965). Only the highest mountain ranges were left unburied by these ash deposits.

Near the end of Pliocene time, a major regional uplift took place (Glaze and Keller, 1965), with many of the structures near the basin, such as the Miles City arch, becoming more prominent. Extensive normal faulting occurred, altering structures to their present form. Examples of this faulting are the Vananda fault, a northeast-trending normal fault just north of the mapped area, and the Lake Basin fault zone to the west of the Powder River Basin (structural features map). Comprised of a series of northeast-oriented en echelon faults, the Lake Basin fault zone bounds the northern extension of the Bighorn uplift and has a general west-northwest alignment.

Subsurface structure northwest of the basin is dominated by the gently southeast-plunging Ashland syncline. This feature probably developed as a trough between the Bighorn uplift to the south and the Porcupine dome to the north during their formation. Subsequent subsidence within the Powder River Basin accompanying continued uplift of the Bighorn Mountains caused the syncline to plunge into the basin.

The major regional uplift near the end of Pliocene time caused streams to be rejuvenated and erode through the ash cover, uncovering buried mountains and re-excavating basins. Erosion continued until Pleistocene time and formed most of the present landscape (Glaze and Keller, 1965).

Geologic units probably have been folded locally since the inception of the basin. However, local deformation generally associated with the burning of a coal deposit and subsequent baking of the overlying units is of a more recent age. Subsidence and slumping generally followed this process, which account for many small structural features in the study area, particularly in the Tongue River Member of the Fort Union Formation.

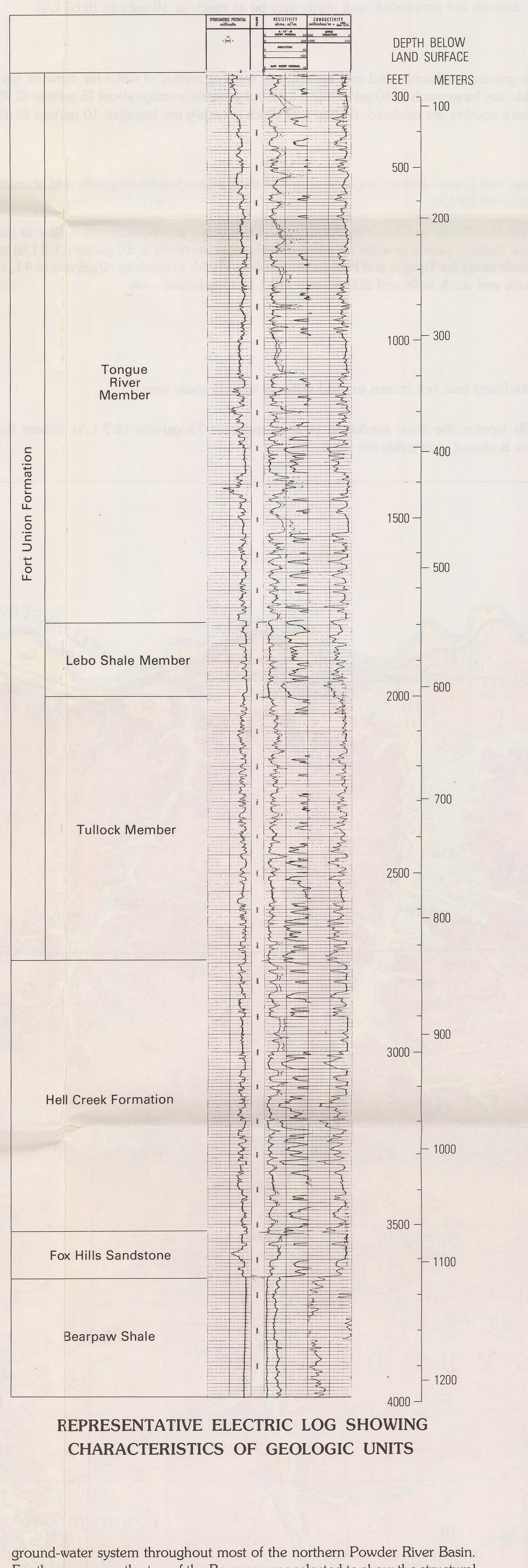
Many small, local faults in rocks of the Tongue River Member were undoubtedly associated with the variations in weight of overlying deposits created by deposition and erosion during the course of their formation. However, the faults visible at the land surface are also generally associated with the burning of a subsurface coal unit and subsequent related stresses and strains created by this process. Faulting of this type is probably expressed by randomly arranged fault patterns, such as those shown on the geologic map near Kirby, Colstrip, and Olive.

Many local fault patterns have a more ordered orientation. The northeast-trending faults near Decker and eastward along the Montana-Wyoming border are oriented in such a manner to suggest that a deep-seated fracture system in the subsurface extends to the land surface. Existence of a subsurface fracture system is supported by a northeast-trending fault shown on the surface of the Bearpaw Shale (geologic map) in the south-central part of the study area. Only limited areas on the geologic map indicate that any faulting has occurred within the mapped area; with more detailed mapping many small-displacement faults in surface units may become apparent.

PRESENT-DAY APPEARANCE OF GEOLOGIC UNITS

SUBSURFACE IDENTIFICATION OF GEOLOGIC UNITS

CONFIGURATION OF TOP OF BEARPAW SHALE



REPRESENTATIVE ELECTRIC LOG SHOWING CHARACTERISTICS OF GEOLOGIC UNITS

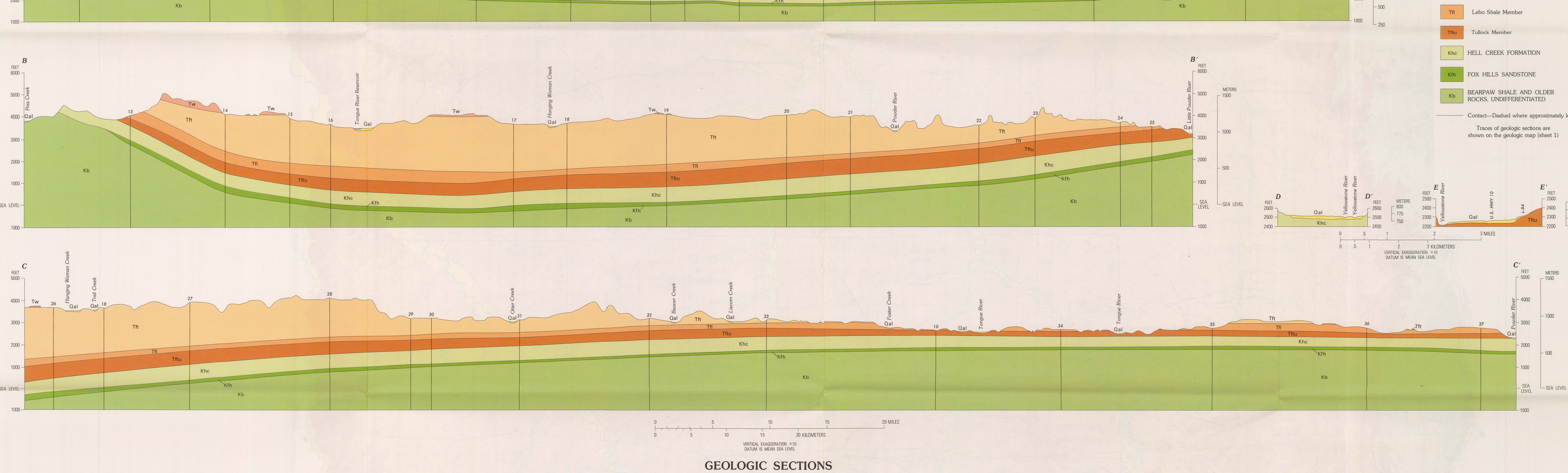
THICKNESS OF UNITS ABOVE BEARPAW SHALE

SUMMARY

SELECTED REFERENCES

METRIC CONVERSION TABLE

EXPLANATION



GEOLOGIC SECTIONS

GEOLOGY AND WATER-YIELDING CHARACTERISTICS OF ROCKS OF THE NORTHERN POWDER RIVER BASIN, SOUTHEASTERN MONTANA

By
Barney D. Lewis and Robert S. Roberts

1978