DEPARTMENT OF THE INTERIOR
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MISCELLANEOUS INVESTIGATIONS SERIES
MAP I–2011

INTRODUCTION

The ten measured sections that compose this stratigraphic cross section are in the upper part of the Paleocene Fort Union Formation 20 mi east-southeast of Wright, Wyo., in the southeastern part of the Powder River Basin (fig. 1). The Fort Union Formation crops out around the margins of the basin in Wyoming and Montana. In ascending order, the formation consists of the Tullock Member, the Lebo Shale Member, and the Tongue River Member. Some previous workers (Denson and others, 1980a, 1980b; Lowe and Christiansen, 1985) recognized only the Tullock and Lebo Shale Members in the southeastern part of the basin. However, we believe that the sandy, coal-bearing upper part of the Fort Union Formation in our study area is correlative with the Tongue River Member of adjacent areas (Pierce and others, 1986).

The Fort Union Formation in this part of the basin is poorly exposed except where dissected by stream erosion or protected by a resistant cap of clinker. Clinker is a metamorphosed rock produced by the burning of an underlying coal bed. The Wyodak coal bed is the major economic coal deposit of the Fort Union Formation in this part of the basin (Denson and others 1980a, 1980b), and it is mined along the east side of the Powder River Basin 8 mi west of the study area. Pierce and others (1986) have shown that this coal bed splits into upper and lower Wyodak beds east of the main deposit and that the lower split pinches out west of our study area. The measured sections are north of Little Thunder Creek on a part of the regional north-south-trending escarpment known as the Rochelle Hills (fig. 2). The Rochelle Hills have been dissected by drainages and protected by the clinker formed when the Wyodak coal bed burned, probably during the Pleistocene and Holocene (Reheis and Coates, 1987; Coates and Naeser, 1984; Denson and others, 1980a). The individual sections range from 0.25 to 0.47 mi apart and were measured below the clinker along an east-northeast-trending exposure and an adjacent north-northwest-trending cliff face (fig. 2). The sections have 183–514 ft of the Tongue River Member below the clinker of the Wyodak coal bed.

The sequence of rock above and including the Wyodak coal deposit has been studied by Ethridge and others (1981) and Budai and Cummings (1987). In contrast, the sequence below the Wyodak coal deposit is less well known. Accordingly, the purpose of this cross section is to provide a better understanding of this interval of the Tongue River Member.

LITHOLOGY

The rocks represented in this cross section comprise five major lithologies.

SANDSTONE

Two types of sandstone are distinguished on the basis of thickness, grain size distribution, color, sedimentary and biogenic structures, and the nature of bounding contacts.

Type I sandstone

Type I sandstone forms bodies that are lenticular in cross section and are generally 3–20 ft thick. One type I sandstone in measured section 3 is as much as 33 ft thick. The bodies are either uniformly very fine or fine grained or fine upward from fine to very fine grained. The sandstone weathers very light gray to yellowish gray. Lower parts of the bodies are trough cross stratified or parallel laminated; upper parts generally consist of thin- to medium-bedded sandstone or sandstone having thin interbeds of mudrock or carbonaceous shale and rare, poorly developed ripple laminations. Internal erosion surfaces marked by mudrock fragments and fossil plant debris are common. Type I sandstone commonly occurs as multistoried bodies separated by erosion surfaces. Low-angle planar surfaces of inferred lateral accretionary origin were observed in the 56-ft-thick multistoried sandstone near the top of measured section 3. At five measured sections, 1, 4, 5, 8, and 9, blocks of steeply dipping, thin- to medium-bedded sandstone that contains finer-grained partings with plant debris are present beneath the base of multistoried type I sandstone. These steeply dipping blocks are generally 8–17 ft thick. Basal contacts of type I sandstone are commonly marked by mudrock fragments and fossil plant debris and are sharp or erosional with as much as 3 ft of local relief; upper contacts are sharp or, rarely, gradational. Paleocurrent directions measured from foreset laminations of trough cross stratification in sections 1, 3, 4, and 8 indicate sediment transport to the northwest, northeast, and south.

Type II sandstone

Type II sandstone forms tabular beds about 1–17 ft thick. Grain size varies from very fine to fine grained, and individual beds may be uniform grained, coarsen upward, or fine upward. Weathered color ranges from yellowish gray to light-olive gray. The lower parts of the beds are generally parallel laminated or trough cross stratified; the upper parts commonly display rooting and (or) poorly developed ripple laminations. Basal contacts are generally sharp and upper contacts are sharp. Fossil plant fragments are common in this sandstone.

Some type II sandstone weathers light-brownish gray and has punky or vuggy weathered surfaces. Fresh surfaces are pale-yellowish brown, and blocky fractures resembling pedogenic structures are common. These beds have sharp upper contacts, and their upper parts have abundant vertical root traces and, commonly, they have spherical, iron-cemented concretions 1–1.5 in. in diameter. Lower contacts are gradational. Fossil plant debris is abundant throughout. Two good examples of this kind of type II sandstone are found near the base of section 3 and in the middle of section 8.

Although many good examples of type I and type II sandstone exist in the study area, some sandstone beds are not easily assigned to one of these two categories.

MUDROCK

Mudrock occurs in units 1–30 ft thick and is composed of interbedded siltstone, mudstone, shale, and claystone. The mudrock is rarely parallel laminated and commonly displays blocky fracture or is weakly fissile. Fresh surfaces are olive gray to light-olive gray. Weathered exposures are light gray, are commonly case hardened, and display "popcorn" texture. Upper and lower contacts are generally sharp. Fossil plant remains are common throughout and consist of vertical root traces, leaf and stem debris, and macerated fragments on horizontal surfaces.

CARBONACEOUS SHALE

Carbonaceous shale is fissile and consists of a mixture of organic matter, clay, and silt. It occurs in beds 1–12 ft thick. Fresh surfaces range from grayish brown to brownish black. Fossil plant remains are abundant and consist of layers of leaf and stem debris and very thin beds of impure coal. Selenite crystals commonly weather out of this rock and are found littering the surface.

COAL

The few occurrences of coal are near the top of section 7 and near the bases of sections 8, 9, and 10, where coal beds reach a maximum thickness of 2 ft. Otherwise, coal occurs in beds 1 ft or less thick or as coaly material in carbonaceous shale.

The Wyodak coal bed is the most significant coal bed in this area. Where it has burned, it has baked the overlying rocks to a hardened, highly fractured, resistant metamorphic rock called clinker. The clinker varies from slightly hardened and discolored to sintered to melted to paralava. Colors vary from shades of red and yellow to purple, brown, gray, and black. Beneath the clinker is coal ash, which in this area consists of 1–3 ft of a crumbly to vesicular gray and white material. Rock beneath the ash is not visibly altered in most places.

IRONSTONE CONCRETIONS

Zones of laterally discontinuous, grayish-red- to dusky-red-purple-weathering ironstone concretions having yellowish-gray interiors are present throughout the sections. These 1–3 ft thick, tabular to spherical concretions are most commonly found within mudrock and occasionally within or near the top of sandstone beds. Some ironstone zones can be traced for short distances but are not generally useful for correlating between measured sections. Vertical root traces, well-preserved impressions of leaves, and other plant debris are common, including fruiting bodies (*J.N. Wolfe, oral. commun.*, 1987). Ironstone locally forms orange-weathering, resistant caps at the top of some sandstone beds.

STRATIGRAPHIC FRAMEWORK

Type I sandstone locally is in erosional contact with other type I sandstone or mudrock or carbonaceous shale beds. Type I sandstone is generally overlain by type I sandstone, mudrock, or carbonaceous shale. Type II sandstone generally overlies mudrock or carbonaceous shale and is overlain by mudrock. Carbonaceous shale beds usually overlie mudrock or sandstone and are commonly overlain by mudrock. Coal usually overlies mudrock and is most commonly overlain by mudrock. Fining-upward sequences are recognized in sections 1, 3, 4, and 7. An idealized sequence begins with sandstone at the base, overlain by sandstone interbedded with thin mudrock beds, and ends with a mudrock bed at the top. Coarsening-upward sequences occur much less frequently. An idealized sequence begins with mudrock at the base, overlain by mudrock interbedded with thin sandstone beds, and ends with a sandstone at the top. Although both of these ideal sequences occur in the study area, more commonly, partial or interrupted sequences are found.

Without continuous lateral exposures, changes in lithology along strike could be only partially observed, and correlation of lithologic units between measured sections is difficult. Type I sandstone thins and pinches out; type II sandstone is more laterally continuous. Coal beds commonly are laterally discontinuous. However, there is a zone that contains carbonaceous shale that can be traced across the entire length of the stratigraphic cross section. This zone occurs in the upper part of the cross section 6–198 ft below the base of the clinker of the Wyodak coal bed and varies from 28 to 106 ft thick. This carbonaceous shale zone and numerous type I sandstone bodies characterize the upper part of the sequence. Finer grained rocks predominate in the lower part of the sequence as observed in sections 8–10, and most of the coal beds are in this lower part.

INTERPRETATIONS

On the basis of observed physical and biogenic characteristics and vertical and lateral lithologic associations, four facies have been described and interpreted as to their environment of deposition.

CHANNEL SANDSTONE FACIES

Type I sandstone bodies compose the channel facies. These channel-form sandstone bodies have sharp or erosional bases and commonly fine upward. Flores (1981) interpreted sandstone having similar characteristics in other parts of the basin to be channel deposits. This interpretation is further supported by the trough cross stratification observed in the lower parts of the bodies and by thinly interbedded sandstone and mudrock that are found in the upper parts. The blocks of steeply dipping, thin-bedded sandstone found below the bases of type I sandstone bodies in sections 1, 4, 5, 8, and 9 are interpreted to be rotated slump blocks of older overbank material.

OVERBANK SANDSTONE FACIES

This facies is composed of type II sandstone beds. Some of these beds can be traced for as much as 0.75 mi. Their lateral extent, thin tabular shape, rooted and (or) ripple-laminated upper parts, and sharp bases are consistent with crevasse splay or sheet-flood deposits. Less common is type II sandstone that, on the basis of color, pedogenic structure, and the presence of abundant root traces, is interpreted to be a weakly developed paleosol (Retallack, 1981, 1984; Miller and Sigleo, 1983). Examples of type II sandstone having paleosol development are found in sections 3, 5, 6, 8, 9, and 10.

FLOOD-PLAIN FACIES

Mudrock is the primary lithology of the flood-plain facies. Ironstone concretions are also common. Clay, silt, and some very fine grained sandstone were deposited on the flood plain from suspension during episodic flooding. The gray color of the mudrock and the presence of ironstone concretions indicate a reducing environment that was probably continuously saturated by a high water table.

SWAMP FACIES

The swamp facies is characterized by carbonaceous shale and coal. Carbonaceous shale indicates a swamp environment where influx of fine-grained clastic material inhibited the accumulation of pure peat. Coal indicates an environment where peat accumulated without significant clastic input.

DEPOSITIONAL ENVIRONMENTS

Ethridge and others (1981) and Budai and Cummings (1987) interpreted the depositional environments of the Fort Union and overlying Wasatch Formations for this interval in this part of the basin. Ethridge and others (1981) suggest that rocks of the upper part of the Fort Union Formation were deposited in a northward-flowing intermountain-basin fluvial system. Budai and Cummings (1987) conclude that the coal-bearing sequence of the Fort Union Formation was deposited in paludal and tributary subsystems along the northern margin of the Wright delta of Ayers (1986).

On the basis of the lithologies and facies associations observed in the study area as compared with features reported from modern environments and other similar ancient environments, we conclude that an alluvial plain existed in this part of the Powder River Basin prior to the accumulation of the Wyodak peat. Low-sinuosity streams flowed generally toward the north across this surface and are now represented by large type I sandstone bodies. The interchannel areas that flanked these channels are represented by beds of mudrock, type II sandstone, carbonaceous shale, ironstone concretions, and coal.

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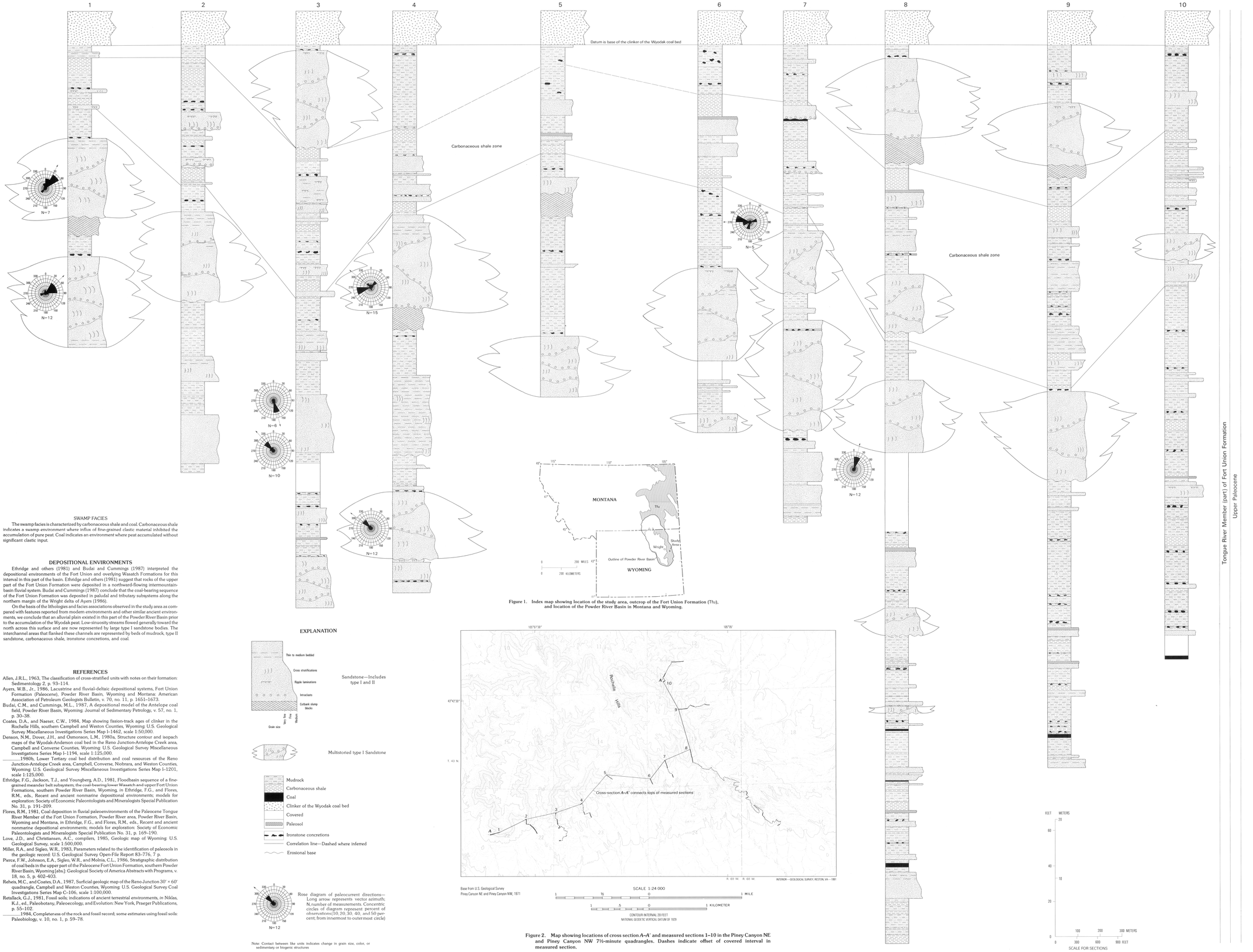

Figure 1. Index map showing location of the study area, outcrop of the Fort Union Formation (Tfu), and location of the Powder River Basin in Montana and Wyoming.

Figure 2. Map showing locations of cross section A–A′ and measured sections 1–10 in the Piney Canyon NE and Piney Canyon NW 7½-minute quadrangles. Dashes indicate offset of covered interval in measured section.

STRATIGRAPHIC CROSS SECTION SHOWING UPPER PALEOCENE COAL-BEARING ROCKS OF THE TONGUE RIVER MEMBER OF THE FORT UNION FORMATION IN THE PINEY CANYON NE AND PINEY CANYON NW QUADRANGLES, CAMPBELL AND WESTON COUNTIES, SOUTHEASTERN POWDER RIVER BASIN, WYOMING

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