DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

MISCELLANEOUS INVESTIGATONS SERIES
MAP I–2013

INTRODUCTION

The seven measured sections that compose this stratigraphic cross section are in the upper part of the Paleocene Fort Union Formation 28 mi 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 (Love and Christiansen, 1985; Denson and others, 1980a, 1980b) 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 streams 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 in the upper part of the Fort Union Formation (Denson and others 1980a, 1980b) and is mined 8 mi northwest of the study area. Pierce and others (1986) have shown that the Wyodak coal bed is within the Tongue River Member and that in this part of the basin the coal bed often splits east of the main deposit into upper and lower Wyodak beds.

The measured sections are on the southeastern edge of the Red Hills (fig. 2) along an arcuate escarpment that is protected from erosion by a cap of clinker formed when the Wyodak coal bed, or a split of the Wyodak coal bed, burned, probably during the Pleistocene and Holocene (Reheis and Coates, 1987; Coates and Naeser, 1984; Denson and others, 1980a). The measured sections, which range from 0.26 to 0.87 mi apart, are along an east-west-trending cliff face and an adjacent northeast-trending cliff face (fig. 2) and have 185–281 ft of the Tongue River Member below the clinker.

Ethridge and others (1981) and Budai and Cummings (1987) interpreted the depositional environments of the Fort Union and overlying Eocene Wasatch Formations that are above the base of the Wyodak coal deposit in this part of the basin. In contrast, the Tongue River Member 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.

LITHOLOGY

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

SANDSTONE

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

Type I sandstone

Type I sandstone forms bodies that are lenticular in cross section and are about 3–28 ft thick. The sandstone weathers light gray and is either uniformly fine or very fine grained or fines upward from fine grained to very fine grained; one 24-ft-thick body near the bottom of section 5 fines upward from medium grained to fine grained. Trough cross stratification and ripple laminations are common; convolute bedding is rare. The upper part of a 21-ft-thick sandstone bed near the top of section 1 contains vertical root traces and vertical burrows. Basal contacts are sharp and often erosional; upper contacts are sharp or gradational. Current directions could not easily be measured. The cast of a fossil log in a sandstone bed near the base of section 5 is oriented northwest.

A multistoried type I sandstone in the upper part of section 7 is 30 ft thick and consists of three individual bodies that are separated by erosional surfaces. The middle body consists of a large block of steeply dipping, thin- to medium-bedded sandstone having thin mudrock interbeds. The other two bodies fine upward and have trough cross stratification in their lower parts. The uppermost body contains the cast of a fossil log that is oriented northwest, and its top is capped by l-ft-thick ironstone.

A unique type I sandstone body near the bottom of section 7, 320 ft below the clinker of the Wyodak coal bed is as much as 28 ft thick and is exposed in drainages over an area about 0.25 mi in diameter. The overall grain size is very coarse, but the unit fines upward from very coarse grained or granule in the lower part to very fine grained at the top. Weathered color is very pale orange, somewhat anomalous for this area, and the sandstone is often micaceous and friable. The lower part contains well-developed trough cross stratification and internal erosion surfaces marked by chert pebbles as much as 3/8 in. in diameter, mudrock fragments as much as 19 in. long, and coalified plant fragments. Above these surfaces, the sandstone locally fines upward usually from very coarse grained to fine grained. Convolute bedding characterizes the upper part of the body. The base of the body is eroded into gray mudrock having as much as 4 ft of local relief, and the base is marked by an iron-oxide-stained rind 4–6 in. thick. The upper contact of the body is sharp and the body has a 10-in.-thick iron-oxide-cemented cap below which is a zone about 10 ft thick that contains spherical sandstone concretions 2–4 in. in diameter. Paleocurrent measurements taken from foreset laminations of trough cross stratification at three locations indicate flow towards the west.

Type II sandstone

Type II sandstone forms tabular beds about 1–7 ft thick. Grain size is usually very fine. Weathered color ranges from light gray to light-yellowish gray. The sandstone commonly contains thin beds of mudrock or carbonaceous shale, and vertical root traces are common. Small-scale trough cross stratification and orange-stained tops or bottoms are present but not common. Basal contacts are sharp, and, rarely, erosional and upper contacts are usually sharp.

The upper part of a type II sandstone bed between the lower parts of sections 5 and 6 (not shown) weathers light-brownish gray, contains abundant vertical root traces and plant debris, and has a punky weathered surface. Similar rocks occur in section 5.

Although good examples of type I and II sandstone are in the study area, many sandstone beds are not easily assigned to one of these two categories. However, we believe that most of these enigmatic sandstone beds are probably type II sandstone.

MUDROCK

Mudrock occurs in units 1–20 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, commonly case hardened, and display "popcorn" texture. Upper and lower contacts are generally sharp. Fossil plant remains are common throughout the rock and consist of vertical root traces or 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 and occurs in beds 1–6 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

Each measured section has 2–7 coal beds ranging from 1 to 6 ft thick. Several of these beds can be grouped into a zone that can be traced the length of the cross section. This zone, which averages 18.7 ft thick, is 123–163 ft below the base of the clinker of the Wyodak coal bed. The zone commonly contains two major coal beds ranging from 2 to 5 ft thick and probably represents the E bed of Dobbin and Barnett (1927). In section 6, the coal in the zone has burned, but the zone can be correlated through the section on the basis of the presence of thermally altered rock. Other coal beds occur in the sections but they are laterally discontinuous.

Where the Wyodak coal bed 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 generally consists of 1–3 ft of a crumbly to vesicular gray and white material. The total thickness of the clinker could not be measured, but at section 6 we measured a minimum of 50 ft.

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 1–2-ft-thick, tabular to spherical concretions are most commonly found associated with mudrock. Some ironstone zones form good marker horizons that can be traced along strike. Vertical root traces, well-preserved impressions of leaves, and other plant debris including fruiting bodies (J.N. Wolfe, oral commun., 1987) are common. Ironstone locally forms orange-weathering, resistant caps at the top of some sandstone beds.

STRATIGRAPHIC FRAMEWORK

Sandstone typically overlies mudrock or, less commonly, carbonaceous shale and is usually overlain by mudrock. Coal usually overlies mudrock or, less frequently, carbonaceous shale and is overlain by either carbonaceous shale or mudrock. Fining-upward sequences are common. An idealized sequence has sandstone at the base, sometimes with thin mudrock interbeds in the upper part, followed by mudrock that may have thin sandstone beds in the lower part. Coarsening-upward sequences also occur but less frequently.

Without continuous lateral exposures, changes in lithology along strike could be only partially observed. Some sandstone bodies thin and pinch out; laterally continuous sandstone is not common. Coal beds often pinch out or grade into carbonaceous shale.

The total percent of sandstone in the sections increases from an average of 22 percent in sections 1–5 to an average of 48 percent in sections 6 and 7. Overall, the rock sequence observed in this area contains a much smaller proportion of sandstone than exposures of the same stratigraphic interval 21 mi to the north.

INTERPRETATIONS

On the basis of observed physical and biogenic characteristics and vertical and lateral lithologic associations, we have described and interpreted the environment of deposition for four facies.

CHANNEL SANDSTONE FACIES

Type I sandstone bodies compose the channel facies. These channel-form bodies commonly have erosional bases and fine upward. Flores (1981) interpreted sandstone with similar characteristics in other parts of the Powder River basin to be channel deposits. We interpret the large block of steeply dipping interbedded sandstone and mudrock seen in the type I sandstone in the upper part of section 7 to be a rotated slump block of older overbank material. Characteristics of the channel facies are particularly well developed in the sandstone in the lower part of section 7.

OVERBANK SANDSTONE FACIES

This facies is composed of type II sandstone beds. Although limited exposure prevents tracing these beds laterally over long distances, their thin, tabular shape, mudrock and carbonaceous shale interbeds, vertical root traces, and sharp bases are consistent with crevasse-splay or sheet-flood deposits. Less common is type II sandstone that, on the basis of color 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 between the lower parts of sections 5 and 6 and in section 5.

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 continually 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) suggest that the rocks of the Fort Union Formation above the Wyodak coal bed were deposited in a northward-flowing intermountain-basin fluvial system. Budai and Cummings (1987) conclude that the same sequence of 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 similar ancient environments, we conclude that the rock sequence below the Wyodak coal bed was deposited on an alluvial plain that existed in this part of the Powder River basin prior to the accumulation of the Wyodak peat. Low-sinuosity streams flowed generally toward the west and northwest across this surface and are now represented by type I sandstone bodies. The interchannel areas that flanked these streams are now represented by beds of mudrock, type II sandstone, carbonaceous shale, ironstone concretions, and coal.

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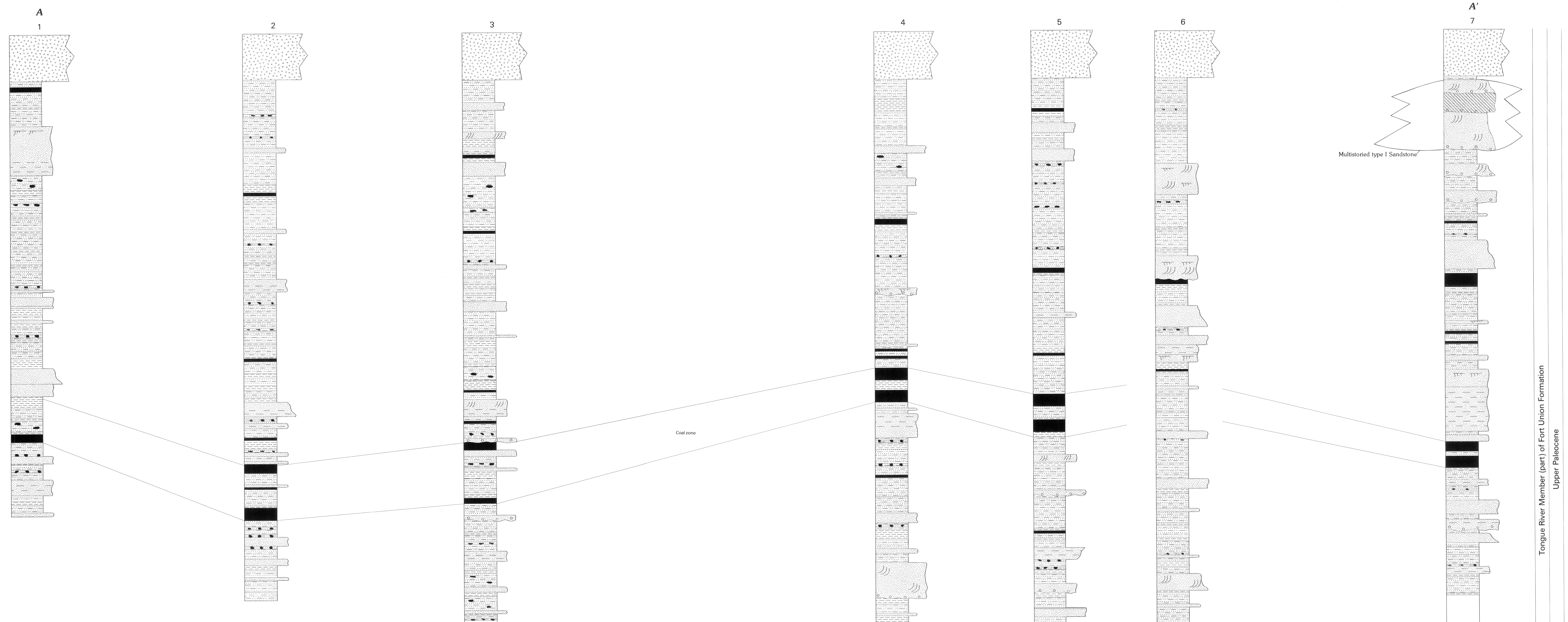
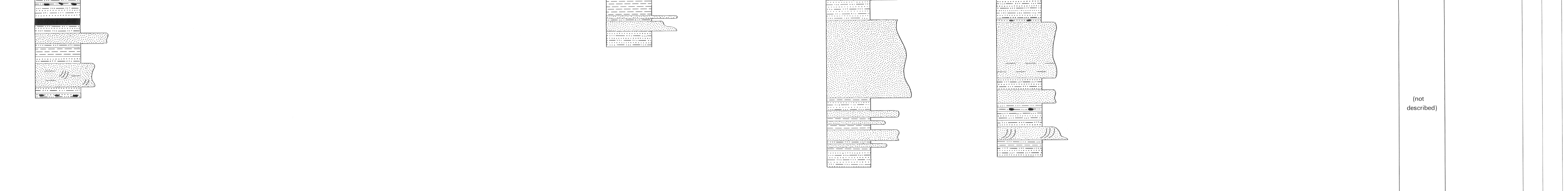
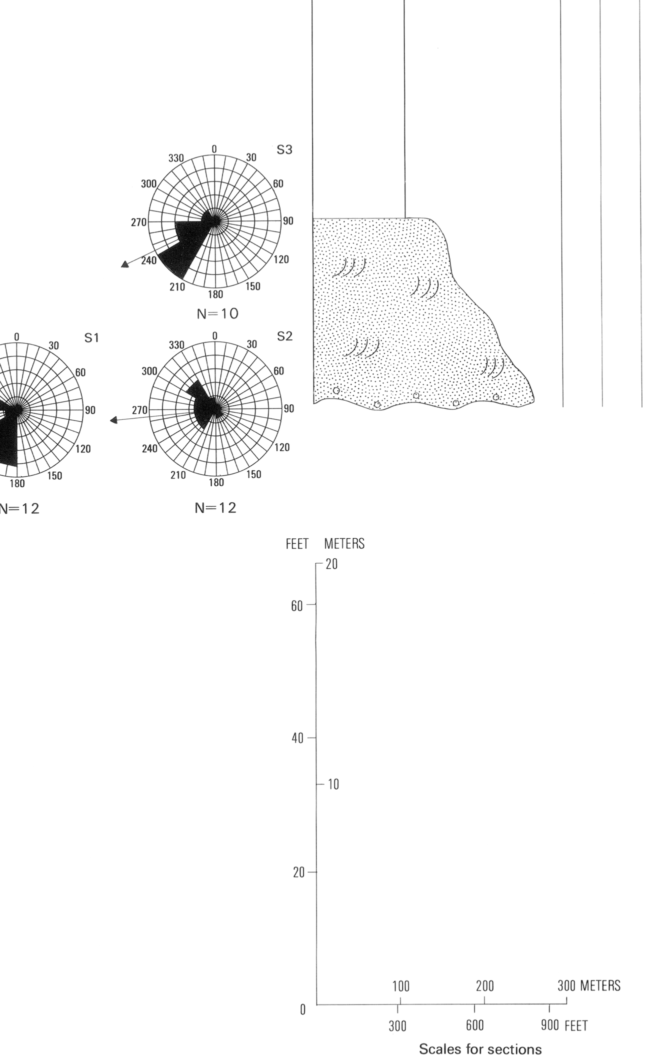
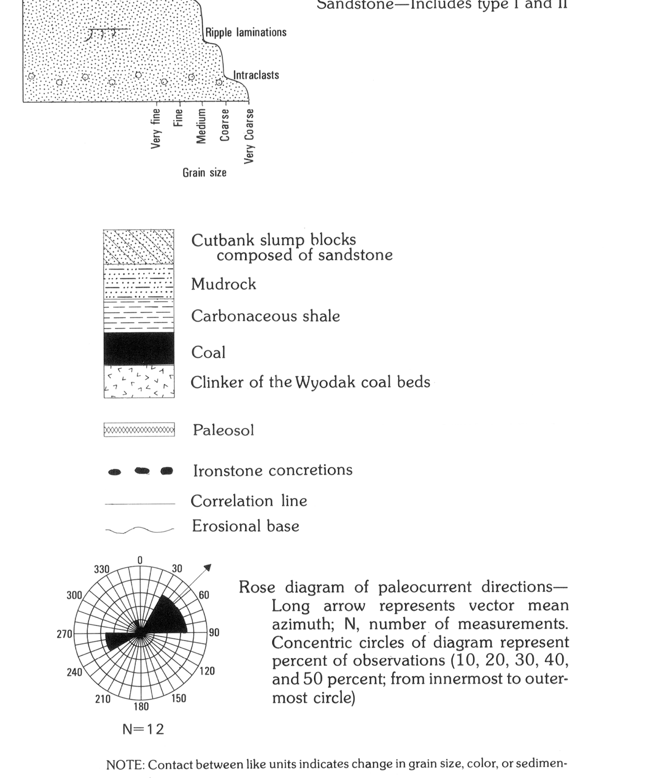






EXPLANATION



NOTE: Contact between like units indicates change in grain size, color, or sedimentary or biogenic structures

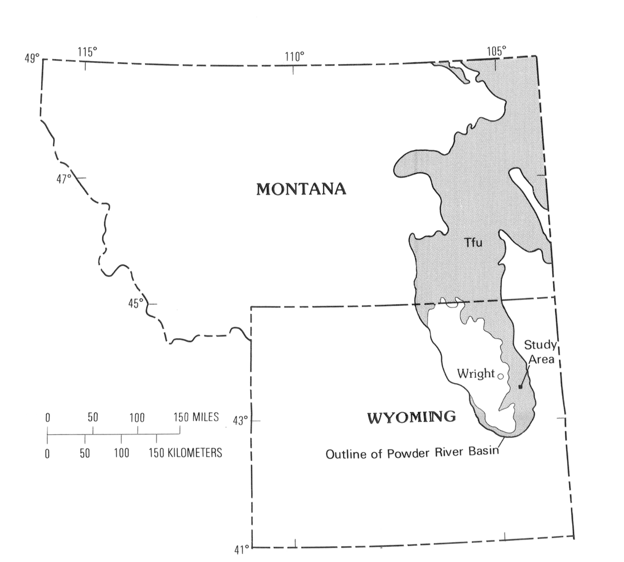


Figure 1. Index map showing location of the study area, outcrop of the Fort Union Formation (Tfu), and location of the Powder River Basin in Montana and Wyoming.

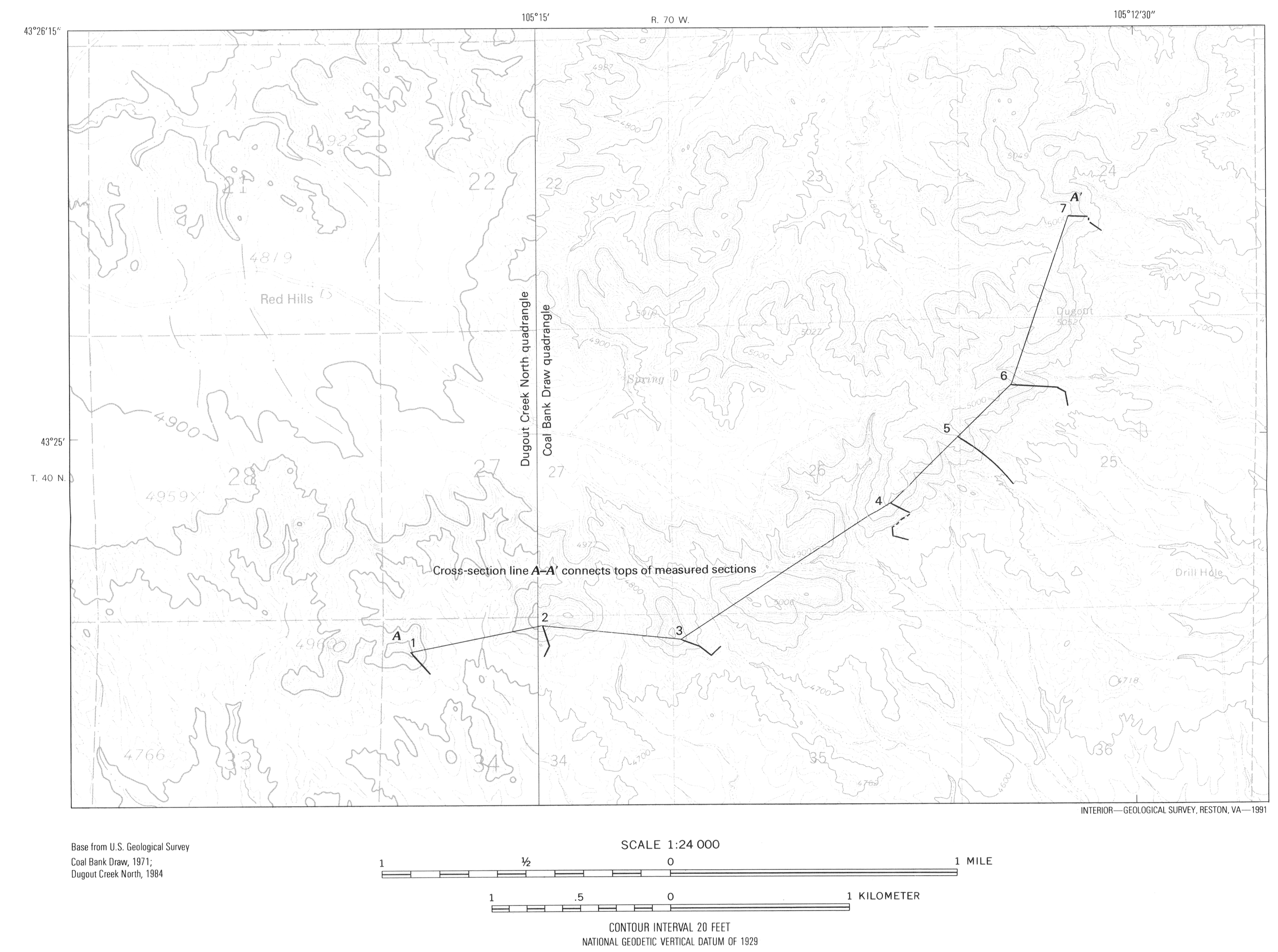


Figure 2. Map showing locations of cross section *A–A′* and measured sections 1–7 in the Dugout Creek North and Coal Bank Draw 7½-minute quadrangles. Dashes indicate offset in measured sections.

STRATIGRAPHIC CROSS SECTION SHOWING UPPER PALEOCENE COAL-BEARING ROCKS OF THE TONGUE RIVER MEMBER OF THE FORT UNION FORMATION IN THE COAL BANK DRAW AND DUGOUT CREEK NORTH QUADRANGLES, CONVERSE COUNTY, SOUTHEASTERN POWDER RIVER BASIN, WYOMING

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