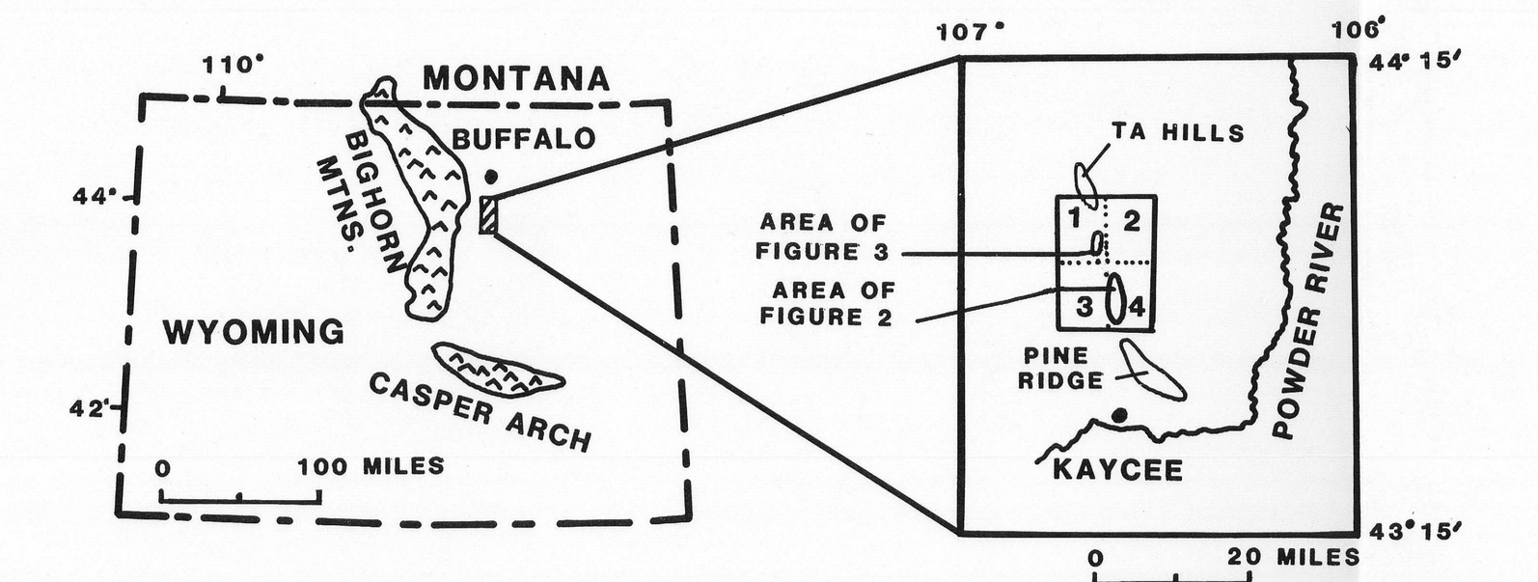

FIGURE 1.--LOCATION OF STUDY AREA AND INDEX TO 15-MINUTE QUADRANGLES

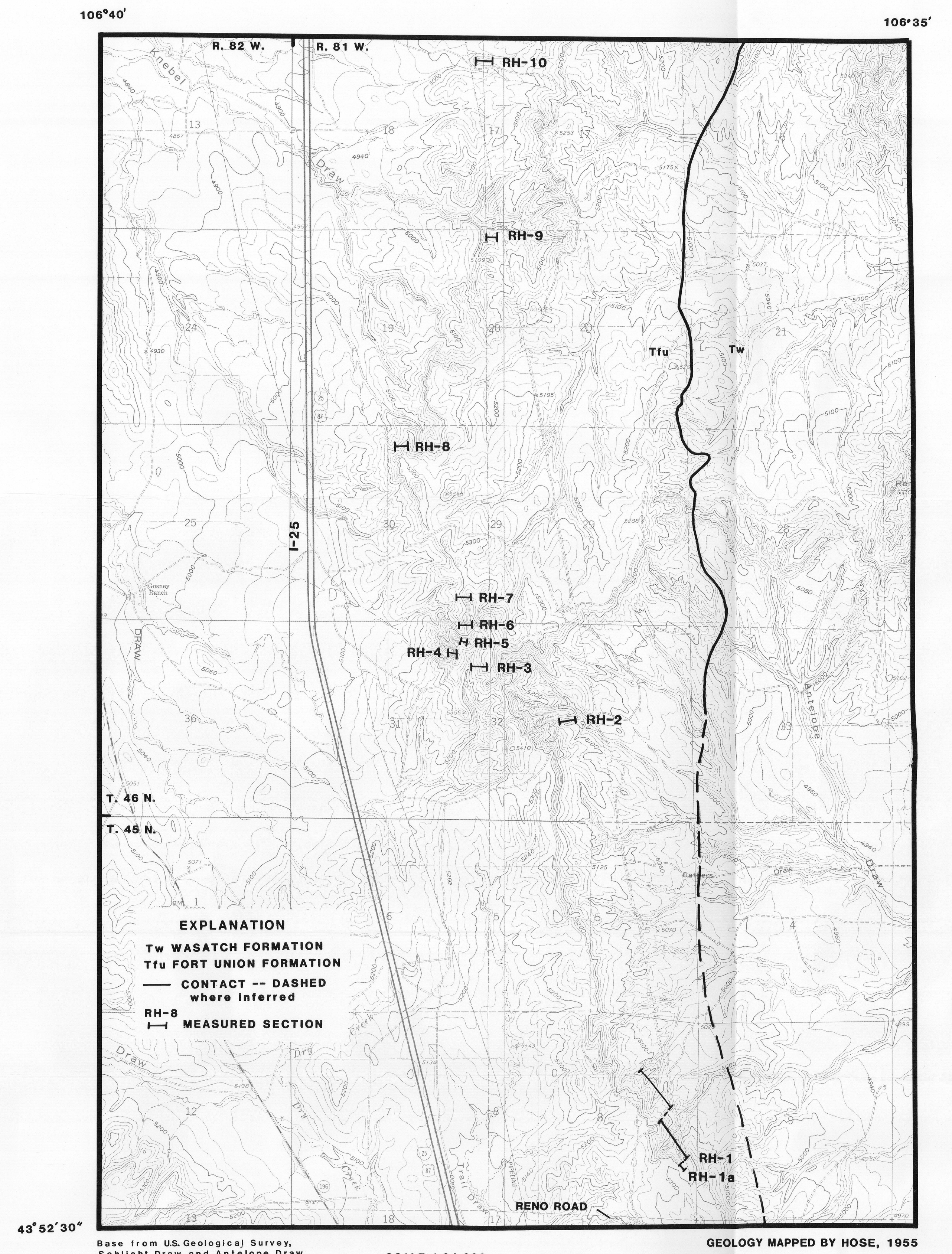

FIGURE 2.--LOCATION OF MEASURED SECTIONS OF CONGLOMERATIC SANDSTONE LITHOFACIES AND COARSE-GRAINED SANDSTONE LITHOFACIES

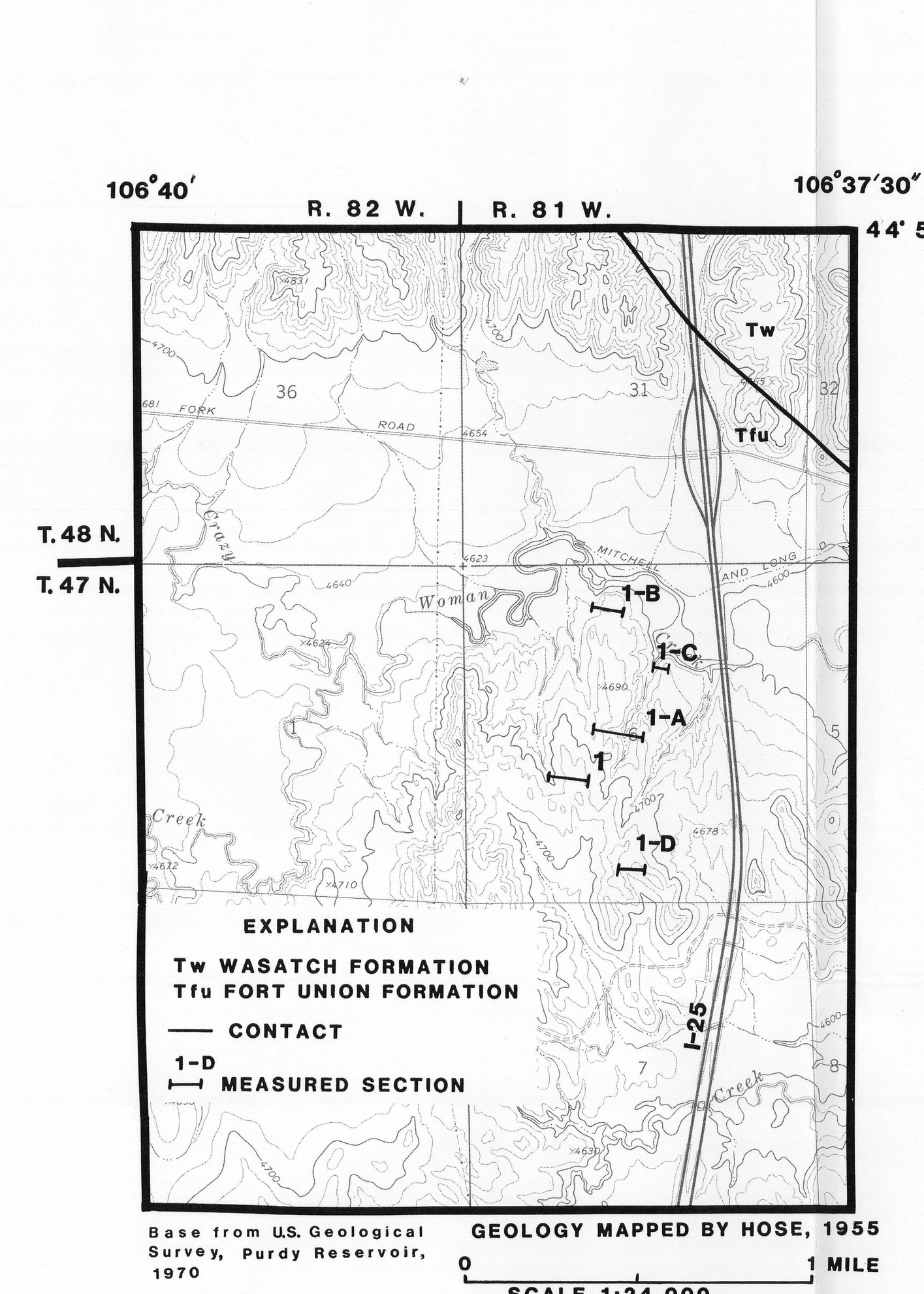

FIGURE 3.--LOCATION OF MEASURED SECTIONS OF FINE-GRAINED SANDSTONE LITHOFACIES

SUMMARY

The purpose of this study is to describe the stratigraphy and interpret the environments of deposition in the upper part of the Paleocene Fort Union Formation. Of all the lithofacies present within the study area, sandstone is the most dominant and makes up most of the upper part of the Fort Union Formation along the western edge of the Powder River basin, Wyoming. This sandstone lithofacies occurs in three forms: 1) pink conglomeratic sandstone, 2) coarse-grained sandstone, and 3) fine-grained sandstone. The pink conglomeratic sandstone lithofacies forms a series of stacked channel bodies in which the clasts are as much as 1 3/4 in. in diameter. The coarse-grained sandstone lithofacies is laterally equivalent to the pink conglomeratic sandstone sequence, but contains smaller clasts; it is arranged en echelon (offset) to the north. The fine-grained sandstone lithofacies, limited to the northern part of the study area, is not as laterally continuous as the pink conglomeratic sandstone lithofacies to the south. Basal lag conglomerate underlies both the conglomeratic sandstone and coarse-grained sandstone lithofacies, but not the fine-grained sandstone. The presence of a fine-grained sandstone lithofacies lateral to the conglomeratic sandstone and coarse-grained sandstone lithofacies suggests the presence of a coarse-grained braided and meandering fluvial system coeval with a fine-grained meandering fluvial system. The meandering fluvial systems drained the alluvial plain flanking the Bighorn Mountains on the west and the Casper arch on the southwest, and flowed north-northeastward within the Powder River basin.

LOCATION AND FIELD METHODOLOGY

The study area extends from south of the TA Hills to north of Pine Ridge, along the western margin of the Powder River basin, Wyoming. The study area is located within four 15-*minute topographic quadrangles*: *Purdy Reservoir*, Trabing, Schlicht Draw, and Antelope Draw (fig. 1). It is bounded to the south by Reno Road (fig. 2), and to the north by Crazy Woman Creek (fig. 3). The foothills of the Bighorn Mountains are about 10 mi west of the western boundary of the study area.

Fifteen detailed measured sections (figs. 2-5), averaging about 100 ft thick, were described and measured, using a Jacob's staff, in the upper 1,000 ft of the Paleocene Fort Union Formation. Some units were exposed by trenching. East of the study area, the Fort Union Formation is overlain by the Eocene Wasatch Formation (figs. 2 and 3) and underlain by the Upper Cretaceous Lance Formation. Dips in the Fort Union Formation within the study area range from 16° NE. at the north to 12° NE. at the south. A laterally extensive pink conglomeratic sandstone (fig. 4, measured section RH-1 to RH-3) was used as a marker bed for the correlation of lithologic units between the various measured sections.

LITHOFACIES TYPES

The Fort Union Formation consists of sandstone, conglomerate, siltstone, mudstone, shale, carbonaceous shale, and coal. Environments of deposition for the upper part of the Fort Union Formation in the study area were determined from analysis of the lithofacies and their vertical and lateral successions.

SANDSTONE LITHOFACIES

The sandstone lithofacies makes up most of the upper part of the Fort Union Formation in the study area and occurs as three types: 1) pink conglomeratic sandstone (fig. 4), 2) coarse-grained sandstone (fig. 4), and 3) fine-grained sandstone (fig. 5).

The pink conglomeratic sandstone lithofacies is present between measured sections RH-1 and RH-3 (fig. 4). The basal lag conglomerate will be discussed separately below. The grain size of the sandstone bodies decreases upward. The sandstone bodies are pink to red in color (in both fresh and weathered outcrops), coarse grained, dominantly trough and planar crossbedded, and have scoured bases. Variations in the direction of the trough crossbeds of the sandstone bodies are shown in the rose diagrams in figures 4 and 5. One of these sandstone bodies (base of measured section RH-1) yielded the anterior part of the carapace of a trionychid turtle of Paleocene or late Puercan to Tiffanian age (J. Howard Hutchison, University of California, Berkeley, written commun., 1985). A mammal tooth about 2 mm long was found with the turtle remains. The fossil remains are interpreted to be lag deposits.

The coarse-grained sandstone lithofacies (fig. 4) is light buff to yellow in color, has scoured bases, and contains trough and planar crossbeds as much as 2 ft thick. The sandstone bodies are arranged en echelon, and in places are laterally equivalent to the pink conglomeratic sandstone lithofacies.

The fine-grained sandstone lithofacies (fig. 5) is light buff to yellow, coarsens upward, and is ripple-marked throughout. Root marks are locally present. The obvious lack of trough crossbeds, conglomeratic lenses, and scour bases distinguishes this lithofacies from the other two lithofacies.

CONGLOMERATE LITHOFACIES

The conglomerate lithofacies consists of gravel clasts in two subtypes: 1) pink framework-supported conglomerate lenses in which clasts are as large as 1 3/4 in. in diameter, associated with the pink conglomeratic sandstone lithofacies and 2) framework-supported conglomerate lenses in which most clasts reach a maximum of 3/4 in. in diameter, associated with the coarse-grained sandstone lithofacies.

Lenses of the framework-supported conglomerate (subtype 1) occur in the pink conglomeratic sandstone lithofacies as lag deposits marked by scoured basal contacts. These conglomeratic lenses are discontinuous and vary in thickness from 2 in. to 2 ft. Clasts are subangular to subrounded and reach diameters as much as 1 3/4 in. A random pebble count, using a simplified color scheme, was made of the light-colored, gray, dark-colored, and reddish-brown clasts present. A petrographic analysis indicates that quartzose sandstone constitutes the light-colored clasts, limestone the gray clasts, chert the dark-colored clasts, and chalcedony and sandstone the reddish-brown clasts. A count of 297 clasts indicated that the light-colored clasts constituted 48 percent, the gray 32 percent, the dark-colored 11 percent, and the reddish-brown 9 percent of the total. Invertebrate fragments in these clasts are numerous throughout this lithofacies.

The conglomerate (subtype 2) associated with the coarse-grained sandstone lithofacies (fig. 4) contains generally smaller clasts than those in subtype 1. Most clasts are no more than 2 cm in diameter but some cobbles reach 5 in. (12.7 cm) in diameter at measured section RH-10 (fig. 4). Conglomerate lenses are as much as 2 ft thick. About 1,030 clasts were studied. Dark-colored clasts (chert) constitute 25 percent, light-colored clasts (quartzose sandstone) 20 percent, gray clasts (limestone) 21 percent, and reddish-brown clasts (chalcedony and sandstone) 14 percent of the total. There are more invertebrate fossil fragments in the pink conglomeratic sandstone lithofacies than in the coarse-grained sandstone lithofacies.

SILTSTONE, MUDSTONE, AND SHALE LITHOFACIES

The siltstone and mudstone lithofacies are here considered as a single lithologic unit inasmuch as the two are commonly interbedded. Color varies from medium to light gray on fresh outcrops to almost white on weathered outcrops, except at the base of measured section RH-6 (fig. 4) where a thick (30 ft) sequence has weathered to yellow, orange, and light purple, probably because of intense oxidation. Roots and occasional burrows have largely destroyed internal structures. The siltstone and mudstone lithofacies are laterally continuous (as much as 1/4 mi) but in places are replaced by sandstone.

The shale lithofacies, light to dark gray in fresh outcrop and locally fissile, is commonly found interbedded with the siltstone and mudstone lithofacies. The maximum thickness is 10 ft. Root marks are less common than in the siltstone and mudstone lithofacies. The shale lithofacies grades laterally into siltstone and mudstone sequences or is replaced by sandstone. In the lower part of measured section RH-6 (fig. 4), the erosional surface at the base of the shale indicates that clay has filled in an abandoned channel.

CARBONACEOUS SHALE LITHOFACIES

Carbonaceous shale is the most abundant organic-bearing lithofacies in the study area. In fresh outcrops, it is fissile, light brown, and contains abundant macerated fragments of plants, stems, branches, and leaves. The thickest carbonaceous shale beds, as much as 12 ft thick, are located in the northern part of the study area (fig. 5). A carbonaceous shale bed present in measured sections 1D, 1, and 1A contains coalified tree trunks (some as much as 2 ft in diameter). This particular unit directly underlies a coarse-grained sandstone approximately 2.5 mi southeast of measured section 1 (fig. 5), which closely resembles the sandstone farther south in measured sections RH-7 and RH-8 (fig. 4). Carbonaceous shale beds are neither as abundant nor as continuous in the southern part of the study area (fig. 4) as they are in the northern part.

COAL LITHOFACIES

A coal lithofacies is commonly found in the study area, but it is not as abundant as the carbonaceous shale lithofacies. Laterally continuous, mappable coal lithofacies is present in the northern part of the study area (fig. 5) but not in the southern part (fig. 4). Coal lithofacies is present as stringers within the carbonaceous shale lithofacies rather than as individual continuous beds. Coal stringers range in thickness from a few inches to as much as 1.5 ft and are laterally continuous for as much as 2 mi. Except for one place in measured section RH-3, individual coal stringers are not shown separately on figure 4, because they are generally thin, and are instead incorporated into the carbonaceous shale units.

ENVIRONMENTS OF DEPOSITION

The environments of deposition of the upper part of the Fort Union Formation in the study area were determined through the study of the vertical and lateral successions of the sandstone, conglomerate, siltstone, mudstone, shale, carbonaceous shale, and coal lithofacies. The sandstone and conglomerate lithofacies are interpreted as channel and crevasse splay deposits. The associated fine-grained lithofacies, which include carbonaceous shale and coal, are laterally equivalent floodplain and backswamp deposits.

The scour-based, trough- and planar-crossbedded, coarse-grained, fining-upward sandstone lithofacies are interpreted to be channel deposits. In places, conglomerate bodies are present as lenses at the base of these channels and are interpreted as lag deposits. In one case, at the base of measured section RH-6 (fig. 4), mud filled an abandoned channel forming a clay plug deposit. Associated with the channel sandstone are interbedded sandstone, siltstone, mudstone, and shale lithofacies, which represent associated fine-grained overbank-floodplain or levee deposits. The lack of carbonaceous shale lithofacies in the floodplain deposits indicates that only well-drained backswamps formed in the floodplain (fig. 6a).

Medium- to fine-grained, trough-crossbedded and ripple-marked sandstone lithofacies is considered to represent small crevasse splay deposits. Fine-grained, occasionally rooted, and ripple-marked sandstone lithofacies is interpreted as sheet flood deposits, resulting from the overtopping of the associated levee. The crevasse splay and sheet flood sandstone beds make up proximal deposits in the floodplain. The sandstone is bounded by siltstone, mudstone, and shale lithofacies, which represent distal deposits in the floodplain.

INTERPRETATION OF FACIES

Three distinct but coeval Paleocene fluvial systems were present in the study area, as indicated by our interpretation of the sedimentologic and stratigraphic framework of the upper part of the Fort Union Formation. The southern part of the study area displays a braided fluvial system as well as a coarse-grained meandering fluvial system. A fine-grained meandering fluvial system was present in the northern part of the study area (fig. 6) and had a poorly drained backswamp in its laterally equivalent floodplain.

COARSE-GRAINED BRAIDED AND MEANDERING FLUVIAL SYSTEMS

In the southern part of the study area (fig. 4), facies variations show a conglomeratic sandstone channel complex, which represents a northern continuation of a braided stream deposit in the Pine Ridge area, described by Coss (1984). This conglomeratic sandstone channel complex is composed of coarse-grained, trough- and planar-crossbedded sandstone and lenses of lag conglomerate. The conglomerate represents transportation of large clasts during high-energy flow and deposition during slackwater flow as braid bars (fig. 6a). The coarse-grained, pebbly, trough-crossbedded sandstone that overlies the conglomerate reflects the deposition of longitudinal bars (trough-crossbedded sandstone) and transverse bars (planar-crossbedded sandstone) (fig. 6a). The coarse-grained deposits are bedload sediments of braided streams (fig. 4) similar to those recognized by Coss (1984) and Weaver and Flores (1984) in the Fort Union Formation and by Miall (1978) in the modern Donjek braided stream deposits. Laterally equivalent to the conglomeratic channel complex is a coarse-grained channel sandstone (fig. 4). This coarse-grained channel sandstone is arranged en echelon and contains, in places, framework-supported basal conglomerate. The coarse-grained sandstone reflects deposition in a coarse-grained meandering fluvial system that was coeval with the braided stream environment (fig. 6a). This braided and coarse-grained meandering stream drained an alluvial plain that had an associated well-drained floodplain (fig. 6a). The fine-grained sediments, such as siltstone, mudstone, and shale, lateral to the channel sandstone, represent floodplain deposits of the braided and of the coarse-grained meandering streams. The lack of carbonaceous shale and coal lenses indicate that only well-drained and oxidized backswamps were developed on the floodplain. Floodplain sedimentation was probably characterized by overbank sheet flooding as indicated by the paucity of thick, ripple-marked crevasse splay sandstone and coarsening upward sequences common to other fluvial floodplain deposits.

The channel deposits consist of sediments deposited in braided and meandering streams. The braided stream deposits consist of the pink conglomeratic channel sandstone (fig. 4, measured section RH-1 to RH-3). This conglomeratic sandstone was deposited as braid bars during low-energy flow. The coarse-grained meandering stream channel deposits consist of the coarse-grained light-buff conglomeratic channel sandstone (fig. 4). The associated trough-crossbedded sandstone was deposited as longitudinal bars and the planar bedded sandstone as transverse bars.

FINE-GRAINED MEANDERING FLUVIAL SYSTEM

In the northern part of the study area (figs. 3 and 5), the Fort Union deposits represent lithofacies formed by a fine-grained meandering fluvial system (fig. 6b), which was associated with a poorly drained backswamp in which coal and carbonaceous shale were deposited. This fluvial system is interpreted to be laterally equivalent to the braided and meandering fluvial system present to the south (fig. 6b). The channel sandstone of the fine-grained fluvial system lacks conglomerate and has a finer grain size than that of the braided channel system. These fine-grained channel sandstone deposits are arranged en echelon. The internal structure shows some trough crossbeds but also a higher number of ripple laminations. This would explain the decrease in the paleocurrent measurement for the northern part of the study area. The lack of conglomerate and the finer grain size of the sandstone indicate deposition in a low-energy, mixed-load meandering system, distal to the sediment source (fig. 6b).

The channel sandstone is interbedded with fine-grained sediments, including carbonaceous shale and coal that were deposited in floodplains and poorly drained backswamps (fig. 6b). The spatial association of a low-energy meandering system with a laterally equivalent poorly drained backswamp is similar to that established for the coal-bearing facies in the southern part of the TA Hills (Weaver and Flores, 1984), just north of Crazy Woman Creek (fig. 3).

PALEOTECTONICS

Fluvial styles were directly controlled by tectonism in the source area. Paleocurrent directions (figs. 4 and 5) indicate that the direction of transport was dominantly northward for the fine-grained sandstone facies and northeastward for the coarse-grained sandstone facies. The difference in percentage of various clast types from the conglomeratic channel sandstone complex imply a somewhat different source area. These factors infer that the source area for the channel sandstone and conglomerate clasts was from the west-southwest. The stratigraphic distribution of the conglomerate and the composition of the clasts suggest that the conglomerate was derived from two source areas that may have been affected by either thrust faulting or upwarping. A northern source area in the ancestral Bighorn Mountains and a southern source area in the ancestral Casper arch (fig. 1) are two potential source areas that may have been contemporaneously uplifted although isolated geographically. The nearby Bighorn Mountains probably supplied sediments for alluvial fans and braided streams that were associated with noncoal-bearing deposits. Fine sediments of the coal-bearing deposits were probably derived from the Casper arch, which was more distant to the basin. The difference in grain size of sediments supplied by these two source areas may also reflect differences in relative uplift of the two source areas. The axes of fluvial systems that drained these two areas flowed northeastward. The composition of the clasts along with their stratigraphic and geographic distribution indicate that the source rocks were exposed as a result of episodic uplift and exposure of Paleozoic and Mesozoic sedimentary rocks of the Bighorn Mountains and Casper arch.

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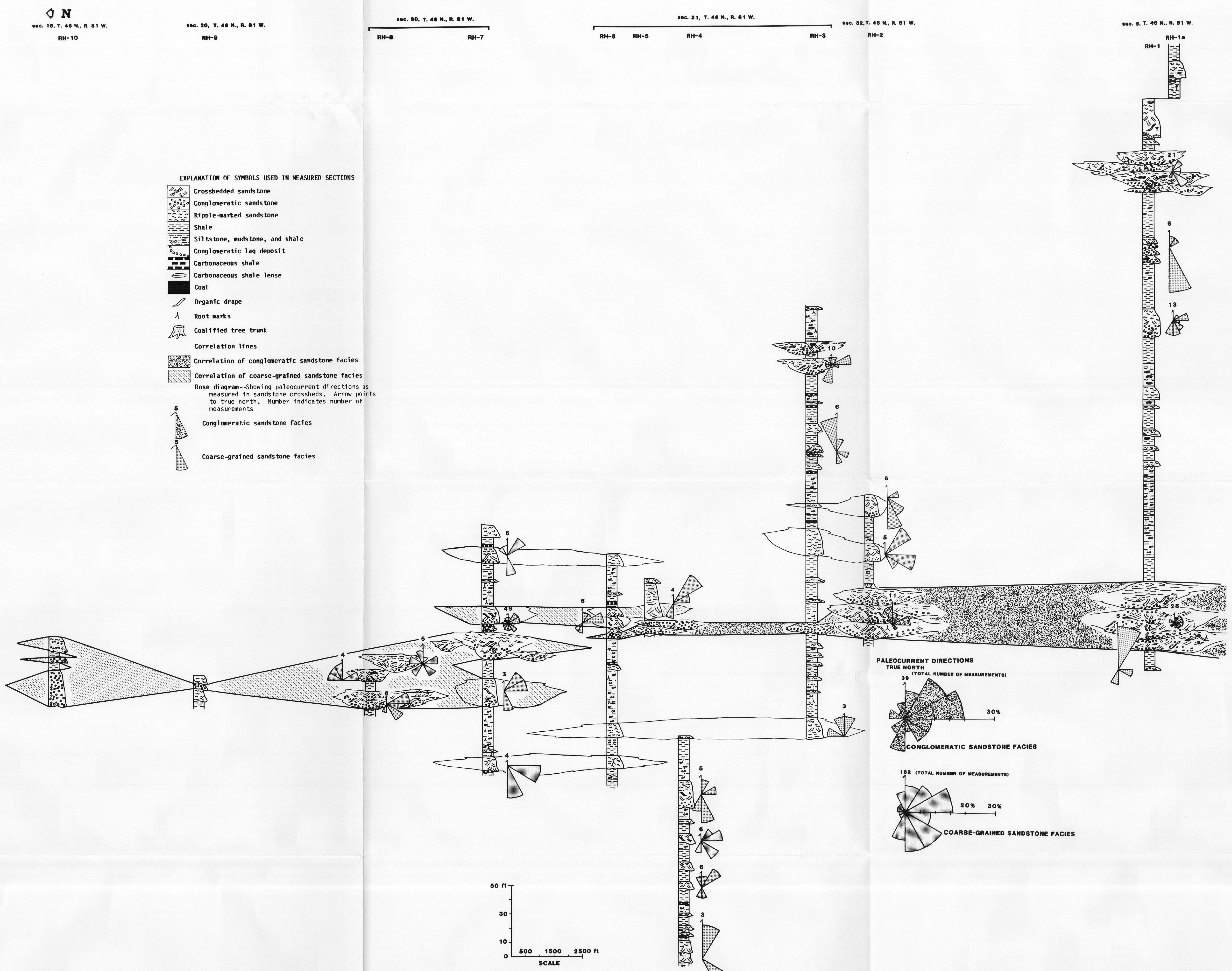

FIGURE 4.--SEDIMENTOLOGIC AND STRATIGRAPHIC FRAMEWORK OF CONGLOMERATIC SANDSTONE LITHOFACIES AND COARSE-GRAINED SANDSTONE LITHOFACIES

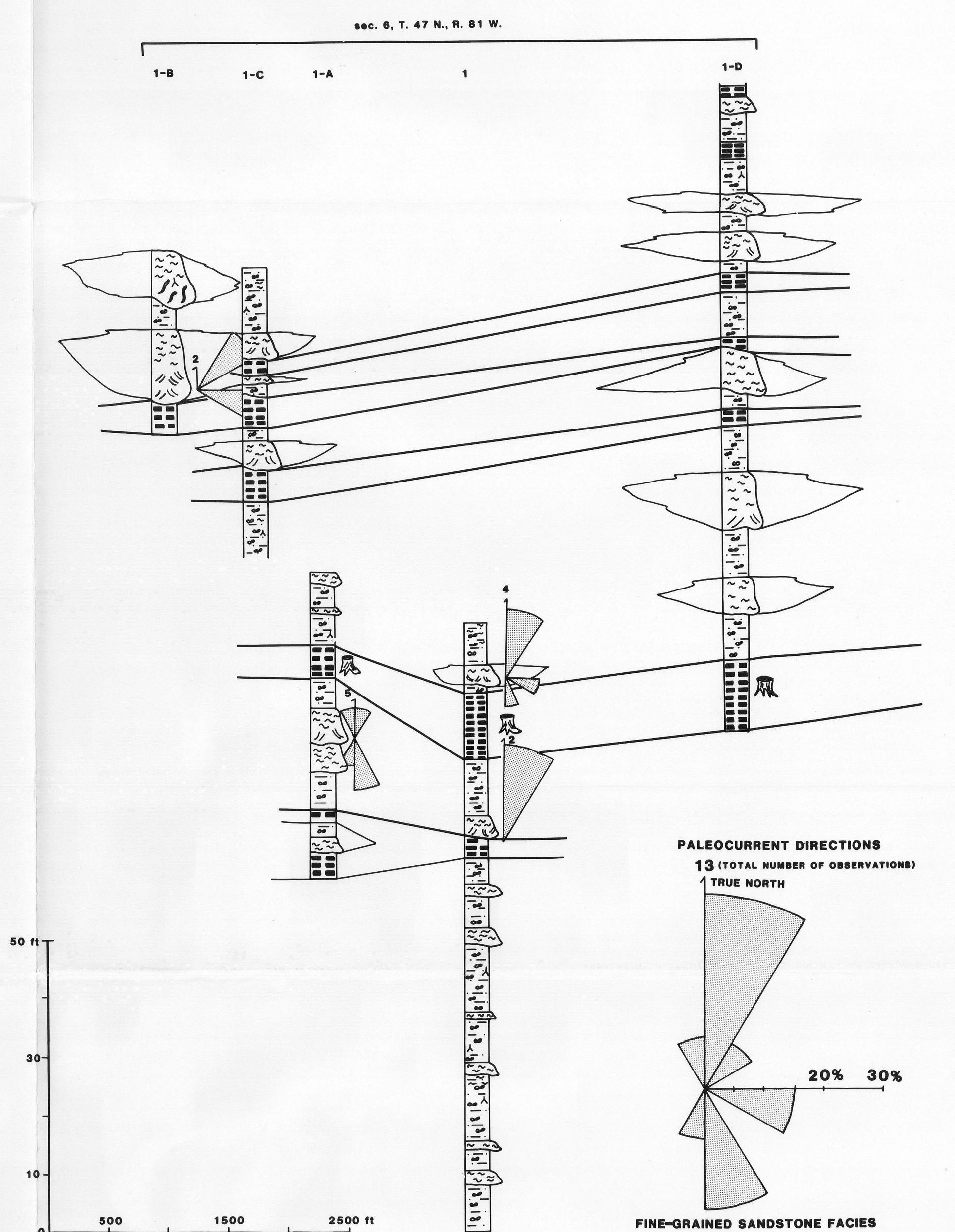

FIGURE 5.--SEDIMENTOLOGIC AND STRATIGRAPHIC FRAMEWORK OF FINE-GRAINED SANDSTONE FACIES

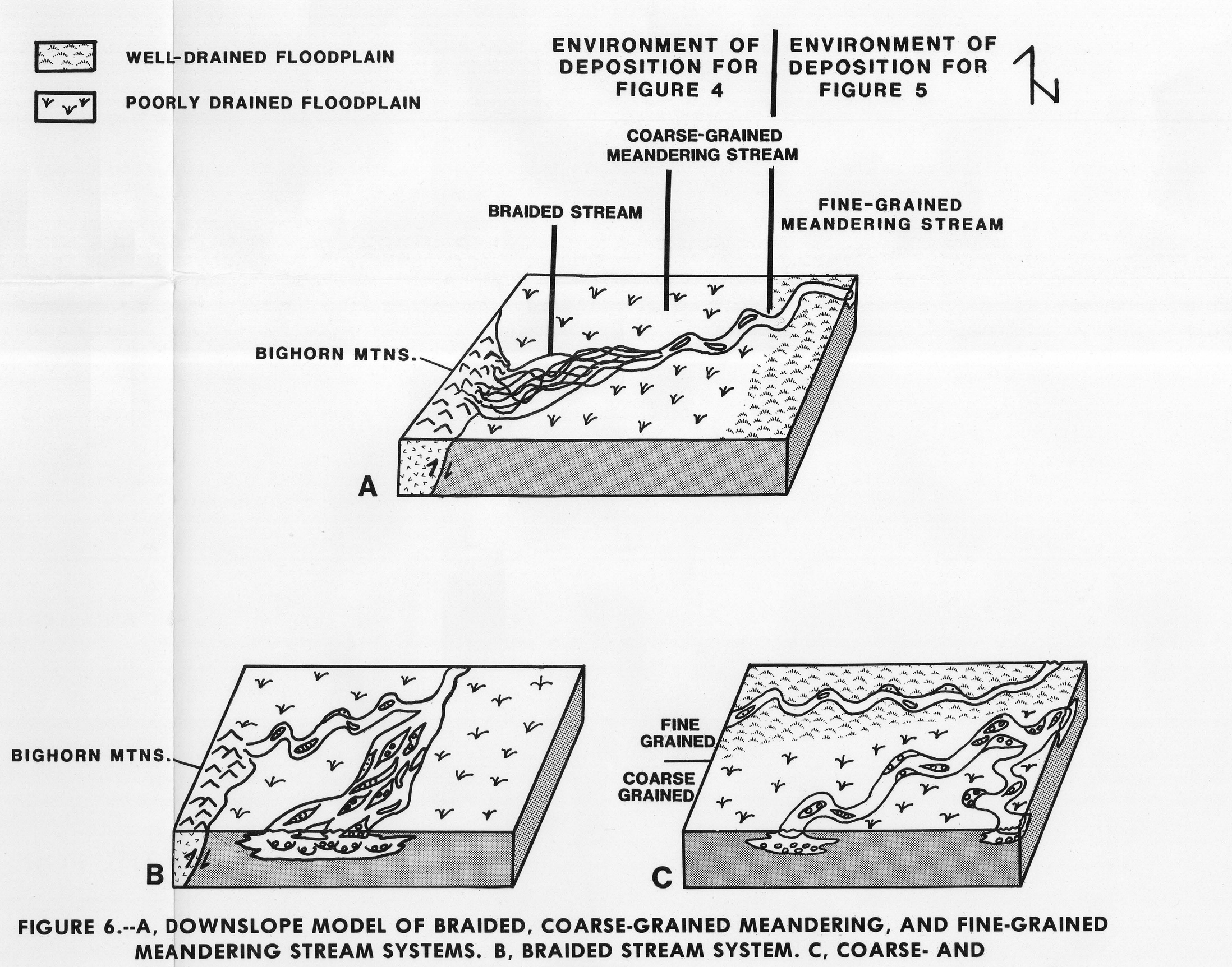

FIGURE 6.--A, DOWNSLOPE MODEL OF BRAIDED, COARSE-GRAINED MEANDERING, AND FINE-GRAINED MEANDERING STREAM SYSTEMS. B, BRAIDED STREAM SYSTEM. C, COARSE- AND FINE-GRAINED MEANDERING STREAM SYSTEMS.

SEDIMENTOLOGIC AND STRATIGRAPHIC FRAMEWORK OF THE UPPER PART OF THE FORT UNION FORMATION, WESTERN POWDER RIVER BASIN, WYOMING

By
J. N. Weaver and R. M. Flores

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