Chapter GS

FORT UNION COAL IN THE GREATER GREEN RIVER BASIN, EAST FLANK OF THE ROCK SPRINGS UPLIFT, WYOMING: A SYNTHESIS

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INTRODUCTION

Subbituminous coal exists in the Fort Union Formation (Paleocene) along the east flank of the Rock Springs uplift in the Greater Green River Basin in south-central Wyoming (figs. GS-1 and GS-2). The formation makes up the surface bedrock over much of the east flank of the uplift (figs. GS-2 and GS-3). The Fort Union strata (fig. GS-4) are unconformably underlain by the Lance Formation (Upper Cretaceous) and conformably overlain by the Wasatch Formation (Eocene).

Coal in the Greater Green River Basin was discovered about the same time as the coal in the Hanna and Carbon Basins in Wyoming. Howard Stansbury conducted a survey along the Overland Trail in southern Wyoming from 1848 to 1850 for the Bureau of Topographic Engineers (Gardner and Flores, 1989). He reported the presence of coal around Evanston and eastward and labeled the area as a coal basin. More specifically he mentioned outcrops of coal along Bitter Creek and near the Point of Rocks (fig. GS-3), which include Cretaceous and Tertiary coal deposits. Coal occurrences elsewhere along the Overland Trail were reported in Fremont's accounts of the "Expedition to Oregon and North California in years 1843-1844." Coal was mined in 1859 along the Overland Trail to provide fuel for Fort Bridger's blacksmith shop. In addition, many stage stations along the Overland Trail (name taken from the Overland Stage Line Company) used locally available coal for heating and blacksmith shops (Gardner and Flores, 1989). Coal mines found adjacent to several stage stations were described by Evans (1865). In 1886 Evans surveyed the proposed Union Pacific rail line along the future route of the transcontinental railroad to explore for coal deposits to provide fuel for the locomotives. The Union Pacific Railroad right-of-way was mapped by Lee (1915).

The first geological mapping in the region was provided by the Hayden Survey during 1877 (Hayden, 1879). The region was subdivided into the Green River (west) and Sweetwater (east) divisions, with the north-south axis of the Rock Springs uplift serving as a boundary. Early geological investigations in these divisions placed emphasis on finding vertebrate fossils. Discoveries of mammalian and fish fossils spurred paleontologists to study the Green River division (currently known as Green River Basin, fig. GS-1). Schultz (1909; 1910) provided the first detailed mapping for the purpose of investigating coal deposits. The Fort Union rocks along the eastern flank of the Rock Springs uplift were first included in the Eocene Wasatch Formation by Schultz (1909). However, Brown (1949) assigned these rocks to the Paleocene Fort Union Formation based on the megaflora. The Fort Union Formation along the eastern flank of the Rock Springs uplift is unconformably underlain by the uppermost Cretaceous Lance Formation; the contact is marked by a paleosol (ancestral soil horizon) at the base of the Fort Union (Ritzma, 1965; Land, 1972; see fig. GS-4). The thickness of the Fort Union Formation in this area varies from 600 to 1,435 ft (Maywood, 1987).

Our study investigates the Deadman coal zone, which is found in the lower 200 ft of the Fort Union Formation. As many as five coal beds of this zone are currently mined and leased within an area of about 25 square miles of the Fort Union that is north and east of Point of Rocks and east and south of Black Buttes (see fig. GS-3). These deposits contributed more than 9,245,390 short tons or more than 0.09 percent of the total U.S. coal production in 1998 (Resource Data International, Inc., 1998). The coal beds are expected to continue to contribute fuel supplies for the Jim Bridger mine-mouth electric power plant. The intensive exploration and development of the Deadman coal zones from the 1970's to the present by the Black Butte Coal Company and NERCO Coal Corporation provided subsurface stratigraphic information for our coal assessment. A total of 1,960 drill holes made by these coal companies are archived as digital records in the U.S. Bureau of Land Management in Rock Springs, Wyoming. These data are proprietary. Significant previous contributions to the Tertiary geology of the Rock Springs uplift were provided by Bradley (1961), Brown (1962), Carey (1955), Fidlar (1950), Hettinger and Kirschbaum (1991), Hettinger and others (1991), Johnston (1959), Morgensen (1959), Nace (1936; 1939), Pipiringos (1955), Ritzma (1965), Roehler (1961; 1979a; 1979b; 1979c; 1983), Severn (1959), and Smithson (1959).

HISTORY OF COAL MINING

Coal mining along the Overland Trail in the Rock Springs uplift began before 1865 (Evans, 1865). Mining occurred mainly adjacent to stage stations, which were built from seven to seventeen miles apart (Jackson, 1982; Gardner and Flores, 1989). Evans (1865) described several coal beds, which ranged from 0.5 to 5 ft thick, that were mined at the Black Butte stage station south of Point of Rocks. The coal provided fuel for heating the stage station and blacksmith shop. The mining activities of the stage operators played a significant role in the decision to use southern Wyoming as the route for the Union Pacific Railroad. The main purpose of this route was to connect major settlements in California and the mining towns in Nevada with the midwestern and eastern cities. The railroad (Union Pacific Coal Company, 1940) operated coal mines and created the market for Wyoming coal for its steam locomotives; the railroad provided a means of transport of fuel to western and midwestern cities (Gardner and Flores, 1989). The large coal deposits in southern Wyoming offered an inducement for development by railroad companies because during the late 1860's American railroads were switching from wood to coal for fuel for steam locomotives. This led to government aid to the railroads through the Railroad Act of 1862, which granted 10 alternating sections of land in a checkerboard pattern along the right-of-way for every mile of track laid; the Railroad Act was modified in 1864 to grant 20 alternating sections for every mile of track laid. This gave the Union Pacific major control of vast amounts of coal in southern Wyoming and the monopoly for transport of coal from its mines.

From 1868 to 1870, underground coal mines were opened on land granted to the railroad in the Greater Green River Basin at Rock Springs, Black Butte, and Point of Rocks. By early 1869, Rock Springs became the most important mining town on the Union Pacific Railroad main line; coal production was mainly from Cretaceous deposits. By 1870 there were six coal mines operating in the Bitter Creek valley, which included the Rock Springs, Black Butte, Van Dyk, Blair, Point of Rocks, and Hall mines. At Hallville, located 30 miles east of Rock Springs, the mines were reported by the Wyoming Tribune to have contributed one hundred car loads per week bound for Omaha and the east (Gardner and Flores, 1989). However, by 1889 the Hallville mines were not even mentioned in the state coal inspector's report, and the mines subsequently were abandoned. The Black Butte, Point of Rocks, Blair, and Van Dyk mines were operated from 1869 to the early Twentieth Century; however, none of these mines had the same production successes as the Hallville and Rock Springs mines. For example, the Rock Springs mines produced a total of 59,417 tons from 1868 to 1870 (Gardner and Flores, 1989); the Union Pacific Railroad consumed 35,359 tons and shipped 2,949 tons, and remaining tonnages were used for heating homes. Production from the Rock Springs mines along the Union Pacific Railroad increased to 208,222 tons by 1875 and to 527,811 tons by 1880. This coal production was from underground mines using pick, shovel, and blasting as well as room-and-pillar mining methods.

From 1875 to 1895, the tonnage produced from Union Pacific mines nearly tripled, spurred on by mechanization. Installation of mining machines in the Rock Springs No. 4 mine increased coal production from 306,150 to 943,943 tons from 1884 to 1892 (Gardner and Flores, 1989). The first electric motor appeared in the Rock Springs mines in 1892. During the early 1900's, increased mechanization (for example, electric cutting machines, electric drills, and electric loading machines) further increased the efficiency and productivity of the Union Pacific mines. Also, installation of underground electric locomotives increased the speed at which coal could be transported out of the mines. Electric generating plants were constructed at the mining camps to power this equipment. Coal was used to fire boilers which supplied steam to run electric generators that provided power for the mines. Electric generating plants became a part of coal mining in the early Twentieth Century. With mechanization more mines were opened in the Rock Springs uplift area; these included the Stansbury, Reliance, and Superior mines (see fig. GS-3).

The 1940's through 1950's constituted a critical period for the Union Pacific mines in the Rock Springs area because of the introduction of diesel locomotives on railroads (Gardner and Flores, 1989). All but three Union Pacific coal mines were closed by the end of 1954. The last Union Pacific mine near Rock Springs closed in 1962 with the termination of the more than 100-year-long dependency on coal by the railroad. In the 1970's energy suppliers built coal-fired power plants as a response to clean-air regulations, the need for cheaper energy, and the oil embargo. Coal in the Rock Springs area once again was in the upswing as strip mining was introduced, particularly in the Jim Bridger and Black Butte mines in the 1970's. The Jim Bridger mine produced from the Fort Union coal beds and the Black Butte mine produced from the Fort Union and Lance coal beds. Since 1974, coal mined at the Jim Bridger mine has almost exclusively supplied the fuel for the nearby 2,000 megawatt Jim Bridger power plant. Some of the coal produced from the Black Butte mine is also consumed by the power plant. At present these mines produce from the Deadman coal zone and equivalent coal beds, which are the target of this coal assessment. The Deadman coal zone in the Bridger mine includes the D1 to D5 coal beds. The Deadman coal zone is laterally equivalent to the A, B, and C coal beds or the A-C coal zone in the Black Butte mine (Maywood, 1987). The Black Butte mine still produces from Lance coal.

GEOLOGICAL SETTING

The Rock Springs uplift is a north-south-trending, doubly plunging, asymmetrical anticline of Laramide age (Eardley, 1951; Ritzma; 1955; see fig. GS-1). The Rock Springs uplift divides the Greater Green River Basin into the Green River, Great Divide, and Washakie Basins, which are structural and sedimentary basins (see fig. GS-1). The Wamsutter arch is aligned with the eastward bulging of the Rock Springs uplift and was postulated by Blackstone (1955) to be an extension of the uplift. The Greater Green River Basin is bounded by the Uinta Mountains on the south, the Wyoming Overthrust Belt on the west, the Gros Ventre Range-Wind River Mountains on the north, and the Granite Mountains-Rawlins uplift-Sierra Madre Mountains on the east (Fidlar, 1950; Hunt, 1967).

The Rock Springs uplift is about 60 mi long and 40 mi wide. The core of the uplift is composed of Upper Cretaceous rocks flanked by the Paleocene Fort Union Formation and Eocene Wasatch Formation. Uplift of the rocks resulted in development of resistant sandstone hogbacks on the west flank and cuestas on the east flank. The rocks on the west flank dip 10-15 degrees and on the east flank they dip 5-8 degrees. Many northeast-trending normal and strike-slip faults break up the continuity of the outcrops.

From Cretaceous to early Tertiary time, prior to uplift, the Rock Springs area served as a depocenter (Keith, 1965; Roehler, 1965; Weimer, 1970; Land, 1972; Levey, 1985). The area was established as a foreland basin bounded to the west by the Cordilleran belt and to the east by the Cretaceous epeiric seaway (Weimer, 1970). Sedimentary infilling of this basin by fluvial, deltaic, and marine deposits during Cretaceous time was controlled by tectonic movement of the Cordilleran belt and the rise and fall (transgression and regression) of the epeiric sea. The onset of the Laramide tectonism during early Tertiary time influenced the sedimentary infilling by fluvial environments of this foreland basin. Early Tertiary Laramide tectonism was characterized by structural partitioning of the Cretaceous foreland basin (Perry and Flores, 1994). Uplifts divided the foreland basin into intermontane basins where sedimentary infilling was controlled by base-level changes affecting fluvial channels.

The Fort Union Formation on the east flank of the Rock Springs uplift ranges from 1,059 to 1,800 ft thick (Roehler, 1979a, 1979b; Winterfeld, 1982; Madden, 1989; Hettinger and Kirschbaum, 1991). Roehler (1979a; 1979b) divided the Fort Union Formation on the southeastern flank of the Rock Springs uplift into lower and upper parts consisting of lithologically similar intervals of sandstone, siltstone, mudstone, carbonaceous shale, and coal (fig. GS-4). The lower part is 300 ft thick and the upper part is about 1,000 ft thick, and they are separated by persistent paleosols. Madden (1989) described paleosol horizons found 200 ft, 360 ft, and 900 ft above the base of the Fort Union Formation. The contact between the Fort Union Formation and the underlying Lance Formation is marked by an unconformity underlain by a thick paleosol (see fig. GS-4). Eastward into the Washakie Basin, this unconformity is marked by a conglomerate at the base of the upper part of an unnamed Cretaceous and Tertiary sandstone. The contact between the Fort Union Formation and the overlying Wasatch Formation is poorly defined because of its gradational characteristics. Hettinger and Kirschbaum (1991) noted a granular sandstone 700-800 ft above the base, which they interpreted as equivalent to the unnamed upper Paleocene basal sandstone as defined on the east flank of the Washakie Basin (see fig. GS-1).

Three coal zones were observed in the Fort Union Formation on the east flank of the Rock Springs uplift (Madden, 1989; Hettinger and Kirschbaum, 1991). These coal zones include the Deadman coal zone, which is present in the lower 200 ft of the formation and which contains coal beds as thick as 32 ft (Maywood, 1987; Madden, 1989). Two unnamed coal zones found above the unnamed upper Paleocene basal sandstone are as much as 800 ft thick; they are 700-800 ft above the base of the formation. The unnamed coal zone immediately above the basal sandstone includes the Nuttal coal bed. The upper unnamed coal zone was first mapped by Schultz (1909) and was remapped by Love and Christiansen (1985) near the top of the Fort Union Formation. This unnamed coal zone was correlated to the Cherokee coal in the subsurface of the Washakie Basin by Hettinger and Kirschbaum (1991).

The lower 300 ft of the Fort Union Formation on the east flank of Rock Springs uplift was dated by Winterfeld (1982) as Torrejonian based on vertebrate fossils and using North American mammalian ages. He also dated the interval from 300 to 1,275 ft as Tiffanian and the upper 275 ft as Clarkforkian. Based on palynomorphs, Nichols (see Chapter GB, this CD-ROM) dated the Deadman coal zone in the lower 200 ft of the Fort Union as palynostratigraphic zone P3; this interval is Torrejonian according to Winterfeld (1982). The interval above the Deadman coal zone that includes the unnamed upper Paleocene unit was dated as zones P3 or P4 to zone P6 by Nichols (Hettinger and Kirschbaum, 1991); this is the Tiffanian and Clarkforkian interval according to the age determinations of Winterfeld (1982).

DEPOSITIONAL SETTING

The Fort Union Formation on the east flank of the Rock Springs uplift was interpreted as fluvial channel, floodplain, lacustrine, and swamp deposits by Roehler (1979a; 1979b), Maywood (1987), Madden (1989), and Hettinger and Kirschbaum (1991). The unnamed basal Cretaceous and Tertiary sandstone and the unnamed upper Paleocene basal sandstone, which comprise stacked bodies (Hettinger and Kirschbaum, 1991), probably represent braided-river deposits. Erosional bases of these basal sandstones probably reflect lowering of base level due to uplifts. These events permitted fluvial channels to downcut and form paleovalleys that were subsequently infilled during succeeding rises in base level. Major events of downcutting and subsequent infilling of paleovalleys by streams occurred during early Paleocene (zone P2) time and middle Paleocene (zone P4) time. The intervening coal-bearing zones (for example, Deadman and unnamed coal zones), consisting of sandstone, siltstone, mudstone, and coal, reflect base-level rises during which alluvial plains were drained mainly by meandering and anastomosed rivers. Thus, cyclic intervals of deposition of conglomeratic sandstone and coal-bearing rocks represent base-level rise and fall controlled by subsidence and tectonism.

Study of sediment dispersal of the coal-bearing part of the Fort Union Formation in the Point of Rocks-Black Butte coalfield by Maywood (1987) suggested a northerly provenance and source, which was most likely the Wind River Mountains (see fig. GS-1). This conclusion is based on the presence of about 10% muscovite in the sandstone, which Maywood (1987) interpreted as derived from the plutonic rocks in the Wind River Mountains. The lower part of the Fort Union in the southern part of the coalfield contains a high sandstone to mudstone ratio (3.6:1) with the sandstone displaying a high width to depth ratio (130:1) (Maywood, 1987). These ratios indicate deposition of the sandstone bodies in braided rivers. However, Maywood (1987) suggested that the presence of a few lateral accretion surfaces in narrow and deep channel sandstone beds indicated deposition in anastomosed and meandering rivers. Maywood (1987) further suggested that these fluvial systems became stabilized as the increased amounts of clay (as much as 95 percent) inhibited lateral channel migration.

Fluvial depositional facies in the Deadman coal zone of the Fort Union Formation is well represented in the mine highwalls of the Jim Bridger coal mine. Vertically stacked, fining-upward fluvial channel sandstone thins and thickens along the mine wall indicating lateral offset pattern formed in meandering rivers (fig. GS-5). The fluvial channel sandstone bodies contain thin "clay drapes" consisting of mudstone and siltstone, which represent lateral accretion units typically formed in meandering rivers. The fluvial channel sandstone is bounded by thin to thick, crevasse-splay sandstone interbedded with floodplain mudstone and siltstone (fig. GS-6). The crevasse-splay sandstone is tabular shaped and locally incised by a crevasse channel (figs. GS-7 and GS-8). Preserved tree stumps (fig. GS-9) in the crevasse splay deposits attest to the rapid sedimentation in this environment. In the Black Butte coal mine highwalls, similar fluvial channel and crevasse splay sandstone, siltstone, and mudstone are exposed in the A-C or Deadman coal zone (fig. GS-10).

The paleosols within the Fort Union Formation on the east flank of the Rock Springs uplift reflect pedogenesis caused by fluctuation of the groundwater table due

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to changes in paleoclimate (Thorez and others, 1994). Paleoclimatic conditions in the area are indicated by the presence of megaflora fossils in rocks associated with the Deadman coal beds (Brown, 1962; Maywood, 1987). The fossil flora includes *Cornus nebrascensis* (dogwood), *Selaginella* sp. (fern), *Salvinia* (floating fern), *Cercidiphyllum* (katsura), and *Sabalites* sp. (palm). This megaflora indicates accumulation of the Deadman peat deposits and associated sediments in warm-temperate to subtropical paleoclimate. The megaflora is interpreted to have inhabited levees (for example, katsura), floodplains (for example, ferns and unidentified monocots) and swamps (palms). That the paleoclimate varied from warm-temperate to subtropical is indicated by the cyclical occurrence of Fort Union paleosols. The thickness (as much as 7.2 ft) and persistent distribution of the paleosols (Ritzma, 1955, 1965; Maywood, 1987; Madden, 1989) suggest more of a regional change than a local change in the paleoclimate.

Sedimentological and paleobotanical evidence suggests that the Fort Union swamps were probably low-lying and were prone to floods by braided, meandering, and anastomosed rivers. This is supported by the moderately high ash yield, varying from 5 to 39 percent (average 12 percent) of the Deadman coal beds (D1 to D5). In addition, splitting and merging of the Deadman coal beds over short distances suggest rapid abandonment and reoccupation of the swamps by these rivers. These fluvial processes are confirmed by abundant standing tree trunks, as much as 28 ft in height, in mine highwalls (Maywood, 1987). The presence of floating ferns suggests vegetation in standing bodies of water, probably in floodplain lakes. The fluvial depositional settings for the Deadman coal zone may explain the high variability of the thicknesses of individual coal beds (0.1 to 17.1 ft) being assessed (coal beds D1-D5 in the Jim Bridger coal mine and coal beds A-C in the Black

Butte mine). These coal beds merge to form a single coal bed as much as 32 ft thick.

COAL GEOLOGY

The Deadman coal zone (coal beds D1-D5) is exceptionally well developed along the eastern flank of the Rock Springs uplift where the beds have been referred to as the Jim Bridger deposit (Glass, 1976). Where the coal beds merge, the Deadman coal zone is as much as 32 ft thick. It is subbituminous in rank. The Deadman coal zone may be traced southward into the Black Buttes area where only three coal beds (A-C) are found. These coal beds are probably equivalent to the Little Valley coal bed of Roehler (1977). Mapping by Roehler in the southeastern part of the Rock Springs uplift shows three persistent coal beds and several local thick beds belonging to the Black Rock coal group (Roehler 1976a; 1976b; 1977). This coal group is composed of, from bottom to top, the Little Valley, Hail, and Big Burn coal beds, which vary from 6 to 15 ft thick. The Hail and Big Burn coal beds are probably equivalent to the Nuttal and Cherokee coal zones in the northeastern flank of the Rock Springs uplift (Madden, 1989; Hettinger and Kirschbaum, 1991).

The coal beds of the Deadman coal zone in the Jim Bridger study area are interbedded with sandstone, siltstone, mudstone, coal, shale, limestone, and conglomerate. Sandstone is the most abundant (more than 65 percent by volume) and shale, limestone, and conglomerate are the least common (less than 1 percent by volume) (Maywood, 1987). Mudstone, siltstone, and coal amount to more than 16, 11, and 9 percent by volume, respectively. The vertical thickness variation of the sandstone, siltstone, mudstone, shale, limestone, and conglomerate control the merging and splitting of the coal beds. The five coal beds of the Deadman coal zone are identified numerically in ascending stratigraphic order as D1, D2, D3, D4, and D5. Coal beds that merge as a result of thinning and/or pinching out of intervening rocks, such as beds D1 and D2, or D1, D2, and D3, are identified as beds D1-D2 or D1-D3, respectively. The merging of five coal beds formed a single 32-ft-thick bed (D1-D5). Rock intervals between coal beds vary from 25 to 75 ft thick, with sandstone composing most of the rock intervals.

In the Black Buttes study area the A to C coal beds, which are laterally equivalent to the Deadman coal beds, are interbedded with sandstone, siltstone, and mudstone. Sandstone and mudstone are the most abundant (as much as 70 percent by volume) and siltstone is the least abundant (30 percent by volume). Merging and splitting of the coal beds are influenced by the vertical thickness variation of these rock types. The three coal beds are identified alphabetically from A to C in an ascending stratigraphic order. Coal beds that merge as a result of thinning and/or pinching out of intervening rocks, such as bed B and C, are identified as bed B-C. The merging of coal beds formed a single bed as much as a 22 ft thick. Rock intervals between coal beds vary from 25 to ft thick, with sandstone composing most of the intervals.

Biostratigraphy based on palynology (analysis of fossil spores and pollen) of the Deadman coal zone utilizes the zonation of Nichols and Ott (1978; see also Nichols, 1994; 1996); additional relevant age determinations of Nichols were published by Hettinger and Kirschbaum (1991). Paleocene Zones P3 through P6 are present in the Fort Union Formation along the eastern flank of the Rock Springs uplift (see fig. GS-4 and Chapter GB). The Deadman coal zone is dated as Zone P3 (early middle Paleocene).

The vertical and lateral variations in coal stratigraphy in the Deadman coal zone and equivalent coal zones are controlled by the sedimentology and depositional environments of the rocks interbedded with the coal. The interbedded rocks consist of sandstone, siltstone, and mudstone, which represent the fluvial channel-overbank deposits of the fluvial systems (Maywood, 1987). In the Deadman coal zone, coal beds split and merge within distances of 1.5-6.3 mi. This coal zone is controlled by the sedimentation of the fluvial depositional systems that formed the deposits. The sandstone was mainly deposited in fluvial channels incised into old floodplain deposits; incision was probably caused by base-level fall. The fluvial channels were successively infilled by stream deposits. Floodplain sedimentation by crevasse splay depositional systems produced intervals composed mainly of siltstone and mudstone, and subordinate sandstone. These floodplain deposits formed platforms on which swamps accumulated peat deposits. Frequent autocyclic (lateral) shifts of the fluvial channels and crevasse splays influenced the splitting and merging of the peat deposits, resulting in repeated abandonment and reoccupation of the swamps.

COAL RESOURCES AND COAL QUALITY

The strippable resource base of the Deadman coal zone is approximately 250 million tons (Smith and others, 1972). No resource calculation is available earlier than this estimate. The Deadman coal zone, otherwise known as the Jim Bridger deposit, was not strip-mined until 1974 (Glass, 1976). Production from this coal deposit in the Jim Bridger mine was 3,567,058 tons in 1976 and 5,448,953 tons in 1977 (Glass, 1976). Total production from the mine during the period 1989-1997 was 62,198,940 tons (Resource Data International, Inc., 1998). No production data are available for the period 1979-1989. The coal resource of the equivalent units to the Deadman coal zone in the Black Buttes area is more than 89 million tons (Black

Butte Coal Company, 1987). The coal resources of the Deadman coal zone in the Black Butte and Jim Bridger areas are estimated to be 2.7 billion short tons (see Chapter GN). The methodology of calculating the resources of these coal beds and zones is discussed in Chapters DB and GN.

The moisture, volatile matter, and fixed carbon values (arithmetic mean; as-received basis) for the Deadman coal zone are 20.7, 32.32, and 34.4 percent, respectively (Smith and others, 1972; Glass, 1976). The sulfur and ash contents of the coal are 1.8 and 12.7 percent, respectively (Glass, 1976). The calorific value of the Deadman coal zone ranges from 9,270 to 10,000 Btu/lb (subbituminous in rank). In contrast, the moisture, volatile matter, and fixed carbon values (arithmetic mean; as-received basis) for the Black Rock coal group are 17.69, 30.93, and 43.85 percent, respectively (VTN Consolidated Incorporated, 1974). The sulfur and ash contents of the coal are 0.41 and 8.48 percent, respectively. The calorific value of the Black Rock coal group is 9,728 Btu/lb (subbituminous in rank).

Our coal-quality investigation of the Deadman coal zone indicates the following arithmetic mean values (on an as-received basis) for the coal not presently being mined or leased: ash yield—11.18 percent, total sulfur—0.56 percent, and calorific value—9,000 Btu/lb (see Chapter GQ for more detail). The trace elements of environmental concern in the Deadman coal zone, which can impact coal utilization and reclamation, include 0.79 ppm antimony, 21 ppm arsenic, 0.69 ppm beryllium, 0.28 ppm cadmium, 13 ppm chromium, 2.8 ppm cobalt, 5.5 ppm lead, 23 ppm manganese, 0.20 ppm mercury, 9.7 ppm nickel, 2.8 ppm selenium, and 5.1 ppm uranium (n=26; Stricker and others, 1998). These workers suggested that the higher sulfur, ash, and trace-element contents of the Deadman coal zone compared to other basins in the Rocky Mountains and northern Great Plains region were controlled by the source rocks in the surrounding uplifts, the intensity of the tectonic activity in these uplifts, and the low-lying swamps associated with the fluvial depositional settings.

CONCLUSIONS

The Deadman coal zone and equivalent coal beds along the eastern flank of the Rock Springs uplift represent a significant energy resource in south-central Wyoming. Mining in this coal zone has taken place during the past 25 years. The most important use of this coal resource is fuel for electric power generating plants. Currently, open-pit mines in the Deadman coal zone and equivalent coal beds supply fuel for the Jim Bridger electric power plant.

In order to evaluate the subbituminous coal needed for electric power plants during the next century, assessment of the coal beds in the Fort Union Formation along the eastern flank of the Rock Springs uplift focused on beds D1, D2, D3, D4, and D5 of the Deadman coal zone (Jim Bridger mine) and the equivalent A, B, and C coal beds (Black Butte mine). These coal deposits are as much as 32 ft thick and have low amounts of sulfur, ash, and trace elements. These Fort Union coal beds contain approximately 250 million tons (Smith and others, 1972) of remaining strippable coal resources under less than 200 ft of overburden. Our study estimates the coal resources to be 2.7 billion short tons (see Chapter GN).

The Deadman coal zone and equivalent coal beds were deposited in swamps associated with fluvial depositional systems. The variable vertical and lateral distribution of these coal beds and zones reflect accumulation in dynamic fluvial settings controlled by autocyclic processes. These fluvial environmental conditions also influenced the coal quality (for example, rank, ash, sulfur, and trace elements) of the coal beds of the Deadman coal zone. These coal beds will serve well as a clean energy resource during the next few decades.

REFERENCES

Black Butte Coal Company, 1987, State program compliance submittal permit application No. 467-T2, v. 4, p. D506-D516.

Blackstone, D.L., Jr., 1955, Notes on a tectonic map of parts of southwestern Wyoming and adjoining states: 10th Annual Field Conference Guidebook, Wyoming Geological Association, p. 122-124.

Bradley, W.H., 1961, Geologic map of a part of southwestern Wyoming and adjacent states: U.S. Geological Survey Miscellaneous Geologic Investigation Series Map I-332.

Brown, R.W., 1949, Paleocene deposits of the Rocky Mountains and Plains: U.S. Geological Survey Preliminary Map.

_____1962, Paleocene floras of the Rocky Mountains and Great Plains: U.S. Geological Survey Professional Paper 373, 257 p.

Carey, B.D., 1955, A review of the geology of Leucite Hills: Wyoming Geological Association Guidebook, 10th Annual Field Conference, p. 112-113.

Eardley, A.J., 1951, Structural geology of North America: New York, Harper and Brothers, 624 p.

Evans, J.A., 1865, Report of Jas. A. Evans of exploration from Camp Walbach to Green River: Union Pacific Historical Museum, File K-13-1, 11 p.

Fidlar, M.M., 1950, Structural features of the Green River Basin in Wyoming: Wyoming Geological Association Guidebook, 5th Annual Field Conference, Southwest Wyoming, p. 86-87.

Gardner, A.D., and Flores, V.R., 1989, Forgotten Frontier: A History of Wyoming Coal Mining: Westview Press, Boulder, Colorado, 243 p.

Glass, G.B., 1976, Review of Wyoming coal fields, 1976: Wyoming Geological Survey, Public Information Circular 4, 91 p.

Green, G., and Drouillard, P.M., 1994, Wyoming digital geologic map: U.S. Geological Survey Open-File Report 94-0425, scale 1:250,000.

Hayden, F.V., 1879, Third annual report of the U.S. Geological and Geographical Survey of the Territories: Washington, 191 p.

Hettinger, R.D., Honey, J.G., and Nichols, D.J., 1991, Chart showing correlations of upper Cretaceous Fox Hills Sandstone and Lance Formation, and lower Tertiary Fort Union, Wasatch, and Green River Formations, eastern flank of the Washakie basin to the southeastern part of the Great Divide basin, Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I-2151.

Hettinger, R.D., and Kirschbaum, M.A., 1991, Chart showing correlations of some Upper Cretaceous and lower Tertiary rocks, from the east flank of the Washakie Basin to the east flank of the Rock Springs uplift, Wyoming: U.S.

Geological Survey Miscellaneous Investigations Series Map I-2152.

Hunt, C.B., 1967, Physiography of the United States: San Francisco, W.H. Freeman and Company, 480 p.

Jackson, W.T., 1982, Wells Fargo in Colorado Territory: Historical Society Monograph Series, 24 p.

Johnston, R.H., 1959, Geology of the northern Leucite Hills, Sweetwater County, Wyoming: University of Wyoming, M.A. thesis, 83 p.

Keith, R.E., 1965, Rock Springs and Blair Formations on and adjacent to the Rock Springs uplift: Wyoming Geological Association Guidebook, 19th Annual Field Conference, p. 43-53.

Land, C.B., Jr., 1972, Stratigraphy of Fox Hills Sandstone and associated formations, Rock Springs uplift and Wamsutter arch area, Sweetwater County, Wyoming: A shoreline-estuary sandstone model for the Late Cretaceous: Colorado School of Mines Quarterly, v. 67, 69 p.

Lee, R.A., 1915, The overland route, with a side trip to Yellowstone Park: Part B of Guidebook of the Western United States: U.S. Geological Survey Bulletin 612, 244 p.

Levey, R.A., 1985, Depositional model for understanding geometry of Cretaceous coals: Major coal seams, Rock Springs Formation, Green River Basin, Wyoming: American Association of Petroleum Geologists Bulletin, v. 69, p.

1359-1380.

Love, J.D., and Christiansen, A.C., 1985, Geologic map of Wyoming: U.S. Geological Survey Map, scale 1:500,000.

Madden, D.H., 1989, Geological map and measured sections of the Bitter Creek NW Quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Coal Investigations Map C-121.

Maywood, P.S., 1987, Stratigraphic model of the southern portion of the Jim Bridger coal field, Sweetwater County, Wyoming: Portland, Oregon, Portland State University, M.S. thesis, 128 p.

Morgensen, P., 1959, Fort Union Formation, east flank of the Rock Springs uplift, Sweetwater County, Wyoming: Laramie, Wyoming, University of Wyoming, M.A. thesis, 86 p.

Nace, R.L., 1936, Summary of the late Cretaceous and early Tertiary stratigraphy of Wyoming: Wyoming Geological Survey Bulletin 26, 271 p.

_____1939, Geology of the northwest part of the Red Desert, Sweetwater and Fremont Counties, Wyoming: Wyoming Geological Survey Bulletin 27, 52 p.

Nichols, D.J., 1994, Palynostratigraphic correlation of Paleocene rocks in the Wind River, Bighorn, and Powder River Basins, Wyoming, *in* Flores, R.M., Mehring, K.T., Jones, R.W., and Beck, T.L., eds., Organics and the Rockies

Field Guide: Wyoming State Geological Survey, Public Information Circular No. 33, p. 17-29.

_____1996, Palynological zonation of the Paleocene of the Rocky Mountain intermontane basins: Geological Society of America, 1996 Annual Meeting, Abstracts with Programs, v. 28, no. 7, p. 372.

Nichols, D.J., and Ott, H.L., 1978, Biostratigraphy and evolution of the Momipites-Caryapollenites lineage in the early Tertiary in the Wind River Basin, Wyoming: Palynology, v. 2, p. 93-112.

Perry, W.J., Jr., and Flores, R.M., 1994, Sequential Laramide deformation and deep gas-prone basins of the Rocky Mountain region, *in* Dyman, T.S., Rice, D.D., and Wescott, W.A., eds., Geologic Controls of Deep Natural Gas Resources in the U.S.: U.S. Geological Survey Bulletin 2146-E, p. 49-59.

Pipiringos, G.N., 1955, Tertiary rocks in the central part of the Great Divide Basin, Sweetwater County, Wyoming: Wyoming Geological Association Guidebook, 10th Annual Field Conference, p. 100-104.

Resource Data International, Inc., 1998, COALdat: Coal database, 1320 Pearl St., Suite 300, Boulder, Colorado 80302.

Ritzma, H.R., 1955, Late Cretaceous and early Cenozoic structural pattern, southern Rock Springs uplift, Wyoming: Wyoming Geological Association Guidebook, 19th Annual Field Conference, p. 10-12.

_____1965, Fossil soil at base of Paleocene rocks, southern Rock Springs uplift, Wyoming: Wyoming Geological Association Guidebook, 19th Annual Field Conference, p. 10-12.

Roehler, H.W., 1961, The Late Cretaceous-Tertiary boundary in the Rock Springs uplift: Sweetwater County, Wyoming: Wyoming Geological Association Guidebook, 16th Annual Field Conference, p. 96-100.

_____1965, Summary of pre-Laramide late Cretaceous sedimentation in the Rock Springs uplift area: Wyoming Geological Association Guidebook, 19th Annual Field Conference, p. 11-12.

_____1976a, Geology and mineral resources of the Cooper Ridge NE Quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Geologic Quadrangle Map GQ-1363.

_____1976b, Geology and mineral resources of the Sand Butte Rim NW Quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Open-File Report 76-495, 24 p.

_____1977, Geologic Map of the Rock Springs uplift and adjacent areas, Sweetwater County, Wyoming: U.S. Geological Survey Open-File Report 77-242.

_____1979a, Geology and energy resources of the Sand Butte Rim, NW Quadrangle, Sweetwater County, Wyoming: U. S. Geological Survey Professional Paper 1065-A, 54 p.

_____1979b, Geology of the Cooper Ridge NE Quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Professional Paper 1065-B, 45 p.

_____1979c, Geology and mineral resources of the Mud Springs Ranch Quadrangle, Sweetwater County, Wyoming: U.S. Geological Survey Professional Paper 1065-C, 35 p.

_____1983, Stratigraphy of Upper Cretaceous and lower Tertiary outcrops in the Rock Springs uplift area: 19th Annual Field Conference Guidebook, Wyoming Geological Association, p. 10-12.

Schultz, A.R., 1909, The northern part of the Rock Springs coal field, Sweetwater County, Wyoming, *in* Coal fields of Wyoming: U.S. Geological Survey Bulletin 341-B, pt. 2, p. 256-282.

_____1910, The southern part of the Rock Springs coal field, Sweetwater County, Wyoming, *in* Coal fields of Wyoming: U.S. Geological Survey Bulletin 381, pt. 2, p. 214-281.

Severn, W.P., 1959, Stratigraphy of the late Upper Cretaceous, Paleocene, and early Eocene deposits within the east flank of the Rock Springs uplift, Sweetwater County, Wyoming: Laramie, Wyoming, University of Wyoming, M.A. thesis, 90 p.

Smith, J.B., Ayler, M.F., Knox, C.C., and Pollard, B.C., 1972, Strippable coal reserves of Wyoming: U.S. Bureau of Mines Information Circular IC 8538, 51 p.

Smithson, S.B., 1959, The geology of the southeastern Leucite Hills, Sweetwater County, Wyoming: Laramie, Wyoming, University of Wyoming, M.A. thesis, 92 p.

Stricker, G.D., Ellis, M.E., Flores, R.M., and Bader, L.R., 1998, Elements of environmental concern in the 1990 Clean Air Act Amendments: A prospective of Fort Union coals in the northern Rocky Mountains and Great Plains region, *in* Sakkestad, B.A., ed., The Proceedings of the 23rd International Technical Conference on Coal Utilization and Fuel Systems, Coal & Slurry Technology Association, p. 967-976.

Sullivan, R., 1985, Origin of lacustrine rocks of Wilkins Peak Member, Wyoming: American Association of Petroleum Geologists Bulletin, v. 69, p. 913-922.

Thorez, J., Flores, R.M., and Caudron, M., 1994, Clay geology, micromorphology, and geochemistry of an Eocene paleosol in the Willwood Formation, southern Bighorn Basin, Wyoming: an overview, *in* Flores, R.M., Mehring, K.T., Jones, R.W., and Beck, T.L., eds., Organics and the Rockies Field Guide: Wyoming State Geological Survey, Public Information Circular No. 33, p. 139-148.

Union Pacific Coal Company, 1940, History of the Union Pacific Coal Mines, 1868-1940: The Colonial Press, Omaha, Nebraska, 265 p.

VTN Consolidated Incorporated, 1974, Preliminary project description, Black Butte Mine, Sweetwater County, Wyoming: 2301 Campus Drive, Irvine, California, 58 p.

Weimer, R.J., 1970, Rates of deltaic sedimentation and intrabasin deformation, Upper Cretaceous of the Rocky Mountain region, *in* Morgan, J.P., ed., Deltaic Sedimentation, Modern and Ancient: Society of Economic Paleontologists and Mineralogists Special Publication 15, p. 270-292.

Winterfeld, G.F., 1982, Mammalian paleontology of the Fort Union Formation (Paleocene), eastern Rock Springs uplift, Sweetwater County, Wyoming: University of Wyoming Contributions to Geology, v. 21, p. 73-112.

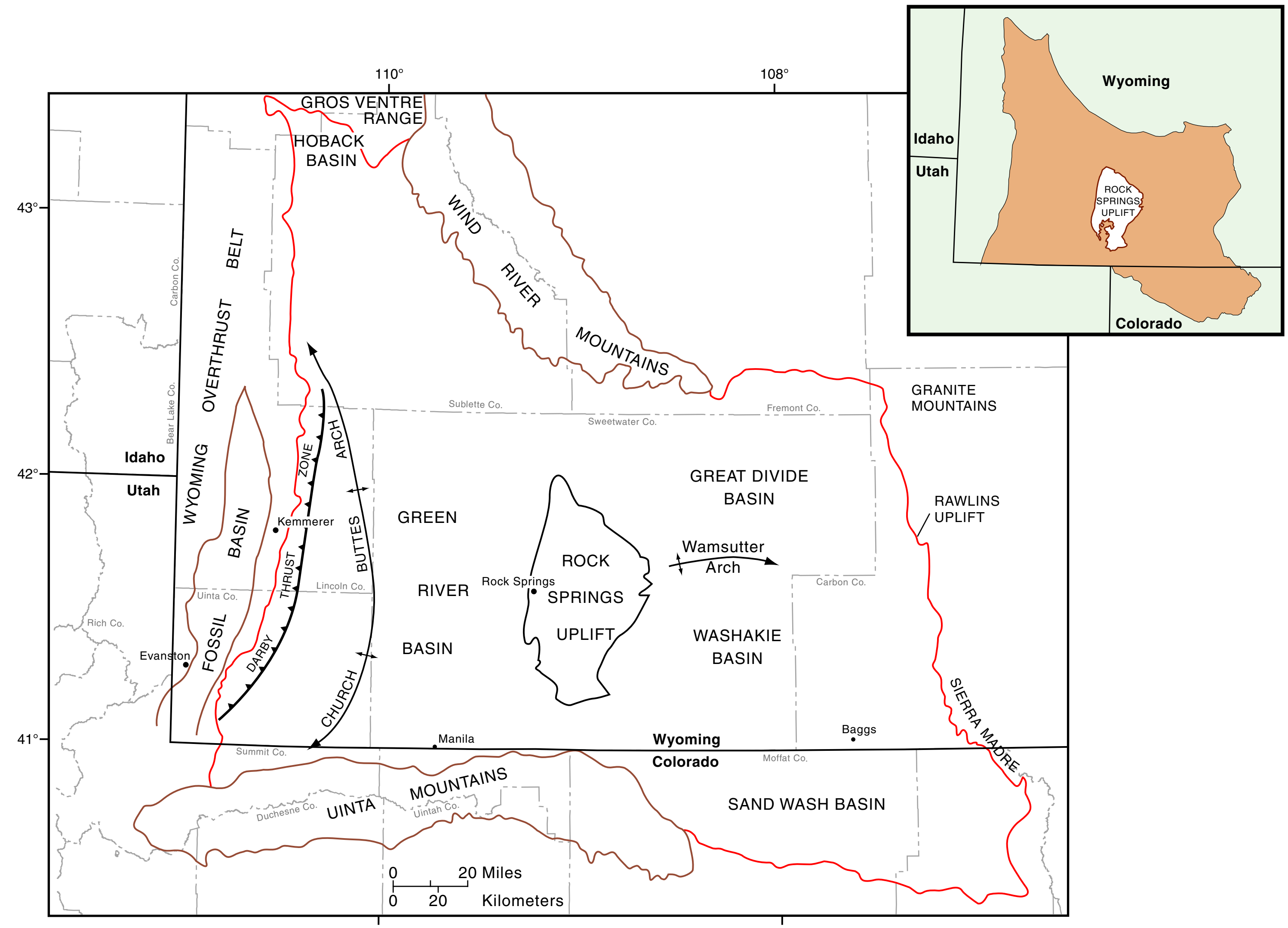

Figure GS-1. Generalized map of the Greater Green River Basin in south-central Wyoming showing associated basins, geologic structures, and surrounding mountains and uplifts (adapted from Sullivan, 1985.)

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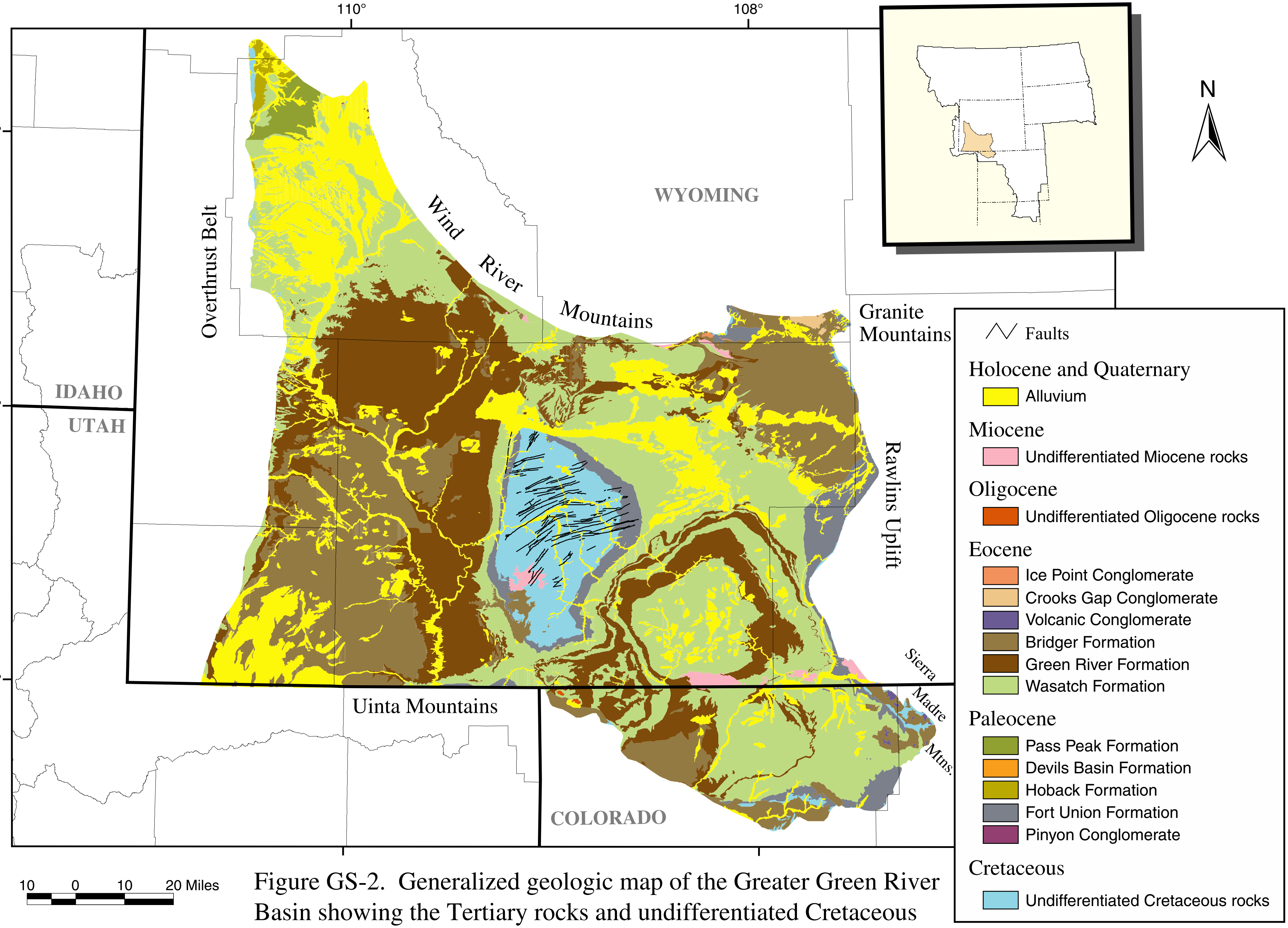

Figure GS-2. Generalized geologic map of the Greater Green River Basin showing the Tertiary rocks and undifferentiated Cretaceous rocks (adapted from Green and Drouillard, 1994.)

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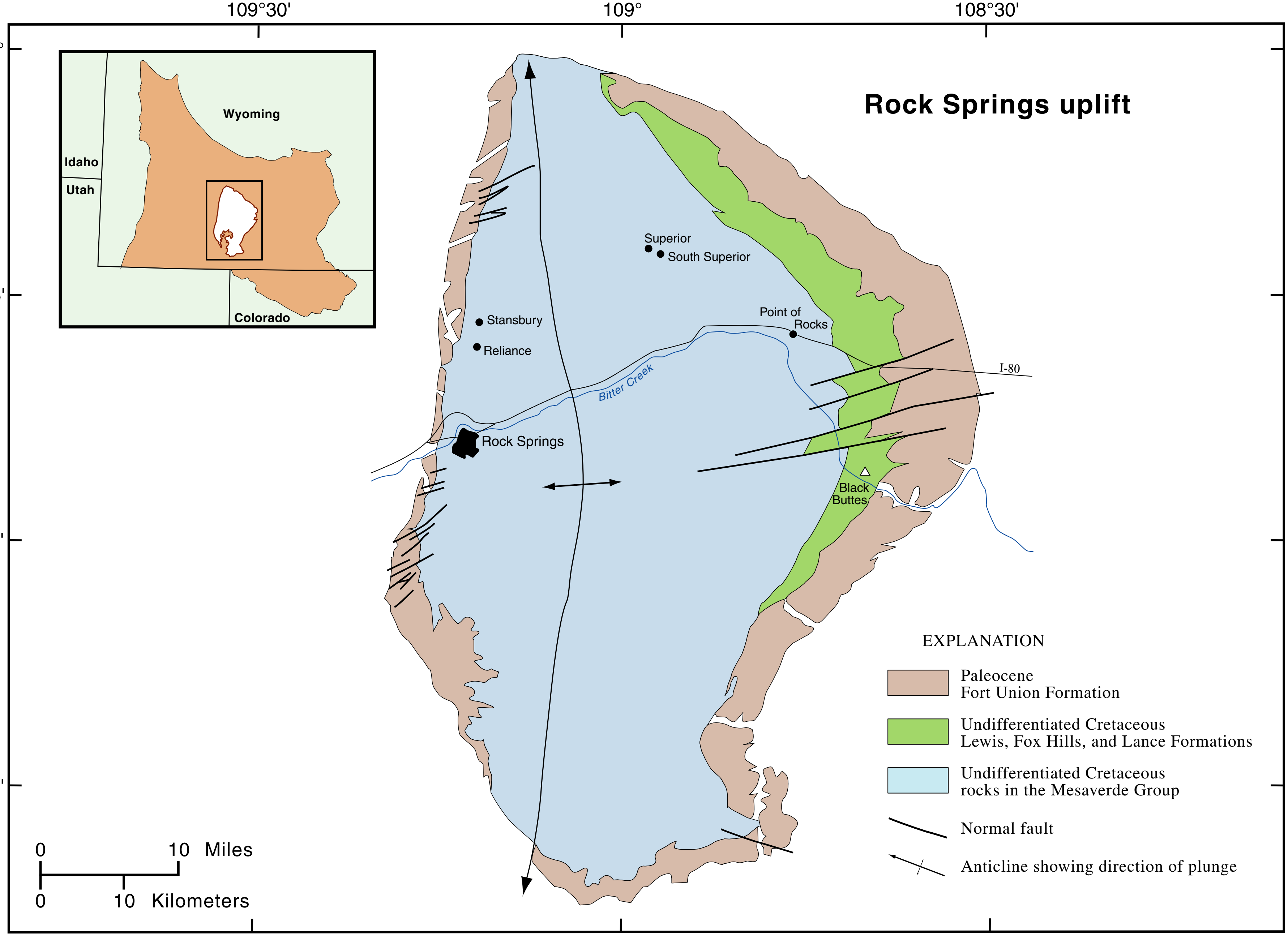

Figure GS-3 Geologic map of the Rock Springs uplift showing outcrops of the Fort Union Formation and Cretaceous rocks (modified from Love and Christiansen, 1985).

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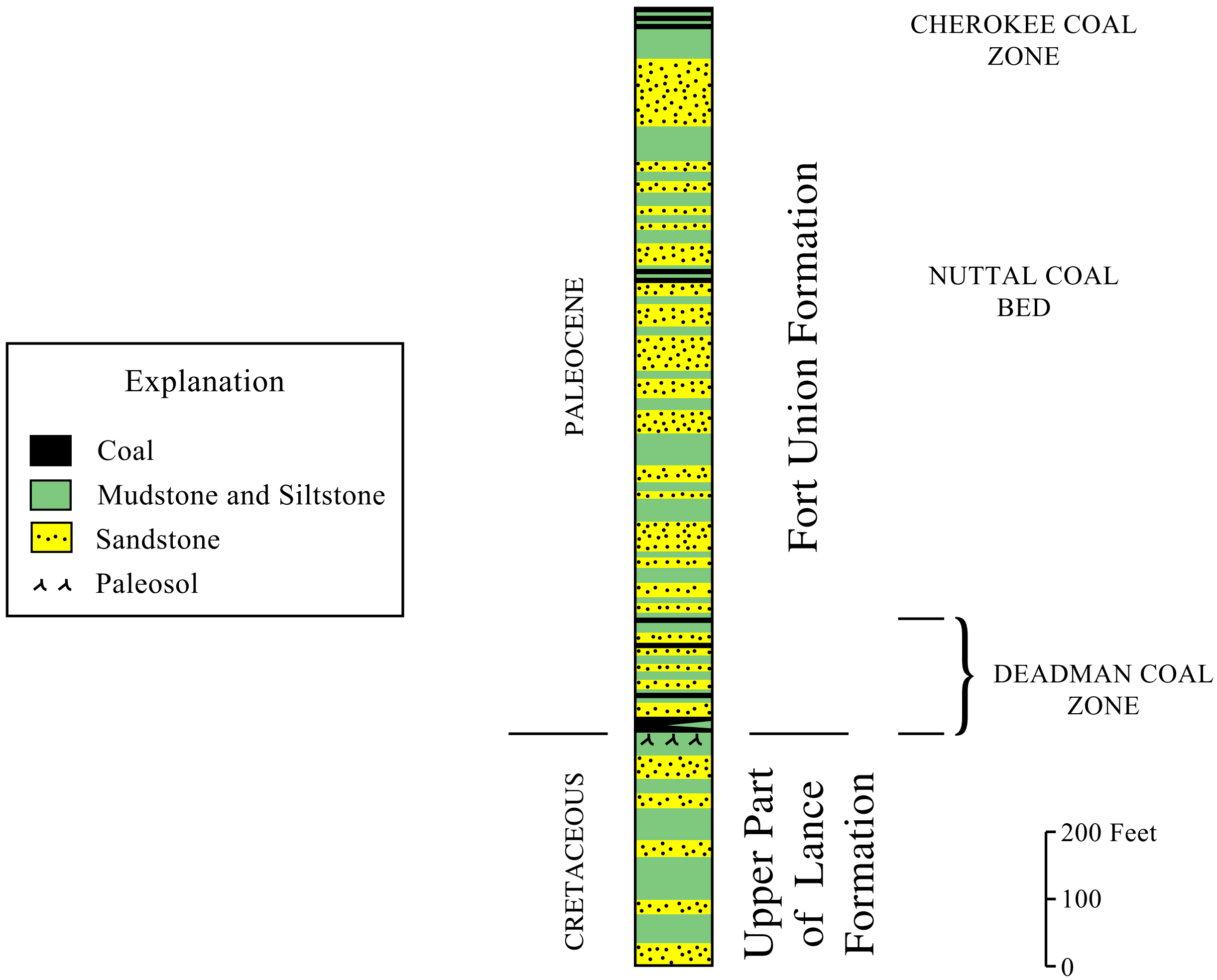

Figure GS-4. Stratigraphic subdivisions of the Fort Union Formation along the eastern flank of the Rock Springs uplift south of I-80 (modified from Hettinger and Kirschbaum, 1991).

Figure GS-5. Stack of fining-upward, erosional-based sandstone bodies along the mine highwall of the Jim Bridger coal mine. Photograph by R.M. Flores.

Figure GS-6. Thinning margin of fluvial channel sandstone bounded by thin-to thick-bedded silty sandstone, siltstone, and mudstone along the mine highwall of the Jim Bridger coal mine. Photograph by R.M. Flores.

Figure GS-7. Tabular-shaped crevasse splay sandstone beds are interbedded with siltstone, mudstone, coal, and carbonaceous shale. These deposits are exposed along the mine highwall of the Jim Bridger coal mine. Photograph by R.M. Flores.

Figure GS-8. Crevasse-splay sandstone beds are locally incised by a small channel infilled by sand (upper left of photo). These deposits are exposed along the mine highwall of the Jim Bridger coal mine. Photograph by R.M. Flores.

Figure GS-9. A tree stump (center of photo) preserved during rapid sedimentation in the crevasse splay. The crevasse-splay deposits are exposed along the mine highwall of the Jim Bridger coal mine. Photograph by R.M. Flores.

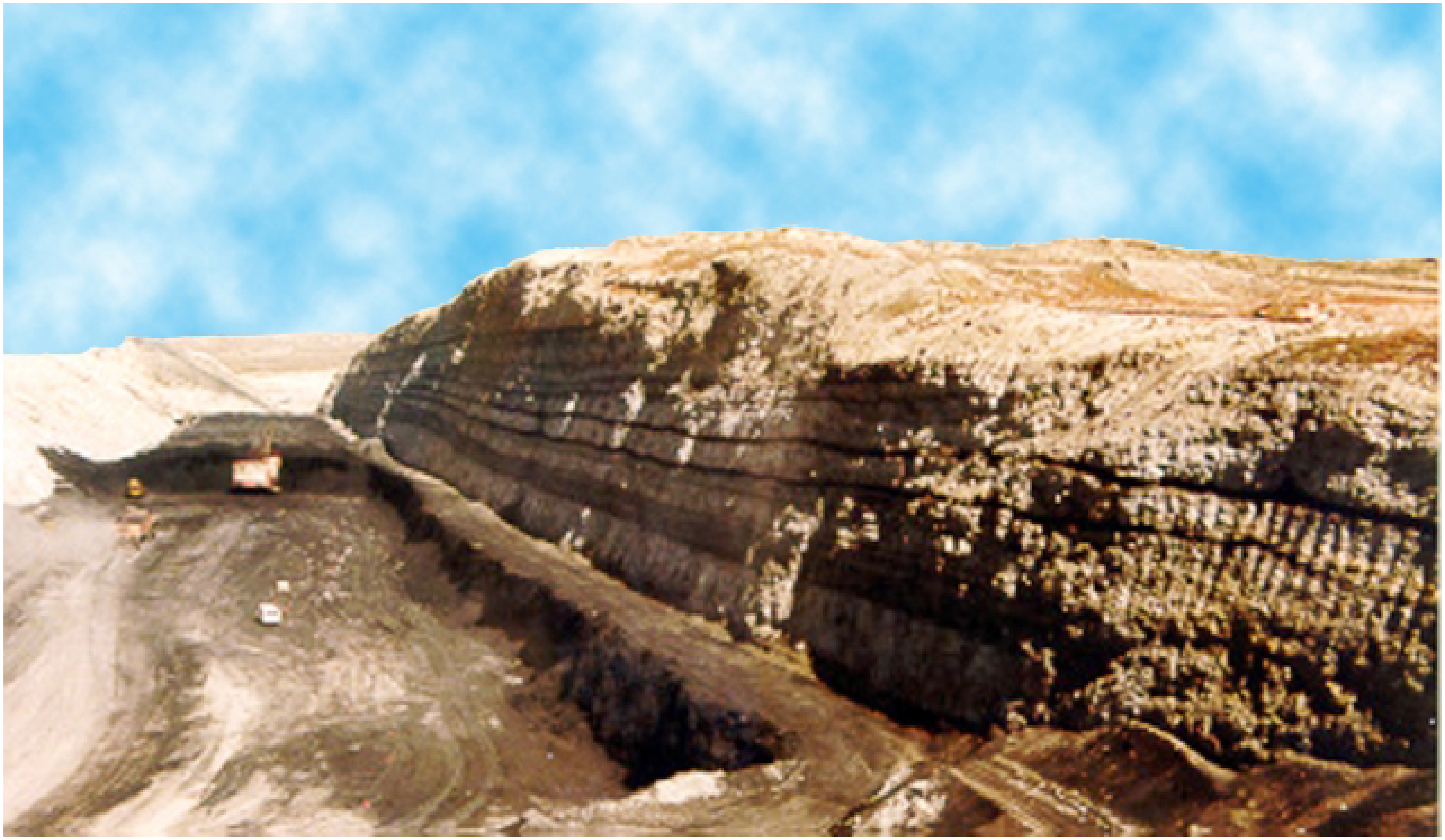

Figure GS-10. Highwall in the Black Butte coal mine showing stacked, fining-upward fluvial channel sandstone and overbank deposits. Photograph by R.M. Flores.