

Chapter GF

FRAMEWORK GEOLOGY OF FORT UNION COAL IN THE EASTERN ROCK SPRINGS UPLIFT, GREATER GREEN RIVER BASIN, WYOMING

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STRUCTURAL SETTING

- The Greater Green River Basin of southwestern Wyoming consists of the Green River Basin, Great Divide Basin, and Washakie Basin (fig. GF-1).
- The Green River Basin is separated from the Great Divide and Washakie Basins by the Rock Springs uplift.
- The Rock Springs uplift is a doubly plunging, north-south trending, asymmetrical anticline.
- The Fort Union Formation (Paleocene) is present at the surface along the flanks of the Rock Springs uplift. Associated beds dip 5-15 degrees on the flanks of the uplift to the subsurface in the center of the basins.
- Fort Union rocks in the Greater Green River Basin are present over a 26,000 square-mile area; they are more than 3,000 ft thick in the subsurface. Fort Union outcrops are present along the margin of the basin. The Fort Union Formation is overlain by rocks of the Wasatch Formation (Eocene) in the central part of the basin.
- Assessment coal units in the Fort Union Formation were investigated along the east flank of the Rock Springs uplift, where there is active mining. The mines produced about 1 percent of the total 1997 U.S. coal production (Resource Data International, Inc., 1997).

STRATIGRAPHIC SETTING

- The Fort Union Formation may be divided into lower coal-bearing, middle sandstone-dominated, and upper coal-bearing parts.
- The middle sandstone-dominated part is as much as 800 ft thick and contains no coal beds.

- Coal beds are as much as 33 ft thick in the lower and upper parts of the Fort Union Formation.
- Proprietary and non-proprietary data from 4,090 drill holes were used for stratigraphic correlation of the coal resource assessment units.

DEPOSITIONAL SETTING

- Depositional environments in the Fort Union Formation are exclusively fluvial settings (Maywood, 1987; Honey and Hettinger, 1989; Hettinger and Kirschbaum, 1991; Hettinger and others, 1991).
- Coal accumulated in peat swamps on fluvial floodplains and in abandoned fluvial channels (Maywood, 1987).

COAL QUALITY

- Coal rank is mainly subbituminous B to C (Glass, 1976).
- Coal quality reflects low to intermediate sulfur content and low to high ash content.
- Concentrations of selected trace-elements of environmental concern are low.

STRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS OF COAL-ASSESSMENT UNITS

STRATIGRAPHY

- The Fort Union Formation is composed primarily of sandstone, siltstone, and

mudstone and secondarily of limestone, carbonaceous shale, and coal. The formation contains 60 percent sandstone, 11 percent siltstone, 17 percent mudstone, 9 percent coal, and 3 percent limestone and carbonaceous shale (Maywood, 1987).

- The assessment coal zones include the Deadman coal zone (fig. GF-2) consisting of the D1, D2, D3, D4, and D5 coal seams in the Jim Bridger mine. 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). In this study, these coal zones are recognized as the Deadman coal zone.
- The Deadman coal zone is in the lower part of the Fort Union Formation. Biostratigraphic zonation of the formation includes Zones P1-P6 (fig. GF-3).

DEPOSITIONAL ENVIRONMENTS

- Deadman coal accumulated in peat swamps within fluvial environments (Maywood, 1987). The Deadman coal zone is interbedded with fining-upward, stacked fluvial-channel sandstone bodies bounded by crevasse-splay and floodplain mudstone, siltstone, and silty sandstone (fig. GF-4). The fluvial channel sandstone bodies thin toward their margins and are intercalated with lateral accretion units composed of siltstone and mudstone typical of deposits in meandering rivers (fig. GF-5). The margins of the fluvial channel sandstone bodies grade into the crevasse-splay deposits, which are locally eroded and infilled by siltstone and silty sandstone (fig. GF-6).
- Coal beds A-C were also deposited in peat swamps within fluvial environments. The A-C coal zone is interbedded with fining-upward, erosional-based, fluvial channel sandstone that grades upward into thick- to thin-bedded silty sandstone, siltstone and mudstone, which represent overbank deposits (fig. GF-7). The

overbank deposits grade laterally (upper right of photo) into erosional-based sandstone deposits that are laterally offset. This offset pattern of fluvial channel sandstone beds indicates deposition in meandering rivers. The fluvial channel sandstone grades laterally into thin- to thick-bedded silty sandstone, siltstone, and mudstone, which were deposited in floodplain/crevasse-splay environments (fig. GF-8).

- Fluvial environments developed in an eastward-flowing fluvial system (Maywood, 1987).

DISTRIBUTION OF THE DEADMAN AND A-C COAL ZONES IN THE POINT OF ROCKS-BLACK BUTTE COALFIELD

- The Point of Rocks-Black Butte coalfield (fig. GF-9) boundary approximately follows the outcrop extent of the Fort Union Formation and includes past and current mines that produced from the Deadman coal zone (Morgenson, 1959; Maywood, 1987). The coalfield is bounded on the west by the line of contact between the Lance Formation (Cretaceous) and the Fort Union Formation (Paleocene). It is bounded on the east by an arbitrary line a few miles from the line of contact between the Fort Union Formation and Wasatch Formation (Eocene); the position of that line is based on the distribution of control points.
- The Deadman coal zone in the Jim Bridger mine, which is laterally equivalent to the A-C coal zone in the Black Butte mine, is in the lower part of the Fort Union Formation (Madden, 1989; Hettinger and Kirschbaum, 1991).
- These coal zones also occur in the subsurface of Sweetwater County, Wyoming, in the east-northeast flank of the Rock Springs uplift, and the northern part of Washakie Basin, and southern part of the Great Divide Basin (Honey and Hettinger, 1989; Hettinger and Kirschbaum, 1991; Hettinger and others, 1991). These authors

identified thick, laterally extensive coal beds of the Deadman coal zone in these basins.

- Surface occurrence of the coal zones is primarily along the east flank of the Rock Springs uplift (Roehler, 1977; Madden, 1989).
- Movable coal of the Deadman and A-C coal zones is present in the Point of Rocks-Black Butte coalfield, which includes the Jim Bridger and Black Butte coal mines (fig. GF-9).

STRATIGRAPHIC FRAMEWORK

- The Deadman and A-C coal zones are interbedded with mudstone, limestone, carbonaceous shale, siltstone, and sandstone (Maywood, 1987). These clastic rocks are undifferentiated in our database. However, we utilized Maywood's interpretation of the depositional environments.
- Coal seams in the Deadman coal zone are within a 125-ft-thick interval, and beds of the A-C coal zone are within a 50-ft-thick interval. The thicker interval is expanded by a sandstone body as much as 40 ft thick interpreted by Maywood (1987) as a fluvial channel deposit.
- Laterally, the coal beds of these zones merge and split. Coal beds coalesce from two or more seams to form a single, thick bed. The coal may split into two or more beds that gradually thin, pinch out, or interfinger with other clastic rocks (Maywood, 1987). Split coal seams may rejoin to form a merged seam and may re-split again throughout the extent of the coal zones.
- Vertically, the Deadman coal zone may consist of as many as five coal seams, as a result of splitting, or as few as one coal seam as a result of merging.
- Vertically, the A-C coal zone may consist of as many as three beds, as a result of

splitting, or as few as two beds as a result of merging.

- Merged coal seams or beds are interbedded mainly with mudstone and carbonaceous shale partings.
- Rocks above and below the Deadman coal zone consist of mudstone, siltstone, and sandstone. These rocks accumulated in channels and floodplains in a fluvial system.
- The Deadman coal seams accumulated in peat swamps on distal floodplains and in abandoned fluvial channel deposits (Maywood, 1987).

DEADMAN COAL ZONE INTERPRETIVE CROSS SECTION A-A'

- This greater-than-15.5-mi-long, north (A) to south (A') cross section ([fig. GF-10](#)) shows the Deadman coal zone and associated rocks in the Jim Bridger mine. Datum is the base of the merged seams D1-D3. The cross section was drawn using data from 51 drill holes, which are not labeled on the cross section.
- Coal beds, 1-26 ft thick, are identified from bottom to top as D1 to D5.
- These coal beds merge and split in a north-south direction.
- Seams D1-D2 merge to form a single seam as much as 13 ft thick.
- Seams D1-D3 merge to form a single seam as much as 16.5 ft thick.
- Seams D1-D4 merge to form a single seam as much as 17 ft thick.
- Seams D1-D5 merge to form a single seam as much as 26 ft thick.
- Splitting of the Deadman seams is prevalent toward the south, and merging is common toward the north.
- Merging and splitting of coal beds reflects accumulation in peat swamps formed perpendicular to the eastward flow direction of the fluvial depositional system ([fig. GF-11](#)).

A-C COAL ZONE INTERPRETIVE CROSS SECTION B-B'

- This greater-than-17-mi-long, north (B) to south (B') cross section ([fig. GF-12](#)) shows the A-C coal zone and associated rocks in the Black Butte mine. Datum is the base of the C coal bed. The cross section was drawn using data from 71 drill holes, which are not labeled on the cross section.
- Coal beds (from less than 1 to 33 ft thick) of this coal zone are identified, from bottom to top, as A, B, and C.
- The C coal bed (as much as 33 ft thick) splits northward into the C1 bed (as much as 24 ft thick) and the C2 bed (as much as 4 ft thick).
- The interval between the A and C coal beds increases in thickness northward.
- Merging and splitting of the coal beds resulted from peat accumulation in swamps formed perpendicular to the eastward flow direction of the fluvial depositional system.

DEADMAN COAL ZONE INTERPRETIVE CROSS SECTION C-C'

- This greater-than-2.8-mi-long, west (C) to east (C') cross section ([fig. GF-13](#)) shows the Deadman coal zone and associated rocks in the northern part of the Jim Bridger mine. Datum is the base of the merged D1-D4 seams. The cross section was drawn using data from 12 drill holes, which are not labeled on the cross section.
- The Deadman coal zone includes in the lower part a merged D1-D4 coal seam, which is as much as 15 ft thick.
- The Deadman coal zone includes in the upper part the D5 coal seam, which is as much as 7 ft thick.

- Merging and splitting are not observed because the coal seams were deposited in peat swamps parallel to the eastward flow direction of the fluvial depositional system.

DEADMAN COAL ZONE INTERPRETIVE CROSS SECTION D-D'

- This greater-than-2.6-mi-long, west (D) to east (D') cross section ([fig. GF-14](#)) shows the Deadman seams and associated rocks in the north-central part of the Jim Bridger mine. Datum is the base of the merged D1-D3 seam. The cross section was drawn using data from 15 drill holes, which are not labeled on the cross section.
- The Deadman coal zone includes in the lower part a merged D1-D3 coal seam, which is as much as 12 ft thick.
- The Deadman coal zone includes in the upper part a merged D4-D5 coal seam, which is as much as 17 ft thick.
- Splitting of the merged D4-D5 coal seam takes place toward the east. The splitting may have resulted from crevasse-splay deposition into a peat swamp on the floodplain ([fig GF-15](#)).
- The coal seams were deposited in peat swamps parallel to the eastward flow direction of the fluvial depositional system.

DEADMAN COAL ZONE INTERPRETIVE CROSS SECTION E-E'

- This 2-mi-long, west (E) to east (E') cross section ([fig. GF-16](#)) shows the Deadman coal zone and associated rocks in the south-central part of the Jim Bridger mine. Datum is the base of the merged D1-D2 seams. The cross section was drawn using data from 13 drill holes, which are not labeled on the cross section.

- The Deadman coal zone includes in the lower part a merged D1-D2 coal seam, which is as much as 12 ft thick.
- The Deadman coal zone includes in the upper part the D4 and D5 coal seams, which are as much as 7 ft and 5 ft thick, respectively.
- The merged D4-D5 coal seam splits toward the east. This splitting may have resulted from crevasse-splay deposition into a peat swamp on the floodplain.
- The coal seams were deposited in peat swamps parallel to the eastward flow direction of the fluvial depositional system.

DEADMAN COAL ZONE INTERPRETIVE CROSS SECTION F-F'

- This 1.8-mi-long, west (F) to east (F') cross section ([fig. GF-17](#)) shows the Deadman coal zone and associated rocks in the southern part of the Jim Bridger mine. Datum is the base of the merged D1-D3 seams. The cross section was drawn using data from 15 drill holes, which are not labeled on the cross section.
- The Deadman coal zone includes in the lower part a merged D1-D3 coal seam, which is as much as 12 ft thick. This coal seam splits eastward into lower D1-D2 and upper D3 coal seams.
- The Deadman coal zone includes in the upper part the D4 and D5 coal seams, which are as much as 8 ft and 5 ft thick, respectively.
- The merged D1-D3 coal seam splits toward the east and may have resulted from crevasse-splay deposition into a peat swamp on the floodplain ([fig. GF-18](#)).
- The coal seams were deposited in peat swamps parallel to the eastward flow direction of the fluvial depositional system.

A-C COAL ZONE INTERPRETIVE CROSS SECTION G-G'

- This 0.37-mi-long, west (G) to east (G') cross section ([fig. GF-19](#)) shows the northern part of the Black Butte mine. Datum is the base of the merged C coal beds. The cross section was drawn using data from 14 drill holes, which are not labeled on the cross section.
- The C coal bed, which is the upper bed of the A-C coal zone, is as much as 33 ft thick. It locally splits into lower and upper beds to the east, and merges into one bed toward the west.
- Splitting of the coal bed was caused by local incursion of crevasse splays in the peat swamps associated with the fluvial depositional system.

A-C COAL ZONE INTERPRETIVE CROSS SECTION H-H'

- This 1.09-mi-long, west (H) to east (H') cross section ([fig. GF-20](#)) shows the C coal bed and associated rocks in the northern part of the Black Butte mine. Datum is the base of the merged C coal bed. The cross section was drawn using data from 20 drill holes, which are not labeled on the cross section.
- The C coal bed, which is the upper coal bed of the A-C coal zone, is as much as 30 ft thick and is a merged bed.
- The merged C coal bed suggests widespread accumulation of peat in swamps associated with the fluvial depositional system.

A-C COAL ZONE INTERPRETIVE CROSS SECTION I-I'

- This 1.06-mi-long, west (I) to east (I') cross section ([fig. GF-21](#)) shows the A-C

coal zone and associated rocks in the southern part of the Black Butte mine. Datum is the base of the C coal bed. The cross section was drawn using data from 16 drill holes, which are not labeled on the cross section.

- The A-C coal zone, which is within a 90-ft-thick interval, consists of coal beds as much as 10.8 ft thick.
- The uppermost thick coal bed is the C coal.
- Coal beds, which vary in thickness laterally and are found in a gradually westward-merging interval, suggest accumulation in peat swamps on floodplains associated with the fluvial depositional system.

A-C COAL ZONE INTERPRETIVE CROSS SECTION J-J'

- This 0.73-mi-long, west (J) to east (J') cross section ([fig. GF-22](#)) shows the A-C coal zone and associated rocks in the southern part of the Black Butte mine. Datum is the base of the A coal bed. Coal beds are as much as 10.6 ft thick. The cross section was drawn using data from 17 drill holes, which are not labeled on the cross section.
- The lower coal bed is the A coal and the upper coal bed is the C coal.
- The occurrence of coal beds that retain uniform thickness across their west-east extent suggests accumulation in peat swamps stacked on floodplains associated with the fluvial depositional system.

A-C COAL ZONE INTERPRETIVE CROSS SECTION K-K'

- This 1.2-mi-long, west (K) to east (K') cross section ([fig. GF-23](#)) shows the A-C coal zone and associated rocks in the southern part of the Black Butte mine.

Datum is the base of the C coal bed. The cross section was drawn using data from 12 drill holes, which are not labeled on the cross section.

- The A-C coal zone, which is a 33-ft-thick interval, consists of coal beds as much as 14.3 ft thick. The lower coal bed locally splits, whereas the upper coal bed is laterally uniform.
- The interval of the A-C coal zone from cross sections I-I' to K-K' shows a merging trend to the south. Southward merging of the A-C coal zone suggests accumulation in peat swamps on a stable part of the floodplain that was not repeatedly flooded by sediments.
- Local splitting of the lower coal bed indicates intermittent flooding of sediments into the peat swamp.

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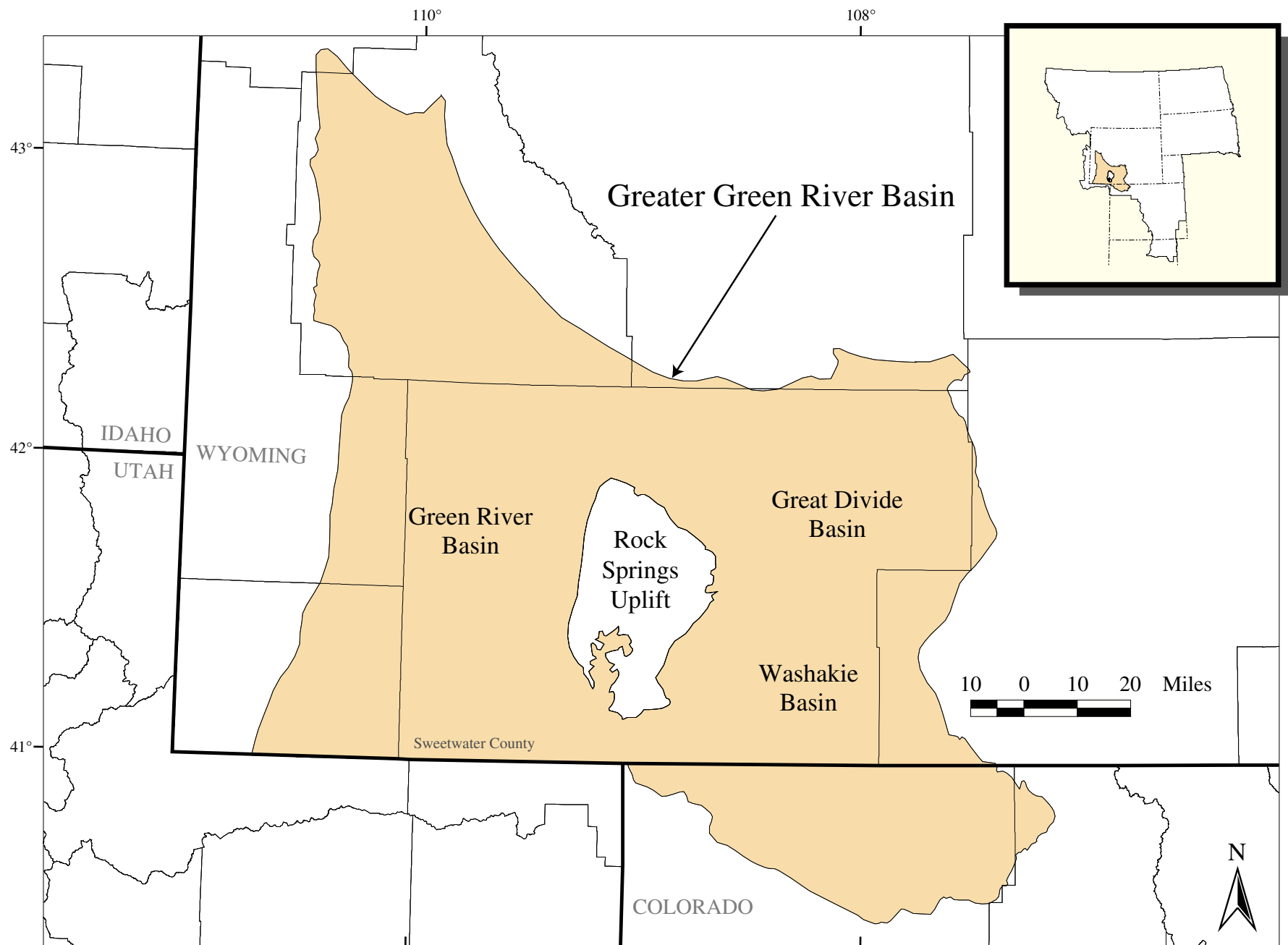


Figure GF-1. Location map showing the Greater Green River Basin.

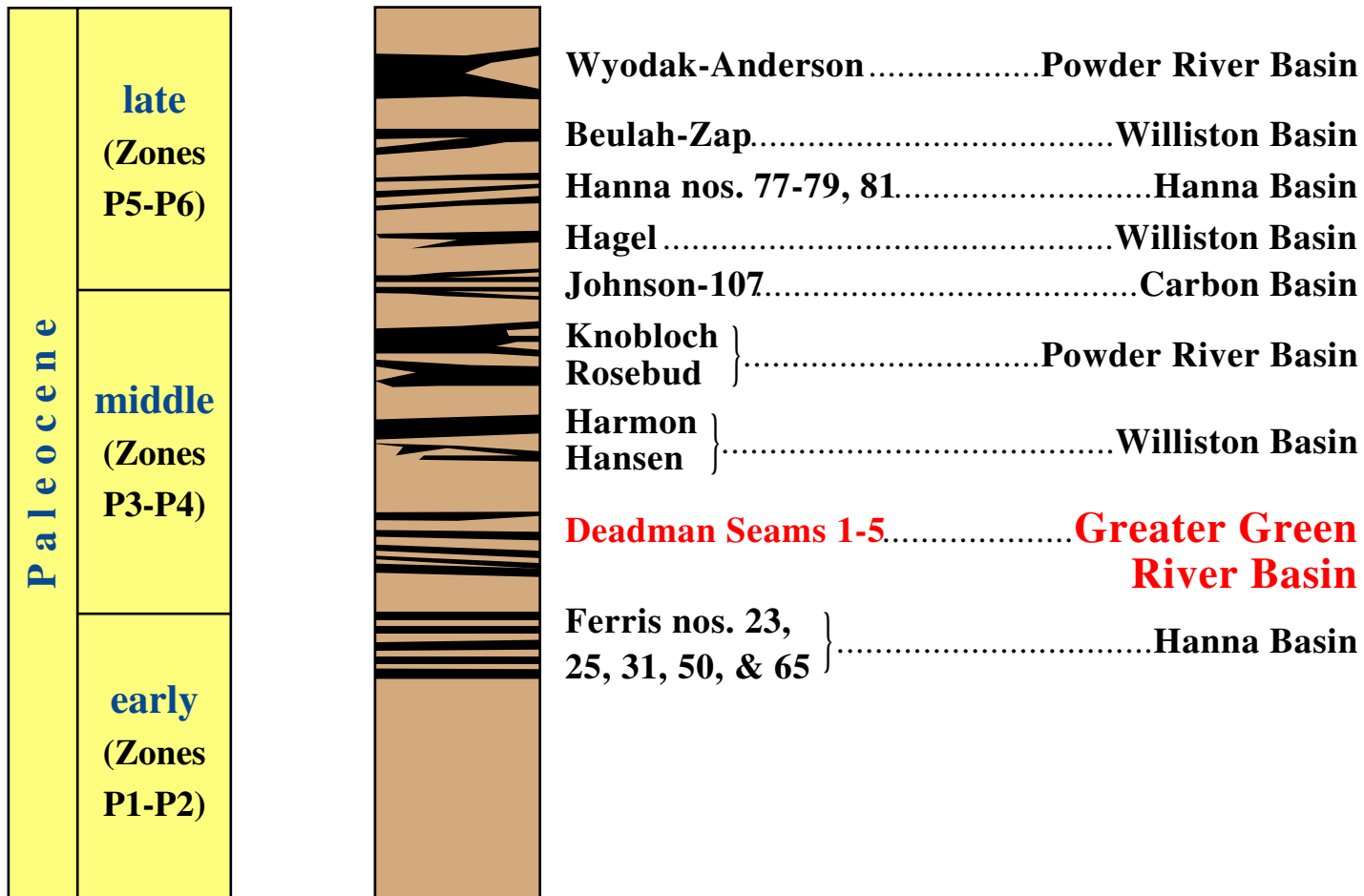


Figure GF-2. Composite stratigraphic section for the assessment region showing the studied coal beds and zones with age relationships based on palynology. Assessment units in the Greater Green River Basin are highlighted in red.

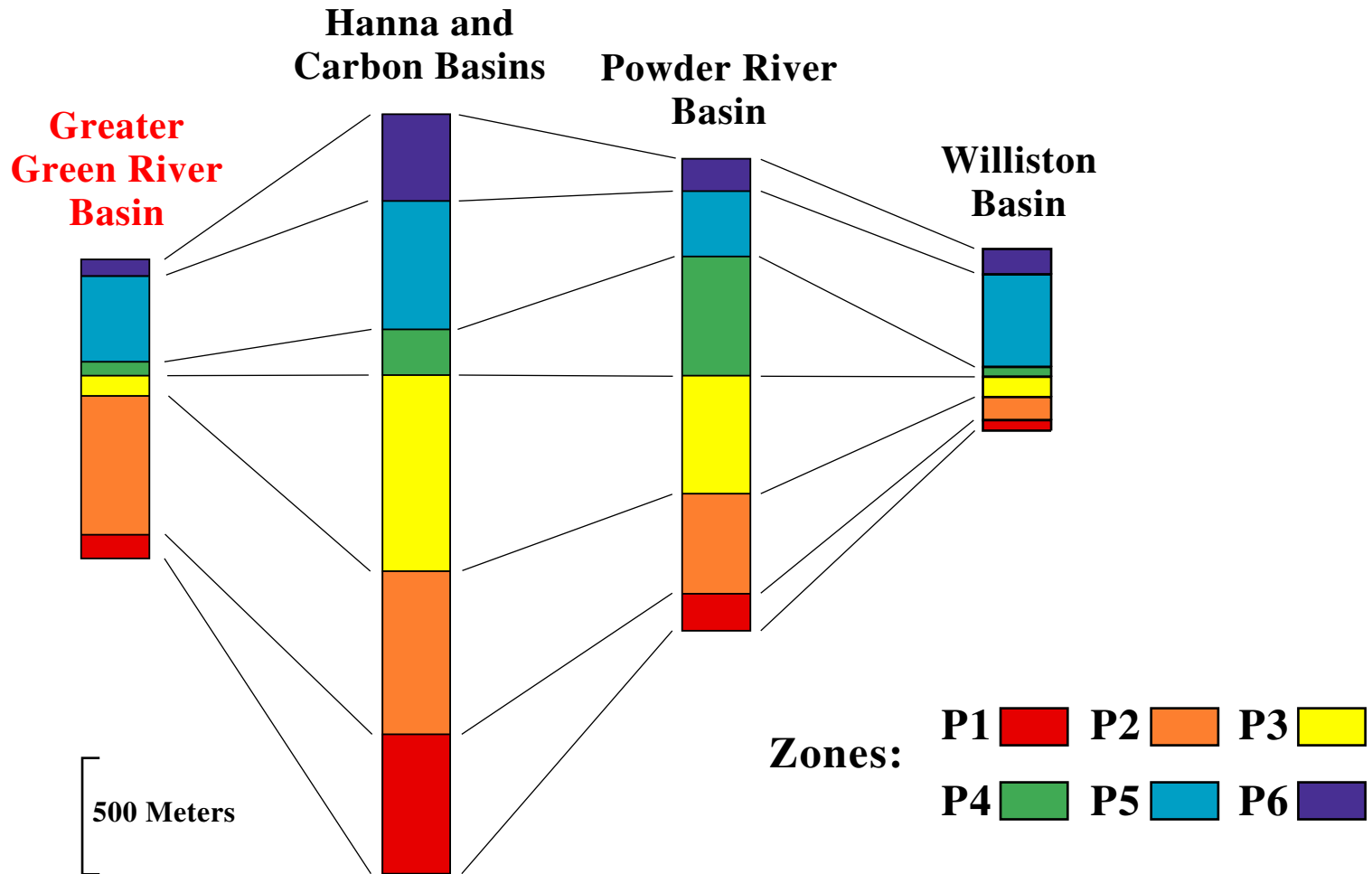


Figure GF-3. Composite correlation of Paleocene sections based on palynostratigraphy.



Figure GF-4. Stacked sandstone bounded by silty sandstone, siltstone, and mudstone above the Deadman coal zone in the Jim Bridger mine. Photograph by R.M. Flores.



Figure GF-5. Fining-upward sandstone bounded by silty sandstone, siltstone, and mudstone above the Deadman coal zone in the Jim Bridger mine. Photograph by R.M. Flores.



Figure GF-6. Fining-upward, stacked sandstone thinning from right to the left of the picture into thin-bedded silty sandstone, siltstone, and mudstone above the Deadman coal zone in the Jim Bridger mine. Photograph by R.M. Flores.



Figure GF-7. A stack of fining-upward sandstone overlain by silty sandstone, siltstone, and mudstone above the A-C coal zone in the Black Butte mine. Photograph by R.M. Flores.



Figure GF-8. Thick-to thin-bedded sandstone, siltstone, and mudstone above the A-C coal zone in the Black Butte mine. photograph by R.M. Flores.



Figure GF-11. Peat swamps on abandoned fluvial channel deposits of the Santee River, South Carolina.
Photograph by C. Connor.

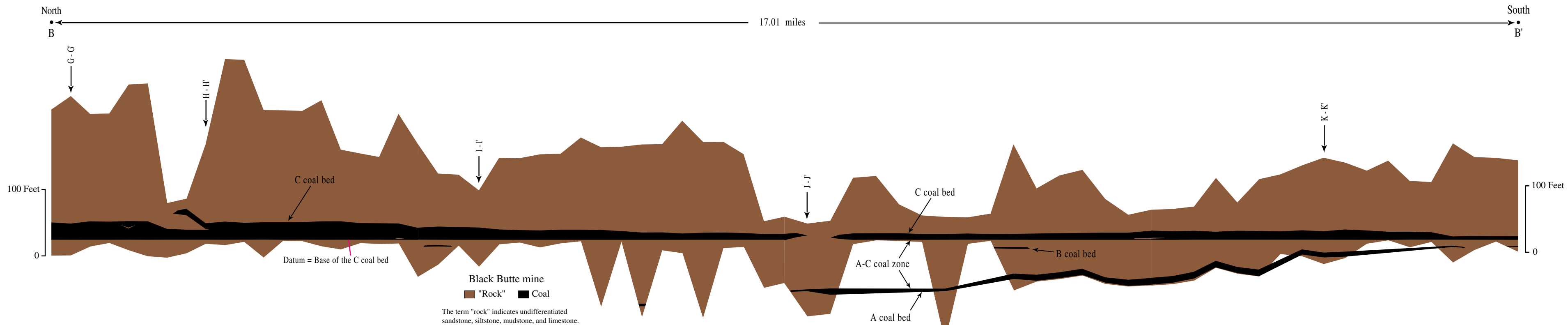


Figure GF-12. A-C coal zone interpretive cross section B-B'.

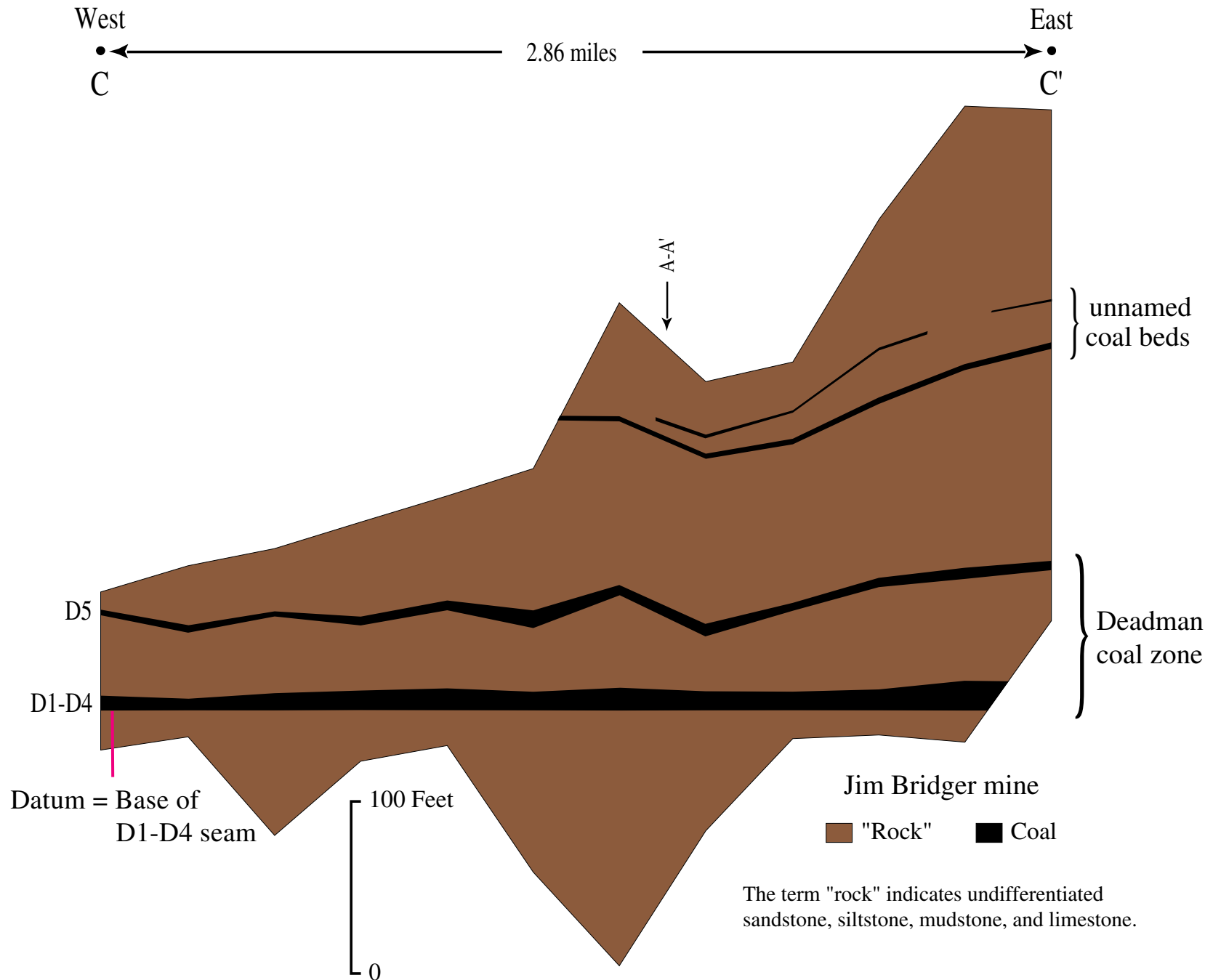


Figure GF-13. Deadman coal zone interpretive cross section C-C'.

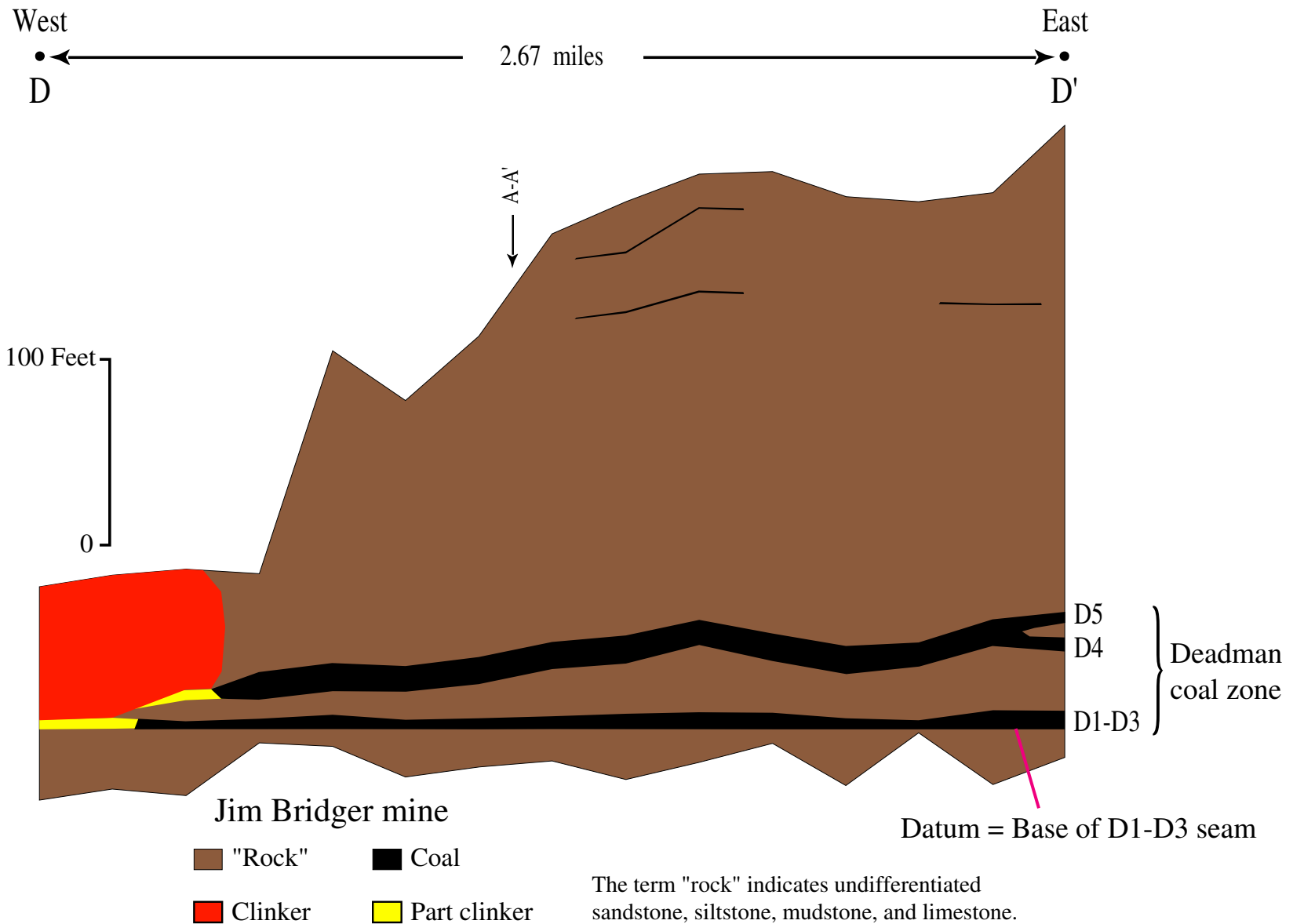


Figure GF-14. Deadman coal zone interpretive cross section D-D'.



Figure GF-15. Crevasse splays, floodplains, lakes, and swamps of the anastomosed Columbia River in the Province of British Columbia, Canada. Photograph by D. Smith.

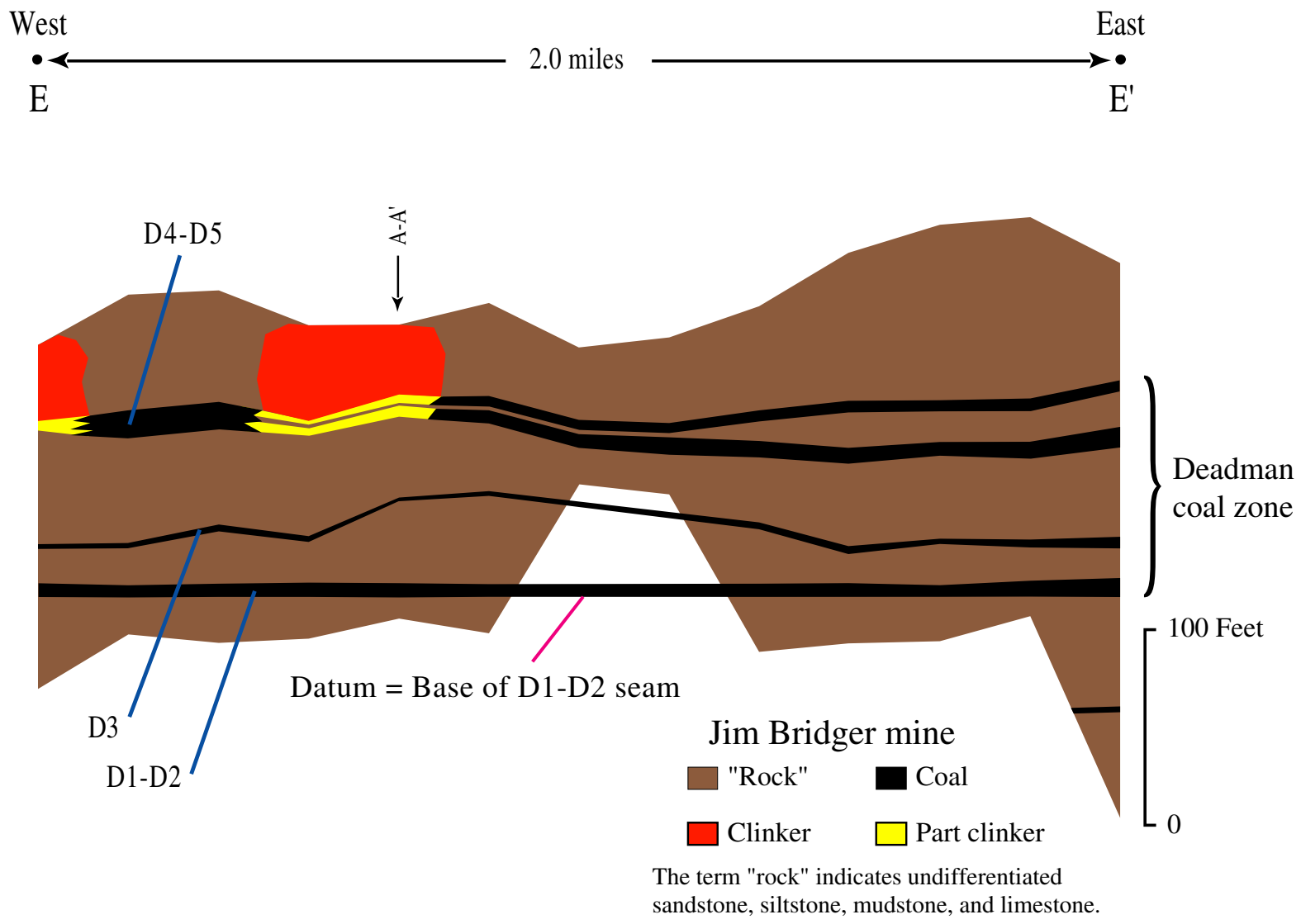


Figure GF-16. Deadman coal zone interpretive cross section E-E'.

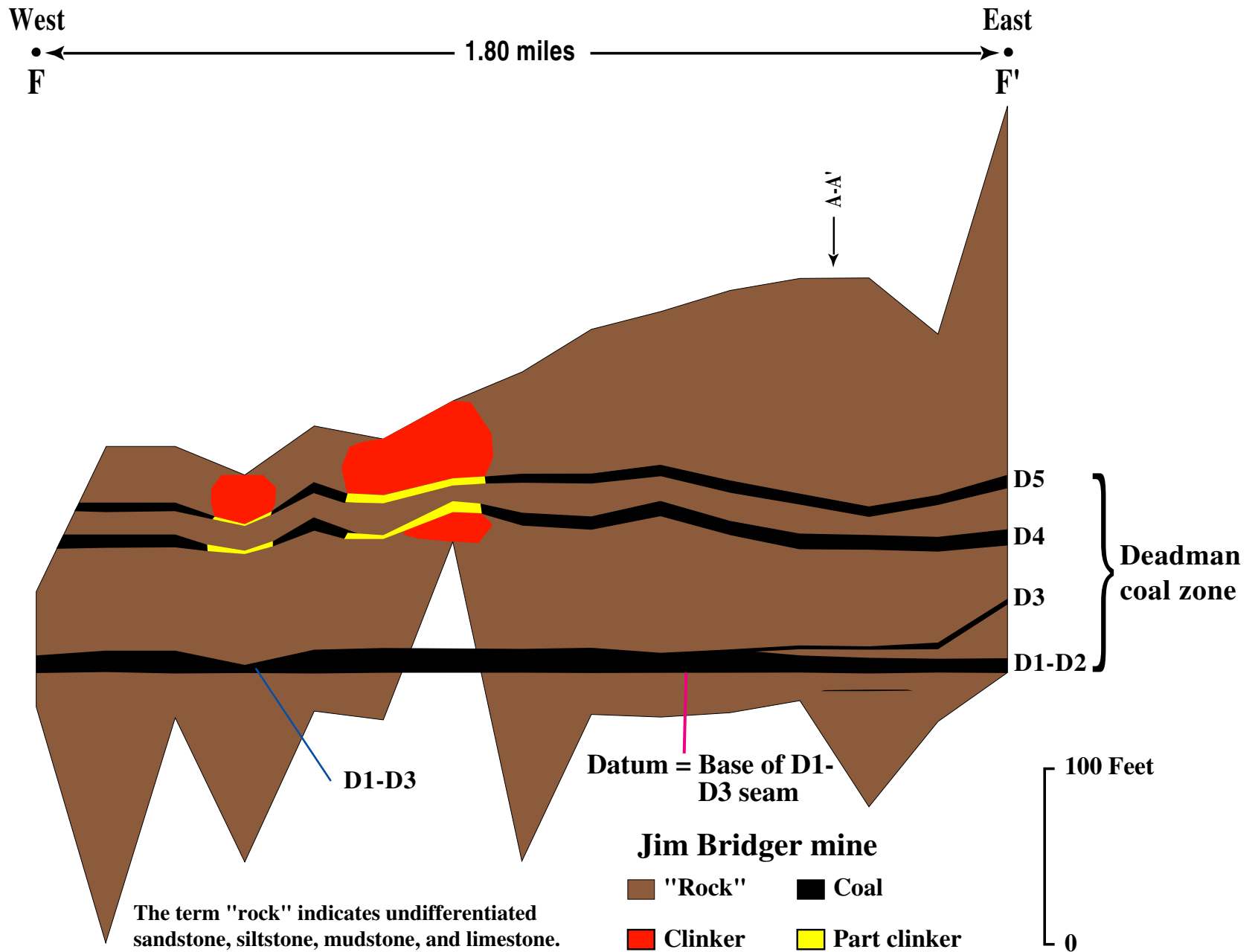


Figure GF-17. Deadman coal zone interpretive cross section F-F'.



GF-18. A crevasse splay draining into a floodplain lake and associated swamps of the Saskatchewan River in the Saskatchewan Province, Canada. Photograph by N. Smith.

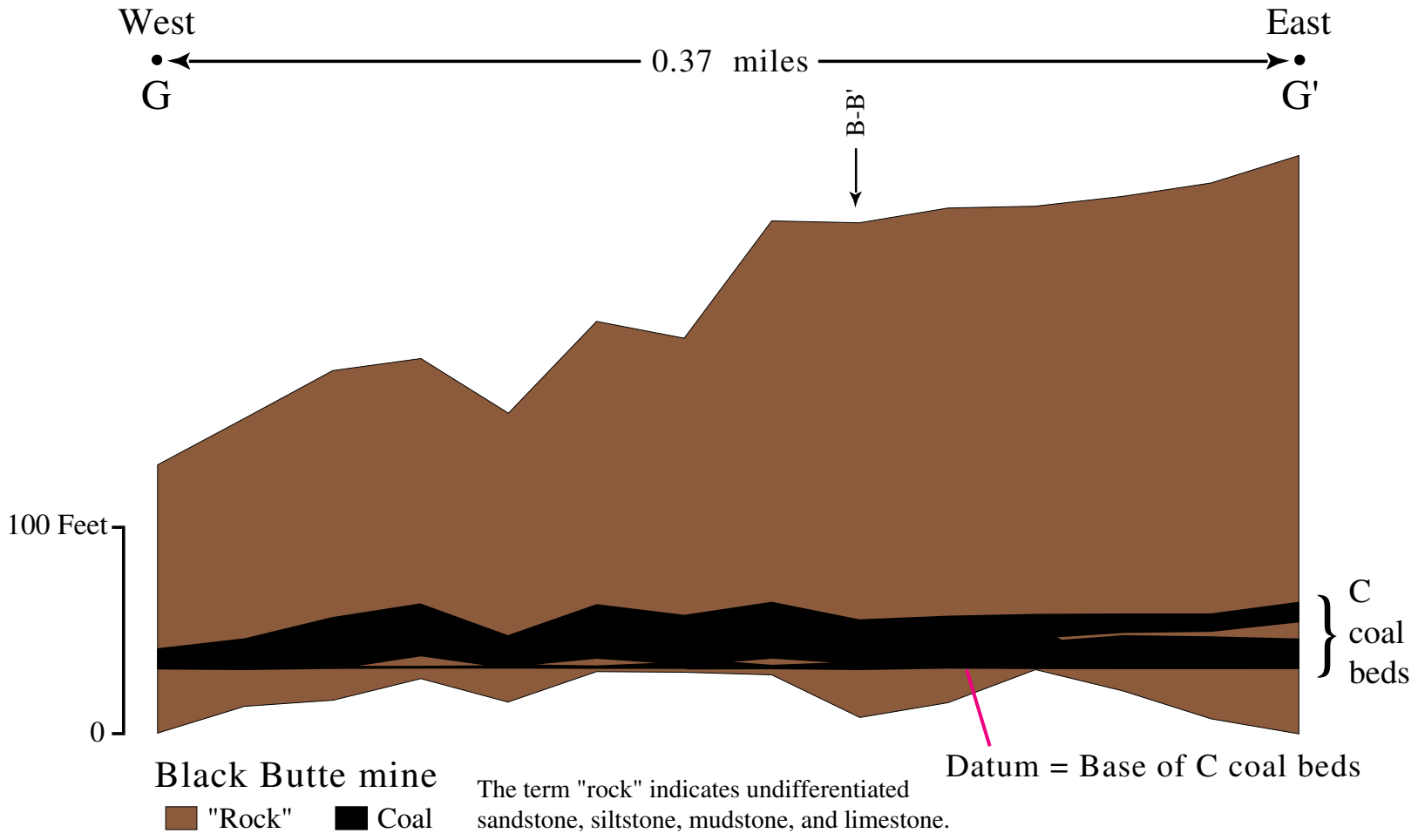


Figure GF-19. A-C coal zone interpretive cross section G-G'.

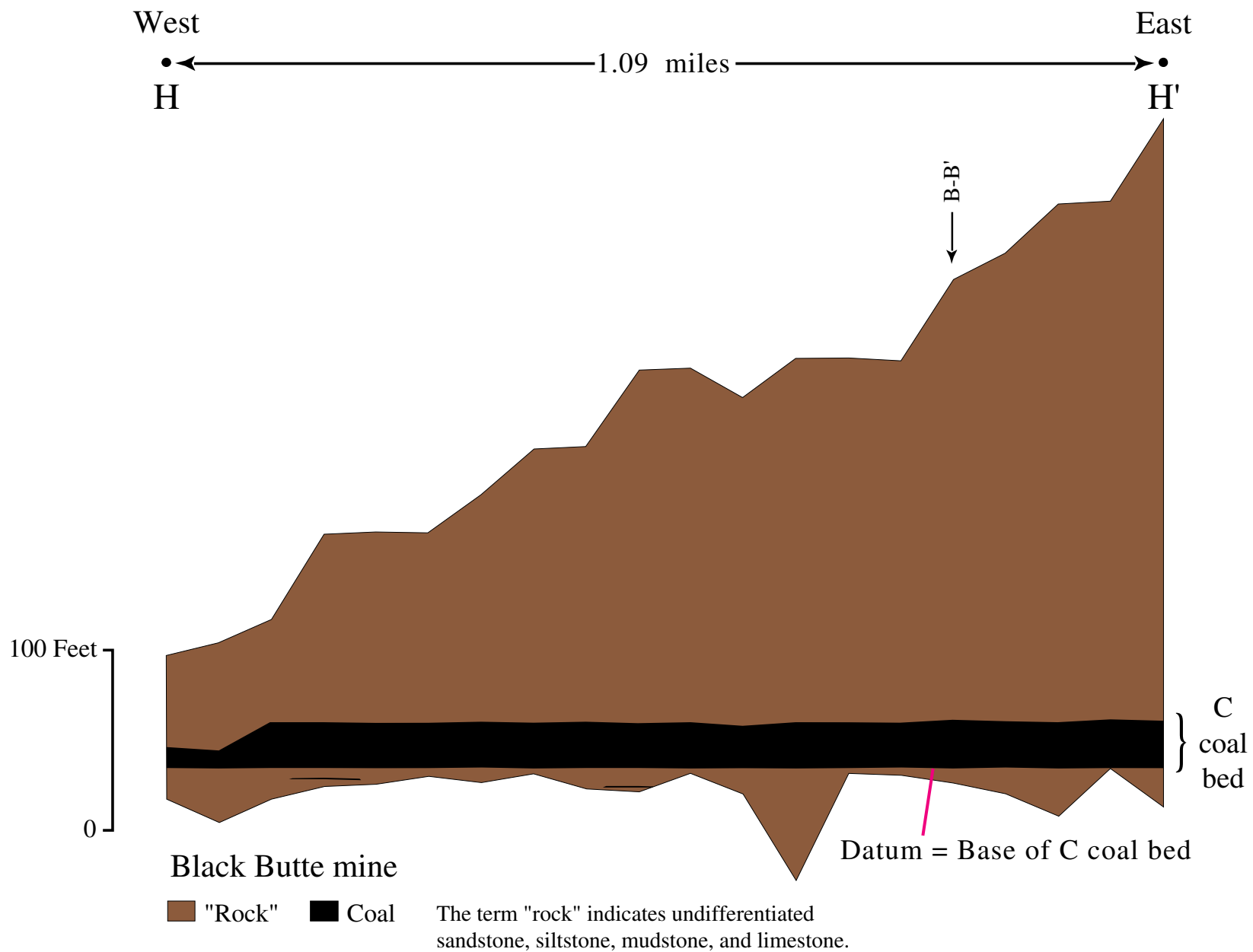


Figure GF-20. A-C coal zone interpretive cross section H-H'.

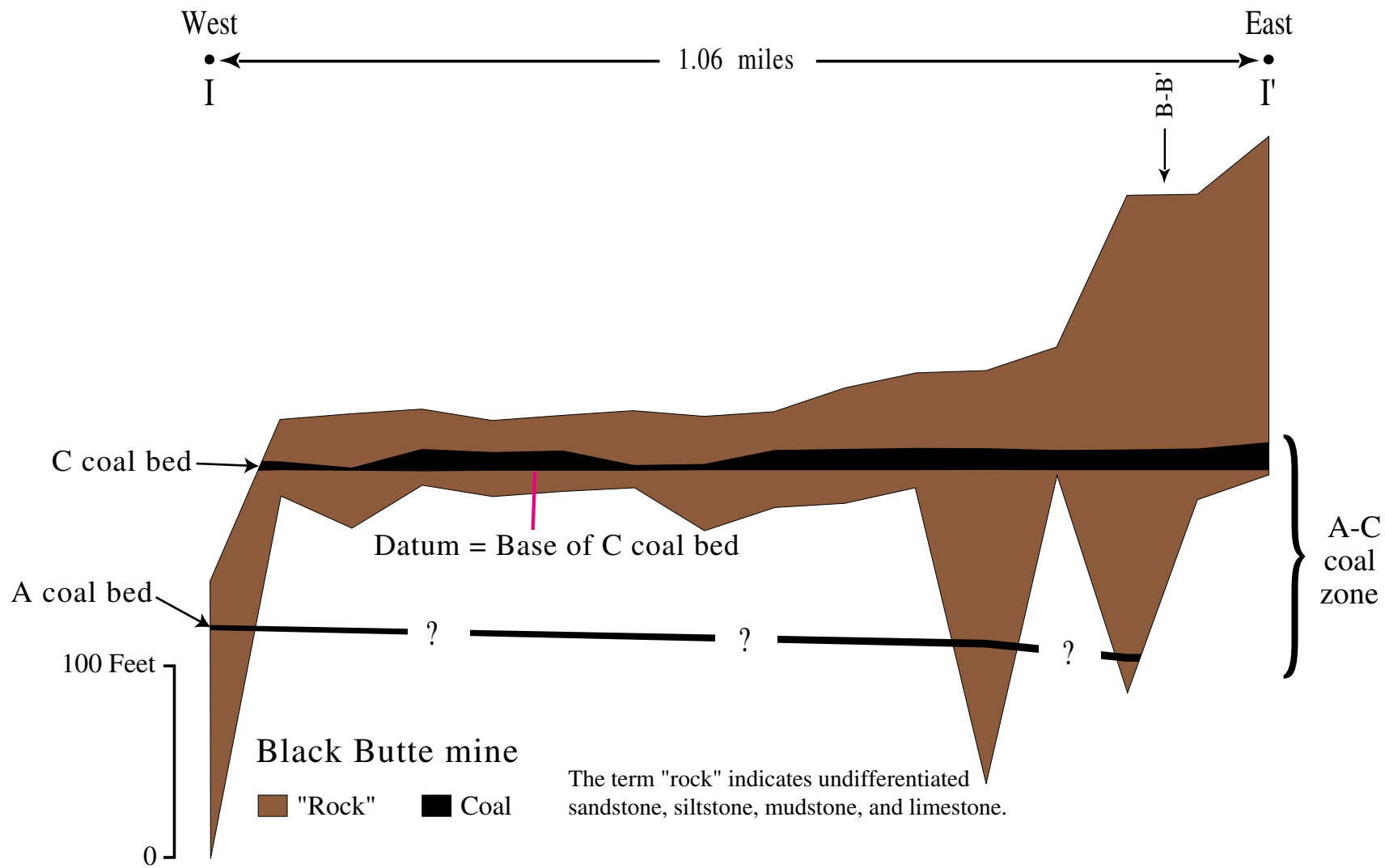


Figure GF-21. A-C coal zone interpretive cross section I-I'.

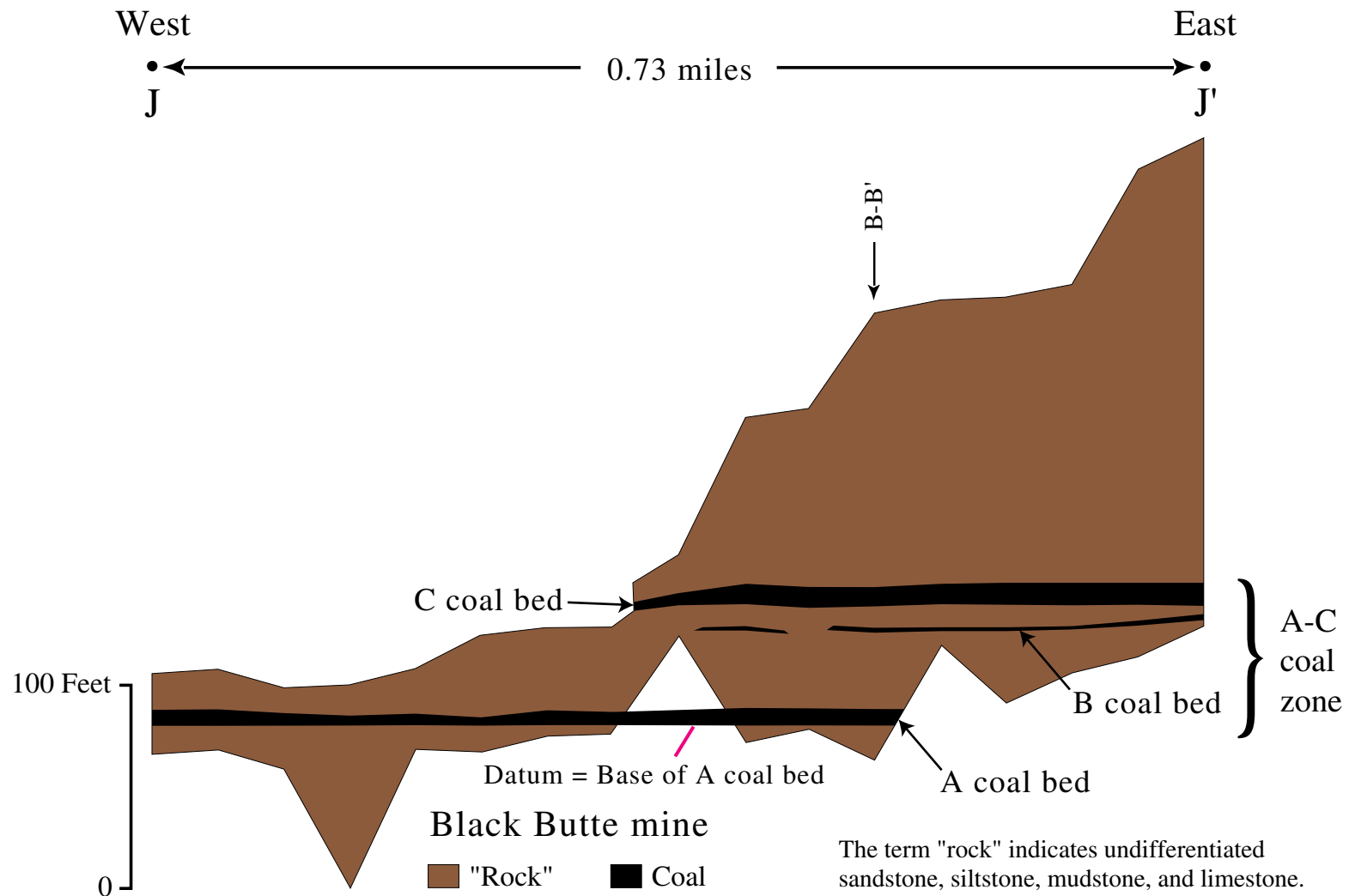


Figure GF-22. A-C coal zone interpretive cross section J-J'.

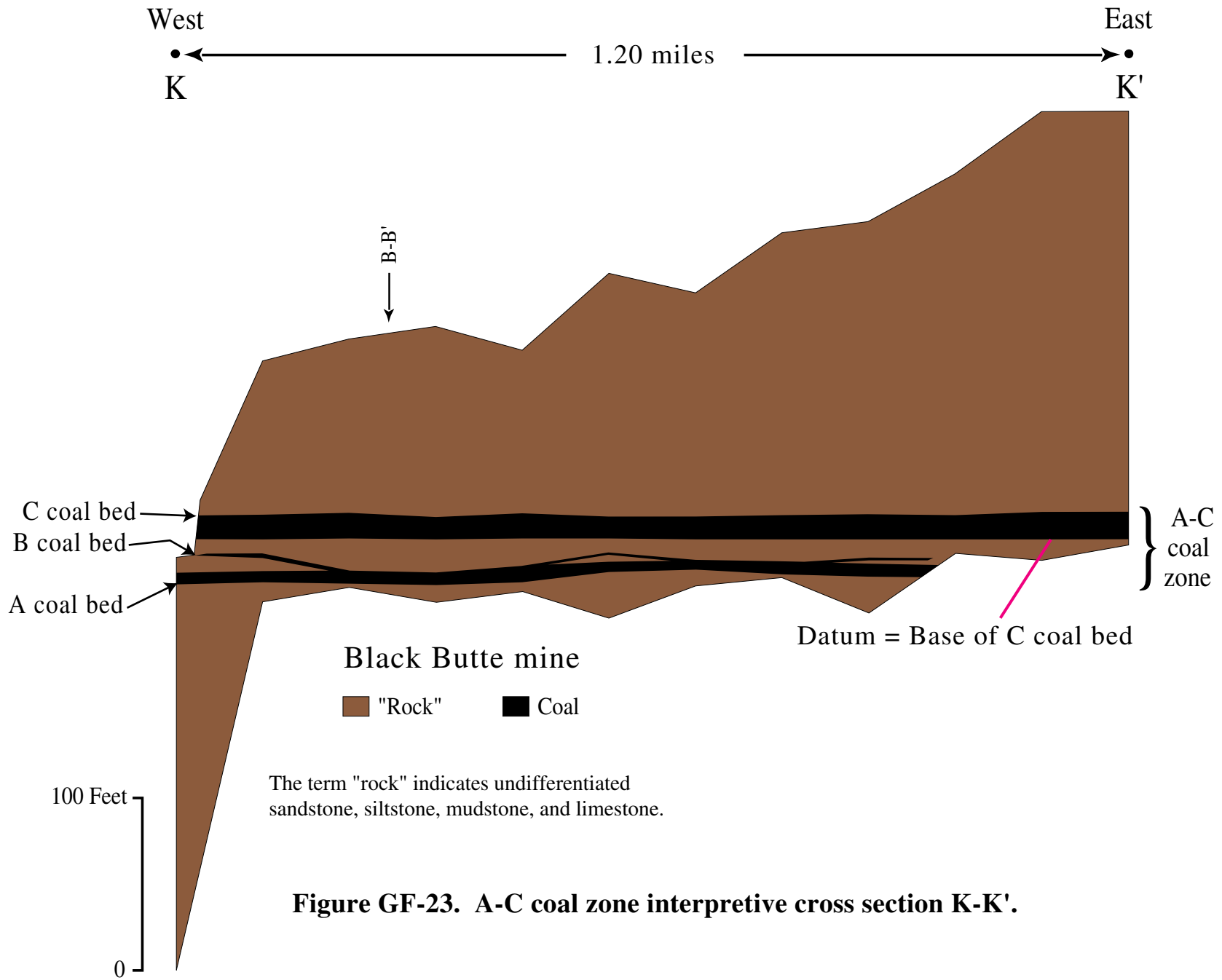


Figure GF-23. A-C coal zone interpretive cross section K-K'.