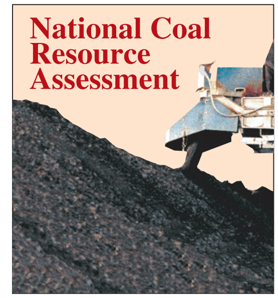
Chapter J

A Summary of Coal Distribution and Geology in the Kaiparowits Plateau, Utah

By Robert D. Hettinger[1]



Click here to return to Disc 1 Volume Table of Contents

Chapter J *of*

Geologic Assessment of Coal in the Colorado Plateau: Arizona, Colorado, New Mexico, and Utah

Edited by M.A. Kirschbaum, L.N.R. Roberts, *and* L.R.H. Biewick

U.S. Geological Survey Professional Paper 1625–B*

[1] U.S. Geological Survey, Denver, Colorado 80225

* This report, although in the USGS Professional Paper series, is available only on CD-ROM and is not available separately

U.S. Department of the Interior
U.S. Geological Survey

Contents

Figures

A Summary of Coal Distribution and Geology in the Kaiparowits Plateau, Utah

By Robert D. Hettinger

Fiftymile Mountain on southeastern margin of Kaiparowits Plateau, as viewed from Lake Powell. Photograph by Peter McCabe.

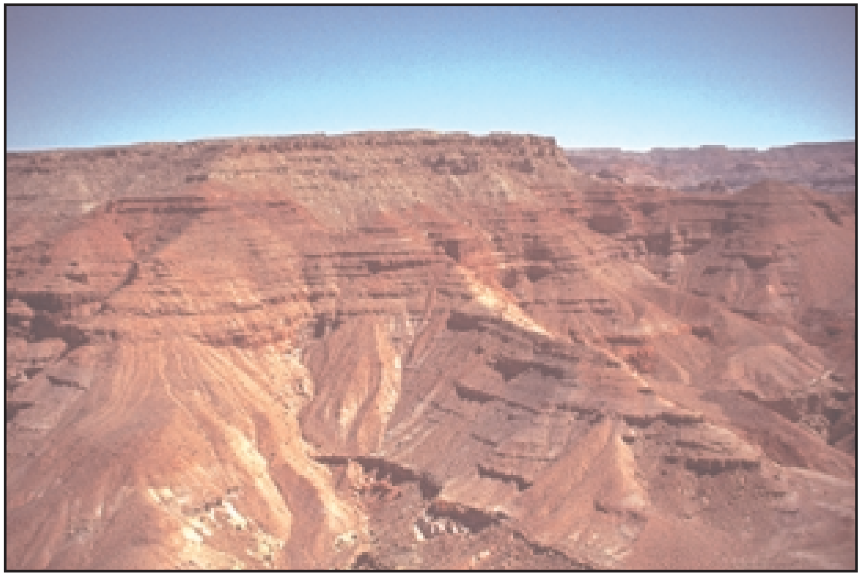
Introduction

During the past 35 years, the U.S. Geological Survey (USGS) has conducted extensive geologic research in the area of the Kaiparowits Plateau, Utah. The studies resulted in numerous publications that described the geology of the region; these studies also provided essential data for land-use planning and resource evaluation. The Kaiparowits Plateau is one of twelve areas on the Colorado Plateau that was evaluated as part of the USGS National Coal Resource Assessment. The Kaiparowits Plateau was evaluated because coal companies had expressed an interest in developing its coal resource and because the potential for coal development had created land-use and environmental issues.

Hettinger and others (chap. T, this CD-ROM) have integrated outcrop geologic and subsurface drill-hole data to assess the coal resources of the Kaiparowits Plateau. This summary report provides a brief description of the geology and coal in the Kaiparowits Plateau and serves as an overview to the more detailed report in chapter T.

Acknowledgments

I thank Peter McCabe (USGS) for providing photographs and Russell Dubiel, Tim Hester, Rick Scott, and Kathy Varnes (USGS) for their technical reviews.



Red strata produced by burned coal beds in the southern part of the Kaiparowits Plateau. Photograph by Peter McCabe.

Location of the Kaiparowits Plateau

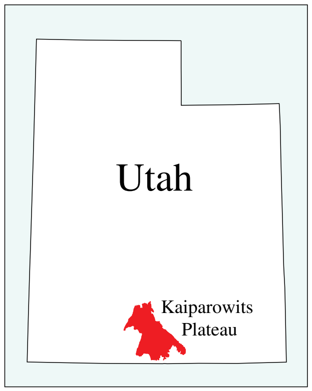


Figure 1. Location of the Kaiparowits Plateau in southern Utah.

The Kaiparowits Plateau is located in south-central Utah (fig. 1) within Garfield and Kane Counties. Nearby towns include Boulder, Escalante, Henrieville, and Glen Canyon City (fig. 2). The plateau is delineated by the base of Upper Cretaceous rocks except at its northern boundary, where it is truncated by the Paunsaugunt fault and merges with the Aquarius Plateau. The plateau extends 65 mi from north to south and 20 to 55 mi from east to west, covering 1,650 mi^2.

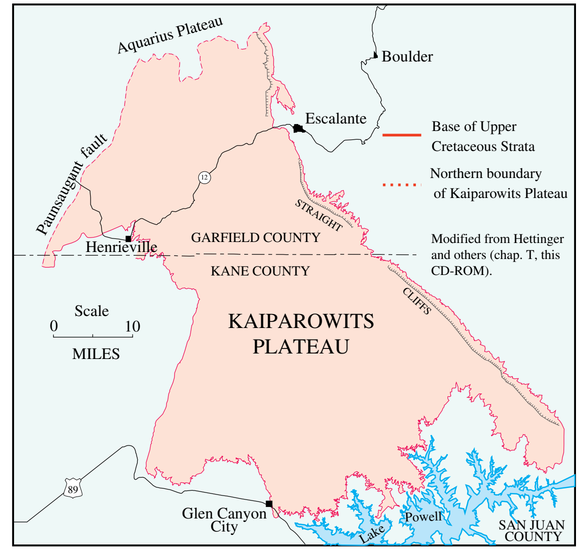


Figure 2. Location of the Kaiparowits Plateau, counties, highways, and towns.

The Kaiparowits Plateau extends through the central part of the Grand Staircase–Escalante National Monument (fig. 3). The northern part of the plateau is within the Dixie National Forest, and the southern part of the plateau is within the Glen Canyon National Recreation Area (fig 3). Capitol Reef and Bryce Canyon National Parks are located east and west of the plateau, respectively (fig 3).

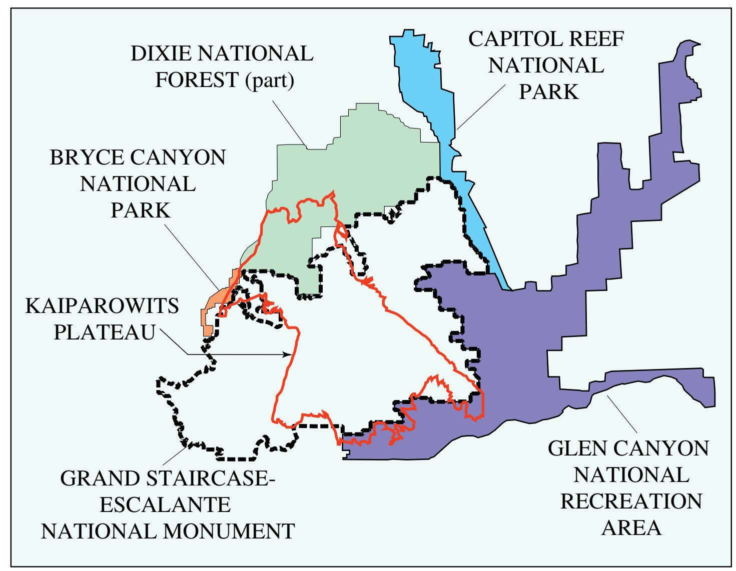


Figure 3. Location of the Kaiparowits Plateau with respect to nearby National Forests, Parks, Monuments, and Recreation areas. After Hettinger and others (chap. T, this CD-ROM).

Physiography of the Kaiparowits Plateau

The Kaiparowits Plateau is a dissected mesa that rises as much as 6,500 ft above the surrounding terrain. Elevations range from 10,450 ft above sea level near the Aquarius Plateau on the north, to 4,000 ft above sea level near Lake Powell on the south. The landscape is defined by four sets of cliffs and benches that are located between the Aquarius Plateau and Lake Powell. One set includes a prominent escarpment along the plateau's eastern flank. This escarpment is called the Straight Cliffs and is 1,100 ft high at Fiftymile Mountain (fig. 4). These various landforms are shown on a shaded relief map that has been modified from a Digital Elevation Model produced by the U.S. Geological Survey (fig. 4).

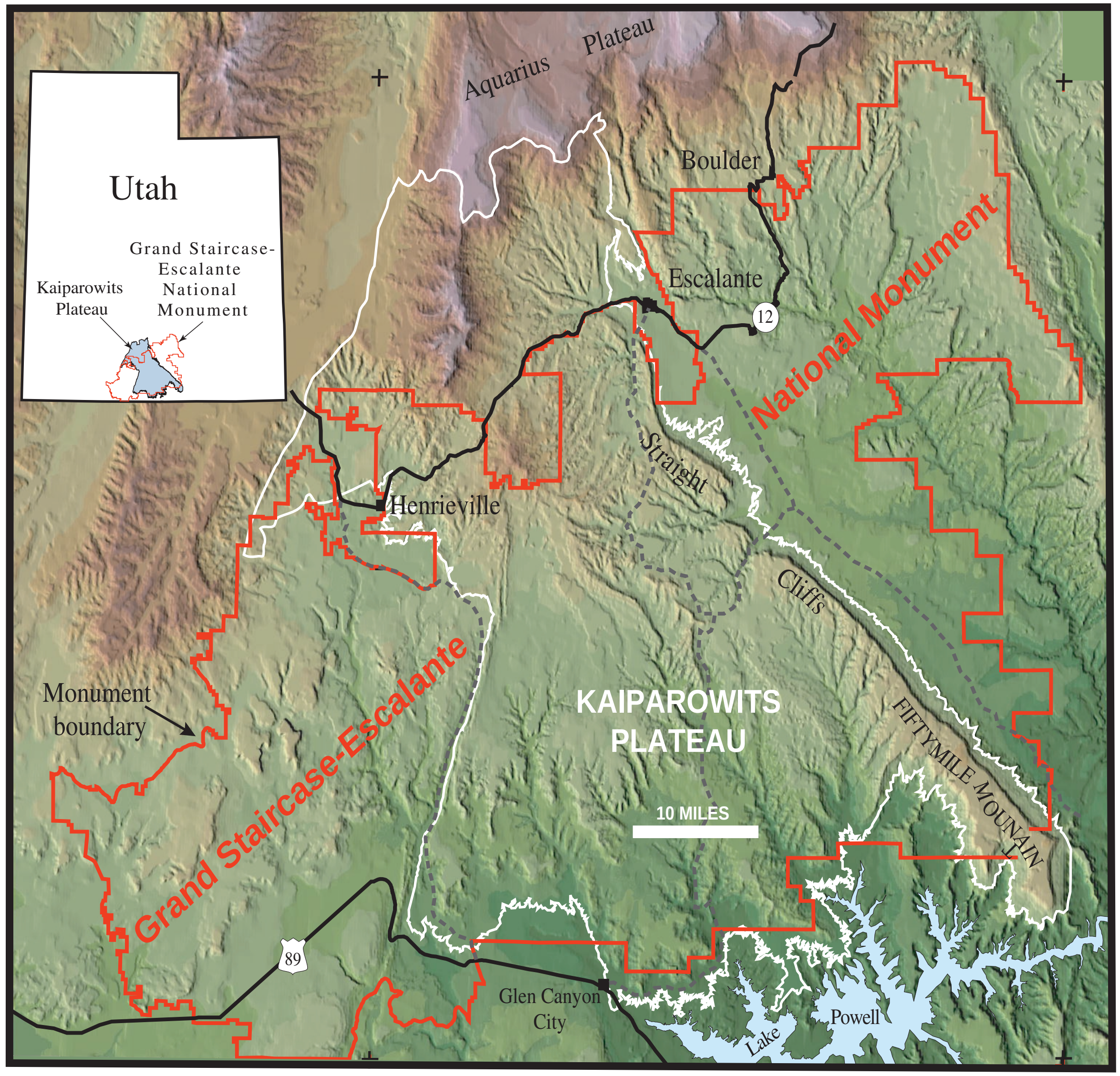


Figure 4. Shaded relief map of the Kaiparowits Plateau and vicinity.

Geologic Mapping

The U.S. Geological Survey (USGS) and the Utah Geological and Mineralogical Survey have published geologic maps at various scales for all areas within the Kaiparowits Plateau. Mapped areas are shown in figure 5 and are referenced below. The geologic maps provided essential data for the assessment of the plateau's coal resources.

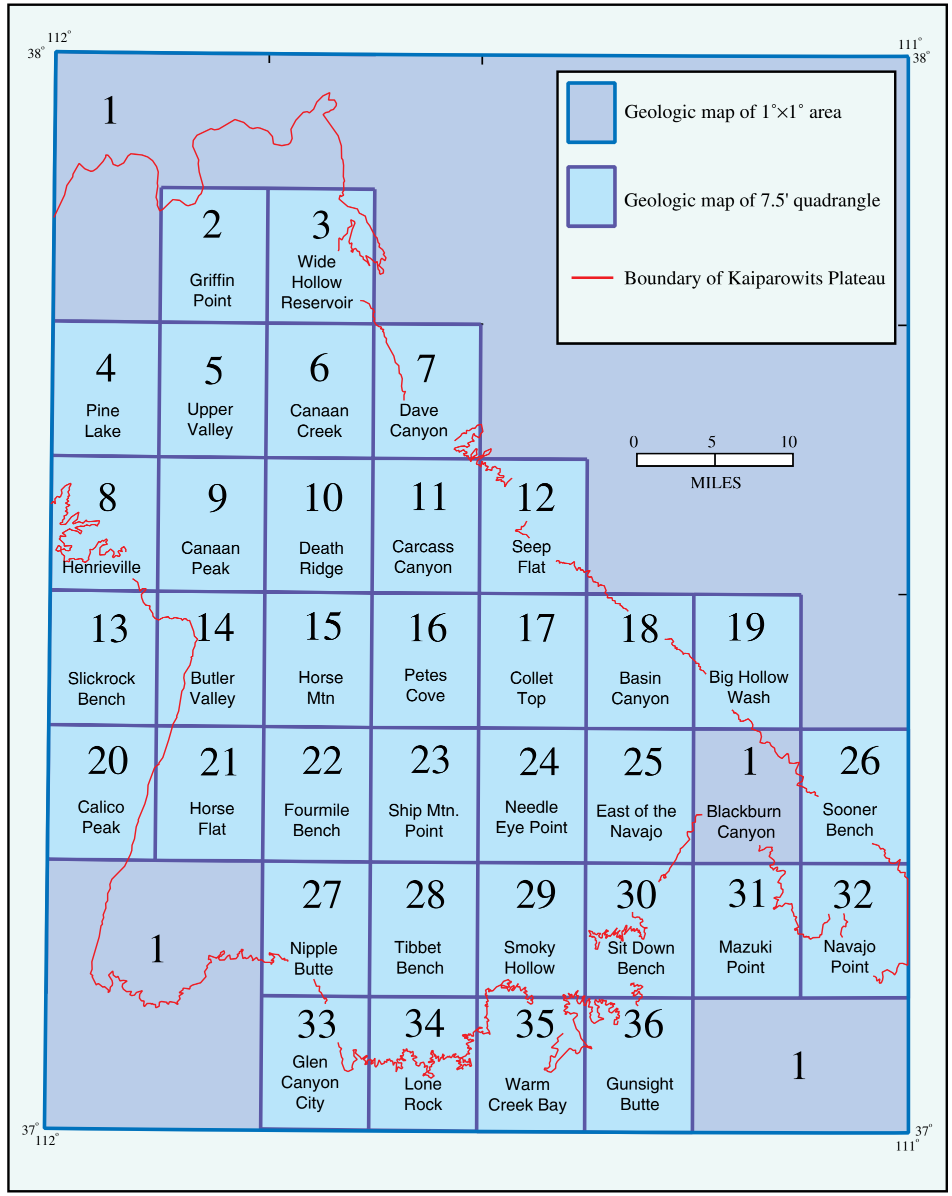


Figure 5. Index map showing detailed geologic mapping used by Hettinger and others (chap. T, this CD-ROM) to assess coal in the Kaiparowits Plateau. Published geologic maps are referenced in table, and names of selected 7.5' quadrangles are shown.

Table showing references to geologic mapping in the Kaiparowits Plateau.

Map no.	Reference	Map no.	Reference
1	Sargent and Hansen (1982)	19	Peterson (1980)
2	Bowers (1973b)	20	Doelling and Graham (1972)
3	Stephens (1973)	21	Bowers (1993)
4	Bowers (1973c)	22	Bowers (1991b)
5	Bowers (1973a)	23	Zeller and Vaninetti (1990)
6	Zeller (1973b)	24	Zeller (1990a)
7	Zeller (1973d)	25	Zeller (1990b)
8	Bowers (1975)	26	Peterson (1975)
9	Bowers (1981)	27	Waldrop and Sutton (1967a)
10	Zeller (1973c)	28	Waldrop and Sutton (1967b)
11	Zeller (1973a)	29	Peterson (1967)
12	Zeller and Stephens (1973)	30	Peterson and Horton (1967)
13	Doelling and Graham (1972)	31	Peterson and Barnum (1973b)
14	Bowers (1983)	32	Peterson and Barnum (1973a)
15	Bowers (1991a)	33	Waldrop and Sutton (1967c)
16	Zeller (1990c)	34	Waldrop and Peterson (1967)
17	Zeller (1978)	35	Peterson (1973)
18	Doelling and Graham (1972)	36	Peterson and Waldrop (1967)

General Stratigraphy

The geology of the Kaiparowits Plateau was first described by Gregory and Moore (1931), but it was not until the 1960's that the region's geology and coal were investigated in detail. Stratigraphic studies by the USGS and the Utah Geological and Mineralogical Survey demonstrated that the plateau was underlain by as much as 10,500 ft of Upper Cretaceous and Tertiary strata (fig. 6). The rocks were grouped by similar age and depositional characteristics and named by Peterson (1969a, 1969b) and Bowers (1972). Their studies provided the basis for geologic mapping and stratigraphic investigations that were subsequently conducted throughout the plateau. During the same time, subsurface drilling revealed that the Upper Cretaceous Straight Cliffs Formation contained significant deposits of coal in the interior region of the Kaiparowits Plateau.

Age	Formation	Thickness (ft)	Description and depositional interpretation Lithologic descriptions and depositional interpretations are based on Sargent and Hansen (1982), Bowers (1972), Peterson (1969a, 1969b) and Shanley and McCabe (1991).
Miocene	**Osiris Tuff**	0-600	Gray, purplish-gray and red-brown welded ash-flow tuff. Volcanic.
Eocene and Paleocene	**Wasatch Fm.**	1,350-1,650	**Variegated sandstone member** (0-600 ft) Red, pink, and purplish-gray, very fine to coarse-grained sandstone, mudrock and minor conglomerate. Fluvial. **White limestone member** (0-600 ft) Light-gray to white, crystalline limestone and minor mudrock. Lacustrine. **Pink limestone member** (0-900 ft) Gray, tan, white, pink or red, fine-grained clastic limestone, mudrock, sandstone, and minor conglomerate. Fluvial.
Paleocene?	**Pine Hollow Fm.**	0-450	Lavender to red and gray mudrock and limestone with coarse-grained, pebbly sandstone in lower part. Low-energy fluvial and lacustrine.
Paleocene? and Late Cretaceous	**Canaan Peak Fm.**	0-900	Gray, tan, and brown conglomerate, conglomeratic sandstone, and minor gray and red mudstone. High-energy fluvial.
Late Cretaceous	**Kaiparowits Fm.**	600-3,000	Greenish- and bluish-gray, fine-grained, silty sandstone with subordinate beds of mudrock and limestone. Low-energy fluvial (meandering river) and floodplain.
	Wahweap Fm.	900-2,600	Light-gray and brownish-orange, fine- to medium-grained sandstone interbedded with gray mudrock and shale. Upper part is mostly sandstone. Fluvial and floodplain.
	Straight Cliffs Fm.	1,000-2,000	**Drip Tank Member** (140-400 ft) Light-gray, medium- to coarse-grained sandstone, conglomeratic sandstone, and minor mudrock. Braided river. **John Henry Member** (600-1,500 ft) Light-gray to brown, very fine to medium-grained sandstone; minor coarse-grained and conglomeratic sandstone; olive-gray, brown, and black mudrock, and coal. Nearshore marine, estuarine, paludal, and alluvial. **Smoky Hollow Member** (20-300 ft) Upper part is light-gray, medium- to coarse-grained pebbly sandstone (Calico bed) and contains coal in the subsurface. Lower part is fine-grained sandstone, mudrock, and coal. Braided river, coastal-plain and paludal. **Tibbet Canyon Member** (60-185 ft) Yellow-gray and gray-orange, fine- and medium-grained sandstone; siltstone and mudrock in lower part. Estuarine and nearshore marine.
	Tropic Shale	600-900	Gray shale with thin beds of siltstone and fine-grained sandstone in upper part. Offshore marine.
	Dakota Fm.	15-250	**Upper member** (0-68 ft) Light-brown, fine-grained to fine-grained sandstone interbedded with gray mudrock. Coastal plain, brackish water, and nearshore marine. **Middle member** (4-76 ft) Gray to brown, very fine grained to fine-grained sandstone interbedded with yellowish-green mudrock, carbonaceous mudrock and coal. Low-energy fluvial, floodbasin, and paludal. **Lower member** (0-66 ft) Gray to brown conglomerate and fine- to coarse-grained, pebbly sandstone and minor carbonaceous mudrock. High-energy fluvial.

Figure 6. Stratigraphic summary of Upper Cretaceous and Tertiary strata in the Kaiparowits Plateau, Utah. Modified from Hettinger and others (chap. T, this CD-ROM).

Stratigraphy of the Coal-Bearing Upper Cretaceous Straight Cliffs Formation

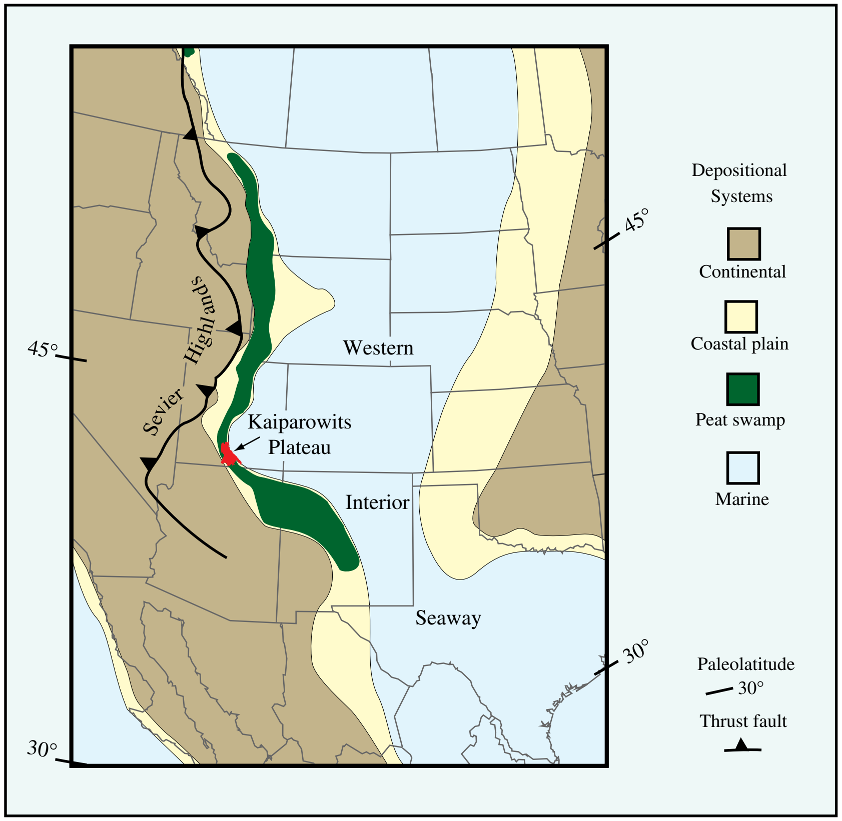


Figure 7. Paleogeographic reconstruction during the Coniacian and Santonian Stages. Modified from Roberts and Kirschbaum (1995).

During the Coniacian and Santonian Stages (88.5–83.5 Ma) of the Late Cretaceous, the area now occupied by the Kaiparowits Plateau was located near the western edge of the Western Interior Seaway (fig. 7). As a result of this depositional setting, the plateau contains Upper Cretaceous strata that accumulated in marine, coastal-plain, and alluvial environments (Peterson 1969a, 1969b). The coastal-plain strata contain coal that developed from the peat that accumulated in raised swamps (Shanley and McCabe, 1991; McCabe and Shanley, 1992). These marine, alluvial, and coal-bearing coastal-plain strata are preserved in the Straight Cliffs Formation.

The Straight Cliffs Formation is divided, in ascending order, into the Tibbet Canyon, Smoky Hollow, John Henry, and Drip Tank Members (Peterson, 1969a, 1969b) (fig. 8). The Tibbet Canyon consists of shallow-marine, beach, and estuarine deposits (Peterson, 1969a, 1969b; Shanley and McCabe, 1991). The Smoky Hollow has coal-bearing coastal-plain strata in its lower part and braided-river strata in its upper part; the braided-river deposits are called the Calico bed (Peterson, 1969a, 1969b). The upper part of the Smoky Hollow also has estuarine and coal-bearing coastal plain strata (Shanley and others, 1992; Hettinger and others, 1994). The John Henry consists of near-shore marine and estuarine strata that grade westward into coal-bearing coastal-plain and alluvial strata (Shanley and McCabe, 1991). The overlying Drip Tank consists of sandstone that was deposited in a fluvial environment (Peterson, 1969a, 1969b).

Drip Tank Member (140-400 ft) Light-gray, medium- to coarse-grained sandstone, conglomeratic sandstone, and minor mudrock. Braided river.

John Henry Member (600-1,500 ft) Light-gray to brown, very fine to medium-grained sandstone; minor coarse-grained and conglomeratic sandstone; olive-gray, brown, and black mudrock, and **coal**. Nearshore marine, estuarine, paludal, coastal plain, and alluvial.

Smoky Hollow Member (20-300 ft) Upper part contains light-gray, medium- to coarse-grained pebbly sandstone (Calico bed) and has some has **coal** in the subsurface. Lower part is fine-grained sandstone, mudrock, and **coal**. The upper part formed in braided river, estuarine, and coastal-plain environments. The lower part formed in paludal and coastal-plain environments.

Tibbet Canyon Member (60-185 ft) Yellow-gray and gray-orange, fine and medium-grained sandstone; lower part is siltstone and mudrock. Estuarine and nearshore marine.

Figure 8. Descriptions and depositional interpretations for members of the Straight Cliffs Formation.

Sequence Stratigraphy of the Upper Cretaceous Straight Cliffs Formation

Stratigraphic and sedimentological studies by Shanley and McCabe (1991) identified four unconformity-bounded sequences in the Straight Cliffs Formation (fig. 9). Deposition in each sequence was controlled by base-level fluctuations whereby each sequence-boundary unconformity was cut during a fall in base level and each overlying sequence was deposited during a rise in base level. Transgressive systems tracts were deposited as incised valleys and were backfilled with deepening-upward successions of strata during the initial stages of base-level rise. Overlying highstand systems tracts contained marine, coal-bearing coastal-plain, and alluvial strata that were arranged in aggradational and progradational stacks during slower rates of base-level rise (Shanley and McCabe, 1991; McCabe and Shanley, 1992; Shanley and others, 1992; Hettinger and others, 1994; and Hettinger, 1995).

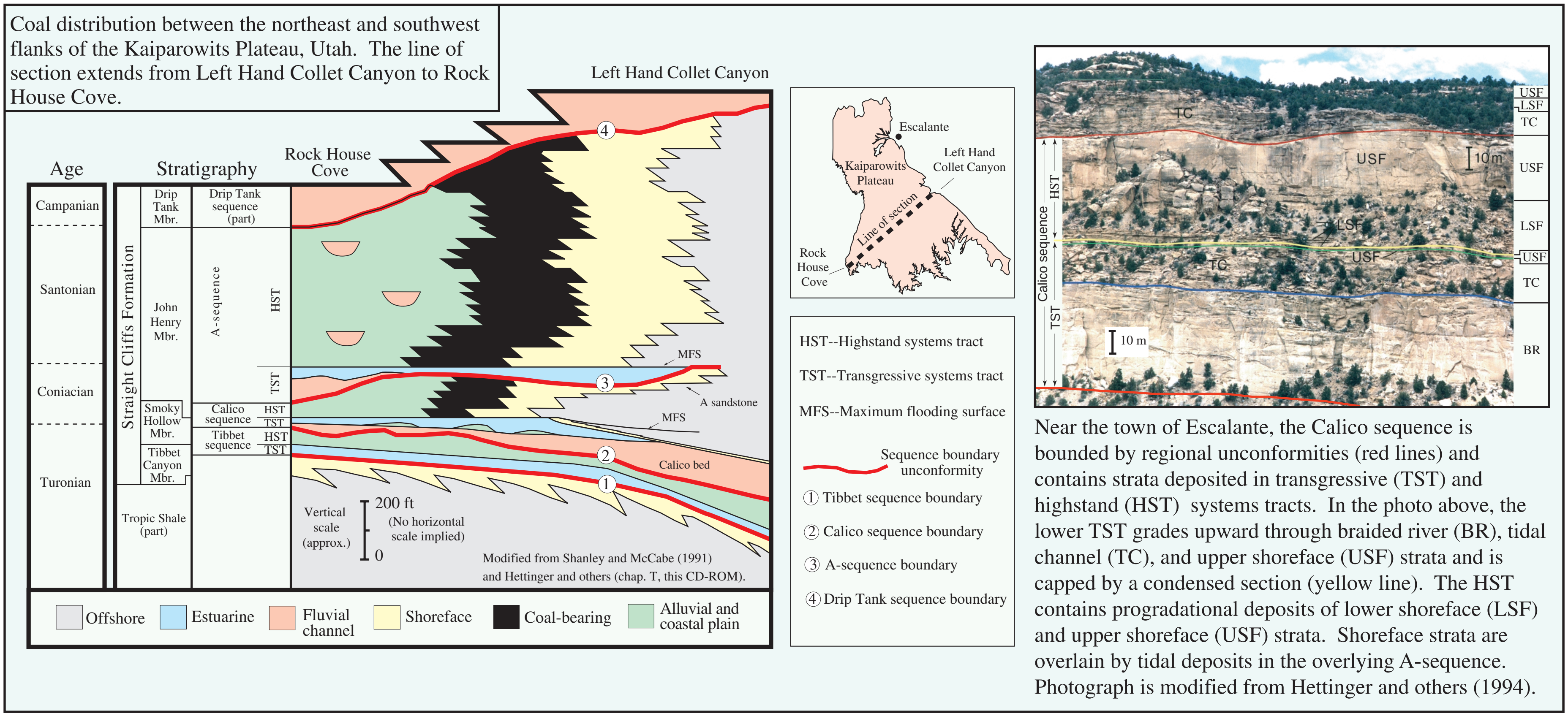


Figure 9. Sequence stratigraphy and facies relations in the Straight Cliffs Formation. The line of section is perpendicular to the paleoshoreline.

Folds and Faults in the Kaiparowits Plateau

Strata in the Kaiparowits Plateau are inclined along numerous north-trending folds that plunge into a deep central basin containing the Table Cliffs, Last Chance, and Coyote Creek–Billie Wash synclines (figs. 10, 11). The northeastern flank of the central basin is defined by the westward-dipping limb of the Dutton monocline. The central basin's western flank is defined by eastward-dipping limbs of the Johns Valley anticline and East Kaibab monocline. There are relatively few faults, and most are located along the flanks of the plateau.

Strata are inclined by less than 6° throughout most of the plateau (fig. 11). However, beds are inclined by as much as 25° near the town of Escalante, 30° on the eastern limb of the Johns Valley anticline, 45° along the Dutton monocline, and 80° along the East Kaibab monocline (fig. 11). Areas where strata are inclined from 0°–6°, 6°–12°, 12°–25°, and >25° are shown in figure 11.

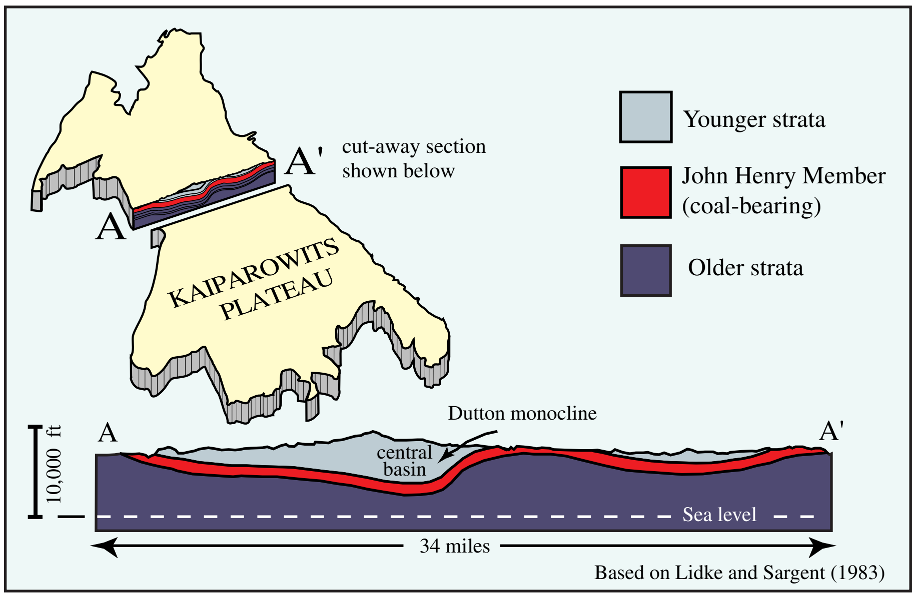


Figure 10. Generalized view of the Kaiparowits Plateau along cross section A-A′.

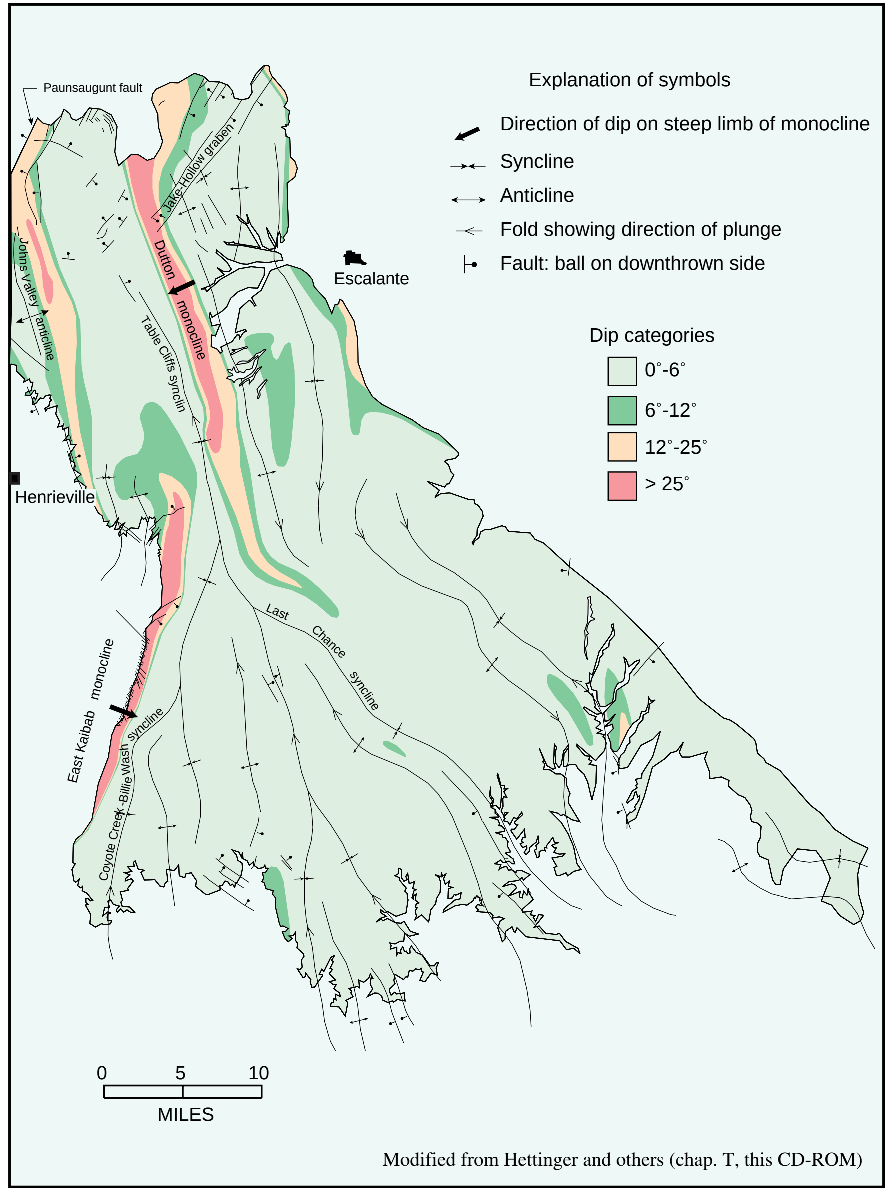
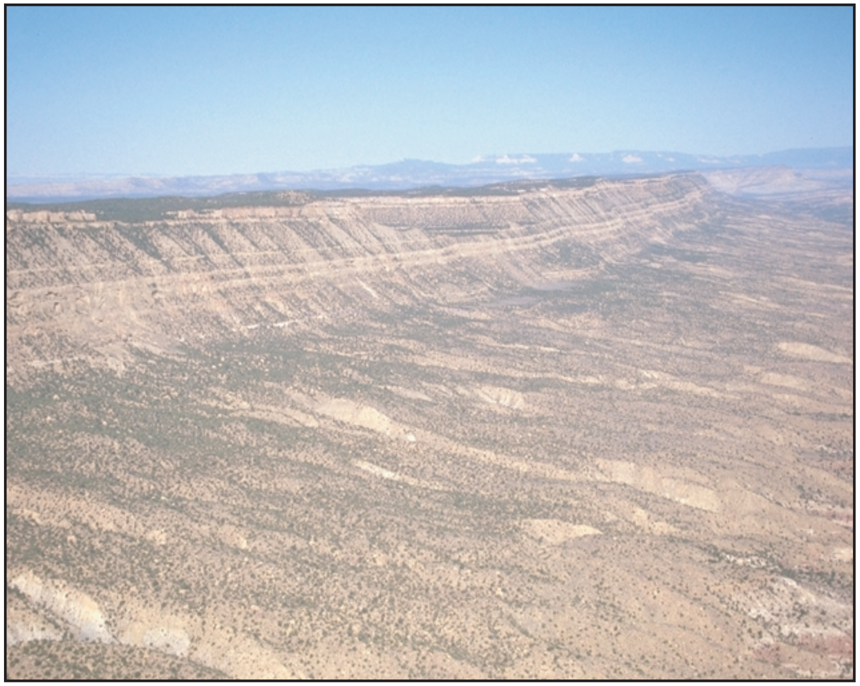


Figure 11. Structural features and inclination of strata of the Kaiparowits Plateau.

Distribution of Strata in the Kaiparowits Plateau

Structural features and exposures of strata in the Kaiparowits Plateau are shown on the accompanying generalized geologic map (fig. 12). Upper Cretaceous rocks in the Dakota, Tropic, and Straight Cliffs Formations are exposed along the flanks of the plateau and are buried by younger strata in the plateau's central region. Outcrops of the coal-bearing John Henry Member are shown in red. Although the Calico and A-sequences have not been mapped, their combined outcrops are nearly identical to those of the John Henry Member as shown in figure 12.



Exposures of the Straight Cliffs Formation along the Straight Cliffs escarpment, eastern flank of Kaiparowits Plateau. Photograph by Peter McCabe.

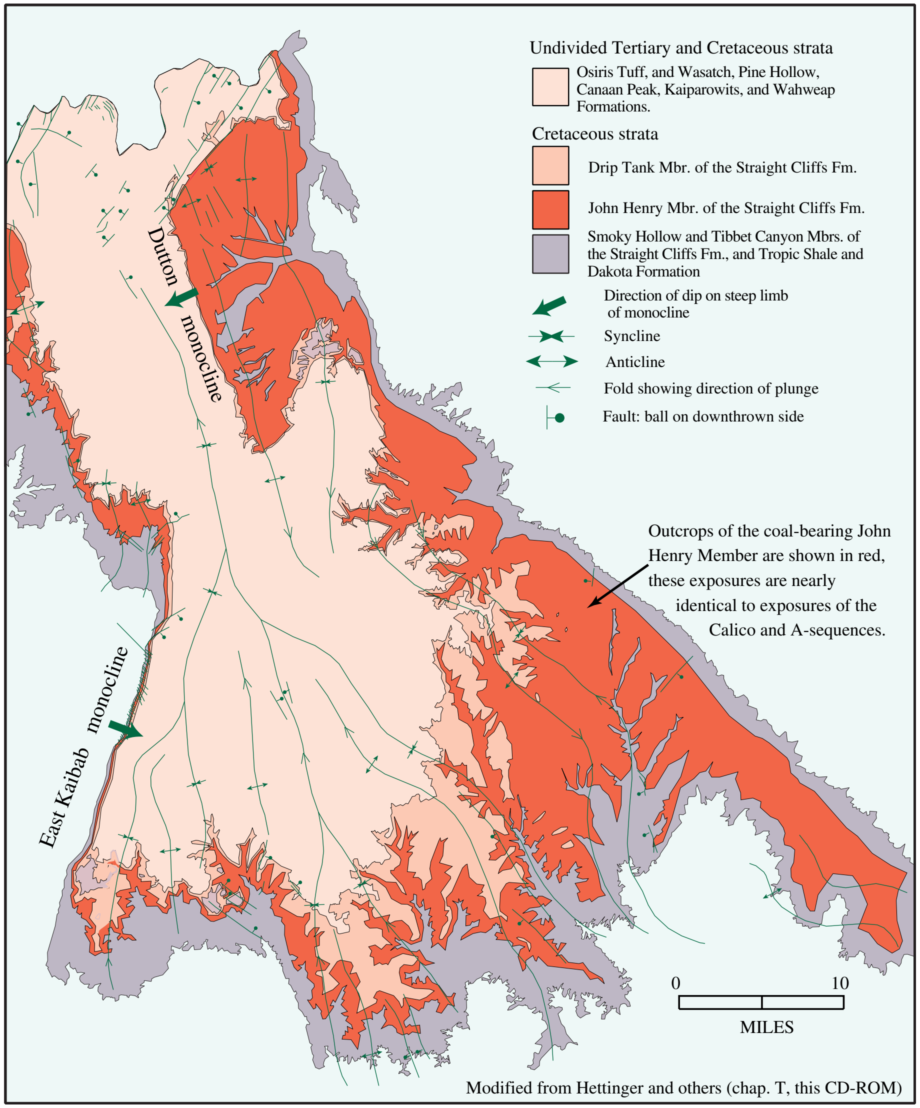


Figure 12. Geologic map of the Kaiparowits Plateau. The geology was digitized and modified from a 1:125,000 scale map by Sargent and Hansen (1982).

Distribution of Coal in the Calico and A-Sequences

The Kaiparowits Plateau has significant deposits of coal in the Calico and A-sequences. These sequences are equivalent to the upper part of the Smoky Hollow Member and the John Henry Member (fig. 13). Coal distribution in outcrops (figs. 12 and 14) has been determined from geologic mapping by the USGS and Utah Geological and Mineralogical Survey (fig. 5). Coal beds generally split and pinch out over short distances along outcrop, and many beds have been naturally burned. The lower, Christensen, Rees, and Alvey coal zones (fig. 13) occupy a 500- to 700-ft-thick interval on the plateau's eastern flank, and contain as much as 70 ft of net coal in that area. Coal-bearing strata thin southwest, and less than 25 ft of net coal is in the Henderson coal zone, which is exposed along the plateau's western flank. A summary of published coal data for each 7.5' quadrangle is provided in Hettinger and others (chap. T, this CD-ROM).

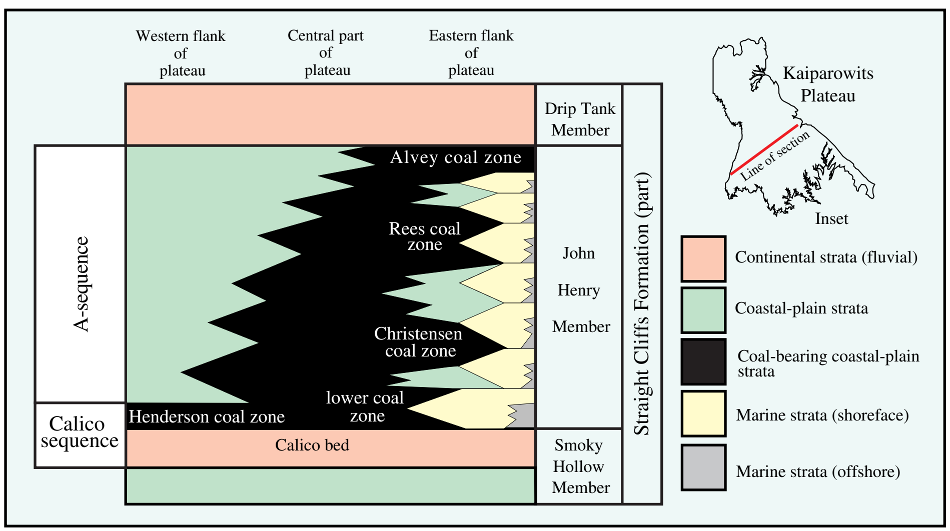


Figure 13. Diagram showing coal zones in the John Henry Member. The line of section trends northeast-southwest (see inset map).

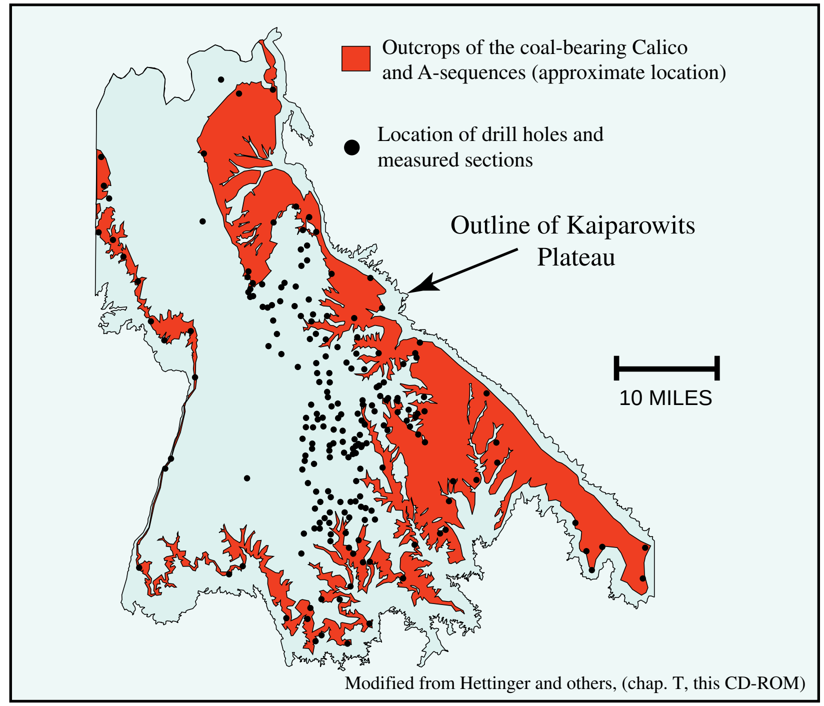


Figure 14. Locations of drill holes and measured sections used to assess coal resources in the Kaiparowits Plateau.

The distribution of coal in the plateau's subsurface has been revealed by exploratory drilling. Drill-hole data show that net coal is thickest in the plateau's interior region. Both outcrop and drill-hole data were used by Hettinger and others (chap. T, this CD-ROM) to determine the distribution of coal throughout the plateau. The locations of drill holes and measured sections are shown in figure 14.

Stratigraphic Cross Sections and Coal Correlations in the Calico and A-Sequences

The Calico and A-sequences (Smoky Hollow (upper part) and John Henry Members) contain as many as 30 beds of coal that range from 1 to 59 ft in thickness. The subsurface distribution of coal is shown by a series of cross sections in Hettinger and others (chap. T, this CD-ROM). Locations of the cross sections are shown below in figure 15, and an example of cross section B-B' is shown to the right in figure 16.

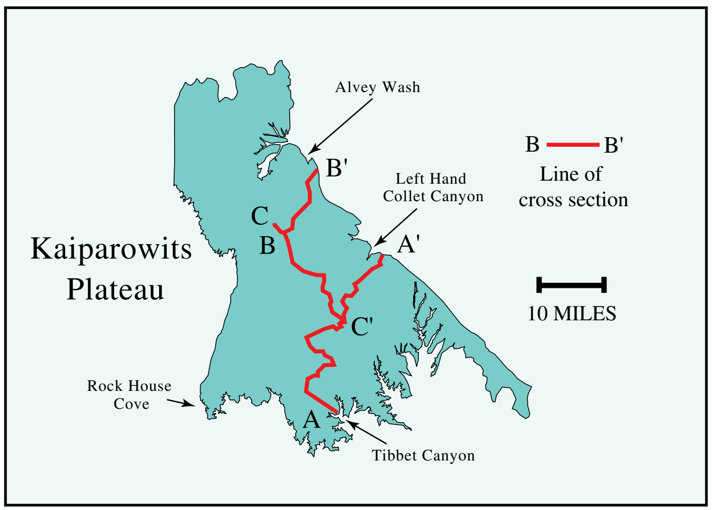


Figure 15. Location of cross sections used to show the subsurface distribution of coal across the Kaiparowits Plateau. All cross sections are shown in Hettinger and others (chap. T, this CD-ROM). Only cross section B-B' is shown to the right.

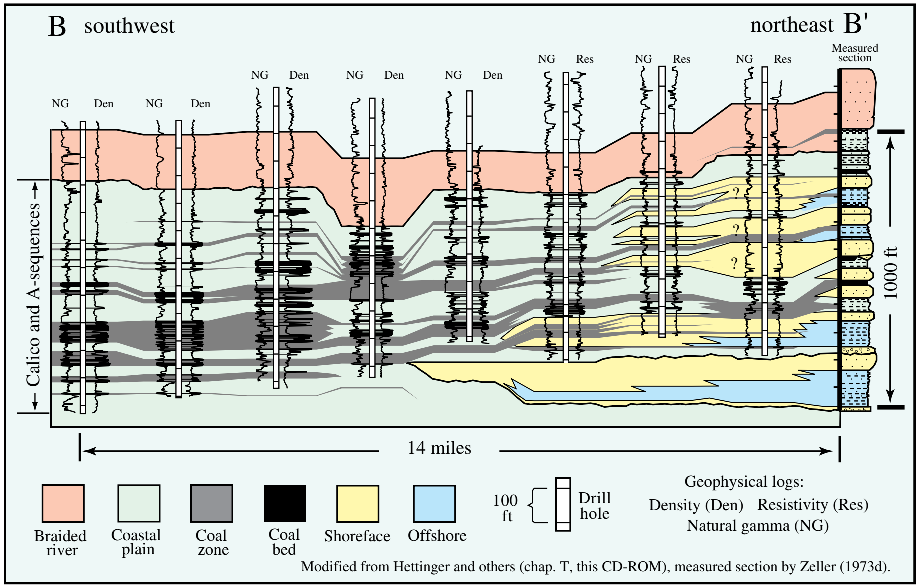


Figure 16. Coal correlations along cross section B-B'. The cross section is located in the northern part of the Kaiparowits plateau (fig. 15) and extends 14 mi perpendicular to the paleoshorelines.

The cross sections were constructed from geophysical well logs, core descriptions, and measured sections. Cross sections A-A' and B-B' are oriented perpendicular to paleoshorelines, and cross section C-C' is oriented parallel to the paleoshorelines. The cross sections show that variations in coal thickness are related to the distance that the original peat accumulated from the shoreline. The shoreline reached a stillstand in the vicinity of the plateau's eastern flank where the sequences are dominated by sandstone and mudrock deposited in nearshore marine environments. Southwestward thinning of shoreface deposits is accompanied by an increase in net coal thickness. As viewed in cross section B-B' (fig. 16), thick beds of coal are located only a few miles landward of the shoreface deposits. More than 100 ft of net coal are located 8–15 mi southwest of the plateau's eastern flank.

Isopach and Overburden Maps of Coal in the Calico and A-Sequences

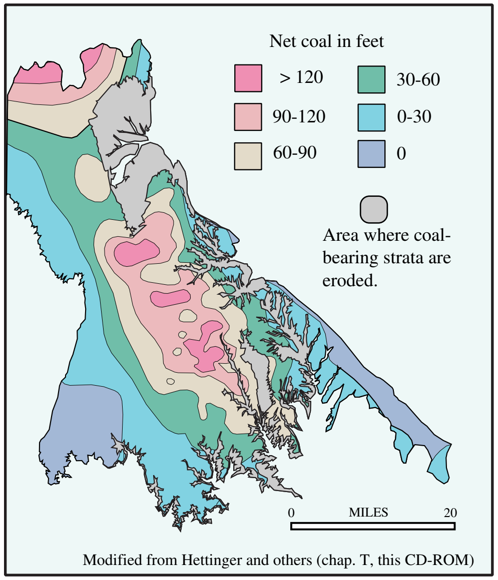


Figure 17. Isopach map of net coal for beds more than 1 ft thick in the Calico and A-sequences.

Coal distribution in the Calico and A-sequences (Smoky Hollow (upper part) and John Henry Members) is also shown in a series of isopach maps by Hettinger and others (chap. T, this CD-ROM). The net (total) coal isopach map (fig. 17) shows that coal is widely distributed throughout the plateau, and more than 100 ft of net coal is in the subsurface of the plateau's central region. Isopach maps by Hettinger and others (chap. T, their figs. 16–21) demonstrate that coal beds of increasing thickness occupy successively smaller areas in the plateau's interior. For example, coal beds that are 14 to 20 ft thick are found only in the central region of the plateau, and they have a cumulative thickness of as much as 80 ft (fig. 18).

The depth of coal below the Earth's surface is shown by the overburden map in figure 19. The map shows that the base of the coal-bearing interval is less than 2,000 ft deep in all areas of the plateau, except for the central basin where overburden is 2,000 to 8,500 ft thick.

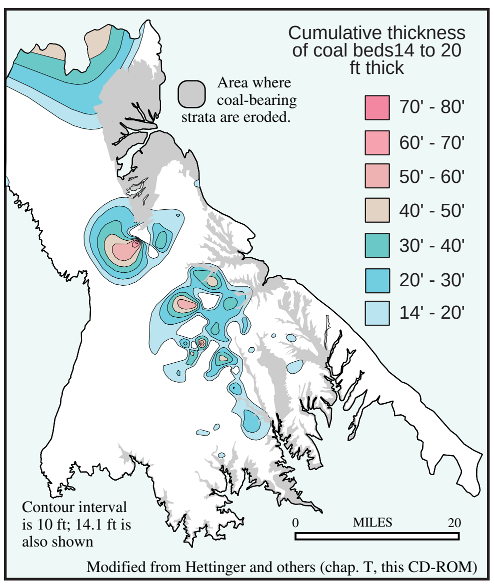


Figure 18. Isopach map of cumulative coal thickness for beds 14–20 ft thick in the combined Calico and A-sequences.

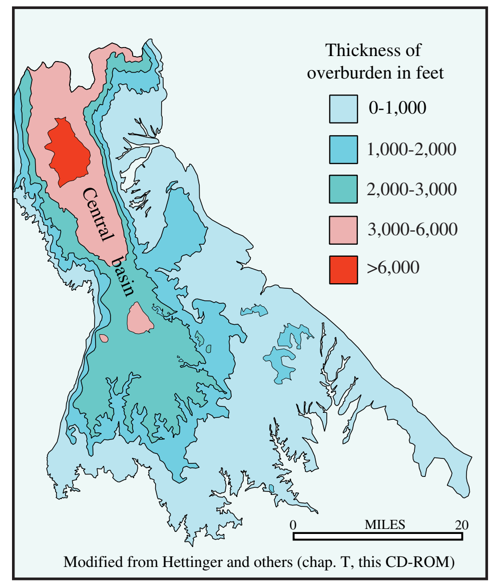


Figure 19. Isopach map of overburden on the base of the coal-bearing interval.

Coal Quality in the Calico and A-Sequences

Coal zone	Moisture %	Volatile matter %	Fixed carbon %	Ash yield %	Sulfur content %	Heating value Btu/lb	Moist, mineral-matter-free heating value Btu/lb	Apparent rank
Coals sampled from core K-DR-1; analyses reported by Zeller (1979)								
Alvey (2 samples)	19.7-20.4	34.7-35.1	37.0-37.7	7.2-8.2	1.0	9,440-9,510	10,240-10,440	Subbituminous B
Rees (3 samples)	15.6-18.4	29.6-35.0	29.9-36.3	10.3-24.9	0.6-0.7	7,640-9,280	10,450-10,460	Subbituminous B
Christensen (3 samples)	19.7-21.1	33.3-34.7	39.8-40.9	4.4-5.8	0.5-0.6	9,830-9,860	10,320-10,520	Subbituminous A and B
Coals sampled from core SMP-1-91; analyses provided by Brenda Pierce (USGS, unpub. data, 1996)								
Rees ? (6 samples)	8.2-9.7	41.7-43.9	41.8-44.7	2.7-8.2	0.4-0.7	11,488-12,381	12,390-12,760	High-volatile C Bituminous
Rees (17 samples)	0.7-7.8	27.9-50.7	24.9-45.4	4.3-42.5	0.5-2.3	6,962-12,387	12,700-13,710	High-volatile B and C Bituminous
Christensen (13 samples)	5.5-7.9	35.3-44.5	34.6-48.0	2.3-24.7	0.3-1.0	9,464-12,477	12,360-13,590	High-volatile B and C Bituminous
lower (15 samples)	4.5-7.1	35.4-46.5	32.1-45.5	3.5-26.4	0.4-2.3	9,002-12,620	12,610-16,720	High-volatile A, B, and C Bituminous
Coals sampled from core CT-1-91; analyses provided by Brenda Pierce (USGS, unpub. data, 1996)								
Christensen (23 samples)	8.5-15.5	34.5-41.1	34.8-4.6	3.7-17.6	0.4-2.2	9,717-11,721	11,110-12,590	Subbituminous A to High-volatile C Bituminous
Coals sampled from core DH-1; analyses summarized from Doelling and Graham (1972)								
Henderson (5 samples)	9.4-18.9	32.4-38.2	26.4-35.6	8.4-29.9	no record	9,740-10,300	11,010-11,350	Subbituminous A

Figure 20. Coal-quality summary for samples collected from cores of the Calico and A-sequences. Coal zone queried where uncertain. Apparent rank calculated using the Parr formula (American Society for Testing and Materials, 1995). Core hole locations are shown in figure 21. Modified from Hettinger and others (chap. T, this CD-ROM).

The apparent rank of coal in the Kaiparowits Plateau is subbituminous C to high-volatile A bituminous, based on proximate and ultimate analyses of about 100 samples collected from abandoned mines and outcrops (Doelling and Graham, 1972). Additional coal-quality data has been reported for samples collected from four cores (fig. 20). Apparent ranks determined from the core samples range from subbituminous B to high-volatile A bituminous. Core hole locations are shown in figure 21.

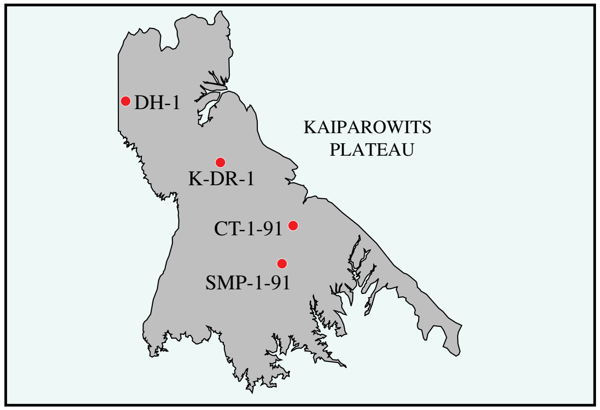


Figure 21. Locations of core holes; analyses are given in figure 20.

Previous Mining Activity in the Kaiparowits Plateau

Coal in the Kaiparowits Plateau was produced from small mines between the late 1800's and early 1960's. Less than 50,000 short tons of coal were produced, and all of the mines have been abandoned (fig. 22). In the 1960's, energy companies expressed an interest to develop the region's coal, and plans were made to develop a coal-burning power plant near the plateau. The plans were revised after controversy over environmental issues, and they were finally discontinued due to Government action and pending lawsuits over environmental issues. The few Federal coal leases that remained were suspended prior to the establishment of the Grand Staircase–Escalante National Monument in 1996, and they remain in suspension as of the date of this publication. By 1999, only one Preference Right Lease Application was in effect; it was located in the northern part of the plateau.

Abandoned adit in a coal bed on the plateau's southern flank. Photograph by Peter McCabe.

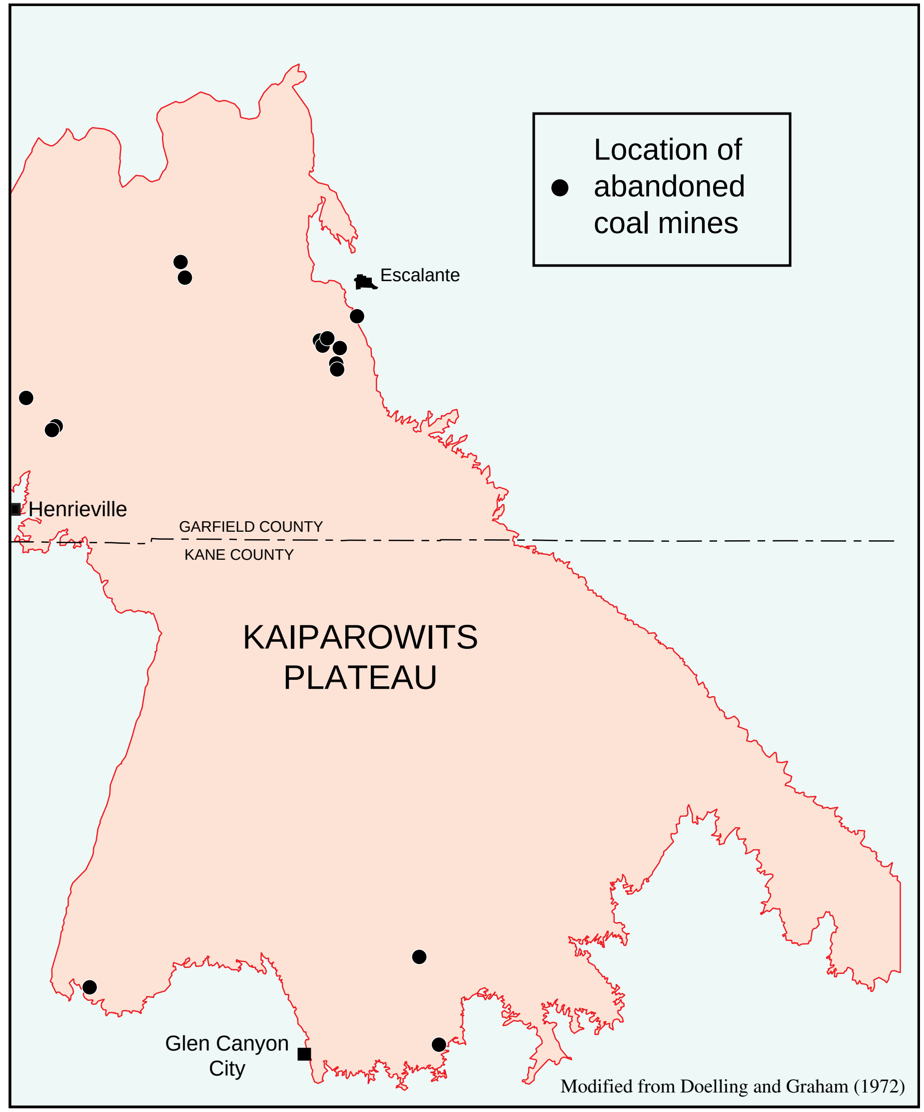


Figure 22. Location of abandoned coal mines in the Kaiparowits Plateau, Utah. No mines are currently in operation.

Coal Resources of the Kaiparowits Plateau, Utah

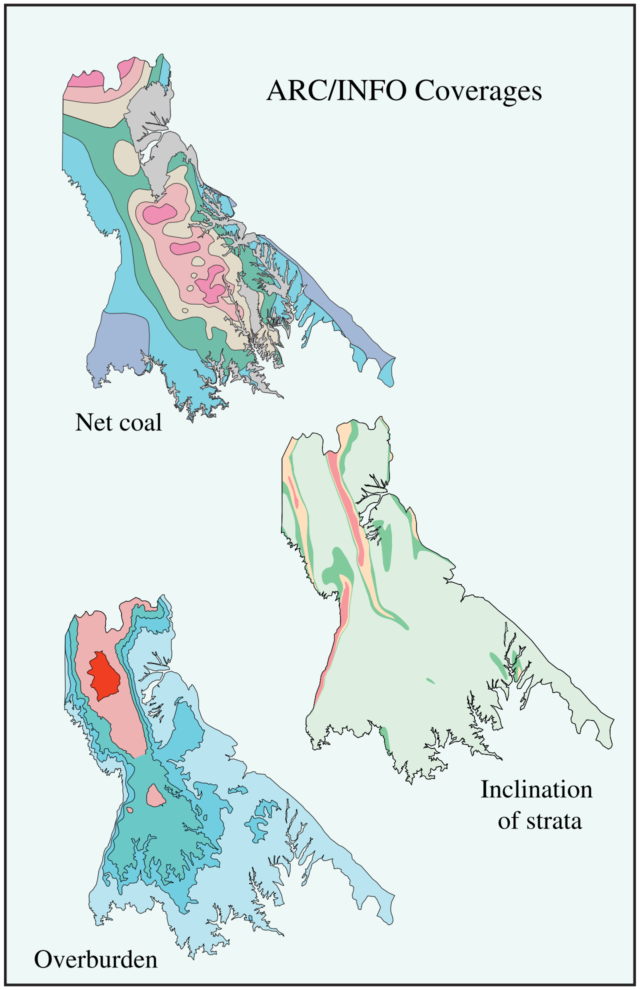


Figure 23. Examples of geologic and geographic coverages queried in GIS to report coal resources within various spatial parameters. In this example, digital maps of net coal, inclination of strata, and overburden were combined to report coal resources in both range of dip and overburden categories.

Digital coverages have been combined in a Geographic Information System (GIS) to report coal resources by various geographic and geologic parameters (fig. 23). Coal tonnages were calculated by multiplying the density of coal by the volume of coal, as determined from the net coal isopach map (fig. 17), and resources were reported in overburden categories by combining the coal isopach map with the overburden map (fig. 19). Additional coverages were used to report resources by county, quadrangle, township, areas of mineral ownership, and in categories that might be useful for longwall mining. Results are reported by Hettinger and others (chap. T, this CD-ROM). Coal resources were determined using the methods described in Wood and others (1983) and Roberts and others (chap. C, this CD-ROM). All digital data are available in a report by Biewick and Mercier (chap. D, this CD-ROM).

The Calico and A-sequences contain about 48 billion short tons of coal that are less than 3,000 ft deep and about 14 billion short tons of coal that are 3,000 to 8,500 ft deep (fig. 24). These coal tonnage figures must be regarded with caution because they do not reflect economic, land-use, environmental, technological, and geologic restrictions that affect availability and recoverability. For example, at least 55 percent of the coal is not likely to be mined because of excessive overburden, steep dip of strata, and limited or excessive coal-bed thickness. Additional coal might not be mined from beds that are discontinuous, used for support, or destroyed while mining adjacent strata. Additionally, a significant part of the resource might remain undeveloped because it is now within the Grand Staircase–Escalante National Monument.

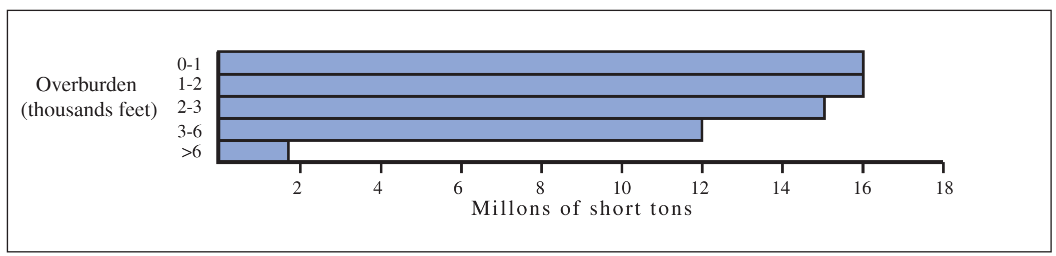


Figure 24. Original coal resources and other occurrences of non-resource coal (in millions of short tons) in the Calico and A-sequences. Coal tonnage is reported by overburden based on Hettinger and others (chap. T, this CD-ROM).

References Cited

American Society for Testing and Materials, 1995, Standard classification of coals by rank [ASTM designation D388-95]: 1995 Annual book of ASTM Standards, v. 05.05, p. 169-171.

Bowers, W.E., 1972, The Canaan Peak, Pine Hollow, and Wasatch Formations in the Table Cliff region, Garfield County, Utah: U.S. Geological Survey Bulletin 1331-B.

Bowers, W.E., 1973a, Geologic map and coal resources of the Upper Valley quadrangle, Garfield County, Utah: U.S. Geological Survey Coal Investigations Map C-60, scale 1:24,000.

Bowers, W.E., 1973b, Geologic map and coal resources of the Griffin Point quadrangle, Garfield County, Utah: U.S. Geological Survey Coal Investigations Map C-61, scale 1:24,000.

Bowers, W.E., 1973c, Geologic map and coal resources of the Pine Lake quadrangle, Garfield County, Utah: U.S. Geological Survey Coal Investigations Map C-66, scale 1:24,000.

Bowers, W.E., 1975, Geologic map and coal resources of the Henrieville quadrangle, Garfield and Kane Counties, Utah: U.S. Geological Survey Coal Investigations Map C-74, scale 1:24,000.

Bowers, W.E., 1981, Geologic map and coal deposits of the Canaan Peak quadrangle, Garfield and Kane Counties, Utah: U.S. Geological Survey Coal Investigations Map C-90, scale 1:24,000.

Bowers, W.E., 1983, Geologic map and coal sections of the Butler Valley quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-95, scale 1:24,000.

Bowers, W.E., 1991a, Geologic map and coal deposits of the Horse Mountain quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-137, scale 1:24,000.

Bowers, W.E., 1991b, Geologic map of the Fourmile Bench quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-140, scale 1:24,000.

Bowers, W.E., 1993, Geologic map of the Horse Flat quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-144, scale 1:24,000.

Doelling, H.H., and Graham, R.L., 1972, Southwestern Utah coal fields—Alton, Kaiparowits, and Kolob-Harmony: Utah Geological and Mineralogical Survey Monograph Series, no. 13, 33 p.

Gregory, H.E., and Moore, R.C., 1931, The Kaiparowits region, a geographic and geologic reconnaissance of parts of Utah and Arizona: U.S. Geological Survey Professional Paper 164, 161 p.

Hettinger, R.D., 1995, Sedimentological descriptions and depositional interpretations, in sequence stratigraphic context, of two 300-m cores from the Upper Cretaceous Straight Cliffs Formation, Kaiparowits Plateau, Kane County, Utah: U.S. Geological Survey Bulletin 2115-A, 32 p.

Hettinger, R.D., McCabe, P.J., and Shanley, K.W., 1994, Detailed facies anatomy of transgressive and highstand systems tracts from the Upper Cretaceous of southern Utah, U.S.A., in Posamentier, H.W., and Weimer, P., eds., Recent Advances in Siliciclastic Sequence Stratigraphy: American Association of Petroleum Geologists Memoir 58, p. 235–257.

Lidke, D.J., and Sargent, K.A., 1983, Geologic cross sections of the Kaiparowits coal-basin area, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1033-J, scale 1:125,000.

McCabe, P.J., and Shanley, K.W., 1992, An organic control on shoreface stacking patterns--Bogged down in the mire: Geology, v. 20, p. 741–744.

Peterson, Fred, 1967, Preliminary geologic map of the northwest quarter of the Gunsight Butte quadrangle [Smoky Hollow 7.5' quadrangle], Kane County, Utah: Utah Geological and Mineralogical Survey Map 24-E, scale 1:31,680.

Peterson, Fred, 1969a, Cretaceous sedimentation, and tectonism, of the southeastern Kaiparowits Plateau, Utah: U.S. Geological Survey Open-File Report 69-202, 259 p.

Peterson, Fred, 1969b, Four new members of the Upper Cretaceous Straight Cliffs Formation in the southeastern Kaiparowits Plateau region, Kane County, Utah: U.S. Geological Survey Bulletin 1274-J, p. J1–J28.

Peterson, Fred, 1973, Geologic map of the southwest quarter of the Gunsight Butte quadrangle [Warm Creek Bay 7.5' quadrangle], Kane and San Juan Counties, Utah, and Coconino County, Arizona: U.S. Geological Survey Mineral Investigations Map MF-306, scale 1:24,000.

Peterson, Fred, 1975, Geologic map of the Sooner Bench quadrangle, Kane County, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-874, scale 1:24,000.

Peterson, Fred, 1980, Geologic map and coal deposits of the Big Hollow Wash quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-84, scale 1:24,000.

Peterson, Fred, and Barnum, B.E., 1973a, Geologic map and coal resources of the northeast quarter of the Cummings Mesa quadrangle [Navajo Point 7.5' quadrangle], Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-63, scale 1:24,000.

Peterson, Fred, and Barnum, B.E., 1973b, Geologic map and coal resources of the northwest quarter of the Cummings Mesa quadrangle [Mazuki Point 7.5' quadrangle], Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-64, scale 1:24,000.

Peterson, Fred, and Horton, G.W., 1967, Preliminary geologic map and coal deposits of the northeast quarter of the Gunsight Butte quadrangle [Sit Down Bench 7.5' quadrangle], Kane County, Utah: Utah Geological and Mineralogical Survey Map 24-F, scale 1:31,680.

Peterson, Fred, and Waldrop, H.A., 1967, Preliminary geologic map of the southeast quarter of the Gunsight Butte quadrangle [Gunsight Butte 7.5' quadrangle], Kane and San Juan Counties, Utah and Coconino County, Arizona: Utah Geological and Mineralogical Survey Map 24-G, scale 1:31,680.

Roberts, L.N.R., and Kirschbaum, M.A., 1995, Paleogeography of the Late Cretaceous of the Western Interior of Middle North America-- Coal distribution and sediment accumulation: U.S. Geological Survey Professional Paper 1561, 115 p.

Robison, R.A., 1966, Geology and coal resources of the Tropic area, Garfield

County, Utah: Utah Geological and Mineralogical Survey Special Studies 18, 47 p.

Rohrbacher, T.J., Teeters, D.D., Osmonson, L M., and Plis, M.N., 1994, Coal recoverability and the definition of coal reserves--Central Appalachian region, 1993, Coal Recoverability Series Report No. 2: U.S. Bureau of Mines Open-File Report 10-94, 36 p.

Sargent, K.A., 1984, Environmental geologic studies of the Kaiparowits coal-basin area, Utah: U.S. Geological Survey Bulletin 1601, 30 p.

Sargent, K.A., and Hansen, D.E., 1982, Bedrock geologic map of the Kaiparowits coal-basin area, Utah: U.S. Geological Survey Miscellaneous Investigations Series Map I-1033-I, scale 1:125,000.

Shanley, K.W., 1991, Sequence stratigraphic relationships, and facies architecture of Turonian-Campanian strata, Kaiparowits Plateau, south-central Utah: Golden, Colo., Colorado School of Mines Ph.D. dissertation, 390 p.

Shanley, K.W., and McCabe, P.J., 1991, Predicting facies architecture through sequence stratigraphy—An example from the Kaiparowits Plateau, Utah: Geology, v. 19, p. 742–745.

Shanley, K.W., McCabe, P.J., and Hettinger, R.D., 1992, Tidal influence in Cretaceous fluvial strata from Utah, U.S.A.—A key to sequence stratigraphic interpretation: Sedimentology, v. 39, p. 905–930.

Stephens, E.V., 1973, Geologic map and coal resources of the Wide Hollow Reservoir quadrangle, Garfield County, Utah: U.S. Geological Survey Coal Investigations Map C-55, scale 1:24,000.

Waldrop, H.A., and Peterson, Fred, 1967, Preliminary geologic map of the southeast quarter of the Nipple Butte quadrangle [Lone Rock 7.5′ quadrangle], Kane County, Utah and Coconino County, Arizona: Utah Geological and Mineralogical Survey Map 24-C, scale 1:31,680.

Waldrop, H.A., and Sutton R.L., 1967a, Preliminary geologic map and coal deposits of the northwest quarter of the Nipple Butte quadrangle [Nipple Butte 7.5′ quadrangle], Kane County, Utah: Utah Geological and Mineralogical Survey Map 24-A, scale 1:31,680.

Waldrop, H.A., and Sutton R.L., 1967b, Preliminary geologic map and coal deposits of the northeast quarter of the Nipple Butte quadrangle [Tibbet Bench 7.5′ quadrangle], Kane County, Utah: Utah Geological and Mineralogical Survey Map 24-B, scale 1:31,680.

Waldrop, H.A., and Sutton R.L., 1967c, Preliminary geologic map and coal deposits of the southwest quarter of the Nipple Butte quadrangle [Glen Canyon City 7.5′ quadrangle], Kane County, Utah and Coconino County, Arizona: Utah Geological and Mineralogical Survey Map 24-D, scale 1:31,680.

Wood, G.H., Jr., Kehn, T.M., Carter, M.D., and Culbertson W.C., 1983, Coal resource classification system of the U.S. Geological Survey: U.S. Geological Survey Circular 891, 65 p.

Zeller, H.D., 1973a, Geologic map and coal resources of the Carcass Canyon quadrangle, Garfield and Kane Counties, Utah: U.S. Geological Survey Coal Investigations Map C-56, scale 1:24,000.

Zeller, H.D., 1973b, Geologic map and coal resources of the Canaan Creek quadrangle, Garfield County, Utah: U.S. Geological Survey Coal Investigations Map C-57, scale 1:24,000.

Zeller, H.D., 1973c, Geologic map and coal resources of the Death Ridge quadrangle, Garfield and Kane Counties, Utah: U.S. Geological Survey Coal Investigations Map C-58, scale 1:24,000.

Zeller, H.D., 1973d, Geologic map and coal resources of the Dave Canyon quadrangle, Garfield County, Utah: U.S. Geological Survey Coal Investigations Map C-59, scale 1:24,000.

Zeller, H.D., 1978, Geologic map and coal resources of the Collet Top quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-80, scale 1:24,000.

Zeller, H.D., 1979, Composite geophysical logs and coal analyses for core-hole drilling in the Kaiparowits coal field, Garfield County, Utah: U.S. Geological Survey Open-File Report 79-1529, 12 p.

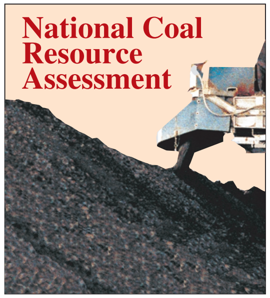
Zeller, H.D., 1990a, Geologic map and coal stratigraphy of the Needle Eye Point quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-129, scale 1:24,000.

Zeller, H.D., 1990b, Geologic map and coal stratigraphy of the East of the Navajo quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-130, scale 1:24,000.

Zeller, H.D., 1990c, Geologic map and coal stratigraphy of the Petes Cove quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-132, scale 1:24,000.

Zeller, H.D., and Stephens, E.V., 1973, Geologic map and coal resources of the Seep Flat quadrangle, Garfield and Kane Counties, Utah: U.S. Geological Survey Coal Investigations Map C-65, scale 1:24,000.

Zeller, H.D., and Vaninetti, G.E., 1990, Geologic map and coal stratigraphy of the Ship Mountain Point quadrangle and north part of the Tibbet Bench quadrangle, Kane County, Utah: U.S. Geological Survey Coal Investigations Map C-131, scale 1:24,000.



Click here to return to Disc 1 Volume Table of Contents