DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

COAL INVESTIGATIONS
MAP C-107

Figure 1.—MAP SHOWING GENERALIZED GEOLOGY AND LOCATIONS OF FENCE-DIAGRAM CROSS-SECTION LINES AND SELECTED DRILL HOLES IN AND ADJACENT TO THE EASTERN PART OF THE KAYCEE 30′ x 60′ QUADRANGLE, WYOMING

Table 1.-Coal bed thicknesses and elevations in the upper Fort Union Formation as interpreted from geophysical logs of drill holes used in fence diagram

Drill hole index number	Drill hole identification[1]	Thickness of Sussex coal zone (feet)	Thickness of all coal beds within Sussex coal zone (feet)	Coal bed thickness (in feet), and elevation (in feet above mean sea level) of upper surface of coal bed[2]
5-2	No. 1 Hesse	469	42	**3** - 3,139; **24** - 2,914; **12** - 2,840; 3 - 2,673
5-3	Dell Tower Federal No. 1	535	31	**3** - 3,052; **7** - 2,864; **5** - 2,736; **3** - 2,727; 10 - 2,715; **3** - 2,520
5-4	No. 1 Curtis Draw II Unit	320	37	**8** - 2,826; **11** - 2,709; **11** - 2,692; **7** - 2,613
6-2	No. 3 Federal Nipple Unit	462	47	**2** - 3,230; **5** - 3,185; **22** - 2,971; **13** - 2,860; **5** - 2,773; **3** - 2,739
6-5	Nipple 2-22B	482	64	**4** - 3,170; **3** - 3,116; **30** - 2,887; **15** - 2,810; **7** - 2,695; **5** - 2,685
6-6	Schaffer Federal No. 1	481	95	**10** - 3,208; **6** - 3,161; **36** - 2,885; **15** - 2,770; **28** - 2,750
6-8	No. 34-1S Stahmhauser	482	50	**3** - 3,221; **5** - 3,172; **27** - 2,955; **4** - 2,823; **5** - 2,815; **6** - 2,745; **2** - 2,230
6-10	11-A Gulf-Recluse	447	45	**3** - 3,287; **4** - 3,246; **30** - 3,039; **3** - 2,946; **5** - 2,929; **3** - 2,848; **3** - 2,827
7-4	No. 14 Heldt Draw Unit	201	144	**2** - 3,445; **42** - 3,289; **75** - 3,194; **27** - 3,115; **7** - 3,027; **2** - 2,967; **2** - 2,917; **3** - 2,900
7-5	No. 17 Heldt Draw Unit	148	129	**2** - 3,404; **3** - 3,299; **7** - 3,208; **3** - 3,185; **31** - 3,150; **69** - 3,117; **29** - 3,031; **3** - 2,955; **7** - 2,944; **2** - 2,867; **4** - 2,816
7-13	No. 29 Culp Draw Unit 2	473	154	**6** - 3,412; **2** - 3,343; **4** - 3,335; **10** - 3,315; **4** - 3,266; **16** - 3,195; **4** - 3,011; **67** - 2,962; **53** - 2,895
7-14	31 Culp Draw Unit No. 2	498	138	**2** - 3,409; **6** - 3,360; **11** - 3,291; **13** - 3,197; **3** - 3,132; **60** - 3,069; **3** - 2,934; **48** - 2,841
7-17	No. 18 Culp Draw Unit No. 1	309	131	**2** - 3,197; **10** - 3,156; **13** - 3,139; **58** - 3,103; **2** - 3,015; **48** - 2,895
7-18	No. 13 Culp Draw Unit II	293	125	**2** - 3,435; **7** - 3,381; **4** - 3,375; **28** - 3,320; **56** - 3,283; **41** - 3,066; **3** - 2,937; **3** - 2,858; **2** - 2,830; **2** - 2,803
7-19	No. 4 Culp Draw Unit II	153	111	**3** - 3,384; **3** - 3,378; **10** - 3,164; **13** - 3,146; **24** - 3,121; **30** - 3,094; **6** - 3,049; **28** - 3,039; **3** - 2,982; **4** - 2,955; **2** - 2,932; **3** - 2,853; **2** - 2,823
7-20	No. 3 Culp Draw Unit II	238	115	**27** - 3,307; **52** - 3,265; **11** - 3,108; **25** - 3,094; **3** - 3,031; **3** - 3,002; **3** - 2,893; **2** - 2,862
7-23	No. 5 Heldt Draw Unit	210	132	**3** - 3,386; **2** - 3,339; **7** - 3,316; **33** - 3,266; **72** - 3,226; **27** - 3,083; **2** - 3,012; **4** - 3,003; **3** - 2,983; **4** - 2,898; **3** - 2,853
7-34	No. 9 Heldt Draw Unit	159	141	**2** - 3,322; **4** - 3,271; **4** - 3,231; **3** - 3,217; **35** - 3,183; **74** - 3,141; **32** - 3,056; **4** - 2,977; **3** - 2,967; **2** - 2,941; **3** - 2,913; **4** - 2,878
7-35	No. 23 Culp Draw Unit II	400	144	**7** - 3,324; **11** - 3,289; **20** - 3,202; **60** - 3,105; **3** - 2,953; **50** - 2,939; **2** - 2,860
7-41	No. 20 Heldt Draw Unit	212	121	**3** - 3,501; **3** - 3,438; **91** - 3,380; **30** - 3,198; **3** - 3,138; **10** - 3,098; **2** - 2,978; **3** - 2,858
13-1	No. 5-C Jepson Draw	348	87	**4** - 3,350; **2** - 3,290; **9** - 3,285; **24** - 3,197; **31** - 3,147; **2** - 3,098; **15** - 3,017; **7** - 2,910
13-6	Jepson Draw 31-4 No. 1	351	86	**9** - 3,325; **7** - 3,308; **23** - 3,244; **30** - 3,168; **17** - 2,991; **3** - 2,875
13-14	Webb Federal 30-15	337	88	**3** - 3,351; **9** - 3,301; **2** - 3,287; **14** - 3,246; **4** - 3,210; **2** - 3,191; **2** - 3,178; **4** - 3,141; **30** - 3,121; **3** - 3,073; **15** - 2,979; **3** - 2,874
13-30	Webb Federal No. 13-A Nipple Unit	403	69	**8** - 3,252; **8** - 3,208; **4** - 3,176; **28** - 3,077; **4** - 2,961; **2** - 2,939; **12** - 2,861; **3** - 2,819
13-31	Federal No. 32-13	435	100	**4** - 3,405; **8** - 3,345; **26** - 3,167; **31** - 3,121; **3** - 3,087; **28** - 2,898; **3** - 2,897
13-35	Federal W-47511 No. 2-B	298	100	**4** - 3,294; **4** - 3,273; **9** - 3,363; **26** - 3,177; **30** - 3,095; **2** - 3,061; **25** - 3,021; **7** - 2,911
13-36	Federal 19-B	403	71	**7** - 3,274; **6** - 3,199; **8** - 3,189; **28** - 3,084; **2** - 2,997; **5** - 2,924; **15** - 2,886; **2** - 2,821
14-6	State of Wyoming No. 1-16	266	109	**5** - 3,418; **9** - 3,367; **13** - 3,351; **27** - 3,310; **34** - 3,244; **26** - 3,127; **6** - 3,012
14-25	Van Irvine No. 2	195	114	**23** - 3,303; **26** - 3,273; **37** - 3,242; **6** - 3,142; **22** - 3,130; **7** - 3,043
14-27	27-1 Irvine	272	116	**27** - 3,314; **25** - 3,281; **32** - 3,249; **32** - 3,074; **7** - 2,994
14-32	Amarillo Federal No. 3	233	124	**95** - 3,410; **29** - 3,206; **2** - 3,167; **7** - 3,132; **2** - 3,004
14-33	Knight State No. 21-1	211	120	**91** - 3,409; **26** - 3,227; **7** - 3,122; **3** - 3,000
14-34	Heldt Draw Federal A-No. 1	158	139	**3** - 3,522; **103** - 3,408; **4** - 3,297; **32** - 3,282; **6** - 3,184; **3** - 3,068
14-35	No. 33 Heldt Draw Unit	191	122	**90** - 3,463; **3** - 3,366; **29** - 3,301; **5** - 3,293; **3** - 3,144; **3** - 3,086
14-37	Christenson No. 18-3	195	131	**98** - 3,374; **7** - 3,217; **26** - 3,205; **2** - 3,137; **6** - 3,107; **3** - 2,977
14-39	No. 1 Webb Christensen	138	125	**90** - 3,291; **35** - 3,188; **9** - 3,073; **2** - 3,028; **2** - 3,010; **3** - 2,975; **5** - 2,941
14-40	J. Streeter No. 1	276	109	**3** - 3,452; **23** - 3,344; **28** - 3,311; **34** - 3,277; **28** - 3,096; **8** - 2,997
14-53	Amarillo Federal 1	183	117	**52** - 3,357; **36** - 3,301; **29** - 3,203; **3** - 3,155; **8** - 3,103
18-1	Uranium exploration drill hole	115	37	**8** - 3,845; **12** - 3,830; **4** - 3,750; **13** - 3,743; **1** - 3,611; **4** - 3,517; **3** - 3,476; **2** - 3,450; **4** - 3,444
19-3	Uranium exploration drill hole	260	117	**3** - 3,329; **7** - 3,324; **11** - 3,316; **31** - 3,296; **2** - 3,266; **44** - 3,193; **19** - 3,088; **8** - 2,982; **2** - 2,973; **2** - 2,946
19-4	Uranium exploration drill hole	190	156	**45** - 3,836; **2** - 3,787; **50** - 3,783; **43** - 3,728; **16** - 3,662
19-5	Uranium exploration drill hole	243	121	**24** - 3,289; **27** - 3,258; **36** - 3,224; **2** - 3,101; **32** - 3,078; **2** - 3,014; **8** - 2,975
19-6	Uranium exploration drill hole	191+	47+	**2** - 3,629; **2** - 3,621; **2** - 3,617; **10** - 3,564; **14** - 3,527; **1** - 3,501; **22** - 3,395 (incomplete measure of Sussex coal zone)
20-2	No. 31 Taylor Ranch II Unit	170	126	**109** - 3,564; **17** - 3,411; **4** - 3,275
20-10	Reinauer Federal 1-34	152	118	**24** - 3,245; **25** - 3,216; **38** - 3,188; **31** - 3,124; **9** - 3,036
20-11	No. 1-4 Murray	135	135	**135** - 3,290; **6** - 3,063
20-12	No. 19-6 Irvine	138	138	**138** - 3,376; **3** - 3,145; **6** - 3,125; **7** - 3,112
20-13	No. 34-12 Hatch Federal	418	107	**76** - 3,540; **9** - 3,461; **18** - 3,147; **4** - 3,126; **8** - 3,083; **8** - 3,035
20-14	Irvine-Fee No. 42-11	370	138	**3** - 3,459; **71** - 3,454; **30** - 3,367; **2** - 3,334; **6** - 3,253; **23** - 3,123; **3** - 3,092; **8** - 3,062; **6** - 3,022
24-1	Fletcher Canyon Federal No. 1	111	94	**10** - 3,673; **31** - 3,660; **46** - 3,606; **3** - 3,573; **4** - 3,566; **3** - 3,418
24-10	Uranium exploration drill hole	62+	50+	**2** - 4,233; **11** - 4,078; **2** - 4,066; **2** - 4,062; **35** - 4,051 (incomplete measure of Sussex coal zone)
24-11	Uranium exploration drill hole	115	113	**111** - 3,901; **2** - 3,788
24-13	Uranium exploration drill hole	146	102	**12** - 3,968; **40** - 3,949; **36** - 3,903; **6** - 3,864; **2** - 3,855; **6** - 3,841

[1]Oil and gas well, unless specified otherwise.
[2]Coal bed thicknesses in bold type represent beds assigned to the Sussex coal zone. Entries, left to right, refer to all coal beds (including beds outside the Sussex coal zone) in the fence diagram panels, top to bottom.
Correlation is not implied by the arrangement of these data.

INTRODUCTION

The study area is located on the western flank of the Powder River Basin, Wyo., in parts of three 30′ x 60′ quadrangles: the eastern part of the Kaycee quadrangle, the southeasternmost part of the Buffalo quadrangle, and the westernmost part of the Reno Junction quadrangle (fig. 1). Geophysical log interpretations reveal the presence of as many as 13 coal beds in the upper part of the Fort Union Formation. Eleven of these coal beds coalesce eastward to form one bed more than 135 ft thick. The Sussex coal zone, named after the town of Sussex, Wyo., and outcropping along the northeast margin of the Sussex coal field, is designated here as the thick family of coal beds and rock interburden that correlates with a thick subbituminous coal bed in the eastern part of the study area (see drill hole 20-12 on fence diagram). Individual coal beds have not been named because they have only recently been studied and correlated in the subsurface.

Geophysical logs of more than 150 oil and gas test holes and uranium exploration holes penetrate the coal-bearing upper Fort Union Formation in the study area. The logs of 53 of the holes (table 1), selected on the basis of location, suite of logs recorded, and interval recorded, were used in this study. Holes were chosen at locations that would best illustrate variations within the Sussex coal zone and that would minimize large gaps between drill hole locations. A suite of logs consisting of natural gamma, normal and lateral resistivity, and conductivity logs was found to be best suited for determining lithologies; thus, drill holes having this suite of logs were preferred to holes having a different suite of logs. The interval recorded was important because many oil and gas logs did not record the coal-bearing interval.

The fence diagram shows the lateral relationships and thicknesses of coal and sandstone beds within the Sussex coal zone as well as of beds immediately above and below the zone. In constructing the fence diagram, the thickness of each coal and sandstone bed was plotted to scale at each data point (represented by a tick mark at the top and bottom of the cross-section panels), reducing the geometric distortion of bed thicknesses inherent in fence diagrams.

GEOLOGIC DISCUSSION

The Sussex coal zone lies within the upper 1,000 ft of the Paleocene Fort Union Formation; the upper Fort Union is believed to be equivalent to what has been mapped as the Tongue River Member in the northern part of the Powder River Basin. The Fort Union Formation conformably overlies the Cretaceous Lance Formation and is apparently conformably overlain by the Eocene Wasatch Formation. The coal-bearing rocks of the upper Fort Union Formation crop out along Pine Ridge (fig. 1), a prominent physiographic feature east of Kaycee, Wyo. The coal-bearing rocks strike parallel to Pine Ridge and dip as steeply as 25° on Pine Ridge, but flatten out to less than 1° a short distance northeast of the ridge.

The coal-bearing interval consists of interbedded sandstone, siltstone, claystone, carbonaceous shale, and coal beds. The sandstone is very light gray to yellowish-gray and contains scour and fill features, and multiple troughs with small- to medium-scale crossbed sets. Grayish-brown, erosion-resistant, ferruginous sandstone beds form flatiron-type features on the dip slope of Pine Ridge. During deposition of the upper Fort Union Formation in middle to late Paleocene time, subsidence occurred along the north-trending axis of the Powder River Basin (Curry, 1971), east of Sussex, Wyo. Thick beds of sandstone were deposited in the basin as uplift and erosion of surrounding highlands continued. The thick accumulations of coal in the Sussex coal zone were formed in backswamps along large northeast-flowing streams (Galloway, 1979; Ethridge and others, 1981; Flores, 1980, 1983).

Northeasterly streamflow can be inferred from the fence diagram by comparing the intervals between the coal beds shown in the cross-section panels. Cross-section panels that parallel streamflow (panels ***E*-*F*-*G*-*H*** and ***B*-*C***) show a parallel to subparallel relationship between coal beds and only subtle, gradual changes in the thickness of the interburden. In contrast, the changes in coal-bed intervals are dramatic and closely spaced in cross-section panels perpendicular to stream flow (panels ***C*-*D*** and ***B*-*F*-*J***). One such change is well illustrated in drill hole 20-13 of panel ***F*-*J***, where almost 300 ft of channel sand was deposited from a major stream on top of a thick blanket of peat. Following deposition of channel sand, the swamp redeveloped over the sand and peat accumulation continued. This peat-sand-peat cycle produced an envelope of coal enclosing the channel sandstone unit: two beds totaling more than 100 ft of coal are separated by almost 300 ft of sandstone. Less than 2 mi southeast in hole 20-12, uninterrupted peat accumulation accounted for the development of one coal bed more than 135 ft thick.

The fence diagram illustrates the many changes that took place within the coal-forming swamp in Paleocene time. At the eastern edge of the map area, approximating the depositional center of the swamp, peat accumulation was continuous. Westward, at the distal part of the swamp, peat accumulation was interrupted many times. Coal in drill hole 13-14 of panel ***B*-*F*** represents discontinuous accumulation of peat at the distal part of the swamp where the edge of the swamp migrated back and forth, causing the development of the 11 coal beds that make up the Sussex coal zone. Drill hole 20-12 of panel ***F*-*J*** is located well within what was the swamp interior, where the more than 135 ft of coal present is a product of continuous peat accumulation.

The development of so thick and widespread a coal bed(s) would seem to require some additional mechanism when compared to depositional factors involved in the development of coal beds of lesser thickness and lateral extent. One such possible mechanism is the "Teeterboard" theory proposed by B.H. Kent (written commun., 1984) to explain other thick, widespread coal deposits in the Powder River Basin. According to the "Teeterboard" theory, subsidence on the west side of the basin and uplift of the east side would provide favorable conditions for widespread development of thick coal deposits somewhere in the basin interior. The theory is based on the assumption that "if a western area is subsiding while an eastern area is being uplifted, some (fulcrum) area inbetween must be in dynamic equilibrium." The fulcrum (along the eastern part of the study area), and the area adjacent to it, would provide a stable platform for the development of thick coal. The further away from the fulcrum, the less stable the area would be, resulting in the development of thinner coal beds.

REFERENCES CITED

Curry, W. H., III, 1971, Laramide structural history of the Powder River Basin, Wyoming, *in* Symposium on Wyoming tectonics and their economic significance: Wyoming Geological Association, Annual Field Conference, 23rd, Casper, Wyo., 1971, Guidebook, p. 49–60.

Ethridge, F. G., Jackson, T. J., and Youngberg, A. D., 1981, Floodbasin sequence of a fine-grained meanderbelt subsystem—The coal-bearing lower Wasatch and Upper Fort Union Formation, southern Powder River Basin, Wyoming, *in* Ethridge, F. G., and Flores, R. M., eds., Recent and ancient nonmarine depositional environments-Models for exploration: Society of Economic Paleontologists and Mineralogists Special Publication No. 31, p. 191–209.

Flores, R. M., 1980, Fluvial coal settings of the Tongue River Member of the Fort Union Formation in the Powder River-Clear Creek area, Wyoming, *in* Glass, G. B., ed., Guidebook to the coal geology of the Powder River Coal Basin, Wyoming: Geological Survey of Wyoming, Public Information Circular No. 14, p. 71–96.

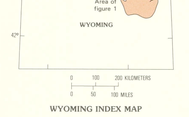
_____1983, Basin analysis of coal-rich Tertiary fluvial deposits in northern Powder River Basin, Montana and Wyoming, *in* Collinson, J. D., and Lewin, J., eds., Modern and ancient fluvial systems: International Association of Sedimentologists Special Publication No. 6, p. 6.

Galloway, W. E., 1979, Early Tertiary Wyoming intermontane basins, *in* Galloway, W. E., Kreitler, C. W., and McGowan, J. H., eds., Depositional and ground-water flow systems in the exploration for uranium—A research colloquium: Austin, Texas, The University of Texas at Austin, Bureau of Economic Geology, p. 197–213.

Horn, G. H., 1955, Geologic and structure map of the Sussex and Meadow Creek oil-fields and vicinity, Johnson and Natrona Counties, Wyoming: U.S. Geological Survey Oil and Gas Investigations Map OM-164, scale 1:31,680.

EXPLANATION FOR FIGURE 1

- TERTIARY AND YOUNGER ROCKS
- CRETACEOUS AND OLDER ROCKS
- 14-25 DRILL HOLE LOCATION AND INDEX NUMBER
- B CROSS-SECTION LINE AND REFERENCE LETTER
- BOUNDARY OF SUSSEX COAL FIELD
- NORMAL FAULT—U, upthrown side; D, downthrown side. Dashed where approximately located
- CONTACT—Dashed where approximately located



WYOMING INDEX MAP

EXPLANATION FOR FENCE DIAGRAM

- SANDSTONE
- COAL
- LITHOLOGY OTHER THAN SANDSTONE OR COAL
- CONTACT
- 7-13 DRILL HOLE INDEX NUMBER AND POSITION OF DRILL HOLE PROJECTED ONTO CROSS-SECTION PANEL—Thicknesses between vertical ticks at top and bottom of cross-section panels are to scale. See table 1 for drill hole identification, coal bed thickness, and elevation of coal bed's upper surface
- C CROSS-SECTION REFERENCE LETTER

Irregular baseline of cross-section panel indicates that data are lacking, and only a part of stratigraphic interval of interest is shown.

FENCE DIAGRAM SHOWING COAL BED CORRELATIONS WITHIN THE UPPER PART OF THE FORT UNION FORMATION, IN AND ADJACENT TO THE EASTERN PART OF THE KAYCEE 30′ x 60′ QUADRANGLE, JOHNSON AND CAMPBELL COUNTIES, WYOMING

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