Coal drilling, John's Valley, Utah

by Hellmut H. Doelling and F.D. Davis

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COAL DRILLING, JOHNS VALLEY, UTAH

by Hellmut H. Doelling and Fitzhugh D. Davis. February, 1978

Summary:

Four holes were drilled in Johns Valley, Garfield County, Utah, for the purpose of finding new coal reserves. Properties drilled are owned by the State of Utah, and at the time of the exploration work, leased to Utah Resources International Inc., a Utah corporation. Drilling costs were arranged by the corporation and geologic assistance was provided by the state in a cooperative information gathering project.

The results of drilling and the accompanying research are summarized as follows:

1. Coal beds are found in Upper Cretaceous rocks; in the Straight Cliffs and Dakota Formations

2. Coal beds exceeding four feet in thickness are present; one discovered exceeds 18 feet.

3. The coal is subbituminous A in rank, some may be marginal high-volatile C bituminous in rank. The average Btu/lb. in the 18-foot bed is 9,500 as received.

4. The sulfur content varies from coal bed to coal bed and within the coal bed. Analyses range from 0.63 to 2.56 percent. The 18-foot bed in section 33 averages 1.5 percent. The lower 10 feet average 0.79 percent sulfur. Much marcasite is present as films in the upper part. Washing will probably yield a good result in sulfur reduction.

5. The ash content of the 18-foot bed is 8.6 percent. If the upper 3 feet are eliminated the content is 7 percent.

6. The Upper Cretaceous rocks underlie Tertiary and Quaternary sediments unconformably. The unconformity generally lies 200 to 600 feet beneath the surface. Mining will probably be confined to underground methods. In section 33, where the 18-foot coal bed was drilled, the unconformity is 345 to 365 feet beneath the surface.

7. The rock formations beneath the unconformity are structurally deformed. The beds are moderately folded and faults are inferred. In section 33 the beds strike N. 23.5° E. and dip 20° northwesterly. Even though the strike and dip of beds in section 33 has been determined, this information should not be assumed for the remainder of Johns Valley without additional drilling or geophysical work. The attitude of beds may be steeper or more gentle than those in section 33. The displacements, number, trends, and positions of the inferred faults are concealed and can only be determined by geophysical work.

8. The measured and indicated reserve as determined by this drilling project is 1.2 and 25 million tons in-place. It is centered around the southeast part of section 33--an 18-foot coal bed contains about 20 million tons in-place per square mile. At a dip of 20° the coal bed will drop 1800 feet per mile, the safe mining width will be limited to a little over a mile perpendicular to strike. The length of the coal body remains undetermined.

9. The potential for finding thick coal beds in the Johns Valley and surrounding plateau area is excellent in both the Straight Cliffs and Dakota Formations. The trend of thick Kaiparowits Plateau field (Straight Cliffs Formation) coal beds is northwesterly and the trend of thick Alton field (Dakota Formation) coal beds is northeasterly. These trends converge in Johns Valley. The depth to the coal and the structural complexity will influence the mineability.

Introduction:

The presence of coal at depth in Johns Valley was reported by Eardley and Cohenour in January of 1963 in Utah Geological and Mineral Survey Report of Investigations 1. The discovery was made by the U. S. Geological Survey drilling wells to study ground water conditions. The best show was in U. S. Geological Survey test hole No. 17 located in the southeast corner of section 33, T. 33 S., R. 2 W. A U. S. Geological Survey letter file indicated the coal to be 20 feet thick. Oral communication with U. S. Geological Survey personnel indicated 30 feet of coal at a depth of 420 feet and 5 feet of coal at a depth of 480 feet. Other wells were drilled, and test hole No. 11, located in the southwest corner of section 29 T. 34 S., R. 2 W., has several thin beds of coal 1-3 feet thick after ~~the~~ drilling to a depth of 354 feet. The cuttings were described and a report subsequently published by Carpenter and others (1964 and 1967). In the 1964 publication the notation for the coal in test hole No. 17 for the 420-450-foot interval reads:

> "Coal, black, mostly lignite(?), but some subbituminous (?) which increases in amount with depth; contains interbeds of white, sandy silt to clay in intervals 440-450 feet; some lignite shows relic, organic-plant structure, some contains pyrite growths."

Location:

Johns Valley is located north of Bryce Canyon National Park in south-central Utah. The drilling area is about 35 road miles east of the Garfield

County seat of Panguitch and 90 road miles east of Cedar City, the largest town in southern Utah. Johns Valley lies 200 miles south of Salt Lake City (figures 1 and 2).

The locations of the four wells drilled for this project are listed with their elevations and total depths: (feet)

	Elev.	Coordinates	Total Depth
Widtsoe Jct. No. 1	7330	78' N/S, 114' W/E 33-33S-2W	633
No. 2	7425	2500' S/N, 2550' W/E 16-34S-2W	622
No. 3	7324	78' N/S, 614' W/E 33-33S-2W	632
No. 4	7316	849' N/S, 622' W/E 33-33S-2W	690

These wells and water wells drilled by the U. S. Geological Survey in their 1962 study are plotted on the geologic sketch map (figure 3).

General Geology and Structure:

No detailed geologic map of Johns Valley is available. All published maps are at a small scale and do not portray the complexity of geology that exists. Published maps include the southwest quarter of the Utah State geologic map (1963), Carpenter and others, plate 1 (1967), and Doelling (1975). There are many differences between the maps and none are completely correct.

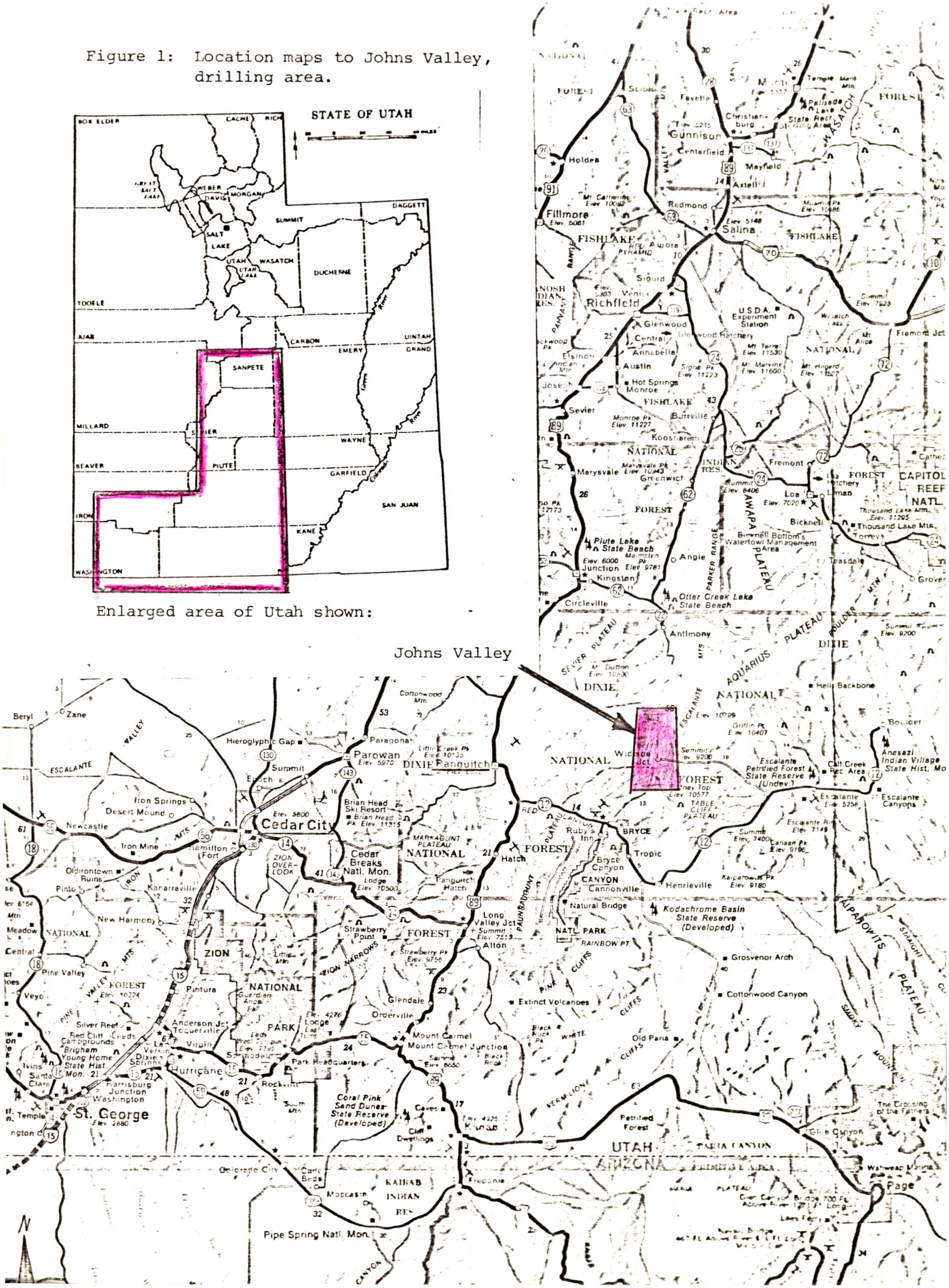
Johns Valley is a high 3-mile wide valley trending roughly north-south. It is bounded on the west by the Sevier Plateau and on the east by the Escalante Mountains. The valley is surfaced by alluvium and other surficial deposits, so that the bedrock is effectively covered. Only a limited amount of geologic information can be extended to the covered units in Johns Valley, such as structural trends from the bordering plateaus. Drilling in the valley has encountered the same bedrock formations cropping out in the surrounding hills. The generalized geologic column is as follows:

Symbol	Formation	Description
Qal	Alluvium	Orange to pale brown silt, clayey silt, sand pebbles and cobbles, unconsolidated, surface of most of Johns Valley
Tv	Volcanics	Many varieties, especially latite, quartz latite, interbedded tuffs, breccias, volcanic sediments.

Figure 1: Location maps to Johns Valley, drilling area.

Enlarged area of Utah shown:

Johns Valley



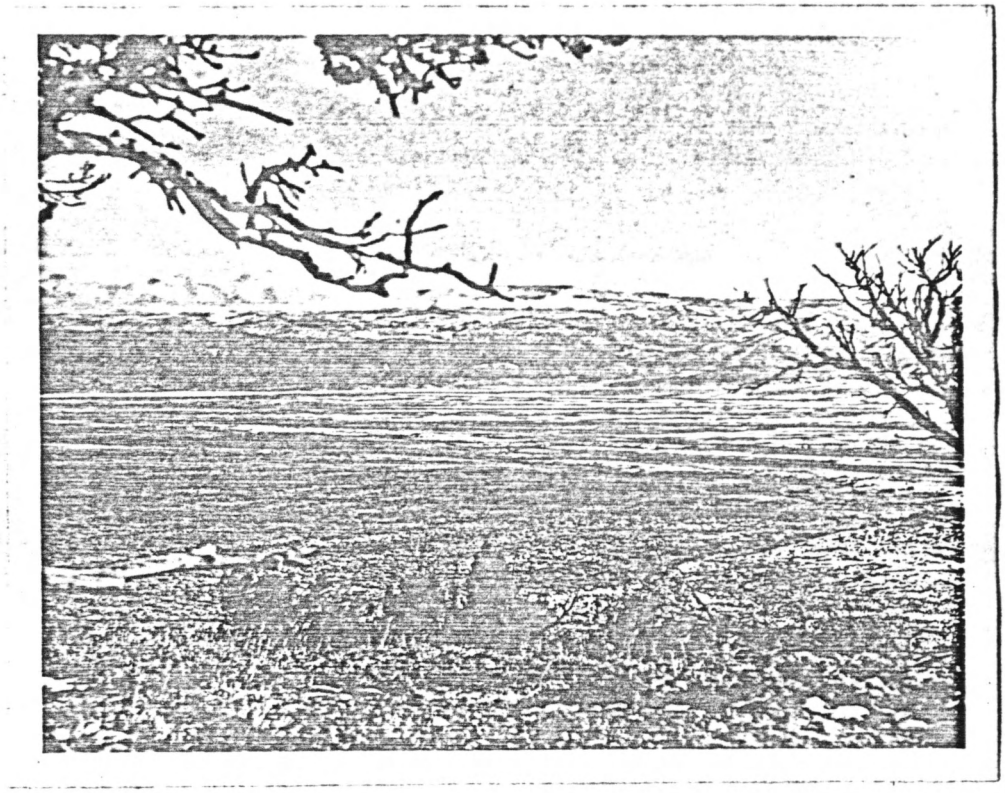


Figure 2: View looking easterly across Johns Valley toward the Escalante Mountains. Beneath 200 to 600 feet of cover under the valley floor are formations of Upper Cretaceous age containing thick coal beds.

Tsr	Sevier River Formation	Cobbles, pebbles, sand, silt and clay, poorly consolidated, older alluvial fans buried beneath the alluvium.
Tc	Claron Formation	Pink and white limestone, calcareous shale, siltstone, sandstone and conglomerate, "Bryce Canyon or Wasatch Formation." Up to 1600 feet thick.
	Angular Unconformity	
Kk	Kaiparowits Formation	Drab gray, slope-forming arkosic sandstone, 0-1500 feet thick.
Kw	Wahweap-Straight Cliffs Fm. undifferentiated	Mostly gray to yellowish gray, interbedded mudstone, claystone, siltstone, sandstone, conglomerate, carbonaceous shale and coal, 900 to 1800 feet thick.
Kt	Tropic Shale	Dark gray, drab marine shale, with subordinate gray fine-grained sandstone, 650 to 1000 feet thick.
Kd	Dakota Formation	Interbedded sandy shale, carbonaceous shale, shaly sandstone, siltstone, claystone, coal, 150 to 400 feet thick.
	Angular Unconformity	
Je	Entrada Sandstone	Mostly reddish brown, orange, or white fine-grained sandstone.

The principal exposed units in the surrounding hills are the lower part of the Claron Formation resting unconformably upon the Upper Cretaceous (Wahweap-Straight Cliffs undifferentiated). Rocks exposed to the west in the Sevier Plateau dip moderately to the northwest, the strike varying N. 20° to N. 35° E. To the south several large faults, trending east-west, project into Johns Valley. On the east side of the valley the sediments dip gently to moderately northward. In response to this regional dip, volcanics are exposed to the north, Claron outcrops dominate most of the east edge of the Escalante Mountains and Upper Cretaceous units are exposed to the south.

Upper Cretaceous units are exposed in the core of an anticline which is faulted at its northwest end (figure 3). The axis trends to the northwest and is truncated by a fault at the southeast edge of Johns Valley. The (Tertiary) units northwest do not reflect a continuation of the axis into Johns Valley, but this might happen in the subsurface. Johns Valley is structurally controlled by faults now concealed by the surficial cover. The Paunsaugunt fault extends into the area from the south but cannot definitely be traced through the valley. The

positions of these faults and the strikes and dips of formations beneath the valley fill will determine the feasibility of mining coal in Johns Valley.

Widtsoe Junction No. 1

The location of W. J. No. 1 was chosen to verify the results of U. S. Geological Survey test hole No. 17. The new hole was positioned 120 feet southwest of No. 17. The log of W. J. No. 1 is given and graphically illustrated in Appendix the 1 and as figure 4. An interpretation of U. S. Geological Survey test well No. 17 is illustrated in figure 5. The alluvium has a depth of 19 to 20 feet. Under this are older alluvial materials, tentatively assigned to the Sevier River Formation. This unit consists of coalescing alluvial fans and contains considerable amounts of volcanic material. At a depth of 200 to 210 feet the color of sediments changes to pink or light brown. Gravel persists, but there are many intervals of very calcareous and clayey well-indurated siltstones with white or pink color. This sequence persists to a depth of about 360 feet. U. S. Geological Survey geologists consider the first 360 feet to be entirely in alluvium and it would be difficult to prove otherwise. The U. S. Survey recognized the Tertiary Claron Formation in test hole No. 9 at a depth of 315 feet which persists to the bottom of the hole at 550 feet. This interval contains no gravel and no volcanic material. The 200 to 360-foot interval in W. J. No. 1 is tentatively assigned to the Claron Formation.

The Cretaceous Tropic Shale is intercepted 360 feet beneath the surface indicating a major unconformity. At 402 feet a core was retrieved containing Exogyra sp., a common fauna found at the base of the Tropic Shale and at the top of the Dakota Formation. At 430 feet a sandstone was encountered of alternating black and white laminae, which indicated the bed had a dip of at least 12°. This sandstone bed is about 15 feet thick. The top of an 18-foot coal bed is found at a depth of 443 feet. This coal was packaged and sent to Commercial Testing and Engineering Co. in Denver, Colorado for testing. The coal is mostly dull black with abundant plant imprints and marcasite films. The floor of the coal bed is

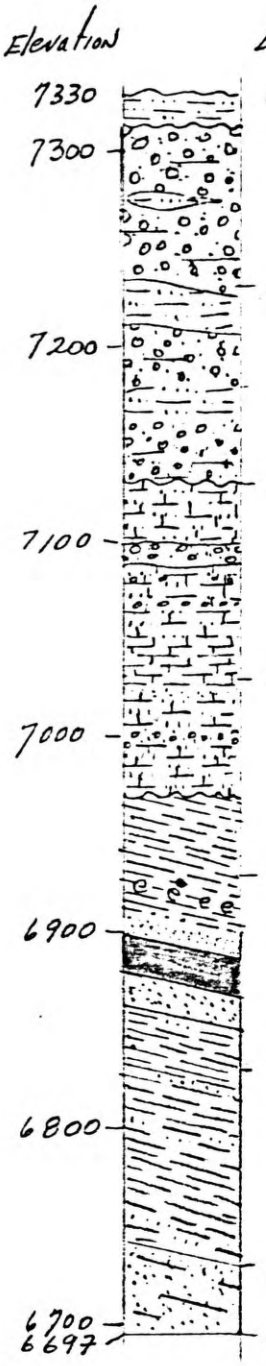
T33S

T34S

Figure 3: Geologic sketch map of Johns Valley showing locations of drillholes.

Figure 4.

Widtsoe Junction No. 1, SESESE 33-33S-2W
78 feet N., 114 feet W. of SE corner



0.0 Alluvium, mostly silt and clay, minor sand, pink to tan-brown, occasional streaks of fine to medium gravel 19 ft

19.0 Sevier River fm.? Older alluvium, poorly consolidated gravel, gritty to very coarse in matrix of silt and sand, has clayey silt lenses, generally tan or pink.

200.0 Claron Formation? Siltstone and claystone with fine to coarse gravel lenses, orange, white, and pink, very calcareous

360.0 Cretaceous Tropic Shale? Shale, gray and clayey.

402.0 FIRST CORE TAKEN, shale, black with oyster coquinas, Exogyra?

430.0 Sandstone, alternating black and white in 1/8 to 1/2 inch laminae.

443.0 COAL, smirl zone?

462.0 Sandstone, light and dark gray, silty, fine grained.

475.0 Siltstone

480.0 Shale, clayey, light to dark gray, occasional sand and silt lenses.

597.0 Sandstone, gray, fine grained to silty, some black shale interbeds

U.S.G.S. Drill Hole No. 17 in the
SESESE Sec. 33, T 33 S, R 2 W

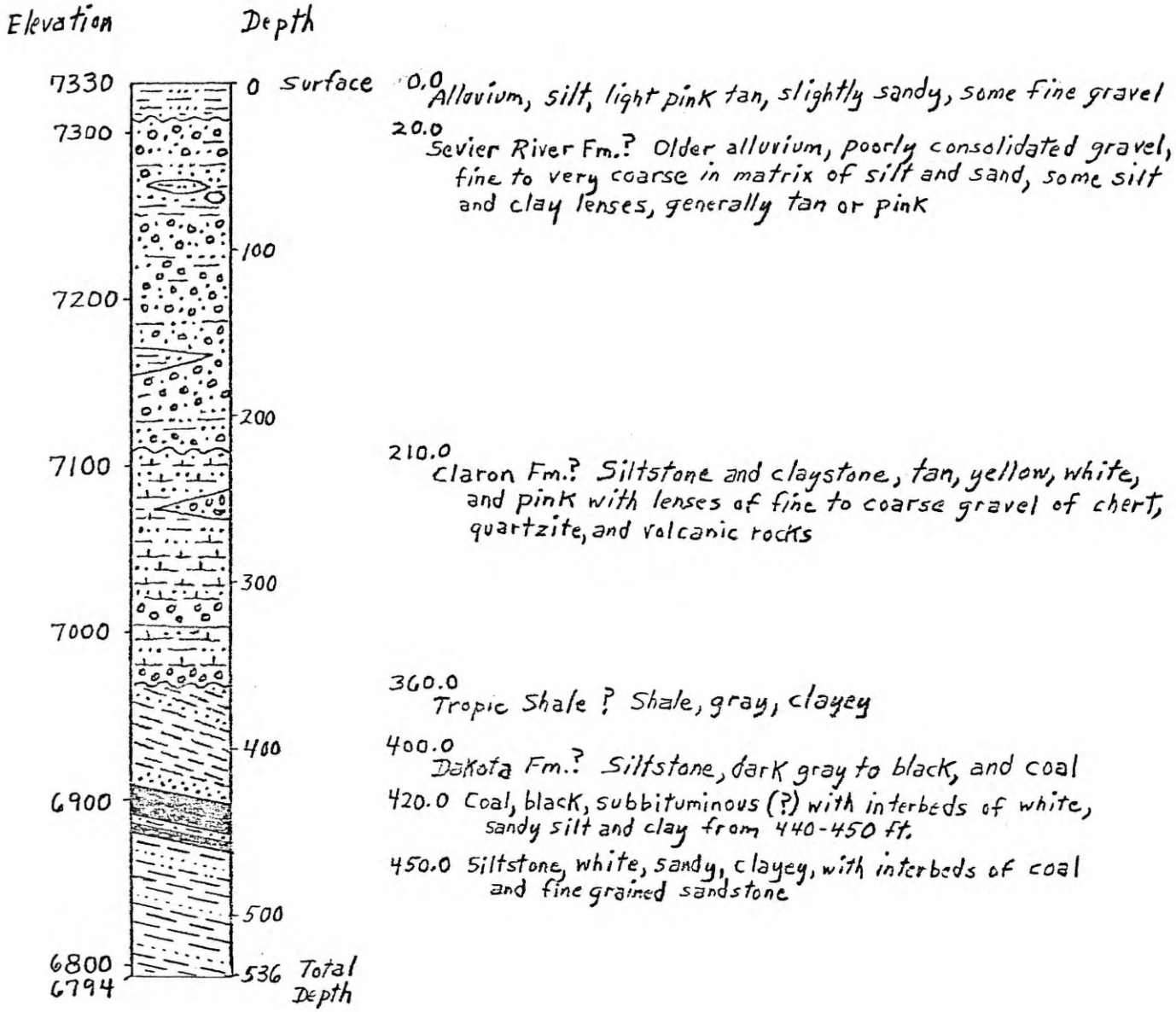


Figure 5: Interpretation of U. S. Geological Survey test hole No. 17, SESESE 33-33S-2W.

a sandstone over 11 feet thick. Drilling continued to a total depth of 633 feet. Most of the subcoal rock is light to dark-gray siltstone and shale. The hole ends in the Dakota Formation, which is 231+feet thick in the hole.

Widtsoe Junction No. 2

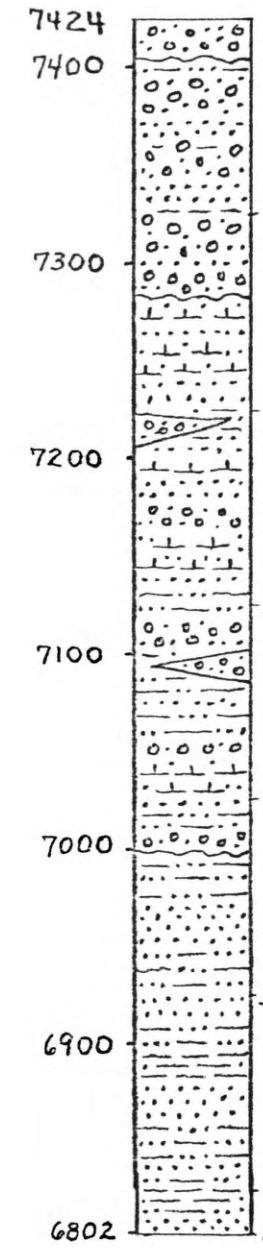
The location of W. J. No. 2 was chosen half-way between W. J. No. 1 and U. S. Geological Survey test well No. 11 in which 1-3-foot coal beds were discovered at depths of 354, 365, 388, and 394 feet. The hole was ended at a depth of 480 feet. There is enough sandstone recorded in the log of test well No. 11 to prove that either the Wahweap-Straight Cliffs was drilled beneath the unconformity or the Dakota Formation. In test well No. 11 the Upper Cretaceous rocks were struck at 223 feet and penetrated 257 feet.

In W. J. No. 2 the unconformity was reached at 425 feet, the drill then passed through 197 feet of formation. The abundant sandstone beds are reminiscent of the Wahweap-Straight Cliffs Formation outcrops nearby. No carbonaceous or coal beds were encountered. Occasional terrestrial gastropods were intercepted. Coal is present in the Straight Cliffs Formation of the area, but in a particular zone in the thick formation. Because the project was committed to shallow drilling it was decided to abandon the hole. A graphic log of W. J. No. 2 is given in figure 6.

Widtsoe Junction No. 3

The drilling of W. J. No. 1 and 2 made it clear that the structure of Upper Cretaceous rocks is complex and that more could be gained by stepping-out on the 18-foot bed discovered in W. J. No. 1. W. J. No. 3 was placed 500 feet to the west (of No. 1) on the assumption that the dip would be in that direction. The Tropic Shale was encountered at 365 feet, the top of the Dakota Formation at 562 feet. The 197 feet of Tropic Shale were a monotonous gray silty or clayey shale with a few fine-grained sands in the upper part (figure 7). The

Figure 6: Widtsoe Junction No. 2, SW SW NE Sec. 16, T. 34 S., R. 2 W.



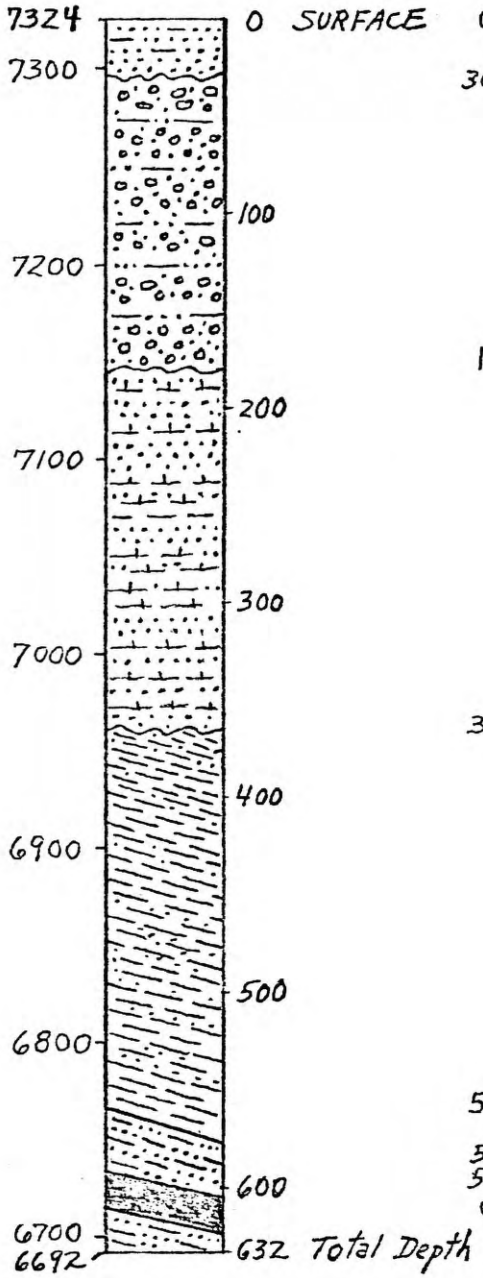
0.0 Alluvium, mostly gravel, fine-to coarse, subrounded to angular quartzite, black chert, limestone, mixed with sand

20.0 Sevier River Fm.? Older alluvium, poorly consolidated gravel of light tan and yellow quartzite, black and gray chert, and gray and white limestone, mixed with sand

142.0 Claron Fm.? Interbedded claystone, siltstone, and sandstone; clay is reddish brown, silt is light brown, sand is white and tan; fine to coarse gravel lenses

425.0 Wahweap Fm.? or Straight Cliffs Fm.? Interbedded mudstone, siltstone and sandstone; mudstone is light gray to dark lavender gray, siltstone is grayish brown, tan, lavender gray, and shades of gray, sandstone is gray, grayish brown, tan and yellow, fine-to medium-grained

Figure 7: Widtsoe Junction No. 3, SW SESE Sec 33, T 33 S, R 2 W
500 feet due west of W. J. No. 1



0.0 Alluvium, mostly sand, red brown, tan and red tan, grains are quartz and gray to black chert, angular to sub round

30.0 Sevier River Fm.? Older alluvium, poorly consolidated gravel of light tan and yellow quartzite, black and gray chert and red volcanic rock in a matrix of medium to coarse grained sand

180.0 Claron Fm.? Interbedded claystone and sandstone, clay is light red, white, and gray, sand is gray, white, tan and black; fine to coarse gravel lenses

365.0 Tropic Shale? Shale, gray, clayey with a few thin interbeds of gray to tan sandstone in the upper part

562.5 Dakota Fm.? Siltstone, mudstone, and coal

562.5 Siltstone, light and dark gray varves, carbonaceous

594.2 Coal, Smirl zone?

612.3 Mudstone, light to medium gray, some calcareous intervals

18-foot bed was encountered at a depth of 594 feet. Much of the core above the coal was lost and no confirming fossils were picked up. Two feet of siltstone with light and dark laminae was picked up immediately above the coal. This unit is present as an 11-foot fine-grained sandstone in W. J. No. 1. From the base of the coal to the bottom of the hole at 632 feet the rock is a silty gray mudstone or shale. The coal bed drops 151 feet in the 500 feet between W. J. No. 1 and W. J. No. 3.

Widtsoe Junction No. 4

This hole is located about 770 feet north of W. J. No. 3 and was drilled to complete a 3-point problem needed to determine the attitude of the coal bed. The entire hole was churn drilled and no core collected. It was electrically logged as were holes W. J. Nos. 1 and 3. The drill intercepted the unconformity at about 345 feet and bottomed at 690 feet. Most of the hole beneath the unconformity was drilled in the Tropic Shale and no coal was encountered to the total depth. Comparison of the electric logs, however, indicates that the drill was halted a few feet above the coal bed, now calculated to be present at a depth of 695 feet ± 5 feet. A generalized log is given as figure 8 and electric logs are compared in figures 9, 10 and 11.

Structure of Section 33, T. 33 S., R. 2 W.
Beneath the Unconformity

The three-point problem created by holes W. J. Nos. 1, 3, and 4 indicates that the coal bed strikes N. 23.5° E. and dips 20° northwesterly similar to rock outcrops along the eastern edge of the Sevier Plateau (figure 3). If the Claron Formation exists in any of the holes in section 33, including U. S. Geological Survey test well No. 9, then a fault must exist between section 33 and the rock outcrops to the west. The valley block would be down-dropped 500 to 1000 feet. The attitude and nature of rocks in the Escalante Mountains indicates another fault(s) to the east of section 33.

Figure 8: Widtsoe Junction No. 4, NW SE SE Sec. 33, T. 33 S., R. 2 W.

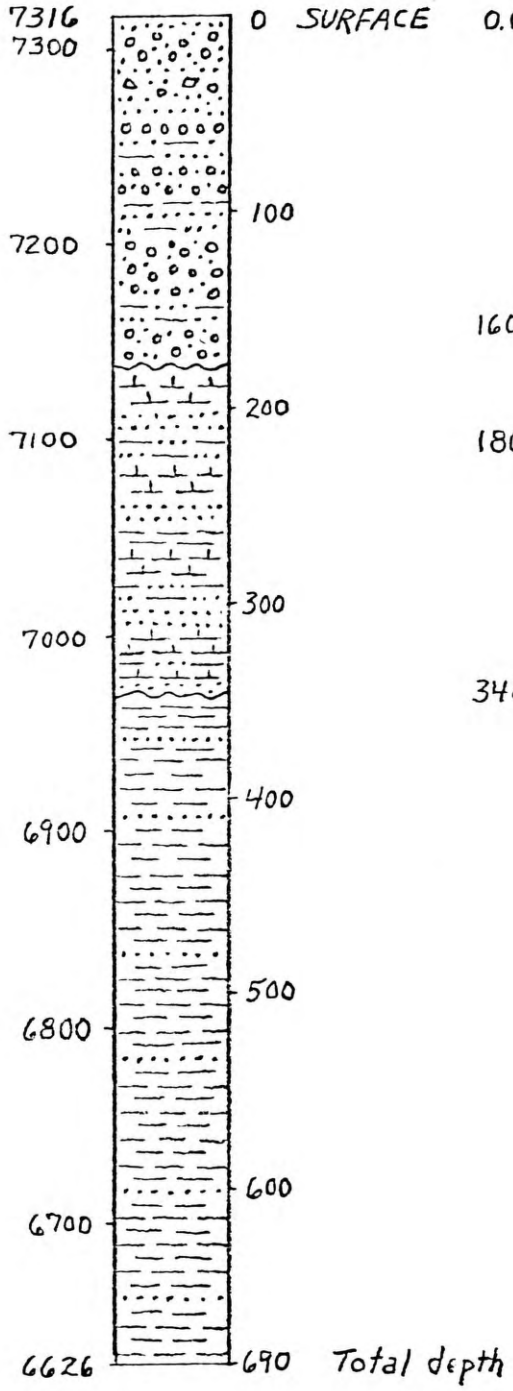


Figure 9: Comparison of natural gamma logs in holes Widtsoe Junction Nos. 1, 3 and 4.

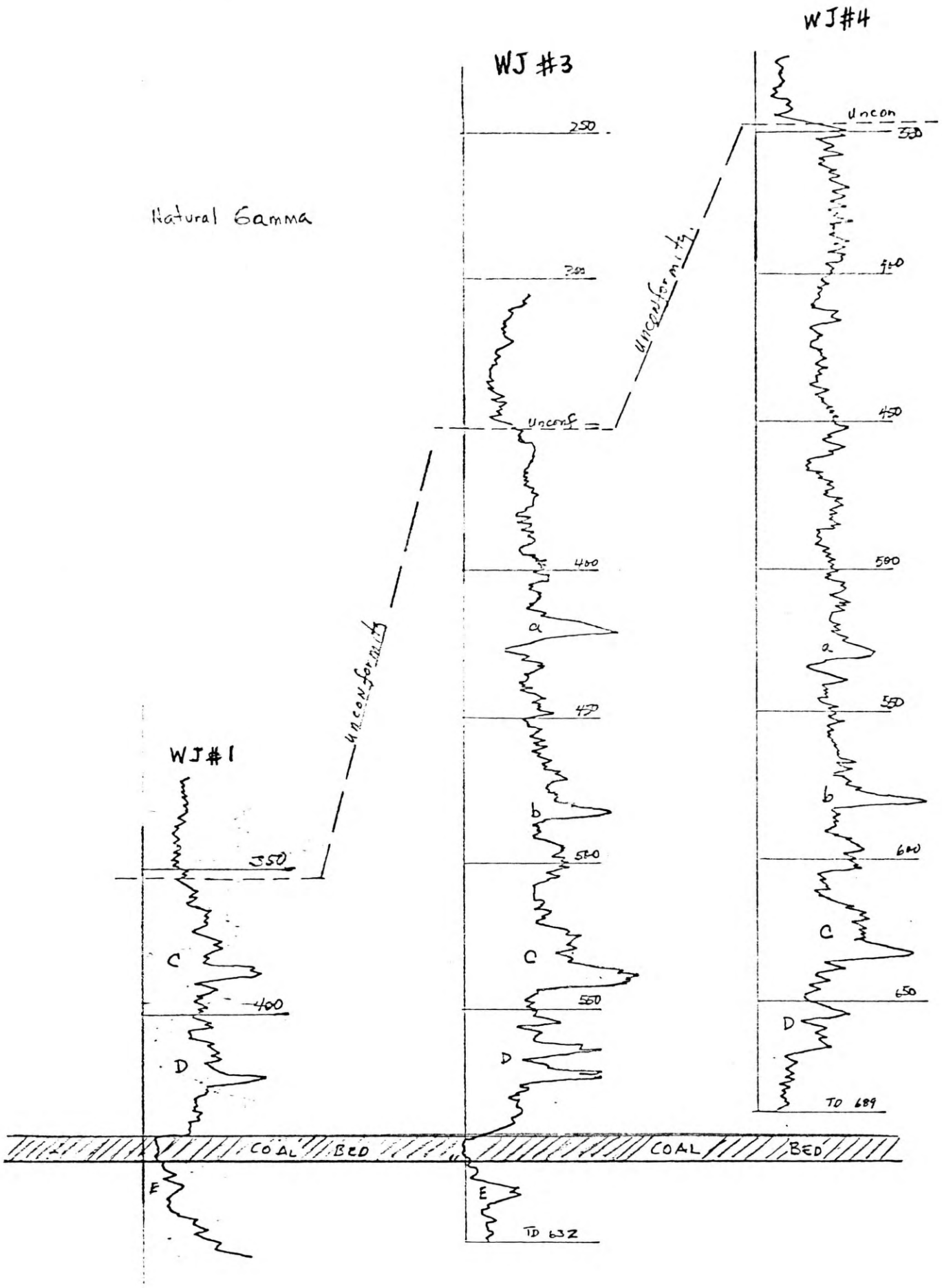


Figure 10: Comparison of resistivity logs in holes Widtsoe Junction Nos. 1, 3 and 4.

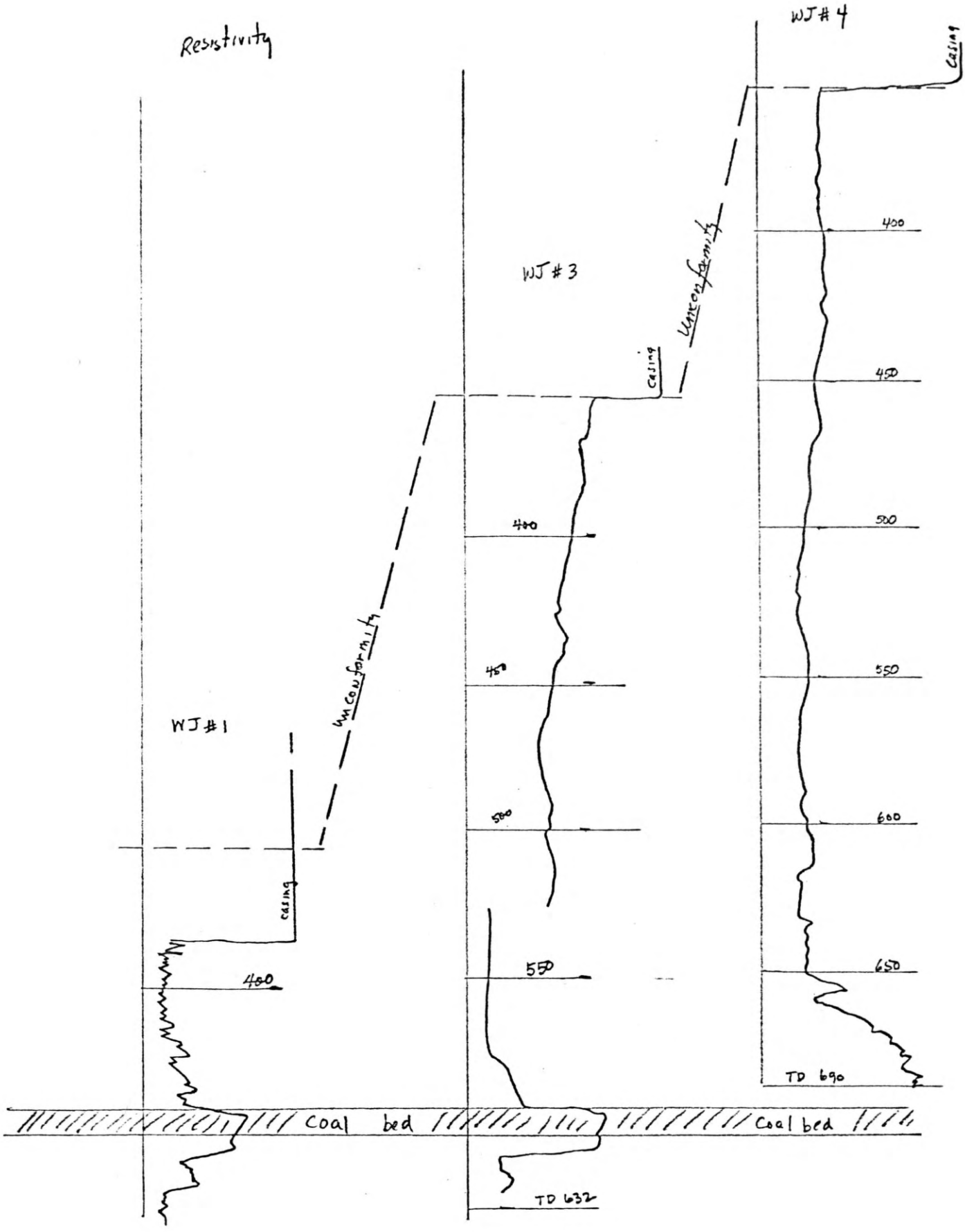
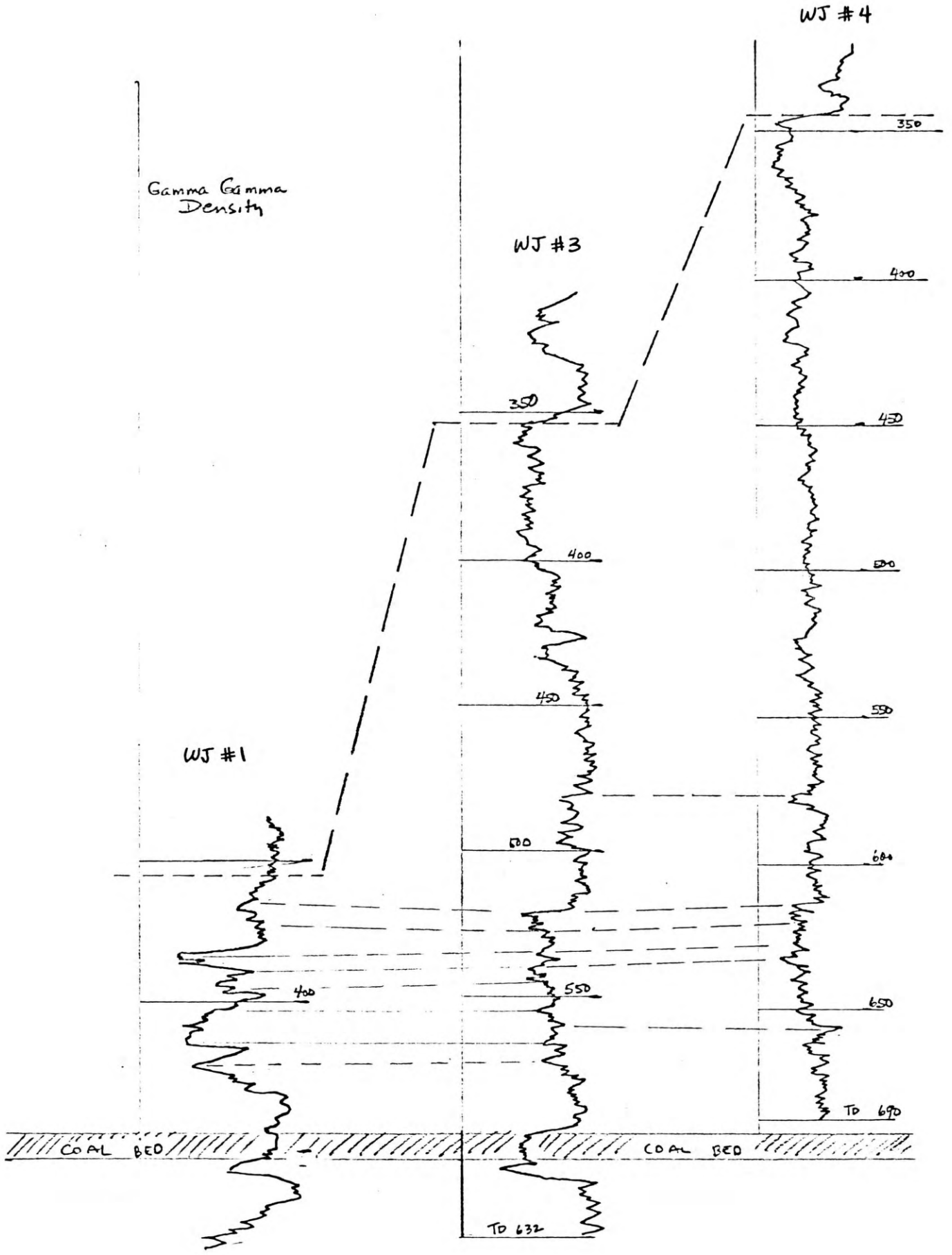


Figure 11: Comparison of gamma gamma density logs in holes Widtsoe Junction Nos. 1, 3 and 4.



Quality of the Coal

The coal core from W. J. No. 1 was divided into six samples for testing, the results follow:

As Received Analyses

	Interval	Thickness	Btu/lb.	Sulfur	Ash content
Sample 1	443.3-446.3	3.0ft.	8440	2.09%	16.29%
Sample 2	446.3-448.3	2.0	9764	2.56	6.26
Sample 3	448.3-451.8	3.5	9704	2.45	7.02
Sample 4	451.8-455.1	3.3	9672	0.88	7.64
Sample 5	455.1-458.5	3.4	9421	0.63	9.45
Sample 6	458.5-461.6	3.1	9787	0.87	4.39
Weighted averages		18.3	9459	1.51	8.57

Moist, mineral free Btu/lb. = 10,247 = Subbituminous A coal

The lower 10 feet of the coal bed is low-sulfur coal. Large amounts of marcasite were noted in the core in the upper part of the bed. Much of this may be washable. The uppermost 3 feet are high in ash. If these 3 feet are sacrificed in mining the remaining coal will have the following characteristics:

Thickness	Btu/lb.	Sulfur	Ash
15.3 ft.	9,658	1.40%	7.06%

The coal bed contains no splits or other observable impurities throughout the entire 18-foot interval.

Reserves and Resources

The coal bed shows no signs of deterioration, splitting, or thinning between holes W. J. No. 1 and W. J. No. 3. A measured reserve is calculated on the basis of 1,000-foot centers. Most of this is located in the SE SE section 33, T. 33 S., R. 2 W. and takes into consideration that the coal will only extend 200 feet southeast of W. J. No. 1 where the bed will be truncated at the unconformity. About 40 acres are considered for 1.2 million tons in place. The indicated reserve, with 1 1/2 mile centers, would provide 25 million tons in place. Each square mile of 18-foot coal will provide 20 million tons of coal in place. Depth considerations

will limit the mining width to about a mile and more drilling is necessary to determine the length of the mineable band.

The trend of thick Kaiparowits Plateau coal beds (Straight Cliffs Fm.) is northwesterly and the trend of thick Alton field coal beds (Dakota Fm.) is northeasterly and these trends converge in Johns Valley. The U. S. Geological Survey recently drilled a hole along Clay Creek (U. S. G. S., K. P. 5 SC, figure 2) and intercepted three thick coal beds, 12, 14, and 12 feet thick at depths of 508, 530, and 551 feet in the Straight Cliffs Formation. The potential for thick beds under Johns Valley is excellent. Their mineability depends on whether they can be found in a reasonable structural situation.

Selected References:

Carpenter, C. H. and others, 1964, Selected hydrologic data, Upper Sevier River Basin, Utah: Utah State Engineer Basic Data Report No. 8.

_____, 1967, Ground-water conditions and geologic reconnaissance of the Upper Sevier River Basin, Utah: U.S. Geological Survey Water Supply Paper 1836.

Doelling, H. H., 1975, Geology and mineral resources of Garfield County, Utah: Utah Geol. and Mineral Survey Bull. 107

Eardley, A. J. and R. E. Cohenour, 1963, Coal resources of the Antimony-John's Valley area, Garfield County, Utah: Utah Geol. and Mineral Survey RI 1.

Robison, R. A., 1966, Geology and coal resources of the Tropic area, Garfield County, Utah: Utah Geol. and Mineral Survey Sp. St. 18.

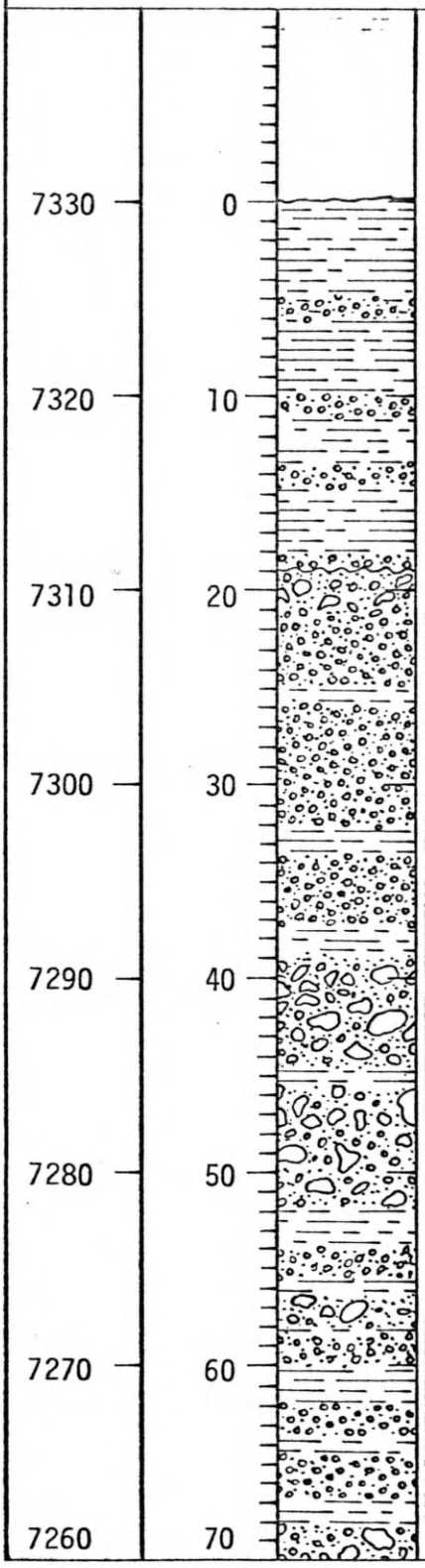
Appendix 1

Project: Widtsoe Junction Coal Drilling, Drill Hole No. 1

Location: SESESE 33-33S-2W, Garfield County, 78 feet north, 114 feet west of the southeast corner of section 33.

Elevation: 7330 feet Total Depth: 633 feet Driller: Unzicker & Wells

Begun: October 4, 1976 Completed: November 5, 1976



Remarks	
SURFACE	ALLUVIUM Clay, silt, and minor sand, pink to tan-brown, occasional zones of fine to medium gravel.
10.0	Silt, orange-brown, occasional streaks of fine pebble gravel
UNCONFORMITY 19.0	SEVIER RIVER FM.? Gravel, gritty to medium, subround to subangular, quartzite, black chert pebbles, interstitial silt and sand, interbedded lenses of silt, loosely consolidated.
30.0	Gravel, as at 19.0, some coarse, increase in sand and silt.
40.0	Gravel, grit to very coarse, interstitial silt and sand, some silt lenses, silt is clayey.
60.0	Gravel, grit to medium, interbedded with silt lenses, much coarse sand.
68.0	Gravel dominates, some coarse.

Project: Widtsoe Junction Drilling, Drill Hole No. 1

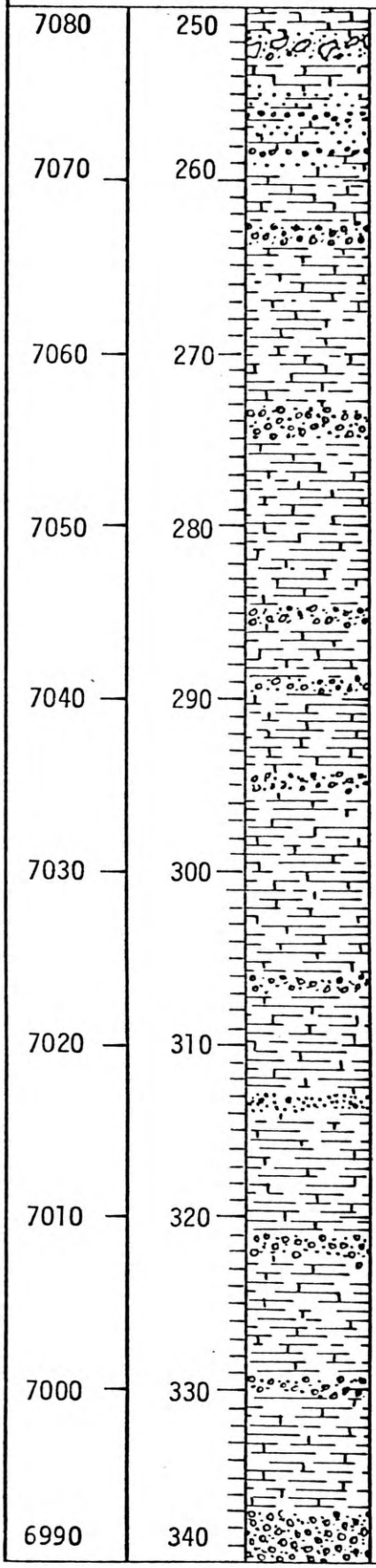
Location: SESESE 33-33S-2W

Elev.	Depth	Log	Remarks
7260	70		
			73.0 Siltstone with lenses of gravel, grit to medium, sandy.
7250	80		
			85.0 Gravel, very fine to coarse, cobbly, only occasional silt or sand lenses. jumpy drilling.
7240	90		
7230	100		100.0 Gravel, grit to fine, tan and pink, interstitial silt and clay, occasional silt and sand interbeds, silt and clay increase to 125.0.
7220	110		
7210	120		
			125.0 Gravel, grit to cobbles, occasional silt or sandy silt lenses.
7200	130		
7190	140		
			147.0 Silt, clay, and sand with interspersed fine gravel.
7180	150		
7170	160		

Location: SESESE 33-33S-2W

Elev.	Depth	Log	Remarks
7170	160		
7160	170	170.0	Gravel, coarse, some silt and clay, difficult drilling.
7150	180	180.0	Siltstone and claystone, fine to medium gravel at intervals, some coarse, slow drilling
7140	190	190.0	Gravel and coarse sand, some silt, smooth and fast drilling.
7130	200	UNCONFORMITY	CLARON FM.? Siltstone and claystone, clay tan to red and sticky, some fine to medium gravel, quick drilling.
7120	210		
		217.0	Drilling slows down.
7110	220		
		223.0	Siltstone, very little claystone, occasional gravel, slow drilling.
7100	230		
		231.0	Gravel, fine to coarse, some cobbles, interbedded with calcareous siltstone, clay, very slow drilling.
		233.0	Siltstone and claystone, pink and white, calcareous and hard, occasional coarse gravel zones (241 & 248).
7090	240		
7080	250		

Location: SESESE 33-33S-2W



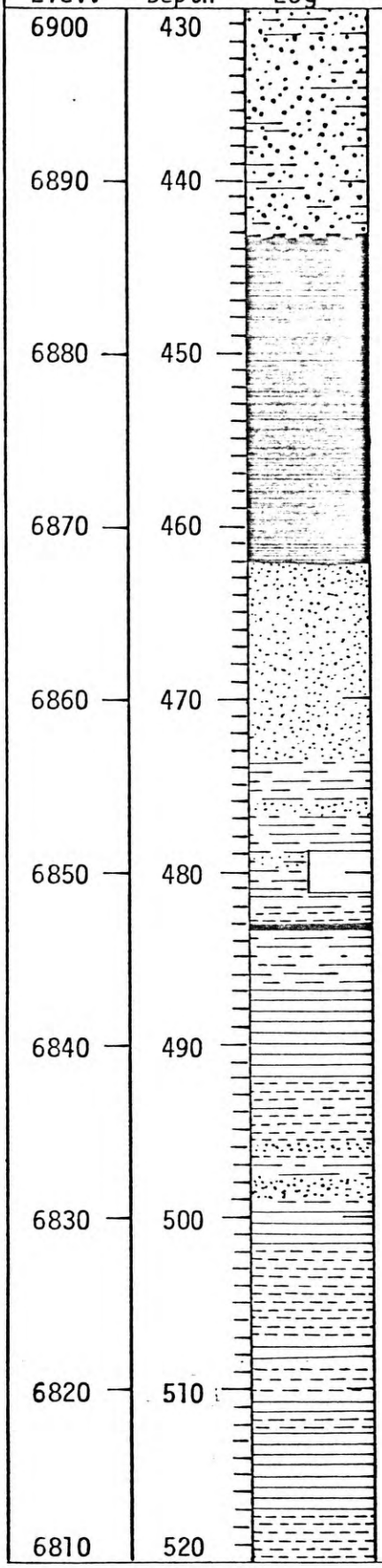
Remarks	
255.0	Siltstone, brown, sandy, some fine gravel, fast drilling.
259.0	Siltstone and claystone, orange-brown, occasional lenses of fine to medium gravel, hard slow drilling.
301.0	Claystone and siltstone, calcareous, tan to red-brown, occasional fine gravel or coarse sand, some volcanic pebbles. Hard drilling
313.0	Sandstone with a few pebbles, smooth quick drilling.
314.0	Claystone and siltstone, like 301.0, alternatingly hard and soft drilling.
337.0	Gravel with interstitial silt and clay, difficult drilling.

Project: Widtsoe Junction Drilling, Drill Hole No. 1

Location: SESESE 33-33S-2W

Elev.	Depth	Log	Remarks
6990	340		
			345.0 Gravel, light tan to brown, grit to medium, with lenses of clay and silt, calcareous
6980	350		
			357.0 Siltstone and claystone, tan-brown, contains grit, calcareous
6970	360		UNCONFORMITY CRETACEOUS, DAKOTA FM.? Shale, gray, clayey. 361.0
6960	370		
6950	380		
			387.0 Siltstone, gray, moderate drilling speed.
6940	390		389.0 Shale, gray, clayey, slow drilling.
6930	400		
			CORING BEGINS 402.0 Sandstone, medium gray, fine-grained, highly fractured with contorted thin laminae of silt-shale, black.
			403.0 Shale, black, carbonaceous, sandy, clayey, fossiliferous (oysters, *Gryphaea?*, *Exogyra?*, best at 403.7)
6920	410		404.5 Core lost but some sludge recovered, sandstone, black, with black shale interbeds, fine-grained, calcareous clayey, about 4 ft. of sludge recovered
6910	420		
			422.0 Shale, dark gray to black, silty, some fine sand, carbonaceous.
			424.0 Siltstone, medium gray, sandy, shaly, with thin calcareous stringers.
6900	430		425.4 Siltstone, medium gray, sandy, massive,

Location: SESESE 33-33S-2W



Remarks	
	calcareous, some finely disseminated pyrite.
427.9	Sandstone, laminated light-gray and black, very fine-grained and silty, laminae paper thin to 1/2 inch thick, calcareous, very silty 3 inches from base, laminae dip 12°, good marker.
443.1	Bone coal
443.3	Coal, black, lustrous, marcasite films on bedding, very uniform, 18.7 ft.
462.0	Sandstone, light and medium gray, fine-grained, some coaly streaks, some contorted bedding, calcareous, looks like beach sand.
473.3	Siltstone, finely laminated light to medium gray, sandy, calcareous
475.1	Sandstone, light gray, very fine-grained, silty, calcareous.
475.6	Siltstone, medium-gray, sandy, marcasite on some bedding planes, some loss of core.
482.0	Shale, light to medium gray, clayey.
483.0	Coal, lignitic.
483.3	Siltstone, light to medium gray, some carbonized wood fragments, argillaceous
486.3	Shale, medium to dark gray, coaly.
492.0	Shale, light gray, silty, argillaceous.
493.4	Siltstone, light gray, shaly.
494.4	Shale, medium gray, minor silt.
495.8	Sandstone, gray-yellow-brown, silty, limonite on small cracks, calcareous.
496.2	Siltstone, light gray, clayey.
497.4	Sandstone, laminated light to medium gray.
499.0	Siltstone, medium gray, sandy.
499.5	Shale, black, coaly, thinly laminated, marcasite films.
501.5	Siltstone, light gray
CHURN DRILLING 502.0	Shale, gray, silty, alternating with dark gray, carbonaceous