

UNITED STATES DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

CORE DRILLING IN 1978 — WILLOW SPRINGS QUADRANGLE,  
EMERY AND SEVIER COUNTIES, UTAH

By

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Open-File Report 78-1049

1978

This report has not been edited for conformity with U.S. Geological Survey editorial standards or stratigraphic nomenclature.

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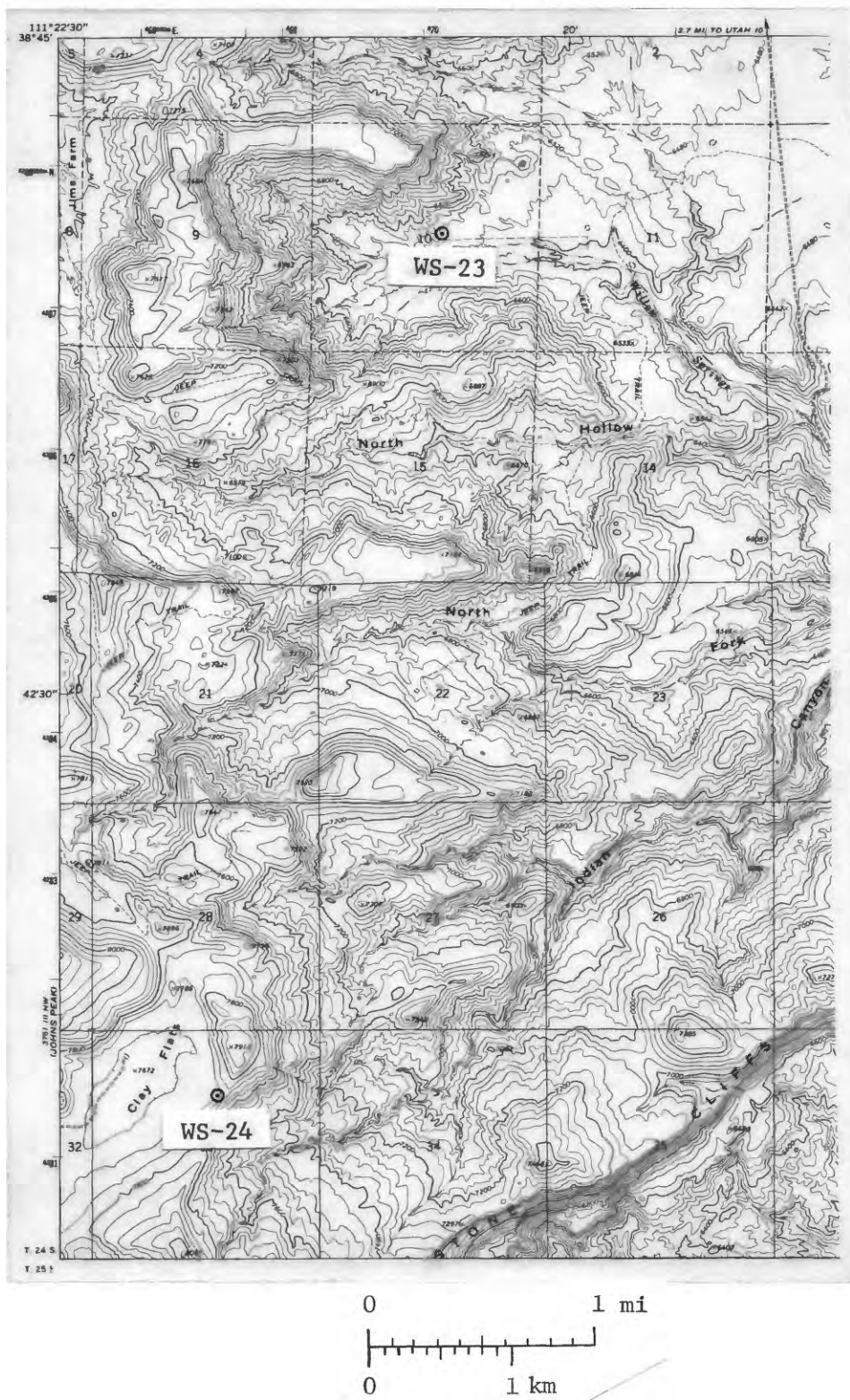
INTRODUCTION

Two core holes were drilled in that part of T. 24 S., R. 5 E., which is in the Willow Springs 7½-minute quadrangle, Emery and Sevier Counties, Utah (fig. 1). This drilling was done from June 21 through August 22, 1978, to obtain coal samples for analysis and to acquire information on the thickness and extent of coal in the Upper Cretaceous Ferron Sandstone Member of the Mancos Shale and on the lithology of the enclosing rocks. The cores provided better coal samples and more detailed lithologic information, supplementing rotary drilling done in 1977 by the Survey in this area (Edson and Barnosky, 1977). The overall goal of the project is evaluation and classification of federally owned coal resources and lands in the Emery coal field.

The holes were drilled under Government Contract No. 14-08-0001-17342, awarded by the U.S. Geological Survey to Himes Drilling Co., Inc., Grand Junction, Colo. Using truck-mounted rotary and core-drilling rigs, the contractor rotary drilled and cased to predetermined depths then cored to total depths. Coring was intended for the entire thickness of the Ferron Sandstone Member of the Mancos Shale and was successful for WS-23, where this unit is approximately 545 ft thick. However, only 309 ft of the Ferron was penetrated in WS-24 because of difficulties in drilling owing to swelling and caving shale interbeds.

Focused density and natural gamma geophysical logs were run by Strata Surveys, Grand Junction, Colo.; these were the only available procedures that could be done through casing or drill stem. Open-hole logging was impossible because of swelling and caving shale intervals.

R. 5 E.



T. 24 S.











Figure 1.--U.S. Geological Survey drill-hole locations in the Willow Springs quadrangle, Utah.






Lithologic descriptions in this report are based on detailed macroscopic core descriptions done in the field. Color terms are from the Rock Color Chart of the Geological Society of America (1970) and refer to dry samples.

In this report, unless stated otherwise, sandstone is clay- and carbonate-cemented with an undertermined amount of feldspar and apparently less than 1 percent chert and accessory grains. As much as 1 percent diagenetic pyrite is present as minute crystals. Grains are angular to subangular and well sorted; porosity and permeability are apparently high. These observations were made using a binocular microscope.

Shale is fissile, whereas claystone is nonfissile and has irregular or sub-conchoidal fracture. Shale and claystone are compositionally dominated by the clay-sized fraction; silty shale and silty claystone contain subequal proportions of silt and clay. Stratification terminology follows McKee and Weir (1953).

Rock lithologies are indicated in the strip logs as follows:

	Structureless or contorted sandstone
	Horizontally stratified sandstone
	Cross-stratified sandstone
	Ripple-stratified sandstone
	Bioturbated sandstone
	Siltstone
	Sandy or silty shale
	Shale
	Carbonaceous sandstone
	Carbonaceous siltstone

	Carbonaceous sandy or silty shale
	Carbonaceous shale
	2.0 Coal and coal thickness
	0.9 Bone coal and bone coal thickness
	Missing core

Depths and thicknesses are given in feet; to convert to meters, multiply by 0.3048.

#### REFERENCES

- Edson, G. M., and Barnosky, C. L., 1977, Lithologic and geophysical logs of holes drilled in the Willow Springs quadrangle, Emery and Sevier Counties, Utah: U.S. Geological Survey Open-File Report 77-866, 31 p.
- Goddard, E. N., Chm., and others, 1948, National Research Council (Repr. by Geological Society of America, 1951, 1970), 6 p.
- McKee, E. D., and Weir, G. W., 1953, Terminology for stratification and cross-stratification in sedimentary rocks: Geological Society of America Bulletin, v. 64, no. 4, p. 381-390.

# DRILL-HOLE LOGS

Hole no. WS-23 Date logged 6-30-78 Surface elevation (ft) 6,475  
 Loc.: State Utah Cty Sevier T. 24 S. R. 5 E. sec. 10 ; 2,210 FEL, 2,590 FNL  
 Drilled depth: Rotary (ft) 101.0 Core (ft) 725.2 ; Logged depth (ft) 711.0  
 Water level (ft) 144.8 Drilling fluid: ☐ Air ☐ Water ☐ Foam ☒ Mud

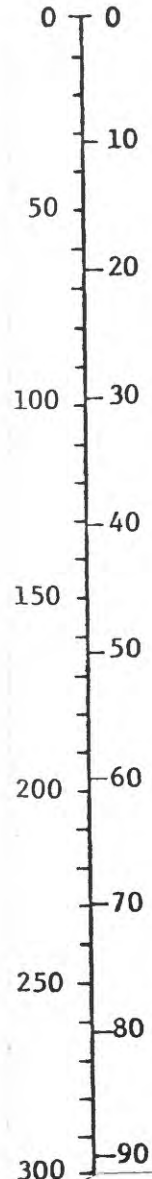
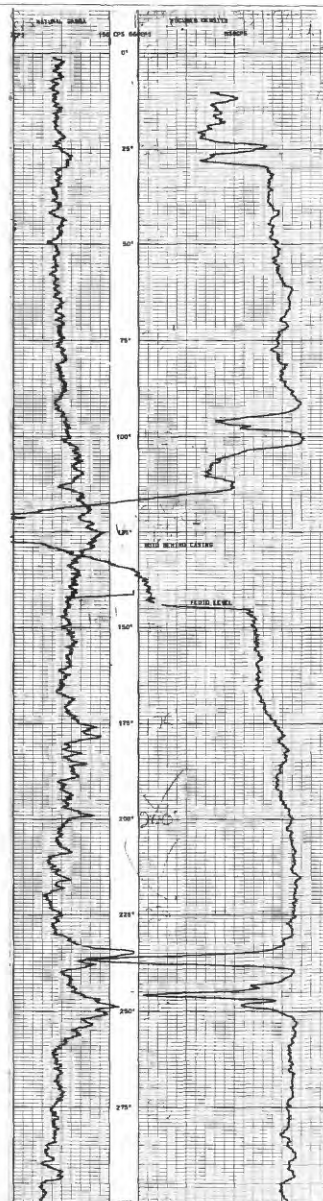
## Geophysical logs:

Gamma: T.C. 2 Scale 150 cps Logging speed 20 fpm  
 Gamma dens.: T.C. 2 Scale 660 cps Logging speed 20 fpm

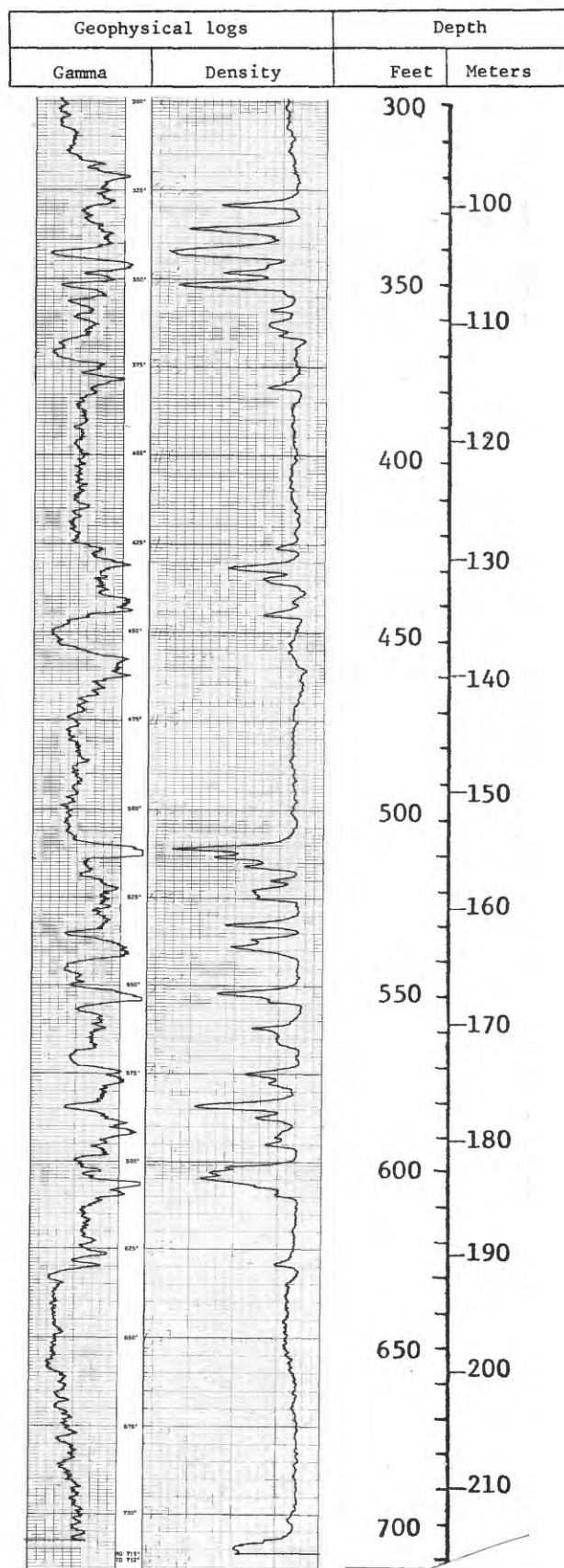
Comments: Hole cased to 100 ft. Logged through drill stem.

Density log shows void owing to caving at 125 ft.

Geophysical logs		Depth	
Gamma	Density	Feet	Meters



Hole no. WS-23 (Continued)





Hole no. WS-23 (continued)

Lithology	Strip log	Depth	
		Feet	Meters

MANCOS SHALE

Blue Gate Shale Member

0-176.5 ft Silty shale, calcareous, medium-dark-gray; contains gypsum laminae and infrequent fossil shells

176.5-179.3 ft Sandy shale and sandstone, interlaminated. Shale is medium gray to dark gray; sandstone is light gray and very fine grained. Interval is contorted and slightly bioturbated

Ferron Sandstone Member

179.3-180.8 ft Sandstone, horizontally stratified, fine- to very fine grained, light-gray; sand grains are rounded and coarsen upward. An iron oxide-cemented concretion is present at 179.6 ft

180.8-185.0 ft Sandstone, ripple-stratified, very fine grained, light-gray; contains shale streaks

185.0-185.3 ft Carbonaceous silty shale, dusky-yellowish-brown

185.3-188.7 ft Sandstone, horizontally and ripple-stratified, very fine grained, light-gray; contains shale streaks

188.7-198.9 ft Sandstone, horizontally and ripple-stratified, fine-grained, light-gray; contains infrequent shale streaks. Contains occasional limonite blebs above 197.3 ft and occasional pyrite blebs below 197.3 ft

198.9-207.5 ft Sandstone, medium-grained, light-gray; structureless, horizontally and low-angle cross-stratified

207.5-208.6 ft Sandstone, structureless, medium- to coarse-grained, light-gray; coarsens upward

208.6-208.7 ft Carbonaceous silty shale, dusky-yellowish-brown

208.7-214.6 ft Sandstone, fine-grained, light-gray; contains shale streaks. High-angle cross-stratified from 212.9-214.1 ft; otherwise horizontally stratified or structureless

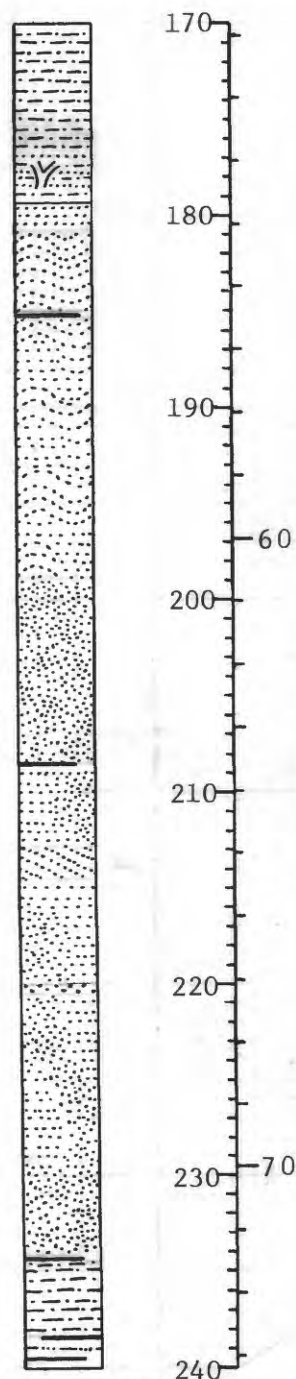
214.6-229.3 ft Sandstone, very fine grained, light-gray; contains shale streaks and occasional sandy shale laminae. Shale clasts occur between 224.6-225.7 ft, 226.5-226.8 ft, and 228.8-229.3 ft. High-angle cross-stratified at 220.0-220.6 ft; otherwise horizontally stratified or structureless

229.3-234.2 ft Sandstone, structureless, fine-grained, light-gray; shale clasts at 229.3-229.5 ft and 230.6-231.3 ft



234.2-234.4 ft Carbonaceous silty shale, olive-black; contains coal fragments

234.4-238.3 ft Silty shale, olive-gray

238.3-243.4 ft Carbonaceous siltstone, light-brownish-gray through brownish-black; contains coal fragments



Hole no. WS-23 (continued)

Lithology	Strip log	Depth	
		Feet	Meters
238.3-243.4 ft Carbonaceous siltstone, light-brownish-gray through brownish-black; contains coal fragments		240	
243.4-256.6 ft Siltstone, silty shale, and very fine grained sandstone, thinly interbedded, light-gray through medium-dark-gray; contains shale fragments. Grades upward into carbonaceous siltstone		250	
256.6-294.2 ft Sandstone, light-gray; coarsens upward from very fine-to coarse-grained. Low-angle cross-stratification with shale streaks below 286.3 ft and structureless above		260	
294.2-303.5 ft Sandstone, structureless, fine-grained, light-gray		80	
303.5-304.1 ft Sandstone, low-angle cross-stratified, very fine grained, light-gray; contains shale streaks		270	
304.1-317.6 ft Sandstone, structureless and horizontally stratified, light-gray. Lower 0.5 ft is fine grained and contains carbonized wood fragments; coarsens upward to 309.3 ft, is coarse grained to 308.6 ft, and then fines upward to 307.0 ft and is fine grained to 304.1 ft		280	
317.6-318.0 ft Claystone, grayish-green		290	
318.0-320.6 ft Sandstone, ripple- and low-angle cross-stratified, fine-grained, light-gray; contains shale streaks		90	
		300	
		310	
		320	

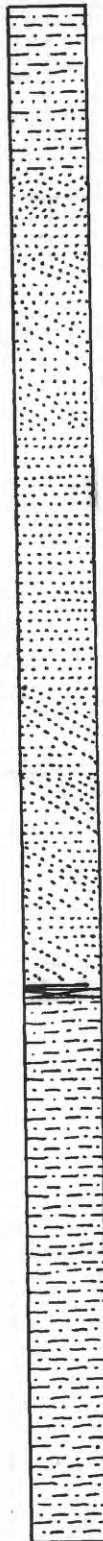
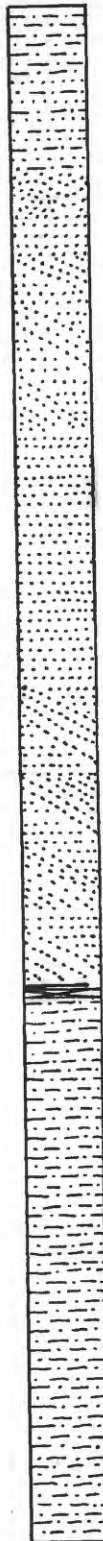
Hole no. WS-23 (continued)

Lithology	Strip log	Depth	
		Feet	Meters
318.0-320.6 ft Sandstone, ripple- and low-angle cross-stratified, fine-grained, light-gray; contains shale streaks			320
320.6-322.2 ft Sandstone, structureless, very fine-through medium-grained, light-gray; contains shale and coal fragments and occasional pyrite blebs			100
322.2-334.8 ft Silty shale and sandstone, interlaminated. Shale is medium light gray to medium dark gray; sandstone is very fine grained and light gray. Contorted stratification			330
334.8-339.4 ft Silty shale; grades upward from medium dark gray with carbonized wood fragments to medium gray. Contains occasional pyrite blebs			340
339.4-341.4 ft Claystone, olive-black		3.0	
341.4-344.4 ft Coal with occasional pyrite crystals			
344.4-345.0 ft Carbonaceous shale, dusky-yellowish-brown; contains coal streaks		0.9	
345.0-348.3 ft Claystone, dark-gray; contains coal streaks and fragments		2.0	
348.3-349.2 ft Bone coal with pyrite blebs and streaks			
349.2-351.0 ft Claystone, medium-dark-gray through grayish-black; contains coal streaks			
351.0-353.0 ft Coal with occasional pyrite crystals			360 110
353.0-353.3 ft Carbonaceous shale, grayish-brown; contains coal streaks			
353.3-355.7 ft Claystone, medium-dark-gray through dark-gray			
355.7-356.0 ft Carbonaceous shale, grayish-brown; grades upward into claystone			370
356.0-358.6 ft Sandy siltstone, light-gray to pale-yellowish-brown; contains coal streaks and carbonized wood fragments. Variably carbonaceous			
358.6-359.8 ft Silty shale, olive-gray			380
359.8-361.7 ft Sandstone, structureless, very fine grained, very light gray			
361.7-367.1 ft Silty shale, olive-gray; grades upward into sandstone			
367.1-373.9 ft Sandstone, structureless, very light gray; fines upward from fine- to very fine-grained. Contains abundant medium to coarse siderite(?) grains at 367.1-368.6 ft			
373.9-378.3 ft Silty shale and sandstone, interlaminated. Shale is medium gray; sandstone is very light gray, very fine grained, and contains shale streaks. Interval is gradational from mostly sandstone at the bottom to shale at the top			
378.3-380.4 ft Silty shale, grades upward from medium gray to dark gray			

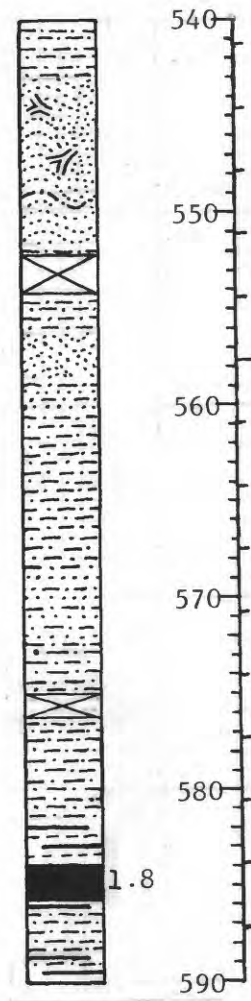
Hole no. WS-23 (continued)

Lithology	Strip log	Depth	
		Feet	Meters
378.3-380.4 ft Silty shale, grades upward from medium gray to dark gray		380	
380.4-380.9 ft Sandstone, structureless, medium-grained, light-gray			
380.9-382.2 ft Missing core			
382.2-426.2 ft Sandstone, medium-grained, light-gray; occasional very coarse grains and pebble rock fragments at 423.7-425.1 ft. Structureless, horizontally, and low-angle cross-stratified		390	
426.2-427.1 ft Claystone, medium-dark-gray			120
427.1-428.5 ft Sandstone, structureless, very fine grained, light-gray; grades upward into claystone		400	
428.5-430.0 ft Sandy shale and sandstone, interlaminated. Shale is medium gray; sandstone is light gray and very fine grained. Contorted stratification. Grades upward into sandstone			
430.0-430.7 ft Silty shale, medium-dark-gray; grades upward into sandstone and sandy shale		410	
430.7-431.7 ft Carbonaceous shale, olive-black			
431.7-432.2 ft Missing core			
432.2-432.7 ft Silty shale, medium-gray			
432.7-433.9 ft Sandy siltstone, medium-light-gray; grades upward into silty shale		420	
433.9-437.2 ft Silty shale, medium-gray; grades upward into sandy siltstone			
437.2-440.5 ft Sandy siltstone, medium-gray; grades upward into silty shale			130
440.5-446.0 ft Silty and sandy shale, interlaminated; medium-gray through dark-gray. Grades upward into sandy siltstone		430	
446.0-446.9 ft Sandy siltstone, medium-light-gray; contains carbonized wood fragments			
446.9-457.1 ft Sandstone, ripple- and low-angle cross-laminated, very fine-through medium-grained, light-gray; with shale streaks and fragments. Fines upward and grades into sandy siltstone		440	
457.1-460.1 ft Carbonaceous silty shale, olive-black; contains coal fragments		450	
		460	140

Hole no. WS-23 (continued)

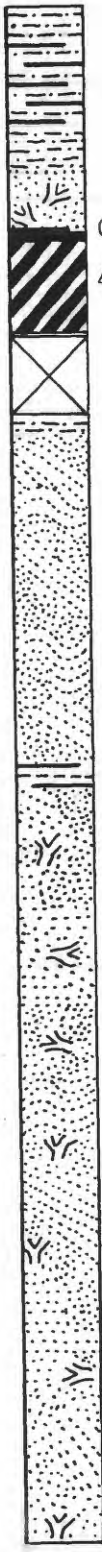
Lithology	Strip log	Depth	
		Feet	Meters
457.1-460.1 ft Carbonaceous silty shale, olive-black; contains coal fragments		460	
460.1-463.8 ft Silty shale; grades upward from medium dark gray to medium light gray			
463.8-468.4 ft Sandstone and silty shale, interlaminated. Sandstone is light gray and very fine grained; shale is medium gray. Contorted stratification		470	
468.4-471.8 ft Sandstone, contorted and ripple-laminated, very fine grained, light-gray; contains shale streaks			
471.8-473.0 ft Sandstone, horizontally stratified, very fine grained, light-gray; contains abundant carbonaceous shale streaks		480	
473.0-482.2 ft Sandstone, horizontally to low-angle cross-stratified, fine-grained, light-gray; shale streaks from 476.0-476.7 ft			
482.2-485.9 ft Sandstone, horizontally stratified, medium-grained, light-gray; contains occasional iron-oxide concretions		490	
485.9-492.2 ft Sandstone, horizontally stratified, fine-grained, light-gray; grades upward into medium-grained sandstone		150	
492.2-495.3 ft Sandstone, horizontally stratified, medium-grained, light-gray; grades upward into fine-grained sandstone		500	
495.3-510.8 ft Sandstone, horizontally and low-angle cross-laminated, fine-grained, light-gray			
510.8-511.2 ft Carbonaceous silty shale, dusky-yellowish-brown; contains coal fragments		510	
511.2-511.5 ft Missing core			
511.5-543.0 ft Silty shale, medium-gray through dark-gray and dusky-yellowish-brown			
		520	
		160	
		530	
		540	

Hole no. WS-23 (continued)

Lithology	Strip log	Depth	
		Feet	Meters
511.5-543.0 ft Silty shale, medium-gray through dark-gray and dusky-yellowish-brown		540	
543.0-549.0 ft Sandstone, very fine grained, light-gray; contains shale streaks. Ripple-stratified, contorted, and bioturbated			
549.0-549.8 ft Sandstone and sandy shale, finely ripple interlaminated; grades upward into sandstone		550	
549.8-551.7 ft Sandstone, ripple-stratified, very fine grained, light-gray; contains shale streaks			
551.7-552.2 ft Silty shale, medium-gray; contains coal fragments		170	
552.2-554.2 ft Missing core		560	
554.2-556.3 ft Silty shale, medium-gray to dusky-yellowish-brown			
556.3-558.7 ft Sandstone, ripple- and high-angle cross-stratified, very fine grained, light-gray; contains shale streaks		570	
558.7-560.2 ft Sandy shale and sandstone, finely interlaminated. Shale is medium gray; sandstone is very fine grained and light gray			
560.2-568.5 ft Silty shale, medium-gray to dark-gray			
568.5-572.9 ft Silty shale and sandstone, interlaminated. Shale is medium gray; sandstone is light gray and fine grained. Contorted stratification; pyrite crystals in fractures at 571.7-572.7 ft		580	
572.9-575.0 ft Silty shale, medium-gray through dark-gray; some carbonaceous streaks. Grades upward into silty shale and sandstone		1.8	
575.0-576.3 ft Missing core		590	
576.3-581.5 ft Claystone, medium- to dark-gray; contains carbonaceous streaks and coal fragments			
581.5-584.0 ft Carbonaceous claystone, dark-gray; contains coal streaks. Grades upward to medium-gray silty shale			
584.0-585.8 ft Coal with pyrite blebs			
585.8-586.0 ft Carbonaceous silty shale, brownish-black; contains coal streaks			
586.0-588.5 ft Silty shale, medium-gray; contains coal streaks and fragments			
588.5-590.3 ft Carbonaceous silty shale, brownish-dark-gray; contains coal streaks and fragments			



Hole no. WS-23 (continued)

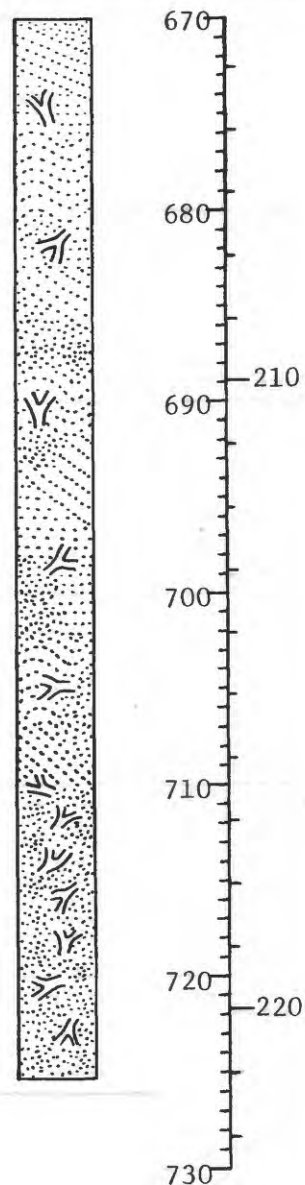
Lithology	Strip log	Depth	
		Feet	Meters
588.5-590.3 ft Carbonaceous silty shale, brownish-dark-gray; contains coal streaks and fragments		590	180
590.3-591.4 ft Silty shale, medium-gray; contains coal fragments			
591.4-596.1 ft Carbonaceous silty shale, dark-gray to brownish-black; contains coal streaks and fragments			
596.1-598.6 ft Silty shale, medium-gray; contains sandy laminae. Grades upward into carbonaceous silty shale		0.5	
598.6-601.5 ft Sandstone, bioturbated, very fine grained, light-gray; contains shale streaks. Grades upward into silty shale		4.8	
601.5-601.7 ft Carbonaceous claystone, brownish-black; contains pyrite blebs			
601.7-602.2 ft Coal with fine-grained pyrite			
602.2-607.0 ft Bone coal and coaly carbonaceous shale with pyrite blebs and streaks			
607.0-607.2 ft Claystone, medium-gray			
607.2-611.2 ft Missing core			
611.2-612.2 ft Sandy shale, light-gray			
612.2-629.6 ft Sandstone, medium- to very fine-grained, light-gray; fines upward and contains shale streaks. Coal streaks occur 629.2-629.6 ft; ripple and low-angle cross-stratified and contorted		610	
629.6-630.5 ft Carbonaceous shale, brownish-black; contains coal streaks and fragments and pyrite blebs			
630.5-725.2 ft Sandstone, fine- to very fine grained, light- to medium-gray; contains abundant shale streaks. Structureless, ripple and low-angle cross-stratified, contorted, and bioturbated. Thoroughly bioturbated from 709.1-725.2 ft		620	
		190	
		630	
		640	
		650	
		200	
		660	
		670	

Hole no. WS-23 (continued)

Lithology	Strip log	Depth	
		Feet	Meters

630.5-725.2 ft Sandstone, fine- to very fine grained,  
light- to medium-gray; contains abundant shale  
streaks. Structureless, ripple- and low-  
angle cross-stratified, contorted, and bioturbated,  
Thoroughly bioturbated from 709.1-725.2 ft

725.2 ft Total depth





# DRILL-HOLE LOGS

Hole no. WS-24 Date logged 8-21-78 Surface elevation (ft) 7,720  
 Loc.: State Utah Cty Sevier T. 24 S., R. 5 E., sec. 33; 2,350 FE L, 1,550 FNL  
 Drilled depth: Rotary (ft) 701.9 Core (ft) 1,258.1; Logged depth (ft) 1,185  
 Water level (ft) above 700 Drilling fluid: ☐ Air ☐ Water ☐ Foam ☒ Mud

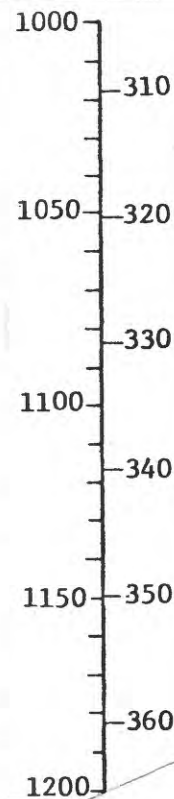
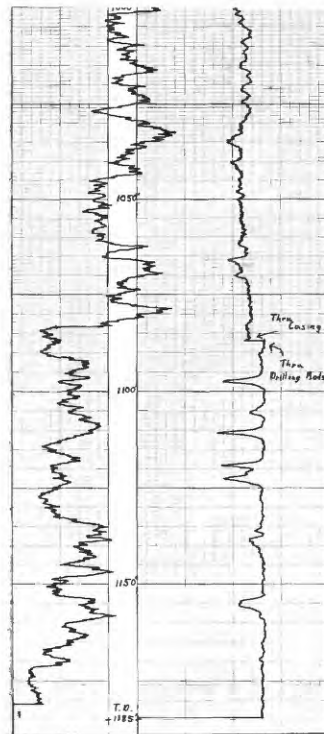
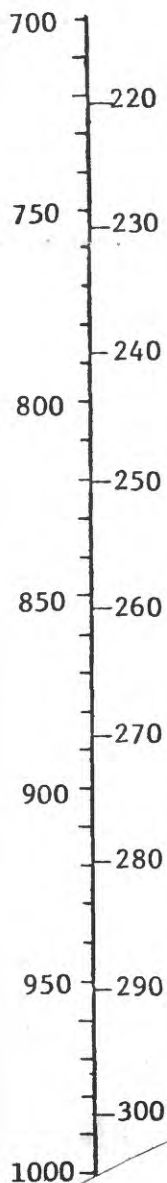
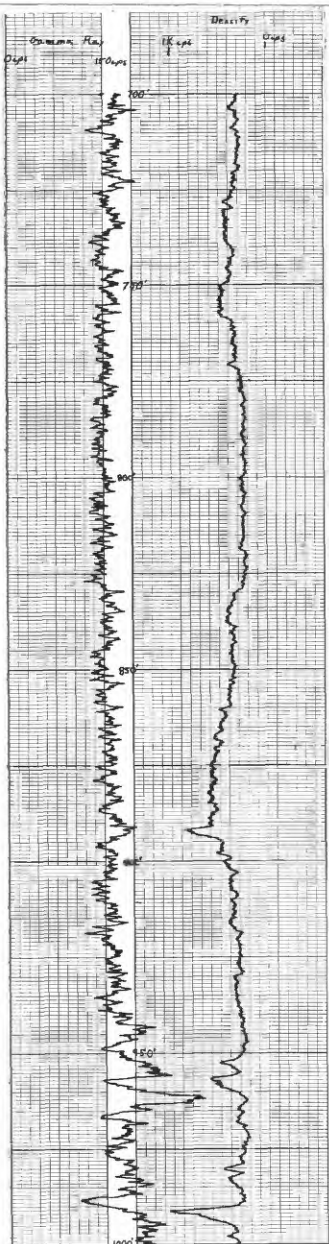
## Geophysical logs:

Gamma: T.C. 1 Scale 150 cps full scale Logging speed 20 fpm  
 Gamma dens.: T.C. 1 Scale 2 Kcps full scale Logging speed 20 fpm


Comments: Hole cased to 1,087.0 ft. Logged through drill stem below  
this level; through casing only above this level.

Geophysical logs		Depth	
Gamma	Density	Feet	Meters

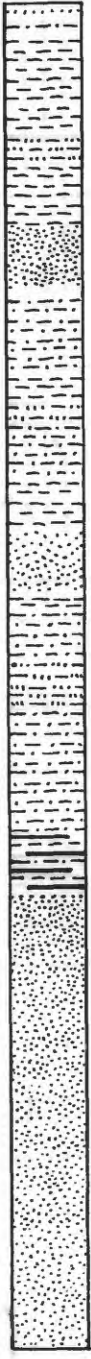
Geophysical logs		Depth	
Gamma	Density	Feet	Meters



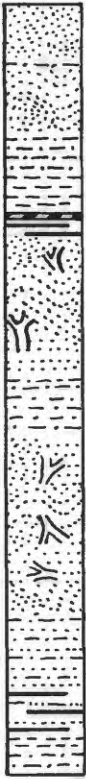
Hole no. WS-24 (continued)


Lithology	Strip log	Depth		
		Feet	Meters	
MANCOS SHALE				
<u>Blue Gate Shale Member</u>				
0-941.2 ft Silty shale, calcareous, medium-dark-gray; contains infrequent fossil shells		930		
941.2-948.7 ft Sandy shale and sandstone, interlaminated and bioturbated. Shale is medium dark gray and calcareous; sandstone is very fine grained and calcareous. Some burrows contain fine-grained pyrite		940		
<u>Ferron Sandstone Member</u>				
948.7-949.6 ft Sandstone, ripple- and cross-stratified, medium-grained, light-gray; contains shale streaks. Grades upward into sandy shale and sandstone			950	
949.6-956.6 ft Silty shale, grayish-black through medium-gray; color lightens upward. Coal streaks and occasional pyrite blebs in lower 1.6 ft				290
956.6-958.5 ft Bone coal with occasional pyrite blebs				
958.5-959.7 ft Carbonaceous silty shale, dusky-yellowish-brown			1.9	
959.7-961.9 ft Claystone, brownish-black			960	
961.9-965.4 ft Silty shale, medium-gray; contains coal streaks and pyrite blebs				
965.4-966.3 ft Claystone, brownish-black				
966.3-968.7 ft Carbonaceous sandstone, structureless, very fine grained, olive-gray; contains abundant coal fragments and streaks and pyrite blebs. Grades upward into claystone			0.6	
968.7-969.3 ft Bone coal with pyrite blebs			970	
969.3-970.5 ft Carbonaceous sandstone, structureless, very fine grained, olive-gray; contains abundant coal fragments and streaks and pyrite blebs			980	
970.5-978.3 ft Silty shale and sandstone, interlaminated. Shale is medium dark gray; sandstone is light gray and very fine grained. Contorted and bioturbated				300
978.3-979.2 ft Sandy shale, medium-dark-gray; contains coal fragments				990
979.2-981.4 ft Carbonaceous sandstone, structureless, very fine grained, olive-gray; contains coal fragments. Grades upward into sandy shale				
981.4-988.3 ft Silty shale, medium-gray; grades upward into carbonaceous sandstone				
988.3-990.8 ft Sandstone, horizontally stratified, very fine grained, light-gray; grades upward into silty shale				

Hole no. WS-24 (continued)

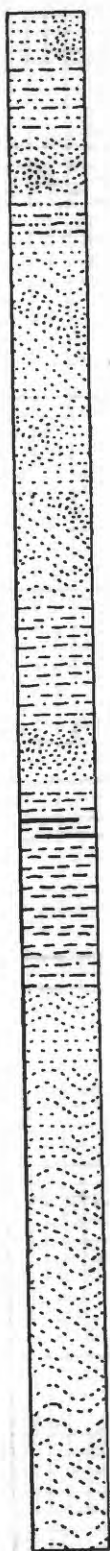
Lithology	Strip log	Depth	
		Feet	Meters
988.3-990.8 ft Sandstone, horizontally stratified, very fine grained, light-gray; grades upward into silty shale		990	
990.8-991.7 ft Silty shale, medium-dark-gray; grades upward into sandstone			
991.7-997.0 ft Claystone, dark-gray to brownish-black; grades upward into silty shale		1000	
997.0-998.5 ft Siltstone, light-olive-gray; with carbonized wood fragments. Grades upward into claystone			
998.5-1001.7 ft Claystone, light-olive-gray; grades upward into siltstone		1010	
1001.7-1004.9 ft Sandstone, structureless, very fine grained, light-olive-gray			
1004.9-1009.1 ft Silty shale, light-olive-gray; grades upward into sandstone			310
1009.1-1010.8 ft Claystone, dark-gray and olive-gray; grades upward into silty shale		1020	
1010.8-1011.9 ft Siltstone, light-gray; grades upward into claystone			
1011.9-1015.0 ft Sandy shale, light-olive-gray; contains coal fragments			
1015.0-1017.4 ft Claystone, medium-dark-gray		1030	
1017.4-1020.5 ft Sandstone, ripple-laminated and bioturbated, very fine grained, light-gray; contains shale streaks			
1020.5-1021.8 ft Claystone, light-olive-gray			
1021.8-1024.3 ft Silty shale, light-olive-gray; grades upward into claystone		1040	
1024.3-1026.9 ft Siltstone, pale-yellowish-brown; grades upward into silty shale			
1026.9-1033.2 Silty claystone, light-olive-gray; grades upward into siltstone		1050	320
1033.2-1034.3 ft Carbonaceous shale, grayish-black; contains coal fragments			
1034.3-1034.8 ft Silty shale, light-olive-gray			
1034.8-1035.4 ft Carbonaceous siltstone, brownish-gray; contains coal fragments			
1035.4-1035.9 ft Carbonaceous shale, olive-black		1060	
1035.9-1036.3 ft Carbonaceous sandstone, contorted, very fine grained, brownish-gray; contains coal fragments			
1036.3-1062.9 ft Sandstone, light-gray and very light gray. Grades upward from medium-through very fine-grained; mostly structureless. Contains shale streaks and some contorted bedding 1036.3-1048.2 ft; carbonaceous streaks 1050.4-1057.5 ft			

Hole no. WS-24 (continued)

Lithology	Strip log	Depth	
		Feet	Meters
1036.3-1062.9 ft Sandstone, light-gray and very light gray. Grades upward from medium-through very fine-grained; mostly structureless. Contains shale streaks and some contorted bedding 1036.3-1048.2 ft; carbonaceous streaks 1050.4-1057.5 ft		1060	
1062.9-1063.3 ft Silty shale, light-olive-gray		1070	
1063.3-1066.5 ft Sandstone, ripple-laminated and bioturbated, very fine grained, light-gray; contains shale streaks			
1066.5-1067.7 ft Silty claystone, dark-gray			
1067.7-1068.7 ft Silty shale, medium-gray			
1068.7-1070.9 ft Claystone, dark-gray; contains coal fragments		1080	
1070.9-1071.2 ft Bone coal			330
1071.2-1071.5 ft Carbonaceous shale, brownish-black			
1071.5-1072.0 ft Carbonaceous siltstone, brownish-gray		1090	
1072.0-1079.2 ft Sandstone, very fine grained, light-gray; horizontally and ripple-stratified, high-angle cross-stratified, and bioturbated. Contains shale streaks, decreasing upward			
1079.2-1080.3 ft Silty shale, dark-gray; contains occasional carbonaceous fragments. Grades upward into sandstone		1100	
1080.3-1082.4 ft Silty shale, dark-gray and light-olive-gray			
1082.4-1091.7 ft Sandstone, very light gray. Grades upward from medium- to very fine-grained; structureless, ripple-laminated, low-angle cross-laminated, and bioturbated. Contains shale streaks; clay clasts in lowermost 0.2 ft			
1091.7-1095.5 ft Silty shale and sandstone, interlaminated and finely interlaminated. Shale is dark gray; sandstone is light gray and very fine grained. Interval contains low-angle cross-laminae and is bioturbated			
1095.5-1097.9 ft Carbonaceous siltstone and sandstone, interstratified. Siltstone is brownish gray; sandstone is dark gray and structureless. Contains coal fragments			
1097.9-1098.8 ft Claystone, dark-gray			
1098.8-1102.6 ft Silty shale, medium-light-gray			


Lithology	Strip log	Depth	
		Feet	Meters
1098.8-1102.6 ft Silty shale, medium-light-gray		1100	
1102.6-1104.9 ft Silty shale and sandstone, finely interlaminated. Shale is medium dark gray; sandstone is light gray and very fine grained. Interval is ripple laminated and slightly bioturbated. Fine-grained pyrite fills a burrow from 1104.5-1104.9 ft. Grades upward into silty shale		1110	
1104.9-1105.5 ft Silty shale, dark-gray			340
1105.5-1107.2 ft Carbonaceous shale, dark-gray and dusky-yellowish-brown; contains coal fragments		1120	
1107.2-1111.2 ft Silty shale, medium-gray			
1111.2-1112.8 ft Carbonaceous shale and siltstone, dark-gray and dusky-yellowish-brown; contains coal fragments		1130	
1112.8-1118.0 ft Sandstone, very fine grained, light-gray; horizontally and ripple-stratified, low-angle, cross-stratified, bioturbated and contorted. Contains shale streaks			
1118.0-1119.0 ft Silty shale, medium-gray		1140	
1119.0-1119.5 ft Sandstone, structureless, very fine grained, medium-light-gray			
1119.5-1120.4 ft Silty shale, medium-gray		1150	350
1120.4-1121.1 ft Sandstone, structureless, very fine grained, medium-light-gray			
1121.1-1125.9 ft Silty shale, medium-gray		1160	
1125.9-1132.4 ft Sandstone, very fine grained, light-gray. Shale streaks, ripple lamination, and bioturbation 1129.2-1132.4 ft; mostly structureless and low-angle cross-stratified above this interval			
1132.4-1132.8 ft Siltstone, medium-light-gray			
1132.8-1133.7 ft Sandstone, horizontally stratified, very fine grained, light-gray			
1133.7-1137.6 ft Silty shale, medium-gray			
1137.6-1138.4 ft Sandstone, horizontally stratified, very fine grained, light-gray			
1138.4-1143.4 ft Silty shale, medium-gray and brownish-gray			
1143.4-1153.7 ft Sandstone, light-gray; grades upward from medium to very fine grained, horizontally and ripple-stratified, low-angle cross-stratified, and bioturbated. Contains shale streaks			
1153.7-1154.2 ft Silty shale, olive-gray; contains quartz, clay, and carbonaceous granules and bivalve fossils. Section of reptile bone at 1154.2 ft			
1154.2-1158.5 ft Silty shale, greenish-gray			
1158.5-1162.5 ft Sandstone, horizontally stratified and contorted, very fine grained, medium-light-gray. Contains shale streaks; grades upward into silty shale			

Hole no. WS-24 (continued)

Lithology	Strip log	Depth	
		Feet	Meters
1158.5-1162.5 ft Sandstone, horizontally stratified and contorted, very fine grained, medium-light-gray. Contains shale streaks; grades upward into silty shale		1160	
1162.5-1166.4 ft Silty shale and sandstone, interlaminated and finely interlaminated. Silty shale is dark gray; sandstone is light gray and very fine grained. Contains contorted bedding and pyrite blebs. Grades upward into sandstone		1170	
1166.4-1169.5 ft Sandstone, ripple-stratified and contorted, very fine grained, light-gray; contains shale streaks. Grades upward into shale and sandstone		1180	360
1169.5-1171.7 ft Siltstone, greenish-gray; contains shell fragments. Grades upward into sandstone			
1171.7-1190.4 ft Sandstone, light-gray; grades upward from fine- to very fine-grained. Horizontally and ripple-stratified, and high-angle cross-stratified; some contorted stratification and carbonaceous streaks and fragments. Clay clasts in lowermost 0.1 ft. Grades upward into siltstone		1190	
1190.4-1197.2 ft Silty shale, light- through dark-gray; contains pyrite blebs			
1197.2-1200.1 ft Sandstone, contorted, very fine grained, light-gray; grades upward into silty shale			
1200.1-1202.0 ft Silty shale, dark-gray		1200	
1202.0-1203.0 ft Carbonaceous shale, dusky-yellowish-brown; contains coal fragments			
1203.0-1209.2 ft Claystone, medium-gray through dusky-yellowish-gray; grades upward into carbonaceous shale			
1209.2-1210.8 ft Silty shale, medium-gray; grades upward into claystone		1210	
1210.8-1249.2 ft Sandstone, light-olive-gray through light-gray; grades upward from medium- to very fine-grained. Interval of 1210.8-1221.8 ft is very fine grained with ripple and horizontal-lamination; 1218.5-1221.8 ft contains shale streaks; 1221.8-1249.2 ft is medium grained with ripple and low-angle cross-stratification. Grades upward into silty shale		1220	370
		1230	
		1240	



Hole no. WS-24 (continued)

Lithology	Strip log	Depth	
		Feet	Meters
1210.8-1249.2 ft Sandstone, light-olive-gray through light-gray; grades upward from medium to very fine-grained. Interval of 1210.8-1221.8 ft is very fine grained with ripple and horizontal lamination; 1218.5-1221.8 ft contains shale streaks; 1221.8-1249.2 ft is medium grained with ripple and low-angle cross-stratification. Grades upward into silty shale		1240	
			380
1249.2-1252.9 ft Carbonaceous shale, grayish-black		1250	
1252.9-1256.9 ft Sandstone, ripple-stratified and bioturbated, very fine grained, light-gray			
1256.9-1258.1 ft Carbonaceous siltstone, medium-dark-gray through olive-black; contains coal fragments		1260	
1258.1 ft Total depth			