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LITHOLOGIC DESCRIPTION OF CORE MATERIAL FROM NICHOLAS COMBS NO. 7239 WELL, PERRY COUNTY, KENTUCKY

By

C. W. Byrer
D. B. Trumbo

Date Published--May 1976

Morgantown Energy Research Center
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LITHOLOGIC DESCRIPTION OF THE DEVONIAN SHALE IN THE HAZARD, KENTUCKY AREA

by

C. W. Byrer[1/] and D. B. Trumbo[2/]

INTRODUCTION

This report presents a detailed lithologic description of the Devonian Shale as observed in a core taken in Perry County, Kentucky. The cored well (Nicholas Combs #7239) is located approximately twelve miles directly north of the town of Hazard, Kentucky (Figure 1).

PURPOSE

The well was drilled and cored to characterize in detail the Devonian Shale in this area of eastern Kentucky. Analysis of the core material will provide information to be used in designing stimulation techniques for the improvement of gas production from the shale. Specifically, the core data will be used in designing an experiment to drill a well near this site directionally deviated to intercept an optimum number of natural fractures that exist in the shale reservoir in this area of eastern Kentucky. The well will be deviated to an inclination of 60° through the shale and then stimulated by multiple stage hydraulic fracturing in an effort to improve the rate of recovery of gas from the shale and increase ultimate gas recovery of the total amount of reserves assigned to a single well.

GENERAL GEOLOGY

The general surface geology of the area contains rocks of Pennsylvanian Age (Figure 2). The Pennsylvanian Breathitt Formation contains no less than ten coal beds along with associated shales and limestones. The Lee Formation containing the "Salt Sands" is immediately below the coal section. This formation contains intermittent zones of shale and sandstone. Deeper formations of economic interest include the massive Maxton Sandstone, the Big Lime, the Big Injun and Berea Sandstones and the the Devonian Shale.

1/ Geologist

2/ Geologist

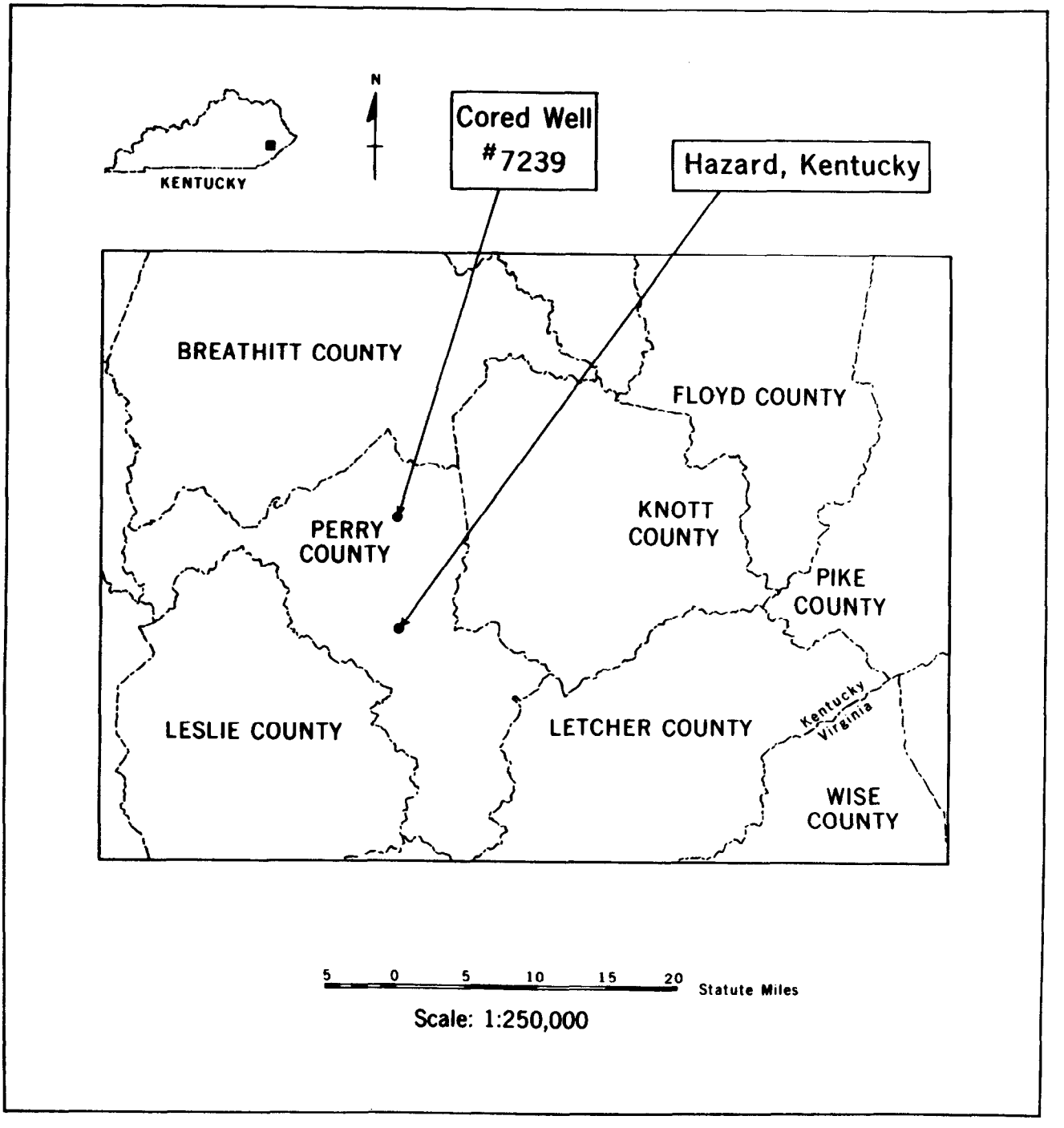

FIGURE 1.-Location of Cored Well No. 7239
in Perry County, Kentucky

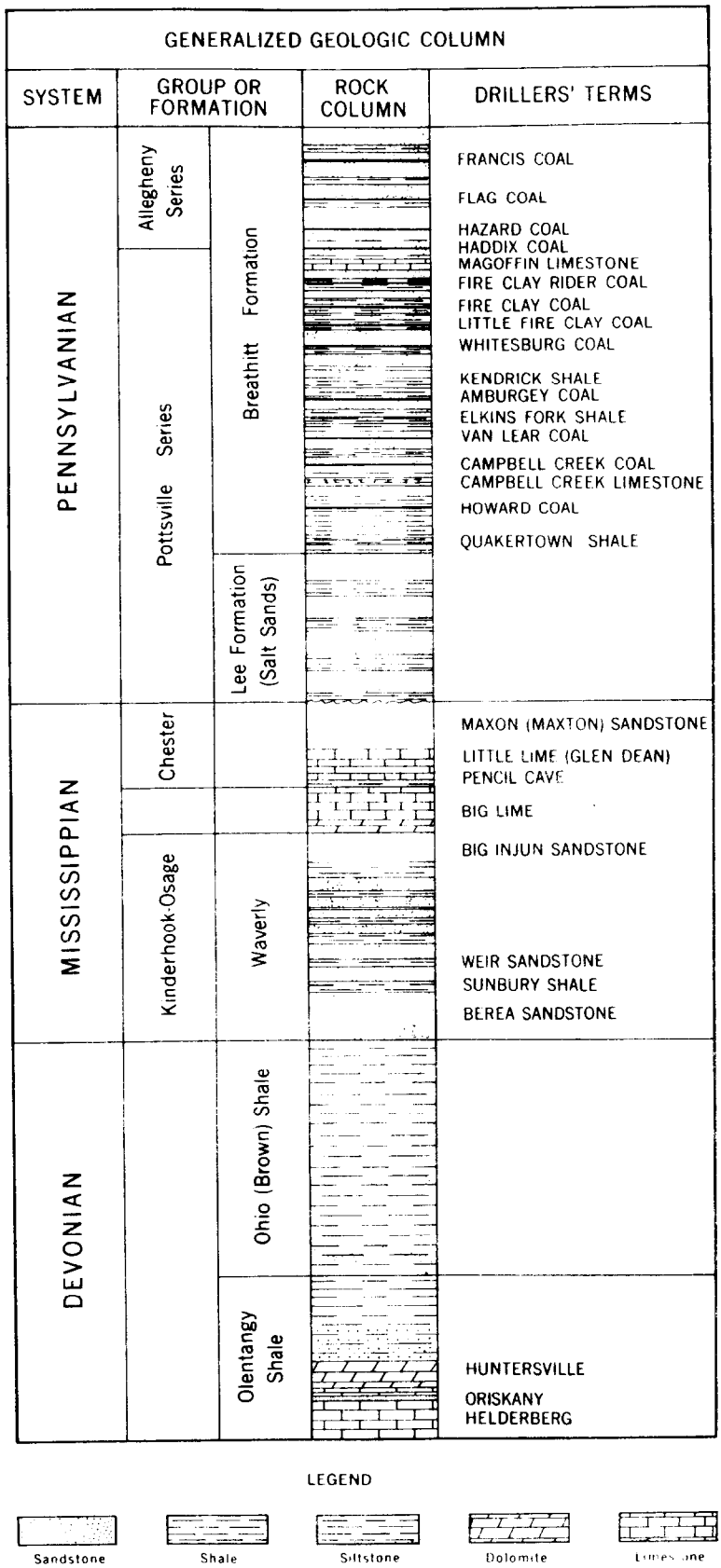

FIGURE 2.--Generalized Geologic Column for Cored Well No. 7239

SUMMARY

The core section which is being studied here is the Devonian Shale. The total thickness of the shale in this region is approximately 400 feet. The top of the cored section begins at 2369.0 feet and ends at 2708.0 feet. The total length of the core is 339.0 feet.

Analysis of this core shows that the top portion (approximately 60 feet) is a medium dark grey shale. A prominent vertical fracture extends almost continuously through this segment. Numerous pyritic nodules and silty stringers are evident throughout (Figure 3). Oblique 60° fractures are found in this interval and throughout the entire core.

The middle section contains zones (3 inches to 4 feet in thickness) of darker shale which apparently have higher organic content than the shale described above. This middle segment of the core is approximately 240 feet in length. Many intervals reveal slickensides, many of which are mineral filled. Mineral filled worm burrows are evident along with many carbonaceous fossil fragments.

The bottom 40 feet of this core is relatively uniform in composition and appearance. A light medium grey texture is prevalent in this shale segment. There are no vertical fractures, but numerous bedding plane fractures are evident. The bottom segement of this core is characterized by very little pyrite, very few organic zones, very few slickensides, very few worm burrows, and very little carbonaceous fossil material.

The gamma ray log (Figure 3) shows zones of high radioactivity in the shales from 2590 feet to 2665 feet. These zones can usually be correlated over rather wide areas. The core generally shows these to be dark organic rich shale beds.

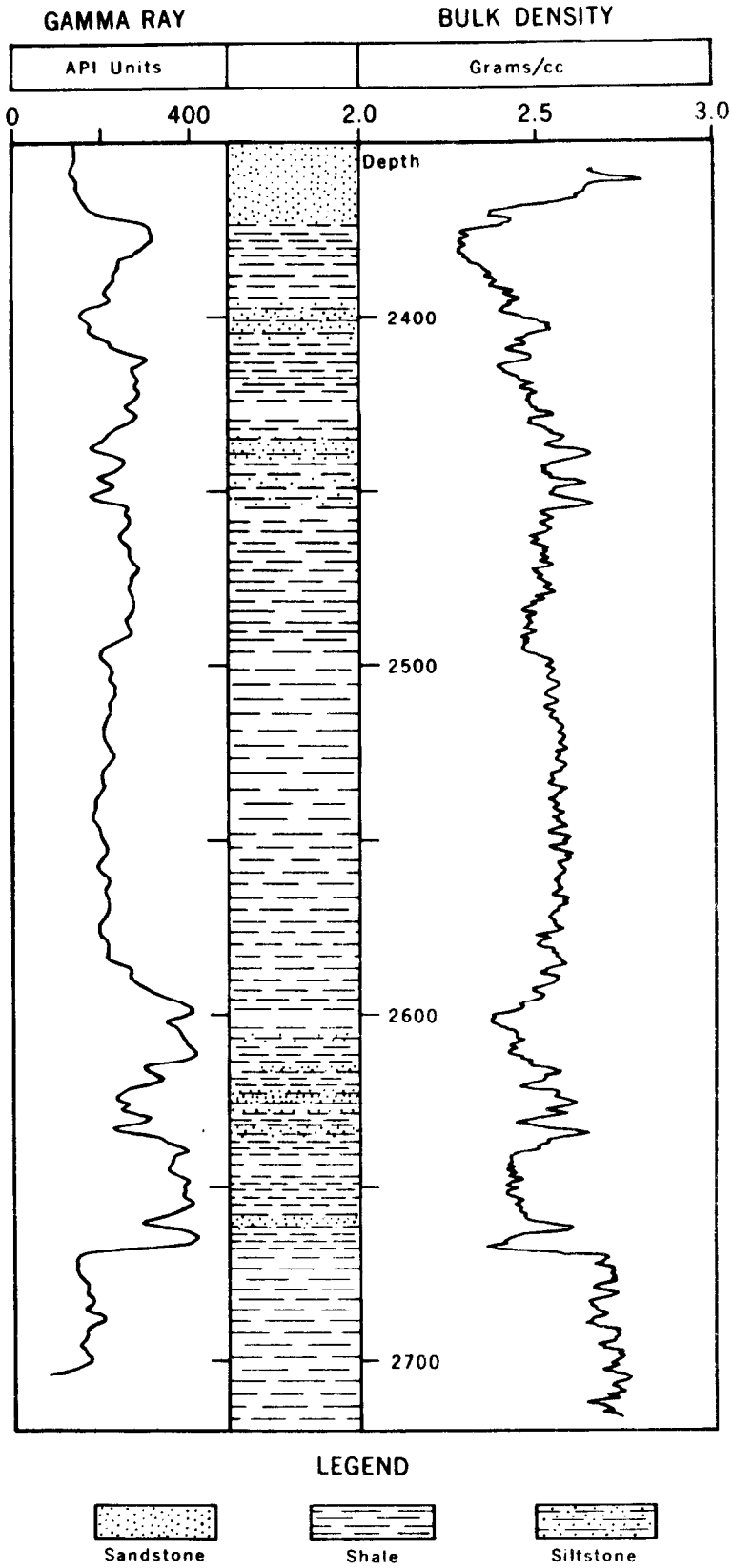

FIGURE 3.-Gamma Ray and Bulk Density Logs for Cored Well No. 7239

NICHOLAS COMBS #7239 WELL, HAZARD, KY.

Top	Bottom	Thickness (ft.)	Lithologic Description
2369.75	2370.00	.25	Shale, medium dark grey N-4, smooth clayey, brown illite. Pyritic nodules ∿ .05' non-calcareous. Bedding plane between N-4 and N-3 at ∿60°. Fractures: Vertical - N41E, Inclined - 17°SW.
2370.00	2371.0	1.0	Shale, medium dark grey N-4, smooth, clayey, brown illite. Pyritic nodules (2) (<.01'). No silty stringers. Bedding is ∿ at 30°SW. Thin laminations can be seen. Fractures: Cone Vertical - N41E, Inclined - 30°SW.
2371.00	2371.25	.25	Shale same as above. One fracture @ N40E.
2371.25	2372.1	.85	Shale, dark grey N-3, smooth clay size, brown illite. Stringers of silt and pyrite along bedding plane with pyrite nodules ≈ .01 - .05 in thickness, non-calcareous, thin laminations. Fractures: Vertical - N40E, Inclined - dip 18°SW, 20°SW.
2372.1	2373.13	1.03	Shale, dark grey N-3, smooth clay size, brown illite. Few stringers of silt and pyrite, along bedding plane, one very large nodule pyrite ≈ .2" long, thick stringer of pyrite ≈.02 thick, noncal-careous. Fractures: Vertical - N44E (2), Inclined - dip 54°SE, 74°NW.
2373.15	2374.00	.85	Shale, dark grey, N-3; soft, and a .06' pyrite lense, non-calcareous. Fractures: Vertical - 2, N44°E; 2, N45°E and Inclined - 4, 54°SE, N74°W; 4, 45°SE.
2374.00	2374.65	.65	Shale, dark grey N-3, noncalcareous, soft; 3 bedding planes, faint; small (.01') pyrite nodules, noncalcareous and also small lenticular pyrite bodies, .03' long. Fractures: Vertical - 1, N39°E, 4 Inclined <10°.
2374.65	2375.40	.75	Shale, medium dark grey, N-4, soft, non-calcareous, numerous bedding planes, finely spaced (< .01'), with very thin (<1 mm.) continuous beds of pyrite. Fractures: 1 vertical N41°E.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2376.25	2376.60	.35	Shale, dark grey N-3, smooth, clay size brown illite. 1 or 2 stringers of silt - very thin, no pyrite present. Non-calcareous. No laminations. Fractures: Inclined 50°NW.
2376.60	2377.27	.67	Shale, dark grey, N-3 smooth clay size brown illite, 1-2 stringers of silt very thin, no pyrite present, no laminations seen. Noncalcareous. Fractures: Vertical - N46E.
2377.27	2377.57	.3	Shale, dark grey N-3, smooth clay size brown illite, pyrite nodules .01-.06 in length, first .15 feet interbedded with pyrite, non-calcareous. Large nodule same type, possibly fossil on top section of core. Fractures: Vertical - N40E.
2377.57	2378.53	.96	Shale, dark grey N-3, smooth clay size brown illite, stringers of silt along bedding plane - ≈5°SW, thin laminations can be seen. Non-calcareous. Fractures: Vertical - N40E.
2378.52	2379.00	.48	Shale, medium dark grey N-4, smooth clayey, brown illite. Thin silty stringers and some pyritic nodules (< .04'). Fractures: Vertical - N41°E (2), N40 E°(1)
2379.0	2379.6	.6	Shale, medium dark grey N-4, smooth, clayey, brown illite, fairly uniform. Pyritic nodules ∿.13' (2). Fractures: Vertical - N44°E (1) Inclined: none, just 3° bedding planes.
2379.6	2380.27		Sample missing.
2380.3	2381.02	1.0	Shale, medium dark gray N-4, smooth, clayey; brown illite. Thin laminations ∿ .05 . Fractures: Vertical - N44°E, Inclined: 3°(SW) = 3
2382.70	2383.35	.63	Shale, dark grey N-3, smooth clay size illite, stringers silt and pyrite ≈ every .1 feet. Stringers slightly calcareous - rest of core - non-calcareous, few pyrite nodules ≈.06. Fractures: Vertical - N43°E Inclined - 50°SE (2)

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2383.35	2383.0		Same as above. Possible plant fossil in coal on top section.
2383.0	2384.0	1.0	Shale, medium grey, soft, 1 or 2 bedding planes well-defined by very thin pyrite beds (<1 mm.) brachiopods.
2385.3	2386.0	0.7	Shale, medium dark grey N-4, smooth, clayey, thin laminations. Fractures: Vertical - ∿N45E, cannot be oriented.
2386.0	2387.0	1.0	Shale, medium dark grey N-4, smooth, clayey, thin laminations. Fractures: Vertical - ∿N45E.
2387.0	2388.0	1.0	Shale, same as above. Silty stringer (calcareous) ∿ 0.05' at 2387.2'. Fractures: Vertical - ∿N45E.
2388.0	2388.3	.3	Shale, same as above.
2388.3	2388.7	.4	Shale, dark grey N-3, smooth clay size illite, non-calcareous.
2388.7	2388.97	.27	Same as above.
2388.97	2389.5		Same as above.
2391.0	2391.85		Shale, dark grey N-3, clay size smooth illite, stringers of silt-pyrite, very thin and calcareous, rest of core non-calcareous. Fractures: along bedding plane 2NW.
2391.85	2393.05	∿2.0	Shale - missing Sample #3 and #37. 2392.77' - 2393.01' only core left. Same as above.
2393.02	2394.64	1.64	Shale, dark grey N-3, smooth, clay size illite. Stringers of silt are less prevalent, non-calcareous. Fractures: Vertical - N36E, N42E, N45E, Inclined - N65NW, 55NW, 55SE.
2394.64	2395.14	.50	Same - Fracture: 45NW Inclined.
2395.14	2396.0	.86	Shale, medium dark grey N-4, smooth, clayey. Thin laminations. Fractures:

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2395.14 (Cont.)	2396.0	.86	Vertical - N35W (1), Inclined: 7NW, 45NW, 55SE, 48NW on each.
2396.00	2397.00	1.0	Shale, same as above. Fractures: Vertical - N38W, Inclined - 48NE.
2397.0	2398.1	1.1	Shale, same as above. Fractures: Vertical - N16W, Inclined - 45NW.
2398.1	2398.66	.56	Shale, medium dark grey N-4, smooth clay size particles brown illite - color change one shade lighter at ≈.23' depth from top of core, few small pyrite stringers at this zone and right below lithologic change. Non-calcareous. Fractures: Vertical - N49E.
2398.66	2398.88	.22	Same as above, with small pyrite stringers.
2398.88	2399.44		Same as above, with pyrite lenses ≈.06. Fractures: Vertical - N44E, N80W, Inclined - N55NE.
2399.86	2400.52		Sample #5 taken.
2400.52	2401.15	.63	Shale, medium dark grey, smooth clay size particles, pyrite lenses ranging from .06-.12 in size with a few small nodules less than .01'. Fractures: Inclined 60SW.
2401.15	2402.45	1.3	Same as above. Smaller pyrite lenses, .02-.05 in length, also pyrite stringer ≈.01 wide fossil on top of core - possibly brachiopod. Fractures: Inclined - 70SE, 30SW, 70SE.
2405.25	2405.48	.23	Shale, medium dark grey N-4, clay size particles, smooth, some pyrite nodules .02 -, highly tarnished pyrite nodules on top of core - possibly replacement pyrite - ranging size .02-.04. Fractures: Inclined - 68NW.
2405.48	2407.12		Same as above, with larger pyrite lenses found at 2406.8, lenses range .01-.08 in size, some very small (.01 wide), color variation all the way down. Fractures: Inclined - 70NW.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2407.12	2407.58		Same as above. No pyrite. Fractures: Inclined 65°NW. "Fracture feather" observed.
2407.58	2408.03		Same as above. Fractures: Vertical N40E.
2408.03	2410.35		Same as above.
2410.35	2410.9	.55	Shale, medium dark grey N-3, clayey, $CACo_2$ stringers 1-2 cm. apart. Carbonaceous layer at 2410.9, with slickensides, showing two directions of movement.
2410.9	2411.6	.7	Same as above.
2411.6	2412.8	1.2	Same as above. Slickensides @ 2412.8 pyrite nodule .8 X 2.0 cm. in size at 2411.7.
2412.8	2415.5	2.7	Same as above. Pyrite nodules 1 cm. in size at 2413.3.
2415.5	2417.7	2.3	Shale, medium dark grey N-4, clayey, smooth, silty stringers (calcareous). Pelecypod (1 cm.) 2417.6'. Drusy pyrite.
2417.7	2418.17	.47	Shale, dark grey N-3, clayey, brown illite, smooth, non-calcareous. Pelecypod (1 cm.). Drusy pyrite. Some stringers (silty).
2418.7	2420.15	1.55	Shale, dark grey N-3, clayey, with some silt, smooth, micaeous (Musco.). Pyritic globules (pelecypod) ∿ 1 cm. Drussy pyrite evident.
2420.0	2422.55	2.55	Shale, dark grey N-3, silty clay size grains, smooth, drusy pyrite with some muscovite, silty stringers. Cubic pyrite. 2 fractures @ N20E.
2422.55	2425.35	1.8	Shale, dark grey N-3, clay size, same as above. One fracture @ N34E, 1 @ N33E.
2425.35	2427.85	2.5	Shale, dark grey N-3, silty clay size, smooth, silty stringer ½" (2426.9), calcareous and stringer (2427.2') non-calcareous.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2427.85	2430.40	2.55	Shale, N-3 dark grey, smooth, clayey, silty stringers (non-calcareous). Some fossils (carbonaceous). Drusy pyrite. Two fractures @ N45E.
2430.4	2432.80	2.4	Shale, N-4 medium dark grey, smooth, clayey, thin silty stringers, slickensides, nodules of pyrite, non-calcareous.
2432.8	2433.4	.6	Shale, dark grey N-3, clayey, smooth surface, thin stringers and ½" silty calcareous stringer at 2433.0'.
2433.4	2435.45	2.15	Shale, medium grey N-5, clayey, smooth, thin stringers.
2435.45	2437.61	2.16	Shale, dark grey N-3, clayey, smooth, silty stringers (non-calcareous). Some coaly fragments 2 mm. scattered.
2437.6	2440.0	2.4	Shale, same as above. One fracture @ N75E, One fracture @ S80E.
2440.0	2440.1	.1	Shale, medium dark grey N-4, clayey, non-calcareous stringers every 1 cm., not continuous over diameter of core, micaceous.
2440.1	2440.6	.5	Shale, medium grey N-5, micaceous, clayey texture, pyrite nodules @ 2440.1 5 mm. in diameter.
2440.6	2440.8	.2	Shale, medium grey N-5 to medium dark grey N-4, clayey, discontinuous calcareous silt stringers every 1 cm., micaceous.
2440.8	2441.6	.8	Shale, dark grey N-3, clayey, micaceous.
2441.6	2442.6	1.0	Shale, medium dark grey N-4, micaceous clayey, occasional pyrite nodules and worm burrows. 2 fractures @ N30E and N70E.
2442.6	2443.6	1.0	Shale, medium dark grey N-4, clayey, small 1 cm. carbonaceous plant fossils at ≈2443.0, micaceous.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2443.6	2444.5	.9	Same as above, but has discontinuous calcareous silt stringers every 1 or 2 cm.
2444.5	2445.25	.75	Same as above, occasional band of medium grey N-5 @ 2444.5 and 2445.25. Worm burrows @ ≈2444.7.
2445.25	2448.15	2.9	Shale, medium dark grey N-4, with occasional 2 cm. bands of medium grey N-5, clayey, occasional plant fossil @ 2447.0, occasional burrowing throughout, micaceous. 1 fracture @ N60E.
2448.15	2448.6	.45	Shale, medium dark grey N-4, clayey, occasional small carbonaceous fossil, micaceous.
2448.6	2450.73	2.13	Shale, medium grey N-5, micaceous, clayey, occasional burrowing with associated drusy pyrite. 2 fractures @ N35E.
2450.73	2453.43	2.7	Shale, medium dark grey N-4, clayey, micaceous, occasional small carbonaceous fossil fragments, worm burrows, and pyrite nodules.
2453.43	2455.85	2.42	Same as above, with addition of poor slickensides at approximately 2452.0.
2455.85	2458.35	2.5	Same as above, with additons of calcareous stringers spaced 1 to 2 cm. apart at 2456.4. 2 fractures @ N45E, 2 @ N50E.
2458.35	2461.05	2.7	Same as above, 1 fracture @ N45E, 2 @ N33E.
2461.05	2463.7	2.65	Same as above, with an occasional calcareous stringer. 1 fracture @ N35E.
2463.70	2466.40	3.70	Shale, dark grey N-3, smooth, clayey, (silty stringer 1/2" calcareous at 2466.20). Pyrite nodules .25 cm. scattered throughout, micaceous. 1 fracture @ N45E, 1 @ N35E, 1 @ N30E.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2468.50	2471.20	2.70	Shale, same as above, with more pyrite crystals and nodules. 1 fracture @ N35E.
2471.20	2473.25	2.05	Shale, same as above, reoccurance of discontinuous calcareous stringers at approximately 2472.0 to 2472.5. 1 fracture @ N35E.
2473.25	2475.8	2.55	Shale, medium dark grey N-4, clayey, micaceous, pyritic with occasional burrowing, silty calcareous stringer @ 2475.7. 2 fractures @ N35E, 1 @ N50E.
2475.8	2478.43	2.63	Shale, dark grey N-3, clayey, micaceous, with .5 cm. small carbonaceous fossil fragments, occasional drusy pyrite and burrowing, large 3 cm. plant fragment (carbonaceous) at 2476.6. 2 fractures @ N35E.
2478.43	2480.8	2.37	Shale, N-3 dark grey, smooth, clayey, pyritic nodules, micaceous, silty thin calcareous stringers. 1 fracture @ N40E.
2480.8	2482.9	2.9	Shale, N-3 dark grey, clayey, smooth, drusy pyrite, pyrite nodules, silty calcareous stringers, small pelecypod fossils (carbonaceous). 1 fracture @ N42E.
2482.9	2485.6	2.70	Shale, N-4, clayey, same as above. Silty stringer (calcareous .1") at 2484.6.
2485.6	2487.98	2.38	Shale, same as above, carbonaceous fossils (plant stems) found throughout. Pyritic stringers. 1 fracture @ N45E, 2 @ N20E.
2487.98 Sent to Los Alamos (4" plug @ 2488.0)	2489.0	1.02	Shale, grayish black N-2, clayey, pyrite stringer .25 cm. wide at 2488.5, pyrite nodules throughout, micaceous.
2489.0	2490.85	1.85	Same as above, except color change to dark grey N-3.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2490.85	2491.6	.75	Shale, same as above, calcareous stringer at 2491.4. 1 fracture @ N25E.
2491.6	2493.4	1.8	Shale, medium dark grey N-4, clayey, micaceous, occasional burrowing. 2 fractures @ N30E.
2493.4	2496.29	2.89	Shale, dark grey N-3, clayey, micaceous, pyrite nodules (occasional). 1 fracture @ N25E, 1 @ N21E.
2496.29	2498.90	2.61	Shale, N-3, same as above, with fossils (carbonaceous 1.5 cm.), drusy pyrite. 1 fracture @ N25E.
2498.90	2501.22	2,32	Shale, same as above. 1 fracture @ N25W, 1 @ N24E.
2501.22	2504.60	3.38	Shale, dark grey N-3, clayey, smooth, micaeous, pyritic cubes and nodules, Silty calcareous stringers (very thin). 1 fracture @ N35E.
2504.60	2507.45	2.85	Shale, medium dark grey N-4, same as above except some small areas of N-3, drusy pyrite is abundant also. Some carbonaceous fossils. 1 fracture @ N45E, 1 @ N35E.
2507.45	2510.30	2.85	Shale, dark grey N-3, with some patches of N-4, drusy pyrite with muscovite, small nodules of pyrite and carbonaceous specimens $<$.02 mm. Very few silty stringers.
2510.30	2513.19	2.89	Shale, medium dark grey N-4, same as above with slickensides @ 2511.0'.
2513.19	2516.0	2.81	Shale, dark grey N-3, same as above, with some shale lighter than N-3. Also some pyritic nodules with stringers found scattered in section. 1 fracture @ N35E, 1 @ N55E.
2516.0	2518.38	2.38	Shale, N-4 and dark grey, smooth, clayey, drusy pyrite, woody fossil at (2516.2'), silty stringers (dolomite), scattered throughout specimen.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2518.38	2521.00	2.62	Shale, N-3 dark grey, same as above with patches of medium dark grey shale.
2521.00	2523.73	2.73	Shale, medium dark grey N-4, same as above, with woody fossil at 2522.9'. 1 fracture @ N20E, 1 @ N25E.
2523.73	2526.3	2.57	Shale, medium dark grey N-4, clayey, micaceous, pyrite nodules .5 cm. in diameter, occasional burrowing and carbonaceous fossil fragments.
2526.3	2529.03	2.73	Shale, same as above.
2529.03	2531.77	2.74	Shale, same as above, with calcareous stringer at ≈2530.0.
2531.77	2534.20	2.43	Shale, same as above.
2534.20	2536.95	2.75	Shale, same as above.
2536.95	2539.6	2.65	Shale, same as above, with small stringer (slightly calcareous) at 2538.75.
2540.0	2542.5	2.5	Shale, medium dark grey N-4, clayey occasional carbonaceous fossil plant fragment and pyrite nodules .5 cm. or less in diameter, micaceous, calcareous stringers at 2542.1. 2 fractures @ N15E.
2542.5	2545.27	2.77	Shale, same as above with mineralized zone of pyrite and other unidentified non-calcareous mineral at ≈2543.3. 3 fractures @ N15E.
2545.27	2547.5	2.23	Shale, same as above, with abundant carbonaceous fossil fragments and silty, calcareous, reddish stringers. 1 fracture @ N20E.
2547.5	2547.9	.4	Shale, dark grey N-3, clayey, micaceous, occasional carbonaceous fossil fragment, pyrite and other minerals in nodule at 2547.9.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2547.9	2550.7	2.8	Shale, dark grey N-3, clayey, micaceous, drusy pyrite, occasional pyrite nodules, occasional carbonaceous fossil fragments and silty calcareous stringers. 1 fracture @ N30E, 2 @ N10E, 1 @ N20E.
2550.7	2553.15	2.45	Shale, same as above, only color changes to medium dark grey N-4, and 1 cm. calcareous stringer at 2552.0. 1 fracture @ N35E.
2553.15	2556.0	2.85	Shale, medium dark grey N-4, clayey, micaceous, pyritic, with occasional calcareous stringer and abundant carbonaceous fossil fragments. 1 fracture @ N10E, 4 @ N25E.
2556.0	2556.6	.6	Shale, same as above, but dark grey N-3, 1 fracture @ N30E.
2556.6	2558.85	2.25	Shale, same as above, but medium dark grey N-4, and 1 - 2 cm. limestone stringer @ ≈2558.0.
2558.85	2561.0	2.15	Shale, same as above, 2 fractures @ N30E, 2 @ N15E.
2561.0	2561.61	.61	Shale, same as above, but dark grey N-3. 1 fracture @ N15E.
2561.61	2564.22	2.61	Shale, same as above, but medium dark grey N-4, and abundant calcareous stringers with a 2 - 3 cm. limestone stringer @ ≈ 2563.0. 1 fracture @ N15E.
2564.22	2566.2	1.98	Shale, same as above, but dark grey N-3. 1 fracture @ N40E, 1 @ N20E.
2566.2	2566.72	.52	Shale, same as above, but medium dark grey N-4.
2566.72	2569.3	2.58	Shale, same as above, but dark grey N-3, with less carbonaceous fossil fragments and becoming more micaceous. 2 fractures @ N35E, 2 @ N39E and 1 @ N38E.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2569.30	2572.0	2.7	Shale, medium dark grey N-4, clayey, micaceous, pyritic, with occasional thin silty stringers. 3 fractures @ N40E.
2572.0	2574.8	2.8	Shale, same as above, but dark grey N-3.
2574.8	2575.3	.5	Shale, same as above. 2 fractures @ N45E.
2575.3	2576.95	1.65	Shale, same as above, but medium dark grey N-4. 1 fracture @ N40E.
2576.95	2579.50	2.55	Shale, dark grey N-3, pyritic nodules, drusy pyrite, thin (2 mm.) silty calcareous stringers present. 1 fracture @ N40E.
2579.50	2581.78	2.28	Shale, same as above. 1 fracture @ N45E.
2581.78	2584.35	2.67	Shale, dark grey N-3, clayey, drusy pyrite, Spores (resinous) .005 very micaeous, with thin silty stringers (calcareous).
2584.35	2586.42	2.07	Shale, dark grey N-3, same as above, except many more silty stringers (calc.). 1 fracture @ N2E, 1 @ N65W.
2586.42	2587.5	1.08	Shale, dark grey N-3, clayey, micaceous, pyrite nodules 1 cm. 2 fractures @ N2E, 1 due N.
2587.5	2588.8	1.3	Shale, dark grey to grayish black (N-3 to N-2), clayey, micaceous, large carbonaceous fossil fragment at 2587.7 with mineral filled fractures and worm burrows, pyrite nodules, occasional silty calcareous stringer. 2 fractures @ N2E.
2588.8	2590.0	1.2	Shale, same as above.
2590.0	2591.49	1.49	Shale, dark grey N-3, clayey, micaceous, 1 cm. pyrite nodules, occasional calc. silty stringer 3-4 cm., calcareous pyritic layered zone at 2588.7.
2591.49	2594.0	2.51	Shale, same as above. 1 fracture @ N15E.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2594.0	2596.65	2.65	Shale, grey-black N-2, with some dark grey N-3 also. Clayey, smooth, with many thin non-calcareous stringers. Very micaceous with some drusy pyrite.
2596.65	2599.40	2.85	Shale, dark grey N-3, to grayish black, N-2. A very dark zone with very few silty areas. Drusy pyrite is very abundant in the micaceous sample. 1 fracture @ N20E.
2599.40	2601.63	2.23	Shale, same as above with more pyritic nodules evident. 1 fracture @ N5E, 1 @ N10E, and 1 @ N35E.
2601.63	2604.48	2.85	Shale, N-3 dark grey, smooth, clayey, with pyritic nodules. Fairly uniform composition. 1 fracture @ N35E, 2 @ N25N.
2604.48	2607.28	2.8	Shale, same as above, large carbonaceous fossile fragment at 2606.5. 1 fracture @ N15E, 1 @ N25E.
2607.28	2609.67	2.39	Shale, same as above, pyrite nodule at 2606.9, poorly developed slickensides at 2608.2, carbonaceous stringer at 2609.3, occasional silty calcareous stringer.
2609.67	2613.11	3.56	Shale, banded zones throughout the sample (N-3 to N-5). The zones average 2-3" in thickness with sharp contacts, some very thin stringers, and some poor slickensides are evident in one fracture. One dark zone of N-2 at 2610.0'. 1 fracture @ N20W.
2613.11	2615.74	2.63	Shale, banded in zones of N-3 to N-6 (3-4") with scattered pyritic silty stringers. Worm burrows are evident.
2615.74	2617.70	1.96	Shale, dark grey N-3, with some banding of 1/2" N-5 medium grey. Large nodules of pyrite -X-, very thin stringers of silty pyrite.
2617.70	2620.42	2.72	Shale, N-5 medium grey with bands of N-3 dark grey (2-3") scattered throughout section. Some silty stringers are also found.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2620.42	2623.20	2.78	Shale, N-5 medium grey, to medium light grey N-6 down to 2622.5, then N-3 to 2623.40 with a 1" band of N-5 in this section.
2623.2	2624.2	1.0	Shale, N-6 medium light grey, with sharp contact with N-3 shale at top.
2624.2	2624.4	.2	Shale, N-3 dark grey, a few stringers of silty pyrite.
2624.4	2625.85	1.45	Shale, N-4 with silt stringers, mixed bands of N-6 to N-3.
2625.85	2628.70	2.85	Shale, N-3 with one 2 1/2" zone of N-6. Slickensides are apparent on a 55° fracture with mineralization evident. Large nodules of pyrite are evident also (∿1"). Carbonaceous areas are also seen.
2628.70	2631.20	2.50	Shale, N-6 medium light grey, some banding of 1/2" N-3 shale at 2631.0.
2631.20	2633.58	2.38	Shale, banded with N-6 and N-3 zones 2-3". Silty stringers at 2633.0-2633.58 with large nodules of pyrite.
2633.58	2636.25	2.62	Shale, dark grey N-3 with a band of N-6 (5") at 2634.0. Dark shale ∿N-2 is found from 2634.5 to 2636.25'. Some 1/4" silty stringers are evident near 2635.0. 1 fracture @ N20W.
2633.58	2633.82	.24	Shale, dark grey to grayish black N-3 to N-2, clayey, micaceous, 1 cm. carbonaceous zone at 2633.6, poorly developed slickensides at 2633.58.
2633.82	2634.1	.28	Shale, medium grey N-5, with medium dark grey N-4 bands, clayey, micaceous and calcareous.
2634.1	2634.35	.25	Shale, dark grey to grey black N-3 to N-2, clayey, micaceous, with carbonaceous layer at 2634.30.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2634.35	2636.25	1.9	Shale, dark grey N-3, clayey, micaceous, frequent thin calcareous stringers, large carbonaceous fossil fragment with mineral filled fractures at 2636.15.
2636.25	2636.95	.7	Shale, same as above.
2636.95	2637.9	.95	Shale, dark grey N-3, clayey, micaceous, pyrite stringers at 2637.8, occasional carbonaceous zones.
2637.9	2639.05	1.15	Shale, dark grey N-3, clayey, micaceous, occasional micaceous zone which is light N-4 to N-5. 1 cm. bands at 2637.9, 2638.05, and 2638.88.
2639.05	2641.38	2.33	Shale, dark grey to medium dark grey N-3 to N-4, clayey, micaceous, frequent pyrite stringers and large nodule, frequent banding of 1 cm. N-4 to N-5.
2641.38	2644.52	3.14	Shale, medium dark grey N-4, clayey, micaceous, occasional pyrite nodules, occasional banding with medium grey N-5.
2644.52	2647.3	2.78	Shale, dark grey to medium dark grey N-3 to N-4, clayey, micaceous, pyrite nodules, large pyrite nodule at 2645.2, large carbonaceous fossil fragment at ≈ 2645.0. 1 fracture @ N55W, 1 @ N10W.
2648.3	2650.77	2.47	Shale, same as above with large carbonaceous zone at 2648.3 and occasional bands of medium grey N-5. 1 fracture @ N32W.
2650.77	2653.32	2.55	Shale, same as above, with frequent pyritic stringers. 1 fracture @ N32W, 1 @ N45.
2653.32	2655.75	2.43	Shale, same as above, silty pyritic 1 cm. zone at 2653.9. 1 fracture @ N35W.
2655.75	2657.7	1.95	Shale, same as above. 2 fractures @ N25W.
2657.7	2658.44	.74	Shale, medium grey N-5, clayey, micaceous, carbonaceous zone with mineral filled fractures at 2658.4.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2658.44	2661.12	2.68	Shale, dark grey N-3, clayey, pyritic, micaceous, mineral filled worm burrows frequent, occasional band of N-4, carbonaceous fossil fragment at 2658.3. 1 fracture @ N30W.
2661.12	2662.96	1.84	Shale, same as above, but not banded. 1 fracture @ N25W.
2662.96	2665.70	2.74	Shale, same as above, except zone of N-4 to N-5 at 2664.8. 1 fracture @ N25W.
2665.70	2668.35	2.65	Shale, N-5 medium grey, smooth, pyritic nodules. A dark N-3 layer 1/2" at 2666.2'. Slickensides present at 2665.9.' 1 fracture @ N45W.
2668.35	2670.87	2.52	Shale, N-5 medium grey with some N-6, uniform lithology with some silty thin stringers.
2670.87	2673.45	2.68	Shale, N-4 medium dark grey, same as above, with calcareous nodules containing microcrystalline pyrite. Drusy pyrite is found in the section.
2673.65	2675.66	2.01	Shale, medium grey N-5, silty calcareous stringers are found laminated at 2674.5 and a banded layer of N-4 at 2674.7' (1 1/2" wide).
2675.65	2678.04	2.39	Shale, N-3 dark grey, with silty pyritic layers from 2676.4' to 2677. 5" calcareous layer containing microcrystalline pyrite. Patches of spores @ 2676.4'.
2678.04	2680.95	2.91	Shale, N-5 medium grey, with some silty pyritic stringers scattered throughout the section. Some carbonaceous fossils evident < (.02 mm.). 2 fractures @ N55W.
2680.95	2683.92	2.98	Shale, N-5 medium grey, with some 1/2" bonding of N-4 and dark grey. Very little pyrite, but scattered silty stringers.

#7239 Well, Hazard, KY (Cont.)

Top	Bottom	Thickness (ft.)	Lithologic Description
2683.92	2685.87	2.95	Shale, N-4 to N-3 medium dark grey to dark grey, with small coaly fragments scattered (3-4 mm.). Pyritic nodules (calcareous) 1-2 cm. are evident around 2684.0'.
2685.87	2688.15	2.28	Shale N-4 same as above, except no pyrite is observed.
2688.15	2690.35	2.20	Shale, N-5, with intermittant bands of 1-2 cm. N-3. Sharp contact between N-5 and N-3 at 2690.25.
2690.35	2692.60	2.25	Shale, N-5, with pyritic calcareous nodules (1-2 cm.) and banding around 2691.0'. A 3 cm. band of N-3 at 2691.7'.
2692.60	2695.57	2.97	Shale, N-5 smooth, clayey. No pyrite or stringers. Section is uniform in lithologic make-up.
2695.57	2698.00	2.43	Shale, N-5 with a 2 cm. band of N-3 at 2695.1'. Also a band of N-3 (4-5 cm.) at 2697.0. Same as above, fairly uniform in texture and composition.
2698.0	2700.88	2.88	Shale, N-4 medium dark grey, worm cast @ 2698.5. Section is void of pyrite and stringers of silt.
2700.88	2703.38	2.50	Shale, same as above. Uniform section with slickensides at 2702.0'.
2703.38	2706.03	2.65	Shale, same as above, N-4. Uniform lithology. No pyrite evident.
2706.03	2708.60	2.57	Shale, N-4 and dark grey. Same as above, uniform section of shale.