GSA Data Repository Item 2019024

Matthew M. Jones, Bradley B. Sageman, Rosie L. Oakes, Amanda L. Parker, R. Mark Leckie, Timothy J. Bralower, Julio Sepúlveda, and Victoria Fortiz, 2019, Astronomical pacing of relative sea level during Oceanic Anoxic Event 2: Preliminary studies of the expanded SH#1 Core, Utah: GSA Bulletin, https://doi.org/10.1130/B32057.1.

Data Repository

The supplemental material for Jones et al. (2019) includes geochemical data, astrochronologic results, coring results, and downhole geophysical logging results.

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Part 1

Table DR 1.1.: Chemostratigraphic data from the Cenomanian-Turonian Boundary interval of the Tropic Shale from the SH#1 core. Bulk organic carbon isotope ratios ($\delta^{13}C_{org}$), bulk carbonate carbon isotope ratios ($\delta^{13}C_{carb}$), bulk carbonate oxygen isotope ratios ($\delta^{18}O_{carb}$), weight percent carbonate content (%Carb), weight percent total organic carbon (%TOC), and the difference between $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$ are reported. Standard deviations (σ) of replicate measurements of SH#1 samples and the Union Springs reference material from Northwestern University are noted at the bottom of the table.

Geochemical data from SH#1 Core (Jones et al., 2019)

Depth (m)	Average $\delta^{13}C_{org}$ (‰ VPDB)	$\delta^{13}C_{org}$ stdev	%Carb	%TOC	Average $\delta^{13}C_{carb}$ (‰ VPDB)	$\delta^{13}C_{carb}$ stdev	Average $\delta^{18}O_{carb}$ (‰ VPDB)	$\delta^{18}O$ stdev	$\Delta^{13}C$
124.97	-25.57		7.80	1.04	-0.23		-7.37		25.34
124.76	-26.01		13.67	0.84	0.01		-6.98		26.03
124.56	-25.29		16.08	0.87	0.07		-7.32		25.35
124.37	-25.54		17.20	1.02	-0.12		-7.82		25.42
124.17	-25.41		10.08	1.05	0.09		-5.98		25.50
124.00	-25.15		11.43	1.13	-0.09	0.02	-8.01	1.52	25.06
123.79	-25.16		13.89	1.27	0.14		-7.63		25.30
123.60	-25.11	0.02	16.50	1.58	-0.21		-8.16		24.91
123.39	-25.24		15.57	1.52	-0.24		-7.44		25.00
123.20	-25.34	0.15	23.03	0.50	-1.65		-12.76		23.69
122.99	-25.12		14.96	1.28	-0.47		-8.57		24.65
122.80	-25.19		17.25	1.21	-0.19		-7.72		24.99
122.59	-25.18		13.97	2.42	-0.27		-9.82		24.92
122.40	-25.30		14.35	1.66	-0.06	0.01	-7.94	0.44	25.24
122.19	-25.66		3.52	0.68	1.16	0.18	-7.37	0.69	26.82
122.00	-24.88		5.02	0.72	2.07		-6.67		26.95
121.80	-25.45		3.34	0.79	1.65		-8.06		27.10
121.60	-25.57		2.98	0.78	1.41		-8.76		26.97
121.40	-25.45	0.12	5.09	0.74	1.33	0.23	-6.86	0.56	26.78
121.20	-25.56		7.59	0.98	1.78		-8.52		27.34
121.01	-24.78	0.27	23.63	1.37	-2.65		-11.84		22.14
120.80	-24.07		16.17	0.97	0.83		-9.68		24.89
120.60	-23.79		24.51	0.33	1.69		-9.99		25.48
120.40	-23.54		18.17	0.36	1.89	0.00	-8.89	0.02	25.43
120.20	-23.50	0.26	6.86	0.53	3.11		-8.11		26.61
120.00	-23.25		5.47	0.60	3.15		-8.96		26.41
119.80	-24.56	0.04	4.29	0.29	-0.46		-10.26		24.10
119.61	-24.98		4.92	0.46	1.41	0.02	-9.31	0.03	26.39
119.41			0.76	0.08					*bentonitic
119.21	-24.51	0.12	2.73	0.21	-1.19		-9.50		23.32
118.99	-24.95	0.13	5.34	0.37	1.76		-8.94		26.71
118.81	-24.76	0.05	5.83	0.50	2.26		-9.59		27.02
118.55	-24.45		3.97	0.29	1.91		-10.08		26.36
118.35	-23.71	0.00	7.35	0.43	3.63		-8.22		27.35
118.19	-24.12		12.19	0.59	2.47		-8.93		26.59
118.01	-24.93	0.07	14.76	0.54	1.70		-8.69		26.63
117.80	-24.23		16.31	0.60	2.43	0.10	-8.22	0.23	26.66

Depth (m)	Average $\delta^{13}C_{org}$ (‰ VPDB)	$\delta^{13}C_{org}$ stdev	%Carb	%TOC	Average $\delta^{13}C_{carb}$ (‰ VPDB)	$\delta^{13}C_{carb}$ stdev	Average $\delta^{18}O_{carb}$ (‰ VPDB)	$\delta^{18}O$ stdev	$\Delta^{13}C$
117.60	-24.17		20.11	0.41	2.94		-7.37		27.11
117.39	-23.42		14.07	0.86	2.98		-8.51		26.40
117.20	-23.75		10.75	0.91	2.65		-8.86		26.41
116.99	-23.35		10.13	0.90	2.62		-8.09		25.97
116.80	-23.73		13.55	0.94	2.80		-10.38		26.54
116.59	-23.23		23.56	0.76	2.10		-10.62		25.33
115.88	-23.01		14.76	0.53	3.25		-8.86		26.26
115.70	-22.84		19.23	0.96	3.45		-9.15		26.29
115.47	-22.65		21.48	0.83	3.62		-8.23		26.27
115.28	-23.22	0.08	20.23	0.48	2.69		-8.18		25.91
115.07	-23.37		22.21	0.71	3.36		-8.89		26.74
114.89	-22.96		23.42	0.90	3.17		-7.09		26.12
114.68	-22.88		26.85	0.97	2.56		-8.03		25.44
114.48	-23.10		32.17	0.97	2.37		-8.37		25.48
114.29	-22.98		36.05	2.12	2.89		-7.79		25.87
114.08	-23.20		19.76	1.73	3.36		-8.16		26.56
113.89	-23.36		25.57	1.14	3.04		-8.21		26.40
113.71	-23.61		24.05	1.18	3.23		-7.34		26.84
113.51	-23.31		23.34	1.51	3.24		-7.42		26.55
113.32	-23.66	0.15	14.87	1.03	3.35		-7.42		27.01
113.11	-24.25		11.37	1.43	3.86	0.03	-7.07	0.28	28.11
112.89	-23.60		13.53	2.88	3.78		-7.12		27.38
112.77	-23.48		23.35	1.65	3.29		-6.99		26.77
112.55	-23.72		24.76	1.71	3.15		-7.74		26.87
112.12			1.03	0.04					*bentonitic
111.87	-23.44		23.62	1.43	2.60		-8.37		26.04
111.69	-23.08		23.34	1.26	2.57		-9.00		25.65
111.46	-22.77		23.22	1.27	2.80		-9.56		25.57
111.25	-23.08		15.86	1.20	3.50		-8.12		26.58
111.06	-22.82		24.29	1.46	3.36		-8.14		26.18
110.87	-22.97		19.28	1.76	3.77		-7.47		26.74
110.65	-23.16		16.67	1.78	3.91		-7.12		27.07
110.45	-22.95	0.09	13.70	1.75	3.94		-7.21		26.89
110.25	-23.35		17.13	1.53	3.94		-7.21		27.30
110.05	-22.79		15.41	2.08	4.13		-7.20		26.93
109.86	-23.09		18.72	1.73	4.30		-7.73		27.39
109.66	-23.09		21.54	0.99	4.08		-7.46		27.17
109.46	-23.40		23.32	1.00	4.29		-6.77		27.68

Depth (m)	Average $\delta^{13}C_{org}$ (‰ VPDB)	$\delta^{13}C_{org}$ stdev	%Carb	%TOC	Average $\delta^{13}C_{carb}$ (‰ VPDB)	$\delta^{13}C_{carb}$ stdev	Average $\delta^{18}O_{carb}$ (‰ VPDB)	$\delta^{18}O$ stdev	$\Delta^{13}C$
109.07	-23.34		21.86	1.66	4.16		-7.26		27.50
108.87	-23.35		30.86	1.40	3.94		-7.36		27.29
108.67	-23.30		39.25	1.30	3.74		-7.95		27.05
108.45	-23.44		48.08	1.17	3.42		-8.19		26.86
108.25	-23.38		32.47	0.87	3.98		-7.90		27.36
108.05	-23.46		30.92	0.94	4.03		-7.42		27.49
107.85	-23.53		40.90	1.00	3.75		-7.19		27.28
107.65	-22.96		40.29	1.07	3.93	0.00	-7.22	0.13	26.89
107.44	-23.02		30.63	1.24	4.11		-7.36		27.13
107.26	-22.86		41.26	1.08	3.78		-7.82		26.63
107.06	-23.16	0.05	54.41	0.96	3.67		-7.38		26.83
106.86	-23.01		51.97	0.97	3.75		-7.44		26.77
106.66	-23.23		45.59	0.95	3.86		-7.56		27.10
106.46	-23.44		53.68	0.82	3.44		-7.54		26.88
106.27	-23.51		51.98	1.04	3.59		-7.49		27.10
106.08	-23.32		51.93	0.85	3.41		-7.69		26.73
105.88	-23.74		61.15	0.84	2.77		-7.65		26.52
105.68	-23.65		53.19	1.05	3.14		-7.77		26.79
105.49	-23.79		39.29	0.97	3.64		-7.90		27.43
105.12	-24.22		13.68	0.37	3.51		-7.60		27.73
104.91	-24.25		37.80	0.82	3.19		-7.93		27.43
104.71	-24.08		38.16	0.93	3.26		-8.32		27.34
104.51	-24.32		35.23	0.92	3.56		-8.00		27.88
104.31	-24.46		33.66	0.77	3.08		-8.08		27.55
104.12	-24.55	0.04	34.89	0.85	2.81		-8.02		27.35
103.93	-24.76		26.88	0.78	2.85		-8.19		27.61
103.73	-25.02		33.63	0.79	2.72	0.02	-8.20	0.03	27.74
103.52	-24.96		38.59	0.77	2.33		-8.51		27.30
102.75	-24.81	0.12	55.00	0.73	2.06		-8.07		26.87
102.55	-24.57		37.77	0.90	2.68		-7.89		27.25
102.35	-24.83		37.91	0.92	2.77		-7.89		27.60
102.15	-24.23		30.85	1.03	2.94		-7.84		27.18
101.96	-24.14		29.76	0.98	2.93		-7.78		27.08
101.77	-24.26		27.49	1.05	3.06		-7.65		27.32
101.56	-24.44		29.28	1.10	2.77		-8.33		27.21
101.36	-24.62		28.04	1.09	2.84		-8.10		27.46
101.16	-24.68		26.05	1.24	2.84		-8.36		27.52
100.95	-24.88	0.07	27.75	1.37	2.70		-8.01		27.59

Depth (m)	Average $\delta^{13}C_{org}$ (‰ VPDB)	$\delta^{13}C_{org}$ stdev	%Carb	%TOC	Average $\delta^{13}C_{carb}$ (‰ VPDB)	$\delta^{13}C_{carb}$ stdev	Average $\delta^{18}O_{carb}$ (‰ VPDB)	$\delta^{18}O$ stdev	$\Delta^{13}C$
100.54	-24.85		24.40	1.20	2.62		-7.70		27.47
100.31	-24.88		21.49	1.06	2.61		-7.73		27.50
100.11	-24.84		22.18	1.08	2.61		-7.46		27.45
99.96			1.16	-0.04					*bentonitic
99.73	-25.29		17.77	0.46	2.30		-8.10		27.58
99.57	-25.19		22.93	0.68	2.49		-8.48		27.68
99.37	-25.29		25.73	0.80	2.52		-8.09		27.81
99.17	-25.05		26.20	0.96	2.46		-8.20		27.51
98.97	-24.94		24.67	1.03	2.54		-8.06		27.47
98.77	-24.89		26.13	1.49	2.58		-8.40		27.46
98.60	-24.89		22.67	1.69	2.55		-7.96		27.44
98.39	-24.82		26.12	1.46	2.78		-8.02		27.61
98.20	-24.86		31.30	1.27	2.56		-8.06		27.42
98.00	-24.84		32.05	1.07	2.80		-8.04		27.64
97.80	-24.90		24.92	1.04	2.78		-8.16		27.67
97.60	-24.96		27.31	1.09	2.55		-8.79		27.51
97.31	-25.13		23.22	0.97	2.65		-8.23		27.78
97.10	-25.01		23.00	1.19	2.74		-8.04		27.75
96.91	-24.82		21.01	1.03	2.59		-7.96		27.41
96.72	-24.99		21.90	1.18	2.59		-8.30		27.58
96.51	-24.95		25.99	1.10	2.53		-8.07		27.48
96.30	-24.79		30.09	1.18	2.43	0.01	-8.23	0.17	27.21
96.11	-24.86		29.09	1.18	2.31		-8.42		27.16
95.91	-24.94		28.21	1.23	2.36		-8.24		27.30
95.70	-24.80		26.39	1.19	2.38		-7.93		27.18
95.51	-24.83		29.15	1.17	2.46		-8.11		27.30
95.30	-24.84		26.85	1.32	2.57		-7.99		27.41
95.12	-24.68		28.60	1.20	2.55		-7.87		27.23
94.93	-25.02		26.16	1.18	2.67		-7.96		27.69
94.71	-24.91		23.98	1.54	2.75		-7.87		27.66
94.51	-24.80	0.25	32.56	1.14	2.59		-8.07		27.39
Avg. 1σ uncert.		0.11				0.06		0.37	

Union Springs internal reference material (n=15):	**Average $\delta^{13}C_{org}$ (‰ VPDB)**	**1σ $\delta^{13}C_{org}$ uncertainty**
	-30.32	0.08

Part 2

Table DR 1.2.: A floating astronomical time scale (ATS) for the lower Tropic Shale in the SH#1 core spanning Oceanic Anoxic Event 2 (OAE2) derived from spectral analysis of the $\delta^{13}C_{carb}$ chemostratigraphy. The upper interval of the ATS was constructed from sedimentation rates resulting from tracing the short eccentricity cycle after evolutive harmonic analysis (Meyers et al., 2001). The lowermost Tropic Shale ATS was constructed from a bandpass of the short eccentricity cycle.

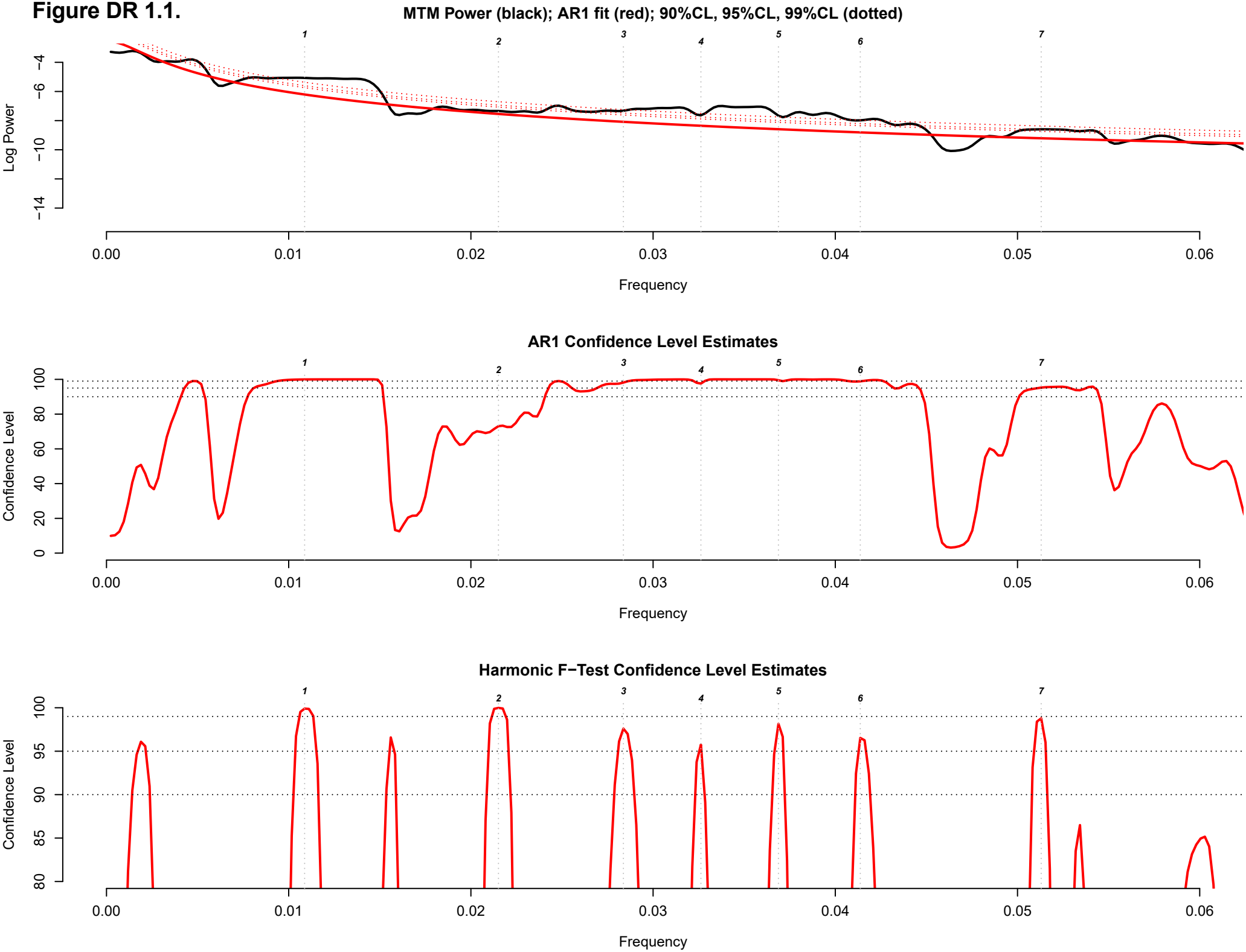
Table DR 1.2. Jones et al. (2019): Floating astronomical time scale (ATS) of SH#1 core

Depth	kyr	Notes
97.01	799.9	*EHA short eccentricity traced sed. rate (97.01-118.81 m)*
97.21	794.8	
97.61	785.2	
98.01	775.9	
98.41	766.4	
98.81	755.9	
99.21	745.6	
99.61	736.3	
100.01	727.2	
100.41	717.8	
100.81	708.4	
101.21	699.2	
101.61	689.1	
102.01	677.7	
102.41	666.0	
102.81	654.5	
103.21	643.7	
103.61	632.8	
104.01	621.3	
104.41	608.7	
104.81	595.3	
105.21	582.6	
105.61	569.3	
106.01	553.2	
106.41	537.7	
106.81	523.7	
107.21	509.7	
107.61	495.6	
108.01	480.9	
108.41	463.8	
108.81	446.2	
109.21	437.1	
109.61	428.5	
110.01	419.4	
110.41	409.8	
110.81	399.6	
111.21	388.9	
111.61	377.8	
112.01	366.6	

112.41	354.6	
112.81	341.0	
113.21	326.4	
113.61	312.0	
114.01	297.3	
114.41	281.4	
114.81	264.9	
115.21	248.0	
115.61	229.7	
116.01	209.1	
116.41	188.5	
116.81	169.9	
117.21	155.2	
117.61	142.1	
118.01	128.3	
118.41	114.7	
118.81	101.4	*Bandpassed short eccentricity sed. rate (118.81-121.51 m)*
119.01	93.3	
119.41	78.3	
119.81	63.4	
120.21	48.5	
120.61	33.6	
121.01	18.7	
121.41	3.7	
121.51	0.0	

Figure DR 1.1.: Multi-taper method (MTM) spectral analysis (Thomson, 1982) results of astronomically tuned $\delta^{13}C_{carb}$ time series from SH#1 core, using the short eccentricity tracing timescale from EHA (see Methods and Results). Significant frequencies in time series (numbered 1-7) identified for spectral peaks with red noise confidence levels (middle) and MTM F-test statistics (bottom) above 90% (see Meyers, 2012 for detailed discussion) and/or F-test statistics above 99%. Figure produced using “astrochron” R package.

Figure DR 1.1.


MTM Power (black); AR1 fit (red); 90%CL, 95%CL, 99%CL (dotted)
Log Power
−4
−6
−10
−14
1
2
3
4
5
6
7
0.00
0.01
0.02
0.03
0.04
0.05
0.06
Frequency
AR1 Confidence Level Estimates
Confidence Level
0
20
40
60
80
100
Frequency
Harmonic F−Test Confidence Level Estimates
Confidence Level
80
85
90
95
100
Frequency

Part 3

Table DR 1.3.: A summary of core recovery for the SH#1 and SH#2 cores, corresponding to different core boxes. Total depth, percent recovery, and GPS data included.

Table DR 1.3: Drilling summary and core box-depth list for SH#1 and SH#2 cores

Core: Smoky Hollow #1
Dates Cored: 7/9/14-7/11/14
Drillers: USGS
Latitude: N37°09'32.93"
Longitude: W 111°31'57.03"
Units: Converted to meters from feet/inches
Total Depth: 430.29
Percent recovery 96%

Core	Box #	Interval Drilled (Top) m	Interval Drilled (Base) m
SH-1	27	310.00	319.58
SH-1	28	319.83	329.29
SH-1	29	329.29	340.04
SH-1	30	340.04	350.04
SH-1	31	350.04	359.79
SH-1	32	359.79	370.21
SH-1	33	370.21	379.71
SH-1	34	379.71	391.04
SH-1	35	391.04	400.63
SH-1	36	400.63	410.33
SH-1	37	410.33	420.00
SH-1	38	420.08	429.50
SH-1	39	429.50	430.29

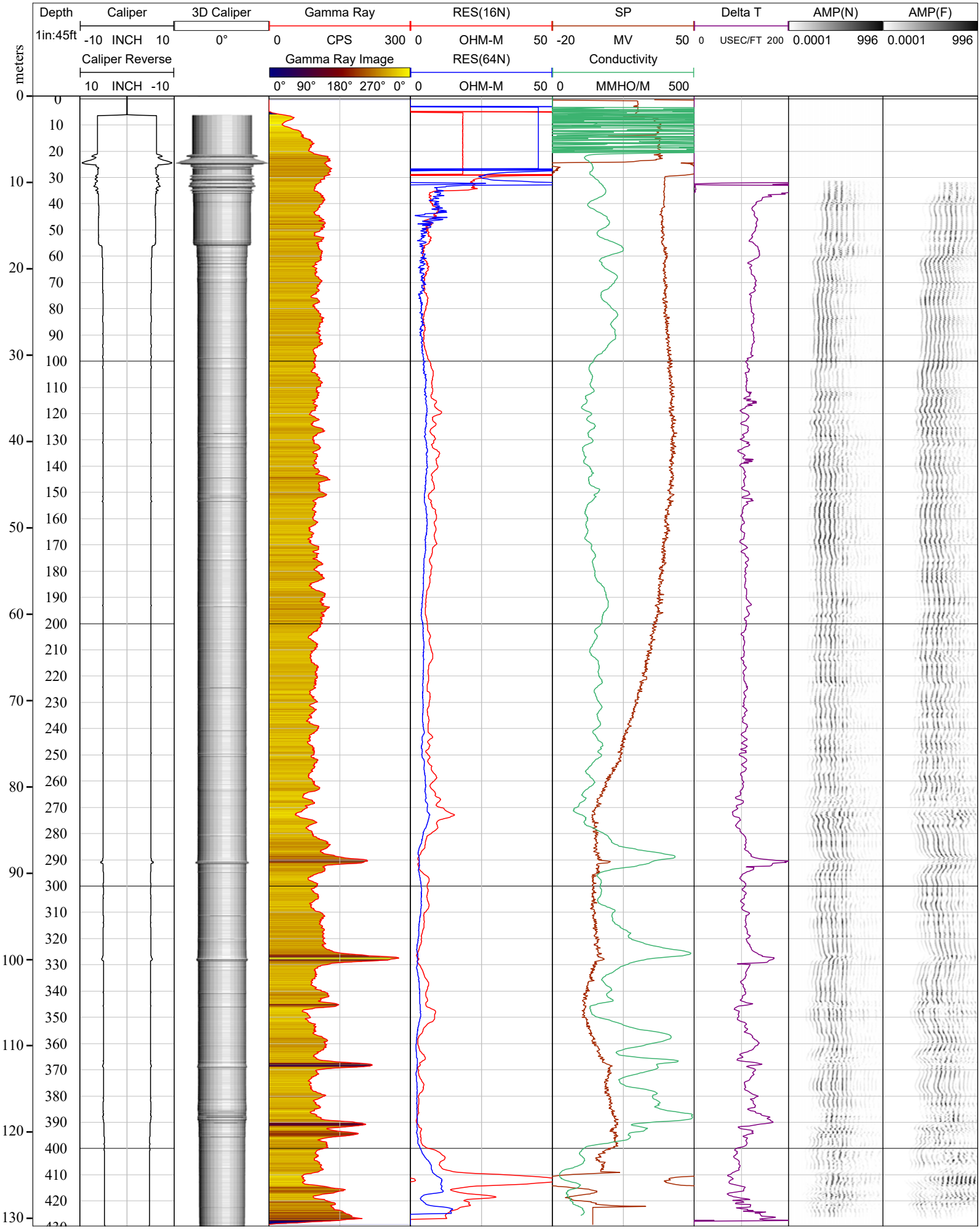
Core: Smoky Hollow #2
Date Cored: 7/11/14-7/13/14
Drillers: USGS
Latitude: N 37°09' 32.93"
Longitude: W 111°31' 57.03"

Total Depth: 420.7917
Percent recovery 93%

Core	Box #	Interval Drilled (Top) m	Interval Drilled (Base) m
SH-2	1	310.75	320.17
SH-2	2	320.17	331.17
SH-2	3	331.17	340.75
SH-2	4	340.83	350.67
SH-2	5	350.67	361.17
SH-2	6	361.17	371.08
SH-2	7	371.08	380.21
SH-2	8	380.21	389.92
SH-2	9	389.92	401.13
SH-2	10	401.13	410.13
SH-2	11	410.13	419.08
SH-2	12	419.08	420.79

Figure DR 1.2.: Plots of downhole geophysical logging data from SH#1 borehole. From left to right: Caliper diameter, 3D caliper diameter, natural gamma ray (counts per second), shallow and deep resistivity (ohm-m), spontaneous potential and conductivity, Delta T (interval transit time), and sonic amplitude.

Figure DR 1.2. Smoky Hollow #1 Borehole - geophysical logging data (7/11/2014)



Supplemental References Cited

Meyers, S. R., 2012, Seeing red in cyclic stratigraphy: Spectral noise estimation for astrochronology: Paleoceanography, v. 27, no. 3.

Meyers, S. R., Sageman, B. B., and Hinnov, L. A., 2001, Integrated quantitative stratigraphy of the Cenomanian-Turonian bridge creek limestone member using evolutive harmonic analysis and stratigraphic modeling: Journal of Sedimentary Research, v. 71, no. 4, p. 628-644.

Thomson, D. J., 1982, Spectrum estimation and harmonic-analysis: Proceedings of the Ieee, v. 70, no. 9, p. 1055-1096.