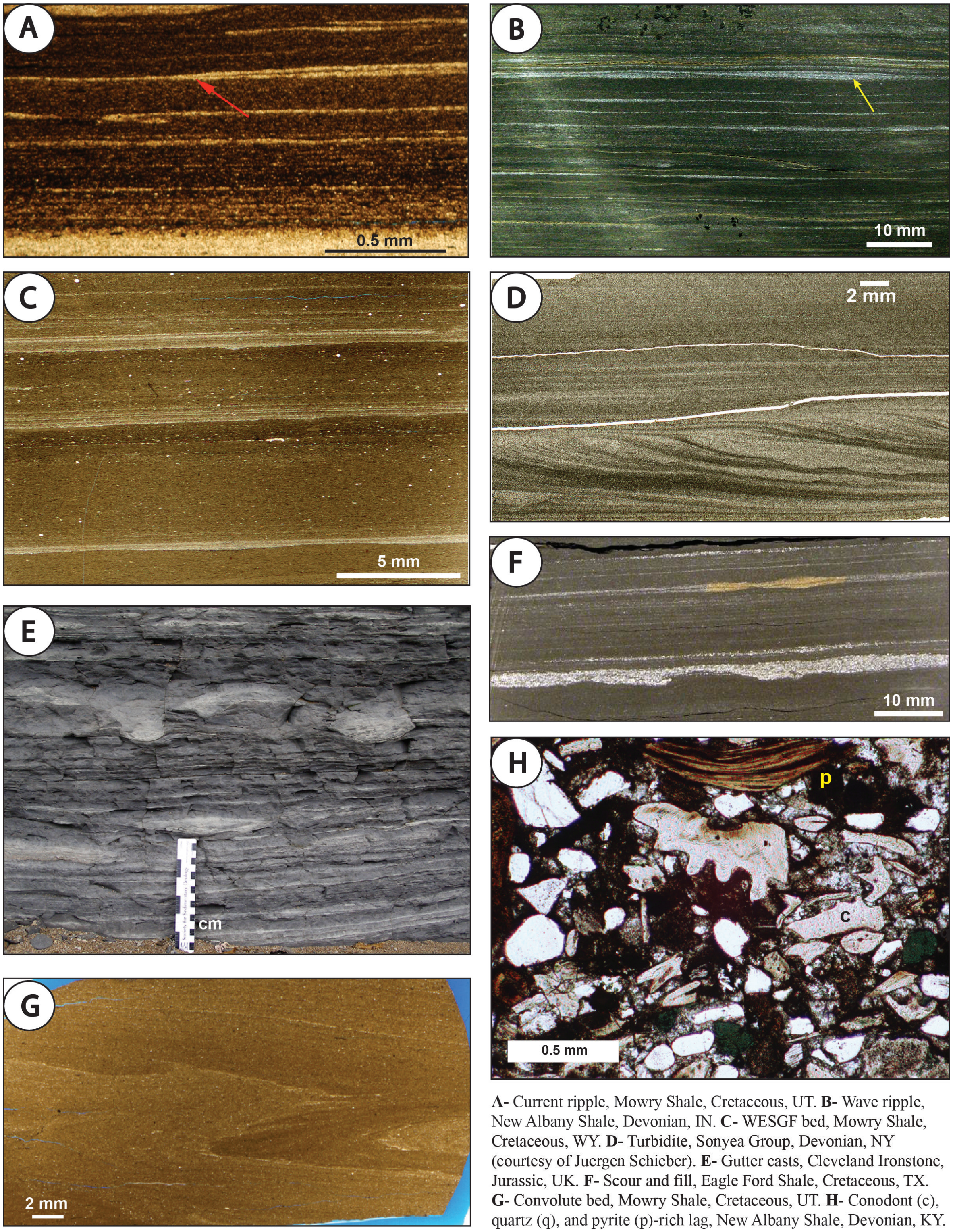
Bohacs et al. Data Repository 2014035



A- Current ripple, Mowry Shale, Cretaceous, UT. **B-** Wave ripple, New Albany Shale, Devonian, IN. **C-** WESGF bed, Mowry Shale, Cretaceous, WY. **D-** Turbidite, Sonyea Group, Devonian, NY (courtesy of Juergen Schieber). **E-** Gutter casts, Cleveland Ironstone, Jurassic, UK. **F-** Scour and fill, Eagle Ford Shale, Cretaceous, TX. **G-** Convolute bed, Mowry Shale, Cretaceous, UT. **H-** Conodont (c), quartz (q), and pyrite (p)-rich lag, New Albany Shale, Devonian, KY.

DR-Figure 1: Core, outcrop, and thin section images showing examples of the sedimentary structures recognized and plotted in our Figures 1 and 2.

DR-Table 1: Stratigraphic units included in study.

Unit	Area	Age	*Storm Wave*	*River Flood*	*Tidal Current*
Sisquoc Fm	southern California	Pliocene	++	++	
Rincon Fm	southern California	Miocene	+++		
Urenui Fm	Taranaki basin, NZ	Miocene	+++		+
Antelat Fm	Sirte basin, Libya	Eocene	++		+
Colorado Sh	W. Canada basin	L. Cretaceous	+++	++	+
Iabe Fm	west Africa	L. Cretaceous	++		
White Chalk Subgroup	United Kingdom	L. Cretaceous	+++		+
Carlile Sh	western USA	L. Cretaceous	+++	+	+
Pierre Sh	western USA	L. Cretaceous	++	+	+
Mancos Sh	western USA	L. Cretaceous	++	++	+
Tropic Sh	western USA	L. Cretaceous	+++	++	+
Blue Gate Sh	western USA	L. Cretaceous	+++	++	
Tununk Sh	western USA	L. Cretaceous	++	++	
Niobrara Fm	western USA	L. Cretaceous	++		+
Eagle Ford Sh	Texas	L. Cretaceous	++		+
2nd White Speckled Sh	W. Canada basin	L. Cretaceous	++		+
Green Horn Ls	Colorado	E. Cretaceous	++		+
Shilaif Fm	Arabian Platform	mid Cretaceous	++		
Belle Fourche Sh	western USA	E. Cretaceous	+	+	+
Graneros Sh	western USA	E. Cretaceous	++		+
Mowry Shale	western USA	E. Cretaceous	+++		+
Thermopolis Sh	western USA	E. Cretaceous	++	+	+
Skull Creek Sh	western USA	E. Cretaceous	++		+
Toolebuc Fm	Eromanga basin	E. Cretaceous	++		
Torok Fm	north Alaska	E. Cretaceous	++	+	+
Pebble Sh Fm	north Alaska	E. Cretaceous	+++		+
Bossier Sh	Gulf Coast, USA	E. Cretaceous	++	+	
Haynesville Fm	Gulf Coast, USA	L. Jurassic	+++		+
Kimmeridge Clay	Wessex, N. Sea basins	L. Jurassic	+++		+
Vaca Muerta	Neuquen basin, Argentina	L. Jr – E. K.	++	+	++
Kingak Fm	north Alaska	E. Jr – E. K.	+++	+	+
Lower Oxford Clay	Weald/Channel basin	M. Jurassic	+++		
Schistes Carton	Paris basin	E. Jurassic	+++		
Whitby Mudstone	Cleveland basin, U.K.	E. Jurassic	+++		+
Posidonia Shale	Northwest Europe	E. Jurassic	+++		+
Cleveland Ironstone	Cleveland basin, U.K.	E. Jurassic	++	+	+
Nordegg Fm	Fernie basin, Canada	E. Jurassic	+++		
Jet Rock Fm	Cleveland basin, U.K.	E. Jurassic	+++		
Blue Lias Fm	Somerset	E. Jurassic	+++		+
Shublik Fm	north Alaska	Triassic	+++	+	+
Kavik Fm	north Alaska	Triassic	++	+	+
Snadd Fm	Barents Sea basin	M. Triassic	+++		+
Steinkobbe Fm	Barents Sea basin	M. Triassic	+++		+
Doig Fm	W. Canada basin	M. Triassic	+++		
Montney Fm	W. Canada basin	M. Triassic	++		
Cutoff Fm	Permian basin, USA	L. Permian	++		+
Phosphoria Fm	W. Interior basin, USA	E. Permian	+++		+
Chimney Rock Shale	Paradox basin	L. Carboniferous	++		++
Gothic Shale	Paradox basin	L. Carboniferous	++		++

Barnett Sh	Fort Worth basin	E. Carboniferous	+++	+	
Woodford Fm	Texas, Oklahoma	E. Carboniferous	+++	+	
Excello Shale	Central USA	E. Carboniferous	++		+
Bakken Fm	Williston basin	L. Dev. – E. Carb.	+++		+
Chattanooga-Ohio Shale	Appalachian Basin	L. Devonian	+++	+	
New Albany Sh	Illinois basin	L. Devonian	+++	+	
Exshaw Fm	W. Canada basin	L. Devonian	+++		+
Canol Fm	Yukon/NWT basin	L. Devonian	+++		
Fort Simpson Fm	W. Canada basin	L. Devonian	++	+	
Muskwa mbr, HRF*	W. Canada basin	M.-L. Devonian	+++		
Otter Park mbr, HRF*	W. Canada basin	M. Devonian	+++		
Evie mbr, HRF*	W. Canada basin	M. Devonian	+++		
Duvernay Sh	W. Canada basin	M. Devonian	+++		+
Marcellus Sh	Appalachian basin	M. Devonian	+++	++	
Wenlockian Sh	Poland	E. Silurian	+++	+	
Caradocian Sh	Poland	L. Ordovician	+++		
Utica Sh	Eastern USA	L. Ordovician	++		

** HRF = Horn River Fm*

+++ = *commonly observed*
++ = *occasionally observed*
+ = *sparsely observed*
blank = not observed

DR Figures 2 – 12: *Graphic data in the form of detailed description logs for specific examples of each parasequence type. SWD = storm-wave-dominated; RFD= river-flood dominated; TCD = tidal-current-dominated.*

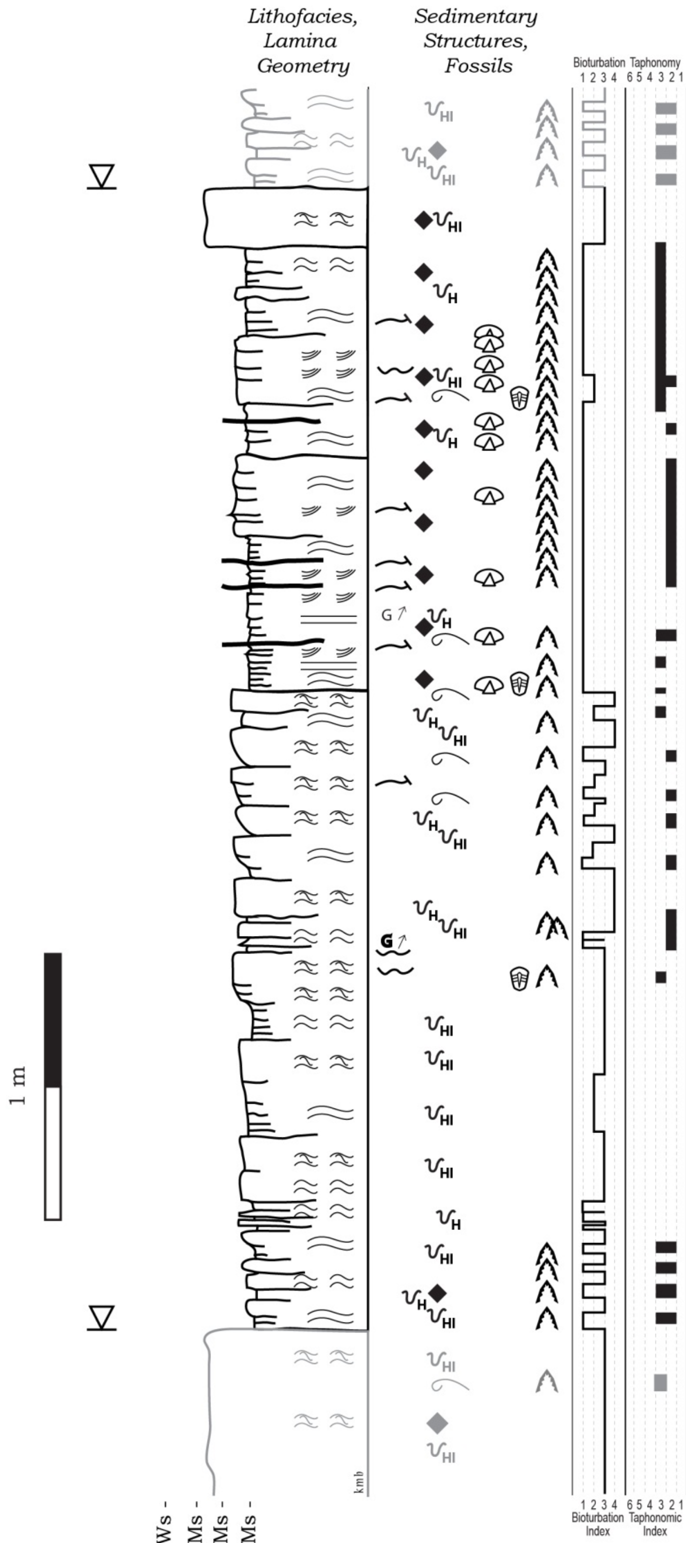
1. **DR Figure 2:** SWD: Pz, Llandoverian Sh, Poland
2. **DR Figure 3:** SWD: Pz, Marcellus Fm, Pennsylvania
3. **DR Figure 4:** SWD: Mz, Kimmeridge Clay Fm, England
4. **DR Figure 5:** SWD: Mz, Haynesville Fm, east Texas
5. **DR Figure 6:** SWD: Mz, Eagle Ford Fm, south Texas
6. **DR Figure 7:** SWD: Cz, Clayton Fm, Alabama
7. **DR Figure 8:** RFD: Pz, Hamilton Group, east Kentucky
8. **DR Figure 9:** RFD: Mz, Mesa Verde Group, Colorado
9. **DR Figure 10:** RFD: Cz, Fleming Group, south Louisiana
10. **DR Figure 11:** TCD: Mz, Curtis Fm, Utah
11. **DR Figure 12:** TCD: Cz, Miri Fm, Borneo
12. **DR Figure 13:** Legend for symbols used in graphic summary descriptions.

Supplemental information about statistical approach*:* To quantify the number of parasequence types, data were gathered into an *RC* contingency table of *R* independent populations/cases (that each represents one stratal unit/parasequence) and *C* categories of sedimentary structures or attributes. In this table, each row was viewed as independently sampled from a mixture model with an unknown number of components (cf. Quintana and Silva, 2006; Dasgupta and Raftery, 1998). This array could then be subjected to a variety of cluster-analysis algorithms, including multinomial sampling and first-order Markov chain analysis as well as standard tests for comparing discrete distributions (Pearson's Chi-Squared, etc.). This approach goes beyond the standard tests (that yield yes-no answers) by identifying clusters *a priori* and measuring the degree of difference among distributions.

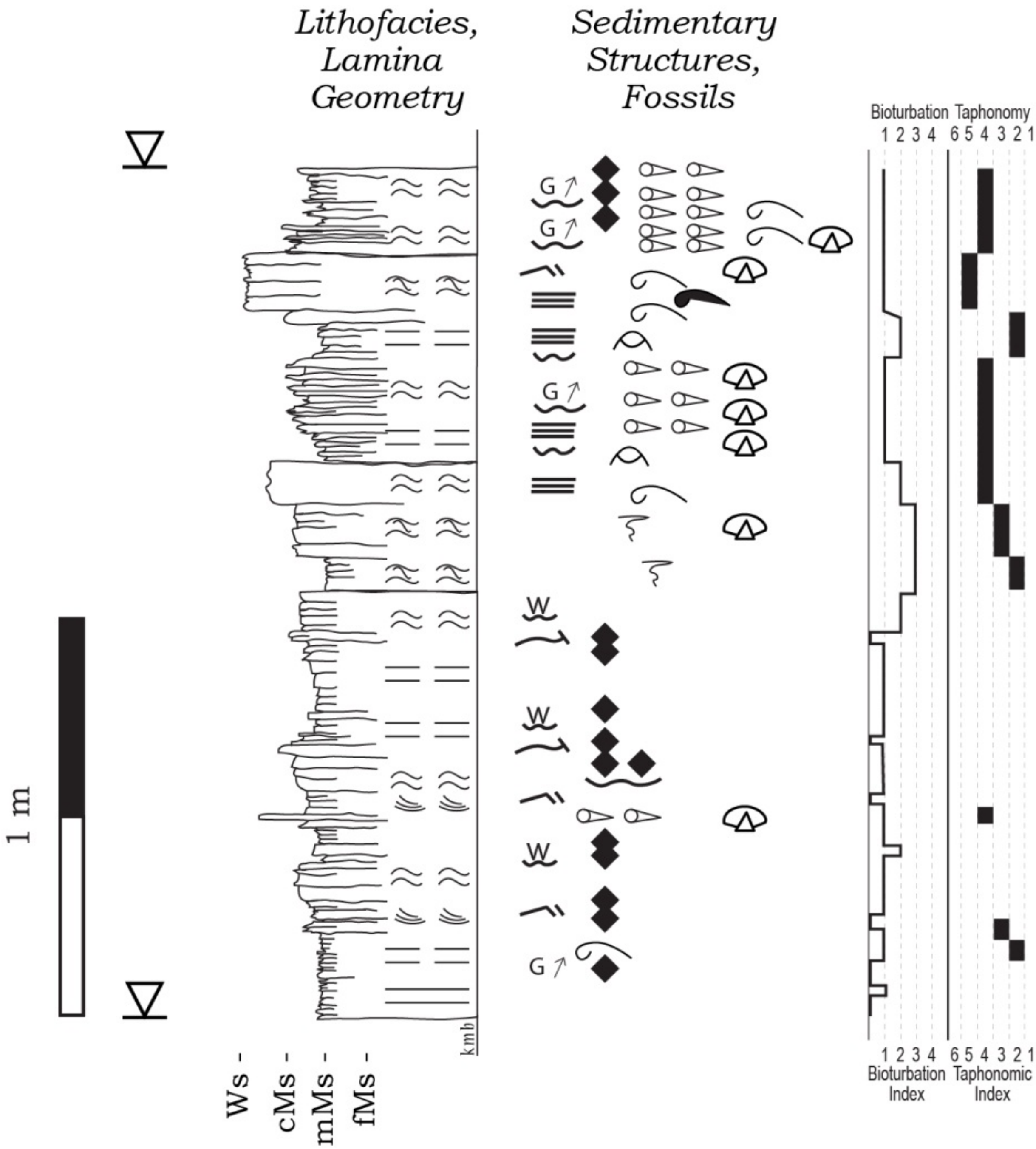
References:

Dasgupta, A., Raftery, A.E., 1998, Detecting features in spatial point processes with clutter via model-based clustering. Journal of the American Statistical Association, v. 93, p. 294-302.

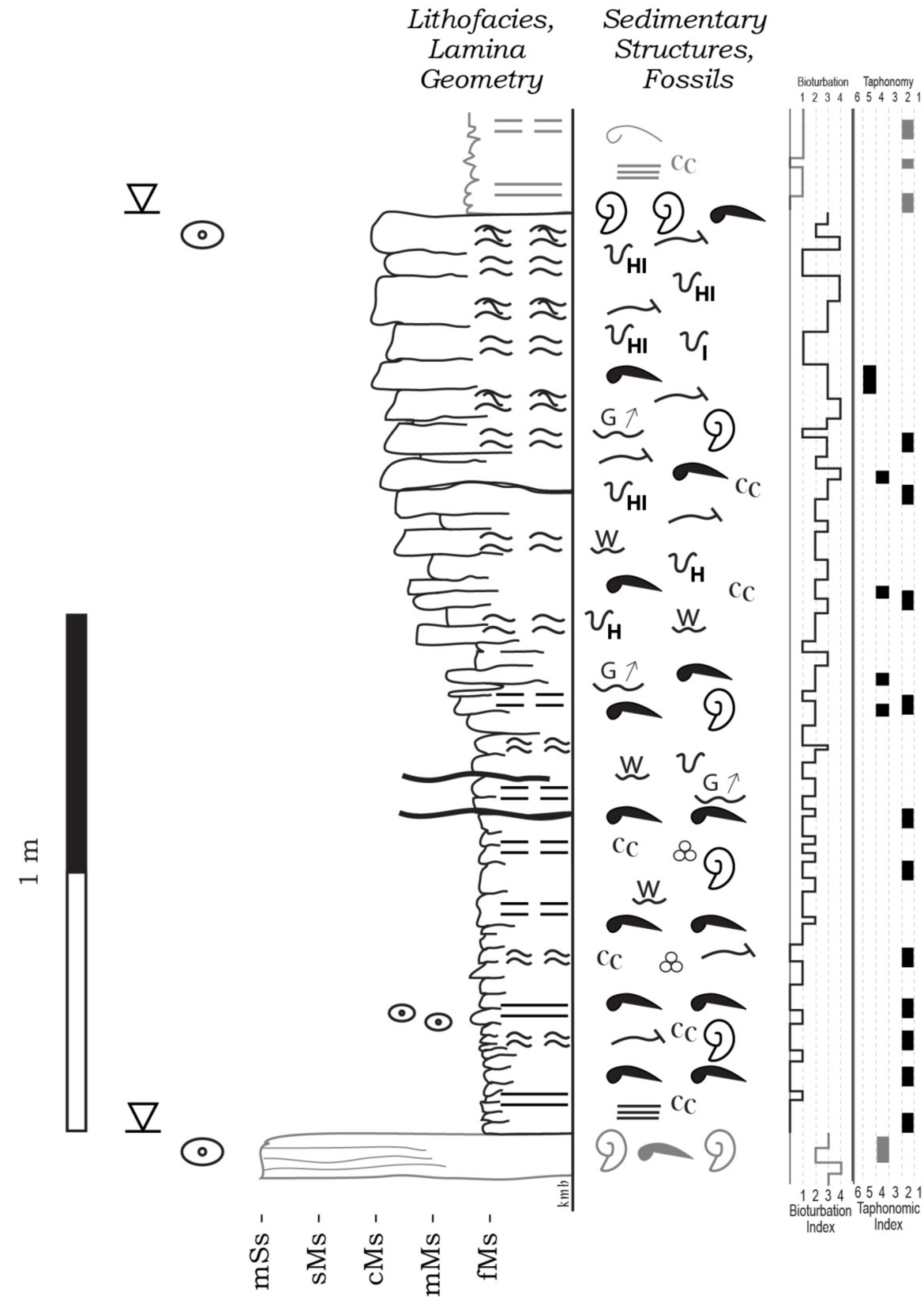
Quintana, F.A., Silva, A., 2006, Testing for differences among discrete distributions: an application of model-based clustering. Brazilian Journal of Probability Statistics v.20, p. 141-152.



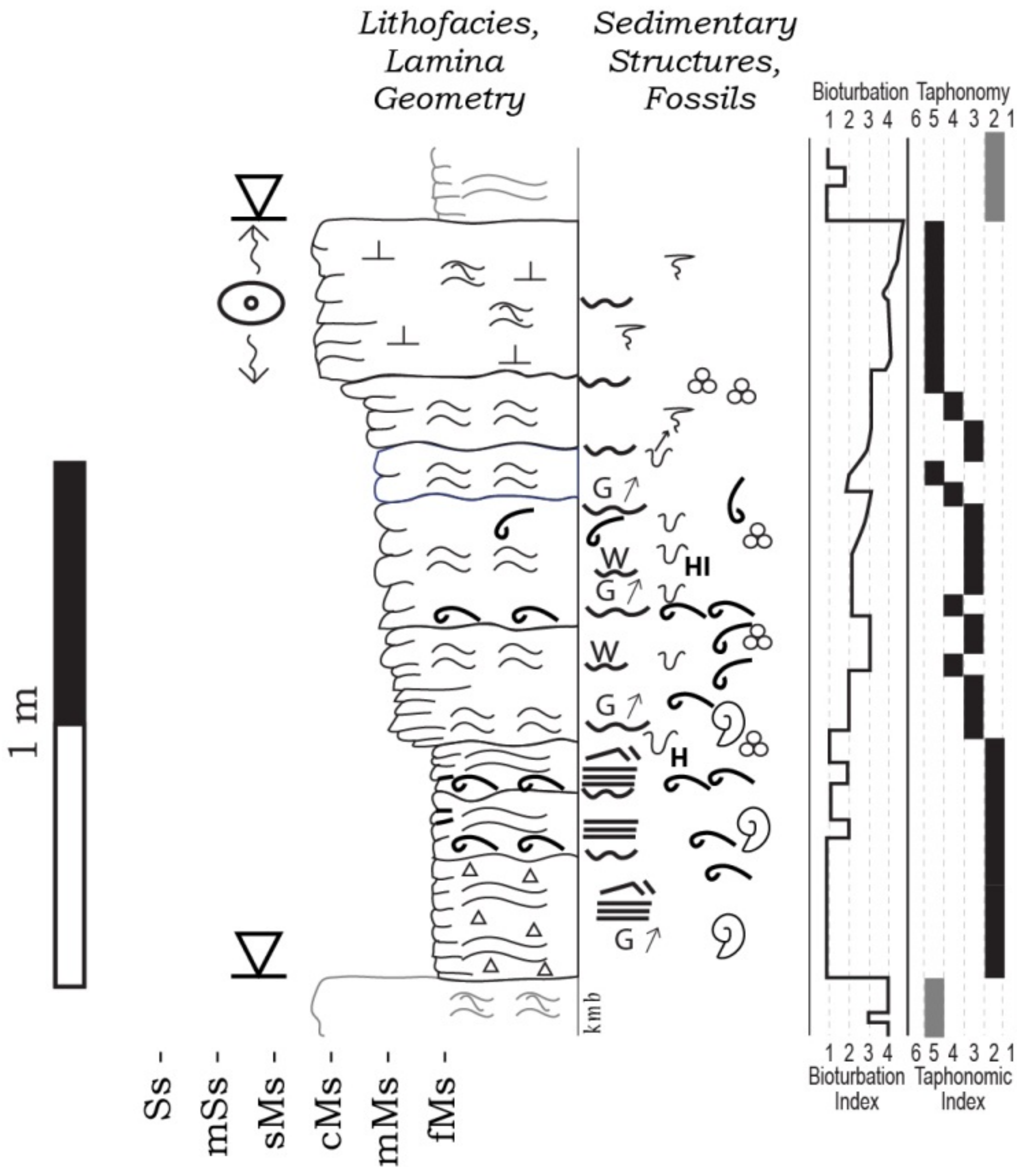
DR Figure 2: Summary of detailed description of a representative storm-wave-dominated parasequence from the Paleozoic Llandoverian Shale (Llandoverian), Podlasie basin, Poland, based on conventional cores.



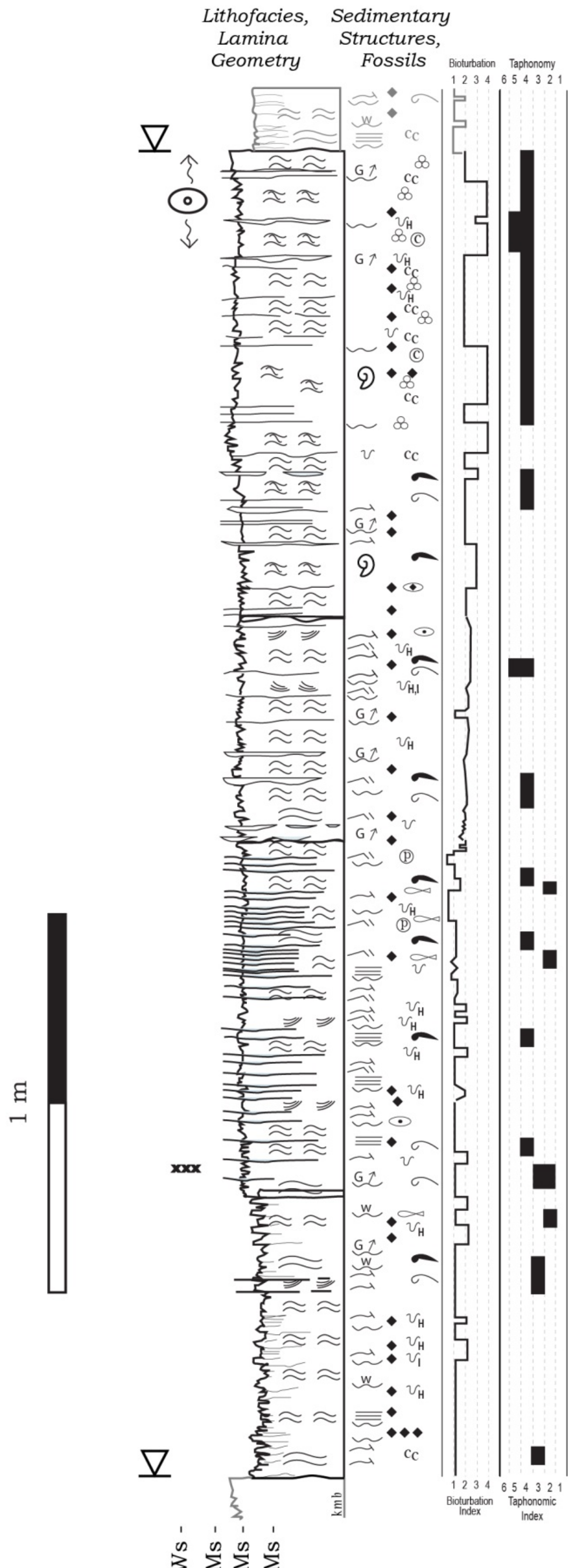
DR Figure 3: Summary of detailed description of a representative storm-wave-dominated parasequence from the Paleozoic Marcellus Formation (Givetian), Pennsylvania, Appalachian basin, based on conventional cores.



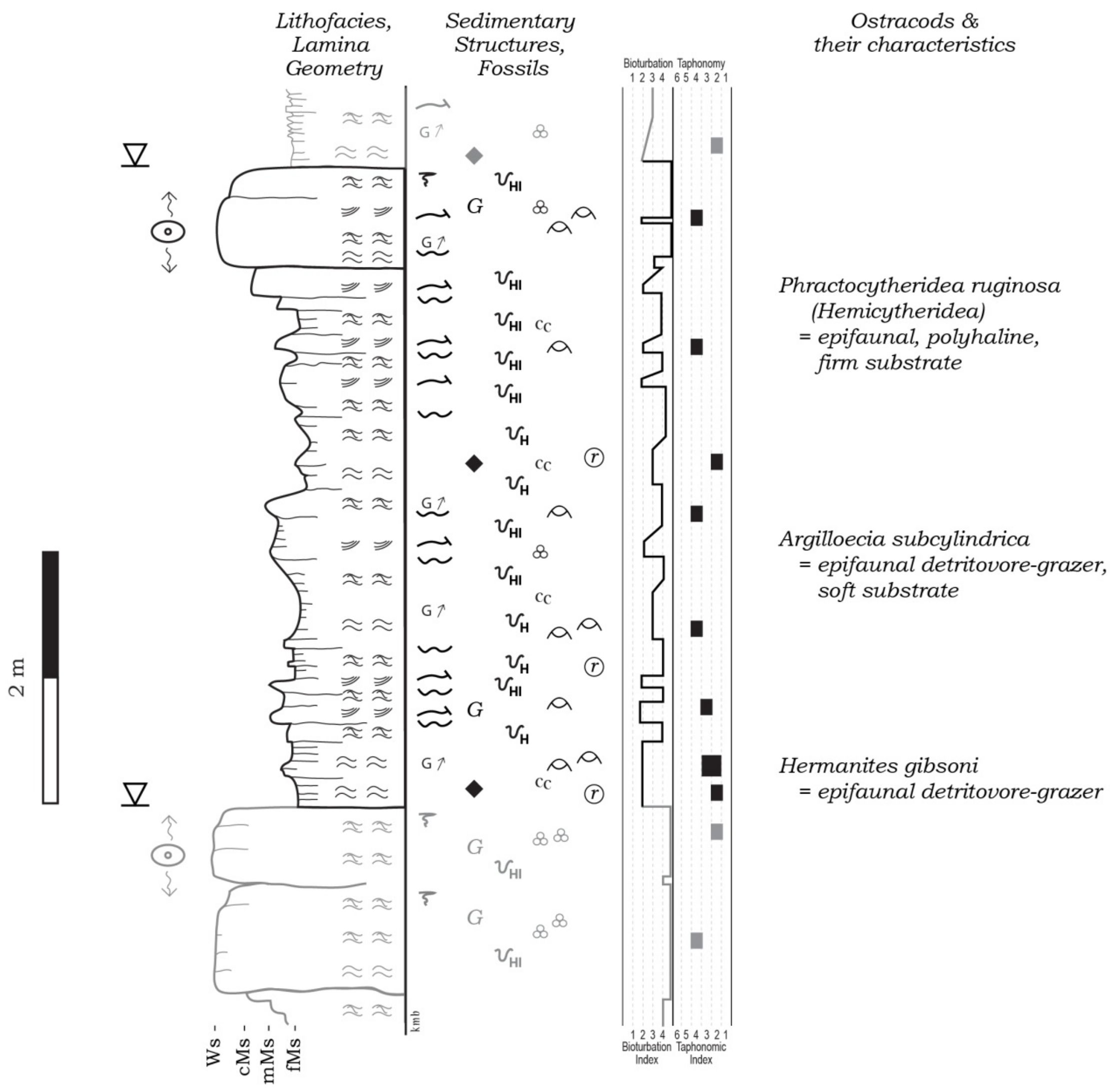
DR Figure 4: Summary of detailed description of a representative storm-wave-dominated parasequence from the Mesozoic Kimmeridge Clay Formation (Kimmeridgian), Wessex basin, based on outcrop observations.



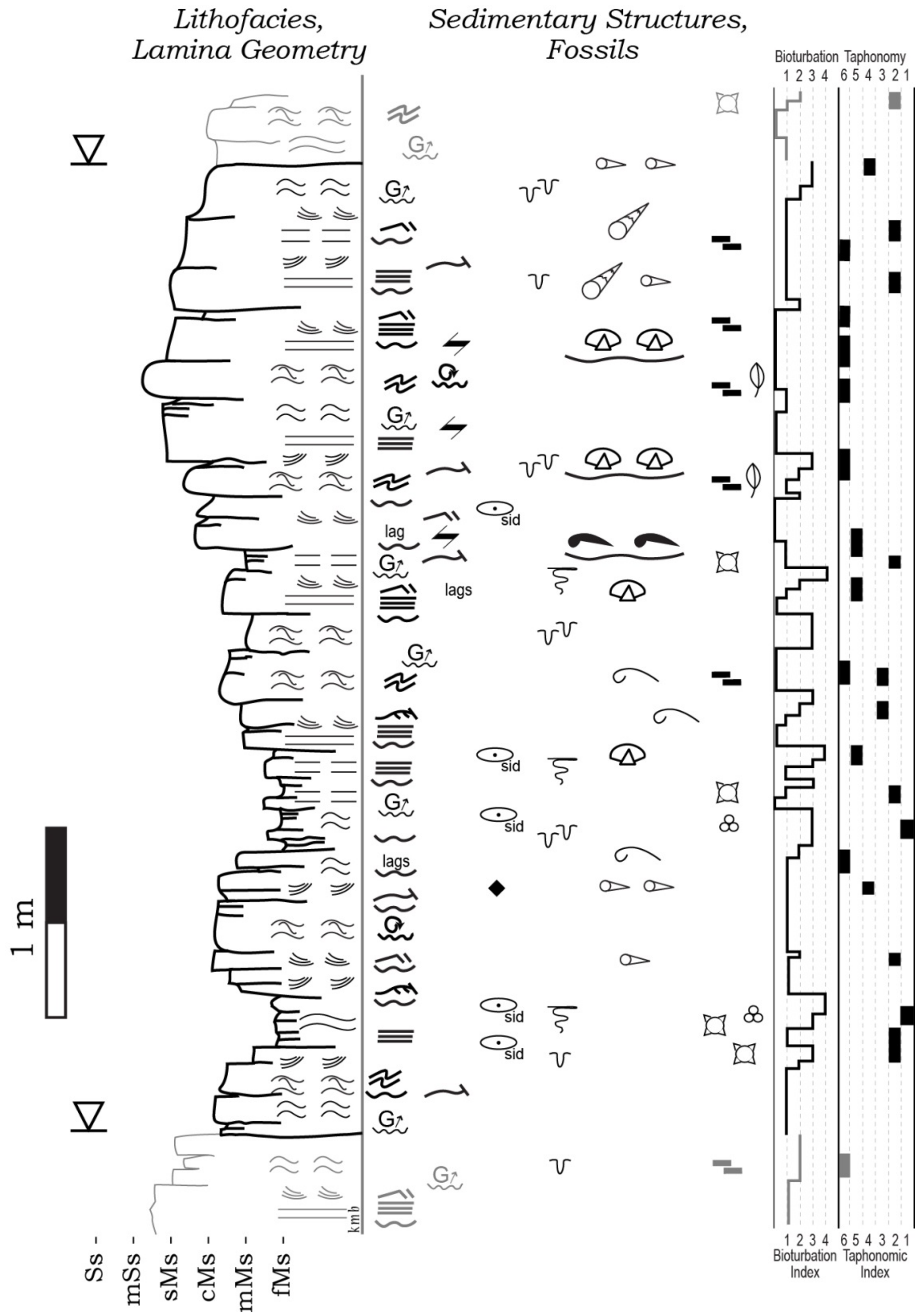
DR Figure 5: Summary of detailed description of a representative storm-wave-dominated parasequence from the Mesozoic Haynesville Formation (Kimmeridgian), east Texas basin, based on conventional cores.



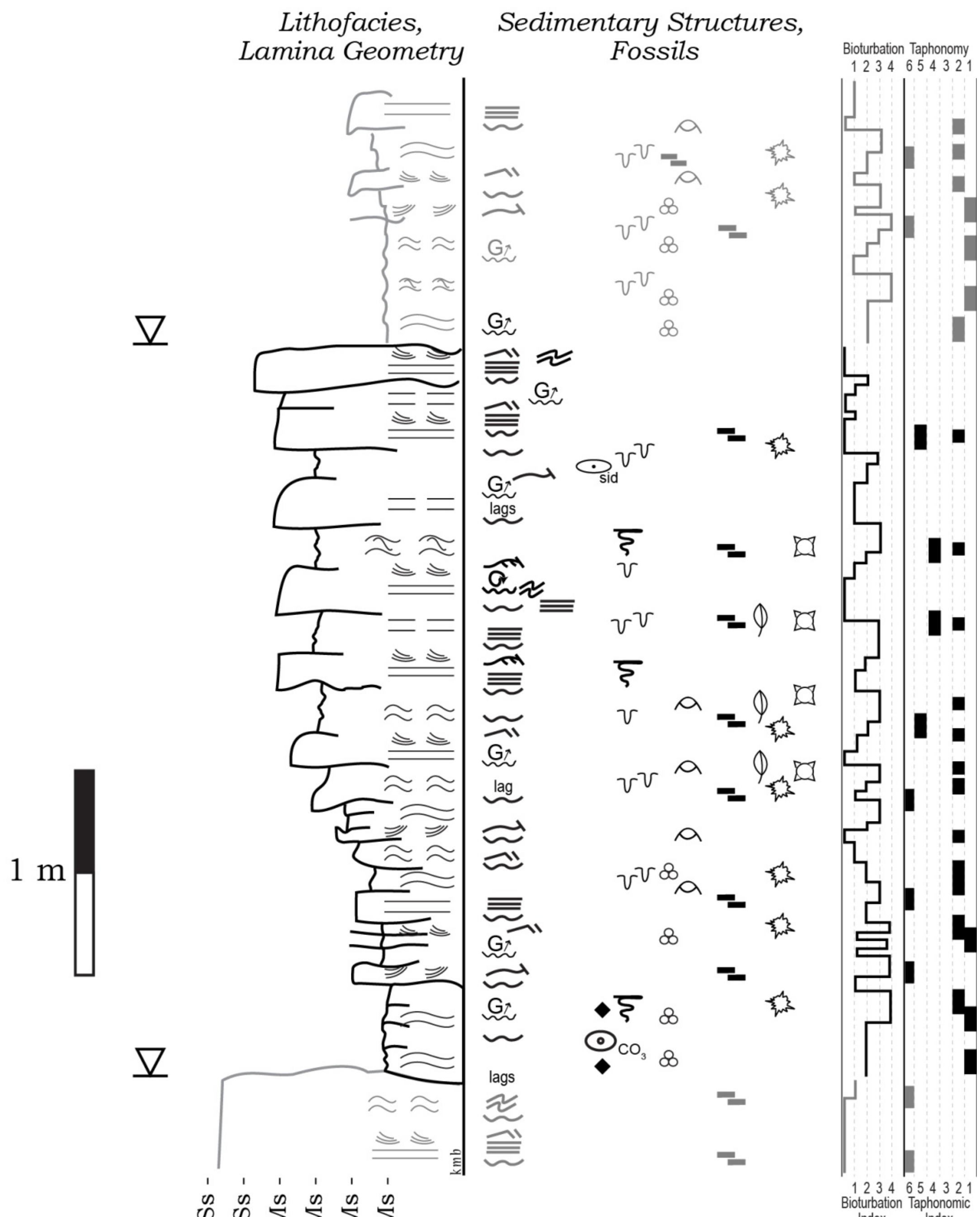
DR Figure 6: Summary of detailed description of a representative storm-wave-dominated parasequence from the Mesozoic Eagle Ford Formation (Cenomanian), south Texas basin, based on conventional core.



DR Figure 7: Summary of detailed description of a representative storm-wave-dominated parasequence from the Cenozoic Clayton Formation (Danian), Alabama, based on outcrop observations. Ostracods identified using Smith, 1978, Ostracoda of the Prairie Bluff Chalk, Upper Cretaceous, (Maestrichtian) and the Pine Barren member of the Clayton Formation, Lower Paleocene (Danian) from exposures along Alabama State Highway 263 in Lowdnes County, Alabama. Transactions--GCAGS vol. 28, p. 539-579.

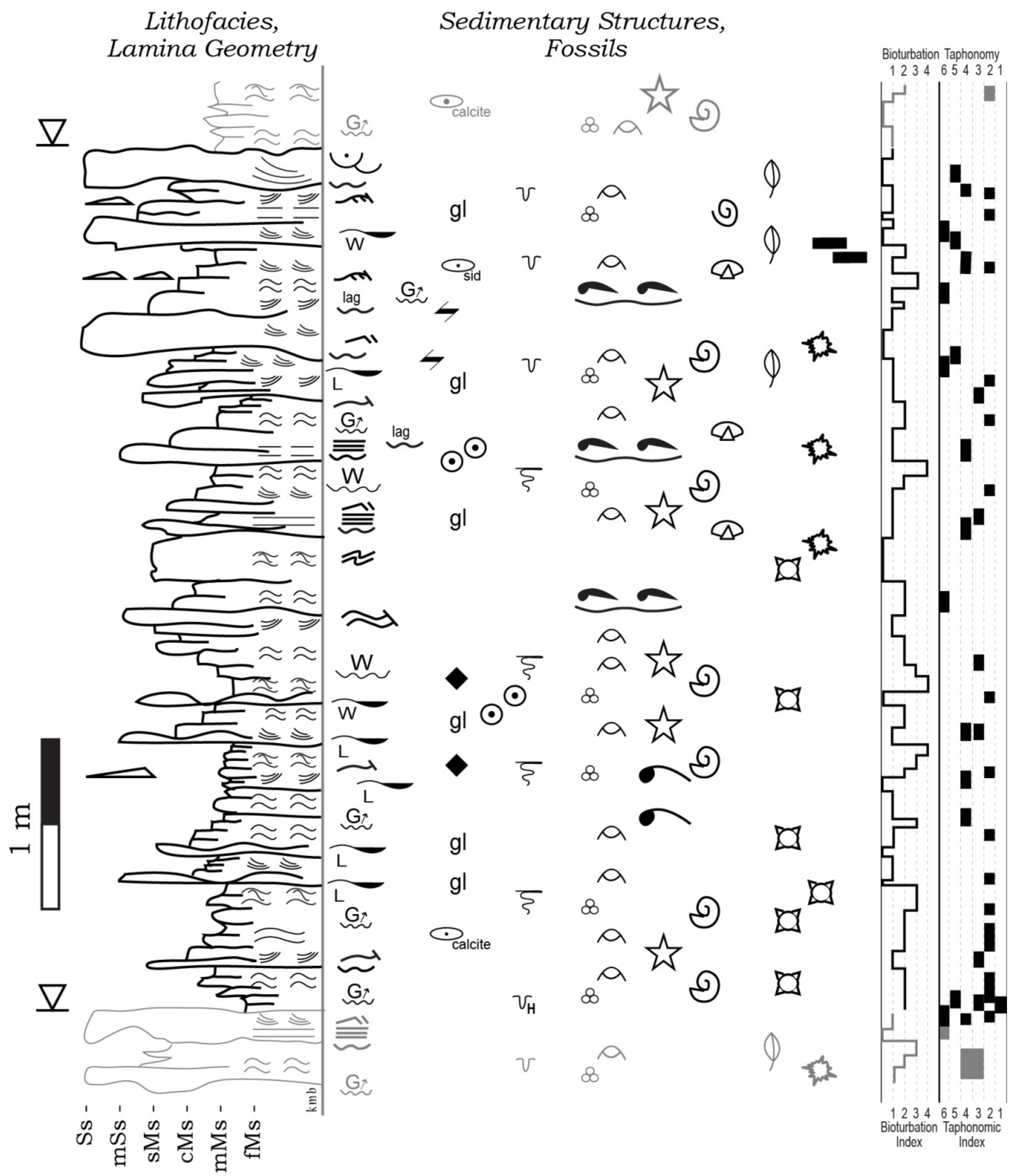


DR Figure 8: Summary of detailed description of a representative river-flood-dominated parasequence from the Paleozoic Hamilton Group (Mississippian), eastern Kentucky, based on conventional core.

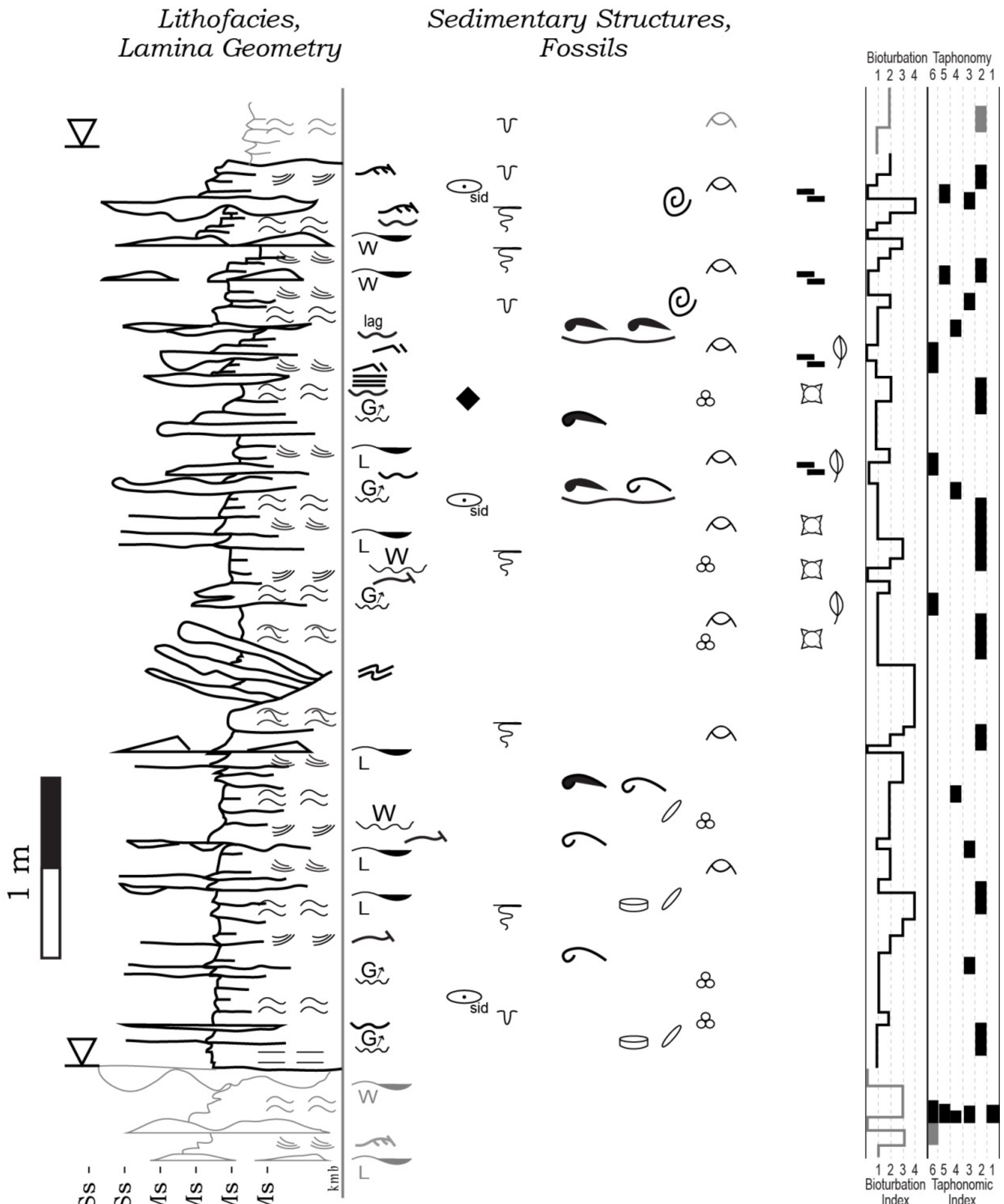


DR Figure 9: Summary of detailed description of a representative river-flood-dominated parasequence from the Mesozoic Mesa Verde Group (Campanian), Colorado, based on outcrop observations.

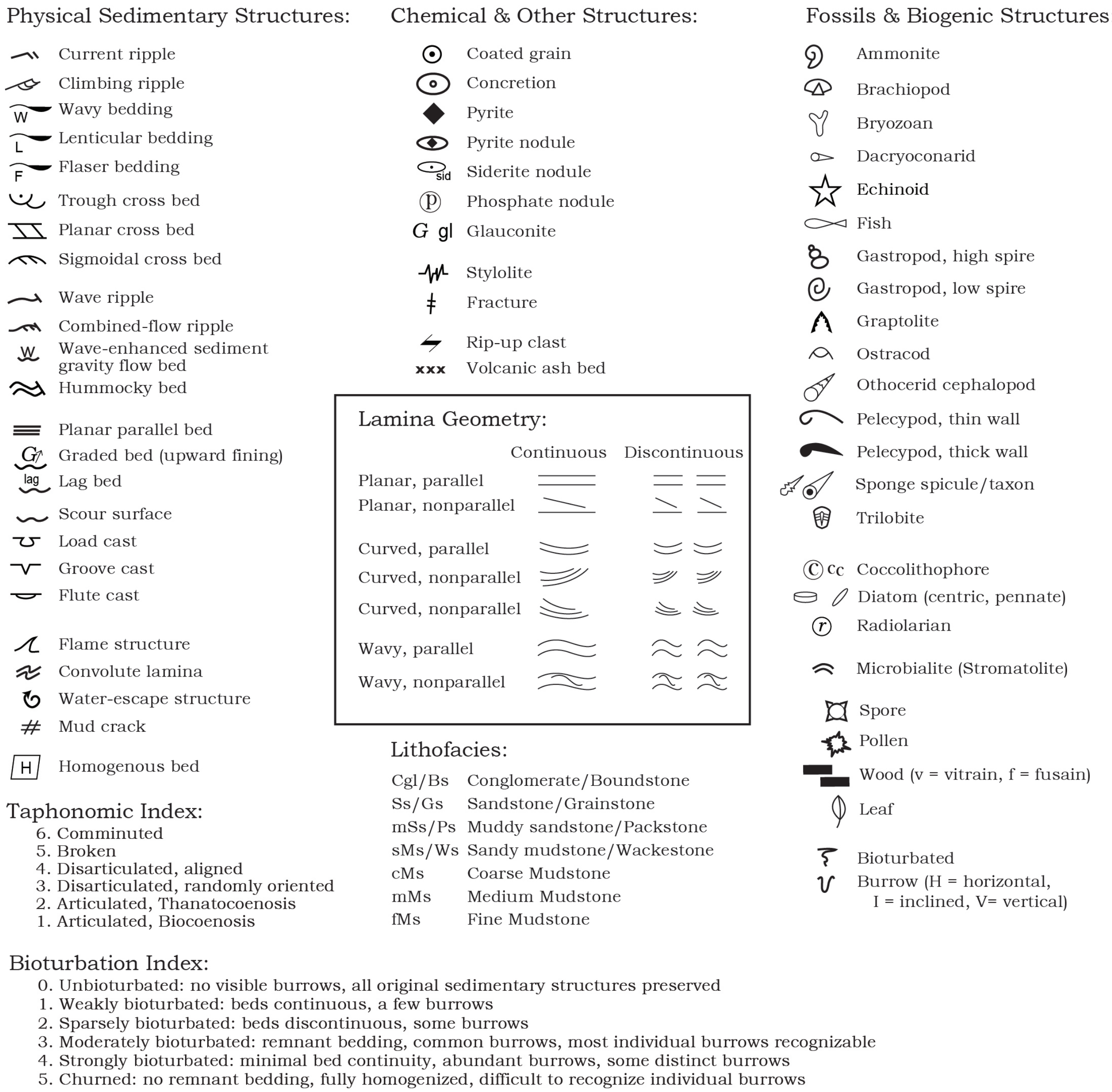
DR Figure 10: Summary of detailed description of a representative river-flood-dominated parasequence from the Cenozoic Fleming Group (Miocene), south Louisiana, based on conventional core.



DR Figure 11: Summary of detailed description of a representative tidal-current-dominated parasequence from the Mesozoic Curtis Formation (Oxfordian), Utah, based on outcrop observations.



DR Figure 12: Summary of detailed description of a representative tidal-current-dominated parasequence from the Cenozoic Miri Formation (Miocene), Borneo, based on outcrop observations.



DR Figure 13: Legend for symbols used in graphic summary descriptions in DR-Figures 3 to 12, and in text Figures 1 and 2.

Eagle Ford Sh			Well A															Well B				
Storm Wave dominated		Thickness (ft):	11	14.5	15.5	10.2	17	5	13.6	11	6	11.5	19.2	10.3	11.9	16.1	13.4	17.8	17.1	9.3	3.3	7.1
			P'seq 1	P'seq 2	Pseq 3	Pseq 4	Pseq 5	Pseq 6	Pseq 7	Pseq 8	Pseq 9	Pseq 10	Pseq 11	Pseq 12	Pseq 13	Pseq 14	Pseq 15	Pseq1	Pseq 2	Pseq 3	Pseq 4	Pseq 5
	Eagle Ford Summary																					
	Normalized	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*
Scour (only)	12.50	143	3	4	4	3	13	1	4	14	0	6	11	7	6	5	8	17	14	12	5	6
Planar bed	2.88	33	1	2	2	0	2	0	0	1	11	4	5	1	4	0	0	0	0	0	0	0
Current Ripple	5.24	60	0	0	4	2	5	0	4	4	0	9	0	2	11	8	6	3	0	1	0	1
Graded bed	7.34	84	0	1	5	5	2	0	4	0	12	7	12	5	7	12	0	2	0	7	2	1
Wave Ripple	37.06	424	8	21	19	5	33	7	25	2	1	10	33	17	13	26	25	57	52	27	16	27
Combined-flow Ripple	1.75	20	0	0	3	1	0	0	0	1	6	3	0	0	0	2	1	1	1	1	0	0
WESGF bed*	25.44	291	7	15	22	0	22	6	32	27	5	0	11	7	11	14	22	28	19	23	3	17
Lags	3.06	35	3	0	2	0	2	0	0	1	3	2	3	1	2	5	0	4	6	1	0	0
Turbidite	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gutter cast	0.70	8	1	1	0	0	1	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0
Hummock	0.17	2	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Water Escape	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Convolute	0.52	6	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0
Flaser/Wavy/Lenticular bed	3.32	38	1	0	1	1	2	0	0	6	0	0	0	0	0	0	8	3	9	7	0	0
Bioturbated		182	10	14	26	12	11	6	7	10	0	14	24	11	15	17	5	7	32	0	2	3
without 'Bioturbated'; n =	100	1144	24	44	64	17	83	14	69	58	40	44	76	51	54	72	70	116	102	79	26	52

Cleveland Ironstone Avicula-Raisdale interval			Outcrop A			
Storm Wave dominated		Thickness (ft):	3.3	3.3	3.3	2.95
			P'seq 1	P'seq 2	P'seq 3	P'seq 4
	Cleveland Ironstone Summary					
	Normalized	*Counts*	*Counts*	*Counts*	*Counts*	*Counts*
Scour (only)	9.24	23	7	5	6	5
Planar bed	1.20	3	1	1	0	1
Current Ripple	1.61	4	1	1	1	1
Graded bed	14.86	37	10	11	9	7
Wave Ripple	43.37	108	39	27	24	18
Combined-flow Ripple	3.61	9	2	2	1	4
WESGF bed*	17.67	44	14	14	10	6
Lags	1.20	3	0	1	0	2
Turbidite	0.00	0	0	0	0	0
Gutter cast	2.01	5	1	1	1	2
Hummock	1.61	4	1	1	1	1
Water Escape	0.00	0	0	0	0	0
Convolute	1.61	4	1	1	1	1
Flaser/Wavy/Lenticular bed	2.01	5	2	0	1	2
Bioturbated		85	27	23	19	16
without 'Bioturbated'; n =	100	249	79	65	55	50

**WESGF = wave-enhanced sediment gravity flow; MacQuaker et al., 2010*

P'seq = parasequence

NOTE: Normalized statistics were calculated without 'Bioturbated' category, to highlight preserved sedimentary structures

DR Table 2: Representative examples of frequency distribution of sedimentary structures and statistics from coeval cored intervals of the Eagle Ford Shale in two wells, Cenomanian-Turonian, Texas, and from outcrops of the Cleveland Ironstone, Jurassic, Yorkshire, UK. Macquaker, J.H.S., Bentley, S.J., and Bohacs, K.M., 2010, Wave-enhanced sediment-gravity flows and mud dispersal across continental shelves: Reappraising sediment transport processes operating in ancient mudstone successions: Geology, v. 38, p. 947–950, doi:10.1130/G31093.1.

DR Table 3: Data shown in Figure 2 histograms.

	Normalized Percentage		
	Storm Wave	River Flood	Tidal Current
Scour	**12.5285**	**25.3968**	**16.6667**
Planar bed	**2.8474**	**11.1111**	**6.2500**
Current Ripple	**5.6948**	**12.6984**	**10.4167**
Graded bed	**7.9727**	**9.5238**	**10.4167**
Wave Ripple	**35.3075**	**6.3492**	**10.4167**
Combined-flow Ripple	**1.8223**	**1.5873**	**6.2500**
WESGF bed	**25.0569**	**0.0085**	**4.1667**
Lags	**3.4169**	**4.7619**	**4.1667**
Turbidite	**0.0072**	**15.8730**	**4.1667**
Gutter cast	**1.1390**	**0.0042**	**0.0018**
Hummock	**0.2278**	**0.0055**	**0.0088**
Water Escape	**0.0095**	**3.1746**	**0.0079**
Convolute	**0.5695**	**6.3492**	**2.0833**
Flaser/Wavy/Lenticular bed	**3.4169**	**3.1746**	**25.0042**