Special Paper 306

Chapter 7

Sequence Stratigraphy of an Apparently Noncyclic Carbonate Succession: Recognizing Subaerial Exposure in a Largely Subtidal, Middle Ordovician Stratigraphic Sequence in Eastern Tennessee

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Table 1 Facies Criteria

	Carbonate Lithologic Criteria						Biotic Criteria						Other Criteria	
Lithology/Micro-facies*	Rock Name Dunham (1962)	Matrix	Peloids	Aggregate Grains	Coated Grains	Sedimentary Structures	Organisms Primary	Organisms Accessory	Biota Diversity	Biota Abundance	Flora	Whole Fossils vs. Fragments	Lateral and Vertical Facies Relations	Comments
A / 8	Wackestone	Mud	Rare	Rare	Rare	Fenestrae; horizontal cavities; keystone vugs, rare	Pelmatozoa, arborescent bryozoa	Rare	Low	Low to moderate	Green algae, rare	Whole fossils	Gradational with facies 9, 10g, 12p, 12g (rarely), 16, 17, and 19.	Preserved infauna and epifauna and vertical burrows.
B / 9	Bioclastic Wackestone/ Packstone	Mud	Rare	Rare	Rare	Bioturbated sediment; Domate algal laminae, rare	Pelmatozoa, bryozoans	Thick-shelled trilobites, sponge spicules	Moderate	Moderate to low	Green algae rare, red algae less common	Whole bryozoans, other fossils as fragments	Gradational with facies 8, 10g, 12p, 12g, 16, 17, 19, 22, shale and siltstone.	Occurs as beds 0.5 to 2 m thick with thin, interfingering grainstone beds, < 0.5 m thick.
C / 10g	Grainstone/ Cortoid Grainstone	Spar with small amounts of mud	Rare	Rare	Very abundant to abundant, most are partially coated	?Megaripples	Pelmatozoa	Gastropods, thick-shelled trilobites, articulate brachiopods	Moderate to high	Moderate to high, Girvanella Oncolites Common	Green algae abundant to rare, red algae rare	Fragments rounded and worn	Gradational with facies 8, 9, 11, 12g, 12p, 13, 16 and 22.	Generally thick bedd-ed, 1+ m thick. Grains more worn, fewer coated grains than facies 11
D / 11	Grainstone/ Cortoid Grainstone	Spar with small amounts of mud	Rare	Abundant oncoids common	Very abundant to abundant, most are partially coated	Not observed	Pelmatozoa, encrusting bryozoa	Gastropods, thick-shelled trilobites, articulate brachiopods	High	Moderate to high	Green algae rare, red algae less common	Fragments	Gradational with facies 10g, 12g and 16.	No worn grains. Coated grains well developed, oncoids common.
E / 12g	Echinoderm Grainstone	Spar	Rare	Rare	Rare	Megaripples	Pelmatozoa, bryozoa	Thick-shelled trilobites	Moderate	High	Green algae abundant to sometimes absent. Red algae less common	Fragments	Gradational with facies 9, 10g, 11, 12p, 13, 17, 18 and 19 (rarely).	Generally occurs as amalgamated beds, 1 to 2 m thick.
F / 12p	Echinoderm/ Bryozoan Packstone	Mud and lesser amounts of spar	Rare	Rare	Rare	?Flaser bedding; keystone vugs; flat algal laminae, rare	Pelmatozoa, bryozoa	Thick-shelled trilobites	Moderate	High	Green algae abundant to sometimes absent. Red algae less common	Fragments very abundant, some fossils whole	Gradational with facies 8, 9, 10g, 12g, 13, 16, 17, 19 and 22.	Generally thick bedded, one or more meters thick.
G / 13	Oncoid Grainstone	Spar, mud is rare	Rare	Rare to present	Very abundant to abundant, oncoids well developed	?Megaripples; organic bands; flat algal laminae, rare	Thick-shelled trilobites, gastropods	Pelmatozoa, articulate brachiopods	High	Low to moderate	Green algae abundant to rare, red algae rare	Fragments	Gradational with facies 10g, 11, 12g, 12p, 16, 17, 19, and 22.	No worn grains, oncoids better developed than facies 10 and 11.

Lithology	Carbonate Lithologic Criteria						Biotic Criteria						Other Criteria	
H / 14	Grainstone, Conglomeratic lag	Spar	Rare	Rare	Partially coated grains	Not observed	Pelmatozoa, bryozoa, thick-shelled trilobites	Rare	Low	Low	Green algae abundant, red algae present	Fragments reworked	Gradational with facies 9, 10g, 21, and 22.	Very rare lithology, few thin beds, < 1 m thick. Blackened and phos-phate coated grains abundant.
I / 16	Peloidal Grainstone	Spar, small amounts of mud	Very abundant	Rare to abundant	Rare to common, generally partially coated	Rare ?megaripples, ?flaser bedding	Ostracodes	Rare, sometimes with gastropods	Low	Low to moderate	Green algae rare to common, red algae less common	Whole ostracodes, other fossils as fragments	Gradational with facies 9, 10g, 11, 12g, 12p, 17, 18, 19, 19l, 19f shale, and siltstone.	Occurs as amalgamated beds, 0.5 to 2 m thick. Superfical ooids present.
J / 17	Grainstone/ Peloidal Grainstone	Spar, mud is rare	Very abundant to common	Very abundant	Rare to common, generally partially coated	Rare	Ostracodes, sometimes with gastropods	Pelmatozoa, articulated brachio-pods, thick-shelled trilobites	Low	High to moderate	Green algae rare to common, red algae less common	Whole ostracodes, other fossils as fragments	Gradational with facies 8, 9, 10g, 11, 12g, 12p, 19, and 22.	Superfical ooids pre-sent, prob-lematic algae Nuia common to abundant.
K / 18	Dasycladacean Grainstone	Spar	Rare	Present	Abun-dant to present, generally one-sided	?Megaripples, Intraclasts present in some beds	Dominated by green algae	Pelmatozoa, thick-shelled trilobites	Low	Low organism abun-dance	Green algae very abundant. Red algae abundant to present.	Whole fossil algae, other fossils as fragments.	Gradational with facies 11, 12g, 12p and 16.	Rare lithology, only a few beds, about 1 m thick.
L / 19	Wackestone/ Mudstone	Mud	Very abundant to common	Rare to common	Present	Fenestrae present, but not abundant, organic bands present	Ostracodes gastropods, encrusting bryozoans	Rare or absent	Low	Low	Green algae rare, red algae absent	Whole ostracodes, other fossils as fragments	Gradational with Facies 8, 9, 11, 12p, 16, 17, 19l, 19f and 22.	Generally occurs as masive, discontinous beds, < 0.5m thick.
L / 19l	Laminated Wackestone/ Mudstone	Mud	Abundant to common	Rare	Rare	Flat algal laminae, fenestrae present, but not abundant	Ostracodes gastropods	Rare or absent	Low	Low	Green algae rare, red algae absent	Whole ostracodes, other fossils as fragments	Gradational with facies 19, 19f, 16 and 17.	Laminated beds < 0.5m thick.
L / 19F	Fenestral Wackestone/ Mudstone	Mud	Abundant to common	Rare to present	Present	Fenestrae, horizonatal cavities, flat algal laminae	Ostracodes	Rare or absent	Low	Low	Green algae rare, red algae present	Whole ostracodes, other fossils as fragments	Gradational with facies 19, 19l, 16 and 17.	Bedded as facies 19 (above).
M / 21	Spongiostrome Mudstone	Mud	Abundant	Common	Partial algal oncoids	Flat algal laminae	Encrusting bryozoans, pelmato-zoans	?Ostacodes	Low	Low	Spongio-stroma	Bryozoans whole, pelmato-zoans as fragments	Gradational with facies 14, 16, 17.	Very rare lithology, one 0.5m bed, ob-served base Rockdell Fm. OTH section,

Lithology	Carbonate Lithologic Criteria						Biotic Criteria						Other Criteria	
N / 22	Wackestone/ Packstone- Oncoid Wackestone Packstone	Mud	Abundant to common	Common to abundant	Very abundant to abun-dant, generally one-sided	?Flaser bedding	Thick-shelled trilobites	Gastropods	Low	Low	Girvanella oncoids common, green algae abundant, red algae less common	Fragments	Gradational with facies 9, 10g, 11, 16, and 17.	Girvanella oncolites common. Problematic algae Nuia abundant.
O / 24	Lithoclastic Grainstone/ Packstone	Spar and mud	Abundant	Abundant to common	Not observed	Not observed, but Intra-clasts abundant in some beds	?Ostracodes	Not observed	Low	Low	Not observed	Fragments	Gradational with 16, 19, and dolomitic limestone.	Rare lith-ology, only one, 1m thick bed near Knox unconformity
P Not Numbered	Dolostone/ Dolomitic Limestone	Fine-grained dolomite and mud	Rare	Not observed	Not observed	Laminae	Rare fragments only	Not observed	Low	Low	?Stromato-lites	Fragments	Gradational with facies 16, 17, 19 and 24.	Rare lithology.
Q Not Num-bered	Siltstone/ Carbonate Siltstone	N/A	Not observed	Not observed	Not observed	Vertical burrows	Brachio-pods occur in carbonate rich intervals	Not observed	Low	Low	Not observed	Brachio-pods occur as whole fossils	Gradational with facies 9, 16, 17, 12p and 19.	Rare lithology (Benbolt and Bowen Fms. only).
R Not Num-bered	Shale/Shaly Carbonate	N/A	Not observed	Not observed	Not observed	?Bioturbated sediment	Not observed		Low	Low	Not observed	Not observed	Gradational with facies 9, 12p, 16 and 17.	Occurs in upper Benbolt and overlying formations.
S Not Num-bered	Bentonite	Green clay	Not observed	Not observed	Not observed	?Bioturbated sediment	Not observed	Not observed	N/A	N/A	Not observed	N/A	Gradational with facies 9, 16, 17, 12p, and 12g.	Thin beds throughout Middle Ordovician.

Key

Very Abundant - Constituent comprises more than 50% of the allochems.
Abundant - More than three counts per thin-section observed in all thin-sections representative of facies.
Common - At least 1 to 3 counts per thin-section observed in all thin-sections representative of facies.
rare - One to three counts per thin-section observed in many, but not all thin-sections representative of facies.
present - Seen in about 1/4 to 1/2 of thin-sections representative of facies.

Diversity

High >>3 classes of organisms High
Moderate 2 to 3 Classes
Low <3 Classes

Abundance

>30% Allochems
>30% Fossils
Moderate >30% Allochems
<30% Fossils
Low <30% Allochems
or
<20% Fossils

*Microfacies numbers generally correspond to standard microfacies of Wilson (1975); however, some microfacies are modified (i.e., 10g, 12g, 12p, 19l and 19f) to account for criteria characteristic of Middle Ordovician limestones, but not generally observed in younger rocks.