

Ichnological and Sedimentological Criteria for Differentiating Brackish-Water Bay-Head Deltas and Fully Marine Open-Coast Deltas*

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Abstract

Differentiating embayment-bound bay-head delta successions and open-coast delta complexes is essential for accurate paleoenvironmental interpretations and paleogeographic reconstructions. Bay-head delta successions of the Lower Cretaceous Grand Rapids Formation are characterized by coarsening-upward heterolithic intervals with abundant fluid mud drapes, rare syneresis cracks, thin (<10cm) sandstones with micro-HCS, oscillation and current ripples, and normally graded, locally laminated-to-burrowed sandstone to siltstone beds. Bioturbation intensities range from BI 1-6. Trace fossil suites of bay-head delta successions are broadly consistent with existing brackish-water ichnological models: suites are of low diversity, contain diminutive ichnogenera, form depauperate marine ichnocoenoses, and are dominated by facies-crossing forms. Common ichnogenera include *Gyrolithes*, *Cylindrichnus*, *Lingulichnus*, *Skolithos*, *Planolites*, rare *Chondrites*, *Lockeia*, *navichnia*, and *fugichnia*.

Deltaic systems interpreted to have prograded into fully marine basins also comprise coarsening-upward successions with claystone drapes of fluid mud origin. Units show more abundant syneresis cracks and oscillation ripples, thicker HCS, and rare current ripples, trough cross-beds normally graded sandstone to siltstone beds, and carbonaceous laminae. Ichnogenera are more robust than brackish-water counterparts, and display increased diversity. Bioturbation intensities range from BI 0-5. Common ichnogenera include *Cylindrichnus*, *Skolithos*, *Planolites*, *Thalassinoides*, *Chondrites*, *Lockeia*, *Teichichnus*, *Asterosoma*, *Rosselia*, *Taenidium*, *Phycosiphon*, rare *Zoophycos*, *Gyrolithes*, *Phycosiphon*, *Rhizocorallium*, *navichnia*, and *fugichnia*. Notable is the sporadic presence of elements that are interpreted to record the activity of organisms deemed intolerant of physico-chemical stress.

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Introduction

- Purpose of study
- Stratigraphic setting and study area
- Review of brackish-water ichnology
- Facies descriptions of brackish-water bays
- Facies descriptions of bay-head deltas
- Conclusions and summary

Purpose of Study

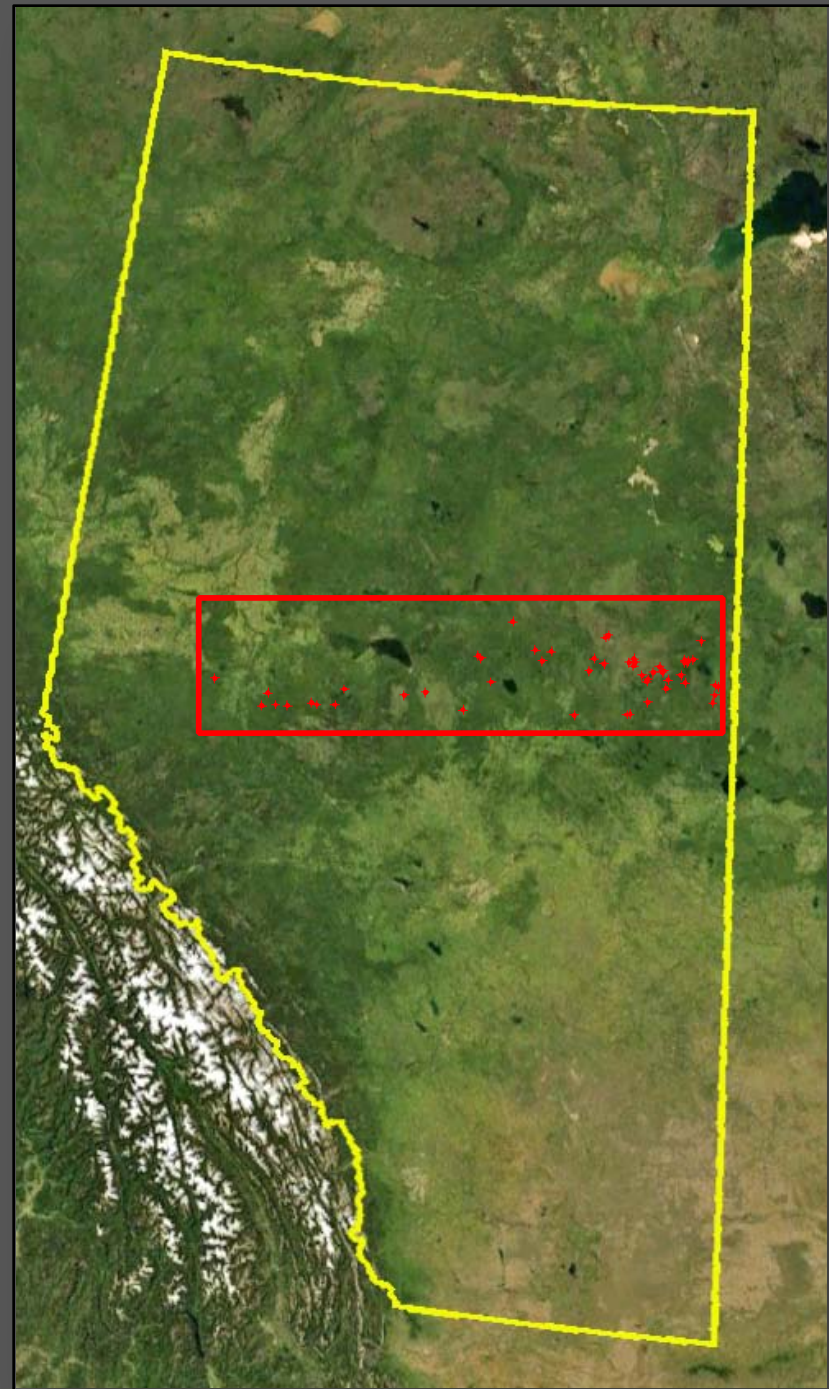
- Differentiate between deposits of bay-head/bay-margin deltas feeding into the brackish-water bays from deposits of deltas feeding into fully marine open-coastal basins
- Differentiate brackish bay deposits from bay-head delta deposits

Study Area

- Central Alberta
- Townships 59-69
- Ranges 1w4-25w5

Data set

- 56 cored intervals from the Grand Rapids Formation and Upper Mannville Group



Stratigraphy

		Northwest Plains Alberta				Central Plains Alberta				Northeast Plains Alberta			
Cretaceous	Cenomanian	91.0	Smoky Gp	Pouce Coupe		Kaskapau	Colorado Gp	Colorado Shale		La Biche Gp	Colorado Shale		
				Doe Creek									
				Dunvegan									
	Albian	97.5	Ft. St. John Gp	Shaftesbury	Fish Scale Zone			Fish Scale Zone			Fish Scale Zone		
				Peace River	Paddy		Westgate			Westgate			
					Cadotte		Viking			Viking / Pelican			
					Harmon		Basal Colorado		Joli Fou		Joli Fou		
				Spirit River	Notikewin								
					Falher								
	Wilrich												
Aptian	113	Bullhead Gp	Bluesky		Mannville Gp	Upper	Upper Mannville		Mannville Gp	Grand Rapids	Colony McLaren	Waseca	
			Gething				Clearwater				Sparky		
			Cadomin				Glaucconite				General Petroleum		
Barremian	119				Lower	Ostracod				Clearwater	Rex		
						Ellerelie				Wabiskaw	Lloydminster		
		124					Detrital				McMurray	Cummings	
												Dina	

after MacEachern and Hobbs (2003)

- Stratigraphic equivalents: Lower Dakota Fm and Upper Kootanai Fm of Montana; Falher Member (Spirit River Fm) of B.C.; and the Inyan Kara Fm of North Dakota

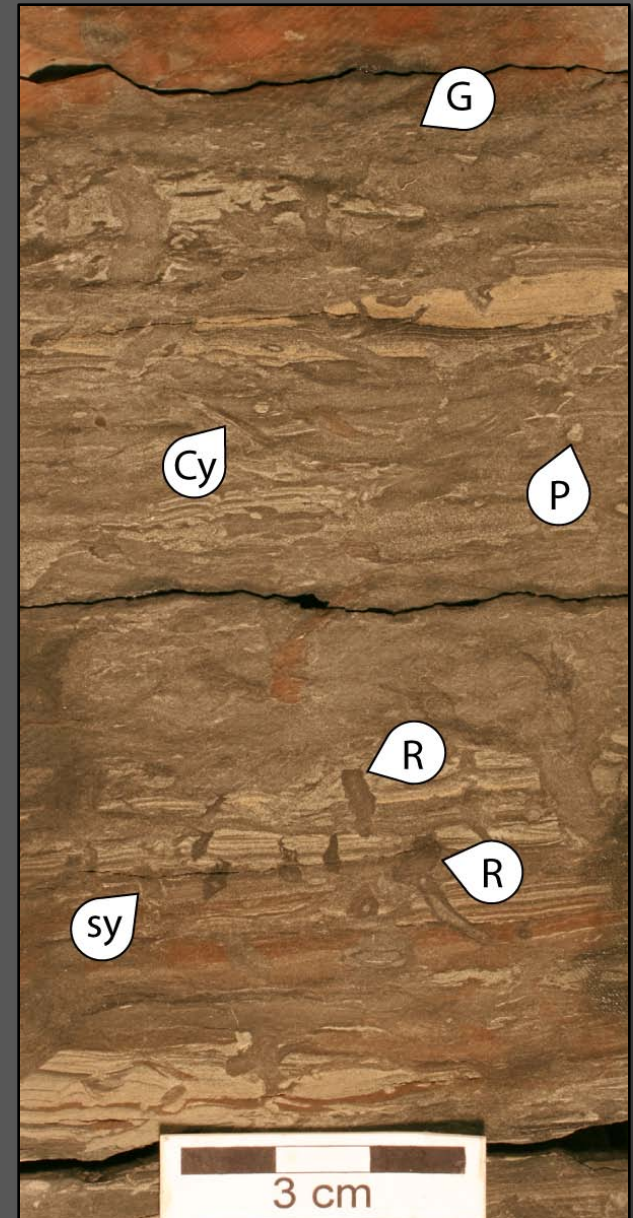
Brackish-Water Ichnological Model

- Reduced numbers and diversities of ichnogenera
- Facies characterized by opportunistic colonization of beds
- Impoverished marine trace fossil suite rather than a mixture of marine and freshwater traces



Brackish-Water Ichnological Model

- Reduced size of traces compared with fully marine counterparts
- Abundance of trophic generalists leads to suites dominated by facies-crossing ichnogenera
- Brackish-water settings support large biomasses; most facies are burrowed to varying degrees



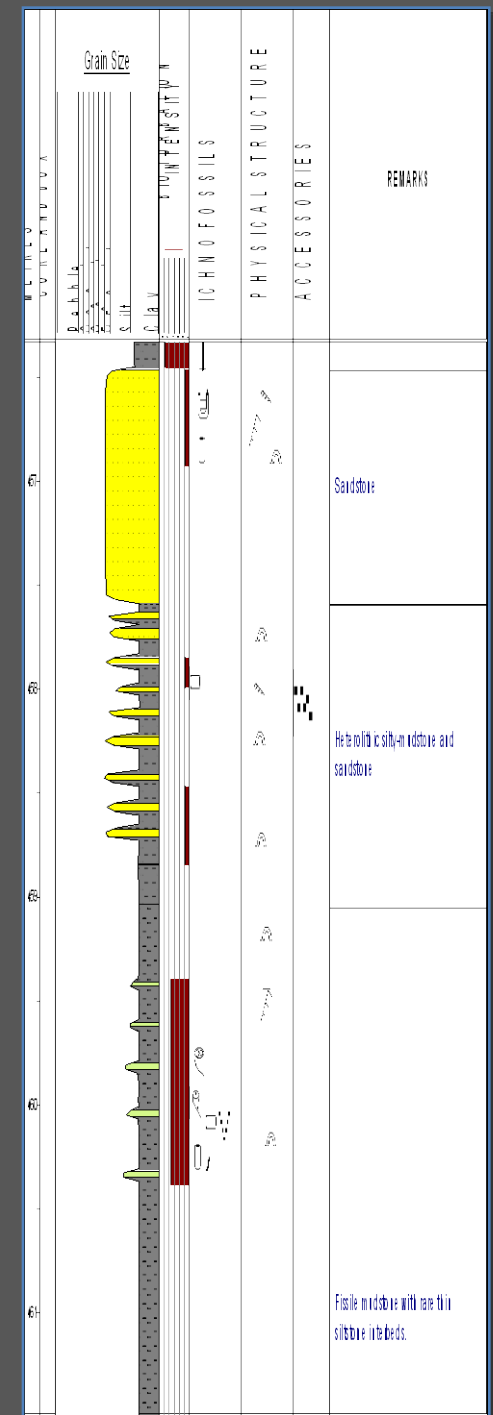
Brackish-Water Bay



Reduced salinity is the result of restricted connection with marine water and input of fresh-water

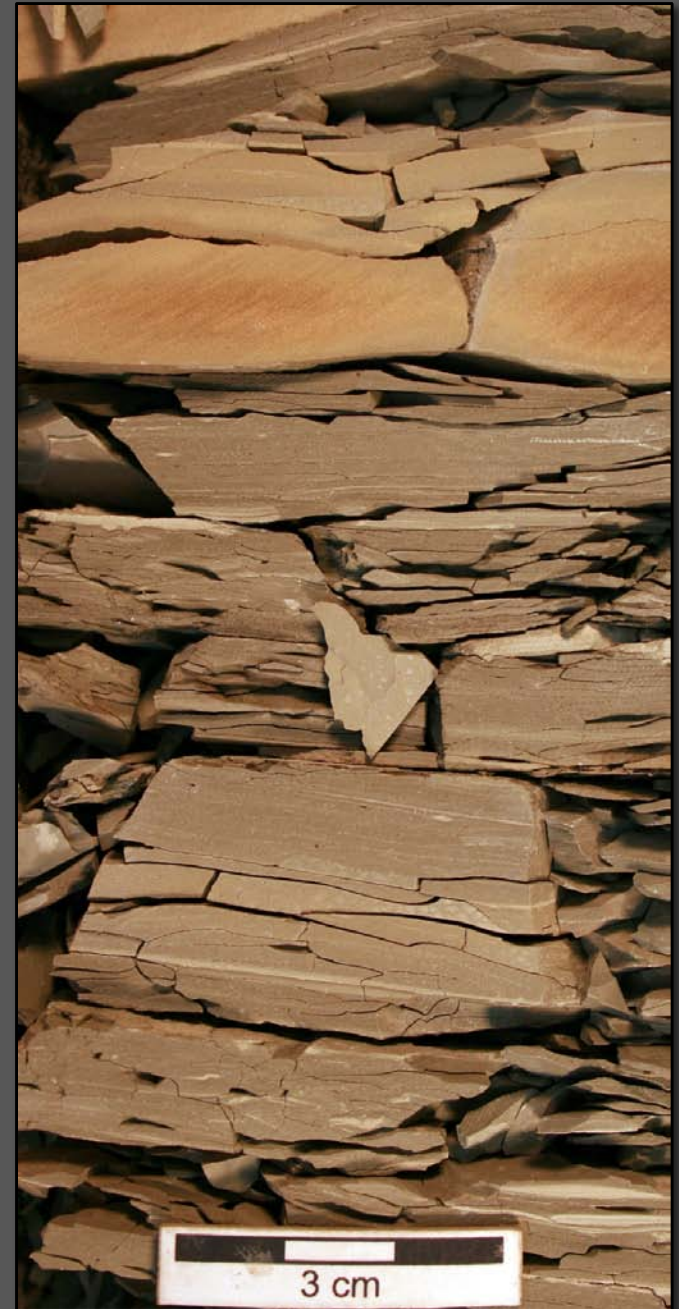
Brackish-Water Bay Deposits

- Consists of 3 main facies:
 - Mudstone Facies
 - Mudstone-Dominated Heterolithic Facies
 - Rippled Sandstone Facies



Mudstone Facies

- Fissile mudstone with very rare siltstone and vf-grained sandstone laminae
- Some normally graded beds
- Common siderite cement
- Some mudstones are structureless
- Swells when wet (bentonitic)
- BI 0-1
- Rare *Planolites*, possible “mantle-and-swirl” structures



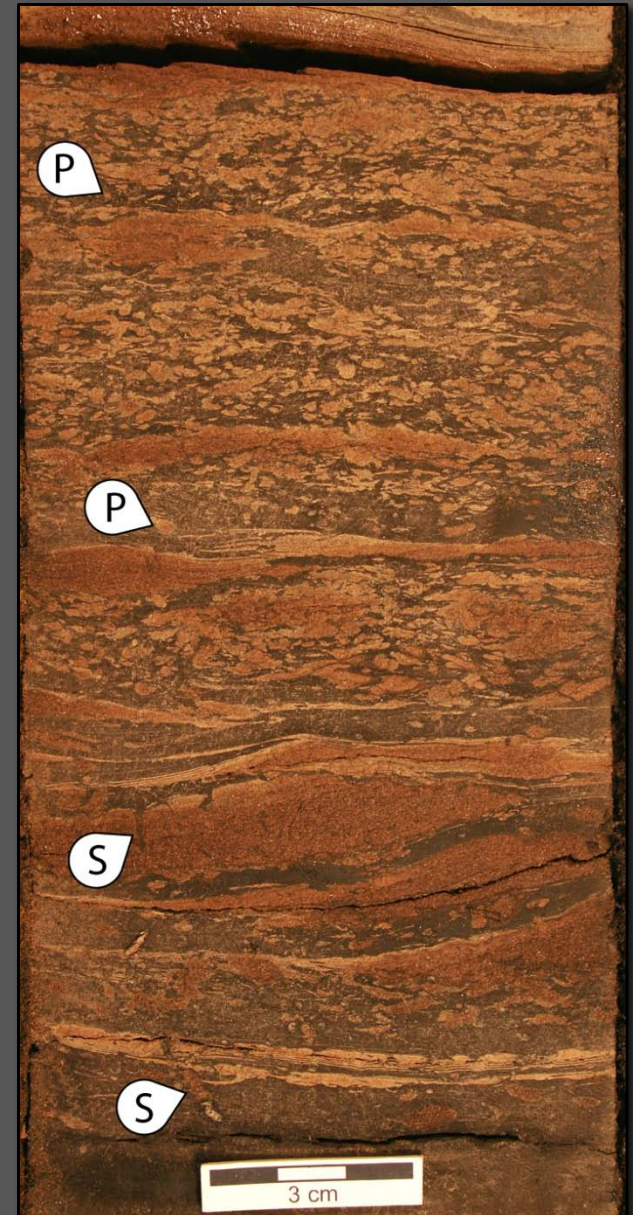
Mudstone-Dominated Heterolithic Facies

- BI 1-4 (typically BI 2-3)
- Laminated-to-burrowed fabric; oscillation rippled
- Mudstones vary from burrowed to fissile drapes
- Trace fossils diminutive
- Common ichnogenera:
 - *Gyrolithes*
 - *Planolites*
 - *Cylindrichnus*
 - *Rosselia*



Lenticular-Bedded Mudstone Facies

- BI 1-4 (typically BI 2)
- Common trace fossils include:
 - *Planolites*
 - *Skolithos*
 - *Arenicolites*
 - *Chondrites*
 - fugichnia
- Common oscillation ripples
- Rare combined flow ripples & very rare current ripples
- Minor soft-sediment deformation & syneresis cracks



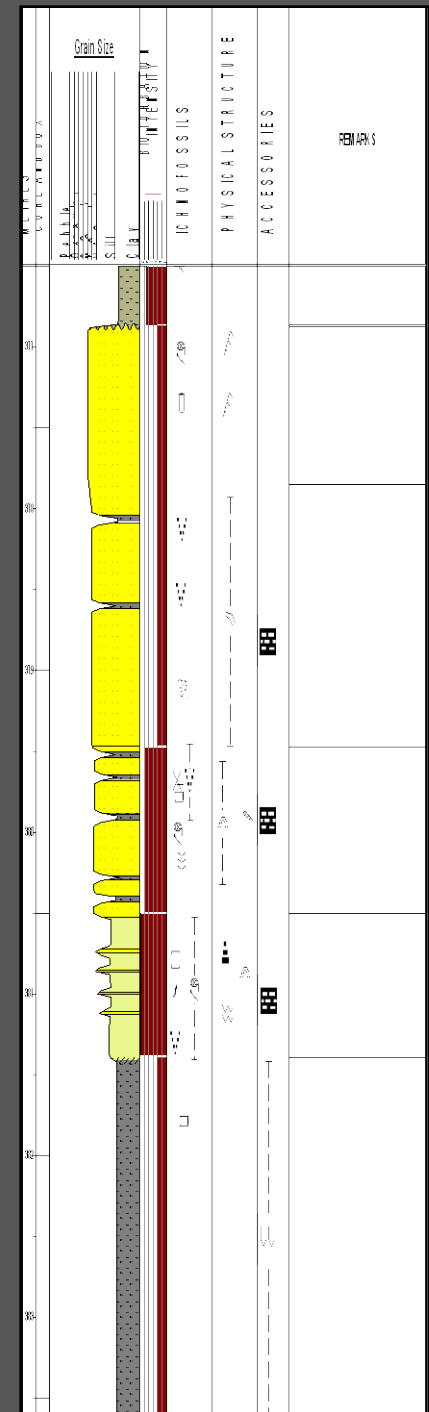
Sandstone Facies

- BI 0-1
- Rare, diminutive ichnogenera:
 - *Planolites*
 - *Skolithos*
 - *Diplocraterion*
- Common current, oscillation, and combined-flow ripples; aggradational forms common
- Rare soft-sediment deformation structures



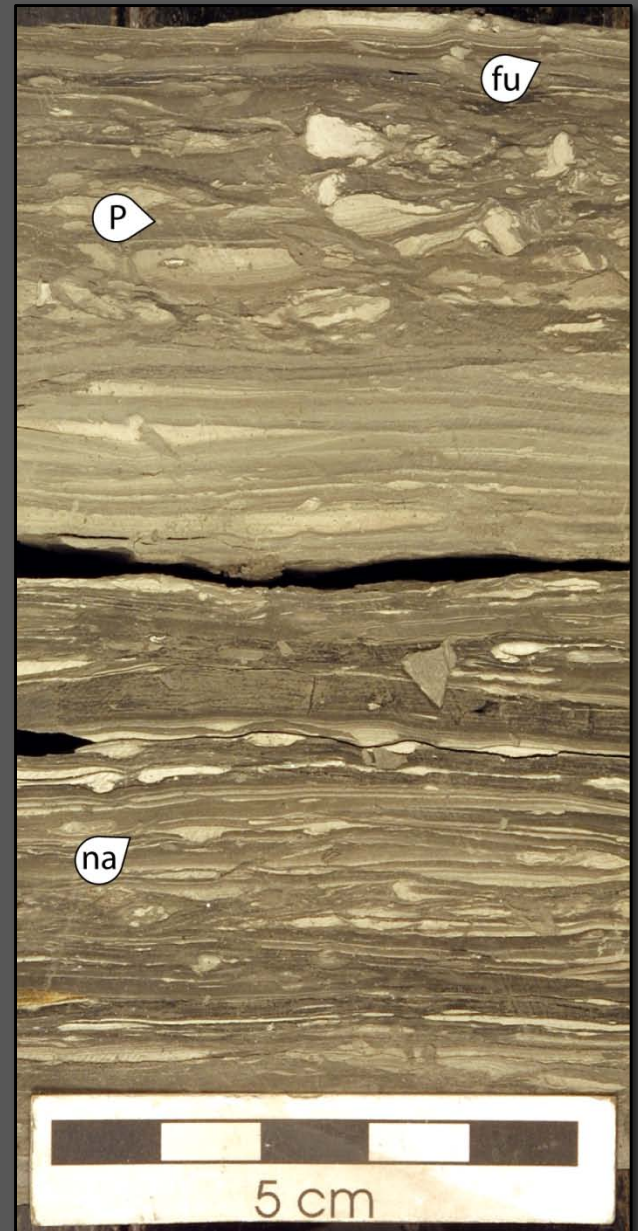
Bay-Head Delta Deposits

- Composed of 4 main facies:
 - Pinstripe-Laminated Mudstone Facies
 - Mudstone-Dominated Heterolithic Facies
 - Hummocky Cross-Stratified Sandstone Facies
 - Current Rippled Sandstone Facies



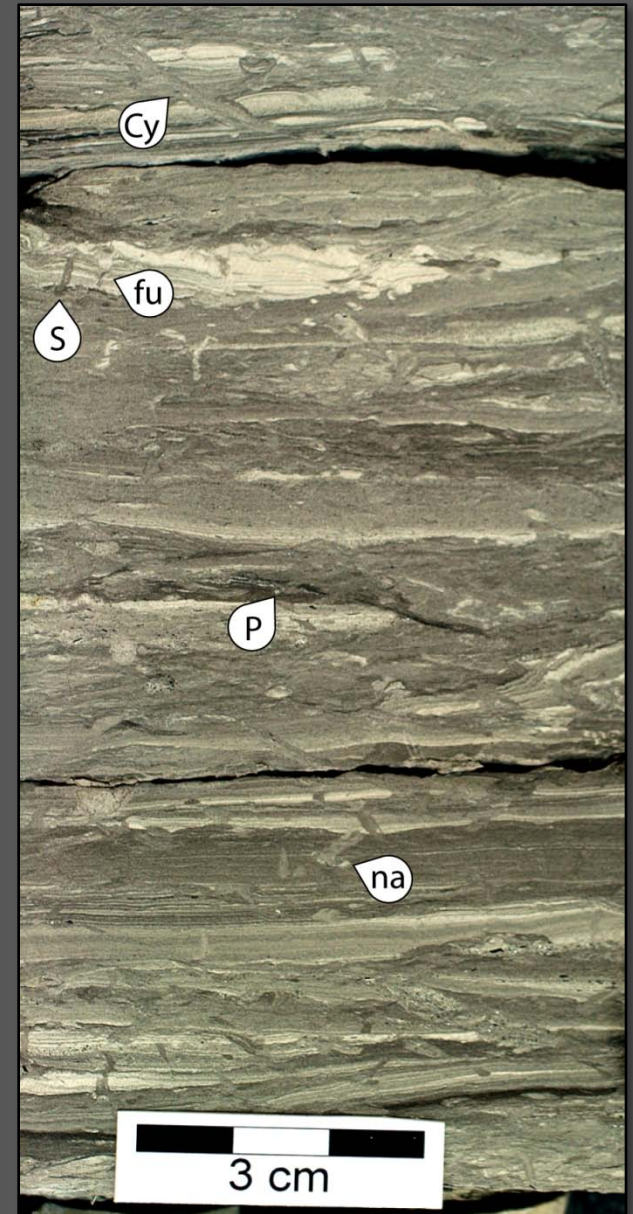
Pinstripe-Laminated Mudstone Facies

- Siltstone or vf-grained sandstone laminations
- Syneresis cracks
- Fluid mudstone drapes
- Trace fossils include:
 - *Planolites*
 - *Cylindrichnus*
 - Fugichnia
 - “Mantle-and-Swirl” structures



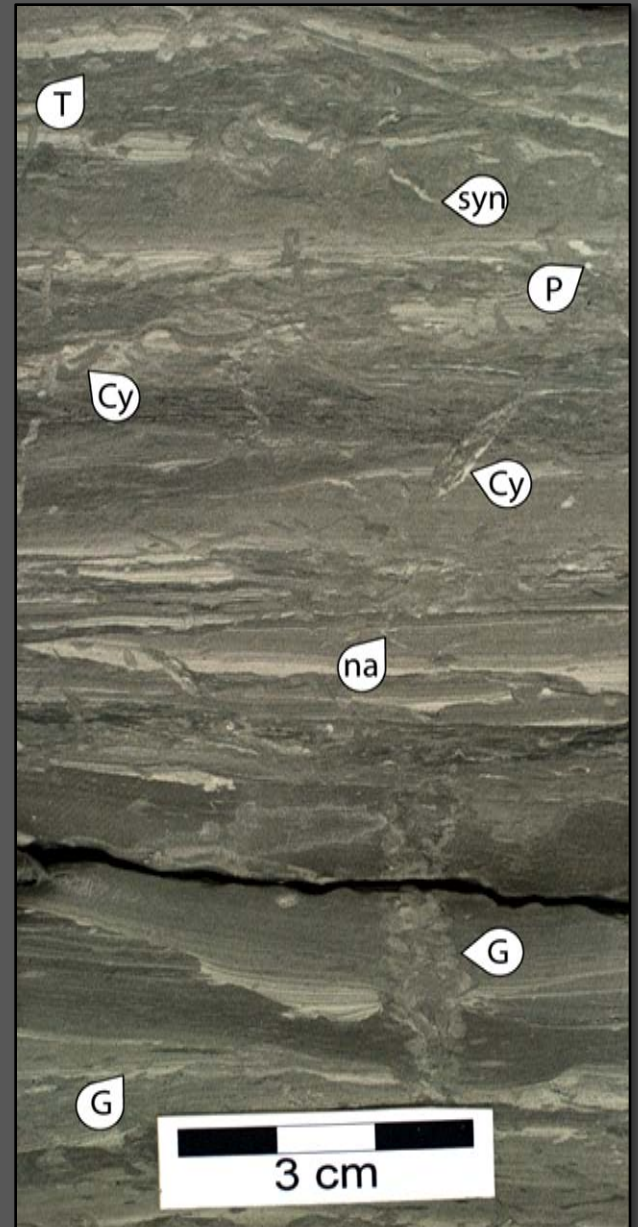
Mudstone-Dominated Heterolithic Facies

- Mudstone with siltstone and sandstone interbeds
- Siltstones are commonly normally graded
- Rare drapes of fluid mud origin
- Common syneresis cracks
- Mudstone-on-mudstone contacts commonly erosional



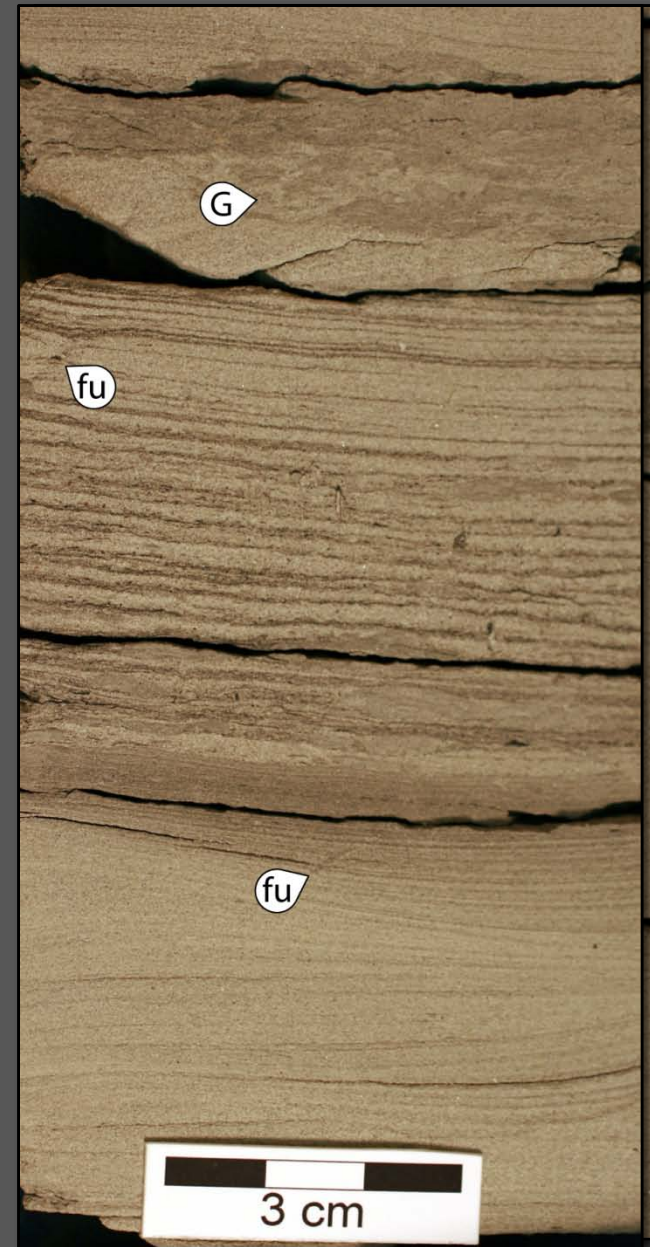
Mudstone-Dominated Heterolithic Facies

- Sporadic bioturbation; laminated to burrowed fabric typical
- BI 1-3
- Common trace fossils:
 - *Cylindrichnus*
 - *Teichichnus*
 - *Gyrolithes*
 - *Planolites*
 - “mantle-and-swirl” structures



Hummocky Cross-Stratified Sandstone Facies

- Hummocky cross-stratified sandstones
- Commonly interbedded with mudstones
- Local carbonaceous laminae
- Syneresis cracks locally abundant
- Rare mudstone rip-up clasts
- Common trace fossils include:
 - *Gyrolithes*
 - *Skolithos*
 - *Planolites*
 - *Cylindrichnus*
 - fugichnia
- Rare trace fossils include:
 - *Asterosoma*
 - *Teichichnus*
 - *Rosselia*



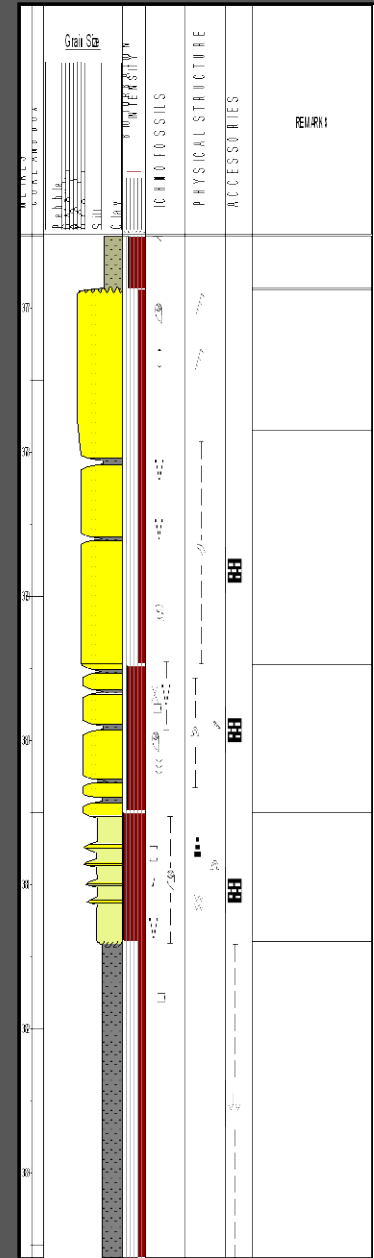
Current Rippled Sandstone Facies

- Sandstone with current ripple lamination and/or trough cross bedding
- BI 0-1
- Rare carbonaceous laminae



Brackish-Water Bay-Head Delta Deposits

- Successions coarsen upward
- Units are generally thin
- Mudstone-on-mudstone contacts are commonly erosional
- Trace fossil suites are broadly consistent with the existing brackish-water ichnological model



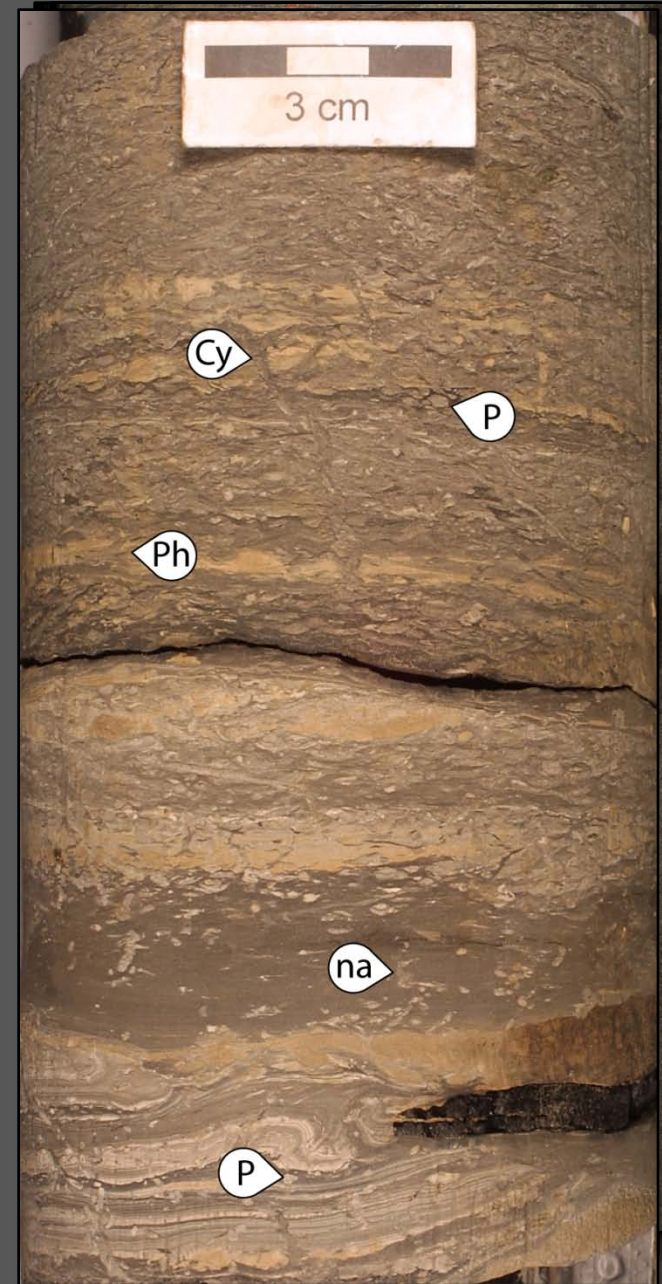
Open-Coast Delta Deposits

- Large salinity contrast between river water and receiving basin
- Units tend to be thicker; reflecting greater accommodation space
- Fluid mud drapes are more common
- Pervasive syneresis cracks



Open-Coast Delta Deposits

- Increased trace fossil diversities
- BI 1-5 (typically BI 3)
- Trace fossils are more robust than their brackish-water counterparts



Summary

Bay-Head Delta Deposits

- Consists of 4 facies, comprising coarsening upward successions
- Overall BI 1-3 (typically BI 2)
- Low ichnological diversity
- Normal grading common
- Common syneresis cracks
- Mudstone drapes locally common
- Intercalation of oscillation, current and combined flow ripples

Brackish-Water Bay Deposits

- Consists of 3 facies, comprising coarsening upward successions
- Overall BI 1-4 (typically BI 2-3)
- Low ichnological diversity
- Normal grading sporadically distributed
- Rare syneresis cracks
- Rare mudstone-drapes
- Dominated by oscillation ripples

Summary

Bay-Head Delta Deposits

- Suites are of lower diversity
- Trace fossils are diminutive
- Lower overall BI
- Thinner successions
- Syneresis cracks common
- Drapes of fluid mud origin less common

Open-Coast Delta Deposits

- Suites are higher diversity (but still low)
- Trace fossils are more robust
- BI is variable, but generally higher
- Thicker successions
- Syneresis cracks more common
- Drapes of fluid mud origin common

Acknowledgements

