Hydrodynamic Interpretation of High Energy Wave-dominated Shoreface Successions, Cretaceous Mount Garfield/Illes Formation, Colorado*

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Abstract

Modern and ancient shoreline successions have been well documented; however, the hydrodynamics of these successions need further study. Comparison of modern studies of the hydrodynamics of shorefaces leads to a better understanding of depositional conditions, such as differences in the day-to-day wave and tide climate, size and frequency of storms, and grain-size effects on the type and scale of bedforms preserved along the shoreface. These data, along with information on progradation rates, can help predict the width of facies tracts. Most studies of ancient shoreface successions are lacking in details of their hydrodynamic conditions. Detailed hydrodynamic interpretations provide insight on wave fetch, shoreline geometry and storm frequency during the time of deposition, as well as possibly the scale or geometry of the marine water bodies (e.g., Cretaceous Western Interior Seaway - KWIS) which existed at the time of deposition.

The Rollins Sandstone Member (Campanian) is the youngest Member of the Mount Garfield Formation. This unit and its time equivalent marine units represent the last pulse of fully marine sedimentation into the Colorado segment of KWIS. The youngest parasequence within the Rollins Sandstone Member contains a well developed progradational marine shoreface succession. This marine shoreface succession is relatively thick (25-40 meters thick) and contains some variability from the "normal" wave-dominated shoreface facies successions of younger strata. A well developed middle shoreface interval within this parasequence indicates this shoreline was a barred shoreface, and that this bar was a constant (not an ephemeral) feature of the shoreline. Bar-related deposits contain a high concentration of large-scale, thick-walled *Ophiomorpha*, indicating a high-energy setting. The scale of cross-stratification within the upper shoreface (individual beds up to 25 cm in thickness) and thickness of upper shoreface facies indicate day-to-day wave heights of 1-2 (plus) meters at the time of deposition, indicating a very high-energy coastline. The high energy of this coastline raises questions about the depth and geometry of this Late Cretaceous seaway. This study suggests shorelines were straighter and water depths more moderate than previous estimates.

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Howard, J.D., and H-E Reineck, 1981, Depositional facies of high-energy beach-to-offshore sequence: Comparison with low-energy sequence: AAPG Bulletin, v. 65/5, p. 807-830.

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University of Kansas

Goals of Research

We know these are high energy shoreface deposits

What was the wave height?

What was the storm frequency, intensity?

What did the shoreline look like at the time of deposition?

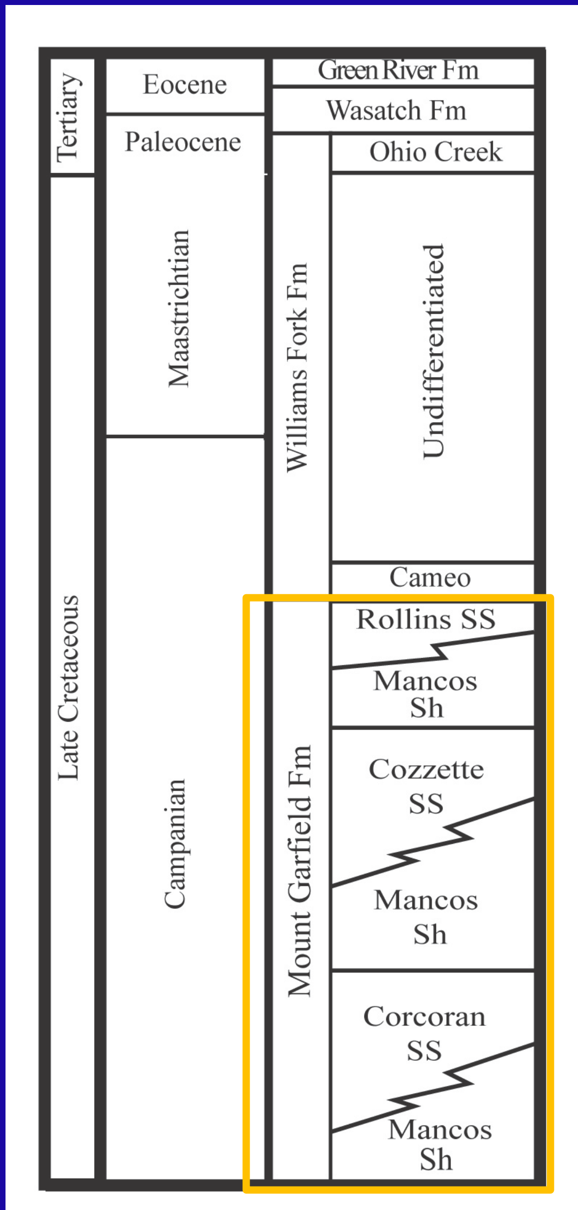
Methods

6 measured sections, detailed facies descriptions

Comparison with modern shoreface deposits

Quantitative analysis based on sedimentary structures
observed within shoreface succession

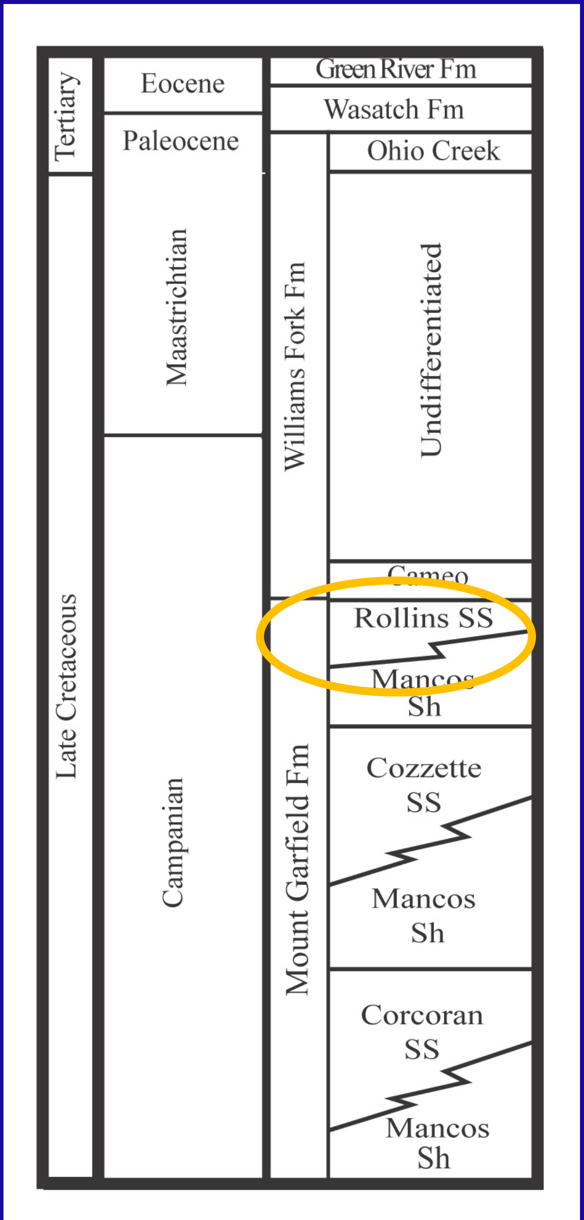
Lithostratigraphic Nomenclature and Background



Illes Fm 72-79 Ma

Rollins SS Mbr is the last pulse of fully marine sediment into the KWIFB

Lithostratigraphic Nomenclature and Background

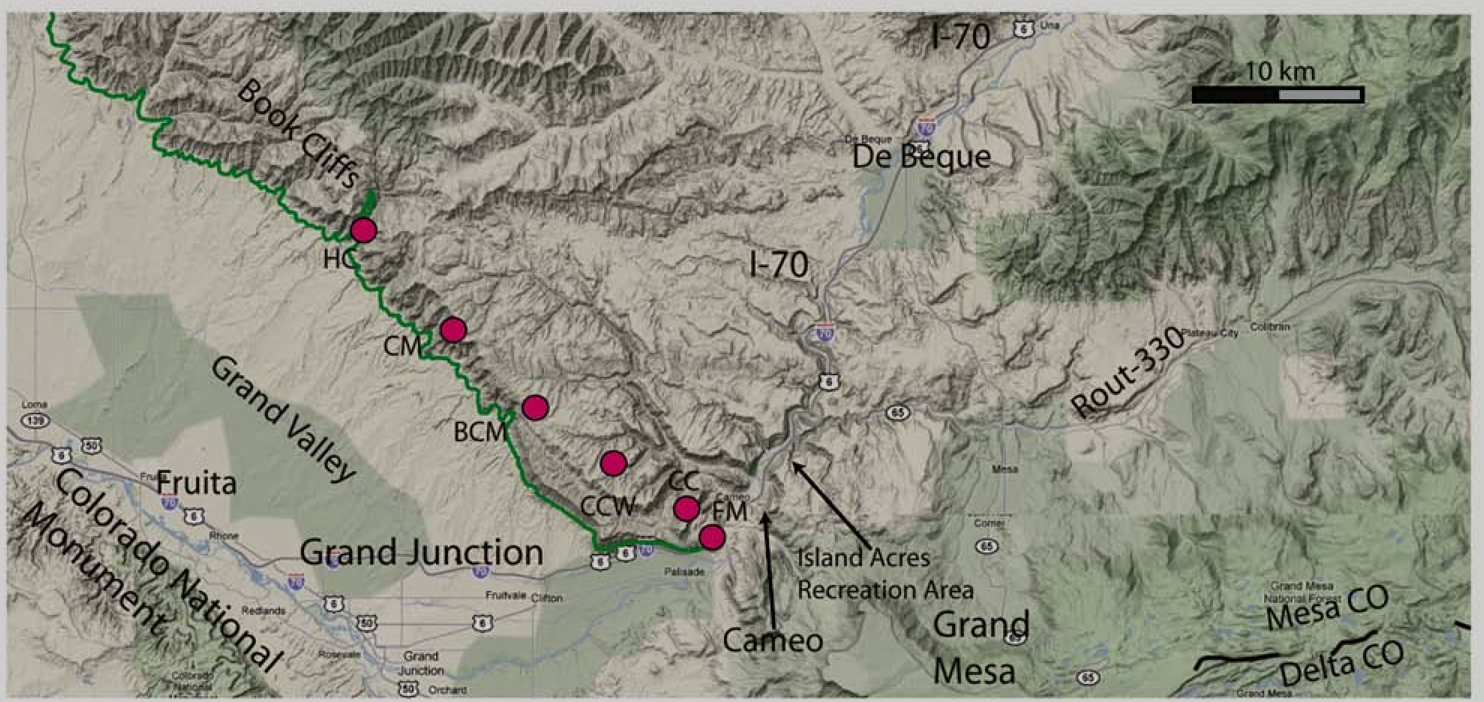


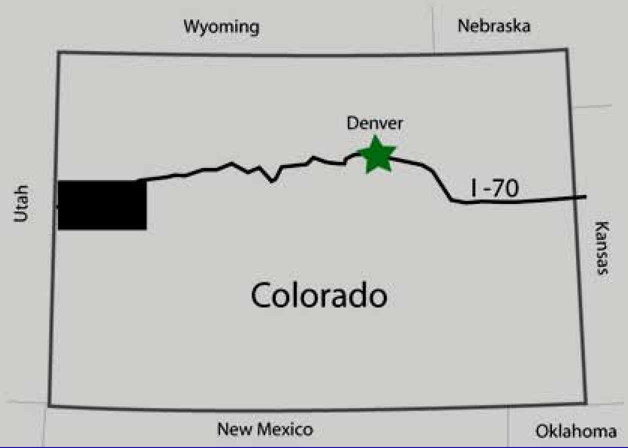
Illes Fm 72-79 Ma

Rollins SS Mbr is the last pulse of fully marine sediment into the KWIFB

(Blakey)
http://jan.ucc.nau.edu/~rcb7/globaltext2.html

Study Area



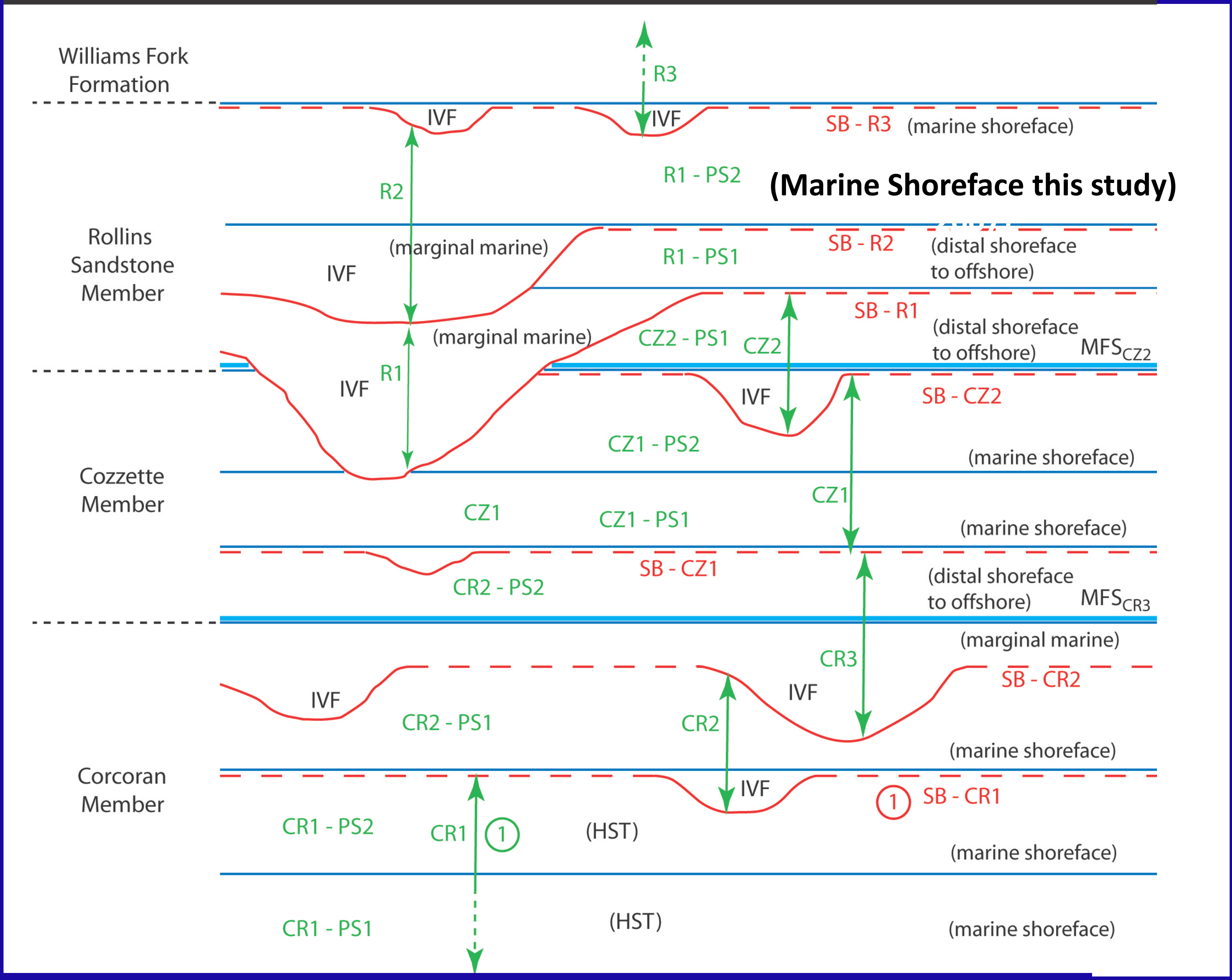


Study area near
Grand Junction, CO

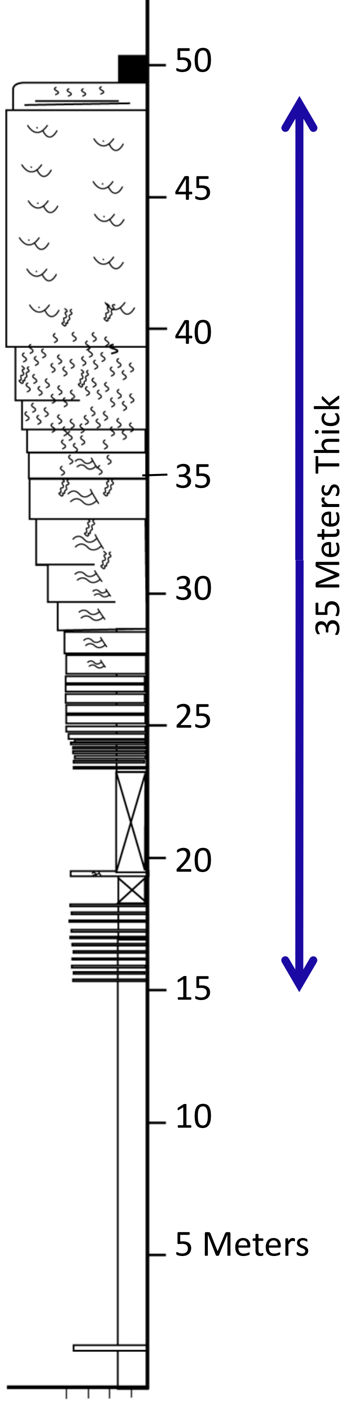
Book Cliffs outlined in Green

Measured section locations in red

Sequence Stratigraphy of the Rollins Sandstone



(Modified from Kamola et al. 2007)



Rollins Sandstone Member

Best exposed and most complete shoreface succession within the Mt Garfield/Illes Fm

Contains many of the attributes of other shoreface succession within the Sevier Foreland Basin

Relatively thick shoreface succession (aprox. 35 meters)

Thick HCS beds

Middle shoreface interval

Thick upper shoreface with well developed trough cross-stratification

Rollins Sandstone Member – Wave Dominated Shoreface Facies

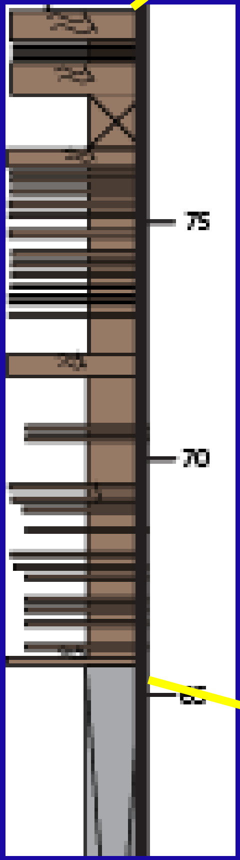
Lower Shoreface Facies

Offshore transition facies grading into LSF

Interbeded mudstone and vfg-fg HCS SS

HCS beds up to .75 meters thick

Water depth of ~ 15-30+ meters



Storm Intensity for the Rollins Sandstone

Thickness of HCS beds within the Rollins SS are similar to those deposited during large storms along the East Coast US (Nor'easter scale storms)

Storms with enough magnitude to produce HCS occur infrequently (a few times a year)

With the progradation rate of the Rollins Sandstone this frequency and magnitude of storms could produce the record we observe within the Rollins

Middle Shoreface Facies

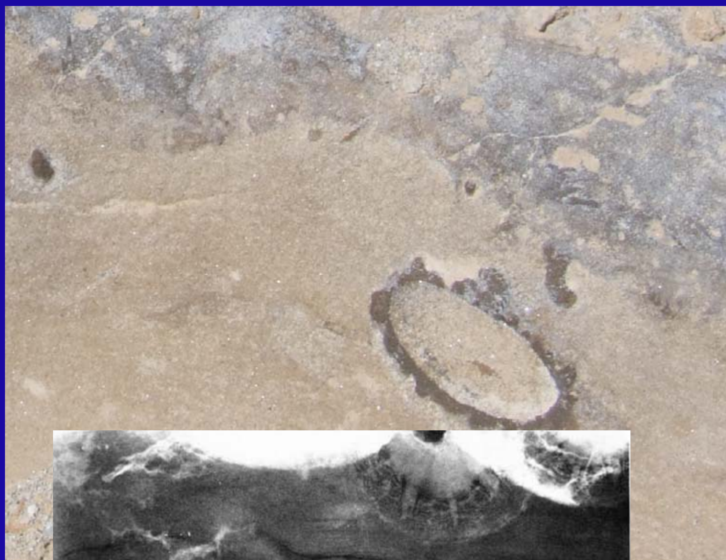
Remnant HCS

Heavily bioturbated

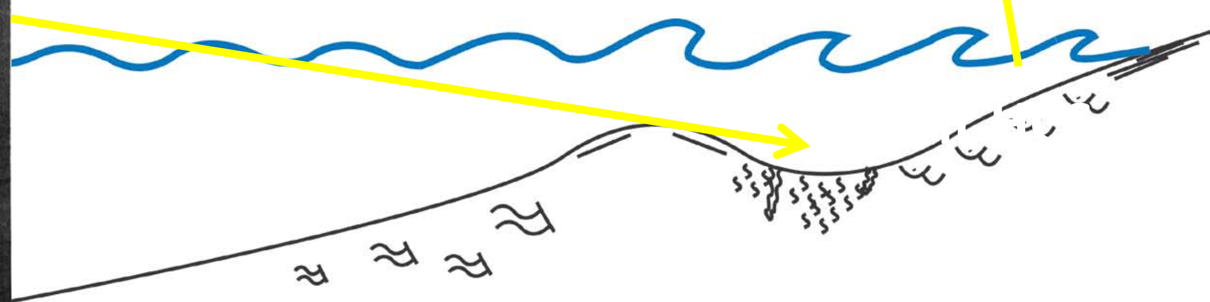
Average 2 meters thick

Always present within the Rollins Sandstone

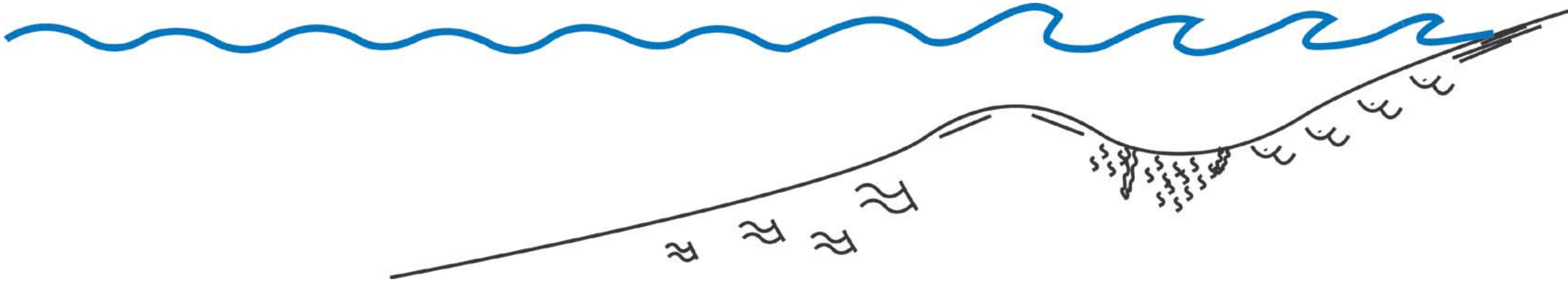
Middle Shoreface Facies



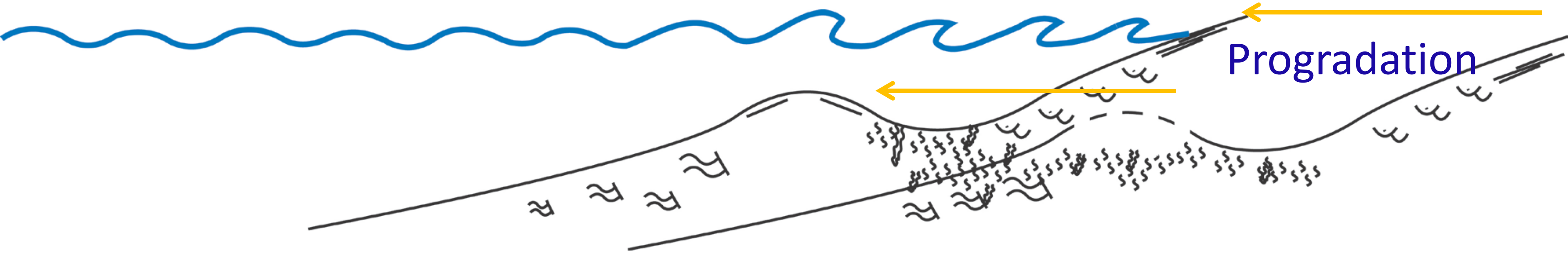
(Howard and Reineck, 1981)



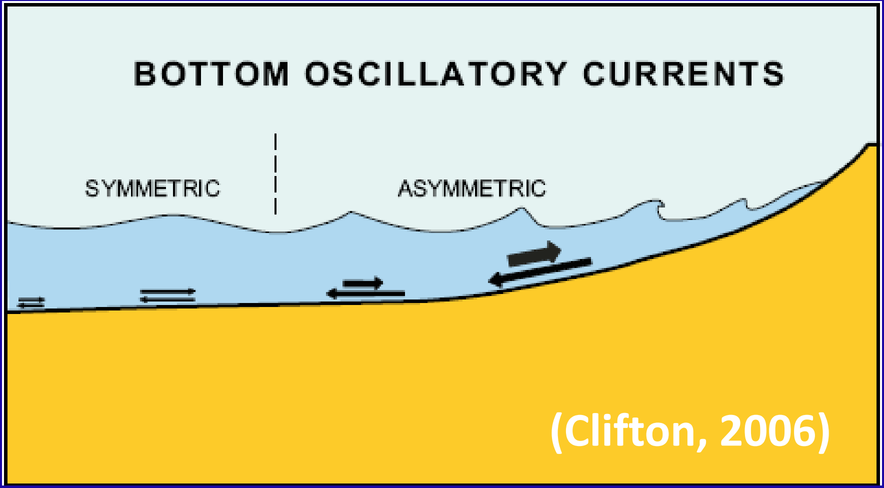
Middle Shoreface Facies



Middle Shoreface Facies



Upper Shoreface Facies



Fine grained sandstone

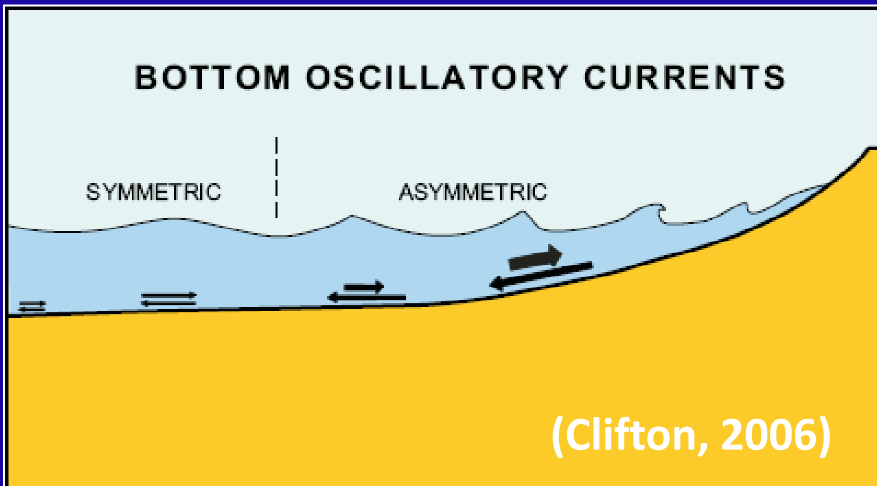
Trough Cross-stratification

(15-25 cm thick)

1-8 meters of water depth

0.5-0.8 m/s currents

Upper Shoreface Facies



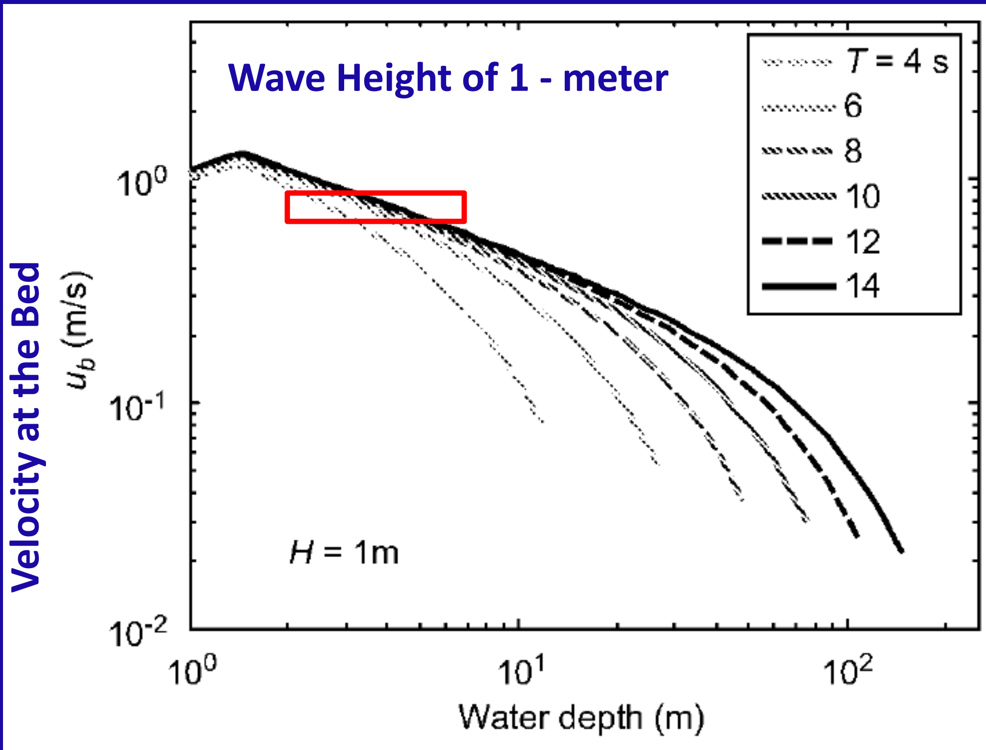
(Clifton, 2006)

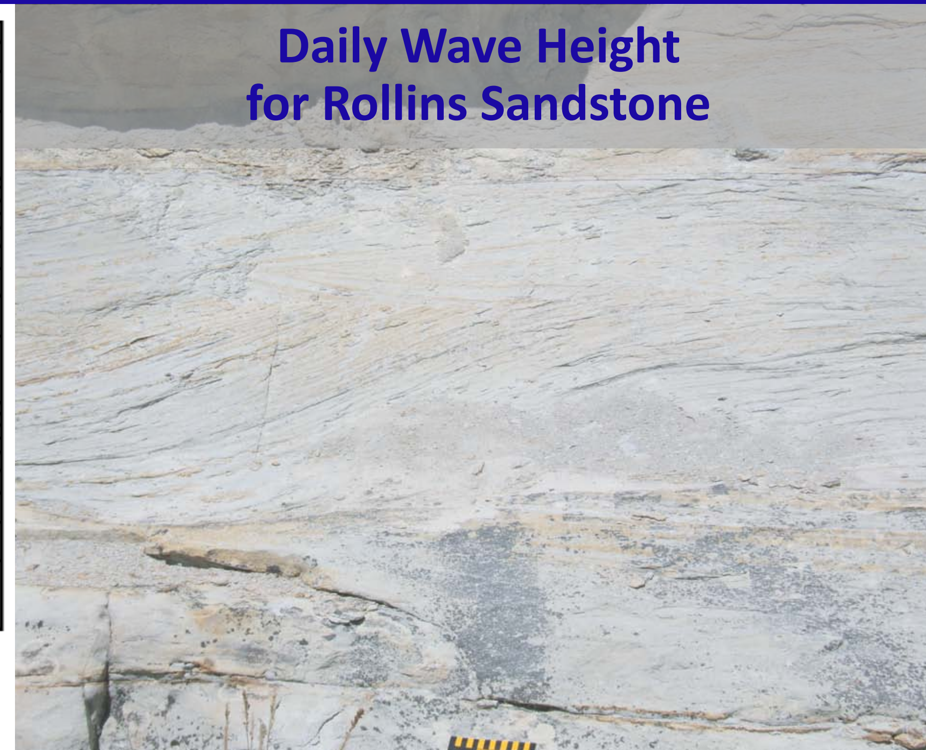
Cross-bed thickness of Rollins Sandstone is larger than those observed along the southern Calif. Coastline

S. Calif. Coast has ~ 1 meter daily wave height

(Howard and Reinech, 1981)

Daily Wave Height for Rollins Sandstone





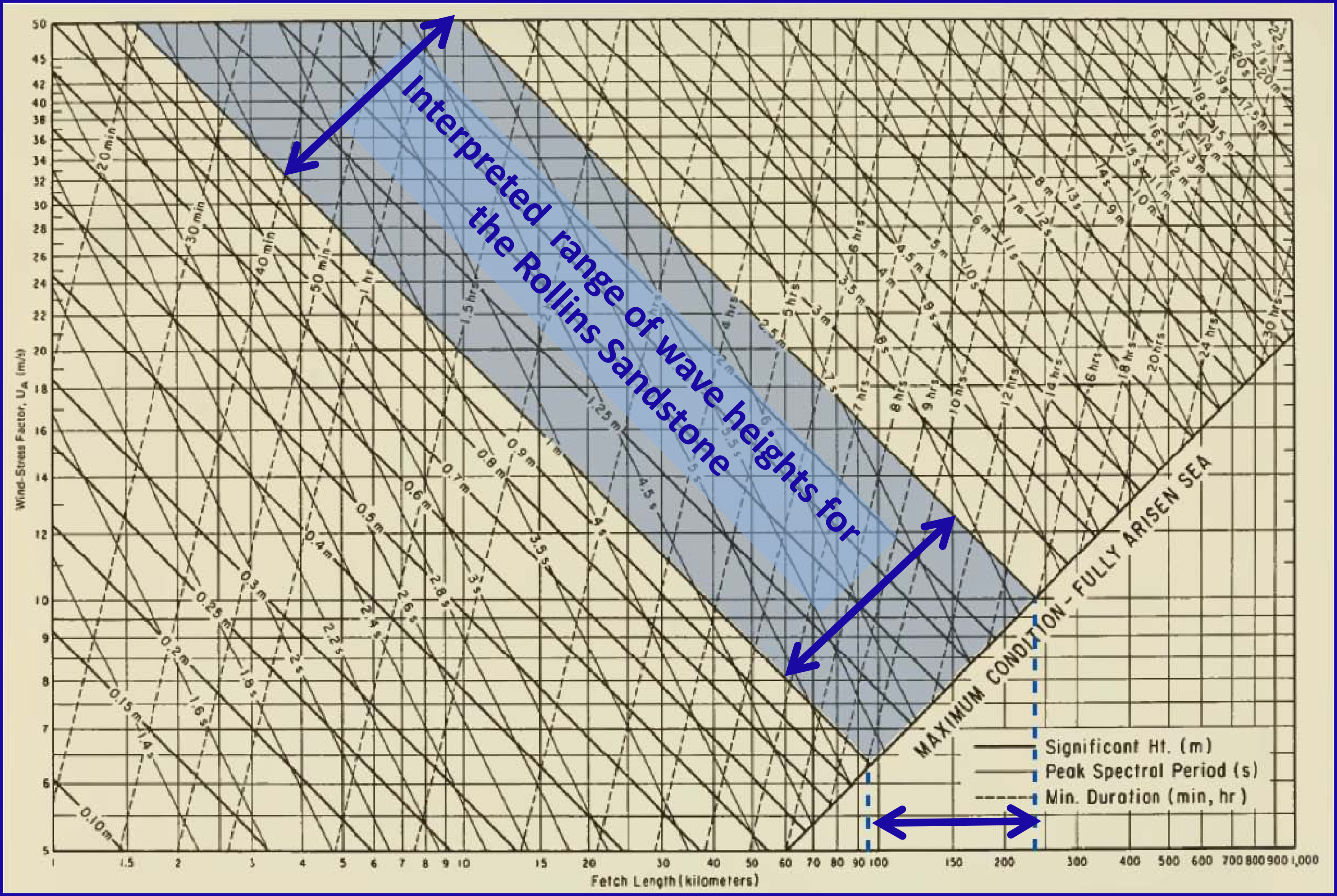
(Wiberg and Sherwood, 2006)

Bottom Orbital Velocities for Wave Heights of 1-2.5m at Varying Periodicity and Water Depth

	Wave Height	1 meter waves		1.5 meter waves		2 meter waves		2.5 meter waves	
	Period	4s	14 s	4s	14 s	4s	14 s	4s	14 s
Water Depth	1 meter	1	1	1.5	1.5	2	2	2.5	2.5
	4 meter	0.4	0.8	0.6	1.2	0.8	1.6	1	2
	8 meter	0.1	0.4	0.15	0.6	0.2	0.8	0.25	1

Range of wave heights for upper shoreface

Wave Fetch

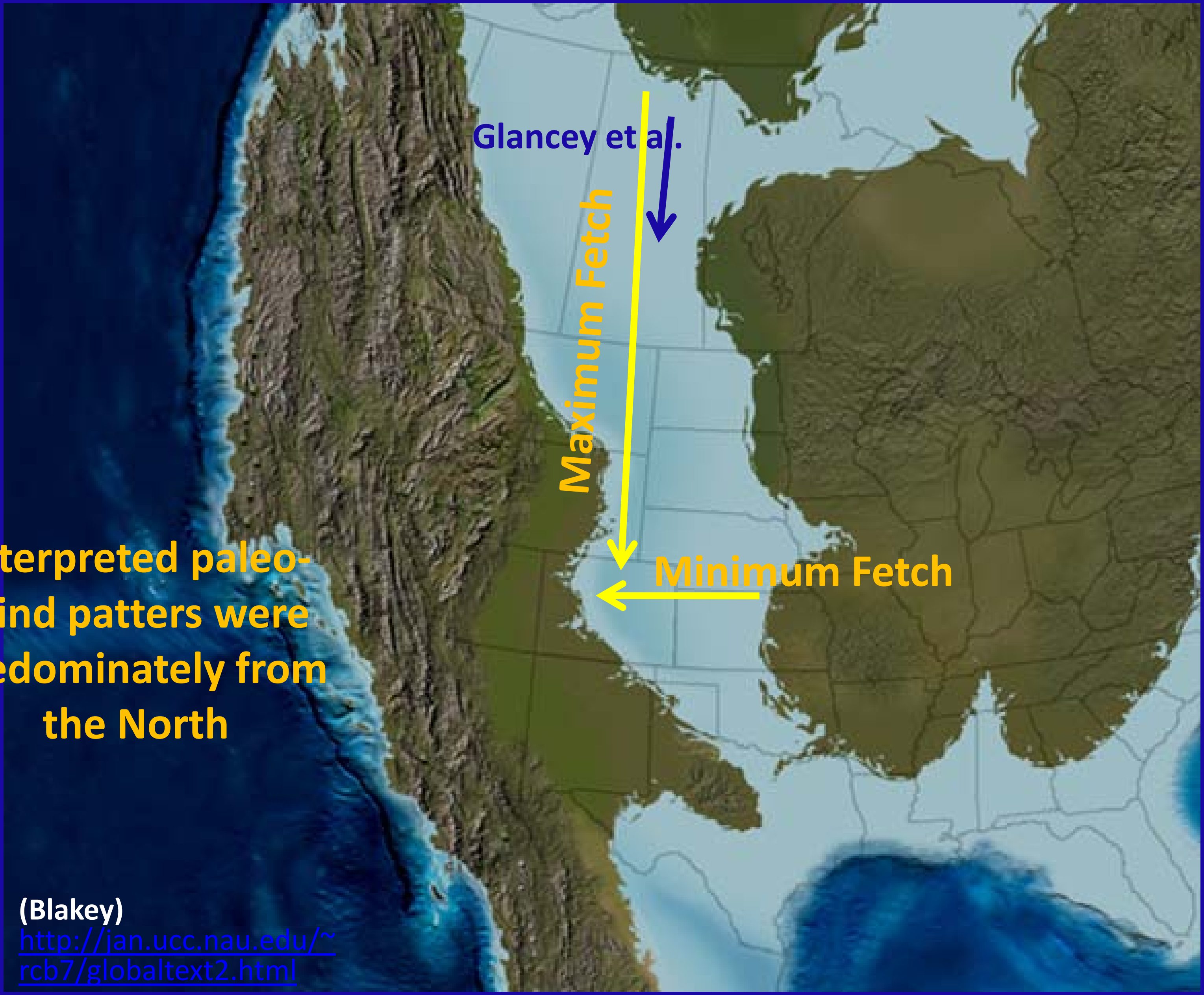


Wind Speed

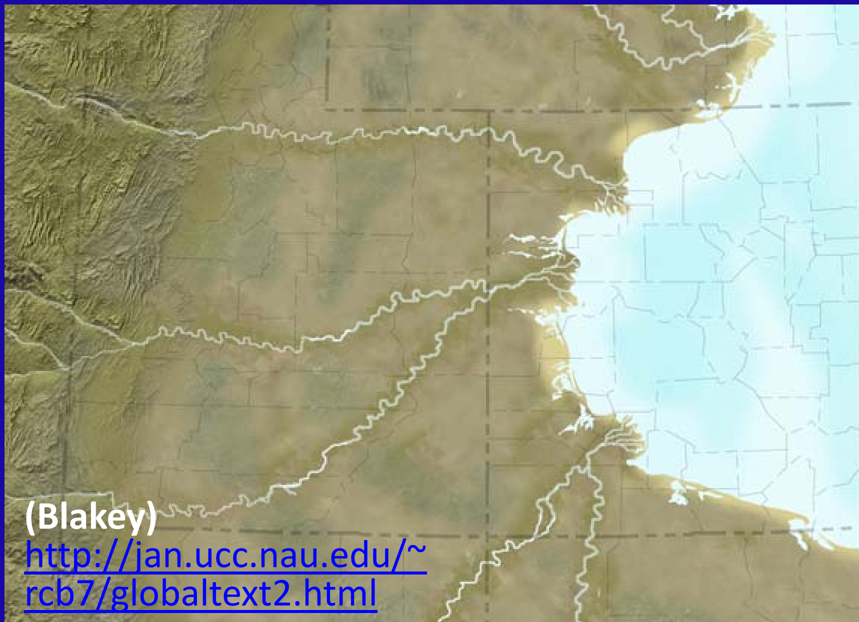
Fetch Length

(Army Corps of Engineers Shoreface Protection Manual, 1984)

Wave Fetch


Glancey et al.
Maximum Fetch
Minimum Fetch
Interpreted paleo-wind patters were predominately from the North
(Blakey)
http://jan.ucc.nau.edu/~rcb7/globaltext2.html

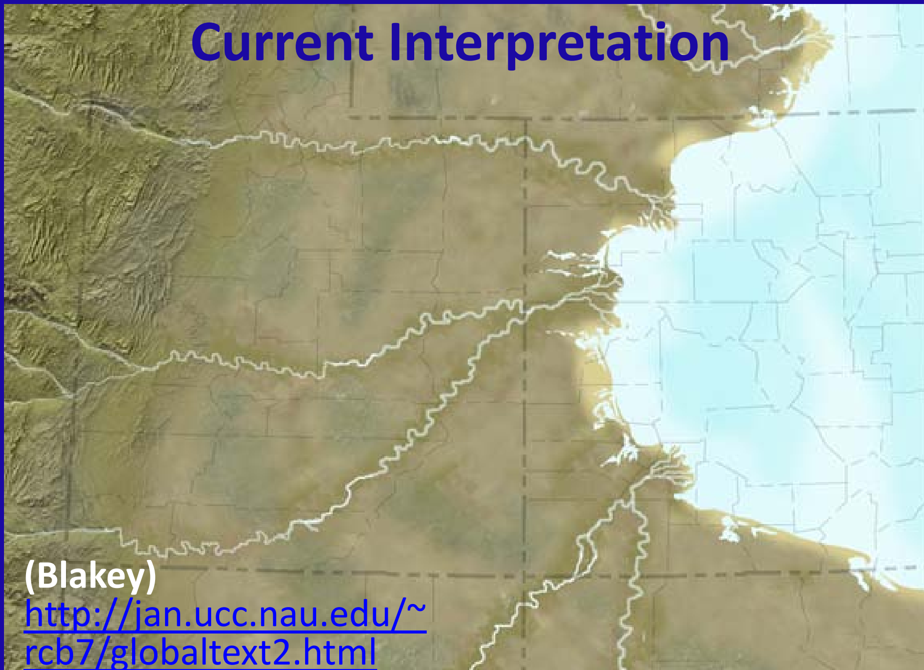
Paleogeography

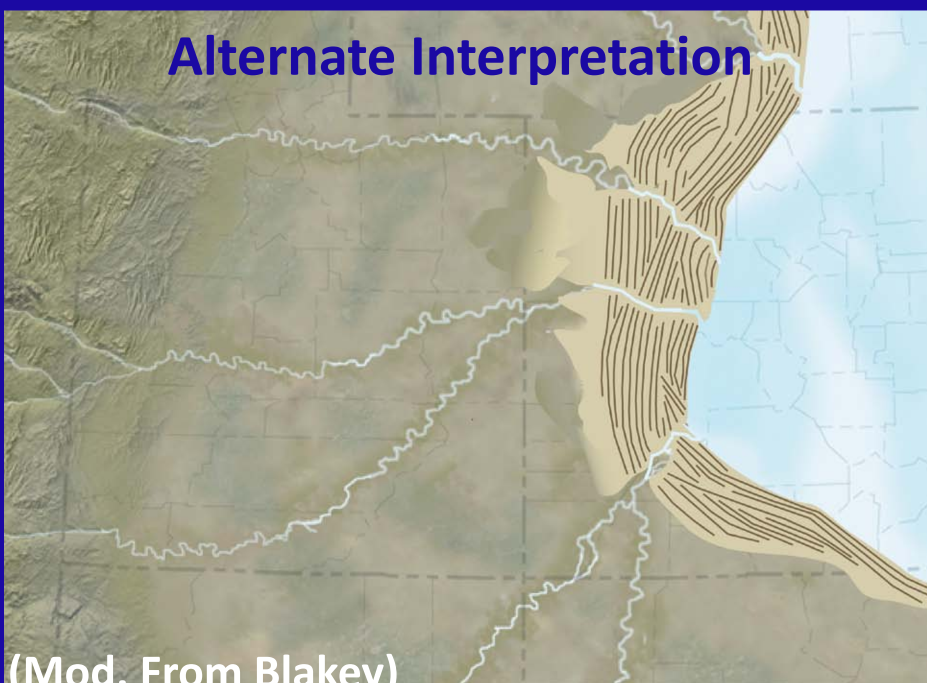


(Blakey)
http://jan.ucc.nau.edu/~rcb7/globaltext2.html

- Irregular coastline
- River dominated deltas
- Embayments
- Barriers

Paleogeography





The high-wave energy coastline would be straight

Sediment brought in by rivers quickly reworked by littoral processes

Beach ridges recording position of shoreline through time

This is supported by the lack of river-dominated delta facies in the record

Conclusions

Shorefaces along the west coast of the KWIS had very high wave energy , with ~1-2 meter daily wave height

Required a minimum Fetch of 100-250 km

These were high storm energy coastlines, with Nor'easter-scale storms possibly occurring several times a year

The presence of a middle shoreface facies in the Rollins Sandstone indicates these were barred shorefaces

Due to the high wave energy these were straight shorelines, and not dominated with embayments or river dominated deltas

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