Using Sequence Stratigraphy to Refine Estimates of Sediment-Component Accumulation Rates in the Monterey Formation

Jon Schwalbach[1] and Kevin Bohacs[2]

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[1]Consultant, Oxnard, California
[2]KMBohacs Geoconsulting, Houston, Texas

Abstract

A primary aspect of sequence stratigraphy is dividing strata into genetically related packages. Traditional biostratigraphic analyses, integrated with paleomagnetic and isotope chronostratigraphy, generally provides million-year (sequence-scale) resolution that has been the standard for most Monterey studies. Thus, most estimates of sediment-component accumulation have been limited to longer duration periods, generally coinciding with biostratigraphic stages or depositional sequences. Recent advances utilizing U-Pb techniques and geochemical correlation of ash beds, however, offer an opportunity for high-resolution chronostratigraphy (0.1 M.Y.) and improved estimates of sediment-component accumulation rates. This will ultimately enhance our delineation of depositional systems of the Monterey.

When integrated with an improved understanding of deposition and diagenesis, high-resolution chronostratigraphy offers the potential to resolve sub-Milankovitch events and component accumulation in specific Monterey Formation stratigraphic intervals. For example, repetitive parasequence-scale lithofacies stacking, recognized in several Monterey outcrops, have been postulated to represent Milankovitch-driven cyclicity. The interpreted parasequences are typically bounded by dolomite beds, interpreted as authigenic deposits that represent slowing or pauses of sedimentation. Sediments deposited between the dolomite beds are typically thin-bedded and heterogeneous, predominantly biogenic-silica-rich porcelanite and chert, interbedded with clay-rich mudstone and siliceous mudstone. Organic matter tends to be concentrated in the mud-rich beds and bedsets. Verification of the frequency of these parasequence-scale units would provide new constraints on estimates of component accumulation rates (biogenic silica, detritus, and organic matter) as well as the mass of sediment contributed by authigenic processes (dolomite and phosphate).

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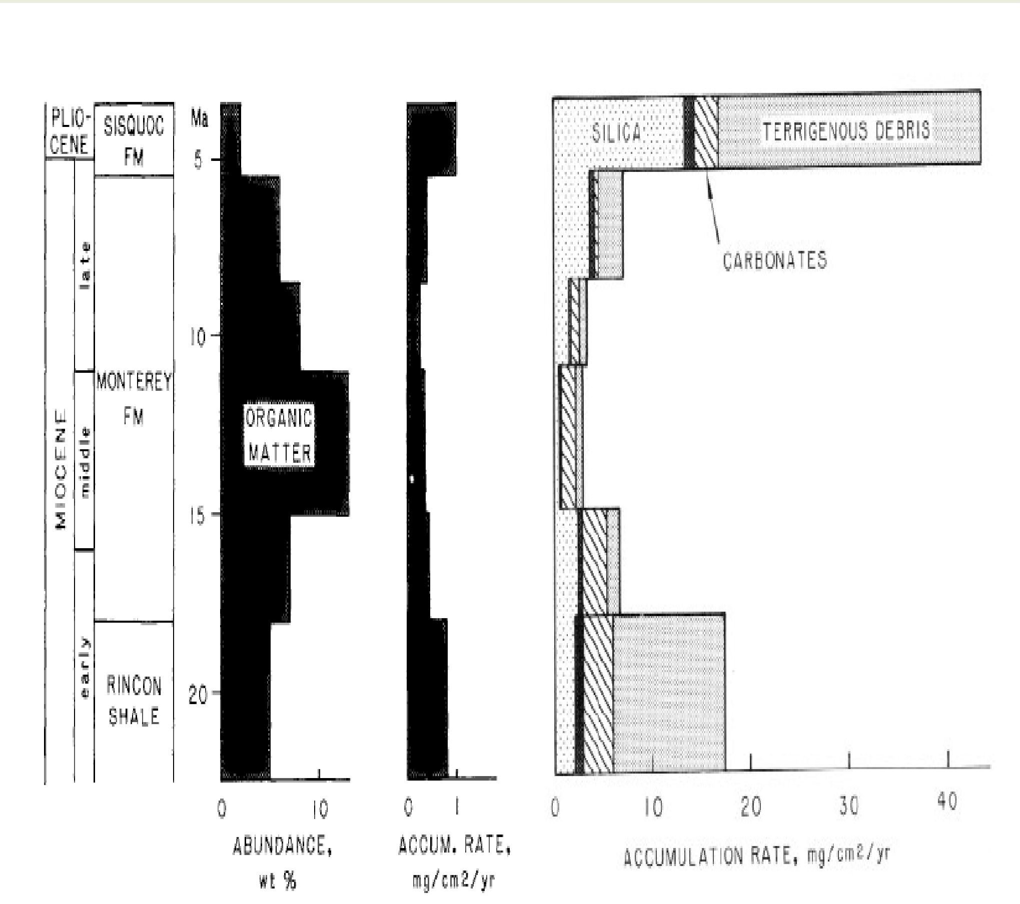
Why is it Important?

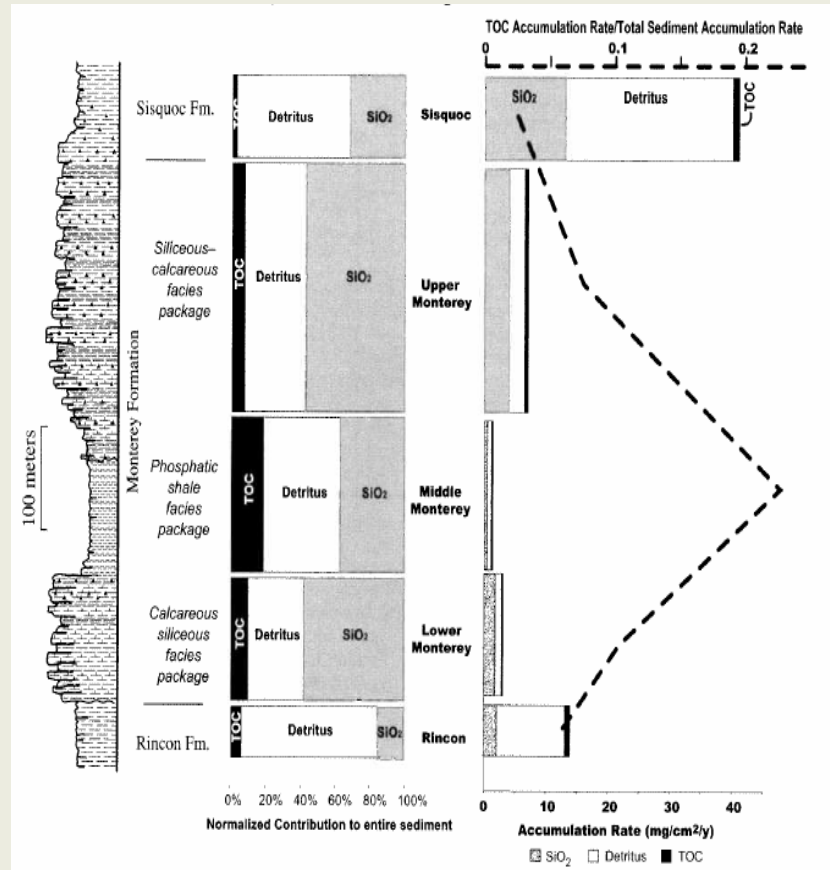
- Sediment-component accumulation rates vary vertically (temporally) and laterally (basin environment).
- Most component rate calculations for the Monterey have been at the zone or member scale over broad time periods and are not always specific to depositional environment.
- *Integrating sequence stratigraphic concepts, basin-scale analysis, and improved age control promises refined sediment-component accumulation rates and improved understanding of depositional settings and basin history.*
- Application for paleoclimate and paleoceanographic studies.

Sediment-Component Accumulation Rates Based Primarily on Biostratigraphic Ages

Member and zone quantification generally cover intervals of several million years



(Isaacs, 1987)



(Bohacs et al., 2005)

- Key aspect of sequence stratigraphic analysis is dividing sediments into genetically related strata, defining timelines that can be mapped throughout a basin.
- Application requires a basic understanding of depositional processes.

A Monterey Scenario

Forcing Mechanisms
(Orbital Parameters/Glacial/Climate Cycles)

↓

Changing Circulation and Water Temperature

Falling/Lower Relative Sea Level

Strong, Cool
Vigorous, Enhanced Upwelling
Silica Productivity
Diatomaceous Ooze and Mud
Higher Accumulation Rate
Chert and Porcelanite

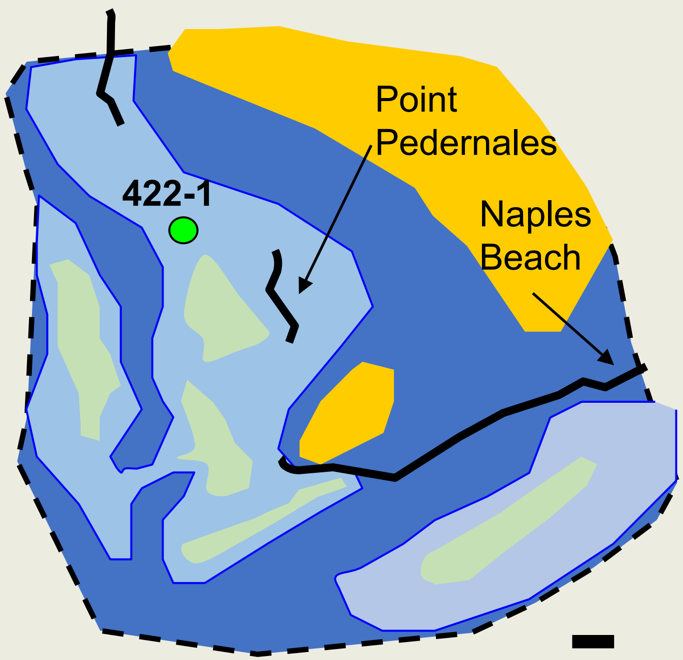
Rising/Higher Relative Sea Level

Weak, Warm
Sluggish Circulation
Carbonate Productivity
Calcareous Ooze and Mud
Lower Accumulation Rate
Dolomite, Phosphate, Clay and Organic-Rich Mudstone

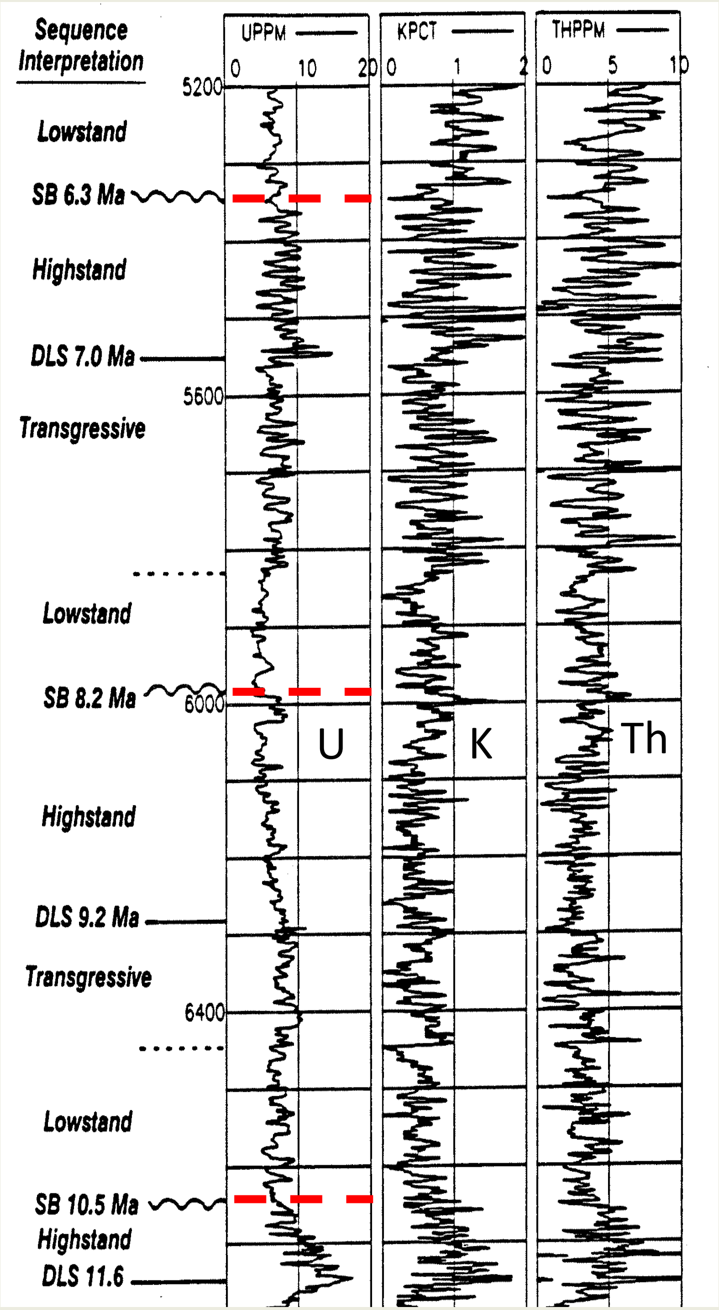
After White et al., 1992

Offshore Santa Maria Basin sequence interpretation and depositional environments based on:

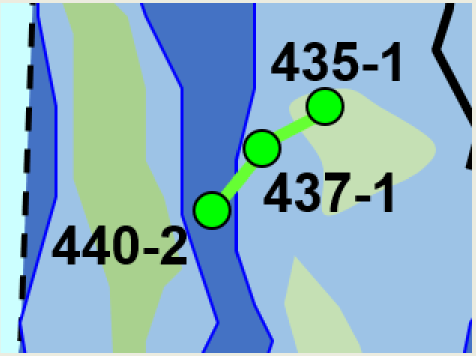
- Outcrop and core observations
- Correlation of outcrop gamma-ray to offshore wells
- Lithofacies and well-log stacking patterns
- Biostratigraphy and limited radiometric dates
- Seismic and well-log geometries
- Basin-wide mapping



Offshore Santa Maria Basin
Approx. 7 Ma



422-1 Sequences and systems tracts



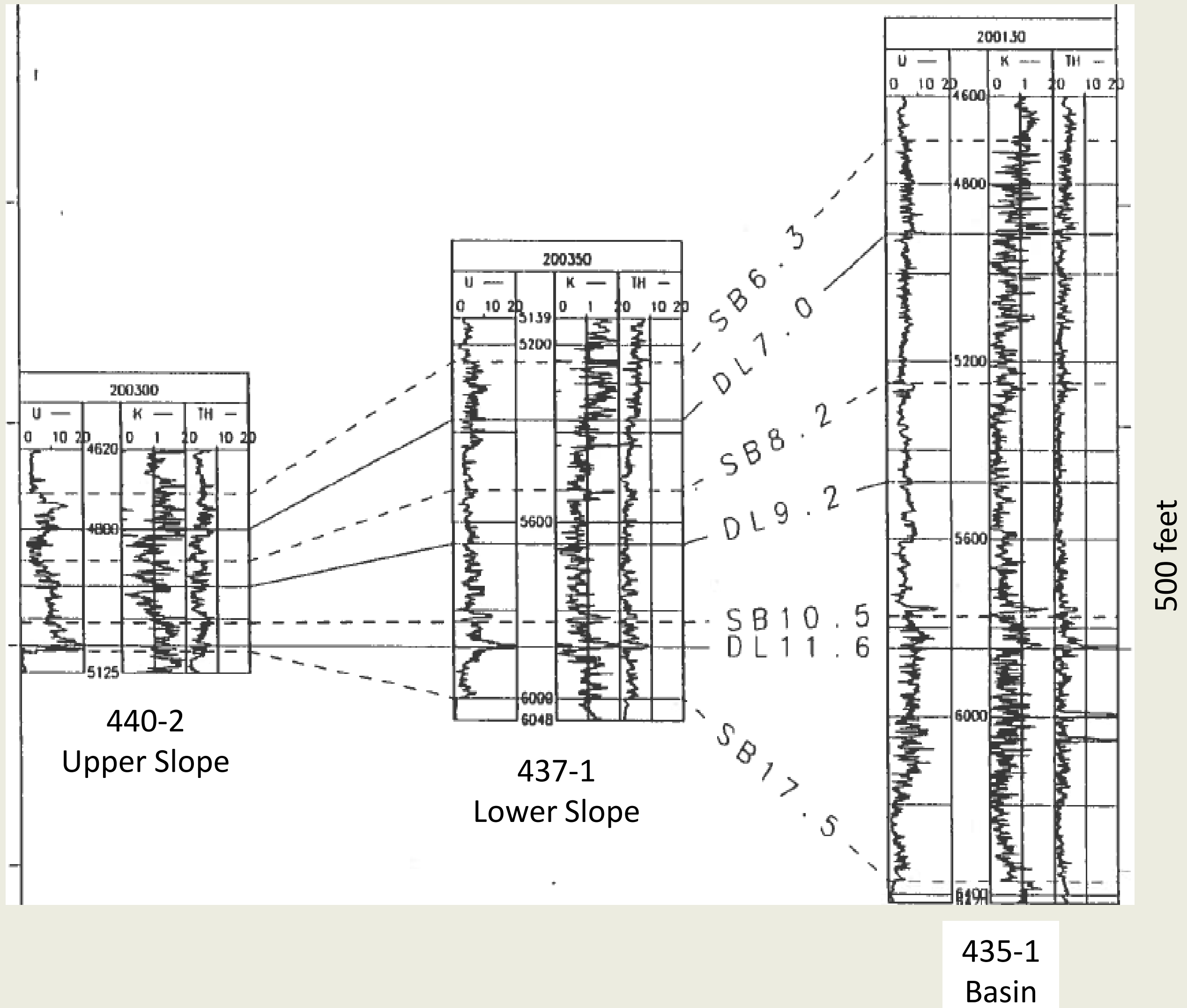
Offshore Santa Maria Basin: Spectral Gamma- Ray Correlation Section

Simplified Log Model Uses Gamma-Ray Proxies and Bulk Density Logs to Estimate Sediment Components

- U → TOC
- K → Detritus

Assume Remainder is Biogenic Silica

Ignores dolomite, phosphate, and calcite, but these are lesser components in the upper zones of the Monterey



Well-Log Calculated Sediment Accumulation Rates ($mg/cm^2/yr$) by Systems Tract and Depositional Environment

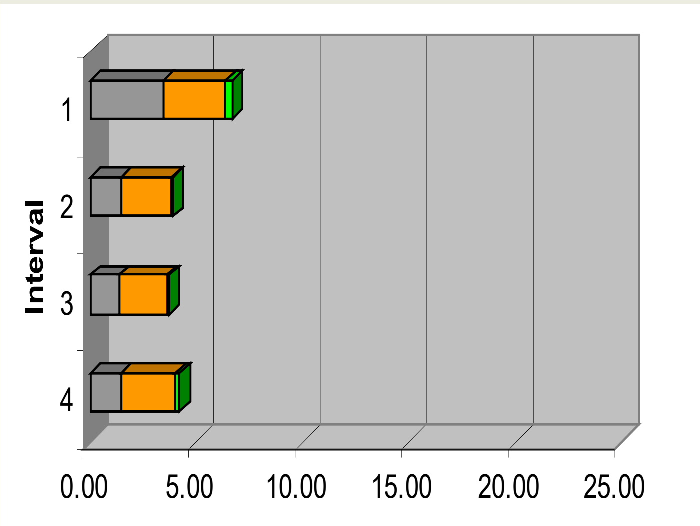
Systems Tract

HS

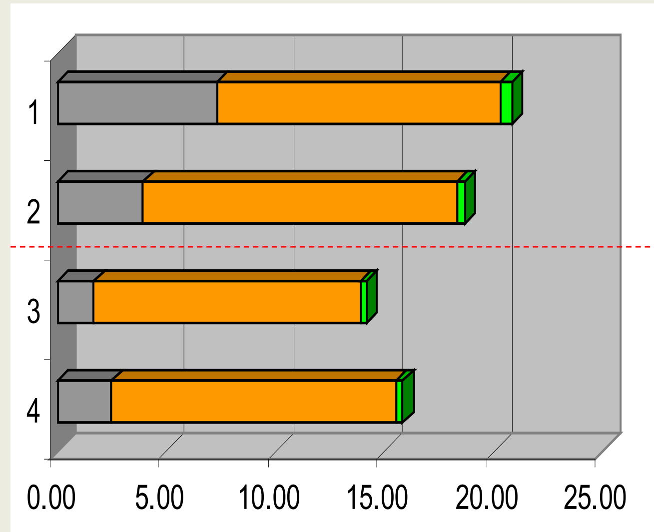
LS/T

HS

LS/T



440-2
Upper Slope



435-1
Basin

6.3-8.2 Ma Sequence

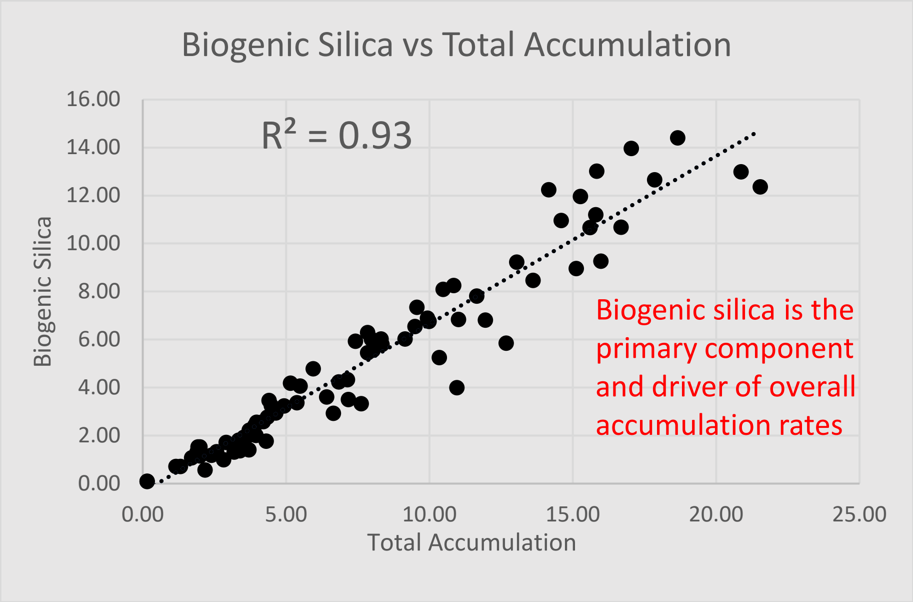
10.5-8.2 Ma Sequence

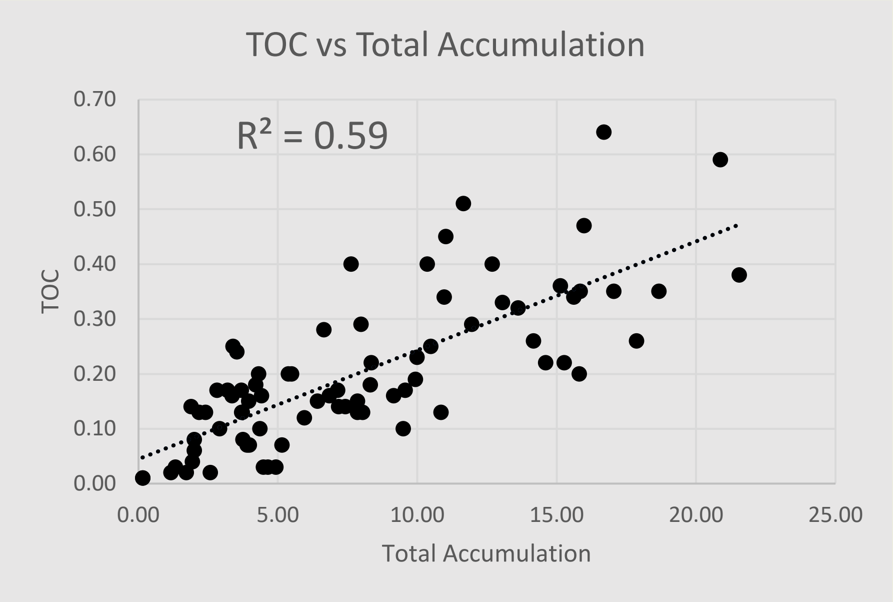
Detritus | Bio Silica | TOC

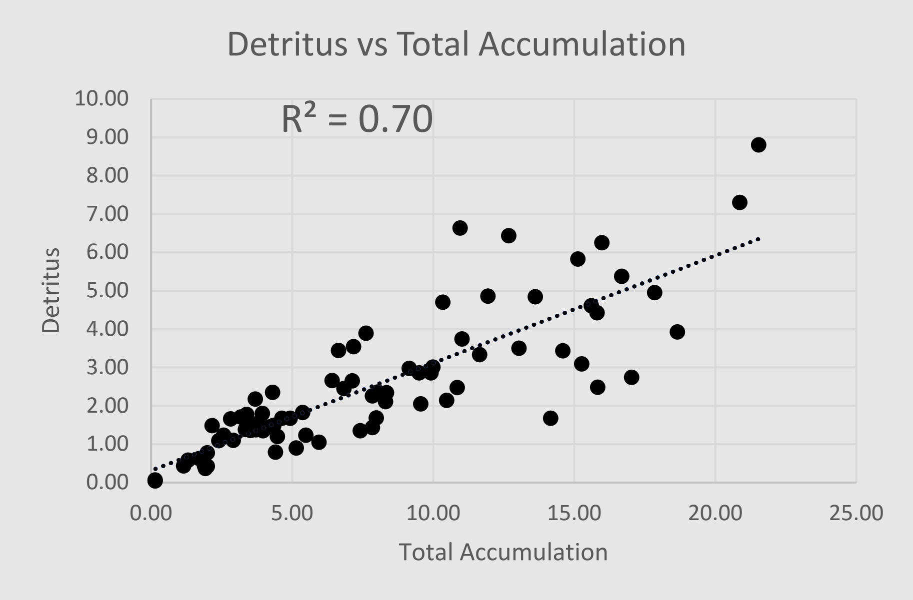
Highest Accumulation Rates in Basin Driven by Biogenic Silica

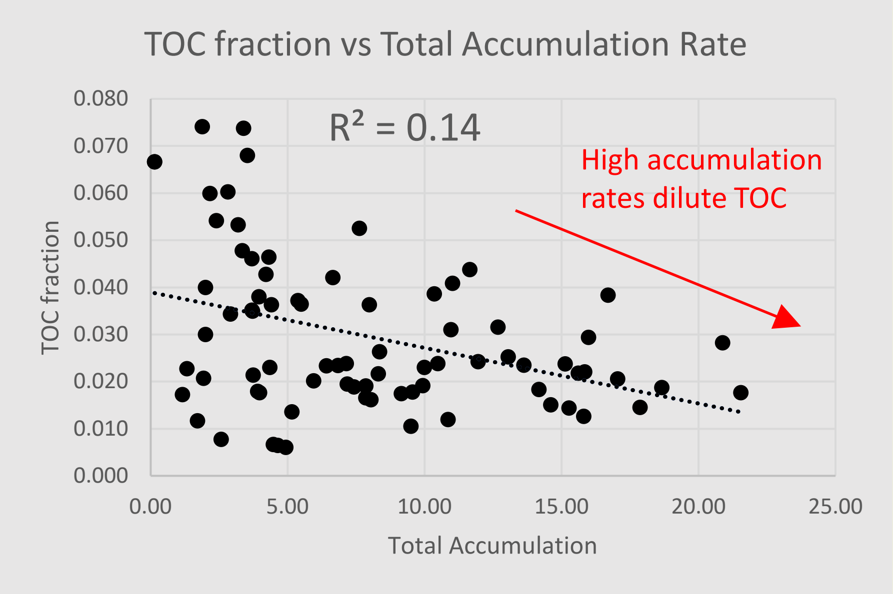
Well logs were screened for log quality and corrected for dip variation. 13 wells passed screening and were used for calculations.

Accumulation Rates (mg/cm²/yr), Offshore Santa Maria Basin



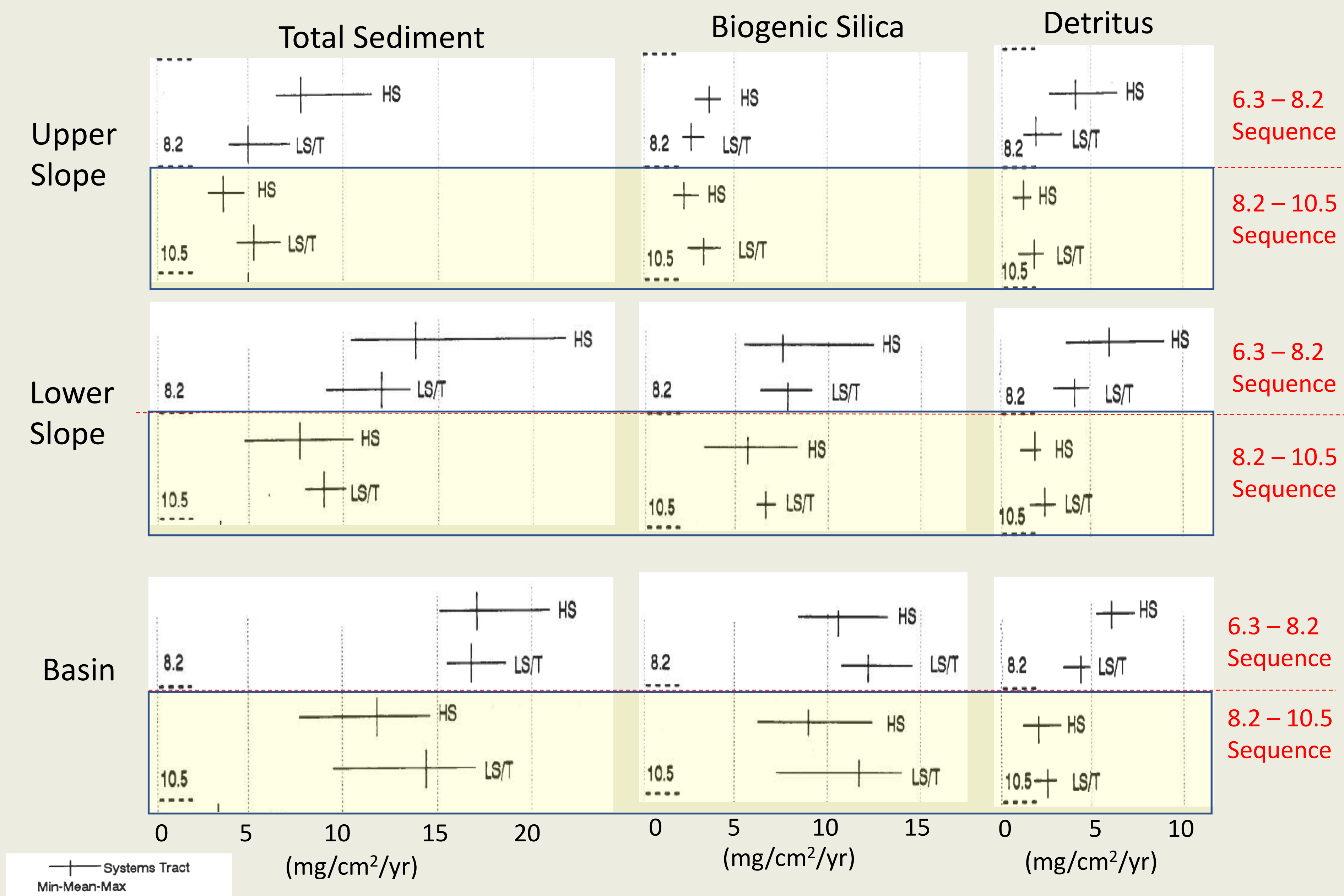






All Environments and Systems Tracts

Accumulation Rates by Systems Tract and Depositional Environment



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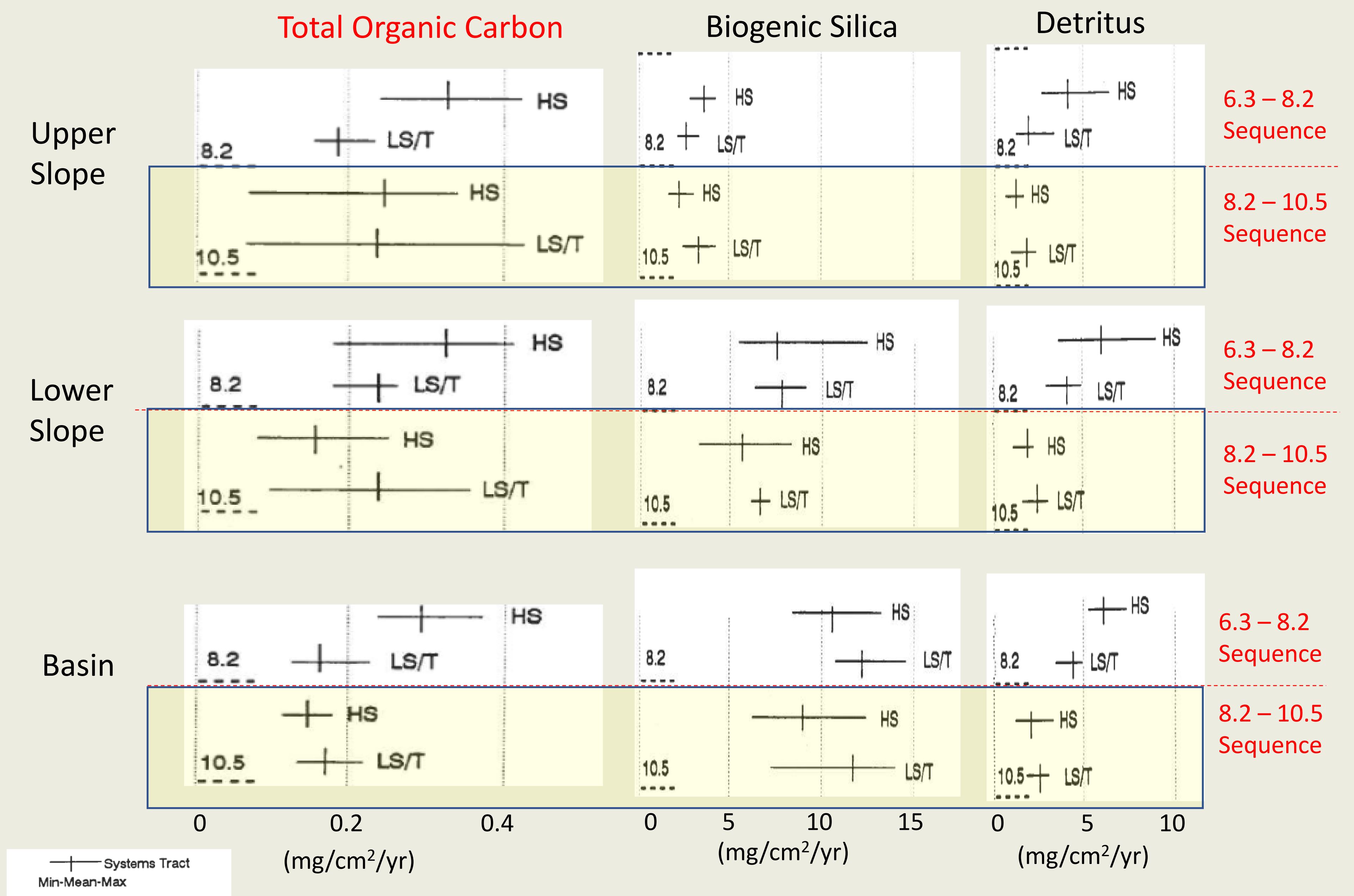
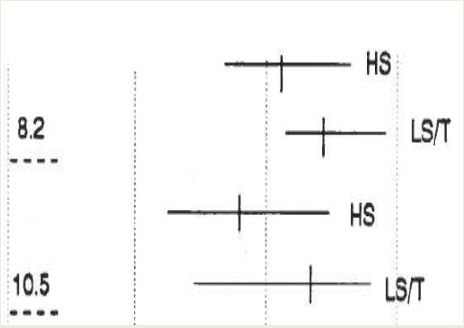
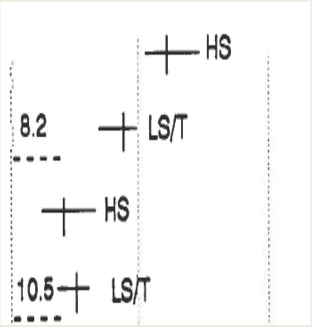


Sequence/Systems Tract Summary
Implications for Basin History

Biogenic Silica



Detritus



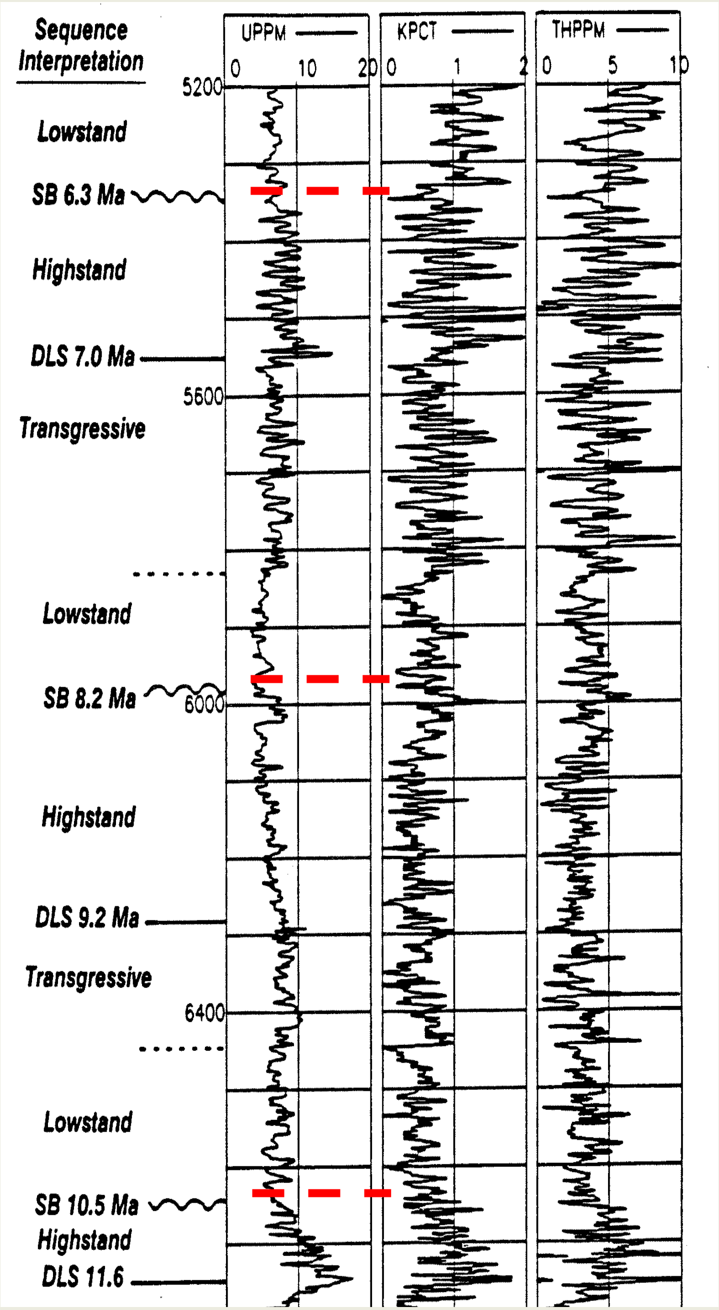
10.5 – 8.2 Ma sequence illustrates "outboard" basin model

- Increased accumulation rate dominated by biogenic silica during lowstand
- Lower accumulation rate but increased detritus fraction during the highstand

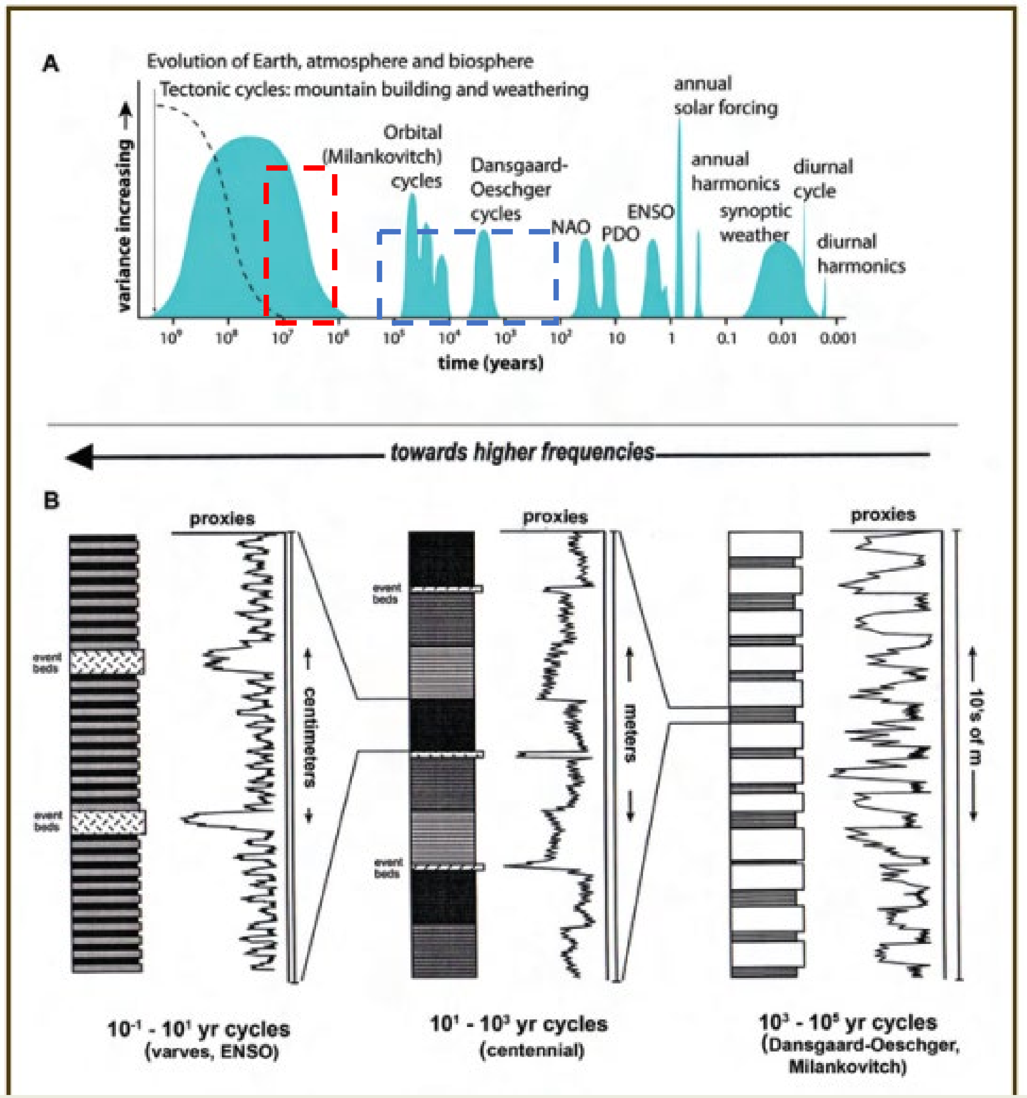
8.2 – 6.3 Ma sequence reflects increasing detritus input, possibly from the filling of "inner" basins or related to significant climate reorganization (Barron, 2022)

- Lowstand still characterized by increased biogenic silica
- Biogenic silica decreases in highstand but detritus increases significantly

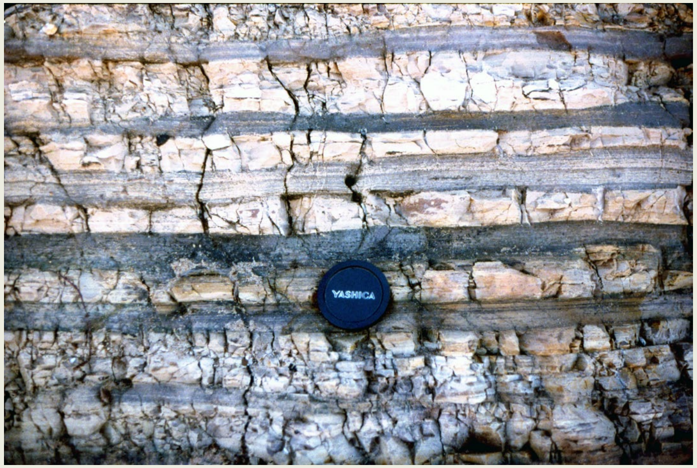
Improved chronostratigraphy to test the models and refine component quantification.



Monterey rocks record variation in silica productivity, detrital input, and geochemical cycles. Higher resolution chronostratigraphy may enable us to link these to various forcing mechanisms.

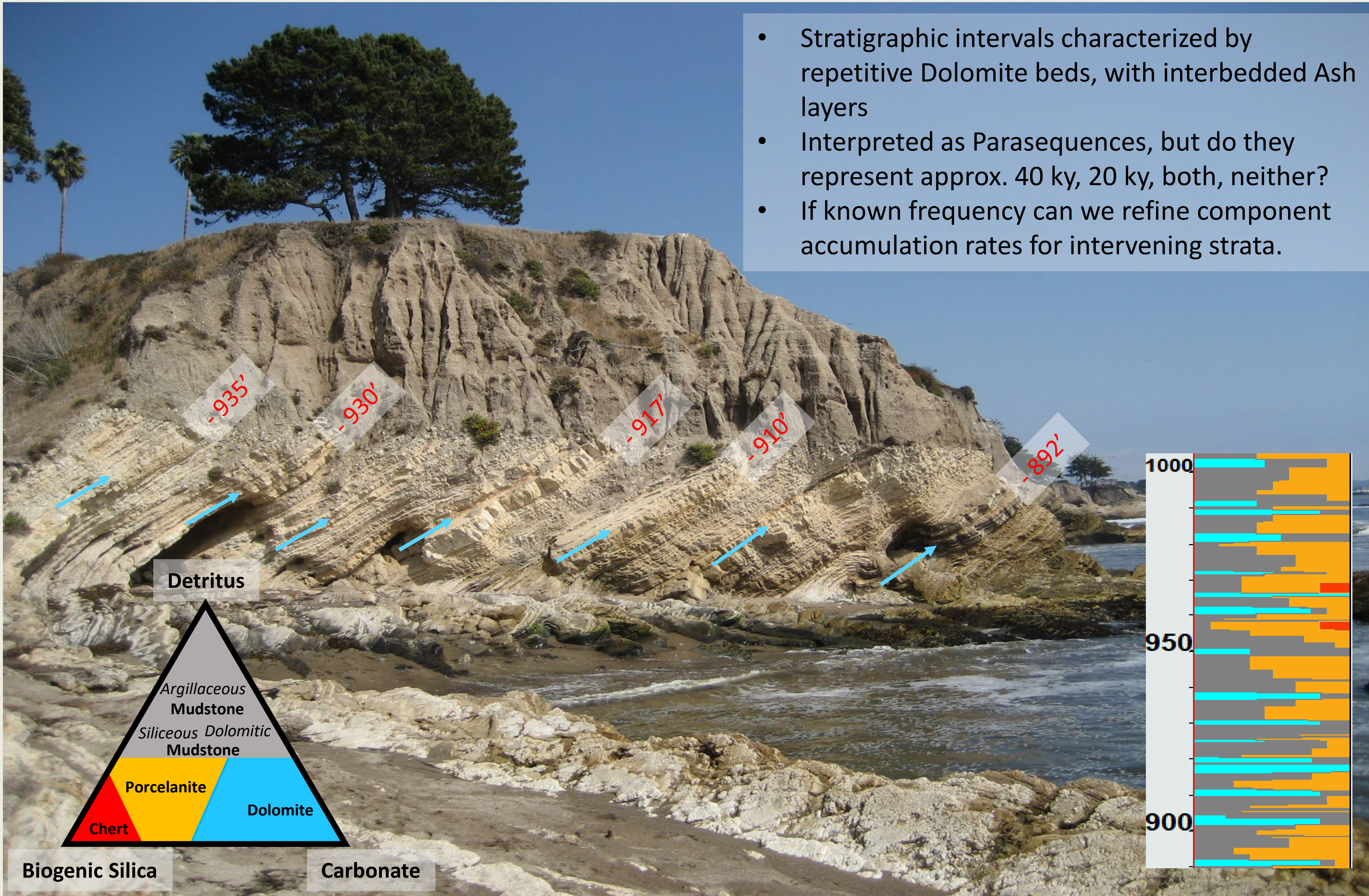


Thurow et al., 2009



One Opportunity Exists Unraveling the Stratal Stacking of Dolomite at Shell Beach

- Stratigraphic intervals characterized by repetitive Dolomite beds, with interbedded Ash layers
- Interpreted as Parasequences, but do they represent approx. 40 ky, 20 ky, both, neither?
- If known frequency can we refine component accumulation rates for intervening strata.



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