[PS]Modeling Reservoir Architecture of Isolated Carbonate Platforms*

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Abstract

Forward stratigraphic modeling of a conceptual isolated carbonate platform produces four distinct depositional profiles determined essentially by water depth. The depositional profiles described below have characteristic facies belt dimensions, geometries, facies-proportions and stratigraphic occurrences. These simulations help to predict facies belt geometries and constrain facies belt dimensions for isolated platform reservoirs like those found in the Caspian Basin.

Profile A (shallowest) shows a grainstone shoal margin on the high-energy edge of the platform, 250-500 m wide, with a raised rim and shallow platform interior dominated by packstones. Profile B also shows a high-energy grainstone rim, 500-1000 m wide with no significant margin relief, and a platform interior dominated by packstones. Profile C occurs in a deeper bathymetric setting; high-energy conditions flood the platform, and platform-centered grainstone shoals develop with widths of 2000 – 5000 m. Profile D (deepest profile) has deeper water packstones developed across the platform top, with no grainstone development.

In an aggrading platform with only monotonous sea-level rise and no sea-level cyclicity, only profile B develops. This is the stable-state for platform-growth in this model. During sea-level stillstands, profile A will eventually develop. During a deepening sequence, profiles B, C, and D develop in rapid succession prior to final drowning. Profiles C and D can be considered transient or unstable states, as their productivity rates are too low to keep up with sea-level rise, and thus are rare during times of monotonous sea-level rise. However, when sea-level cycles are introduced, unstable profiles C and D may dominate the platform. Grainstones (profile C) or packstones (profile D) can dominate platform-top deposition throughout the cycle, with abrupt shallowing to the raised grainstone rim (profile A) occurring at maximum sea-level fall.

Modeling Reservoir Architecture of Isolated Carbonate Platforms

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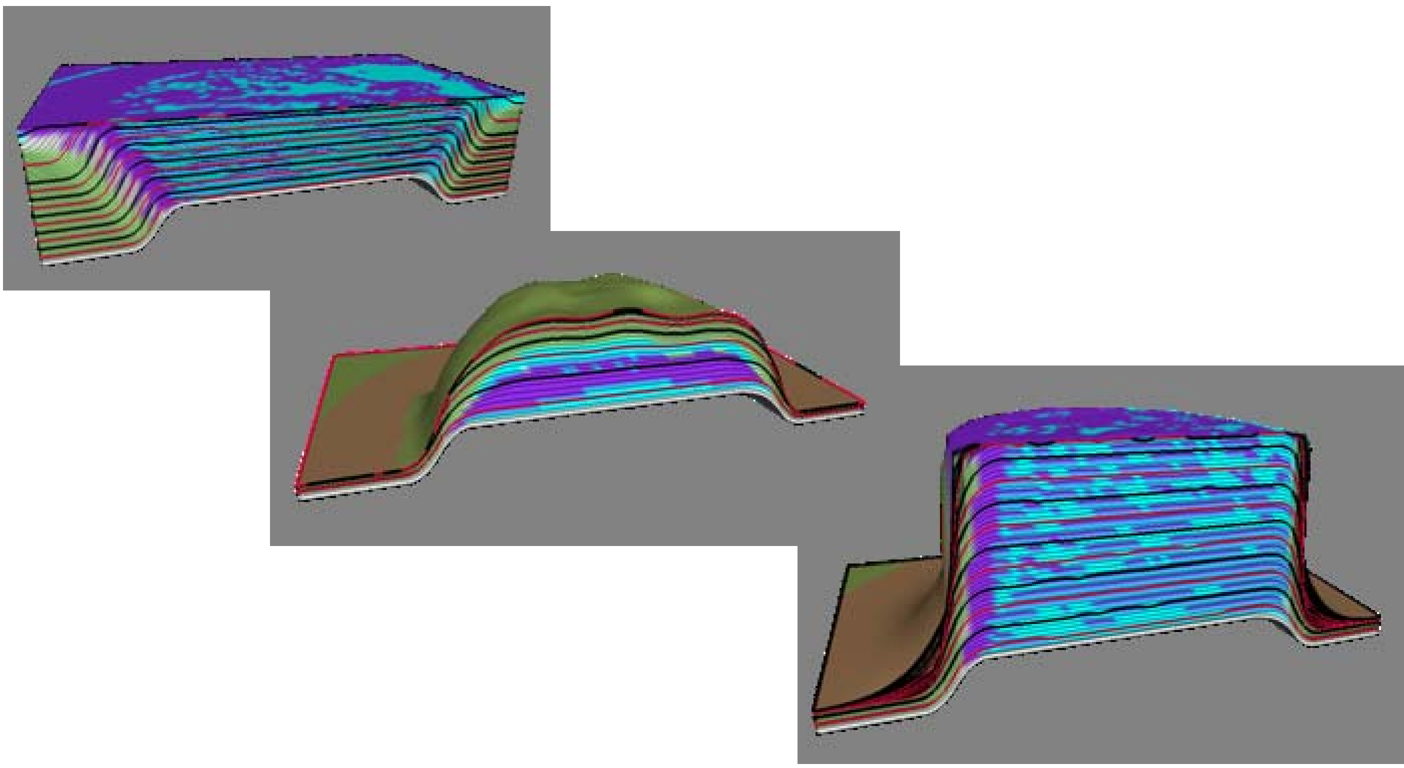
Can forward stratigraphic modeling add insight to our understanding of architecture and reservoir distribution in isolated platforms?

We investigate a series of simple models where sea-level is varied in both a linear and cyclic fashion.



Workflow

Build a base-case model

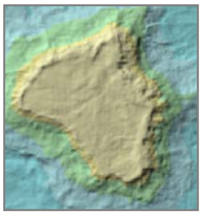
Generate a range of simulations with varying rates of accommodation change (both linear and cyclic)

Analyze these models:

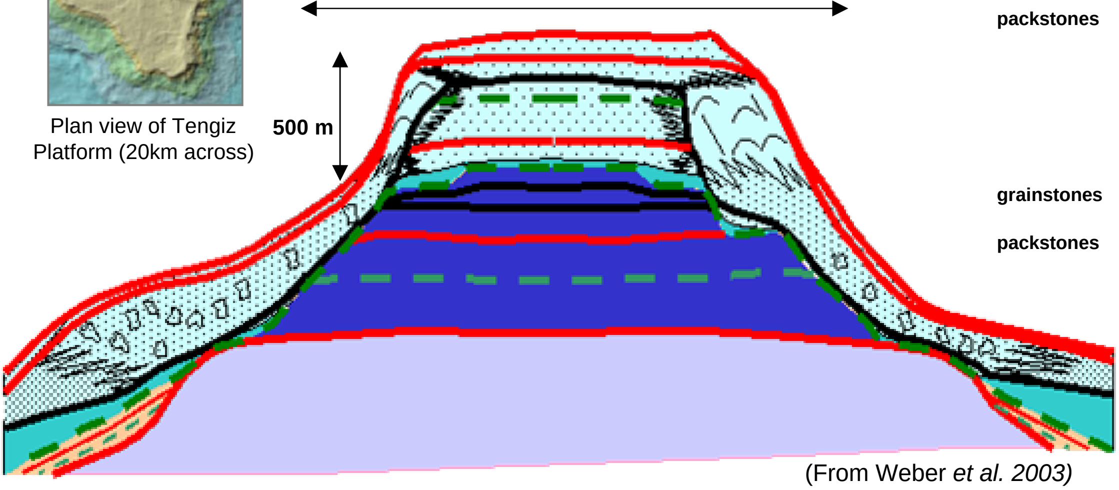
- Gross platform geometries
- N/G and reservoir volume
- Resulting depositional profiles
- Examine root causes of changes
- Implications for sequence stratigraphic interpretations

Build a Base Case Model

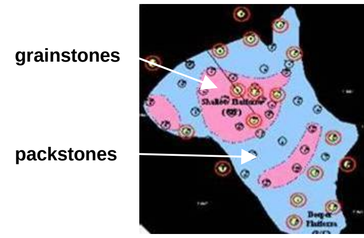
Parameters chosen to approximately resemble a Carboniferous grain-dominated platform with microbial boundstone slopes like Tengiz



Plan view of Tengiz Platform (20km across)

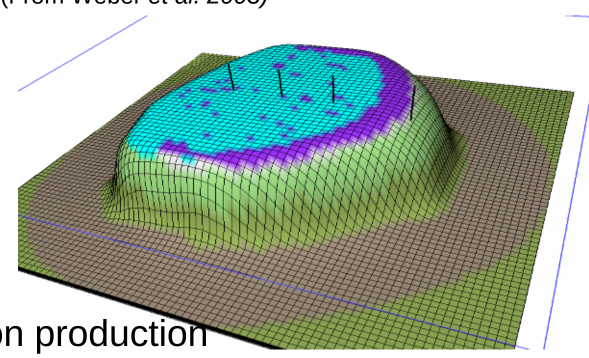


(From Weber *et al. 2003)*



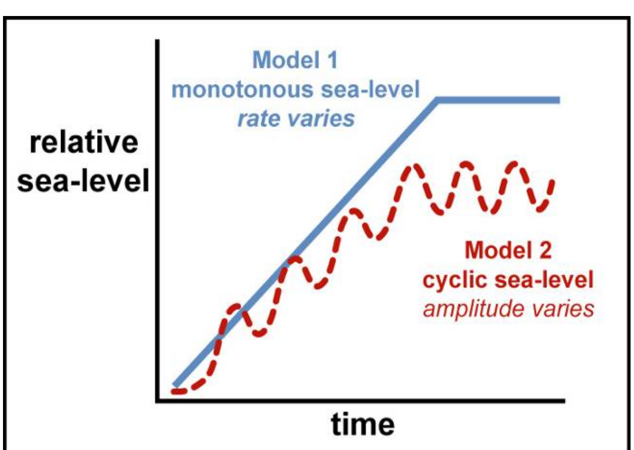
Platform-center grainstones

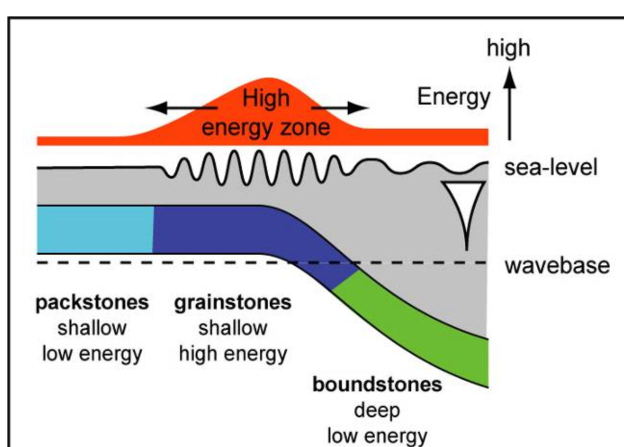
Platform-rim grainstones



<u>Input parameters :</u>

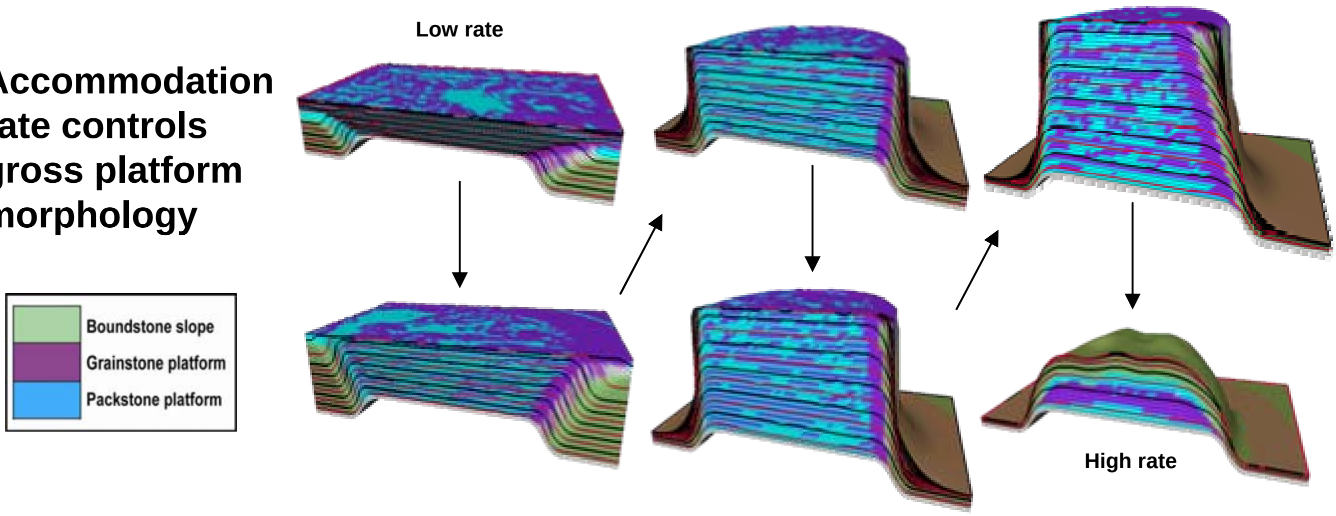
Model size = 20 km x 20 km
Cell size = 250 m x 250 m (80 x 80 cells)
Time step = 0.5 Ma for 30 Ma duration
Production rules : depth and energy control on production
Transport rules : downslope transport (gravity)
Accommodation changes : linear (model 1) and **cyclic** (model 2)



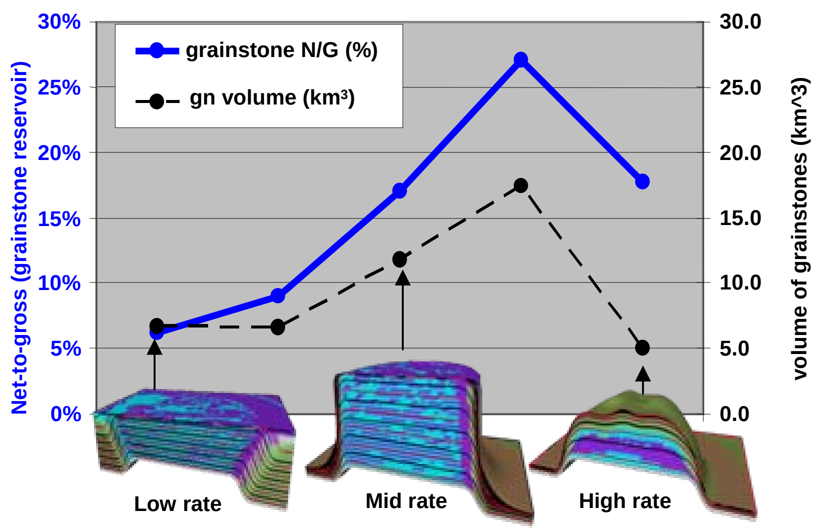


Linear Accommodation-Increase Simulation

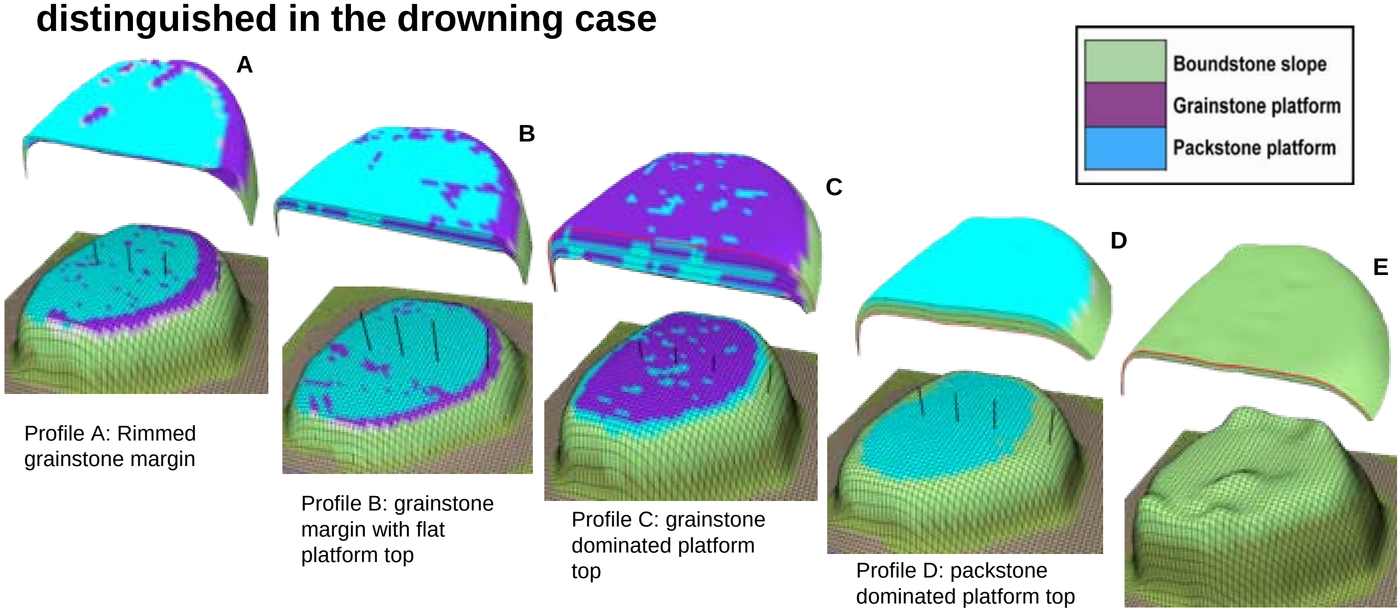
Accommodation rate controls gross platform morphology



Reservoir volume and net-to-gross increase with increasing accommodation rate up to a drowning threshold



Five seemingly depth-dependent depositional profiles (A-E) have been distinguished in the drowning case



Profile A: Rimmed grainstone margin

Profile B: grainstone margin with flat platform top

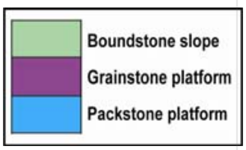
Profile C: grainstone dominated platform top

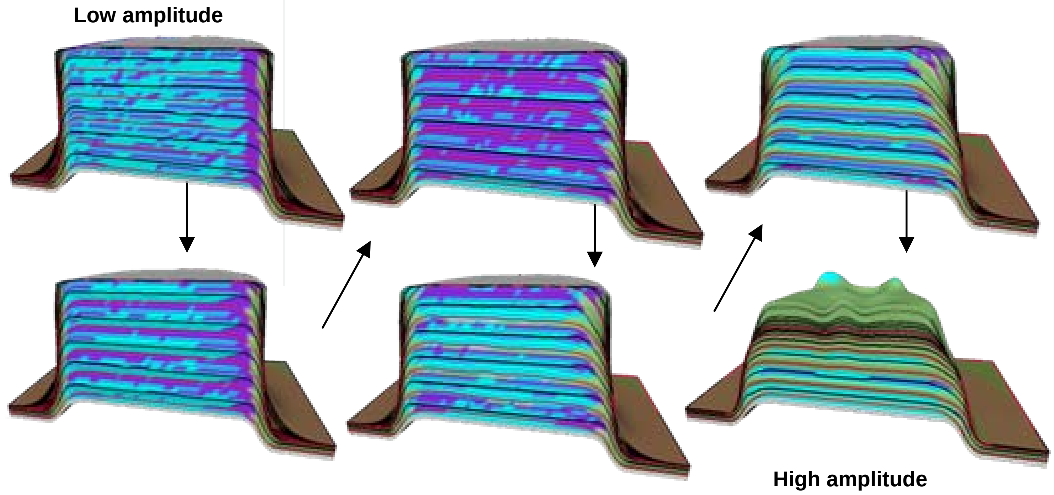
Profile D: packstone dominated platform top

Profile E: drowned platform

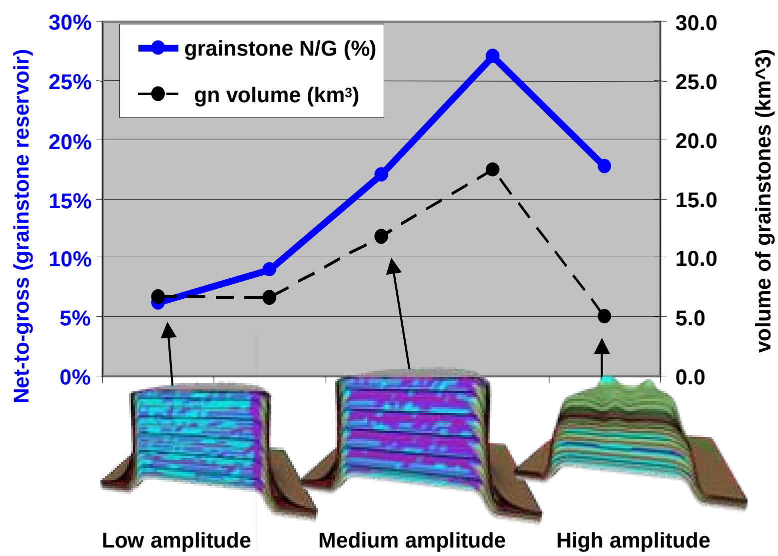
Cyclic Accommodation-Increase Simulation

Cycle amplitude controls stacking pattern



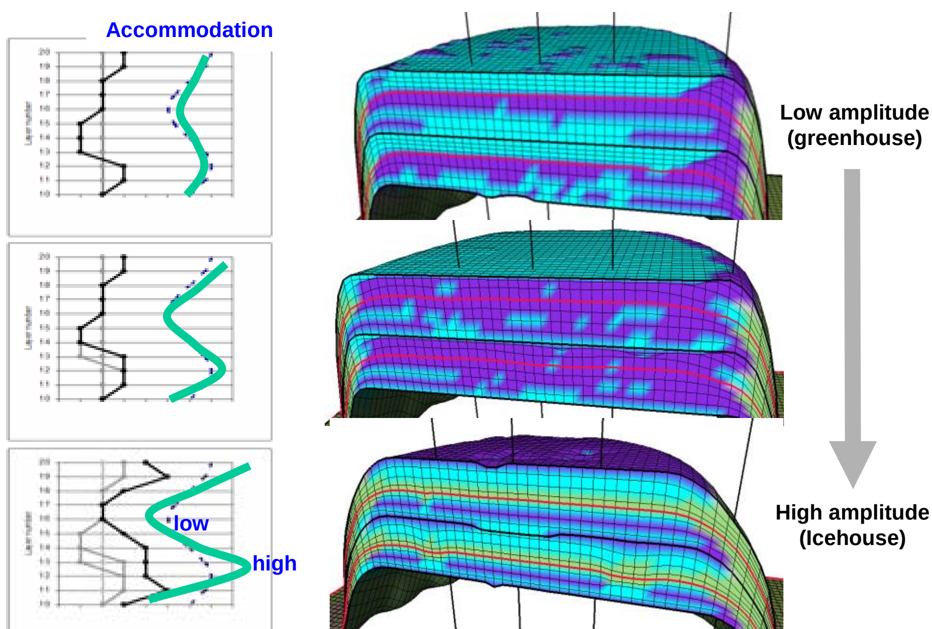


Reservoir volume and net-to-gross increase with increasing cycle amplitude up to a drowning threshold



Applying low-amplitude accommodation cycles initially creates symmetrical oscillations of the depositional profile-type around the “stable state” (profile B)

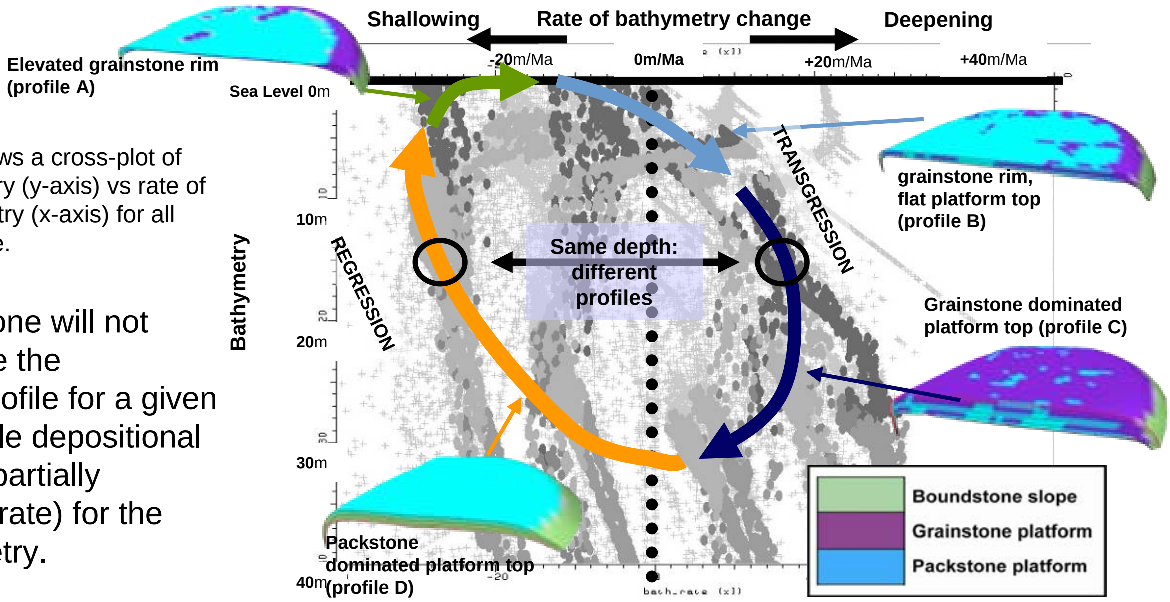
With increasing accommodation cycle amplitude asymmetry of depositional profiles develops & deepening occurs within each cycle



Implications for Sequence Stratigraphic Interpretations

The plot (right) shows a cross-plot of values of bathymetry (y-axis) vs rate of change of bathymetry (x-axis) for all cells from one cycle.

Bathymetry alone will not uniquely define the depositional profile for a given system: multiple depositional profiles exist (partially dependent on rate) for the same bathymetry.



The interpreted positions of Sequence Boundaries & Maximum Flooding Surfaces change relative to accommodation cycle change with cycle amplitude

Low amplitude accommodation cycles

-Sequence Boundaries (SB) 180 degrees out of phase with accommodation cycle (SB occurs at sea-level highs)

-SB picked is diachronous

- Maximum Flooding Surface (MFS) is 90 degrees out of phase with accommodation cycles

High amplitude accommodation cycles

- Sequence Boundaries & Maximum Flooding Surfaces in phase with accommodation lows & highs respectivley