Analyzing Reservoir Architecture of Isolated Carbonate Platforms*

By
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Search and Discovery Article #40295 (2008)
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See companion article, "Modeling Reservoir Architecture of Isolated Carbonate Platforms," Search and Discovery Article #40294 (2008).

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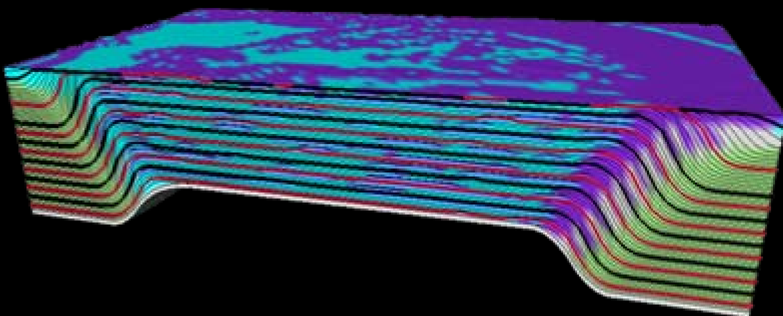
Abstract

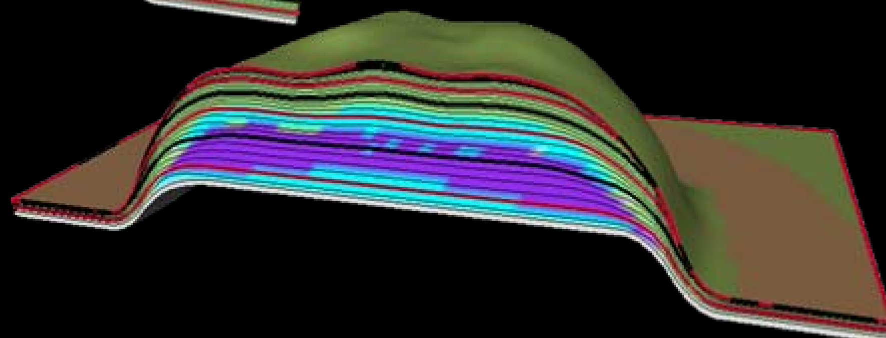
Forward stratigraphic modeling of a conceptual isolated carbonate platform produces four distinct depositional profiles, determined essentially by water depth, with characteristic facies belt dimensions and lateral relationships. Profile A (shallowest) shows a grainstone shoal margin on the high-energy 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.

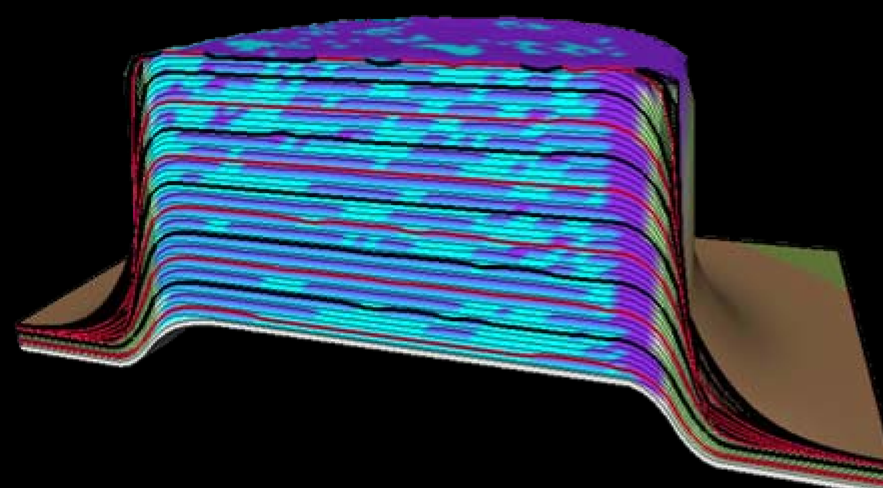
In an aggrading platform with only monotonous sea-level rise and no sea-level cyclicity, only profile B develops. This is the stable-state for platform-growth in this model. During sea-level stillstands, profile A will eventually develop. During a deepening sequence, profiles B, C, and D develop in rapid 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.

The depositional profiles described above 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 found in the Caspian Basin.

Analyzing Reservoir Architecture of Isolated Carbonate Platforms







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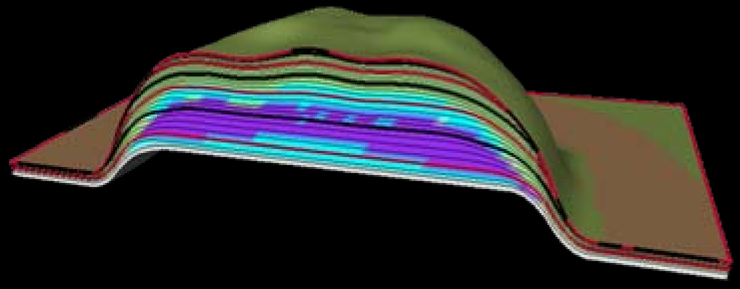
Introduction & aims

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

Investigate a series of simple models where we vary sea-level in both a monotonous & cyclic fashion.



Method & outline

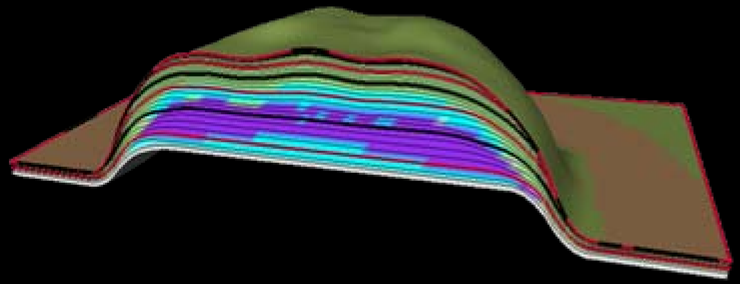
Build a base-case model

generate a range of simulations with varying rates of accommodation change (both monotonous & cyclic)

Analyze these models:

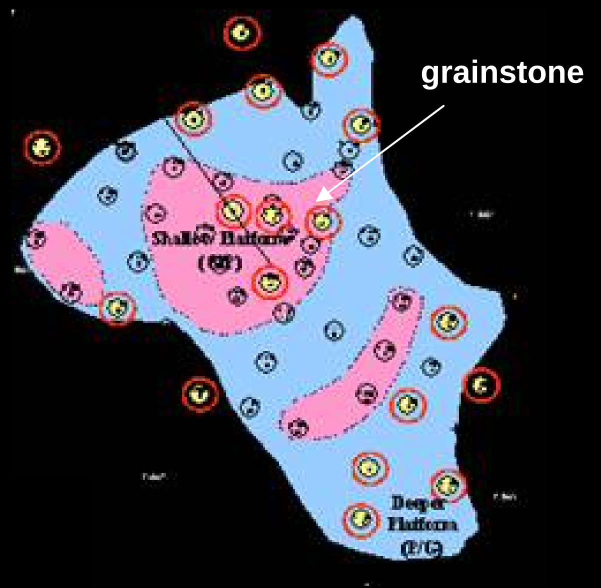
- gross platform geometries
- n/g & reservoir volume
- resulting depositional profiles
- examine root causes of changes
- implications for sequence stratigraphic interpretations

Conclusions

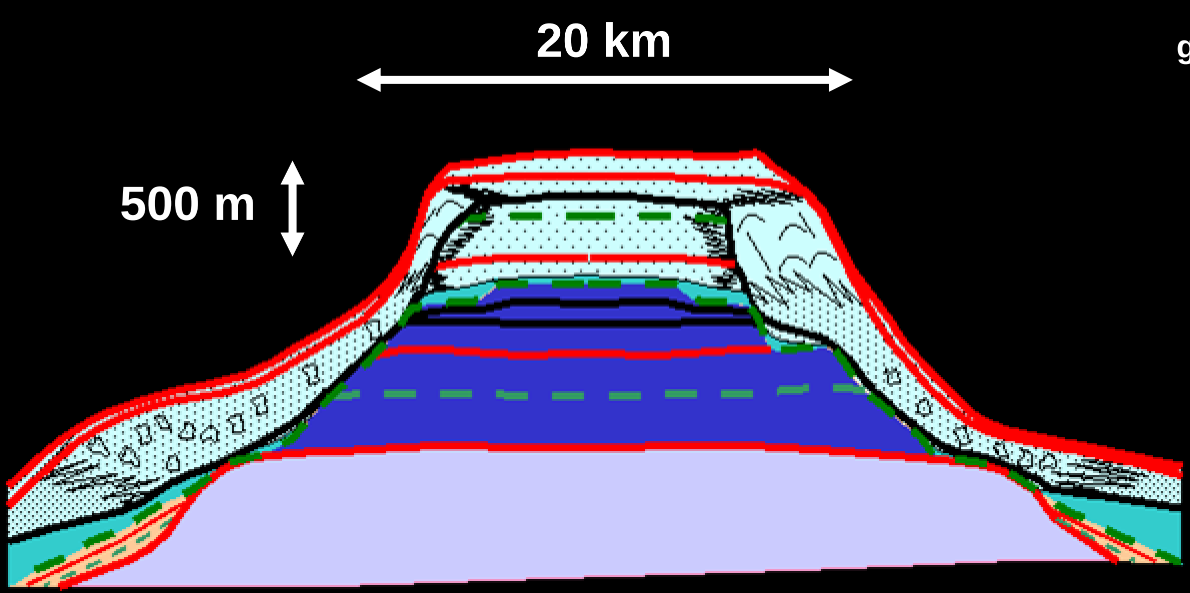


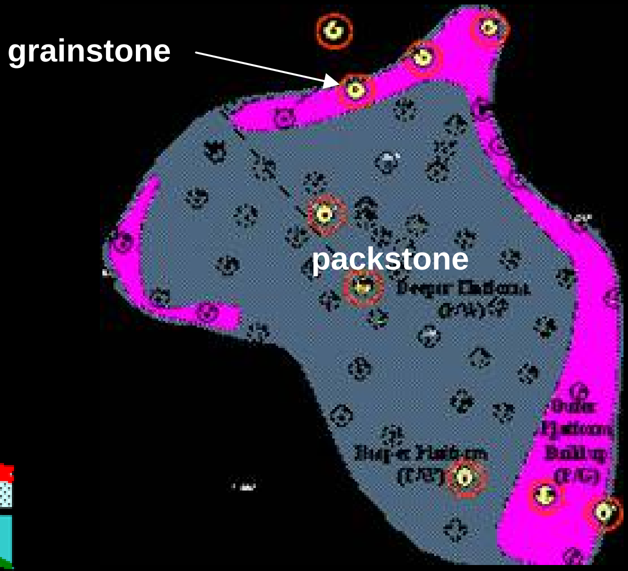
Building a base-case model

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



Platform-center grainstones

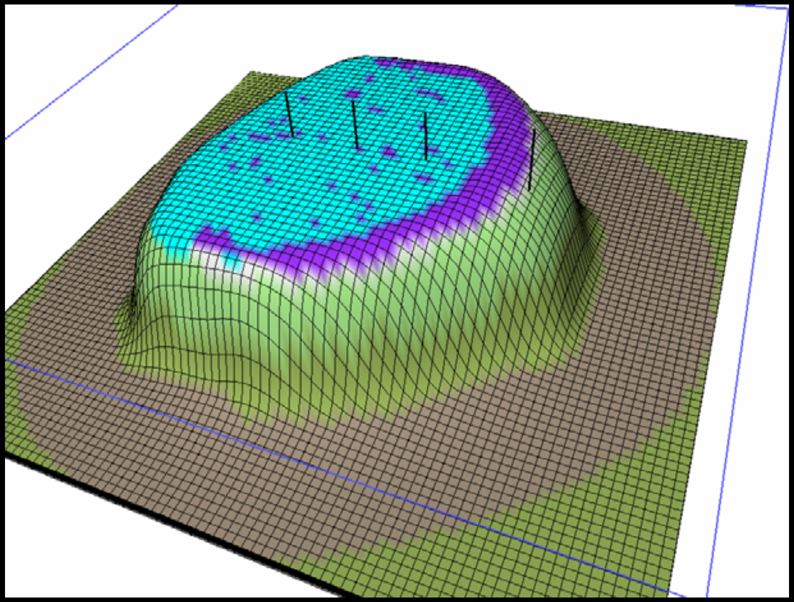




from Weber et al., 2003

Platform-rim grainstones

Building a base-case model: using Dionisos…



<u>Input parameters :</u>

Model size = 20 km x 20 km

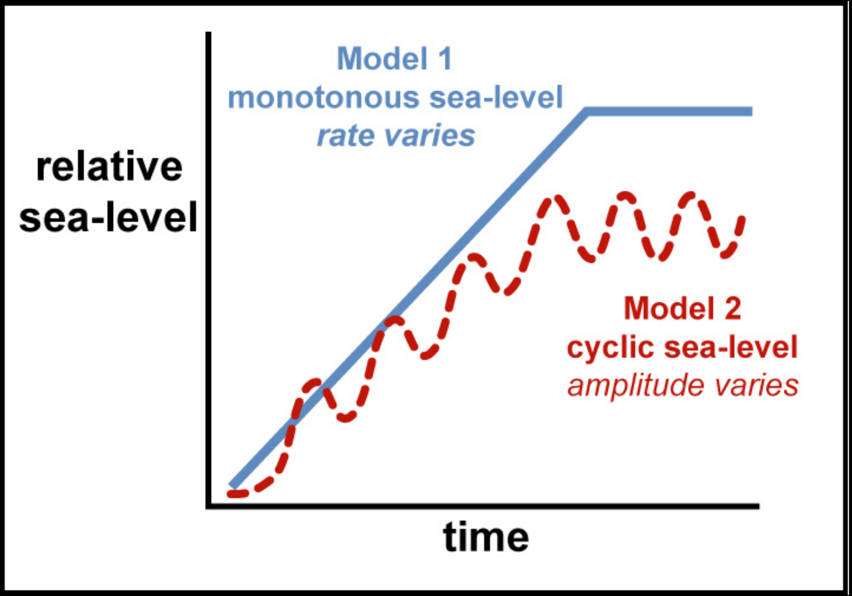
cell size = 250 m x 250 m (80x80 cells)

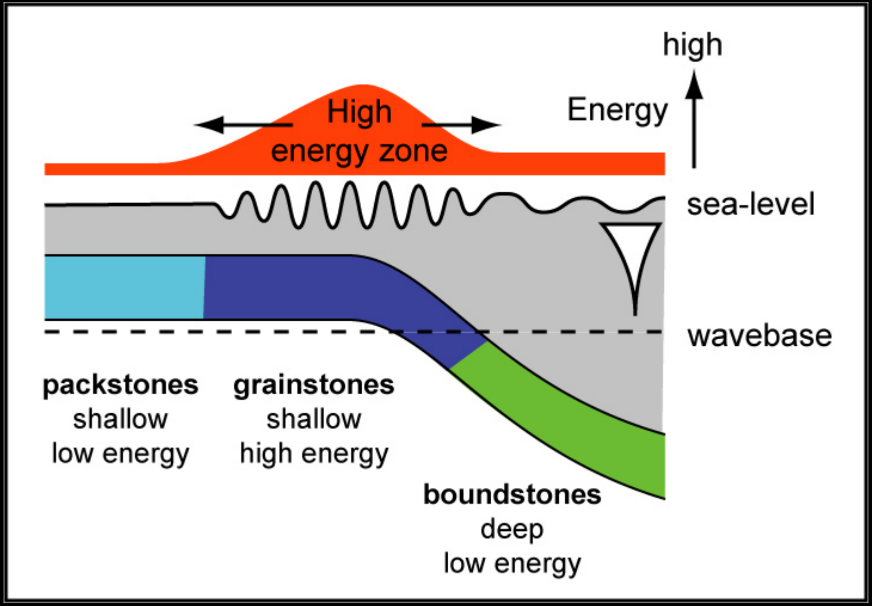
time step = 0.5 Ma for 30 Ma duration

production rules : depth & energy control on production

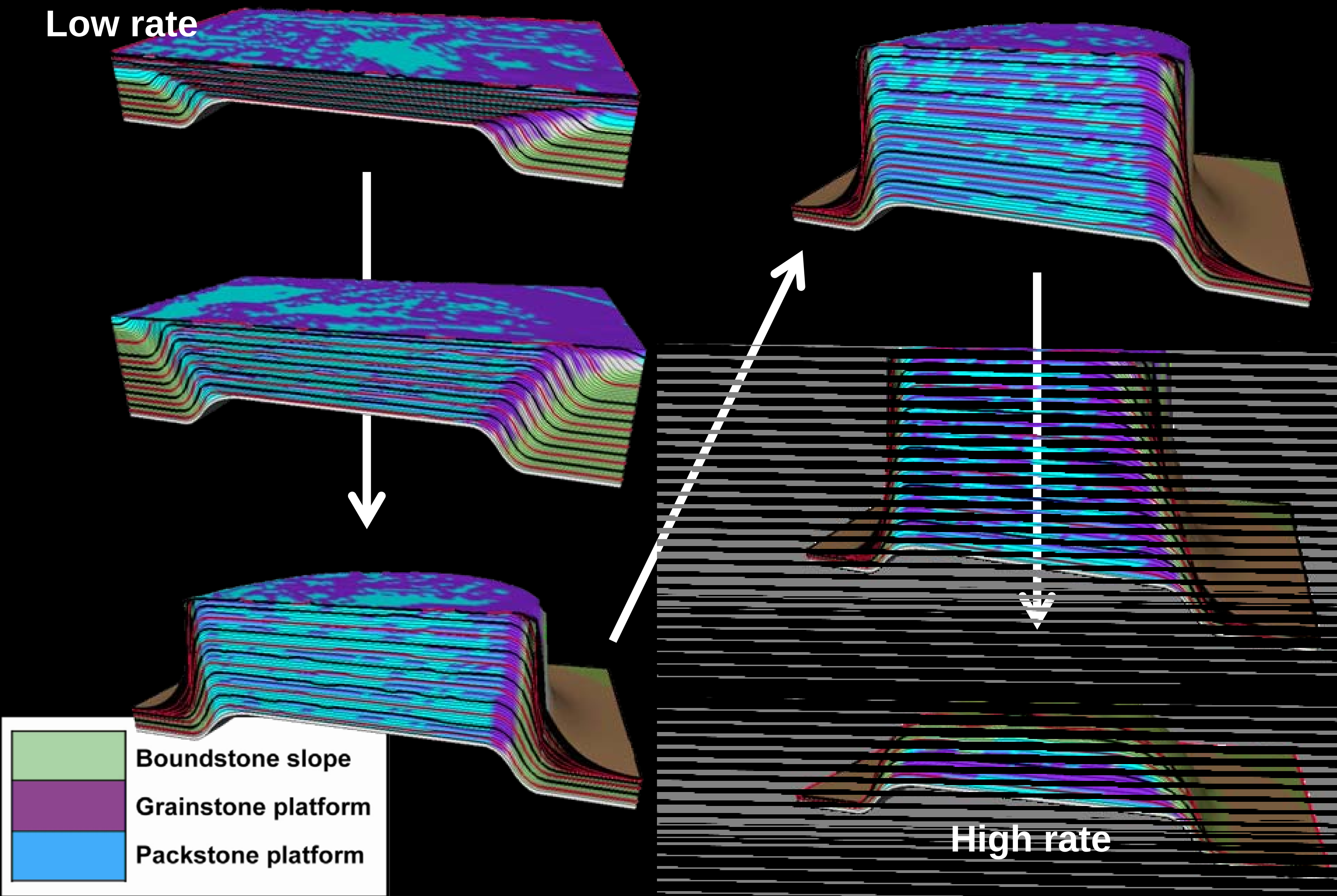
transport rules : downslope transport (gravity)

accommodation changes : linear (model 1) & cyclic (model 2)

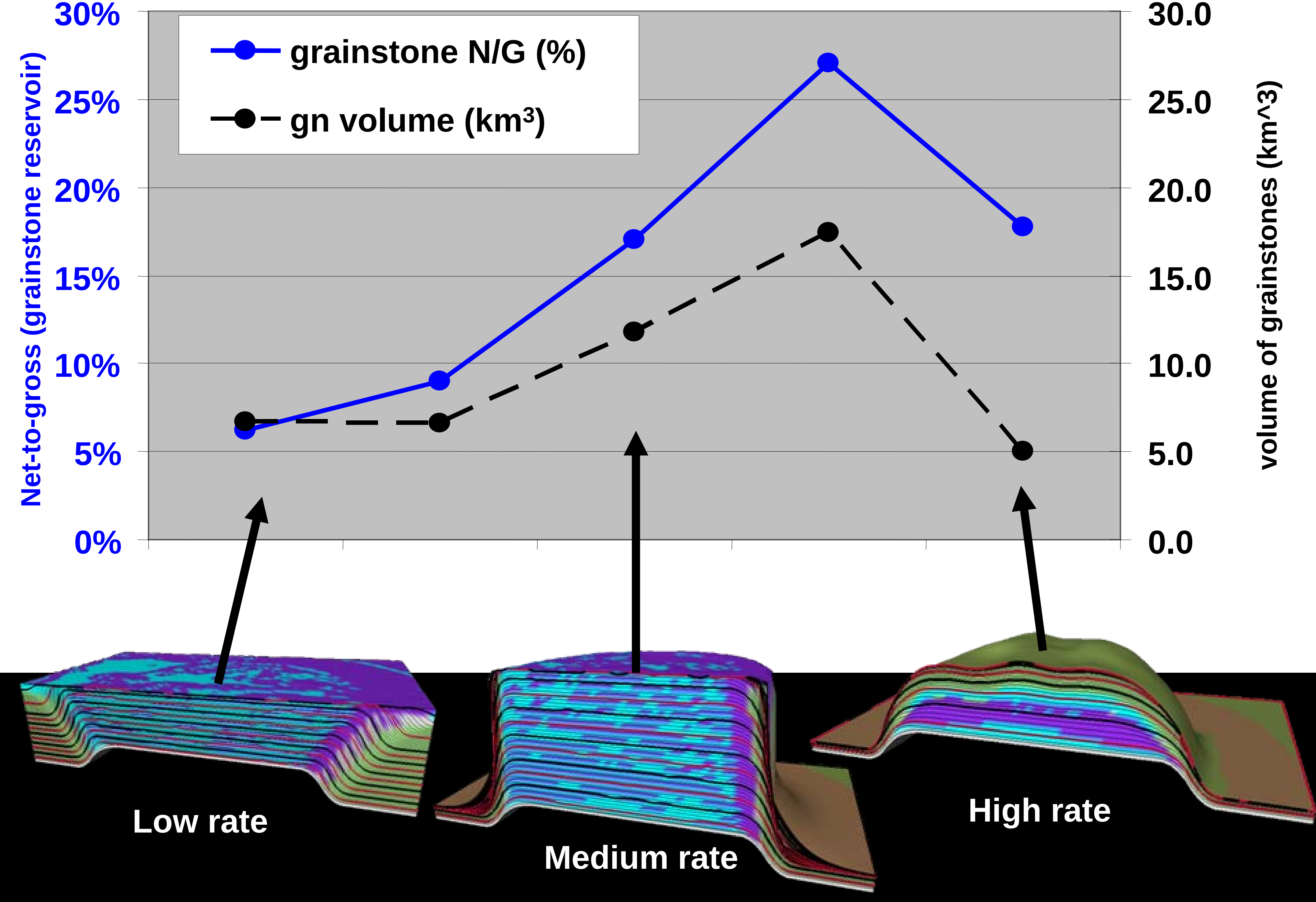




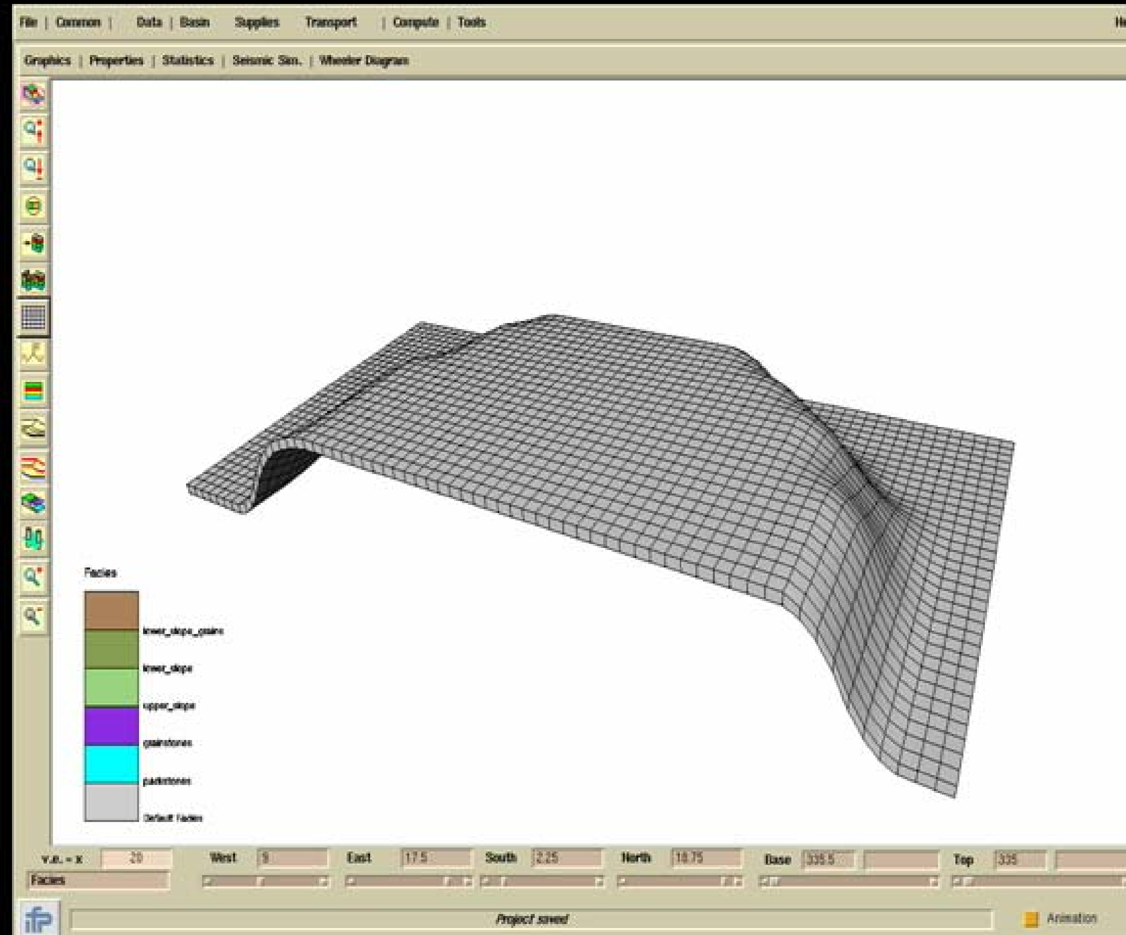
Linear accommodation increase model



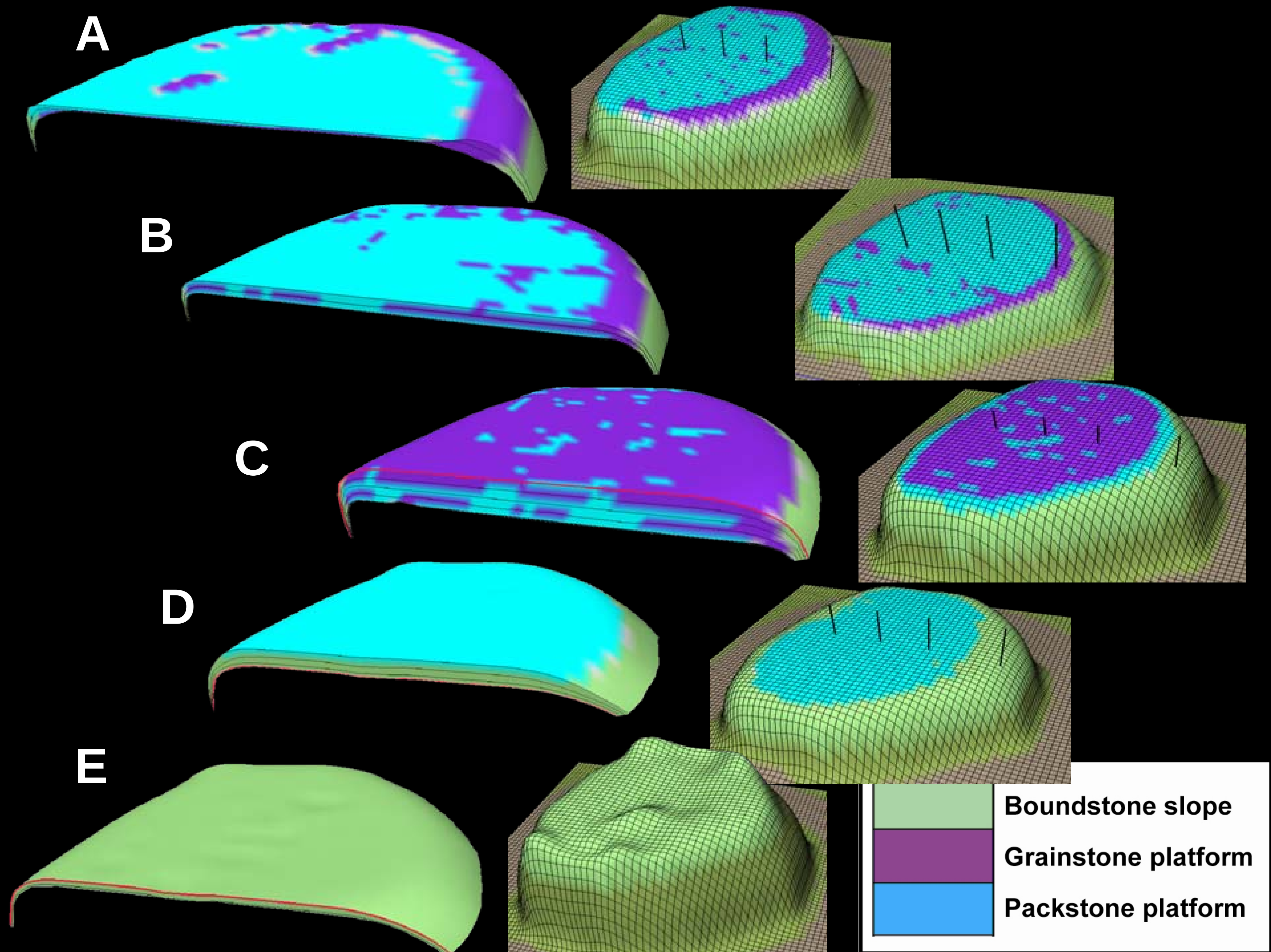
Net-to-gross variation with accommodation rate



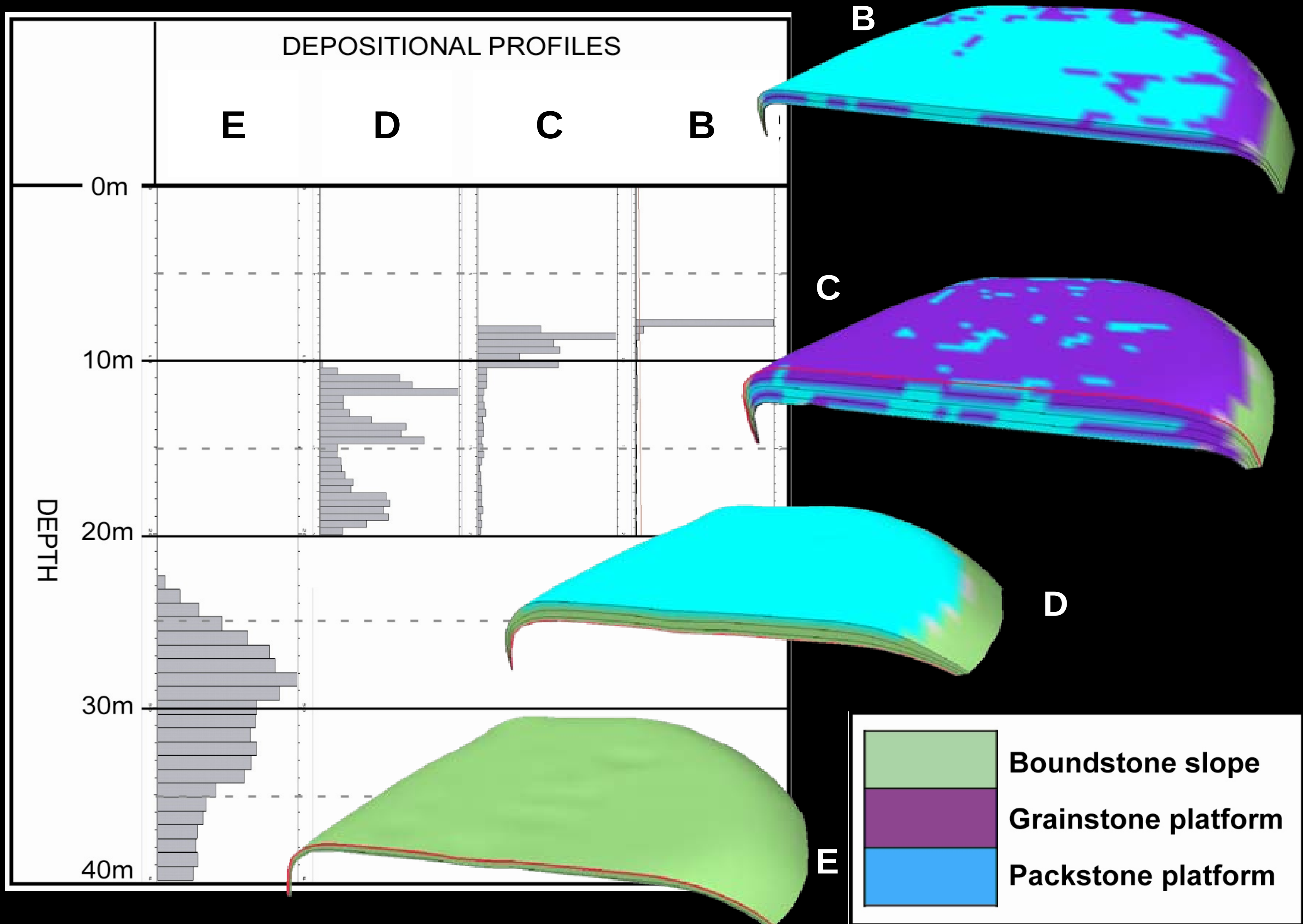
Drowning with linear accommodation increase



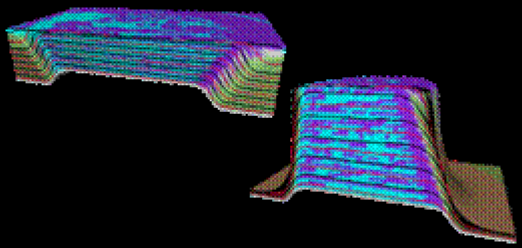
- Boundstone slope
- Grainstone platform
- Packstone platform


A
B
C
D
E
Boundstone slope
Grainstone platform
Packstone platform

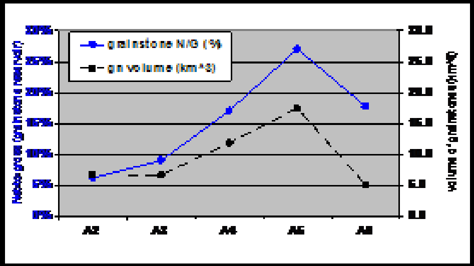
Bathymetry variations with depositional profile



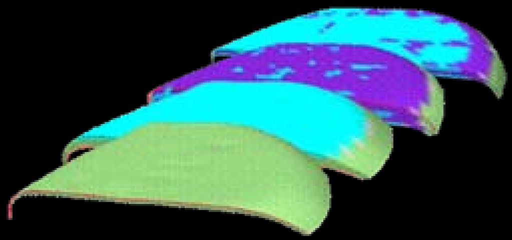
Linear accommodation model results



1. **Accommodation rate controls gross platform morphology**

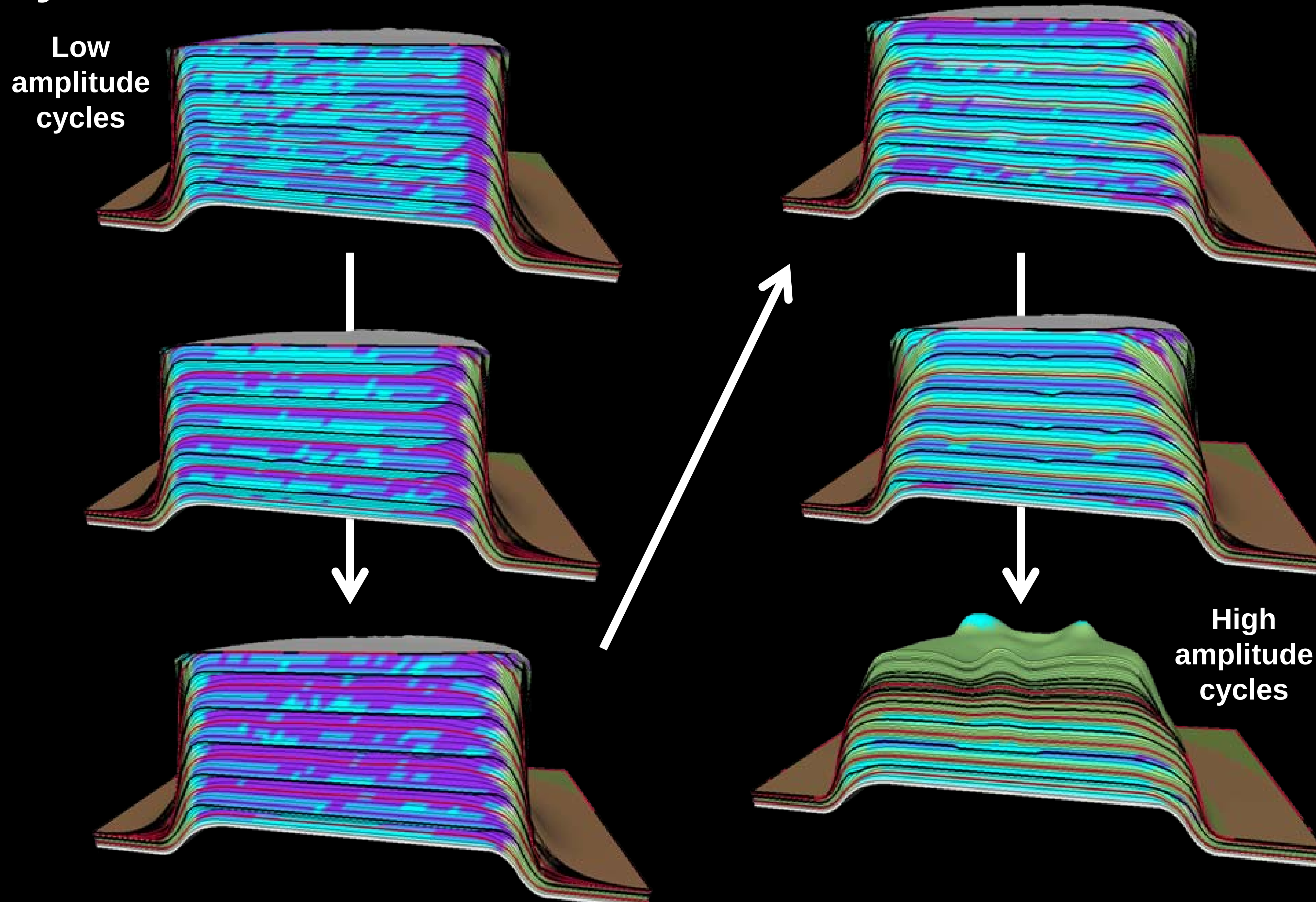


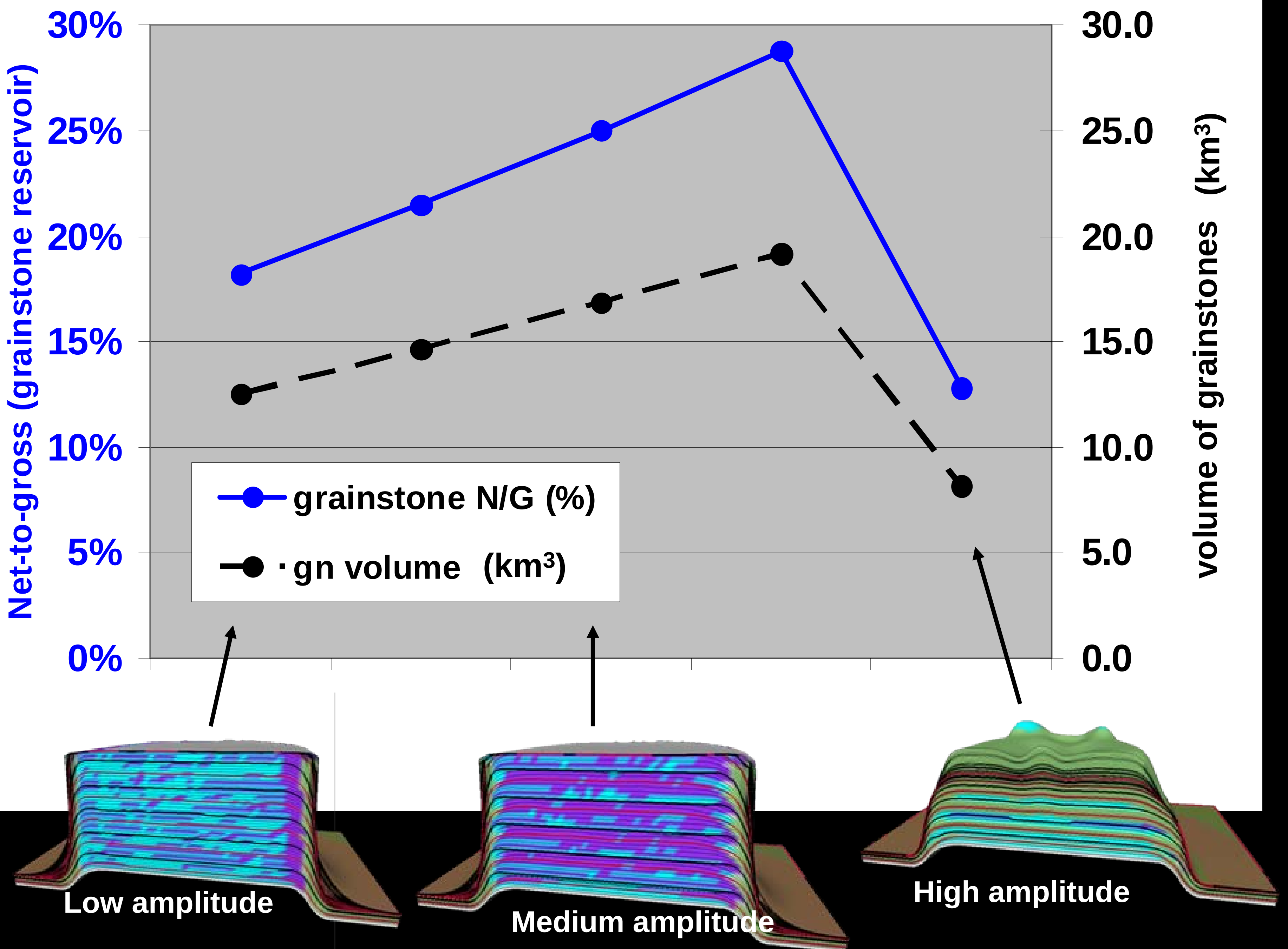
2. **Reservoir volume & net-to-gross increase with increasing accommodation rate up to the drowning threshold**



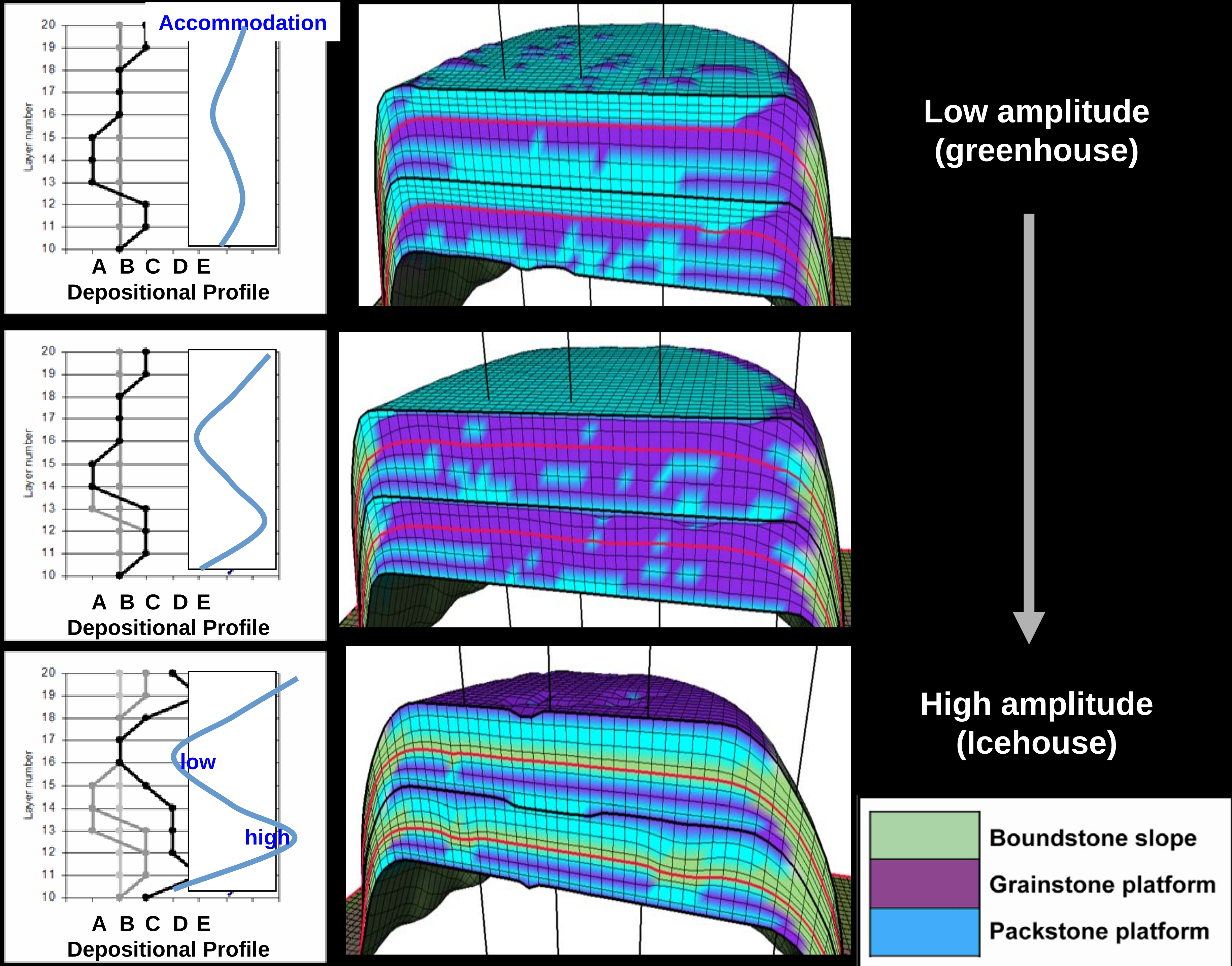
3. **Five seemingly depth-dependent depositional profiles (A-E) have been distinguished in the drowning case**

Cyclic accommodation model

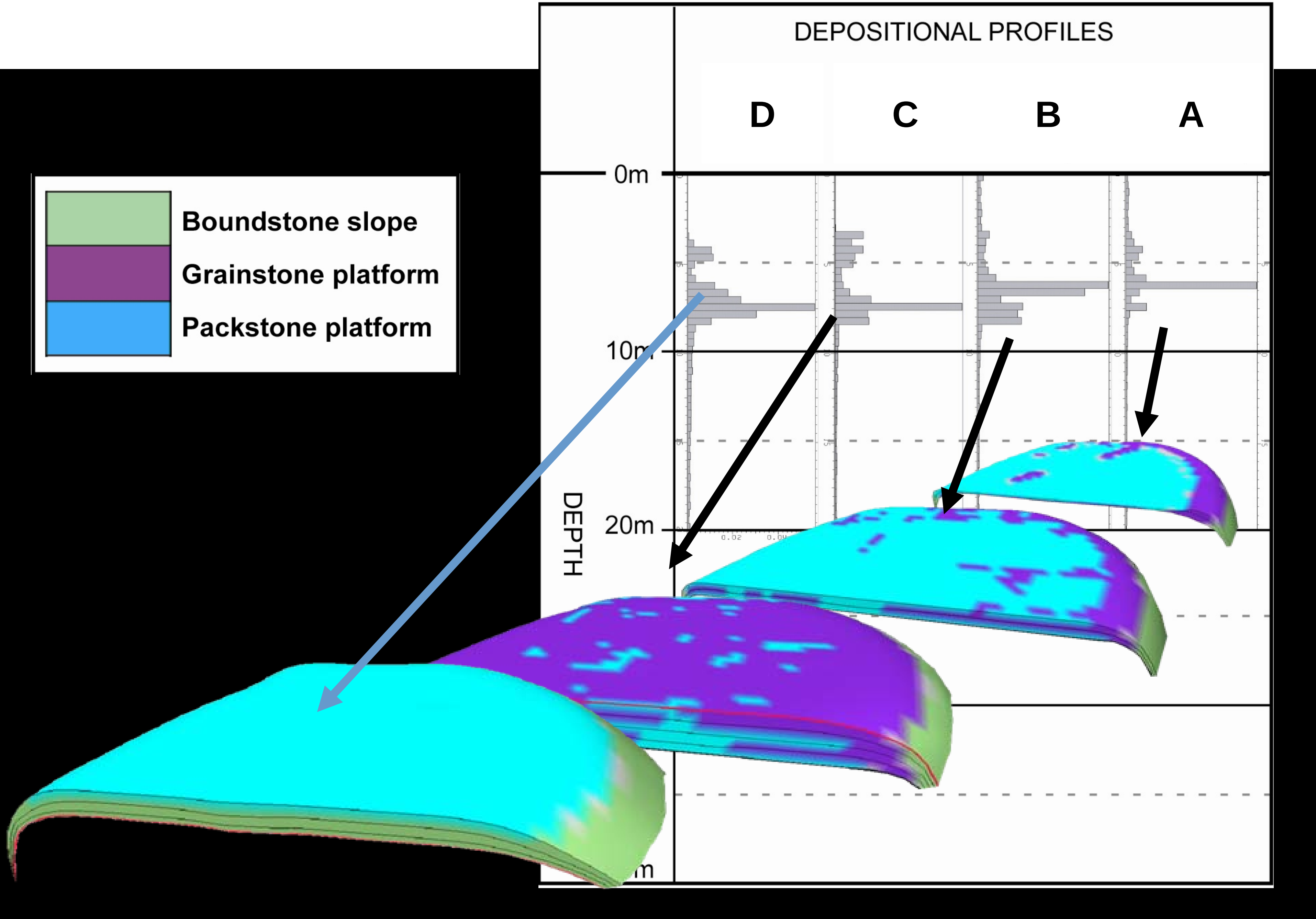




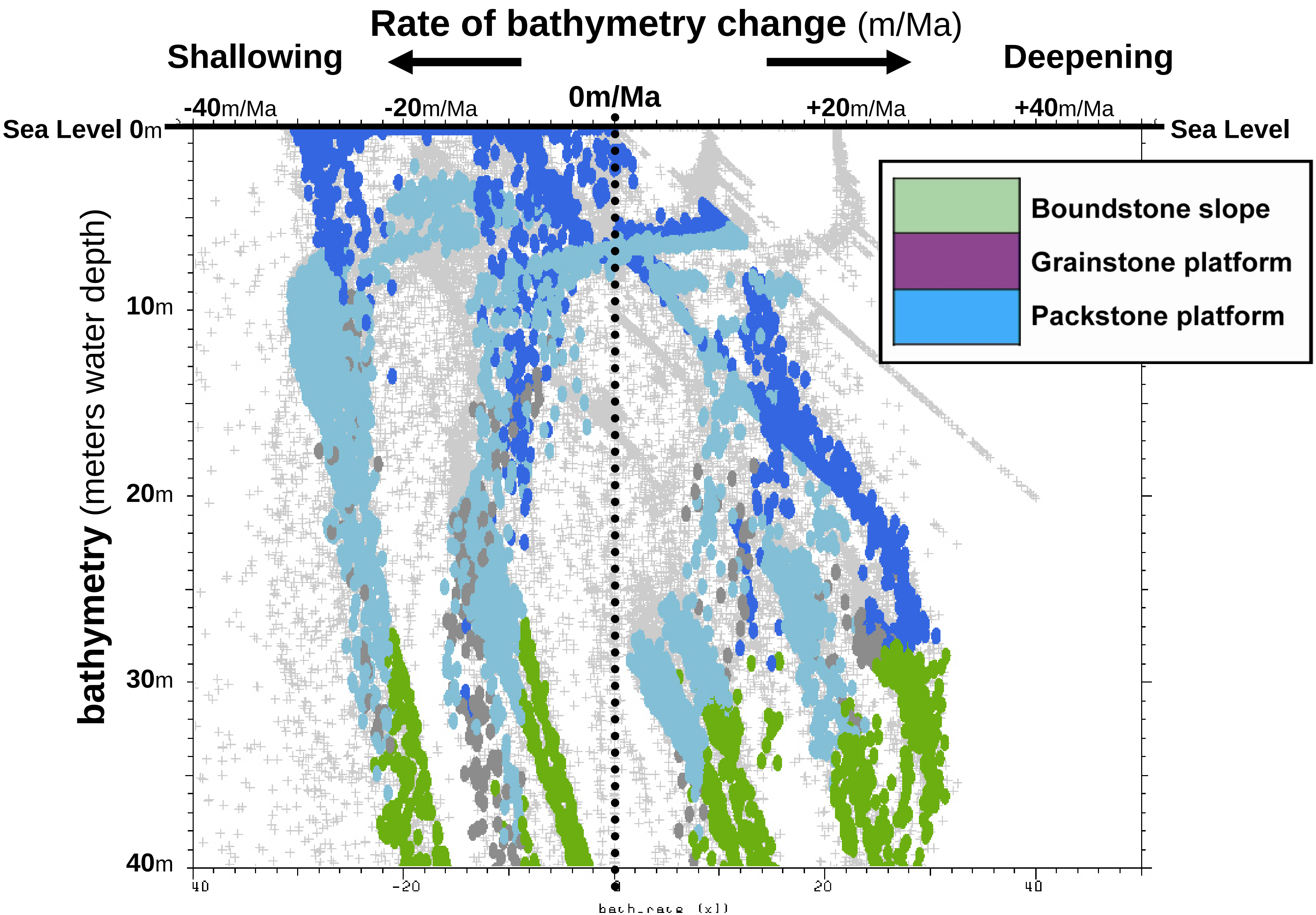
Net-to-gross (grainstone reservoir)
30%
25%
20%
15%
10%
5%
0%
30.0
25.0
20.0
15.0
10.0
5.0
0.0
volume of grainstones (km³)
grainstone N/G (%)
gn volume (km³)
Low amplitude
Medium amplitude
High amplitude


Accommodation
Layer number
20
19
18
17
16
15
14
13
12
11
10
A B C D E
Depositional Profile
Layer number
A B C D E
Depositional Profile
low
high
Layer number
A B C D E
Depositional Profile
Low amplitude
(greenhouse)
High amplitude
(Icehouse)
Boundstone slope
Grainstone platform
Packstone platform

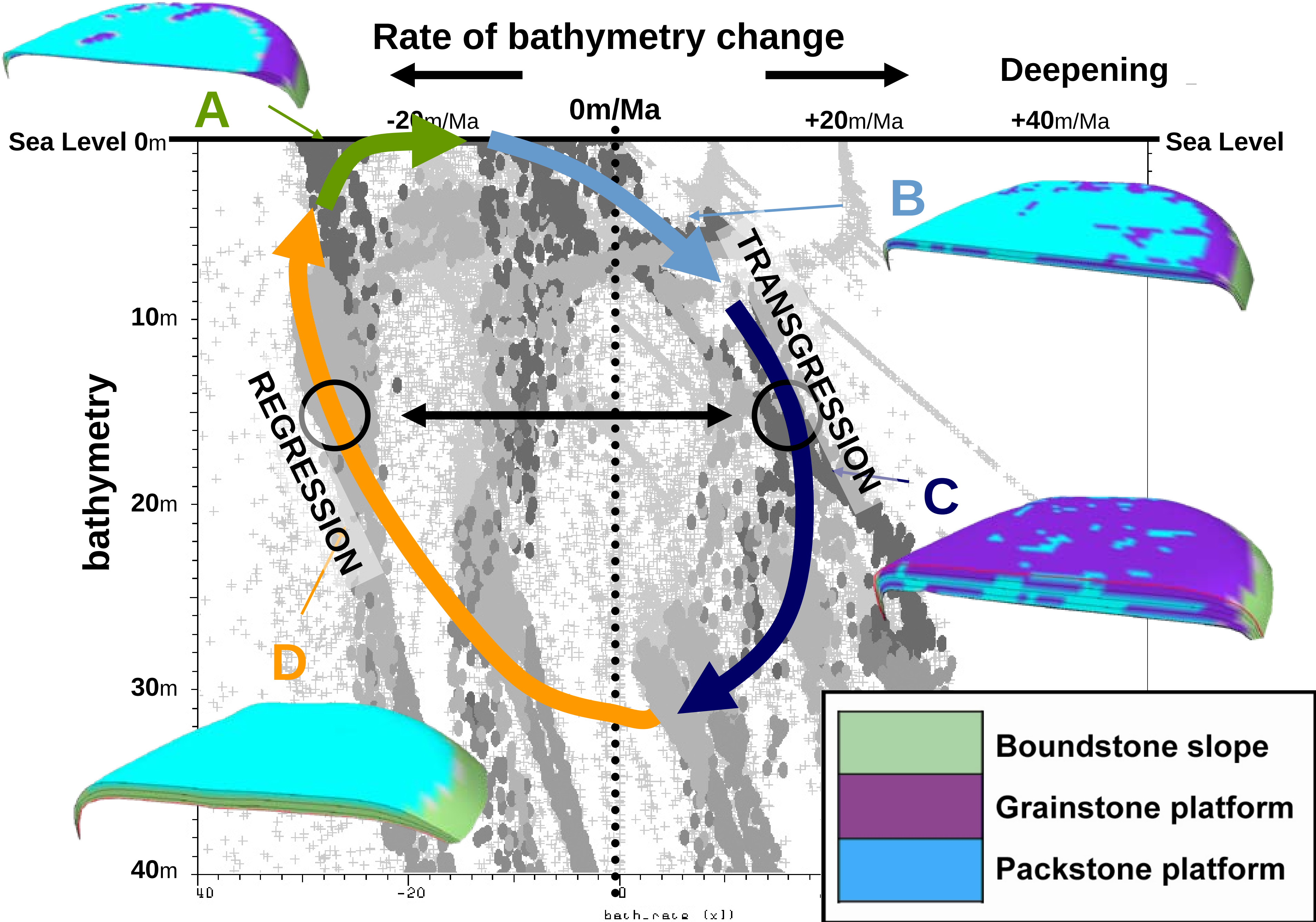
Bathymetry variations with depositional profile



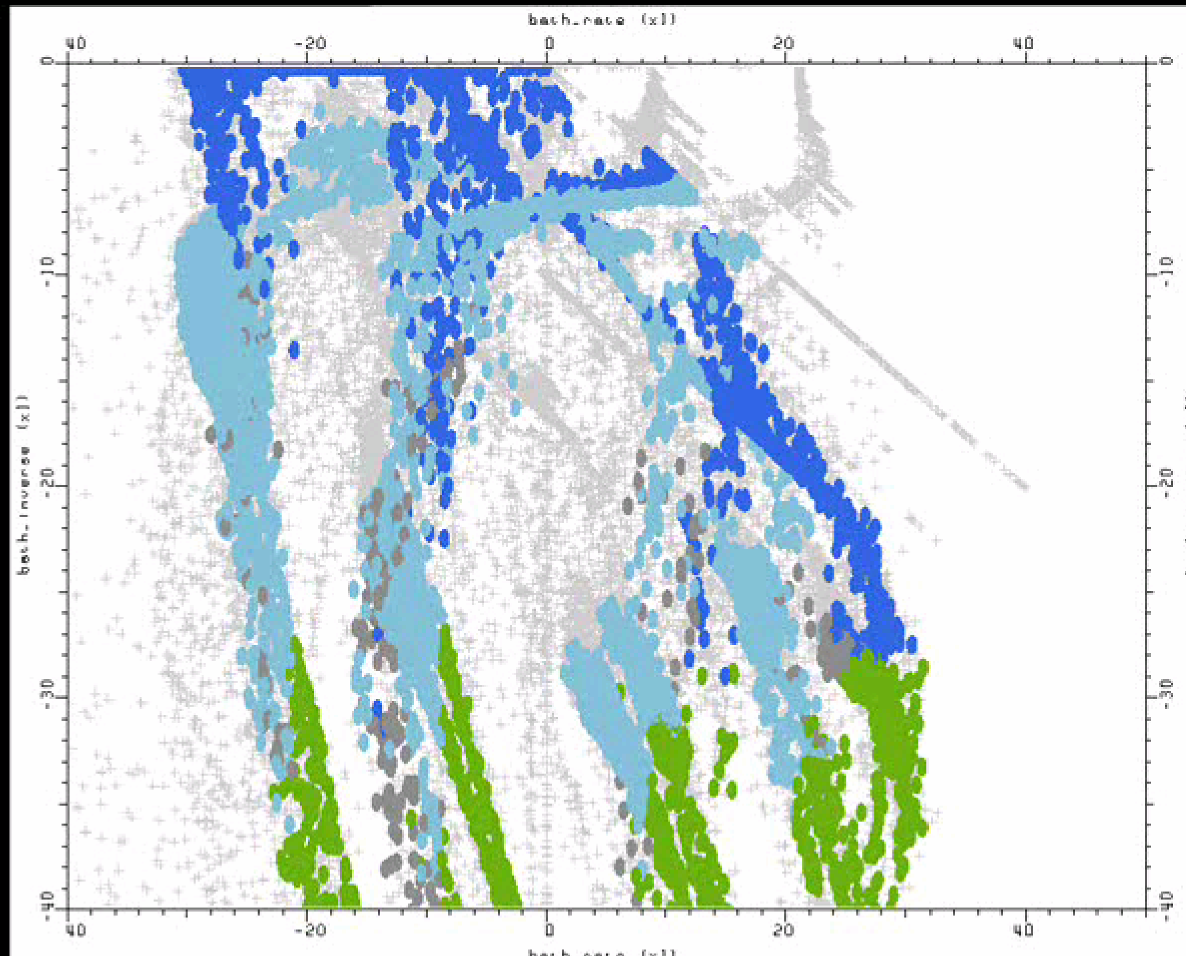
Rate of bathymetry change (x-axis) vs bathymetry (y-axis)



Rate of bathymetry change (x-axis) vs bathymetry (y-axis)



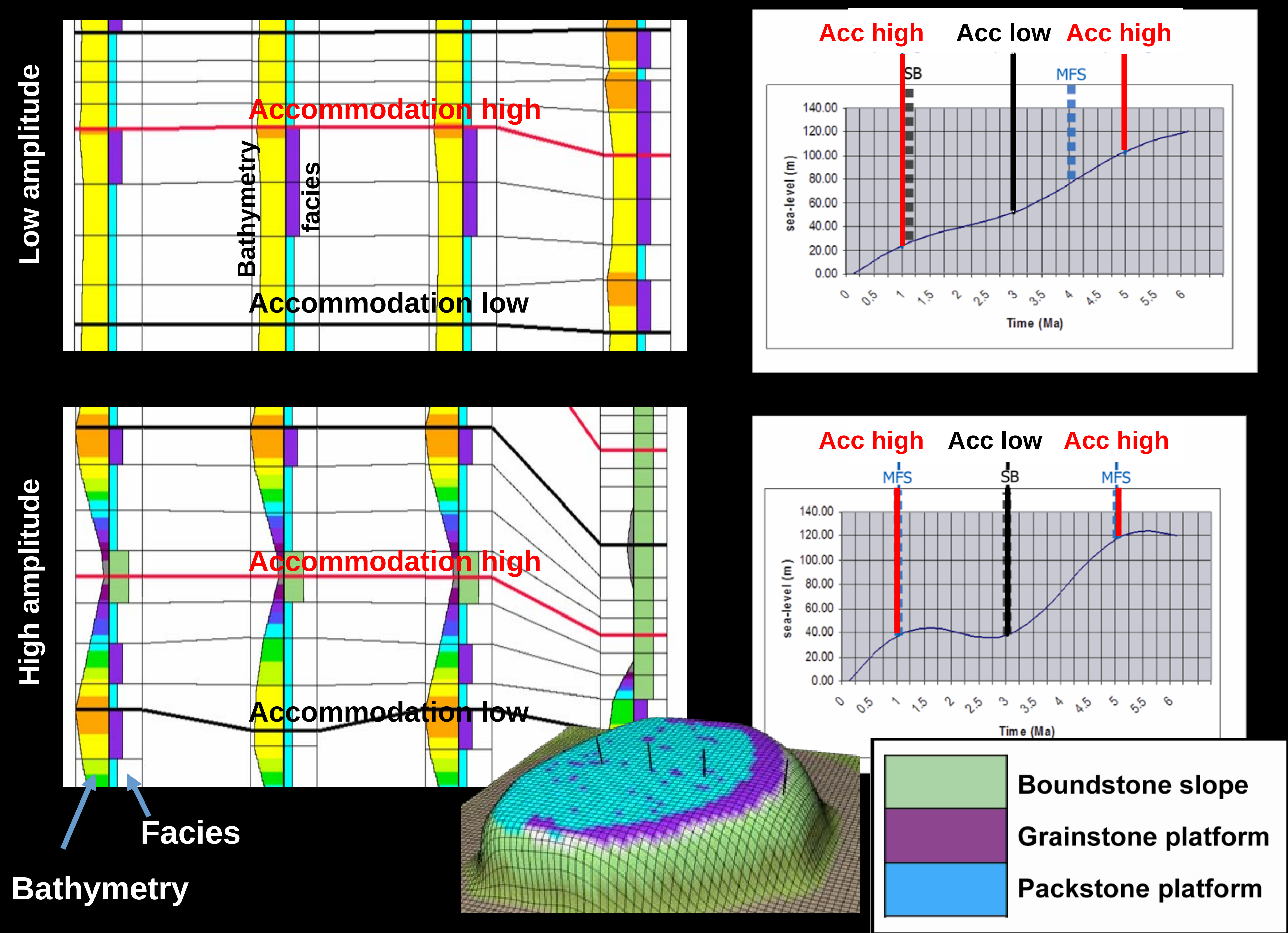
Rate of bathymetry change (x-axis) vs bathymetry (y-axis)



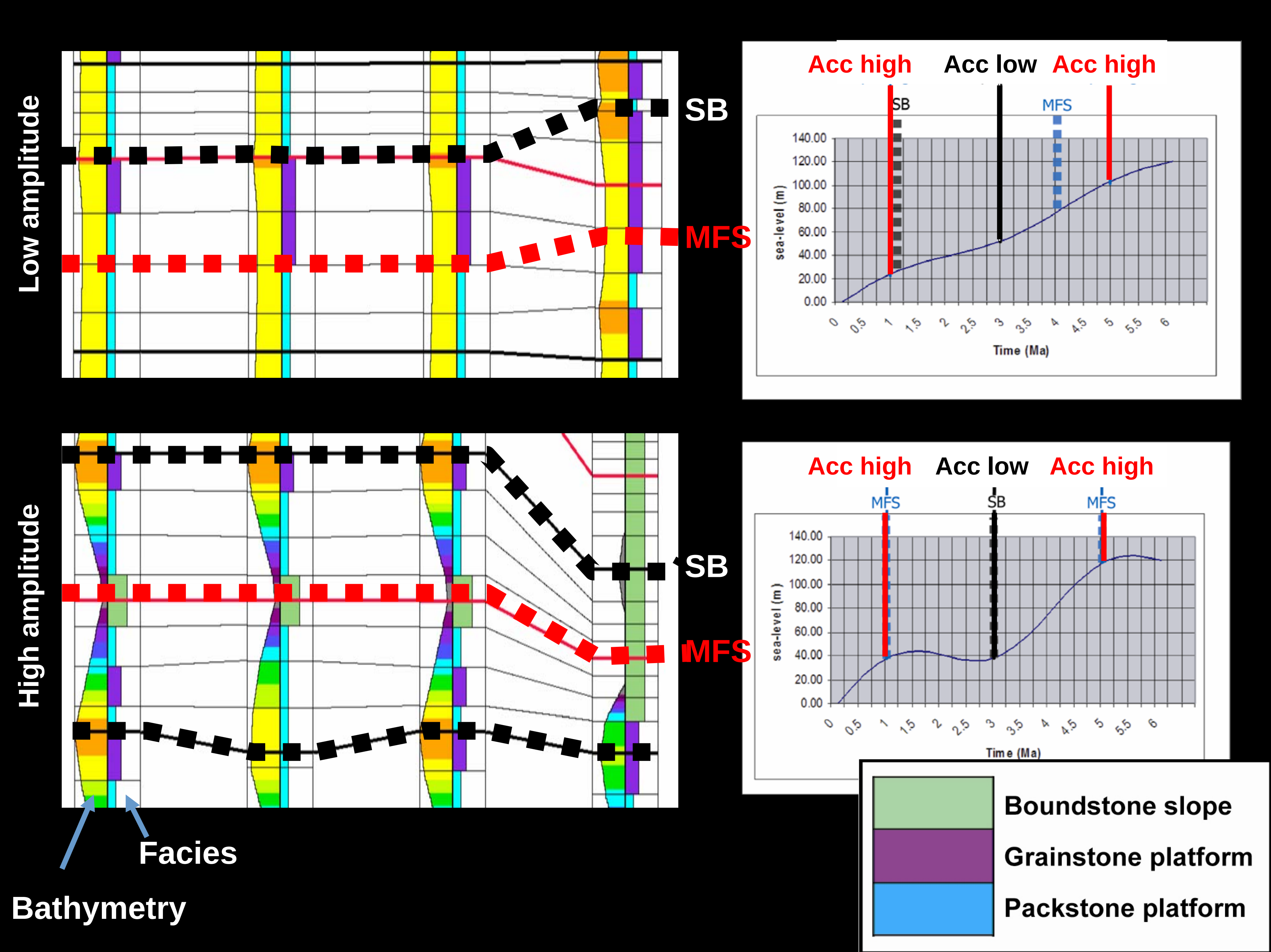
Boundstone slope

Grainstone platform

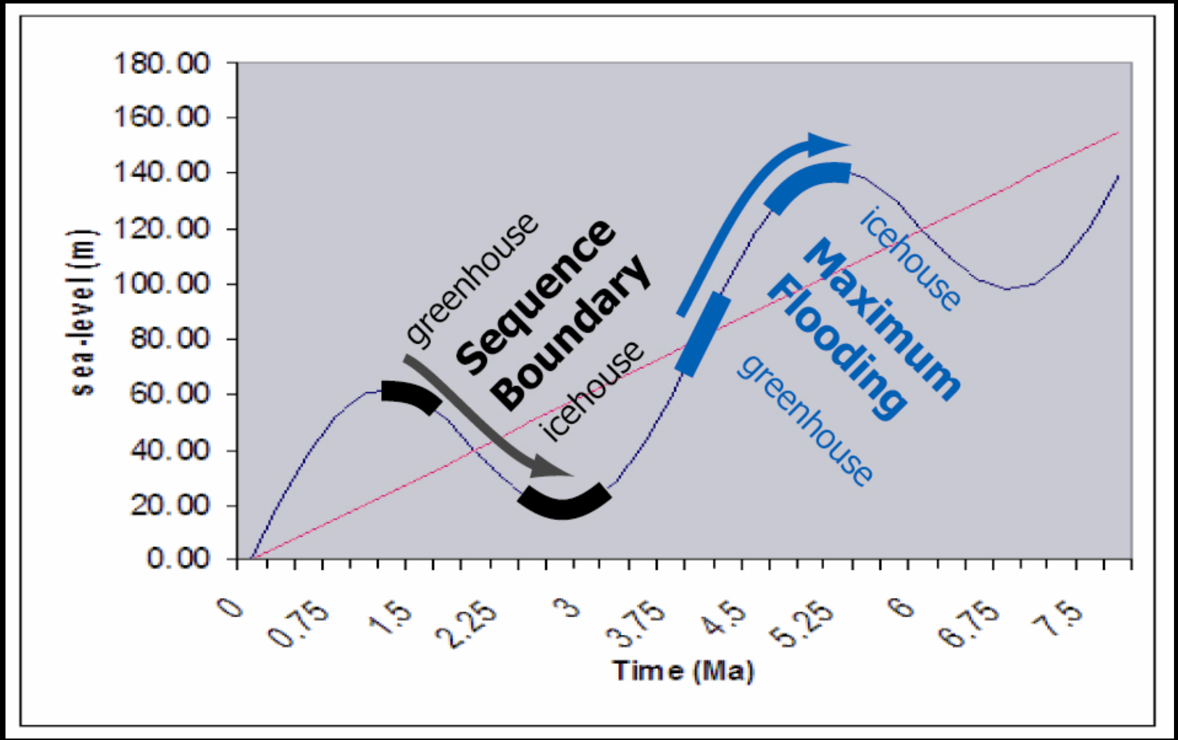
Packstone platform



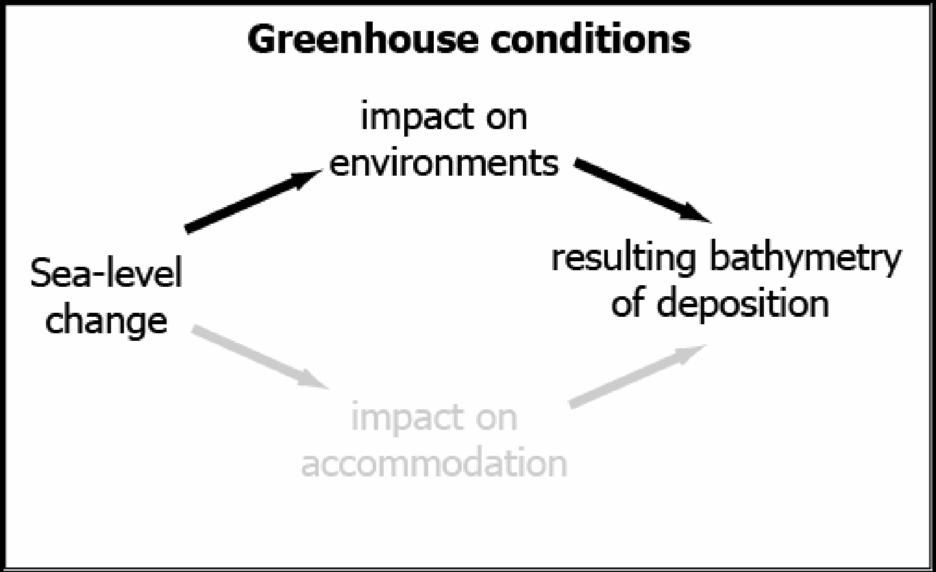
Low amplitude
Accommodation high
Bathymetry
facies
Accommodation low
Acc high
Acc low
Acc high
SB
MFS
sea-level (m)
Time (Ma)
High amplitude
Accommodation high
Accommodation low
Acc high
Acc low
Acc high
MFS
SB
MFS
sea-level (m)
Time (Ma)
Facies
Bathymetry
Boundstone slope
Grainstone platform
Packstone platform



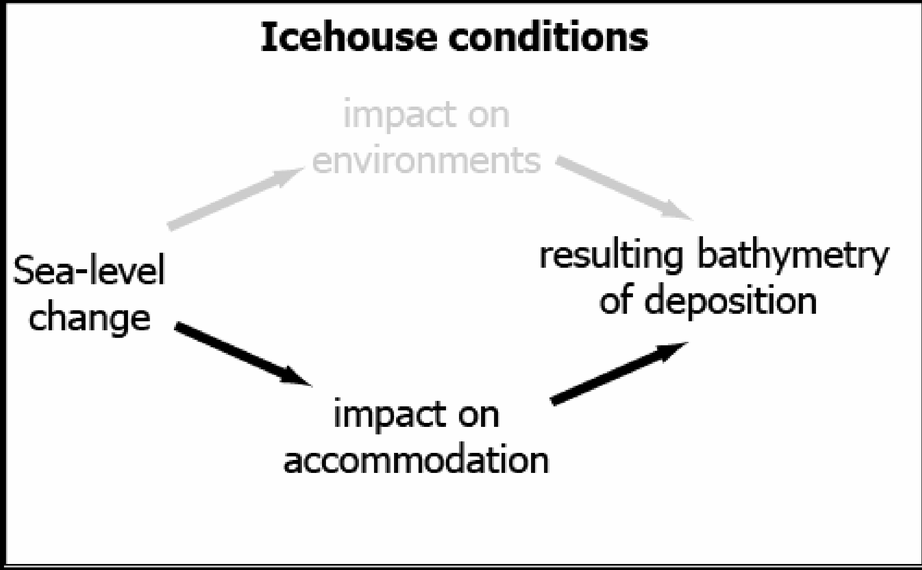
Low amplitude
SB
MFS
Acc high
Acc low
Acc high
SB
MFS
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
sea-level (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
Time (Ma)
High amplitude
SB
MFS
Acc high
Acc low
Acc high
MFS
SB
MFS
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
sea-level (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
Time (Ma)
Boundstone slope
Grainstone platform
Packstone platform
Facies
Bathymetry



180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
sea-level (m)
0
0.75
1.5
2.25
3
3.75
4.5
5.25
6
6.75
7.5
Time (Ma)
greenhouse
Sequence Boundary
icehouse
icehouse
Maximum Flooding
greenhouse

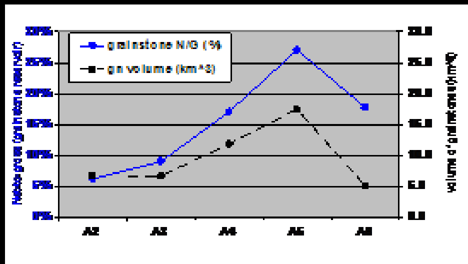


Greenhouse conditions
impact on environments
Sea-level change
resulting bathymetry of deposition
impact on accommodation

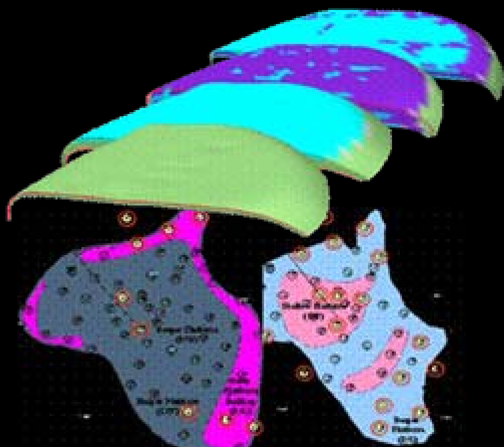


Icehouse conditions
impact on environments
Sea-level change
resulting bathymetry of deposition
impact on accommodation

Conclusions

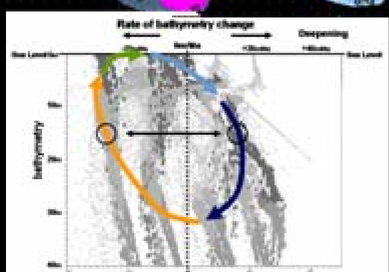


1. N-G increases with increased accommodation rate (up to drowning threshold).

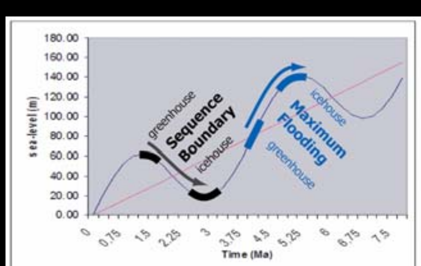


2. The simulator produces a limited number of depositional profiles (solutions) showing variations in reservoir distribution.

3. Even a simple simulation resembles reality.



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



5. Interpreted SB & MFS positions relative to accommodation cycle changes with cycle amplitude.

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