

# **Record of Sea-Level Fall in Tropical Carbonates - Falling-Stage Systems Tract Versus Standard Model Architecture\***

**Wolfgang Schlager<sup>1</sup> and Georg Warrlich<sup>2</sup>**

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<sup>1</sup>Earth & Life Sci., Vrije Univ. Amsterdam, Amsterdam, Netherlands ([wolfgang.schlager@falw.vu.nl](mailto:wolfgang.schlager@falw.vu.nl))

<sup>2</sup>Petroleum Dev. Oman, Muscat, Oman.

## **Abstract**

The record of sea-level fall in sequence stratigraphy is described by two contrasting models. The standard model (STM) postulates that deposition occurs principally during rise and stillstands of relative sea level; a continuous erosional unconformity develops during sea-level fall. The falling-stage systems tract model (FST) postulates significant deposition during sea-level fall. We treated these models as giant sedimentary structures and used sedimentologic principles, stratigraphic forward modeling and real-world case studies to determine the control parameters and stability domains of the two models. All three lines of evidence indicate that the presence or absence of the FST in tropical carbonates is not simply a function of the rate of sea-level fall but depends on the balance of the rates of erosion, sea-level fall and carbonate production. The FST is favored by high production, slow erosion and slow sea-level fall, the STM by the opposite configuration of rates. Case studies plotted in the parameter space spanned by the rates of sea-level fall, erosion and production support the modeling results. However, case specific estimates of rates of production, erosion and sea-level fall of the distant geologic past are fraught with uncertainty and the number of case studies with well-constrained rates is rather small. It is clear though that the overall ranges of rates required for the falling-stage systems tract are common in the geologic record. Consequently, the falling-stage systems tract can be expected to be more common in tropical carbonate rocks than published records, particularly seismic data, currently indicate.

# Sea-Level Fall in Tropical Carbonates: Falling-Stage Systems Tract vs. Standard Model

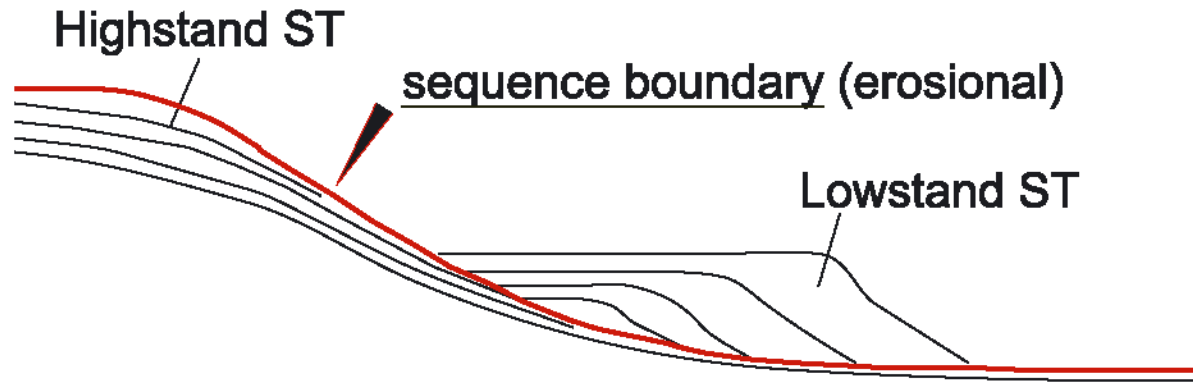
*Wolfgang Schlager*  
*Vrije Univ. Amsterdam*

*Georg Warrlich*  
*Shell Petrol. Dev. Oman*

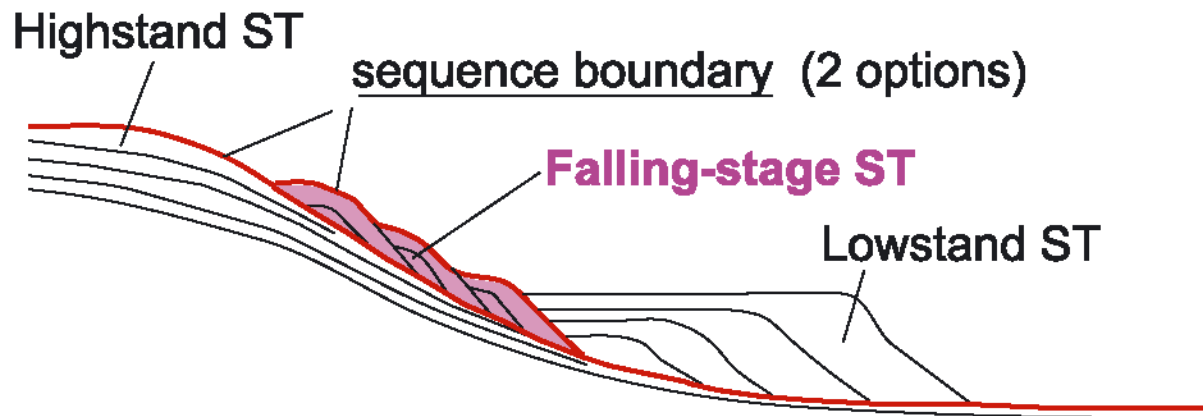
Treated systems tract like giant sedimentary structure  
control parameters  
stability domain

Modeling in “Carbonate 3D” and case-studies in same parameterspace

## Standard model (STM)

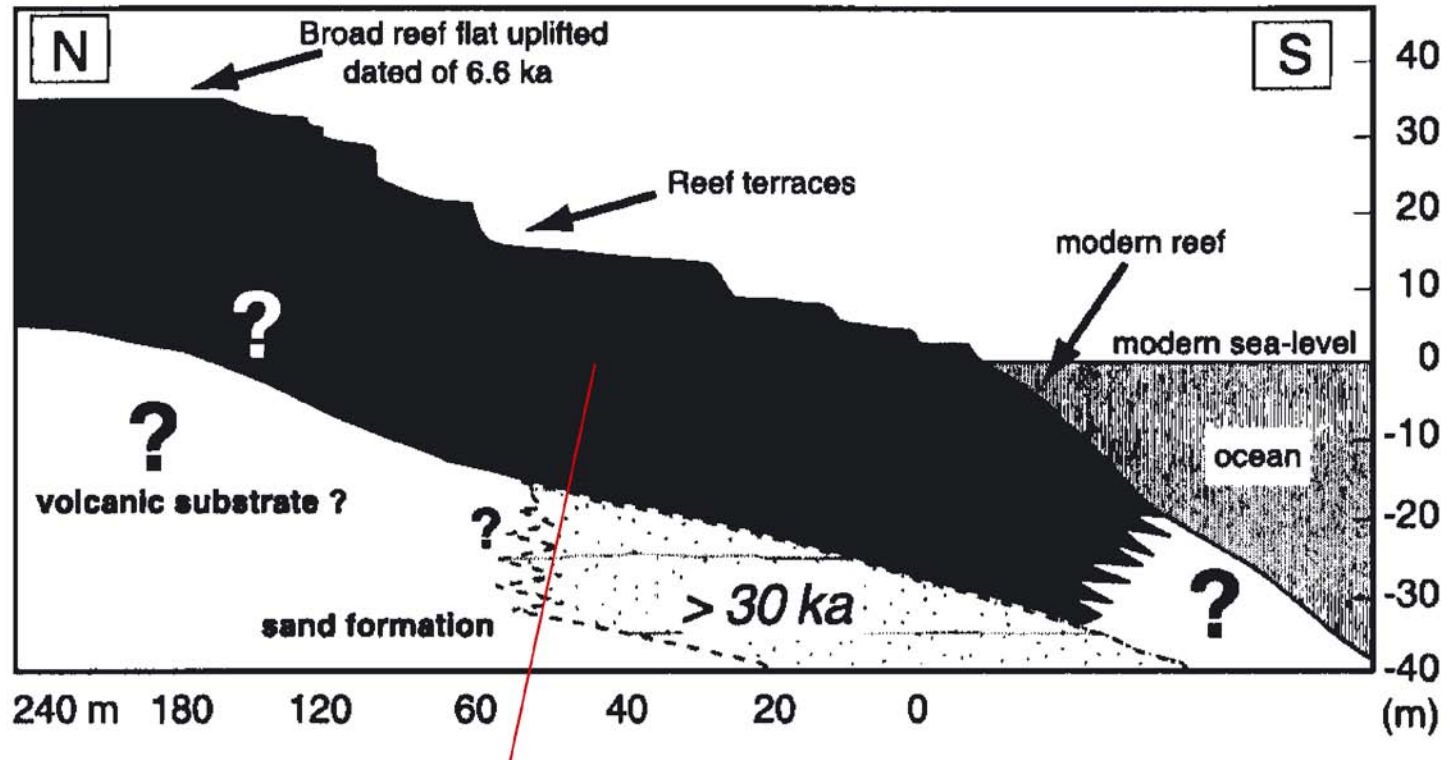


## Falling-stage systems tract model (FST)



*Schlager & Warrlich (2009)*

# Holocene Tasmaloum Reef, Vanuatu, W Pacific



FST of reef and reef debris formed during 6.6 kyr of Holocene uplift

*Cabioch (2003)*

CONTROLS ?

Rate of fall

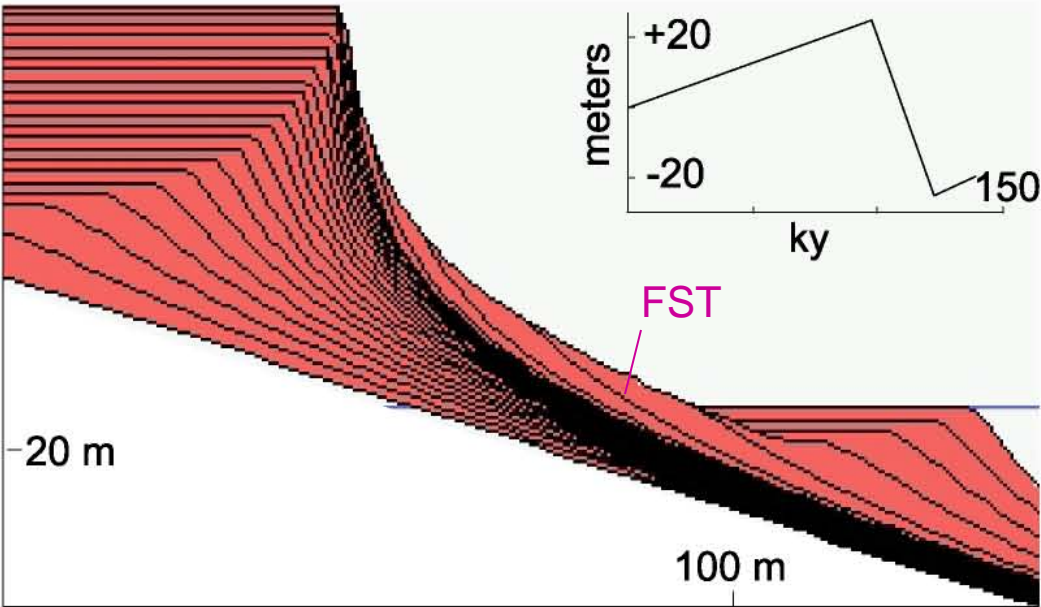
Rate of production

Rate of erosion

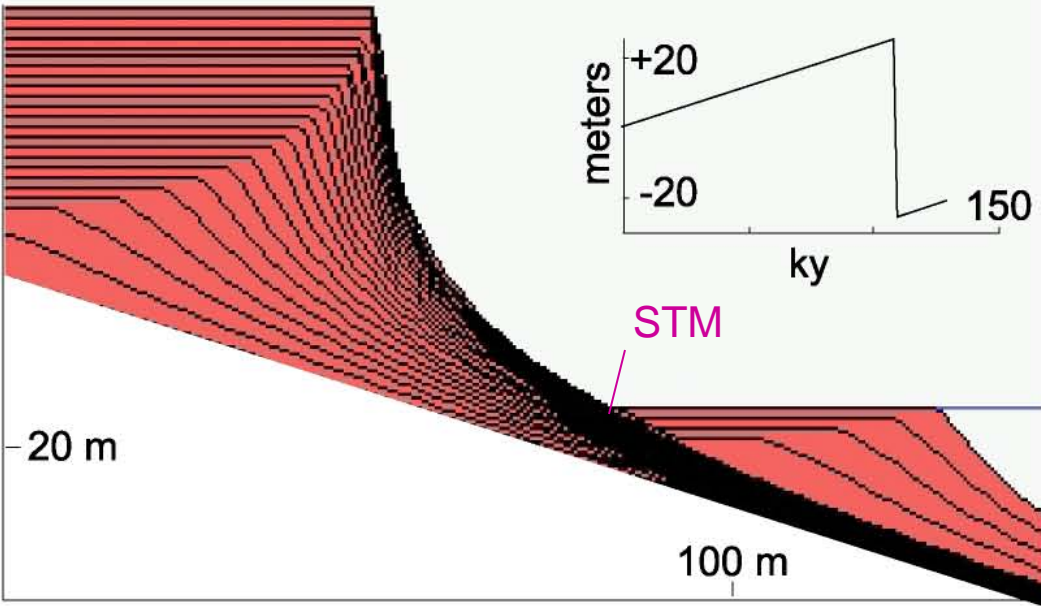
→ tested by C3D modeling  
“FST-to-STM experiments”

FST and  
rate of fall

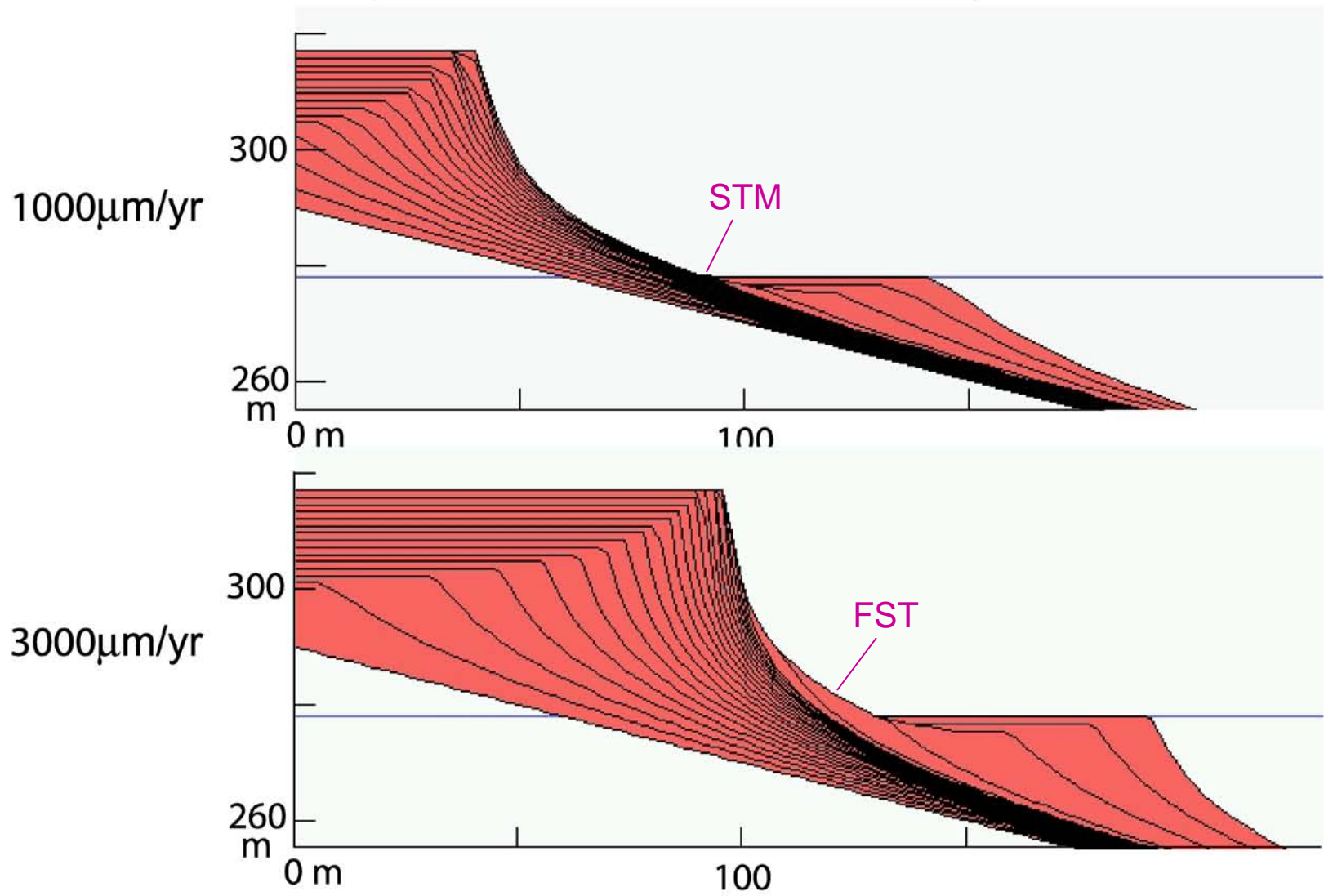
2000 $\mu\text{m}/\text{yr}$



40000 $\mu\text{m}/\text{yr}$



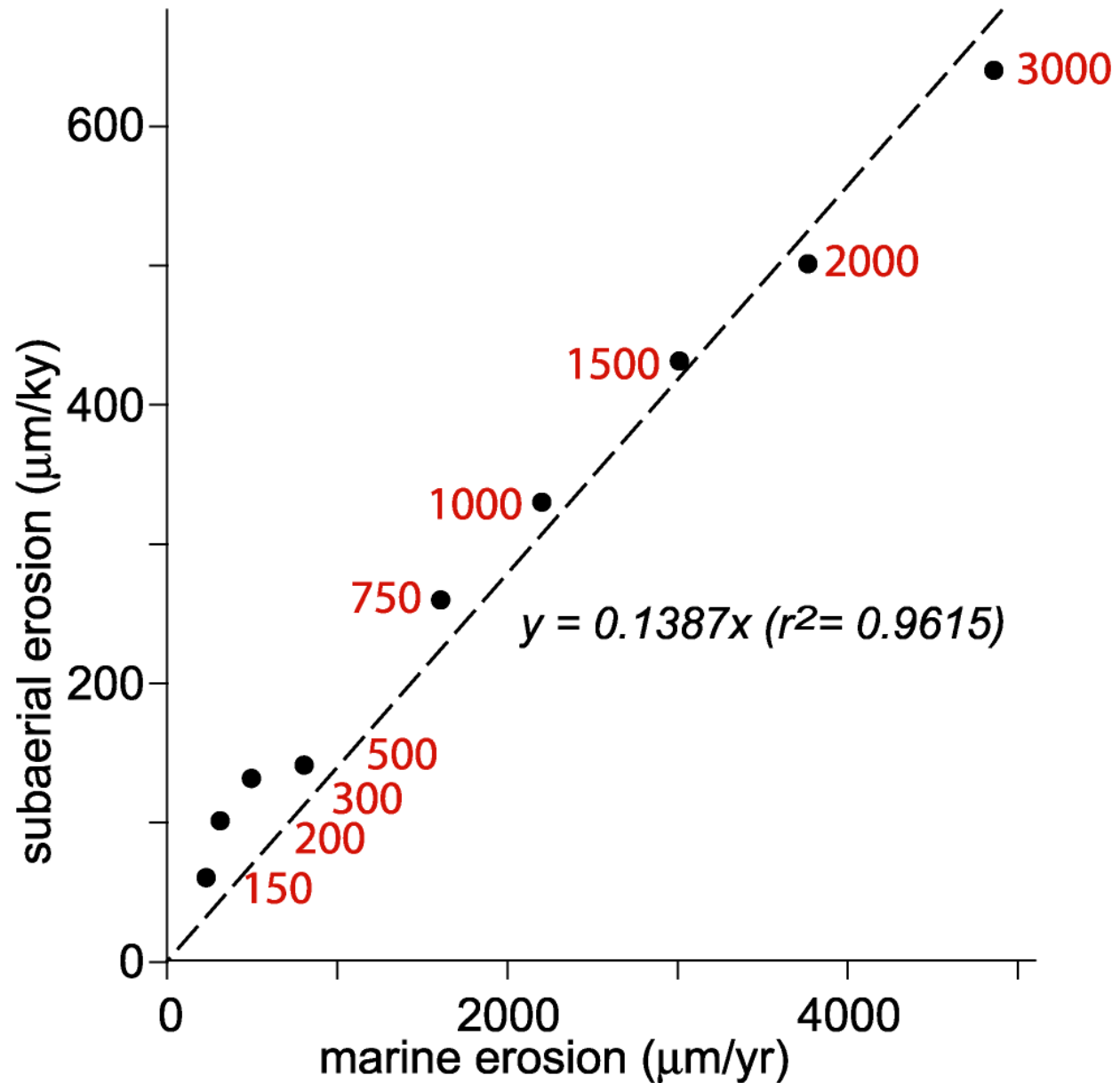
## FST and carbonate production



both runs: subaerial ero  $275 \mu\text{m/yr}$ , fall  $3000 \mu\text{m/yr}$

Efficiency of  
marine & subaerial  
erosion in destroying  
FST

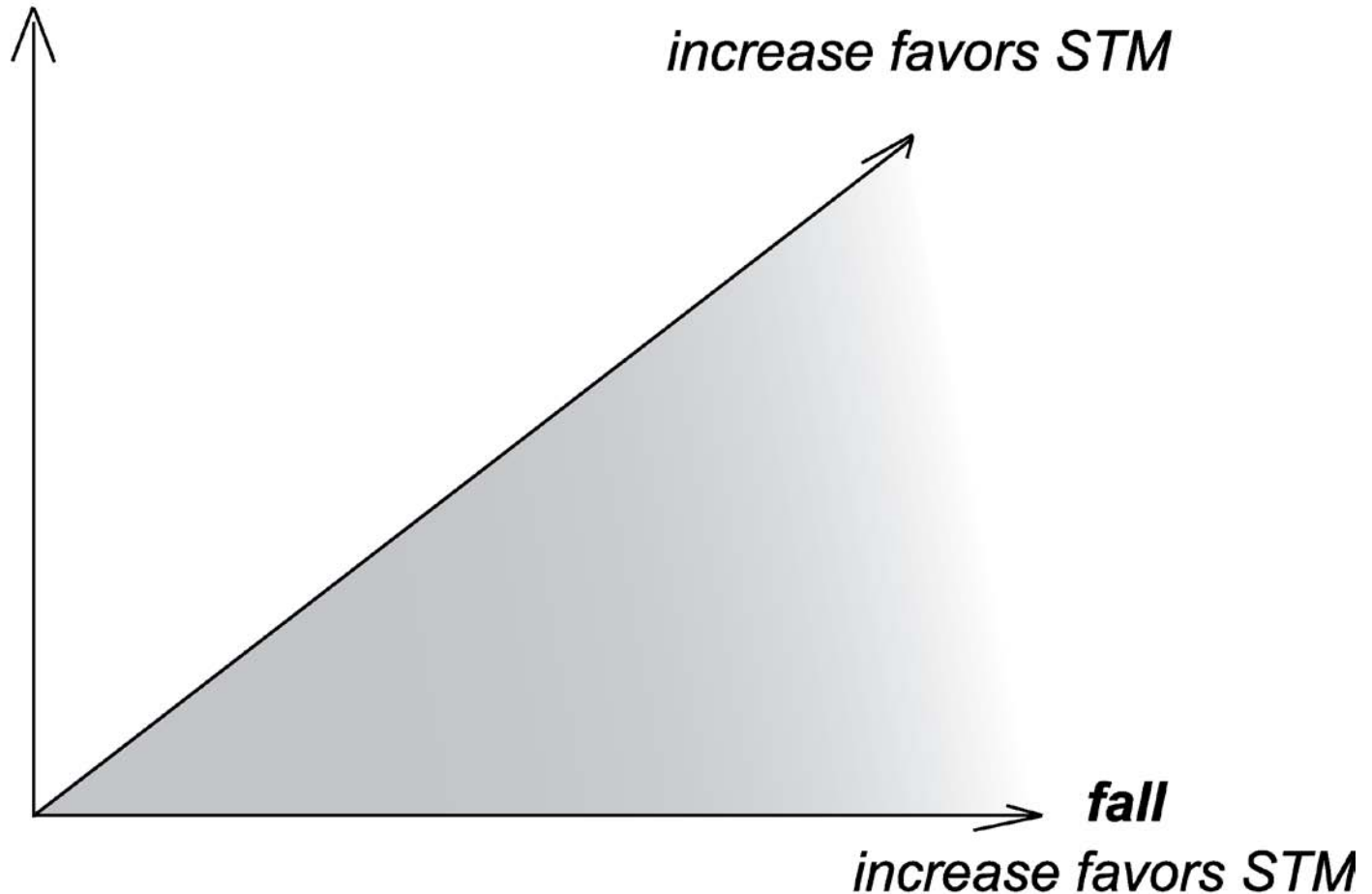
Red: production rate  
( $\mu\text{m}/\text{yr}$ )



# PARAMETER SPACE DETERMINED BY MODELING

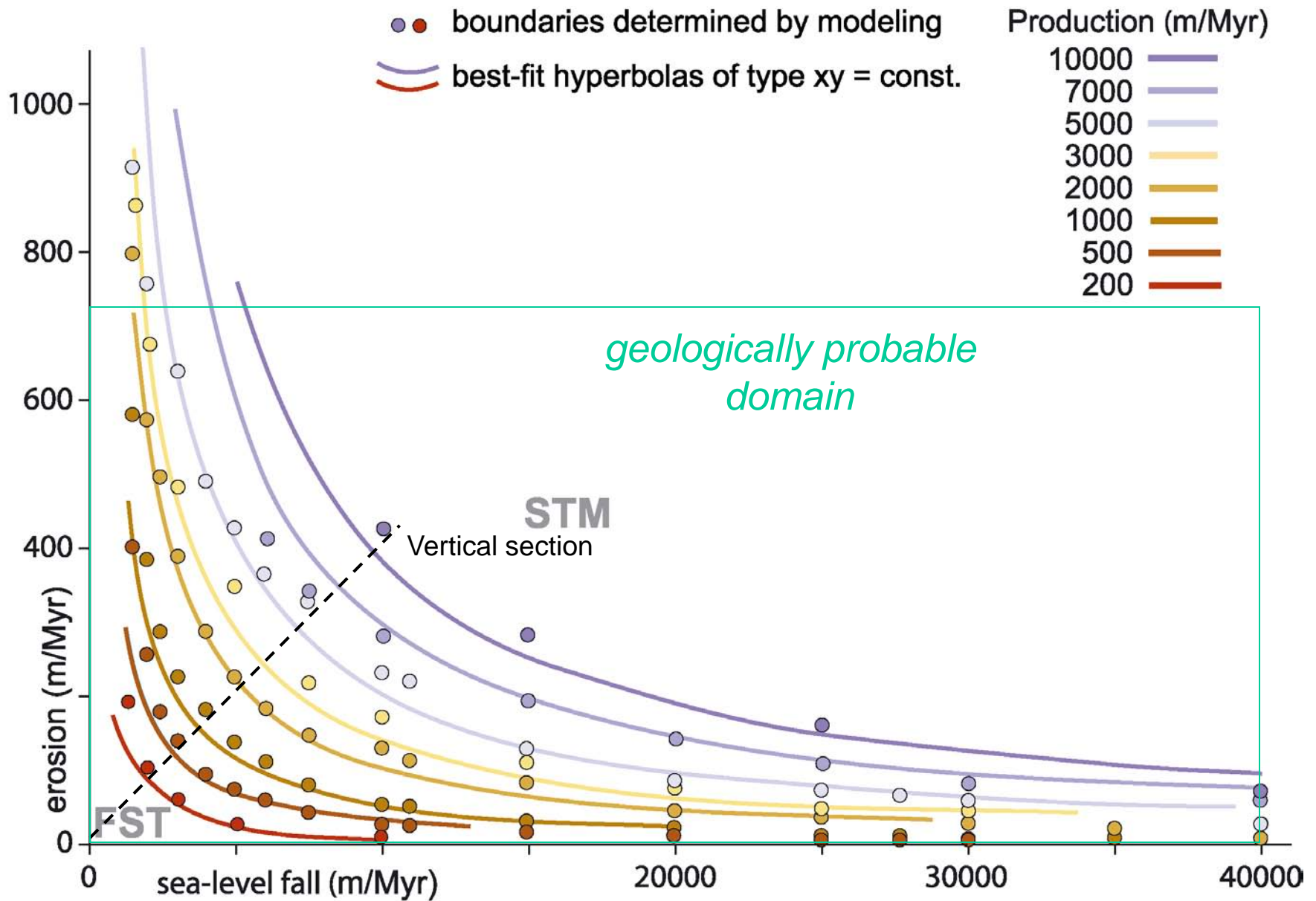
***production***  
*increase favors FST*

***erosion***  
*(subaerial + marine)*  
*increase favors STM*



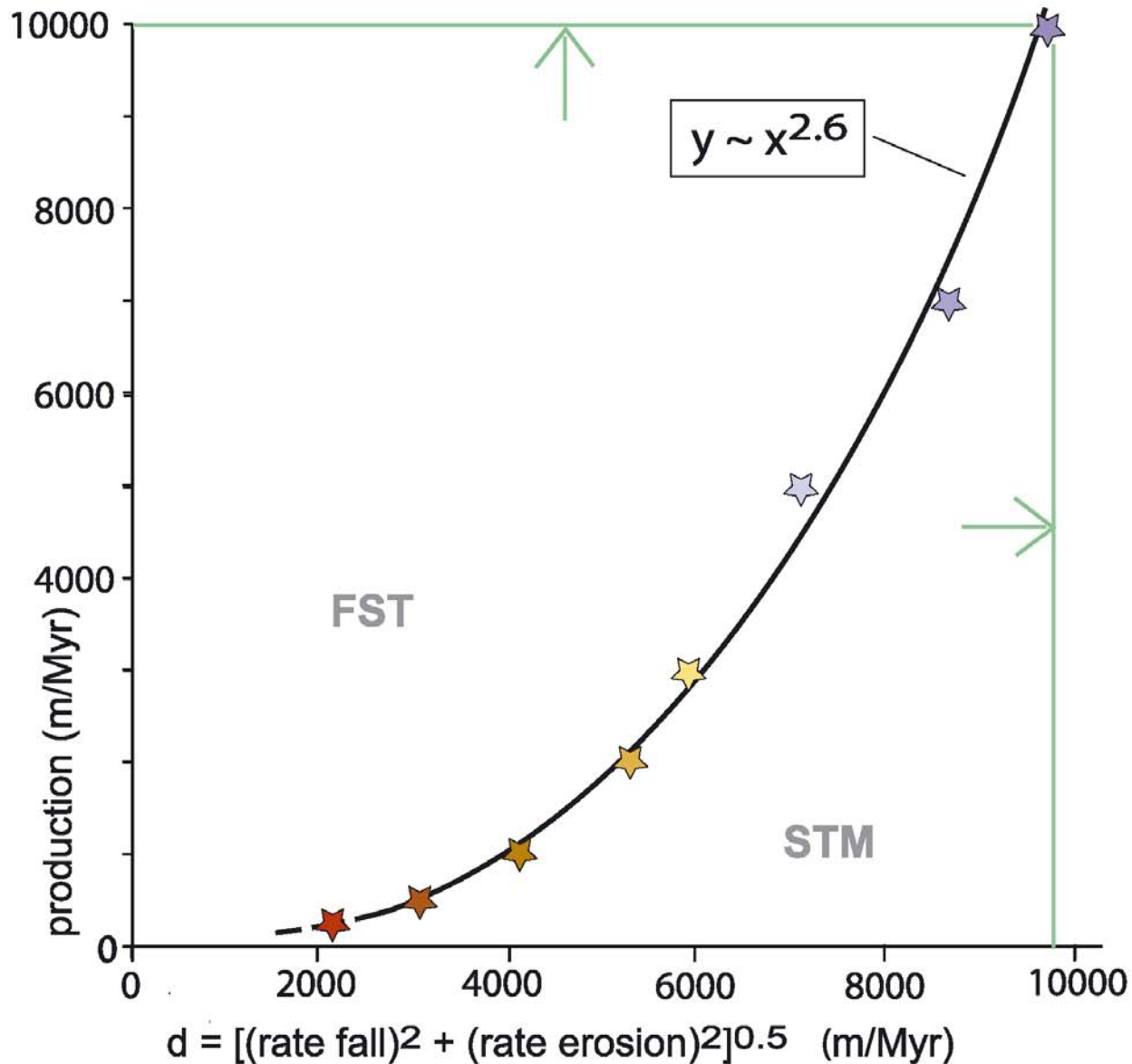


# Sealevel-erosion plane - FST/STM boundaries at different production levels

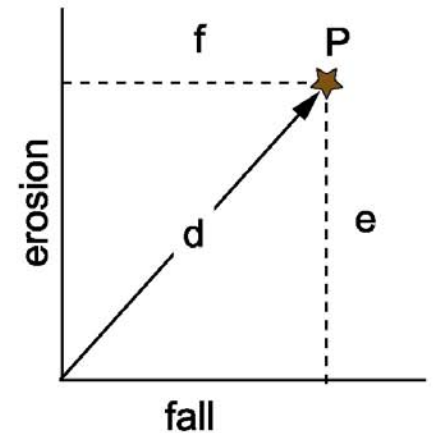


Schlager & Warrlich (2009)

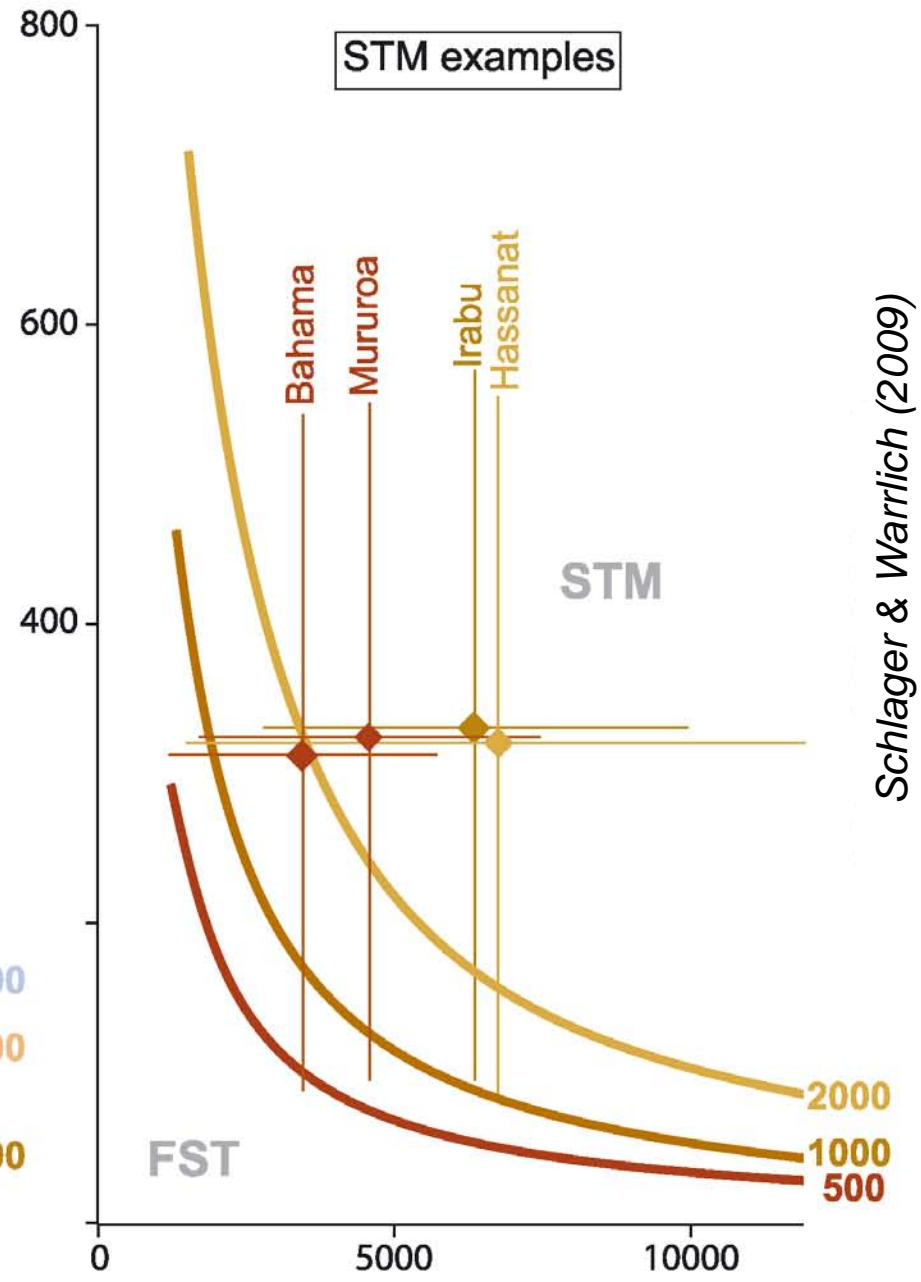
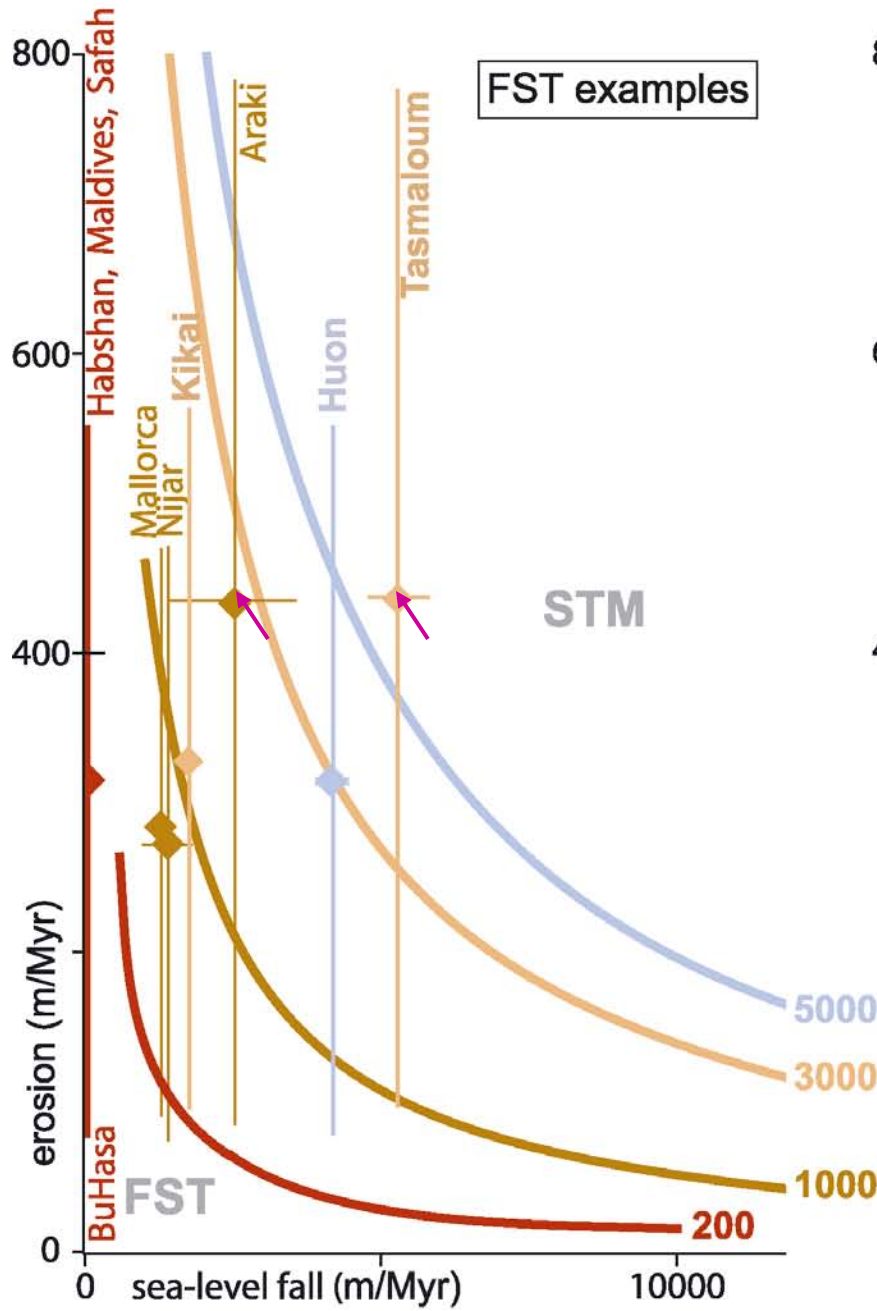
# Vertical section along 45°-transect of sea-level/erosion plane

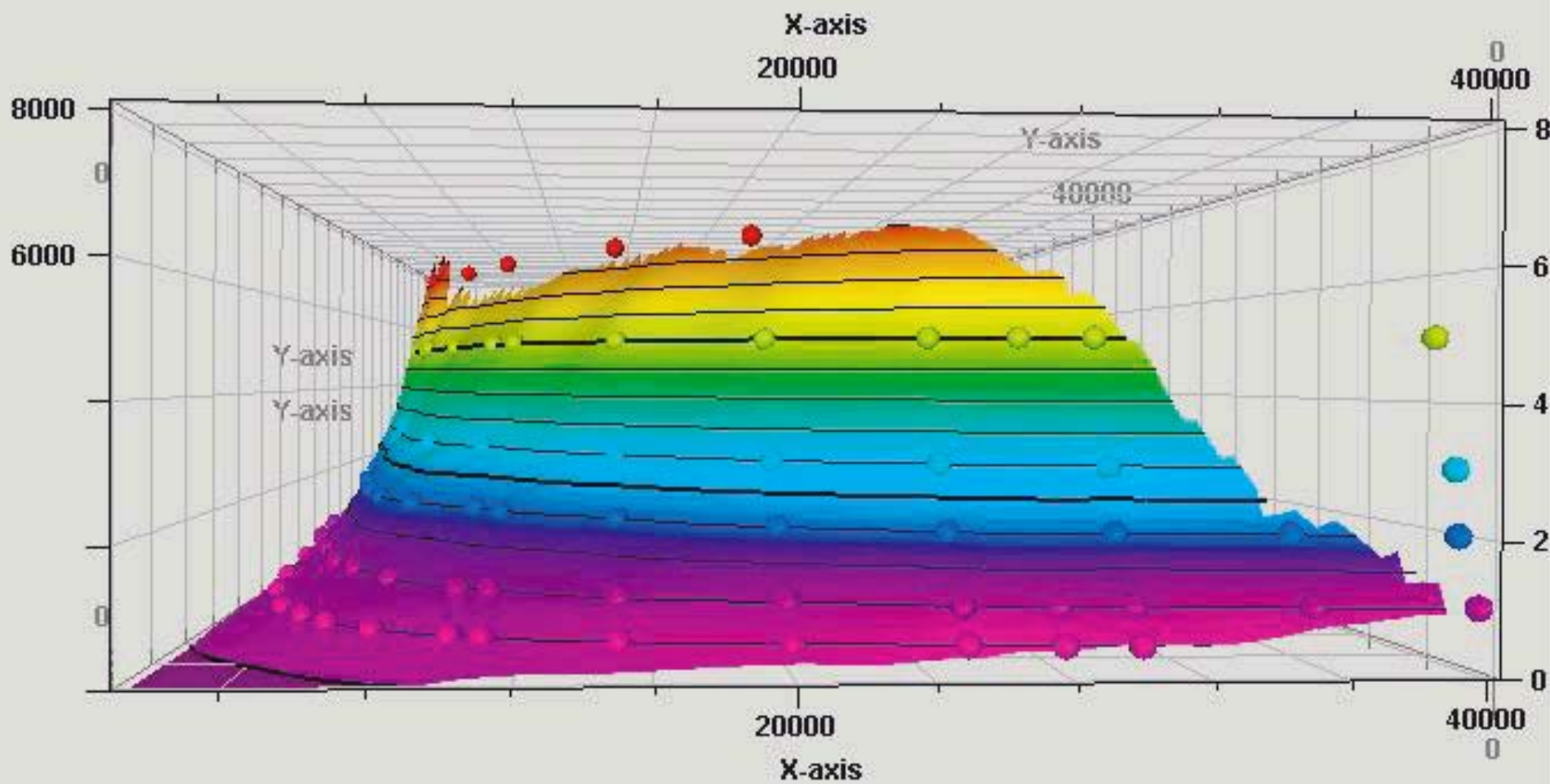


Position "P" on  
sea-level/erosion plane:  
 $d = (f^2 + e^2)^{0.5}$



# Case studies in sea-level/erosion plane (production in color)





# ***The upshot***

**---- Rates of sea-level fall, erosion, production control FST vs. STM**

**---- FST favored by slow fall, low erosion and high production**

**---- Numerical modeling: boundaries of FST/STM domains are simple functions.  
In sea-level/erosion plane: hyperbolas of type  $xy = \text{const.}$   
In third dimension: parabola-like but exponent  $> 2$ .**

**---- Real-world examples of FST and STM with well-constrained rates are scarce.  
Of 14 examples, 12 plot in the stability domain predicted by modeling.**

**---- Rates required for FST are common, FST should be common too.**

## **References**

Cabioch, G., 2003, Postglacial reef development in the South-west Pacific; case studies from New Caledonia and Vanuatu: *Sedimentary Geology*, v. 159/1-2, p. 43-59.

Schlager, W. and G. Warrlich, 2009, Record of sea-level fall in tropical carbonates: *Basin Research*, v. 22/1/2, p. 209-224.