

PS 3D Numerical Stratigraphic Model for Basin Scale Modeling of the Organic Matter Deposition in a Marine Environment: Application to the Natih Formation (Late Cretaceous, Oman)*

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Abstract

One of the main objectives of numerical tools in Geosciences is to better evaluate the oil and gas potential in sedimentary basins. Basin models simulate the main physical and chemical processes that control the maturation and the migration of hydrocarbons. Despite the complexity of these models, their predictive capability is still limited by the quality of the input parameters. Among the list of poorly constrained parameters, the distribution and the quality of the initial source rock is one of the most important. Estimations of the initial TOC and HI (before thermogenic transformation) are difficult as their values result from a set of degradation processes and depend on the nature of the organic matter initially preserved. To fill this gap, we present a new numerical model of the organic matter deposition and preservation fully coupled with a 3D numerical stratigraphic model. Our method consists in simulating the production, the transport and the degradation phases of the organic matters deposition during the filling of the sedimentary basin using a forward approach. The nature of the source-rock is estimated in terms of TOC and HI and mainly depends on the depositional environments. These environments are defined by the sedimentation rate and the redox conditions, two parameters that are estimated in our model for every time-steps of the simulation. Our goal is to bring a simple but powerful tool that will help the geologists in building realistic scenarios for the organic matter deposition within a stratigraphic framework. We illustrate the model by simulating an intrashelf basin derived from the geological framework of the Upper Cretaceous Natih formation of Oman. We show in particular that even simple organic matter accumulation scenario allow reproducing the main signatures of the two source-rocks formations.

References Cited

- Granjeon, D., and P. Joseph, 1999, Concepts and applications of a 3-D multiple lithology, diffusive model in stratigraphic modeling. Numerical experiments in stratigraphy: recent advances in stratigraphic and sedimentologic computer simulations: SEPM Spec. Publ. No. 62, p. 197– 210.
- Van Buchem, F.S.P., A.Y. Huc, B. Pradier, and M. Stefani, 2005, Stratigraphic patterns in carbonate source-rock distribution: Second-order to Fourth-order control and sediment flux: in Nicholas B. Harris (Ed.), The Deposition of Organic-Carbon-Rich Sediments: Models, Mechanisms, and Consequences, SEPM (Society for Sedimentary Geology), Special Publication, no. 82, p. 191-223.

3D numerical stratigraphic model for basin scale modeling of the organic matter deposition in a marine environment: Application to the Natih formation (Late Cretaceous, Oman)

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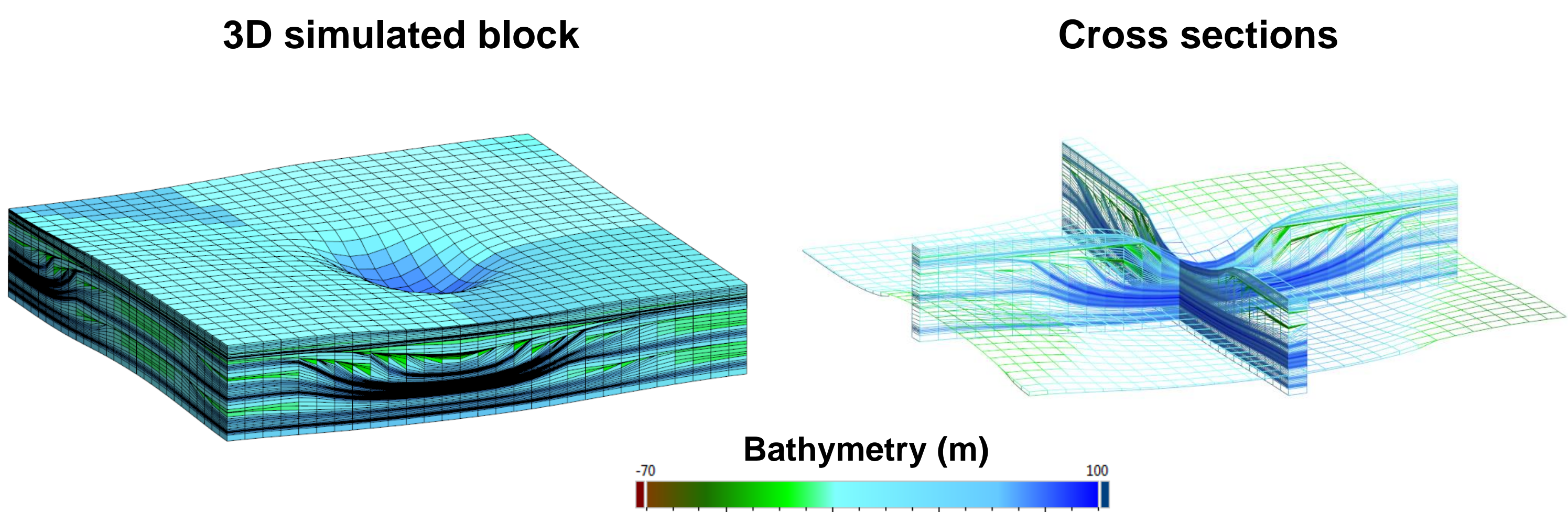
Abstract

We present a new model of organic matter deposition and preservation fully coupled with DionisosFlow™, a 3D numerical stratigraphic model (Granjeon and Joseph, 1999). Our method consists in simulating production, transport and early degradation of organic matter during the filling of sedimentary basins using a forward approach. Initial source-rock richness (TOC₀ and HI₀ before any maturation and migration processes) mainly depends on depositional environments. These environments are strongly linked to sedimentation rate and redox conditions, two parameters that are deduced from the model at every time-step of simulation. Our goal is to bring a simple but powerful tool that will help geologists in building realistic scenarii for the organic matter deposition within a stratigraphic framework. We illustrate the model by simulating an intrashelf basin derived from the geological framework of the Upper Cretaceous Natih Formation of Oman.

Presentation of the model

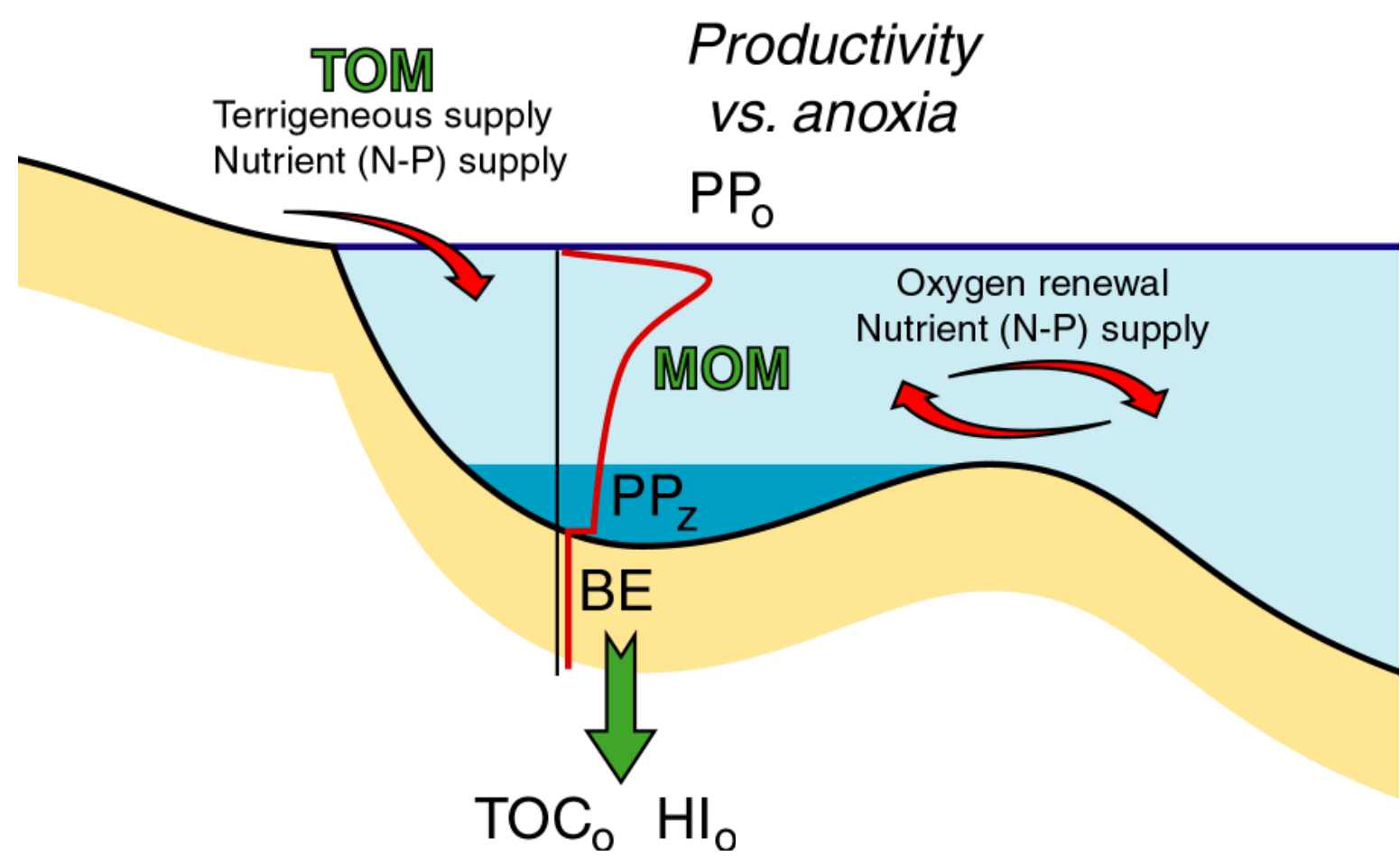
3D stratigraphic numerical model

- **Input parameters**
Subsidence, eustasy, sediment supply...
- **Simulated processes**
Accommodation, sediment transport and carbonate production
- **Outputs**
Environment of deposition (e.g. water depth, sedimentation rates, wave energy), facies distribution, stratigraphic architecture...



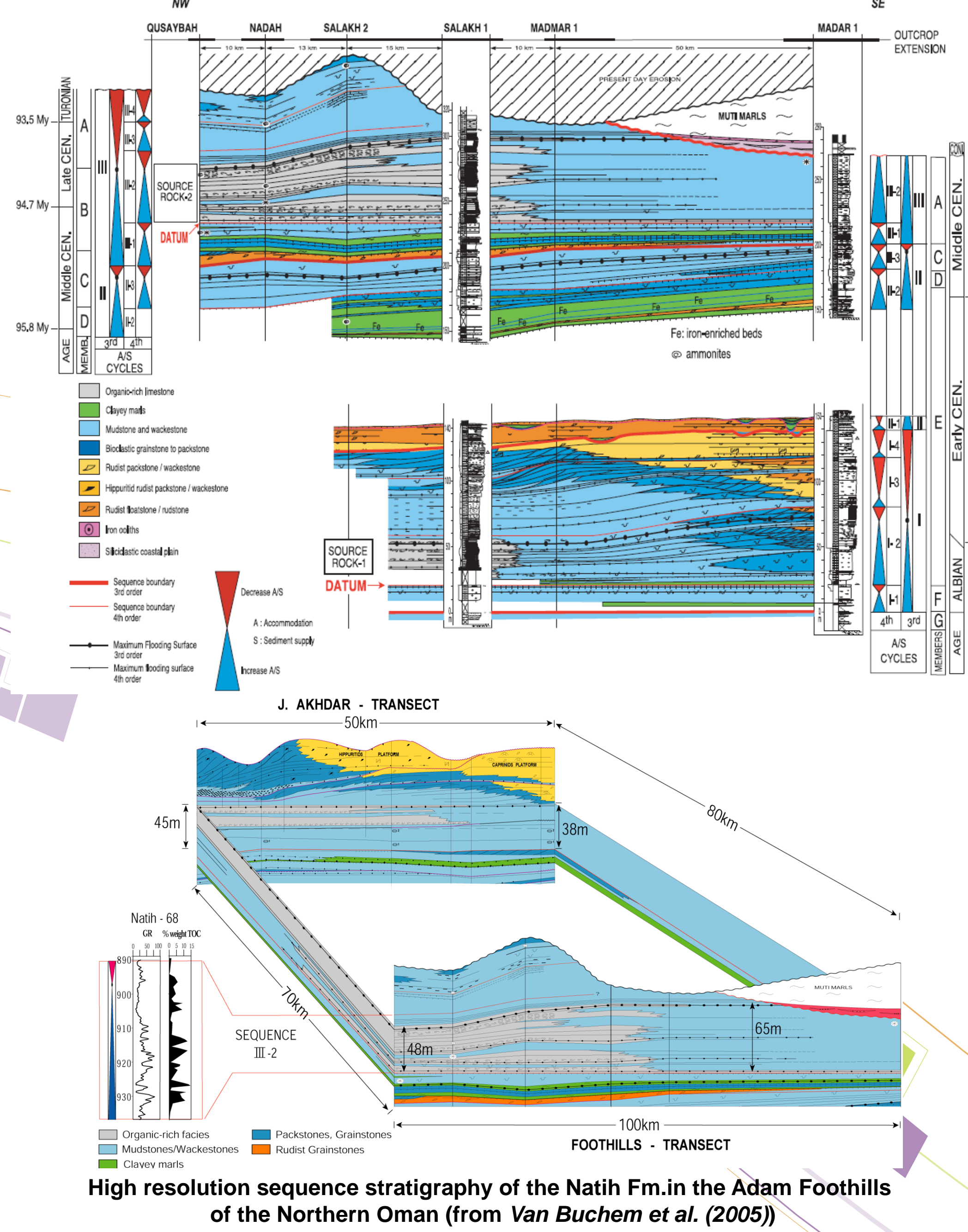
Marine Organic matter module

- **Input parameters**
Sedimentation rate, bathymetry, terrestrial organic matter supply (TOM), nutrient supply.
- **Simulated processes**
Primary production (related to nutrient availability),
Redox conditions: oxygen renewal (basin physiography) and oxygen demand (organic flux),
Organic matter degradation: exported organic flux in the water column (PP_z) and early diagenesis.
- **Outputs**
TOC₀, HI₀, redox conditions, burial efficiency (BE)



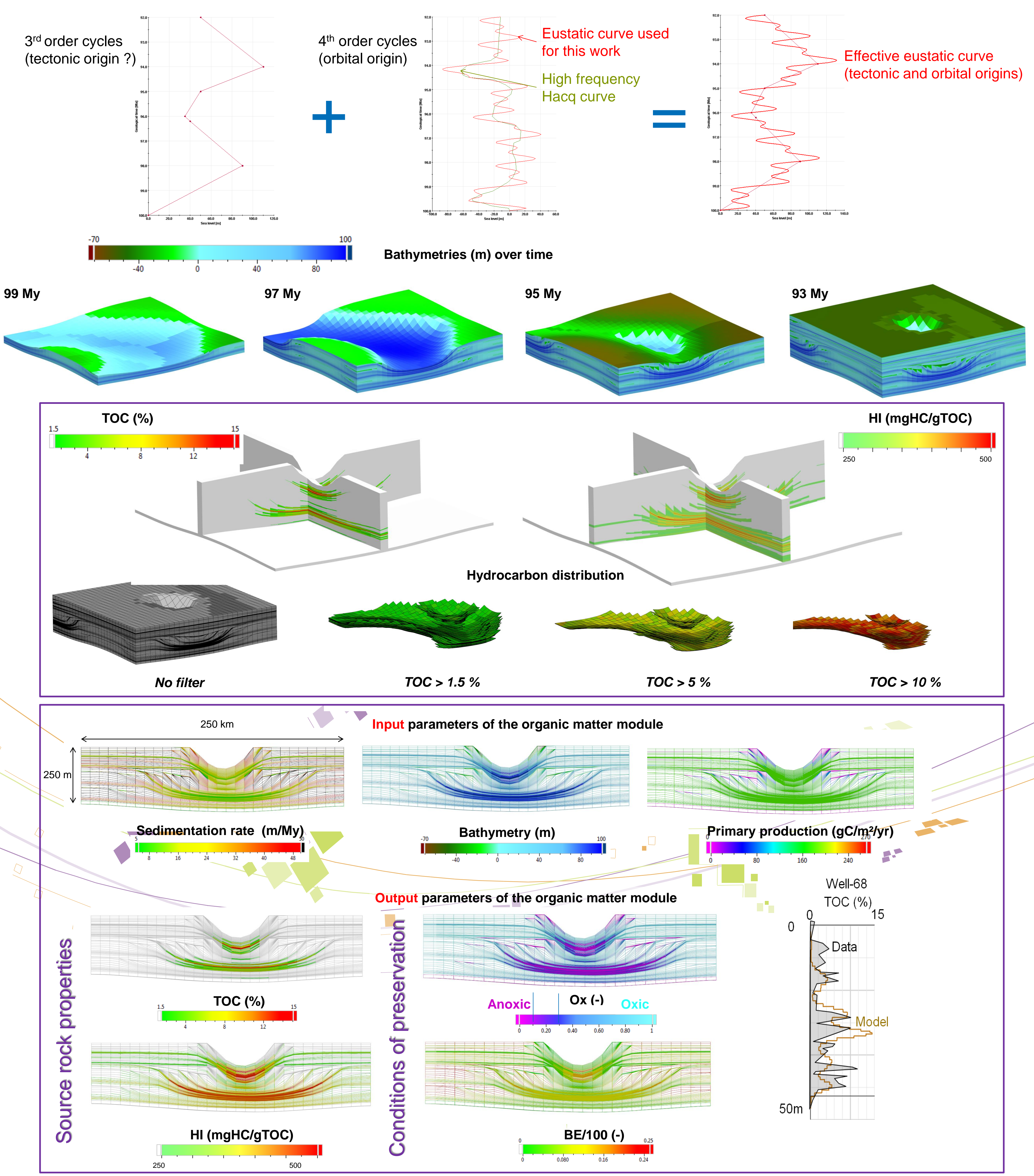
Geological model of the Natih Fm.

Two carbonate source-rock mb. (B and E) deposited in an intrashelf basin mainly composed of mud and rudists.



Application

Sediment-starved and organic-rich intrashelf based on the stratigraphy of the Natih Fm. (with mud and rudists) and using a constant organic production



Conclusion and perspectives

We have shown that even a simple hypothesis on primary production allows reproducing the main distributions and qualities of the organic-rich facies identified in the Natih Fm. This approach is therefore well adapted to provide consistent distributions of source-rocks properties even in frontier areas. From a process point-of-view, it also demonstrates the key role of the bathymetry variation on the source-rock signature, at least for this type of basin. One perspective could now be to make the link between environment of deposition and sulfur content. These results can then be used as input data in petroleum system models.

References
Granjeon, D., Joseph, P., 1999. Concepts and applications of a 3-D multiple lithology, diffusive model in stratigraphic modeling. Numerical experiments in stratigraphic and sedimentologic computer simulations. SEPM Spec. Publ. 62, 197–210.
Van Buchem, F.S.P., A.Y. Huc, B. Pradier and M. Stefani 2005. Stratigraphic patterns in carbonate source-rock distribution: Second-order to Fourth-order control and sediment flux. In, Nicholas B. Harris (Ed.), The Deposition of Organic-Carbon-Rich Sediments: Models, Mechanisms, and Consequences. SEPM (Society for Sedimentary Geology), Special Publication, no. 82, p. 191-223.