Sedimentary Responses to OAE2 across a Spectrum of Carbonate Depositional Settings: A Case Study from Examples in Central and Southern Italy*

R. Forkner[1], G. Frijia[2], M. Mutti[2], D. Minisini[1], and A. Dickson[3]

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[1]Shell International Exploration and Production, Leiden, The Netherlands (rob@metloef.com)
[2]University of Potsdam, Potsdam, Germany
[3]Oxford University, Oxford, United Kingdom

Abstract

Investigations into the deposition and maturation of high-TOC source rocks associated with environmental perturbations spanning the Cenomanian-Turonian boundary (CTB/OAE2) have led to the development of several unconventional resource plays around the world. Imperative to the development of plays targeting tight, high-TOC beds is the ability to either stimulate the interval through hydraulic fracturing, or instead be able to produce from vertically adjacent intervals that may preserve a measure of matrix permeability. It is therefore clear that an understanding of both the occurrence of high TOC source rocks and their adjacent carrier beds is required for successful development of unconventional resources.

In order to better constrain the sedimentary response of carbonate systems to OAE2, a case study was undertaken to describe Cenomanian-Turonian deposits occurring across a spectrum of carbonate depositional settings cropping out in central and southern Italy. Depositional settings include basinal pelagic deposits around Gubbio (predominantly chalks with interbedded black cherts and black shales); slope deposits in Gran Sasso d'Italia (including stacked calciturbidies and mass transport deposits interbedded with black cherts and black shales); platform interior lagoon deposits from the Majella massif in central Italy(skeletal and peloidal packstones interbedded with bituminous marly mudstones); and lagoonal to peritidal deposits from the Appenine carbonate platform in Southern Italy.

In each setting, the repetitive successions of facies making up the majority of the section were interrupted in distinct stratigraphic intervals across the CTB by black shales or laminated marls. This indicates that whatever environmental perturbation affected the area in the late Cenomanian, it was pronounced enough to temporarily suppress local carbonate production in both pelagic and neritic settings and, instead, preserve higher-TOC rocks in their place. This is important information to be considered when developing resource plays that may target depositional environments other than deep pelagic basins, as encasing rock may be better able to contribute to overall matrix permeability.

Selected Reference

Dercourt, J., N. Cotiereau, and B. Vrielynck, 1993, Reconstruction of Tethys from Permian to Recent; implications for sedimentary facies distribution and oceanic circulation: AAPG Annual Meeting Expanded Abstracts, p. 91.

Sedimentary response to OAE2 across a spectrum of carbonate depositional settings: a case study from examples in central and southern Italy.

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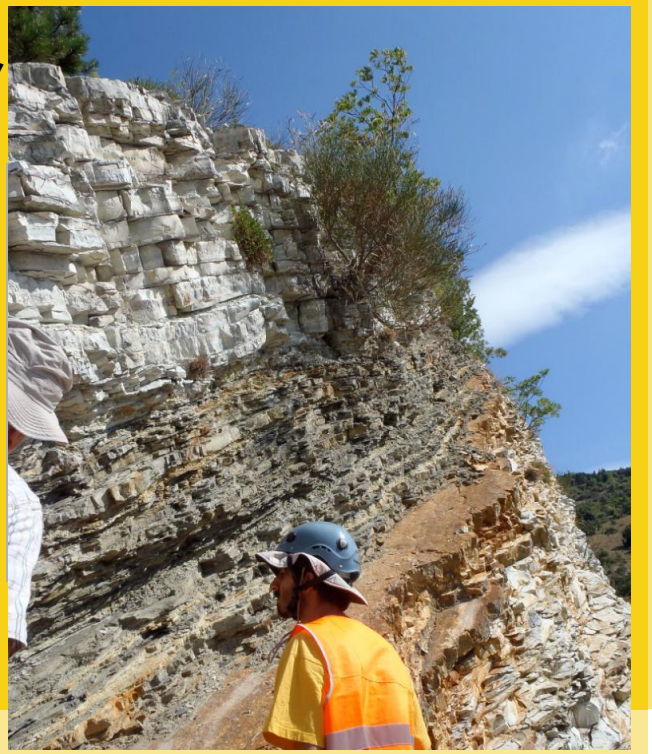
1. Shell International Exploration and Production
2. University of Potsdam
3. Oxford University



Livello Bonarelli, Furlo Quarry, Umbria, Italy

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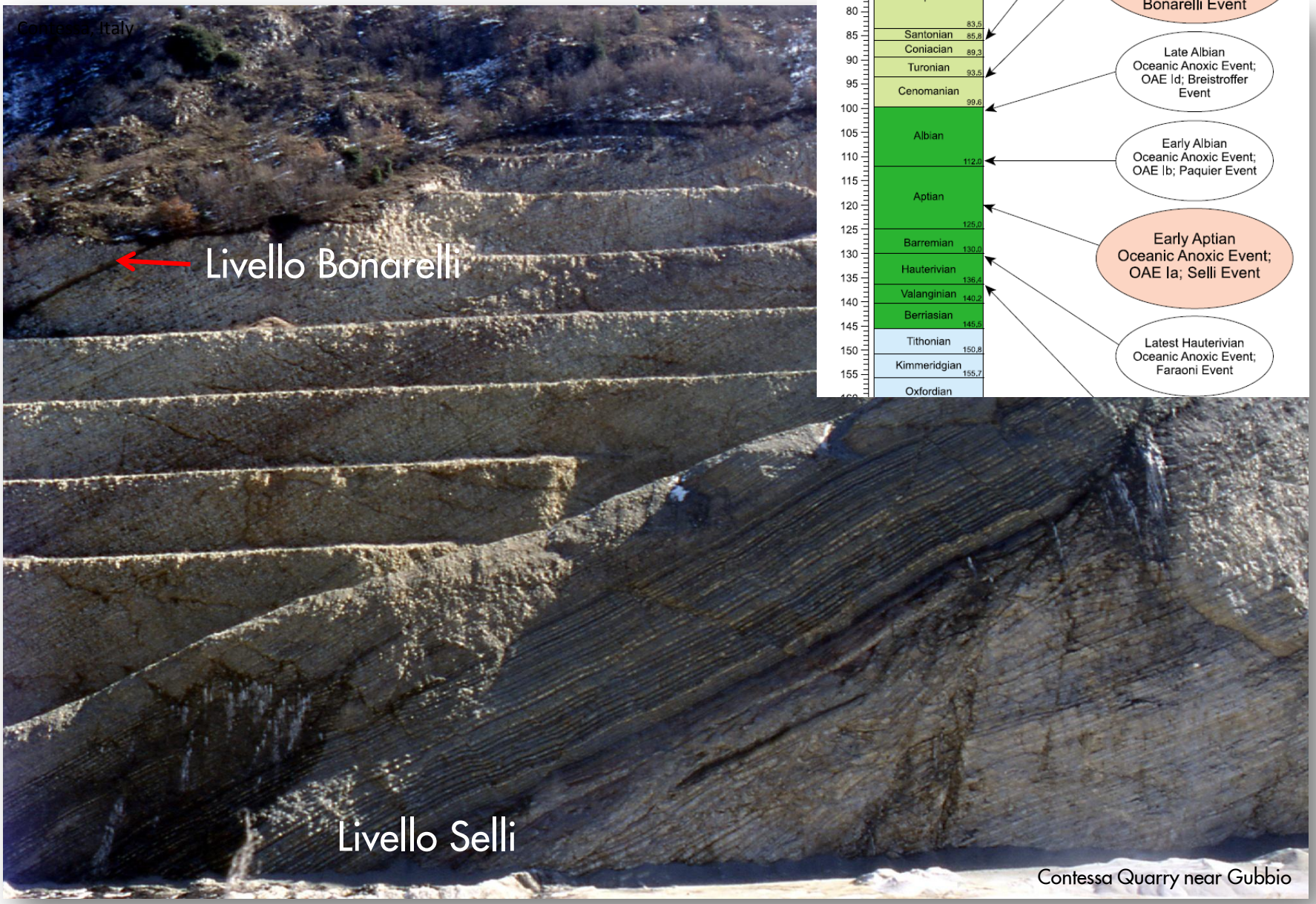
Hugh Jenkyns (U. of Oxford)
Steve Bergman (Shell)
Daniele Masetti (U. Ferrara)
J. Van Konijnenburg (Shell)

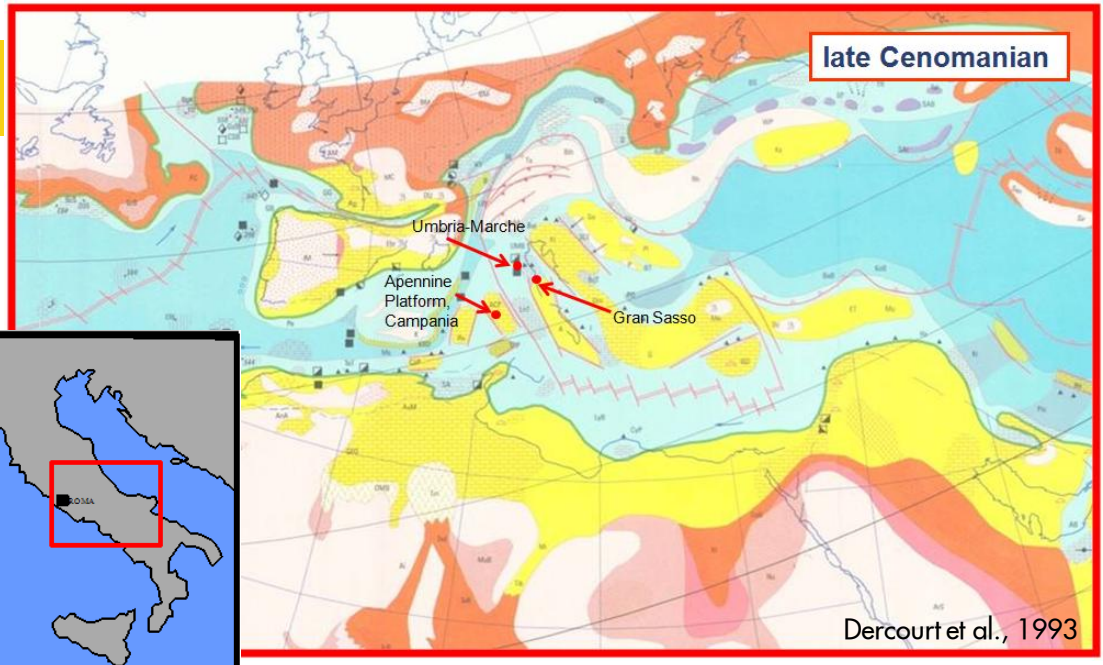
Purpose

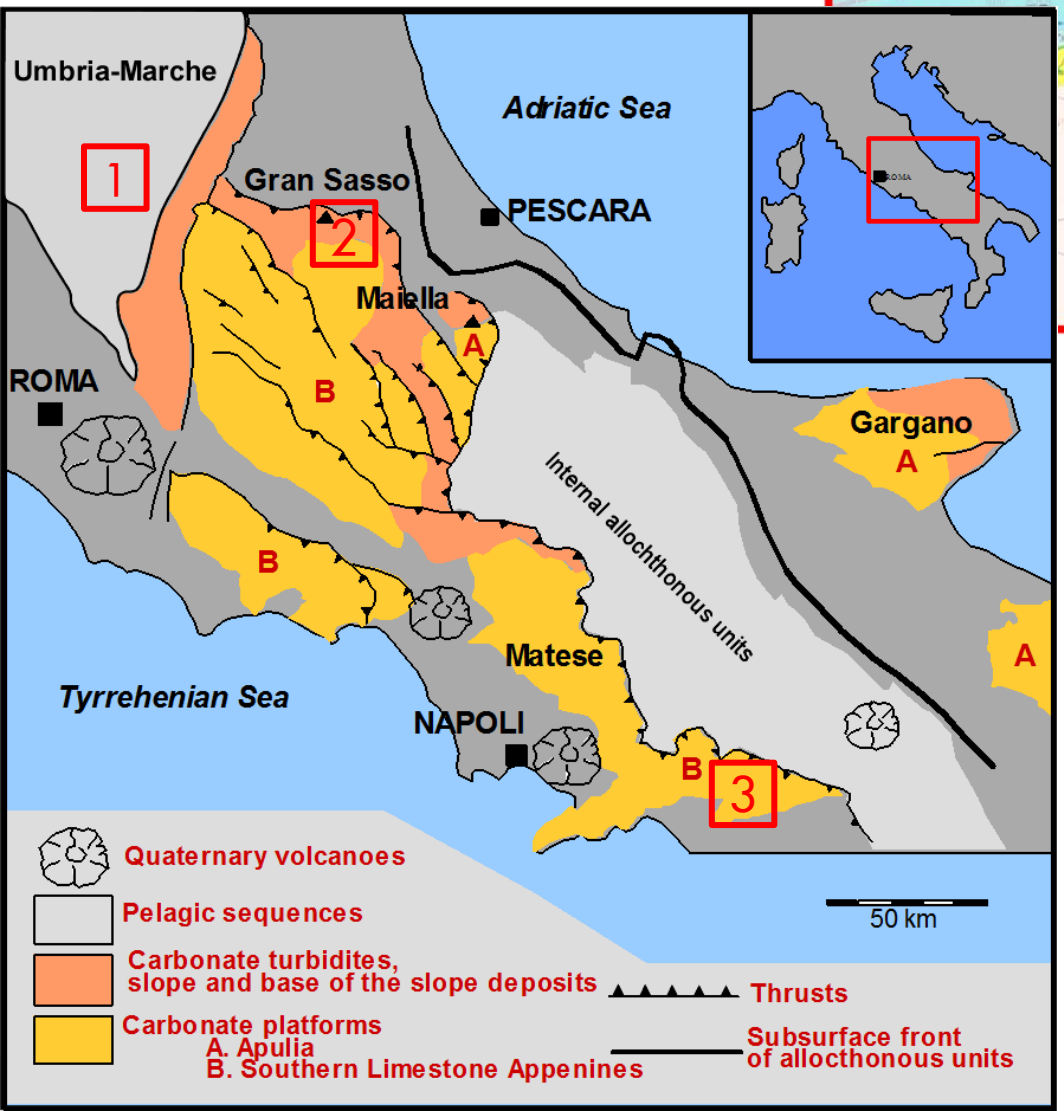
- Snapshot of interrelated carbonate depositional environments that are affected by circum CTB events. Important because:
  - Provides views of classic, recognizable carbonate environments (e.g., tidal flats, lagoon, reef, slope, etc.), as opposed to more cryptic ones, e.g., Eagle Ford.
  - Determine whether *diagnostic* facies are present within each succession
  - Improve facies understanding and prediction
  - Correlation may yield more discernible record of eustasy, environmental shutdown, etc.

Cretaceous anoxic events



Paleogeography





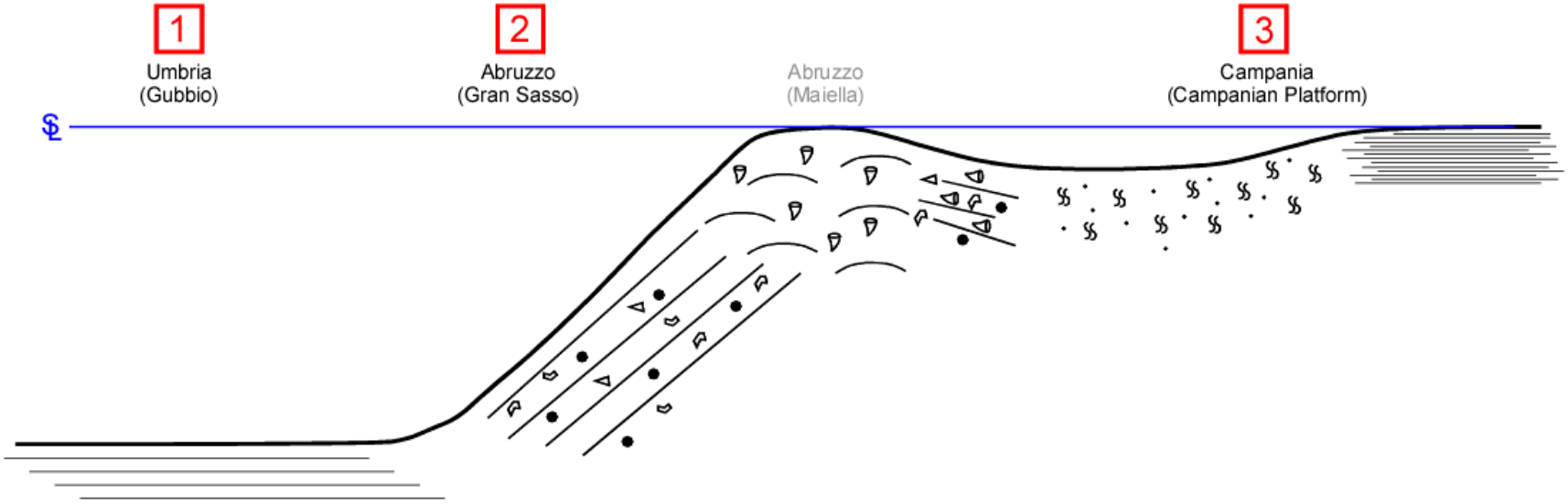
1 Pelagic successions near Gubbio

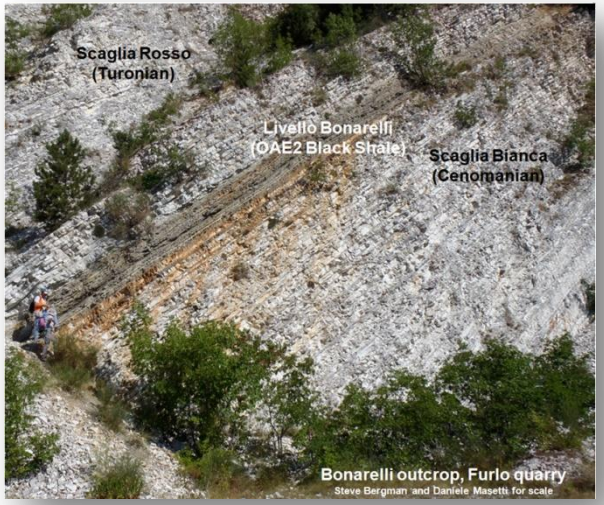
2 Lower slope successions at Gran Sasso

3 Platform interior successions in Campania

After van Konijnenburg, 1994

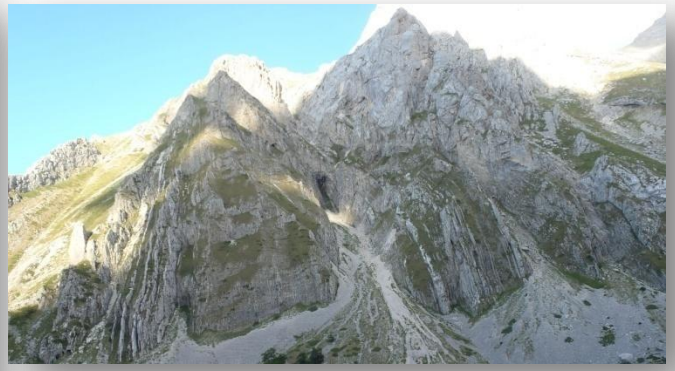
Carbonates and OAE2 in central Italy: simplified cross section





Scaglia levels near Gubbio

Basinal Pelagics



Gran Sasso

Slope Sediments

Campanian Platform

Platform interior Successions

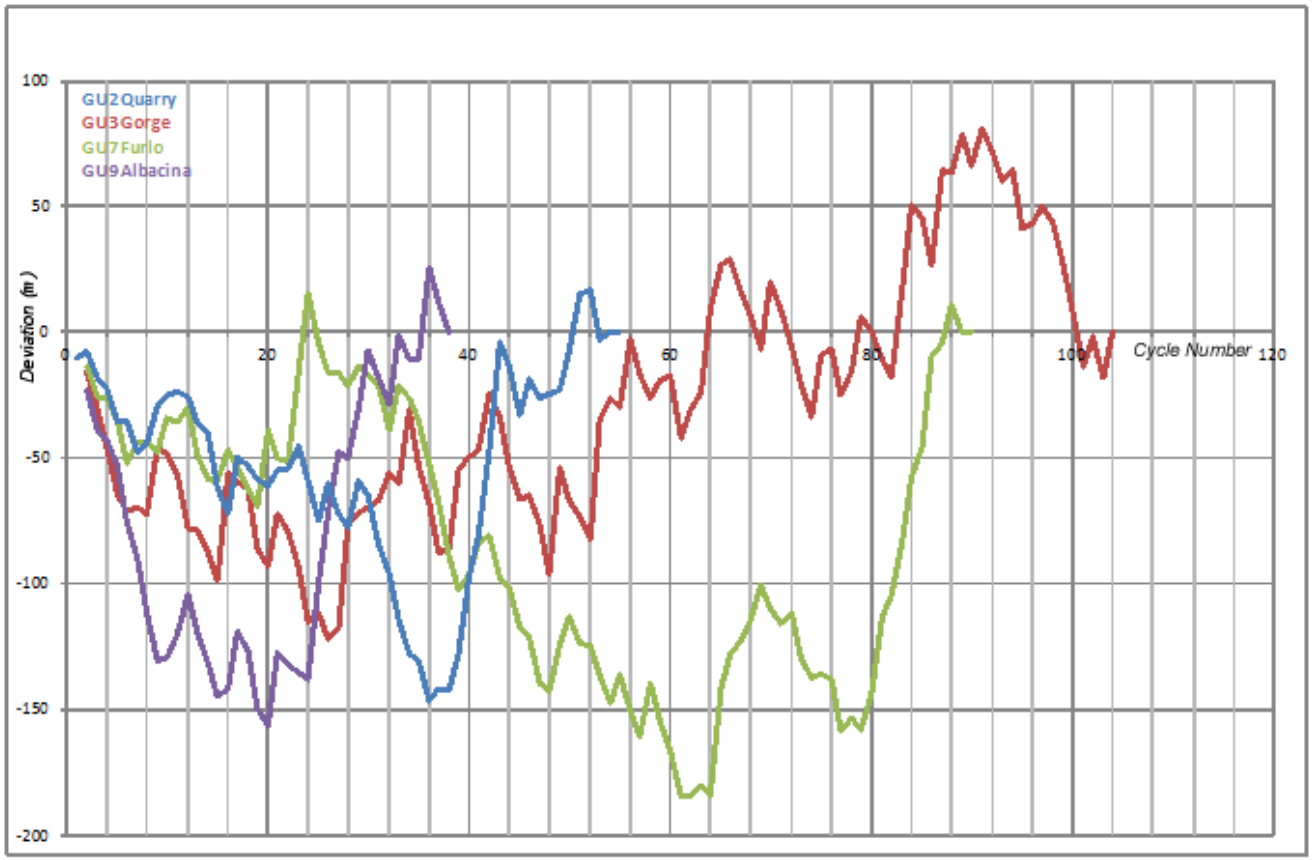
Furlo Quarry

Contessa Quarry

Cerbara Gorge

Contessa Quarry

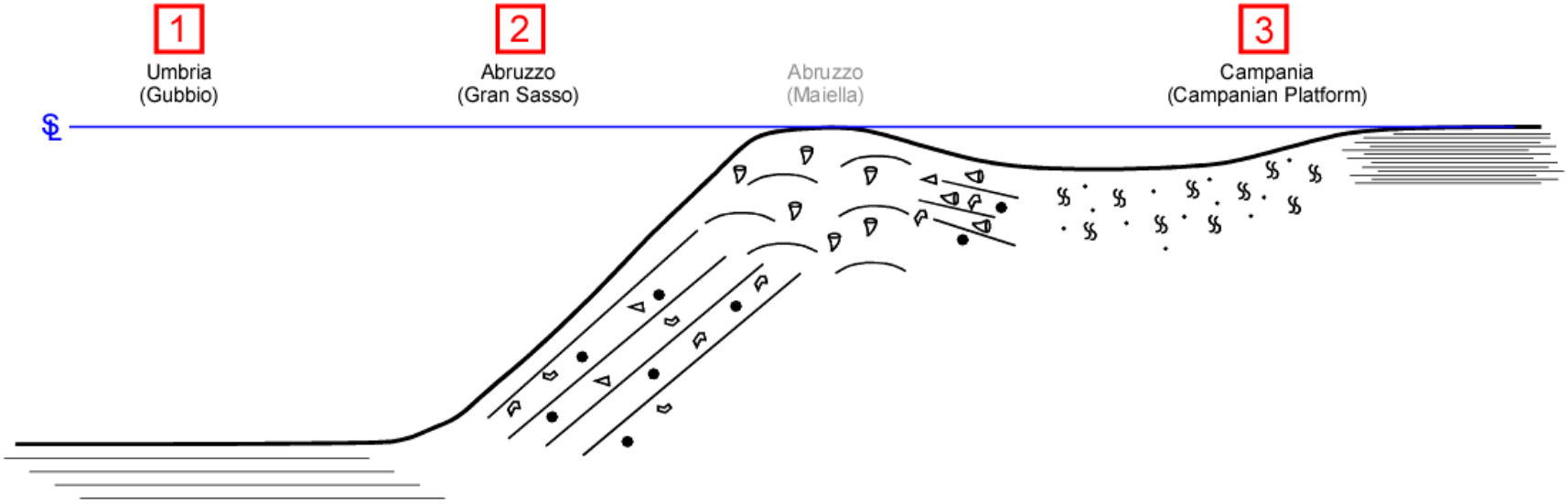
Scaglia successions near Gubbio

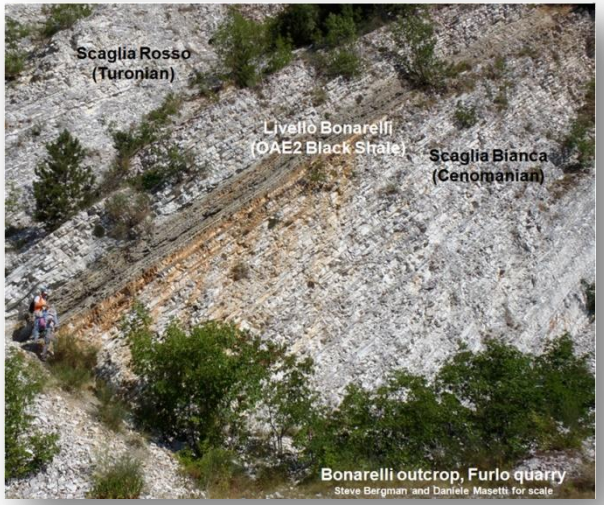


Basinal Deposits – Learnings from around Gubbio

- OAE2 interval (Livello Bonarelli) contains no carbonate or benthic forams. Instead, in general, white radiolarian silts, black massive mudrock, and black fissile mudrock/shale.
- Sections correlated via biostratigraphy, chemostratigraphy, spectral gamma ray, and cycle stacking patterns
- Cherts/mudstones separating many chalk beds become black cherts/mudstones ca. 20 meters from the Bonarelli level
- Chalk sedimentation resumes after Bonarelli

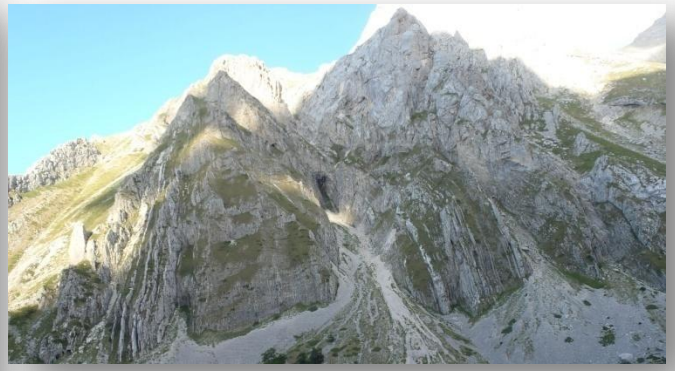
Carbonates and OAE2 in central Italy: simplified cross section





Scaglia levels near Gubbio

Basinal Pelagics

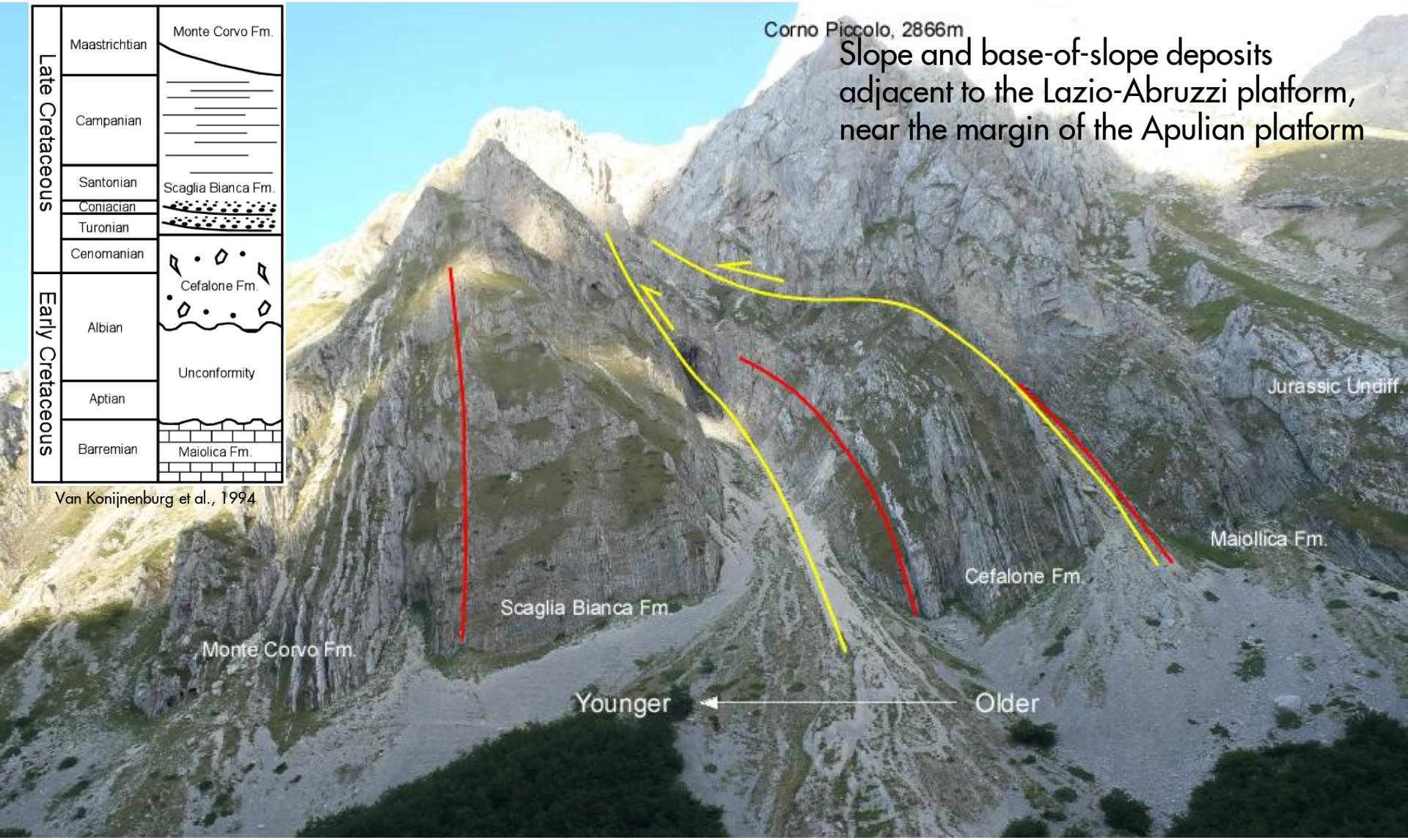


Gran Sasso

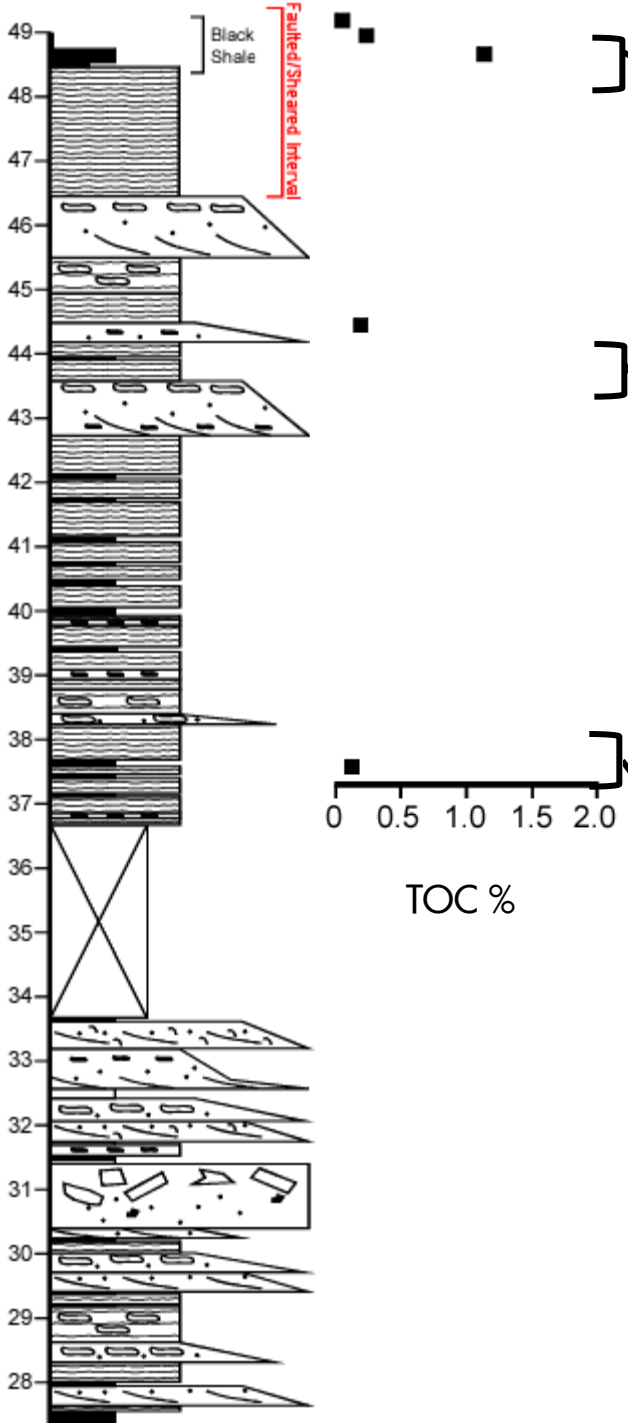
Slope Sediments

Campanian Platform

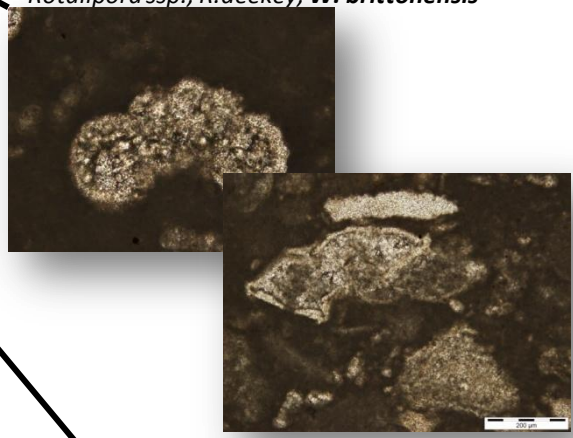
Platform interior Successions



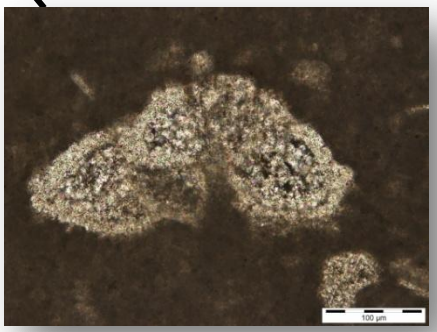
Gran Sasso Black Shale



R. Cf. greenhornensis,
Rotalipora ssp., R.deekey, ***W. brittonensis***



Rotalipora spp.,
P. gibba, ***P. Cf. stephani***

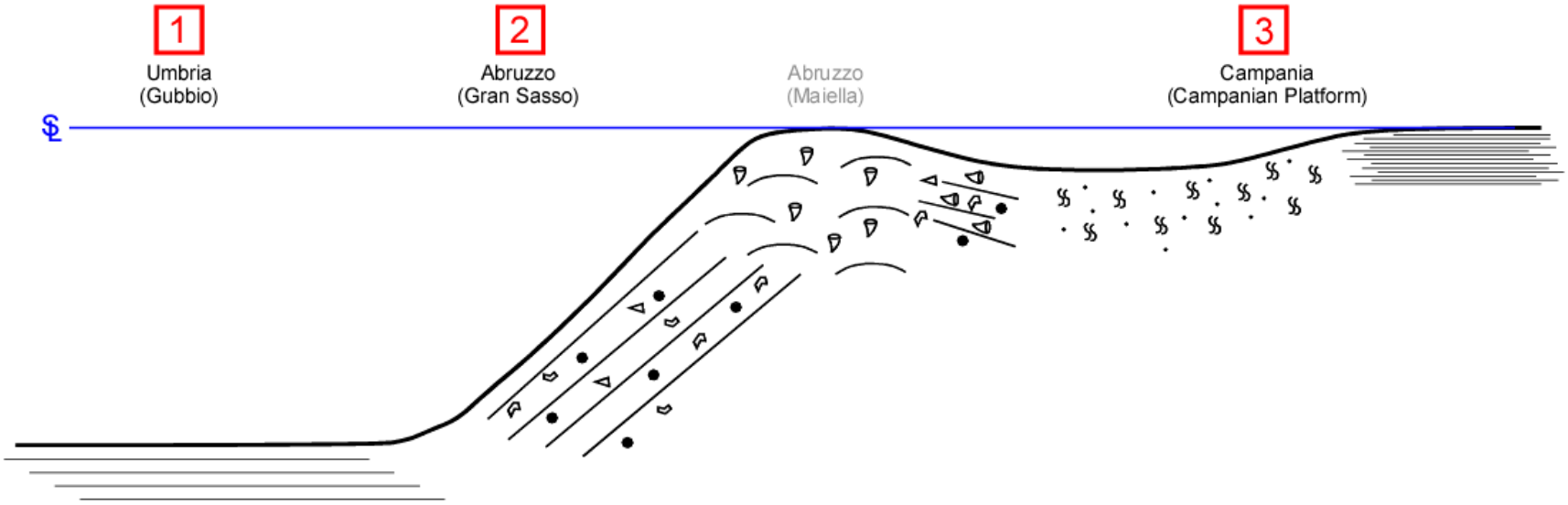


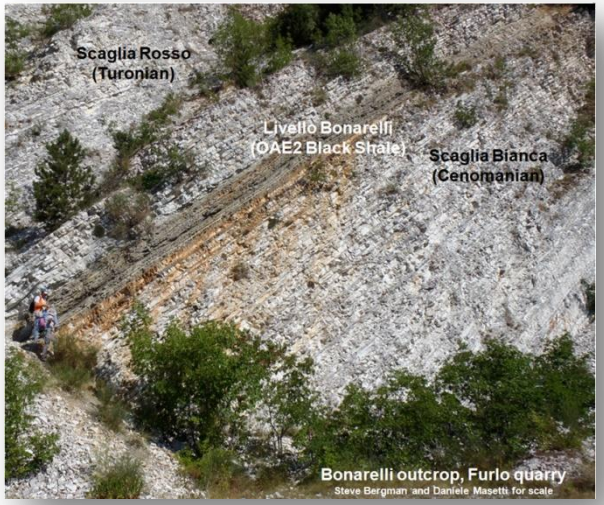
D.algeriana*, Rotalipora spp.*
P. Cf. stephani

Slope Deposits – Learnings from Gran Sasso

- Thin cherts and shales occurred between turbidite and mass transport deposits; become black ca. 20 meters from where the CTB black shale should be.
- Remnant of what may be the OAE2 black shale was discovered within Gran Sasso lower slope deposits. We found no other lithology like this in outcrop at Gran Sasso
- It is not yet known how rock properties of the black shale (% carbonate, %TOC, etc.) may vary up-slope or down slope, needs further investigation. Full outcrop exposure preserved?

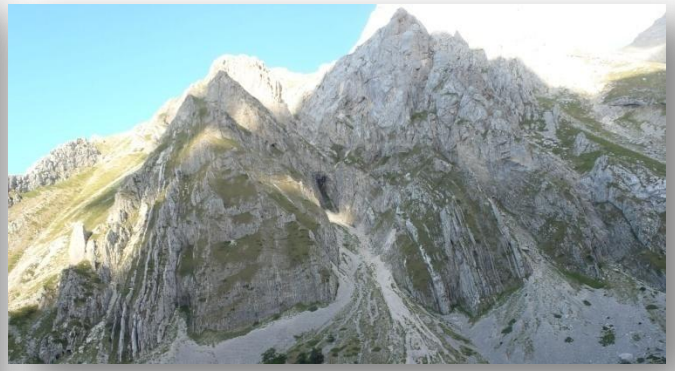
Carbonates and OAE2 in central Italy: simplified cross section





Scaglia levels near Gubbio

Basinal Pelagics



Gran Sasso

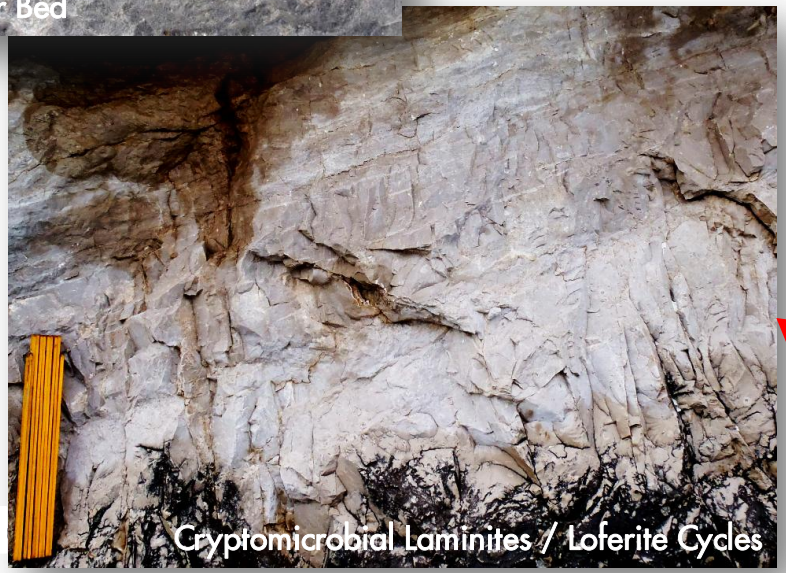
Slope Sediments

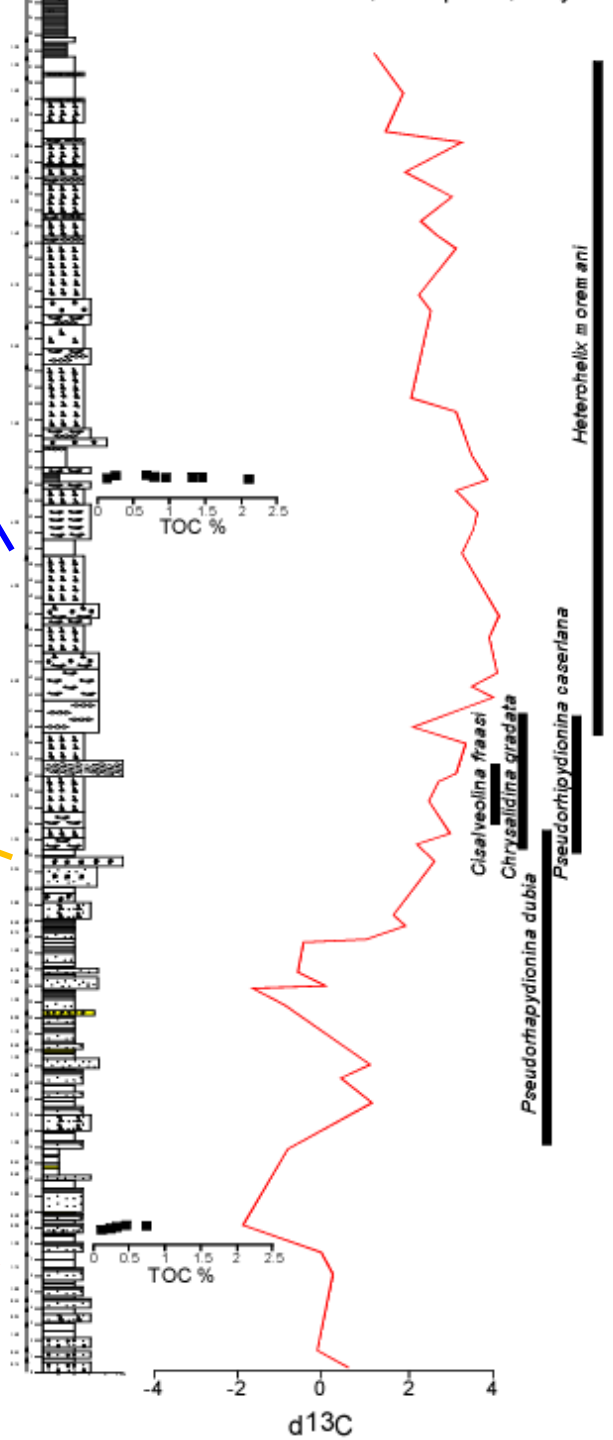
Campanian Platform

Platform interior Successions

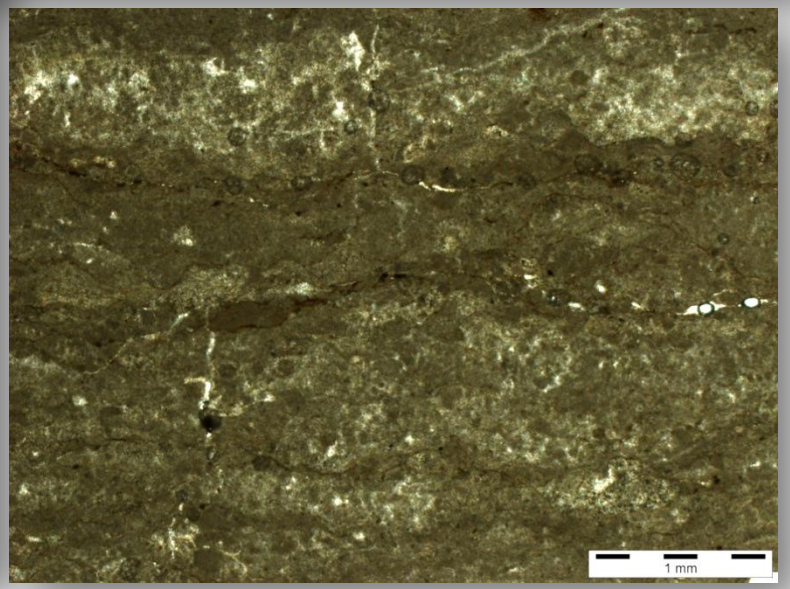

Thalassinoides Galleries / Subtidal Cycles


Radiolitid Marker Bed


Cryptomicrobial Laminites / Loferite Cycles


TOC %
0 0.5 1 1.5 2 2.5
TOC %
0 0.5 1 1.5 2 2.5
Heterohelix moremani
Pseudorhapydionina caserlana
Chrysalidina gradata
Cisalveolina fraasi
Pseudorhapydionina dubia
-4 -2 0 2 4
d13C


O'NEILL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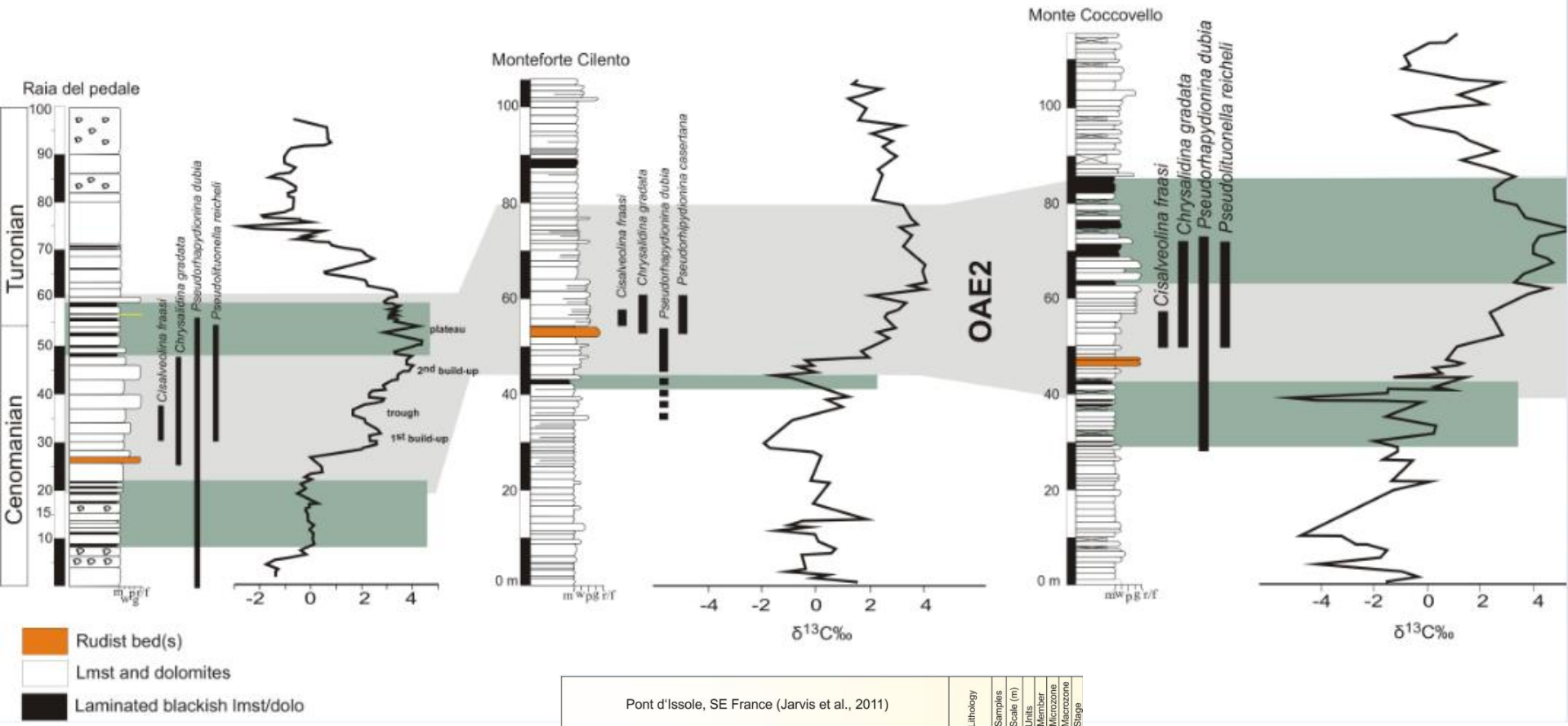
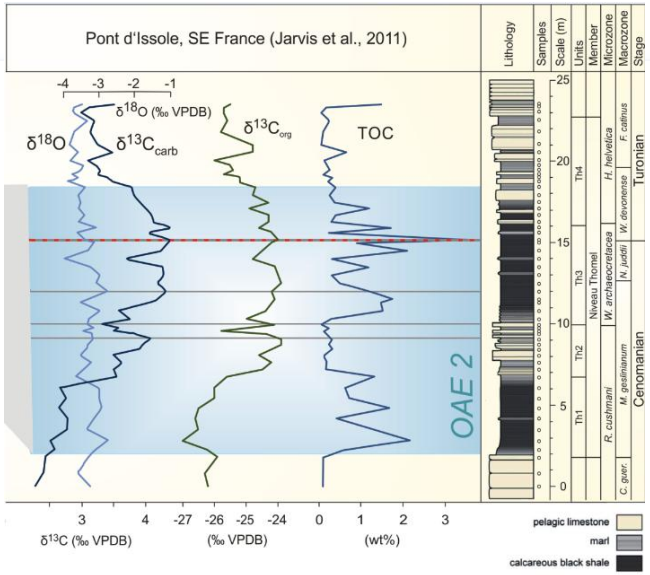


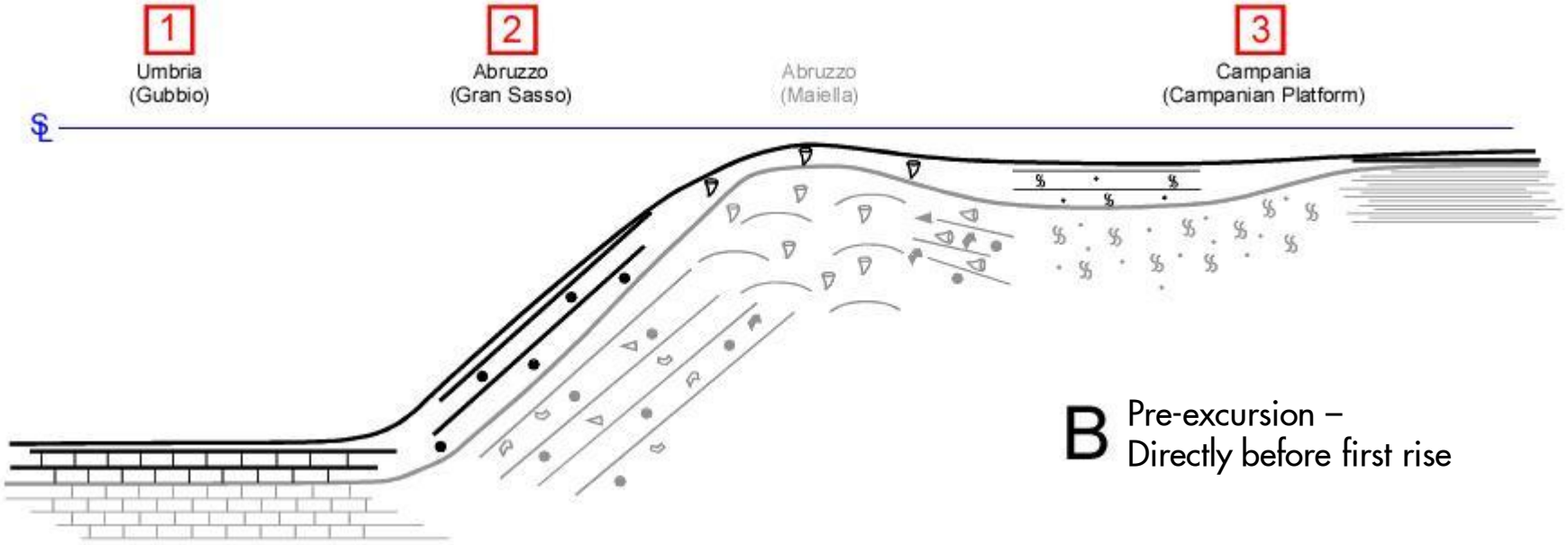


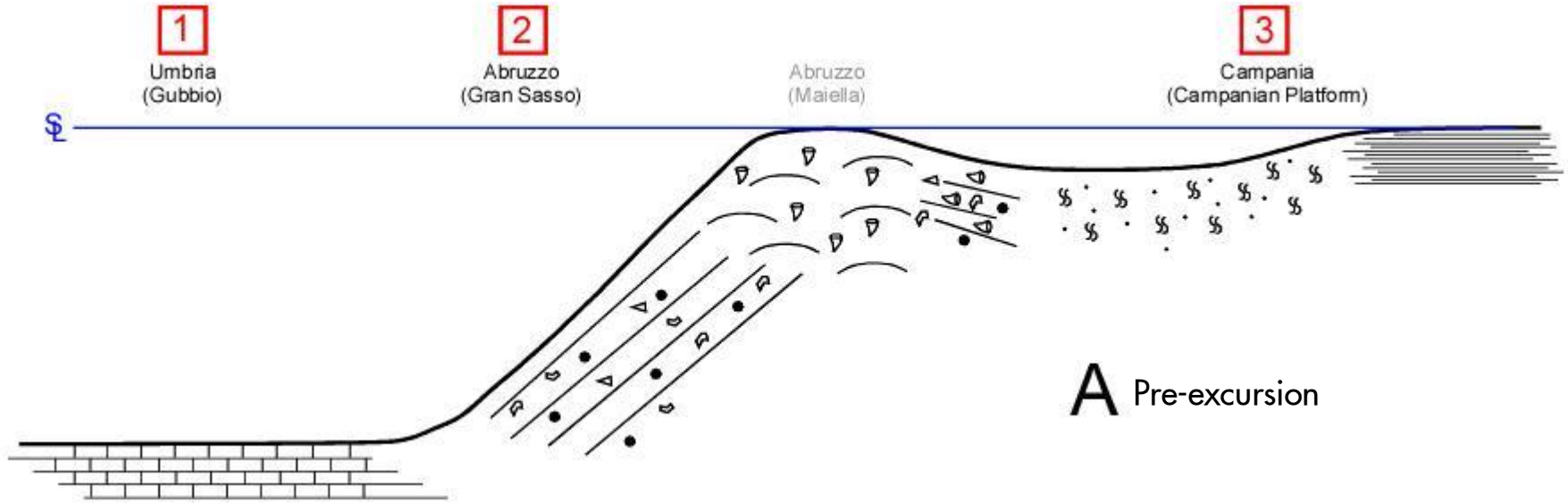
Platform Interior Deposits – Learnings from Campania

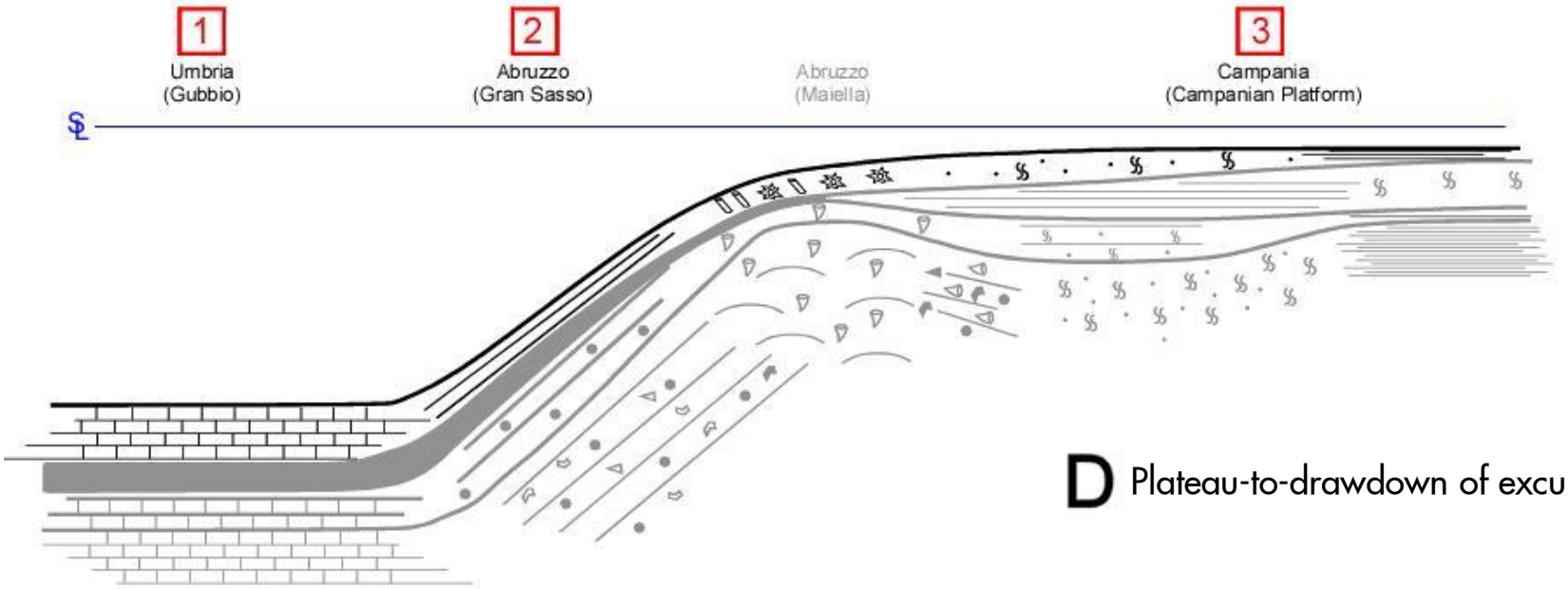
- Basal peritidal deposits develop marly, higher TOC laminites. This facies may be *diagnostic* of environmental change associated with OAE2.
- Subtidal cycles immediately overly peritidal cycles in all sections, commensurate with the start of the carbon isotope excursion. Likely a eustatic signal – SL rise at the base of the excursion.
- Subtidal cycles are generally muddy and do not preserve a diverse ecological community
- Sections preserve very similar lithologic successions and stacking patterns

Conclusions: response of carbonates in Italy to OAE2

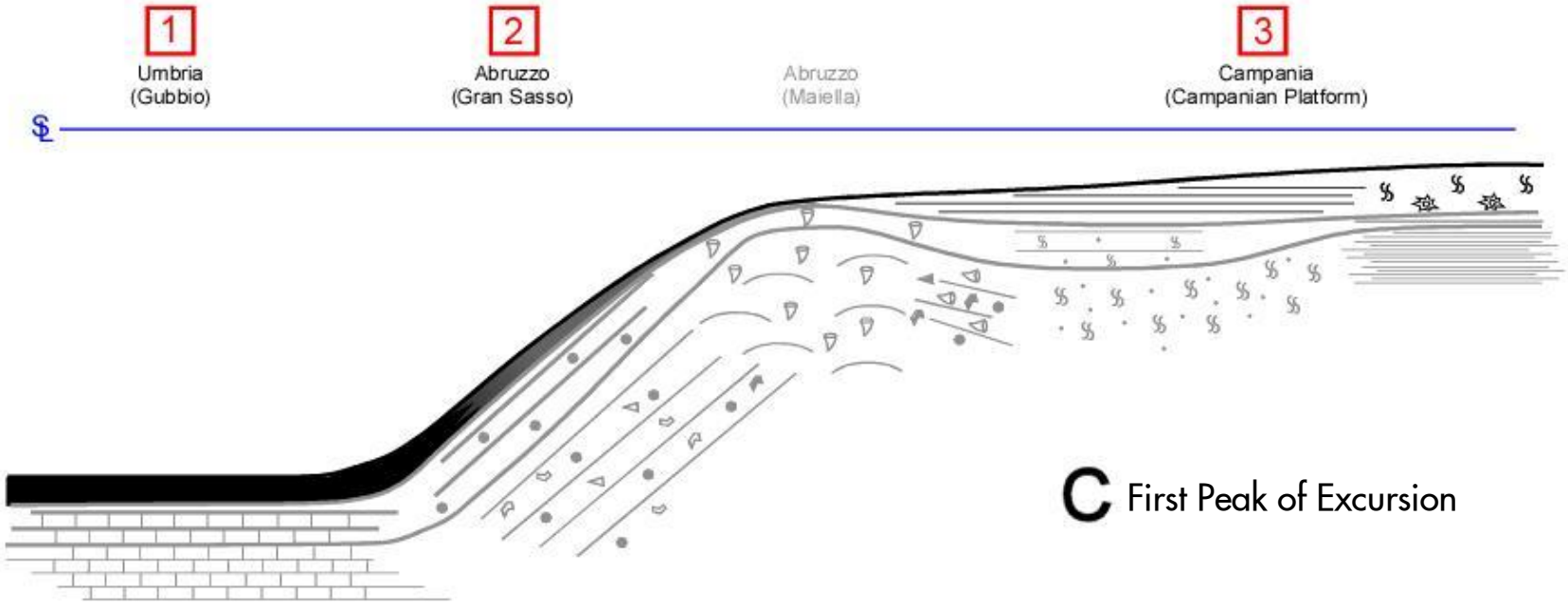
- Proof of concept of presence and preservation of high TOC facies in a broad spectrum of carbonate-producing environments from basin to tidal flat.
- Diagnostic facies occur within all subenvironments.
  - Deeper water environments preserve true black shales and black cherts (former radiolarian black shales).
  - Shallower water deposits preserve high-TOC laminated marly wackestones interbedded with subtidal shelf carbonates.
- The carbonate system recovers post OAE2, and in some cases continues to produce sediment to the end of the Cretaceous.







D Plateau-to-drawdown of excursion



C First Peak of Excursion