High-Frequency Forced Regressions and Their Influence on Stratigraphic Trap Generation: Examples from the Paleogene in Pelotas Basin, South Brazil*

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Abstract

The stratigraphic evolution of the Paleogene section in Pelotas Basin (South Brazil) was interpreted using 2D time data integrated with well data. High-frequency changes in the trajectory of the shelf break during the Paleogene and Eocene are interpreted to represent periods of forced regression, transgression and normal regression. These events influenced sand dispersion patterns as well as the distribution of shale-prone intervals throughout the basin, indicating the possible existence of important stratigraphic traps.

These observations, when placed within robust stratigraphic models, represent key components of the sequence stratigraphic framework, and may result in a powerful tool for reservoir and seal prediction. According to many traditional models, periods of forced regression may cause a substantial increase in sediment availability. Consequently, these events are important for delivering sediments to the deep basin, creating sand-prone submarine fans that are covered by basinal shales during the subsequent transgression. However, in this analysis, we recognize a stratigraphic signature that conflicts with these traditional models, suggesting that other processes may be affecting the studied area. An example of these apparent conflicts includes abundant evidence for forced regressive shelf edge deposits with no correspondent down dip sandy counterpart in the Eocene.

Based on this interpretation, the potential for stratigraphic traps in the deep part of the basin will be presented. Uncertainties related to the quality of potential reservoirs in relation to the timing of the shelf break migration will also be discussed.

References Cited

Catuneanu, O., 2006, Principles of Sequence Stratigraphy: Elsevier, 375 p.

Tomazelli, L.J., and J.A.O. Villwock, 2000, O Cenozóico no Rio Grande do Sul: geologia da planície costeira, *in* M. Holz, and L.F. De Ros, eds., Geologia do Rio Grande do Sul. Porto Alegre: CIGO/UFRGS, p. 375-406.

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(Edited version for AAPG web sites)

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Objectives

This talk aims to illustrate a specific limitation in current models of sequence stratigraphy as regards the temporal and spatial relation between shelf deposits and their deep basin counterparts during a forced regression.

This limitation impacts the prediction of deepwater reservoirs and the reasons for some unexpected stratigraphic responses will be explored.

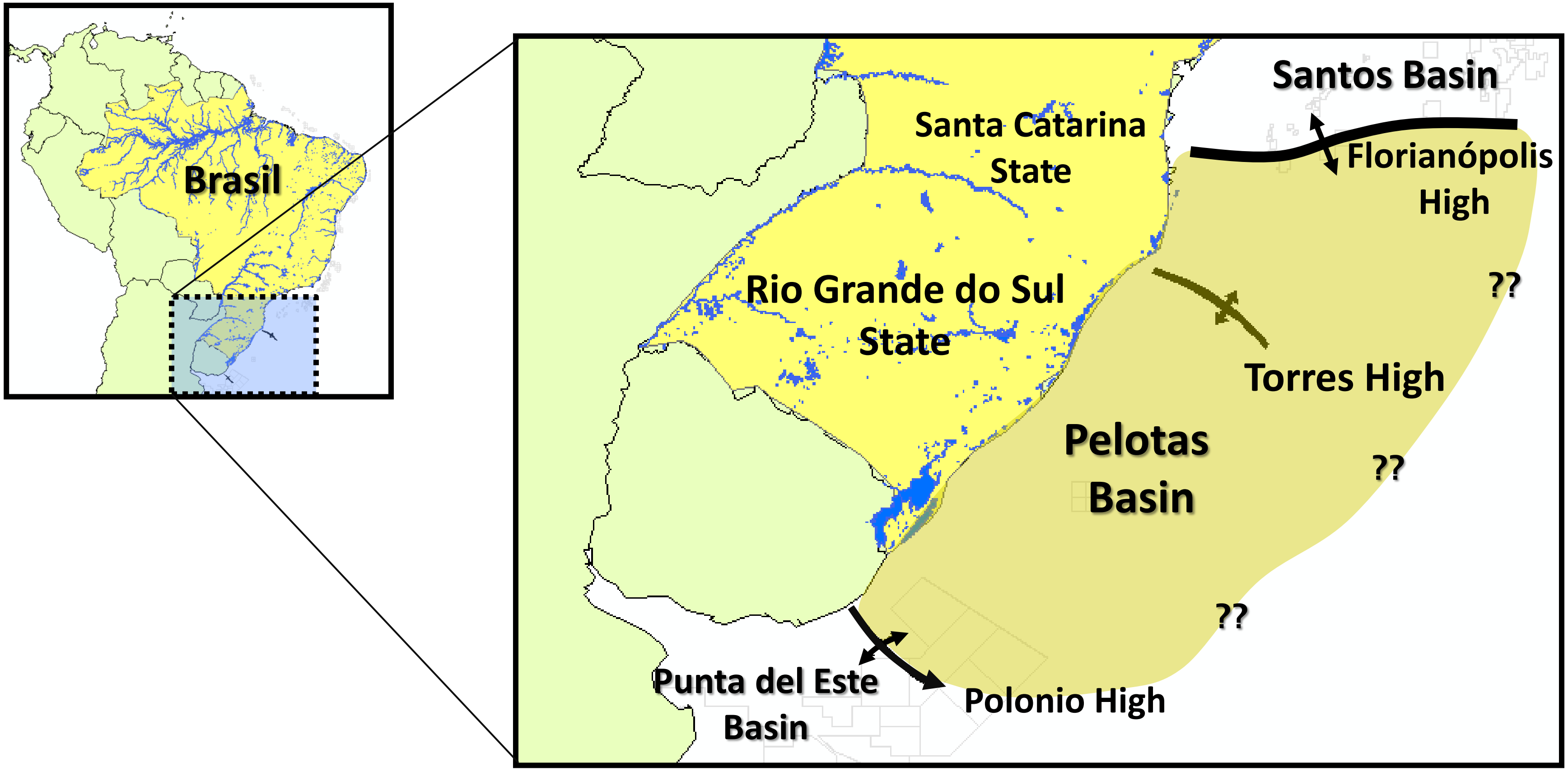
Outline

-Models dealing with forced regression configurations and the influence of them in the generation of stratigraphic traps

-Examples from the Paleogene section in Pelotas Basin, South Brazil: unexpected stratigraphy?

-Summary

Location and Data



-Studied Area:

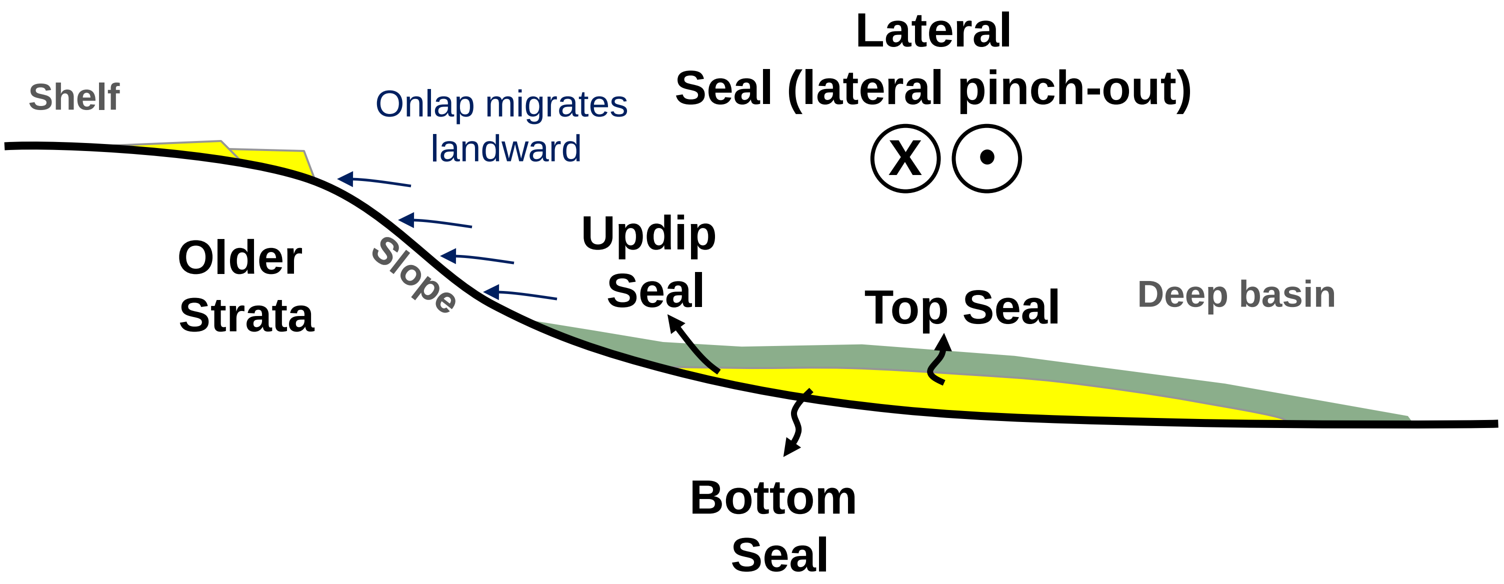
-Interpretation constrained by 6 wells with litholog (two with paleodata);

-Several 2D Seismic lines in time (PSTM)

We are going to talk about…

-A stratigraphic trap in deep water realm requires…

- The porous rock to be the container,
- A non permeable rock that can serve as seal in the updip direction, in two lateral directions and on the bottom.



… it is a common sense that…

-Sequence stratigraphy is a powerful tool for reservoir and seal prediction, especially in siliciclastic domains;

-Mapping shoreline trajectories (or shelf breaks shifts) is a key step in building any stratigraphic framework in Exploration;

-Forced regressions (FR) are interpreted as part of the Falling Stage Systems Tracts (FSST), periods where the sand availability is greater and the potential to carry these sands to the deep-water realm is higher. Overlying systems tracts (LST and TST) can provide additional reservoir rocks and sealing intervals to form a "wonderful" stratigraphic trap;

** Key points to understand:

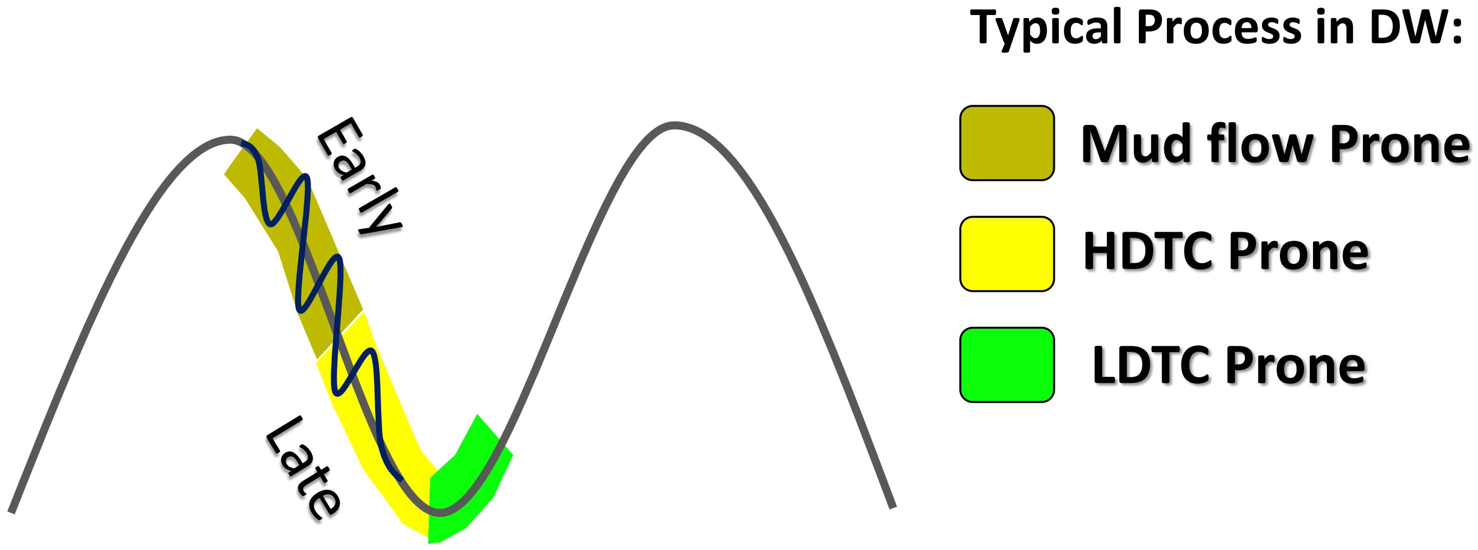
- What is the time of the forced regression in the base level curve, early or late FSST?

- What controls the deposition of sand on the shelf, the bypass zone, and the deposition of sand as part of a deep water submarine fan?

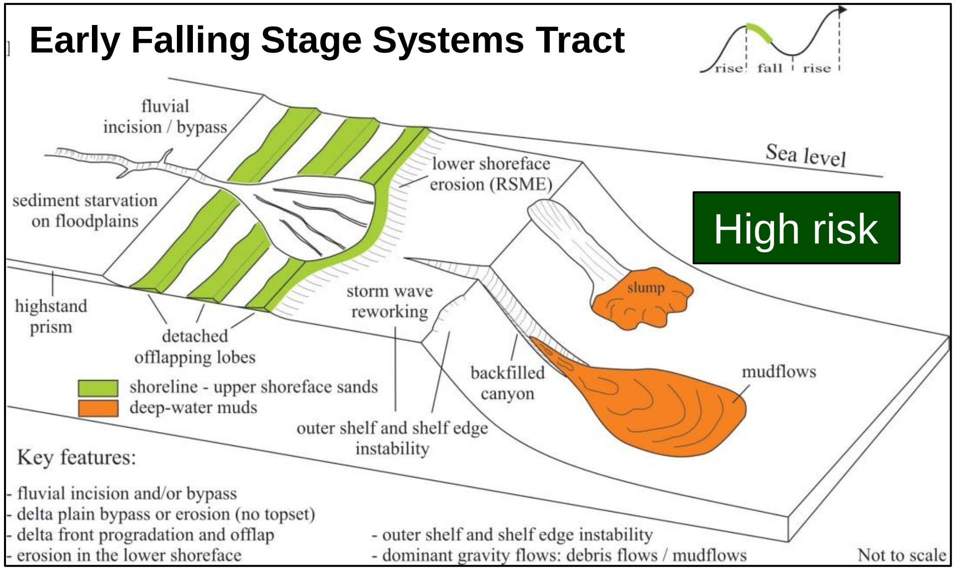
Reservoir presence/quality – where am I in this curve?

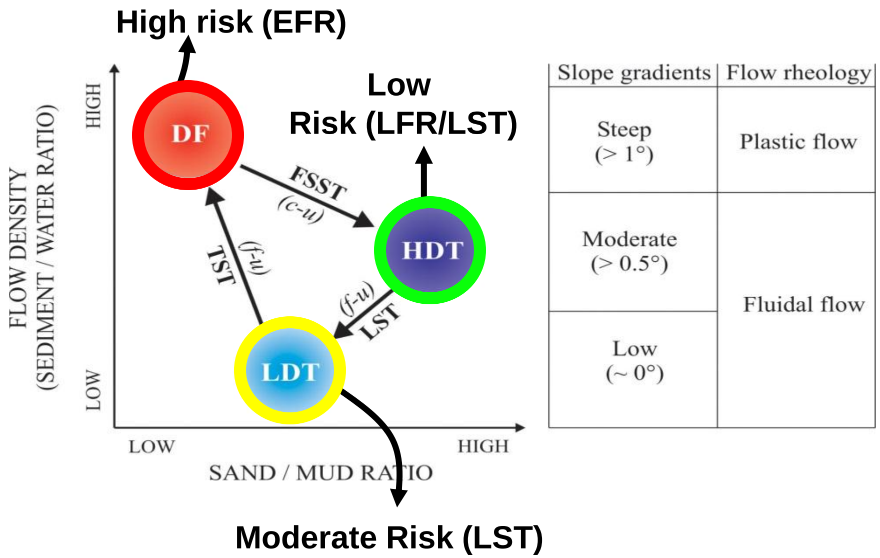
In which part of the base level curve are we during FSST?

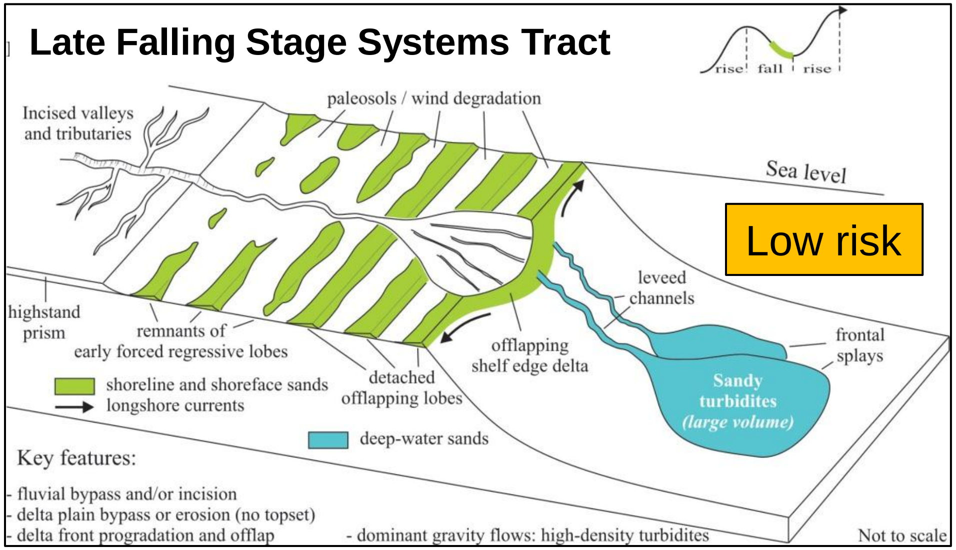
it would be easy to answer if the deep water deposits often were not physically disconnected from their updip counterparts!!

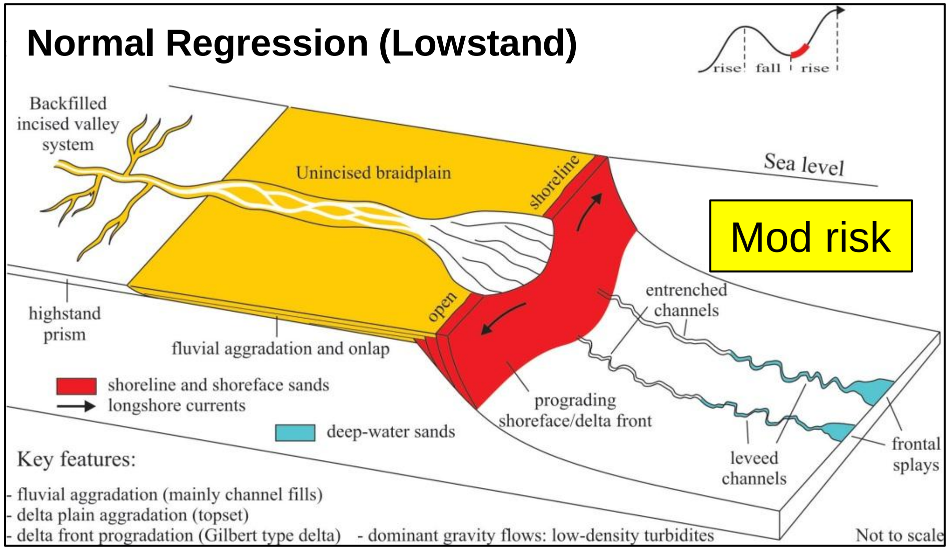


Where am I in this curve? Reservoir presence/quality risk



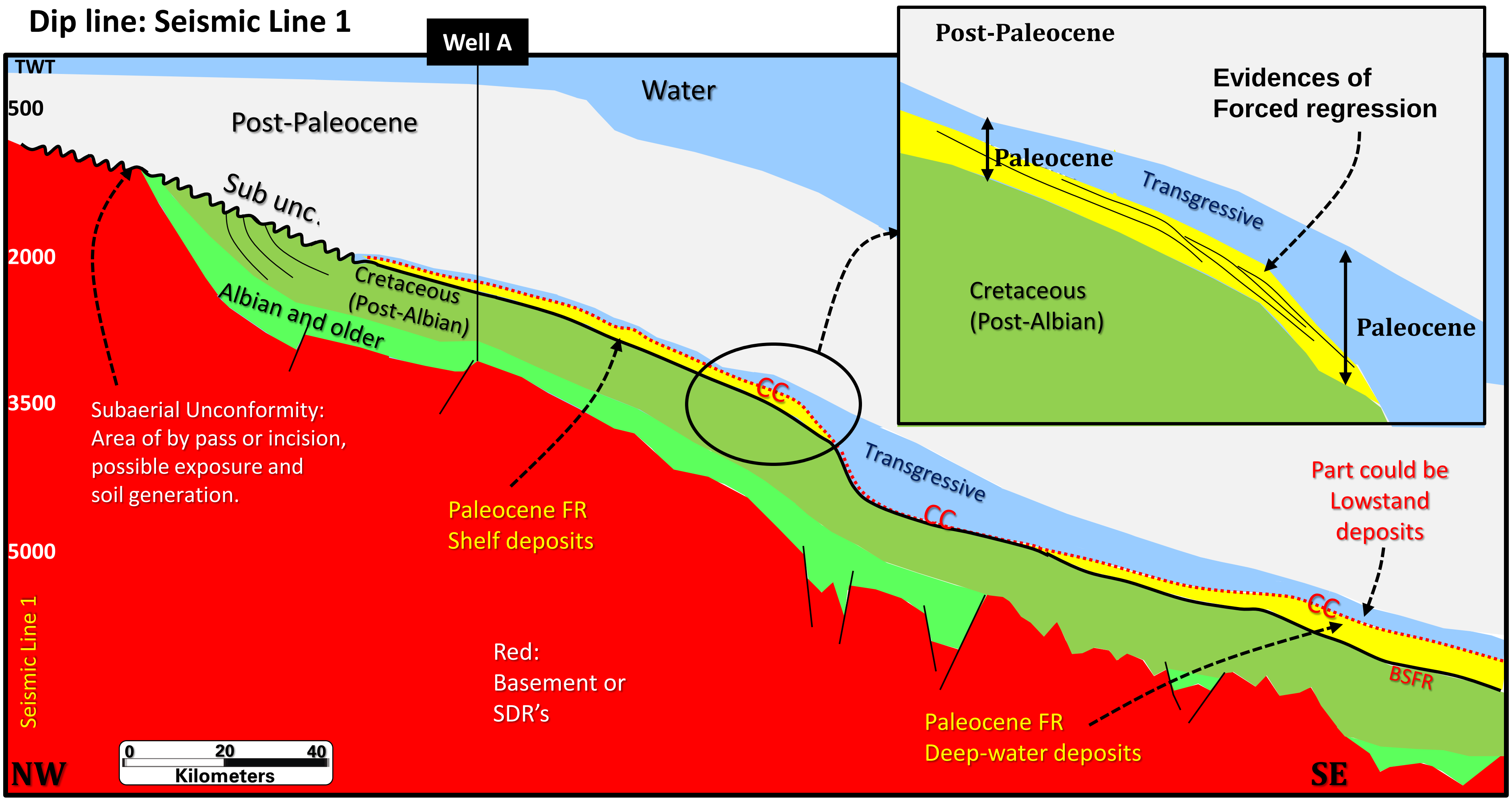






From Catuneanu, 2006.

Paleocene Section: observations, top-down approach



Early Paleocene: Little preservation of forced regression deposits on the shelf; huge lobate geometry downdip; steep slope.

K/T event generates a strong angular unconformity and extreme by-pass in the more proximal area (observe the drastic angular unconformity).

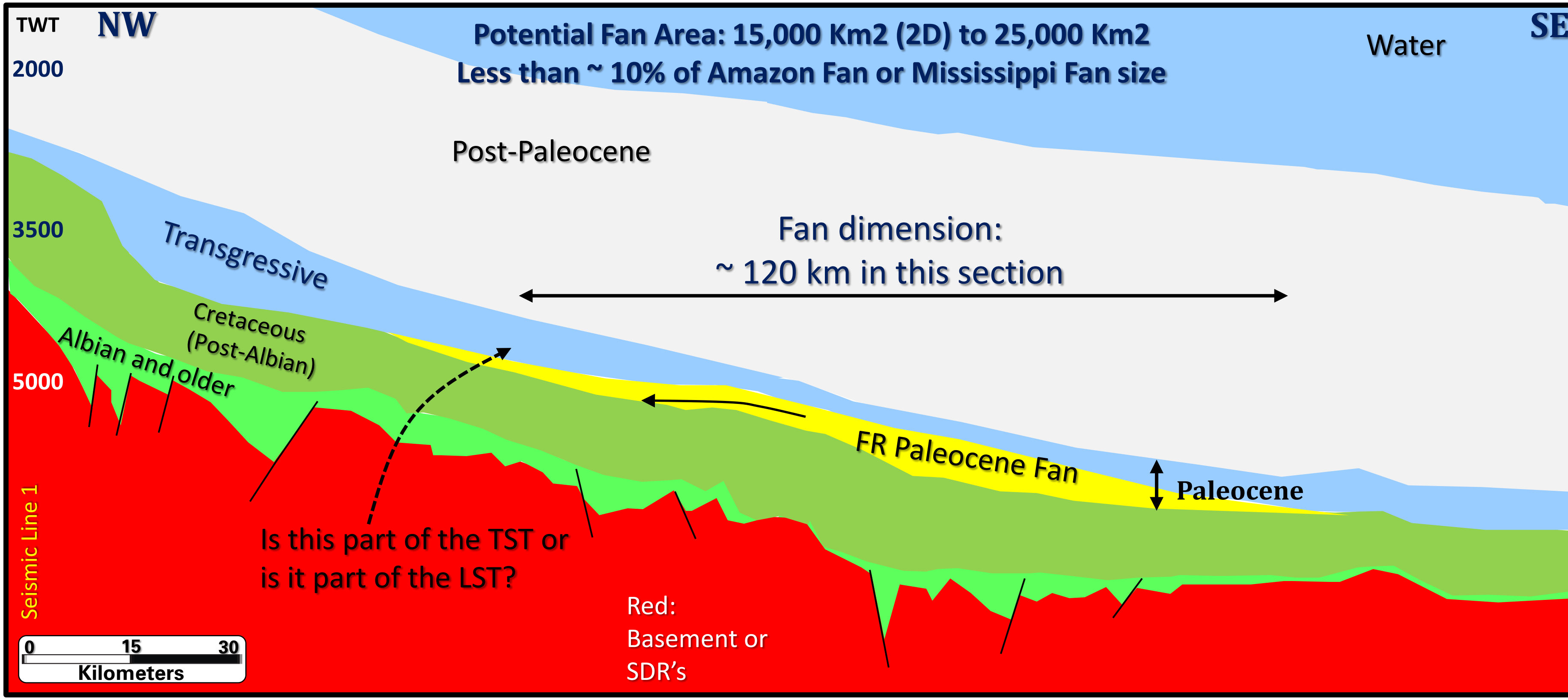
Estimated gradient: between 5 and 8 °

Late Paleocene: Lowstand (??) to transgressive deposits with coastal onlap migrating toward the continent, depositing deeper facies (shales) over the shelf (good seal for the sands deposited during the FR). Deep water deposits are completely disconnected from their updip counterparts.

CC: Correlative conformity; BSFR: Basal surface of Forced Regression; FR: Forced Regression; SDR's: Seaward Dipping Reflections

Evidences of Fan type deposits in the Paleocene section

Dip line: Seismic Line 1

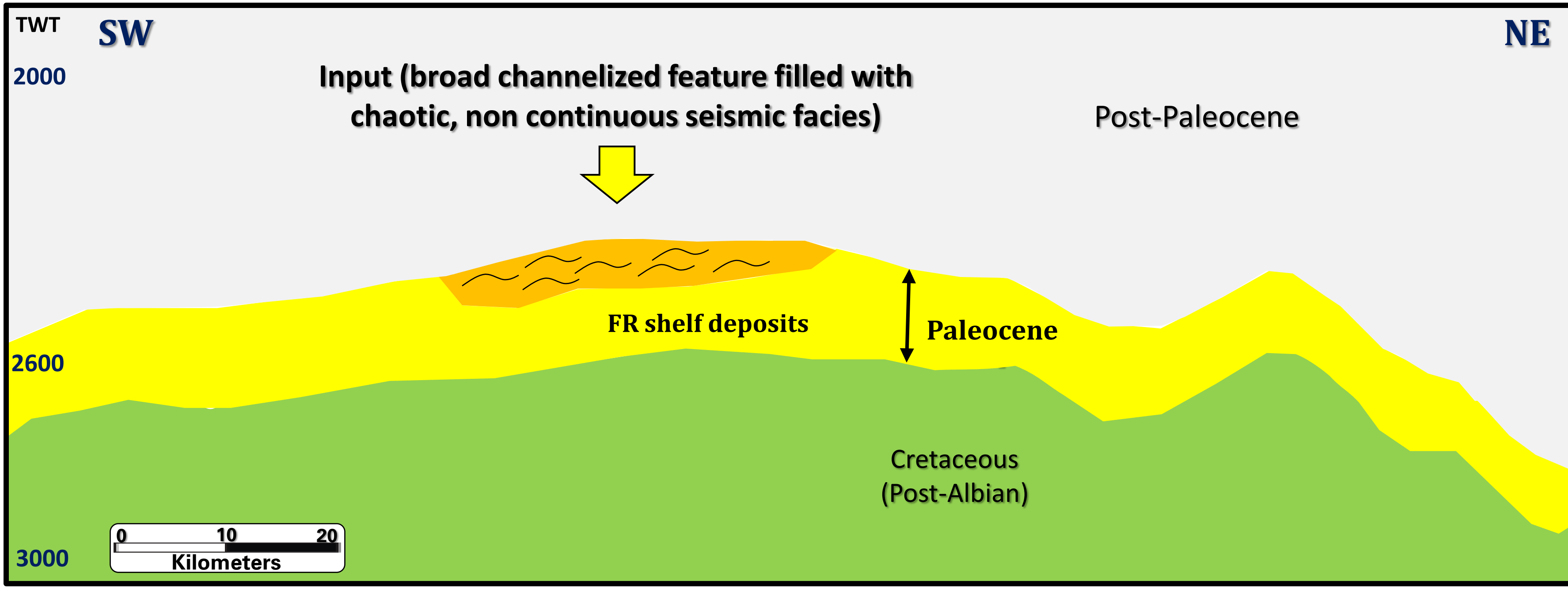


Seismic dip line showing the external geometry of the FR deep water deposits and the pinch-out configuration toward both updip and downdip areas.

FR deep water deposits (mud debrites or high density turbidites?) are covered by a poorly developed LST deposit (low density turbidite system).
Transgressive deposits are onlapping over the LST (?) deposits.
Bottom seal, in this case, may be a regional shale on top of Cretaceous.

Possible input area in the Paleocene

Strike line: Seismic Line 2

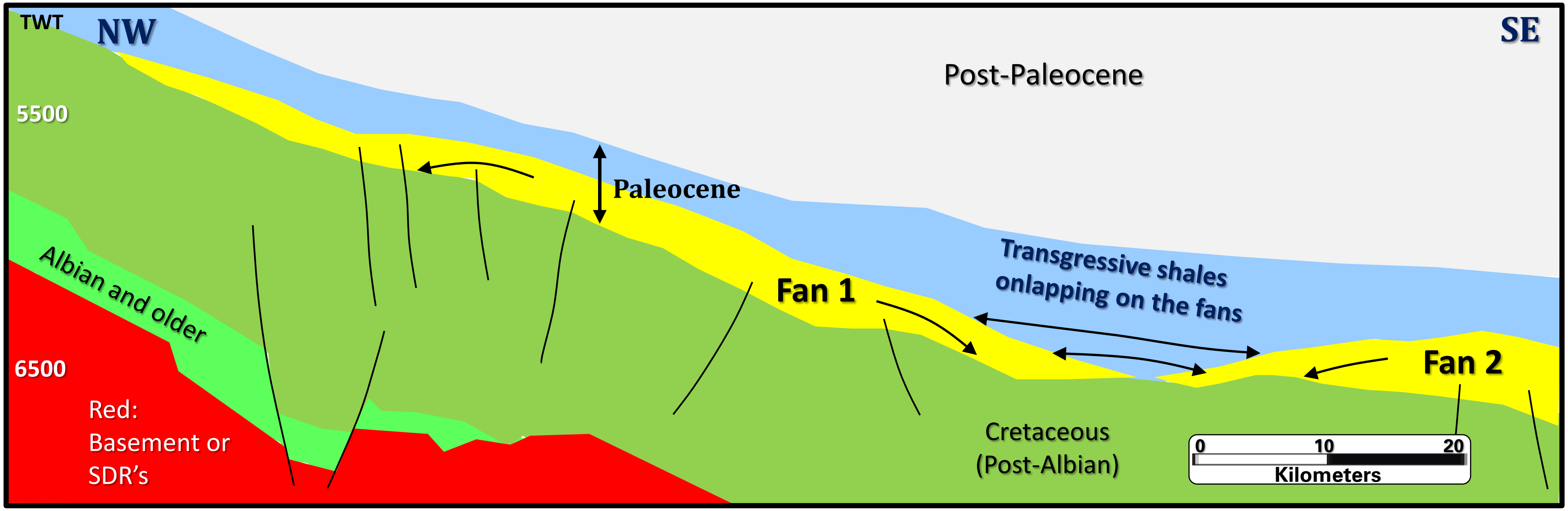


Input for the Paleocene sands is not easy to recognize in the data. This is the only feature that suggests a NW-SE valley feeder in a strike seismic line. Sparse 2D data is also a limitation for the understanding of the depositional complexity.

Evidences of Fan type deposits in the Paleocene section

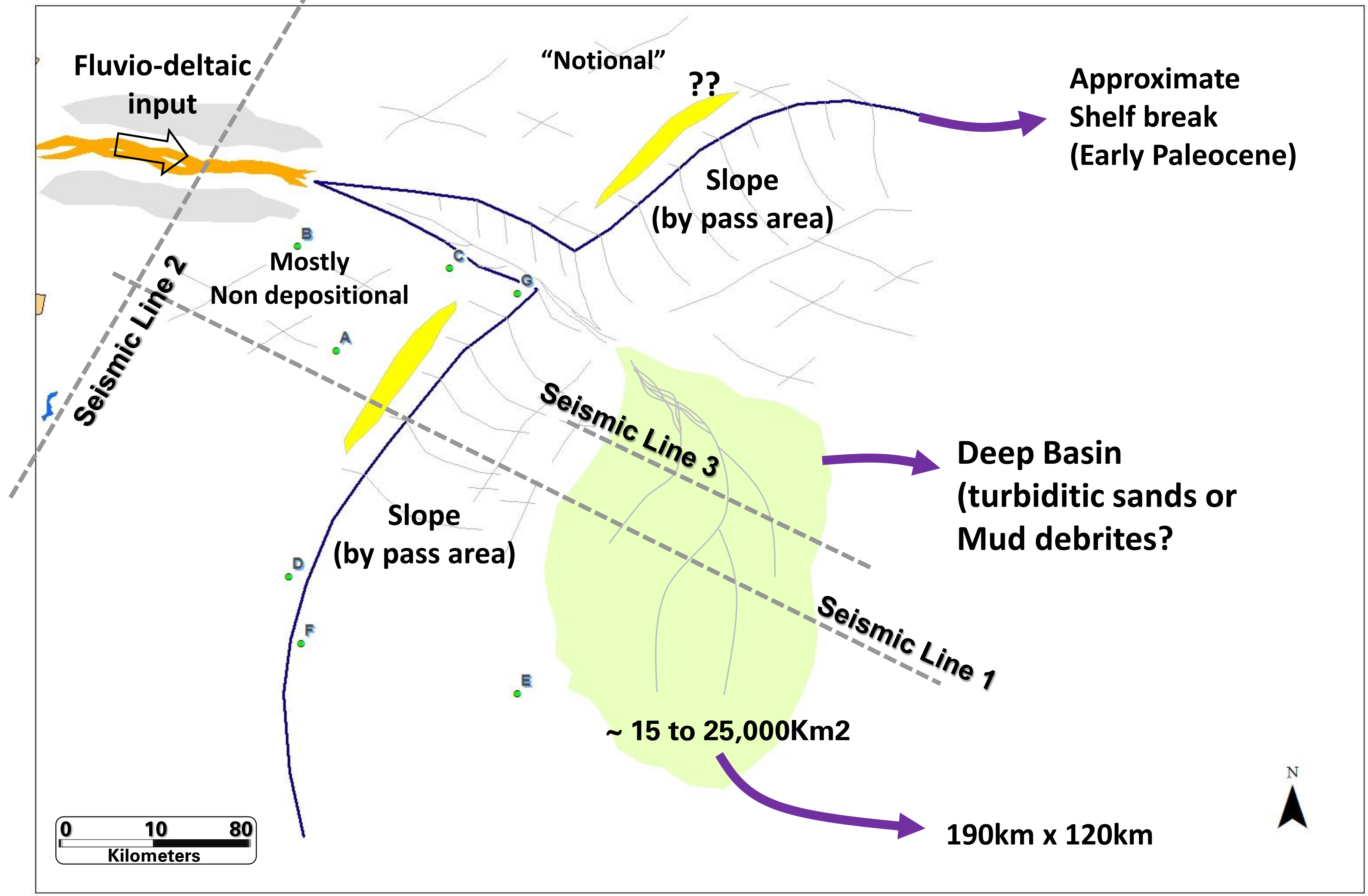
Dip line: Seismic Line 3

Multiple fans are possible



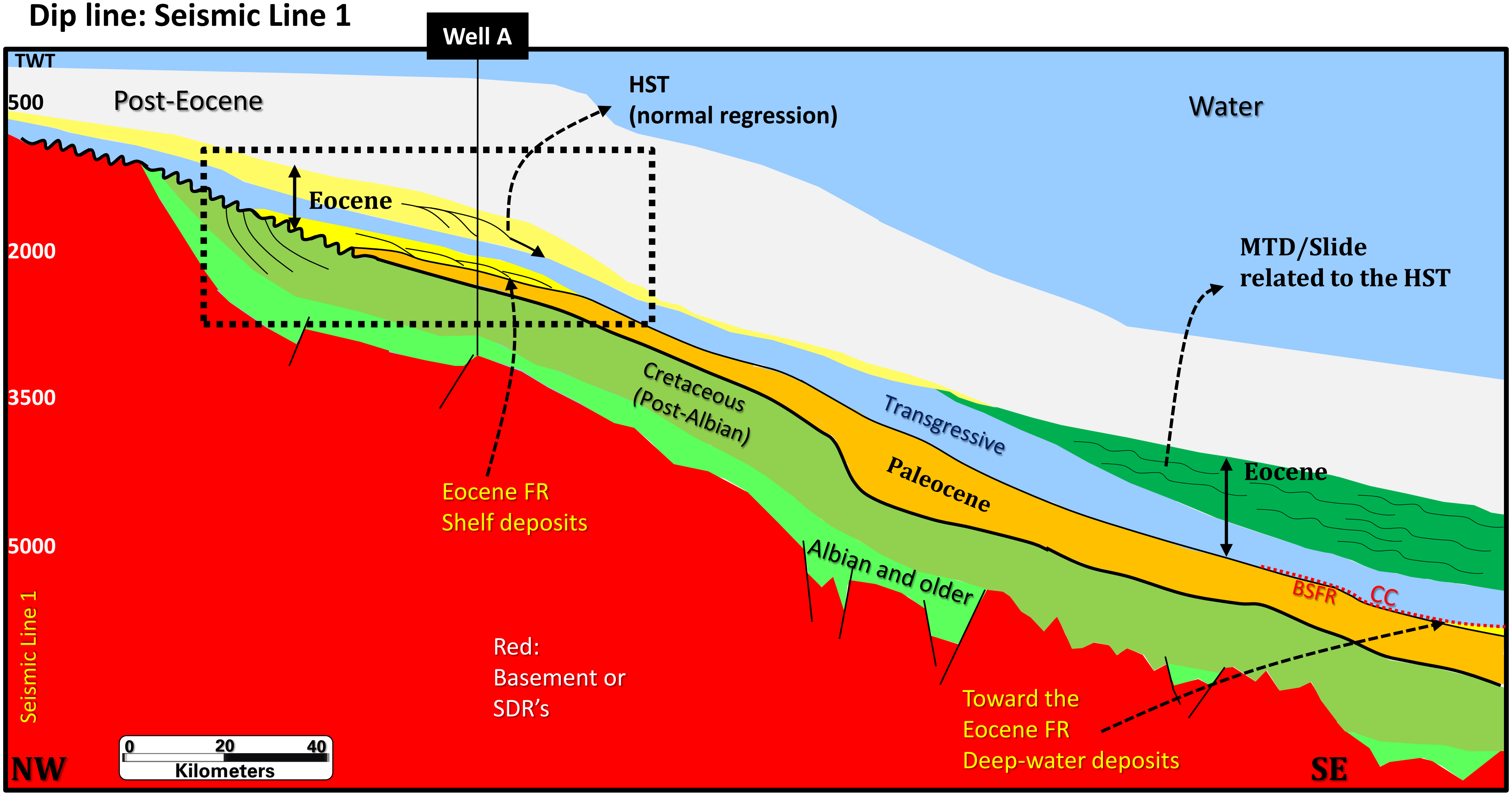
Amalgamation and/or compensation of multiple fans are possible with onlap of the transgressive shales over the lobate geometries.
The high amplitude event on the top of Cretaceous may represent shale prone interval (bottom seal).

Paleocene Paleogeography in the studied area



Eocene Section: observations, top-down approach

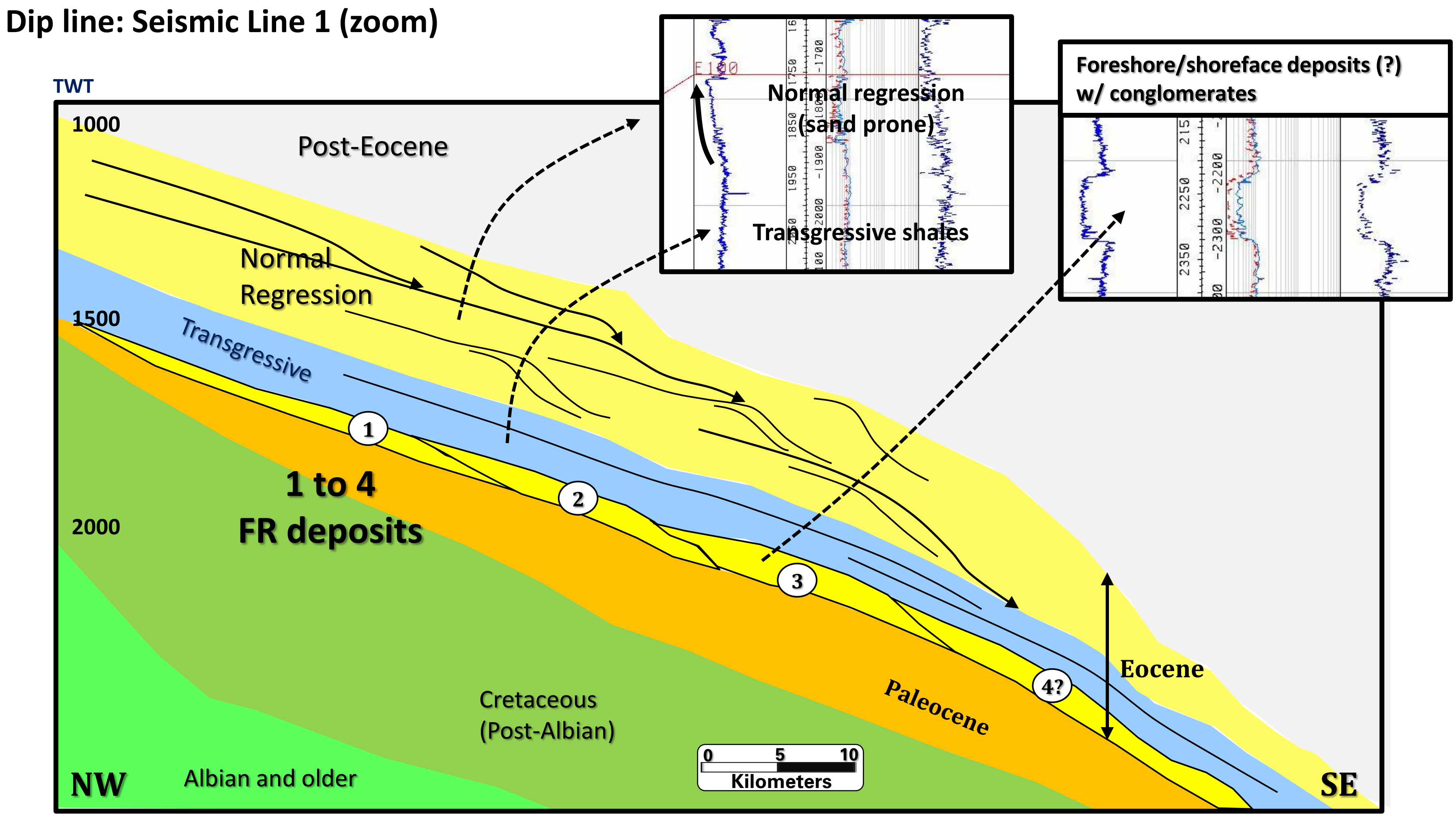
Dip line: Seismic Line 1



Eocene section is characterized by a gentle shelf and slope with clear evidences of FR deposits on the shelf. The box indicates the zoomed area in the next slide.

CC: Correlative conformity; BSFR: Basal surface of Forced Regression; FR: Forced Regression; SDR's: Seaward Dipping Reflections

Eocene Section: observations, top-down approach

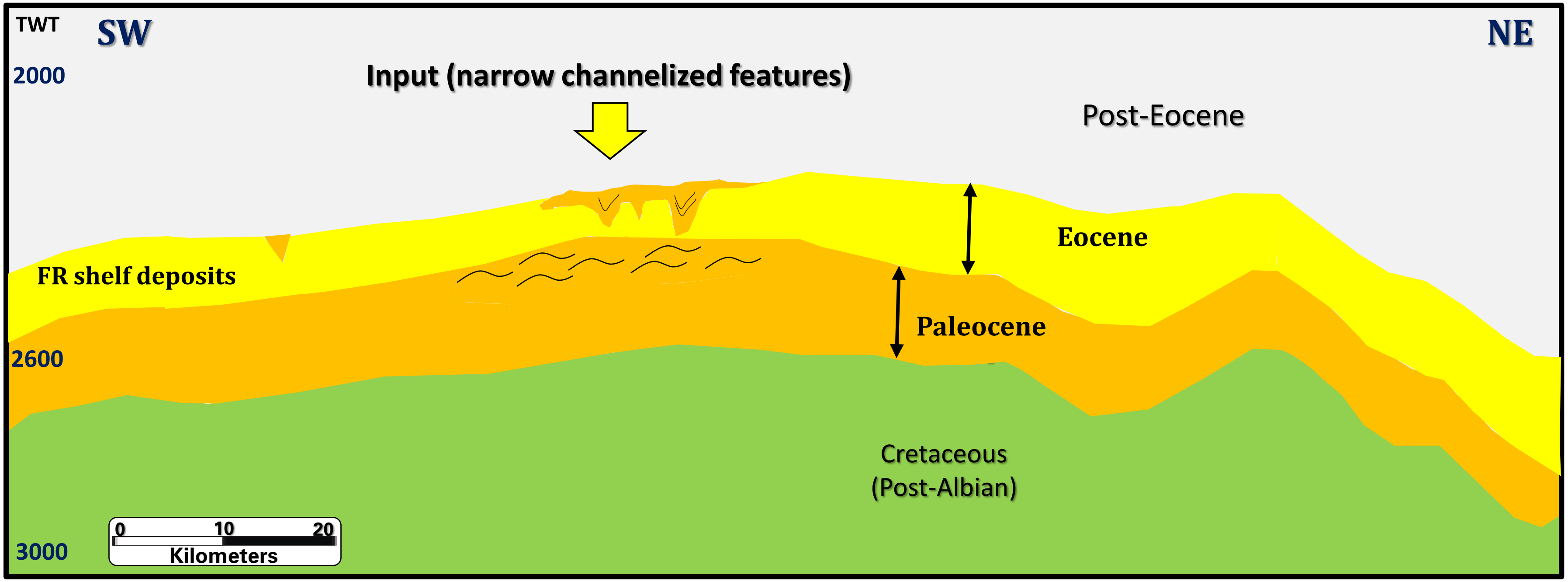


Detail of the possible FR deposits during the Early Eocene: At least 4 events of FR were recognized. Well penetrated event 3 and found blocky shape conglomeratic deposits that could be related to foreshore/shoreface environments (?).

After a transgressive phase, a normal regression is established in the Late Eocene.

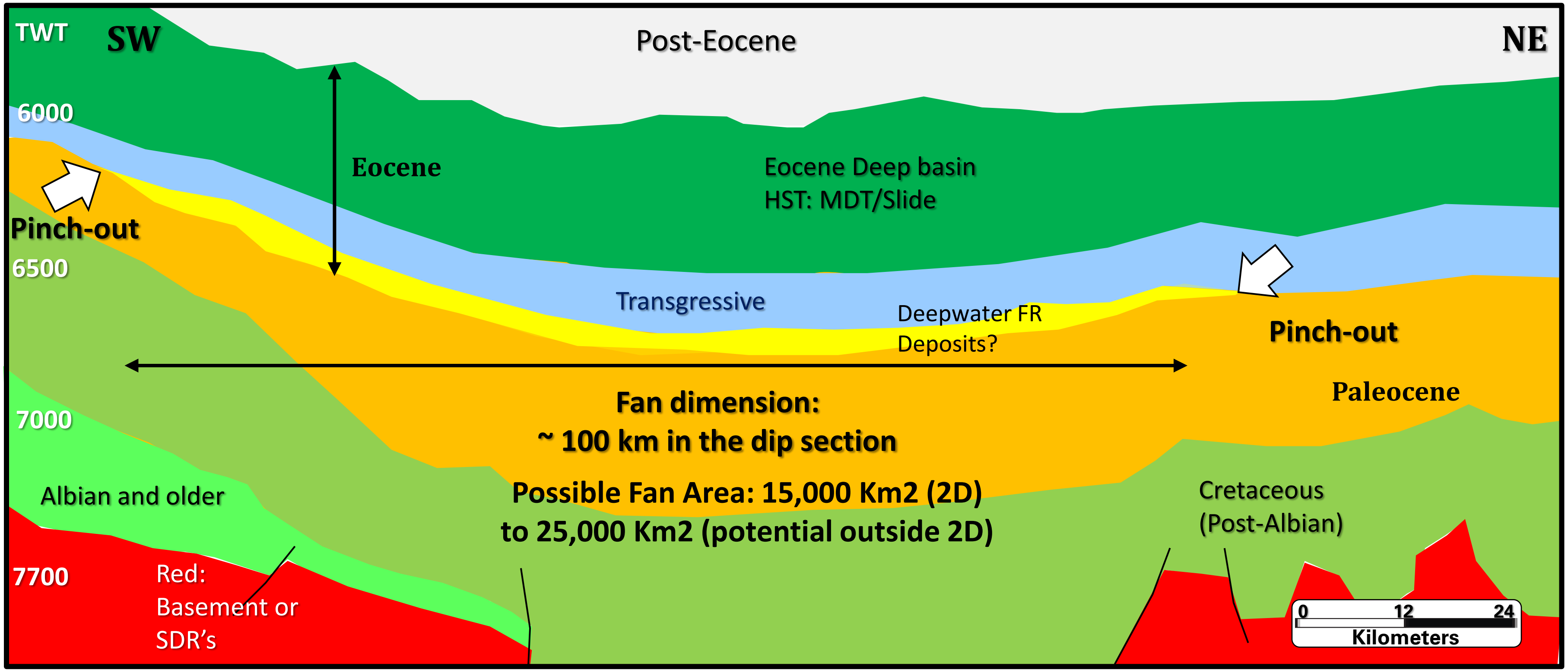
Input area for Eocene

Strike line: Seismic Line 2



Similar to the Paleocene, the input for Eocene sands is not easy to recognize in the data. It may be here, represented by much narrower channels when compared to the Paleocene section. Again, sparse 2D data is a limitation (Seismic Line 2).

Eocene: Why fan geometries are very difficult to identify?

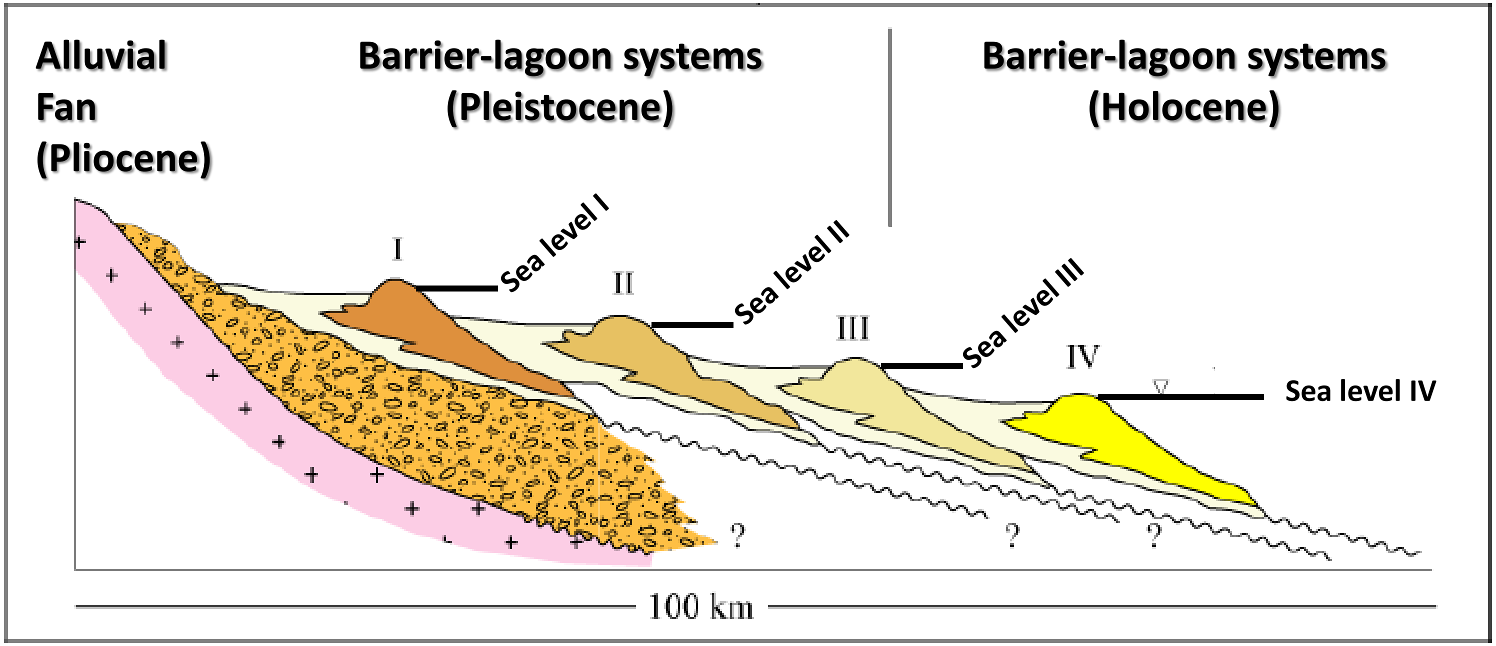


Strike line: Seismic Line 3

It is very difficult to find fan-shape geometries in the area downdip of the Eocene shelf-edge deposits. If the deep water counterpart of the FR shelf deposits do exist, they are represented by a relatively thin lobe (less than 100m thick) of approximately 180km x 120km. Alternatively, the deepwater FR deposits may be outside of the 2D grid area.

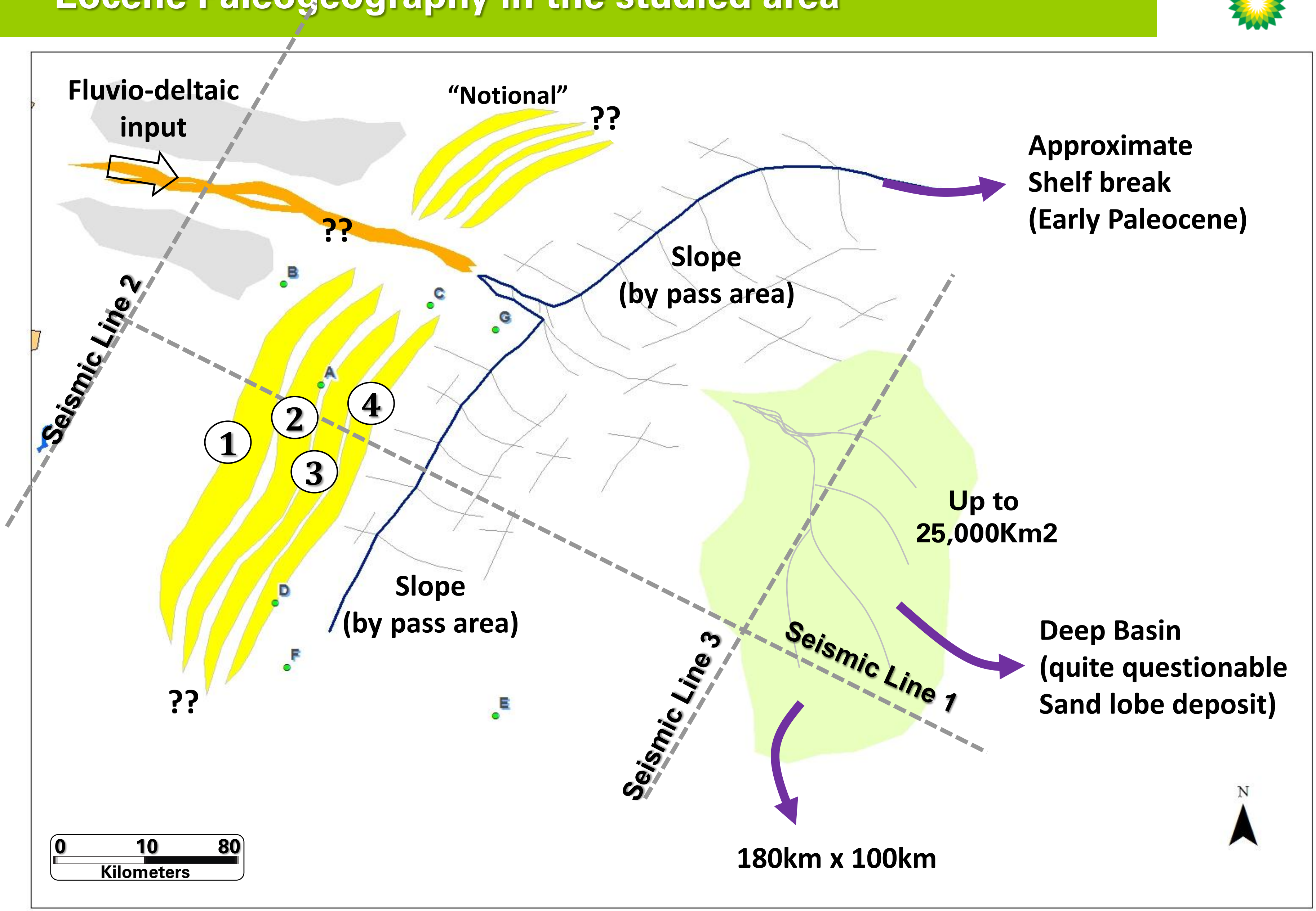
But it is clear that, contrary to what the observations and models suggest, abundant FR features on the shelf do not assure abundant sand deposits downdip.

Analogy in the same basin?



"Almost" Modern analogy? The evolution of the siliciclastic coast in Rio Grande do Sul State (Pelotas Basin) since the Pliocene to the Holocene shows similar downstepping pattern in a more barrier-island type configuration (Tomazelli & Vilwock, 2000).

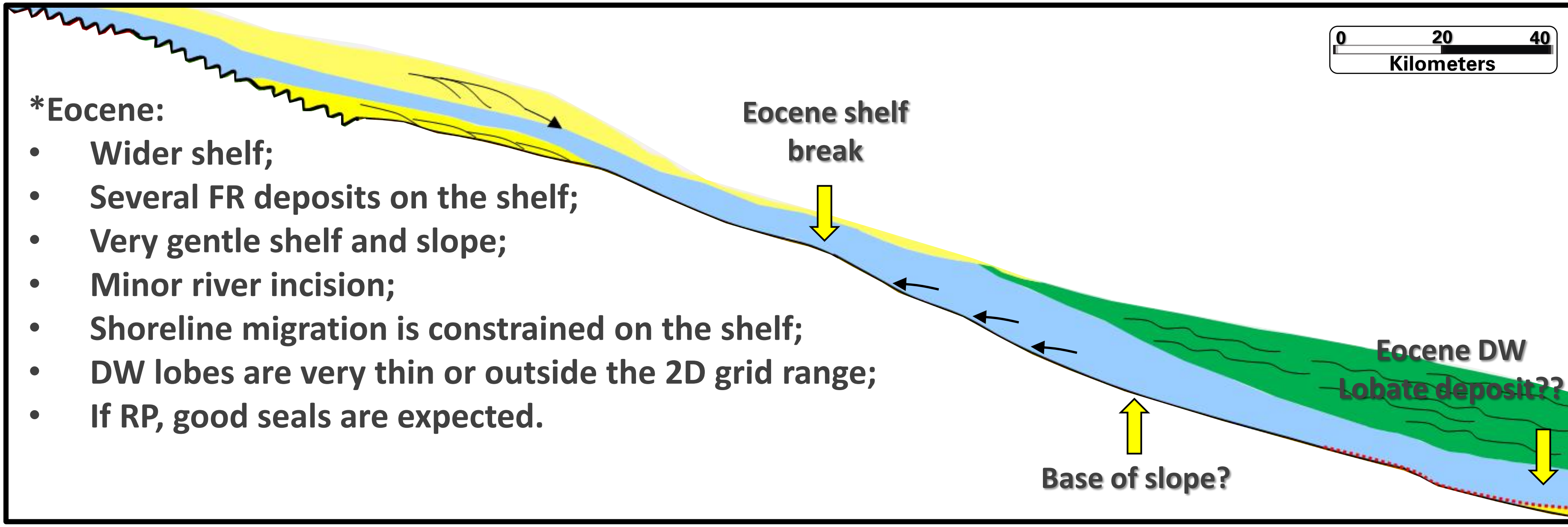
Eocene Paleogeography in the studied area



Summary: in the search for stratigraphic traps

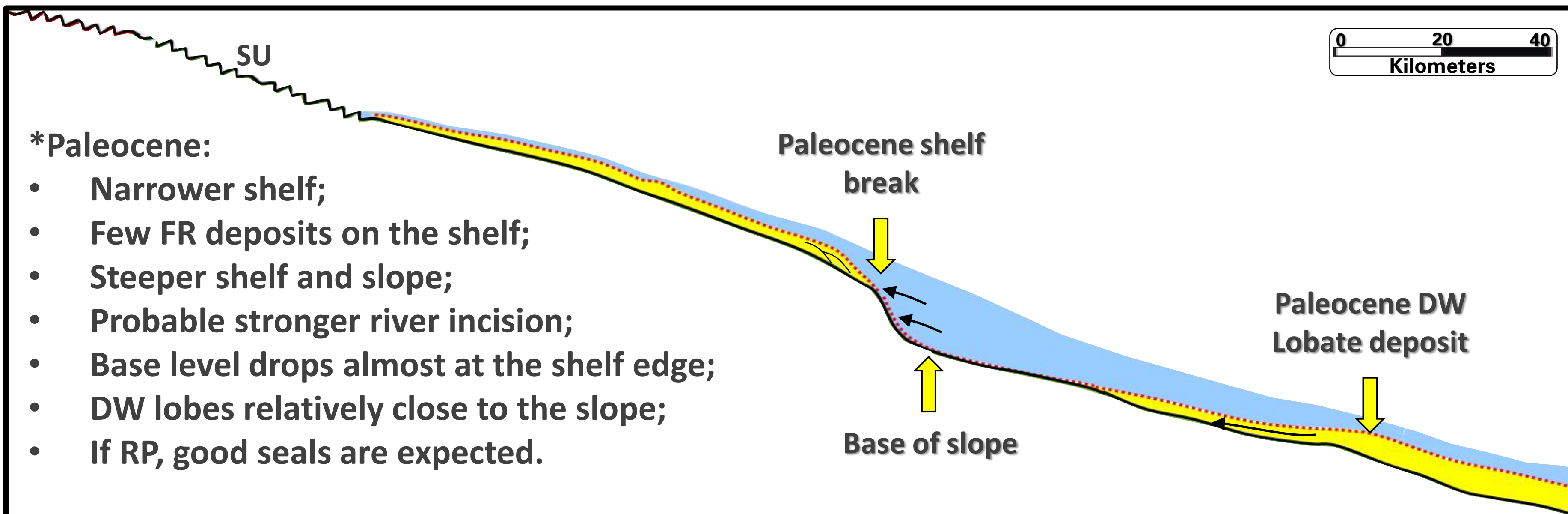
- **Two intervals were described:**
- Paleocene:
  - RP/RQ: some evidence of FR/downstepping configuration on the shelf, abundant lobate geometries downdip (many questions regarding the quality of these deposits because it is impossible to tie them with a specific part of the base level curve – Early or Late FSST?);
  - Seal: updip, and lateral seals are TST shales. Bottom seal is riskier but it is probably a regional high amplitude shale.
- Eocene:
  - RP/RQ: at least 4 events of shoreline downstepping were recognized but no clear evidence of associated downdip fans (thin deposit in a lobate geometry identified downdip may be sand poor);
  - Seal: updip, and lateral seals are TST shales. Bottom seal is Paleocene TST shales.

Summary: Paleocene/Eocene: Contrasting styles during FSST



*Eocene:

- Wider shelf;
- Several FR deposits on the shelf;
- Very gentle shelf and slope;
- Minor river incision;
- Shoreline migration is constrained on the shelf;
- DW lobes are very thin or outside the 2D grid range;
- If RP, good seals are expected.



*Paleocene:

- Narrower shelf;
- Few FR deposits on the shelf;
- Steeper shelf and slope;
- Probable stronger river incision;
- Base level drops almost at the shelf edge;
- DW lobes relatively close to the slope;
- If RP, good seals are expected.

Final Remarks

- **Models vs Observations:**
- Models seem to be oversimplified, not providing all the elements to predict downdip reservoir presence. The lack of clear temporal relationship between the FR shelf deposits and their deepwater counterparts is the main limitation in current models. The physical disconnection between these “end members” also prevents a good understanding of the stratigraphic evolution during the forced regression;
- High-frequency events can be very effective in carrying sands downdip during the forced regression. However, the final distribution of these sands depend on several elements.

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