Carrier Beds as Reservoirs

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Abstract

Carrier beds are migration pathways linking source rocks with reservoirs in conventional petroleum systems. Today the existence of carrier beds and source rocks is taken as axiomatic, and the mechanics of migration are well understood. However, when John Rich introduced the term carrier bed in 1931, many respected geologists considered the terms *carrier beds* and *source rocks* as merely theoretical constructs whose existence had yet to be proven.

Carrier beds may—but need not—have the same reservoir properties as the conventional reservoirs supplied by them. Indeed, the downdip limits of many conventional fields are defined by changes in porosity, and, more often, permeability, associated with a change in facies between the carrier beds and the reservoir. The low permeability of the carrier beds does not preclude them from supplying the reservoir at geological time scales. If sufficient porosity exists for economic volumes of hydrocarbons to be present, the low permeabilities that previously marked the economic limits of some fields need no longer preclude extension of the field downdip into strata that served as carrier beds for the conventional reservoir. Horizontal wells and multistage hydraulic fracturing allow low permeability carrier beds to become viable hydrocarbon reservoirs.

Carrier beds are already being exploited as unconventional reservoirs in Cretaceous strata along the length of the Western Interior seaway from New Mexico to Canada. Among plays now being interpreted as carrier bed plays are the offshore Mancos shale play in the San Juan basin, the Codell Sandstone in the Denver Basin, the Turner Sandstone in the Powder River Basin, and the halo play around Pembina field in the Western Canada basin. Similar plays are likely to be present in other sedimentary basins and in other parts of the geologic column—perhaps even in Pennsylvania strata on the Eastern shelf of the Midland basin. Strawn sediments on the Eastern shelf have much in common with Cretaceous carrier bed plays along the Western Interior seaway. Carrier bed plays may be present downdip from the Haskell delta along the shelf edge break in Fisher and Nolan counties and elsewhere in the region. Applying new ideas in old areas can lead to successful discoveries and economic production. With a nod to Michel Halbouty, now might be the time for a deliberate search for carrier bed plays on the Eastern shelf.

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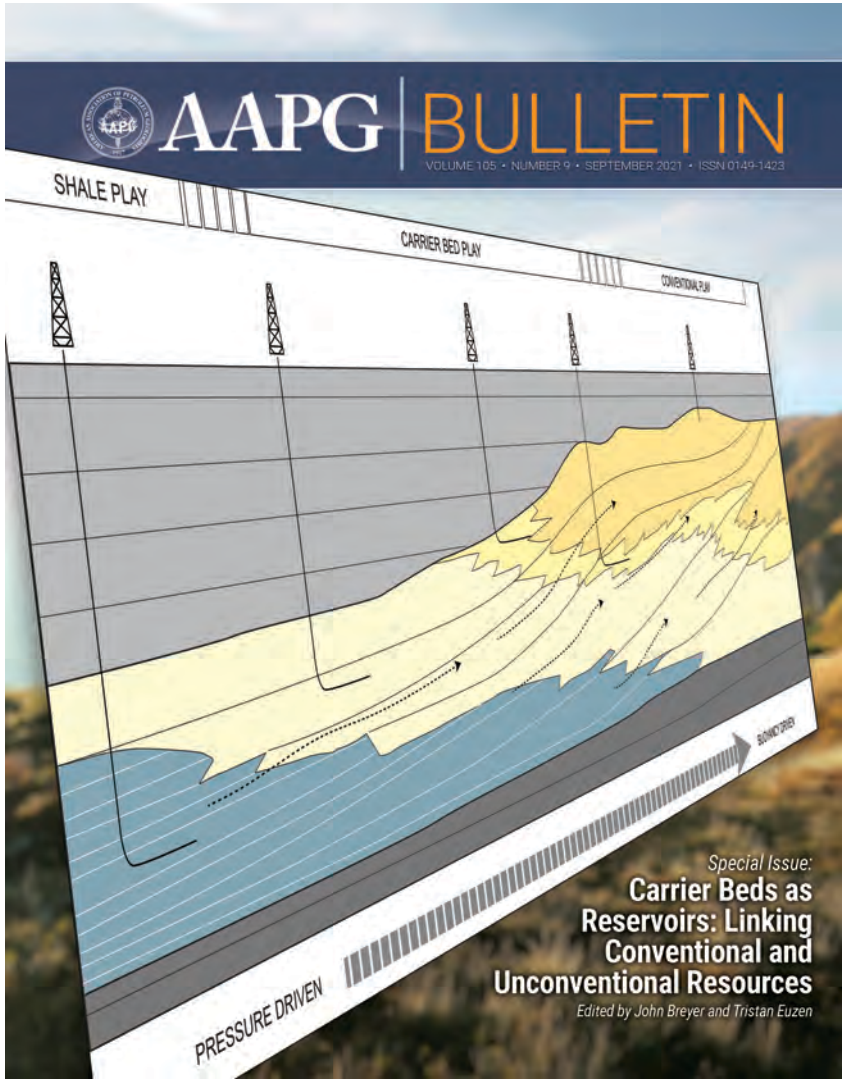
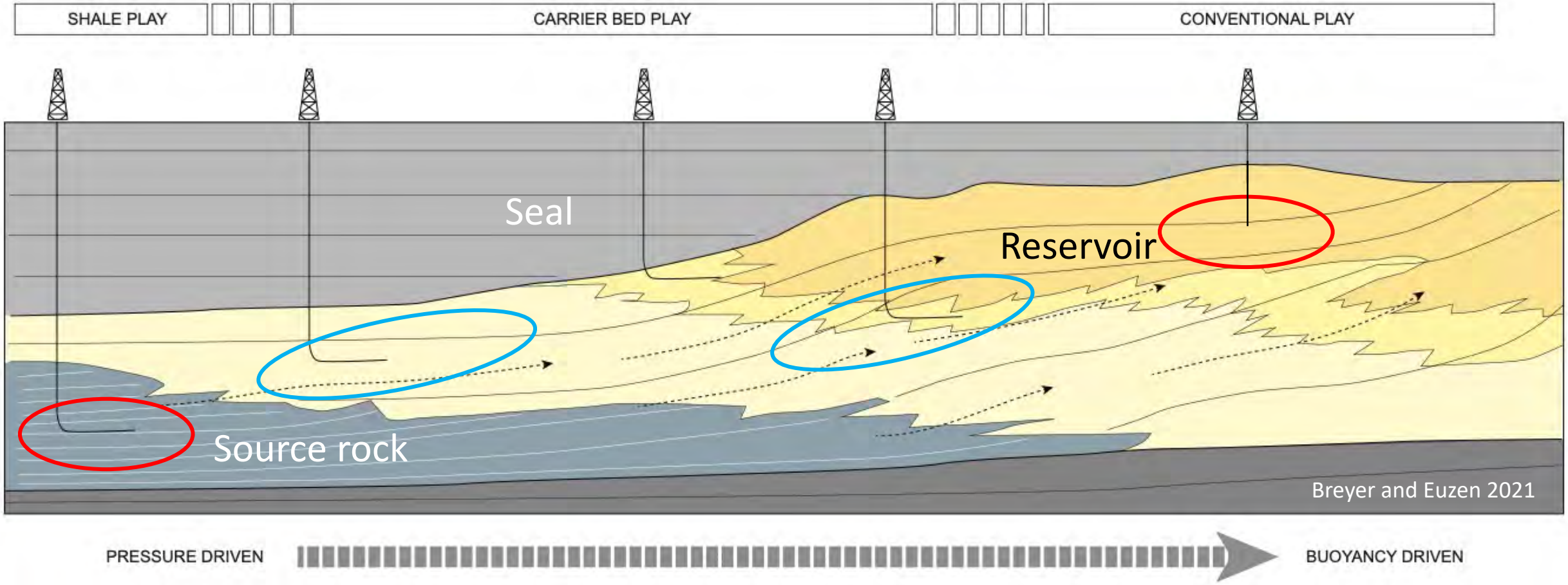
Carrier Beds as Reservoirs



1. Review the concept of carrier bed plays
2. Provide examples of producing reservoirs
3. Suggest application to the Eastern Shelf

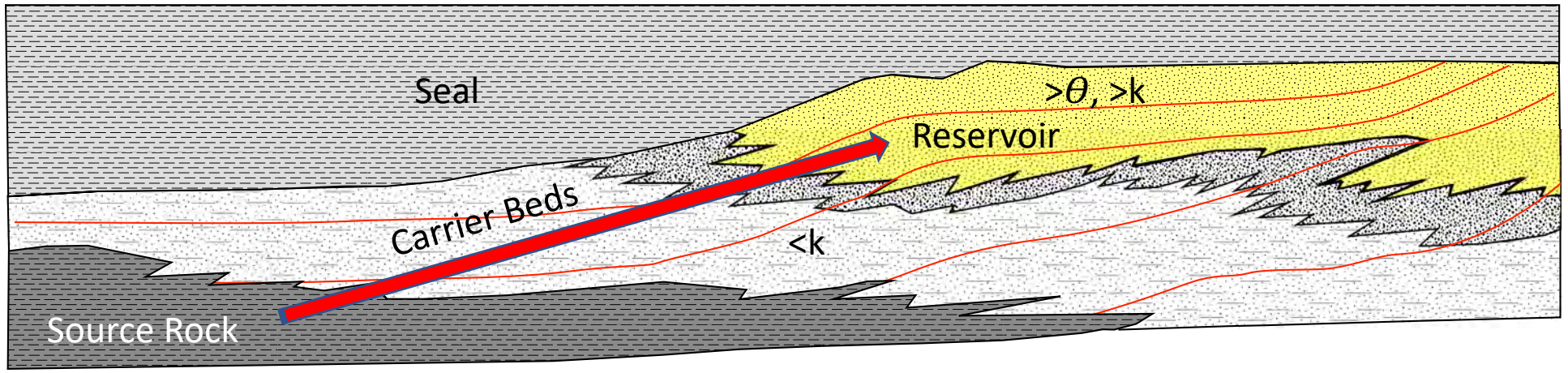
Play Types in Conventional Petroleum Systems



"Petroleum migrating in low-quality carrier beds can result in pervasive hydrocarbon saturated reservoirs."

Sonnenberg 2021

Migration Pathways in Petroleum Systems



Carrier Beds vs Reservoir

Φ may be the same, k often much lower

Low k does not preclude carrier beds from supplying reservoirs.

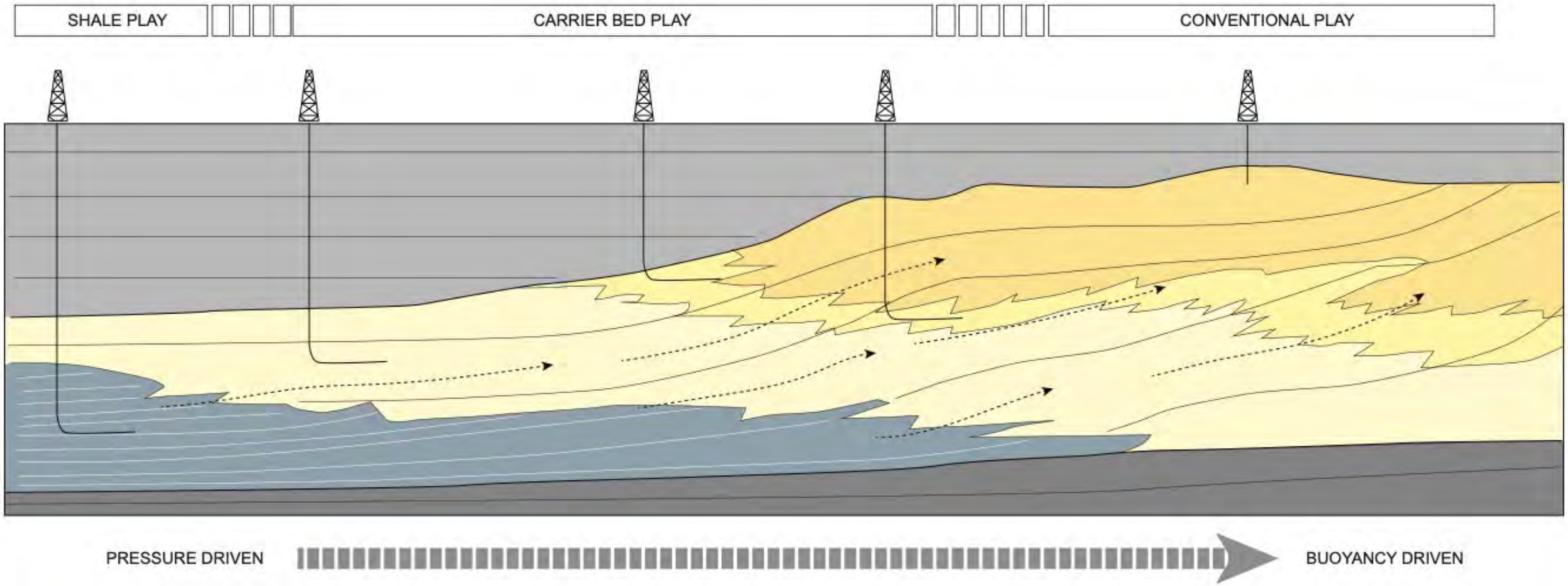
Migration is not the rate-limiting process at geologic time scales.

Horizontal wells and multistage completions may allow low permeability carrier beds to become reservoirs.

Conventional Petroleum System

Source Rock Reservoir

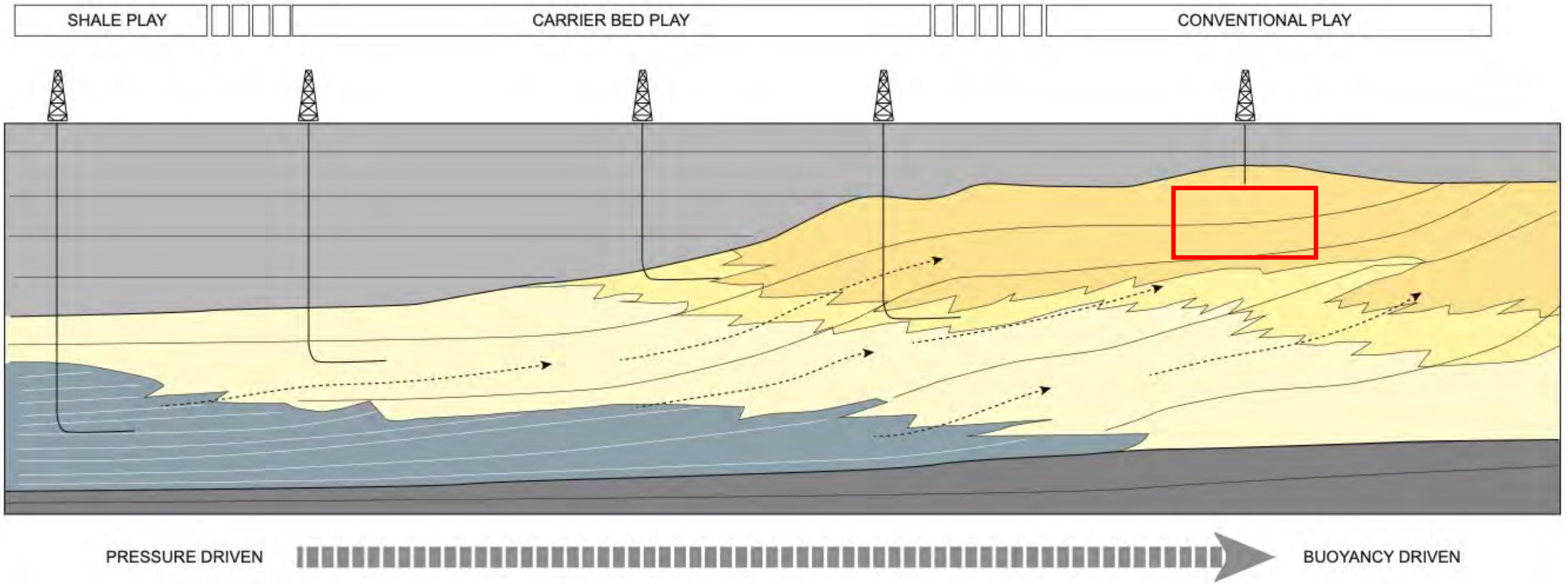
Conventional Reservoir



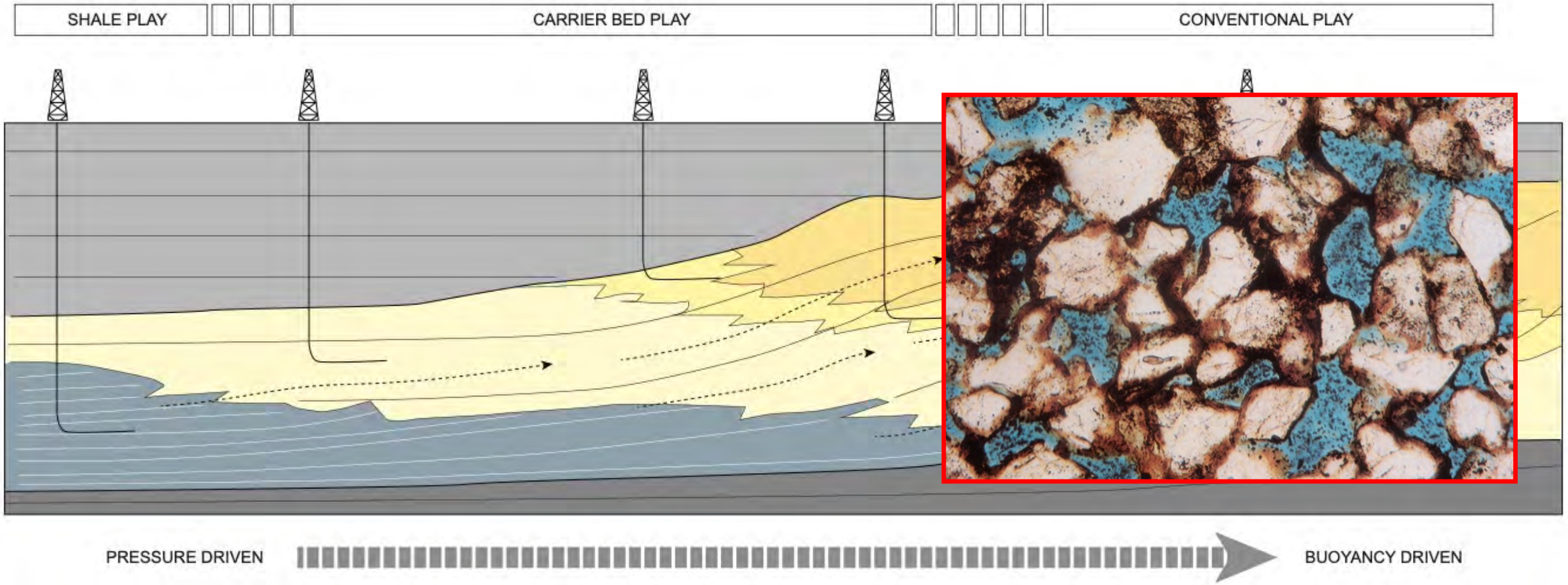
Pore throats in nm
Permeability in nD

Pore throats in µm
Permeability in mD

Conventional Reservoir

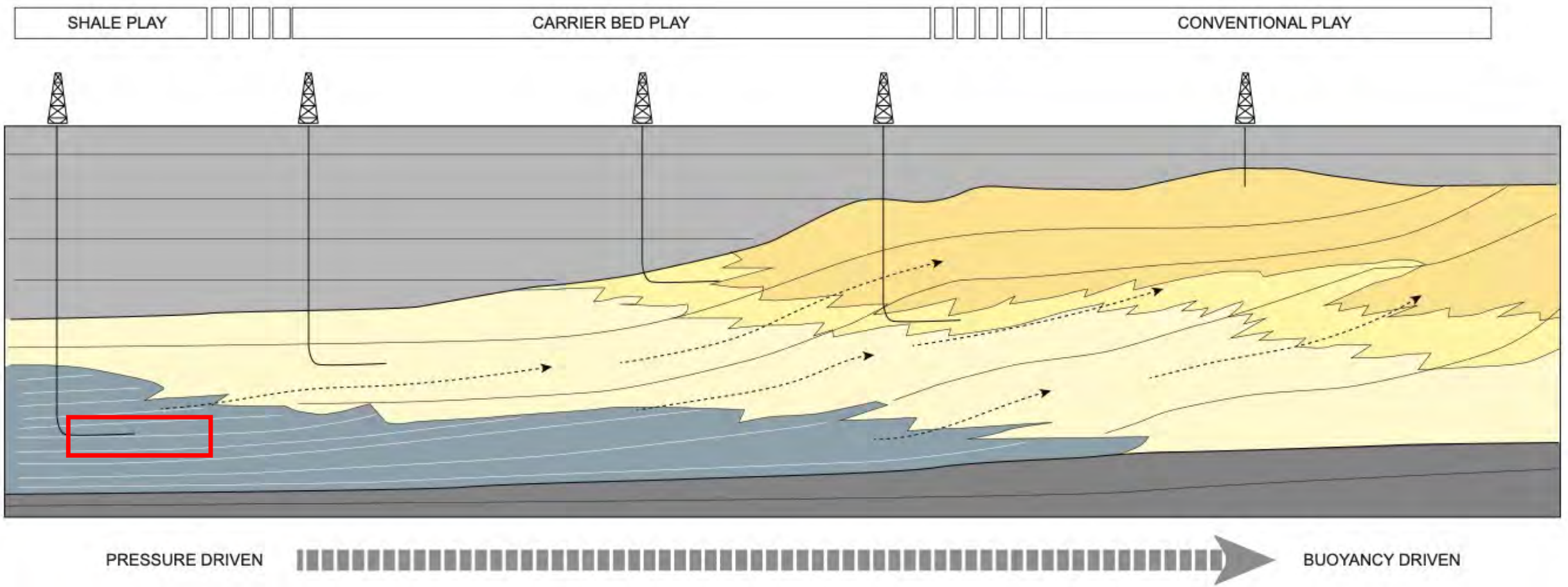


Conventional Reservoir

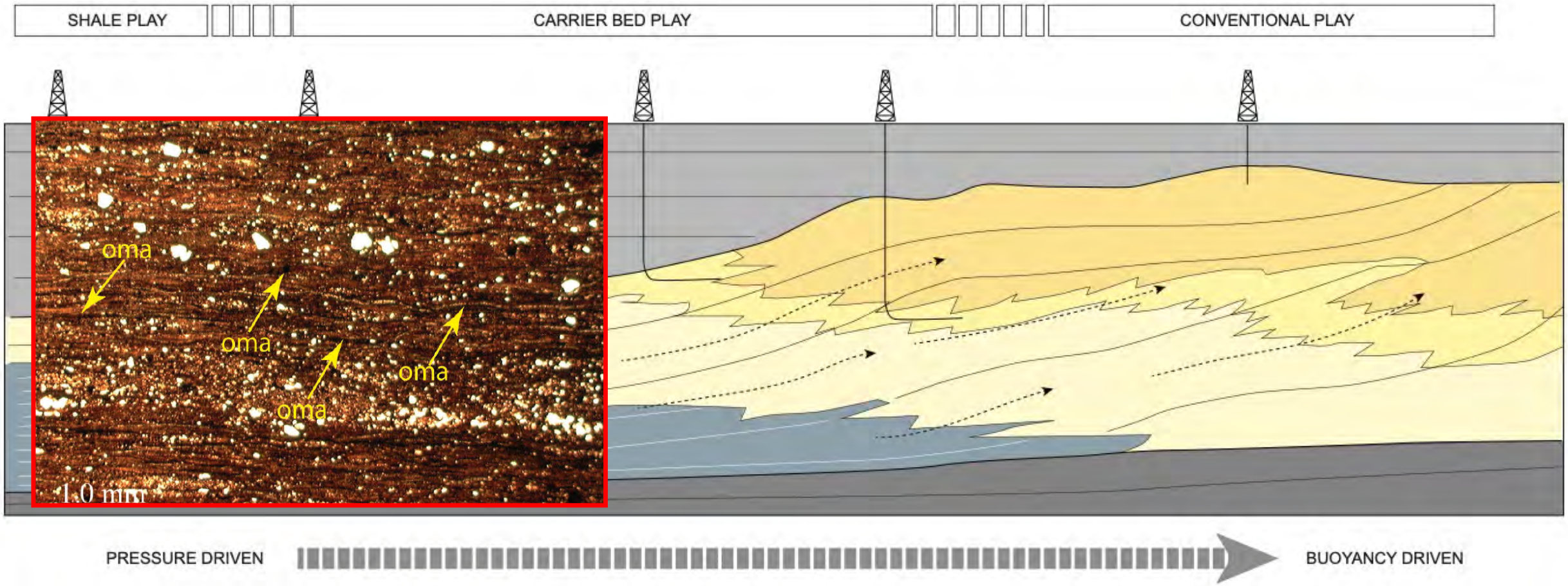


Medium-Grained Sandstone
Pore-throat sizes 10-20 µm
Permeability 20-30 md

Source Rock Reservoir



Source Rock Reservoir



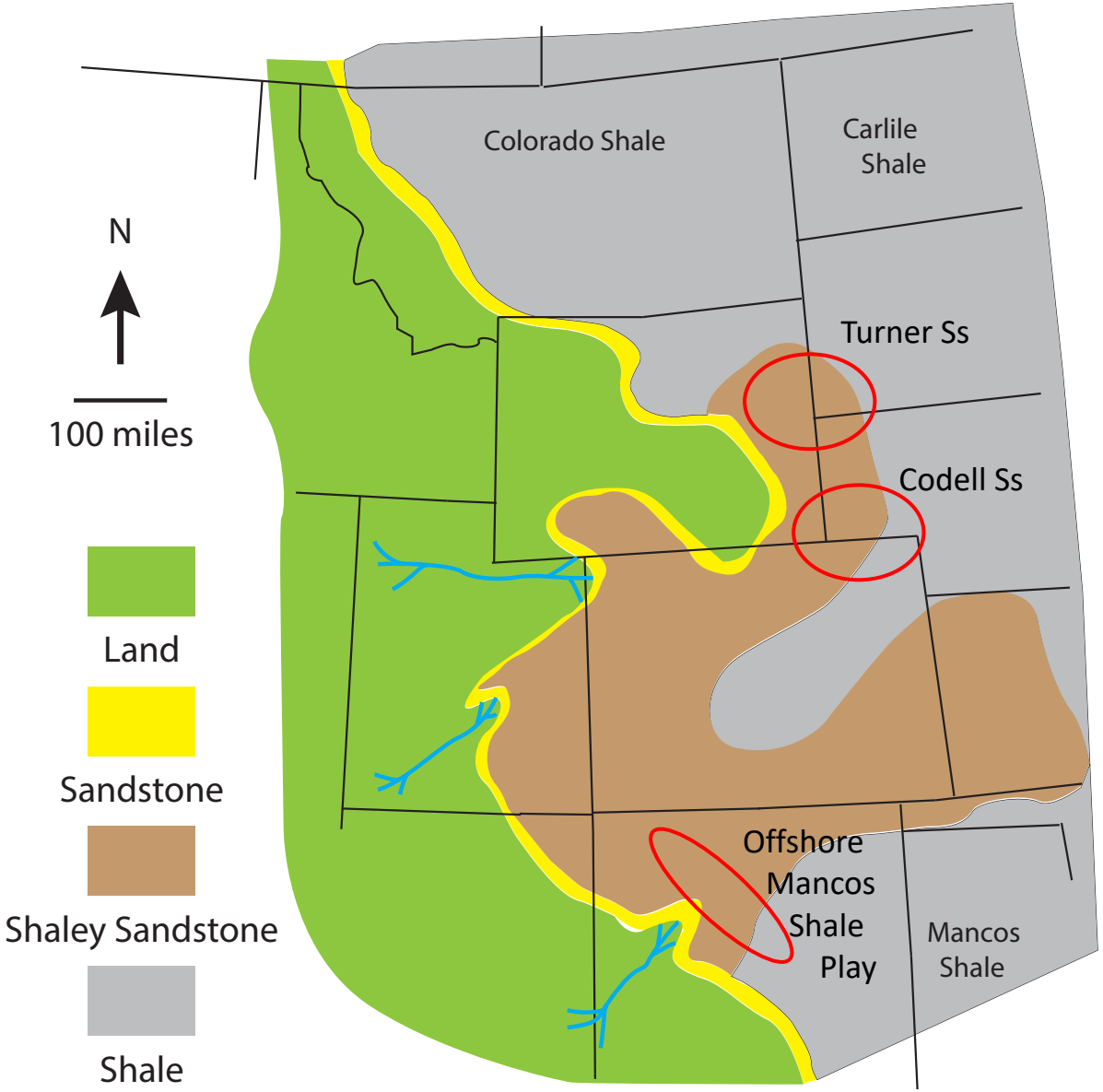
Claystones and mudstones
Pore-throat sizes measured in nm
Permeability measured in nD

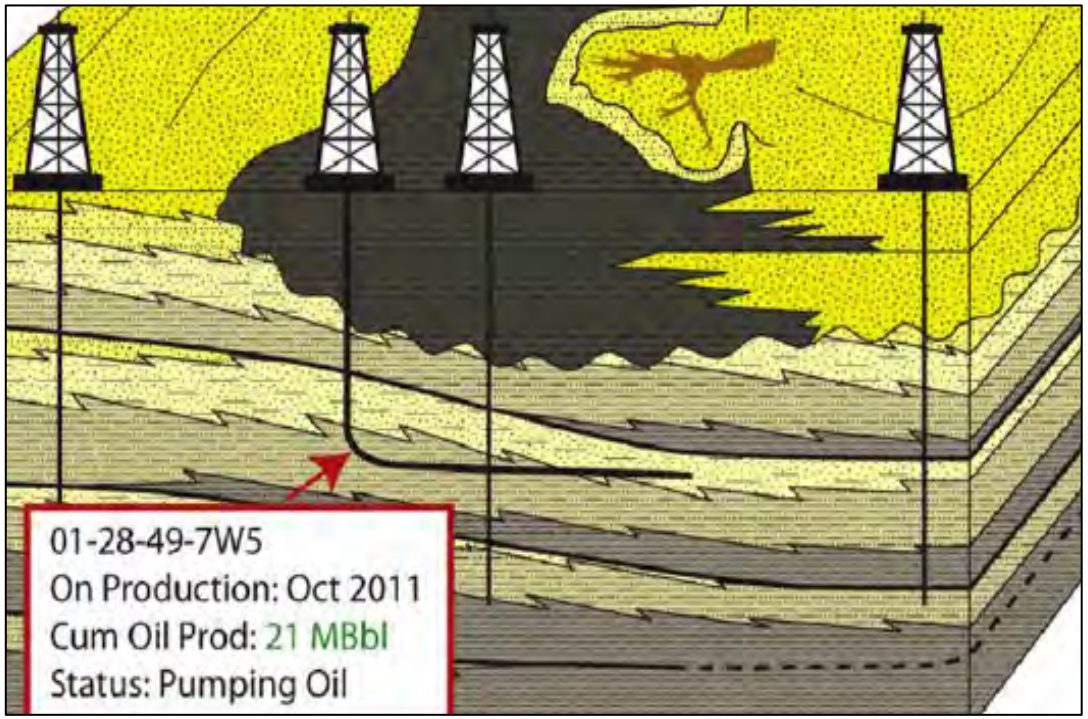
Carrier Bed Reservoirs

Petroleum migrating in low-quality carrier beds can result in pervasive hydrocarbon saturated reservoirs.

Sonnenberg 2021

Western Interior Seaway Late Cretaceous

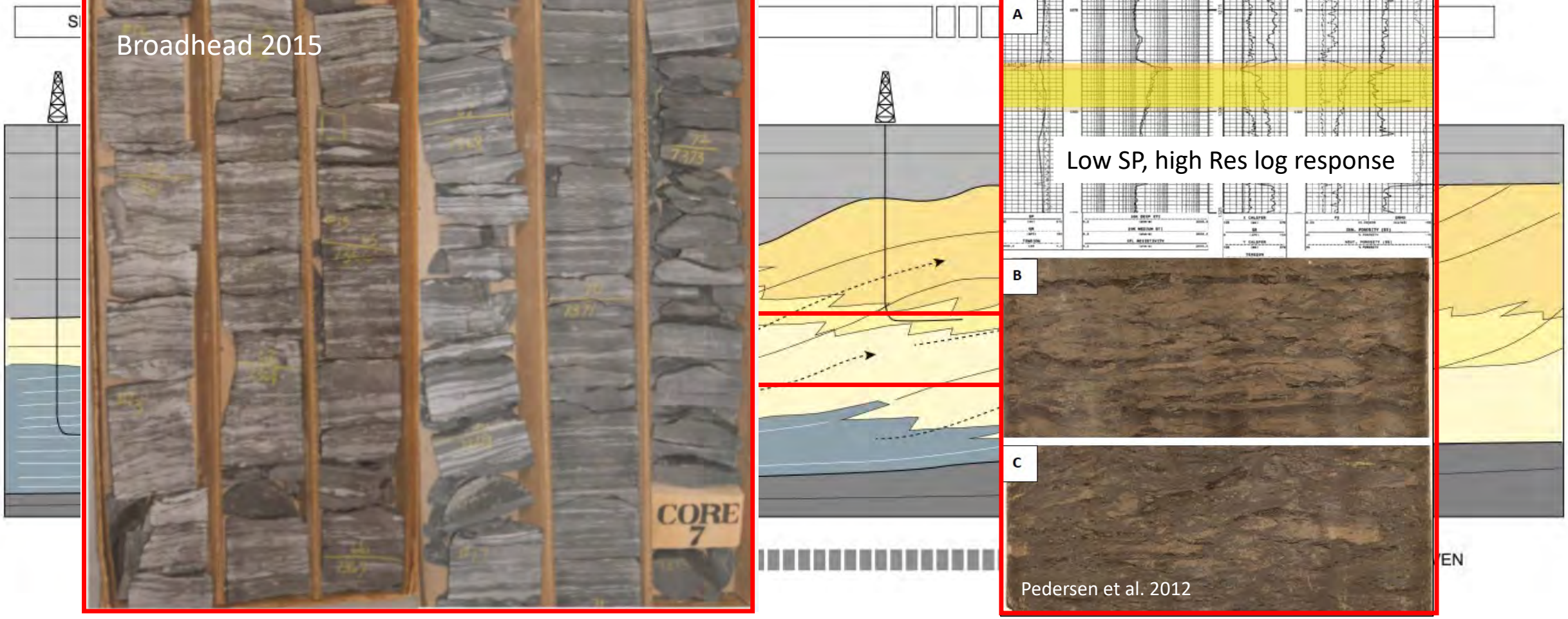




Pembina field, Western Canada sedimentary basin

Pedersen et al. 2013

Carrier Bed Reservoirs: Lithology



"…low porosity and permeability muddy, intensely bioturbated sandstone reservoirs… offshore to transitional offshore…"

Reservoir Quality

Muddy heterolithic strata

Basinward

Sandy interbeds thin

Sediment size decreases

Pore-throat size and k decrease

Reservoir Evaluation

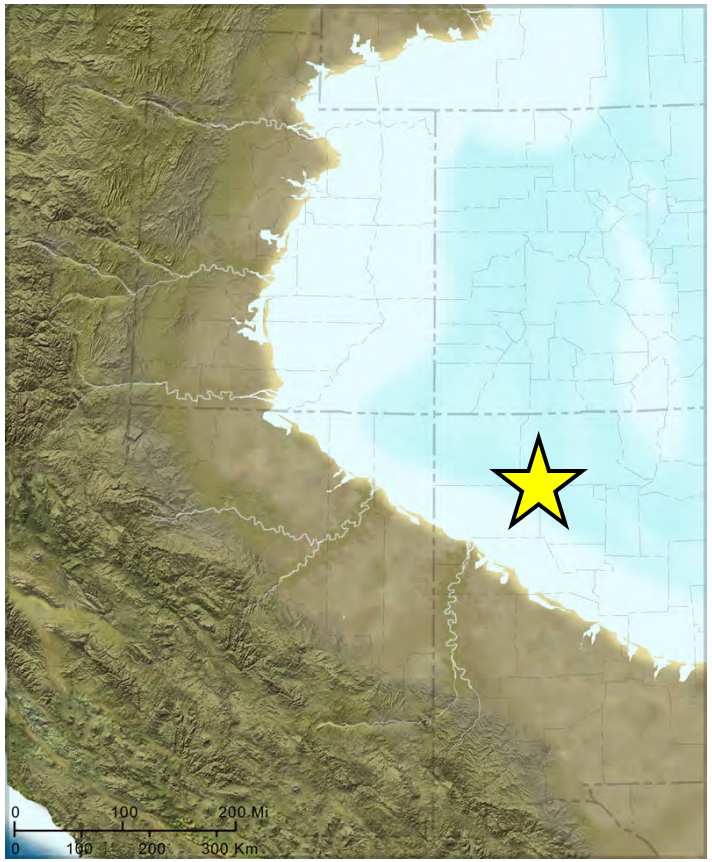
Petrophysical evaluation difficult

Heterolithic (thin bedded) strata

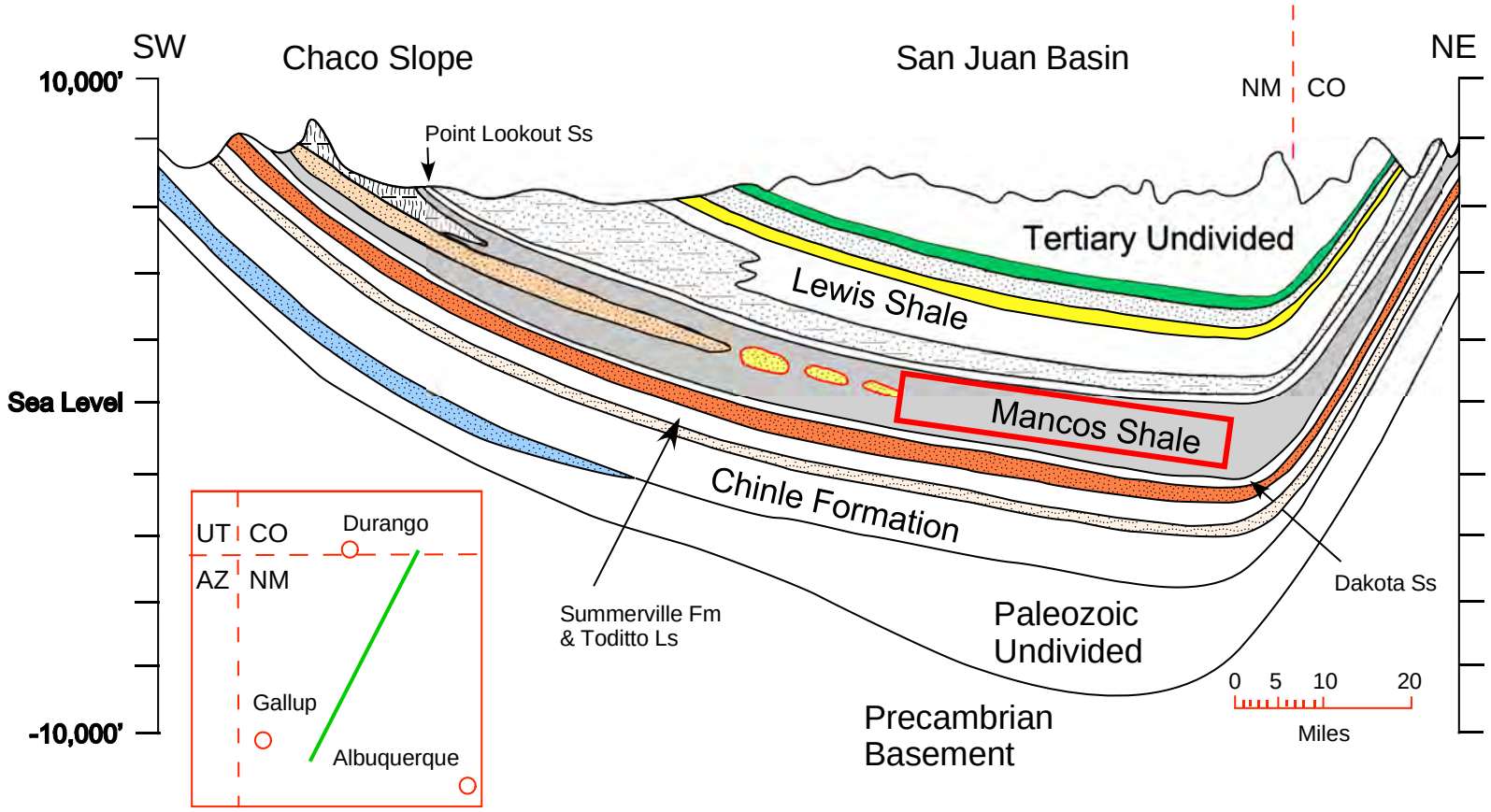
Heterogeneous strata from mixing by bioturbation

High clay content → low resistivity, low contrast pay

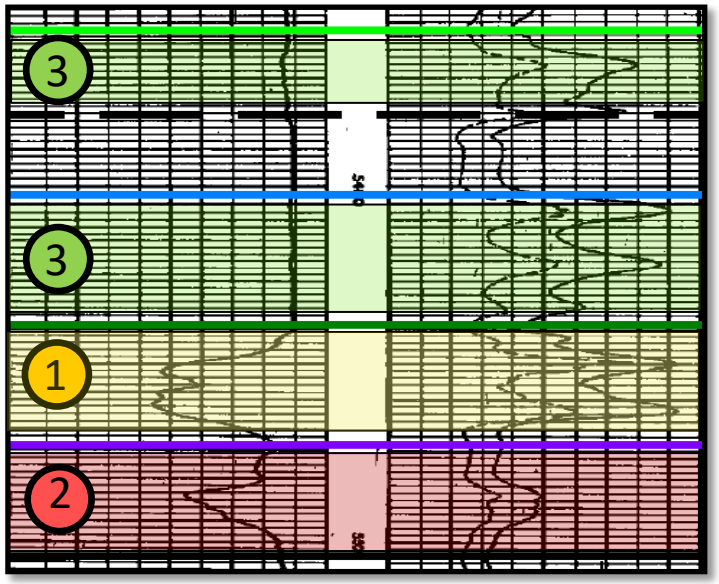
Offshore Mancos Shale Play



Paleogeography



Electrofacies and Lithofacies at Bisti Field



Electrofacies:

1. High SP/high RES
2. High SP/low RES
3. Low SP/high RES

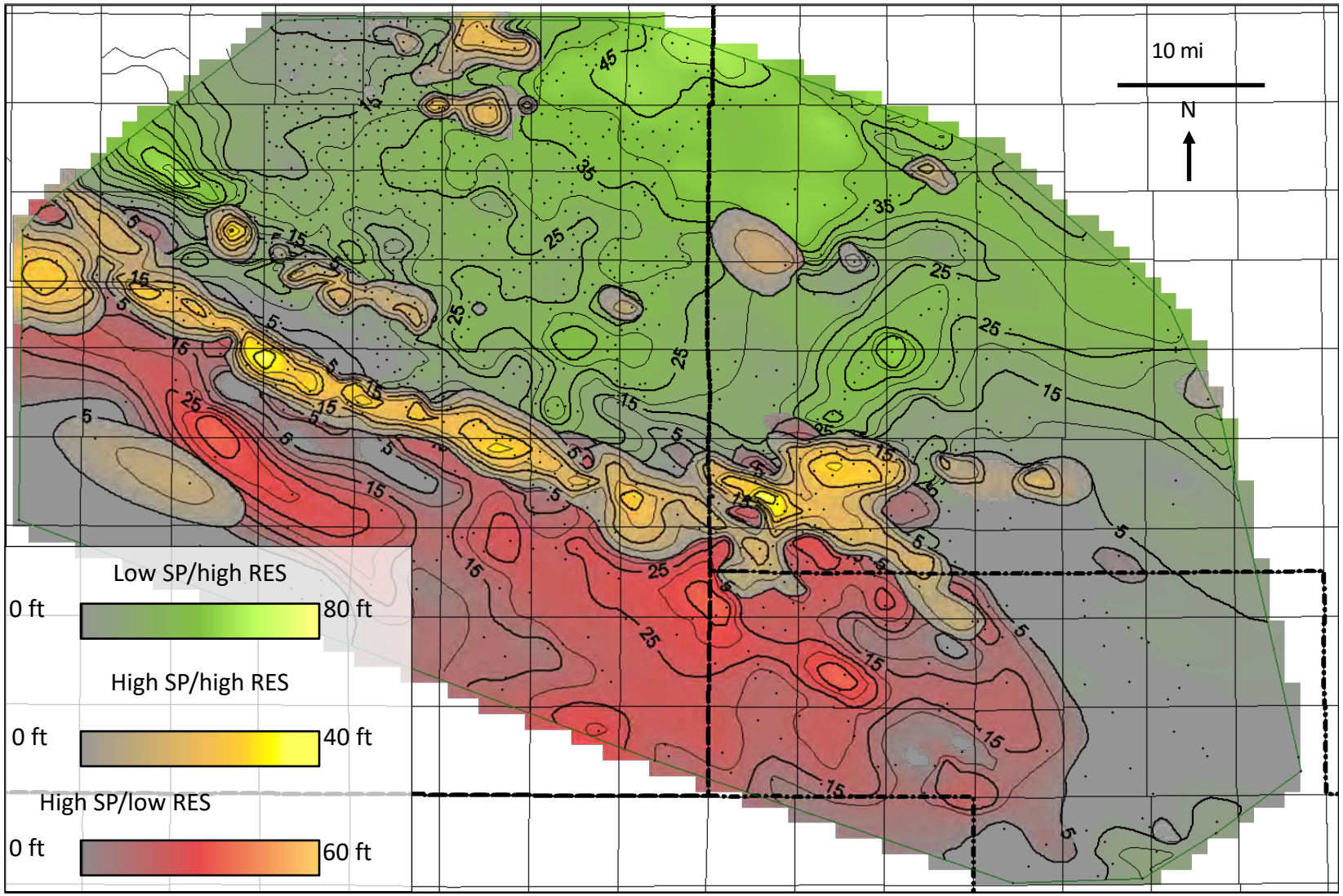
Porosity 11.7%
Permeability 61.d md

Porosity 11.06%
Permeability 0.11 md

Est. porosity 11%
Est. perm 0.3 md

Hough and Breyer 2021

Electrofacies Distribution in Interval M7



Electrofacies:

1. High SP/high RES
2. High SP/low RES
3. Low SP/high RES

Conventional Play

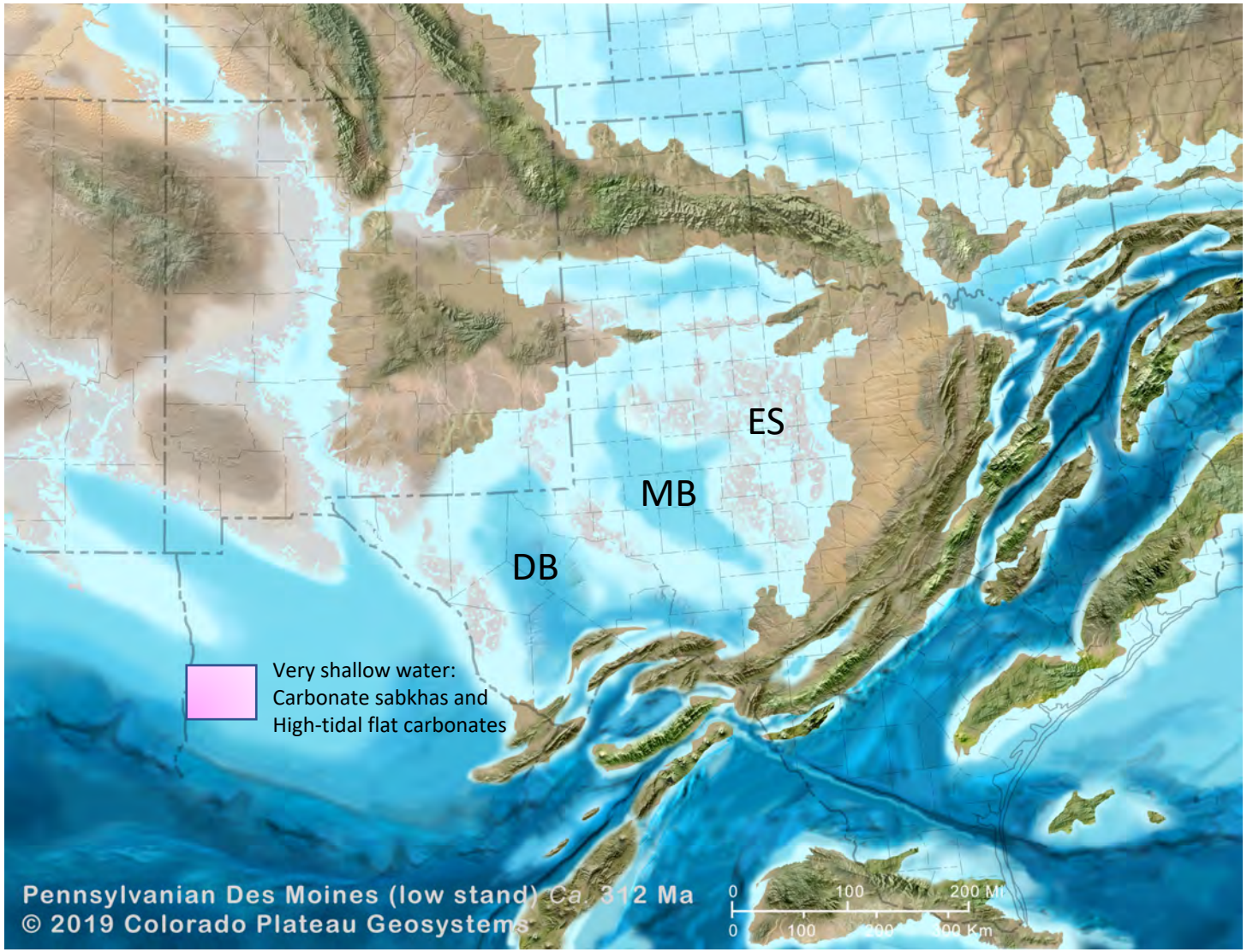
1

Carrier Bed Play

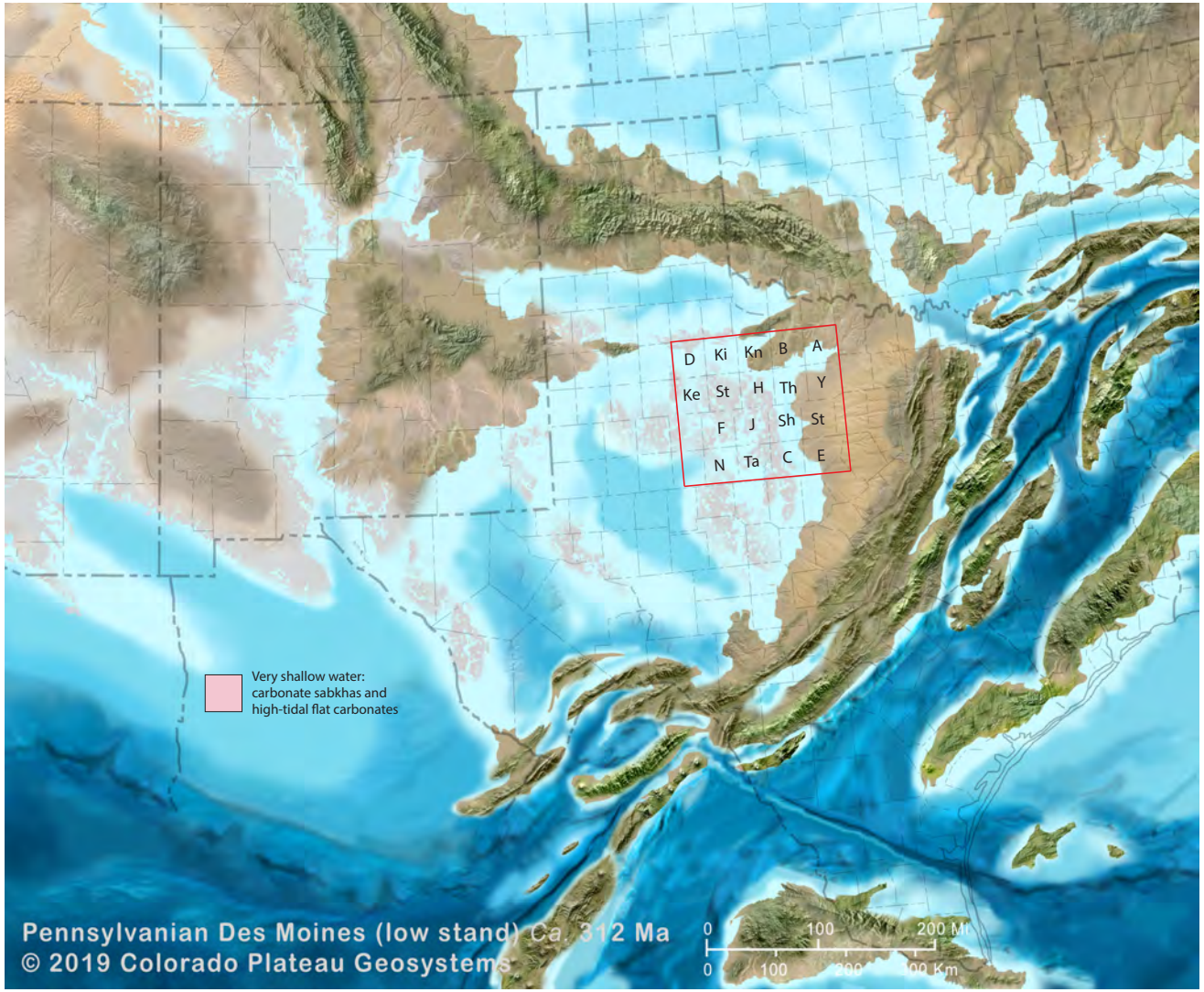
3

Hough and Breyer 2021

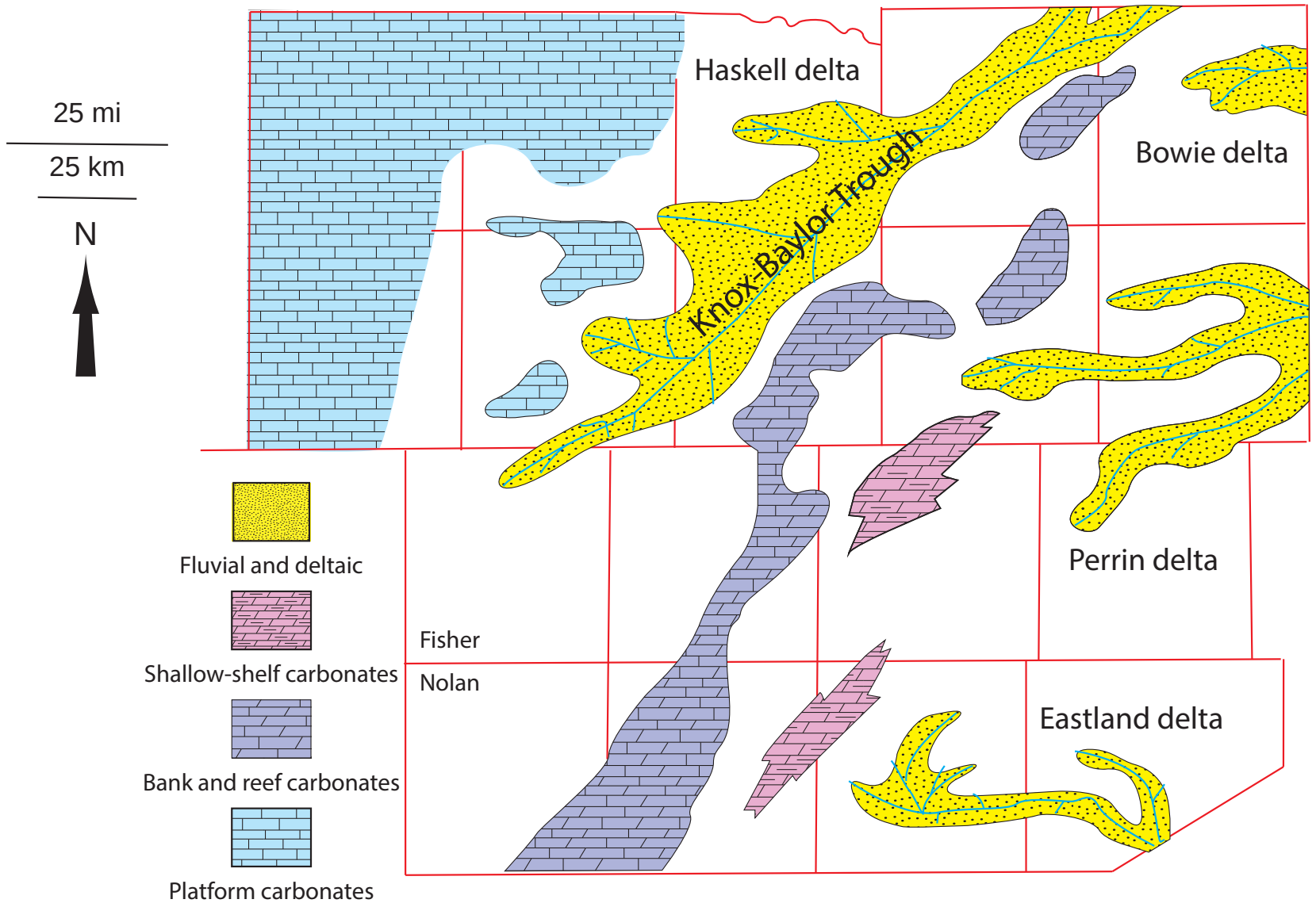
Paleogeography of the Permian Basin



Paleogeography of the Permian Basin

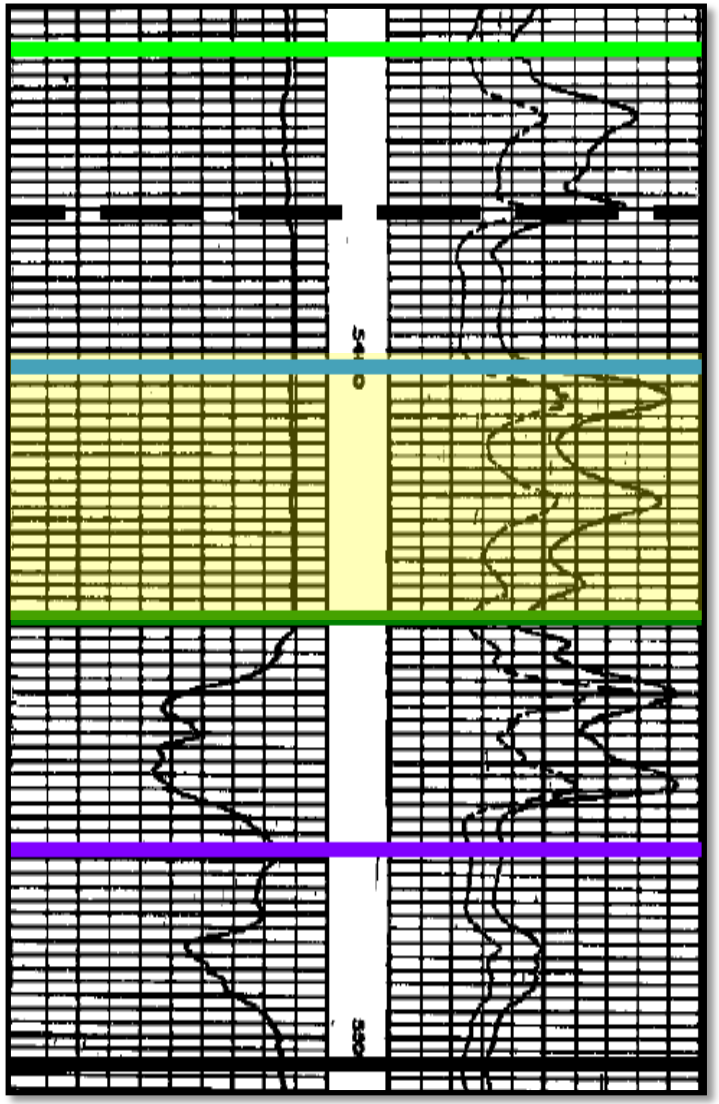


Paleogeography of the Eastern Shelf (Desmoinian)

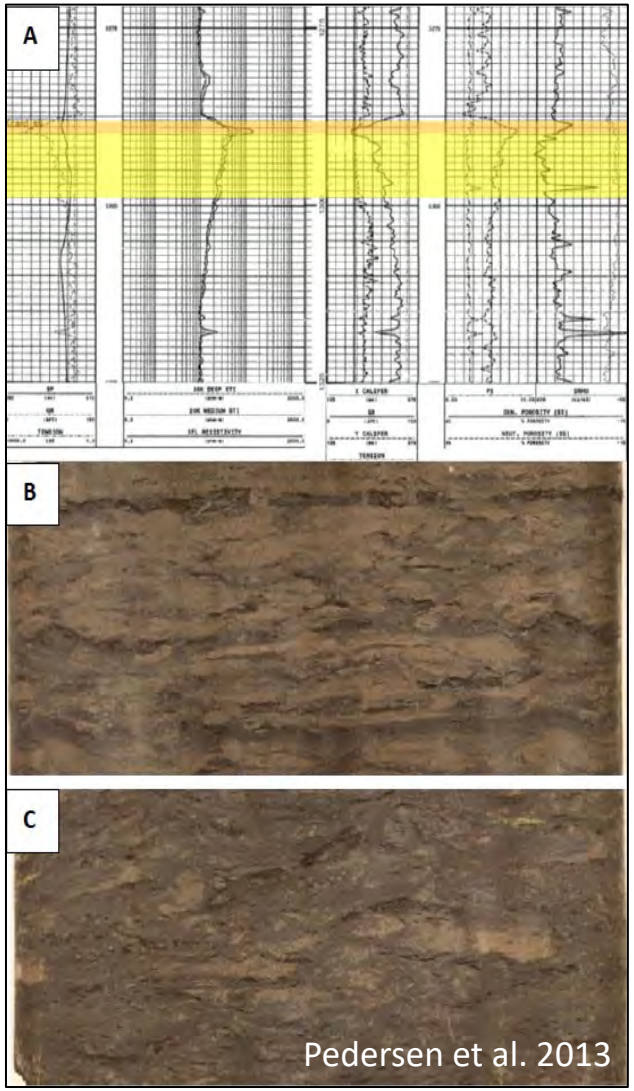


Low SP, High Resistivity Log Response

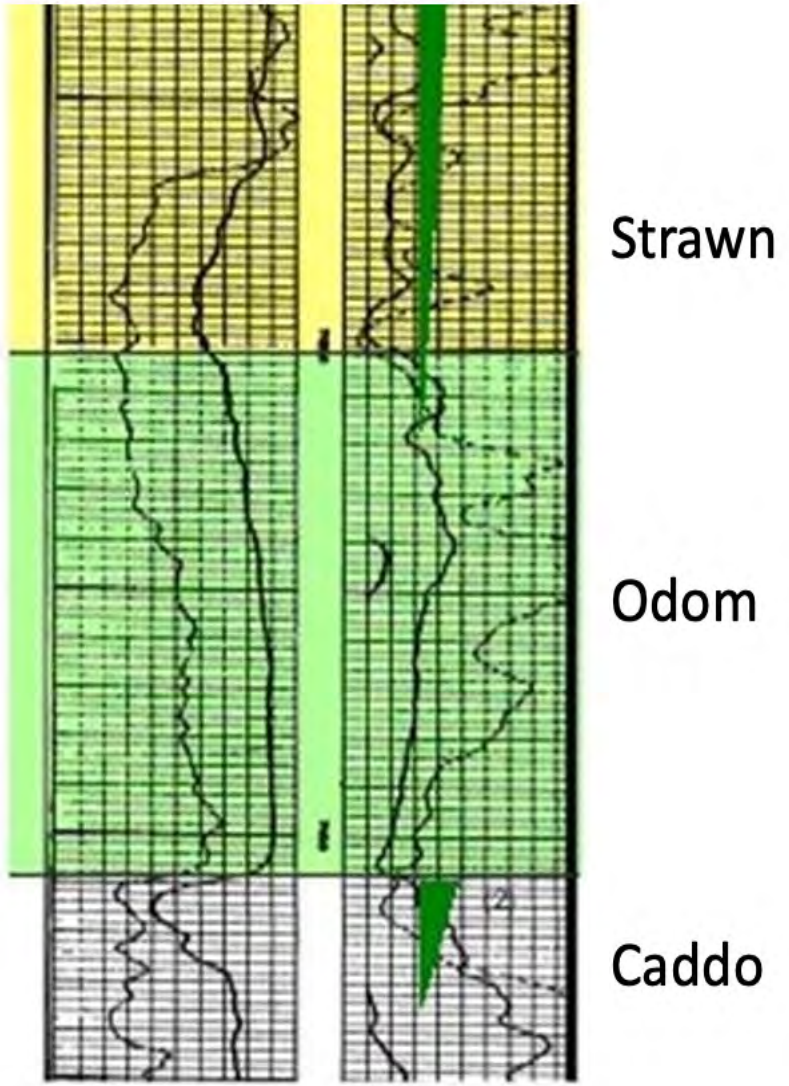
Offshore Mancos Shale Play



Halo Play, Pembina Field



Odom-Strawn Interval, Eastern Shelf



Oil is Found with Ideas

Several times in the past we have thought we were running out of oil whereas actually we were only running out of ideas.

Parke Dickey 1958

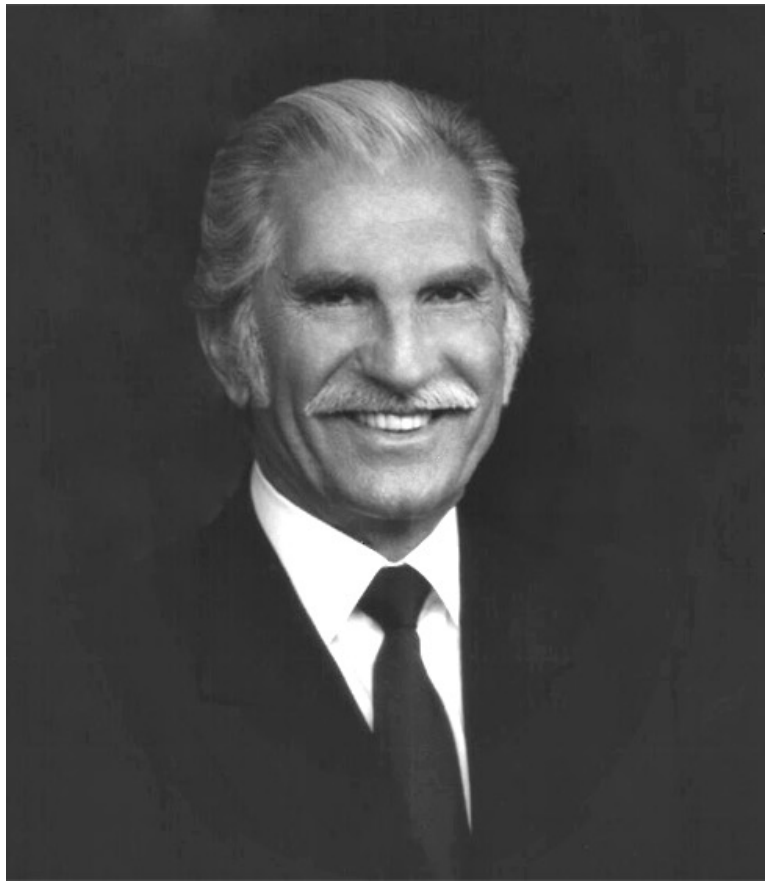
Risk and Reward

Places \ Ideas	Old	New
Old		
New		

What are you playing on the Eastern Shelf?

AAPG Memoir 32

The Deliberate Search for the Subtle Trap

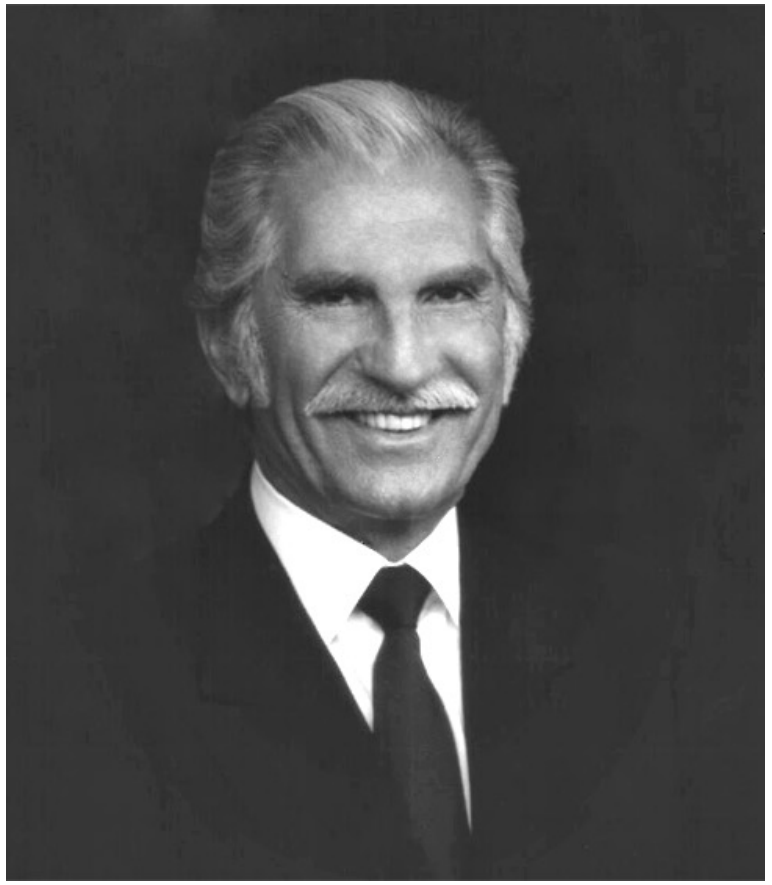


Michel T. Halbouty 1909-2004

Ask yourself: Am I a real oil finder? If your answer is yes, then go out and find a subtle trap.

AAPG Memoir 32

The Deliberate Search for the Subtle Trap



Michel T. Halbouty 1909-2004

Ask yourself: Am I a real oil finder? If your answer is yes, then go out and find a ~~subtle trap~~.

Ask yourself: Am I a real oil finder? If your answer is yes, then go out and find a carrier bed play.