Unconventional Plays Analysis and Modeling: Lessons Learned from an Integrated Study of the Lower and Middle Triassic of Western Canada*

Sébastien Rohais[1], E. Bemer[1], B. Chauveau[1], V. Crombez[1], M. Ducros[1], T. Euzen[2], M. Fleury[1], D. Granjeon[1], S. Pauthier[1], M. F. Romero-Sarmiento[1], and W. Sassi[1]

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[1]IFPEN, Rueil-Malmaison, France / Calgary, Alberta, Canada (sebastien.rohais@ifpen.fr)
[2]IFP Technologies (Canada) Inc., Calgary, Alberta, Canada

Abstract

The challenges that the industry and active research face to understand and develop self-contained source-reservoir systems have demonstrated that unconventional systems are extremely complex and heterogeneous at all scales. In this paper, we will illustrate an integrated approach from pore-to basin-scale, and from characterization to modeling on a producing case study (Triassic, Western Canada) that could be used as a generic workflow to delineate unconventional plays such as those that exist in the Neuquén Basin.

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AAPG
Latin America & Caribbean Region

ARGENTINA 2016
Geosciences Technology Workshop
Co-hosted by the Argentine Association of Petroleum Geologists and Geophysicists

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- **IFPEN:** ROHAIS Sébastien, BEMER E., CHAUVEAU B., CROMBEZ V., DUCROS M., EUZEN T., FLEURY M., GRANJEON D., PAUTHIER S., ROMERO-SARMIENTO MF., SASSI W.

IFP Energies nouvelles

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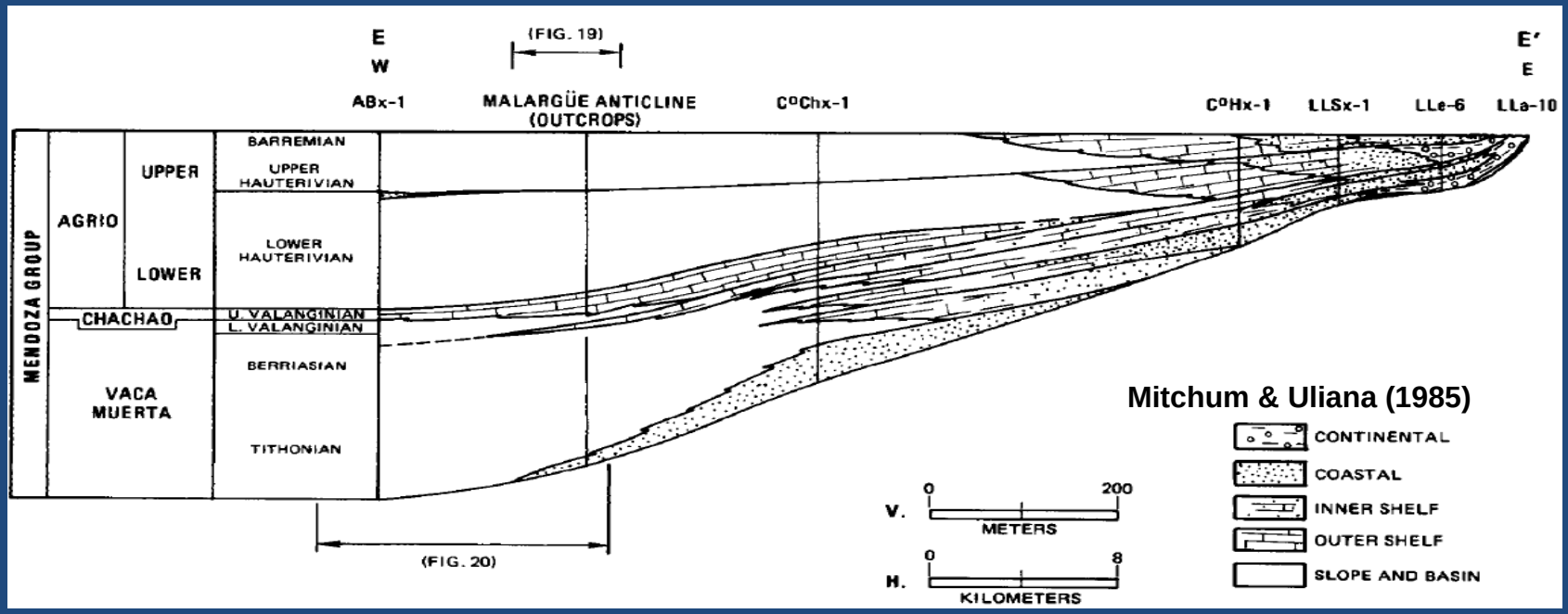
Harris N. and Vaisblat N. (Univ. of Alberta, Canada)

Core facilities in Calgary and Fort St John

….

Starting point: the “black box”

Proximal setting (conventional) are well-constrained using the common tools/concepts in sedimentology, stratigraphy, mineralogy and petrophysics… – Reservoir and basin modeling workflows are robust too



=> How to extend our knowledge for characterizing heterogeneities in the "black box"? And being more predictive in resource assessment for the unconventional domain?

Unconventional systems: problematic

Challenges faced by the industry and active research to understand and develop self-contained source-reservoir systems, have demonstrated that unconventional systems are extremely complex and heterogeneous at all scales

=> Sedimentology and sequence stratigraphy in fine-grained sediments?

=> Permeability, porosity, organic porosity, maturity and compaction relationship?

=> Mineralogy, diagenesis, natural fractures and “fracability”

=> Gaz still in place, free gaz, adsorption, production design…?

=> Abnormal pressures and water saturations?

Background at IFPEN

- Source-rock characterization & basin modeling

- Unconventional resources : Sedimentology, Petrophysics, Fracturing and modeling

  Europe, Africa, Canada, South America, US

=> Need for an integrated study to derive lessons for being more predictive

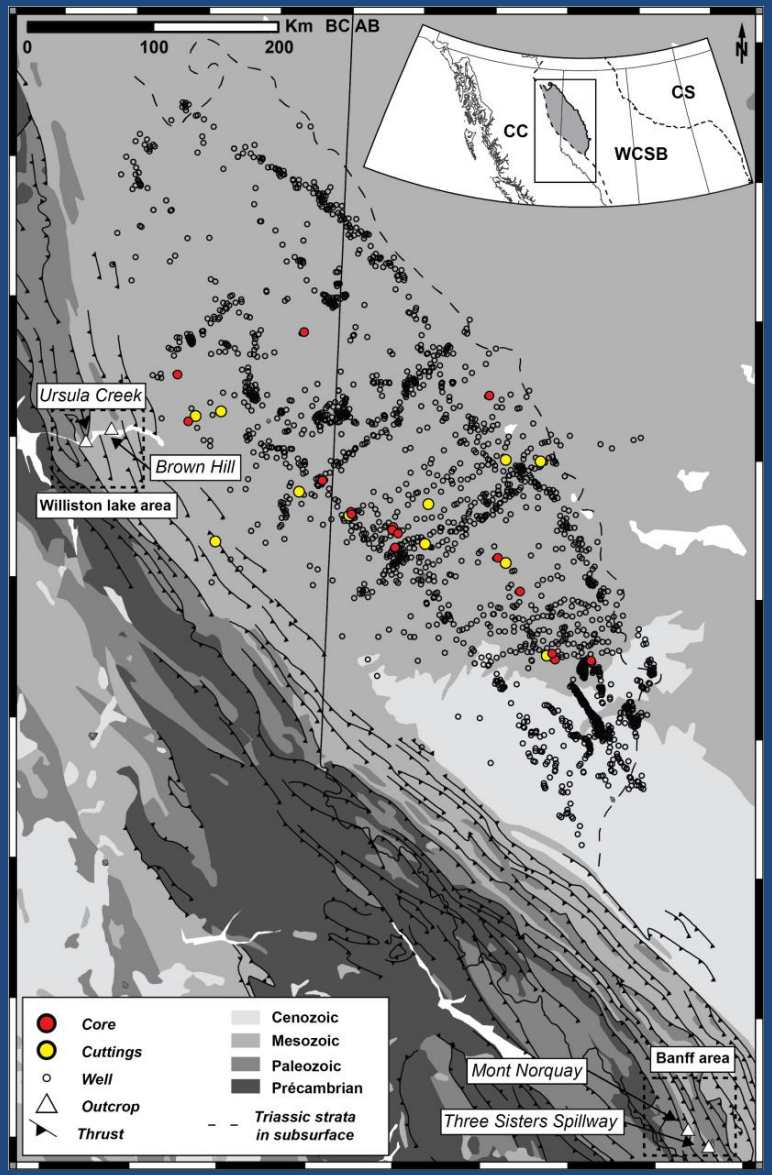
  Full dataset: outcrops, cuttings, core, well logs, seismic, basin geometry, well geometry, production, completion…

=> Montney-Doig Fms (Canada): Perfect case study for carrying out major insights onto unconventional system behavior (e.g. Crombez et al., 2014, Crombez PhD, 2016; Crombez et al., 2016a, 2016b; Euzen et al., 2015; Romero-Sarmiento et al., 2016; Rohais et al., 2016; Ducros et al., 2016, Fleury & Romero-Sarmiento, 2015 …)

Case study: Montney-Doig Fms, W-Canada

DATABASE

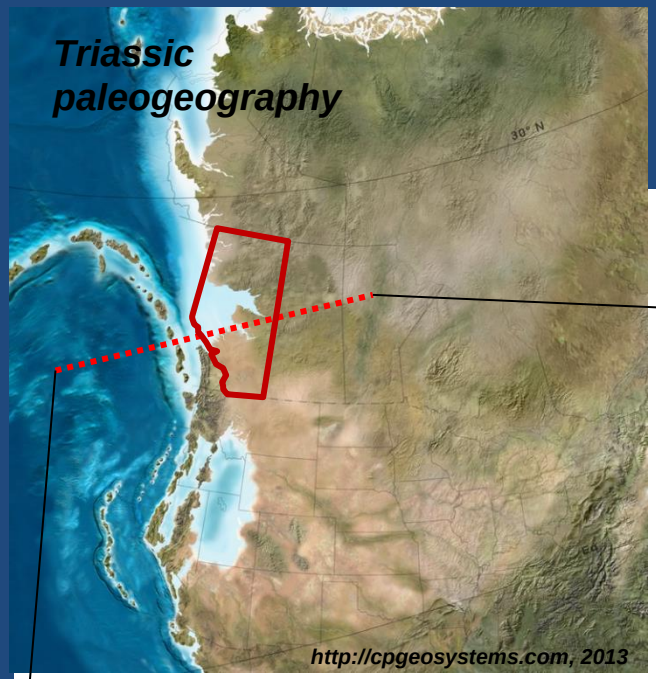
- Well data
  - 2210 wells
- Sedimentary descriptions
  - 17 cores (approx. 750m cumulated)
  - 4 outcrops (approx. 850m cumulated)
- Samples
  - 496 from cores
  - 365 from cuttings (11 wells)
  - 176 from outcrops
- Numerous previous works
  - Stratigraphy
  - Biostratigraphy



Crombez (2016)

Case study: Montney-Doig Fms, W-Canada

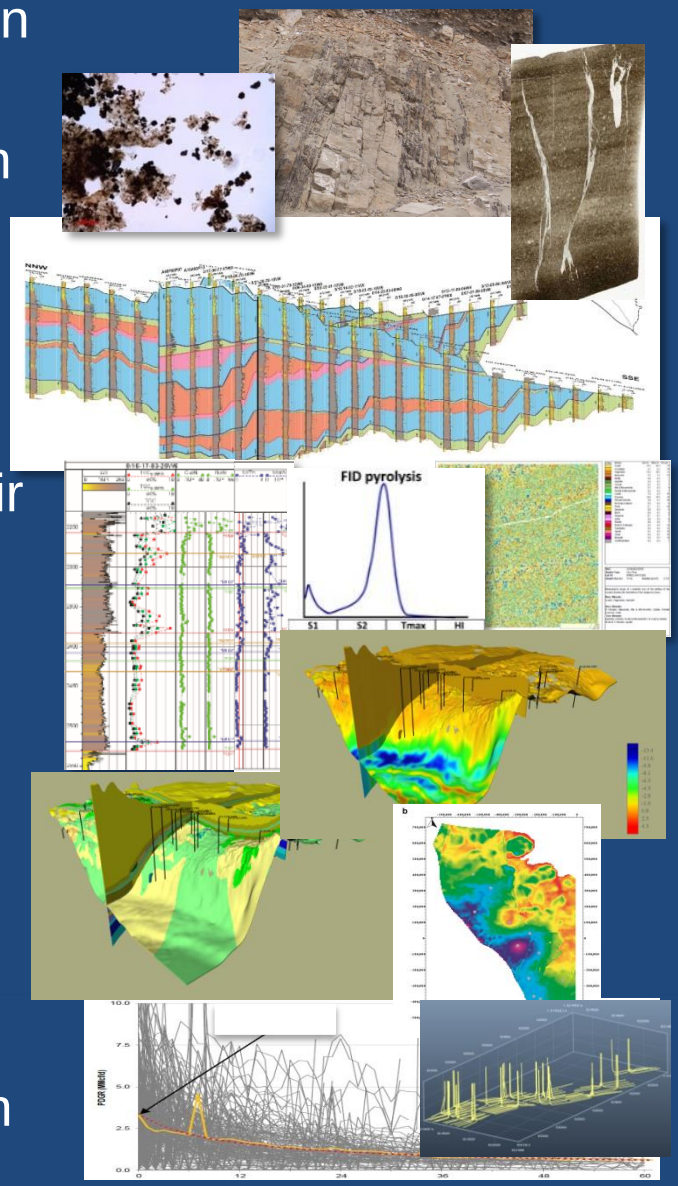
GEODYNAMIC SETTING



Rohais et al., in prep.

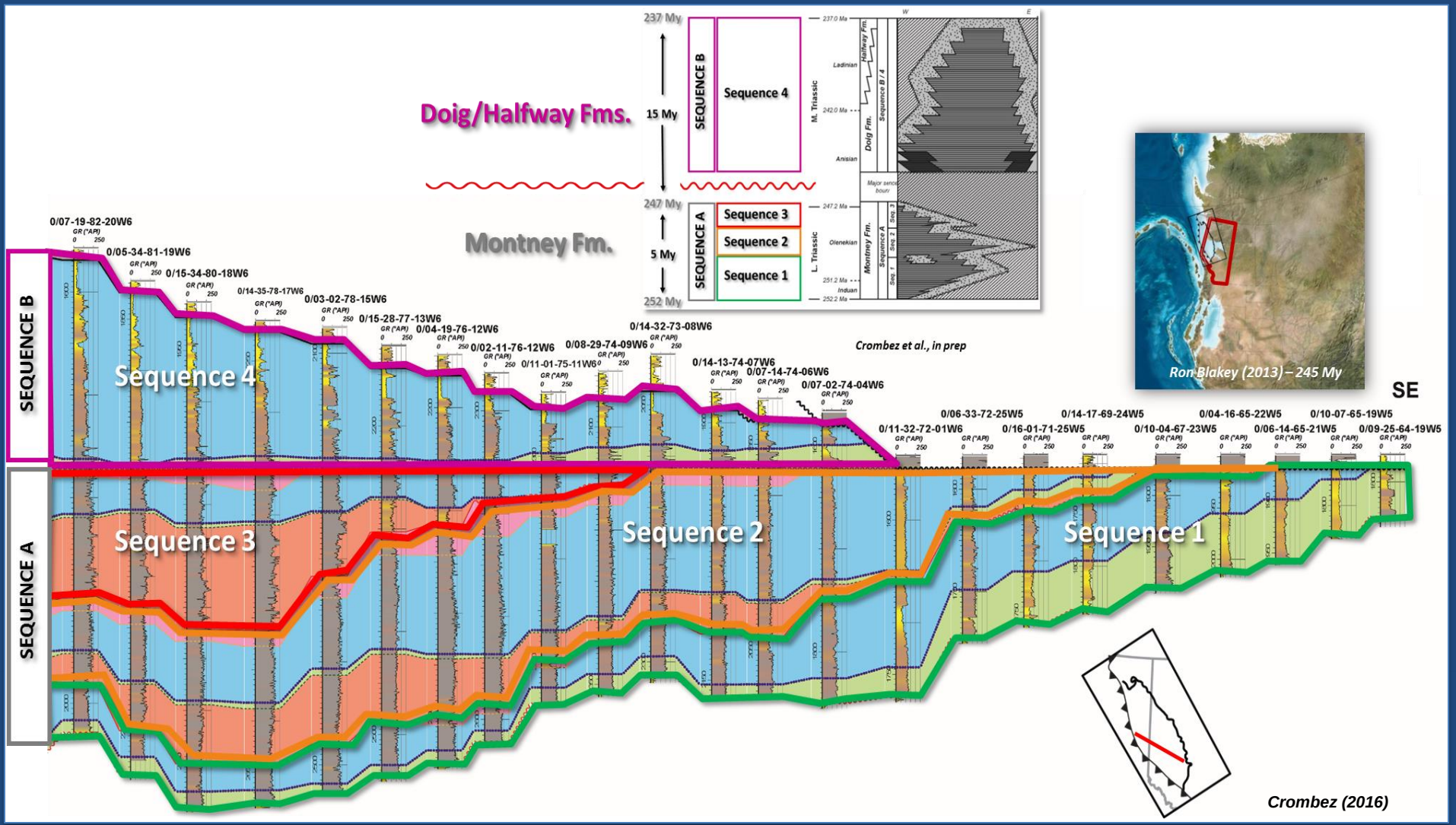
Workflow

1. Stratigraphic architecture basin characterization to establish the framework (units, rock-types…)
2. Organic matter and heterogeneities distribution characterization (fracture, diagenesis, mineralogy…)
3. Stratigraphic modeling to insure a most likely 3D distribution of the main facies and their associated petrophysical / geochemical / reservoir properties (+ TOCini and HIini)
4. Sampling strategy and high-tech lab characterization for specific problematic (e.g. kinetic, organic porosity versus maturity, brittleness versus maturity, adsorption versus mineralogy…)
5. 3D petroleum basin modeling to constrain the hydrodynamic regime
6. Uncertainty analysis, Feedback and production strategy, Cash flow



Workflow: 1. Stratigraphic architecture

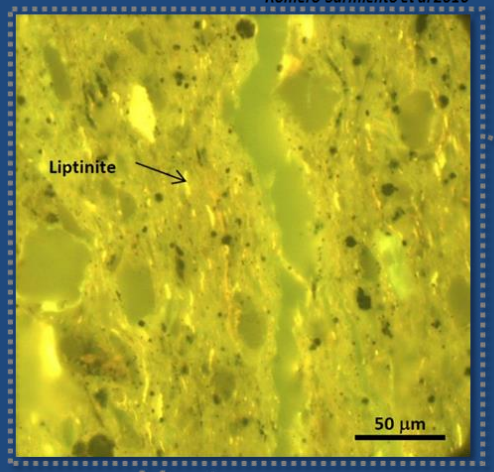
Objective: to establish the framework (units, sequence, rock-types…)



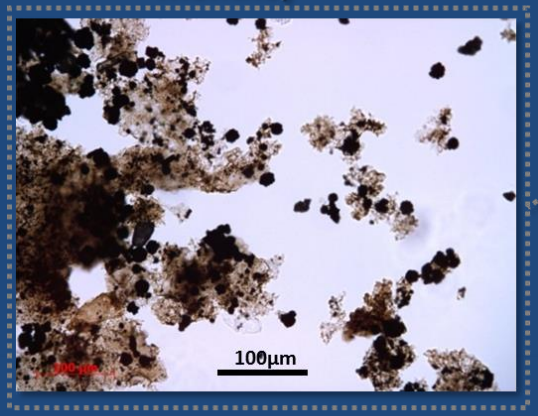
Workflow: 2. Heterogeneities distribution

Objective: to characterize the main parameters and their relationship (fracture, diagenesis, organic matter…)

Romero-Sarmiento et al 2016



Montney



Crombez et al., in prep

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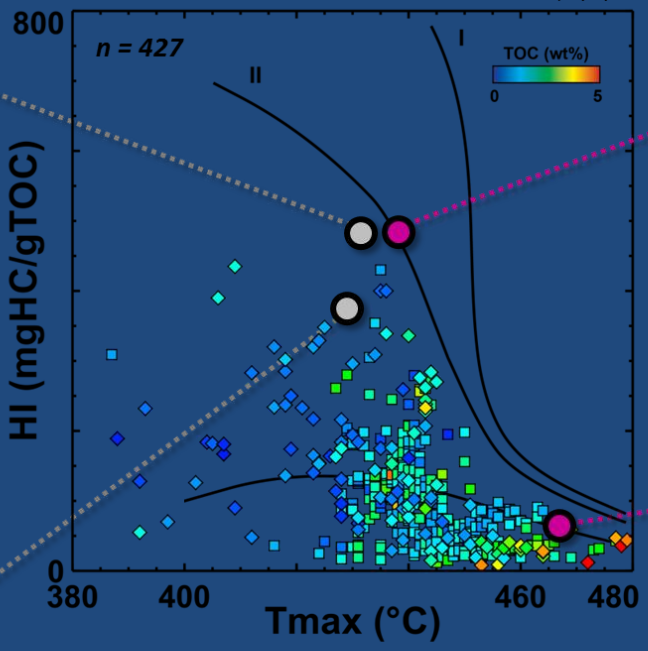
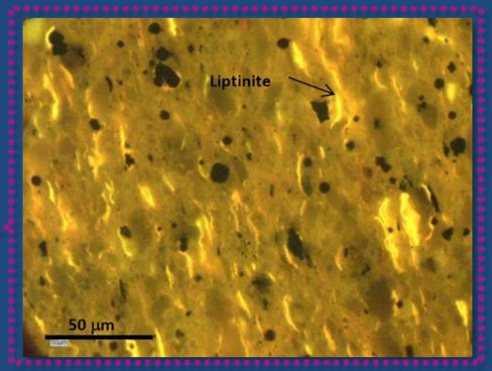
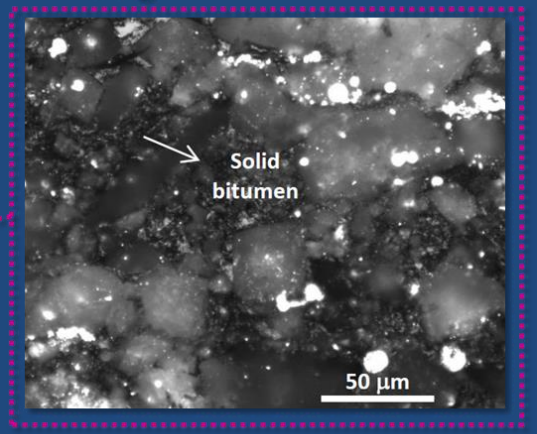




Romero-Sarmiento et al 2016

Doig

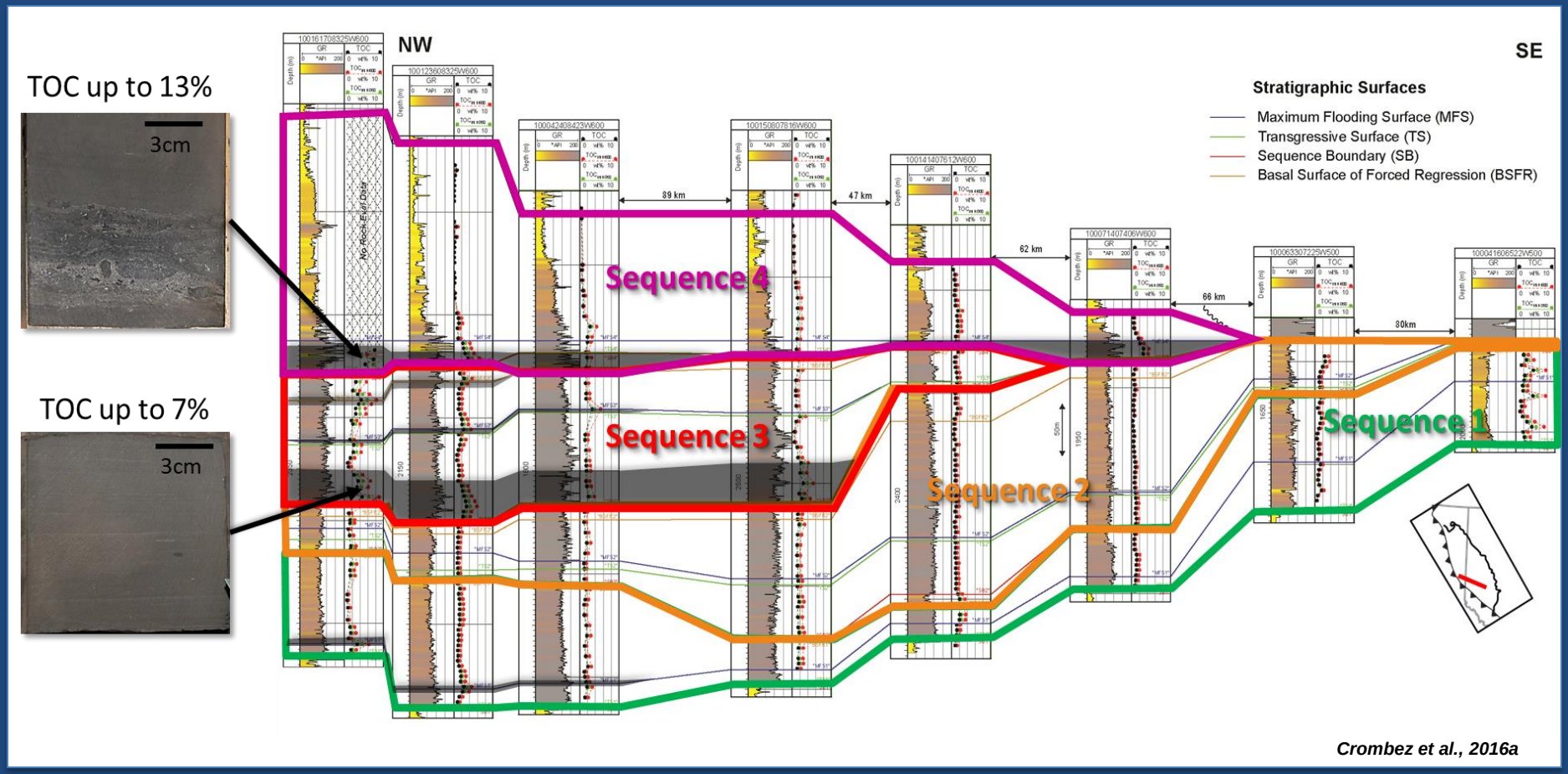


Romero-Sarmiento et al 2016

- Organic-rich intervals tend to be over-matured
- Mainly marine amorphous organic matter
- Rock-Eval analyses show type II-III organic matter

Workflow: 2. Heterogeneities distribution

Objective: to characterize the main parameters and their relationship (fracture, diagenesis, organic matter…)



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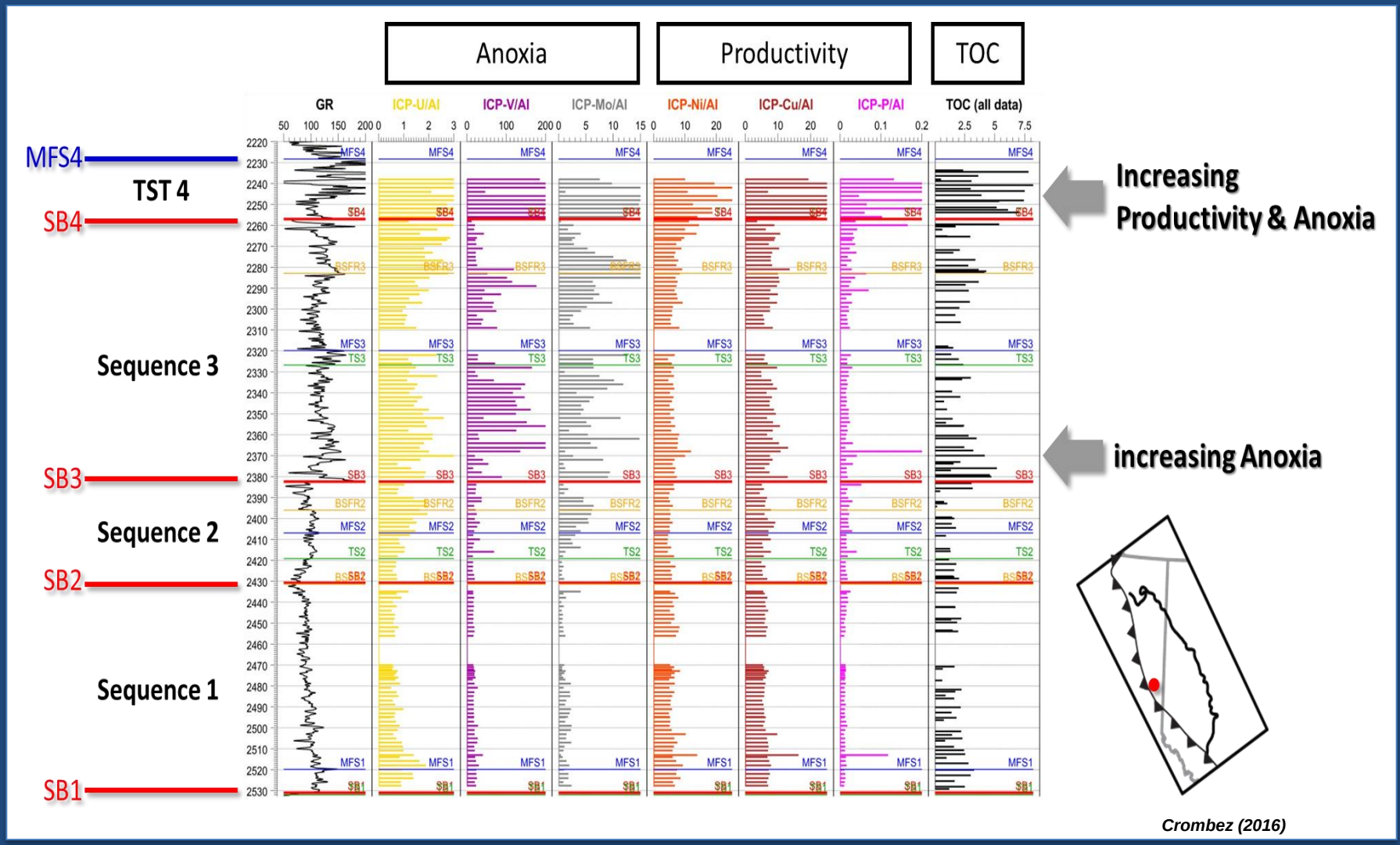
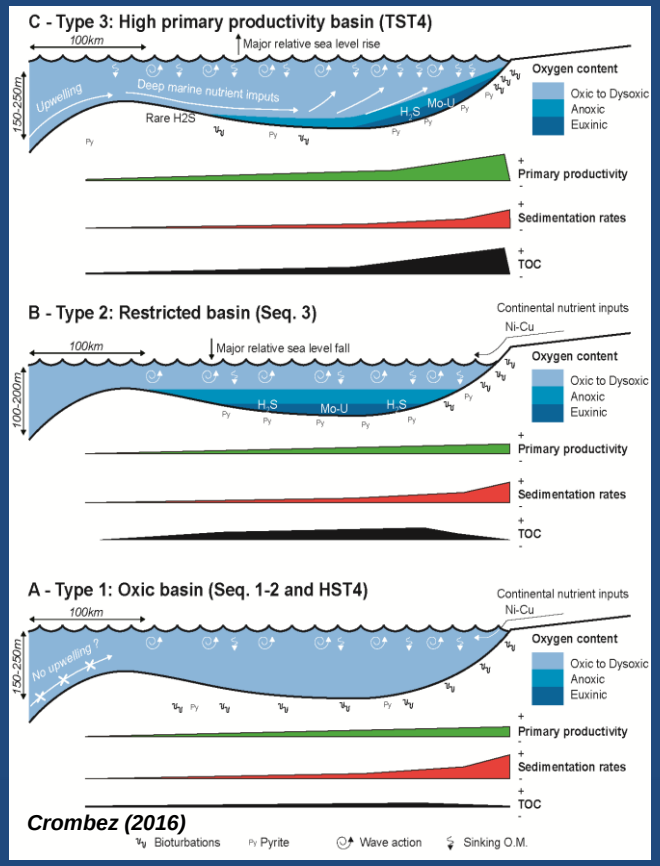


Crombez (2016)

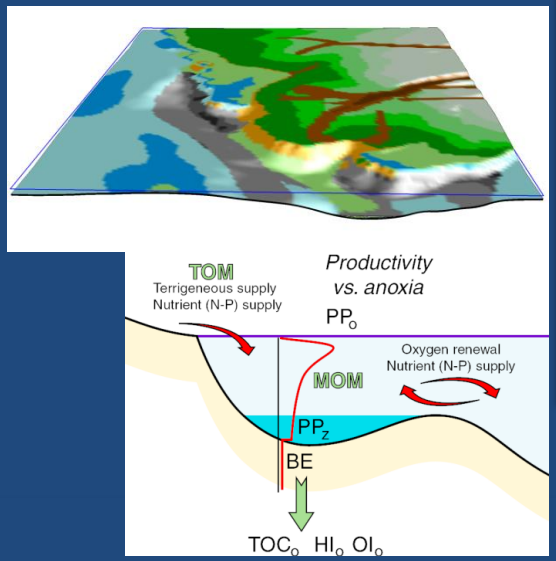
Workflow: 3. Stratigraphic modeling

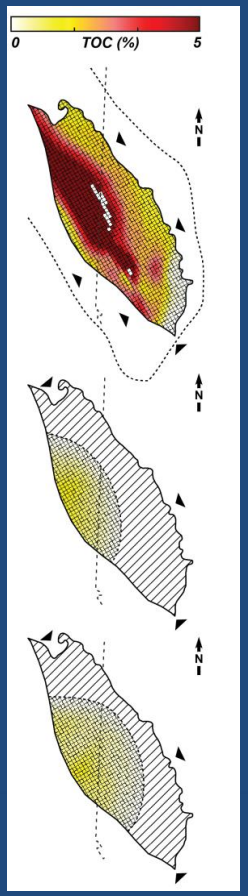
Objective: to extrapolate properties/parameters using a process-based model - DIONISOSFLOW



Geological model

DIONISOSFLOW

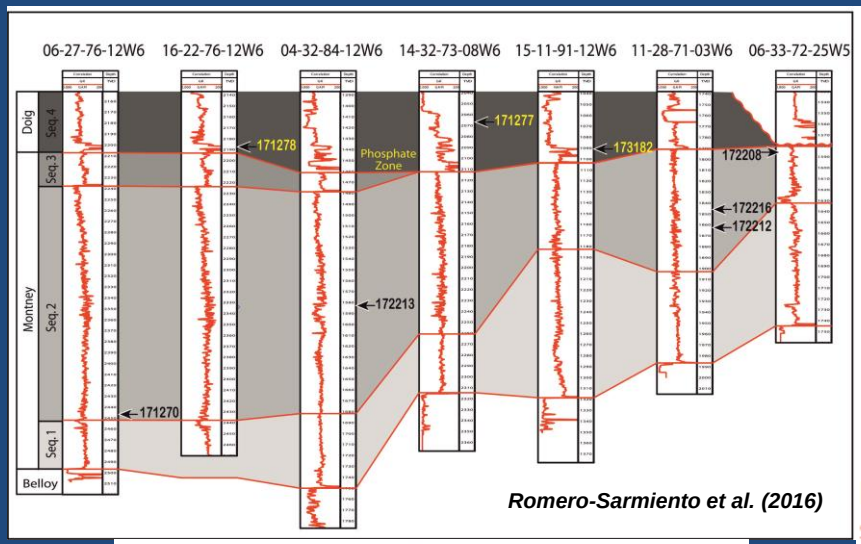




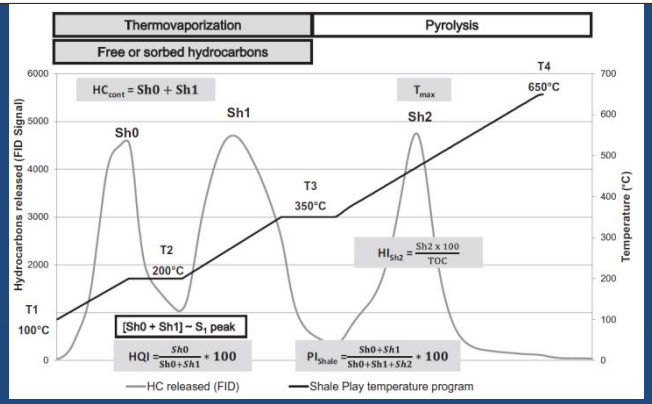
TOCini, Hiini, lithology…

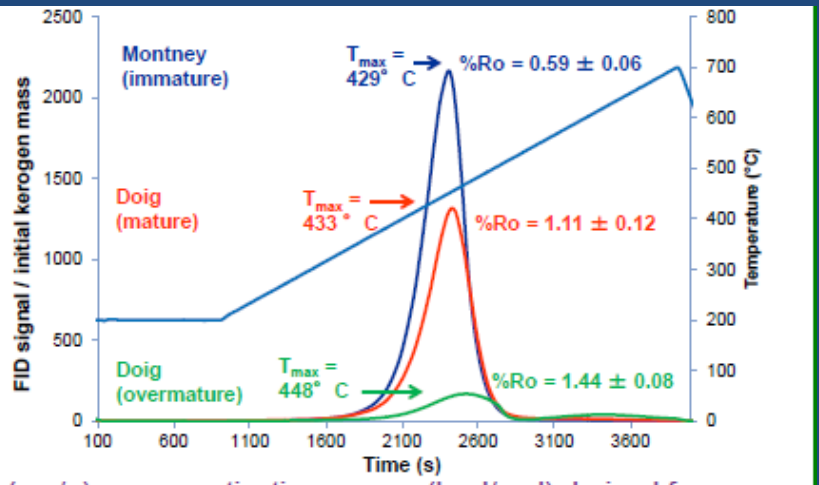
Workflow: 4. High-tech lab characterization

Objective: to constrain the petroleum system better (Kerogen kinetic, organic porosity vs maturity, Rock-Eval shale play, adsorption vs mineralogy…)

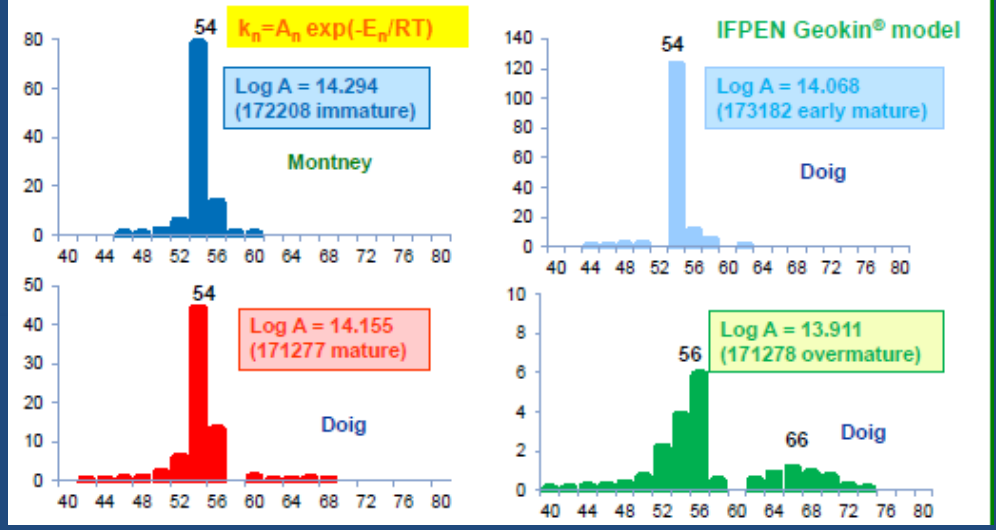


Romero-Sarmiento et al. (2016)





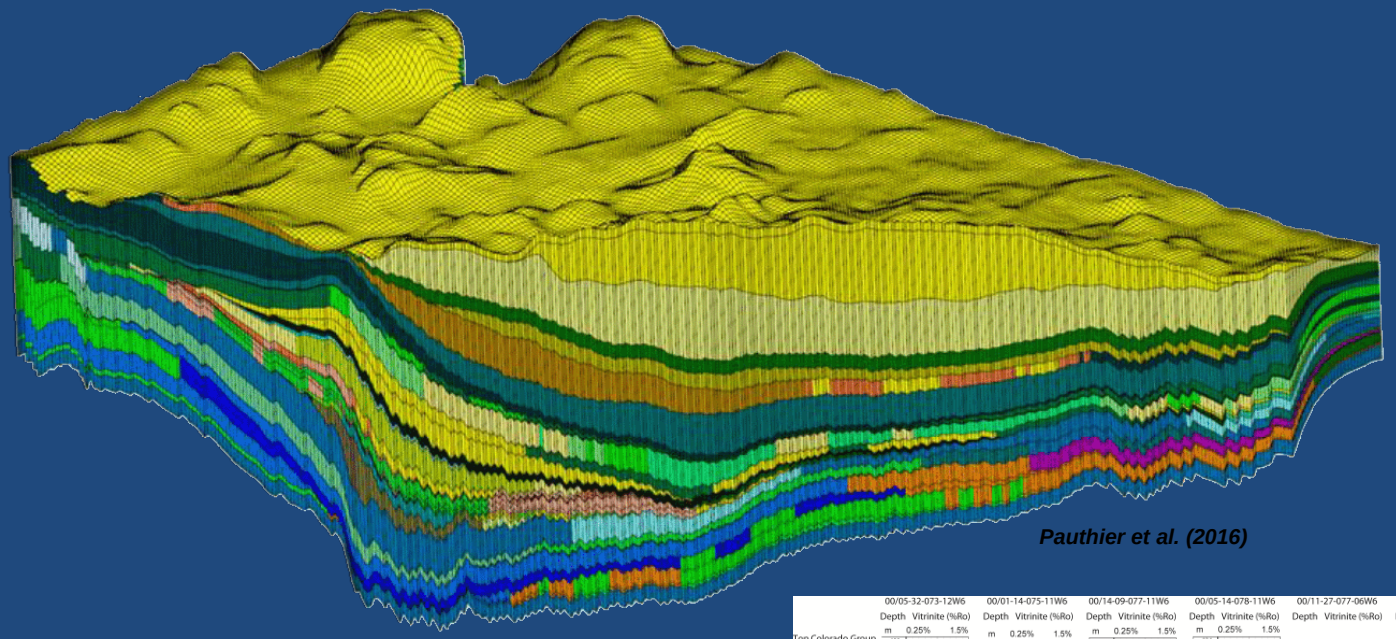
HC potential (mg/g) versus activation energy (kcal/mol) derived from open-system pyrolysis of kerogen samples at different thermal maturity levels



=> To constrain the expulsion / early migration processes better

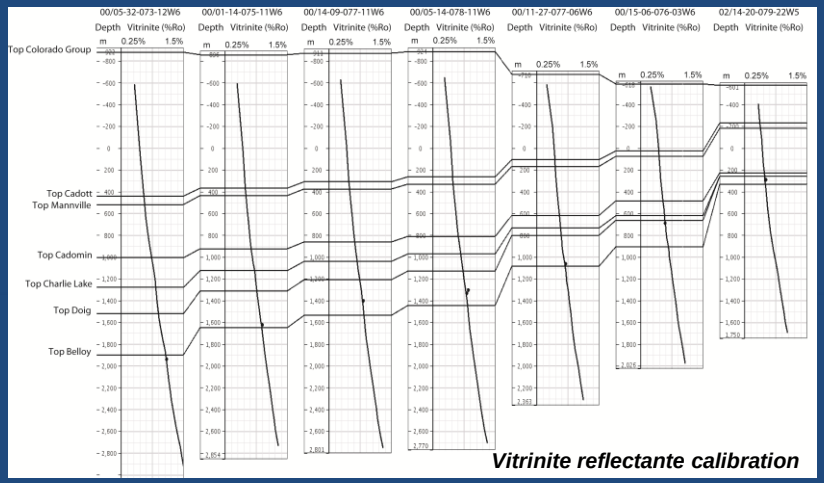
Workflow: 5. Petroleum basin modeling

Objective: to constrain the hydrodynamic regime (overpressure…)



Pauthier et al. (2016)

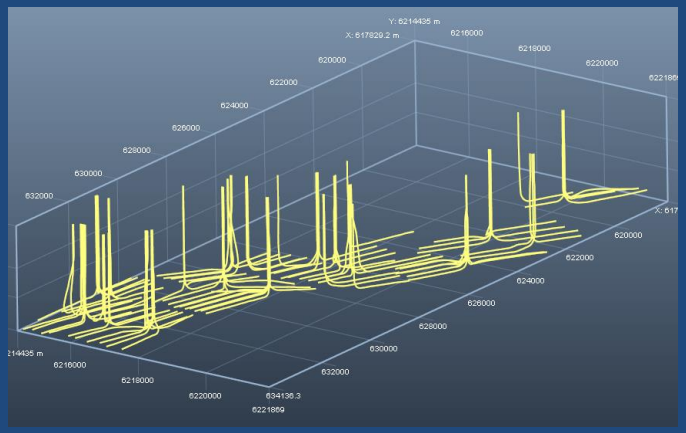
=> To establish a consistent geological model where the relationship and inter-dependency of different parameters are restored and calibrated with the observed data

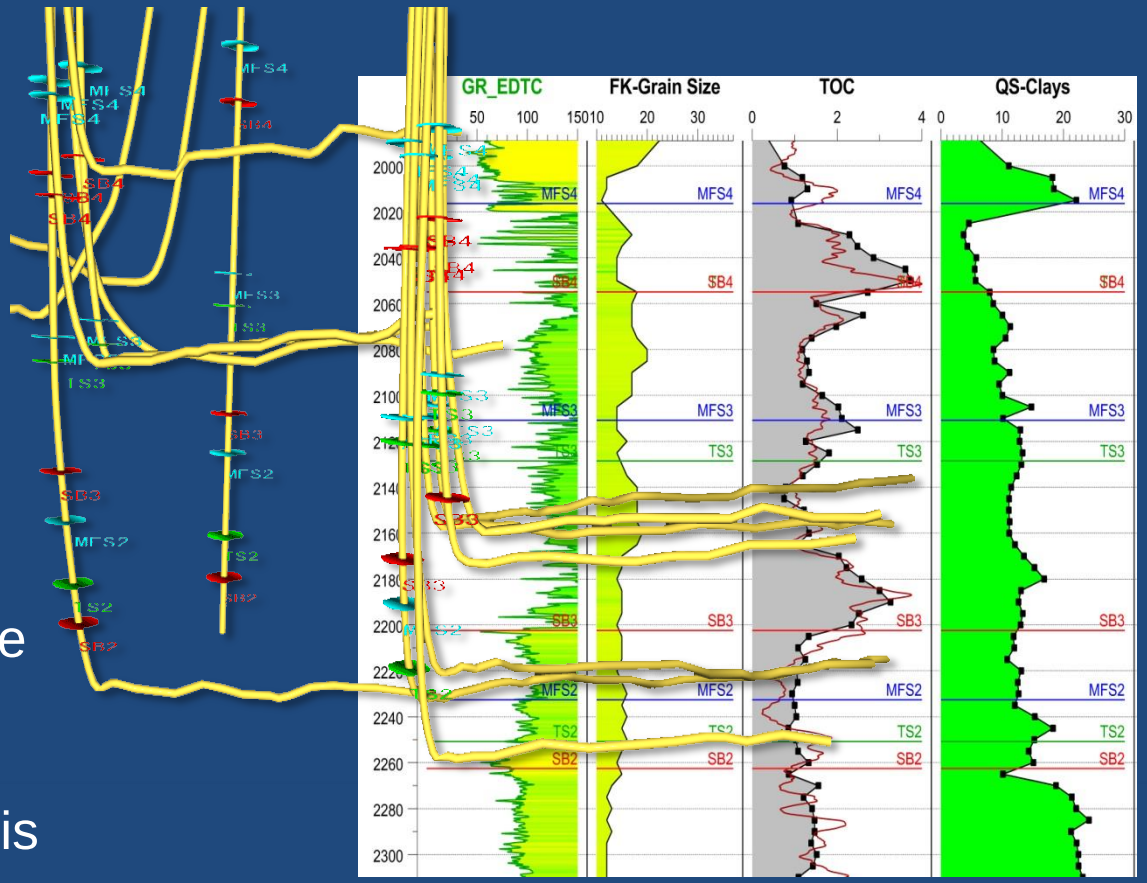


Vitrinite reflectante calibration

Workflow: 6. Uncertainty & strategy

Objective: to understand the relationship of the controlling parameter for good production (facies and mineralogy, initial fracture density, sequences, proppant, frac stage, frac spacing…)





=> To establish a database with all the geological and production parameters to carry out statistical analysis

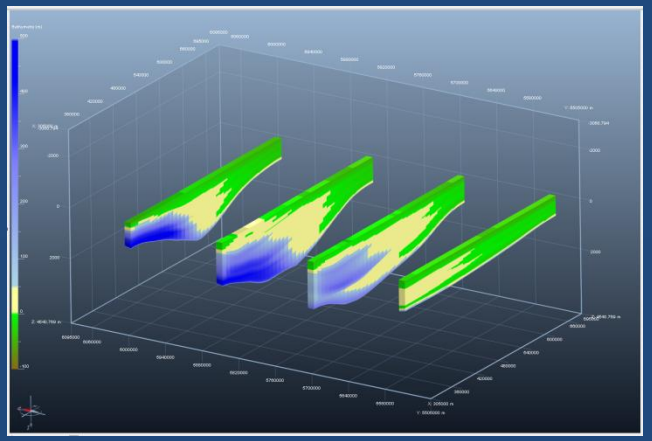
Conclusion, take-home messages and lessons

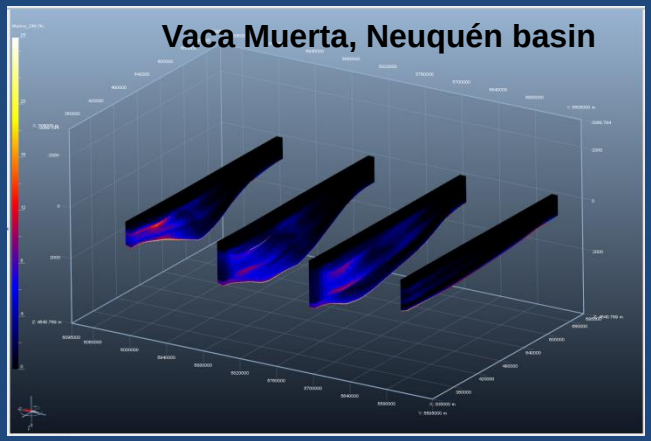
1. Geological characterization (facies, sequence, petrophysics, rock-types) = TOP1 priority !

2. Want to be more predictive: to implement process-based modeling tools to better restore and insure the inter-dependency / coherency of some parameters

3. Adaptive workflow from basin scale to prospect area

4. Powerful workflow that was implemented / validated on a world-class unconventional system. It has to be double check on some more case study…





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