SIS Global Forum 2019

Stratigraphic Forward Modeling Applied to Reservoir Characterization of Aptian Carbonate Reservoirs, Santos Basin

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Agenda:

✓ **Stratigraphic Forward Modeling (SFM), why?**

✓ **Previous works at Petrobras**

✓ **Case Study**

✓ **Perspectives**

Stratigraphic forward modeling (SFM), why?

✓ This technique can generate scenarios within different geometries and facies distributions in distinct depositional systems.

✓ It can be used to test and quantify concepts about the siliciclastic and carbonate deposition.

For each time step chosen, 3 main

processes are considered:

i) Accomodation space (subsidence +

△ lake level)

ii) Production of carbonate facies by

time (m/My)

iii) Coefficient *of* carbonate facies

productivity by bathymetric range
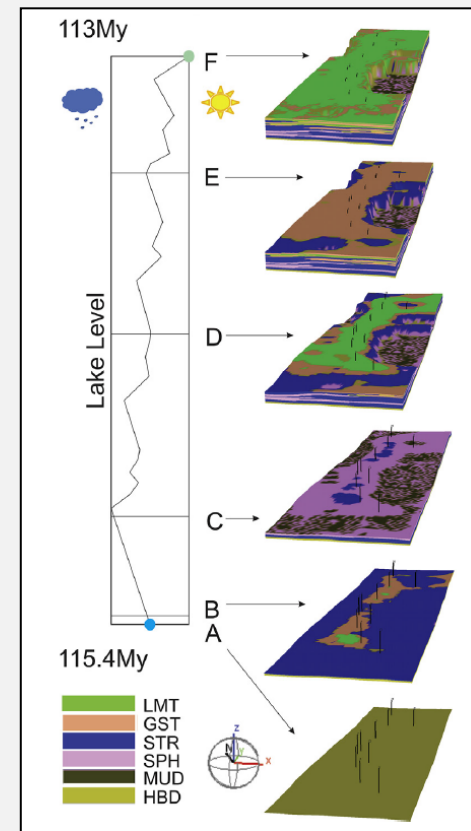
(Faria, D.L.P., Reis, A.T. & Souza Jr, O.G., 2017)

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Previous works at Petrobras

✓ Since the discovery of the pre-salt fields (carbonate reservoirs), there was a Petrobras efforts representing vertical facies heterogeneity in reservoir characterization;

Master Degree

2013 - "Simulação de processos deposicionais: caracterização de dois ciclos de alta frequência da Sequência Balbuena IV, Bacia do Noroeste Argentino." João Paulo Borges Gomes.

2017 - "Modelagem estratigráfico-sedimentológica da distribuição espacial de fácies sedimentares em reservatório carbonático aptiano da bacia de Santos". Desiree Liechoscki de Paula Faria.
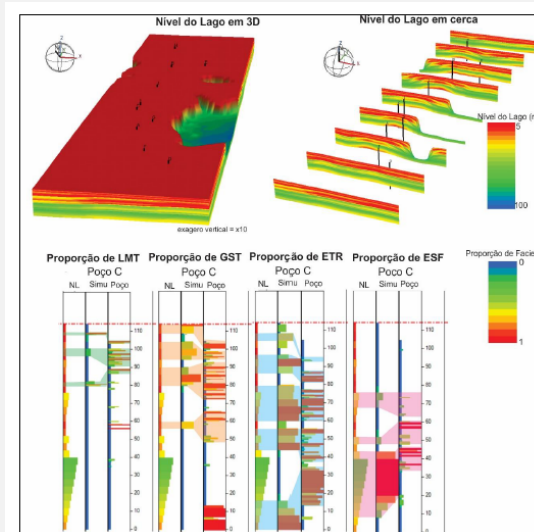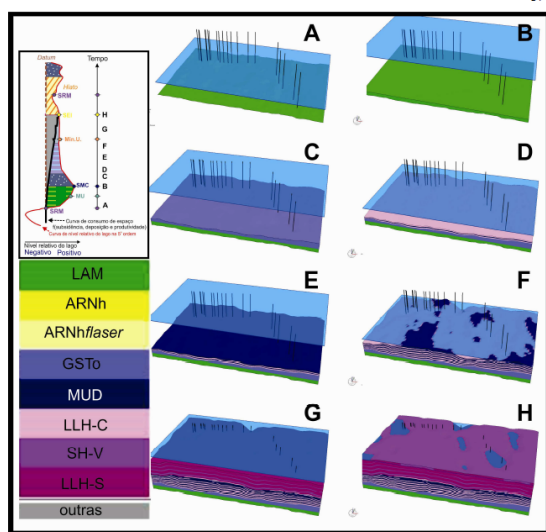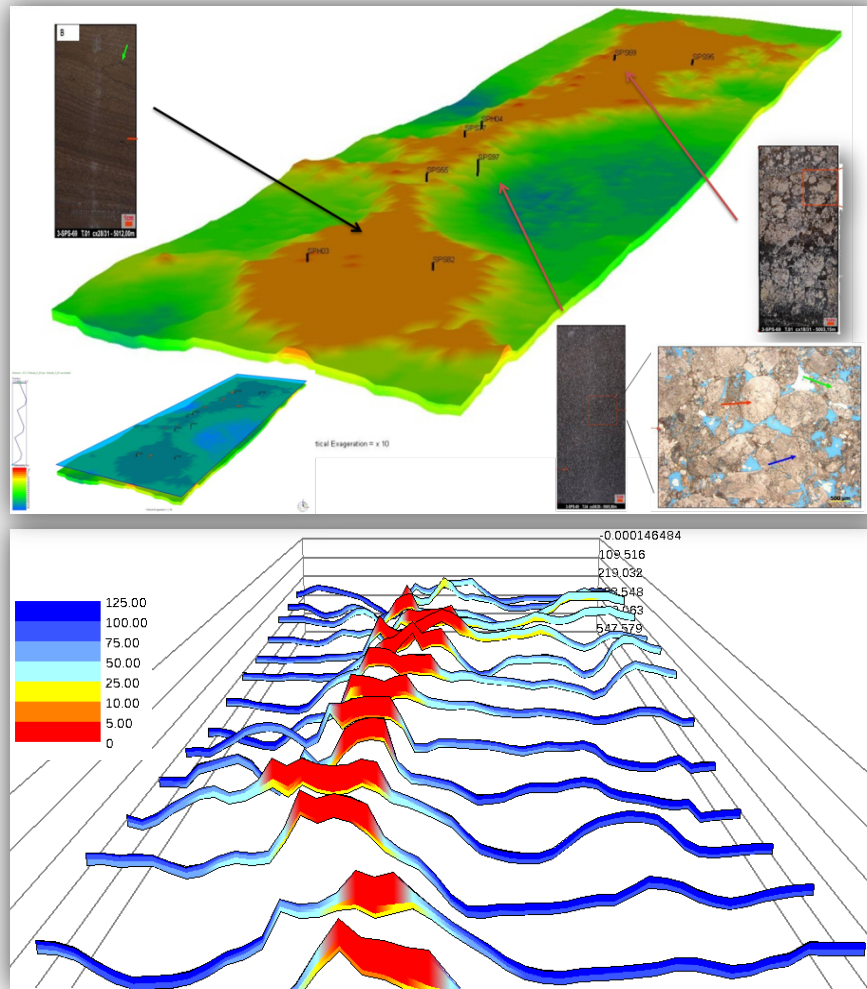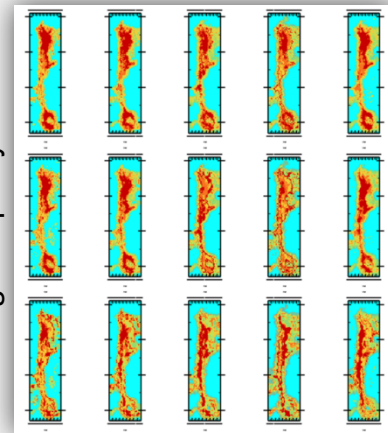
Previous works at Petrobras

✓ The use of sedimentary process modeling is well diffused in pre-salt reservoirs, both as a tool for understanding carbonate sedimentation and for generating trends to probabilistic facies models in the reservoir characterization;
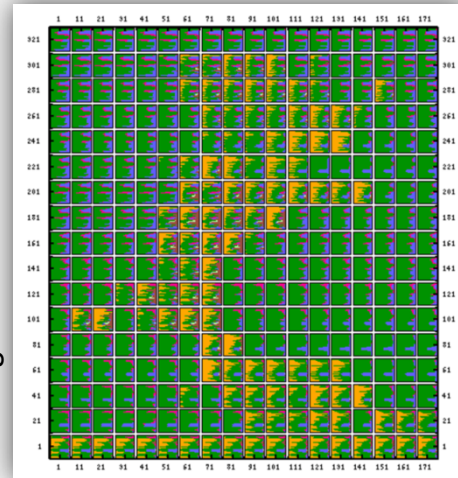

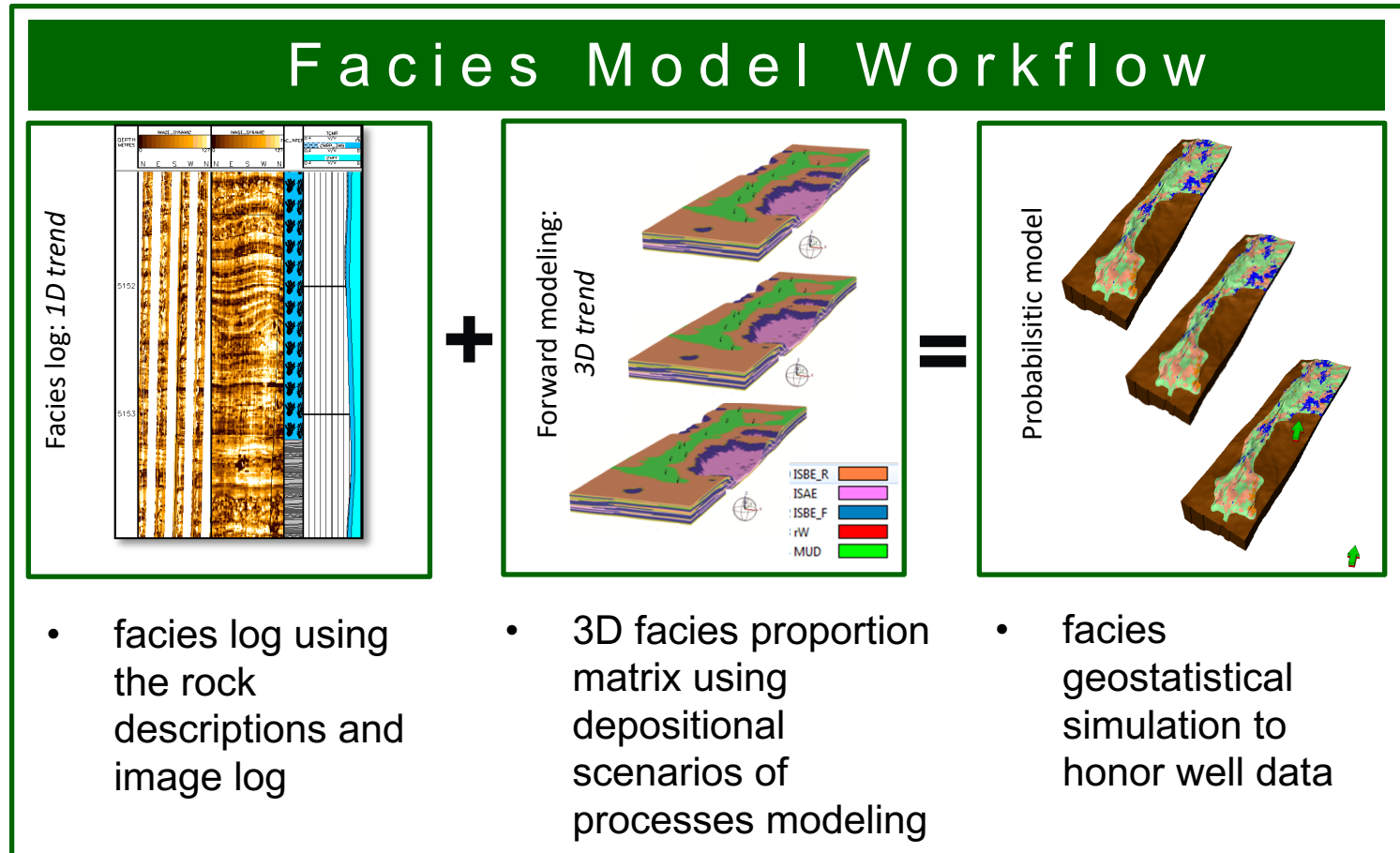*First model – Sapinhoá Field (2012)*
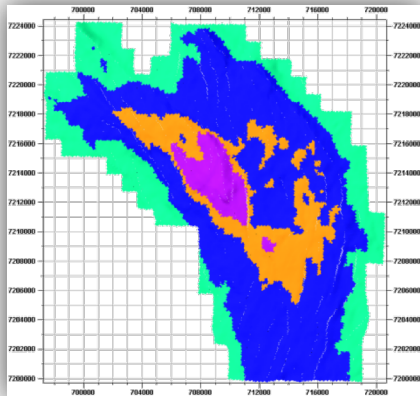
Average maps by zones

Plurigaussian facies model

Facies Model Workflow in PreSalt Fields

✓ the stratigraphic forward model resulted in a 3D facies distribution matrix to be used as a trend in the facies probabilistic model;
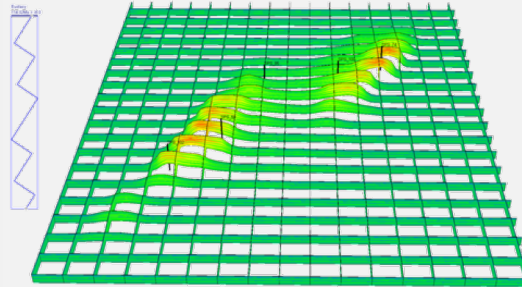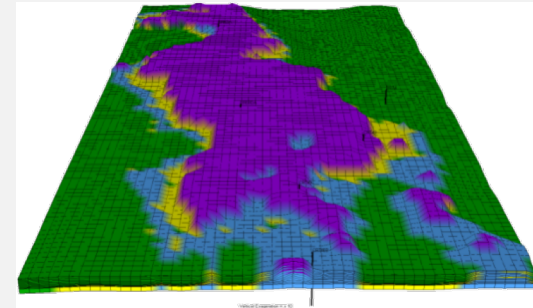

F a c i e s   M o d e l   W o r k f l o w

Facies log: *1D trend*

Forward modeling: *3D trend*

Probabilsitic model

- ISBE_R
- ISAE
- ISBE_F
- rW
- MUD

- facies log using the rock descriptions and image log

- 3D facies proportion matrix using depositional scenarios of processes modeling

- facies geostatistical simulation to honor well data

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Previous works at Petrobras

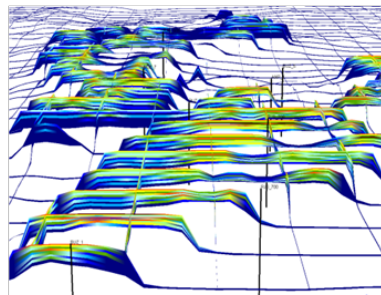Iracema (2013)

Lapa (2014)

Macabú (2015)
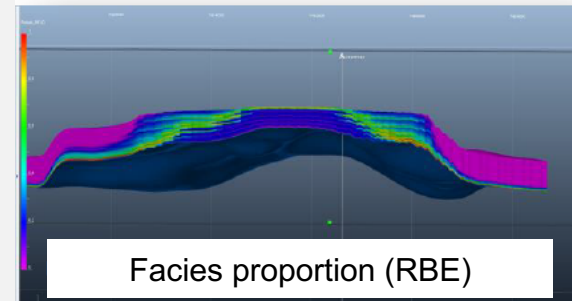
Mero (2016)
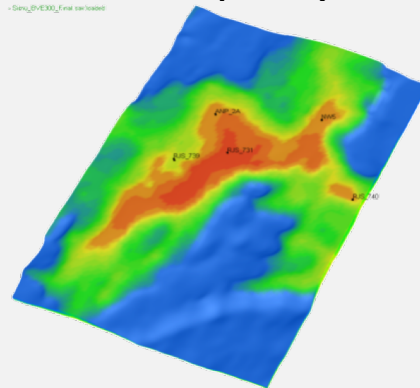
Búzios (2017)
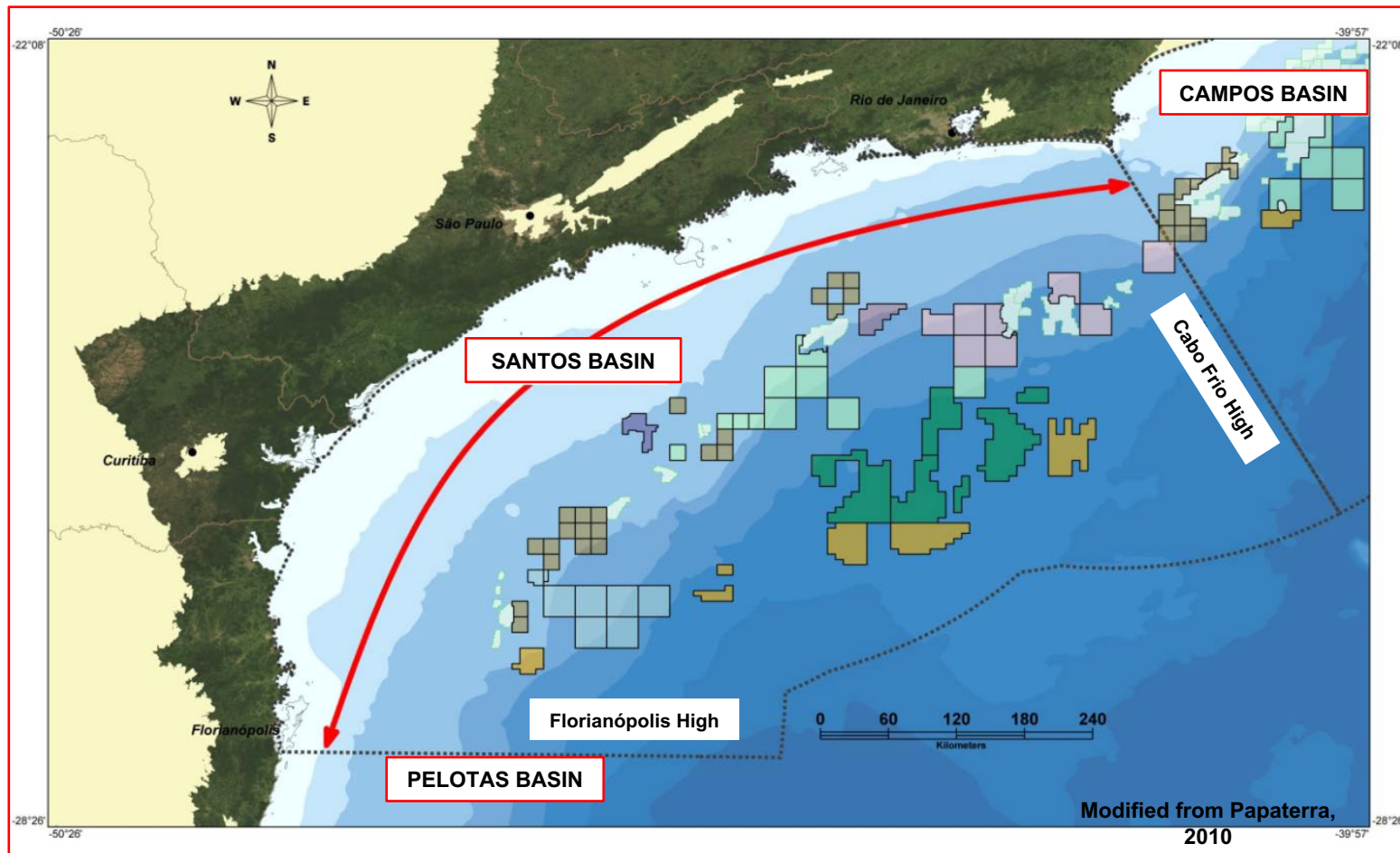
Facies proportion (ETR)

Pão de Açúcar (2018)

Facies proportion (RBE)

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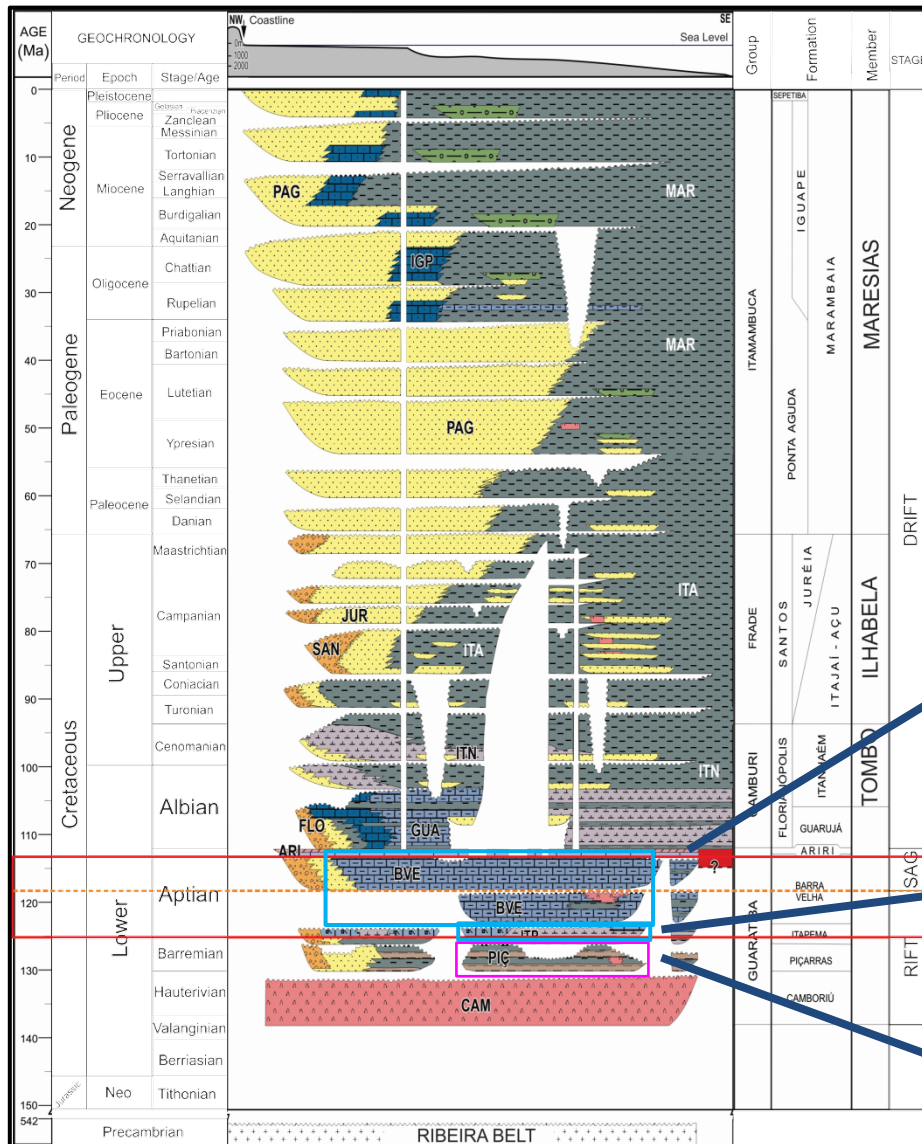# *Case Study*

Location

Area
~350.000 Km²

Santos basin
310 km from coast
Aptian carbonate reservoir

Case Study
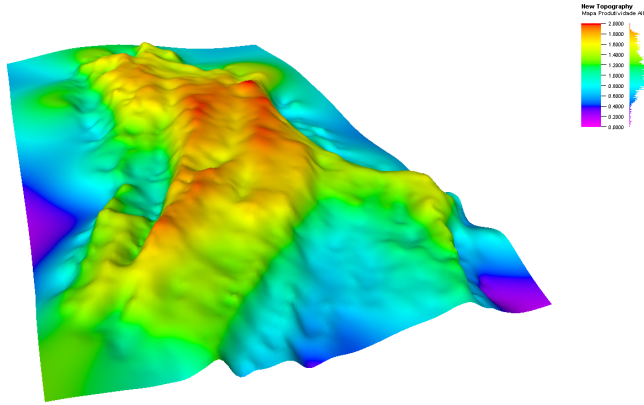
Stratigraphic context

Reservoir:
Barra Velha Fm.

Reservoir:
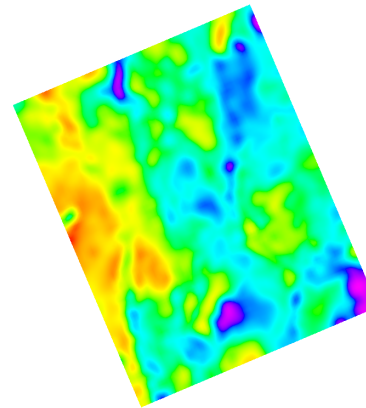Itapema Fm.

Source:
Piçarras Fm.

Modified from Moreira *et al*. (2017)
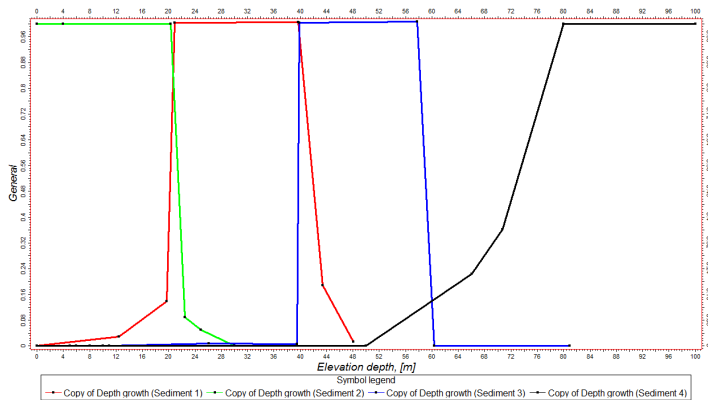
Case Study – Barra Velha Formation

Structurally Restored Base Topography

Subsidence Rate and Carbonate Productivity Maps
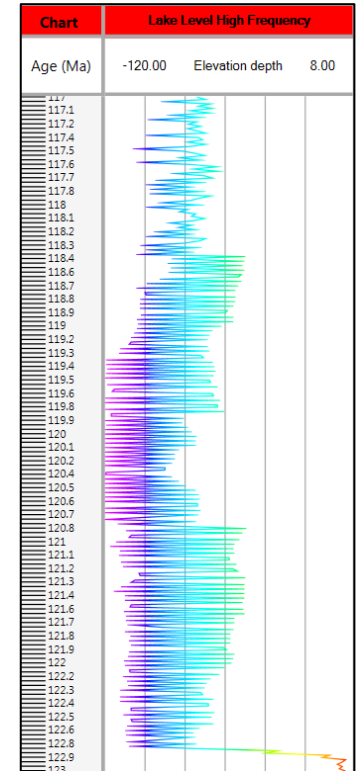
High-Frequency Lake Level Variation

Depth-dependent carbonate growth functions

Sediment Properties
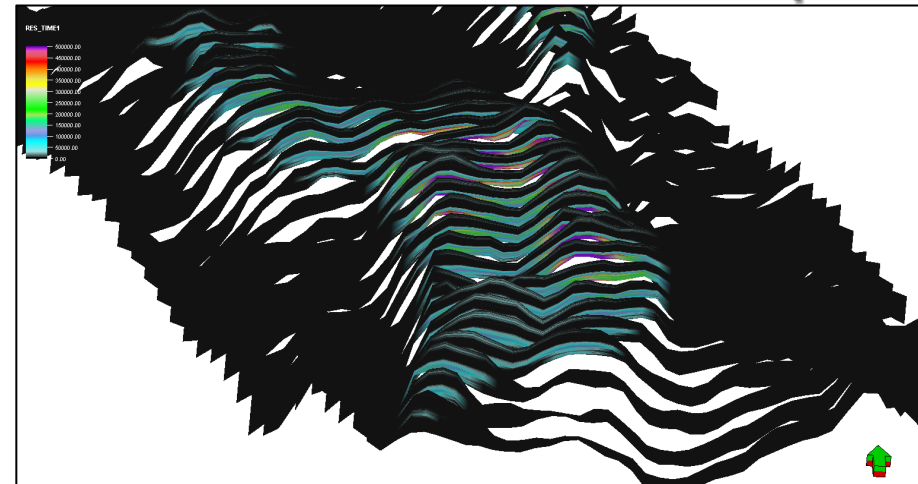
Case Study – Barra Velha Formation
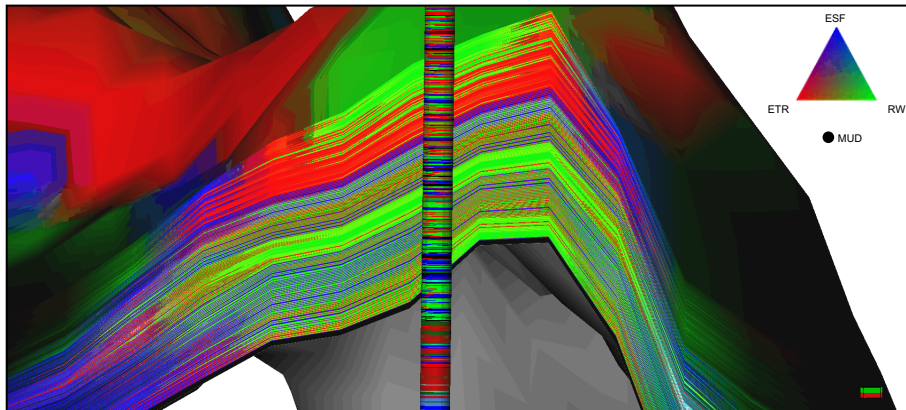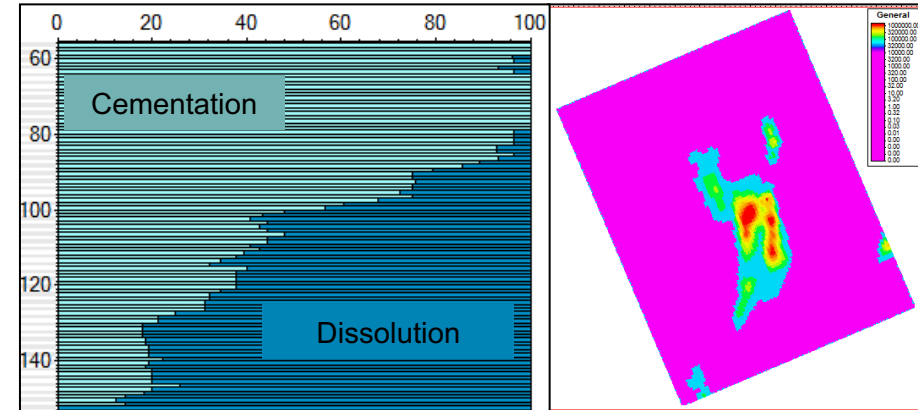
Outputs
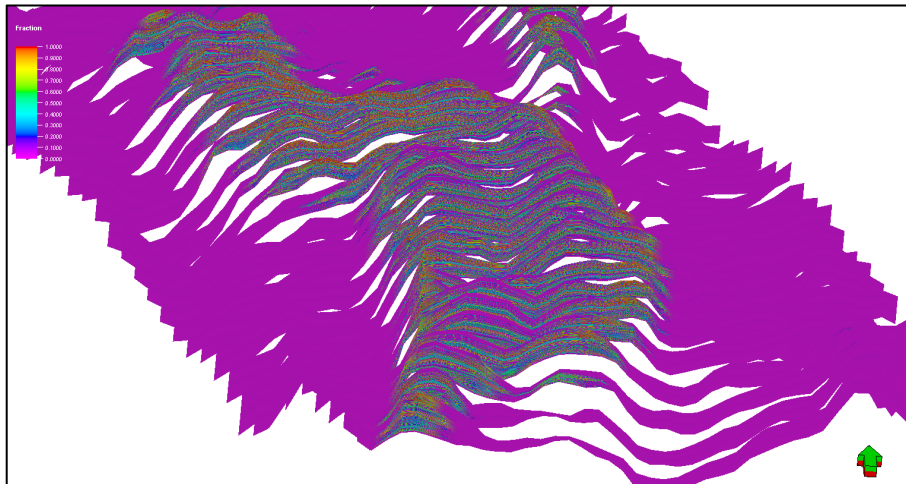
Sediment Proportion Properties

Residence-Time in Diagenetic Zones (i.e. Vadose Zone)
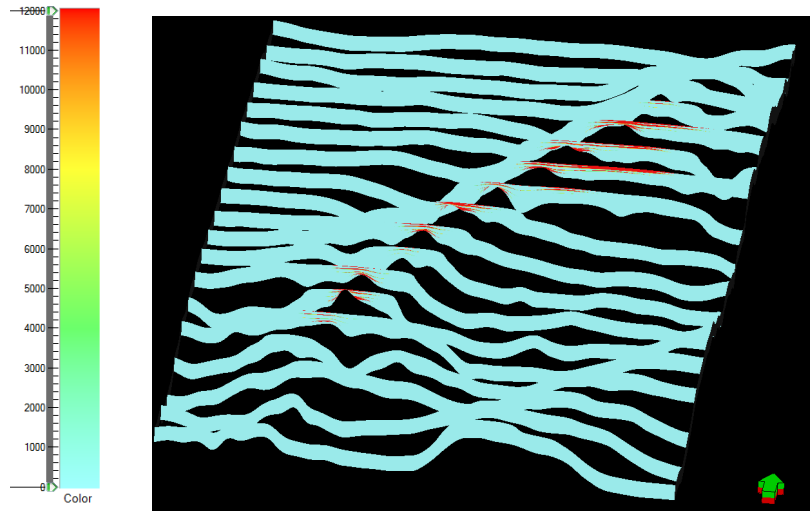

High-Resolution Sediment Distribution

Dissolution Trends and Maps

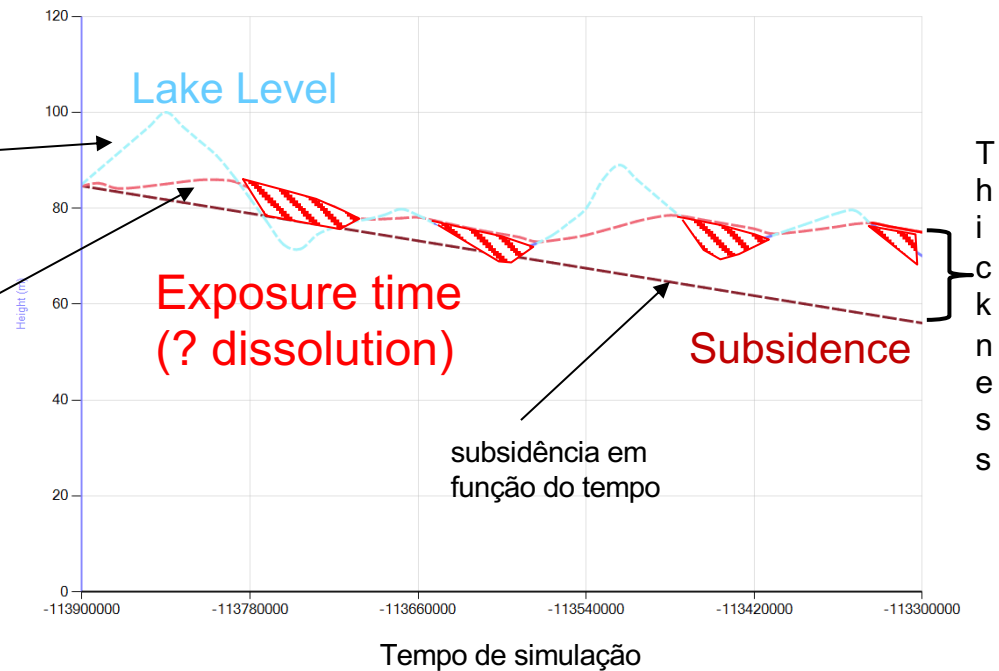**PETROBRAS**

Outputs

+12000a

Vadose Zone

GPM Diagenesis Plot

Lake Level

Variação do nível do lago em função do tempo

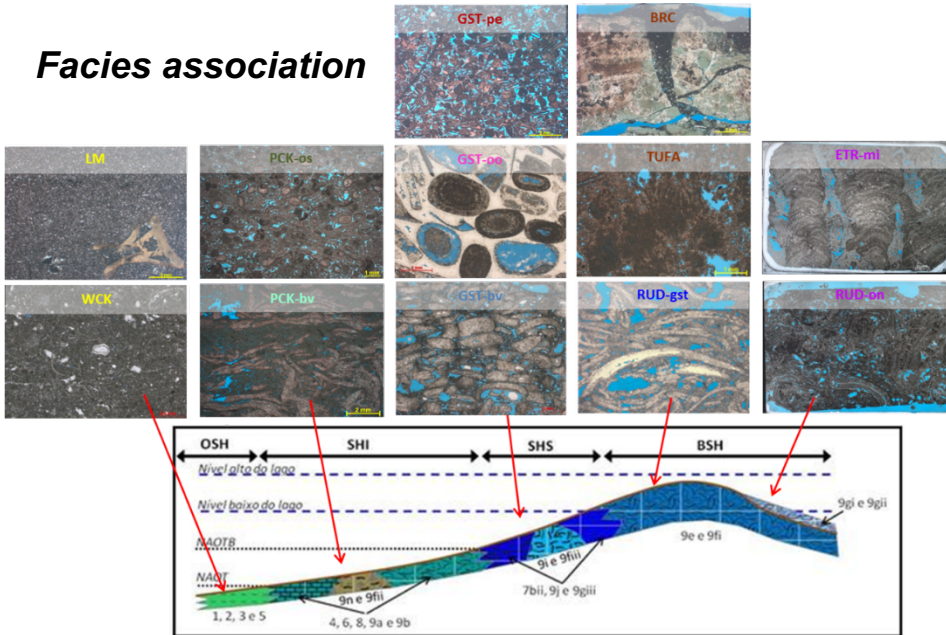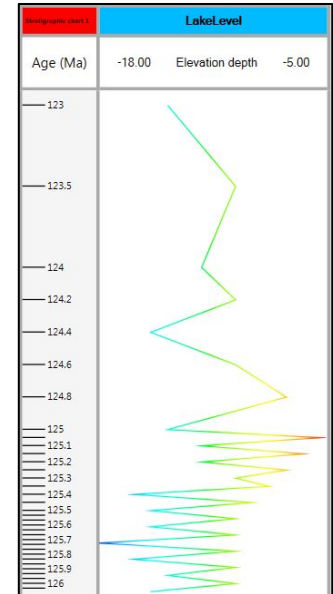Variação da espessura dos sedimentos em função do tempo

Exposure time (? dissolution)

Subsidence

subsidência em função do tempo

Thickness

Tempo de simulação

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Case Study – Itapema Formation

Facies association

Lake level variation

- BSH
- SHS
- SHI
- OFH
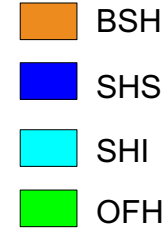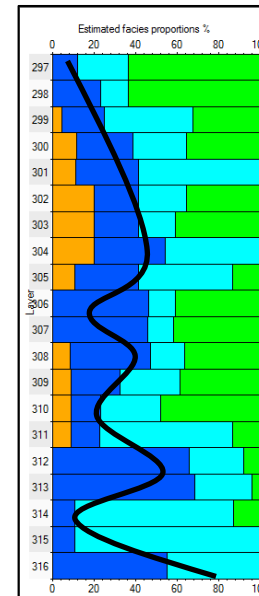
Initial Topography
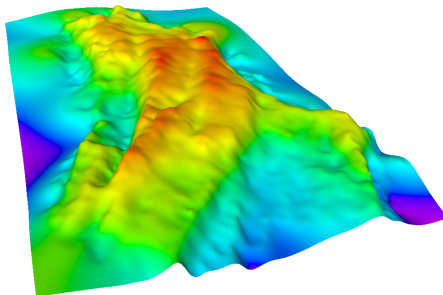
Depth-dependent carbonate growth functions
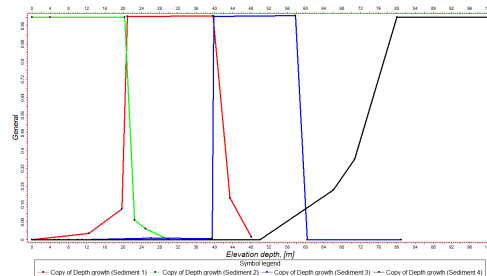
Longshore energy

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Outputs

Facies association

SHI

BSH   SHS

OFH
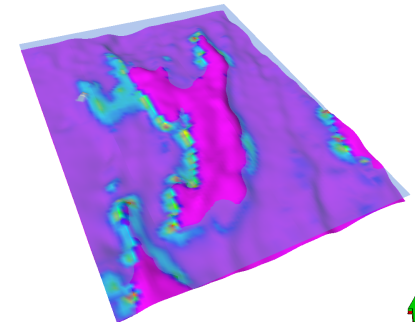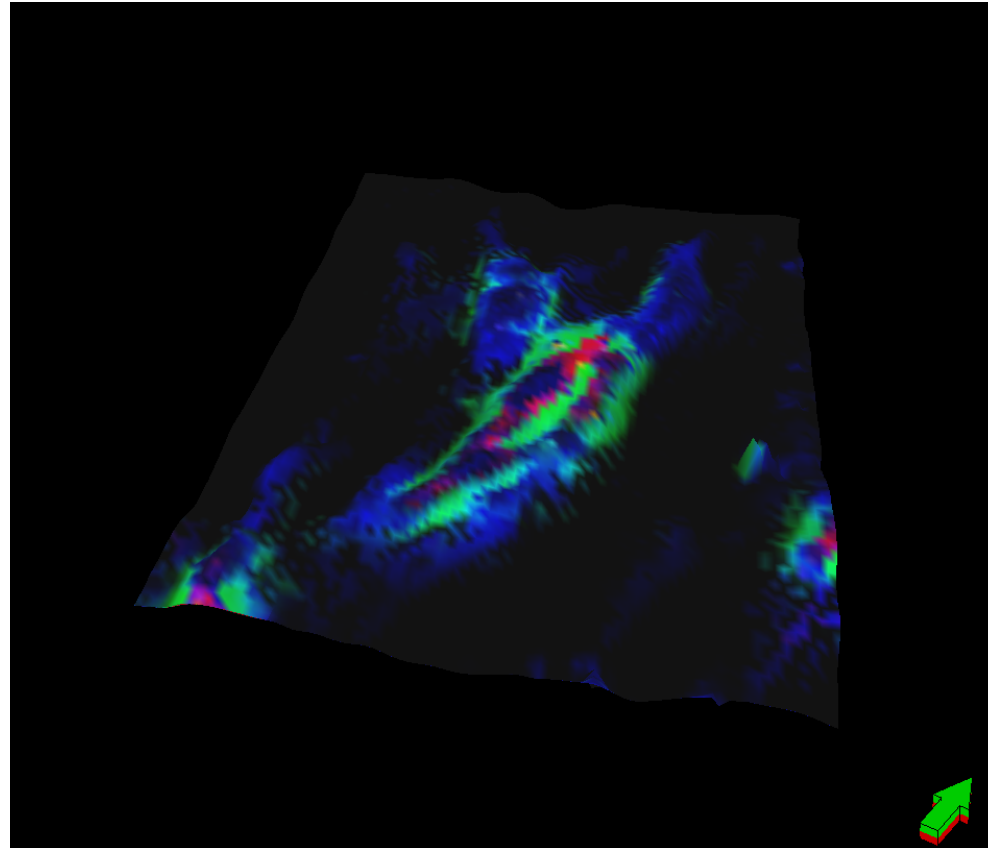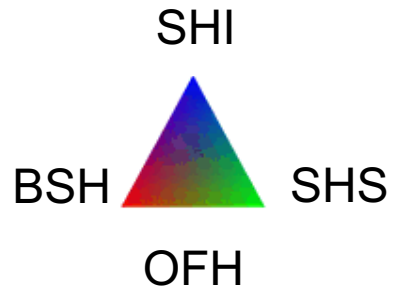
✓ The use of sedimentary process modeling is well diffused at Petrobras, both as a tool for understanding carbonate sedimentation and for generating trends in probabilistic facies models. However, the understanding and <u>incorporation of diagenetic events</u> would make more precise the porosity and permeability estimates of the geological models.

✓ The new generation of geological modeling seeks to <u>construct scenarios of heterogeneities</u> of carbonate reservoirs through <u>the modeling of physical and chemical phenomena</u> that control geological processes, improving the predictive potential of geological models reservoirs, which are now built within a probabilistic approach.

✓ In relation to the new phase of the project, it is expected to guide and clarify the researchers on the main lines of research that should be addressed in diagenetic modeling, such as <u>the problem of dolomitization and silicification</u> in the carbonates reservoirs.

✓ There is a need for optimize <u>the calibration of the process models</u> through techniques of <u>uncertainty analysis</u> (quantitative calibration).

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THANK YOU !