3D source-rock modelling of the Espirito Santo Basin, Brazil

Jarbas Guzzo 1, Ute Mann 2, Maarten Felix 2, Monika Majewska-Bill 2

1 Geochemistry, Petrobras/Cenpes, Rio de Janeiro, Brazil. 2 Basin Modelling, SINTEF Petroleum Research, Trondheim, Norway

guzzo@petrobras.com.br; ute.mann@sintef.no

References

Introduction and background

Geological setting

The study area covers a 110 km x 332 km offshore portion of the Espirito Santo Basin (see location map). The studied section consists of a transgressive sequence that drowned the Albian carbonate platform with deltaic and prodeltaic sediments and canyon-fill turbidite sandstones (Urucutuca Fm.).

This study examines to which extent the local canyon-fill turbidite sediments overprint the possible influence of the Cenomanian/Turonian Anoxic Event on the source rock properties of Top Albian to Top Turonian (99.0 – 89.0 Ma) sediments.

The process-based modelling software OF-Mod 3D - Organic Facies Modelling (Mann and Zweigel, 2008) was used to model Total Organic Carbon (TOC) and Hydrogen Index (HI) distribution throughout the area during the Cenomomanian -Turonian interval.

The data show:
- Distinct terrestrial input in all wells including ESS-86A 'Campos Basin type'
- Terrestrial organic matter confirmed by biomarkers: high hopanes/steranes ratio; high C29 steranes > 45 % and saturated hydrocarbons dominated by long-chain n-alkanes (e.g. ESS-151 well)
- ESS-86 well (distal, Campos Basin type) shows the signature of the C/T anoxic event, higher TOC but only slightly higher HI

Geochemical information available from wells:

Three key wells were selected for comparison between measured and modelled results. These wells were chosen because of
1) their geographical position within the investigated area and
2) data density including biomarker data.

- ESS-40 - proximal, influenced by river input,
- ESS-151 - intermediate distance from shore,
- ESS-86A - distal, “Campos Basin type”.

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Source rock modelling

The organic input into OF-Mod:

Primary productivity – defined in OF-Mod as a function of distance from shore:

- **PP at the coast:** 10 gC/(m²a) to reflect high energy environment, low export production out of the photic/shallow water zone, and transport of deposited organic material away from shore
- **PP in the open ocean:** 60 gC/(m²a)

Preservation variable with time:

- (Deep water) preservation in the model is increased during the time period of the CTAE, to reflect the reduced oxygen conditions to a max. PF of 2% (Bralower & Thierstein, 1984).

### Organic Matter Properties:

OF-Mod calculates the HI from the amount of marine, terrestrial and residual organic matter

- **HI MOC:** 550 (mg HC/gTOC)
- **HI pTOM:** 80 (mg HC/g TOC)
- **HI SOM:** 20 (mg HC/g TOC)

### Terrestrial Organic Matter:

- pTOC constant over time
- High content of residual organic matter (SOC) - the highest value in anoxia period (93.5 – 96Ma)

#### OF-Mod considers

- basin-fill stratigraphy
- organic carbon source fractions: marine/autochthonous and terrestrial/allochthonous
- degradation of the organic matter in the water column and burial efficiency at sea floor
- oxic and anoxic conditions
- calibrated with analytical data from well samples

#### Stratigraphic input into OF-Mod

**Geometry**

- Seismic depth maps: Top Albian (99Ma) and Top Turonian (89Ma)
- 110 x 332 km area of the Espirito Santo Basin

**Age model**

- Modelled interval: 99.0 – 89.0 Ma;
- 40 layers - i.e. 250 ky/layer on average

Reconstructed palaeowater depth

- top Turonian
- top Albian

#### Sea level:

- Eustatic sea level curve of Miller et al. (2005)

#### Sand fraction model created based on:

- V-shale logs data from 29 wells (V-shale calculated from gamma ray), and a background model based on the water depth
- Results in isolated sand patches, which are reminiscent of actual turbidite sands
## Results

### Distal - Campos Basin type well:

<table>
<thead>
<tr>
<th>Particulate Terrestrial Carbon (wt.%)</th>
<th>Soil/Residual Org. Carbon (wt.%)</th>
<th>Marine Org. Carbon (wt.%)</th>
<th>Total Organic Carbon (wt.%)</th>
<th>Hydrogen Index (mg HC/g TOC)</th>
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</thead>
<tbody>
<tr>
<td>Modelled TOC and HI values (colours) compared to measured data (dark blue crosses) vs. depth for proximal (ESS-40) and intermediate (ESS-151) distance to shore wells. In both wells the data indicates a predominance of terrestrial organic matter.</td>
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### Intermediate distance from shore well:

- Total Organic Carbon (wt.%)
- Hydrogen Index (mg HC/g TOC)

### Proximal influenced by the southern river input well:

- Total Organic Carbon (wt.%)
- Hydrogen Index (mg HC/g TOC)

### Maps showing trends of increasing TOC and HI distribution to the deep sea for the entire modelling interval.

- Source Rock Potential before CTAE
  - Age: 99 – 98.75 Ma
- Source Rock Potential in CTAE
  - Age: 94.25 – 94 Ma

### W-E cross-sections showing the influence of the anoxic enhanced TOC values but only slightly enhanced HI values. The wells are indicated by drifting symbol.

### Conclusions

- The model results in a good match between modelled and measured TOC and HI values.
- Increased preservation has been modelled during the CTAE to match the high TOC values in well ESS-86A and to produce a slight increase in HI.
- Influence of the turbiditic infill decreases and influence of the CTAE increases from NW to SE.
- CTAE event has minor impact in near shore area but more prominent in the distal area.