Basin modelling as a predictive tool for potential zones of chimney presence

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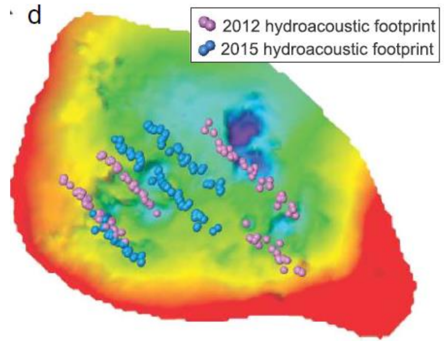
Focused Fluid Flow and Chimney Phenomena

- Focused fluid-flow is associated with excess pore-fluid pressure which can be attributed to varying processes:
  - rapid sediment loading,
  - uplift and erosion
  - dissociation of gas hydrate
  - polygonal faulting
  - leakage from source and reservoir

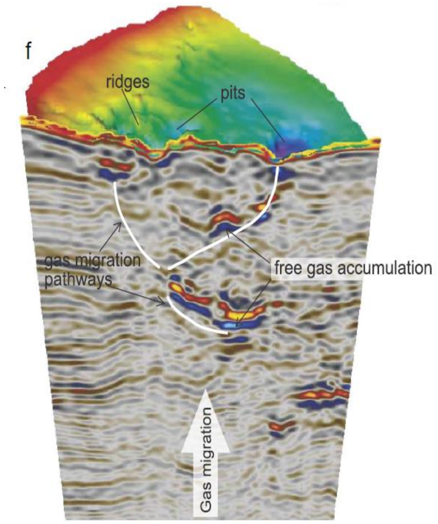


- While the origin of focused fluid flow is still under debate, its practical significance is two-fold:
  - It is an indicator of hydrocarbon presence,
  - It is a potential location CO2 leakage pathway.

The aim of this work is to use basin modelling to identify precursors of chimney formation in the geological history.

In this work:

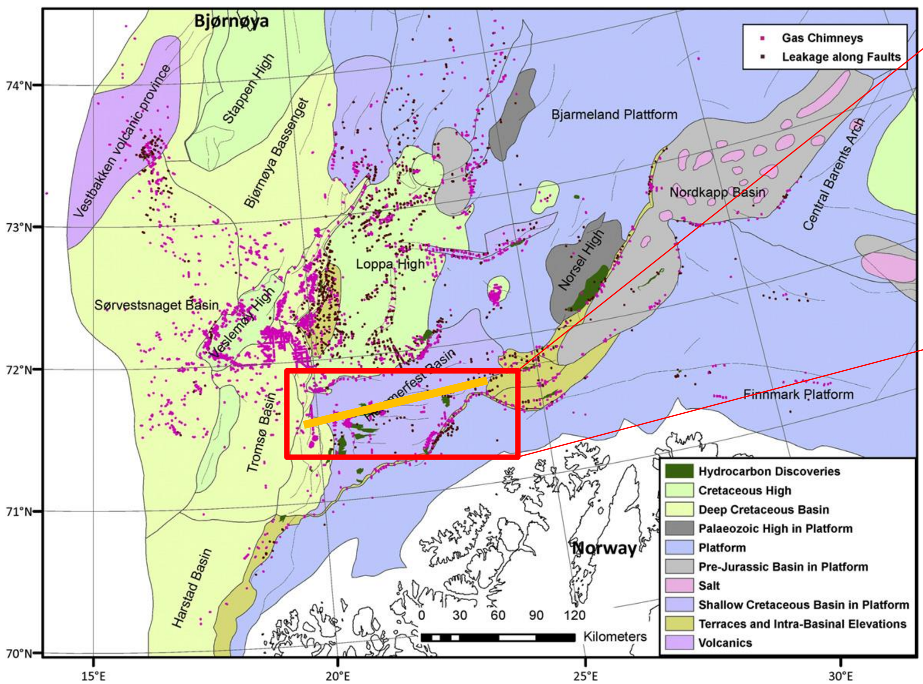
- High-quality 3D seismic data are used to analyze the location of hydrocarbon leakage in the Snøhvit Field, Southwestern Barents Sea
- Two different basin modelling approaches complement each other



(Panieri et al., 2017)

Dataset

Distribution of gas chimneys and leakage in SW Barents Sea

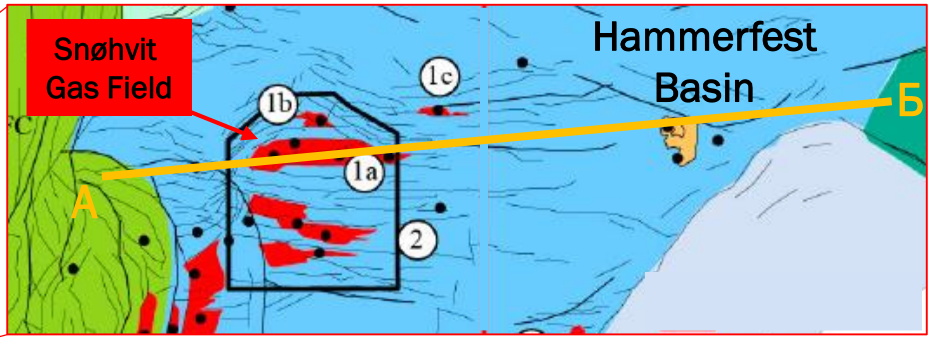


(Vadakkepuliyambatta et al, 2013)

location of modelled geological section

location of gas chimney

Structural map of the SW Barents Sea

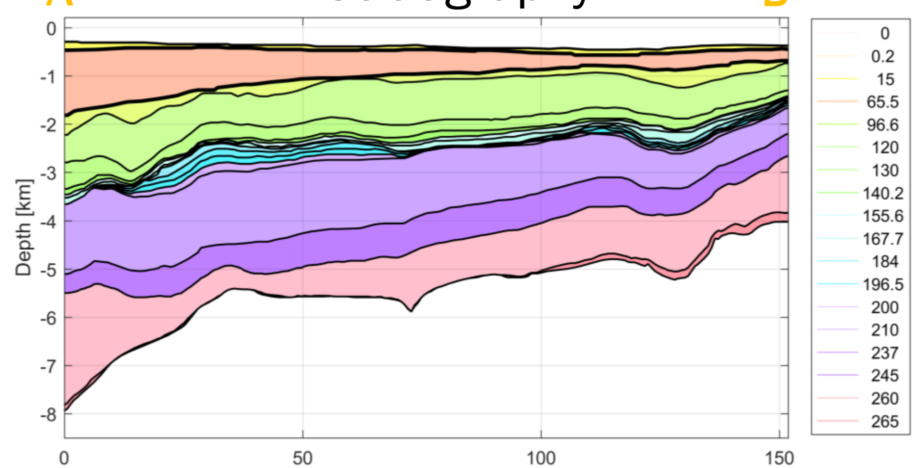


discovered gas fields

(Ostanin et al., 2017)

Stratigraphy

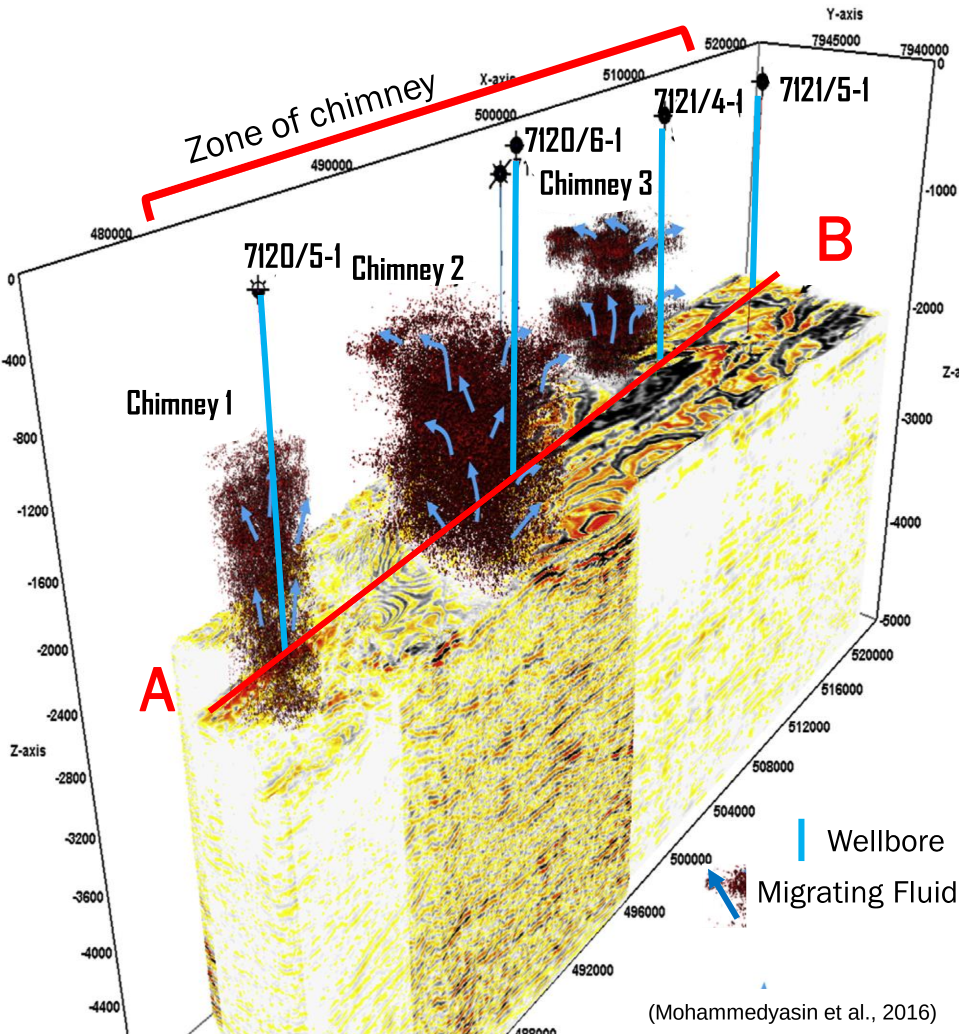
A Б



(*based on* Ostanin et al., 2017)

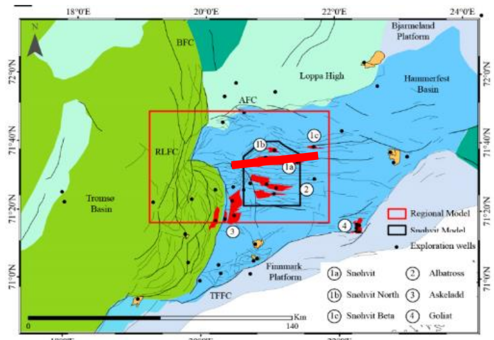
Chimney Location

In Probe of Seismic Cube



(Mohammedyasin et al., 2016)

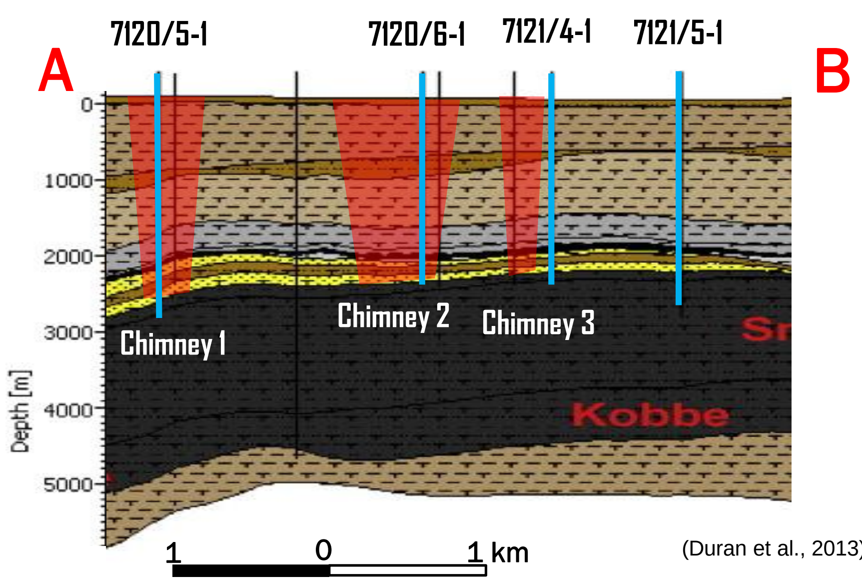
On Base Map



(Ostanin et al., 2017)

location of geological section

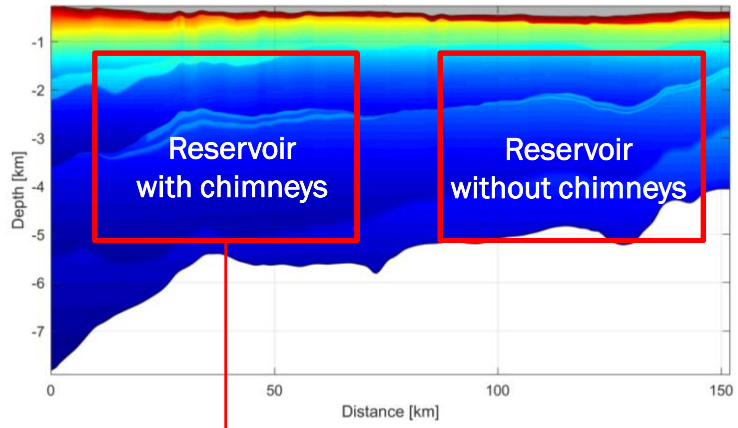
In Geological Section



(Duran et al., 2013)

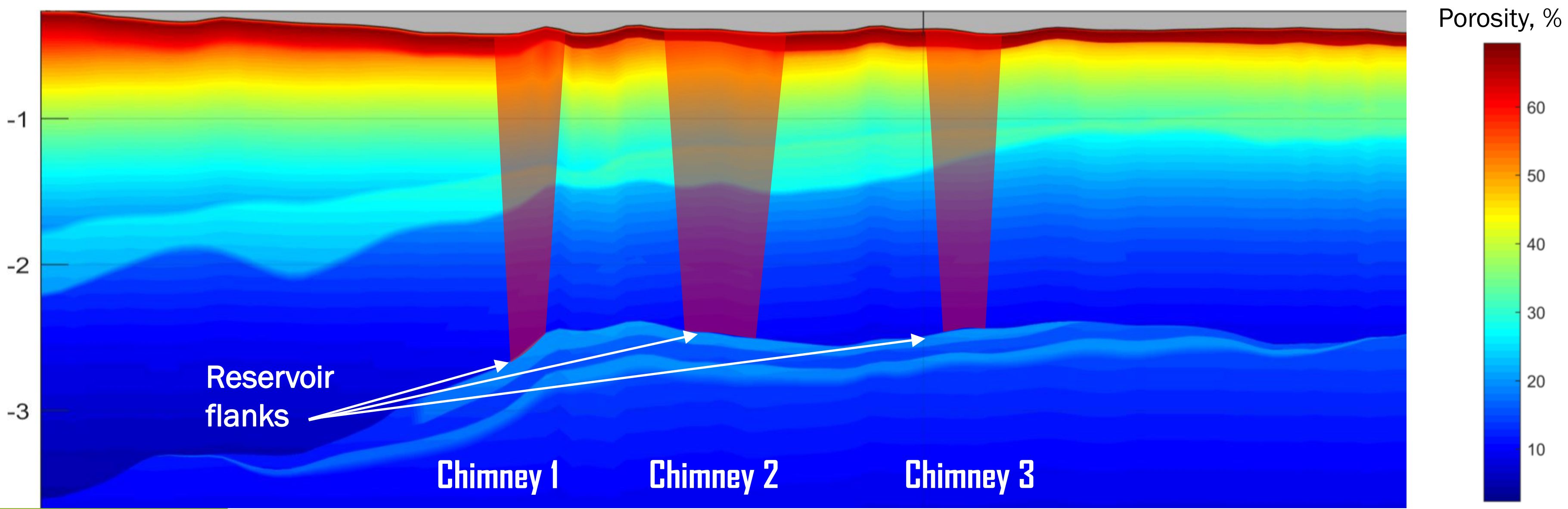
Basin Model I: Porosity modelling with Tecmod2D cont.

Plot of Porosity distribution

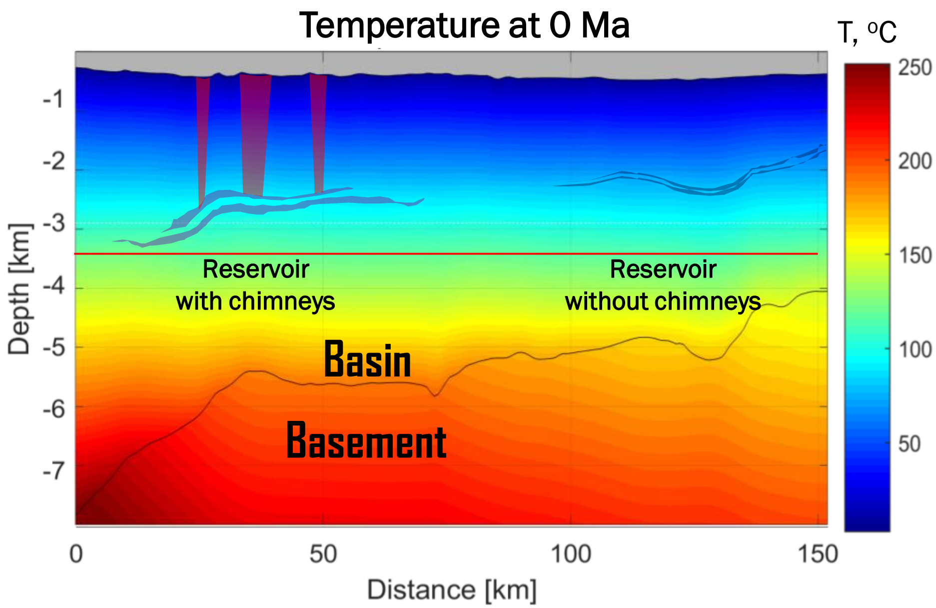


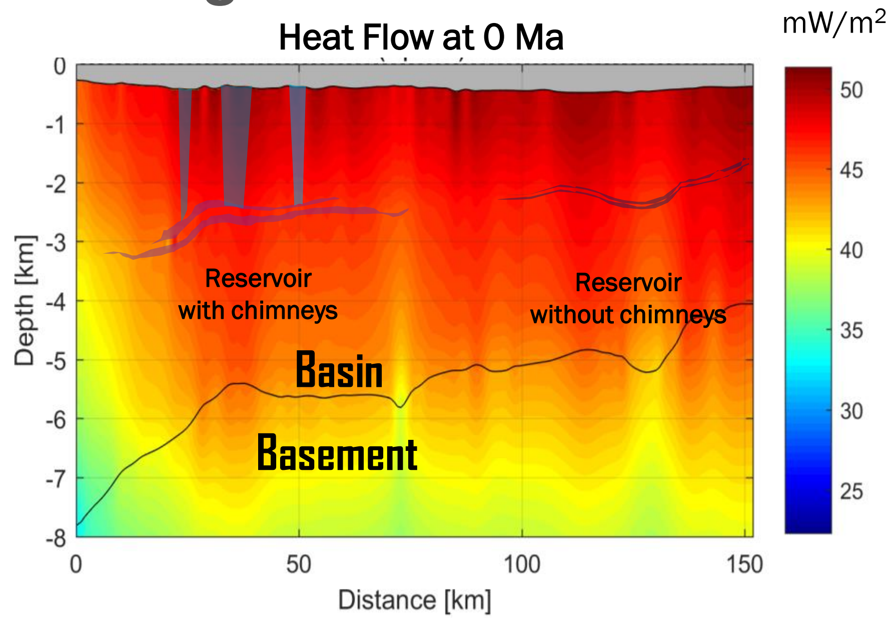
- Gas chimneys tend to reservoir thickened flanks, with the best petrophysical characteristics:
  - the highest porosity
  - maximum vertical thickness
- This might indicate the role of gas/liquid dynamics in chimney formation

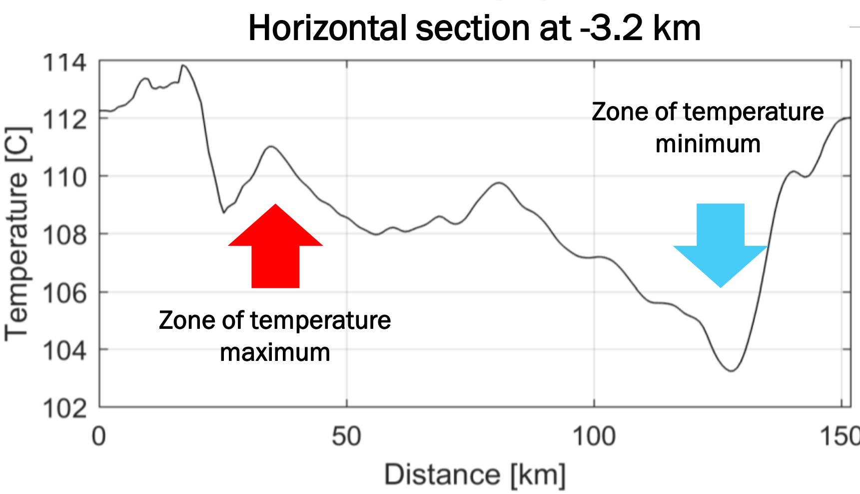
Focus on Reservoir Zone with Chimney

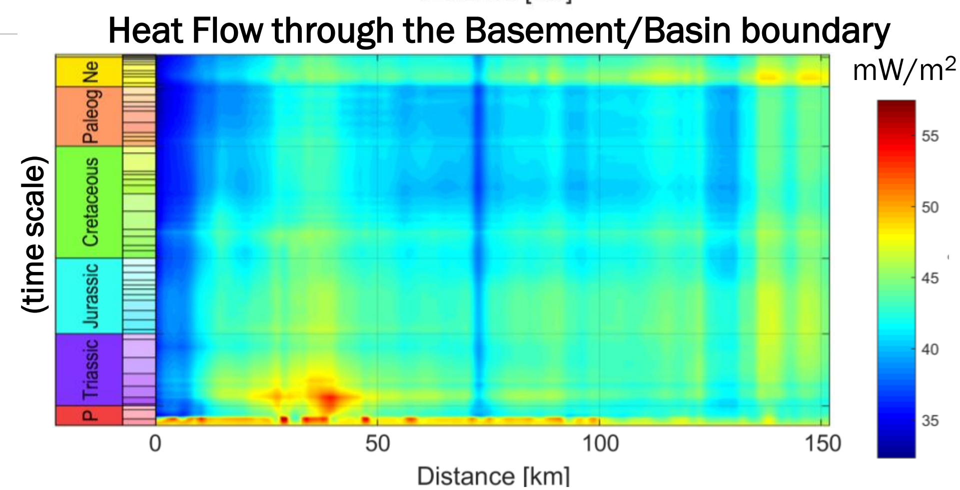


Basin Model I: Temperature modelling with Tecmod2D cont.





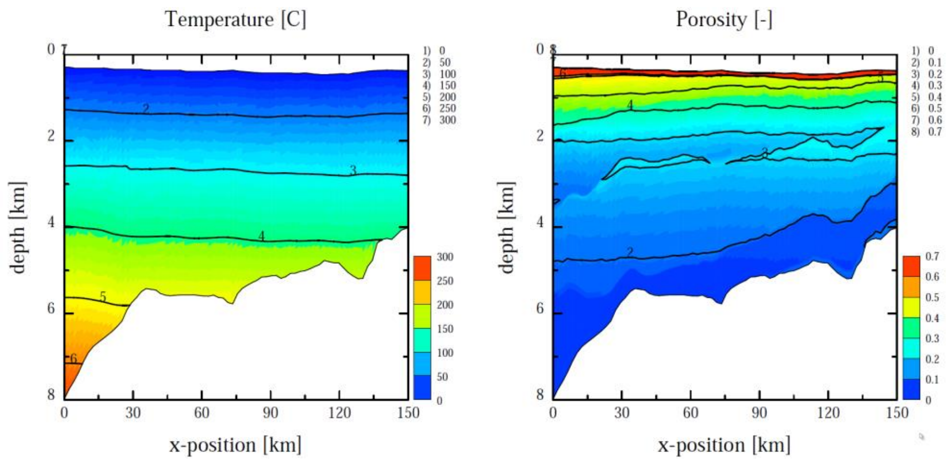




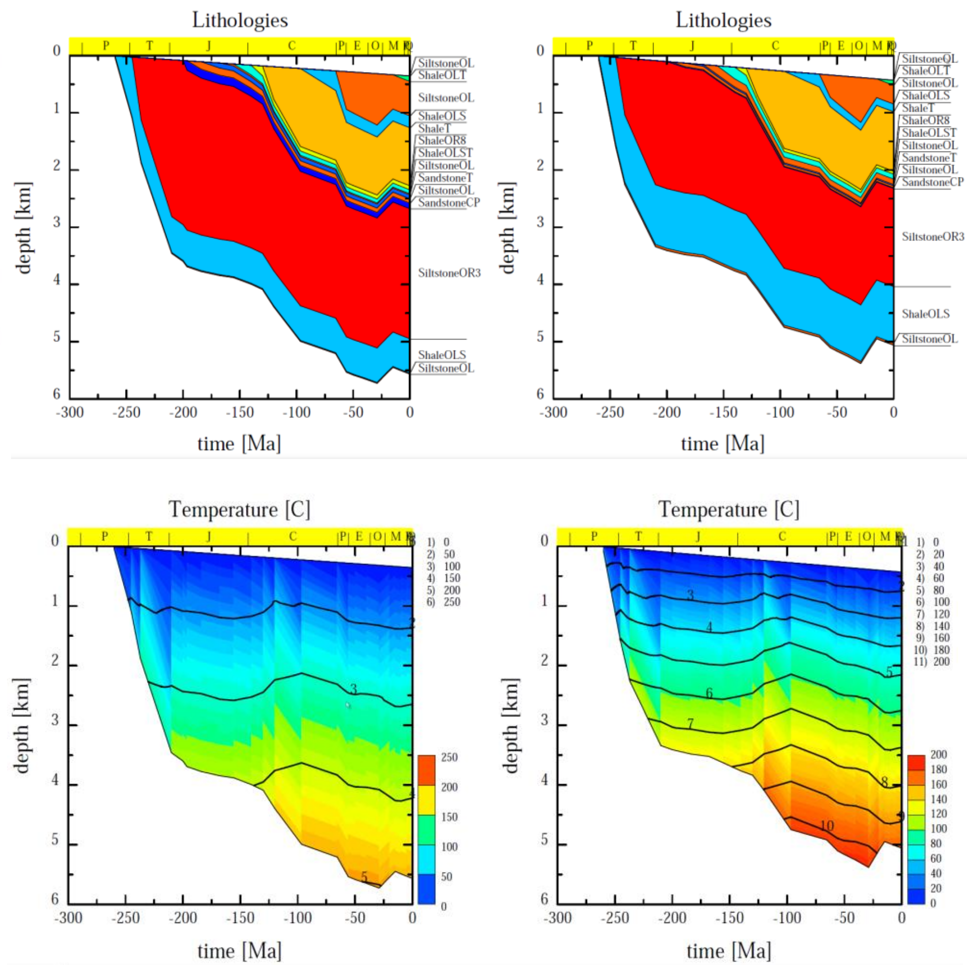
- In reservoir area with chimneys we observe the local maximum of heat flow density in temporary and today, and hence temperature values, that contributes the source rock formations to produce more hydrocarbons and increase the overpressure within the overlaying reservoir in the most buried part od the basin
- Area without chimney locates in less conducive thermic conditions for their formation

Basin Model II: Temperature modelling with Bas14

Present day temperature and porosity



Burial histories at x=50km and x=100km

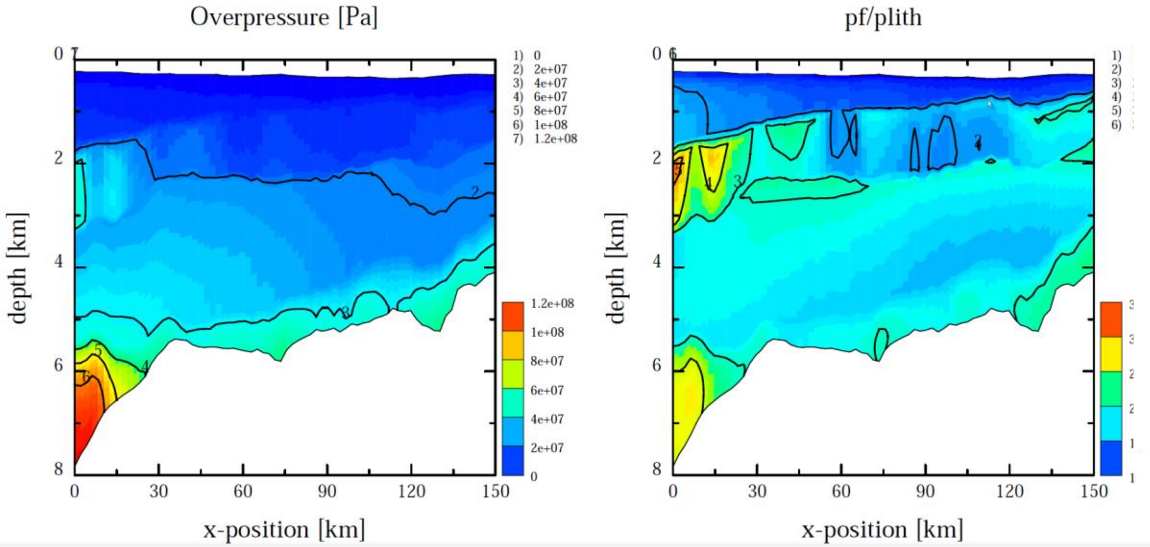


- The basin appears to be at maximal burial towards Mid Oligocene before the basin was uplifted and eroded. Thermal maximum coincides with maximum burial.
- Therefore, rates of hydrocarbon generation reach maximum during Oligocene.
- Quartz cementation of the sandstone units also reaches maximum rates during Oligocene.

- The hiatus during Tertiary is uncertain. Different representations of the hiatus can produce quite different thermal maximum during Mid Oligocene.

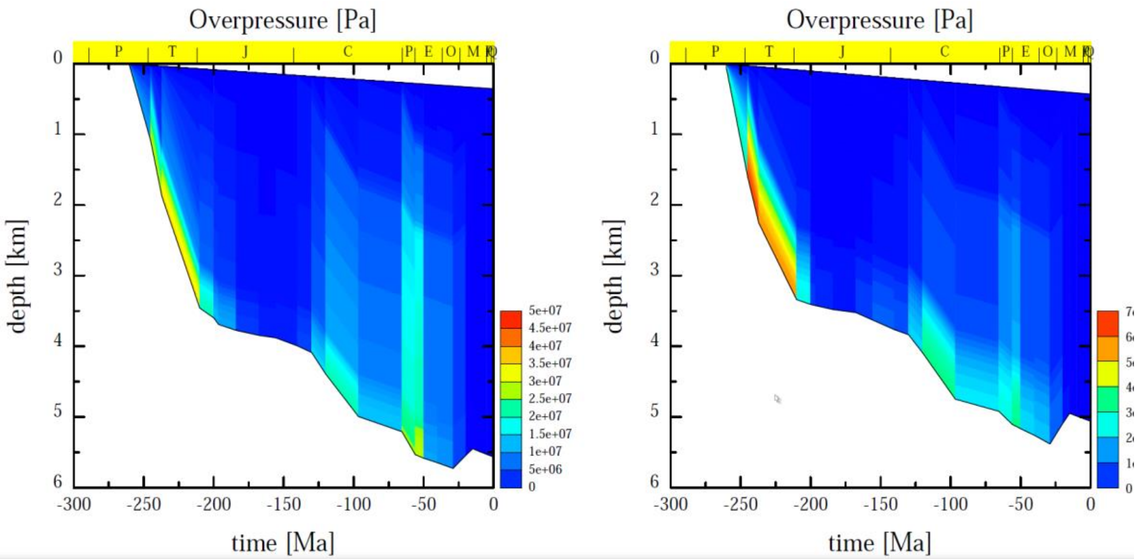
Basin Model II: Overpressure modelling with Bas14

Overpressure at 56 Ma



- Compaction is modelled by assuming porosity as a function of depth
- Only a small fraction of the porosity that is lost during compaction is recovered during unloading by erosion
- Maximum overpressure build-up takes place when burial rates are at maximum
- Maximum burial rates are during Triassic, Early Jurassic and during Paleocene.

Overpressure histories at x=50km and x=100km



- Burial rates during the Tertiary hiatus are uncertain
- The timing of maximum overpressure build-up is therefore uncertain during the Tertiary.
- Erosion and unloading during Eocene and Miocene may have removed high overpressure from before the erosion process
- Conditions for chimney formation appear to be prior to the last erosion process.
- We have not studied pressure build-up by glacial loading which could also be a cause for chimney formation.

Conclusion

- Detailed seismic analysis facilitated the location of chimneys on our basin model
- Petrophysical and geological characteristics of the reservoir are described in the location of chimneys
- Two examples of the neighbor reservoir are shown and characterized by the presence or absence of chimneys, that justified by the different thermobaric history of the underlying source rock formations
- This explanation are proved by two different approaches of basin modelling
- An additional study is needed of the effects of glaciation periods on the formation of over-solders and winter trees