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## **Geological Modelling of the Offshore Orange Basin, West Coast of South Africa (2<sup>nd</sup> Edition)\***

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### **Abstract**

The Orange Basin covers an area of roughly 130,000 square kilometers relevant to the 200 m isobath (Gerrard and Smith, 1982) and has roughly one well drilled for every 4000 square kilometers. The basin has proven hydrocarbon reserves and potential for further discoveries.

The study area is located within South African exploration license blocks 3A/4A and 3B/4B and covers a region of roughly 97 km by 150 km. The study aims at understanding the geological processes responsible for the formation of the Orange Basin with a focus on the evolution of source rocks maturity. The Petrel software was used for seismic interpretation and well correlation and PetroMod (IES, Version 10) for basin modelling and assessing source rock maturity.

Preliminary seismic interpretation of the post Hauterivian succession shows a relative thickening of the sedimentary sequence westward as the basin evolves from the early drift to complete drift phase. Initial results from petroleum system modelling indicate that the Barremian- early Aptian source rock is at present over mature and producing mostly gas in the shelf areas, whereas potential for oil is most likely still present in the deep water area of the basin where Tertiary progradation has resulted in renewed petroleum generation. The younger Cenomanian-Turonian source rock shows a lower transformation ratio than the older source rocks and modelling indicates that the source rock is mainly producing oil. Additional modelling is needed to further constrain the model results.

# GEOLOGICAL MODELLING OF THE OFFSHORE ORANGE BASIN

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# Contents

- Introduction
- Aims and Objectives
- Research material and methods
- Results
- Points of Discussion
- Conclusions

## INTRODUCTION

- The Orange Basin.
- Southernmost West African basin & largest and youngest South African offshore basin.
- Covers an area of roughly 130 000 square kilometers relevant to the 200m isobath (Gerrard & Smith, 1982)
- Underexplored with approximately one well drilled for every 4000 square kilometers.
- Despite being under explored the basin has proven hydrocarbon reserves and potential for further discoveries.
- Study investigates the source rock potential of the basin using seismic interpretation, well correlation and 3D basin modelling.



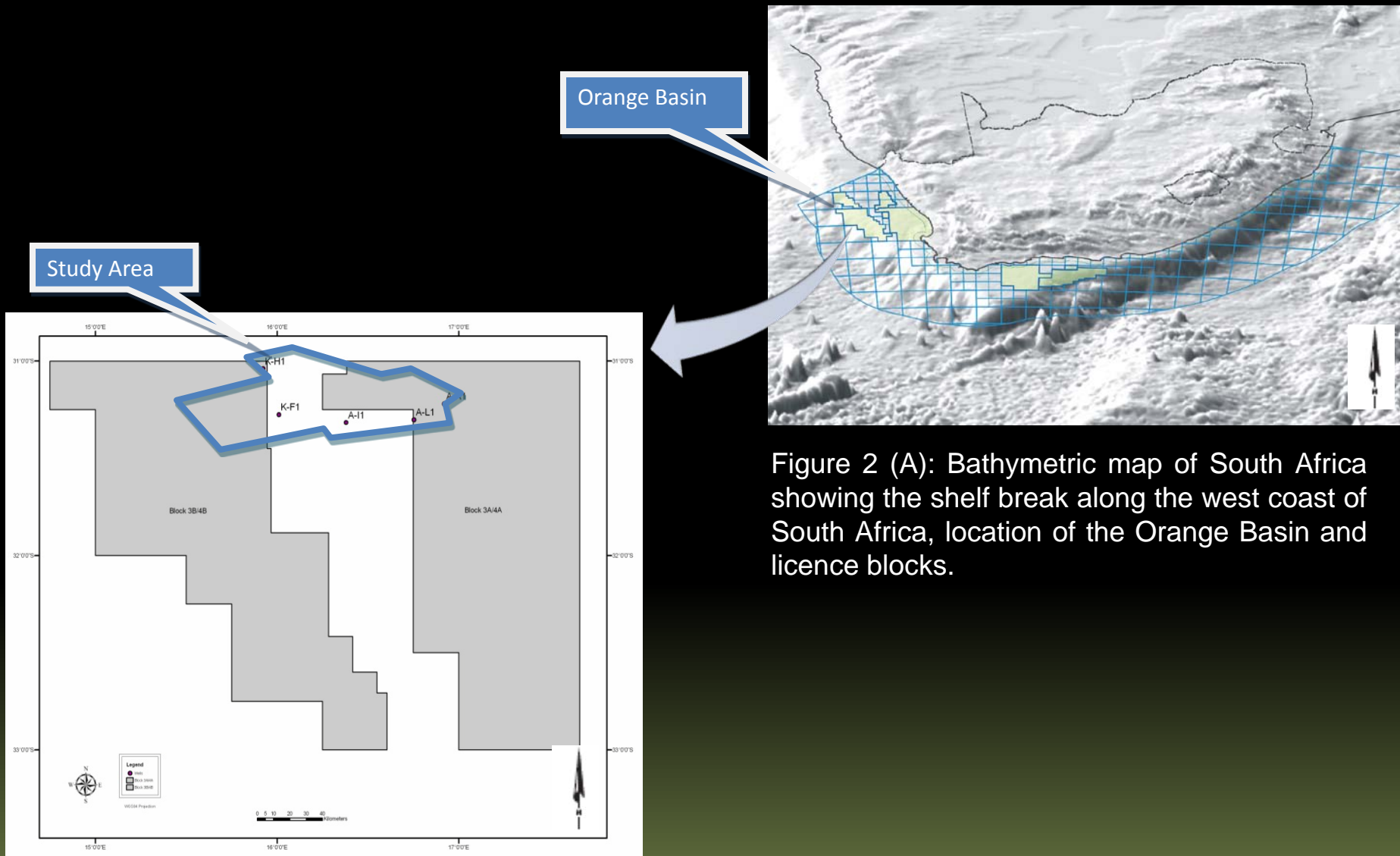


Figure 2 (B): Licence blocks, study area, well locations.

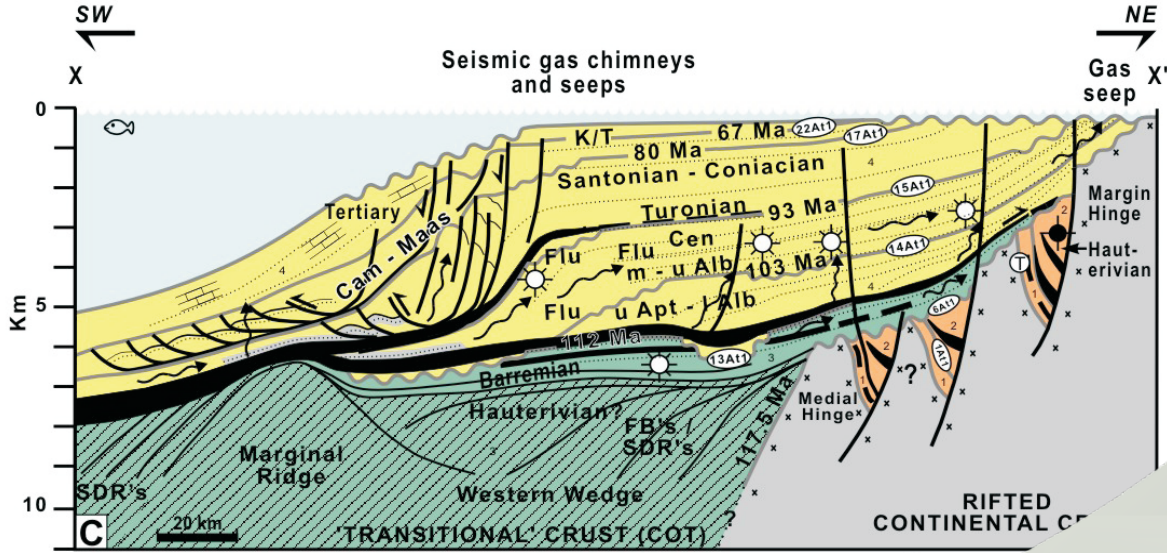
- Inkaba Ye Africa: joint initiative between the German and South African geological science communities.
- Aims at understanding various earth systems on different scales.
- Consists of 12 projects divided into three themes namely Heart of Africa, Margins of Africa and Living Africa.



## Aims and Objectives

Aims at understanding the various geological processes responsible for the formation of the Orange Basin with a FOCUS on the evolution of source rocks and their present day maturity.

Petrel software for seismic interpretation and well correlation and PetroMod (IES, Version 10) for basin modelling and assessing source rock maturity.



## Rifting

- Rifting occurred along the west coast during the late Jurassic (Munting 1993)
- Divergent passive margin with underlying grabens and half grabens.
- Rifting continued until the late Hauterivian marked by 6At1 unconformity (Munting 1993)

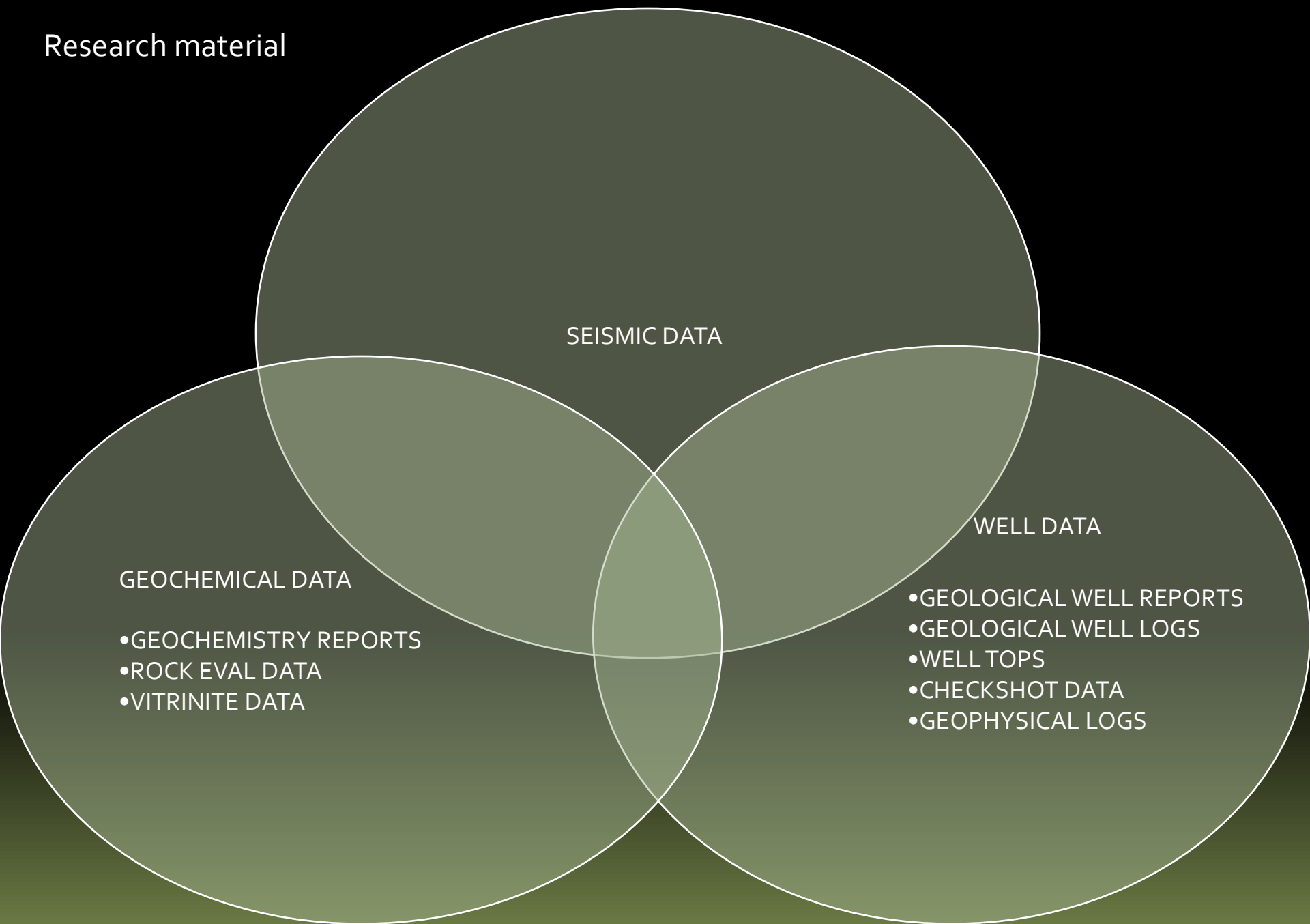
## Early Drift

- Between Hauterivian (130 Ma) and Mid Aptian (100 Ma)
- Corresponding to unconformities 6At1 and 13At1
- Succession classified as intermediate succession.
- Barremian-early Aptian source.

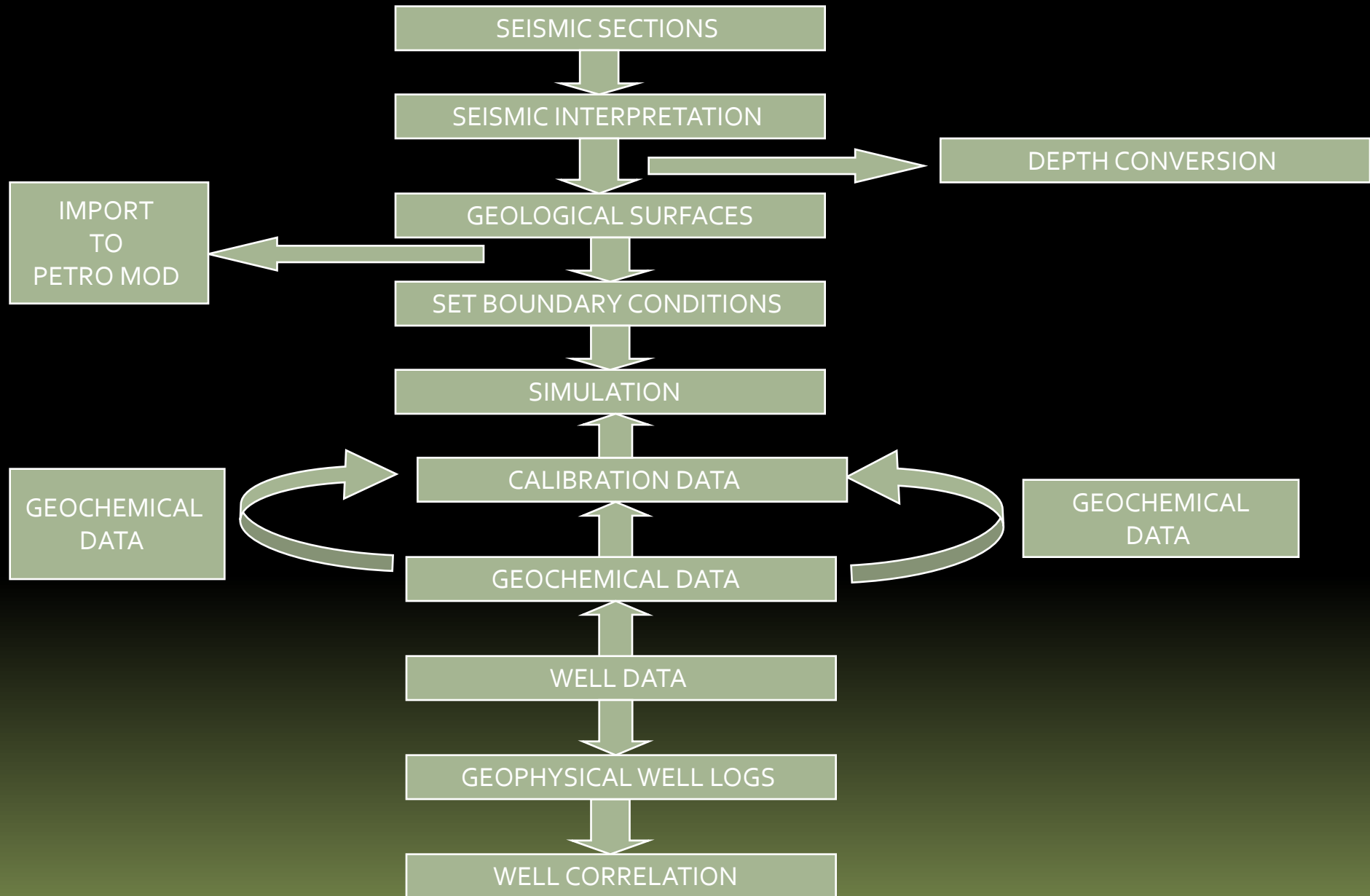
## Drifting

- Onset of full drift signified by 13At1 unconformity
- Sequence described as thick sedimentary wedge
- Contain large growth, slump structures and associated toe thrusts along shelf edge
- Source rock association with global Cenomanian-Turonian anoxic event.

# Research material



# Research methods



# RESULTS

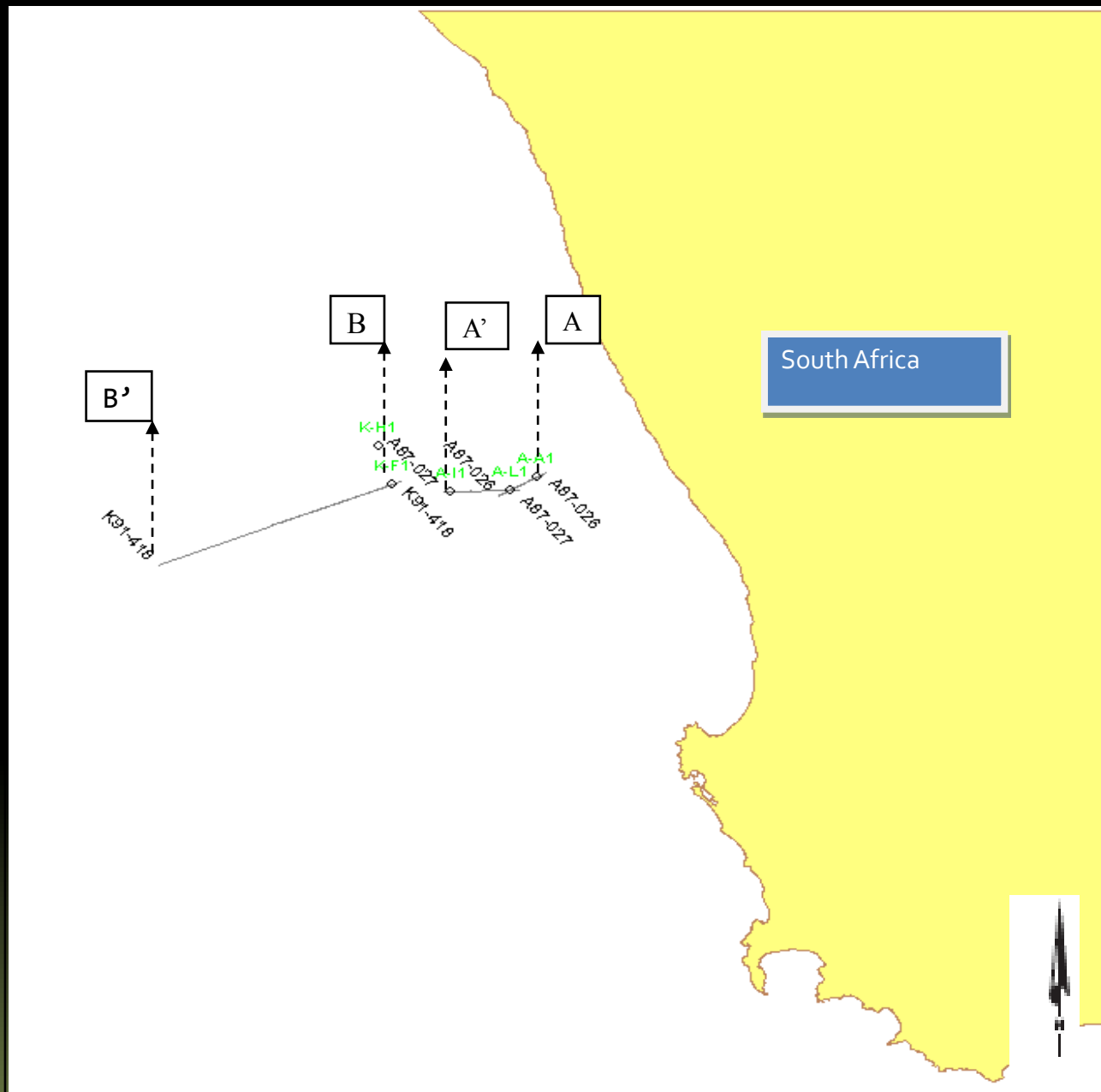
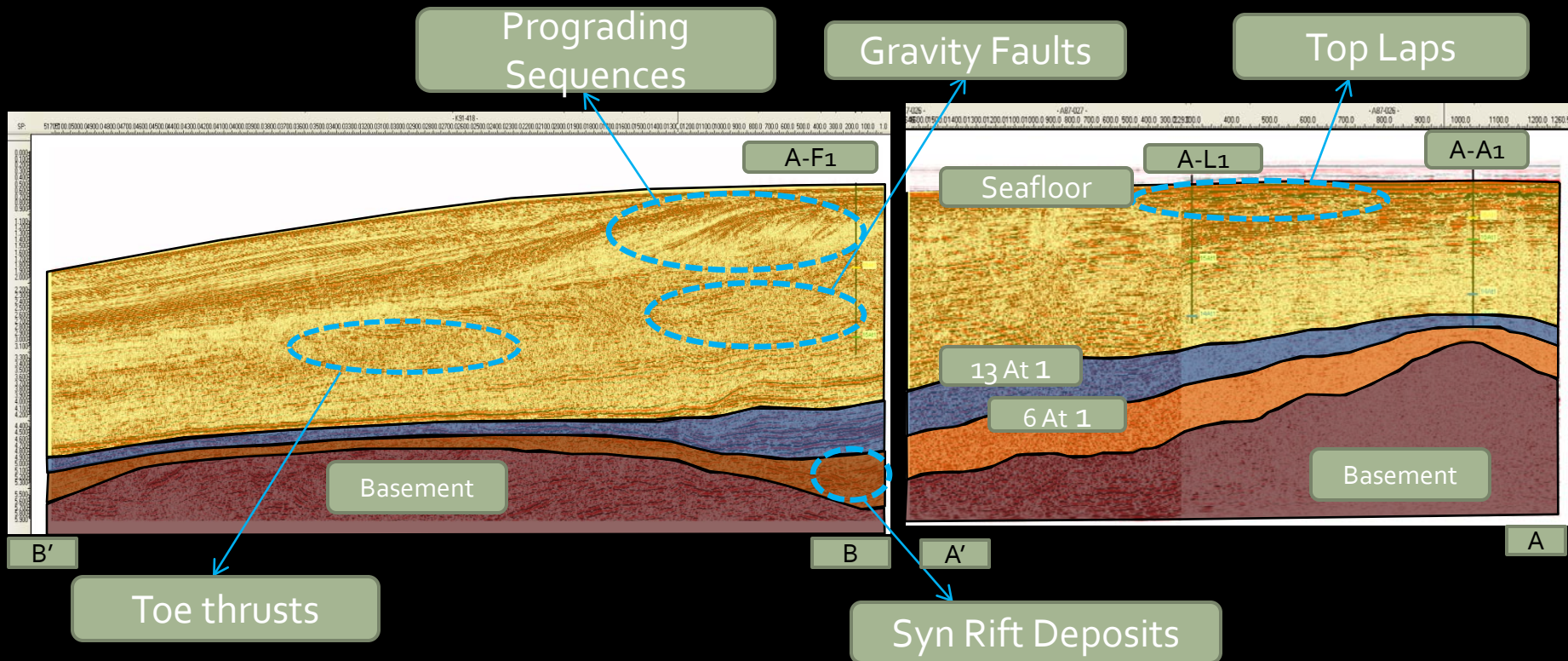


Figure 3: Location of the profile lines



### Preliminary results of seismic interpretation

- Post-Hauterivian succession indicates a thickening of the sedimentary sequence westward
- Early transitional drift succession bounded by two major unconformities 6At1 (late Hauterivian drift-onset unconformity) and 13At1 (early Aptian full drift onset unconformity) (Muntingh, 1993).
- Generally transgressive, indicative of the lower sedimentation rates in the distal part of the basin and the landward building of the sequence.
- Drift succession overall prograding sequence, postulated to attain a maximum thickness of approximately 8000 meters proposed by van der Spuy et al, (2003).

# Source rock maturity modelling

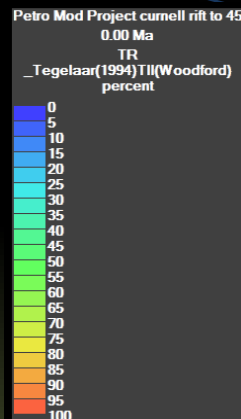
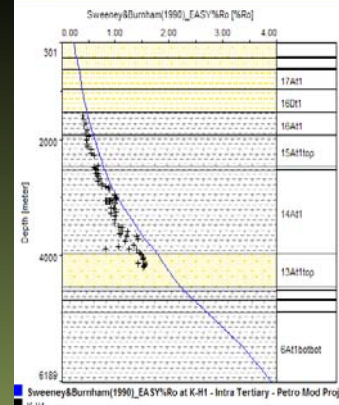
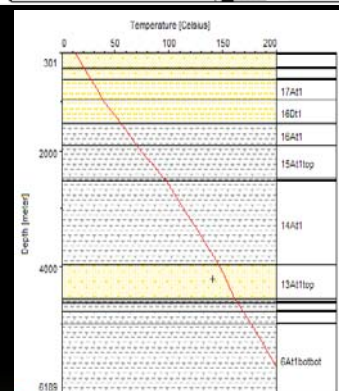
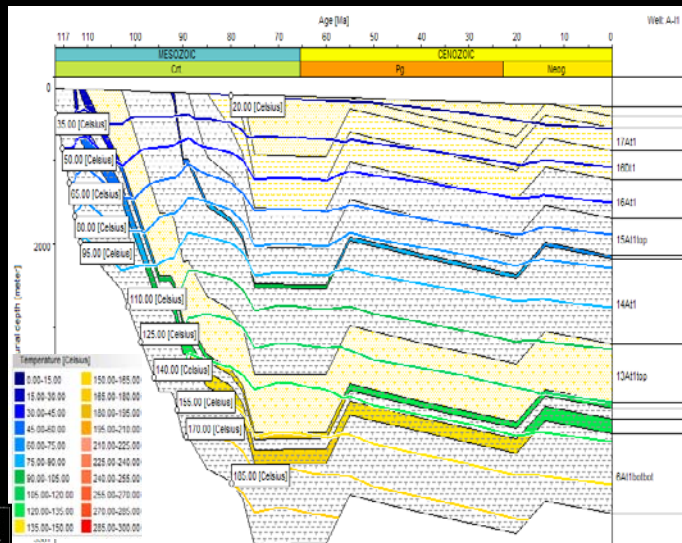
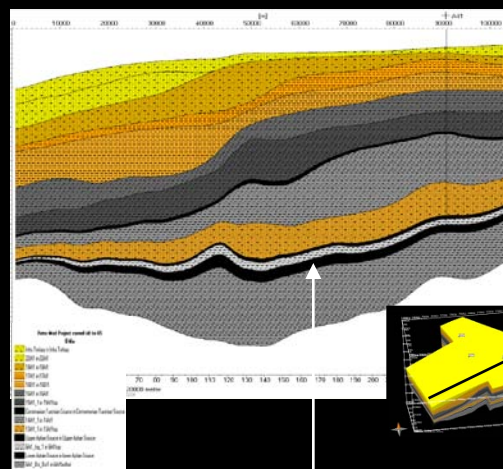
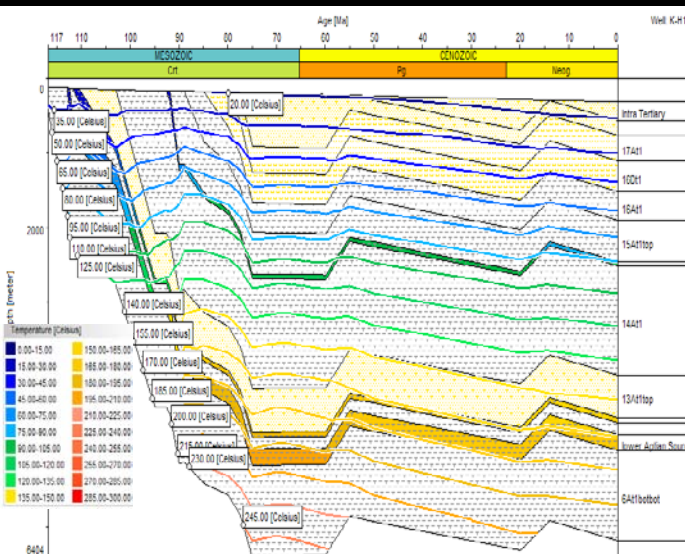
Two main source rock units are known to occur in the Orange Basin

- Late Hauterivian synrift source rock
- Barremian-early Aptian source rock
- Indication of a regionally developed Cenomanian-Turonian source rock (Barton, et al 1993).

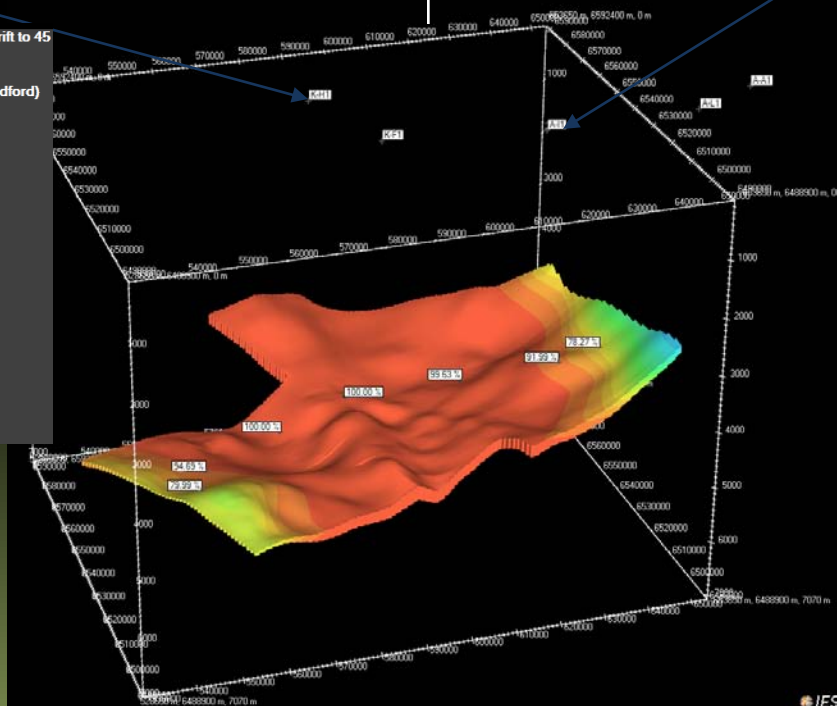
Each related to one of the three main phases of development in the Orange Basin

- Rift
- Early drift
- Complete drift phases

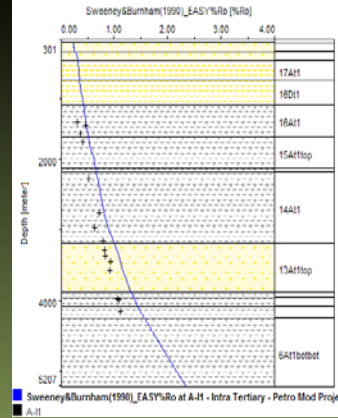
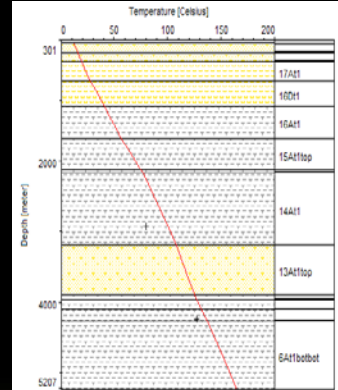
The Barremian-early Aptian source rock and the postulated Cenomanian-Turonian source rock will be investigated in the study.

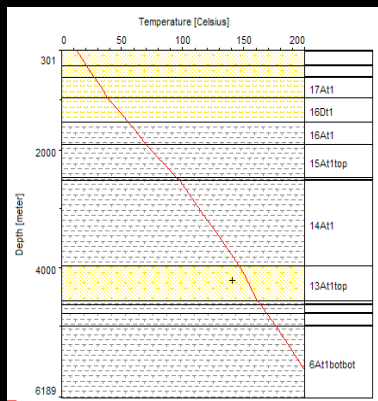


K-H1

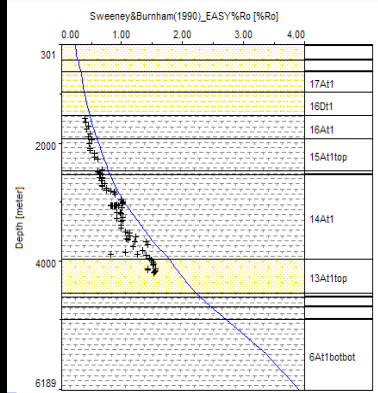


A-I1

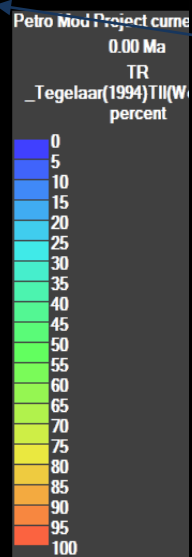




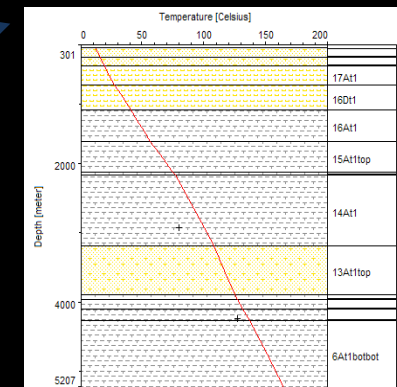
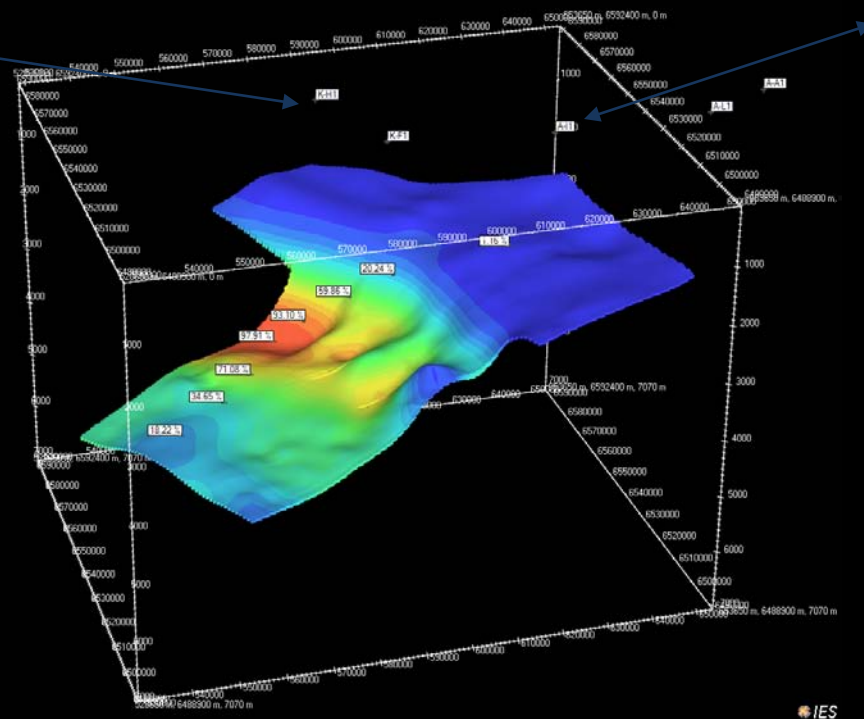
Temperature at K-H1 - Intra Tertiary - Petro Mod Project curnell rift to 45  
K-H1



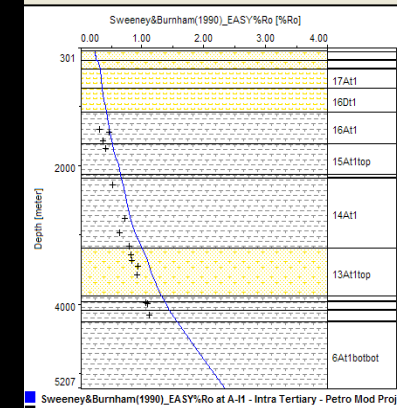
Sweeney&Burnham(1990)\_EASY%Ro at K-H1 - Intra Tertiary - Petro Mod Project  
K-H1



K-H1

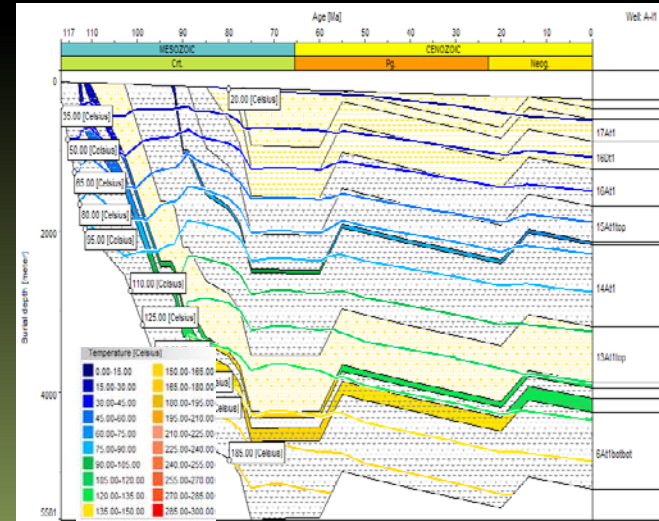
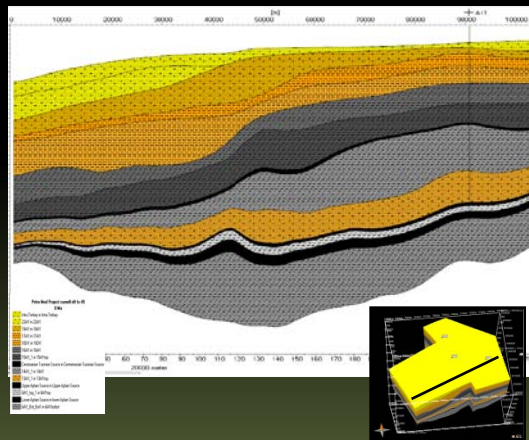
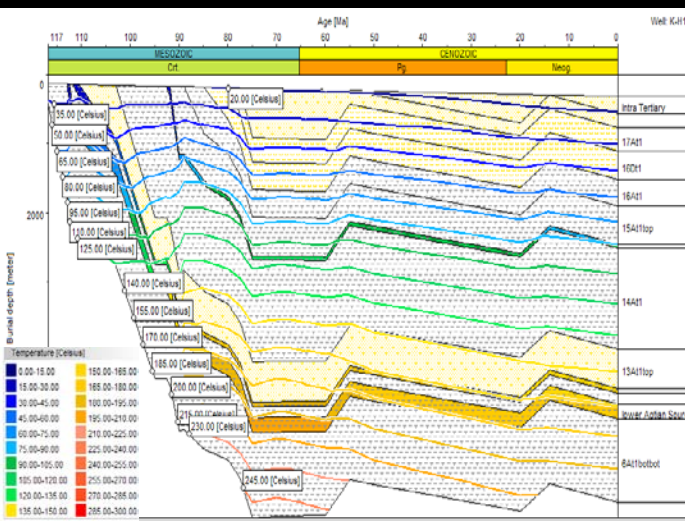


Temperature at A-I1 - Intra Tertiary - Petro Mod Project curnell rift to 45  
A-I1

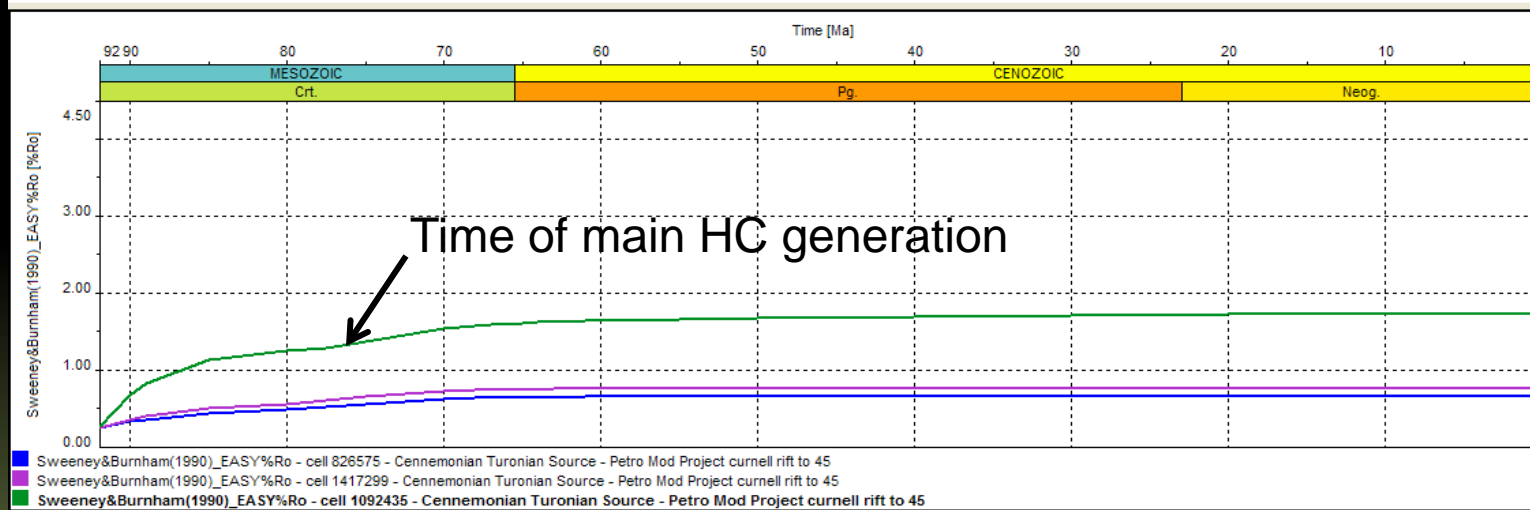
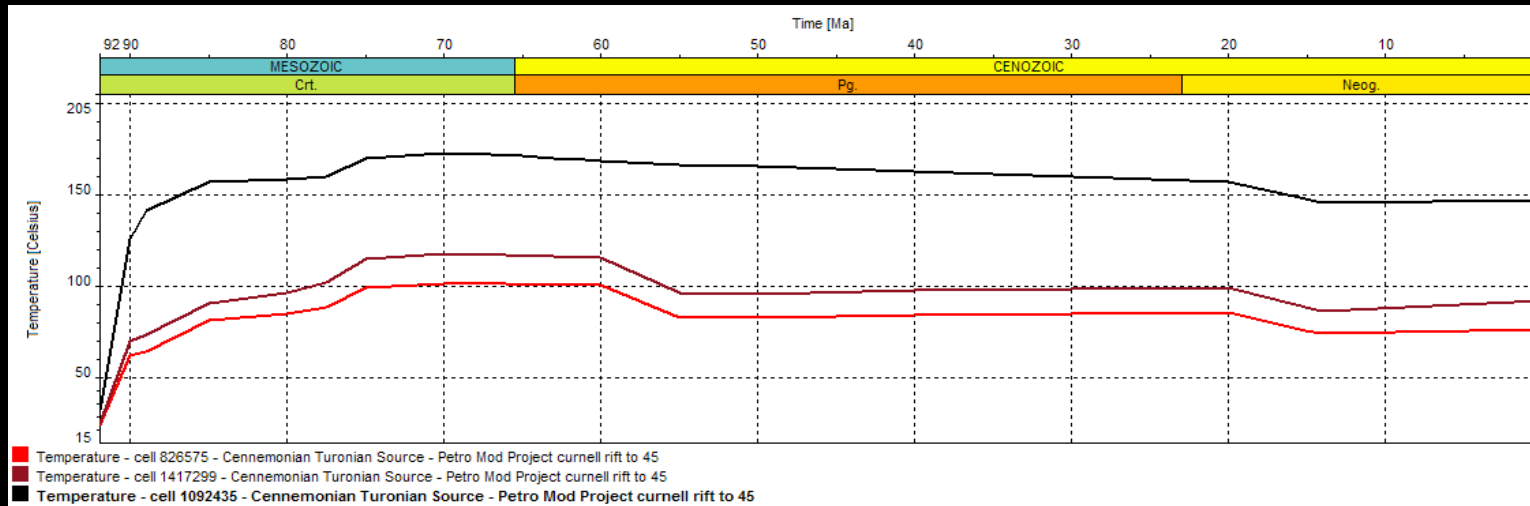


Sweeney&Burnham(1990)\_EASY%Ro at A-I1 - Intra Tertiary - Petro Mod Project  
A-I1

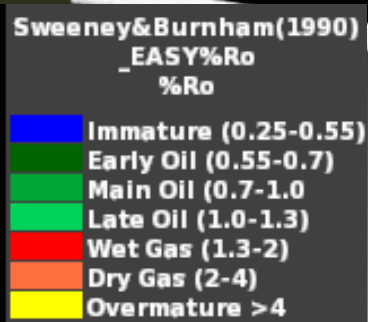
A-I1



# Time extraction



Blue line is at location A-L1 (shelfal area of basin)  
 Purple line at location K-H1 (middle of basin)  
 Green line is at th depocentre area of the basin



# Conclusion

3 dimensional thermal model of the northern part of the Orange Basin developed and calibrated to well data.

Modeling results indicate

Similar evolution of maturity of the two source rocks studied

Difference in present day maturity level

Both source rocks have a centrally mature region owing to the thick depocentre over the section

Similar maturity trends, i.e a centrally gas mature region and a distal oil mature area between previous models such as the maturity of the Barremian- early Aptian source rock by Jungslager (1999)

Next step: reconstructing HC migration paths and accumulation

# GEOLOGICAL MODELLING OF THE OFFSHORE ORANGE BASIN



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!! Thank You !!