GEO620 Thesis Presentation Introduction

Lisa Bingham, course instructor

University of Stavanger

The purpose of GEO620

- Prepare MSc candidates with the skills and knowledge to research and write the thesis
- Write and present a thesis proposal

Activities in GEO620

- Thesis topic selection and proposal
- Regular lectures and class activities related to writing, research, and presentations
- Guest lectures from industry covering various topics related to geology and petroleum exploration
  - If you'd like to guest lecture, contact me

Expectations from students

- A well-organized and coherent presentation showing that the student understands the objectives of the thesis and knows how to approach the problem
  - MSc thesis in spring
  - Not expected to have results or conclusions now
- 10-12-minute oral presentation with 3-5 minutes for questions
- Varying amounts of progress
  - Progress is not a grading factor

Grading

- All presentation attendees and presenters should fill in the score sheets for each presenter
  - Final mark determined by advisor and instructor
  - All feedback will be shared with students

Quality of scores

- 36-40: Excellent
- 32-36: Very good
- 28-32: Good
- 24-28: Average
- 20-24: Fair, needs improvement
- 16-20: Needs significant improvement
- <16: Failure to present a coherent presentation

Schedule

- 8:30-9:45 – Presentations
- 9:45-10:00 – Coffee break
- 10:00-11:30 – Presentations
- 11:30-12:30 – Lunch in Optimisten Cantine
- 12:30-14:00 – Presentations
- 14:00-14:15 – Coffee break
- 14:15-15:30 - Presentations

Facies Modeling Based on Multi-Point Statistics (MPS) in Submarine Fan Deposits

Fikri Yunus

4 December 2015

Supervisors;

- Christopher Townsend (University of Stavanger)
- Lothar Schulte (Schlumberger)

University of Stavanger

Outline

- Introduction
- Objective
- Methodology
- Timeline
- Reference

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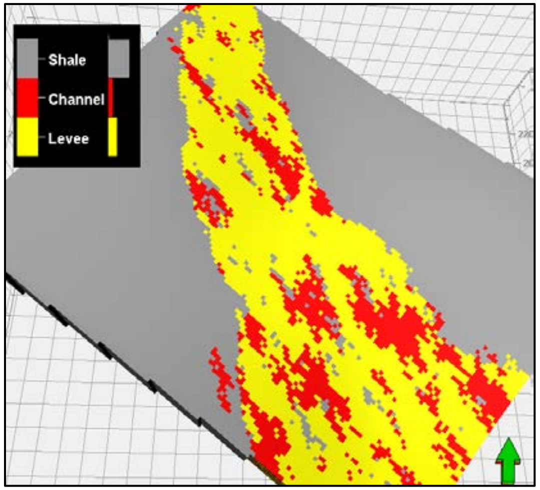
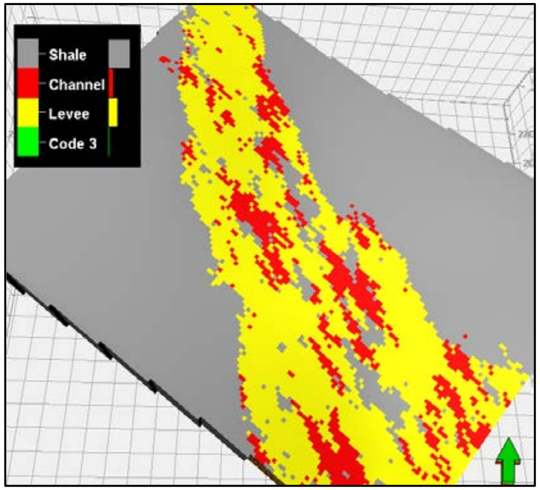
Introduction

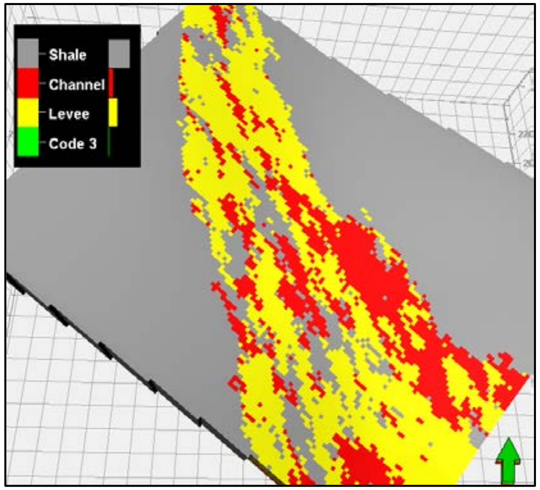
Geostatistics is a statistical application method in the earth science, especially in geology (Olea, 1991).

Daniel Krige (1950’s) – Kriging estimation
Georges Matheron (1960’s) – Kriging and conditional simulation

In 1970’s, Stochastic simulation allows drawing alternative, equi-probable, spatial distribution of the objects or pixel values (Journel, 1994).



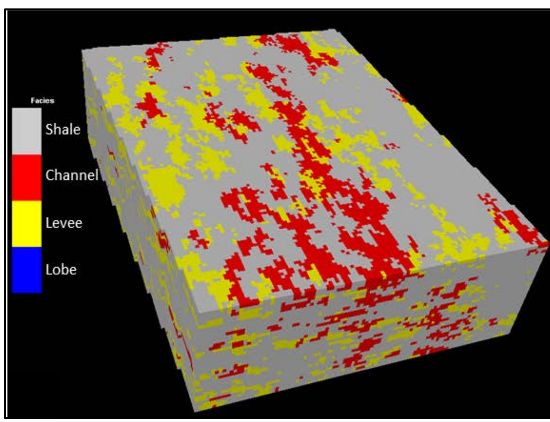




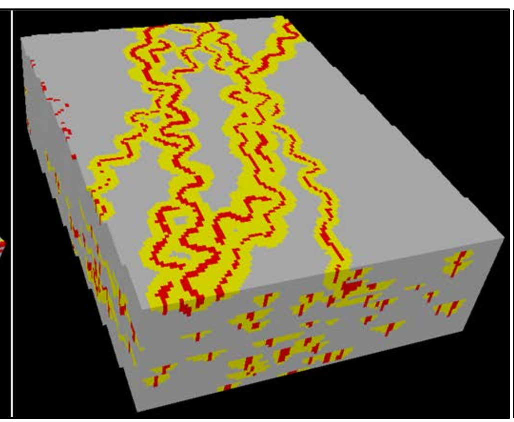
Introduction

Facies modeling techniques have been developed based on:

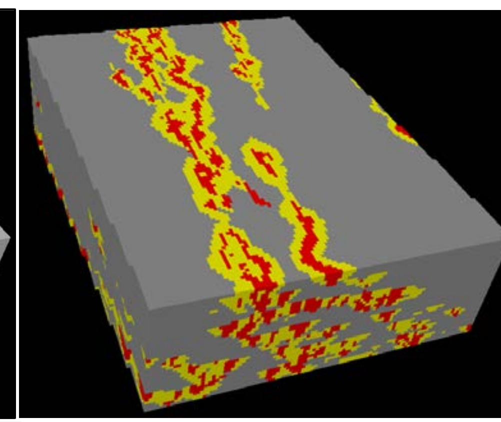
- Pixel-based simulation
- Object-based simulation
- Multi-point statistics (MPS) simulation



Pixel-based simulation



Object-based simulation

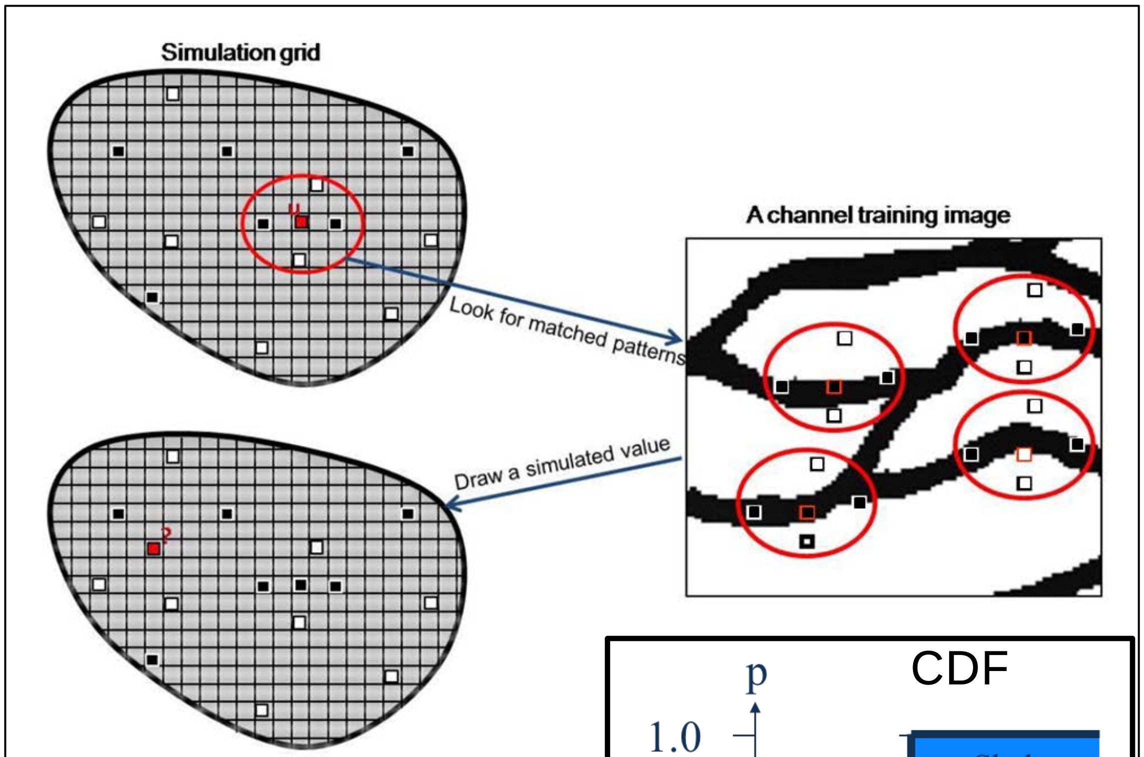


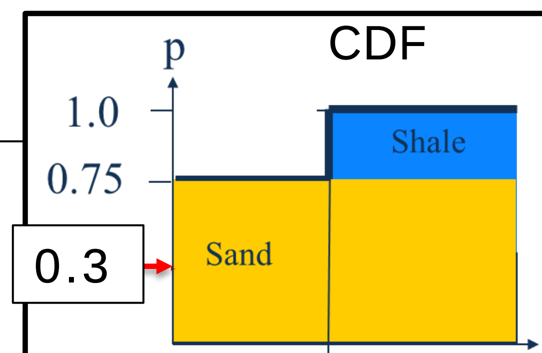
MPS simulation

(Schulte, n.d.)

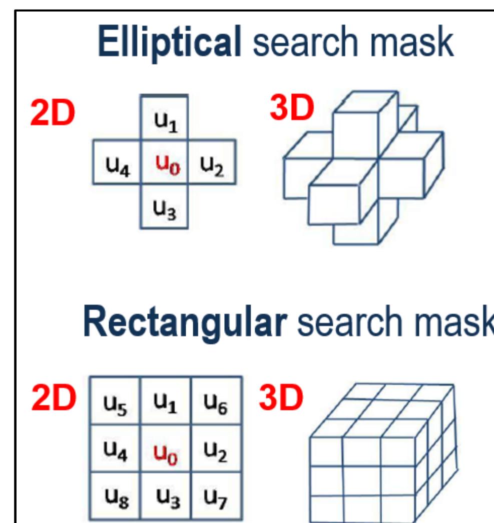
Multi-Point Statistics (MPS) Simulation

MPS is a method employing training images as the main driver to generate 3D depositional facies models.





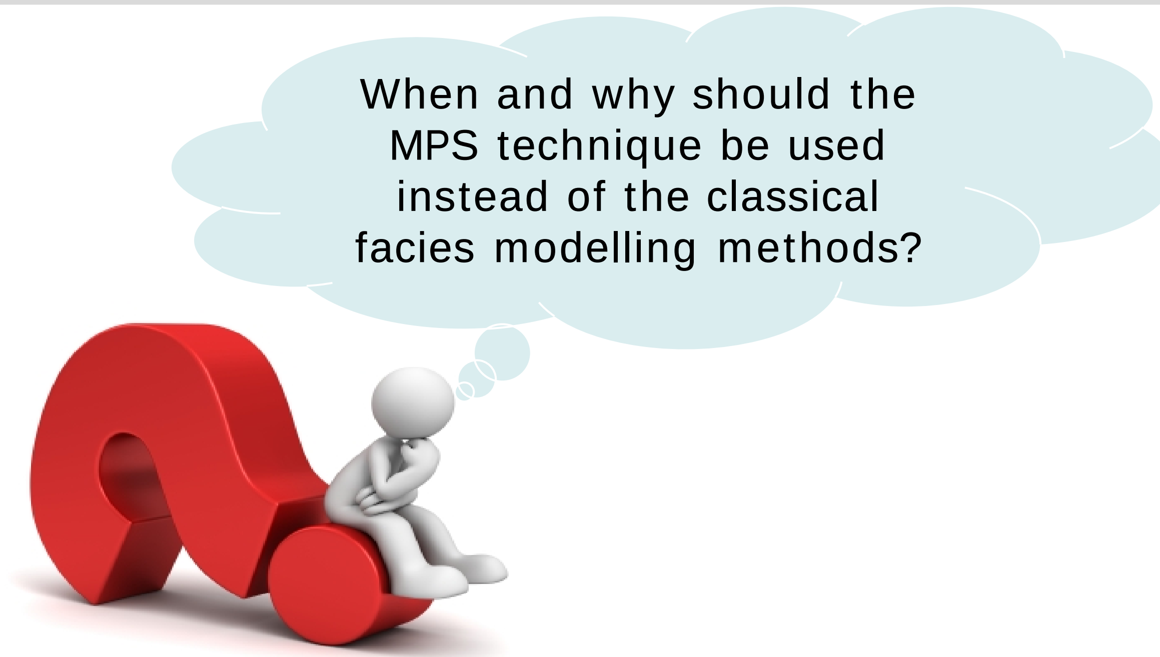
Training image is a simplified numerical representation of the subsurface



(Zhang, 2009)

Objective

Demonstrate the advantage of the MPS method compared to other simulation techniques



- Develop methodologies and best practices of MPS based facies modeling
- Comparison of MPS results with the classical methods

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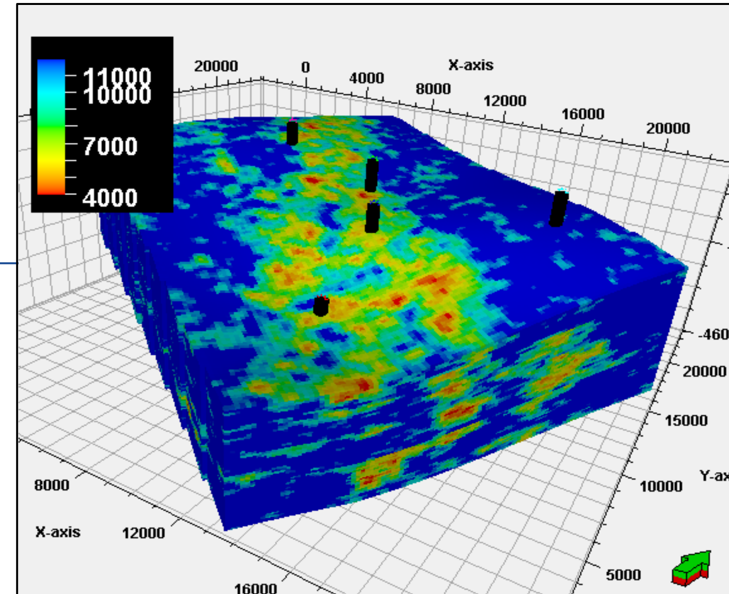
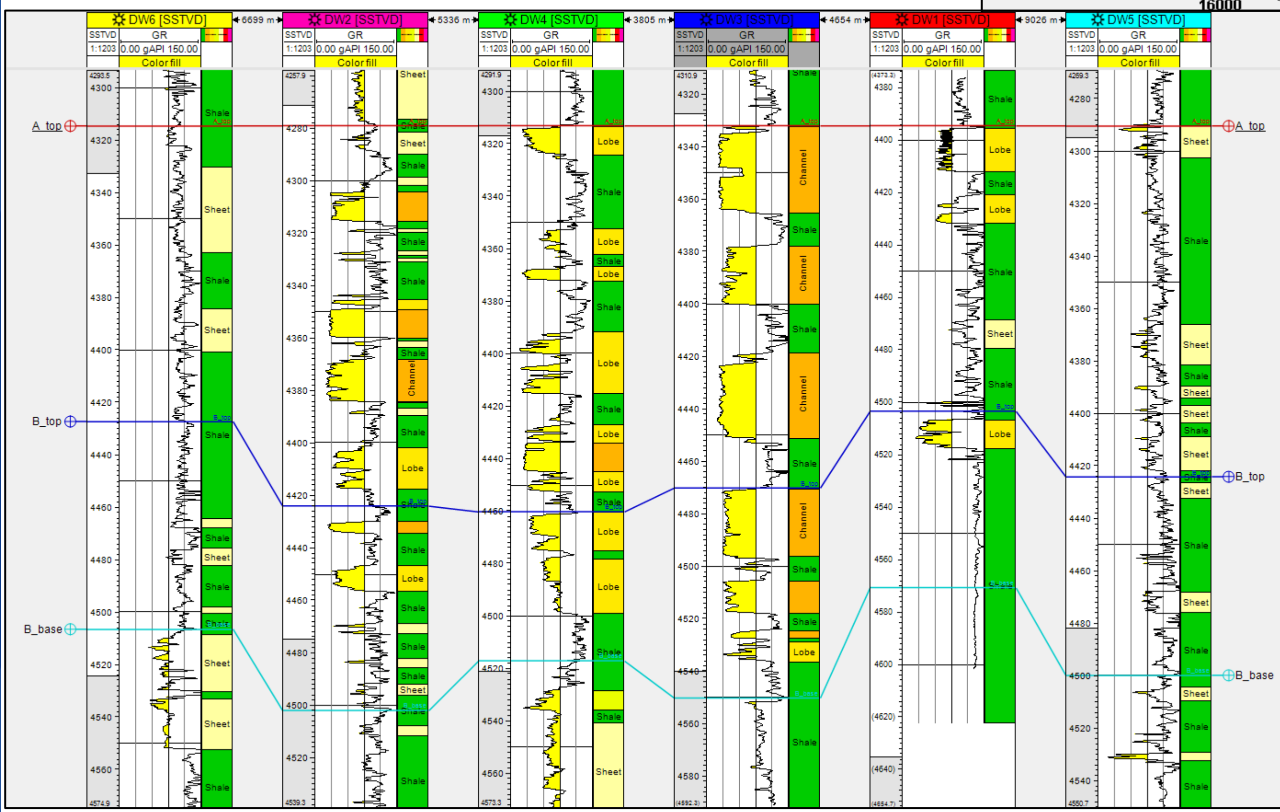
Data Set

- Well data (6 wells)
  - Petrophysical logs (GR, RT, PHIE, PERM)
  - Facies Logs
- Well Tops
- Seismic Inversion Cube (49.8 km^2)





Methodology

Build conceptual models of the subsurface

↓

Create training images from multi-sources

↓

Integration of “soft data” (e.g. region, scaling, azimuth, and probability cubes)

↓

Simulate facies models based on different techniques

↓

Evaluate and compare the results

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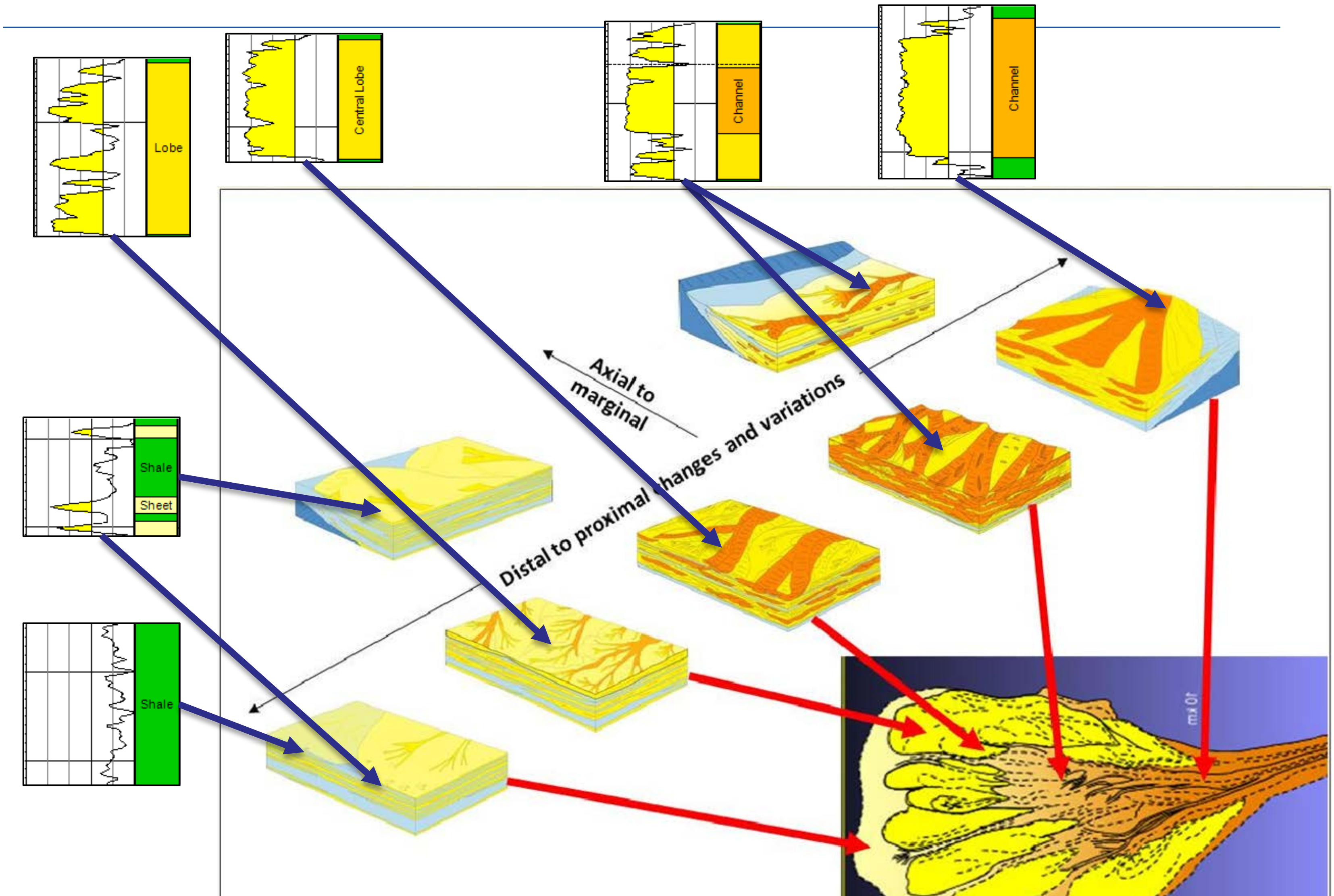
Conceptual Model: collecting information from literature for submarine fans



(Modified from Ravnås et al., 2014)

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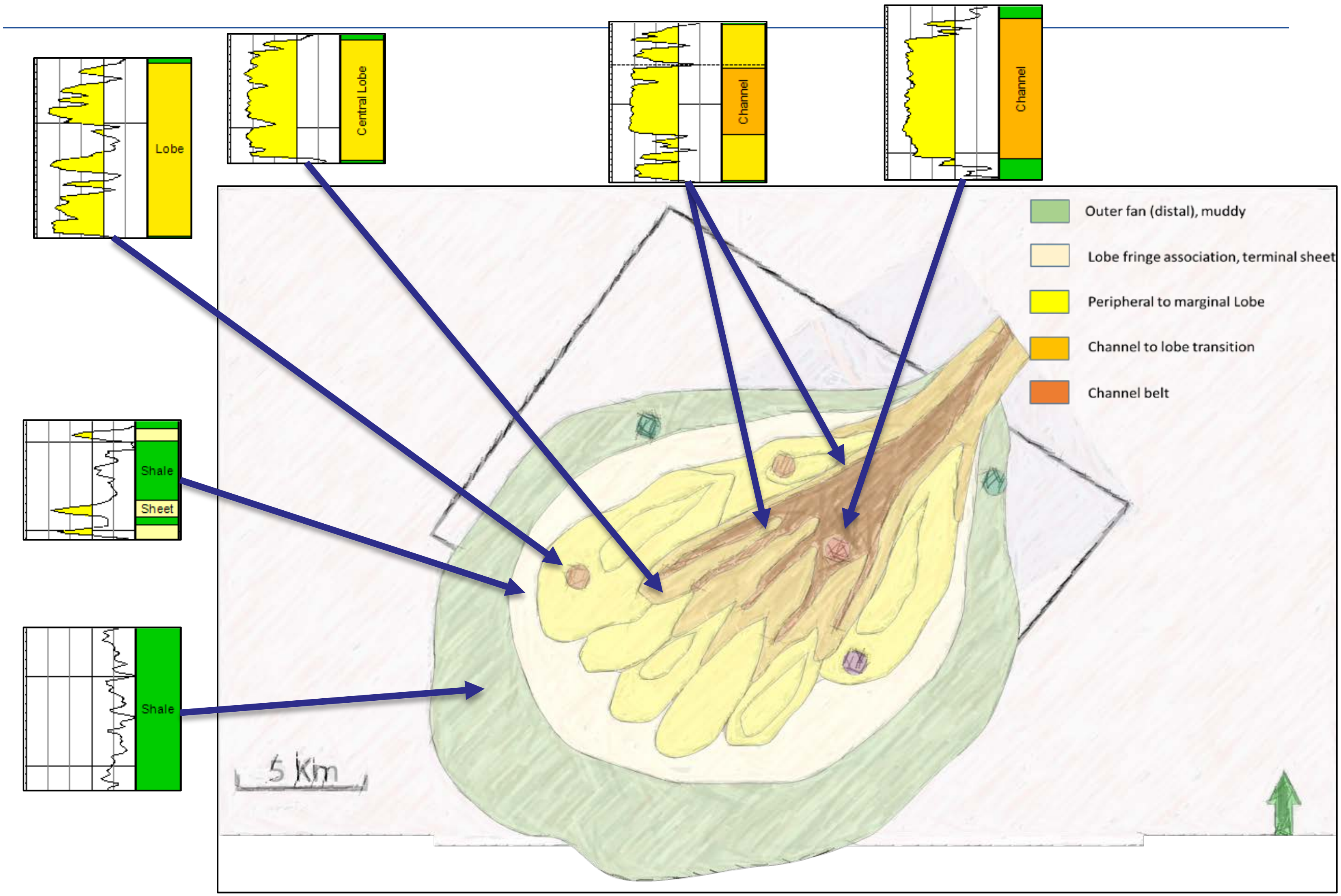
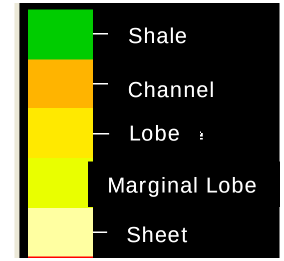
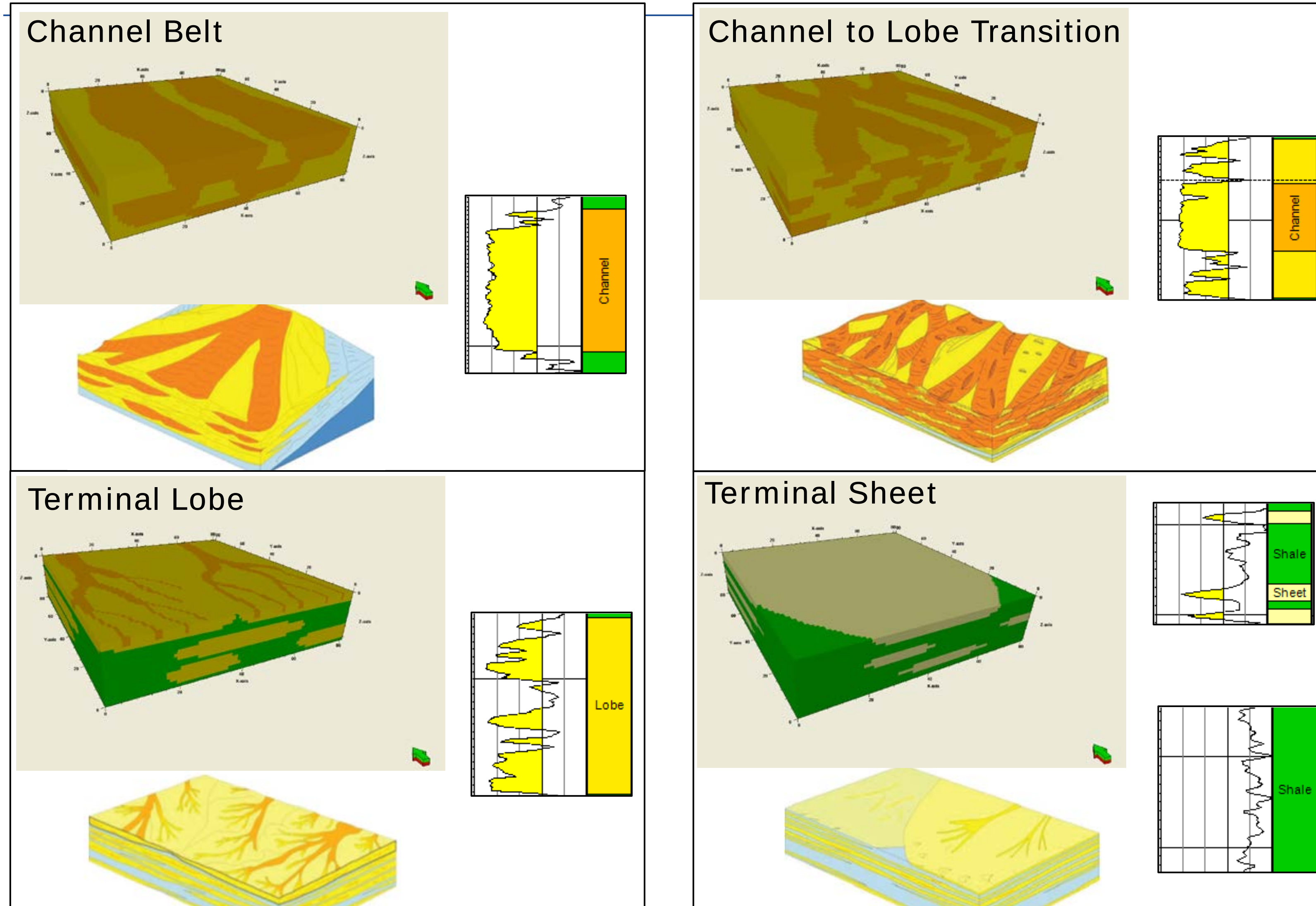
Conceptual Model: setup of concepts based on study data



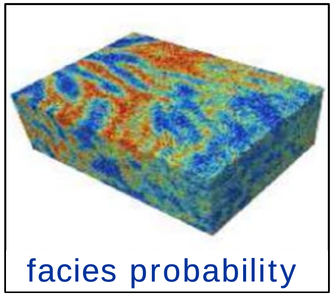
Training Image

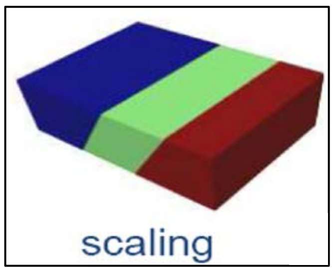


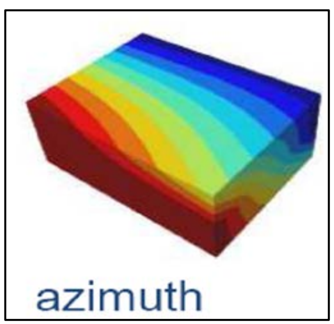


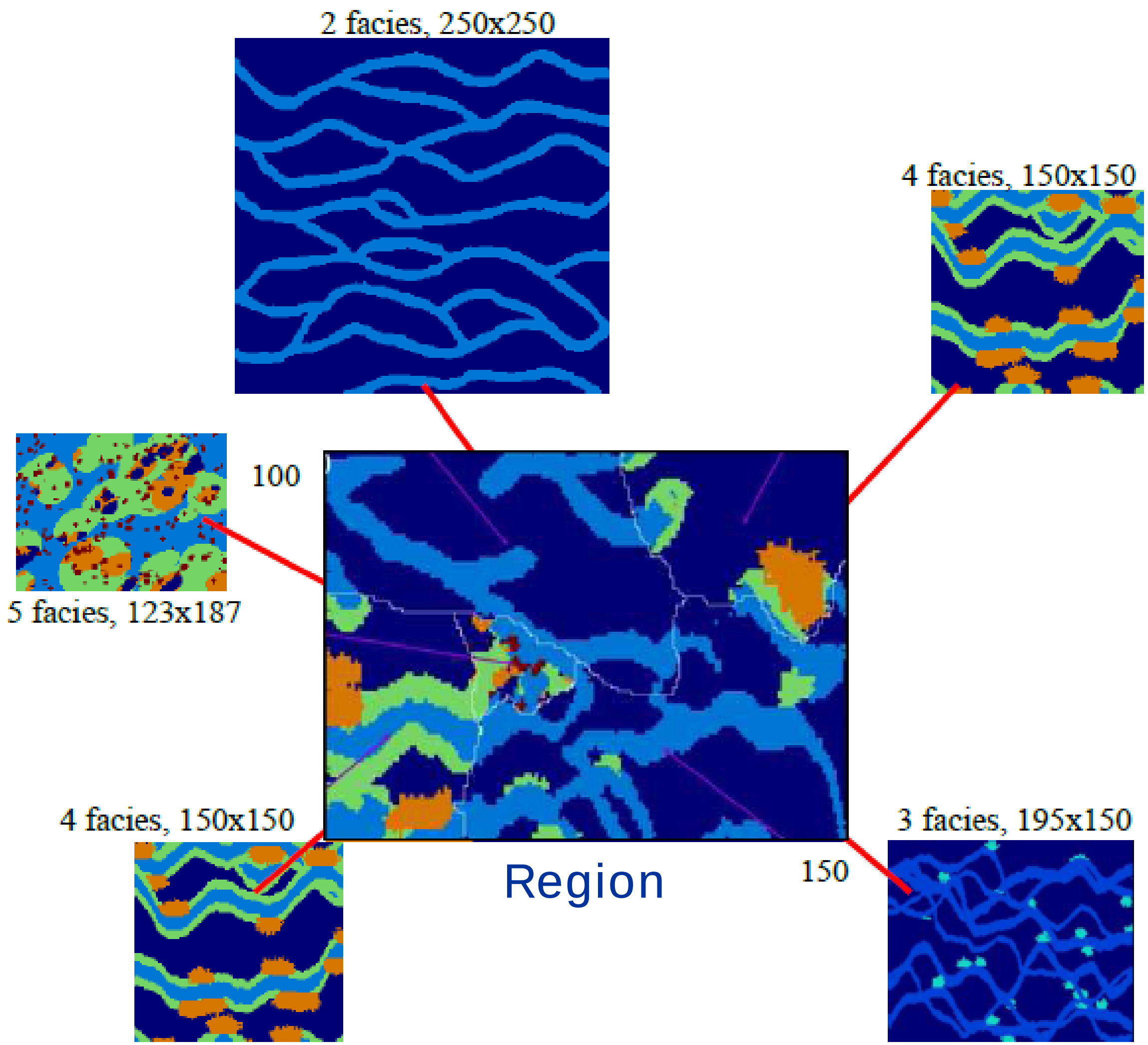
(Modified from Ravnås et al., 2014)

Integration of “soft data”



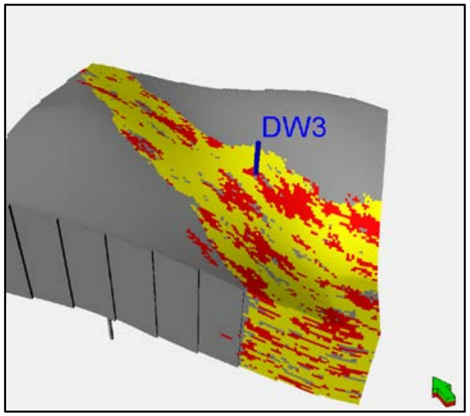


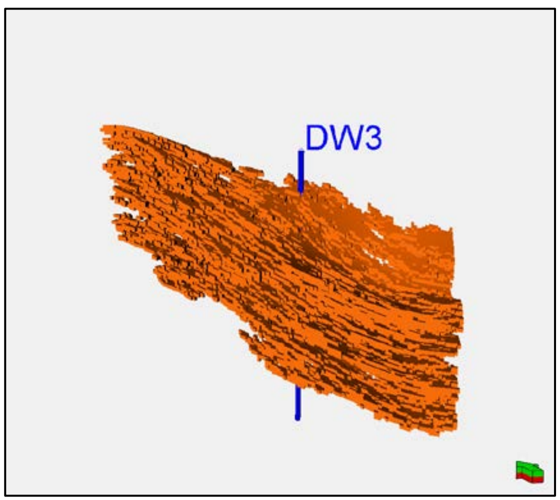




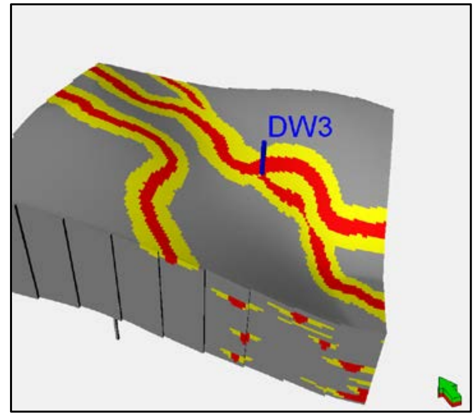
(Zhang, 2009)

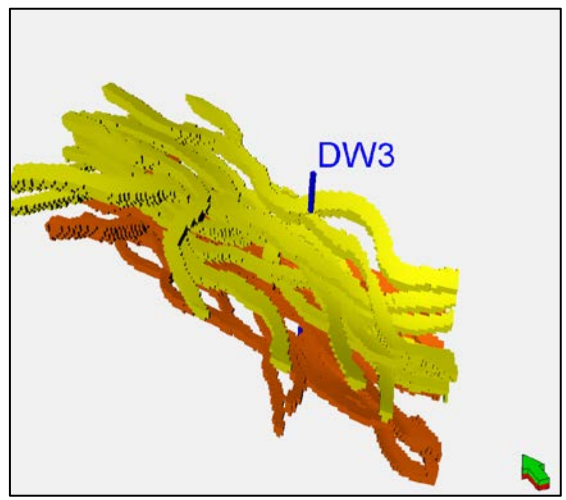
Comparison of results of different facies simulation techniques





Pixel-based modeling





Object-based modeling

MPS modeling

Timetable

Activity	January				February				March				April				May				June		
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Study literature	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Project:																							
Build submarine fan conceptual model	■	■																					
Creating training image and conditional data		■	■	■	■	■																	
Multi-point statitic (MPS) modeling				■	■	■	■	■	■	■													
Pixel-based modeling										■	■	■											
Object-based modeling												■	■	■									
Report:																							
Initial writing			■	■	■																		
Writing the results and summary						■	■	■	■	■	■	■	■	■	■	■	■						
Final editing																		■	■	■	■	■	
Submit the thesis																							■

Reference

Journel, A. G. (1994). Geostatistic and Reservoir Geology. *Stochastic Modeling and Geostatistics Principles, Methods, and Case Studies, AAPG Computer Applications in Geology, No. 3*, 2.

Olea, R. A. (1991). Geostatistical glossary and multilingual dictionary. *Choice Reviews Online, 29*(03), 29-1267-1229-1267. doi: 10.5860/CHOICE.29-1267

Ravnås, R., Cook, A., Engenes, K., Germs, H., Grecula, M., Haga, J., . . . Maceachern, J. A. (2014). The Ormen Lange turbidite systems: sedimentary architectures and sequence structure of sandy slope fans in a sediment-starved basin. *International Association Sedimentology Special Publication, 46*, 38.

Zhang, T. (2009). Introduction to MPS and a Guide to Using Multi-point Facies Modeling in Petrel 2009.1Schlumberger-Doll Research (Vol. 1, pp. 60).

Schulte, L. (n.d.). *Multi-Points Statistics (MPS)*.

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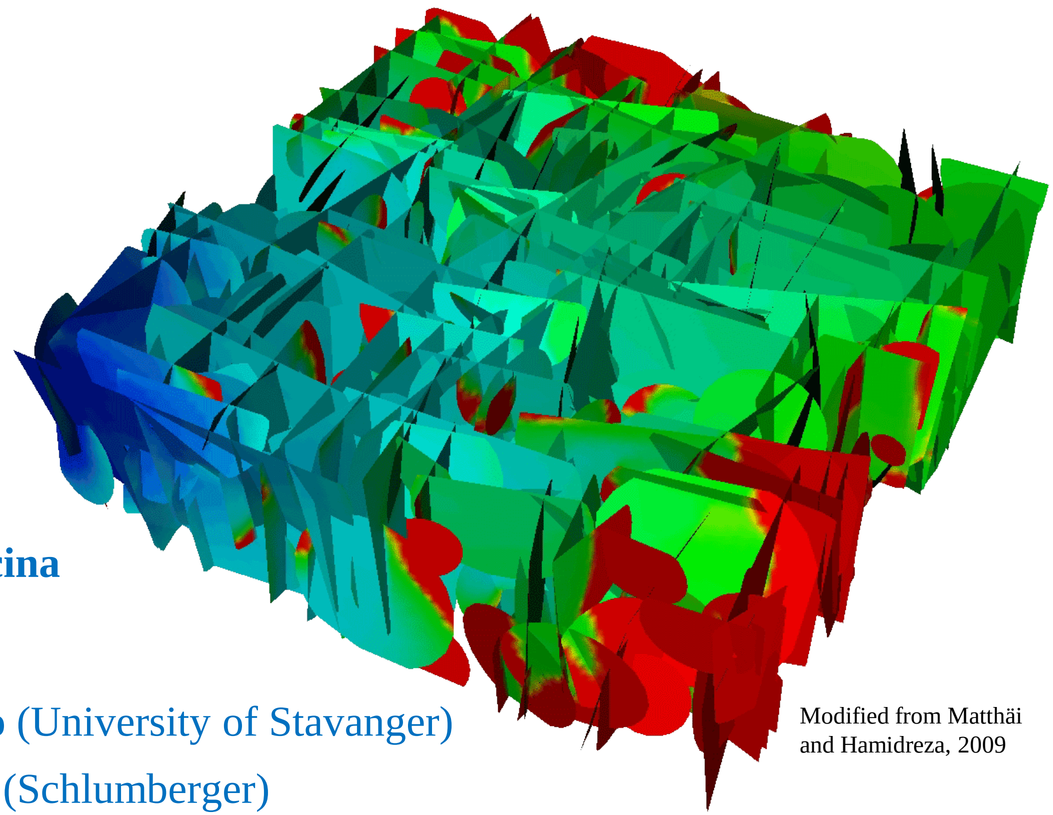
Thank You...

All models are wrong, but some are useful.

— George E. P. Box —

Master thesis proposal

Evaluation of strategies in fracture modeling, a case study from the Teapot Dome, Wyoming



Modified from Matthäi and Hamidreza, 2009

By:

Darjan Kundacina

Supervisors:

Nestor Cardozo (University of Stavanger)

Lothar Schulte (Schlumberger)

04/12/2015

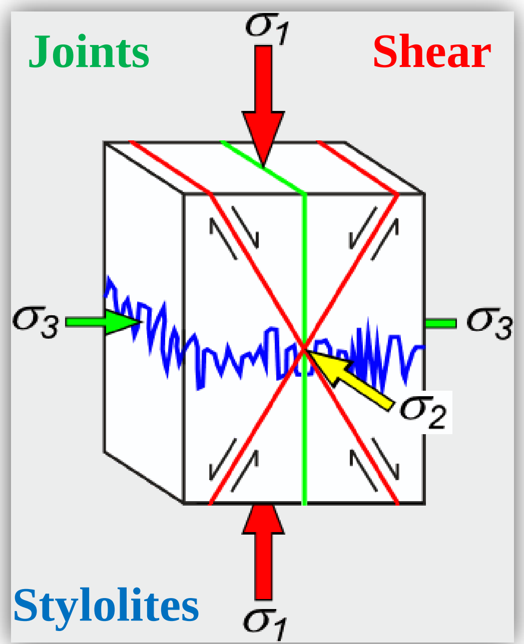
Outline

- Introduction
- Objectives
- Dataset
- Methodology
  - Principles of fracture modeling
  - Seismic attributes
  - Stress and strain
- Comparison of fracture models
- Time frame

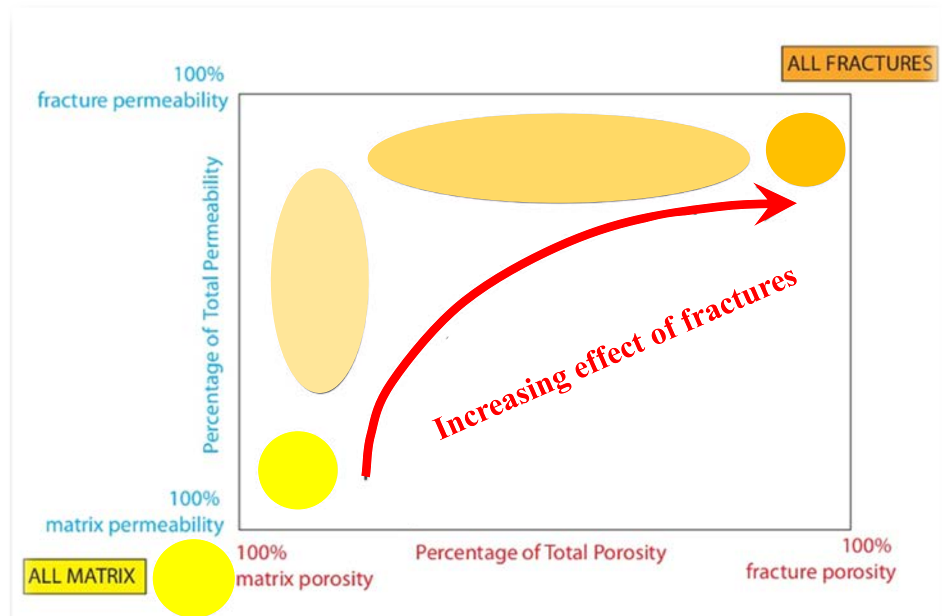
Introduction

- Fractures – discontinuities in displacement and mechanical properties
- They form as result of stresses
- Fractures influence fluid flow
- Fracture modeling with aim to describe reservoir behavior

Natural fractures in granite, Owl`s Head State Park (Mervine 2009)



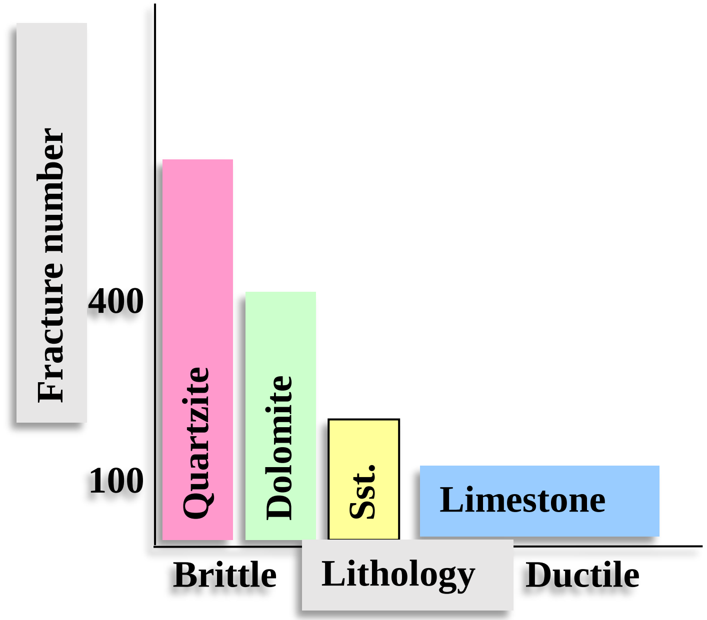
Fracture types with respect to the principal stresses (modified from Lacazette, 2009)



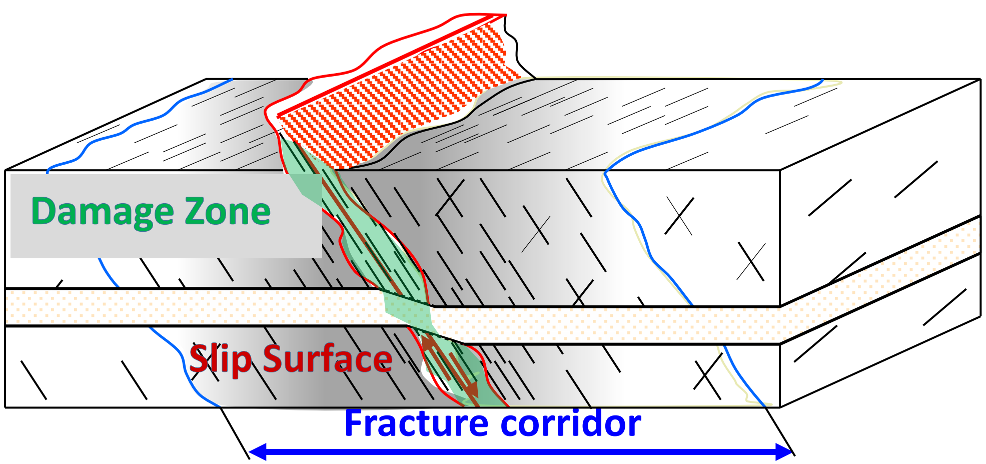
Clasification of reservoirs based on petrophysical properties of fractures (modified from Nelson, 2001)

Introduction

- Fracture density is proportional to:
  - Fault damage
  - Mechanical stratigraphy (lithology)
  - Structural curvature



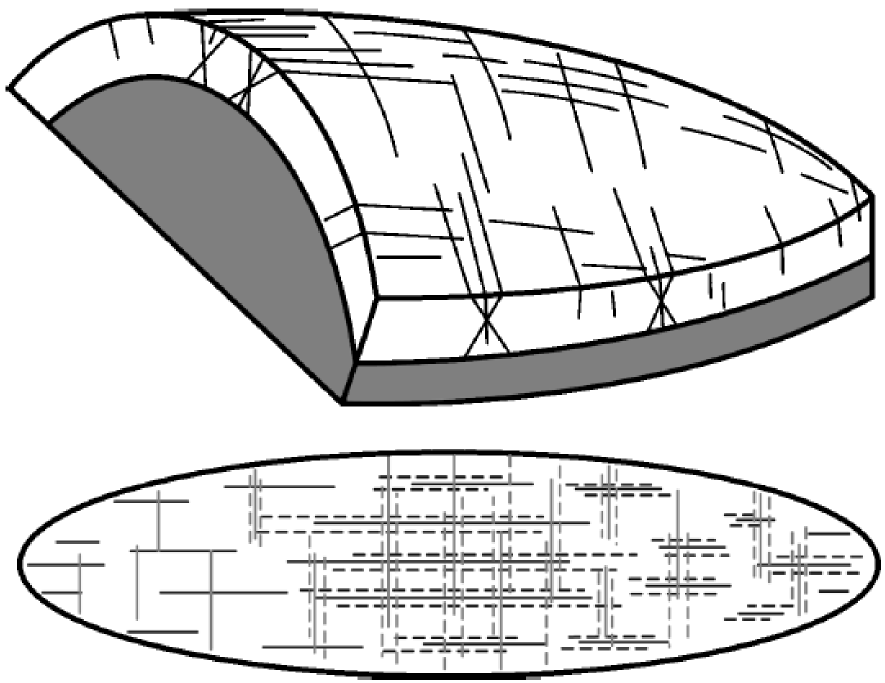
Fracture dependence on lithology (modified from Schulte, 2015)



Fractures associated to the fault (modified from Nelson, 2002)

Introduction

- Fracture density is proportional to:
  - Fault damage
  - Mechanical stratigraphy
  - Structural curvature



Conceptual 3D fracture pattern model and plan view at Teapot Dome (from Cooper et al., 2006)

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Challenges

How can we represent natural fractures by a numerical model?

How to guide interpolation of fracture density in a realistic way?

What type of data can we used for guiding fracture density?

What are the different approaches for fracture modeling?

Objectives

Comparison of different approaches of fracture modeling

Prediction of fracture distribution based on analytical laws

Sensitivity analysis of analytical law parameters

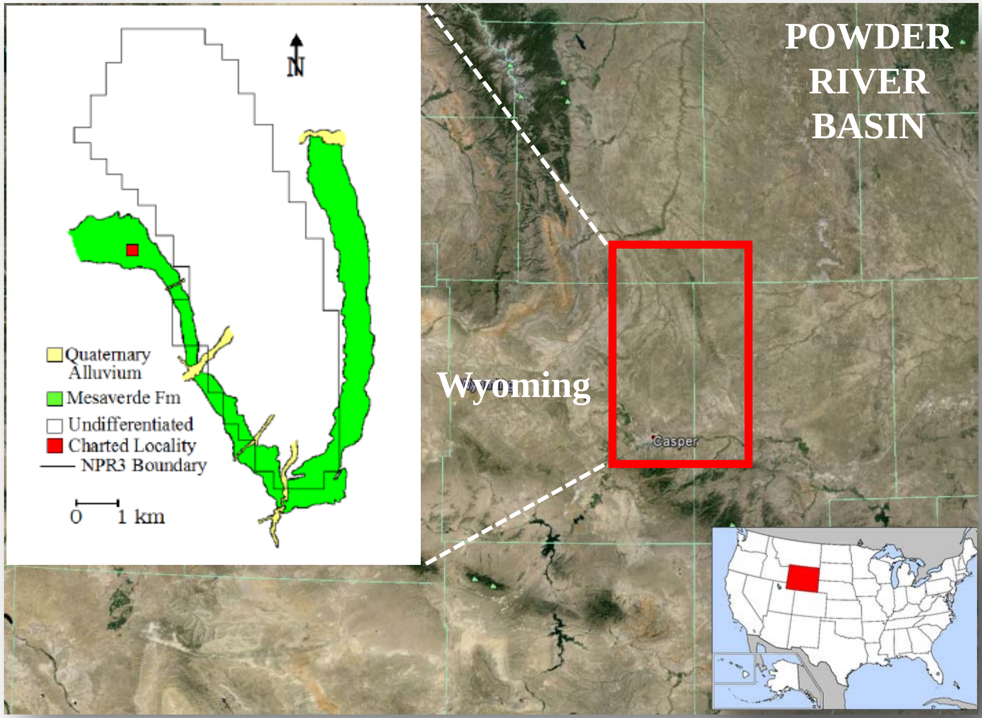
Integration of seismic attributes in fracture modeling

Fracture modeling conditioned by stress or strain fields

Evaluation and uncertainty analysis of the different modeling techniques

Dataset

- Teapot Dome is located in central Wyoming
- 3D seismic cube
  - 345 Inlines and 188 Crosslines
  - Covering over 80 km^2
  - Faults and horizons
- 4 Wells
  - Fracture point data
  - FMI logs and well tops
- Check shot surveys



Location of Teapot dome in Wyoming/USA and geological map (from Cooper, 2000)

Dataset

- Teapot Dome is located in central Wyoming
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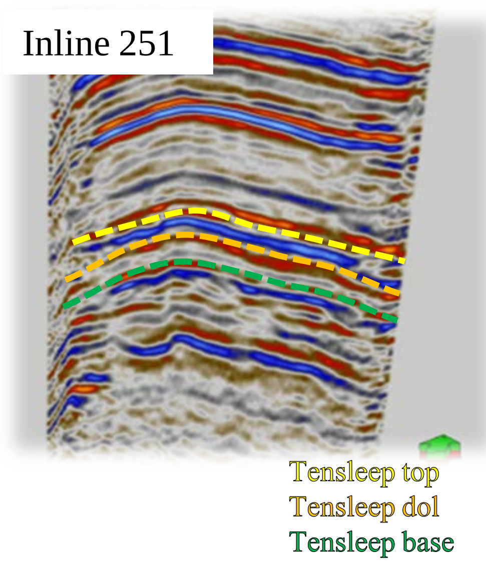

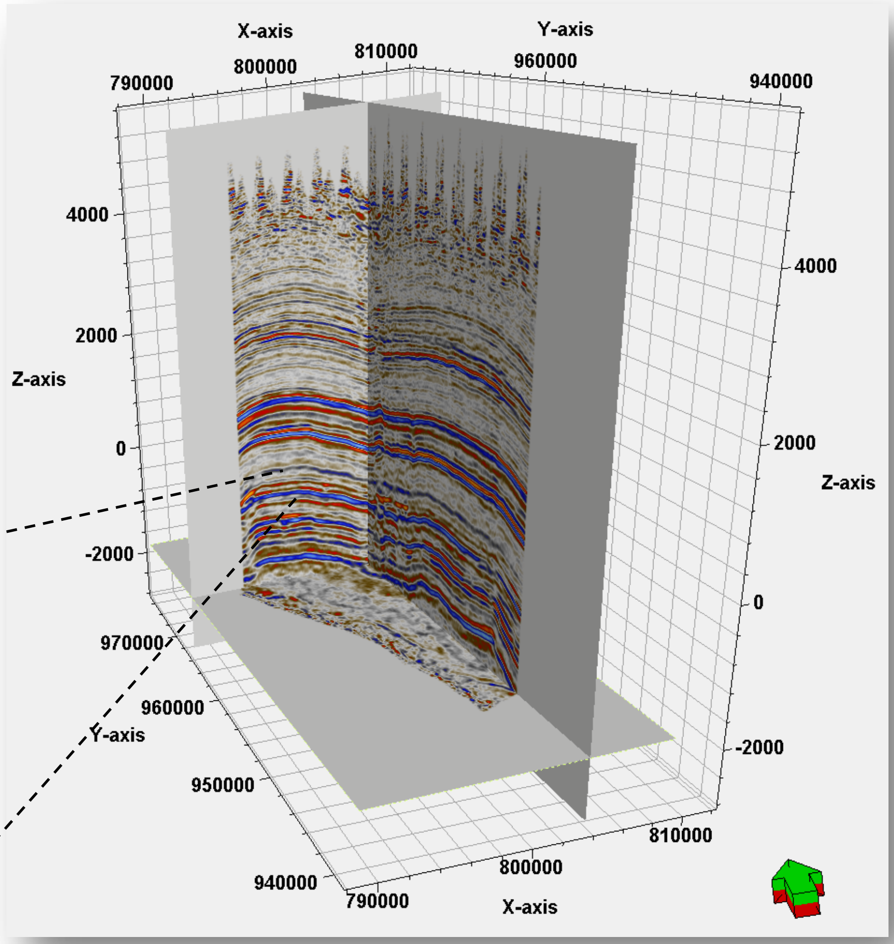

3D seismic cube (Inline 251, Crossline 139)

Dataset

- Teapot Dome is located in central Wyoming
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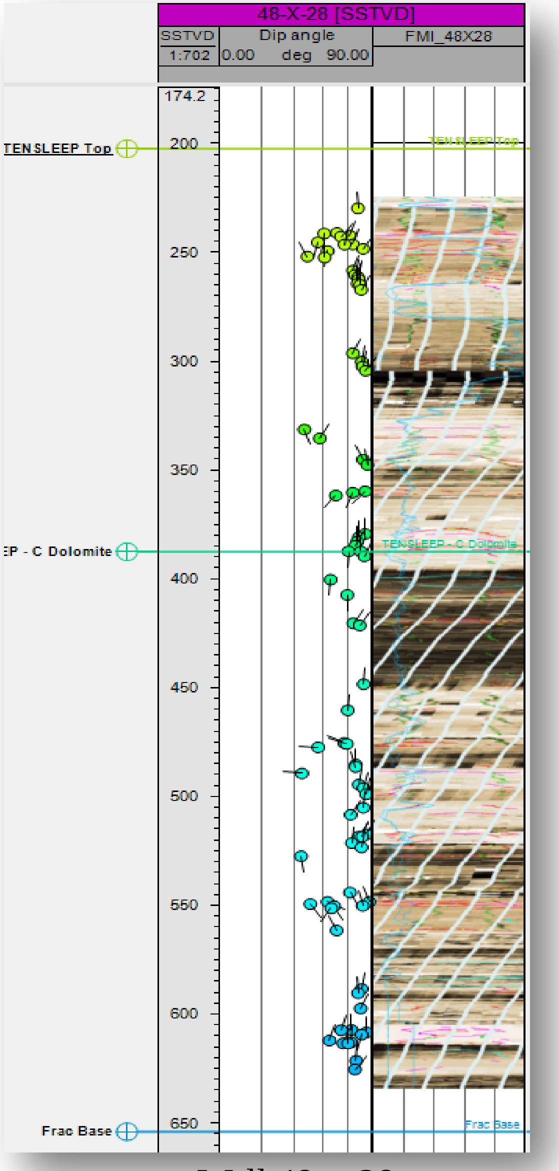
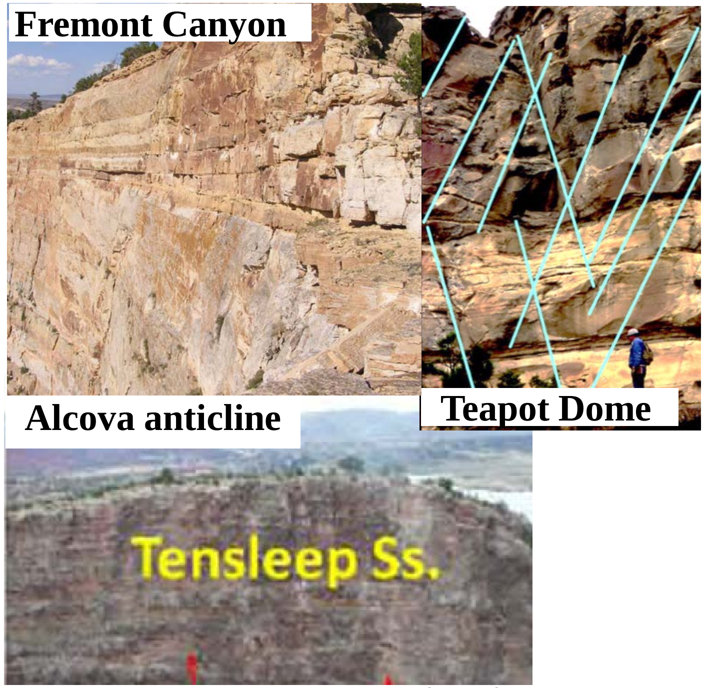


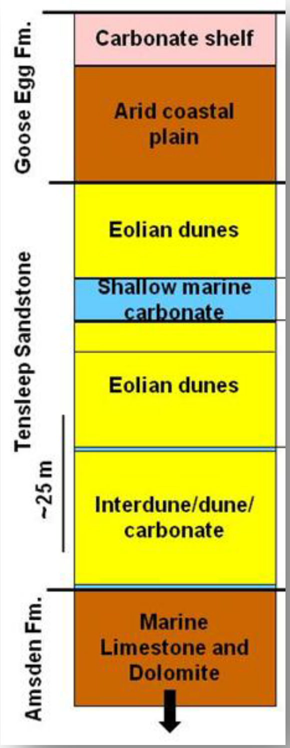
Well 48-x-28

Geology

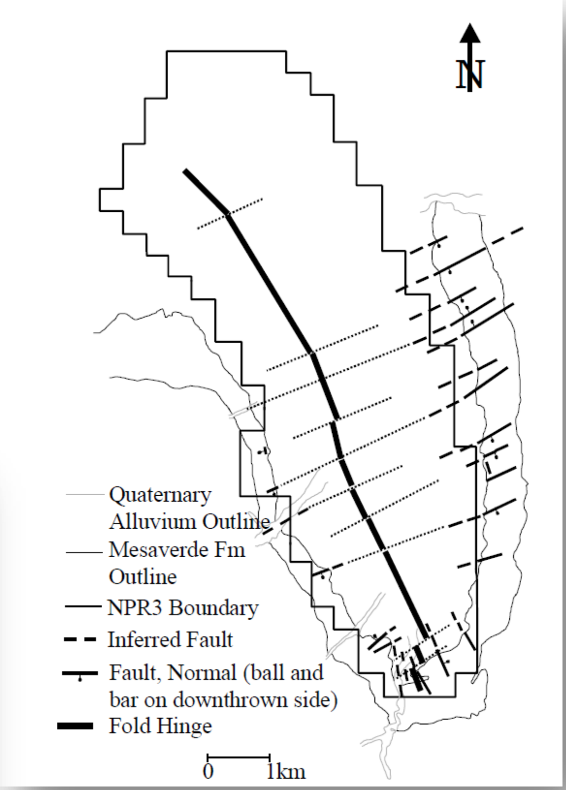
- Asymmetric, basement cored anticline
- Two sets of faults: perpendicular and normal to the fold hinge
- Tensleep Formation: sandstone deposits interbedded with shallow marine dolomites
- Three sets of fractures



Tensleep analoges (modified from Zhang 2004, Wilson 2012, Cooper, 2006)



Stratigraphy column of Tensleep Formation (from Gilbertson 2006)



Main fault sets at Teapot Dome (from Allison, 1989)

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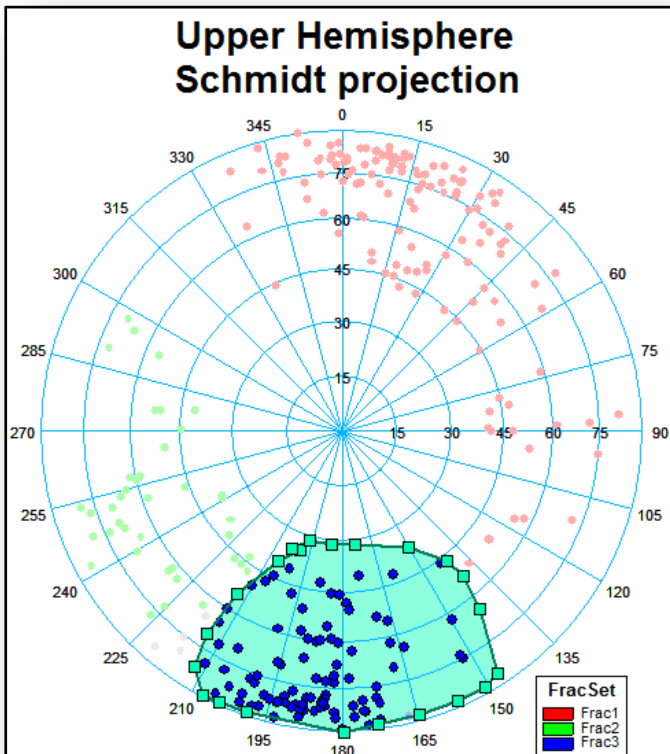
Methodology

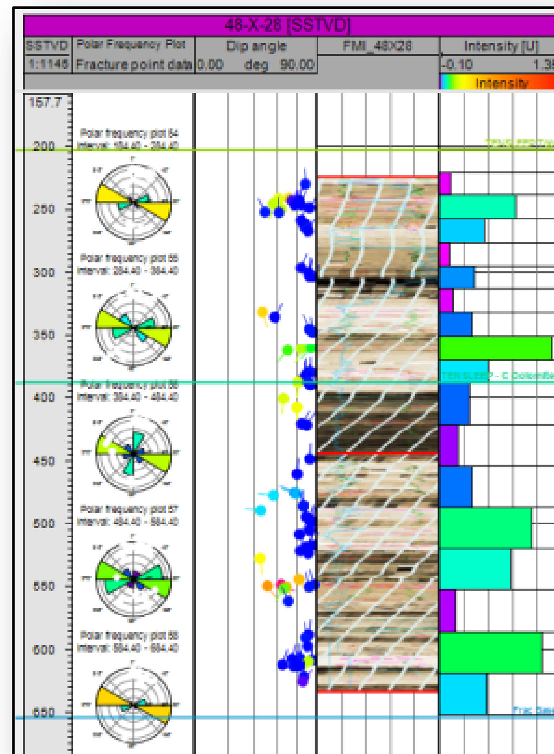
Well data

QC and data analysis

- Fracture sets
- Intensity logs
- Fracture intensity



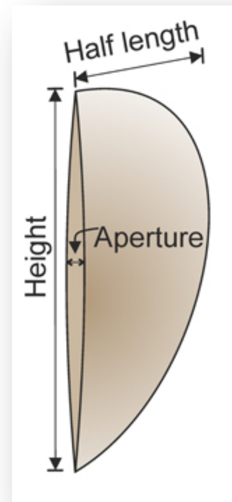
Definion of fracture sets
(Schlumberger training manual)



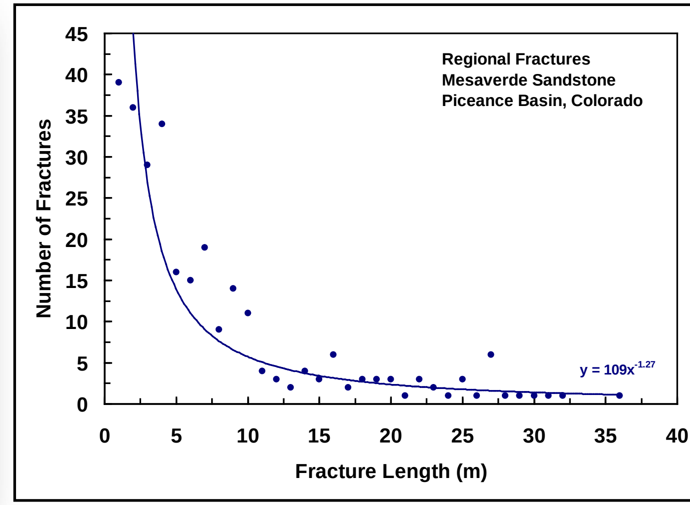
FMI and intensity logs
(Schlumberger training manual)

Methodology

Well data



Fracture parameters (from Gudmundsson, 2000)



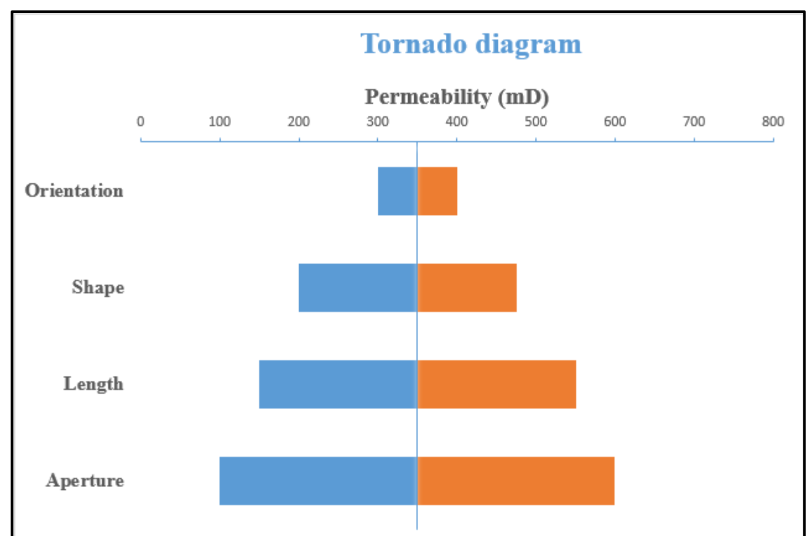
Power law distribution (Odling, 1999)

QC and data analysis

- Fracture sets
- Intensity logs
- Fracture intensity

Fracture network parameters

- Fracture geometry
- Geometry distribution



Sensitivity analysis of fracture parameters

Methodology

Well data

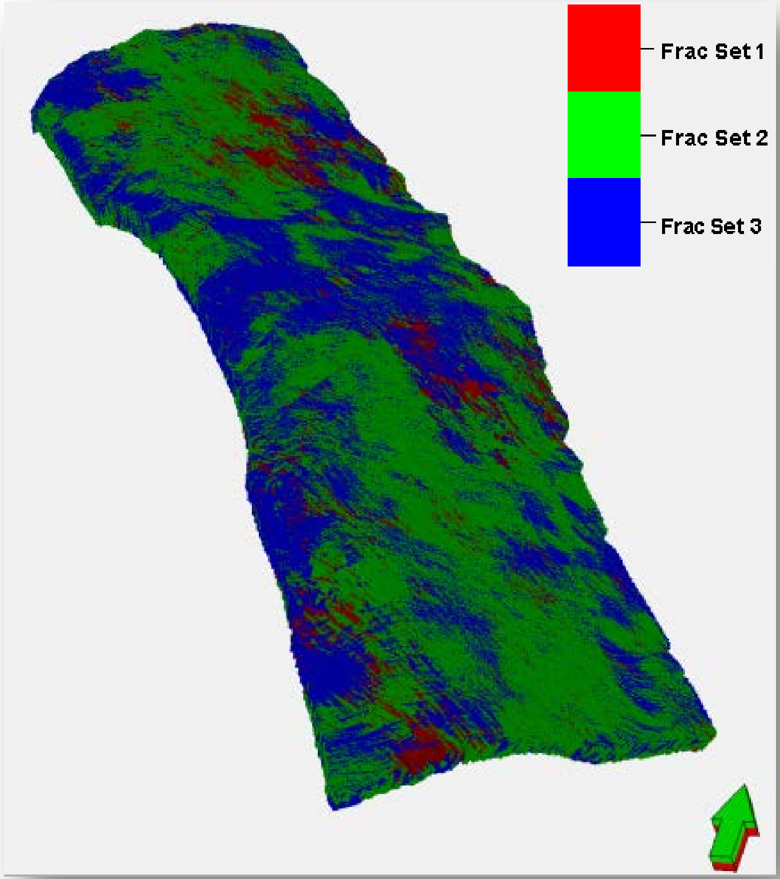
QC and data analysis

- Fracture sets
- Intensity logs
- Fracture intensity

Fracture network parameters

- Fracture geometry
- Geometry distribution

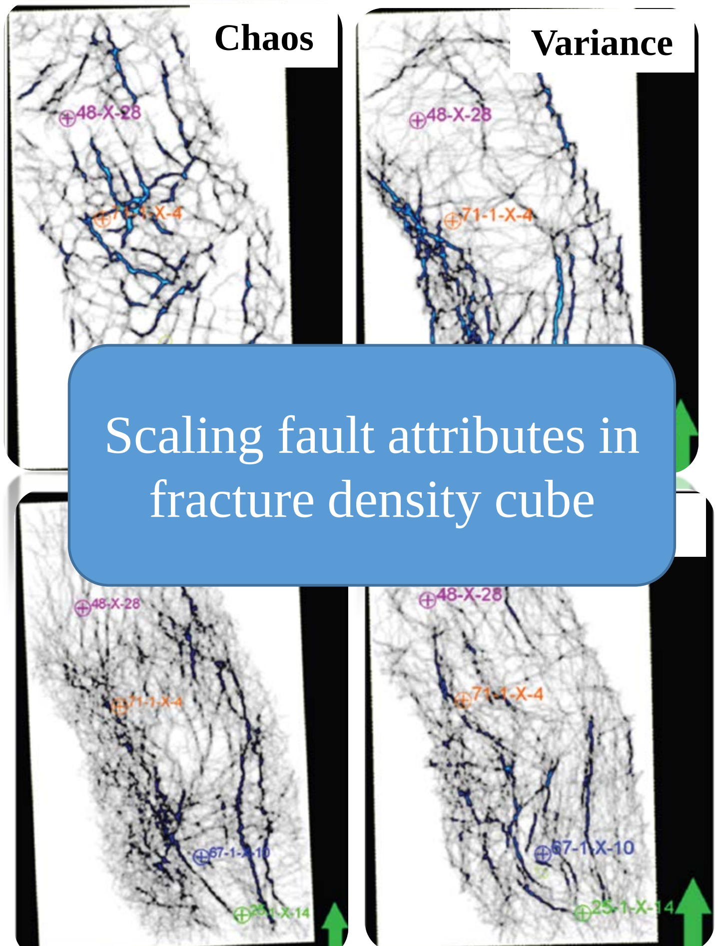
Fracture model



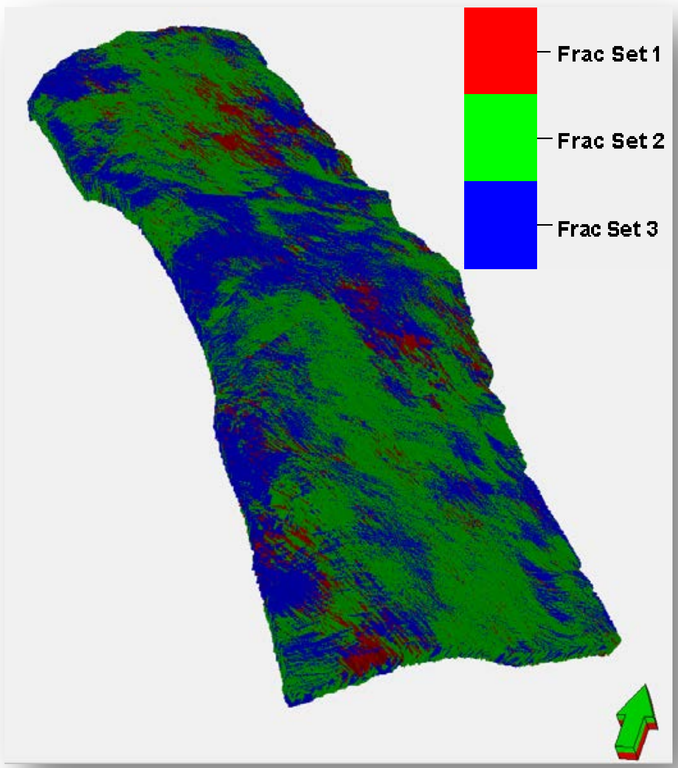
Fracture network model
(Schlumberger training manual)

Methodology Seismic attributes

- Derivation of seismic volume attributes
- Identification of representative fault patterns
- Attributes for faults (Ant tracking)



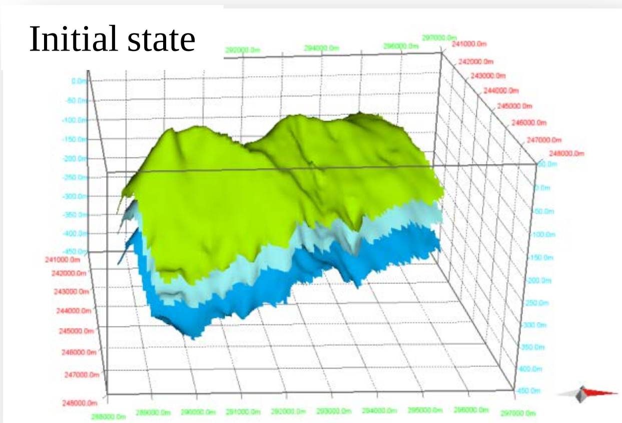
Seismic volume attributes (from Thachaparambil, 2015)

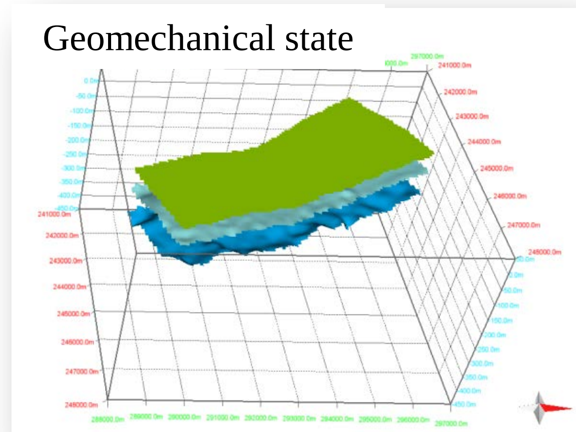


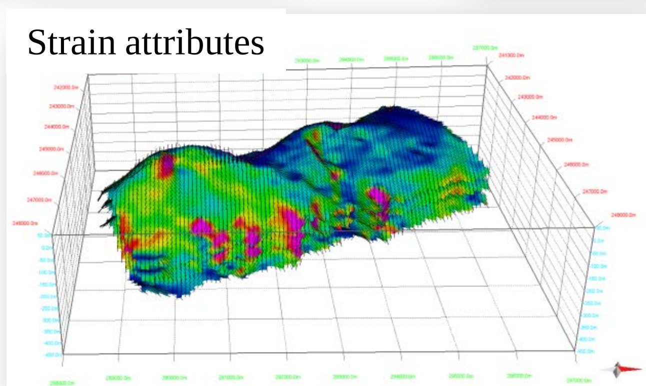
Fracture network model
(Schlumberger training manual)

Methodology — Strain field

- Kinematic or mechanical restoration of Teapot Dome
- Strain attributes as the result
- Derived strain field as input for fracture extraction







Restoration of Teapot Dome resulting in derived strain attributes

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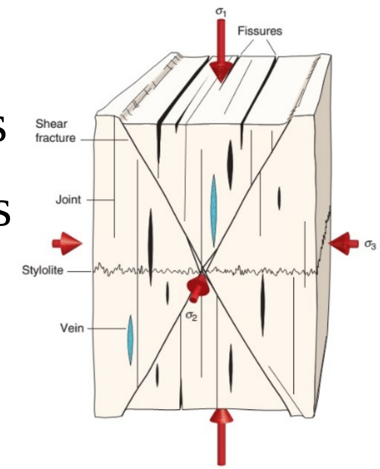
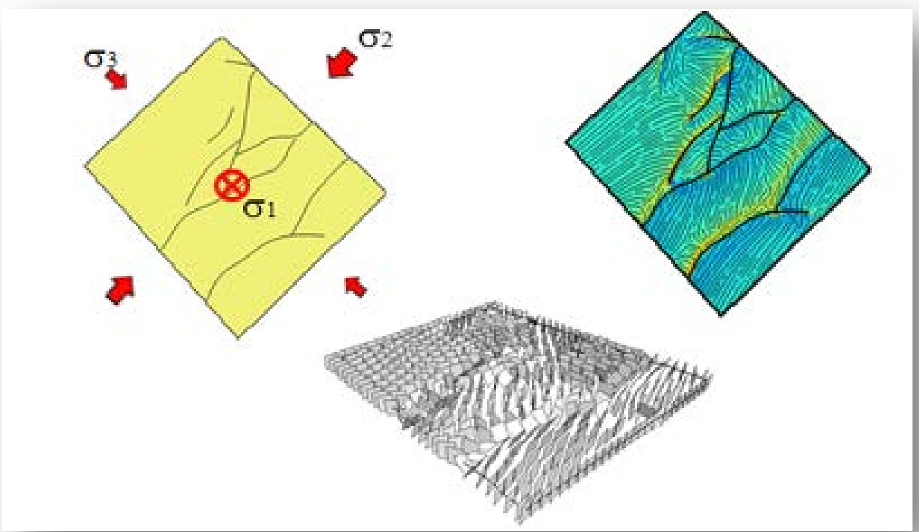
Methodology

Stress field

- Fracture simulation using random stress fields influenced by the faults
- Faults and defined fracture types as a main inputs
- Choose the stress field best matching observed fractures

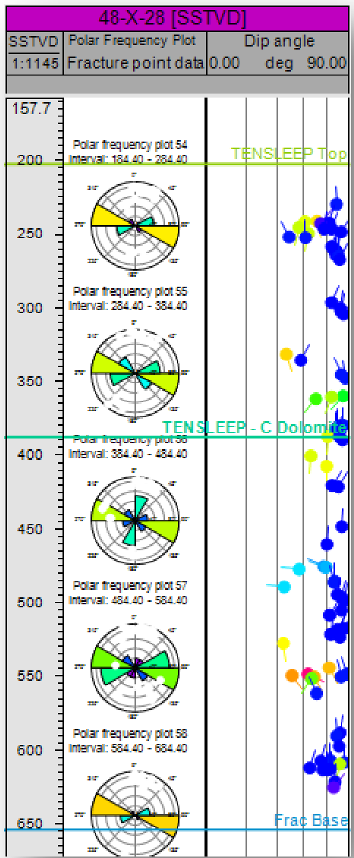


Fracture classification with respect to the principal stresses (from Fossen, 2010)



Perturbed stress field
(Schulte, personal communication, 2015)

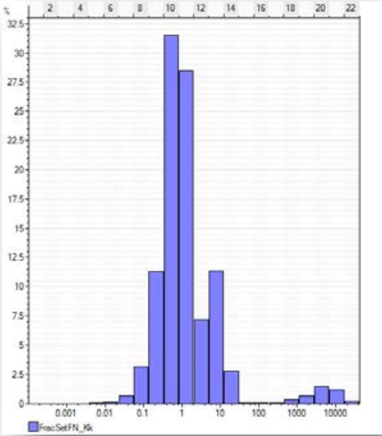
VS.



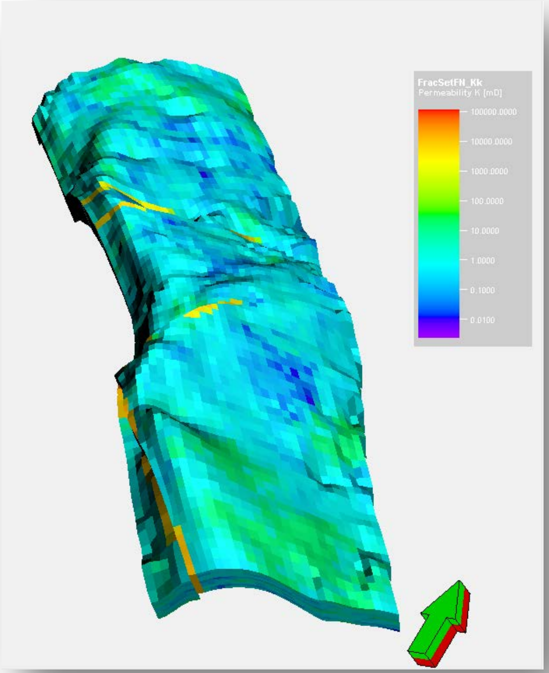
Observed fractures
(Schlumberger training manual)

Comparison of the models

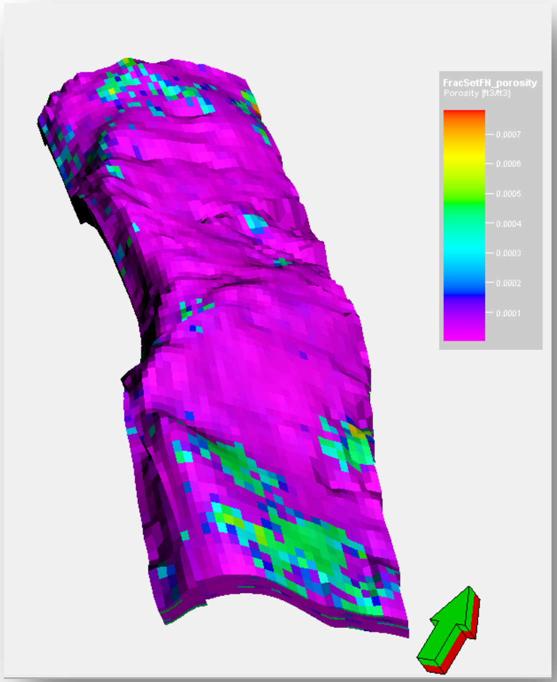
- Upscaling of fracture parameters porosity and permeability into 3D grid
- Comparison of generated fracture models by analyzing upscaled properties using histogram
- Propose the best practice in fracture modeling based on results



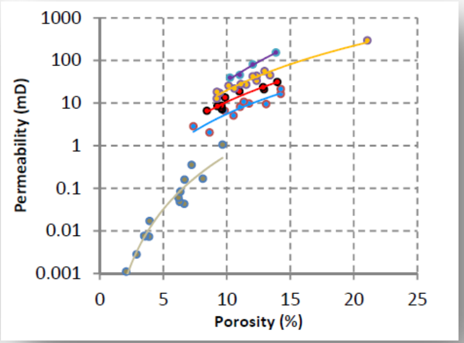
Permeability histogram



Permeability
(Schlumberger training manual)



Porosity
(Schlumberger training manual)



Permeability and porosity from core data (Elfeel et al., 2013)

Time frame

ACTIVITIES	January			February				March					April				May				June		
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Evaluation of strategies in fracture modeling																							
Literature Review																							
Objective 1: Fracture modeling using provided borehole data																							
a) Analysis of the fracture geometry and setting up fracture sets																							
b) Defining the fracture geometry based on statistical laws																							
c) Modeling of the fracture density for each fracture set																							
d) Building of the fracture model																							
e) Upscaling of the fractures into a 3D model of porosity and permeability																							
Objective 2: Sensitivity analysis																							
Objective 3: Fracture modeling driven by seismic attributes																							
a) Derive seismic attributes suitable for fault detection																							
b) Setup strategies for identifying the fault pattern																							
c) Strategies for using the derived fault pattern in fracture modeling																							
Objective 4: Geomechanically driven fracture modeling																							
Objective 5: Comparison of the created fracture network mo																							
Summary and conclusion for each chapter																							
Preliminary draft																							
Corrections and final review																							
Final report and submission																							

THANK YOU
FOR YOUR ATTENTION!

Detailed Structural Mapping of a Thick Sequence of Syn-Rift Deposits in the Kerpini Fault Block, Greece.

Student: Espen Sigmundstad
Supervisor: Chris Townsend
Co-Supervisor: Alejandro Escalona

Universitetet i Stavanger

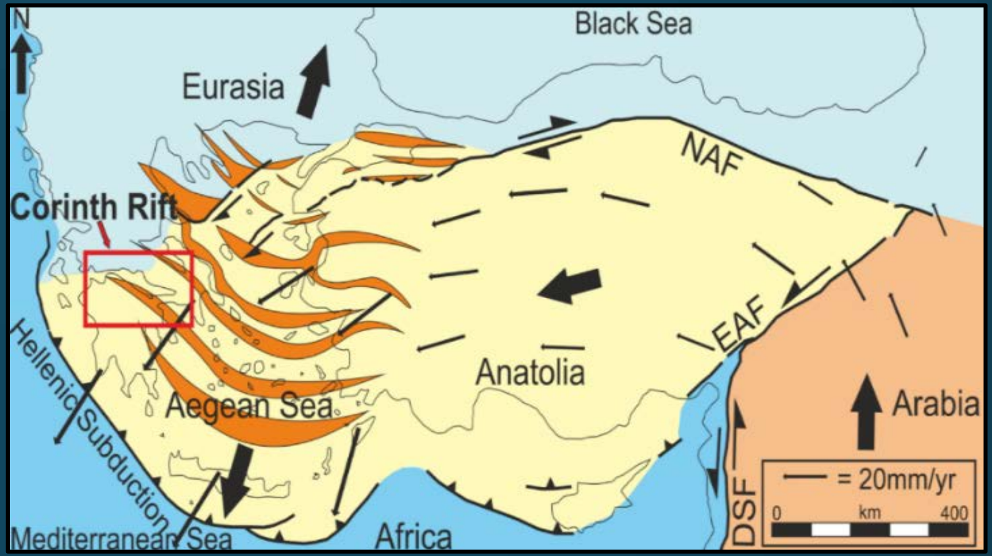
Project Overview

- Kalavrita, Greece

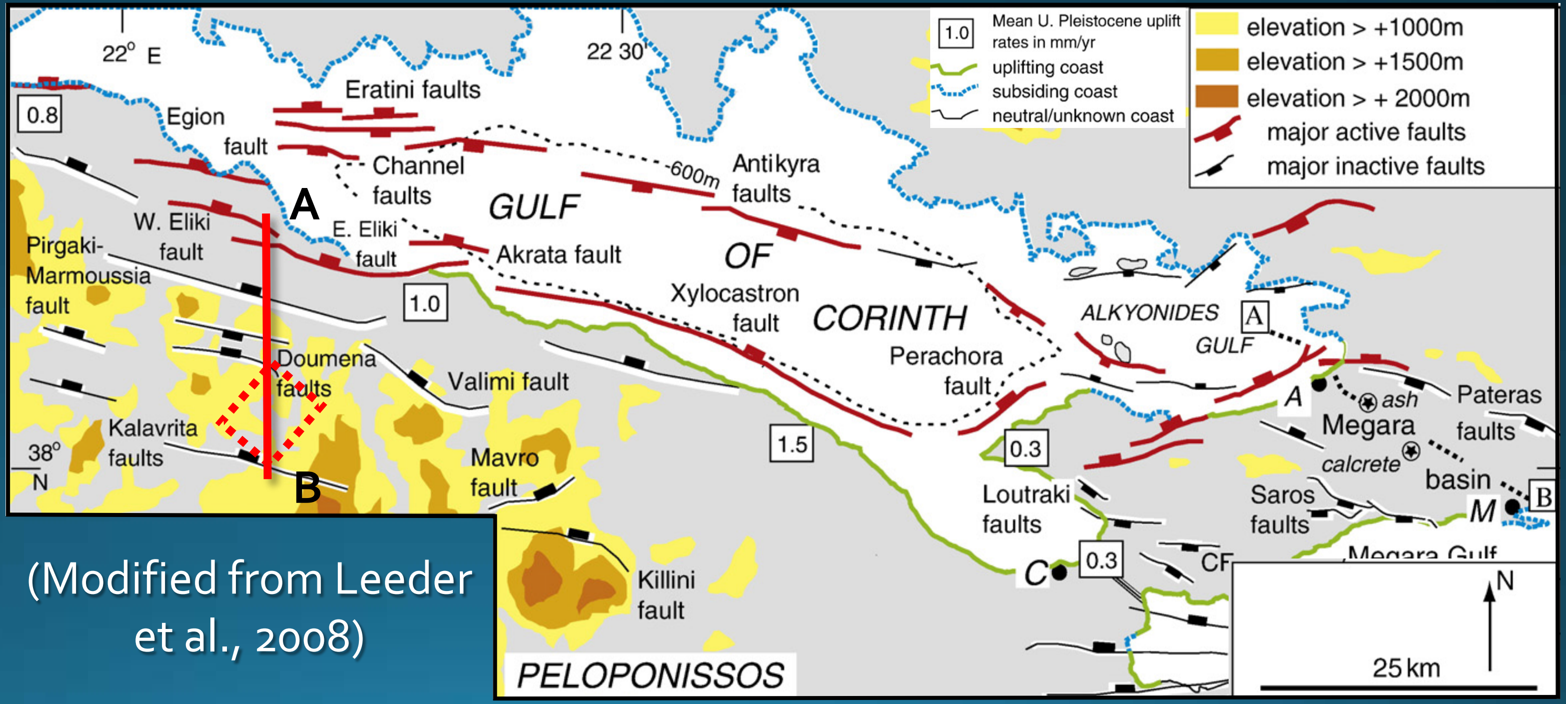
(Google, 2015)

Project Overview

- Kalavrita, Greece
- Kerpini Fault Block
- Syn- rift deposits
- Previous work
- Advanced Mapping Methods
- Present day structure
- Tectonic evolution

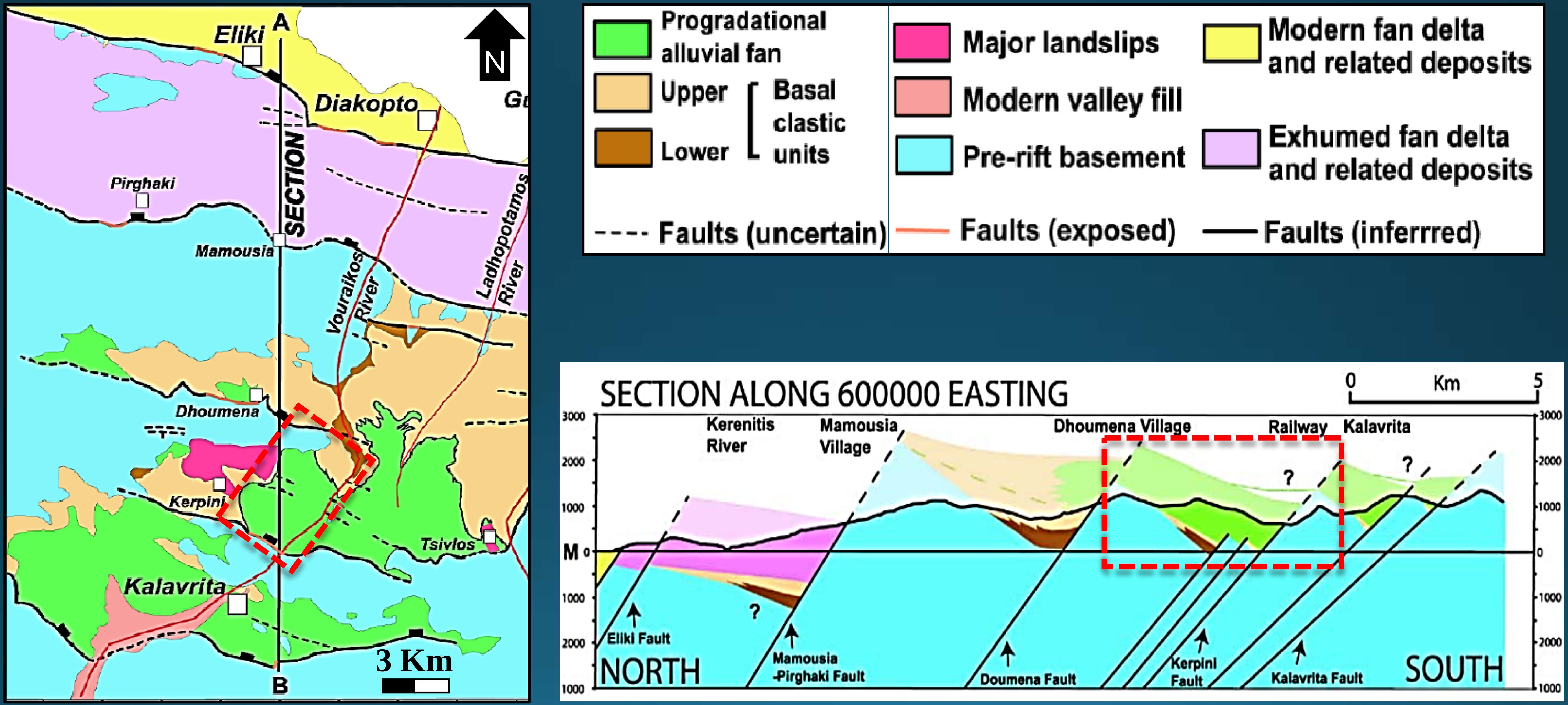


(Wood, 2013)



(Modified from Leeder et al., 2008)

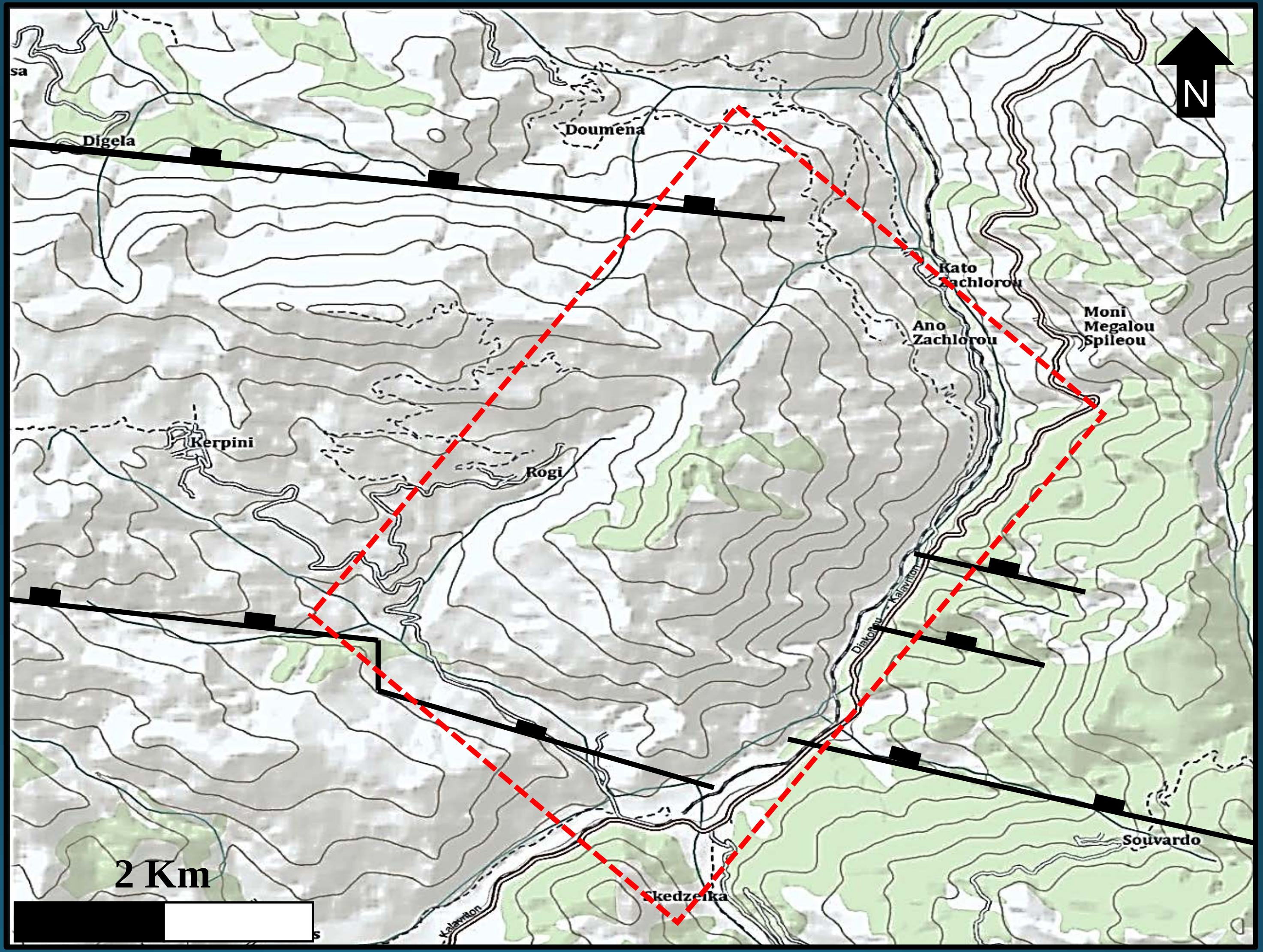
Geological Setting



(Modified from Collier & Jones, 2003)

Geological Challenges

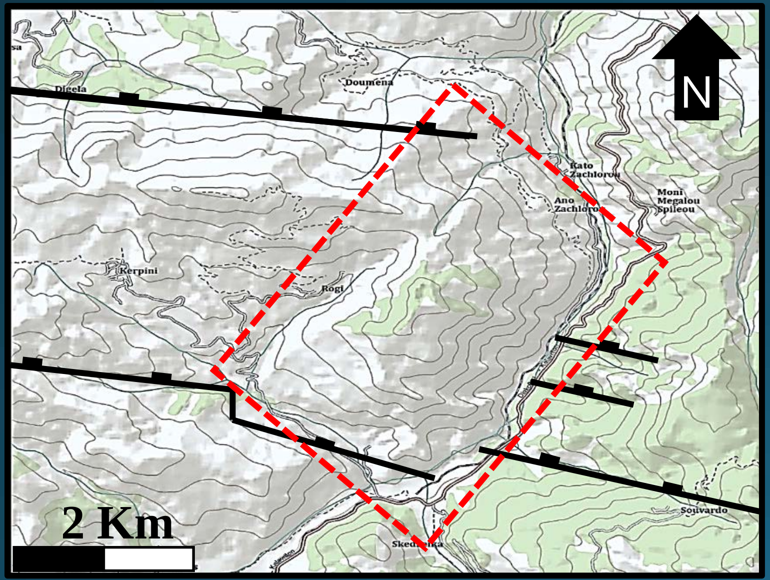
- Complex fault interactions



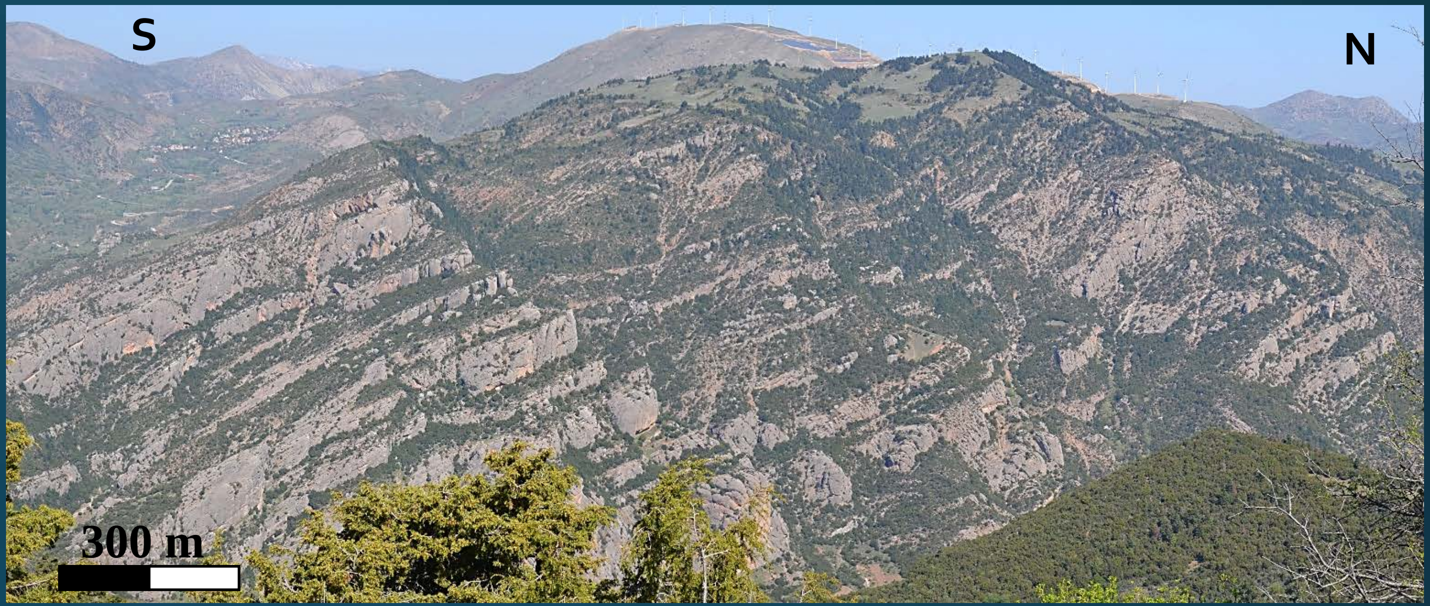
(GIS compilation by Sigmundstad, 2015)

Geological Challenges

- Complex fault interactions
- Rapid facies changes or faults?
- Lack of bed rotation
- Poor accessibility to outcrops



(GIS compilation by Sigmundstad, 2015)

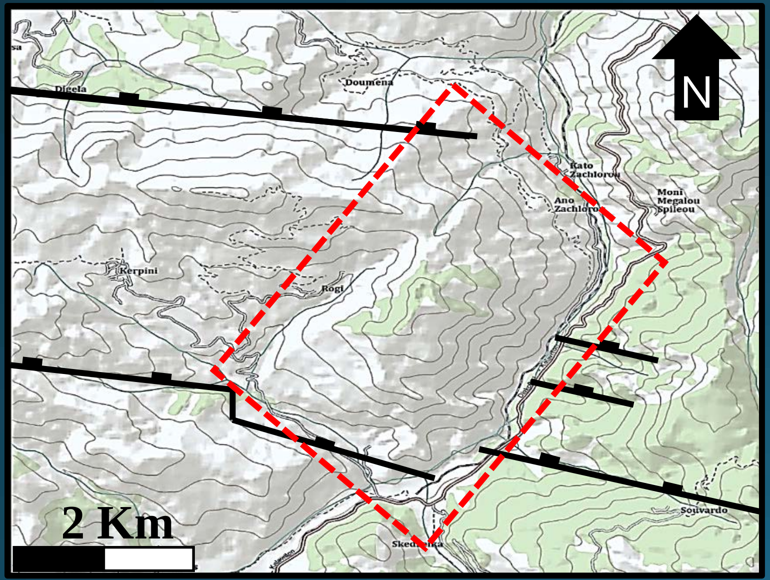


Eastern Profile

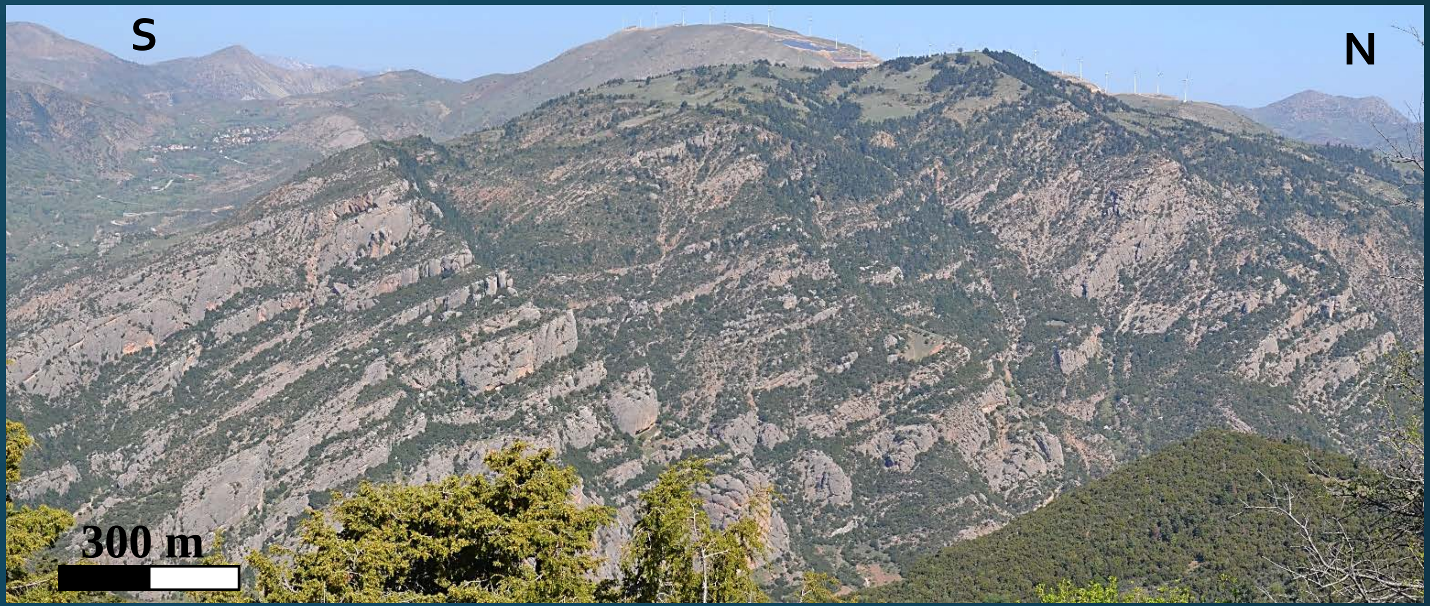
Western Profile

Geological Challenges

- Complex fault interactions
- Rapid facies changes or faults?
- Lack of bed rotation
- Poor accessibility to outcrops



(GIS compilation by Sigmundstad, 2015)



Eastern Profile

Western Profile

Geological Challenges

- Complex fault interactions
- Rapid facies changes
- Lack of bed rotation
- Poor accessibility to outcrops

Project Objectives

- 3D Structural model
- Tectonic evolutionary model
- Development of Kerpini Fault Block
- Understanding of rift systems

Dataset

<u>Light Detection And Ranging (LiDAR)</u>

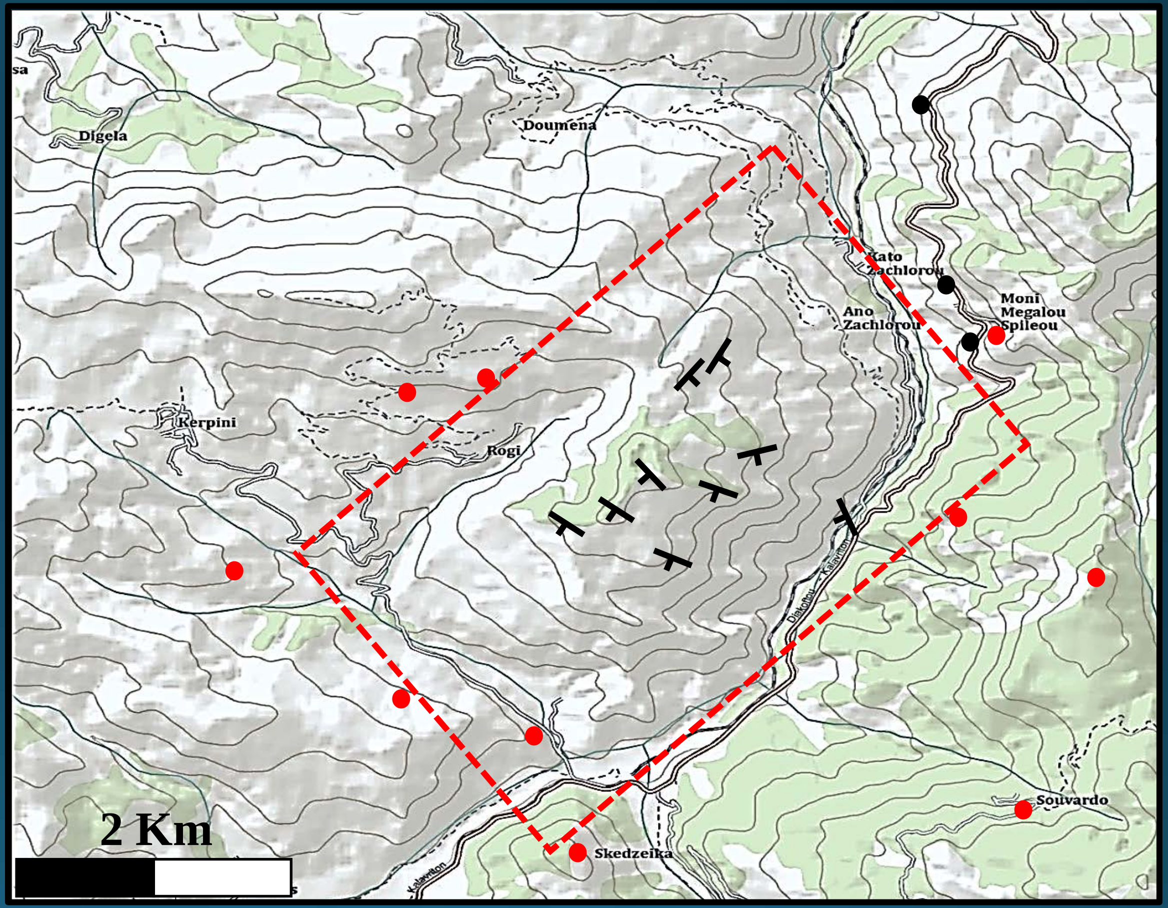
- 11.0901 km^2 area covered, collected and processed by the Heidelberg University in Germany.
- Three LiDAR scans were collected during fieldwork in August 2015.

<u>Photogrammetry</u>

- Approximately 5500 pictures collected during fieldwork.

<u>Dip Measurements and Mapping</u>

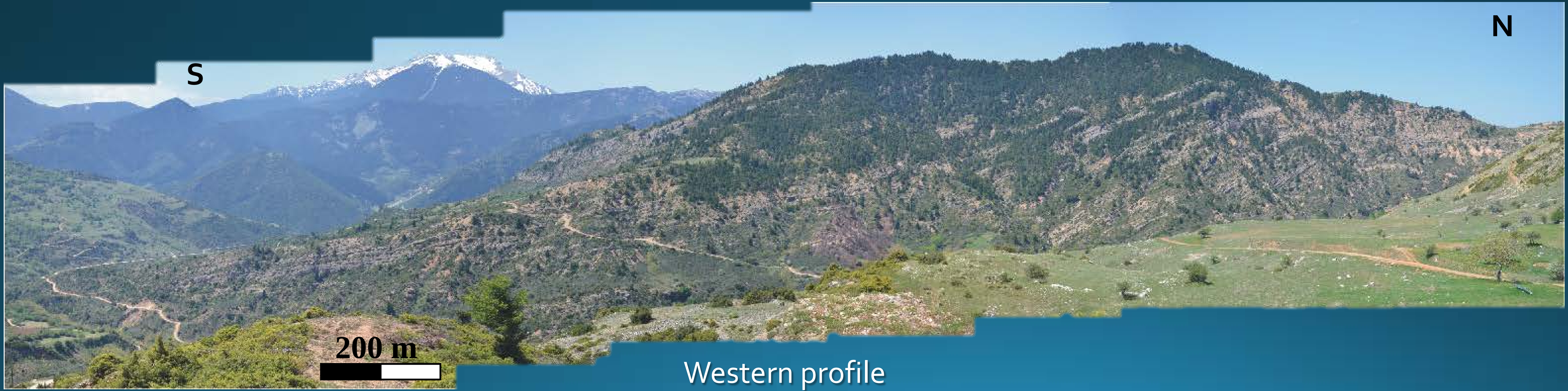
- Geological maps with dip- and dip-direction measurements.



(GIS compilation by Sigmundstad, 2015)

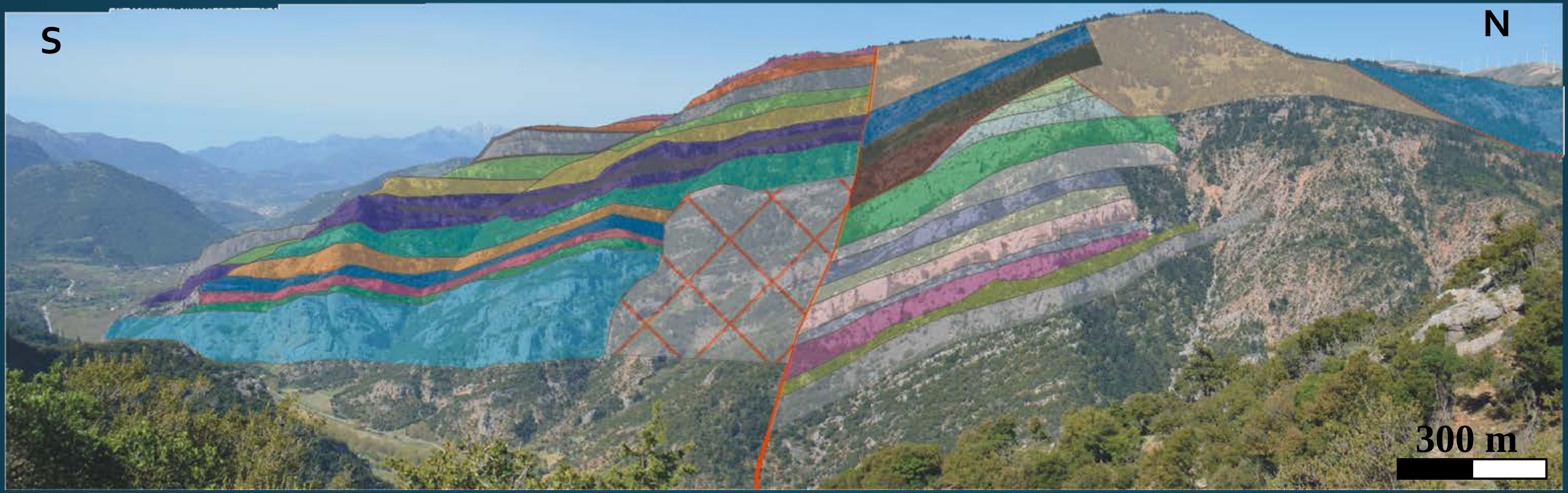
Methodology

Eastern profile



Western profile

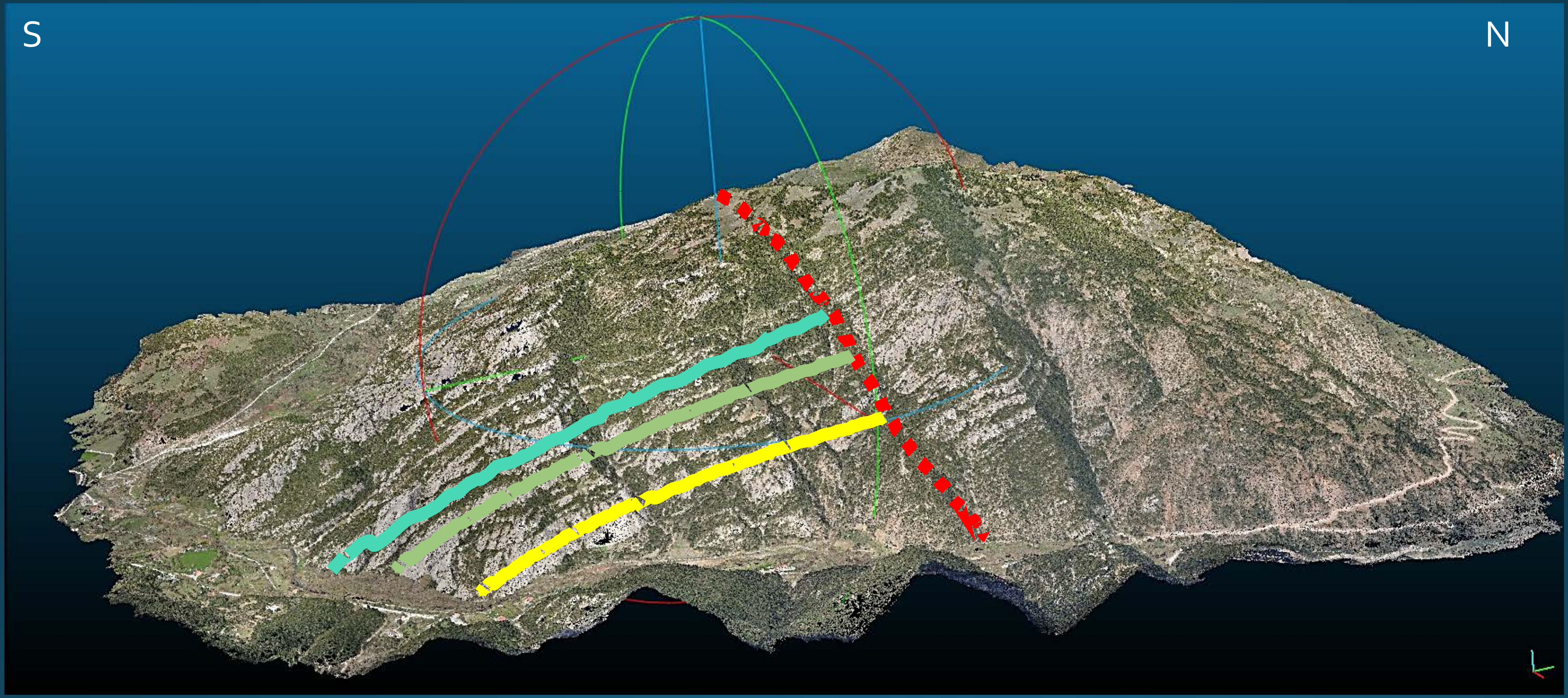
Methodology



Eastern profile

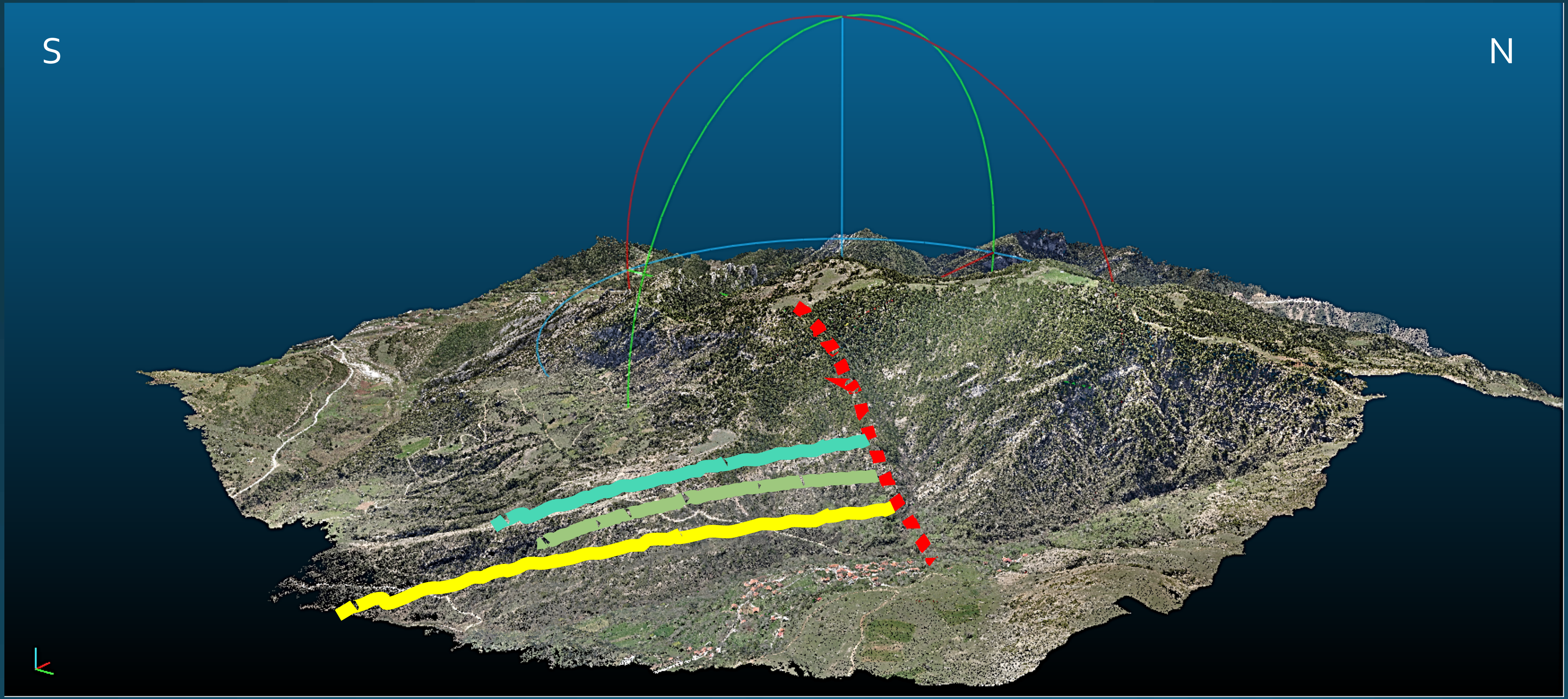
Western profile

Methodology



Eastern profile, LiDAR point cloud.

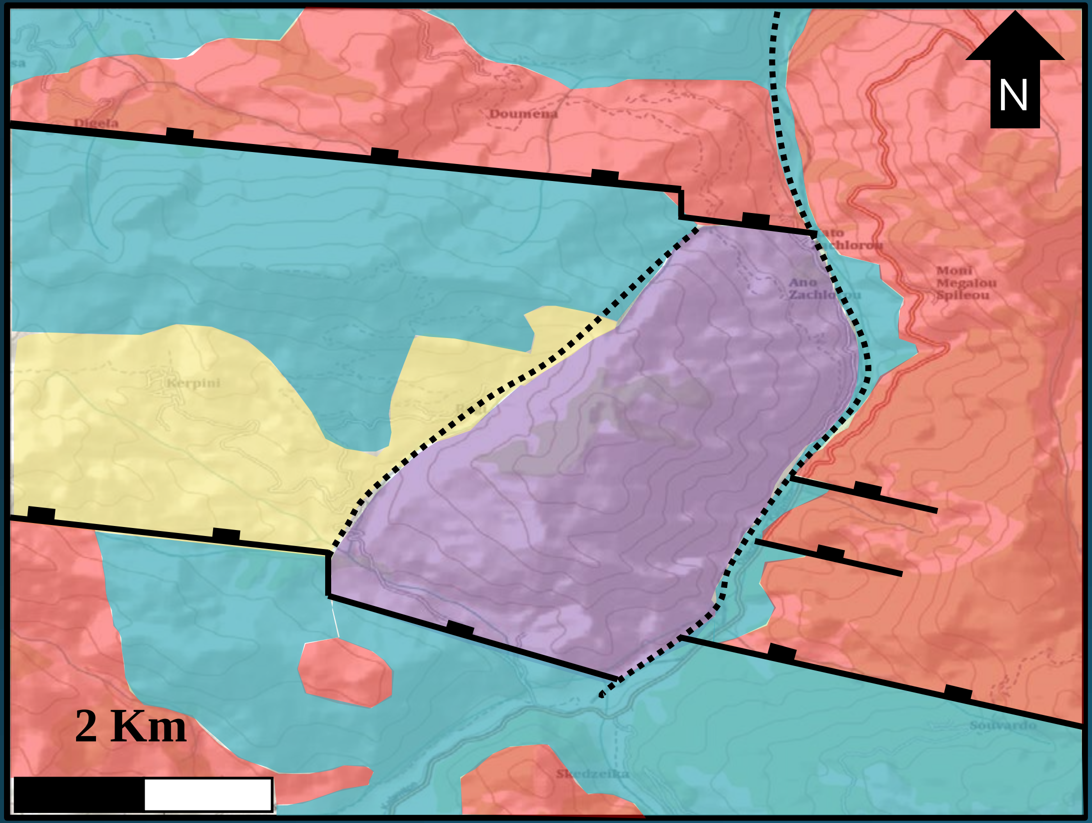
Methodology

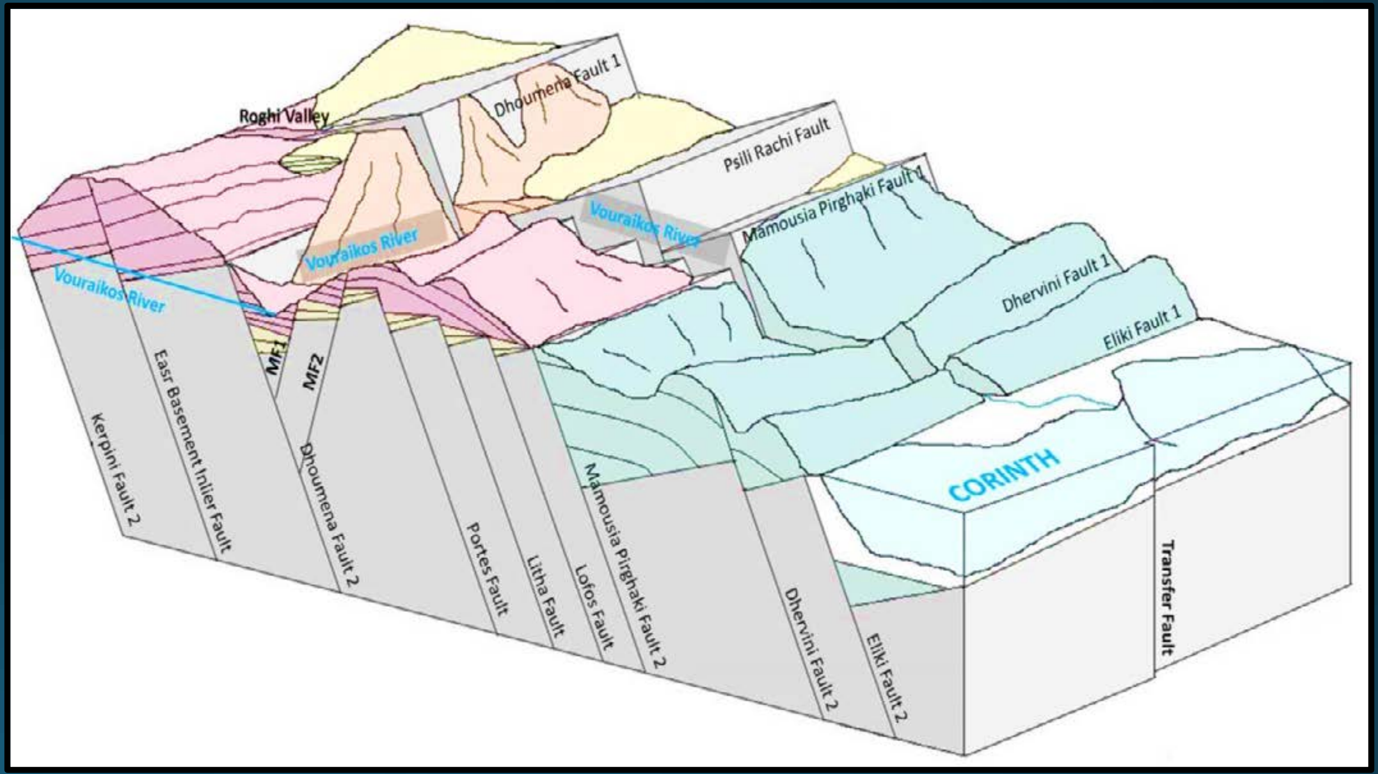


300 m

Western profile, LiDAR point cloud.

Methodology





(Dahman, 2015)

Roghi Sediments:

Kerpini Sediments:

Basement:

Fault:

Proposed Fault:

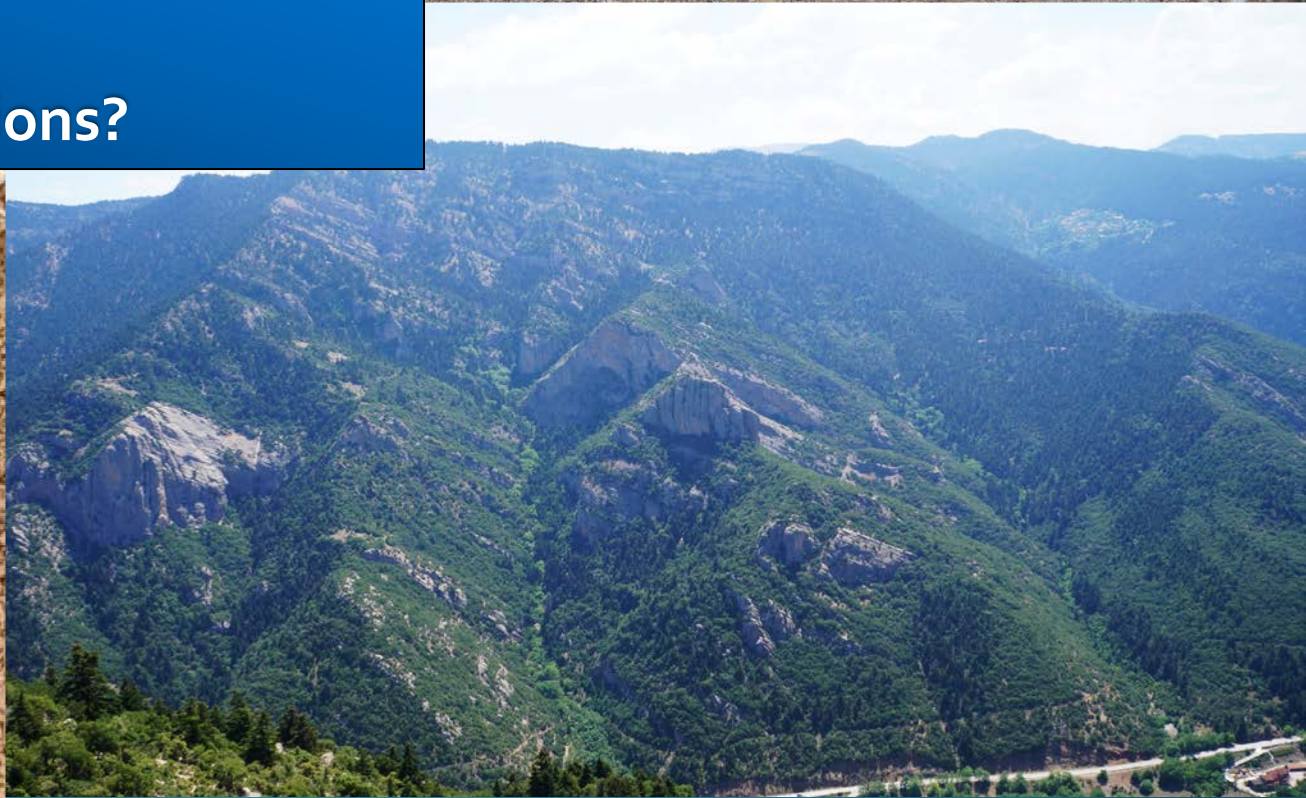
Sediments:

Timeframe

Activity	2015														2016											
	June		July		August		September		October		November		December		January		February		March		April		May		June	
Literature Review	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
Field Work Preparation	■	■	■	■																■	■					
Field Work					■																	■	■			
Field Data Analysis						■	■	■	■	■	■	■	■	■									■			
Software Acquisition and Familiarization								■	■	■	■	■	■													
Interpretation and Modelling													■	■	■	■	■	■	■	■	■	■				
Thesis Writing											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Submit Thesis																										■


Thank you for your attention!

Questions?

Case Study of Roghi Mountain (Achaea, Greece) — Mapping and modelling of facies development within an alluvial sequence

By: Stian Seglem Bjåland
Supervisor: Chris Townsend
Co-supervisor: Alejandro Escalona

University of Stavanger

Presentation overview

- Objectives
- Geological Framework
- Previous Work
- Data
- Methodology
- Timeframe
- Summary

Eastern Section

Western Section

Objectives

Primary Objective:

- Constructing a evolutionary tectono-sedimentological facies model
- Construct detailed facies models in rapidly varying environment

Secondary Objective:

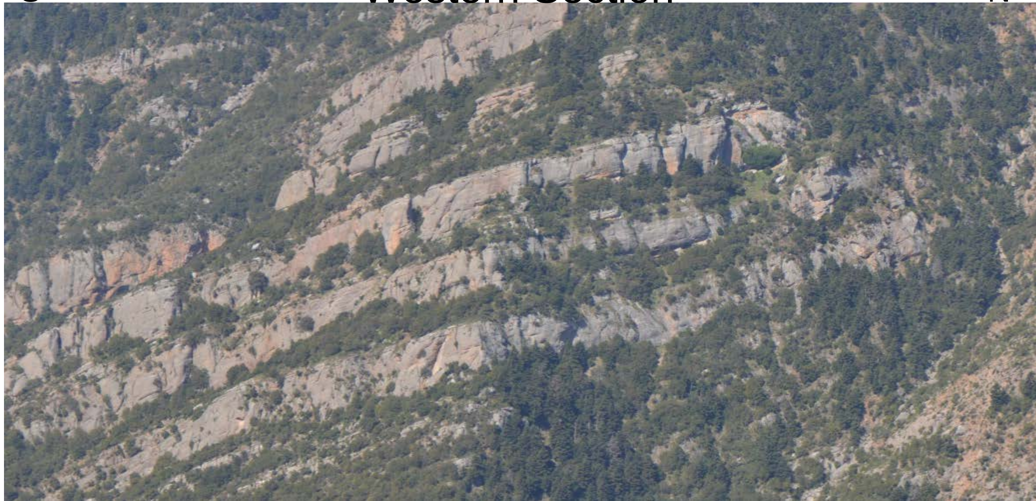
- Correlation of facies changes based on pseudo-wells.

Research Questions:

- Can facies and facies changes be mapped from LiDAR data?
- What were the processes behind the deposition of the alluvial sequence, and from where was it sourced?

S Eastern Section N

S Western Section N

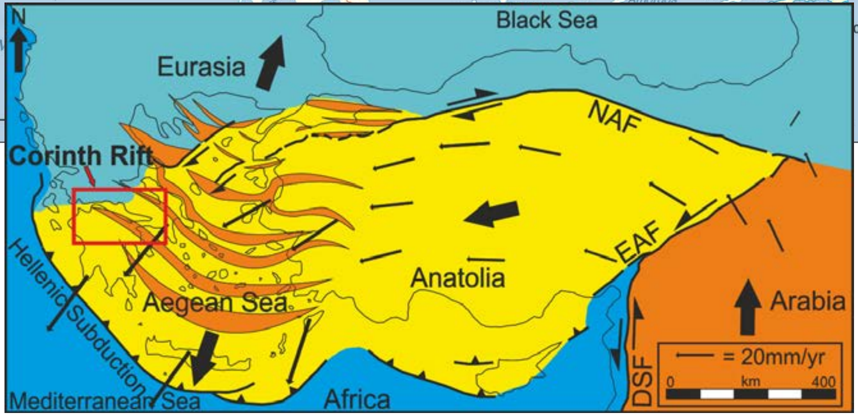


Geological Framework

Regional Geology

- Gulf of Corinth
- Rifting started in Miocene times
- North Anatolian Fault
- Hellenic Subduction Zone
- Subduction of African plate

- Causes include;
  - Gravitational collapse of crust inherited from earlier orogens
  - Lithospheric thinning in the Aegean back arc region

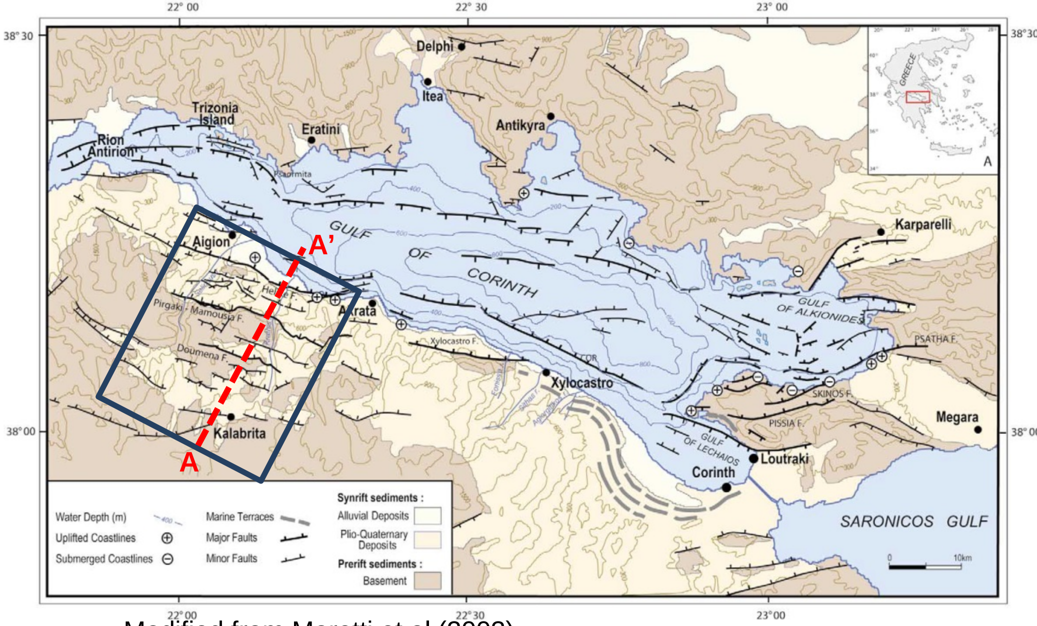


Modified from Armijo et al.(1999)

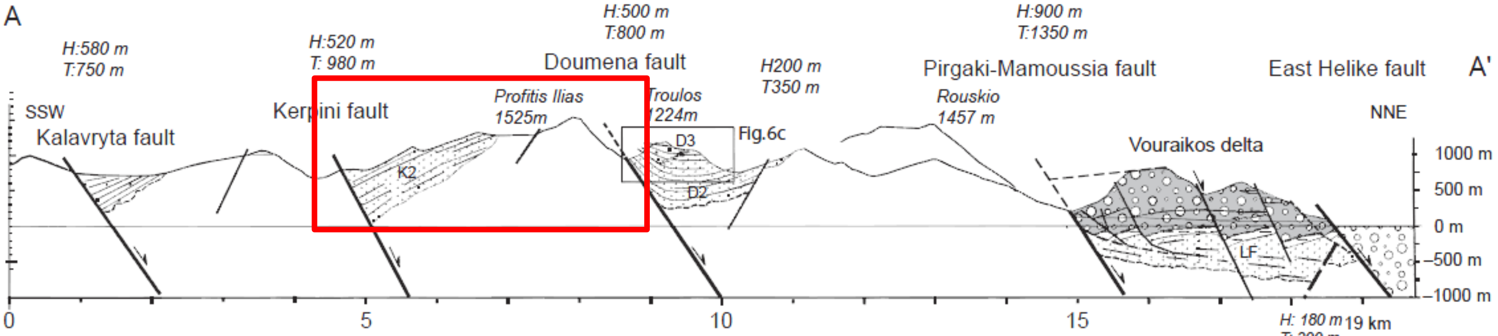
Geological Framework

Study area

- Northern part of the Peloponnese Peninsula
- Southern section of the Corinth rift
- Series of rotated normal fault blocks
- Roghi Mountain located within the Kerpini Fault Block (KFB)
- Thick alluvial package
- Poor accessibility to outcrops



Modified from Moretti et al.(2003)



Modified from Ford et al.(2013)

Previous Work

Regional

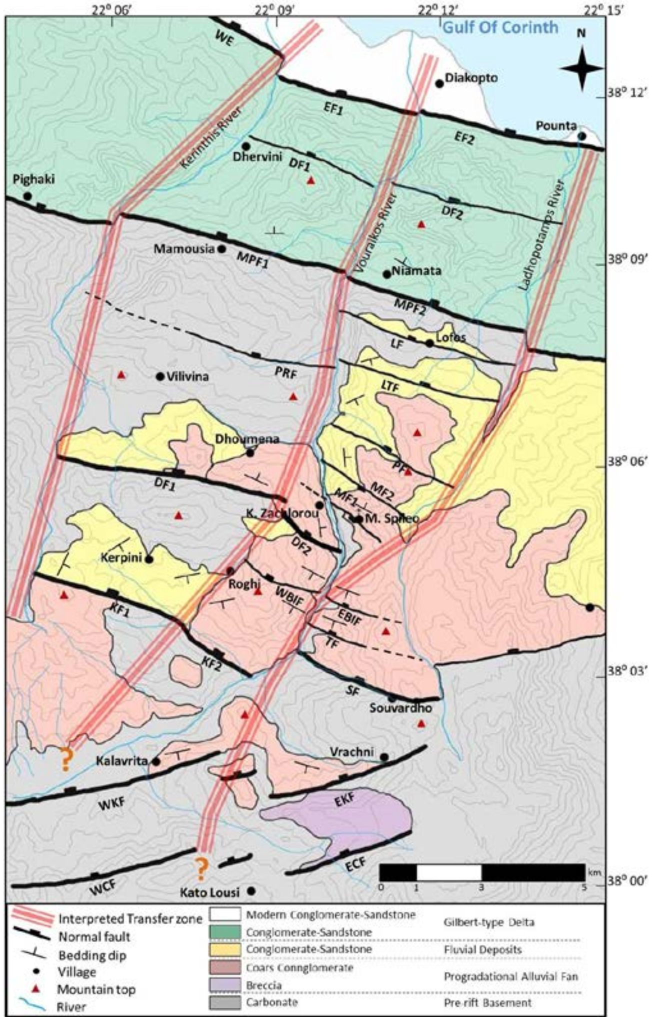
- The geological evolution of the Gulf of Corinth has been an area of interest for decades, it is thus well understood.

The Kerpini Fault Block has;

- not previously been the focus of detailed studies
- in previous studies been defined as syn-sedimentary basal conglomerates(Ford et al., 2013 and Wood, 2013)

In recent years UiS has performed case-studies of the region:

- Dahman(2015)
- Rognmo(2015)
- Stuvland(2015)
- Syahrul(2014)



Source: Dahman (2015)

Data

Light Detection and Ranging(LiDAR)

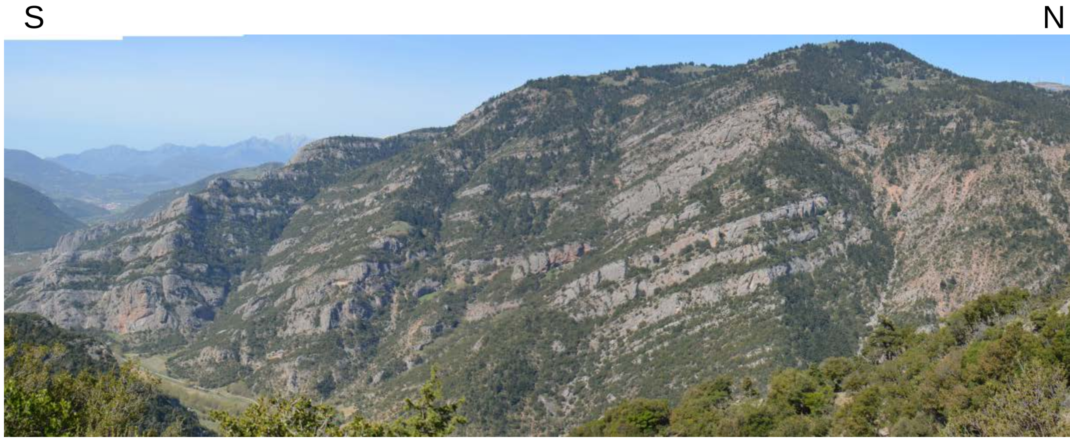
- April 2015: Ruprecht-Karls-Universität-Heidelberg
- August 2015: University of Stavanger

Photogrammetry

- ~ 7000 images

- Outcrop descriptions
  - Clast type and composition
  - Roundness and grain-size
  - Strike and dip
  - Changes in facies

- Pseudo-wells



Methodology - LiDAR

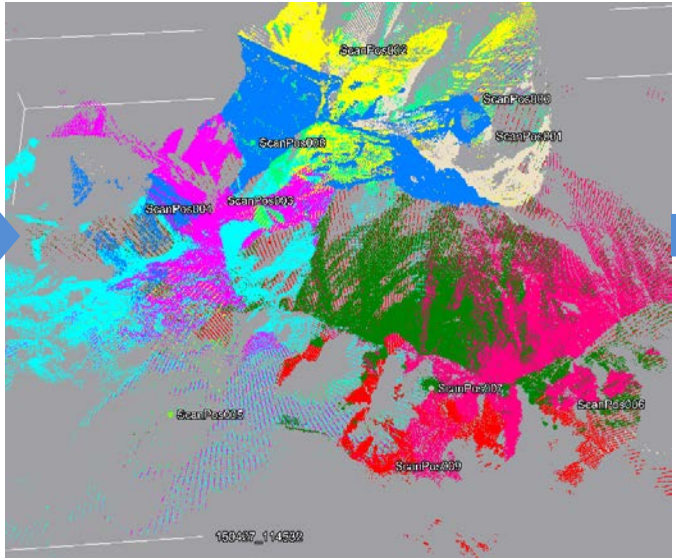
Creation of RiSCAN-project

Loading of data from scan-positions

- GPS-data
- Photos
- LAS-data
- QCing data

Processing of data

- MSA
- Vegetation-filter
- Undistorting photos
- Texturing
- QCing data



Methodology – Facies models

Creation of Petrel-project

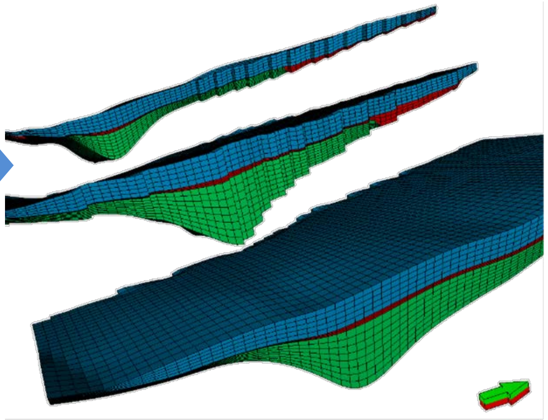
- Plugin: PointCloudViz by Mirage

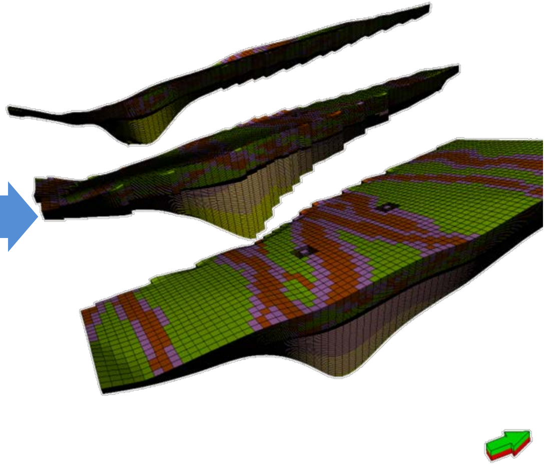
Loading of data

•LAS-file
•WGS-grid
•Point-Pyramid
•QCing data

Processing of data

- Creation of DEM
- Structural Model
- Facies Model





Timeframe

	August		September		October		November		Desember		January		February		March		April		May		June
Date	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-14	14-28	1-15	16-31	1-15	16-30	1-15	16-31	1-15
Deadlines																					
1st Draft															01.mar						
1st Draft Feedback																15.mar					
2nd Draft																			01.mai		
2nd Draft Feedback																				15.mai	
Application registration									01.des												
Announcement of topic										15.des											
Final title/topic													01.feb								
Final submission																					15.jun
Excursion																					
1st excursion	6-23 aug																				
2nd excursion																		20.apr -	05.mai		
Activity																					
Literature study																					
Interpretation of photos																					
Creation of "well logs"																					
Dummy modelling																					
Processing																					
Merging of LiDAR																					
Processing of LiDAR																					
Creation of photogram.																					
Initial modelling																					
Final modelling																					
Writing																					
Introduction																					
Data																					
Methodology																					
Results																					
Discussion																					
Conclusion																					

Summary

Objectives:

- Construct a tectono-sedimentological facies model
- Come up with a plausible theory of how Roghi Mountain was deposited.

Roghi Mountain show rapid changes in facies both vertically and horizontally

Project is based on;

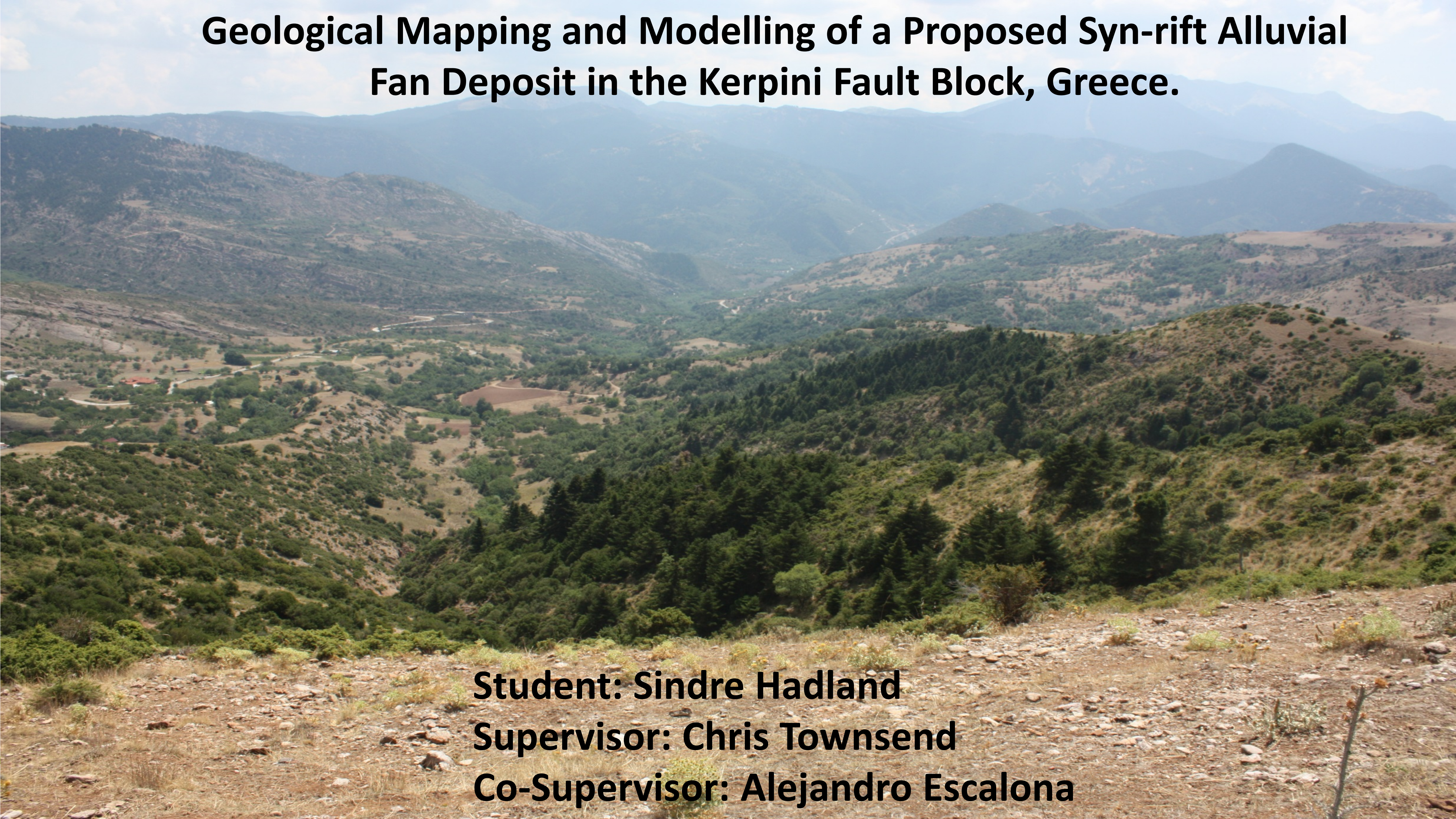
- previous studies performed by UiS
- data gathered during three fieldtrips
- LiDAR data gathered and processed by Uni-HD and UiS

THANK YOU FOR YOUR ATTENTION!

Questions?

University of Stavanger

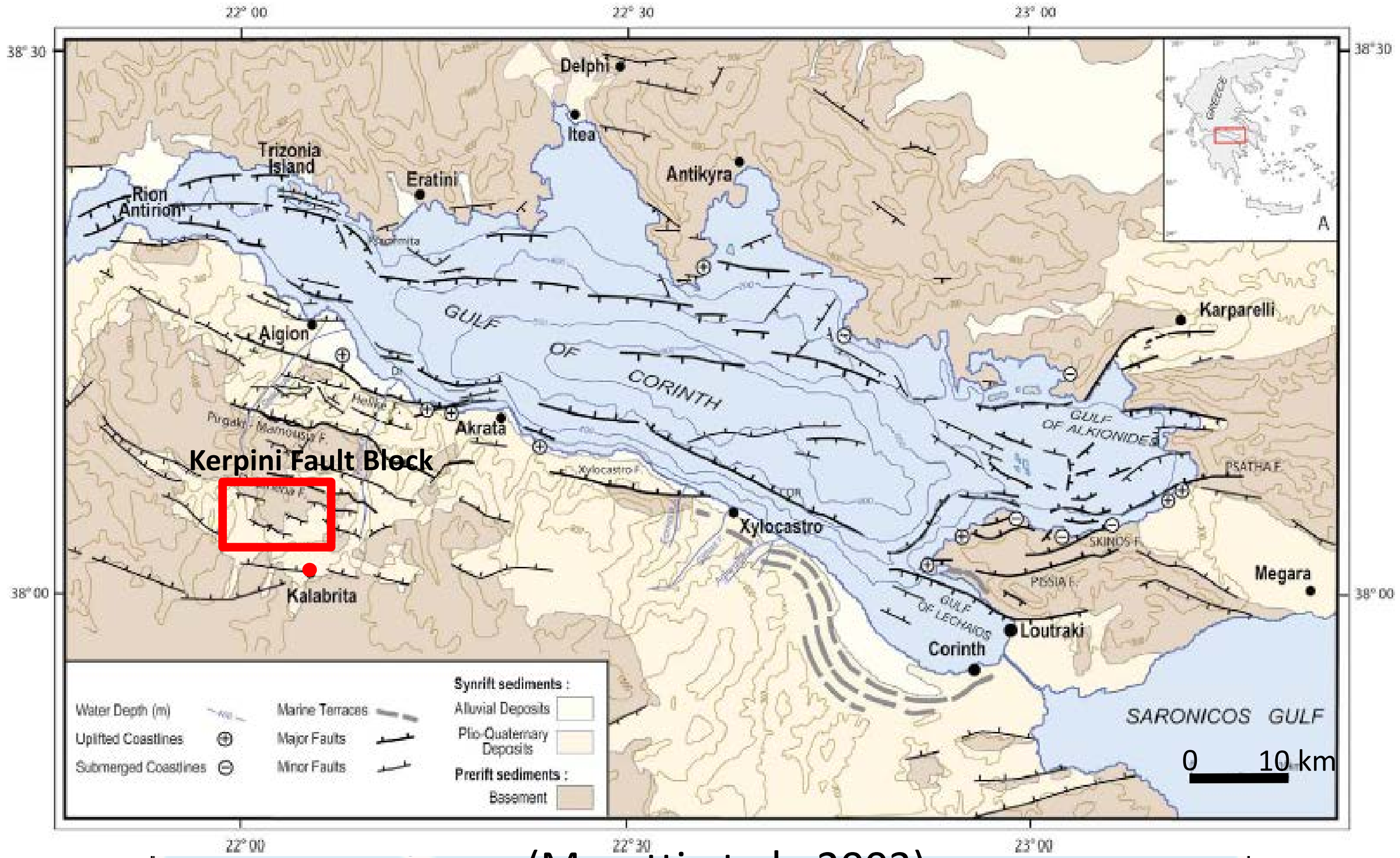
Geological Mapping and Modelling of a Proposed Syn-rift Alluvial Fan Deposit in the Kerpini Fault Block, Greece.



Student: Sindre Hadland
Supervisor: Chris Townsend
Co-Supervisor: Alejandro Escalona

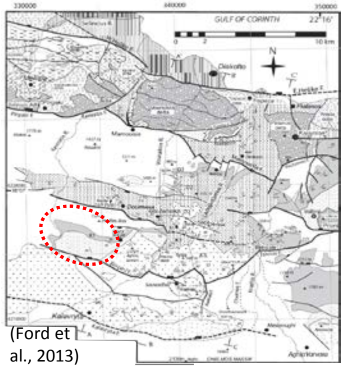
Project Overview

- Peloponnese peninsula, Greece
  - Three fieldtrips
- Western part of Kerpini Fault Block

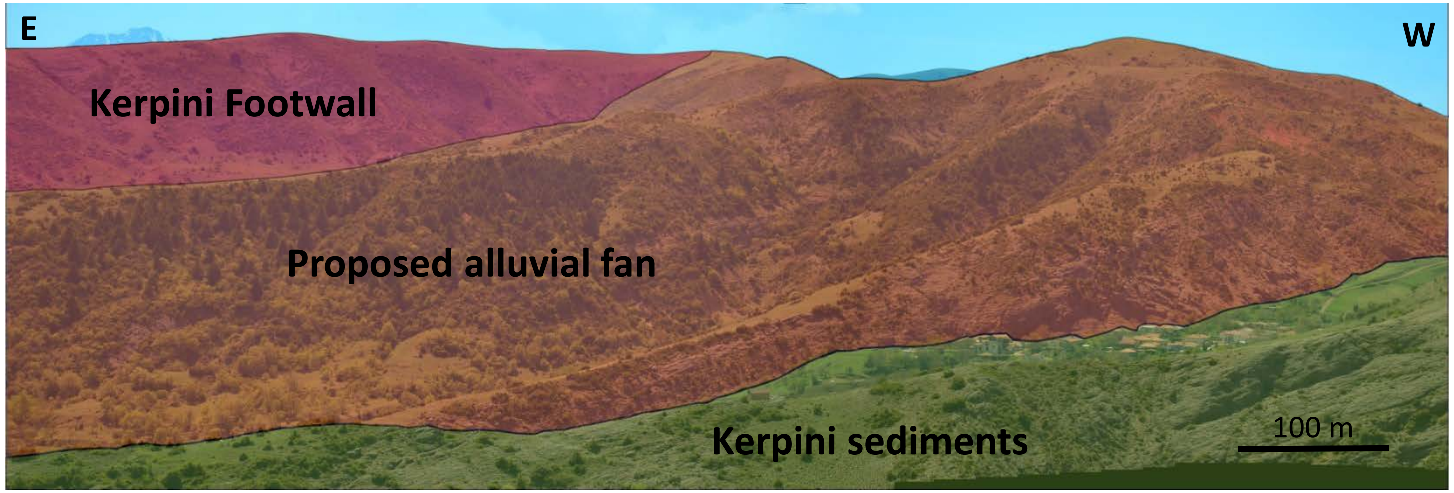


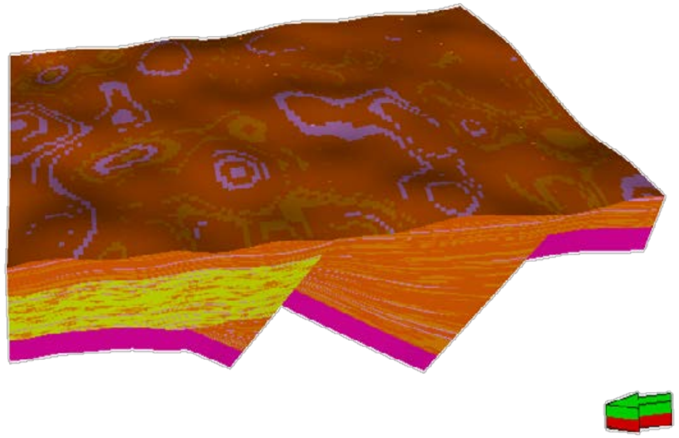
(Moretti et al., 2003)

Project Overview



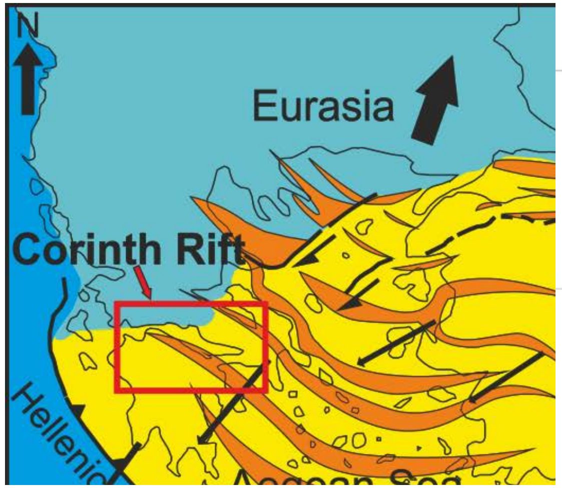
- Peloponnese peninsula, Greece
  - Three fieldtrips
- Western part of Kerpini Fault Block
- Contribute to better understanding of rift-systems and half-graben structures
  - From outcrops to geological models

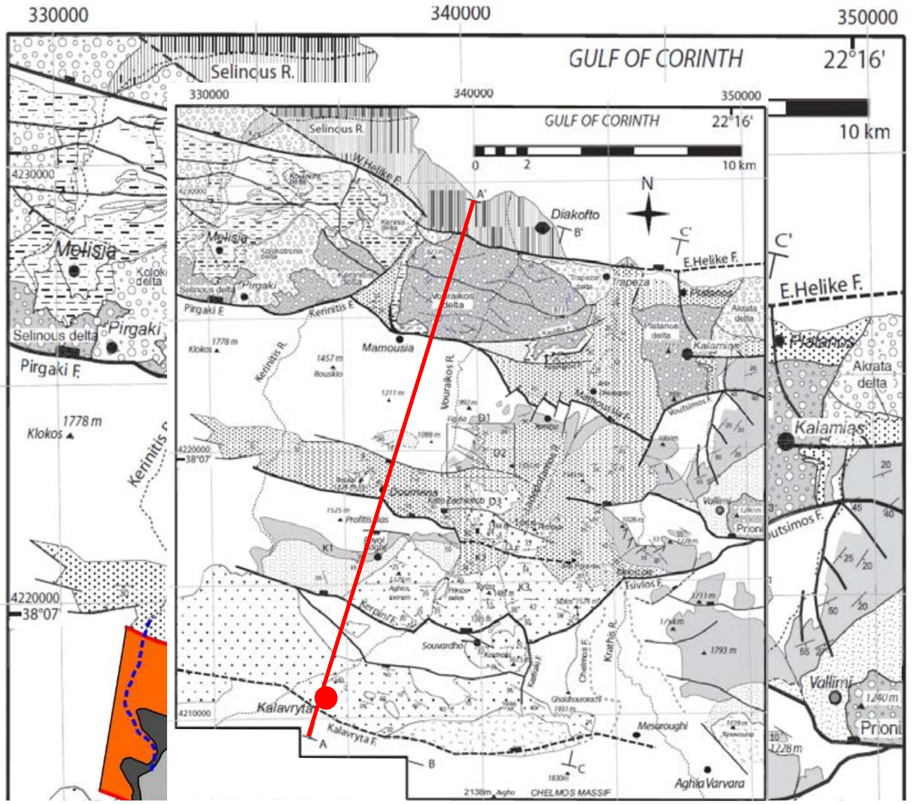




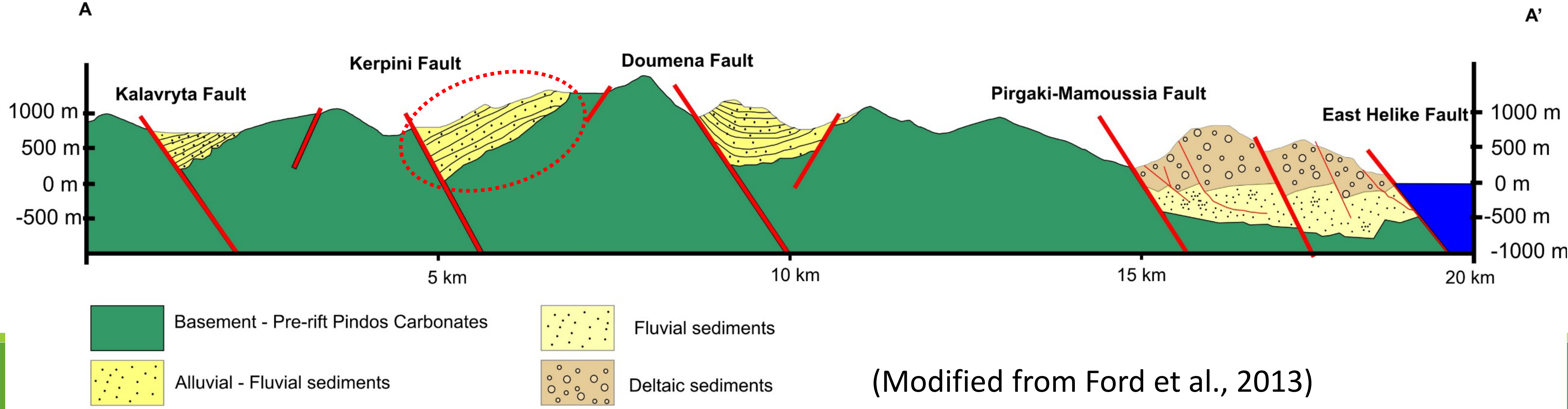
Geological Background

- Plate tectonics
  - Back-arc extension
- Structural framework
  - Half graben structures
- Stratigraphic framework
  - Syn-rift deposits
  - Terrestrial to marine





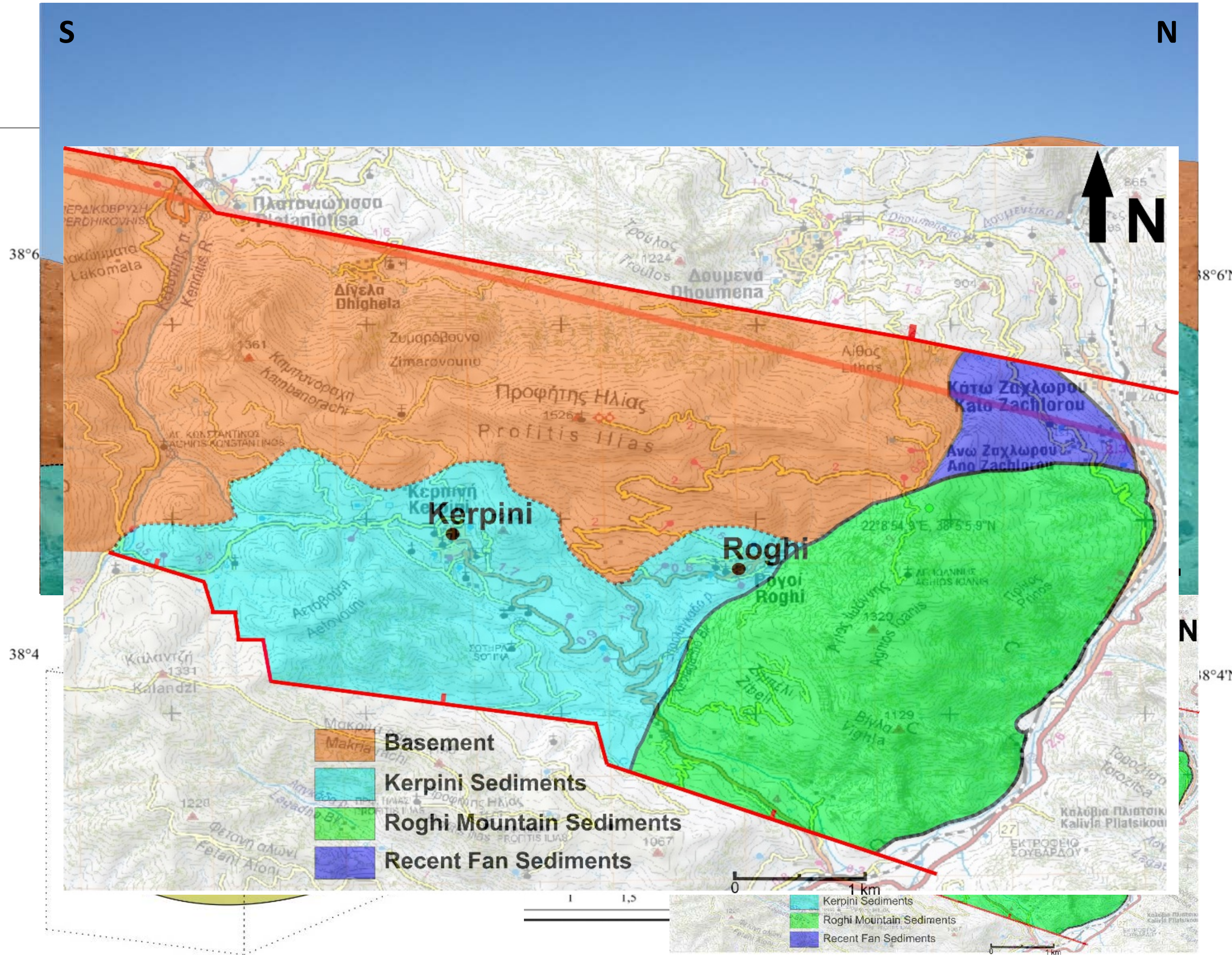
West Vouraikos-Doumena section A-A'



(Modified from Ford et al., 2013)

Geological Challenges

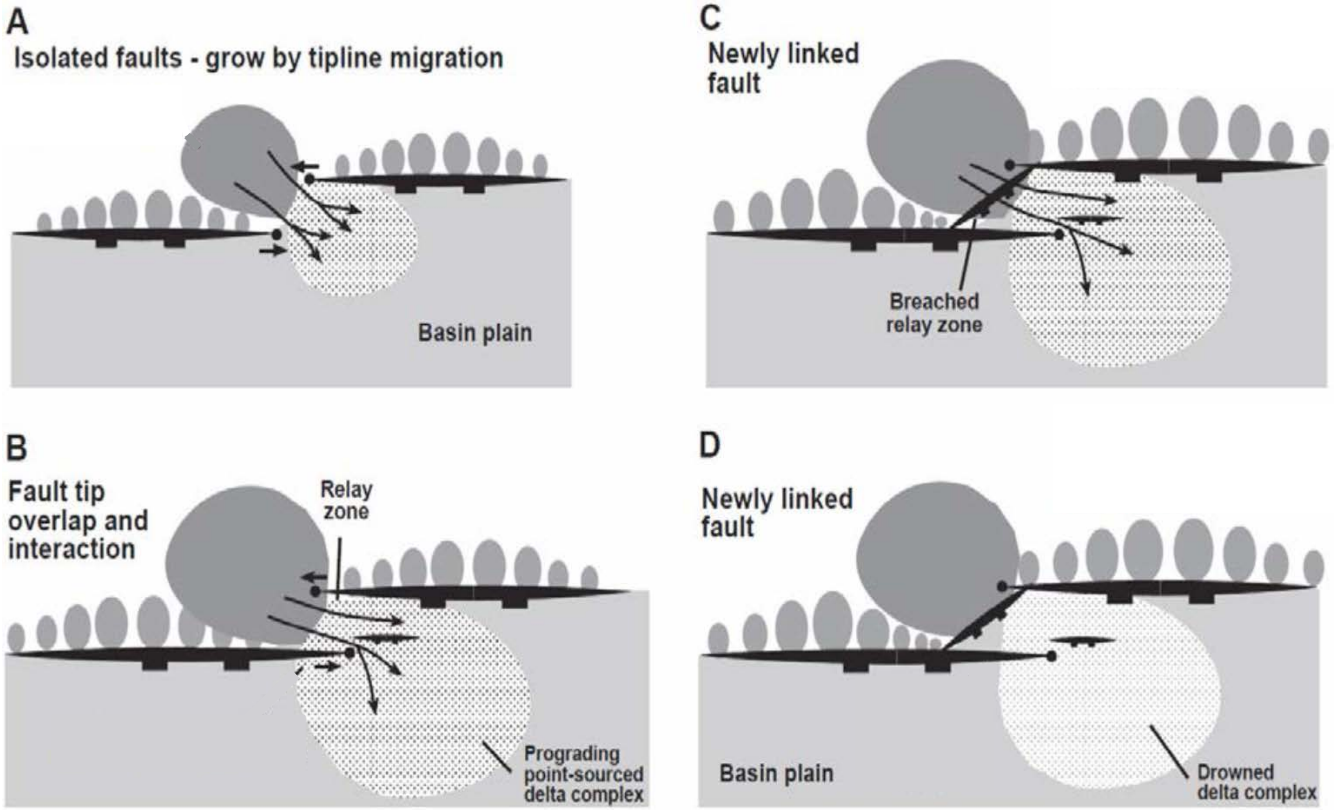
- Western Kerpini sediments
  - Individual fans?
  - Timing
- Kerpini Fault
  - Displacement – Constant?
  - Linkage



(Modified from Fossen, 2010) Syahrul, 2013

Objectives

- Determine:
  - Is it an individual fan?
- Understand:
  - The structural development of the Kerpini Fault
  - Structural control on the deposition of the proposed alluvial fan
- Develop:
  - Paleo drainage pattern of the Kerpini Fault Block

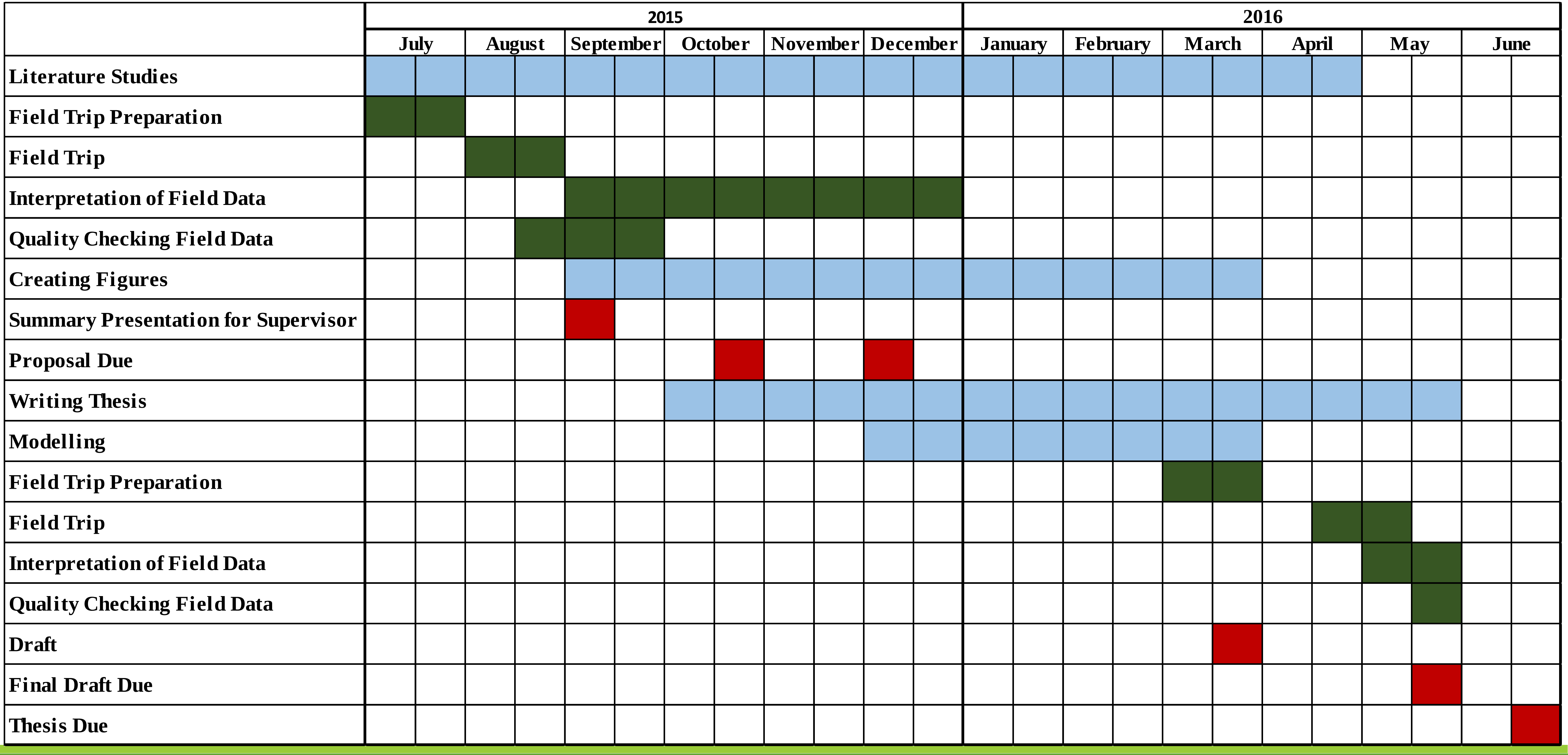


(Modified from Gupta et al., 1999)

Methodology

- Detailed mapping of Kerpini Fault
- Map and describe alluvial fan
    - Facies changes
    - Imbrication
- Facies and structural modelling
- LiDAR data
    - Explore the value

Timeframe



2015
2016
July
August
September
October
November
December
January
February
March
April
May
June
Literature Studies
Field Trip Preparation
Field Trip
Interpretation of Field Data
Quality Checking Field Data
Creating Figures
Summary Presentation for Supervisor
Proposal Due
Writing Thesis
Modelling
Field Trip Preparation
Field Trip
Interpretation of Field Data
Quality Checking Field Data
Draft
Final Draft Due
Thesis Due

Thank you for your attention! Questions?

Structural evolution and controls on fluviodeltaic sedimentary architecture in salt-influenced rift-basins:

Examples from the Triassic Nordkapp and Tiddlybanken basins

Master thesis proposal by Ine Reppen

Supervisors:
Rodmar Ravnås (Norske Shell/University of Stavanger)
Heather Campbell (Norske Shell)
Kerr Greenaway (Norske Shell)

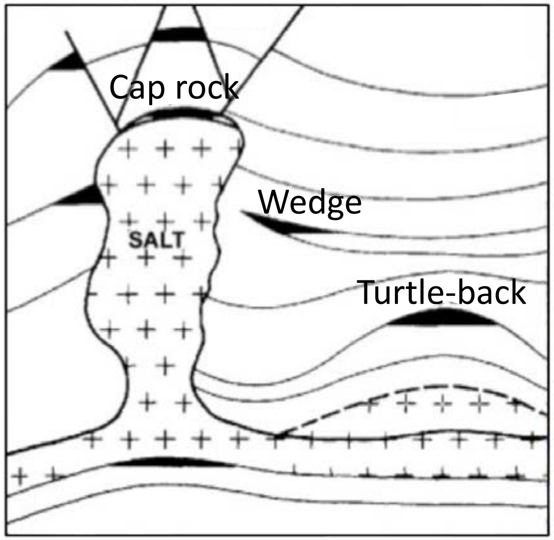
University of Stavanger

Agenda

- Introduction
- Objectives
- Geological Setting
  - Paleogeographic Reconstructions
  - Controlling Factors for Sedimentary Architecture
- Data
- Methodology
- Scope
  - Preliminary Observations
- Time Frame

Introduction

- Salt play an important role in exploration
- Examples are North Sea, Gulf of Mexico and Oman
- Tectonics and sedimentation
- Halokinesis:
  - Creates traps
  - Influence reservoir and source rock distribution
  - Create or destroy seal and trap
- Timing of salt movement – prospectivity of salt related basins
- Nordkapp and Tiddlybanken basins
  - Interest areas
  - Fluviodeltaic sediments



(Source: http://bit.ly/1e2MeZe)

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Objectives

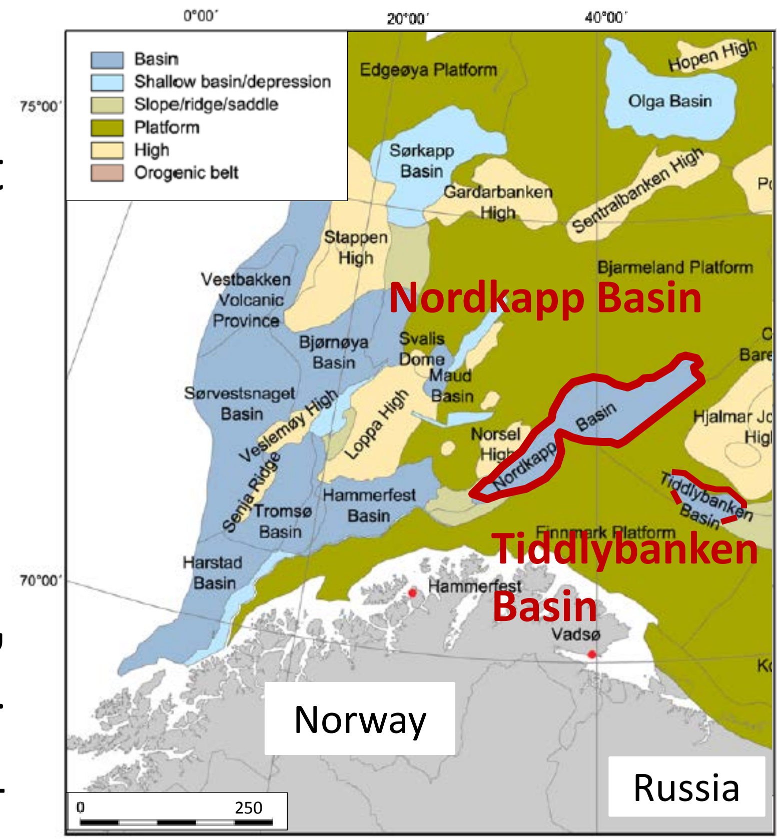
- To investigate the evolution of the fluvial successions
- To understand how the sediment supply, subsidence rates, and salt-wall growth interact and control the accommodation creation and sedimentation styles in salt mini-basins

Geological setting

- Characterized by several salt diapirs
- Major tectonic events controlled salt structure initiation, growth and reactivation

	Nordkapp Basin	Tiddlybanken Basin
Paleogene	Diapiric reactivation	?
Cretaceous	Reactivation of diapirs	?
Jurassic		?
Triassic	Diapiric growth Halokinesis	?
Permian	Salt deposition	?
Carboniferous		Salt deposition
Devonian	Rift basin	?

Regional subsidence



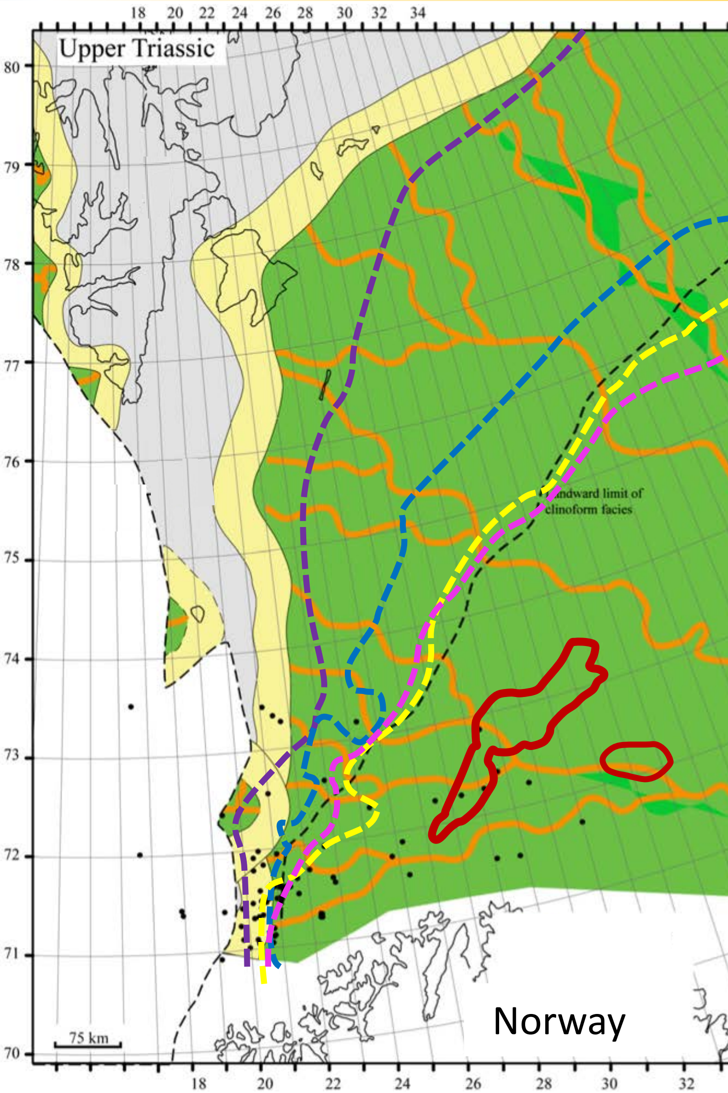
Modified after Henriksen et al. (2011)

- Development of Tiddlybanken basin is not well established

Paleogeographic reconstructions of Triassic

- Gradual sedimentary infill during Triassic
- Delta plain

- **Are the salt diapirs controlling the depostion in the Nordkapp and Tiddlybanken basins?**



Snadd Fm (Upper Triassic)
Mid Snadd (Ladinian–Early Carnian)
Kobbe Fm (Anisian–Early Ladinian)
Klappmyss Fm (Olenekian)
Havert Fm (Induan)

Shoreline location

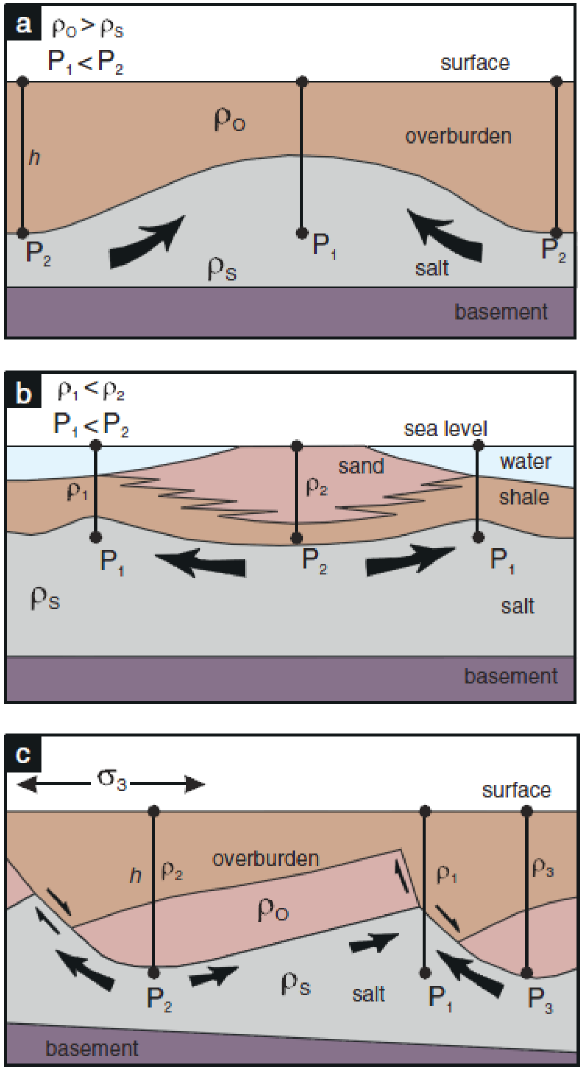
Modified after Glørstad-Clark et al. (2010)

Controlling factors for sedimentary architecture

- Mechanisms for initiation of halokinesis
  - a) Buoyancy driven
  - b) Differential loading
  - c) Extensional phase

- Reason for salt movement in the Barents Sea:
  - Regional tectonics
  - Loading of sediments

- Important for the evolution of the mini-basins
  - Reservoir and source distribution



Modfied after Banham and Mountney *(2013)*

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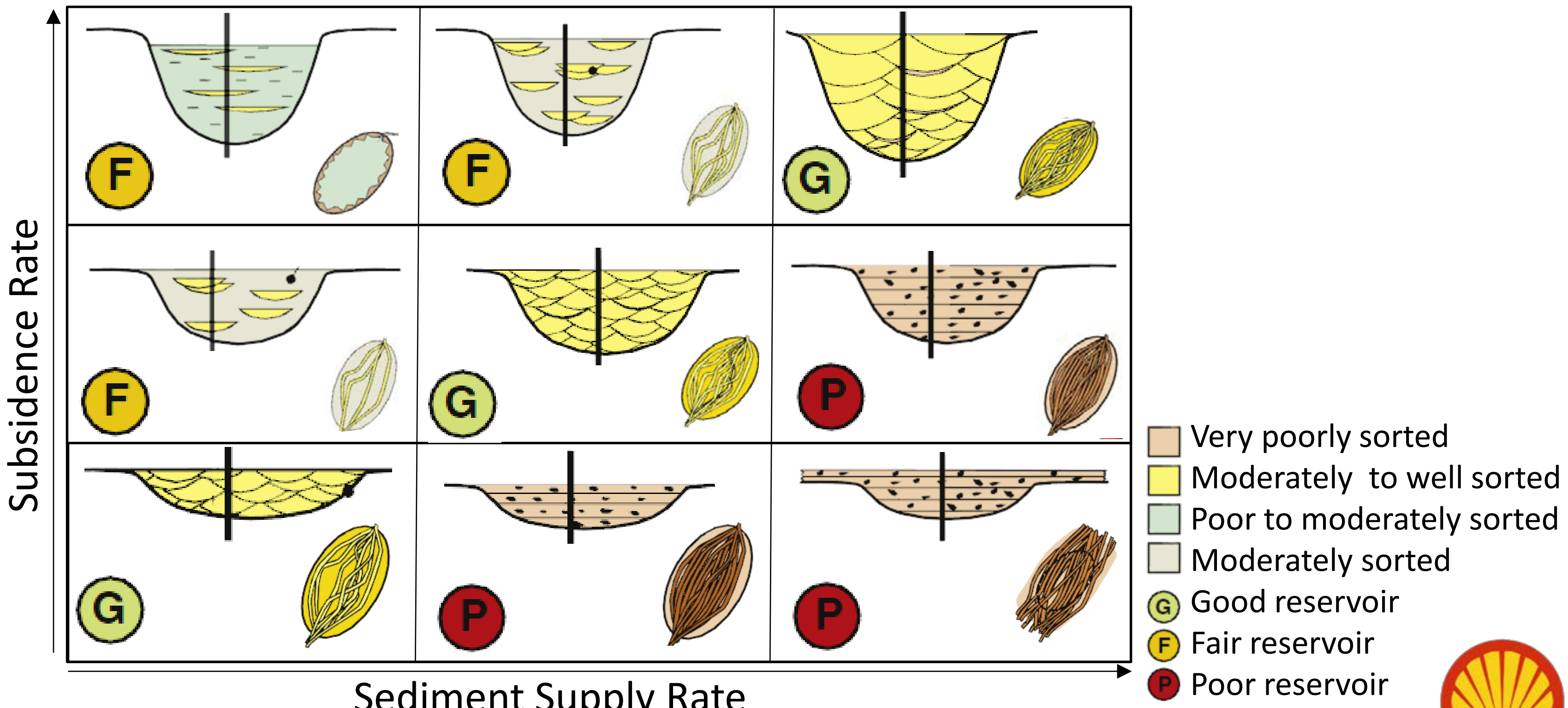
Controlling factors for sedimentary architecture

- Fluvial drainage pathways are a result of a combination of:
  - Sediment supply
  - Subsidence
  - Salt-wall growth



Modified after Banham and Mountney *(2013)*

Controlling factors for sedimentary architecture

- Fluvial drainage pathways are a result of a combination of:
  - Sediment supply
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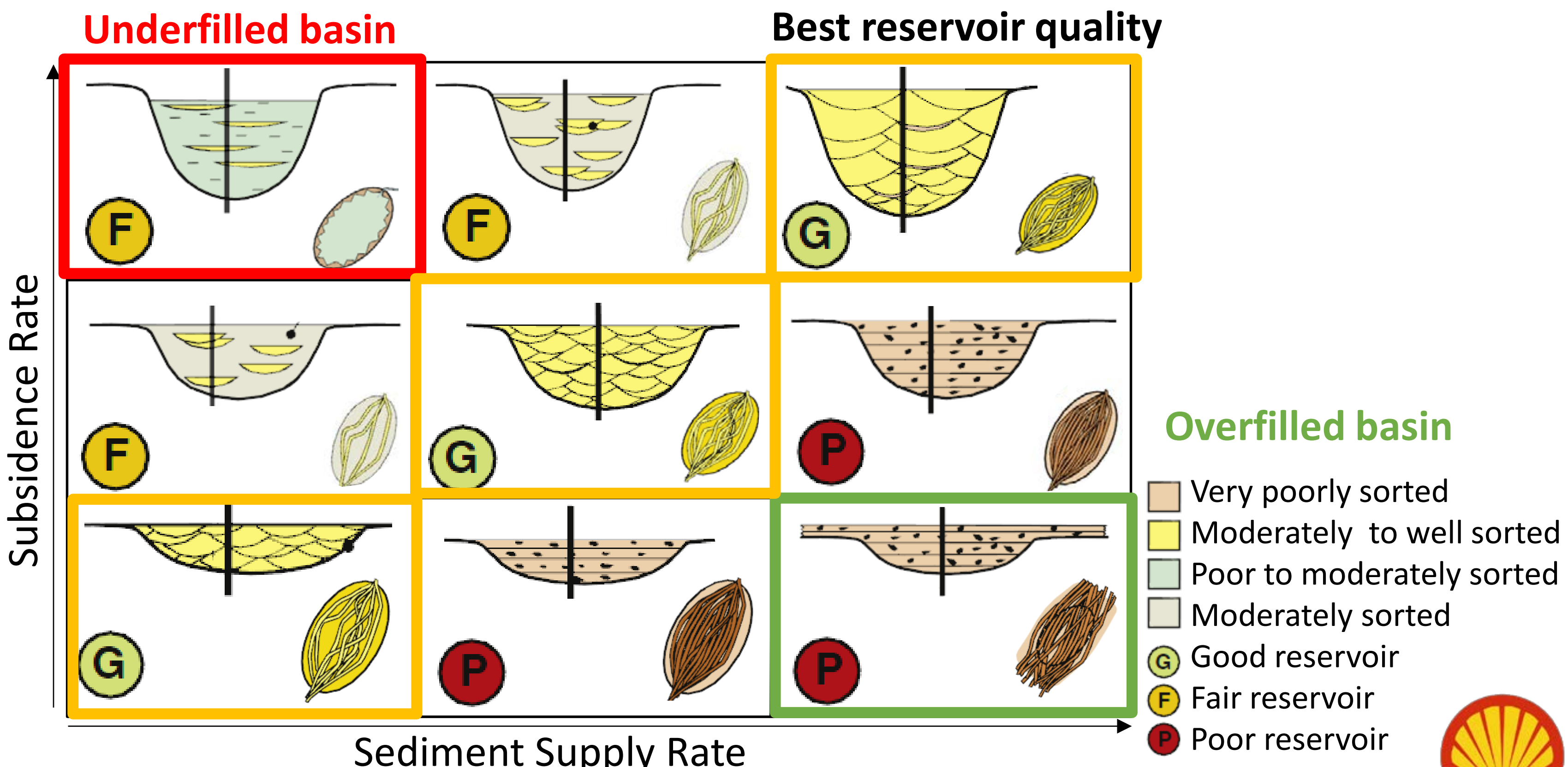

Modified after Banham and Mountney *(2013)*

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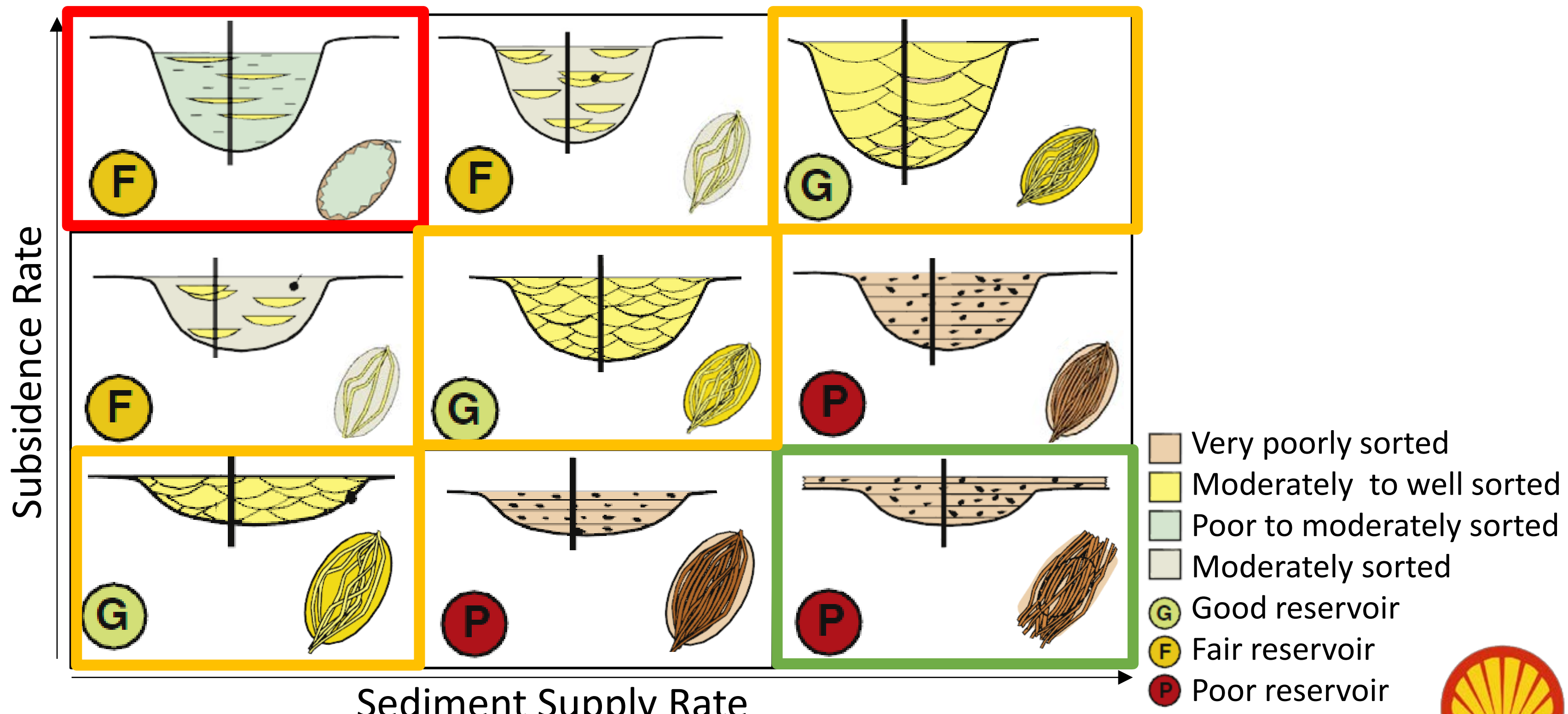
Controlling factors for sedimentary architecture

- **What are the controlling parameters for the basin infill styles in the Nordkapp and Tiddlybanken basins?**



Modified after Banham and Mountney *(2013)*

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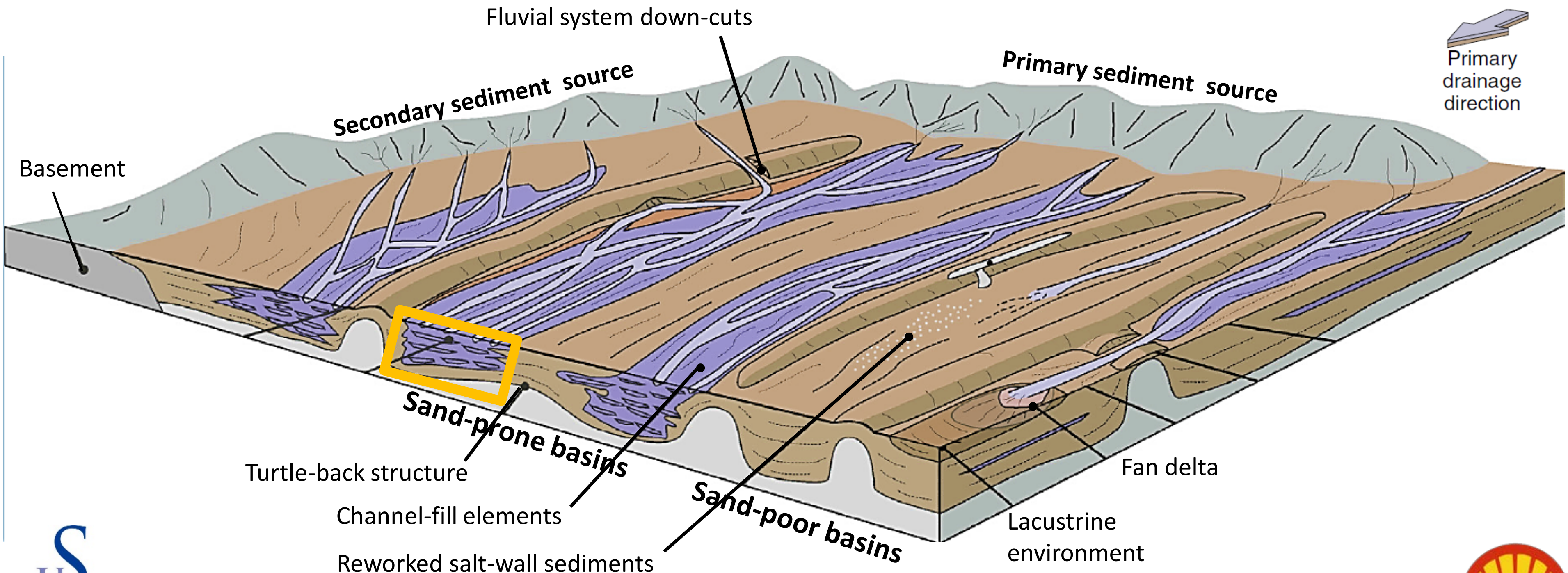
Controlling factors for sedimentary architecture

- Rim synclines
- Topographic lows
- Mini-basins

Style of fluvial interaction with salt walls and subsiding mini-basins



Modfied after Banham and Mountney *(2013)*

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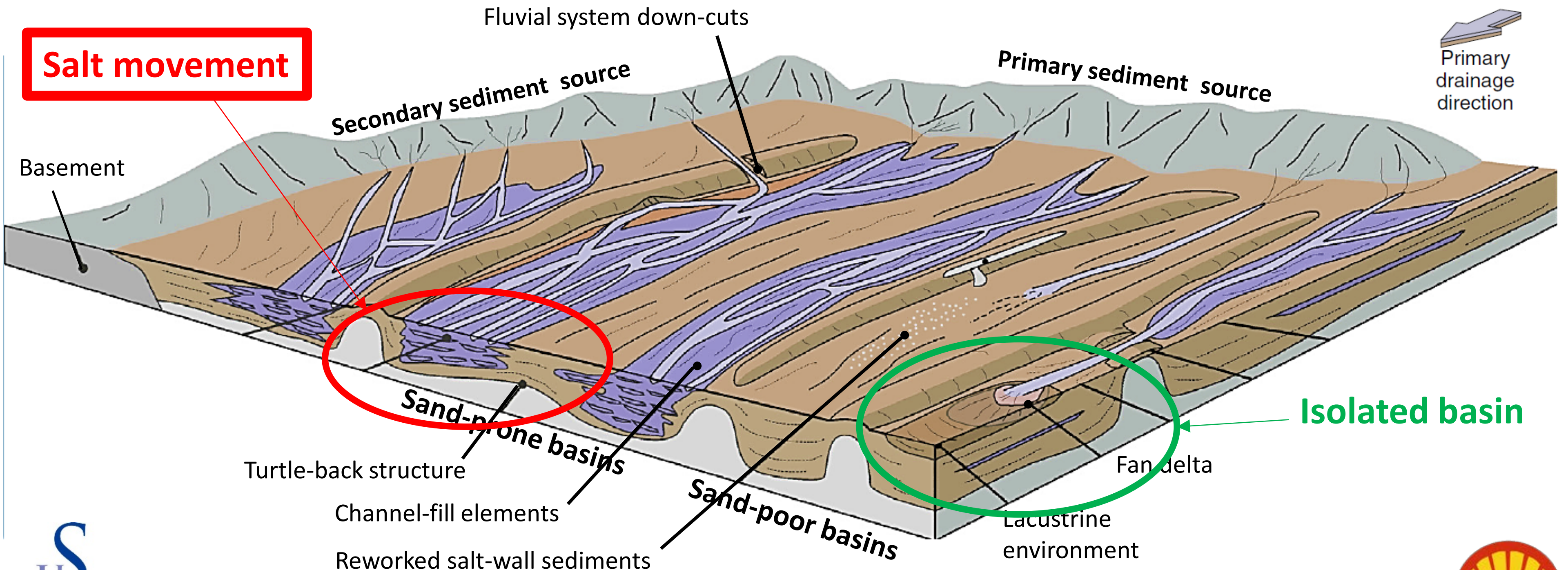
Controlling factors for sedimentary architecture

- Isolated and/or neighboring basins
- Feding systems
- Explore primary control parameters

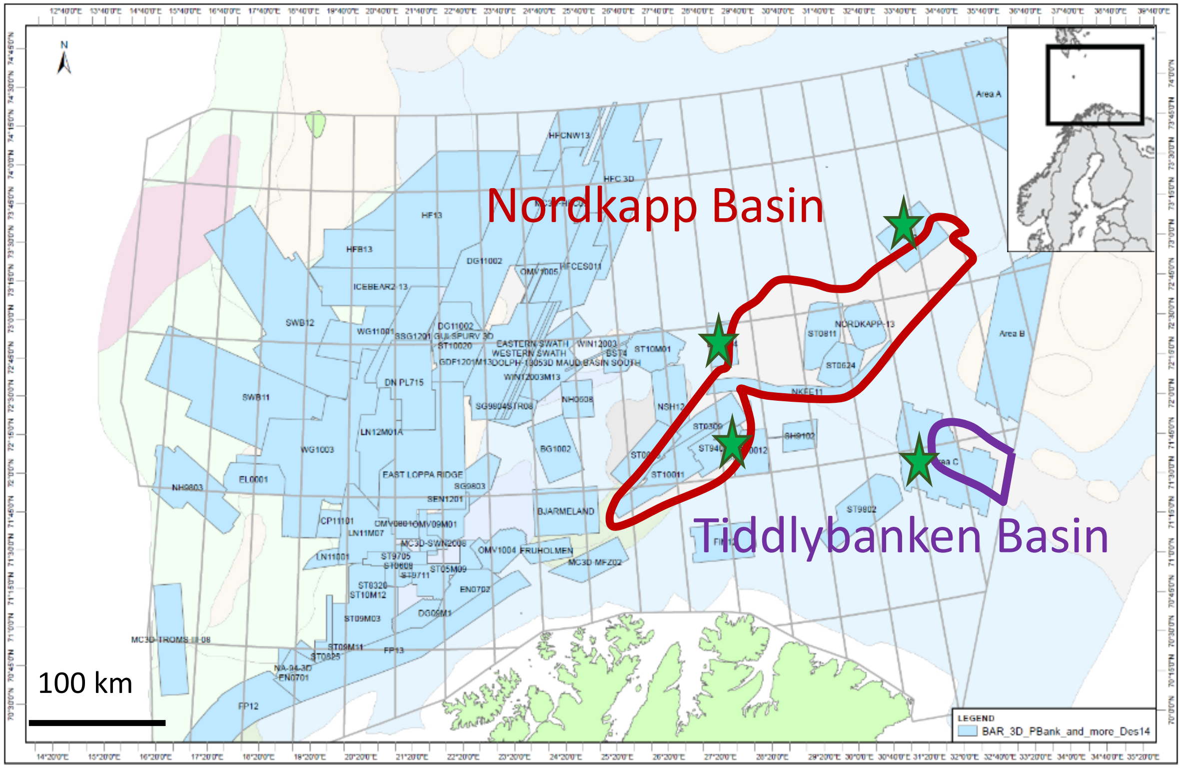
Style of fluvial interaction with salt walls and subsiding mini-basins



Modfied after Banham and Mountney *(2013)*

Data

- Located in the Southwestern Barents Sea
- Dataset
  - 3D and 2D seismic data
- Norske Shell



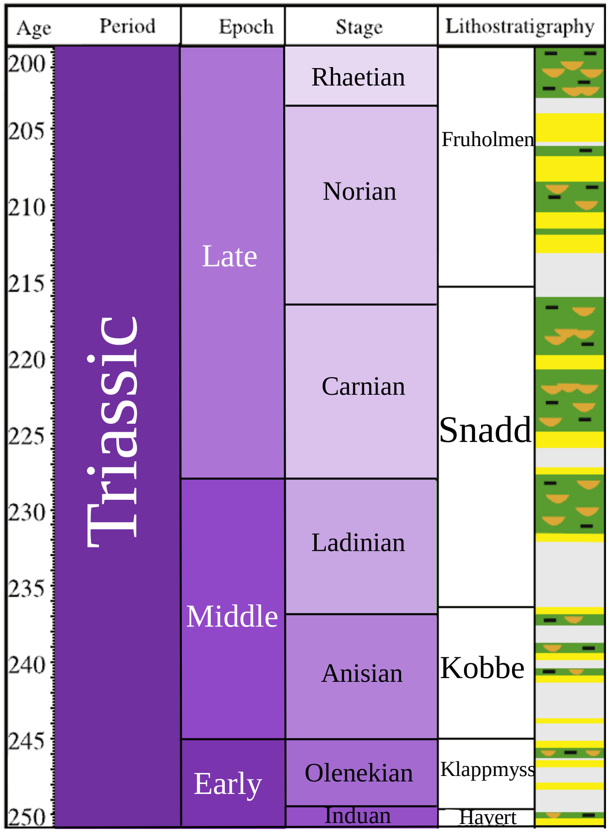
★ Key 3D cubes

Methodology

- Focus on Triassic intervals
  - Candidates of source and reservoir rocks
  - Mainly Snadd and Kobbe formations

- **Key deliverables**
  - Seismic interpretation (surfaces and faults)
  - Maps (depth and isochore)
  - Attribute maps
  - Dating of salt movement
  - Conceptual models

- Stratigraphic trap, with a fluvial environment



Modified after Glørstad-Clark et al. (2011)

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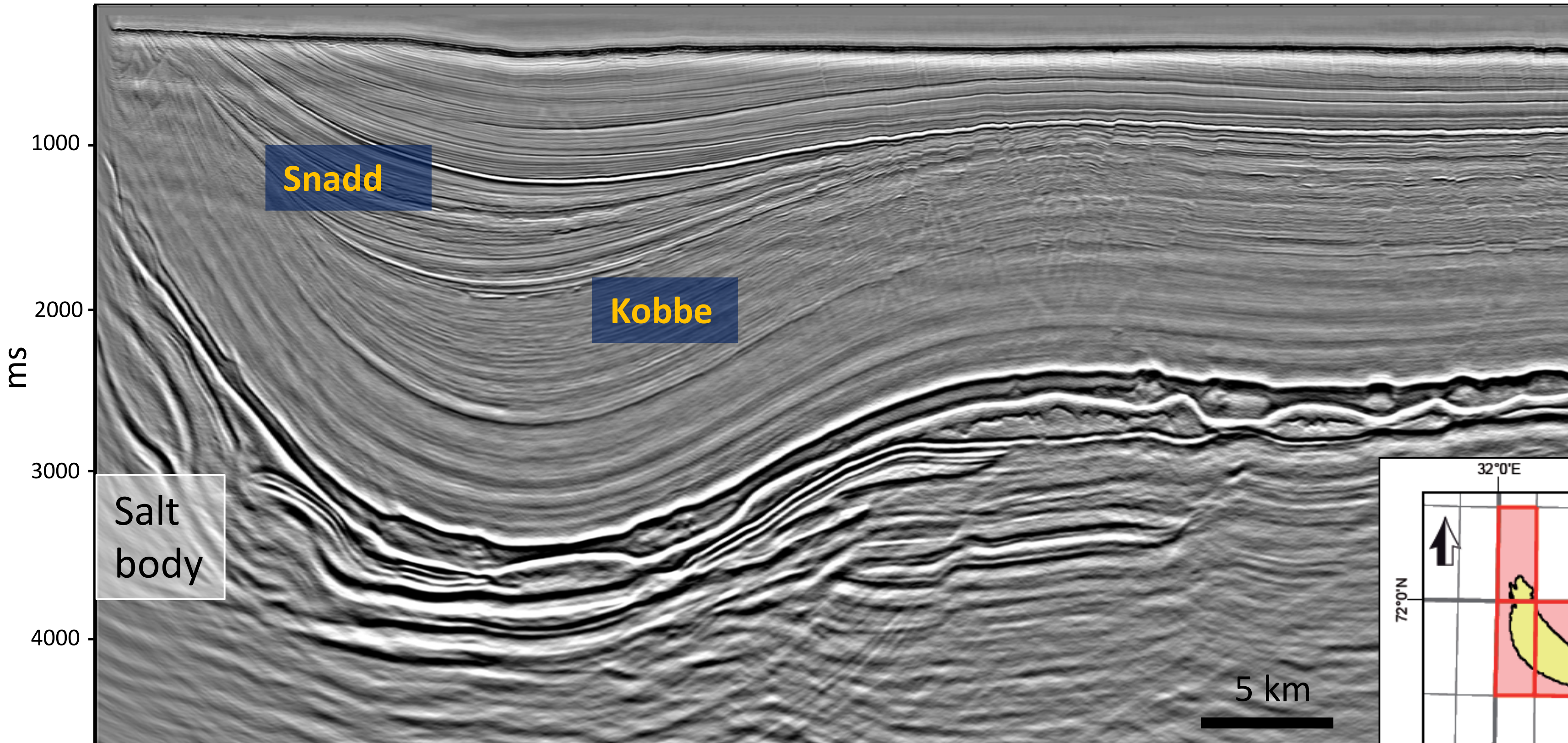
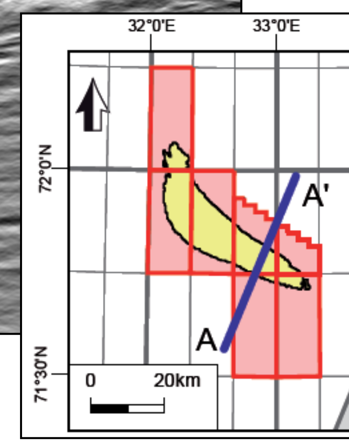
Preliminary Observations

Seismic line across Tiddlybanken Basin





- Lateral shift in depocenter from Kobbe to Snadd formations

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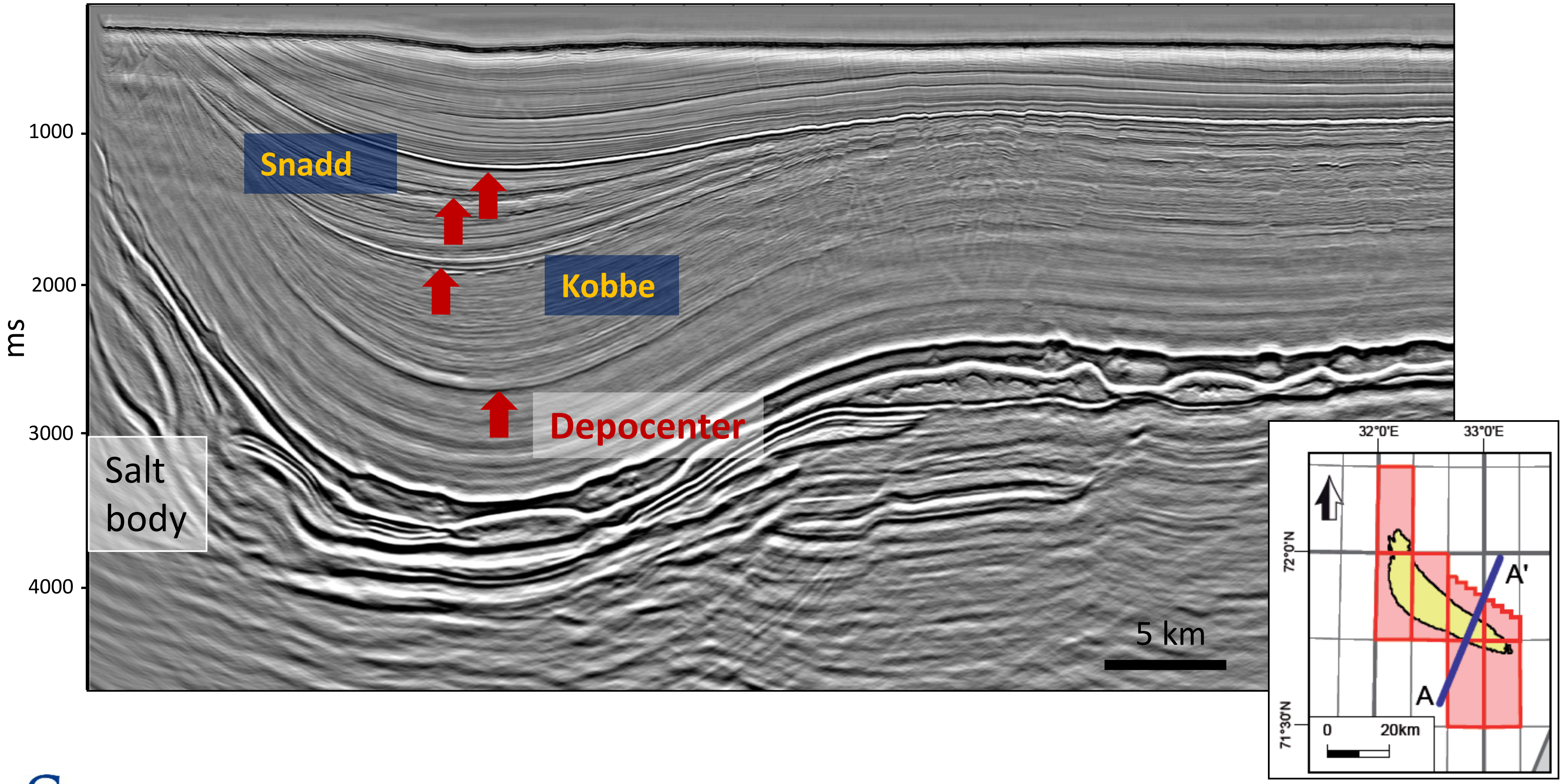
Preliminary Observations

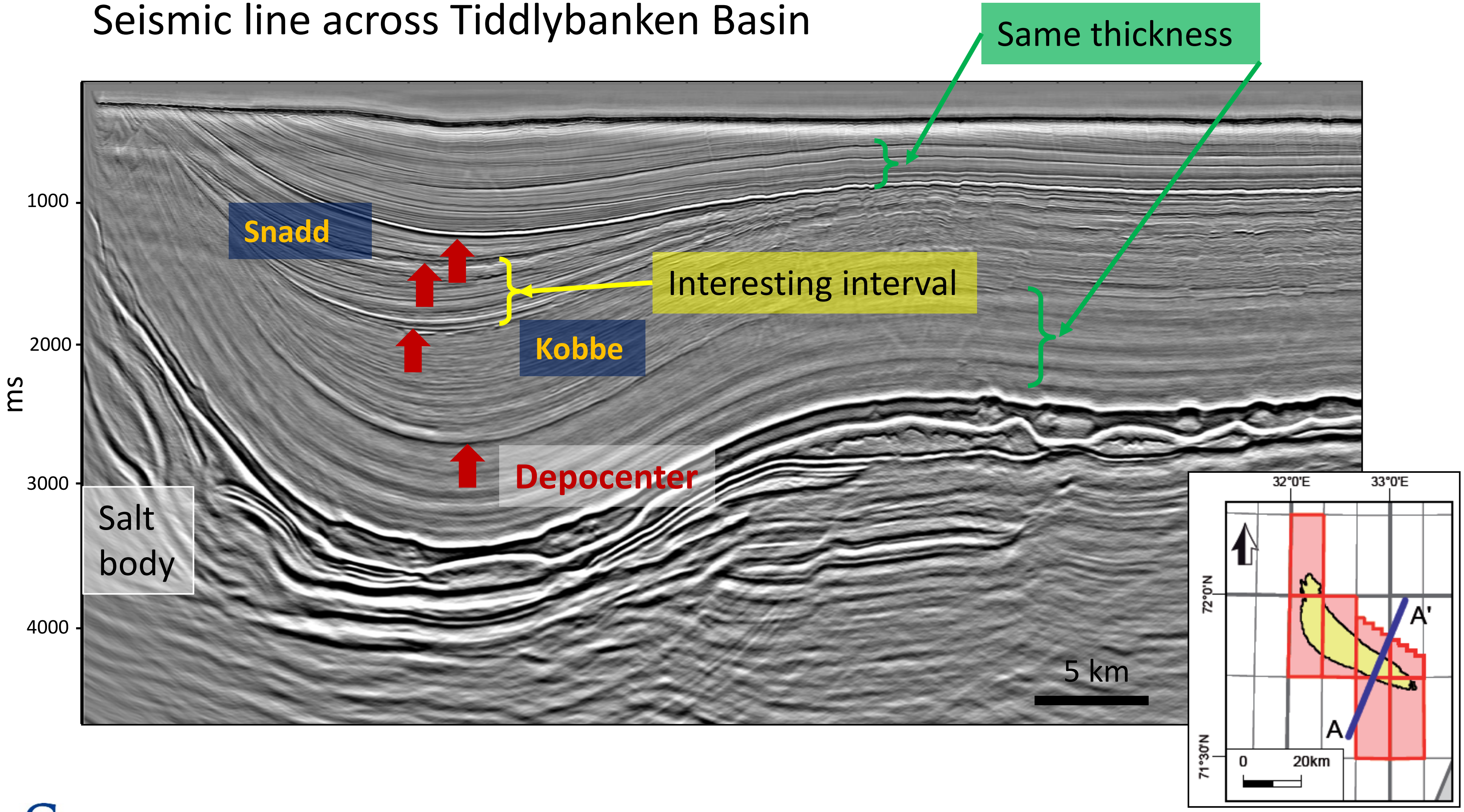
Seismic line across Tiddlybanken Basin



- Lateral shift in depocenter from Kobbe to Snadd formations

Preliminary Observations

Seismic line across Tiddlybanken Basin



- Lateral shift in depocenter from Kobbe to Snadd formations

Time Frame

Activity	2016																							
	January				Februrary				March					April				May				June		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Literature research																								
● Meetings ★ Important deadlines		●		●		●		★		●		●		★		●		★		●		●		★
INTERPRETATION																								
Seismic well tie																								
Halokinesis analysis and diapir interpretation																								
Seismic interpretation of key reflectors (2D/3D)																								
Generate maps																								
Fault interpretation																								
Seismic facies analysis																								
Seismic amplitude and attribute analysis																								
Evaluate fluvial infill patterns and architecture in mini basins/basin																								
WRITING																								
Introduction and regional geology (1. draft)																								
Observations (1. draft)																								
Create figures																								
First draft report																								
Rewriting and correction of mistakes																								
Submission of thesis																								

Thank you

Any questions?

Permo-Triassic rifting and post-rift halokinesis in the Norwegian-Danish Basin

Ekaterina Gulyaeva, 227460

Supervisors:
Rodmar Ravnås (UiS & A/S Norske Shell)
Kieron Bennett (A/S Norske Shell)

University of Stavanger

Shell

Agenda

- Introduction
  - Salt-influenced basins
  - Impact of salt
- Project Review
  - Objectives
  - Regional setting
  - Dataset
  - Methodology
  - Time frame with key deliverables
- Summary
- Questions

Salt-influenced basins

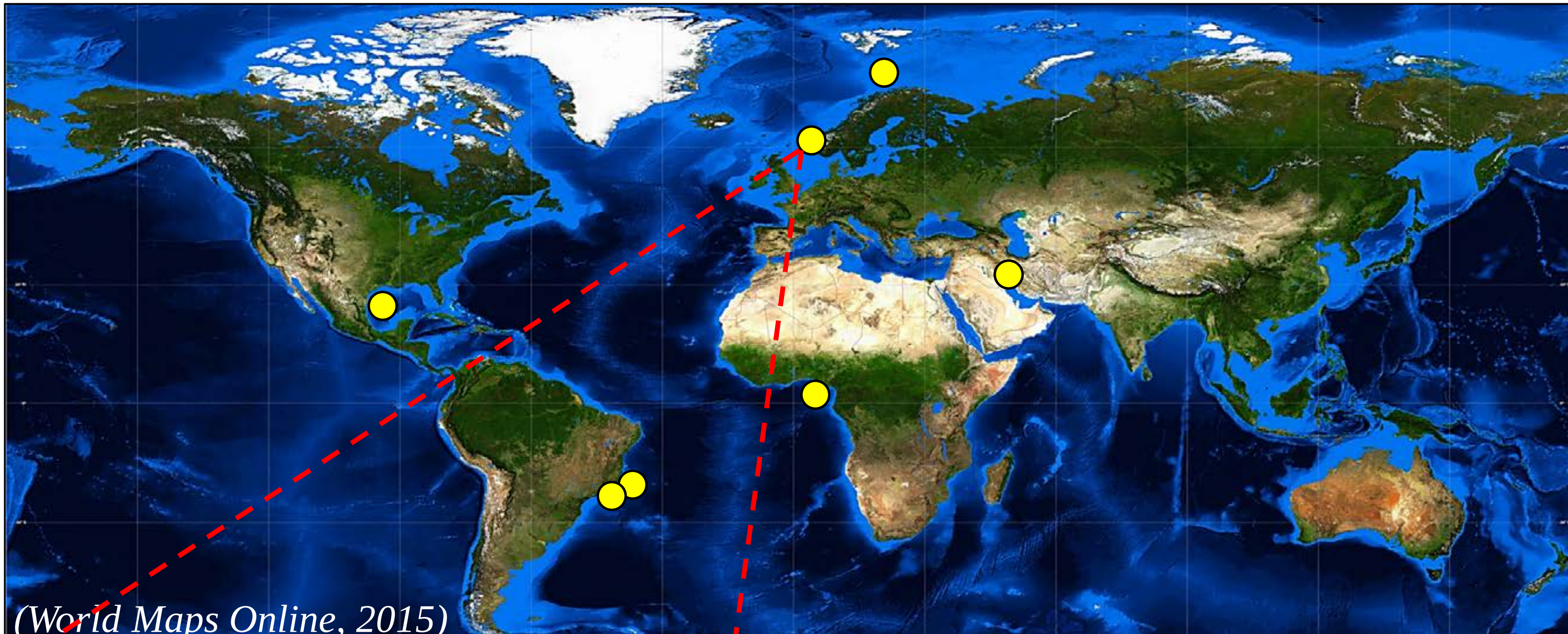


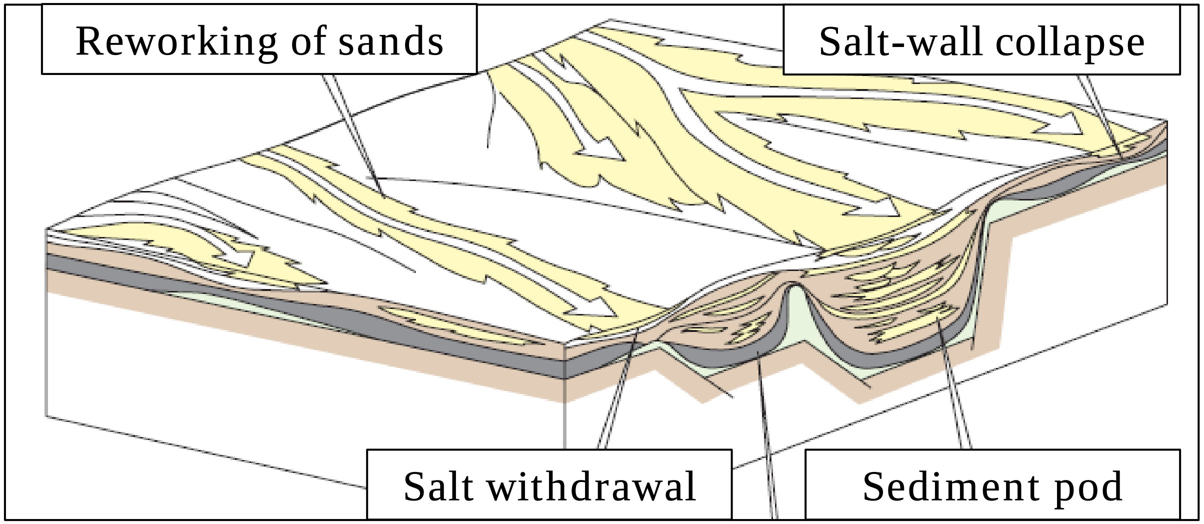
Photo: Kjetil Alsvik/ConocoPhillips

Ekofisk field:

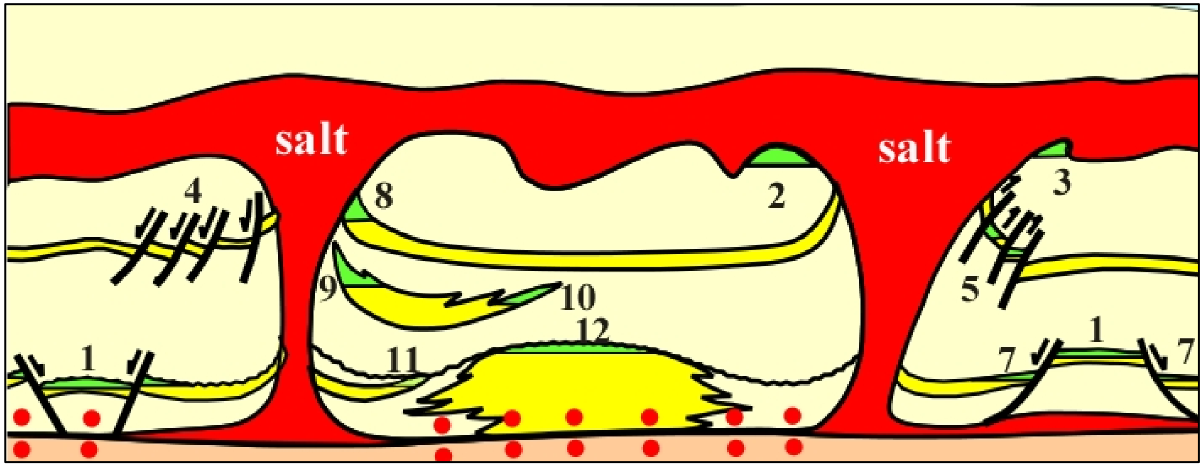
- The largest Chalk play in the North Sea
- 4-way closure above salt diapir
- Discovery in 1969
- Production since 1971
- Production 127,000 barrels per day

Impact of salt

- Accommodation space:
  - Reservoir
  - Source rock
- Thermal evolution
- Generation of traps:
  - Structural
  - Stratigraphic
- Sealing mechanism
- Hydrocarbon fairways



Central Graben (Hodgson et al., 1997, Smith et al., 1993)



Potential traps in GOM (Fonck et al., 1997)

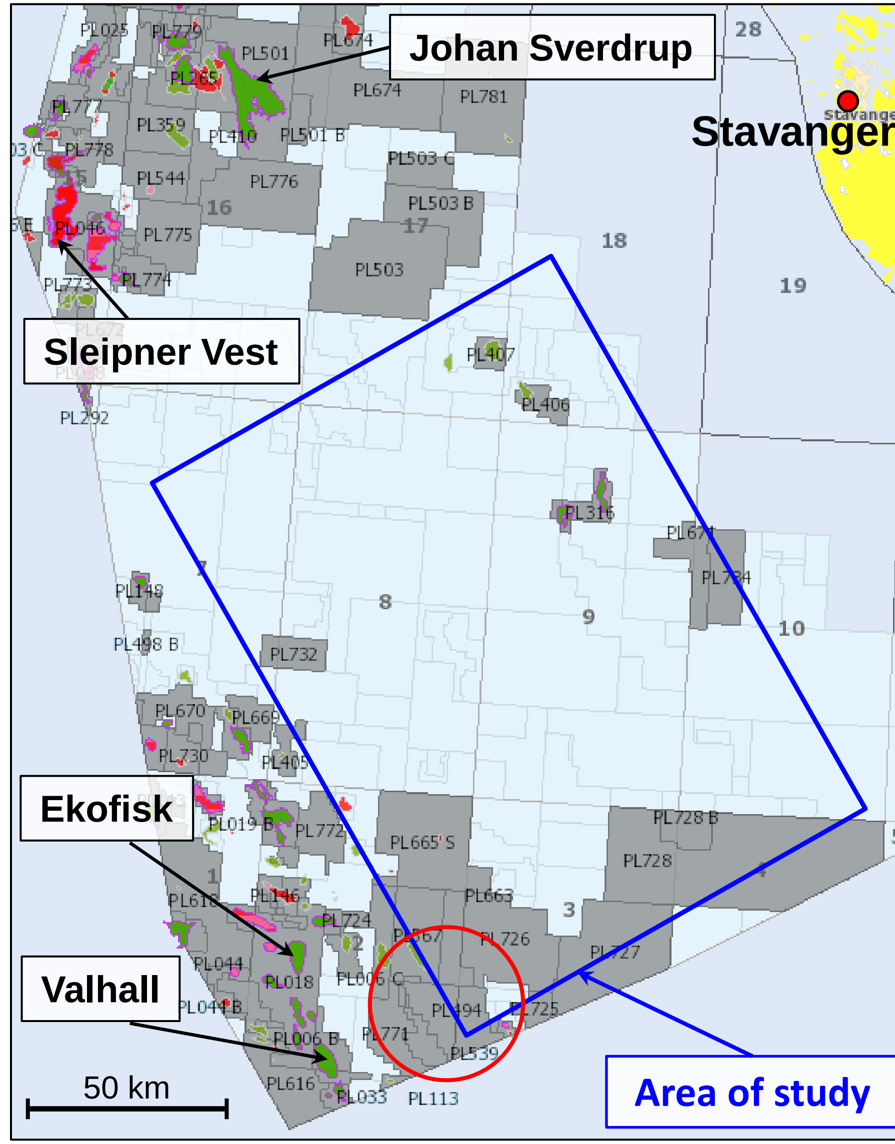
Motivation & Objectives

Extensively investigation:

- Central North Sea
- Danish side of NDB

Challenges:

- Trapping configurations
- Reservoir distribution



(Advanced NPD FactMaps, 2015)

Major Objectives:

- Tectono-stratigraphic evolution of the Norwegian-Danish Basin
- Prospectivity of Upper Paleozoic-Triassic plays

Regional setting

Carboniferous-Permian:

- Extensional domain, formation of "sub-basins"

Early Triassic:

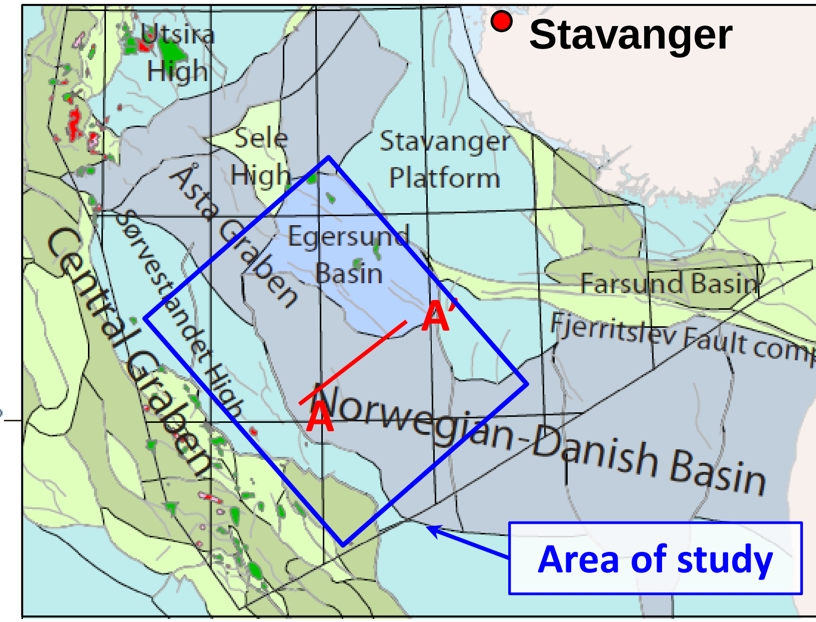
- Next stage of rifting with halokinesis

Triassic-Early/Middle Jurassic:

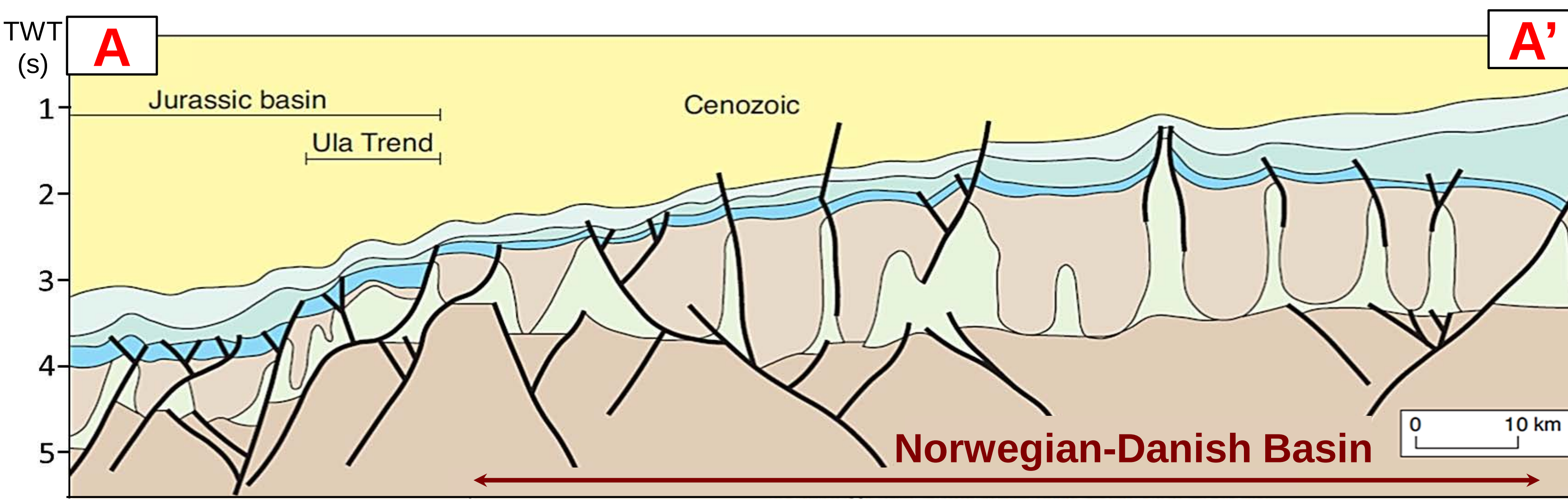
- Salt withdrawal and dissolution (30 %)

Late Cretaceous-Early Cenozoic:

- Inversion with reactivation of salt movements

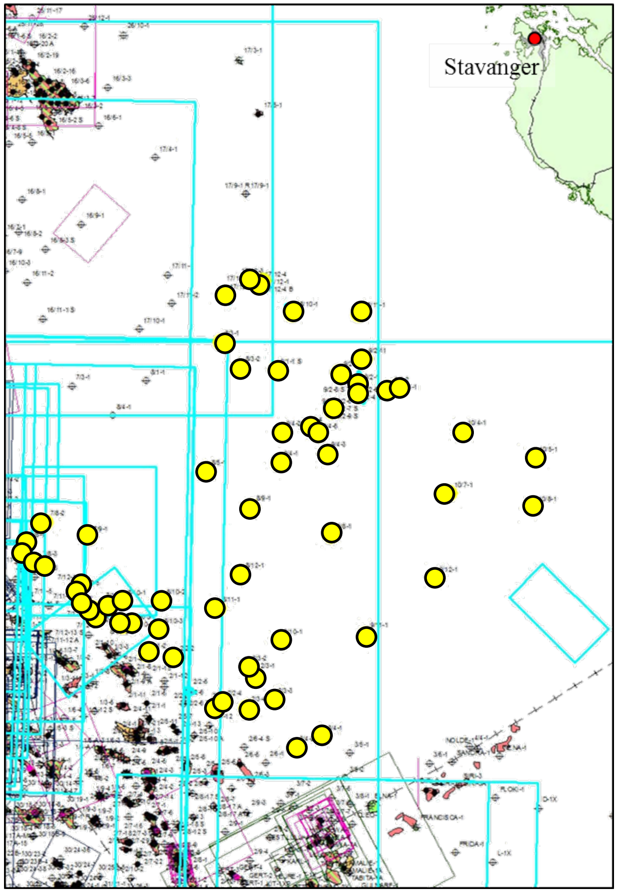


(Halland et al., 2011)

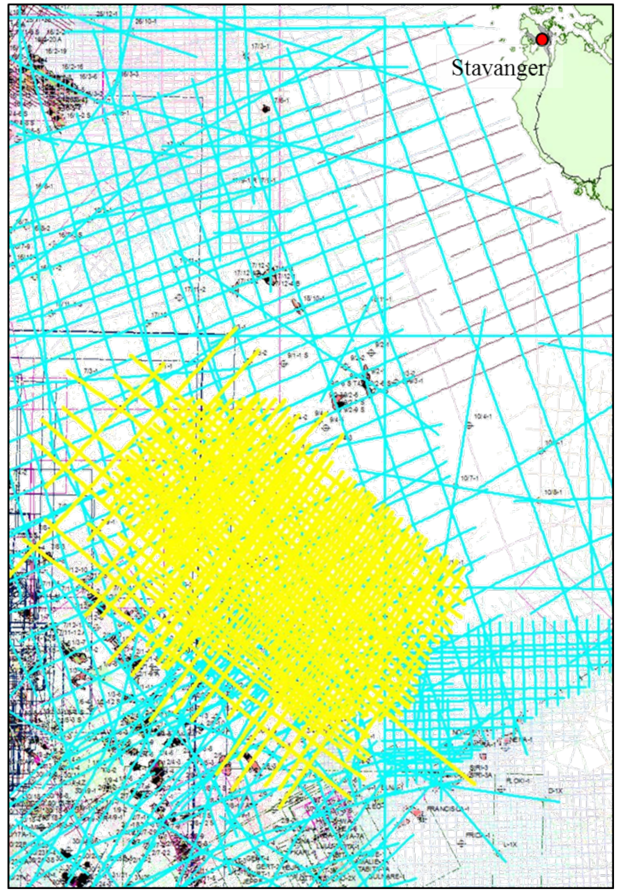


Geoseismic cross-section in NDB (Evans et al., 2003)

Dataset



Location of wellbores (provided by Shell)

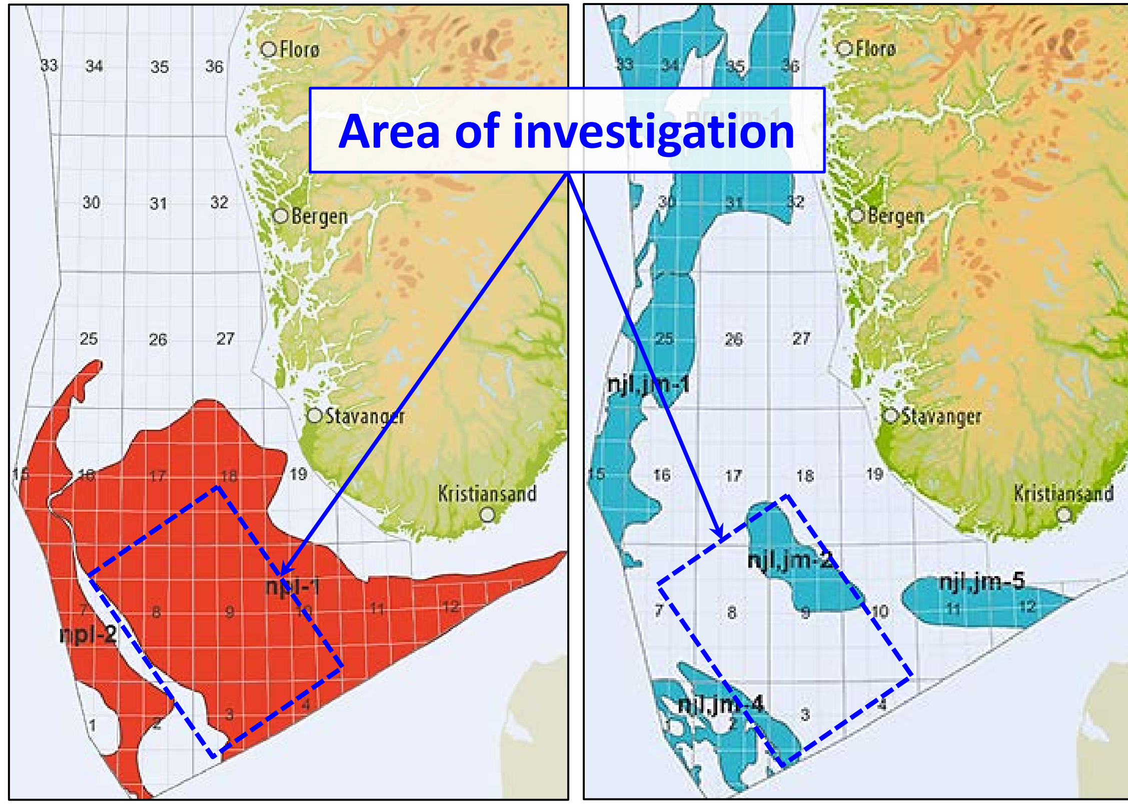


Location of seismic surveys (provided by Shell)

- 20,000 km^2
- Available hard data:
  - 67 wellbores
  - Well logs
  - Check-shots
  - Well tops
- 2D seismic surveys:
  - CGME-96
  - SHD-97
- Analogues

Methodology

1) Research about the area of interest and adjacent areas



Sub Triassic plays (NPD, 2015)

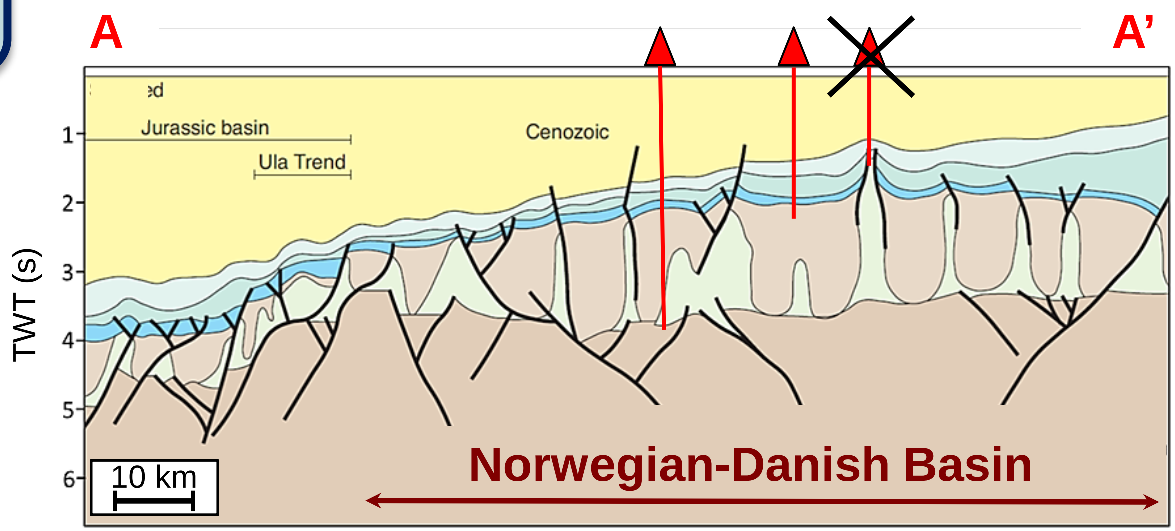
Upper Triassic, Lower to Middle Jurassic plays (NPD, 2015)

Methodology

1) Research about the area of interest and adjacent areas

2) Build up the Petrel project, import of dataset and data mining

Wellbore name	Total depth (m)	Completed date	Oldest penetrated age	Oldest penetrated formation	1st level with HC, age	1st level with HC, formation
17/12-2	2333	1973	Devonian	No Gp defined	Middle Jurassic	Sandnes Fm
17/12-3	2730	1980	Late Triassic	Skagerrak Fm		
17/12-4 A	2319	2009	Middle Jurassic	Bryne Fm	Middle Jurassic	Bryne Fm
17/12-4 B	2312	2009	Middle Jurassic	Bryne Fm	Middle Jurassic	Bryne Fm
17/12-4	2470	2009	Triassic	Skagerrak Fm	Middle Jurassic	Bryne Fm



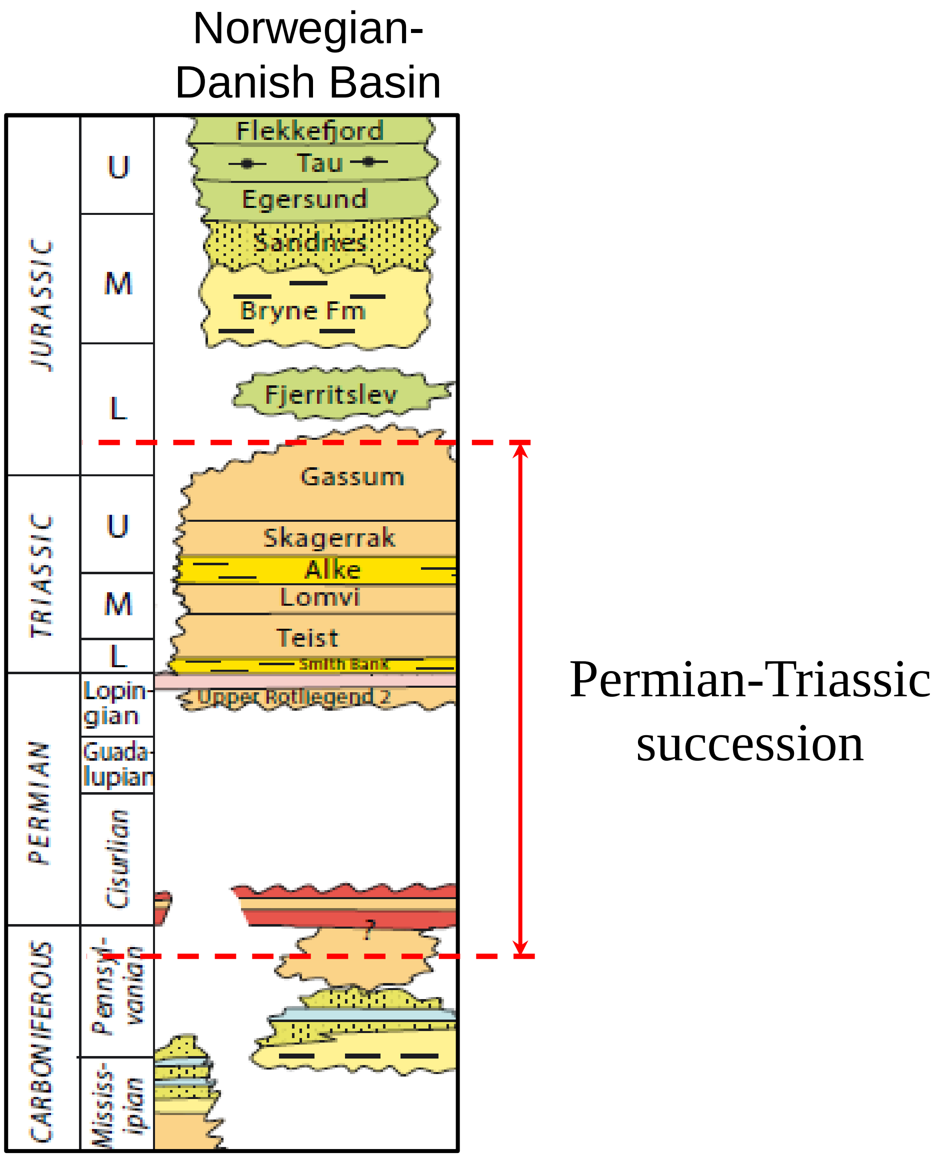
Geoseismic cross-section in NDB (Evans et al., 2003)

Methodology

1) Research about the area of study and adjacent areas

2) Build up the Petrel project, import of dataset and data mining

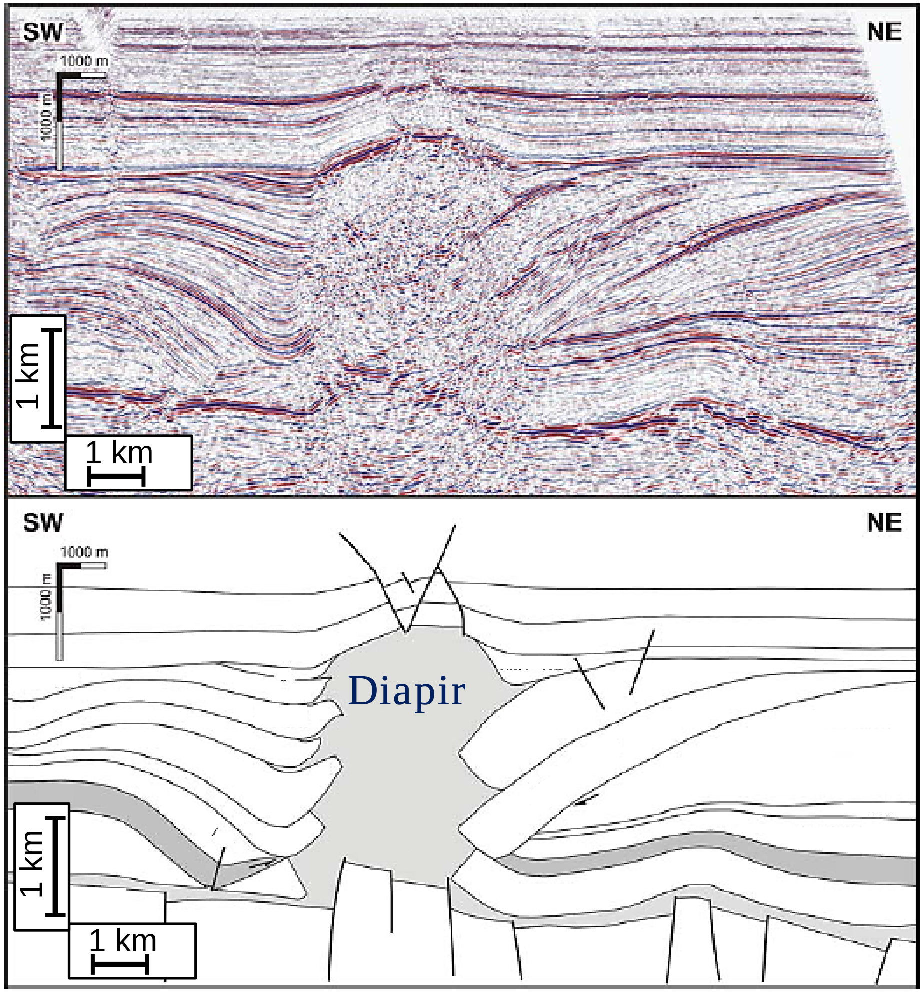
3) Complete well-to-seismic tie



Lithostratigraphic chart (NPD, 2015)

Methodology

4) Seismic interpretation of faults and horizons

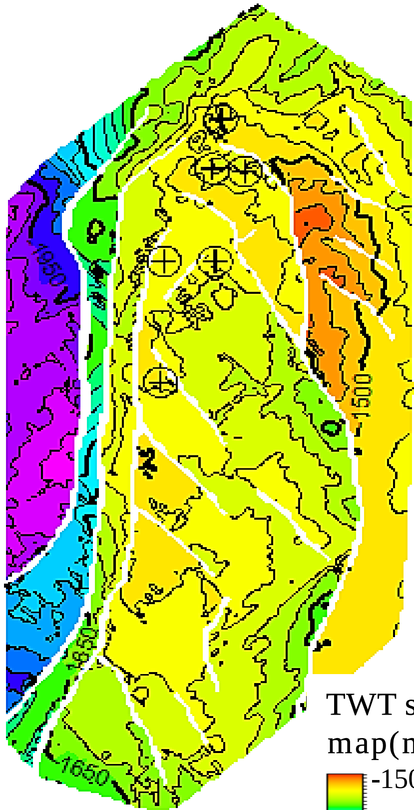


Seismic section and geological interpretation of the German Basin (Mohr et al., 2005)

Methodology

4) Seismic interpretation of faults and horizons

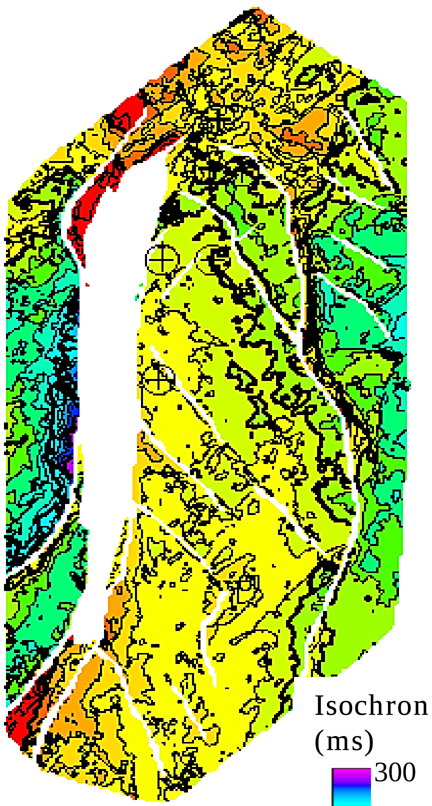
5) Generation of time-thickness (isochron), fault and facies maps



TWT structural map(ms)

-1500

-2000



Isochron map (ms)

300

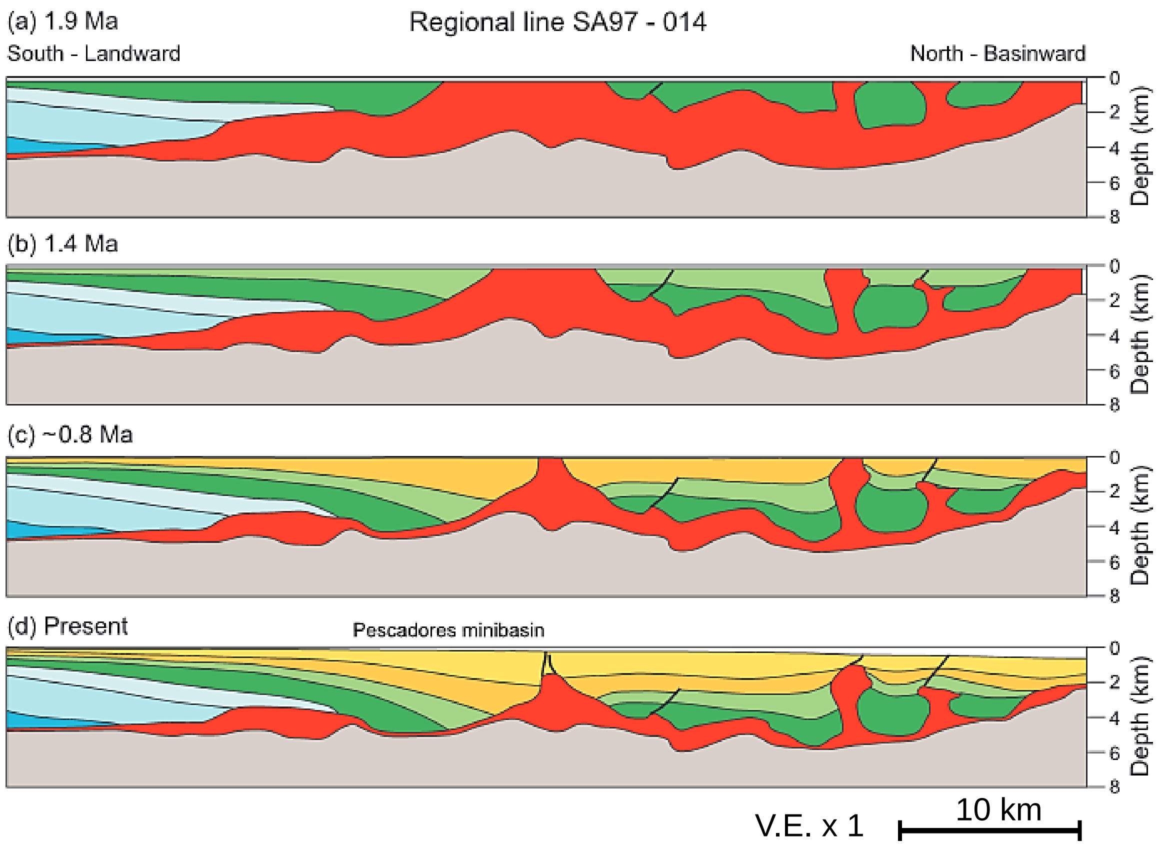
0

Methodology

4) Seismic interpretation of faults and horizons

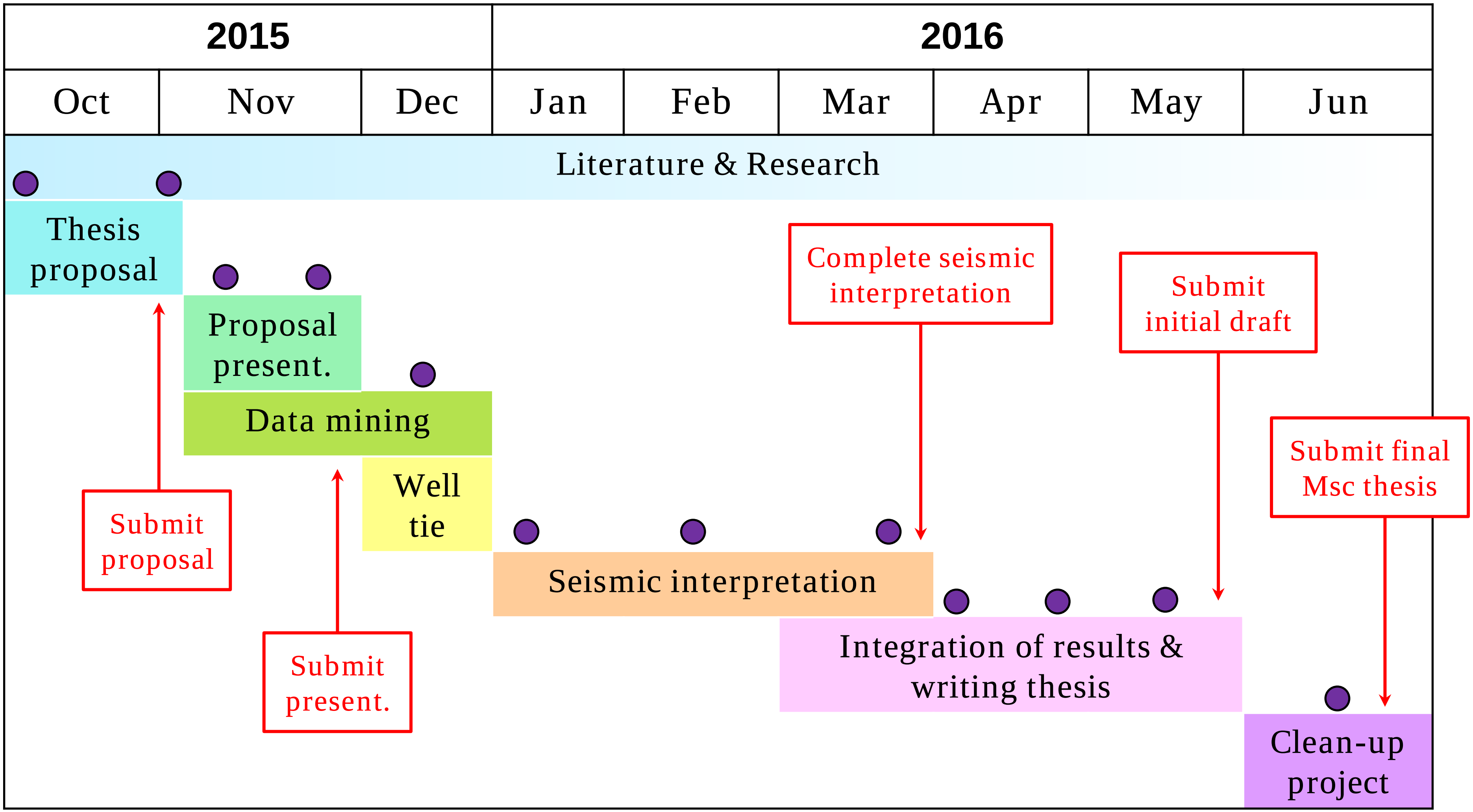
5) Generation of time-thickness (isochron), fault and facies maps

6) Structural restoration of selected lines and defining promising geological plays, integration of results



Structural restoration of a depth section in the offshore Salina del Istmo Basin, GOM (Gómez-Cabrera and Jackson, 2009)

Time frame with key deliverables



● Meetings with supervisors

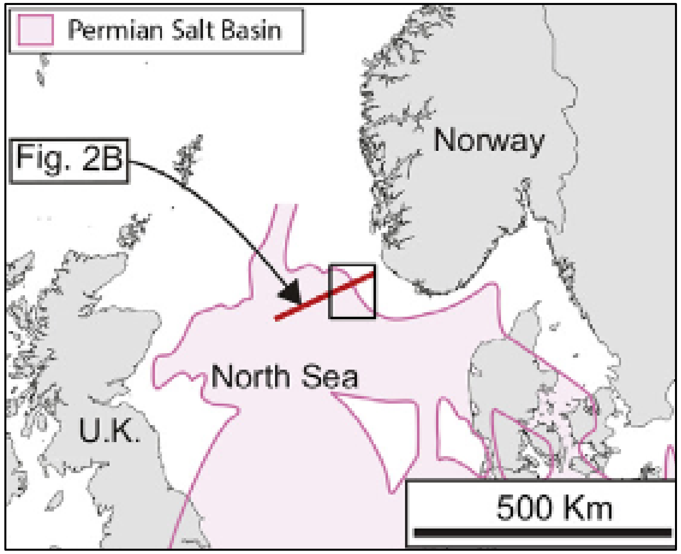
Summary

1) Permian-Triassic rifting

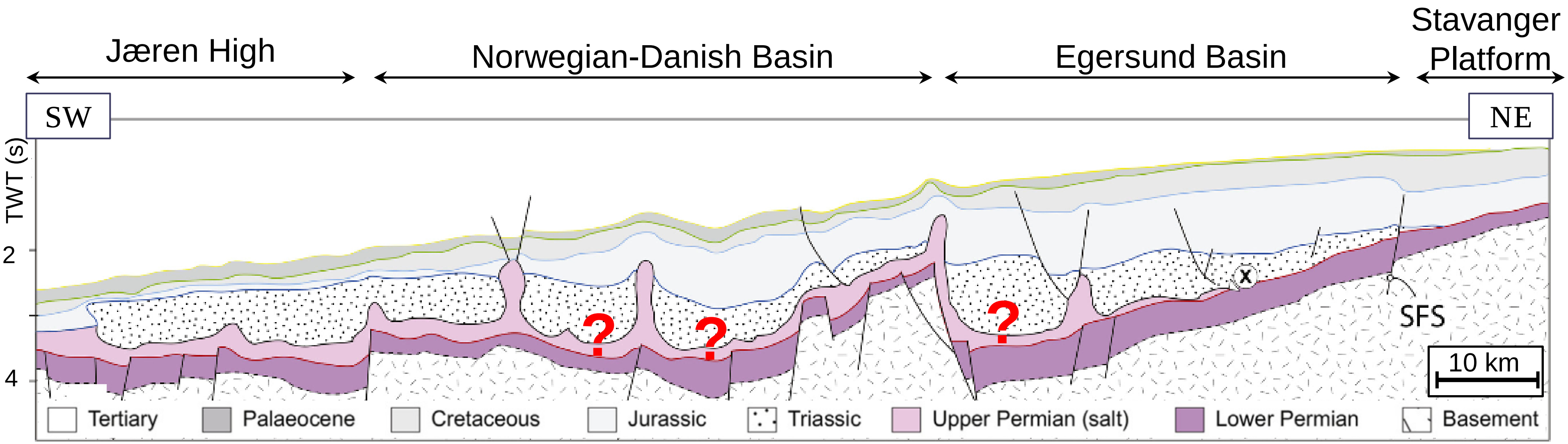
2) Triassic sediment infill

3) Salt-influenced structural styles

4) Impact on NDB deep prospectivity



(Lewis et al., 2013)



Simplified geo-seismic section (Lewis et al., 2013)

Thank you!

Middle Jurassic Brent Group fault seal prediction for Troll-Oseberg-Brage area

A locally calibrated method to increase exploration success

Erik Johan Helland

University of Stavanger

Supervisor: Rodmar Ravnås (University of Stavanger & Norske Shell)
Co-Supervisor: Thomas Sandison (Norske Shell)

Agenda

- Area of Interest
- Objectives
- Data
- Methodology
- Project Timeframe

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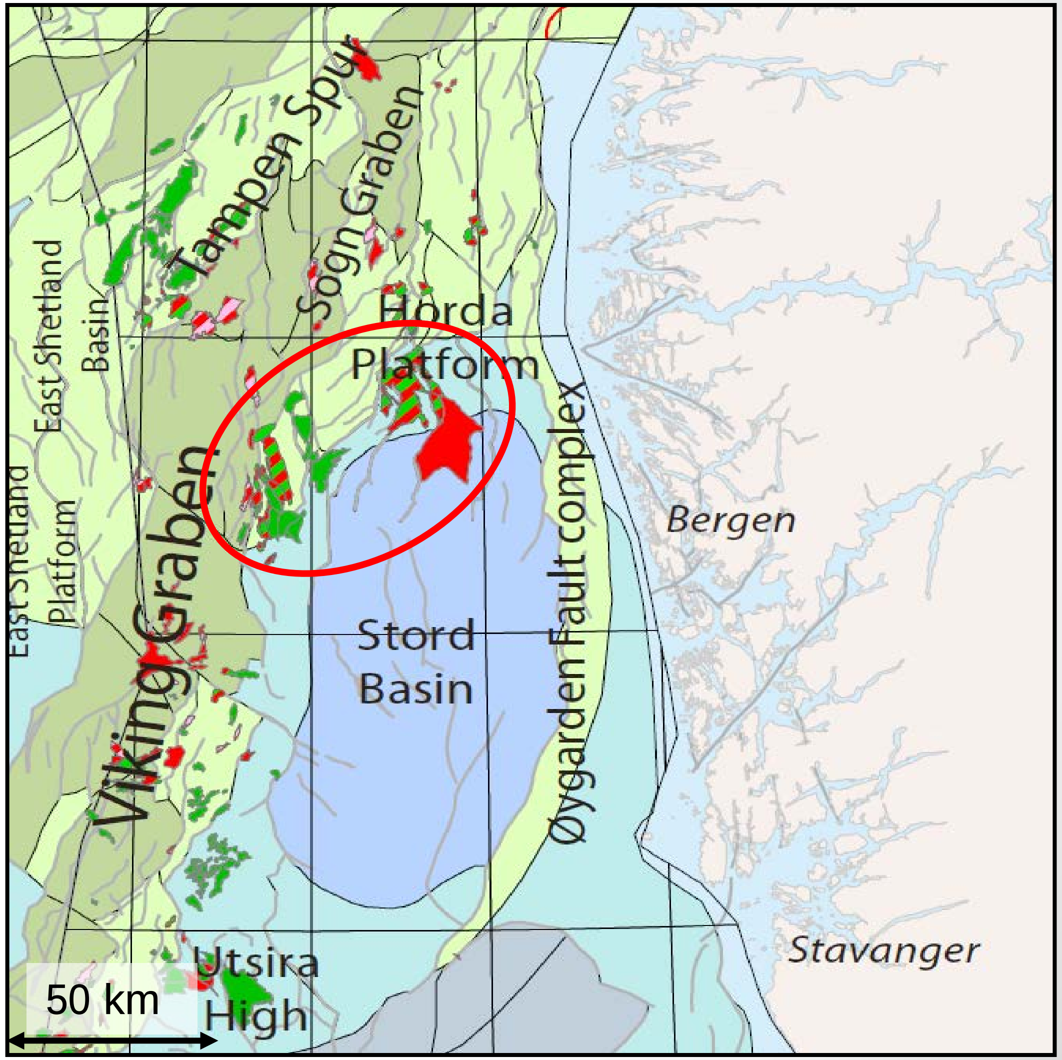
Area of Interest

- Troll-Brage-Oseberg



(Modified from Evans et al., 2003)

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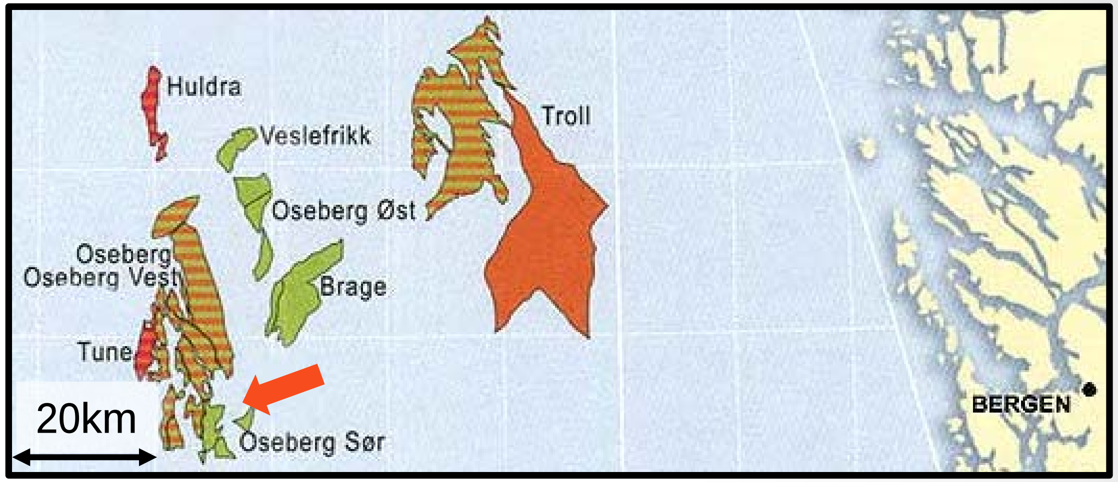
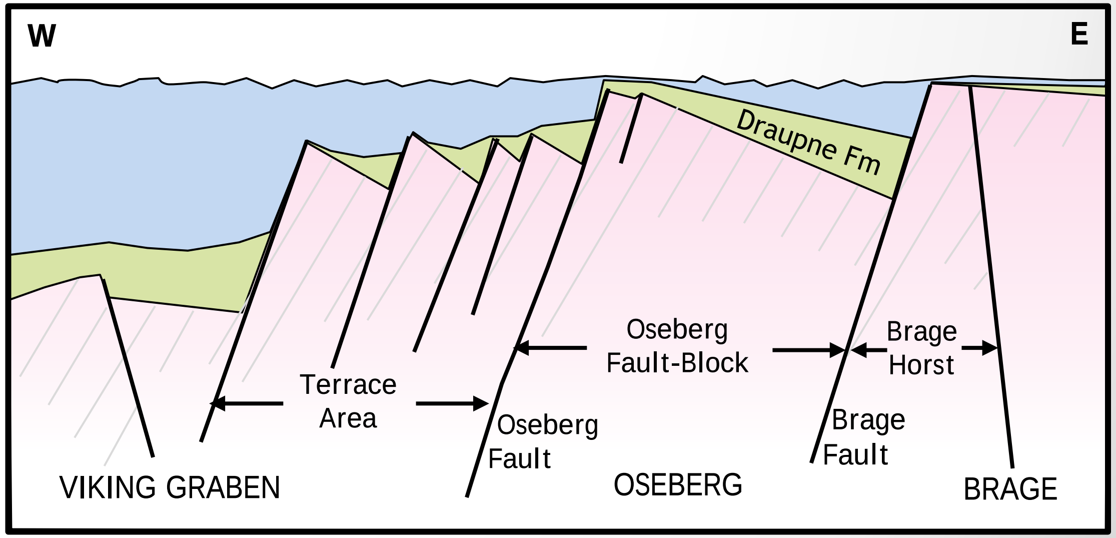
Area of Interest

- Troll-Brage-Oseberg
- Oseberg South
- Late Jurassic Fault blocks



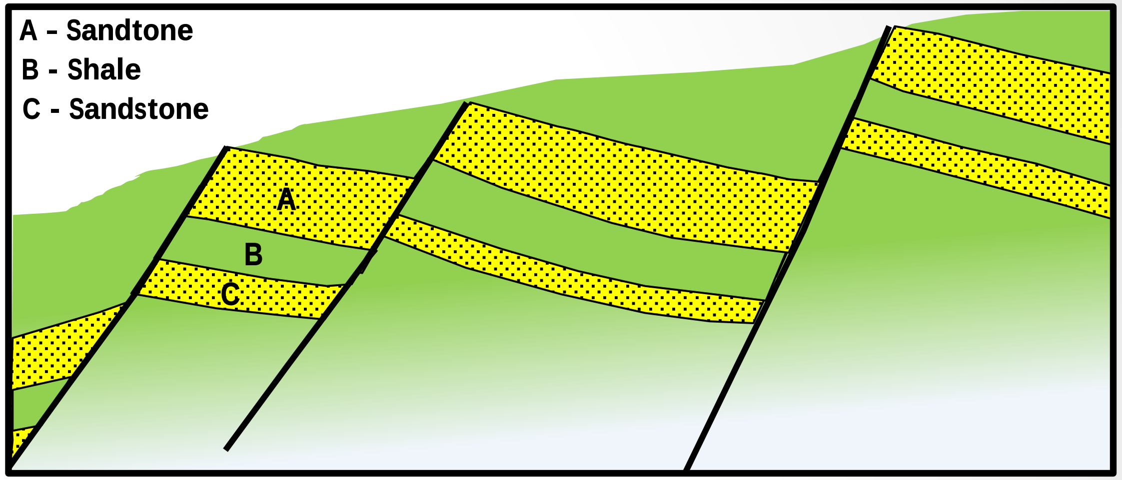
(Petroleumstilsynet, 2005)

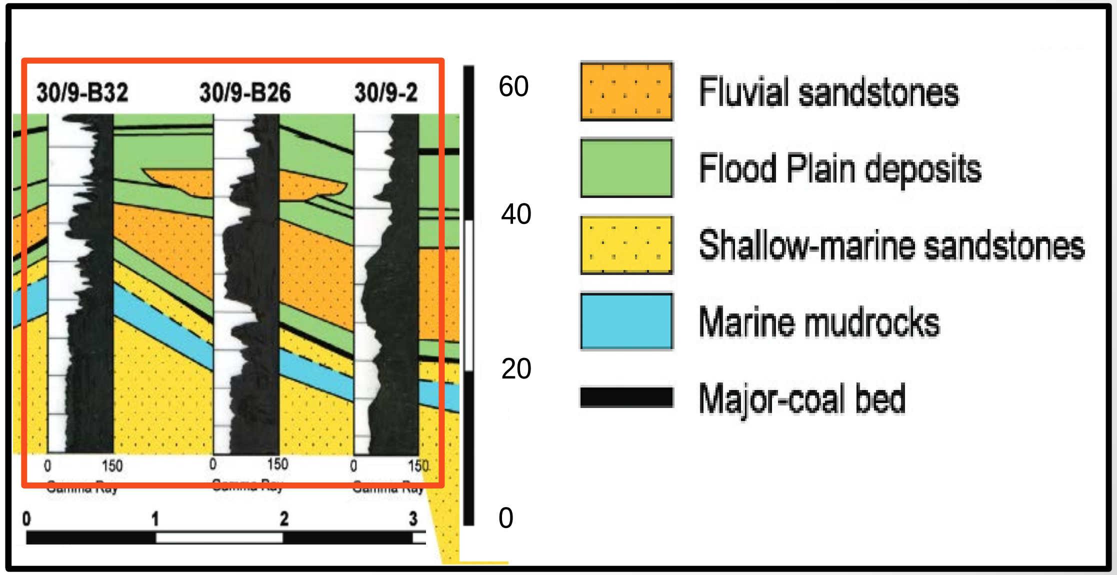


(Modified from Færseth and Ravnås, 1997)

Area of Interest

- Troll-Brage-Oseberg
- Oseberg South
- Late Jurassic Fault blocks
- Fault retained reservoirs
- Brent Group stratigraphy
- Variable well success rate





(Modified from Færseth and Ravnås, 1997)
(Løseth and Ryseth, 2003)

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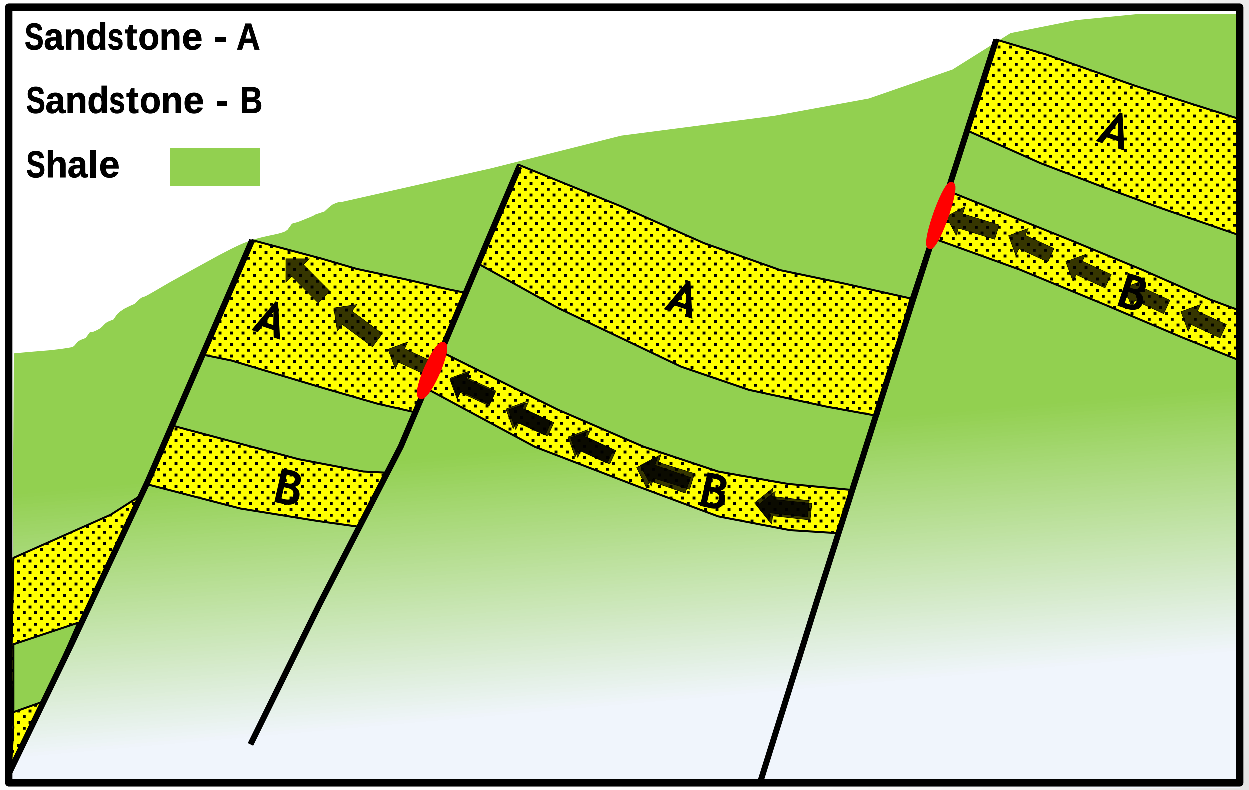
Fault seal concept

- Juxtaposition
  - Shale reservoir contact
- Clay smear
  - Clay minerals in fault plane



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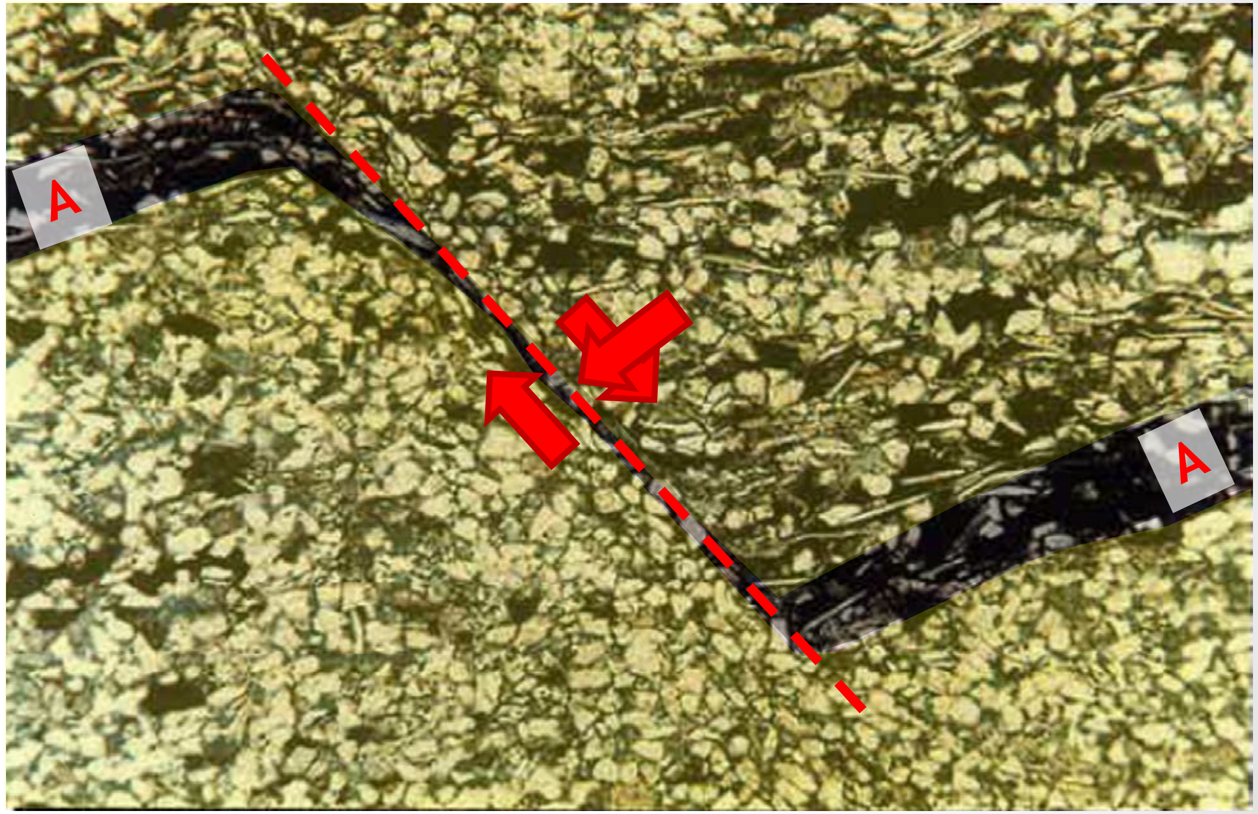
Fault seal concept

- Juxtaposition
  - Shale reservoir contact
- Clay smear
  - Clay minerals in fault plane



(Modified from Fristad et al., 1997)

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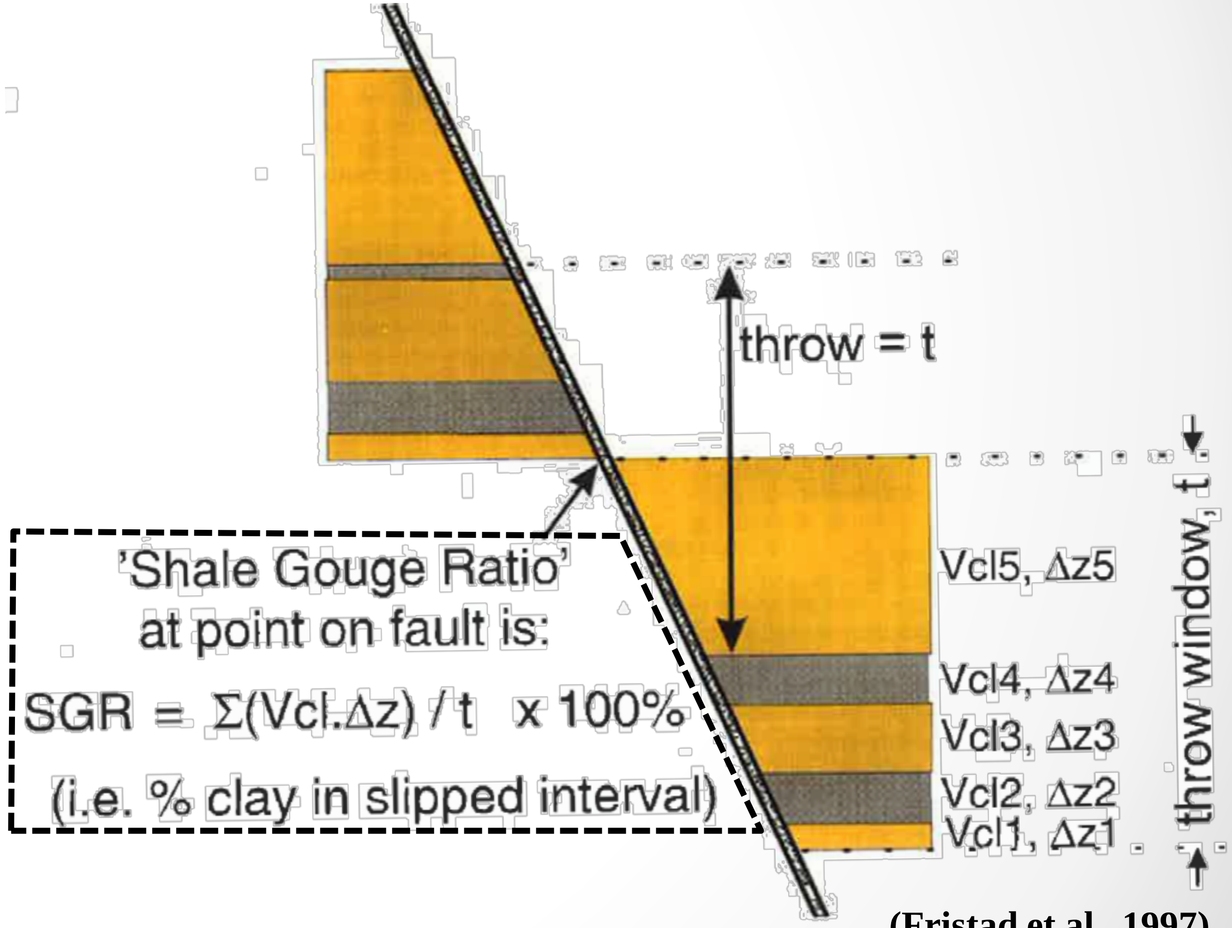
Fault seal concept

- Juxtaposition
  - Shale reservoir contact
- Clay smear
  - Clay minerals in fault plane
- Shale gouge ratio
  - Previous studies
    - SGR < 15%
    - SGR > 18%
- Vcl
  - Determine most consistent method



(Fristad et al., 1997)

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Objectives

- Study fault structures and reservoirs
- Investigate individual fault seal capacity
- Evaluate fault-seal dependent reservoirs
- Examine applicability of Shell fault seal predictive software
- Contribute to North Sea fault-seal database

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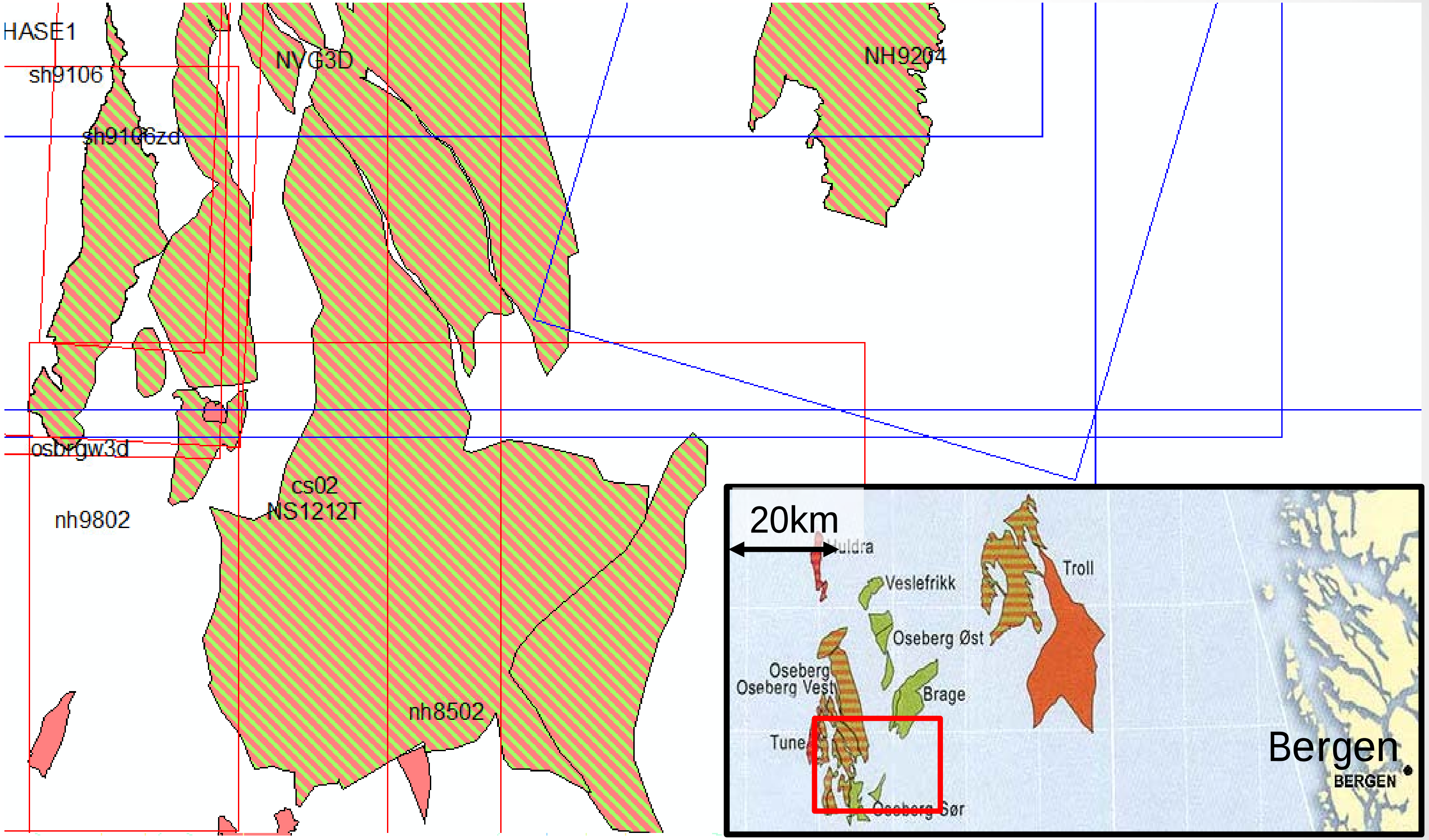
Data

- Well data
  - Well logs
  - Well tops
  - Pressure data
- Seismic data
  - 2D surveys
  - 3D surveys



(Courtesy of Norske Shell)

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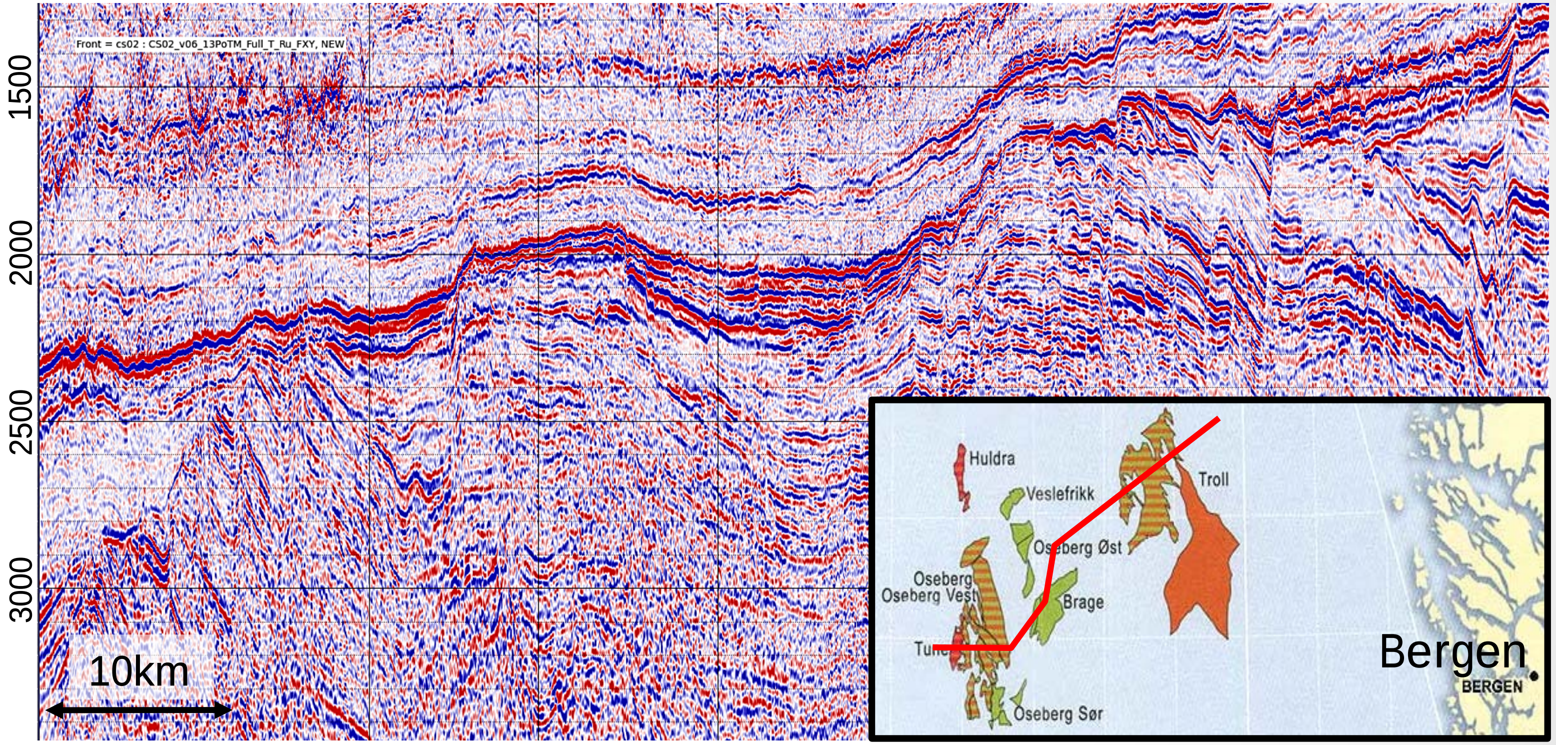
Data

- Well data
  - Well logs
  - Well tops
  - Pressure data
- Seismic data
  - 2D lines
  - 3D cubes
  - Regional lines



(Courtesy of Norske Shell)

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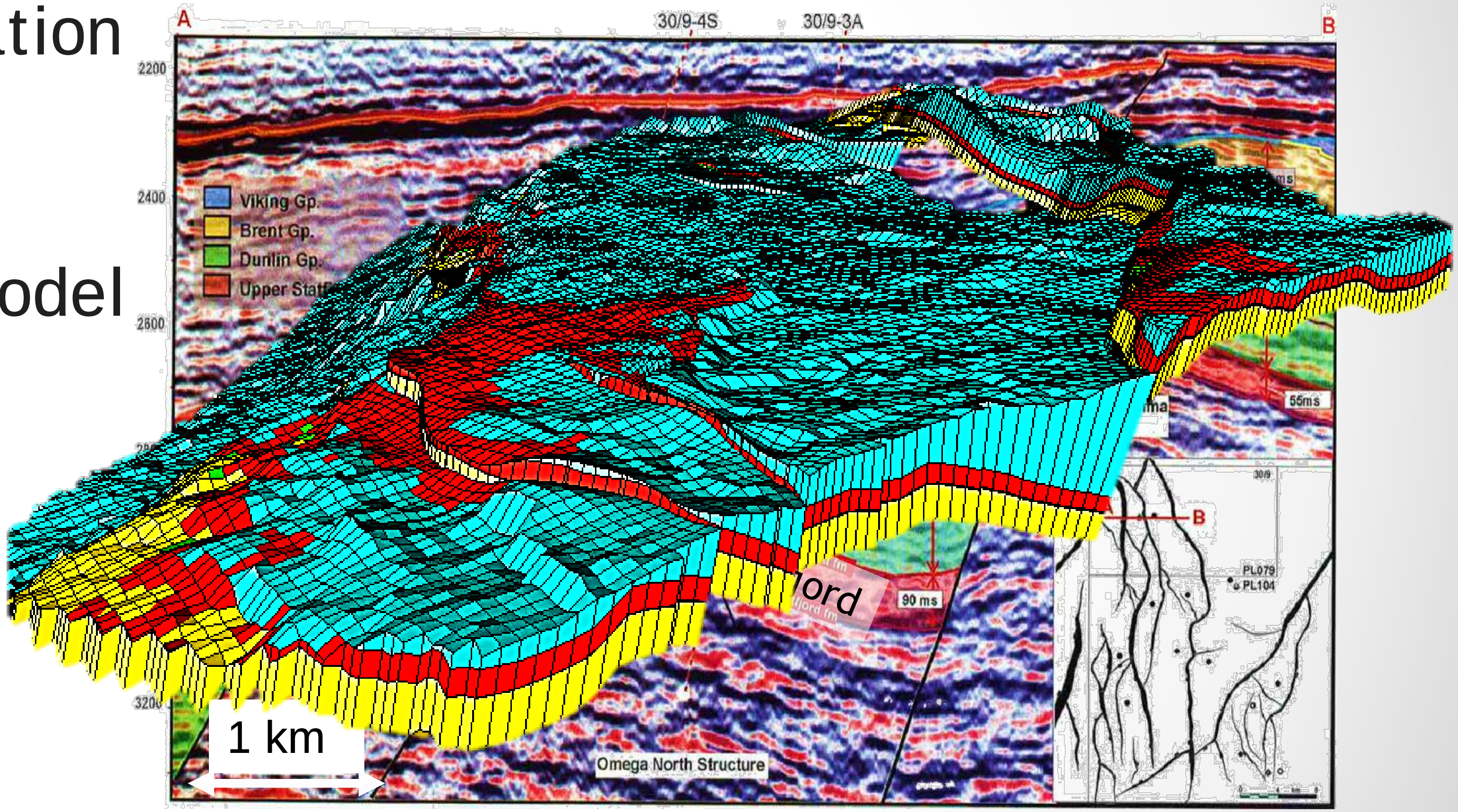
Methodology

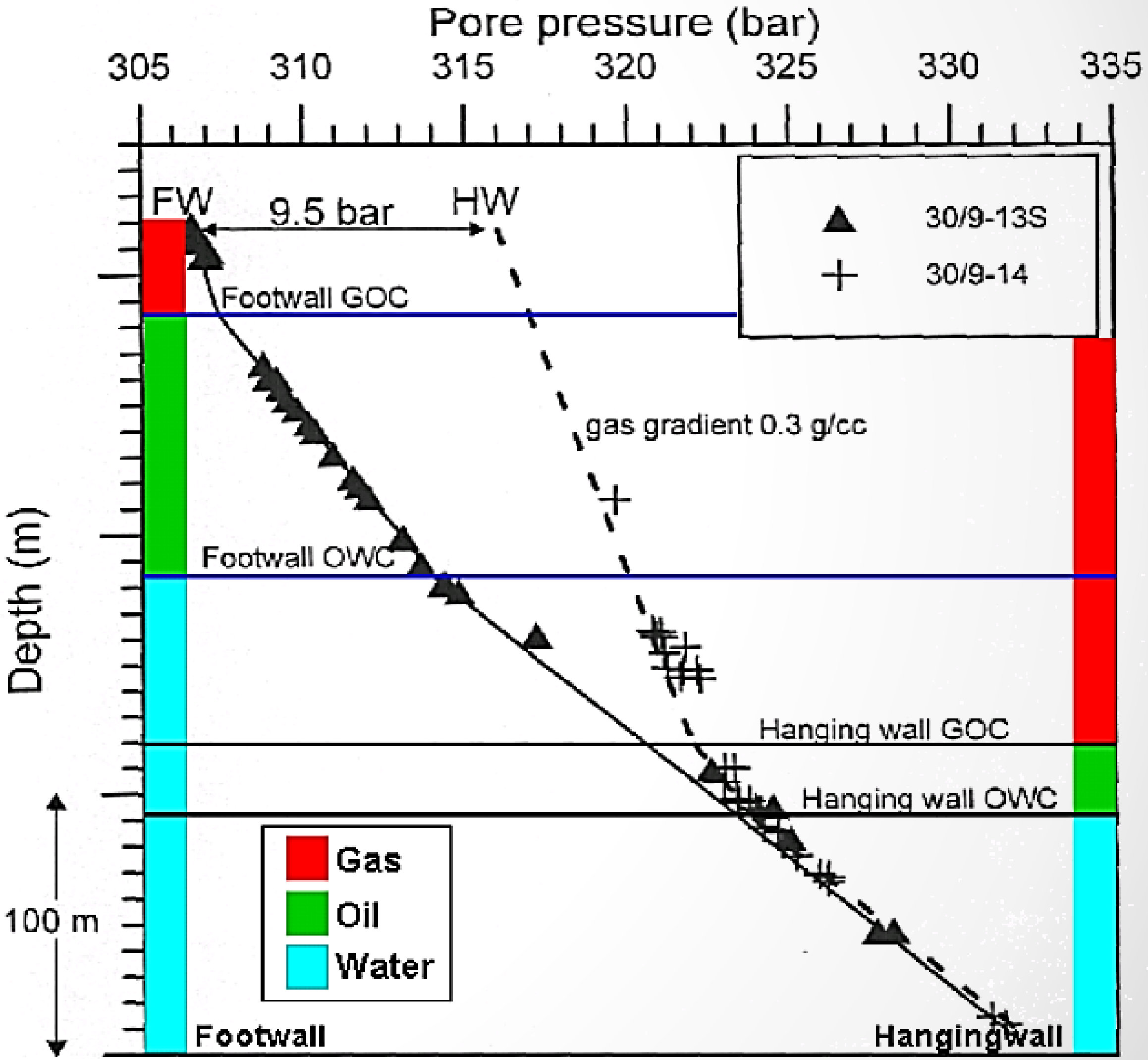
- Seismic interpretation
  - Faults and formations
- Build structural model



(Fristad et al., 1997)

Methodology

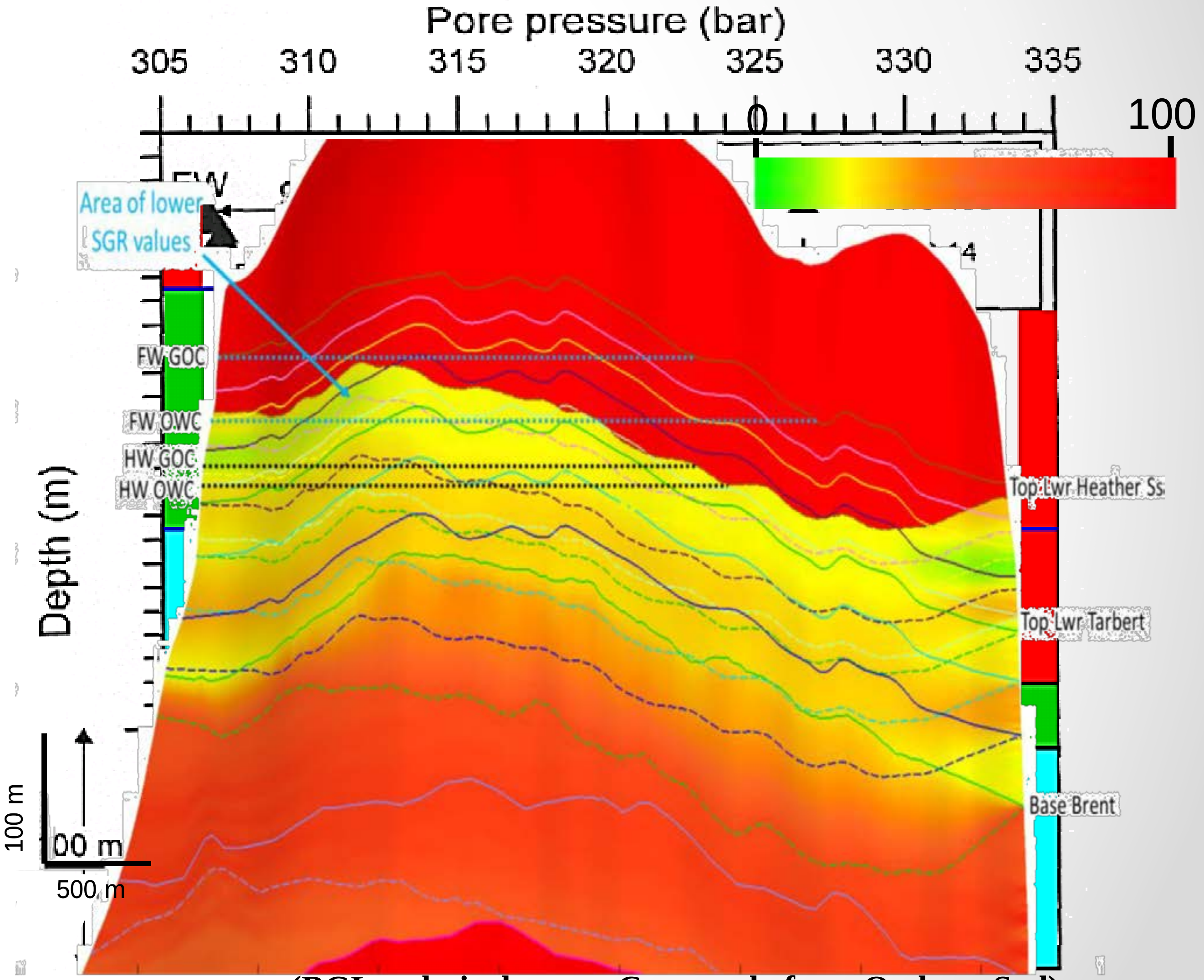
- Seismic interpretation
  - Faults and formations
- Build structural model
- Fault seal analysis
  - Interpretational
  - Core analysis
  - SGR
  - Petrophysical & dynamic data



(BGL technical paper, Case study from Oseberg Syd)

Methodology

- Seismic interpretation
  - Faults and formations
- Build structural model
- Fault seal analysis
  - Interpretational
  - Core analysis
  - SGR
  - Petrophysical and dynamic data
- Allan diagrams

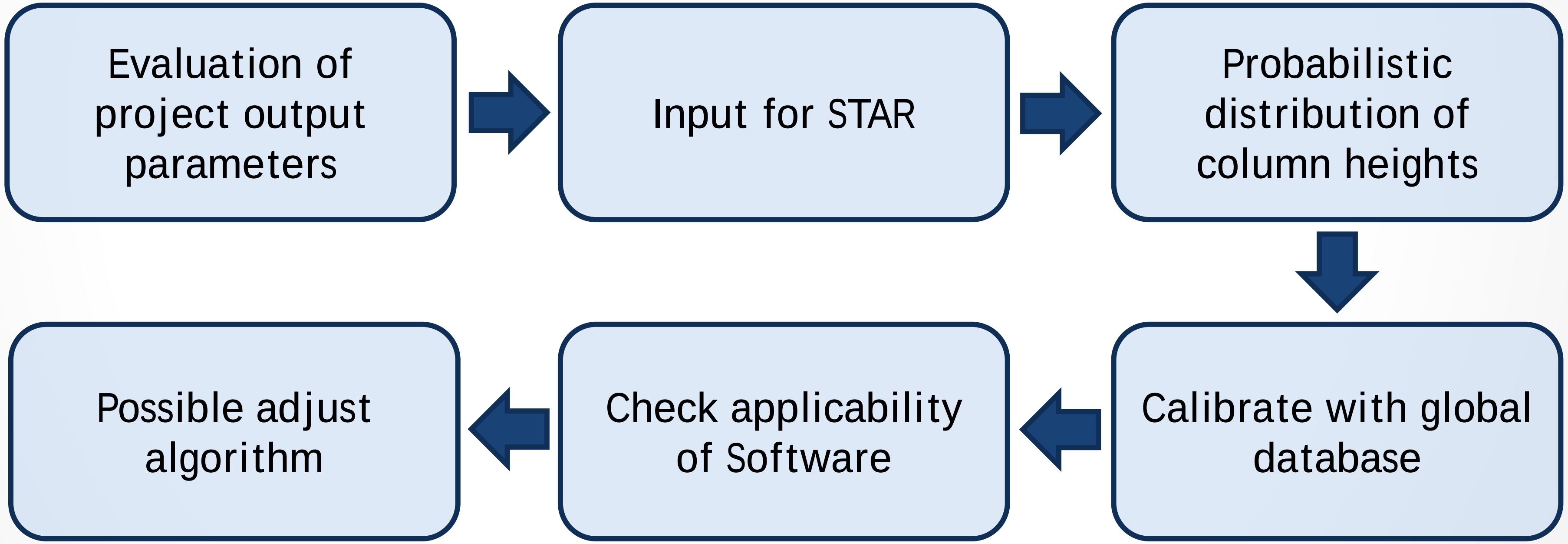


(BGL technical paper, Case study from Oseberg Syd)

(BGL technical paper, Case study from Oseberg Syd)

Methodology

- Stochastic Trap Analysis and Risking tool – STAR



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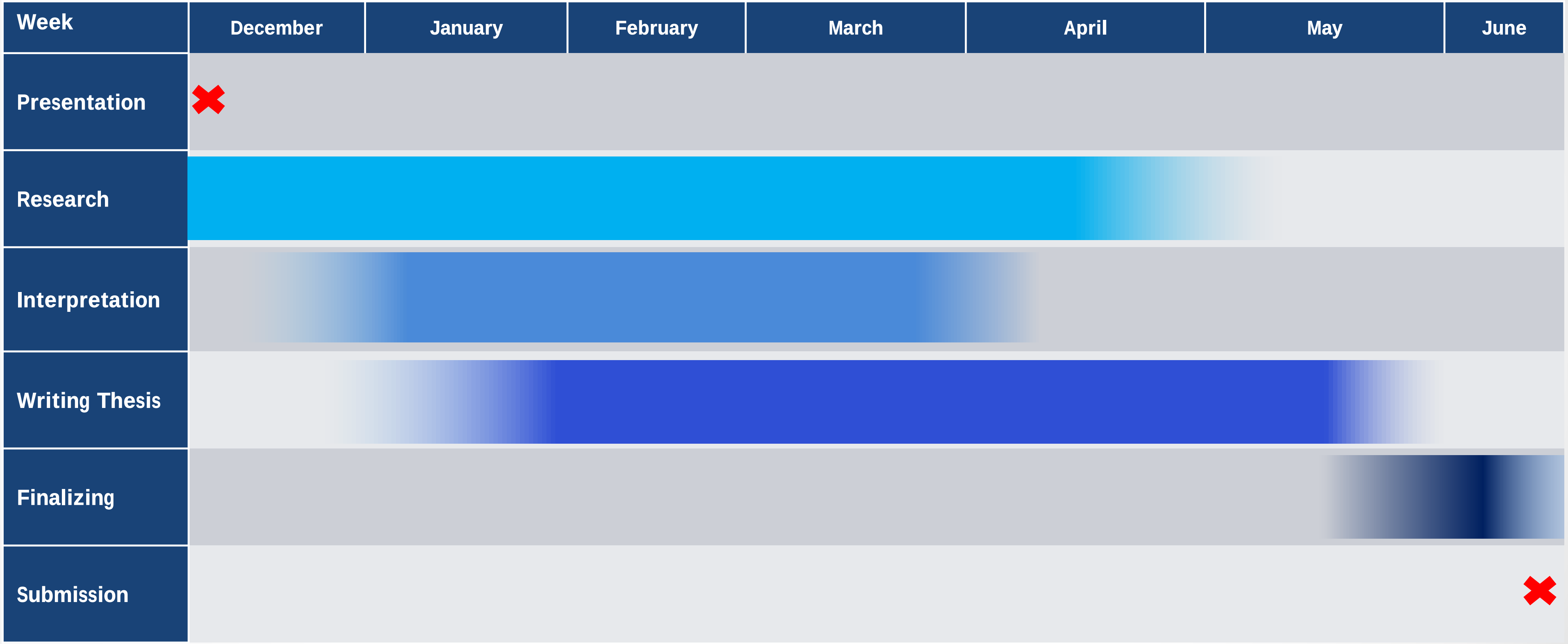
Project timeframe



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THANK YOU!

Provenance of Mesozoic reservoir rocks (Barents Sea, Norway) by Pb – Hf isotopes in detrital zircons

Lena Støle
Advisor:
Dr. Udo Zimmermann

LoCrA
Universitetet i Stavanger

Problem statement

Escalona, LoCrA 2015

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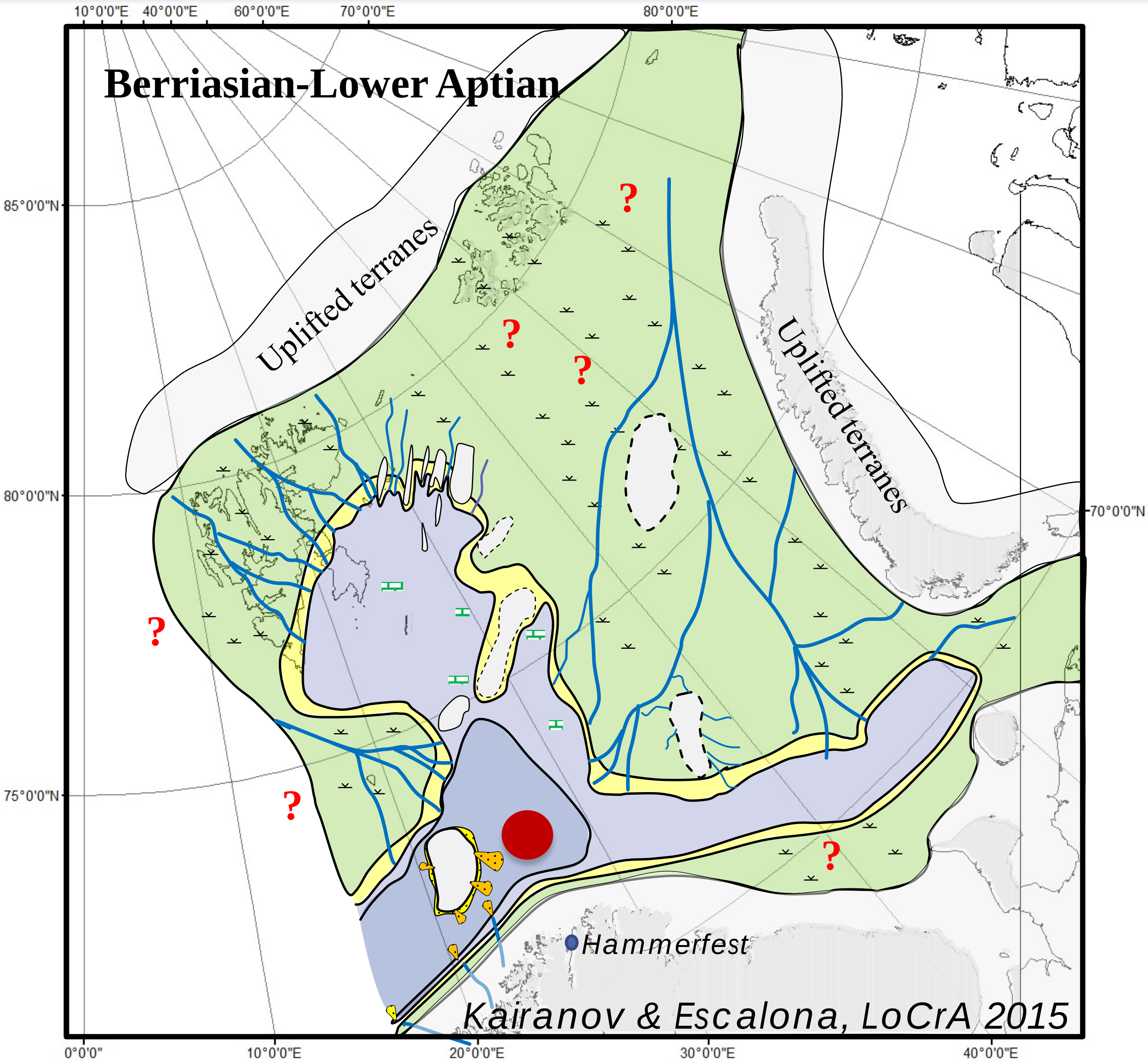
Problem statement



Predicted shoreline position and source direction based on:

- Large bypass area
- Migrating clinoforms
- Paleo-currents

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Motivation

- The provenance study using Hf isotopes will provide an innovative understanding of the potential sources of the Lower Cretaceous formations in Hammerfest Basin, Barents Sea

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Prevous work

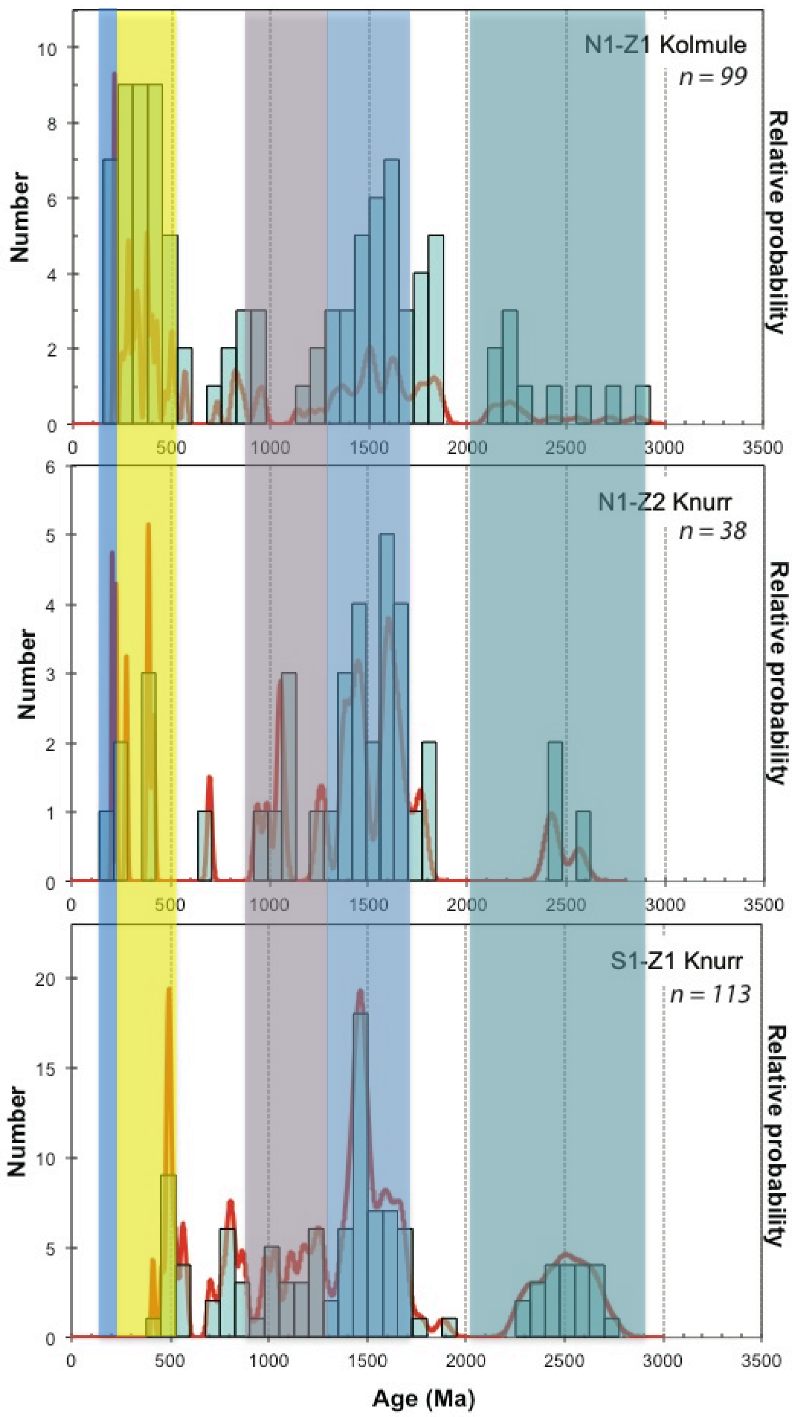
Zicon age spectra: Cretaceous

- Uralian Orogeny (365 – 250 Ma) (Urals, Novaya Zemlya, Taimyr) & granitic magmatism associated with Siberian traps in Kara Sea & Taimyr Peninsula (249 – 232 Ma)
- Caledonides (c.430 – 380 Ma)
- Grenville/Sveconorwegian orogenies (1200 – 900 Ma)
- Gothian (c.1700 – 1300 Ma)
- Palaeoproterozoic rocks (2500 – 1950 Ma) & Archaen craton (>2500 Ma)

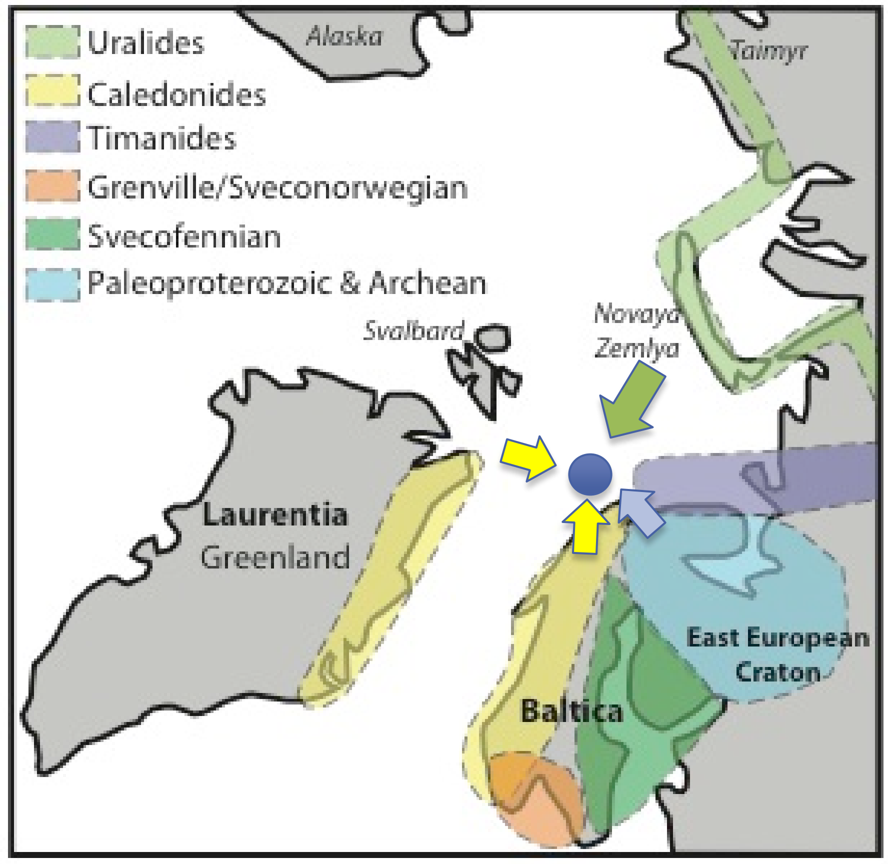
Missing significant influence of Svecofennian (1950 – 1750 Ma)

- Analytical data with a discordance of <10%

Matthews, LoCrA 2014



Previous work
Origin of detritus



Matthews, LoCrA 2014

- 365 – 232 Ma (Urals, Novaya Zemlya, Taimyr)
- c. 400 Ma (Caledonides)
- Grenville & Sveconorwegian (1700 – 900 Ma)
- Svecofennian (1950 – 1750 Ma)
- Palaeoproterozoic & Archaen (1950 - >2500 Ma)

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Outline

- Introduction
  - Zircon
  - Pb – Hf isotopes in zircons
- Objective
- Data set
- Methodology
- Time Frame

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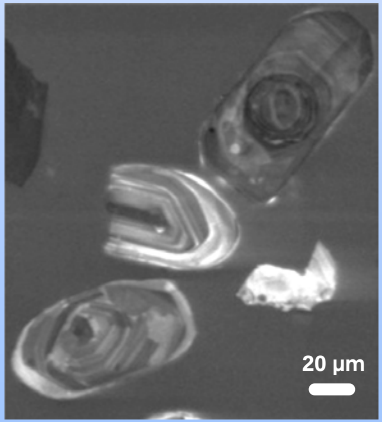
Introduction
Zircon as a Provenance Tool

- Zircon
  - Ultra stable mineral
  - Appears in nearly all felsic and intermediate rock types
  - Effectively reworked into sandstones or other clastic rocks
- Two systems available
  - U-Pb isotopes
    - Crystallization Age
  - Lu-Hf isotopes
    - Model Age of the original magma

Knurr Fm: SW Well, 2225.75m

Knurr Fm: NE Well, 1866.5m



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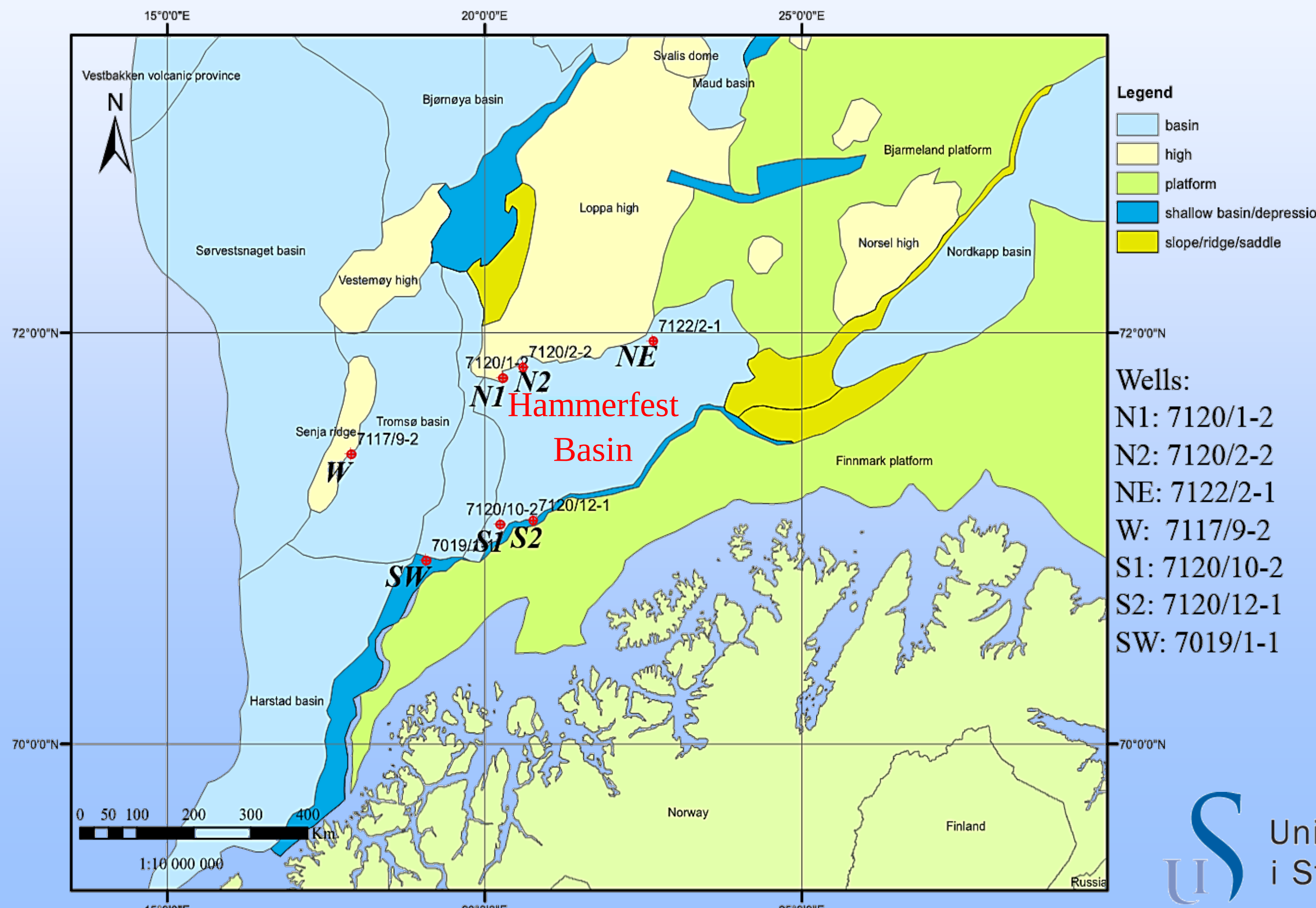
Objectives

- Define and explain age population of Mesozoic rocks in the Hammerfast basin
- Understand the location of the involved sources by applying Lu-Hf isotopes on Lower Cretaceous rocks in the Hammerfast basin
- Add valuable information for the interpretation of the location of the sources

Data set

- U-Pb sample sets: 27 (with ~120 grains measured per sample)
- Lu-Hf samples: selected 10-15 grains from 27 samples



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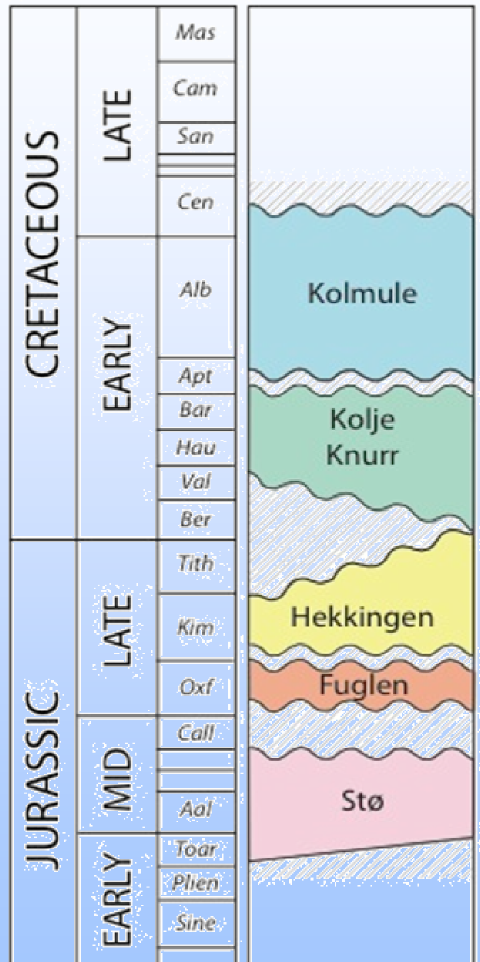
Mesozoic formations

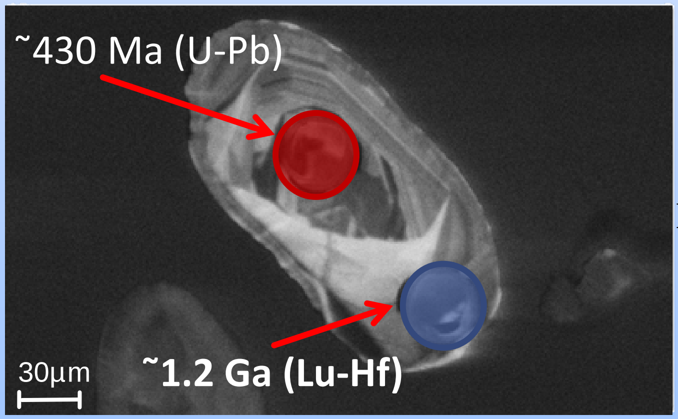


Adapted from Worsley et al., 1988

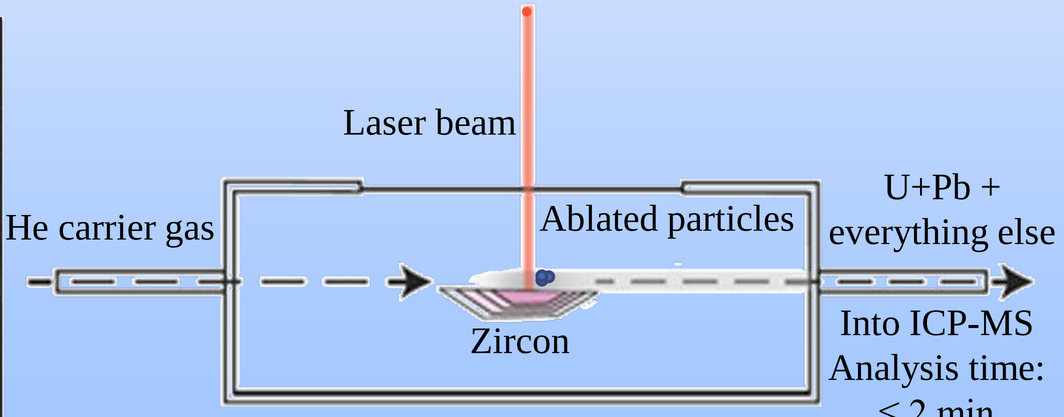
Formations	Depositional environment
Kolmule	Open marine environment
Kolje	Open marine environment
Knurr	Open marine environment
Hekkingen	Marine, deep water with anoxic environment
Fuglen	Marine environment
Stø	Coastal environment

Analytical Method

- Lu – Hf analyses of zircon grains are carried out on Varian 810 laser ablation multicollector inductively coupled plasma mass spectrometry (LA-ICP-MS) at the University of Houston.
- Well selected Lu-Hf samples from Pb age population



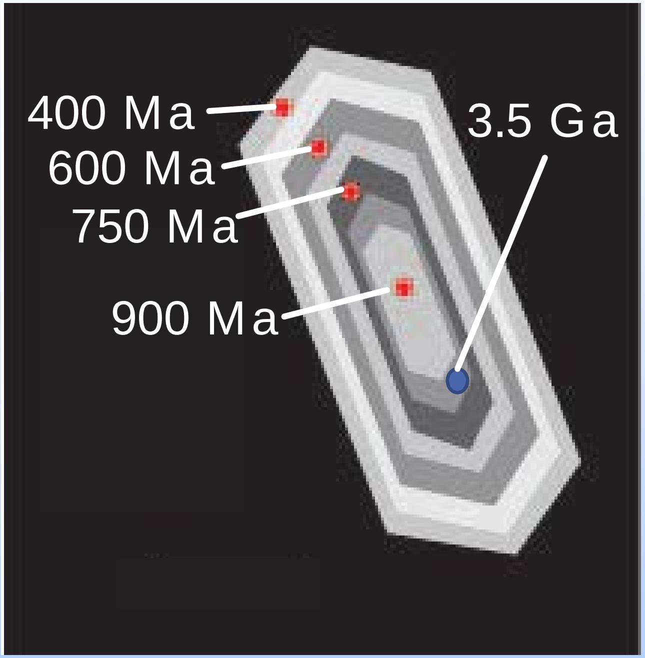
Laser ablation inductively coupled plasma mass spectrometry



Adapted from Cottle et al. 2009

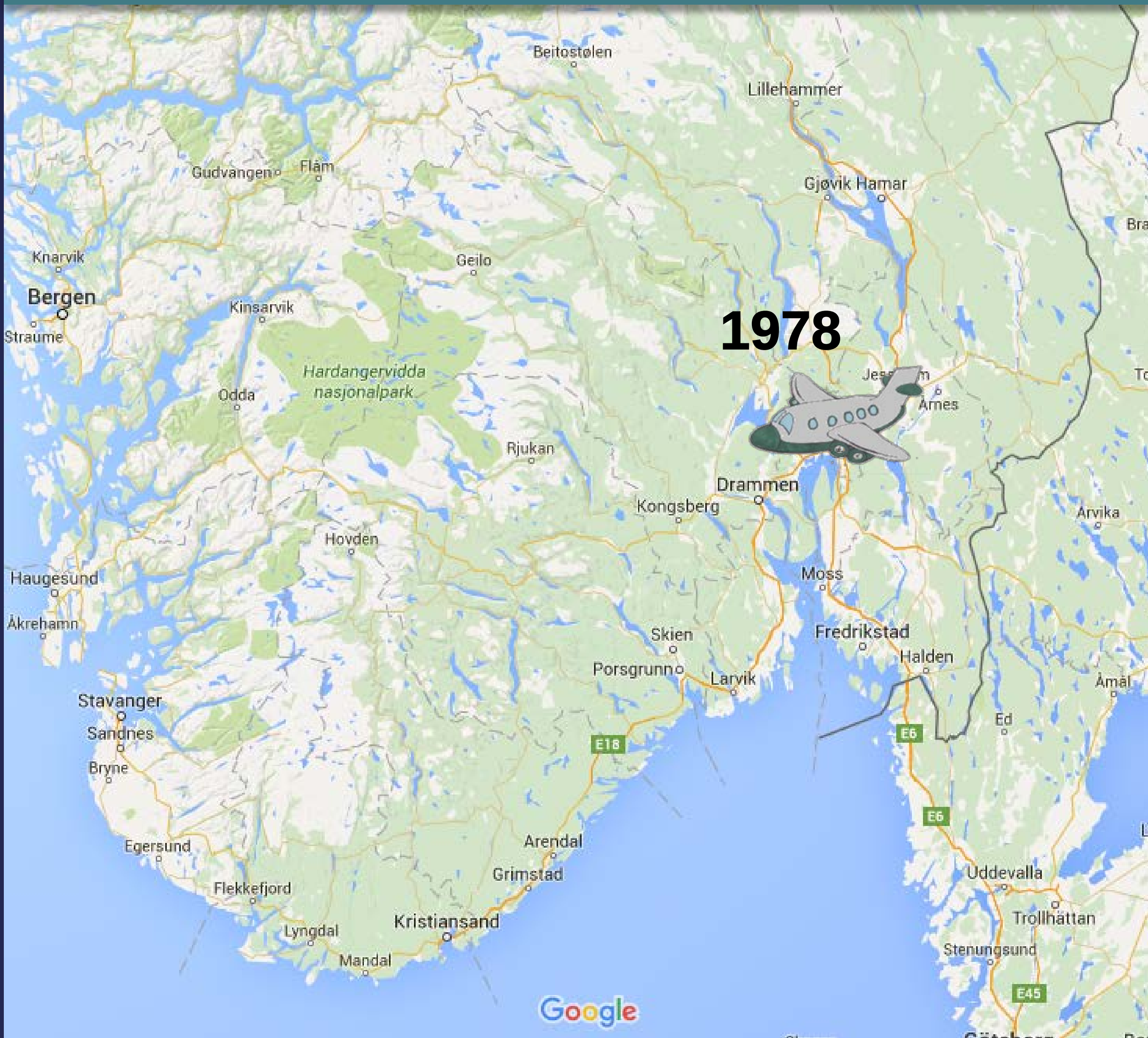
Analytical Method

- The power of Pb – Hf isotopes
  - Crystallization age (U-Pb)
    - Effected by recrystallization
  - Model age (Lu-Hf)
    - Not effected by recrystallization



- Indicates the age of crust and the time from mantel separation to final crystallization

Analog



From Oslo to Stavanger 1978 (Lu-Hf)

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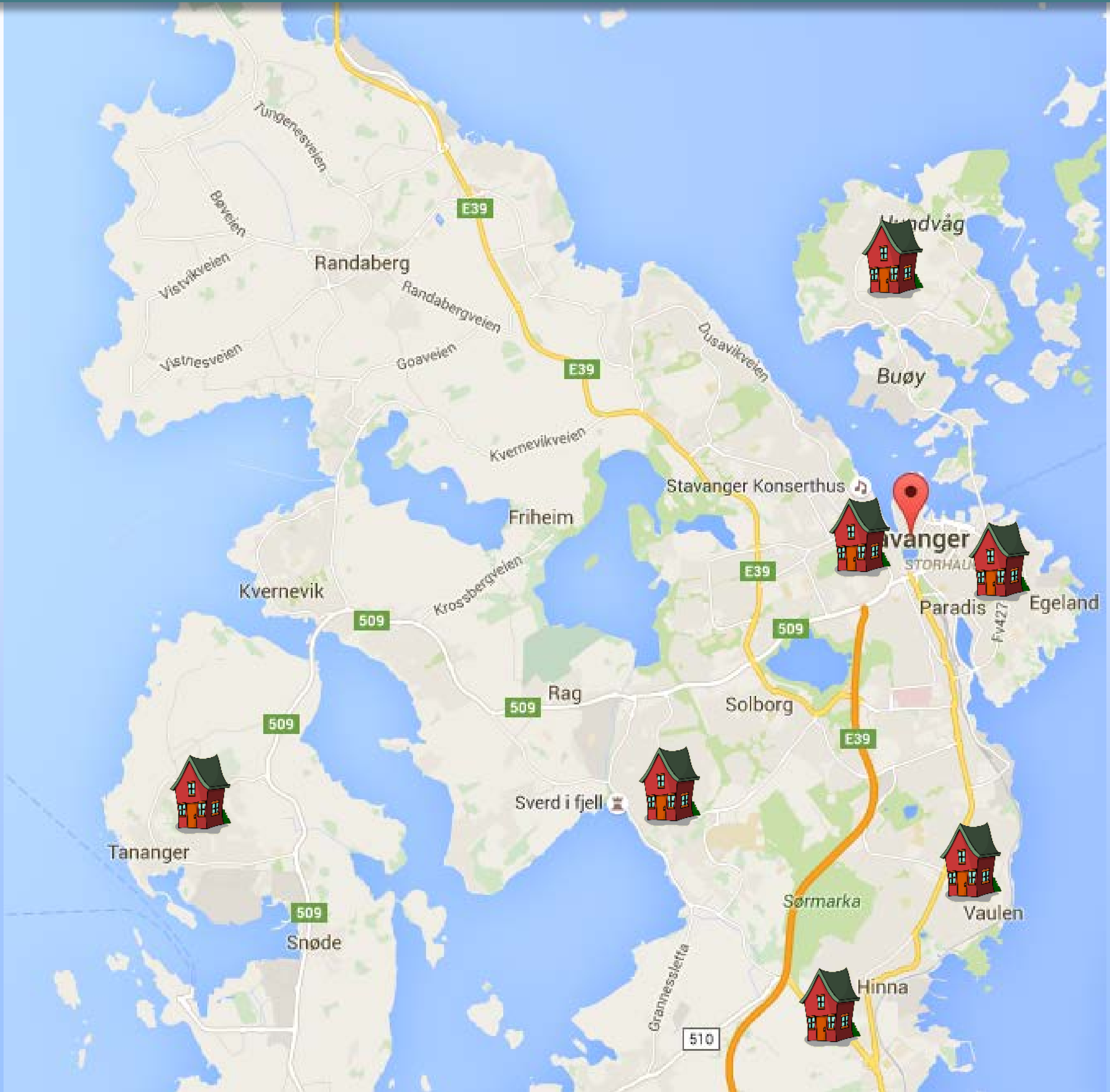
Analog



In Stavanger
you move
6 times (U-Pb)

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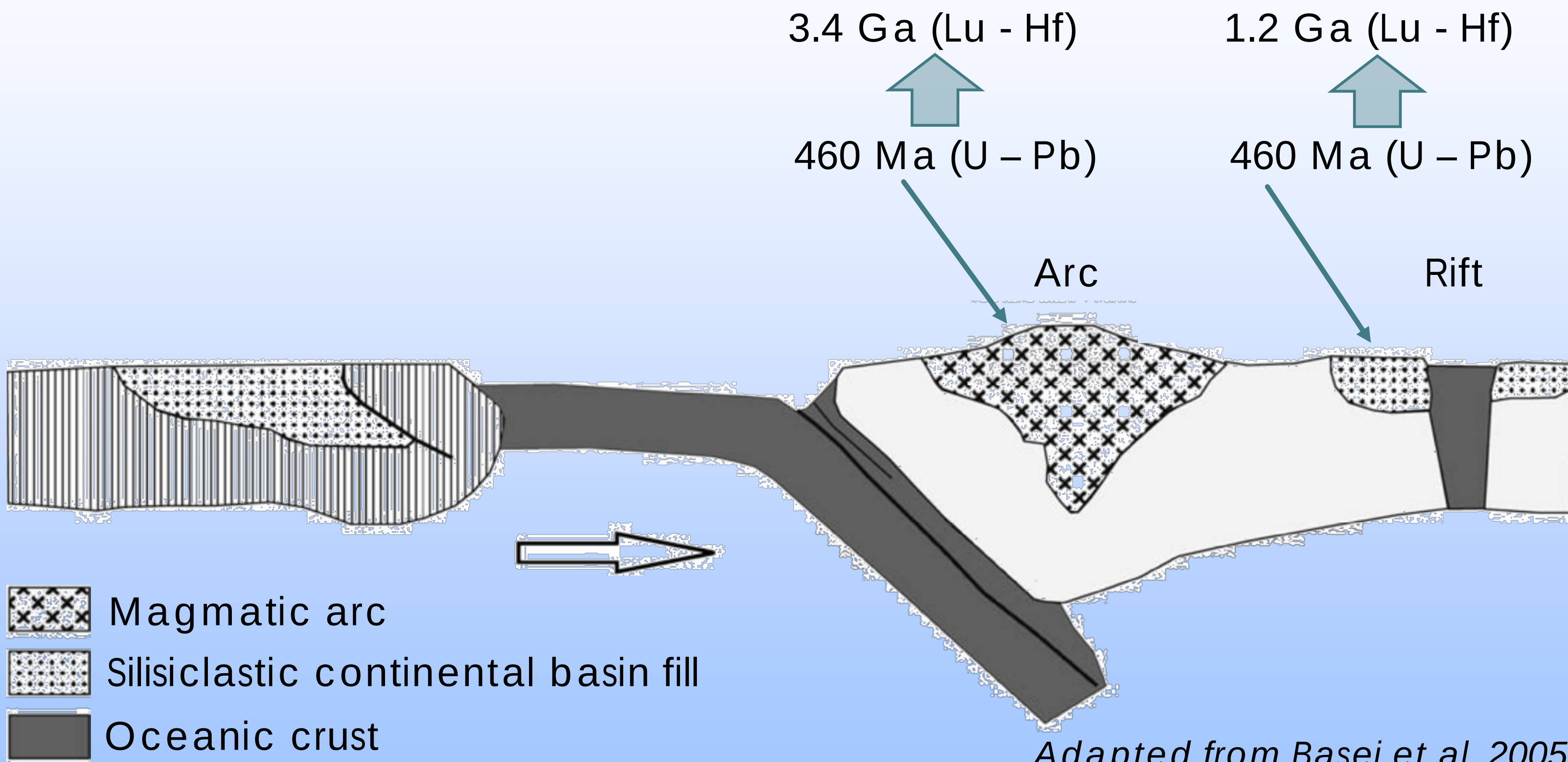
An Example



Adapted from Basei et al. 2005

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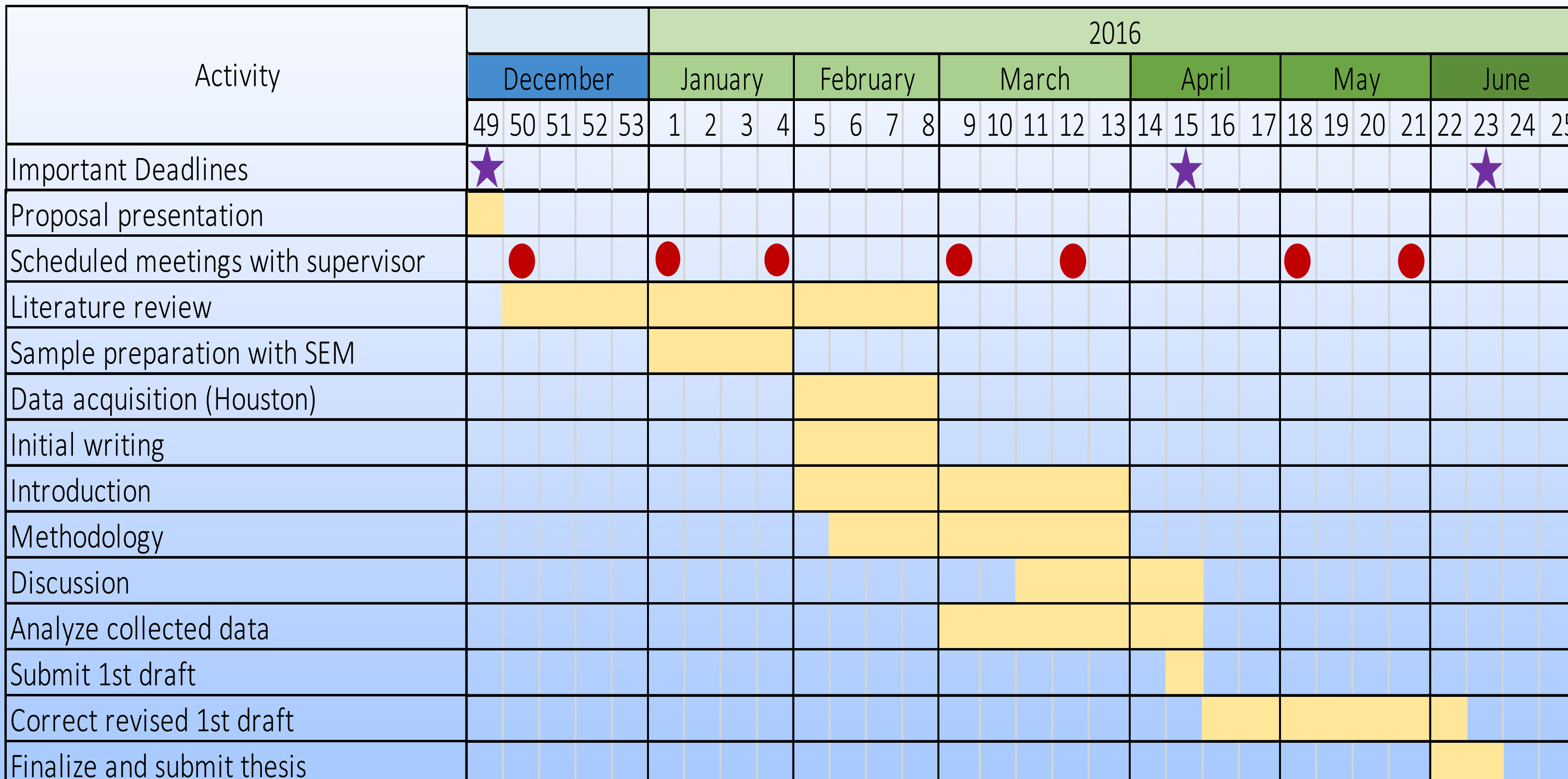
Time Frame



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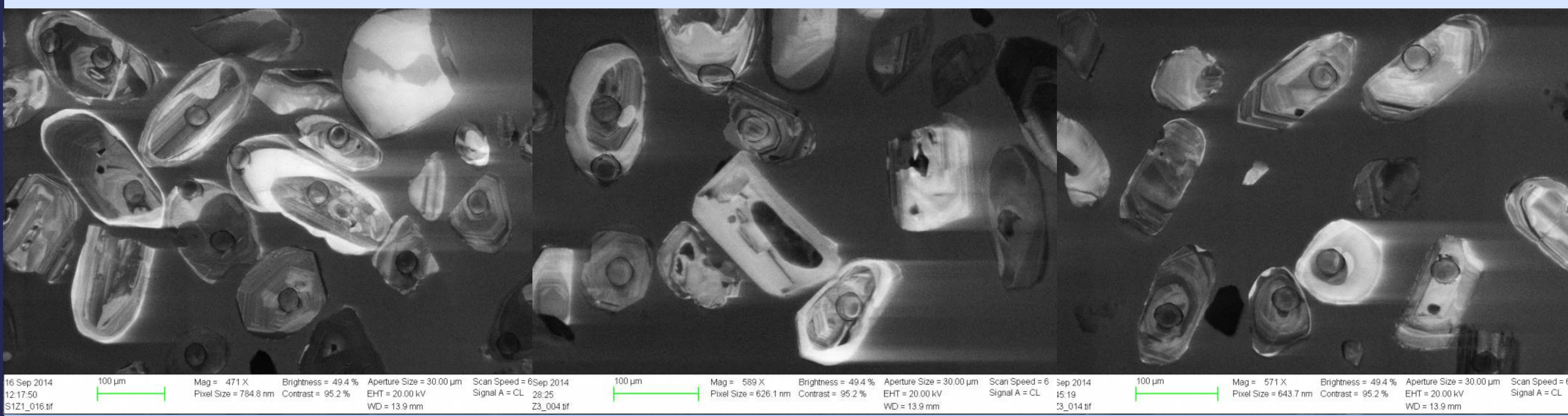
Thank you for your attention!



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Master thesis proposal

Mechanical modeling of salt-influenced extensional forced folding

Muhammed Elsheikh, MSc

Supervisor: Nestor Cardozo

University of Stavanger

Department of Petroleum Engineering

4th December 2015

OUTLINES

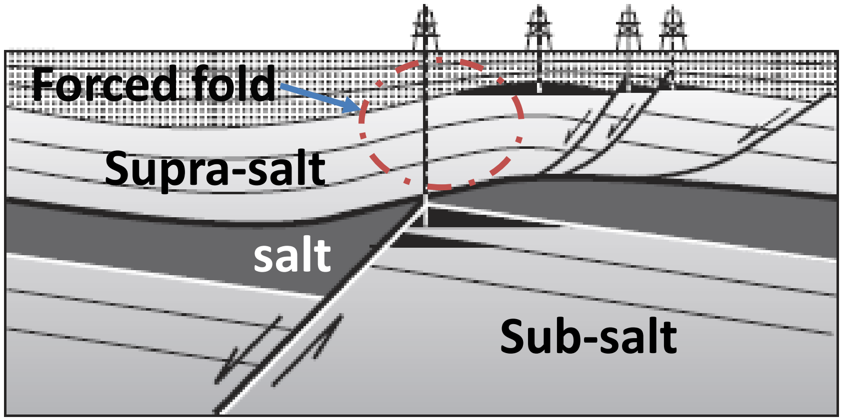
- Introduction
- Scope & research questions
- Methodology
- Timeline

INTRODUCTION

➢ Salt as a decoupling material

- The salt rock
- Where do salt deposits occur?
- Rheology of salt

- In extensional systems, salt layers can act as intra-stratal detachments

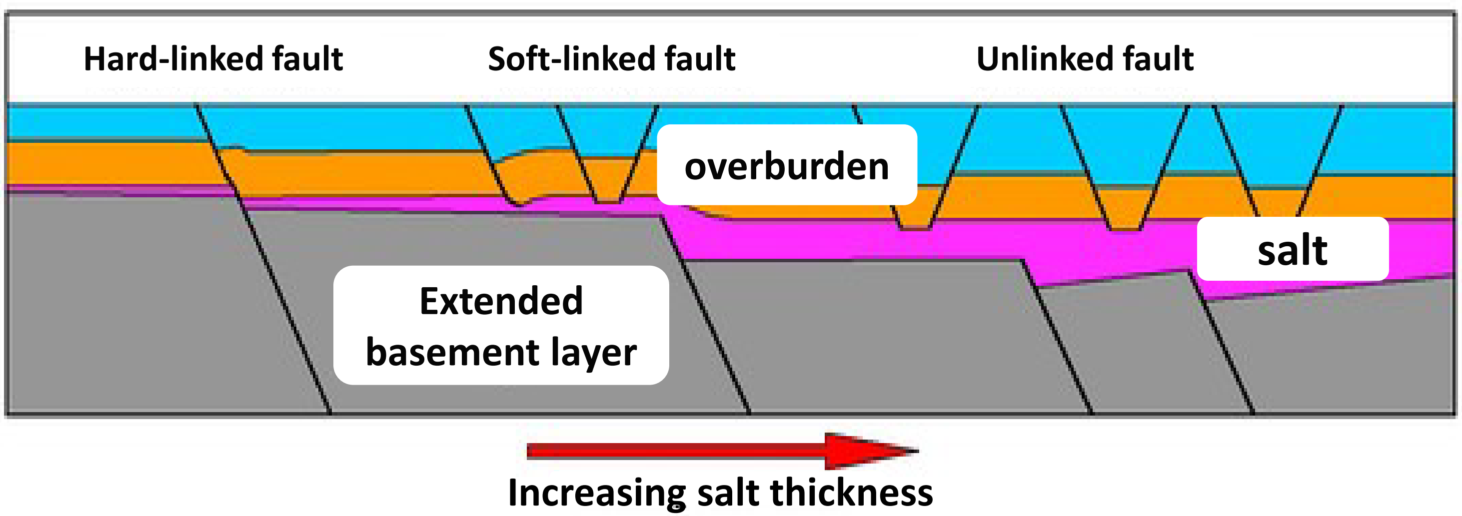


Sketch of an extensional forced fold above a master normal fault, Source: Withjack et al,. 2000.

INTRODUCTION

➢ Factors controlling the degree of decoupling

- evaporite thickness
- overburden thickness
- cohesive strength and ductility of the overburden
- total fault displacement
- Others: displacement rate, preexisting faults…etc

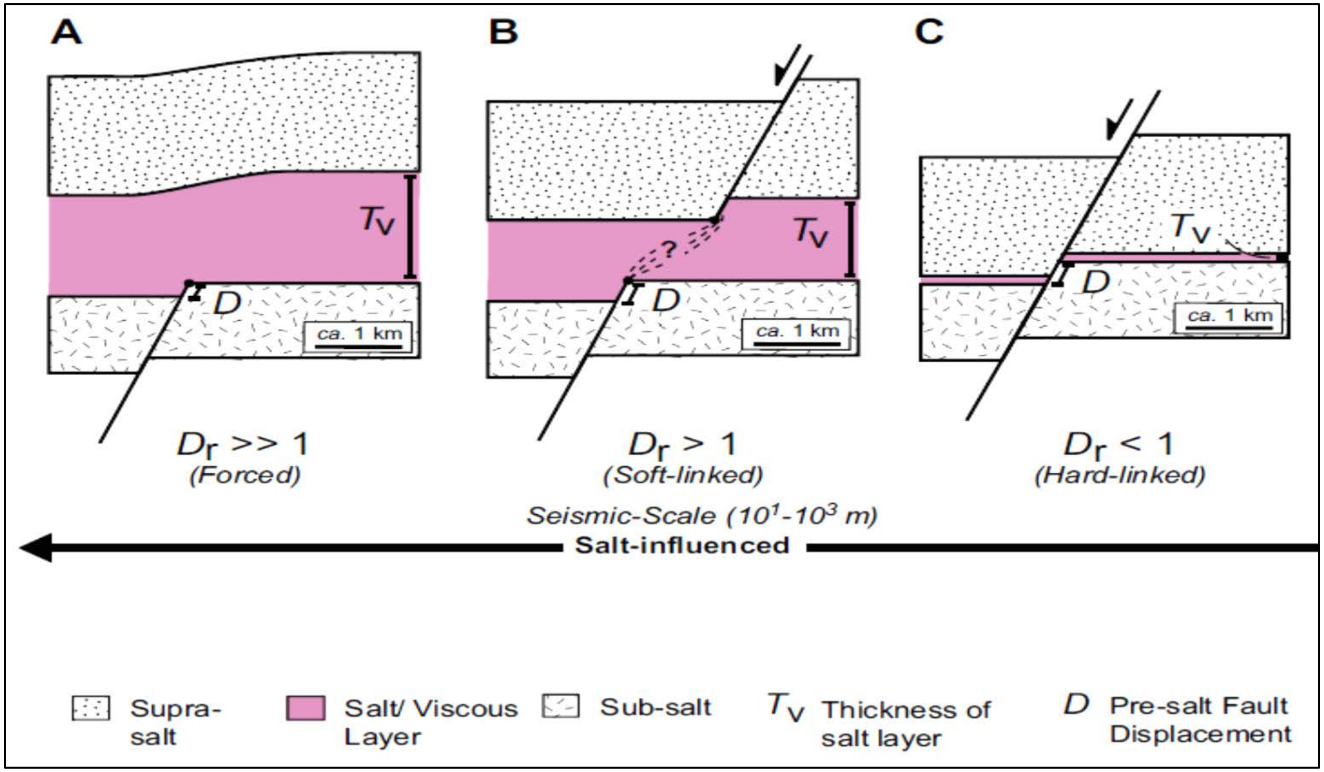


Cartoon showing types of fault linkage depending on thickness of salt layer source: unknown

INTRODUCTION

➢ Previous work

- Many analogue modelling and seismic interpretations
- Lewis et al., 2013; predicted the linkage style using the displacement ratio: the ratio between original salt thickness (Tv) and sub-salt fault displacement (D)



Source: Lewis et al., 2013.

SCOPE & RESEARCH QUESTIONS

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To understand:

- The role of salt thickness in influencing the deformation in extensional forced folds
- The effect of varying salt location within brittle sedimentary sequences
- The impact of growth sedimentation

METHODOLOGY

Geomechanical simulation of extensional forced folding using the discrete element modeling (DEM)

Varying salt thickness and location and running several models

Computing strain fields to express the evolution of the structure

METHODOLOGY

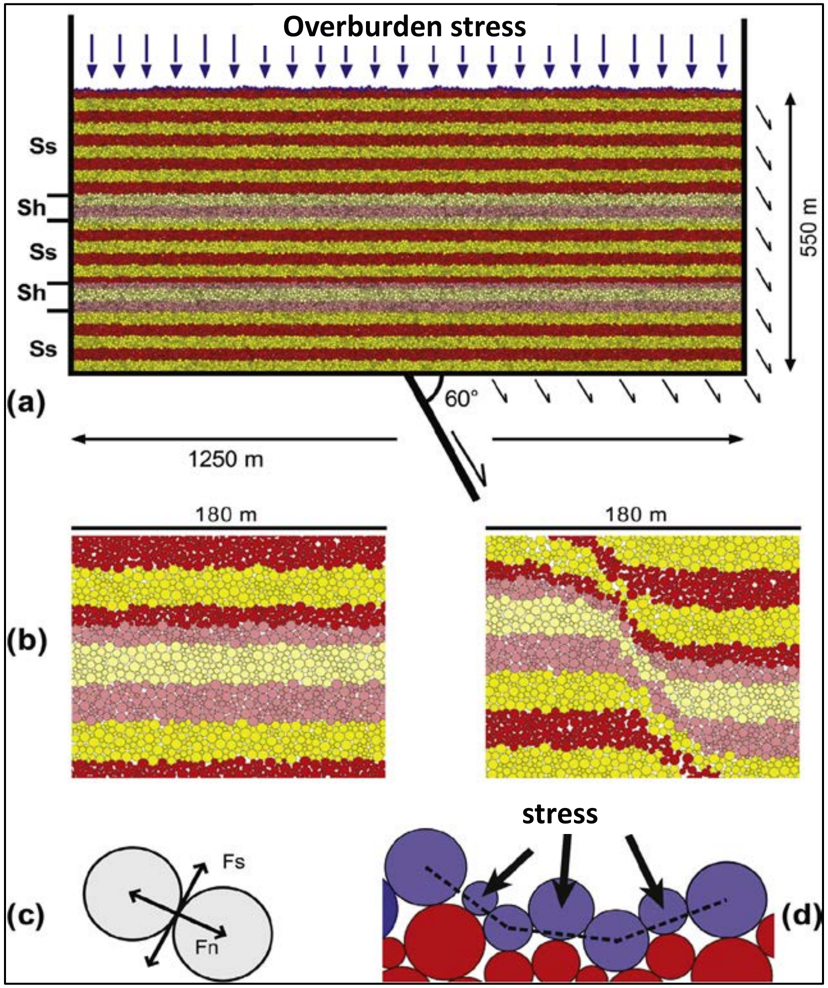
➢ Discrete Element Modelling (DEM)

- A numerical method that models the rock as an assemblage of circular rigid particles in 2D.

- DEM advantages and disadvantages.

- Cdem2D as a discrete element code:

1. Frictional brittle cover.
2. Viscous layer.
3. Strain rates.

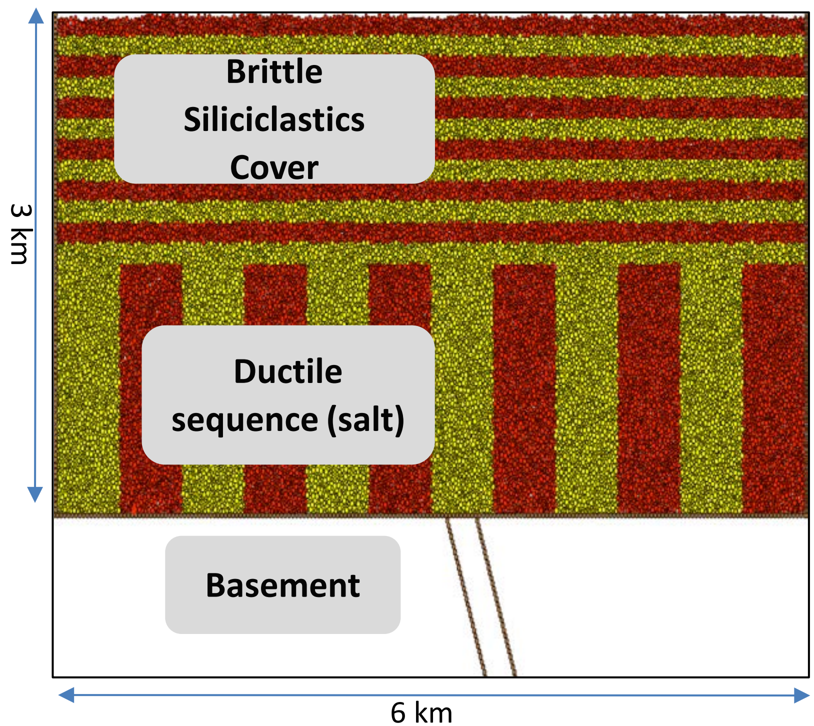


Example of the DEM, Source: Botter et al., 2014.

METHODOLOGY

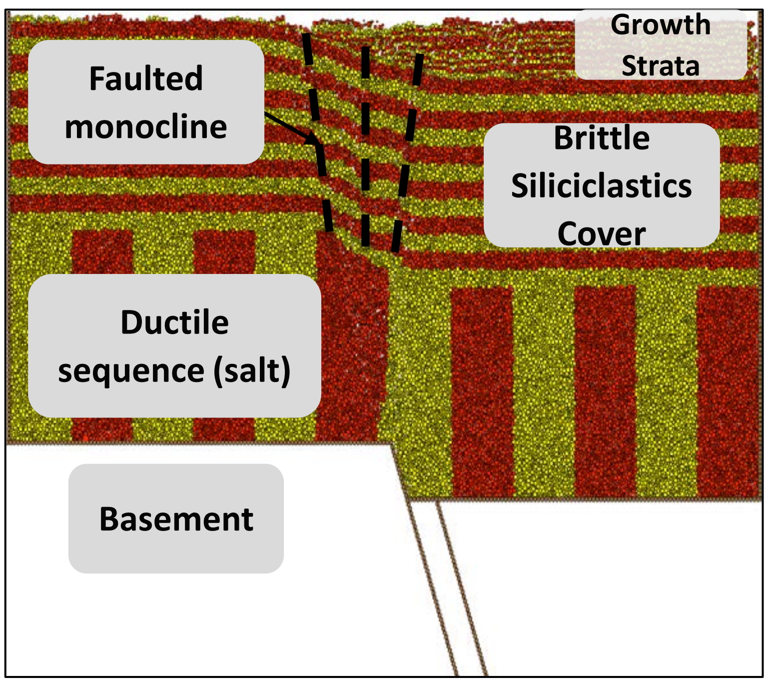
➢ Discrete Element Modelling (DEM)

- Example of DEM in extensional setting in different time steps; initial number of particles = 46500, maximum particle radius = 16 m, minimum particle radius = 6 m, normal fault dip = 70˚.



Initial

Source: kindly offered by communication with Stuart Hardy, University of Barcelona

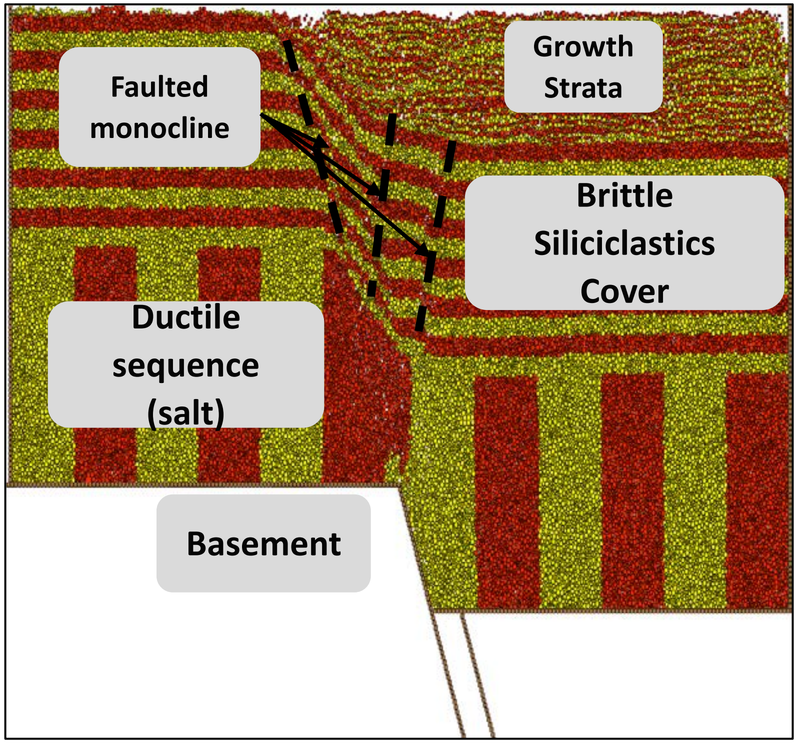


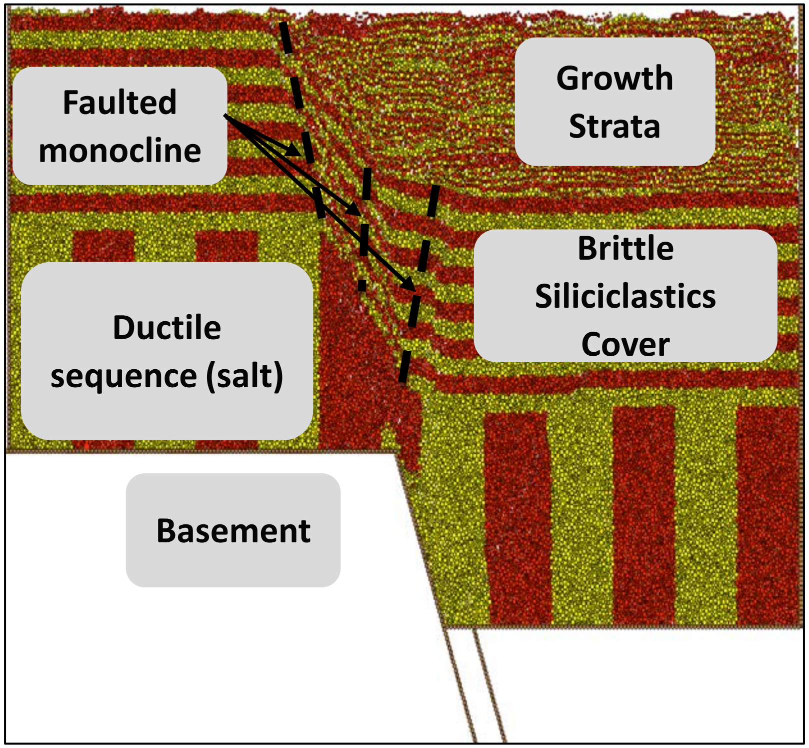
Increment 820

Fault displacement = 132 m

METHODOLOGY

➢ **Discrete Element Modelling (DEM)**





Increment 820

Fault displacement = 197 m

Increment 1220

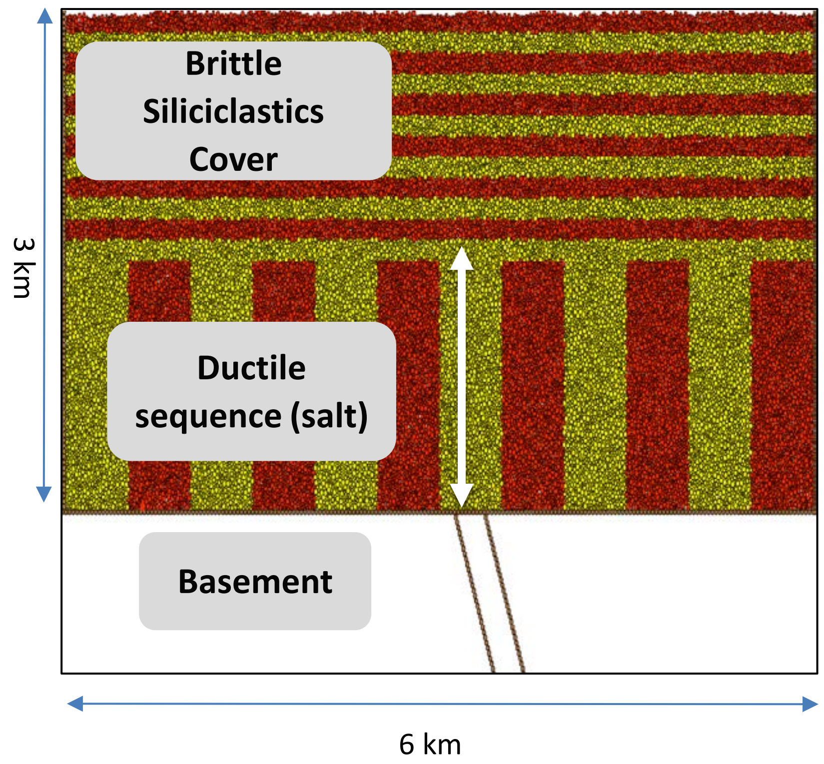
Fault displacement = 263 m

METHODOLOGY

➢ Model parameters

- Default parameters:
  - initial number of particles = 46500.
  - maximum particle radius = 16 m.
  - minimum particle radius = 6 m.

- Changed parameters:
  - Ductile formation (salt) thickness.
  - Ductile formation (salt) location.
  - Sedimentation rate.
  - Fault geometry.

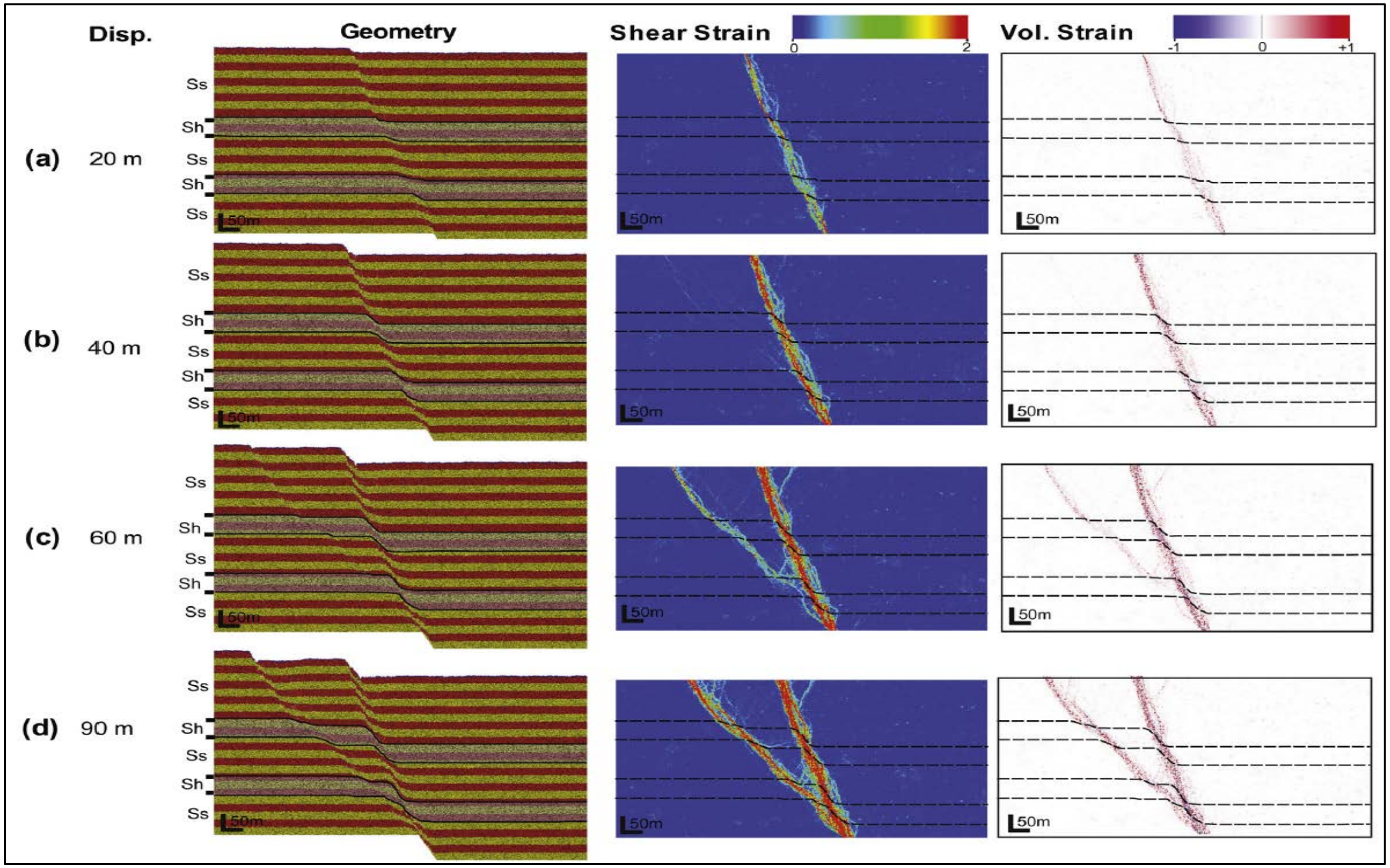


Initial

METHODOLOGY

➢ Strain Field Computation

- Strain will be computed using SSPX (Cardozo and Allmendinger, 2009) .



Evolution of a DEM normal fault simulation at: (a) 20, (b) 40, (c) 60 and (d) 90 m of fault displacement, source: Botter et al., 2014.

TIMELINE

	JAN		FEB		MAR		APR		MAI		JUN	
Check Software and readings												
Run DEM models												
Varying the salt thickness and location												
Compute the strain												
Results and Discussion												
First draft												
Reviewing the thesis structure												
Final draft												
Review the submission requirements												
Final read proof from supervisor												
Final submission												

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Thank you

Master thesis proposal

Seismic imaging of salt-influenced compressional folds

Author:
Diana Castillo

Supervisors:
Nestor Cardozo
Charlotte Botter

University of Stavanger

4^{th} December, 2015

Agenda

1. Introduction

2. Motivation

3. Objectives

4. Methodology

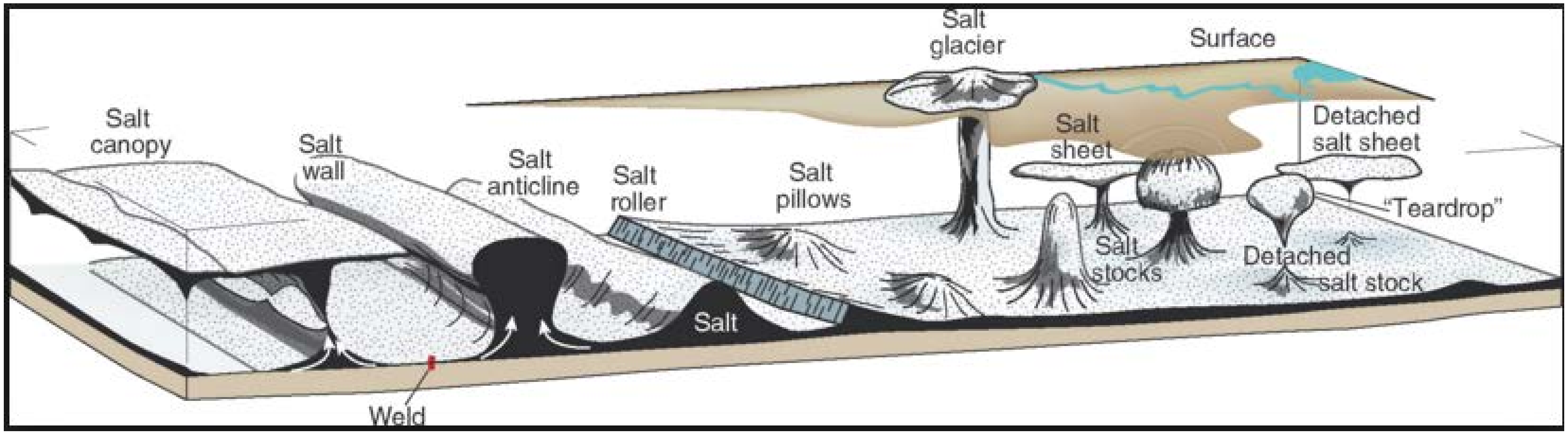
   - Model fold and thrust belt (FTB) – Discrete element method (DEM)
   - Finite strain Computation
   - Modify seismic properties based on finite strain
   - Seismic imaging simulation and sensitivity studies

5. Time frame

Introduction

Rock Salt:

- ✓ Controls the dynamical evolution of many sedimentary basins
- ✓ Occurs in different tectonic settings and influences the deformation of surrounding rocks
- ✓ Deformation styles of salt basins and non-salt basins can share some similarities

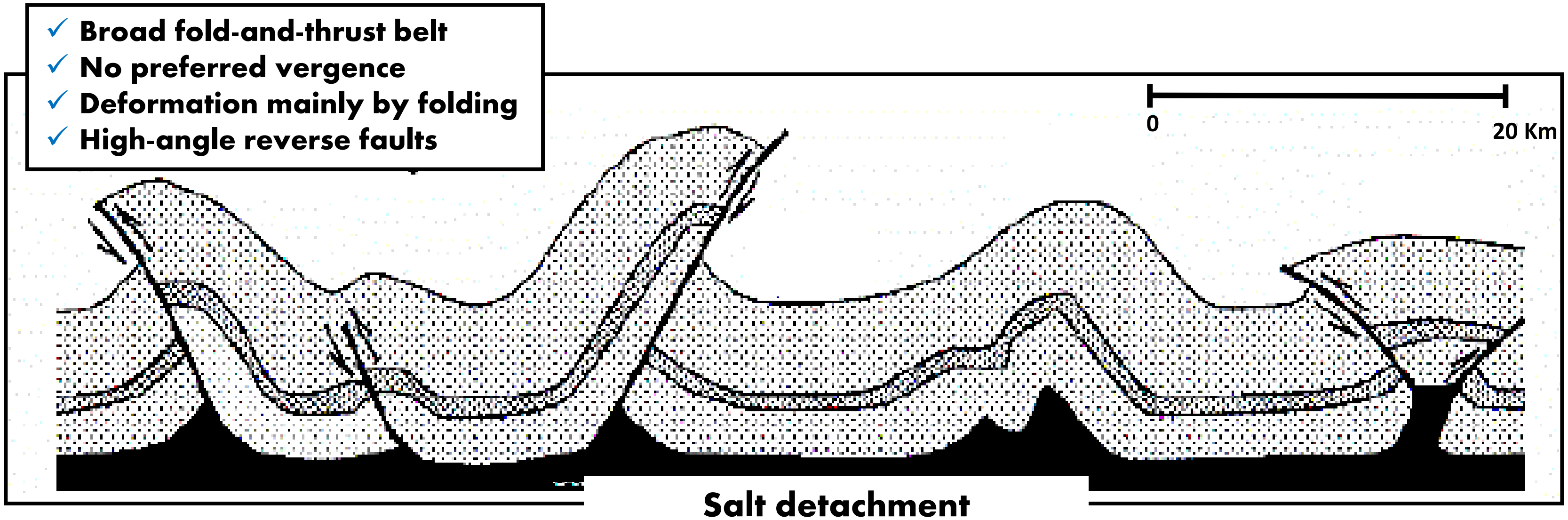


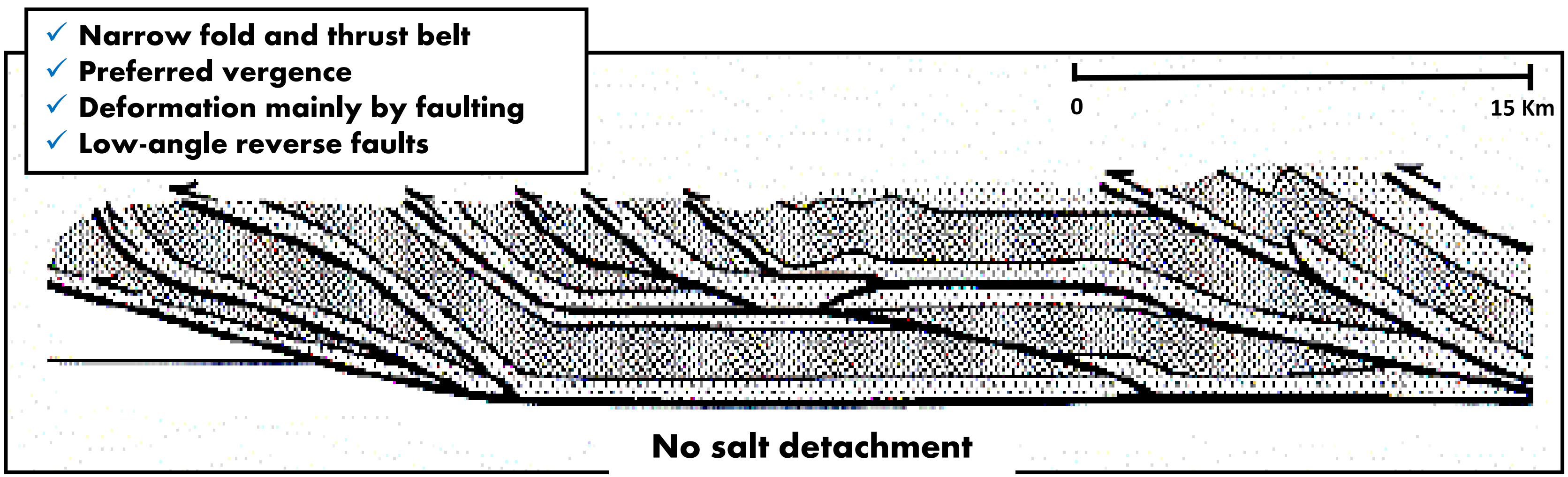
Most notable types of salt structures. *Source: Fossen, H., 2010.*

However, some less obvious aspects may be even more important!

Introduction

Effect of salt detachment on (FTB)



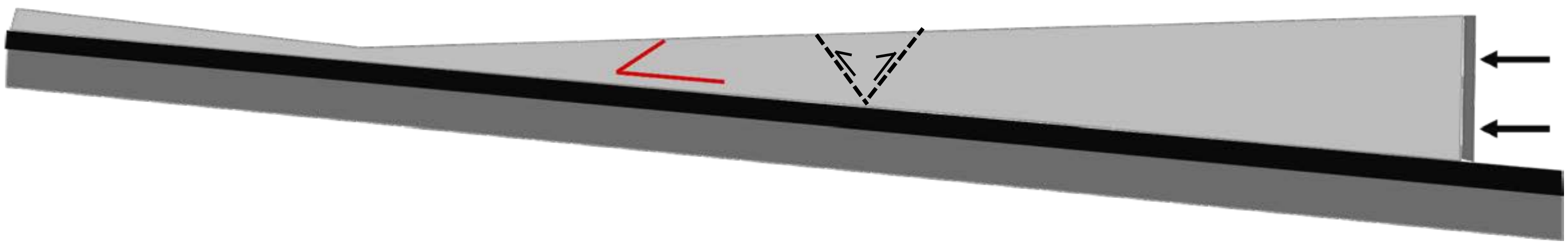


Source Jackson and Talbot, 1991

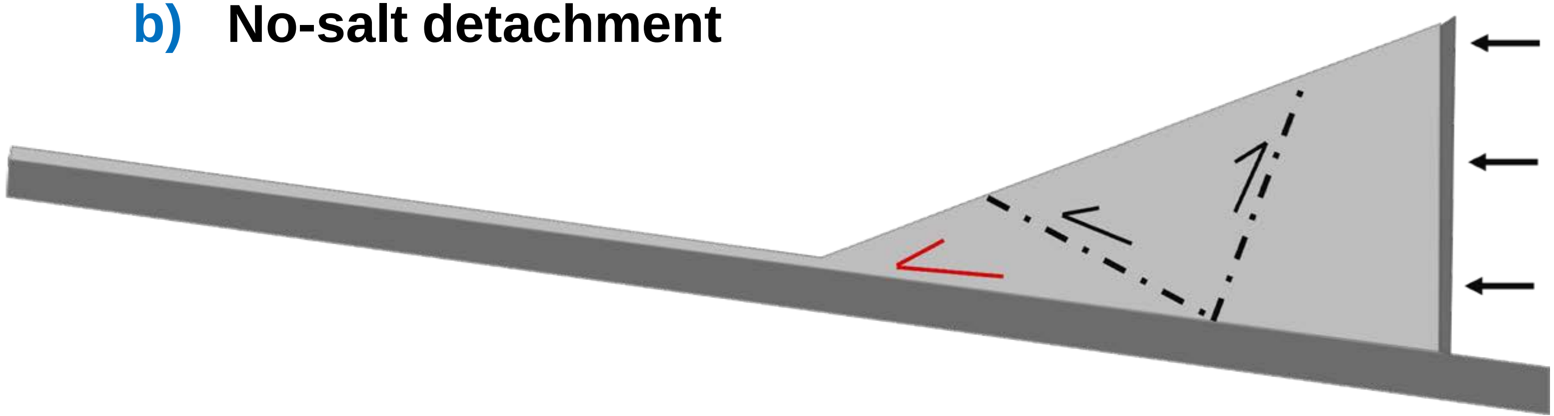
Introduction

Critical - taper theory

a) **Salt detachment**



b) **No-salt detachment**



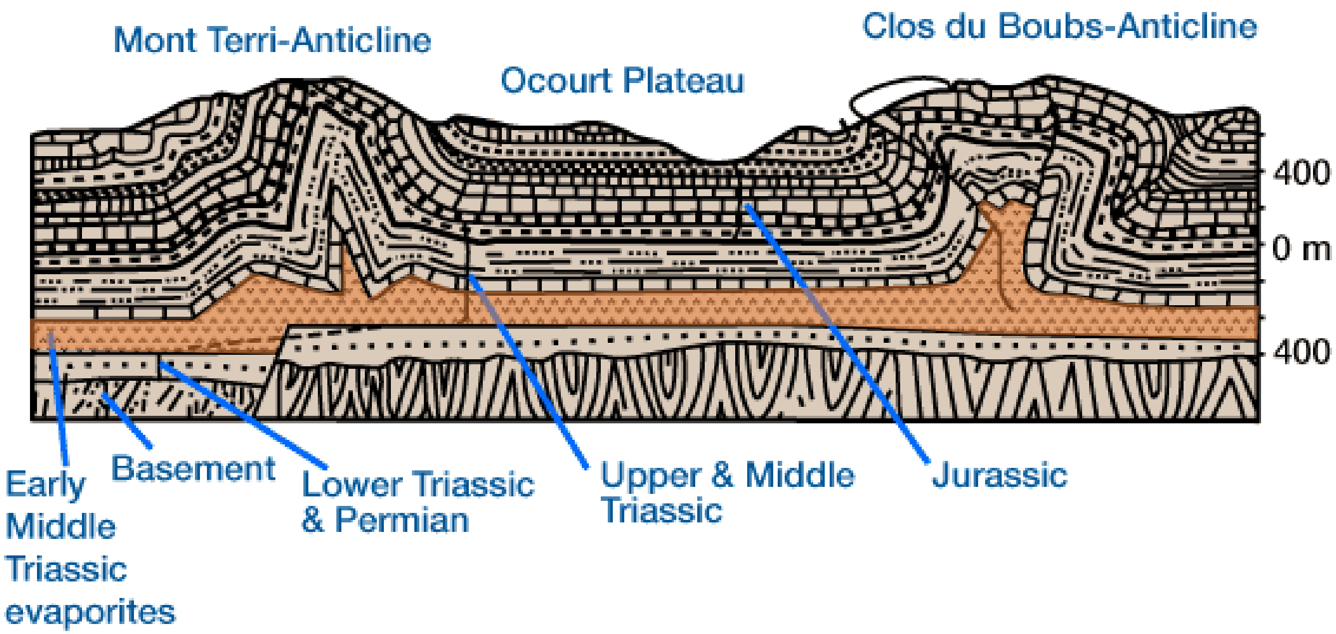
Source: Jaume, S.C. and Lillie, R.J. (1988)

Motivation

- ✓ FTB host large oil and gas fields
- ✓ Structural complexity
- ✓ Low seismic quality

\+ Salt

- ✓ Affects maturation and migration pathways of HC
- ✓ Strong acoustic impedance
- ✓ Difficulty seeing through the salt



Classic section through the Jura Mountains. *Source: Laubscher, 1977*

Objectives

- Study the impact of compressional folds influenced by the presence of a salt layer on seismic imaging.

- Study acquisition and processing challenges (illumination direction and wave frequency) involved in imaging salt-influenced compressional folds.

Methodology

1. Model fold and thrust belt (FTB)
Discrete element method (DEM)

↓

2. Finite strain computation

↓

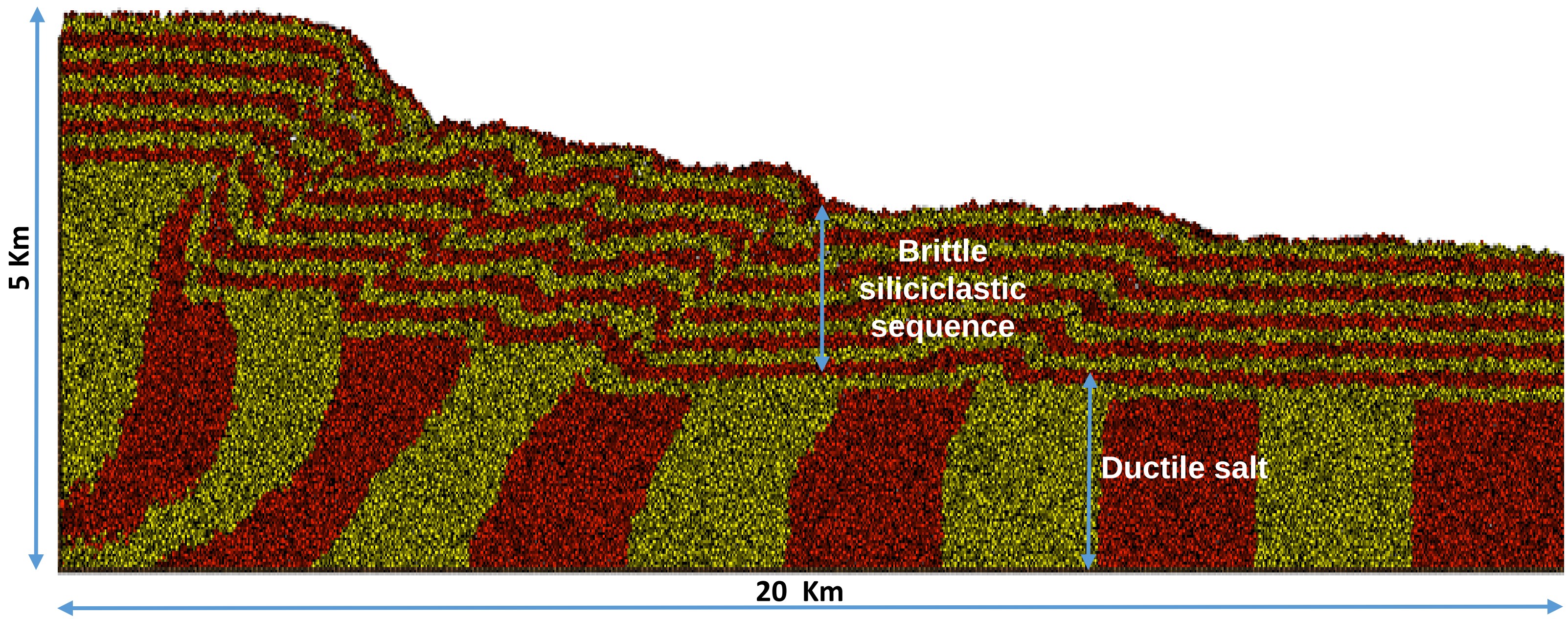
3. Modify seismic properties
based on finite strain

↓

4. Seismic imaging simulation and
sensitivity studies

1. Geomechanical simulation of the FTB using the DEM Provided by Stuart Hardy (University of Barcelona)

✓ Produce a realistic FTB



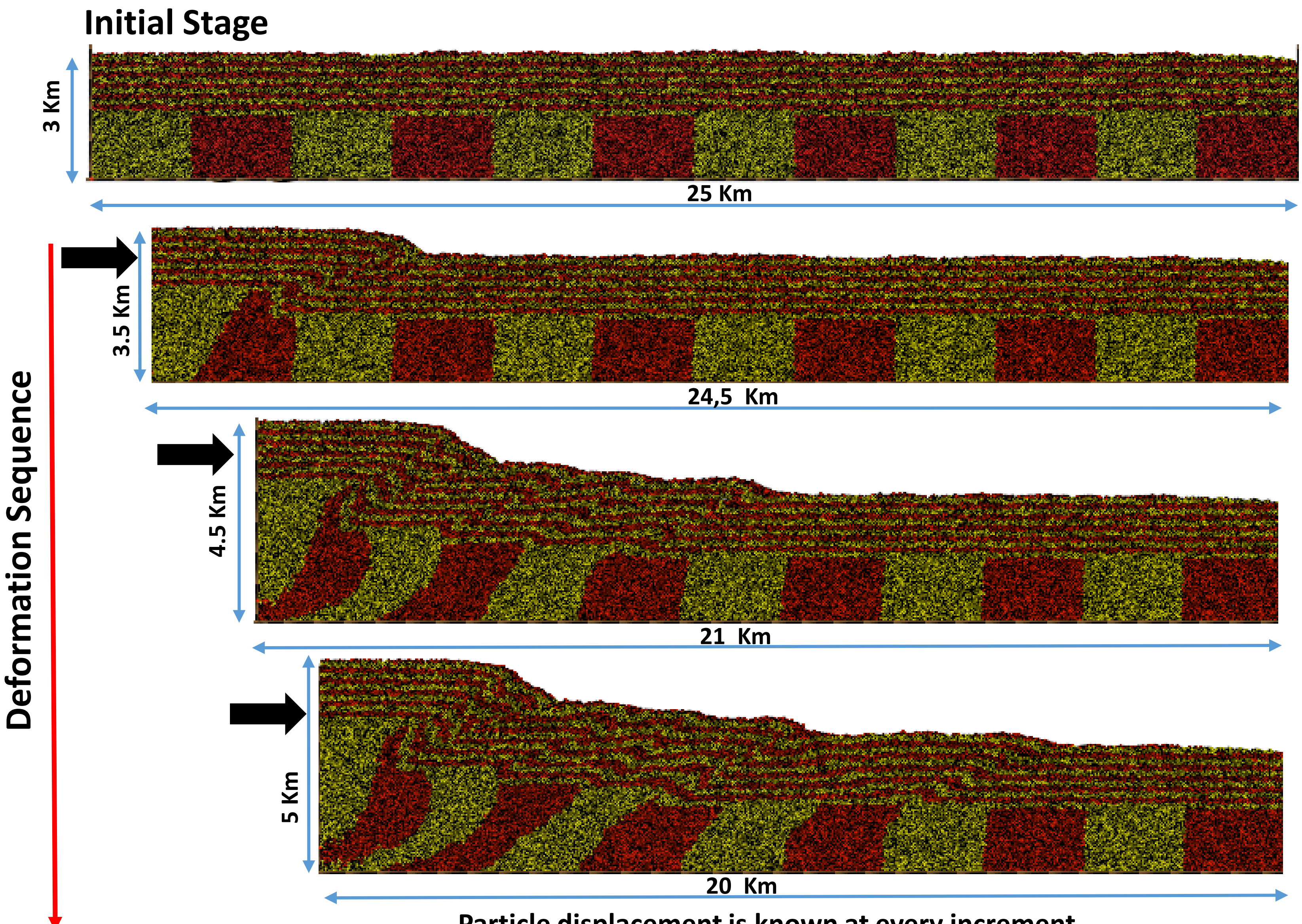
Example of DEM model to be used as input in the workflow. Note the ductile (vertical layering) and brittle (horizontal layering) sequences. *DEM model kindly provided by Stuart Hardy*

DEM model

- Consists of a brittle (strong) – ductile (weak) sequence.
- Brittle cover (siliciclastic) purely frictional (no tensile strength)
- Viscous layer (salt): Viscous force proportional to the derivative of the velocity field

- Particles: 44000
- Maximum particle radius: 31m
  Minimum particle radius: 12.5m
- Allows initiation, propagation and development of the FTB in a realistic way.

1. Geomechanical simulation of the FTB using the DEM Provided by Stuart Hardy (University of Barcelona)



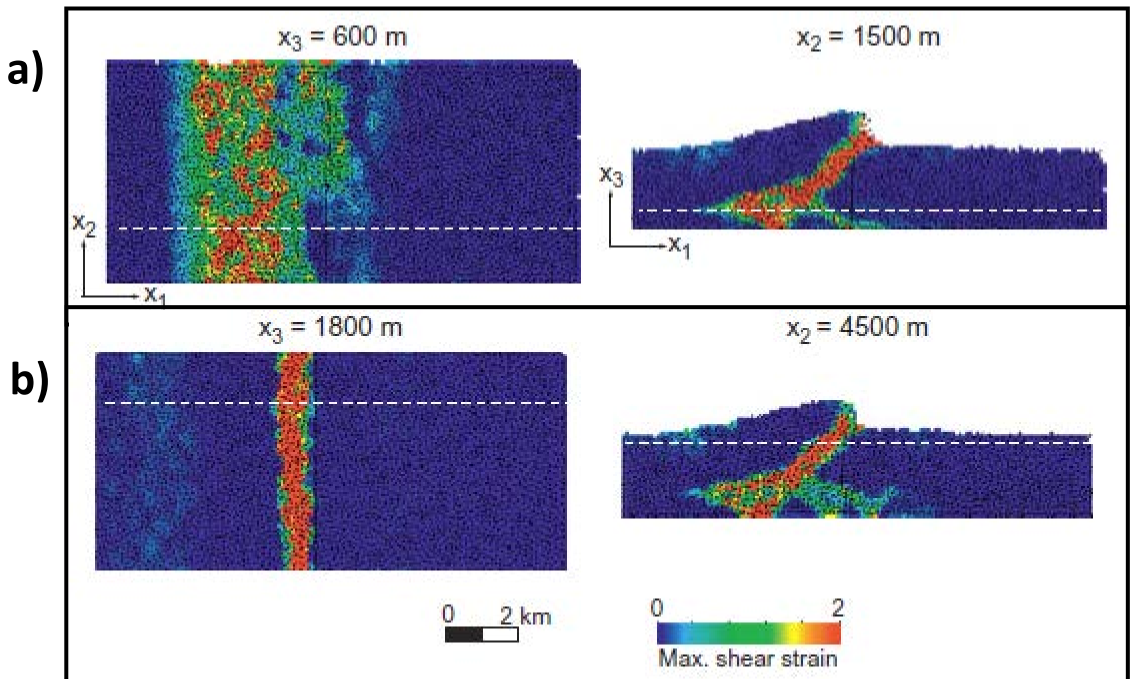
Particle displacement is known at every increment

DEM model kindly provided by Stuart Hardy

2. Strain computation
SSPX program (Cardozo and Allmendinger, 2009)

✓ Compute finite strain

- The DEM provides particle displacements at each increment of the model
- SSPX can be used to compute the strain.
- A regular grid is made. Strain in each cell is computed from the displacement of n particles within a radius from the cell center.
- Assumption that finite strain is homogeneous within each cell.
- Cell size should capture the complexity of the FTB related to strain.



Finite strain of a 3D DEM of thrusting *(Cardozo and Allmendinger, 2009)*

3. Modification of seismic properties

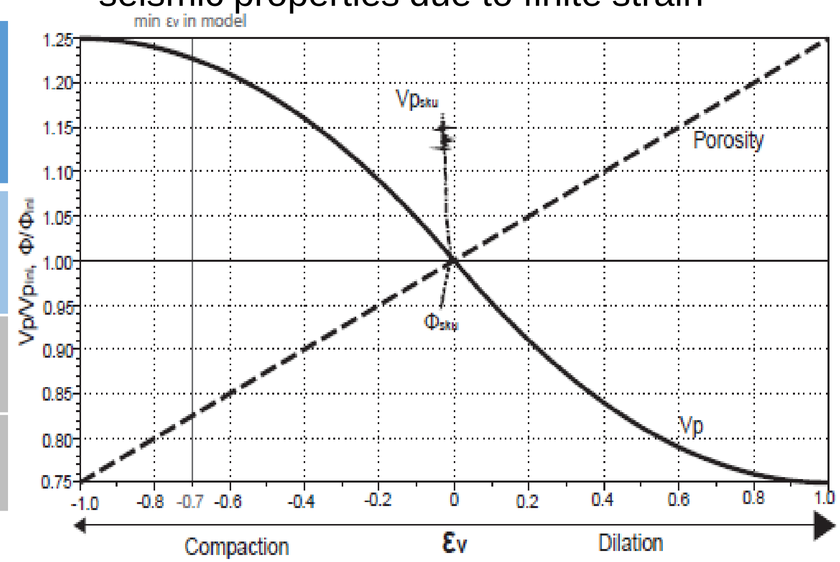
✓ **Empirical relations applied to the geomechanical model to modify its initial acoustic properties based on finite strain**

- Seismic imaging requires an input reflectivity grid computed from elastic properties
- Strain parameters can be used to condition the distribution of rock properties: Density and seismic velocities
- Volumetric strain

	Density (g/cm3)	P-wave (Vp) (km/s)	S-wave (Vs) (km/s)
Halite	**2.16**	**4.50 – 4.55**	**2.59 – 2.63**
Sandstone	**2.65**	**4**	**2.389**
Shale	**2.7**	**2**	**0.801**

Initial average values. *Source: Mavko et al., 2009*

1. Values assigned to DEM model before deformation
2. Density and seismic velocities of sandstone and shale modified only by volumetric strain
3. Simple empirical relations to modify initial seismic properties due to finite strain



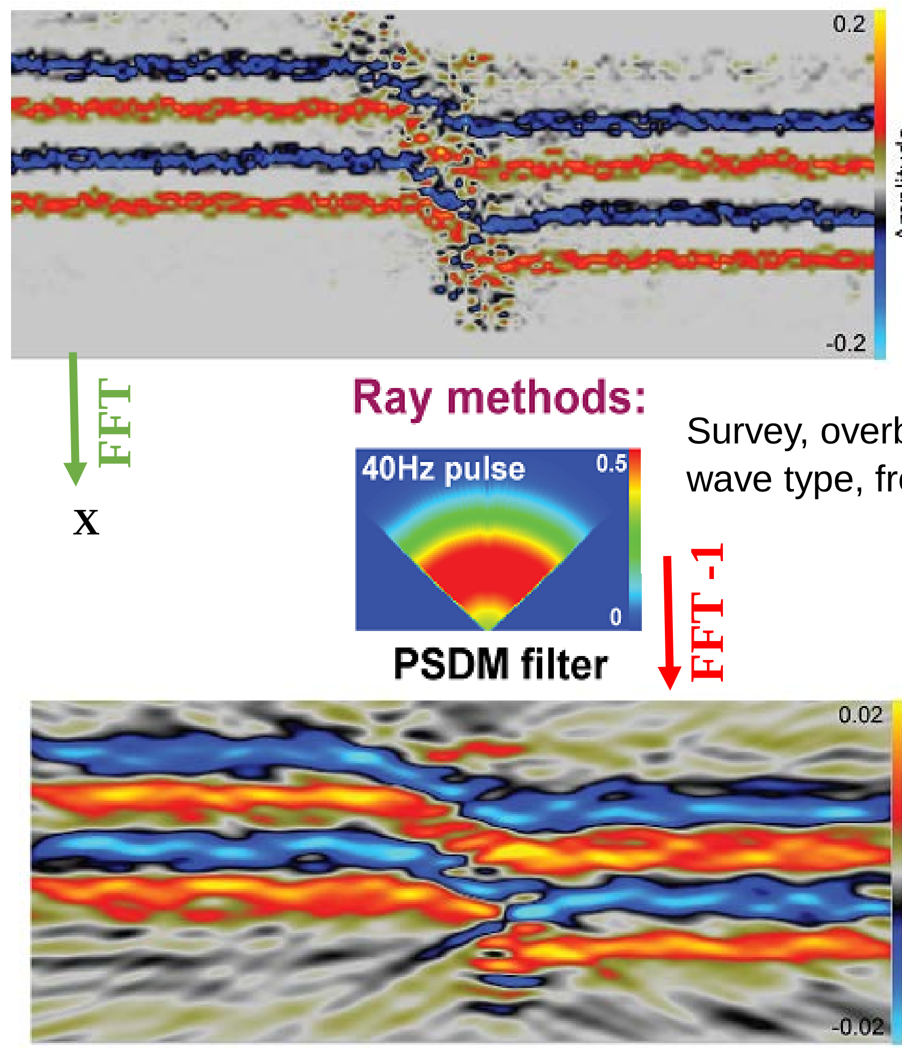
Assumed change of porosity and P-wave velocity VP with volumetric strain. *Source: Botter., et al. 2014*

4. Seismic imaging using a PSDM simulator (Lecomte, 2008)

- ✓ **Assess the impact of salt in the structure and properties on the resulting seismic image**

Spatial Domain

Input reflectivity 0°



Survey, overburden, depth, wave type, frequency

Wavenumber domain

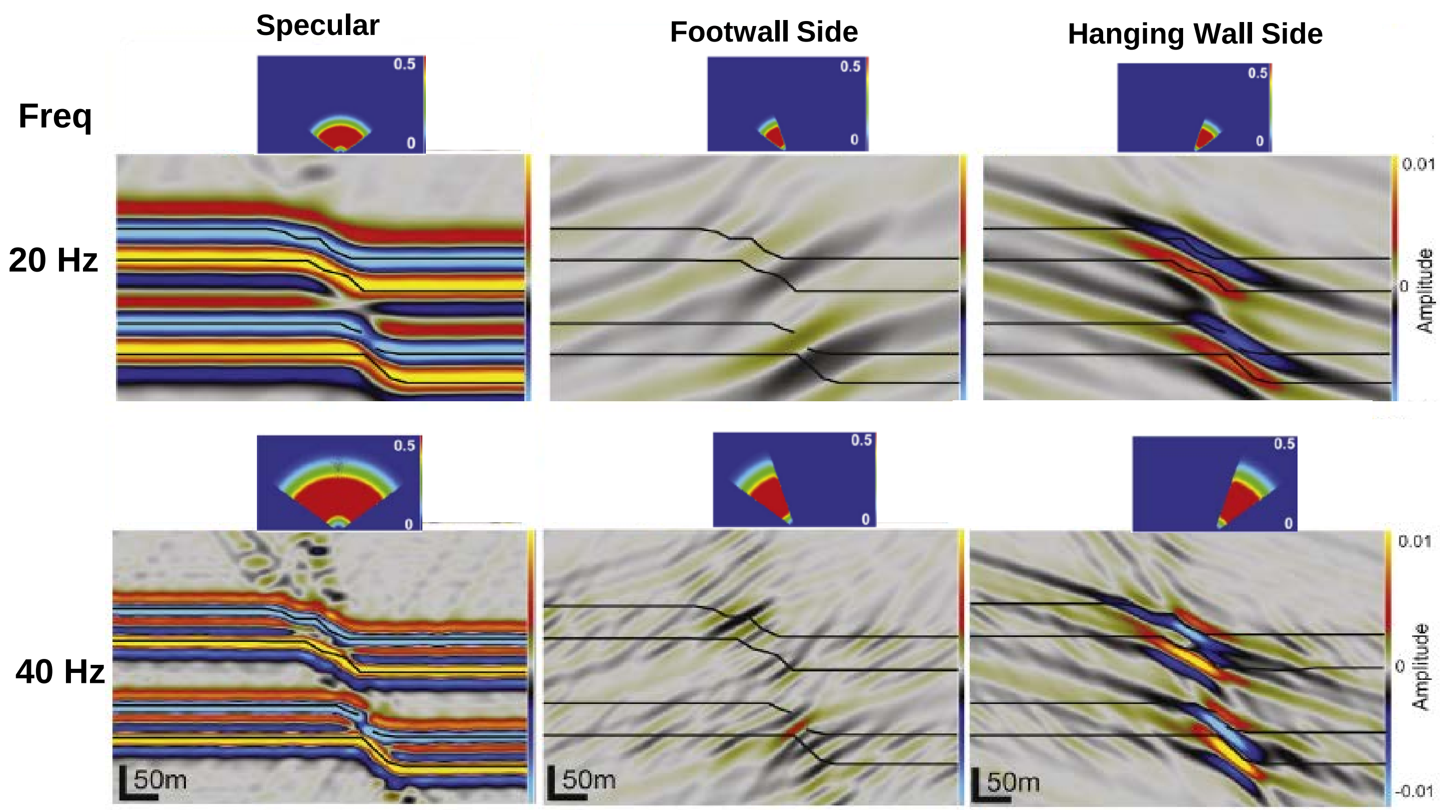
Spatial Domain

Simulated PSDM image

Illustration of the PSDM simulator. *Source Botter et al., submitted*

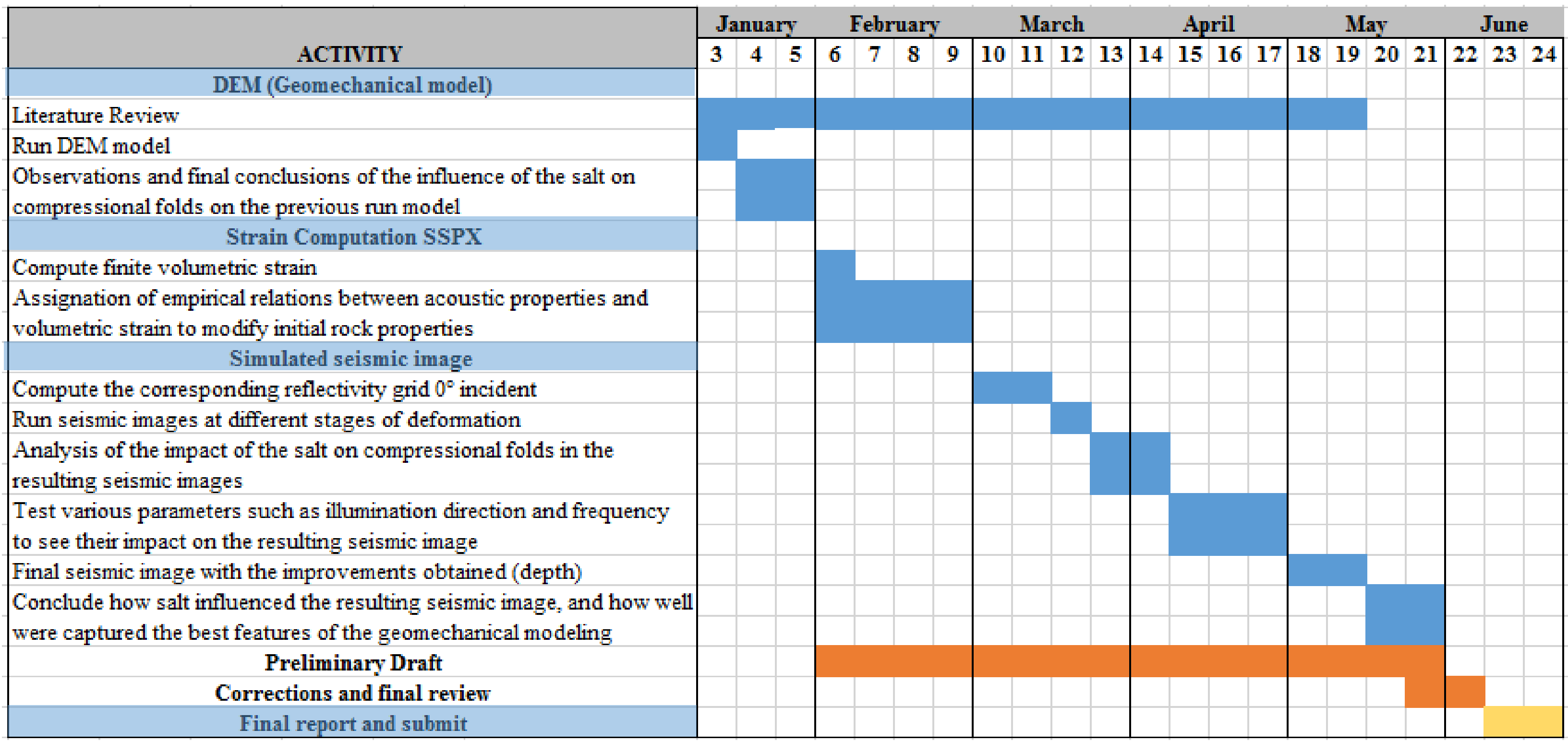
4. Sensitivity studies on the resulting seismic images

- ✓ **Test various parameters such as illumination direction and frequency to see their impact on the resulting seismic images**
  - Better seismic characterization since the structure and properties of the FTB are known
  - More accurate imaging depending on the target zone



PSDM seismic images of a normal fault, with three different illumination directions (specular, footwall side and hanging wall side) and two different frequencies (20 and 40 Hz). Source: Modified from *Botter., et al 2014*

Time frame


ACTIVITY
January
February
March
April
May
June
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
DEM (Geomechanical model)
Literature Review
Run DEM model
Observations and final conclusions of the influence of the salt on compressional folds on the previous run model
Strain Computation SSPX
Compute finite volumetric strain
Assignation of empirical relations between acoustic properties and volumetric strain to modify initial rock properties
Simulated seismic image
Compute the corresponding reflectivity grid 0° incident
Run seismic images at different stages of deformation
Analysis of the impact of the salt on compressional folds in the resulting seismic images
Test various parameters such as illumination direction and frequency to see their impact on the resulting seismic image
Final seismic image with the improvements obtained (depth)
Conclude how salt influenced the resulting seismic image, and how well were captured the best features of the geomechanical modeling
Preliminary Draft
Corrections and final review
Final report and submit

Thank you for your attention!

An approach to assess the impact of reserves uncertainty on oil and gas production in a gas cap field based on the material balance equation

Yichen Yang

Supervisor: Dr. Reidar B. Bratvold

04/12/2015

Universitetet i Stavanger

Problem statement

- Reserves uncertainty effects oil production which further influences the loan from the bank and the number of wells to drill ➡ Money problem

- It is time consuming to assess the impact of reserves uncertainty on oil and gas production using a traditional reservoir simulator such as Eclipse

Motivation

- To maximize the overall value of the field by combining production uncertainty with the cash flow model
- To develop an easy and efficient way to assess the impact of reserves uncertainty on oil and gas production

Introduction

Material balance equation

Surface oil and gas production

Expressed →

Underground withdrawal

The expansion of the fluids in the reservoir due to a limited pressure drop

Underground withdrawal = Expansion of oil and dissolved gas + Expansion of gas cap + Reduction in HCPV + Natural Water Influx

General form of the material balance equation

Objectives

- Generate the production curve based on the material balance equation
- Assess the impact of reserves uncertainty on oil and gas production using Monte Carlo simulation

Methodology

Production model

Inflow performance relationship (IPR)

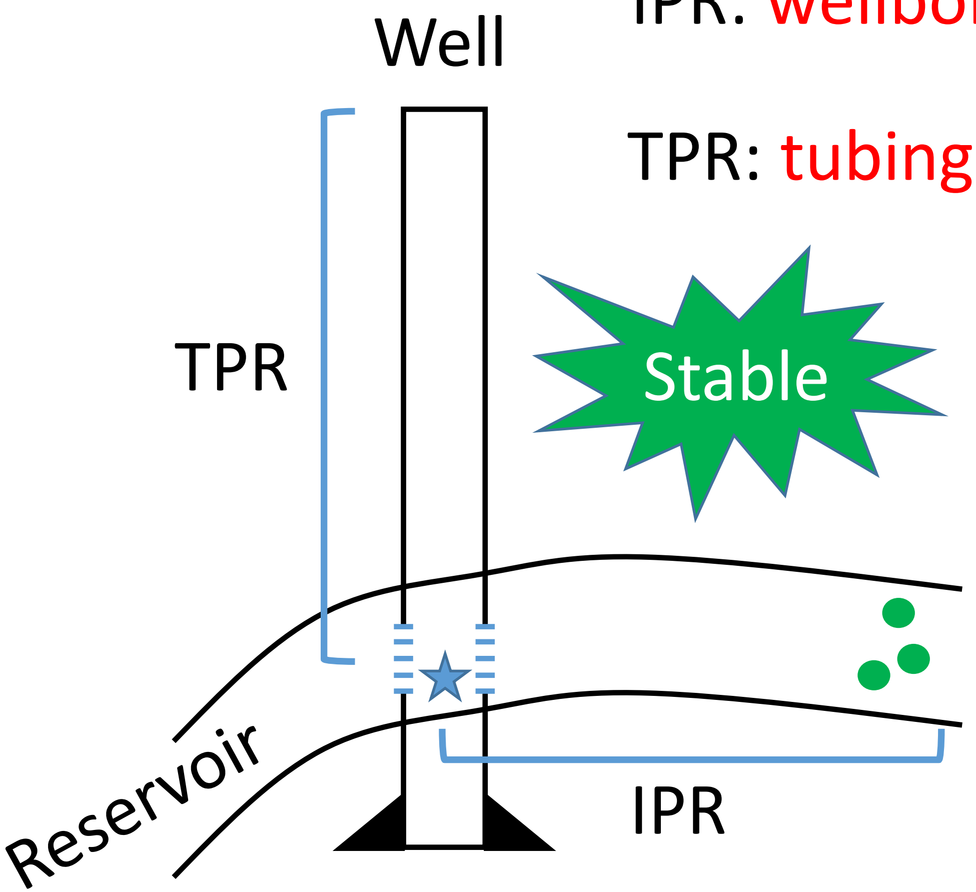
Tubing performance relationship (TPR)

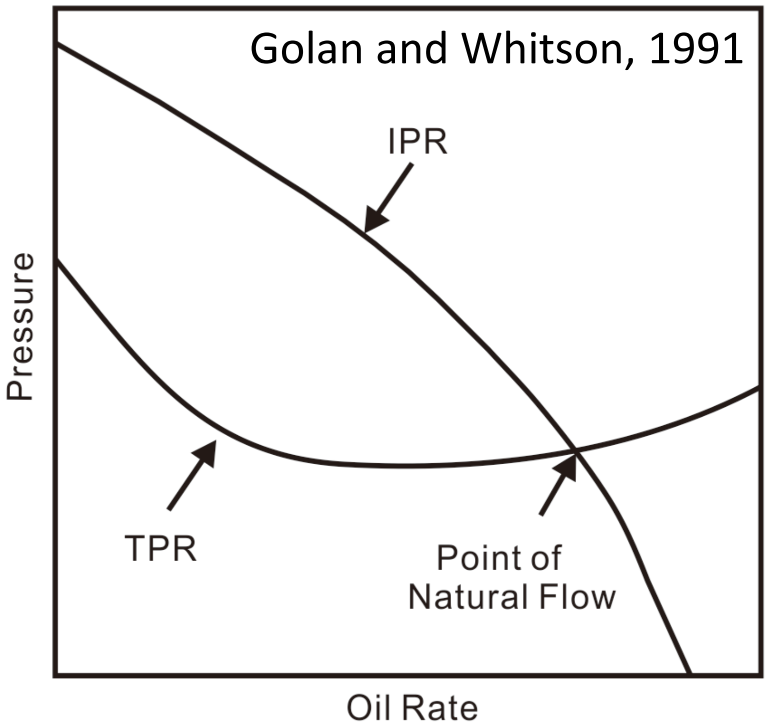
Production rate at different pressures

IPR: wellbore flowing pressure VS oil rate

=

TPR: tubing intake pressure VS oil rate



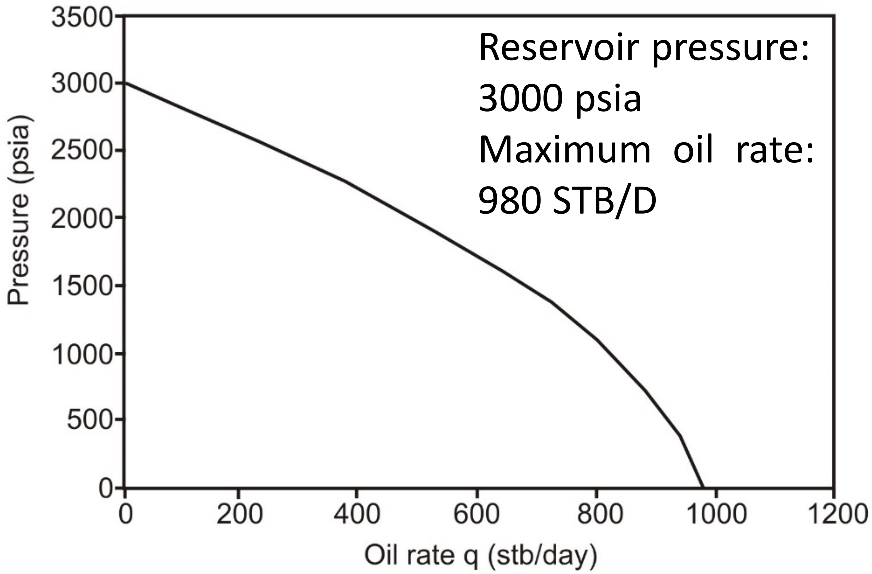


Methodology

Production model

- Generate the IPR and TPR curves by empirical equations

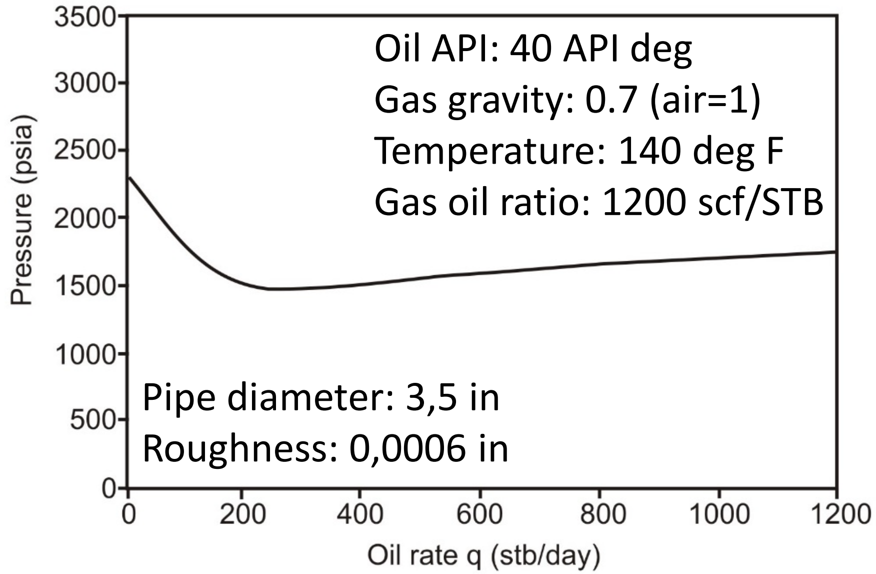
IPR curve



Golan and Whitson, 1991

- Pressure data
- Production test data

TPR curve



- Oil gravity and gas gravity
- Producing gas/oil ratio
- Average tubing temperature
- Basic tubing parameters (e.g. Pipe Diameter, Roughness)

Methodology

PVT properties calculation

B_o	oil formation volume factor
B_g	gas formation volume factor
R_s	solution gas oil ratio

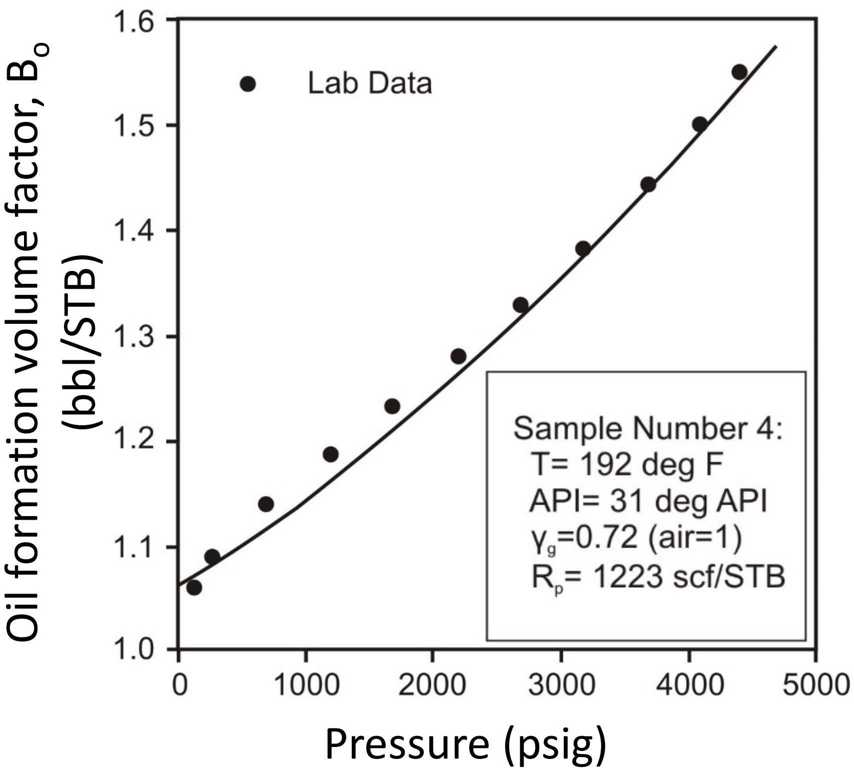
Pressure and temperature

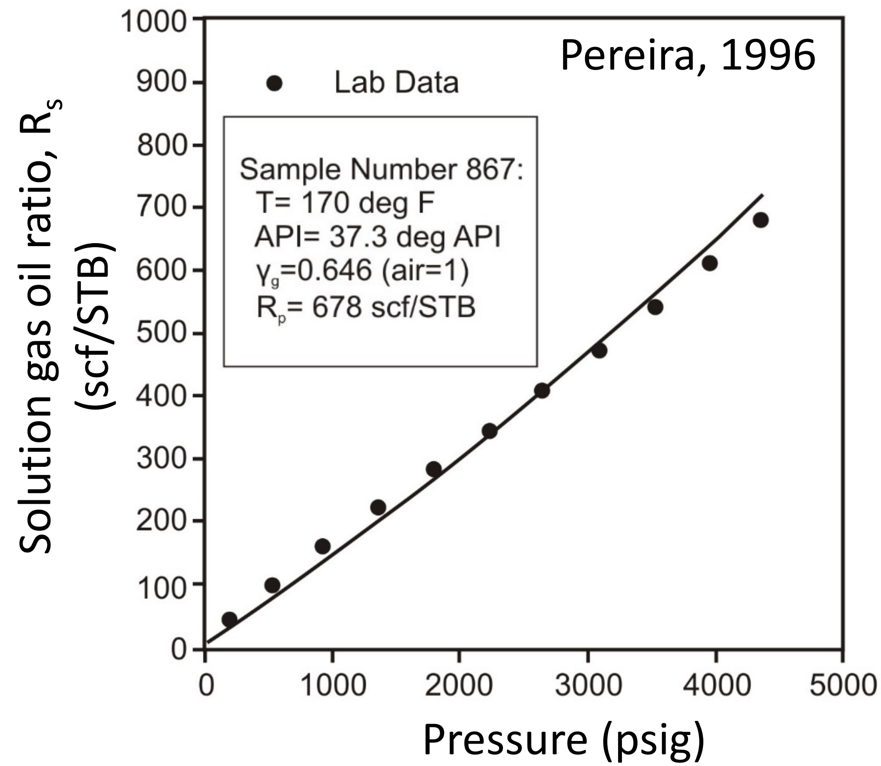
Oil gravity

Gas gravity

Producing gas/oil ratio

Empirical Equations





Methodology

Equation balance

- Choose the material balance equation for a gas cap field and balance it

Underground withdrawal = Expansion of oil and dissolved gas + Expansion of gas cap + Reduction in HCPV + Natural Water Influx

Underground withdrawal ← Oil Production

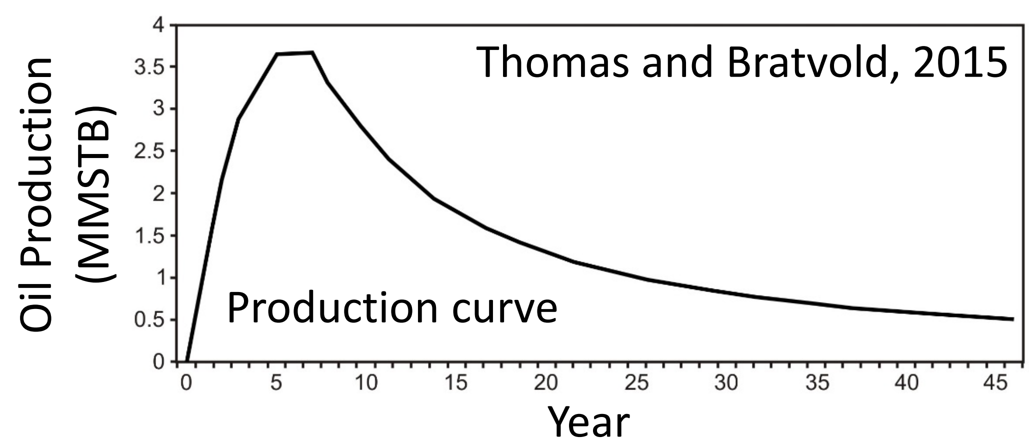
Expansion of oil and dissolved gas, Expansion of gas cap ← Reserves, PVT properties

Reduction in HCPV, Natural Water Influx ← negligible

High gas compressibility

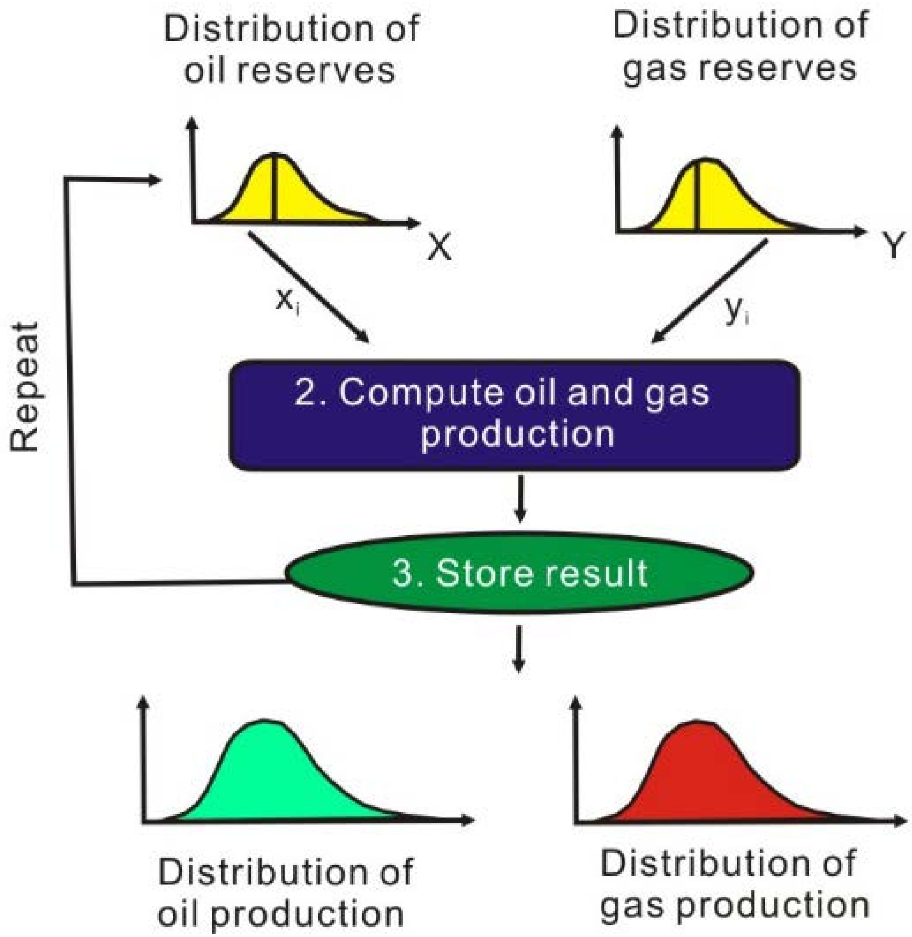
Repeat

For each different pressure →



Methodology

- Add uncertainty to reserves and use Monte Carlo simulation to assess the impact of reserves uncertainty on oil and gas production



1. It takes a sample from each input distribution
2. It uses the samples to calculate the result
3. It stores the result and repeats the previous processes
4. It generates the distribution of results

A full distribution of the oil and gas production at different times

Time Frame

Time		Main Tasks
Dec 2015	Jan 2016	Production model construction PVT properties calculation
Jan 2016	Feb 2016	Balance realization of the material balance equation
Feb 2016	Mar 2016	Production curves generation
Mar 2016	Apr 2016	Uncertainty analysis
Apr 2016	May 2016	Draft master thesis completion and revision
May 2016	June 2016	Finalized master thesis completion and submission

KEEP READING!

Thank you for your attention!

Any questions?

Low-frequency seismic analysis and direct hydrocarbon indicators

Bilal Ahmed Bhatti

University of Stavanger

The Low Frequency Project

Supervisors: Robert James Brown (UiS)

Børge Rosland (Skagen 44)

Agenda

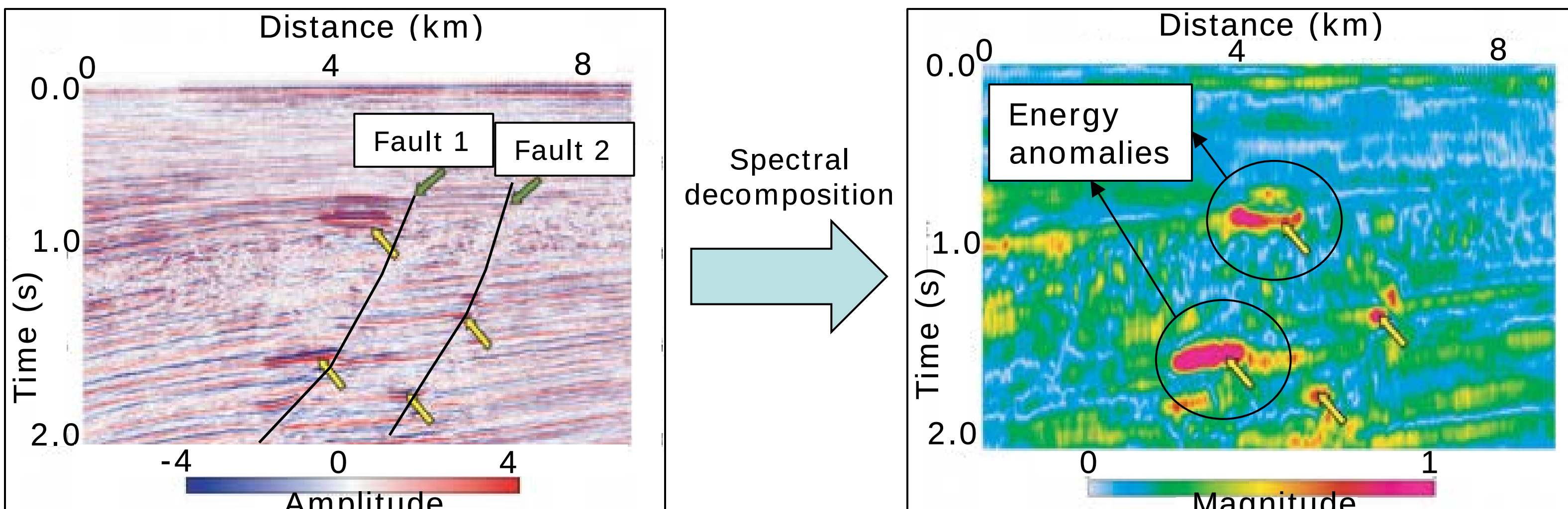
- Motivation
- Introduction
- Objectives
- Data
- Methodology
- Time Frame

Motivation

- Previous studies suggest that hydrocarbons often exibit low-frequency anomaly (5 Hz-20 Hz)
- Cheap and effective way to identify hydrocarbons

Introduction

Spectral decomposition: Convertion of seismic signal to its frequency components



Seismic section

Spectral section (20 Hz)

(Khonde and Rastogi, 2013)

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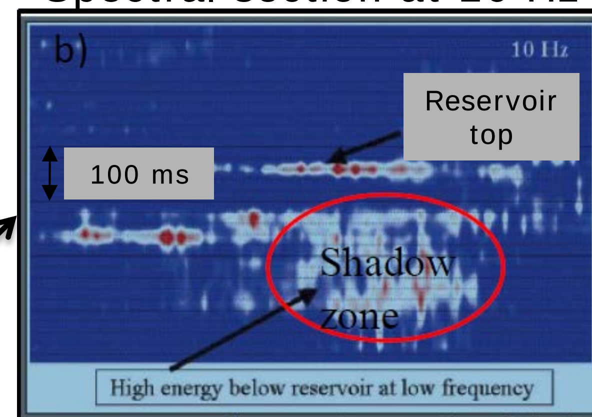
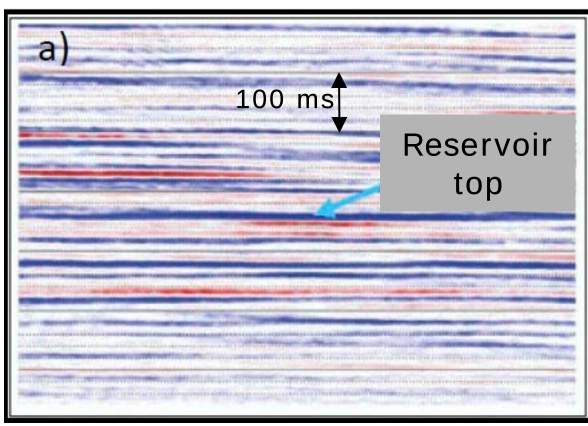
Introduction

Hydrocarbon indicators:

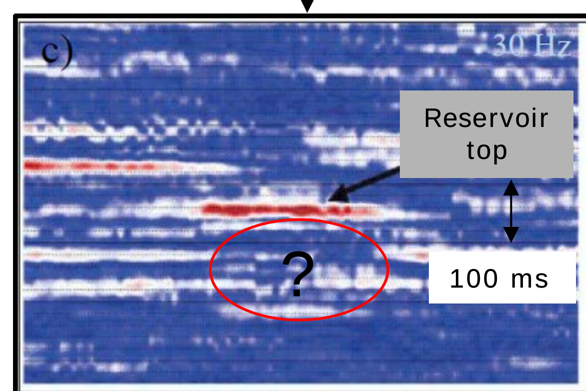
- Low-frequency energy anomaly
- Shadow zone

Spectral section at 10 Hz





Seismic section



Spectral section at 30 Hz

Castagna et al. (2003)

Objectives

- perform low-frequency seismic analysis on wells having hydrocarbons potential

- map out petroleum potential prospects based on low-frequency energy anomalies and structural features.

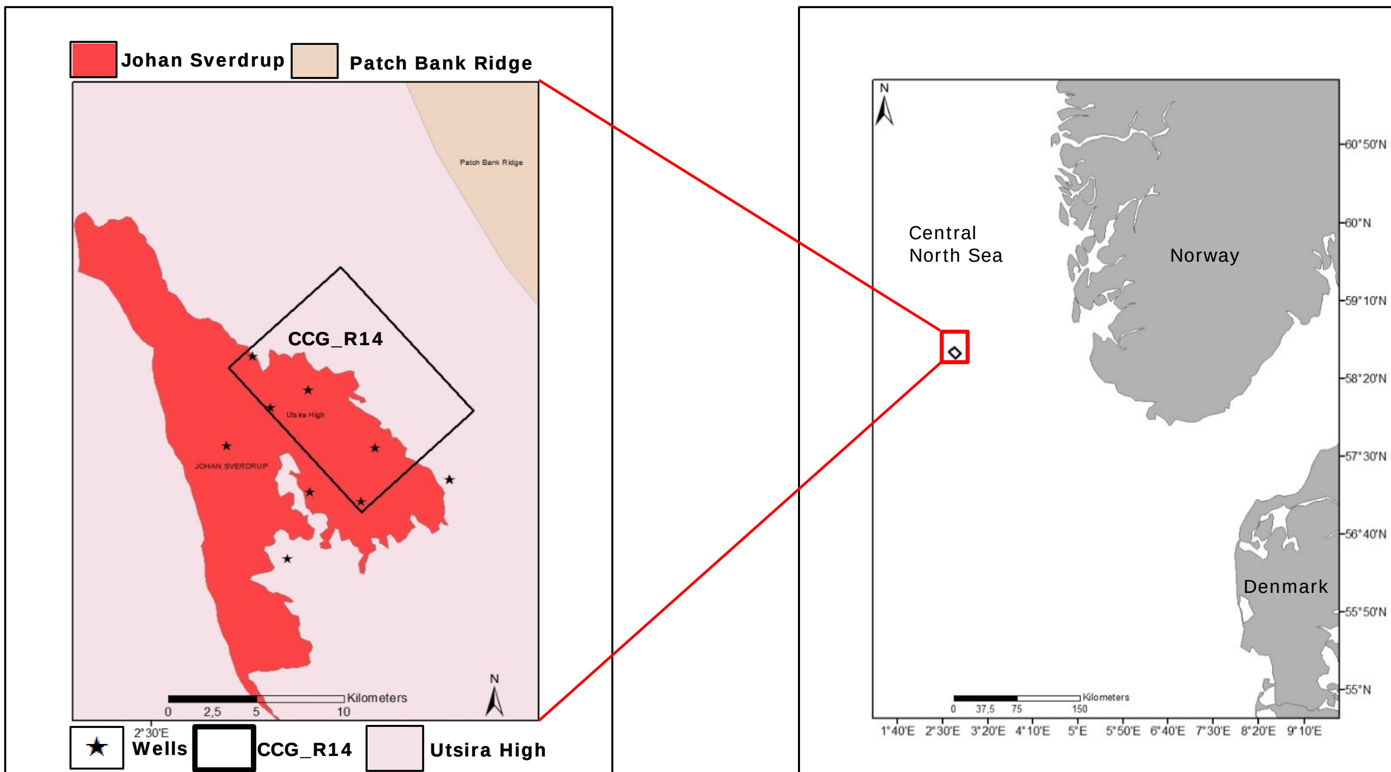
Data

Location:

- Johan Sverdrup
- 140 km off the west coast
- 200 km^2
- 5th largest discovery at NCS

Data:

- 9 wells
- 48 km^2 of post-stack 3D broadband seismic data (CCG_R14)



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Methodology

1. Geological studies

2. Well analysis

3. Seismic-to-well tie

4. Seismic interpretation

5. L-f analysis using spectral decomposition (STFT, CWT)

Methodology

The visualization of data in low-frequency analysis:

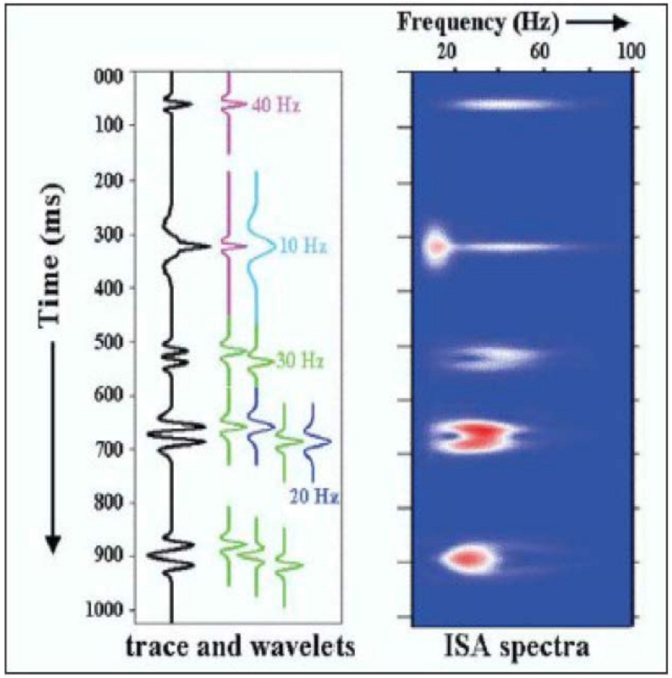
- Time vs frequency spectrum of a trace
- Spectral section (constant frequency)

Time versus frequency spectrum (Instaneous Spectral Analysis)

The ISA consists of following steps:

1. Decomposition of seismogram
2. Produce frequency gathers
3. Sort the frequency gathers to produce common frequency cubes.

A frequency spectrum can be extracted at any sample of trace through ISA

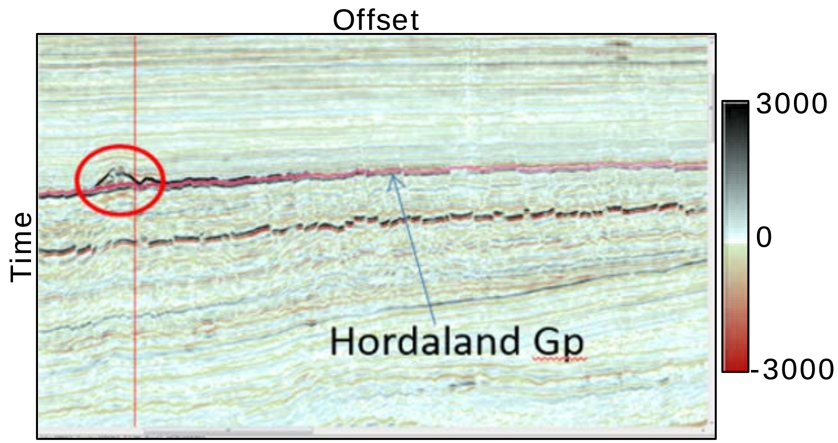


Castagna et al. (2003)

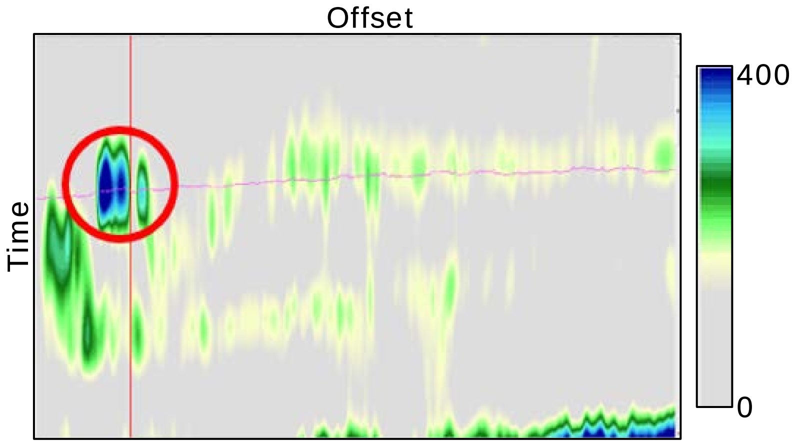
Methodology

Spectral section:

- Spectral section contains the energy distributions at any desired frequency



Seismic section (Amplitude)



Spectral section (7 Hz)

- Horizon slices
- Time slices

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Time Frame

Activity	Year/Month						
	2015	2016					
	December	January	February	March	April	May	June
Literature Review							
Preparing seismic for interpretation and well-tie							
Seismic interpretation and mapping							
Low-frequency analysis using spectral decomposition							
Writing initial draft							
Final draft after correcting errors							

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Thank you for listening!

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3D reconstruction of Oak Ridge fault, Saticoy oil field, southern California, U.S.A

JIN XU

Advisor: Nestor Cardozo

University of Stavanger

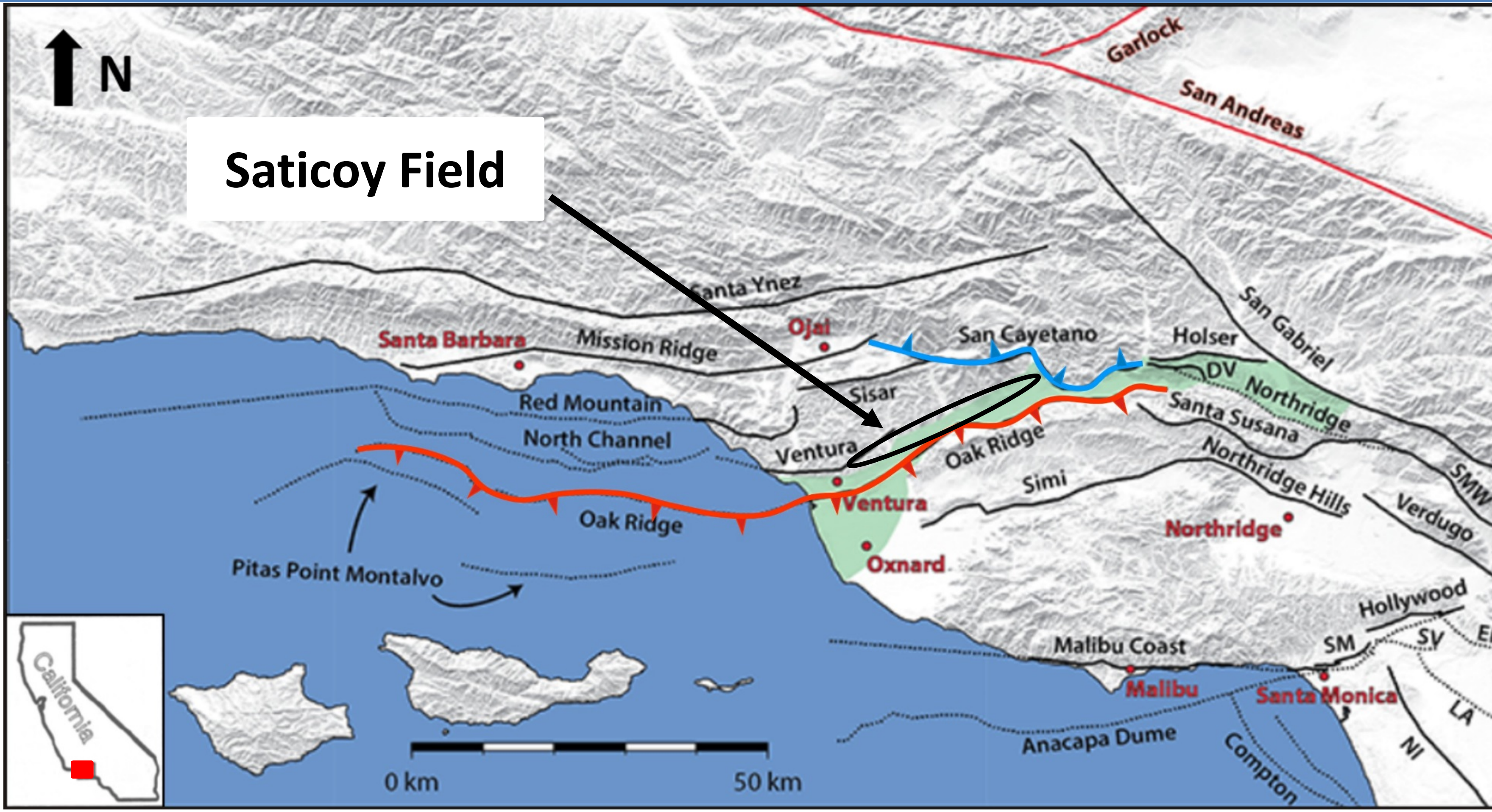
2015

Agenda

- Introduction
- Previous work and problems
- Objectives
- Dataset
- Methodology
- Time frame

Introduction

❑ Location



From Marshall (2013)

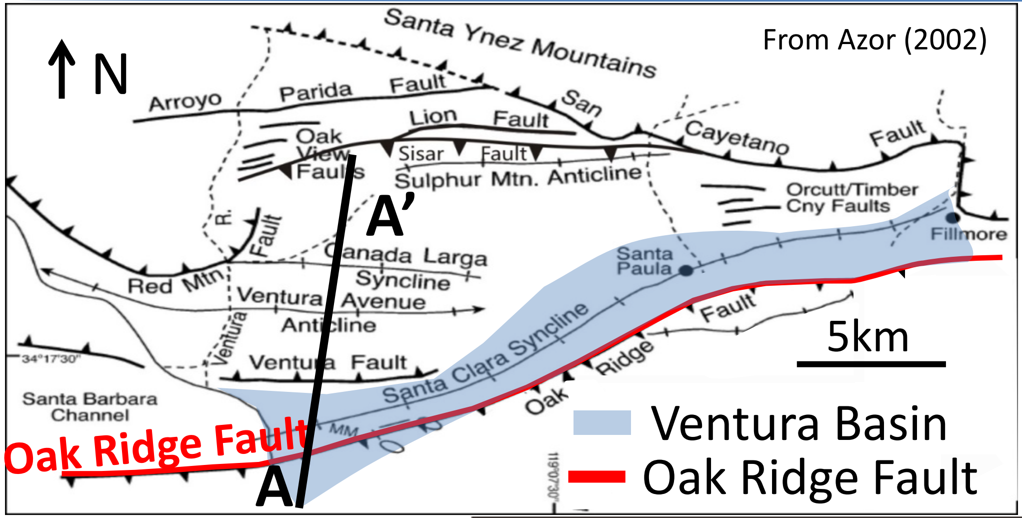
Saticoy Oil field

- Santa Clara Valley
- Lies within Ventura Basin
- Two reverse faults limit the oil field

Ventura Basin
Oak Ridge Fault
San Cayetano Fault

Introduction

❑ Local geology

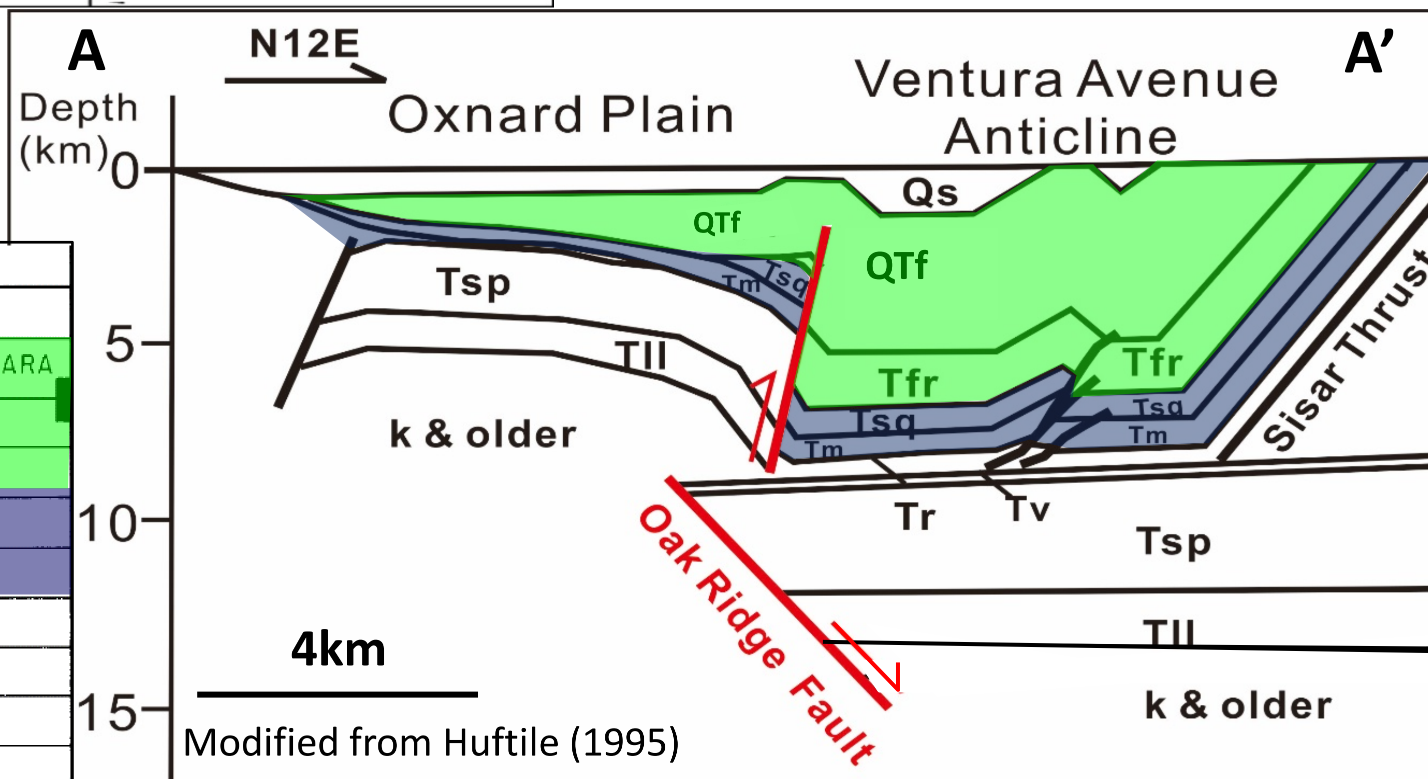


From Azor (2002)

- Ventura Basin evolution includes:
  - ➢ Extensional tectonic regime (Late Miocene); and
  - ➢ Contractional regime (Late Pliocene and Quaternary).

From Yeats (1990)

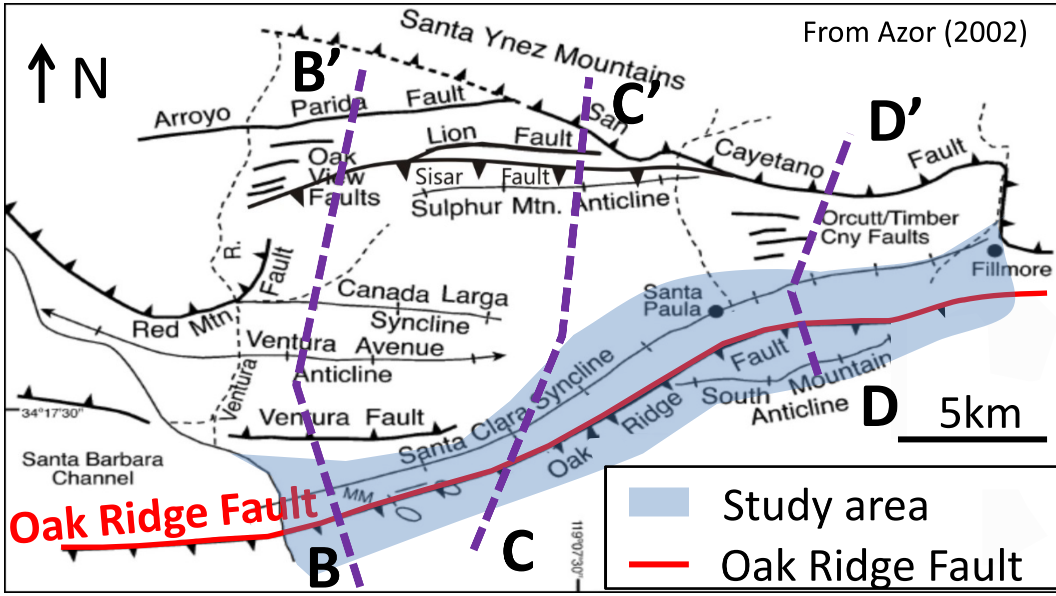
			FORMATION
Qs			SAUGUS
QTf		FERNANDO	SANTA BARBARA
	QTp		PICO
	Trp		REPETTO
Tsq			SISQUOC
Tm			MONTEREY
Tr			RINCON
Tvq			VAQUEROS
Tsp			SESPE
Tll			LLAJAS



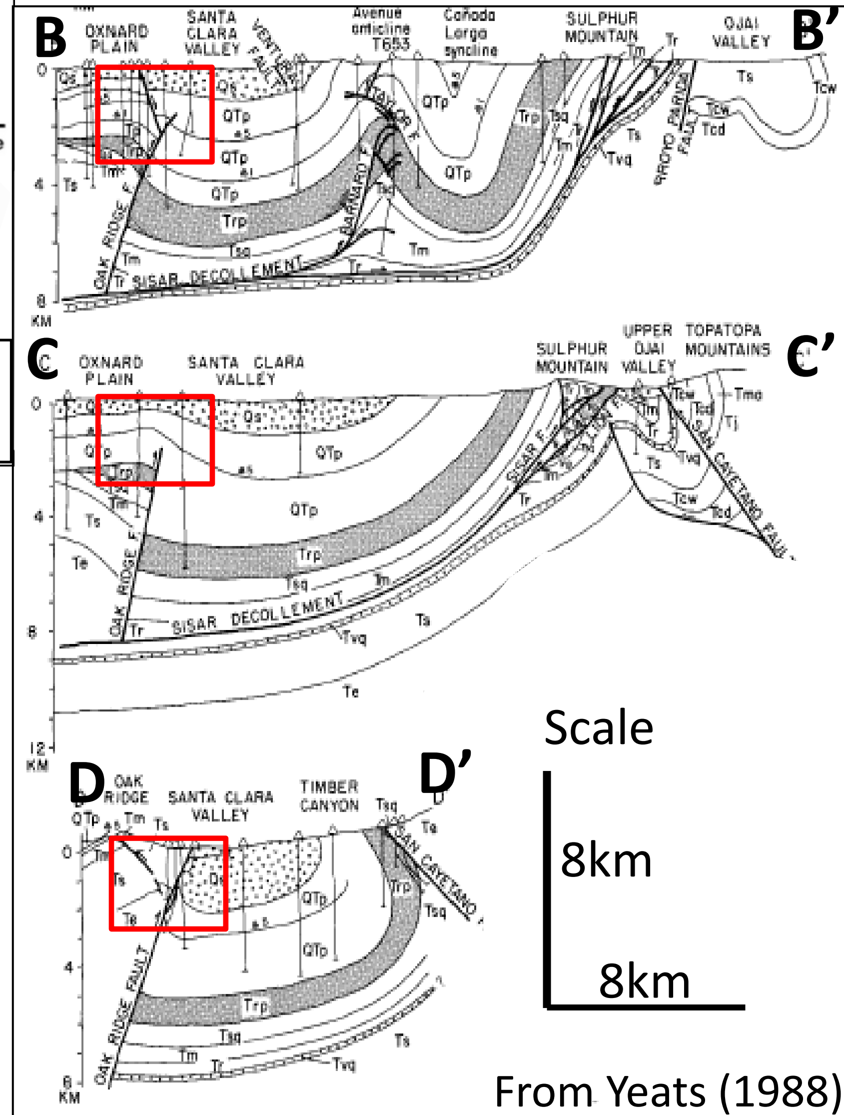
Modified from Huftile (1995)

Introduction

❑Model area



Lateral variation



- Stratigraphy

From Yeats (1990)

		FORMATION	AGE
	Qs	SAUGUS	PLEISTO-CENE
QTf	Qs	FERNANDO: SANTA BARBARA	PLEISTO-CENE
QTf	QTp	FERNANDO: PICO	PLIO-CENE
QTf	Trp	FERNANDO: REPETTO	PLIO-CENE
Tsq		SISQUOC	MIO-CENE
Tm		MONTEREY	MIO-CENE
Tr		RINCON	MIO-CENE
Tvq		VAQUEROS	OLIGO-CENE
Ts		SESPE	OLIGO-CENE
Tll		LLAJAS	EOCENE

Previous Work and Problems

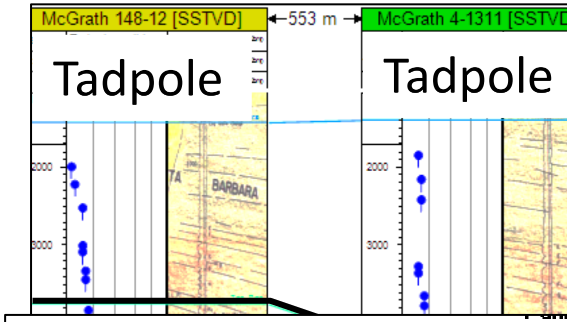
Previous Work

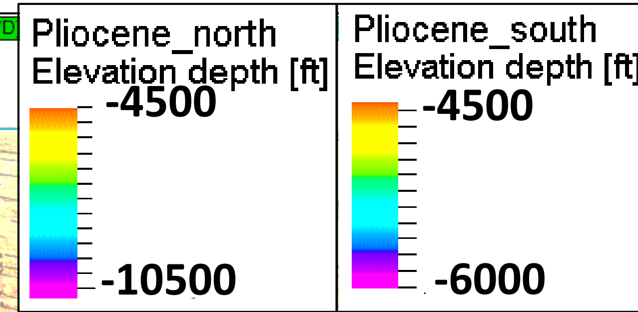
- Available structural and stratigraphic information & digitization.
- Preliminary 3D model.

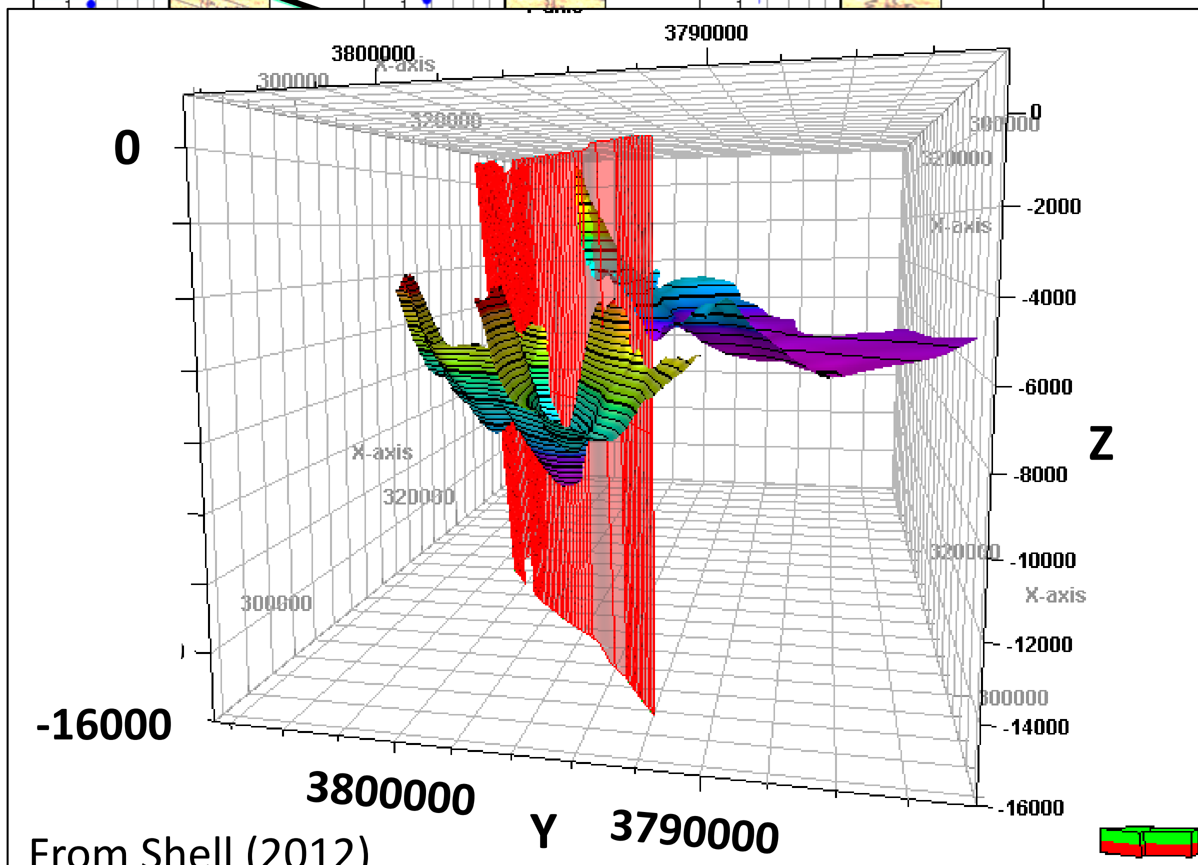
Problems

Previous work in Petrel was not modeled accurately due to:

1) Complex fault structure; and
2) Local syncline steep fold limb.







Tadpole well log & Well Top

Structural map & Fault model

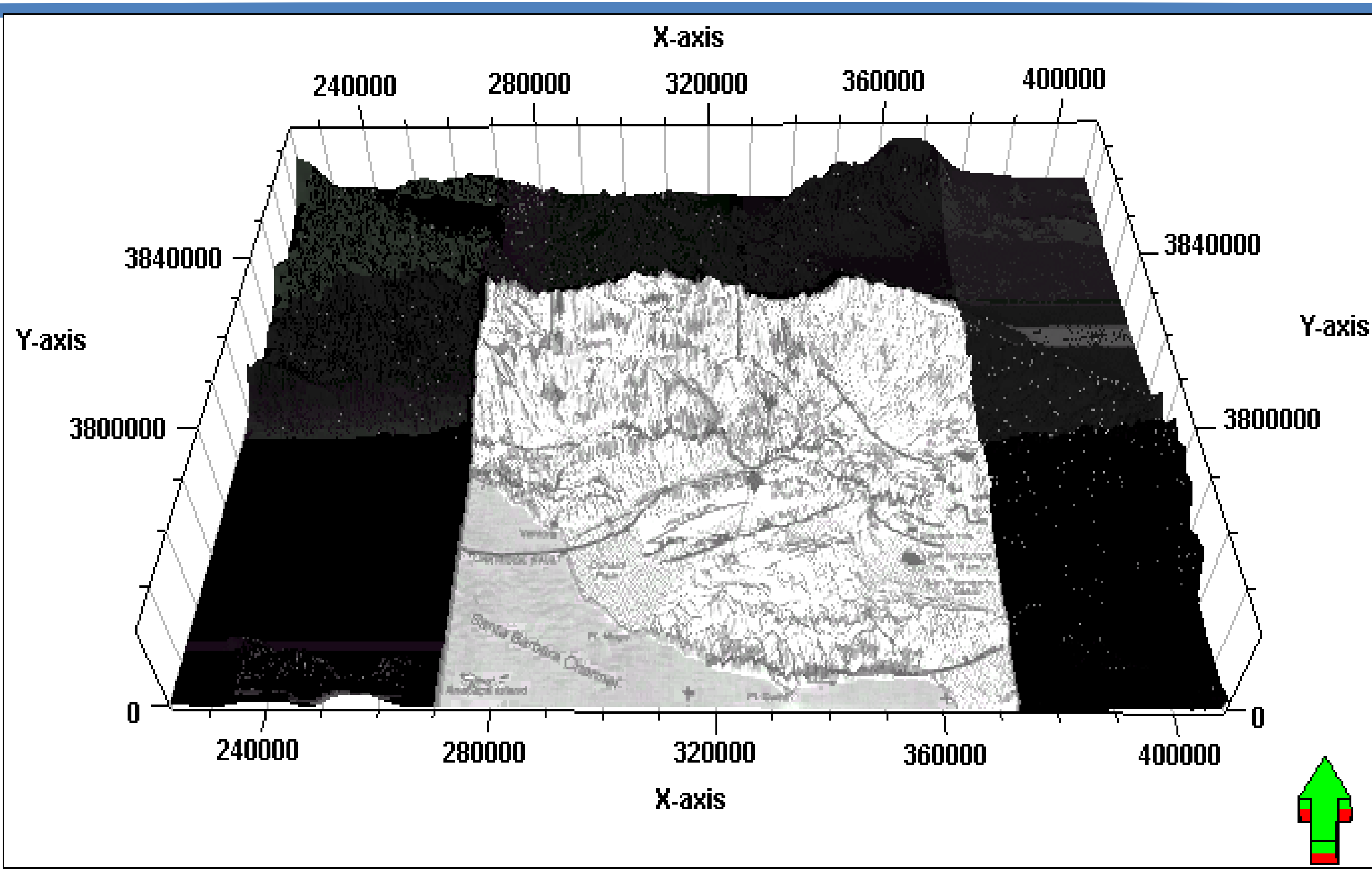
Objectives

The objective in this project is the 3D reconstruction of the Oak Ridge fault in the Saticoy field:

(1) Reconstruction of cross sections with well control and projected data from structure maps
  - ❑ Serial cross sections

(2) Construction of 3D surfaces from serial cross sections
  - ❑ Fault surface
  - ❑ Stratigraphic horizons

Dataset



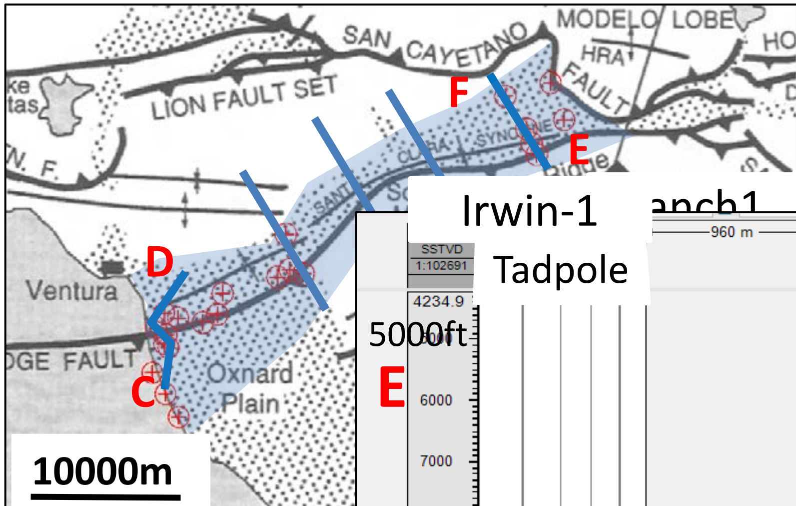
From Shell (2012)

108 wells (54 wells with dip and azimuth), 4 structure maps, preliminary fault interpretation, digital elevation model.

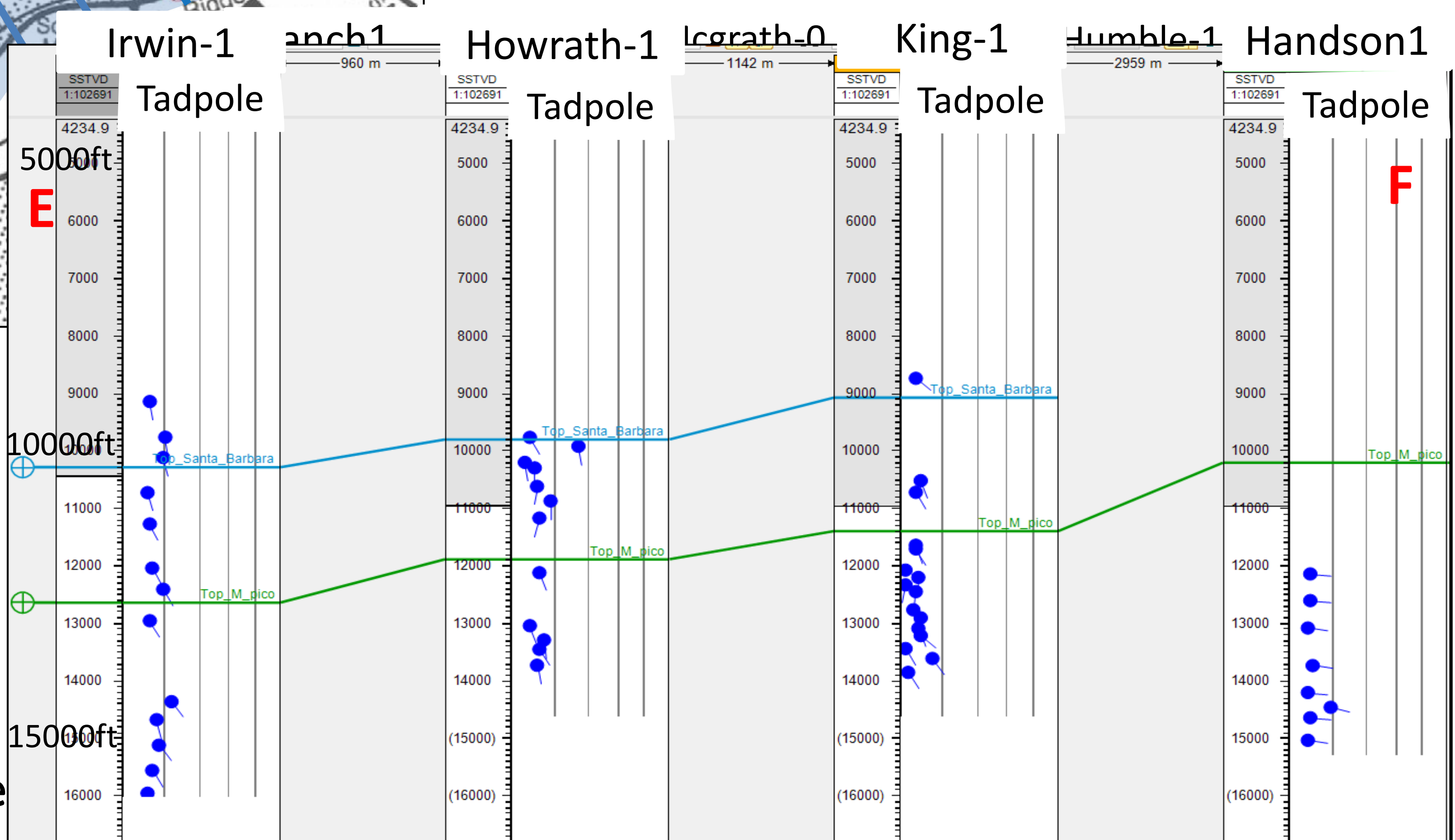
Methodology

❑ Work Flow

Raw data transfer & digization → **Cross section reconstruction** → Fault surface reconstruction → Horizon reconstruction → QC

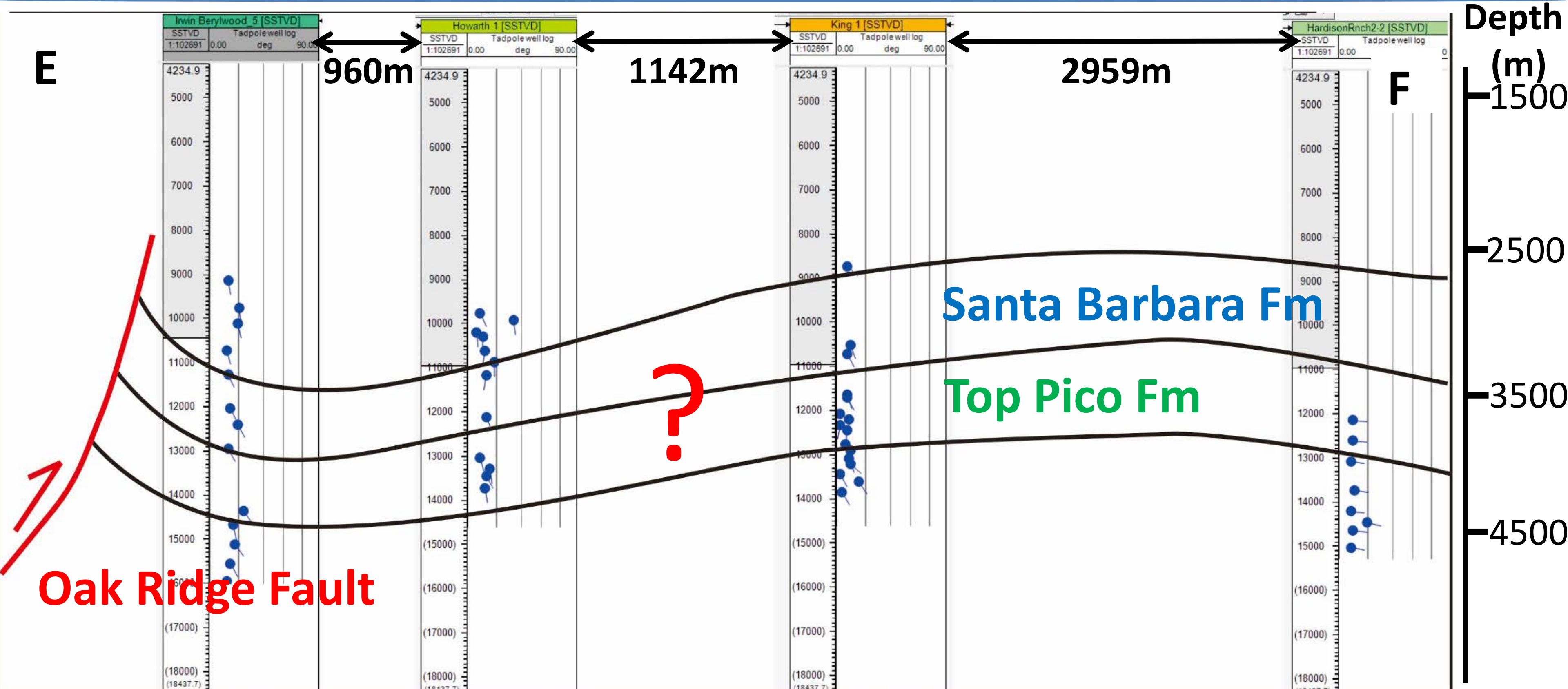


From Peter (1998)



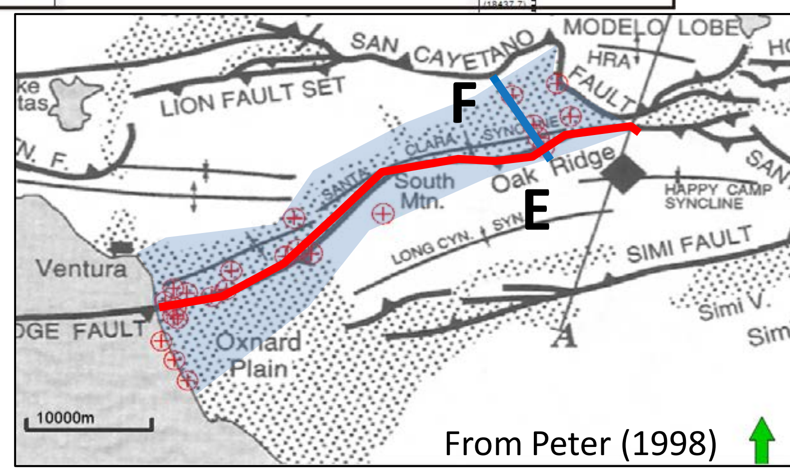
Methodology

❑ Cross Section Reconstruction



Uncertainty

✓ Well top and structure map



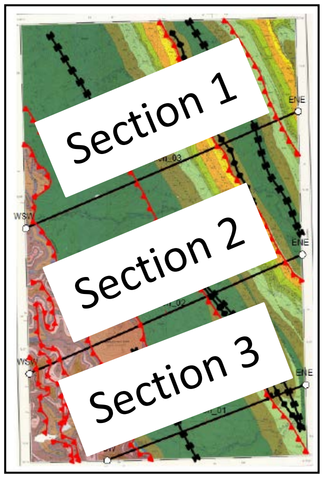
From Peter (1998)

Methodology

Raw data transfer & digization → Cross section reconstruction → Fault surface reconstruction → Horizon reconstruction → QC → Kinematic modeling (If there is time)

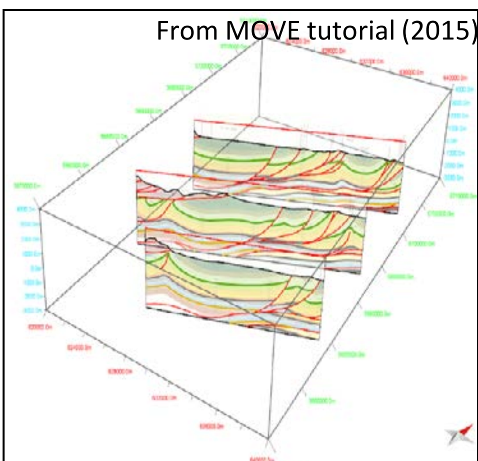
Example

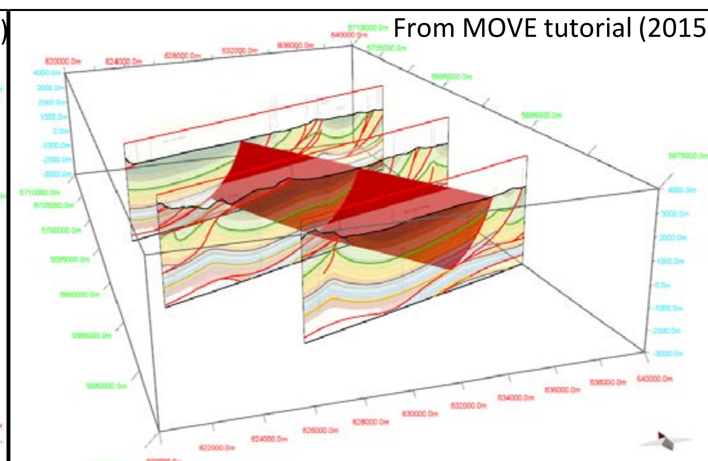
Rocky Mountain thrust belt reconstruction

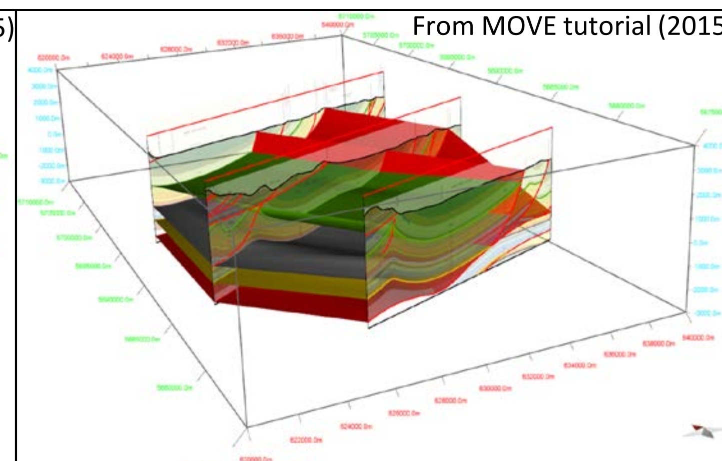


Expected model needs to be:

- Consistent;
- Follow the well data; and
- Honor regional geological setting.







Cross sections → Fault surface reconstruction → Horizon reconstruction

Time Frame

Activity	2016					
	January	February	March	April	May	June
Study Literature						
3D Structural Modeling						
• Transfer of Petrel project to Move						
• Reconstruction of cross sections with well control and projected data from structure maps						
• Construction of 3D surfaces from serial cross sections						
• QC						
Kinematic modeling, if time is enough						
Writing						

Reference

Azor, A., E. A. Keller, and R. S. Yeats, 2002, Geomorphic indicators of active fold growth; South Mountain- Oak Ridge Anticline, Ventura Basin, Southern California, Geol. Soc. Am. Bull. 114, P. 745-753.

Huftile, G.J., and Yeats, R.S., 1995, Convergence rates across a displacement transfer zone in the western Transverse Ranges, Ventura basin, California: Journal of Geophysical Research, v. 100, p. 2043–2067.

Peter M. Shearer, 1998, Evidence from a Cluster of Small Earthquakes for a Fault at beneath Oak Ridge, Southern California. Bulletin of the Seismological Society of America, Vol. 88, No. 6, p. 1327-1336.

Yeats, R. S., G. J. Huftile, and F. B. Grigsby, 1988, Oak Ridge fault, Ventura fold belt, and the Sisar decollement, Ventura basin, California, Geology 16, p. 1112–1116.

Yeats, R.S., and Taylor, J.C., 1989, Saticoy oil field—U.S.A., Ventura basin, California, in Beaumont, E.A., and Foster, N.H., eds., Structural traps III, Tectonic fold and fault traps: American Association of Petroleum Geologists, Treatise of Petroleum Geology, Atlas of Oil and Gas Fields, p. 199–215.

Move tutorial from http://www.mve.com/software/move.

Thank you

Seismic Imaging of Salt-Influenced Extensional Forced Folding

Presented by: Rosita Haftbaradaran

Supervisors:
Nestor Cardozo
Charlotte Botter

4th December 2015

Universitetet i Stavanger

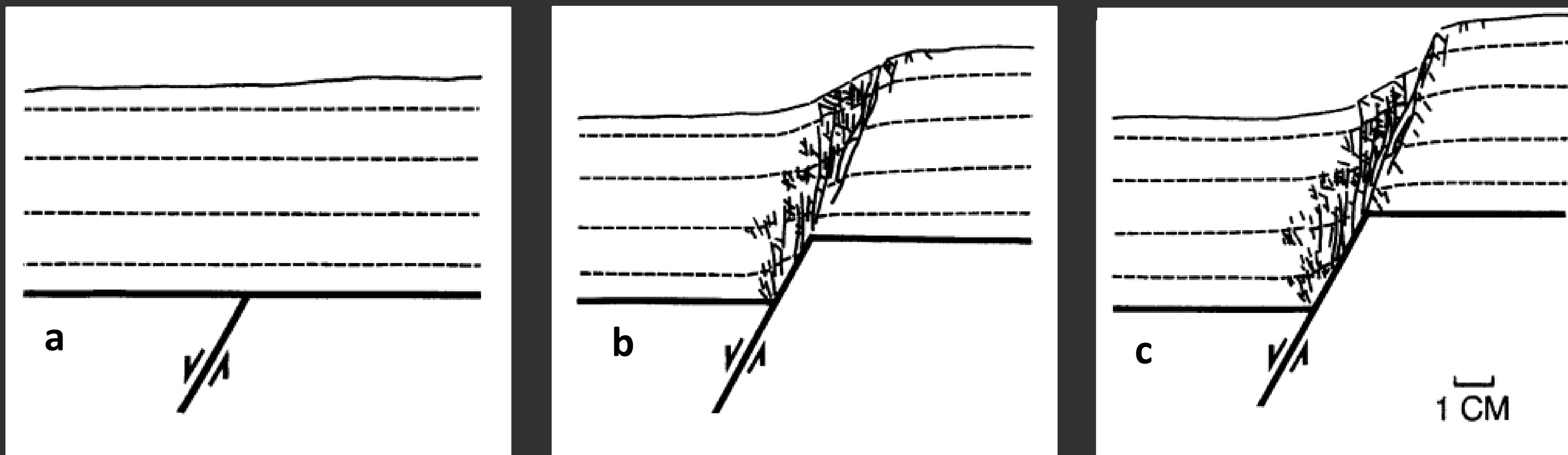
Outline

- Introduction
- Motivation
- Objectives
- Methodology
  - Discrete Element Method (DEM) modelling
  - Finite strain computation using SSPX
  - Modification of initial seismic properties
  - Prestack Depth Migration (PSDM) simulation
  - Interpretation of seismic images
- Timeline

Introduction

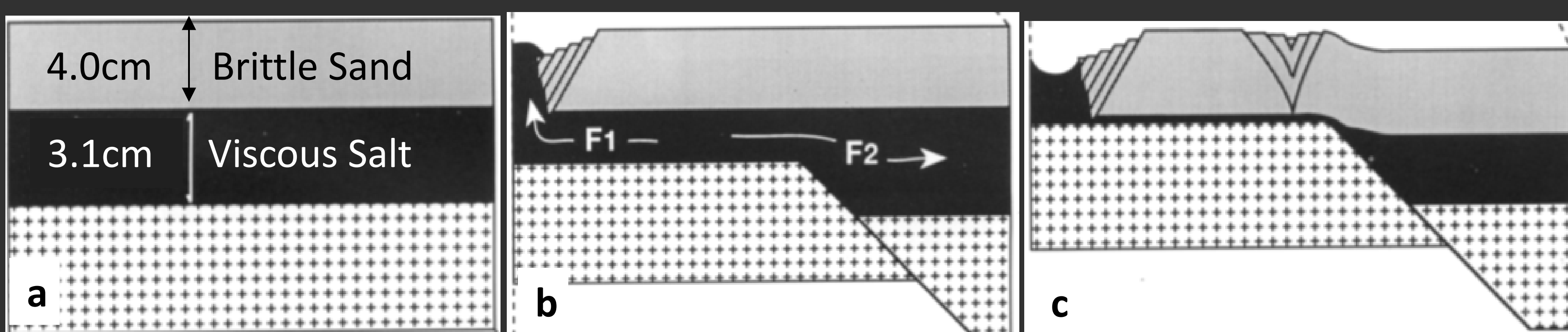
Extensional Forced Folds

Model 1: Without Salt



Withjack et al., 1995

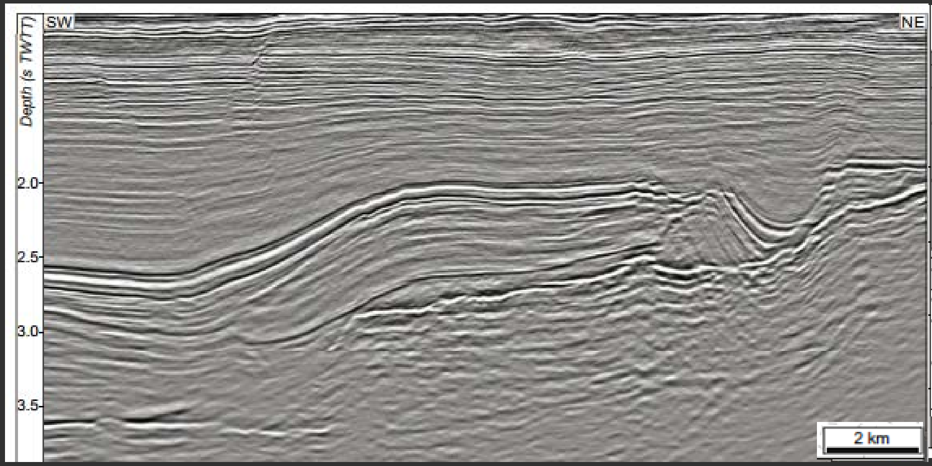
Model 2: With Salt

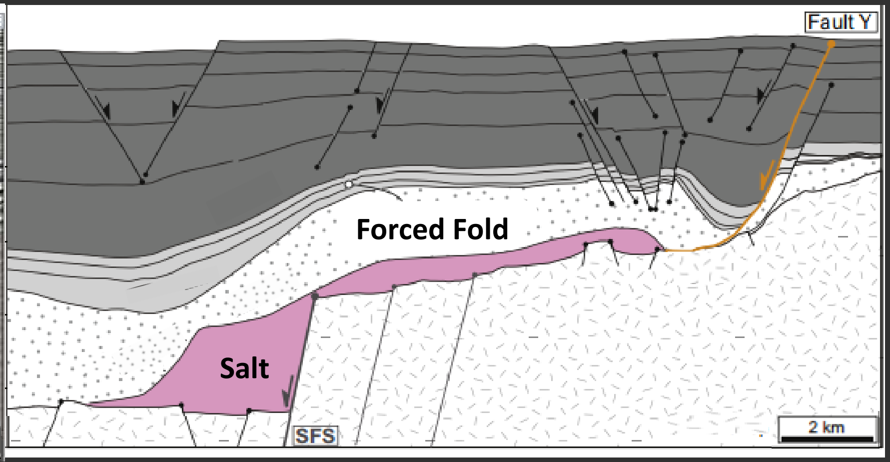


Vendeville et al., 1995

Motivation of Seismic Imaging of Salt

Stavanger Fault System, North Sea:





Lewis et al., 2013

- Salt is challenging to characterize on seismic.
- Salt is mechanically weak, creating complex structures.
- Hydrocarbons are commonly trapped within the structures associated with extensional forced folding and salt.

Objectives

- Evaluate the impact of salt-influenced extensional forced folding on seismic image.

- Fine tune seismic parameters: wave frequency and illumination direction.
  - To evaluate their impact on seismic

Methodology

Step 1) Model: Discrete element method (DEM) (Hardy et al., 2009); mechanical modelling of salt-influenced extensional forced-folds.

Step 2) Finite strain computation of the DEM model using the program SSPX (Cardozo and Allmendinger, 2009).

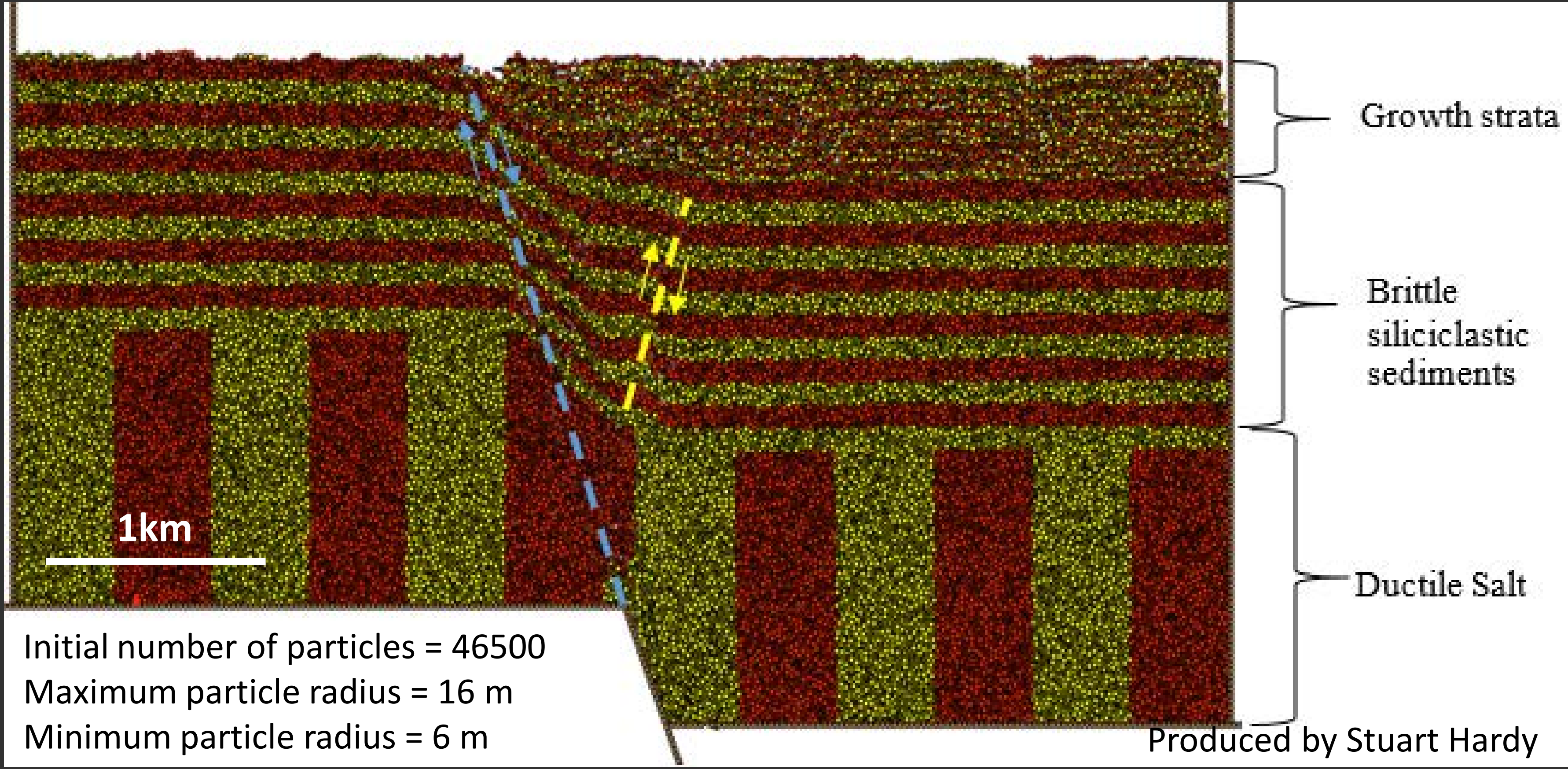
Step 3) Modification of initial seismic properties; density and seismic velocities, based on the finite strain.

Step 4) Seismic imaging: Prestack depth migration (PSDM) simulation (Lecomte, 2008).

Step 5) Interpretation of seismic images.

1. Discrete Element Method (DEM) (Hardy et al., 2009)

- Example of DEM model representing an extensional forced fold with a layer of salt
- DEM model: assemblage of rigid circular particles; modelling;
  - frictional behaviour of brittle siliciclastic sediments
  - ductile behaviour of salt layers.

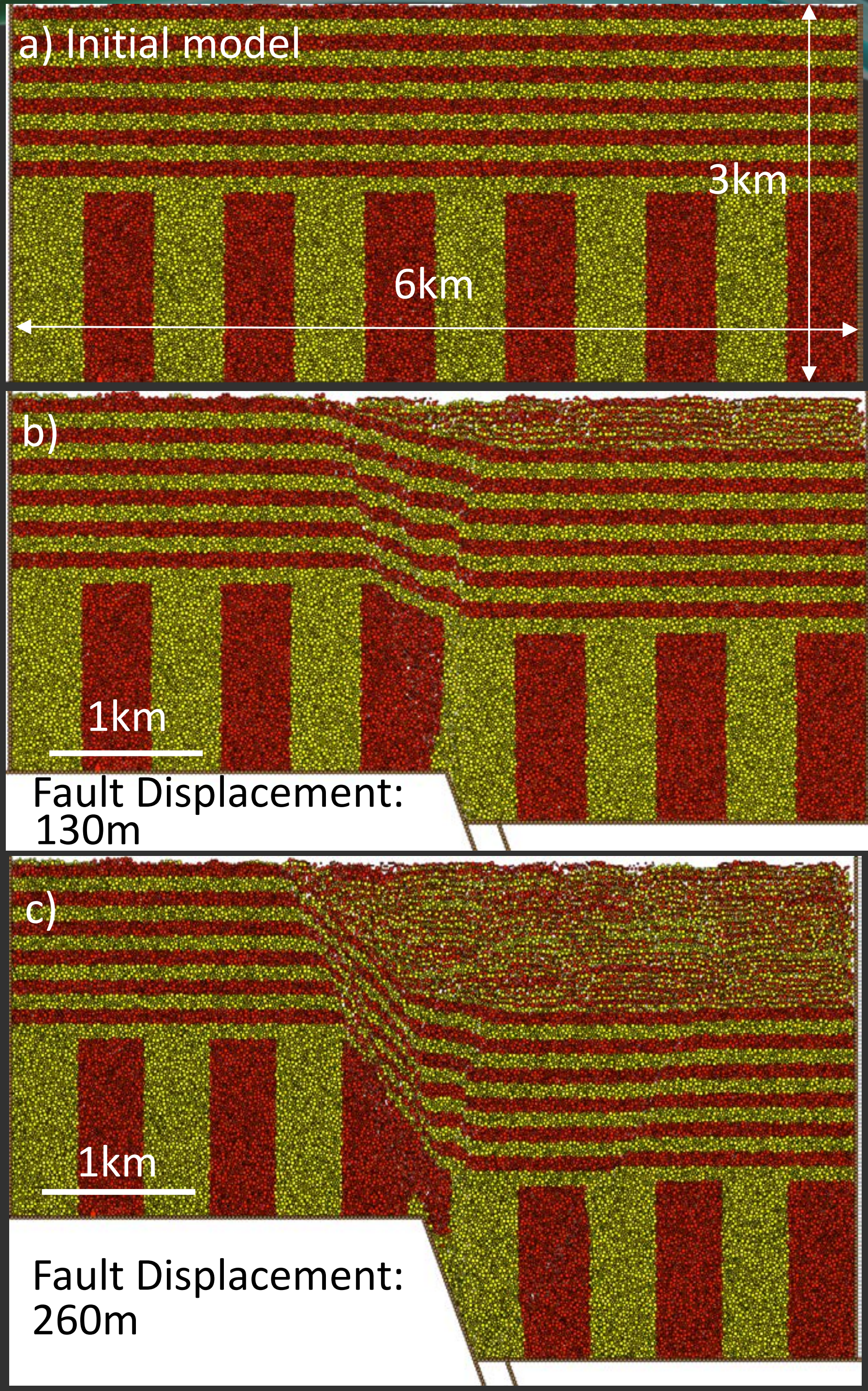


Initial number of particles = 46500
Maximum particle radius = 16 m
Minimum particle radius = 6 m

Produced by Stuart Hardy

Evolution of Discrete Element Method (DEM) model (Hardy et al., 2009)

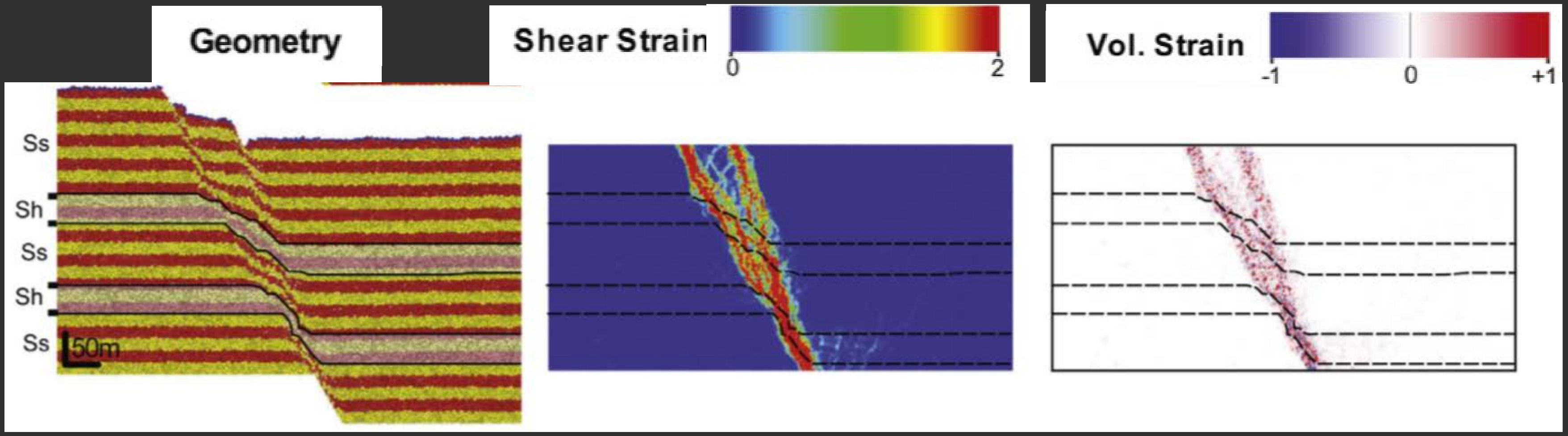
- The DEM model produces a realistic fault and salt-related structural geometry in an extensional setting



Produced by Stuart Hardy

2. Finite Stain Computation using the program SSPX (Cardozo and Allmendinger, 2009)

- Nearest-neighbor routine
- Finite strain used for modification of seismic properties.



(Botter et al., 2014)

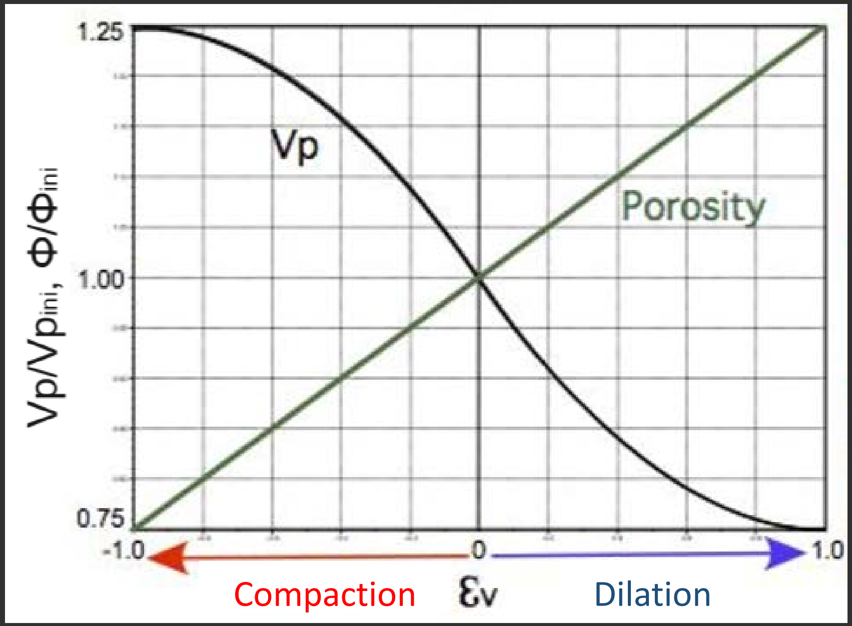
3. Modification of Initial Seismic Properties

- Modify the initial elastic properties; density and seismic velocities, by the finite strain.

	Density (g/cm^3)	P-wave (Vp) (km/s)	S-wave (Vs) (km/s)
Halite	2.16	4.50 - 4.55	2.59 - 2.63
Sandstone	2.65	4	2.389
Shale	2.65	2	0.801

Table 1: Initial values from (Mavko et al., 2009) and (Botter et al., 2014)

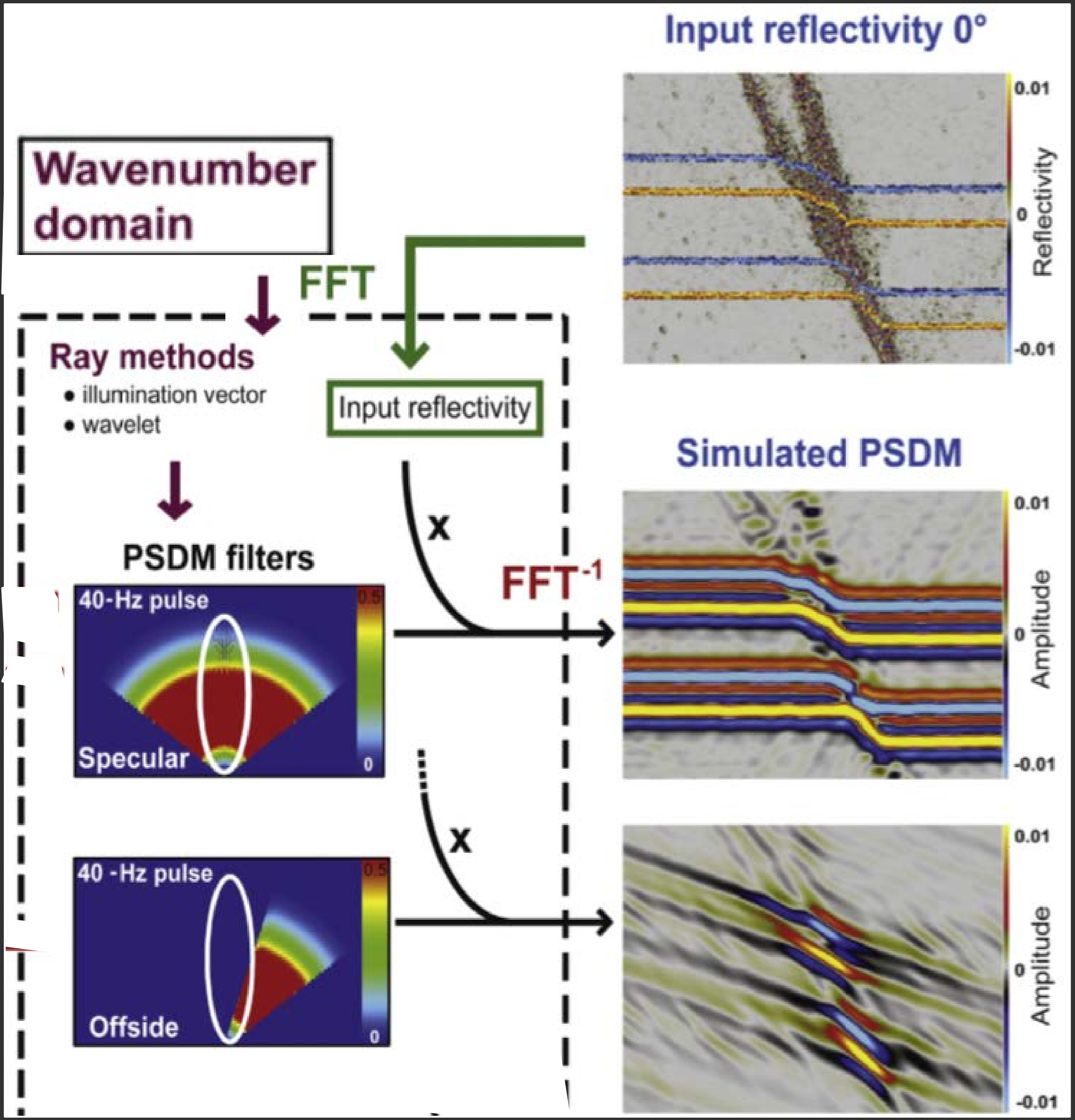
- Modification using sigmoidal relations between volumetric strain and changes in seismic properties.
- Property variation according to strain differs between siliciclastic sediments and salt.



(Botter et al., 2012)

4. Prestack Depth Migration (PSDM) Simulation (Lecomte, 2008)

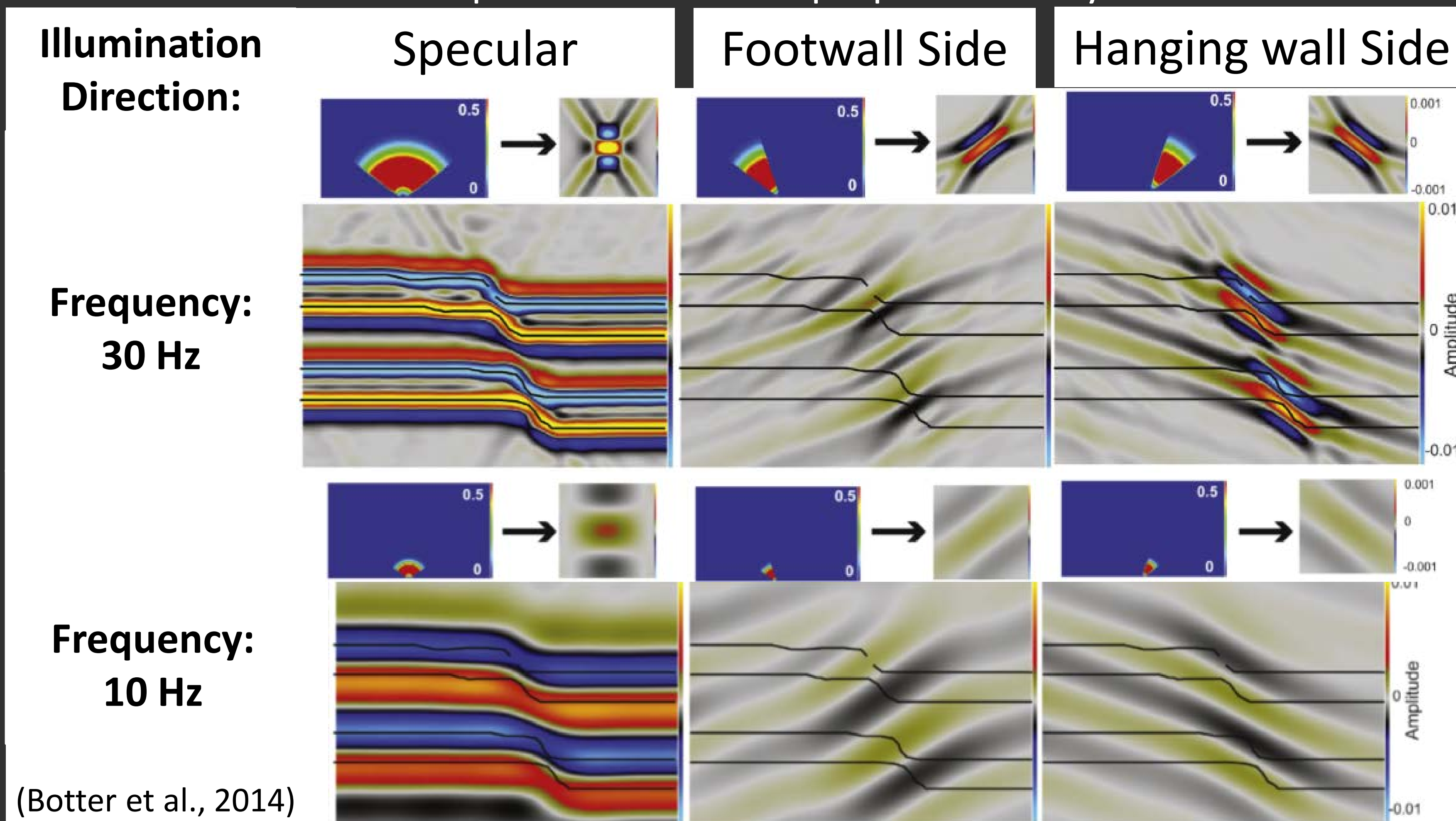
- Evaluate the impact of salt-influenced extensional forced folding on the resultant seismic image.



(Botter et al., 2014)

5. Interpretation of Seismic Image

- Sensitivity Analysis; fine tune parameters: to understand which combination of these parameters image better on seismic.
  - Illumination direction: impact on the total fault volume
  - Wave frequency: controls the resolution
- Correlation between amplitude and elastic properties analysis.



(Botter et al., 2014)

Timeline

	December			January					February				March				April					May				June			
	51	52	53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Literature Review	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Main Research Study																													
Analyse and treat data with the proposed methods					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Analyse and interpret results													■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Writing of Thesis																													
Results															■	■	■	■	■	■	■	■	■						
Discussion																■	■	■	■	■	■	■	■						
Summary and conclusion																	■	■	■	■	■	■	■						
First Draft of Thesis																													
Compilation and editing																					■	■	■	■	■				
Final Draft of Thesis																													
Error-check																										■	■	■	
Final proof read (check with advisor)																										■	■	■	
Submission of Thesis																													■

Thank you for your attention

2D Flexural Modelling of the Barents Sea

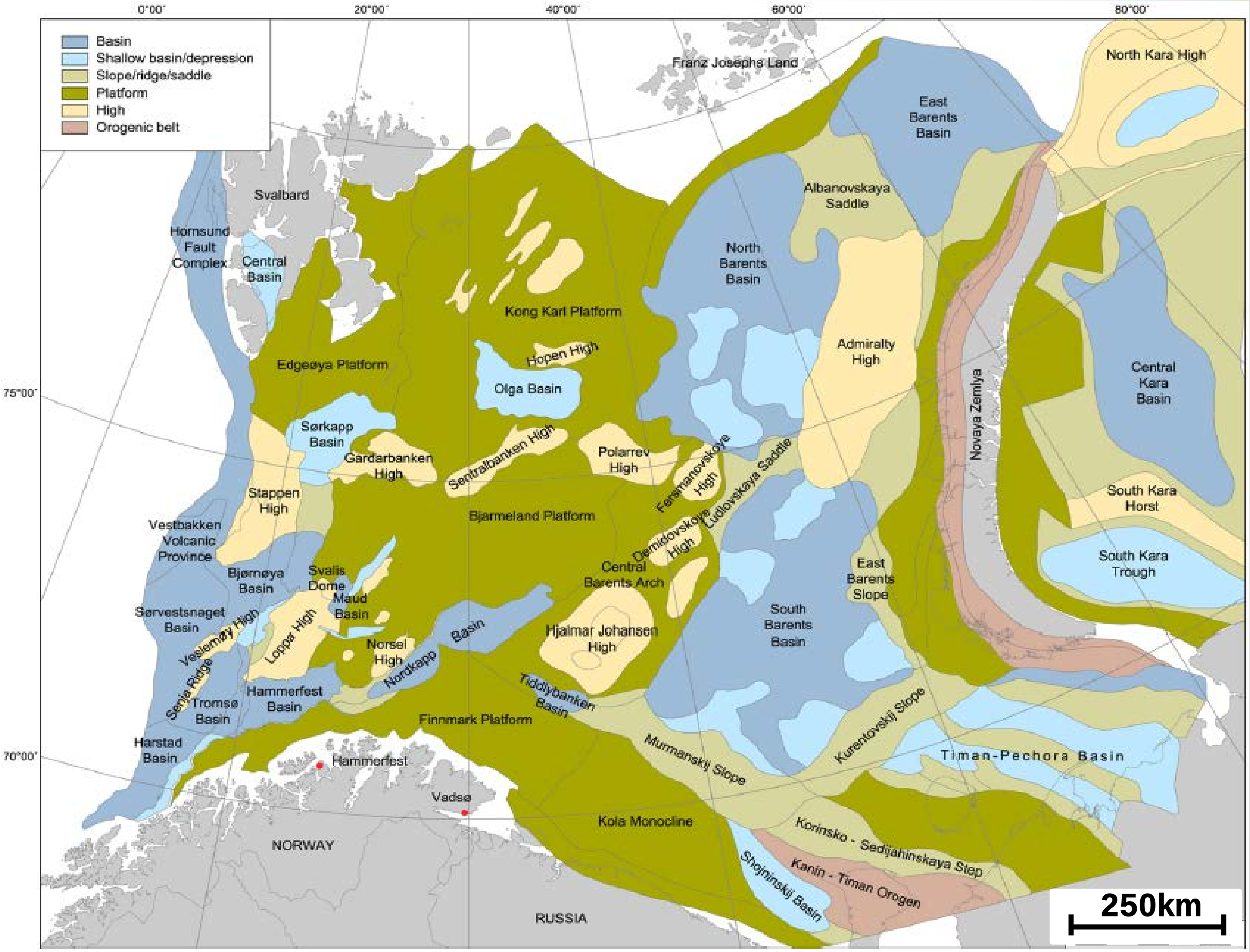
Hans Østebø

University of Stavanger

Supervisor: Alejandro Escalona (University in Stavanger)
Co-Supervisor: Nestor Cardozo (University in Stavanger)

Outline:

- Introduction
- Motivation
- Previous work
- Objectives
- Geological setting
- Methodology
- Time Plan



(Henriksen *et al.,* 2011)

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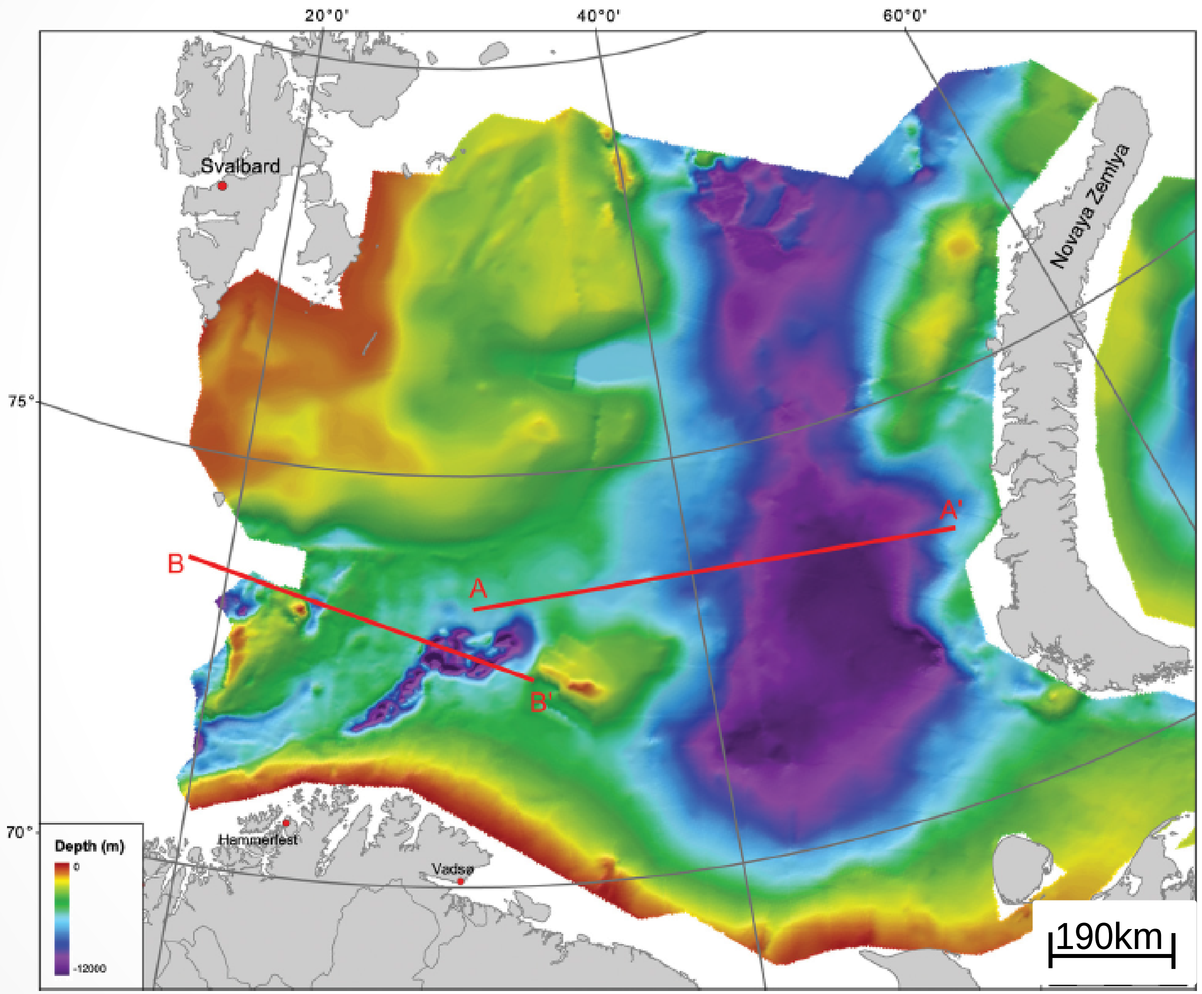
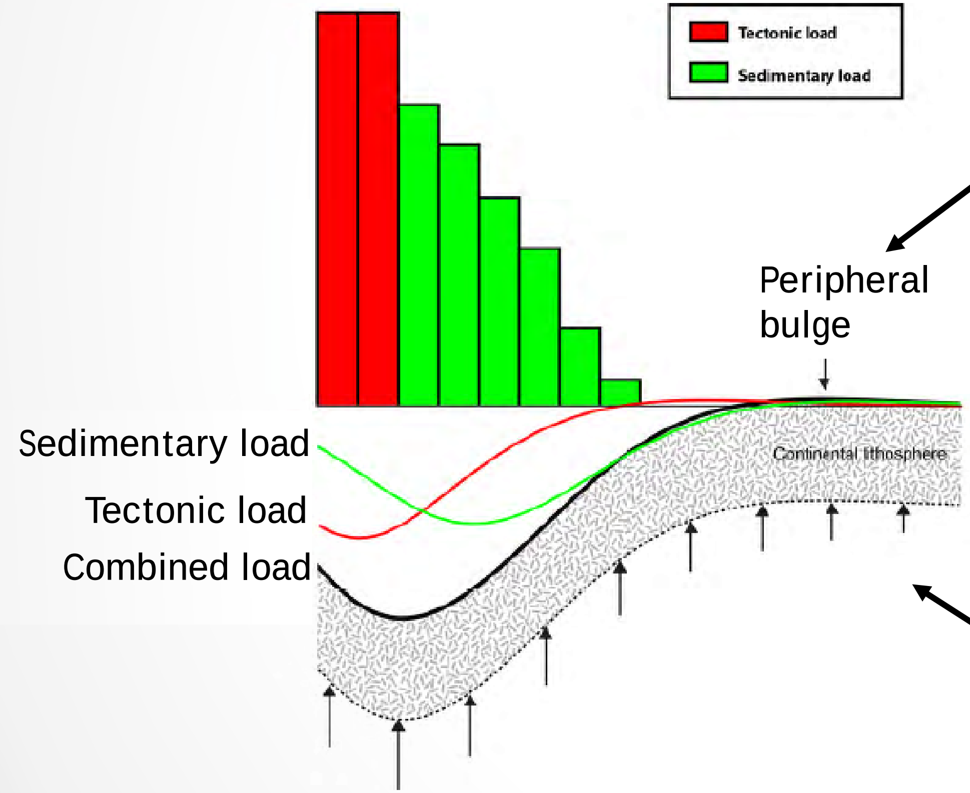
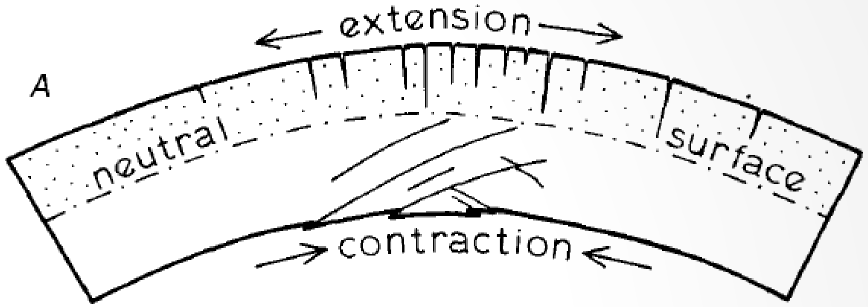
Introduction



Introduction



(Campos, 2011)

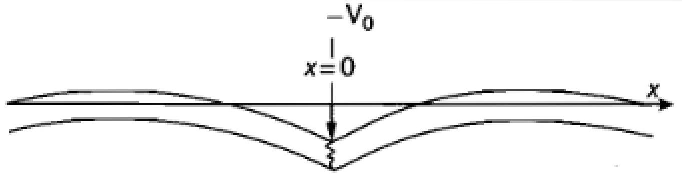


(Bradley *et al.*, 1991)

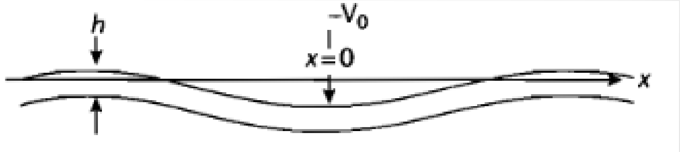
Flexural response in two dimensions:

$$q(x) = D * \frac{d^4w}{dx^4} + \Delta\, pgw$$

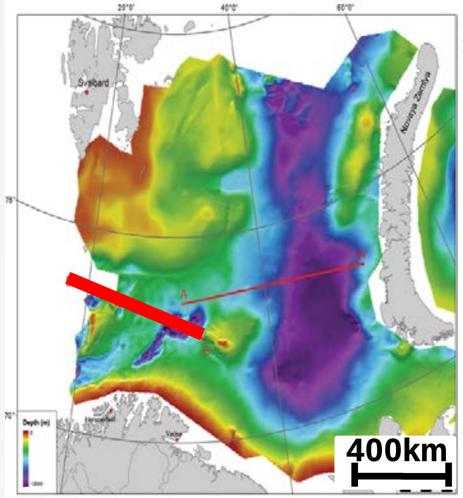
Deflection of a broken elastic plate under a line load applied at its end

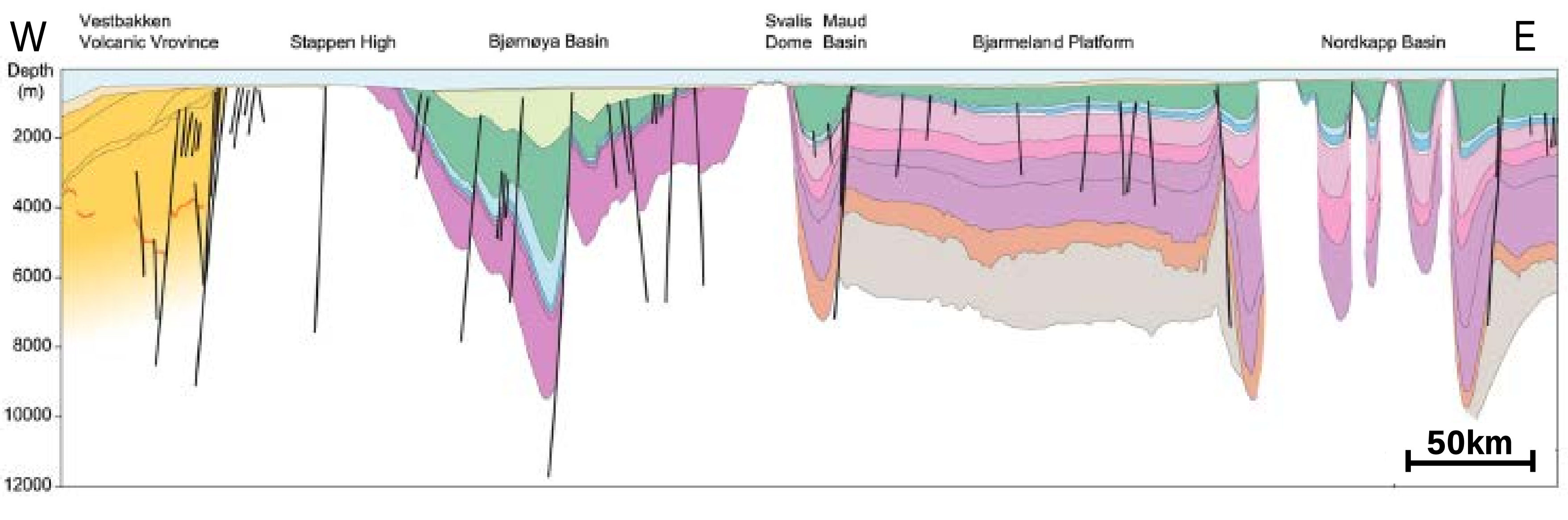


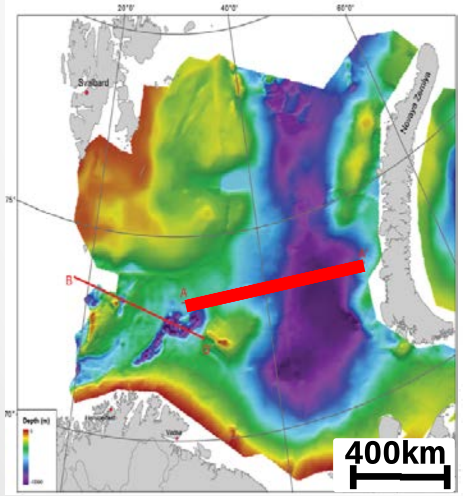
A continuous elastic plate under a line load

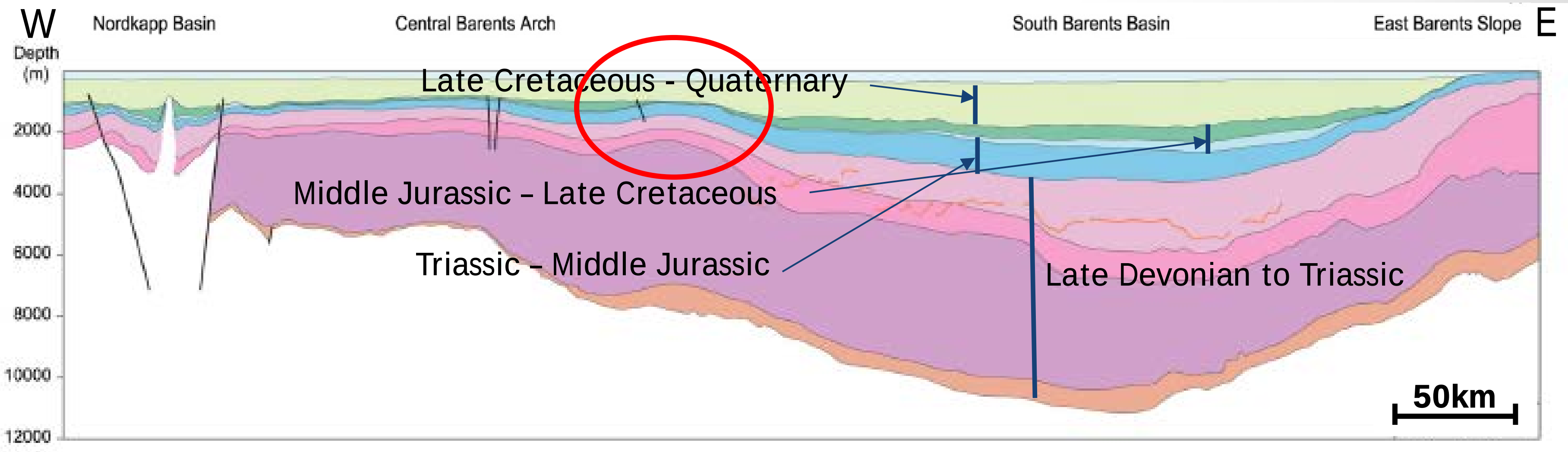


Motivation









(Henriksen *et al.*, 2011)

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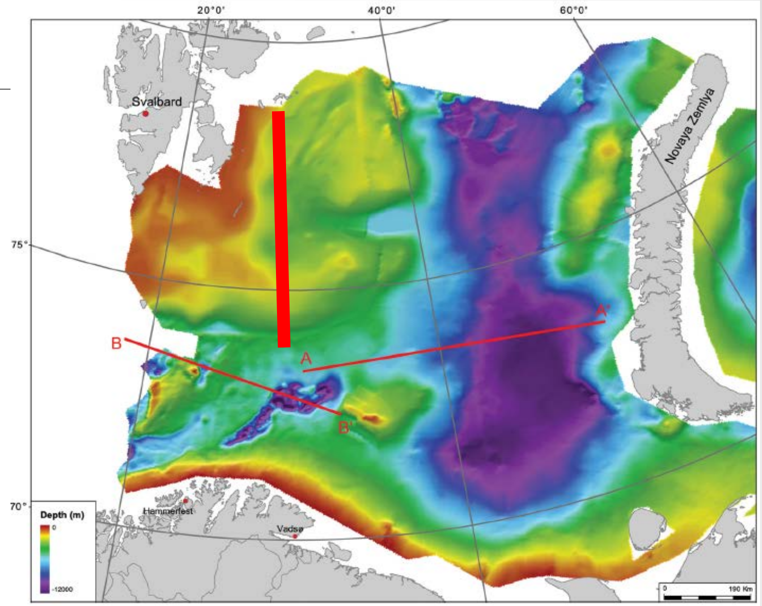
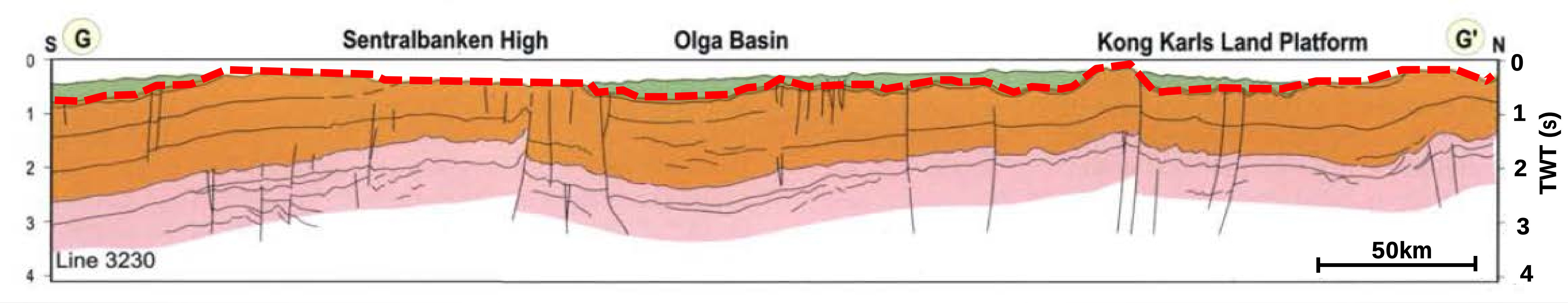
Motivation

North – South lines shows similar features of sedimentary loads and bulges.



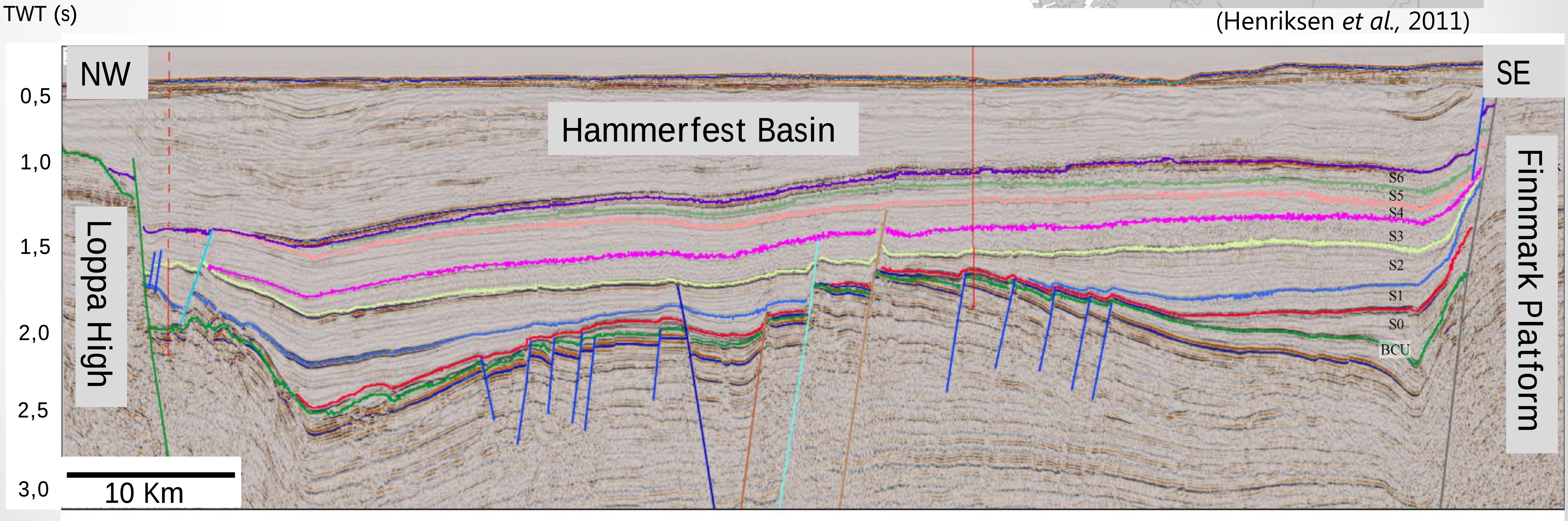
(Henriksen *et al.*, 2011)



(Grogan *et al.*, 1999)

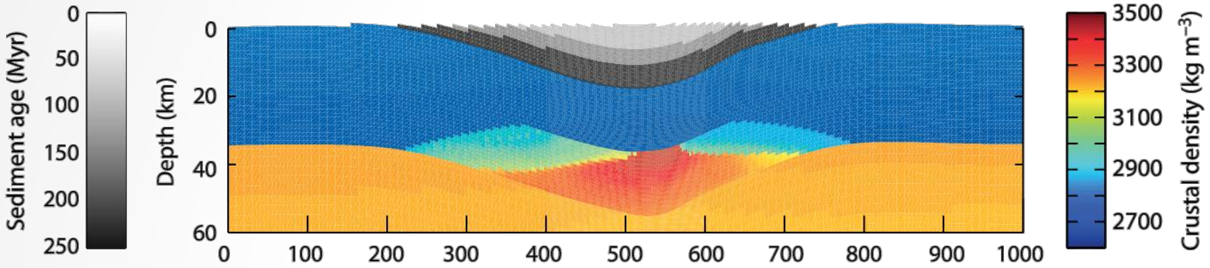
Motivation

(Henriksen *et al.*, 2011)

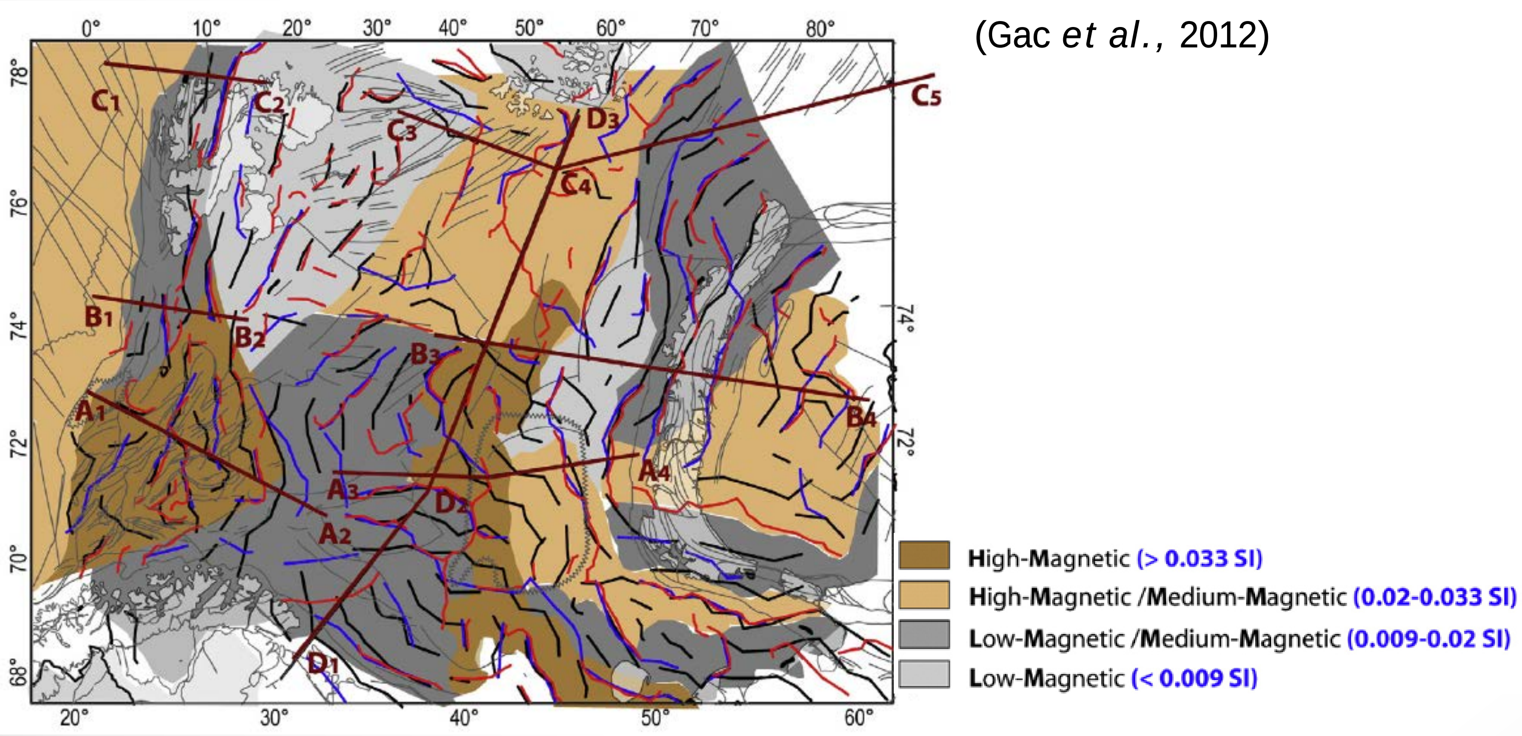


(Marin *et al.,* 2014)

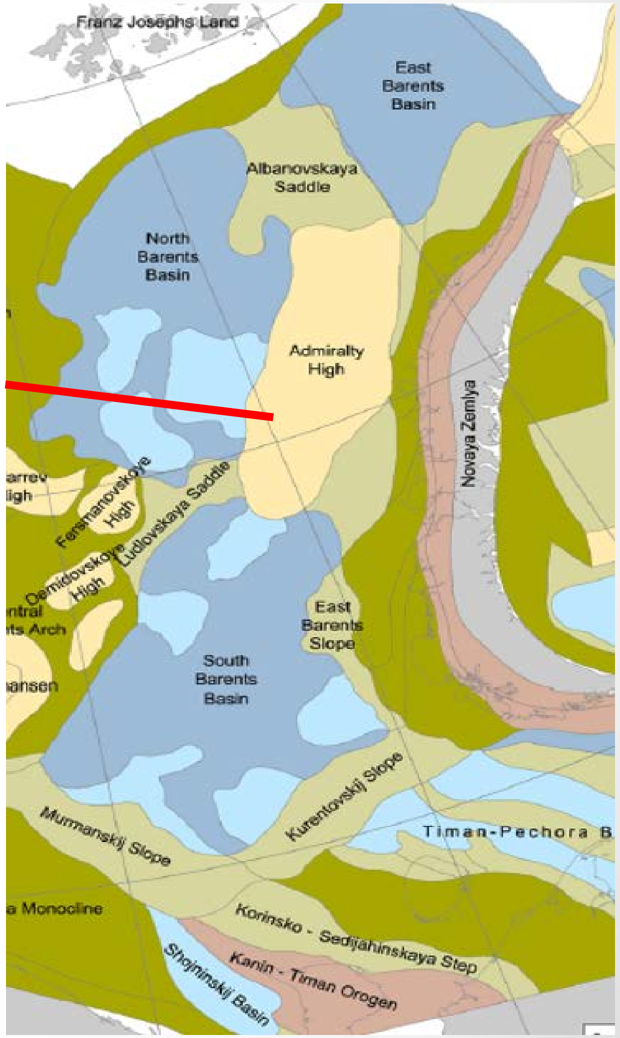
Previous work



(Gac *et al.*, 2012)



(Marello *et al.*, 2010)



(Henriksen *et al.*, 2011)

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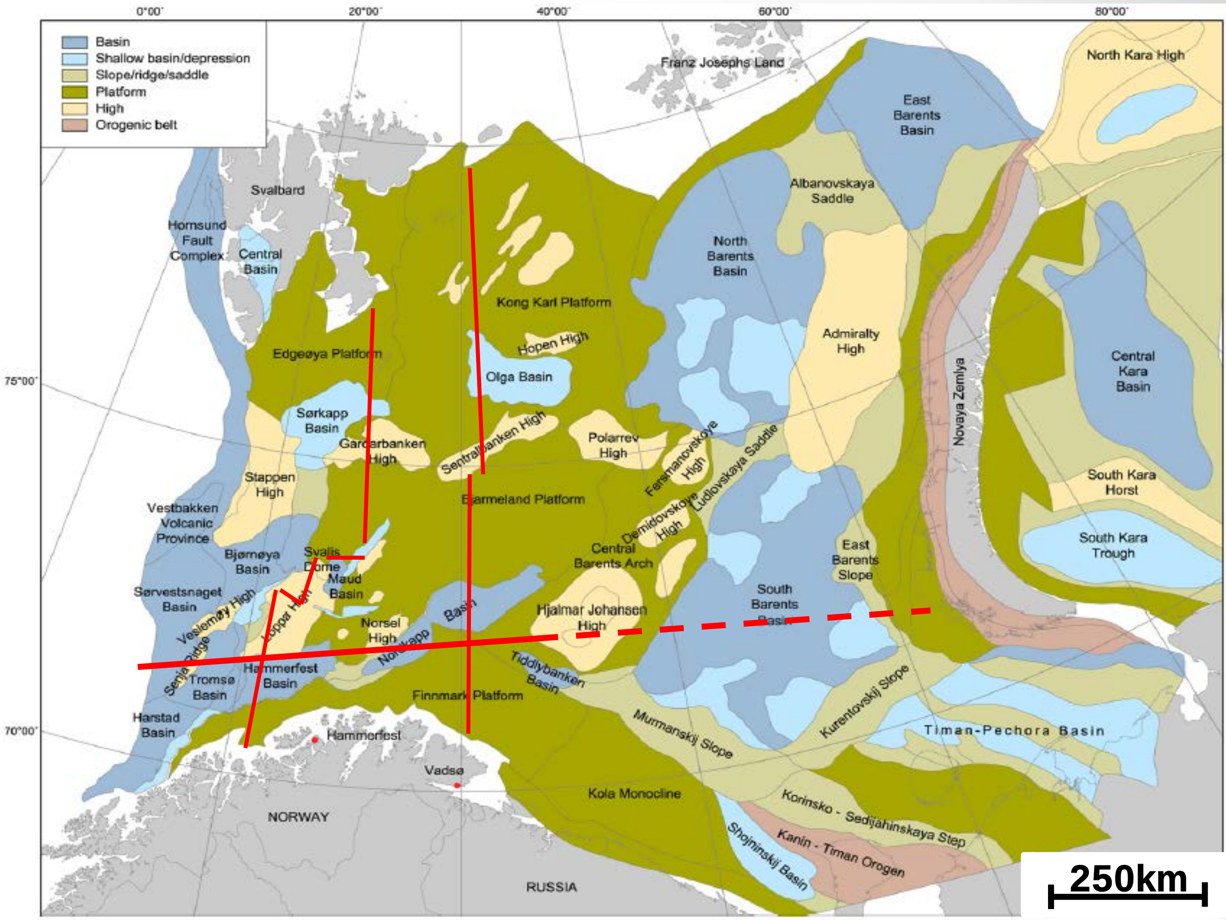
Objectives

- To build 2D flexural models for the main sequences from Devonian to Quaternary.

- This will be done to evaluate the flexural effect from the sedimentary and tectonic loads.



(Modified from Henriksen *et al.*, 2011)

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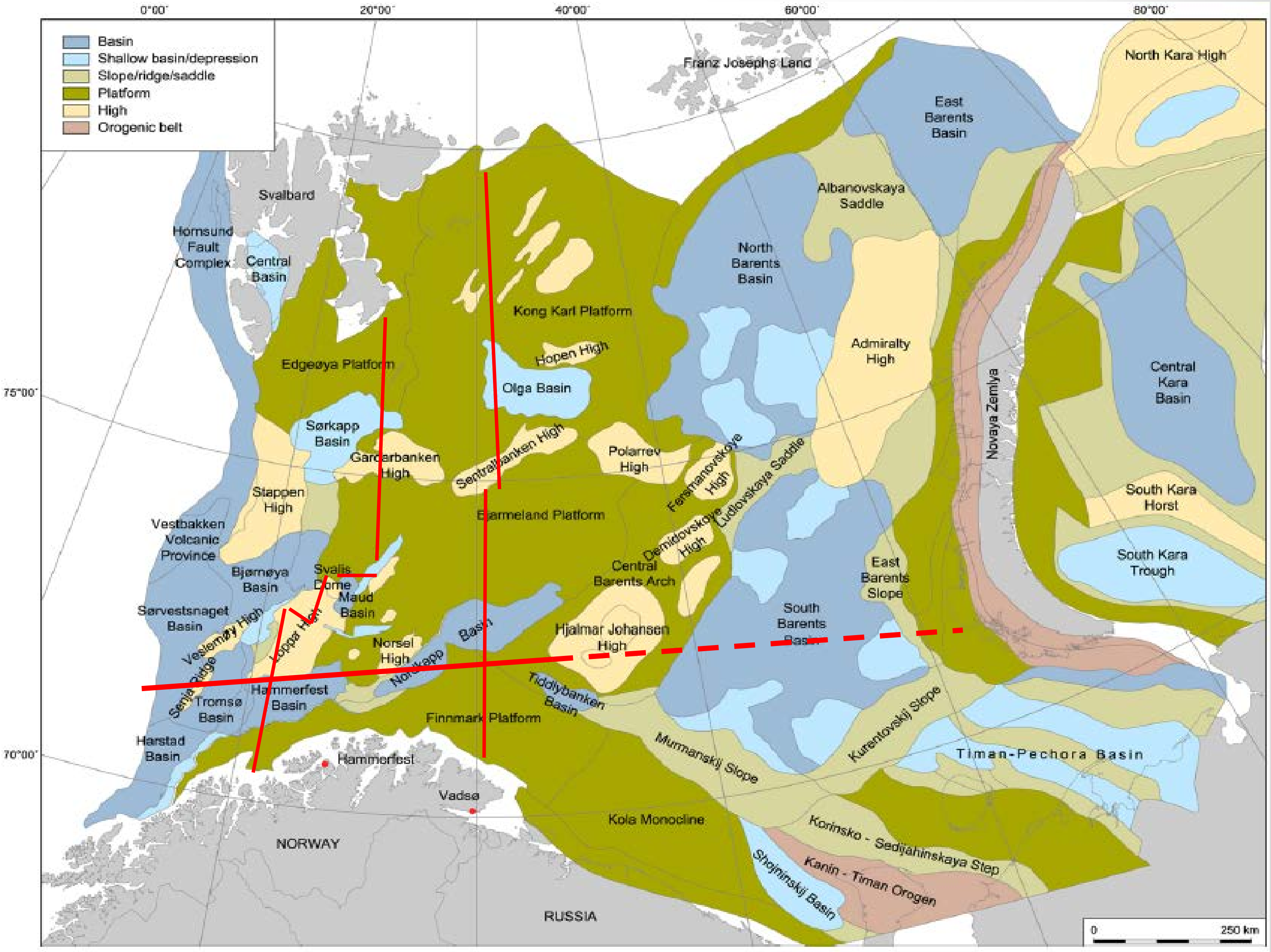
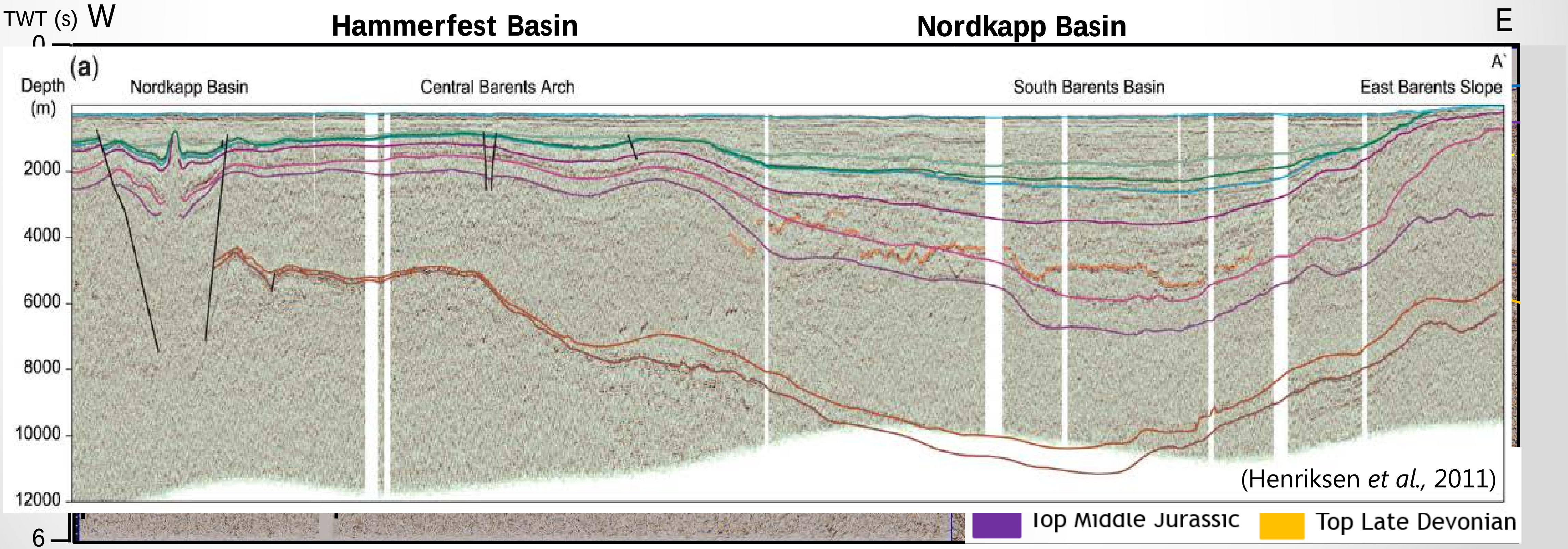
Data



(Henriksen *et al.*, 2011)

Data

(Modified from Henriksen *et al.*, 2011)



(Henriksen *et al.*, 2011)

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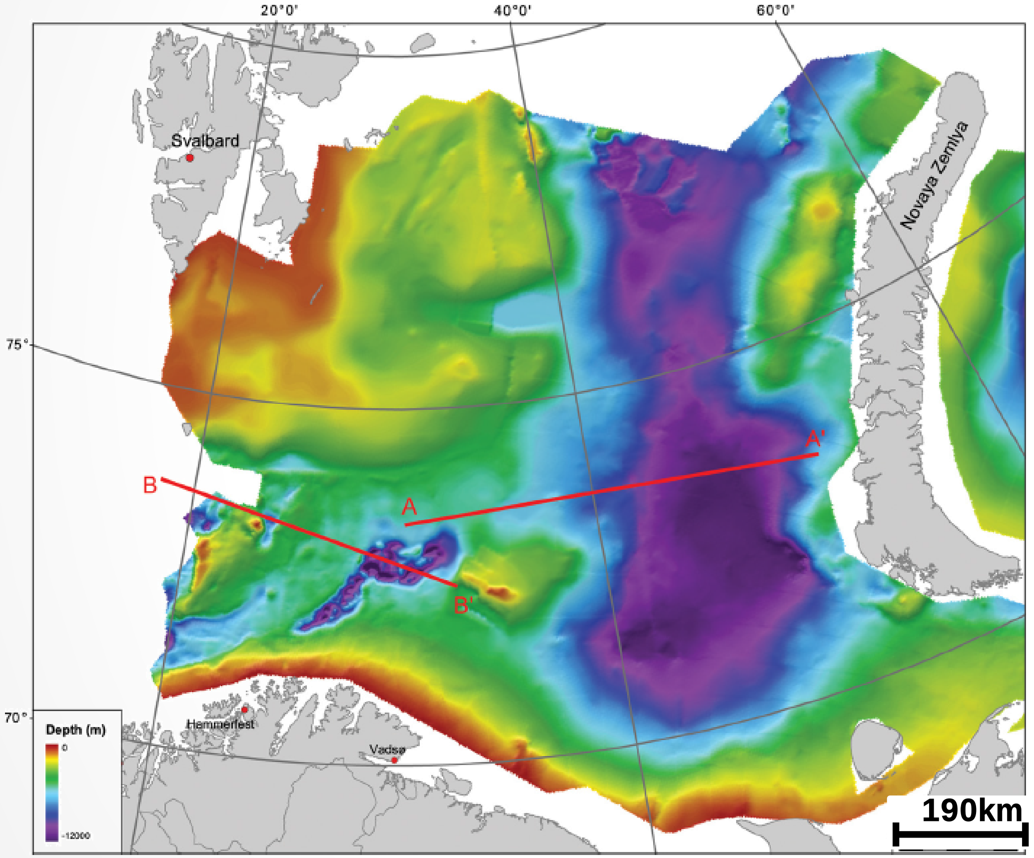
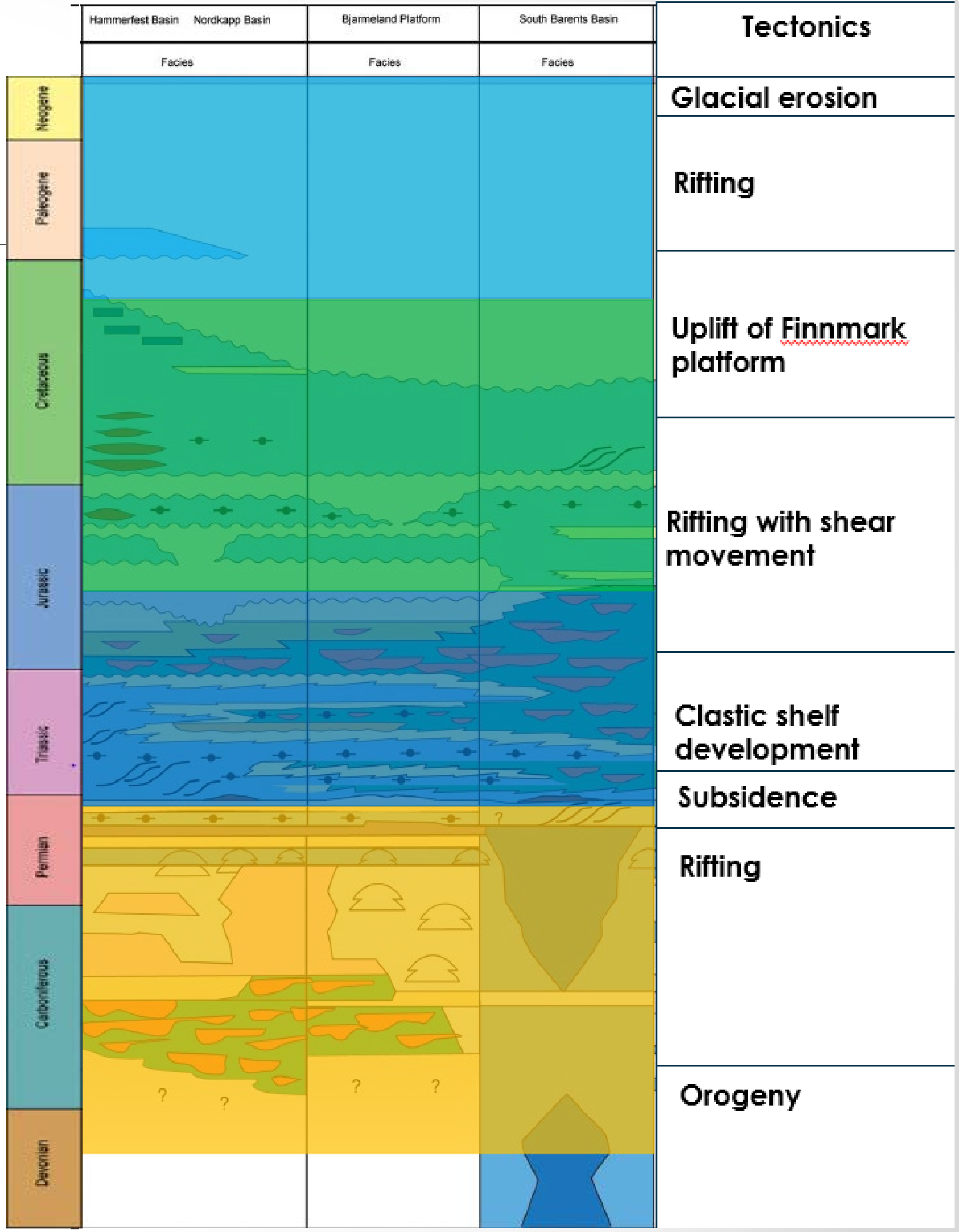
Geological setting



Late Cretaceous - Quaternary
Middle Jurassic - Late Cretaceous
Triassic- Middle Jurassic
Late Devonian - Triassic



(Modified from Henriksen *et al.*, 2011)

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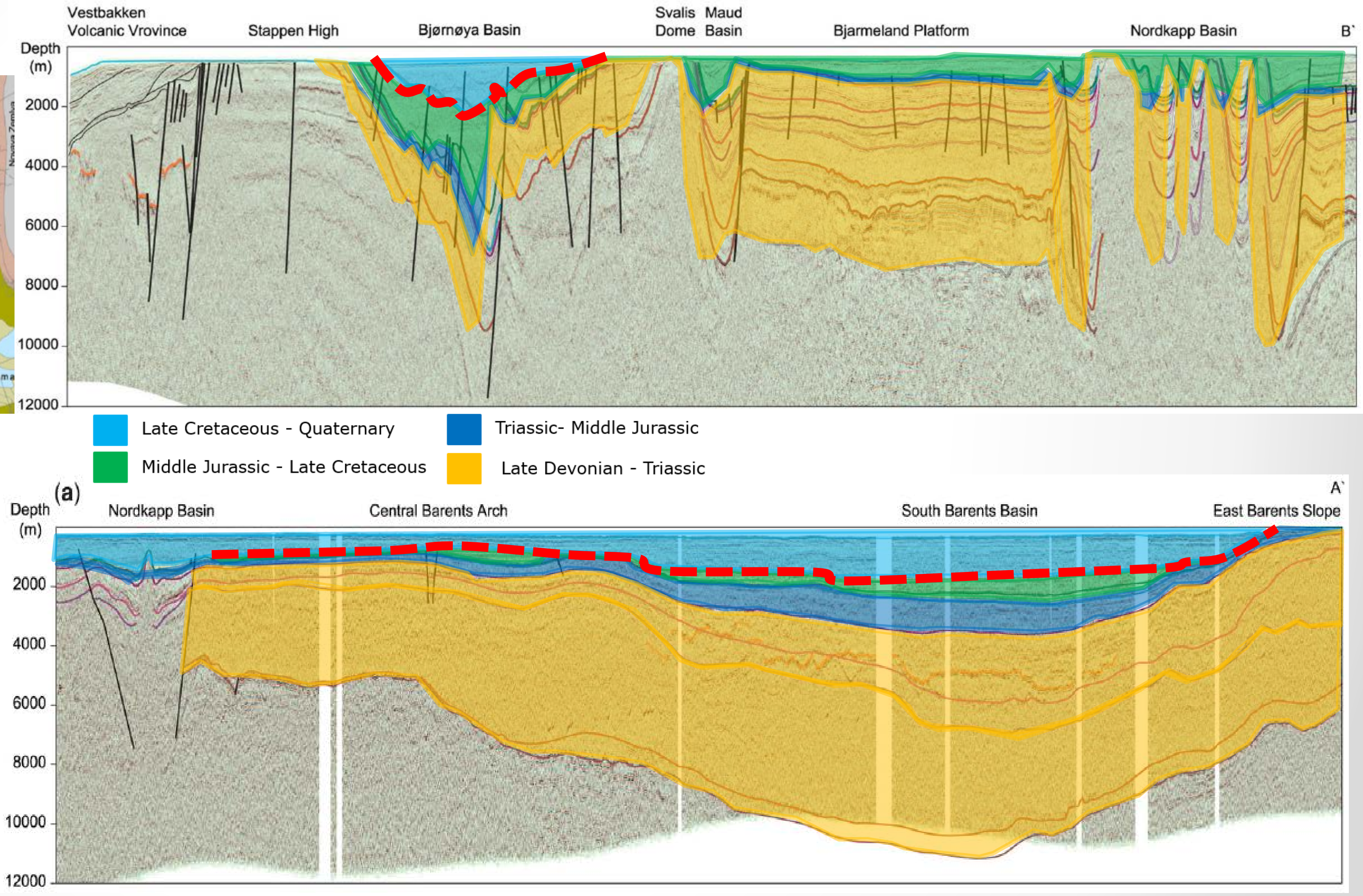
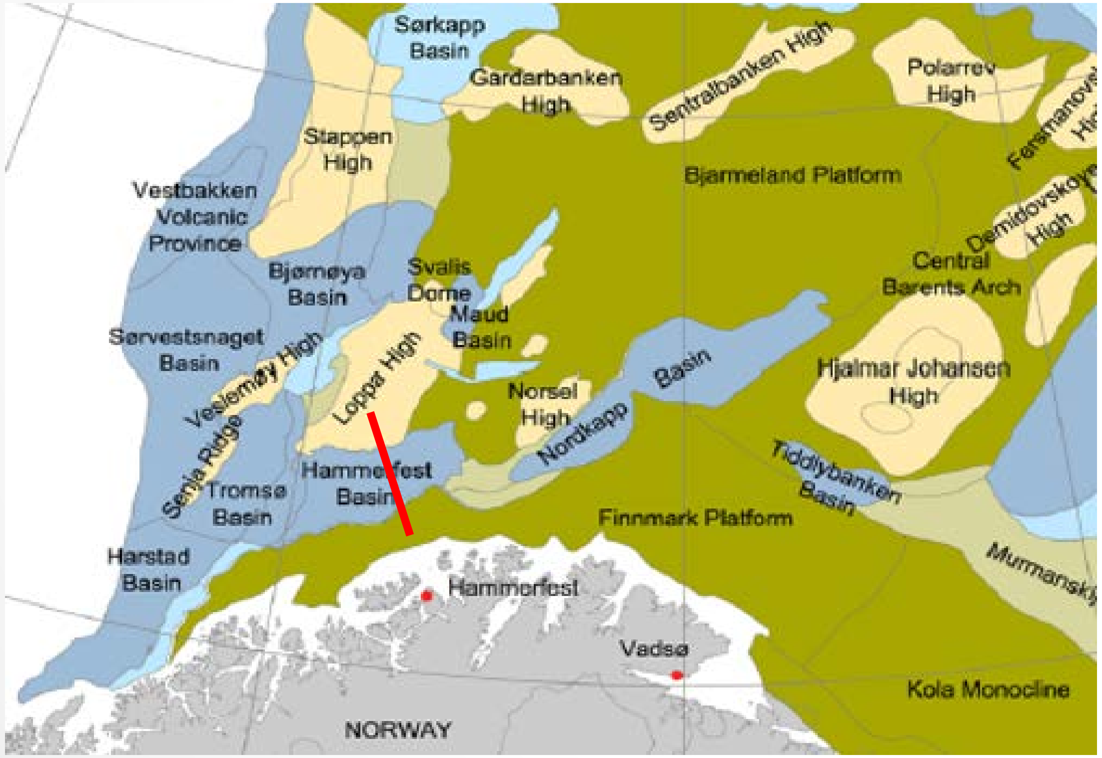
Geological setting



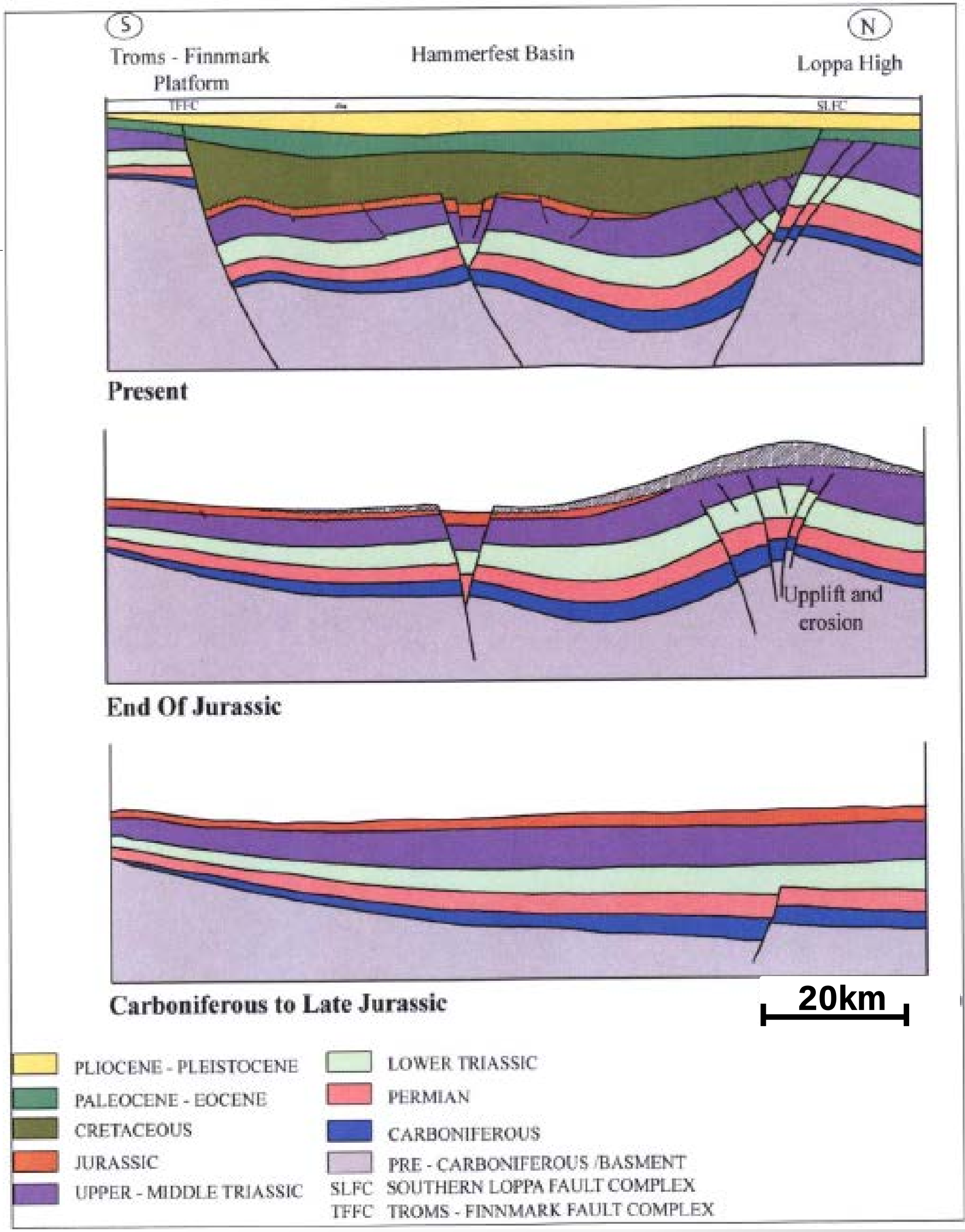
(Modified from Henriksen *et al.*, 2011)

Methodology

- Nazarova (2009), Leknes (2009) and Belalahy (2009) have provided research on the impact of subsidence and tectonic events in the Hammerfest Basin and Loppa High.



(Henriksen *et al.*, 2011)



(Belalahy, 2009)

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Methodology

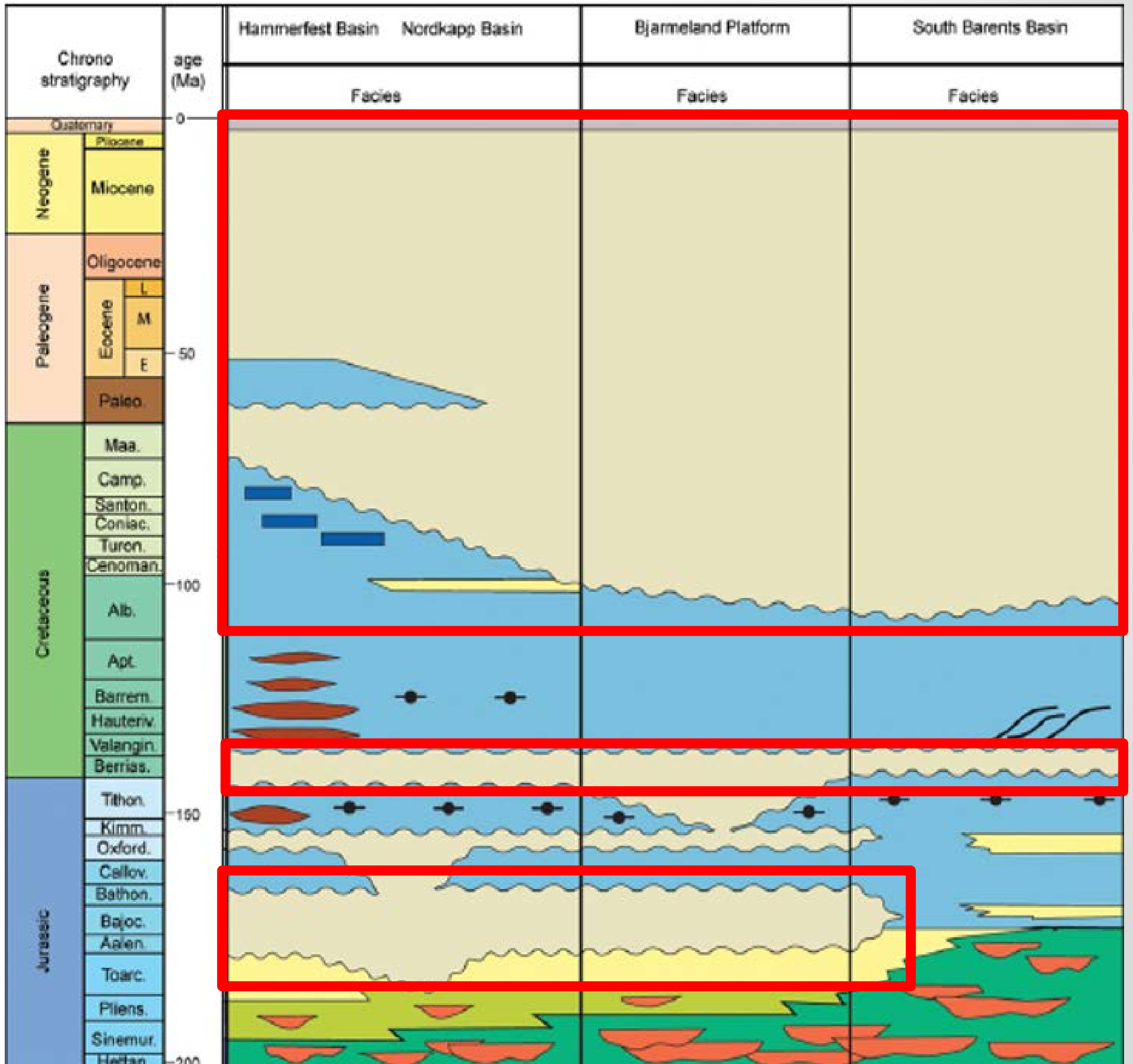
Four steps that will be performed:

- Define Mega sequences

- Create different scenarios

- Perform Isostasy analysis

- Create 2D restorations of the transect lines to evaluate the flexural model of the transect lines



(Henriksen *et al.*, 2011)

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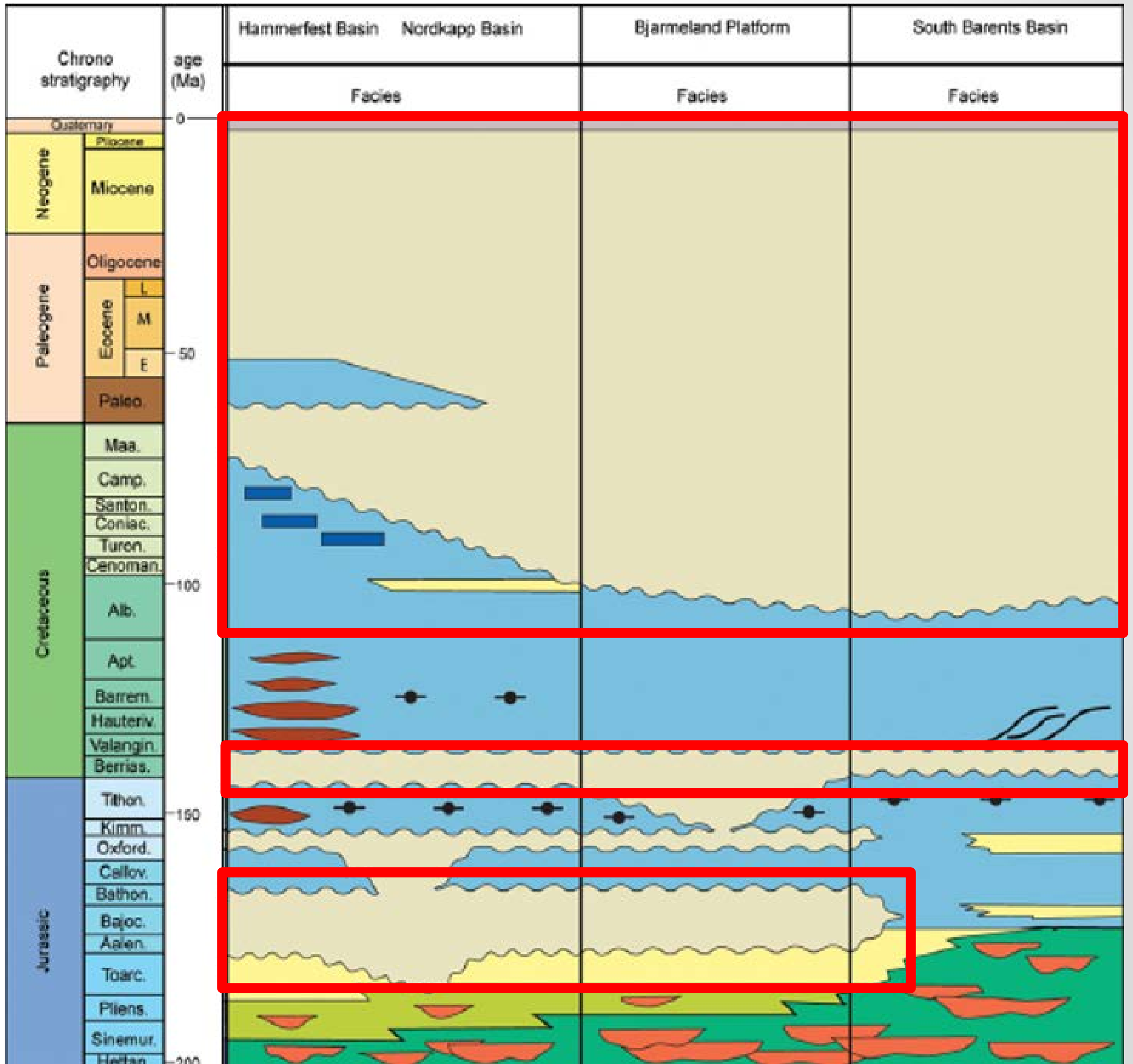
Methodology

Largest uncertainties in the study:

- Effect of tectonic loads

- Amount of erosion
  - Hammerfest Basin:
    Pliocene - Pleistocene: 800-1000m
    Paleogene: 900-1300m erosion

- Sedimentary loads



(Henriksen *et al.*, 2011)

Time Plan

Activity	Des	Jan	Feb	Mar	Apr	May	June
Study Literature							
Seismic interpretation							
- Fault interpretation							
- Stratigraphy interpretation							
2D seismic analysis							
- Restoration							
- Flexural strength analysis							
- Isostasy analysis							
Report and Summary							
- Initial writing start							
- Submit 1'st draft							
- Correct revised 1'st draft							
- Submit Finalized thesis							

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Thanks for listening!
Any questions?

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Reservoir characterization of Lower Cretaceous clastic wedges in southwestern Barents Sea using rock physics and seismic analysis

Javed Iqbal

Supervisor: Alejandro Escalona

Department of Petroleum Engineering

University of Stavanger

04/12/2015

University of Stavanger

Outline

- Introduction to Area
- Previous Work
- Geological Problem
- Objectives
- Dataset
- Methodology
- Expected Results
- Time plan

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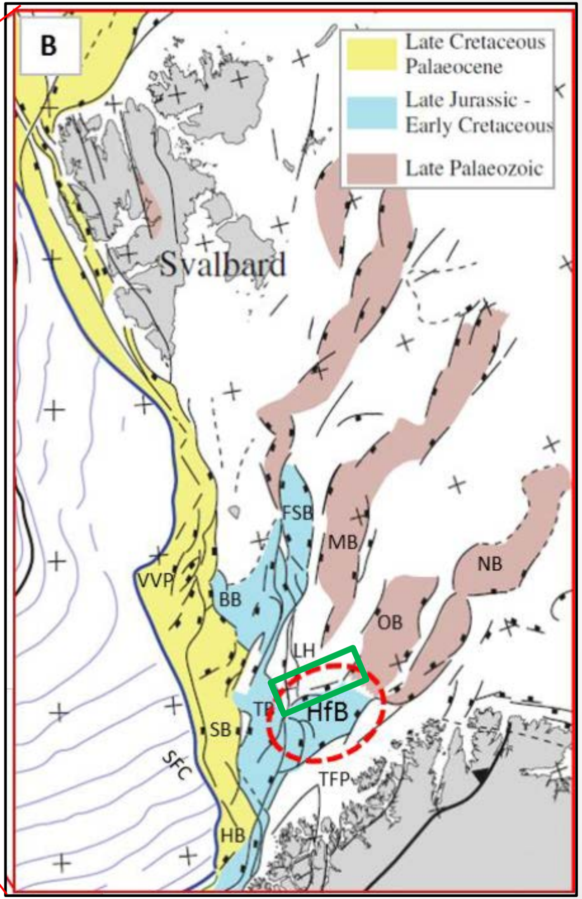
Introduction to Area



Hammerfest Basin

Project Area

(After Faleide et al., 2010)

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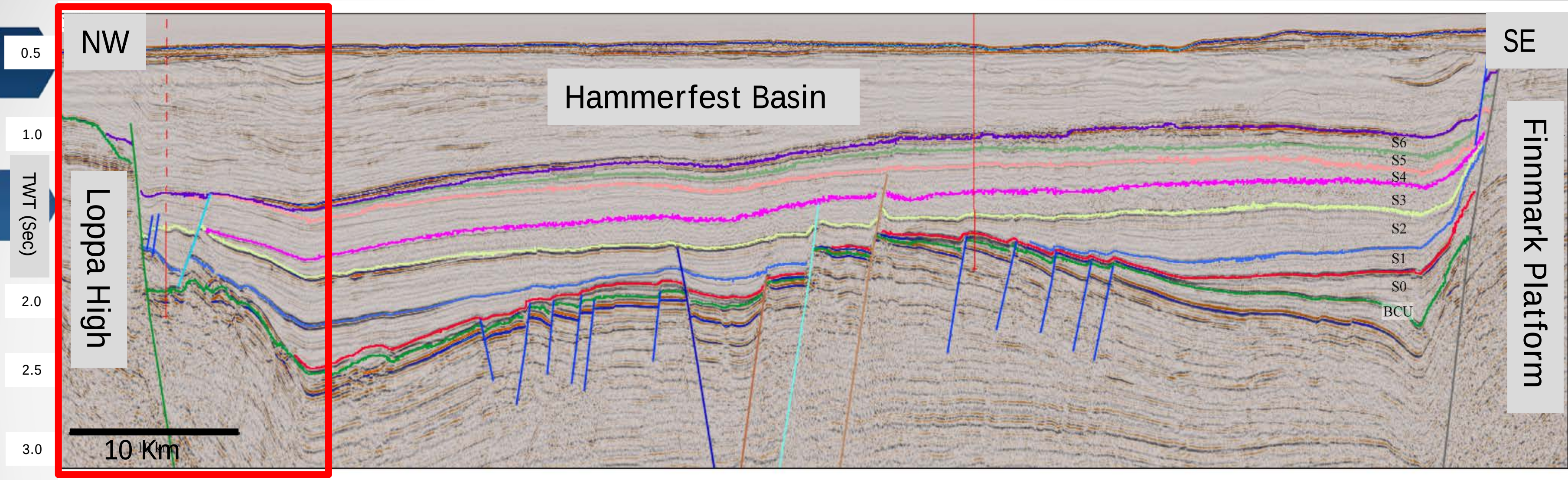
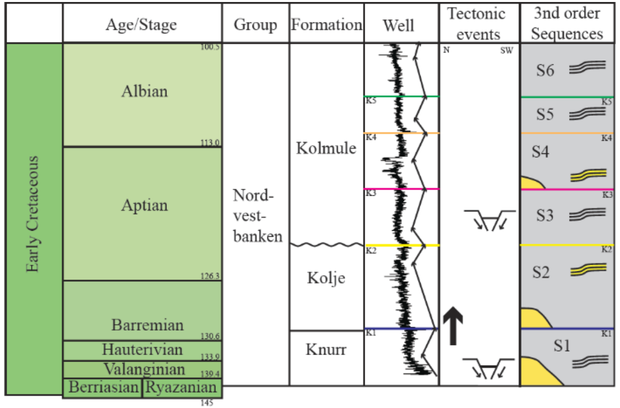
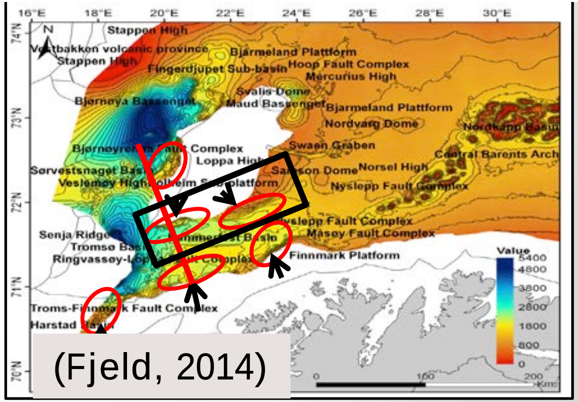
Hammerfest Basin



(Marin et al., 2014)





(Fjeld, 2014)

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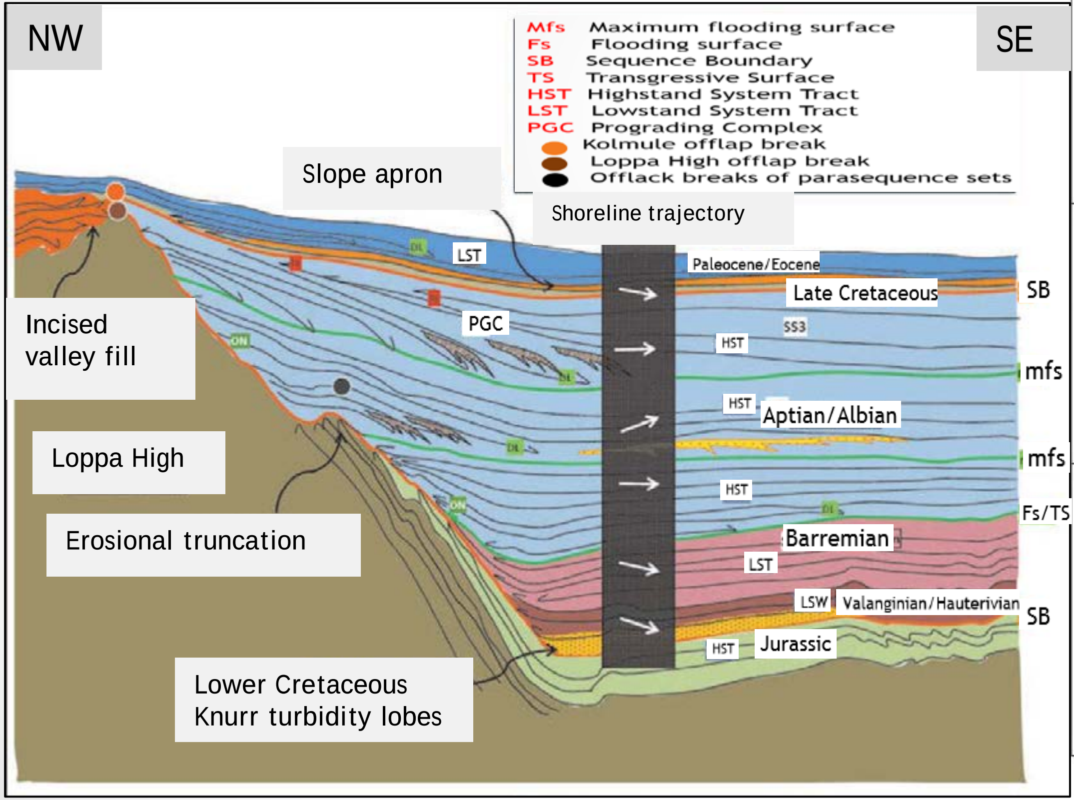
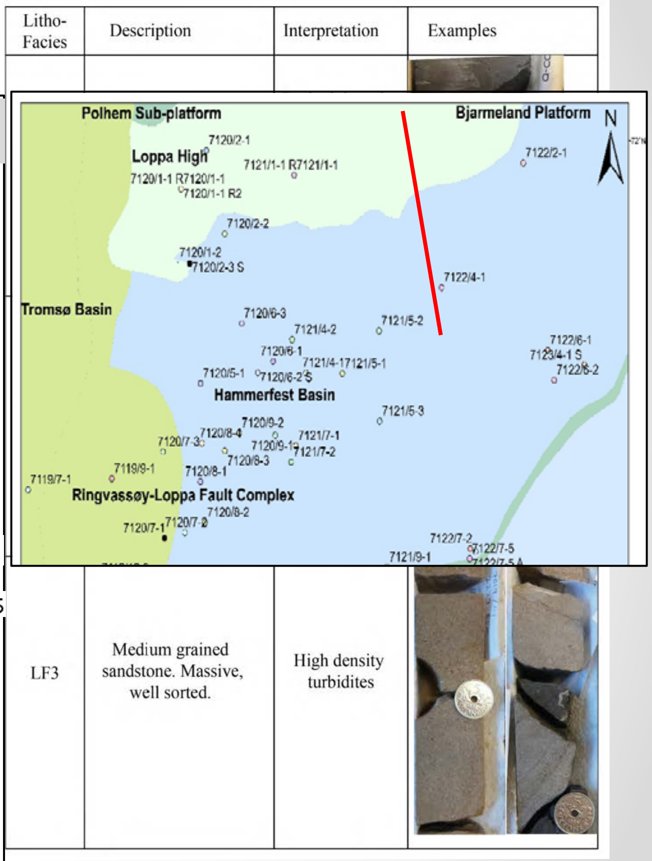
Previous Work

- Deep marine deposits



(Sattar et al., 2005)



(Fjeld, 2014)

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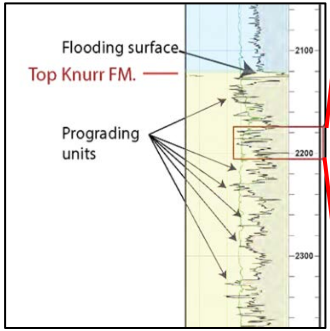
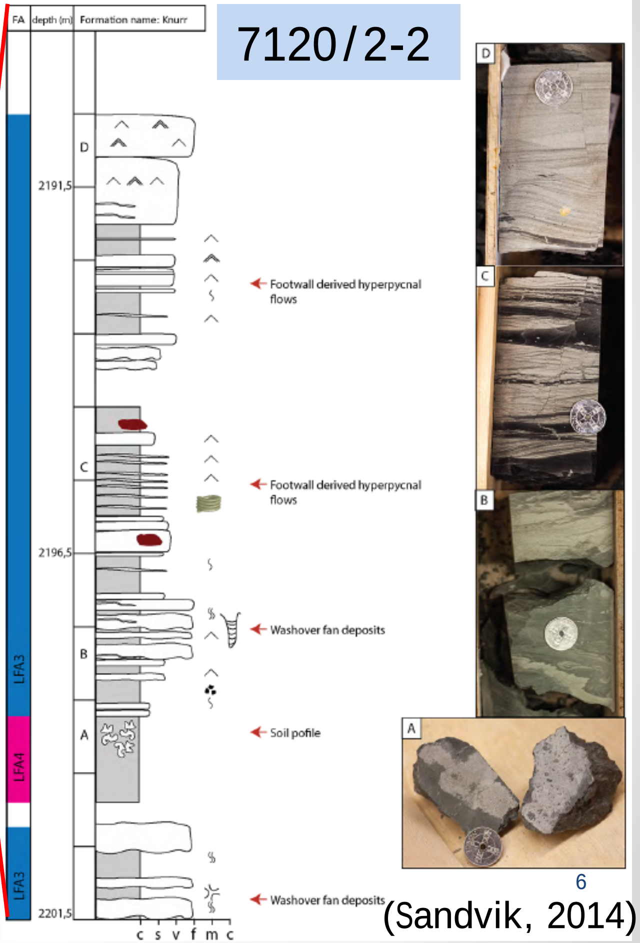
Previous Work

- Shallow marine deposits
  - Tempestites
  - Interdistributary bay facies
  - Coastal plain facies





(Sandvik, 2014)

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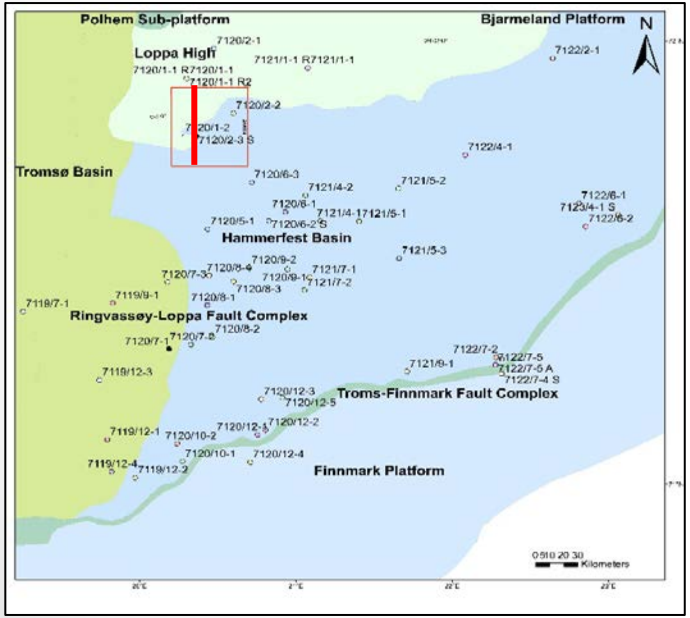
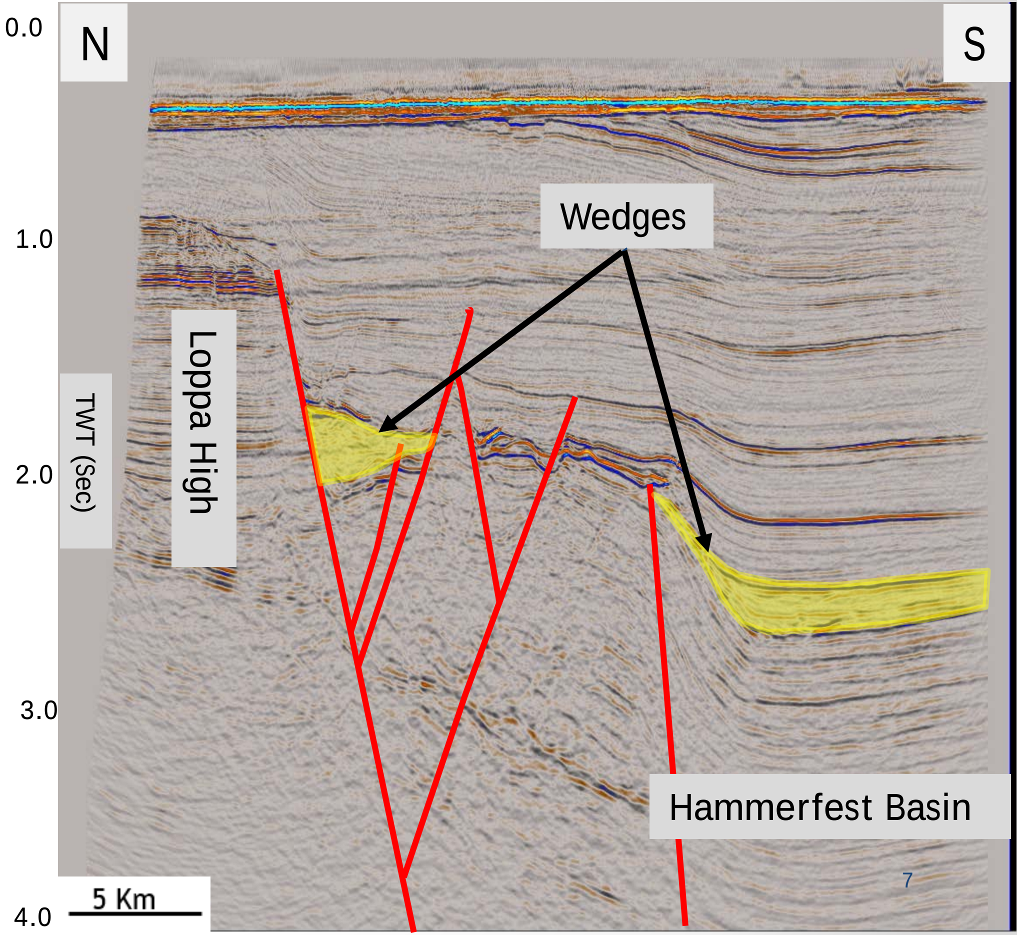
Geological problem

- Lack of understanding
  - Depositional environment
  - Reservoir properties





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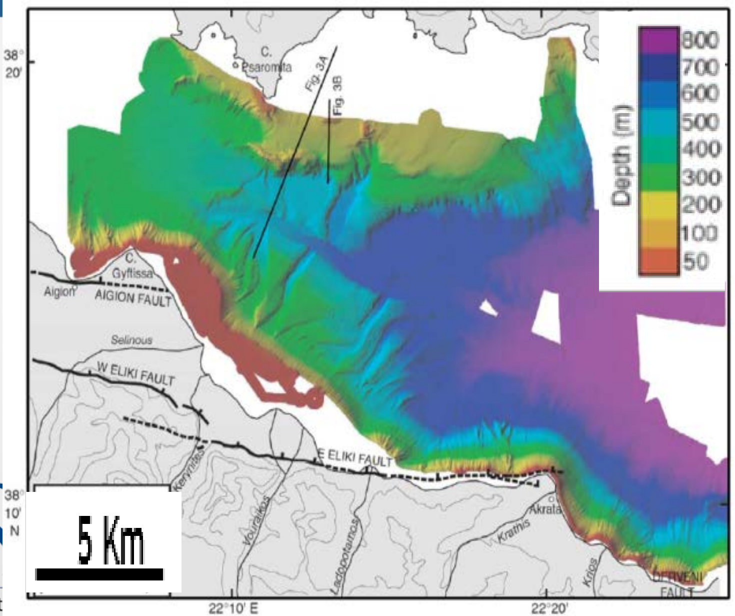
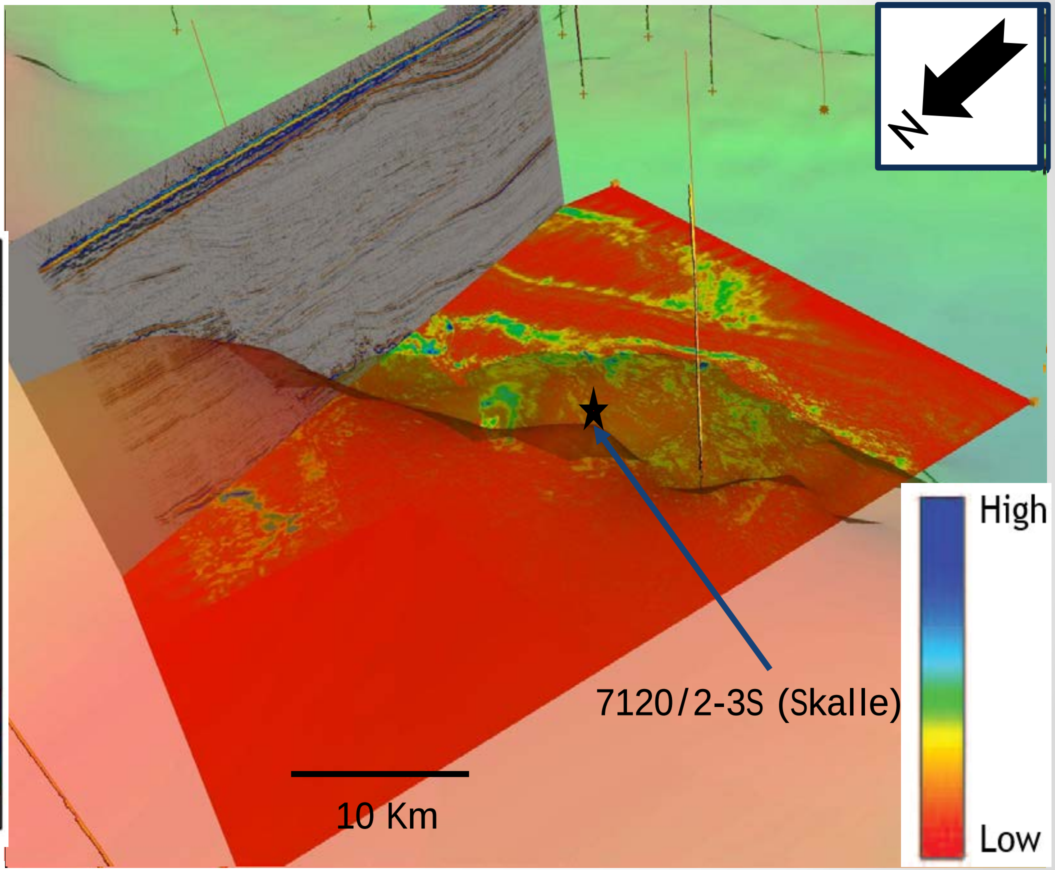
Fan Delta concept

- Fan delta approach



(McNeill et al., 2005)



(LoCrA)

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Stavanger

Objectives

- To characterize the depositional environment using cores and seismic attributes
- To characterize reservoir properties using seismic attributes and rock physics

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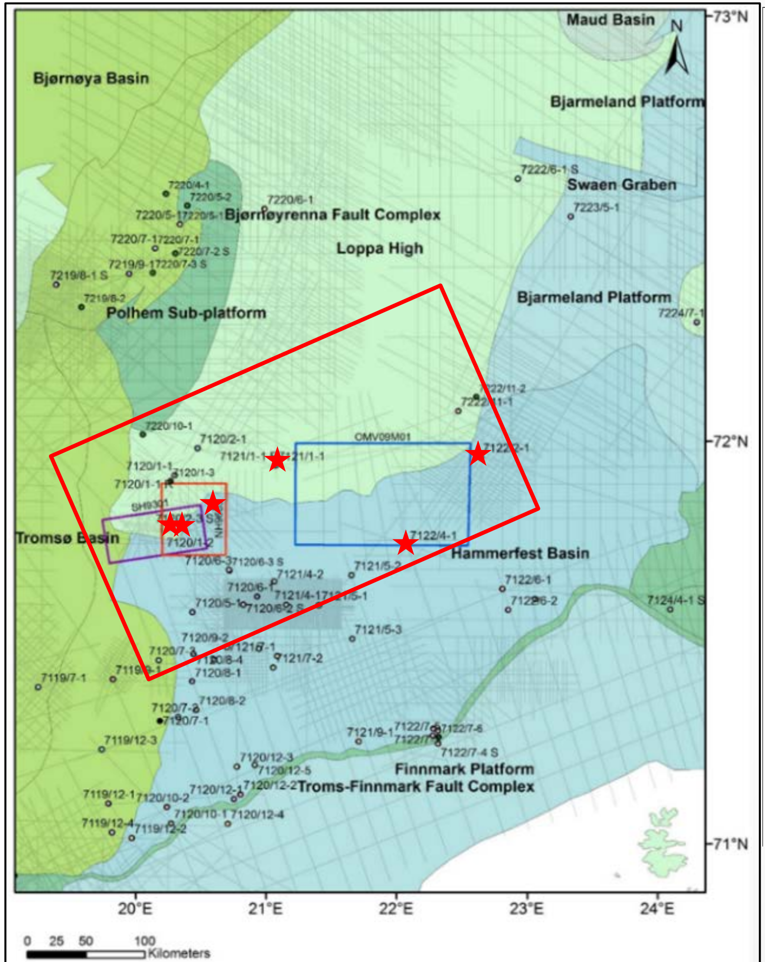
Dataset

- Three 3D seismic cubes
  - NH9605, SH9310 & OMV09M01
- 2D seismic lines
- Well Data (logs and cores)
  - 7120/1-2
  - 7120/2-3S (Skalle)
  - 7122/4-1
  - 7120/2-2
  - 7121/1-1
  - 7122/2-1



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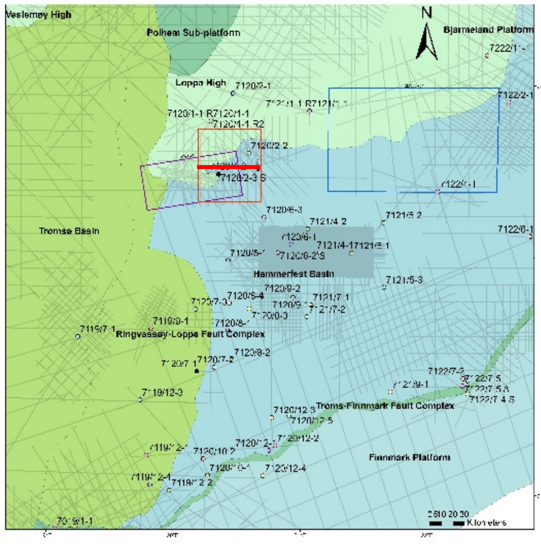
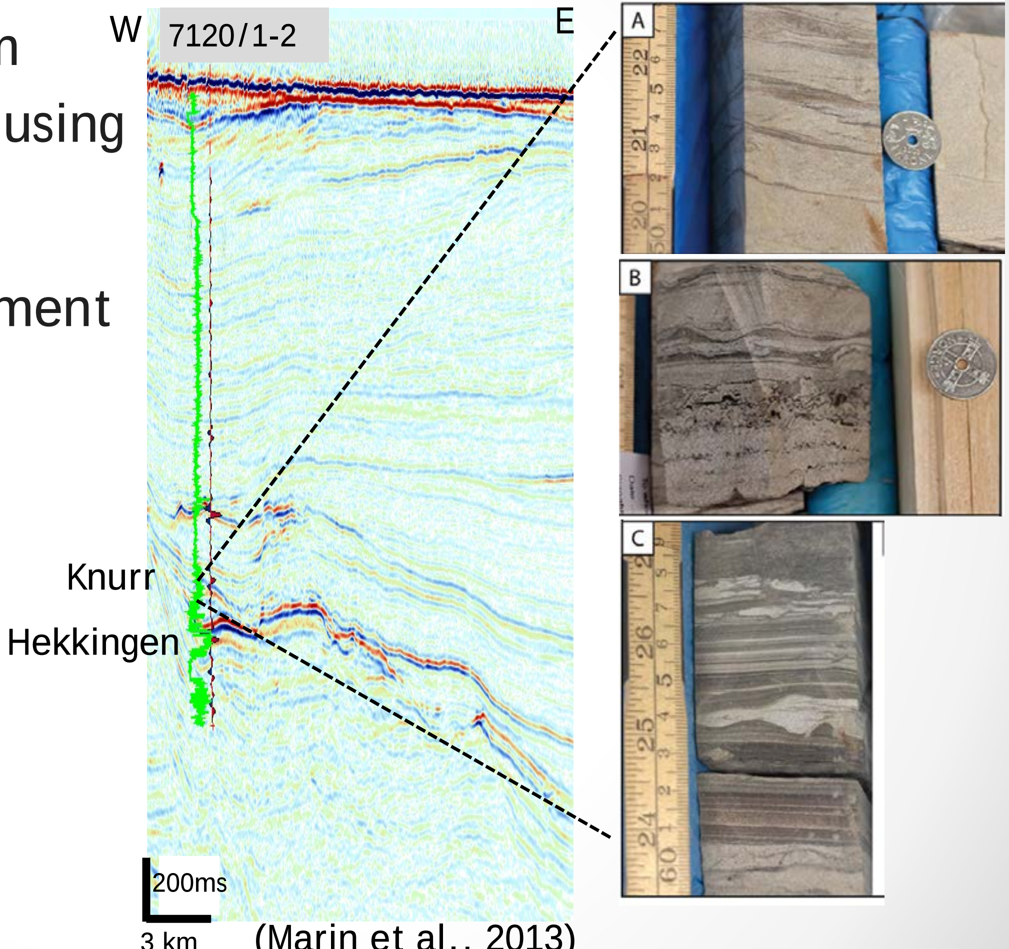
Methodology (Logs and Core data)

- Synthetic seismogram
- Facies identification using
  - Available core data
  - Well Logs
- Depositional environment





(Marin et al., 2013)

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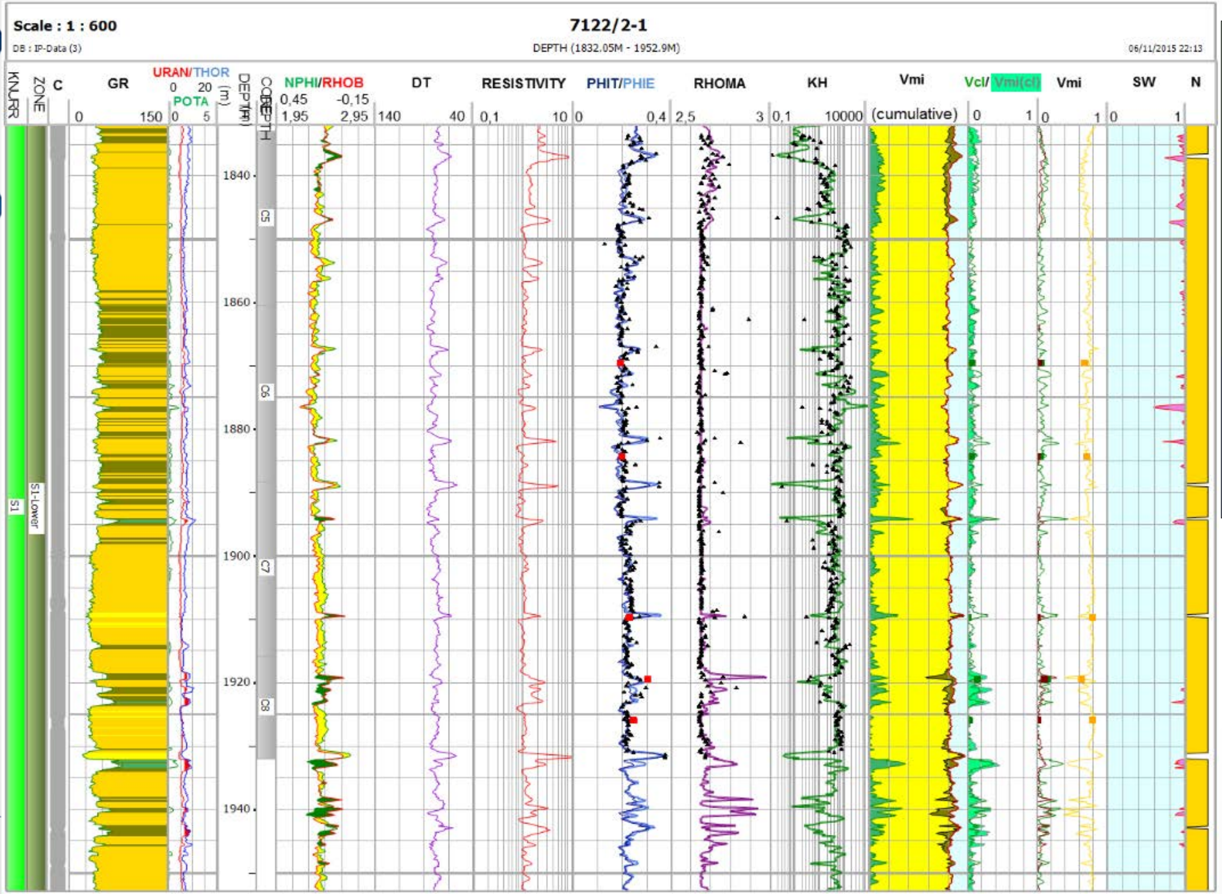
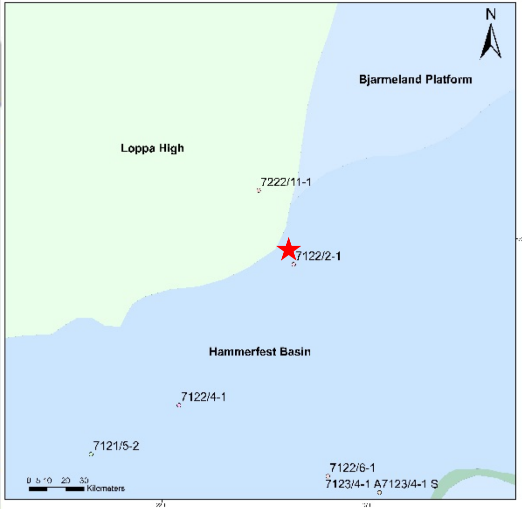
Methodology (Petro-physical Analysis)





(Gomez, 2015)

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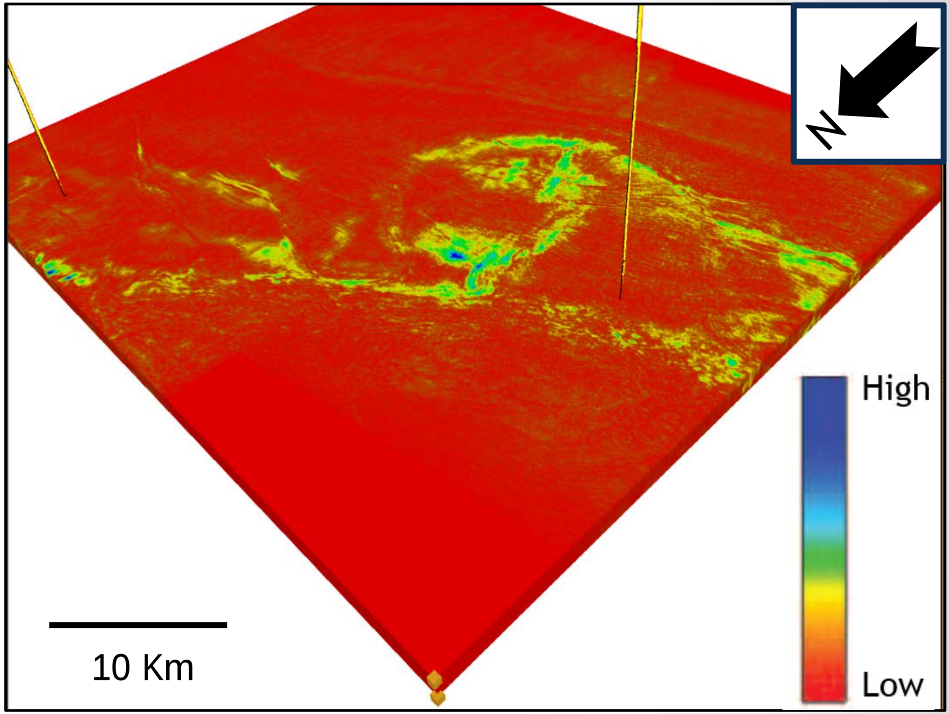
Methodology (Seismic Attributes)

- Spectral decomposition
- Low frequency analysis
- Curvature/Roughness
- Coherence
- Amplitude
- Sweetness attribute
  - Cold colors show sands
  - Hot colors for shaly deposits



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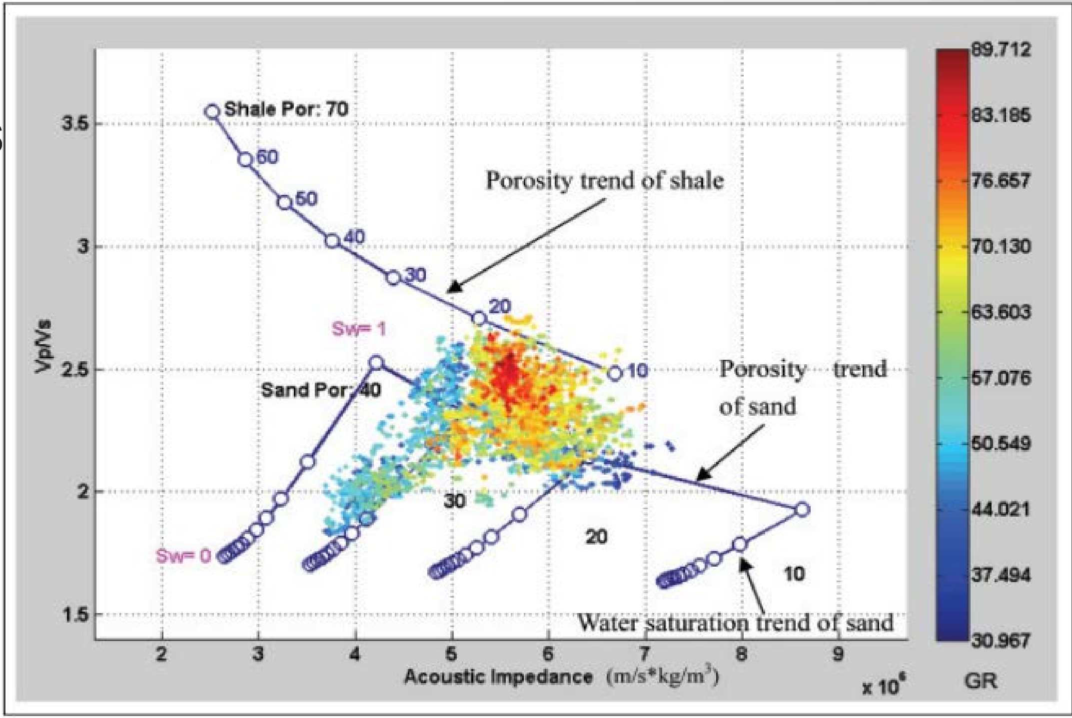
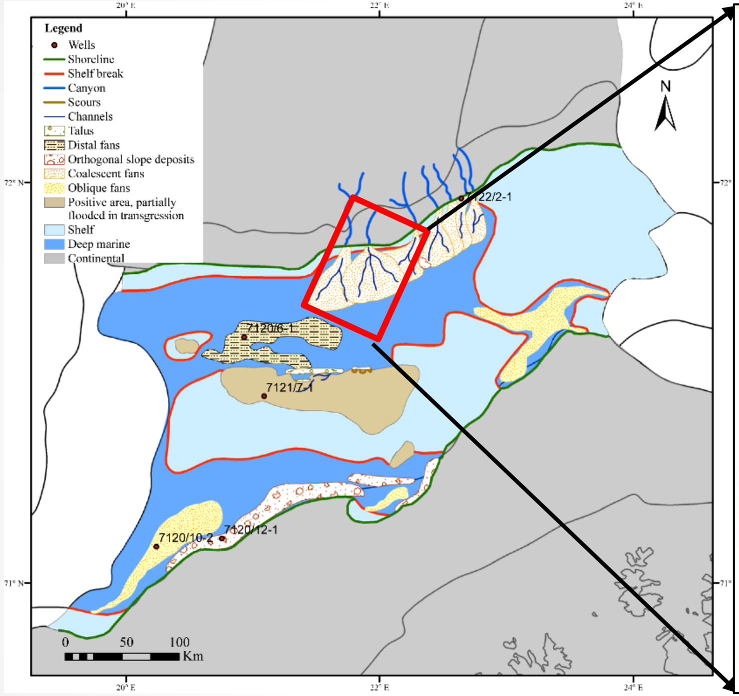
Methodology (Rock Physics)

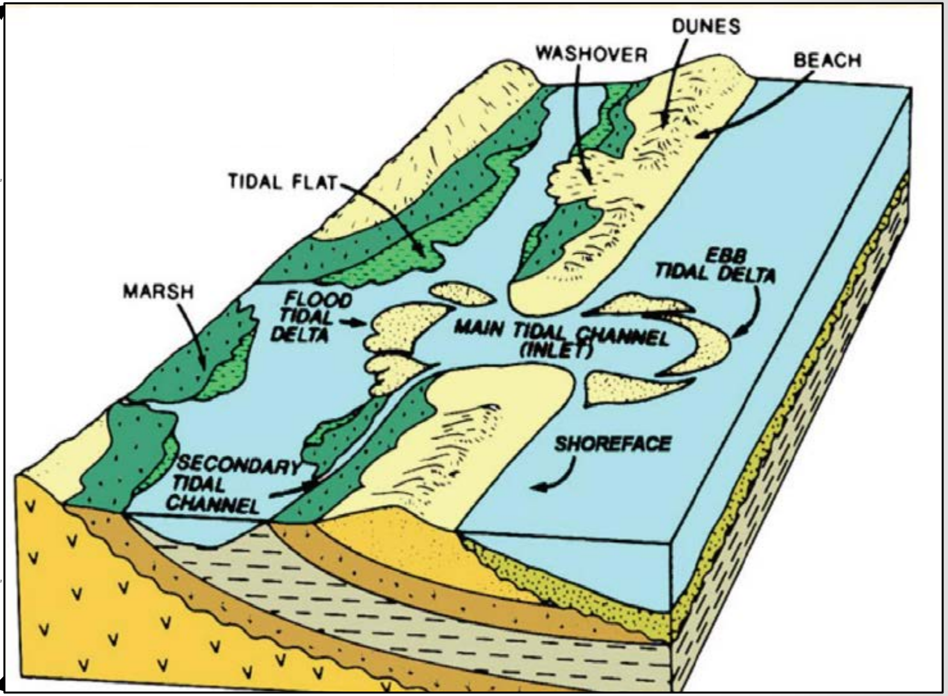
- S-wave velocity
- Rock physics cross plots
- Rock physics template
- Results
  - Lithology variations
  - Porosity
  - Hydrocarbon saturation



(Chi and Han, 2009)

Expected Results





(After Reinson, 1992)

Paleogeographic Interpretation
(Berriasian?- Valanginian)

(Marin et al., 2013)

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Timeline

Tasks	December	January	February	March	April	May	June
Literature review							
Data review and delimiting							
Seismic Interpretation and evaluation							
Evaluation of depositional environment							
Reservoir characterization of clastic wedges							
Initial draft of master thesis							
Refining and finalization							
Final master thesis							

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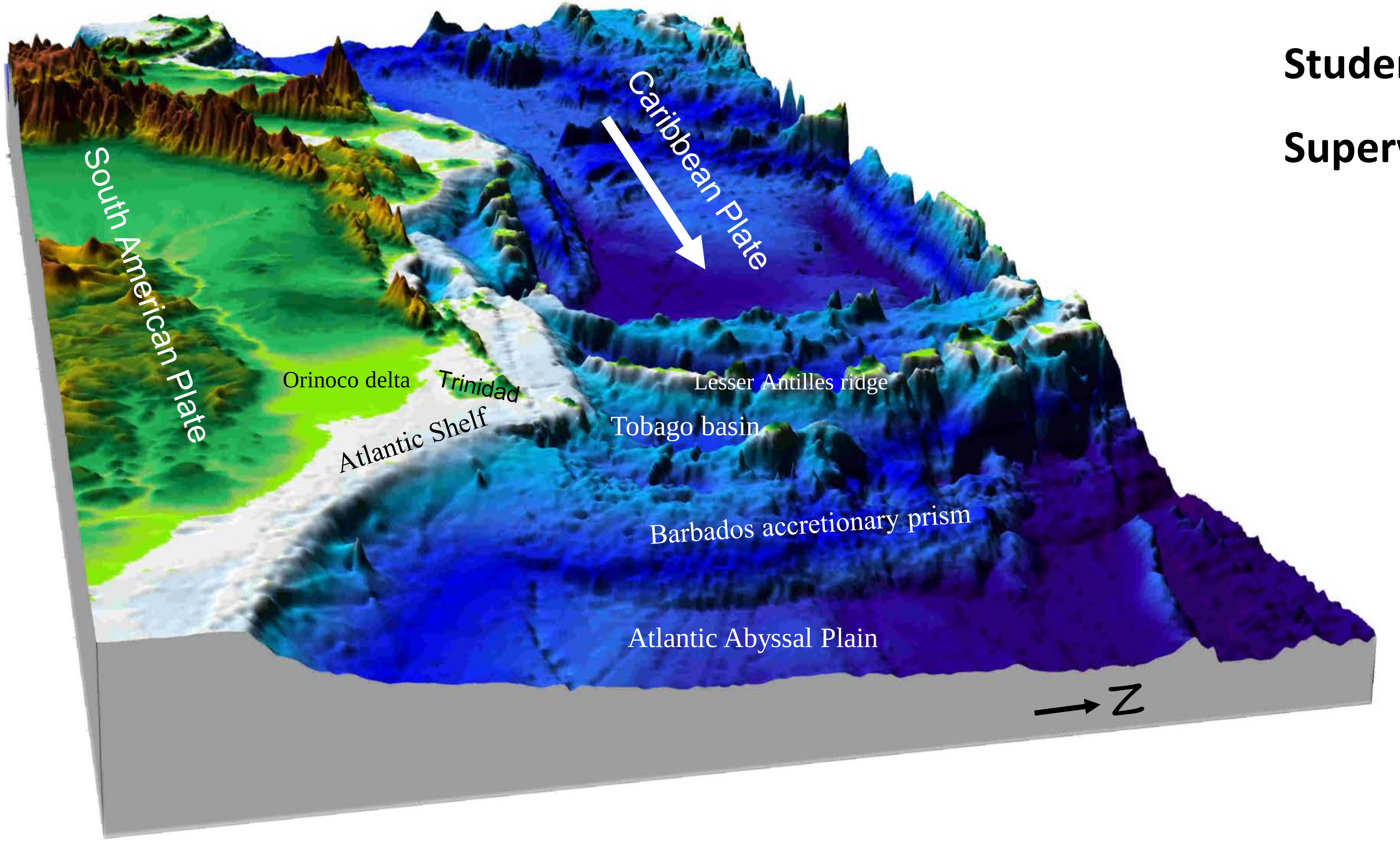
Thank You for your attention!

Tectonostratigraphic evolution of Tobago basin and Barbados accretionary prism: Implications for petroleum systems



Student: Mudussar Ahmed

Supervisor: Alejandro Escalona

University of Stavanger

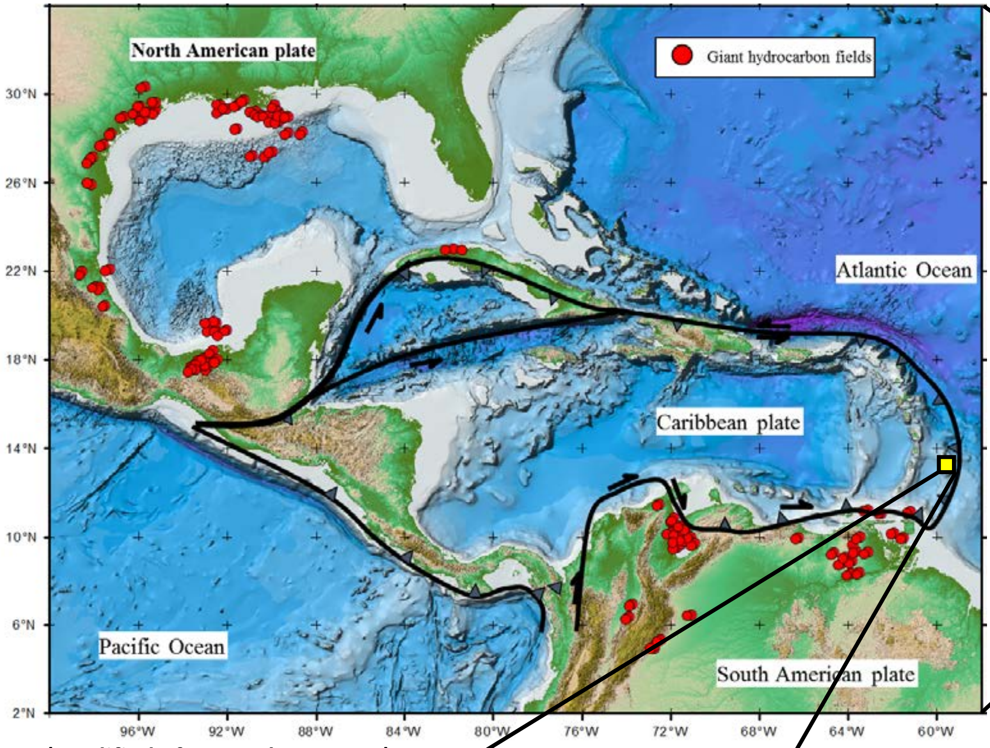
Talk Outline

- Motivation
- Regional Geological Setting
- Tectonostratigraphy
- Geological Problems
  - Source Rocks
  - Maturation and Preservation
  - Reservoir and Provenance
- Objectives
- Dataset & Methodology
  - New Data
  - Structural Styles
- Timelines
- Acknowledgement

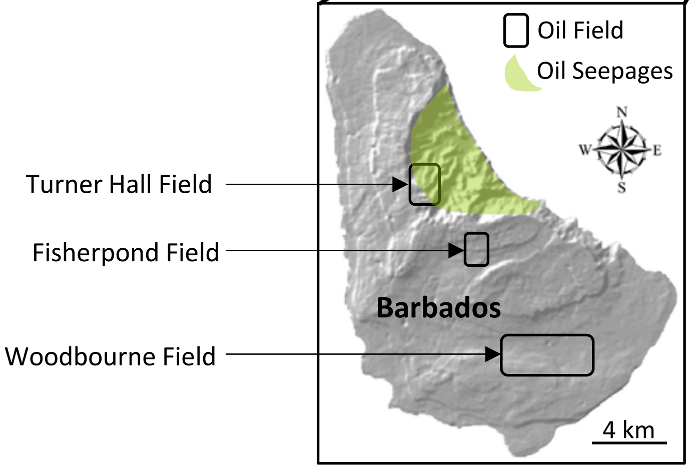
Oil seepage in the Barbados Island

(Chaderton, 2009)

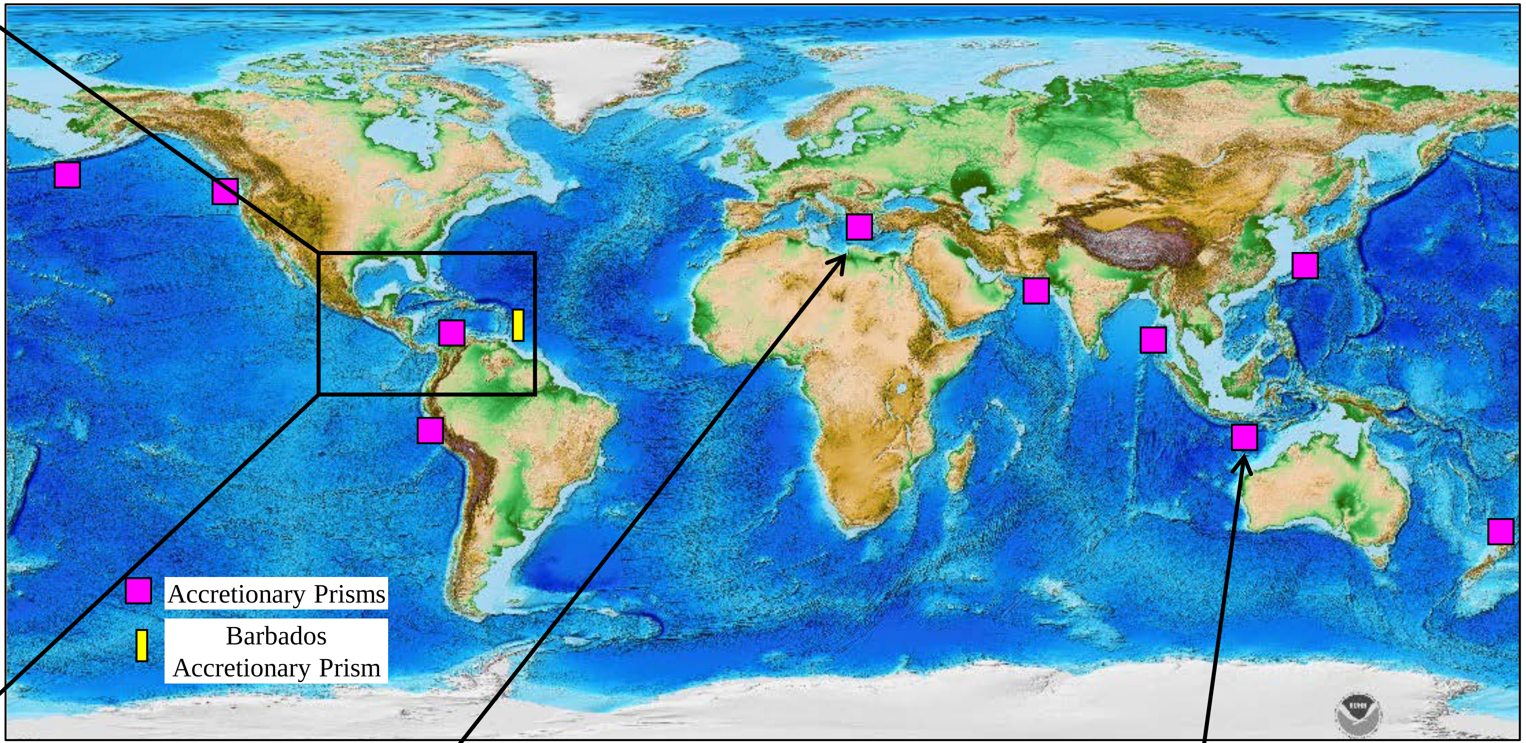
Motivation



(Modified after Escalona, 2008)

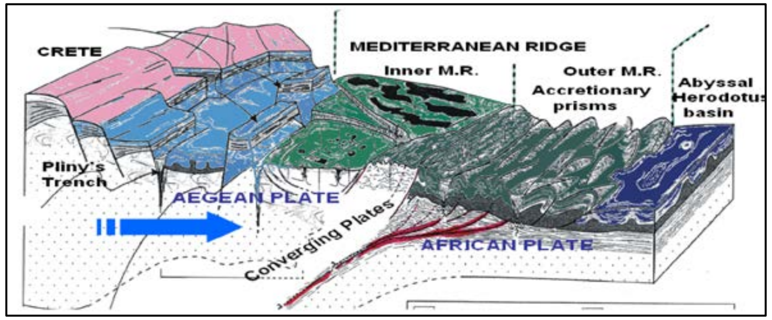


Accretionary prisms around the world



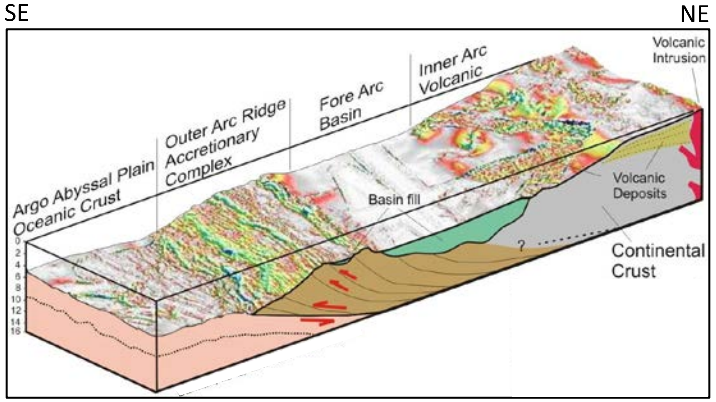
(Map from NOAA)

Creete Accretionary Prism



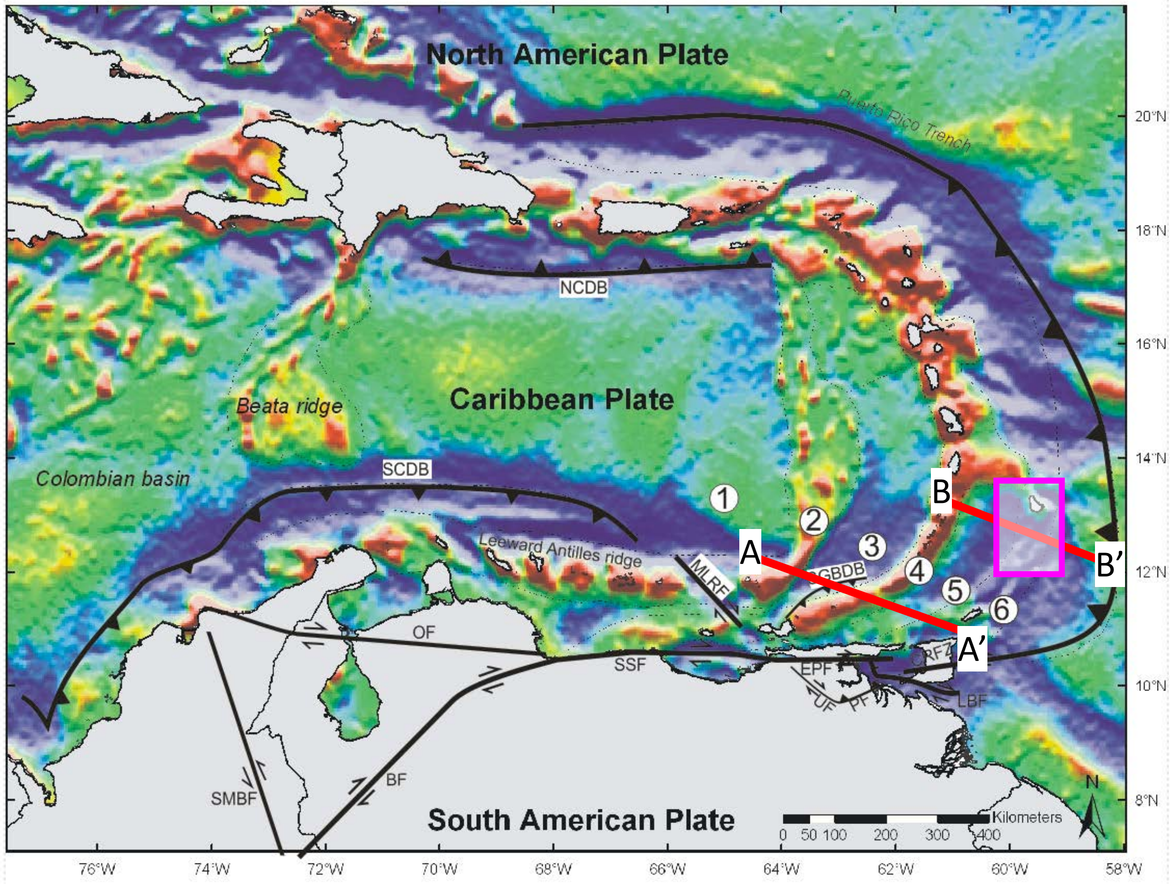
(Foscolos et al., 2012)

Timor, Sumatra-Java Accretionary Prism



(Darman, 2012)

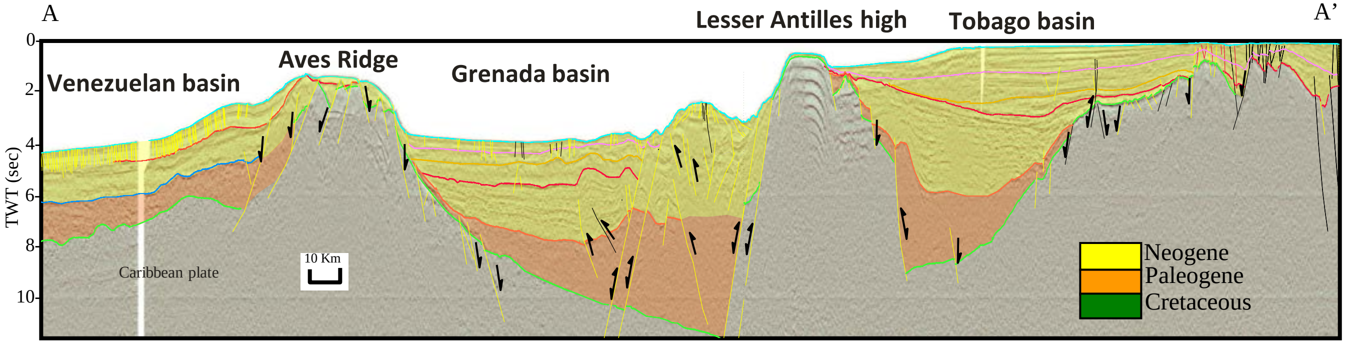
Regional Geological Setting



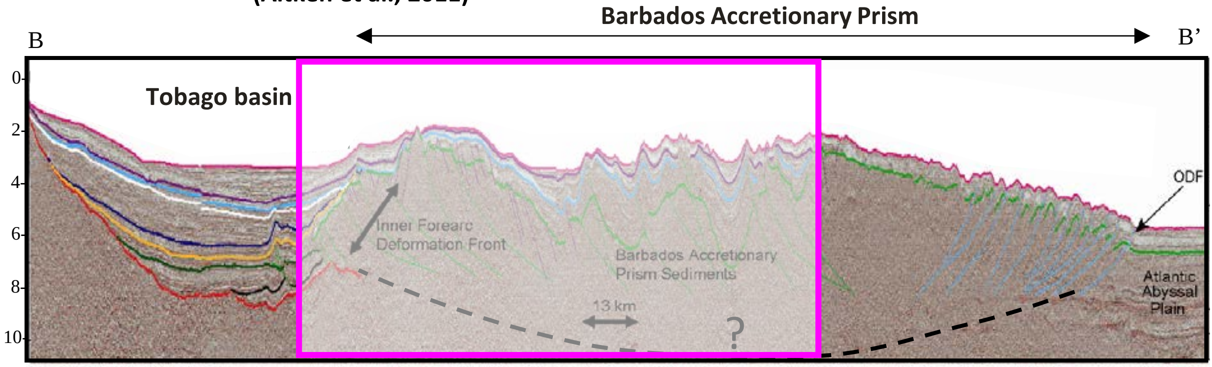
(Aitken et al., 2011)

1) Venezuelan basin;
2) Aves Ridge;
3) Grenada basin;
4) Lesser Antilles arc;
5) Tobago basin;
6) Barbados accretionary prism

Study Area

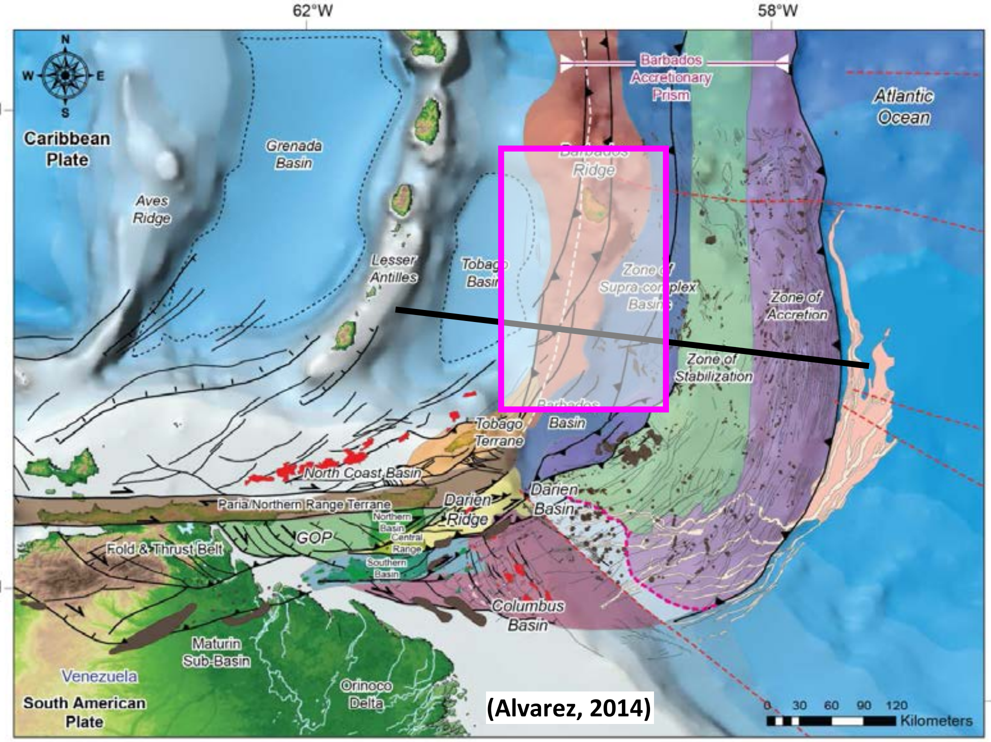


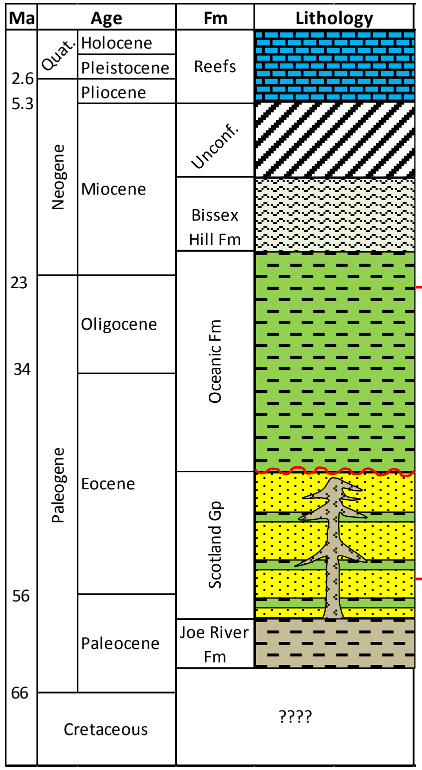
(Escalona et al., 2011)



(Modified after Chaderton, 2005)

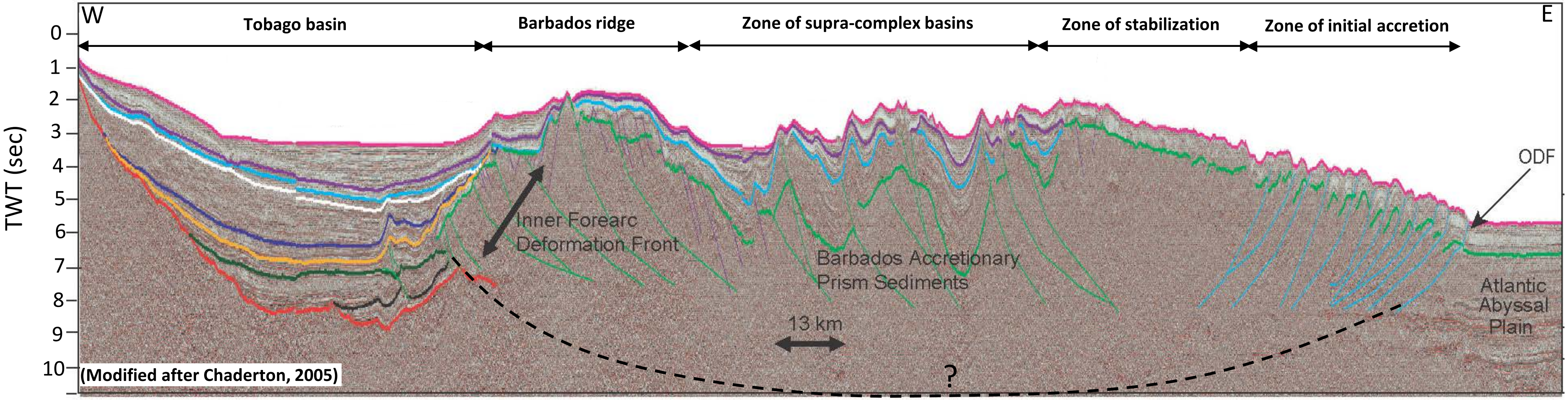
Tectonostratigraphy





Seal (Pelagics)

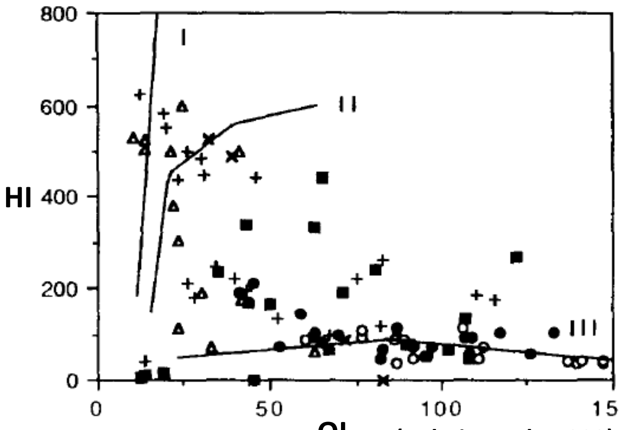
Reservoir (Deep marine turbidites)



Geological Problems - Source Rock

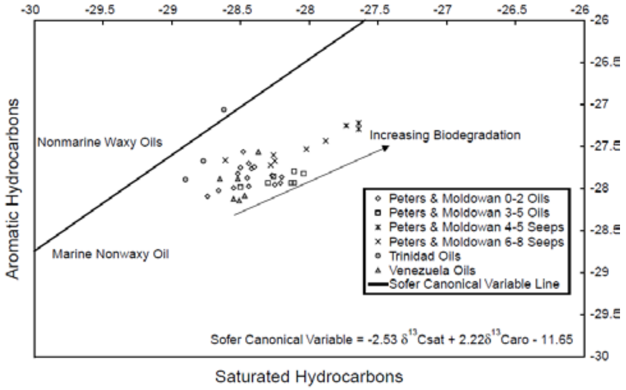
What is the source rock of oil producing from Barbados island?

1) Terrigenous, Paleogene



(Babaie et al., 1992)

2) Marine, Cretaceous

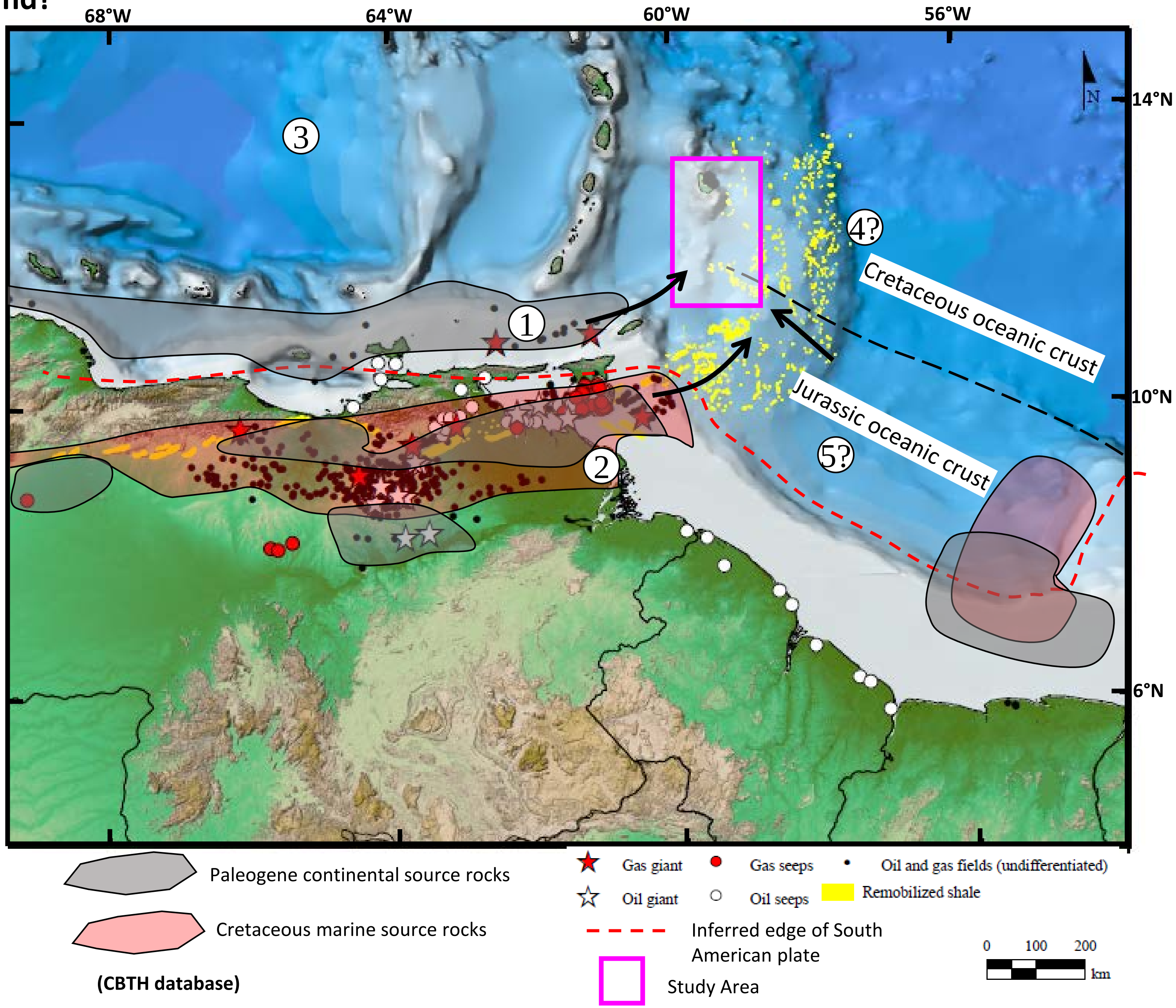


(Hill and Schenk, 2005)

3) Cretaceous rocks of Caribbean origin

4) Cretaceous rocks of Atlantic origin

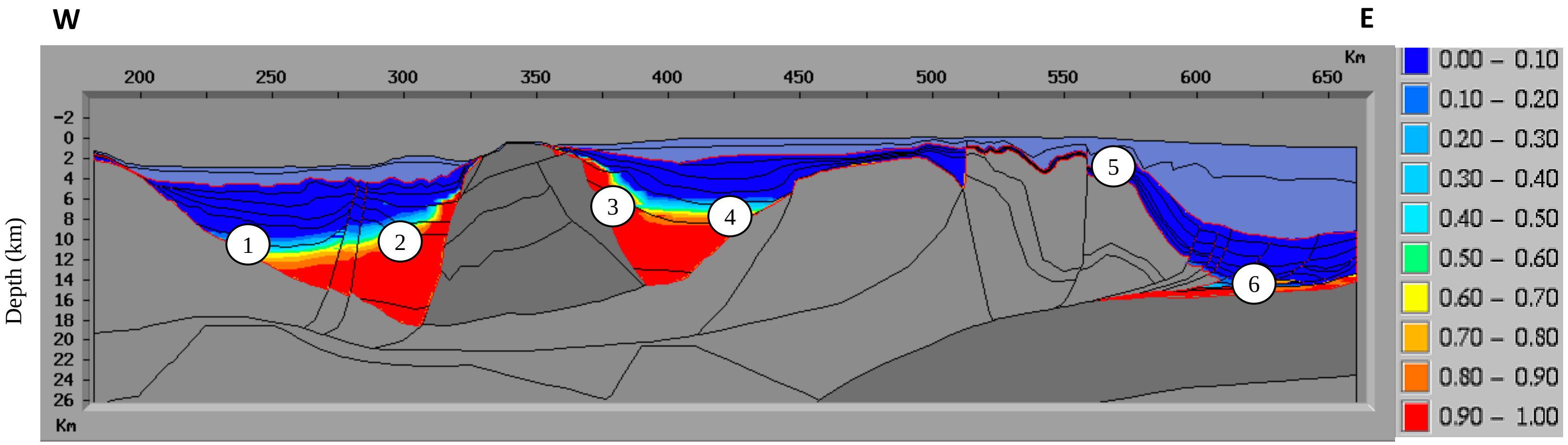
5) Jurassic rocks of Atlantic origin



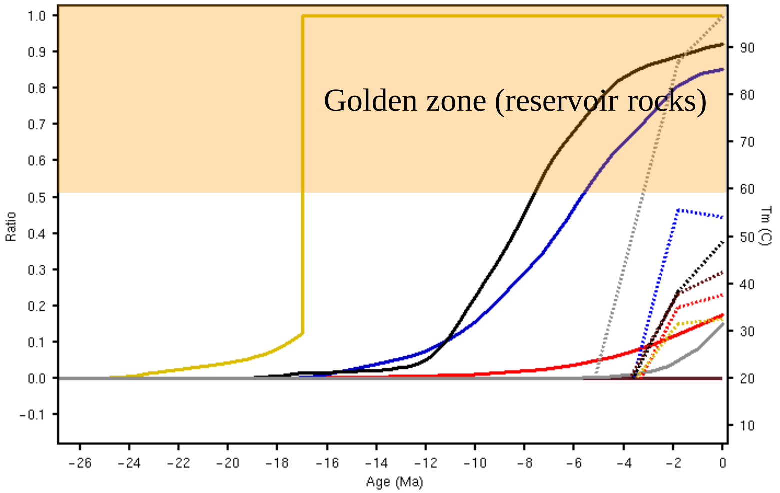
(CBTH database)

Geological Problems – Maturation and Preservation

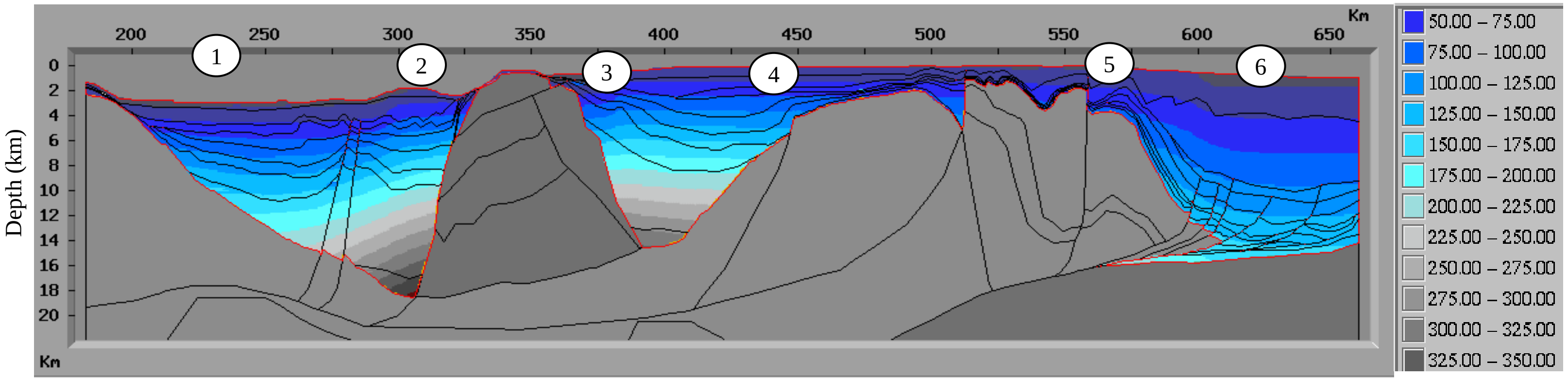
Present day maturity of the section

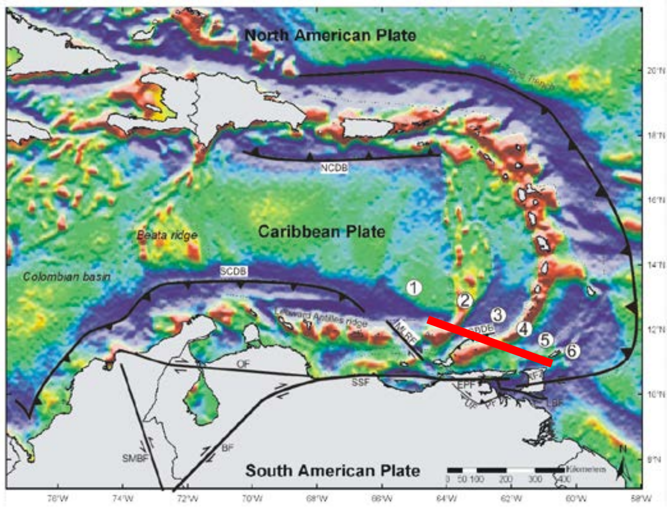


Tranformation ratio of source rock and temperature history of Miocene reservoir rocks



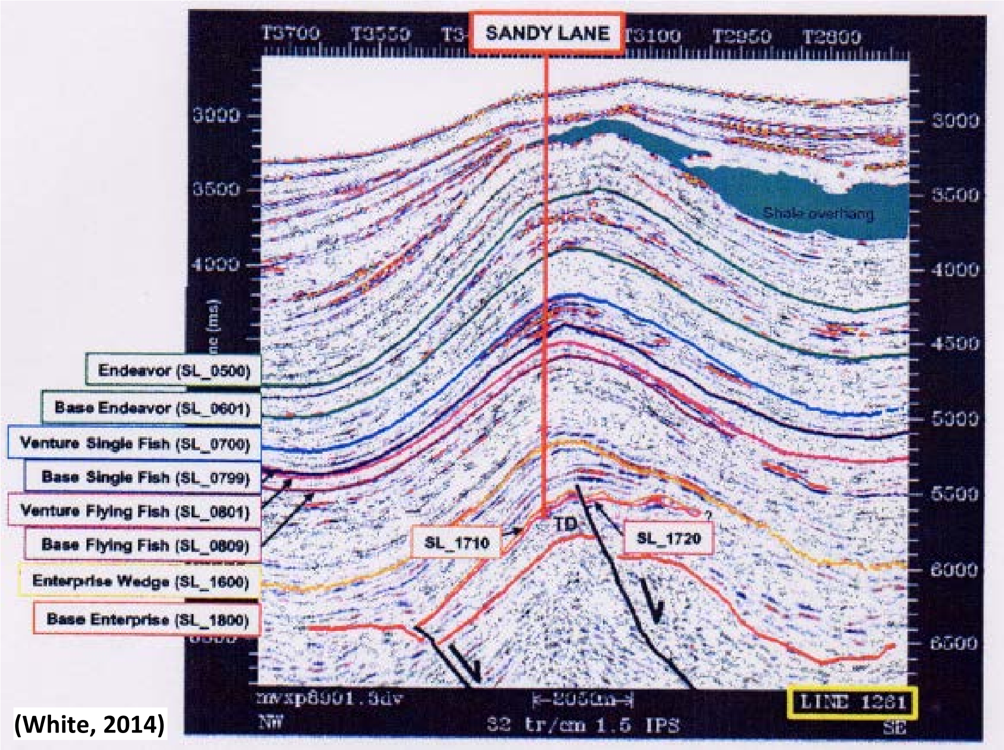
Present day temperature of the section





(Escalona et al., 2011)

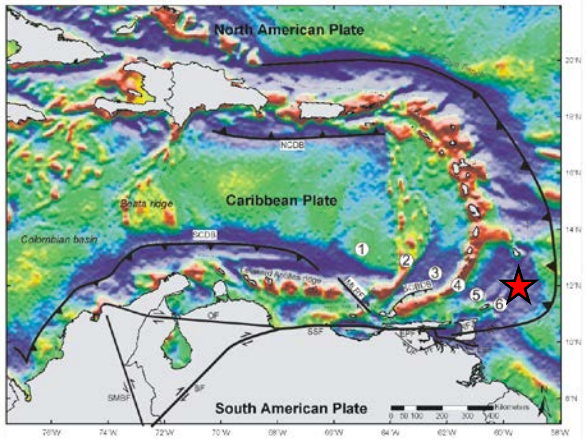
Geological Problems - Reservoir and Provenance



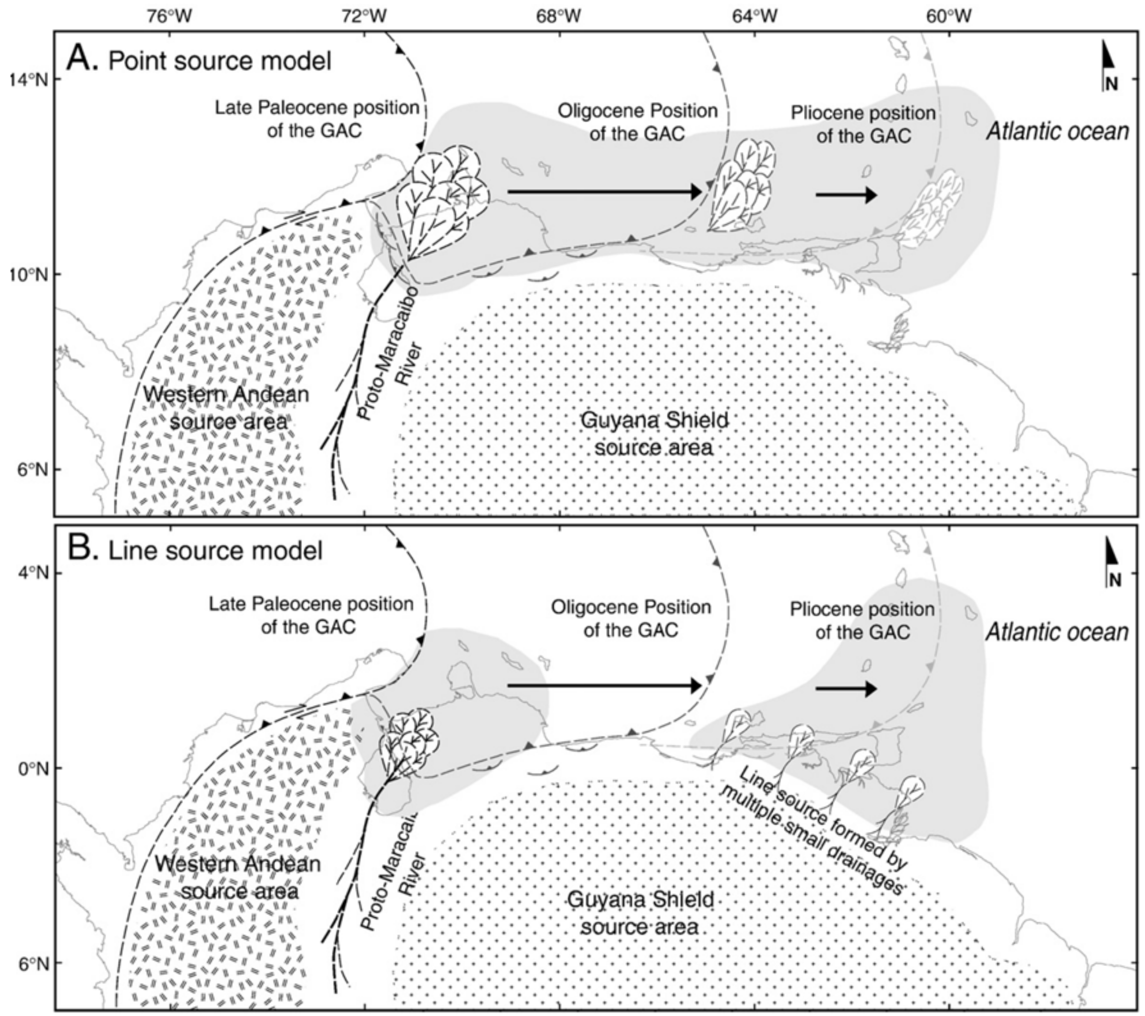
(White, 2014)

Where is the source of the sandstones and how far have they been transported?

- Proto-Maracaibo vs Proto-Orinoco?
- Point source vs Line source?



- Proven reservoir not encountered
- Structure was breached



(Xie et al., 2010)

Objectives

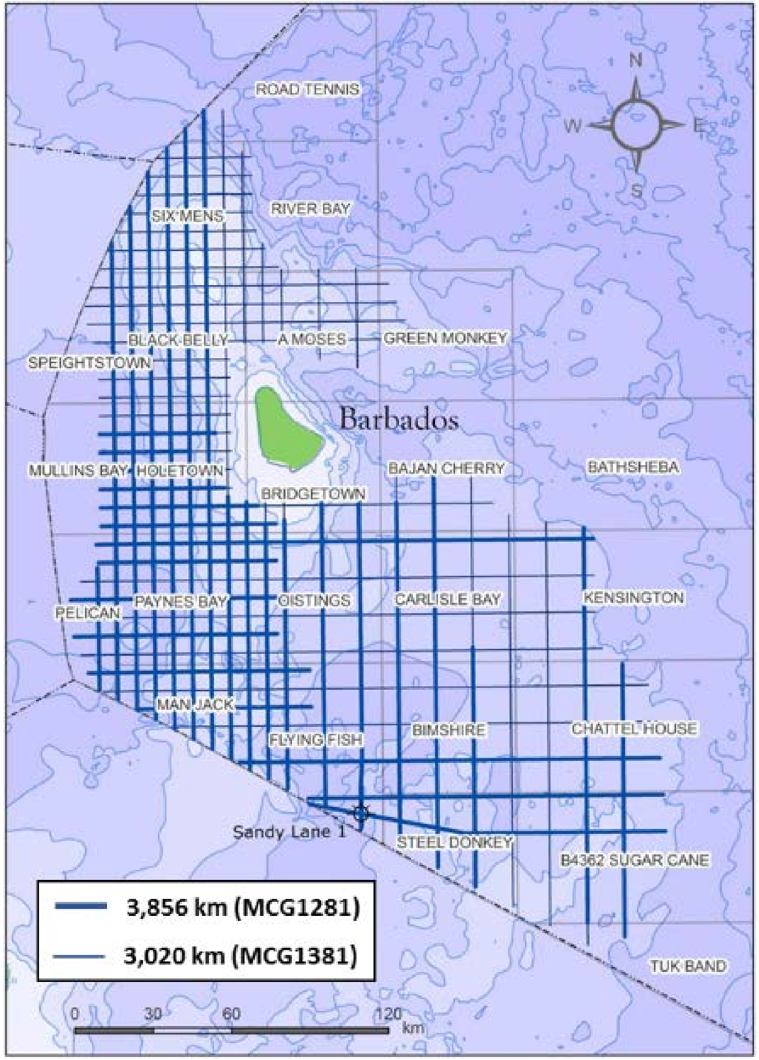
1. Tectonostratigraphic evolution of Tobago basin and Barbados accretionary prism

2. Classifying the area into different structural domains and establishing the trap types

3. Seismic sequences and their relation to the plate tectonic evolution of the region

4. Source rock evaluation and basin modeling

Data and Methodology



(Courtesy of MCG)

Interpretation of the seismic data (fault and horizons)

→ Subsurface mapping of megasequences and

generation of isopach maps

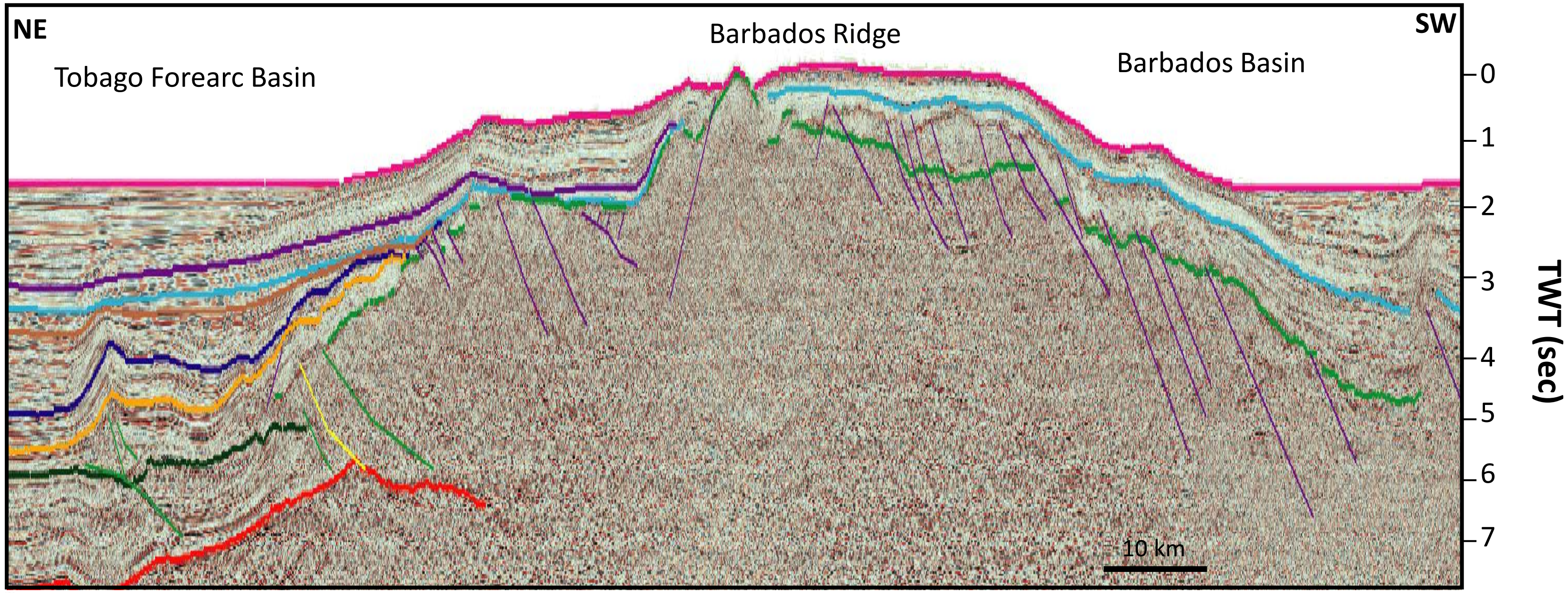
→ Identification of depocenters to find the areas for mature source rock

→ Forward basin modeling

New data

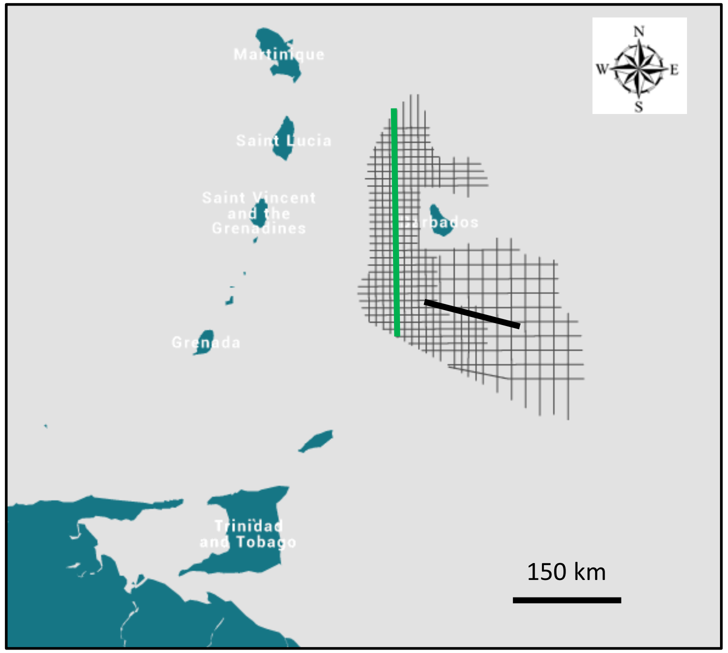
Previous Data

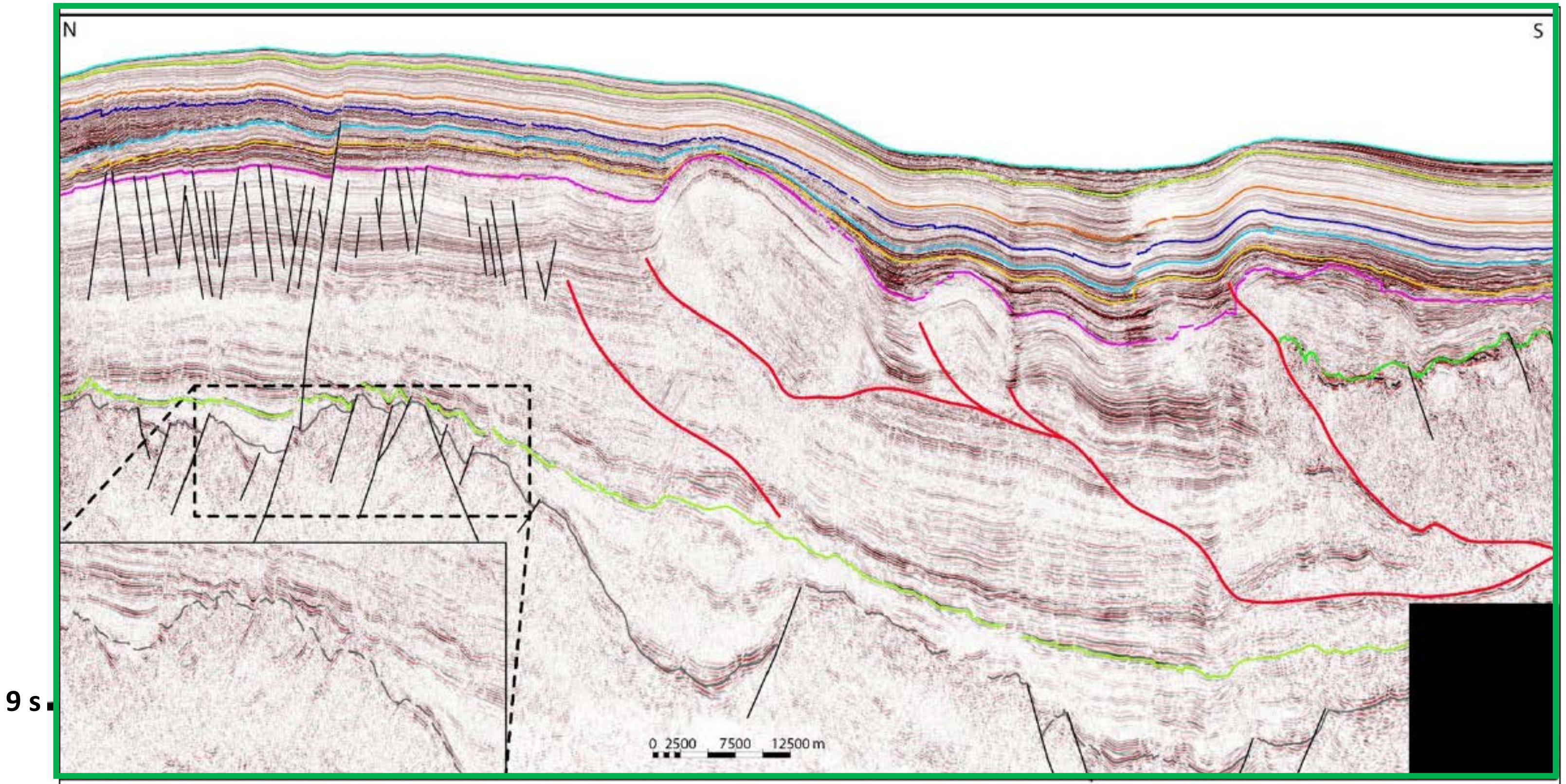
(Chaderton, 2009)



Current Data

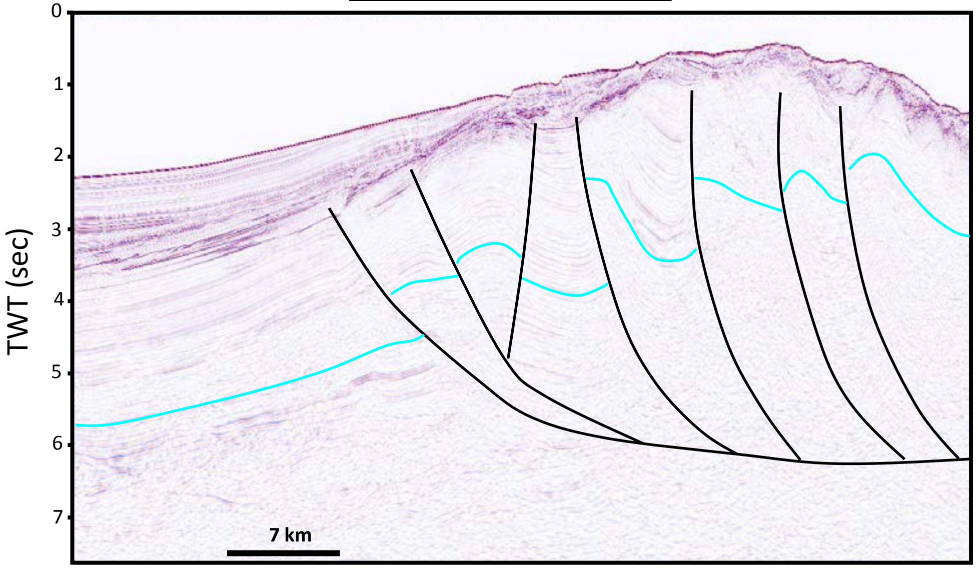
(White, 2014)



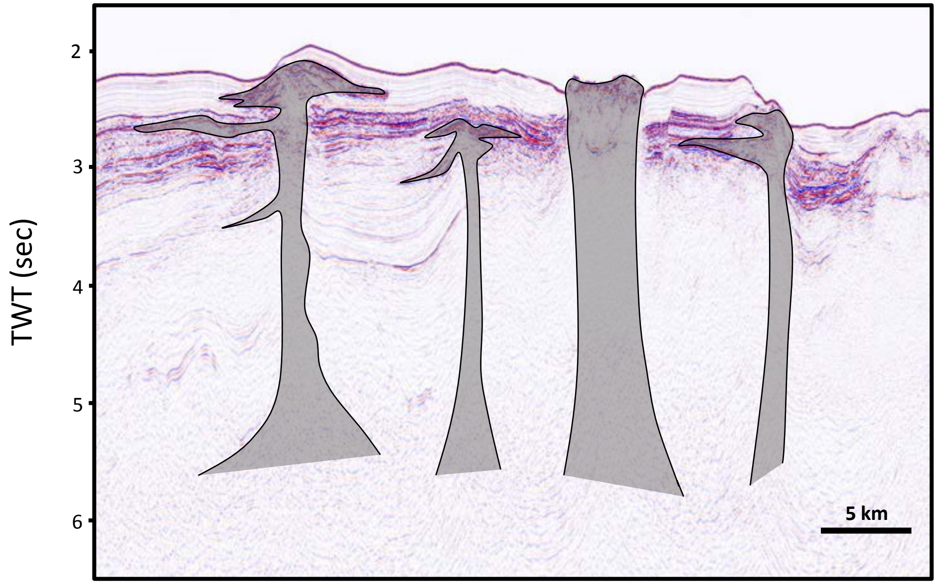


Structural Style

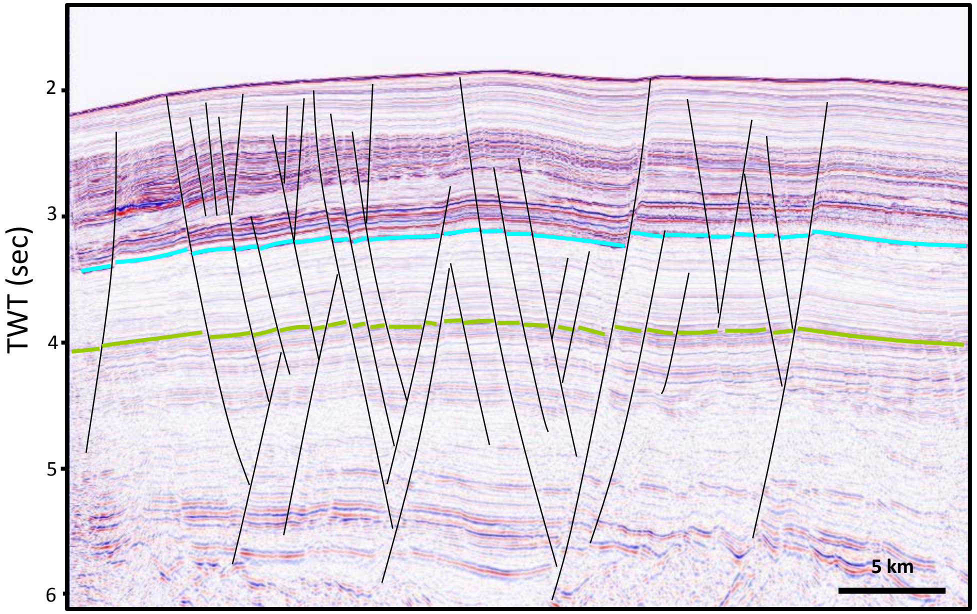
Fold and Thrusts



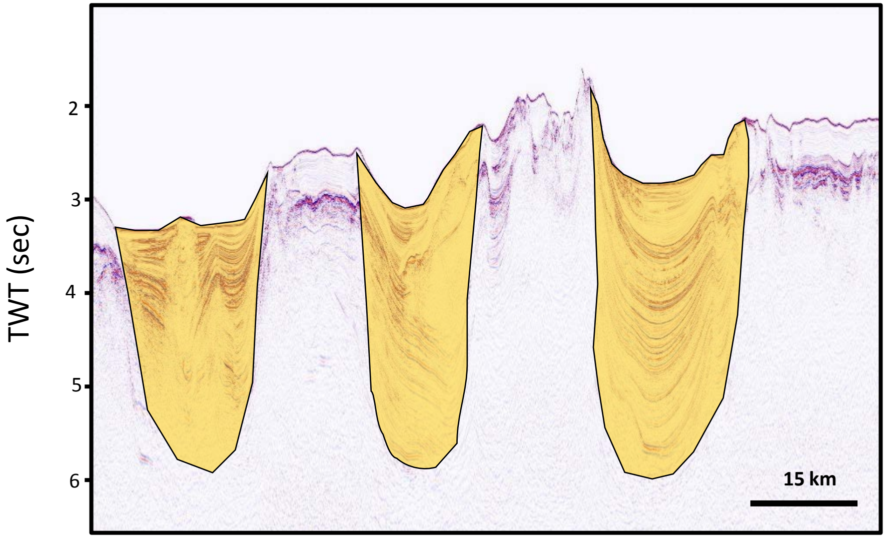
Mud Volcanoes



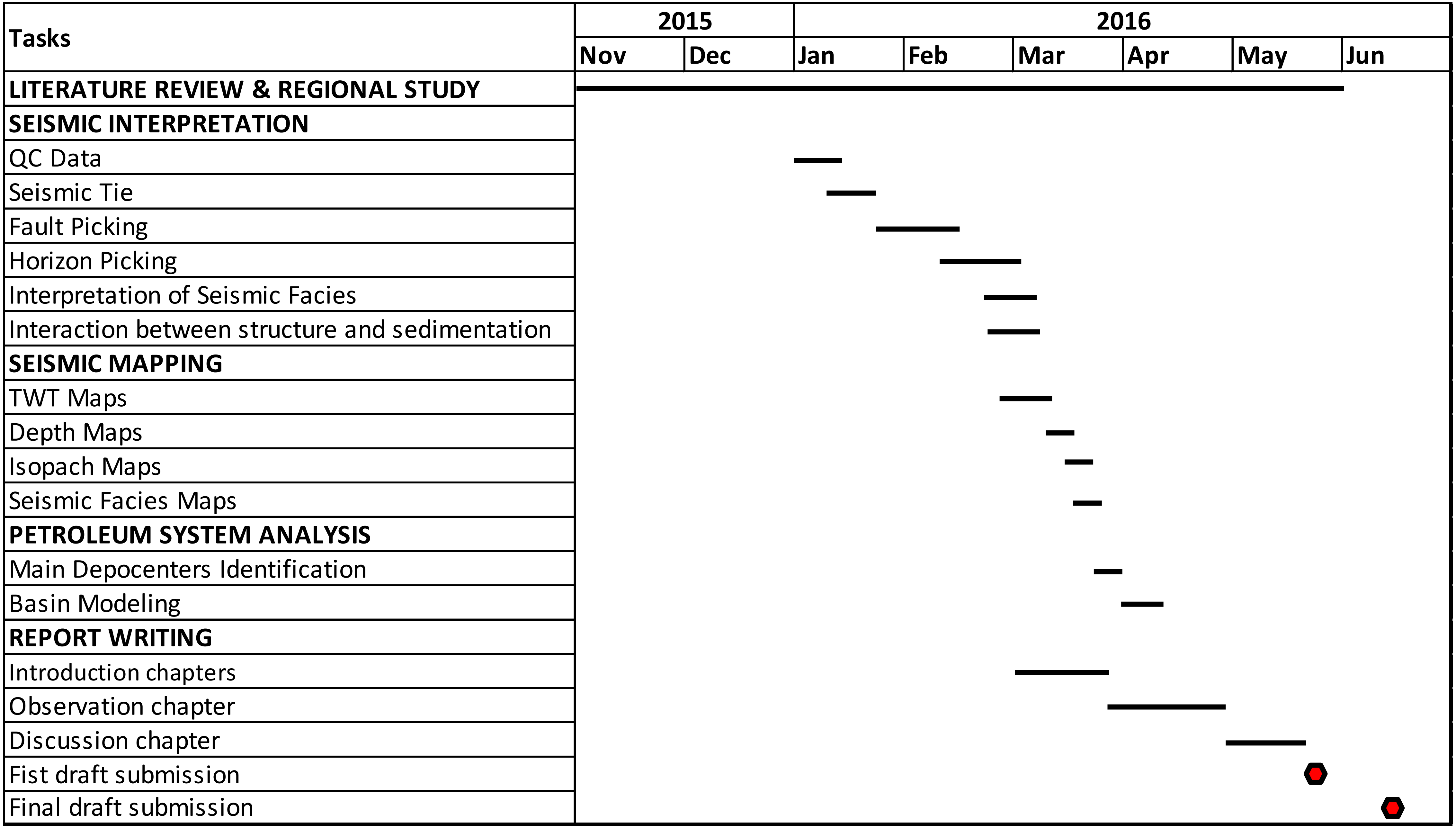
Normal Faults



Piggy back basins



Timelines


Tasks
2015
2016
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
LITERATURE REVIEW & REGIONAL STUDY
SEISMIC INTERPRETATION
QC Data
Seismic Tie
Fault Picking
Horizon Picking
Interpretation of Seismic Facies
Interaction between structure and sedimentation
SEISMIC MAPPING
TWT Maps
Depth Maps
Isopach Maps
Seismic Facies Maps
PETROLEUM SYSTEM ANALYSIS
Main Depocenters Identification
Basin Modeling
REPORT WRITING
Introduction chapters
Observation chapter
Discussion chapter
Fist draft submission
Final draft submission

THANK YOU

Acknowledgement

- MultiClient Geophysical (MCG) for providing the seismic data
- Department of Petroleum Engineering, University of Stavanger

Seismic Characterization of Lower Cretaceous Clinoform Packages in the Fingerdjupet Sub-basin, Southwestern Barents Sea

Camilla H. Hinna

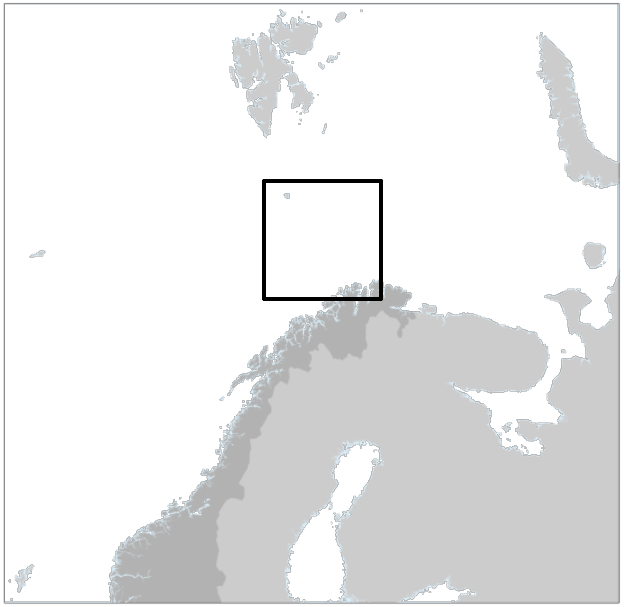
04.12.2015

Supervisors:
Alejandro Escalona (UiS)
Bjørn Kåre Bryn (Centrica)
Stian S. Haaland (Centrica)

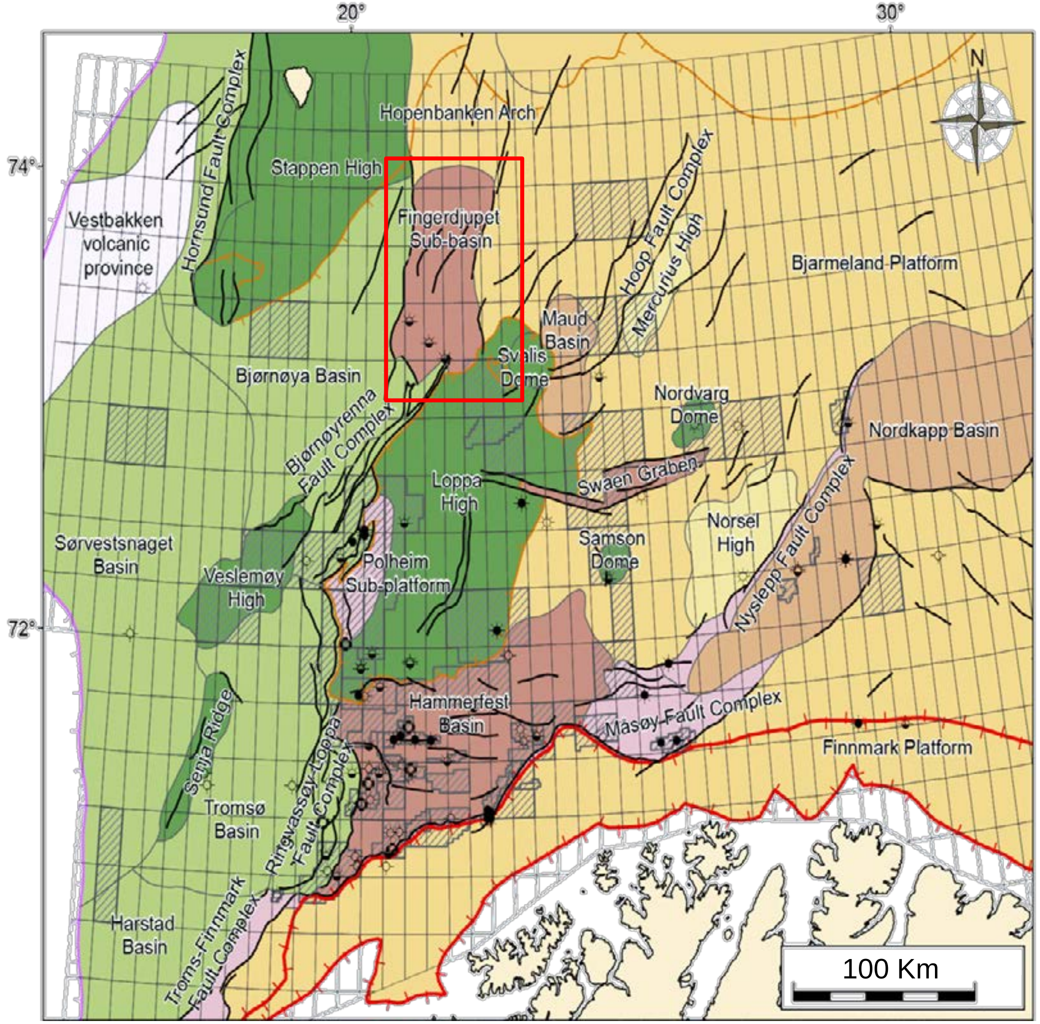
Agenda

- Introduction
  - Regional Geological Setting
  - Previous Work → Geological problem
  - Motivation
- Objectives
- Data
- Methodology
- Time Frame

Study Area

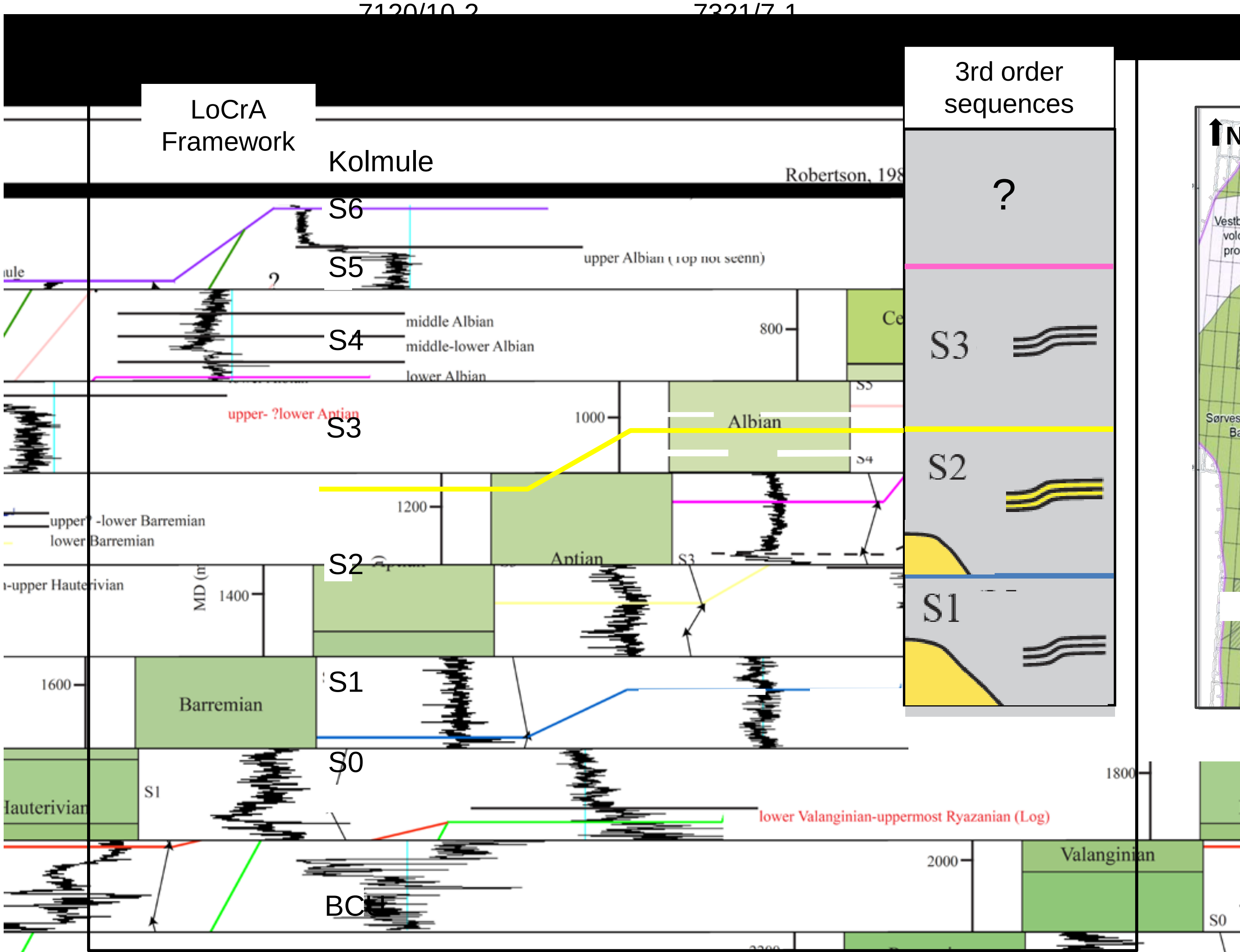


(Courtesy of Centrica)

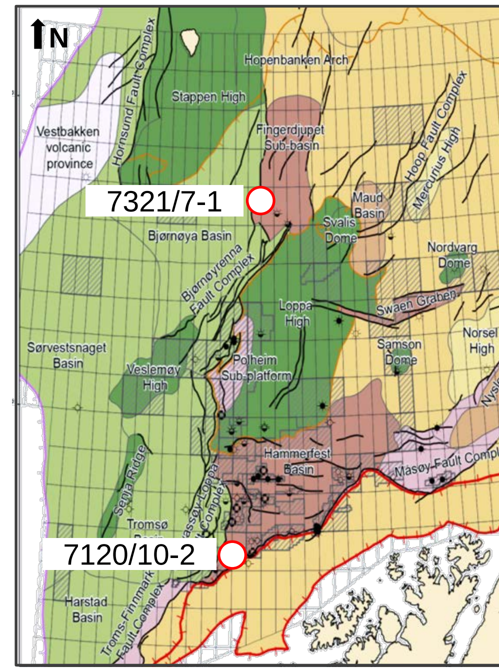


(Courtesy of Centrica)

Geological Setting



(Modified from Marin and Escalona, 2015)

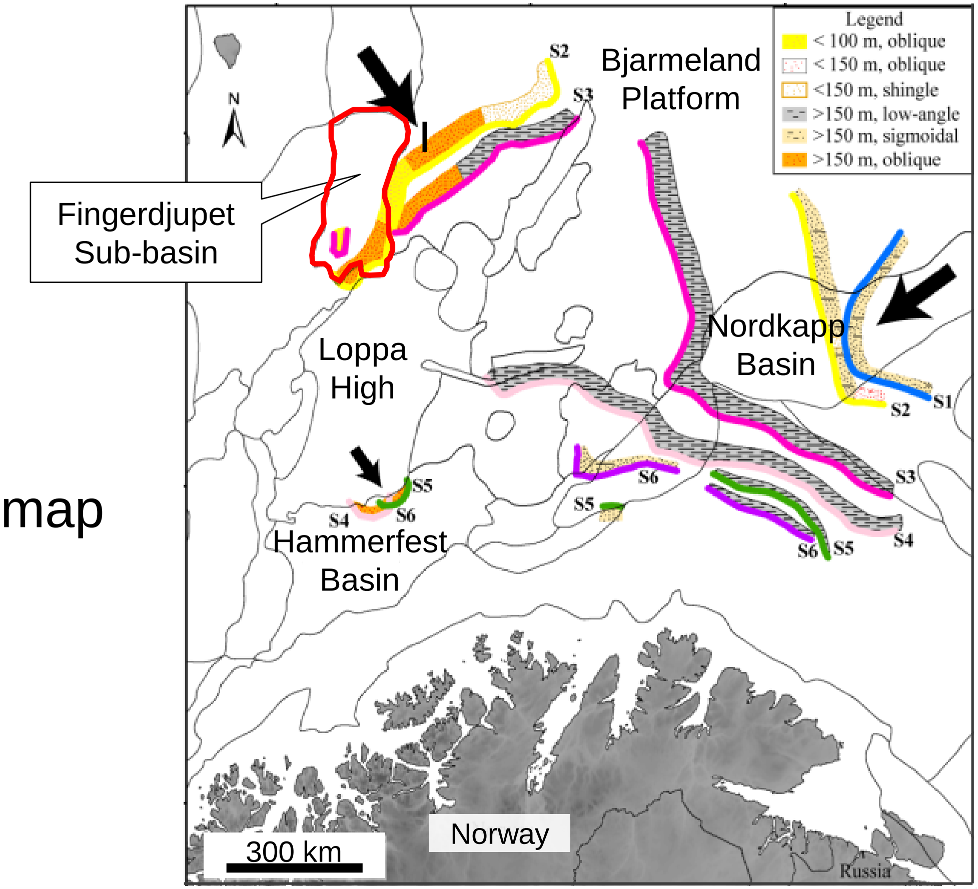


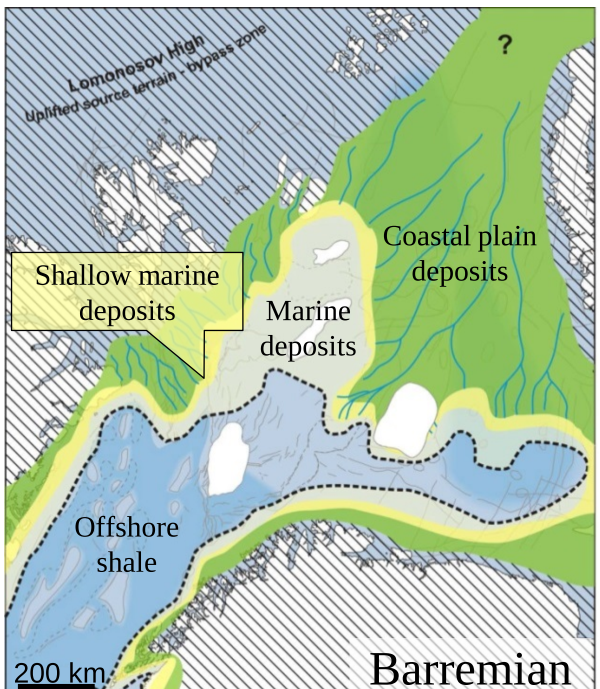
(Courtesy of Centrica)

Previous Work

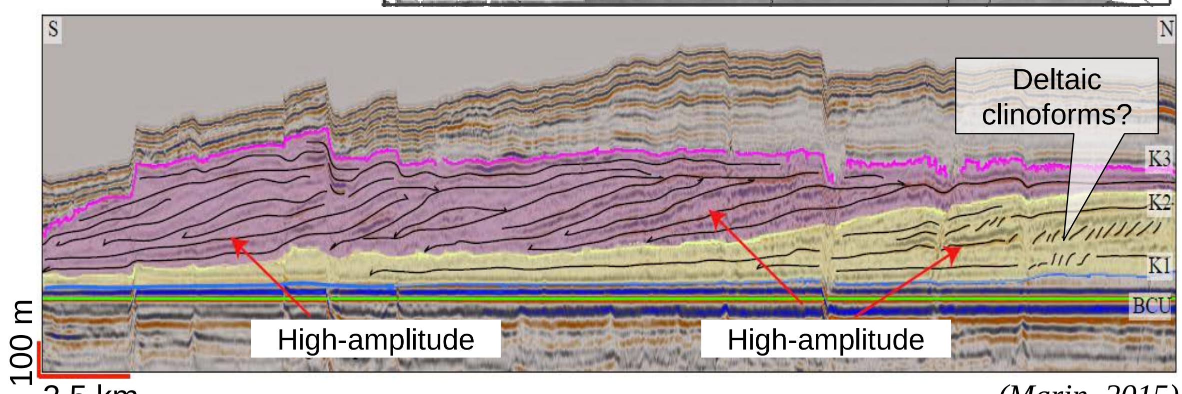
- LoCrA Project
- Sandstone-prone clinoforms
- Progradation towards SE

- Preliminary paleogeographic map





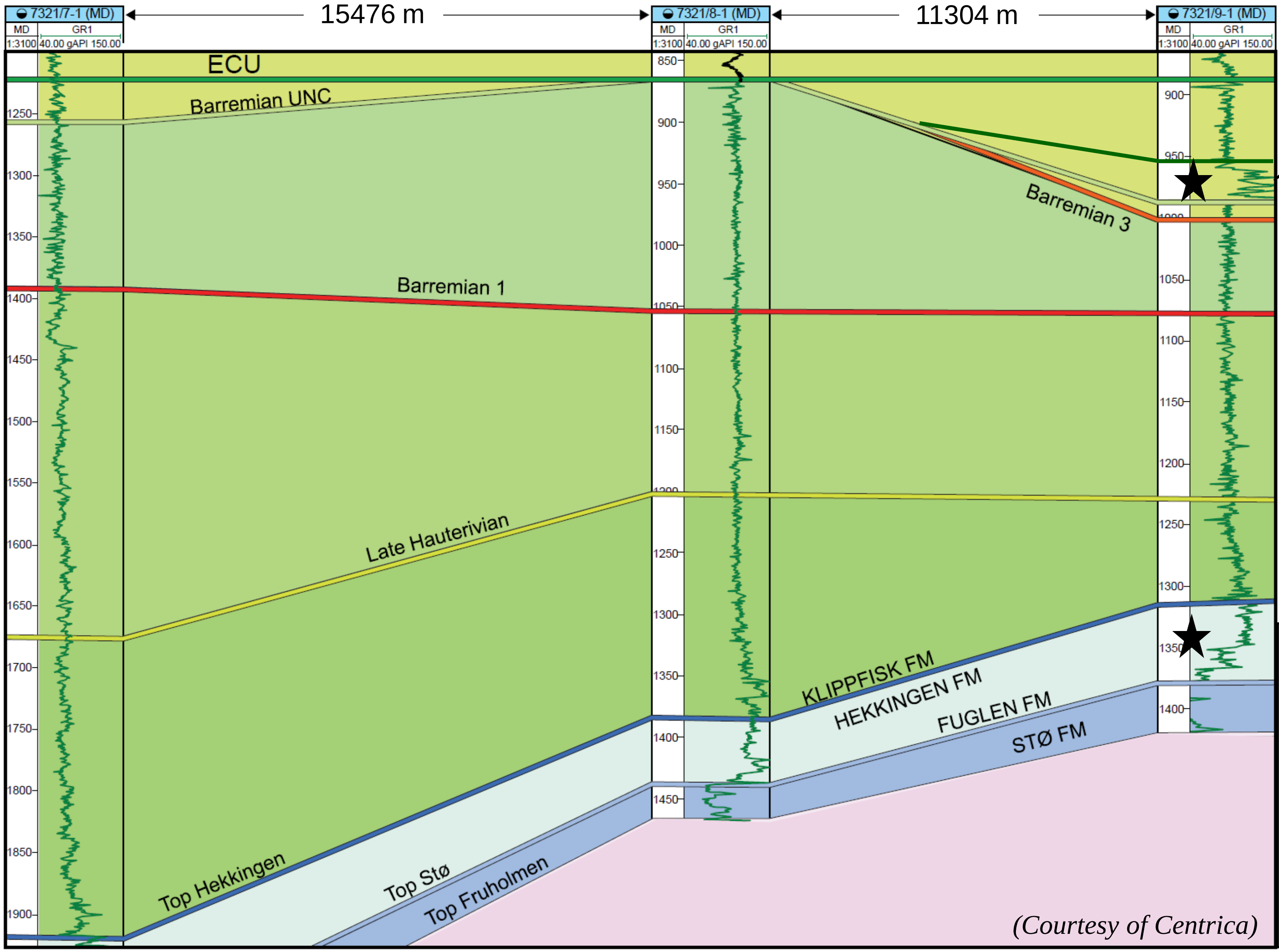
(Grundvåg et al., 2015)

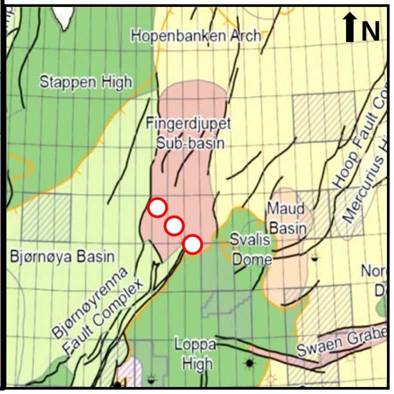


(Marin, 2015)

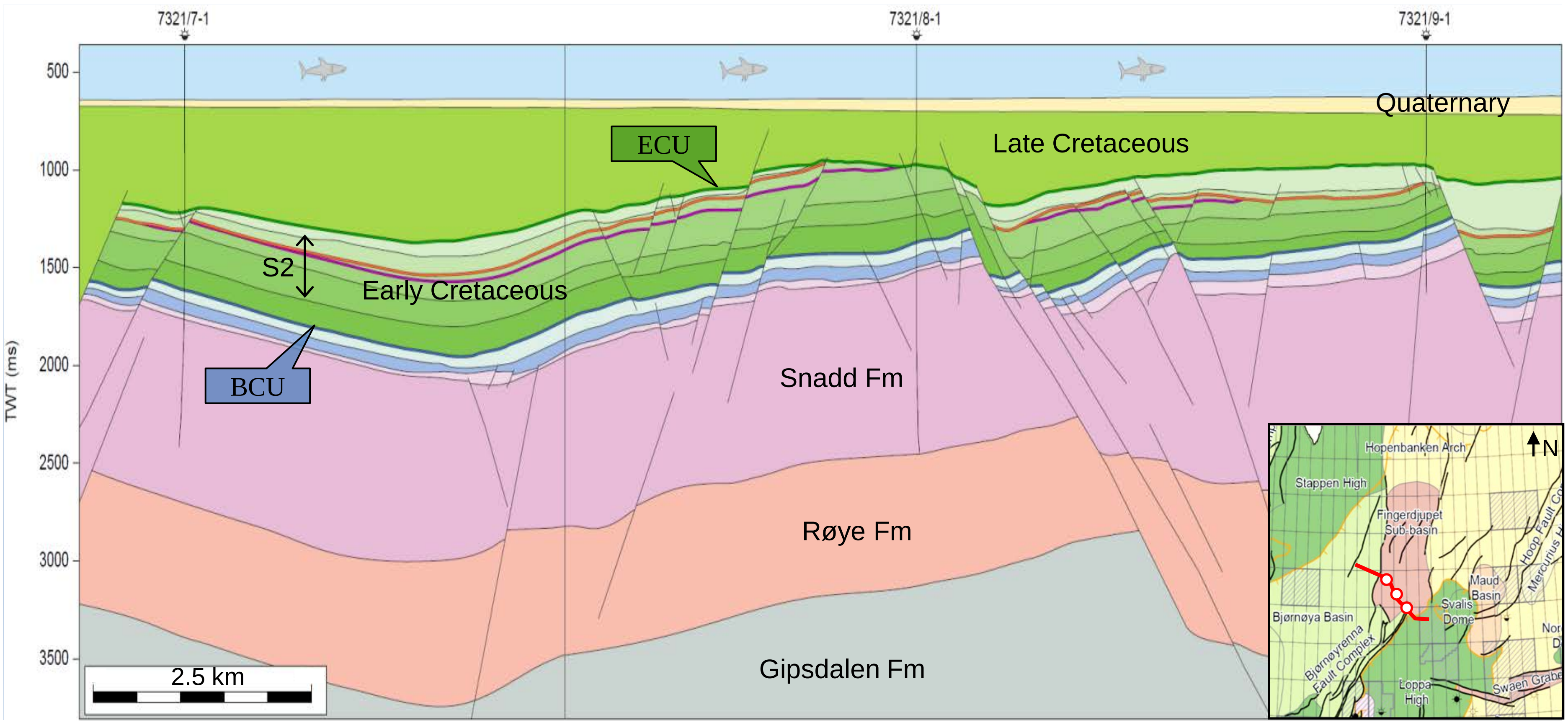
Universitetet
i Stavanger

Well Correlation



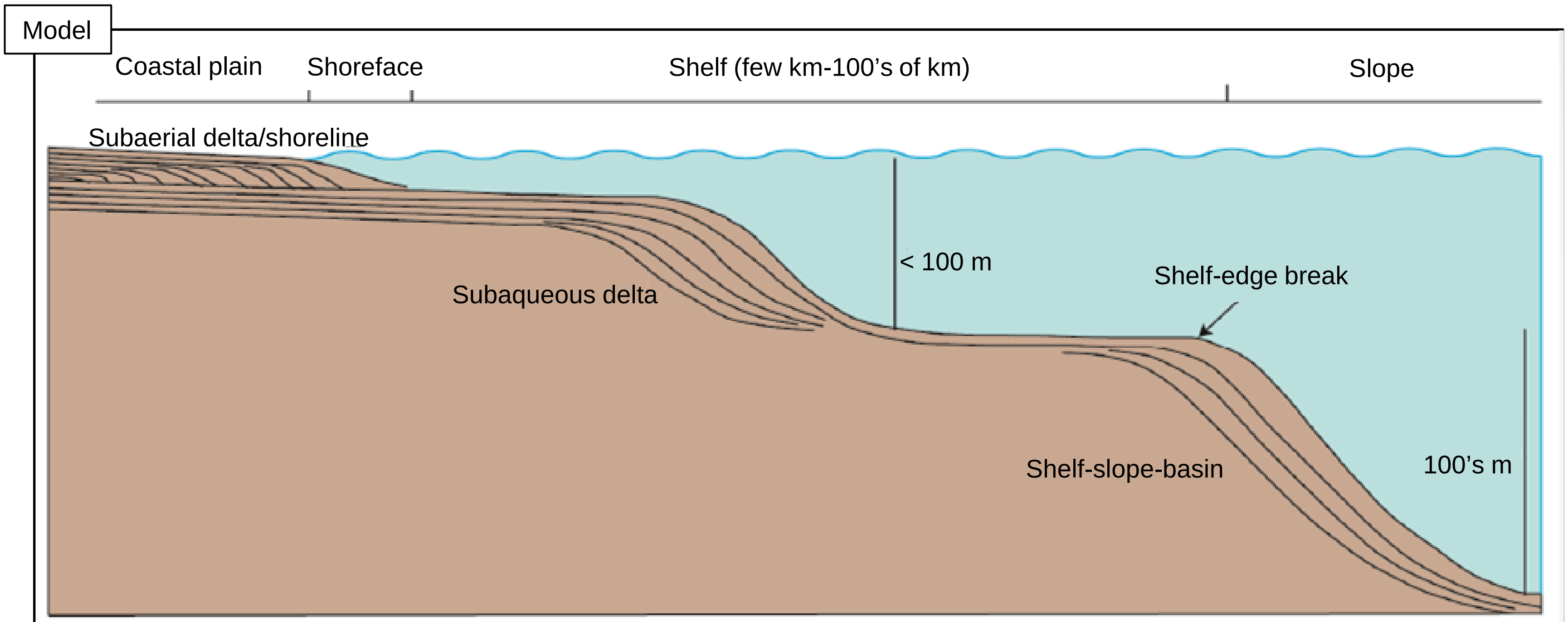


Geoseismic Section



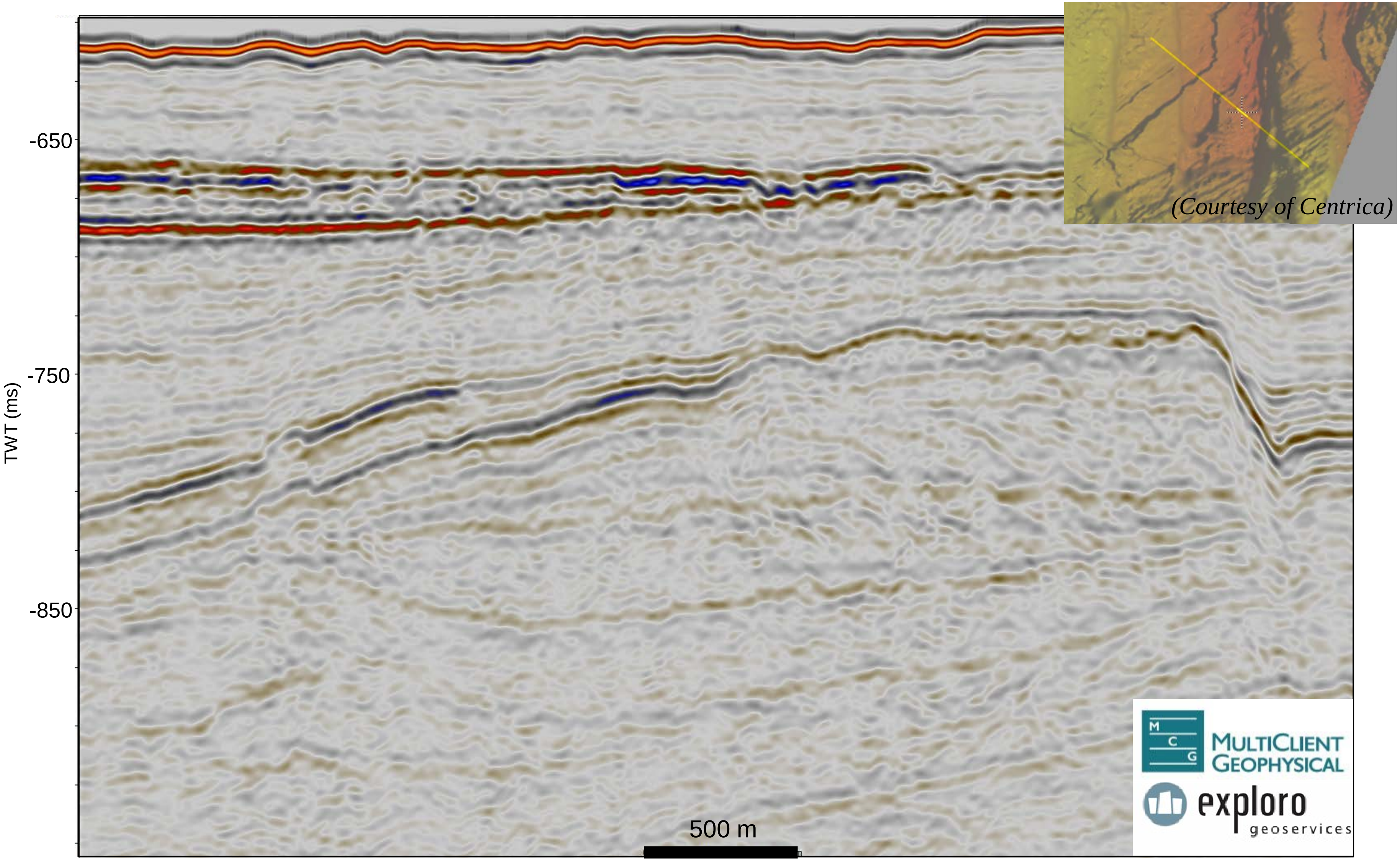
(Courtesy of Centrica)

Clinoform Shape and Size



(Helland-Hansen et al., 2012)

Seismic Geomorphology Mapping

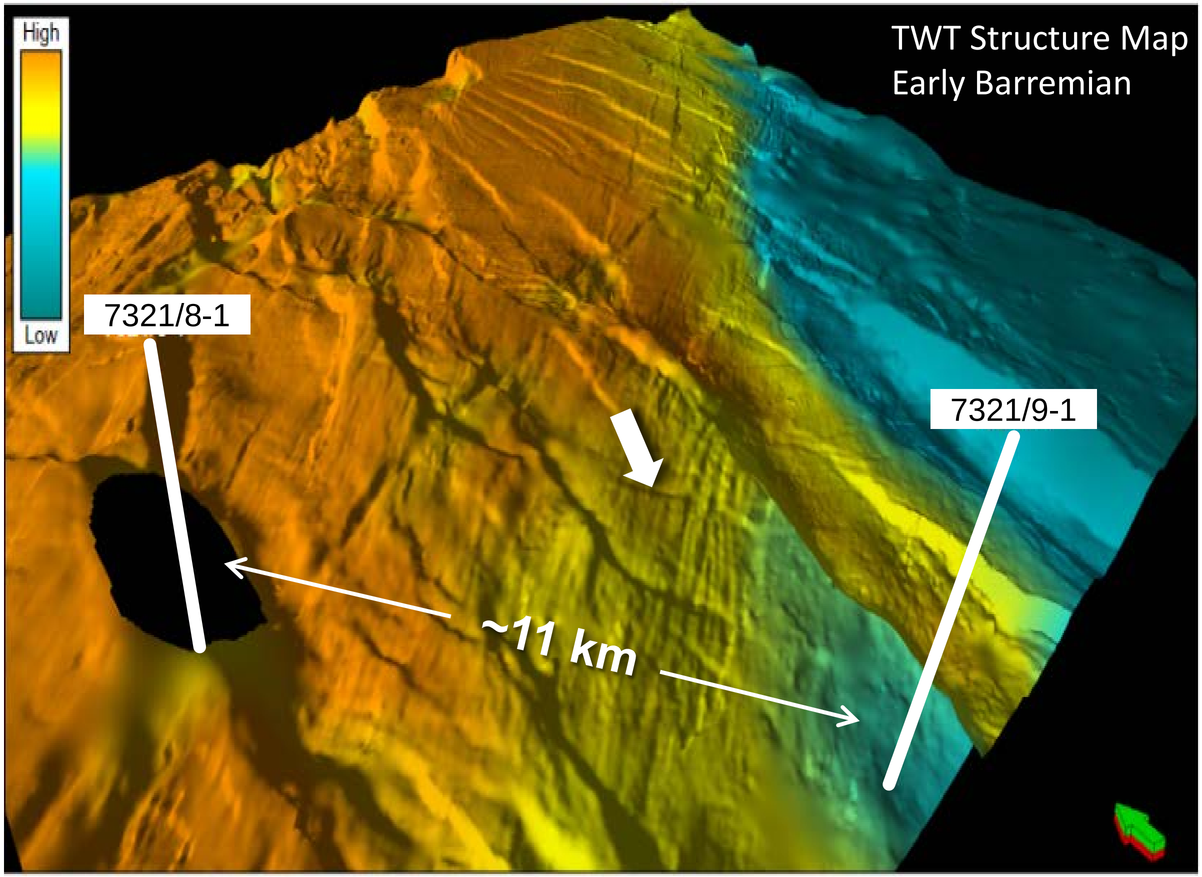


No Sand at Well Locations

1) Sand not deposited at well locations

2) Sand deposited but eroded later

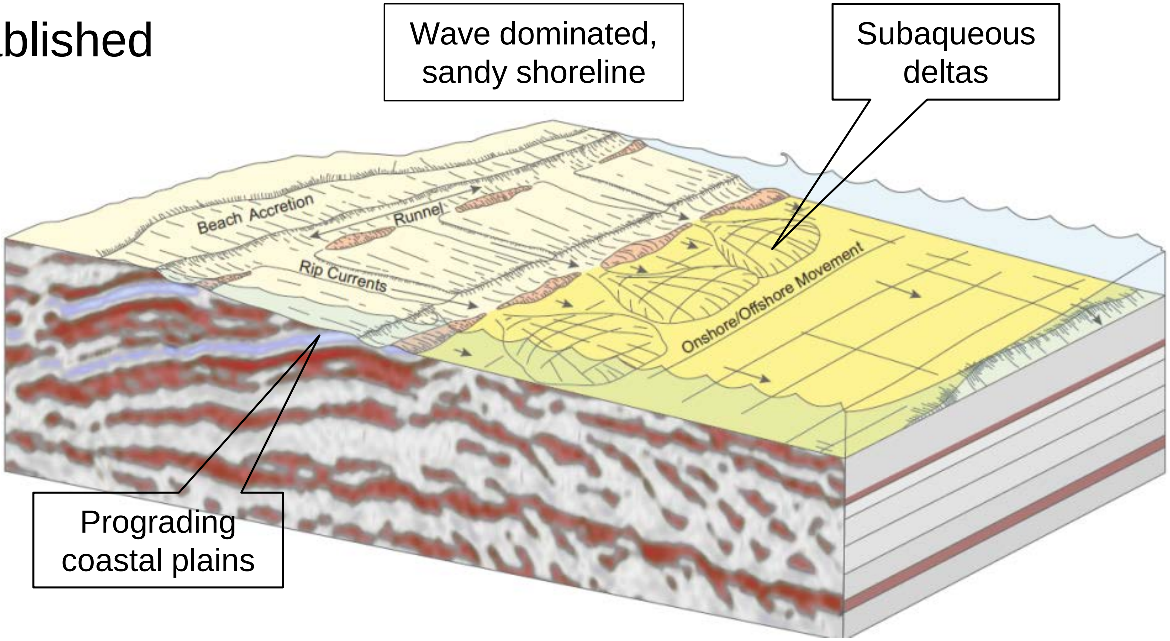
3) Sand deposited and present in the area, but faulted out at the exact well location



(Courtesy of Centrica)

Geological Problem

- No sandstones in the wells
- Little published work – distribution
- Stratigraphic framework and age control not well established
- Analogue from Spain



(Modified from Hernandez-Molina et al., 2000. Courtesy of Centrica)

Objectives

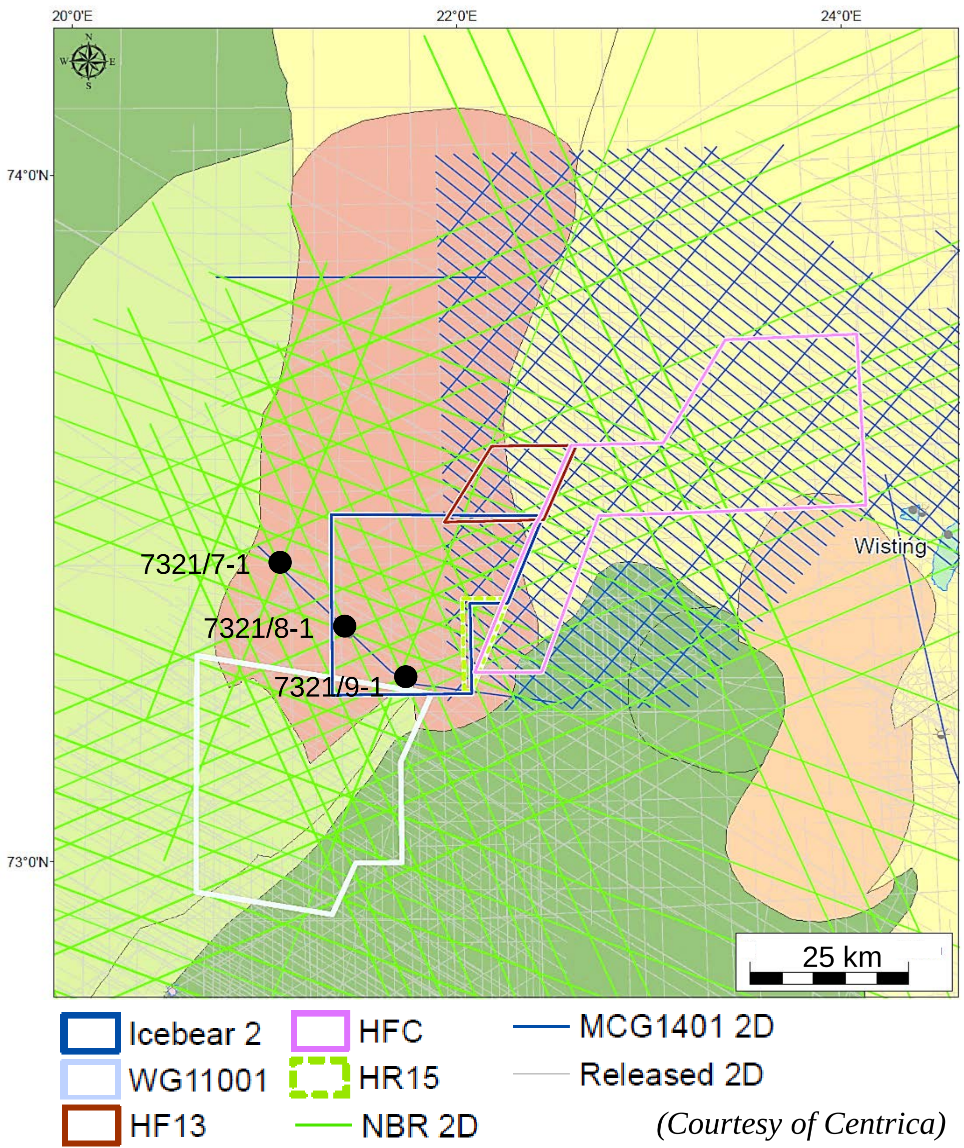
- Description and characterization of Lower Cretaceous clinoforms

1. Investigate the depositional environments/systems → Models

2. Quantitative classification (resolution vs. order)

3. Large-scale and detailed sequence stratigraphic history

Data Coverage



(Courtesy of Centrica)

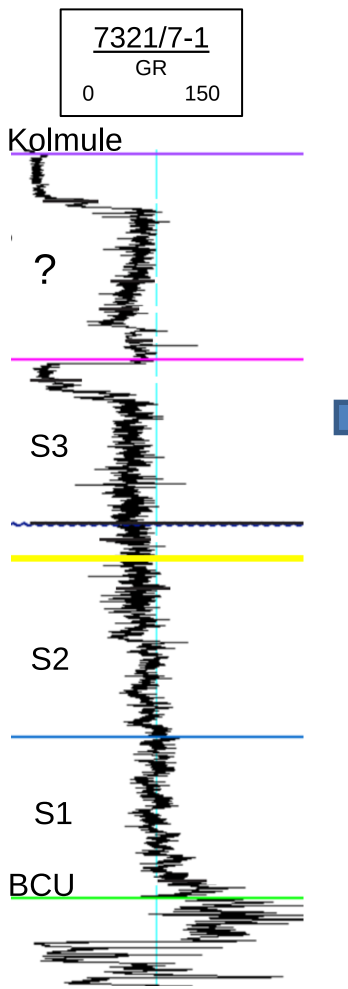
- **Wells:**
  - 7321/7-1
  - 7321/8-1
  - 7321/9-1

  CPI reports
  Biostratigraphy
  Dipmeter

- **Seismic:**
  - 3D Cubes: 4
  - 3D P-cable: 1
  - 2D Surveys: 3

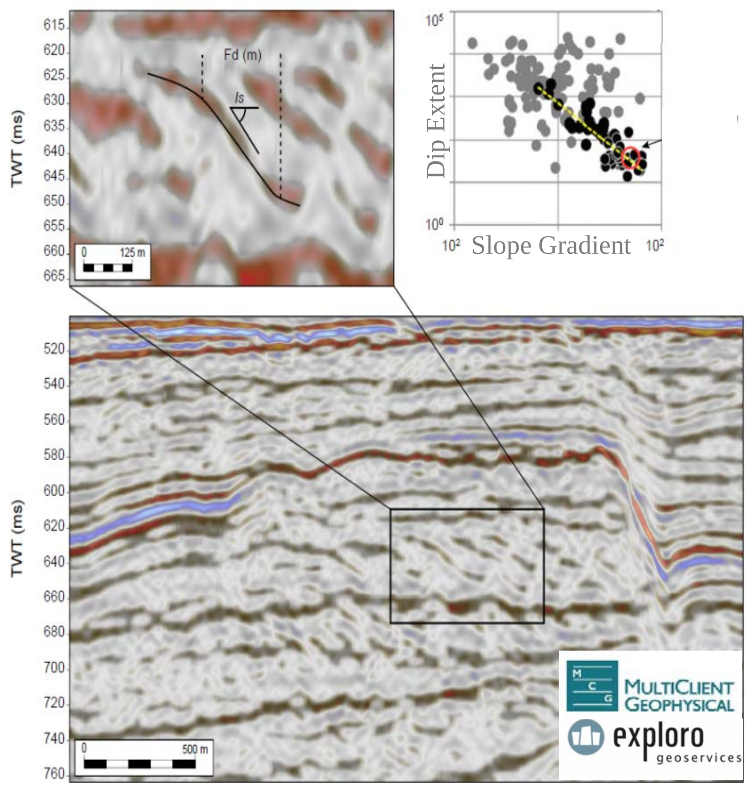
Methodology

1) Well log variations



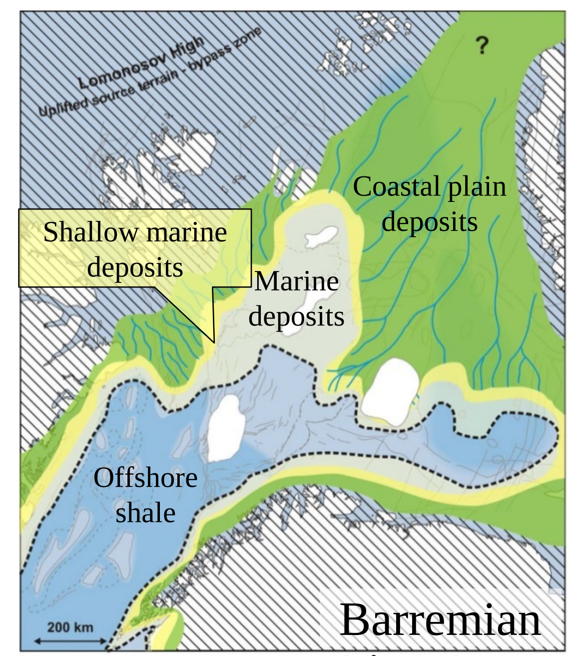
(Marin and Escalona, 2015)

2) Seismic interpretation (together with biostratigraphic and dipmeter data)



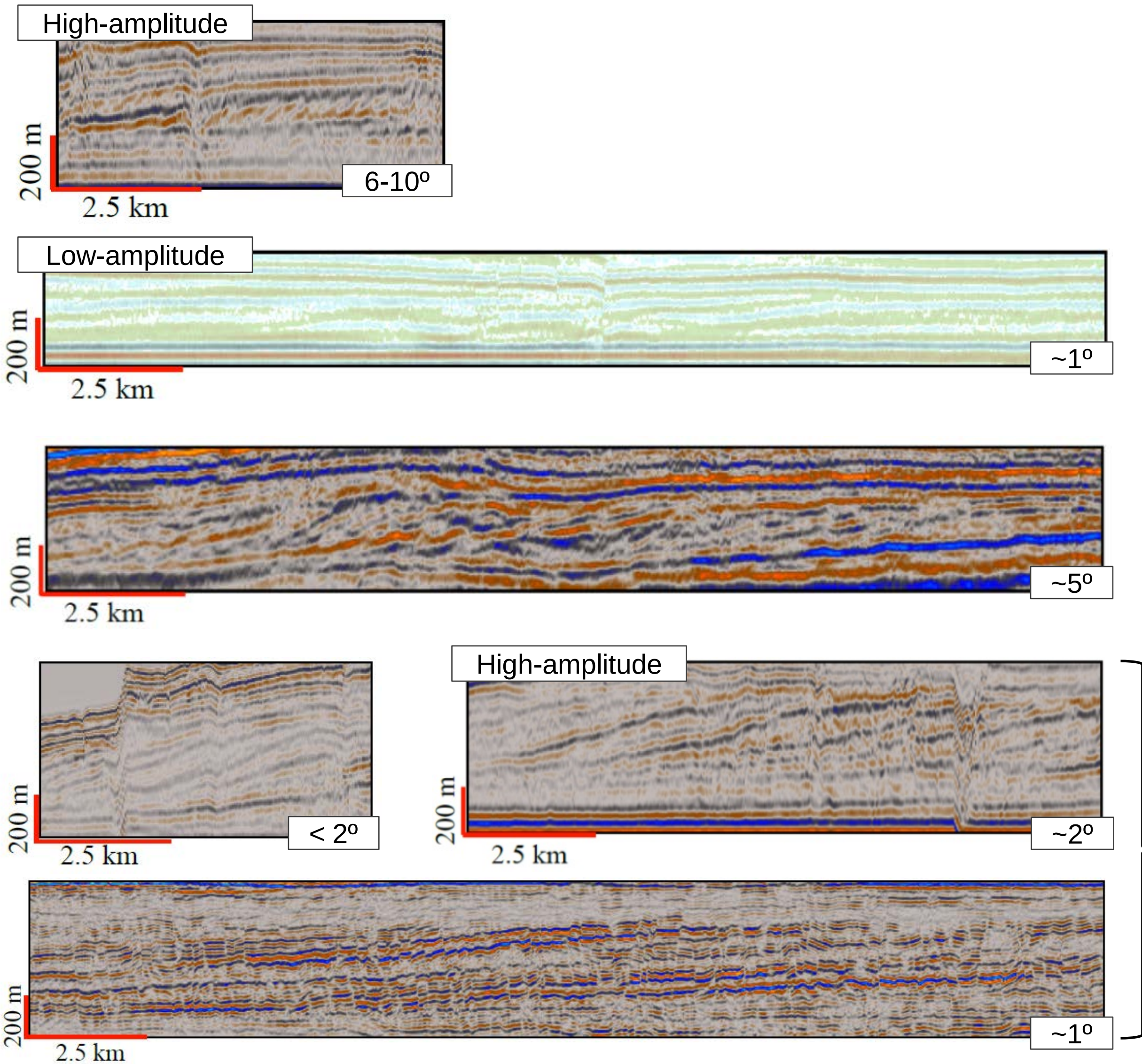
(Courtesy of Centrica)

3) Geomorphological studies (maps)



(Grundvåg et al., 2015)

Clinoform Classification



1) **Deltas/shorelines**:
   < 100 m

2) **Offlapping sediment bodies on a continental shelf (Miall, 2010):**
   < 150 m

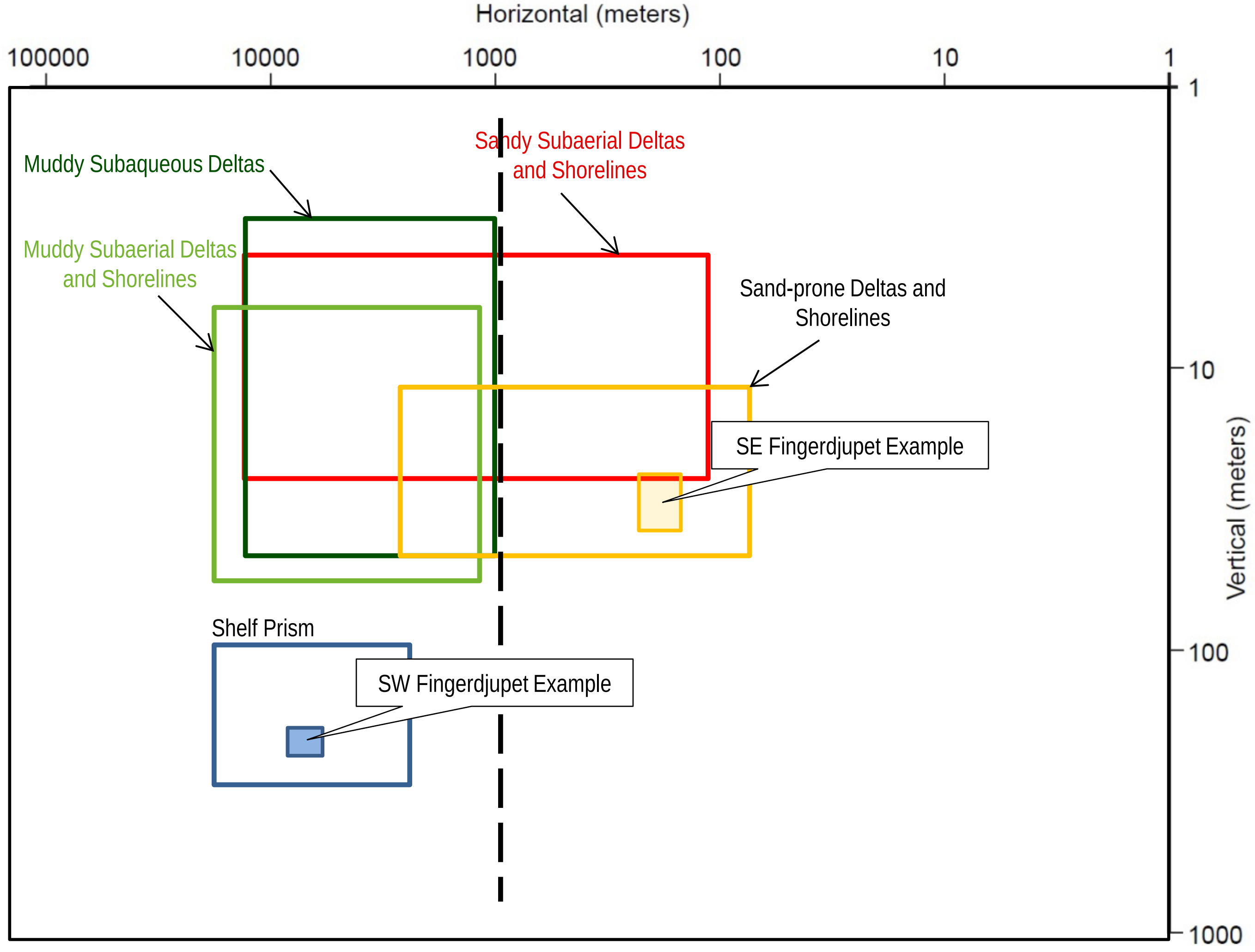
3) **Shelf-edge deltas:**
   < 150 m

4) **Shelf-slope clinoforms:**
   > 150 m

(Modified from Marin, 2015)

Quantitative Clinoform Analysis

- Ranges of analogues:
- Sand-prone deltas and shorelines
  - Short length
  - Far from any known muddy analogues
- Shelf prism
- Uncertainties
  - Measurements
  - Depth conversion
  - Decompaction



(Courtesy of Centrica)

Time Frame

Activity	2015	2016					
	Dec	Jan	Feb	Mar	Apr	May	Jun
Literature review and regional geology							
Seismic interpretation							
Field trip to Svalbard?					?		
Produce maps and figures							
Writing							
First draft and correction							
Submit thesis							

Thank you for your attention!

Any questions?

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i Stavanger

LoCrA

centrica

Tectono-Stratigraphic Evolution of the Fingerdjupet Sub-basin

Master Thesis Proposal : **Biswarup Acharyya**

Advisors:

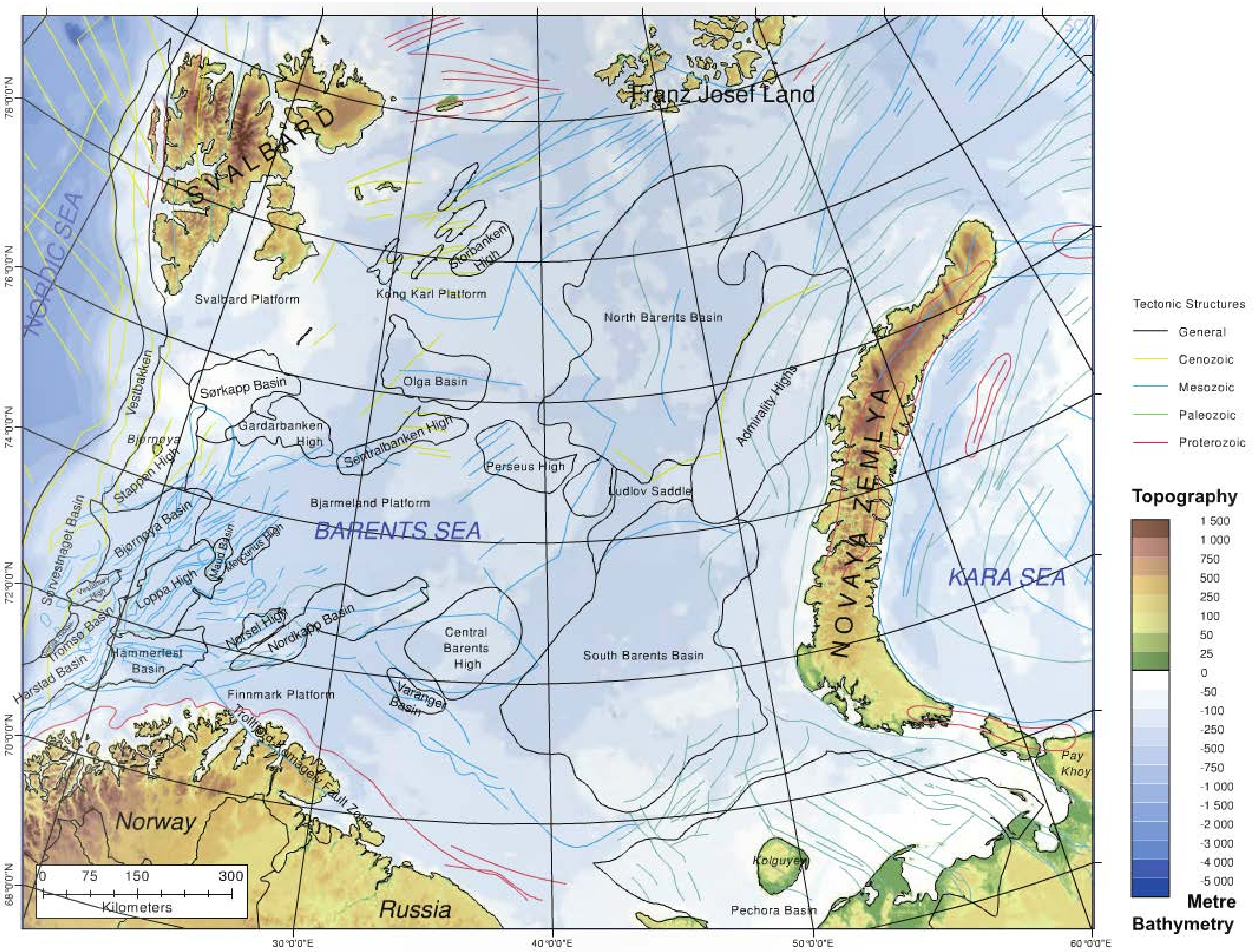
Alejandro Escalona (UiS)

Bjørn Kåre Bryn (Centrica)

Stian Schjelderup Haaland (Centrica)

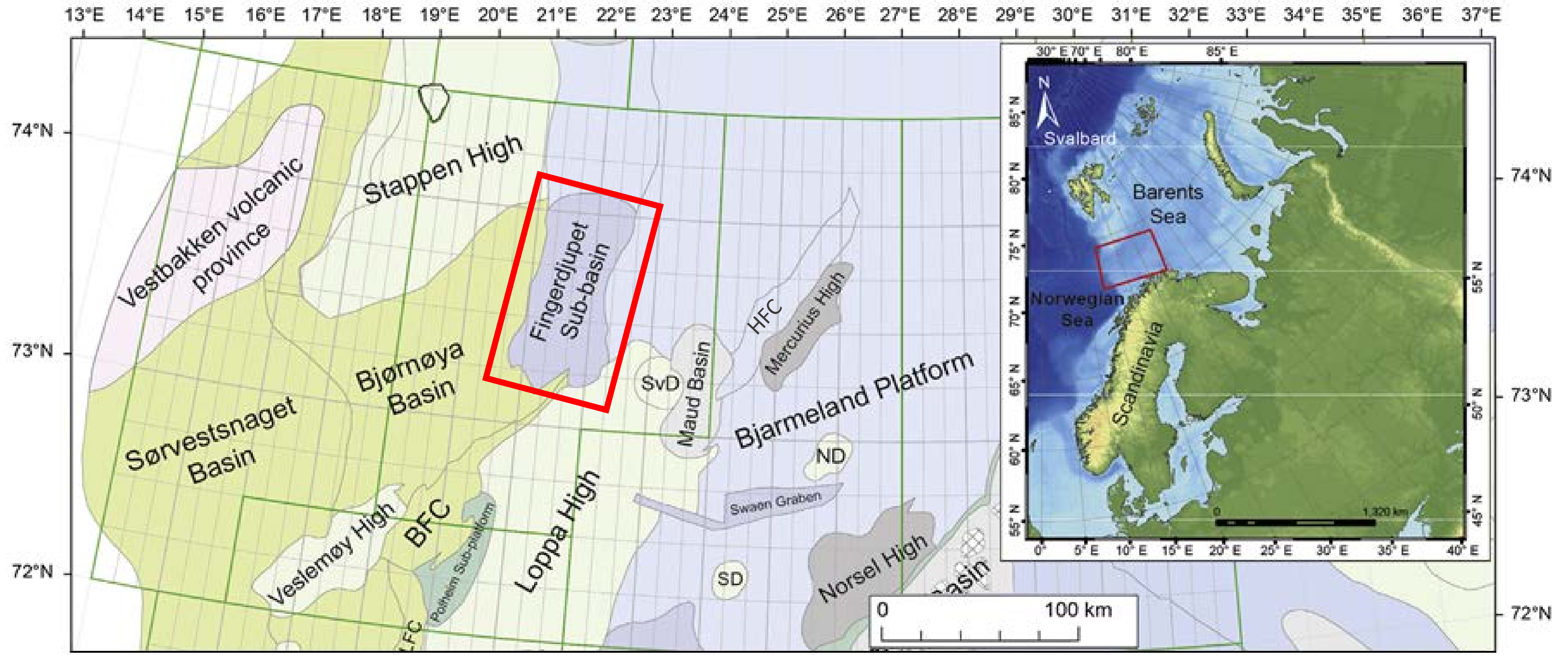
Agenda

- Introduction
- Previous Work
- Motivation
- Objective
- Data
- Methodology
- Time Line



(Smelror et al., 2009)

Area of Interest



Legend:

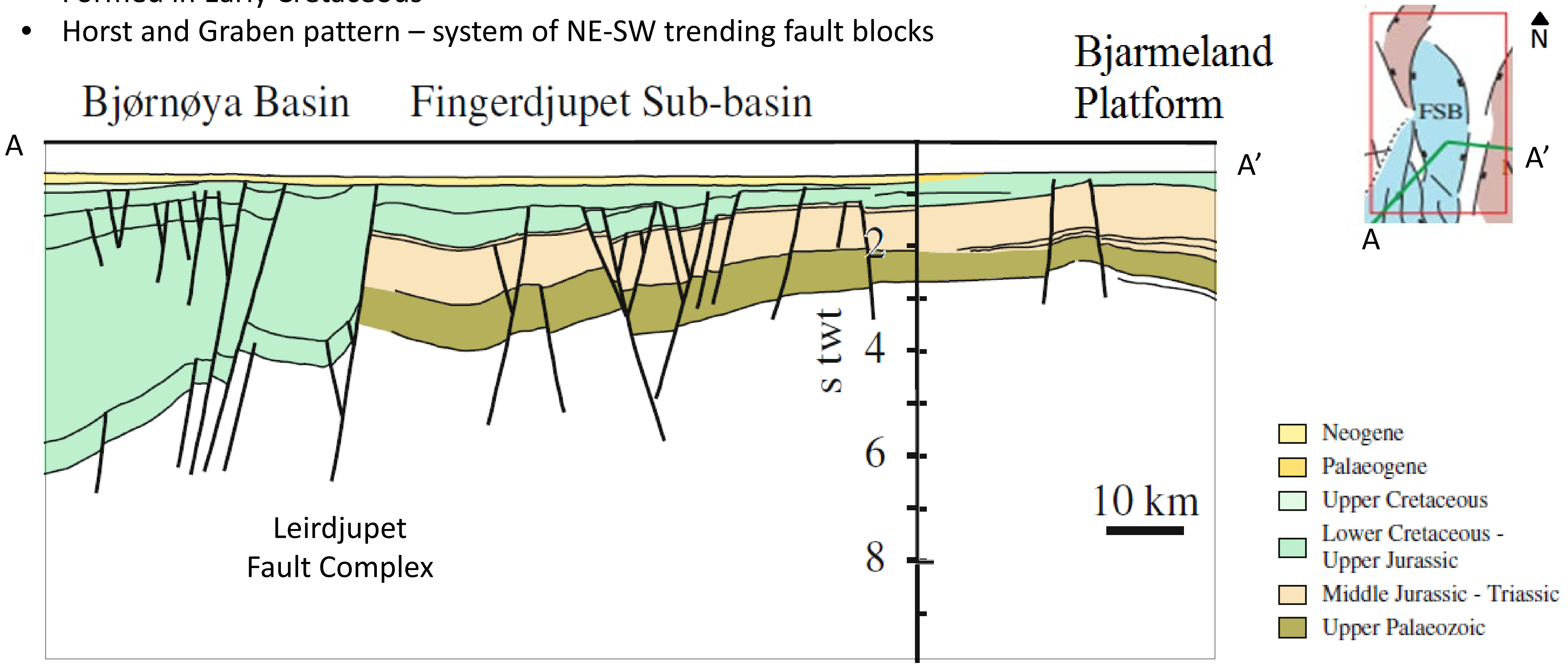
Cretaceous High	Volcanics
Deep Cretaceous Basin	Paleozoic High in Platform
Shallow Cretaceous Basin in Platform	Pre-Jurassic Basin in Platform
Platform	Terraces and Intra-Basinal Elevations

BFC = Bjørnøyrenna Fault Complex
HFC = Hoop Fault Complex
SD = Samson Dome
SvD = Svalis Dome
ND = Nordvarg Dome

(Modified from Duran et al., 2013)

Introduction

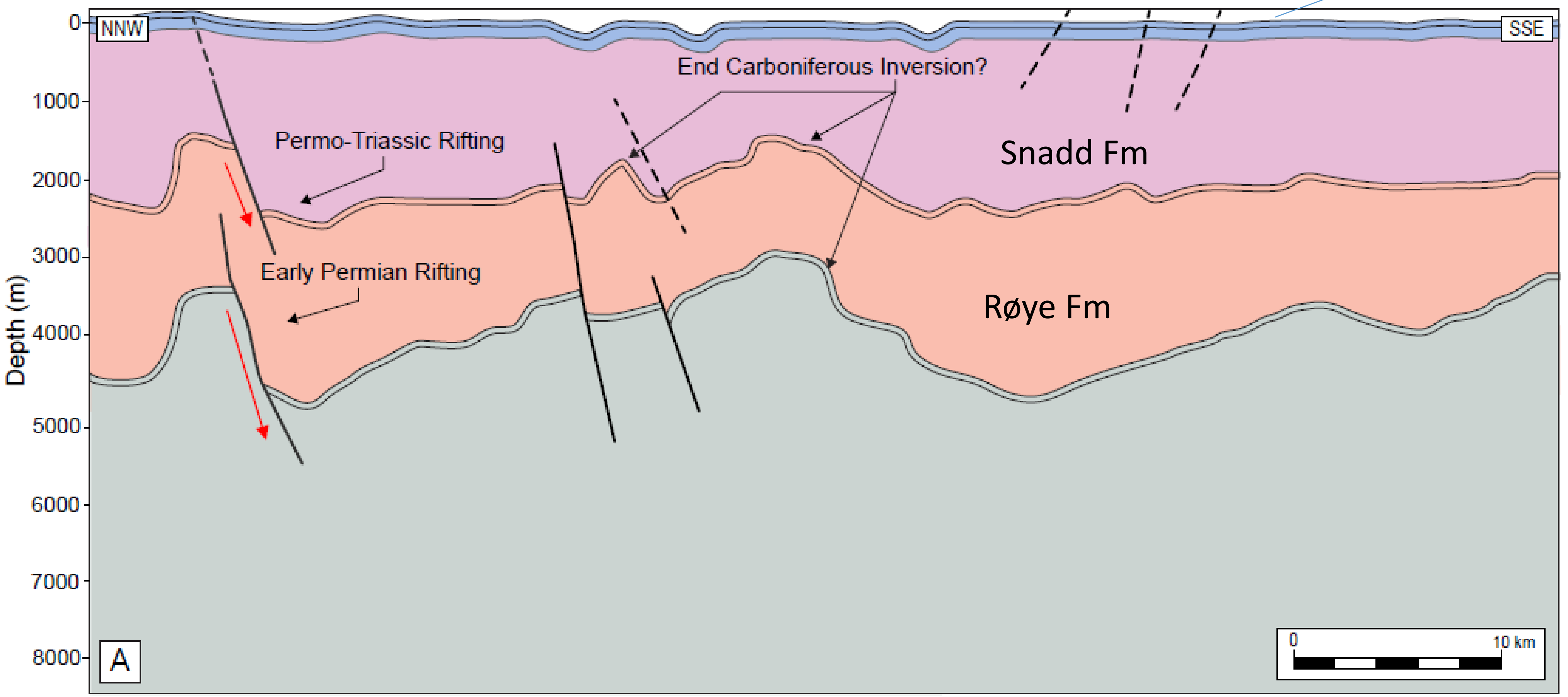
- Formed in Early Cretaceous
- Horst and Graben pattern – system of NE-SW trending fault blocks

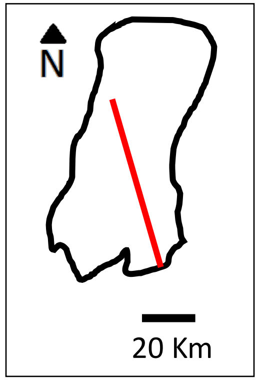


(Modified from Faleide et al., 2010)

Previous Work

- Permo-Triassic structures has been leveled out
- Little affect of Late Jurassic tectonism

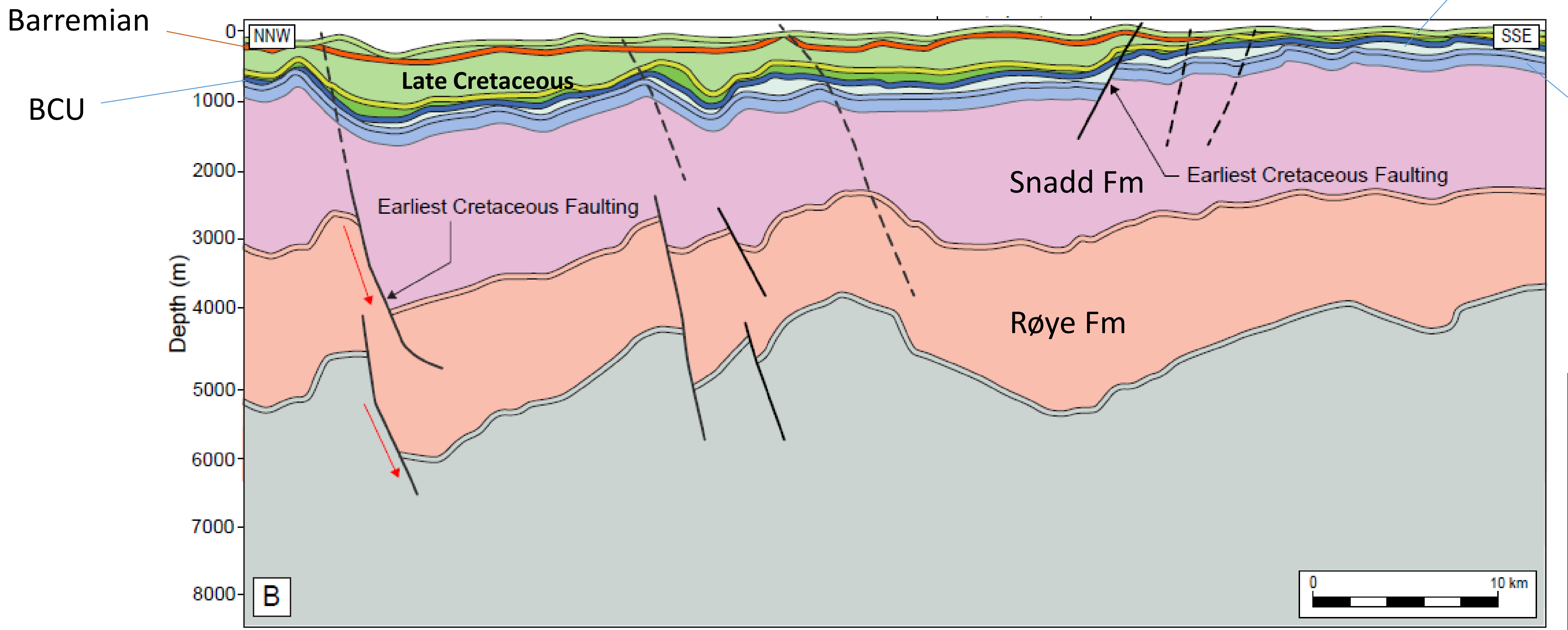


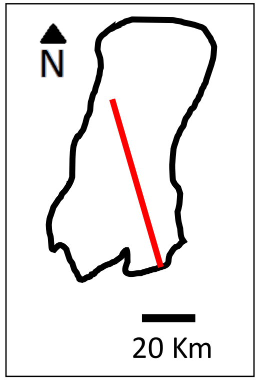


Evolution of accommodation space

(Courtesy of Centrica Energy)

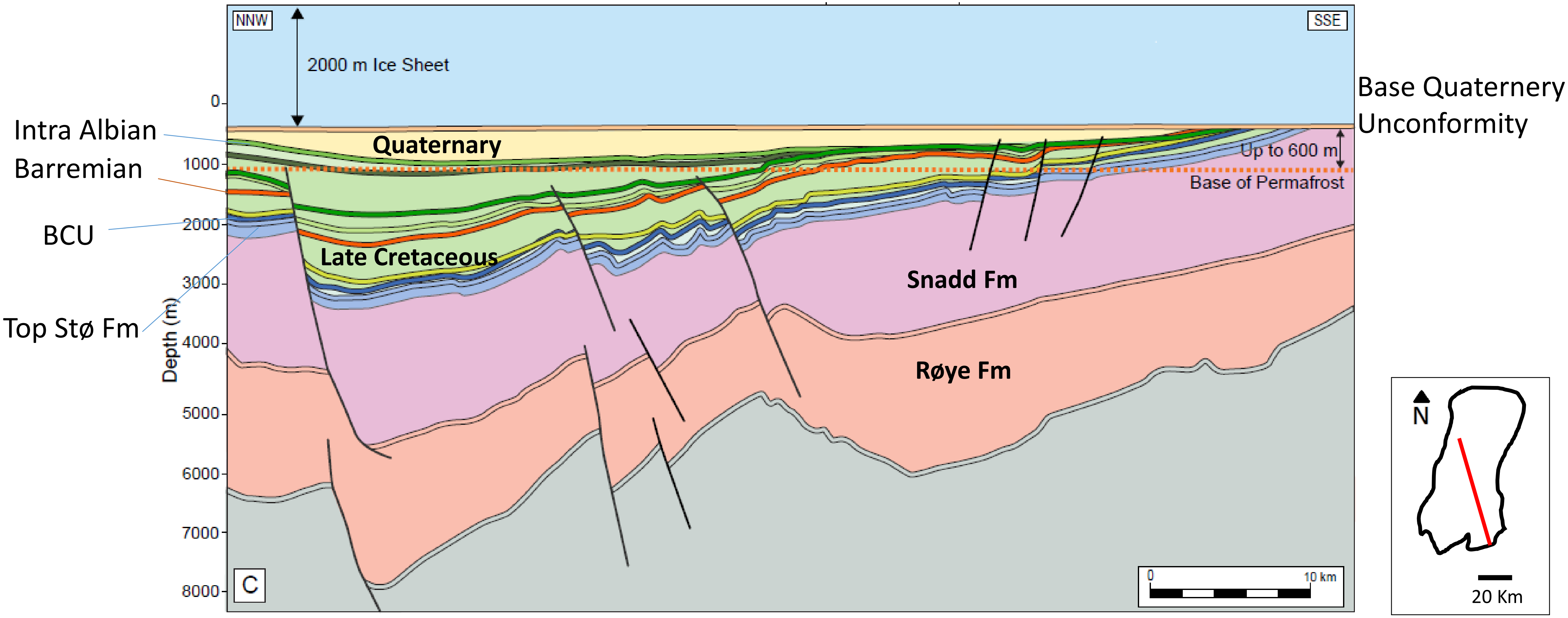
- Normal faulting – Early Cretaceous age
- A thick clinoform complex prograded





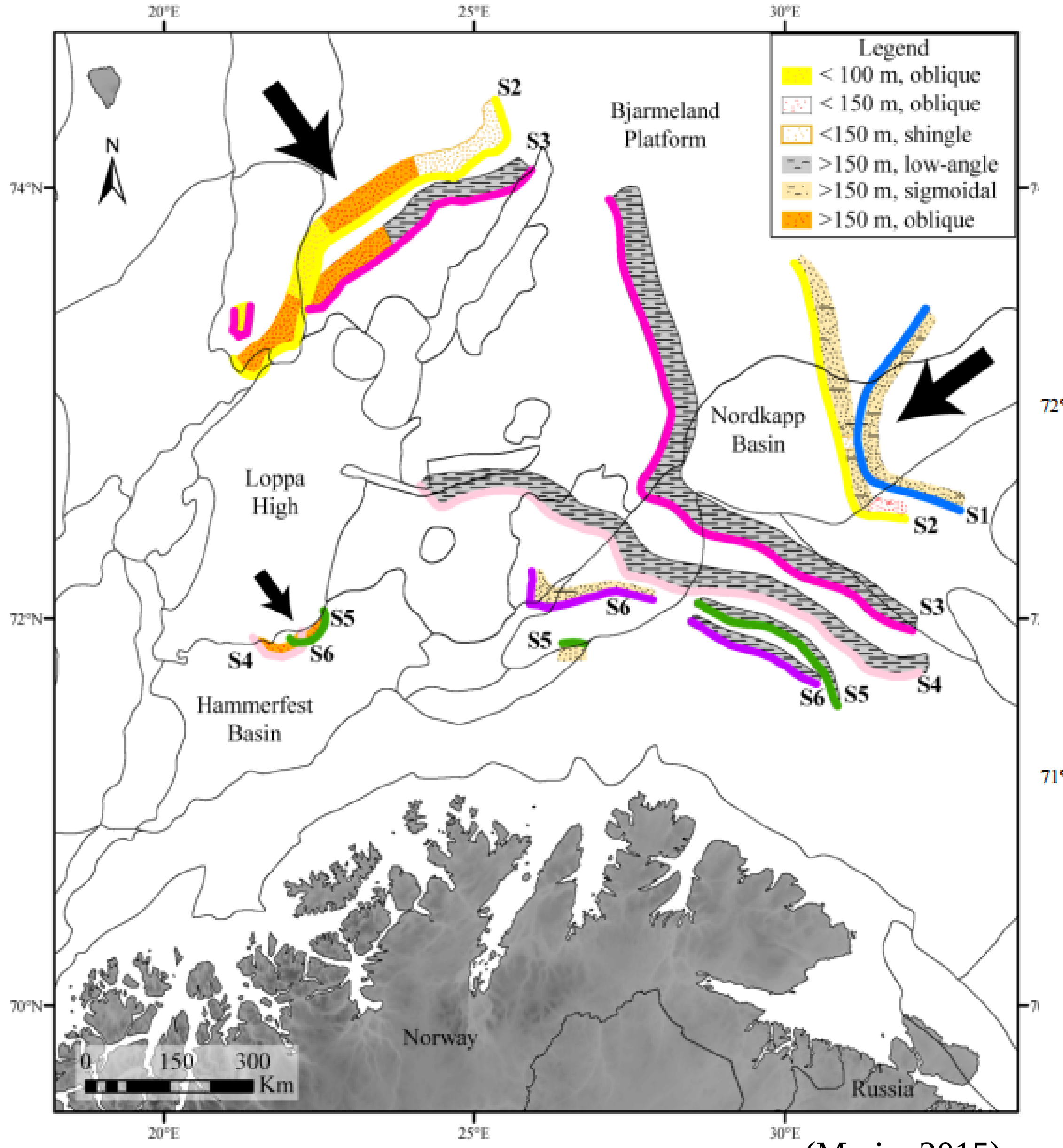
Evolution of accommodation space

(Courtesy of Centrica Energy)

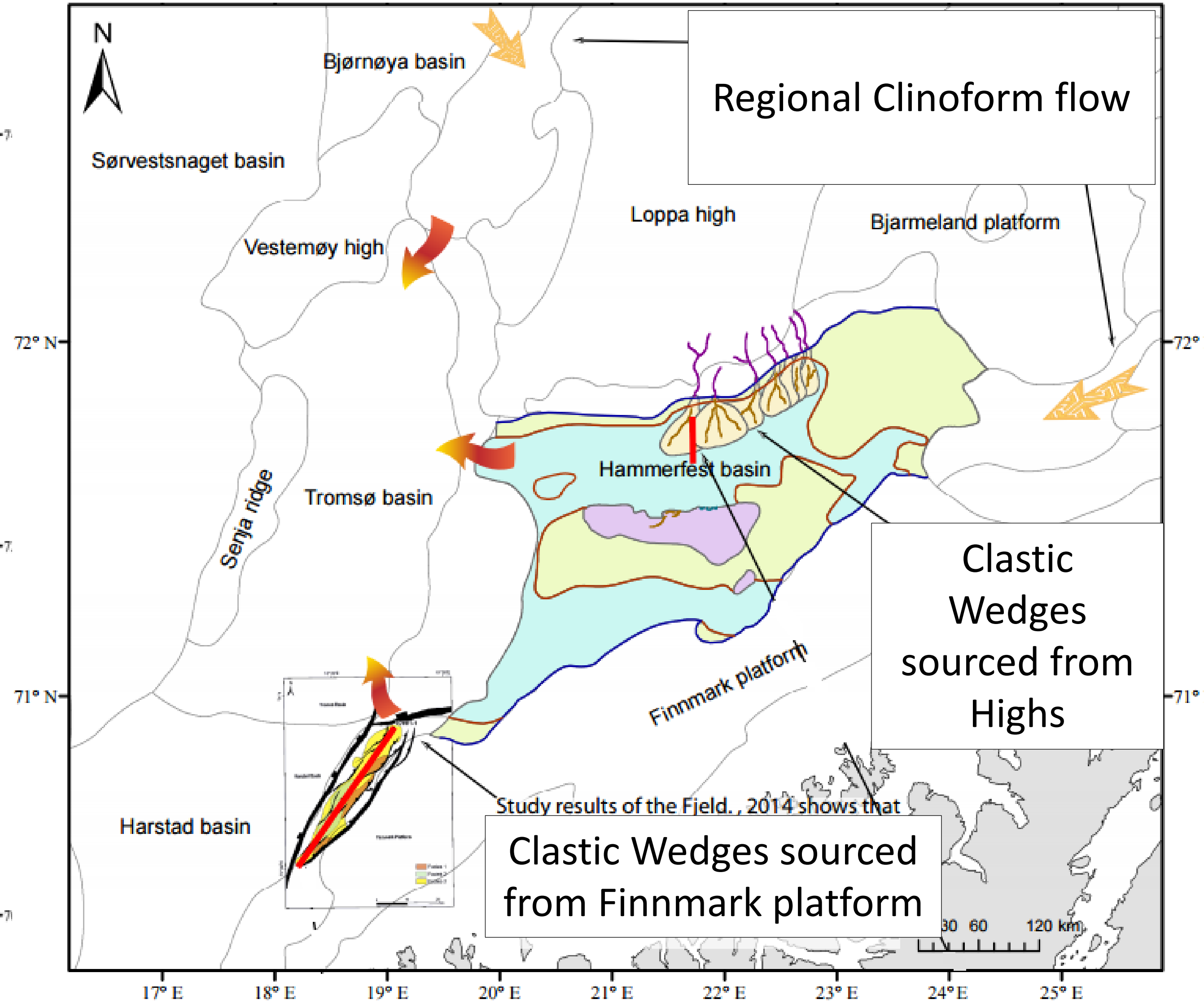


Evolution of accommodation space

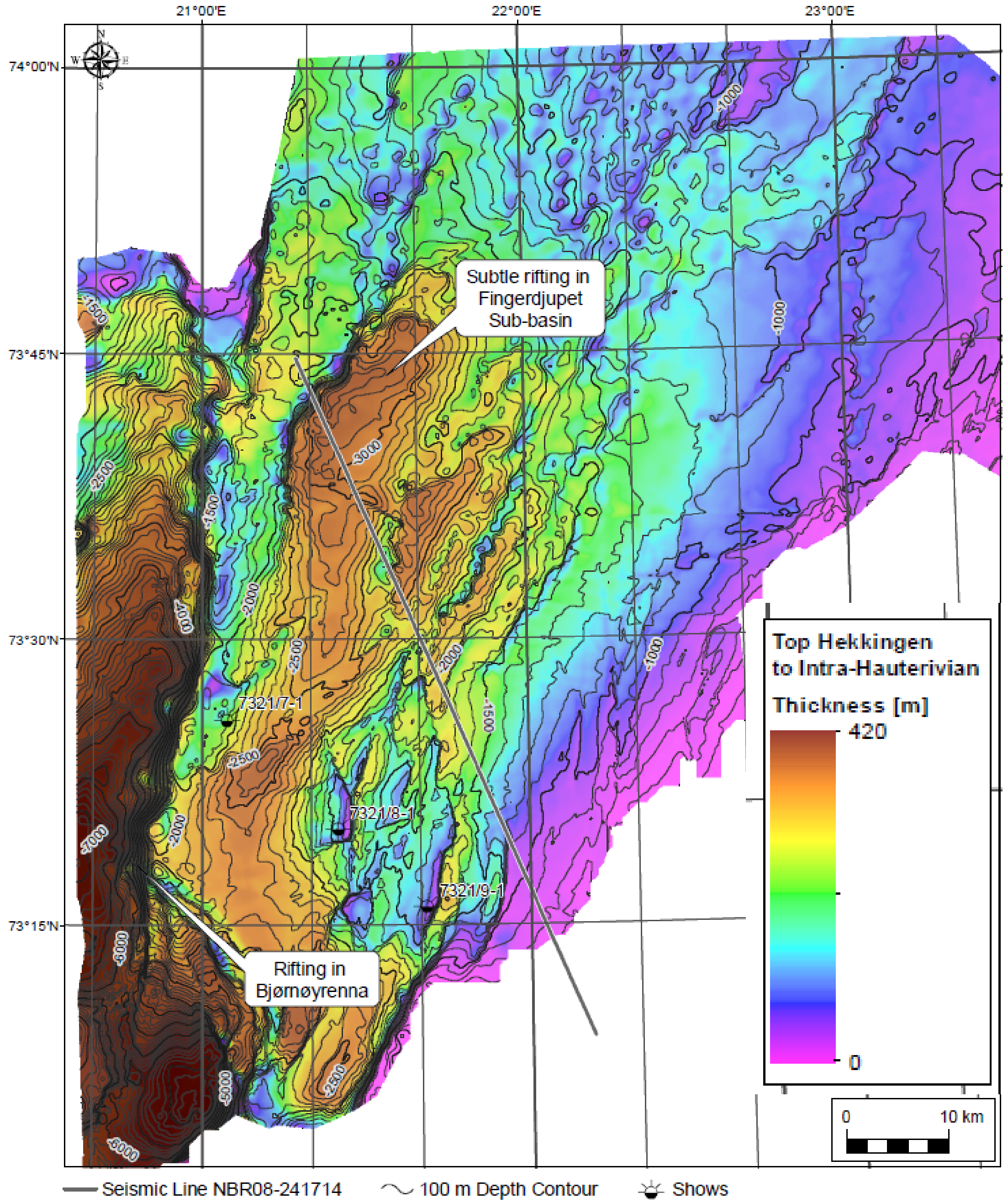
(Courtesy of Centrica Energy)



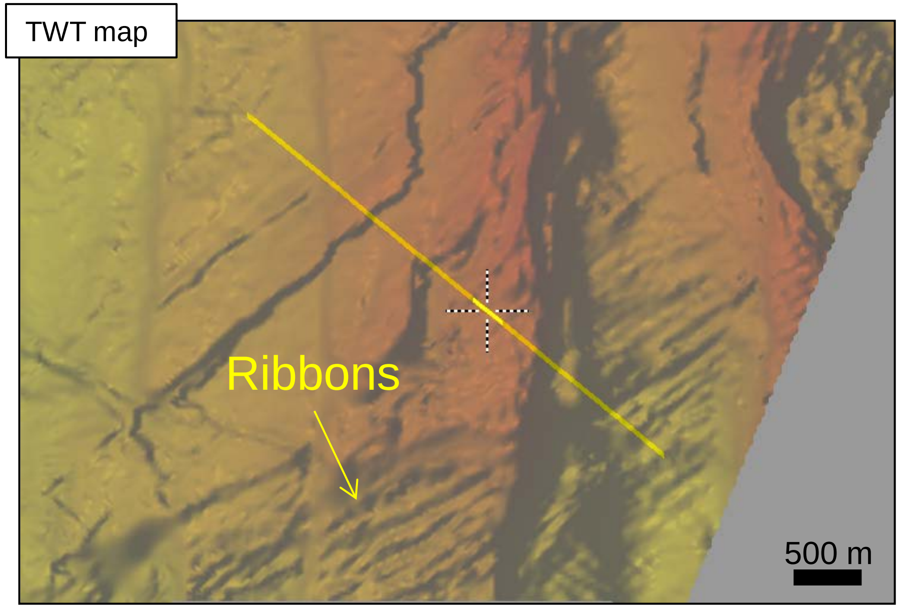
(Marin, 2015)

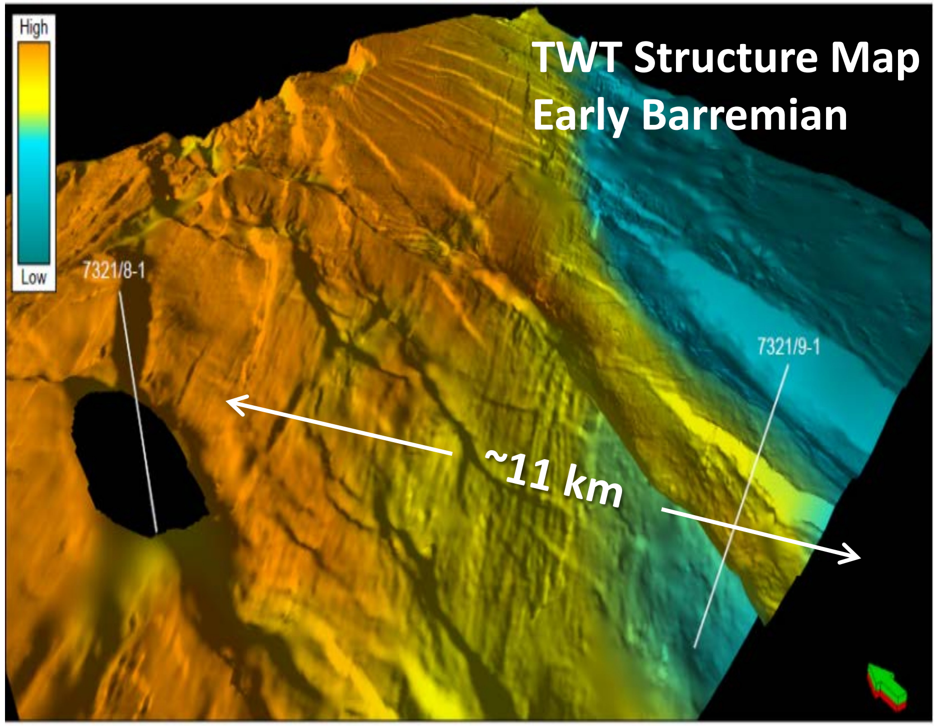


(Kairanov, 2015)



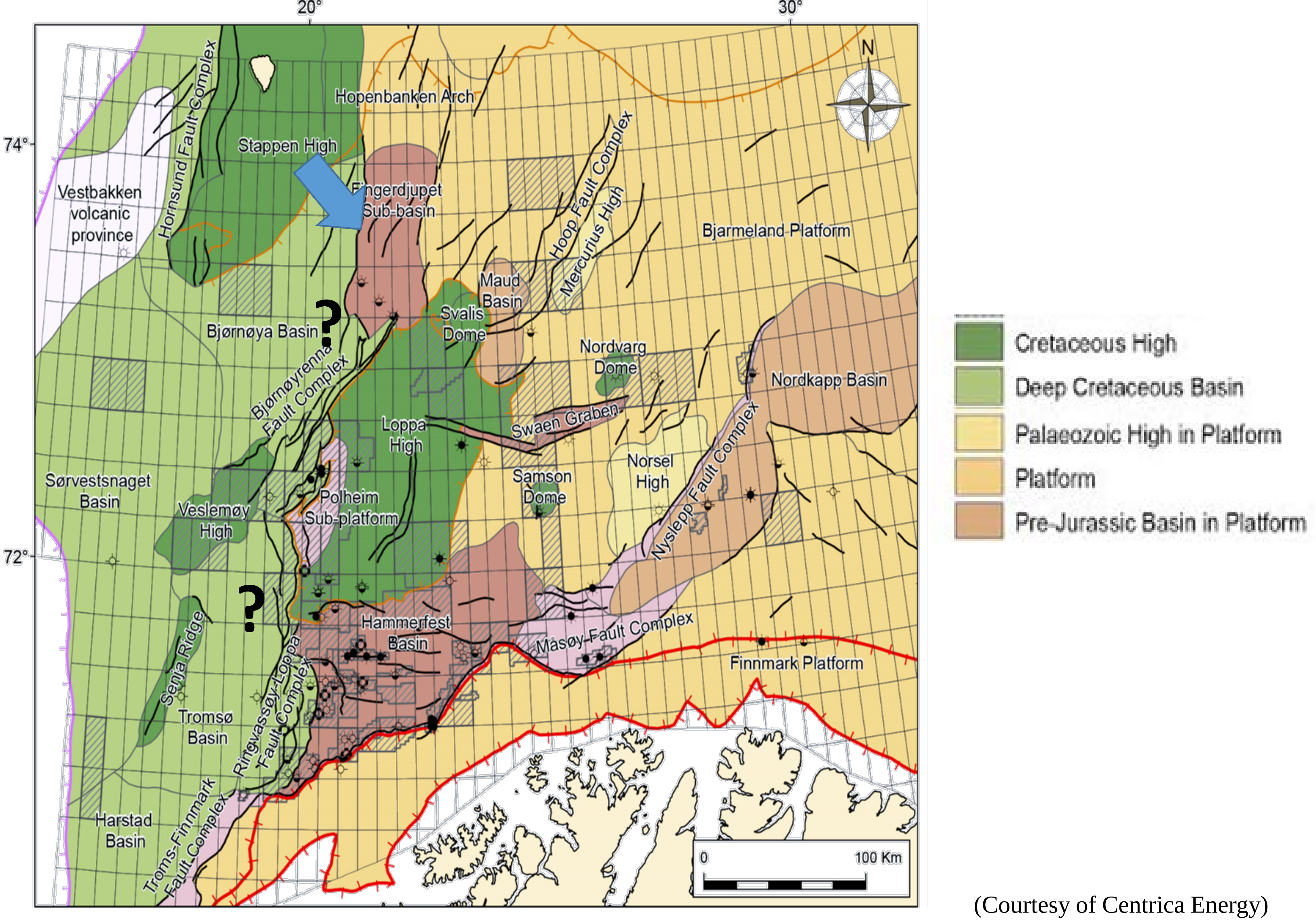
Late Jurassic – Early Cretaceous Isopach and Structure Map





(Courtesy of Centrica Energy)

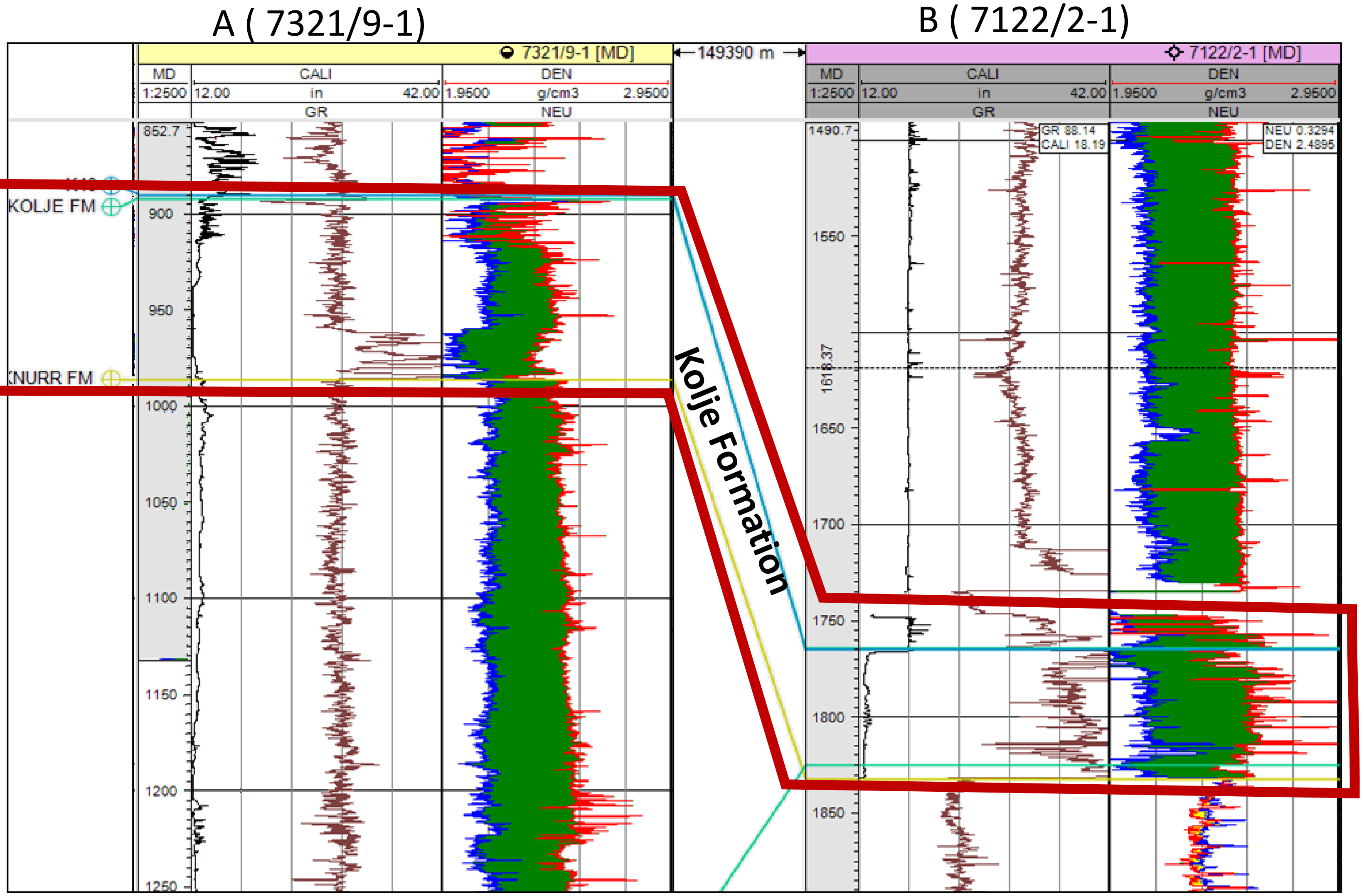
Motivation

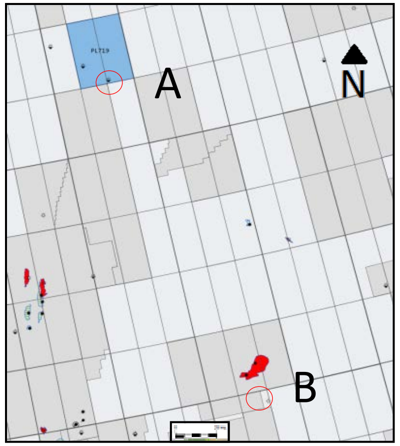


(Courtesy of Centrica Energy)

Motivation

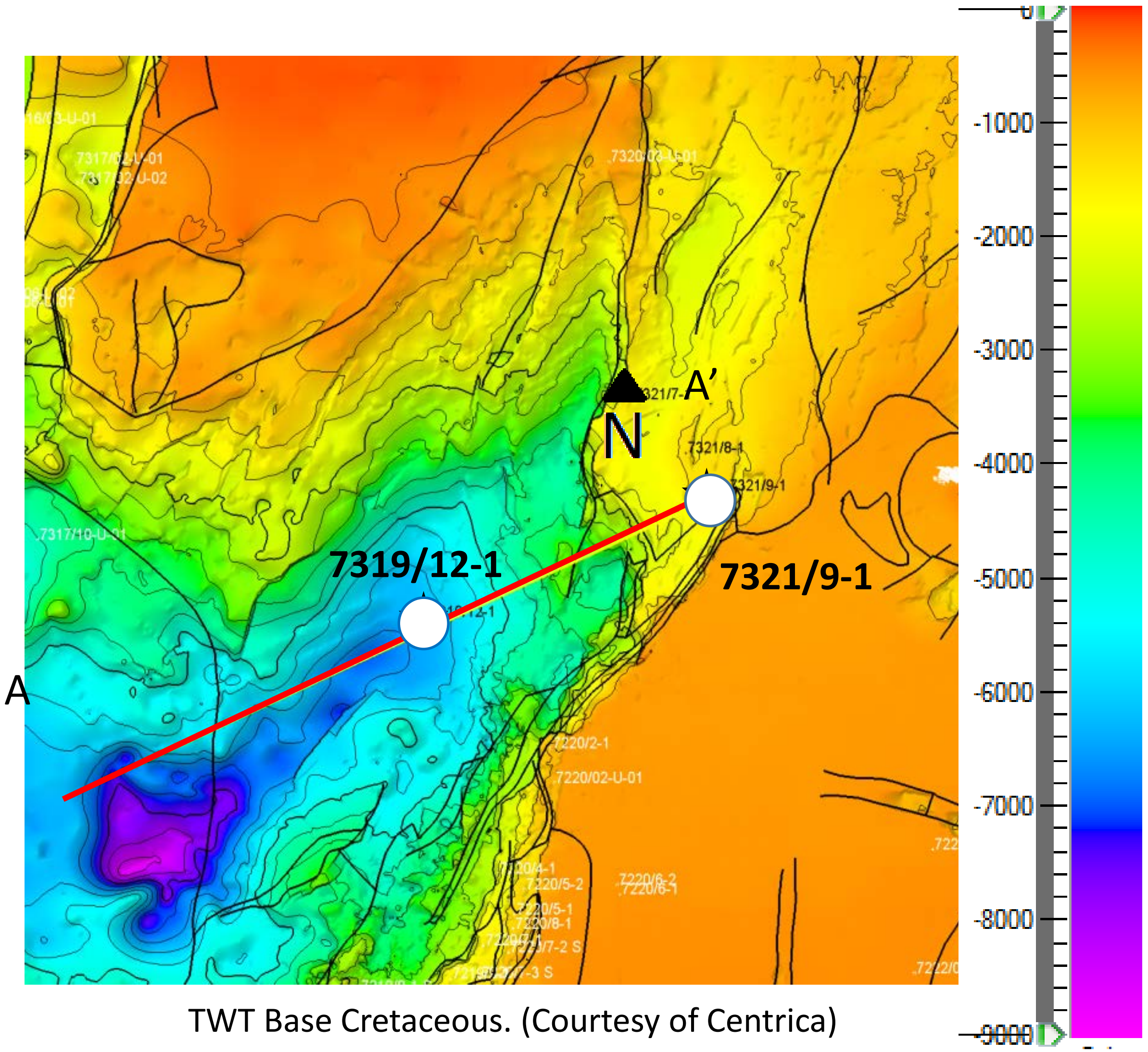
Drilling Results: Organic rich shale reported in (7321/9-1)





(Modified from Centrica and NPD 2015)

Objective



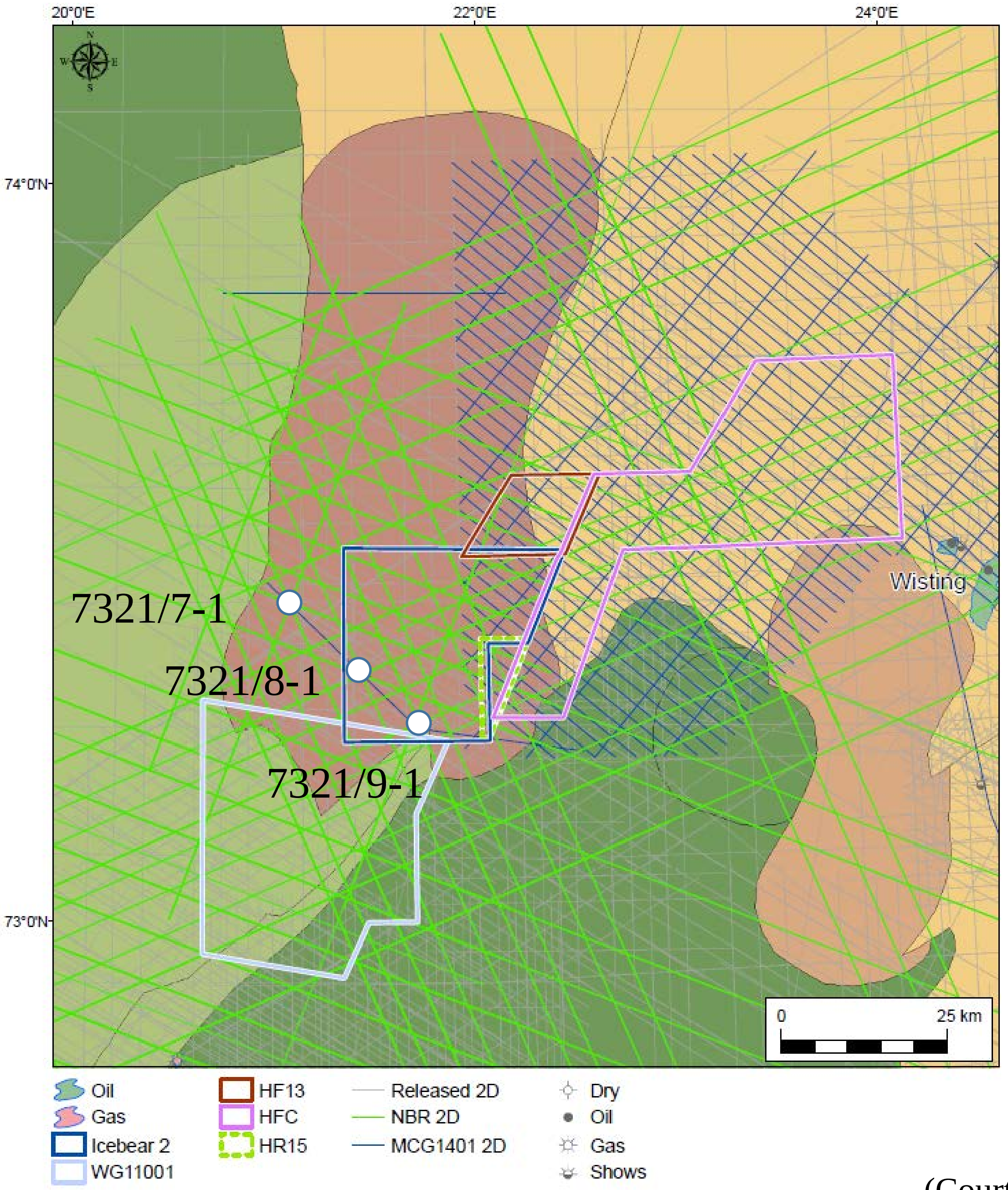
TWT Base Cretaceous. (Courtesy of Centrica)

Data

2D Seismic data
- NBR 2D Megasurvey
- MCG14012D Survey
- Released 2D

3D Seismic
- Icebear 2
- WG11001
- HF 13
- HFC
- HR15
- HR14

Wells
- 7321/7-1
- 7321/8-1
- 7321/9-1



(Courtesy of Centrica Energy)

Methodology

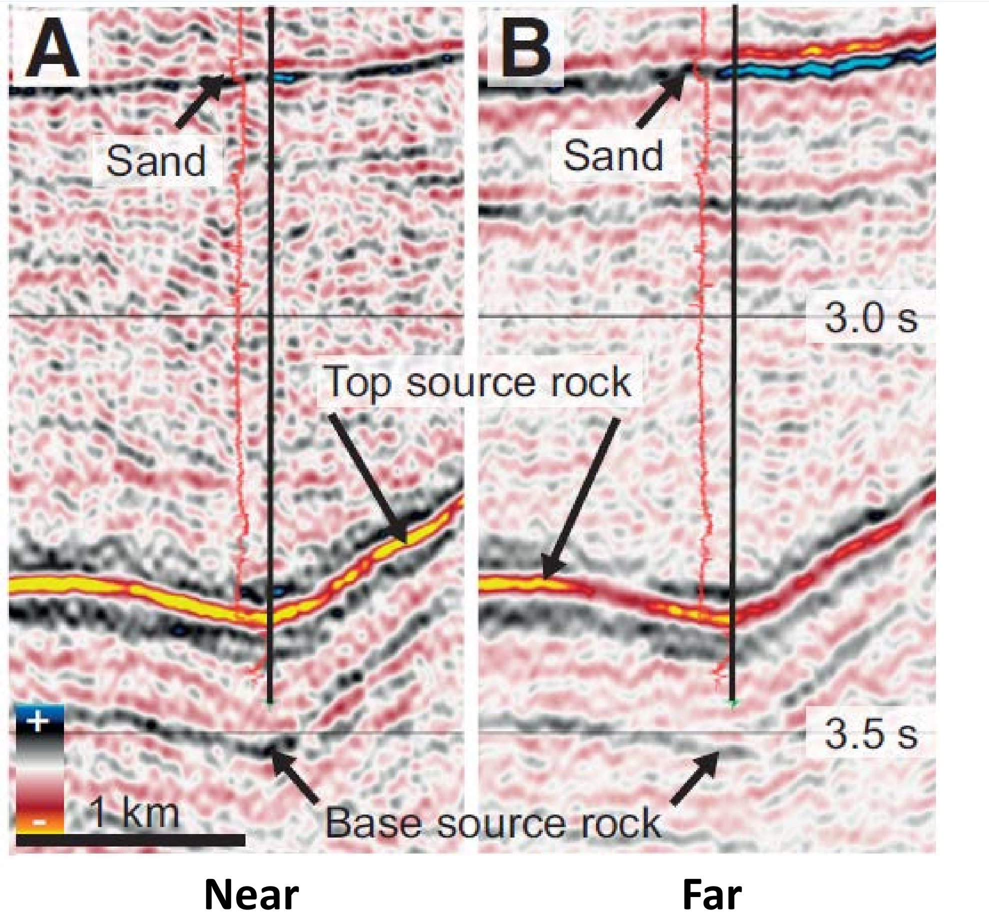
Seismic – Well Tie

Seismic Interpretation and AVO analysis

Describe fault timings, growth, reactivation, and its effect on sediment steering and deposition

Interpret basin setting and depositional environment

Investigate impact of structural evolution on source rock deposition and maturation.



(Løseth et al., 2011)

Methodology

Seismic – Well Tie

Seismic Interpretation and AVO analysis

Describe fault timings, growth, reactivation, and its effect on sediment steering and deposition

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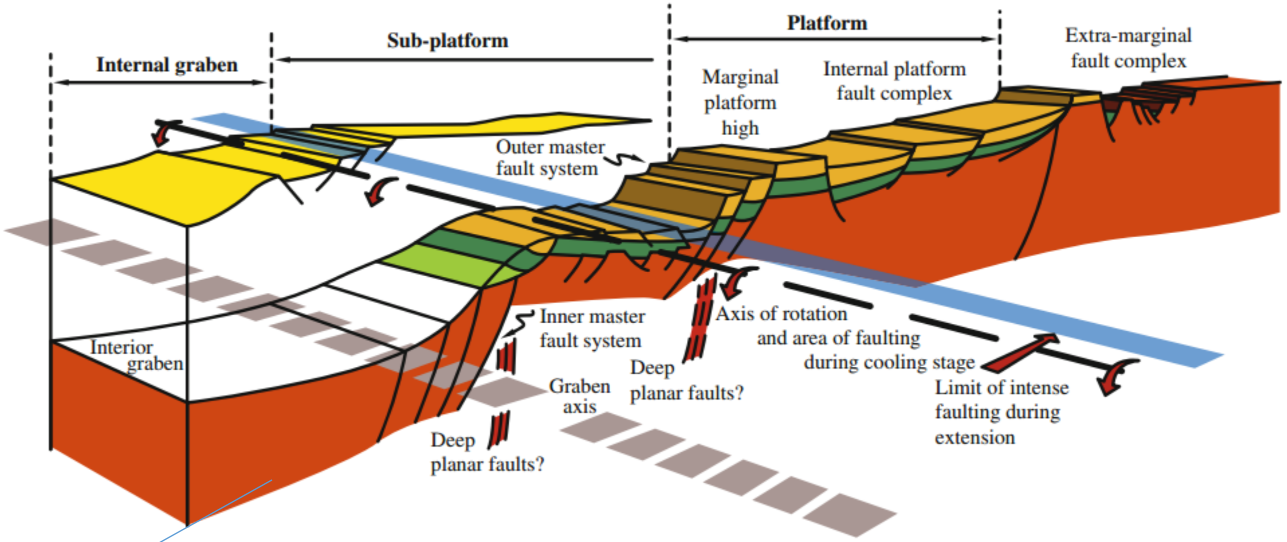

(Gabrielsen, 2010)

Time Line

Month	Dec 2015			Jan 2016				Feb 2016					Mar 2016				April 2016				May 2016					June 2016		
Week Number	51	52	53	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Literature Review	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
Main research study				■	■	■	■	■	■	■	■	■	■	■	■	■★	■	■	■	■	■	■	■	■	■			
Seismic Interpretation				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■								
AVO Analysis								■	■	■	■	■	■	■	■	■	■	■	■	■								
Initial writing													■	■	■	■	■	■	■★	■	■	■	■	■	■			
Write results chapters													■	■	■	■	■	■	■	■	■	■	■	■	■			
Write summary and conclusions for each chapter																	■	■	■	■	■	■	■	■	■			
First Draft																						★	■	■	■			
Compile and editing																						■	■					
Checking dissertation flow																								■	■			
Final Draft																										■	■	■
Check for errors and polish some writings																										■	■	■
Final proof-read (consult with supervisor)																										■	■	
Make minor revision, if necessary																												■
Submit dissertation paperwork																												■★

THANK YOU

LoCrA

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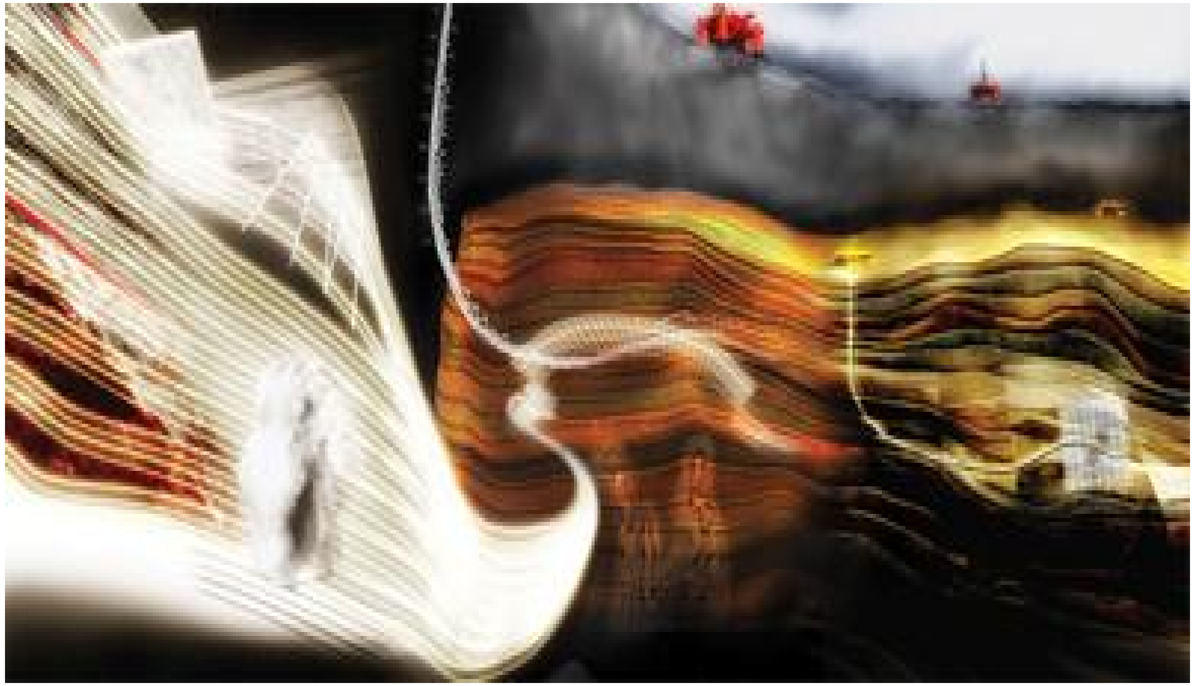
centrica

SEISMIC INVERSION FOR FLUID AND LITHOLOGY PREDICTION
Case Study: Block 607/6-Mikkel Field



Student: Nguyen, Phuong Thanh

Supervisor: Dr. Arild Buland

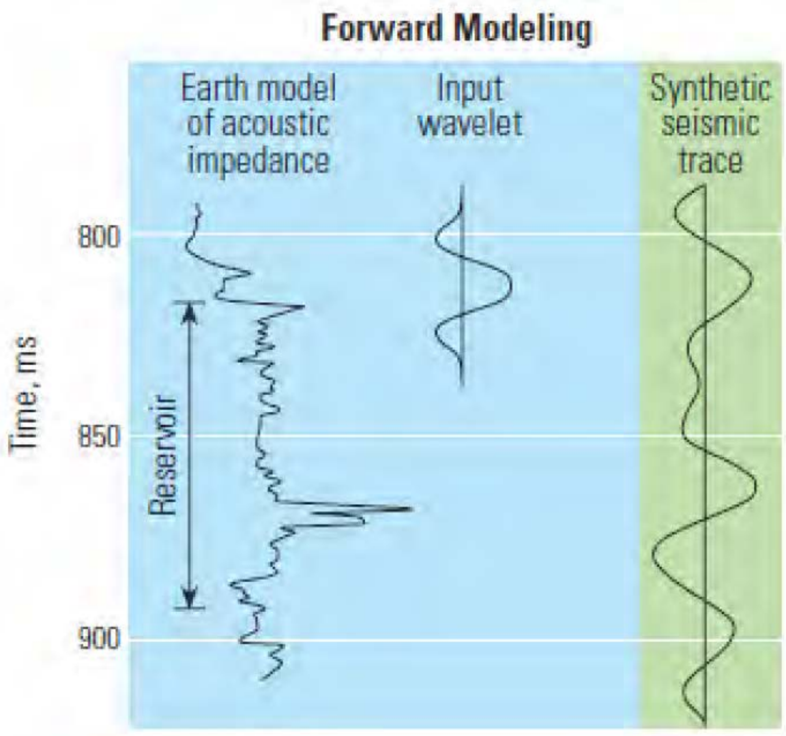
University of Stavanger

Agenda

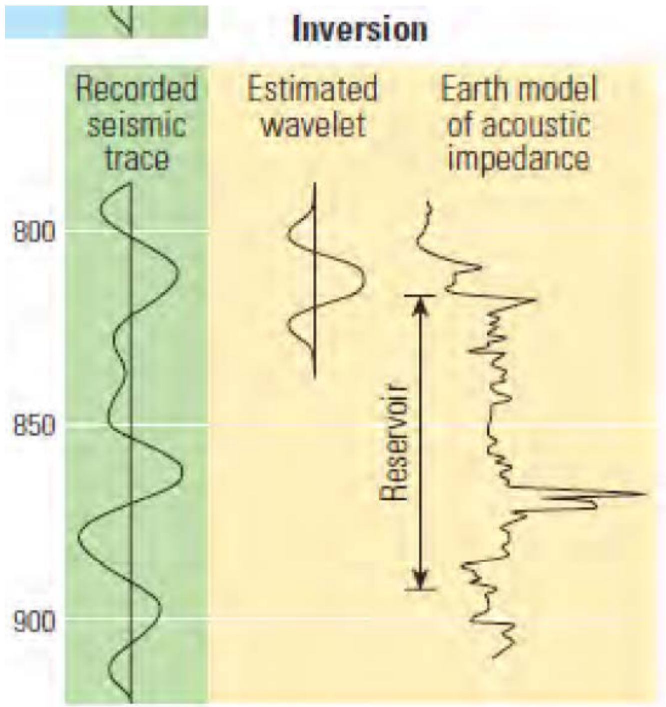
- ✓ Introduction
- ✓ Study Area Location
- ✓ Motivation
- ✓ Objective
- ✓ Work Proposal
- ✓ Dataset
- ✓ Methodology
- ✓ Time Frame

Introduction

FORWARD MODELLING



INVERSE MODELLING



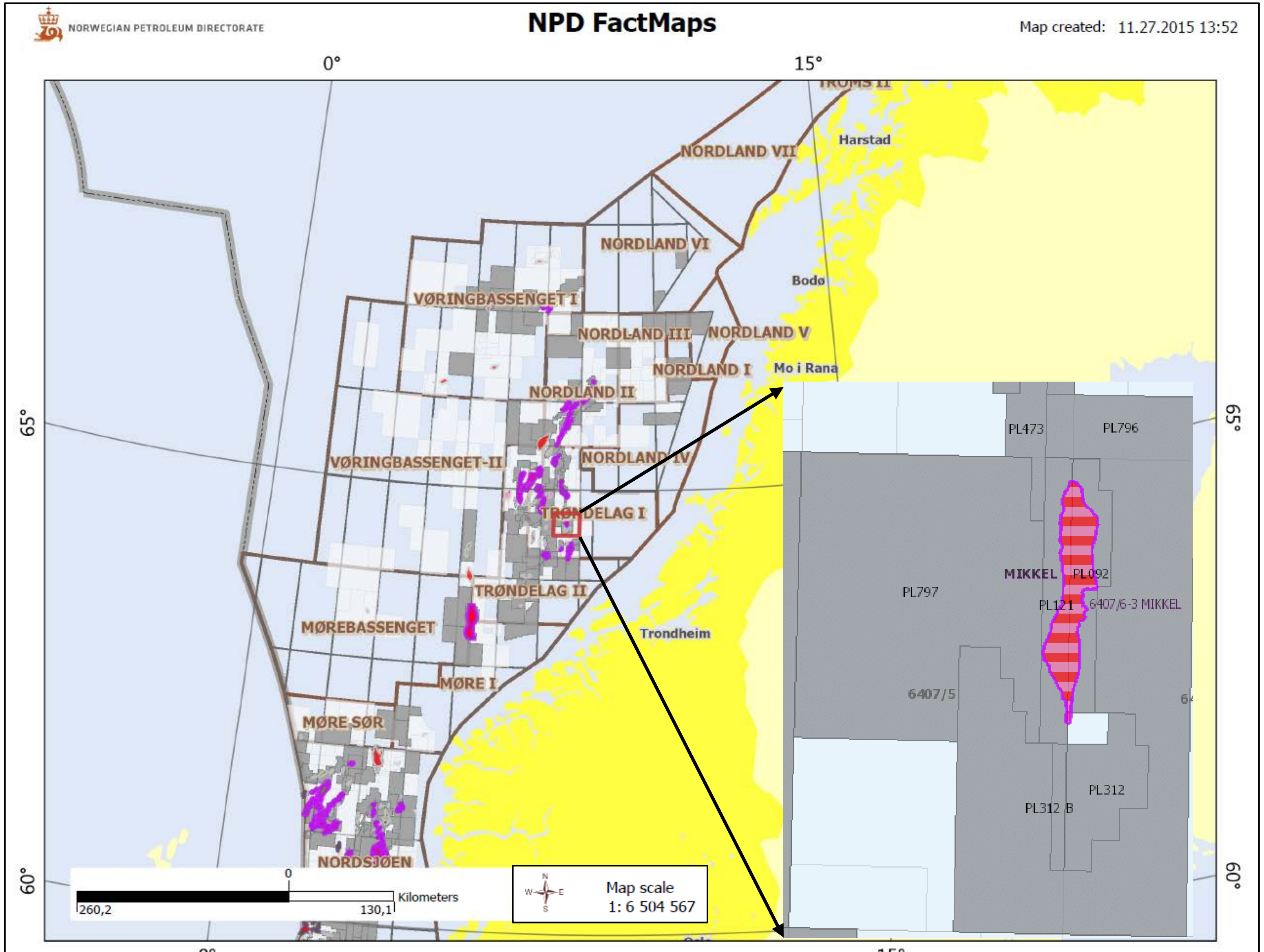
Oilfield Review, 2008

Inversion to lithology and fluid prediction (LFP) is NON-UNIQUE, COMPLICATED:

- **Observing contrasts, errors**
- **Imprecise processing, simplified forward modeling.**

➡ **The uncertainty related to LFP is LARGE**

Study Area Location



From NPD, 2015

Field: 607/6-Mikkel Field

Location: eastern part of the Norwegian Sea, about 30 km north of Draugen

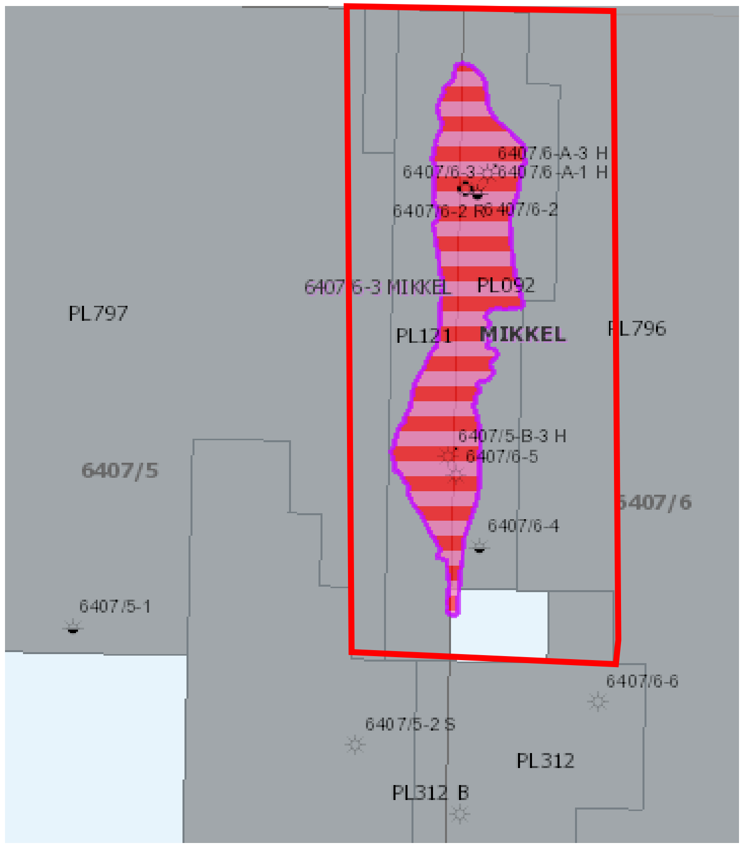
Water depth: 220 m

Reservoirs:

- 300-meter-thick gas and condensate in Jurassic sandstone.

Status: produce gas and condensate since 1st August 2003

Motivation



From NPD, 2015

Current field status

- ✓ No full wireline log in reservoir zones
- ✓ The pressure decline in the reservoir is less than expected and results in increased gas estimation
- ✓ Work is ongoing to develop proven gas resources

Motivation:

- ✓ Map LFC distribution to predict reservoir quality to optimize future development plans

Objectives

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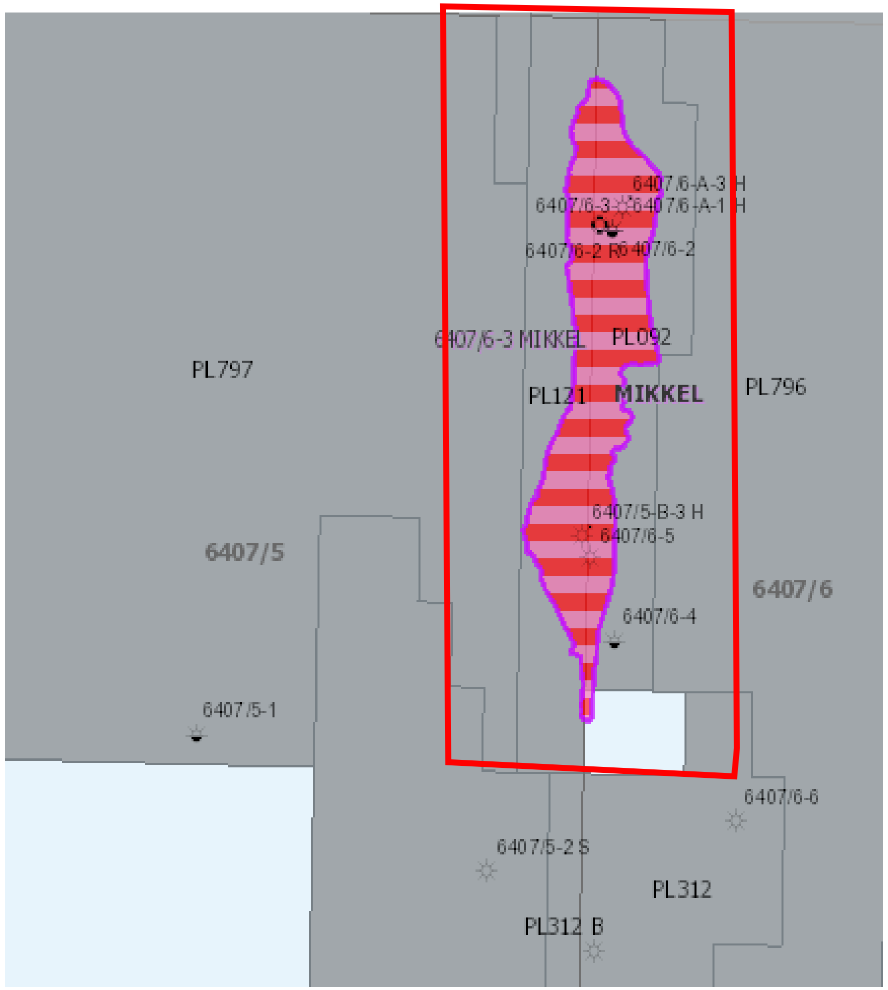
- Perform qualitative seismic inversion (coloured inversion –extended elastic inversion) and quantitative seismic inversion (Bayesian Inversion).
- Map the 3D volume distribution for each LFC and its probability cube.
- Highlight and quantify the hydrocarbon pay volume versus the non-productive zones.

Data



From NPD, 2015

DATA SET

<u>1. Seismic Survey:</u>

- 186 sq.km of PSTM, Pre-stack Kirchhoff time migration
- Migration velocity cube

<u>2. Well data</u>:

- 6 wells: wireline log, LWD
  - Lower part of overburden
  - A part of reservoirs

Work Proposal

Load pre-stack seismic data & well log data

↓

Define lithology and fluid class (LFC) from well log

↓

Forward rock physics model

Qualitative Workflow

- Color inversion (CI)
- ↓
- Extended elastic impedance (EEI)
- ↓
- Define rotation angle (χ) for LFP
- ↓
- LFP impedance volume from angle χ

Quantitative Workflow

Bayesian inversion

- Background model
- ↓
- Inversion model
- ↓
- Interpret inversion in form of probability density function (PDF) of LFC cube
- ↓
- Probability cubes for LFC

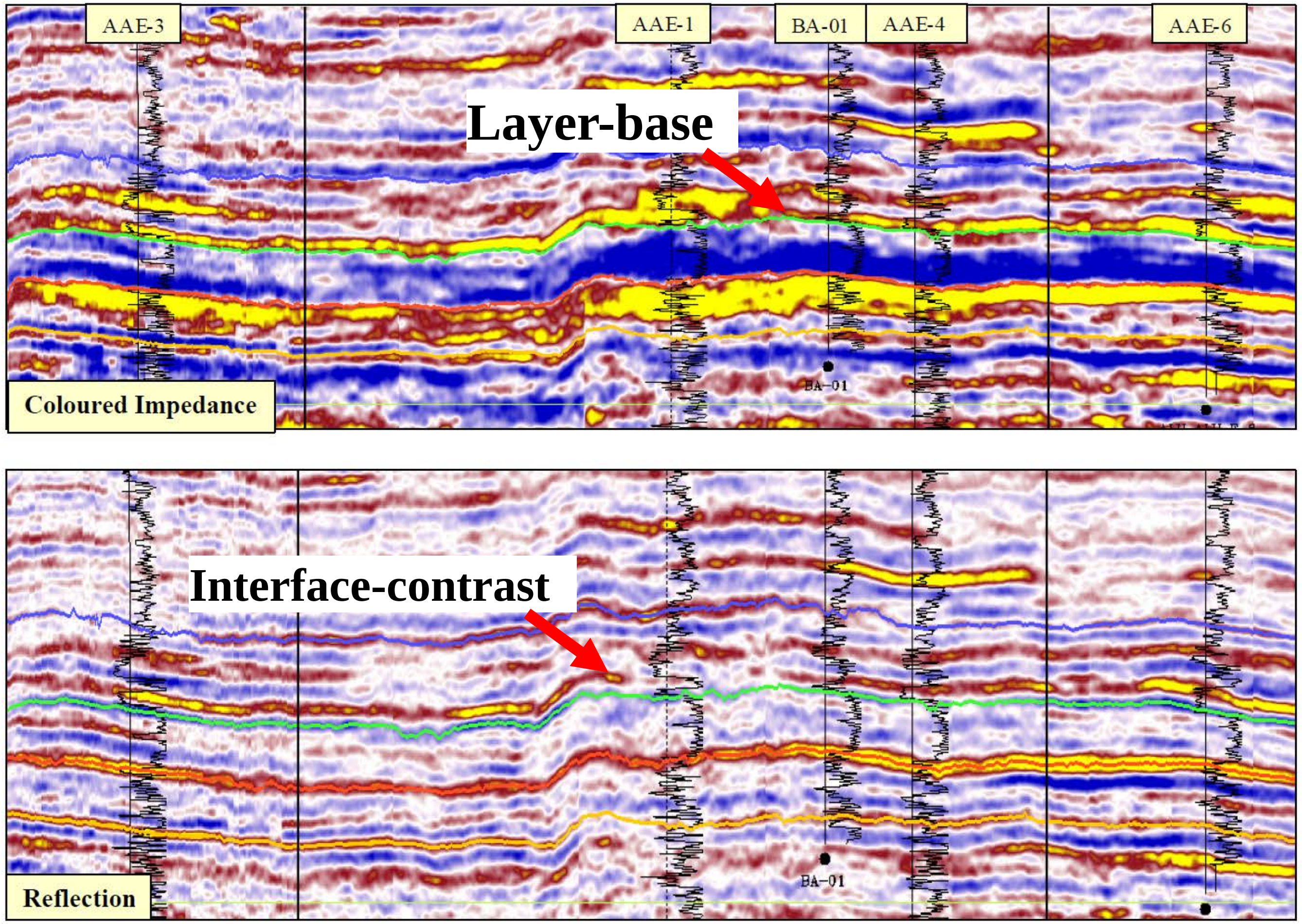
Methodology: Coloured Inversion (CI)

Idea:

- Match the seismic data to well acoustic impedance spectrum (within seismic frequency band)

Delivery:

- Relative acoustic impedance which indicates hard-soft rock properties



Comparison coloured impedance to reflection data in Belida field, Indonesia (Maynard et al., 2003)

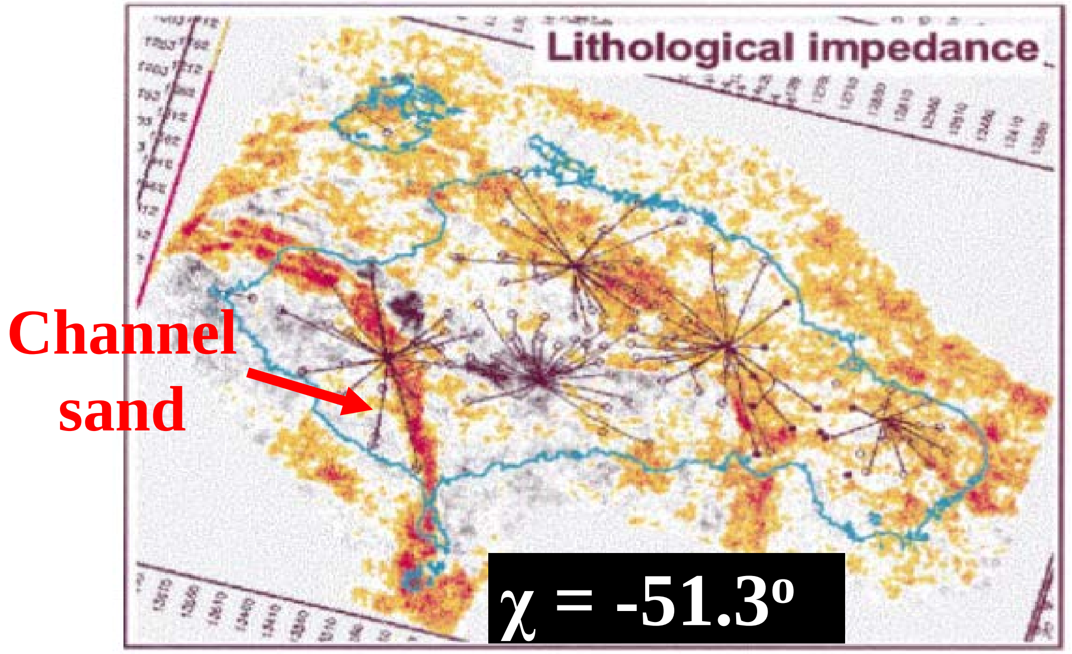
Methodology: LFP from Extended Elastic Impedance (EEI)

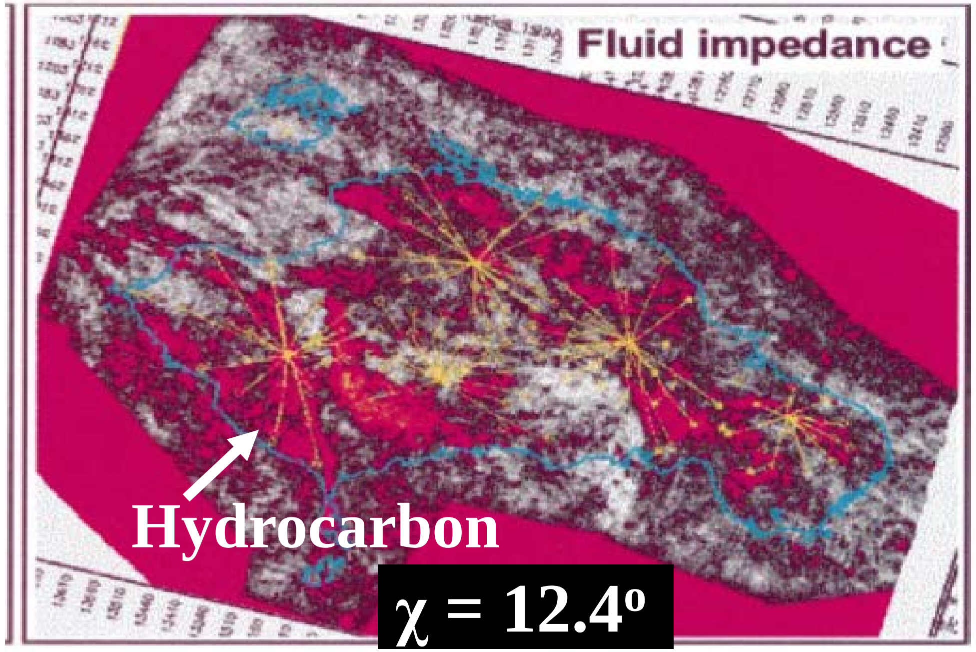
Idea :

- The rotation of EEI in impedance domain is similar to rotation of intercept and gradient in reflectivity domain.

Delivery:

- Mean of fluid and lithology seismic impedance volume from a defined rotation angle χ





Average EEI from top reservoir for the Forties field central North Sea (Whitcombe et al., 2001)

Methodology : Bayesian Inversion

Bayesian's Principle

(Posterior distribution) $\longrightarrow$ $p(x|m) \sim p(x) * p(m|x)$

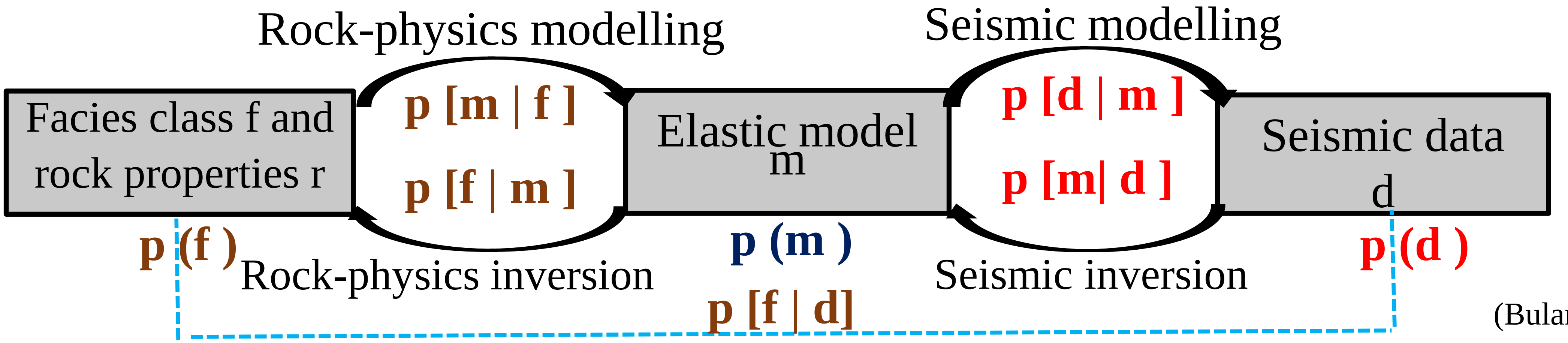
Prior distribution — **Likelihood function**

Prior Distribution is everything we know about the subsurface prior to the inversion

Likelihood is match between synthetic and actual seismic

Idea of Bayesian inversion:

- Combines stochastic rock physics with the fast Bayesian seismic simultaneous inversion



(Buland et al., 2008)

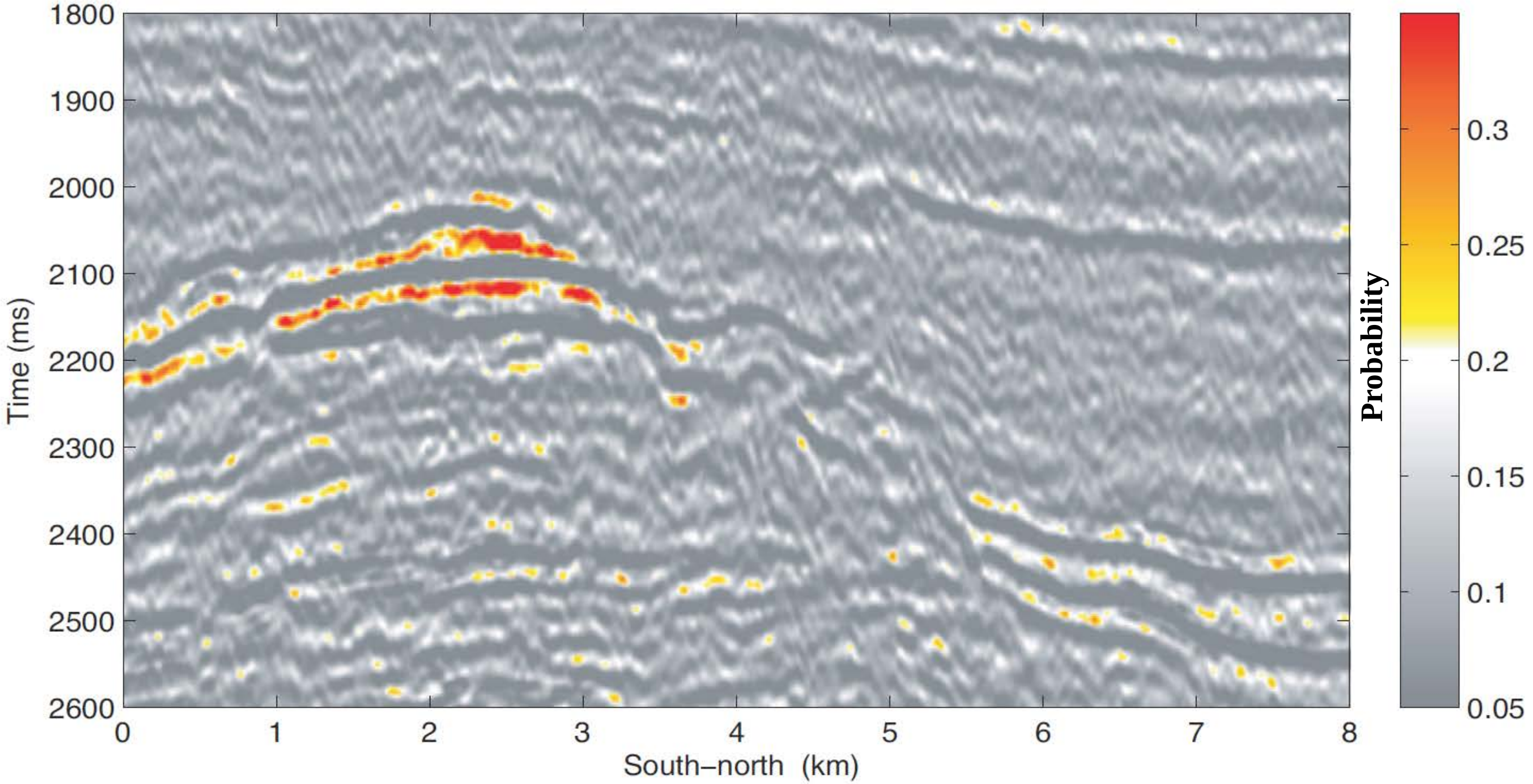
Methodology: Bayesian Inversion

Delivery:

- Probability cube of lithology and fluid classes

Advantage:

- Quantify the uncertainties in realistic way, especially in minimum well control area



(Buland et al., 2008)

Posterior probability for gas sand

Time Frame

ACTIVITY	January				February				March				April				May				June	
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
Discuss outline and design workflow																						
Main Research study																						
1. Analyze well log to find the LFC																						
2. Define elastic rock properties vs LFCs																						
3. Color inversion																						
4. EEI cube to define angle of LFCs response																						
5. Spatial probability model for LFCs																						
6. Background model																						
7. Inversion model																						
8. Interpreted inversion result in form of P(LFC) cube																						
First Draft																						
1. Write the methodology chapters																						
2. Write the procedure chapter for implication case																						
3. Write the conclusion on implication case																						
Final Draft																						
1. Check error and polish																						
2. Prepare for submission																						
3. Consult with supervisor																						
4. Read																						
Submit MSc thesis																						

THANK YOU & ANY QUESTION?

Prospect Evaluation in Nordland Ridge

Prateek Saxena

Department of Petroleum Geoscience
University of Stavanger

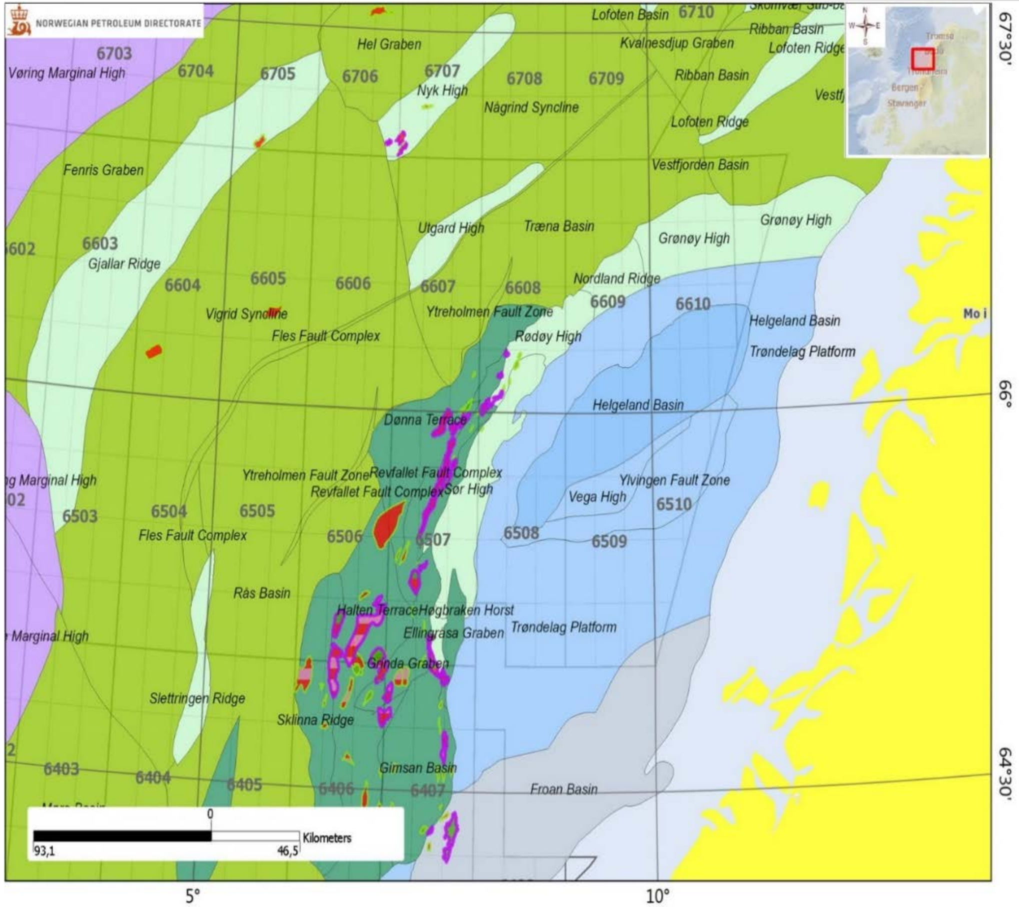
Supervisor: Sylvia Nordfjord

University of Stavanger and Statoil ASA

University of Stavanger

Agenda

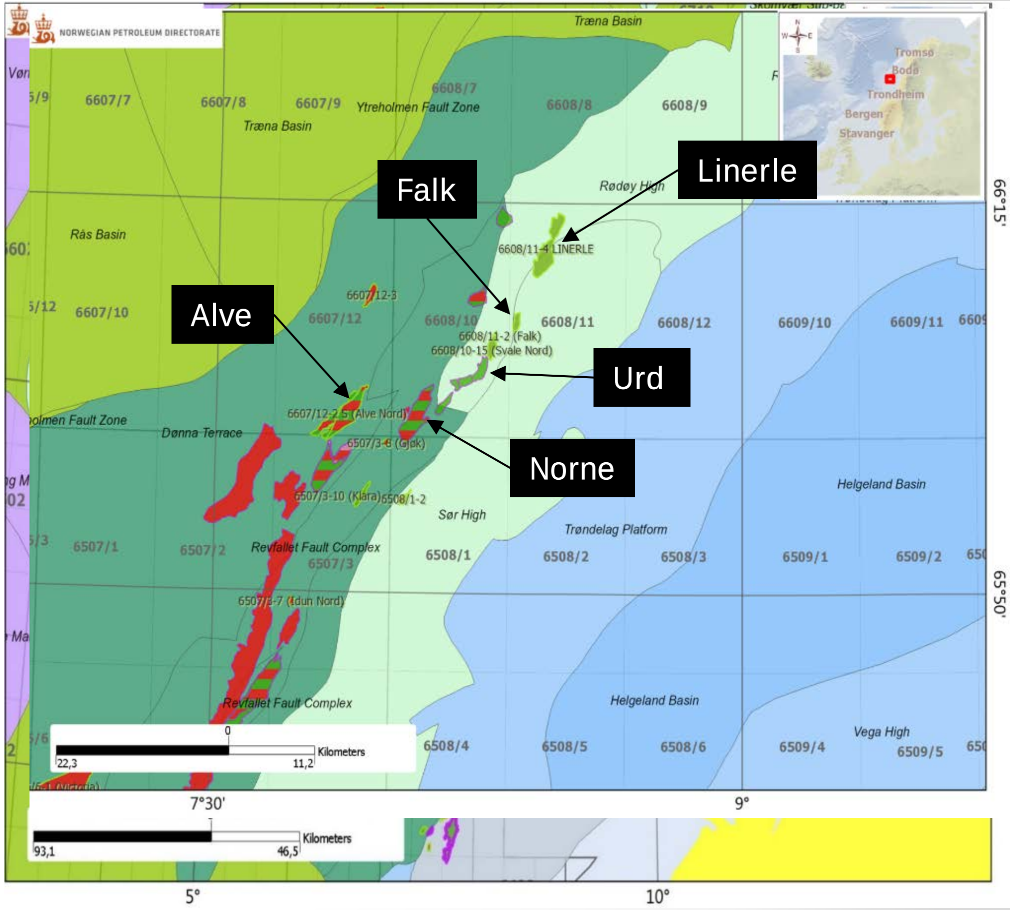
- Introduction
- Regional setting
- Geological problem
- Objective
- Data
- Methodology
- Timeline



(Modified from NPD FactMaps, 2015)

Introduction

- Nordland Ridge
- Previous discoveries



(Modified from NPD FactMaps, 2015)

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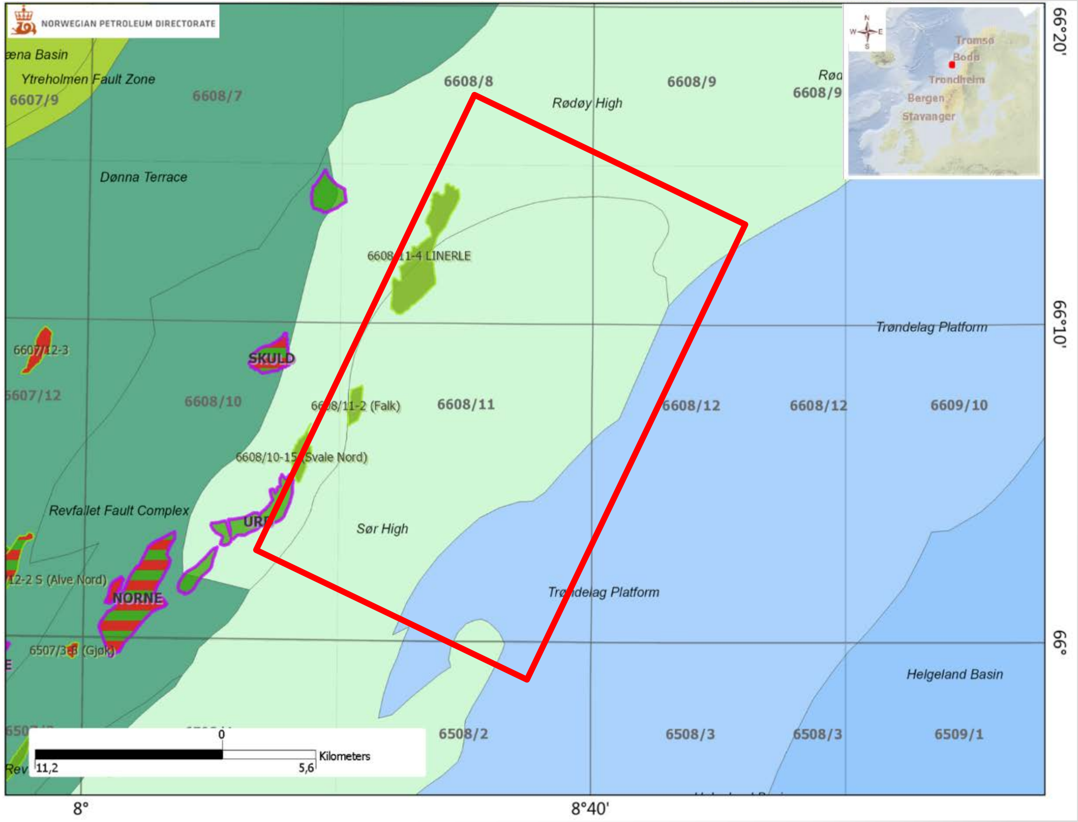
Regional setting

Area of interest

- Extension
  - Late Middle Jurassic
  - Early Cretaceous
- Nordland ridge
- 6608/11
- Inversion
  - Middle and Late Cretaceous
  - Early Tertiary
- Erosion
  - Several episodes
  - Late Cretaceous-Early Tertiary



(Modified from NPD FactMaps, 2015)

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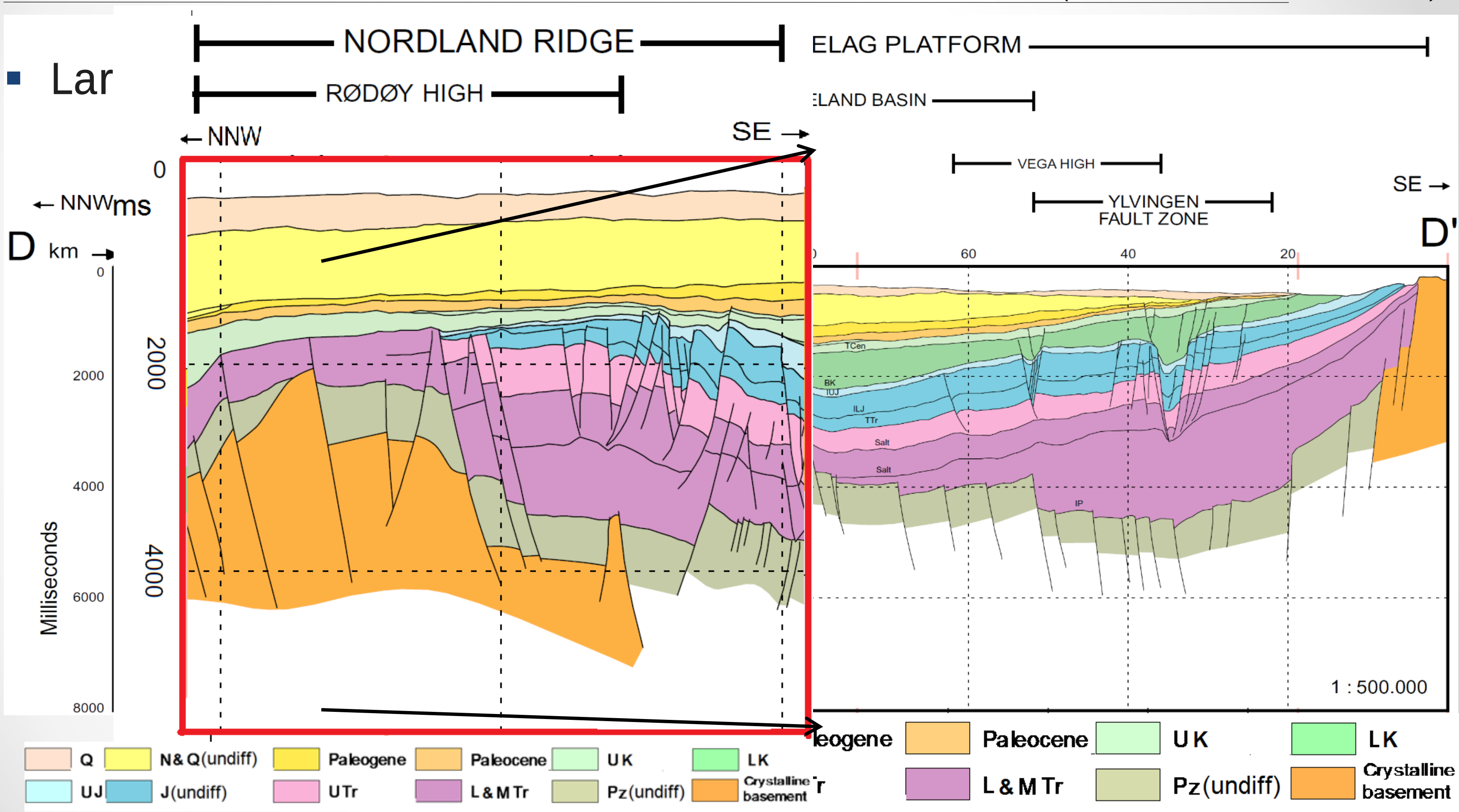
Regional setting

(Modified from NPD Bulletin No. 8, 1995)

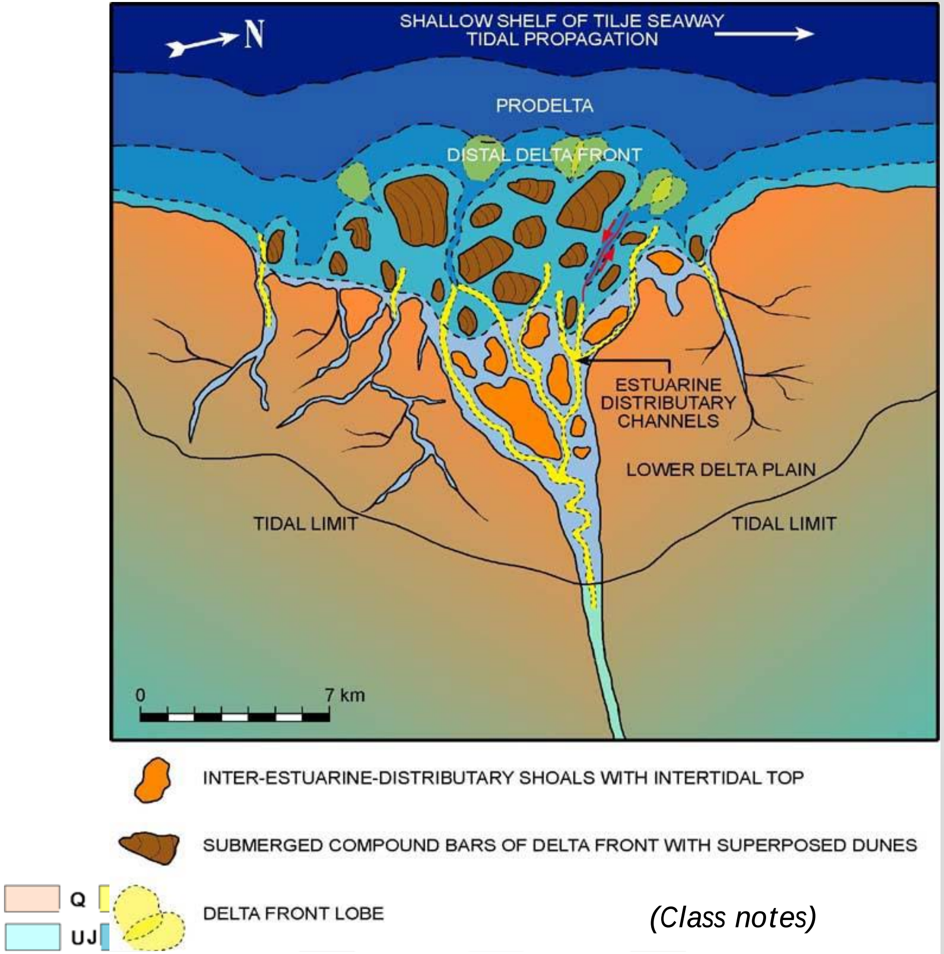
- Lar



Regional setting

(Modified from NPD Bulletin No. 8, 1995)

- Large internal faulting
- Båt group
  - Åre
  - Tilje
  - Tofte
  - Ror
- Cretaceous seal



(Class notes)

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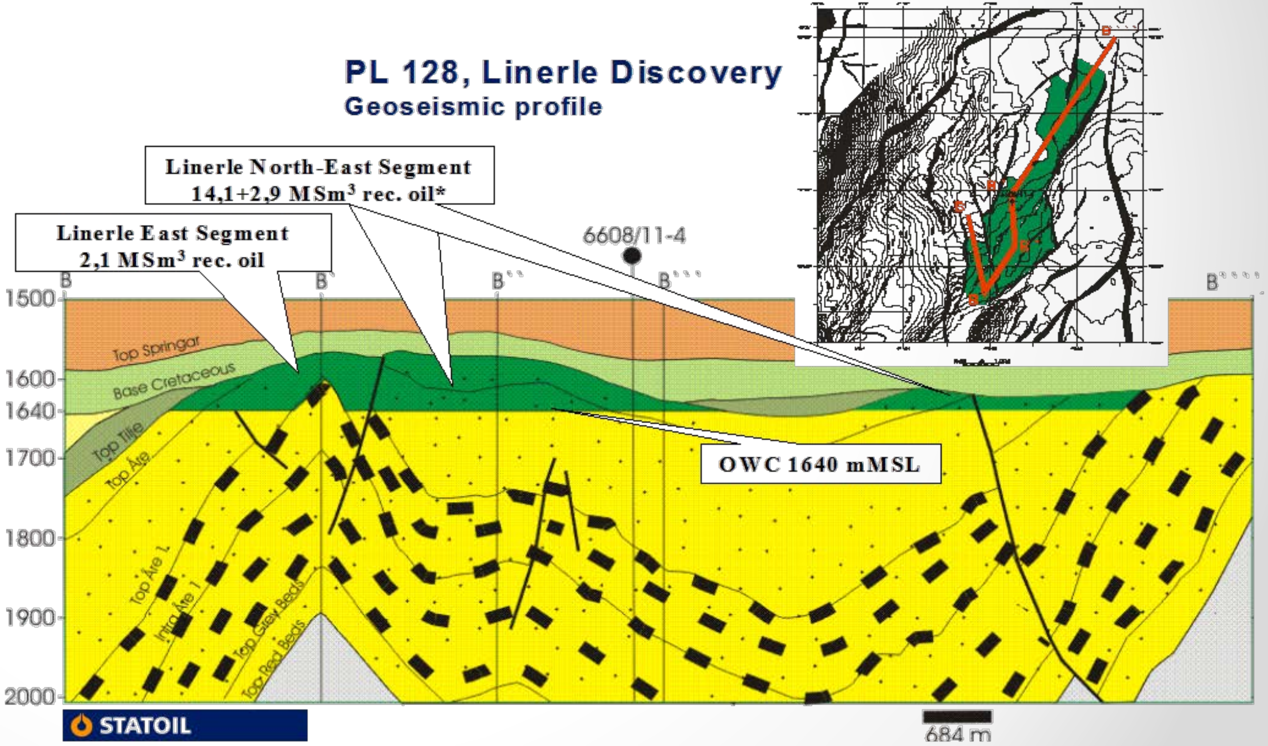
Geological problem

- Seal
  - Erosion
  - Faulting
- Migration
  - Faulting
- Heavy oil
  - High viscosity
  - High wax content



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Objectives

- Investigate the potential of hydrocarbon prospectivity along the Nordland Ridge.
- In order to determine the existence of a petroleum system we would need to:
  - Investigate basin framework to better understand the development of trap mechanism.
  - Examine regional source rock maturation to determine the extent of the hydrocarbon charge.
  - To analyze possible migration risks due to extensive faulting in the region.

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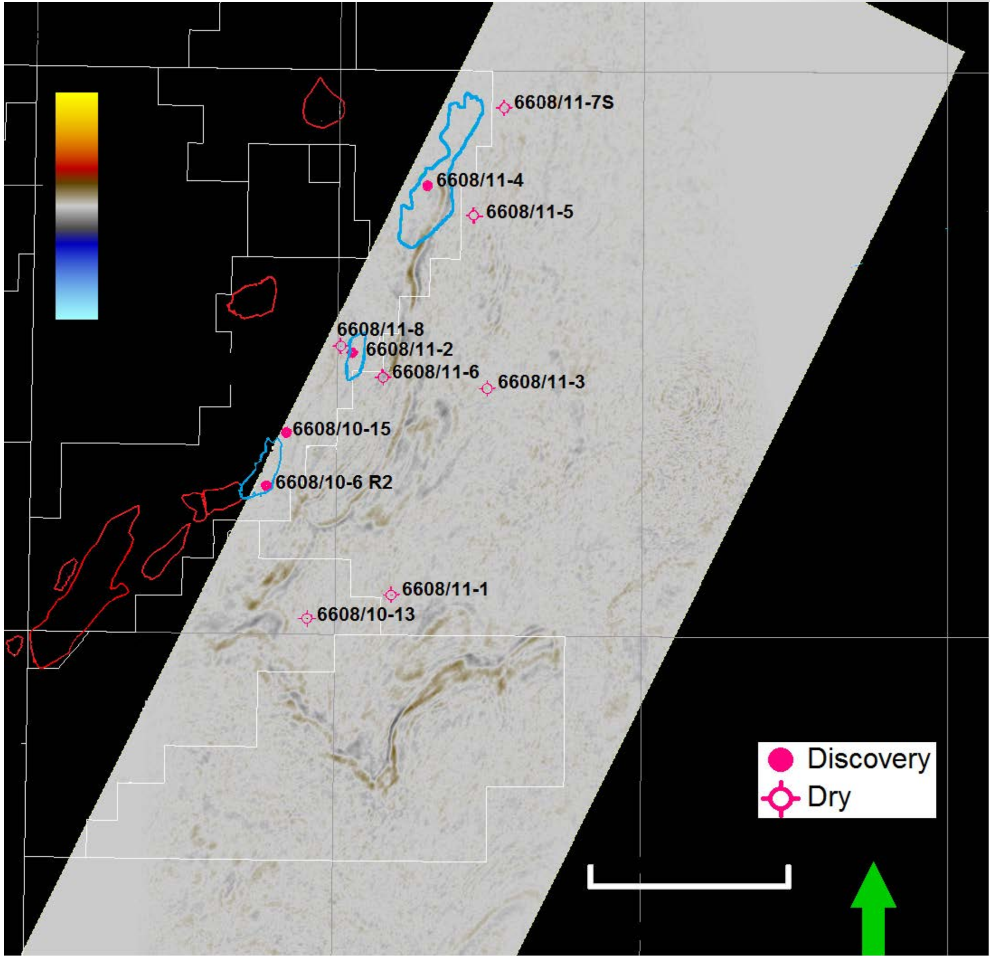
Data

- ST13M09 3D survey
- RS1002 survey
- Well data from 11 wells



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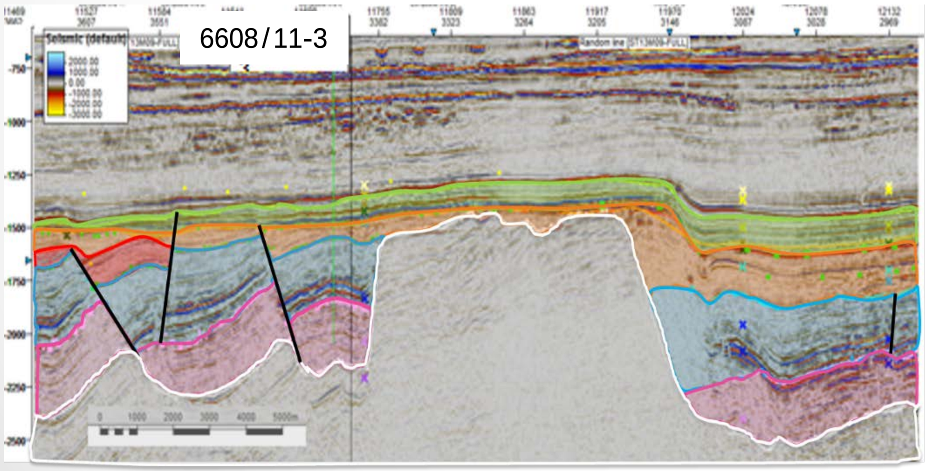
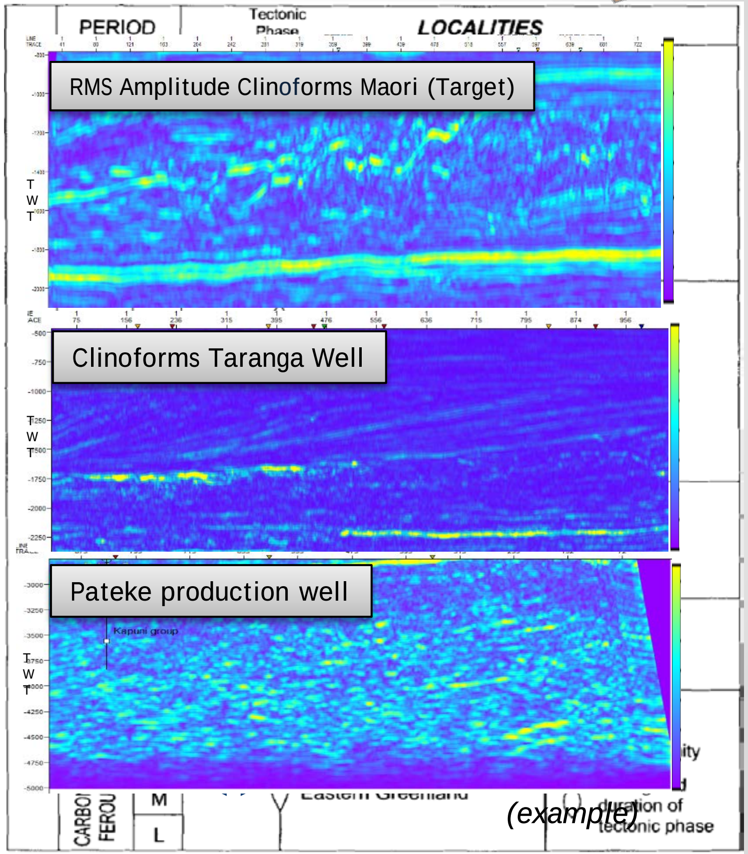
Methodology

- Basin focus
  - Regional tectonostratigraphic framework
  - Well correlation
  - Seismic attributes
  - Fault throw and seal assessment





(from Brekke et al., 2001)

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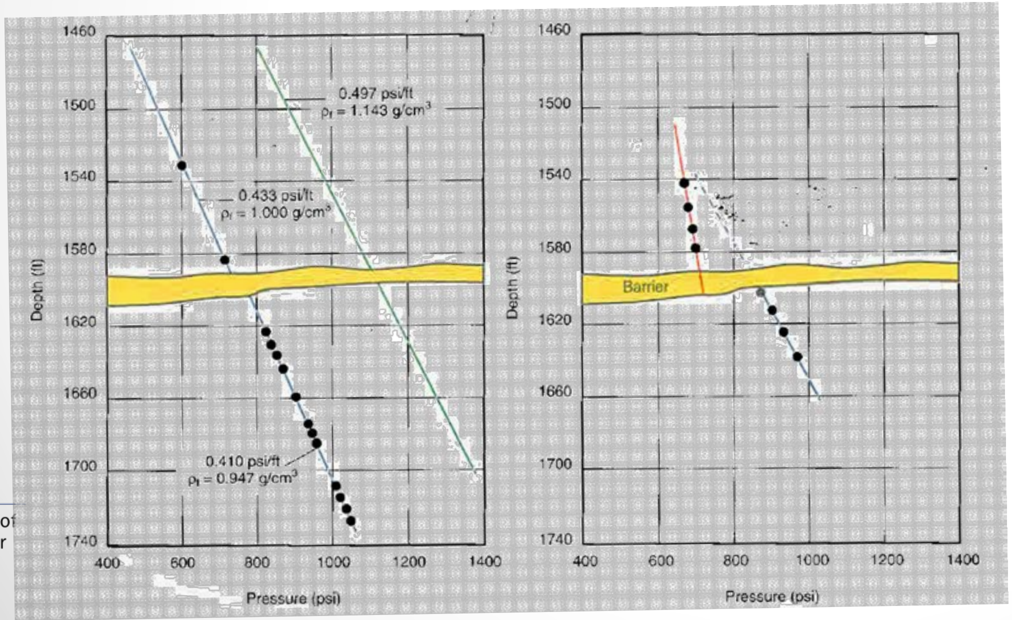
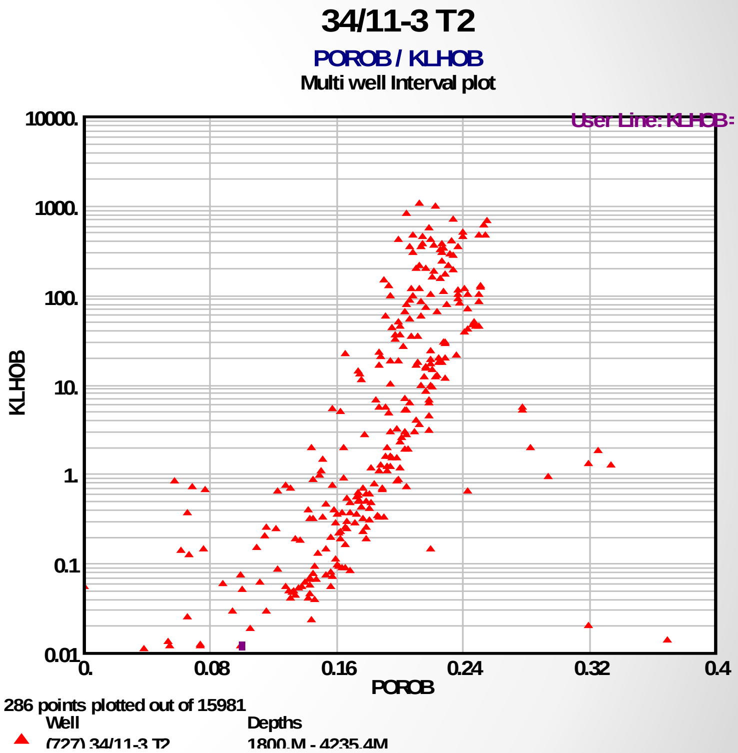
Methodology

- Basin focus
  - Crossplots
    - Porosity vs Permeability
    - Porosity vs Depth
  - Pressure data for seal capacity





(Class notes)

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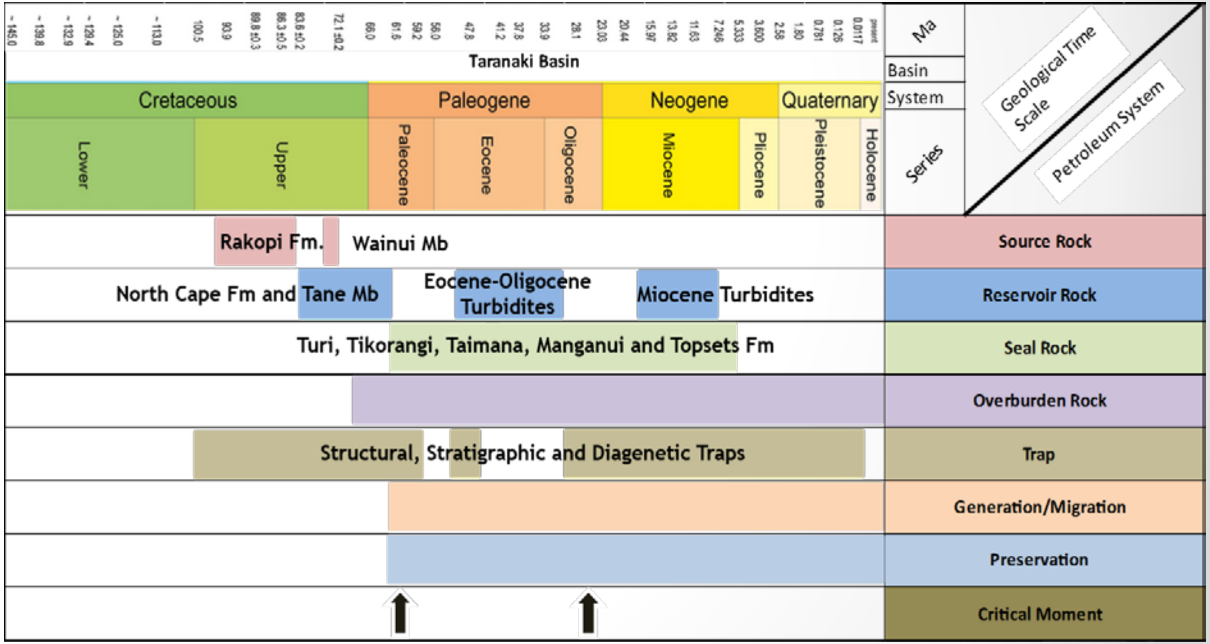
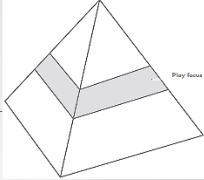
Methodology

- Basin focus
  - Petroleum system event chart



(example)

Methodology



- Play definition
  - Delineation (isochore, structural, paleo-geographic maps)
  - Dry well analysis
  - Analogues

Ariki-1					
Objective : Test prospects associated with major Cretaceous Rifting					
Source	Migration	Reservoir	Charge	Seal	Trap

Wainui-1					
Objective: Evaluate Pakawau Formation					
Source	Migration	Reservoir	Charge	Seal	Trap

Witiora-1					
Objective: Test potential reservoirs from the Miocene Mokau formation					
Source	Migration	Reservoir	Charge	Seal	Trap

Taranga-1					
Objective: Large faulted four-way dip closure mapped at top Cretaceous level					
Source	Migration	Reservoir	Charge	Seal	Trap

Tane -1					
Objective: Test reservoir potential of Pakawau Group					
Source	Migration	Reservoir	Charge	Seal	Trap

Kora-1					
Objective: Evaluate Eocene Tangaroa Sandstone Member					
Source	Reservoir	Trap	Migration	Charge	Seal

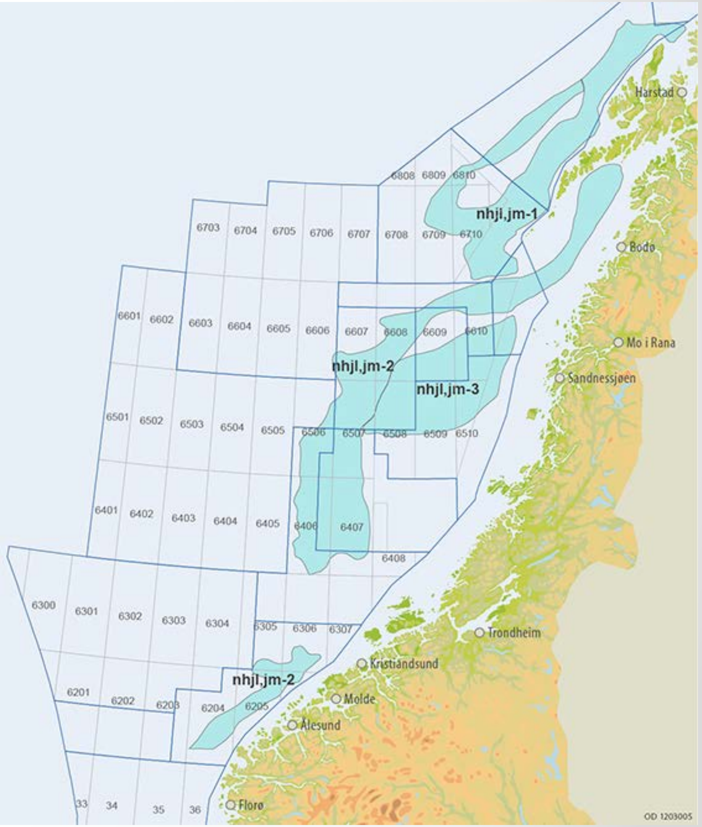
- Long term production test sustained an average flow rate of 668 BOPD.

Tui-1					
Objective: Basement High					
Source	Reservoir	Seal	Trap	Migration	Charge

- Penetrated 10 meters of high quality crude in Kapuni F Sandstone

Pateke 2					
Objective: Test the Paleocene Kapuni F reservoir					
Source	Reservoir	Seal	Trap	Migration	Charge

- Penetrated 12 meters of high quality crude oil



(NPD, 2015)

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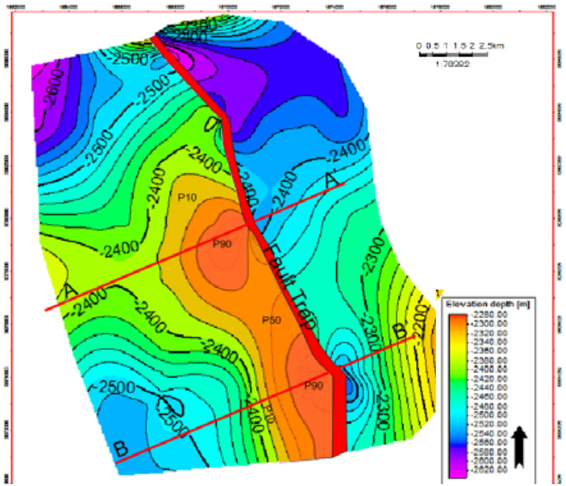
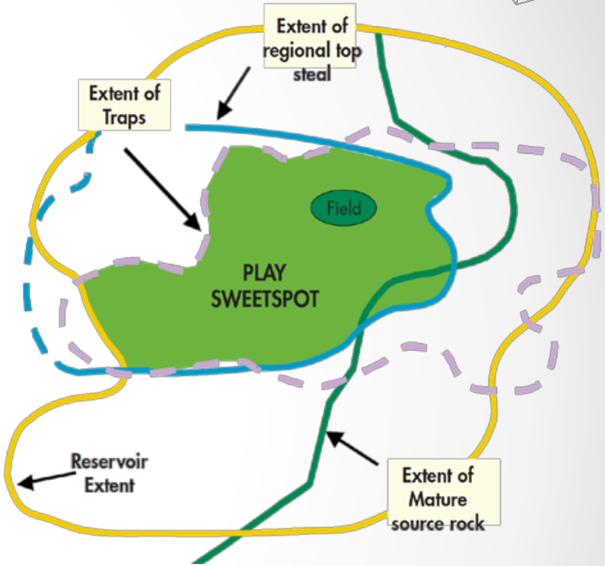
Methodology

- Prospect focus
  - Map of prospects and play outlines
  - Contour maps spill points (p10, p50, p90 cases)
  - GeoX
    - Gross rock volume
    - Risk analysis



prospect contour map (example)



(Prospect evaluation guide, Shell E&P)

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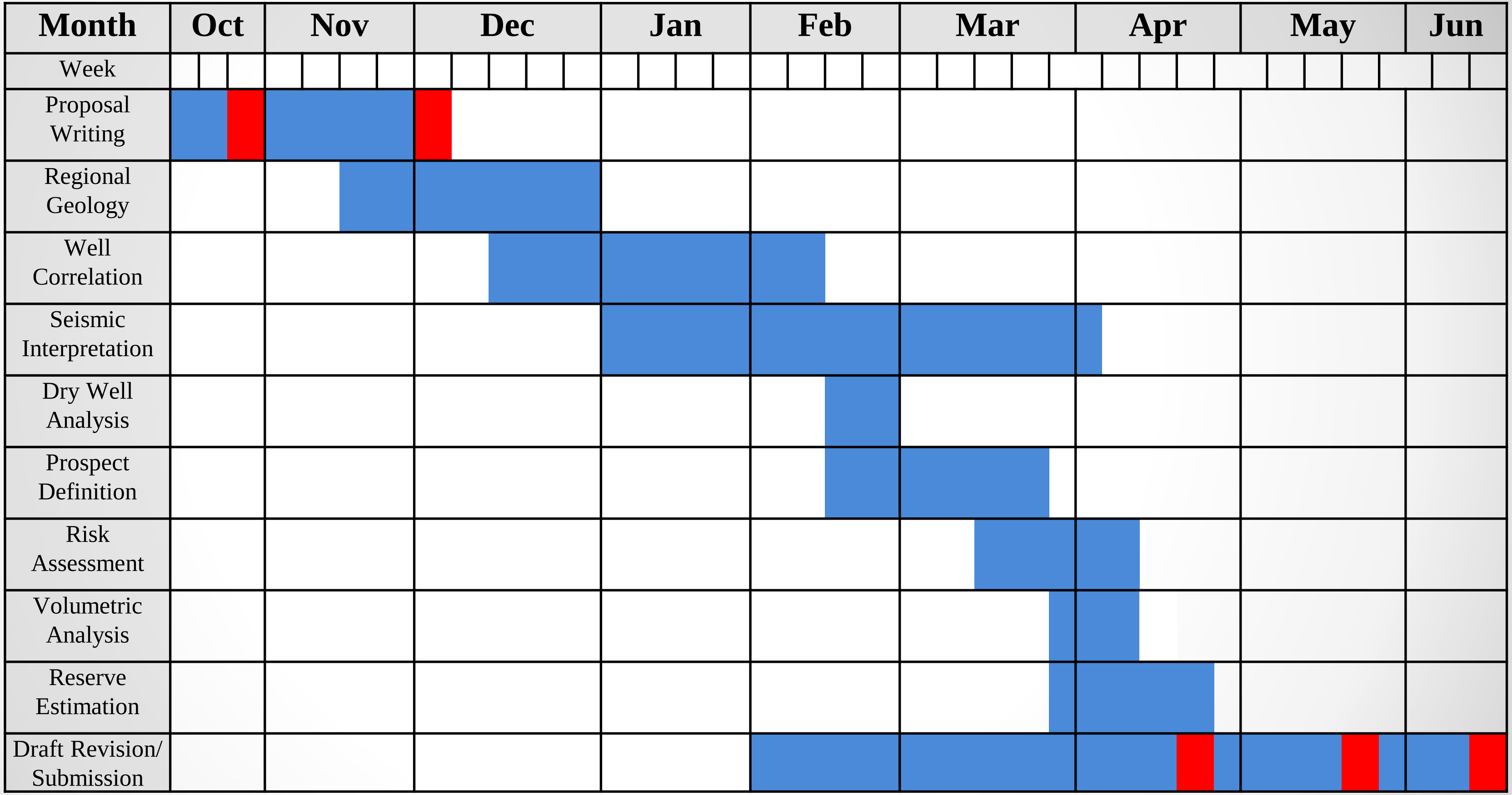
Timeline


Month
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Week
Proposal Writing
Regional Geology
Well Correlation
Seismic Interpretation
Dry Well Analysis
Prospect Definition
Risk Assessment
Volumetric Analysis
Reserve Estimation
Draft Revision/ Submission

THANK YOU

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