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

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
- 15-minute oral presentation with 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

- 8:00-9:10 – Presentations
- 9:10-9:25 – Coffee break
- 9:25-10:45 – Presentations
- 10:45-11:00– Coffee break
- 11:00-12:00 – Presentations
- 12:00-12:05 – Orec MSc prizes
- 12:05-13:00 – Lunch in Optimisten Cantine
- 13:00-14:20 – Presentations
- 14:20-14:35 – Coffee break
- 14:35-16:00 - Presentations

Interpretation, modelling, and halokinetic evolution of salt diapirs in the Nordkapp Basin

Master thesis proposal by:

Luis Alberto Rojo

Supervisors:

- *Alejandro Escalona (University of Stavanger)*
- *Lothar Schulte (Schlumberger)*
- *Sultan Abdullah Sayghe (Schlumberger)*

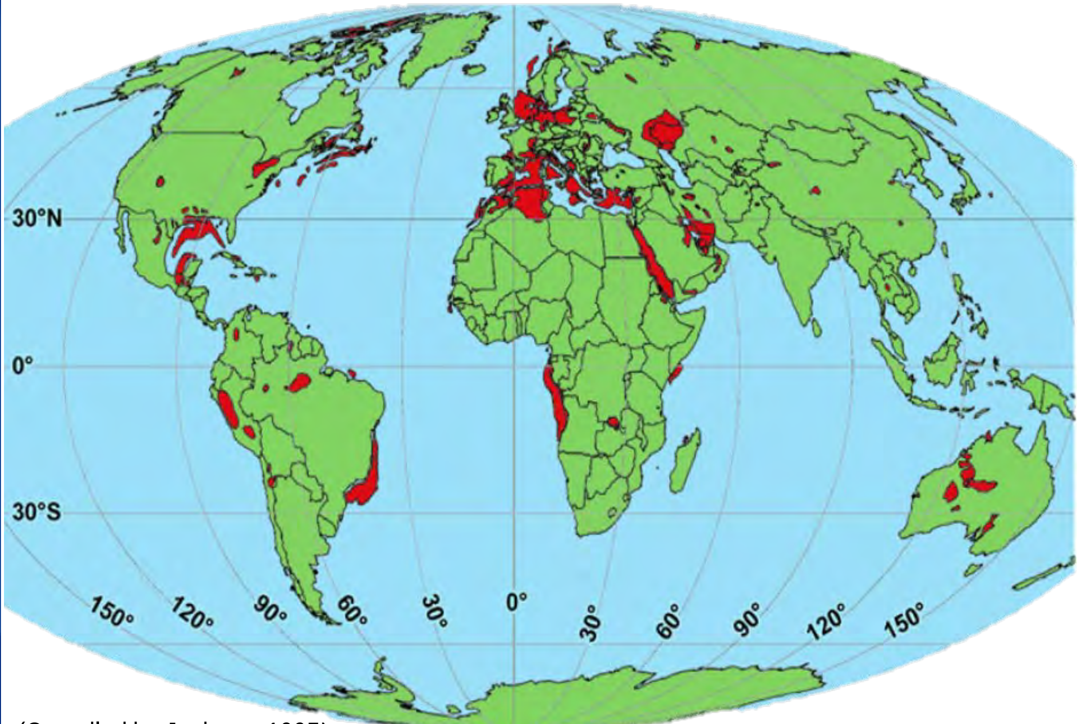
(Photographs by Jackson, 2004)

University of Stavanger

Agenda

- Salt background
- Introduction
  - Salt Properties
  - Salt-related Petroleum Plays
  - Salt-related Problems
- Previous work
- Objectives
- Dataset
- Methodology
- Time Frame

Background



(Compiled by Jackson, 1995)

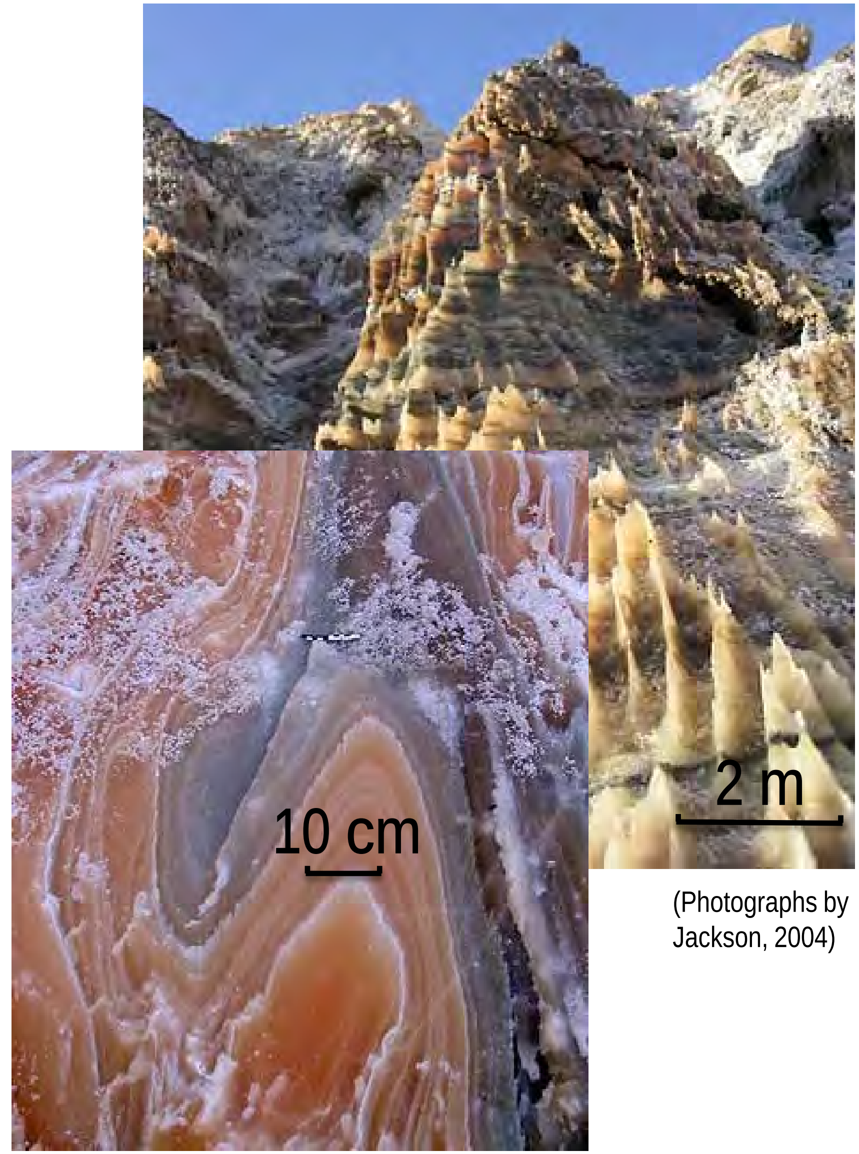
(Stiles et al.,2008)

- First discovery located in Beaumont (Texas)
- Attractive areas for hydrocarbon exploration
- Many of the world´s largest fields are located in salt-related hydrocarbon provinces
- Examples: North Sea, Zagros, Campos Basin, Santos Basin, Gulf of Mexico, and Lower Congo Basin.

Introduction

Salt Properties

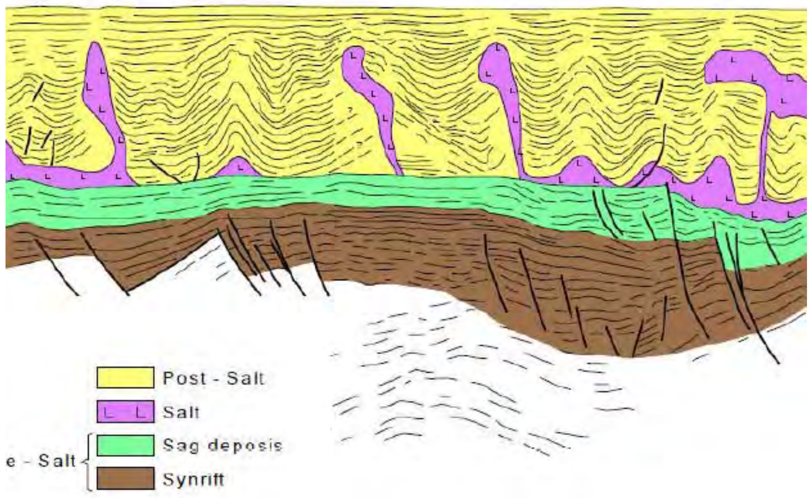
- Composition: Halite (NaCl), gypsum (CaSO4), and anhydrite.
- Additionally, it can be interbedded with carbonates and fine grain siliciclastics.
- Viscous, behaves as a fluid
- Low density (2,160 g/cm3)
- Causes wide areas of deformation
- High thermal conductivity
- Creation of top and side seals of hydrocarbon accumulations



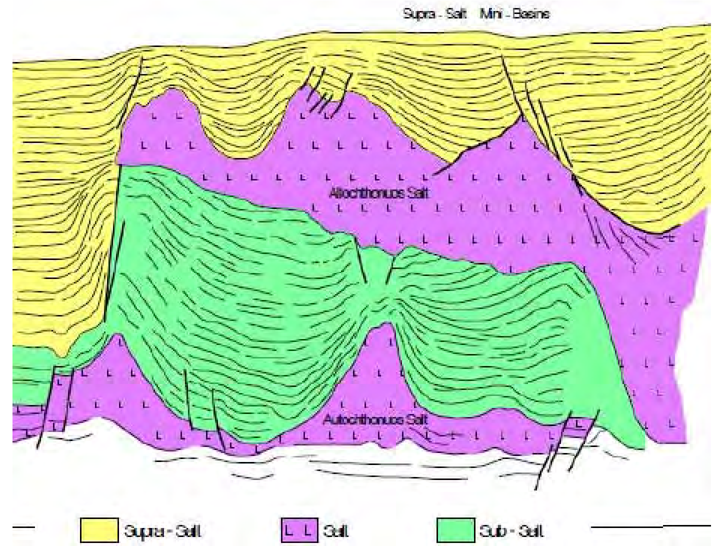
(Photographs by Jackson, 2004)

Introduction

Salt-related Petroleum Plays

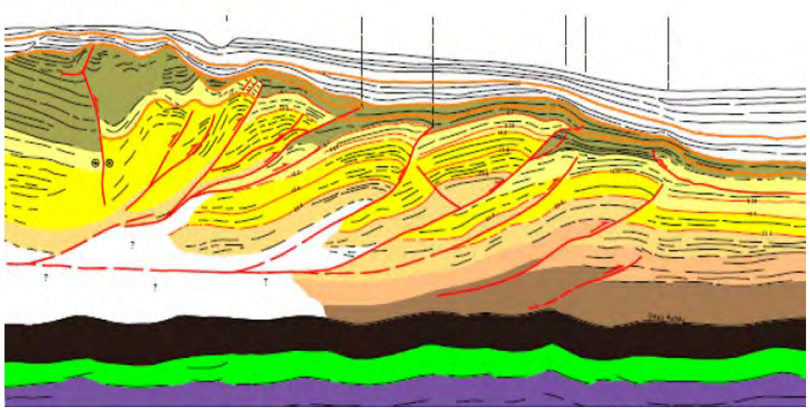


Pre-Salt Play

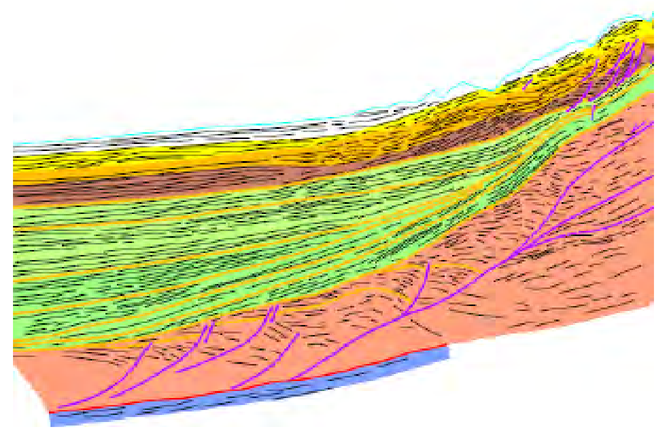


Sub-Salt Play

(Modified after Duerto, 2010)



Folded Belt Play



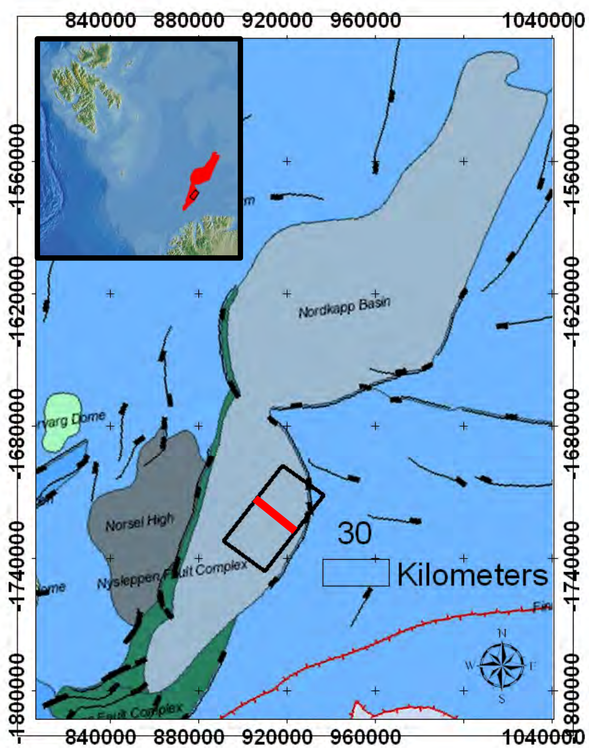
Stratigraphic Pinch –Out Play

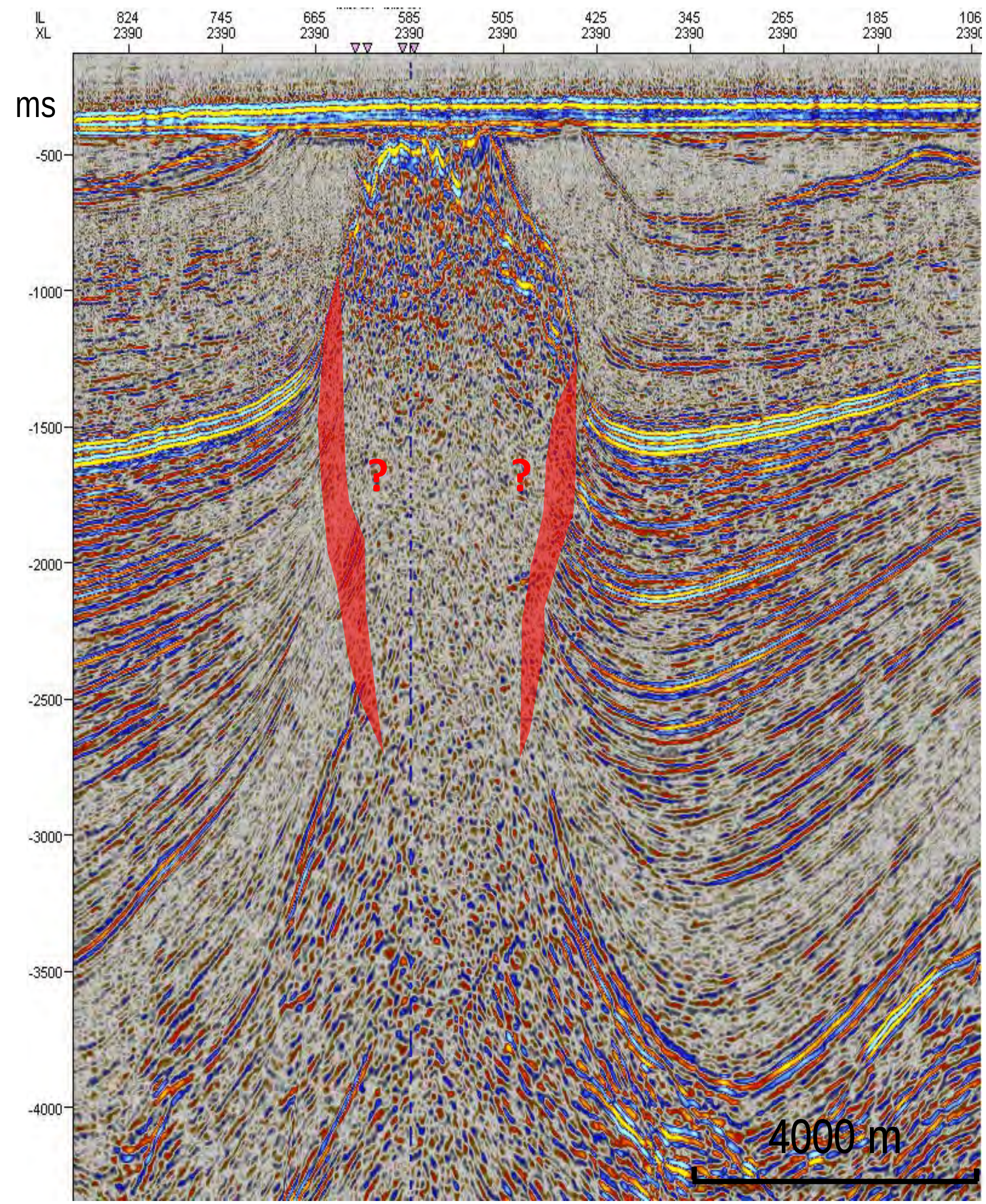
Introduction

Salt-related Problems

- Areas of uncertainty located mainly in salt flanks

- What are we missing in areas of uncertainty?





3D Cube ST9403_Xline 2390

Previous work

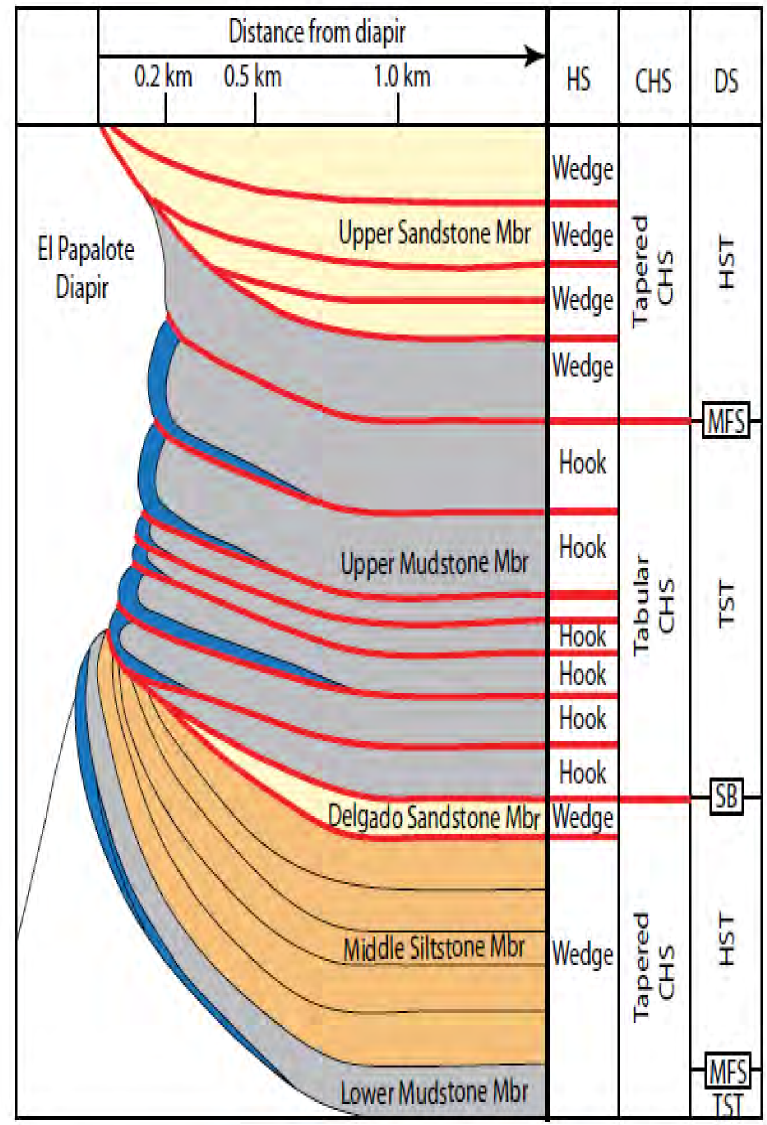
Composite Halokinetic Sequences:

- Formed in less than 1 Km from the diapir

Two types:

  - Tabular Composite Halokinetic Sequences
  - Tapered Composite Halokinetic Sequences

- Generated by changes in net diapir rise rate vs. net local sedimentation rate
- Important tools for predictions of trap geometries, reservoir characterization and distribution, and diapir evolution



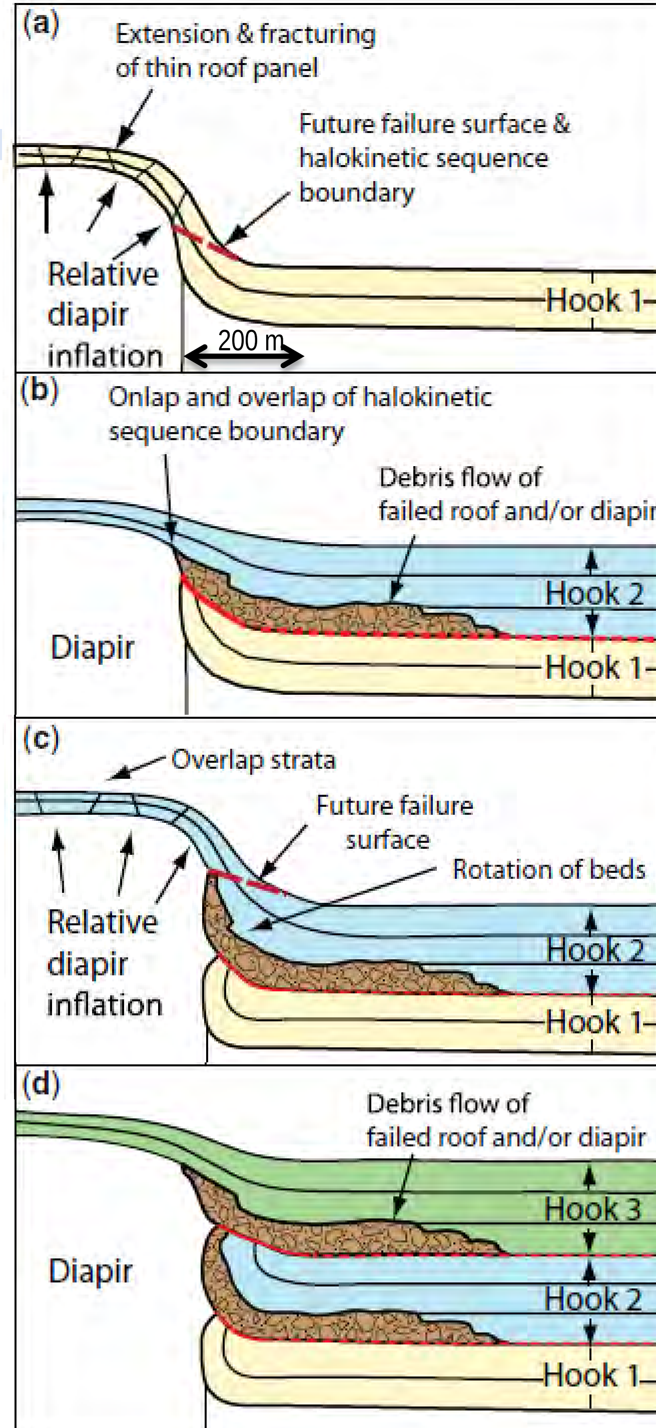
(Giles and Rowan, 2012)

Previous work

Tabular Composite Halokinetic Sequences

- Drape folding 50-200 m from diapir
- Slower deposition deposition leads to increase topographic relief
- This situation occurs during Transgressive System Tract Periods (TST). However, there are many exceptions
- Rapid changes in facies

(Giles and Rowan, 2012)

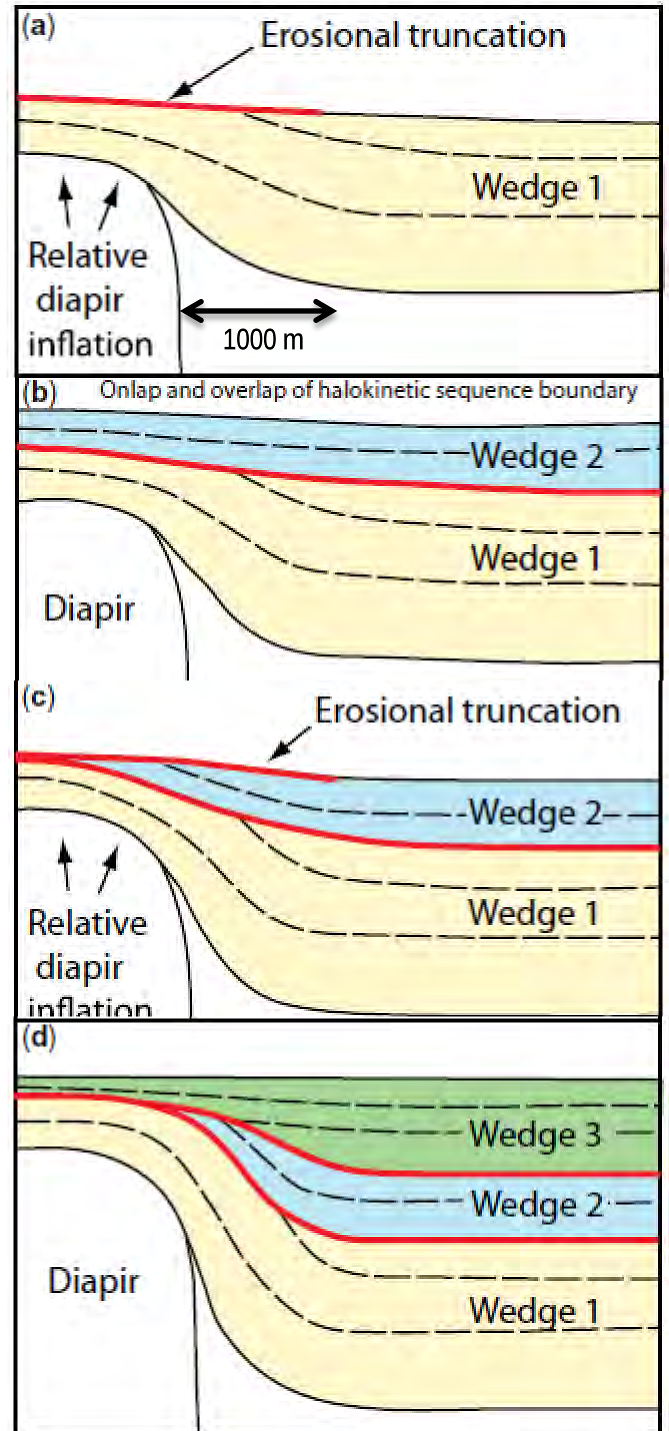


Previous work

Tapered Composite Halokinetic Sequences

- Overall sediment-accumulation rate adjacent to the diapir exceeds diapir – rise rate
- This situation occurs during Highstand System Tract periods (HST). However, other external factors might change this relationship
- Gradual facies changes

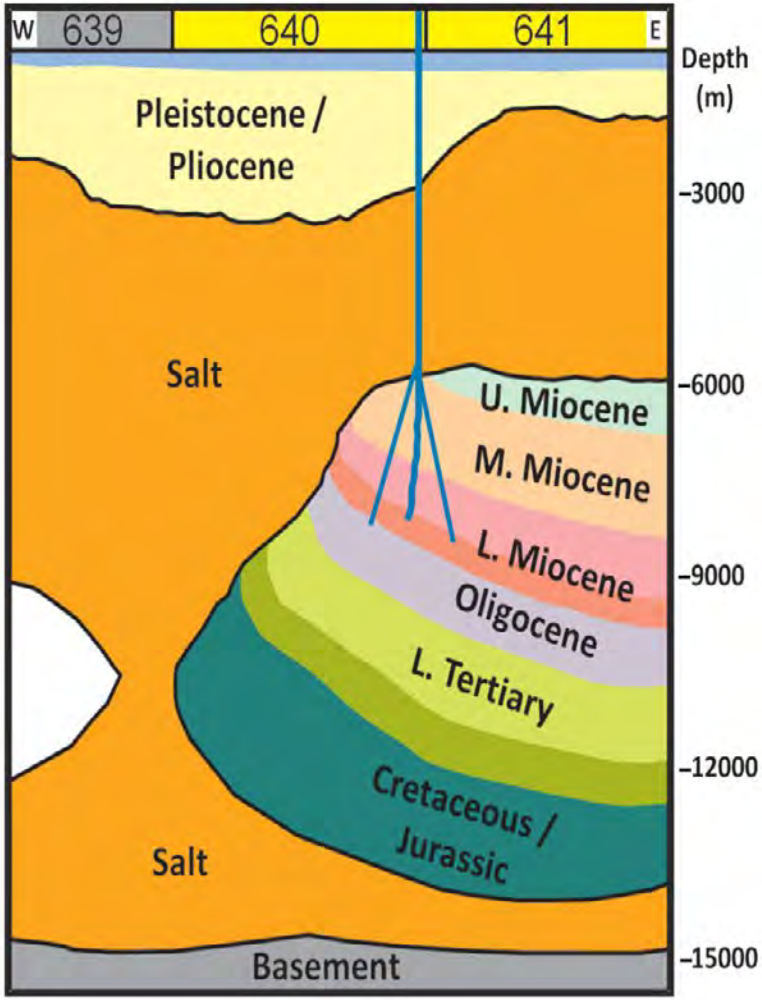
(Giles and Rowan, 2012)



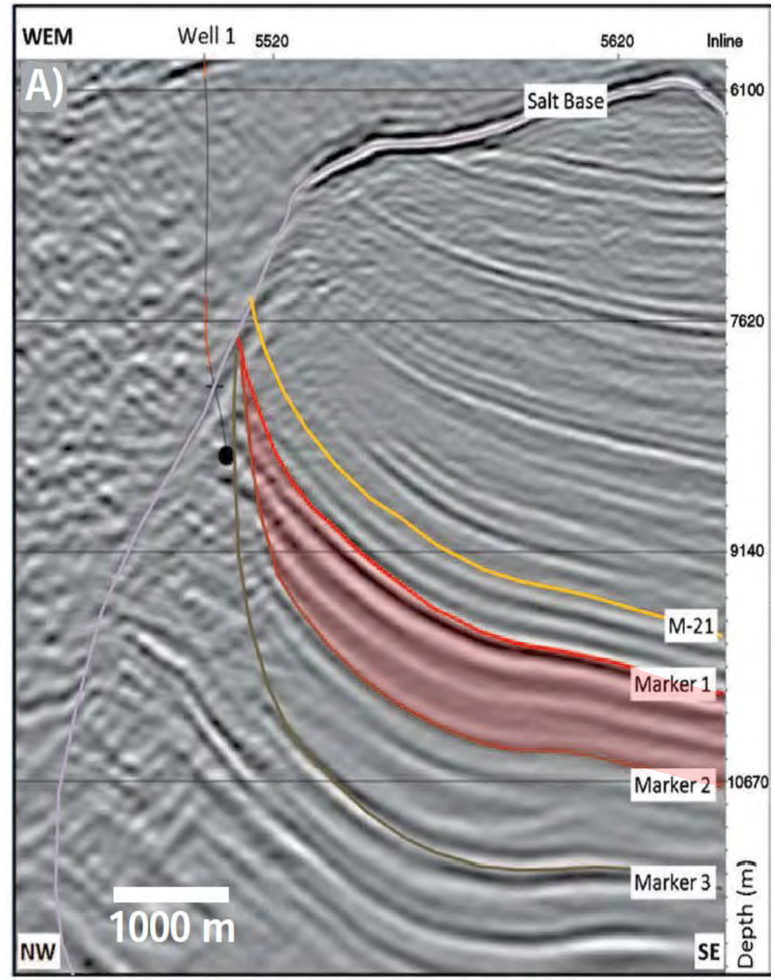
University of Stavanger

Some Pitfalls

Pre-well interpretation



Post-well interpretation

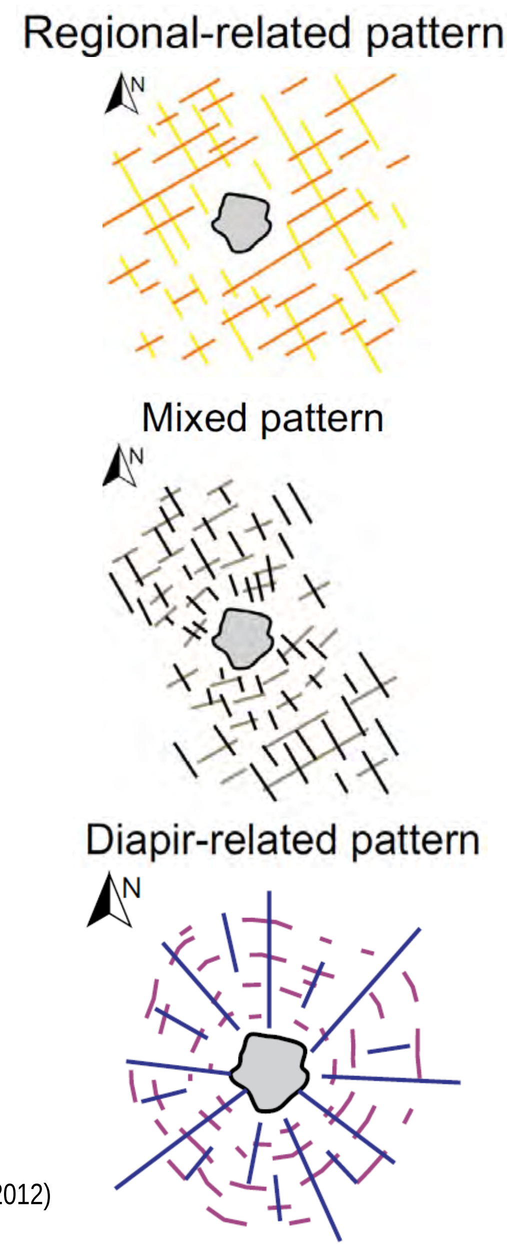


(Swanston et al., 2011)

Previous work

Analysis of structural elements close to salt diapirs

- Often not taken into consideration
- In fact, fractures play an important role in fluid flow and its accumulation in salt diapir-related reservoirs
- Faults/fractures can provide useful information for understanding diapir kinematics
- Can be separated into faults created by regional stress field, and fractures created by induced diapir stress field

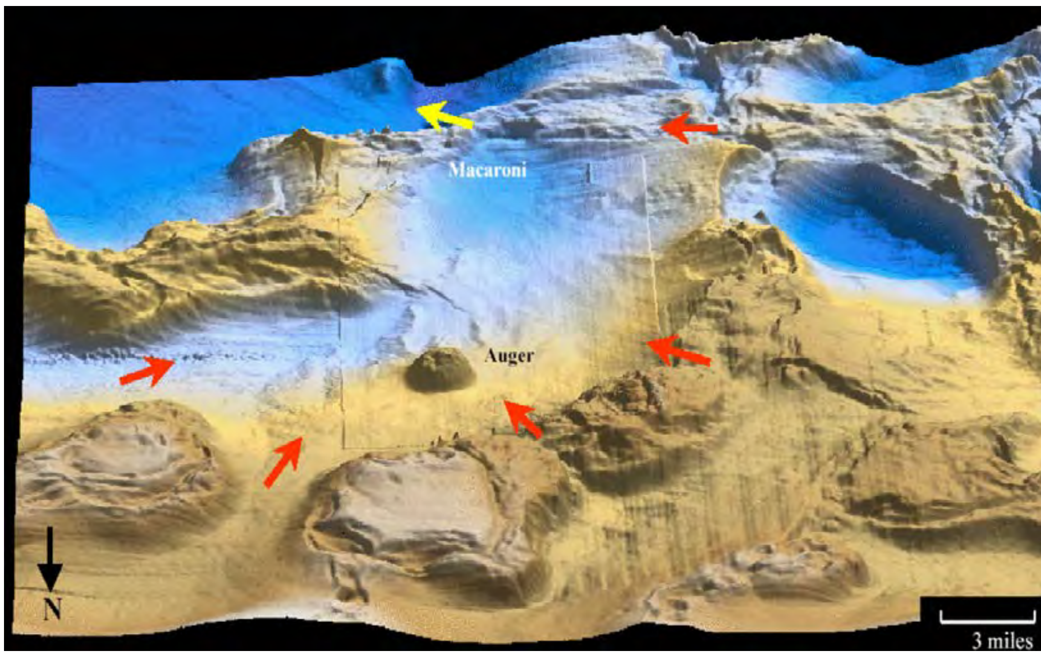


(Quintá et al, 2012)

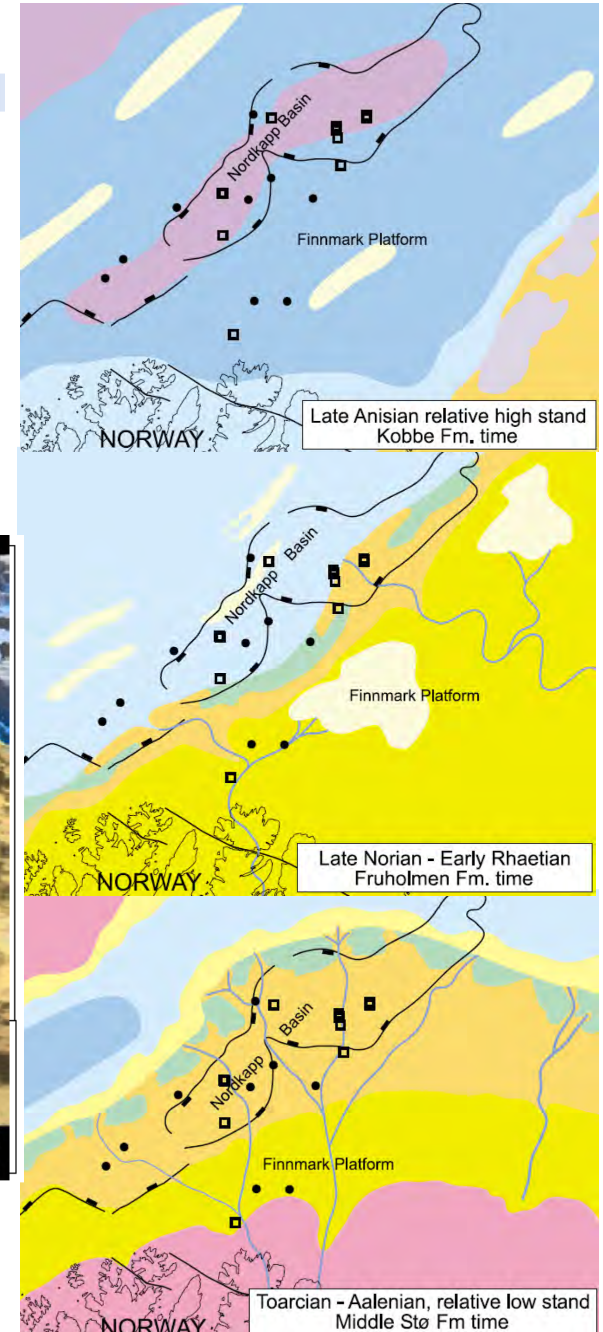
Previous work

Paleogeography of the Nordkapp Basin

- Are salt diapirs controlling the deposition in the Nordkapp Basin?



(Booth et al., 2000)



(Bugge et al., 2002)

Objectives

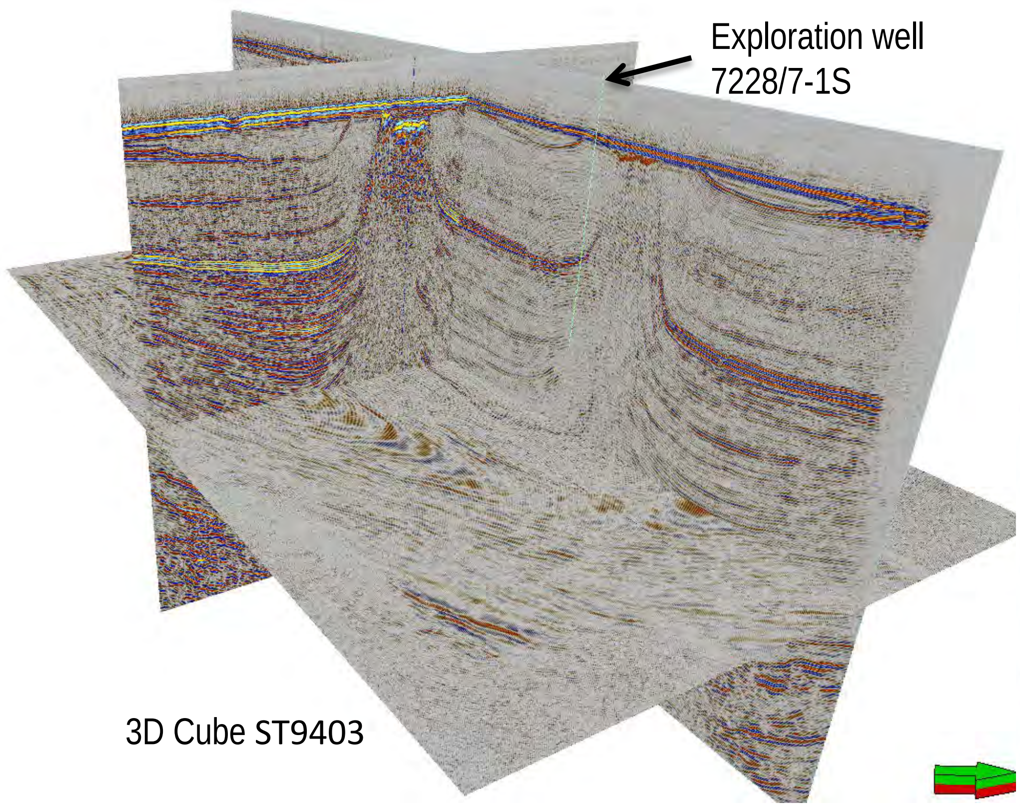
University of Stavanger

- (1) Investigate attribute workflows with the aim of defining accurately:
  - Salt diapirs boundaries,
  - Structural elements,
  - Composite halokinetic sequences
- (2) Investigate the types and origin of halokinetic sequences, and structural elements
- (3) Salt restoration: periods of salt-controlled sedimentation in the surface

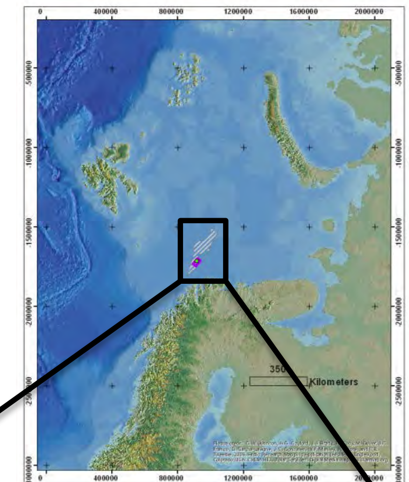
Dataset

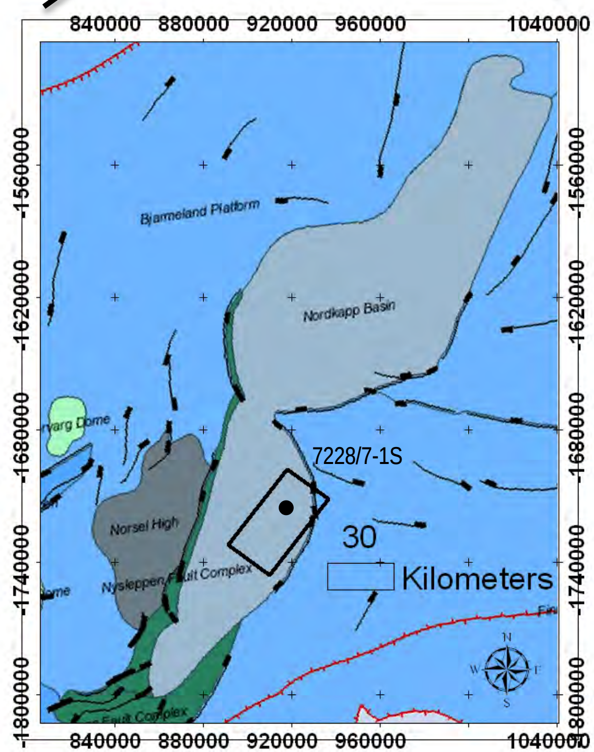
University of Stavanger

- Research area located in the southwestern sub-basin of the Nordkapp Basin
- Data provided by the Norwegian Petroleum Directorate
- 3D Seismic data covering 1010 Km^2
- Exploration Well 7228/7-1s
- Possibility to obtain 2D Seismic lines across the basin



3D Cube ST9403

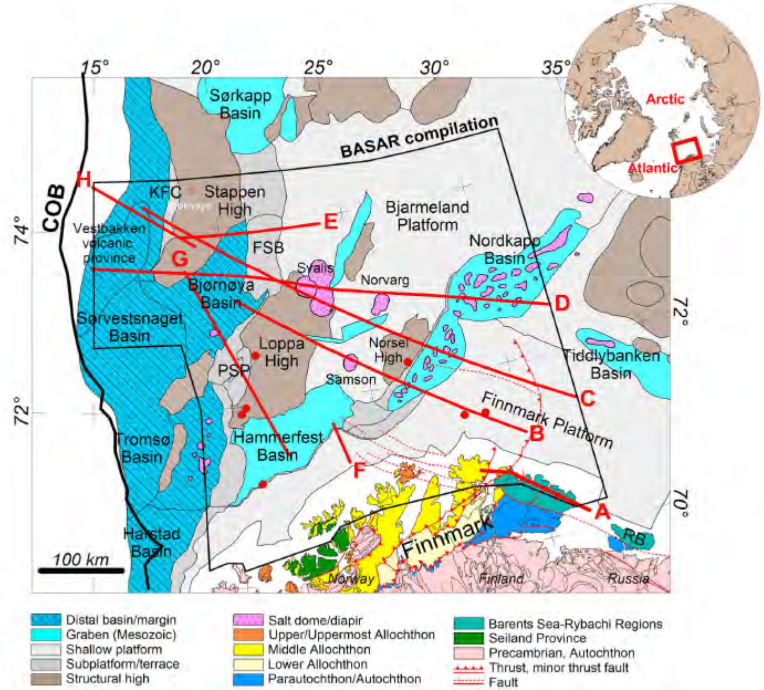




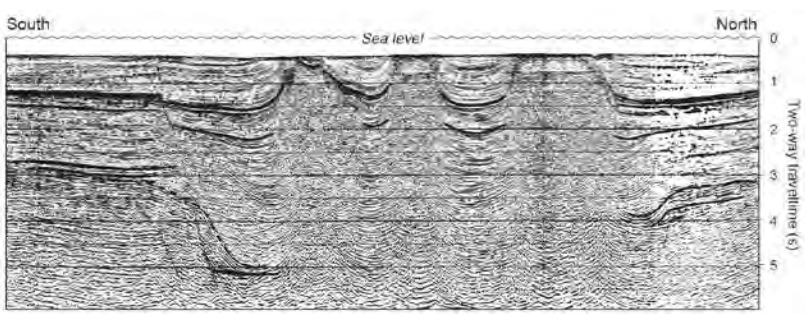
Methodology

(1) Regional Geology studies

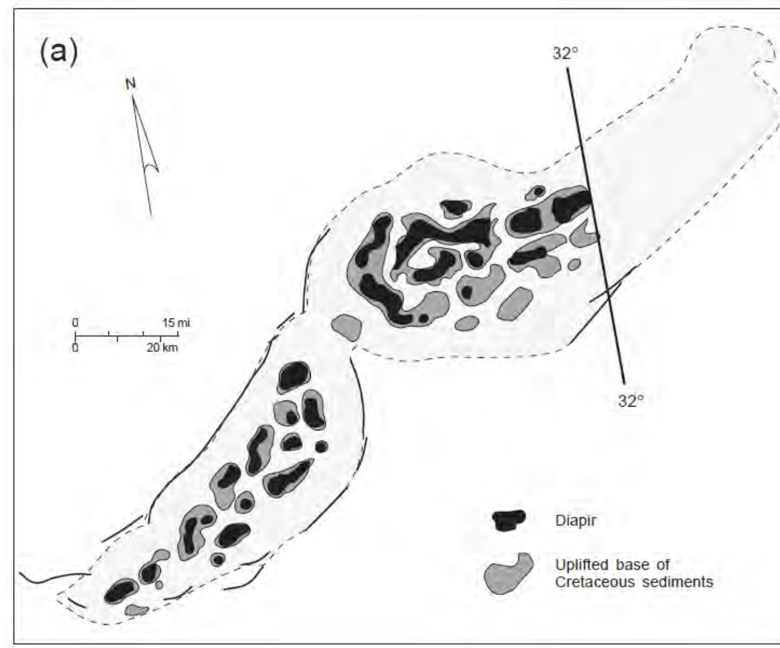
- Western Barents Sea from Late Paleozoic to Quaternary
  - Plate tectonic configuration
  - Main tectonic events and structural elements
  - Sedimentation
- Nordkapp Basin from Late Paleozoic to Quaternary:
  - Main tectonic events
  - Main halokinetic movements
  - Source rocks and reservoir deposition along the geological history



(Gernigon et al., 2014)



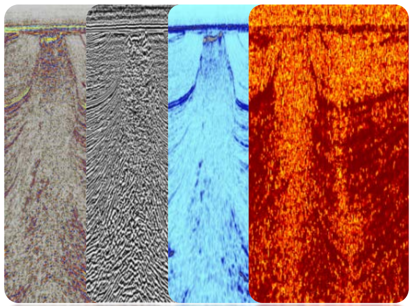
(Nilsen et al., 1995)



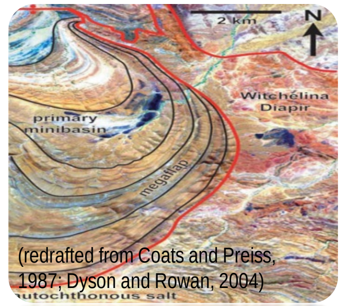
University of Stavanger

Methodology

2) Definition of salt bodies - Workflow

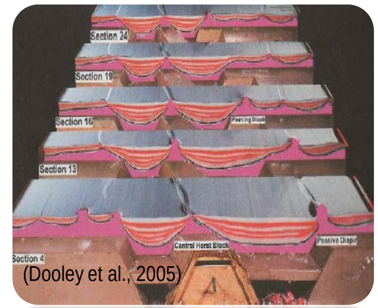


+



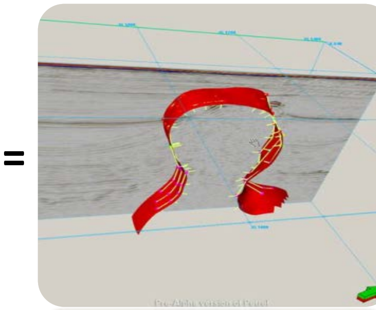
(redrafted from Coats and Preiss, 1987; Dyson and Rowan, 2004)

+



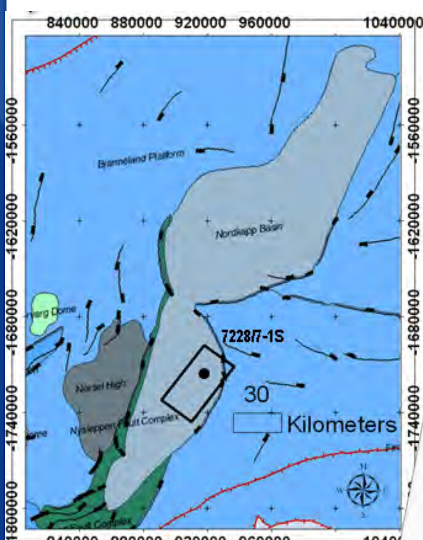
(Dooley et al., 2005)

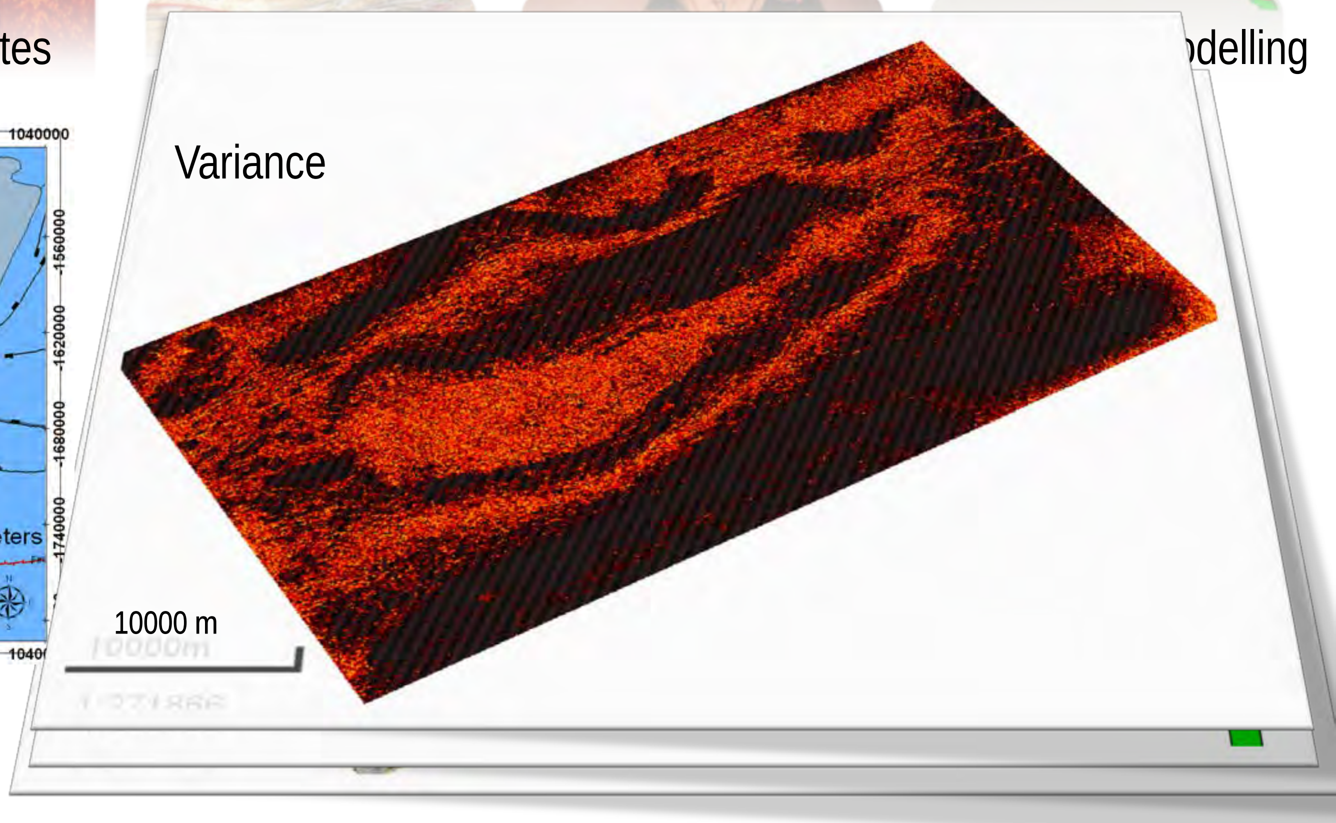
=



Seismic Attributes

delling

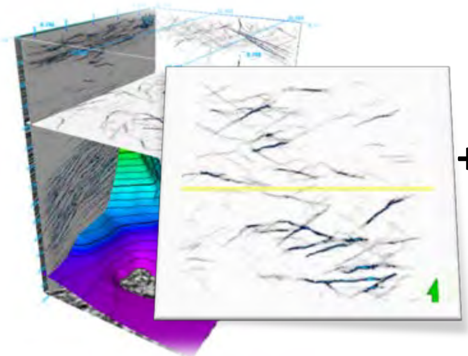




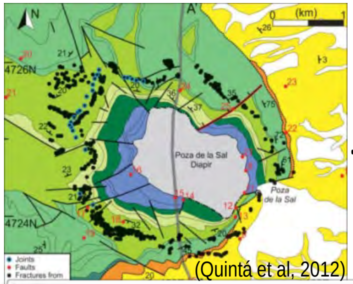
Time Slice - 652 ms

Methodology

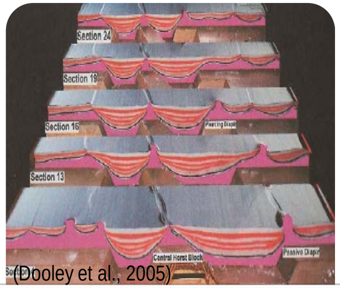
3) Structural elements - Workflow



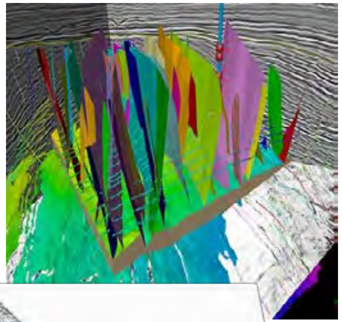
+



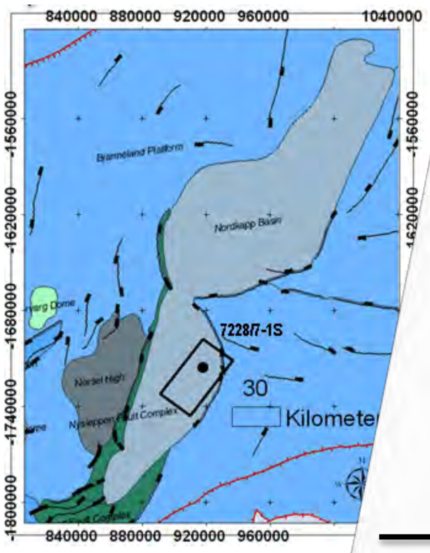
+

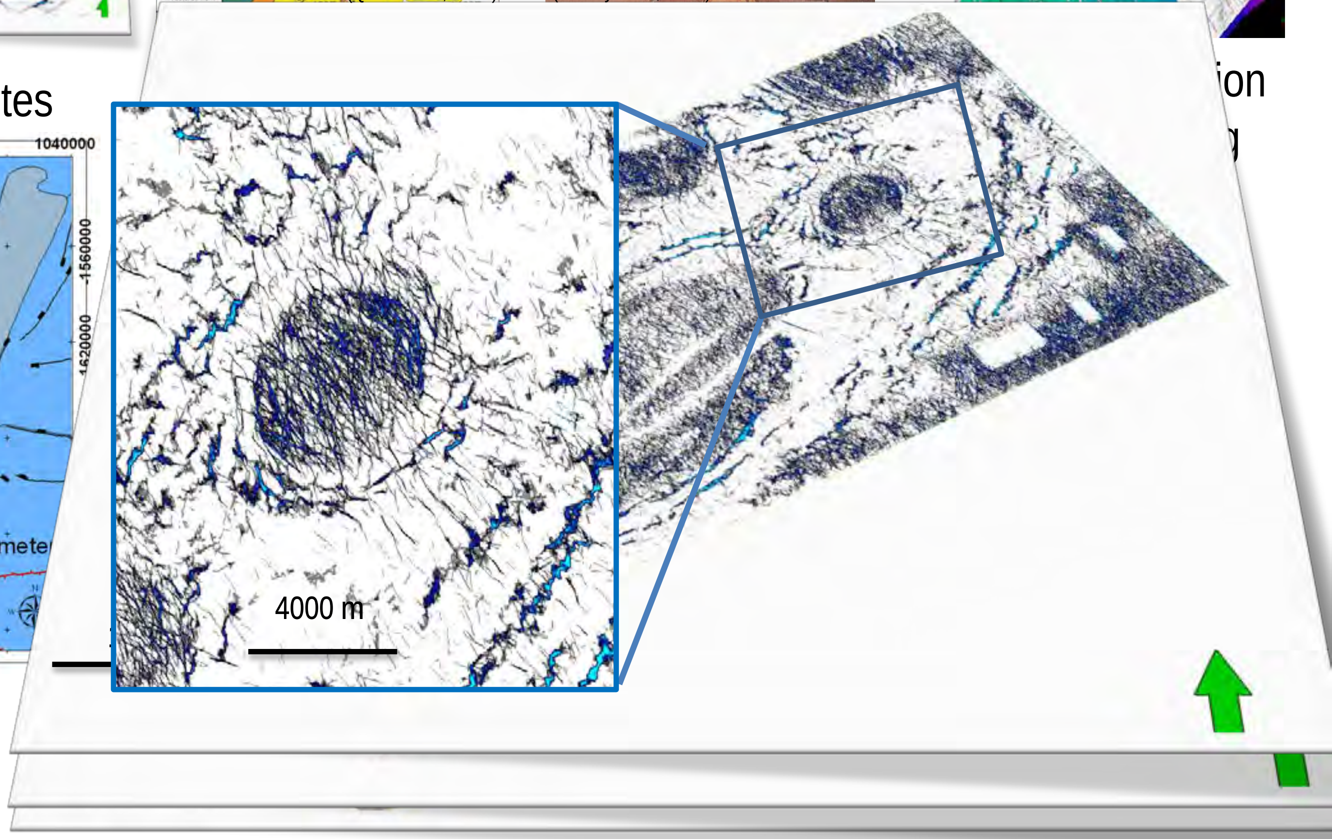


=



Seismic Attributes





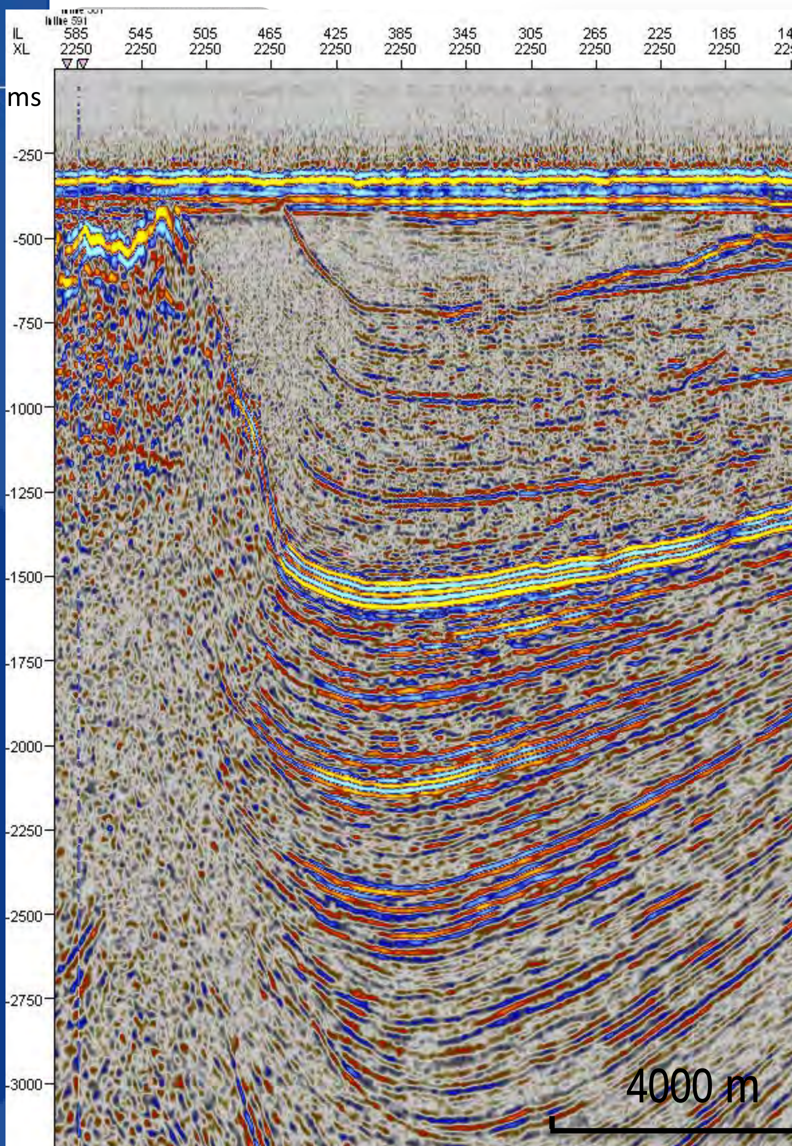
Time Slice - 652 ms

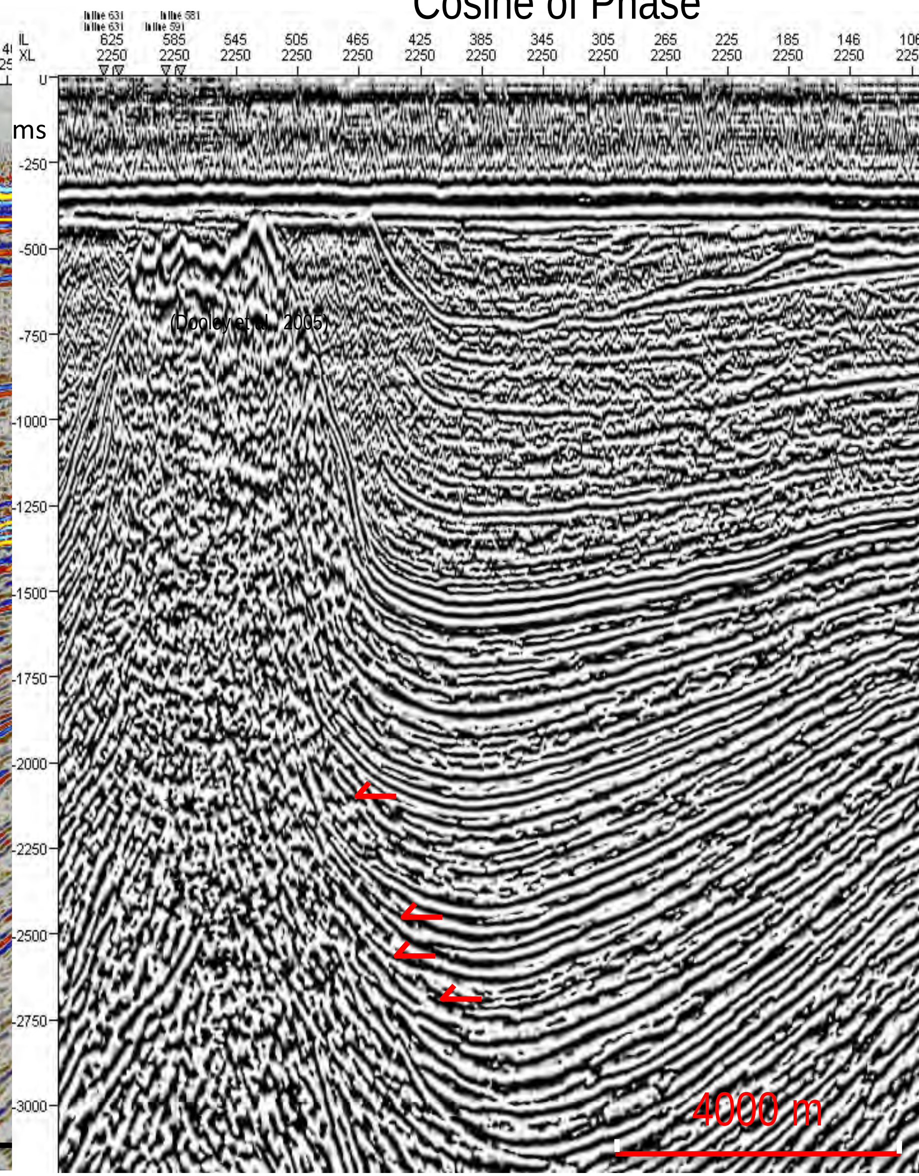
Methodology

4) Halokinetic Stratigraphy - Workflow

3D Cube ST9403_Xline 2250

Cosine of Phase



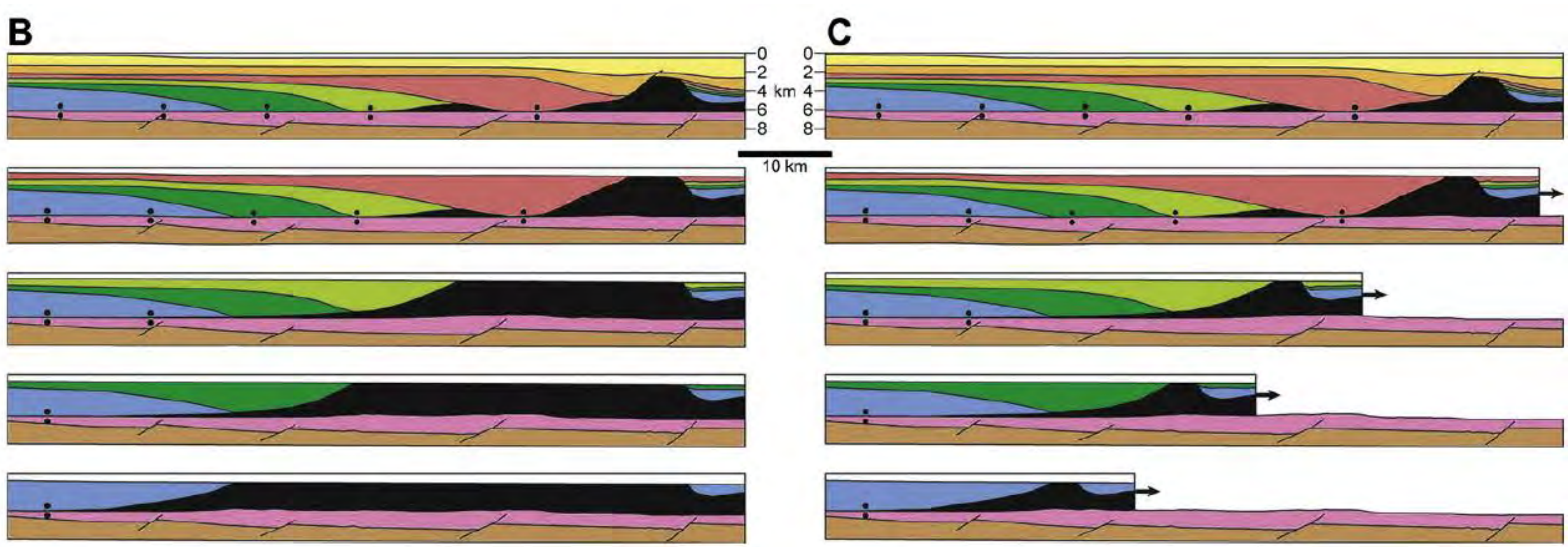


University of Stavanger

Methodology

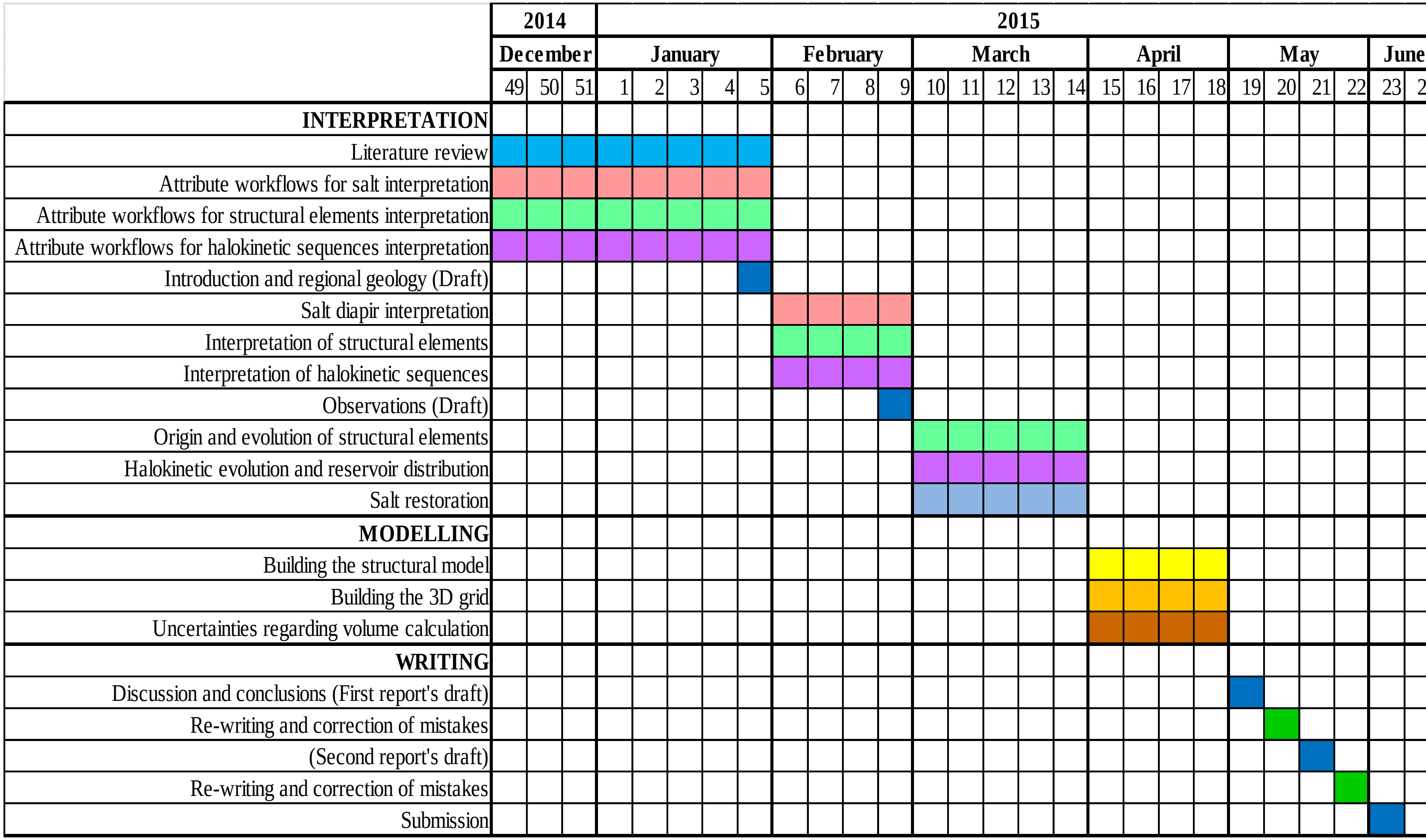
4) Salt restoration

- Understand the different methodologies
- Identify the direction of the main salt flow in the Nordkapp Basin
- Identify the periods when salt controlled sediment flow patterns and deposition from Late Paleozoic to Quaternary



(Rowan and Ratliff, 2012)

Time Frame


2014
2015
December
January
February
March
April
May
June
49 50 51 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
INTERPRETATION
Literature review
Attribute workflows for salt interpretation
Attribute workflows for structural elements interpretation
Attribute workflows for halokinetic sequences interpretation
Introduction and regional geology (Draft)
Salt diapir interpretation
Interpretation of structural elements
Interpretation of halokinetic sequences
Observations (Draft)
Origin and evolution of structural elements
Halokinetic evolution and reservoir distribution
Salt restoration
MODELLING
Building the structural model
Building the 3D grid
Uncertainties regarding volume calculation
WRITING
Discussion and conclusions (First report's draft)
Re-writing and correction of mistakes
(Second report's draft)
Re-writing and correction of mistakes
Submission

University of Stavanger

Thank you

Any questions?

INFLUENCE OF DIFFERENT FACIES MODELLING TECHNIQUES ON RESERVOIR VOLUME

Presented by

Ayyub Aghamoghlanov

Department of Petroleum Engineering

University of Stavanger

Outline

- Introduction
- Definition of problem
- Objectives
- Data
- Methodology
- Timeframe

Introduction

- Two facies modeling methods

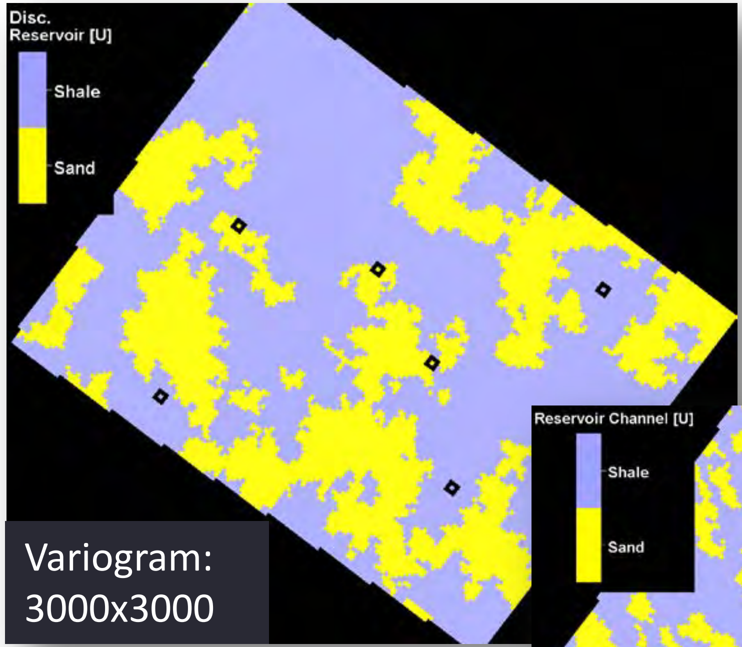
- Parameters influencing on reservoir volume uncertainty

- Influence of seismic impedance cube on reservoir volume uncertainty

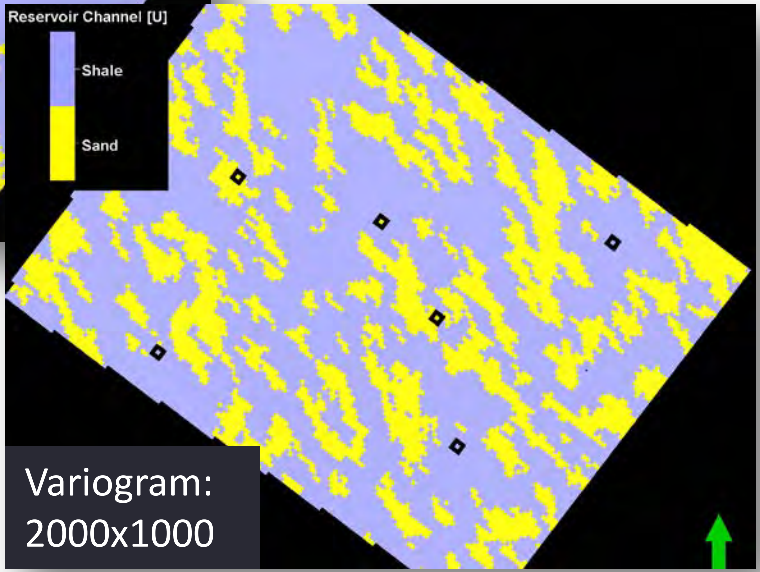
Definiton of problem

- Subject to uncertainty
- Huge impact on reservoir volume
- Importance to estimate the reservoir volume reliably and its uncertainty range

Methods for facies modeling:
Sequential Indicator Simulation (SIS)



Variogram:
3000x3000



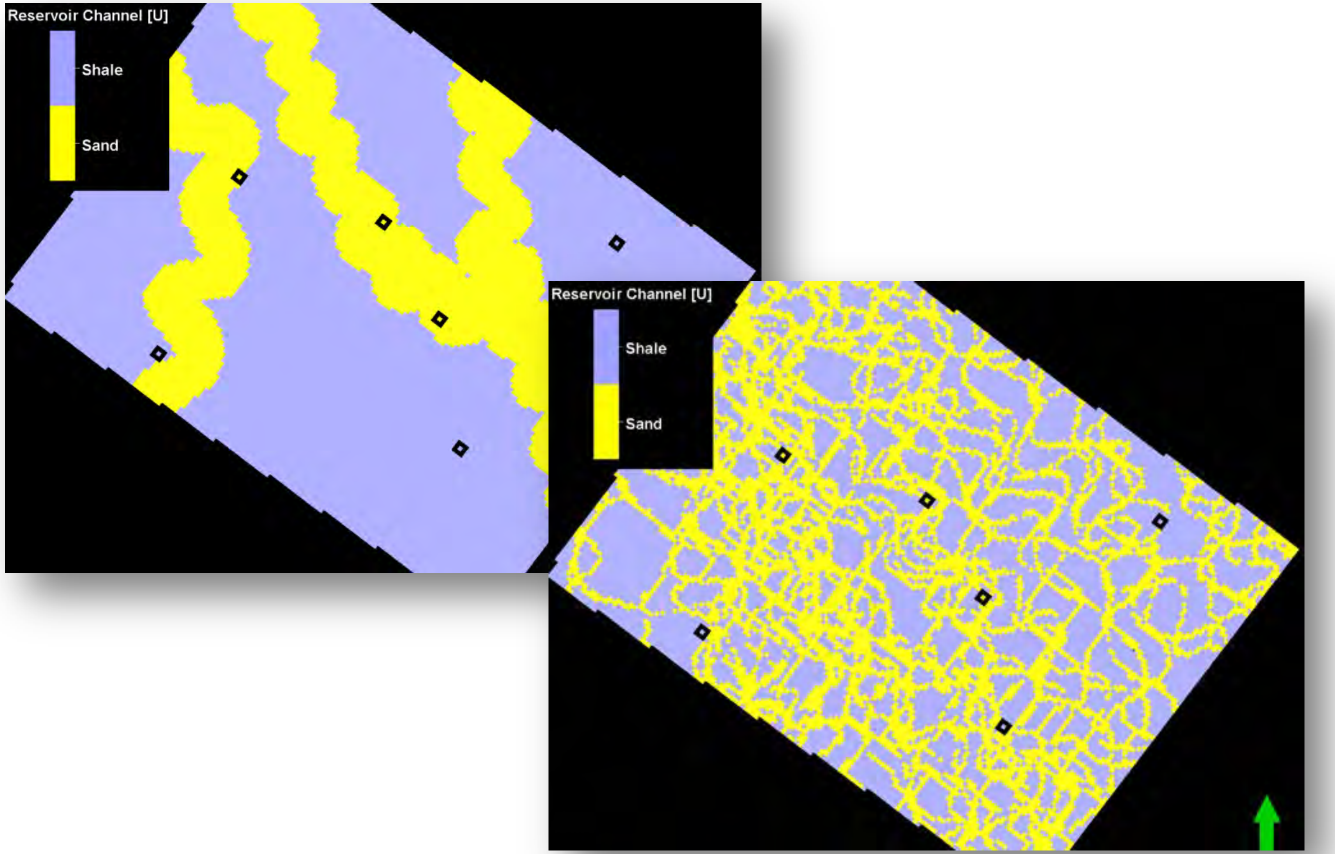
Variogram:
2000x1000

Parameters:

Variogram parameters

- Horizontal variogram range
- Vertical parameter range
- Anisotropy direction
- Variogram model
- Nugget

Methods for facies modeling: Object modeling

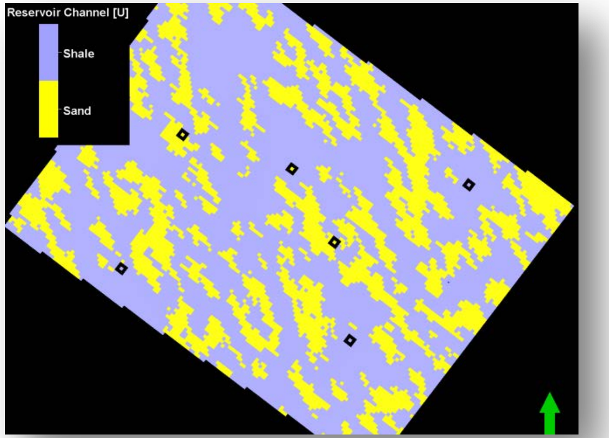


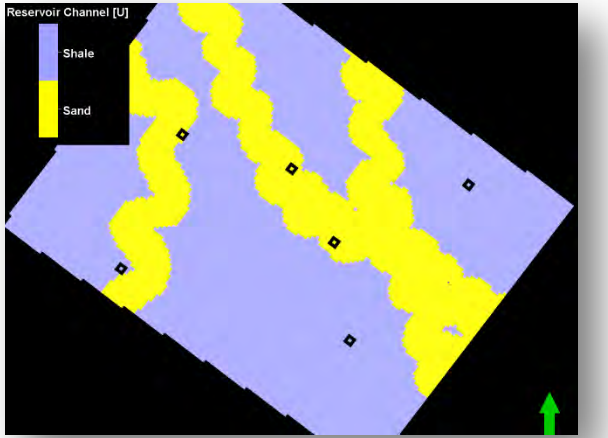
Parameters:

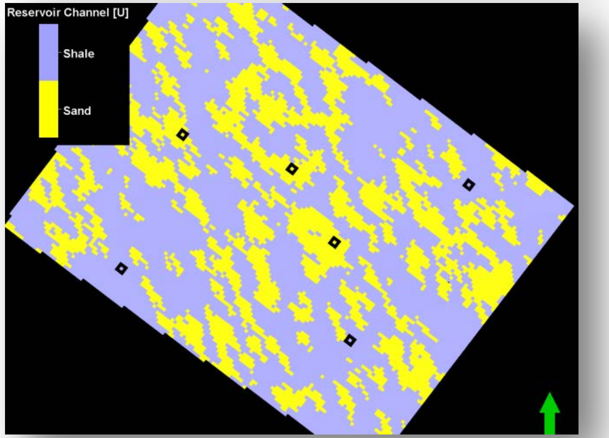
Channel geometry

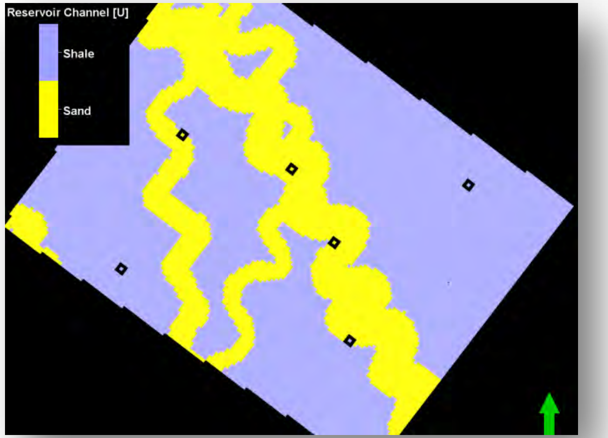
- Wavelength
- Amplitude
- Thickness
- Sinuosity
- Width

Influence of SEED









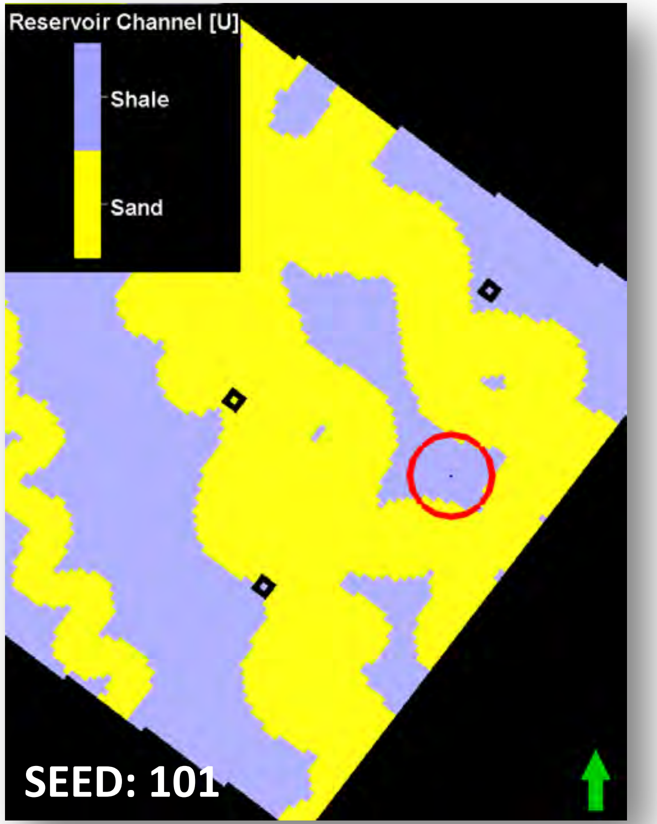
SIS: different SEED numbers

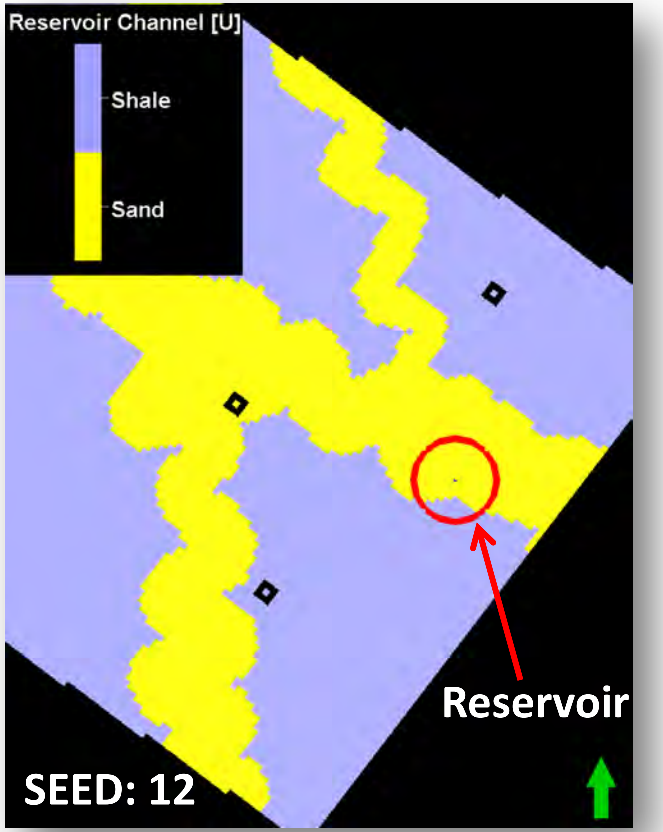
Object modelling: different SEED numbers

Simulation of several equivalent models:

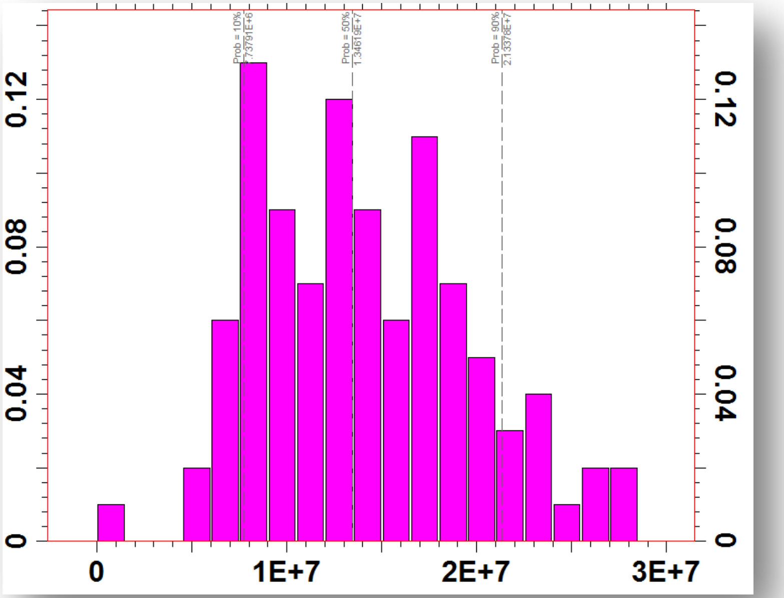
- SEED controls the facies distribution while all other model parameters remain unchanged
- All models are equally probable
- No model is ''better'' than the others

Impact of SEED parameter on reservoir volume
Channel modeling using large channel width

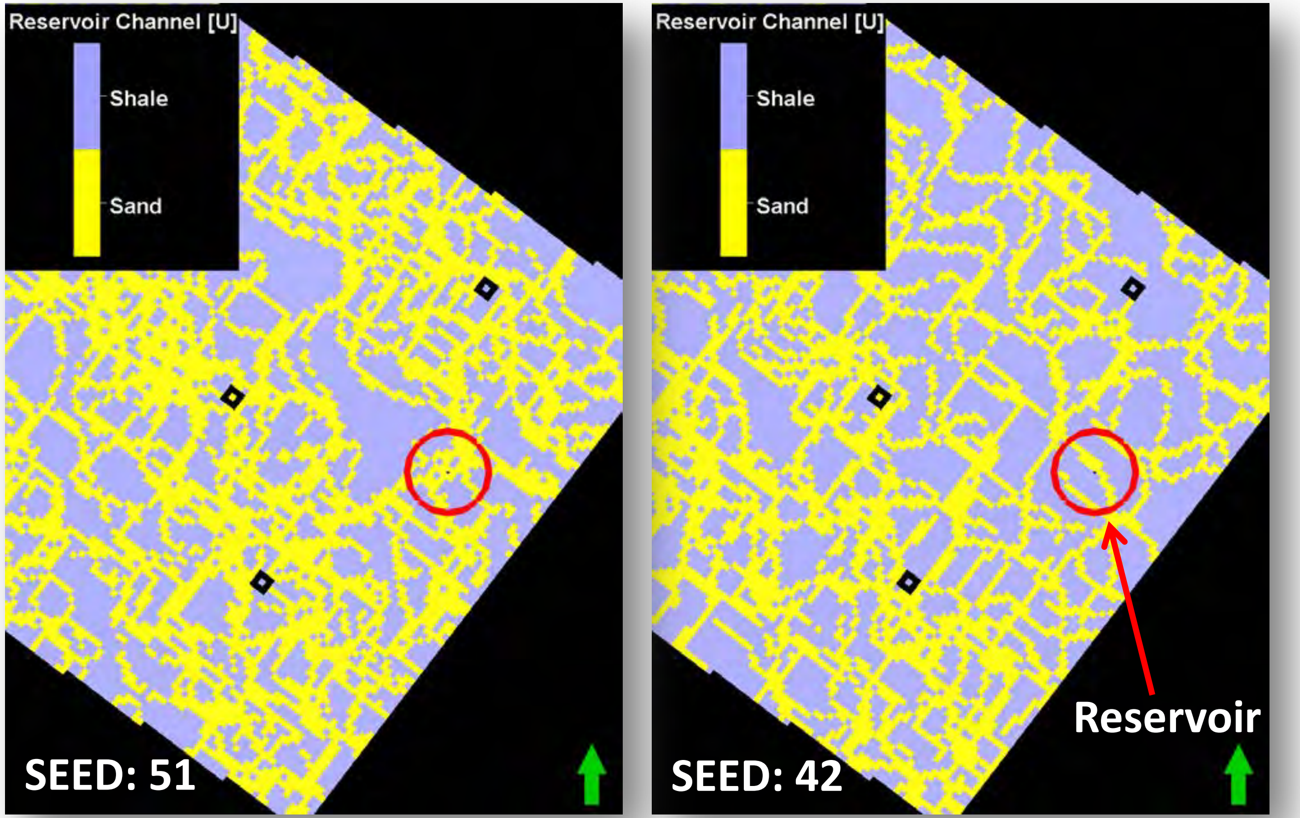




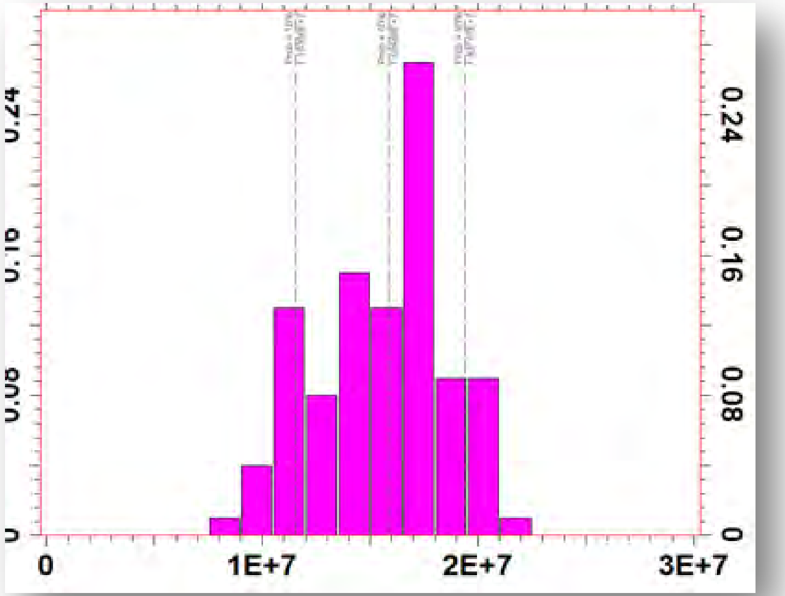
Volume uncertainty distribution



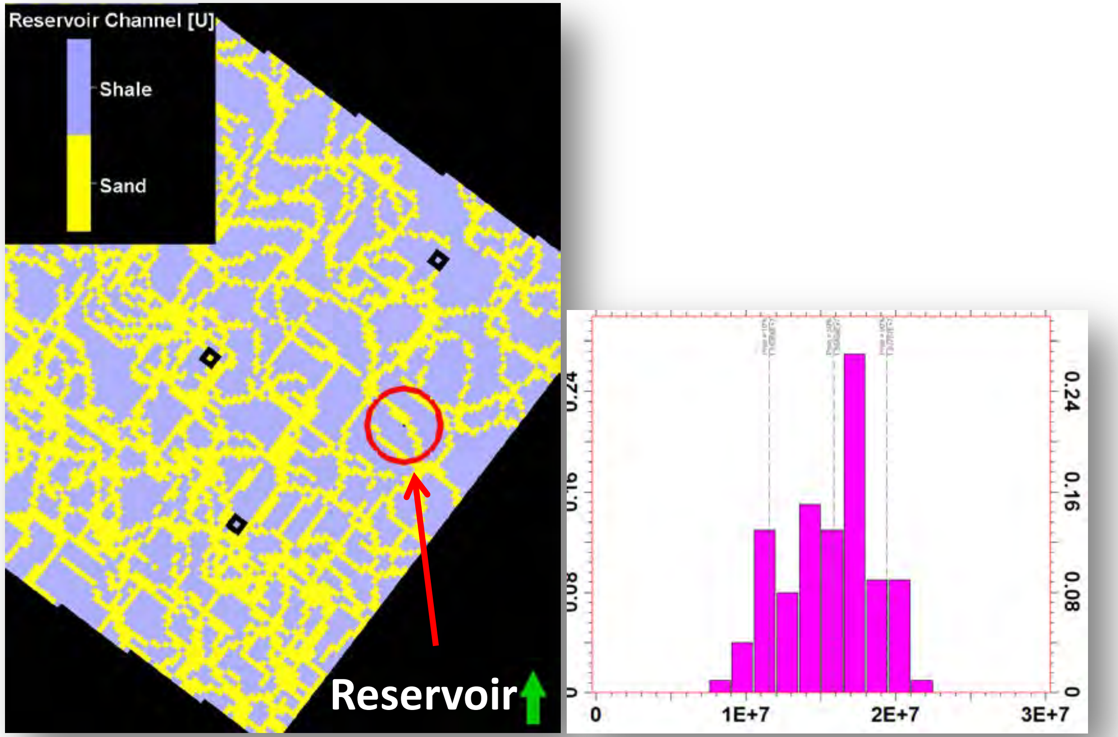
Impact of SEED parameter on reservoir volume
Modeling using small channel width compared to reservoir area

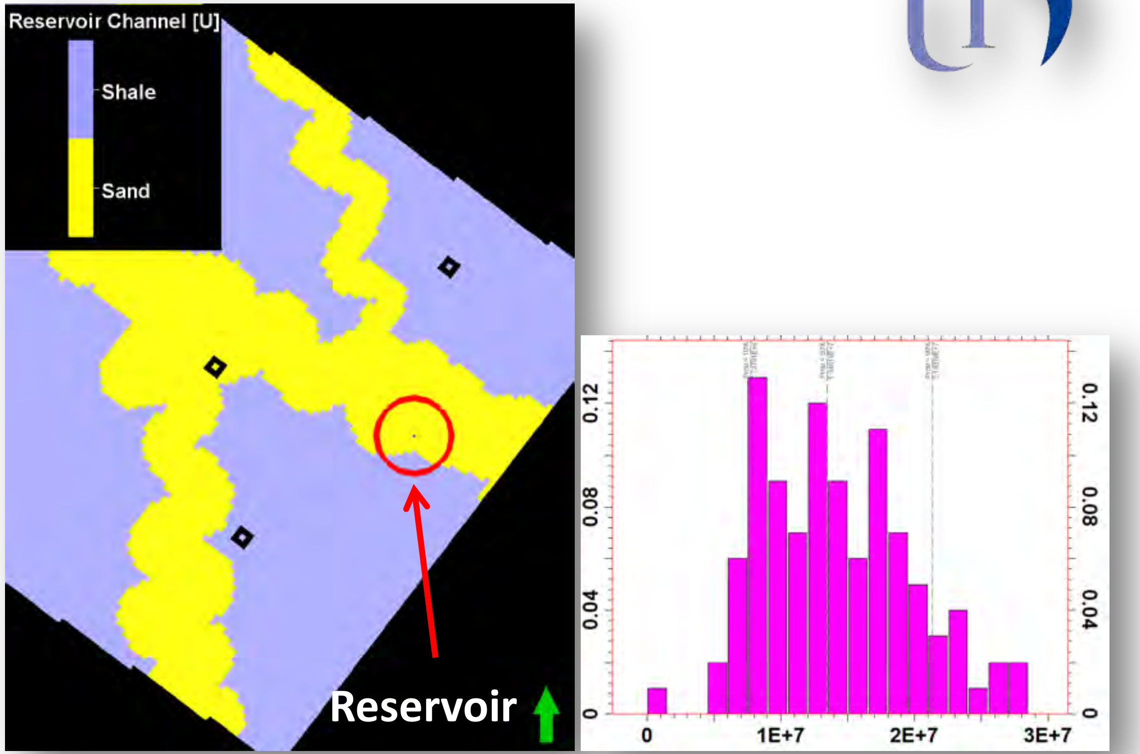


Volume uncertainty distribution



Different channel width - Different volume uncertainty

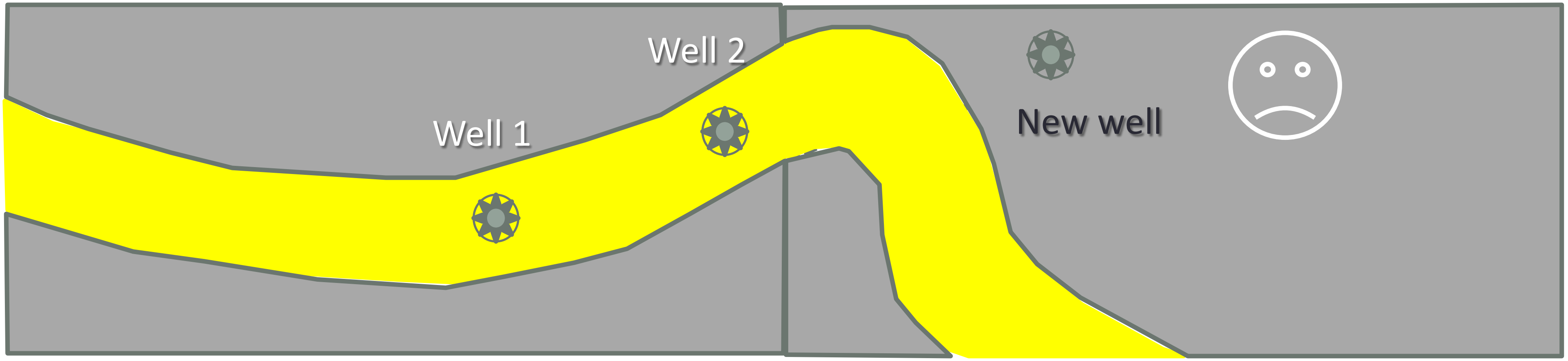




- Channel modelling using different channel widths, but same sand fraction.
- Probably relationship between channel width, reservoir area and volume uncertainty spread.
- Both reservoir volume distributions show the same P50 value but have different spreads.

Objectives

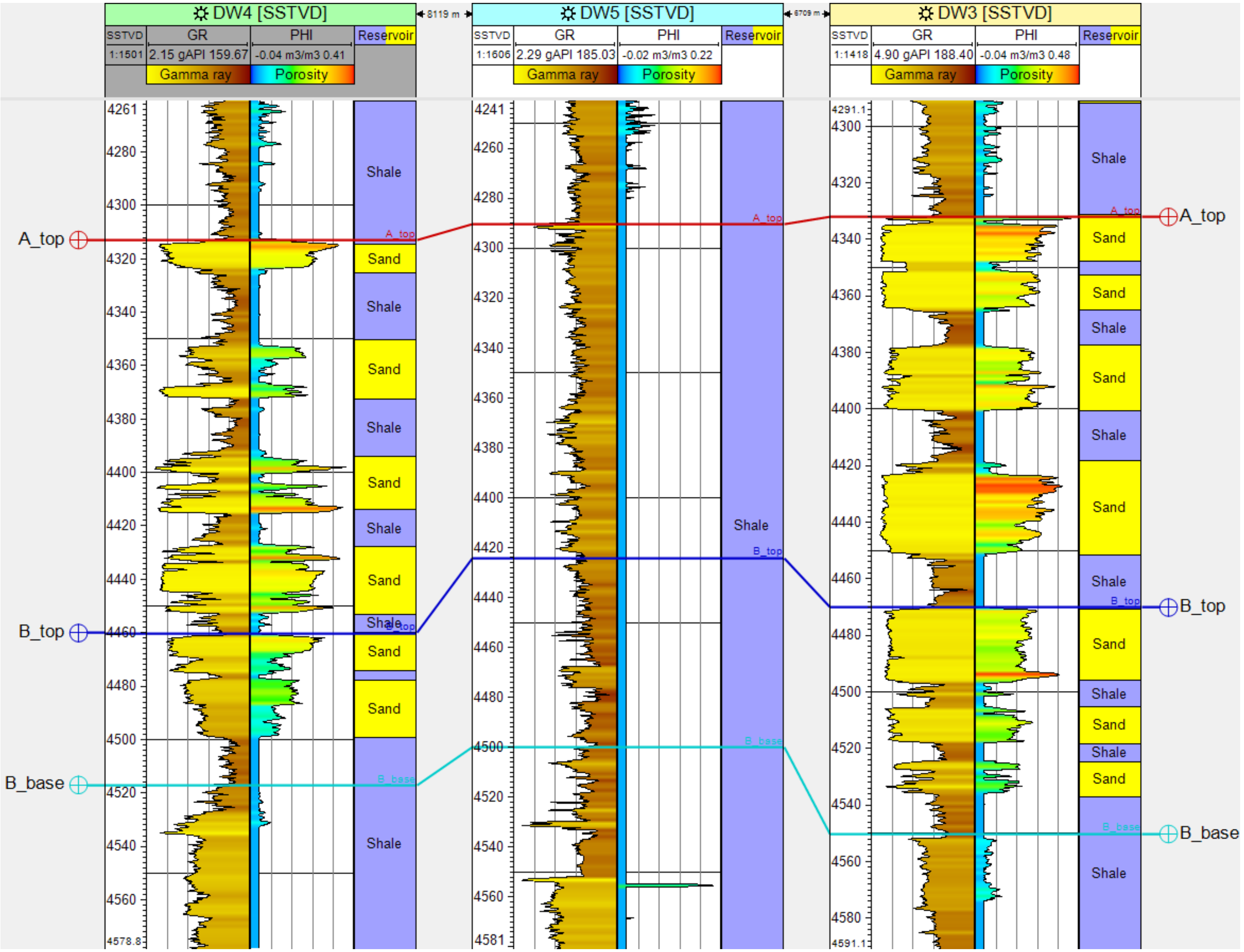
- Stacked channel system
- Challenging geological environment for modelling
- Channels have a limited extension



Objectives

- Capturing and ranking the influence of the facies modeling parameters
- Parameters most influential on the volume and volume uncertainty
- Strategies for reducing the reservoir volume uncertainty
- Study impact of seismic impedance cube

Data



Conceptual model based on real well data

- 6 Wells with GR, PHI, Facies etc.
- Well tops
- Structure: flat surfaces; no faults; no hydrocarbon contact

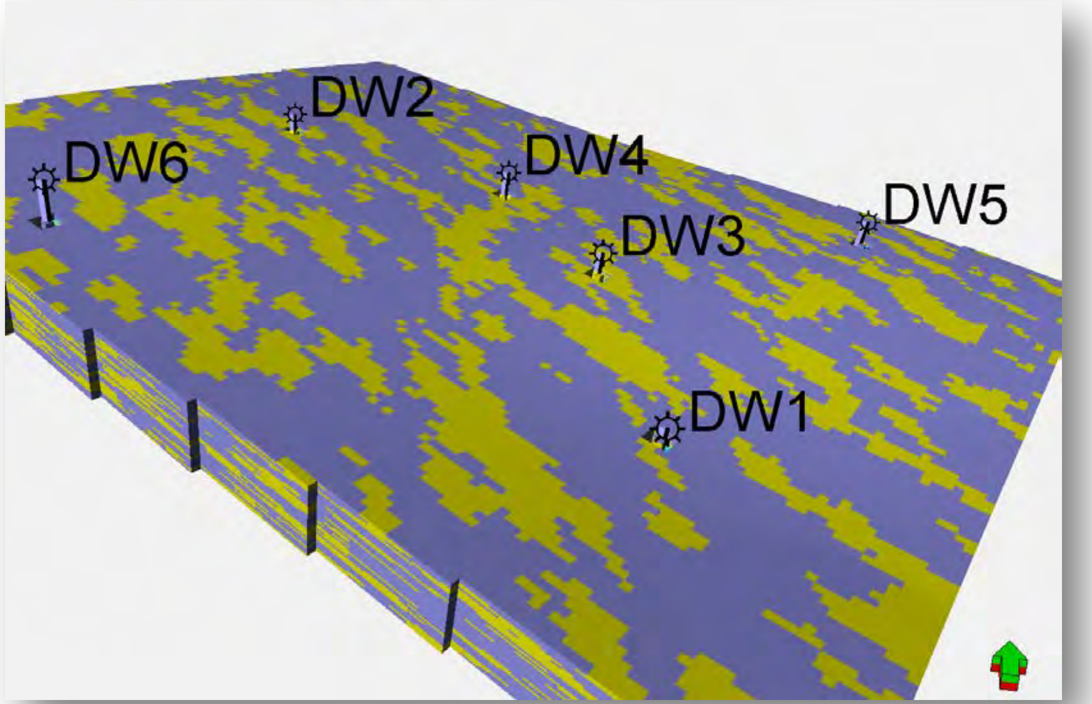
Methodology

Strategy

- Make simple models

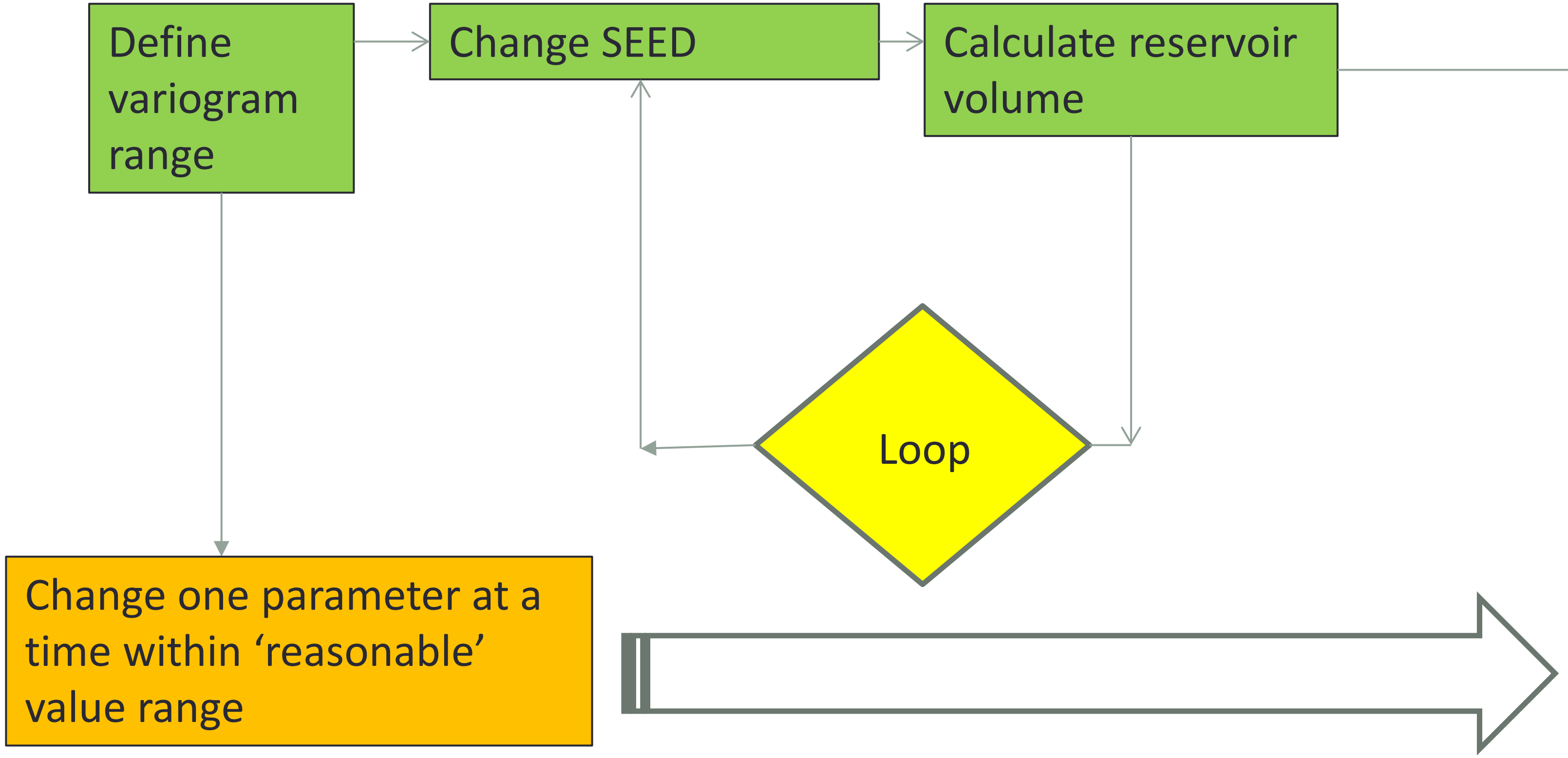
Simplification

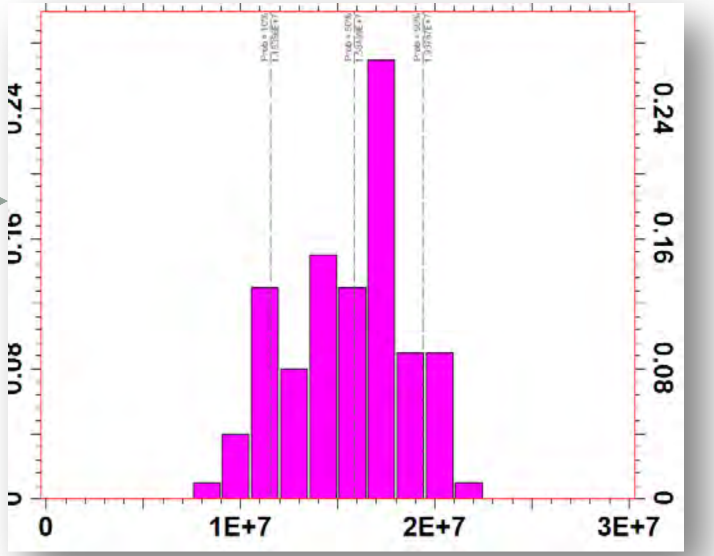
- Reservoir and non reservoir facies
- Simple geometrical shape for the reservoir
- Simple structure

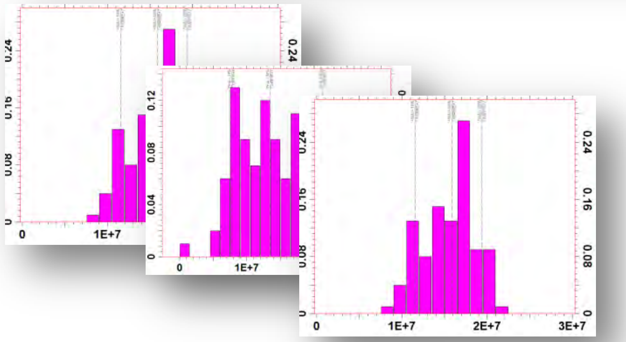


Task 1

Sequential Indicator Simulation (SIS) workflow

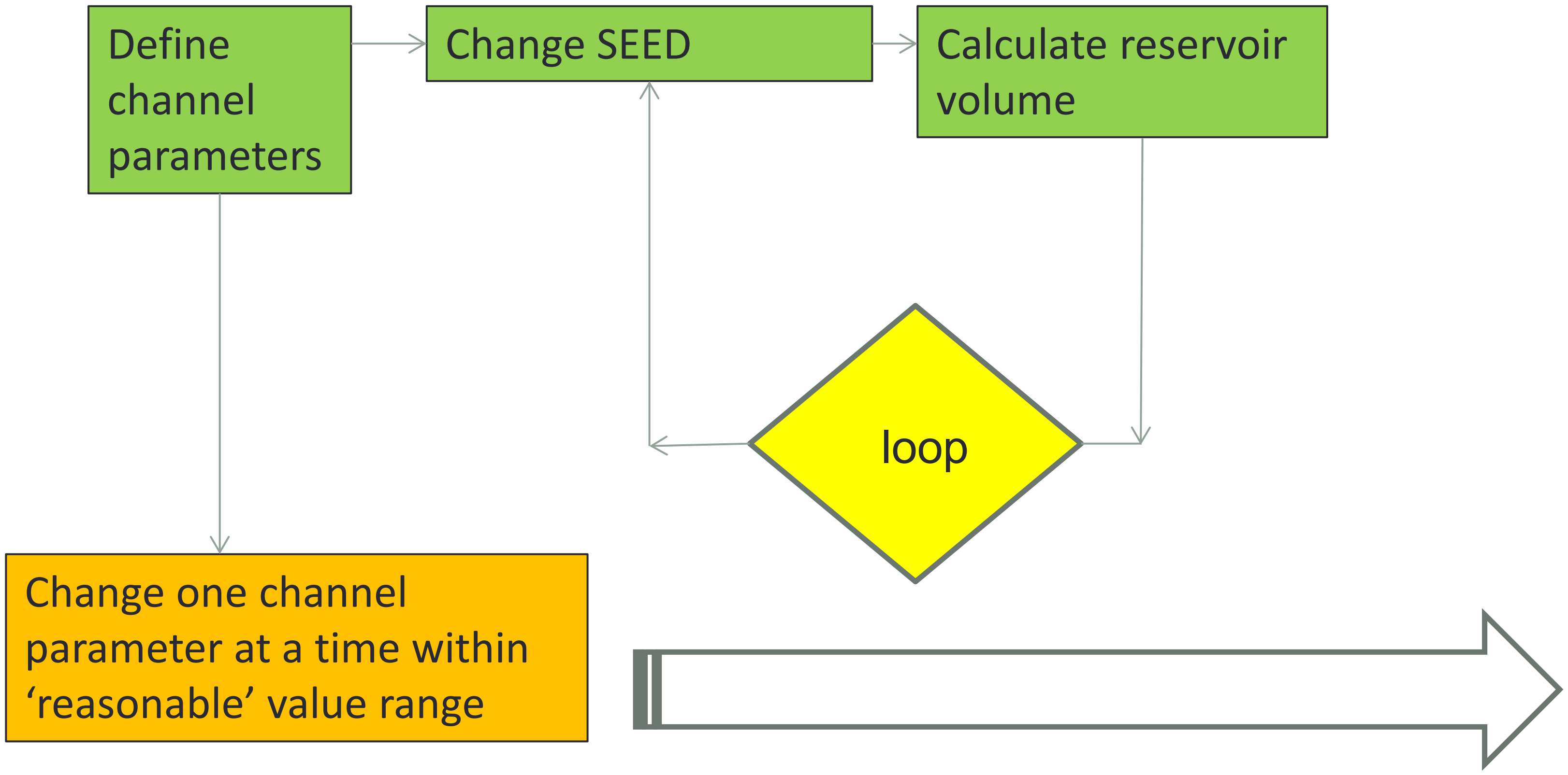


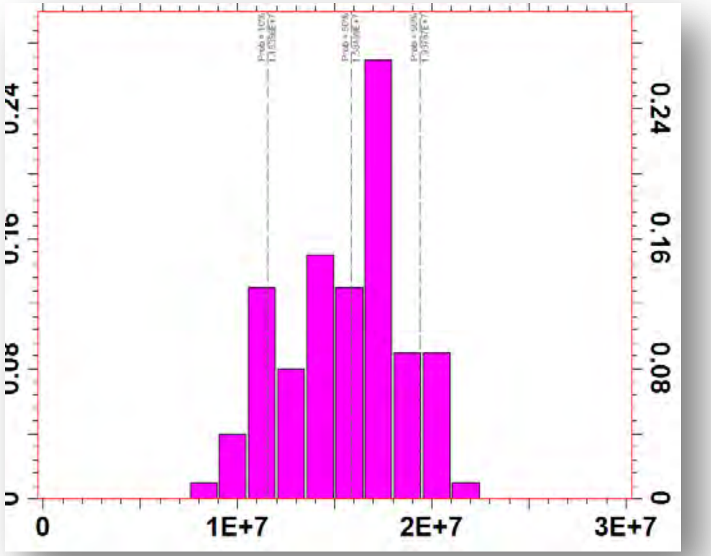


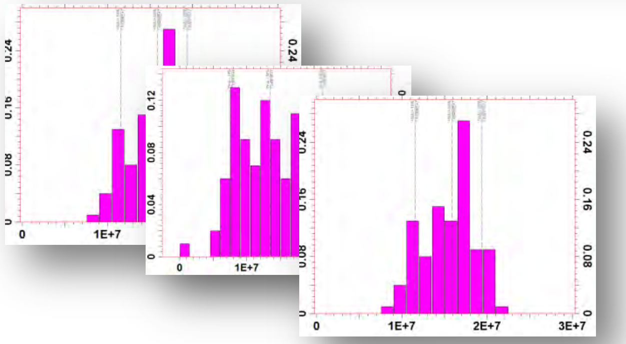


Task 2

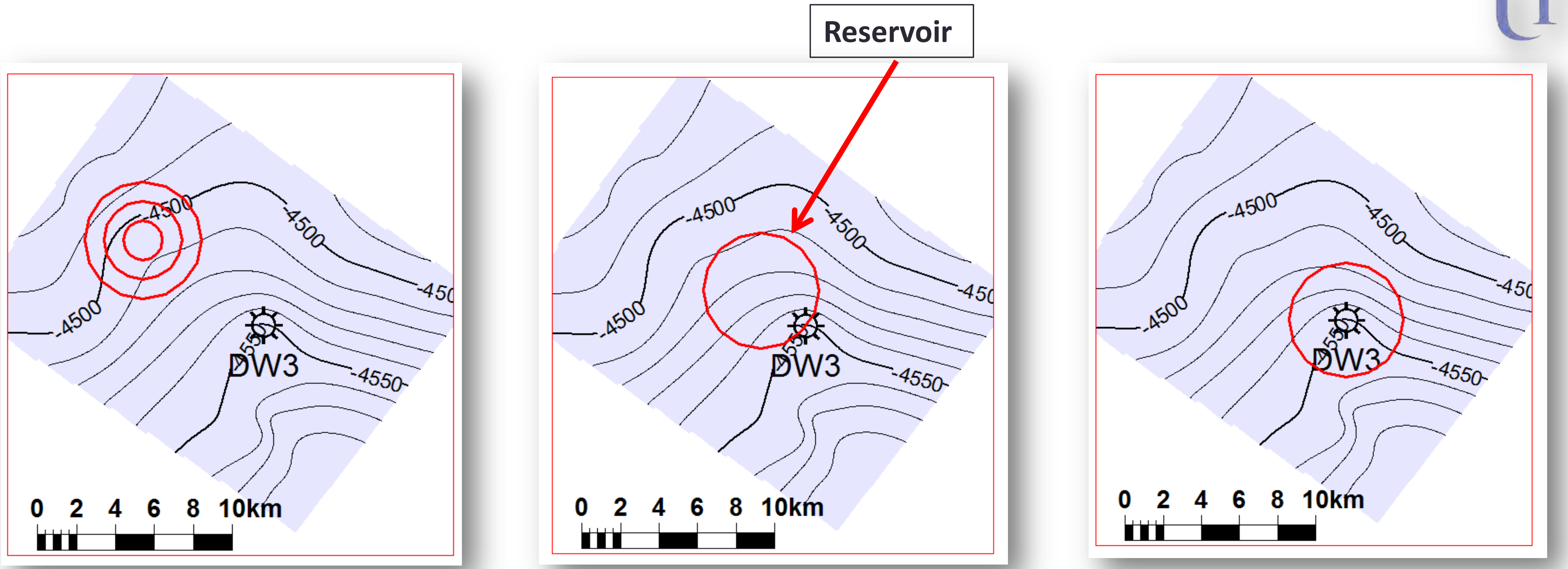
Object (channel) modelling workflow





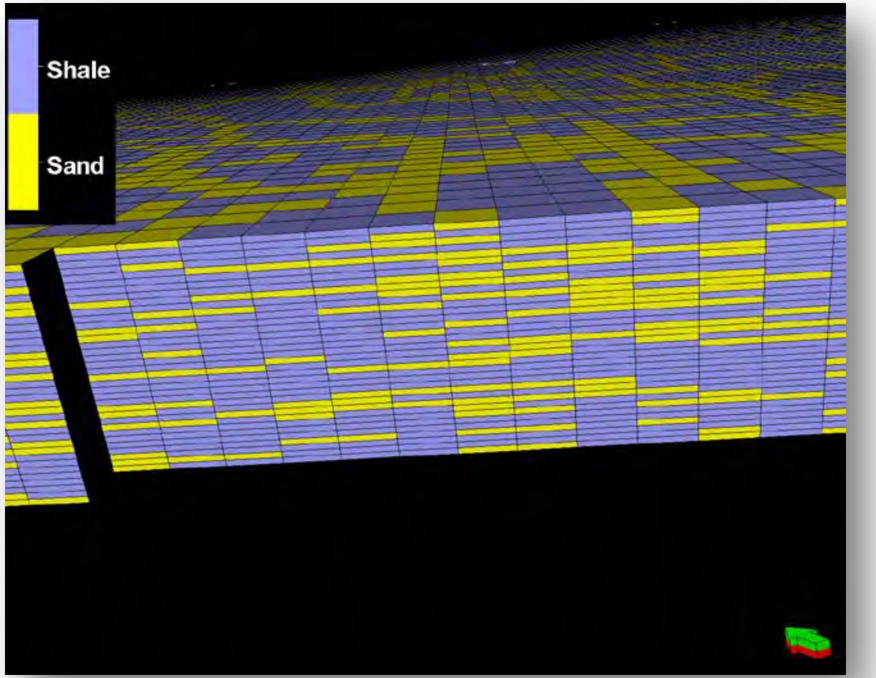


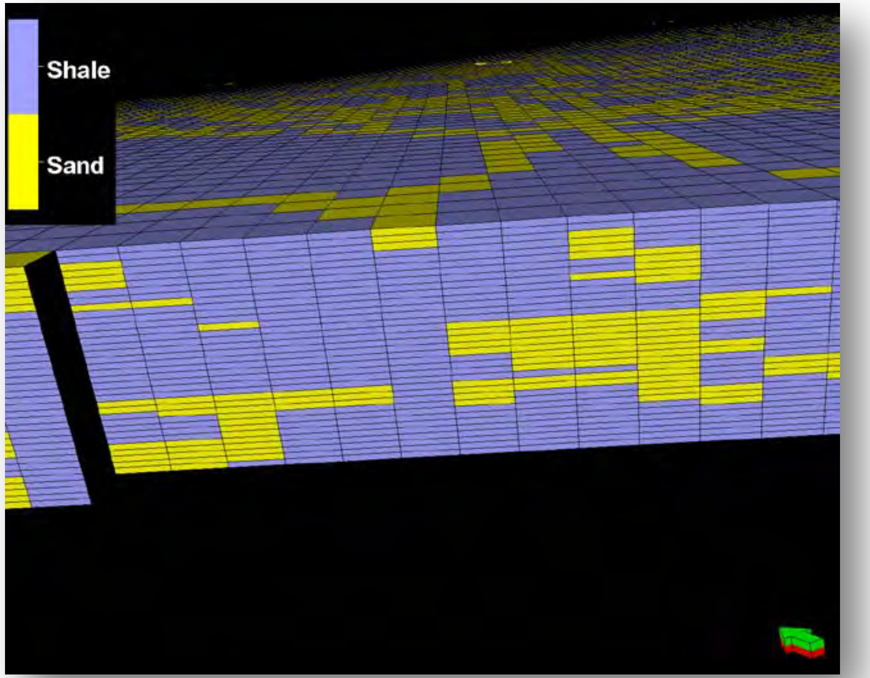
Task 3



Extension of analysis to reservoirs of different sizes and different locations with respect to a well.

Task 4

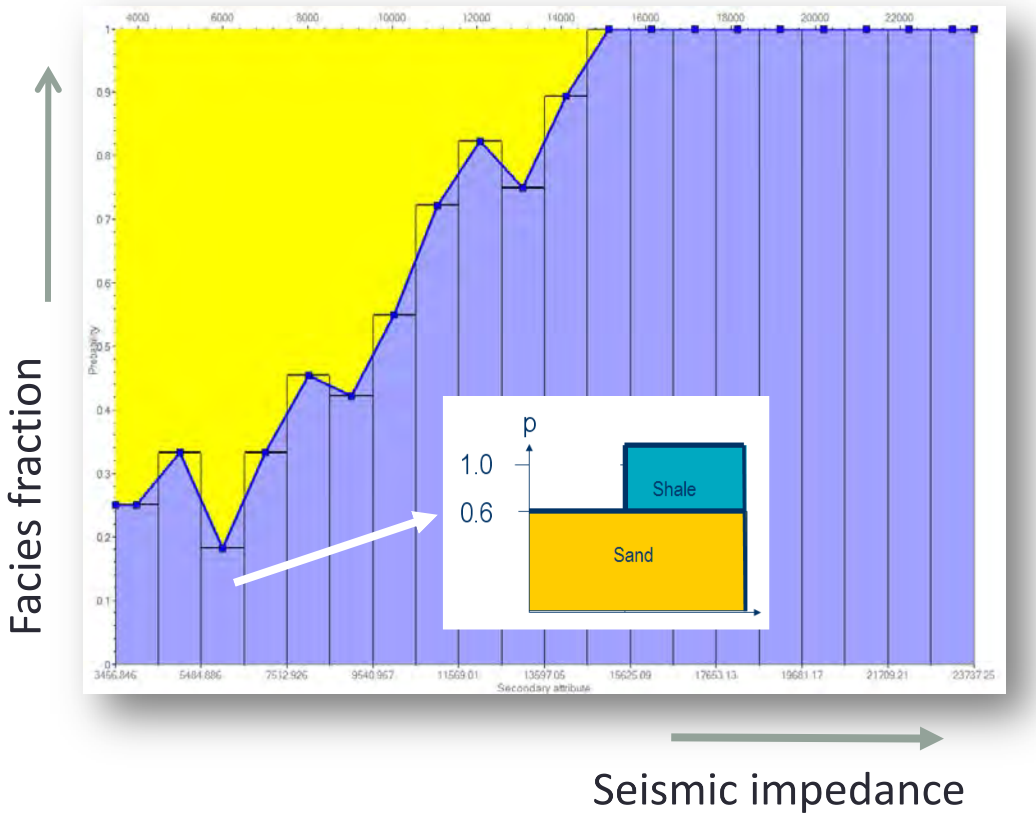




- Impact of the channel thickness and the reservoir thickness on the reservoir volume uncertainty

Task 5

Impact of seismic impedance cube on SIS modeling

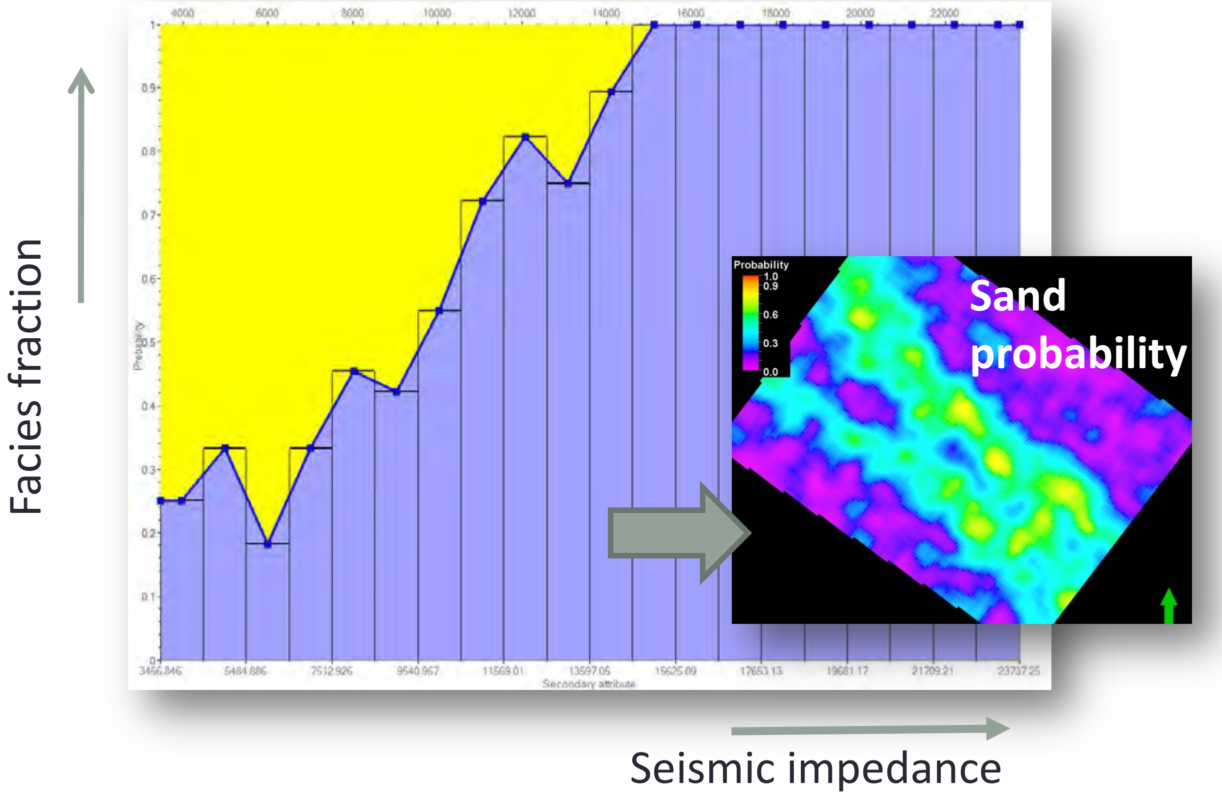


Study

- Influence of seismic impedance cube on global facies distribution
- Influence of seismic impedance cube on reservoir volume P50 and volume uncertainty

Task 6

Impact of seismic impedance cube on Object modeling



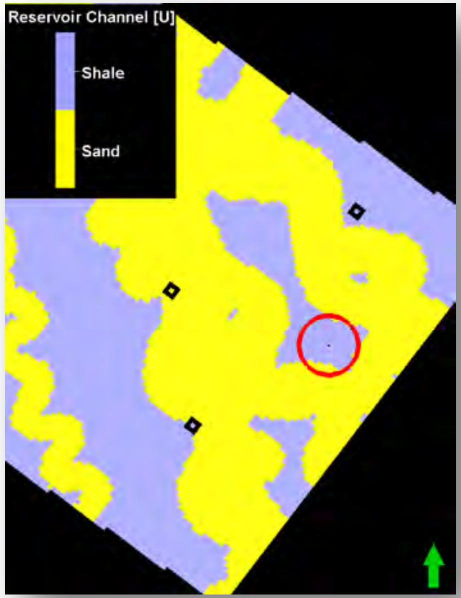
To study:

- Influence of seismic impedance on global facies distribution
- Influence on reservoir volume P50 and volume uncertainty

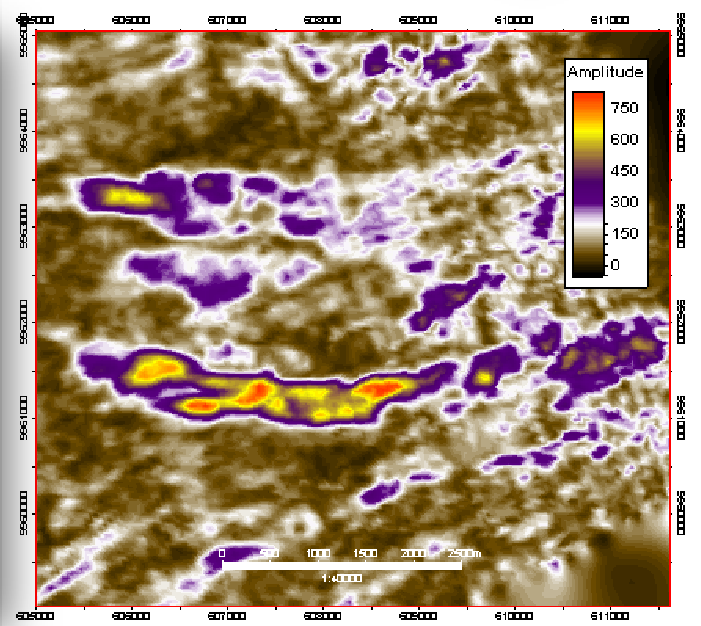
Task 7

Comparison of the two modelling techniques: SIS and channel object modelling

- Advantage of each method
- Possible weaknesses
- Recommendations



Modelled channel (object modelling)



Amplitude map showing channels (Yuniyanto et al 2005)

Time frame

Activity	2015					
	January	February	March	April	May	June
Literature review	X					
Building of conceptual model	X					
Well log interpretation		X				
Sequential Indicator Simulation		X	X			
Object Modelling			X	X		
Seismic Impedance Analysis				X		
Draft of graduation thesis					X	X
Final version thesis work						X

Influence of seismic and velocity uncertainties on reservoir volumetrics

David Thor Odinsson

MSc. Petroleum Geoscience and Engineering

University of Stavanger

uis.no

University of Stavanger

Outline

- Introduction
- Objectives
- Dataset
- Methodology
- Time frame

University of Stavanger

Introduction

Construction of a structural model

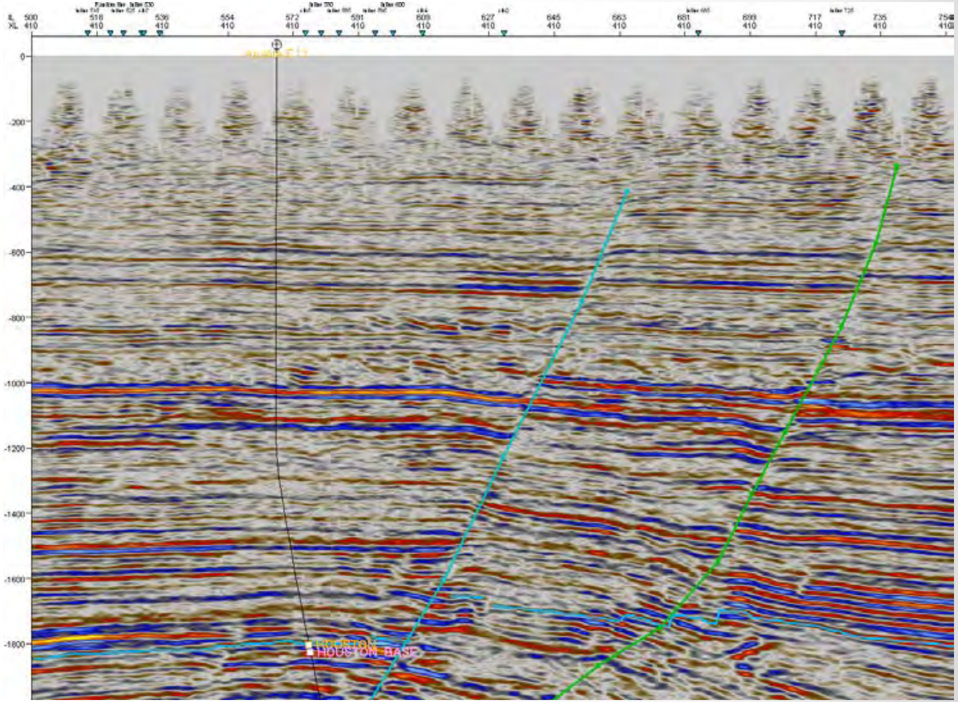
- Step 1 • Acquisition
- Step 2 • Preprocessing
- Step 3 • Stacking
- Step 4 • Migration
- Step 5 • Interpretation
- Step 6 • Time-to-depth conversion

This project (Steps 5–6)

Structural model

Introduction
Interpretation

- Extract information from seismic image
- High versus low S/N
- For normal faults uncertainties are horizontal and horizon uncertainties are broadly vertical



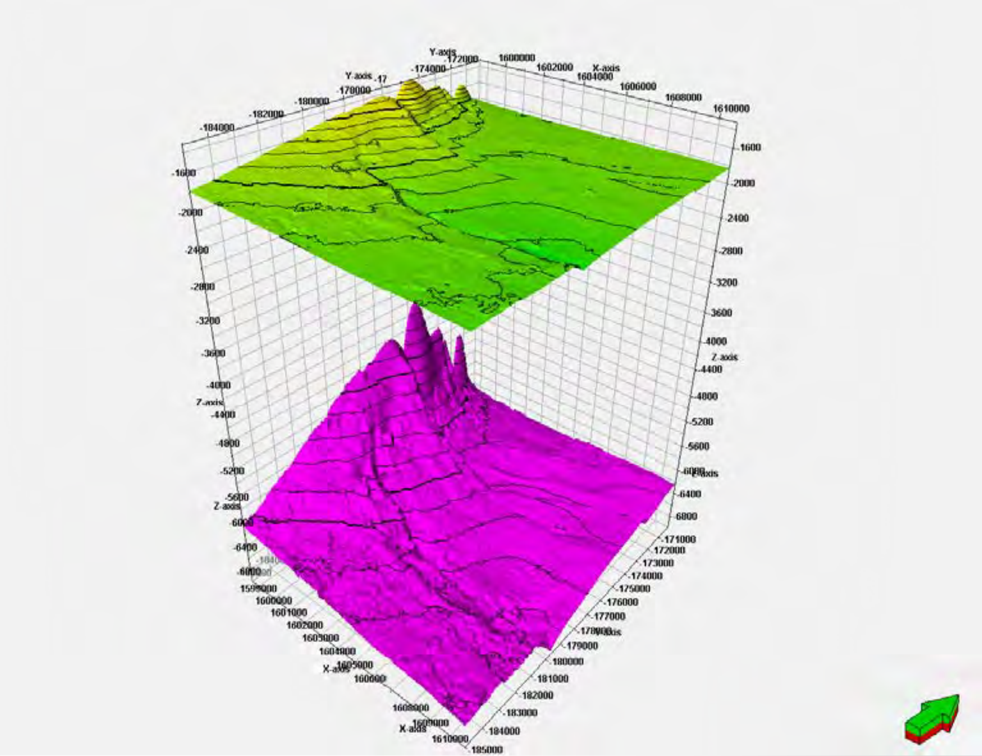
Cross-line 410, showing fault and horizon interpretations

University of Stavanger

Introduction

Time-to-depth conversion

- Requires velocity information
- Stacking velocities, well measurements, check-shot survey etc.
- Limited to borehole location



Top reservoir in time and depth

University of Stavanger

Introduction
High, base and low case

- Base case
  - Best fit to the most reliable data (wells)
- Low case
  - Volume **decrease** with reference to the base case
- High case
  - Volume **increase** with reference to the base case

University of Stavanger

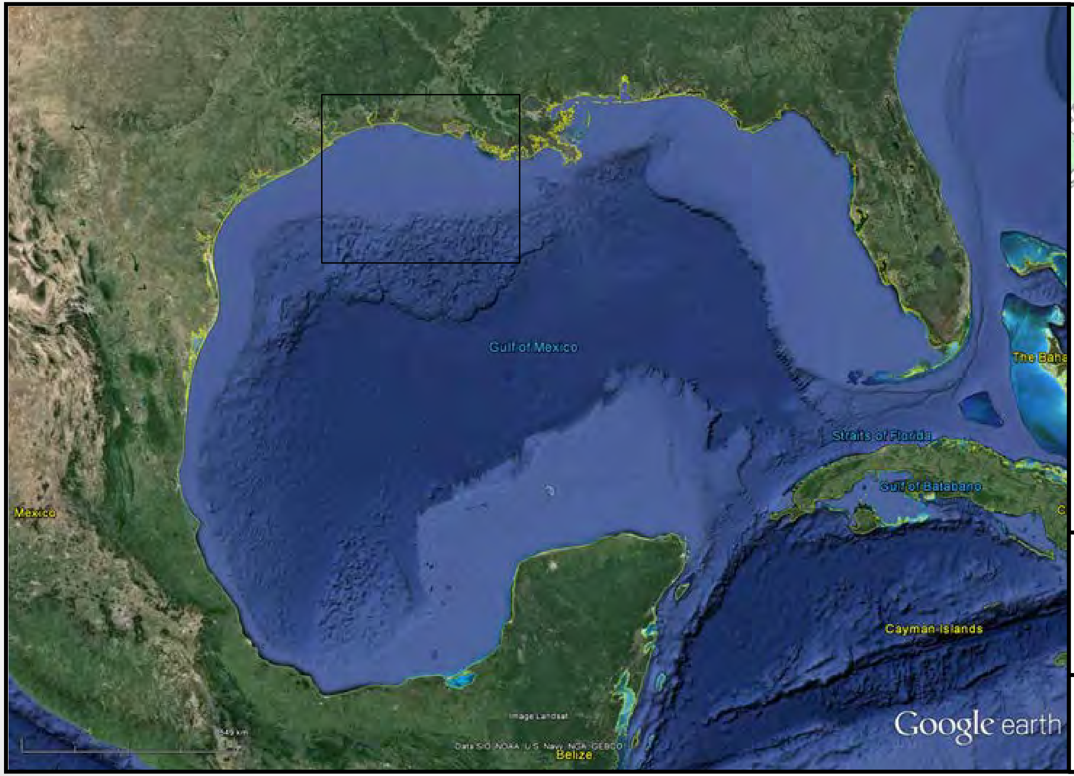
Objectives

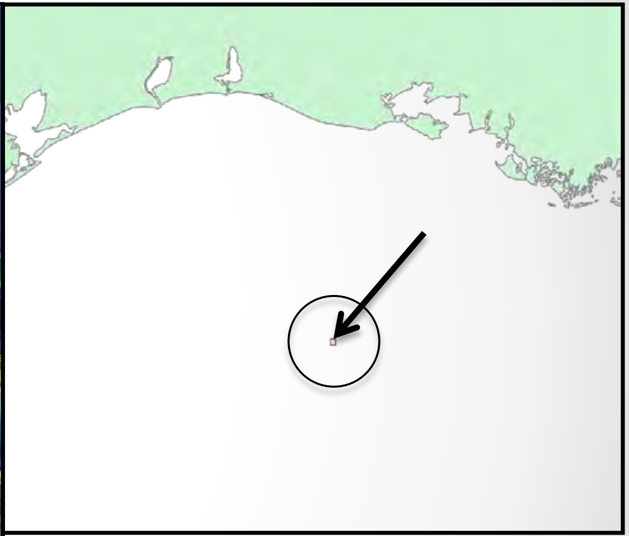
- Study of the structural (fault and horizon) uncertainties
- Capturing the velocity uncertainty
- Estimate the influence of the structural uncertainty on the bulk volume uncertainty using Experimental design.

University of Stavanger

Dataset

Location





Gulf of Mexico

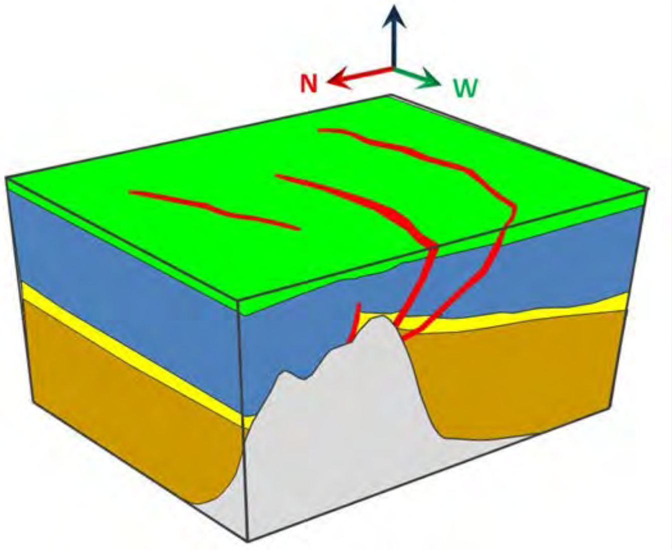
28.151978°	28.193311°
-92.579025°	-92.540822°

University of Stavanger

Dataset

Geology

- The reservoir is bounded to the west by a salt dome and its local structure is characterized by
  - small to large scale west-east growth faults
  - Rollover anticlines and
  - Diapiric salt.



Cartoon of the structural model (Schulte, L., personal communication, November 2014.)

University of Stavanger

Dataset

Area of interest

- Outline of reservoir defined by oil water contact

- Bounded by two east to west striking normal faults and a salt dome

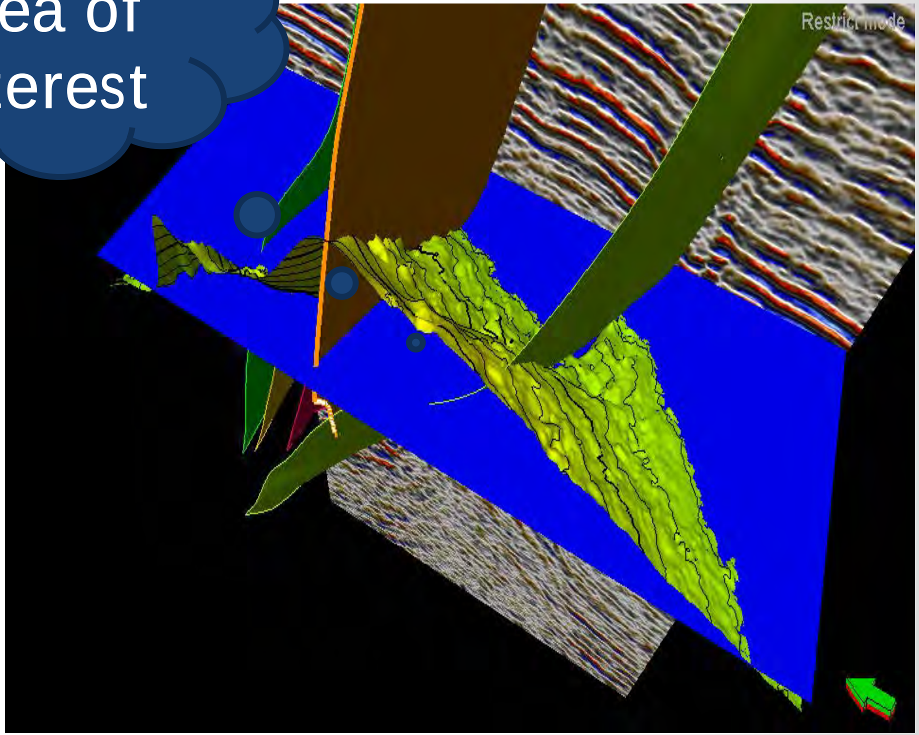


Illustration of the area of interest and how it is defined by the OWC

Dataset
Information

- 3D seismic data consisting of 270 in-lines and 220 cross-lines with 55 feet spacing ranging from 0 to 3500 ms
  - Borehole information from 28 wells
  - Check-shot survey for all wells
  - Well tops
  - Top reservoir and salt dome interpretation

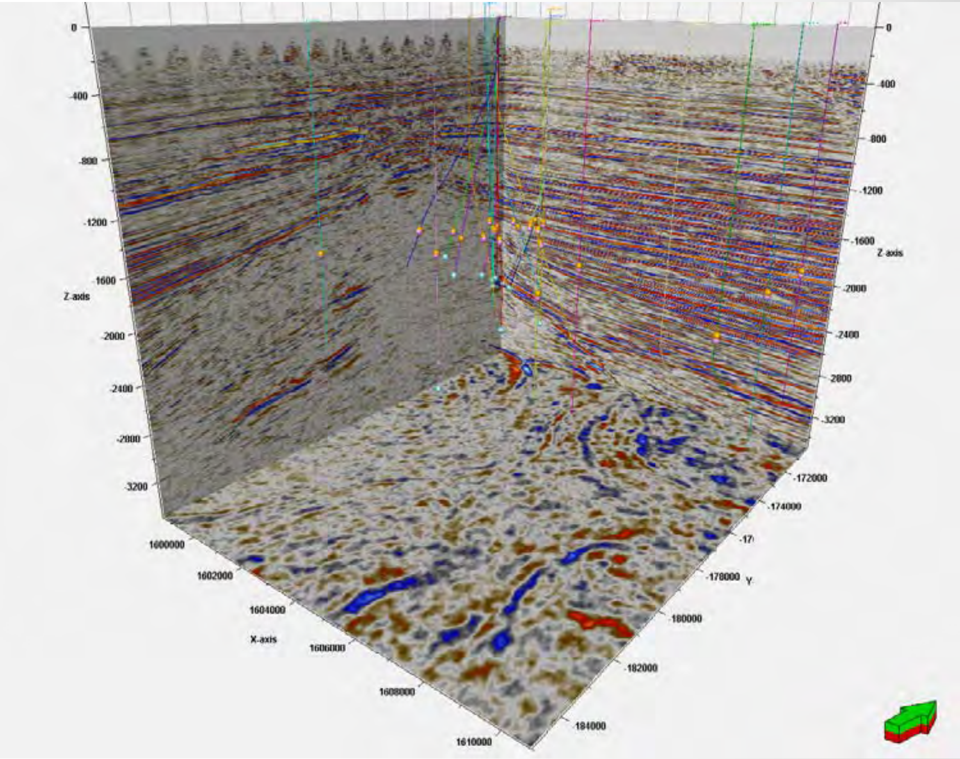


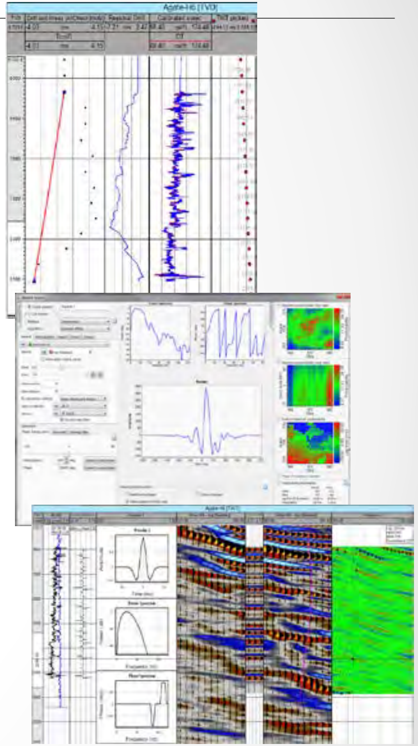
Illustration of the dataset

University of Stavanger

Methodology

Data calibration?

Step 1	• Convert wells to TWT
Step 2	• Sonic calibration
Step 3	• Synthetic seismogram • Seismic well tie

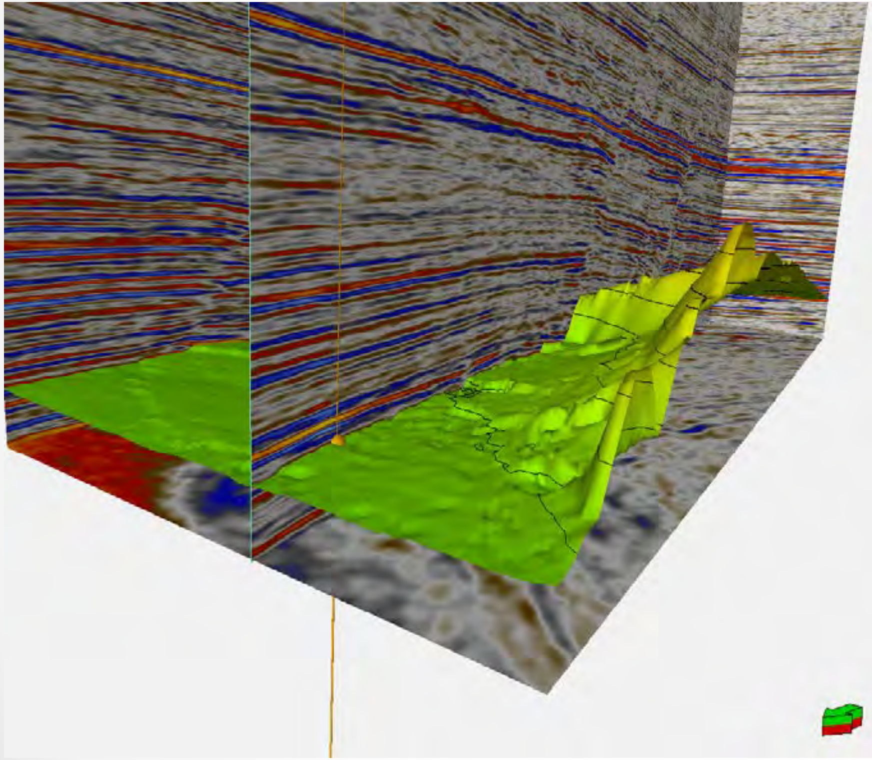


Workflow for data calibration (Schulte, L., personal communication, November 2014.)

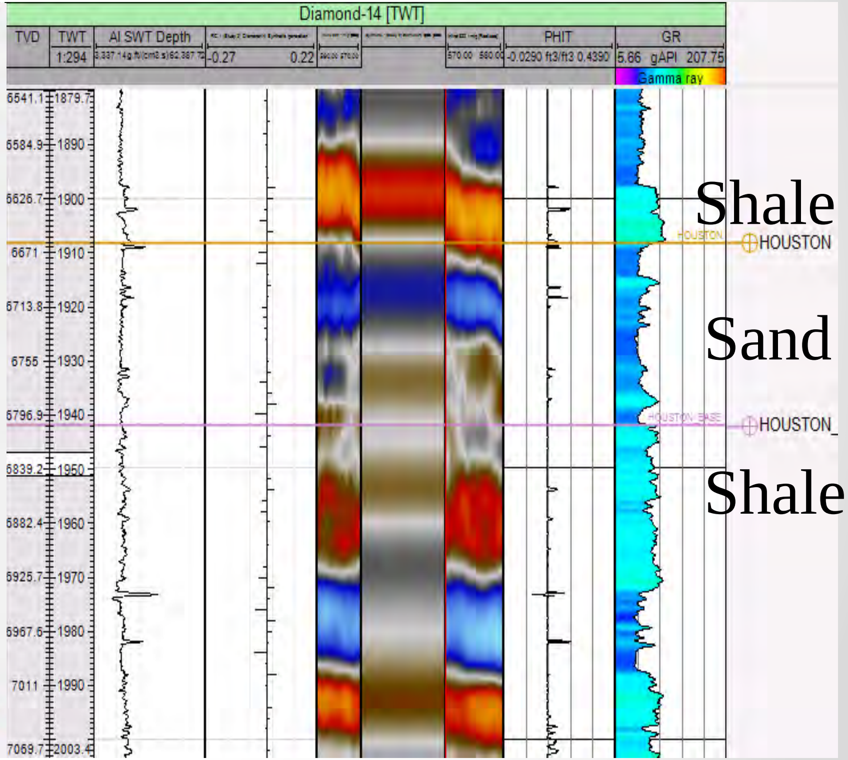
University of Stavanger

Methodology

The seismic event



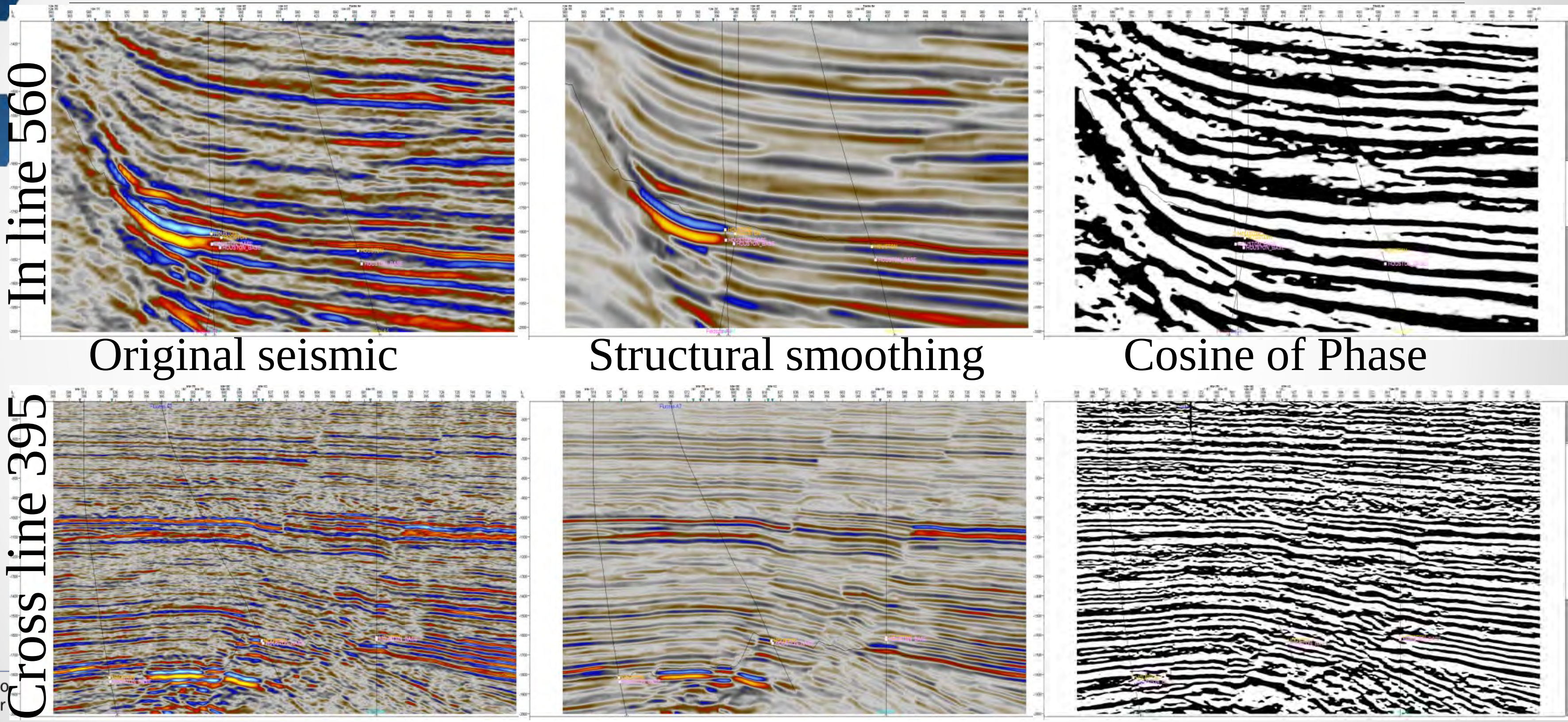
Top reservoir shown tied to the top reservoir well top



Synthetic seismogram showing signature of top and base reservoir

Methodology

Horizons



University of Stavanger

Methodology
Horizon uncertainties

- High S/N areas
  - Oscillation in original seismic
- Low S/N areas
  - Distortions on salt flank and in the vicinity of faults, highly fractured zones
  - Artifacts due to high velocity overburden layers (shadow zone of faults)

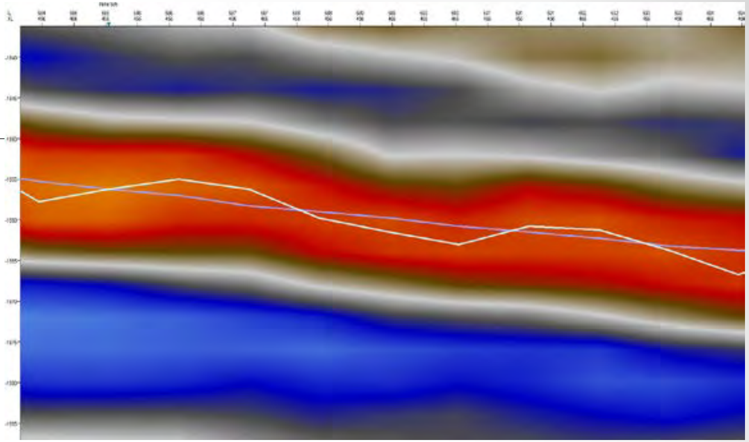
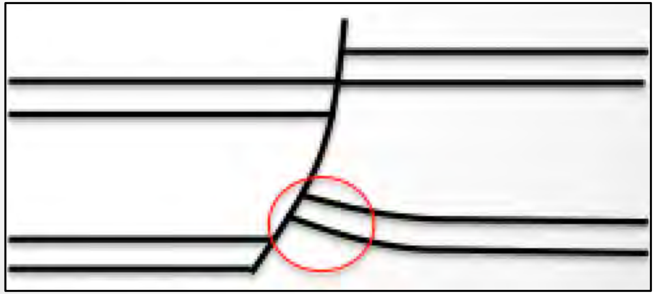
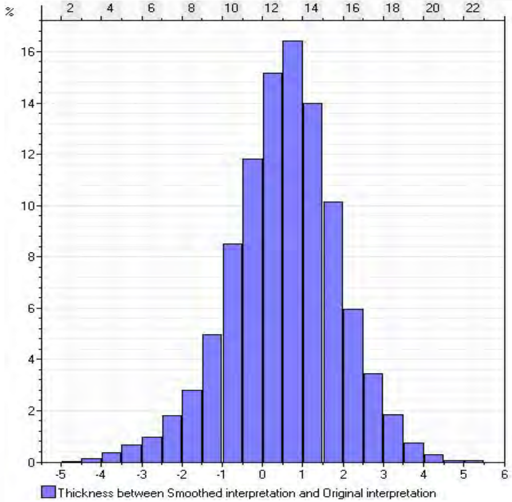


Illustration of the minor oscillations in trough amplitude



Cartoon showing the shadow zone of faults

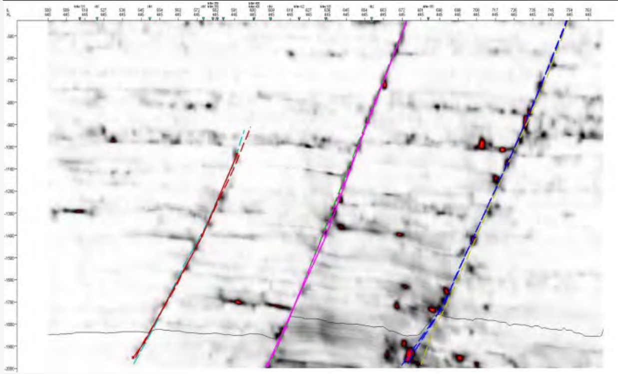


University of Stavanger

Methodology

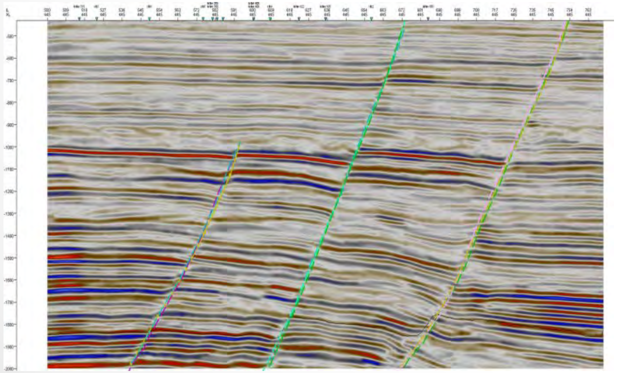
Method 1: Fault uncertainties

Variance cube

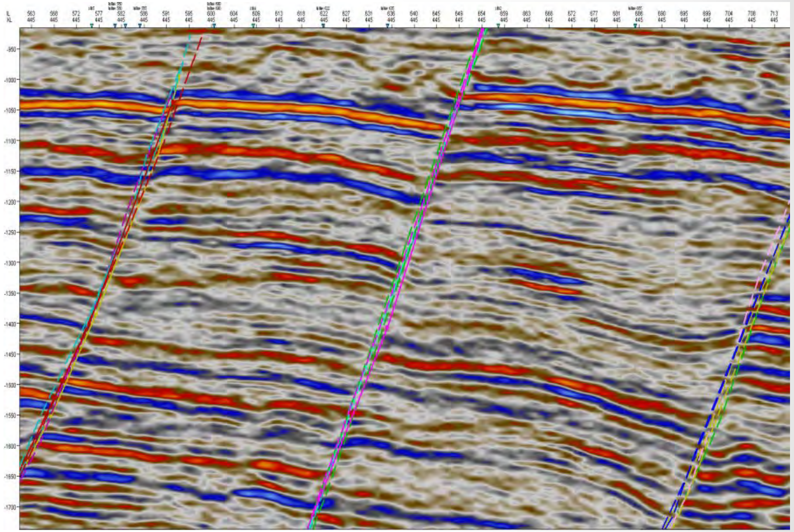


+

Structural smoothing



=

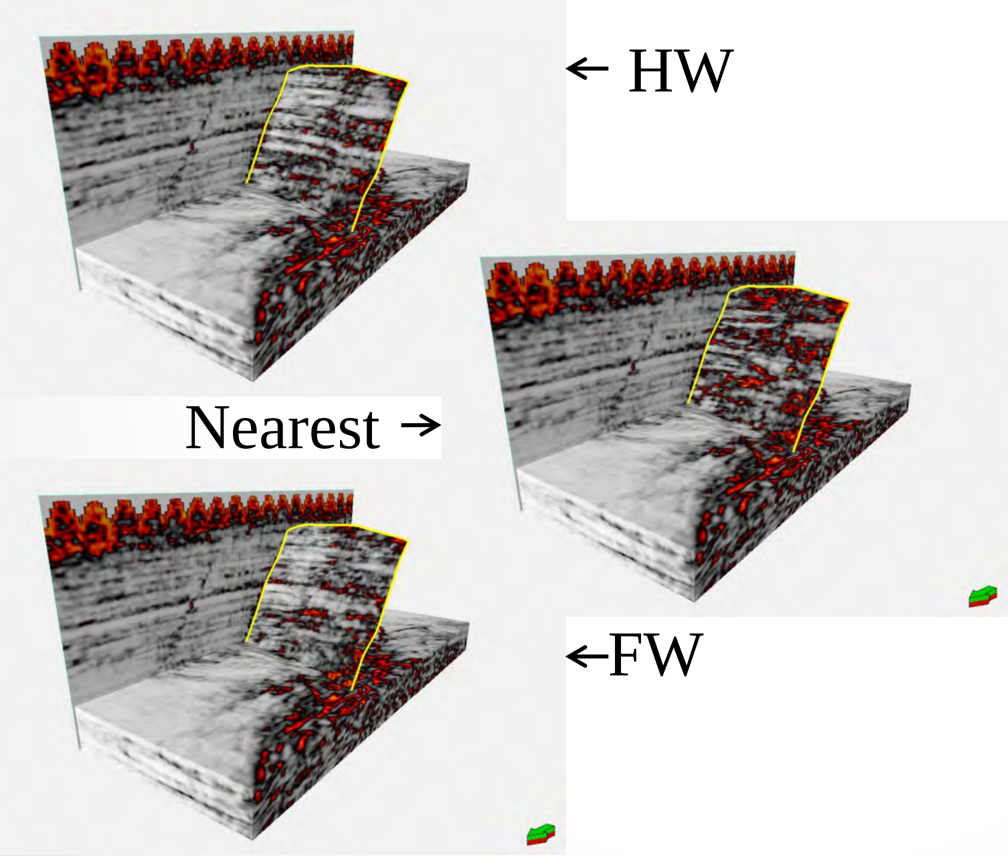


Original seismic

University of Stavanger

Methodology

Method 2: Fault uncertainties

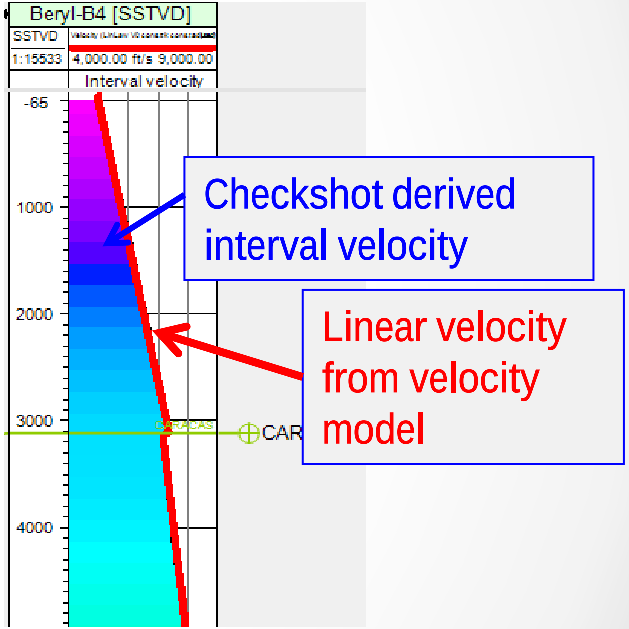


- Extract envelope from variance using fault slicing
- Quality check

Methodology
Depth conversion

- Derive the velocity law
- Blind well test

Requires the calculation of a velocity model. Taking the depth error at the left out well.

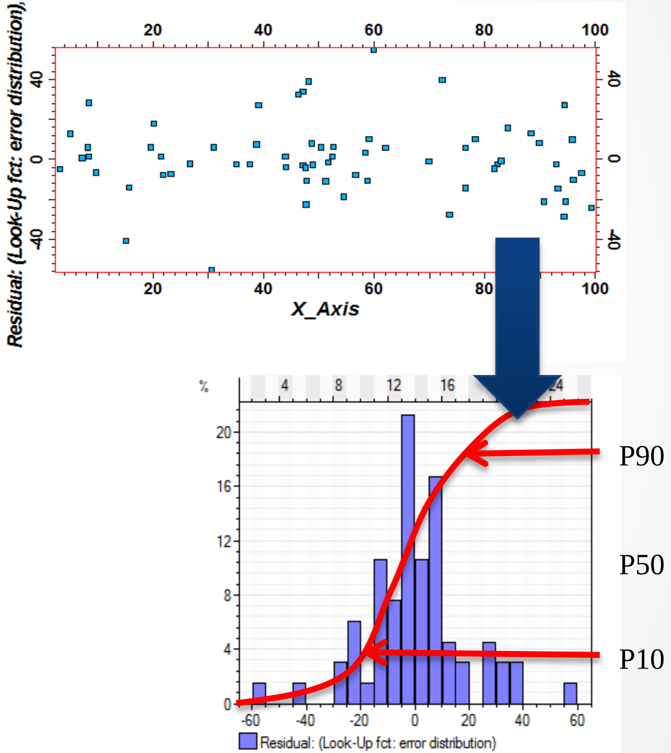


(Schulte, L., personal communication, November 2014.)

Methodology

Velocity uncertainties

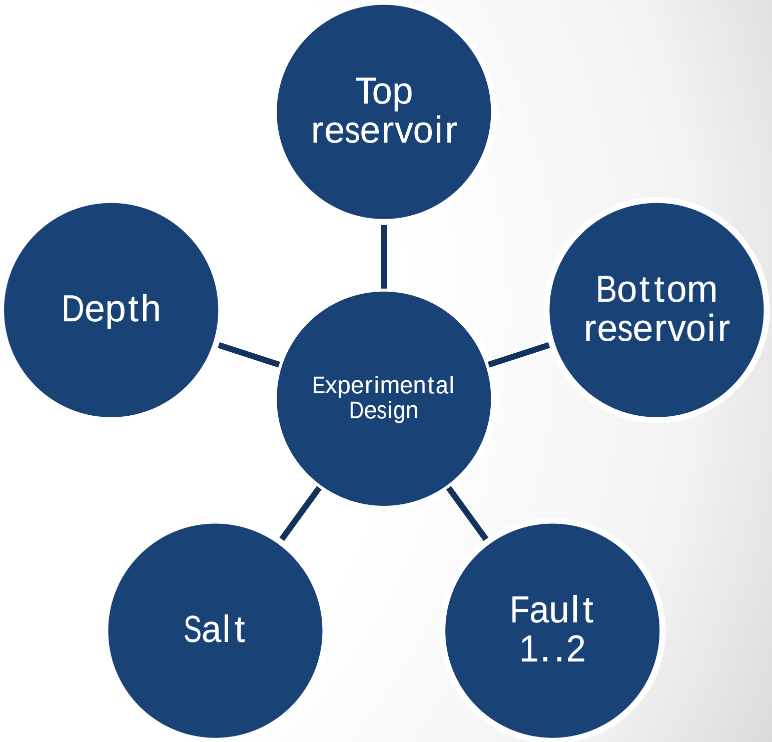
- Blind well test delivers error distributions
- Depth uncertainty extracted from error distributions
- CDF of depth errors delivers P10 (low case) and P90 (high case)



Depth error distribution from blind well test (Schulte, L., personal communication, November 2014.)

Methodology
Essential experimental design

- Integrates any possible scenario with minimum simulations
- Definition of Low, Base and High case for all parameters



Methodology

Essential experimental design

Most common types of polynomial functions used in Experimental Design

1st degree model for linear effects:

$$\text{Prod} = a_0 + a_1 x_1 + a_2 x_2$$

1st degree model for linear effects & interactions:

$$\text{Prod} = a_0 + a_1 x_1 + a_2 x_2 + a_{12} x_1 x_2$$

2nd degree model for linear effects, interactions, quadratic effects

$$\text{Prod} = a_0 + a_1 x_1 + a_2 x_2 + a_{12} x_1 x_2 + a_{11} x_1^2 + a_{22} x_2^2$$

Prod: Predicted volumes; a: coefficients; x: parameters

Polynomial functions used in experimental design
(Schulte, L., personal communication, November 2014.)

$$V_{pred} = a_0 + a_1 * Horizon$$

Model	Horizon	Volume(V_{pred})
1	0	30
2	-1	10

a0	a1
30	20

Prediction	Horizon	Volume
1	-0.2	26
2	0.91	48.2
3	1	50
4	0.34	36.8

University of Stavanger

Time frame

	2014	2015					
	December	January	February	Mars	April	May	June
Literature review	■	■					
Data interpretation		■					
Uncertainty analysis			■				
Structural modeling			■	■			
Volume calculation				■			
Writing graduation thesis				■	■		
Draft preliminary graduation thesis						■	
Finalize graduation thesis							■

References

Hart, B. S. (2011). Structural Interpretation *An Introduction to Seismic Interpretation* (pp. 42): AAPG.

Samson, P., Dubrule, O., & Euler, N. (1996). *Quantifying the impact of structural uncertainties on gross-rock volume estimates.* Paper presented at the NPF/SPE European 3-D Reservoir Modelling Conference.

Thore, P., Shtuka, A., Lecour, M., Ait-Ettajer, T., & Cognot, R. (2002). Structural uncertainties: Determination, management, and applications. *Geophysics, 67*(3), 840-852.

Vincent, G., Corre, B., & Thore, P. (1999). Managing structural uncertainty in a mature field for optimal well placement. *SPE Reservoir Evaluation and Engineering, 2*(4), 377-384.

University of Stavanger

Thank you

University of Stavanger

Interaction of Extensional Tectonics on Synrift Deposition: Using Field Analogues From Greece and a North Viking Graben Dataset

Paul Rhodes

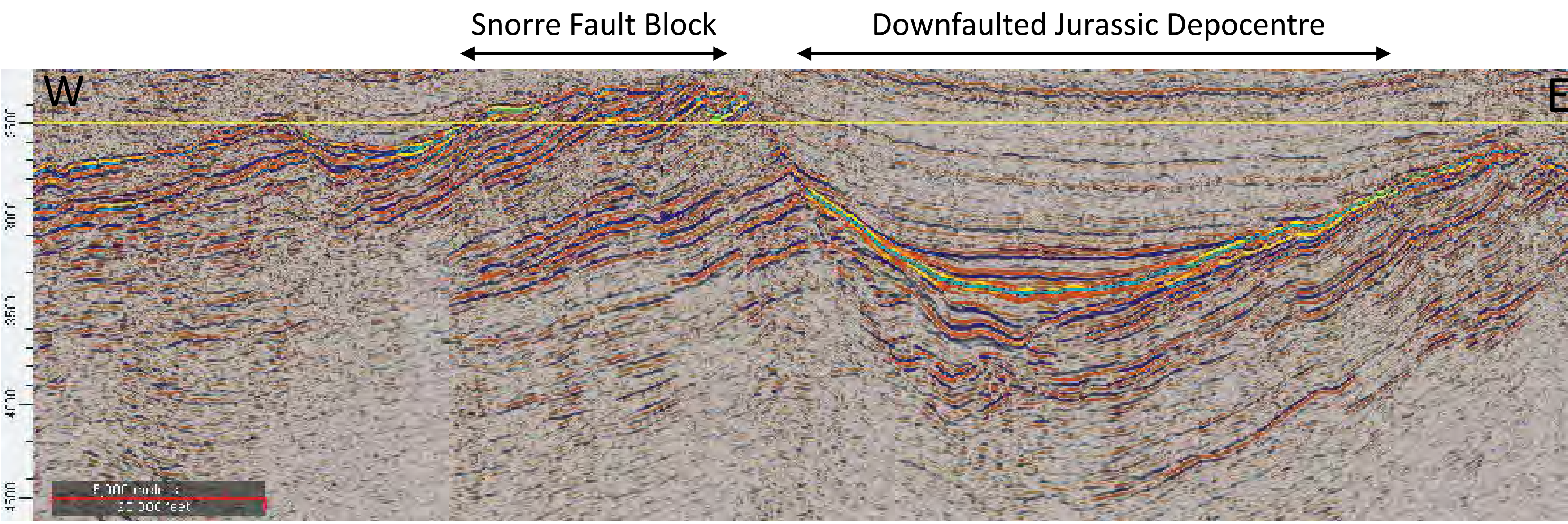
Supervisors: Chris Townsend[1] and Steve Thomas[2]

[1]University of Stavanger, Stavanger, Norway
[2]Lundin Petroleum, Oslo, Norway

Universitetet i Stavanger

Interaction of Extensional Tectonics on Synrift Deposition: Using Field Analogues From Greece and a North Viking Graben Dataset

Paul Rhodes



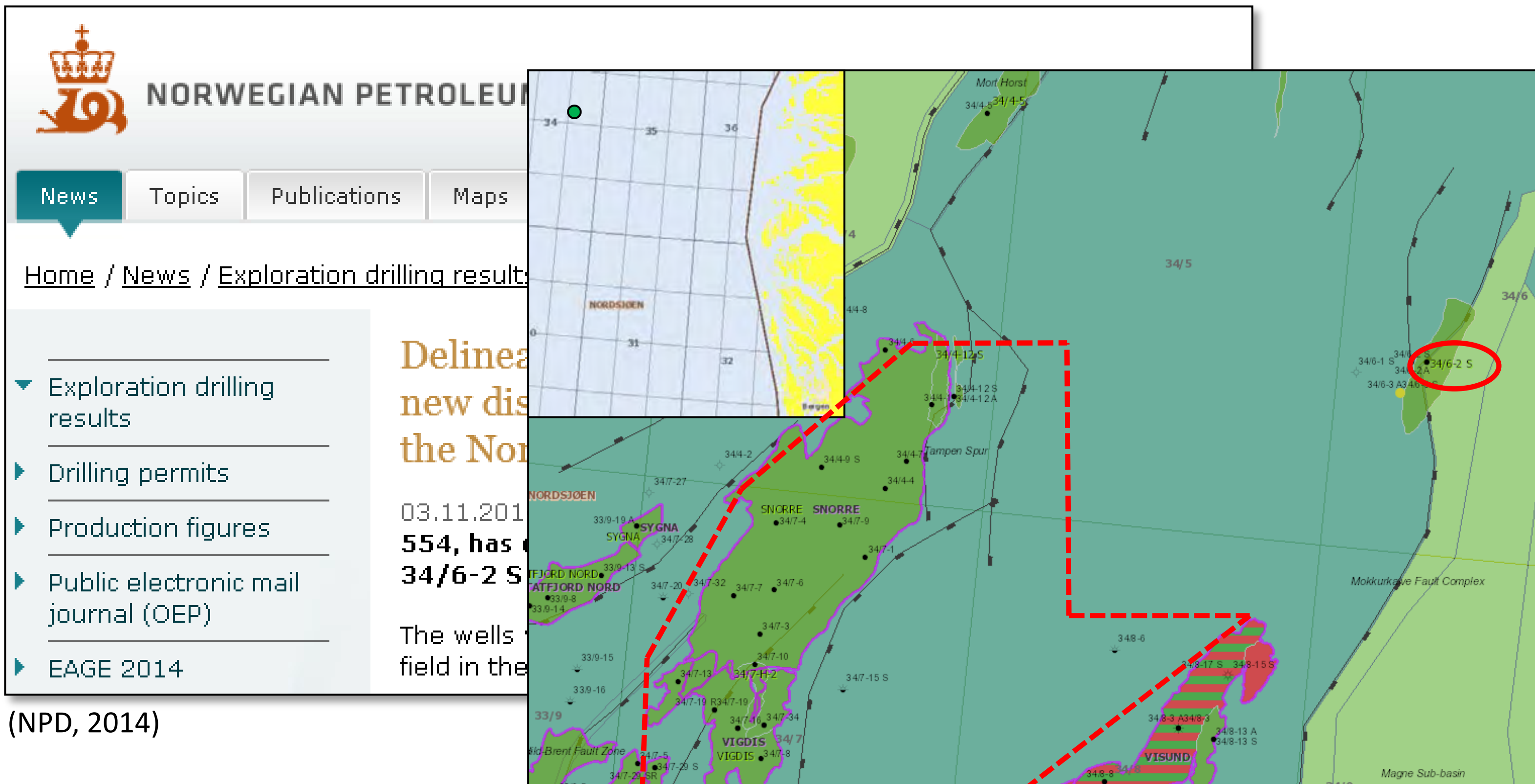
Supervisors: Chris Townsend[1] and Steve Thomas[2]

[1]University of Stavanger, Stavanger, Norway
[2]Lundin Petroleum, Oslo, Norway

Universitetet i Stavanger

Interaction of Extensional Tectonics on Synrift Deposition: Using Field Analogues From Greece and a North Viking Graben Dataset

Paul Rhodes



(NPD, 2014)

Supervisors: Chris Townsend[1] and Steve Thomas[2]

[1]University of Stavanger, Stavanger, Norway
[2]Lundin Petroleum, Oslo, Norway

Universitetet i Stavanger

Phase 1: Field Mapping Northern Peloponnese

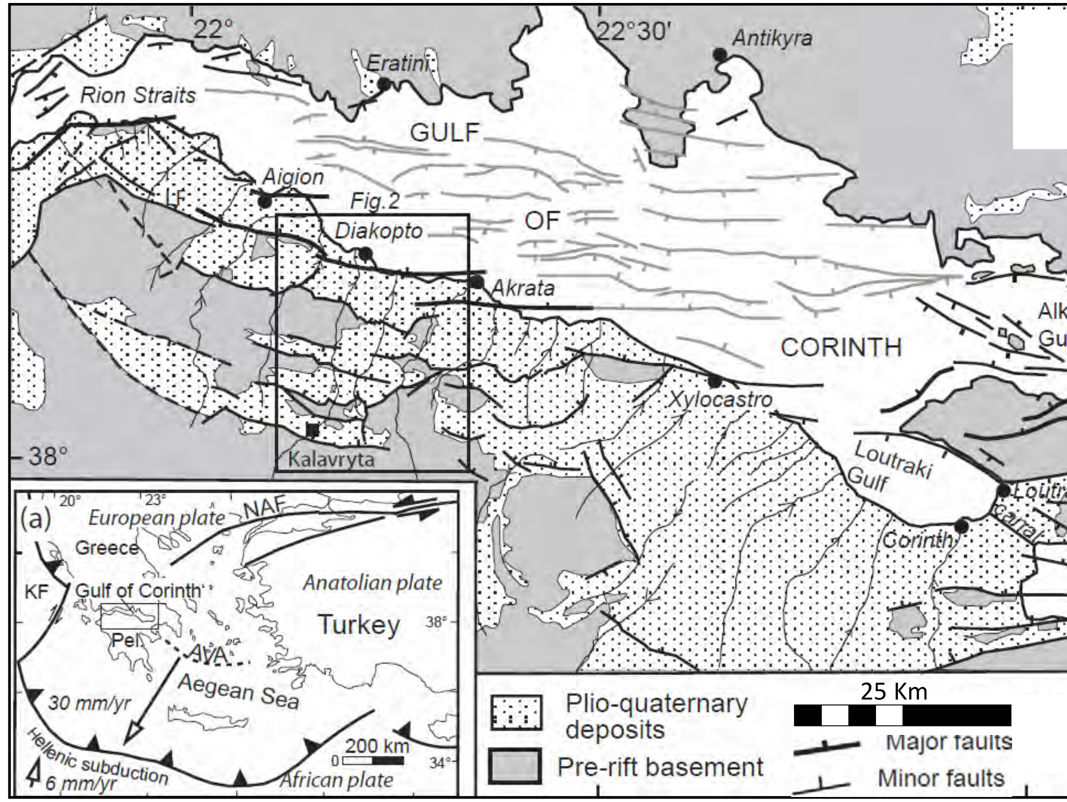
Phase 1: Field Mapping Northern Peloponnese

Field Study Aims

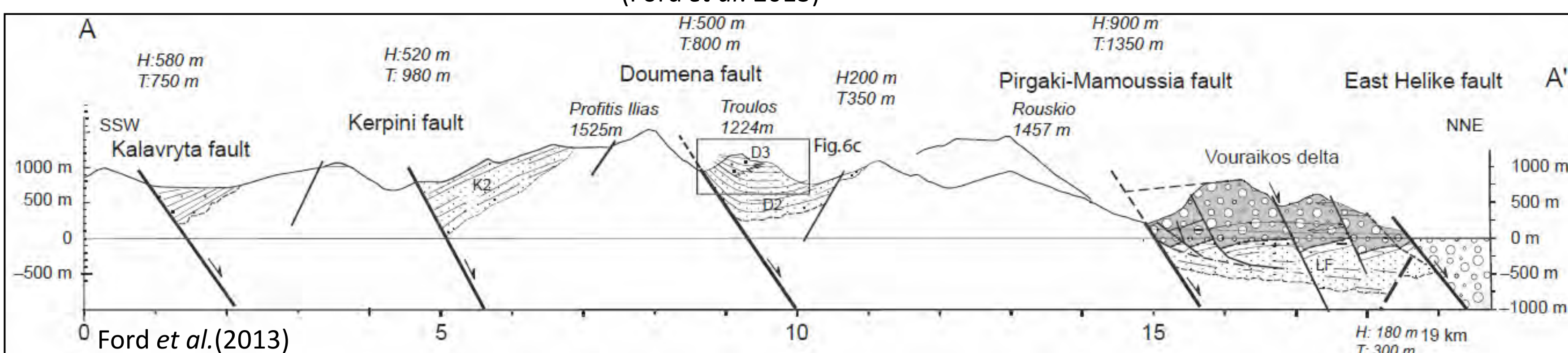
Produce geological surface maps

Generate palaeogeographic reconstructions at key times

Construct 3D geomodel in Petrel



(Ford *et al*. 2013)



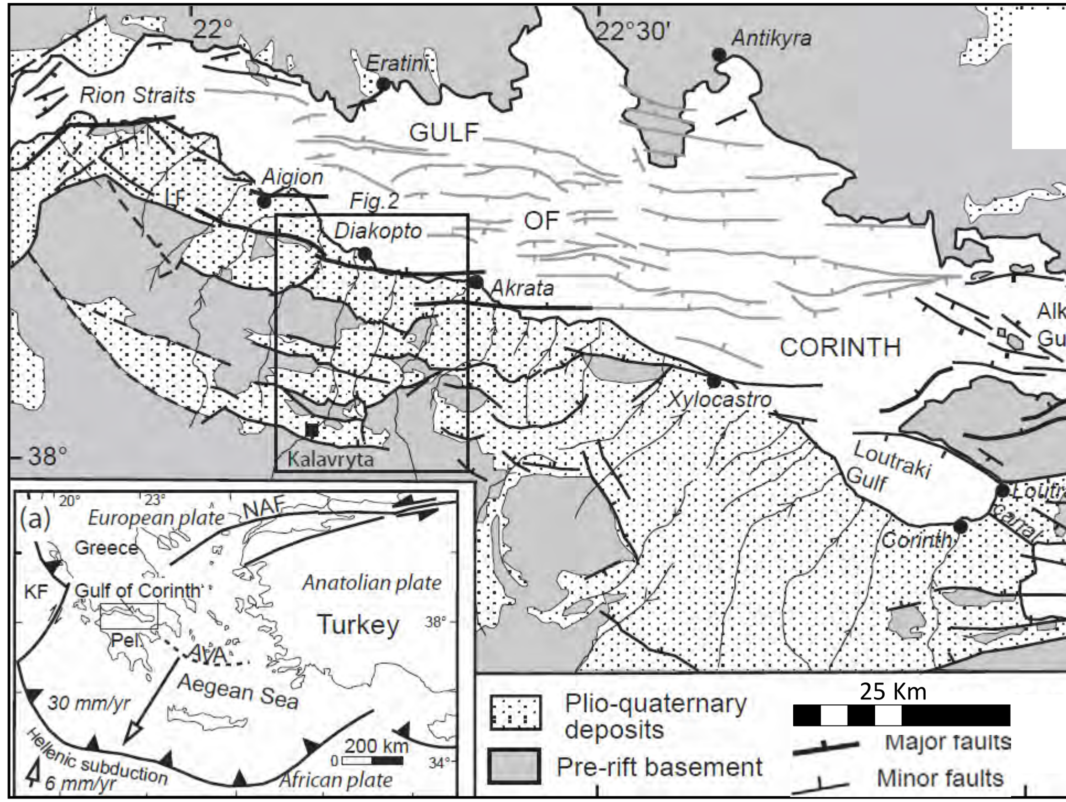
Ford *et al.*(2013)

Phase 1: Field Mapping Northern Peloponnese

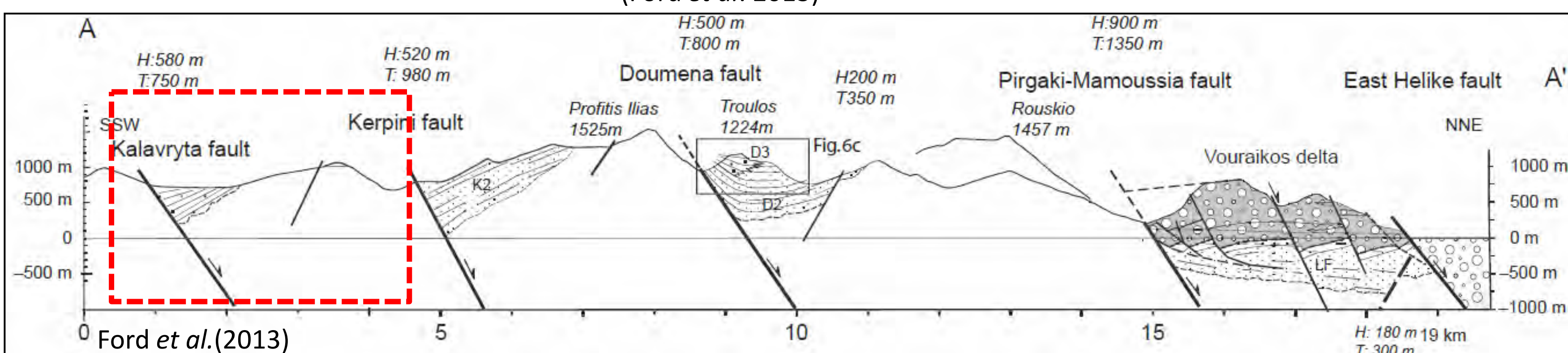
Produce geological surface maps

Generate palaeogeographic reconstructions at key times

Construct 3D geomodel in Petrel

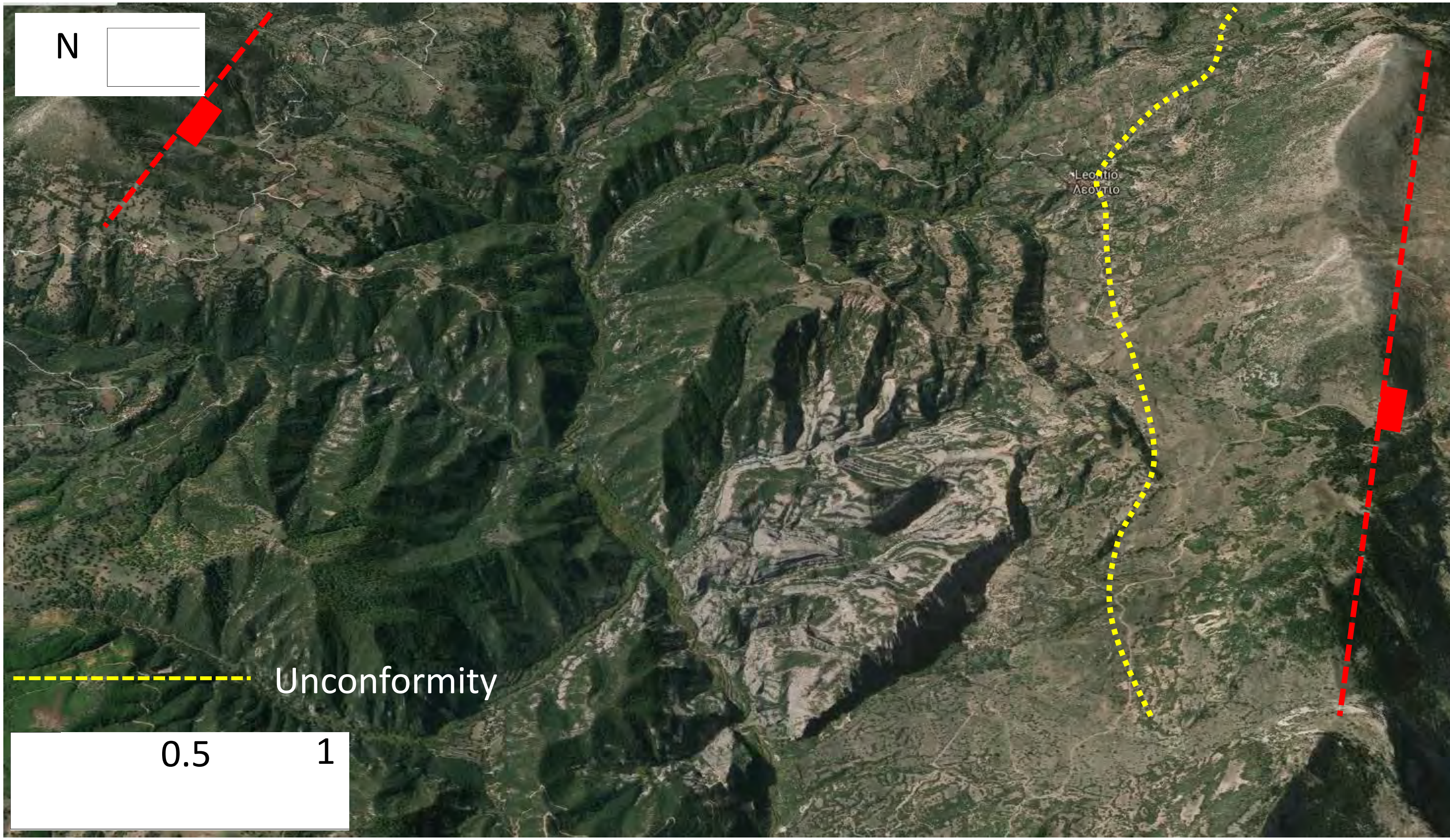


(Ford *et al*. 2013)



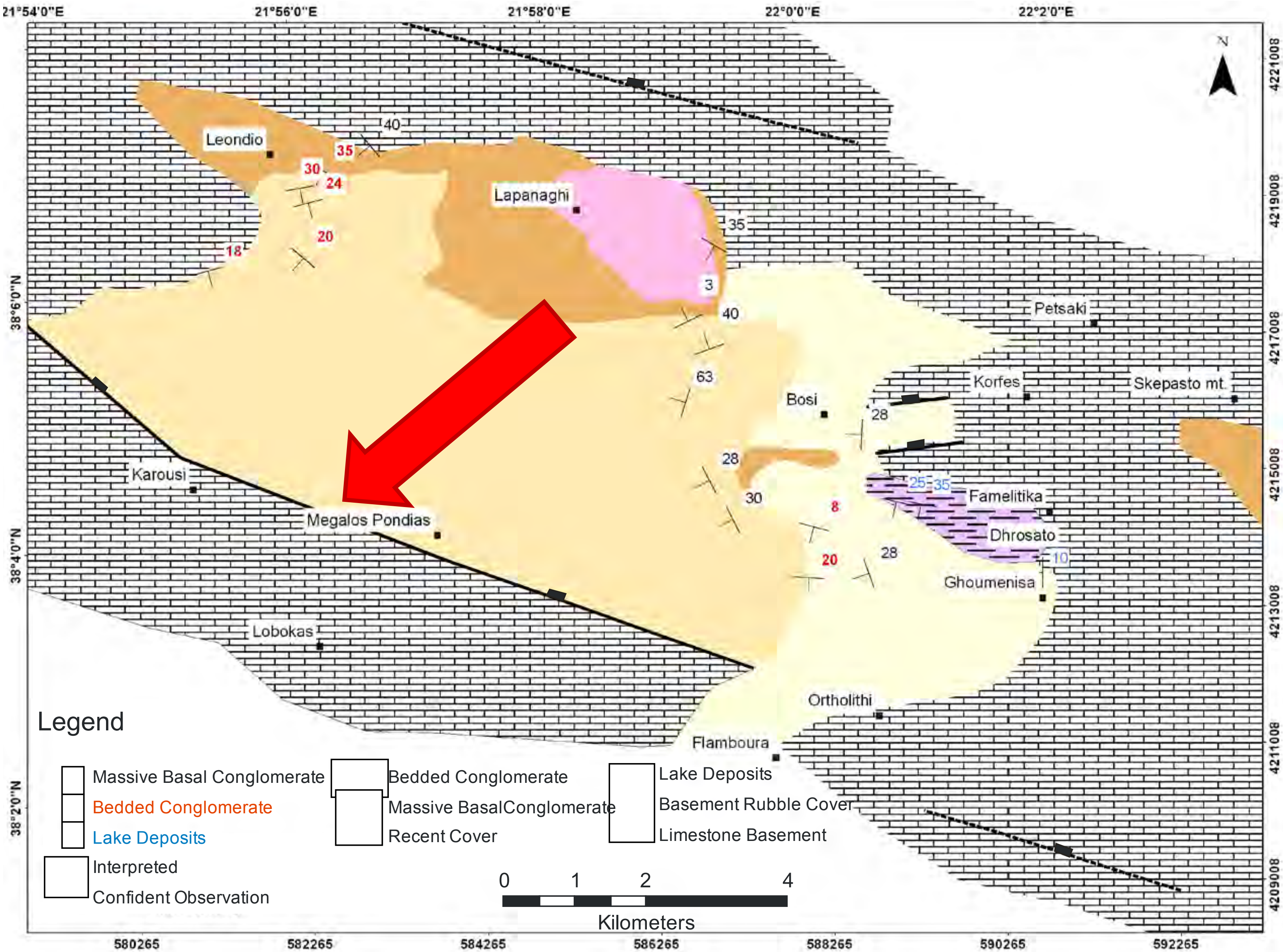
Ford *et al.*(2013)

Phase 1: Field Mapping Northern Peloponnese



(Google Maps, 2014)

Phase 1: Preliminary Field Map



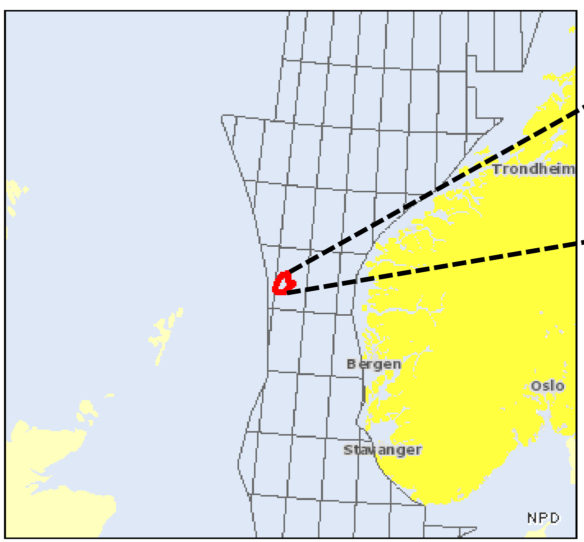
Phase 2: Study of North Viking Graben Seismic Dataset

Dataset

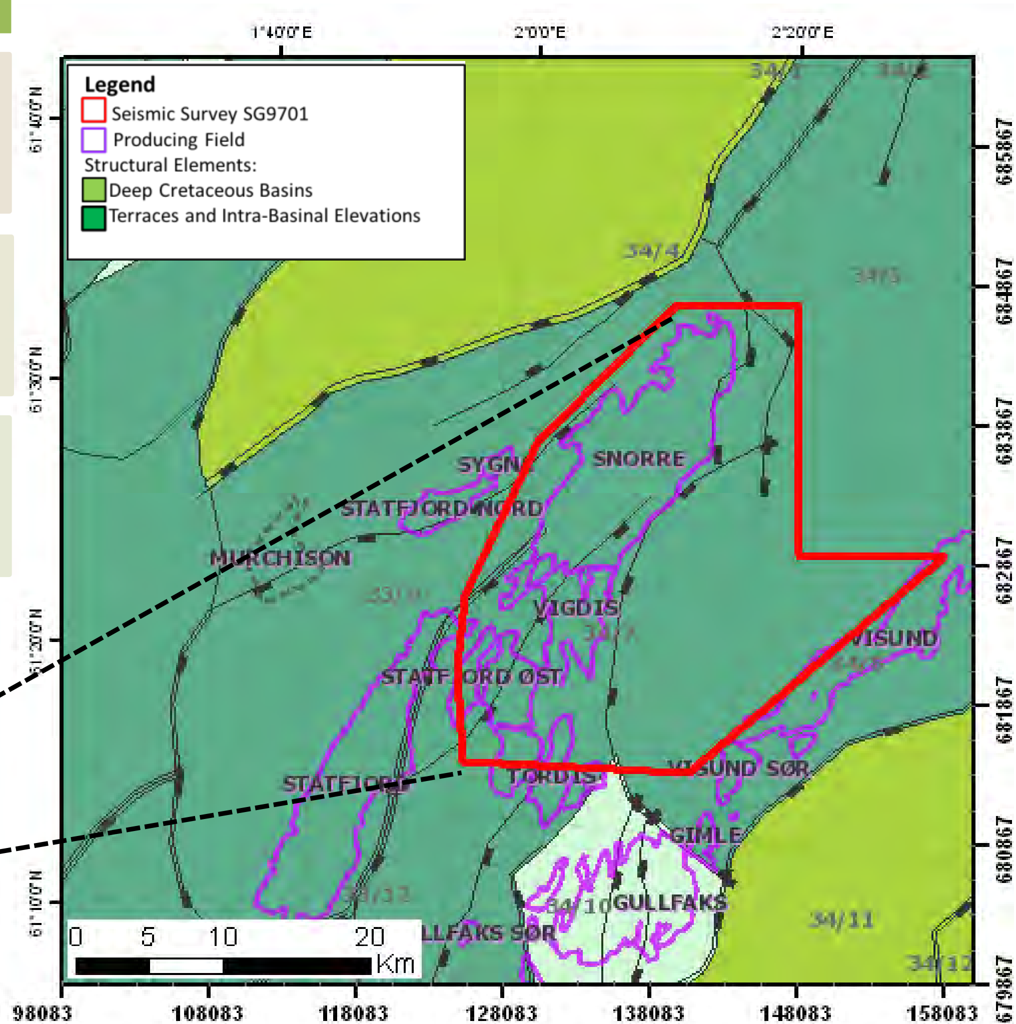
Seismic dataset: SG9701 full-stack 3D cube

7 Representative exploration wells (GR, RHOB, NPHI, DT & checkshots)

Load into Petrel



(NPD, 2014)



Phase 2: Study of North Viking Graben Seismic Dataset

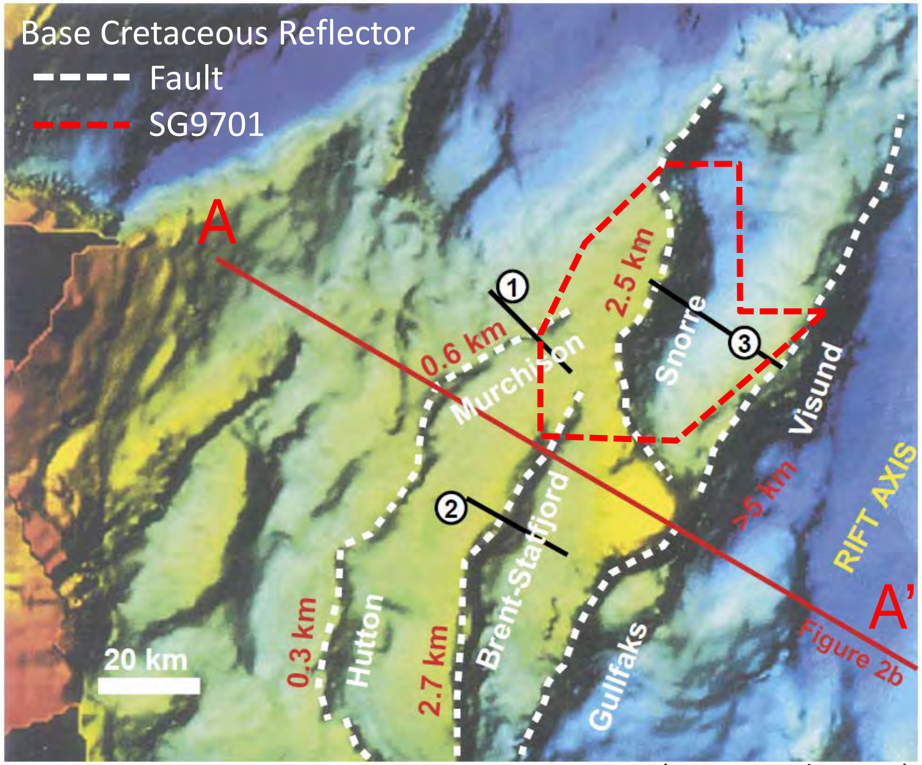
Methodology

Calibrate data with representative wells

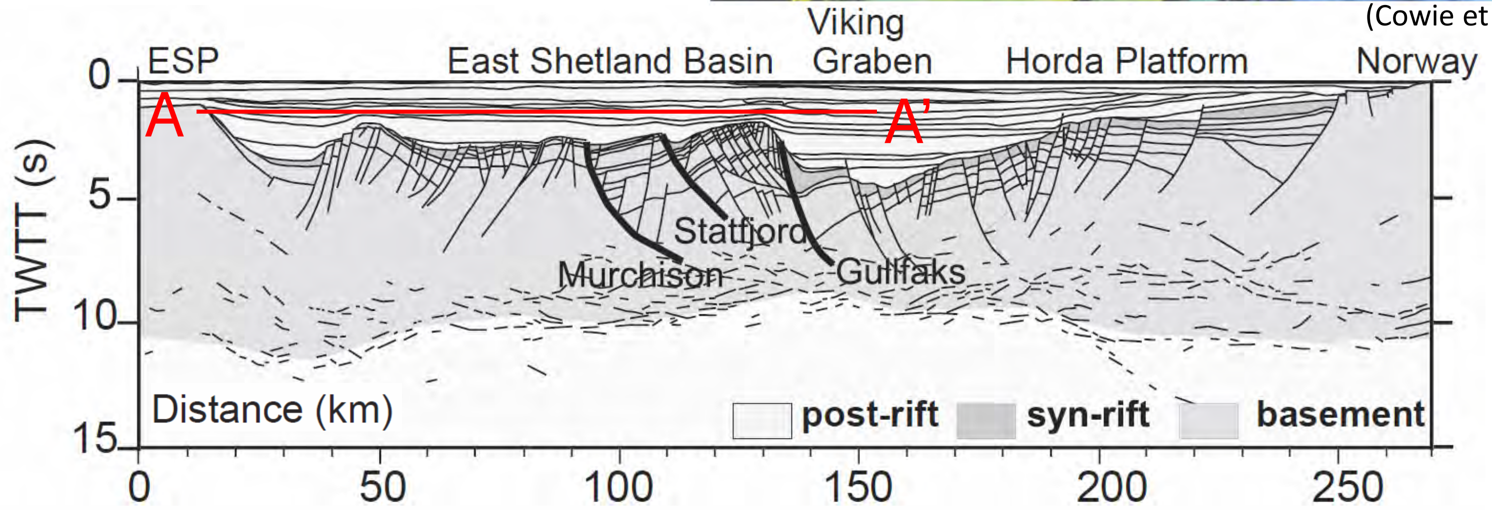
Construct a fault framework and identify the Upper Jurassic synrift package

Make observations of the structural and sequence geometries

Construct 3D geomodel in Petrel



(Cowie et al., 2005)



Phase 2: Study of North Viking Graben Seismic Dataset

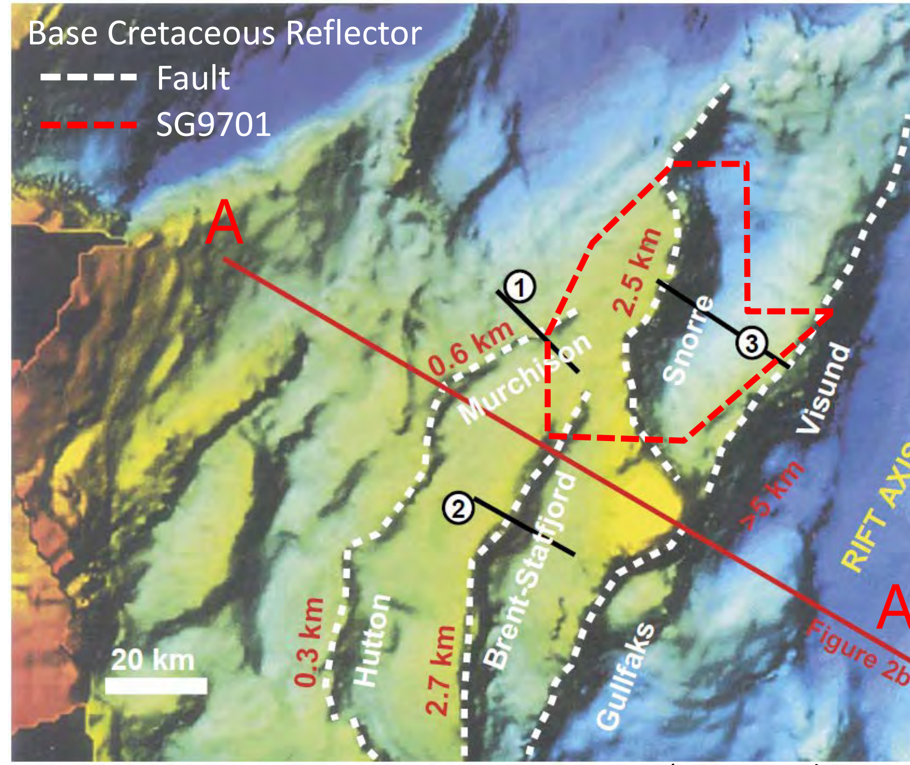
Methodology

Calibrate data with representative wells

Construct a fault framework and identify the <u>Upper Jurassic synrift package</u>

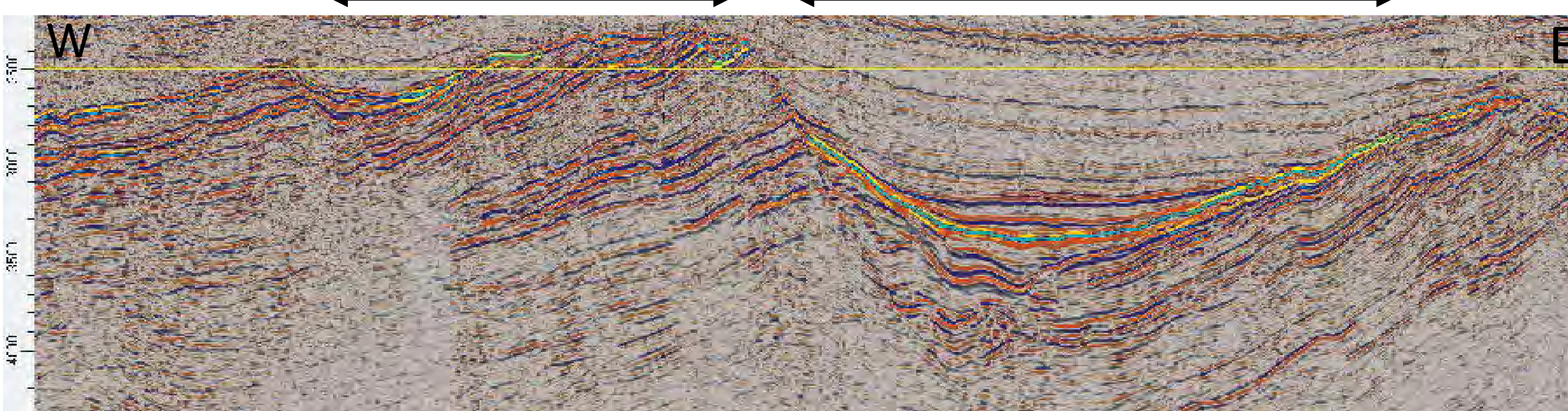
Make observations of the structural and sequence geometries

Construct 3D geomodel in Petrel



(Cowie et al., 2005)

Snorre Fault Block — Downfaulted Jurassic Depocentre



Phase 3: Cross-Assessment of Field and Seismic Datasets

Principle Objectives

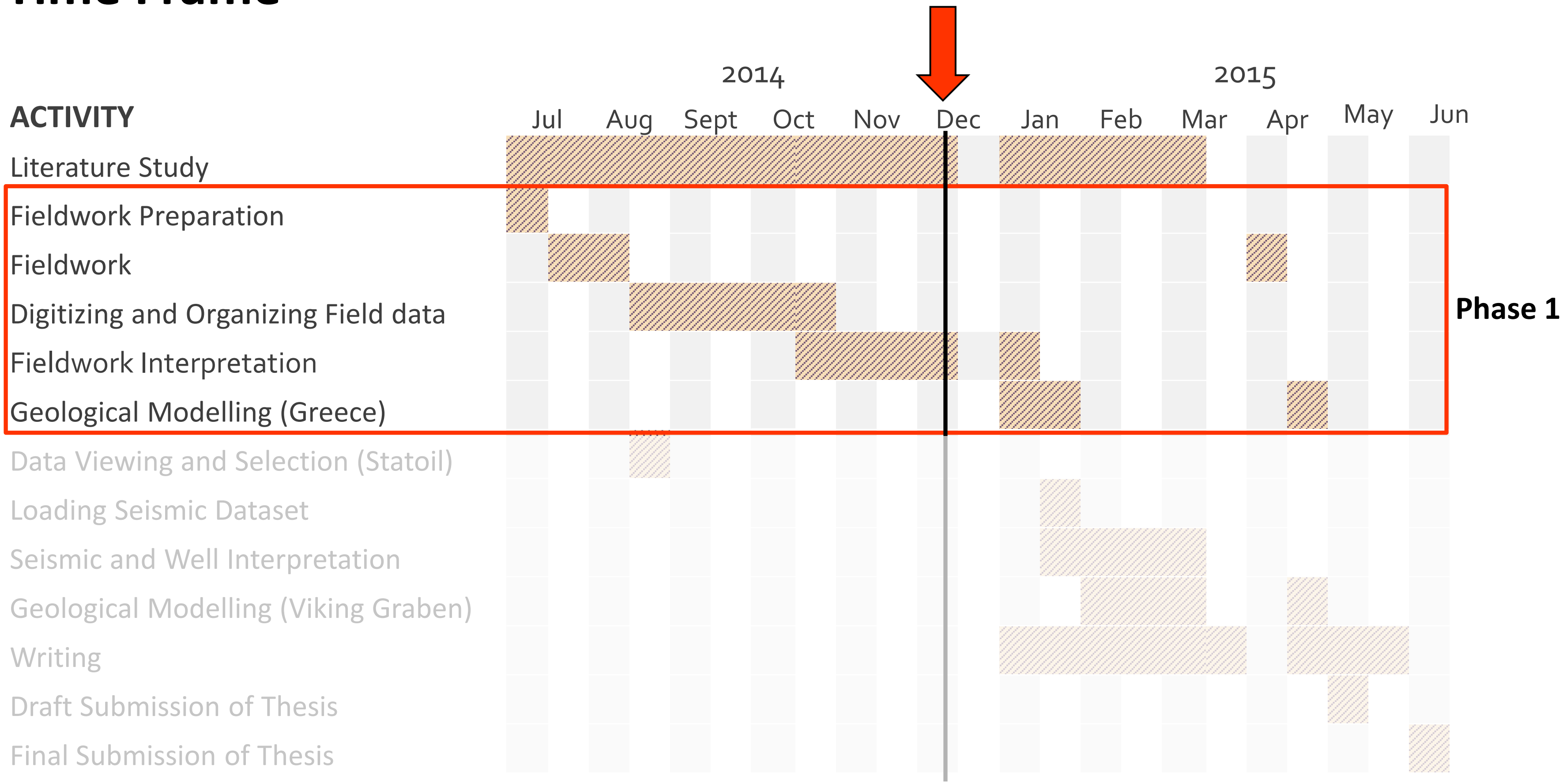
Compare the scale and style of structural and sequence geometries observed.

What can be seen and learned in one area that may enhance the assessment of the other?

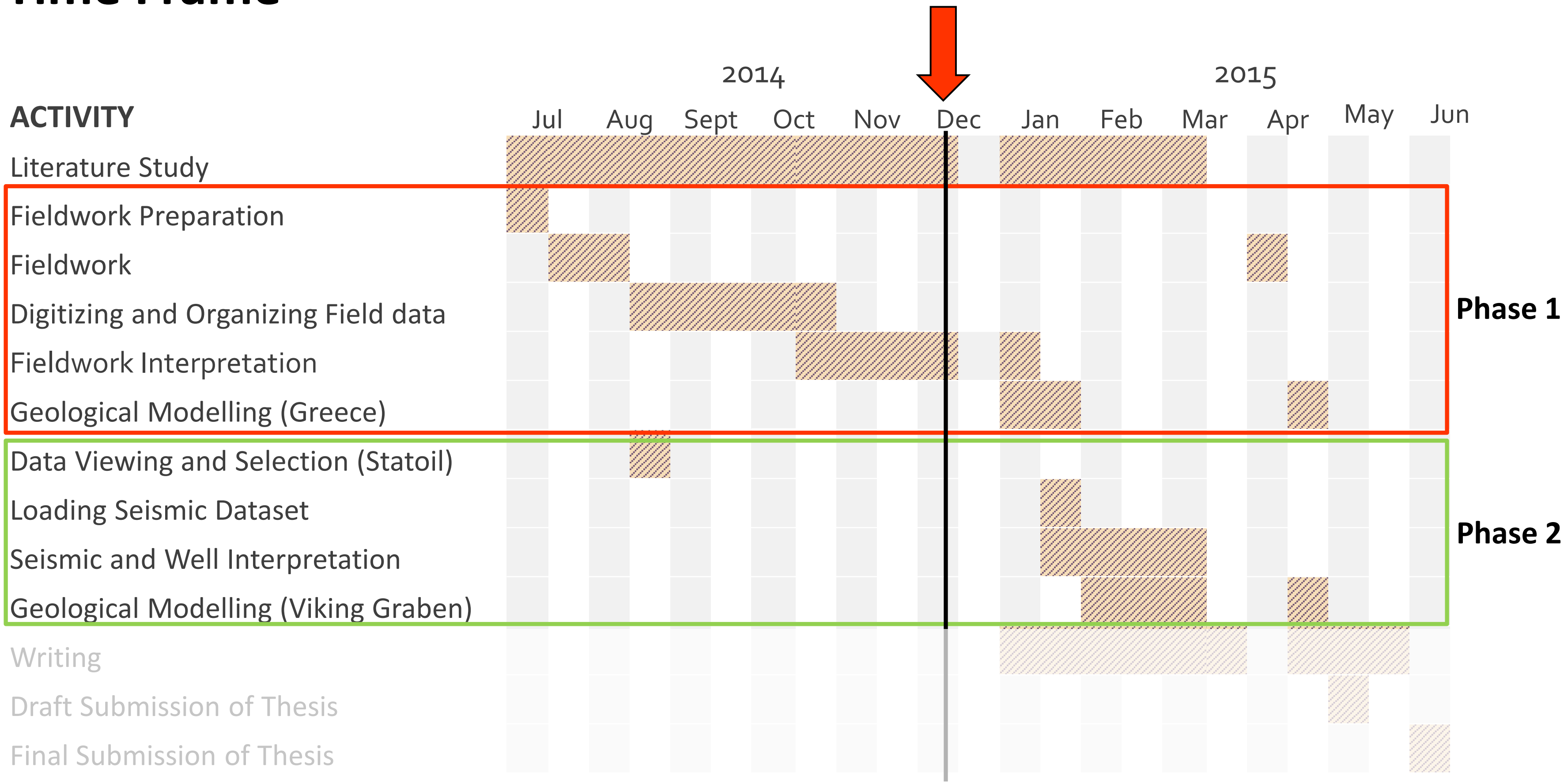
Can any aspects of the field aid exploration efforts in the seismic dataset?

Revise Geomodels

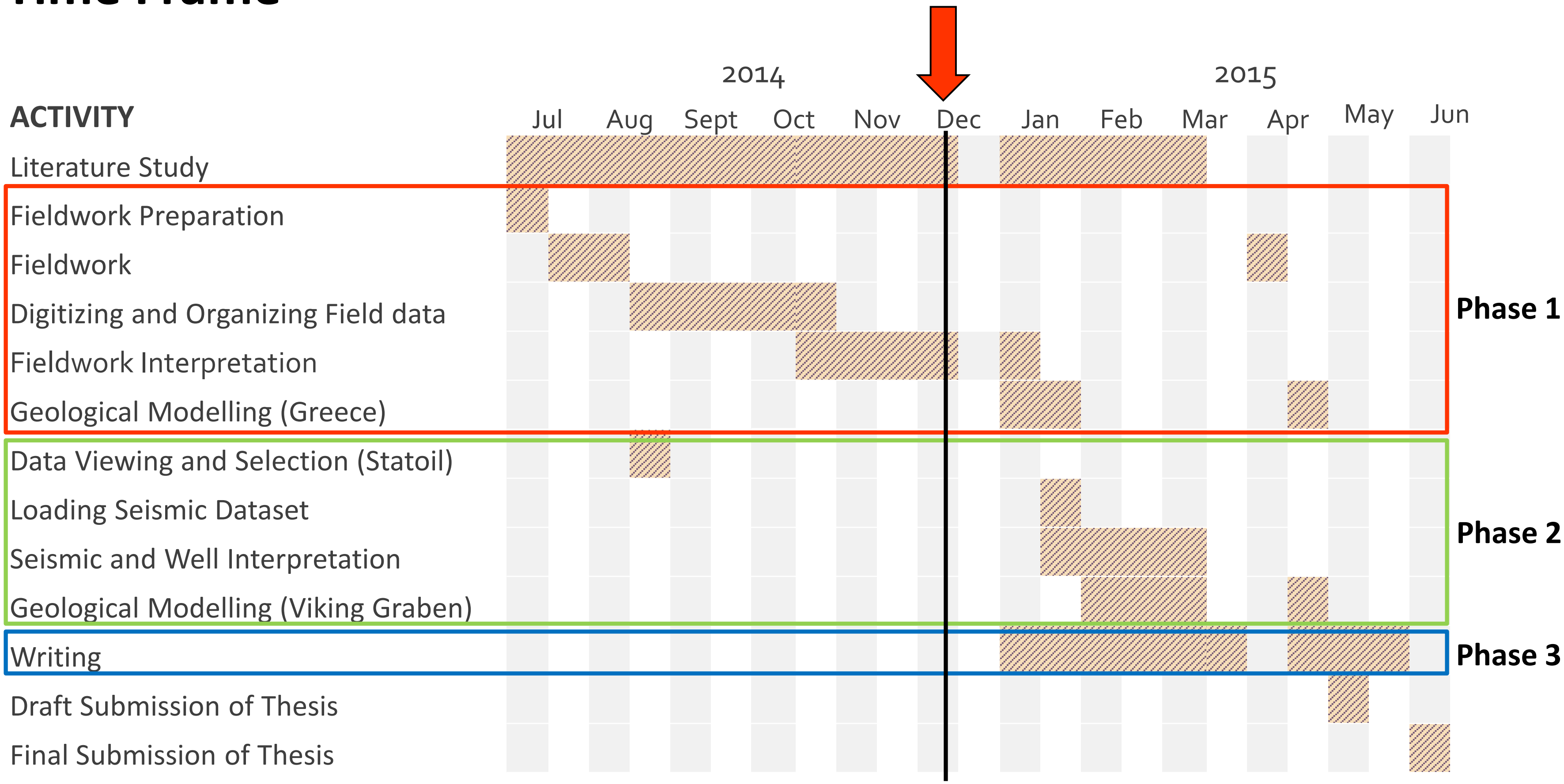
Time Frame


2014
2015
ACTIVITY
Jul
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Literature Study
Fieldwork Preparation
Fieldwork
Digitizing and Organizing Field data
Fieldwork Interpretation
Geological Modelling (Greece)
Phase 1
Data Viewing and Selection (Statoil)
Loading Seismic Dataset
Seismic and Well Interpretation
Geological Modelling (Viking Graben)
Writing
Draft Submission of Thesis
Final Submission of Thesis

Time Frame


2014
2015
ACTIVITY
Jul
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Literature Study
Fieldwork Preparation
Fieldwork
Digitizing and Organizing Field data
Fieldwork Interpretation
Geological Modelling (Greece)
Phase 1
Data Viewing and Selection (Statoil)
Loading Seismic Dataset
Seismic and Well Interpretation
Geological Modelling (Viking Graben)
Phase 2
Writing
Draft Submission of Thesis
Final Submission of Thesis

Time Frame


2014
2015
ACTIVITY
Jul
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Literature Study
Fieldwork Preparation
Fieldwork
Digitizing and Organizing Field data
Fieldwork Interpretation
Geological Modelling (Greece)
Data Viewing and Selection (Statoil)
Loading Seismic Dataset
Seismic and Well Interpretation
Geological Modelling (Viking Graben)
Writing
Draft Submission of Thesis
Final Submission of Thesis
Phase 1
Phase 2
Phase 3

Key References

Cowie, P., A., J. R Underhill, M. D. Behn, J. Lin, & C. E. Gill, 2005, *Spatio-temporal evolution of strain accumulation derived from multi-scale observations of Late Jurassic rifting in the northern North Sea: A critical test of models for lithospheric extension*: Earth and Planetary Science Letters, v. 234(3), 401-419.

Doutsos, T., N. Kontopoulos, and D. Frydas, 1987, *Neotectonic evolution of northwestern-continental Greece*: Geologische Rundschau, v. 76, p. 433-450.

Ford, M., S. Rohais, E. A. Williams, S. Bourlange, D. Jousselin, N. Backert, and F. Malartre, 2013, *Tectono-sedimentary evolution of the western Corinth rift (Central Greece)*: Basin Research, v. 25, p. 3-25.

Fossen, H., T. Odinsen, R. B. Færseth, and R. H. Gabrielsen, 2000, *Detachments and low-angle faults in the northern North Sea rift system*: Geological Society Special Publication, v. 167, p. 105-131.

NPD, 2014, [online] Available at: http://gis.npd.no/arcgis/rest/services [Accessed 27 Oct. 2014].

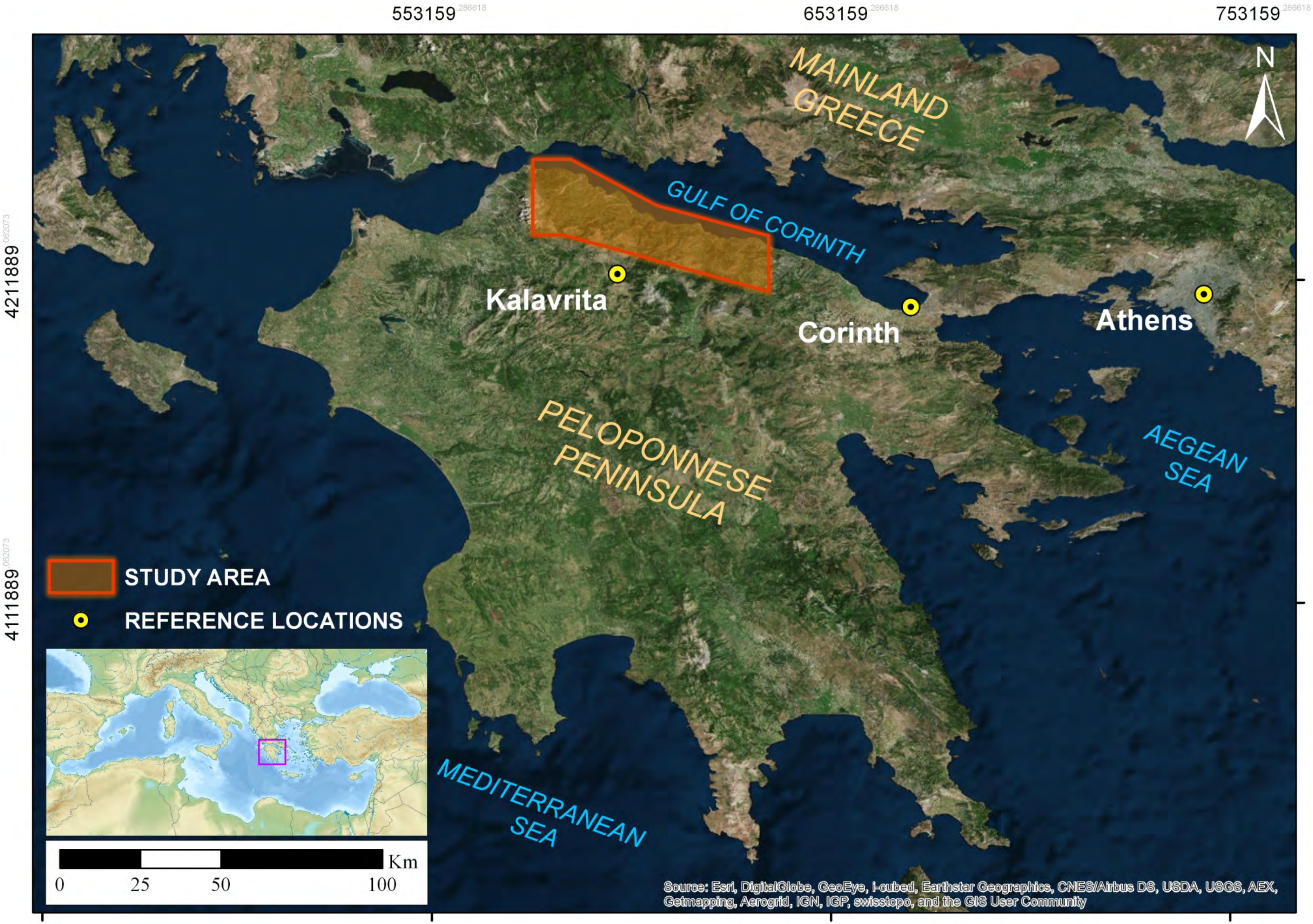
Wood, A.M, 2013, *The influence of fault geometric uncertainty on hydrocarbon reservoir and simulation models:* Unpublished doctoral dissertation, University of Leeds, Leeds, United Kingdom.

Universitetet i Stavanger

Geological mapping and forward modelling of the south-central Gulf of Corinth coastal fault system - Greece

Gustavo Lopes
Paul Rhodes
Chris Townsend
Alejandro Escalona
Steve Thomas

LOCATION



Study area ≈ 1200 Km²

OBJECTIVES

✓ Understand evolution of normal faults and their control over syn-rift sedimentation

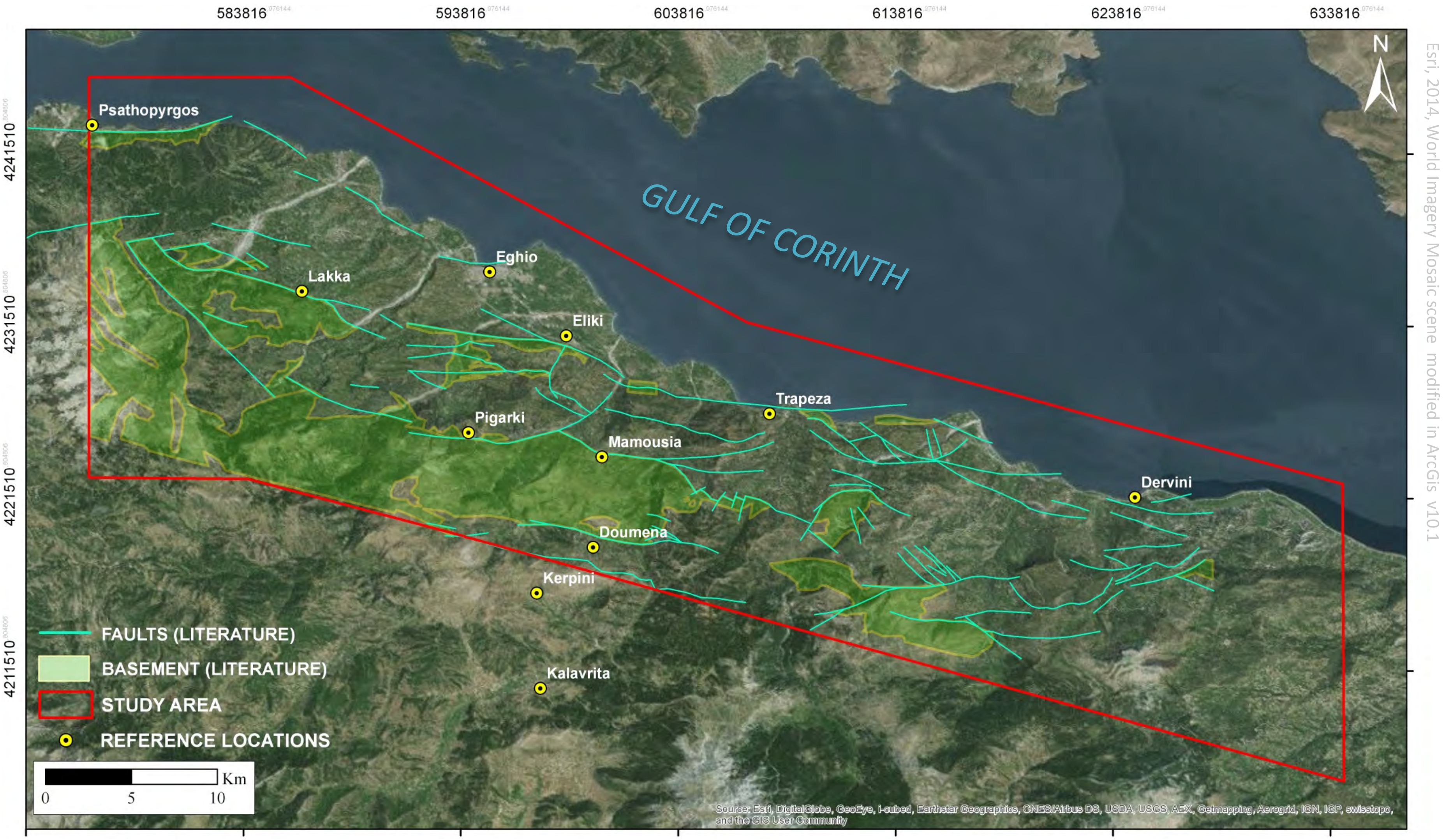
✓ Make field observations

✓ Build 3D geological forward model

✓ Compare observed data to forward model

✓ Determine how modelling can cope with complexities of field observations

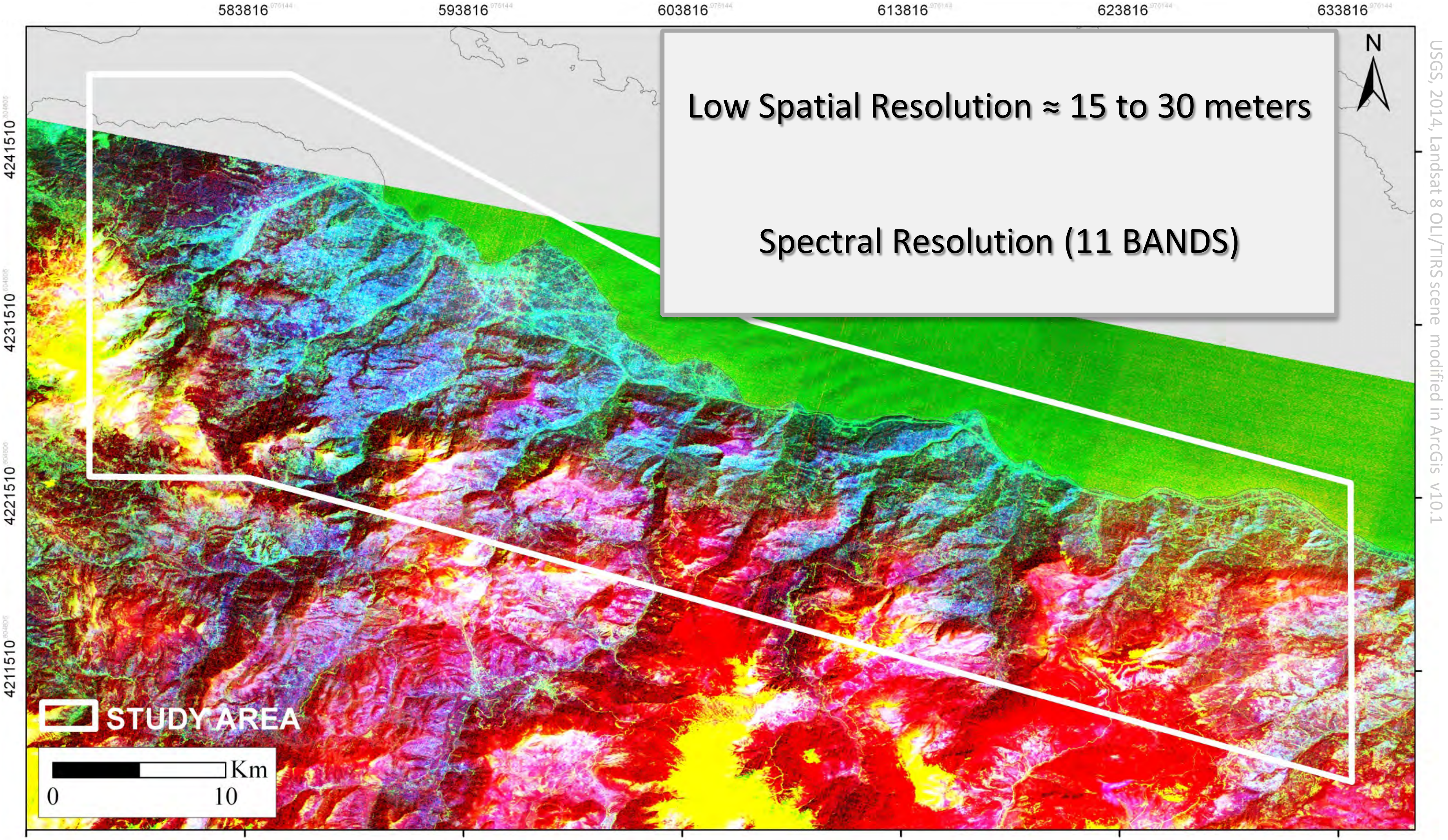
LITERATURE RESEARCH



Compilation of data from previous studies.

Published work has emphasis on sedimentological observations.

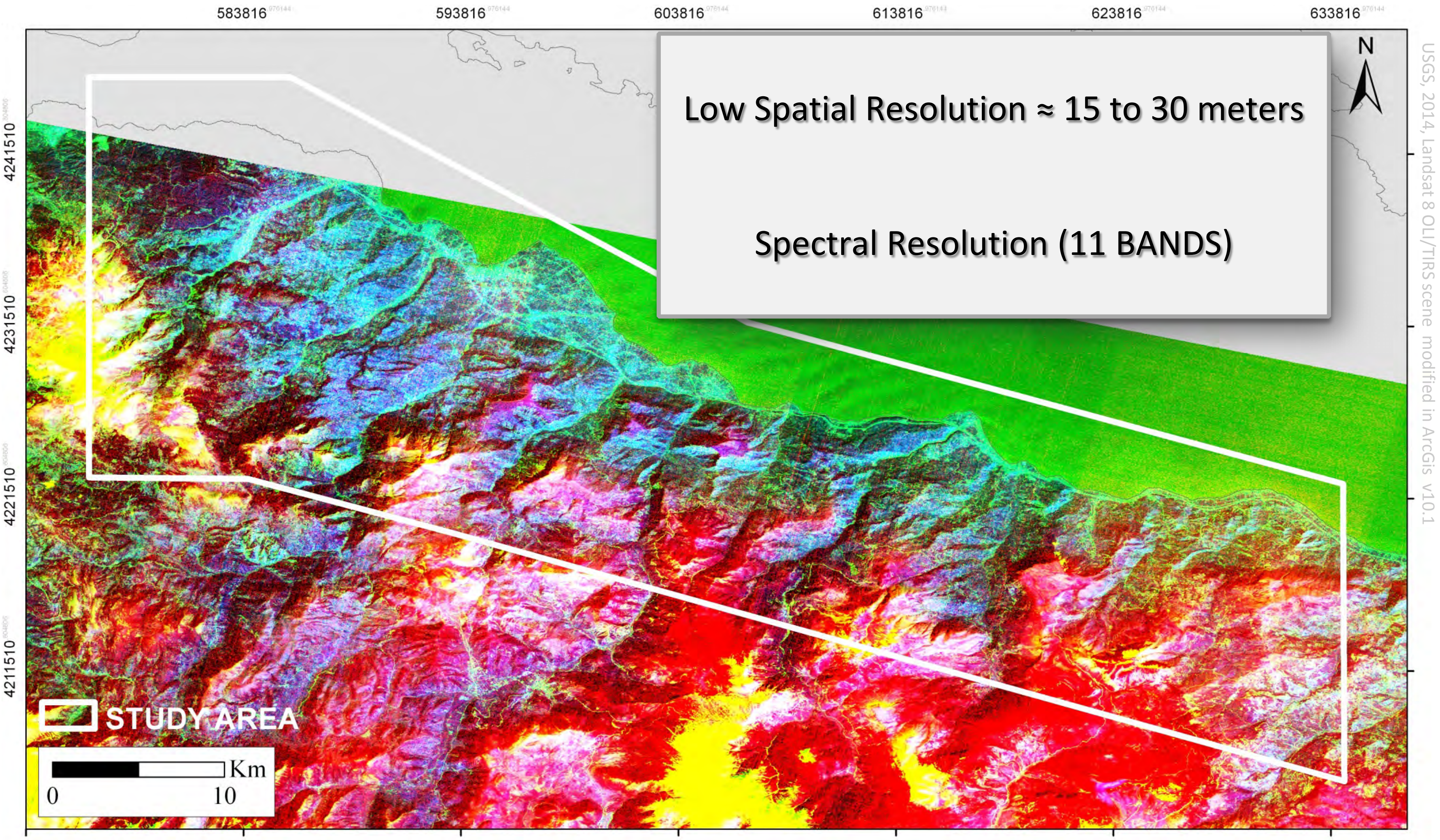
LANDSAT 8



Composition 9-1-10 shows contrast between carbonate and clay reflectance.

Landsat was not designed for geology but can be adapted for our purposes.

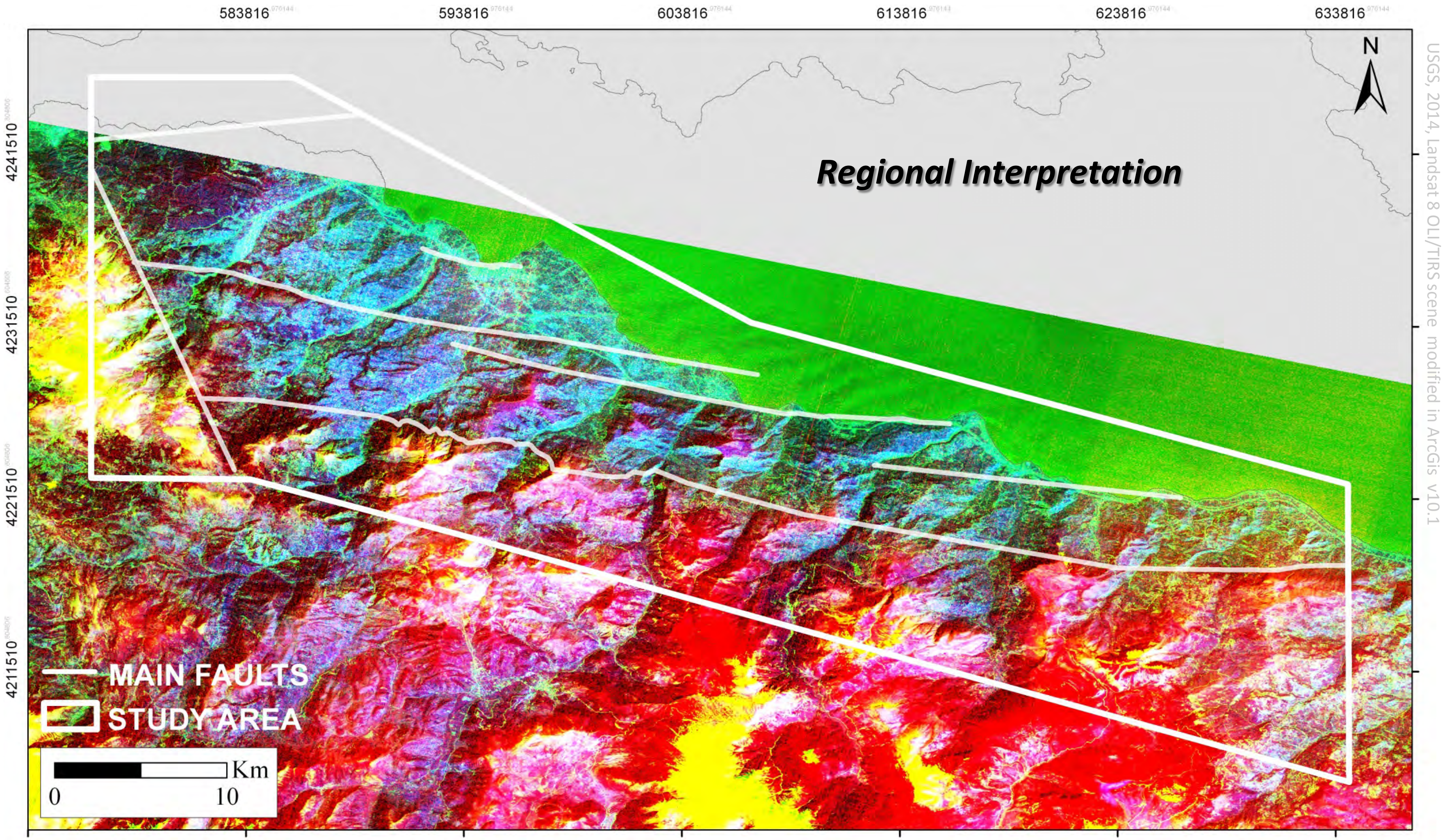
LANDSAT 8



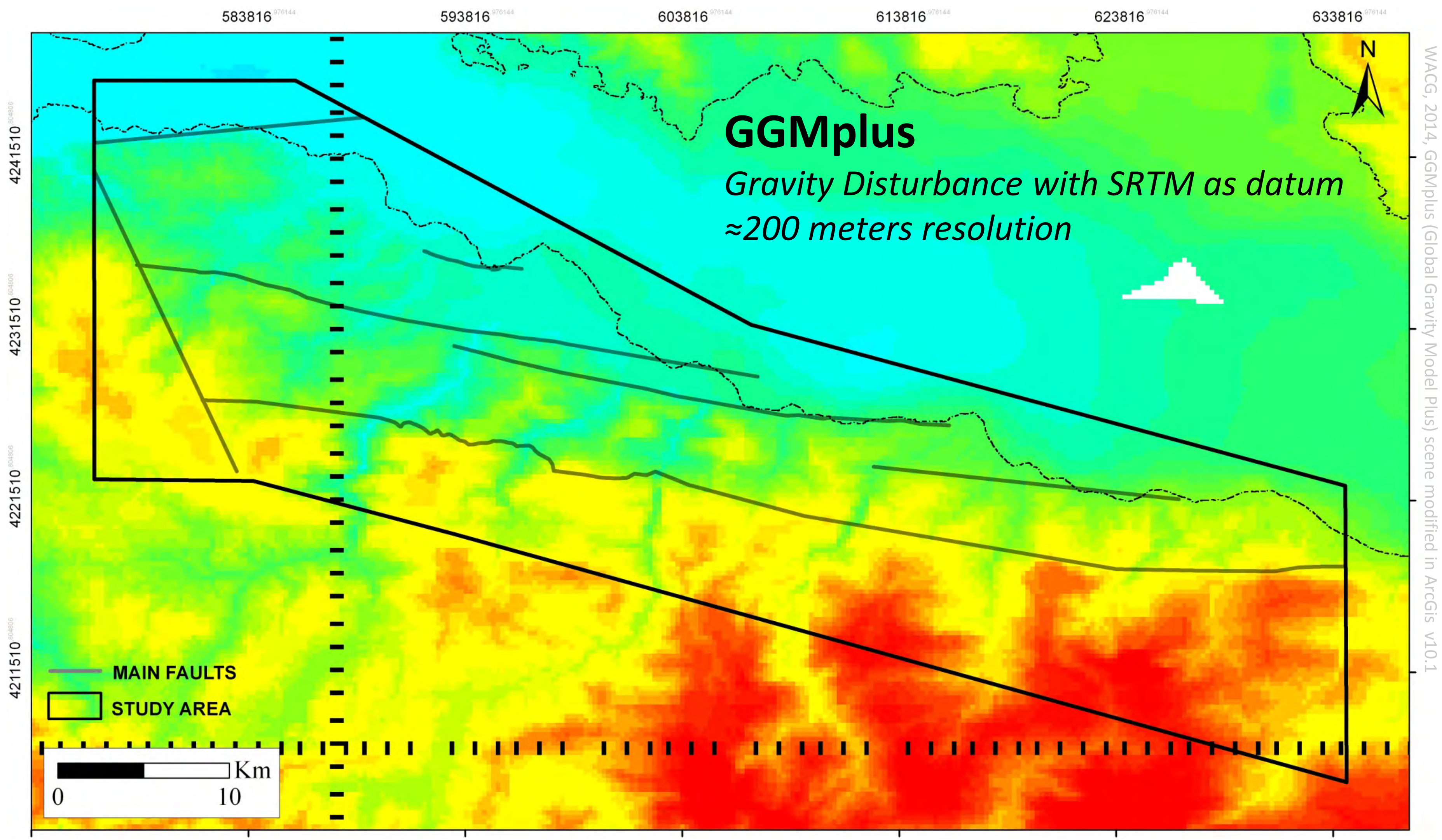
Composition 9-1-10 shows contrast between carbonate and clay reflectance.

Landsat was not designed for geology but can be adapted for our purposes.

LANDSAT 8


583816
593816
603816
613816
623816
633816
4241510
4231510
4221510
4211510
N
Regional Interpretation
USGS, 2014, Landsat 8 OLI/TIRS scene modified in ArcGis v10.1
MAIN FAULTS
STUDY AREA
Km
0
10

WORLD GRAVITY

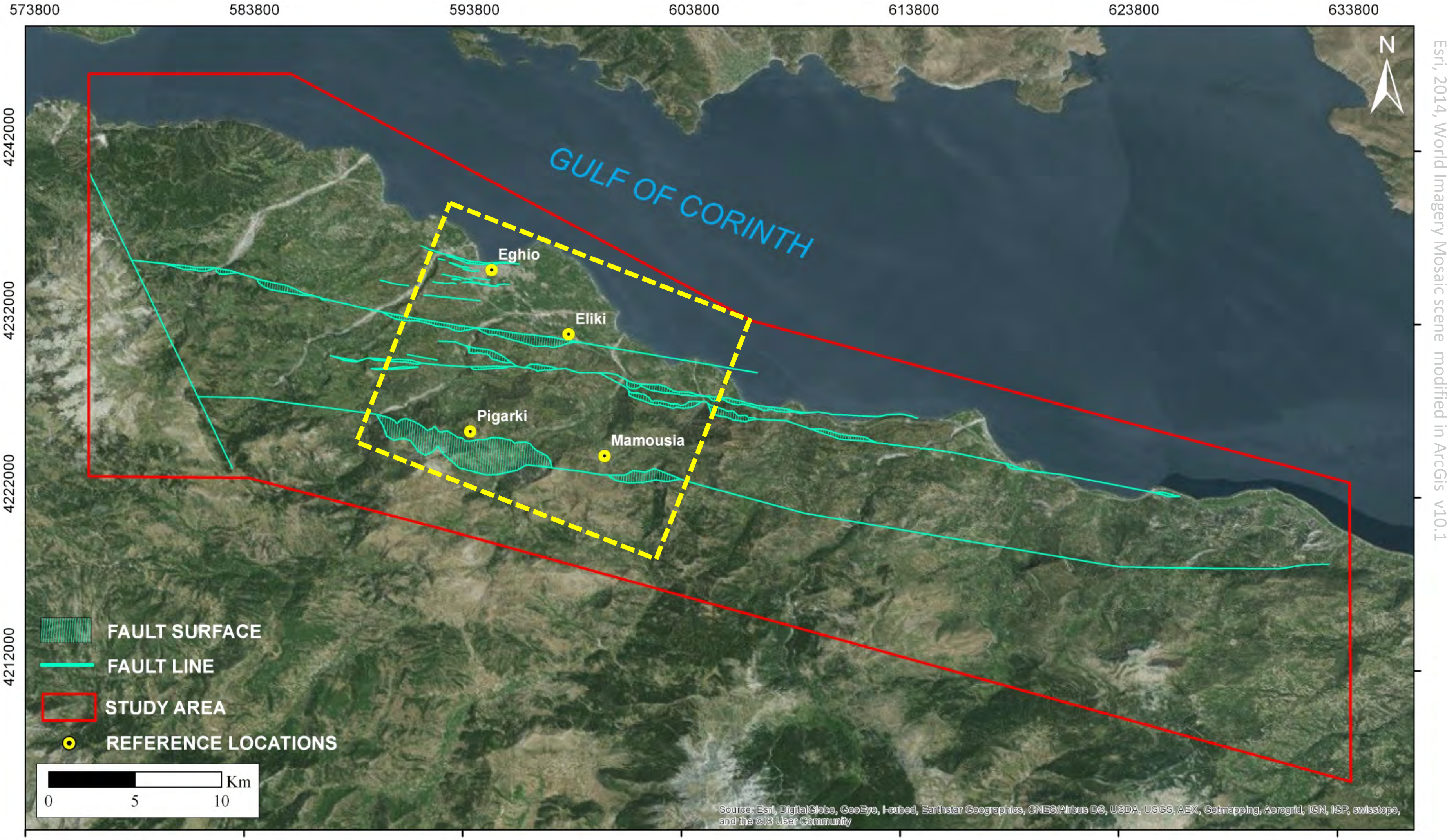


<u>No Free-Air correction</u> *(does not provide info on geological units at scales less than 10km)*

FIELD DATA

288 observation points collected in 10 days over 850km of roads and paths.

REGIONAL FAULT INTERPRETATION

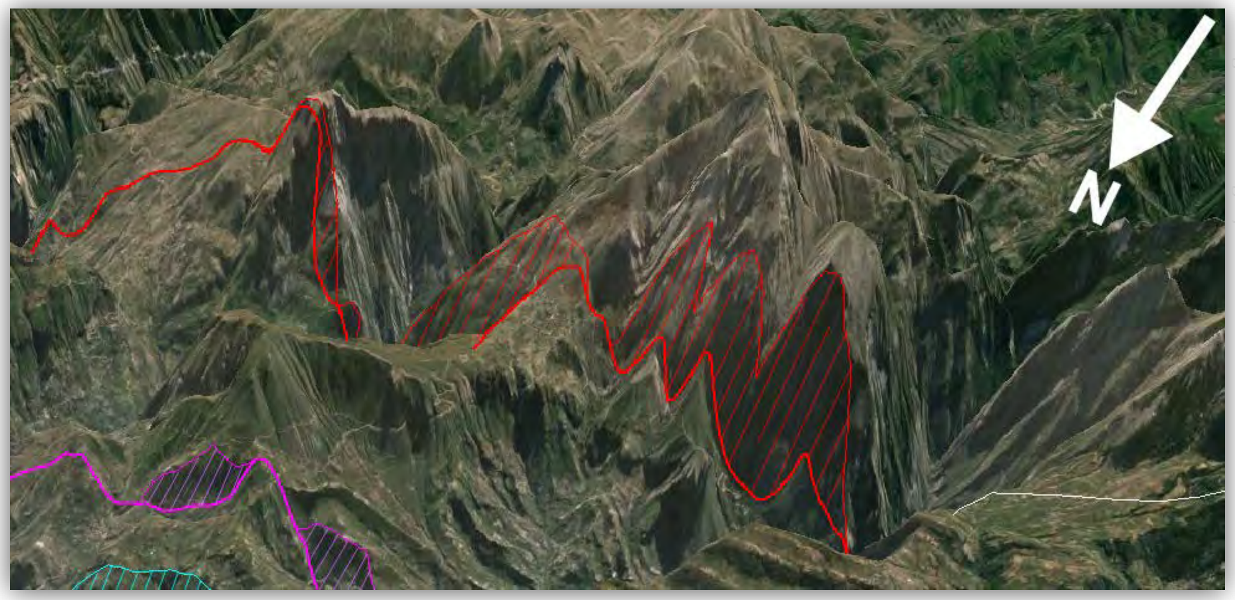


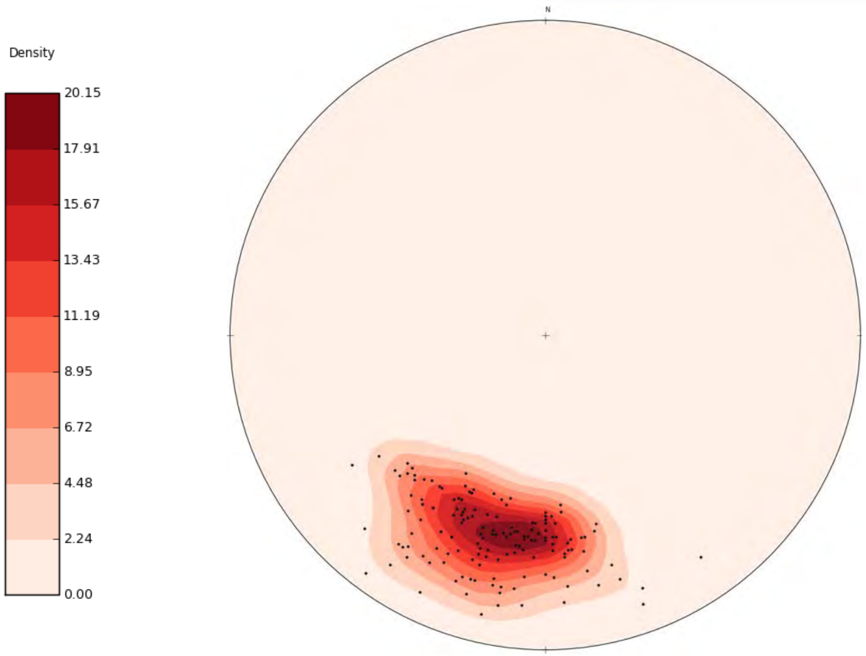
Preliminary fault interpretation based on remote sensor and field data.

LOCAL INTERPRETATION

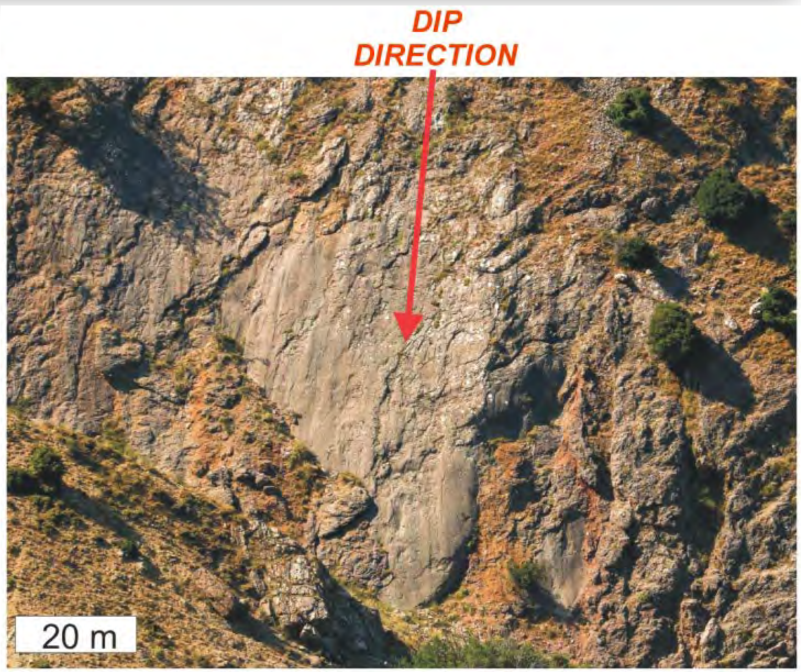
MEASUREMENTS

- ✓ Fault surfaces
- ✓ Fault lineations
- ✓ Unconformities between basement and syn sediments
- ✓ Delta topsets

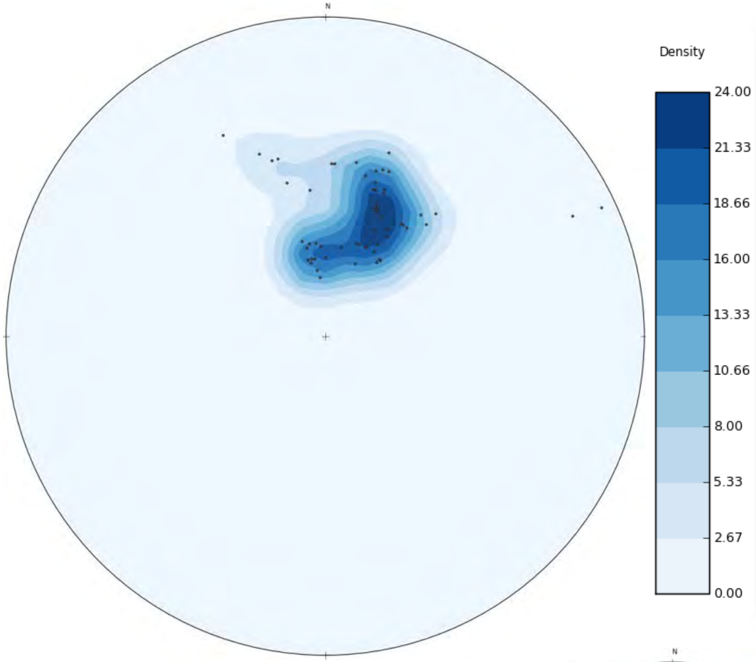


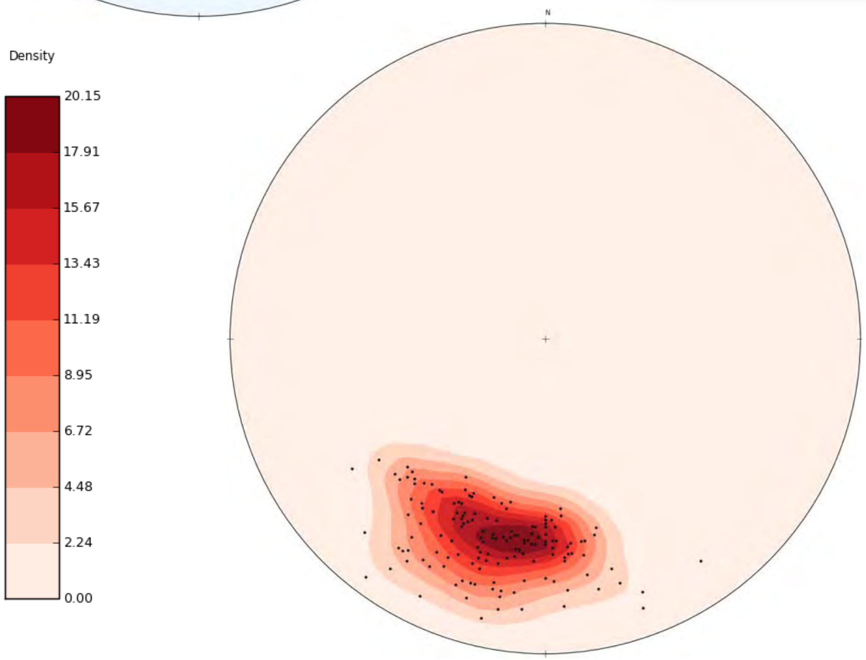


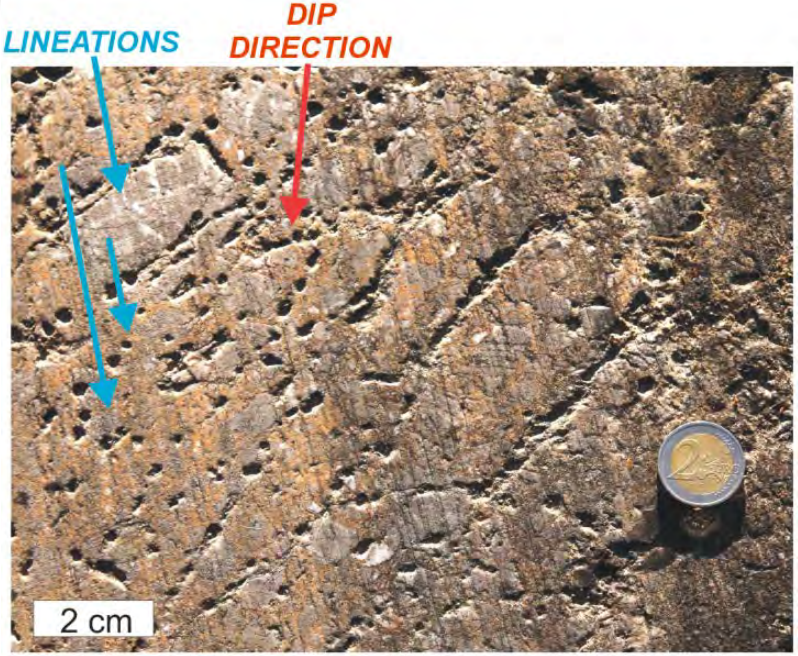
Equal area lower hemisphere plots displaying poles of measured structures (lines and planes)



MEASUREMENTS



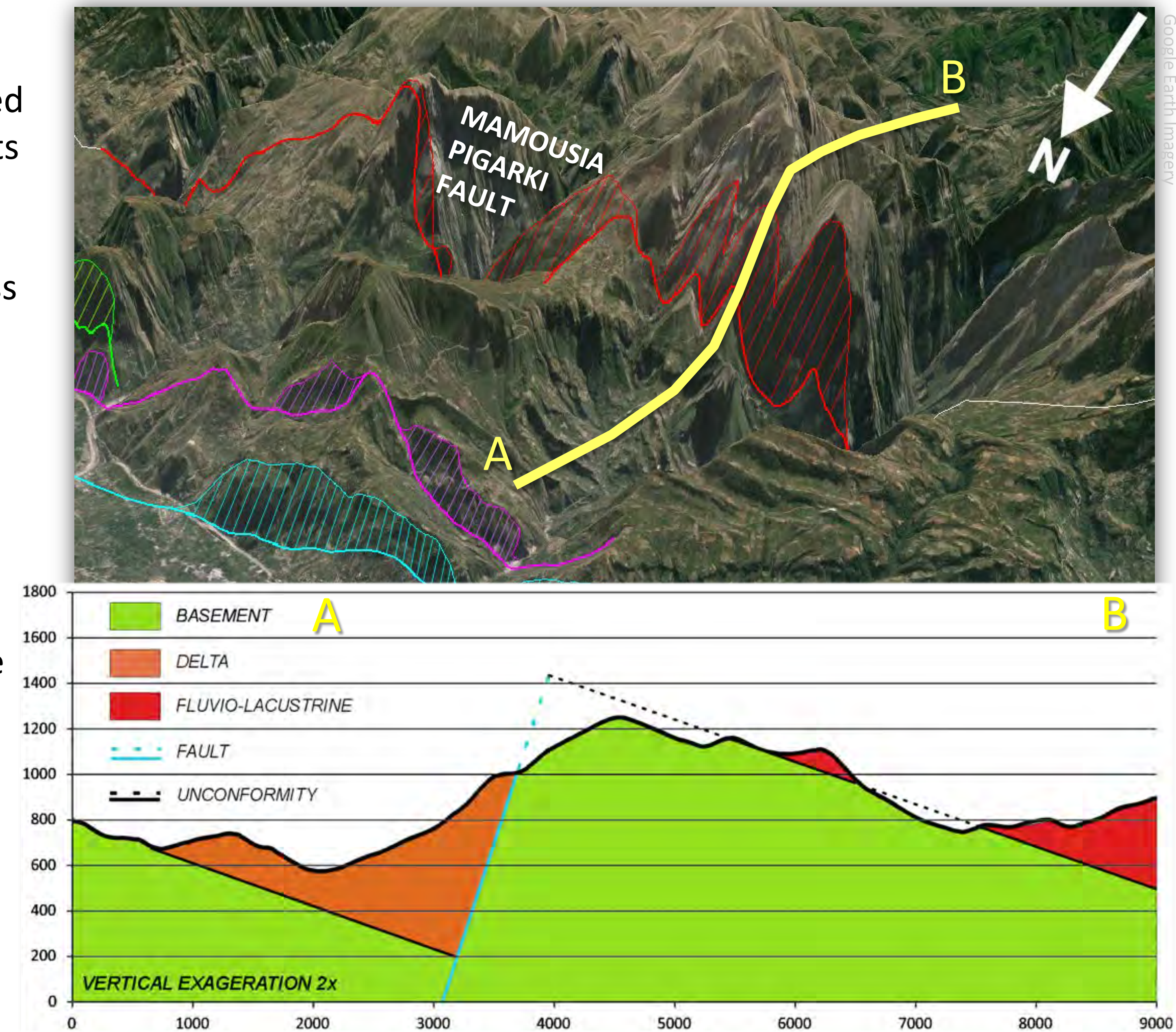




Equal area lower hemisphere plots with plotted poles measured structures (lines and planes)

DISPLACEMENT ESTIMATION

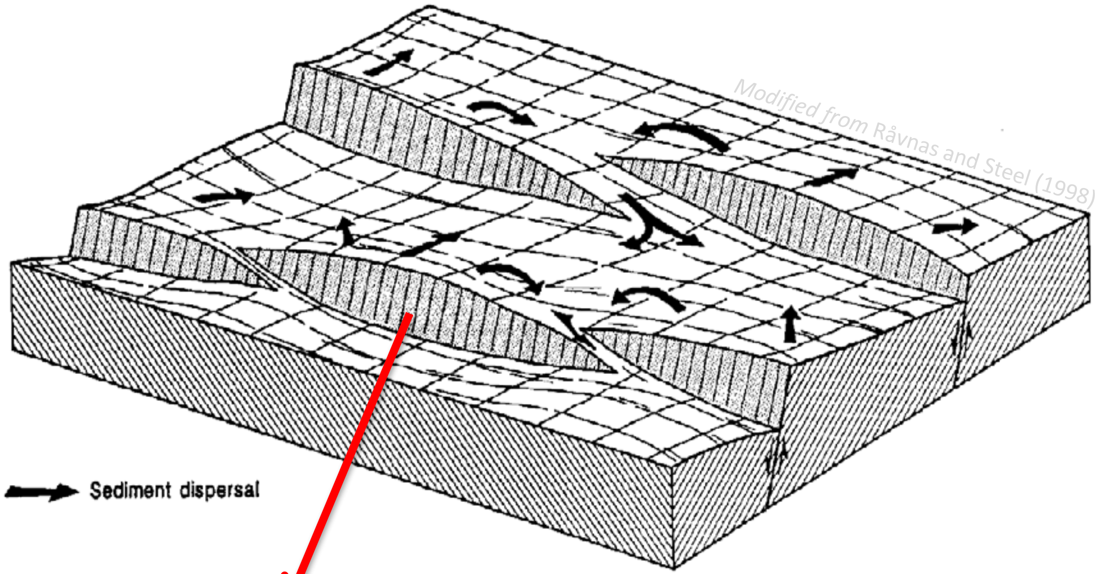
- ✓ Representative surfaces are created with measurements
- ✓ Apperant dips are projected into cross sections
- ✓ Constraints of topography are taken into account
- ✓ Sub-cropping unconformities are predicted
- ✓ Fault throw is calculated

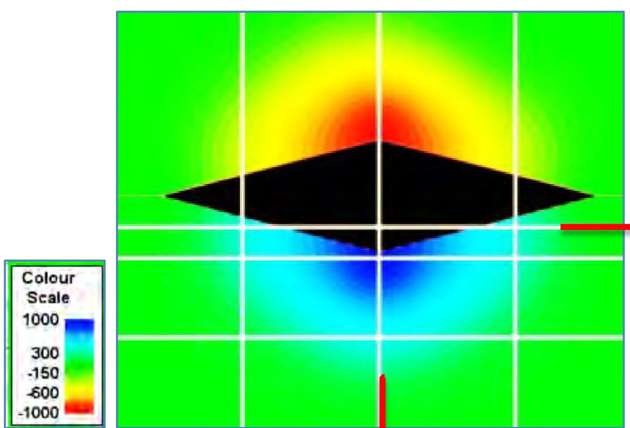


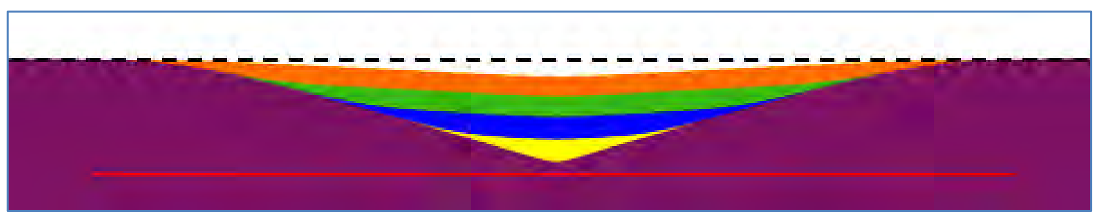
DISPLACEMENT

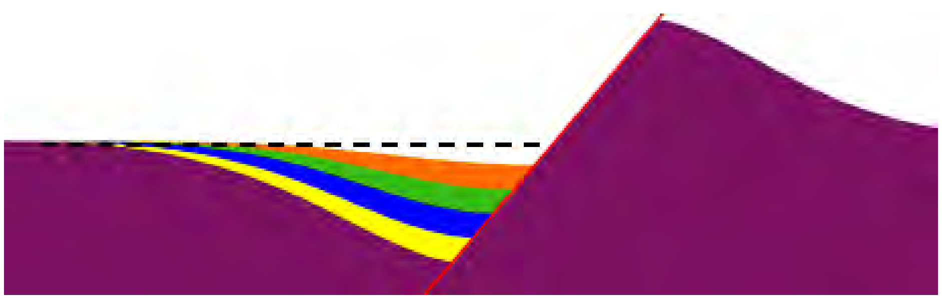
Egion Fault displacement calculated by Place et al., 2007

ONGOING WORK



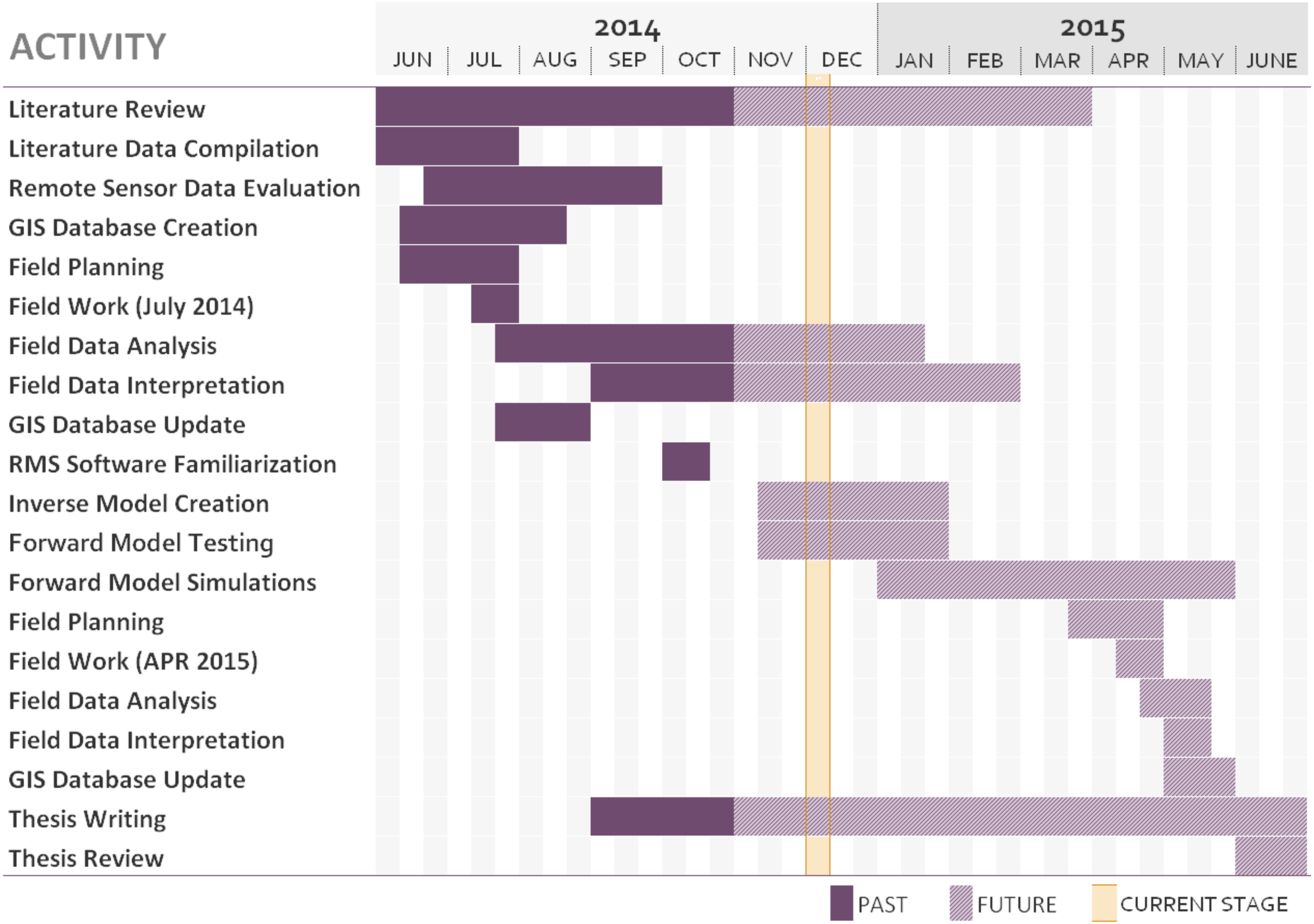






Forward models modified from Rizky Amanda Syahrul thesis

TIME FRAME


ACTIVITY
2014
2015
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUNE
Literature Review
Literature Data Compilation
Remote Sensor Data Evaluation
GIS Database Creation
Field Planning
Field Work (July 2014)
Field Data Analysis
Field Data Interpretation
GIS Database Update
RMS Software Familiarization
Inverse Model Creation
Forward Model Testing
Forward Model Simulations
Field Planning
Field Work (APR 2015)
Field Data Analysis
Field Data Interpretation
GIS Database Update
Thesis Writing
Thesis Review
PAST
FUTURE
CURRENT STAGE

QUESTIONS?

AN INVESTIGATION INTO THE NATURE AND RELATION OF THE FLAT SEDIMENTARY LAYERS IN THE KALAVRITA AND KERPINI FAULT BLOCKS, SOUTH CENTRAL GULF OF CORINTH, GREECE.

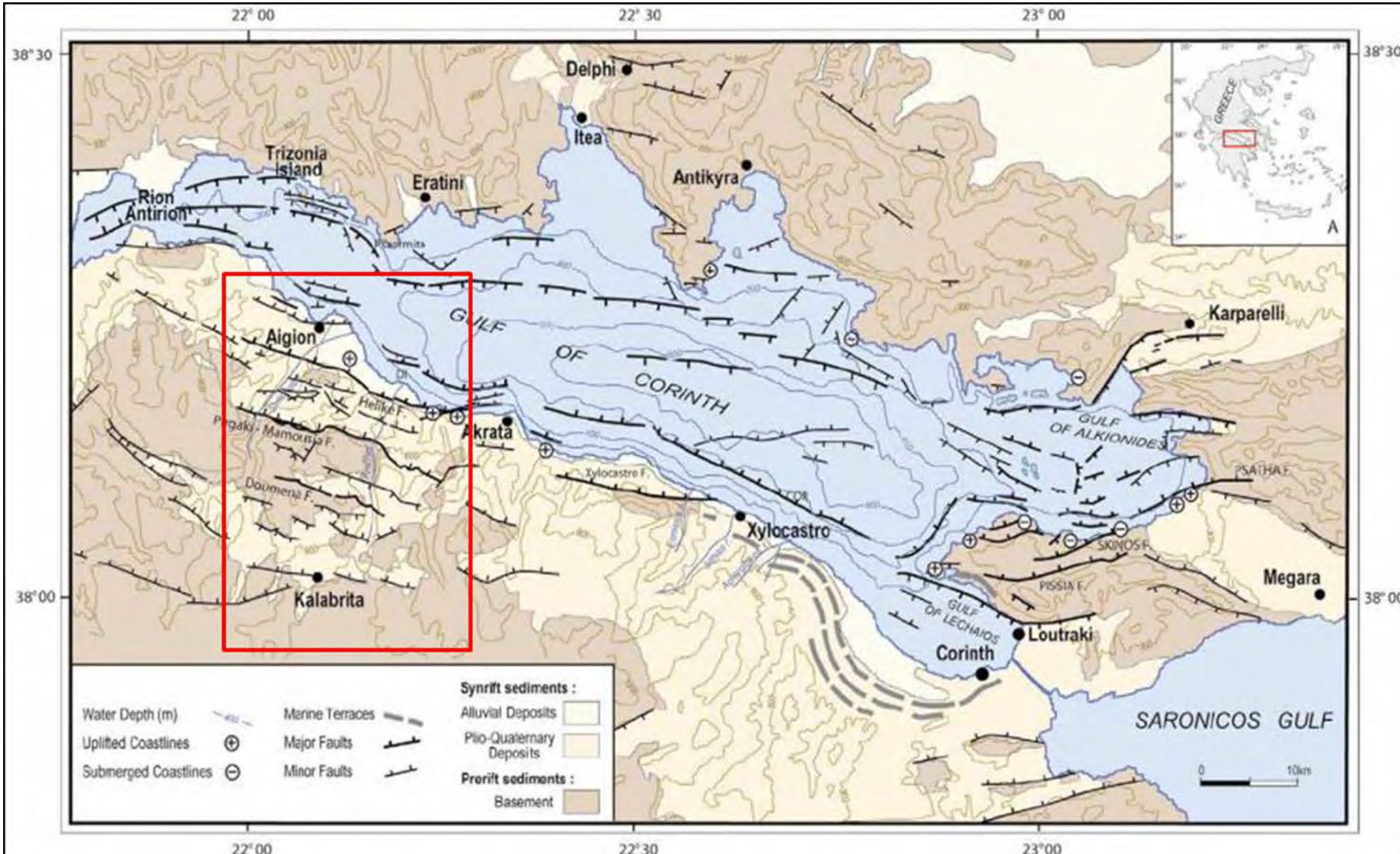
By
Eivind Marius Stuvland
Supervisor
Chris Townsend

Agenda

- Introduction / Motivation
- Regional Geology
- Geological Problem
- Objectives
- Methodology & Data
- Future Work
- Timeframe

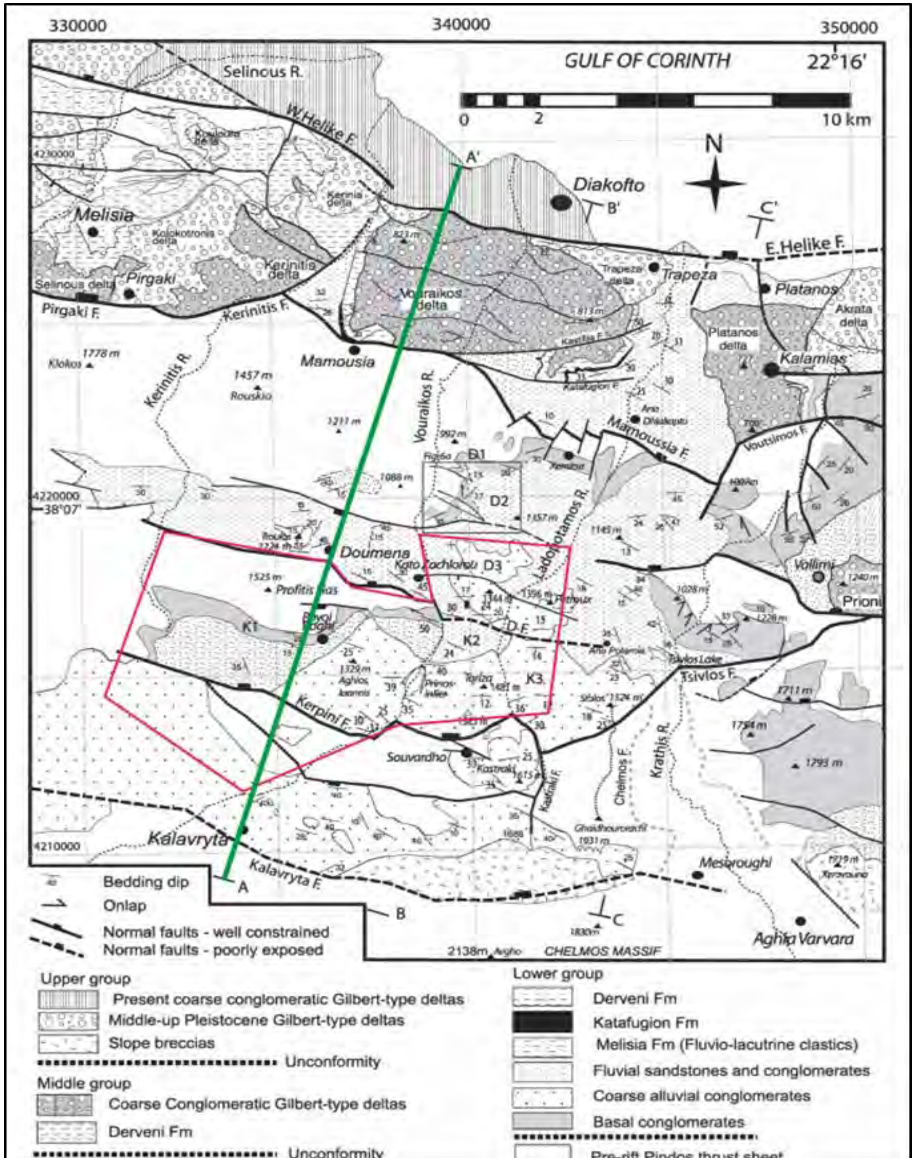
- Question

Regional



Moretti et al, 2003

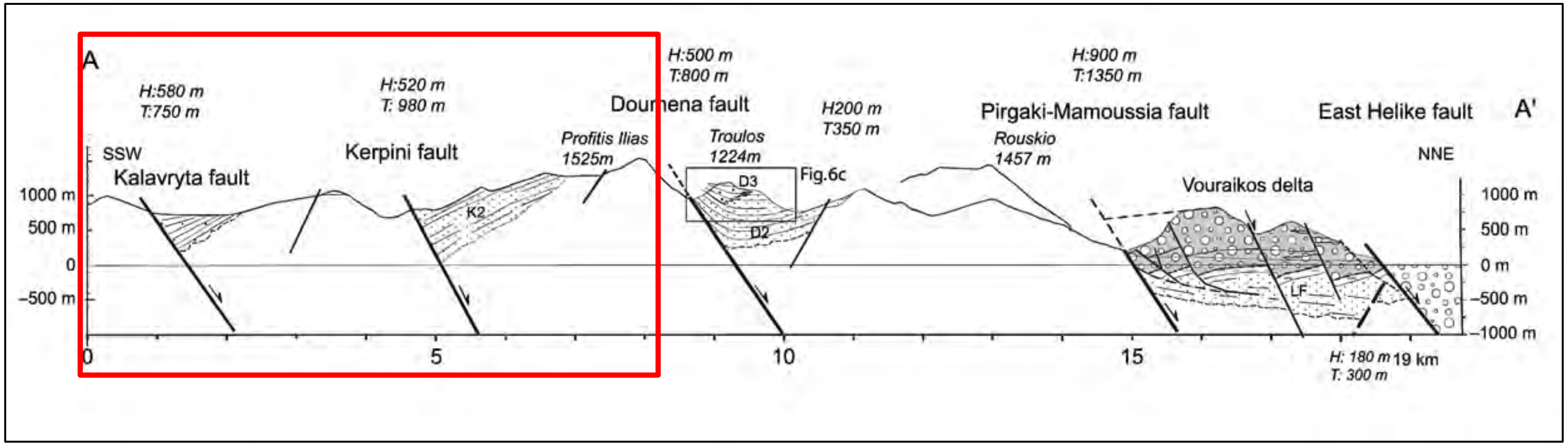
Area of Intrest



Ford et al. 2013

- Kalavrita Fault block
- Kerpini Fault block
- Area east of Vouraikos River

Geological Problem



Modified after Ford et al. 2013

- Flat sedimentary layers?
  - Where?
  - When? (Late syn?)
  - How?

- No growth strata
- Far from main depocenter
- Complex geomorphology

Objectives

- «Flat» sediments
  - Map «flats» to determine nature and relation
  - Can the two blocks be correlated
  - Determine depositional conditions
  - Propose model

- Fluvial units - East
  - Trace fluvial-alluvial sediments and faults east of Vouraikos River
  - Propose model to explain nature, initial interpretation suggest not correlated to Kerpini block.

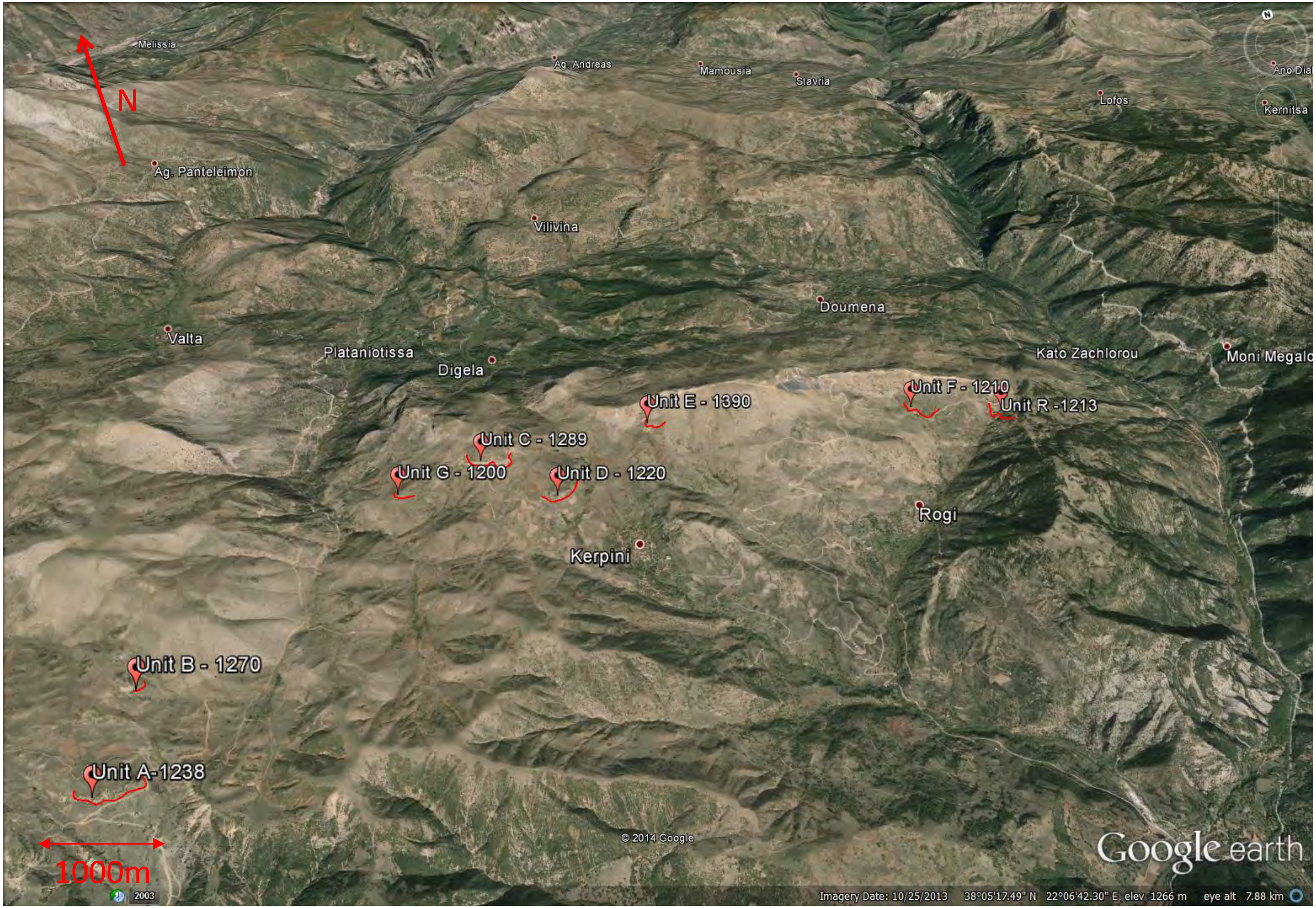
Methodology & Data

- Initial phase : Preparation
  - Literature study
  - Map study
  - Satelite imagery analysis

- Second phase : Field Work
  - Locate and identify «Flat» sedimentary layers
  - Record Dip & Dip Direction
  - Take detailed photographs for later analysis
  - Trace east-trending fluvial-alluvial sediments & faults
  - Verify previous mapping in the east

Fluvial/Alluvial Units - East

Flat Units



N
Melissia
Ag. Andreas
Mamousia
Stavria
Lofos
Ano Dia
Kernitsa
Ag. Panteleimon
Vilivina
Doumena
Valta
Plataniotissa
Digela
Kato Zachlorou
Moni Megalo
Unit F - 1210
Unit R -1213
Unit E - 1390
Unit C - 1289
Unit G - 1200
Unit D - 1220
Rogi
Kerpini
Unit B - 1270
Unit A-1238
1000m
© 2014 Google
Google earth
2003
Imagery Date: 10/25/2013 38°05'17.49" N 22°06'42.30" E elev 1266 m eye alt 7.88 km

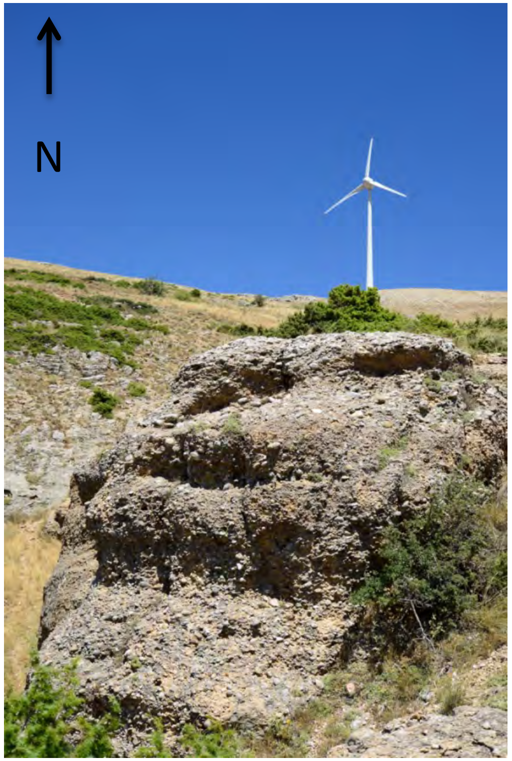
Unit A

N SE

- North of Skepasto
- Isolated
- Alluvial conglomerates
- Sandstone layers
- $8\text{-}10^{o}/000\text{-}020^{o}$

Unit A

Unit E

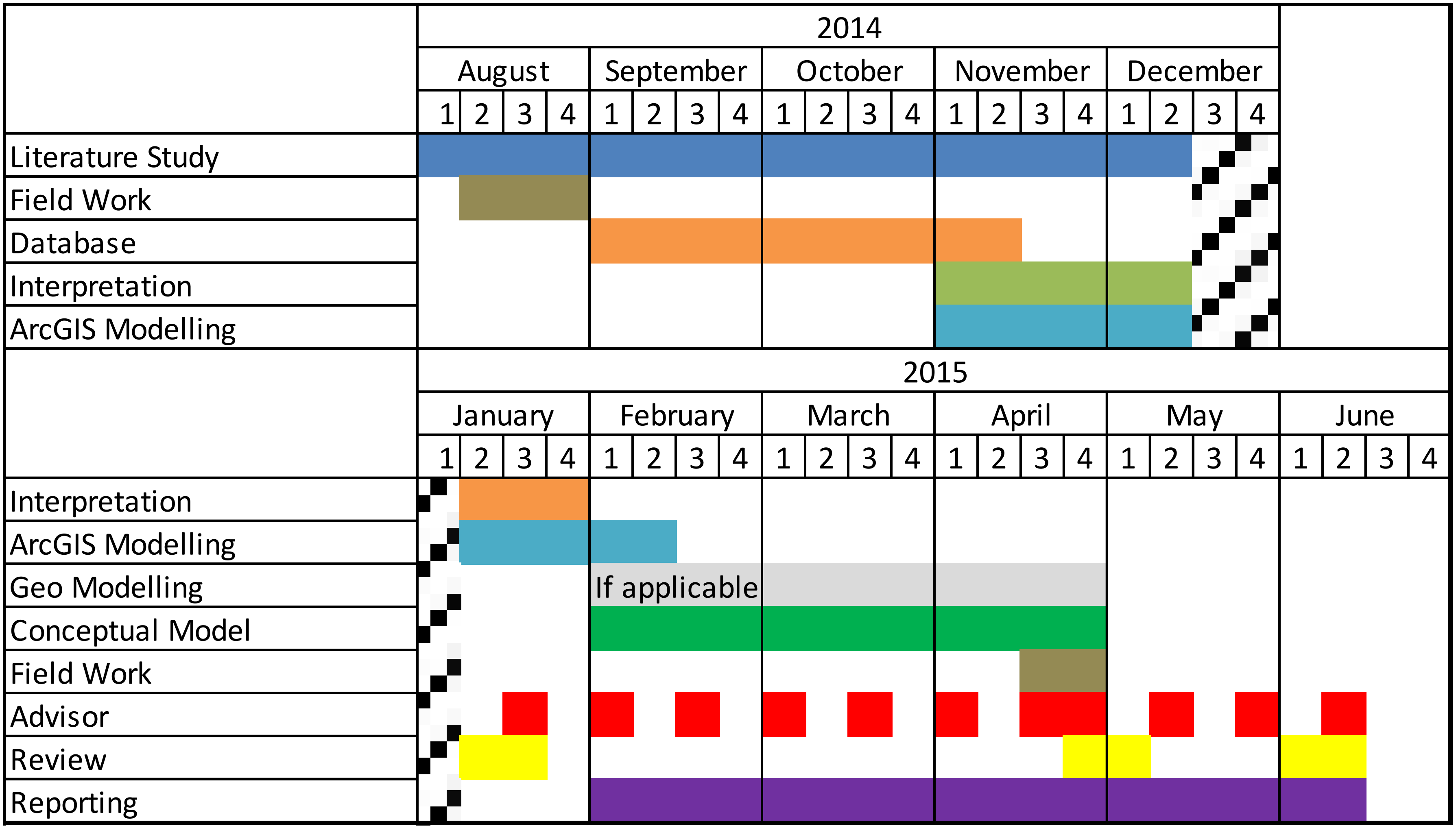


- Thick packet of conglomerates.
- North dipping (Difficult)
- Ca.1400m elevation, very high on footwall
- Onlap basement

Future Work

- Database work
- Analyse data and images: Clast sizes, sorting, imbrication etc.
- Perform statistical analysis
- Construct elevation model
- Possible analogues
- Create conceptual model to aid explanation

Time frame


2014
August
September
October
November
December
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Literature Study
Field Work
Database
Interpretation
ArcGIS Modelling
2015
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 3 4
Interpretation
ArcGIS Modelling
Geo Modelling
If applicable
Conceptual Model
Field Work
Advisor
Review
Reporting

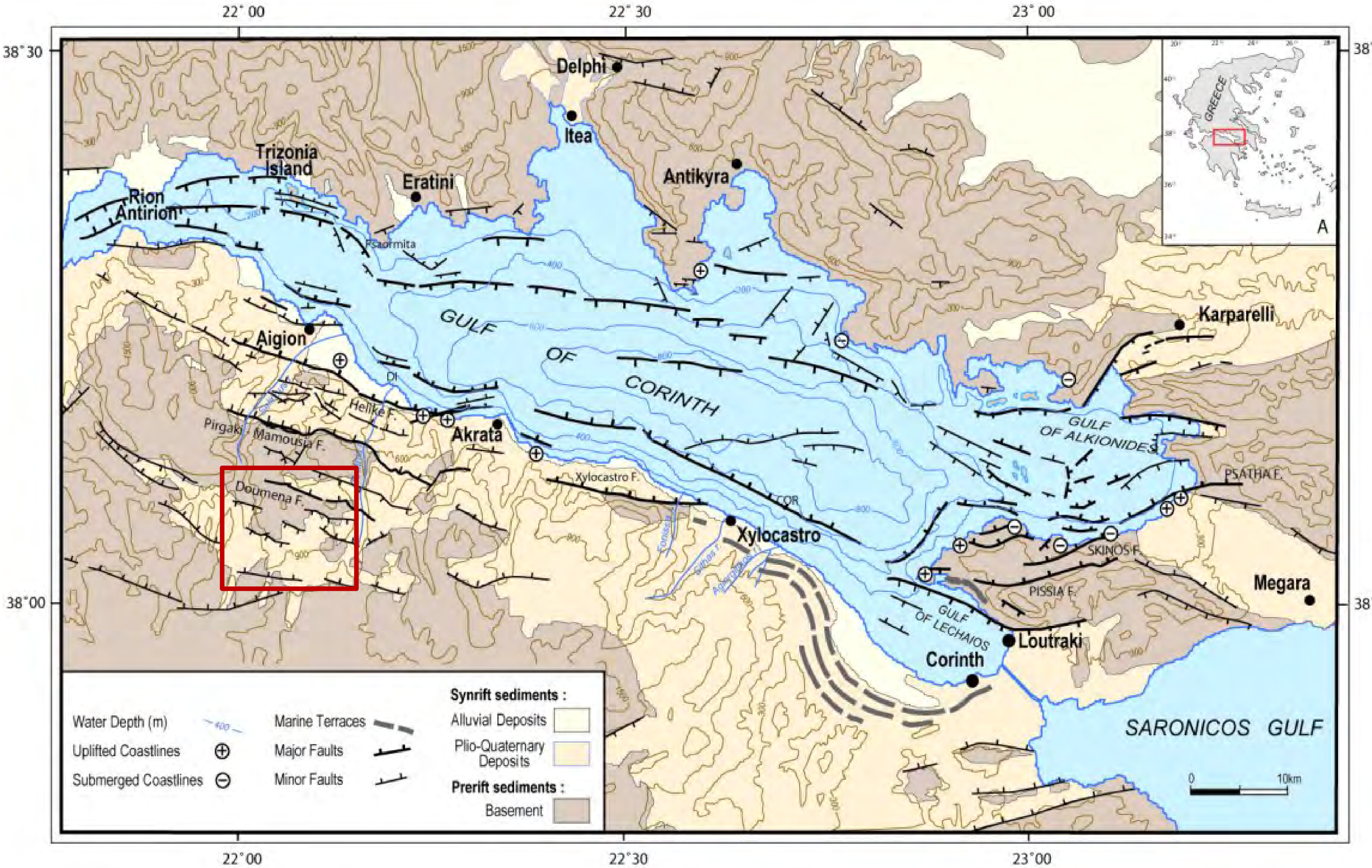
Thank you

Questions?

Sedimentary infill in the Kalavrita faulted block, south-central Gulf of Corinth, Greece

By Trym Rognmo

Study area:



Map of the Gulf of Corinth, study area marked in red. Figure taken from Moretti et al. (2003).

Objective

- To investigate how active tectonics influence and control facies distribution within a half-graben system.
- To conduct a statistical analysis of the clast-size distribution.

Planing

- Read up on regional geology.
- Previous papers on the area.
- Made maps.
- Find outcrops using Google Earth.

Kalavrita Fault Block

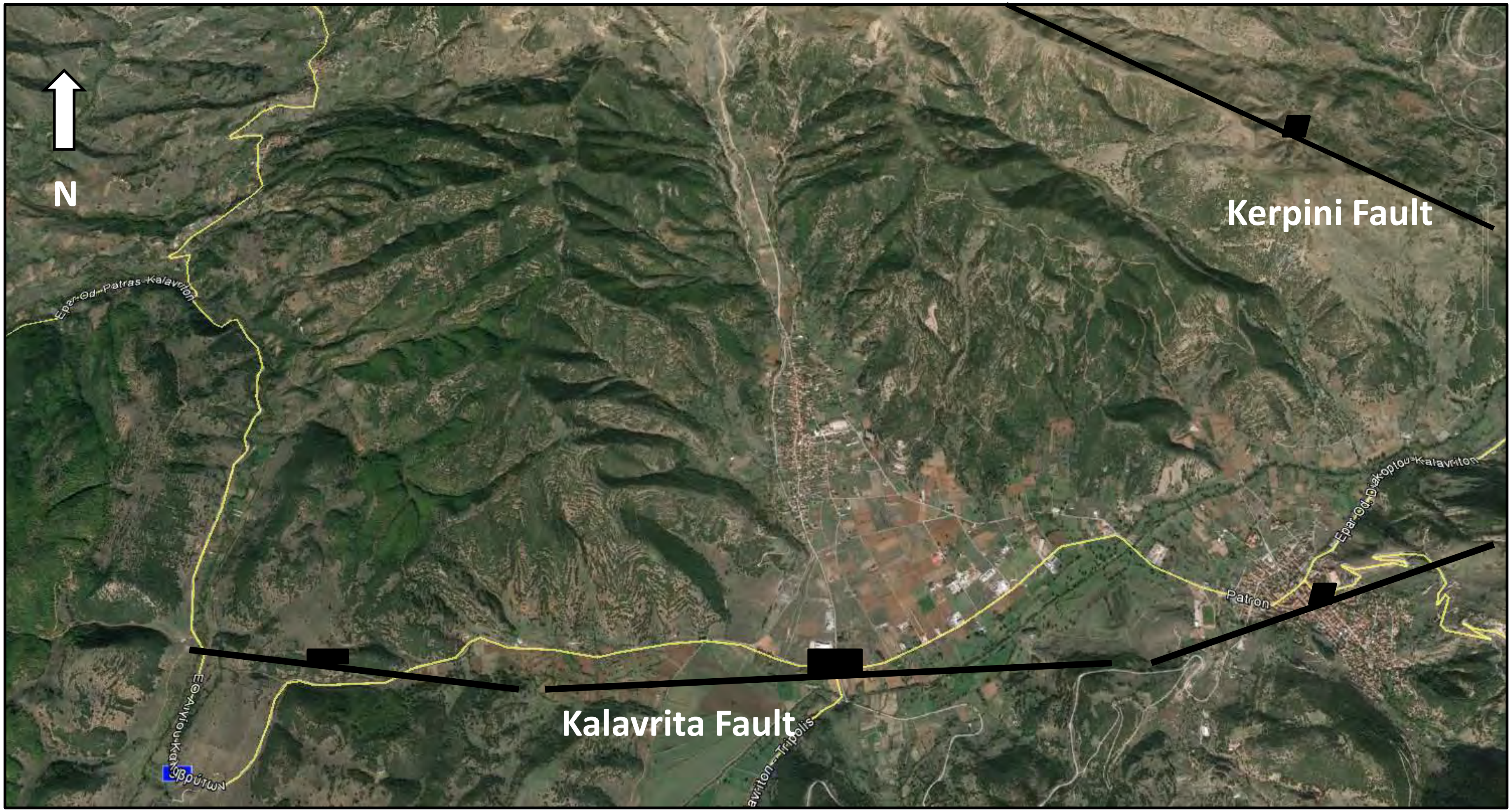


Image taken from Google Earth

Initial thoughts

- Layers of conglomerate with marl inbetween.

Image taken from Google Earth

Initial thoughts

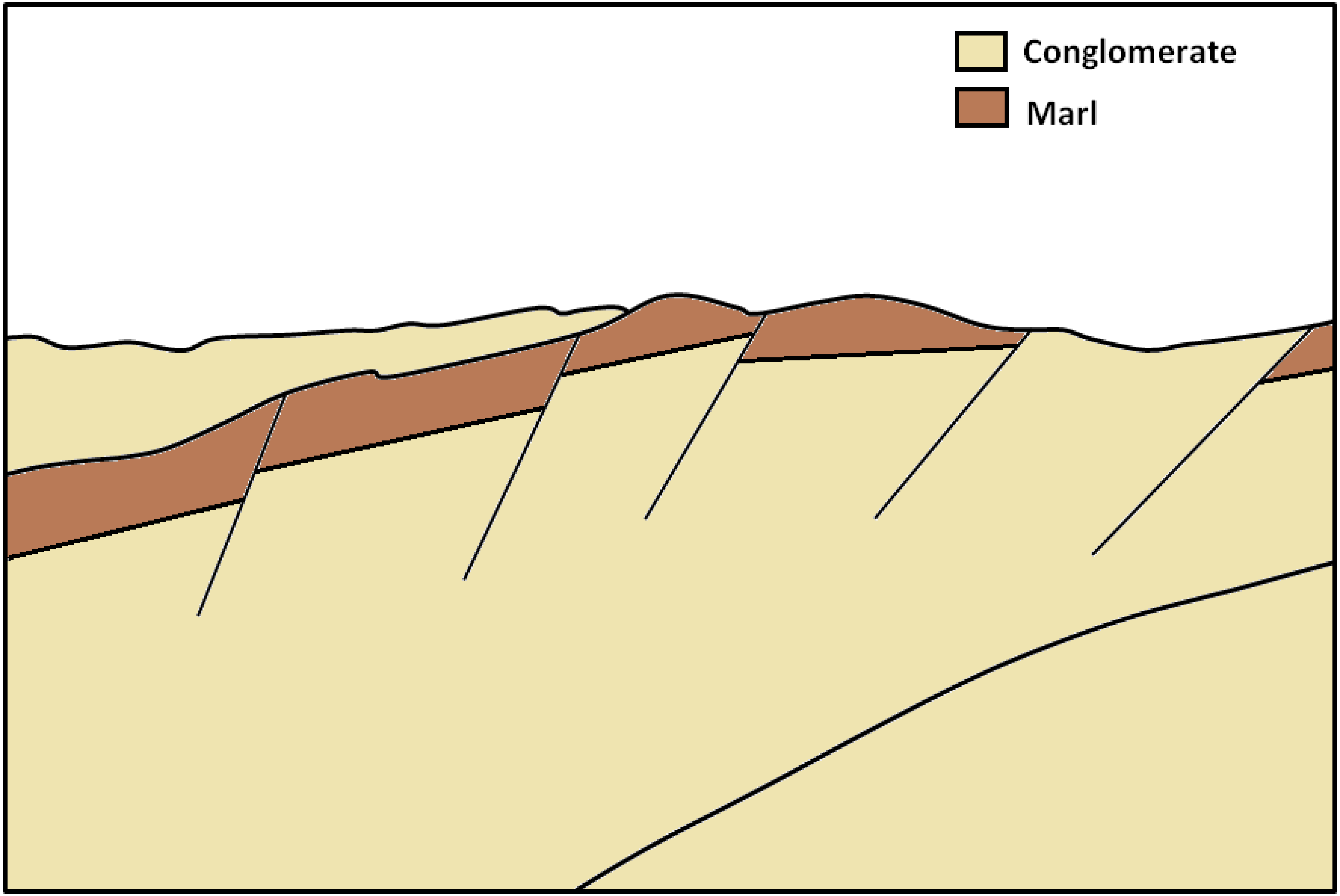
- Layers of conglomerate with marl inbetween.

Image taken from Google Earth

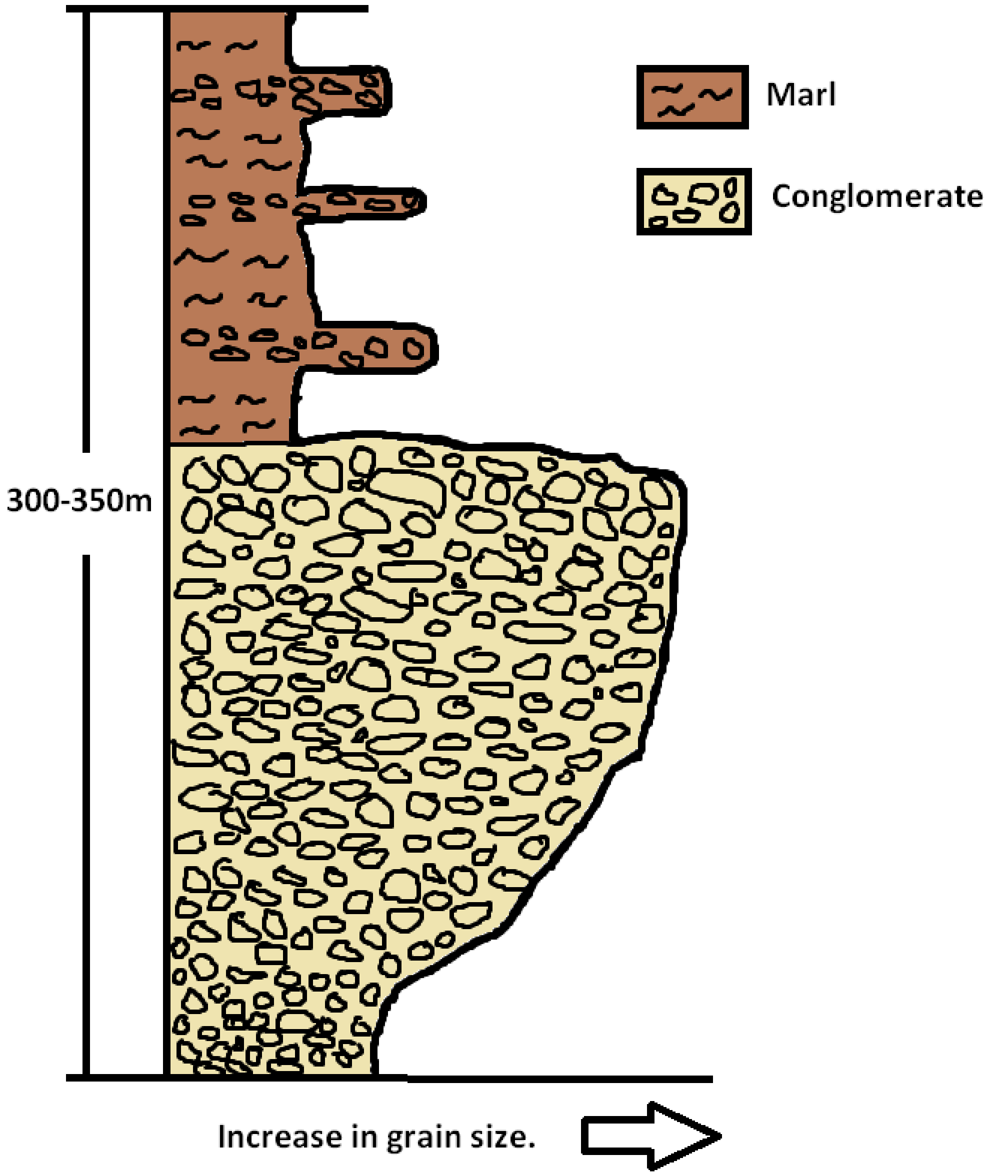
Simplified model.

Image taken by Marius Stuvland

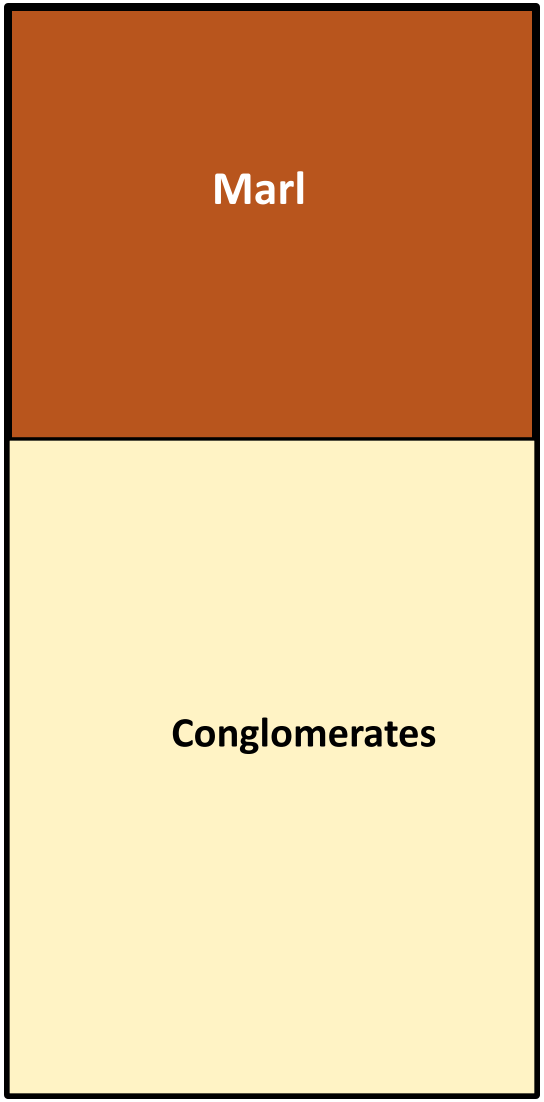
Image taken by Marius Stuvland



Simplified model of the previous image.



Marl
Conglomerate
300-350m
Increase in grain size.



Marl
Conglomerates

Image taken from Google Earth

Facies distribution within the half-graben system.

- How does active tectonics influence and control facies distribution?
- What was the initial setting?
- What tectonics might have caused it?
- And where did the sediments come from?

Conglomerates

- Alluvial Conglomerates.
- Dip: 19-22˚
- Dip direction: 190-210˚
- Clasts: Limestone, Chert and reworked sediments.

- Poorly sorted.
- Coarsening upwards.
- Layers beween 20-40m thick.

Image taken by Marius Stuvland

Marl

- Unconsolidated.
- Limestone clasts and chert.
- Dip: 19-22˚
- Dip direction: 190-210˚

Image taken by Marius Stuvland

Image taken by Marius Stuvland

Kalavrita Fault Block

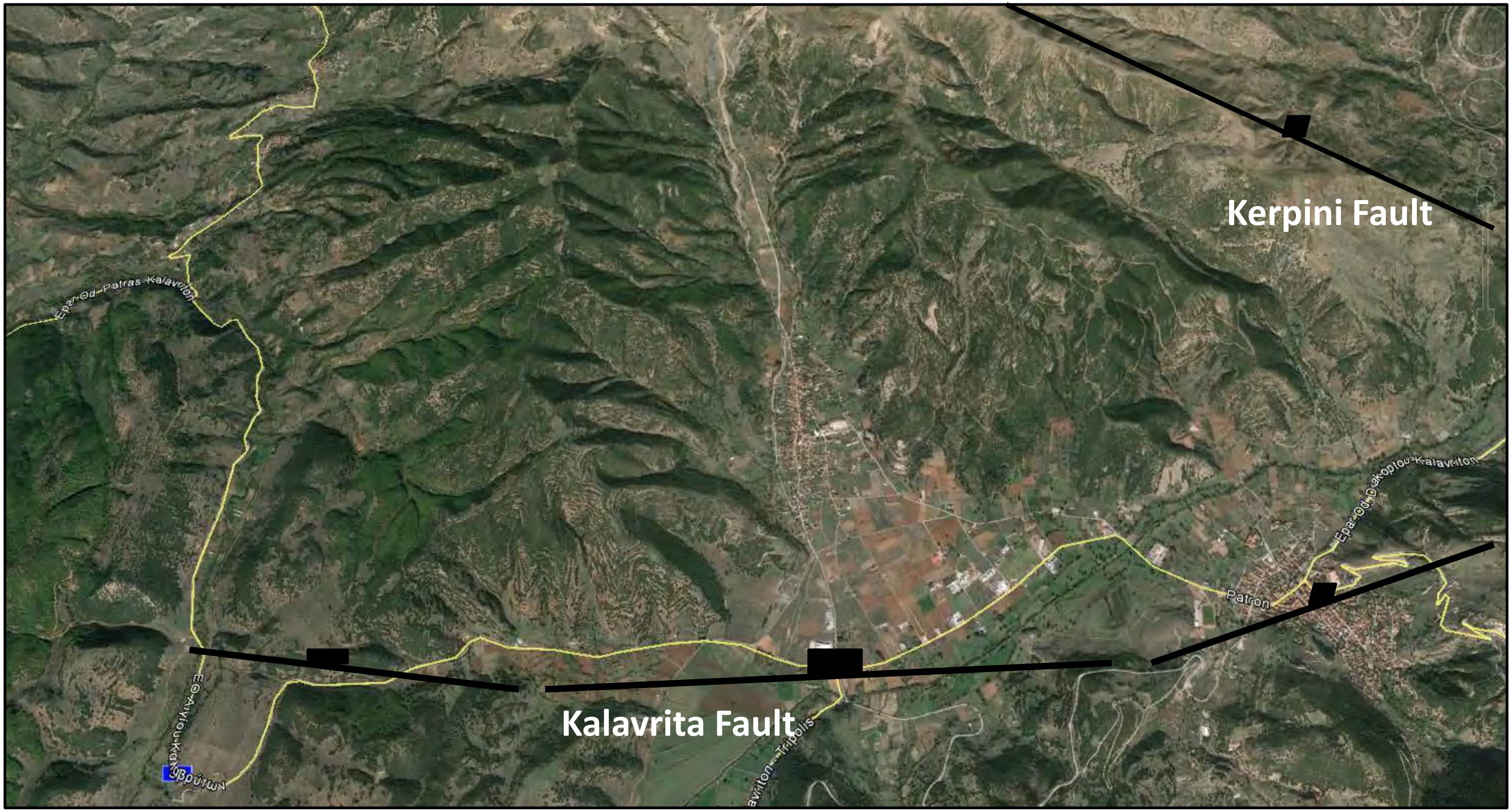
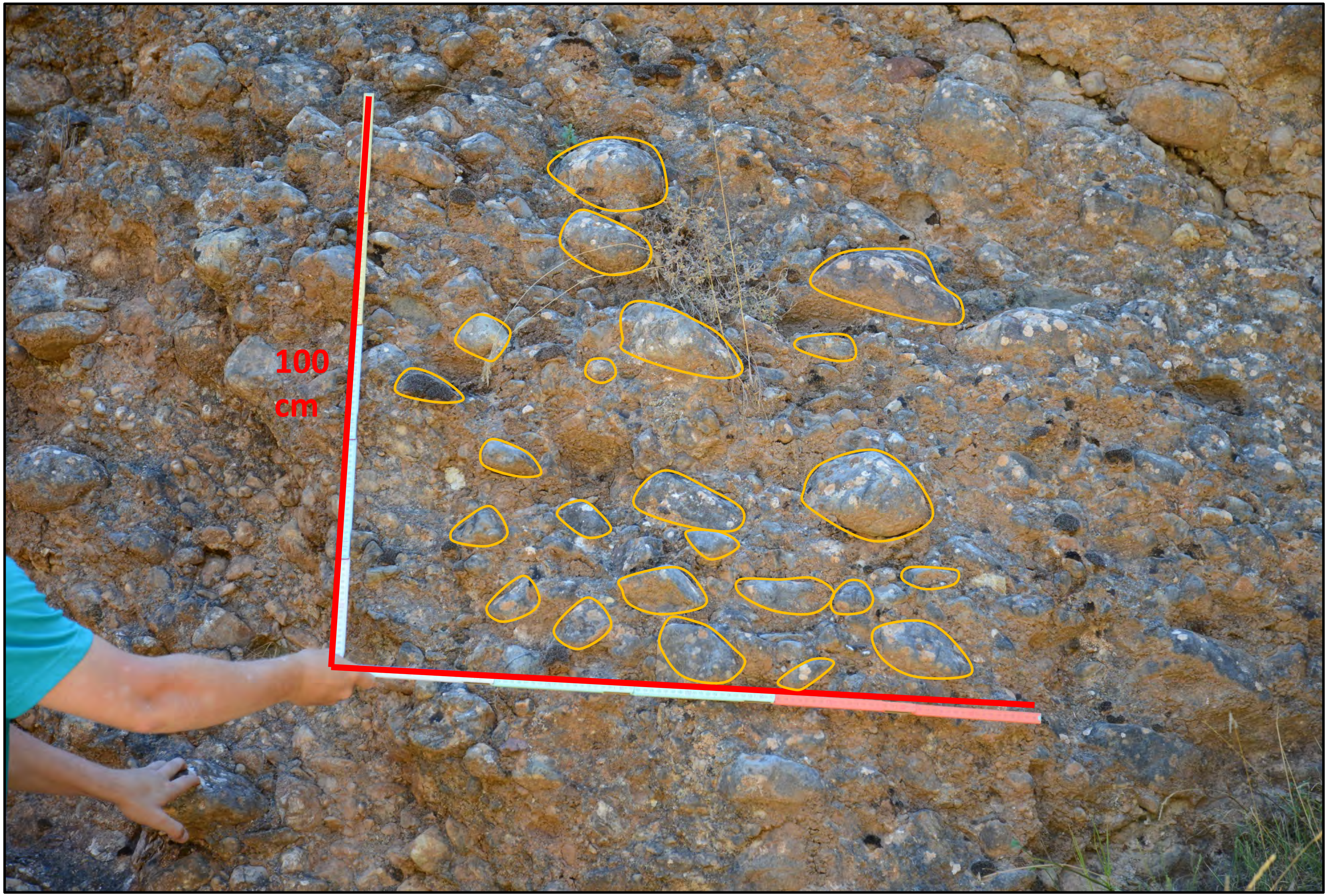


Image taken from Google Earth

Statistical Analysis

- Constrain where the source areas are.
- Determine how far have the sediments been transported.

Image taken by Marius Stuvland


100
cm

Questions?

North Sea Reservoir Chalk Characterization

Emanuela I. Kallesten
Supervisor: Dr. rer. nat. Udo Zimmermann

Outline

Introduction

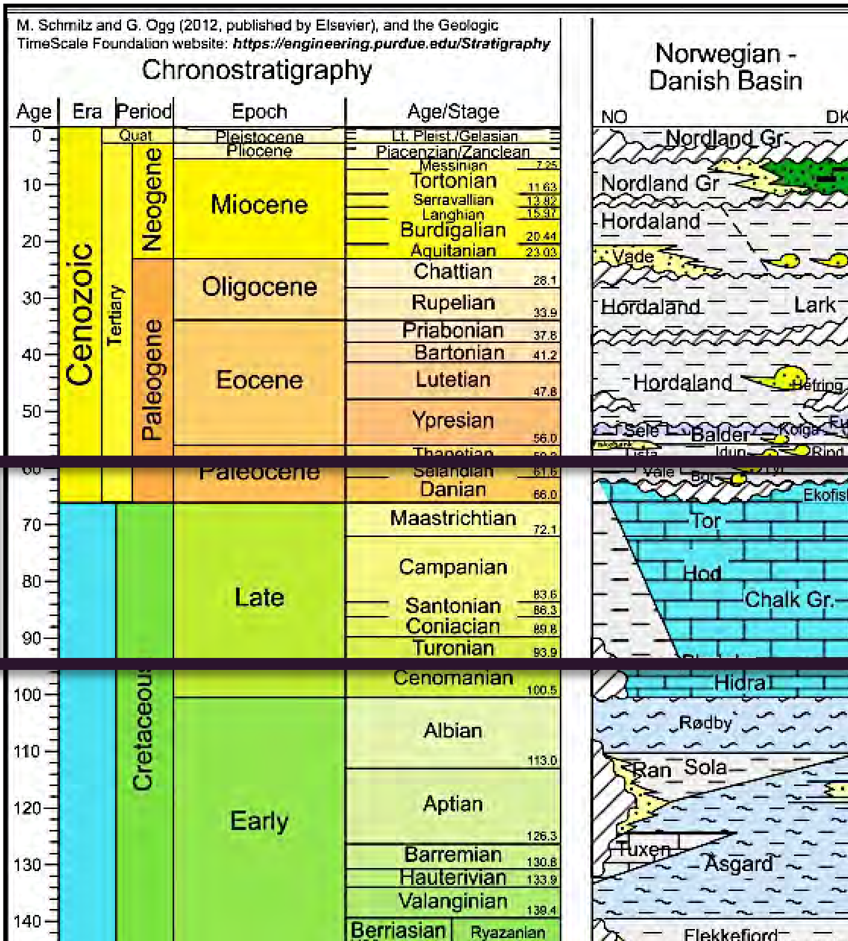
Methods

Dataset

Time frame

Summary

Introduction – Geological Setting



Discos database, NPD

Ekofisk Formation
- Danian
- Grey to white chalk
- Stylolites
- Autochtonous periodites, open marine

Tor Formation
- Campanian to Maastrichtian
- White to grey chalk
- Chert nodules
- Turbidites, pelagic chalk, open marine

Hod Formation
- Mid-Turonian to Campanian
- Grey, partly pink chalk
- Lamination, burrows
- Grainstone turbidites, open marine

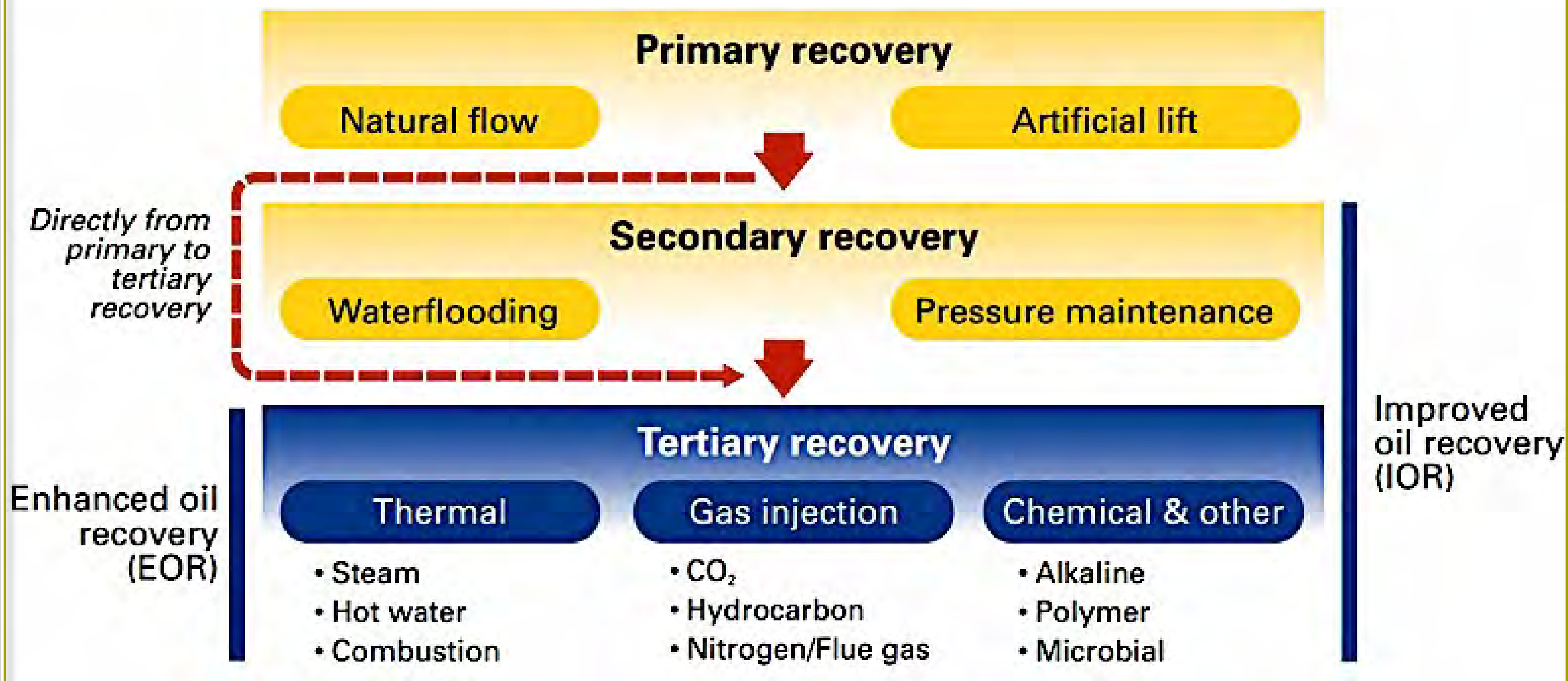
Introduction – Enhanced Oil Recovery

"The golden age is over"

The experts agree: the Norwegian oil adventure is coming to an end.

tv2.no
28.11.2014

Introduction – Enhanced Oil Recovery



www.sbc.slb.com

Introduction - Objective

a thorough description of the composition and the texture of unflooded reservoir chalk

Methods

- Optical petrography
- Scanning Electron Microscopy
- Mineral Liberation Analysis
- X-Ray Diffraction
- Stable Isotopes
- Geochemistry

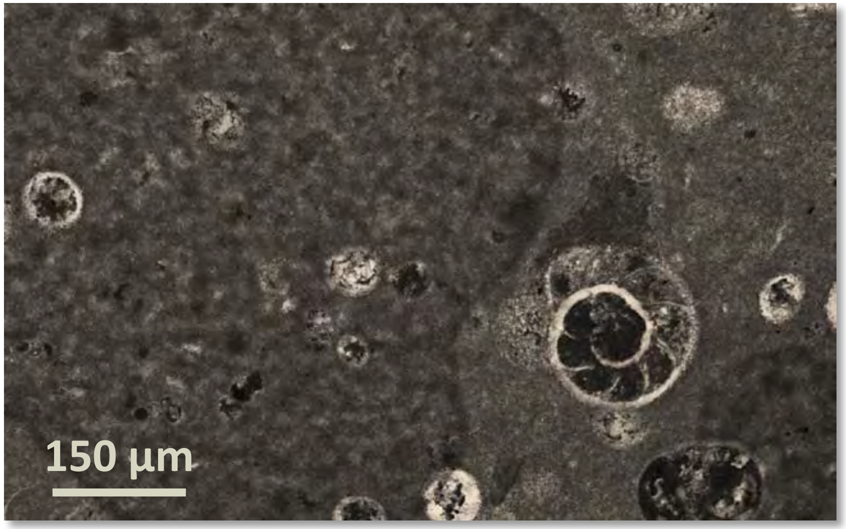
Mineral structure

Texture

Chemical composition

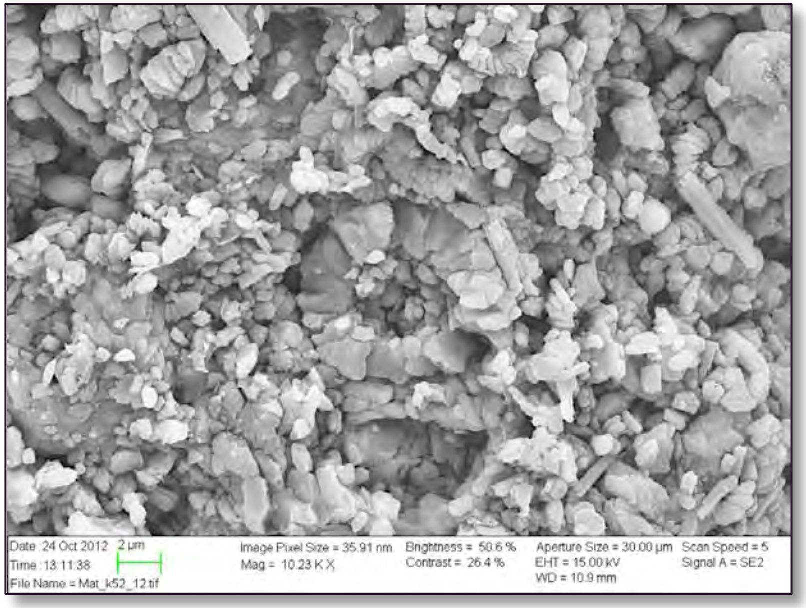
Methods – Optical Petrography

- Location: UiS
- Sample: thin section
- Magnification: 5X – 20X
- Objective: preliminary data on texture and composition

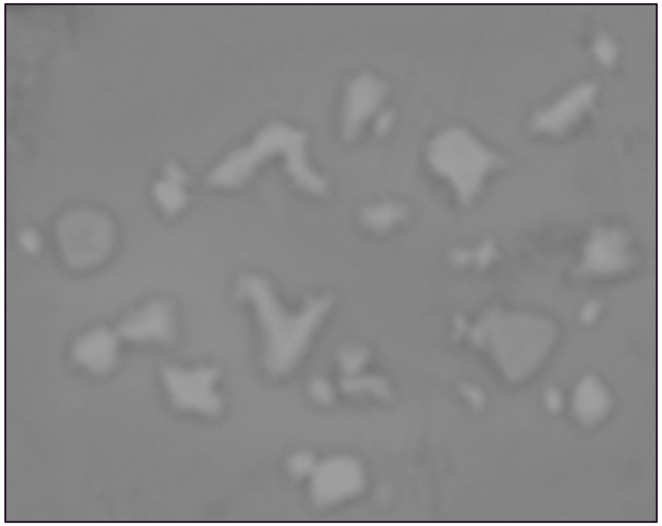


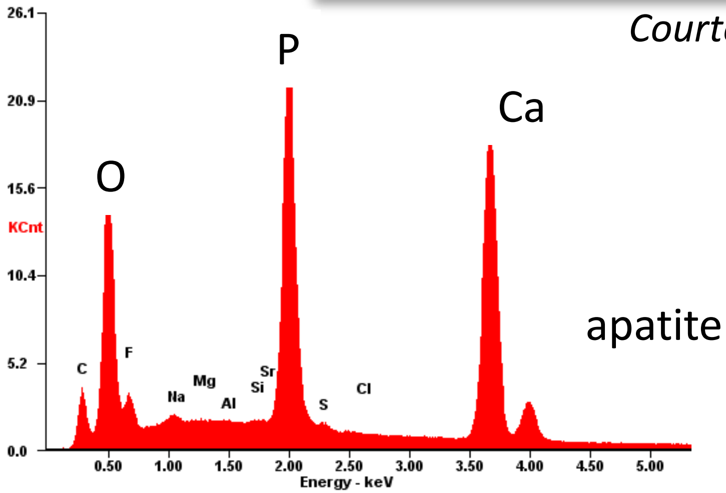
Methods – Scanning Electron Microscope

- Location: UiS
- Sample: thin section
- Magnification: 150 kX
- Objective: high-resolution sample images, mineral content, texture



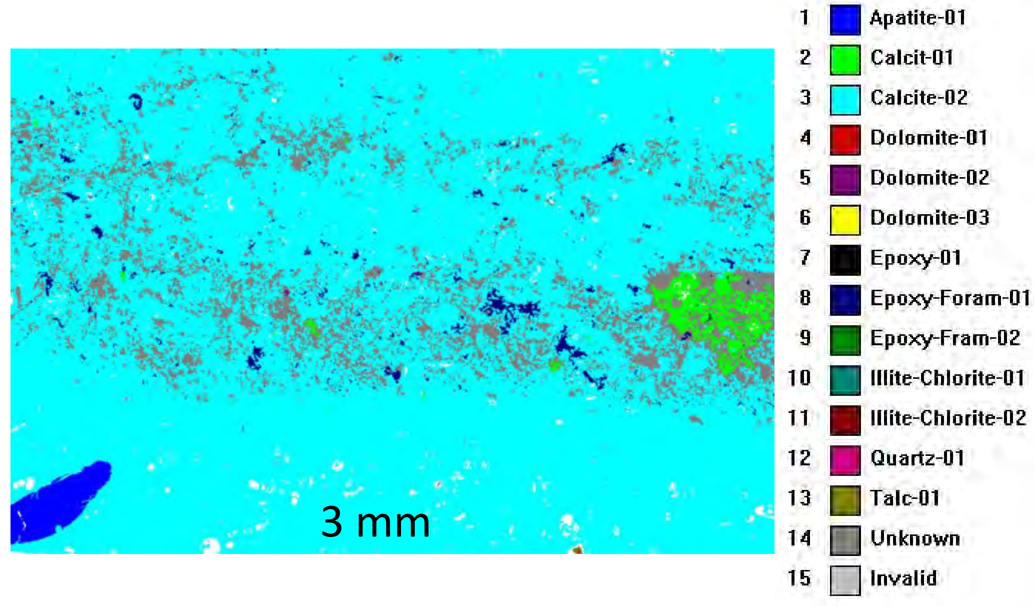
Courtesy of Mona Minde

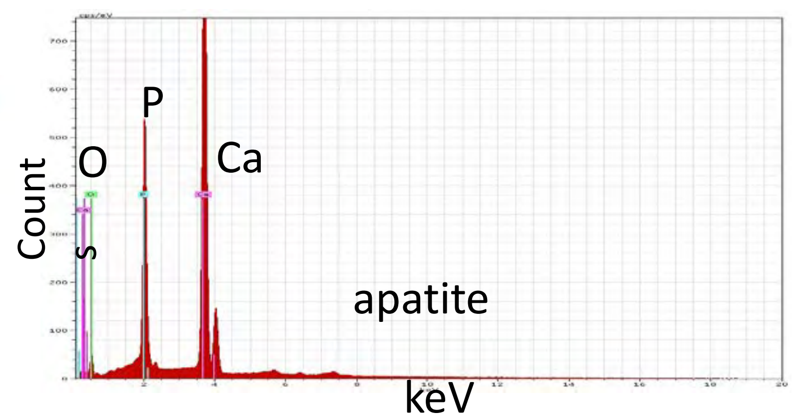




Methods – Mineral Liberation Analysis

- Location: Freiberg, Germany
- Sample: polished epoxy mounds, polished core
- Objective: quantification of chemical and mineralogical composition

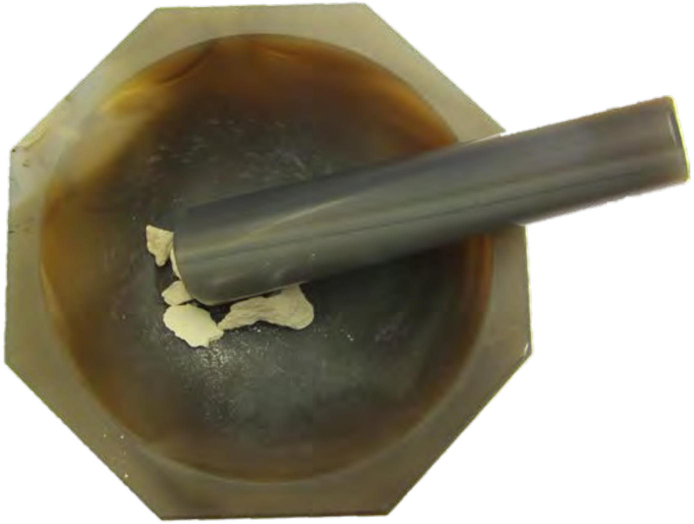


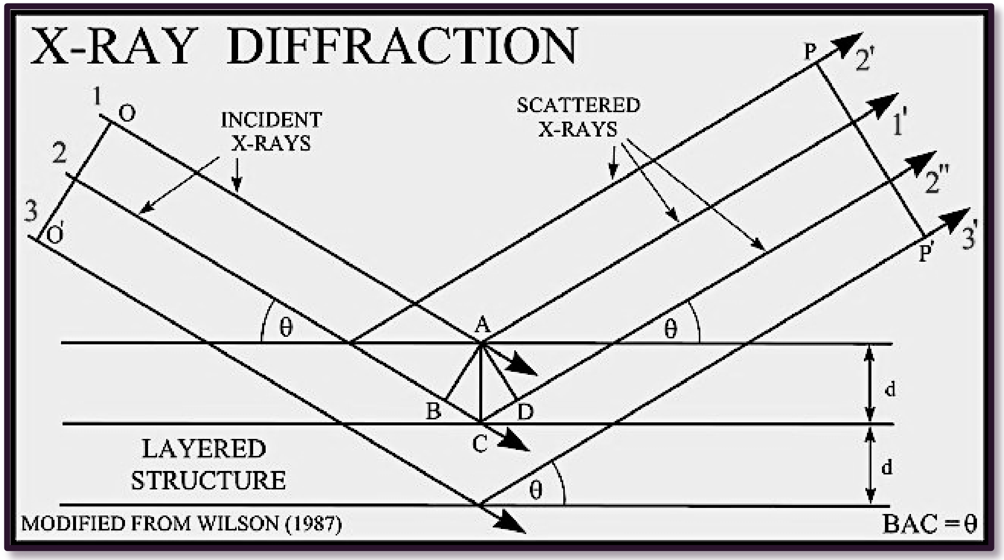


Courtesy of Udo Zimmermann

Methods – X-Ray Diffraction

- Location: outsourced
- Sample: hand-milled powder
- Objective: mineral structure description

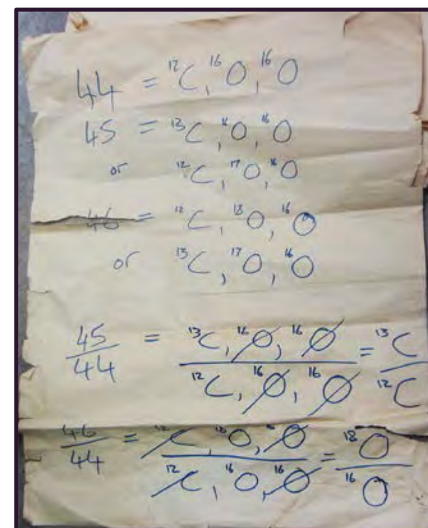




pubs.usgs.gov

Methods – Stable Isotope

- Location: outsourced
- Sample: fine powder
- Objective: stable isotope ratios of C and O for correlation efforts and impact of diagenesis and fluid flow



Methods - Geochemistry

- Location: outsourced
- Sample: machine-milled powder
- Objective: whole-rock analysis, mineral structure description

Dataset – core samples

Dataset – Sample overview

Well	Box	Core	C-O	XRD	GC	SR	TS	DIS
	1	1=A	3,4,114-117	7	7	7	7	
	1	2=B	6,7,17-25	8	8	8	8	
	1	3=C	8,106-113	9	9	9	9	
	1	4=D	9,100-105	10	10	10	10	
	1	5=E	5,118-125	11	11	11	11	
	1	6=F	1, 2, 26-32	12	12	12	12	
	2	1=A	15,16,33-40	1	1	1	1	
	2	2=B	10,126-130	2	2	2	2	
	2	3=C	14,41-47	3	3	3	3	
	2	4=D	11,131-137	4	4	4	4	
	2	5=E	12,13,48-55	5	5	5	5	
	2	6=F	138-147	6	6	6	6	
	3	2	302					
	3	3	303					
	3	4	304					
	3	5	305				prepared	
	3	6	306				sent	
	3	7	307				results in	
	3	8	308					
	3	9	309					
	3	10	310					
	3	11	311					

Time frame

	December	January	February	March	April	May	June
Sample preparation							
Data acquisition							
Petrography analysis							
Thesis introduction							
Objective and methodology							
Data interpretation							
First draft							
Revised version							
Final version submission							

Summary

- North Sea
- Reservoir chalk characterization
- Qualitative, quantitative analysis
- EOR

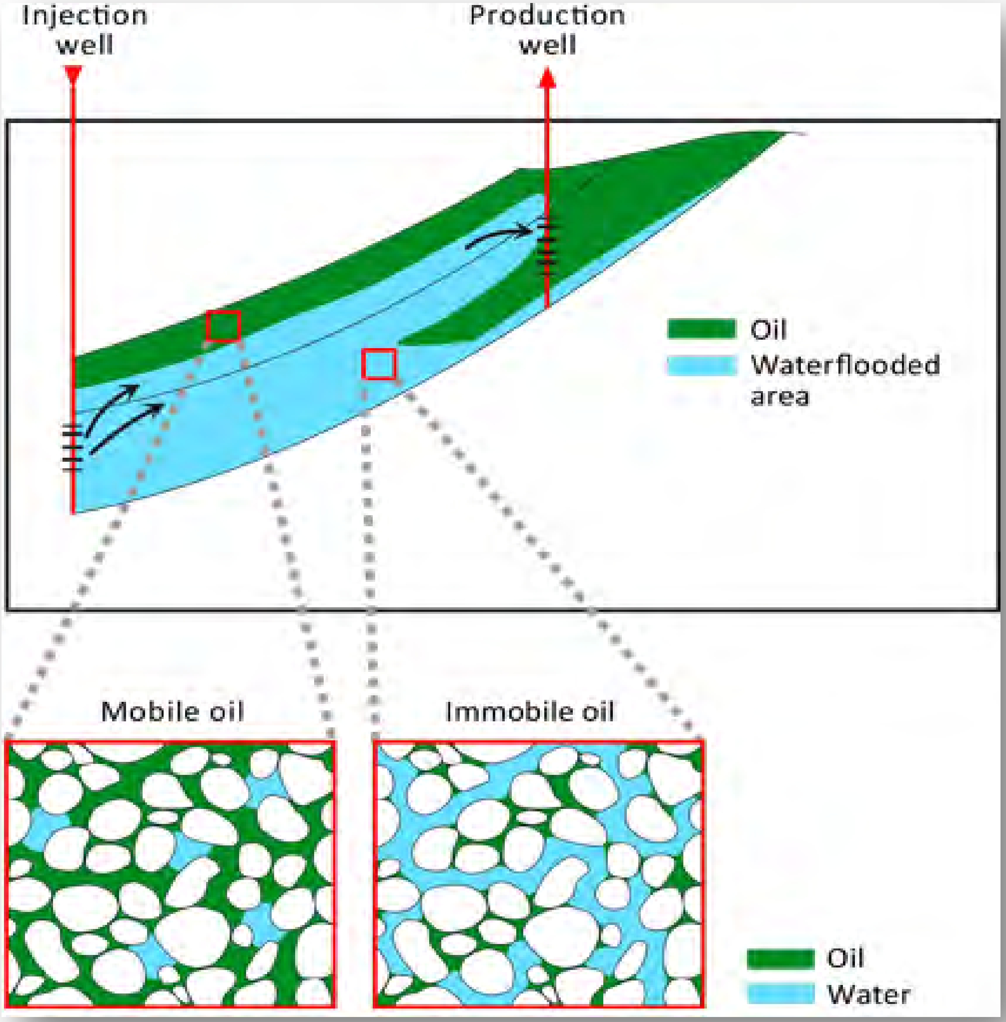
Micro- and Nano-applications to Monitor the Rock-Fluid Interaction in Fractured Chalk

Mona Wetrhus Minde
Advisor:
Dr. rer. nat. Udo Zimmermann

Objectives

- Study in detail formation of new minerals in fractures in a chalk core during flooding with brine.
- Study how the textural composition of the chalk influences the rock-fluid interaction in the fractures.
- Contribute to the research of Improved Oil Recovery

IOR and EOR



From www.npd.no

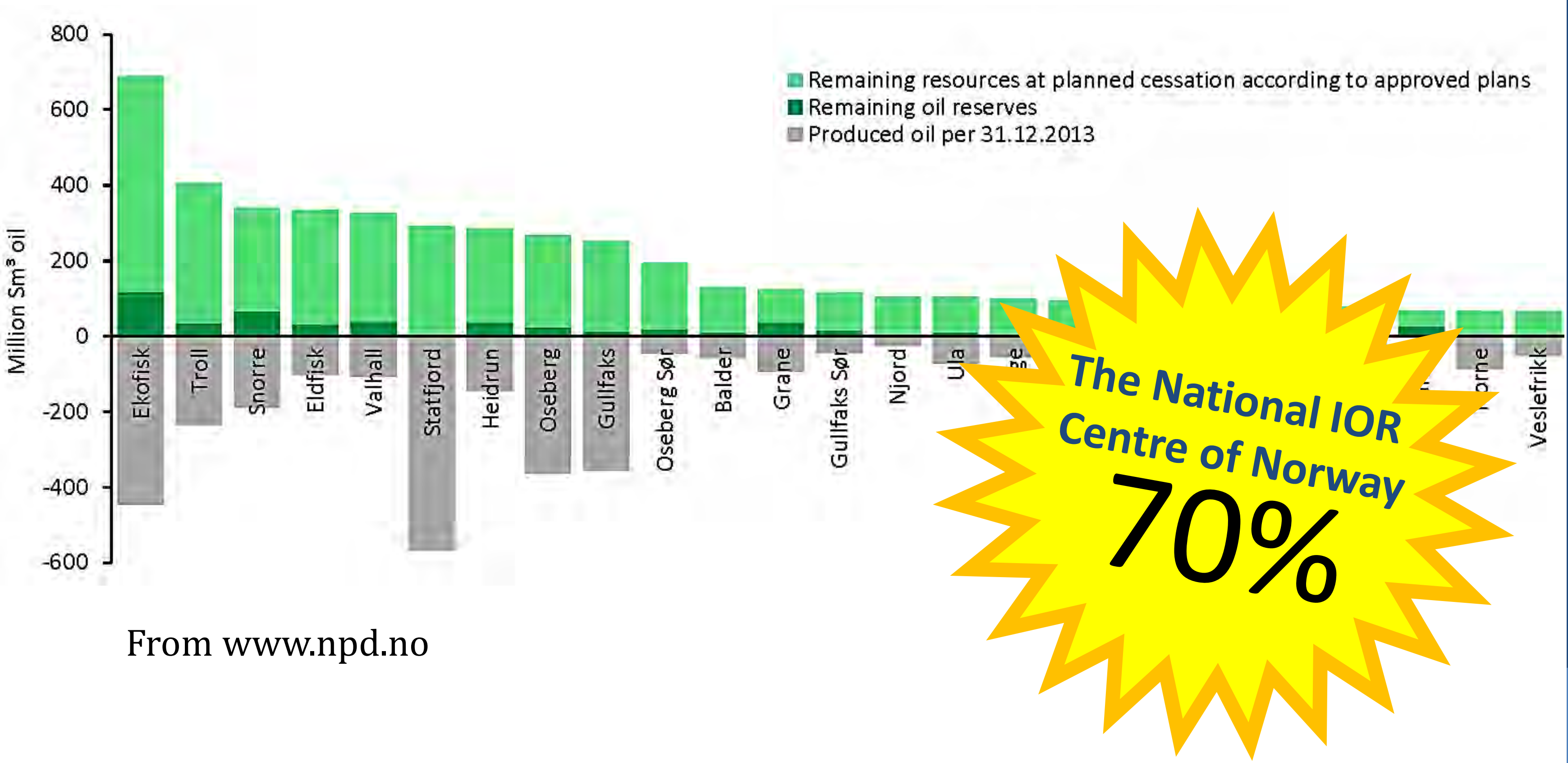
IOR:

Improved oil recovery

EOR:

Enhanced oil recovery

IOR and EOR



From www.npd.no

EOR in chalk

- Chemical and textural alteration of chalk:
  - Dissolution and precipitation
  - Ion exchange
  - Changes in surface charge

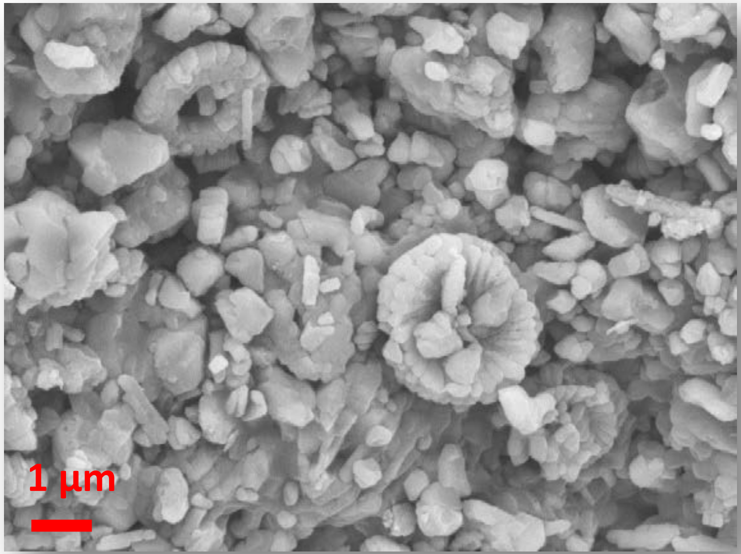
- From **pore** to **core** to **field** scale

Methodologies

- Optical light microscopy
- Scanning Electron Microscopy (SEM)
- Mineral Liberation Analyses (MLA)
- Nano Secondary Ion Mass Spectrometry (NanoSIMS)

Scanning Electron Microscopy (SEM)

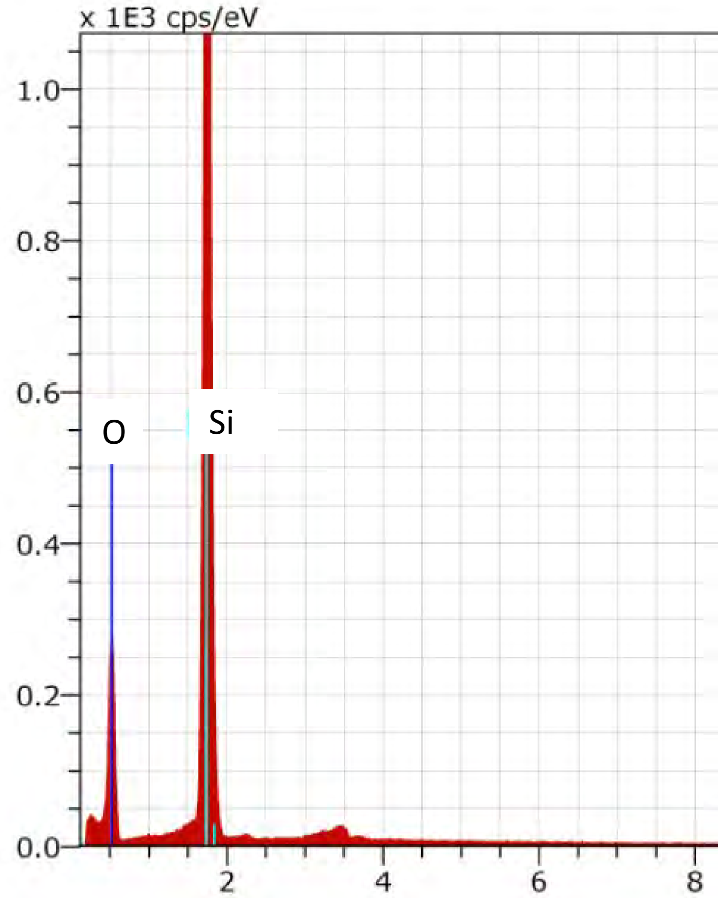
- Electron beam
- Detectors:
  - Secondary electrons (SE)
  - Backscattered electrons (BSE)
  - Cathodoluminescence (CL)
  - Energy dispersive system (EDS)



SE-image of the surface chalk.

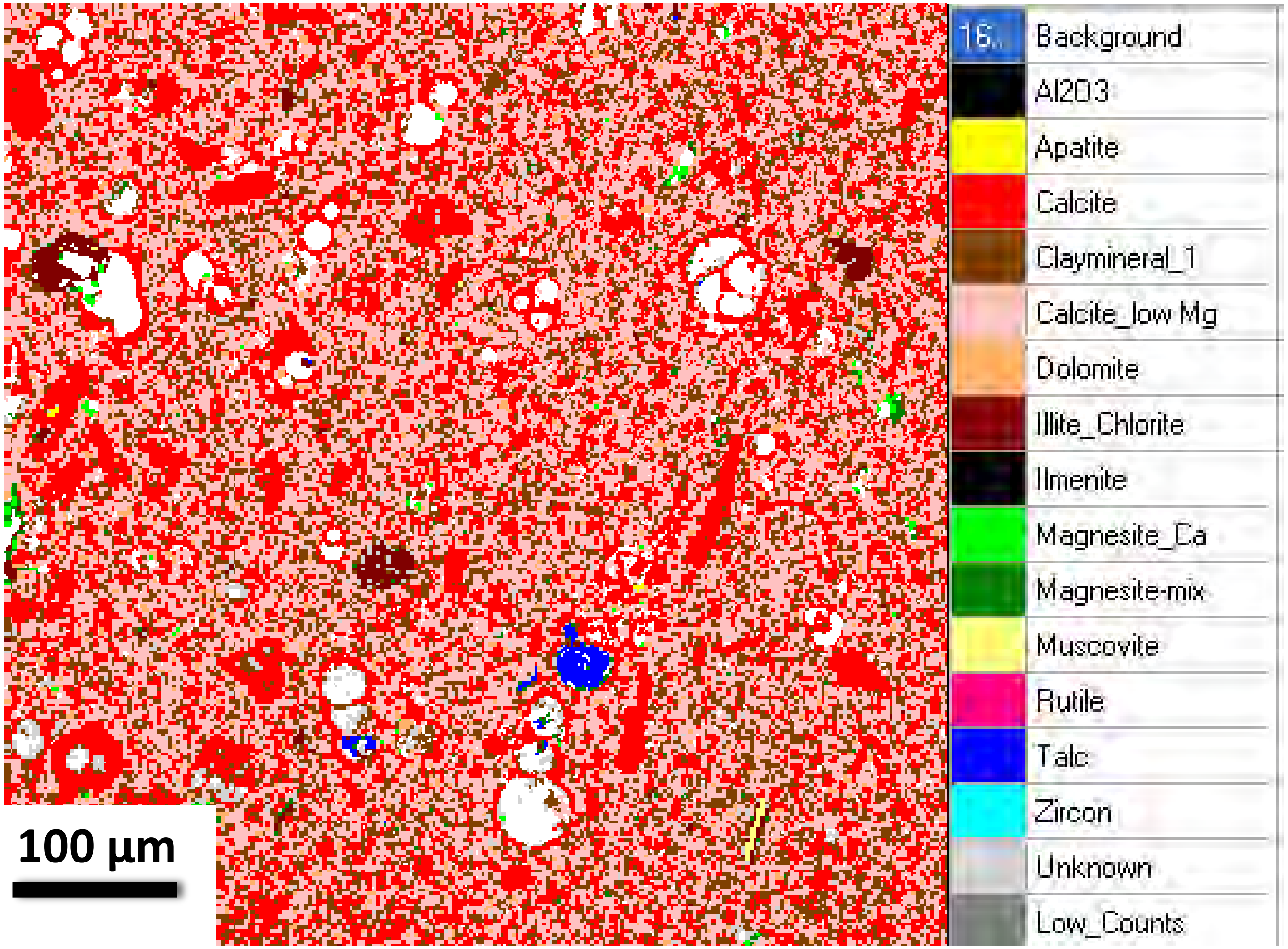
Mineral Liberation Analyses (MLA)

- Polished surface or thin section
- BSE image
- EDS
- Mineral database
- Mapping of an area
- Resolution: < 1 μm per pixel



EDS-spectra of quartz

Mineral Liberation Analyses (MLA)

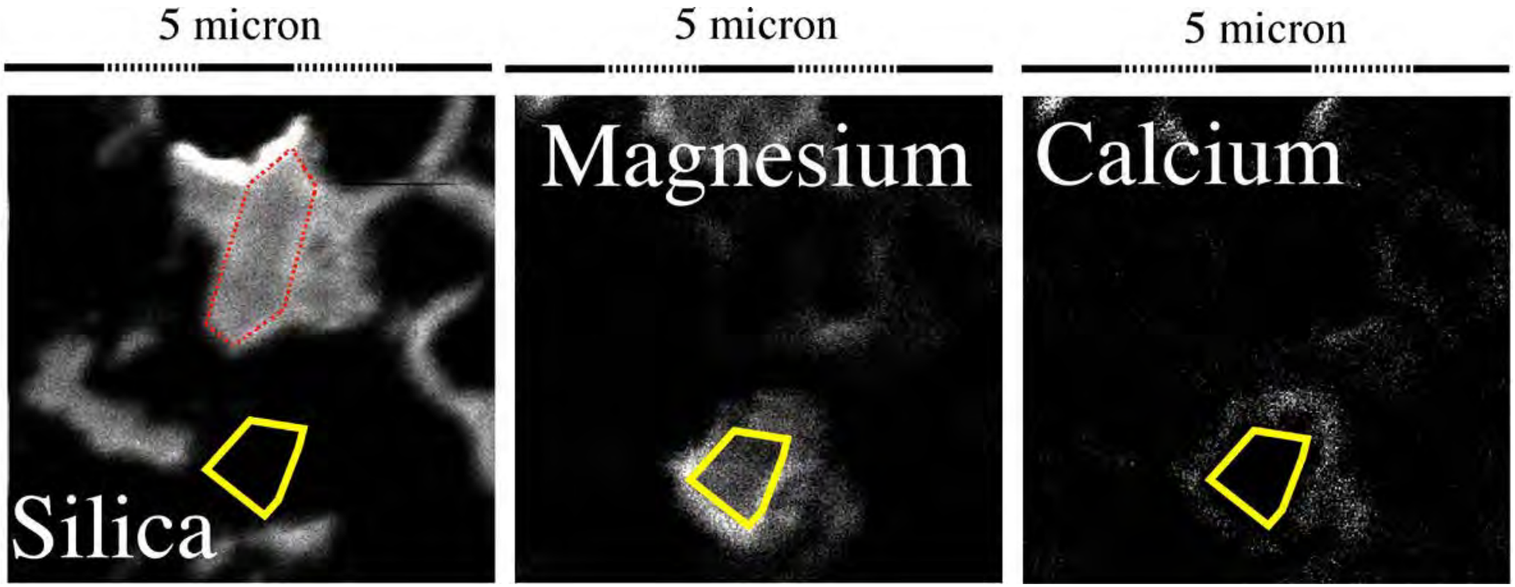


Color-coded map of a chalk thin section.
Courtesy of Dr. Udo Zimmermann

NanoSIMS

- Ion beam penetrates polished surfaces of materials: oxygen or cesium source
- Released ions are accelerated into a mass spectrometer
- 5 masses can be measured simultaneously
- Resolution c. 80-120 nm

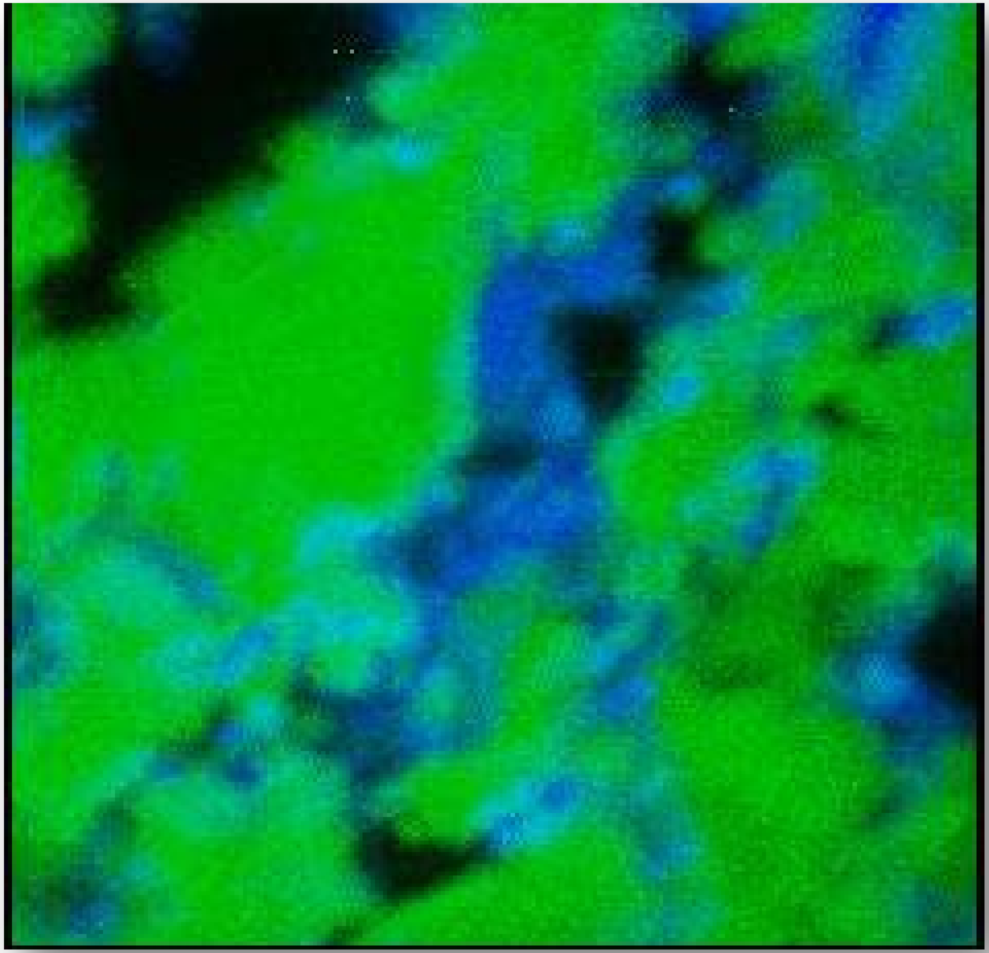
NanoSIMS



Name:	**Counts:**
^{12}C	4177,43 (Not shown here)
^{26}Si	1,01
^{16}O	970,31 (Not shown here)
$^{24}Mg^{16}O$	17,86
$^{40}Ca^{16}O$	0,14

Identification of minerals based on elements present in grain.
(Zimmermann et al., in press)

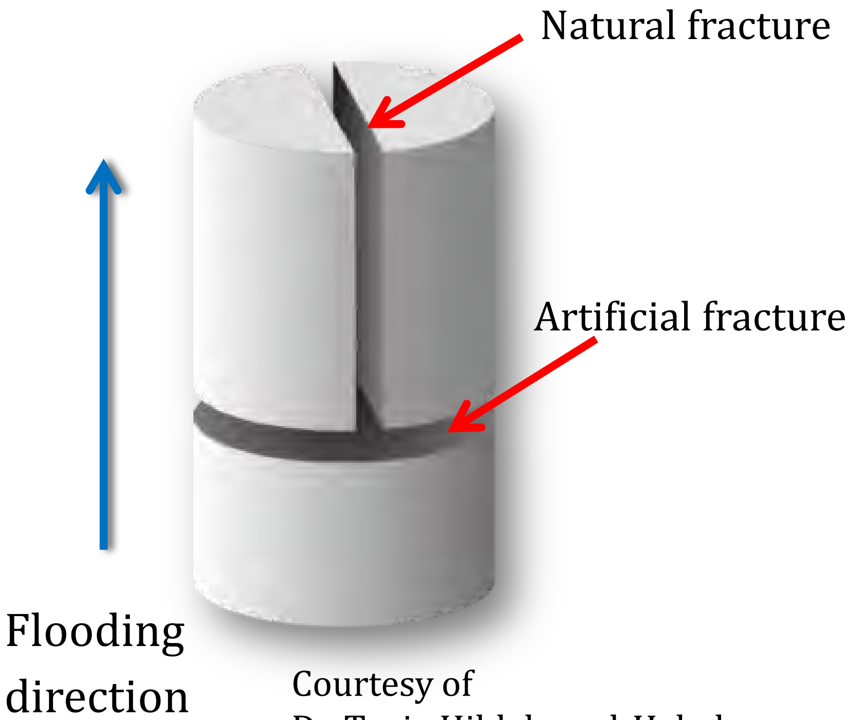
NanoSIMS



Mg (green) and Si (blue) 10 x 10 µm, 1 µm depth.
Courtesy of Dr. Udo Zimmermann

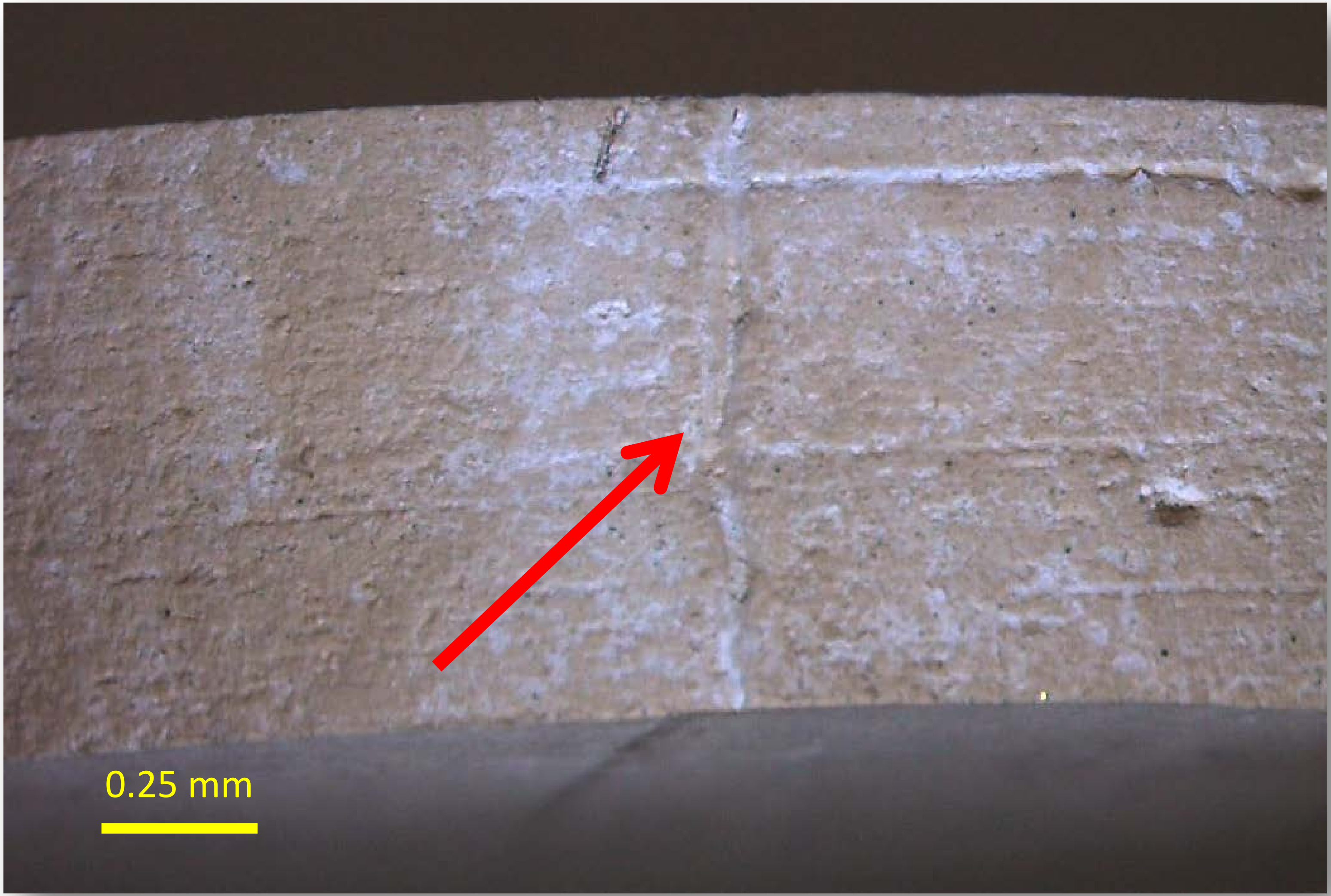
Data

- Liège chalk
- Flooding with synthetic seawater
- Flooding rate 1 PV/day
- Temperature 130 ˚C
- Flooded for 30 days

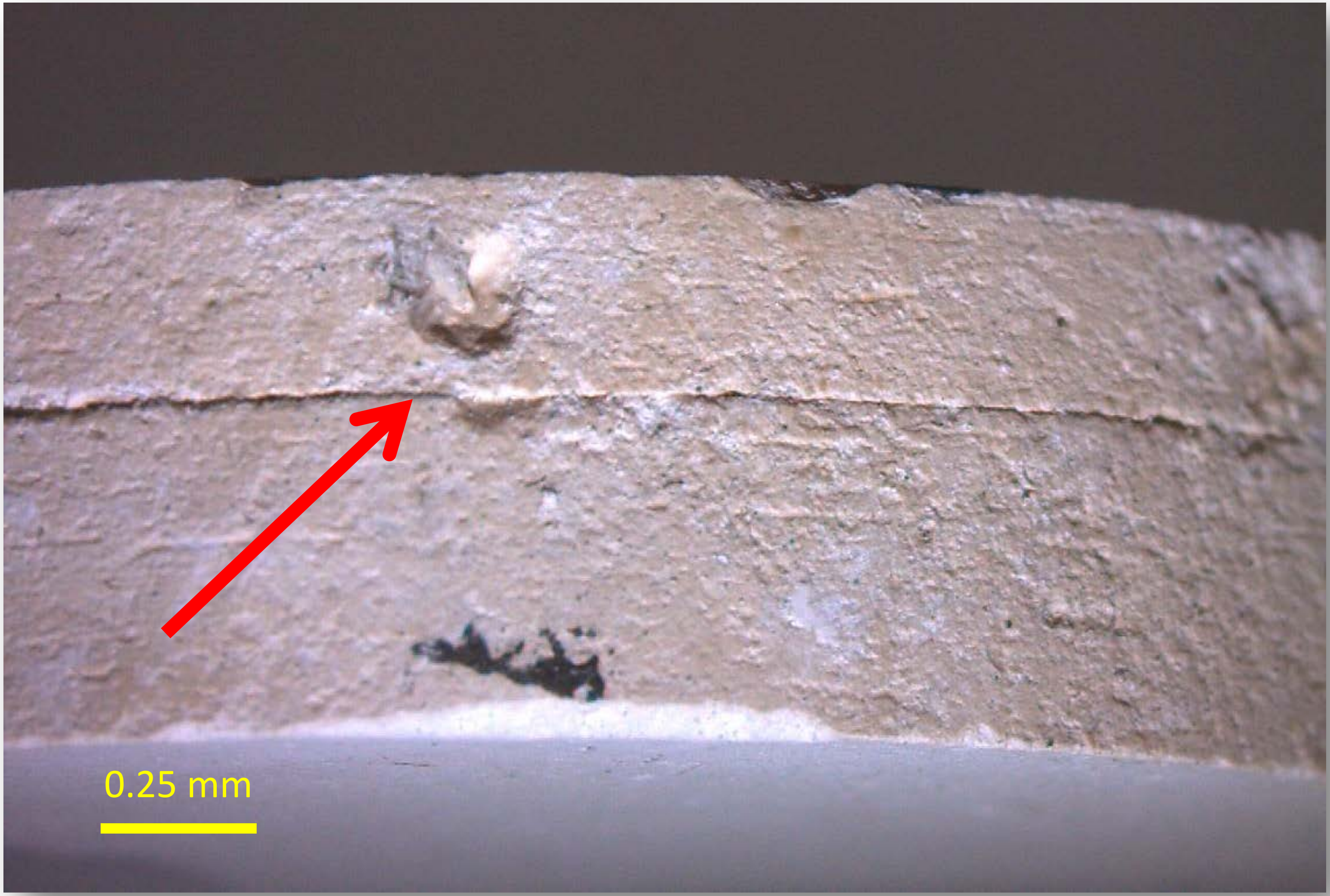


Courtesy of
Dr. Tania Hildebrand-Habel

Data – Natural fracture



Data – Artificial fracture



Timeframe

Time	Task
2014:	
December	Sample preparation Write introduction Write methodology
2015:	
January–February	Data acquisition: • SEM, BSE, EDS at UiS • MLA at “TU Bergakademie Freiberg” in Freiberg, Germany • NanoSIMS at “Centre de Recherche Public Gabriel Lippmann” in Luxembourg
March	Data interpretation
April	First draft finished
May	Revised version correction
June	Back-up time Submission of thesis

Summary

- Study alteration and rock-fluid interaction in fractures in a chalk core during flooding with brine

- SEM
- MLA
- NanoSIMS

Thank you for your attention!

Questions?

RAMAN SPECTROSCOPY APPLIED TO EOR

By Nina Egeland

Advisor: Dr. rer. nat. Udo Zimmermann

Introduction

- Enhanced oil recovery (EOR) is a topic of high interest
- 30-50% of oil in existing fields on the Norwegian Continental Shelf cannot be produced with current methods
- Aqueous chemistry affects the mechanical strength of chalk
- An ultra long-term tested (ULTT) sample, flooded with $MgCl_2$ for 1100 days (3 years) will be investigated with Raman spectroscopy

Objectives

- Describe one specific research method in detail: Raman spectroscopy (to be carried out at University of Milano-Bicocca)
- Describe and quantify mineralogical and chemical effects after chalk (ULTT) has been flooded

Sample for Raman spectroscopy

- Sample collected from Liège in Belgium
- Formation: Gulpen
- Age: Campanian to early Maastrichtian (83.6 to ~73 Ma)
- Relatively pure composition with $SiO_2 < 5\%$
- Suggested as best match for reservoir successions in the North Sea

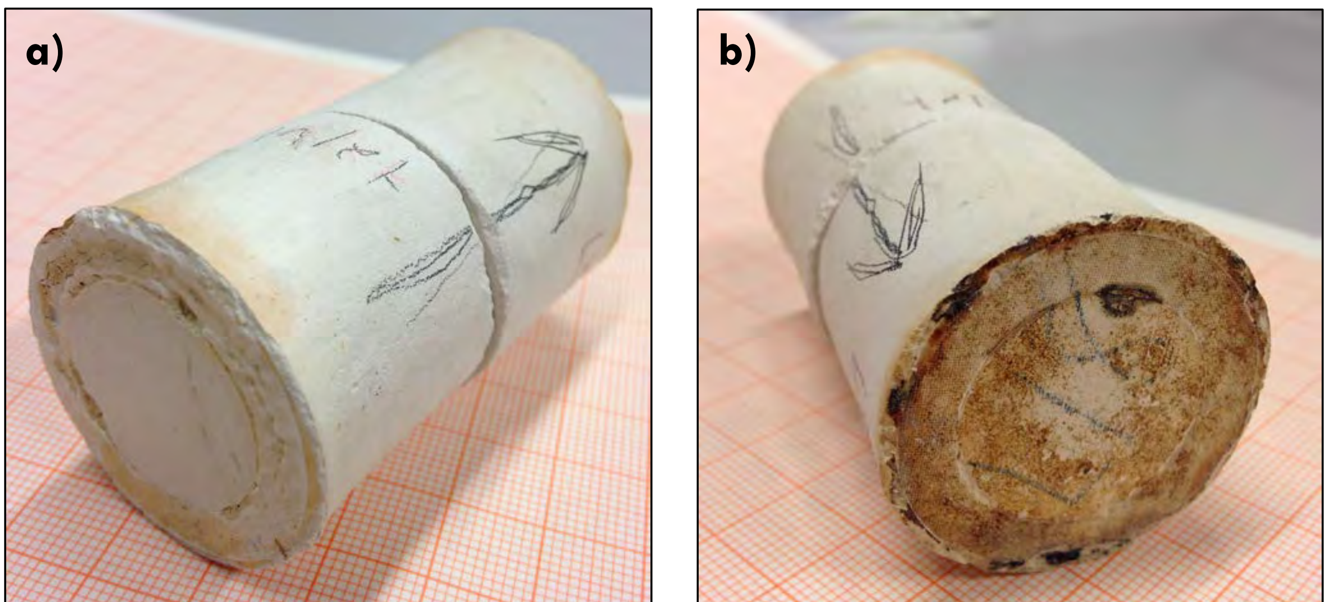


Figure: a) Inlet of ULTT **b)** Outlet of ULTT.

Flooding

- Onshore chalks are used as analogues in order to understand chemical changes in offshore chalk

- Triaxial cells under reservoir conditions:
  - Temperature = 130°
  - Confining pressure = 1.2 MPa
  - Pore pressure = 0.7 MPa
  - Flooding rate 33.12 - 99.36 cm^3/day

Flooding

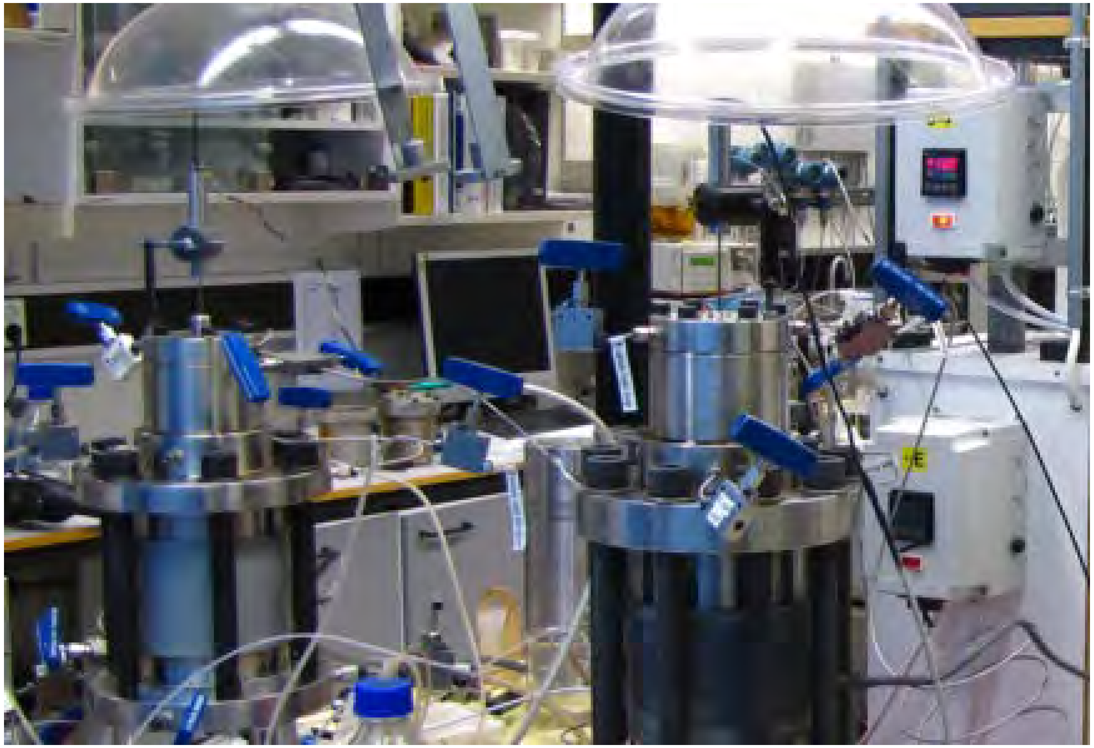


Figure: Triaxial cells at UiS laboratory where the rock is exposed to mechanical compression tests under reservoir conditions (www.uis.no).

Flooding

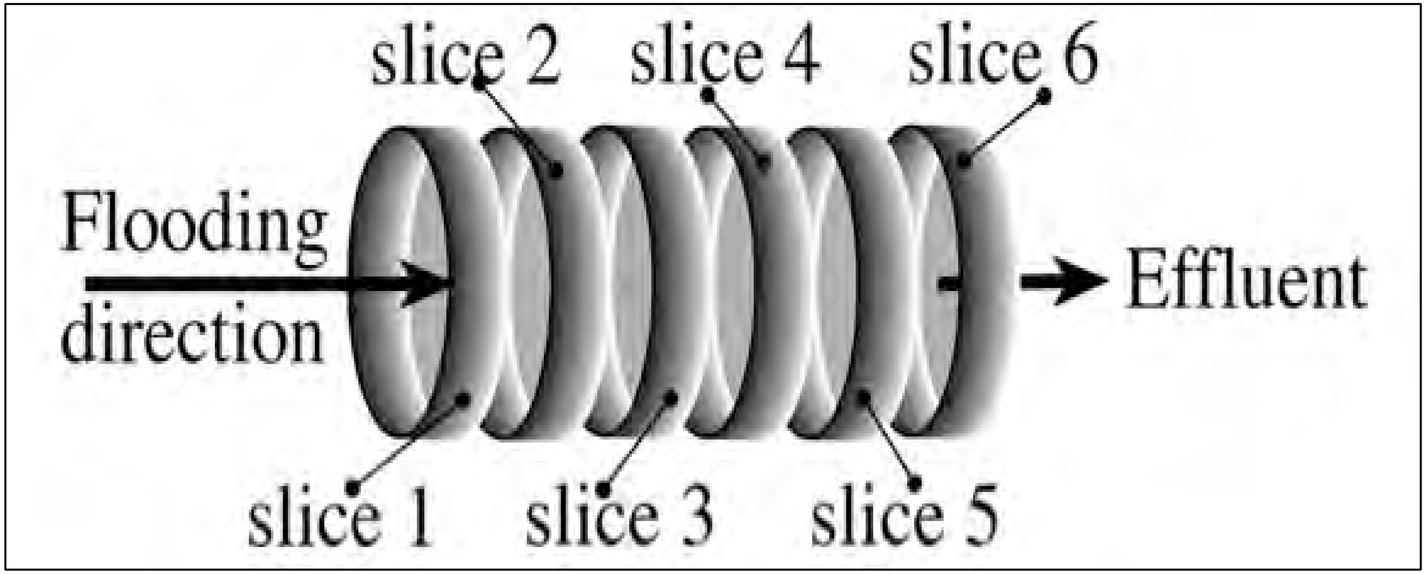


Figure: Sketch of cutting of the ULTT. $MgCl_2$ fluid was injected from left into sample core and the effluent collected on the right (Zimmermann et al., 2013).

Methodology of Raman spectroscopy

- Monochromatic light source on a sample to detect scattered light
- Two types of scattered light:
  - Rayleigh
    - Elastic
    - Majority of the light
  - Raman
    - Inelastic
    - Very weak
    - Contains frequencies $v_0 \pm v_m$, where v_m is a vibrational frequency of a molecule

Raman spectroscopy

- $v_0 - v_m$: stokes radiation
- $v_0 + v_m$: anti-stokes radiation
- The observed Raman shift is a direct measure of the vibrational energies of the molecule, mineral or substance

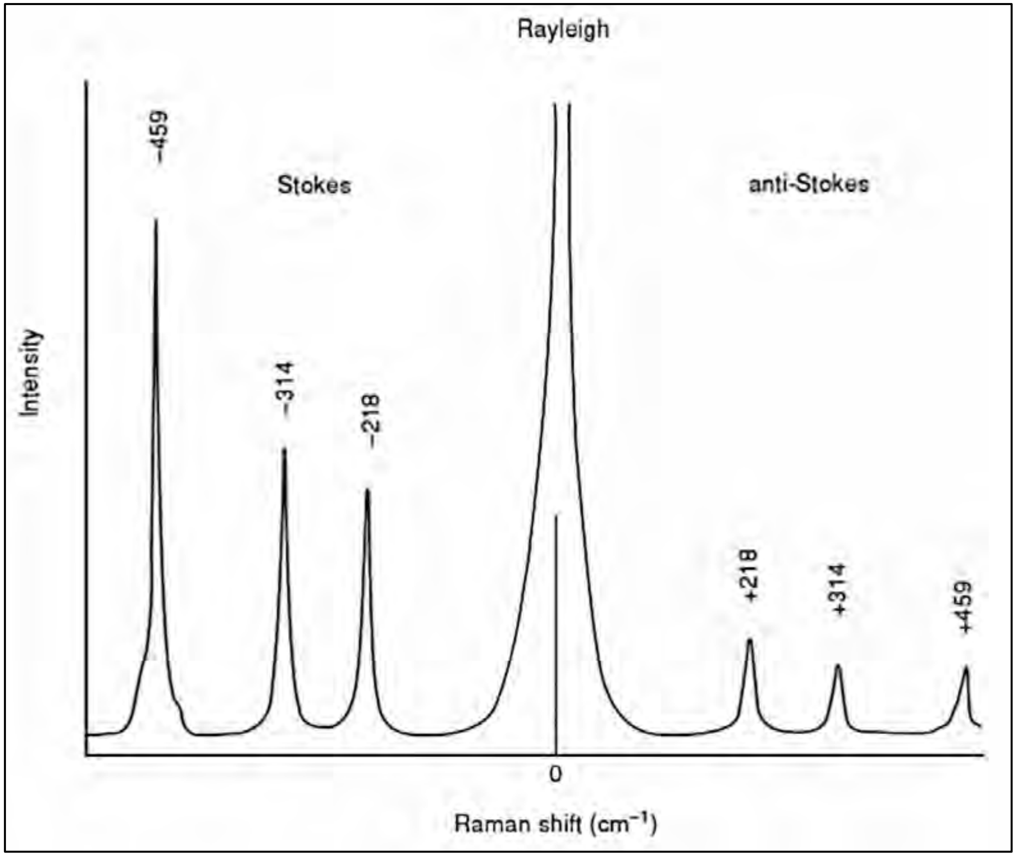


Figure: Anti-Stokes radiation occurs at a higher energy and Stokes radiation at lower energy when comparing with the Rayleigh radiation. (Ferraro et al., 2003).

Raman spectroscopy

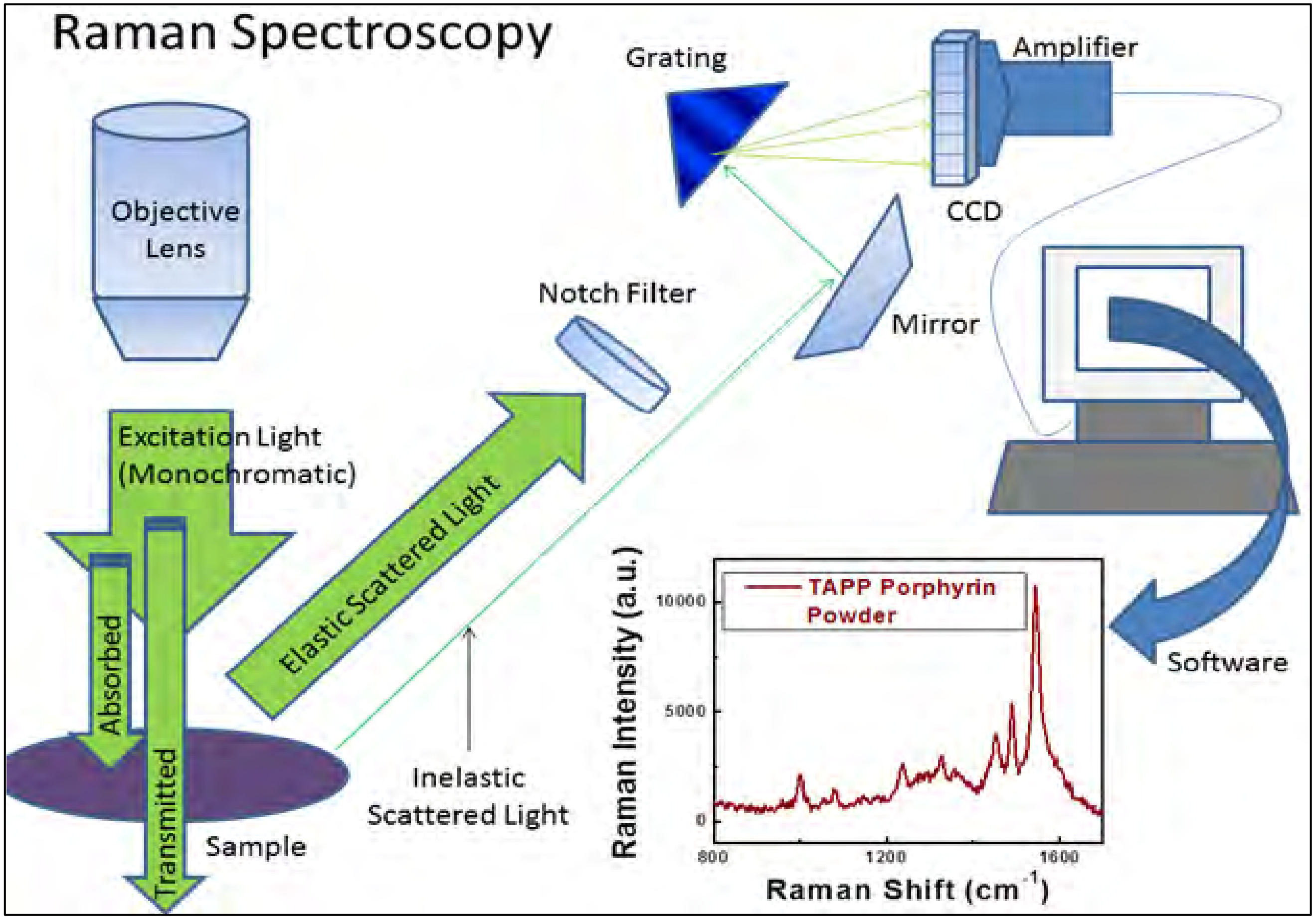


Figure: *The construction of a Raman spectrometer (Maryland, 2014).*

Raman spectroscopy

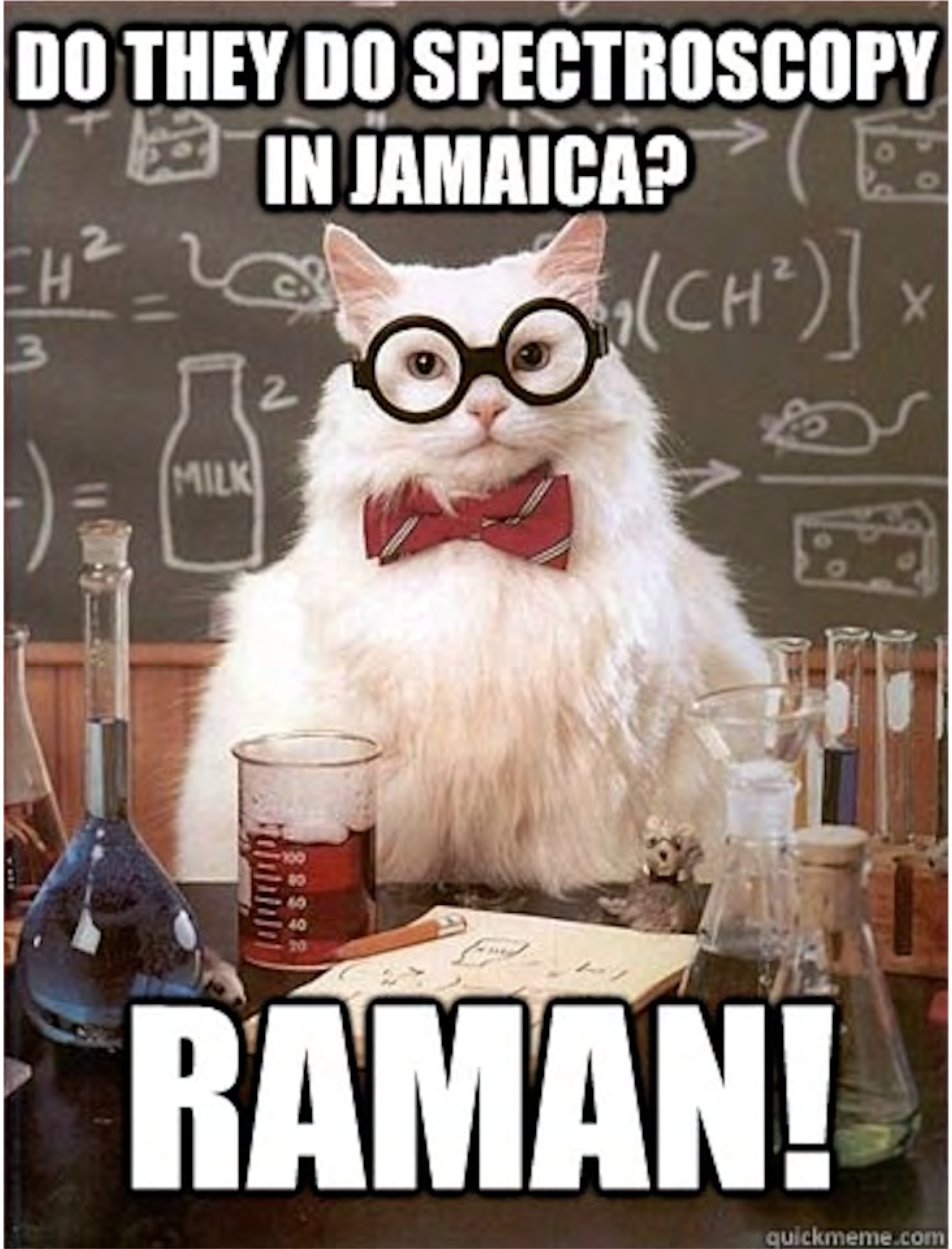
- Advantages:
  - Non-destructive
  - Used to characterize any material
  - Resolution down to 5 microns
    (below 1 micron in special arrangements)
  - Very quick and simple to use
  - Very cheap
  - Polymorph differentiation
  - Can be used offshore

Time frame

Activity	**2014**	**2015**					
	Dec	Jan	Feb	Mar	Apr	May	Jun
Preparations of samples							
Data acquisition (Milan, Italy)							
Raman application on ULTT							
Initial writing							
Introduction							
Methodology							
Data interpretation							
Submit 1st draft							
Correct revised version							
Submit thesis							

Summary

- Describe the methodology of Raman spectroscopy
- Apply Raman spectroscopy to ULTT in order to describe and quantify mineralogical and chemical effects of flooding processes


DO THEY DO SPECTROSCOPY IN JAMAICA?
RAMAN!
quickmeme.com

Seismic Stratigraphy and Geomorphology of the Chalk Group of the Central Graben, North Sea

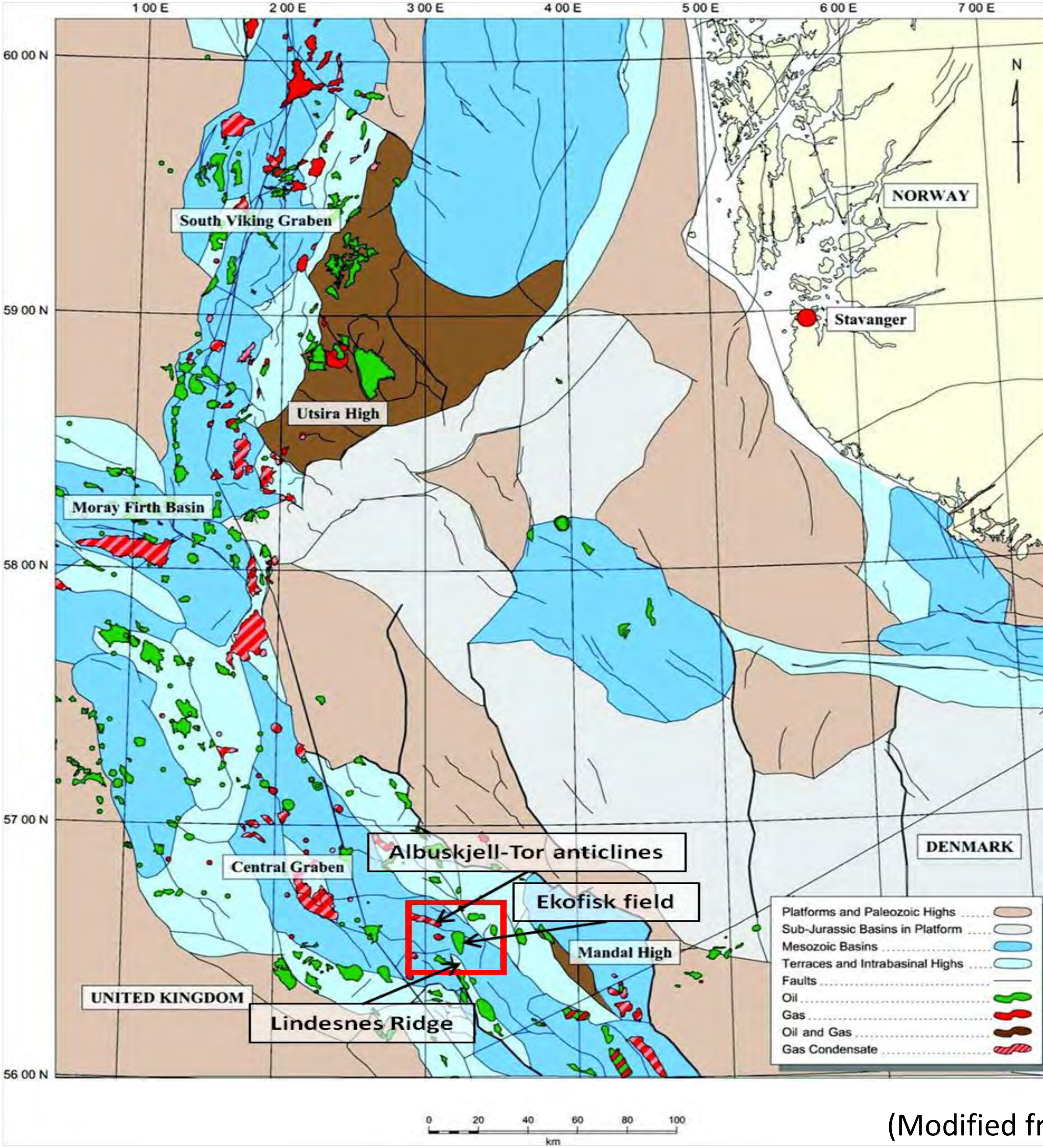
Sarasi Das

Supervisor: Sylvia Nordfjord

Outline

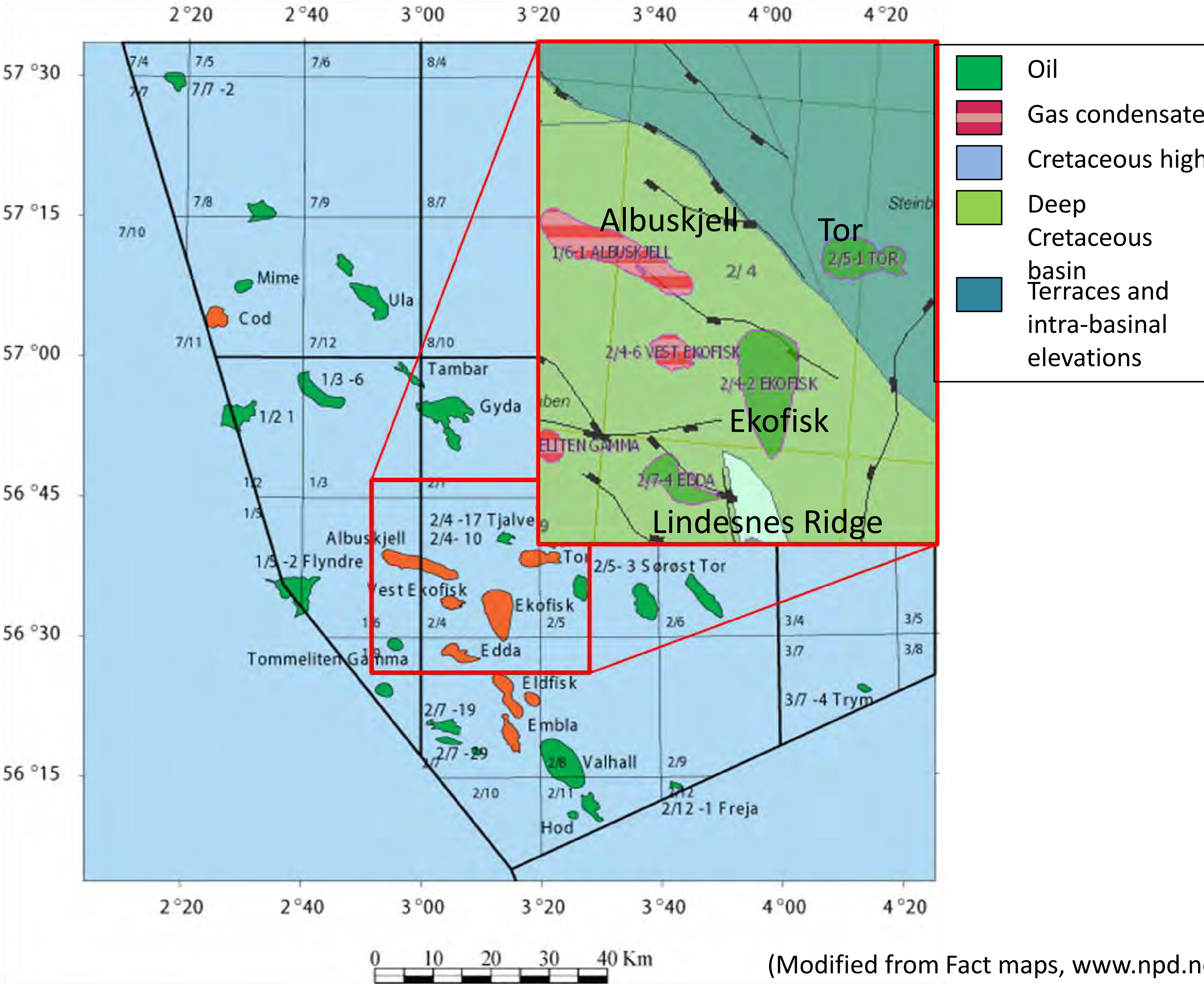
1. Introduction
2. Chalk and depositional setting
3. Regional geology
4. Objectives
5. Dataset and Methodology
6. Summary

Introduction



(Modified from Rossland et al., 2013)

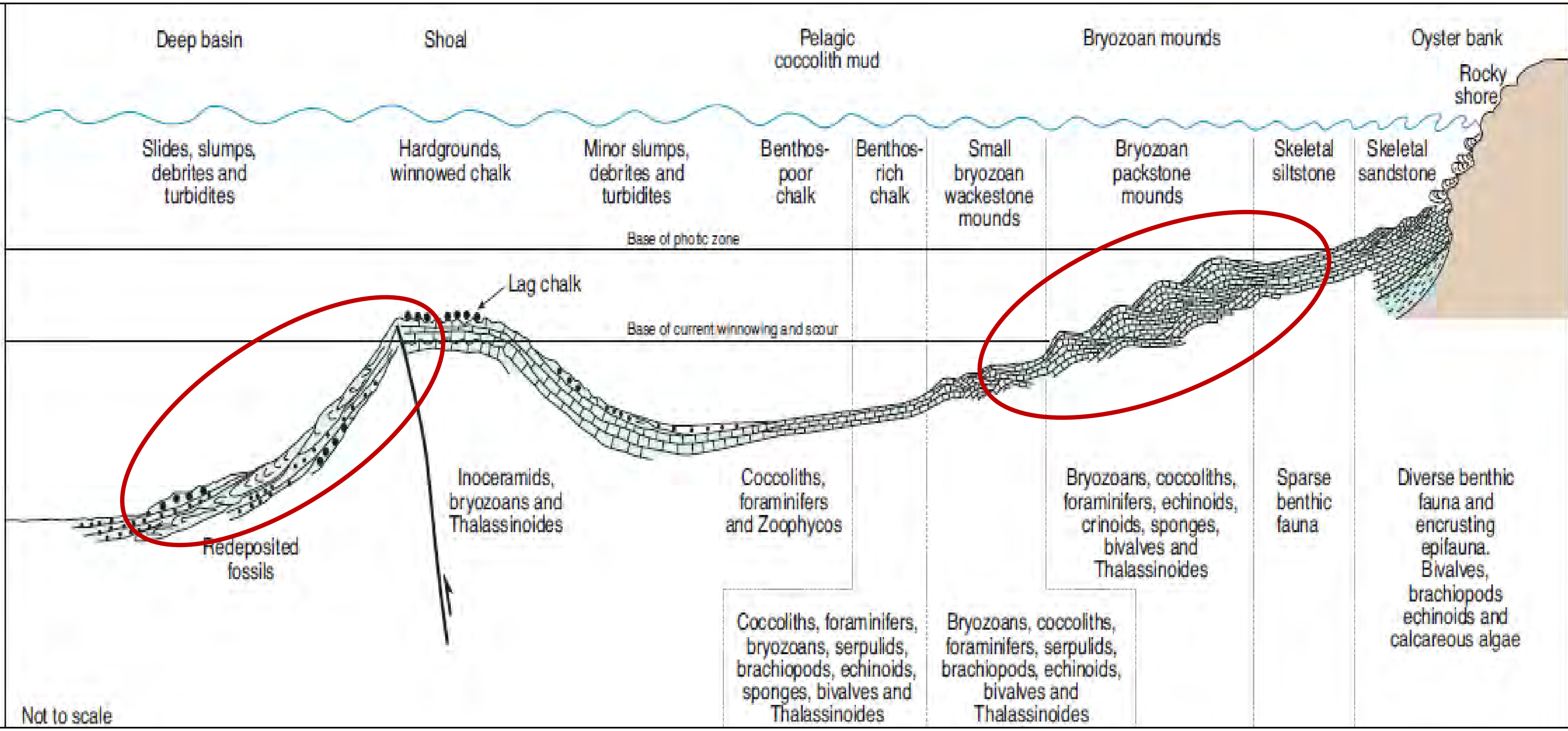
Introduction



(Modified from Fact maps, www.npd.no)

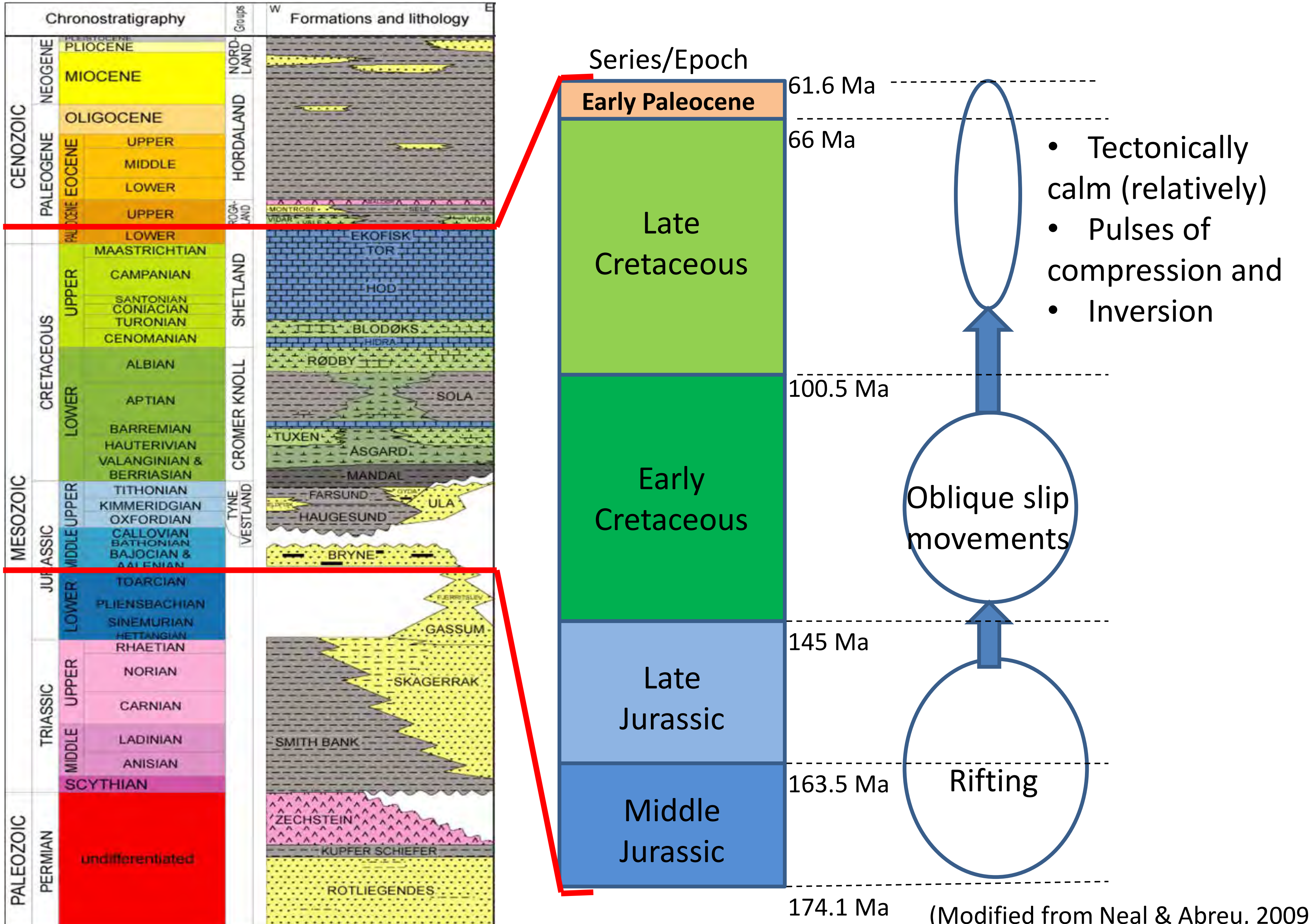
Chalk and Depositional Setting

- Biogenic sediment
- By slow settlement of coccoliths, foraminifers and calcispheres
- They are below photic zone in Central Graben
- Produces volatile oil



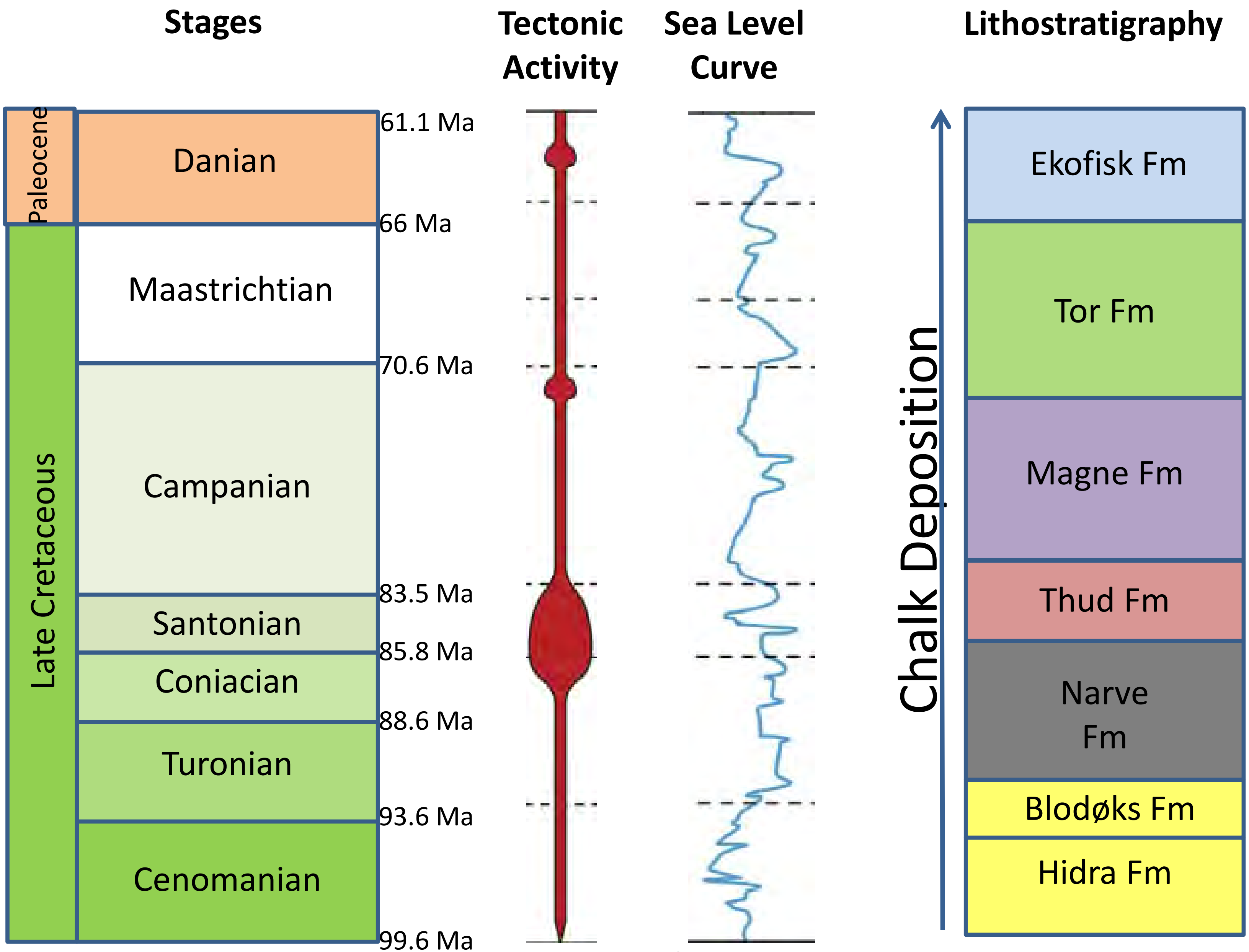
(Surlyk et al., 2003)

Regional Geology



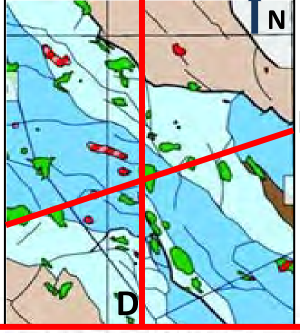
(Modified from Neal & Abreu, 2009)

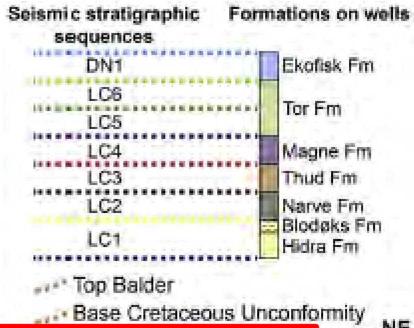
Regional Geology

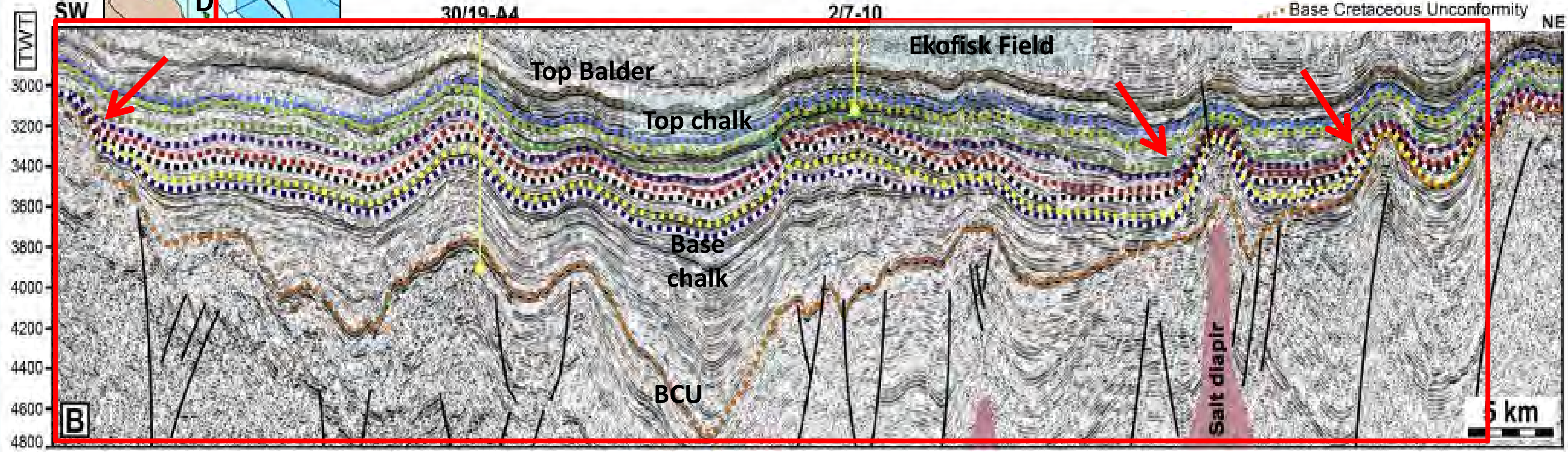


(Based on Gennaro et al., 2013)

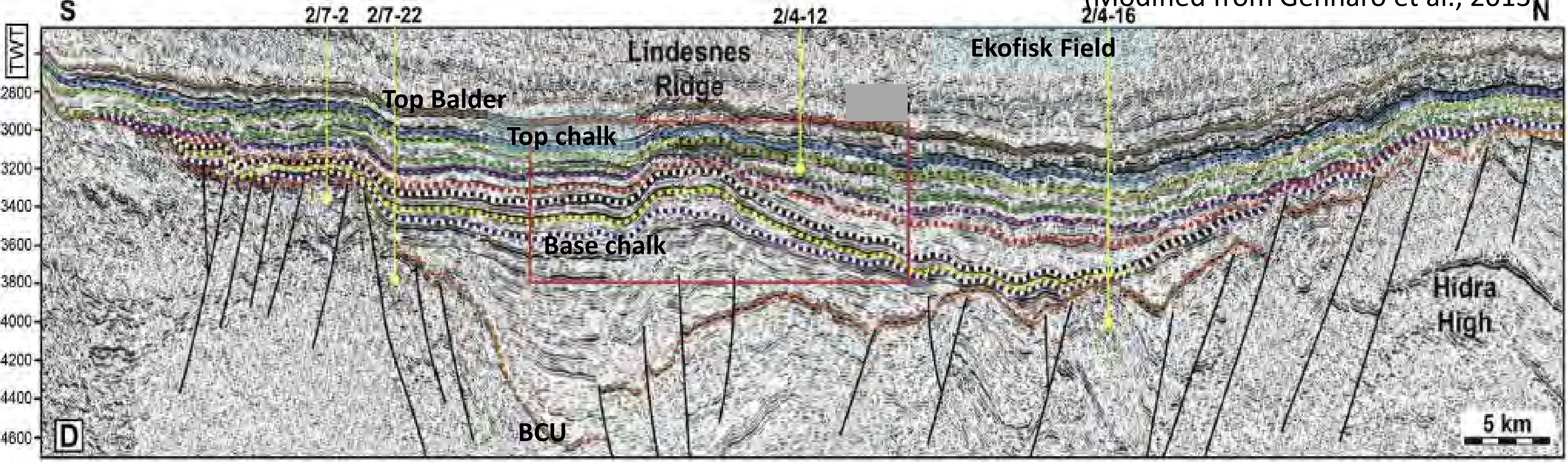
Regional Geology







(Modified from Gennaro et al., 2013)



Objectives

1. To provide a sequence stratigraphic framework for the chalk deposits

2. To predict facies and lithology away from the control points

3. To understand the geomorphology of the chalk deposits by paleogeographic reconstructions

4. To explain the known hydrocarbon presences within a sequence stratigraphic framework.

Dataset

3D Seismic Data: VGCNS05

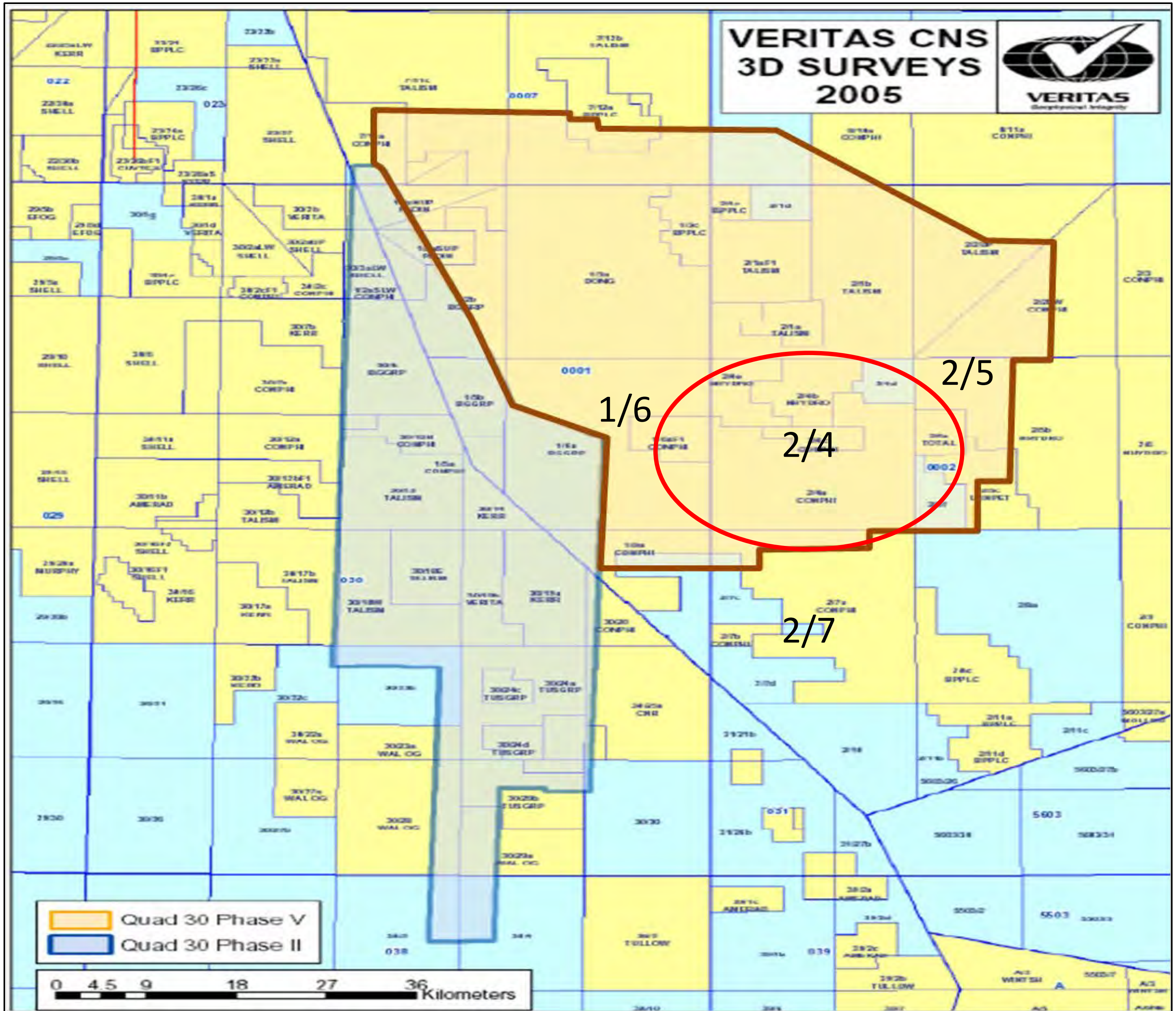
- 3D Multi-Client Survey Phase 5
- 6 Km cable length
- Area: 1500 square km
- Acquired in 2004

Well Data:

- Around 25 exploration and production wells
- From blocks 2/4, 2/7, 2/5 and 1/6
- GR, resistivity, sonic, density and others

Dataset

3D Seismic survey: VGCNS05



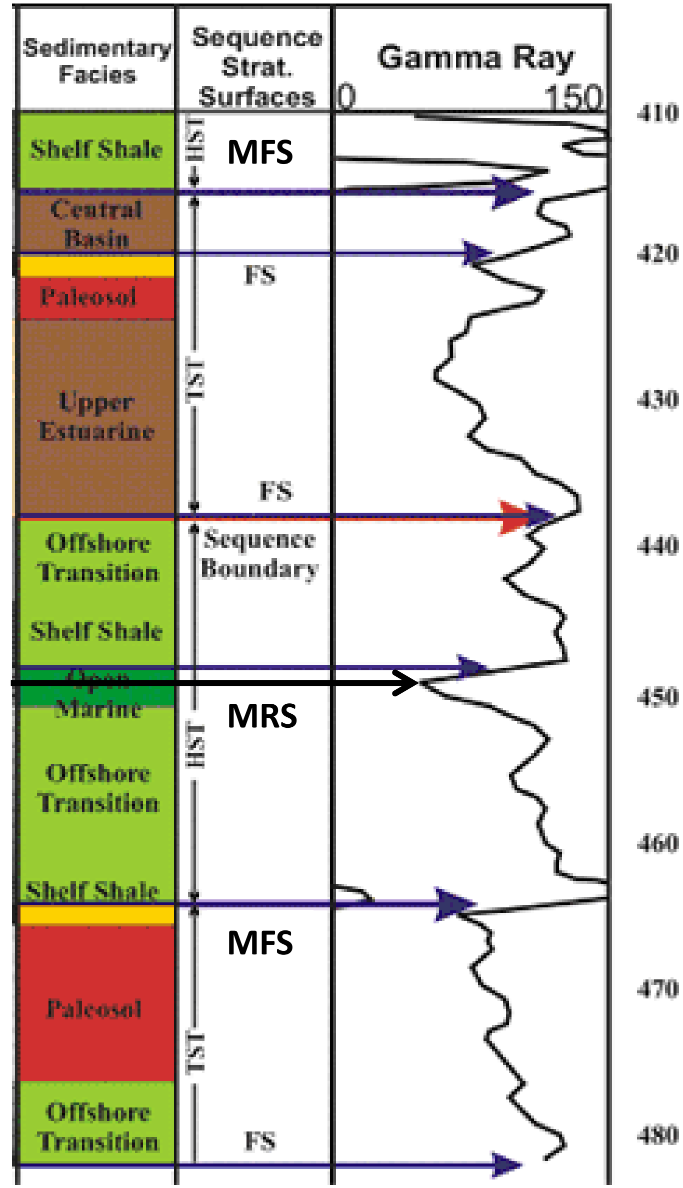
Methodology

1. Well log interpretation
2. Seismic-Well tie
3. Mapping the reflectors
   – Stratal terminations
   – Indentify different structural elements related to the chalk deposition
4. Study seismic facies
5. Perform Stratal slicing
6. Geomorphological studies

Methodology

1. Log interpretations
   - Sequence boundaries (SB)
   - Maximum flooding surface (MFS)
   - Maximum regressive surfaces (MRS)

2. Seismic – Well tie
   - Generate synthetic seismograms
   - Identify main horizons /reflectors



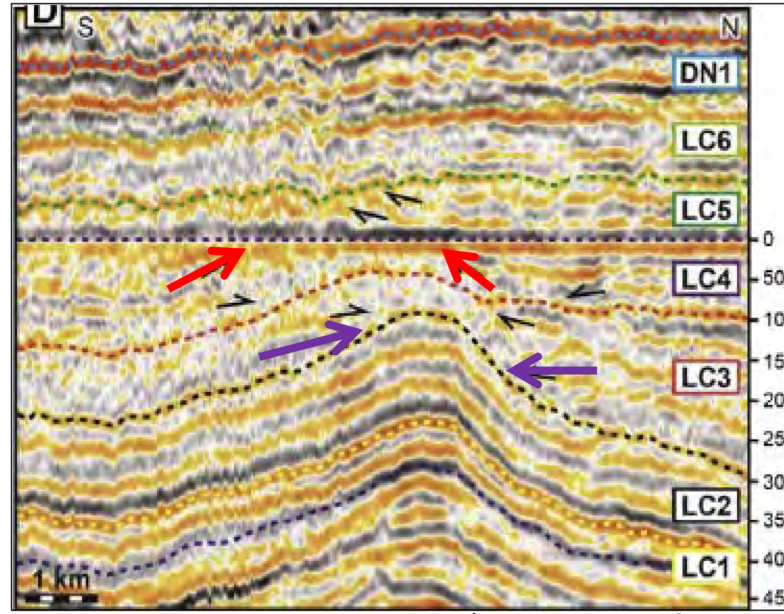
(Image Source: http://www.kgs.ku.edu/PRS/publication/ofr2003-82/chapter4_1.html)

Methodology

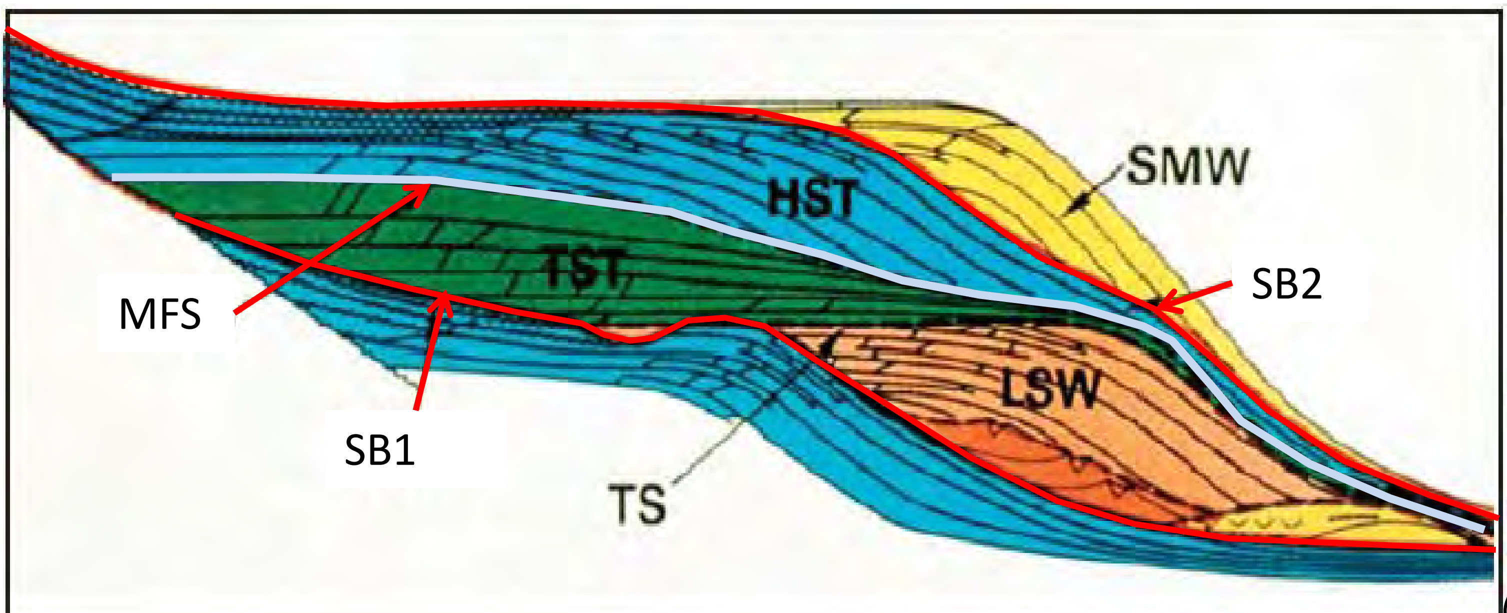
3. Mapping the reflectors

 – Unconformities and stratal terminations

 – Identify MFS, SB



(Gennaro et al., 2013)



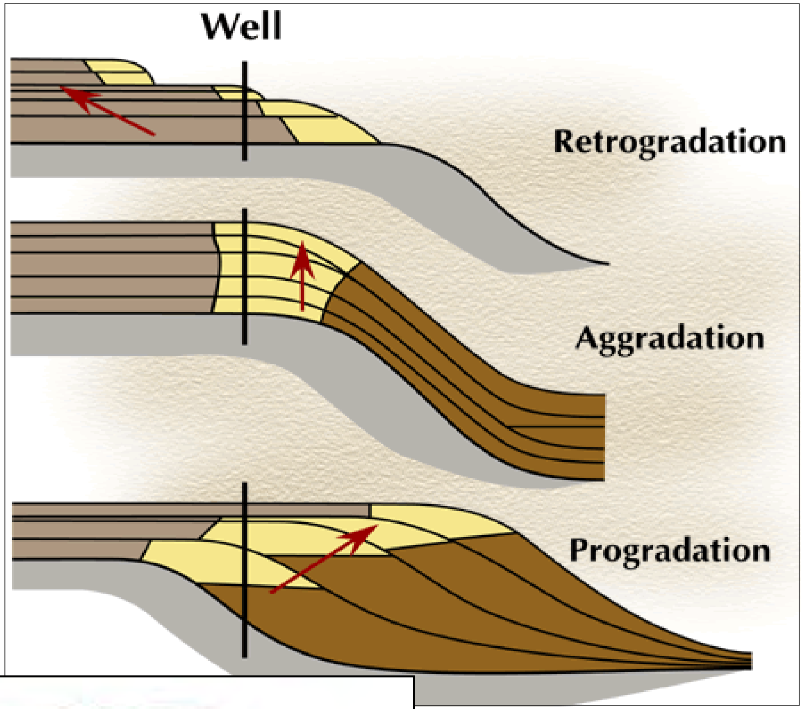
(Embry, 2009)

Methodology

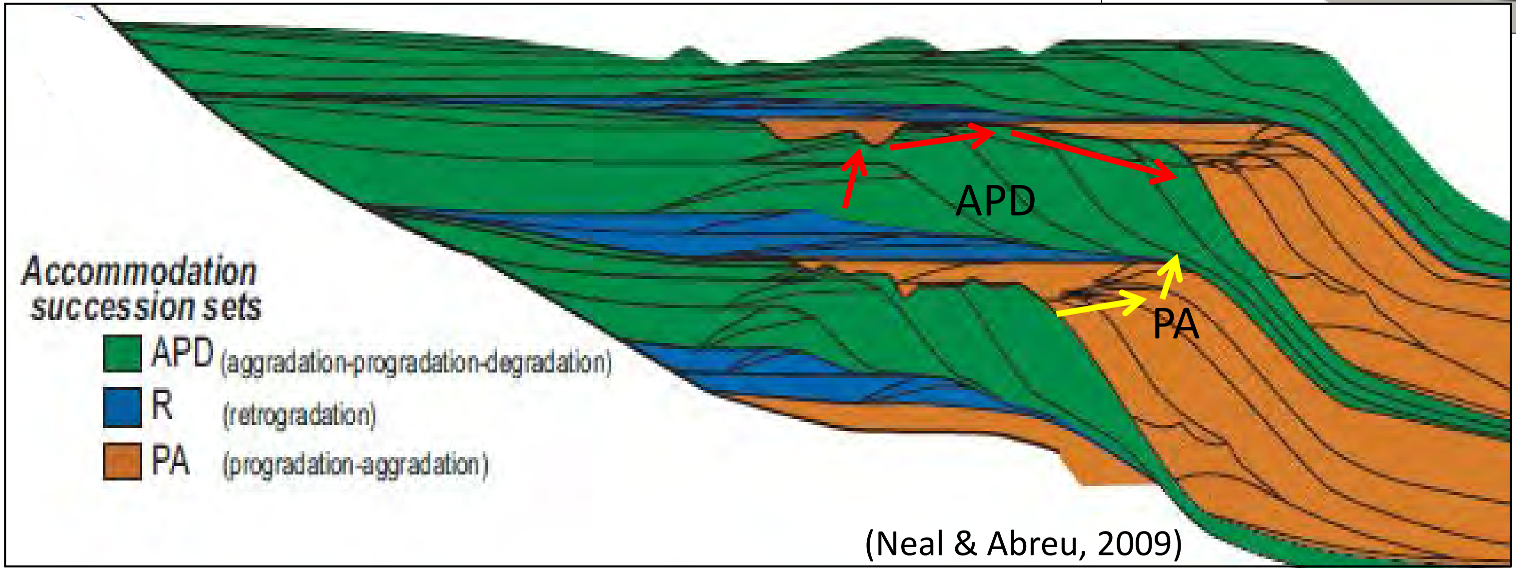
3. Mapping the reflectors

   – Identify progradation, aggradation or retrogradation

   – System tract classification (TST, HST, FSST and LST)

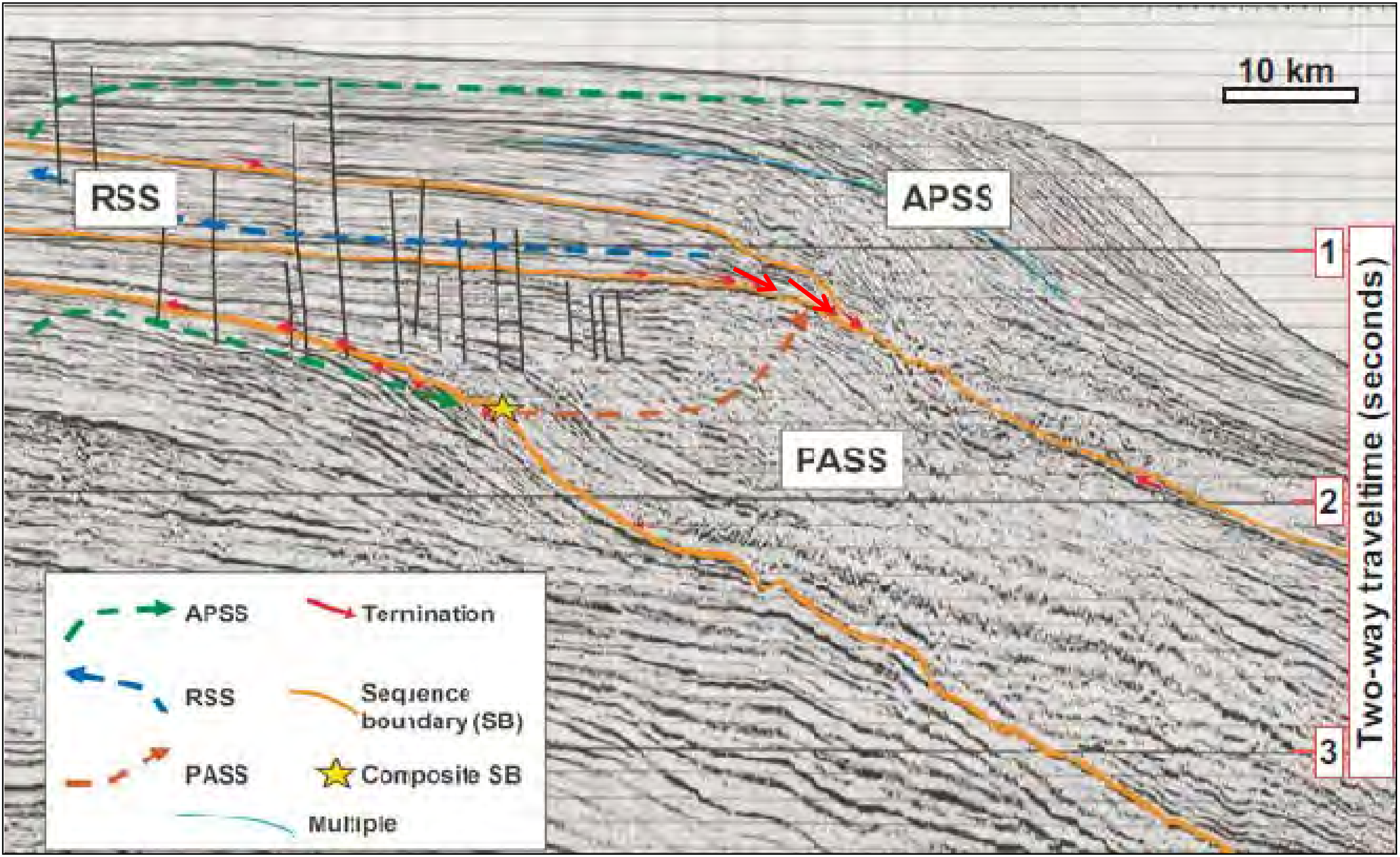


(Emery & Myers, 1996)



(Neal & Abreu, 2009)

Methodology



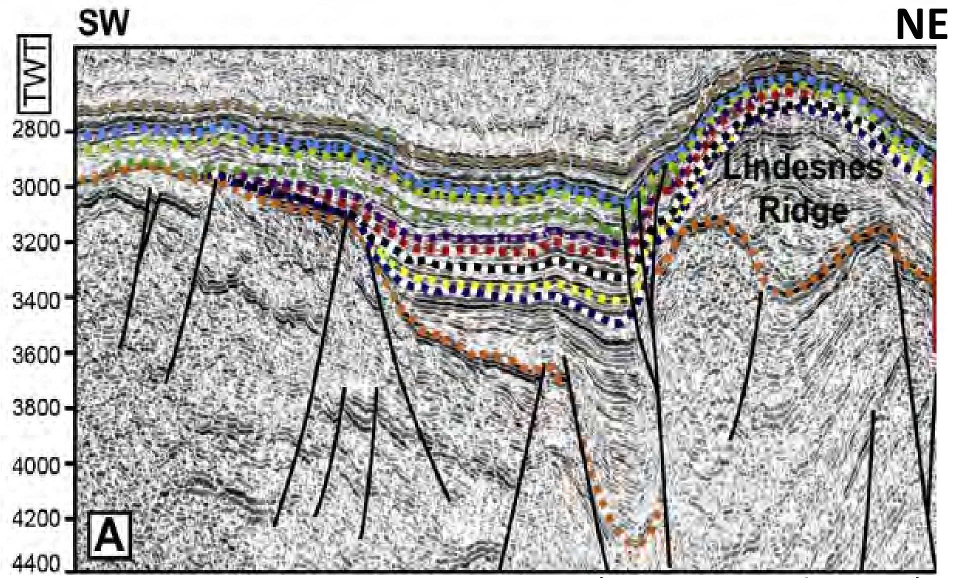
(Neal & Abreu, 2009)

Methodology

3. Mapping the reflectors

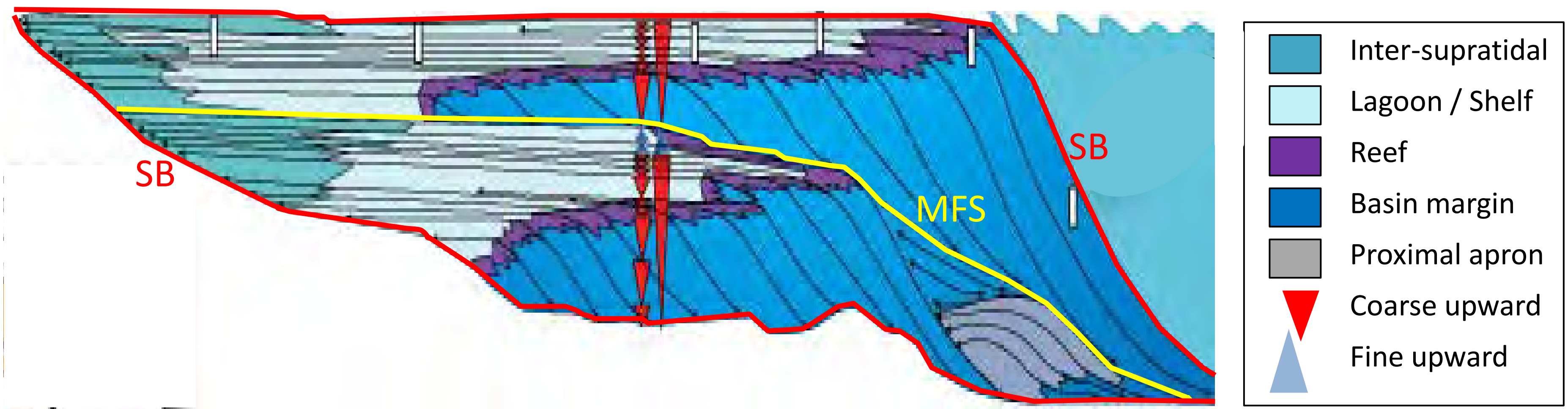
   – Define sequences and parasequences

   – Identify tectonostratigraphic sequences related to chalk deposition



(Gennaro et al., 2013)

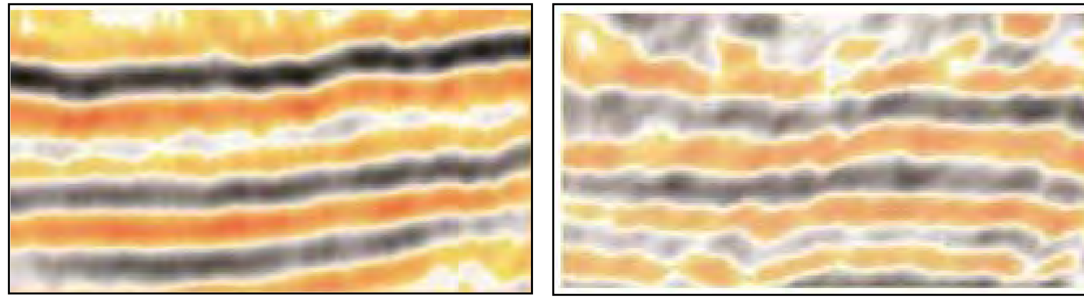
Thus building up a sequence stratigraphic framework



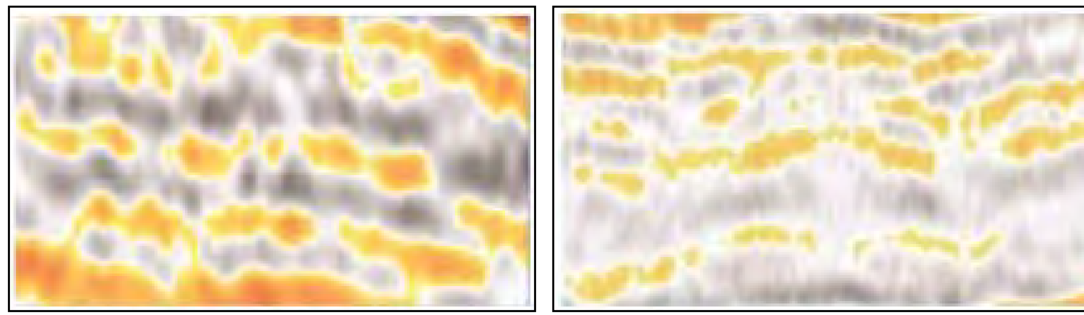
(Catuneanu et al., 2011)

Methodology

4. Seismic facies study
   - Identify seismic facies
   - Deposit identification
   - Depositional environment identification

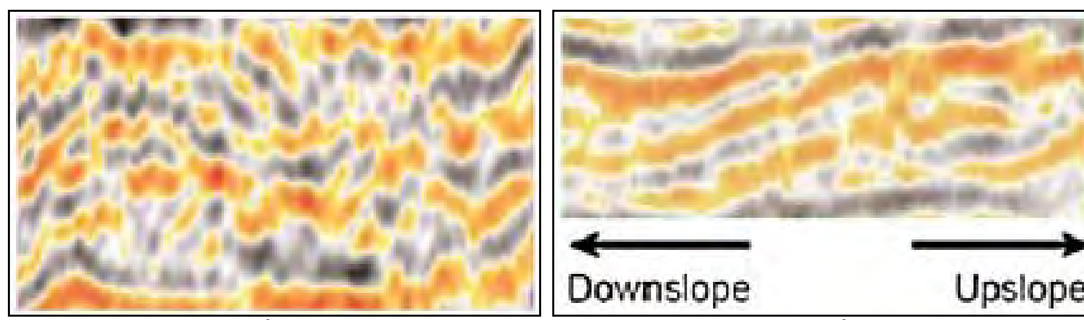


Parallel continuous



Parallel discontinuous

Prediction of facies and lithology away from control points



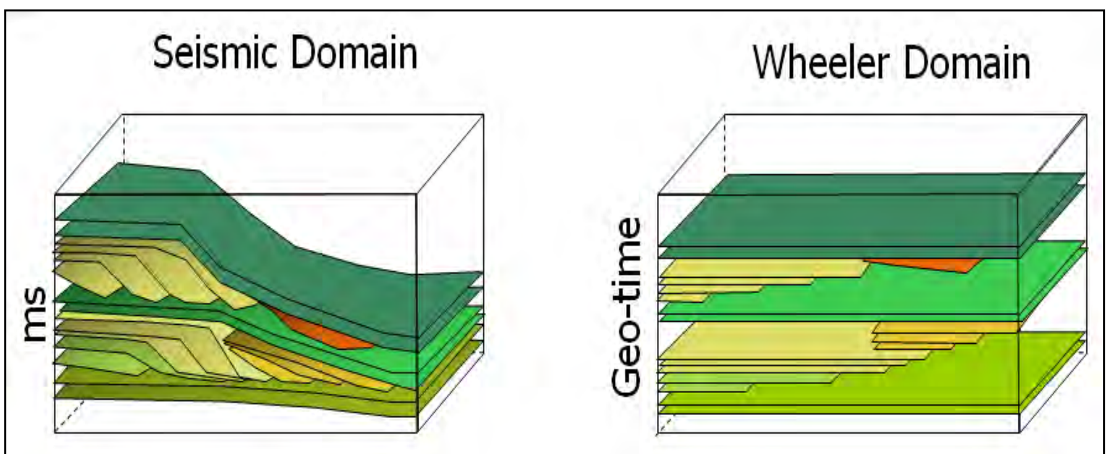
Chaotic/mounded amplitudes

Oblique/shingled amplitudes

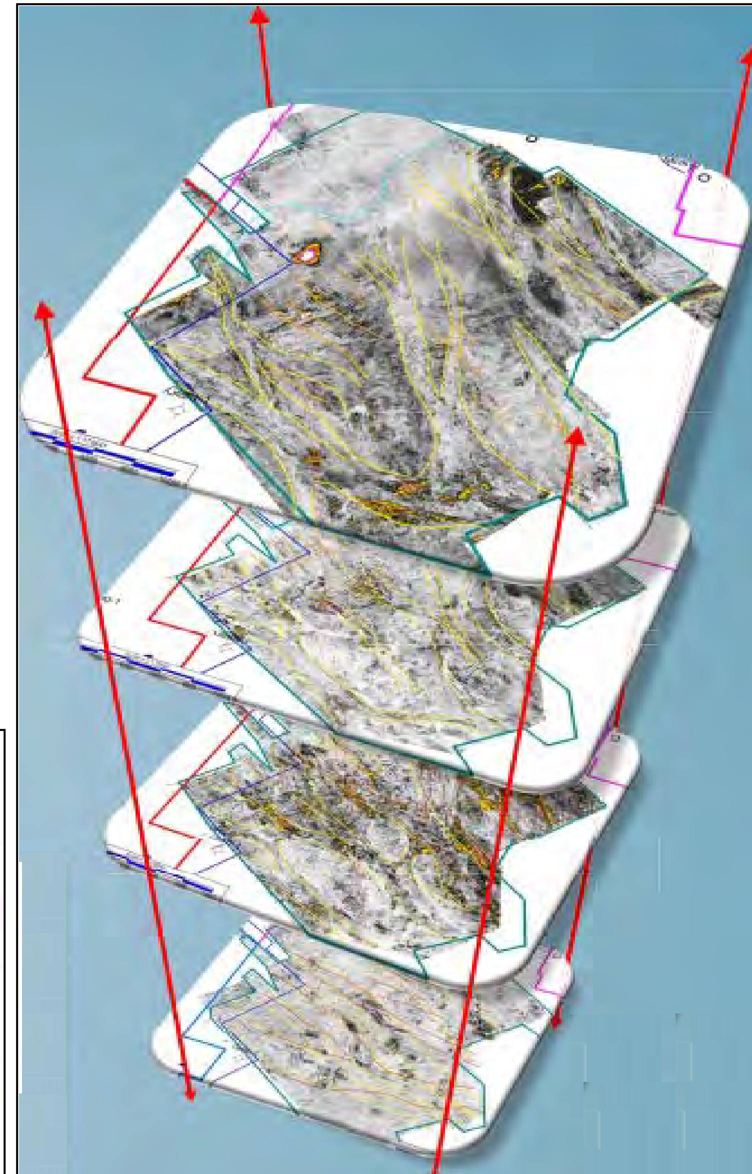
(Gennaro et al., 2013)

Methodology

5. Perform stratal slicing
   - Represent seismic horizons with time slices in wheeler domain
   - To reveal sedimentary and structural features of the system tracts
   - OpendTect software, SSIS plug-in



(From user manual of OpendTect, http://www.opendtect.org/index.php/support/documentation)

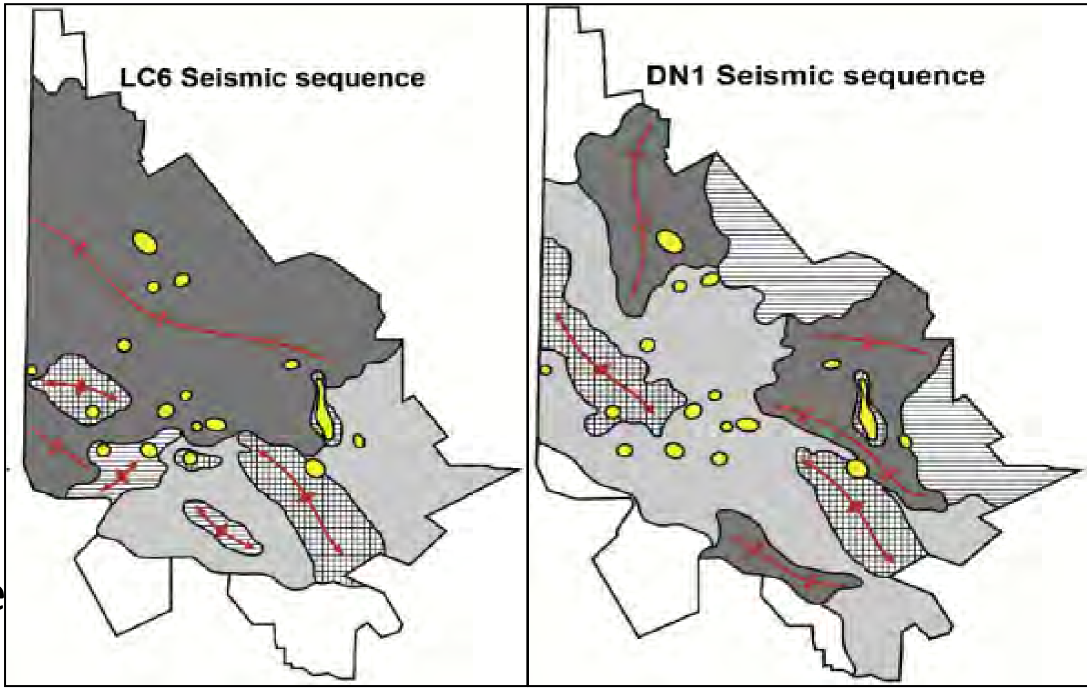


(White et al., 2012)

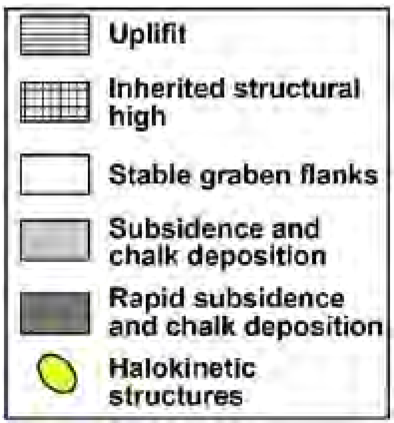
Methodology

6. Geomorphological studies

- Paleogeographic maps
- Isochron maps
- Chalk behavior in response to active syndepositional tectonics and halokinesis



Thus understanding the evolution of the chalk deposits

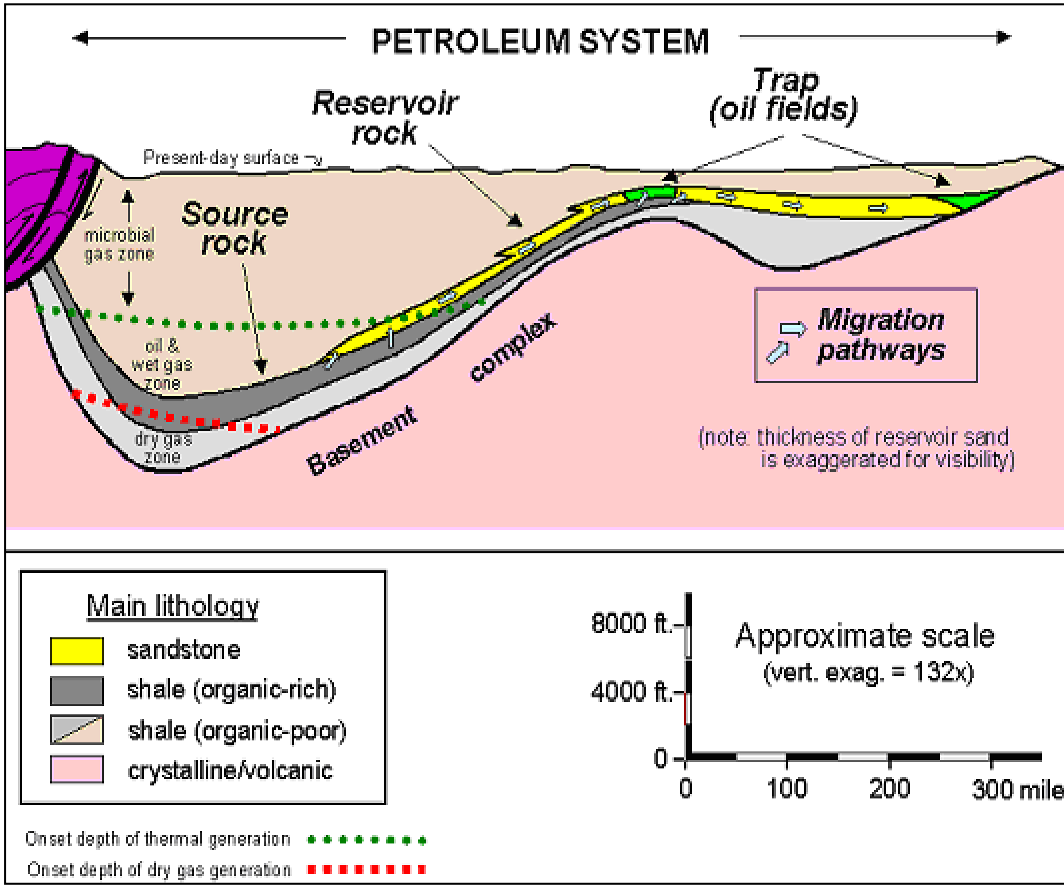


(Gennaro et al., 2013)

Methodology

7. Mentioned steps combined

- Reservoir – seal pairs
- Traps concepts within chalk



Explain the known hydrocarbon presences within a chalk sequence stratigraphic framework

(Image source: http://thepttc.org/workshops/eastern_060514/eastern_060514_Laughrey.pdf)

Summary

- Provide sequence stratigraphic framework by 3D seismic survey interpretation
- Facies and lithology identification by studying seismic facies
- Study evolution of the chalk deposits using paleogeographic maps and isochron maps
- Explain the known hydrocarbon presence

THANK YOU

References

Catuneanu, O., Galloway, W. E., Kendall, C. G. S. C., Miall, A. D., Posamentier, H. W., Strasser, A., & Tucker, M. E. (2011). Sequence stratigraphy: methodology and nomenclature. *Newsletters on Stratigraphy, 44*(3), 173-245.

Chopra, S., & Marfurt, K. J. (2012). Seismic attribute expression of differential compaction. *The Leading Edge, 31*(12), 1418-1422.

Emery, D., & Myers, K. Sequence stratigraphy, 1996. *London, Uxbridge*, 297.

Evans, D. (2003). *The Millennium Atlas: Petroleum geology of the central and northern North Sea*: CD produced by Lynx Geographic Information Systems.

Fontaine, J. M., Cussey, R., Lacaze, J., Lanaud, R., & Yapaudjian, L. (1987). SEISMIC INTERPRETATION OF CARBONATE DEPOSITIONAL ENVIRONMENTS. *American Association of Petroleum Geologists Bulletin, 71*(3), 281-297.

Gennaro, M., Wonham, J. P., Gawthorpe, R., & Sælen, G. (2013). Seismic stratigraphy of the Chalk Group in the Norwegian Central Graben, North Sea. *Marine and Petroleum Geology, 45*, 236-266. doi: 10.1016/j.marpetgeo.2013.04.010

NPD FactMaps. (2014).

Rossland, A., Escalona, A., & Rolfsen, R. (2013). Permian–Holocene tectonostratigraphic evolution of the Mandal High, Central Graben, North Sea. *97*(6), 923–957. doi: 10.1306/12031212093

Surlyk, F., Dons, T., Clausen, C. K., & Higham, J. (2003). Upper Cretaceous. In D. Evans, C. Graham, A. Armour & P. Bathurst (Eds.), *The Millennium Atlas: Petroleum Geology of the Central and Northern North Sea* (pp. 222-242): The Geological Society of London.

Van Wagoner, J. C., Mitchum, R., Campion, K., & Rahmanian, V. (1990). Siliciclastic sequence stratigraphy in well logs, cores, and outcrops: concepts for high-resolution correlation of time and facies.

Neal, J., & Abreu, V. (2009). Sequence stratigraphy hierarchy and the accommodation succession method. *Geology, 37*(9), 779-782.

Relationship between anhydrite on top of Zechstein salt diapirs and Upper Jurassic Ula sandstone in the Greater Butch Area

Ligia Naveira

Advisors:

Nestor Cardozo (UiS)

Stein-Åge Østensen (Centrica Energi)

Philip Milstead (Centrica Energi)

Agenda

- Introduction
- Regional Geology
- Objectives
- Methodology
- Time Frame

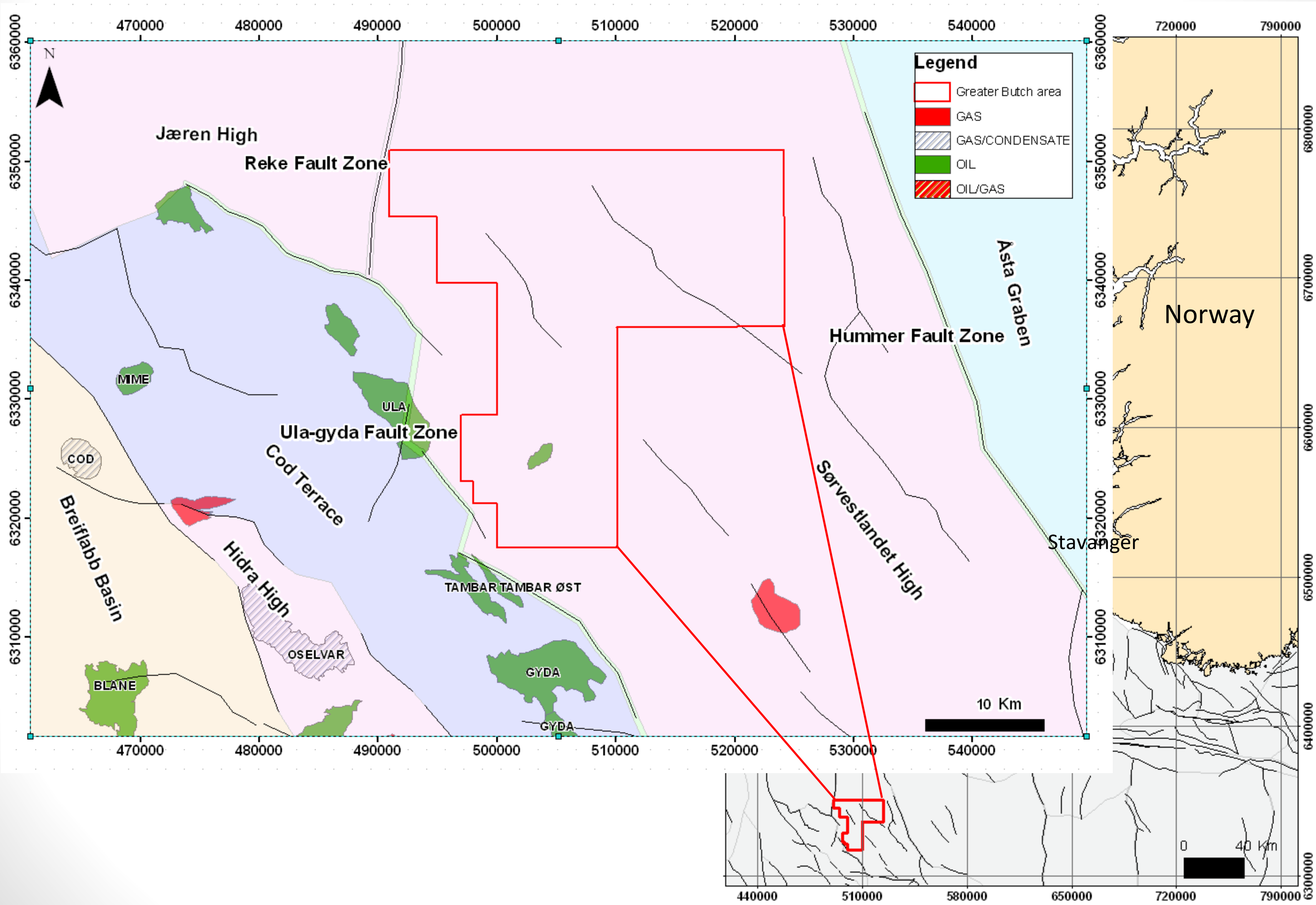
Introduction

- In the Central Graben of the North Sea, salt diapirs have a key role in the largest hydrocarbon field discoveries, in which the Upper Jurassic play is one of the most prolific.

- Net-transgressive, shallow-marine reservoirs deposited on top of the Zechstein salt host several hydrocarbons fields, e.g. Fulmar, Ula, and Angus.

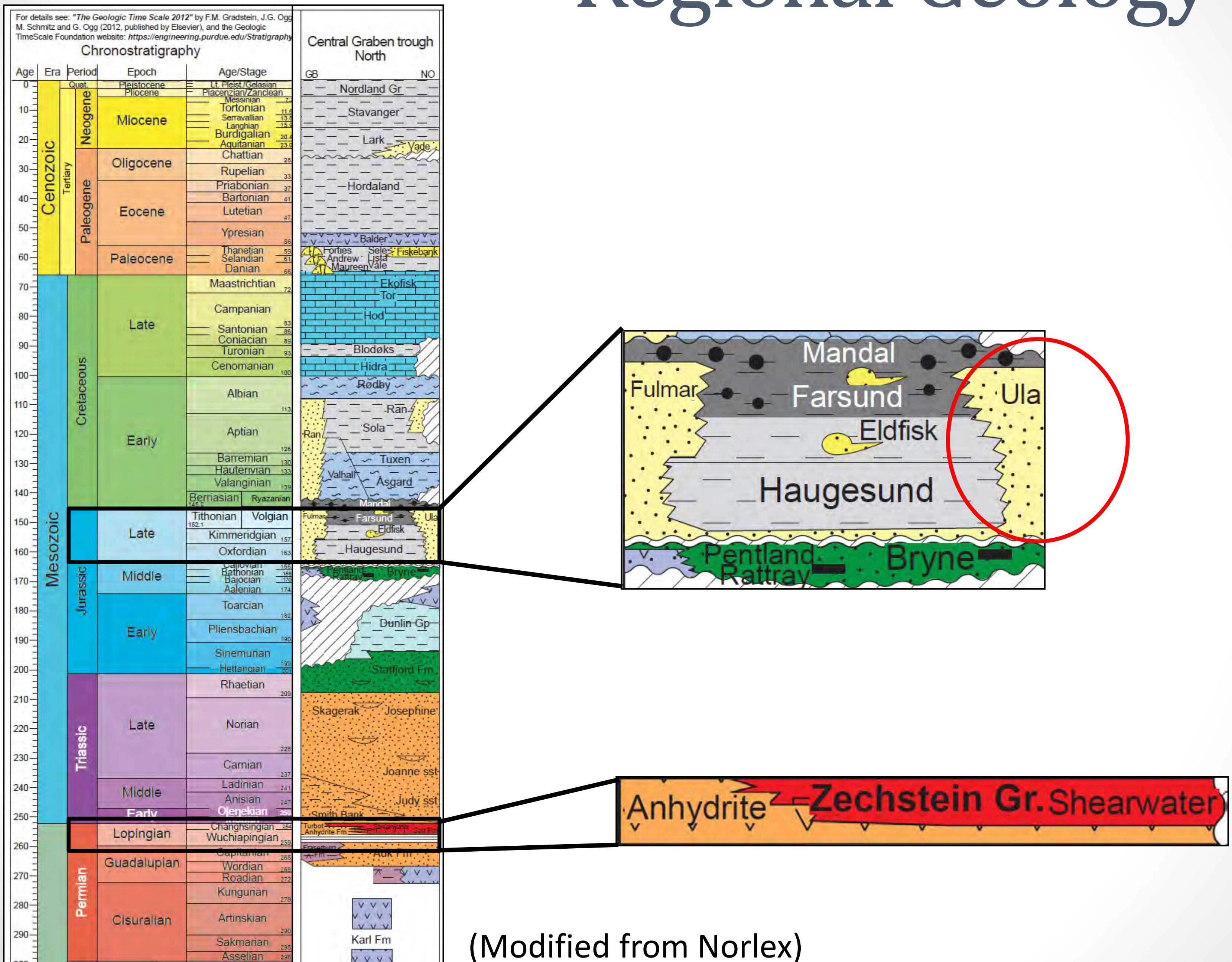
- The occurrence of salt in a sedimentary basin affects all petroleum system:
  - It transmits heat efficiently.
  - It can act as a seal to fluid migration.
  - Salt flow creates structural traps and affects reservoir distribution.

Study Area



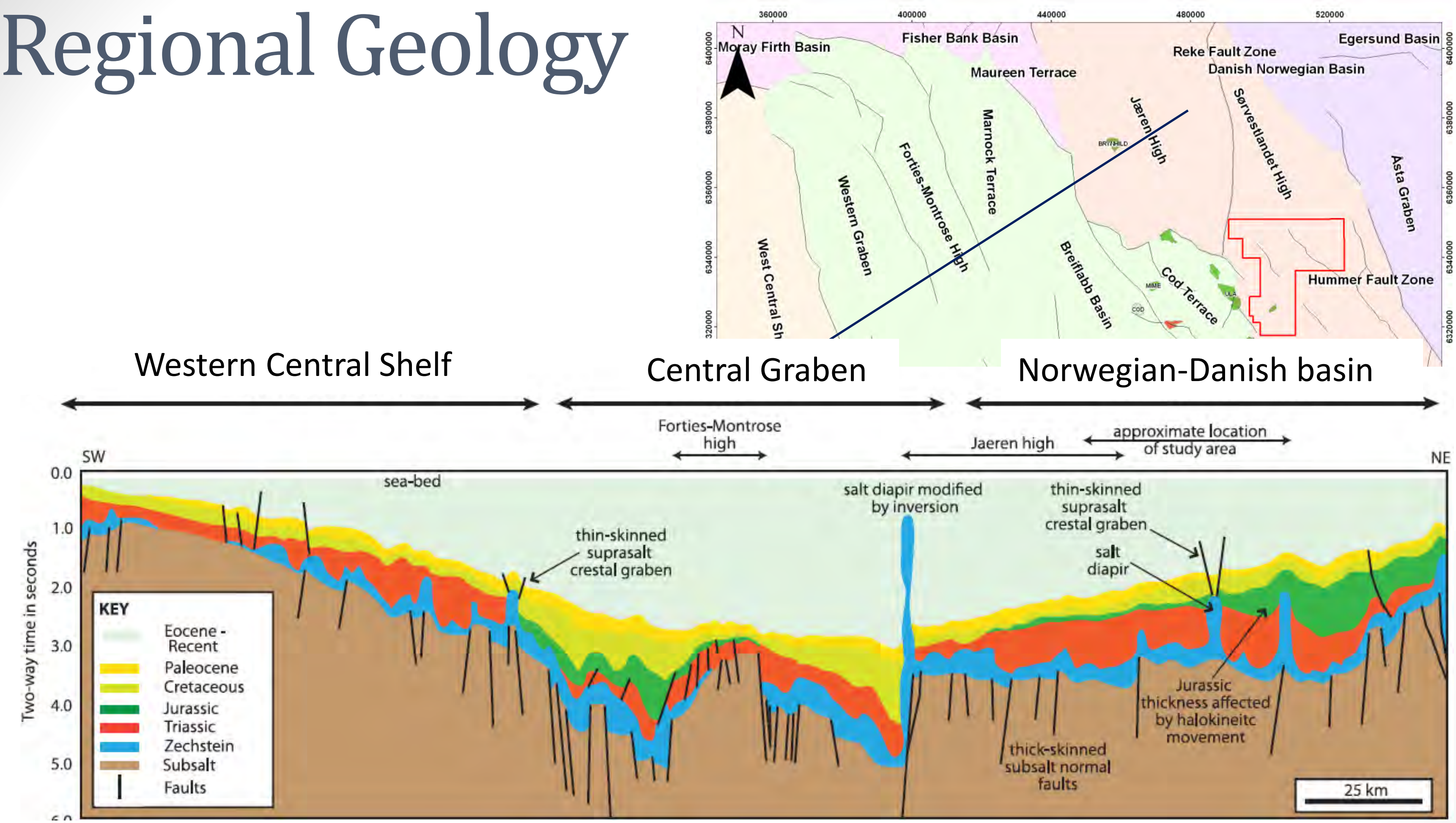
Legend
Greater Butch area
GAS
GAS/CONDENSATE
OIL
OIL/GAS
Jæren High
Reke Fault Zone
Hummer Fault Zone
Asta Graben
Ula-gyda Fault Zone
Cod Terrace
Sørvestlandet High
Breiflabb Basin
Hidra High
MIME
ULA
COD
TAMBAR
TAMBAR ØST
OSELVAR
GYDA
BLANE
10 Km
Norway
Stavanger
0
40 Km

Regional Geology



(Modified from Norlex)

Regional Geology

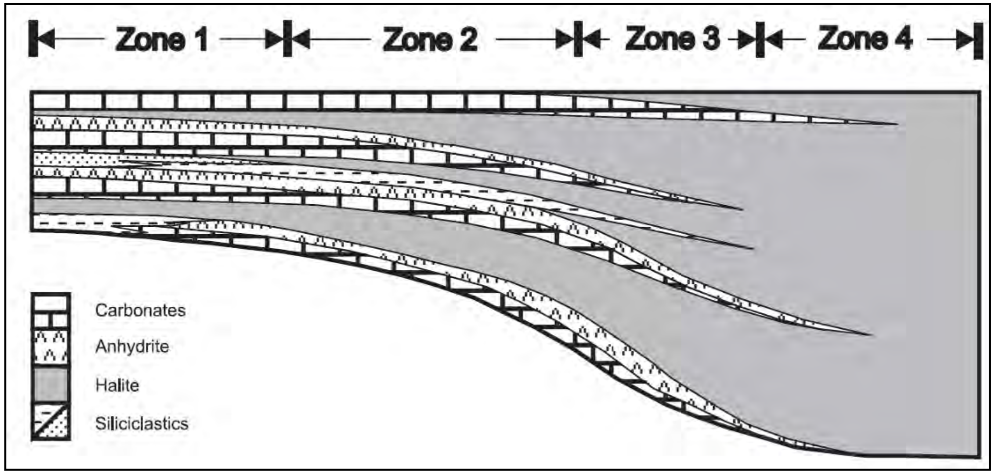


(Mannie et al., 2014)

- The movement of the Zechstein salt led to a complex structural evolution - affected Triassic, Jurassic, and Cretaceous sequences.

- The ZCS salt flow was driven by sediment loading, extension in the Triassic, Jurassic, and Early Cretaceous, and tectonic inversion in the Late Cretaceous.

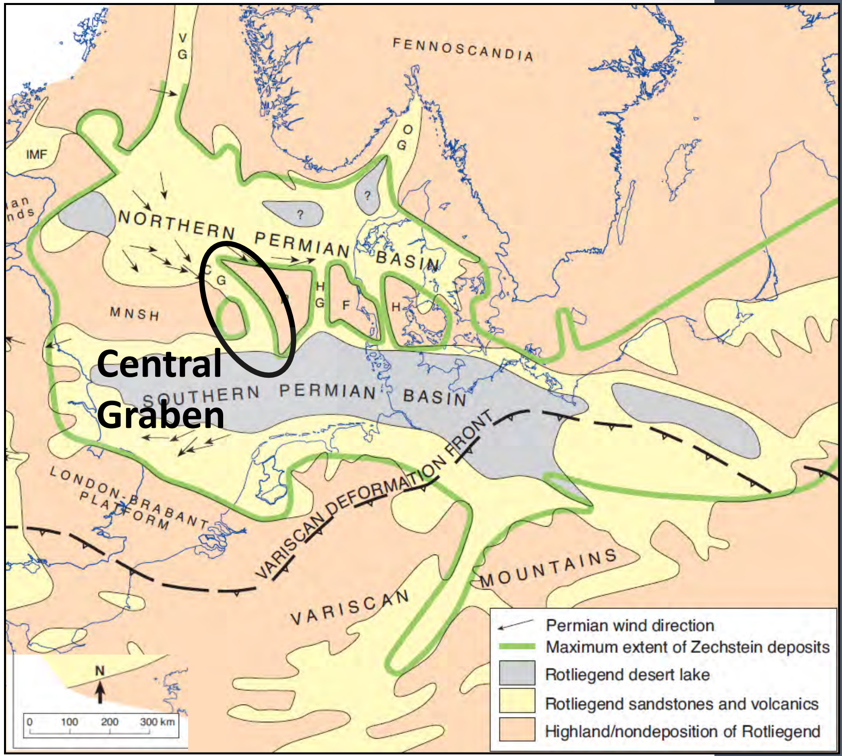
Zechstein depositional zones (Primary deposition)



(Clark et al., 1998)

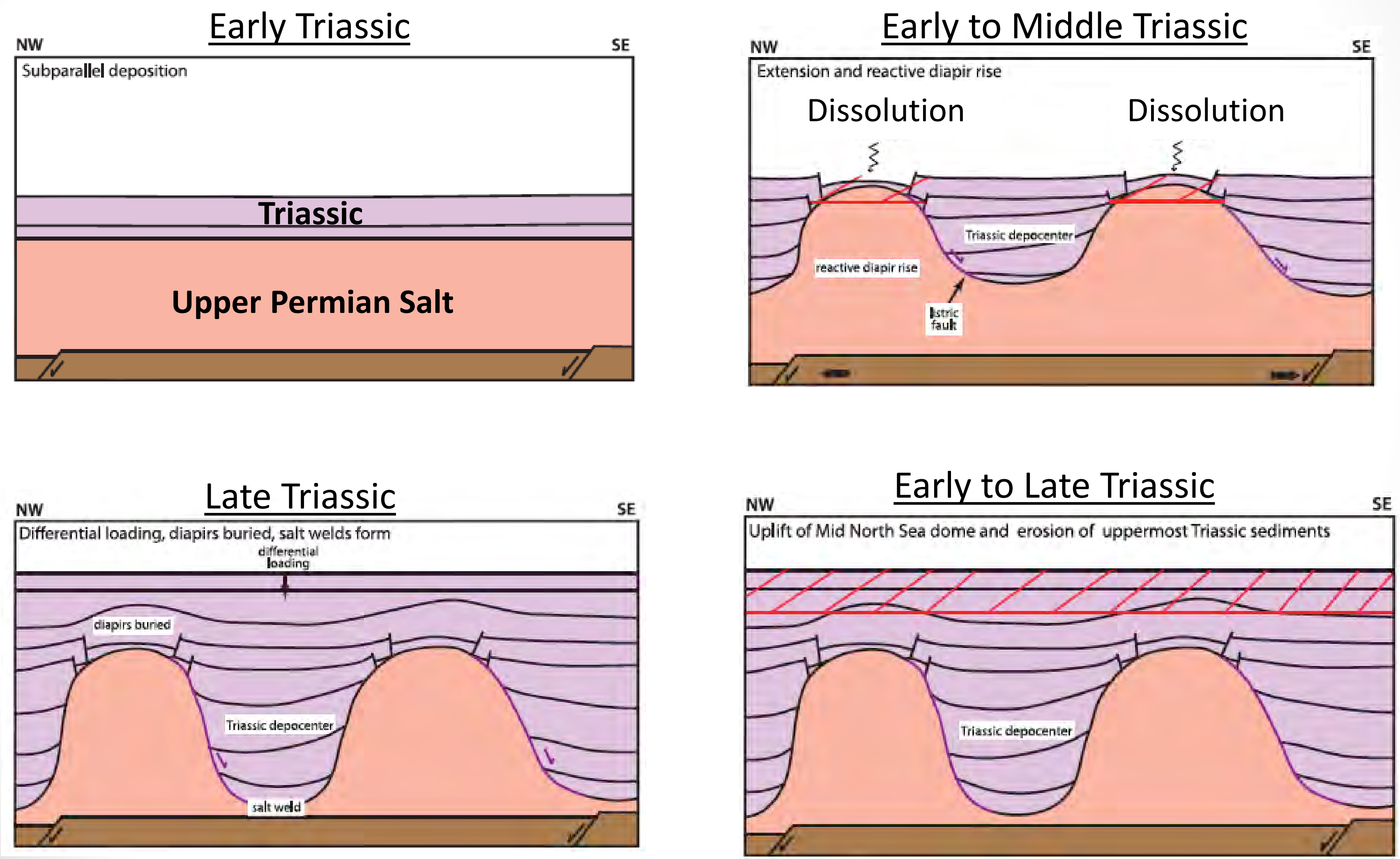
Increasing in halite

Increasing in carbonates, anhydrite and siliciclastics



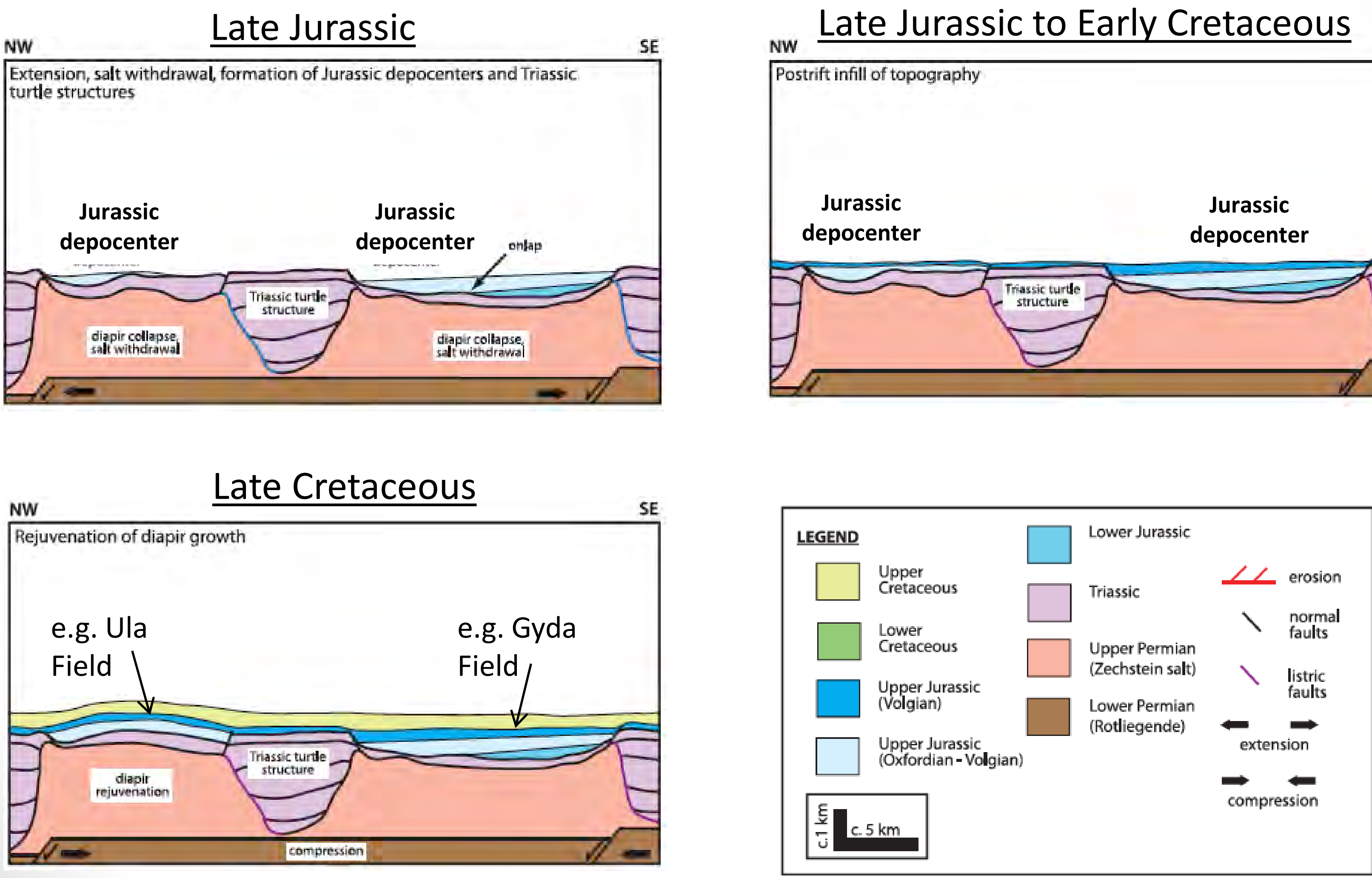
(Glennie et al., 2003)

Jurassic reservoir development in the Central North Sea



(Mannie et al., 2014)

Jurassic reservoir development in the Central North Sea



(Mannie et al., 2014)

Tectono-stratigraphic models for Upper Jurassic reservoirs in the Central North Sea

Interplay between salt movement, accommodation space and sediment dispersal:

- Pod-interpod model (Hodgson et al., 1992)
- Rift-raft model (Penge et al., 1993)
- Salt dissolution model (Clark et al., 1999)
- Minibasins model (Mannie et al., 2014)

Little systematic work has addressed the influence of salt composition on accommodation space!

Objectives

The main objective of this master thesis is:

- To investigate the relationship between the presence of anhydrite on top of Zechstein salt diapirs and the distribution of the Upper Jurassic Ula sandstone in the greater Butch area.

Could the anhydrite thickness indicate anything about accommodation space in the Upper Jurassic sandstone?

Objectives

- Other objectives are:

(1) to use borehole, seismic data, and core data to map the regional facies and development of the Ula sandstone.

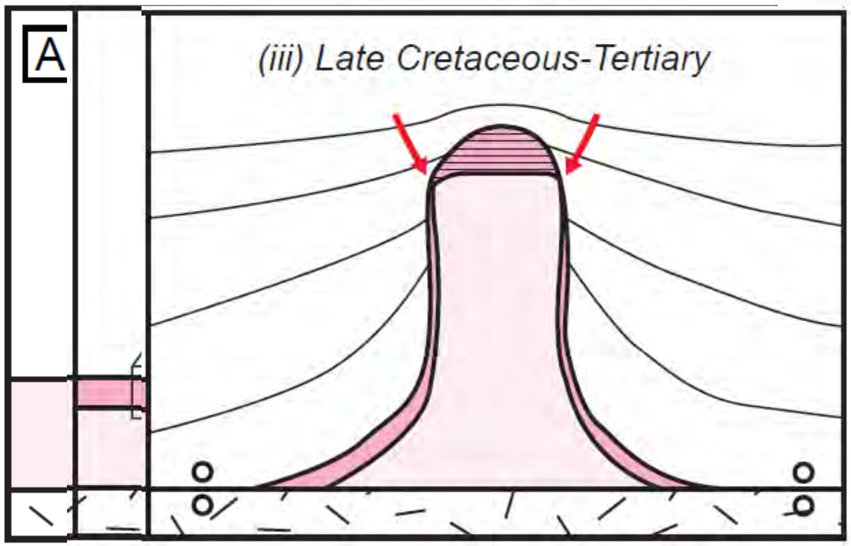
(2) To propose a model for the origin of anhydrite on top of the halite-dominated inner-part of the salt diapir.


Salt movement
Tectonics
Sediment dispersal
Salt composition (?)
Accommodation space
Reservoir
Ula Ss

Possible origins for anhydrite

Primary lateral or vertical lithology variations within the source salt body

- Anhydrite deposited at the top of ZCS Supergroup during late Permian
- Caprock-type residue formed as a result of halite dissolution during Early Triassic exposure
- **Diapir growth was hindered by anhydrite**

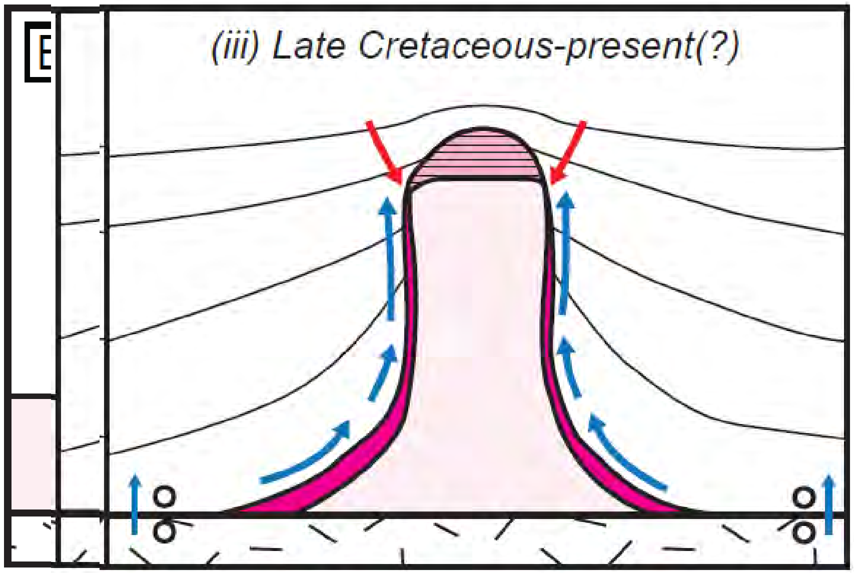


(Jackson et al., 2012)

Possible origins for anhydrite

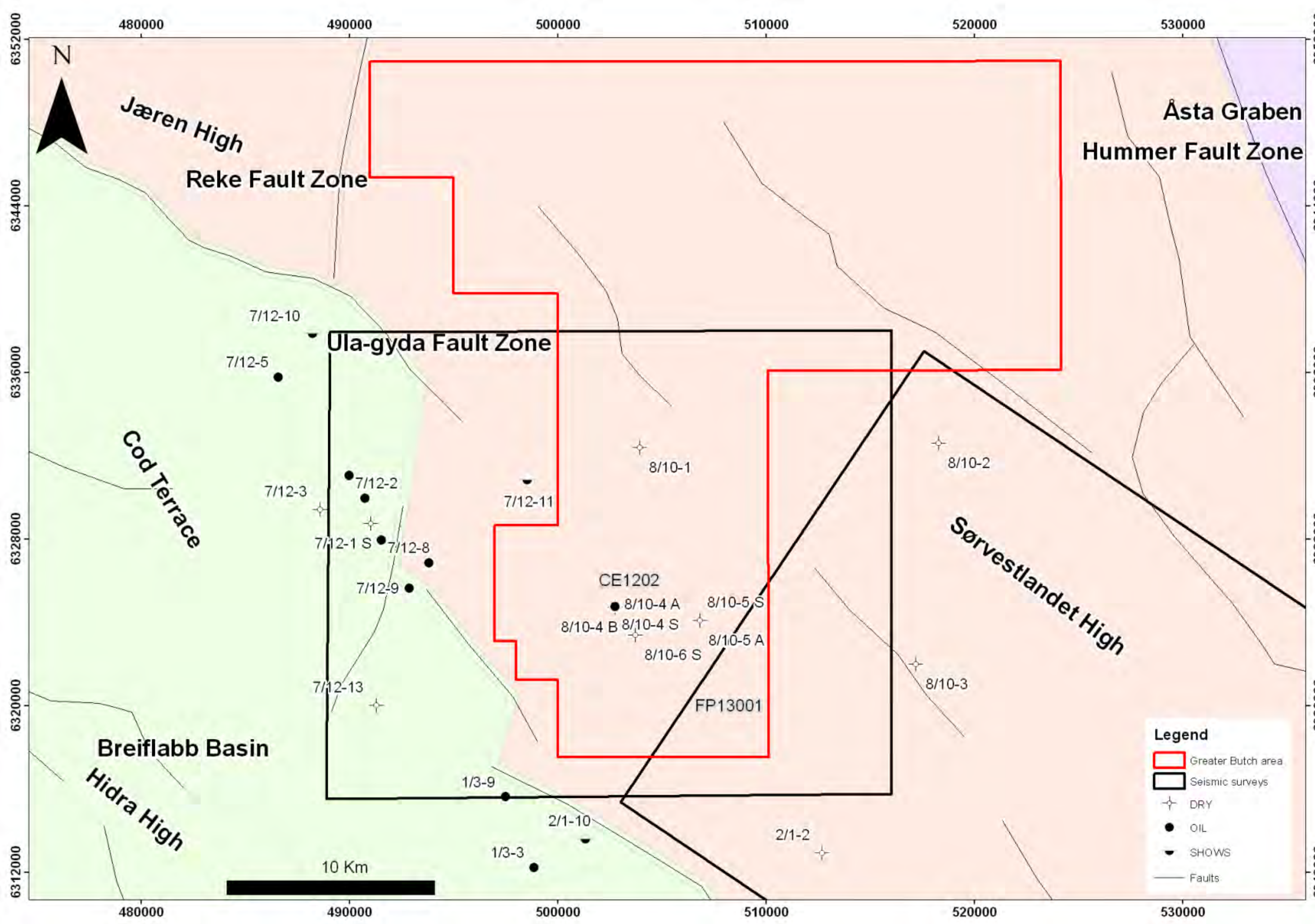
Post-depositional diagenesis

Anhydrite-rich caprock: diagenetic product of deep basin fluid flow



(Jackson et al., 2012)

Dataset



PRIMARY WELLS
8/10-4A
8/10-4B
8/10-4S
8/10-5A
8/10-5S
8/10-6S
8/10-1
8/10-2
8/10-3
7/12-11
SECONDARY WELLS
7/12-1S
7/12-2
7/12-3
7/12-4
7/12-6
7/12-8
7/12-9
1/3-3
1/3-9S
2/1-10
7/12-13S
7/12-5
7/12-10
2/1-2
Seismic Data set
CE1202
FP13001

Methodology

Literature study

Tie seismic and well data

Interpretation of seismic data: regional thickness in the salt (halite /anhydrite) and Jurassic sequences

Isochore maps - accommodation space developed as the salt moved

Analysis of the Ula ss thicknesses in the wells (as well Lower Jurassic and Triassic formations)

Brief analysis of core data to check facies changes within the Ula ss.

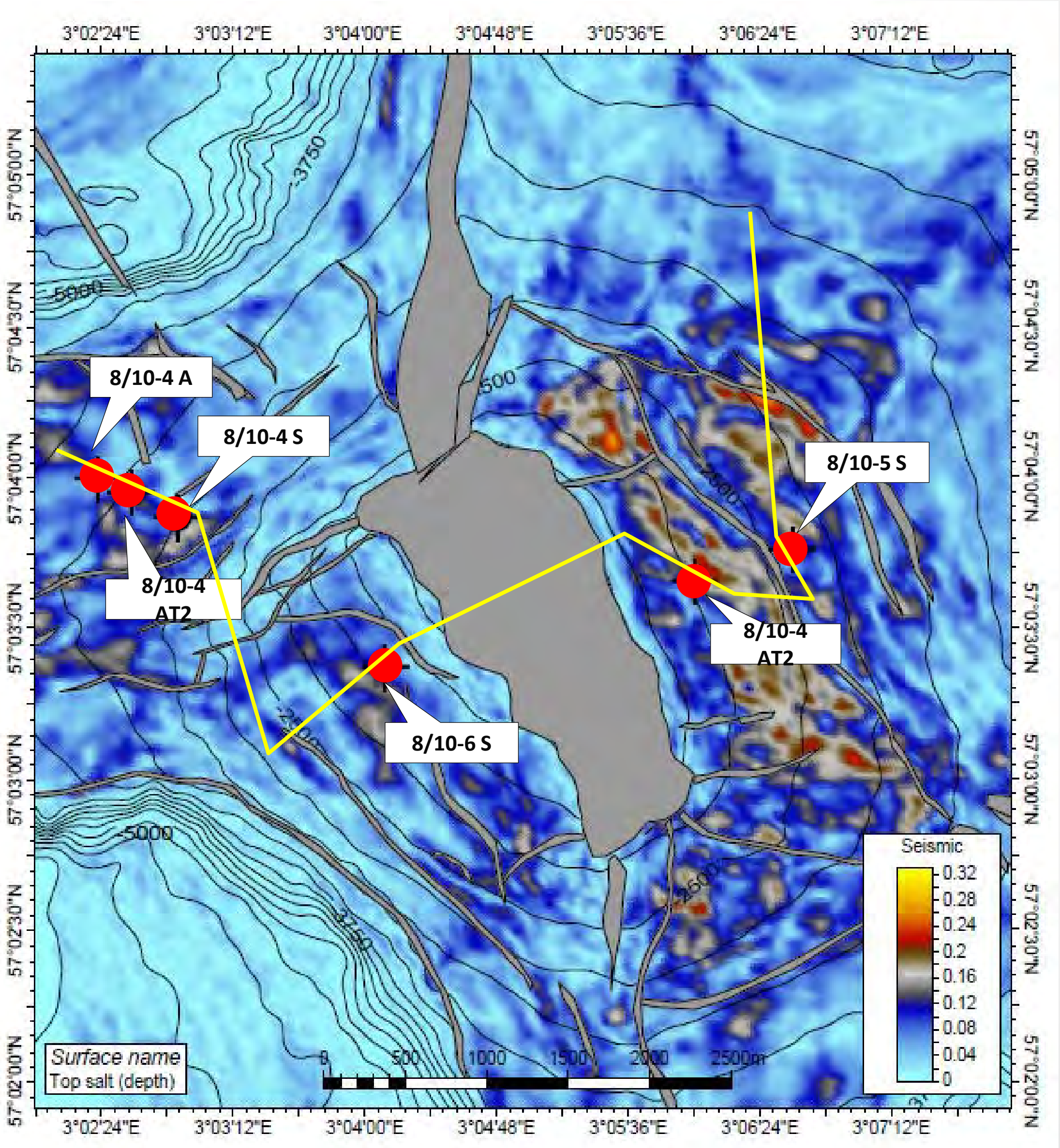
Timing of reservoir development, salt movement, and accommodation space during the deposition of the Ula ss.

Construction of a conceptual geological model linking (or not) anhydrite with the thickness and accommodation space of the Ula ss.

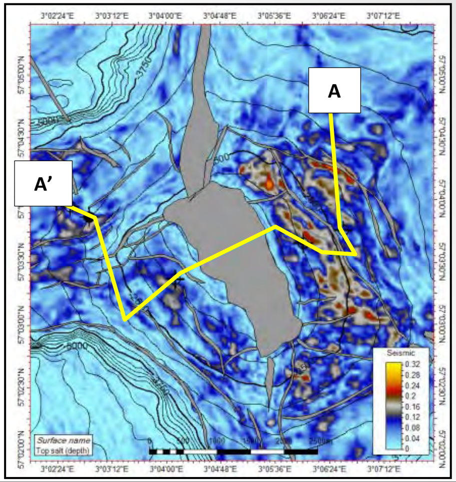
RMS attribute

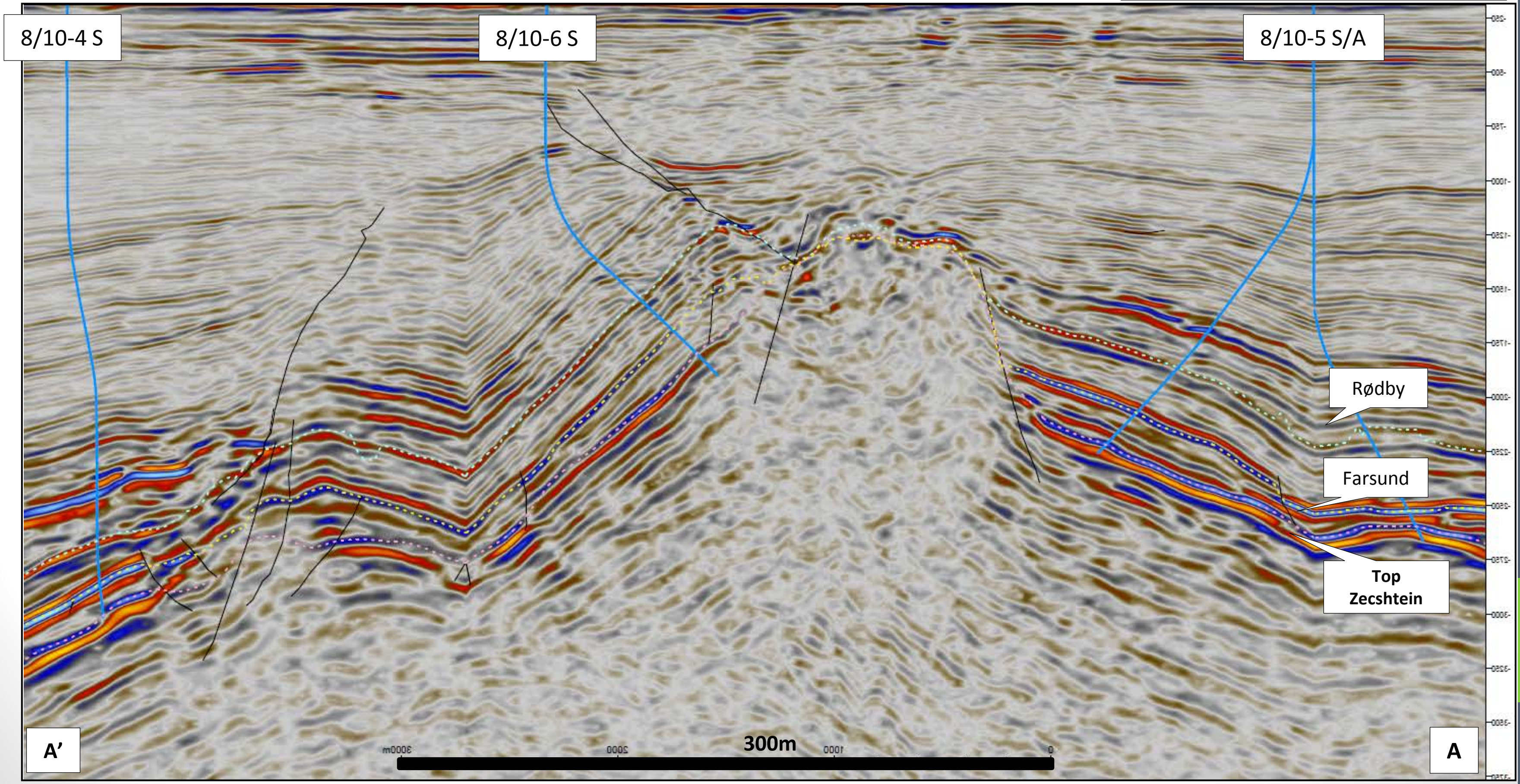
Top salt (+- 20m)

- RMS amplitude extraction of the top salt layer showing higher amplitudes on the eastern side of the Butch diapir.
- Is this anhydrite?

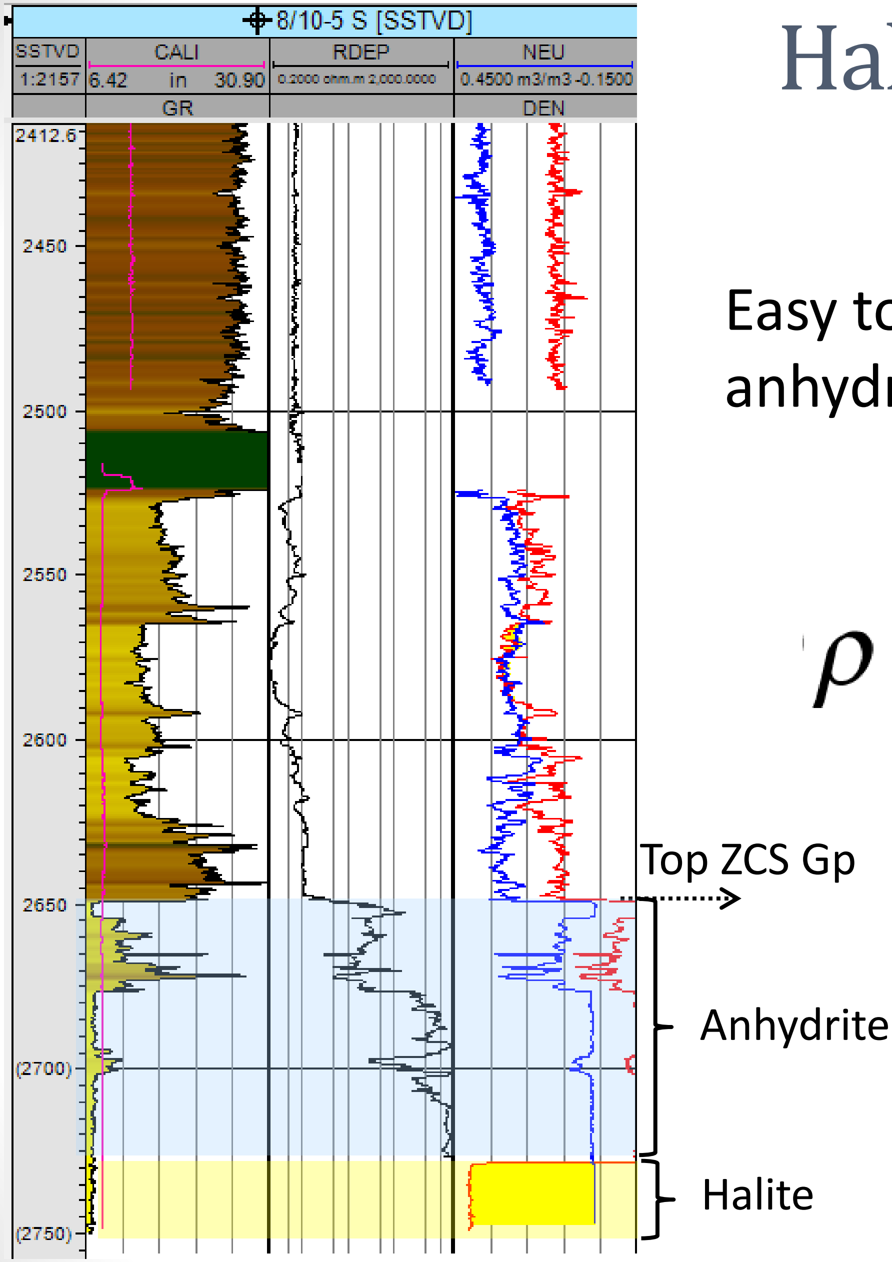


Seismic Line





Halite vs. Anhydrite in wellbore



Easy to distinguish between halite and anhydrite in well logs.

$$\rho_{\text{anhydrite (2,98g/cc)}} > \rho_{\text{halite(2,05g/cc)}}$$

Time Frame

	January	February	March	April	May	June
Literature study						
Seismic interpretation:						
- Well tying						
- Horizon interpretation						
- Basic regional depth conversion						
- Isochore maps						
Wells interpretation						
Core analysis						
Writing						
First Draft:						
- Compile and editing						
- Checking structure/dissertation flow						
Second Draft						
- Correct minor problems						
Submit thesis						

Thank you!!

Questions???

INFLUENCE DIAGRAMS FOR REAL OPTIONS VALUATION

Sophia Liu
Supervisor: Reidar B. Bratvold

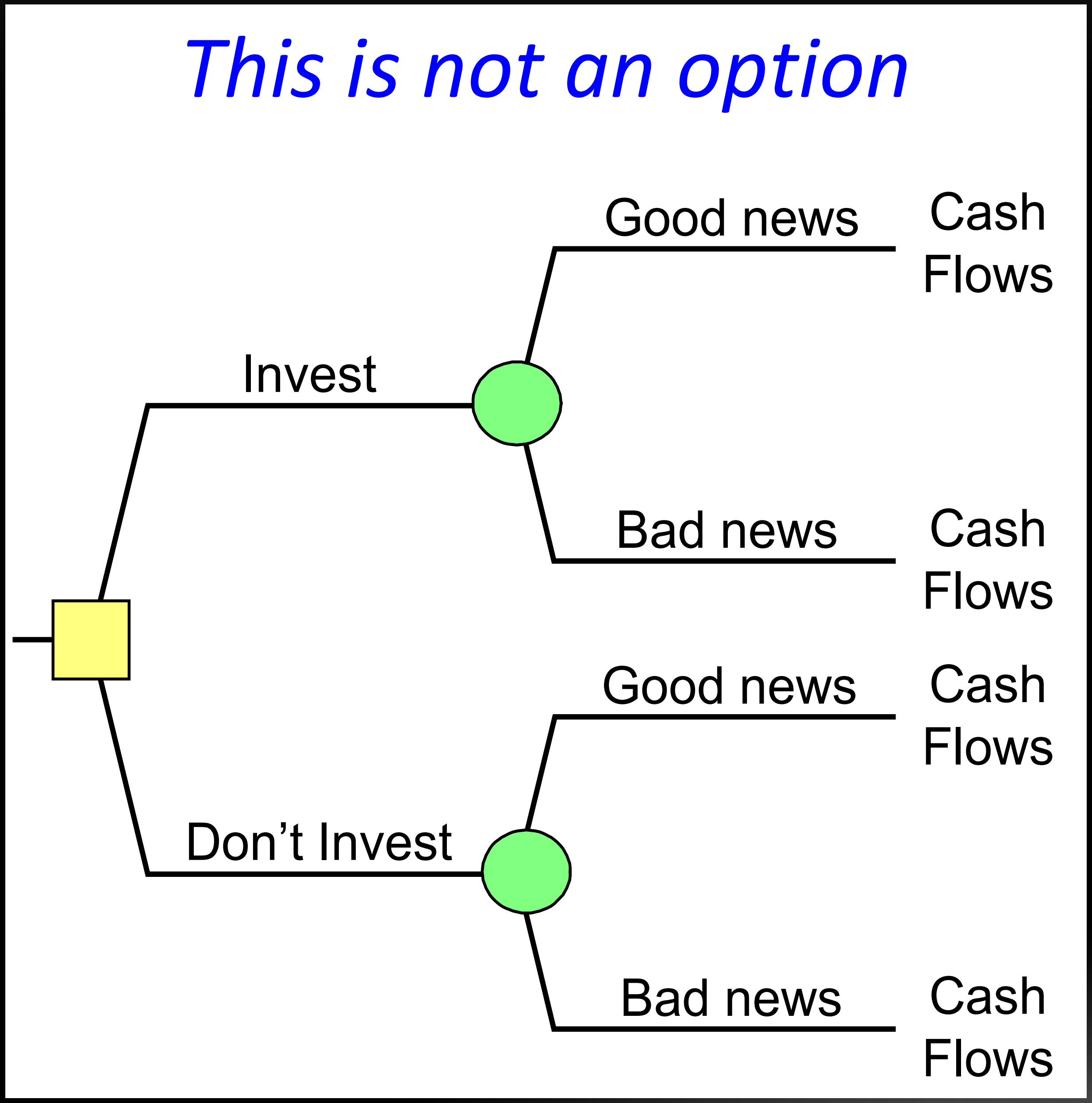
AGENDA

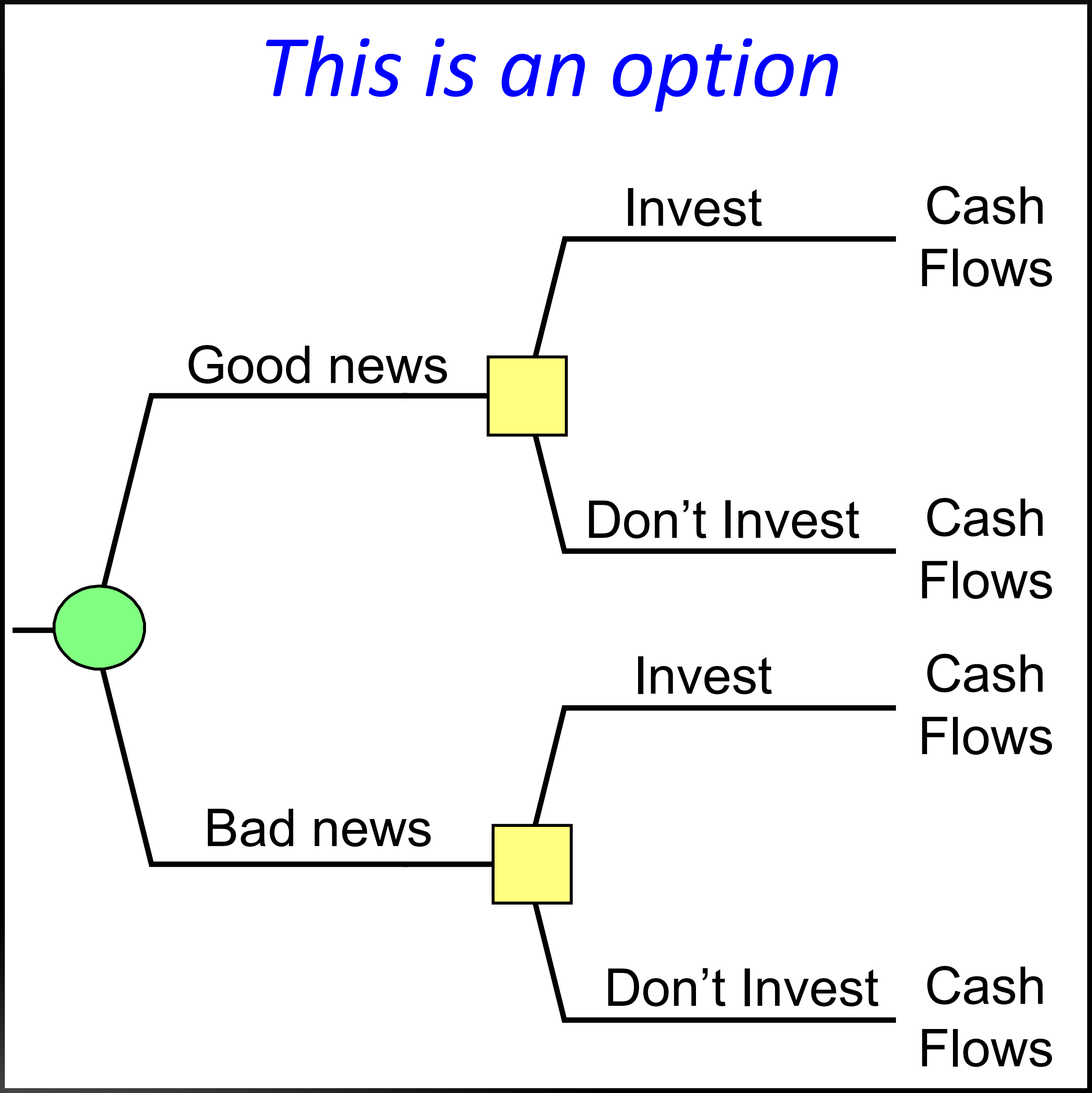
- What are real options and why are they relevant to oil and gas business?
- How to model the real option problems?
- What is a influence diagram?
- To what extent are influence diagrams applicable for modeling real option problems?
- What are my thesis objectives?

"All business decisions are real options, in that they confer the *right* but not the *obligation* to take some initiative in the future."

–Judy Lewent, CFO, Merck

REAL OPTIONS

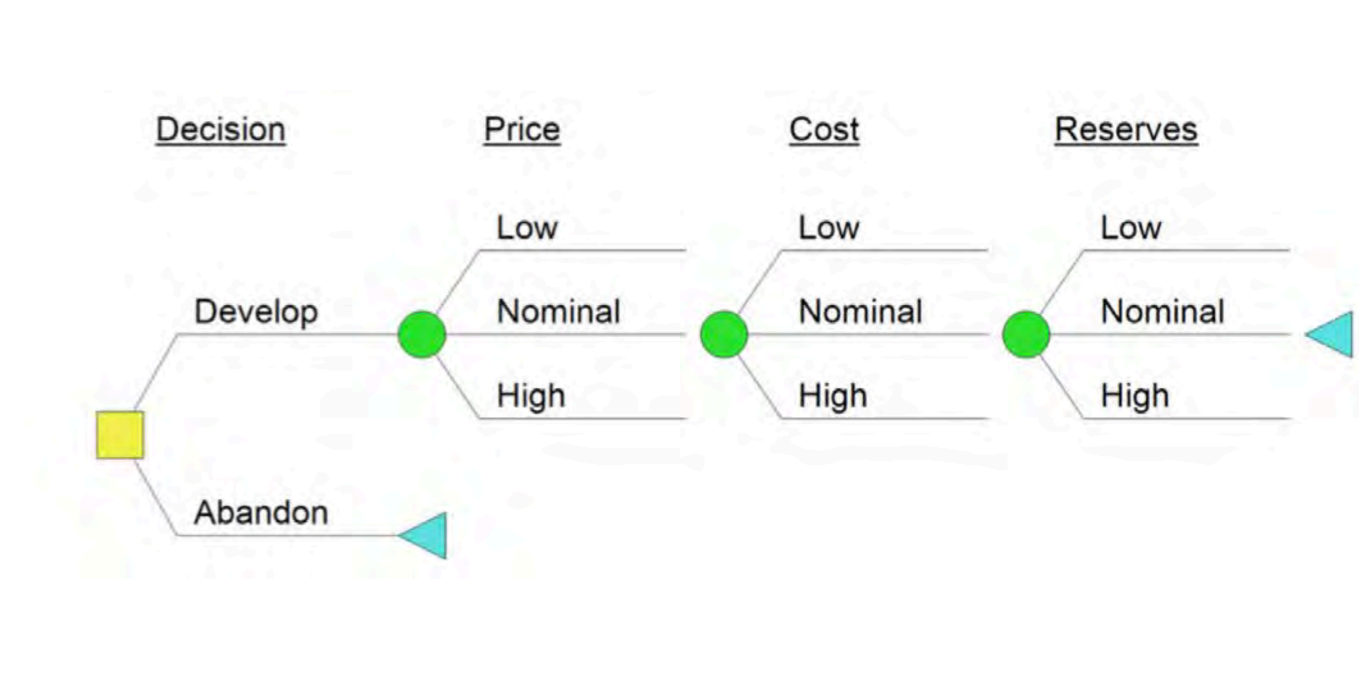




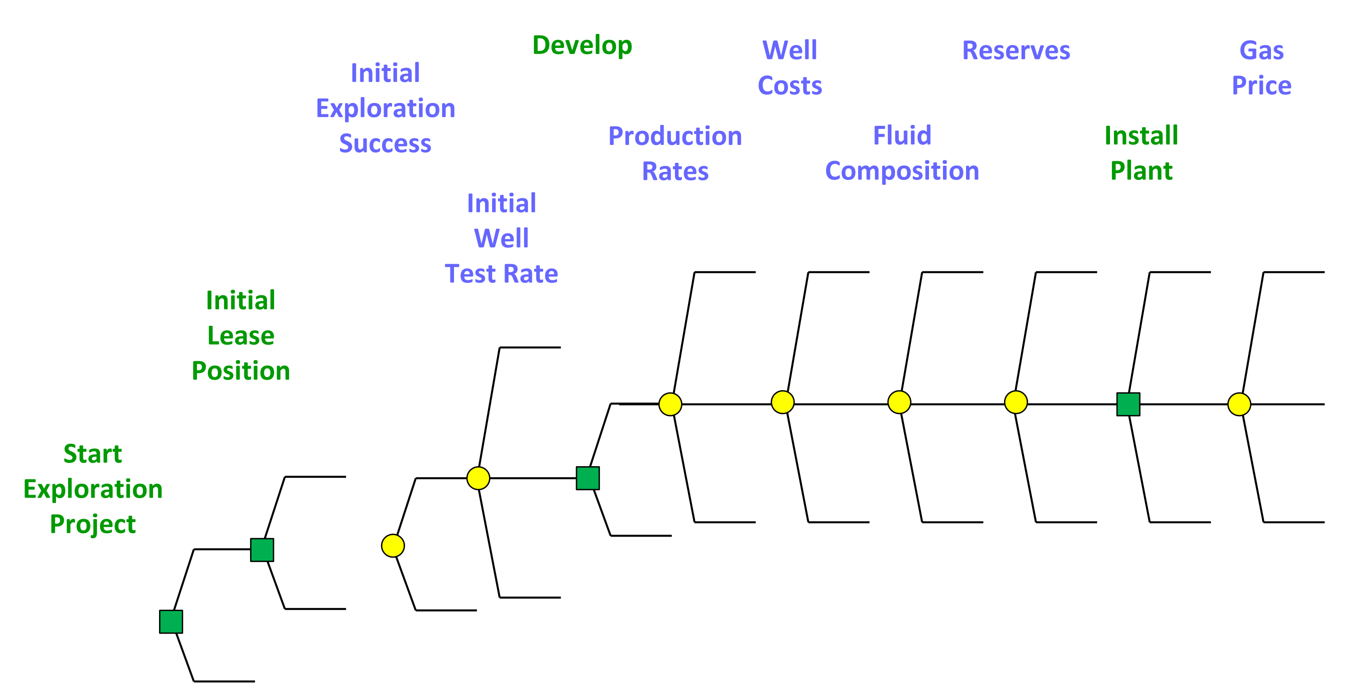
REAL OPTIONS (RO)

- Coined by Stewart Myers in 1977
- The application of option pricing theory to the valuation of real assets with management flexibility
- To qualify the uncertainty in investments
- To make a decision including flexibilities to *expand, postpone, abandon, or temporarily suspend* a project or production

REAL OPTIONS IN OIL & GAS



Decision tree for "decision now" decision
a major offshore development project



Decision tree with downstream decisions
a unconventional gas exploration play

No options

Not realistic

Multiple real options

Real world management

of an oil or gas field

REAL OPTIONS VALUATION (ROV)

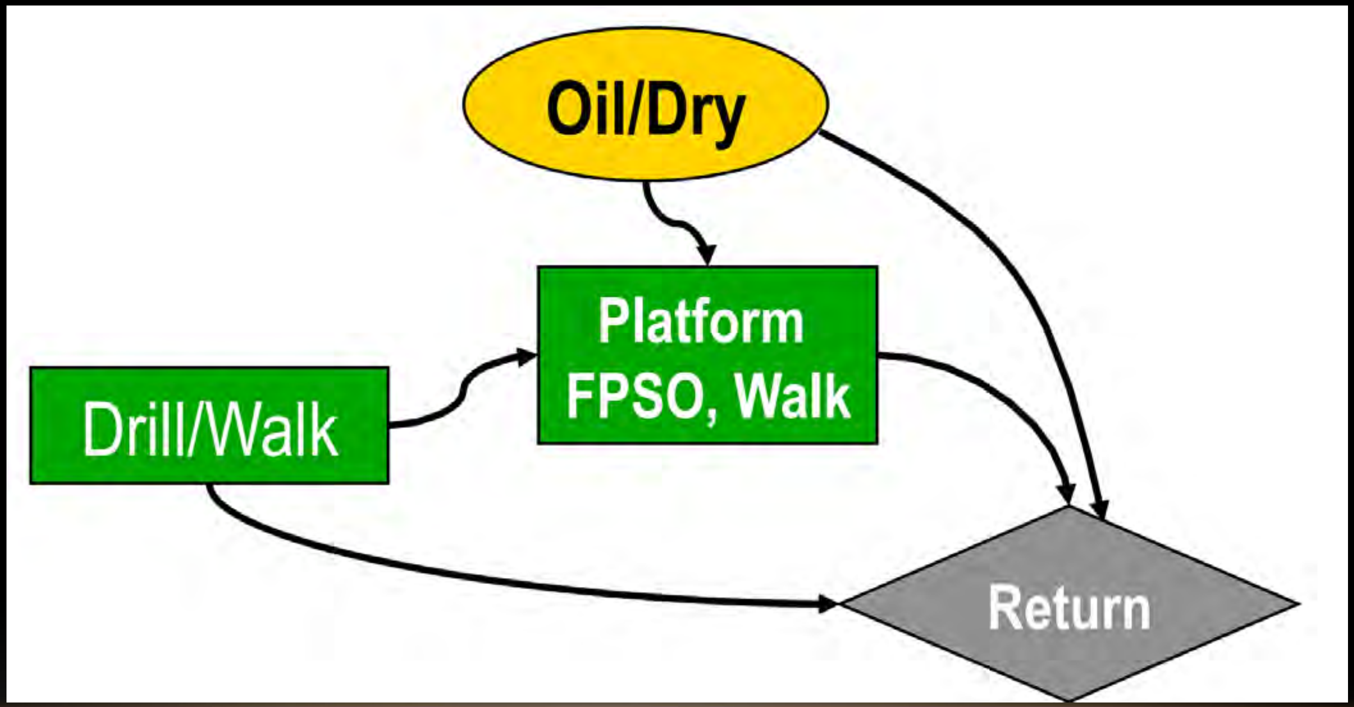
- Modeling the options
- Valuing the associated risky cash flows

APPROACHES TO MODEL RO PROBLEMS

- Black-Scholes
- Finite difference modeling
- Least-Squares Monte Carlo (LSM)
- Binomial lattices
- Decision trees
- Influence diagrams (ID)

INFLUENCE DIAGRAMS

- Influence diagrams are another visual graphical model of decision problems.
- The key elements are linked by arrows, including decisions, uncertainties, objectives, and the information constraints.



WHY WE ARE USING INFLUENCE DIAGRAM TO MODEL THE RO PROBLEMS?

- **Decision tree/binomial lattices**

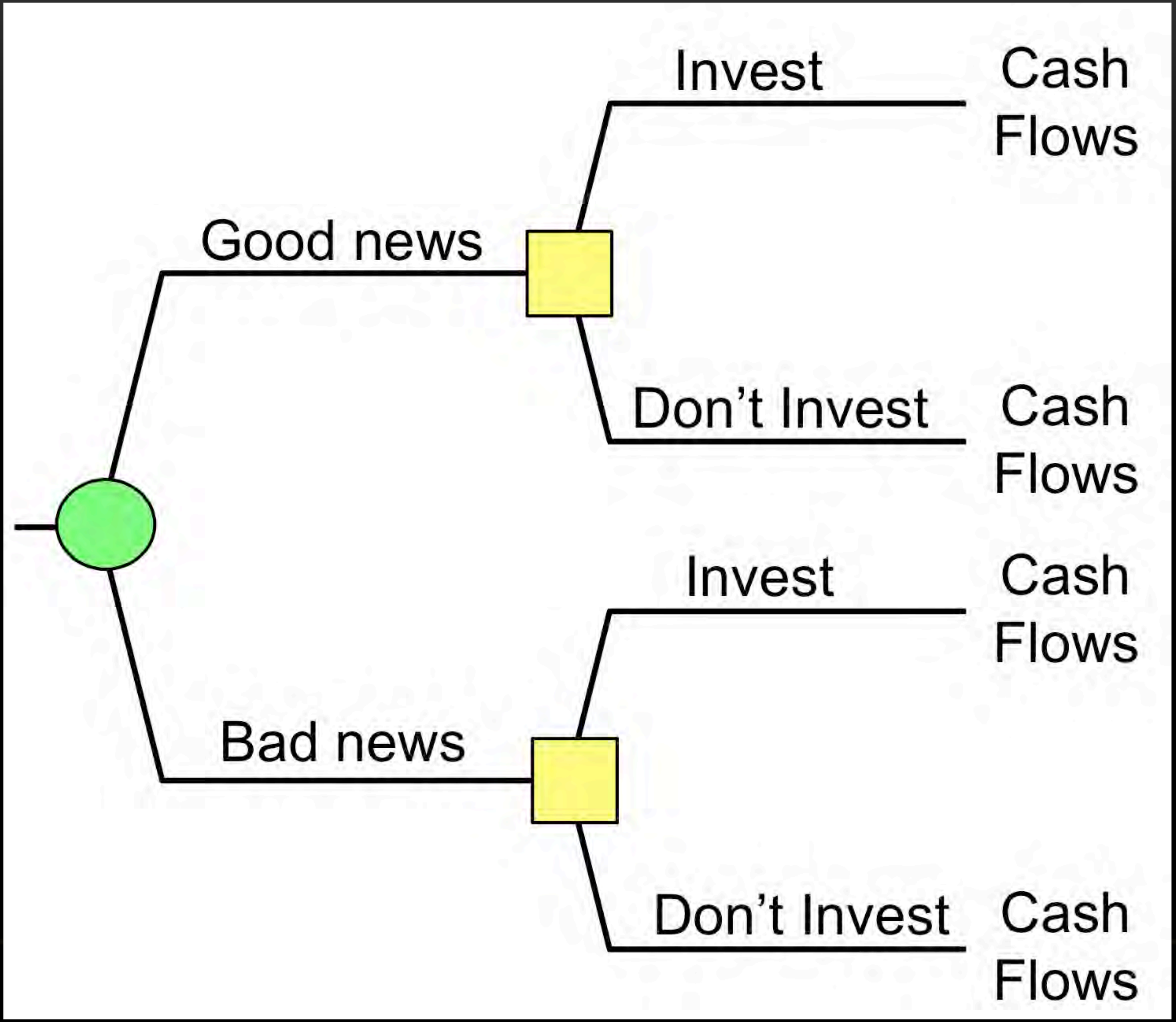
  - easy to model simple options with only one uncertainty and only a few decisions

  - could be too crowded in many realistic option situations

- **Influence diagrams**

  - much more compact

  - very few work have been done


Invest
Cash Flows
Good news
Don't Invest
Cash Flows
Invest
Cash Flows
Bad news
Don't Invest
Cash Flows

WHY WE ARE USING INFLUENCE DIAGRAM TO MODEL THE RO PROBLEMS?

- **Decision tree/binomial lattices**

  - easy to model simple options -only one uncertainty and only a few decisions

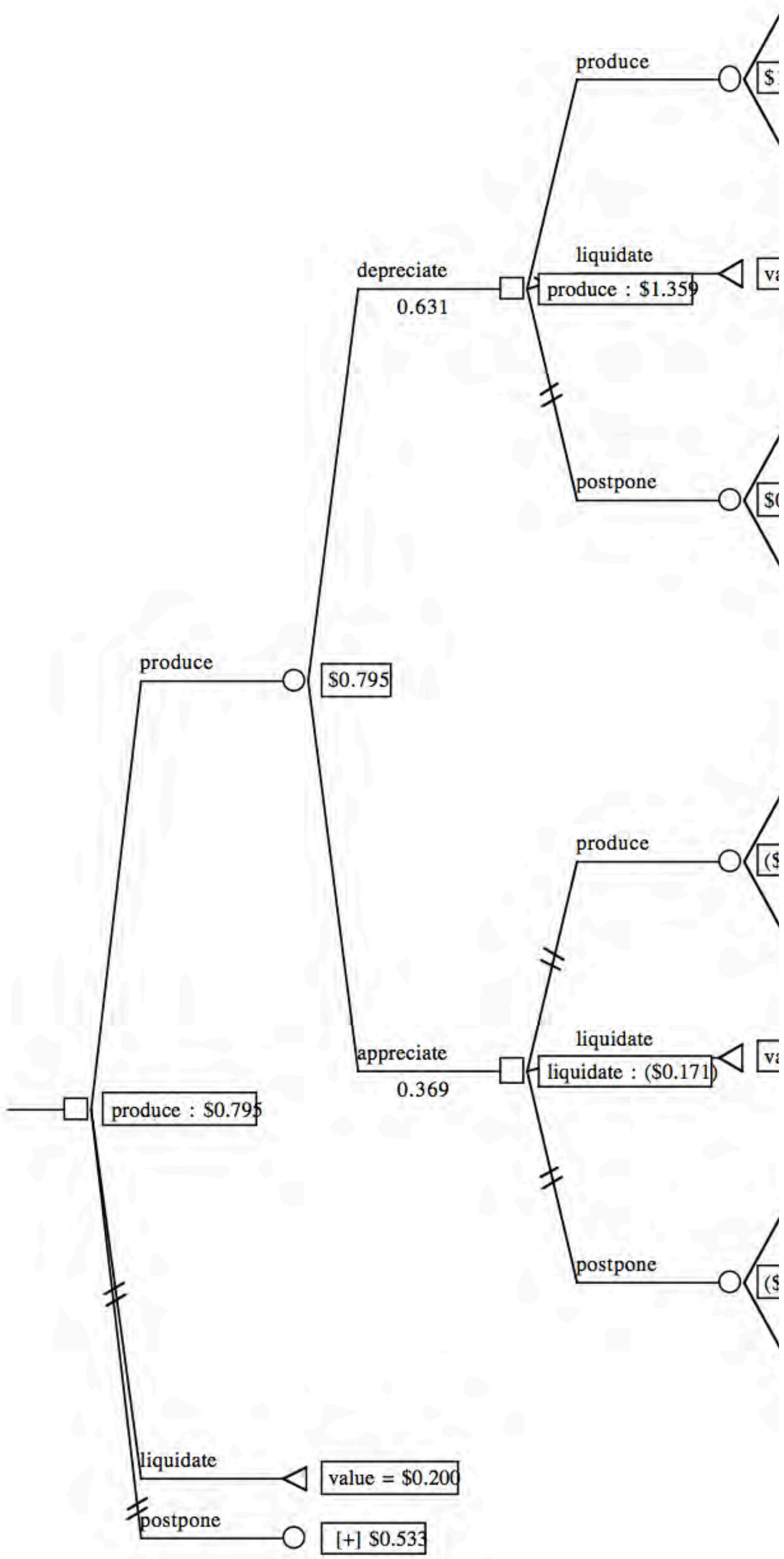
  - could be too crowded in many realistic option situations

- **Influence diagrams**

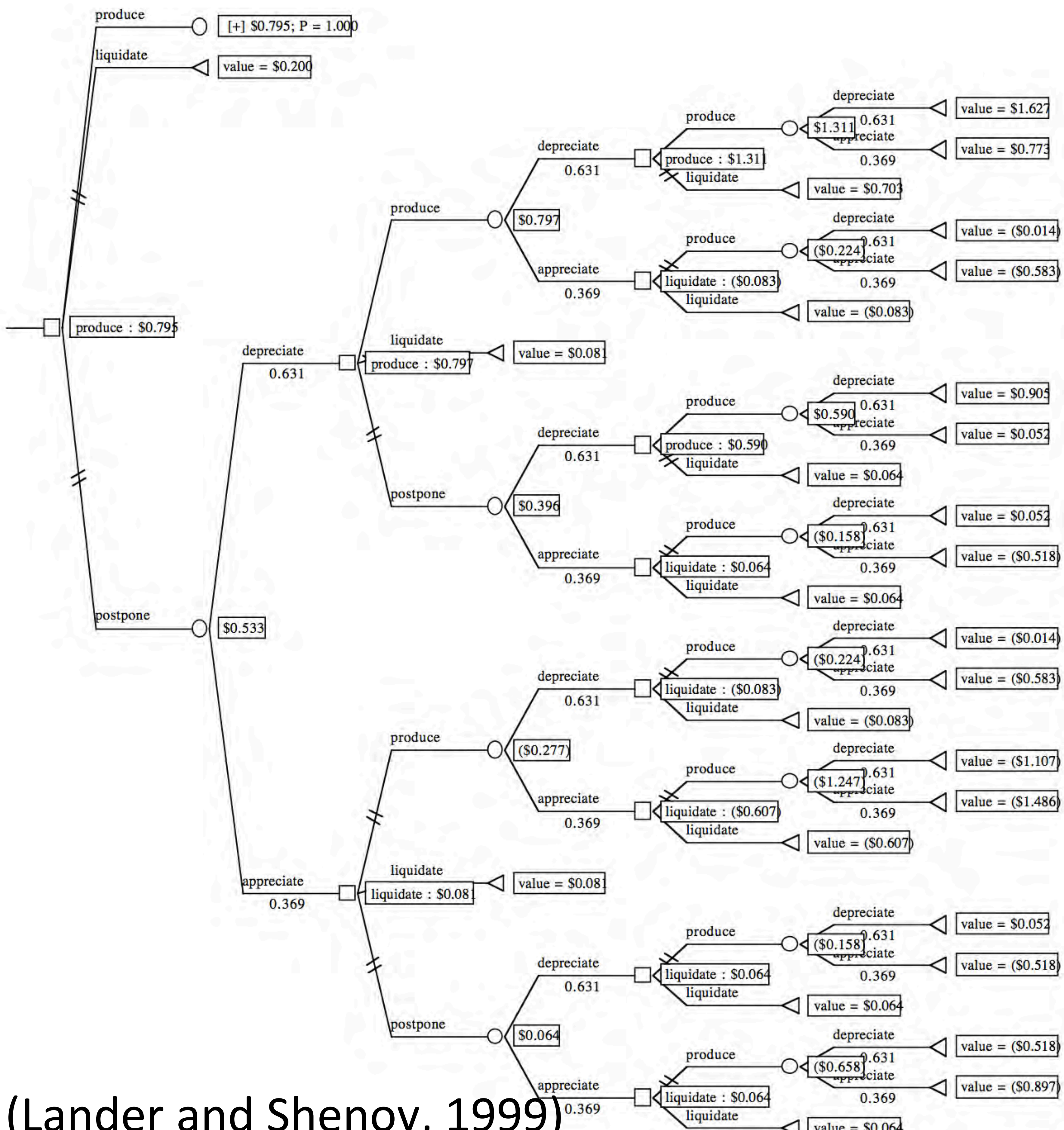
  - much more compact

  - very few work have been done

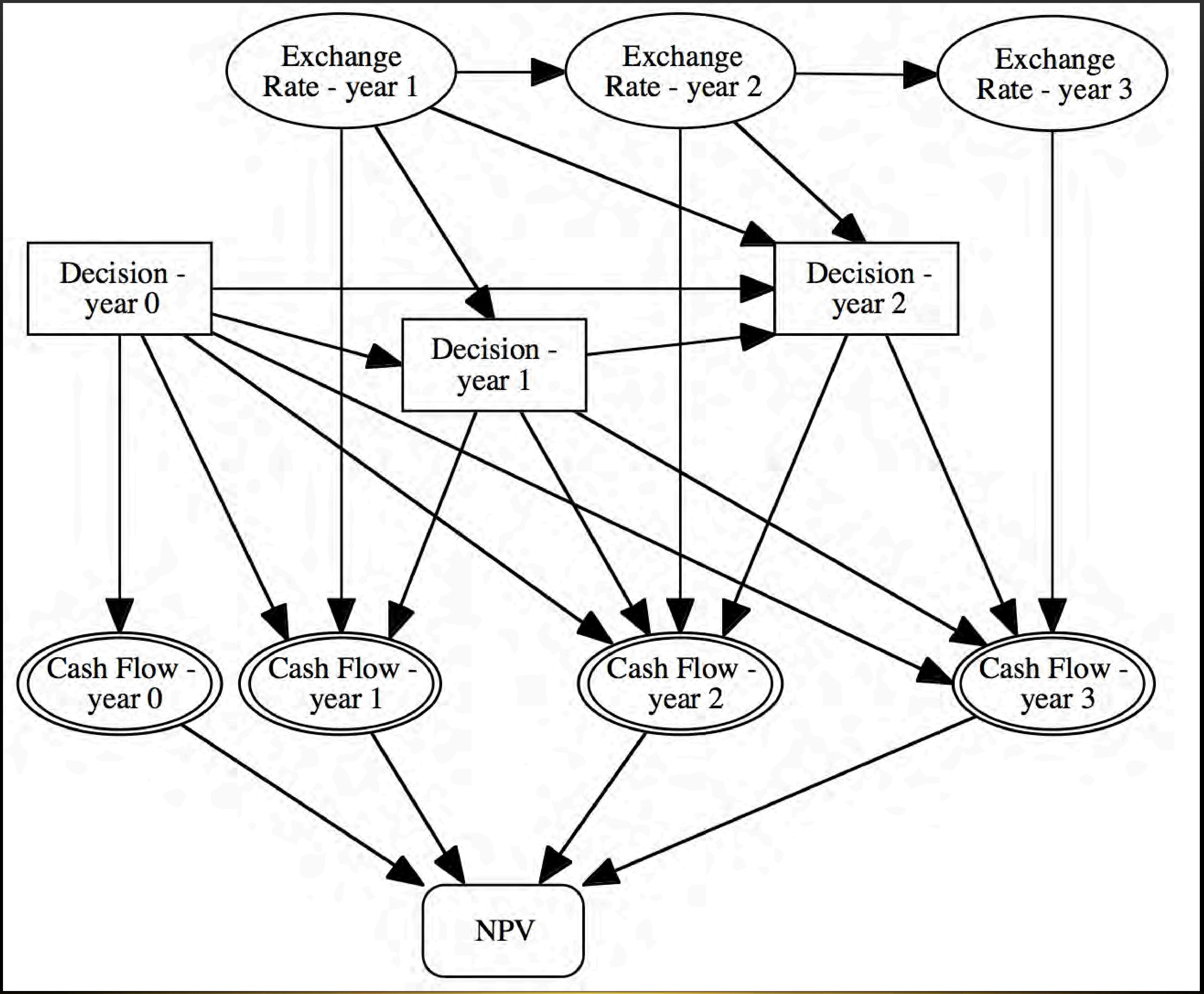
Top-half of Solved



Bottom-half of Solved Decision Tree



(Lander and Shenoy, 1999)



(Lander and Shenoy, 1999)

WHY WE ARE USING INFLUENCE DIAGRAM TO MODEL THE RO PROBLEMS?

- **Decision tree (DT) /binomial lattices**

  - easy to model simple options -only one uncertainty and only a few decisions

  - could be too crowded in many realistic option situations

- **Influence diagrams**

  - much more compact

  - very few work have been done

THESIS OBJECTIVES

- Model the selected cases in influence diagrams
- Compare with DT/lattice
  - implementation effort
  - clarity of communication of the problem
  - computing effort
  - sensitivity analysis

- For what type of RO problems is the DT/lattice a better approach?
- For what type of RO problems is the ID a better approach?

TIME FRAME

January	February	March	April	May	June
Literature review					
Software familiarization					
RO problems selection					
	Use ID to solve the RO problems				
			Draft preliminary master's thesis		
				Finalize master's thesis	

IMPACT OF BIASES ON PROSPECT VALUATION

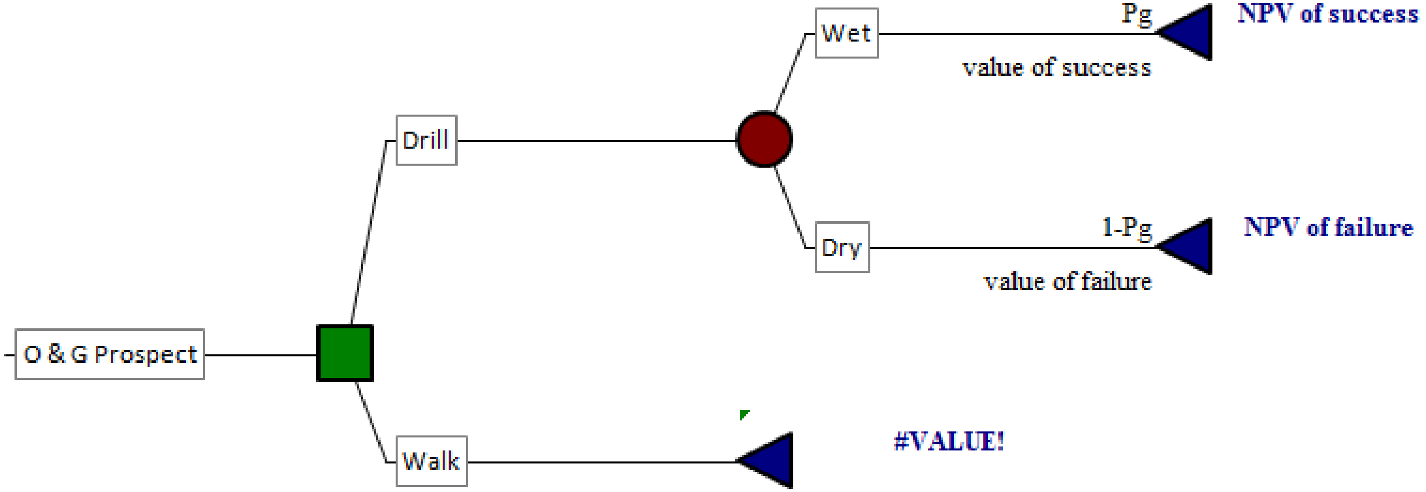
PHAM DUC VIET

Contents

- Prospect valuation
- Biases and impacts
- Conclusion

Prospect Valuation

- **Prospect valuation** is a process of measuring the worth of a specific prospect under uncertainty, by judging Pg and Reserves.
- It helps decision maker clarify the alternatives!



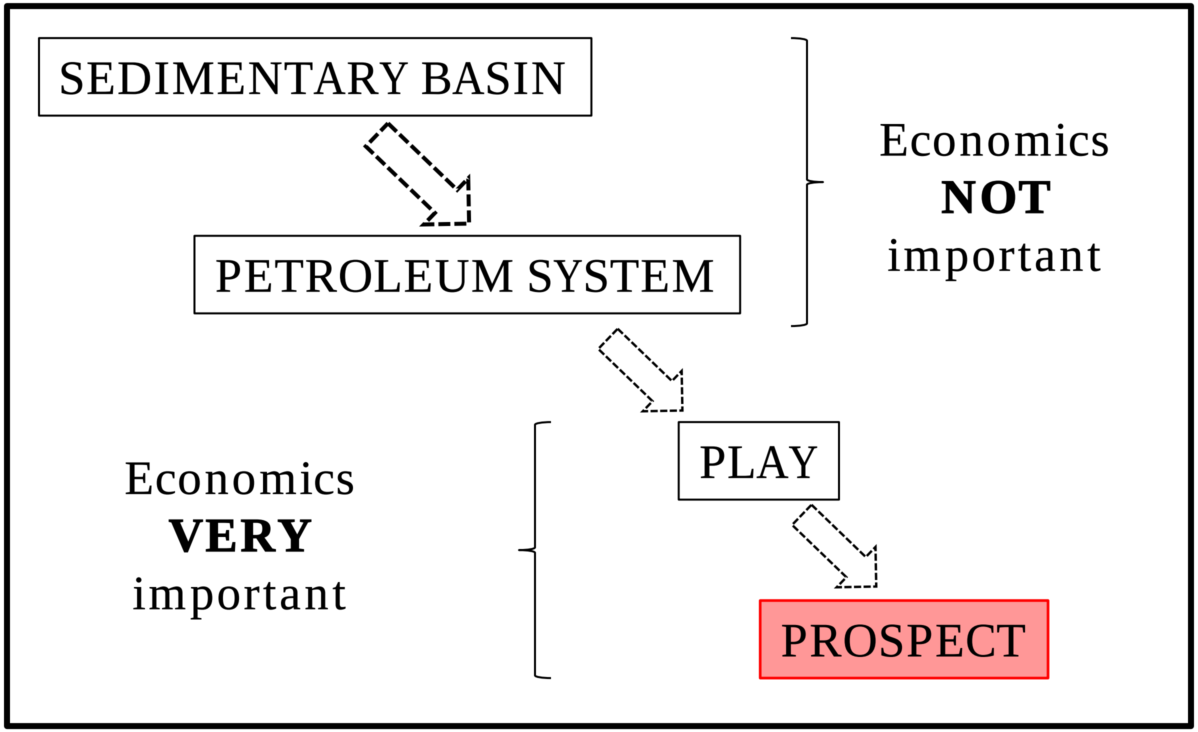
Characteristics of prospect valuation

- Prospect valuation is an important task of geoscientists and it does under many different circumstances.

Discipline	Produce
Geology and Geophysics (G&G)	Reserves, Probability of Success (Pg)
Reservoir Engineering	Production profile, recoverable reserves
Drilling and Well	Well design and drilling cost
Facility Design	Development concept
Commercial Analysis	Value of the prospect

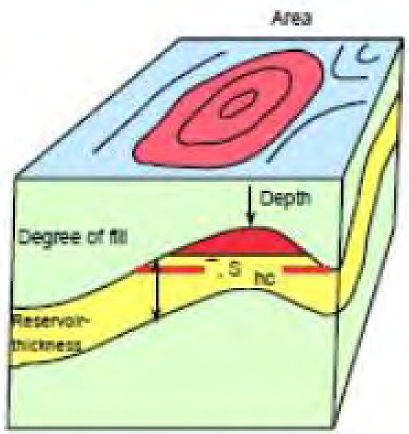
Approach to a Prospect

- Study sedimentary basin to find prospect

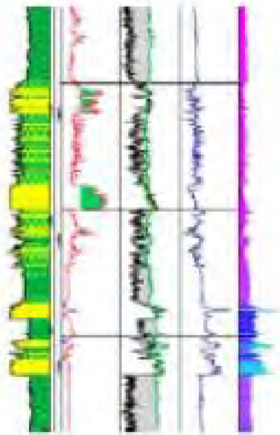


Four levels of petroleum investigation. From Magoon and Dow (1994)

Calculate Hydrocarbon Reserves



Seismic/ reservoir maps



Well logging analysis

Core analysis

- GRV (area x thickness)
- N/G (reservoir quality part)
- Porosity (pore volume/rock volume)
- Sw (part of pore saturated with water)
- FVF (vol. at res./vol. at surface)

$$\text{Reserve} = A \times h \times N/G \times Phi \times (1-Sw) \times 1/FVF \times \text{Recovery factor}$$

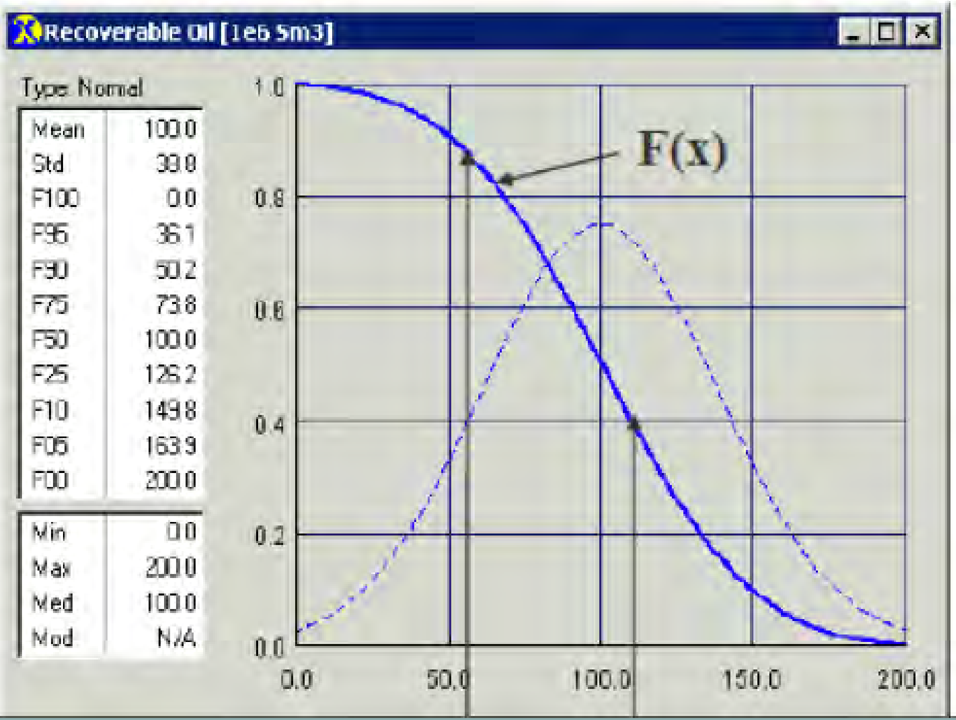
Probability Distribution for Reserves

The ***cumulative probability function, F(x),*** *is defined by :*

$$\int_{-\infty}^{x} f(u)du$$

The oil industry use ***the reversed cumulative probability function, F(x),*** *defined by :*

$$\int_{x}^{\infty} f(x)dx$$



The reversed cumulative distribution, F(x), shows the probability for being greater or equal to the numbers on the horizontal axis.

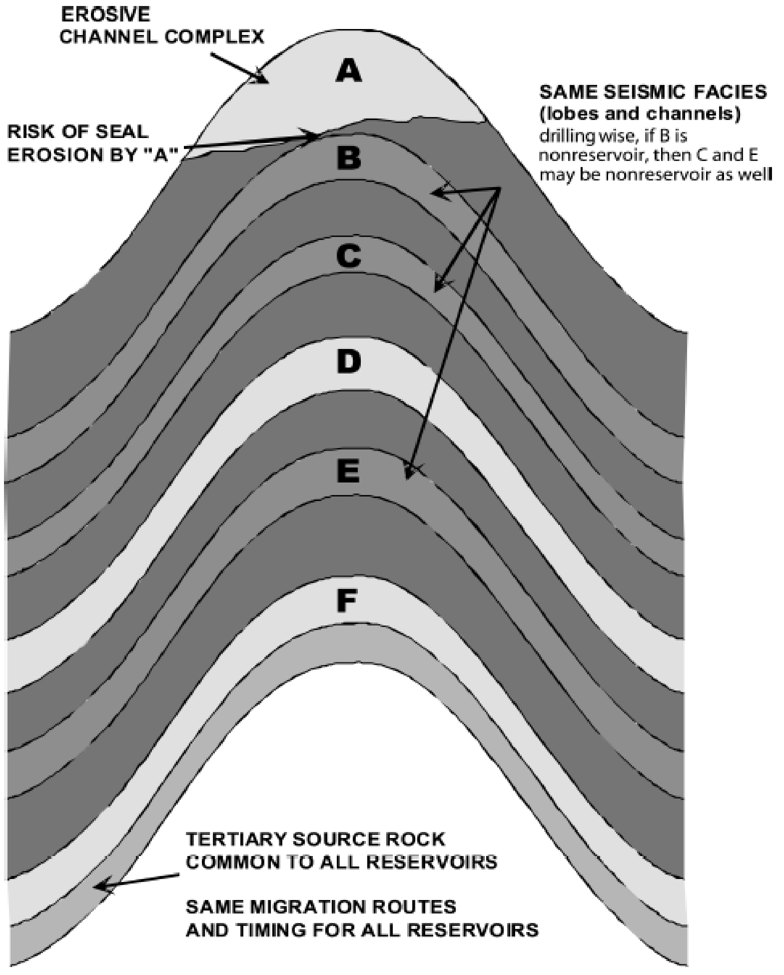
Probability of Geologic Success

- Pg is joint probability of all geologic chance factors which constitutes petroleum system.
- Assuming that the probability factors are independent.

Pg = P(source) x P(seal) x P(reservoir) x P(trap) x P(timing/migration)

Multiple Targets Prospect

- Targets are dependent as they share common geologic factors.



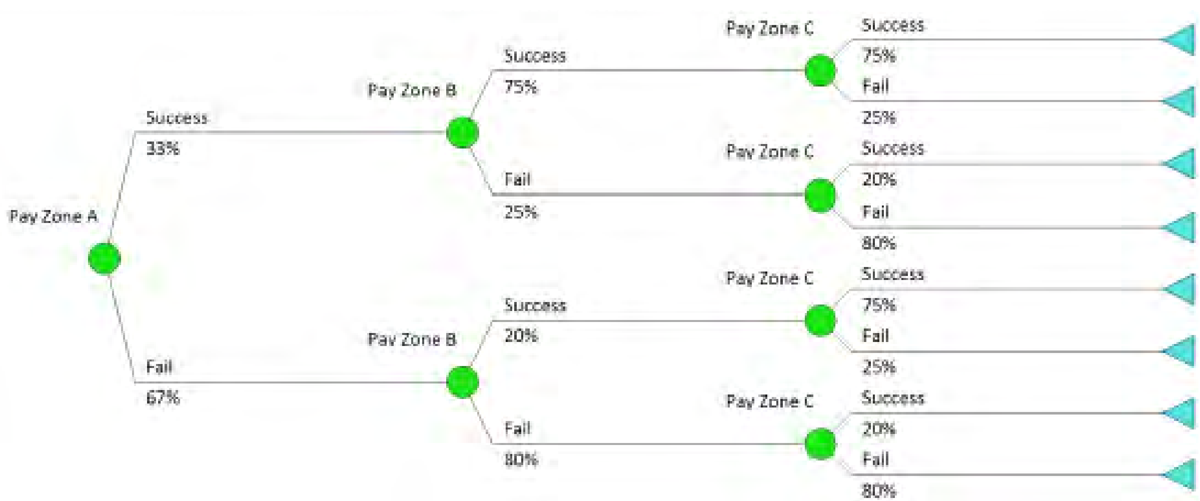
Schematic section showing dependencies between targets

From Delfiner (2003)

Dependency model for multi-target Prospect

A prospect with three targets (A,B,C). What is the chance of prospect success? with:

- At least one target success
- All 3 targets success



Joint Probability	Outcomes
0.1875	ABC
0.0625	ABC'
0.0167	AB'C
0.0667	AB'C'
0.1000	A'BC
0.0333	A'BC'
0.1067	A'B'C
0.4267	A'B'C'

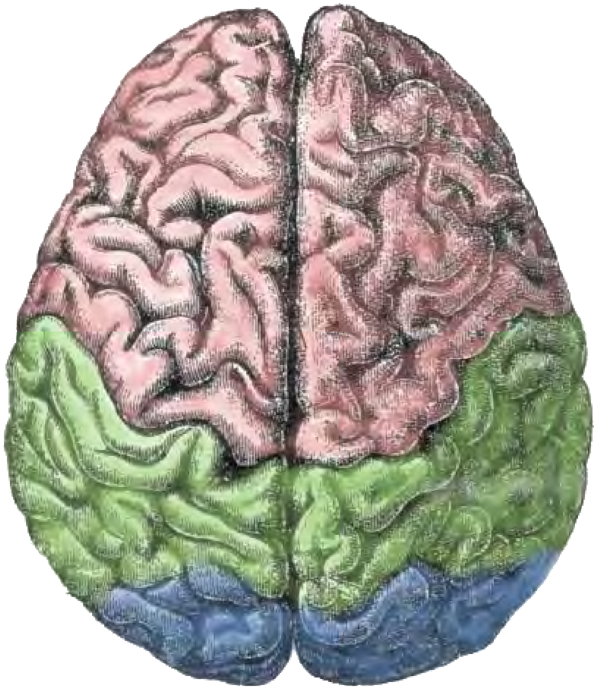
BIAS

- **Bias** is an unconscious error that arises from human brain while processing information in the face of uncertainty.

Left-brain functions

- Analytical thought
- Rational thought
- Logic
- Detail oriented perception

More complex decisions
Slower, conscious, effortful



Right-brain functions

- Intuitive thought
- Emotional thought
- Imagination
- Holistic perception

Simple decisions, quick

Typical biases in prospect valuation

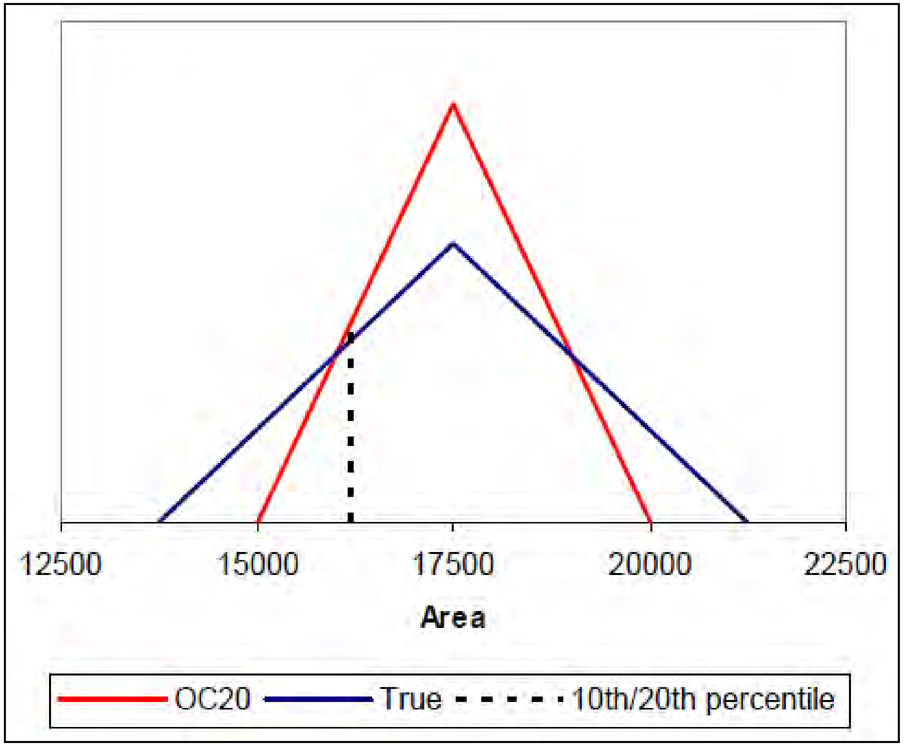
Type of bias	Common example
Overconfidence	Predictive ranges too narrow. Symptom: surprises about exploration results.
Representativeness	Analog based on small sample size; chosen analog may not be analogous
Availability	Recent or spectacular examples are prone to be cited, regardless their nature; limits number of possible interpretation
Anchoring	Desired iterative-reiterative process is attenuated
Unrecognized limits	Forecasting future discoveries may disregard non-geologic factors
Over optimism	Exaggerate magnitude of reserves or Pg
Conservatism	Underestimating – stay on the safe side

Rose (2001)

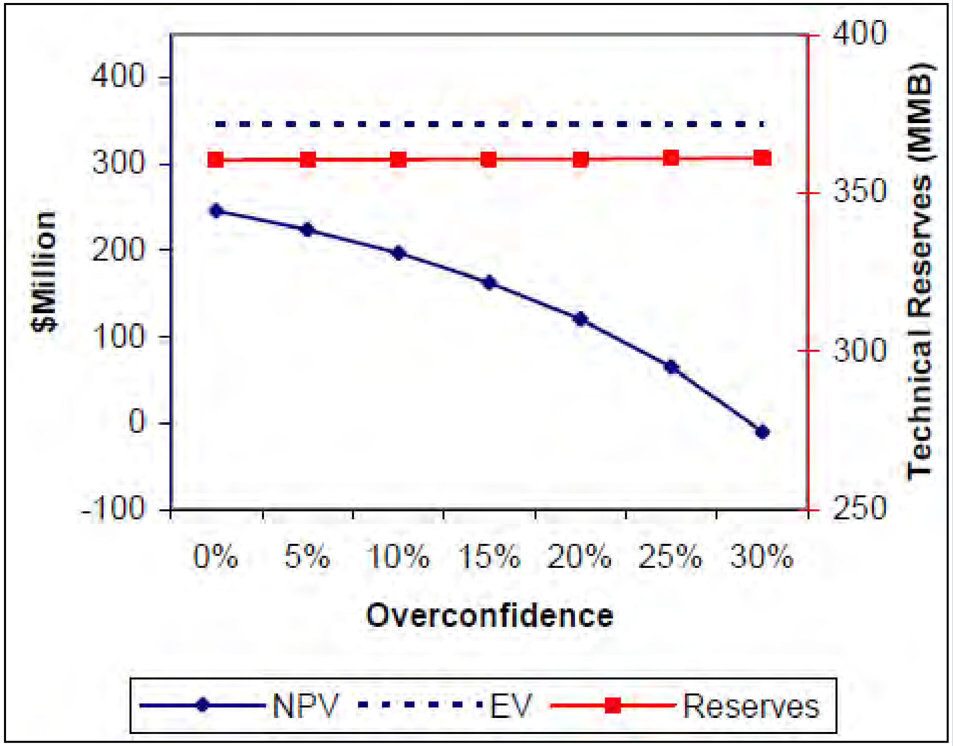
Modeling Biases

- Define bias based on its properties
- Model it by using MCS and evaluate impact
- Remove the bias

An example of Overconfidence



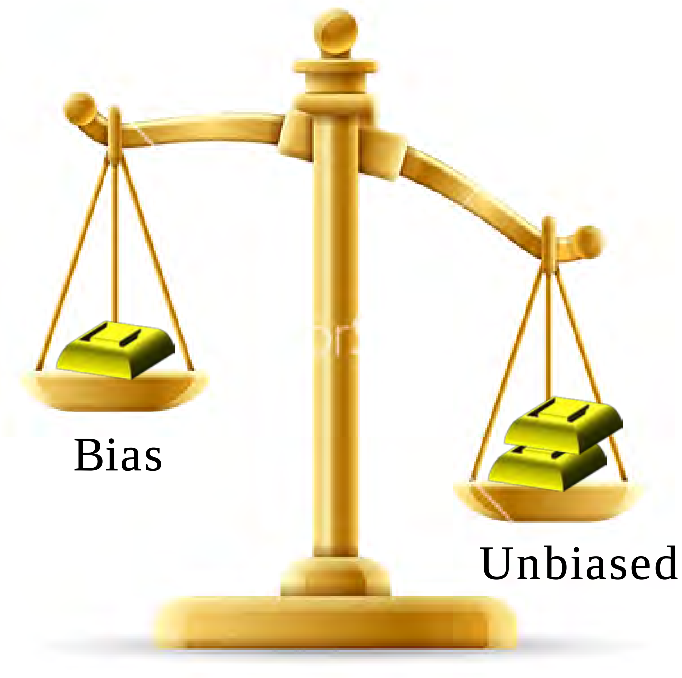
Overconfidence transformation of PDF



Effect of overconfidence on NPV

Impact of biases

- To cause our estimations on prospect valuation to be inconsistent: both in Pg and reserves --> Poor decision and the result is either **making less** or **losing** money than it would have without the biases!



Conclusion

- The biases are cognitive illusions. It leads to wrong judgment of prospect's value and suboptimal choices.
- Awareness of biases does not generate more accurate perception.
- Modeling and eliminate bias will bring consistent judgments about uncertain factors and better results.

Thank you

SUBSURFACE CHARACTERIZATION OF STRUCTURAL TRAPS IN THE NUNCHIA LLANOS FOOTHILLS, COLOMBIA

Jhon Meyer Munoz-Barrera

Advisors :

Nestor Cardozo

Alejandro Escalona

Department Petroleum Geosciences Engineering
Faculty of Petroleum Engineering
University of Stavanger
uis.no

Fold and Thrust Belt

Sierra Nevada de Santa Marta
From www.eltiempo.com

Sierra Nevada del Cocuy

Laguna de Guatavita

Volcán Nevado Ruiz

SE

SE

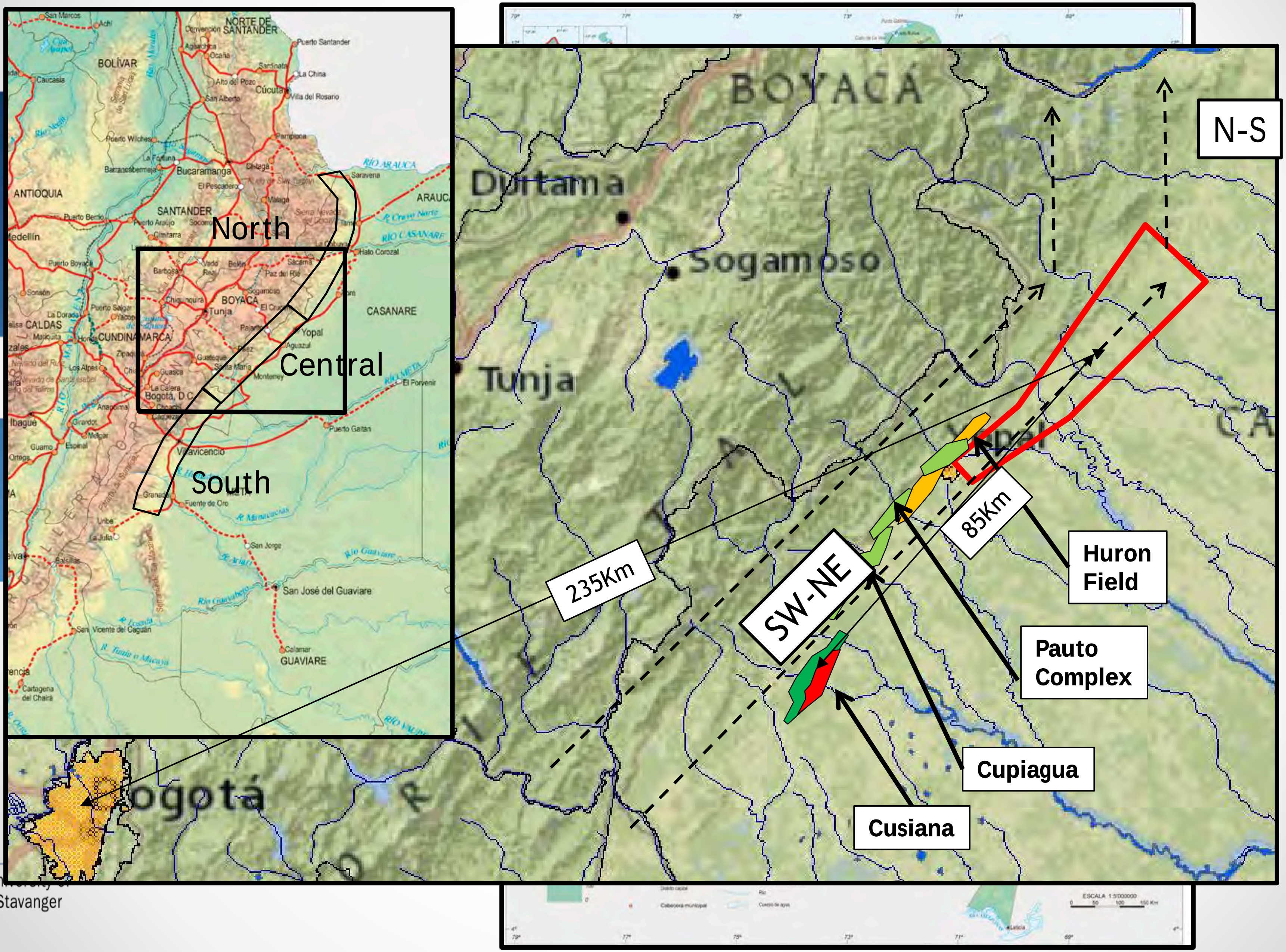
University of Stavanger

Outline

- Location
- Motivation
- Geological framework
- Work Proposal
- Objectives
- Data
- Time frame

University of Stavanger

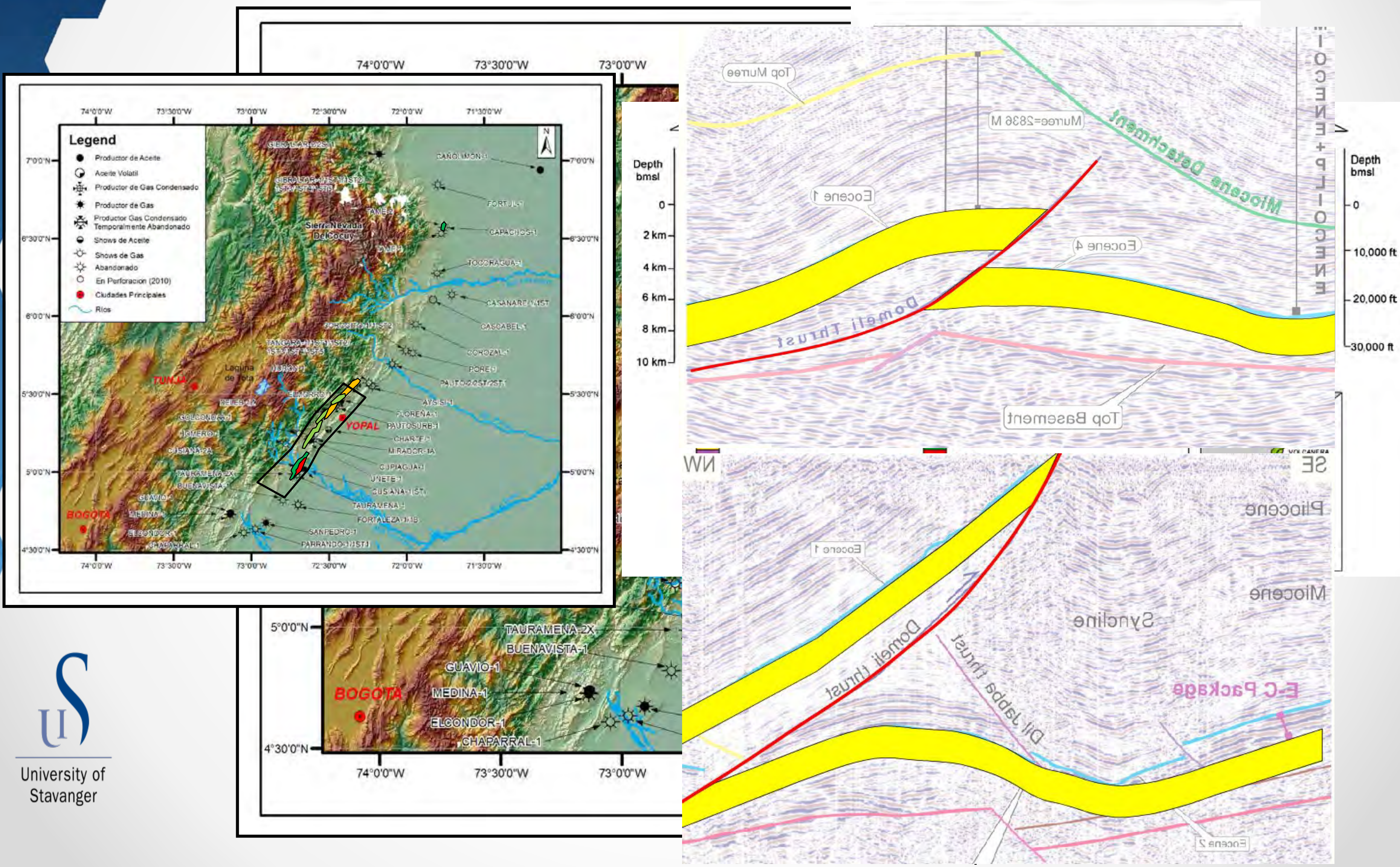
Location



North
Central
South
BOYACÁ
Duitama
Sogamoso
Tunja
Bogotá
N-S
SW-NE
235Km
85Km
Huron Field
Pauto Complex
Cupiagua
Cusiana

Motivation

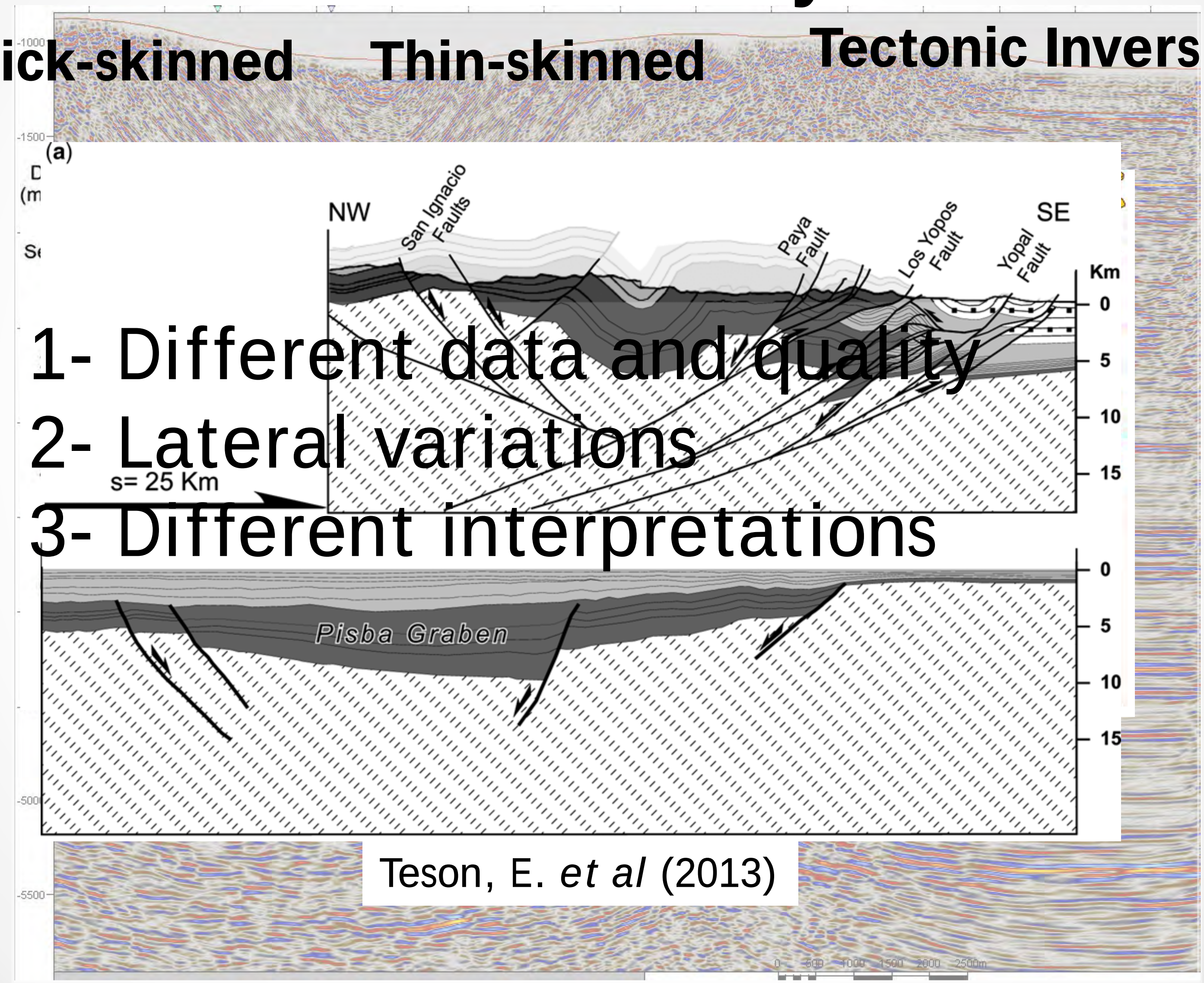
Front deformation zone: 1 Giant oild filed (Cusiana)
However, in northern part more than 20 wells dry. Why?



University of Stavanger

Structural styles

Thick-skinned **Thin-skinned** **Tectonic Inversion**



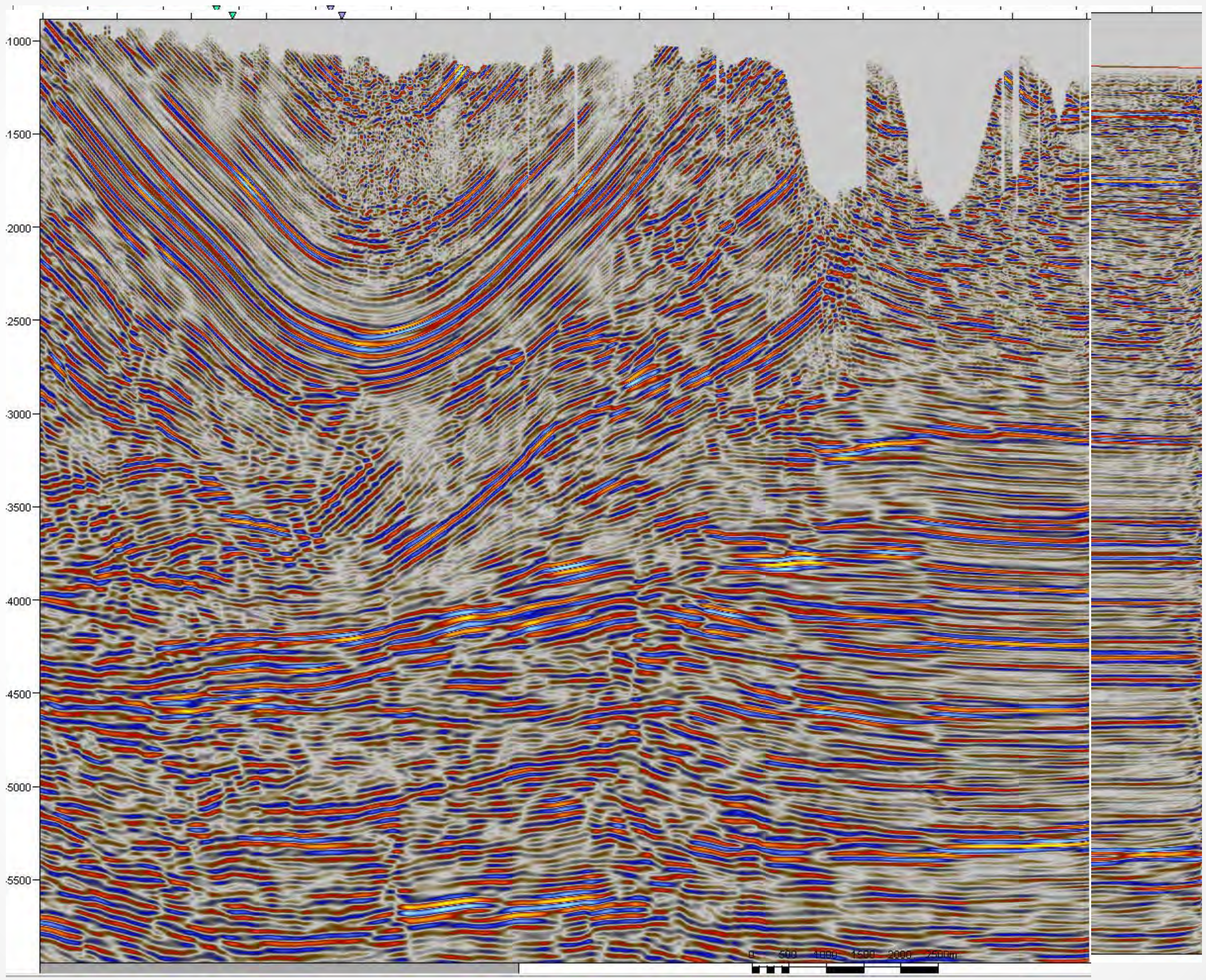
1- Different data and quality
2- Lateral variations
3- Different interpretations

Teson, E. *et al* (2013)

University of Stavanger

Motivation

2- Different Data

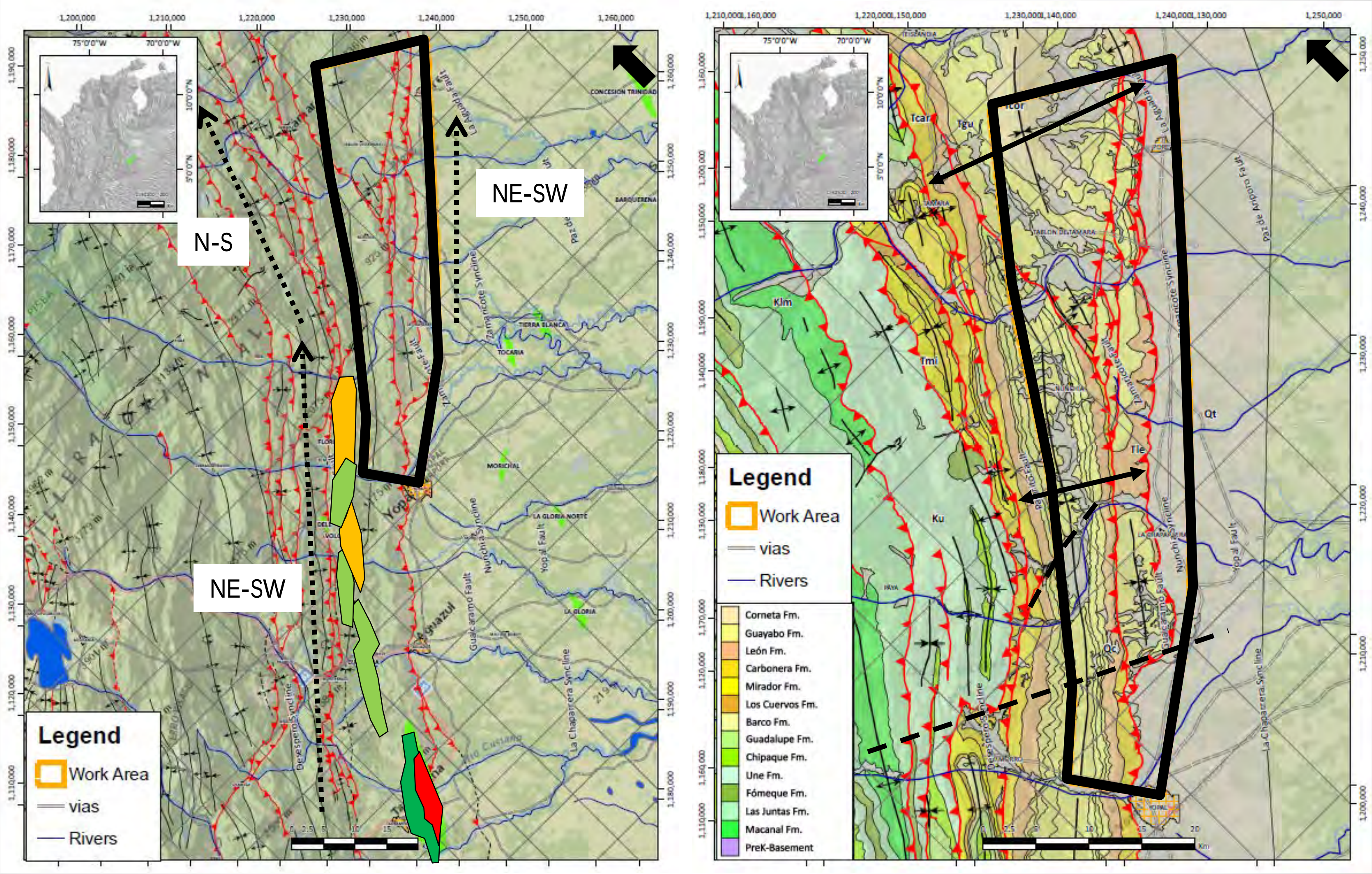


3D Seismic

2D Seismic

Motivation

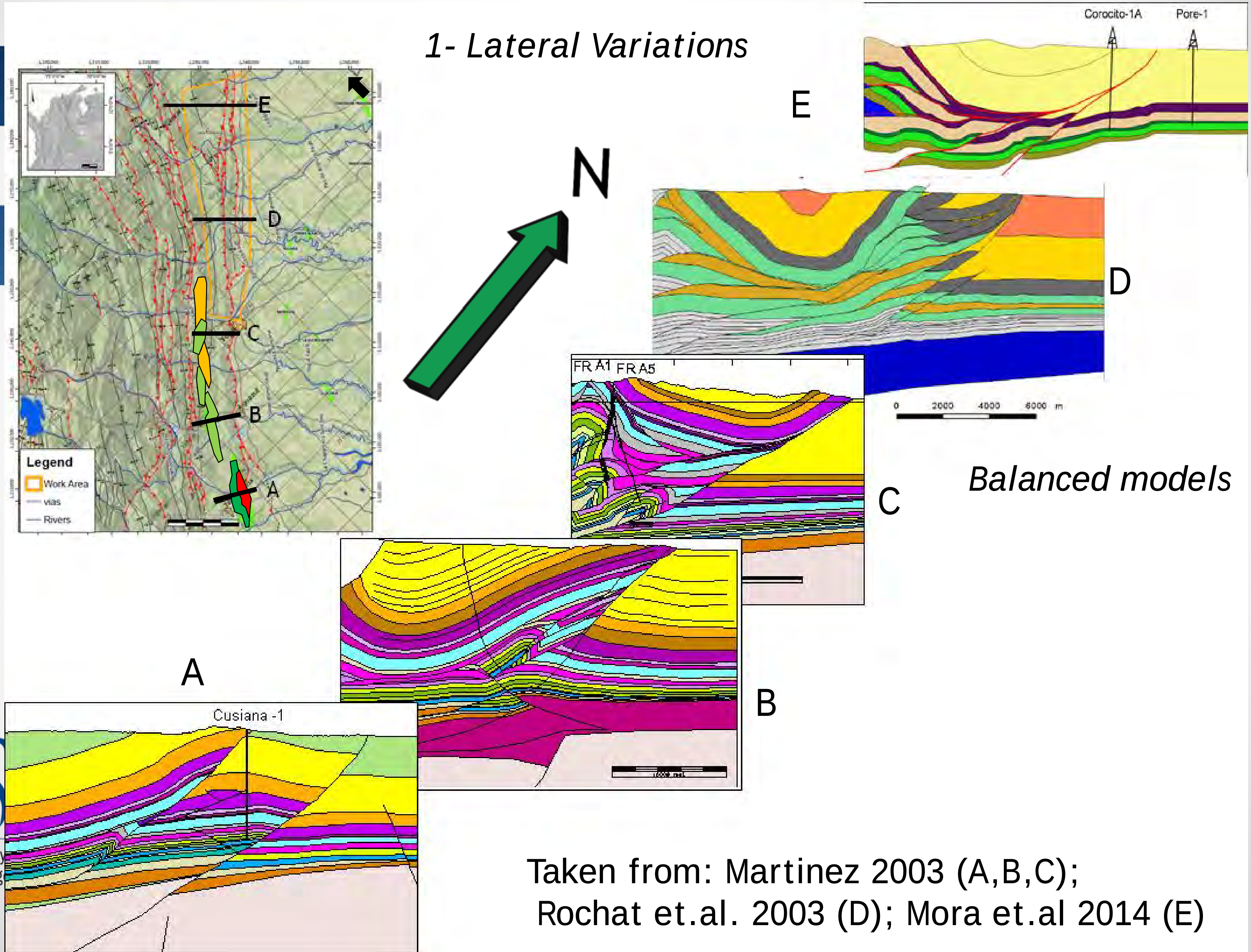
1- Lateral Variations



Lateral variations: New faults; Initial point where the EC changes direction

Motivation

1- Lateral Variations



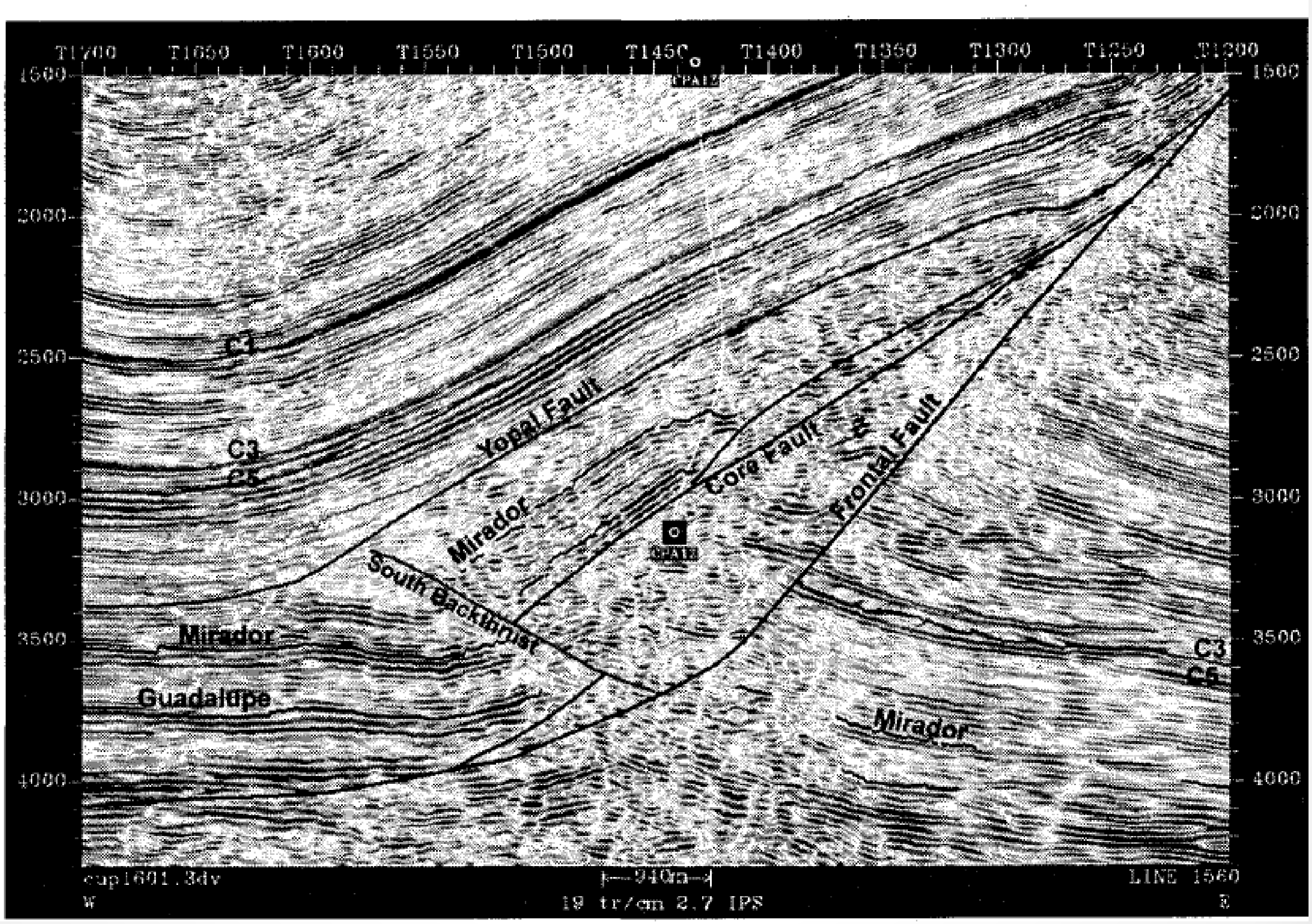
Balanced models

Taken from: Martinez 2003 (A,B,C);
Rochat et.al. 2003 (D); Mora et.al 2014 (E)

University of Stavanger

Motivation

3- Different interpretations

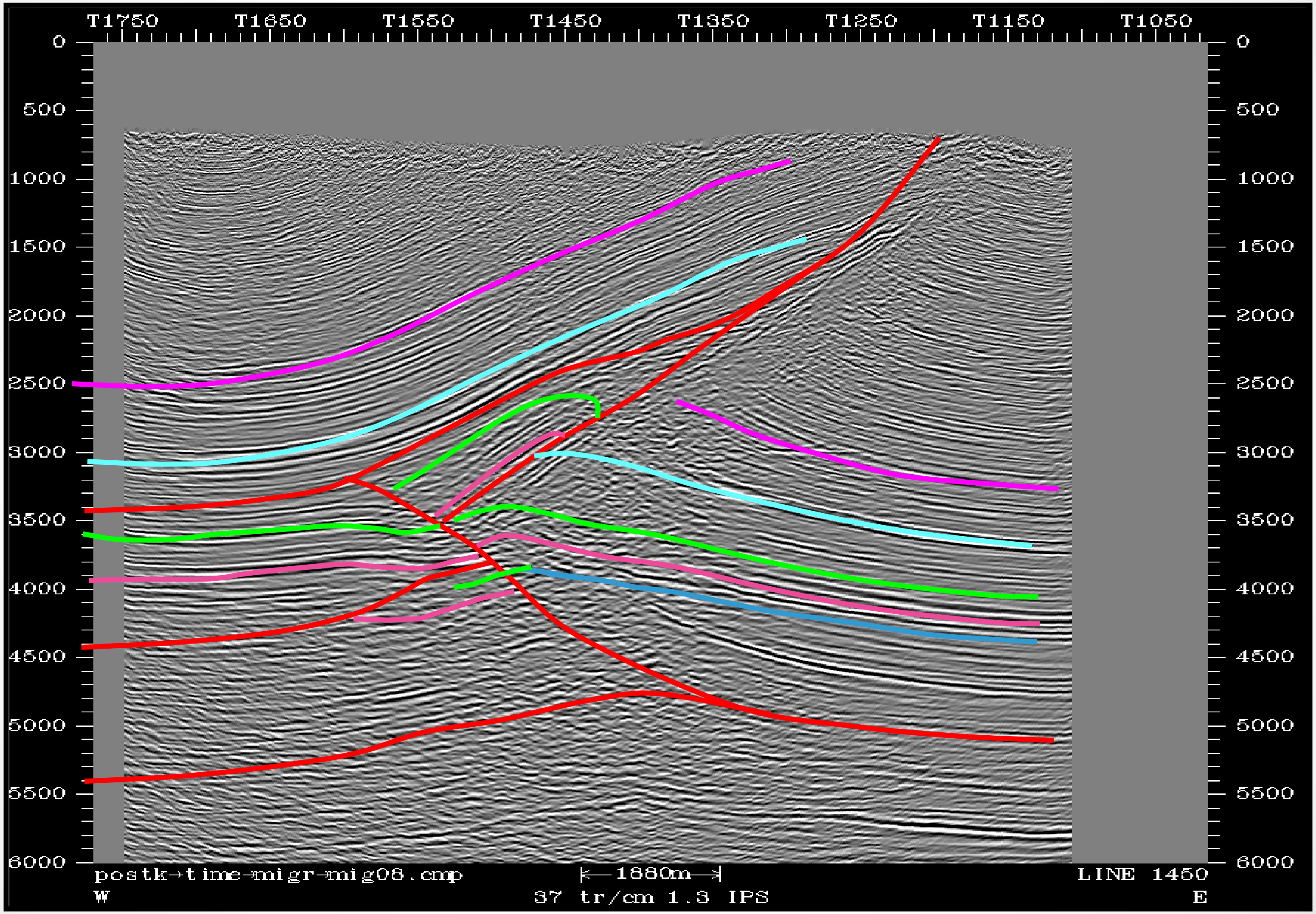


Cupiagua oil field

Rathke and Coral 1997

Motivation

3- Different interpretations

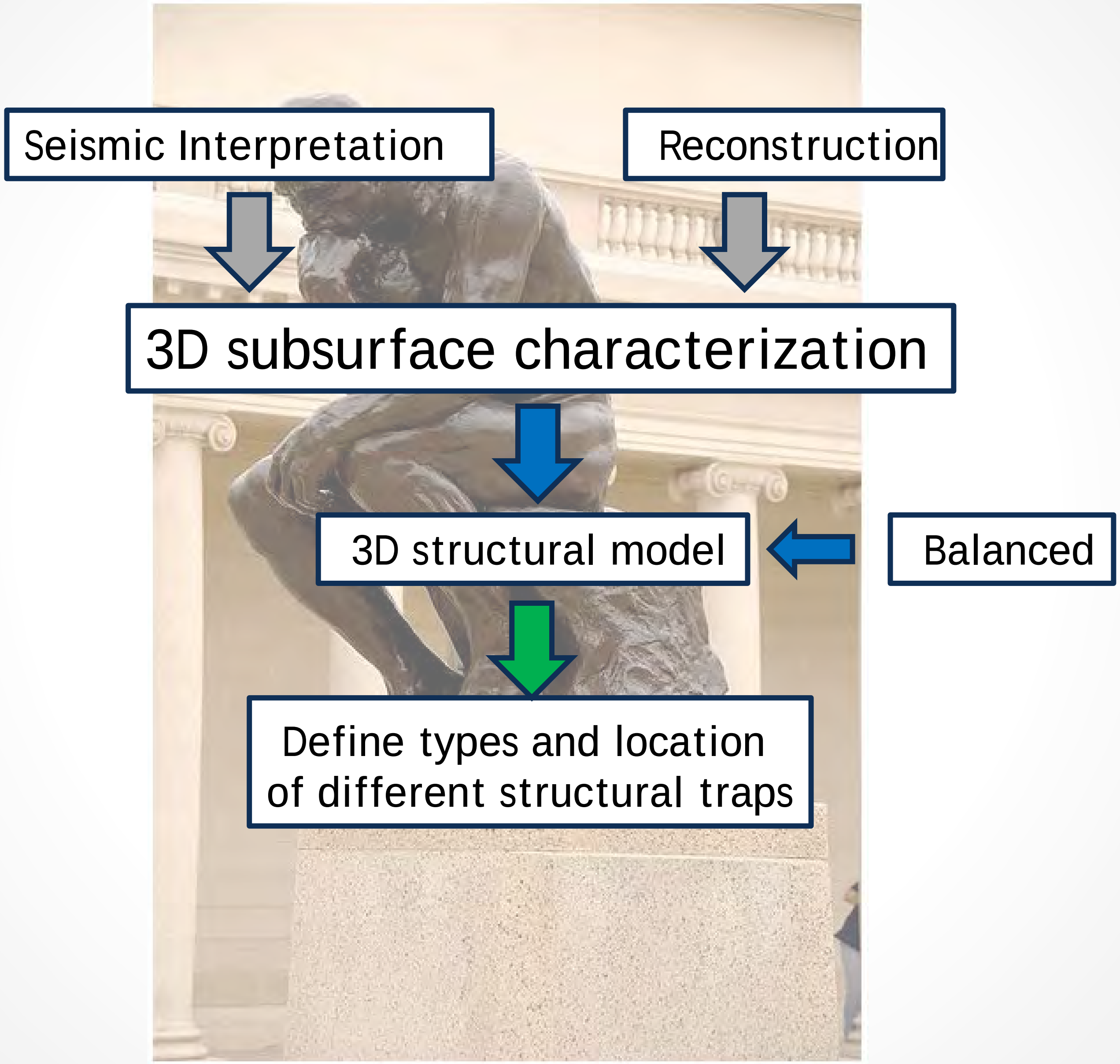


Cupiagua oil field

Martinez 2003

University of Stavanger

Work Proposal

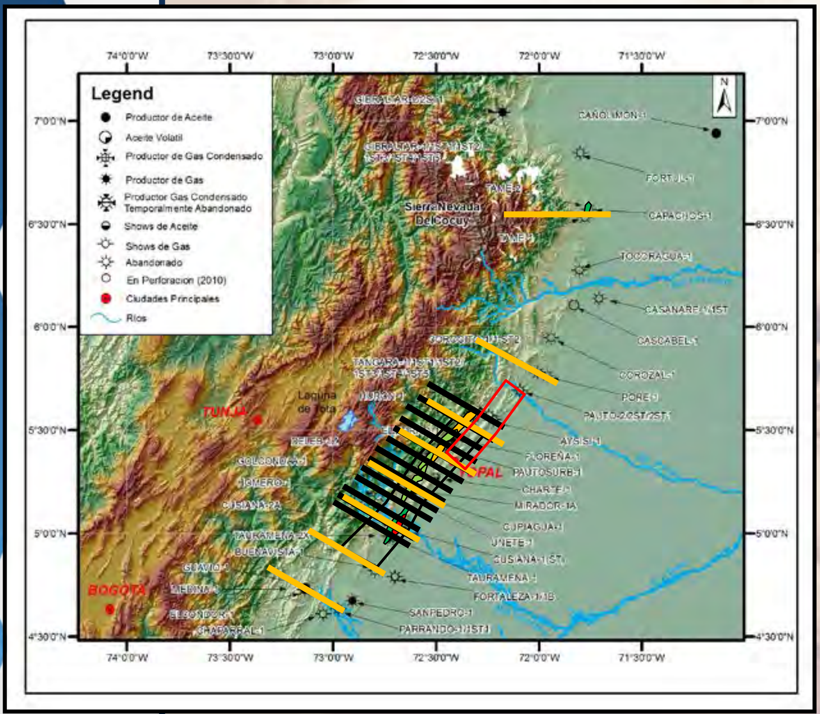


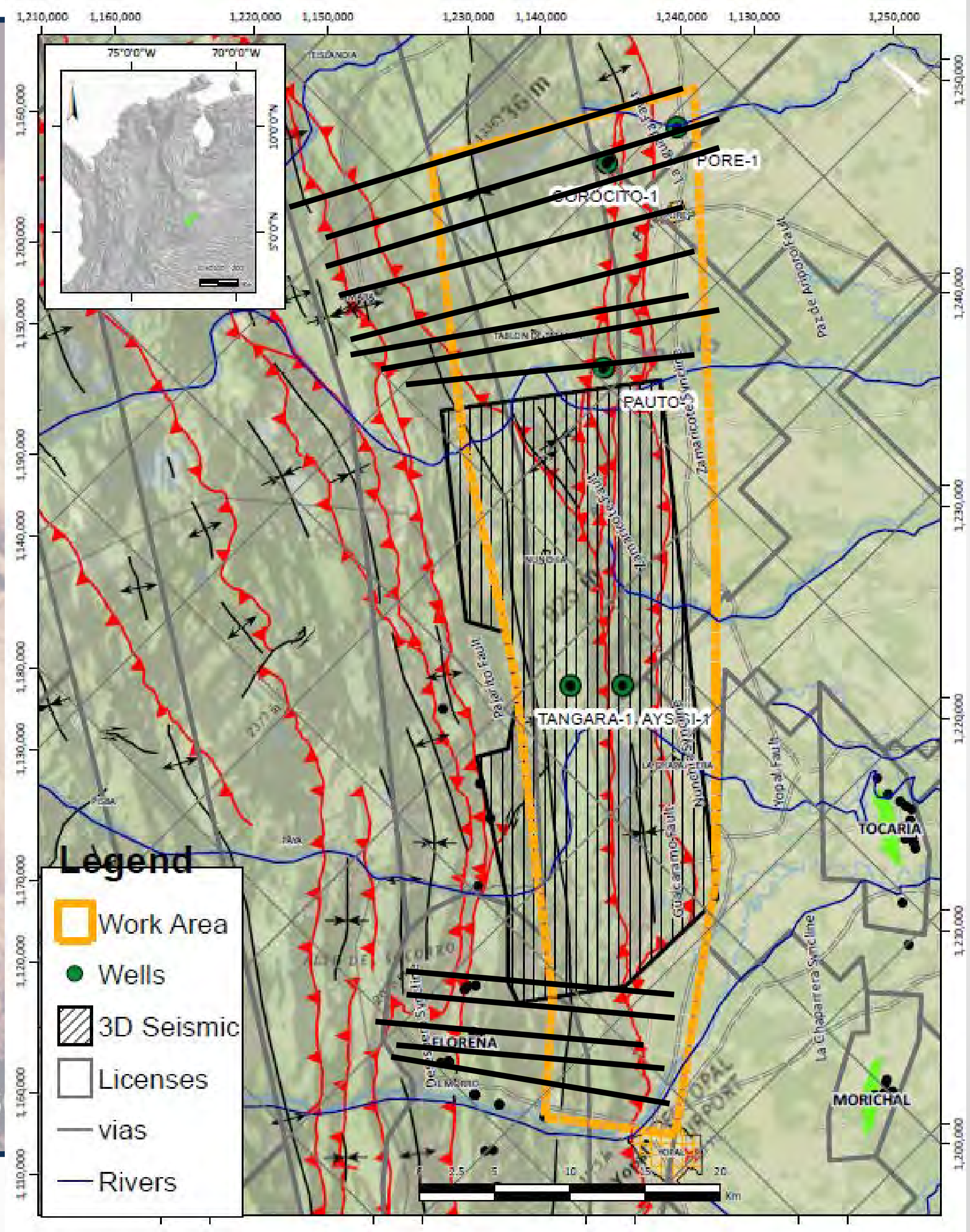
The Thinker, by Aguste Rodin.

Taken from http://commons.wikimedia.org.

University of Stavanger

Work Proposal





Objectives

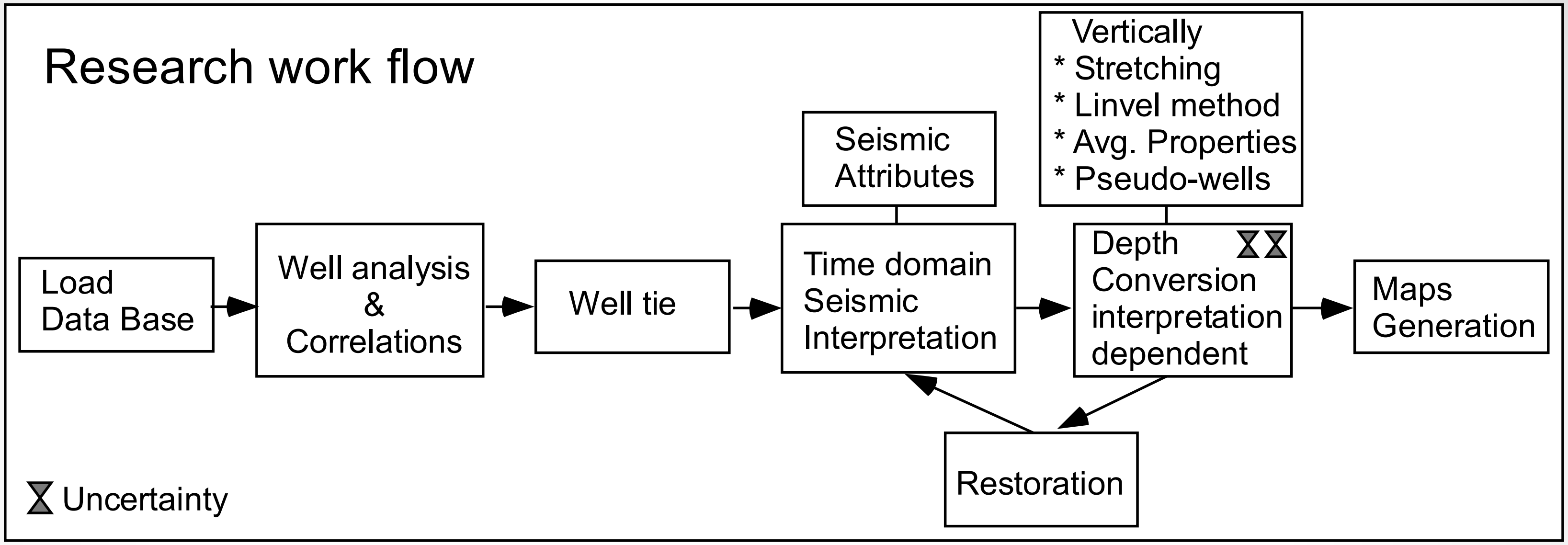
- **Principal**

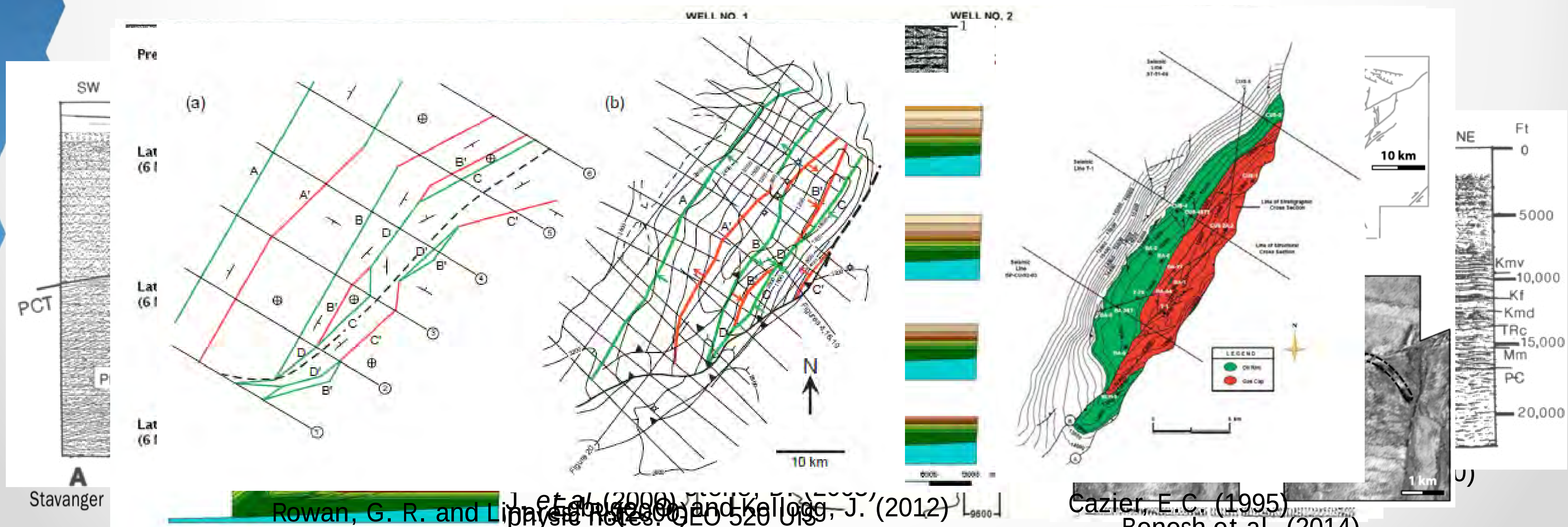
  The main goal of this thesis project is to define the 3D structural framework of the frontal deformation zone between the Caño Sur and Pore rivers.

- **Secondary Objectives**
- To detect the possible HC traps of the Yopal – Borde Llanero fault system
- To define the type of orogenic wedge, the structural geometry of the frontal fault system, its lateral variation and quatify the shortening across the region.
- To compare the petroleum system in this area with that of the Cusiana-Cupiagua.

University of Stavanger

Methodology



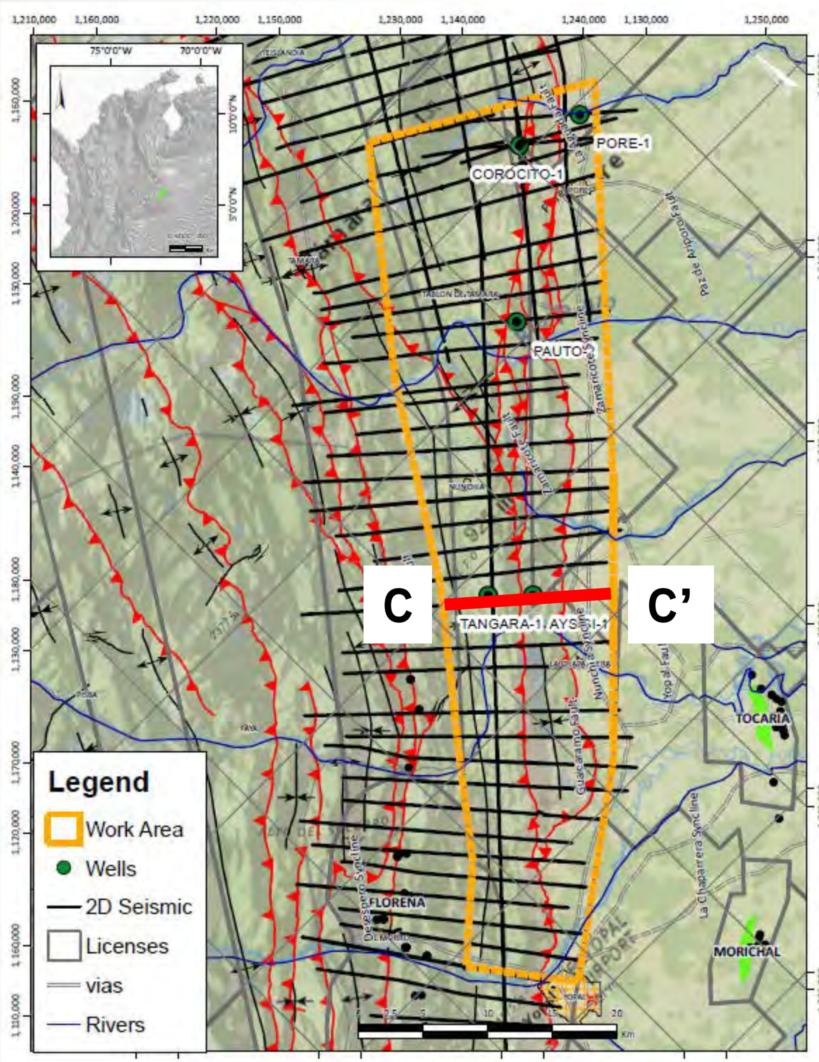


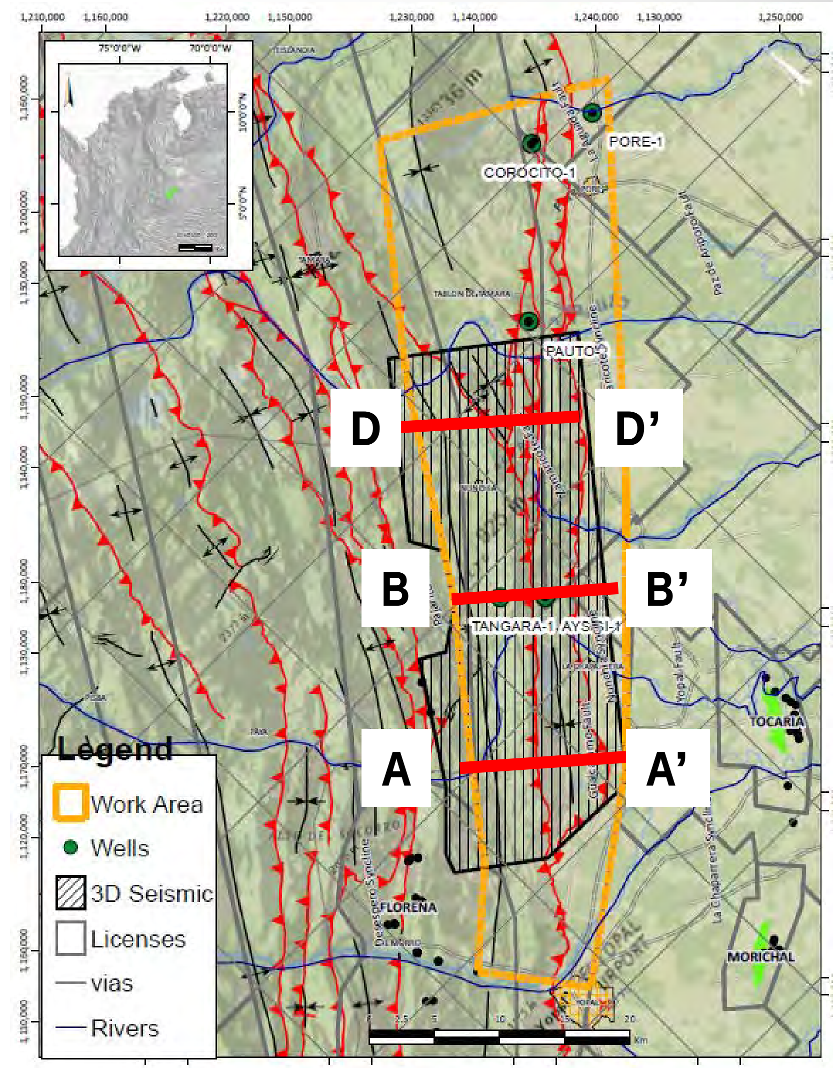
Rowan, G. R. and Linares, R. (2000) and Kellogg, J. (2012)

Cazier, E.C. (1995)

Benesh et al. (2014)

Data

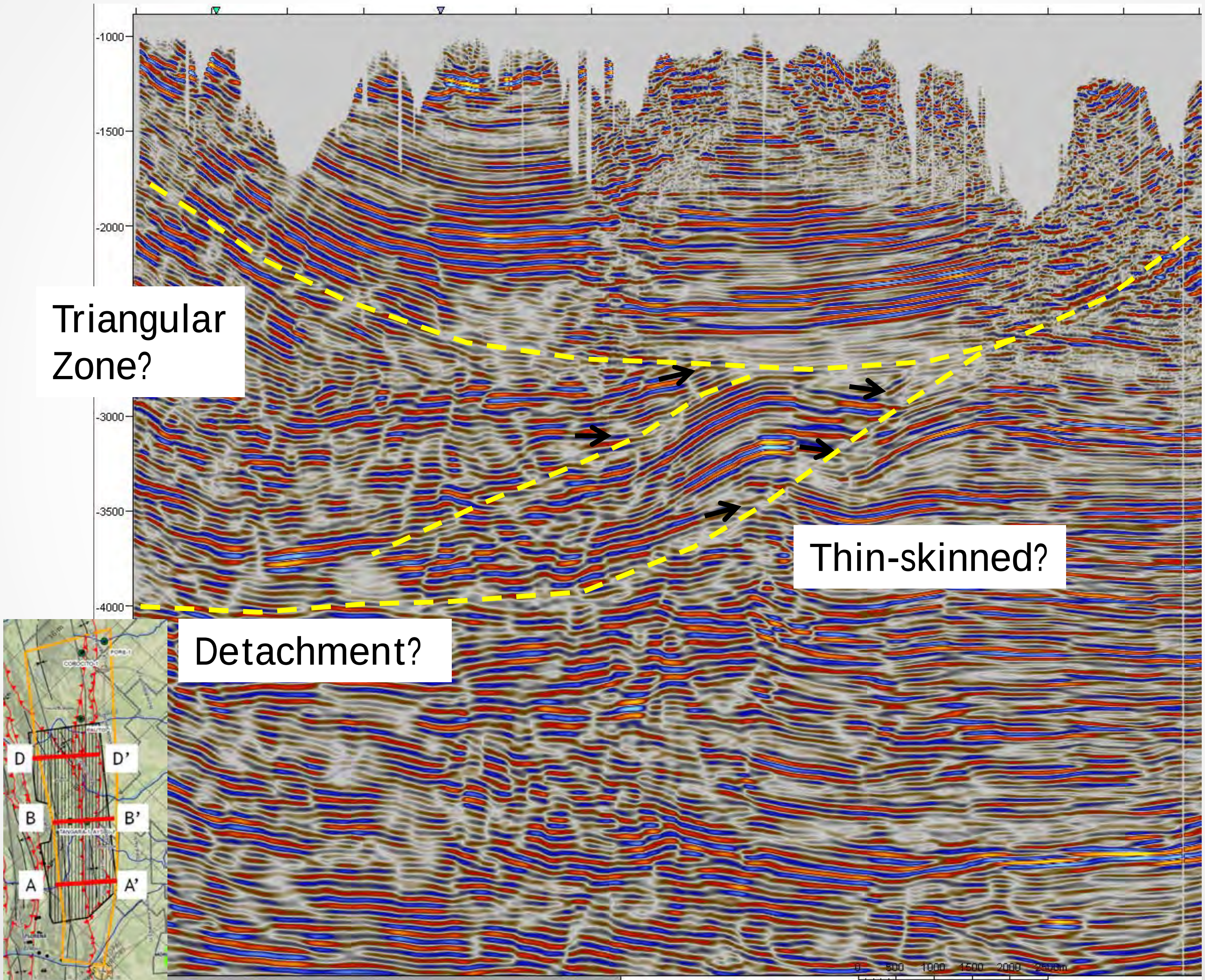




1000Km 2D seismic; 600Km^2 3D seismic; 5 wells

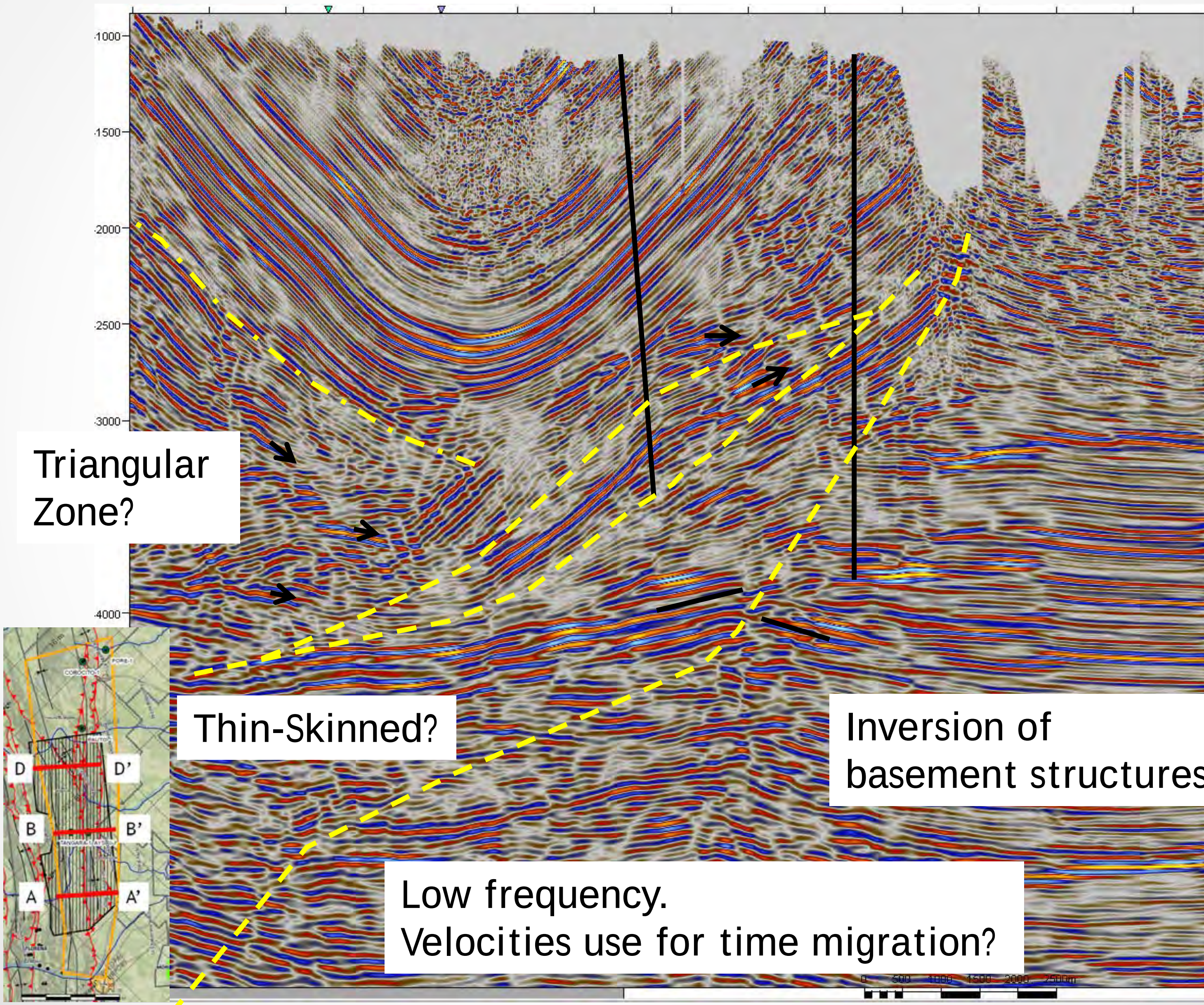
University of Stavanger

Line A-A' 3D Line



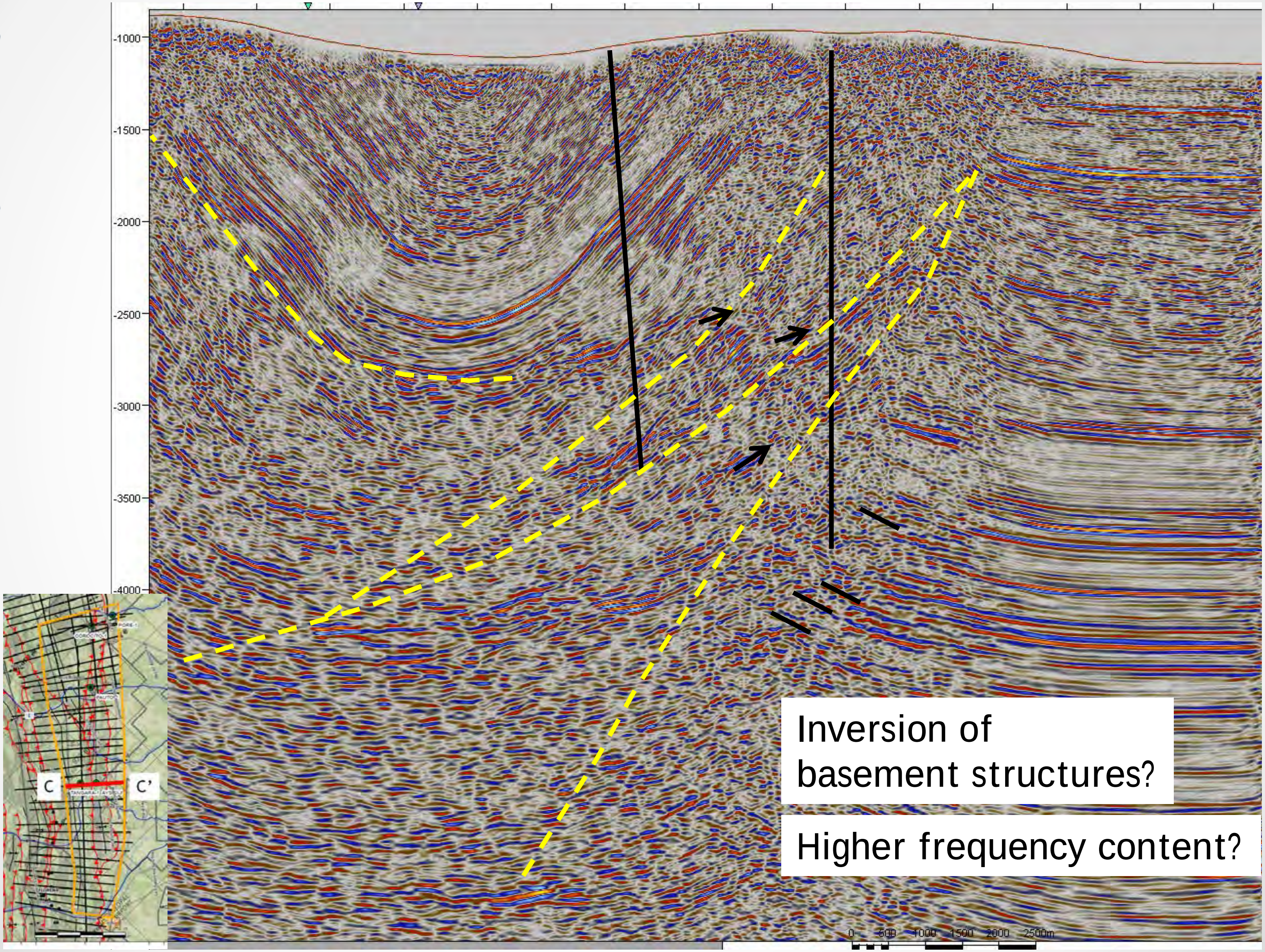
University of Stavanger

Line B-B' 3D Line



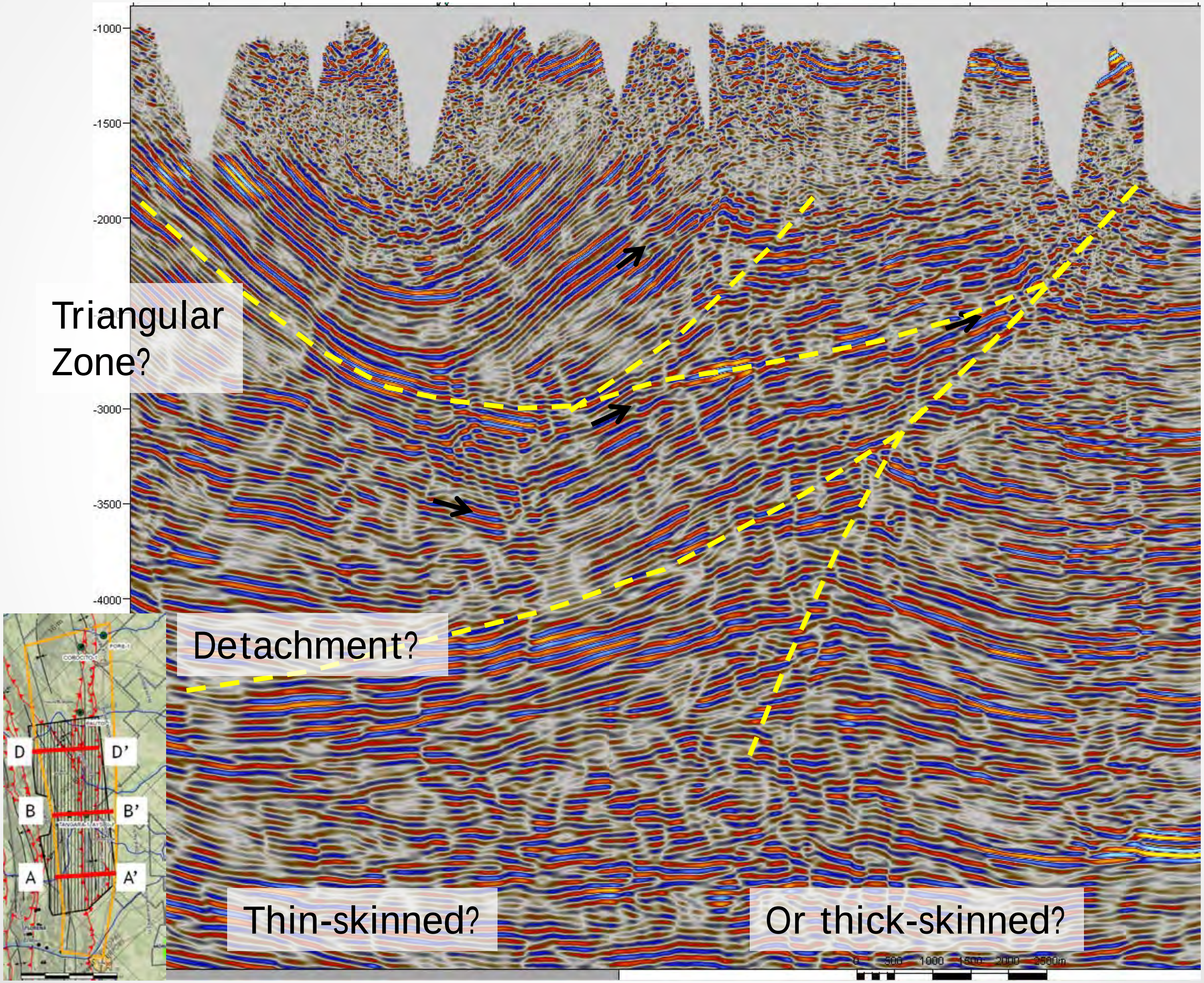
University of Stavanger

Line C-C' 2D Line



University of Stavanger

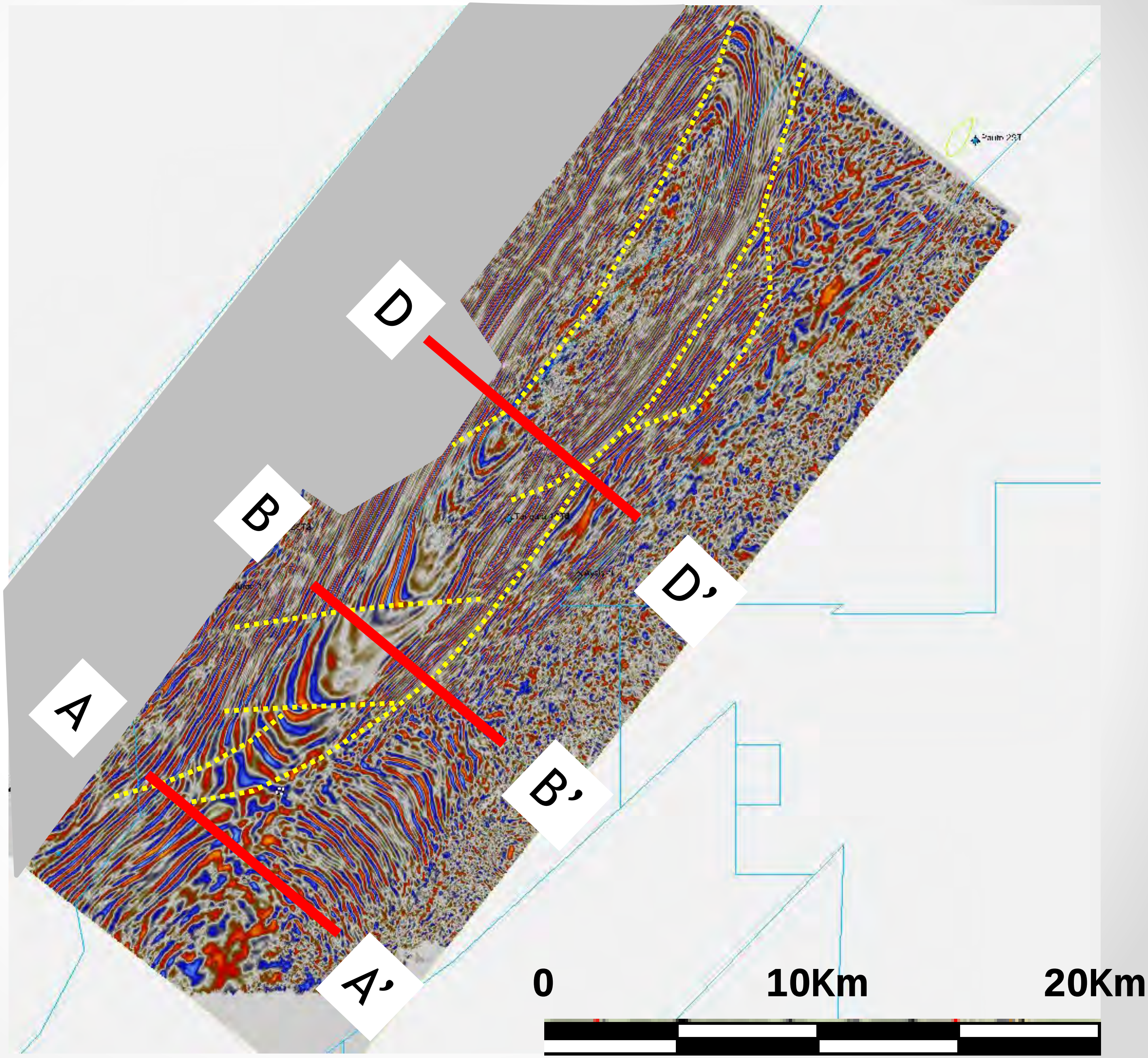
Line D-D’ 3D Line



University of Stavanger

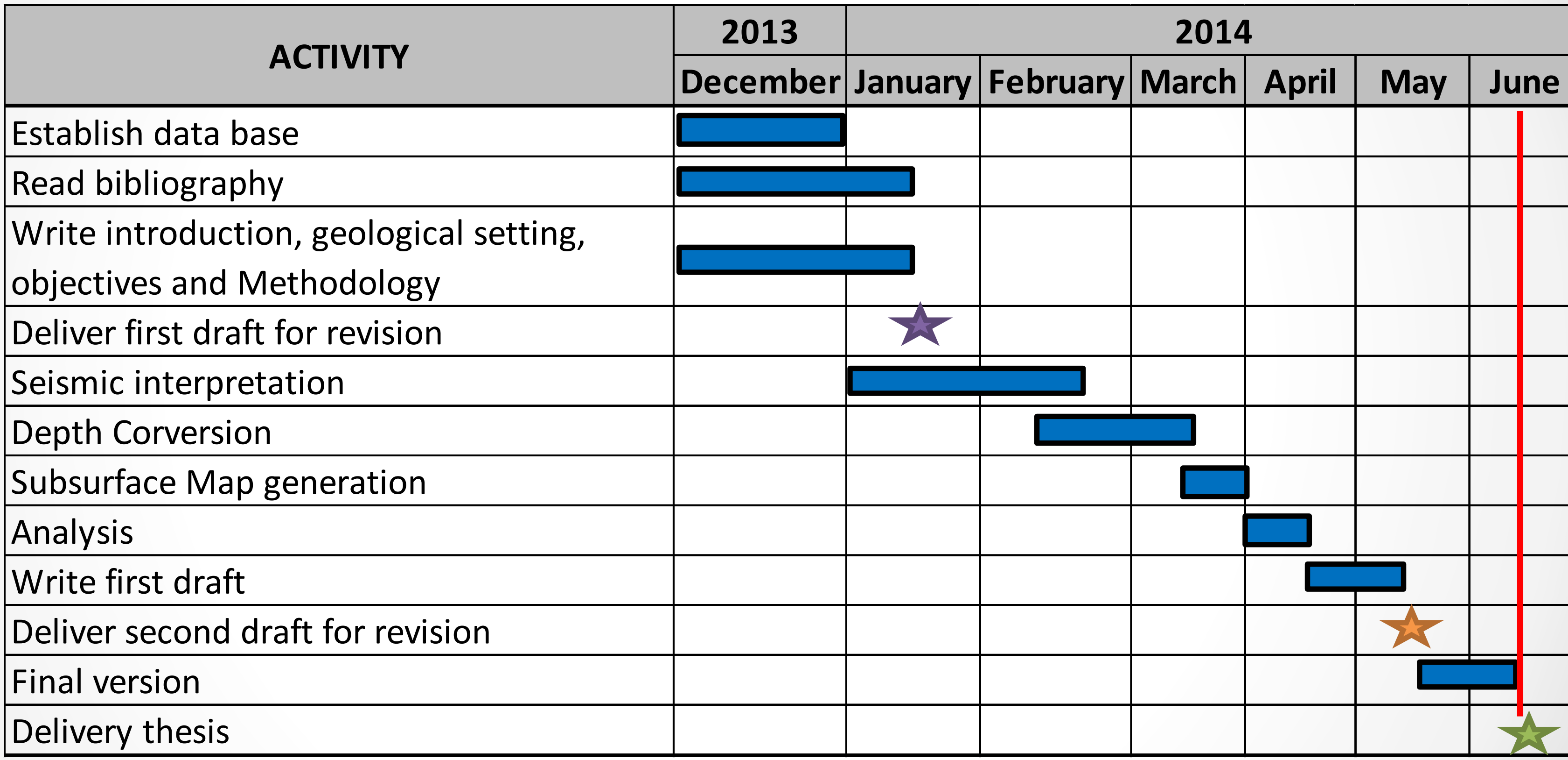
Time slide

-2000ms



University of Stavanger

Time frame



University of Stavanger

Thank you for the attention!

CBTH PHASE IV

Caribbean Basins, Tectonics, & Hydrocarbons

University of Stavanger

UNIVERSITY of HOUSTON

Control on Upper Paleozoic Carbonate Buildup Development in the Norwegian Barents Sea

Erik Magnus Nordaunet-Olsen

05.12.2014

University of Stavanger

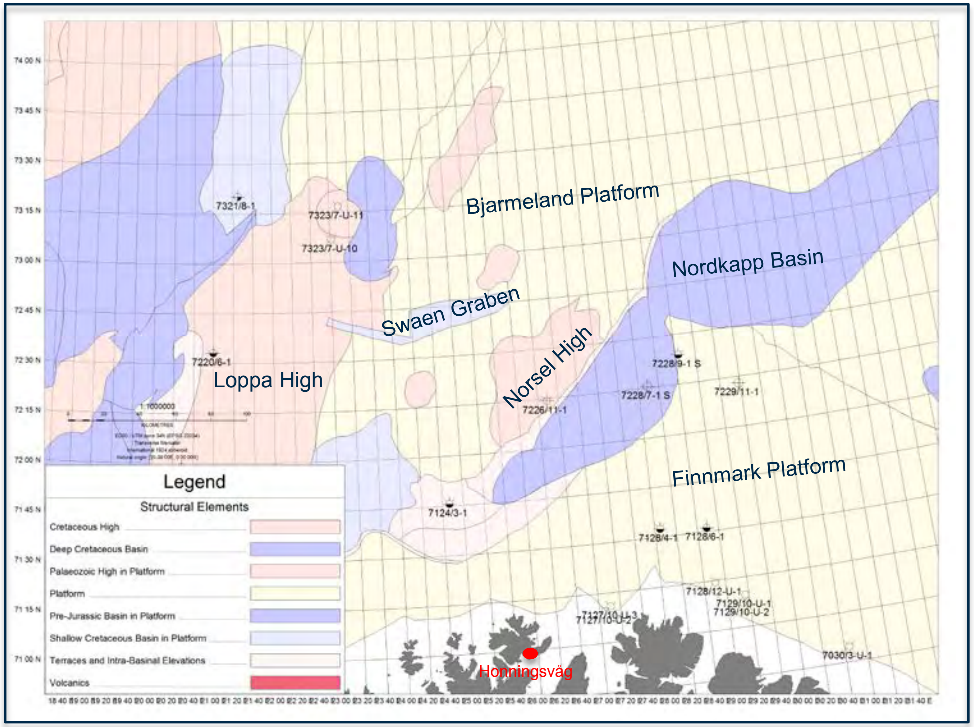
SUNCOR

Content of Presentation

1. Objective
2. Data and Methodology
3. Regional geological setting
4. Controlling factors for deposition of carbonates
5. Preliminary observations
6. Timeframe

Objectives

- 1) Develop a Seismic Stratigraphic framework in order to confidently interpret in areas without well data in the south-eastern Norwegian Barents Sea
- 2) Determine the main controlling factors of Carbonate build-up development: a comparison between Finnmark Platform and Bjarmeland Platform
- 3) Improve understanding of heterozoan (warm water) and photozoan (cold water) carbonate facies distribution in response to antecedent topography

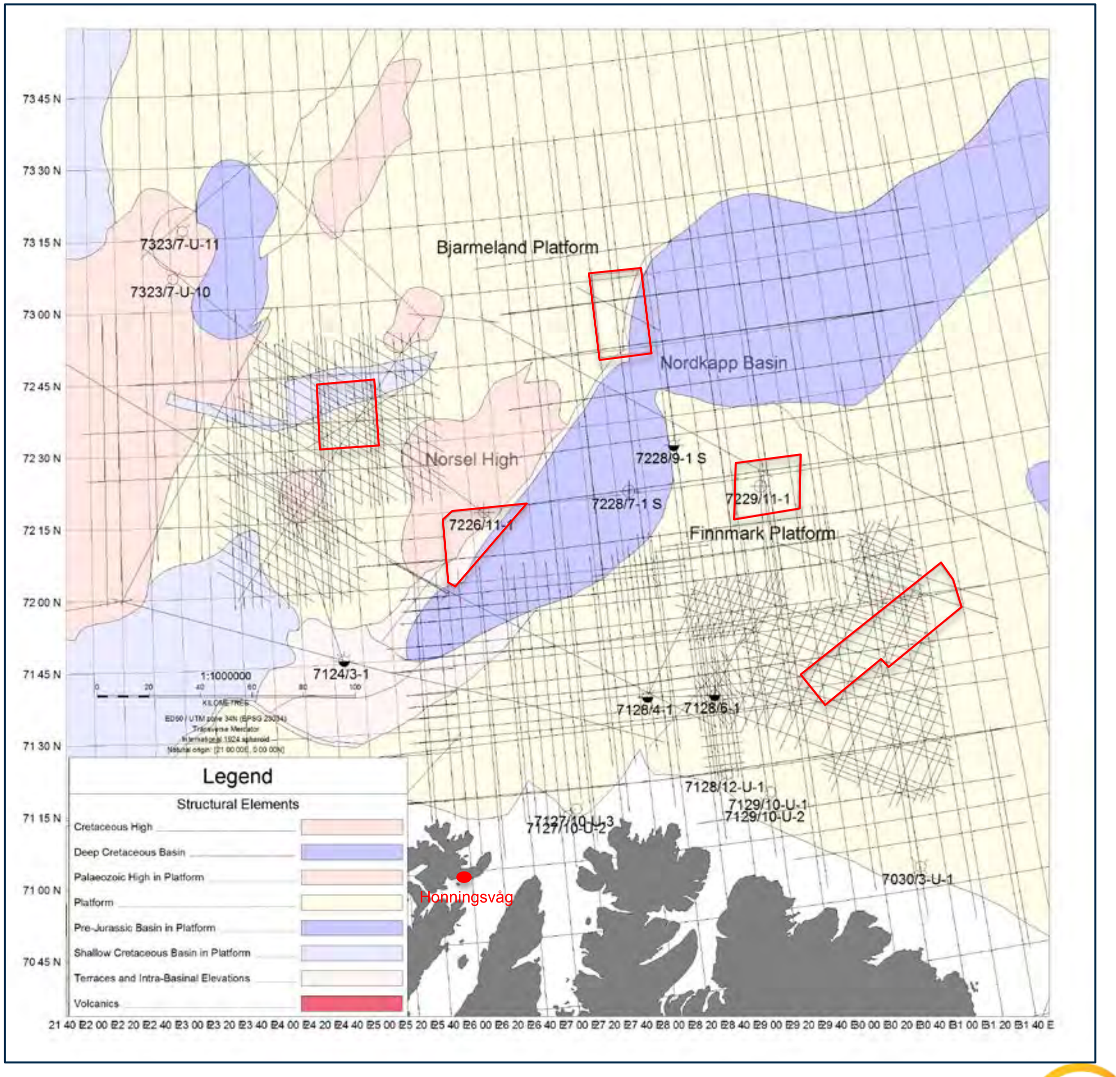


University of Stavanger

SUNCOR

Data Coverage

- Five 3D seismic cubes
- 2D Seismic data to tie between the 3D cubes
- 15 Wells penetrating the Upper Paleozoic succession:
  - 7 Wildcat wells
  - 8 IKU Shallow drilling wells

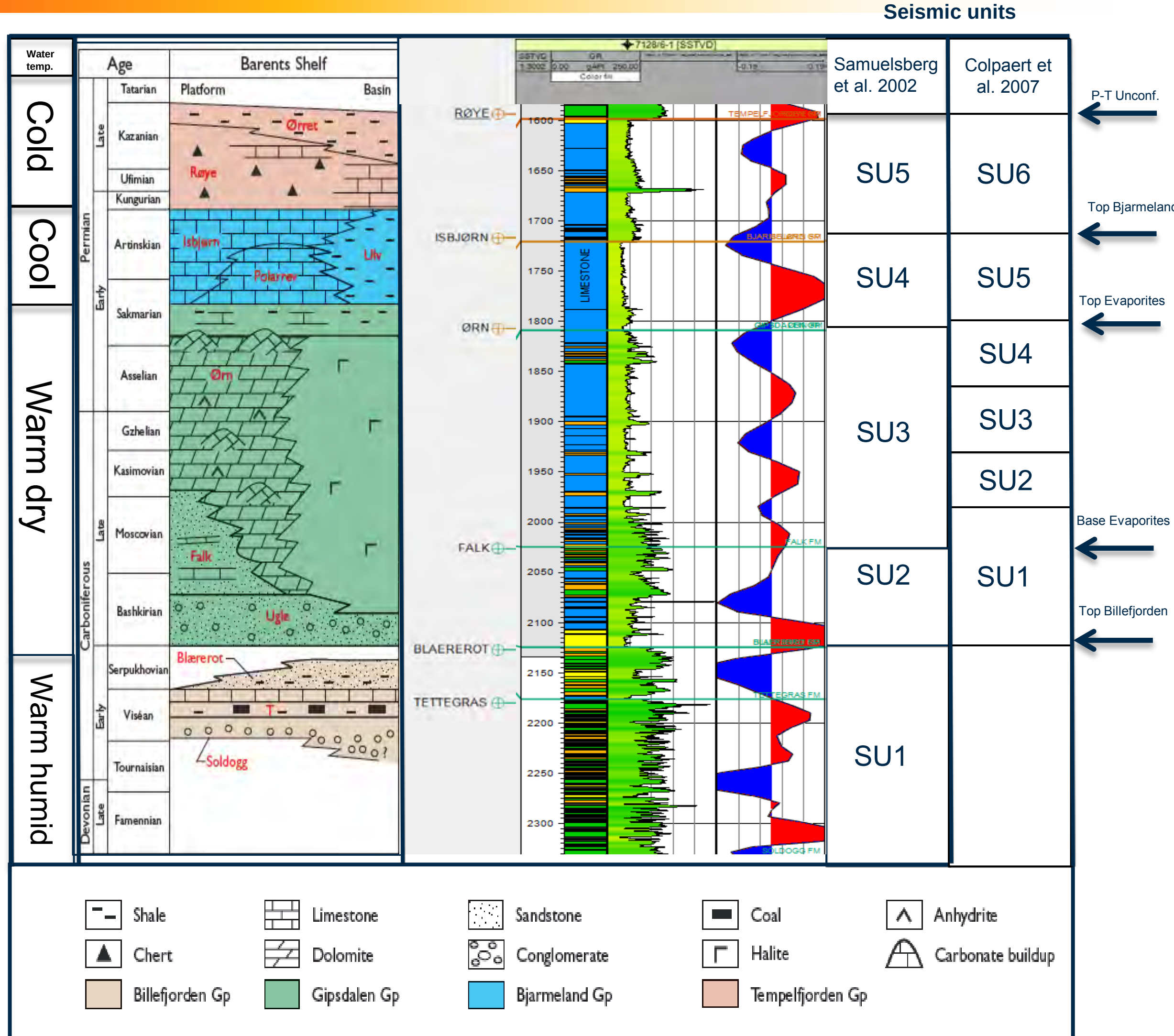


University of Stavanger

SUNCOR

Methodology

- Build a seismic stratigraphic framework based on key wells
- Detailed seismic interpretation of the Gipsdalen- and Bjarmeland Groups on the Finnmark- and Bjarmeland Platforms
- Apply seismic attributes to enhance visibility of carbonate build-ups, faults, and evaporite ponds
  - Petrel 2014
  - ffA GeoTeric

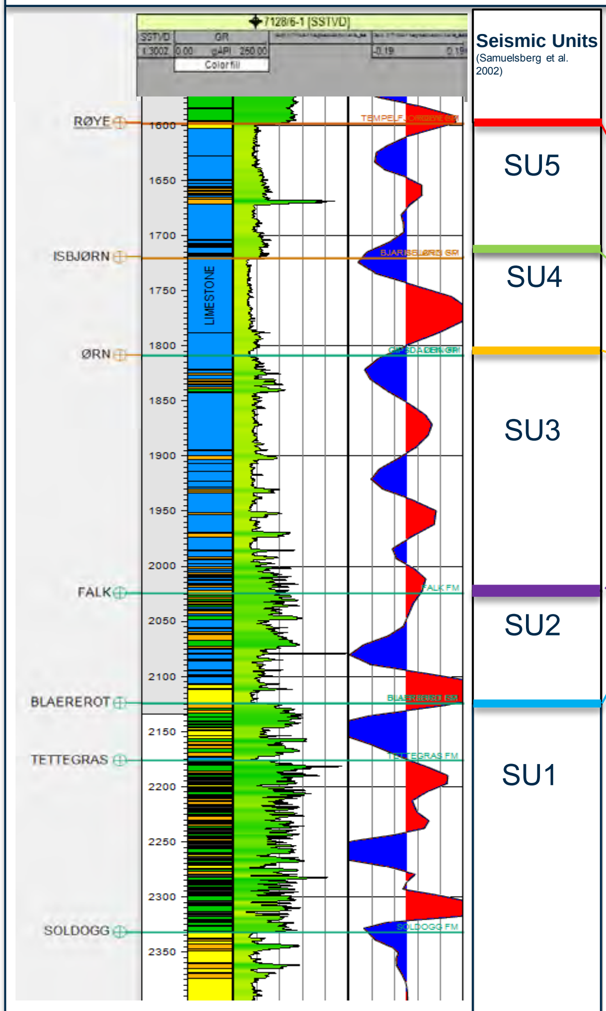


Modified from Colpaert et al. (2007); Samuelsberg et al. (2002)

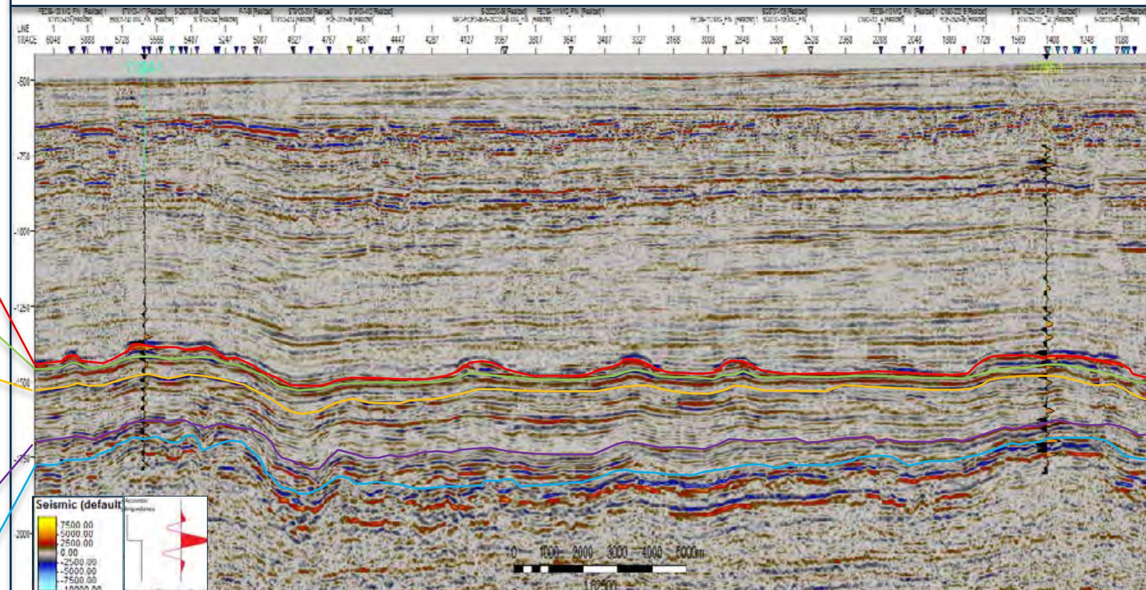
University of Stavanger

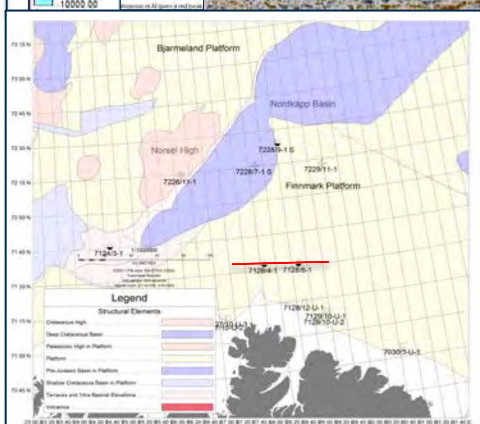
Methodology

7128/6-1



2D Seismic section throuh well 7128/4-1 and 7128/6-1



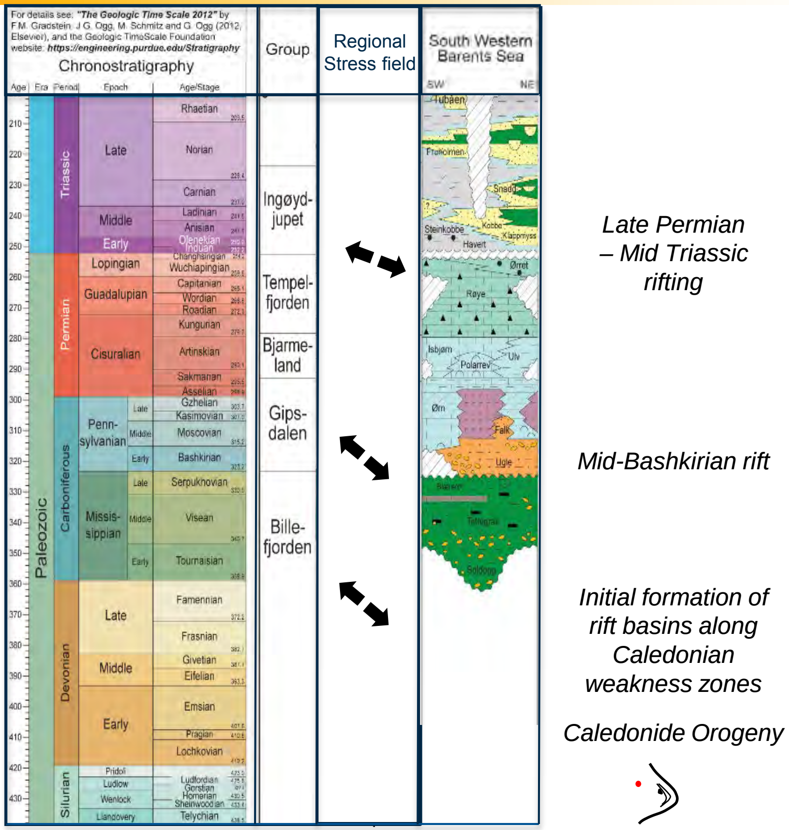


University of Stavanger

SUNCOR

Regional Structural Framework

- Late Devonian rifting
- Pre-evaporite peneplane in Mississippian
- Synrift infill of evaporites and deposition of basinal salts in Pennsylvanian
- Deposits of warm to cold water carbonates from Pennsylvanian to Late Permian

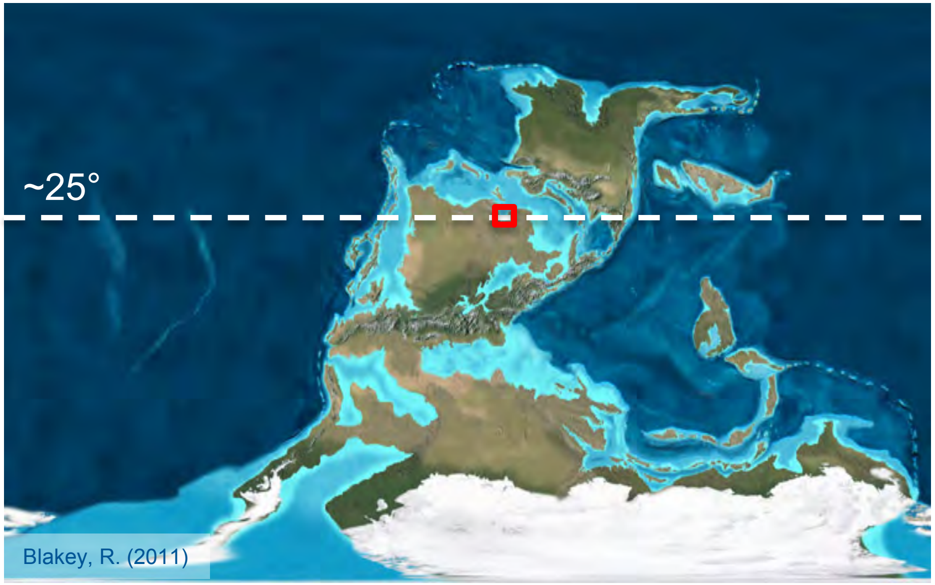


University of Stavanger

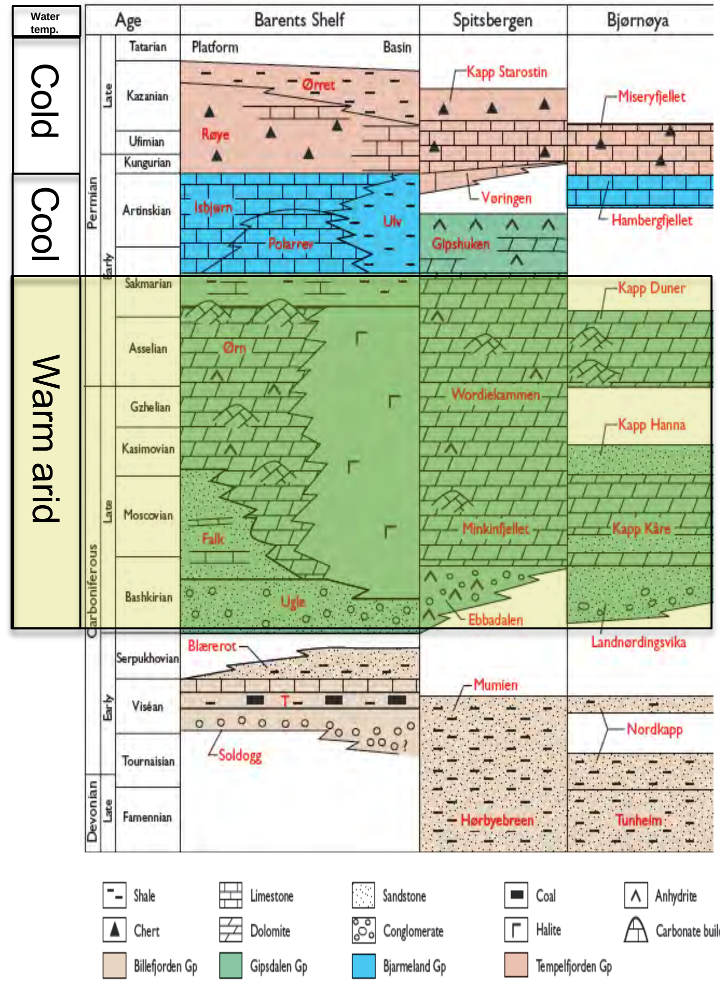
SUNCOR

Modified from Norlex lithostratigraphy, 2014

Regional Setting - Upper Paleozoic – Gipsdalen Group



Paleolatitude located in arid-tropical setting

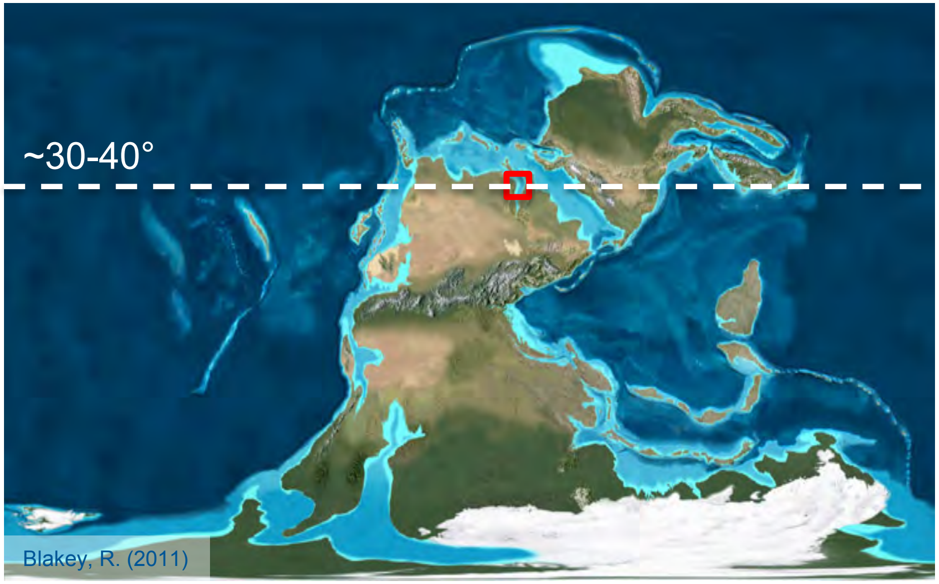


Modified from Larssen et al. (2005)

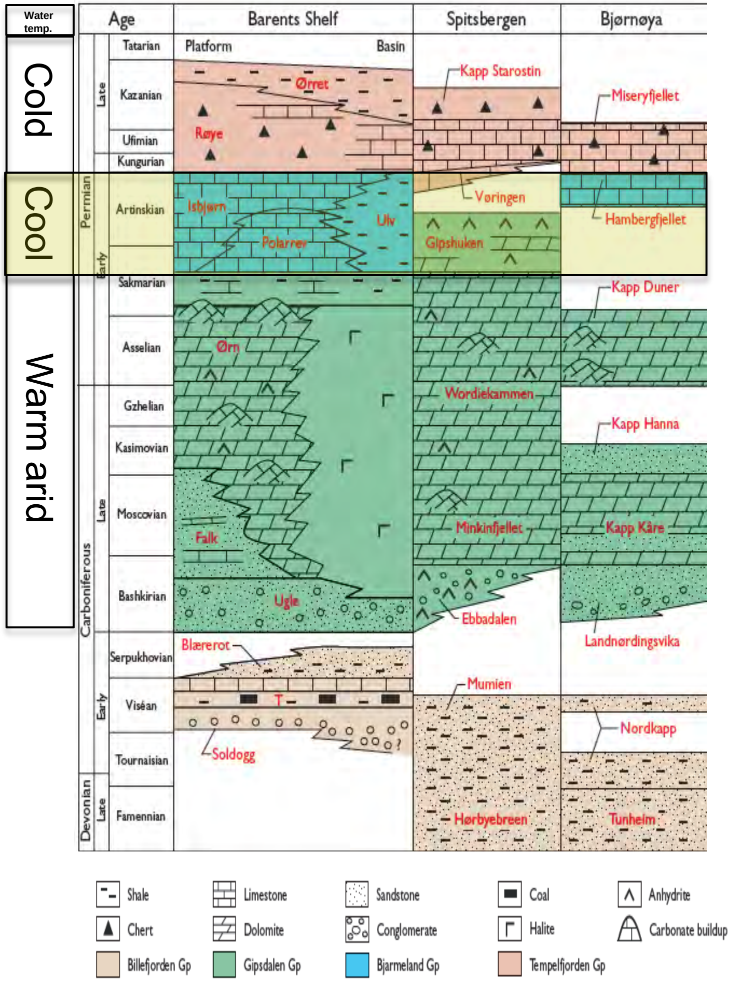
University of Stavanger

SUNCOR

Regional Setting - Upper Paleozoic – Bjermeland Group



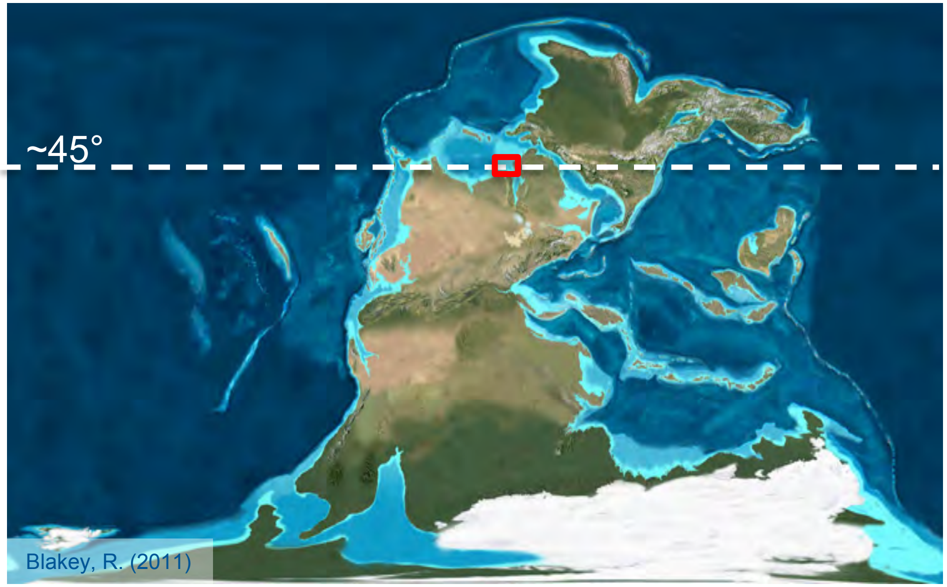
Dramatic change in paleolatitude
from tropical to sub-tropical environments



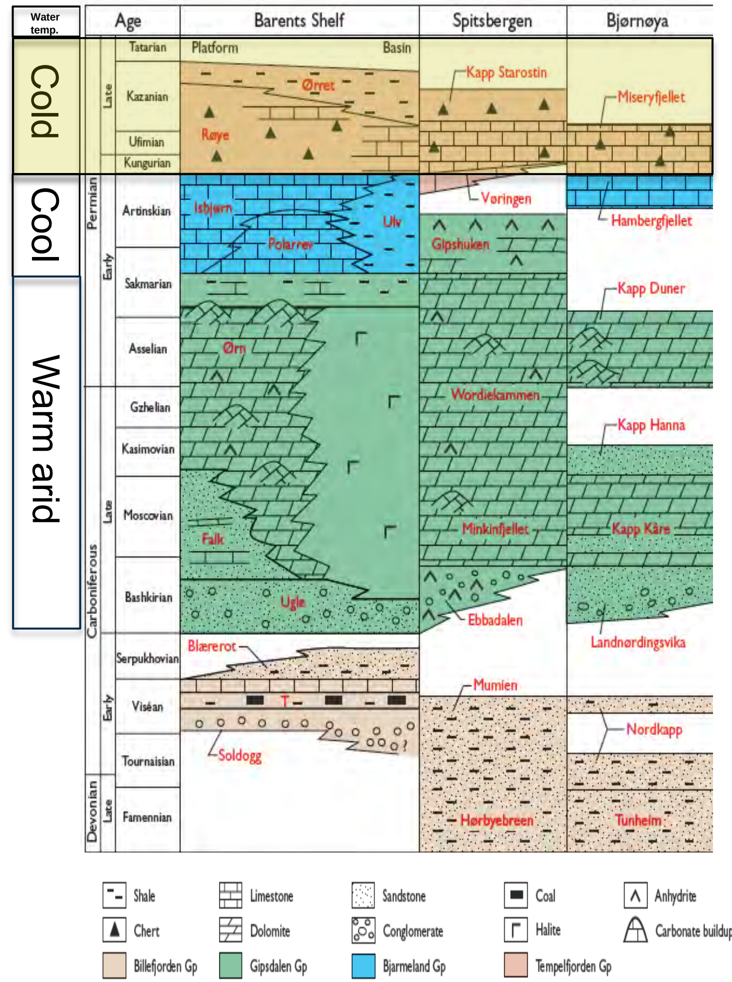
Modified from Larssen et al. (2005)

University of Stavanger
SUNCOR

Regional Setting - Upper Paleozoic – Gipsdalen Group



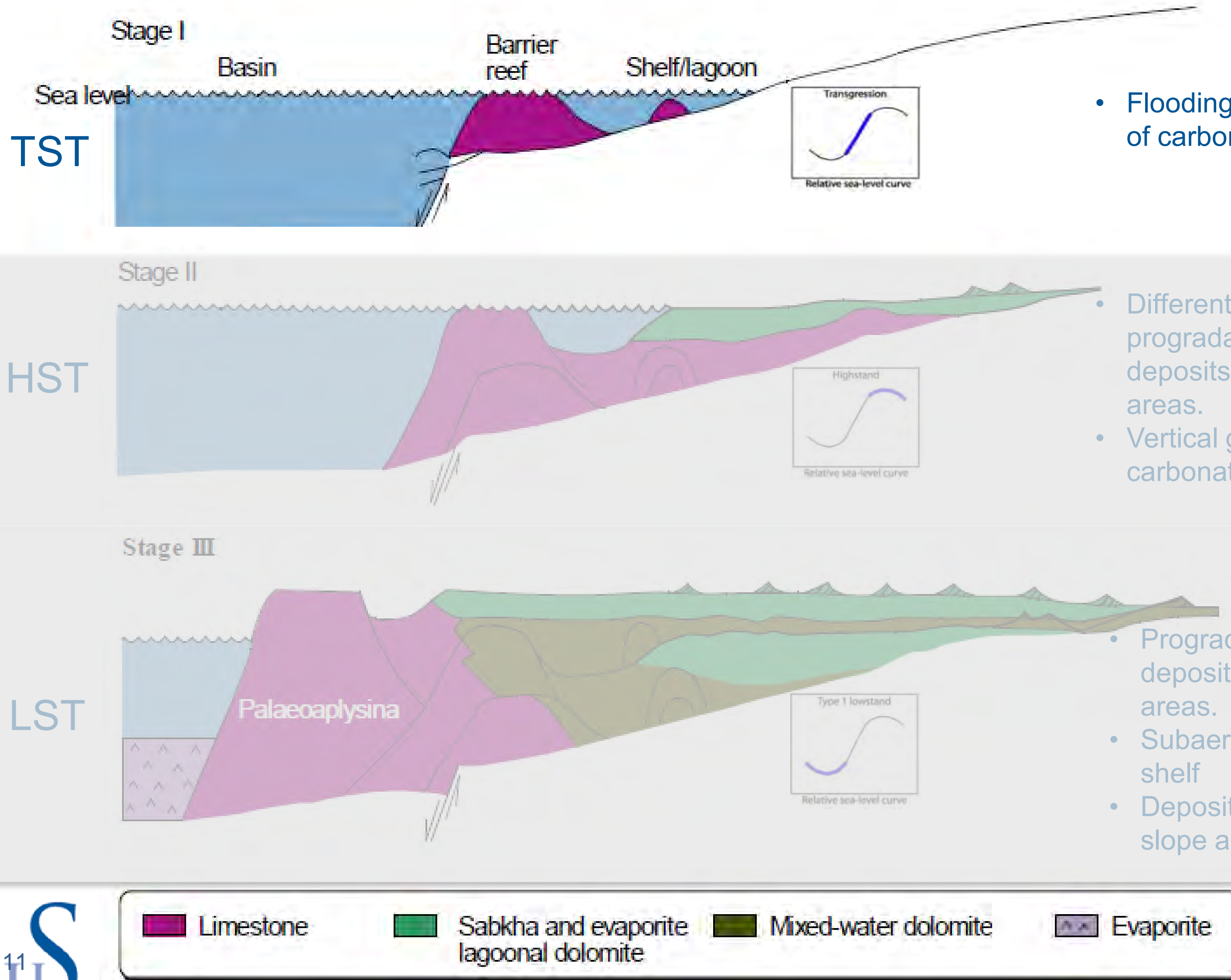
Dramatic change in paleolatitude
from sub-tropical to colder environments



Modified from Larssen et al. (2005)

University of Stavanger
SUNCOR

Depositional Evolution – Gipsdalen Group



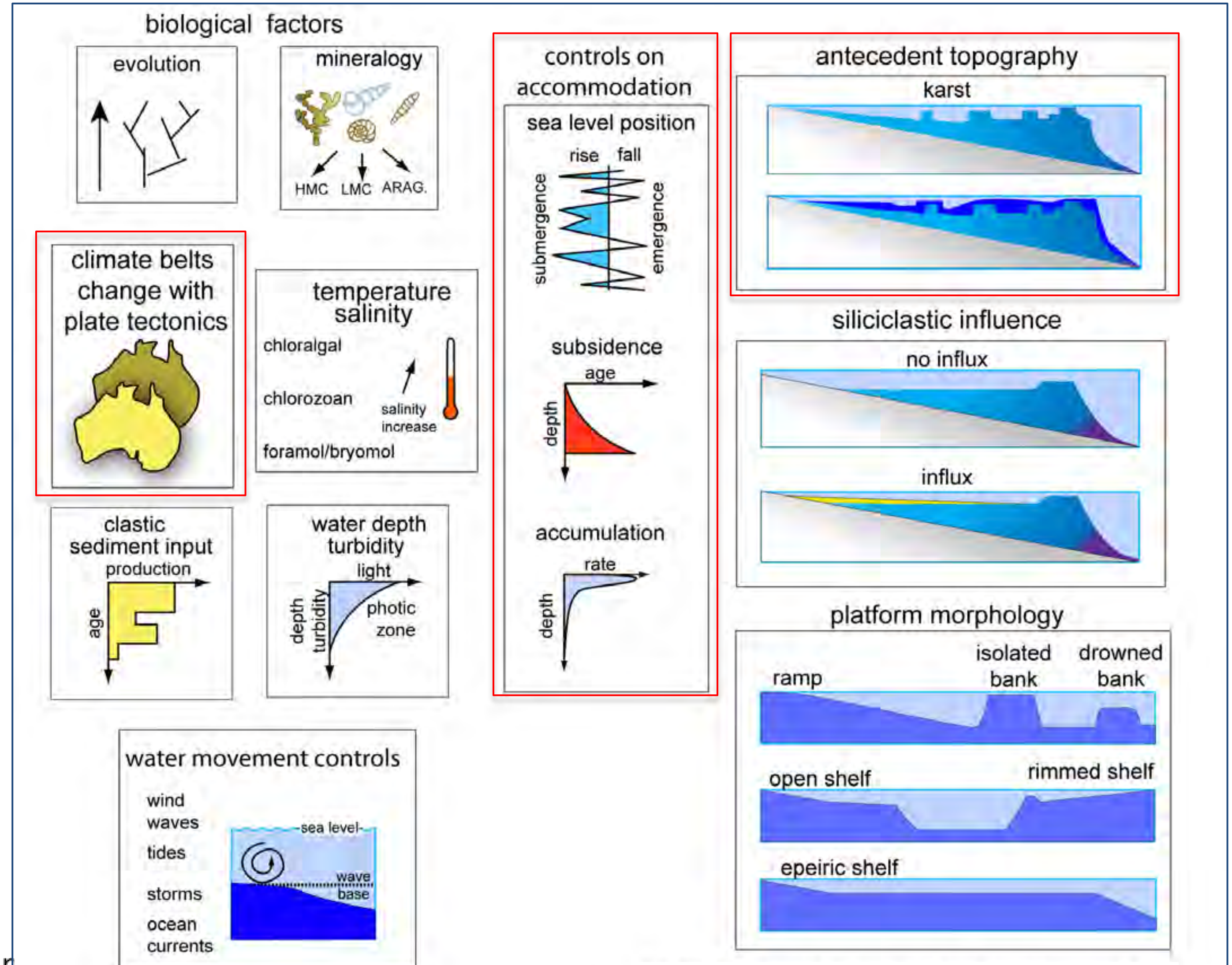
- Flooding the platform and initial growth of carbonate reefs on flooding surface.

- Differential subsidence led to progradation of sabkha and lagoonal deposits in the inner- and mid-shefal areas.
- Vertical growth and progradation of carbonate reefs in the outer shelf

- Progradation of sabkha and lagoonal deposits in the inner- and mid-shefal areas.
- Subaerial exposure of the entire shelf
- Deposits of evaporites in the shelf, slope and basin.

Modified from Elvebakk et al. (2003)

Controlling Factors for Deposition of Carbonates



Kendall and Tucker (2010); Jones and Desrochers (1992)

Preliminary Observations

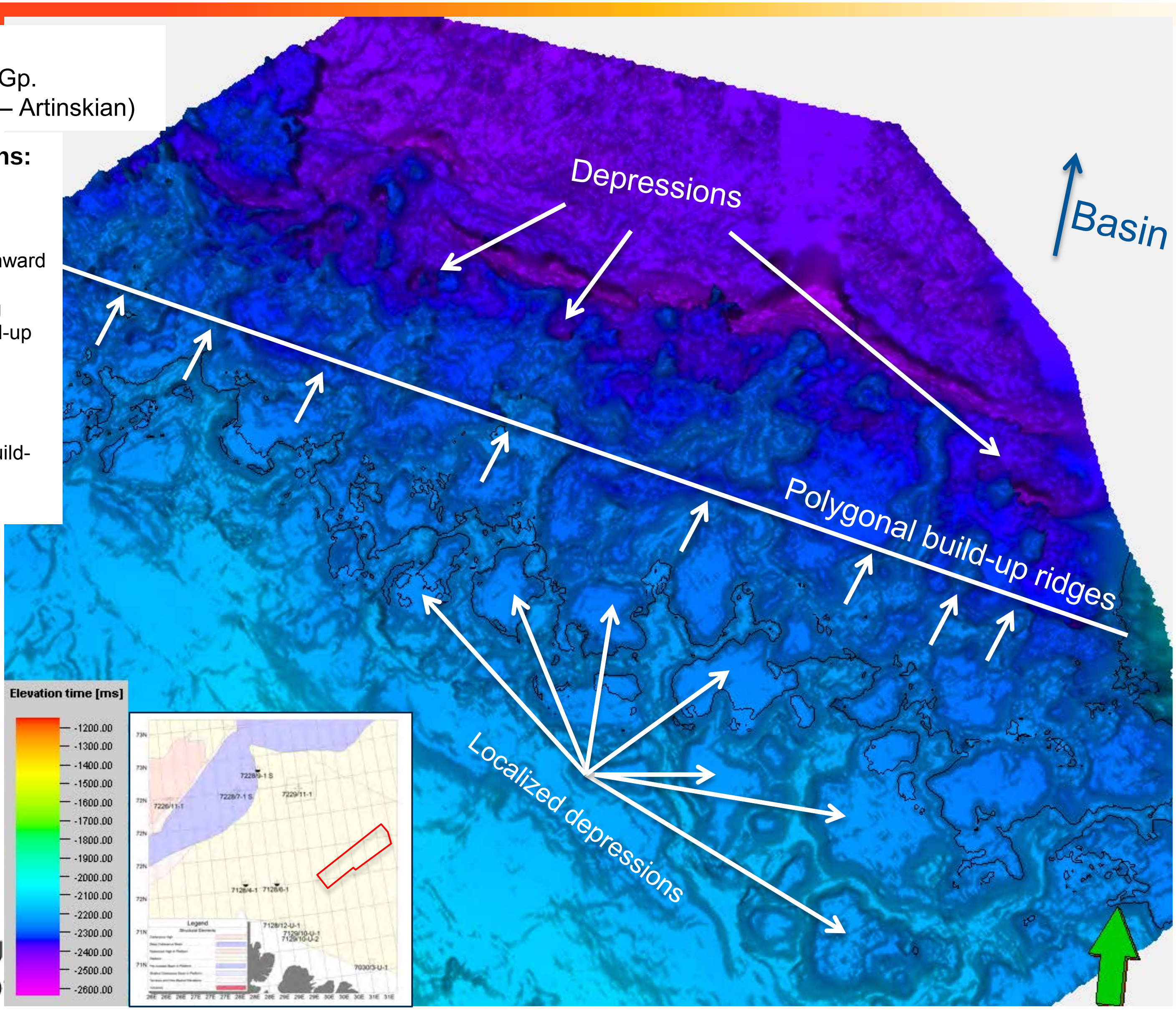
Surface:
Bjarmeland Gp.
(Sakmarian – Artinskian)

Observations:

1) Small depressions observed basinward

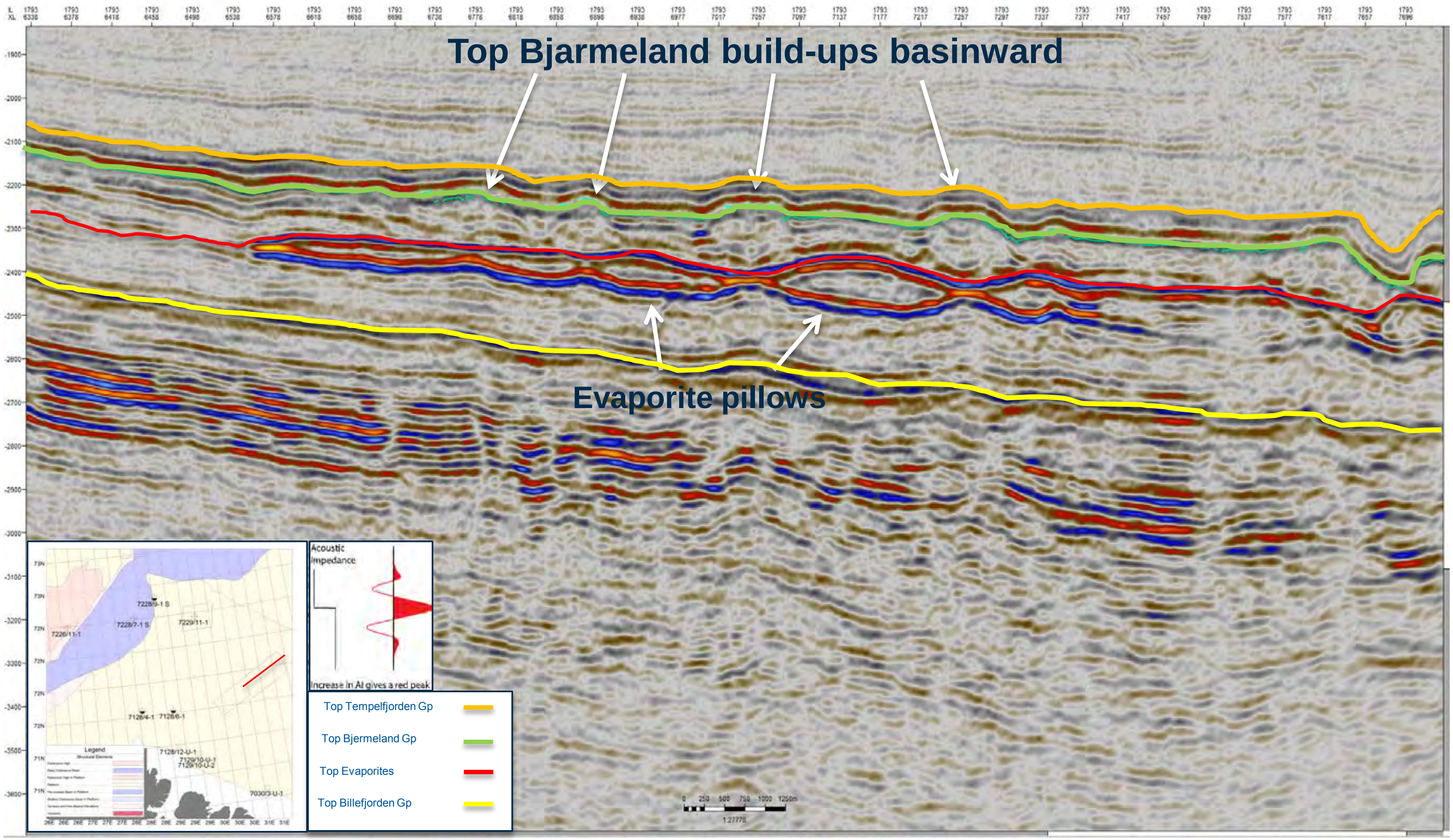
2) E-W Striking Polygonal build-up ridges

3) Localized depressions in between the build-up ridge.



3D Cube - ST0902

Preliminary Observations

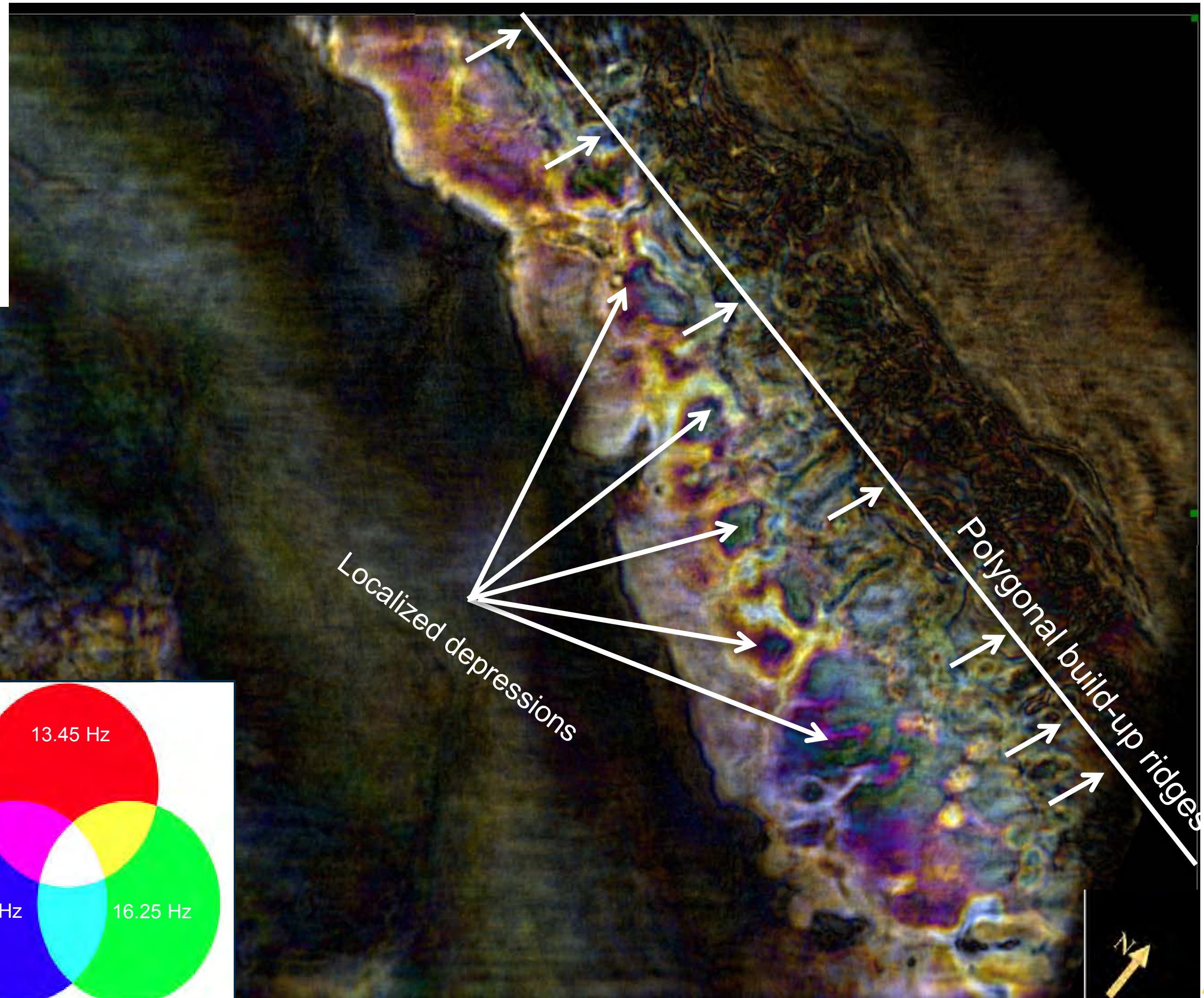


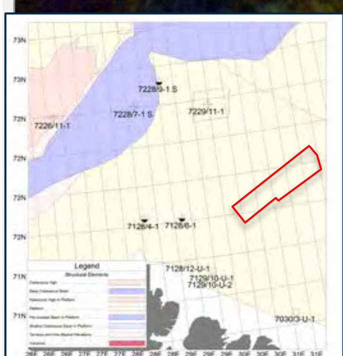
ST9802 – Inline 1756

Preliminary Observations – GeoTeric Example

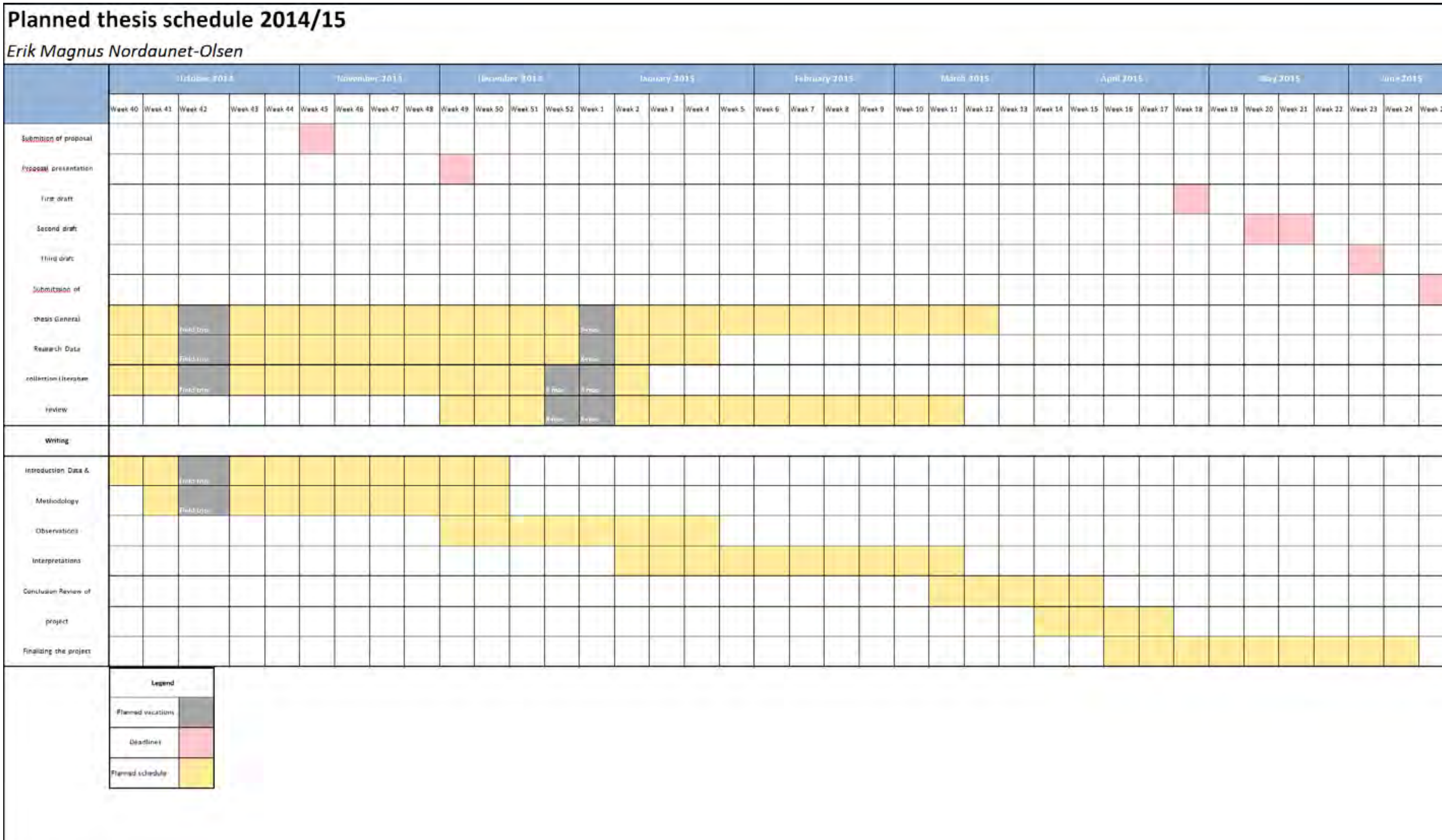
Surface:
Bjarmeland Gp.
(Sakmarian – Artinskian)

Colorblended Spectral Decomposition
Red: 13.45 Hz
Green: 16.25 Hz
Blue: 27.86 Hz





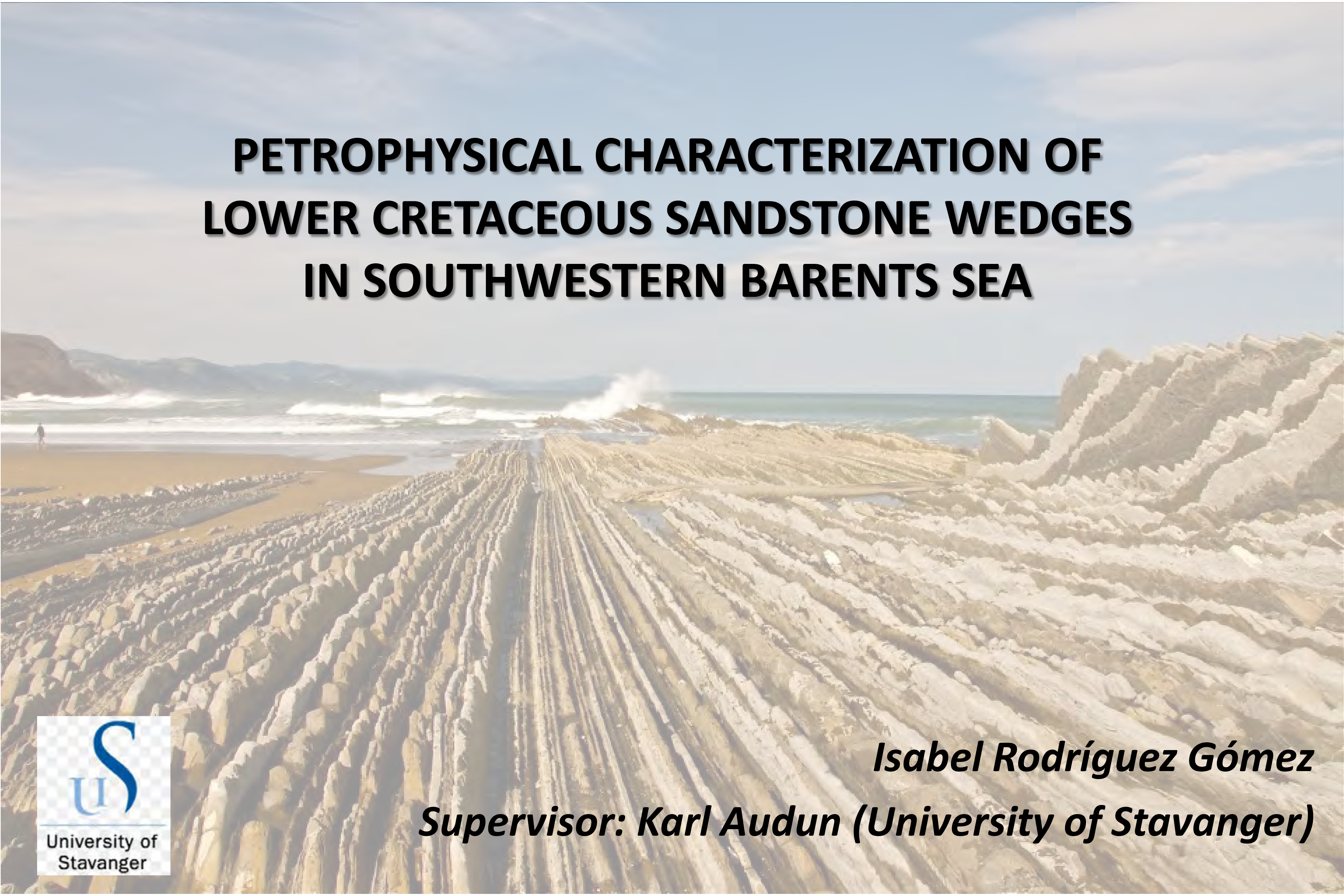
Timeframe



University of Stavanger

Thank you

Q&A



PETROPHYSICAL CHARACTERIZATION OF LOWER CRETACEOUS SANDSTONE WEDGES IN SOUTHWESTERN BARENTS SEA

Isabel Rodríguez Gómez

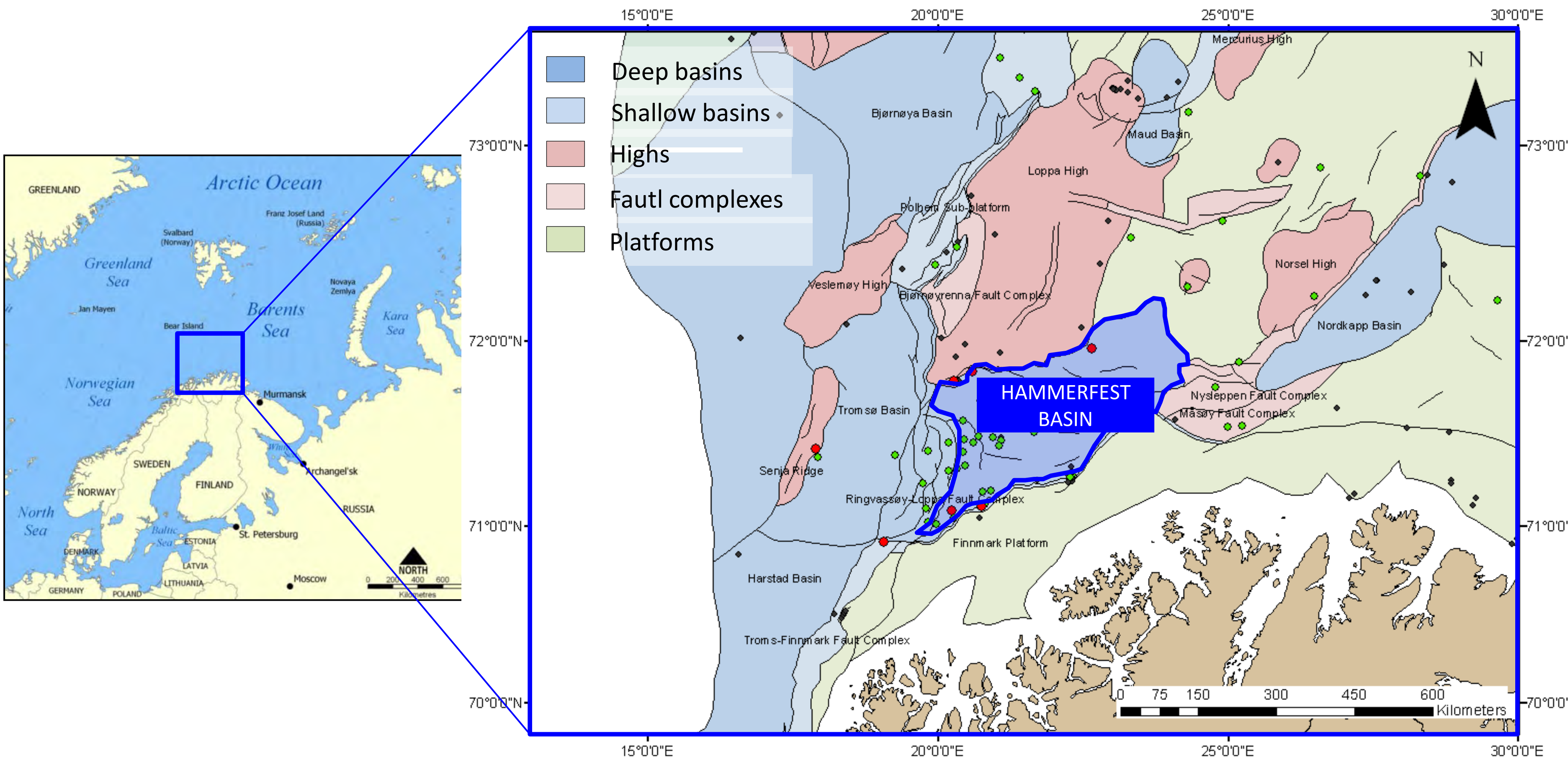
Supervisor: Karl Audun (University of Stavanger)

University of Stavanger

OUTLINE

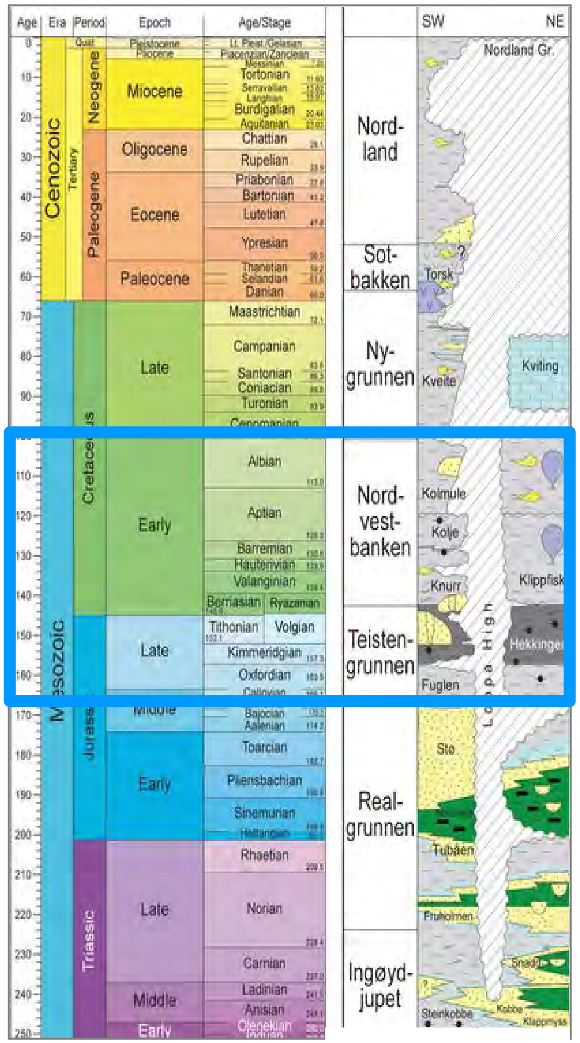
1. STUDY AREA
2. REGIONAL GEOLOGY
3. LOWER CRETACEOUS PLAY
4. OBJECTIVES
5. METHODOLOGY
6. DATA
7. TIME FRAME

STUDY AREA

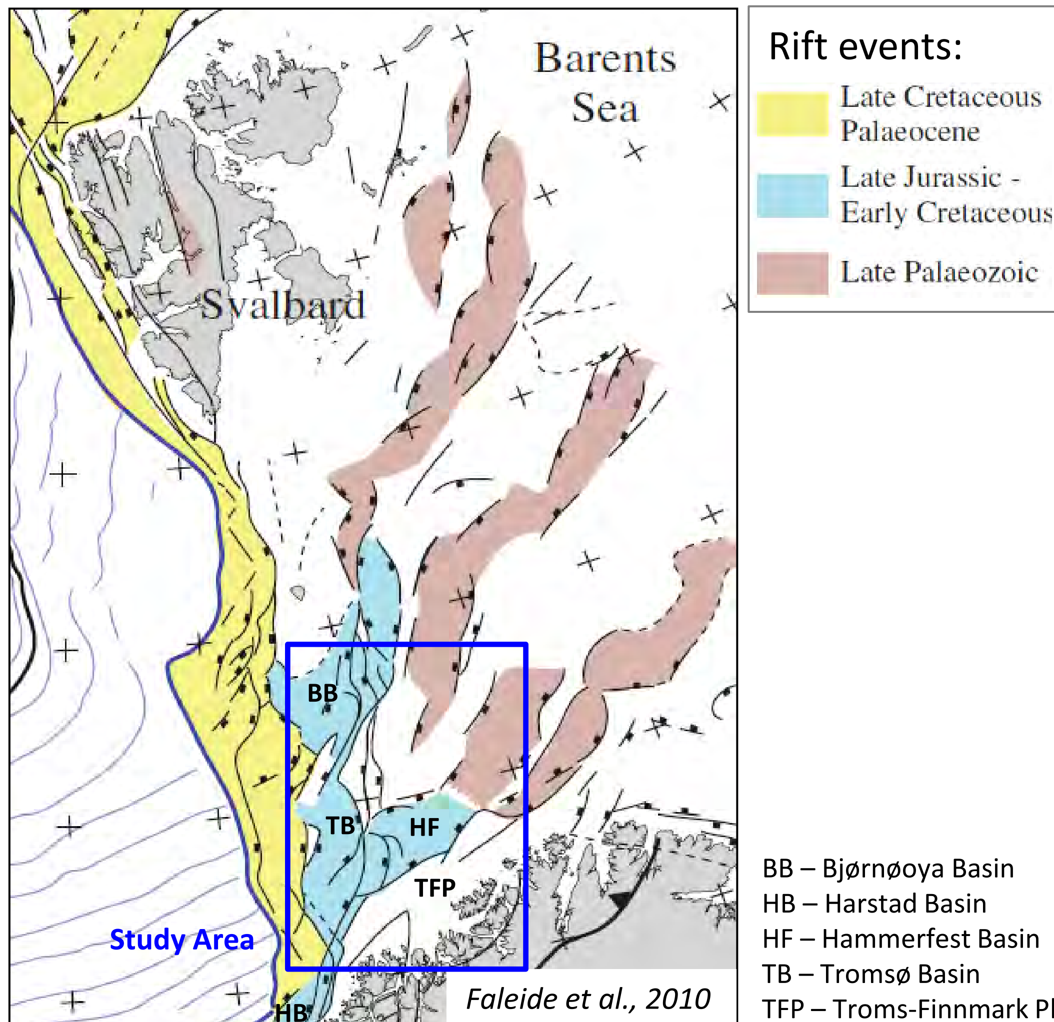


GREENLAND
Arctic Ocean
Franz Josef Land (Russia)
Svalbard (Norway)
Greenland Sea
Novaya Zemlya
Jan Mayen
Barents Sea
Bear Island
Kara Sea
Norwegian Sea
Murmansk
SWEDEN
FINLAND
NORWAY
Archangel'sk
RUSSIA
North Sea
Baltic Sea
ESTONIA
St. Petersburg
DENMARK
LATVIA
LITHUANIA
Moscow
GERMANY
POLAND
NORTH
Kilometres
Deep basins
Shallow basins
Highs
Fautl complexes
Platforms
15°0'0"E
20°0'0"E
25°0'0"E
30°0'0"E
73°0'0"N
72°0'0"N
71°0'0"N
70°0'0"N
N
Mercurius High
Bjørnøya Basin
Maud Basin
Loppa High
Polhem Sub-platform
Veslemøy High
Bjørnøyrenna Fault Complex
Norsel High
Nordkapp Basin
HAMMERFEST BASIN
Nysleppen Fault Complex
Måsøy Fault Complex
Tromsø Basin
Senja Ridge
Ringvassøy-Loppa Fault Complex
Finnmark Platform
Harstad Basin
Troms-Finnmark Fault Complex
0 75 150 300 450 600
Kilometers

REGIONAL GEOLOGY



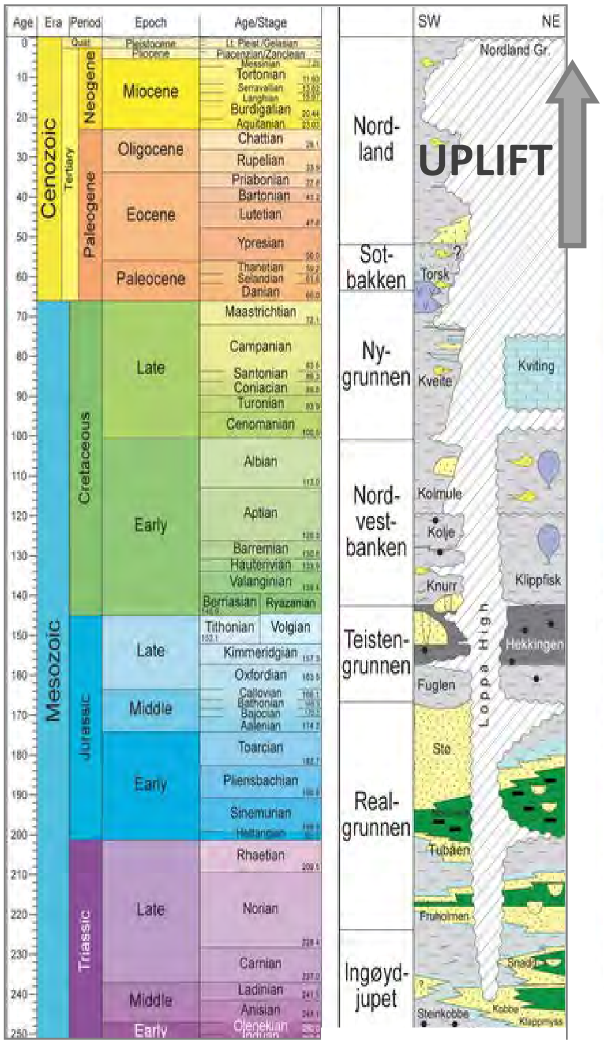
Gabi Ogg, 2013



Faleide et al., 2010

BB – Bjørnøoya Basin
HB – Harstad Basin
HF – Hammerfest Basin
TB – Tromsø Basin
TFP – Troms-Finnmark Platform

REGIONAL GEOLOGY

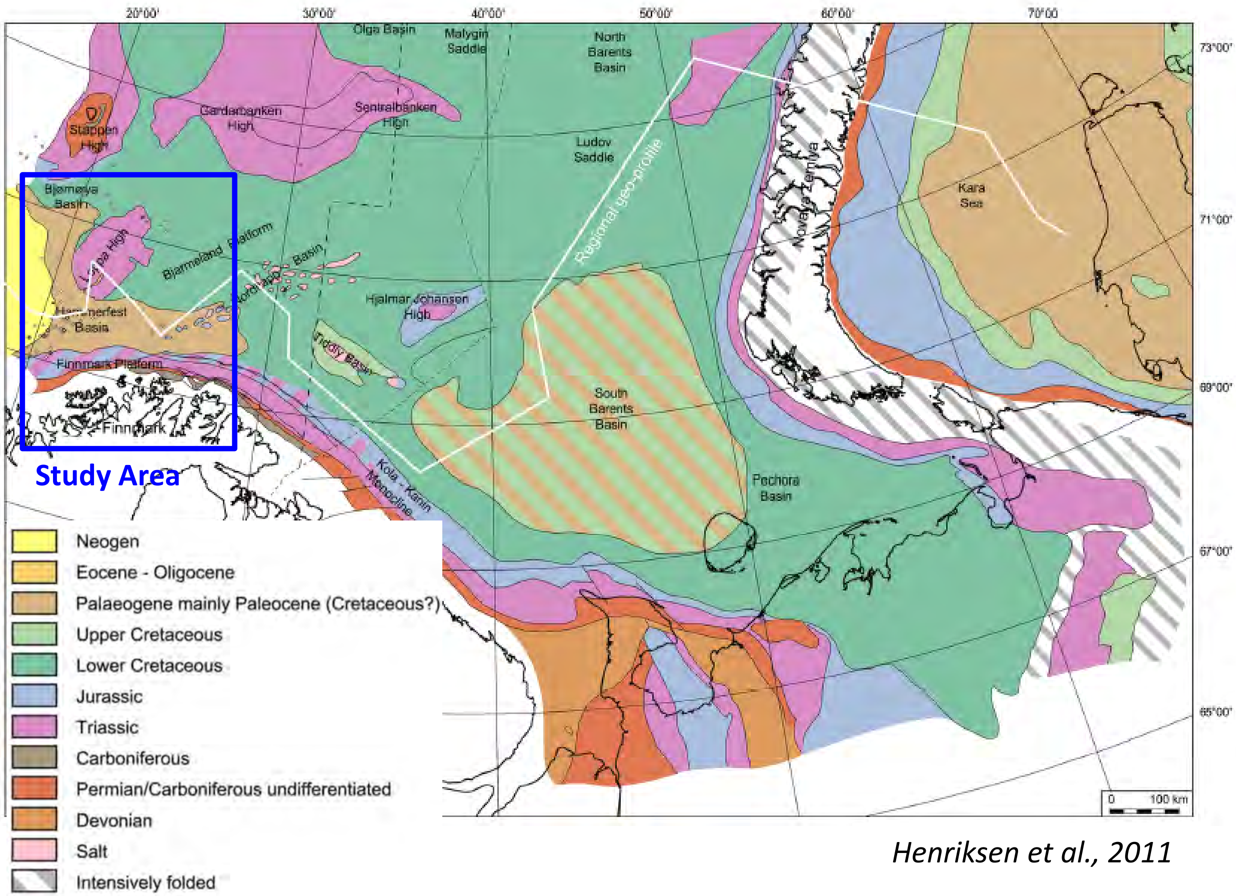


Gabi Ogg, 2013

MATURITY

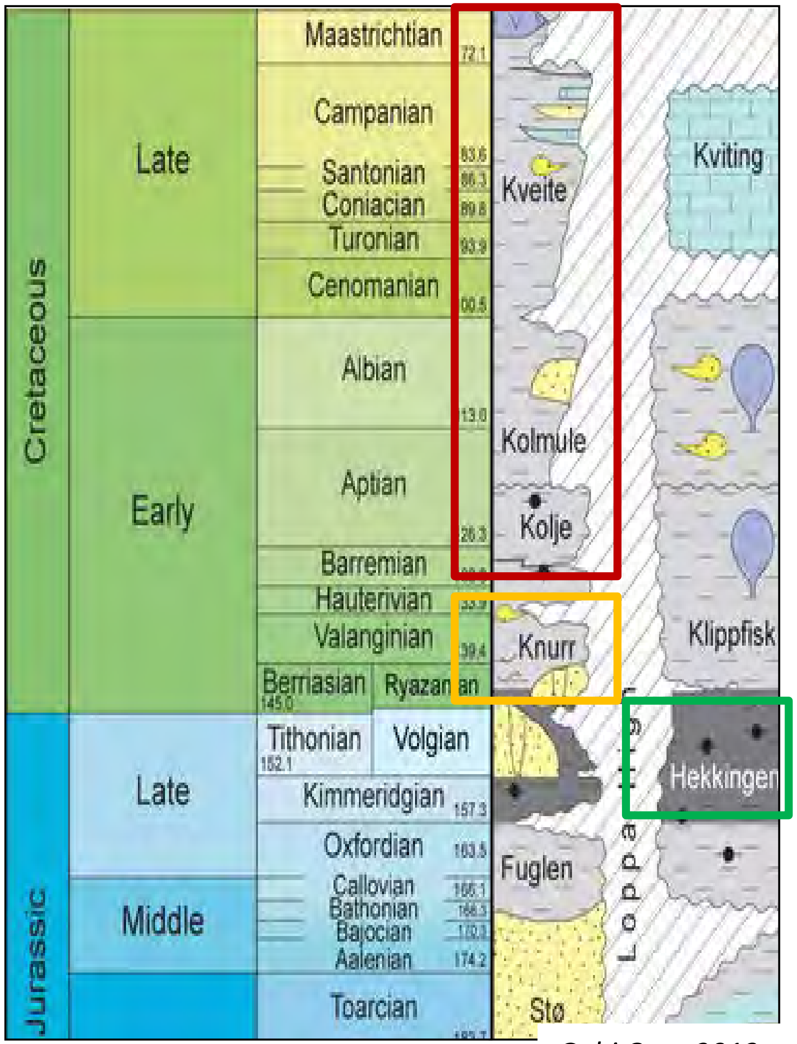
MIGRATION

RESERVOIR QUALITY



Henriksen et al., 2011

LOWER CRETACEOUS SANDSTONE WEDGES
A PROMISING PLAY



Gabi Ogg, 2013

SOURCE – HEKKINGEN FM

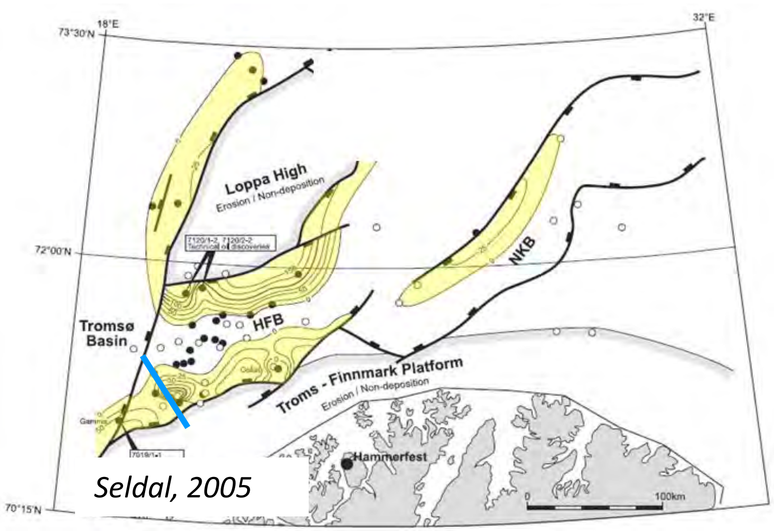
RESERVOIR – KNURR FM

SEAL – LOWER/UPPER CRETACEOUS

TRAP – STRUCTURAL + STRATIGRAPHIC PINCH OUT

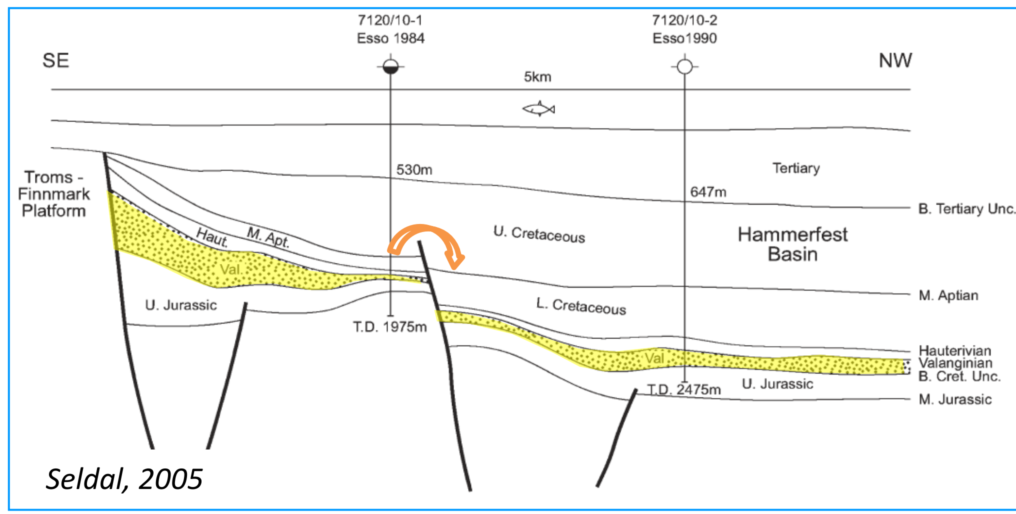
PLAY CONCEPT

KNURR RESERVOIR:
Turbidites forming hanging-wall wedge fans and spillover fans



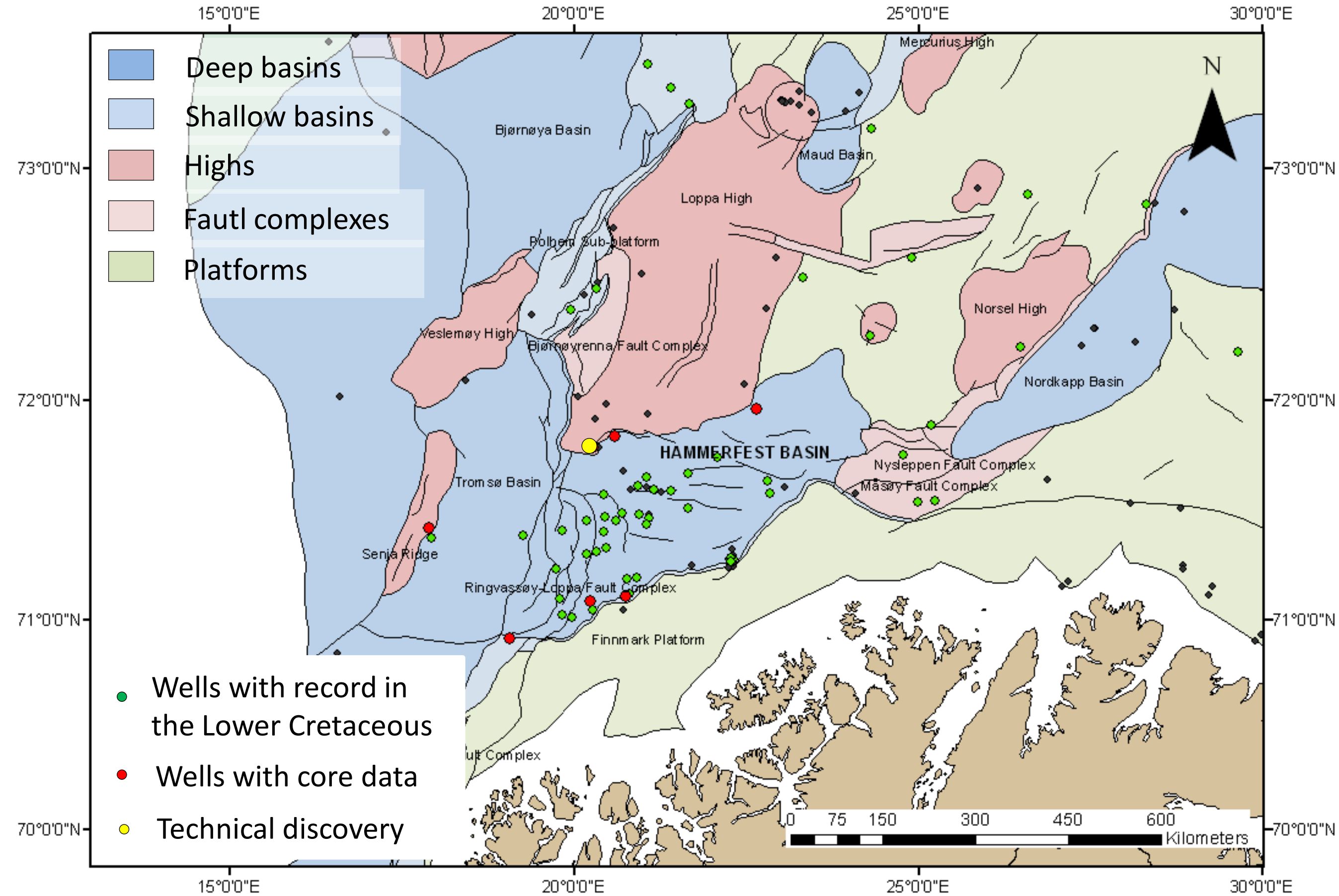
Seldal, 2005

Lower Cretaceous gross sandstone thickness map



Seldal, 2005

INTERESTING FACTS



- **21 wells with shows in Lower Cretaceous**
- **1 technical discovery**
- **Only 4 wells had Knurr as a target**

OBJECTIVE

Petrophysical analysis of Lower Cretaceous sandstone wedges

- Reservoir quality of Knurr turbidites
- $V_{HC} = A * \boxed{H * \frac{N}{G} * \emptyset * (1 - Sw)}$ <u>Oil Column Estimation</u>
- Integration of results in a basin scale to improve the understanding of the Lower Cretaceous

METHODOLOGY

POROSITY

PERMEABILITY

WATER SATURATION

$\emptyset_T$ $\emptyset_E$

$$\emptyset_T = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f}$$

mineral 1 mineral 2 mineral 3

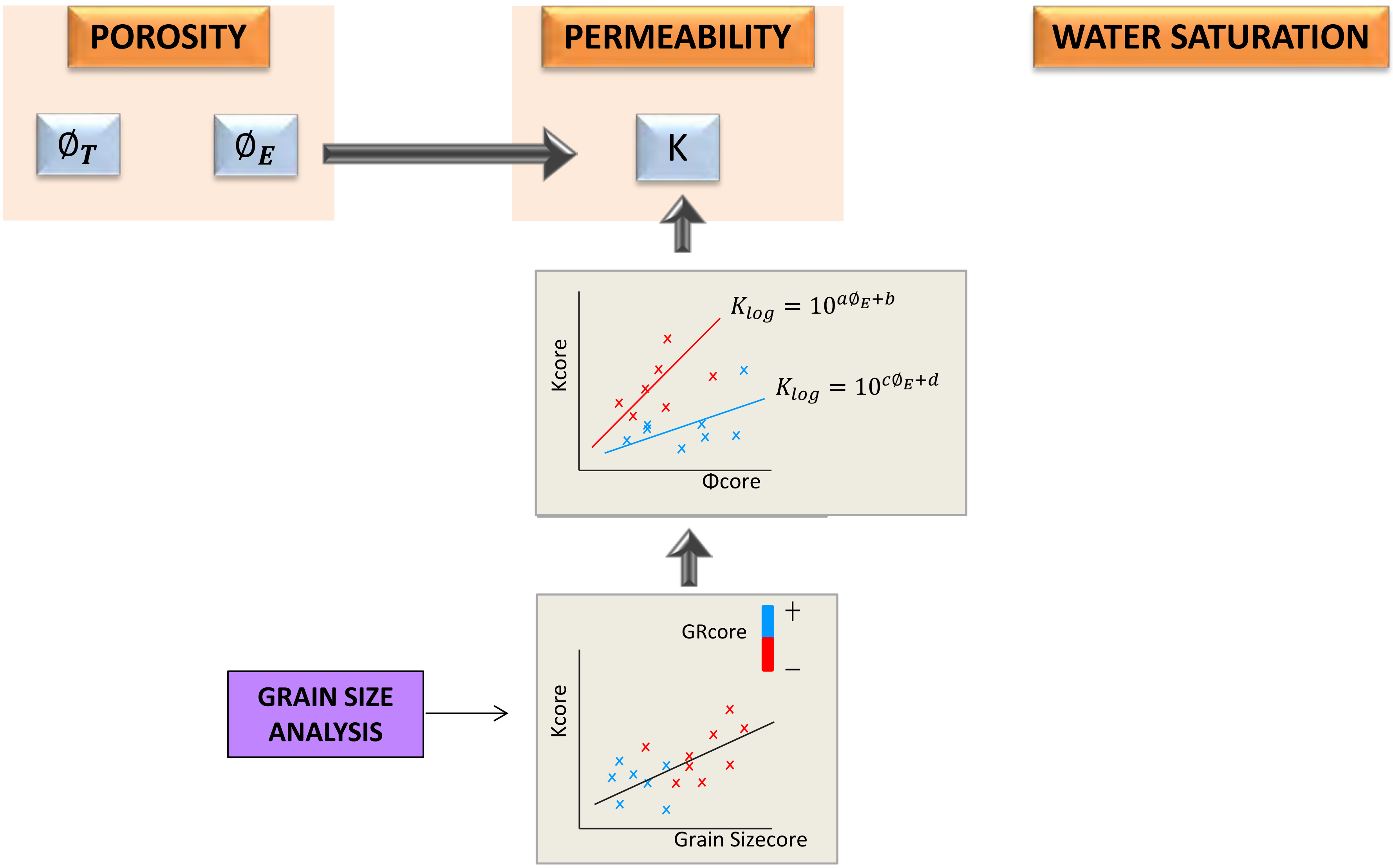
$$\rho_{ma} = \rho_{ma1} * V_1 + \rho_{ma2} * V_2 + \rho_{ma3} * V_3$$

MINERAL MODELS → V1 V2 V3

INPUNT

MINERALOGY FROM CORE DATA

METHODOLOGY



METHODOLOGY

POROSITY

$\emptyset_T$ $\emptyset_E$

PERMEABILITY

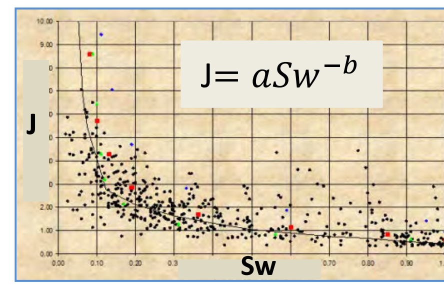
K

WATER SATURATION

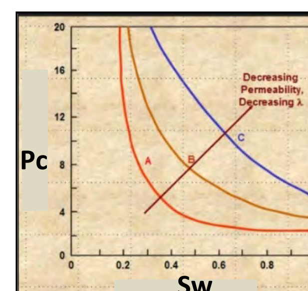
Sw

UNCERTAINTY !!

Sw= cJ^{-d}



ANALOGUE



METHODOLOGY

POROSITY

$\emptyset_T$ $\emptyset_E$

PERMEABILITY

K

WATER SATURATION

Sw

NET SAND

SERVOIR QUALITY

$$V_{HV} = A * H * \frac{N}{G} * \emptyset * (1 - Sw)$$

METHODOLOGY

POROSITY

$\emptyset_T$ $\emptyset_E$

PERMEABILITY

K

WATER SATURATION

Sw

NET SAND

RESERVOIR QUALITY

$$V_{HC} = A * H * \frac{N}{G} * \emptyset * (1 - Sw)$$

- Reservoir quality correlation
- Porosity vs depth trends

RESULTS INTEGRATION

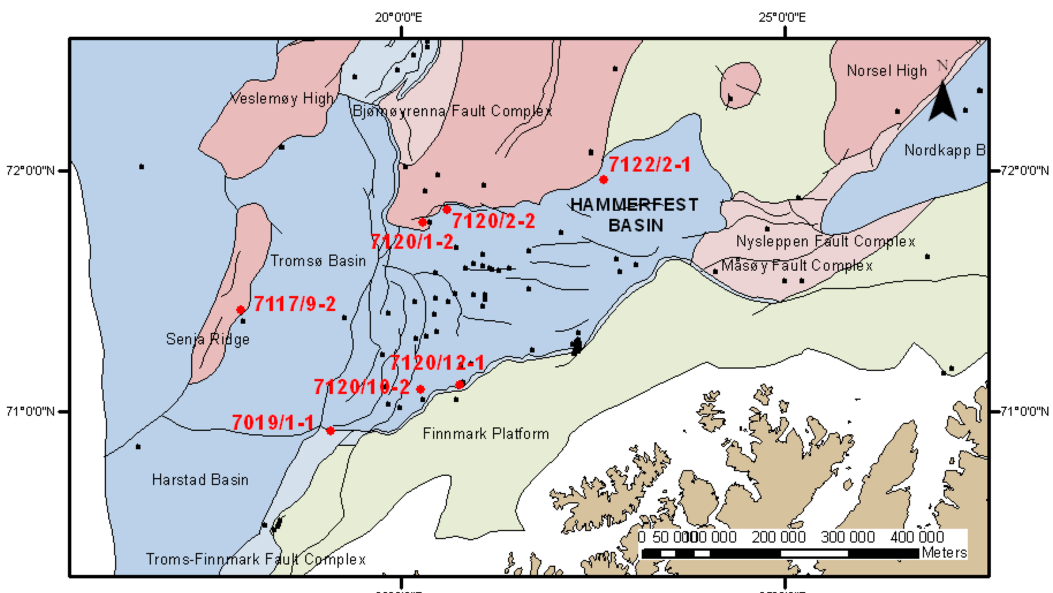
DATA

7 WELLS

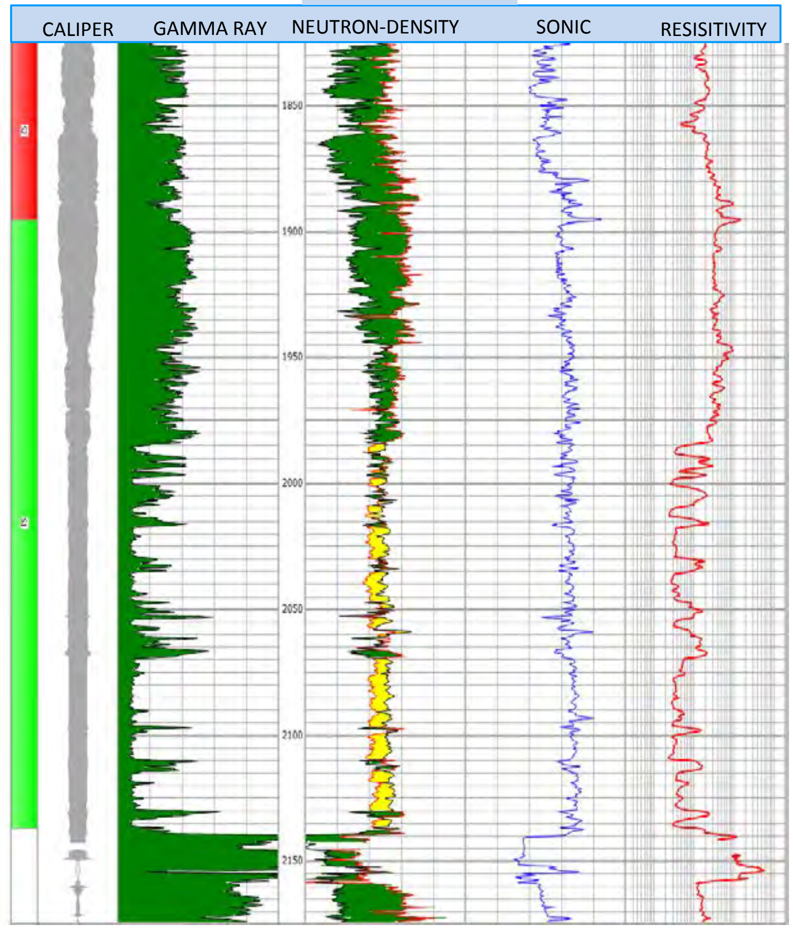
WIRELINE LOGS

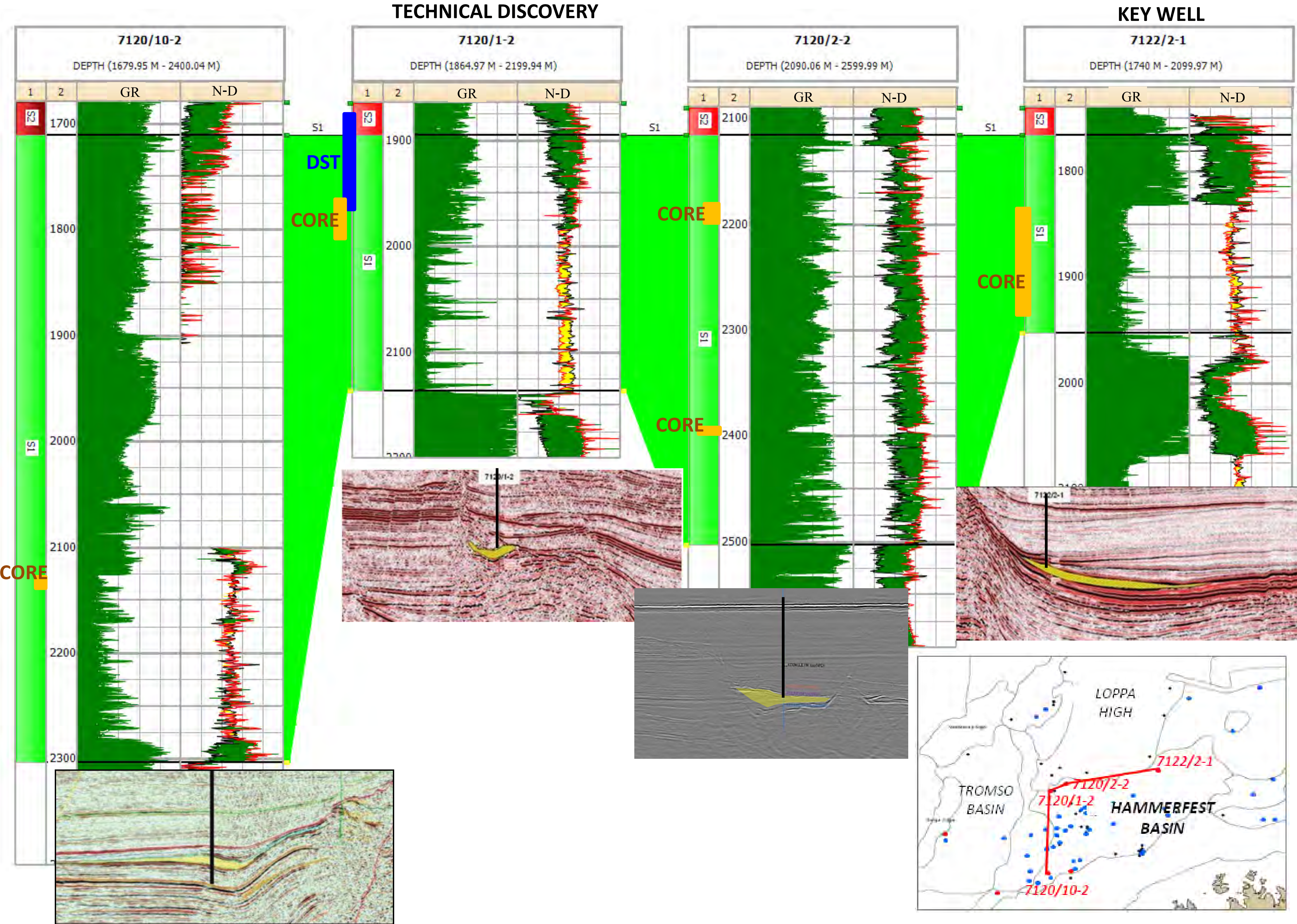
- Caliper
- Gamma ray
- Density
- Neutron
- Sonic
- Resistivity logs (S,M,D)
- Thz-log, U-log, K-log

- **Cores**
- **Convential and spectial core analyses**
- **Mudlogging**
- **Pressure tests**
- **Production tests**

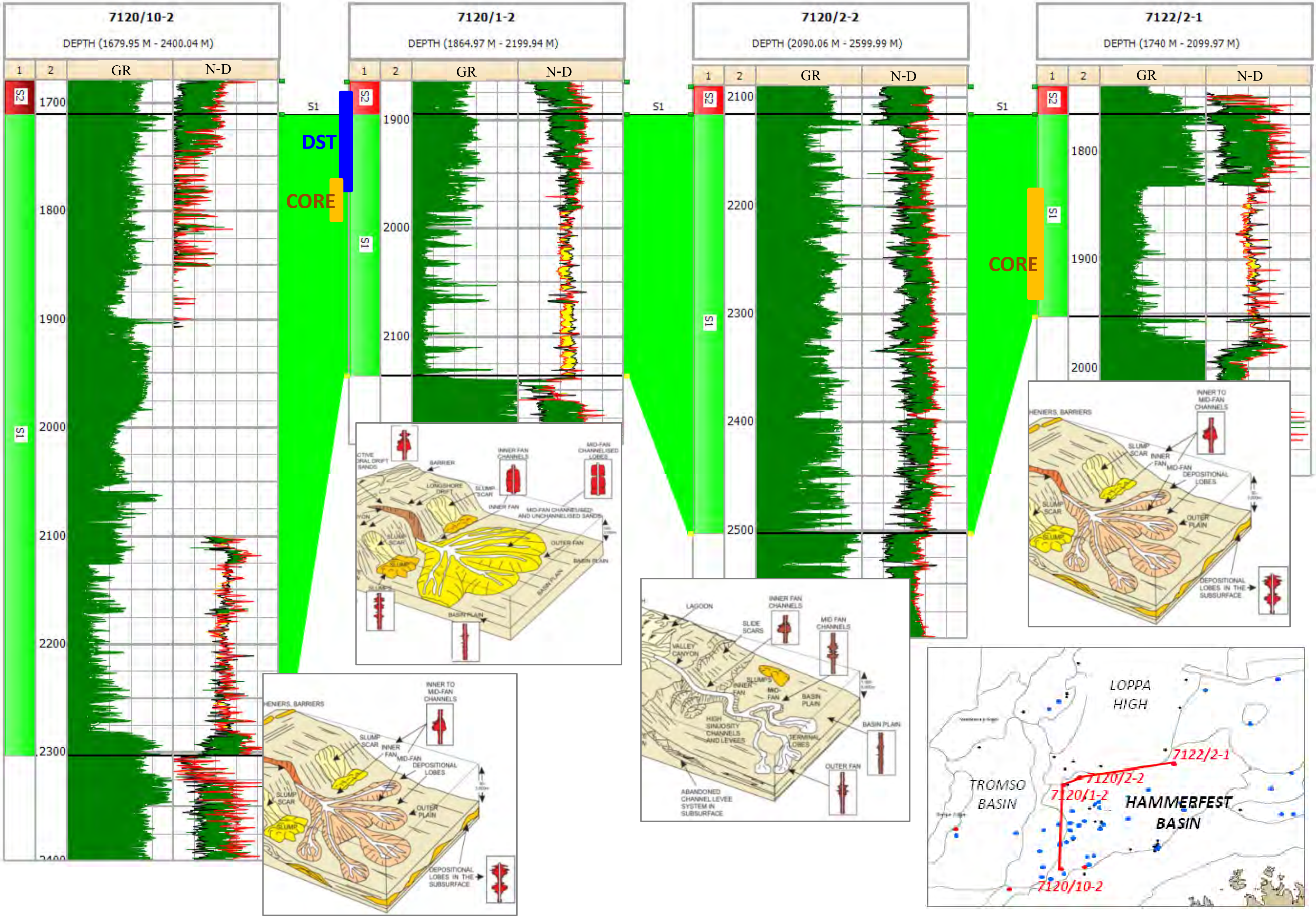


7210/1-2



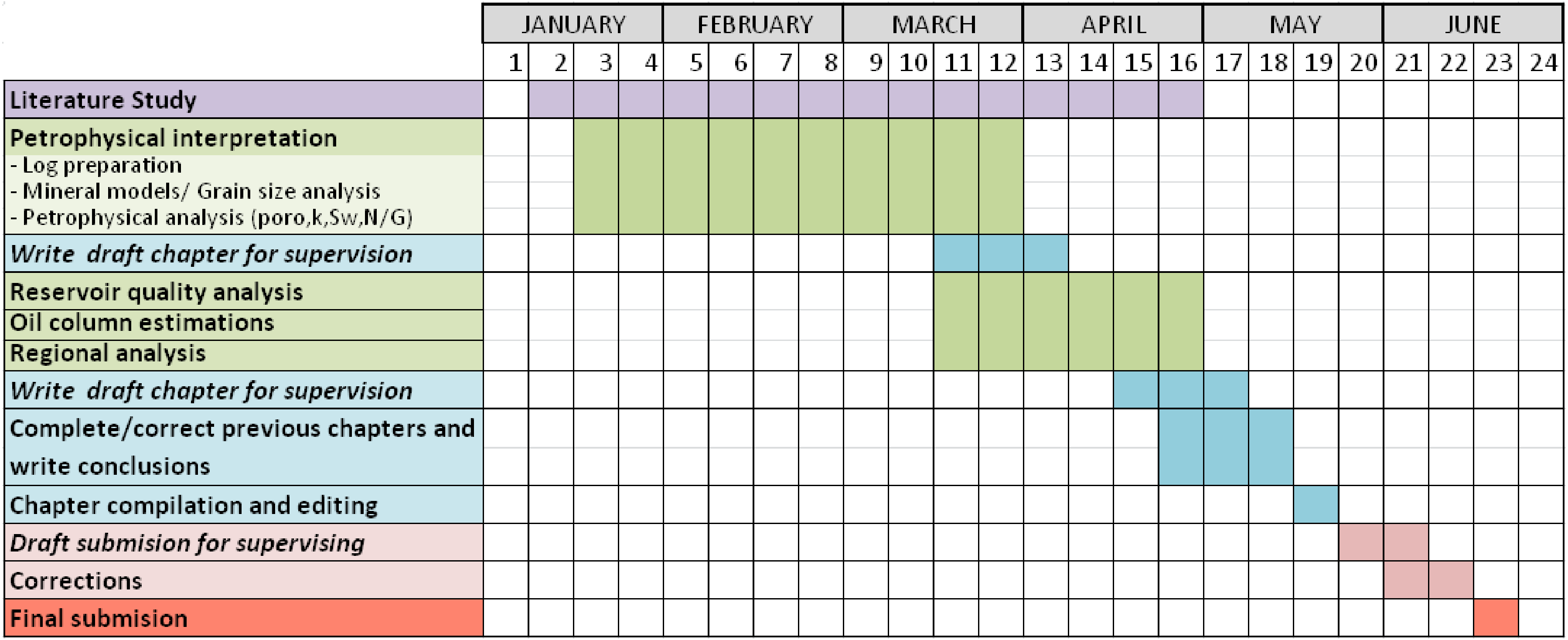


TECHNICAL DISCOVERY
KEY WELL
7120/10-2
DEPTH (1679.95 M - 2400.04 M)
7120/1-2
DEPTH (1864.97 M - 2199.94 M)
7120/2-2
DEPTH (2090.06 M - 2599.99 M)
7122/2-1
DEPTH (1740 M - 2099.97 M)
1
2
GR
N-D
S2
S1
DST
CORE
LOPPA
HIGH
TROMSO
BASIN
HAMMERFEST
BASIN
7122/2-1
7120/2-2
7120/1-2
7120/10-2



7120/10-2
DEPTH (1679.95 M - 2400.04 M)
7120/1-2
DEPTH (1864.97 M - 2199.94 M)
7120/2-2
DEPTH (2090.06 M - 2599.99 M)
7122/2-1
DEPTH (1740 M - 2099.97 M)
GR
N-D
S1
S2
DST
CORE
CORE
LOPPA HIGH
TROMSO BASIN
HAMMERFEST BASIN
7122/2-1
7120/2-2
7120/1-2
7120/10-2

TIME FRAME


JANUARY
FEBRUARY
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 Study
Petrophysical interpretation
- Log preparation
- Mineral models/ Grain size analysis
- Petrophysical analysis (poro,k,Sw,N/G)
Write draft chapter for supervision
Reservoir quality analysis
Oil column estimations
Regional analysis
Write draft chapter for supervision
Complete/correct previous chapters and write conclusions
Chapter compilation and editing
Draft submision for supervising
Corrections
Final submision

THANK YOU FOR YOUR ATTENTION

Zumaia turbidites (Bilbao, Spain)

University of Stavanger

Electrofacies Analysis - A possible use in Paleogeographic understanding of a North Sea reservoir.

Anastasia Titova

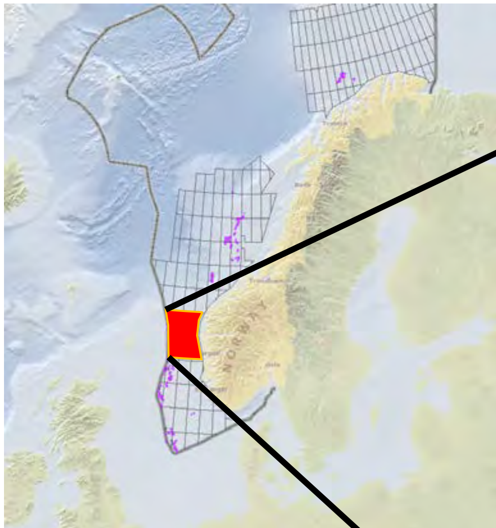
Faculty of Science and Technology

University of Stavanger, 2014

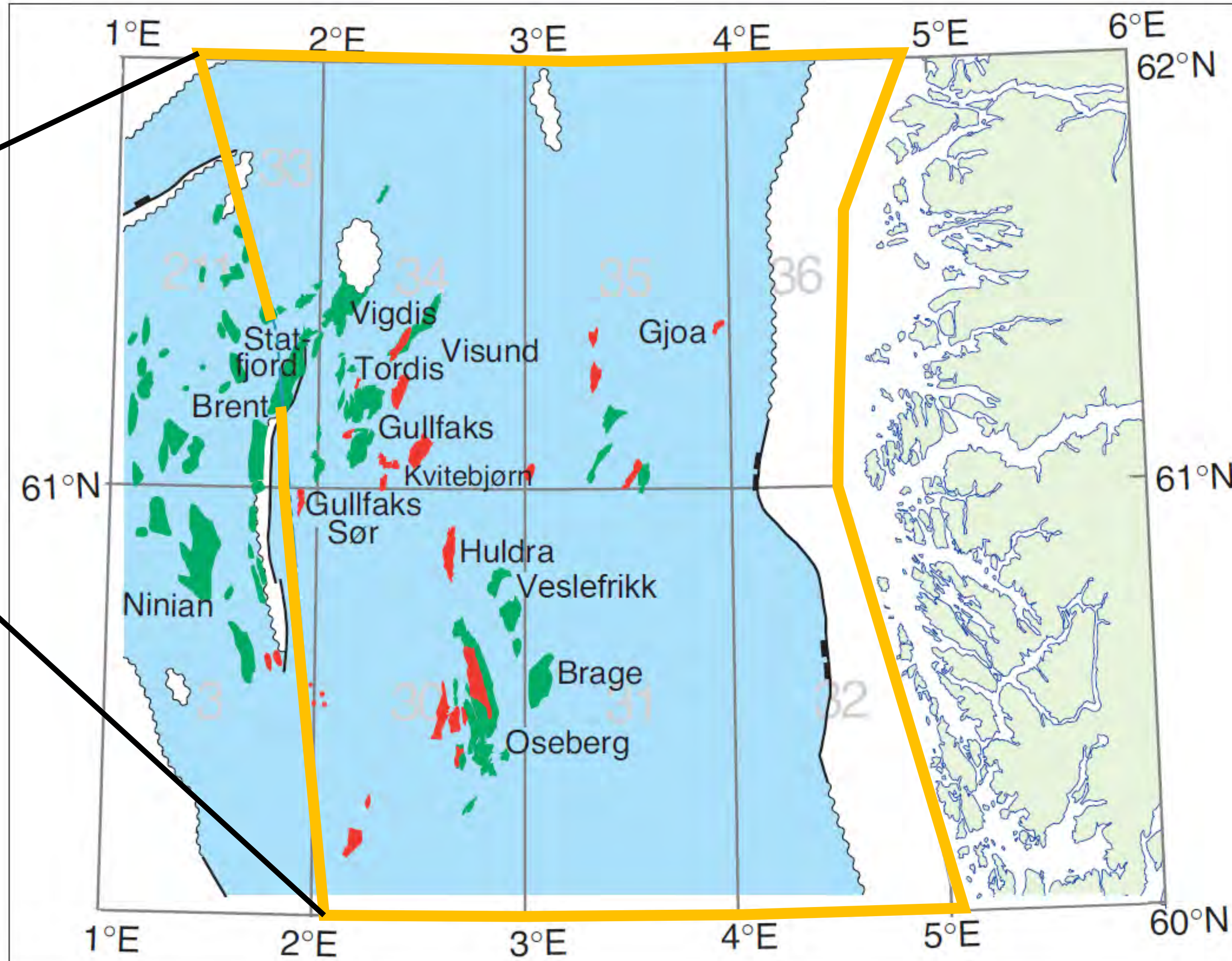
University Supervisor: Karl Audun Lehne

Company Supervisor: Chisom-Christiana Onubogu (TOTAL E&P Norge)

General and geographical information



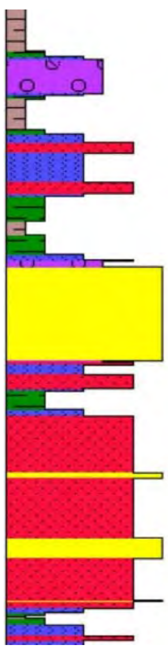
From NPD.no

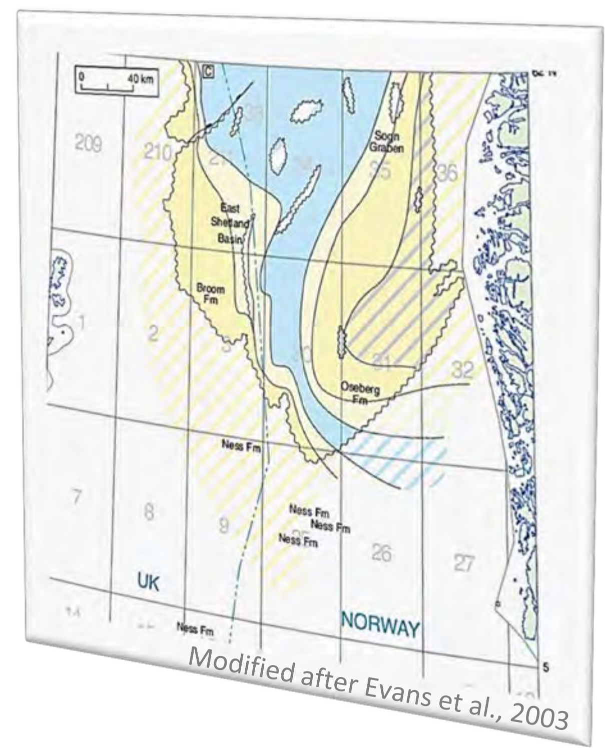


Modified after Evans et al., 2003

Objectives

To test electrofacies as a possible tool that can aid the understanding of the paleogeographical evolution of a North Sea reservoir during Jurassic time



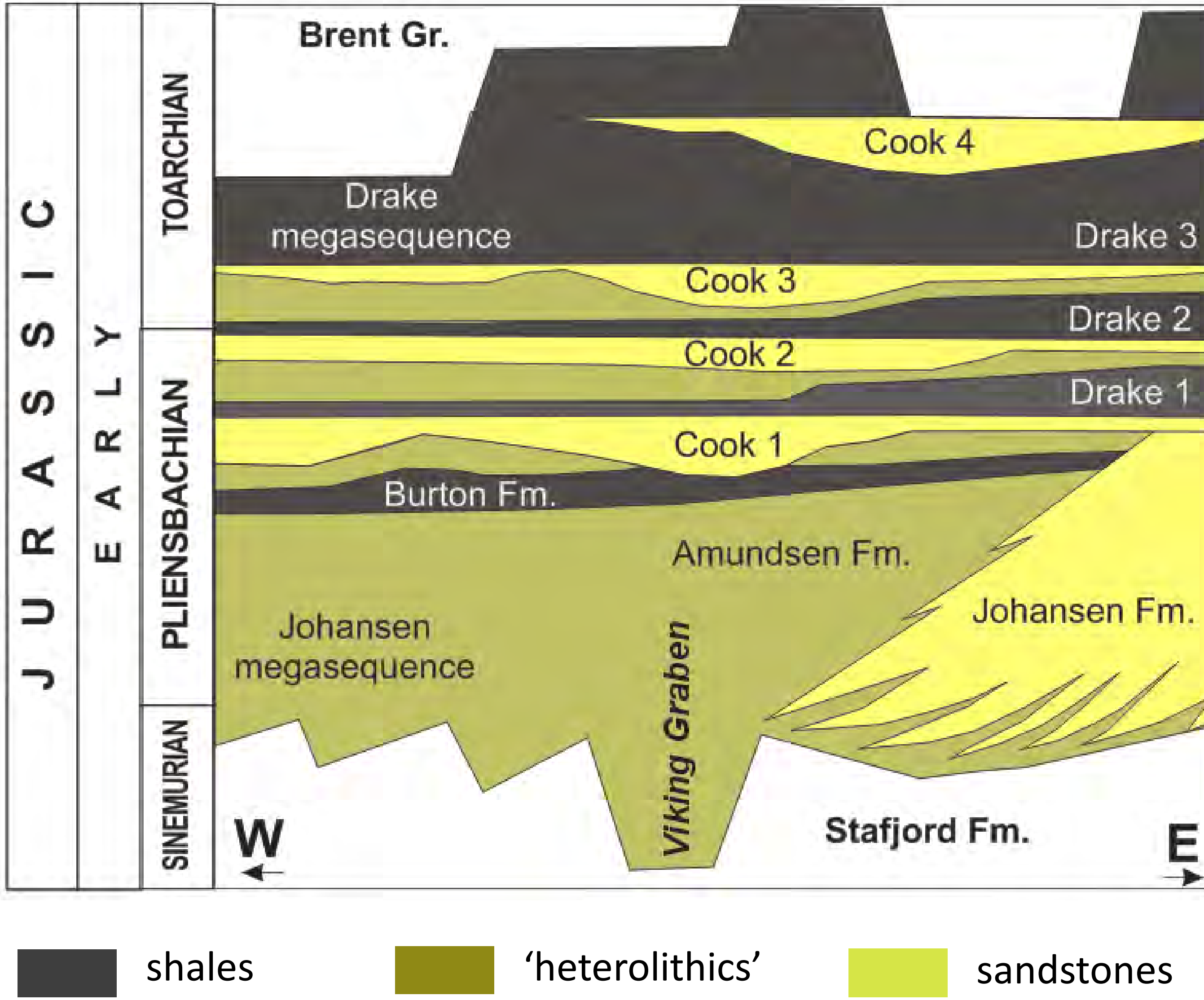


Modified after Evans et al., 2003

The **Lower Jurassic** strata

Dunlin Gr. (<600 m)

- Amundsen Fm.
- Johansen Fm.
- Burton Fm.
- Cook Fm.
- Drake Fm.



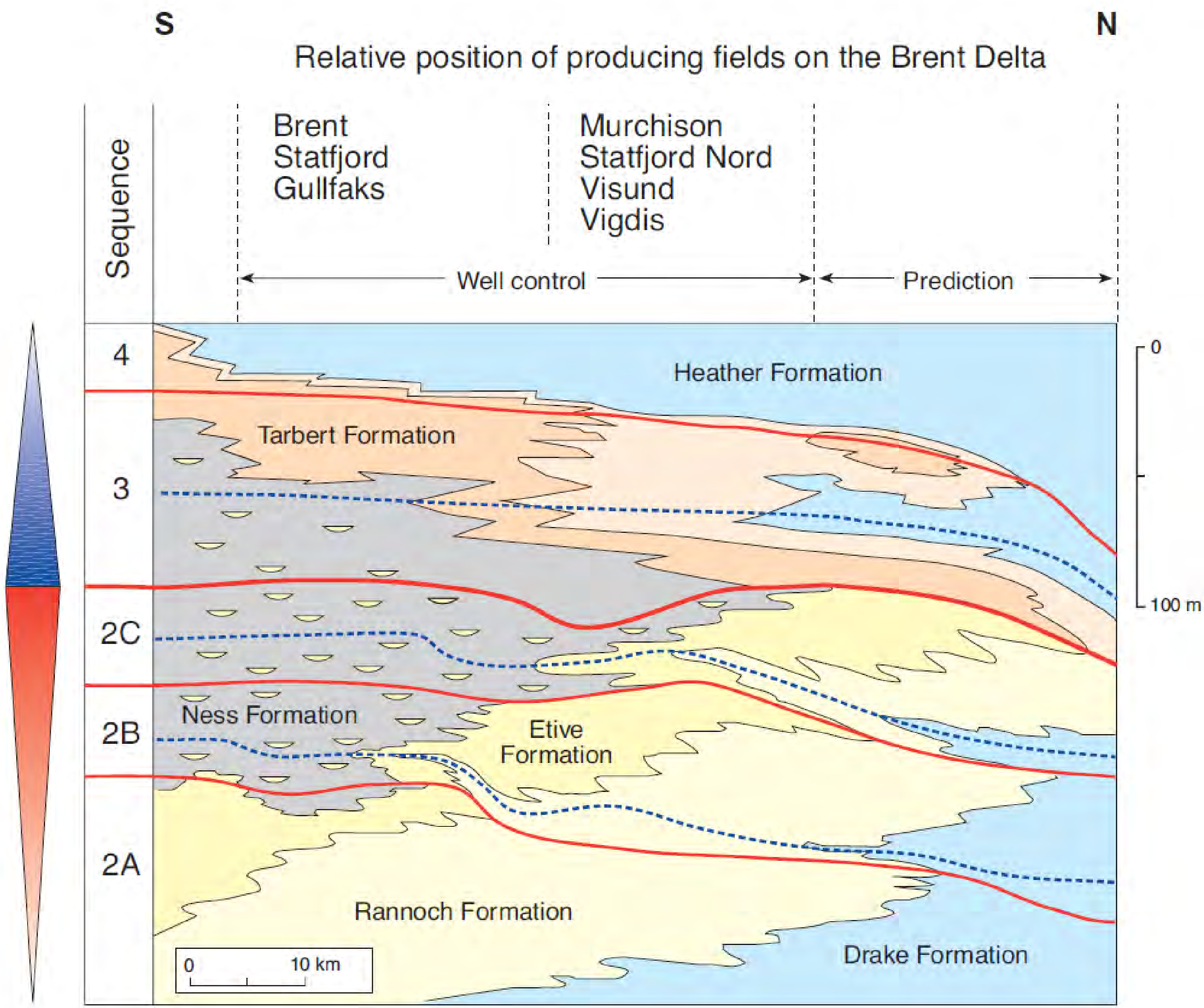
Modified after Marjanac and Steel, 1997

The **Middle Jurassic** rocks

Brent Gr. (100 – 500 m)

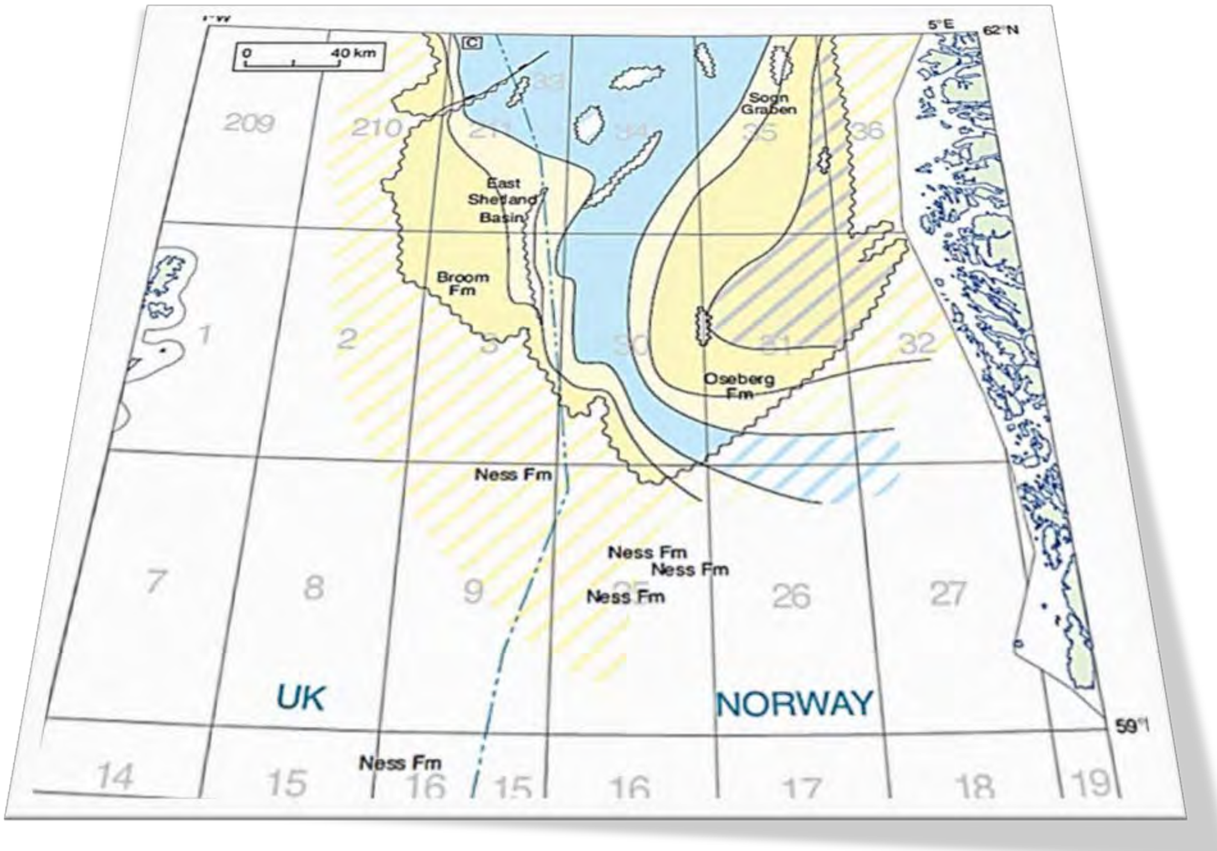
- Broom Fm.
- Rannock Fm.
- Etive Fm.
- Ness Fm.
- Tarbert Fm.

+ Oseberg Fm.



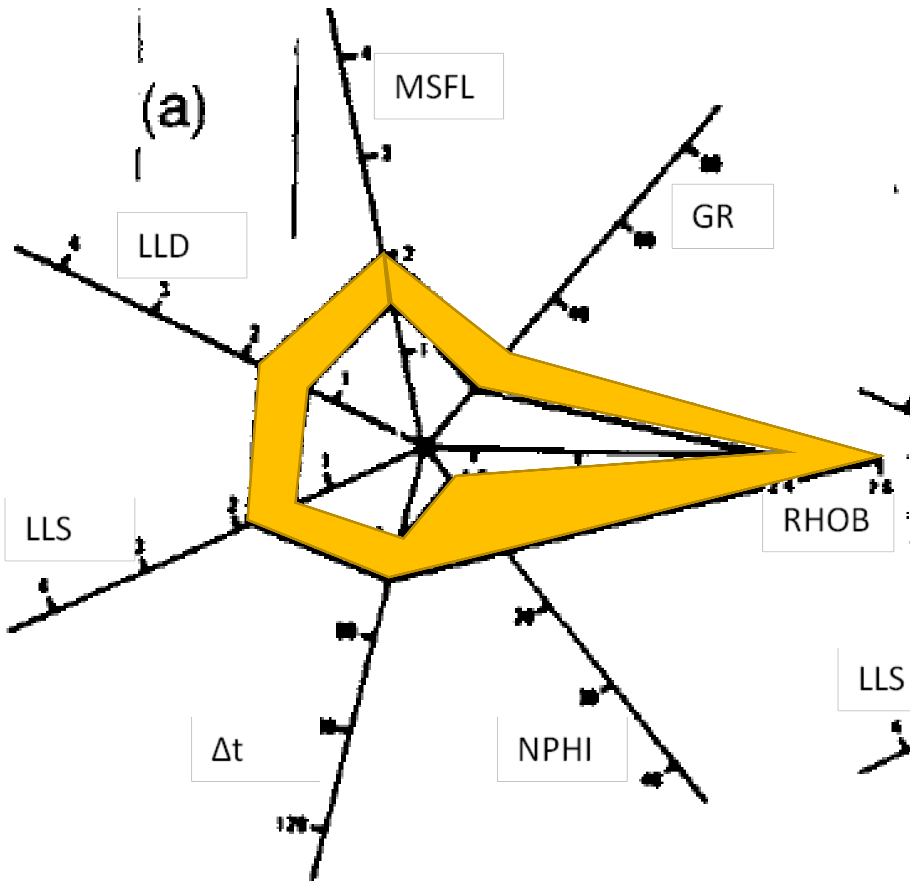
From Evans et al., 2003

Methodology and data

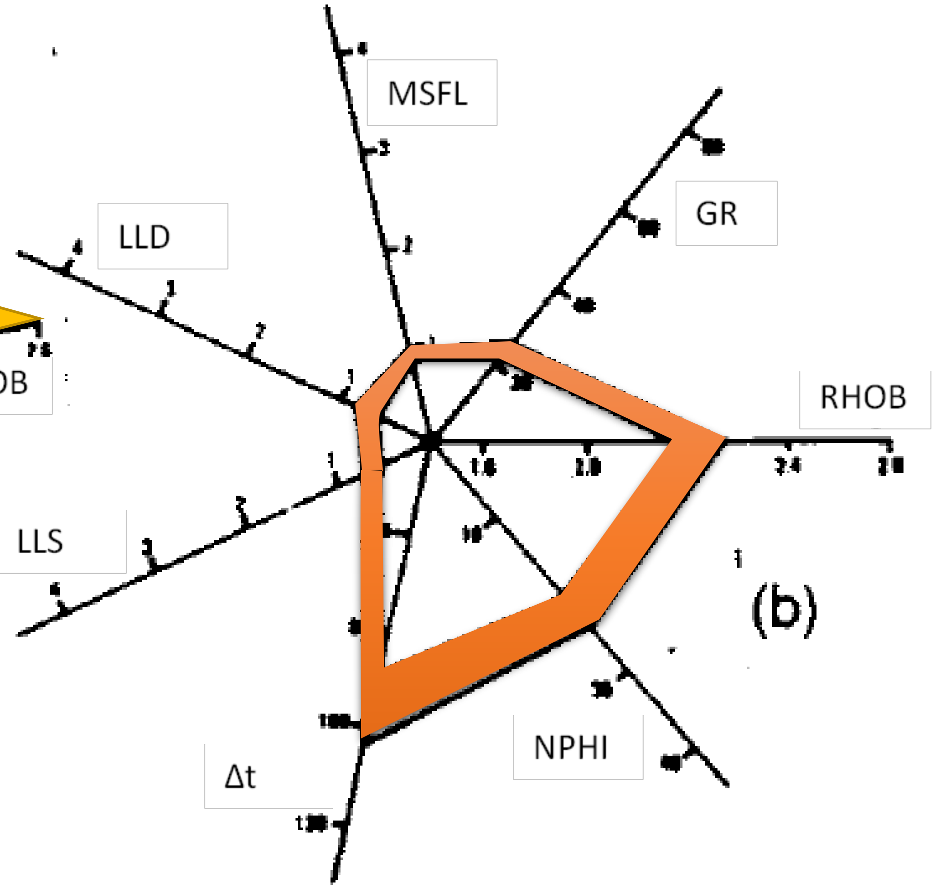


Methodology

- **Electrofacies** - a suite of wireline **log responses** and characteristics sufficiently **distinctive** to be able to be separated from other electrofacies (Serra and Abbott, 1982)
- Provides a **connection** between logging measurements and **classical facies approach**
- The goal of this analysis is to analytically describe the logging response and to recognize all fundamental electrofacies, representative to the depositional environment



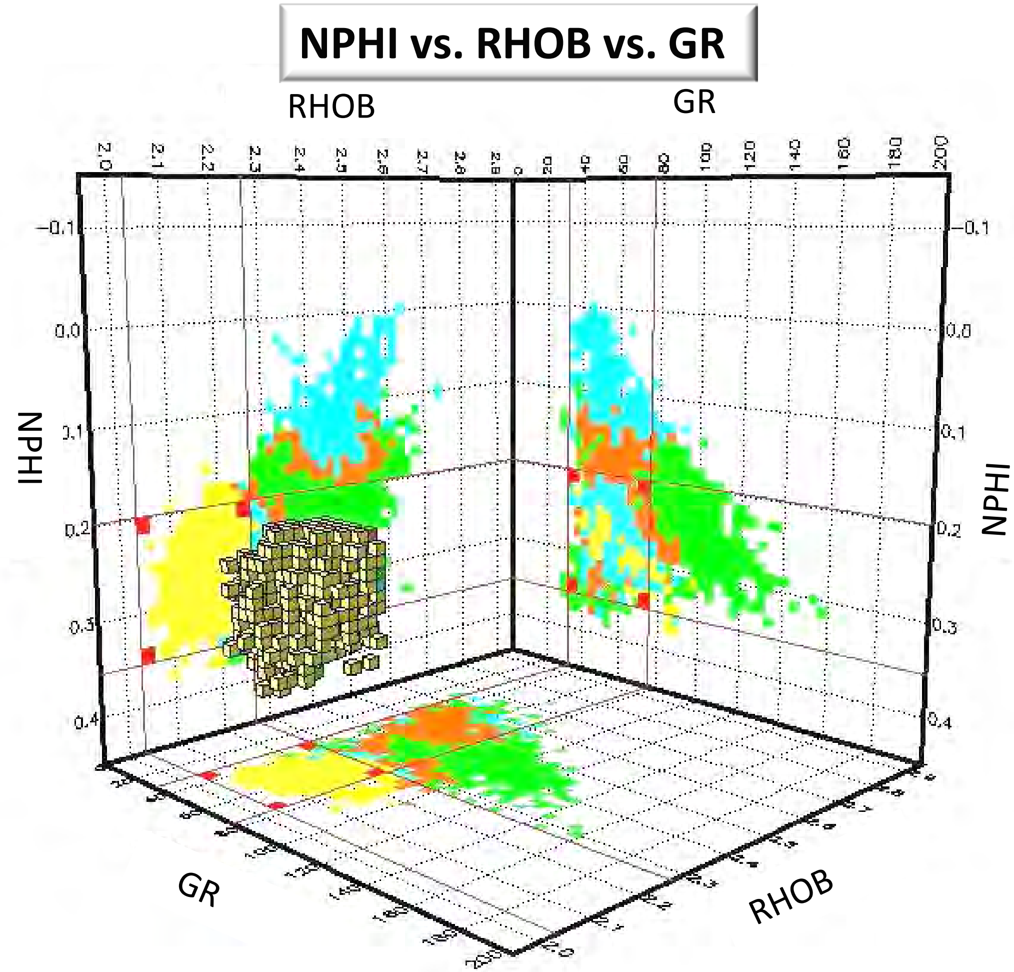
LIMESTONE ELECTROFAICES



SANDSTONE ELECTOFAICES

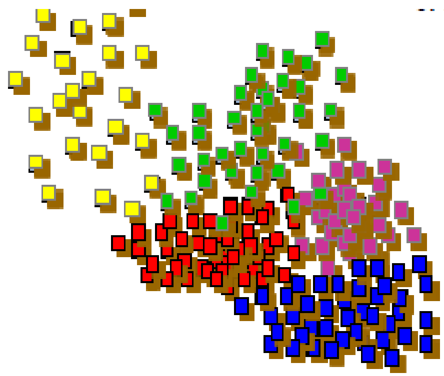
Electrofacies methodology: Clusters analysis

- A way of trying to divide n-dimensional log space into definable volumes corresponding to electrofacies
- Classification method applied: *Multi-Resolution Graph Based Clustering (MRGC)*



Modified after De Ribet at al., 2011

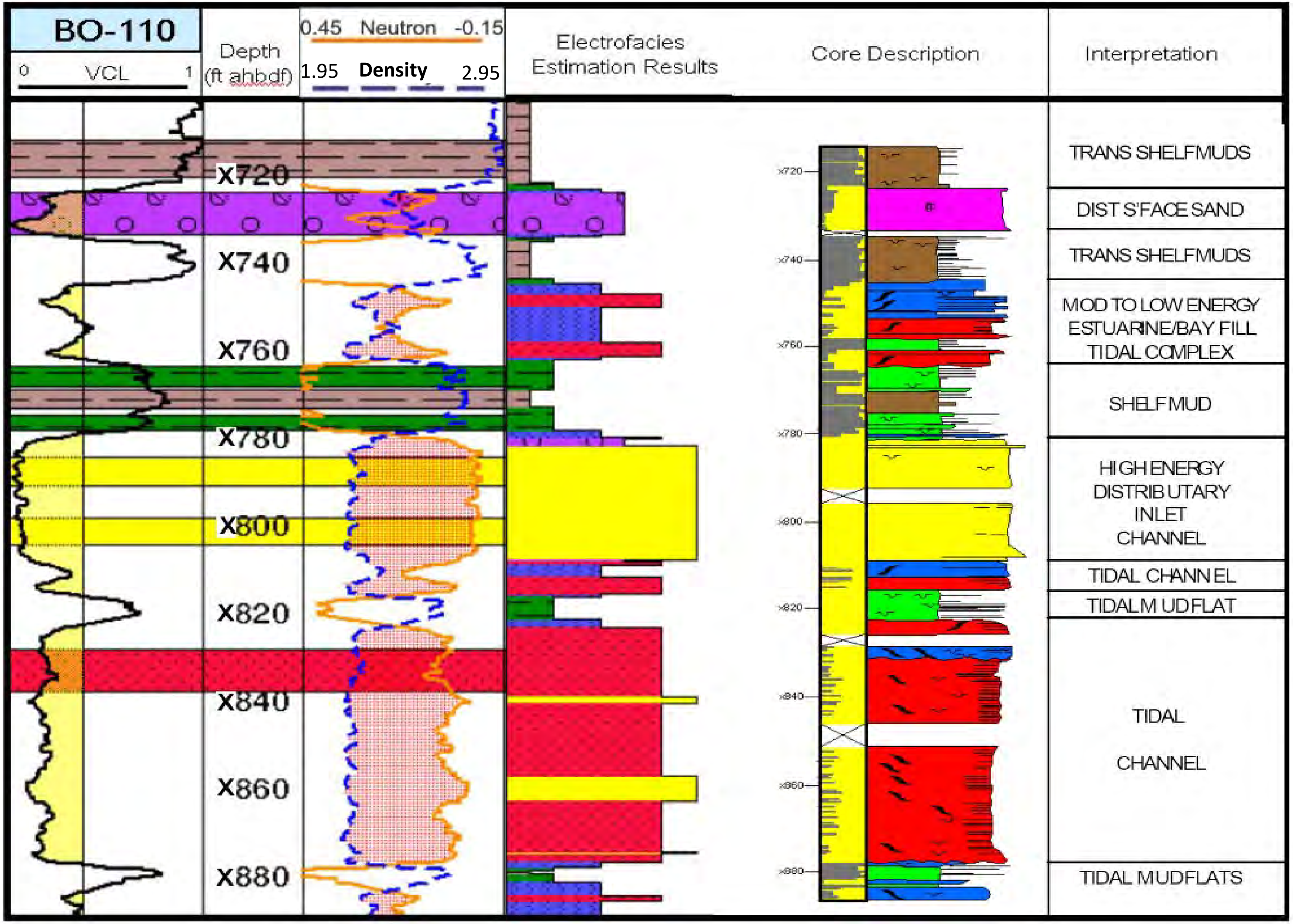
MRGC - Multi Resolution Graph-based Clustering



	NAME	COL	PAT	WEIGHT	DT	GR	NPHI	RHOB
1	Facies 4			2708				
2	Facies 2			231				
3	Facies 3			637				
4	Facies 1			2069				

Modified after De Ribet at al., 2011

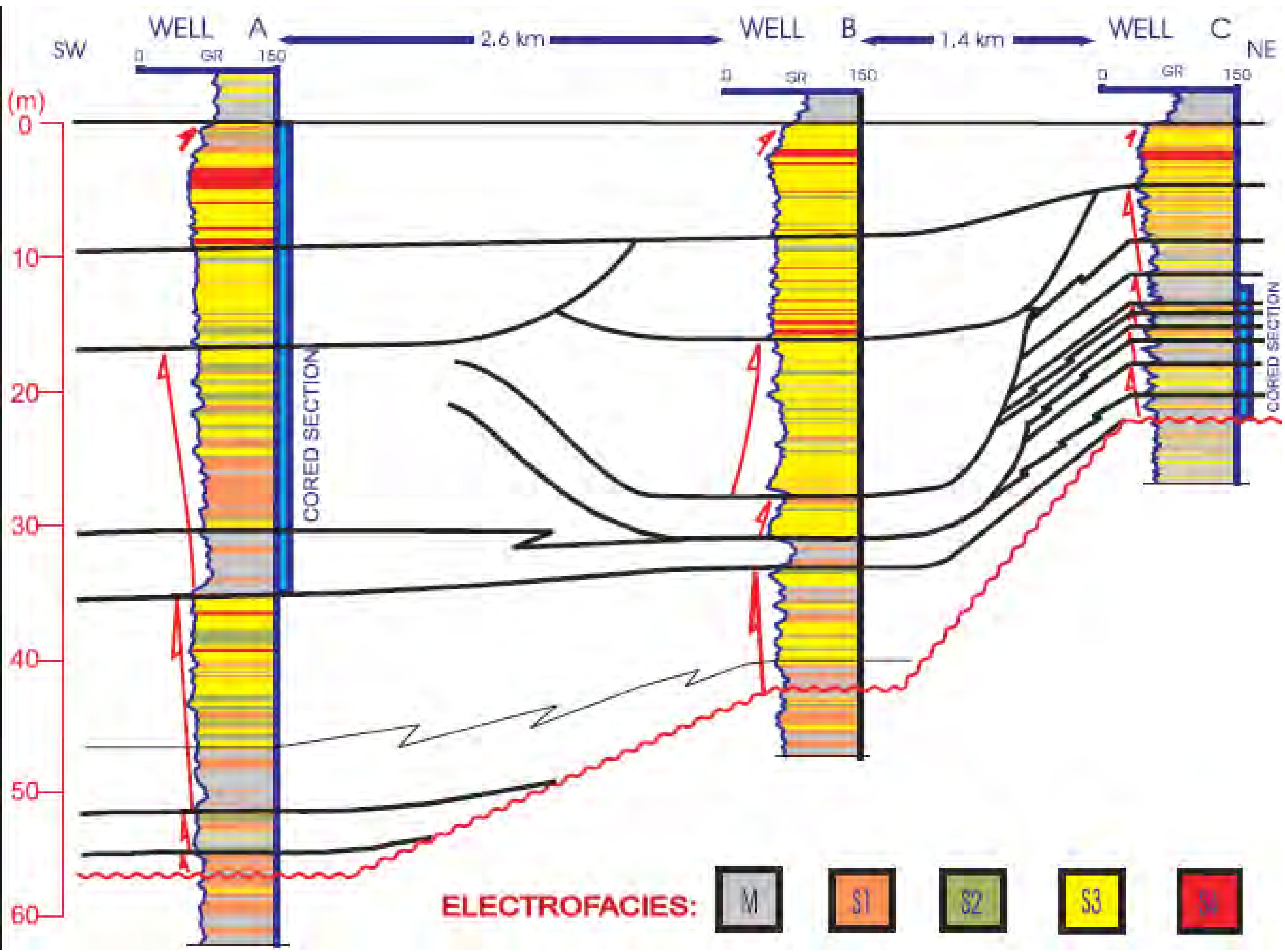
- This method analyzes the underlying data structure to define natural groups of electrofacies
- A priori knowledge of the number of facies is not required



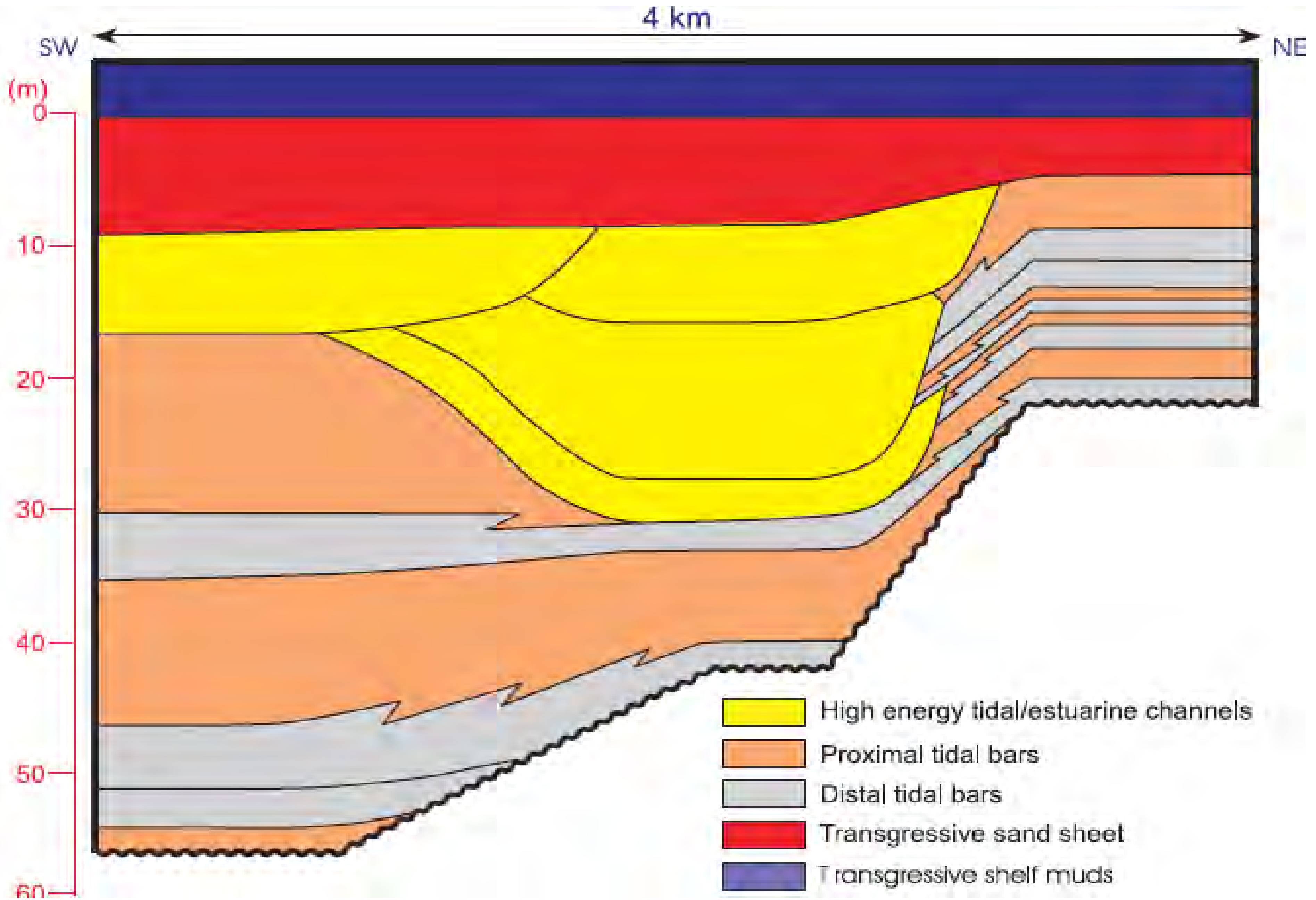
From http://www.searchanddiscovery.com

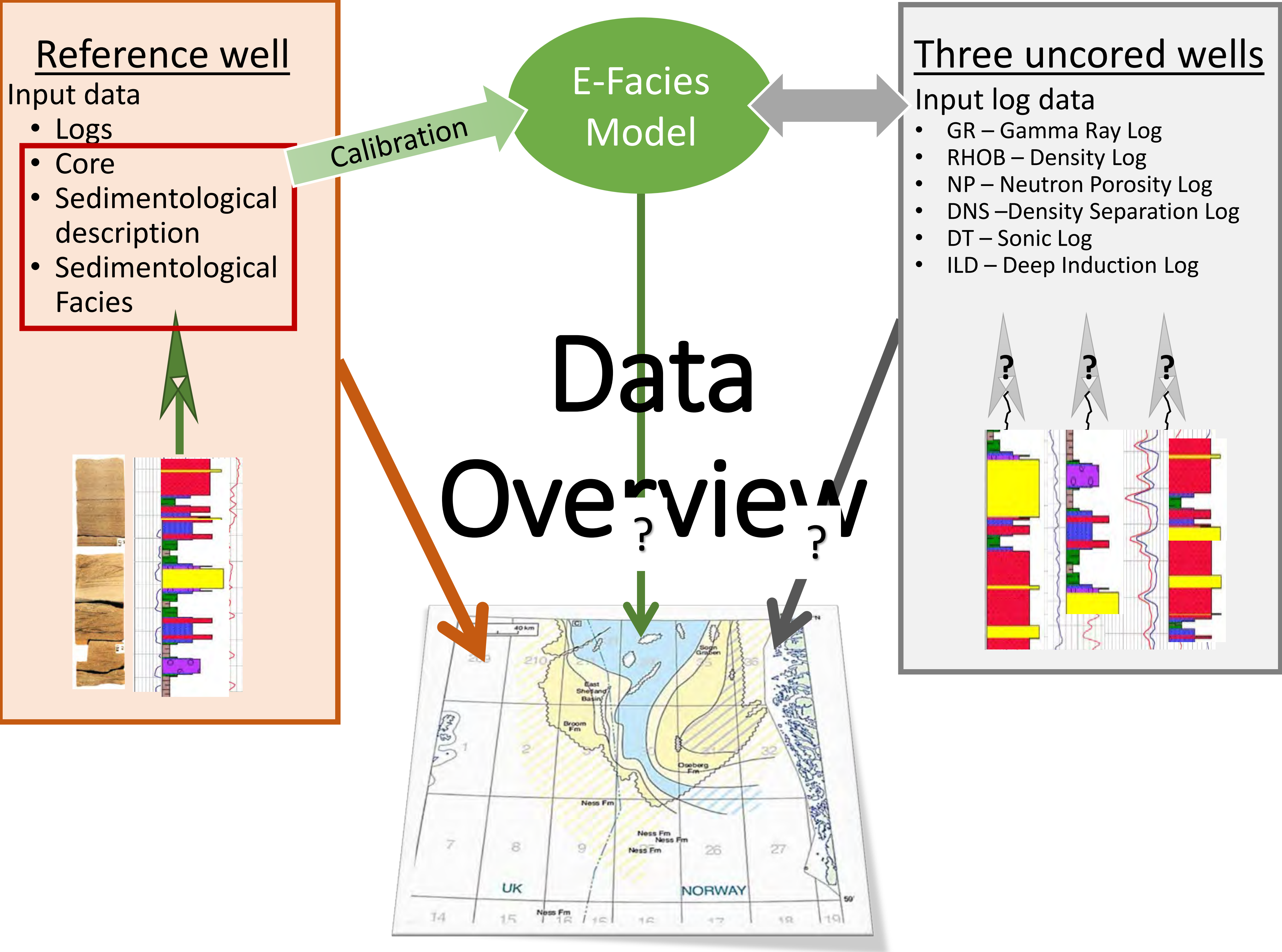
An example of the workflow from Gulfaks Field

Gupta, R., & Johnson, H. D. (2001). Characterization of heterolithic deposits using electrofacies analysis in the tide-dominated Lower Jurassic Cook Formation (Gullfaks Field, offshore Norway). *Petroleum Geoscience, 7*(3), 321-330.



SW
WELL A
2.6 km
WELL B
1.4 km
WELL C
NE
0 GR 150
(m)
0
10
20
30
40
50
60
CORED SECTION
CORED SECTION
ELECTROFACIES:
M
S1
S2
S3
S4


4 km
SW
NE
(m)
0
10
20
30
40
50
60
High energy tidal/estuarine channels
Proximal tidal bars
Distal tidal bars
Transgressive sand sheet
Transgressive shelf muds



Reference well
Input data
• Logs
• Core
• Sedimentological description
• Sedimentological Facies
Calibration
E-Facies Model
Three uncored wells
Input log data
• GR – Gamma Ray Log
• RHOB – Density Log
• NP – Neutron Porosity Log
• DNS –Density Separation Log
• DT – Sonic Log
• ILD – Deep Induction Log
?
?
?
Data Overview
?
?
East Shetland Basin
Broom Fm
Sogn Graben
Oseberg Fm
Ness Fm
UK
NORWAY

Time frame

Activity	2014			2015					
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Contract	Receipt								
Literature review									
Data collection									
Data interpretation and analysis									
Writing			Introduction						
Reviewing									

Thank you
for your attention