GEO620 Thesis Presentation Introduction

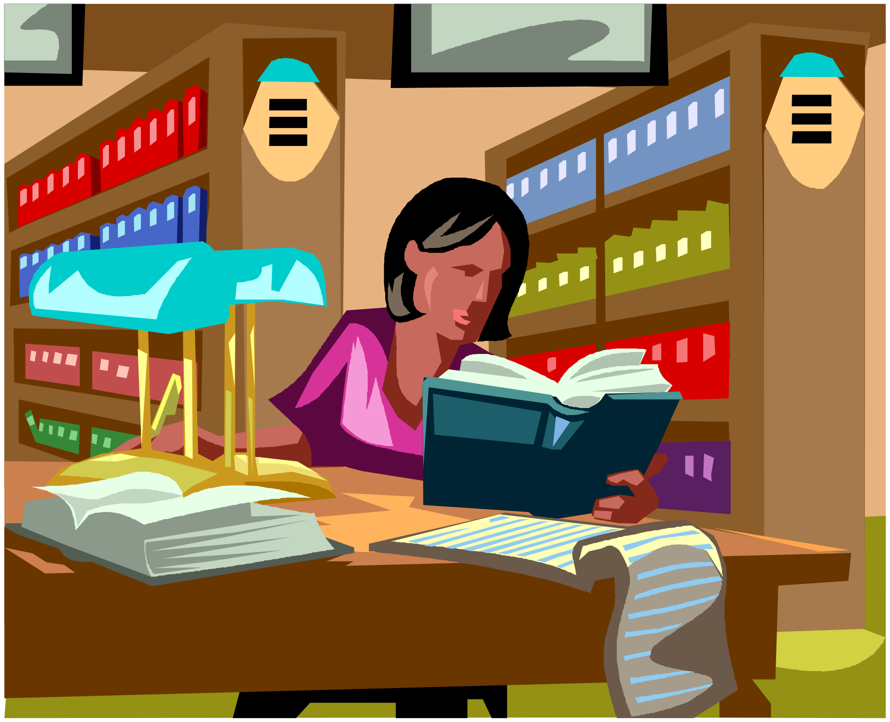
Lisa Watson, course instructor

University of Stavanger

Excuse the projector…

The purpose of GEO620

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



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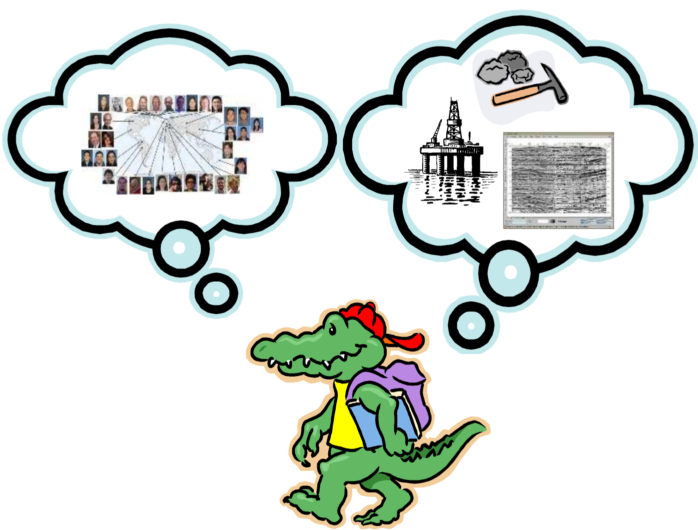
Activities in GEO620

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



Expectations from students

- A well-organized and coherent presentation showing that the student understands the objectives of the thesis and knows how to approach the problem
  - Not expected to have results or conclusions now
  - MSc thesis in spring
  - All students expected to finish in June 2017
- 10-12-minute oral presentation with 3-5 minutes for questions
- Varying amounts of progress
  - Progress is not a grading factor

Grading

- All guests are asked to fill in the score sheets for each presenter
  - Students required
  - Final mark determined by advisor and instructor
  - All feedback will be shared with students

- A new format this year

Student Name	UiS Advisor	Criteria Area 1: Organization and Clarity			Criteria Area 2: Visual aids				Criteria Area 3: Delivery						Criteria Area 4: Grasp of project				Criteria Area 5: Discussion					
		Is there an introduction?	Facts developed logically?	Well-developed questions/objectives?	Aid in illustrating points?	Well-crafted?	Are figures described?	Sources cited?	Pronounciation clear?	Volume high enough?	Grammar essentially correct?	Technical vocabulary?	Delivery satisfactory?	Within time-limit?	How much knowledge was exhibited?	Original and independent component?	Novel approach?	Topic addressed such that the student understands the objectives?	Are questions spontaneous?	Are questions related to lack of clarity?	Are question for further interest?	Does the speaker show self assurance in answering?	Is ability to think demonstrated?	Overall impression (Excellent, Very Good, Good, Average, Fair, Needs signficant improvement)
Eirik Oppedal	Townsend																							
Herman Birkeland	Townsend																							
Asbjørn Veiteberg	Townsend																							
Emera Mostafa	Townsend																							

Schedule

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

Fault-related sedimentation: Structural mapping of syn-rift successions in the Kerpini and Dhoumena fault blocks, Greece

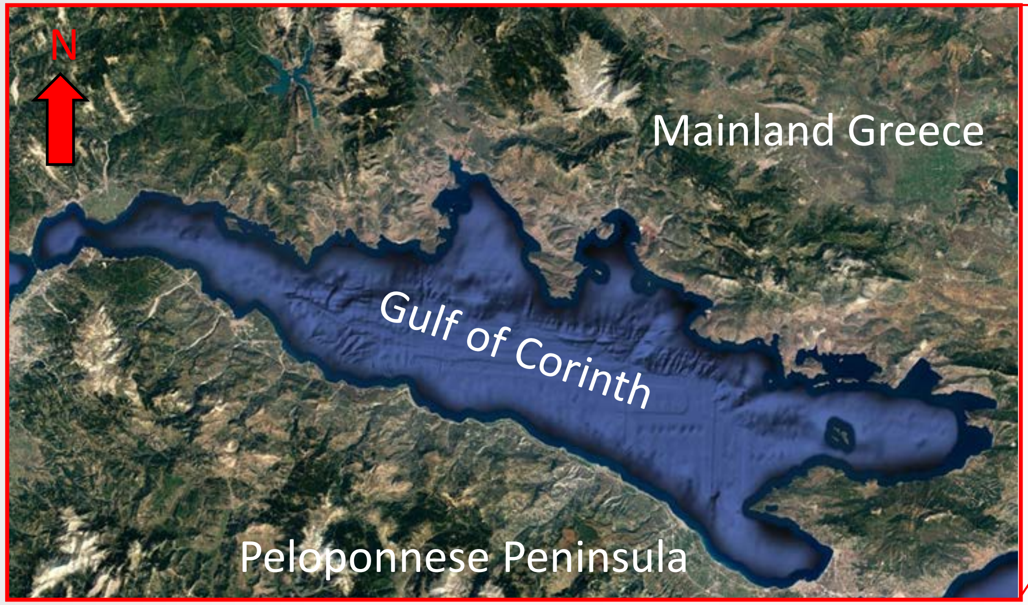
Student: Eirik Oppedal

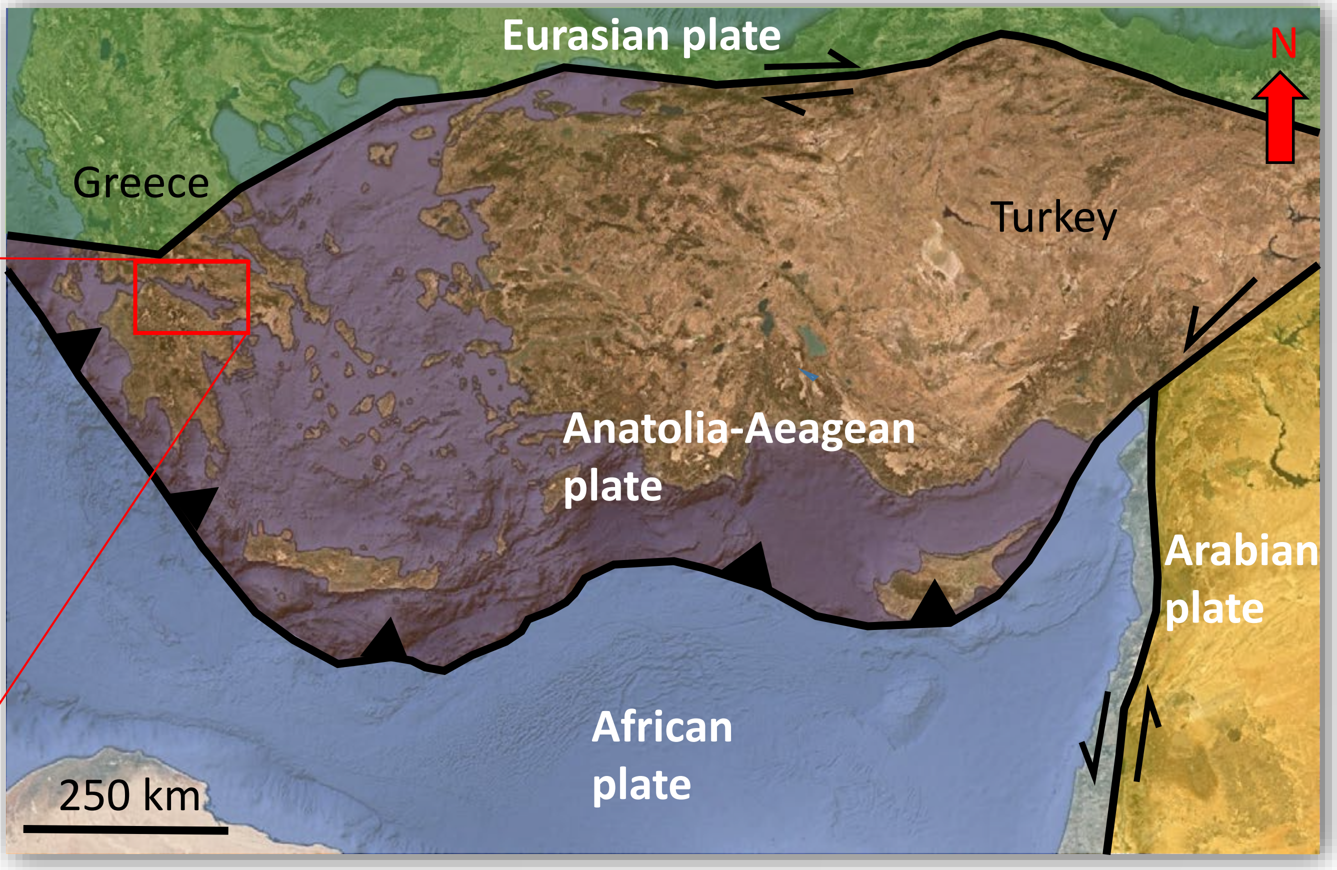
Supervisor: Christopher Townsend

Co-supervisor: Alejandro Escalona

Corinth rift

- Initiated 5 million years ago
- High extension rate (11-16 mm/year)
- Active in the Gulf of Corinth
- Early-rift faults preserved south of the Gulf





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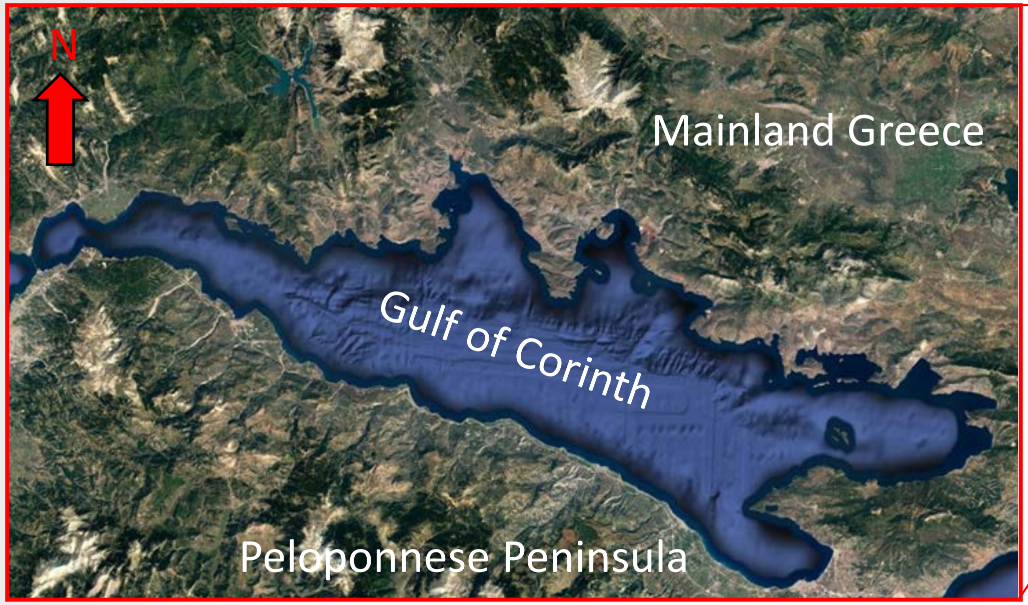

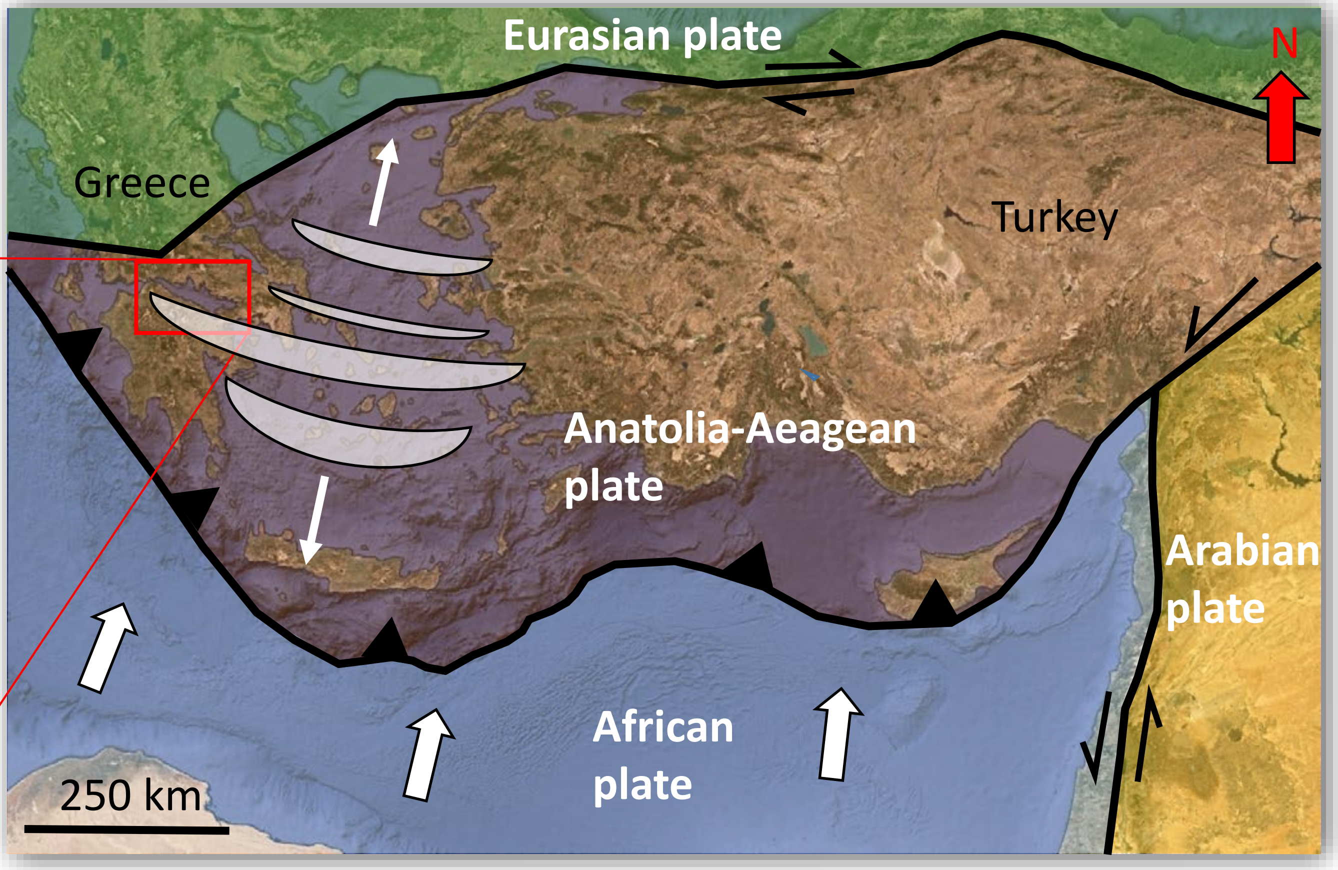

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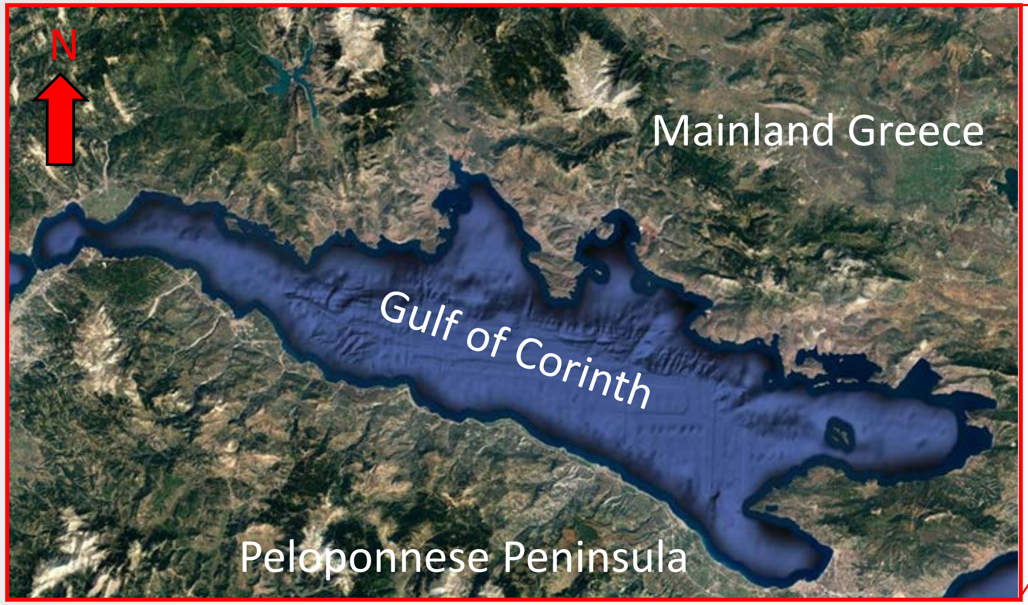

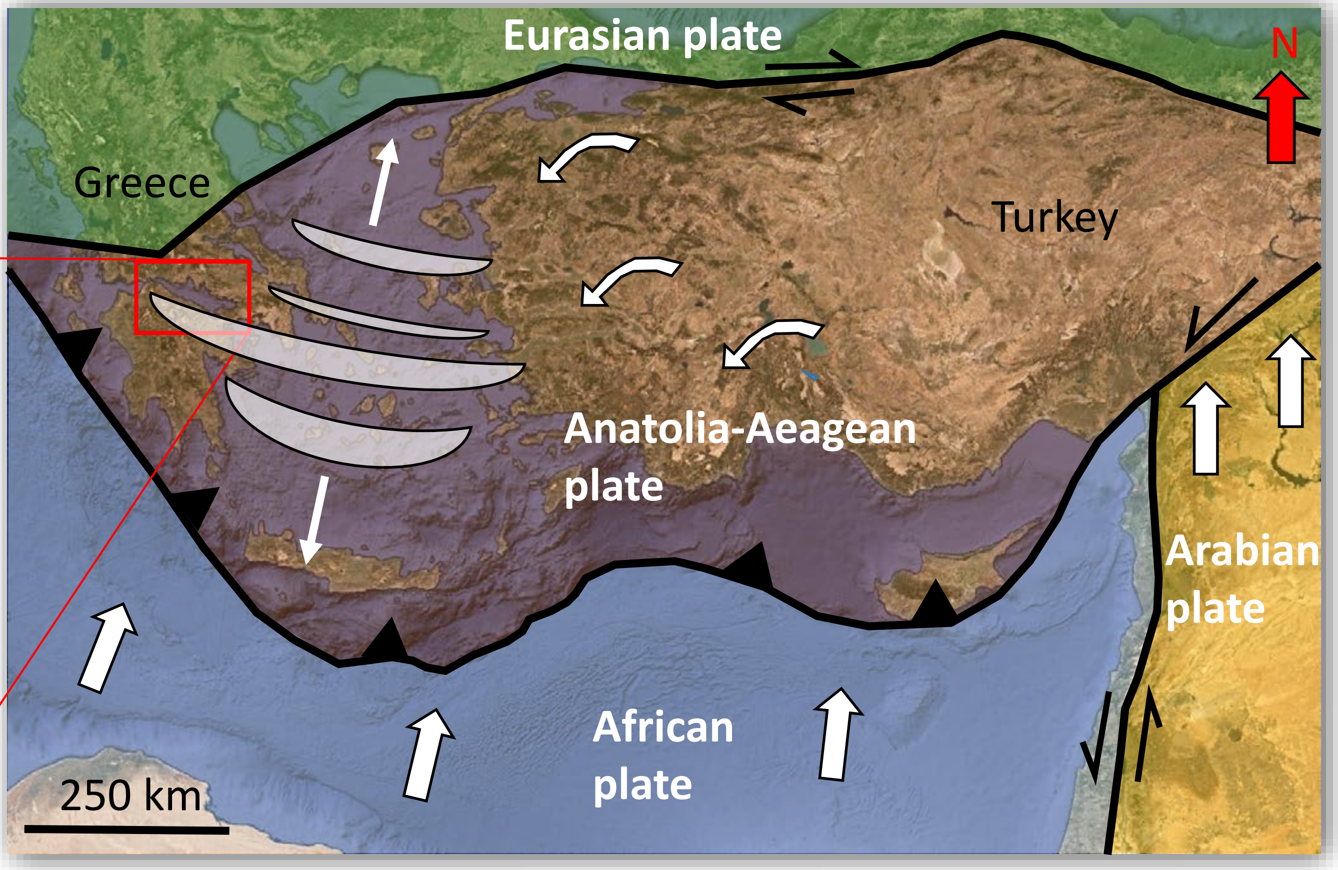

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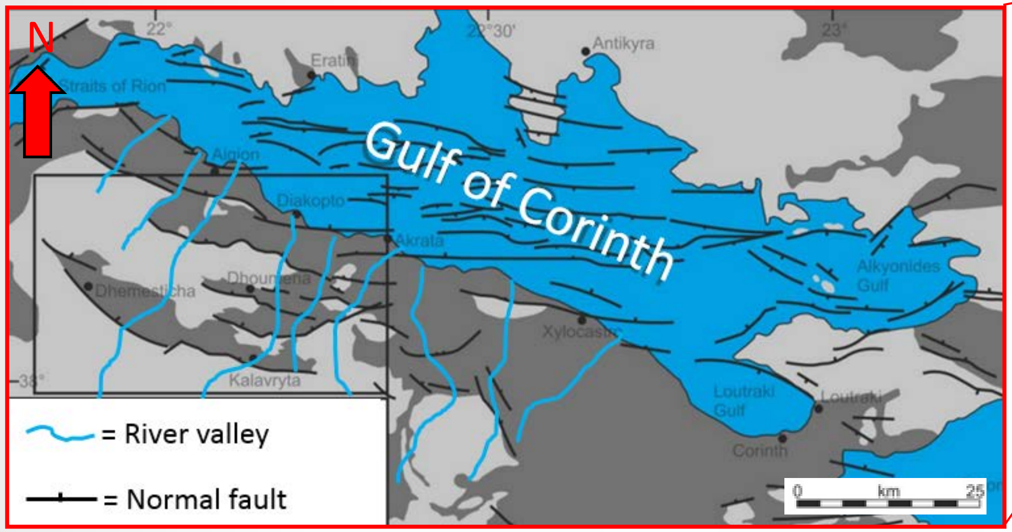
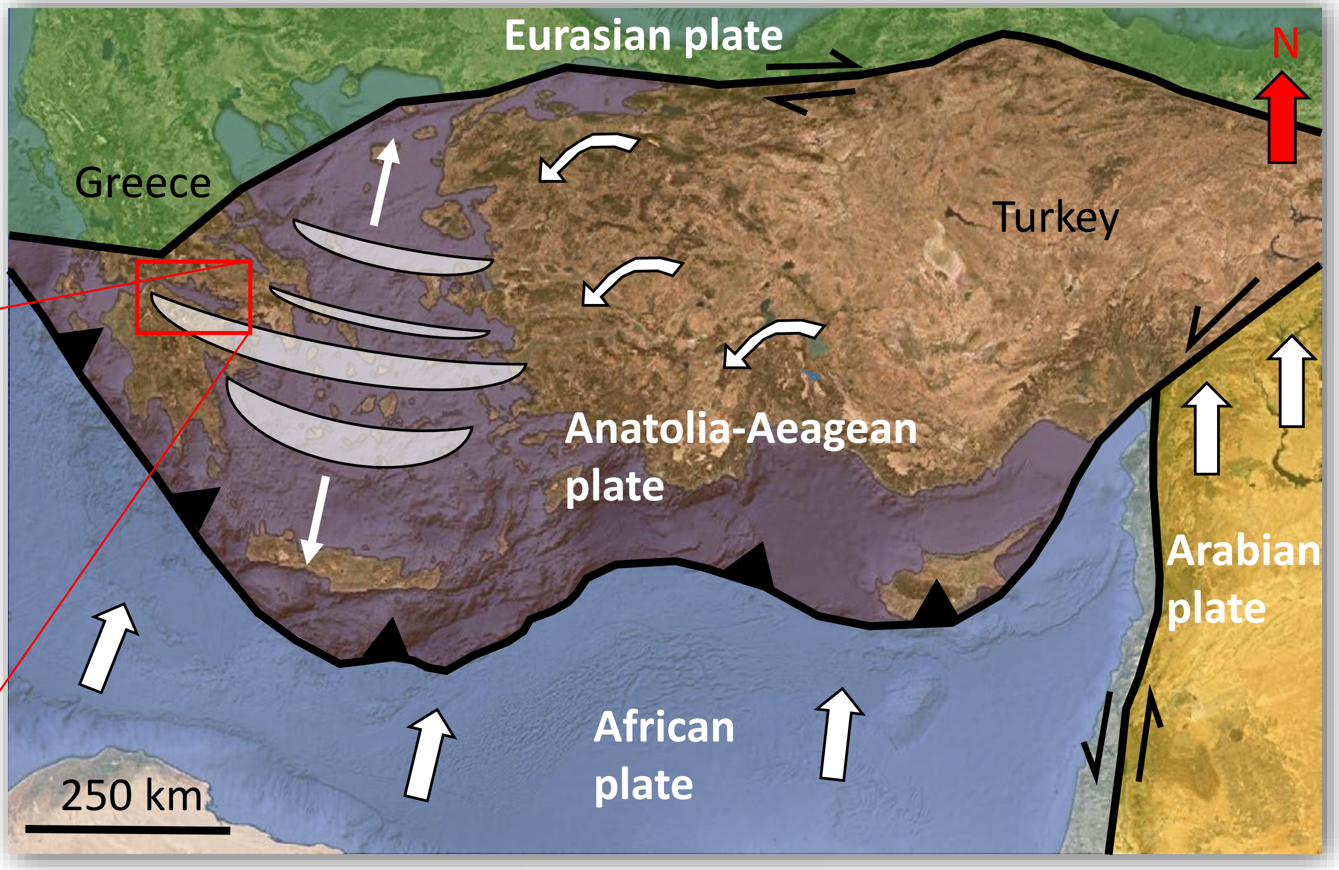


Modified after Wood (2013)



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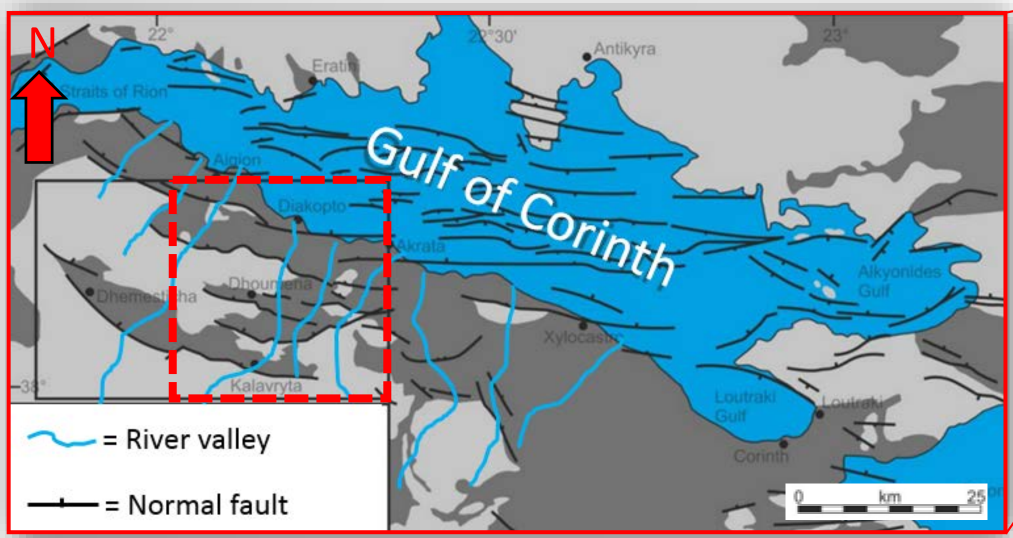

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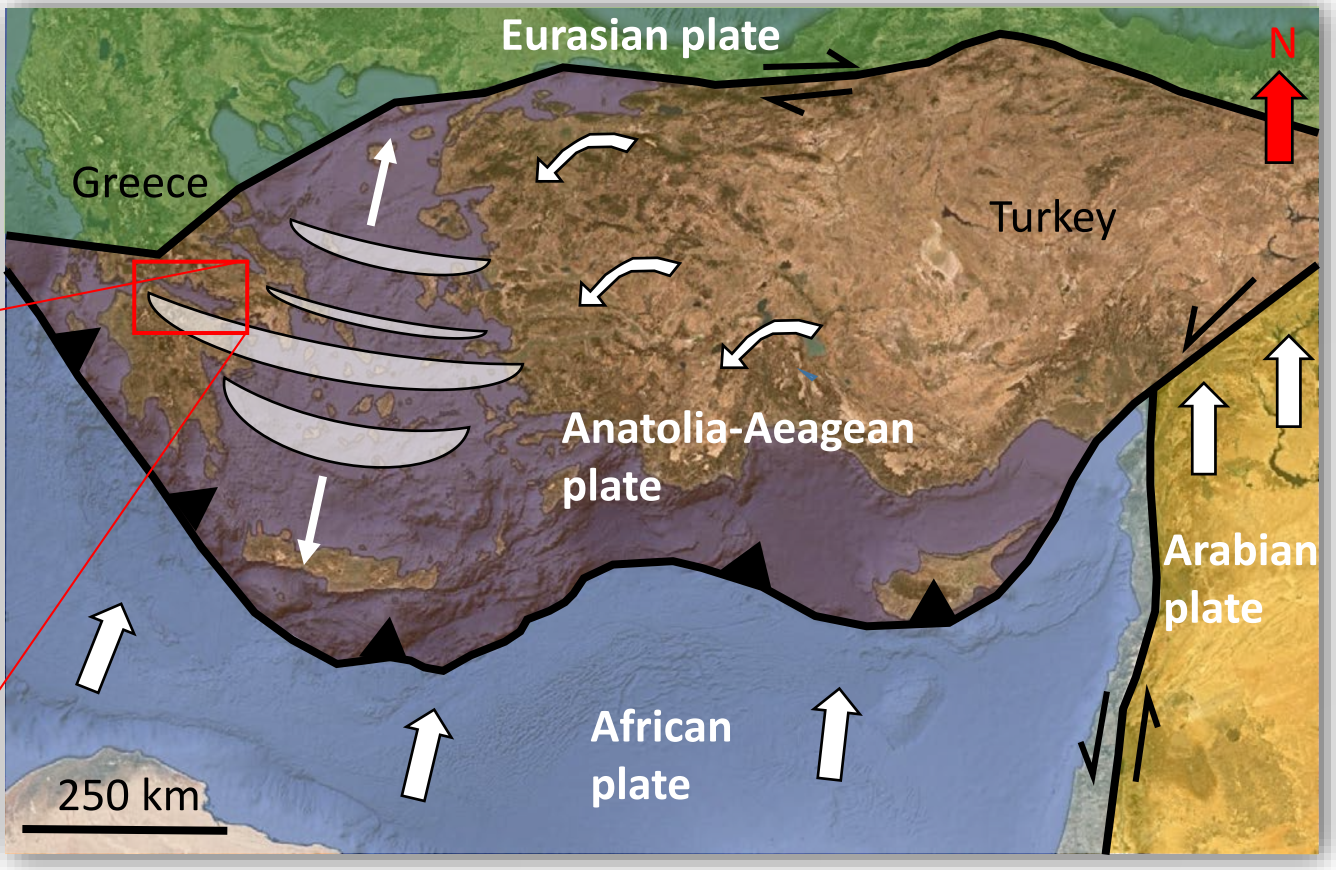
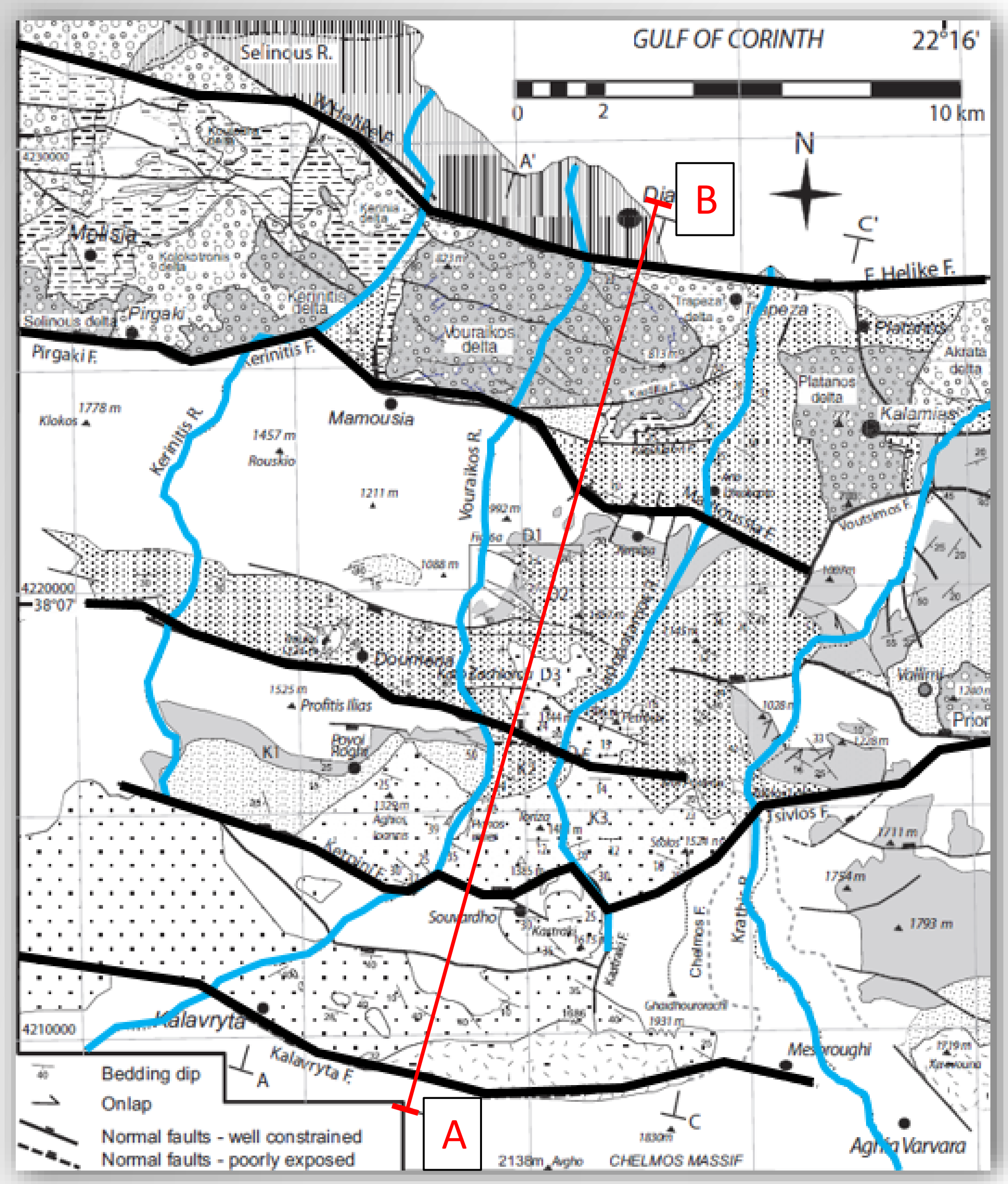
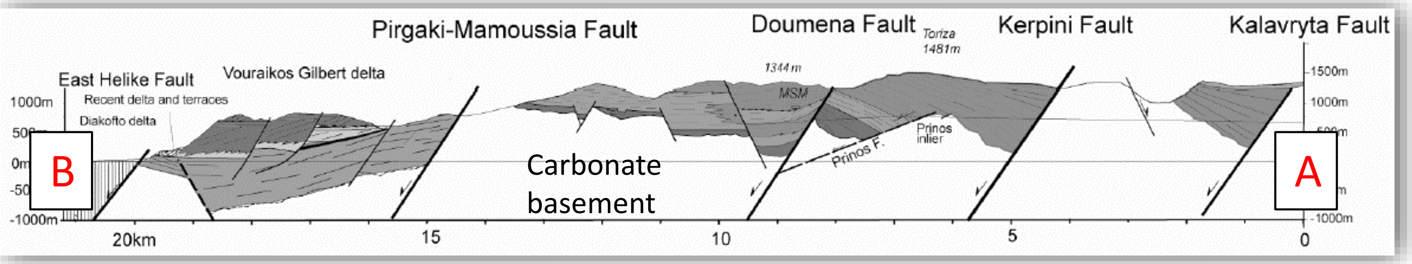




Modified after Ford et al. (2013)

- Graben infill: Pliocene - present
- Pre-rift basement: Cretaceous-Miocene thrust sheet, trending ~ N-S



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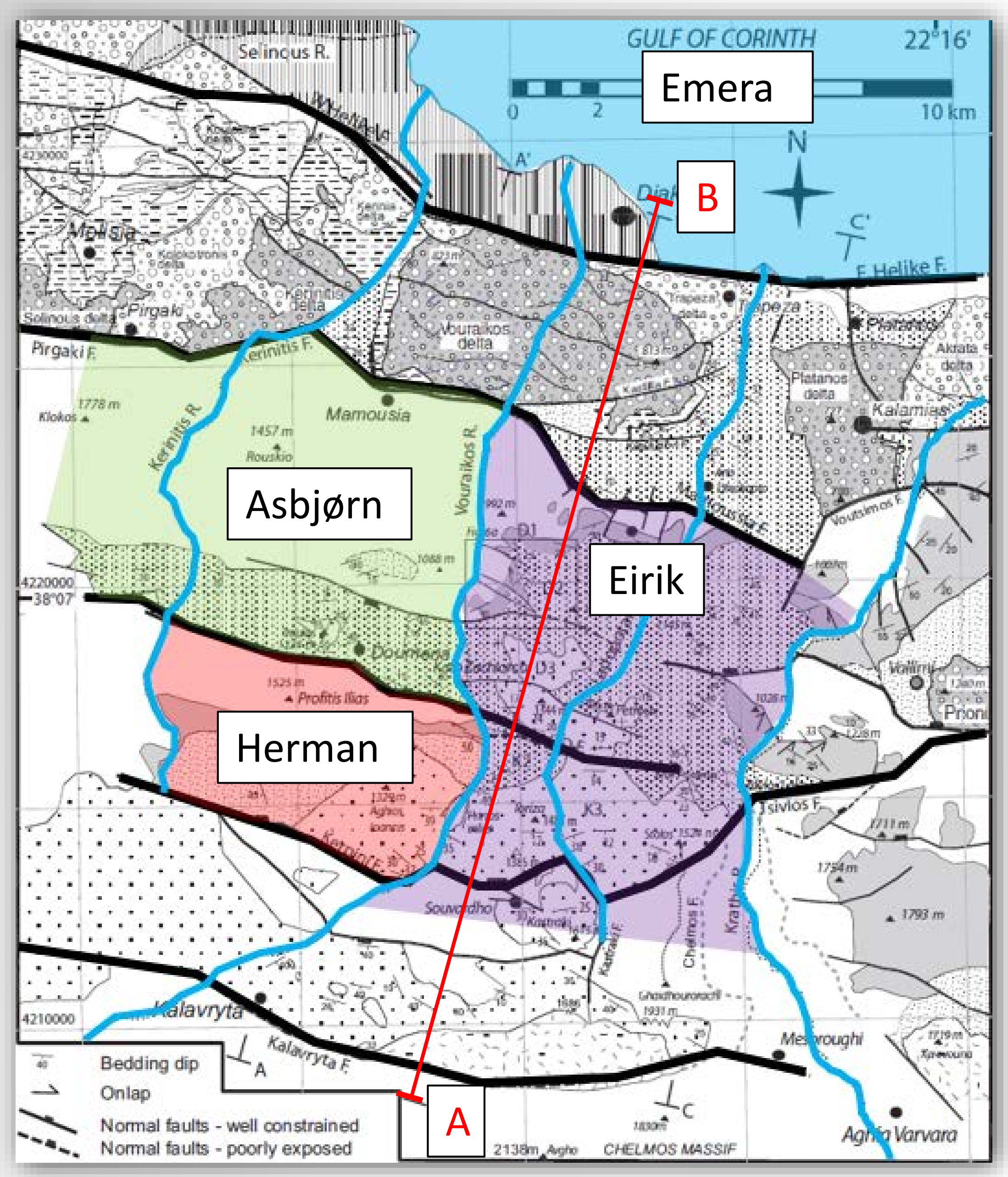

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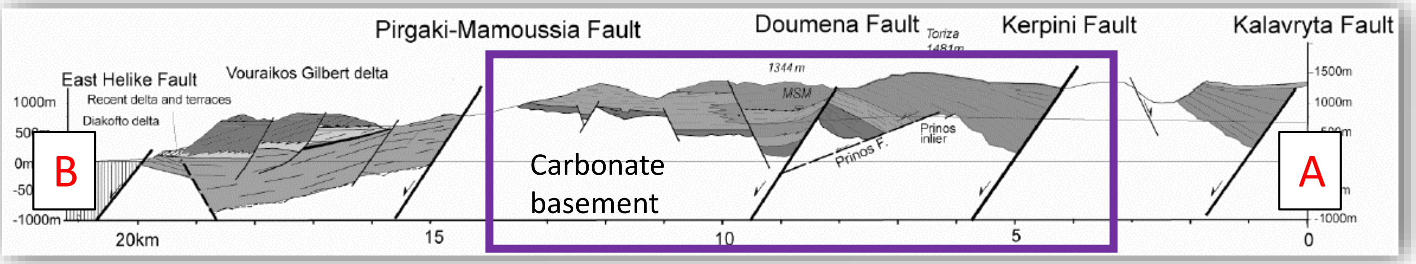

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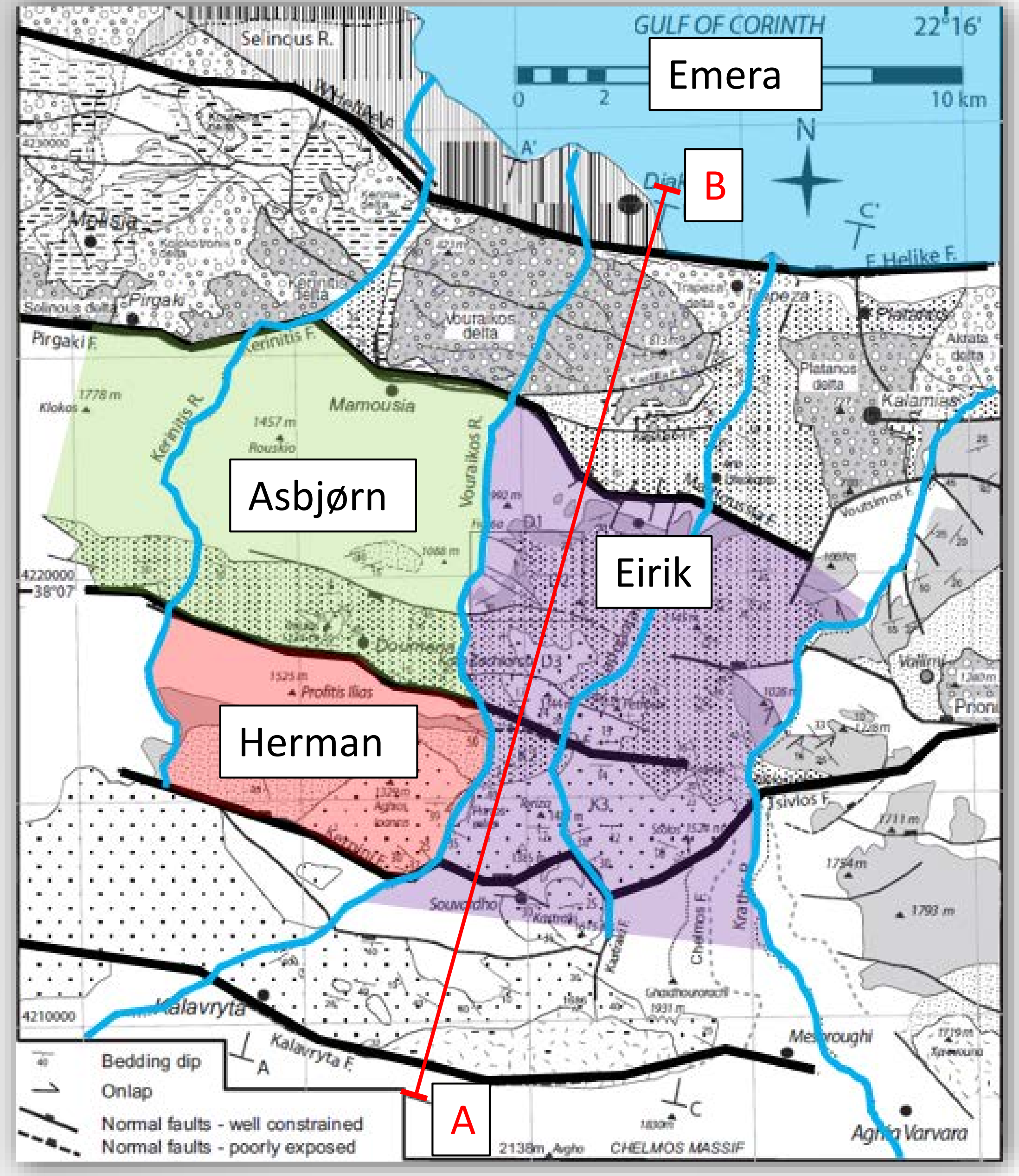
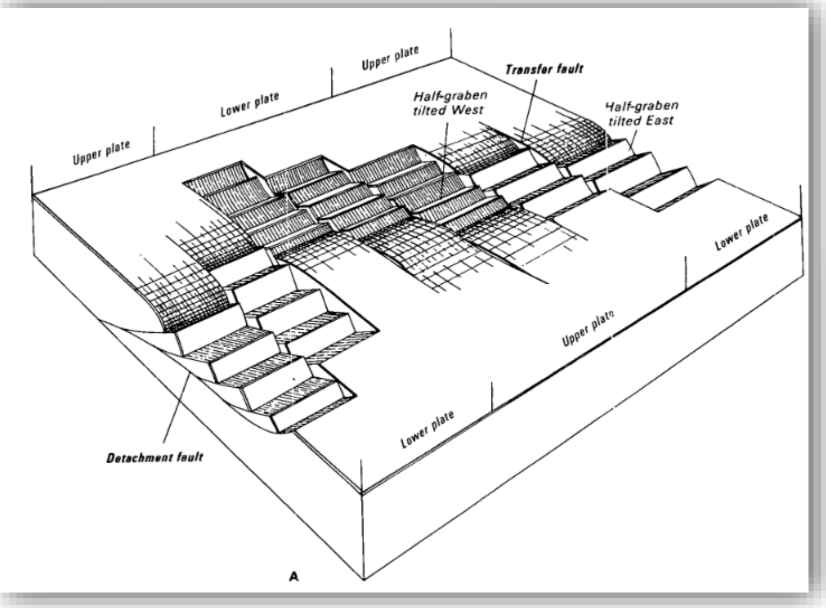


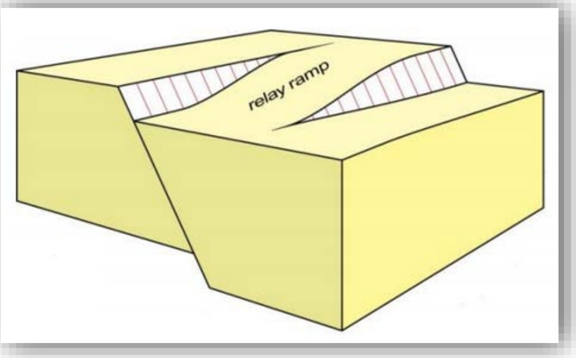
Modified after Ford et al. (2013)

Transfer fault model

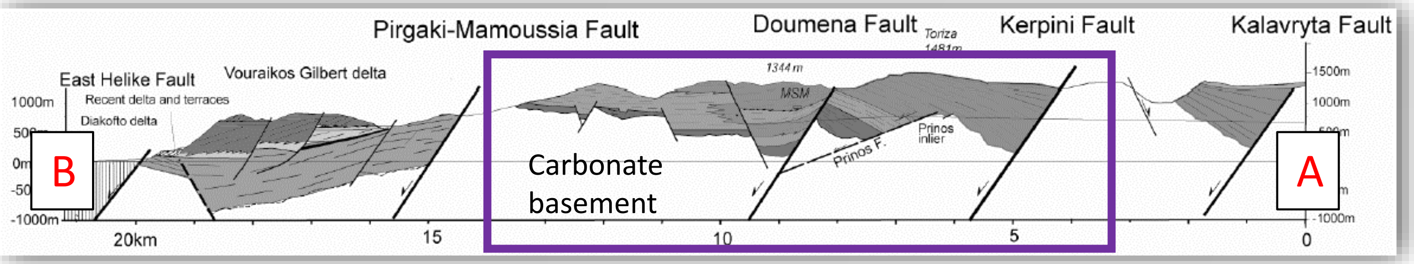


Lister et al. (1986)

Relay ramp model



Dahman (2015)



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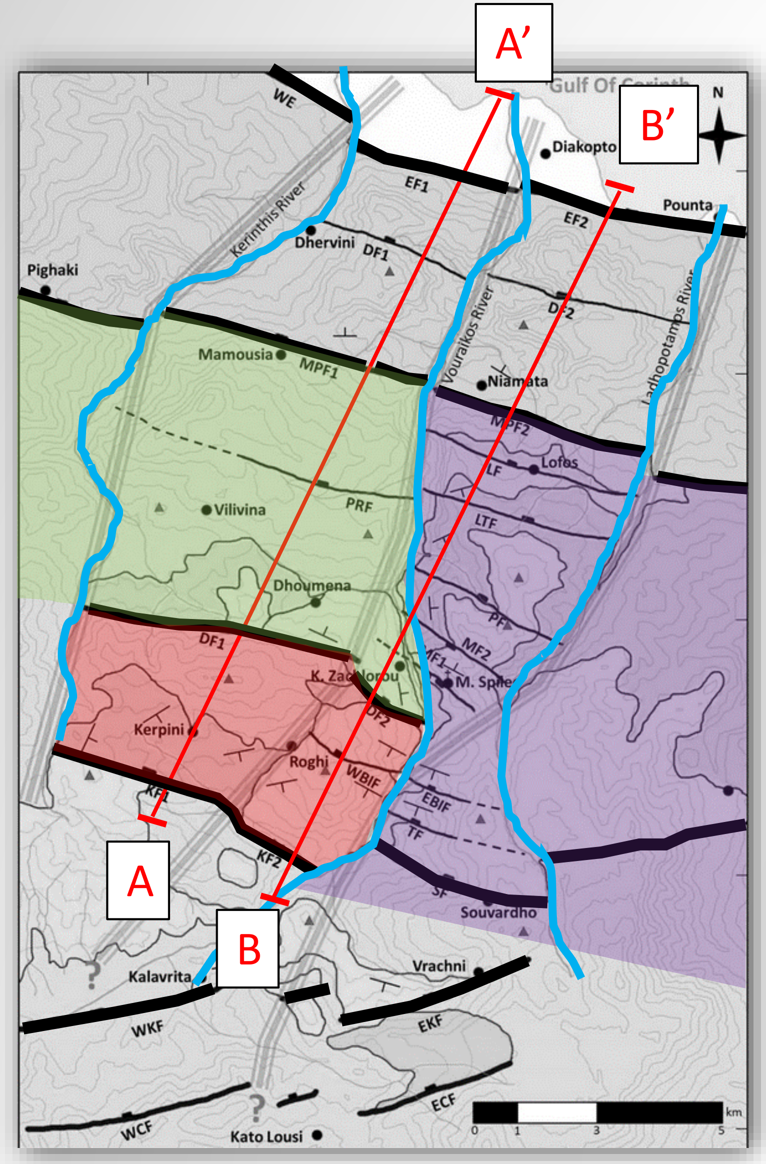

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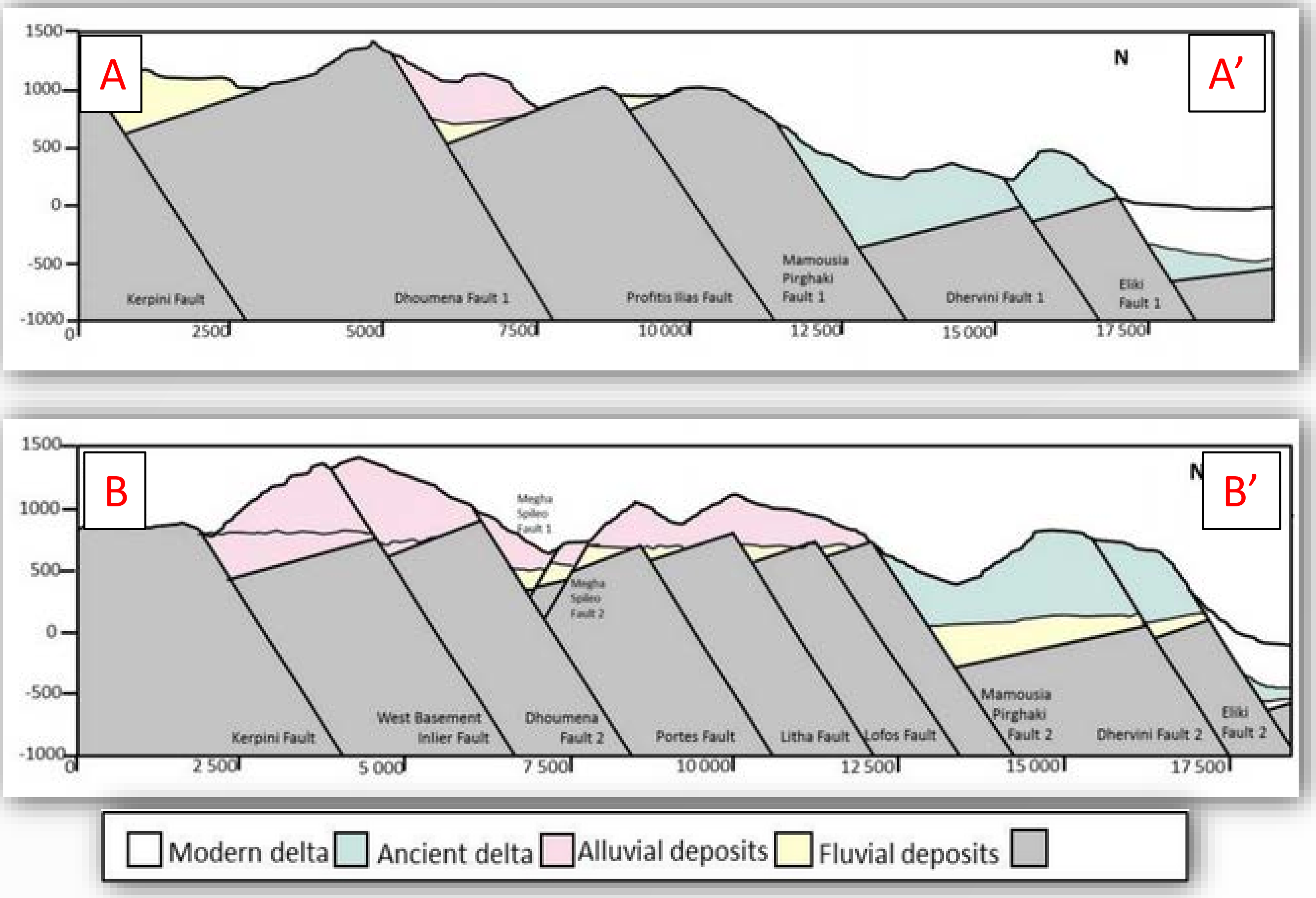
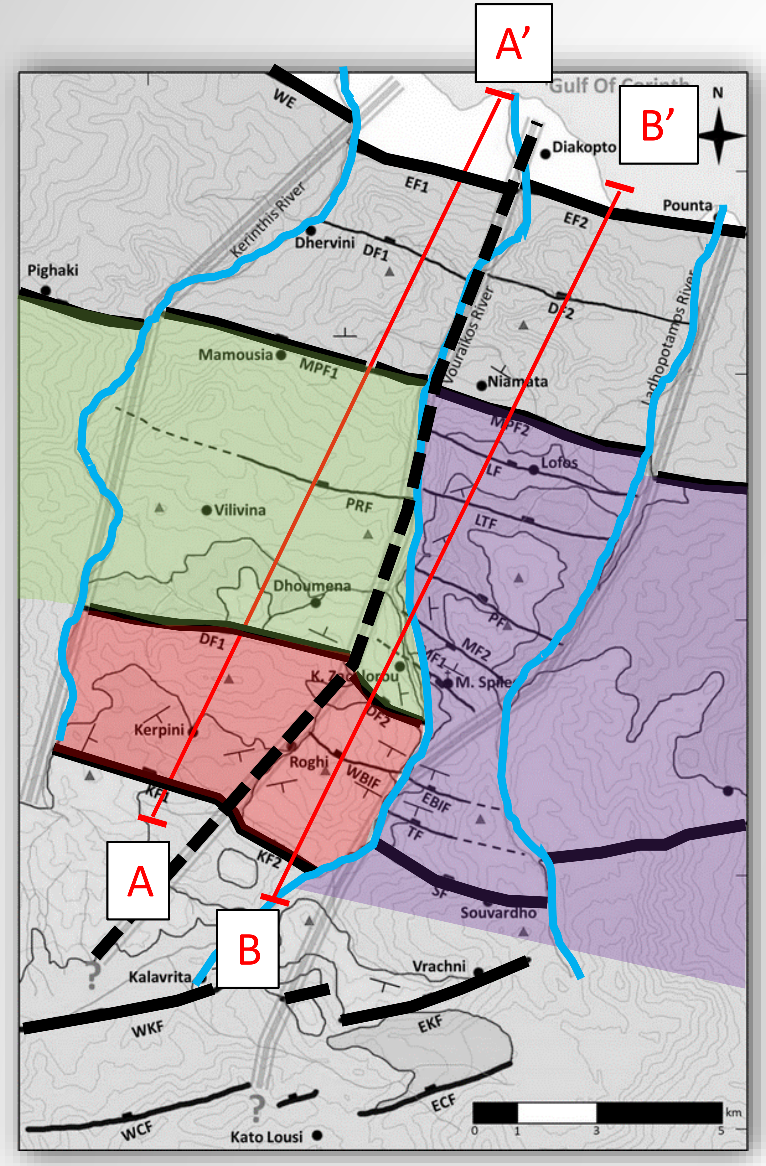


Modified after Dahman, 2015



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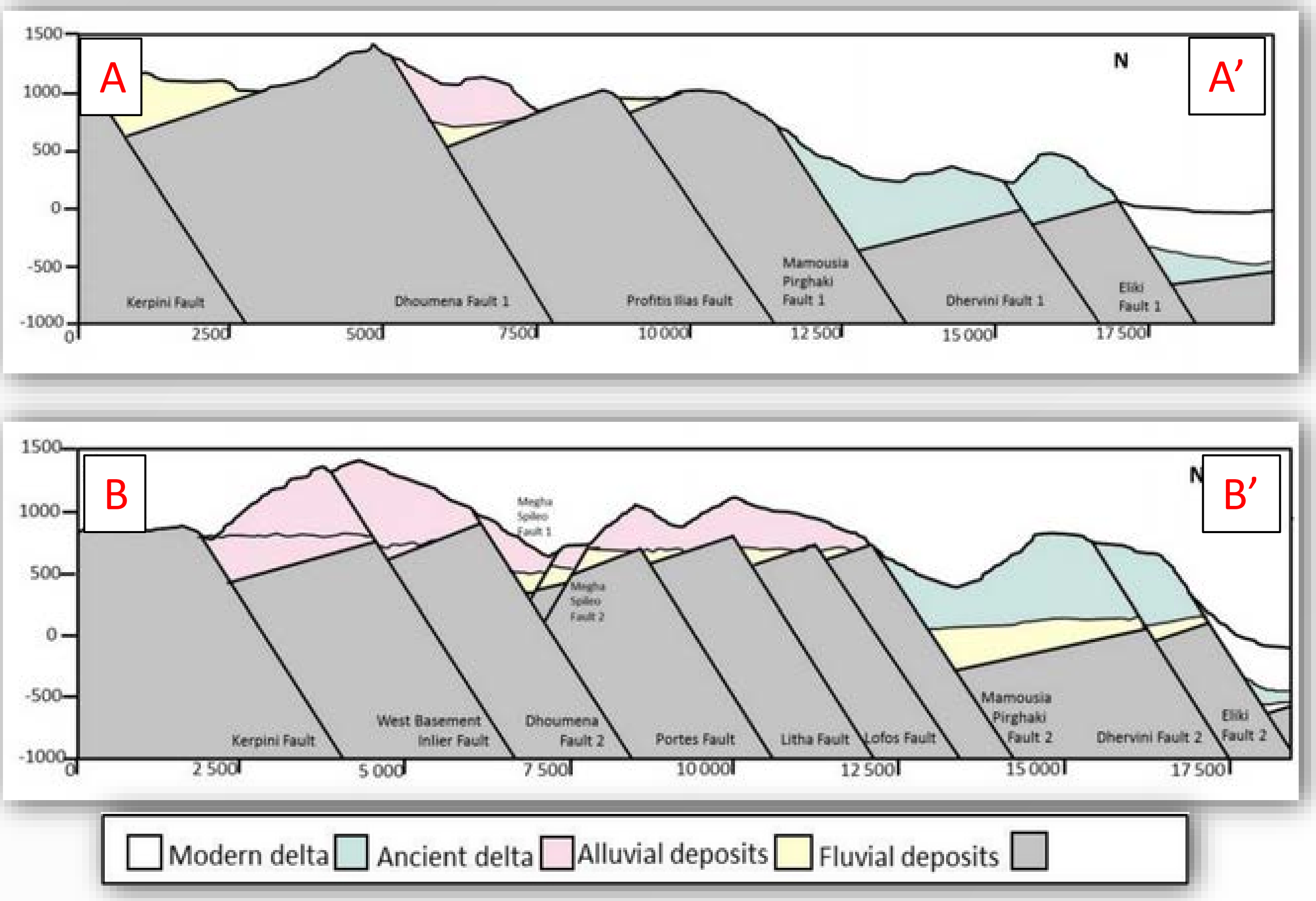

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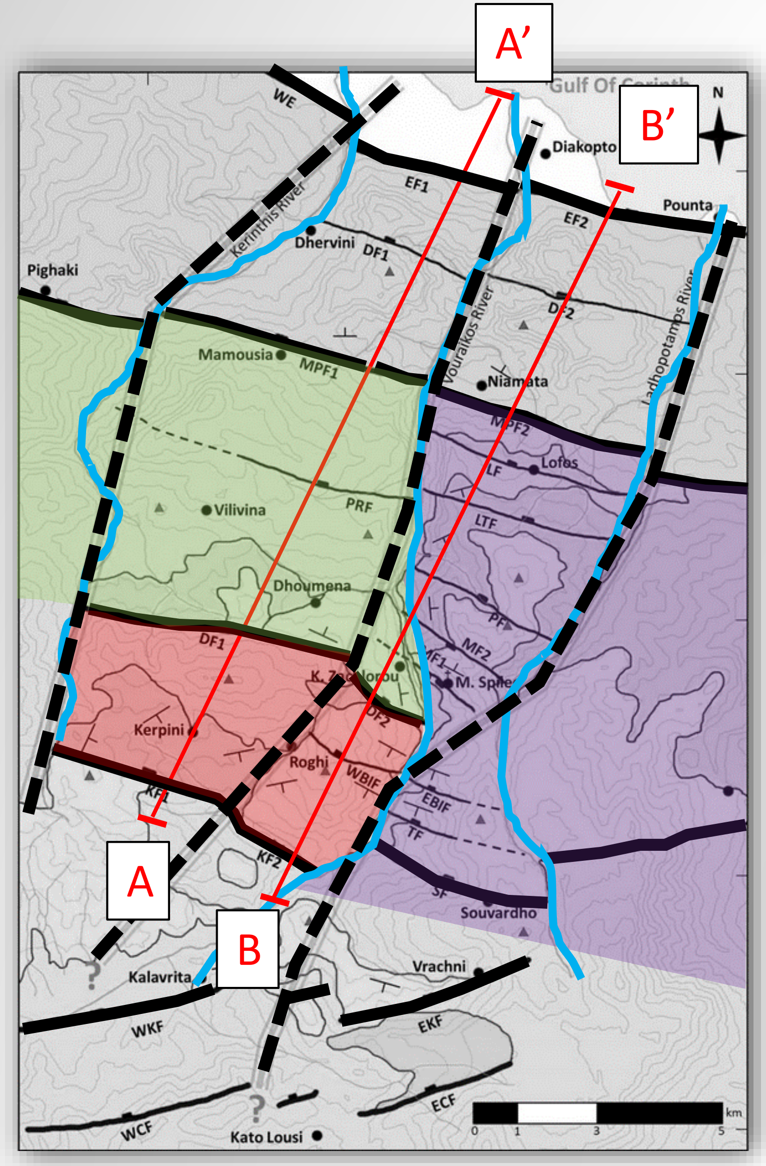

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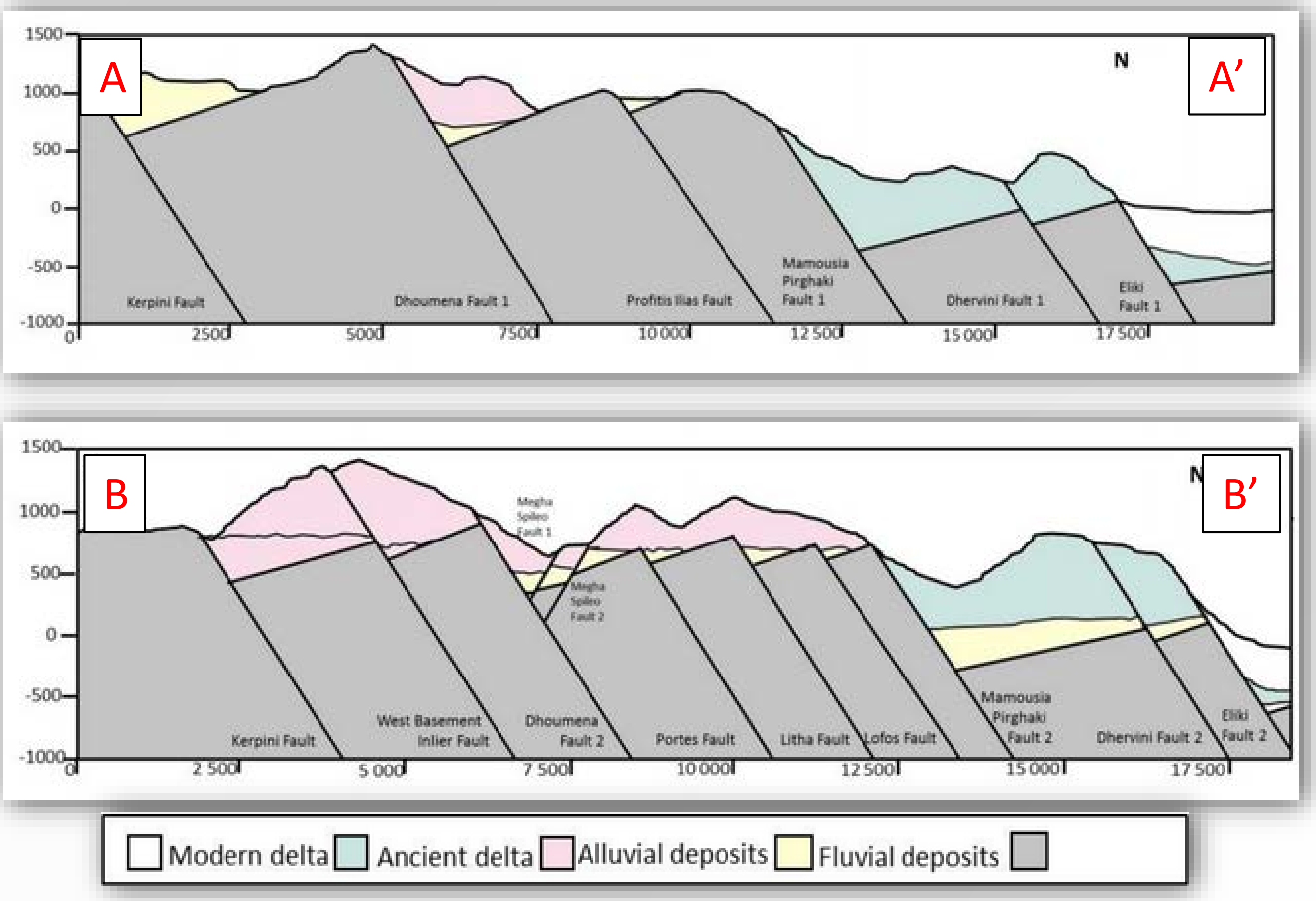

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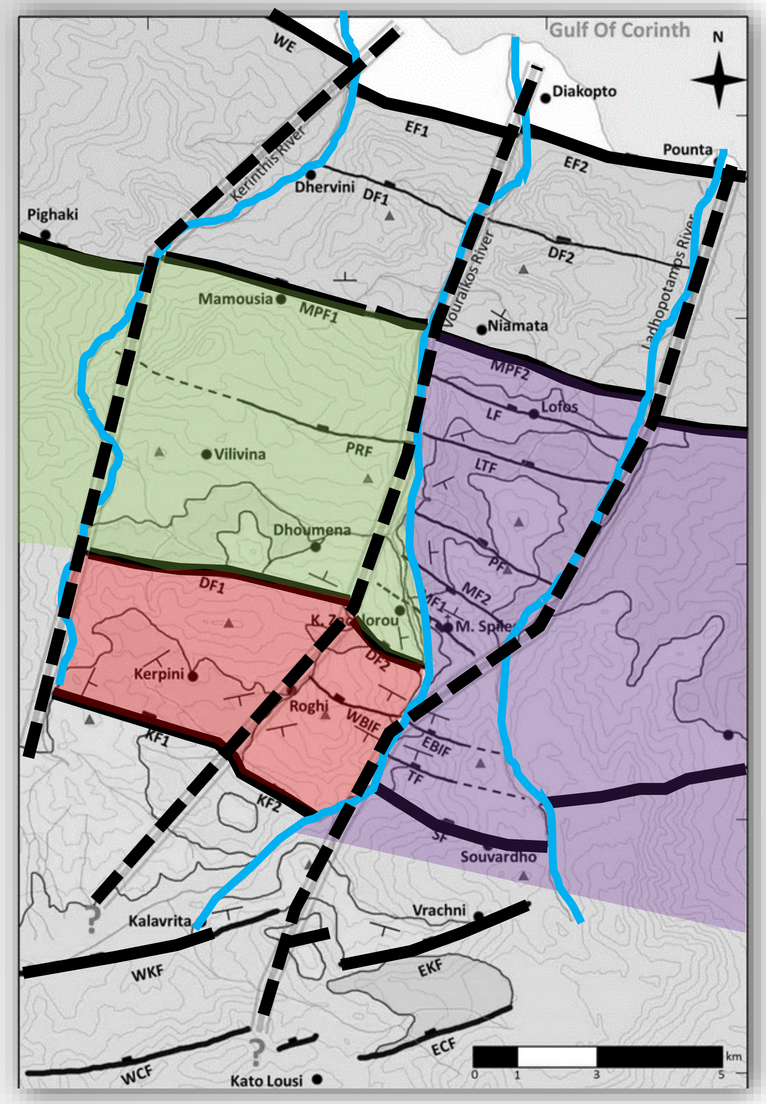

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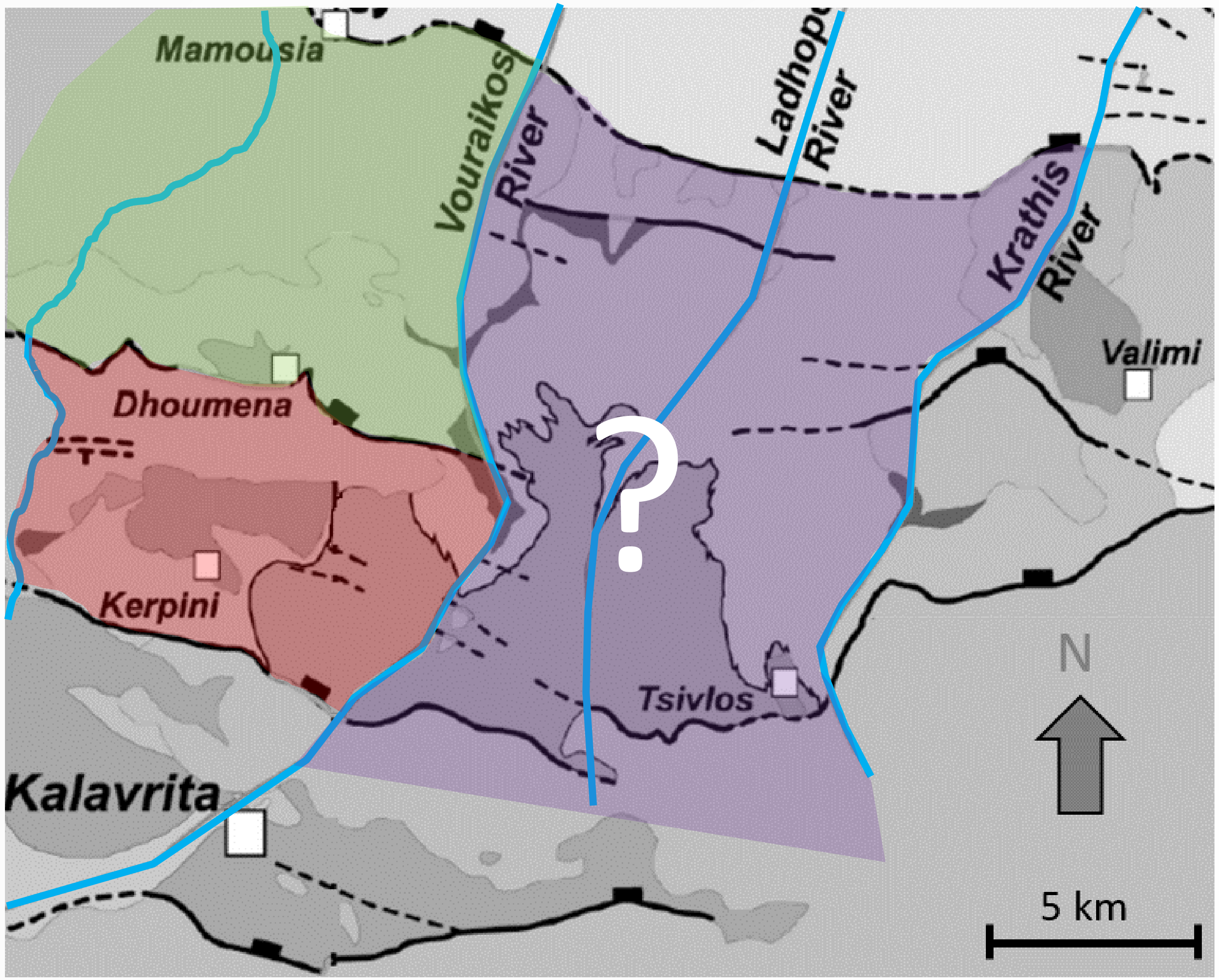


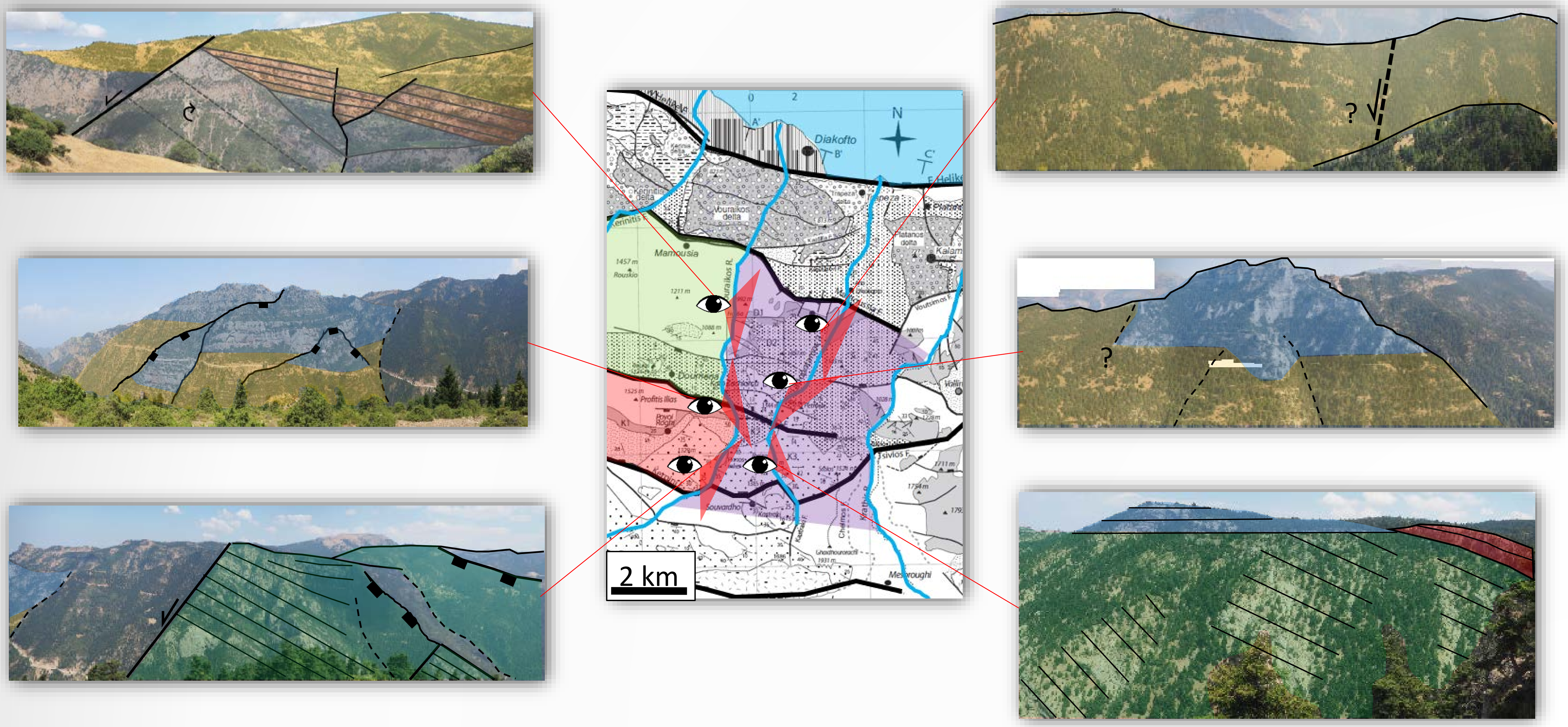
Modified after Collier and Jones (2003)

Objectives

- What are the relative age relationships between faults and sedimentary units?
- How do faults and sediments correlate between the river valleys, and which structures can explain the lateral changes?

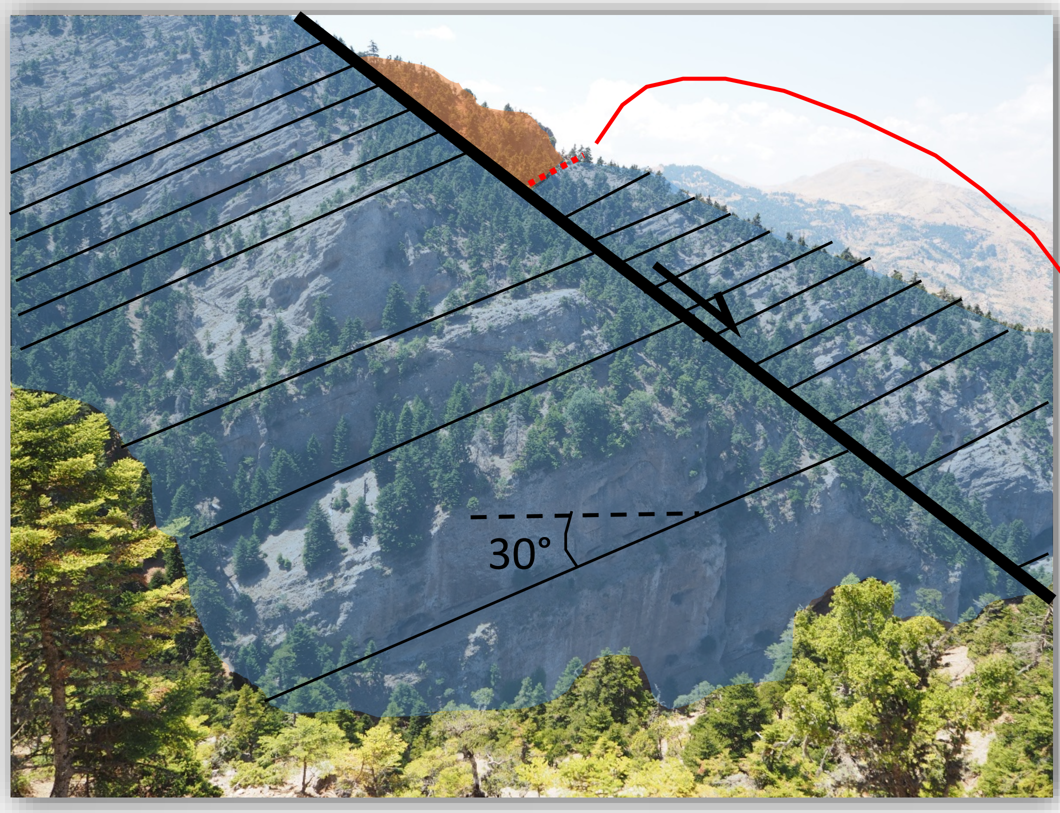
Field work

Valley side photographs



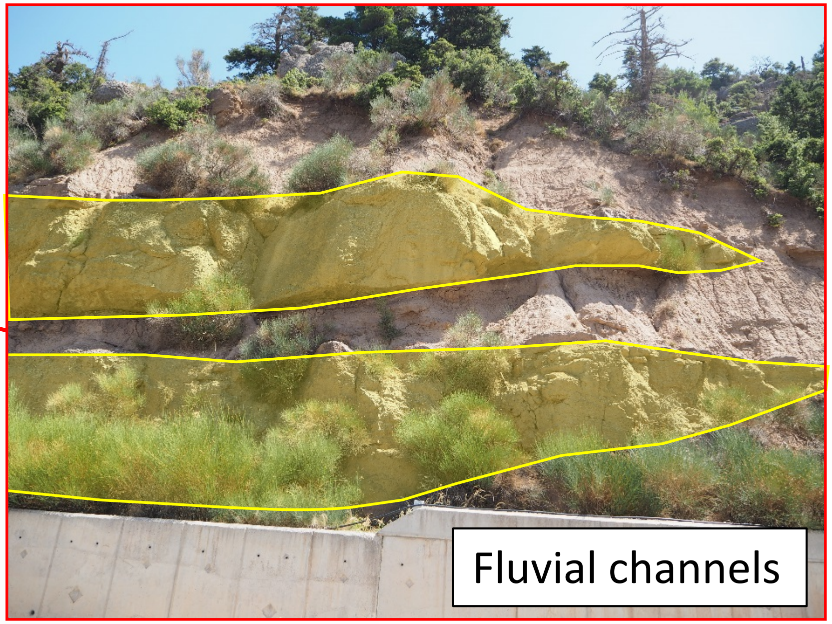
Field work

Strike/dip measurements



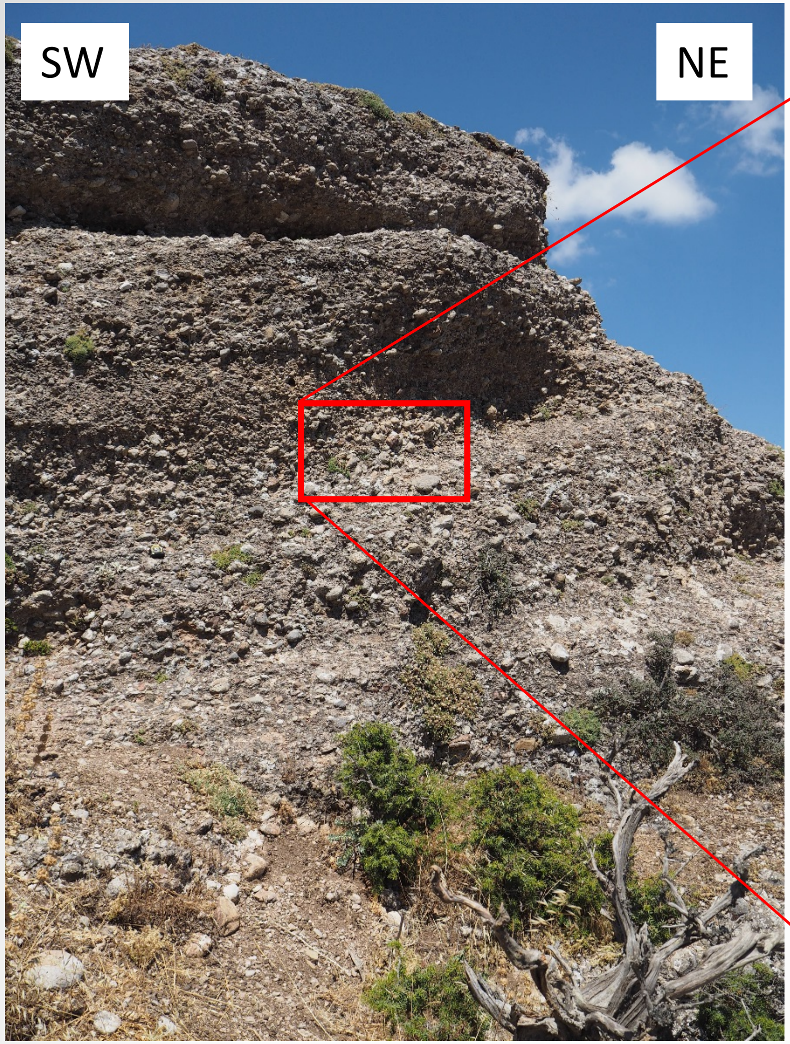
Field work

Outcrop descriptions



Field work

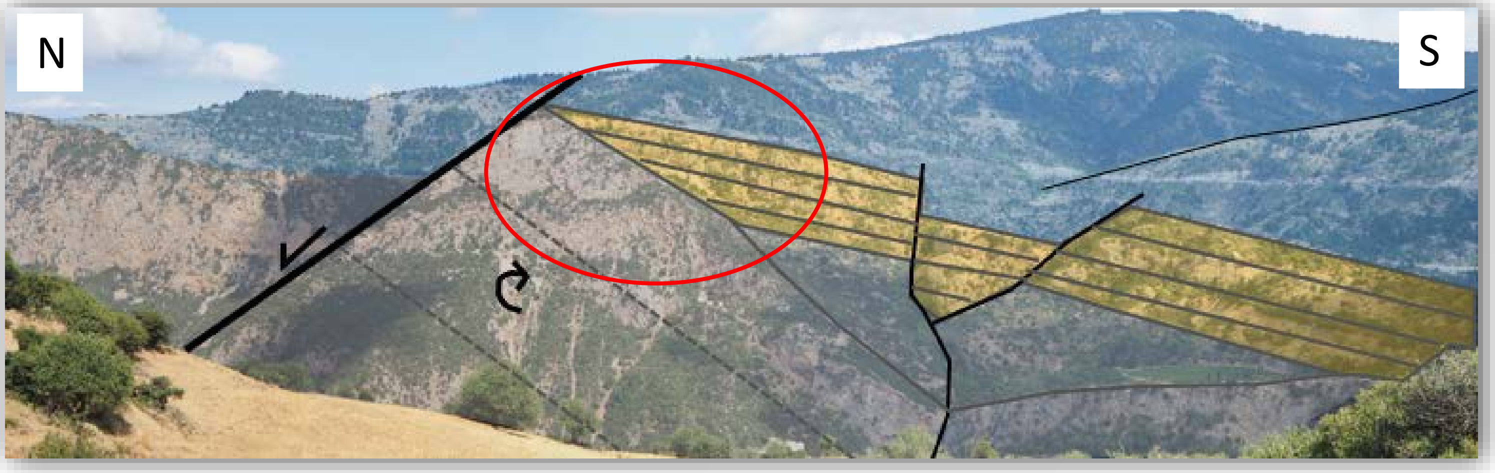
Paleocurrent indicators



Field work

Age relationships

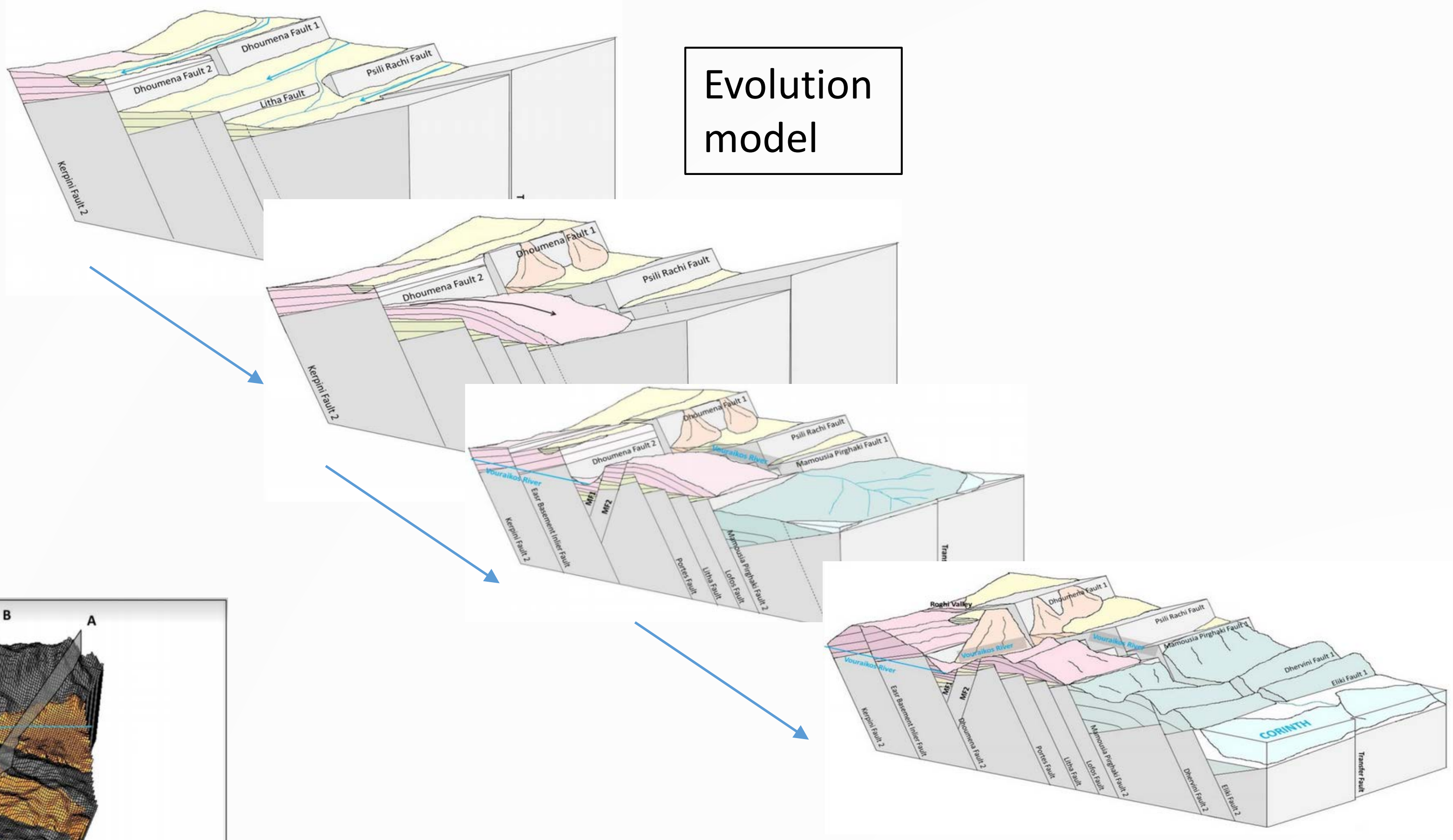
Truncation



Onlap

Post-field work

- Structural map
- 3D model in Petrel
- Evolution model



Evolution model

Dahman (2015)

Dahman (2015)

Thank you!

A comprehensive study of several proposed footwall-derived, syn-rift, alluvial fan deposits in the hanging wall of the Kerpini fault block, Greece

By: Herman Birkeland

Main supervisor: Chris Townsend
Co-supervisor: Alejandro Escalona

University of Stavanger

Introduction

- Geological setting
  (covered by Eirik)

- Rotated normal fault blocks

- Kerpini Fault Block (KFB)

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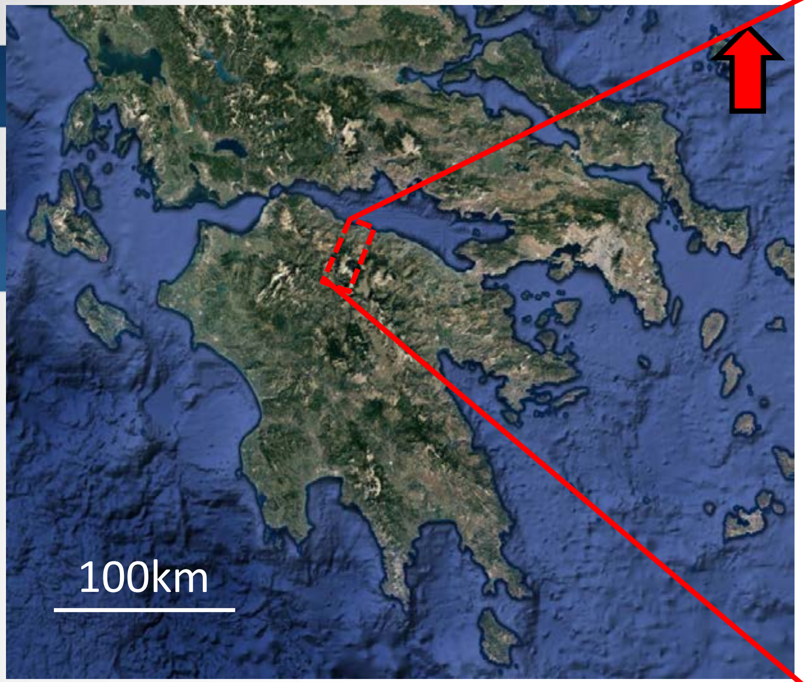
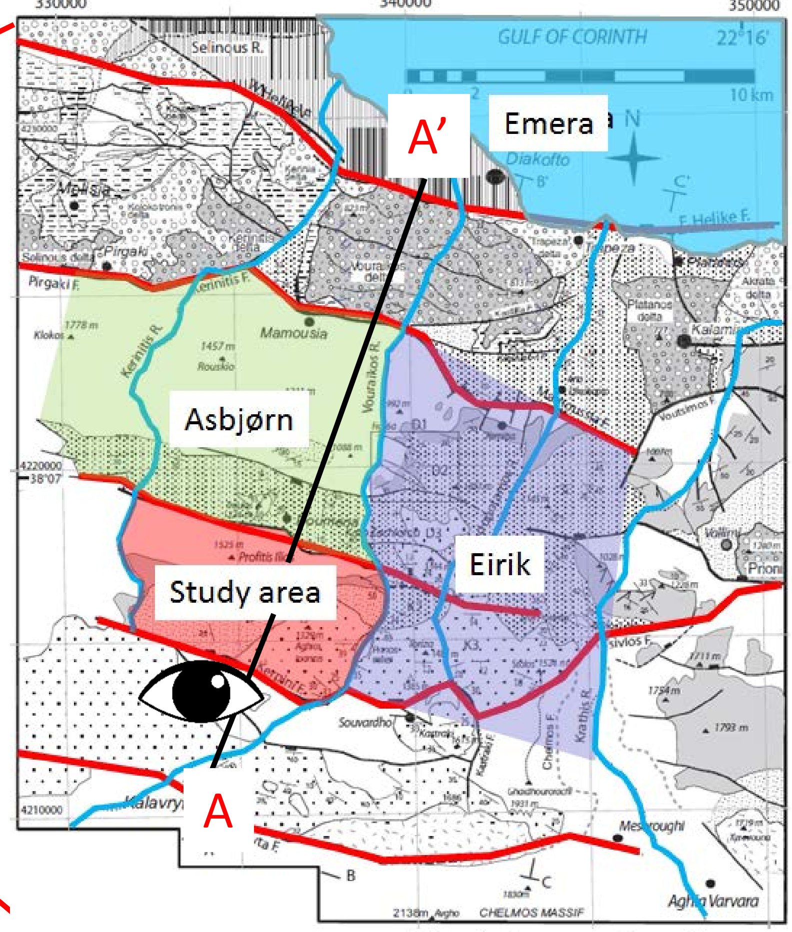
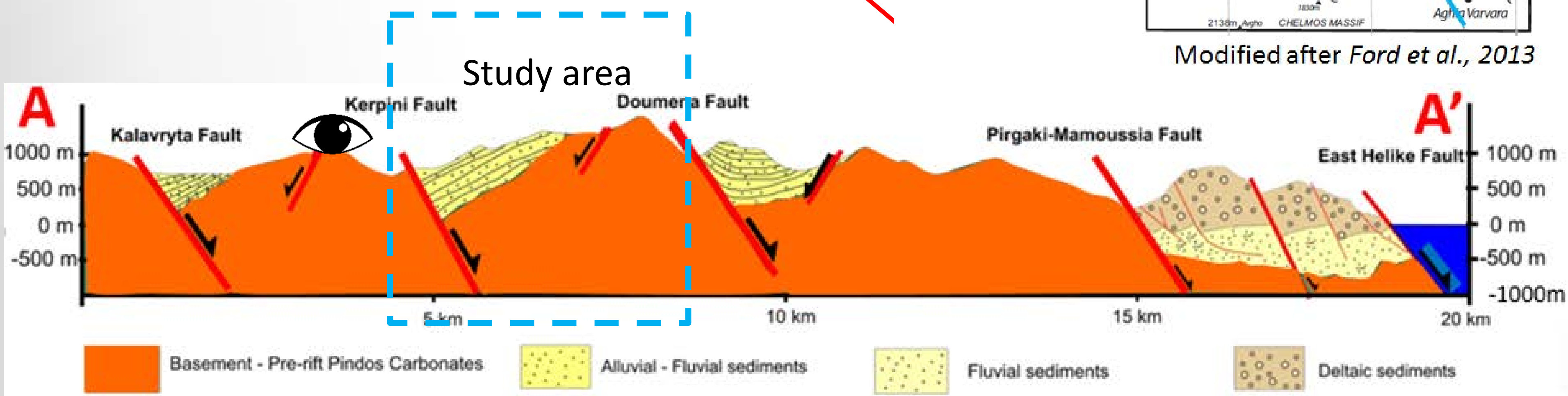
Study area



Google Earth, 2016



Modified after *Ford et al., 2013*

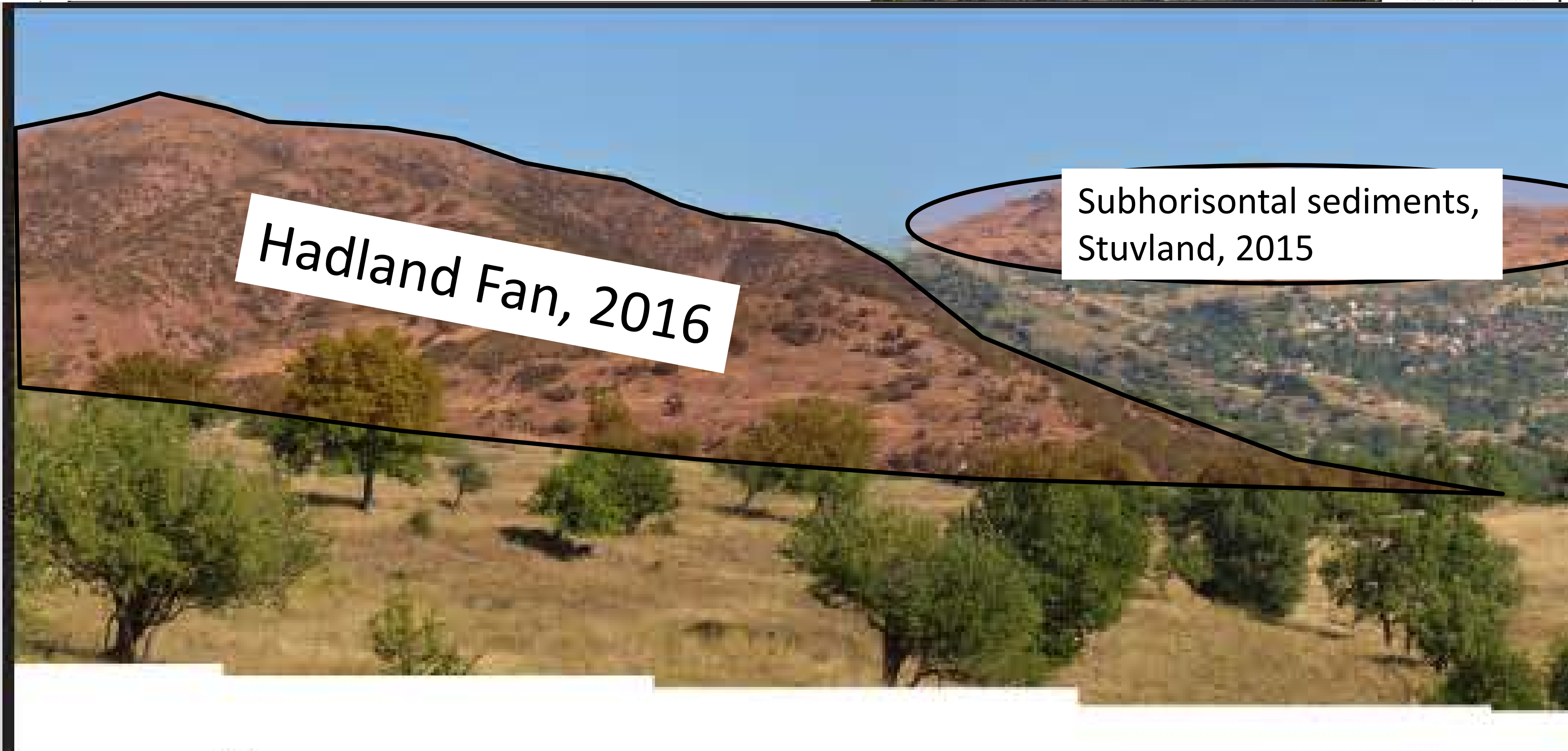


(Modified after Collier and Jones, 2004)

Panorama of the Kerpini Fault Block from the south

W

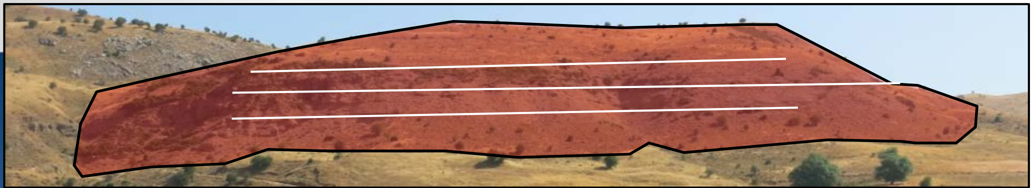
E



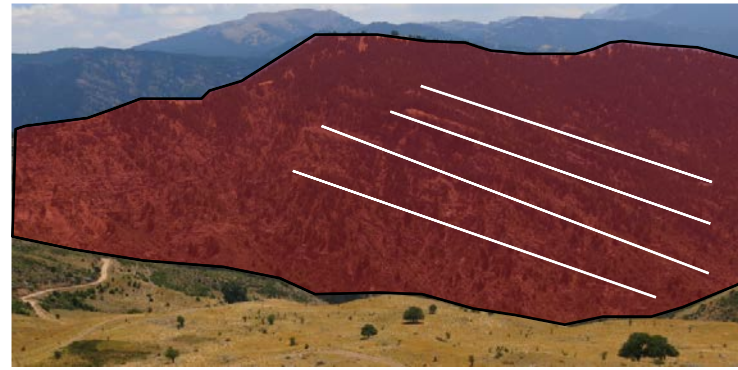
Locality 5.6

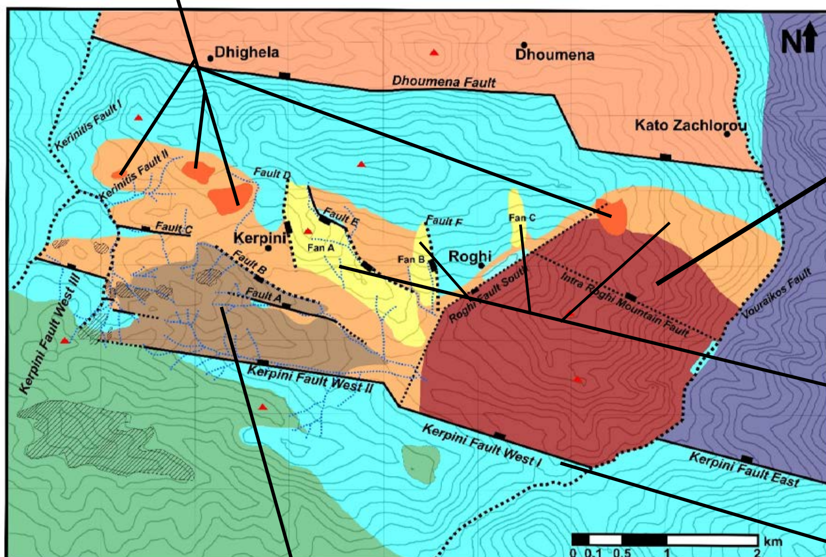
Recent work in the study area

Sub-horisontal sediments – Stuvland, 2015



Roghi Mountain
Seglem 2016, Sigmundstad, 2016





Proposed fans - not studied in detail

(Kerpini fault block – Hadland, 2016)

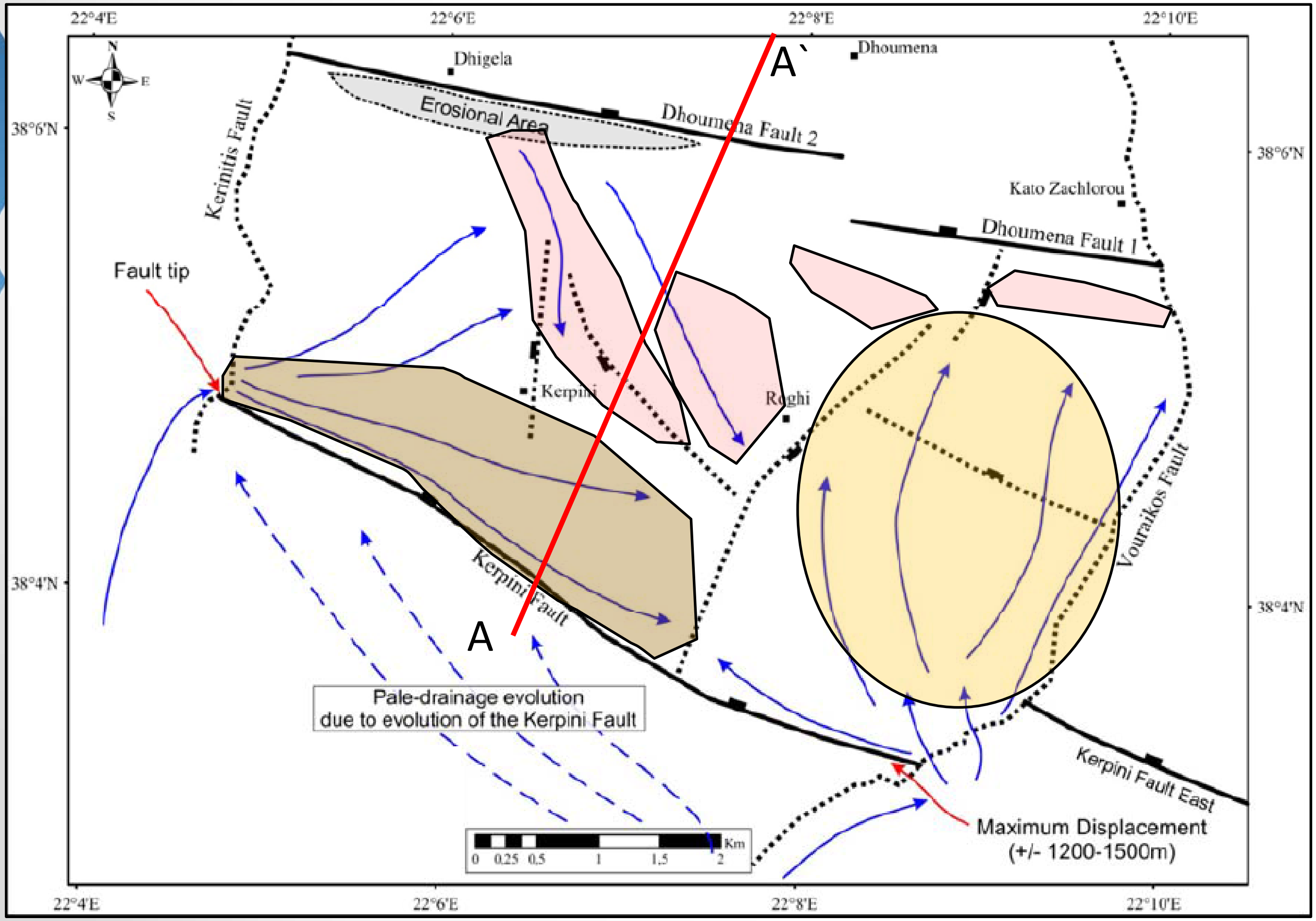
Alluvial fan – Hadland 2016

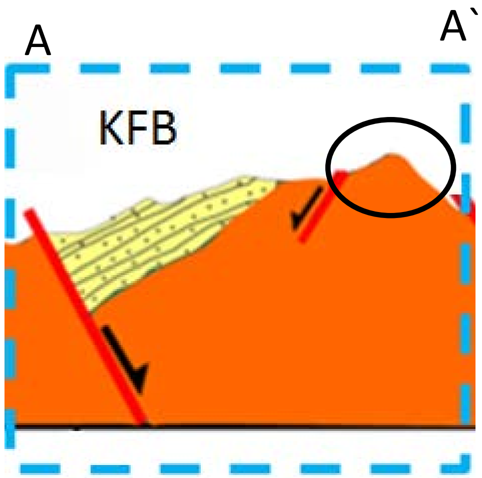
Kerpini fault, Syarhul 2014

Geological problems in the area

- Complex interaction of units
- Several source possibilities

Paleo-drainage patterns





Modified from Syarhul, 2014

Objectives

Determine:

- Are the 4 units fans?
- What is the relative timing of these units?
- How are the structural elements affecting the development of the units?
- Can the units be used to indicate timing of Doumena/Kerpini faults?
- Where are the sediments sourced from?

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Methodology

Tasks in order to fulfill objectives:

- Do a sedimentary and structural analysis of the 4 units, and map contacts and lithologies in the general area

- Develop a stratigraphic-tectonic 3D model for the development of the KFB, to see if observations/interpretations makes sense in a 3D model

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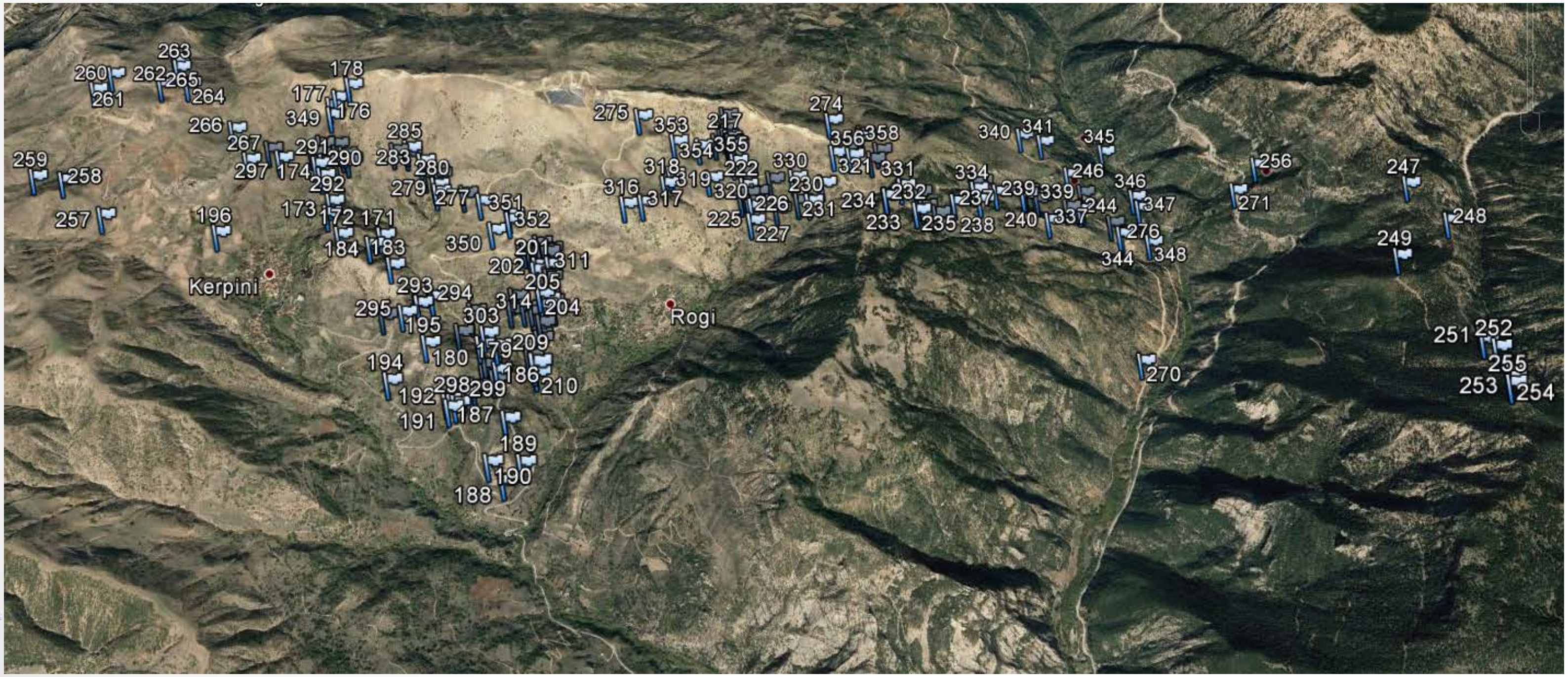
Data

- 1500 photos tied with 230 GPS points
- Dips / dip directions, faults, unconformity, lithological contacts



Google Earth

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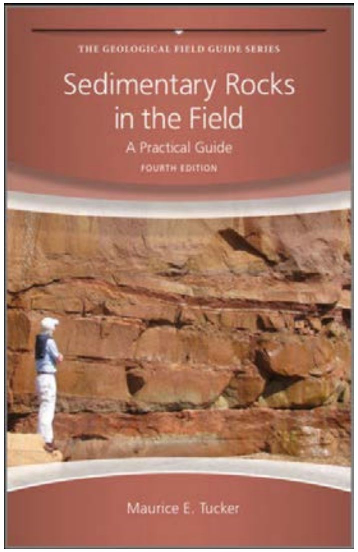
Fieldwork and observations

Framework:



Main lithologies

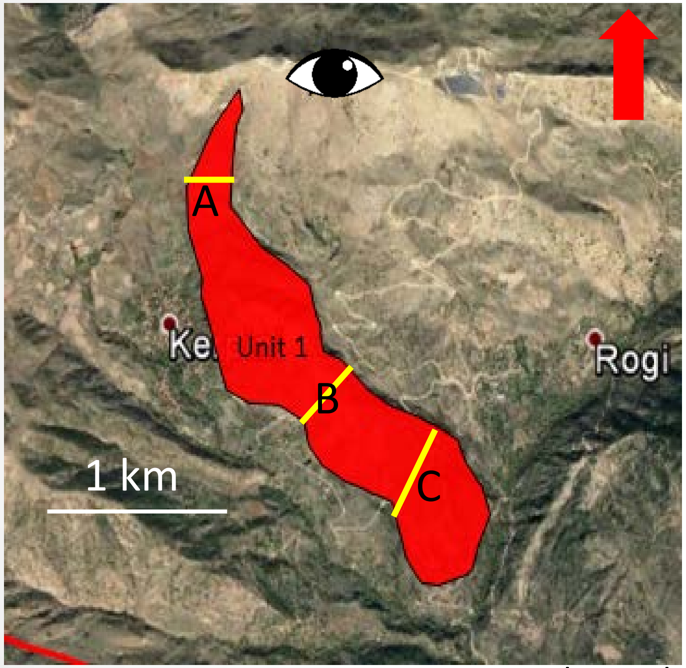
Basement carbonate, limestone

Basement, red chert

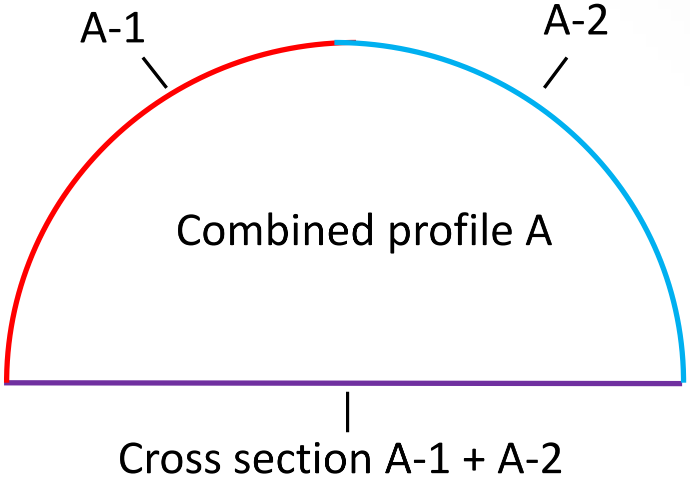
Sedimentary infill, conglomerates

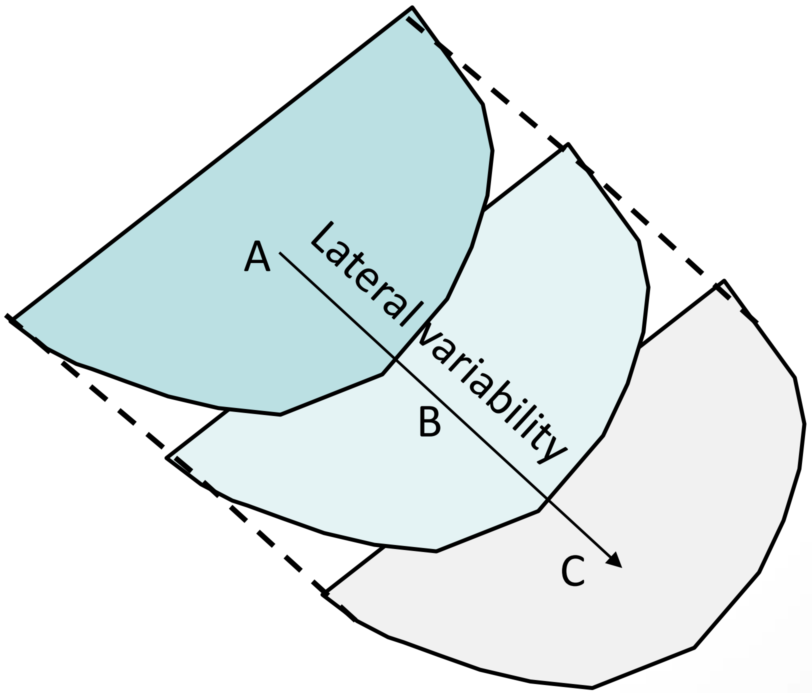
Creation of lithological logs

Unit 1 example



Google Earth





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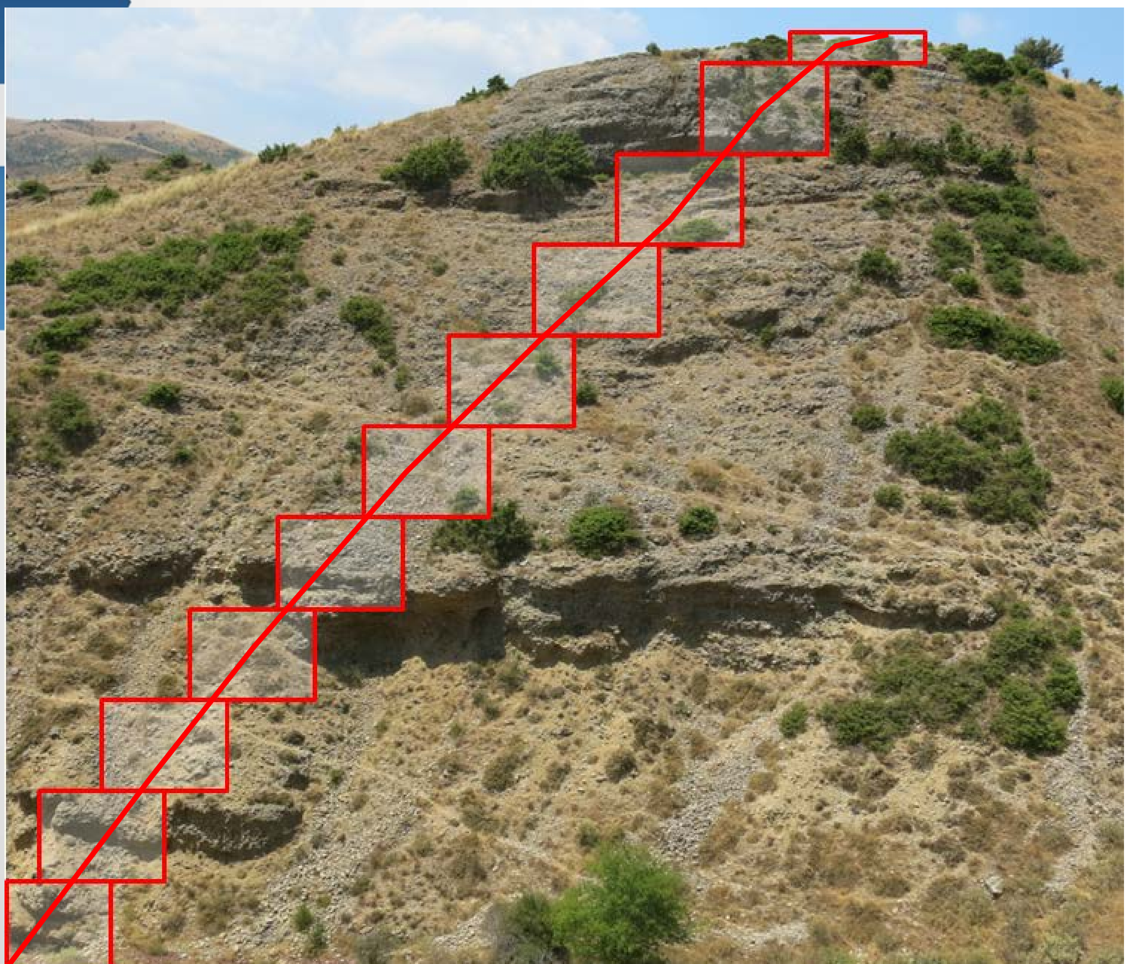
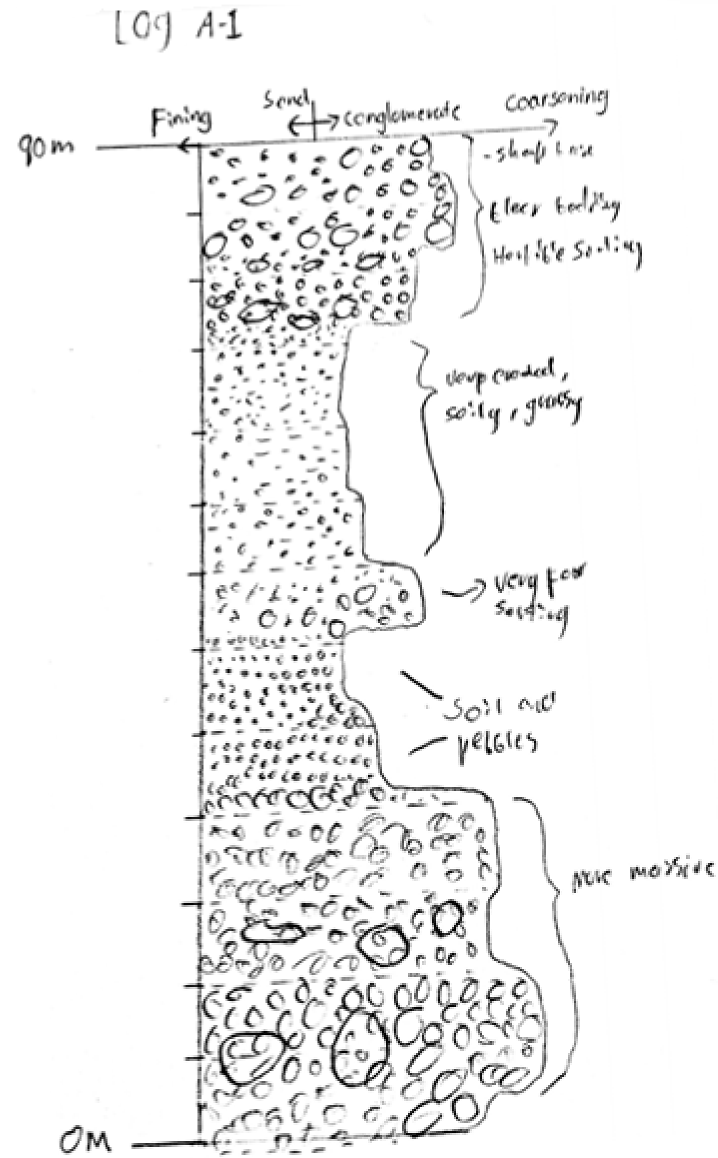
Creation of lithological logs

Log A-1

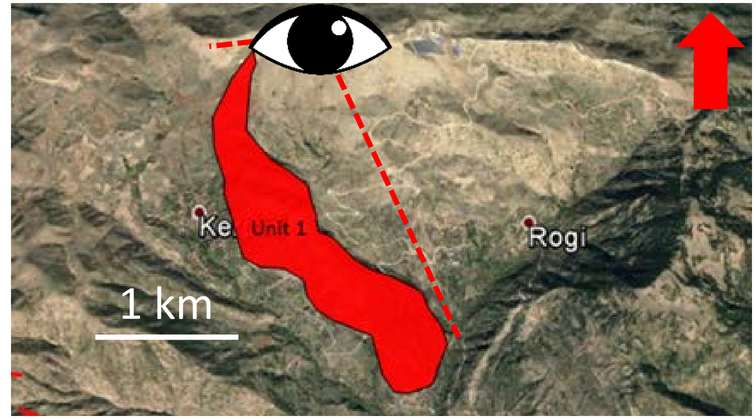


Stavanger

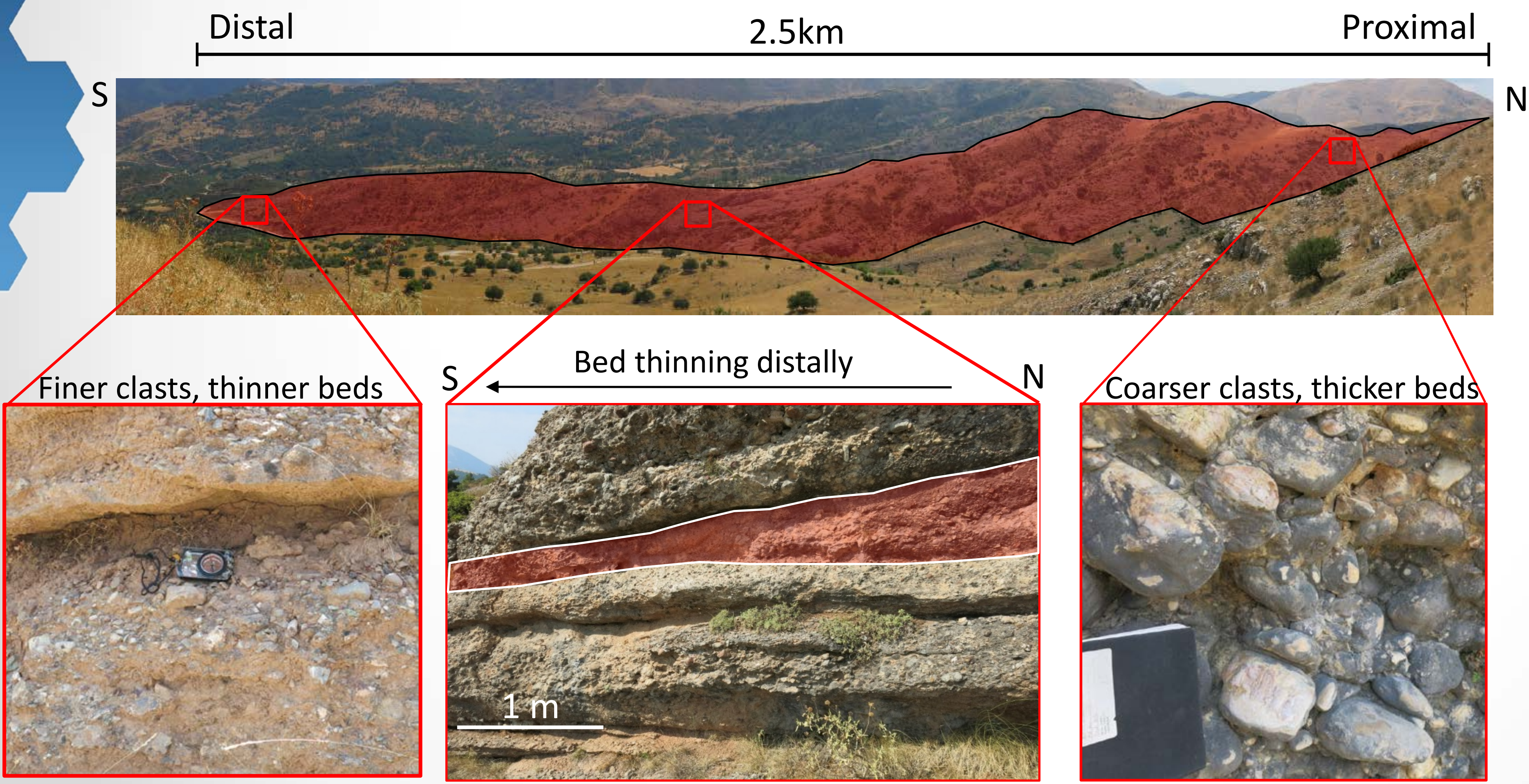
Field log



Unit 1

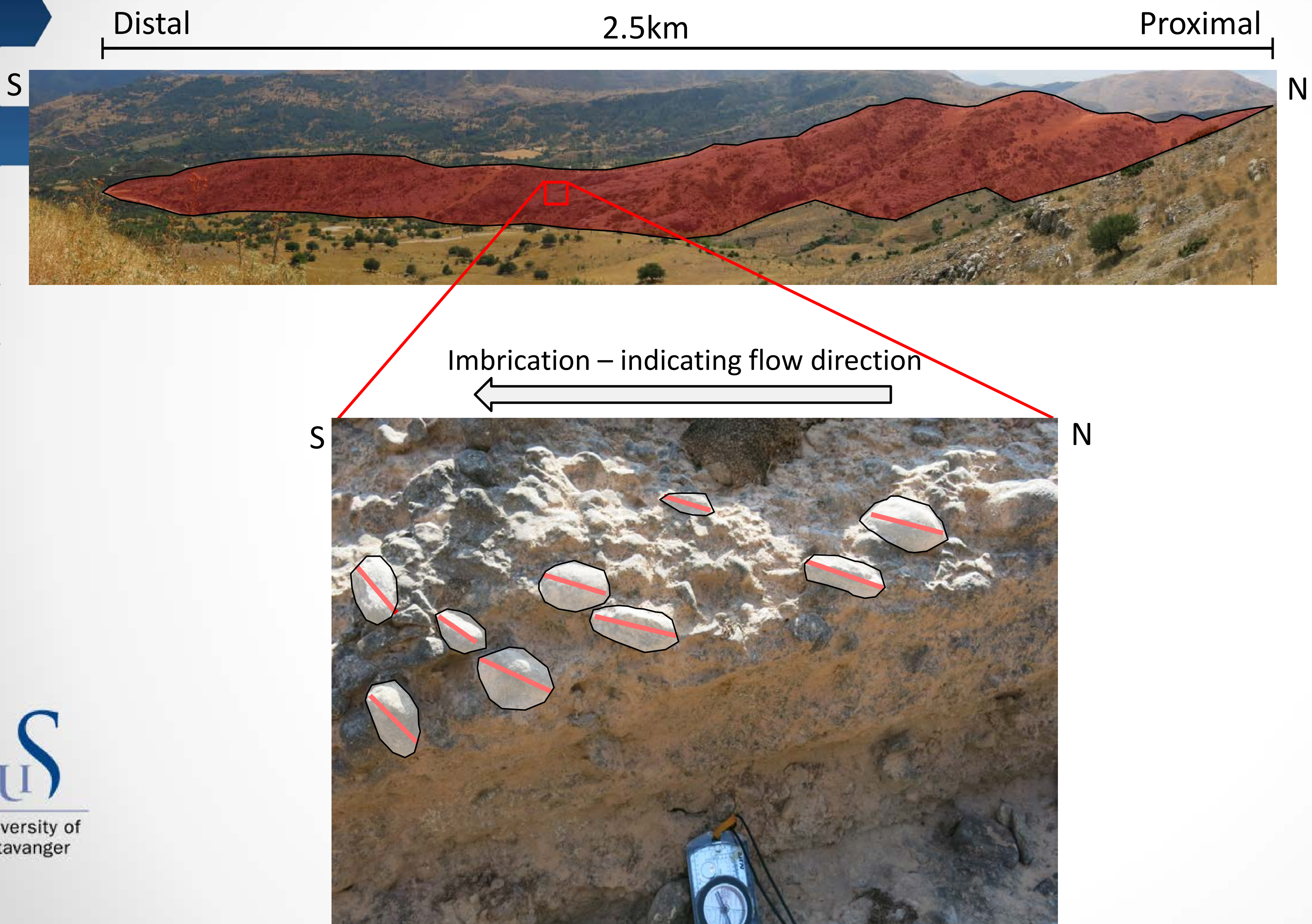


Unit 1
Rogi
1 km



Distal
2.5km
Proximal
S
N
Finer clasts, thinner beds
S
Bed thinning distally
N
1 m
Coarser clasts, thicker beds

Unit 1



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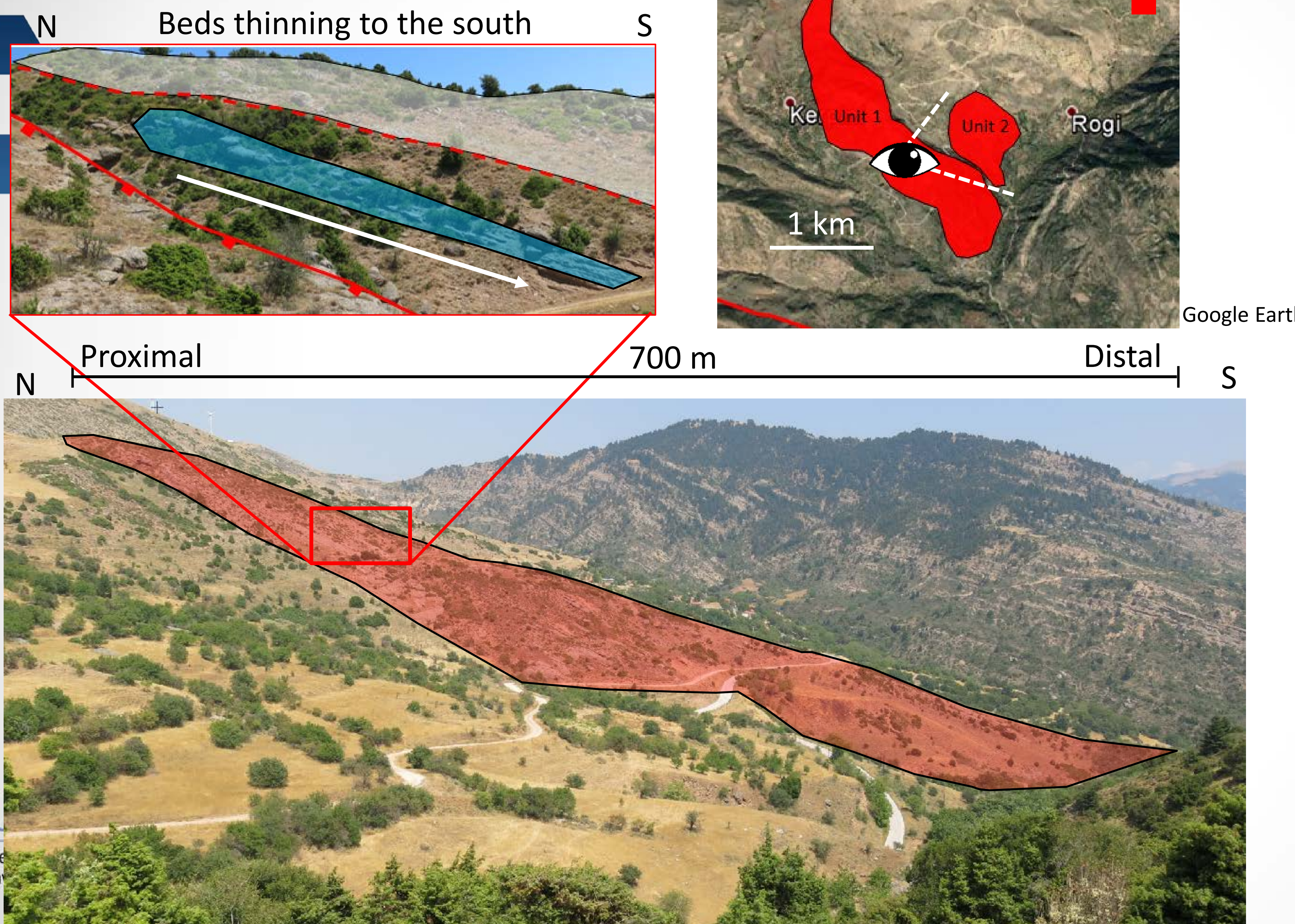
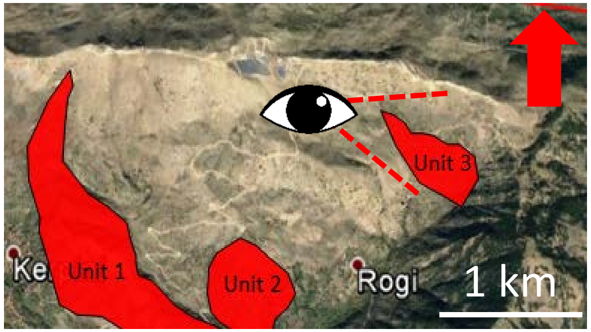
Unit 2

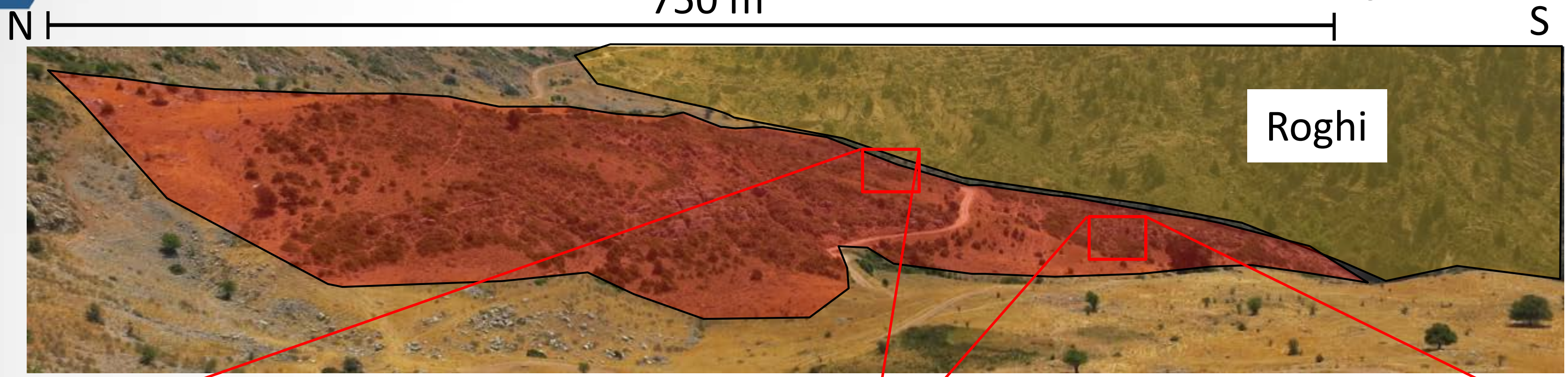


N
Beds thinning to the south
S
Ke
Unit 1
Unit 2
Rogi
1 km
Google Earth
Proximal
700 m
Distal
N
S

Unit 3



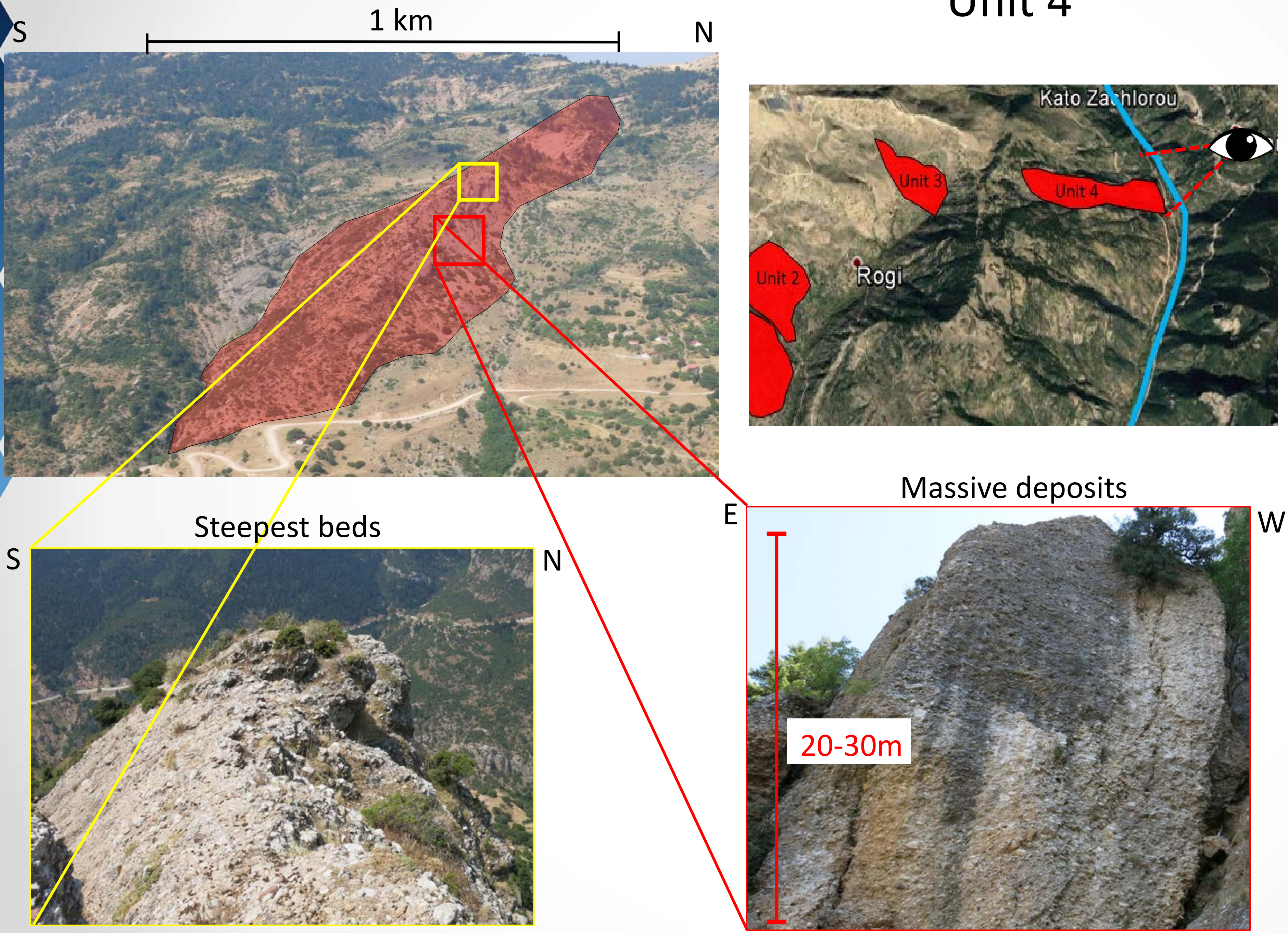
Google Earth



Fining eastwards

Largest clasts of all units

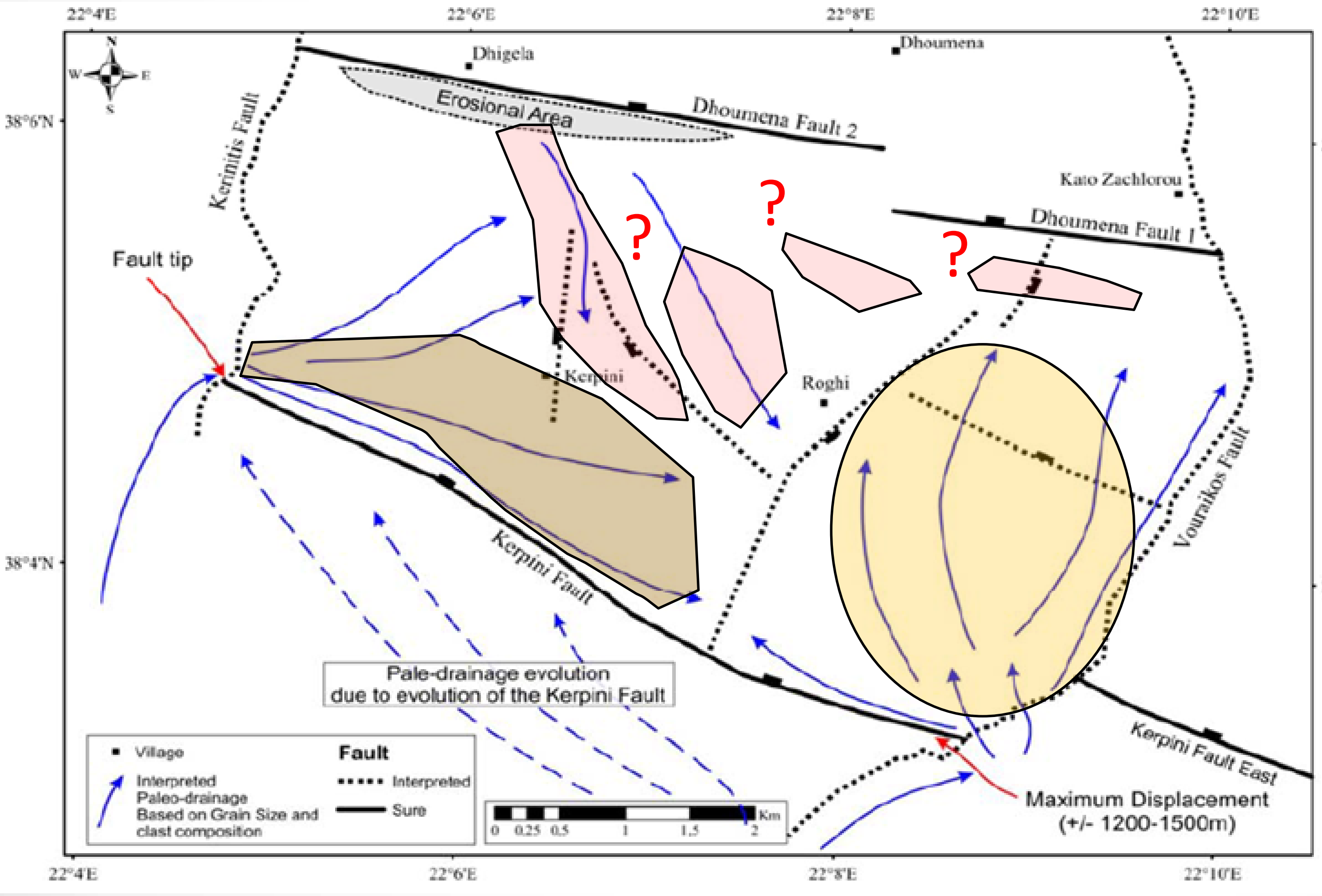
Unit 4



S
1 km
N
Kato Zachlorou
Unit 3
Unit 4
Unit 2
Rogi
Steepest beds
S
N
Massive deposits
E
W
20-30m

Summary

- Preliminary observations
- Challenges



Modified after Syarhul, 2014

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Thank you for your attention!

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Geologic Mapping and Investigation into Tectonic Control on Deposition in an Active Rift Setting. A Case Study of the Doumena Fault Block, Greece.

GEO620

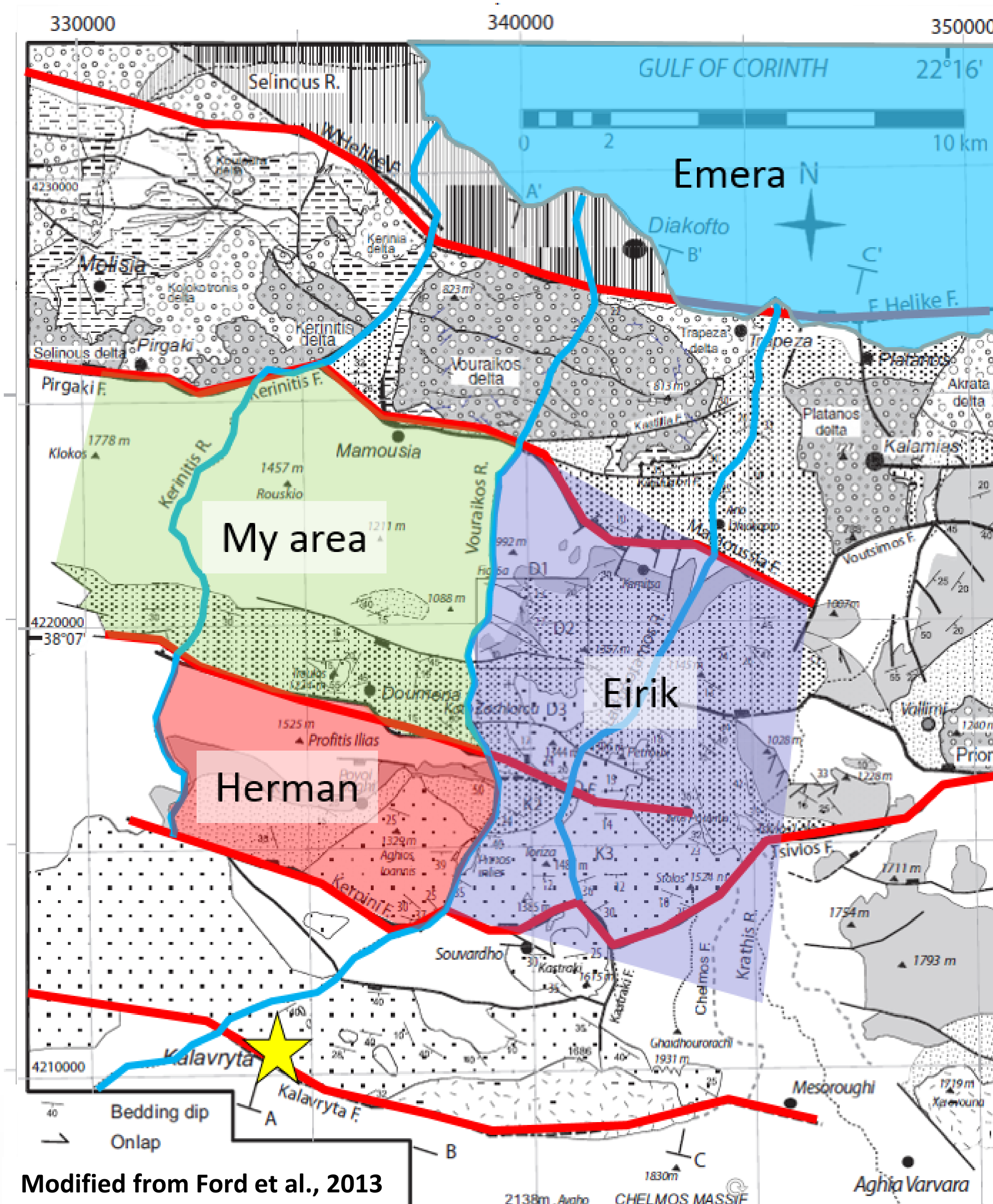
02.12.2016

University of Stavanger

Presenter:	Asbjørn Veiteberg
Supervisor:	Chris Townsend (UiS)
Co- Supervisor:	Alejandro Escalona (UiS)

Project overview

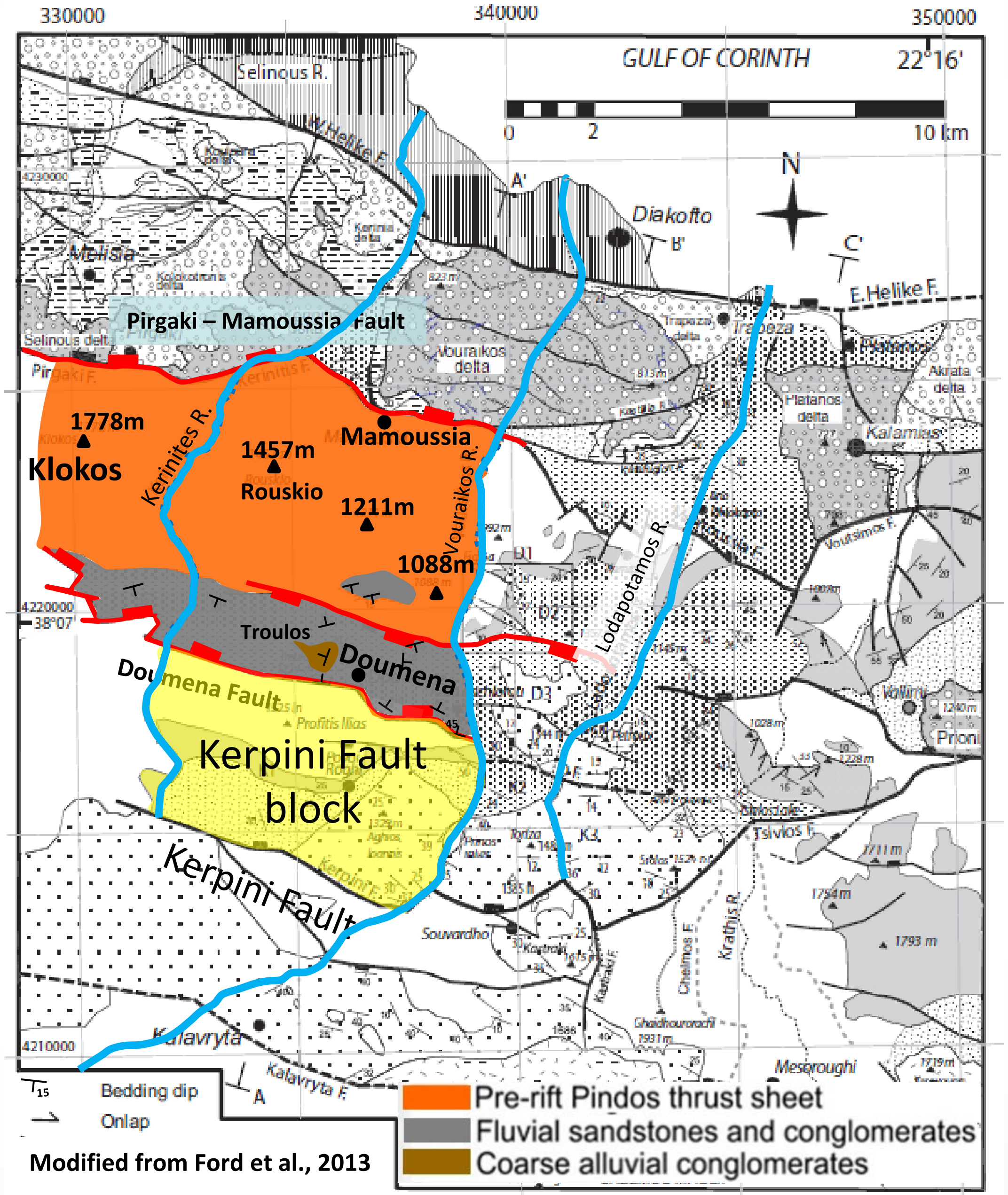
- Peloponnese peninsula
- The Doumena Fault Block
- Field work
- Geological models
- Contribute to better understanding of rift systems and half graben structures.



Modified from Ford et al., 2013

Project overview

- Main lithologies
  - Pre rift carbonate
  - Fluvial sandstones and conglomerate
  - Coarse alluvial conglomerates
- Paleo topography
- North sea analogue



Modified from Ford et al., 2013

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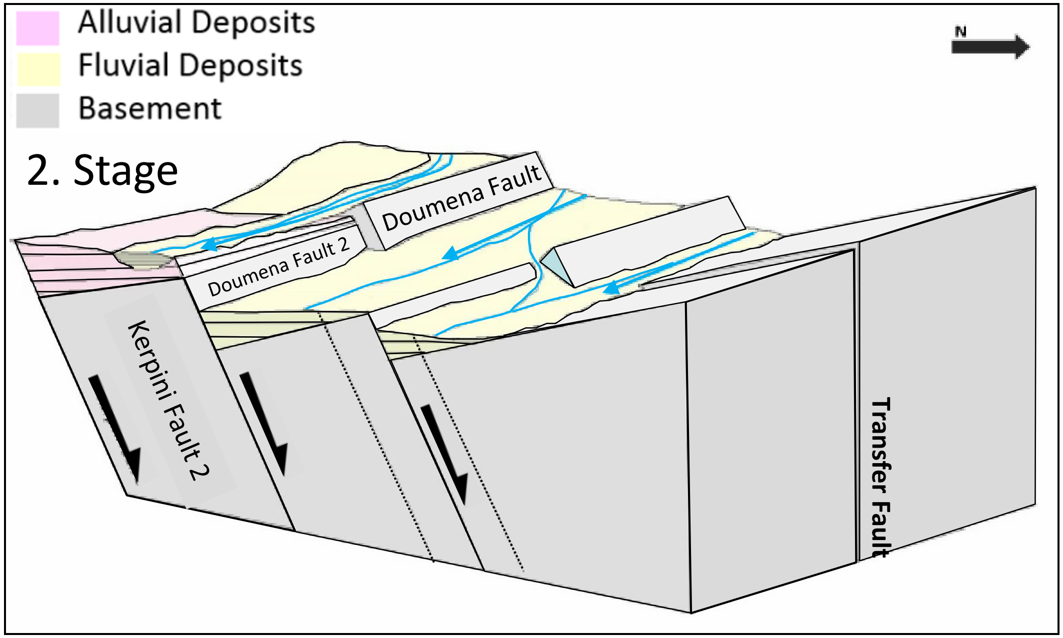
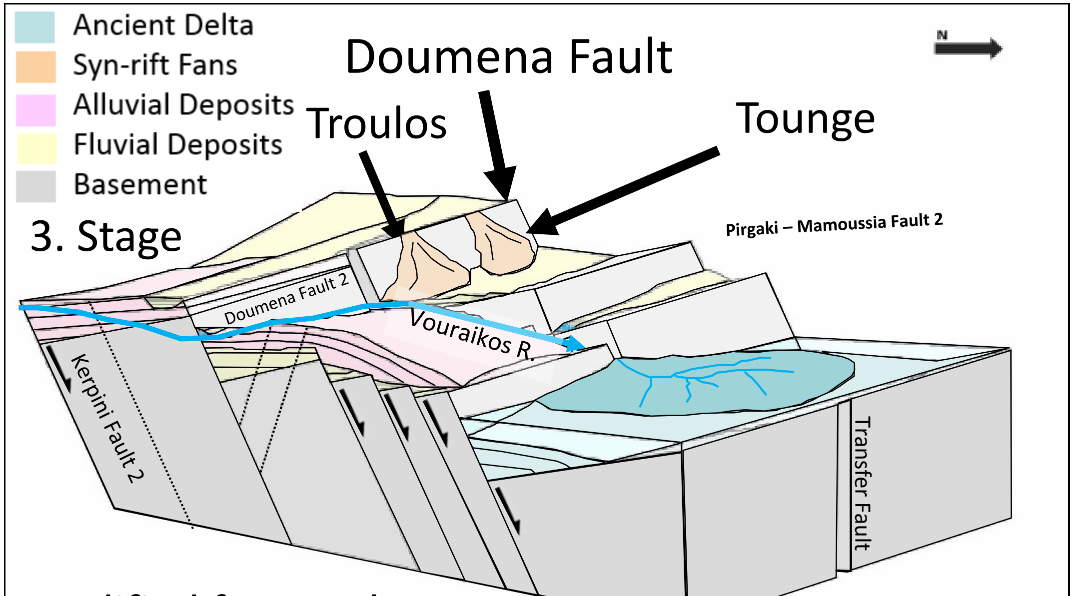
Geological background

- Three stages of rifting:
- 1. Stage
    - Coarse alluvial fans
    - Deposited orthogonal
- 2. Stage
    - Fluvial deposits
    - Directed east to west
- 3. Stage
    - Progradational alluvial fan
    - Deposited orthogonal





Modified from Dahman, 2015

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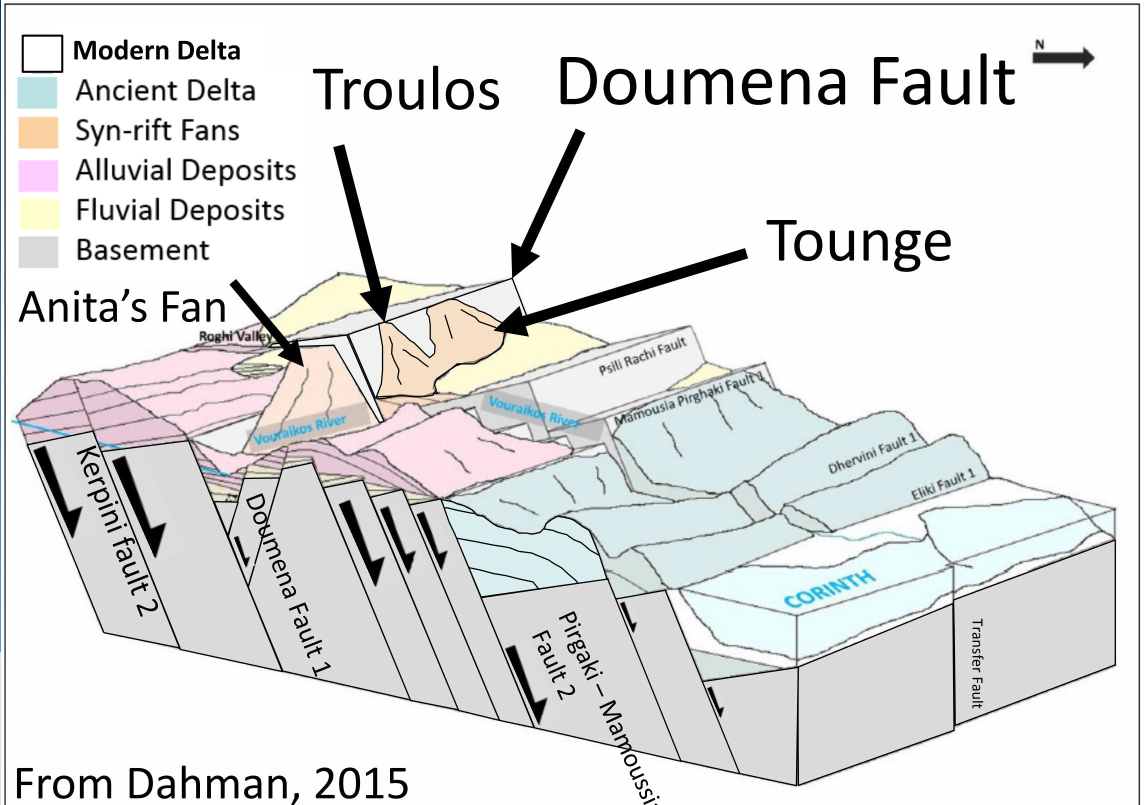
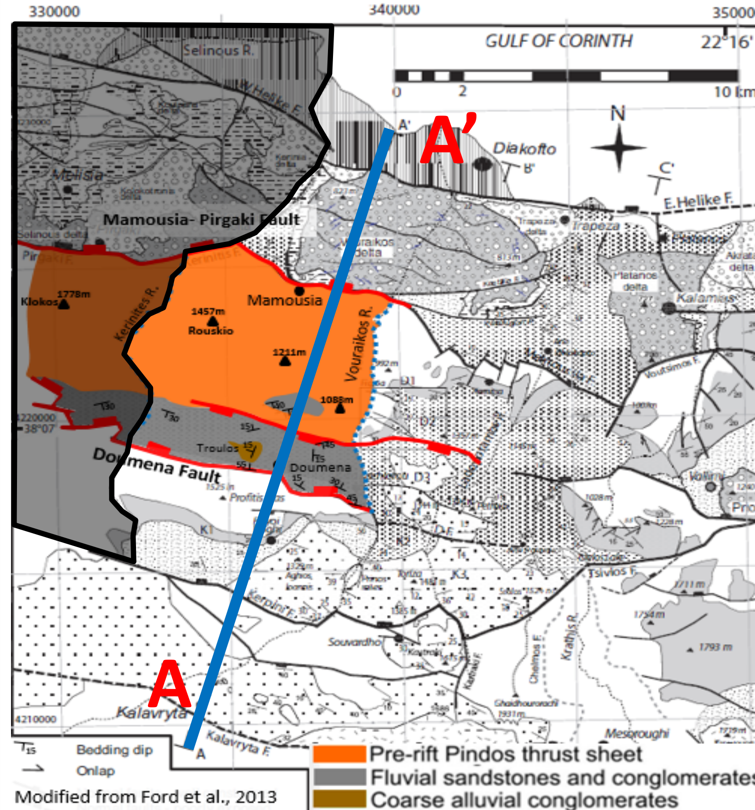
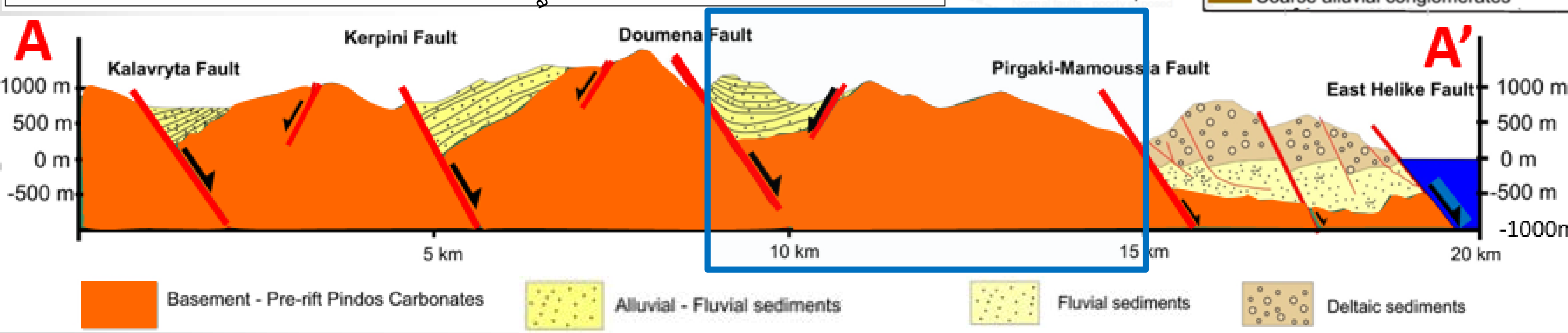
Geological background



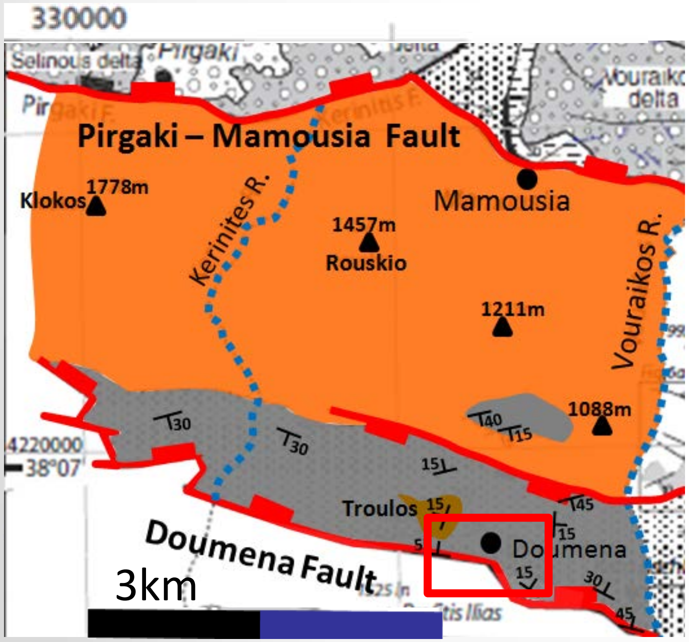




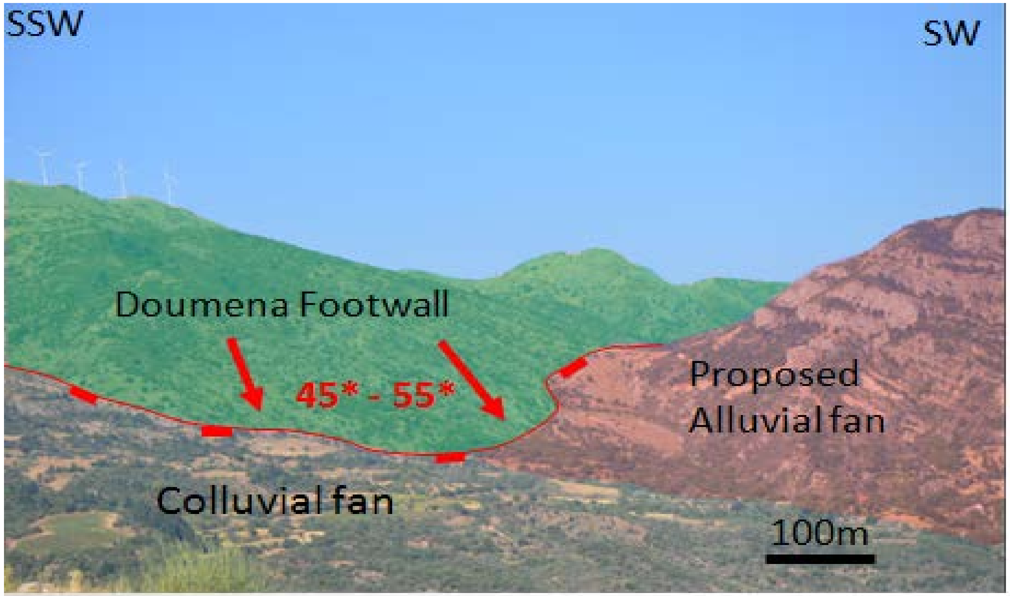
Modified from Ford et al., 2013

Geological problems

- Basal unconformity
- Doumena Fault
  - Linkage
  - Displacement
- Sub horizontal sediments
- Proposed fans
  - Morphology
  - Relative age
- Sedimentary infill



Modified from Ford et al., 2013



Objectives

- Determine:
  - If the three proposed units are fans?
  - Whether the sedimentary infill is parallel to the basal unconformity?
  - What the main controls are on the dip of the plane of the basal unconformity?
  - What environment the sediments where deposited in, and what the possible provenance could be?
  - If there are any evidence of N-S transfer faults?
  - How the displacement of the Doumena Fault change along strike?

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Methodology

- Tasks:

- Make a detailed evaluation of the Doumena Fault Block and the three fans including faults, unconformities and facies distributions.

- Build a 3D structural facies model and propose a tectonostratigraphic evolutionary model for the Doumena Fault Block.

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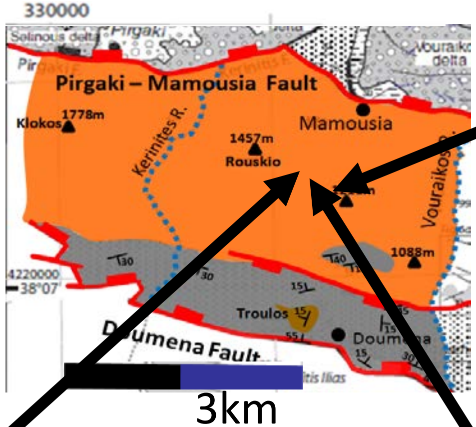
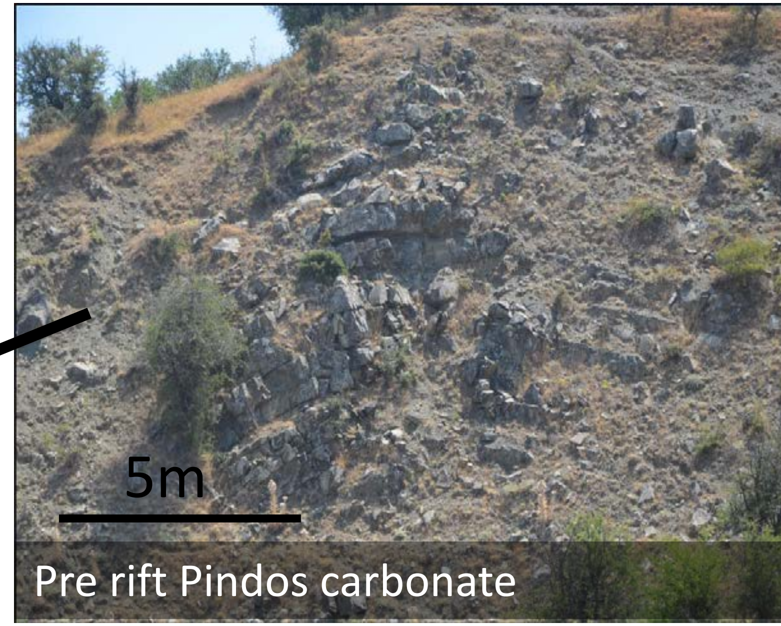
Field work and methodology

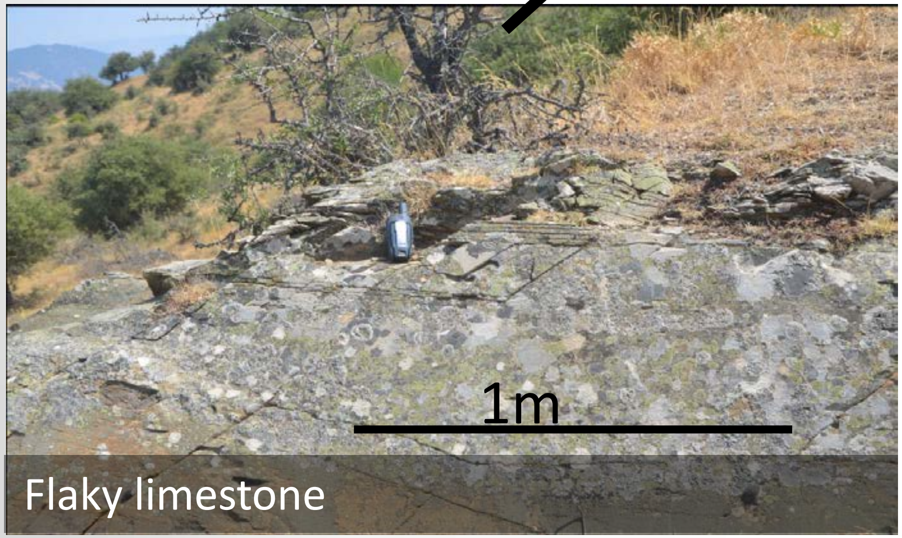
- Equipment
  - Photogrammetry
  - Satellite imagery
  - Silva Compass
  - Ruler
  - GPS

Modified from Ford et al., 2013

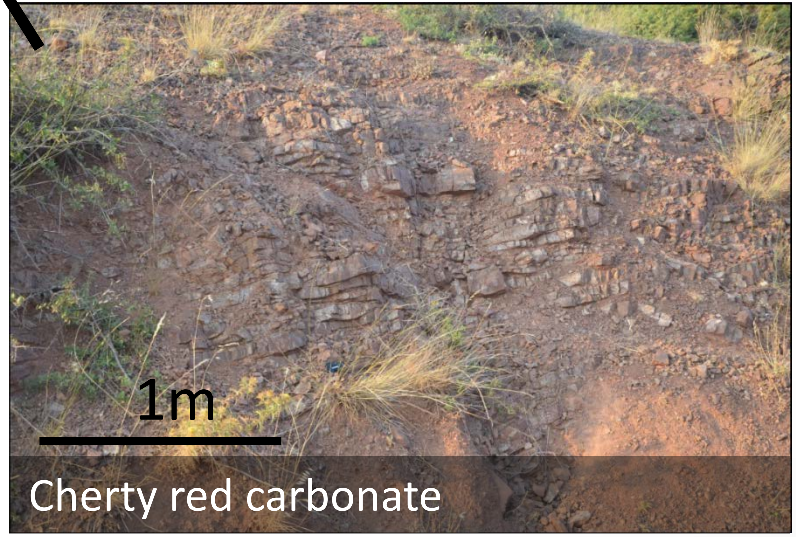




Pre rift Pindos carbonate



Flaky limestone

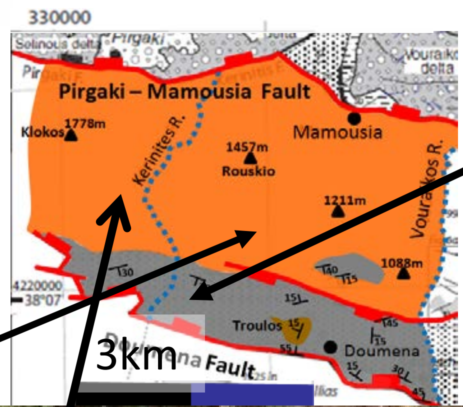


Cherty red carbonate

Field work and methodology

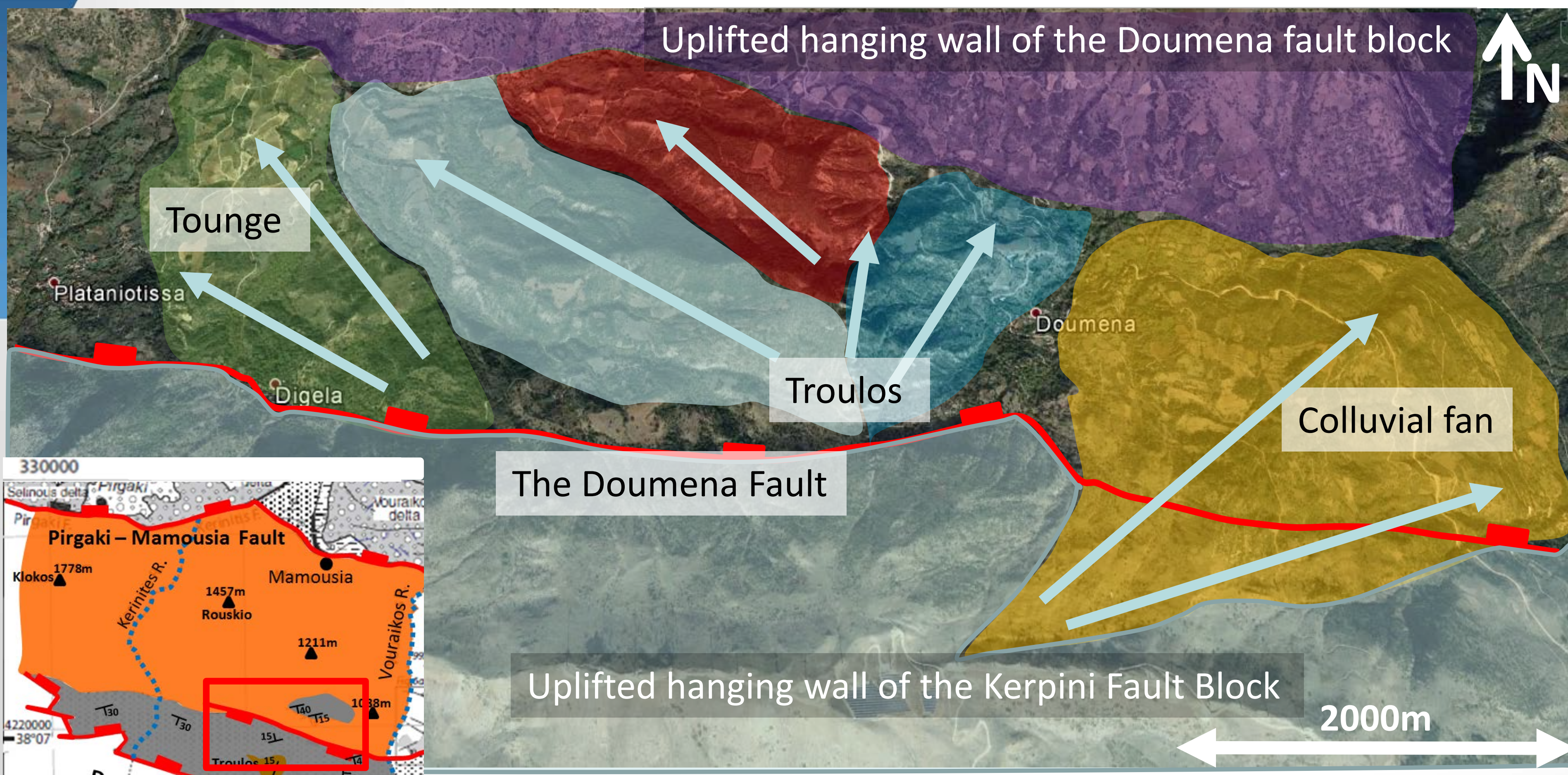
- Field data
  - Outcrop descriptions
  - Dip and dip directions
  - Imbrications
  - Clast sizes
  - Sorting
  - 1600 photos

Modified from Ford et al., 2013



Preliminary observations

- Doumena sediments
  - Individual fans
  - Timing
  - Lobes
  - Clasts

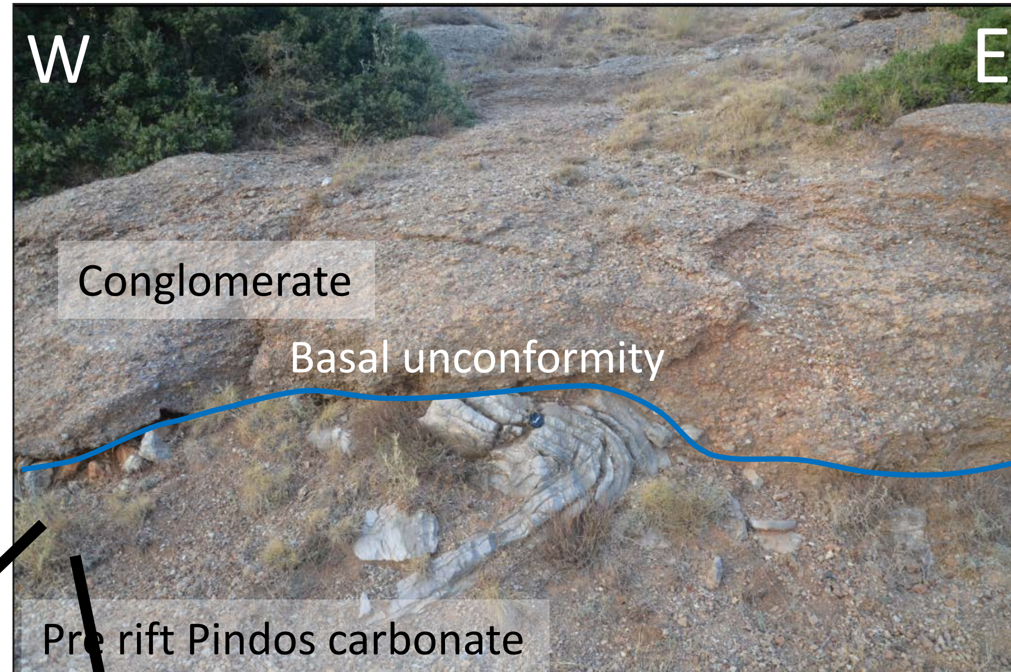


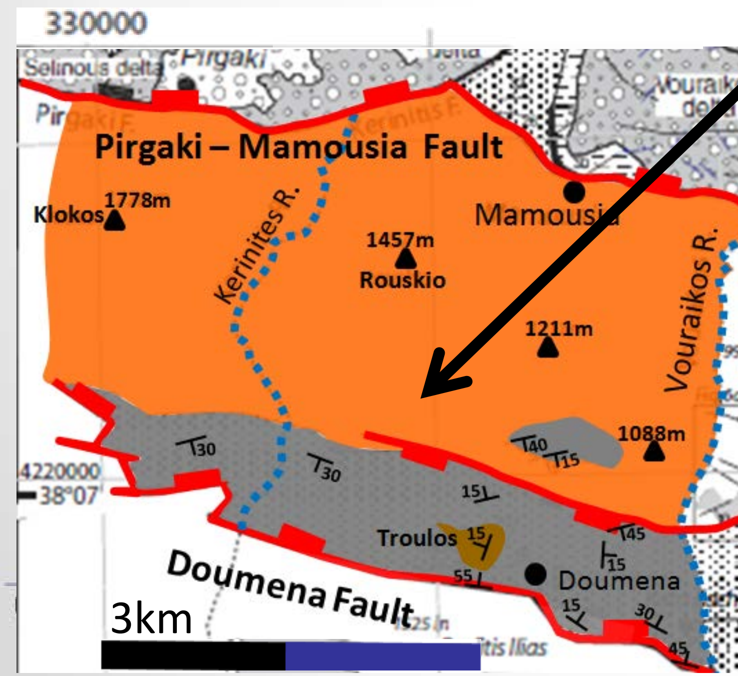
Modified from Ford et al., 2013

Taken from Google Earth, 29.11.2016

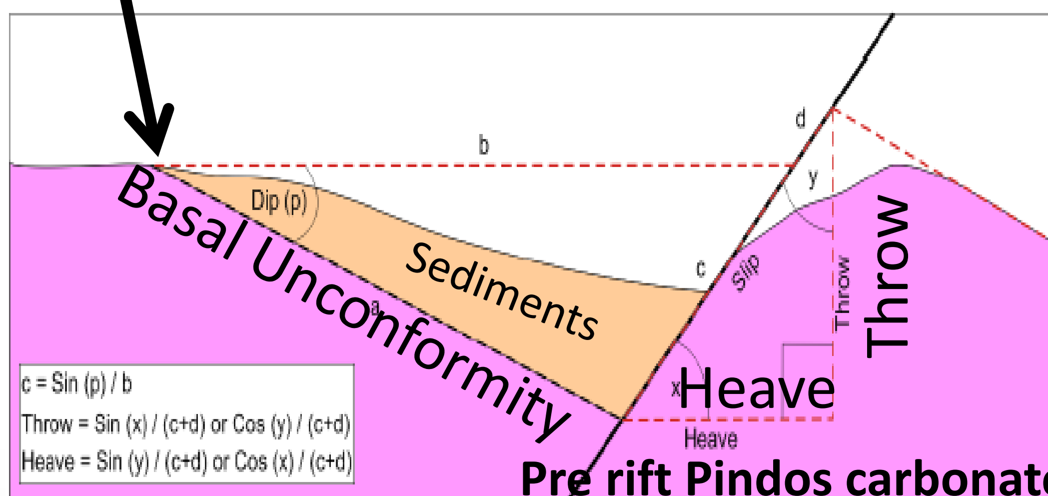
Preliminary observations

- Doumena Fault
  - Displacement
- Basal unconformity
  - Dip change of the plane





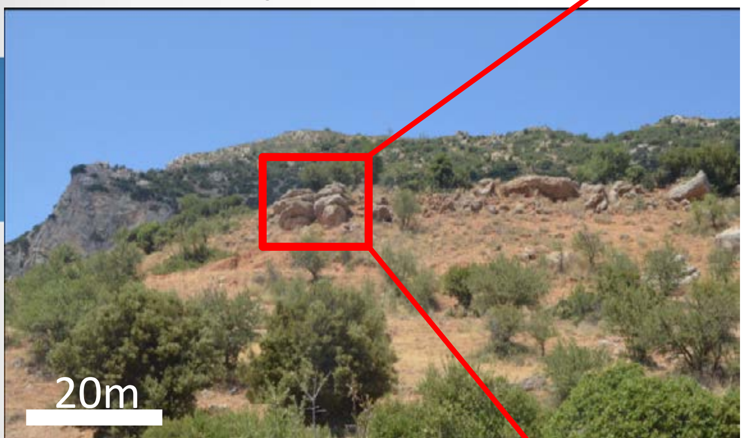
Modified from Ford et al., 2013

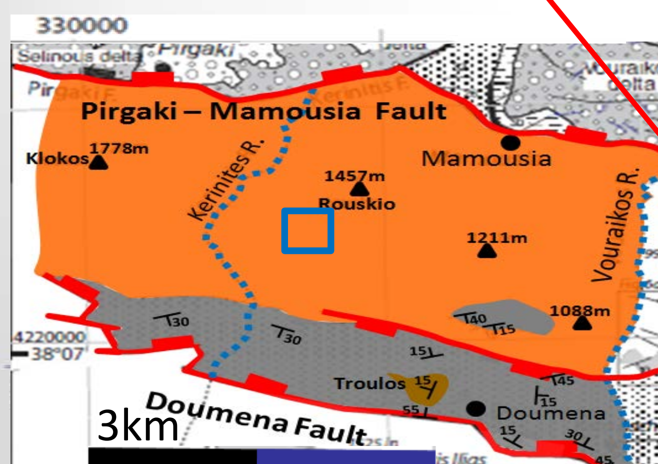


Modified from Syahrul, 2012

Preliminary results

- Sub - horizontal sediments
    - Could signify basin infill
    - Post rift deposition
    - Dip = +\- 10%

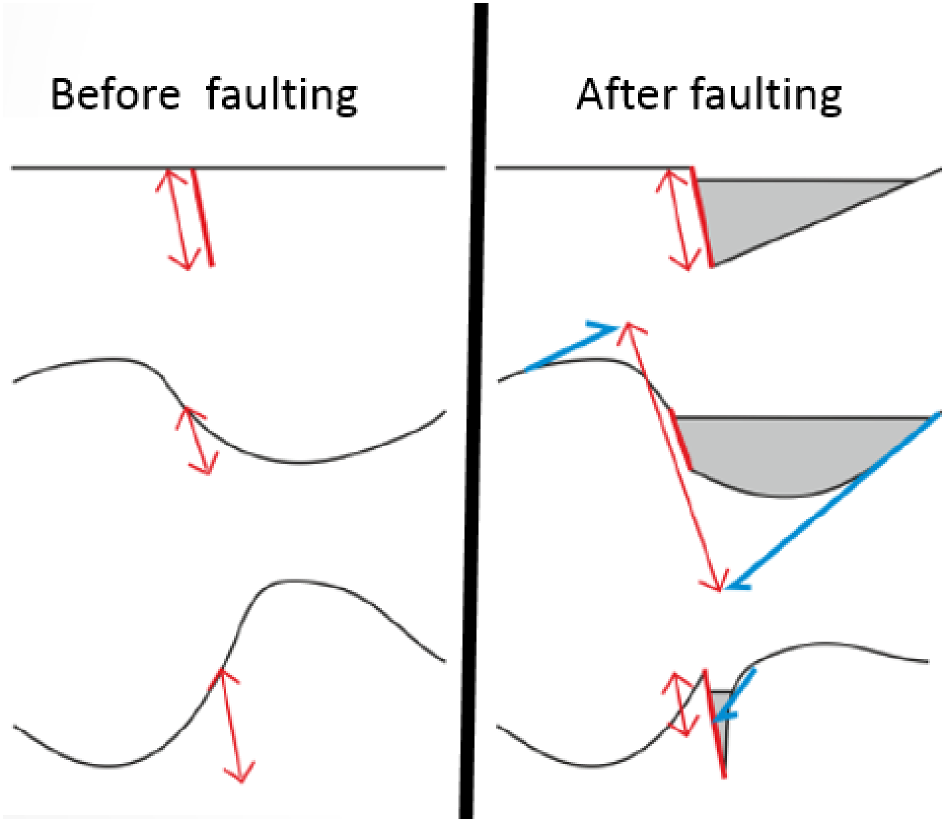




Modified from Ford et al., 2013

Summary

- Several uncertainties
  - Displacement
  - Facies variability
  - Basal unconformity
  - Paleo topography
  - Fan deposition



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Modified from Wood, 2012

Thank you for your attention!
Do you have any questions?

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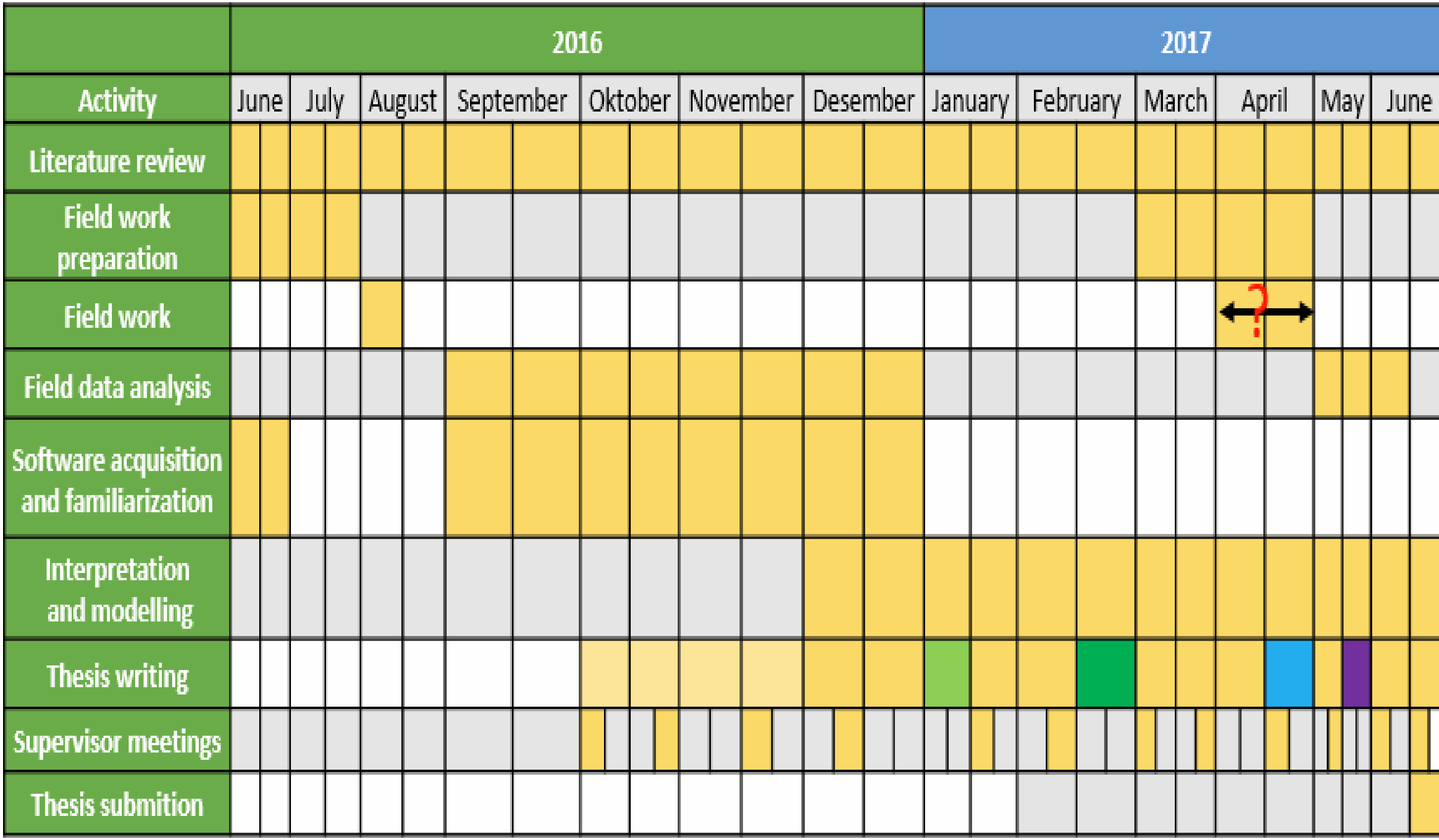
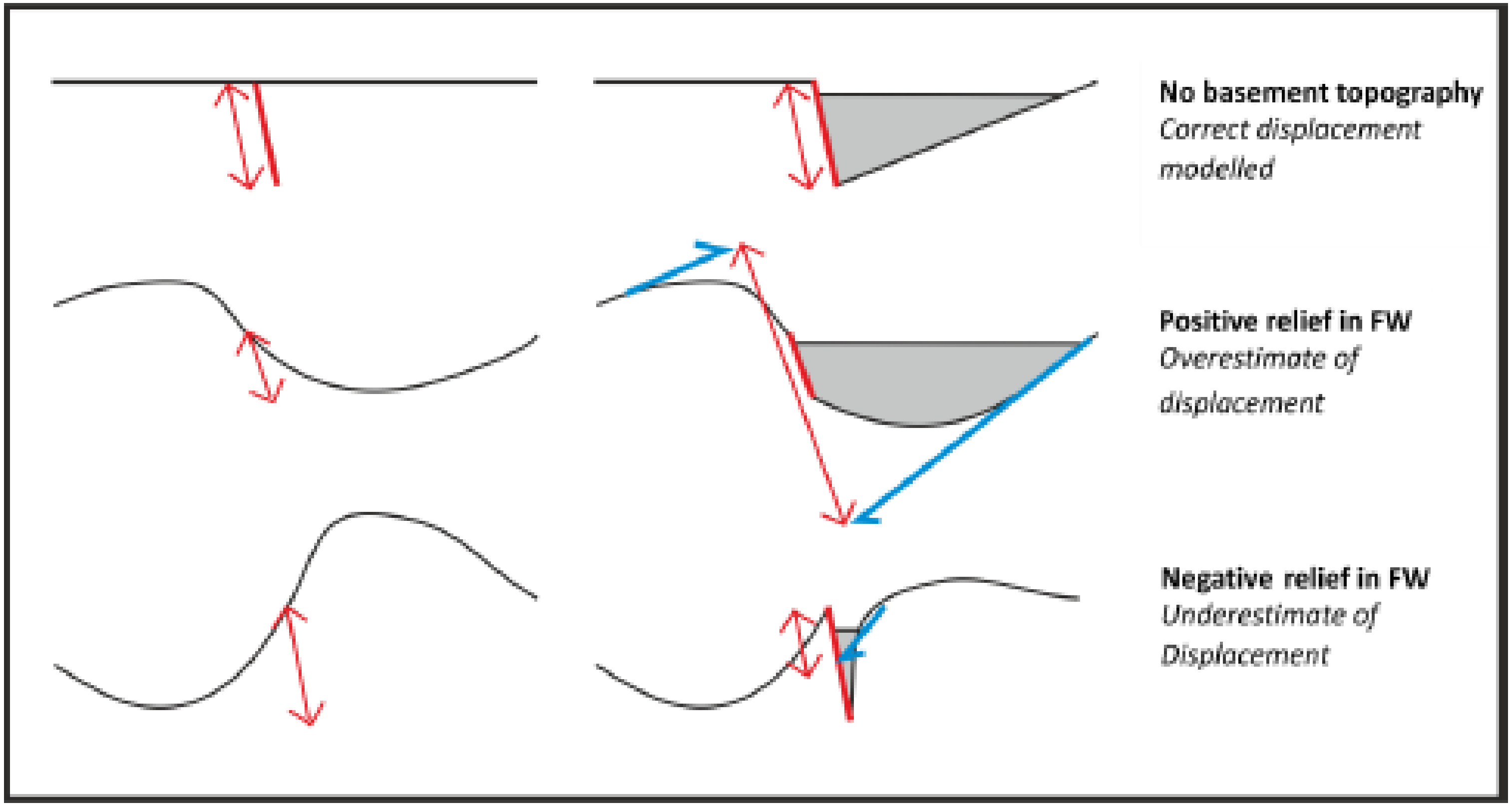
Timeframe


2016
2017
Activity
June
July
August
September
Oktober
November
Desember
January
February
March
April
May
June
Literature review
Field work preparation
Field work
?
Field data analysis
Software acquisition and familiarization
Interpretation and modelling
Thesis writing
Supervisor meetings
Thesis submition

Original backups- Can be modified



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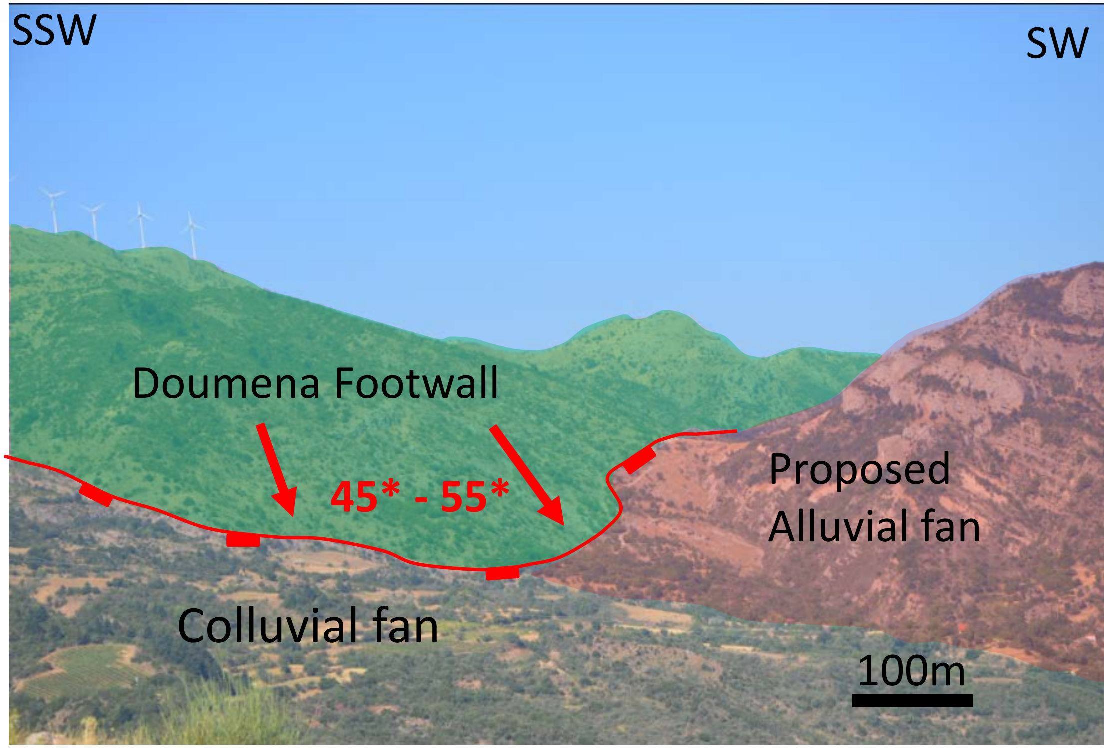
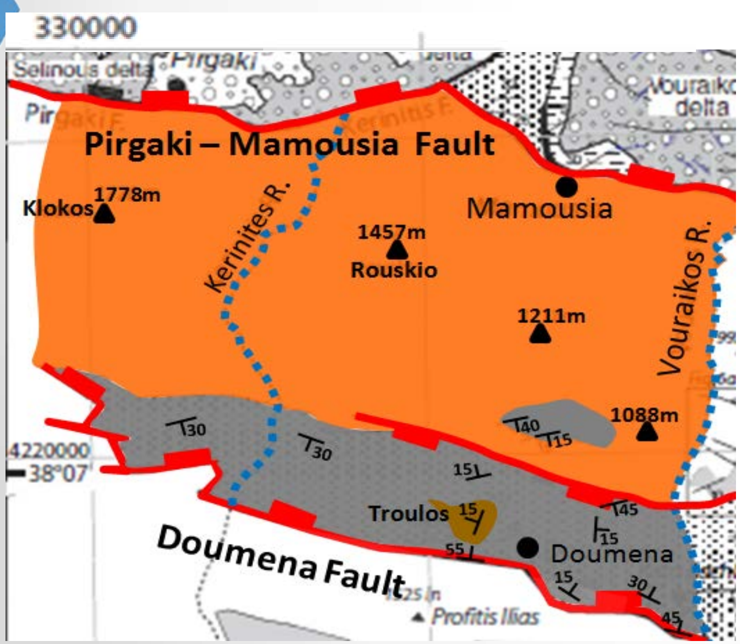
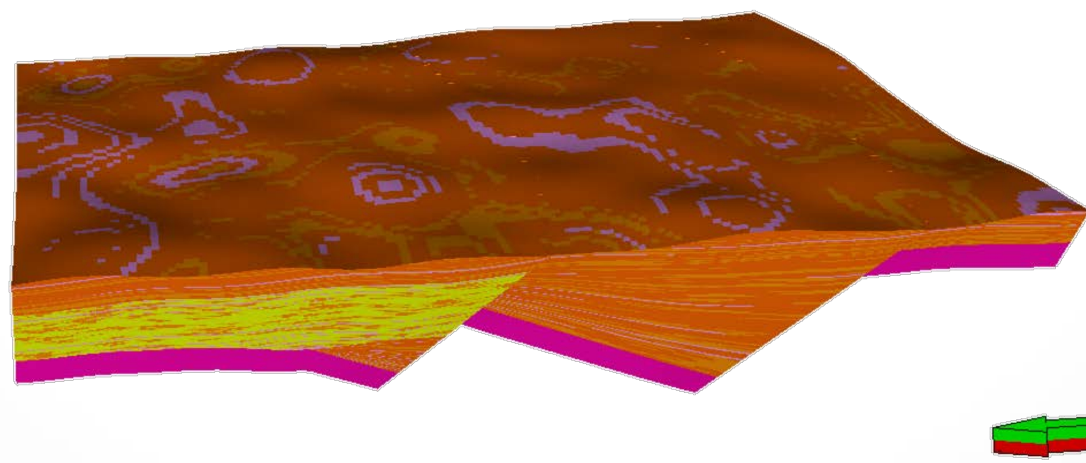
Introduction

- Peloponnese peninsula, Greece.
- The Doumena Fault Block.
- Contribute to better understanding of rift systems and half graben structures.
- Compare structural and depositional features for the Kerpini and the Doumena Fault Block.
- From outcrops to geological models.







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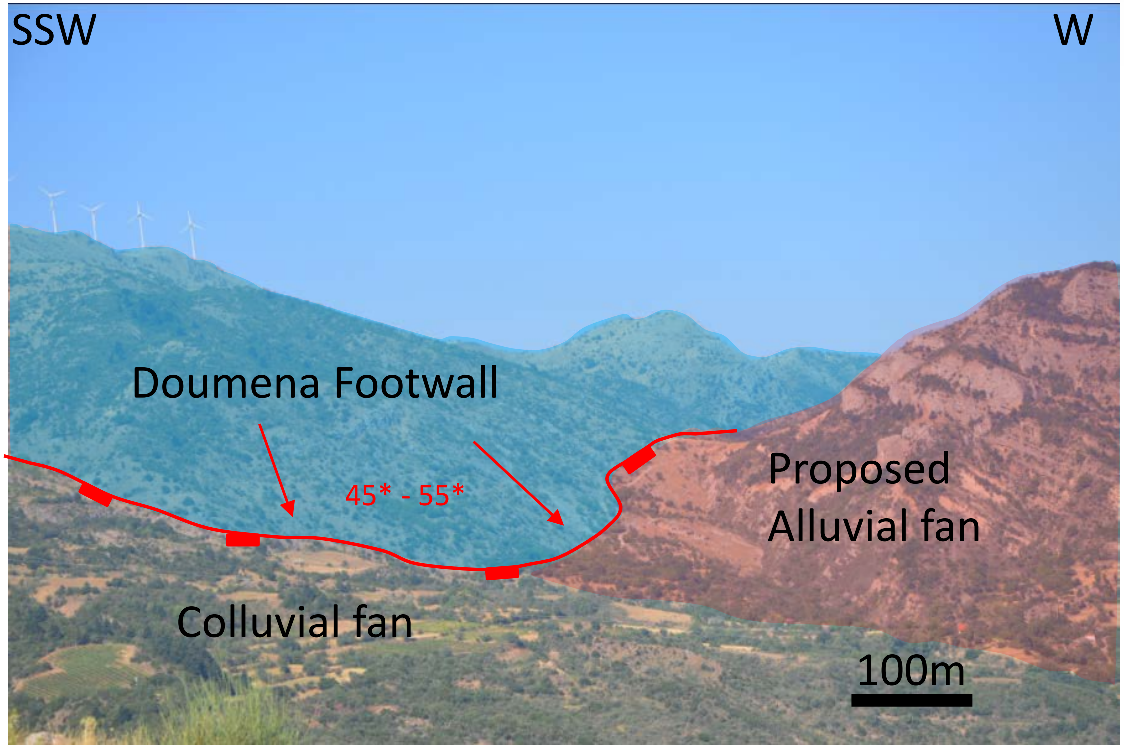

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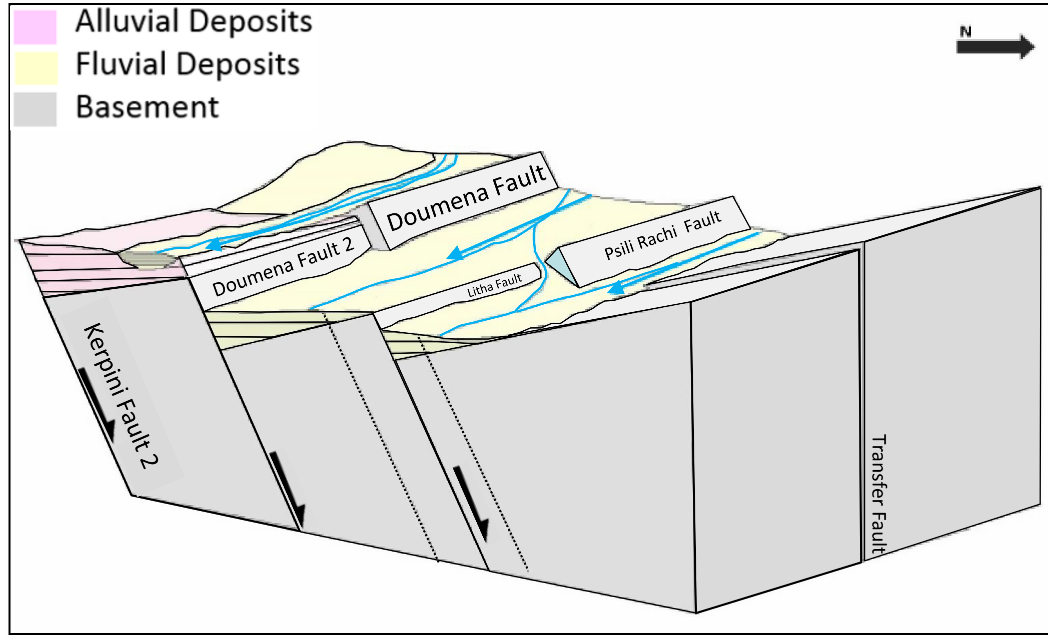
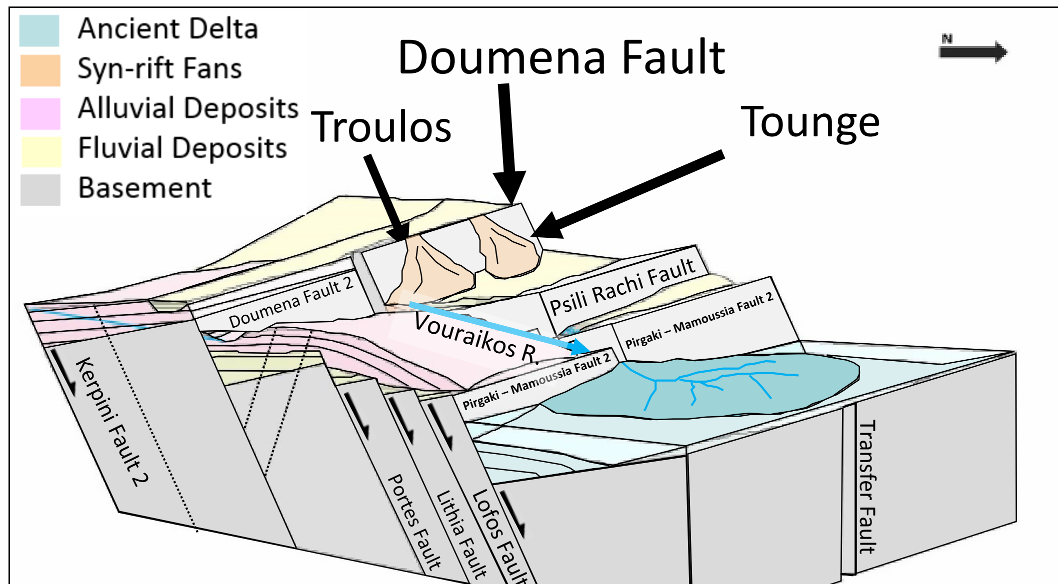
Geological background

- Initial stage of rifting consist of coarse alluvial fans deposited orthogonal to the faults due to uplift and erosion of the of early initial faults.
- Second stage of rifting had west to east directed fluvial deposits, which covered nearly the entire Doumena Fault block.
- The third stage of rifting represent a major progradational alluvial fan going south to north that may be linked to the initiation of the Pirgaki Mamoussia Fault.





Modified from Dahman, 2015

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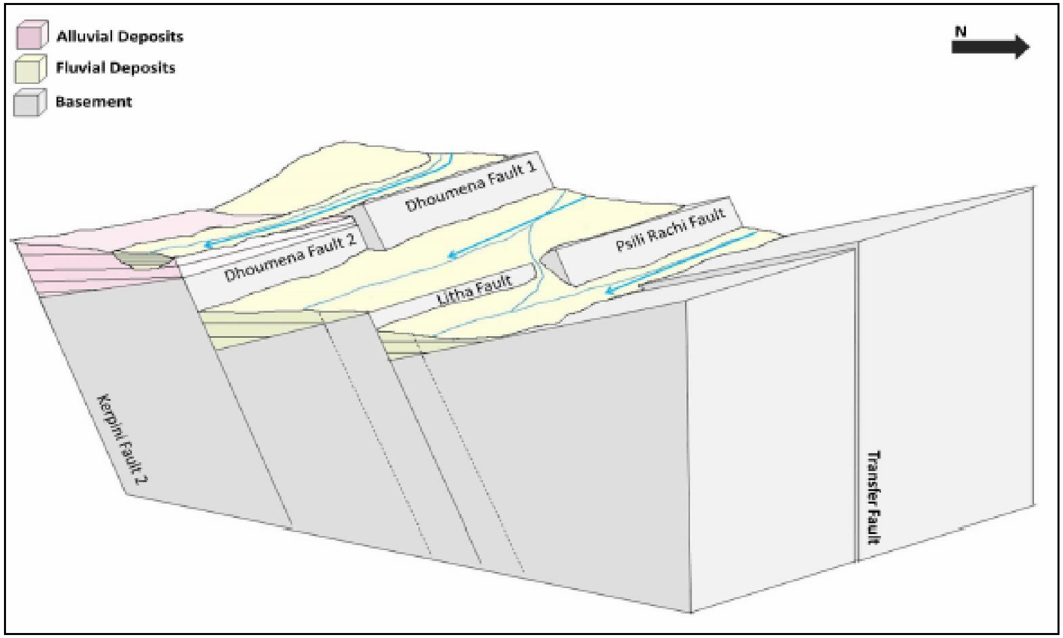

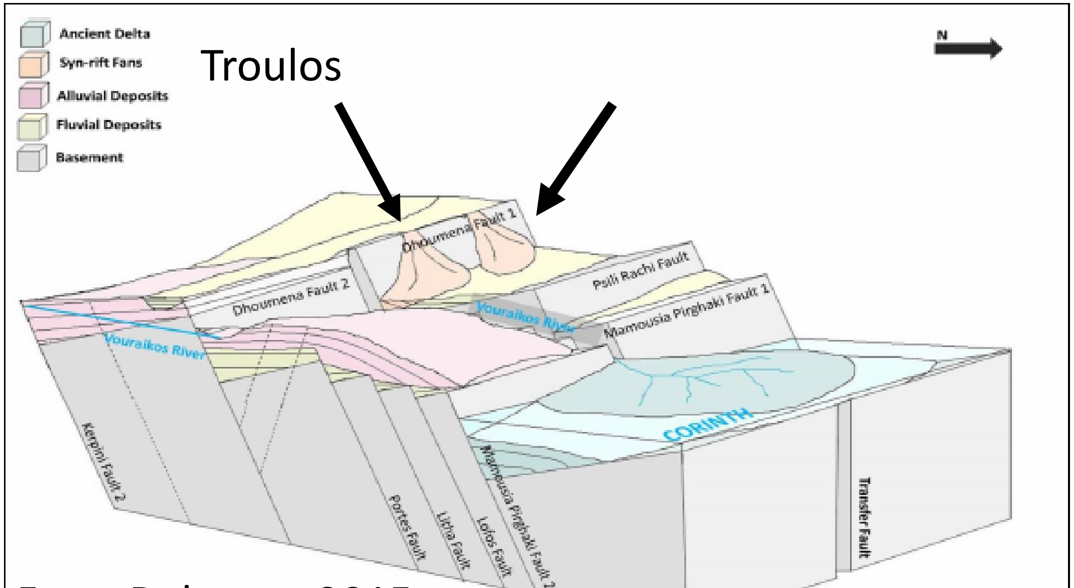

From Dahman, 2015

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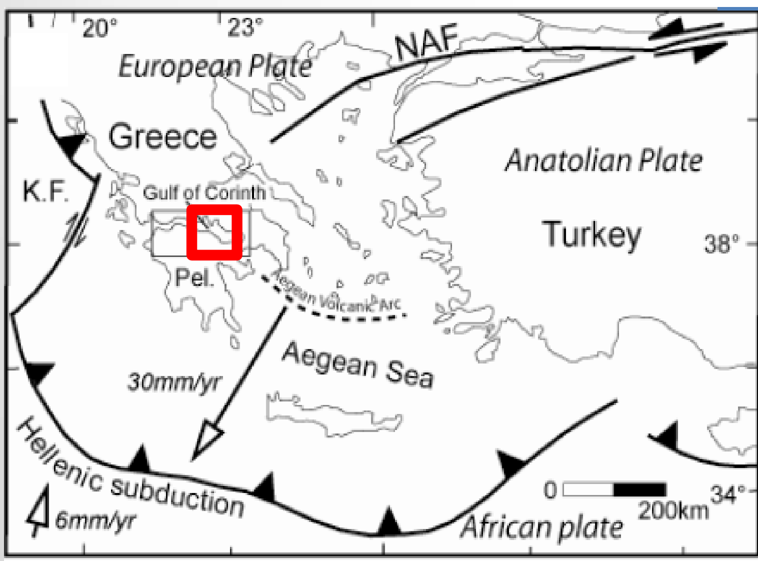
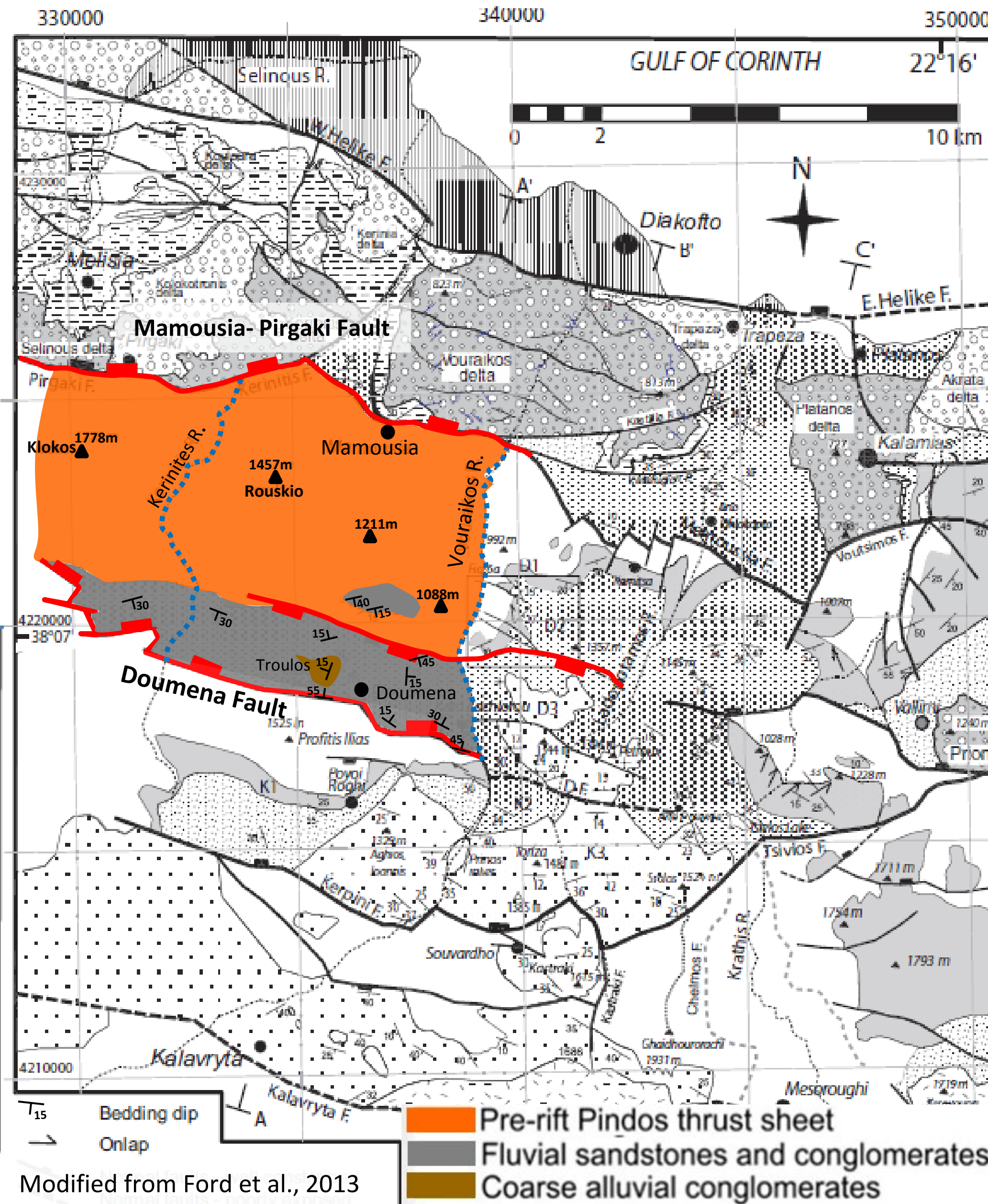


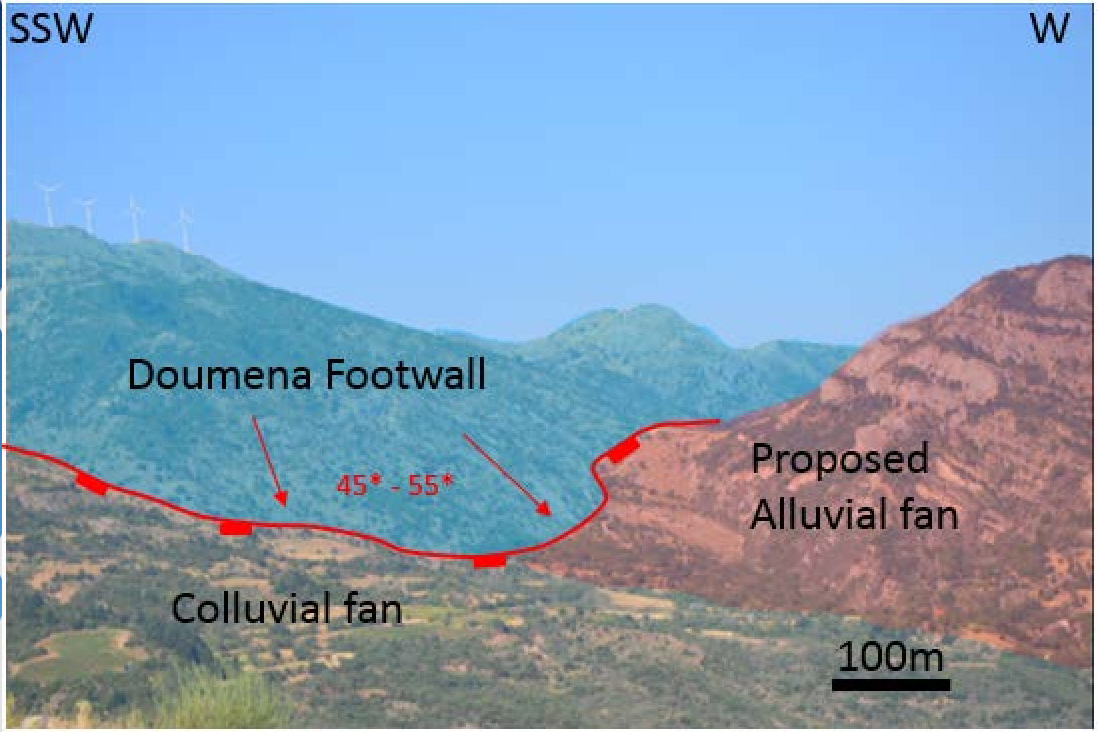
Area of interest ☐ Modified from Ford et al., 2013

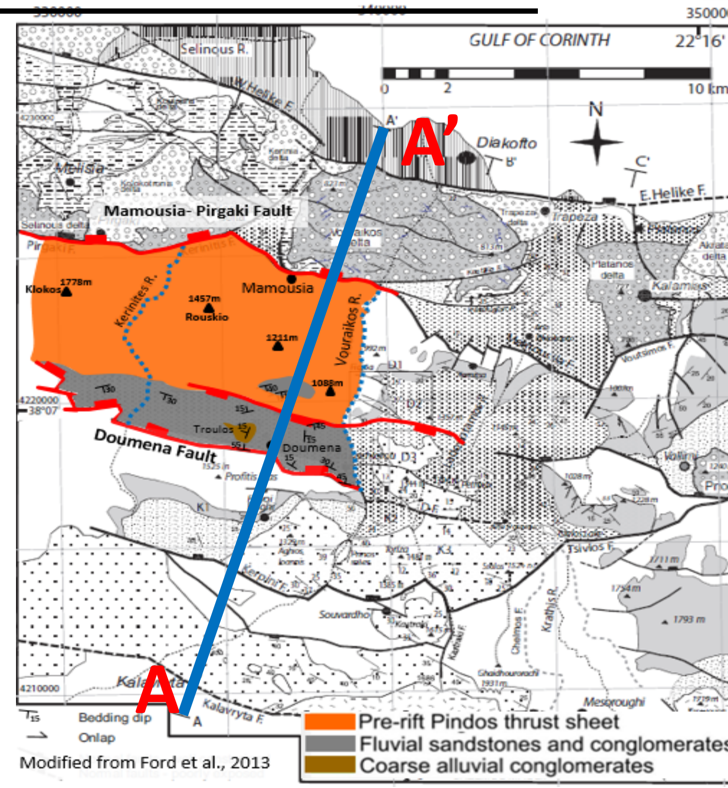


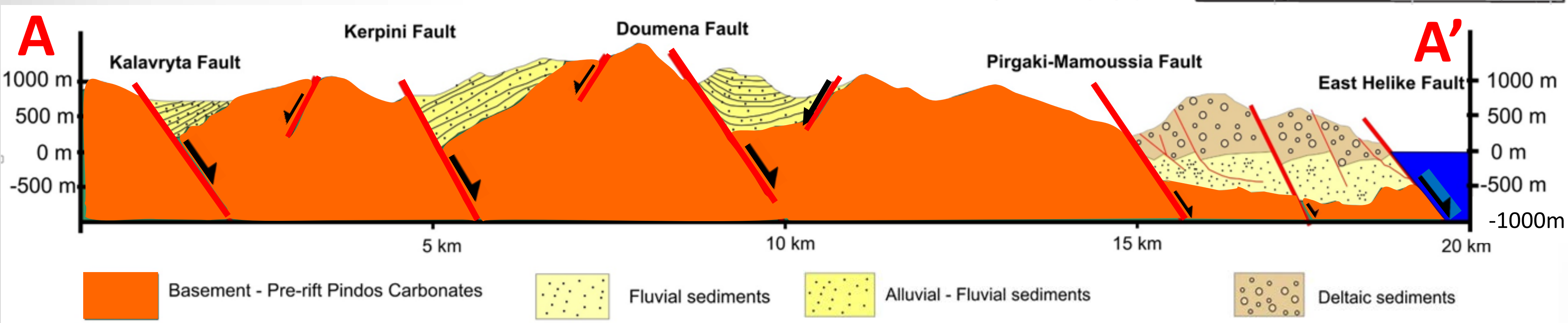
Modified from Ford et al., 2013

Project overview

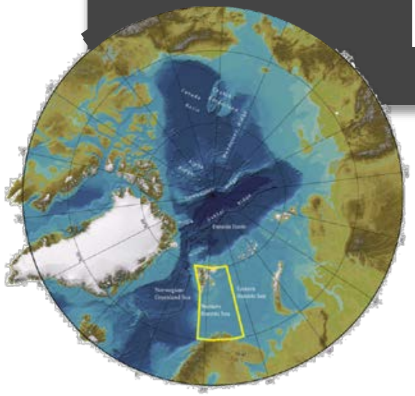
Modified from Ford et al., 2013







Characterization of Lower Cretaceous reservoir wedges at the southern flank of Loppa High, SW Barents Sea



Glørstad-Clark *et al.* (2010)

Angelica Ärlebrand

Supervisors:
Carita Augustsson
& Alejandro Escalona

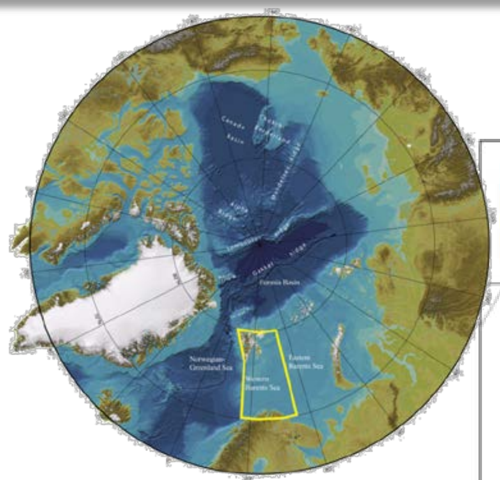
Universitetet i Stavanger

Lundin Petroleum

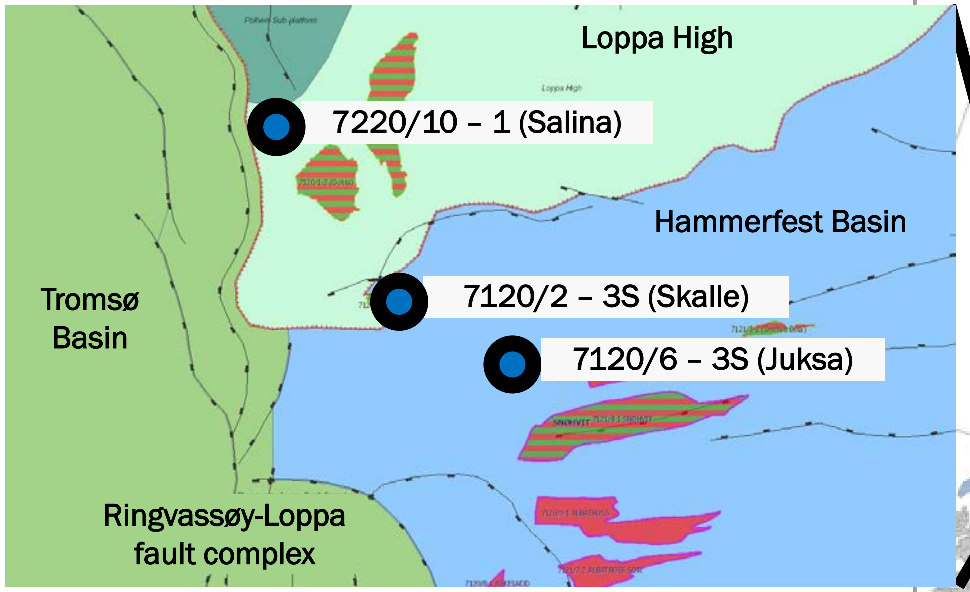
LoCrA

Introduction

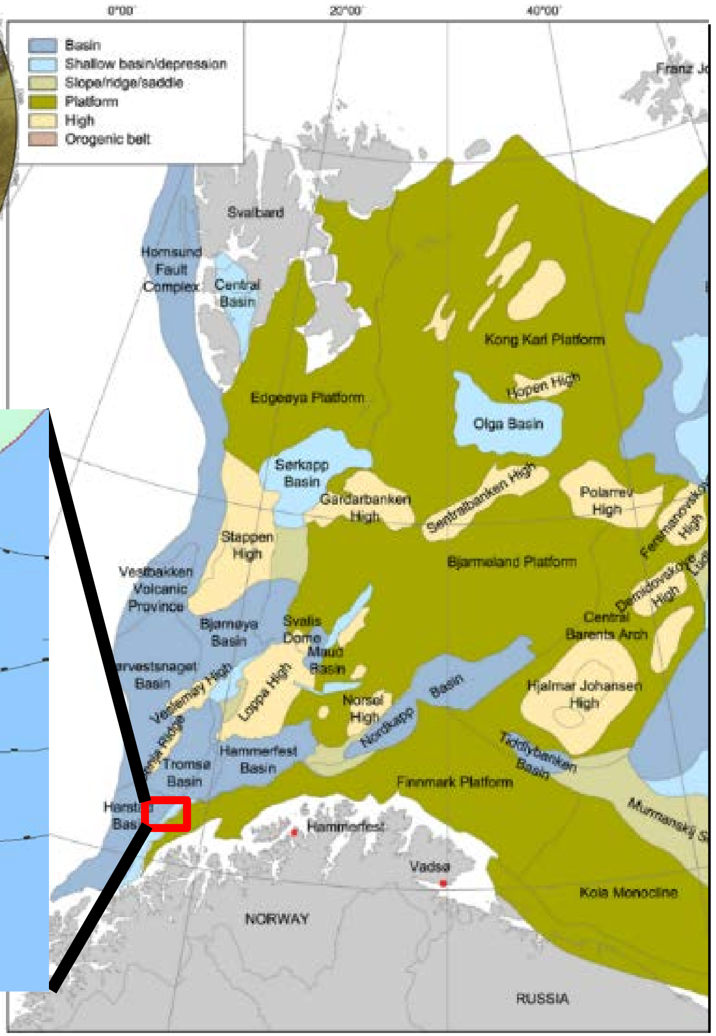
- Three recently drilled wells
- Two with discoveries, one with shows
- Represent different depositional settings



Glørstad-Clark *et al.* (2010)

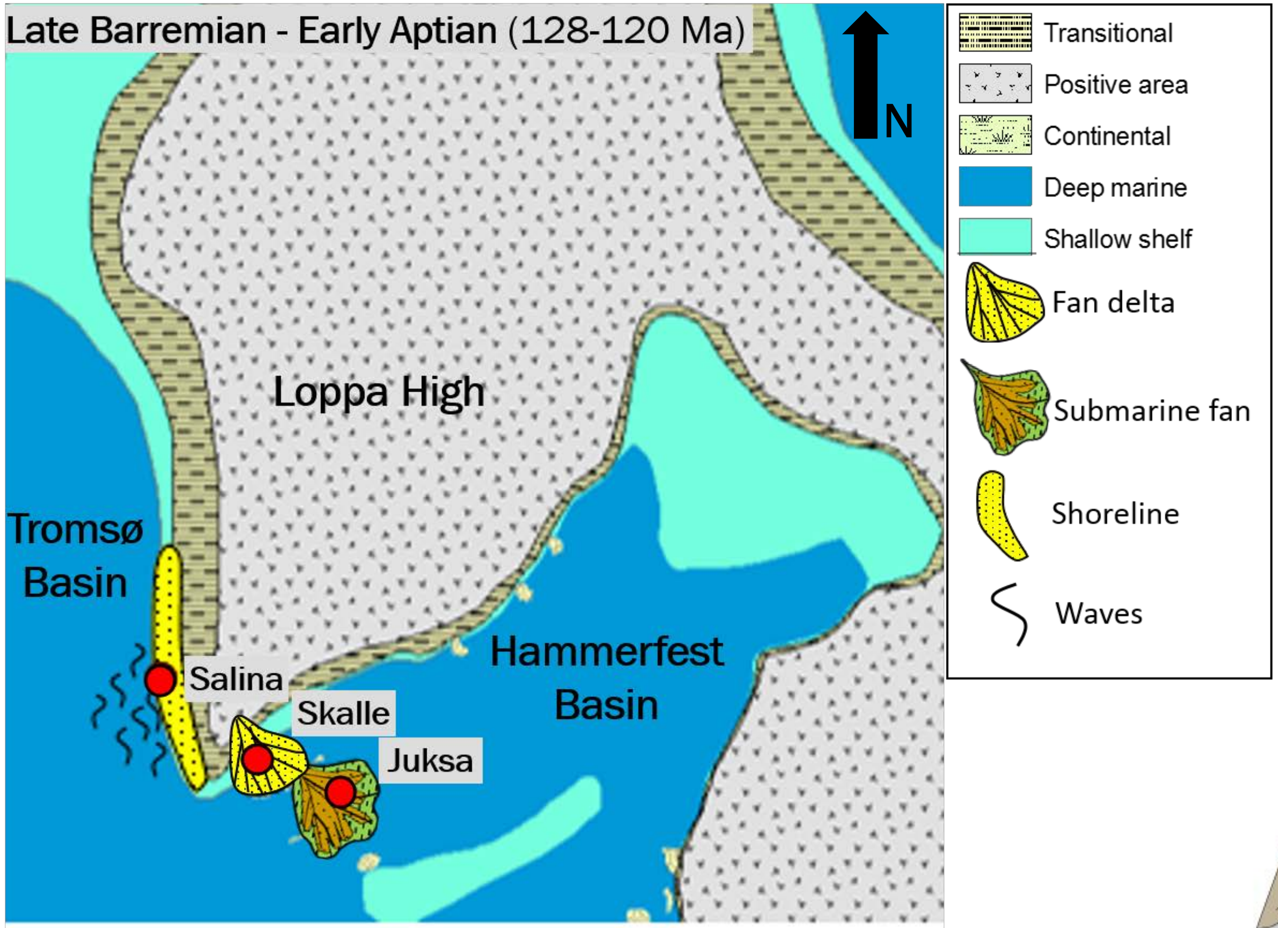


NPD (2016)



Henriksen *et al.* (2011)

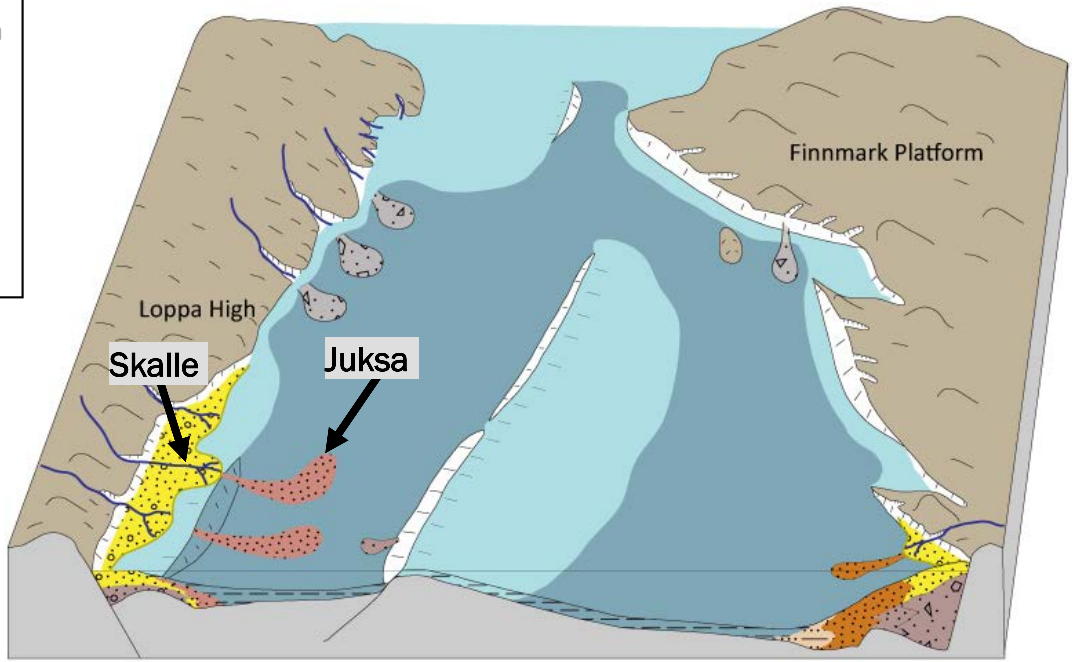
Depositional environment



Paleogeographic base map from LoCrA. Depositional settings include information from Iqbal (2016), Marin (work in progress) & Grundvåg (work in progress)

- Skalle: Fan delta
- Juksa: Submarine fan
- Salina: Wave dominated shoreline

- Loppa High: Main sediment source

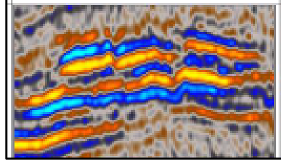
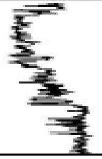


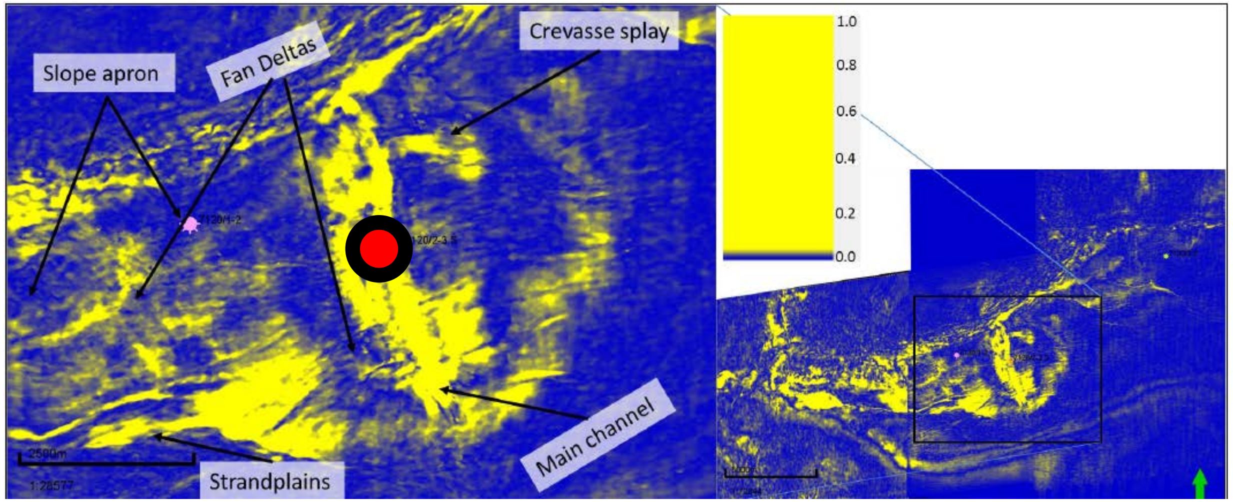
Marin (work in progress)

Previous work

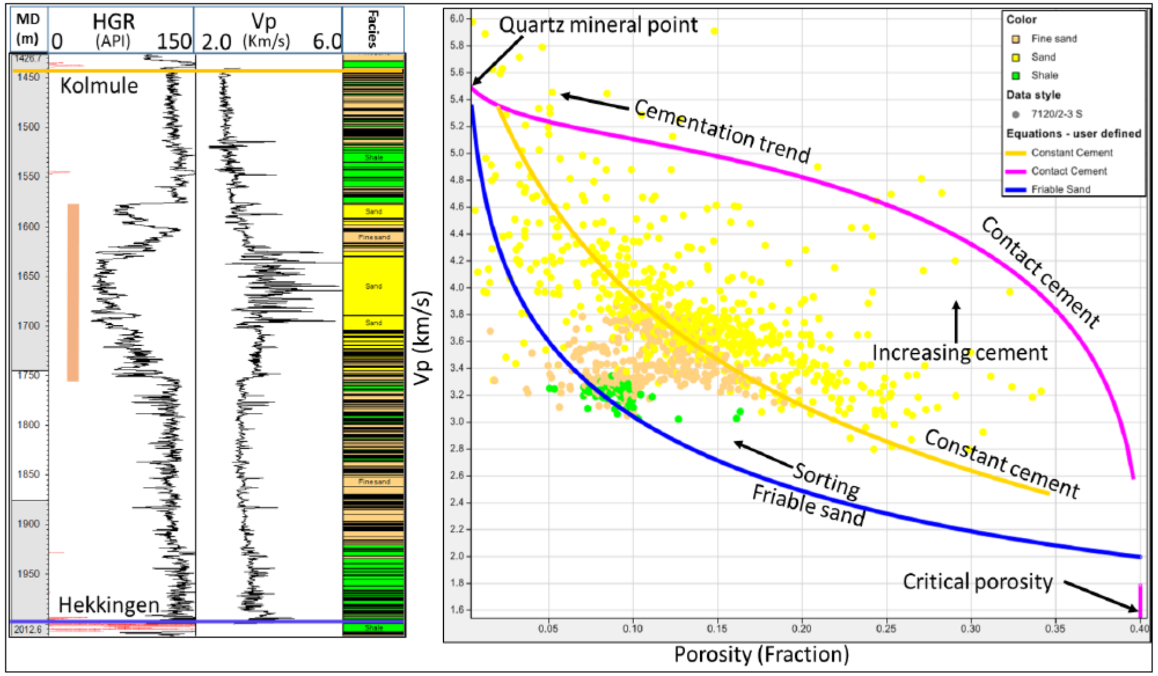
Skalle

- Channelized part of the delta front
- High reservoir quality
- Reduction of initial porosity due to cementation

Gamma ray (GR) response	Seismic facies description	Gamma-ray (GR) response	GR description	Interpretation
	High amplitude, continuous with incisions		coarsening-up with spikes and blocky top	Delta front, mouth bar with amalgamated fluvial channels on top



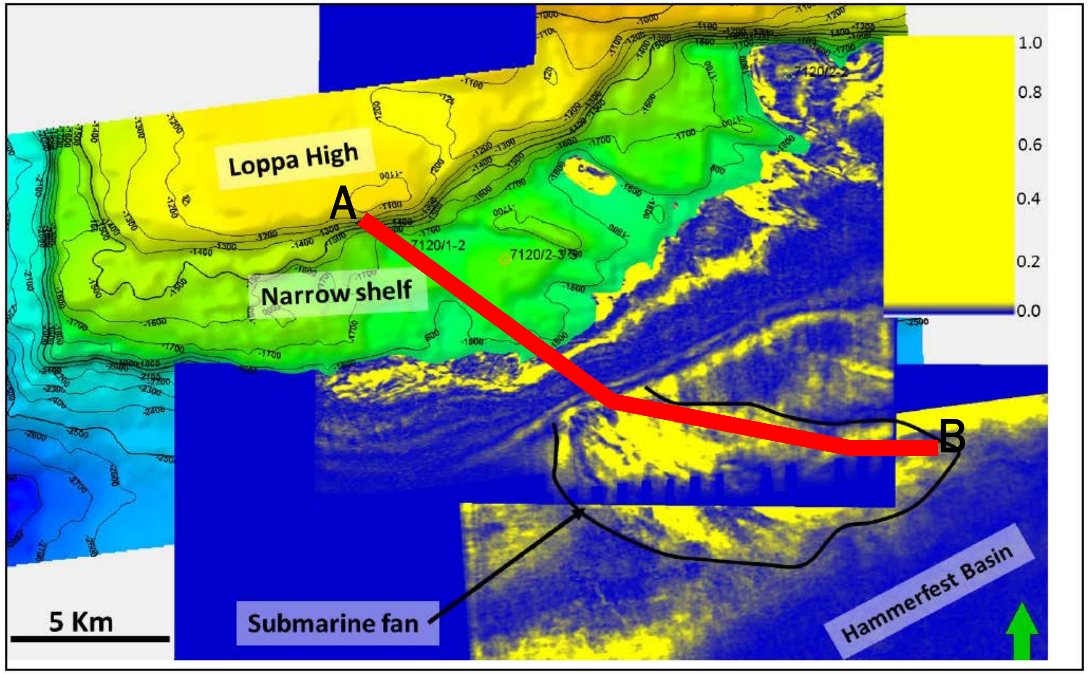
Iqbal (2016)



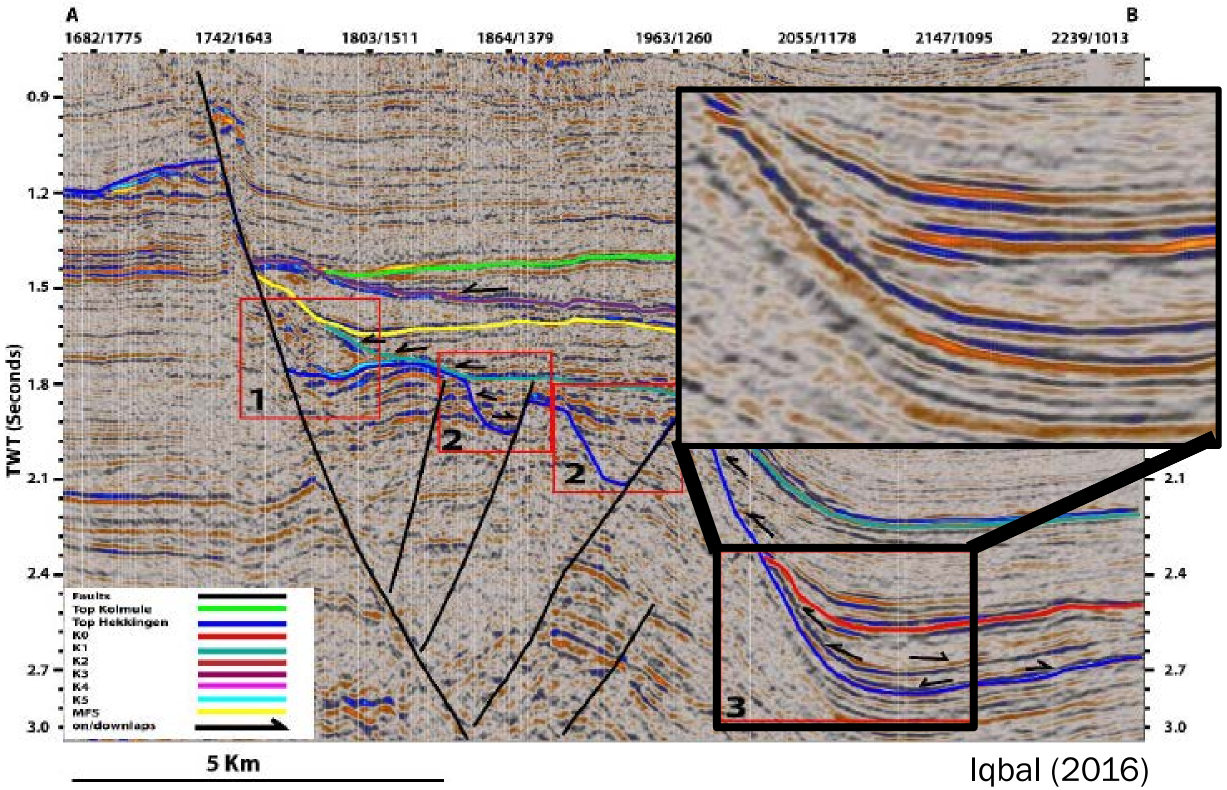
Iqbal (2016)

Previous work
Juksa

- Adjacent to the shelf edge
- Gravity flow



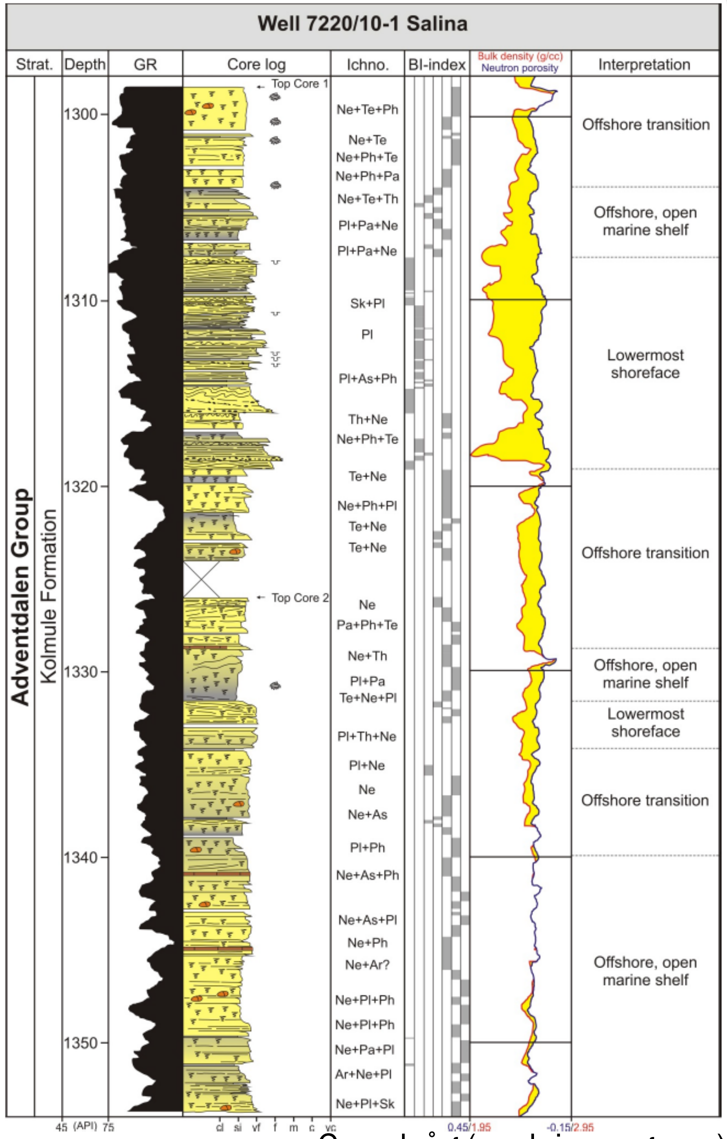
Iqbal (2016)



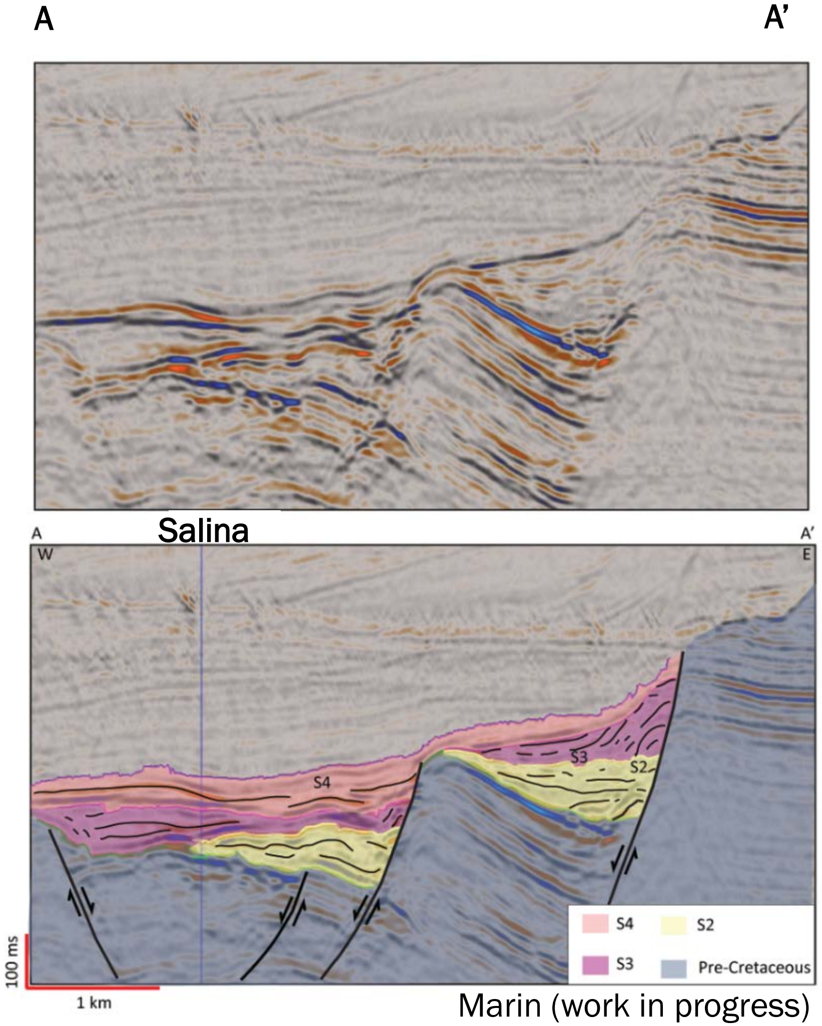
Iqbal (2016)

Previous work

Salina

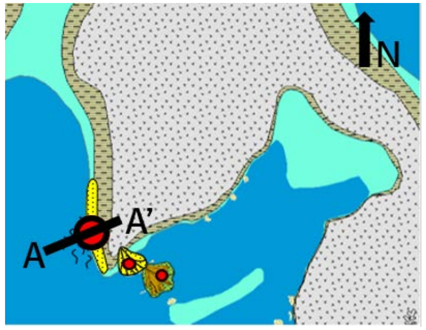


Grundvåg (work in progress)

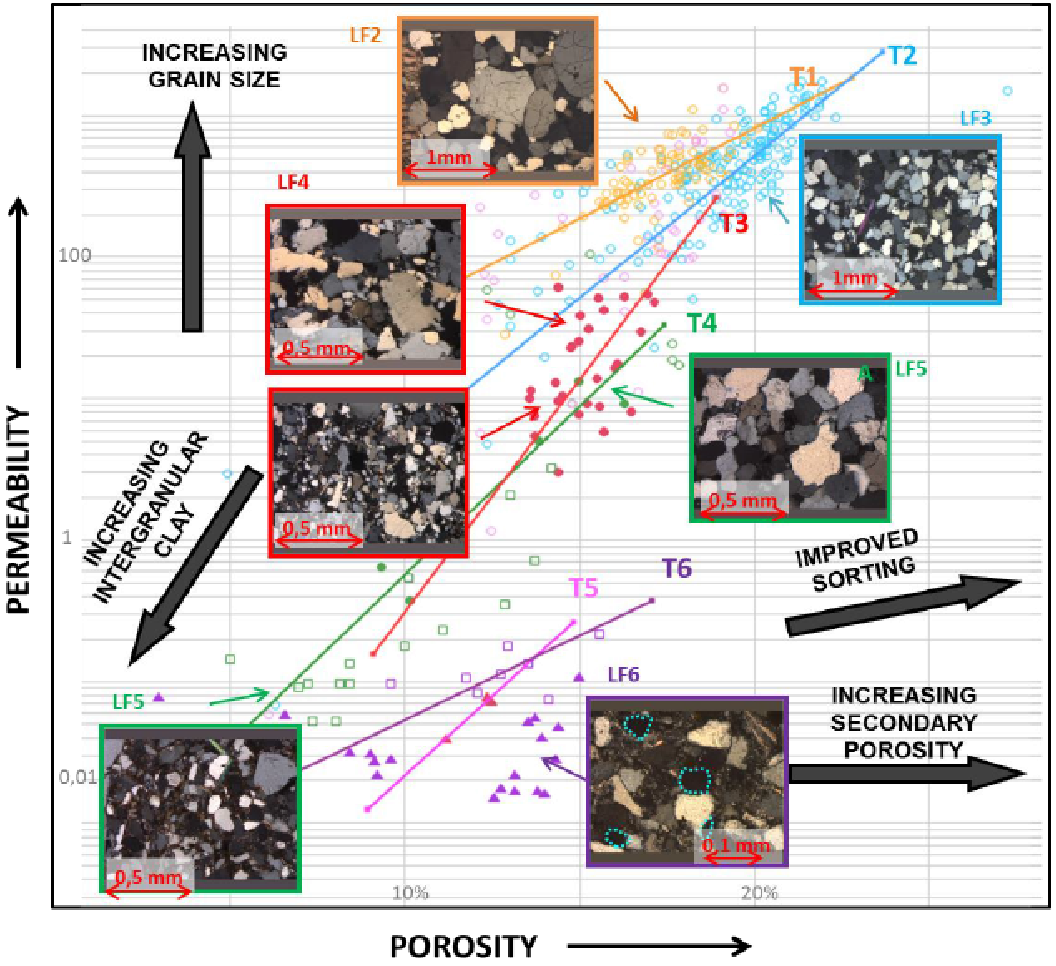


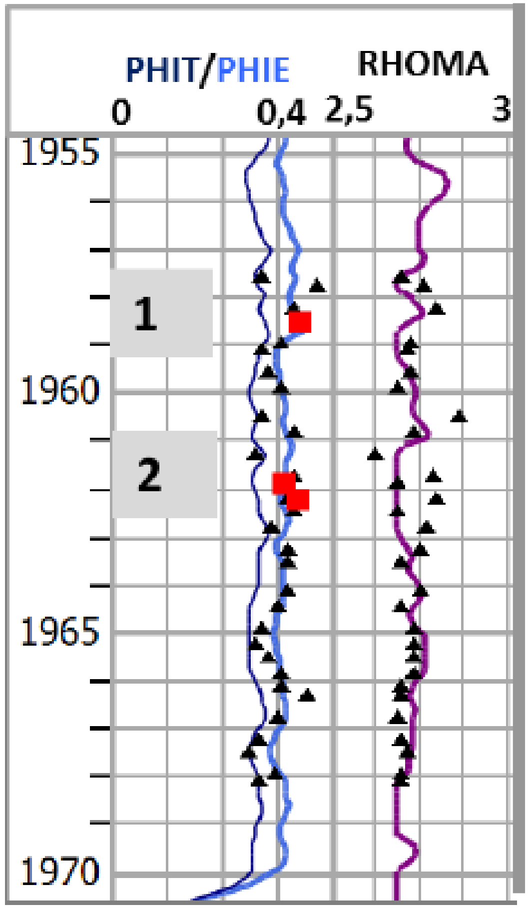
Marin (work in progress)

- Upward shallowing cycles
- Distal, shelfal part of the shoreline

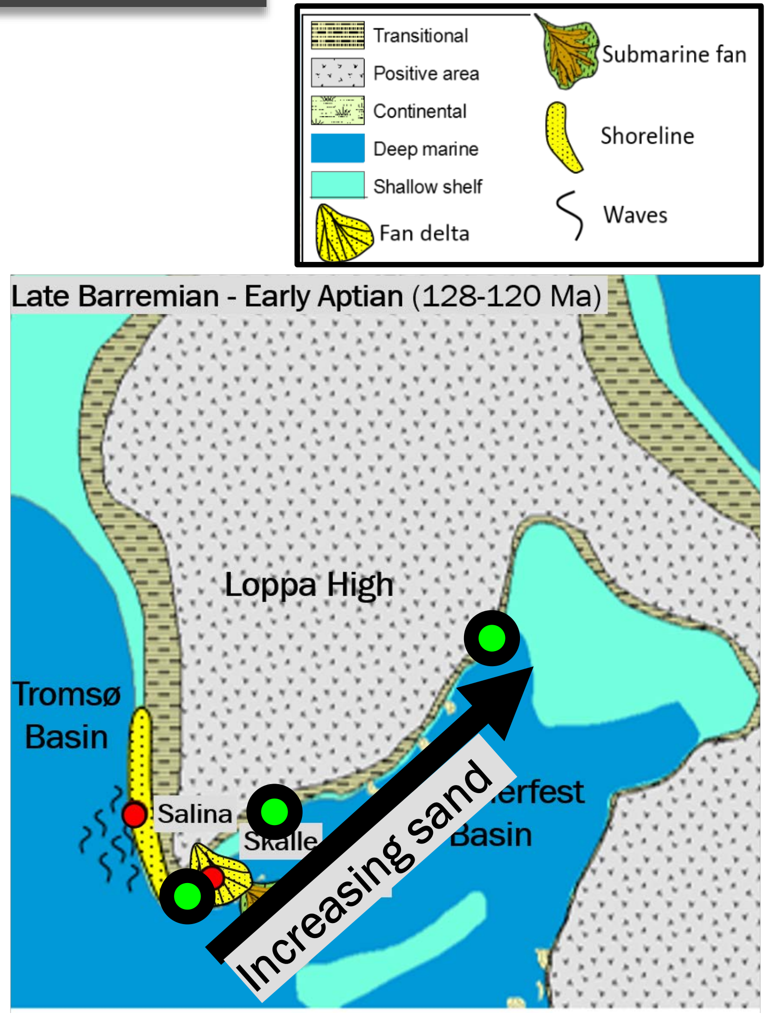


Previous work





Rodríguez (2015)



Information from Rodrígues (2015), Iqbal (2016), Marin (work in progress) & Grundvåg (work in progress)

Motivation

Skalle

Seismic & Petrophysics
↓
Reservoir quality
Facies

Juksa

Seismic
↓
Facies

Salina

Seismic & Core Description
↓
Facies

- Not analyzed internal properties or made detailed sedimentological description
- Limited understanding of the small-scale sedimentology
- Reservoir quality highly depends on sedimentological & diagenetic processes
- If well understood → higher chance of successful development & production

Objectives

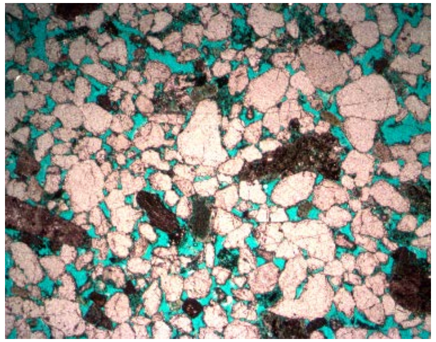
Compare the Salina, Skalle & Juksa wells in order to understand how different depositional environments in the southwestern Barents Sea control the reservoir properties of the wedges.

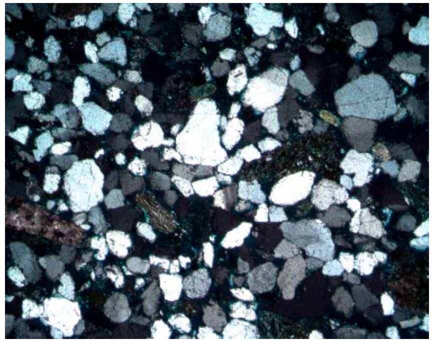
I will define the wedges in terms of:

1. Facies & depositional environment,
2. Diagenetic processes, &
3. Reservoir quality

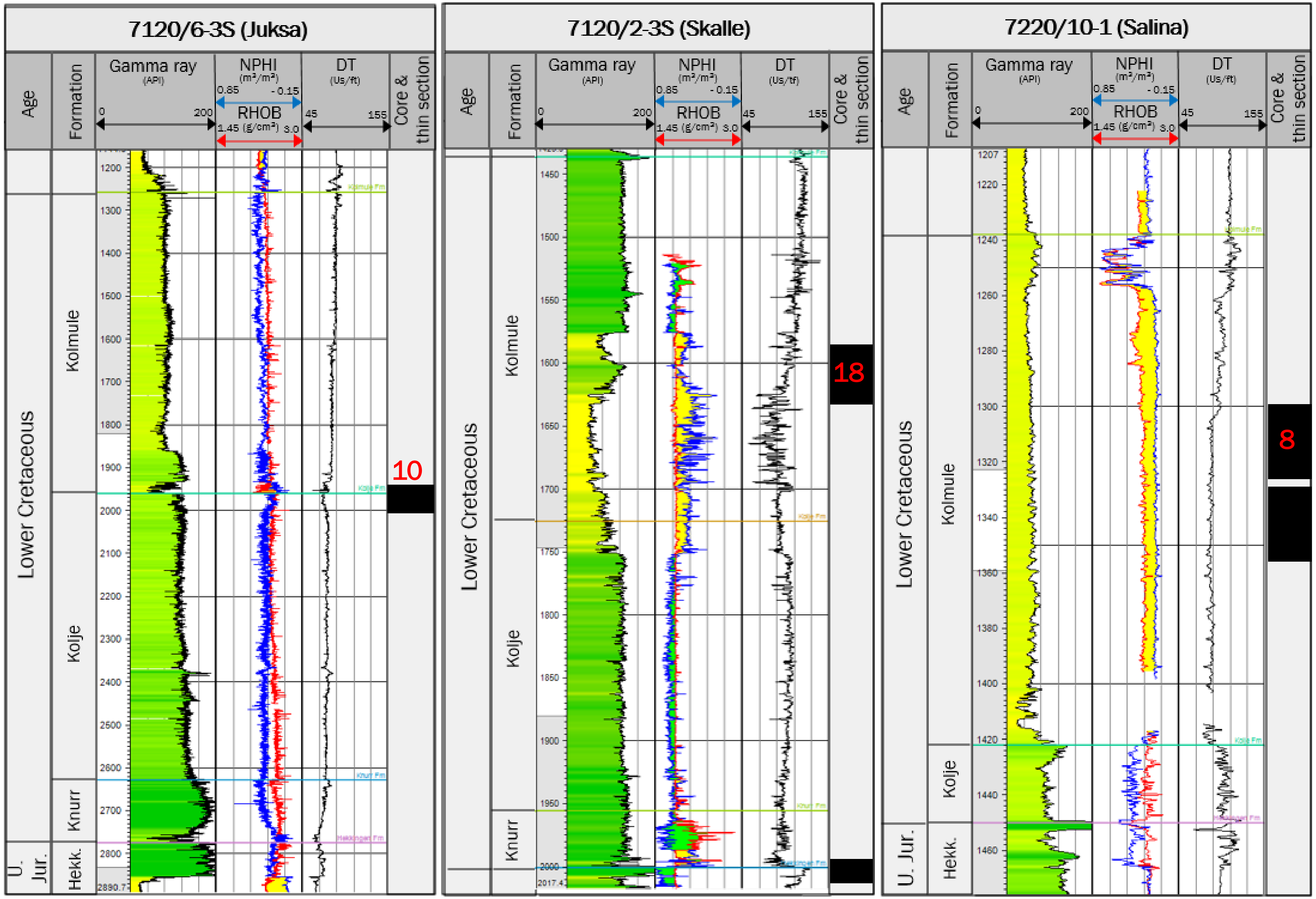
Data

- Well logs
- Core sections
- Thin sections



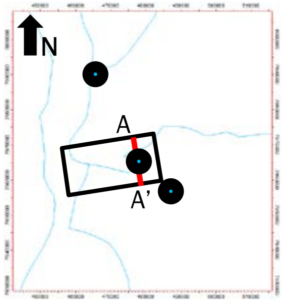


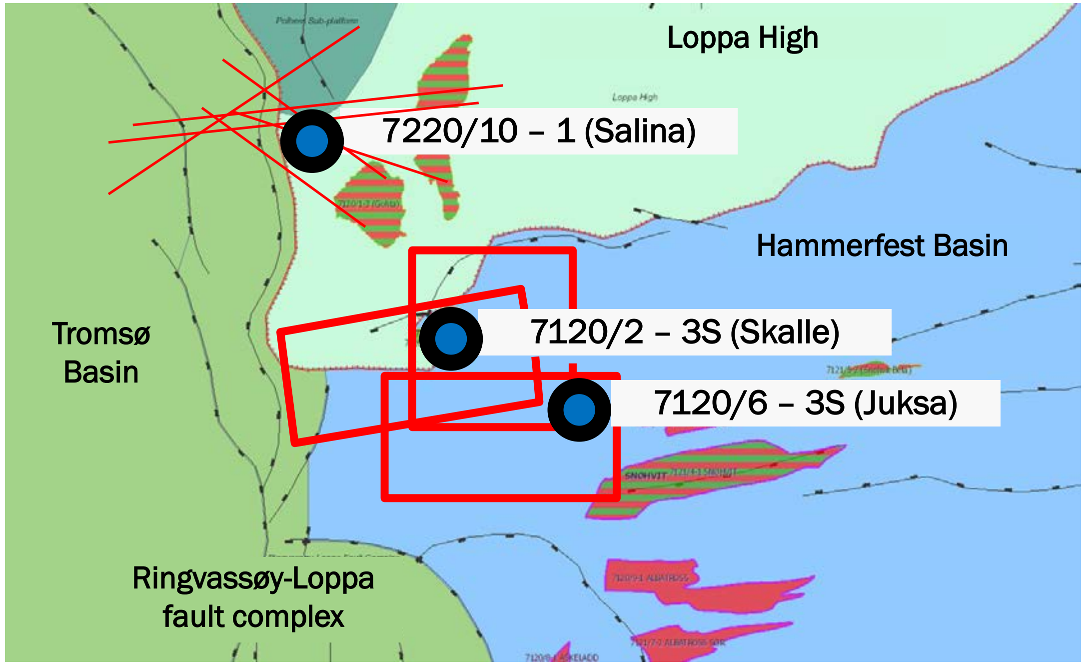
500 µm



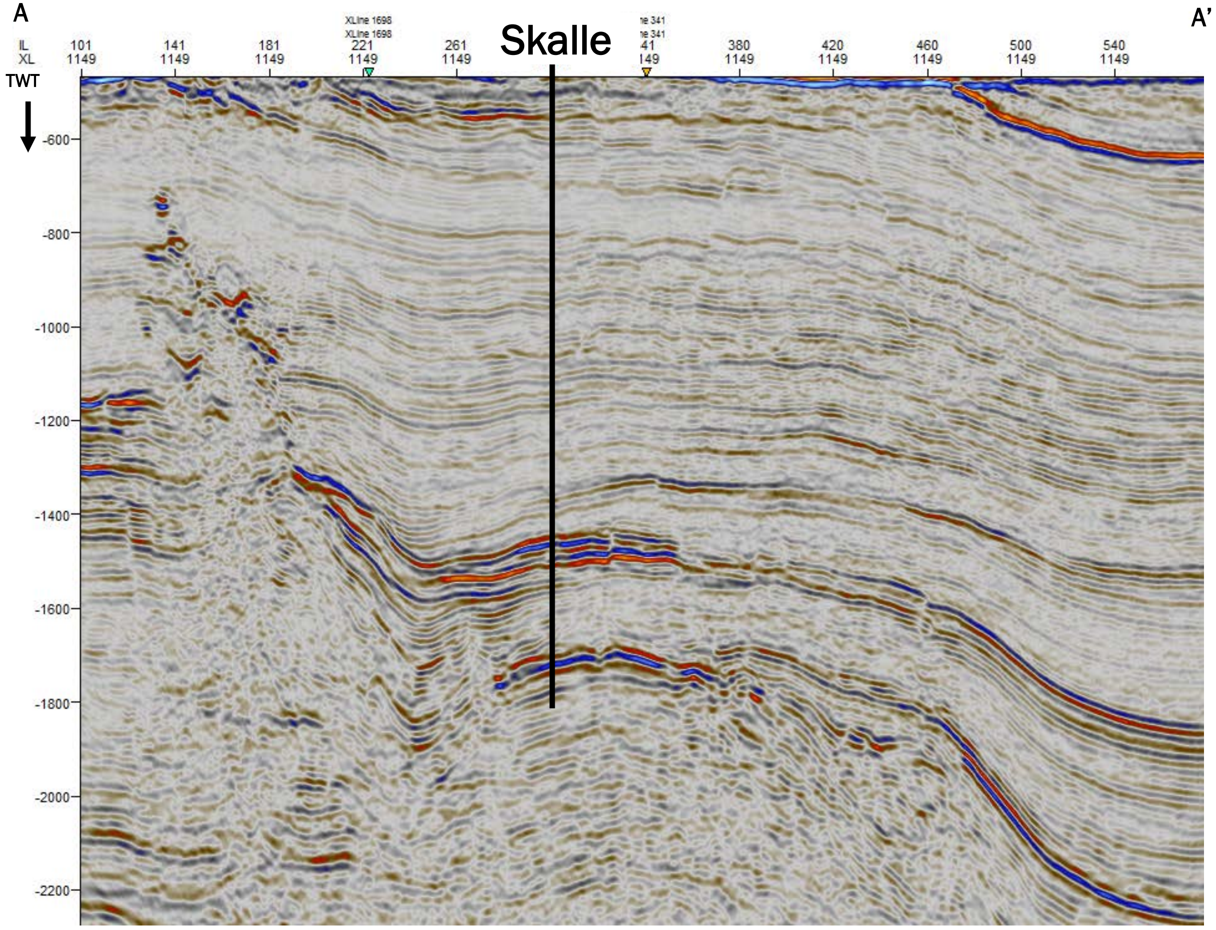
Data

- Seismic data (2D & 3D)





NPD (2016)



Methods

Cores & well logs

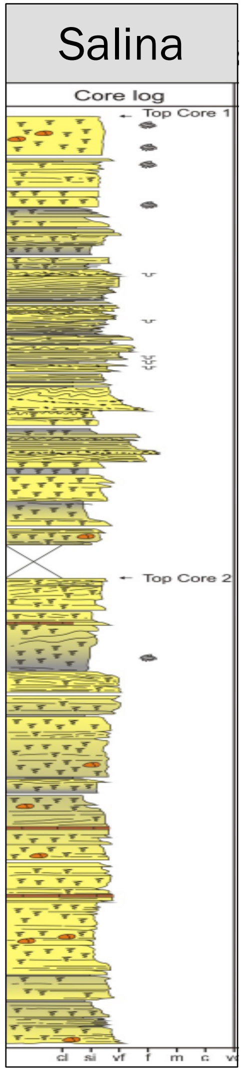
Core description

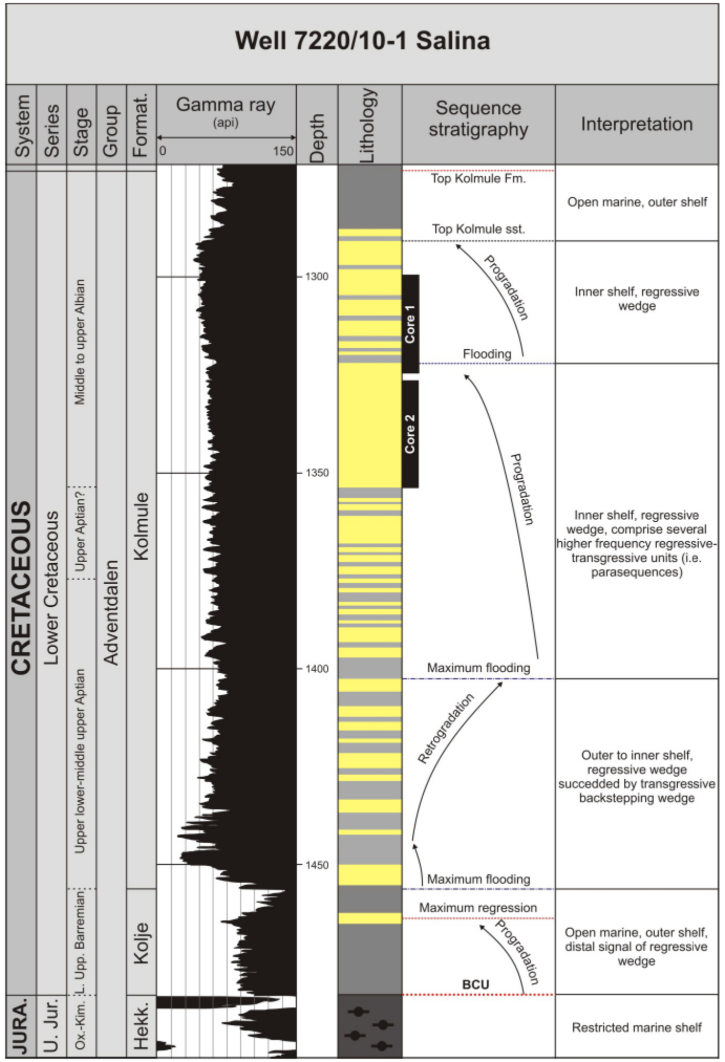
- Rock type, texture, sedimentary structure etc.

Well logs

- Key surfaces, log trends

→ Correlate cores & well logs



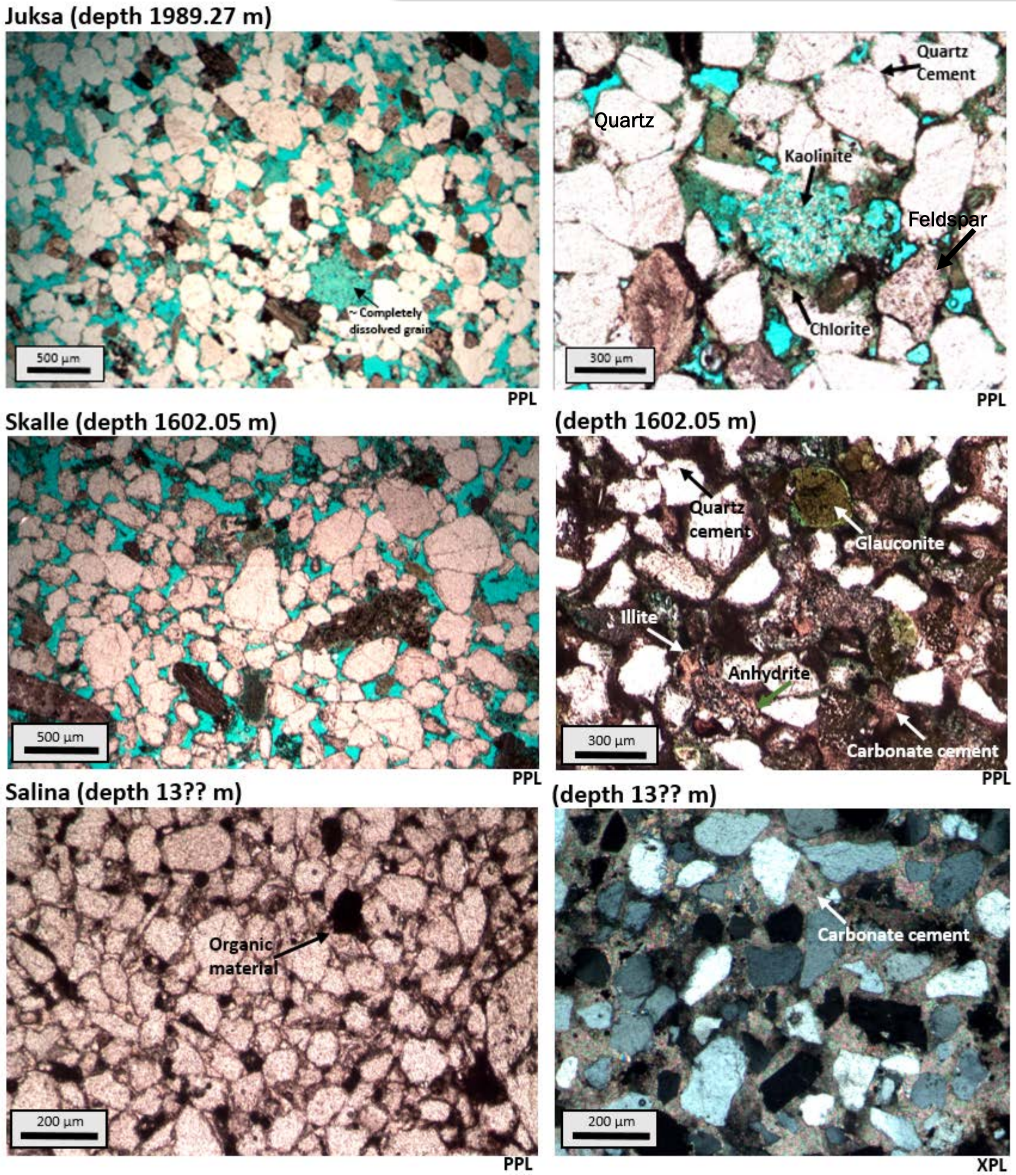


Grundvåg (work in progress)

Methods

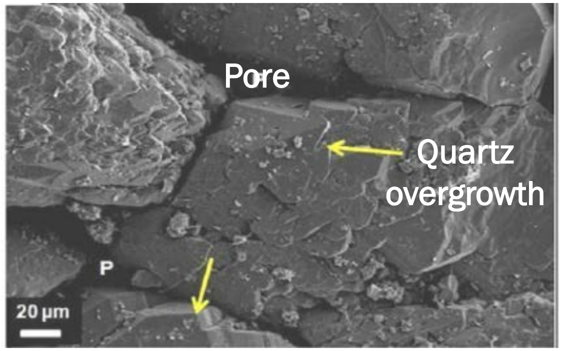
Thin sections

Polarizing microscope



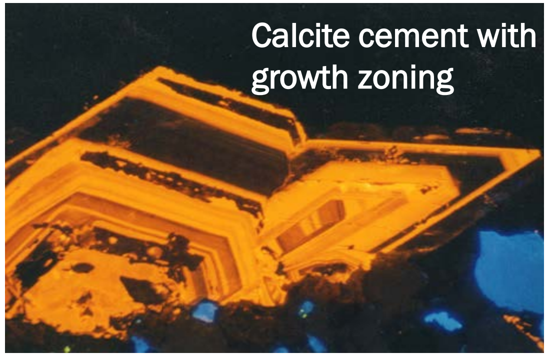
- Analyze mineral composition – primary & diagenetic
- Textures & sedimentary structures
- SEM & CL to aid the identification of minerals & cement types

Scanning Electron Microscope (SEM)



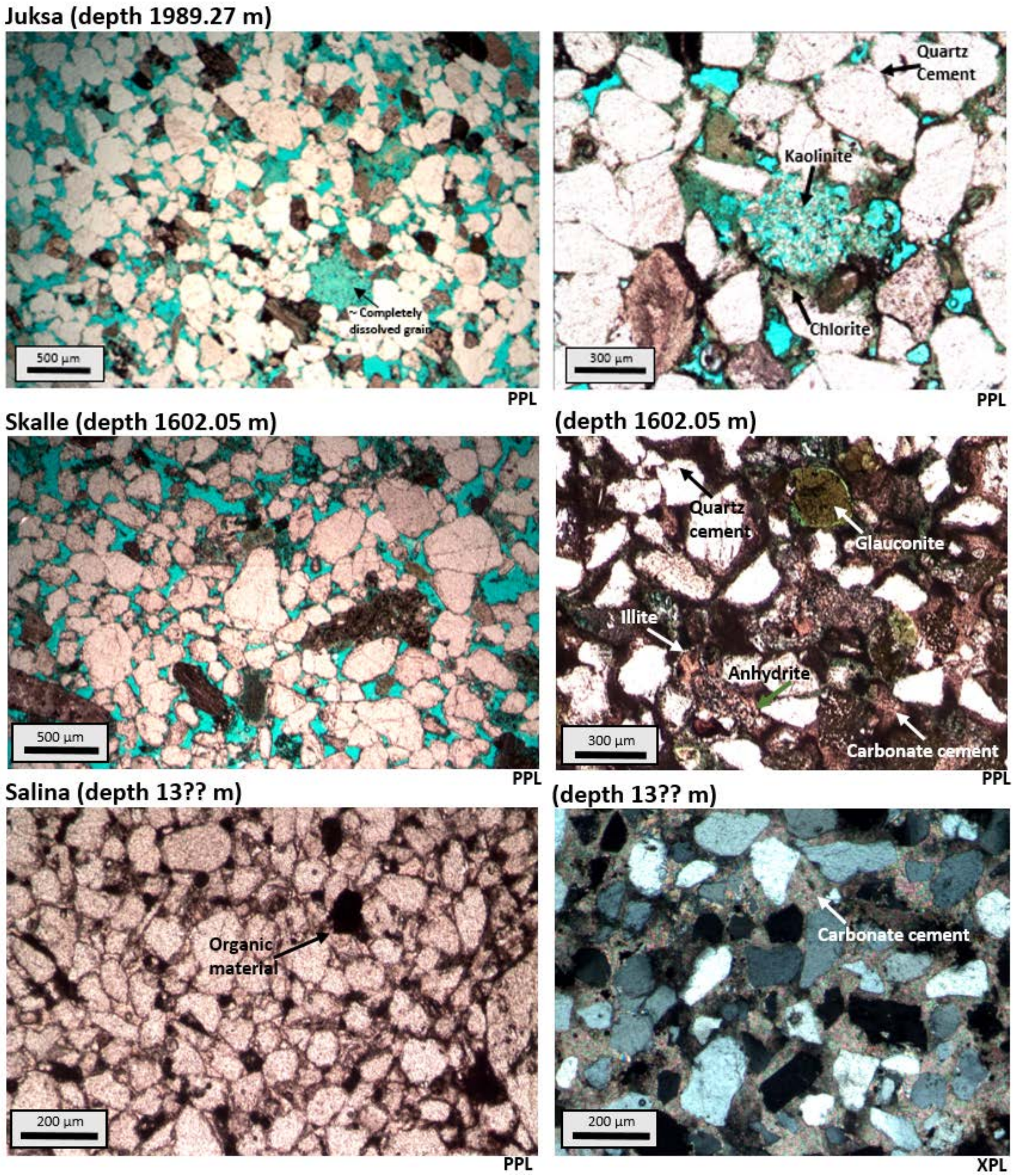
Khalifa & Morad (2015)

Cathodoluminescence (CL)



British Geological Survey (2016)

Preliminary observations



Skalle & Juksa

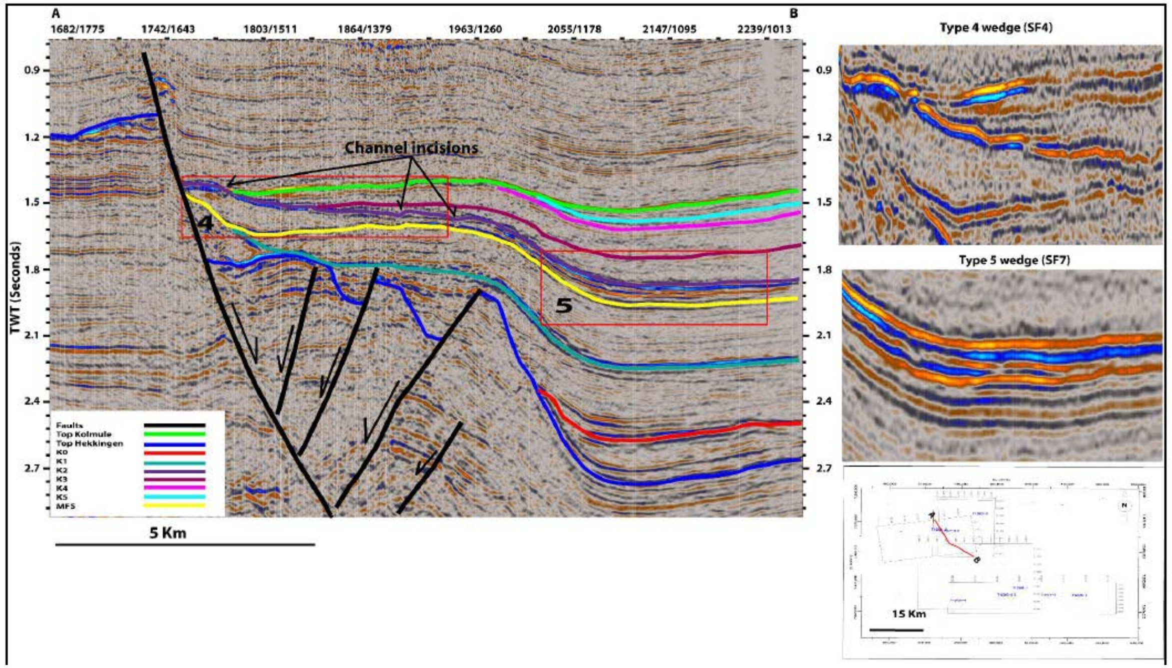
- Mod. to well sorted, medium-grained sandstone w. angular to subrounded grains
- Point & plane contacts
- Chlorite coating – may have prevented compaction & cementation
- High porosity

Salina

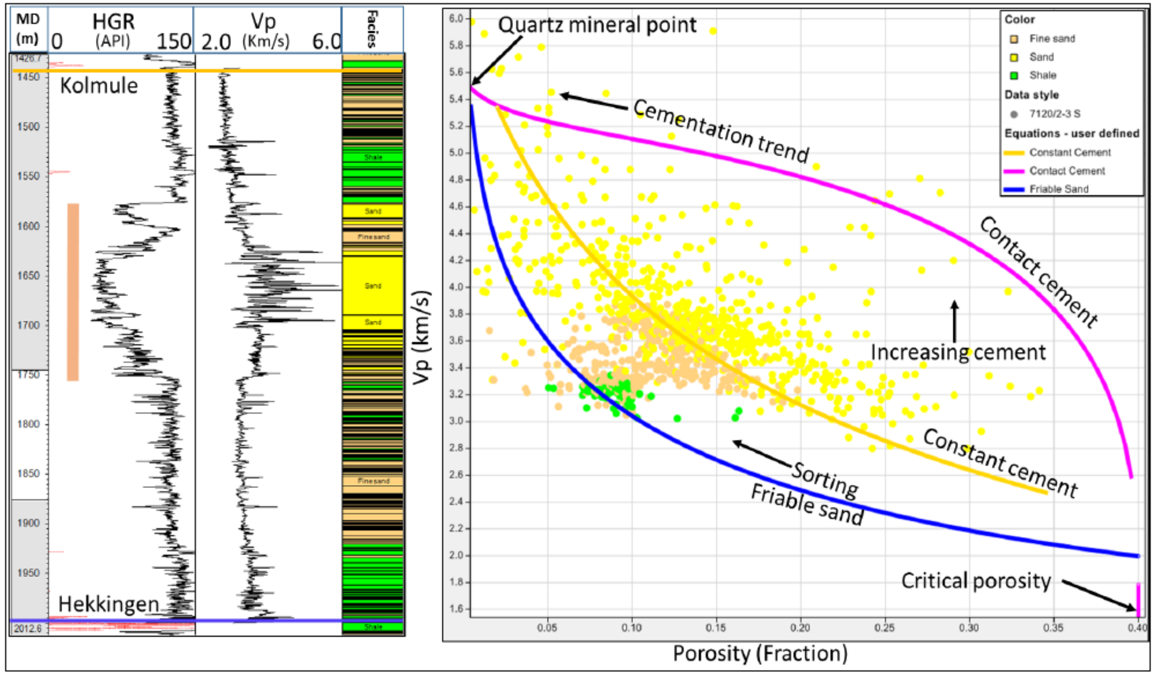
- Poorly to mod. sorted, fine to medium-grained sandstone w. subangular grains
- Plane & sutured contacts
- Porosity reducing cement (Illite & Carbonate)
- Low porosity

Methods

Thin sections + Core + Well logs



Iqbal (2016)



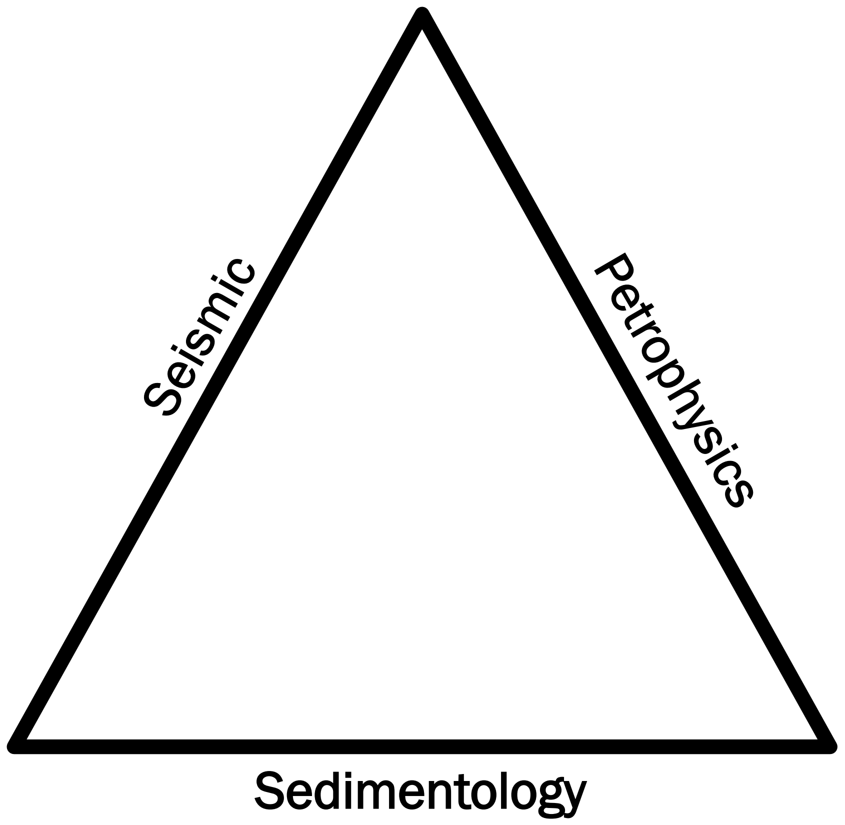
Iqbal (2016)

Expected outcome

More accurate & complete interpretation of the wedges

→ Improve the current understanding of the paleogeographic framework & the effect facies have on reservoir properties

→ Better prediction of:
- facies variations & relation
- distribution of reservoirs



Thank you for your attention ☺

Masters thesis proposal

DEVELOPMENT OF FRACTURE MODELING STRATEGIES: CASE STUDY OF SOUTH ARNE FIELD, DANISH NORTH SEA

Syed Danish Haider

2 December 2016

Supervisors: Lothar Schulte (Schlumberger SIS)

Nestor Cardozo (University of Stavanger)

Outlines

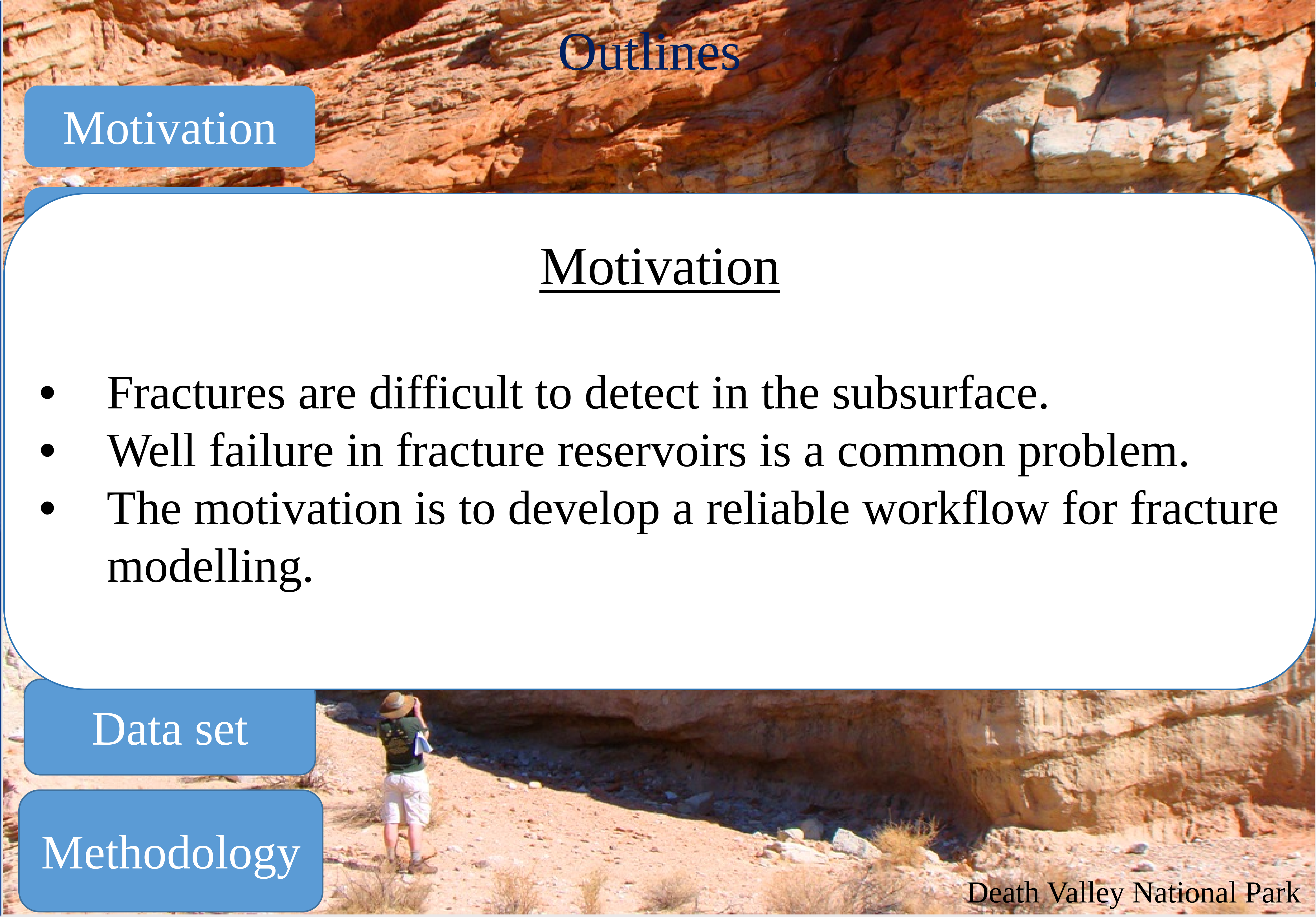
Motivation

Motivation

- Fractures are difficult to detect in the subsurface.
- Well failure in fracture reservoirs is a common problem.
- The motivation is to develop a reliable workflow for fracture modelling.

Data set

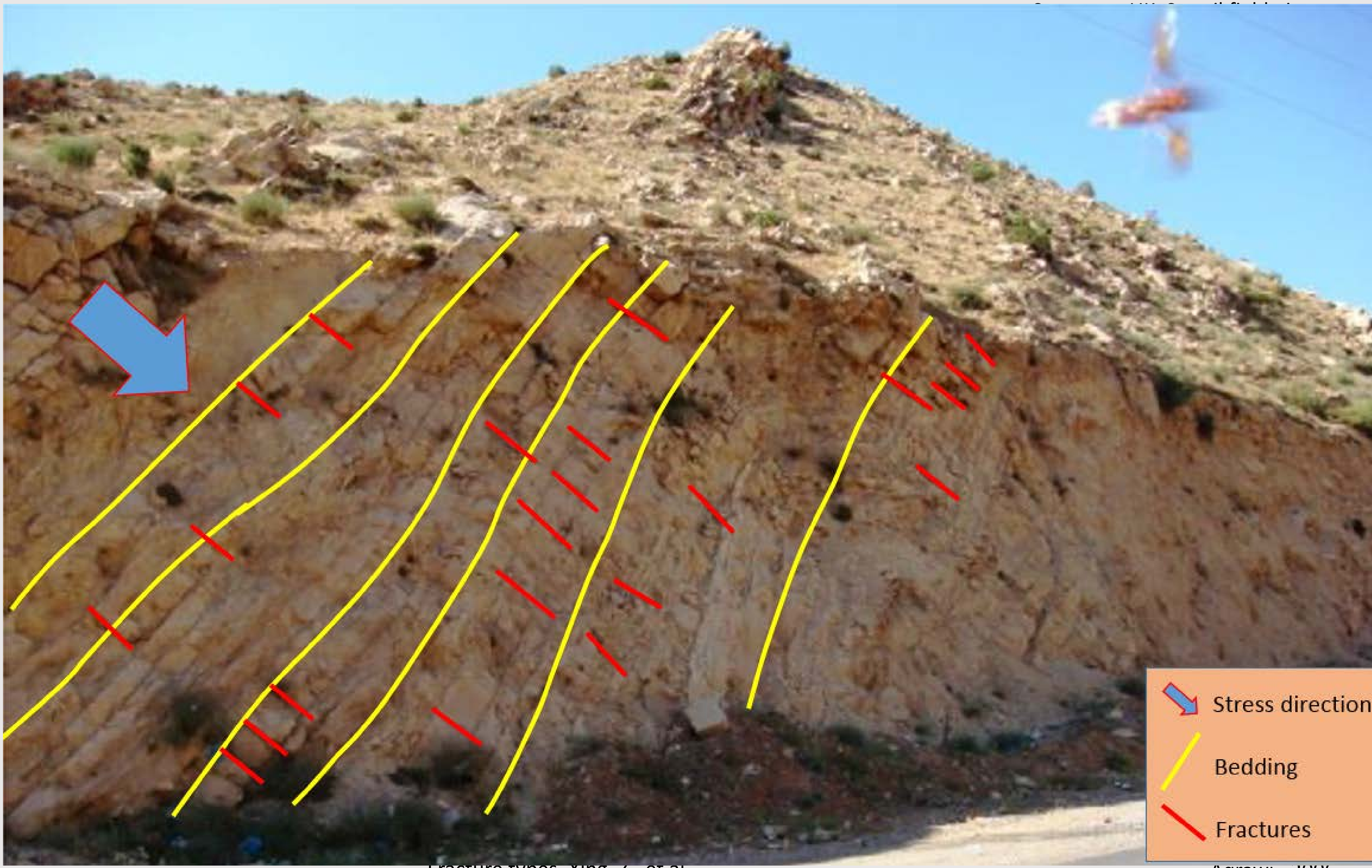
Methodology



Death Valley National Park

University of Stavanger

Introduction (What are fractures??)



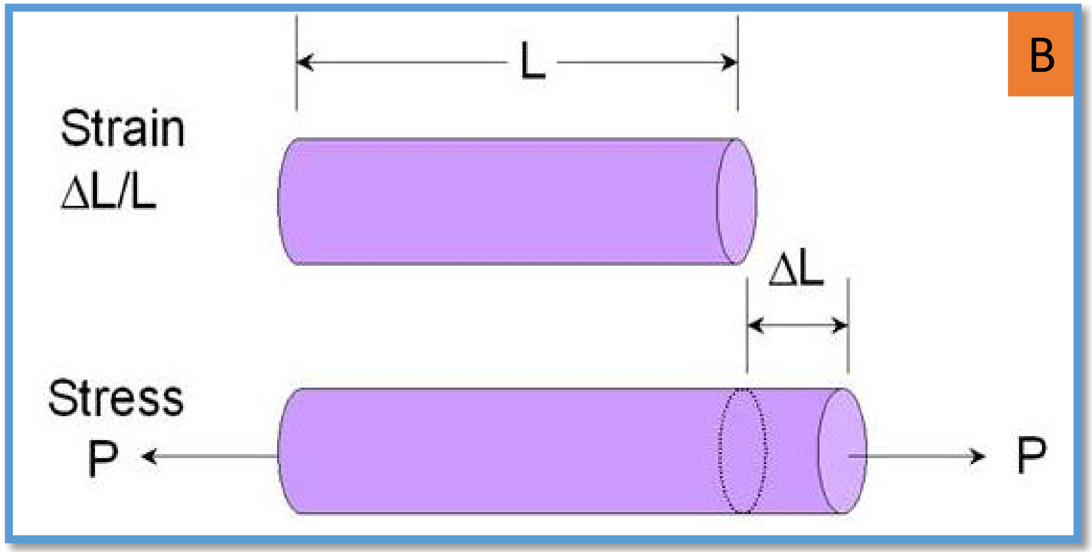
Fracture types, Xing, Z., et al

Aqrawi., 2006

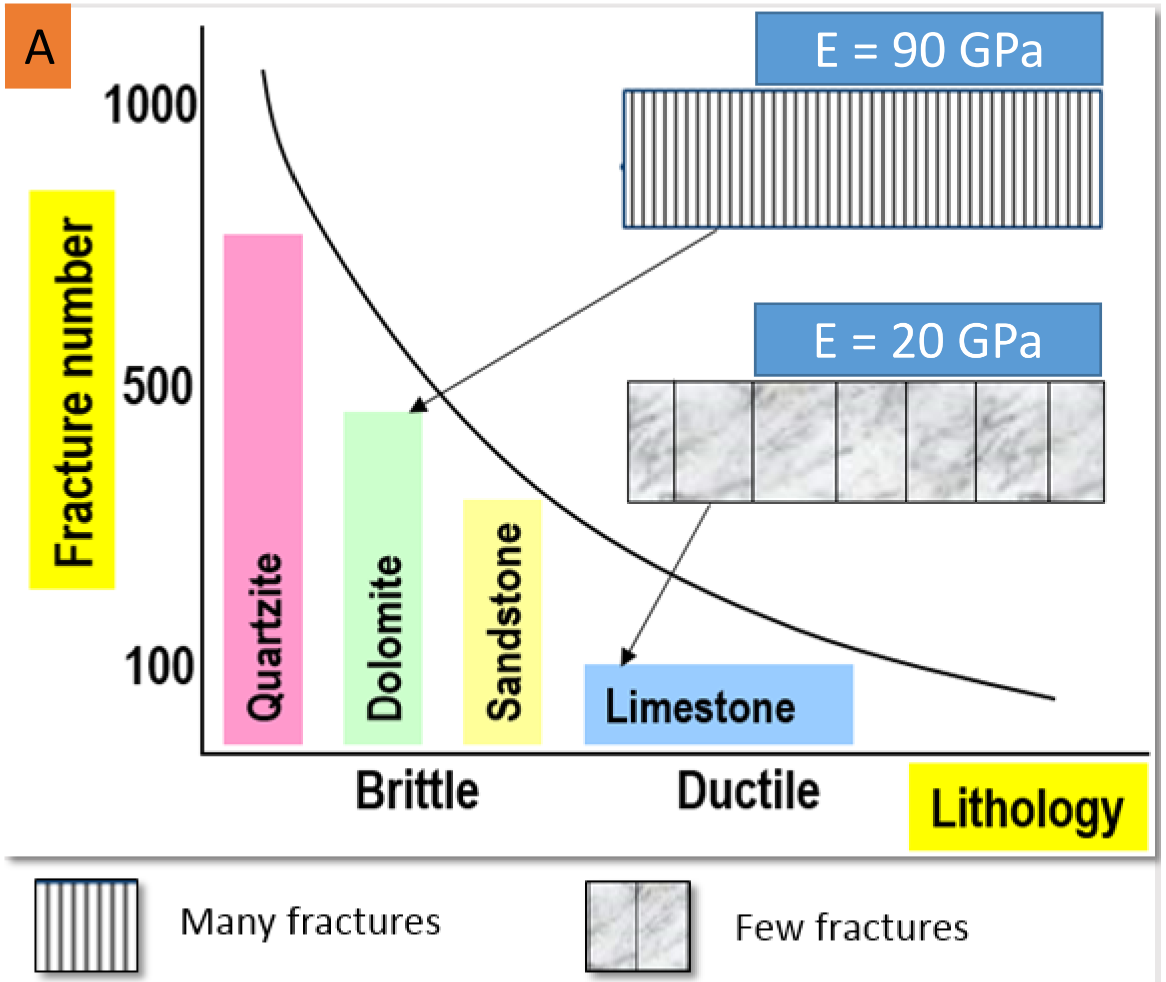
Introduction (How Fractures develop??)

- Elastic material: few fractures
- Brittle material: many fractures

Elasticity of the rock is defined by the Young modulus



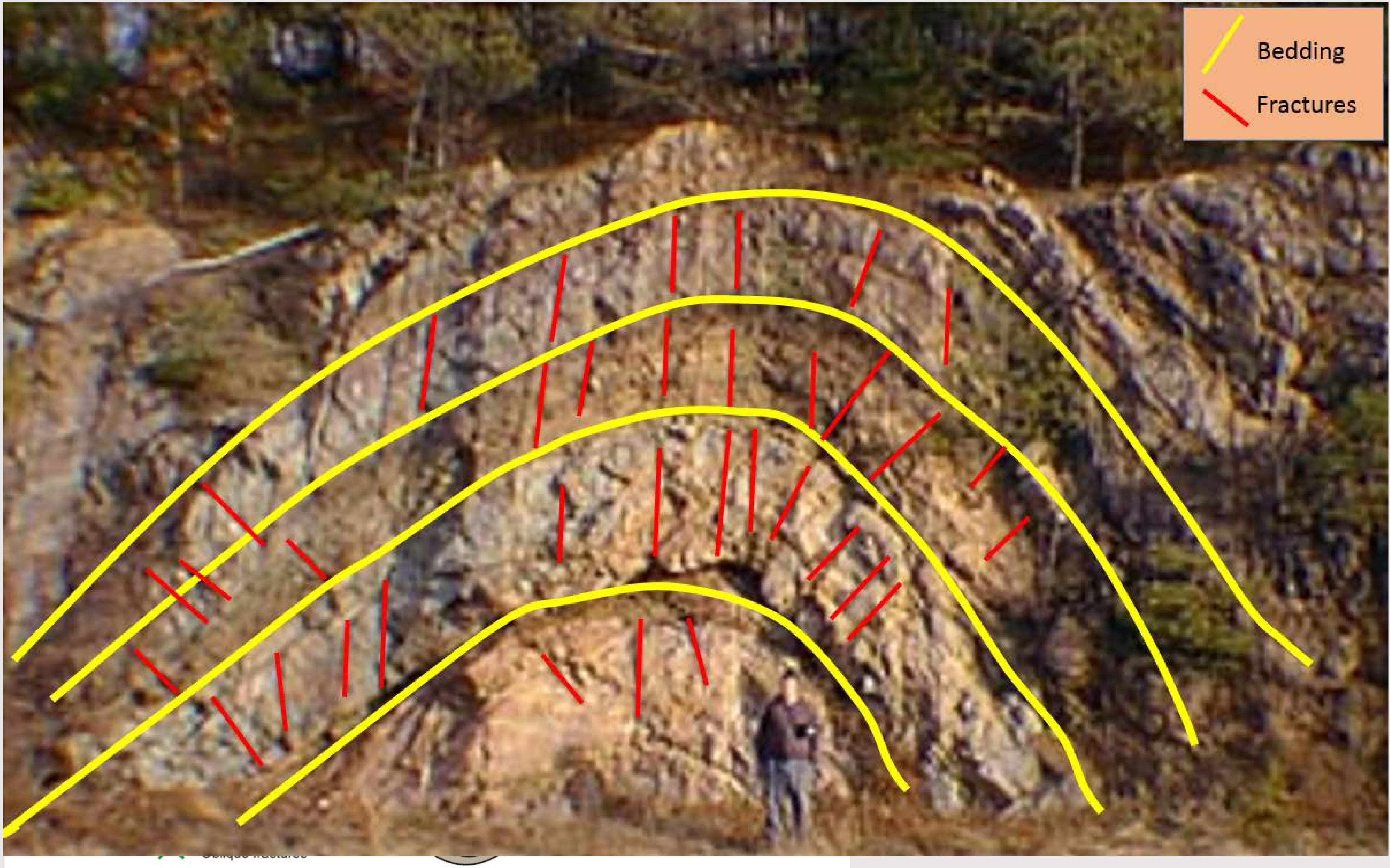
$$\text{Young's Modulus} = \frac{\text{Stress}}{\text{Strain}} = \frac{P}{\Delta L/L}$$



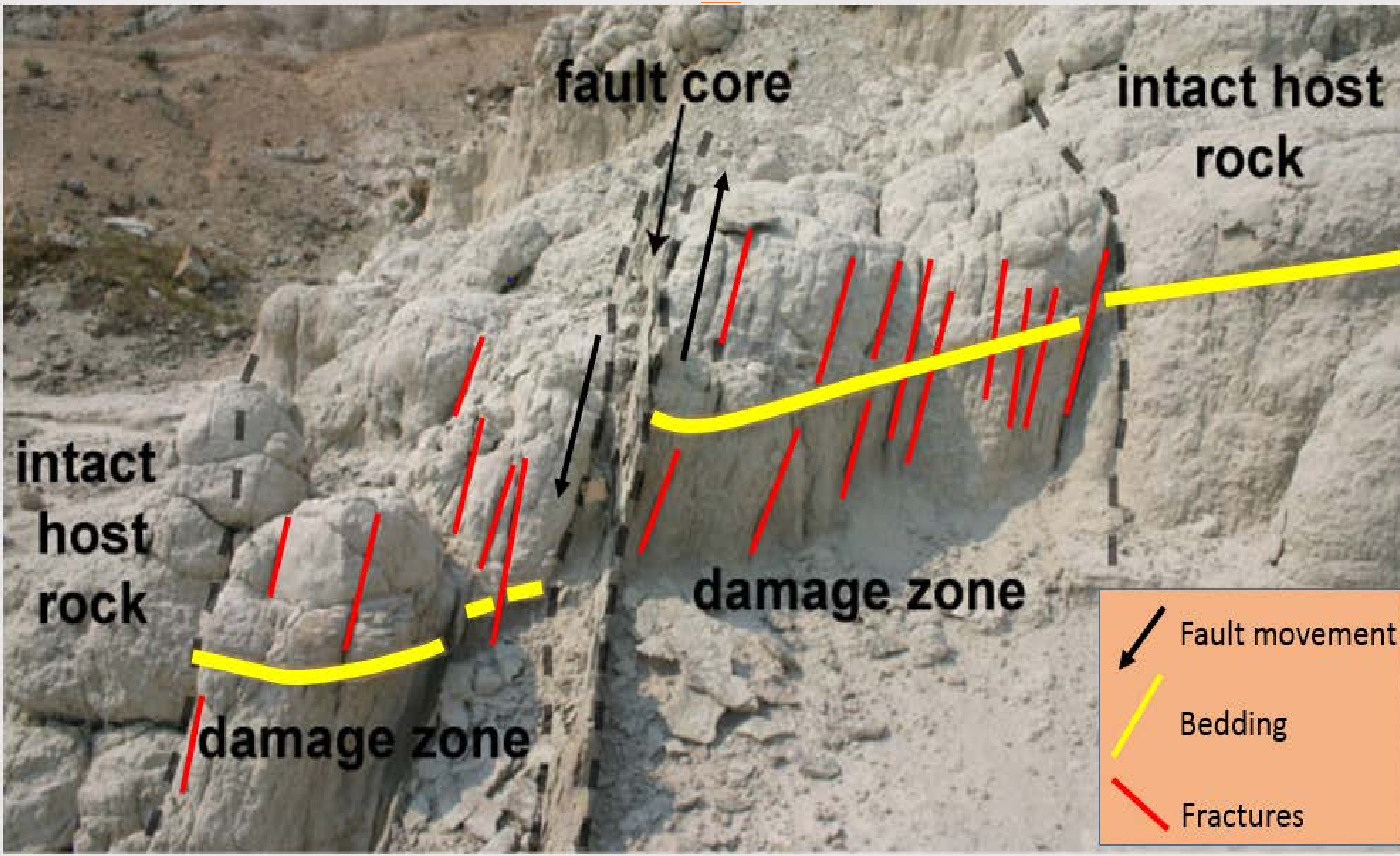
(modified from Schlumberger, 2010)

- Elastic material: small Young modulus
- Brittle material: large Young modulus

Introduction (Where do we find natural fractures)??



Introduction (Where do we find natural fractures)??



(Modified from schlumberger, 2010)

Challenges and Objectives

How can we represent a fracture reservoir in a numerical model?

How can we guide the modelled fractures between the wells?

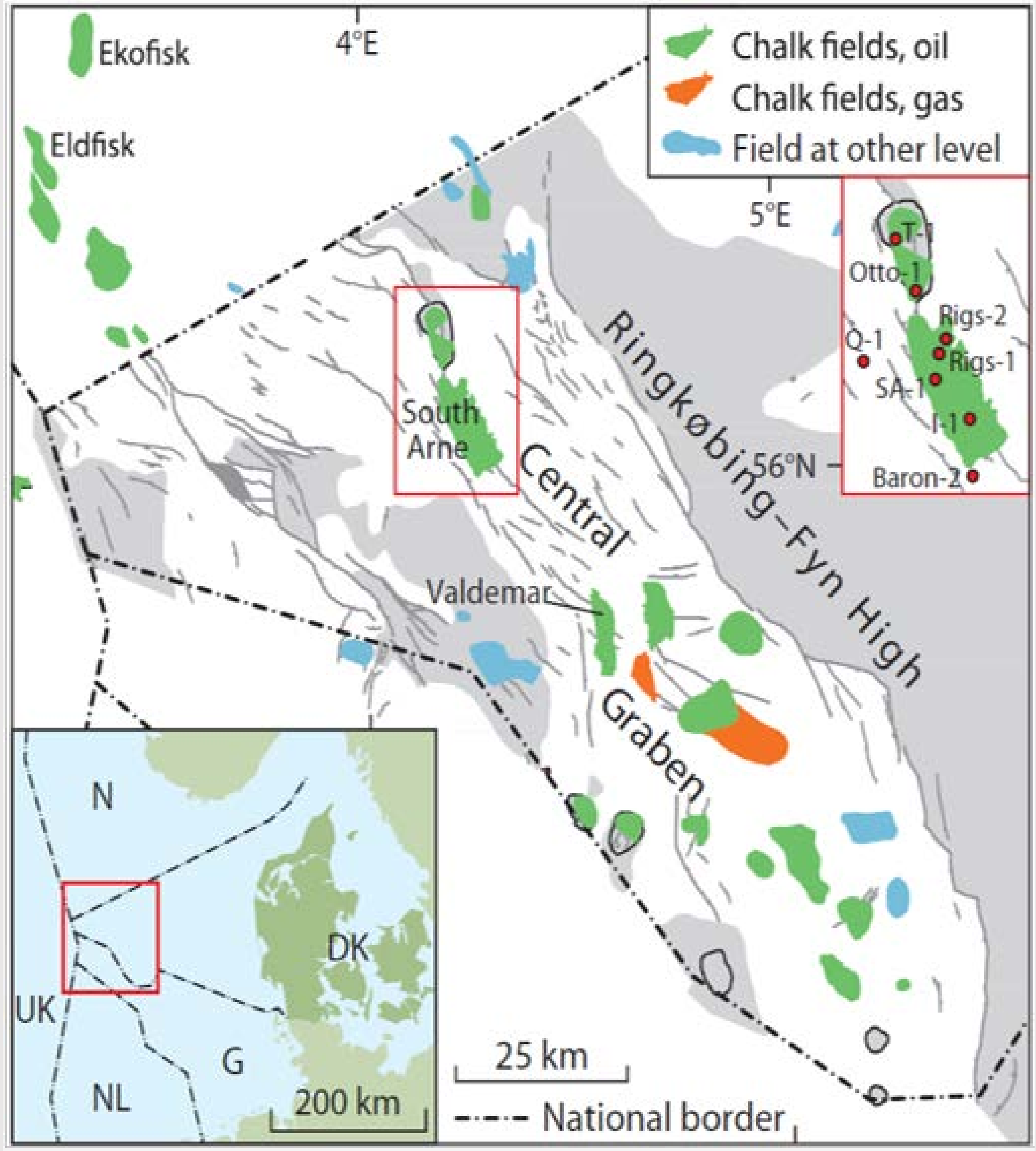
How can we compare and rank different fracture models?

Objectives

- Classify the measured fractures.
- Correlate fractures with seismic data (fault pattern, horizon folding and attributes).
- Build seismic guided fracture models
- Comparison and evaluation of the fracture models

Geology of Area

- Project area is South Arne field.
- Reservoir is naturally fractured chalk.
- Field lies on doubly dipping anticline.
- Reservoir stratigraphy is the Tor and Ekofisk formation
- Mastrichtian and Danian age.
- Reservoir deposited in Central Graben structure shown in the figure.



(Lindgreen et al., 2008)

University of Stavanger

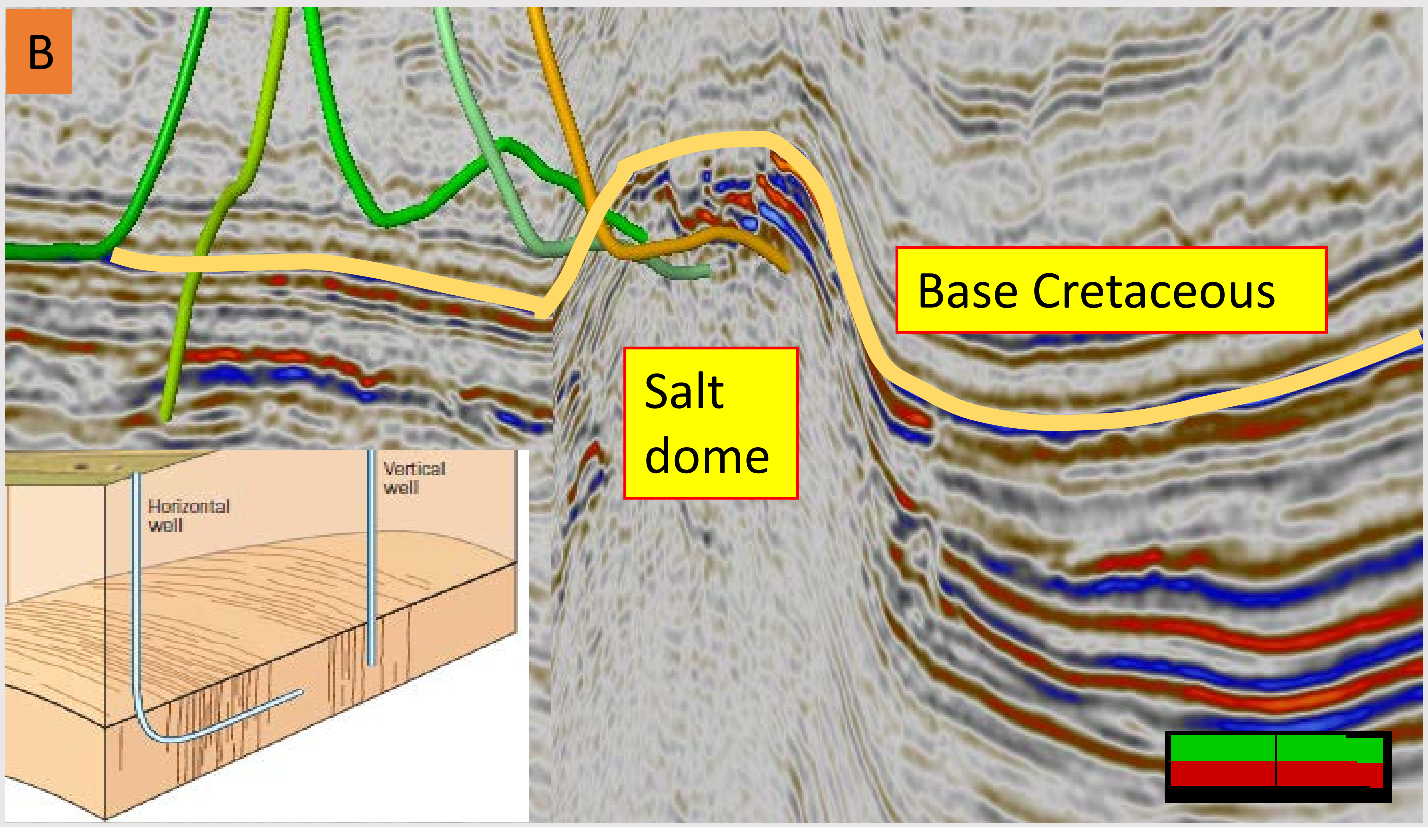
University of Stavanger

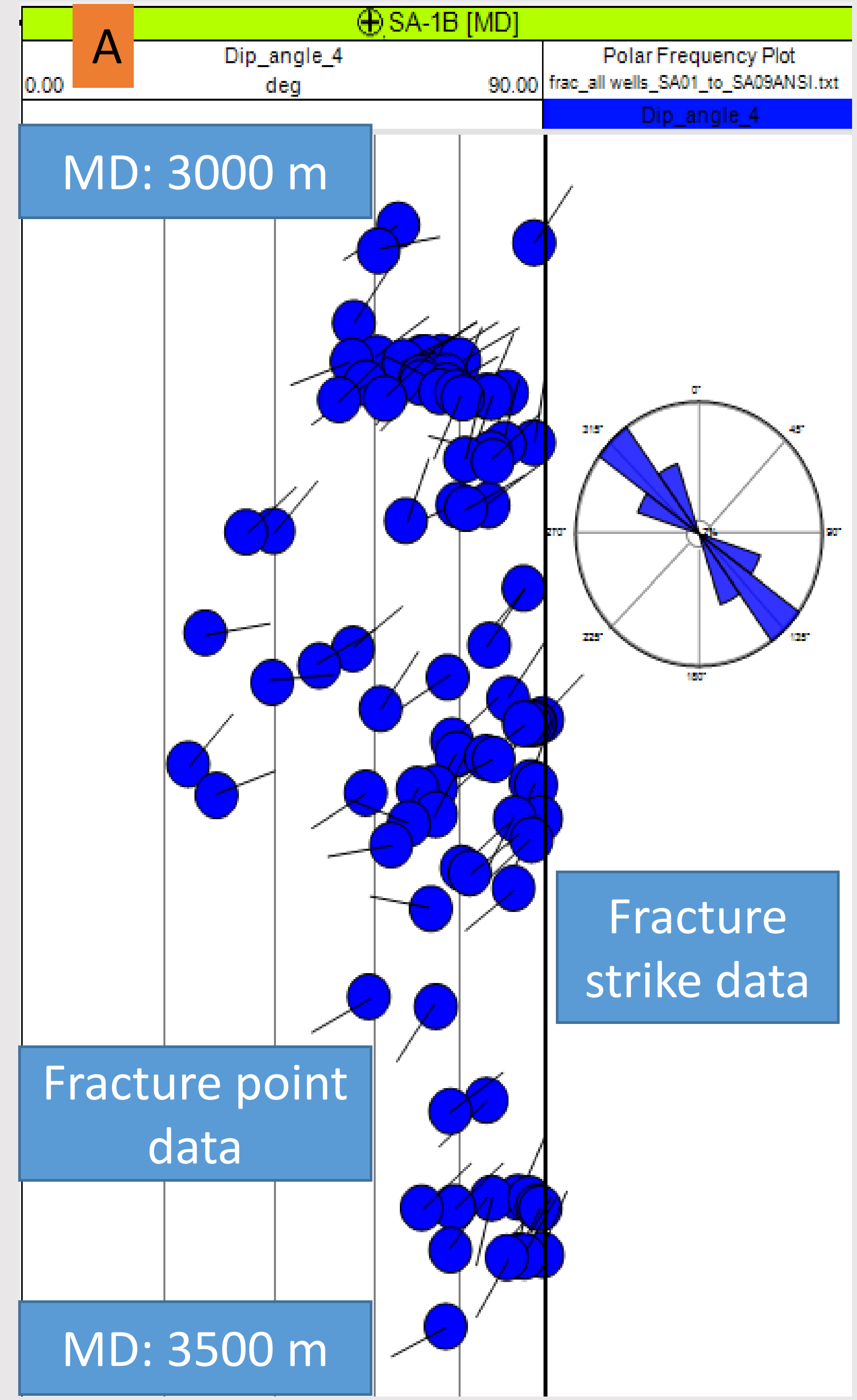
Data set

Data source From Hess, Denmark.

- 13 wells
  - Fracture point data
  - Well tops
  - Check shots

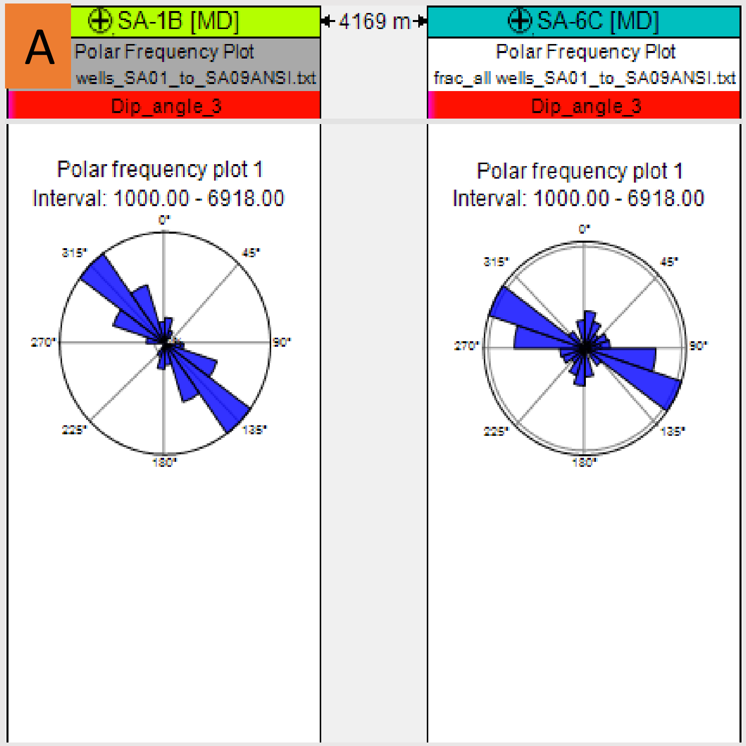
- 3D seismic data

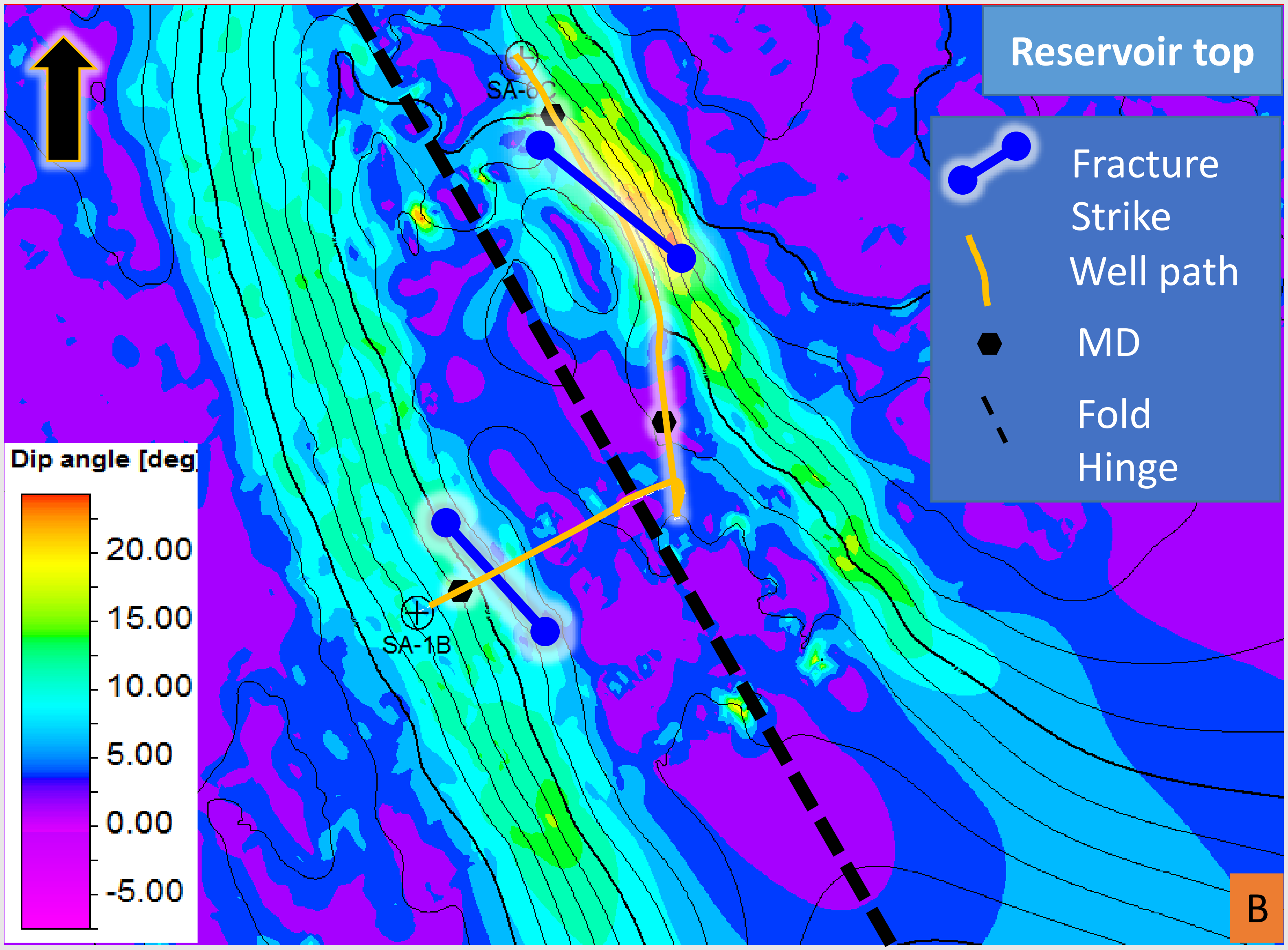


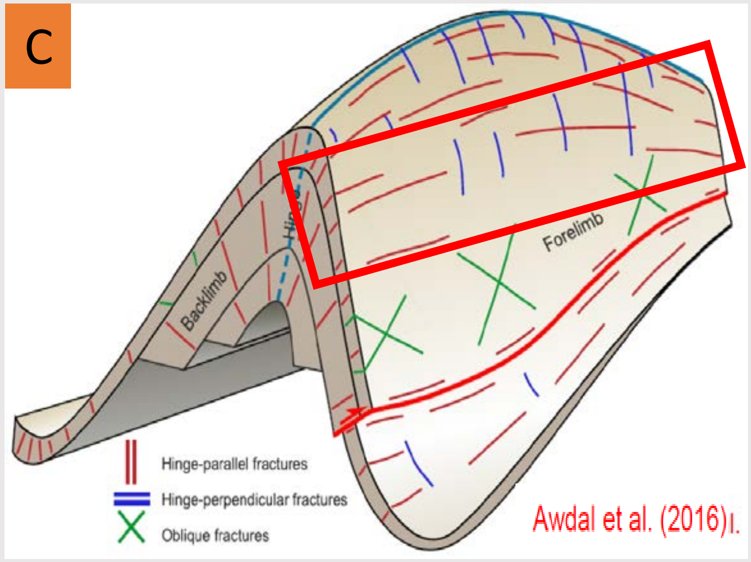


Methodology--Fracture strike comparison with structure morphology

- Example of fractures in the vicinity of the flanks of the fold.
- Fractures are parallel to the fold strike

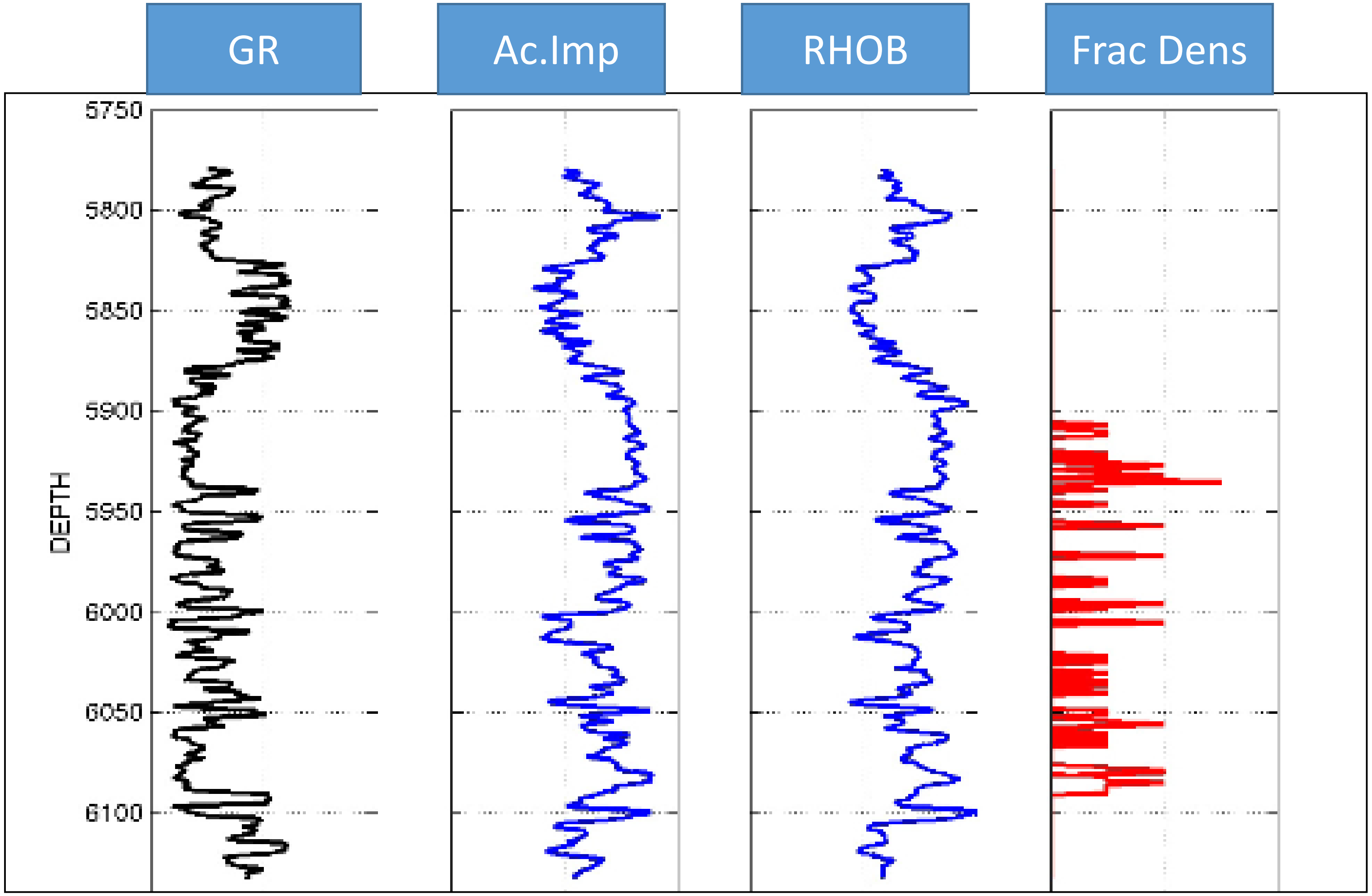






Fractures linked to physical properties

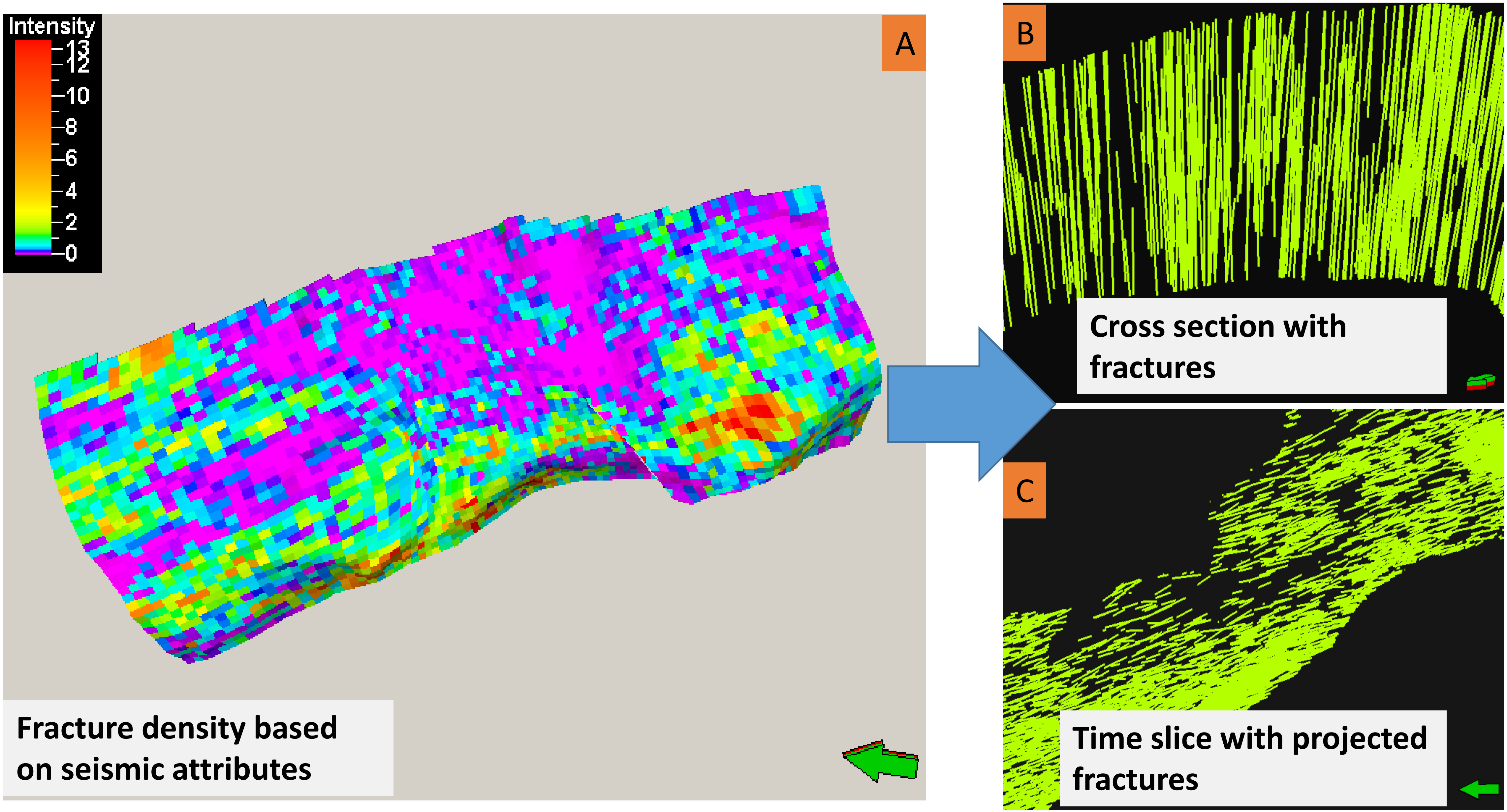
- Correlation of fracture density with acoustic impedance.
- If correlation exists, then fracture density may have an influence on seismic.



(Mavko, G. 2005)

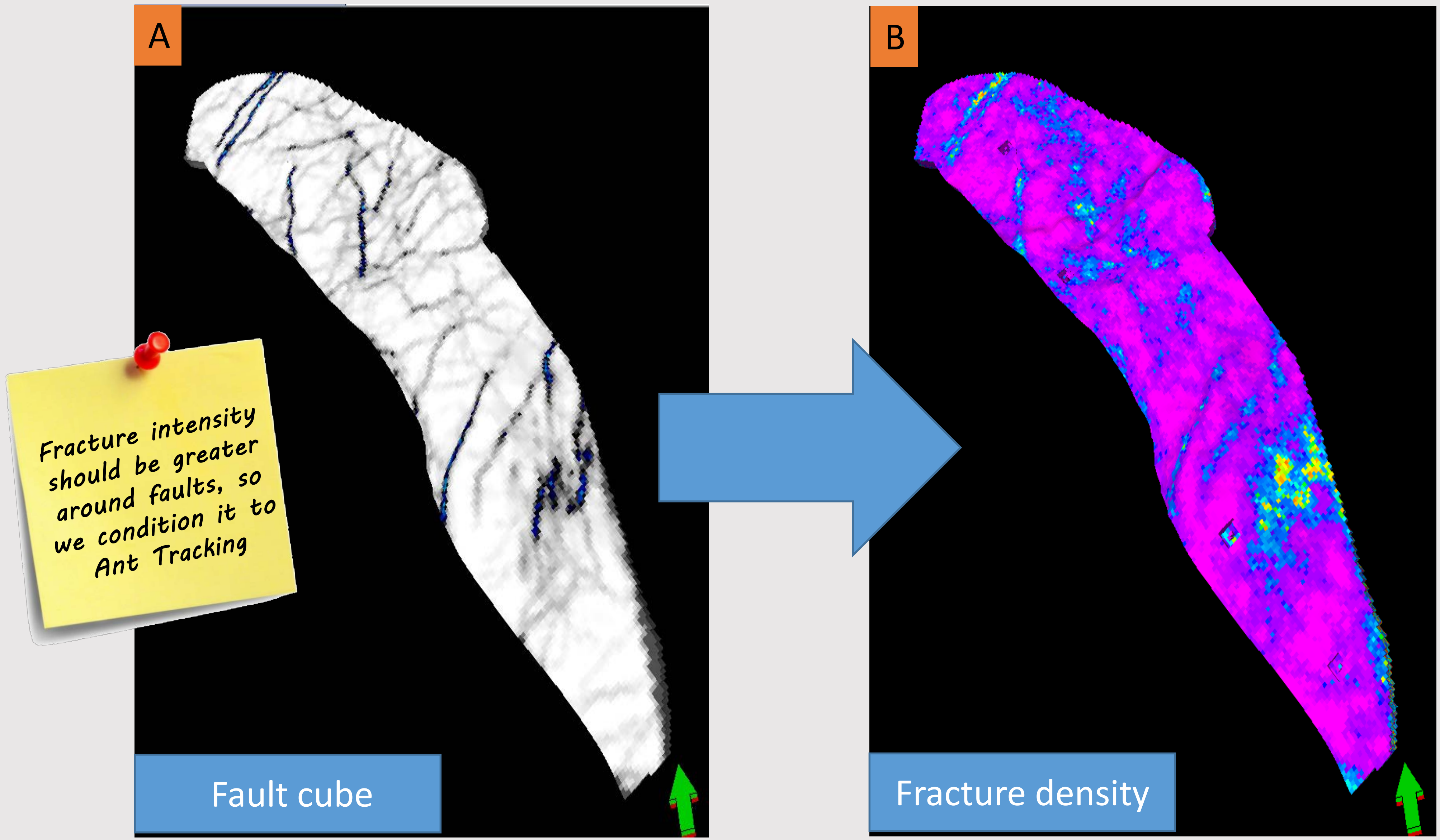
Fracture modeling based on seismic attributes

- Example of guiding fractures by modeled fracture density.



Conditioning of fracture density to seismic fault/fracture cube

- As shown in a previous slide, faults may be surrounded by fracture corridors.
- Therefore faults can be used for fracture guiding.



(Schlumberger, 2010) (Schlumberger, 2010)

University of Stavanger

DRY WELL ANALYSIS OF WELL 6407/10-5 AND REMAINING EXPLORATION POTENTIAL EVALUATION AT EXPL512 AREA, MID-NORWAY.

JAVERIA QAMAR

234833

University of Stavanger

Supervisors: Nestor Cardozo
Lothar Schulte
Bing Wang

OUTLINE

- OBJECTIVES
- INTRODUCTION
- DATASET
- METHODOLOGY
  - SEISMIC INTERPRETATION
  - DRY WELL ANALYSIS
  - POTENTIAL EVALUATION CALCULATION

OBJECTIVES

Propose failure reasons of well 6407/10-5.

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Populate a list of leads/prospects for Jurassic reservoirs

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Extend the analysis to the seismic cube i.e. the Triassic potential in the area.

OBJECTIVES

Propose failure reasons of well 6407/10-5

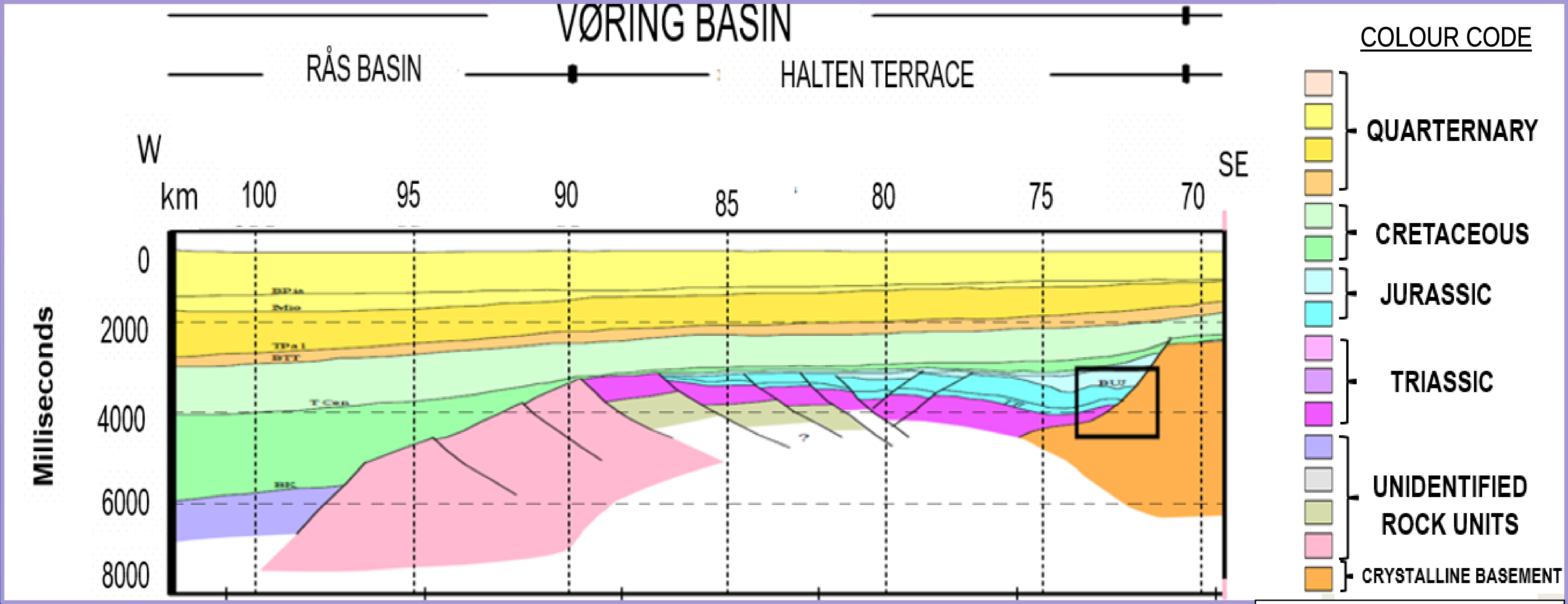
Populate a list of leads/prospects for Jurassic reservoirs

Extend the analysis to the seismic cube i.e. the Triassic potential in the area.

Remaining potential exploration evaluation of the Jurassic reservoirs

GEOLOGICAL HISTORY

- **PERMIAN-EARLY TRIASSIC**
  - Crustal extension, development of rift basins, formation of a shallow seaway.

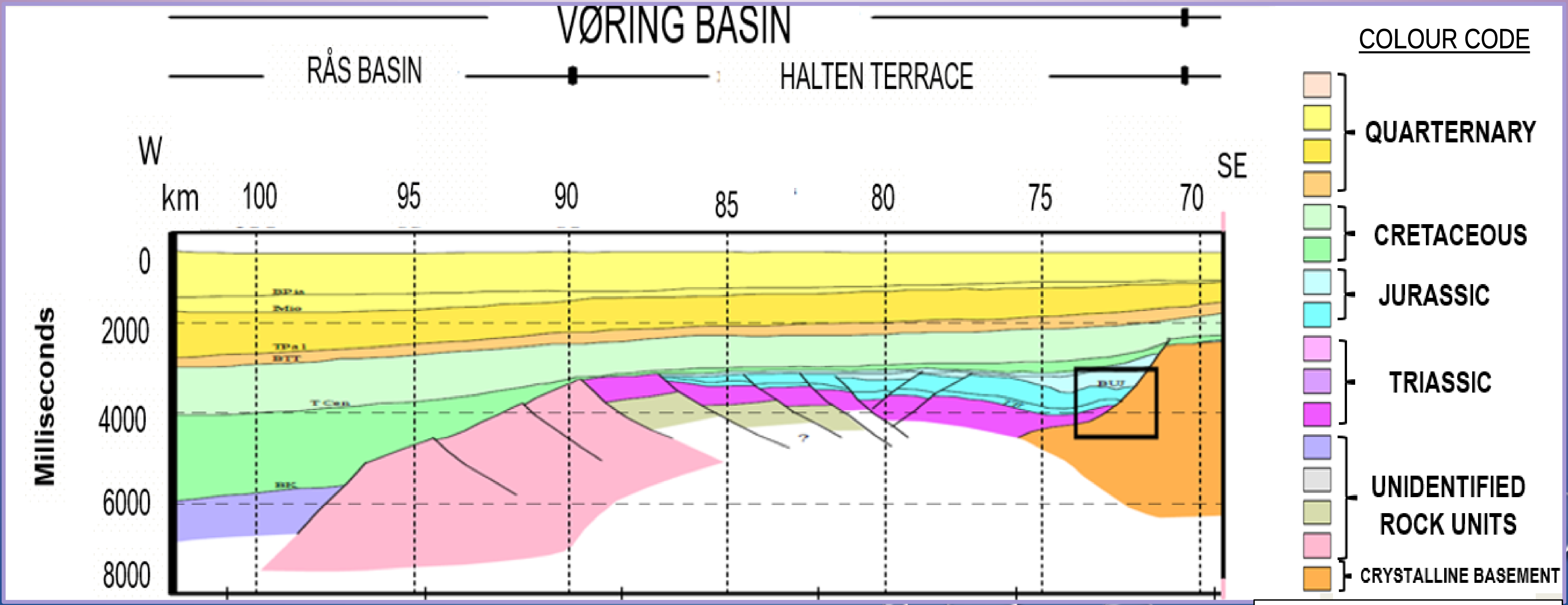


From Blystad et al., 1995).

GEOLOGICAL HISTORY

MIDDLE TO LATE JURASSIC

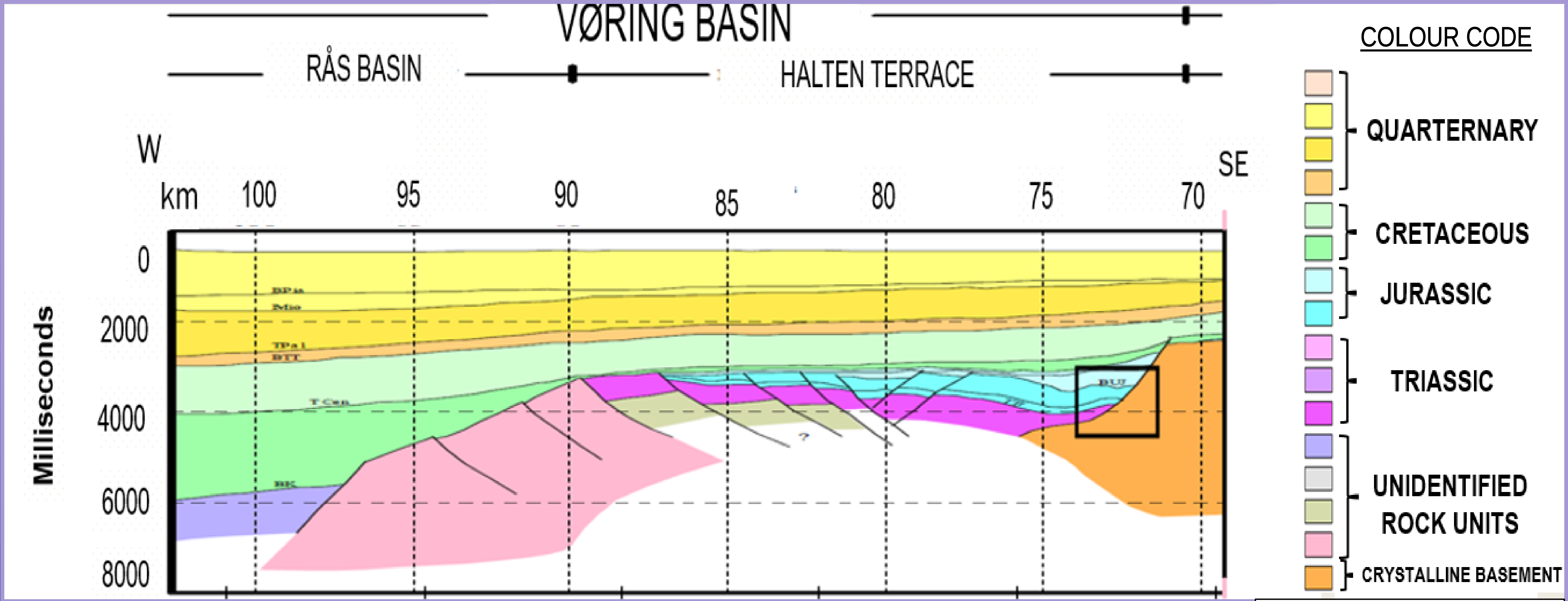
- Renewed extension, development of horst and graben structures.
- Deposition of organic rich mud. (BØE ET AL., 2010).



From Blystad et al., 1995).

GEOLOGICAL HISTORY

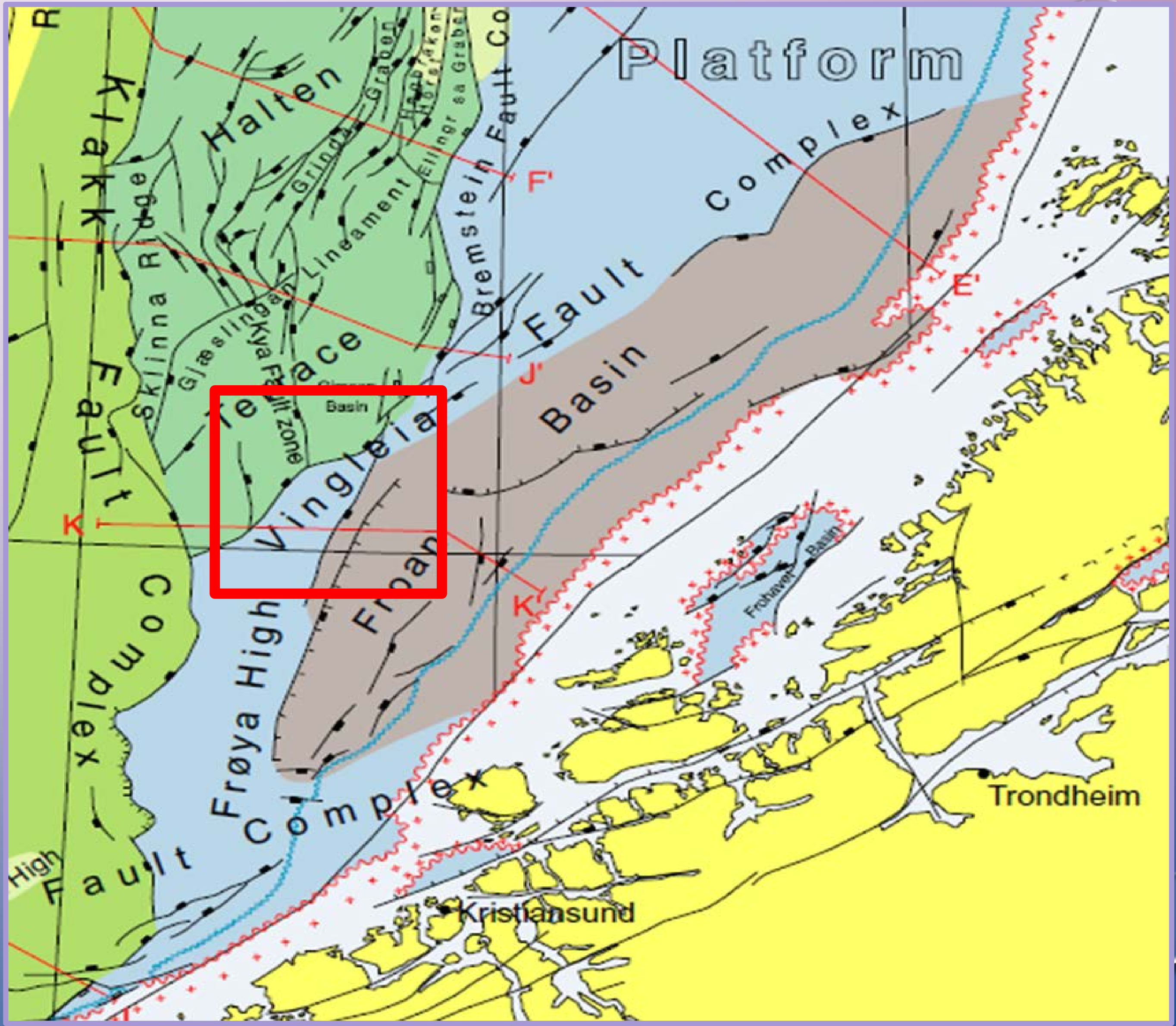
- **JURASSIC**
  - Development of a Jurassic Rollover Anticline (the area of interest).



From Blystad et al., 1995).

PREVIOUS WORK & GEOLOGICAL PROBLEM

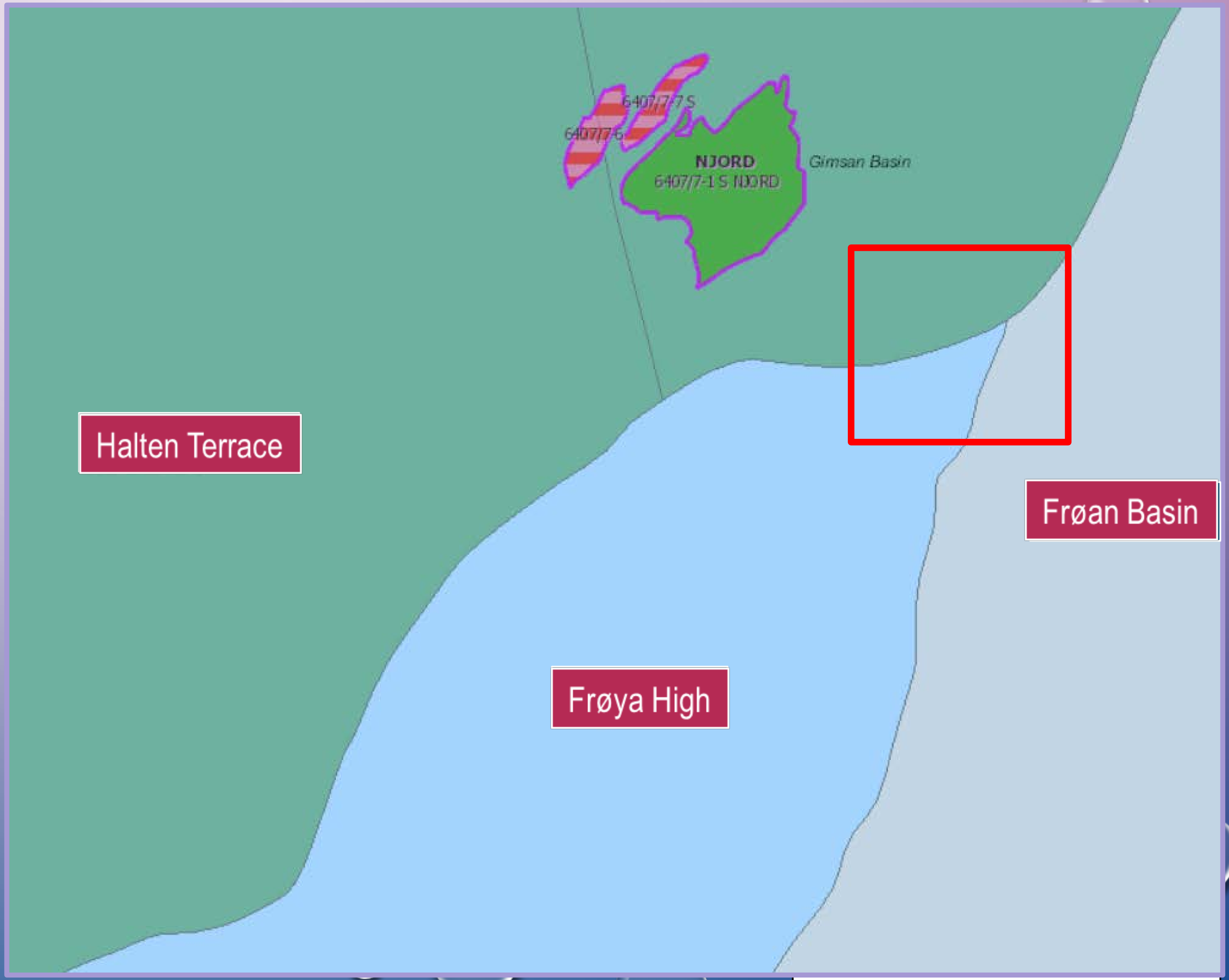
- Study Area



From Blystad et al., 1995

PREVIOUS WORK & GEOLOGICAL PROBLEM

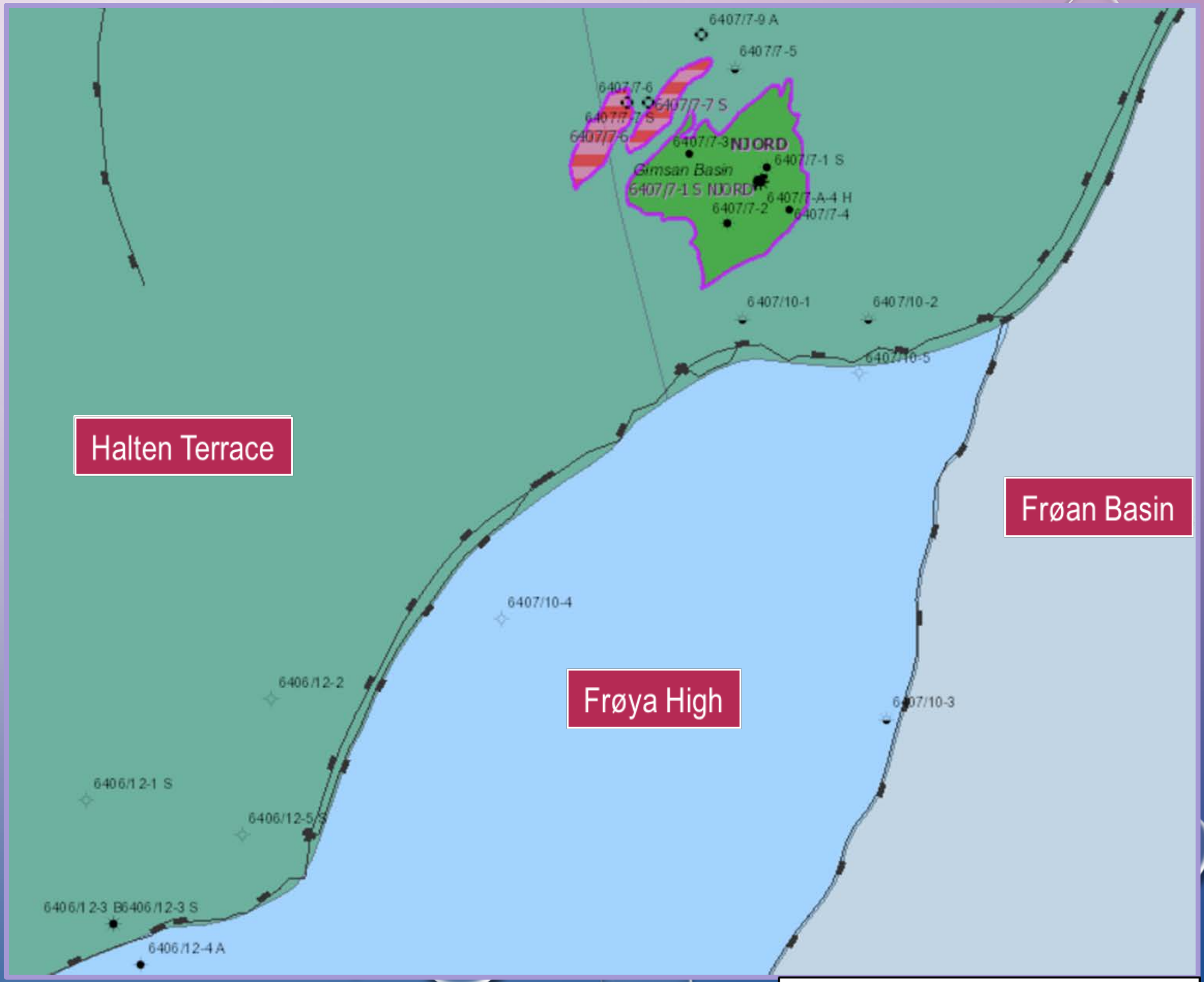
- Study Area



modified from NPD, 2015

PREVIUOS WORK & GEOLOGICAL PROBLEM

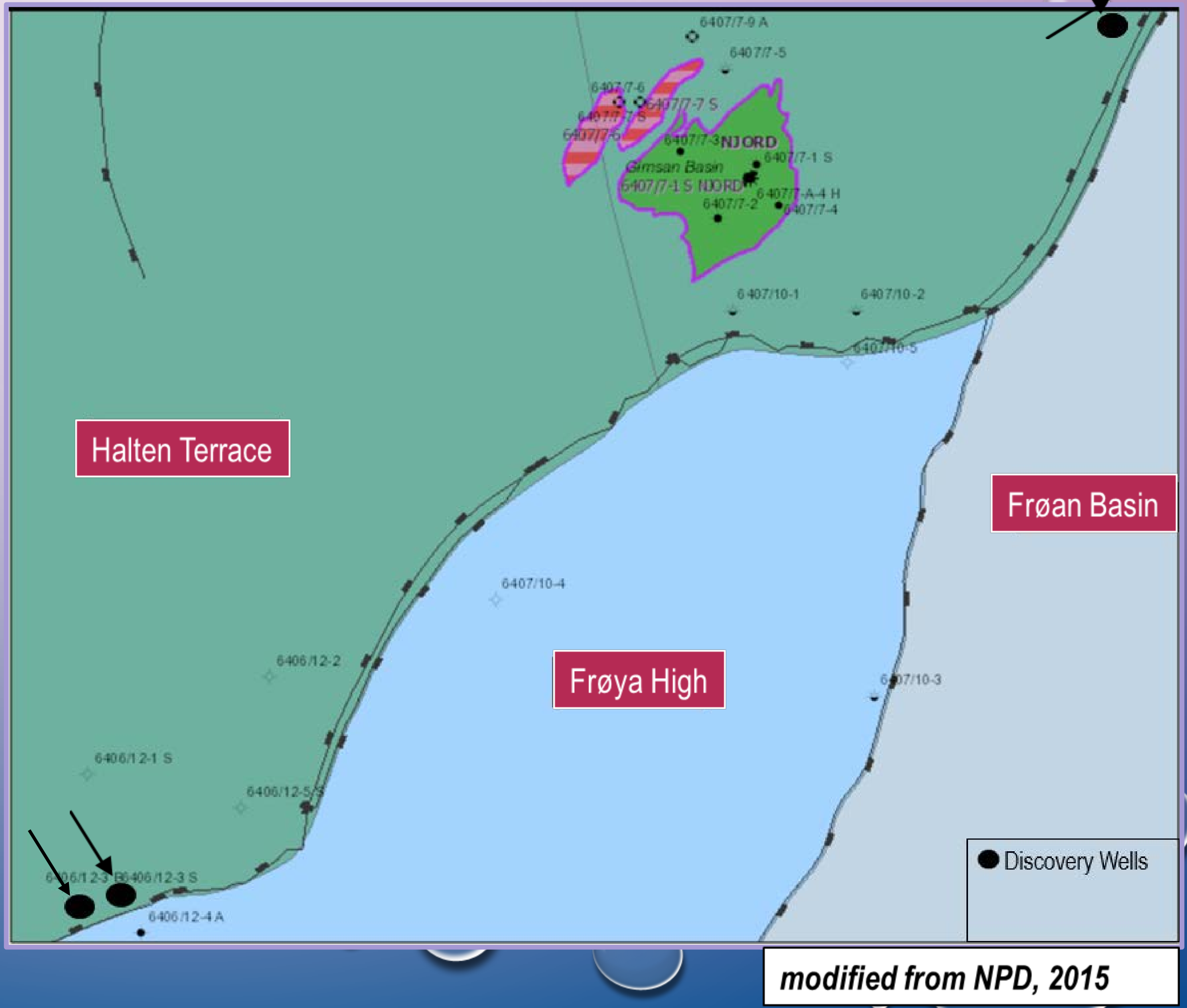
- **PREVIOUS WORK**
  - Block 6407/10; located immediately to njord field.



modified from NPD, 2015

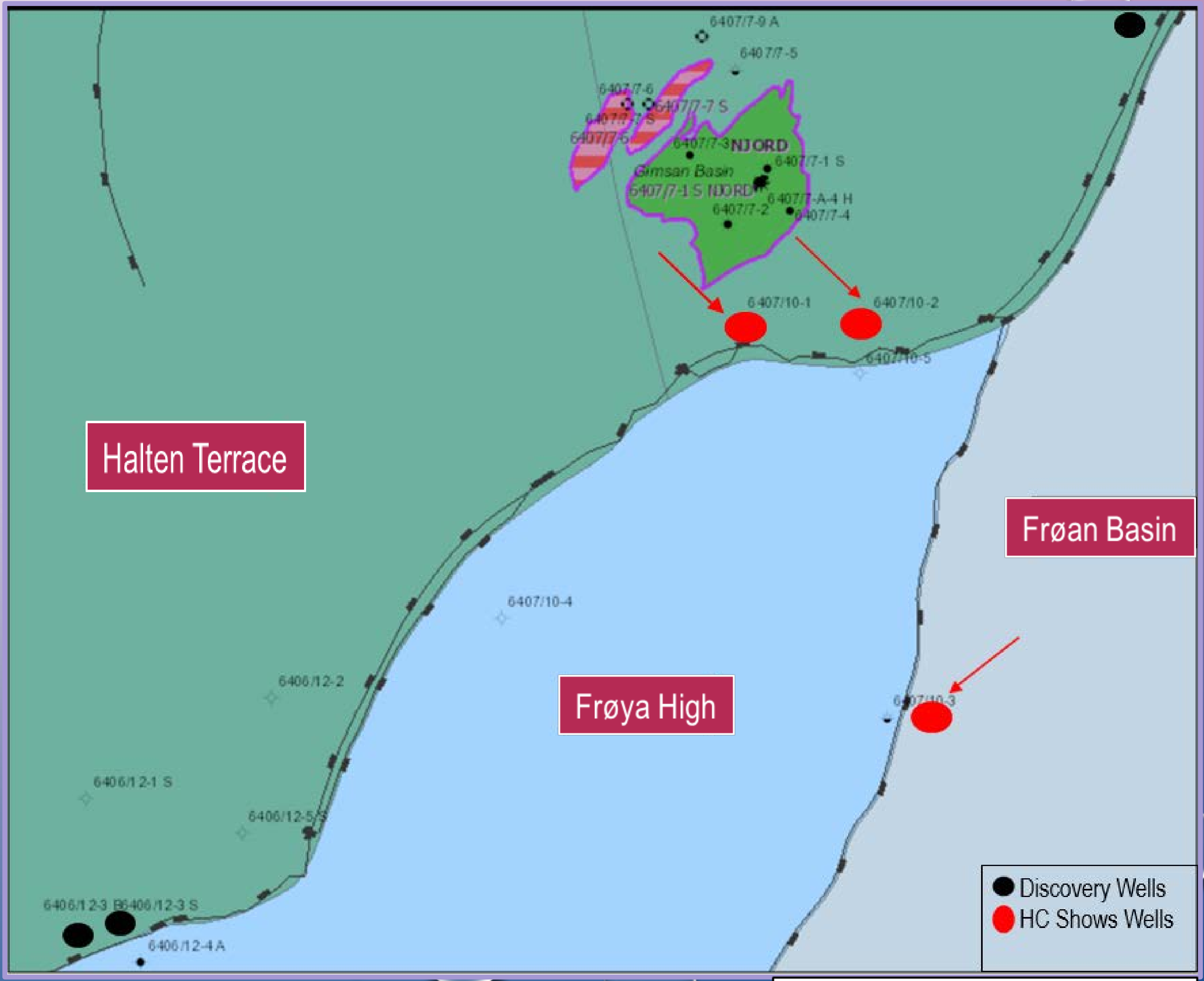
PREVIUOS WORK & GEOLOGICAL PROBLEM

- **PREVIOUS WORK**
  - Discoveries in same geological and structural trend.



PREVIOUS WORK & GEOLOGICAL PROBLEM

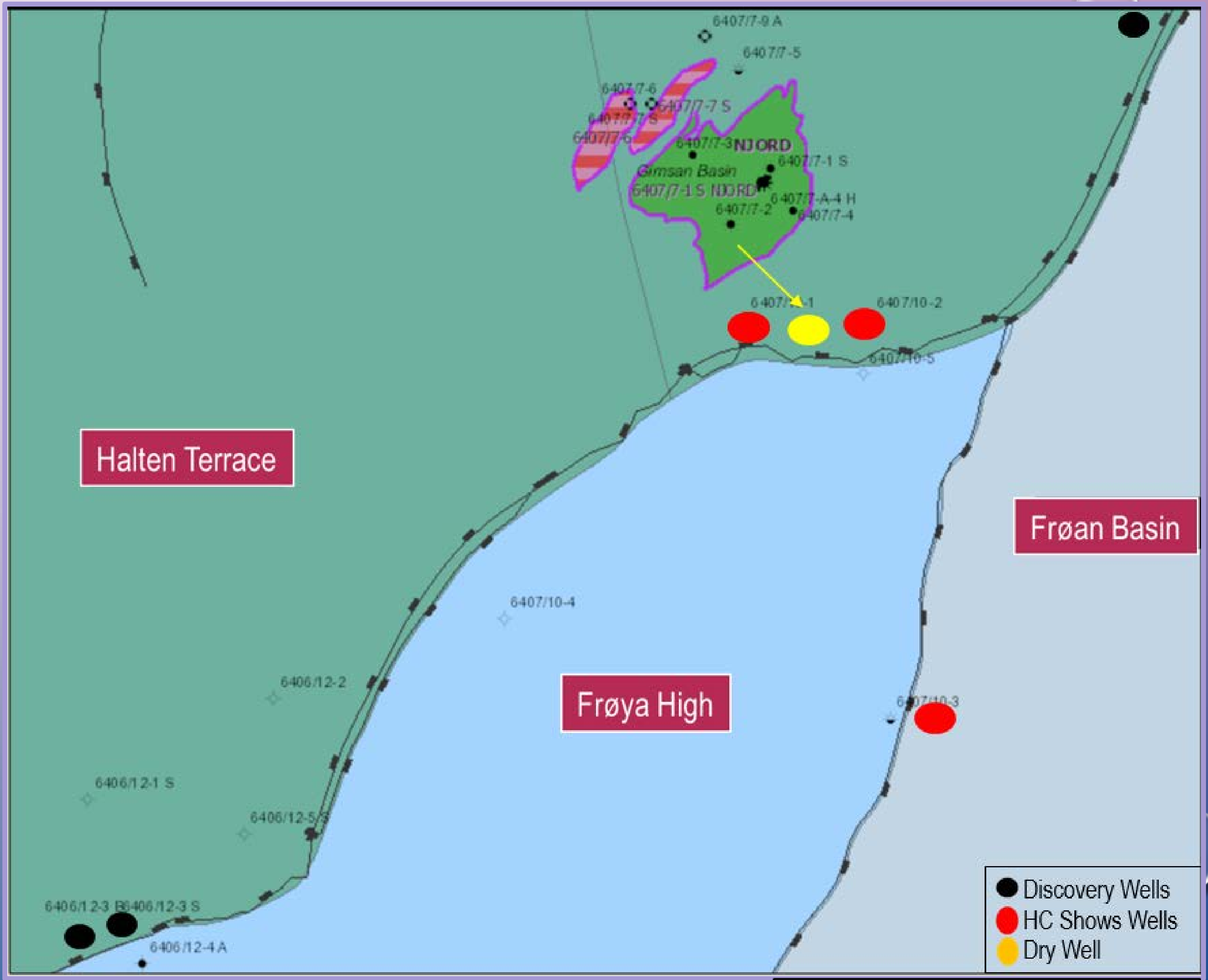
- **PREVIOUS WORK**
  - Three wells, containing hydrocarbon shows.



modified from NPD, 2015

PREVIOUS WORK & GEOLOGICAL PROBLEM

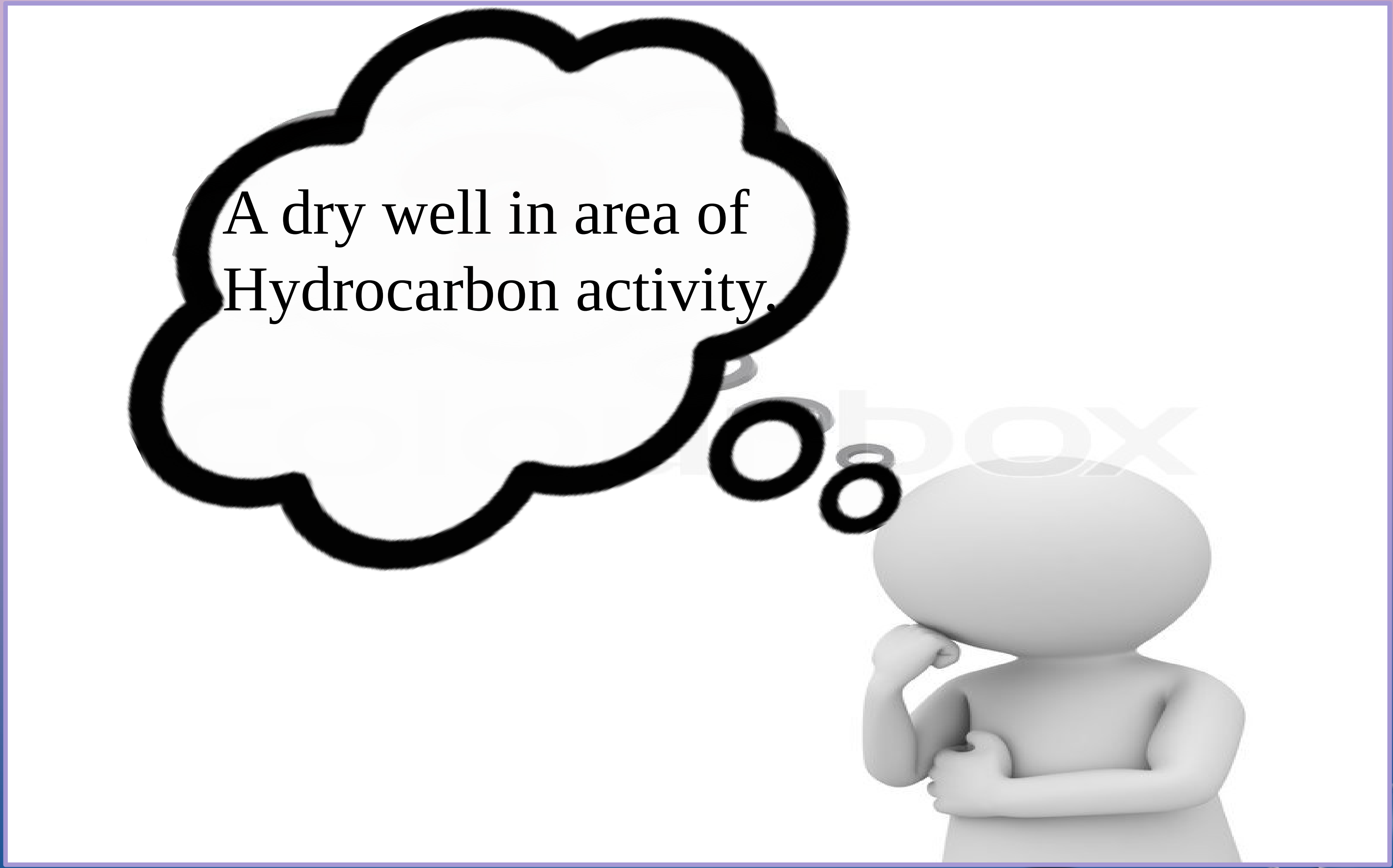
- **PREVIOUS WORK**
  - Well 6407/10-5 by drilled by A/S norske shell, declared dry.



modified from NPD, 2015

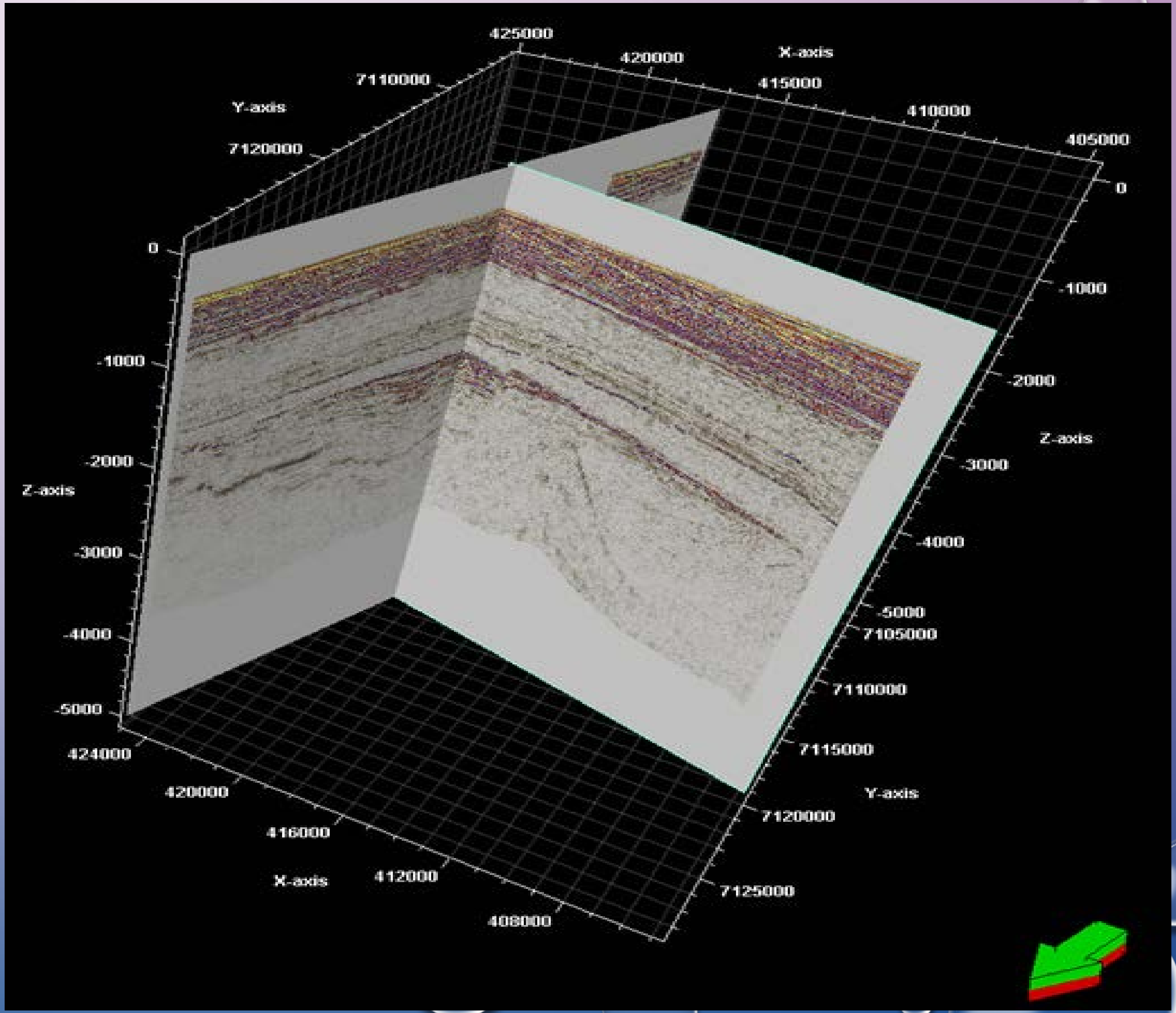
PREVIOUS WORK & GEOLOGICAL PROBLEM

- **GEOLOGICAL PROBLEM**



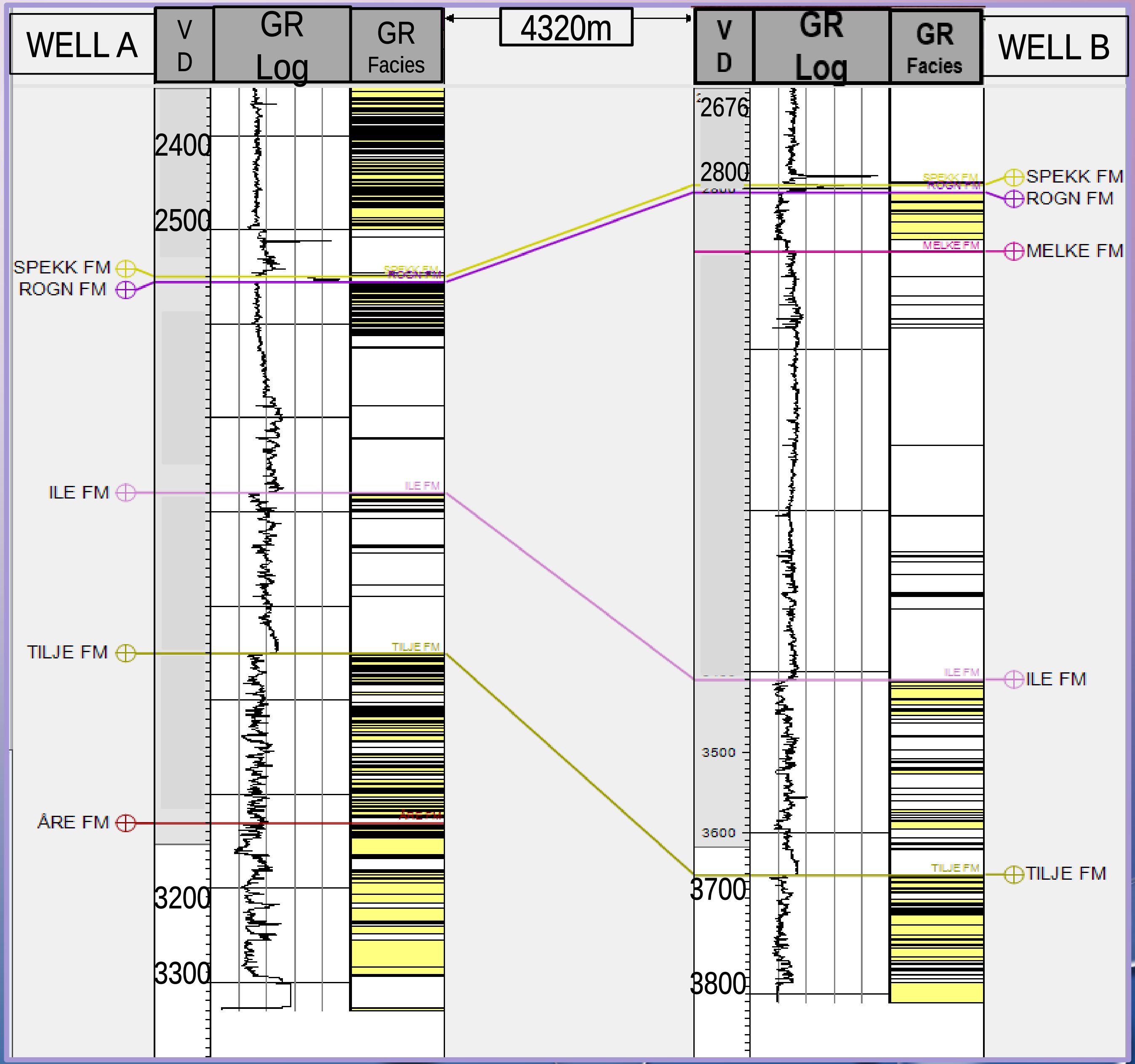
DATASET

- **3D SEISMIC DATASET**
  - Ex PL512 License Area



DATASET

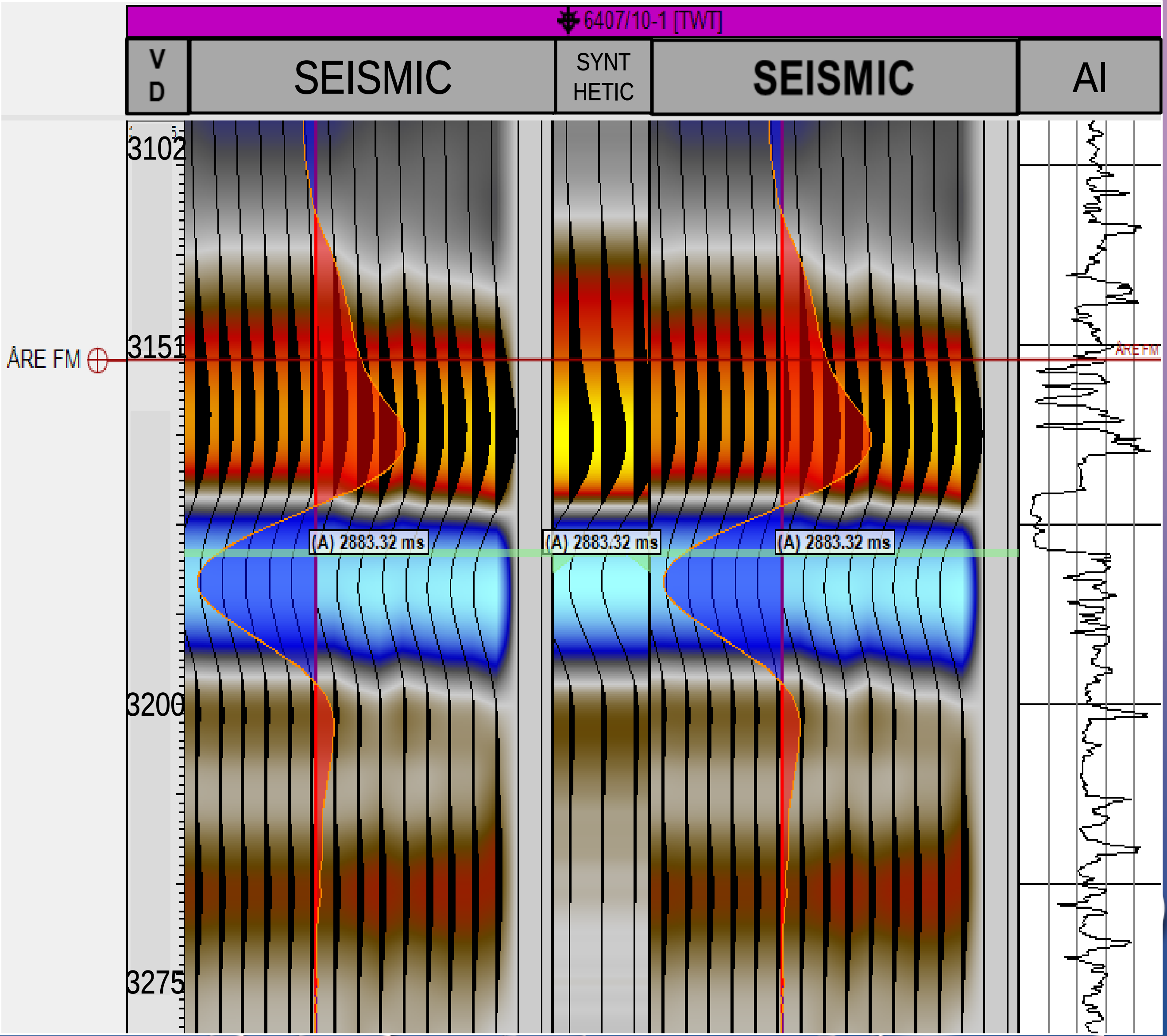
- **LOG DATA OF WELLS**
  - 6407/10-1
  - 6407/10-2



METHODOLOGY

SEISMIC INTERPRETATION:

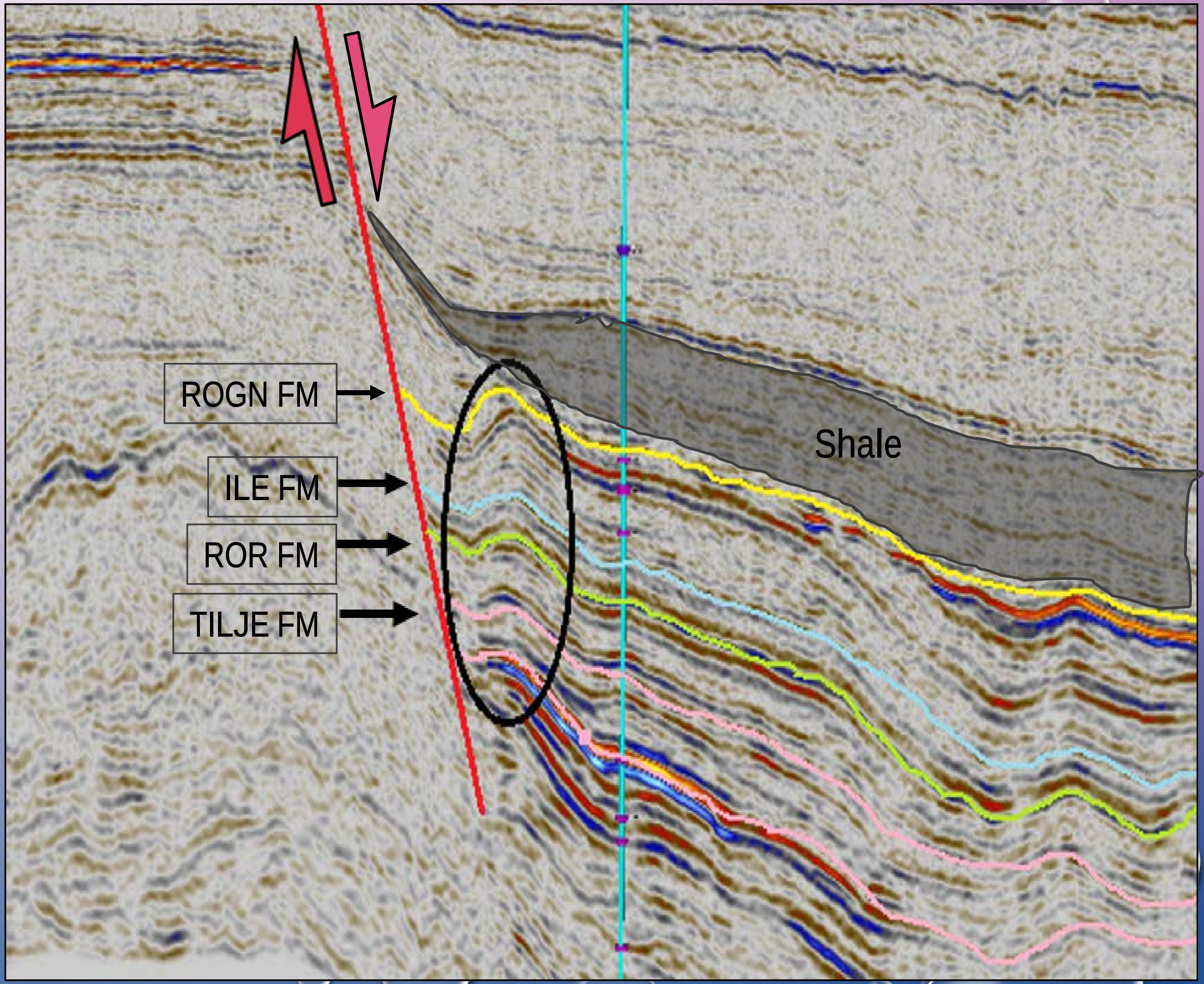
- Seismic-well tie is performed to correlate well data with seismic.



METHODOLOGY

SEISMIC INTERPRETATION:

- Seismic-well tie is performed to correlate well data with seismic.
- Interpretations depicts well data corresponds to the reflectors on seismic lines.

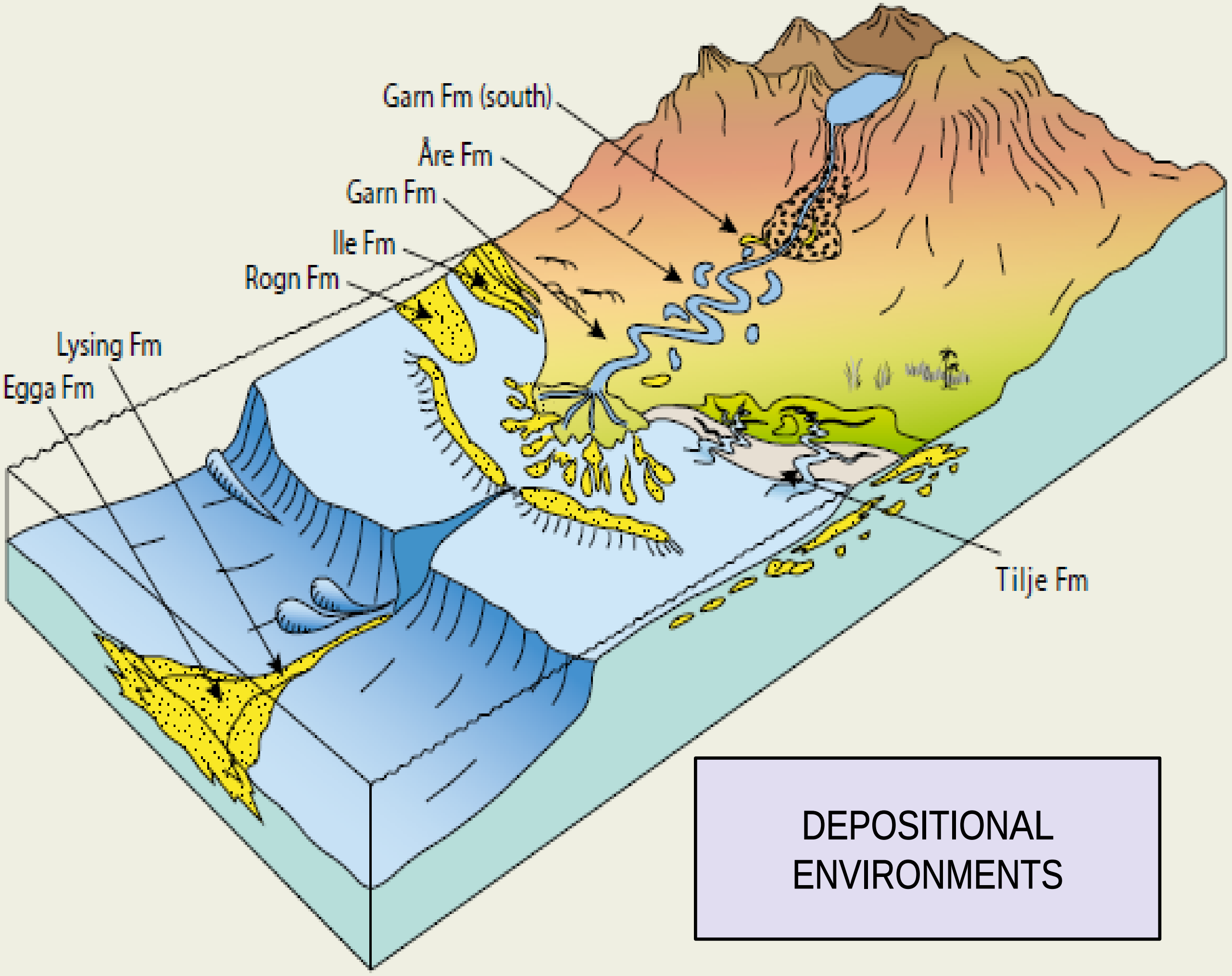


METHODOLOGY

DRY WELL ANALYSIS:

i. **Reservoir:**

- Facies maps for reservoir units will be generated.
- Determining the provenance area, quality and distribution of the reservoir sands.



DEPOSITIONAL ENVIRONMENTS

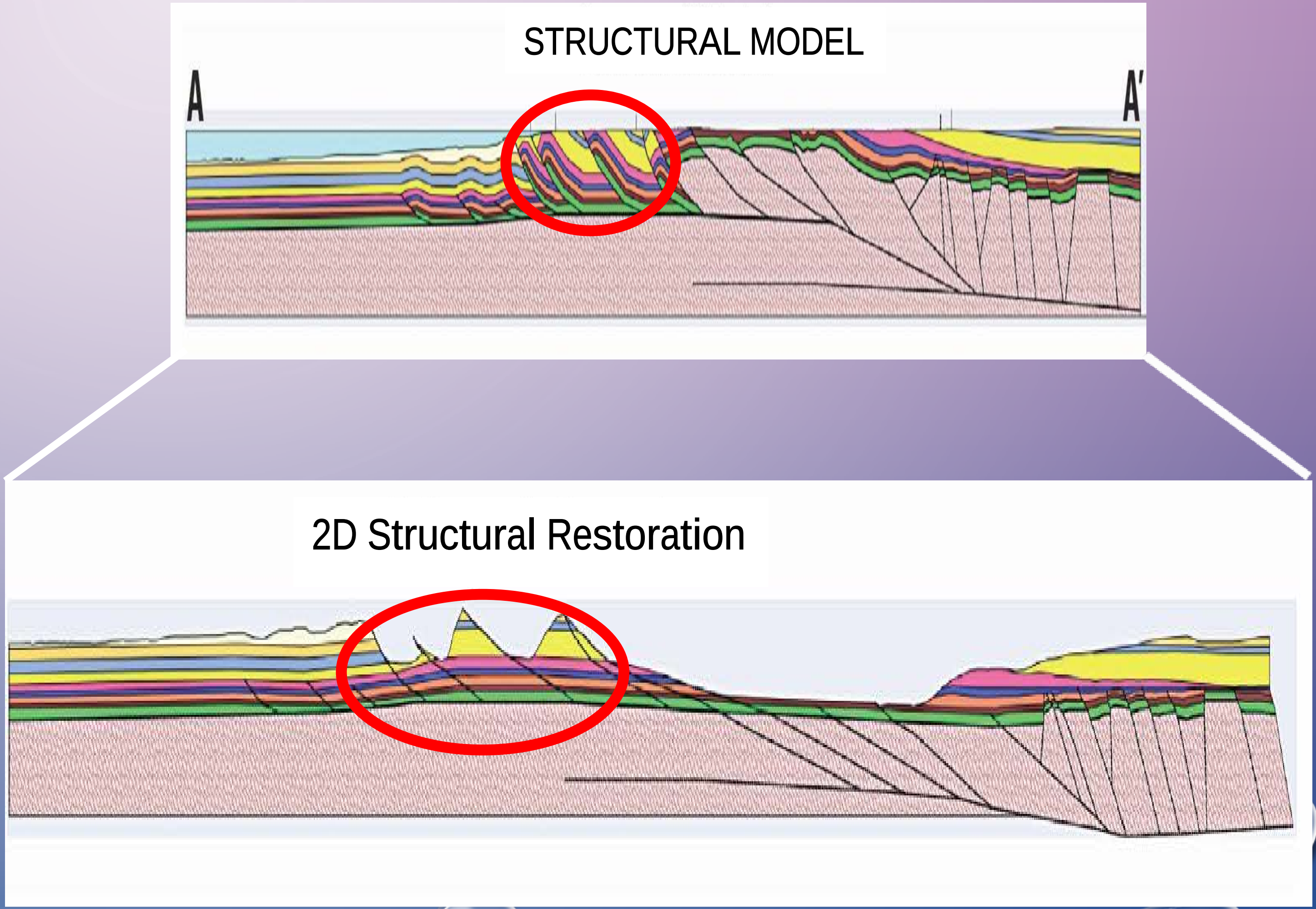
METHODOLOGY

DRY WELL ANALYSIS:

ii. Trap:

- Time-depth conversion methods will be applied.
- 2D structural restoration will be done.

2D Structural Restoration of an Analogue in Brazil



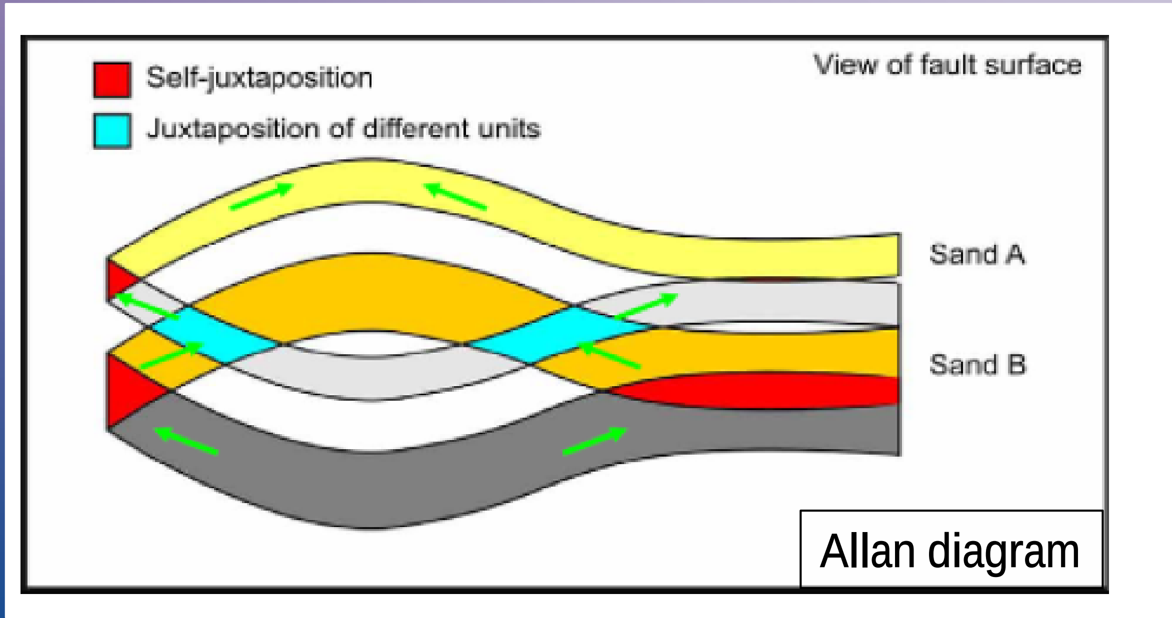
Modified from Halliburton, 2014.

METHODOLOGY

DRY WELL ANALYSIS:

iii. Seal:

- A regional review on seal unit thickness & facies mapping.
- Allan diagrams or fault juxtaposition diagrams.



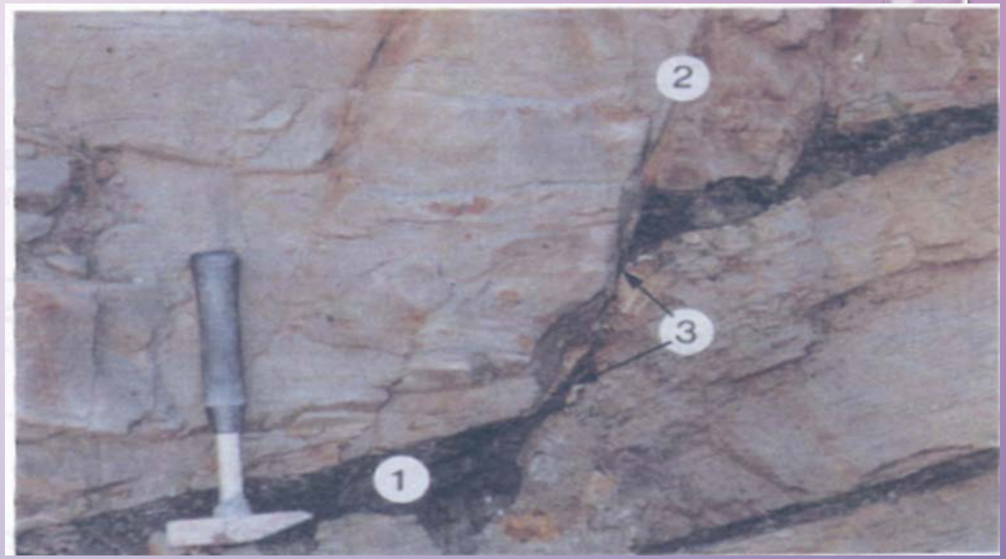
Allan diagram

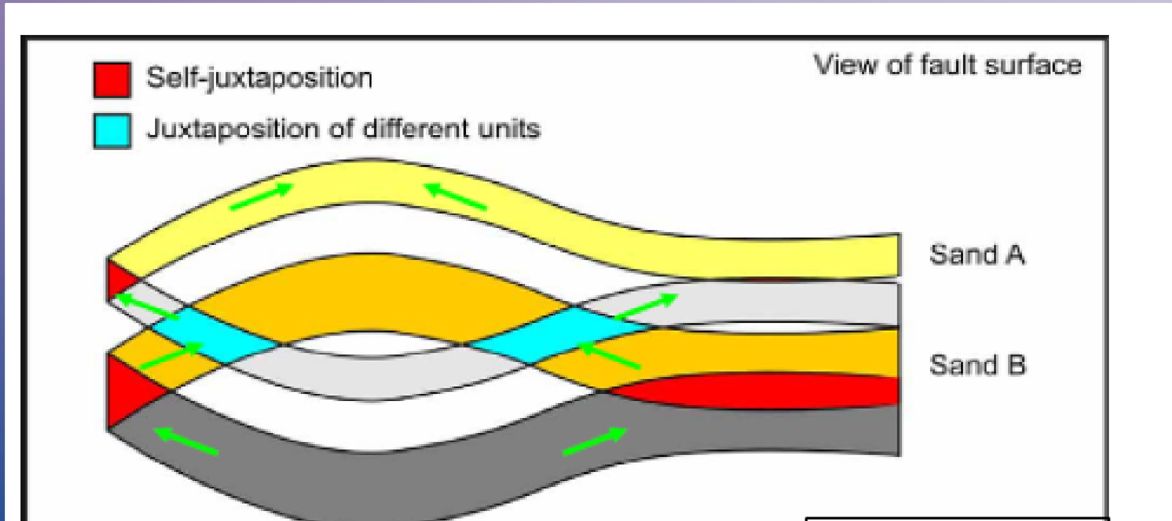
METHODOLOGY

DRY WELL ANALYSIS:

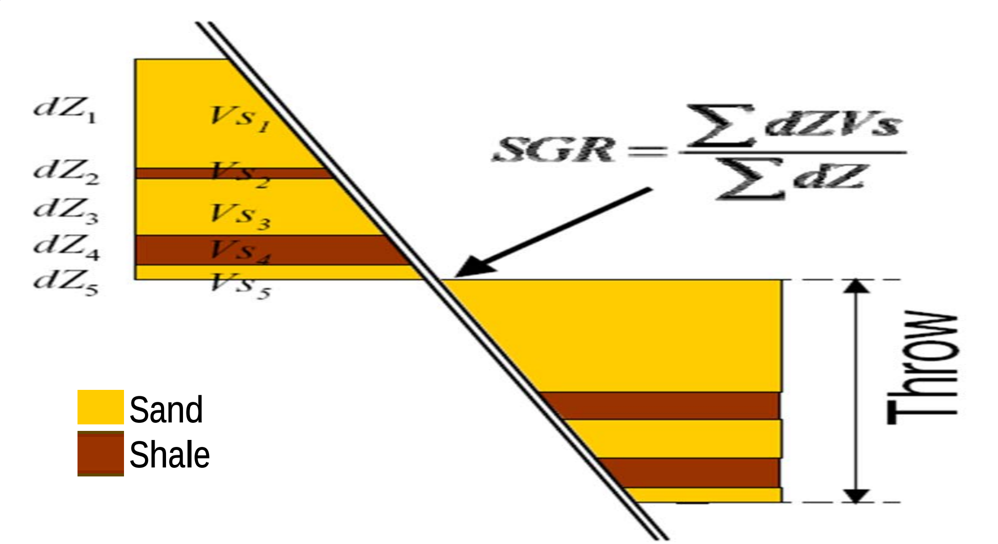
iii. Seal:

- A regional review on seal unit thickness & facies mapping .
- Allan diagrams or fault juxtaposition diagrams.
- The dry well is located along the fault; thus fault-seal analysis.





Allan diagram



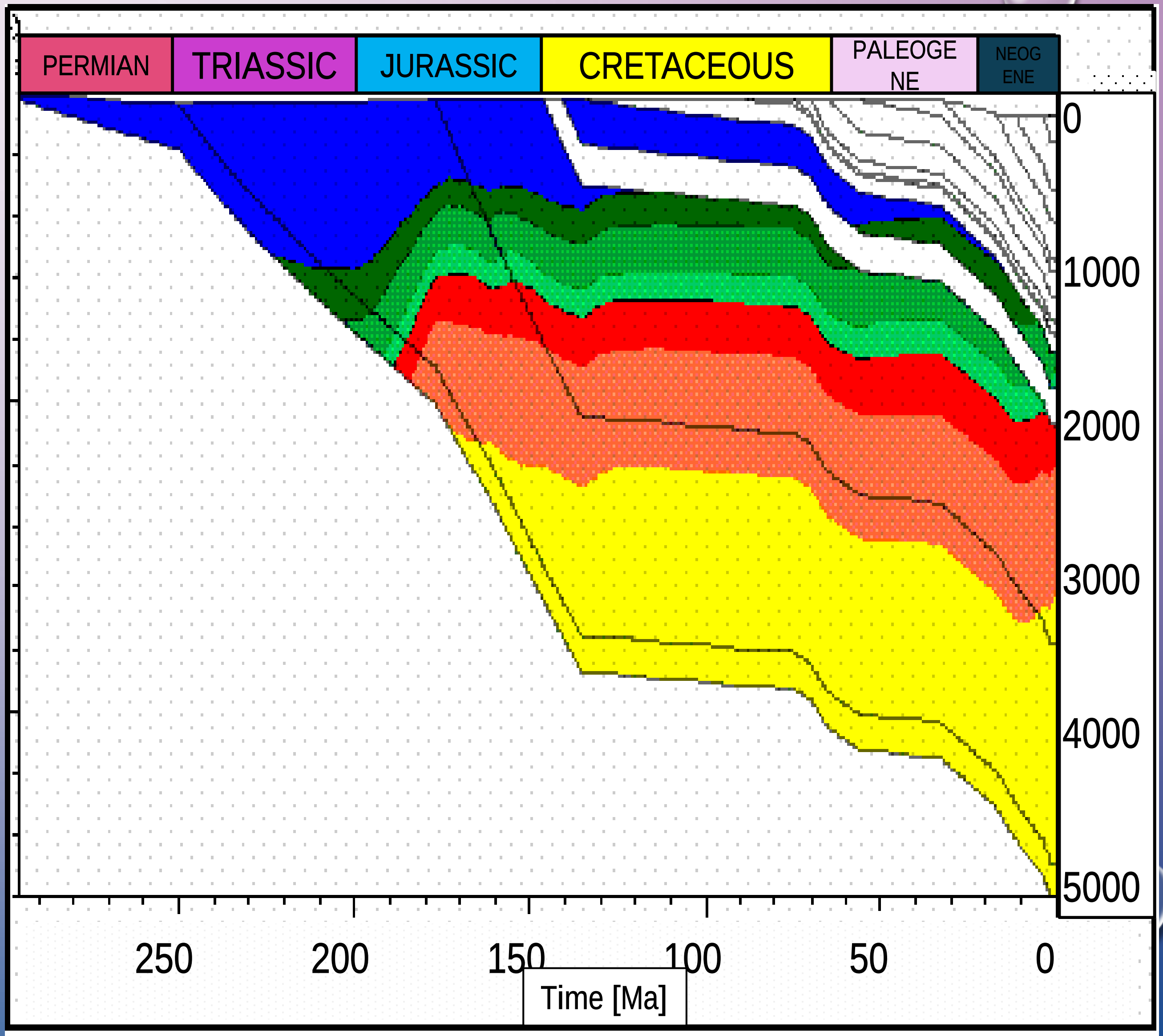
SHALE GOUGE RATIO (SGR), From Lindsay et al., 1993

METHODOLOGY

DRY WELL ANALYSIS:

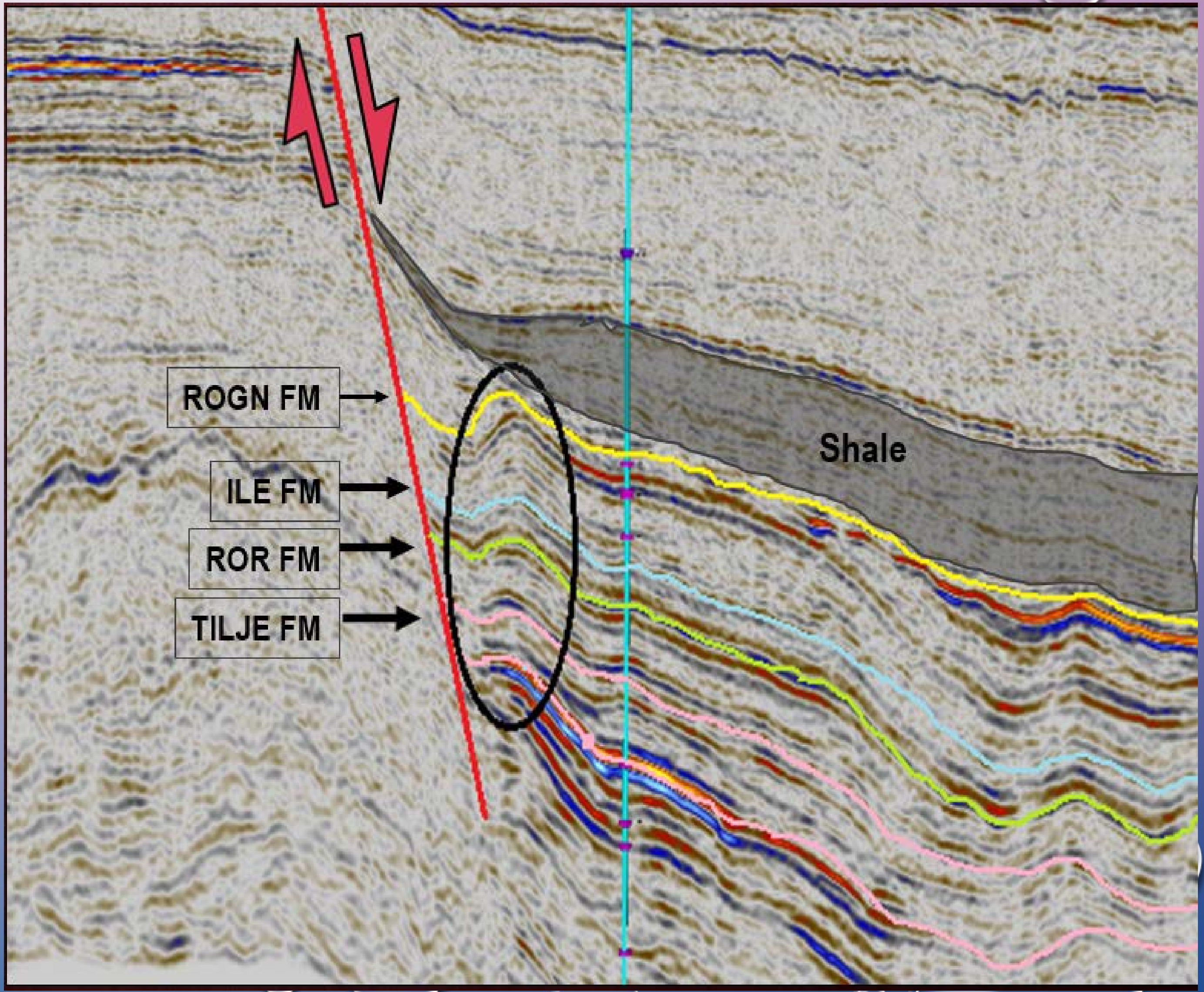
iv. **Hydrocarbon charge:**

- Literature review of the surrounding fields and wells.
- Basin modelling using the software Genesis.
- Location of the kitchen of source rock will be estimated.



POTENTIAL EVALUATION CALCULATION

- **AVAILABILITY OF KITCHEN**
- **PRESENCE OF RESERVOIR SANDS**
- **CLOSURE**
- **TOP SEAL**



THANK YOU FOR LISTENING

3D reconstruction of a normal fault zone: A trenching study on a strand of the Baza fault, Central Betic Cordillera, south central Spain

Leah J. Koch

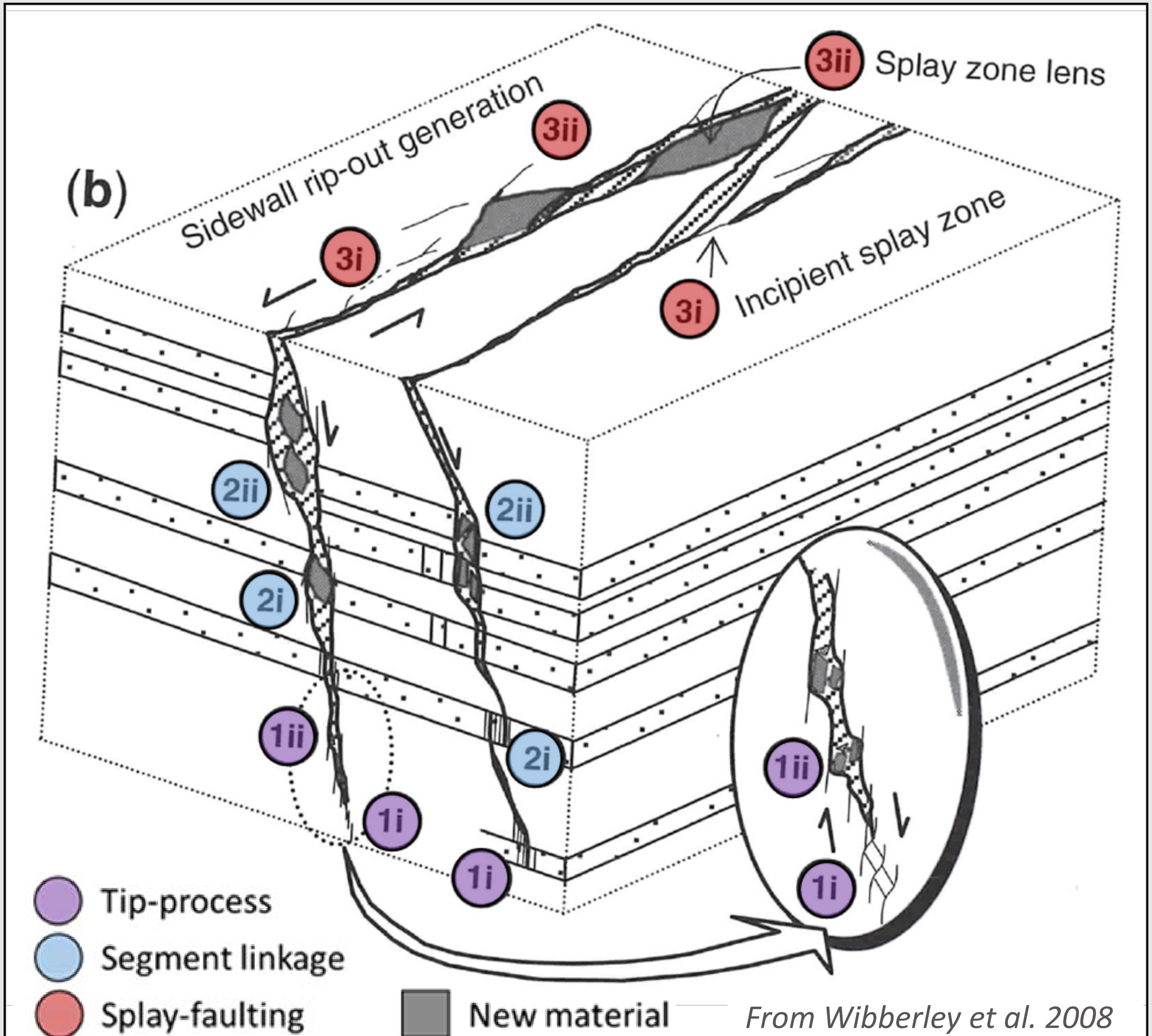
02.12.2016

Objective

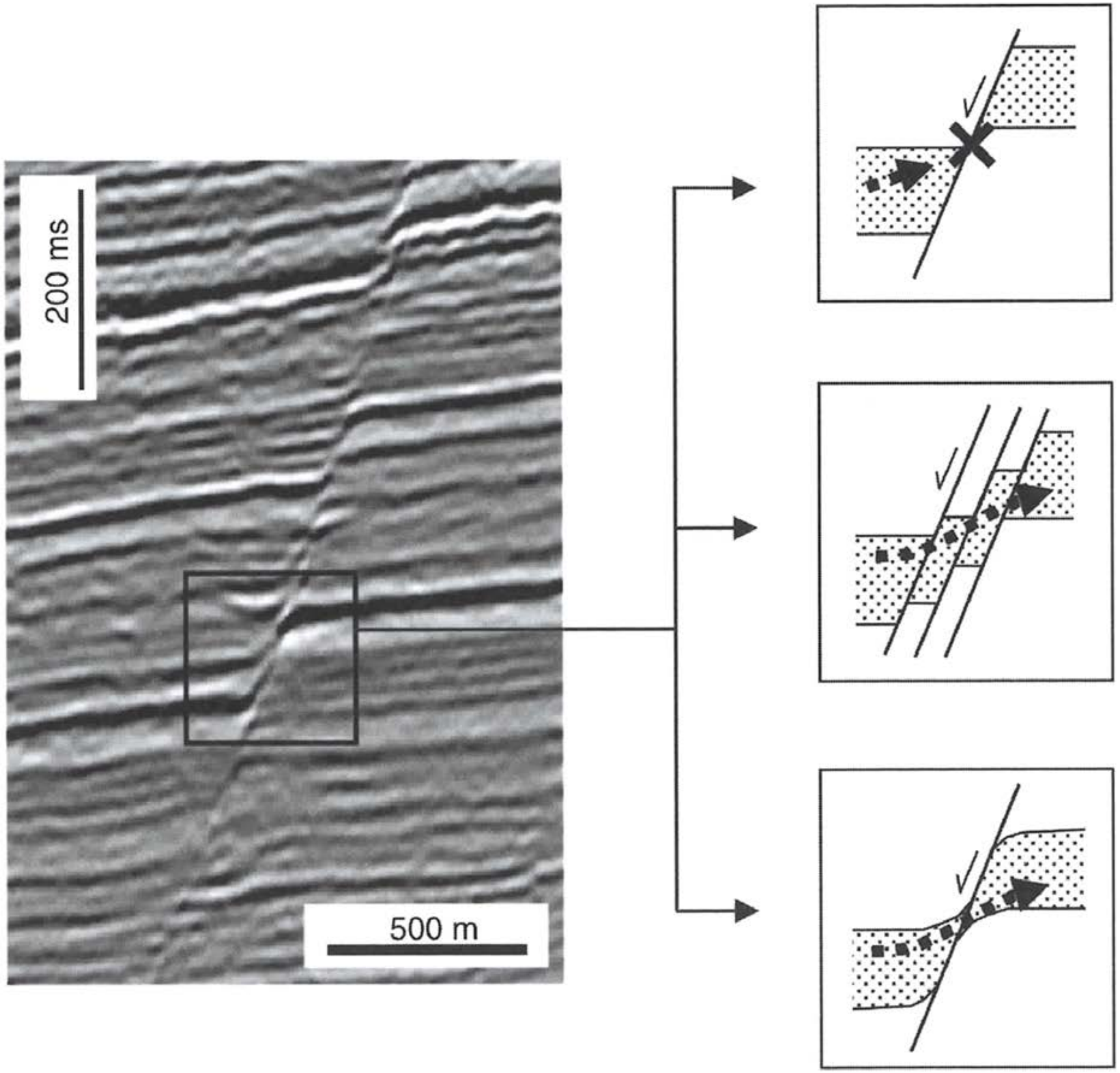
Produce a detailed 3D reconstruction of a normal fault zone with ~30 m throw excavated in a trenching campaign in south central Spain.

- Previous Work
- Geological Background
- Dataset
- Methods
- Constraints
- Questions

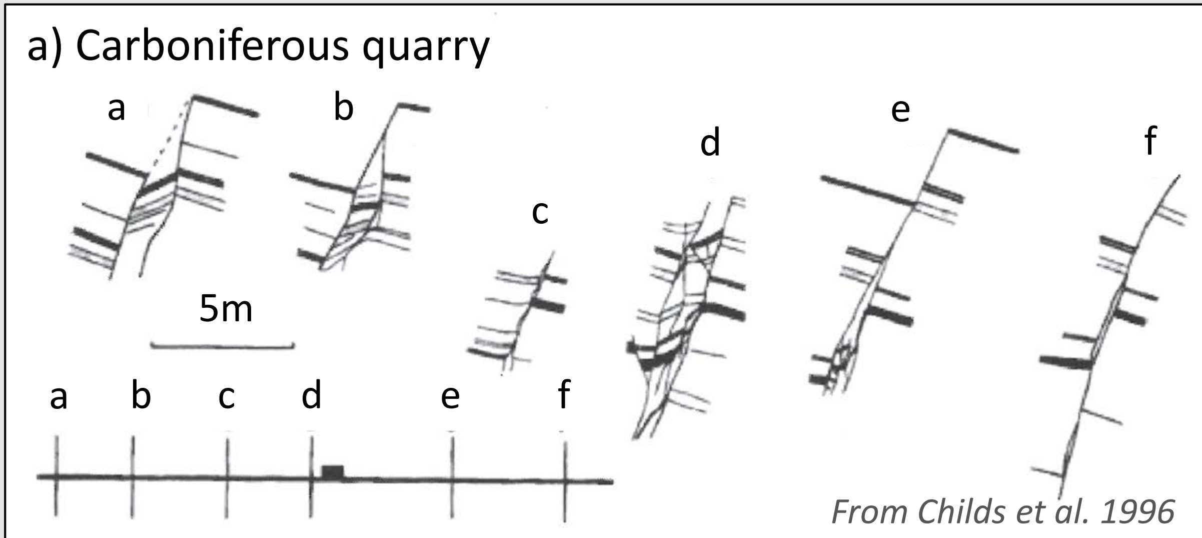
This project is in collaboration with the Universidad de Alicante, and Universidad de Jaén.

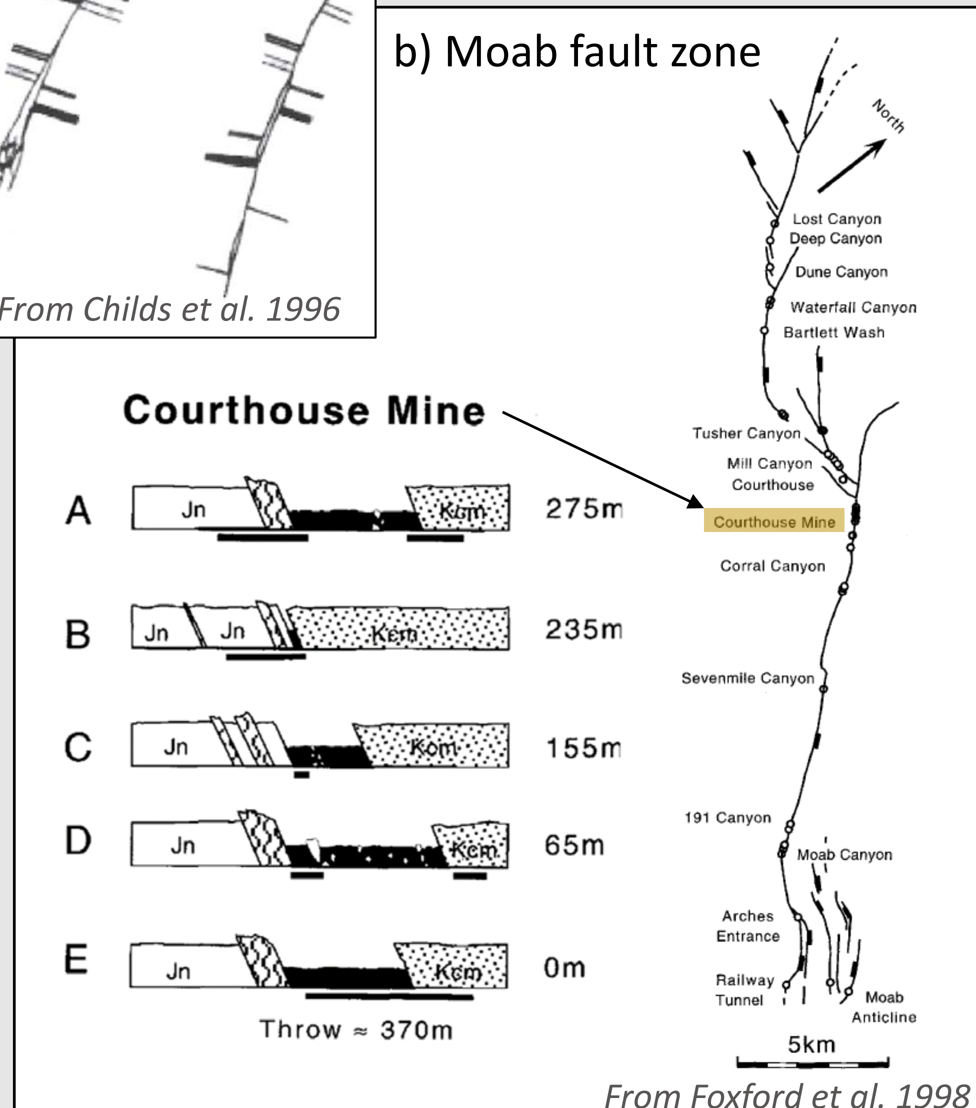


From Wibberley et al. 2008



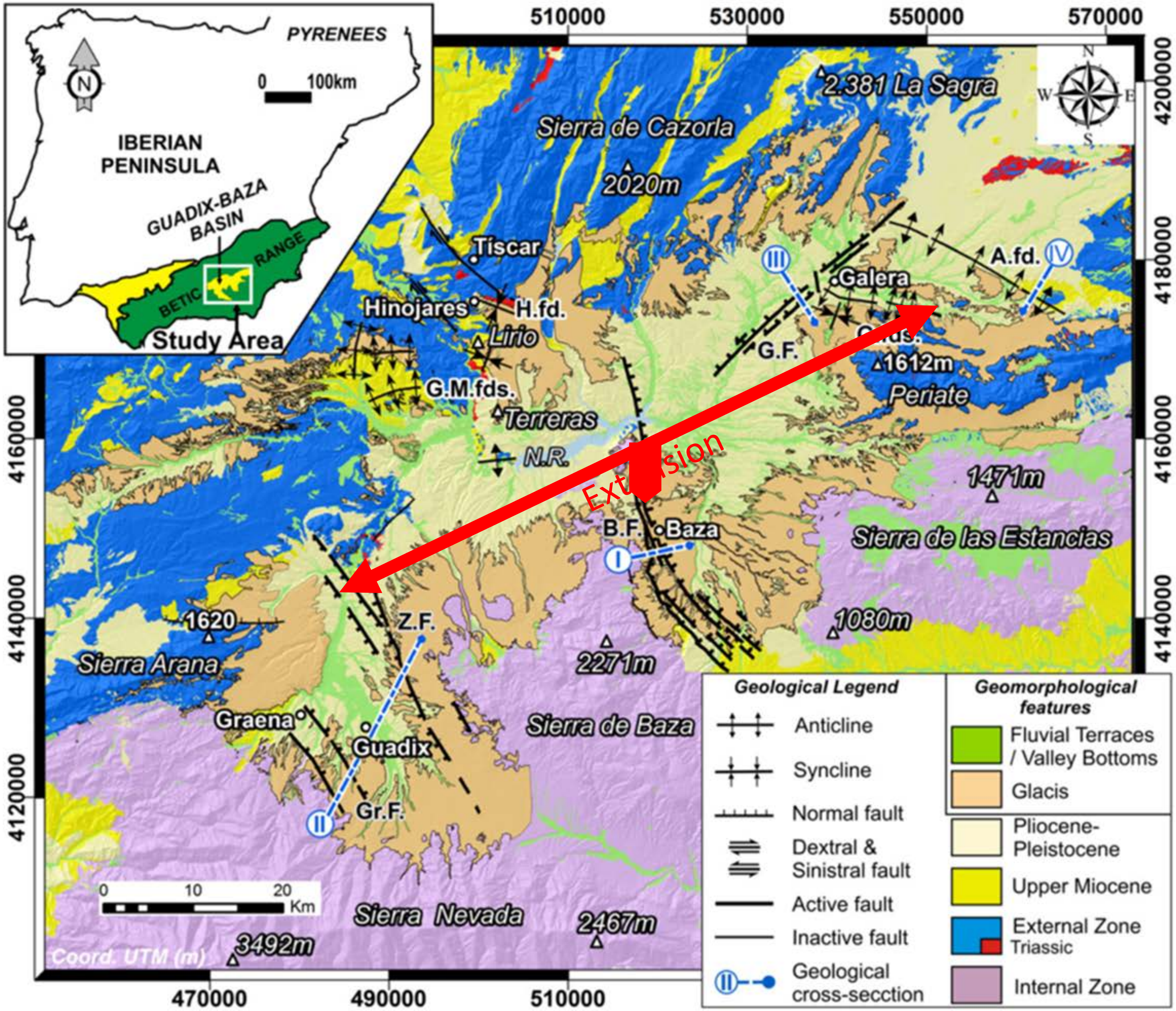
From Wibberley et al. 2008


a) Carboniferous quarry
a
b
c
d
e
f
5m
a b c d e f
From Childs et al. 1996

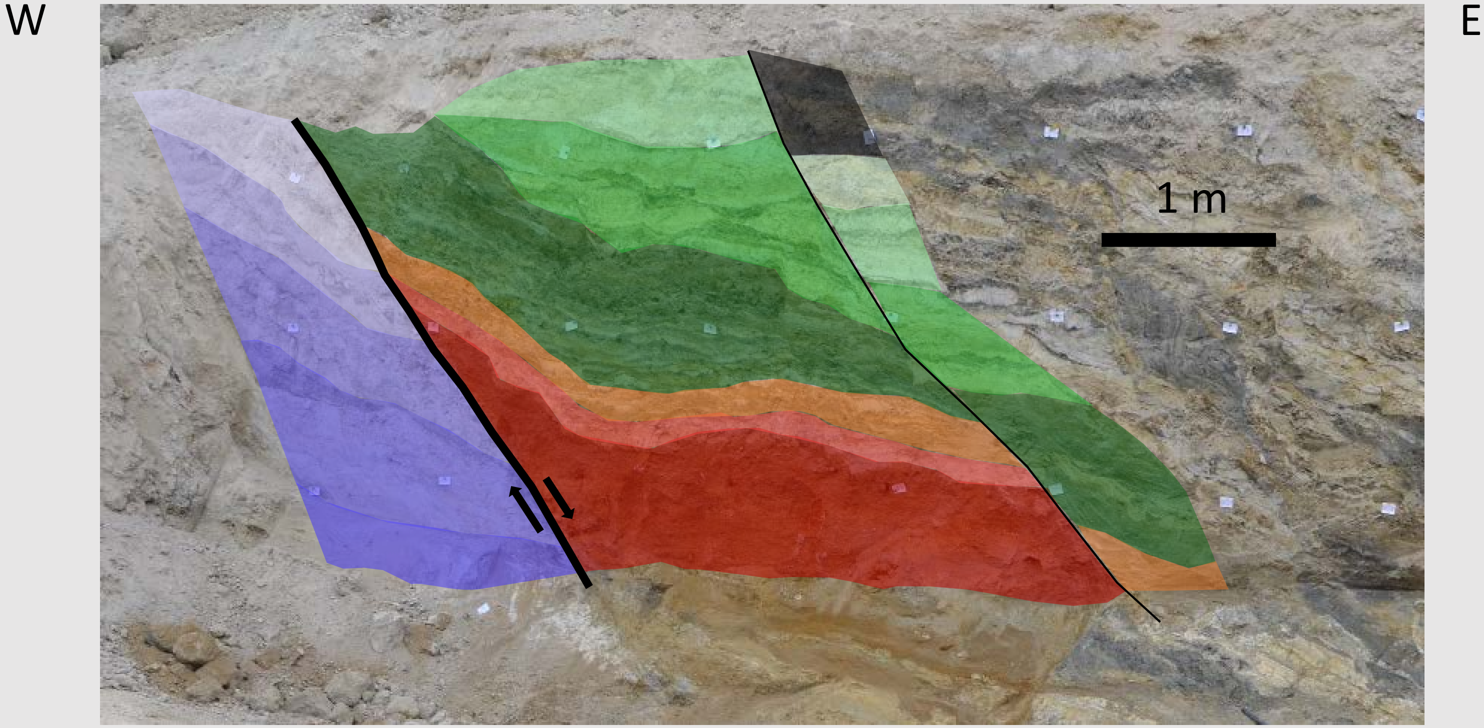

b) Moab fault zone
North
Lost Canyon
Deep Canyon
Dune Canyon
Waterfall Canyon
Bartlett Wash
Courthouse Mine
Tusher Canyon
Mill Canyon
Courthouse
Courthouse Mine
Corral Canyon
Sevenmile Canyon
191 Canyon
Moab Canyon
Arches Entrance
Railway Tunnel
Moab Anticline
5km
A Jn Kcm 275m
B Jn Jn Kcm 235m
C Jn Kcm 155m
D Jn Kcm 65m
E Jn Kcm 0m
Throw ≈ 370m
From Foxford et al. 1998

"Modern structural and fault seal analysis and modeling is guiding the next generation of questions that need to be answered through more focused outcrop studies."

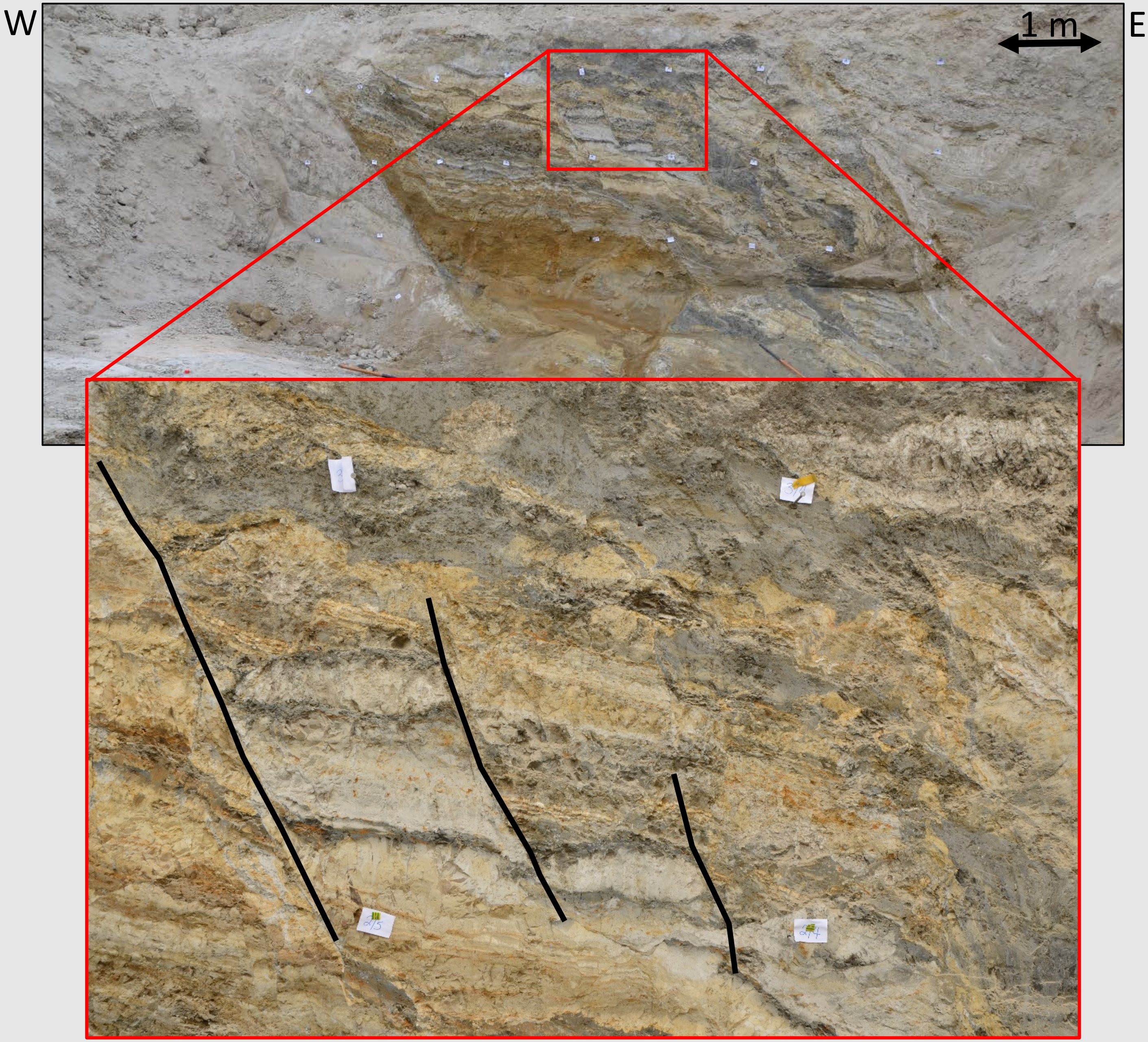
– Manzocchi et al. 2010

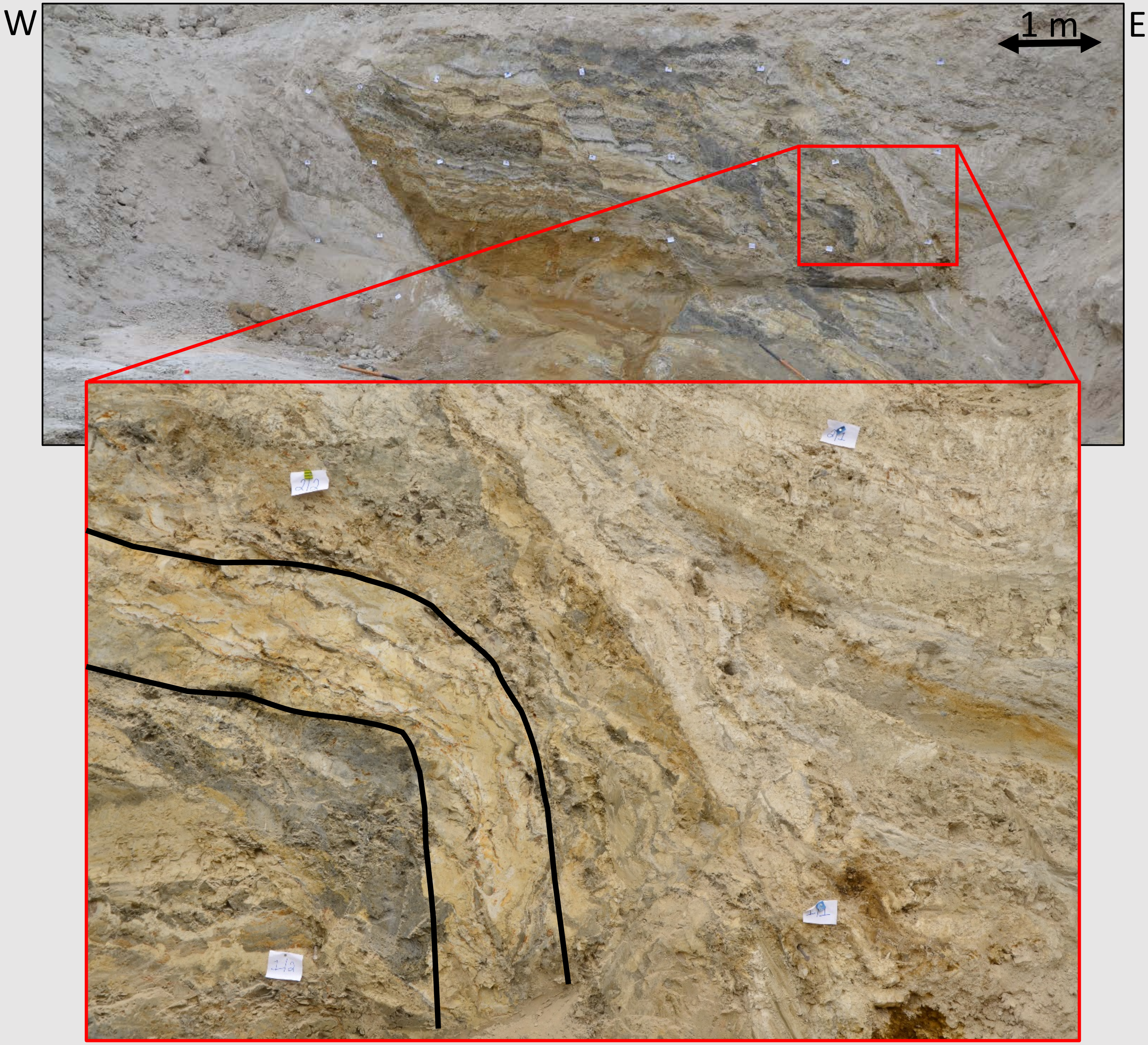


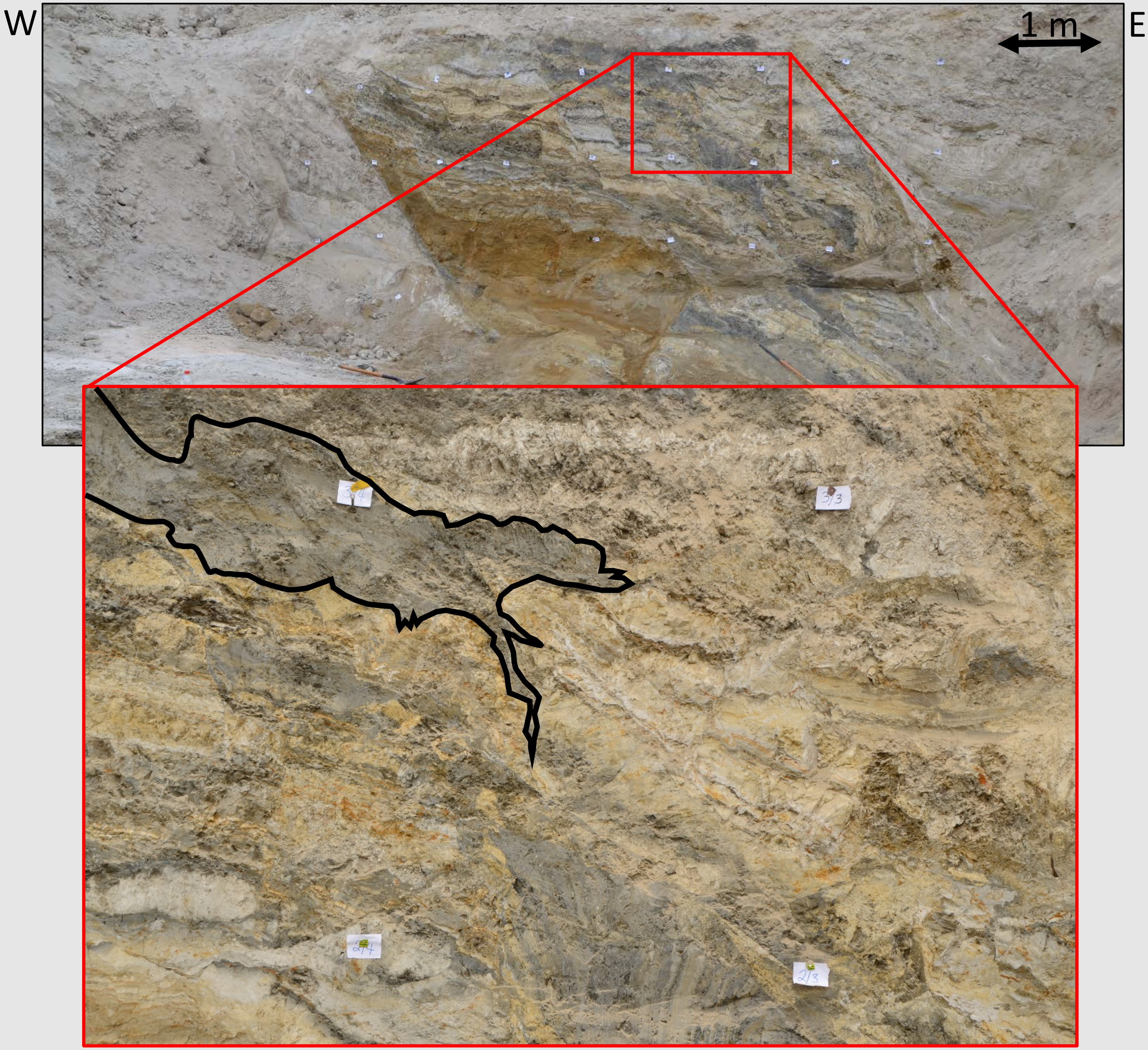
From García-Tortosa et al. 2011



	White massive **chalk**		Black **clay** with large gypsum crystals
	Pink Calcareous **siltstone**		Finely (mm sized) laminated **clay**
	White massive **chalk**		Massive **siltstone** with dark gray **clay**
	Laminated light **clay**		Light gray-yellow **clay rich siltstone**
	Laminated dark **clay**		White-red-yellow **silty clay**
	Red coarse grained **sandstone**		Red-gray laminated **sandy siltstone**
	Red sandy **gravel**		


W
E
1 m


W
E
1 m


W
1 m
E
3/3
2/3

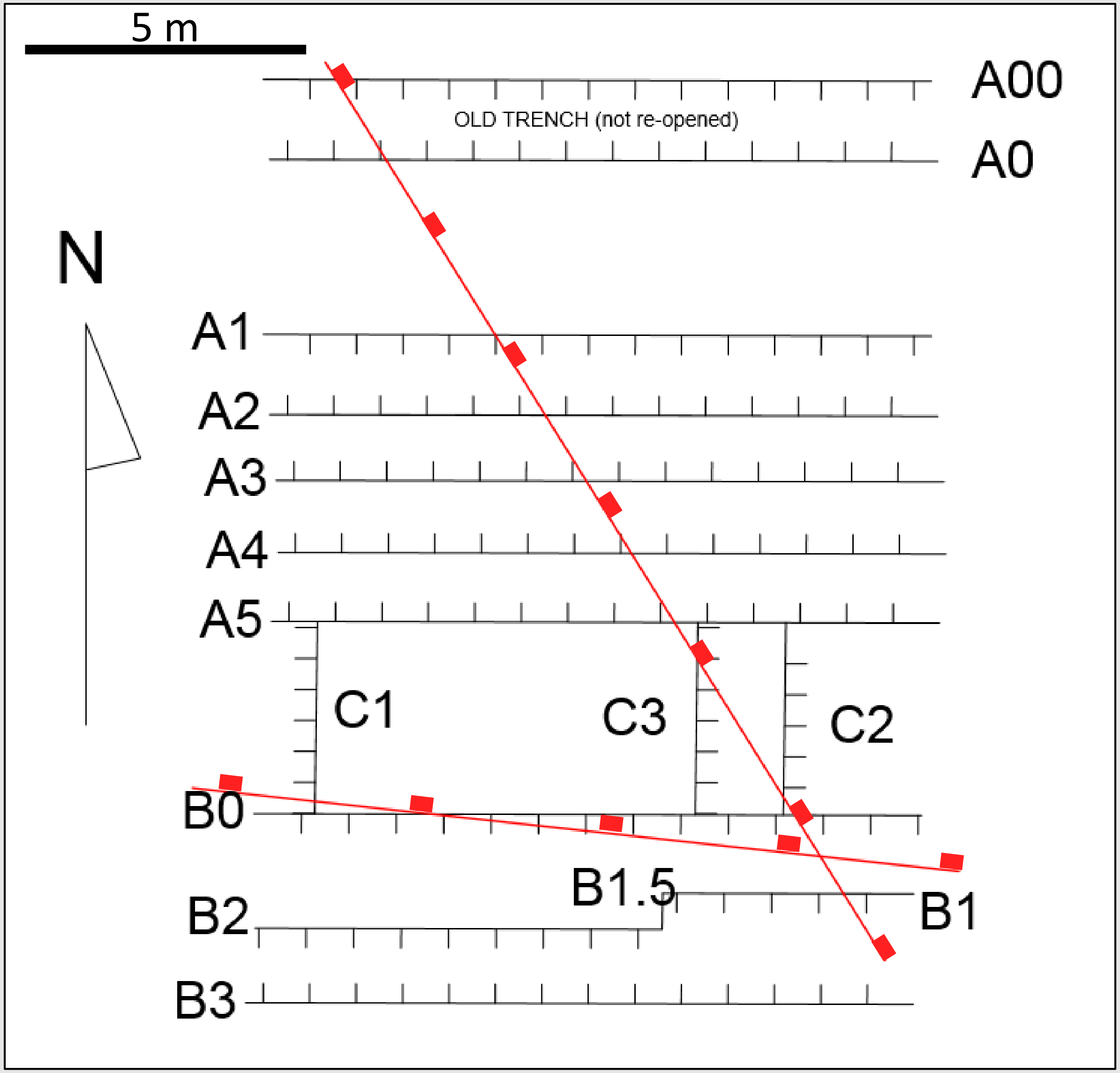
Dataset:

-Photogrammetry

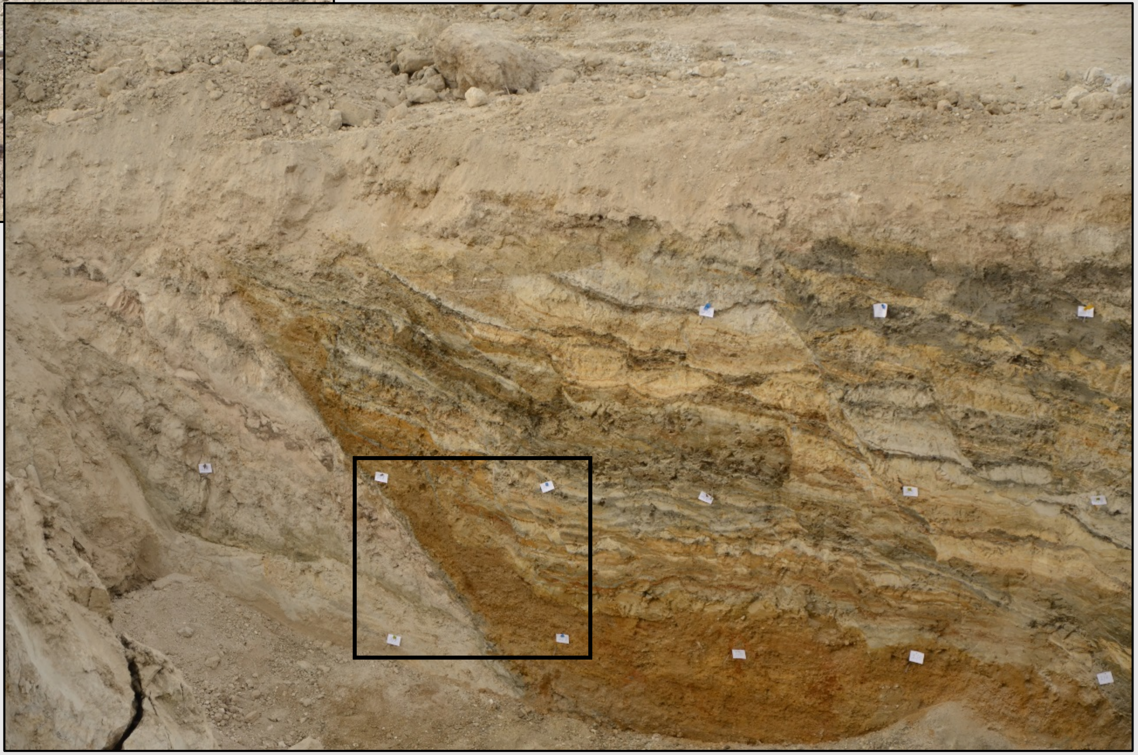
-Lidar

W-E Trenches	10
N-S Trenches	3
Floor	1

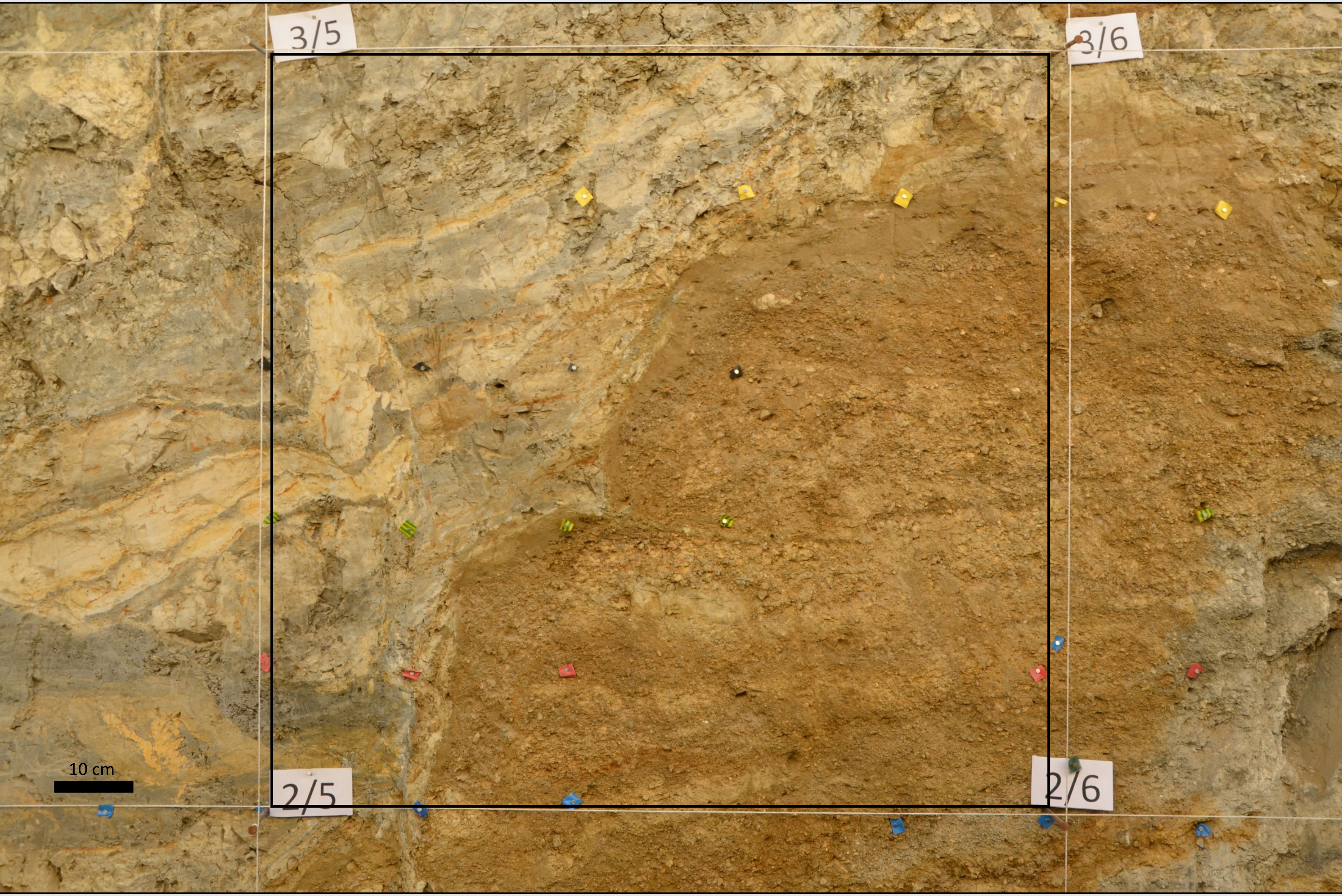
Total	14





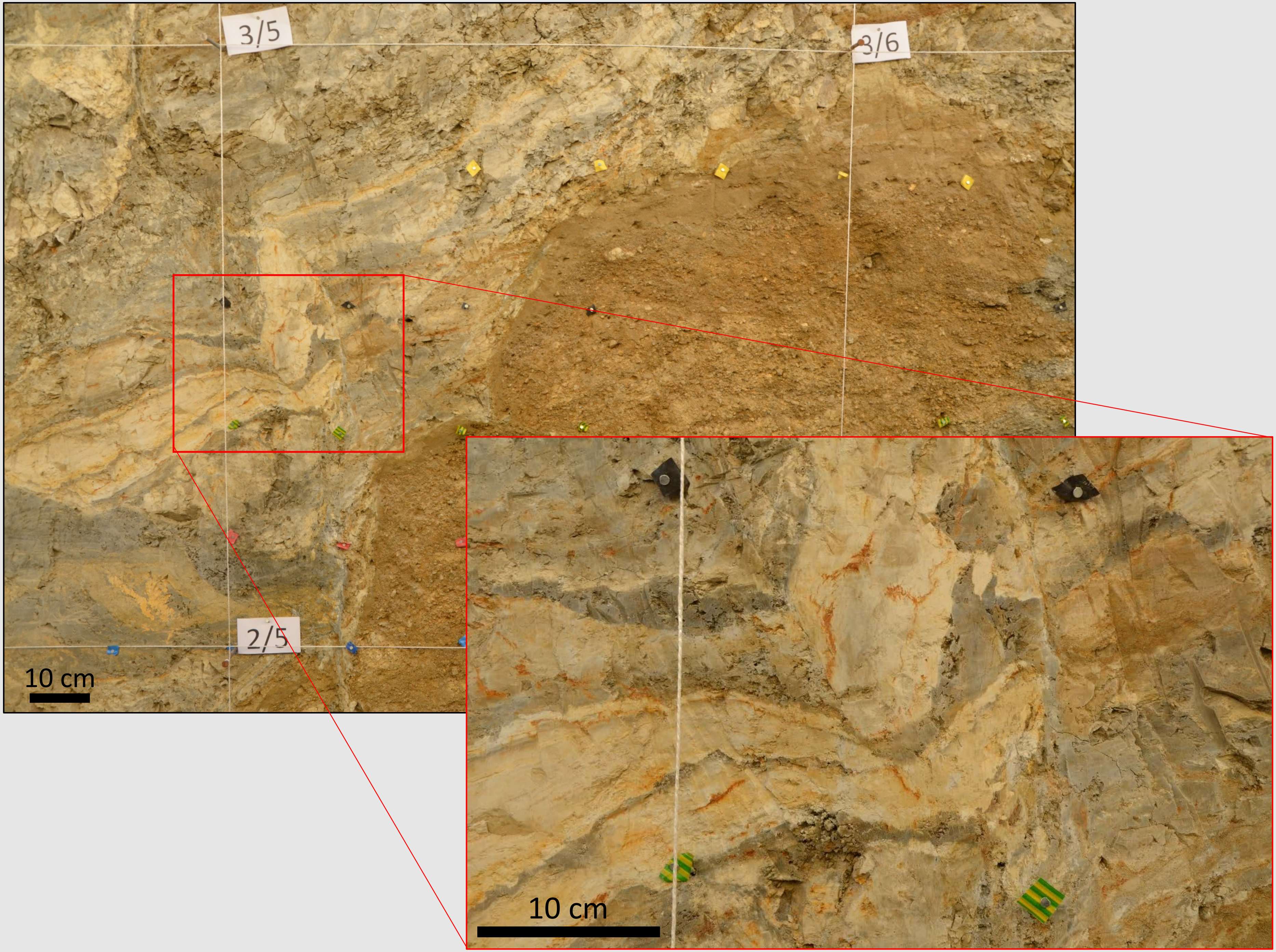



3/5
3/6
2/5
2/6
10 cm

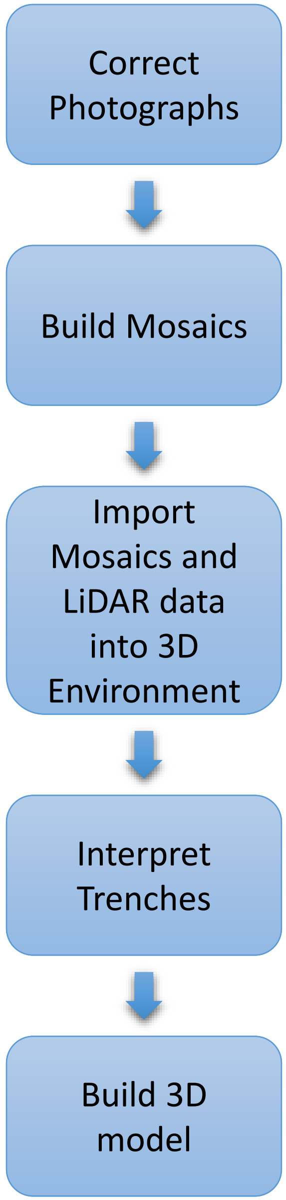


3/5
3/6
2/5
2/6
10 cm

Courtesy of Julia Castro


3/5
3/6
2/5
10 cm
10 cm

Workflow



Constraints

- Distance between trench faces
- Field of view
- Resolution of the photographs (cm sized)

Acknowledgements

Universidad de Alicante:

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Jan Tveranger

Universitetet i Stavanger:

Jacob Dieset
Nestor Fernando Cardozo Diaz


Thank You

COUPLING OF THRISHEAR FAULT-PROPAGATION FOLDING AND GROUND PROCESS MODELLING

Per Kristian Malde

Supervisors:
Nestor Cardozo (UIS)
Per Salomonsen (Schlumberger)
Jan Tveiten (Schlumberger)

Outlines

- Description of project
- Objectives
- Introducing the programs
- Trishear 3D
- GPM
- Parameters
- Process

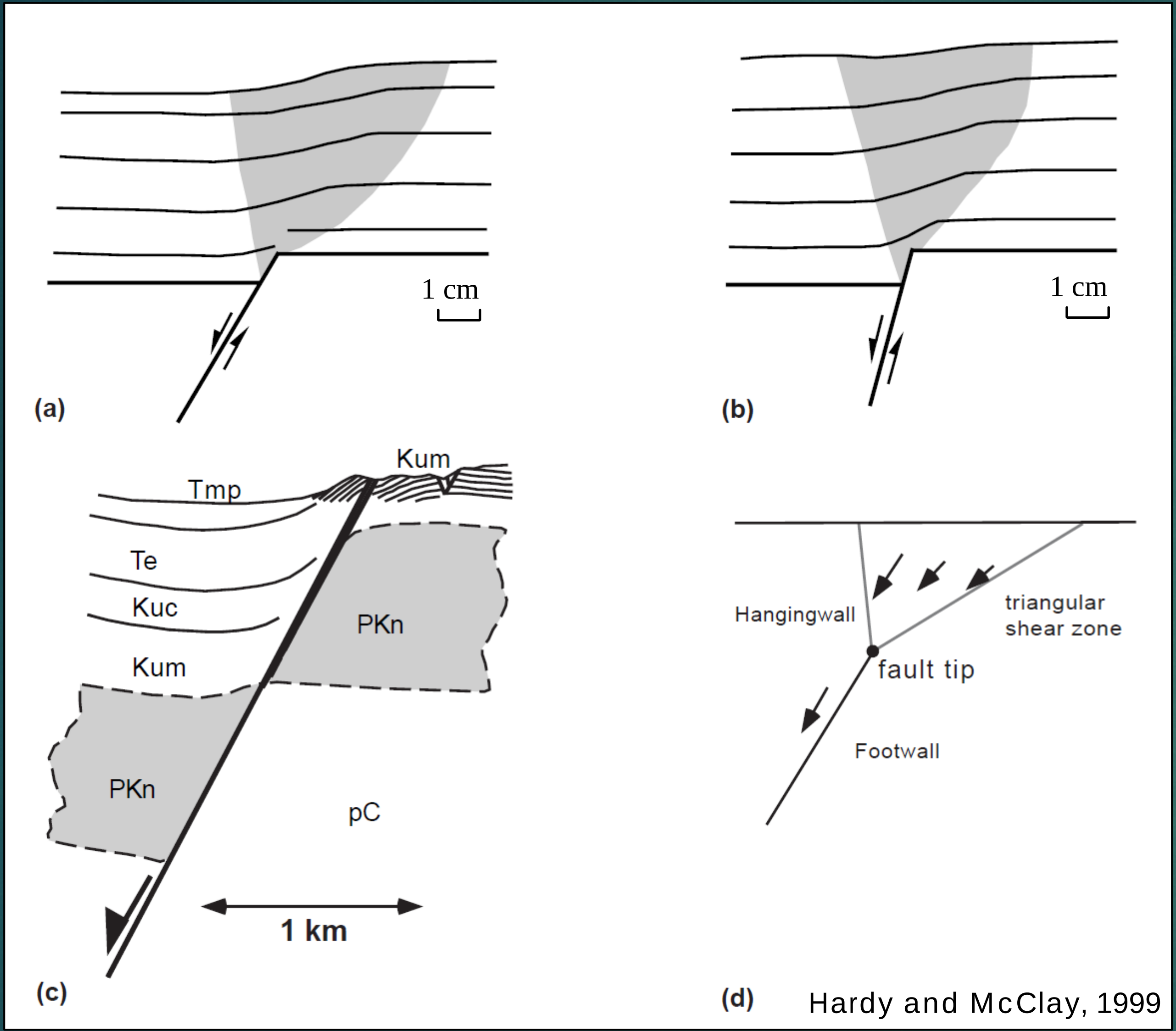
Tectonic + Sedimentation

Photo: Geology in

Photo: University of Hull

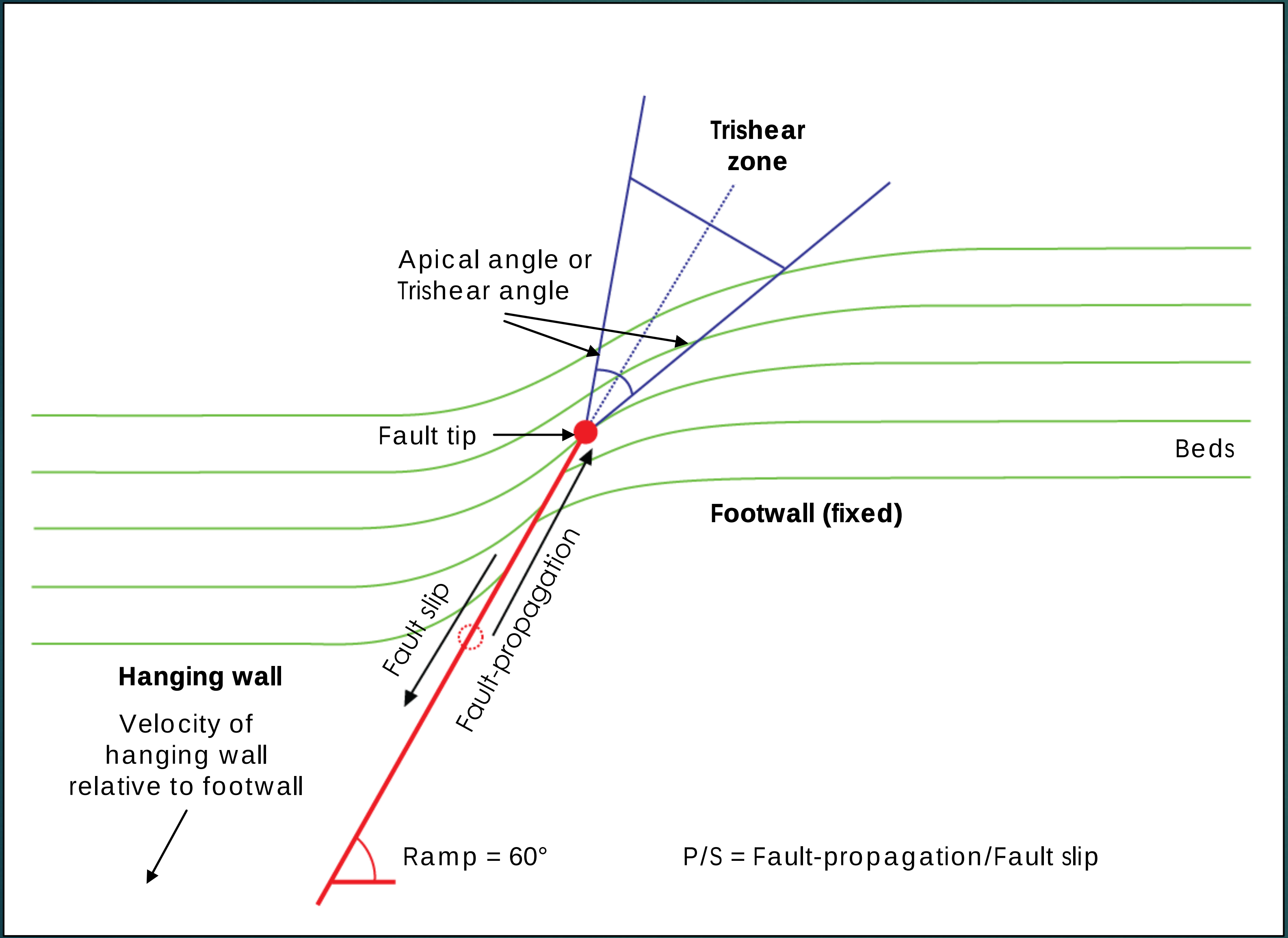
Objectives

- To couple the two programs
- To Visualize tectonics-sedimentation in 3D
- To better understand sedimentation, using an advanced ground process modelling tool



- (a) and (b) Cross-section from analogue clay models
- (c) Outcrop of breached fold from the Gulf of Suez
- (d) Schematic illustration of kinematic model of fault-propagation folding

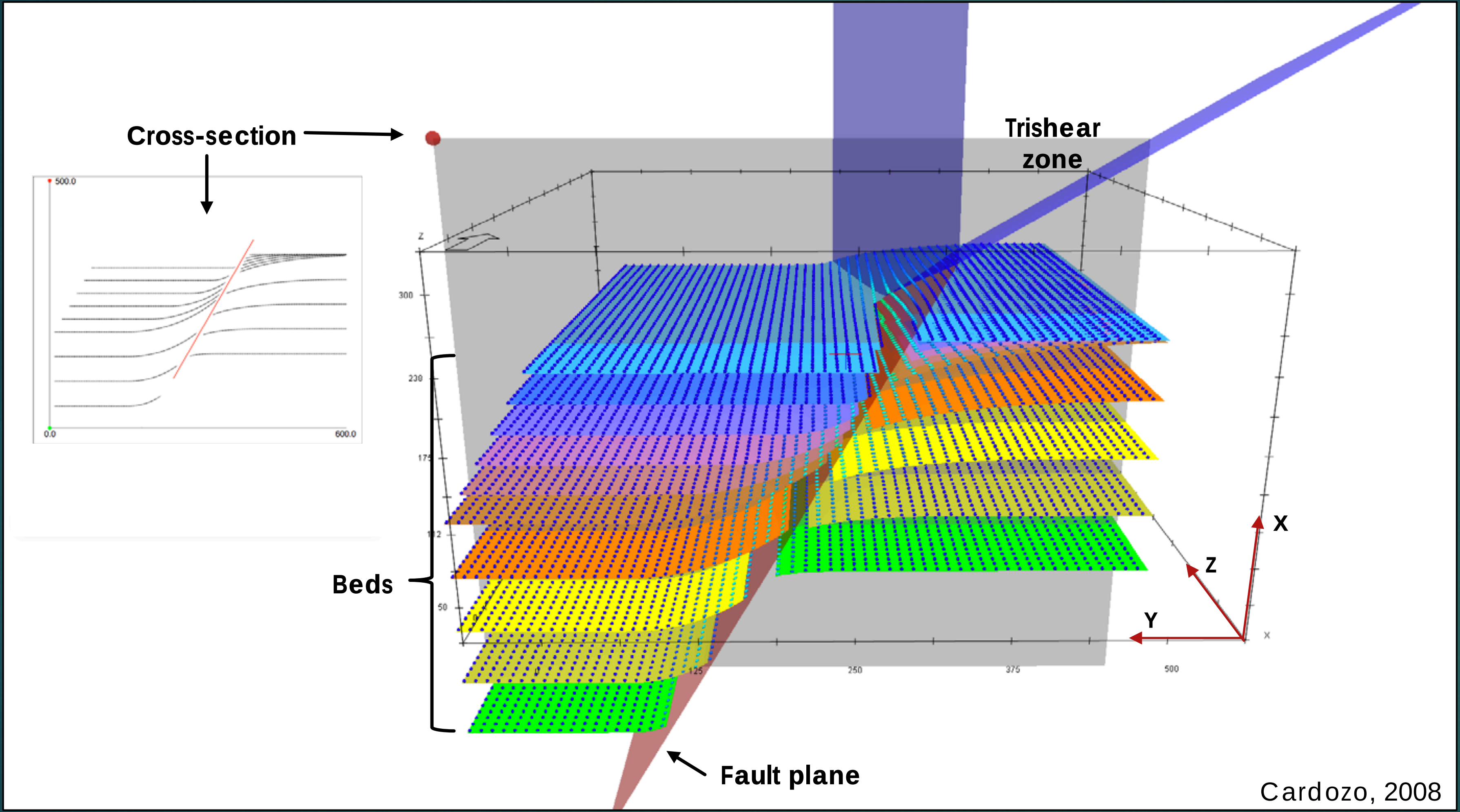
Trishear



- Trishear is a kinematic model of fault-propagation folding **in which the decrease in displacement along the fault is accommodated by deformation in a triangular shear zone** radiating from the tip line.

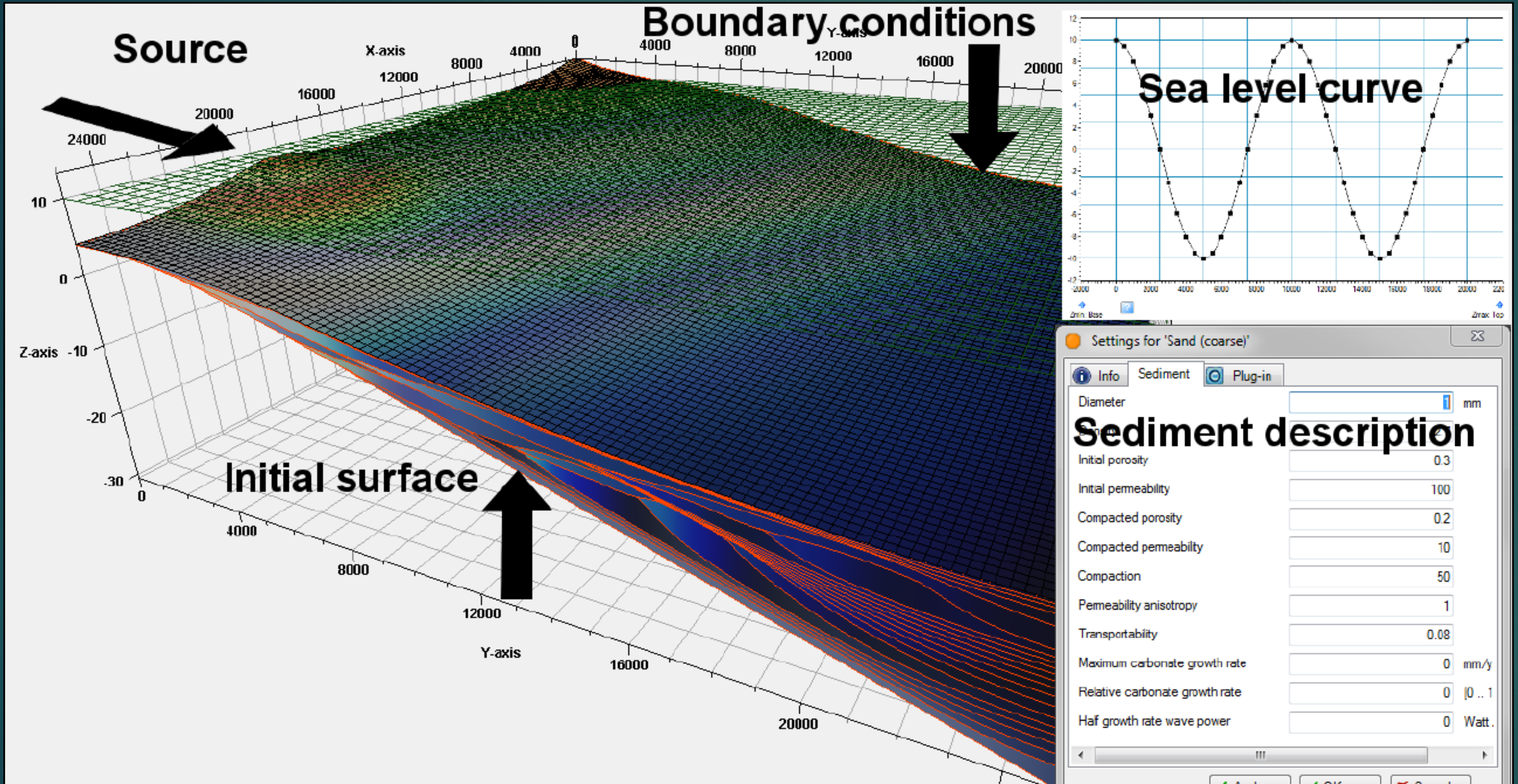
- The model is Incremental and needs to be run in a computer

Trishear 3D



- A kinematic model of fault-propagation folding
- Based on two algorithms. A pseudo-3D and a true-3D algorithms

GPM



GPM - Schlumberger plugin

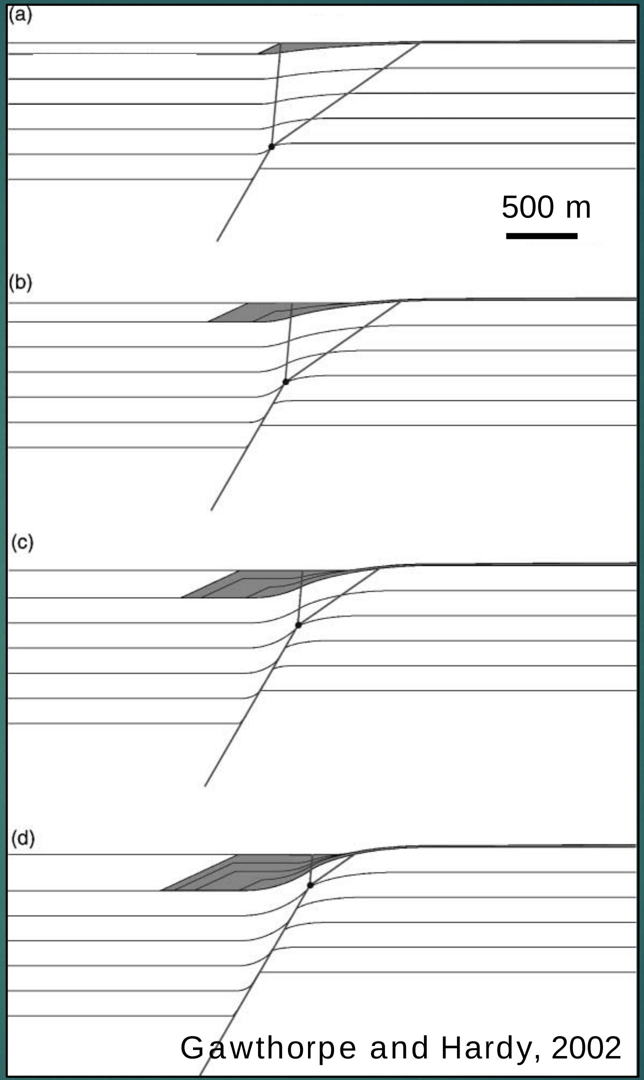
Overview from GPM basic input

- A Plugin within Petrel
- A Powerful ground process modelling tool
- A large variety of parameters
- Take vertical movement into account

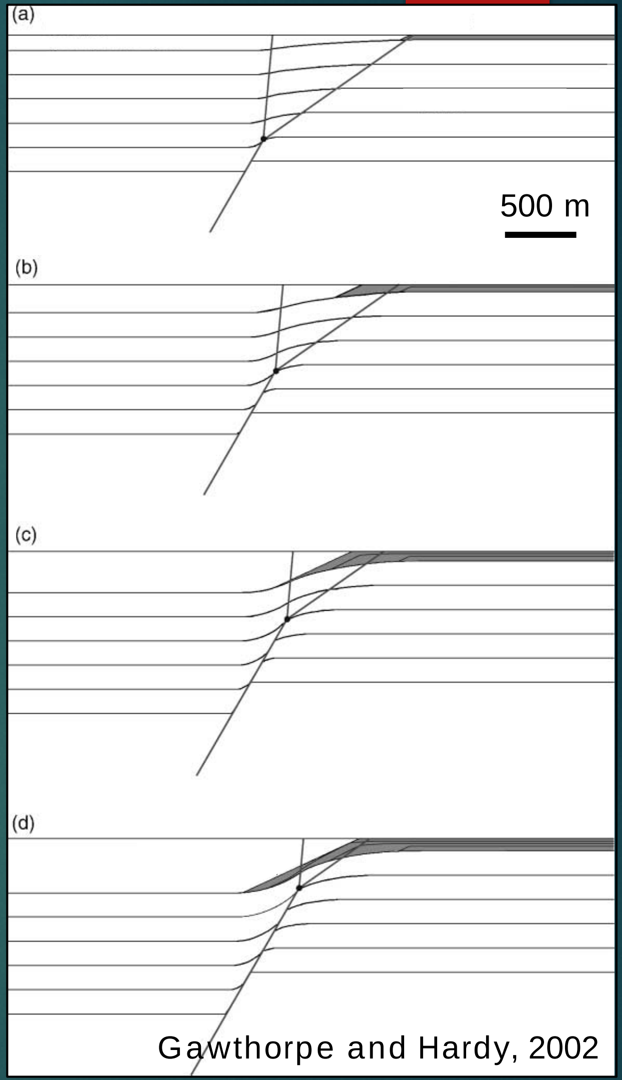
Parameters

Trishear	GPM
Fault-propagation to slip ratio (P/S)	Base level
Slip rate	Grain size
Apical angle	Erosion
Fault ramp angle	

- P/S is the single most important parameter determining the shape of a trishear fold
- Possible to do variations along strike
- Base level can have significant impact on deposition



Effect of sea-level fall in 2D

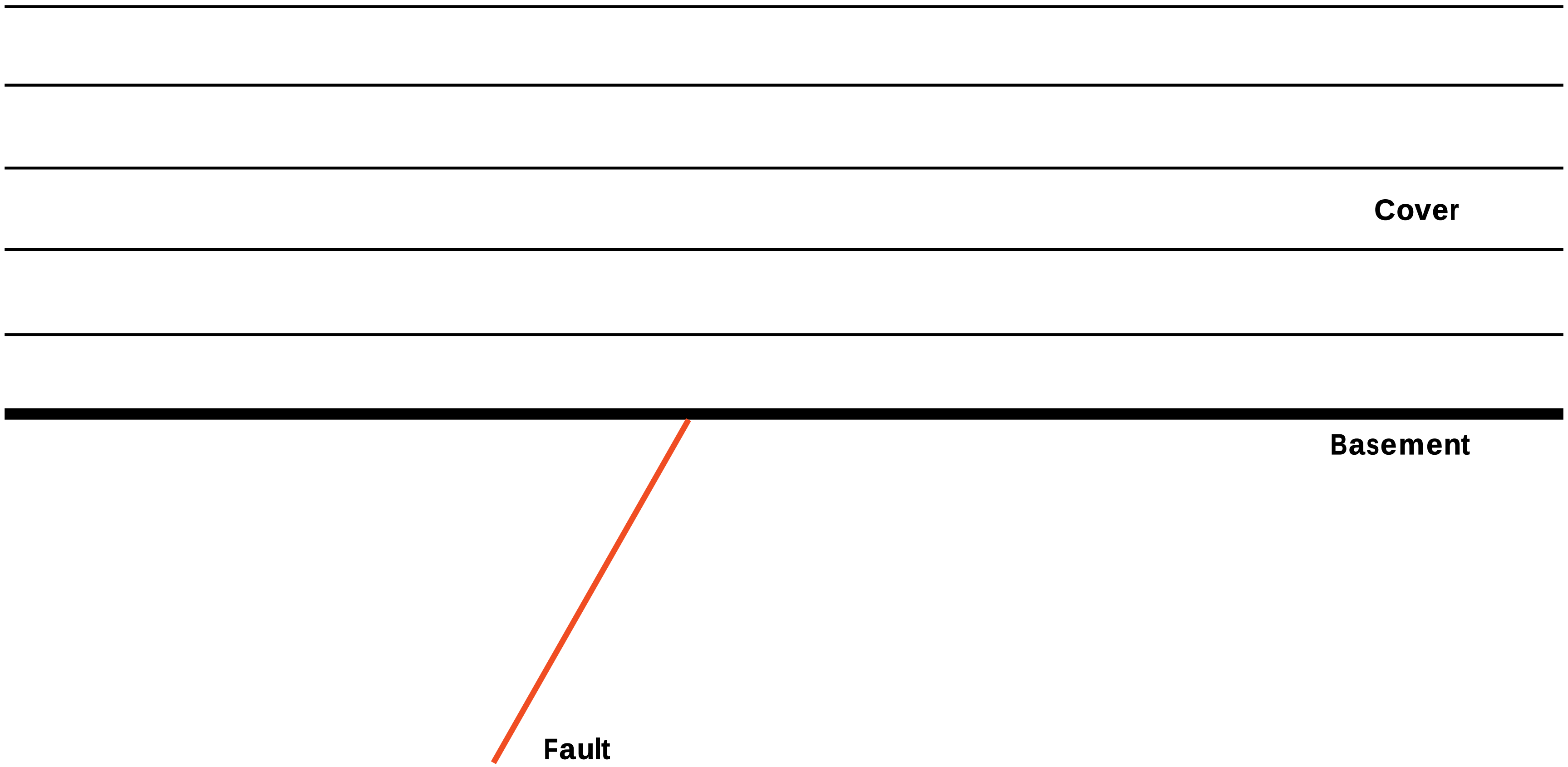


Effect of sea-level rise in 2D

Process

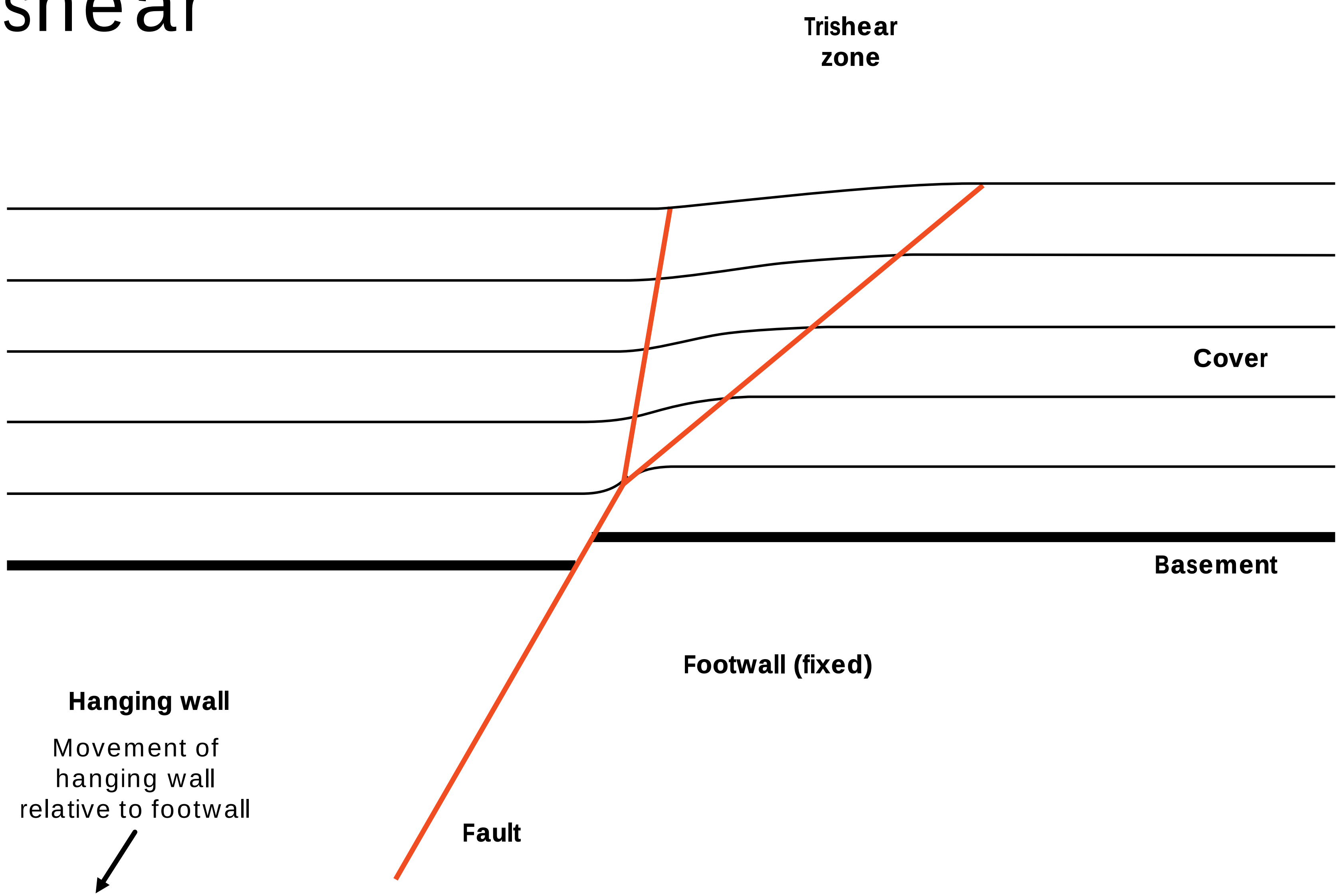
- Simplified example in 2D

Trishear



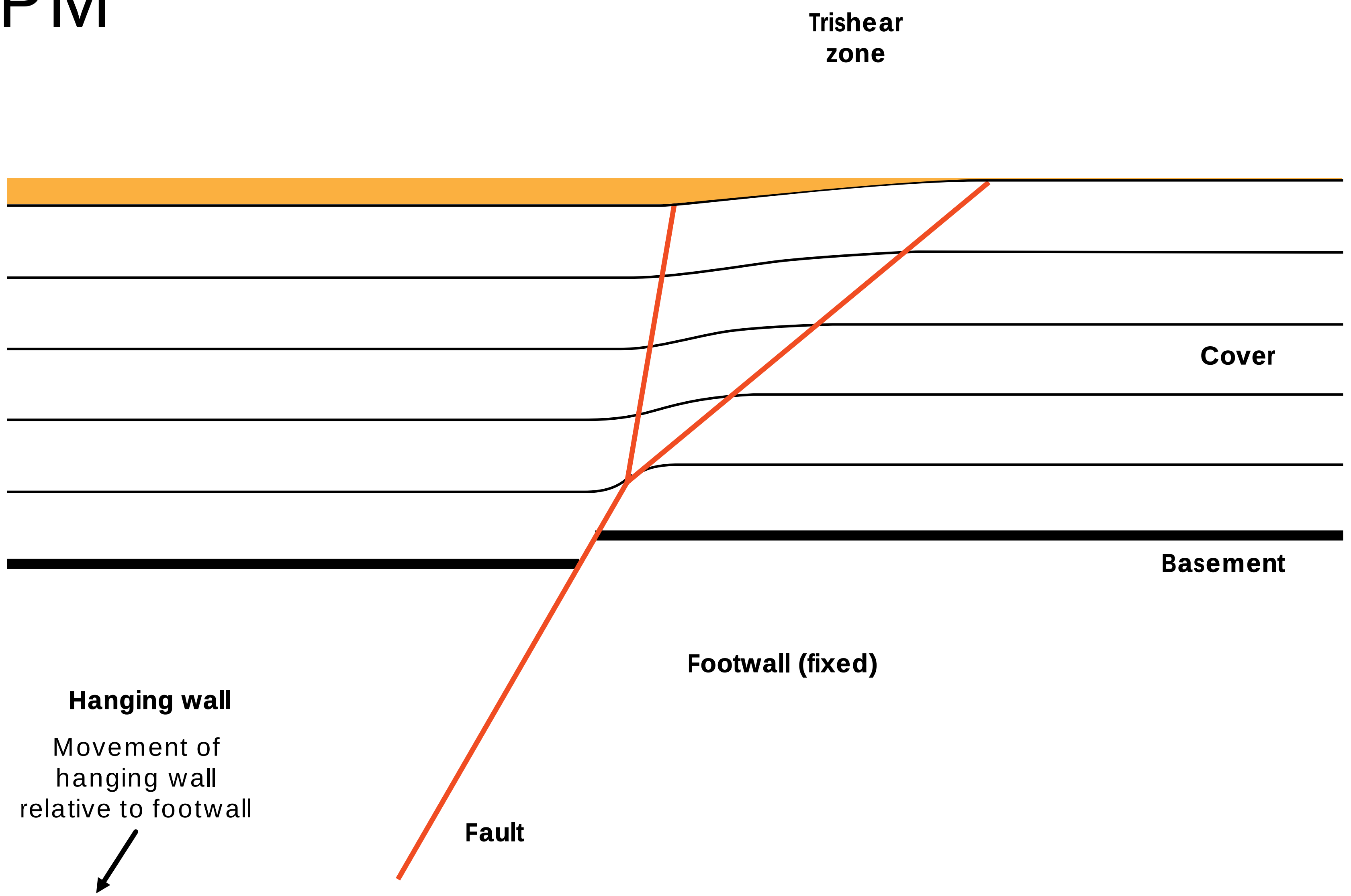
1) Initial start in trishear

Trishear



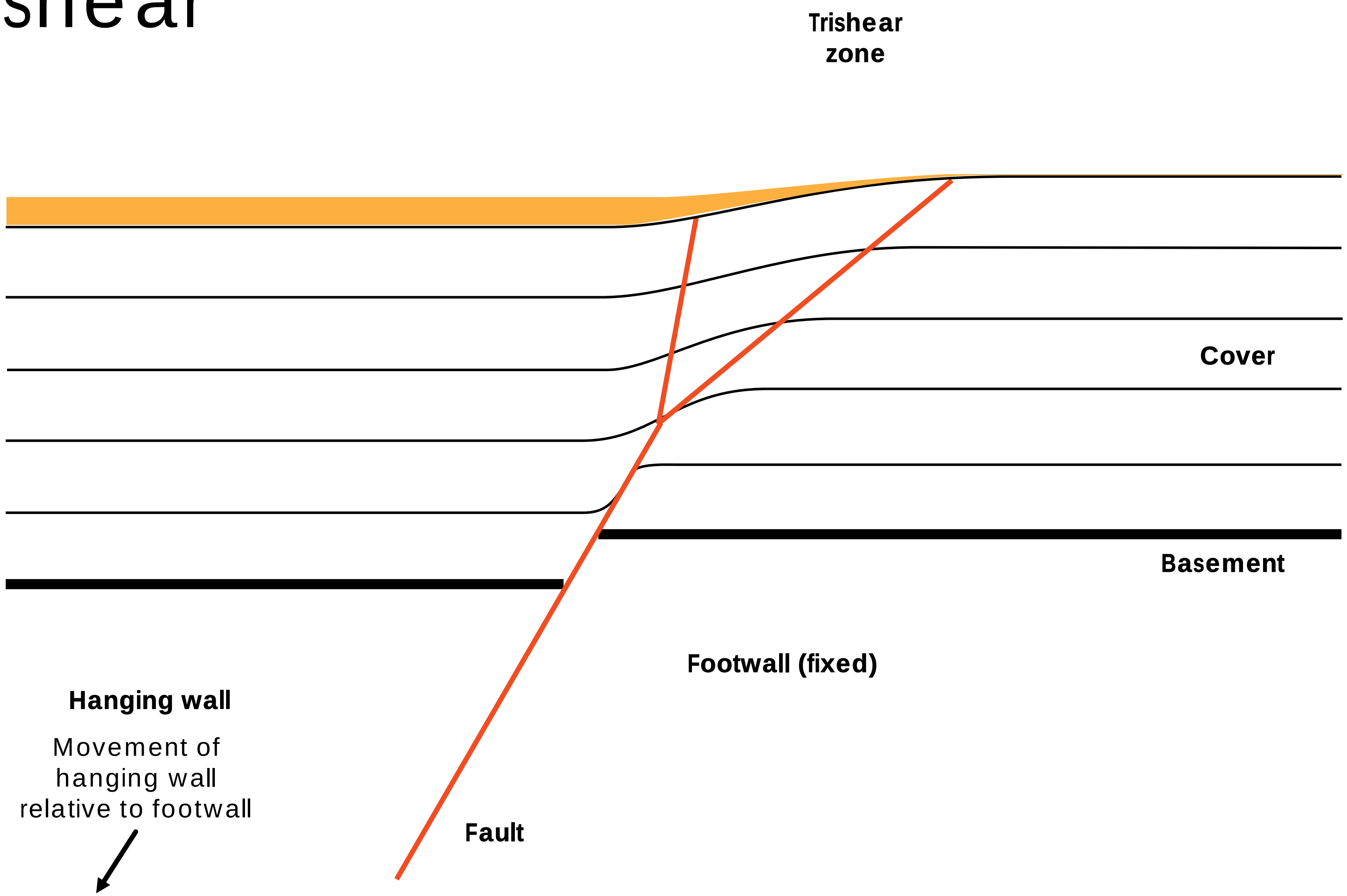
1) Run fault-propagation folding
2) Convert a text file

GPM



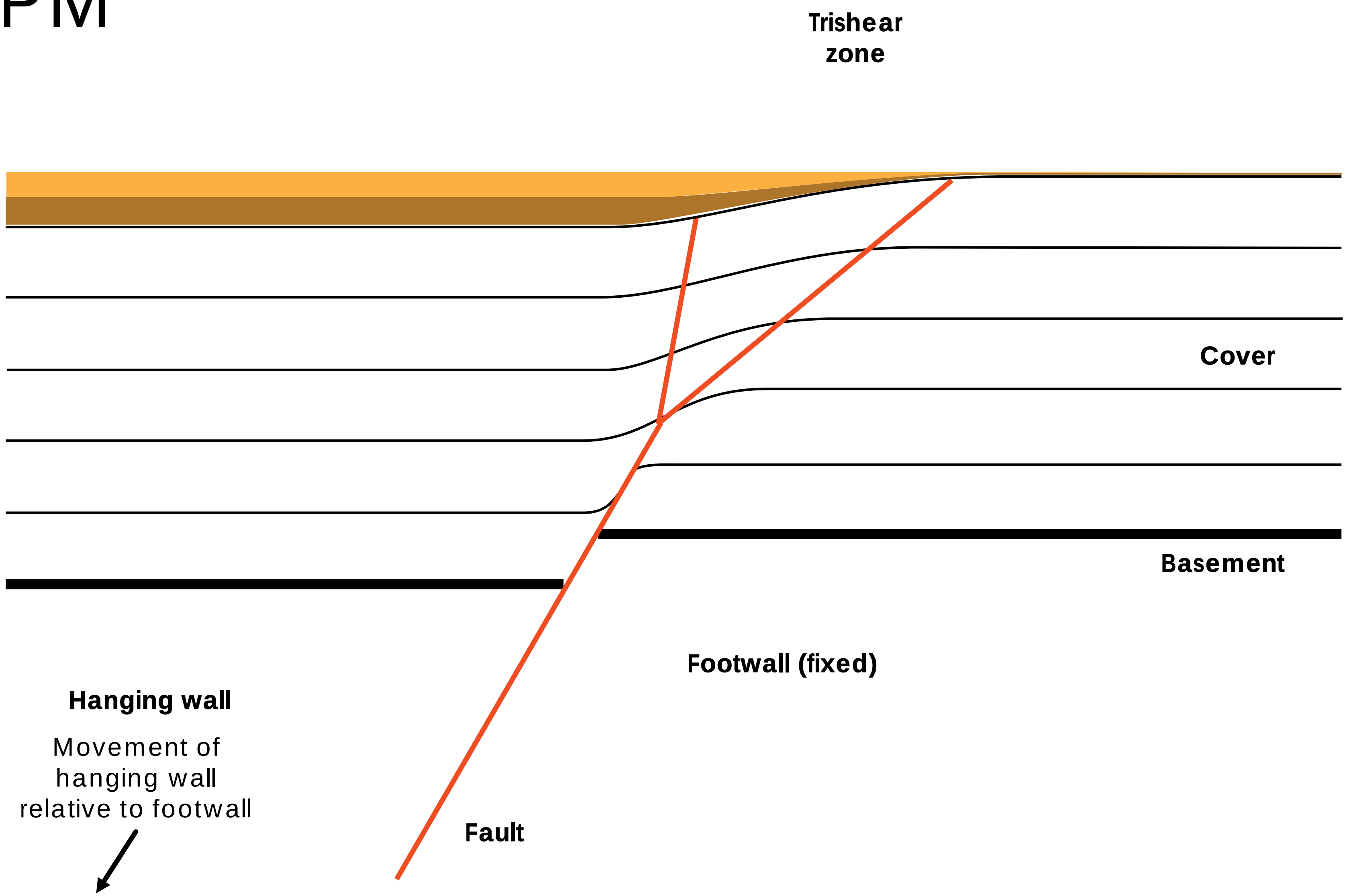
1) Import text file in to GPM
2) Deposit a layer
3) Export text file

Trishear



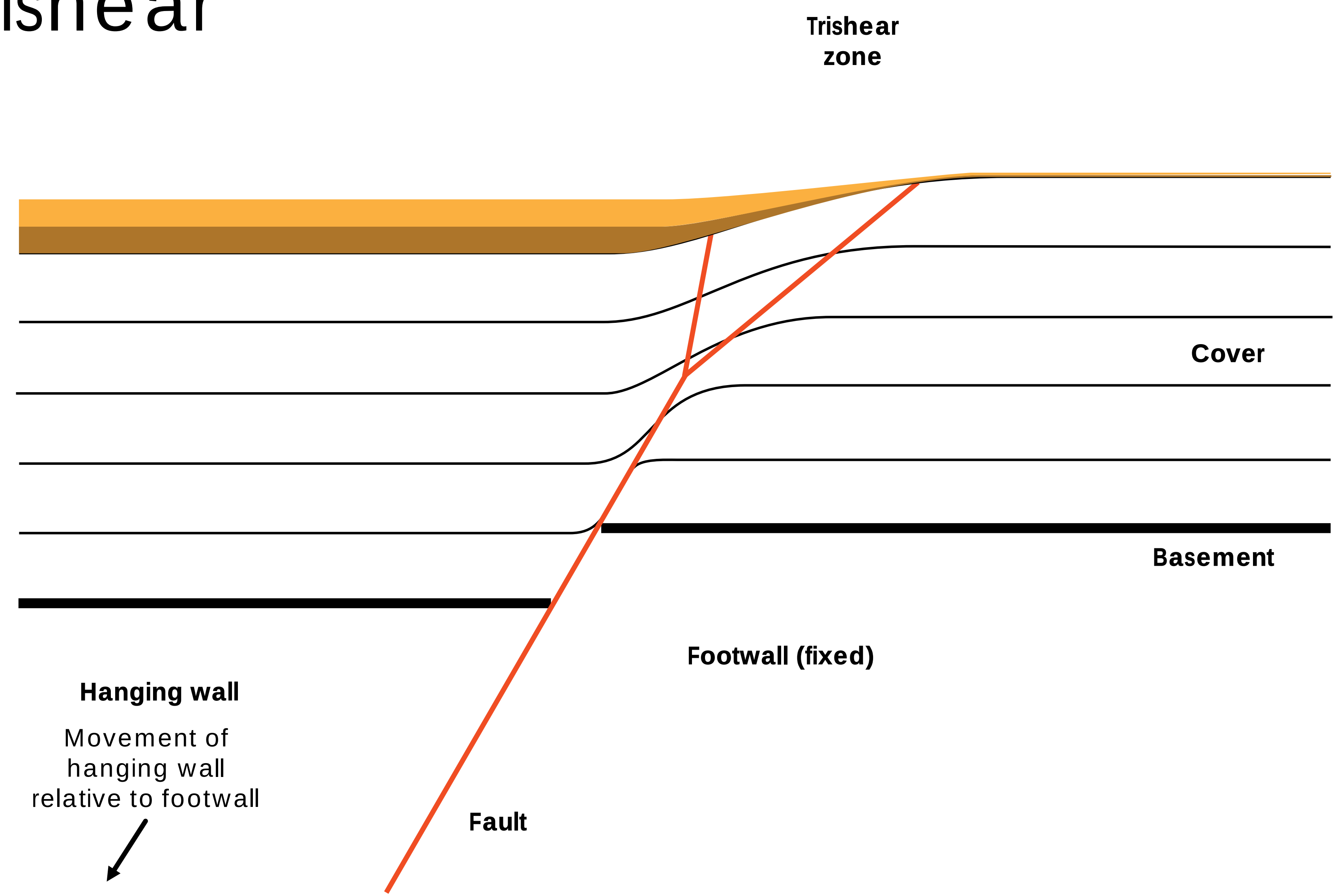
1) Import text file in Trishear
2) Run fault-propagation folding
3) Export text file

GPM



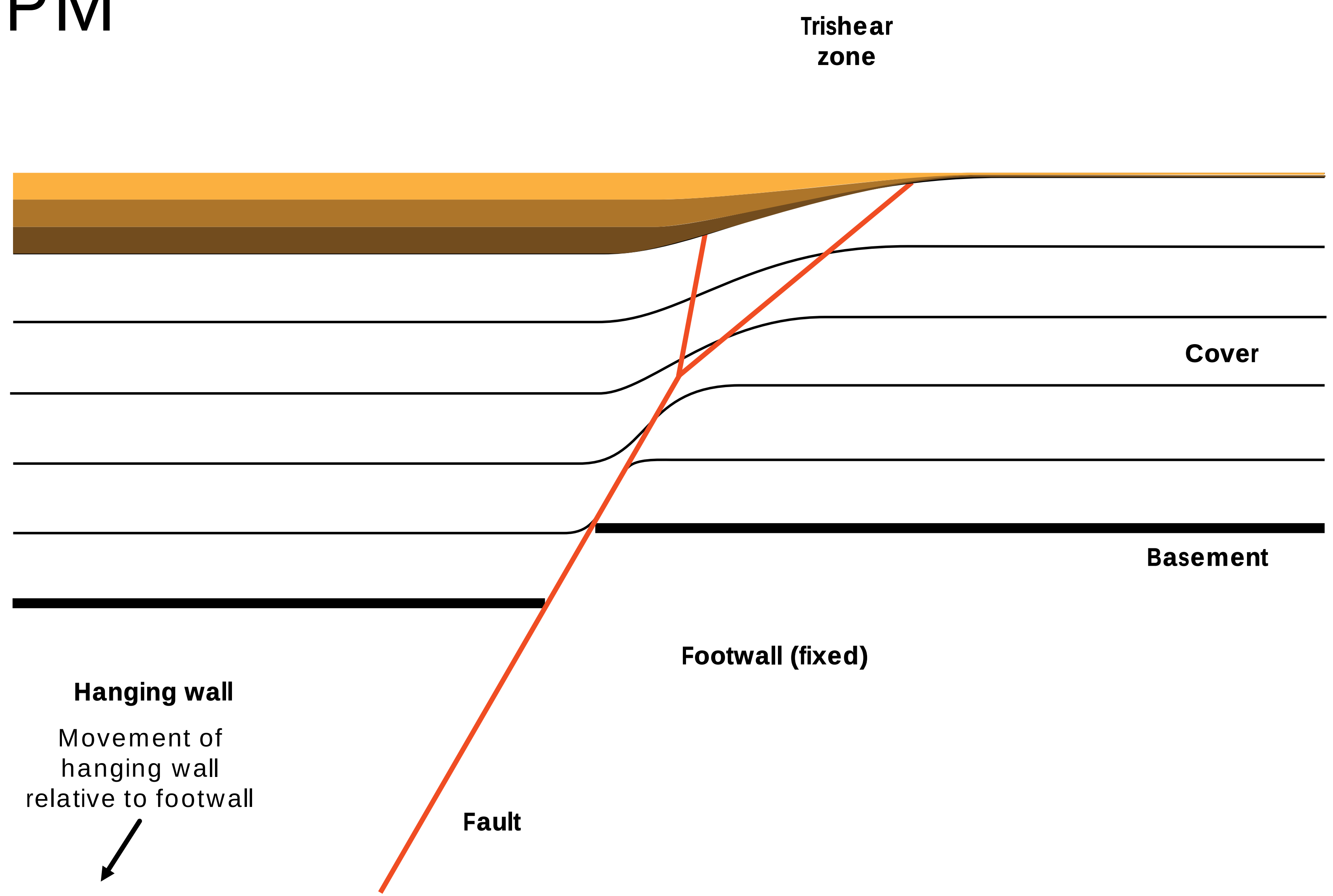
1) Import text file in to GPM
2) Deposit a new layer
3) Export text file

Trishear



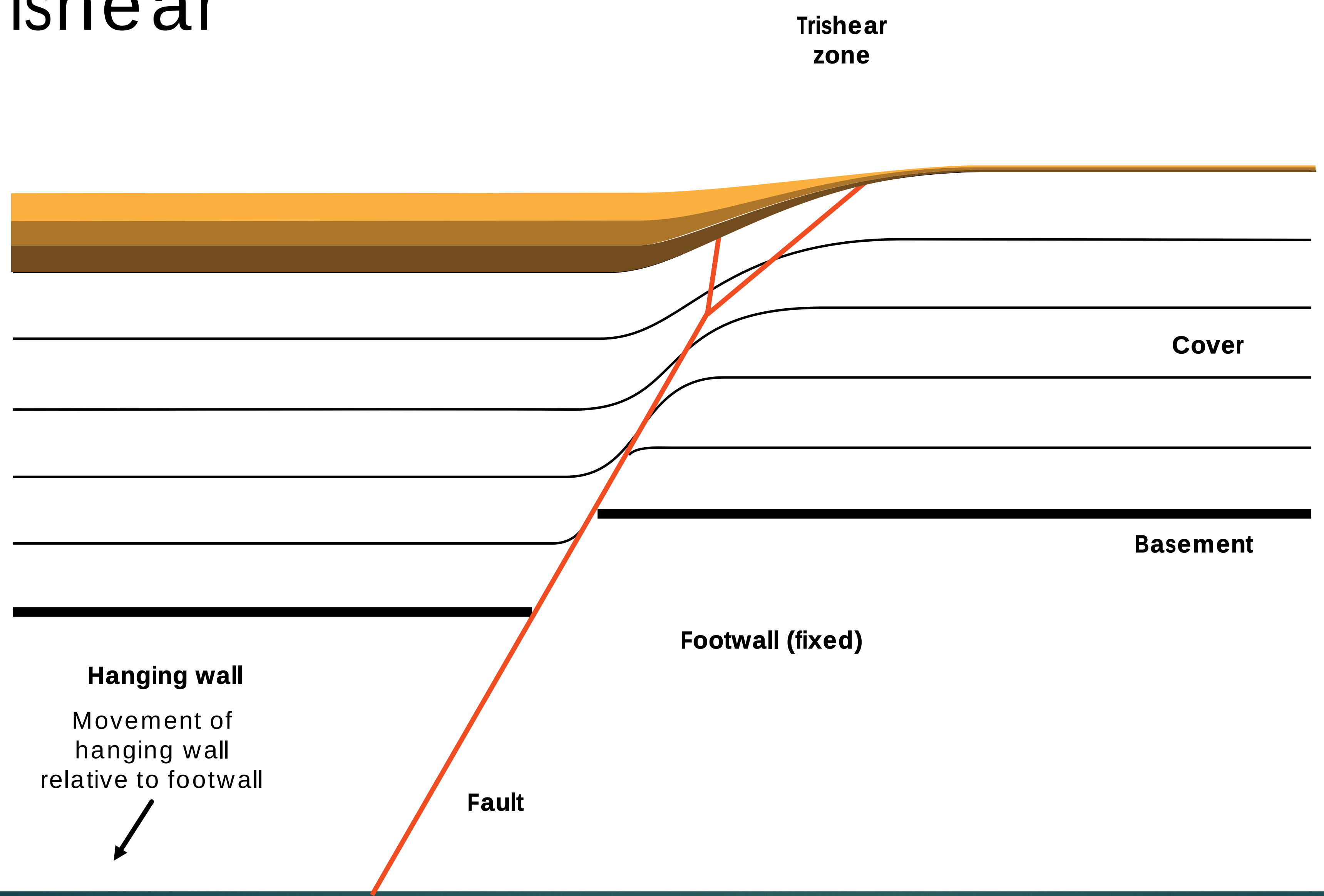
1) Import text file in to trishear
2) Run fault-propagation folding
3) Export text file

GPM



1) Import text file in to GPM.
2) Deposit a new layer.
3) Export text file

Trishear



1) Import text file in to trishear
2) Run fault-propagation folding
3) Export text file

Thank you!

Application of Trishear and Elastic Dislocation models to the Teapot anticline, Wyoming: Prediction of fracture network

By: **Ivan Gutierrez**

Supervisor: **Nestor Cardozo (UiS)**

University of Stavanger

The problem

Natural Fracture Reservoirs (NFR) ⇒ Complex Characterization →
- Orientation
- Spatial Distribution
- Density

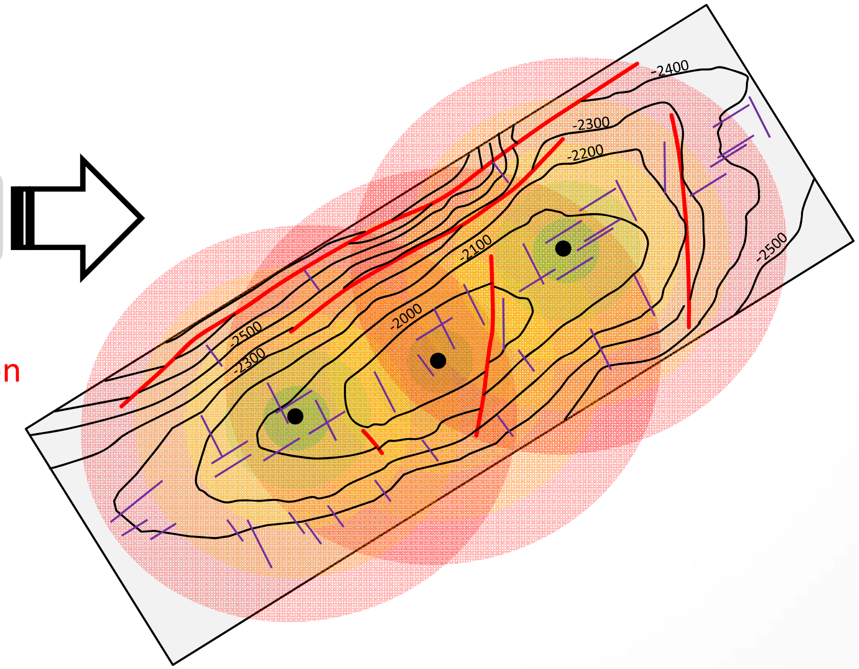
Geometry / Fracture Network / Elastic Rock Physics Properties (Stress and Strain)

Statistical Models (Stochastic): Algorithms for well data interpolation.

Seismic attribute guidance: Improve fracture models between wells by using seismic attributes sensitive to faults and fractures.

Challenges:

1. Scale gap problem (wells and seismic):
   - Wells: detailed and values for NFR but localized and difficult to extrapolates
   - Seismic: Helpful for reservoir geometry modelling but the confidence of the models is hindered by the low resolution in sub-seismic structures
2. Poor-imaged reflectors and fault tip in the forelimb



University of Stavanger

The problem

Challenges:

1. Scale gap problem (wells and seismic):
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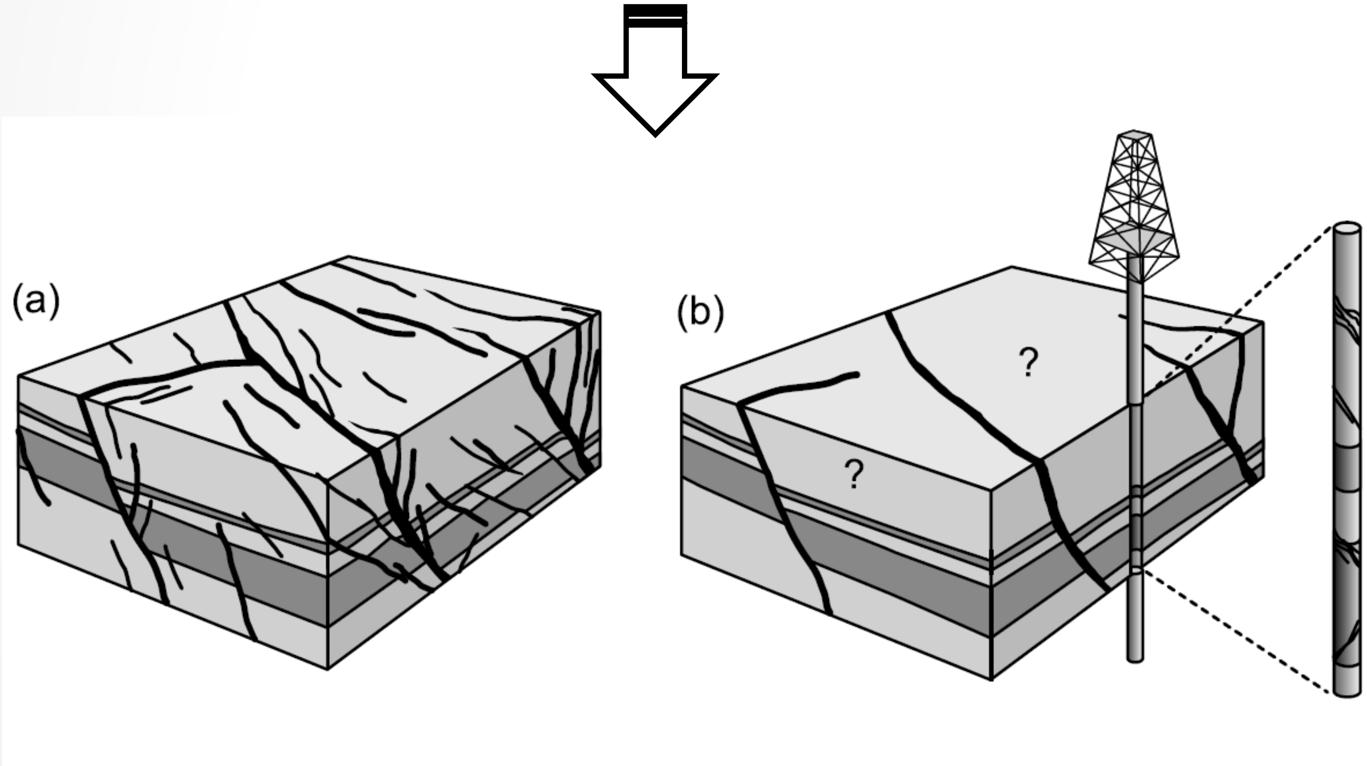

Modified from Maerten, L et al., (2006)

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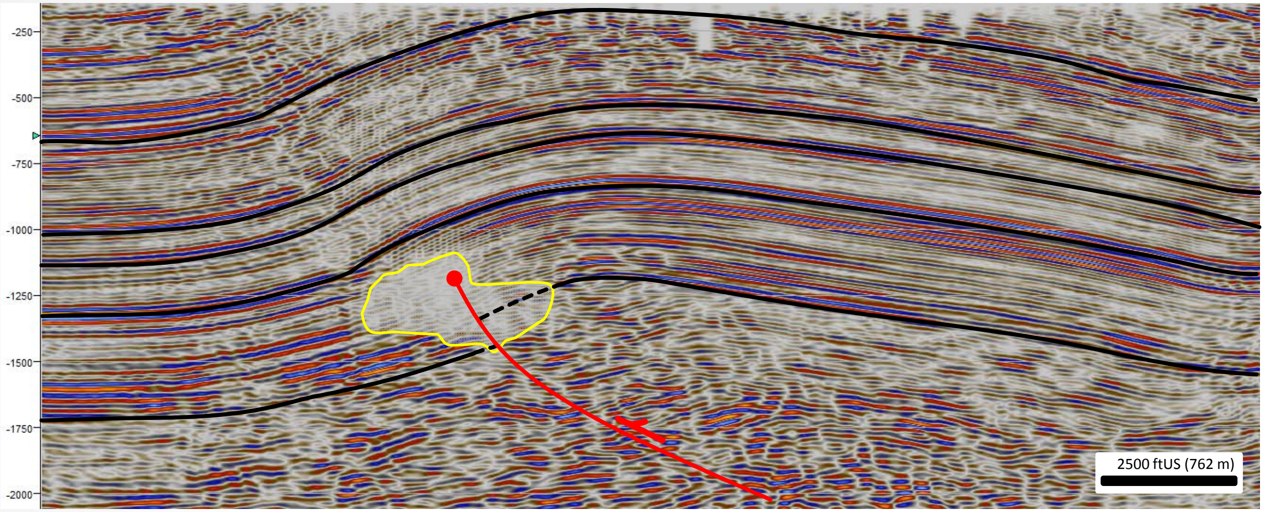
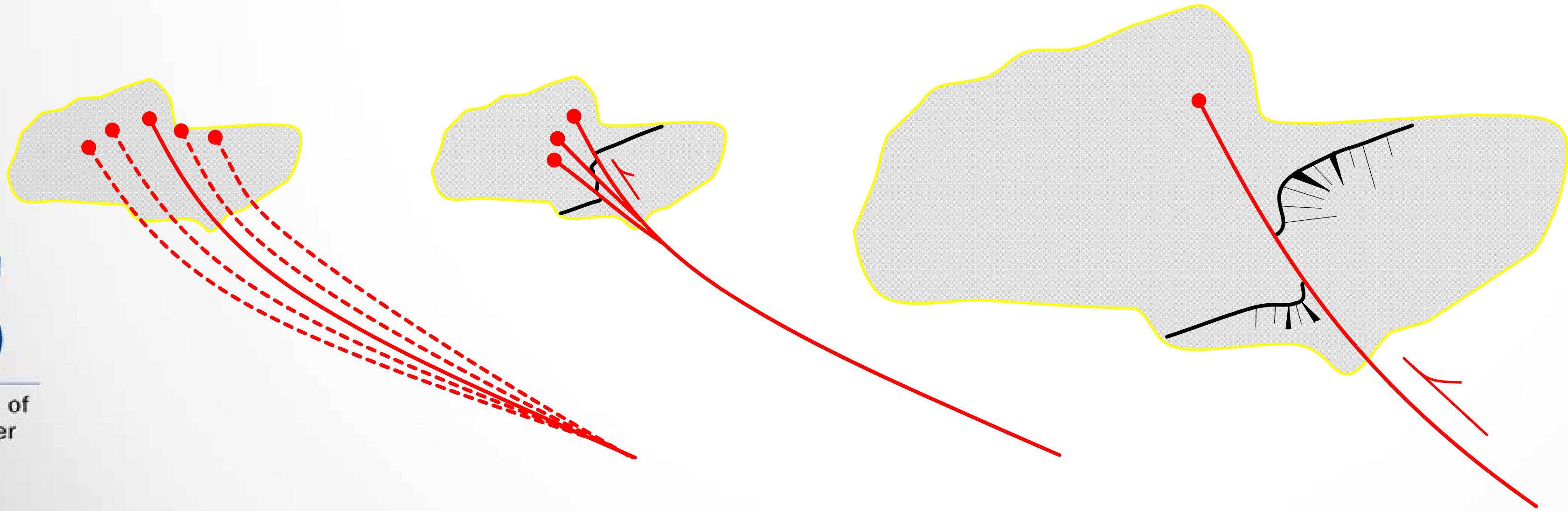
The problem

Challenges:

1. Scale gap problem (wells and seismic):
2. Poor-imaged reflectors and fault tip in the forelimb: **Steep dip angles**





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Objectives

- Study how well trishear and elastic dislocation models predict the geometry of the structure, the spatial distribution and orientation of fractures.

- Explore how the two models complement each other.

- Explore how these models provide more constraints for fracture generation.

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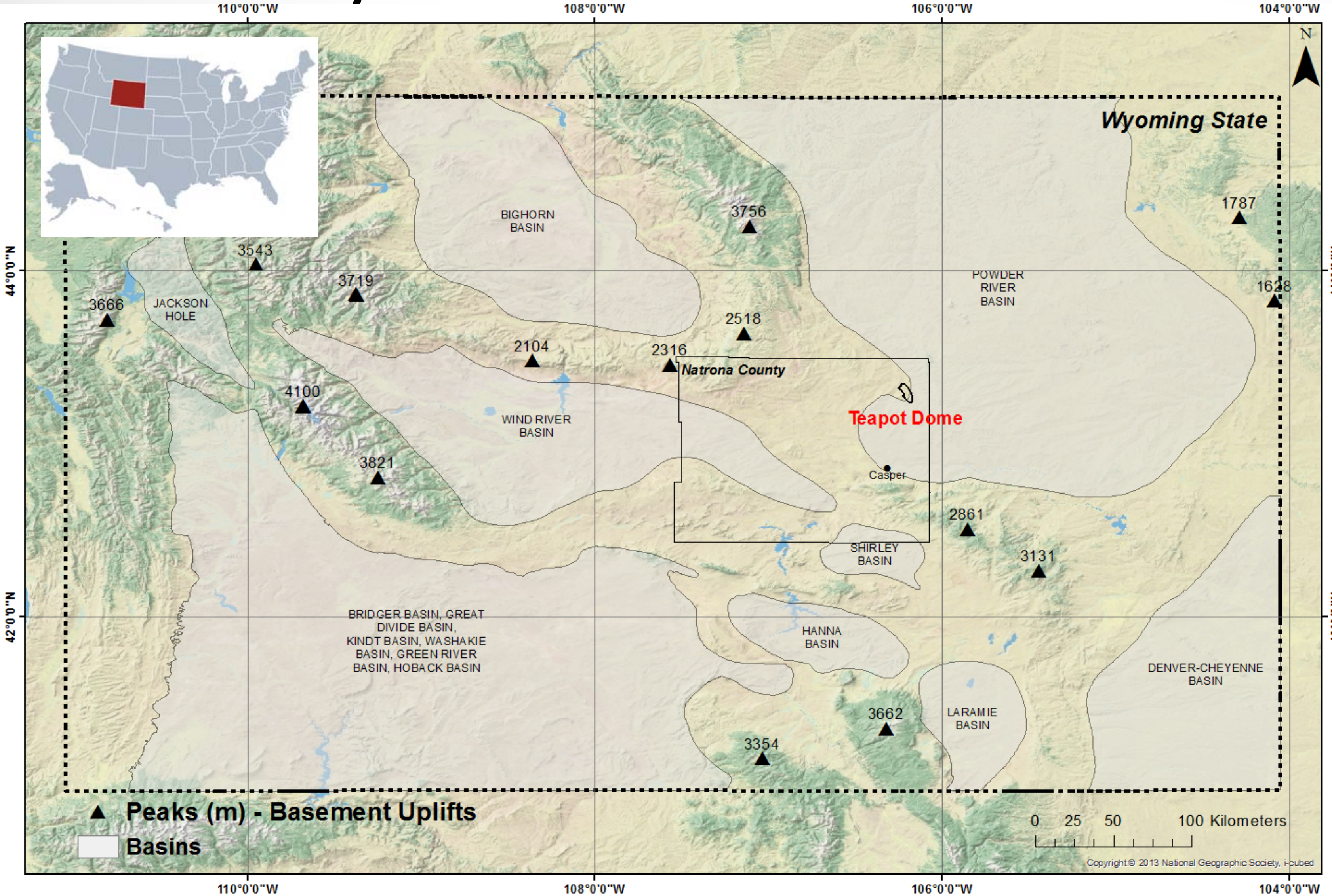
Case study - Location



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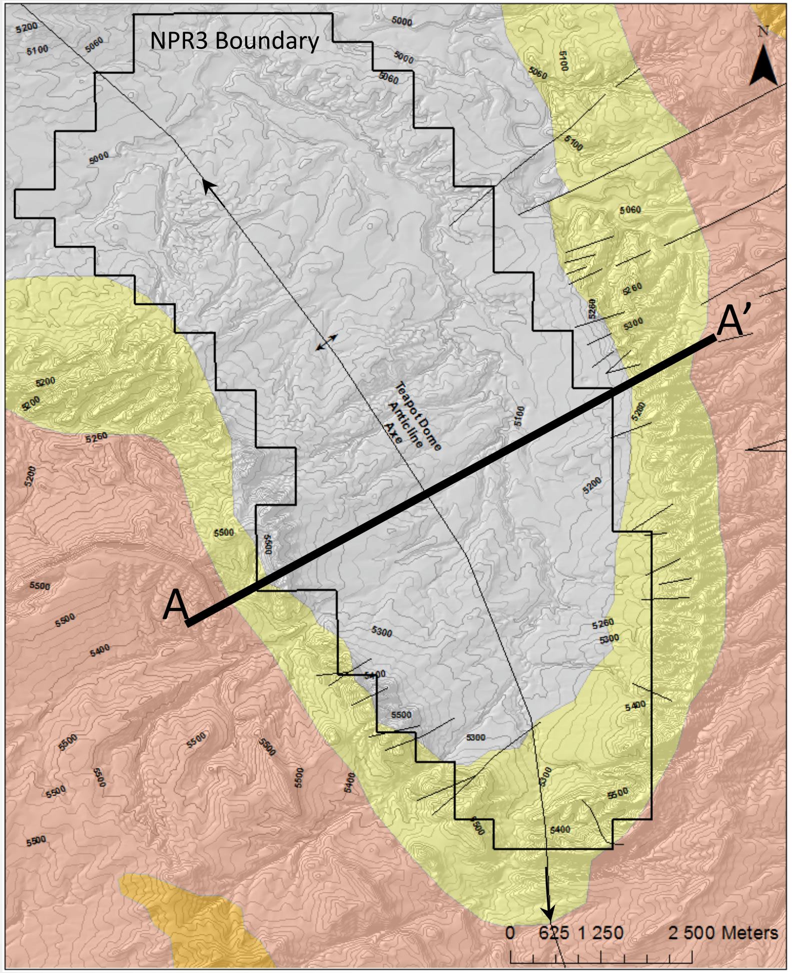
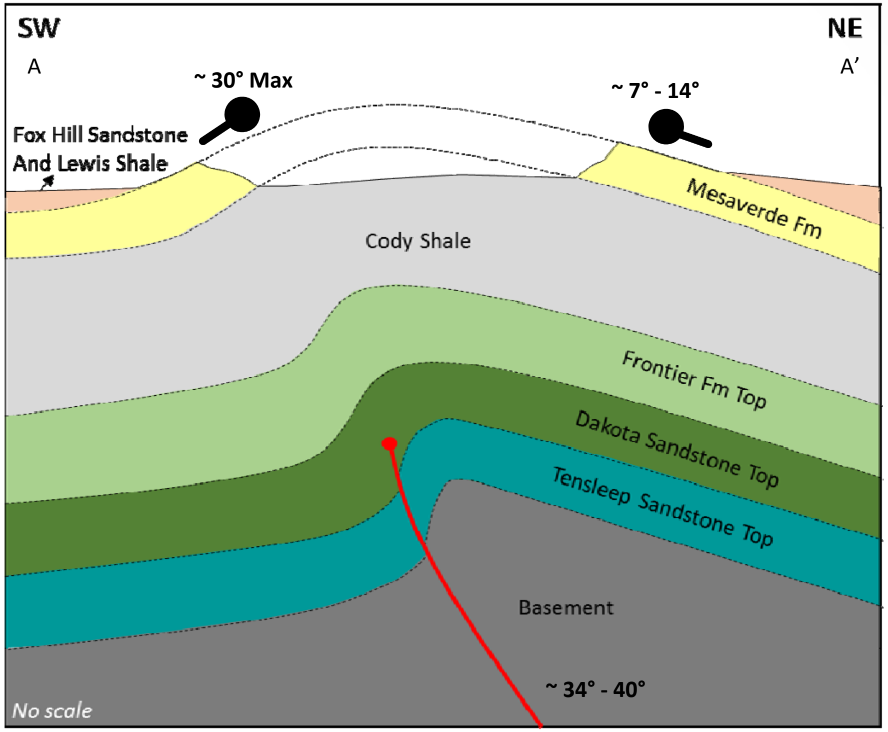
Case study – Geology



Lance Formation
Fox Hills Sandstone and Lewis Shale
Mesaverde Formation
Cody Shale



The Teapot Dome:

- Laramide-aged structure (Deep-seated, thick-skinned thrust system)
- Basement-cored anticline
- Asymmetric and double plunging
- Sedimentary units from Pennsylvanian to Cretaceous
- NPR3 - Naval Petroleum Reserve (~70 Km^2)

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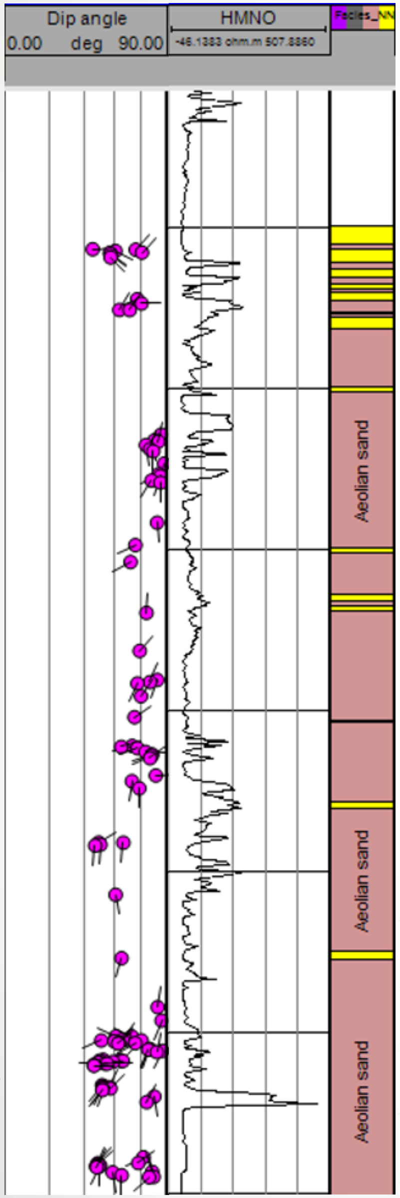
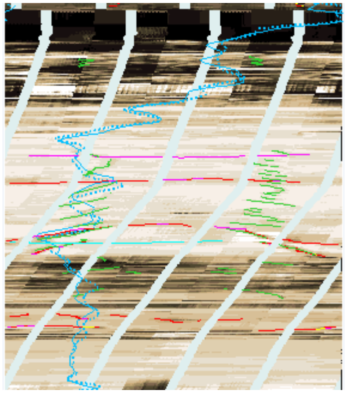
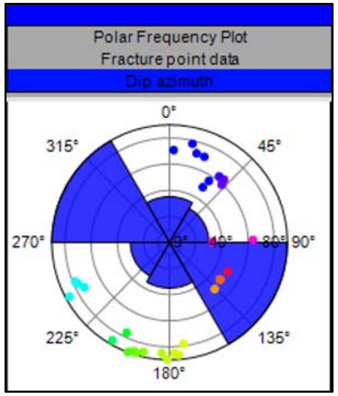
Case study – Data set

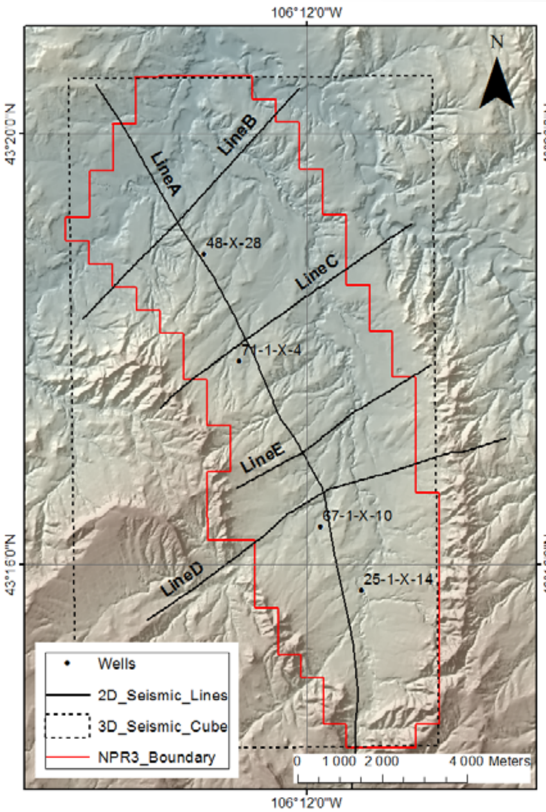


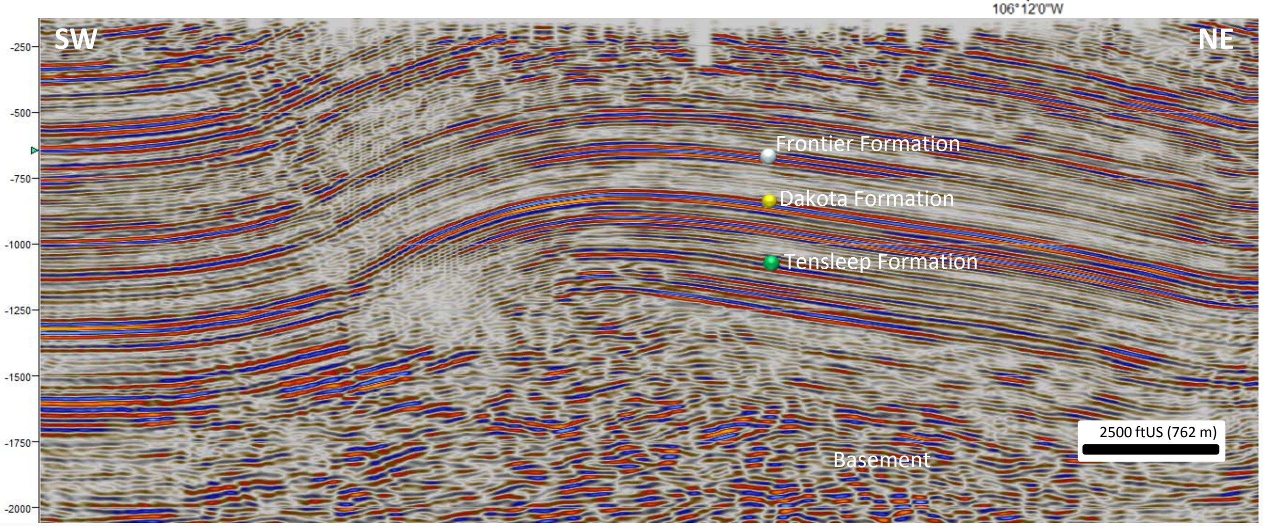
Public data set (RMOTC, 2005a, b)

- Seismic: A 3D cube (~75 Km²) and five 2D lines
- Check shot surveys (Time to depth)
- 4 Wells: Fracture point data, FMI logs and well tops









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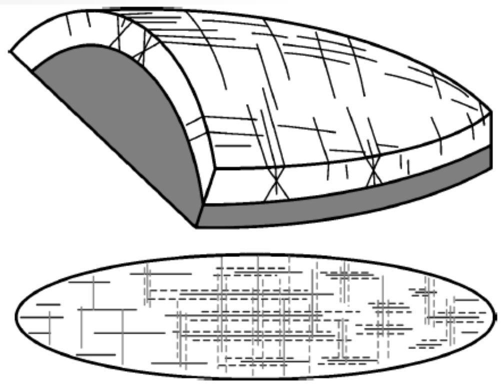
Previous studies

Cooper et al., 2006

Outcrop characterization of fractures in the Teapot Dome:

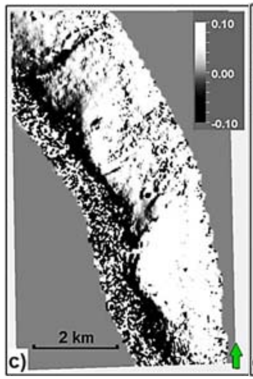
- 3-D conceptual model of fracture patterns. Three main set of fracture relatives to the hinge of the anticline.



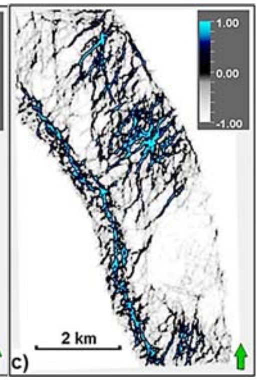
Kundacina, 2016

Fracture modelling by applying seismic attribute guidance between wells in the Teapot Dome:

- Comparison between a standard statistic interpolation (Kriging and Gauss simulation) model and seismic attribute-guided model.



consistent dip cube

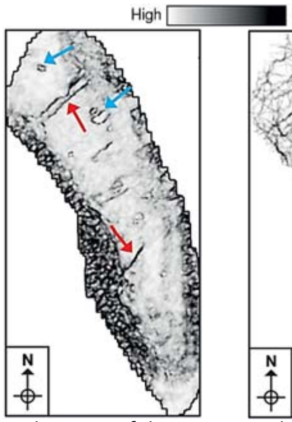


consistent dip cube + Ant-tracking algorithm (Petrel)

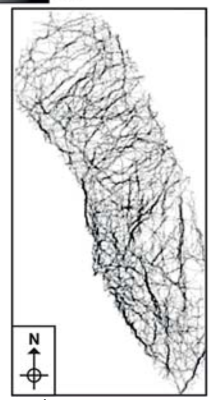
Schneider et al., 2016

Interpretation of fracture zones using seismic attribute and DFN modelling:

- Comparison between the fracture patterns interpreted from seismic attributes with the image log interpretations of the wells.



coherence of dip steered and fault enhancement filtered seismic data.



Coherence + Ant-tracking algorithm (Petrel)

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Methodology

Statistical Models (Stochastic)

Seismic attribute guidance

Inverse Structural Modelling (Trishear and Elastic Dislocation models)

Stage	Input		Modelling		Output
Process	Structural interpretation	Horizon interpolation (geological surfaces)	Trishear (2D - 3D)	Elastic Dislocation (2D - 3D)	Model Validation Interpretation Comparison
Software	Petrel	Petrel or Move	Matlab script and Trishear 3D (by Nestor Cardozo) Move	TrapTester	No defined yet

Petrel (Schlumberger)
Move (Midland Valley)
Matlab script and Trishear 3D (Nestor Cardozo)
TrapTester (Badleys)

Modelling
Fracture generation
Move

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Methodology - Modelling

Trishear

Kinematic model: it is a suitable method for fault-propagation folding modelling, including basement-cored anticlines (Teapot Dome).

Input:

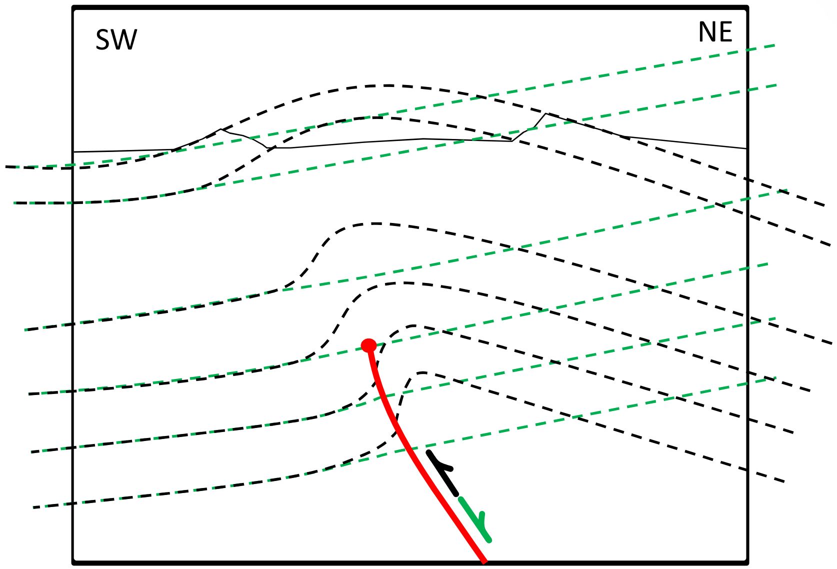
- o Structural interpretation

Inverse trishear modelling consists of unfold geological horizons by running the fault deformation backwards.

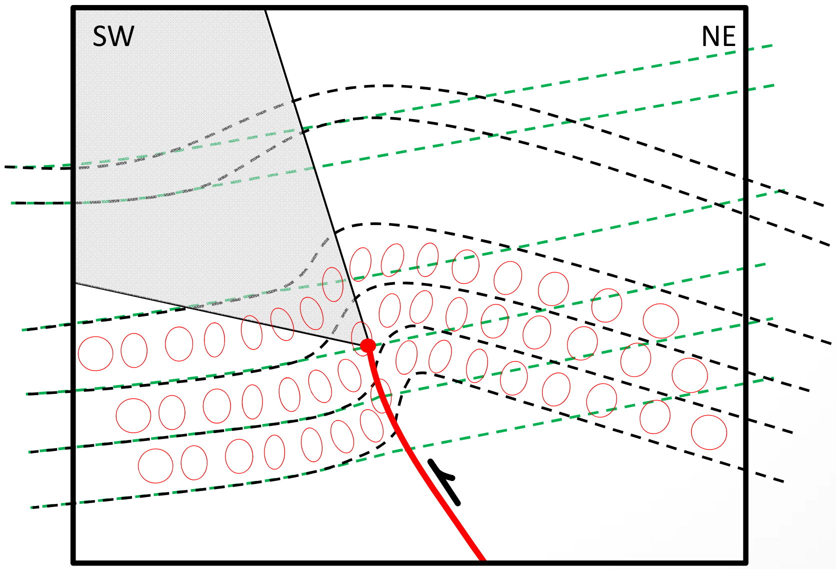
Best-fit model will best restores the folded horizons to planar surfaces

Forward model will provide finite strain and kinematic parameters

Inverse Model



Forward Model



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Methodology - Elastic Dislocation Model

Geomechanic model: prediction of the distribution of subsurface strain related to larger faults which are represented as dislocations in elastic medium. Strain Modelling.

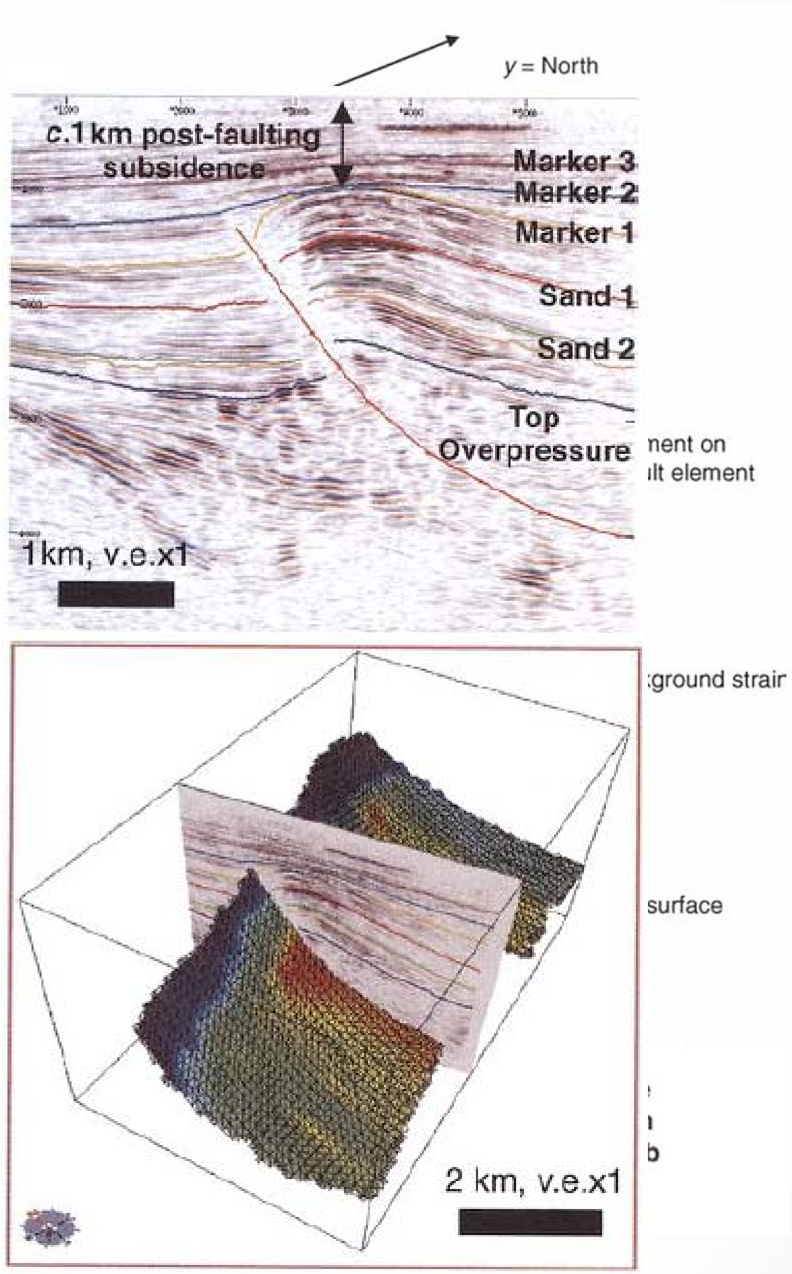
Input:

- Fault geometry and slip patterns
- Regional background strain i.e. 1% shortening (optional)
- Mechanical properties

Discretization of fault surfaces (Panels)

Algorithm to compute displacement vector and strain tensor

Calculation of stress tensor and **prediction** of rock fracturing



Modified from Dee, S et al., 2007

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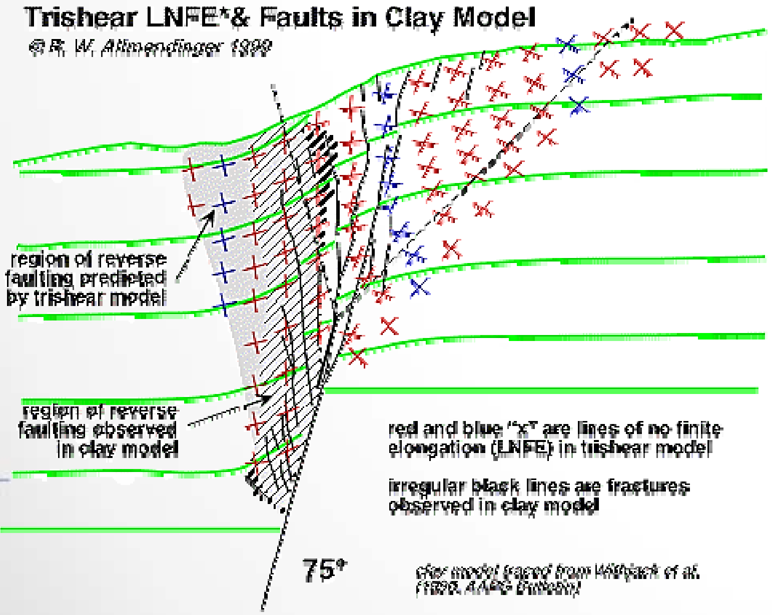
Expected Results

Structural Inverse Modeling

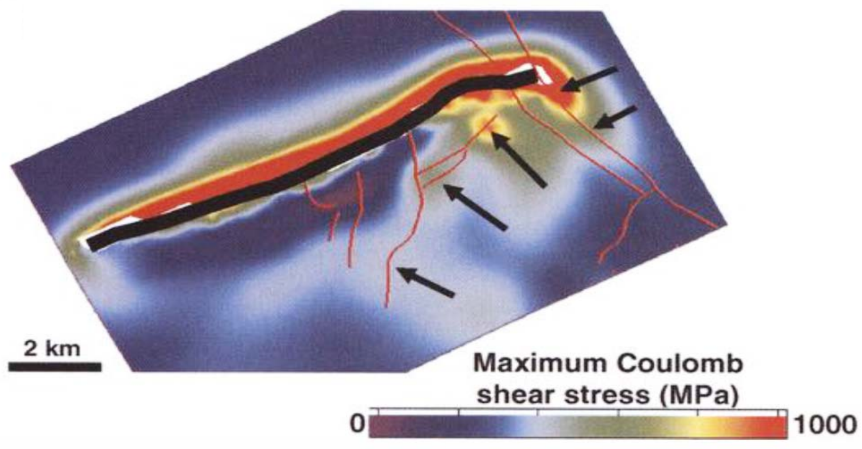
Trishear (Kinematic)

- Well geometry representation;
- Finite strain: magnitude and orientation;
- Lines of no finite elongation (fractures orientation) – 2D;
- Thrust dip angle;
- Kinematic parameters: faults slip, P/S, trishear angle;



Elastic Dislocation (Geomechanic)

- Strain tensor;
- stress tensor;
- Intensity and distribution of the fractures;
- Distribution of displacements in the major fault planes.



Modified from Dee, S et al., 2007

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Thanks

University of Stavanger

Analysis of expected results

- Model validation (anticline geometry);
- The results will be compared with fracture data provided by the wells;
- Comparison with fracture data published in previous works;
- Assessment of how trishear and elastic dislocation complement each other;
- High confidence resulting models. Output data can be used as input parameters for further fracture model generation.

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Outline

- The problem
- Objectives
- Case study
- Previous studies
- Methodology
- Expected results
- Analysis of expected results

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Lavinia Lenig
2 December 2016

Applications of Artificial Neural Networks for Modeling Biogas Production

Supervisors:

Dr Mohsen Assadi (University of Stavanger)

Dr Homam Nipkey (University of Stavanger)

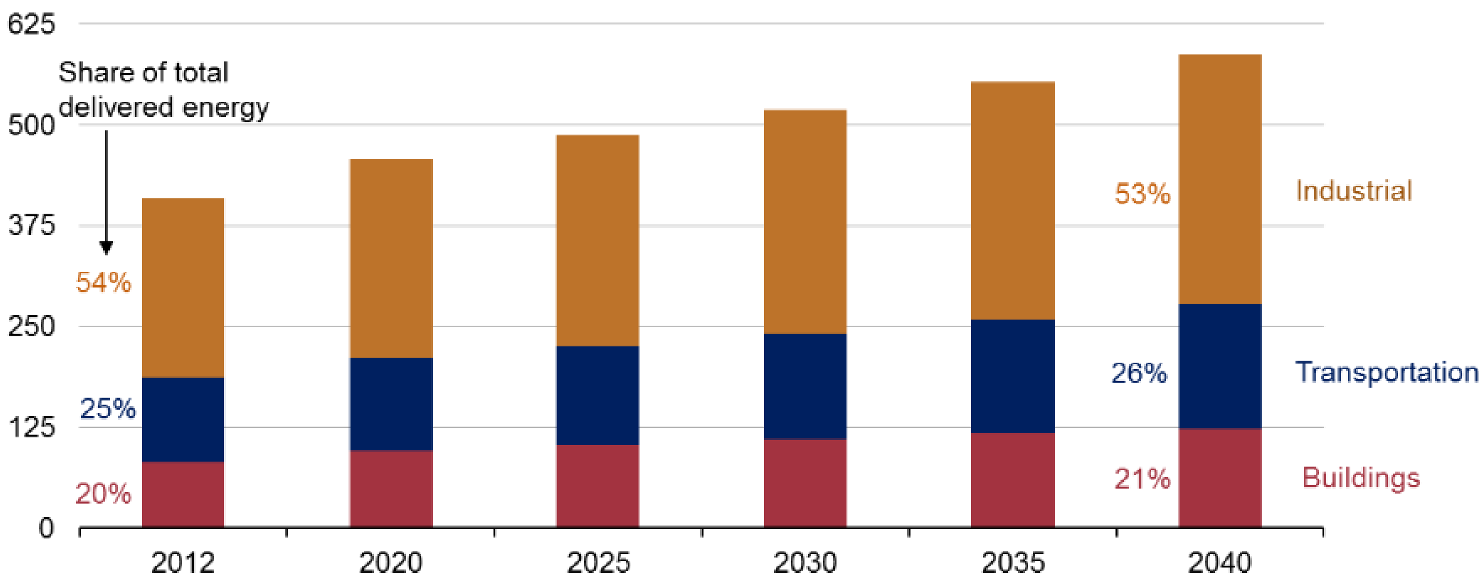
Outline

1. Introduction
2. Objectives
3. Methodology
4. Data

Introduction

- Decreasing amount of fossil fuels resources
- Growth of population and industries
- Overall goal for most of the developed countries in the world: Increase of renewable energy consumption

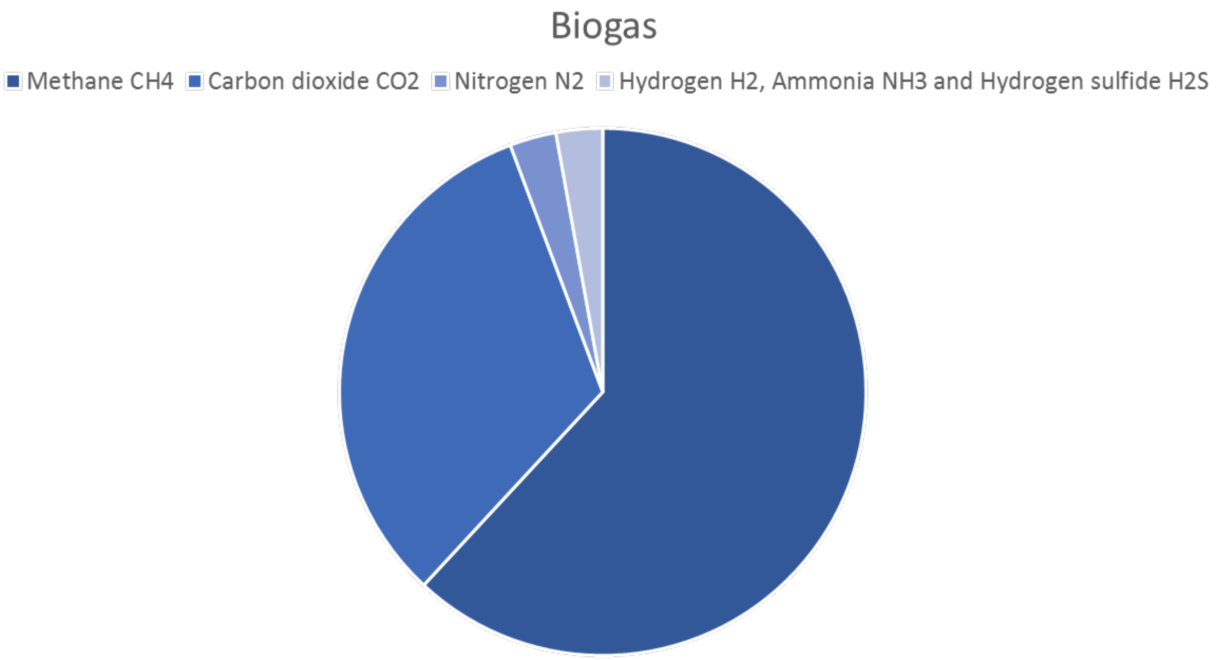
Total energy consumptions grows by end use sector (quadrillion Btu)



After: EIA, International Energy Outlook 2016

Biogas

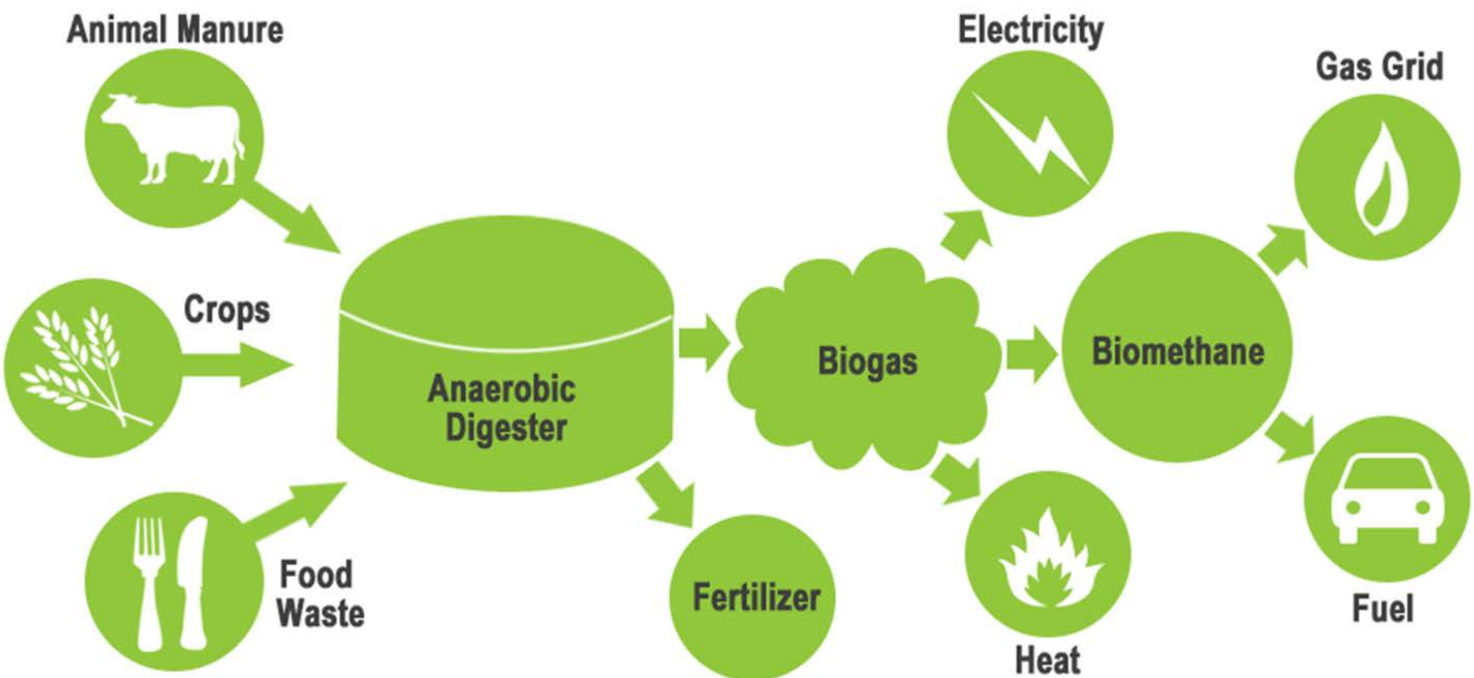
- One of the most promising renewable energies
- Fuel gas
- The valorization of biogas can be heat or electricity, a combination of both is also possible



After: Abu Quadis et al., 2009

Anaerobic digestion

- Biogas is produced through the fermentation of biodegradable materials or the process of anaerobic digestion
- Anaerobic digestion is the most beneficial and advantageous process to convert biomass into energy
- ANNs are tested to understand which organic compounds are most suitable for biogas production and supply the highest energy outcome

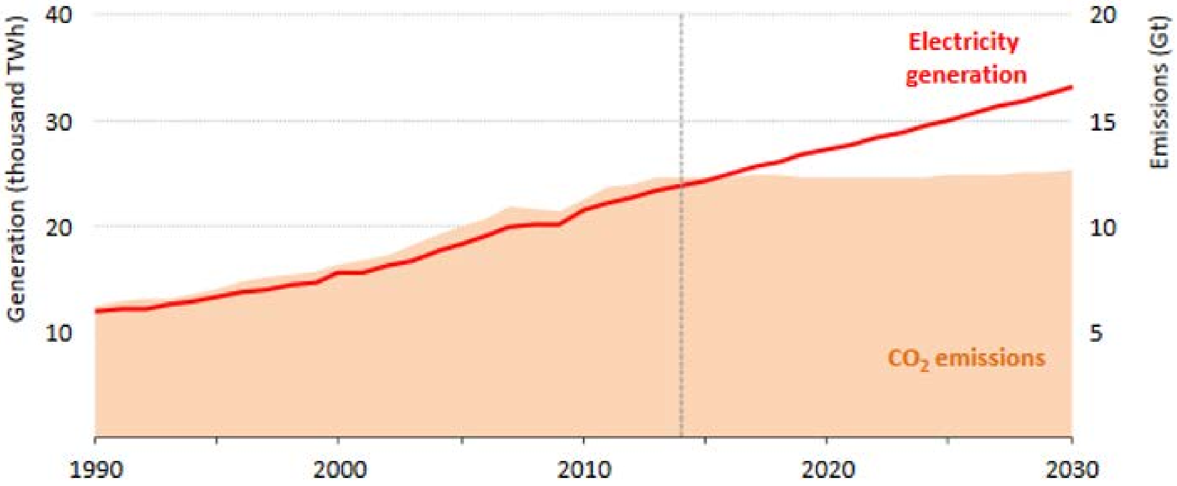


After: GLW Energy 2016

Clean energy option

- The biogas production process is a clean energy option for reducing energy dependency and greenhouse gas emissions
- The main advantage is that biogas is nearly carbon dioxide neutral
- The carbon dioxide that is formed through the combustion of organic compounds stays in the carbon cycle

World electricity generation and related CO2 emissions

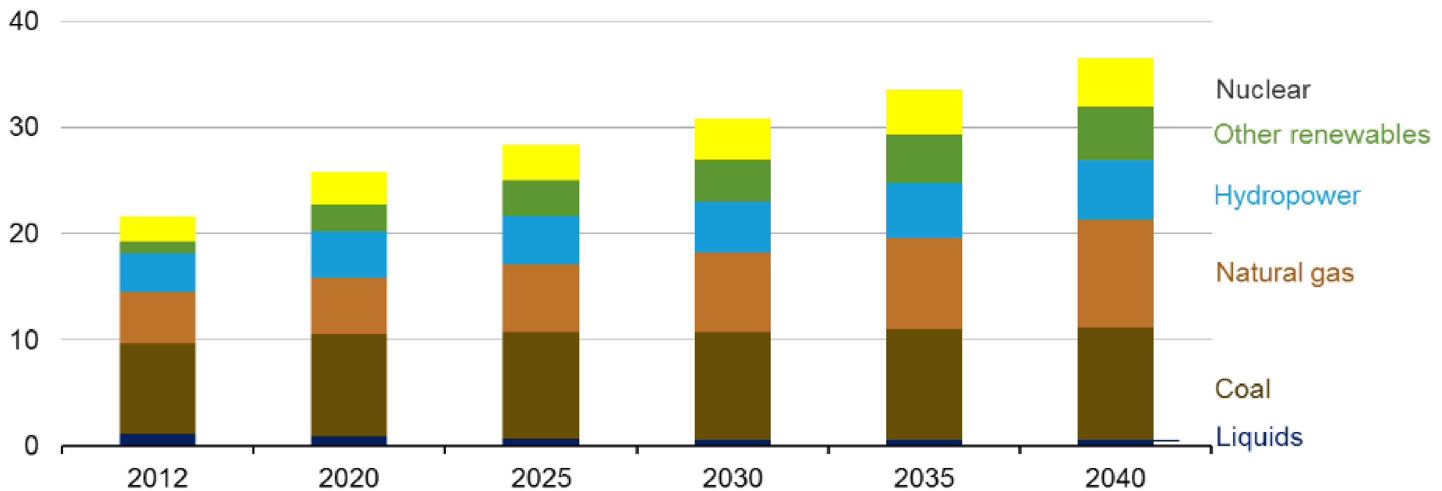


After: IEA, World Energy Outlook 2015

Renewable energy

- Renewable energy is the world's fastest-growing energy source, increasing by 2.6% per year
- In 2012, coal provided 40% of the world's total net electricity generation
- By 2040, coal, natural gas, and renewable energy sources provide roughly equal shares (28-29%) of world generation

<u>Expected world net electricity generation by source (trillion kWh)</u>



After: EIA, International Energy Outlook 2016

Objectives

- Investigation of the scientific literature of ANNs in the sector of biogas production
- Identifying the application area
- Understanding the possibilities and limitations of using ANN
- Identifying the commonly used type of networks for each particular application
- Developing an ANN model to evaluate its capability
- Identifying the optimum ANN structure based on the modeling results

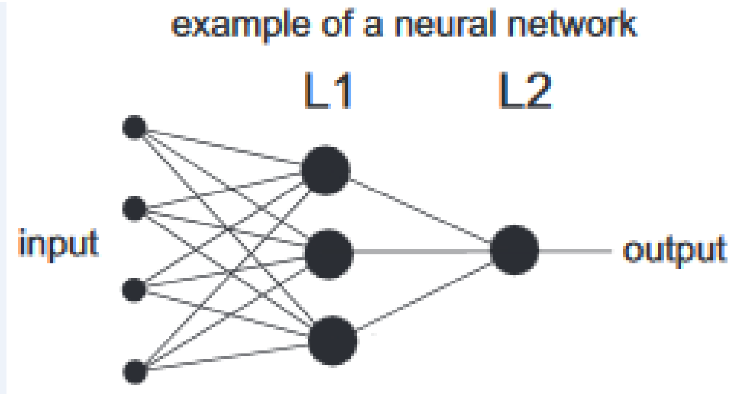
Methodology

- ANN is a data driven method to model and evaluate multidimensional and/or complex systems in different fields of research
- ANN functions as a mathematical representation of the neurological functioning of a brain
- Simulates the brains learning process through mathematically modeling
- ANN models are reliable models for prediction, analysis, simulation, the monitoring process, and the optimization of a process of interest
- Advantages: robustness, speed and capability of learning, predictive capabilities, nonlinear characteristics, and the optimization capability

ANNs

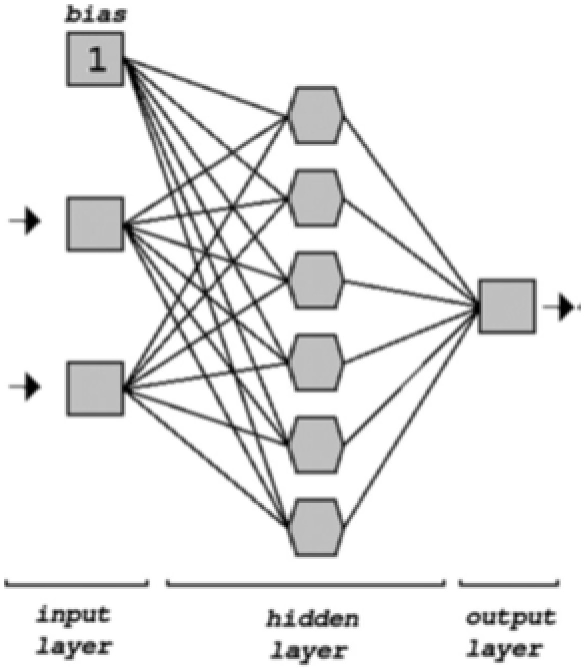
- They are specified by the net topology, the node characteristics, and the training rules
- ANNs are constructed with an input layer, a hidden layer, and the output layer

4-3-1



After: Strike et al., 2005

3-6-1



After: Benoìt et al., 2013

Data

<u>Step-by-step development of the model:</u>

1. Data analyzing
2. Selection of input and output parameters
3. Data filtering
4. Selection of training and validation data sets
5. ANN training and validation
6. Sensitivity analysis
7. Model finalization

Thank you for your attention.

Questions?

Converted wave imaging and velocity analysis using elastic reversed time migration

Farid Ebrahim

Supervisor: Wiktor Weibull

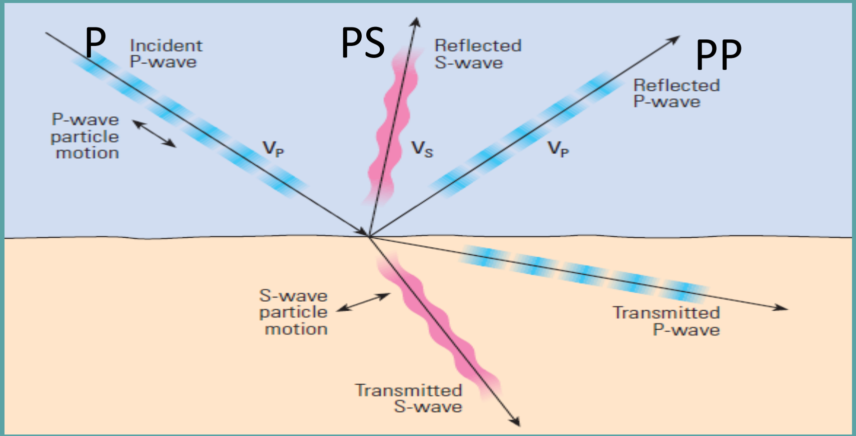
Overview

- Motivation
- Imaging challenges
- Project objectives
- Methodology
  -Imaging (ERTM)
  -Velocity analysis
  -Workflow
- Summary

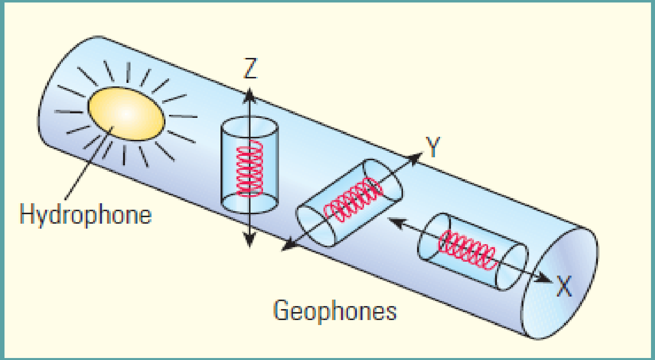
Motivation for PS imaging

PS wave characteristics

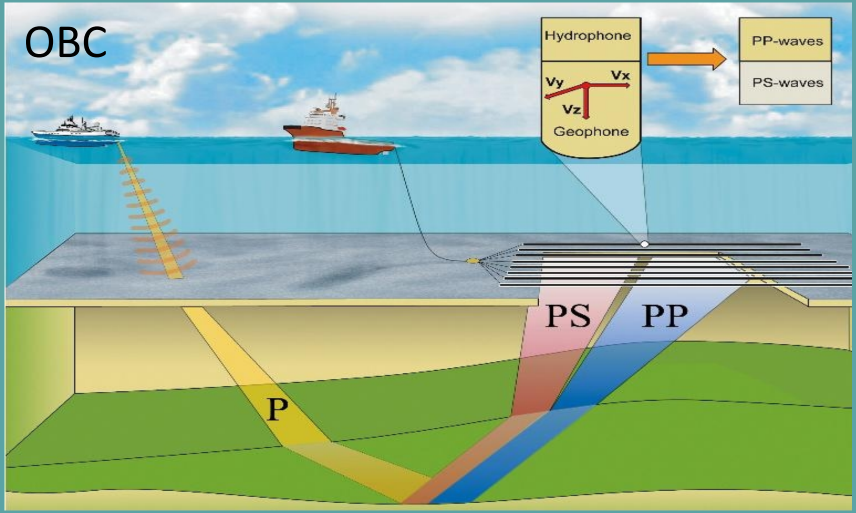
- Lower S-wave velocity than P-wave velocity (shorter wavelength)
- S-waves do not propagate in fluids (Insensitive to fluids)
- Multicomponent data acquisition
- Asymmetric PS ray-path



O Barkved et al. (2004)



O Barkved et al. (2004)

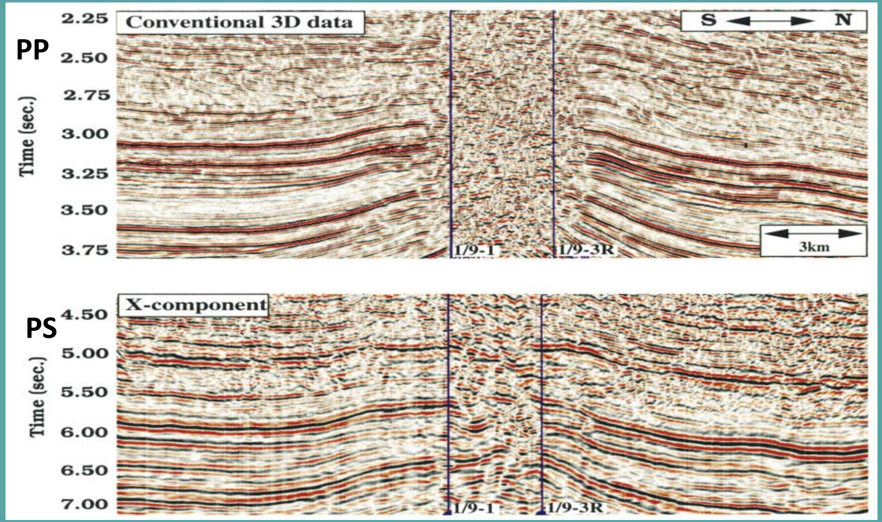


Ikelle and Amundsen, (2005)

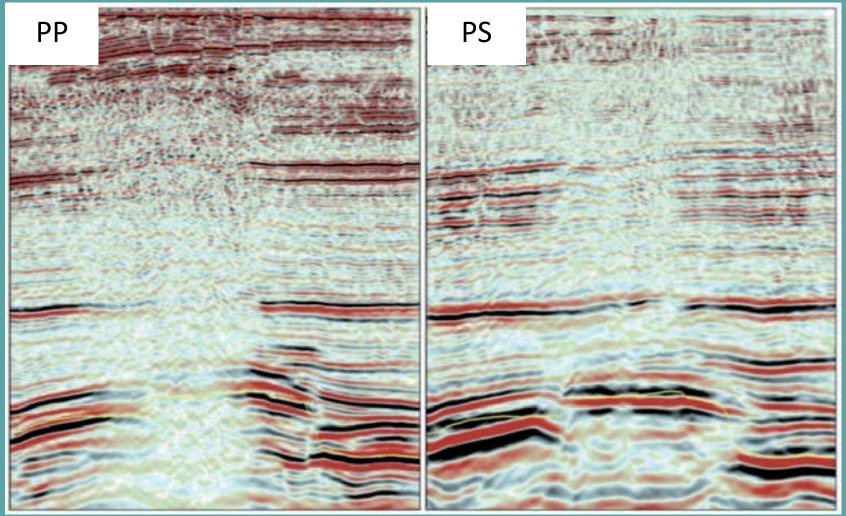
Motivation for PS imaging

PS imaging advantages

- Producing higher resolution images than PP image (shorter wavelength)
- Producing significantly better images through gas zones, and beneath high velocity layers as salt (Insensitive to fluids)
- Mitigating risk in hydrocarbon exploration and production



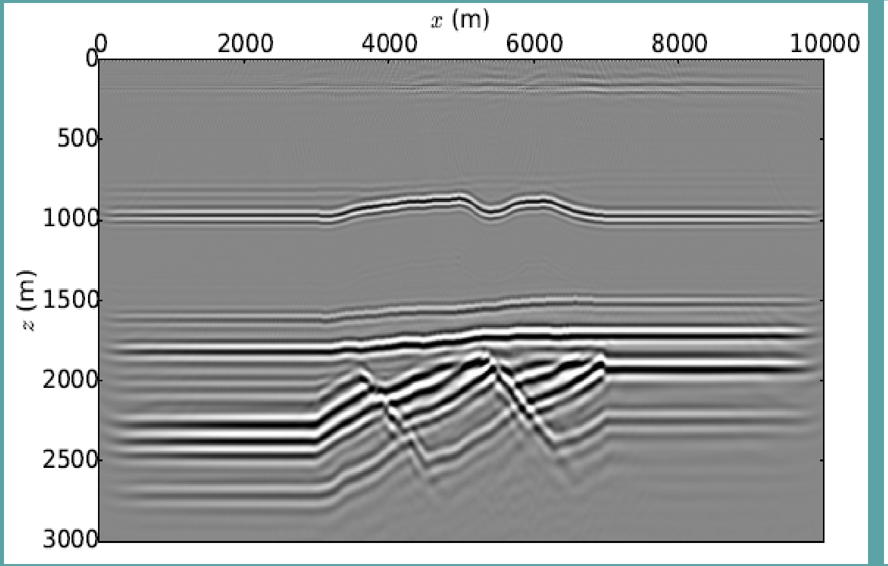
Gas chimney effect over Ekofisk. Granli et al (1999)



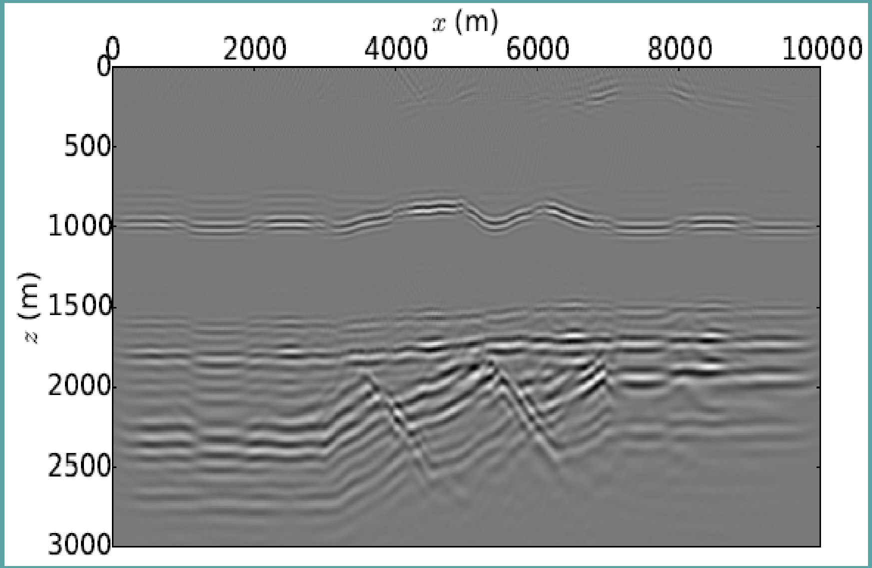
Shallow gas effects. Adopted from CCGVeritas multicomponent brochure (2010).

With great power come great challenges

- Asymmetric PS ray-path
  -Breaching ray tracing theory with infinite number of ray-paths
- Sensitivity to velocity variations
  -Shallow statics



Simulated PS image with true velocity



with near seabed velocity variations.

W. Weibull (2016)

Project objectives

- Produce a workflow to enhance PS imaging in isotropic medium based on:
  - -Using advanced migration algorithm (ERTM)
  - -Producing the optimum velocity model
- Test the workflow behavior and parameters optimization
- Field data application

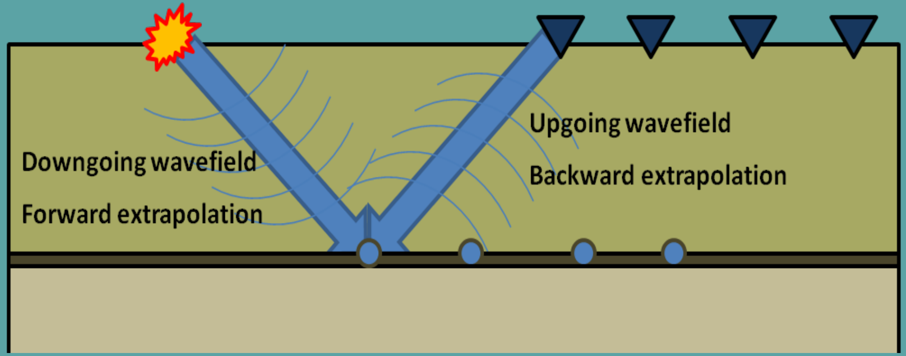
Methodology

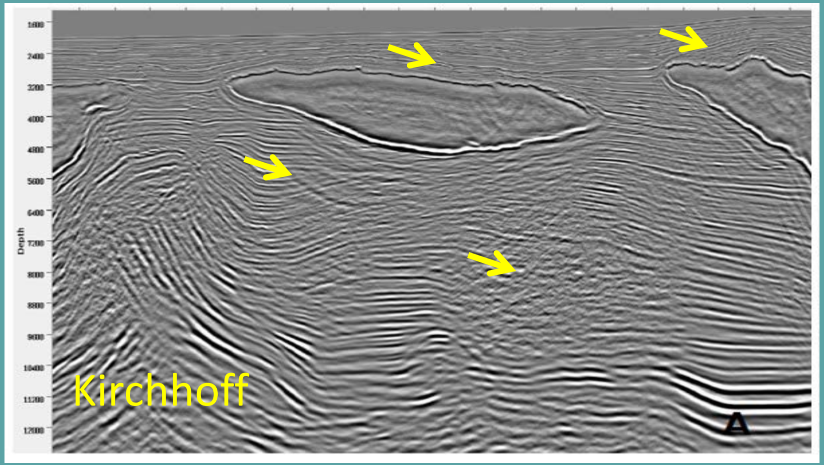
Elastic reversed time migration (ERTM)

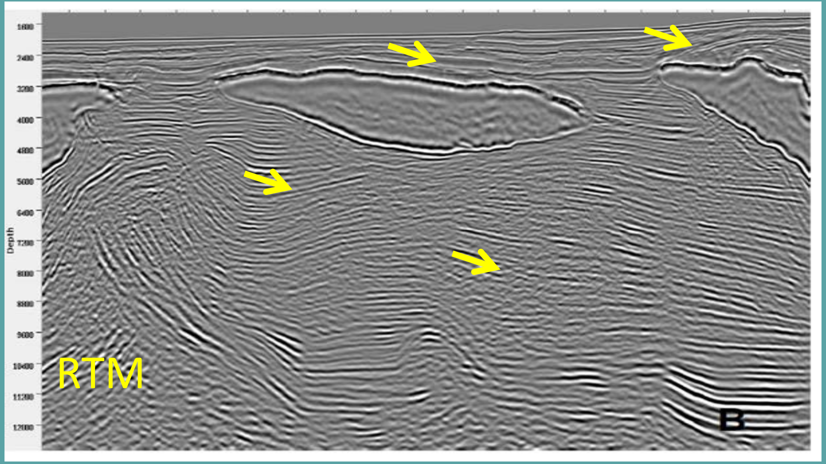
- Two way wave equation depth migration
- Combines steep-dip capability of Kirchhoff and multi-pathing capability of WEM
- Two steps

  1- wavefield reconstruction

  2- Imaging condition







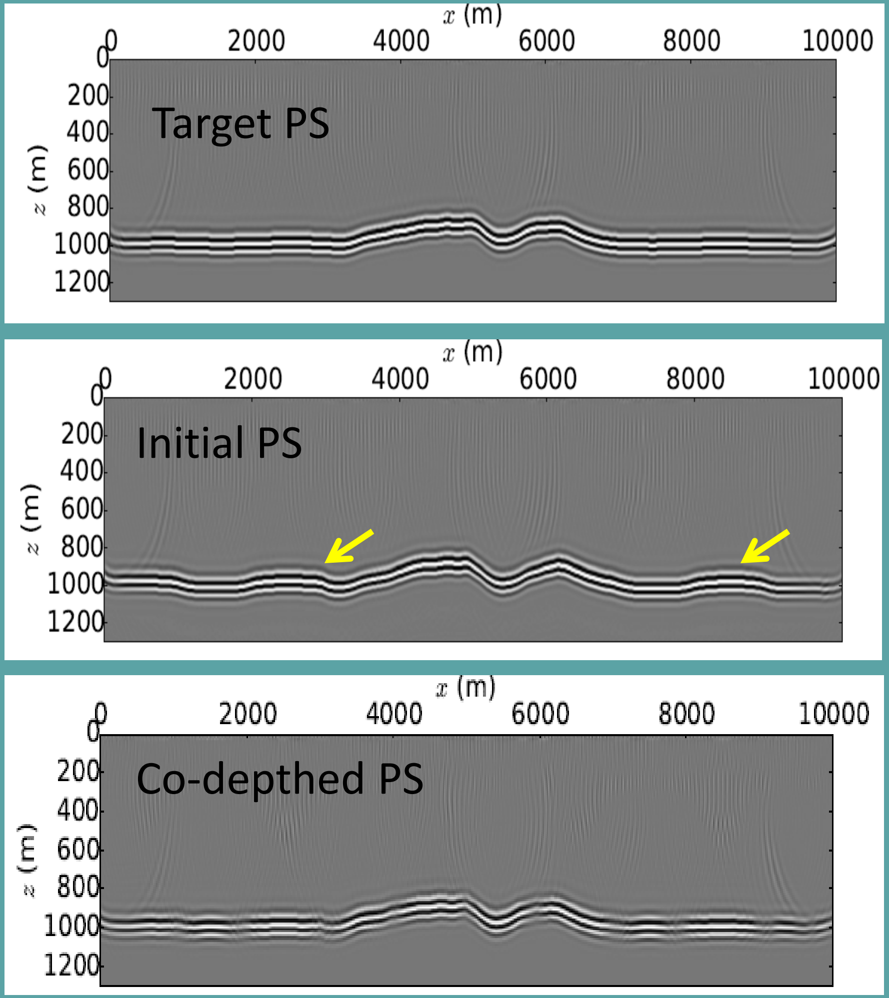
Ma et al., (2011)

Co-depthing and de-migration

- Estimates the velocity that matches PP and PS key reflectors on both depth images

De-migration

- Process to generate target PS image from PP image
- Using Vp model to generate data out of the migrated PP image and re-migrate using Vs model

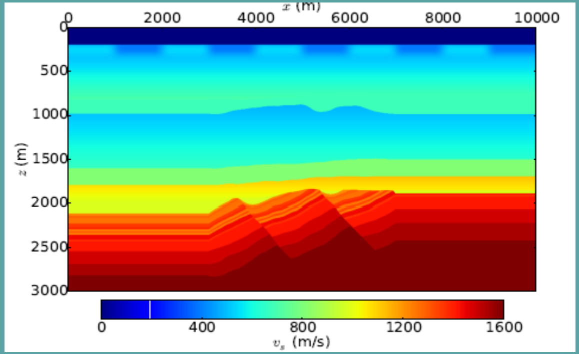


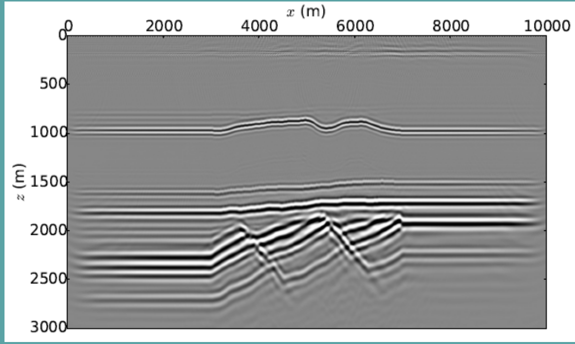
W. Weibull (2016)

Wave equation migration velocity analysis (WEMVA)

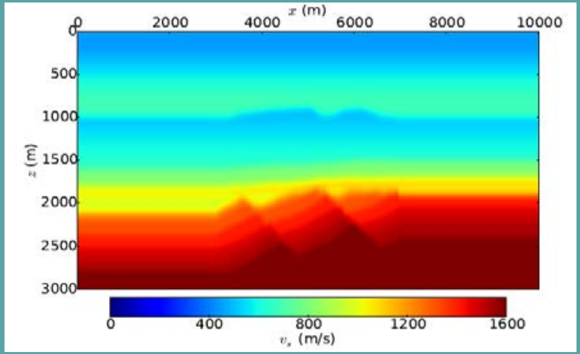
- Automatic iterative inversion of pre-stack data in the image domain
- Maximize the image focusing (Stacking power)

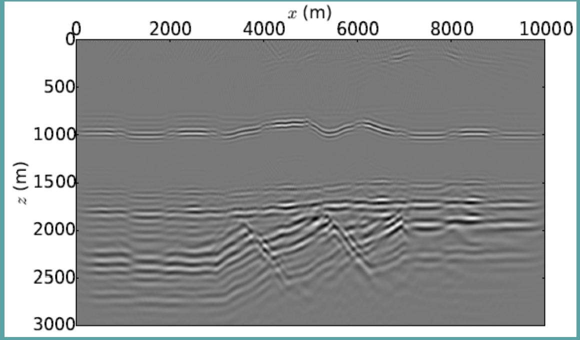
True Vs model



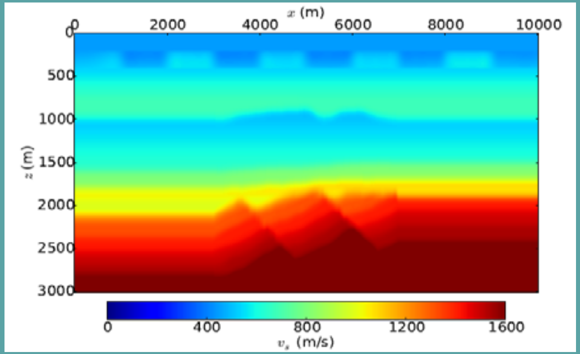


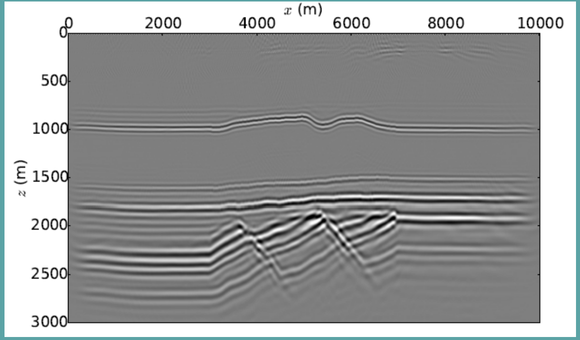
Initial model





WEMVA updated model



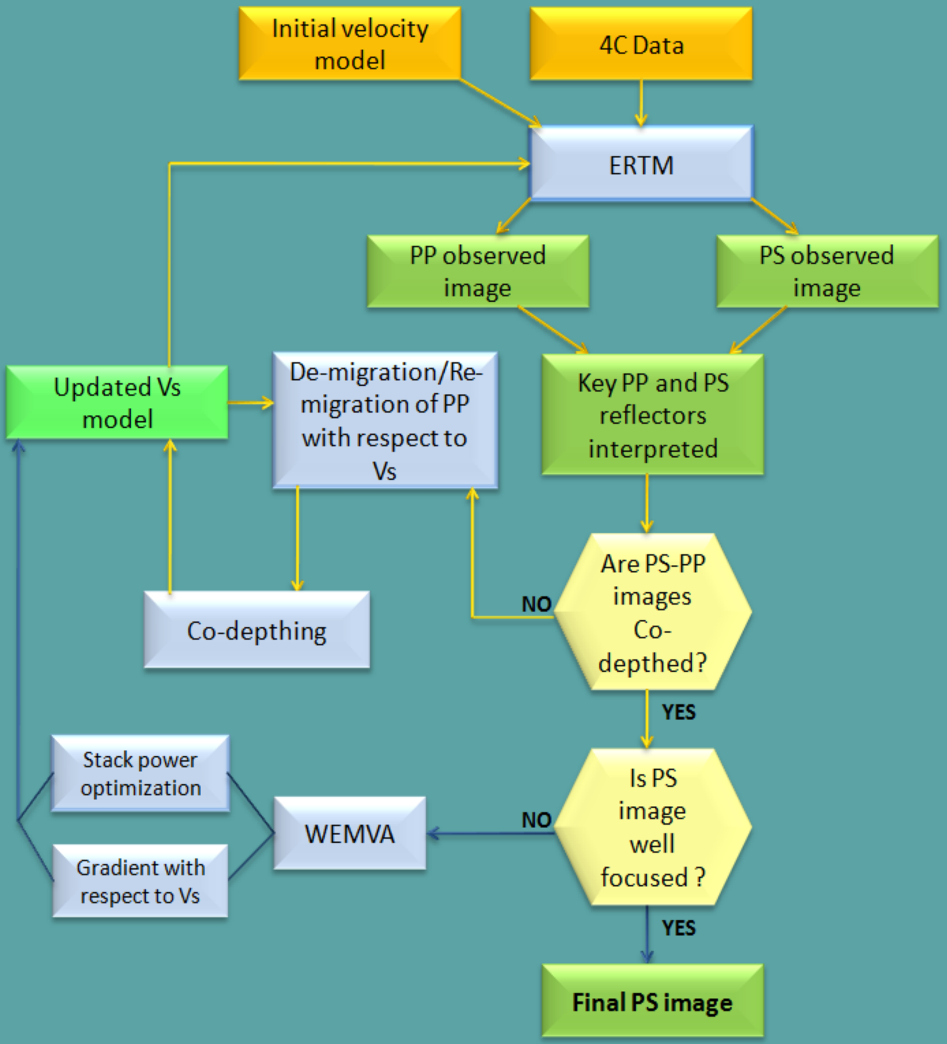


W. Weibull (2016)

Workflow

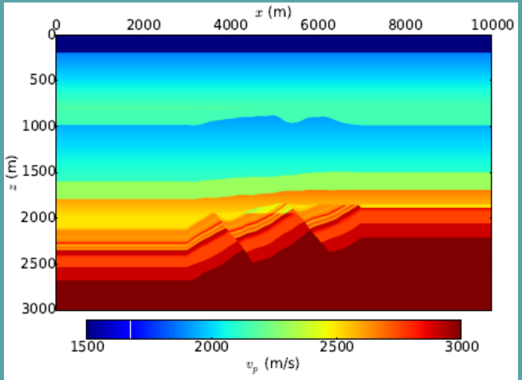
How are we going to do it ?

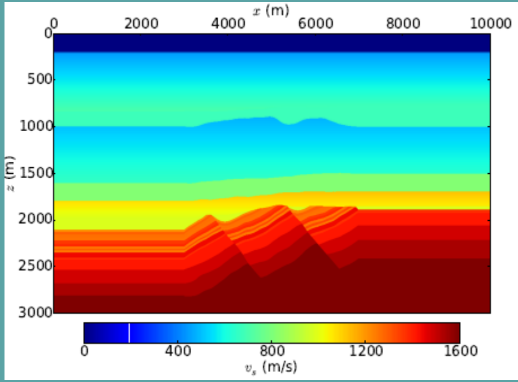
- Final enhanced PS image is
  -Accurately co-depthed
  -Well focused

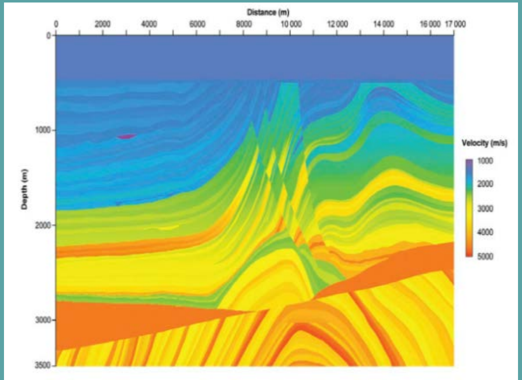


Data

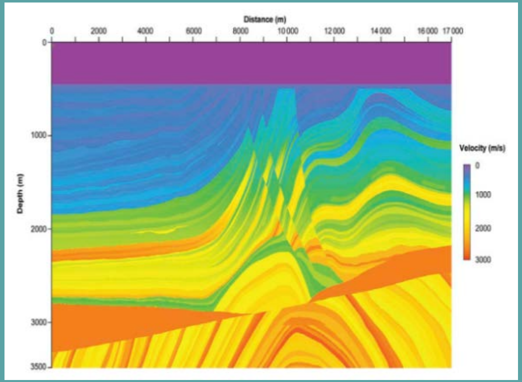
- Numerical models
- Multicomponent Field data
  -Volve field OBC
   (Waiting for Statoil confirmation)
  -Available Blackfoot 3C (land)







Vp



Vs

Summary

- Converted PS data play a complementary role to the conventional PP data
- Imaging PS data is challenging in practice
- The proposed workflow work on producing accurately co-depthed and well focused images.

Thank you!

Questions

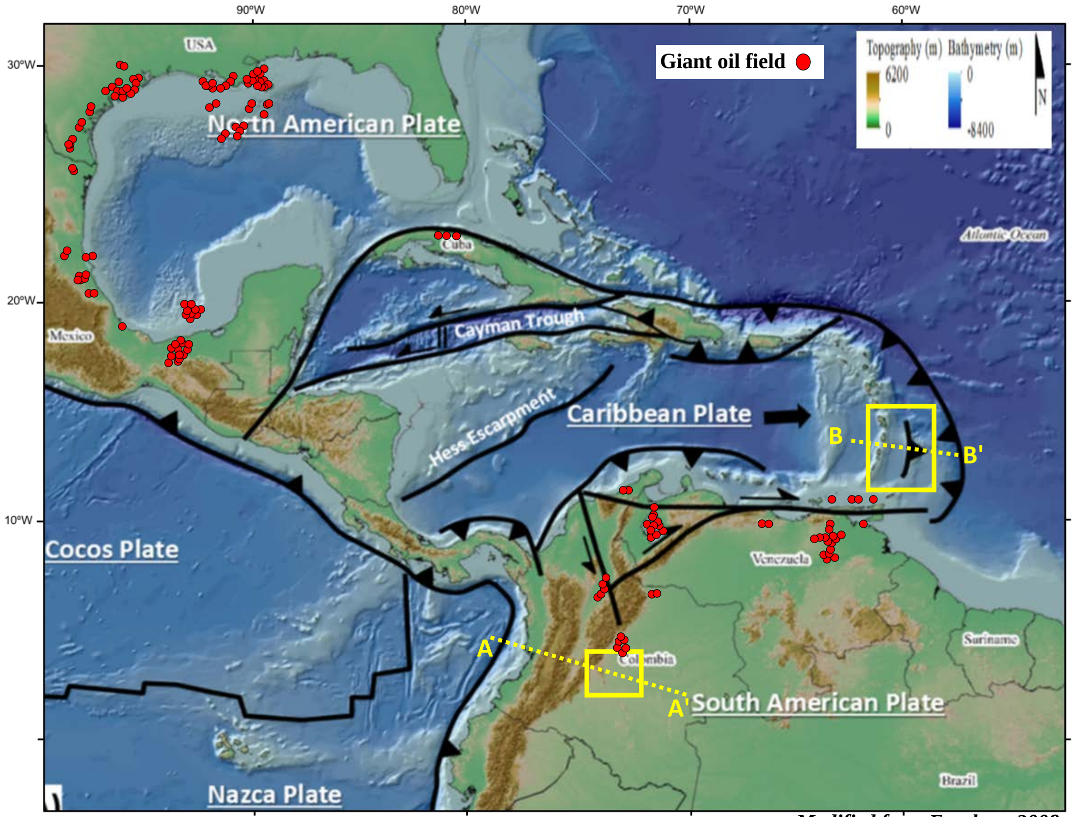
Integrated 2D basin and petroleum system modelling of the southern Llanos basin and the Barbados accretionary prism and easternmost extension of the Tobago basin.

Student: Andres Felipe Cedeño
Supervisors: Alejandro Escalona-Sverre Ohm

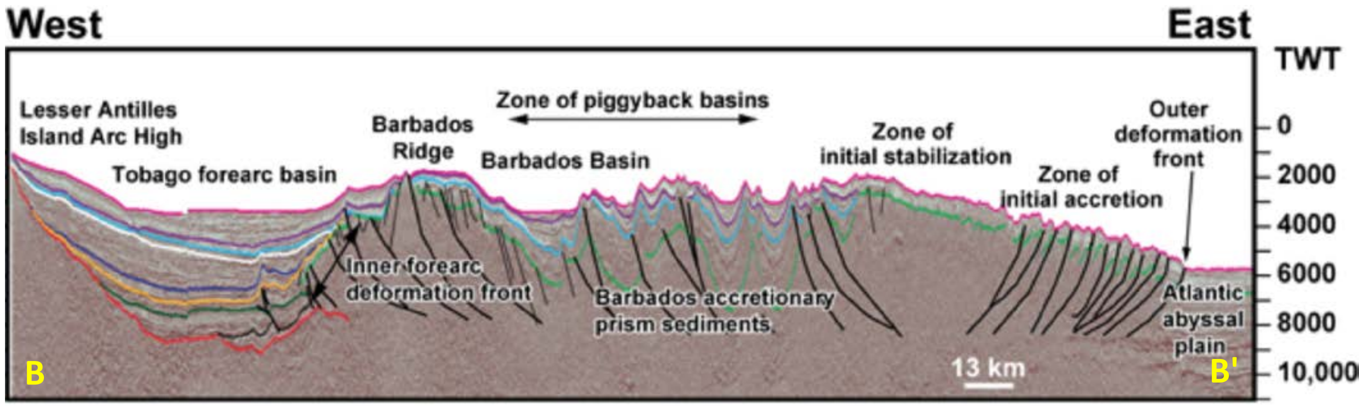
Universitetet i Stavanger

cbth project

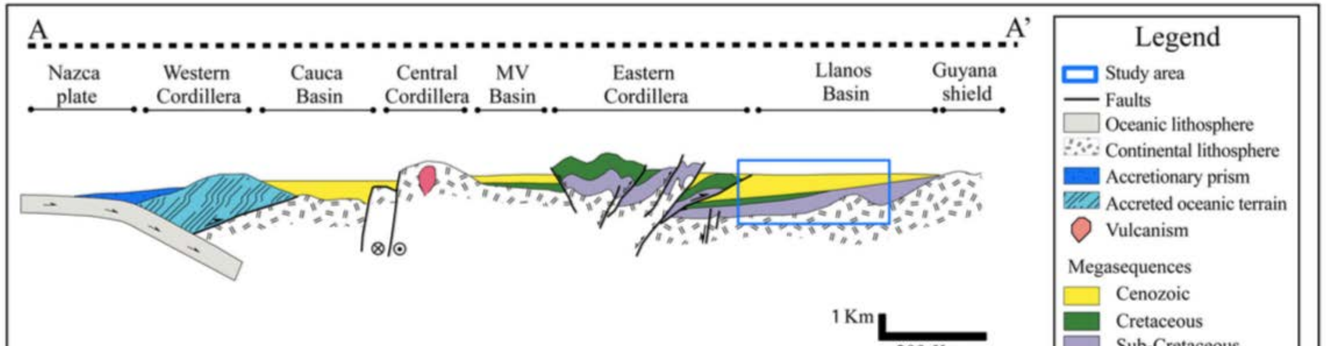
STUDY AREA



Modified from Escalona 2008



Modified from Chaderton 2005



Moreno and Escalona 2015

2 frontier basins

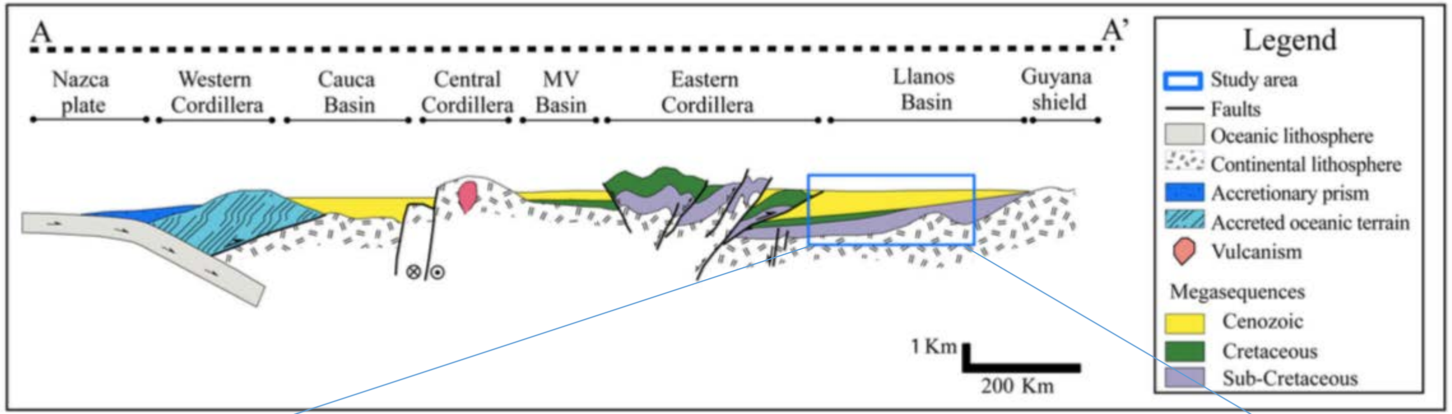
Compressional settings

1. Southern Llanos basin (Paleozoic interval unknown)
2. Barbados Accretionary Prism, Including easternmost extension of Tobago Basin (offshore area has been evaluated).

Economic significance of Caribbean region and Neighboring areas.

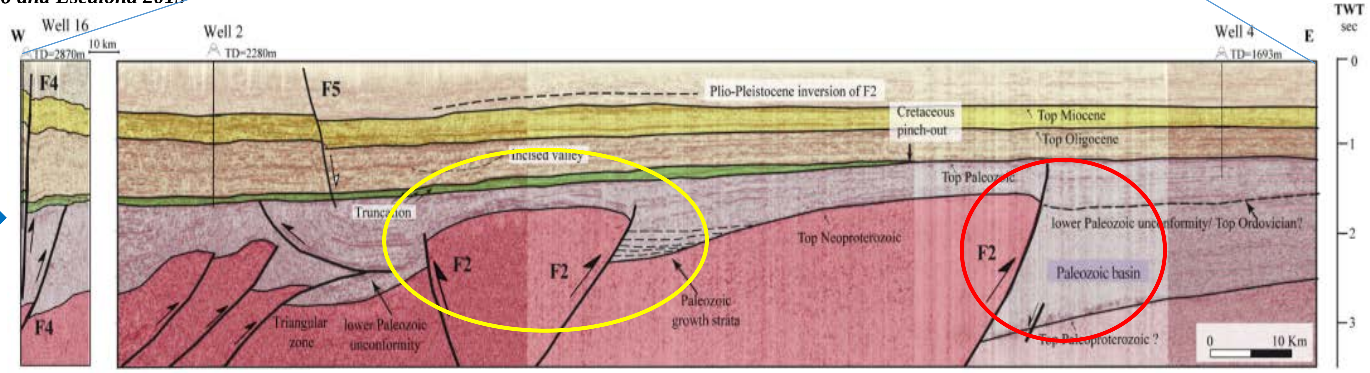
Two in-house projects have been conducted on basin evolution at UIS, but no study on basin and petroleum system modeling has been documented (unprecedented).

GEOLOGICAL SETTING (Southern Llanos basin)

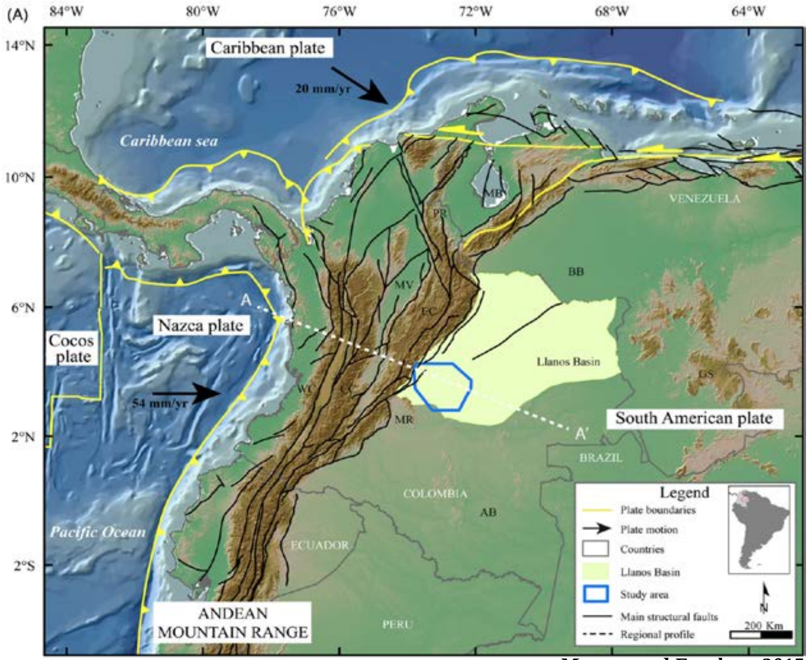


Moreno and Escalona 2015

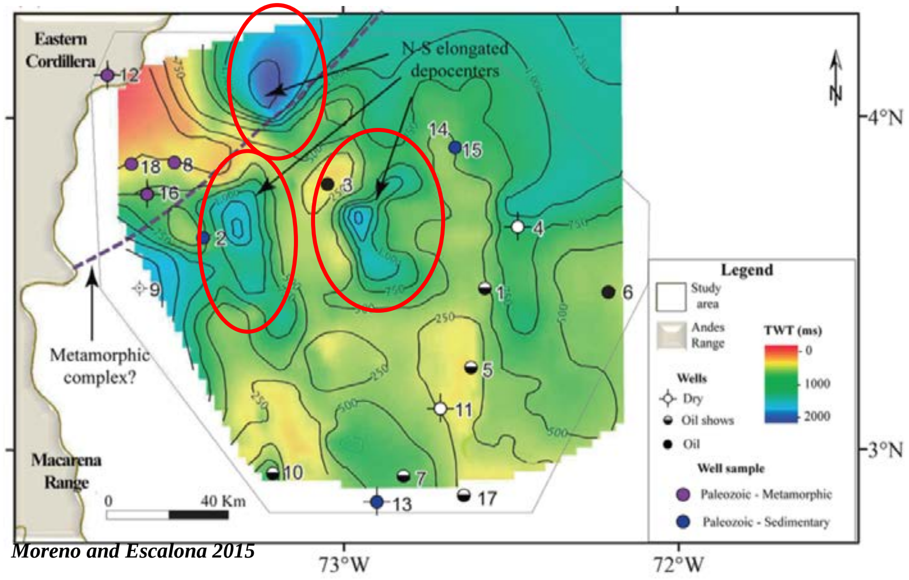
Major uncon



Moreno and Escalona 2015



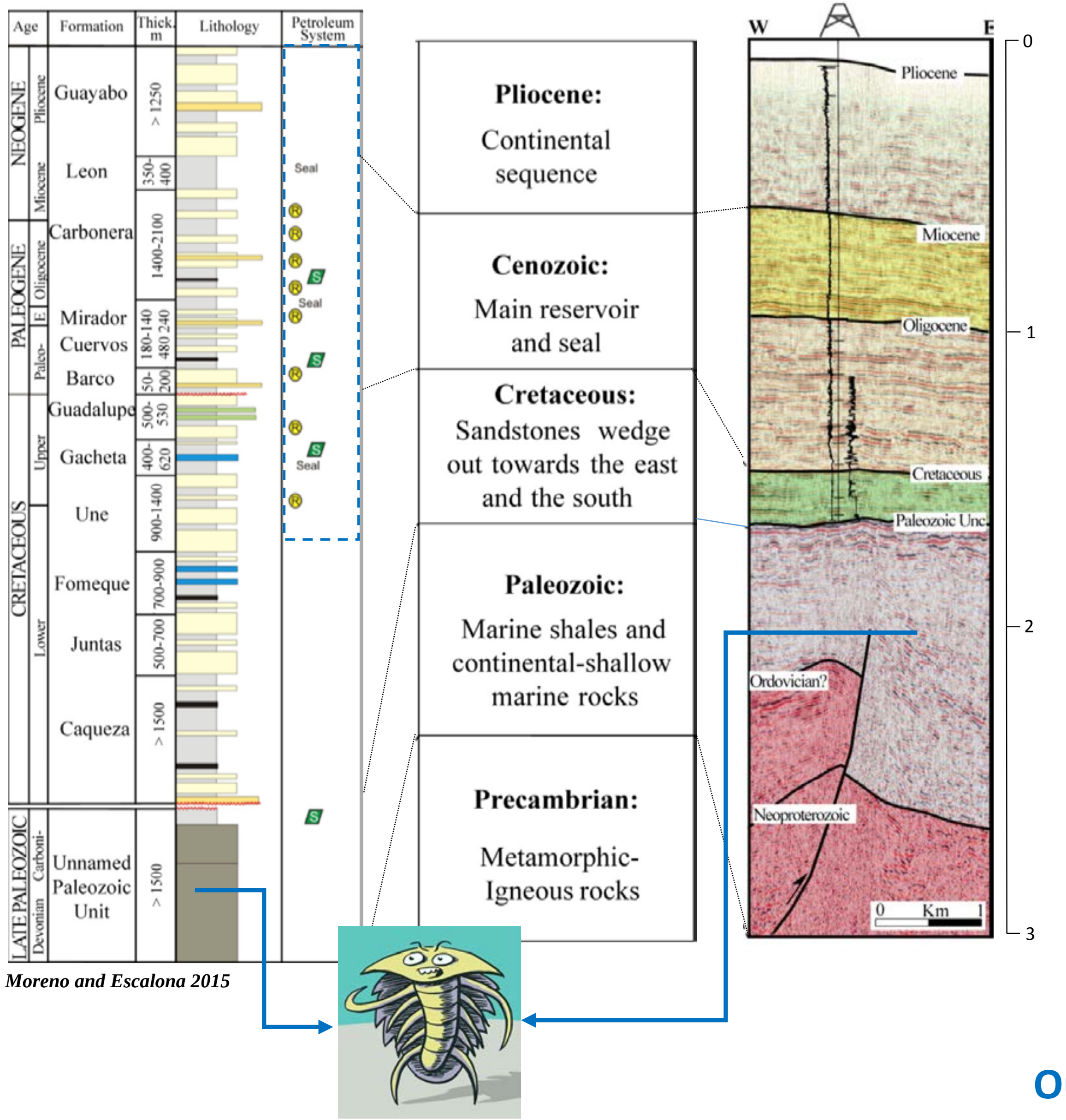
Moreno and Escalona 2015



Moreno and Escalona 2015

- ✓ Part of major Andean foreland basin
- ✓ Precambrian basement- Paleozoic interval- Cretaceous/Cenozoic interval
- ✓ Two structural trends:
  - NS, pre-foreland stage creating basement highs and elongated depocenters
  - NW, foreland stage structures
- ✓ Reactivation in Pleistocene

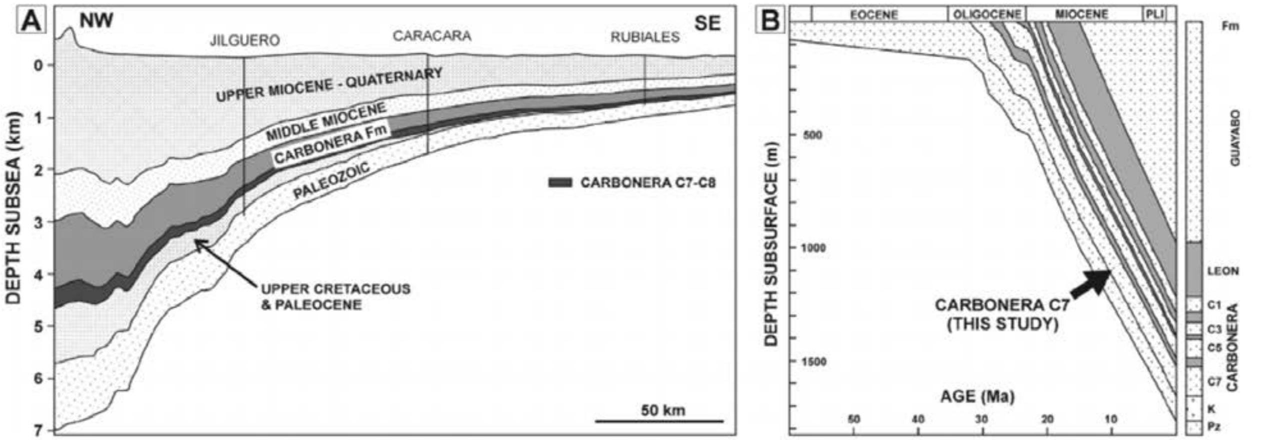
PREVIOUS WORK ON BASIN AND PETROLEUM SYSTEM MODELING (Southern Llanos basin)



Moreno and Escalona 2015

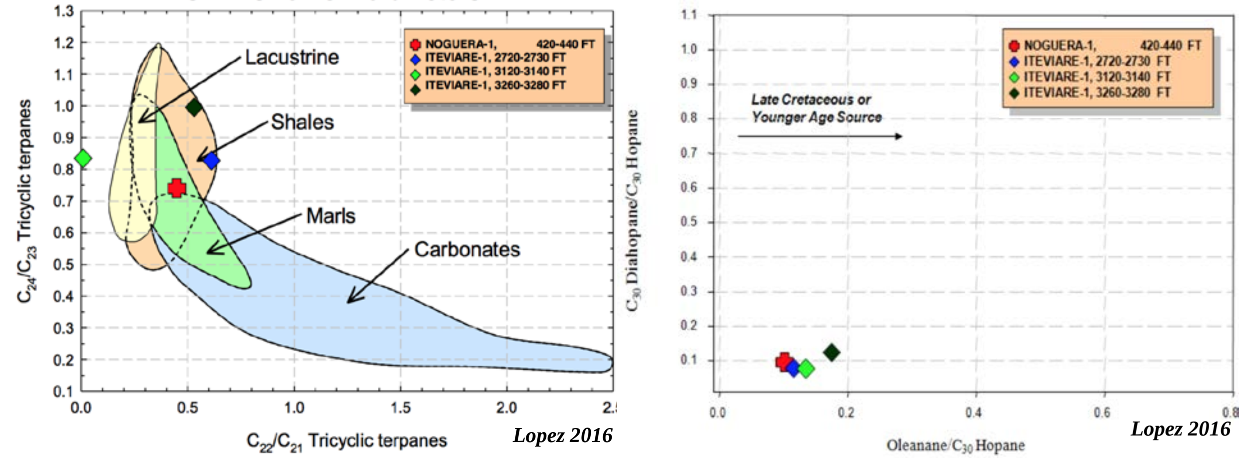
Wrongly ignored the Paleozoic!

Traditional basin modeling exercise for Cretaceous and Cenozoic units in the southern Llanos basin



Castro and Restrepo 2013

Facies and age related biomarkers for a typical oil in the Llanos basin



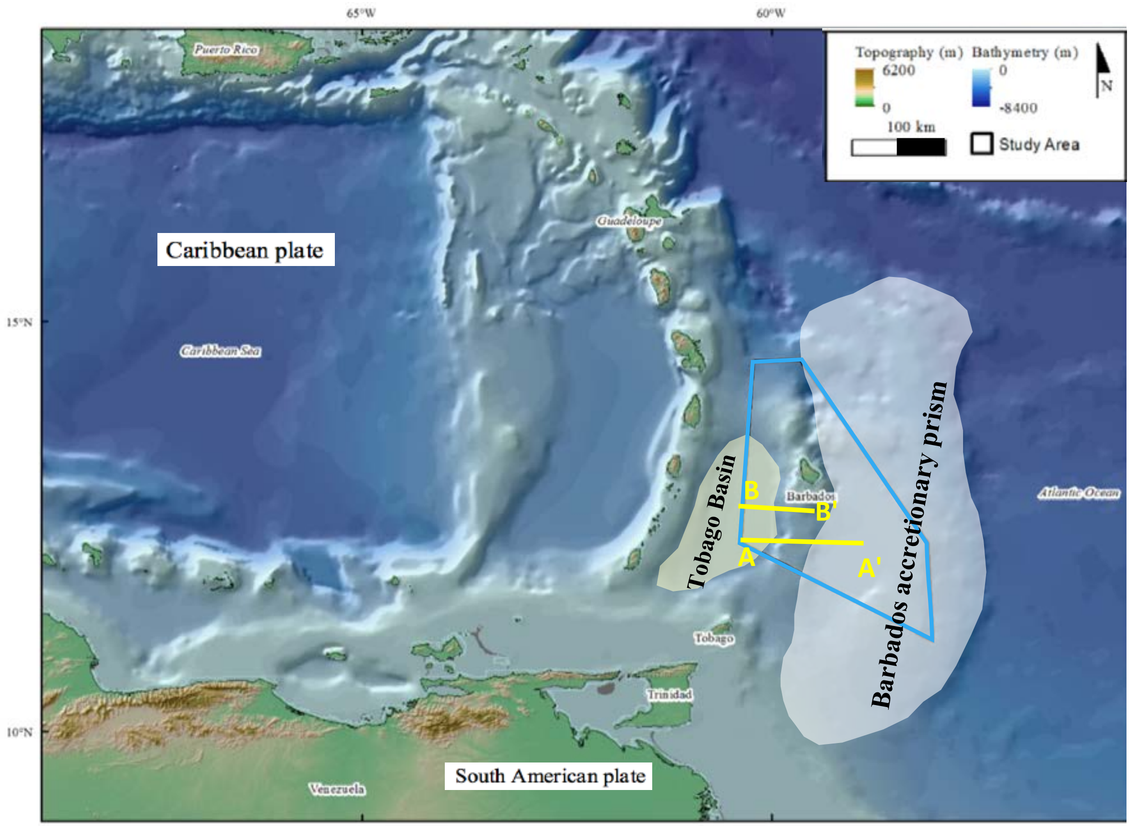
Lopez 2016

Lopez 2016

Outcrops with organic-rich units (source rocks?)

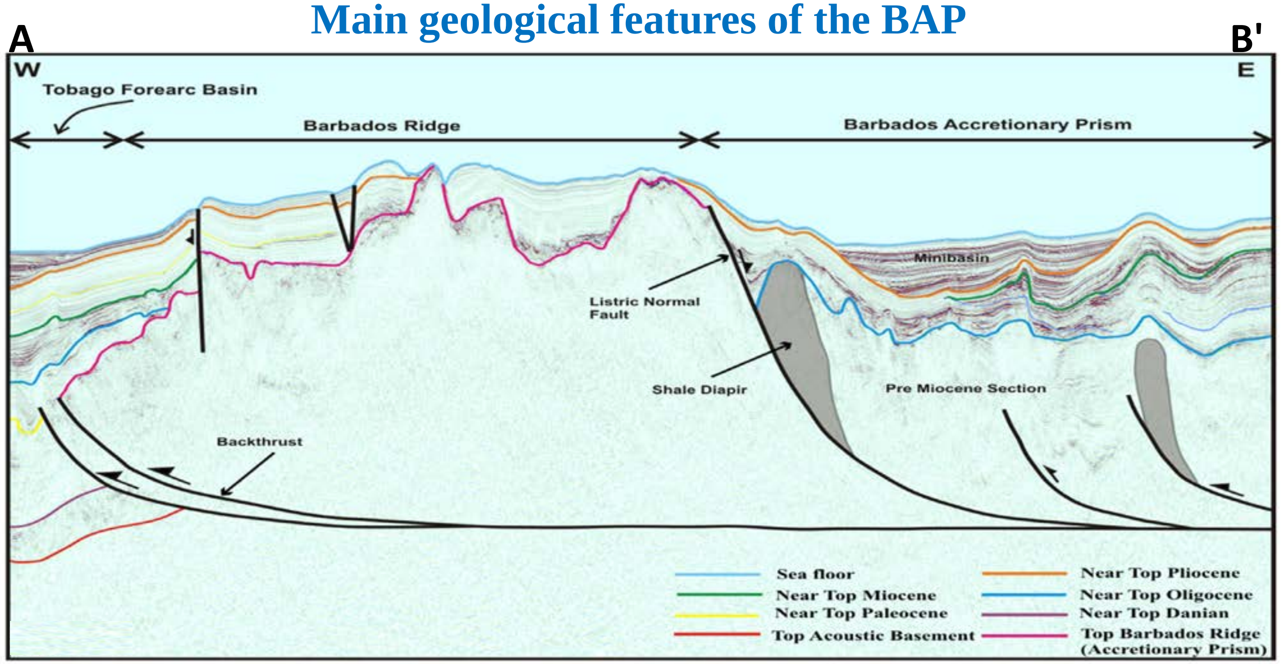
Quarzoarenites deposited in transitional environments (Reservoirs)

GEOLOGICAL SETTING (Barbados Accretionary Prism and easternmost extension of the Tobago basin)



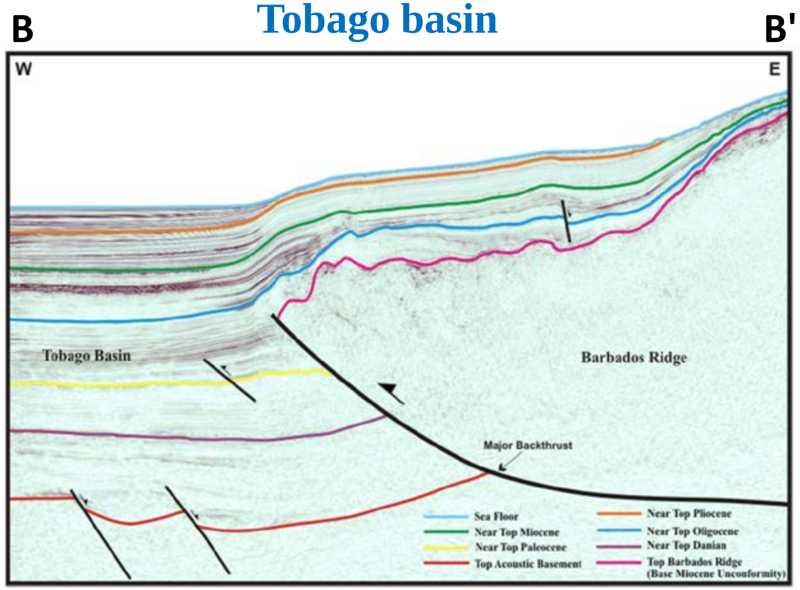
Modified from Jarvis et al. 2008

Main geological features of the BAP



Mudussar 2016

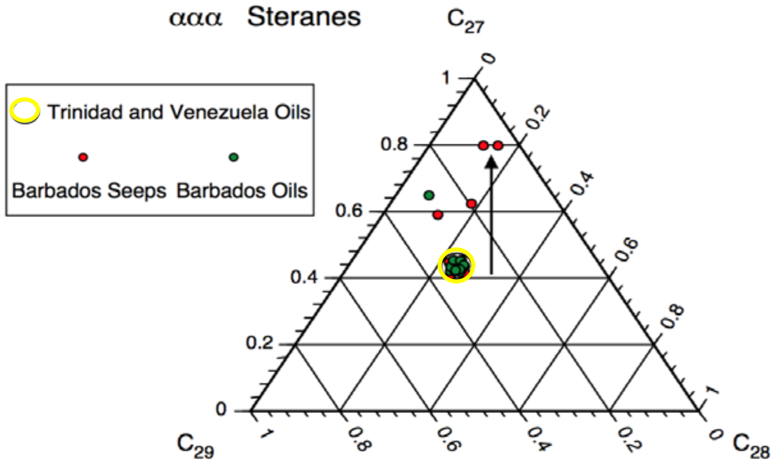
Tobago basin



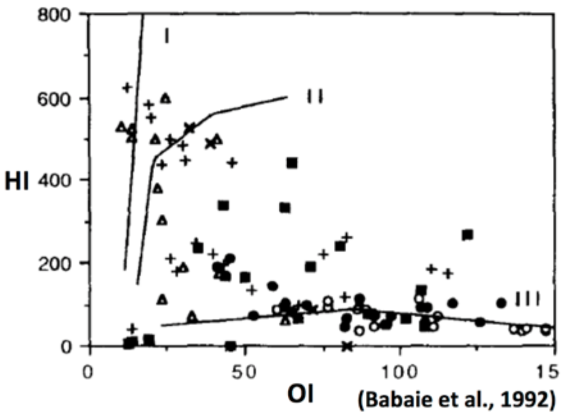
Mudussar 2016

- ✓ Formed due to off-scraping of sediments previously brought to the marine floor.
- ✓ Late Jurassic-Cretaceous oceanic basement.
- ✓ Sediments trusted on the top of each other disturbed by mud activity.
- ✓ half-graven structures inherited from previous extensional phase in the Tobago basin.

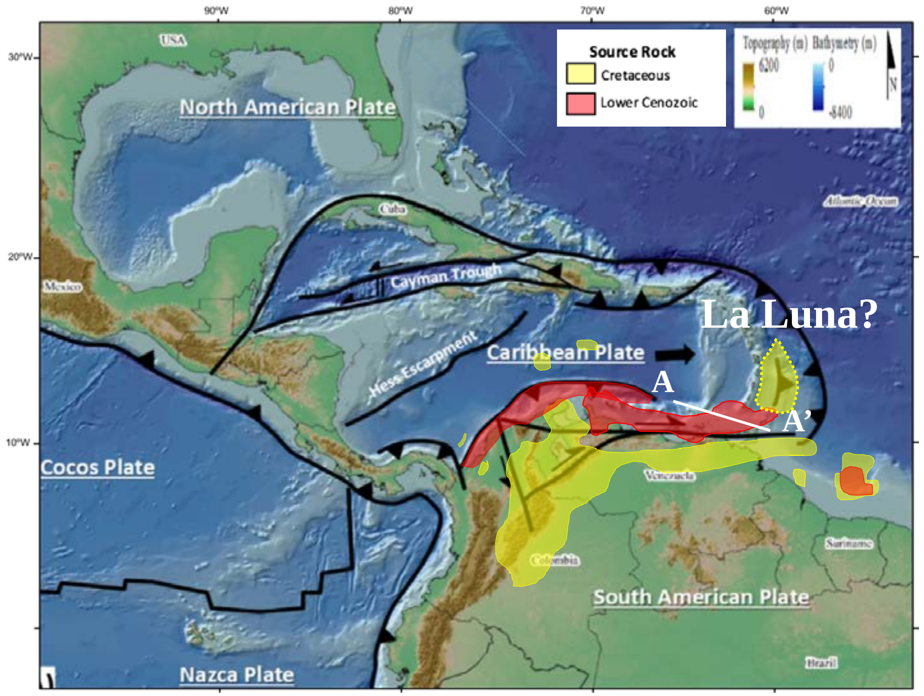
PREVIOUS WORK ON BASIN AND PETROLEUM SYSTEM MODELING (BAP and TB)



Marine, Cretaceous *(Hill and Schenk, 2005)*

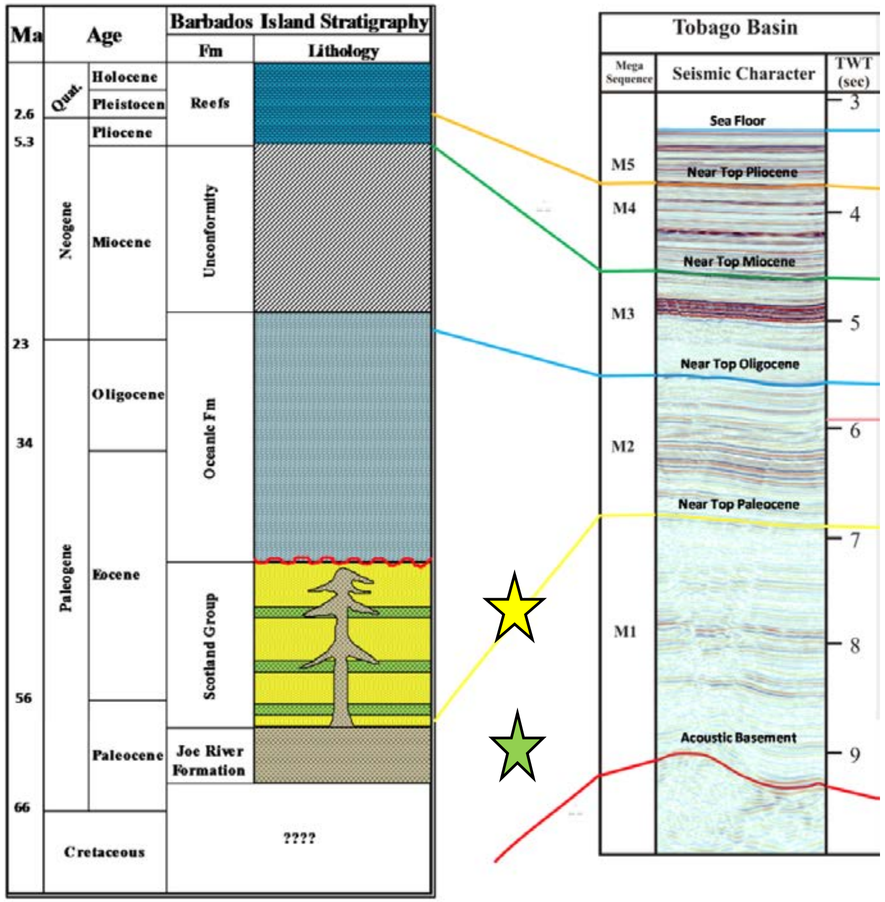


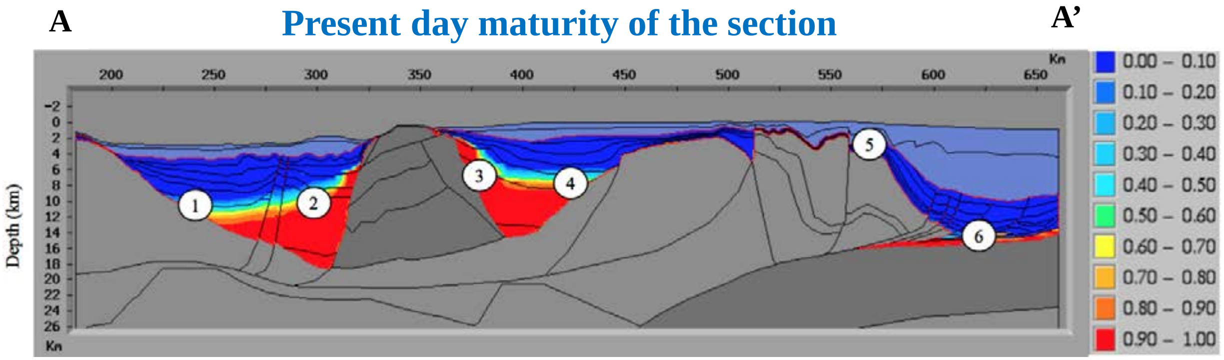
Terrigenous, Paleogene *(Barbaie et al.,, 1992)*



Modified from Escalona 2008

Source rock distribution Cretaceous and Lower Cenozoic rocks





Escalona et al. 2011

OBJECTIVES

To investigate the hydrocarbon potential of the Paleozoic units within the southern Llanos basin and the Barbados accretionary prism and easternmost extension of the Tobago basin.

Recognize the implications of long-term deformation to the thermal history, maturity, and entrapment.

.

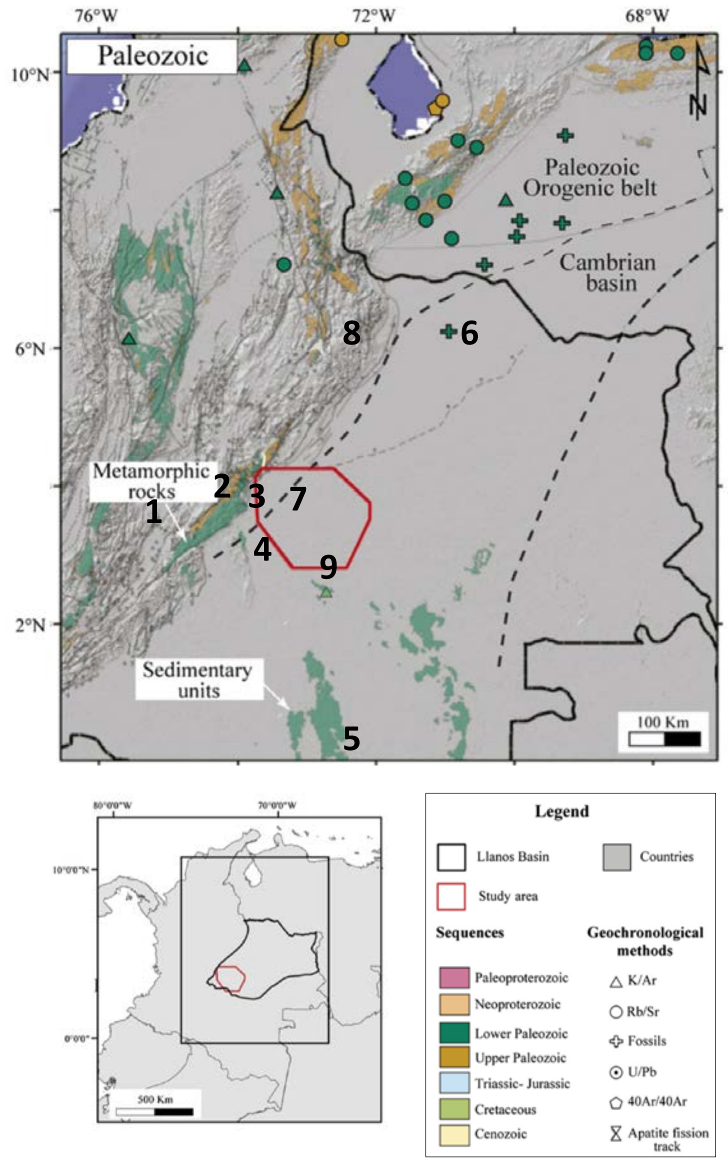
Investigate the impact of reactivation of older sub-Mesozoic structures on the petroleum systems in the SLB

Accurately identify the nature, quality and possible age of source rocks within the BAP/TB.

Establish the number of viable petroleum systems

Determine potential correlation of source rock facies within the BAP/TB with world-class, Cretaceous la Luna-like shales, which are also present in the Cretaceous cover of the southern Llanos basin.

DATA (Southern Llanos basin)



Moreno and Escalona 2015

NEW DATA

Sampling

Eastern Cordillera and Llanos Basin

Ordovician Rocks

1. Fm El Hígado
2. Fm Rio Venado
3. La Uribe
4. La Macarena
5. Fm. Araracuara
6. La Heliera well
7. Negritos well

Devonian-Carboniferous Rocks

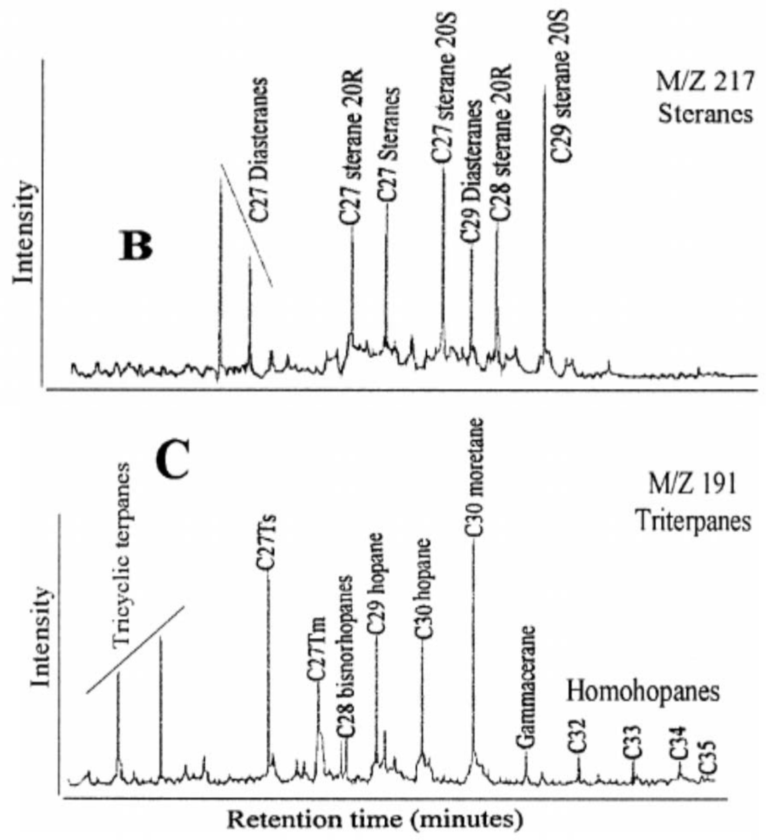
8. Fm. Cuche and Floresta
9. SM-4 Well

Determining potential source rock richness of Paleozoic units

- ✓ TOC (rocks)
- ✓ Rock eval (rocks)
- ✓ GC-GCMS
- ✓ Isotopes

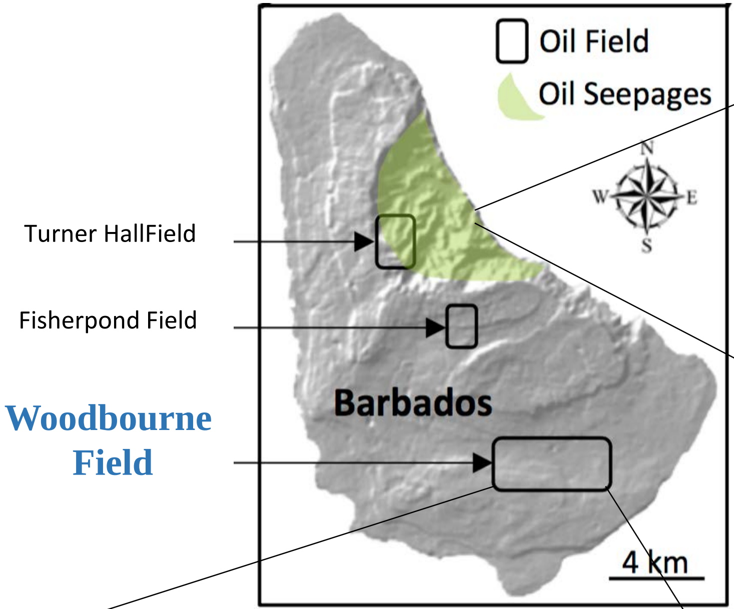
EXISTING DATA

Complete set of Biomarkers from Cretaceous oils

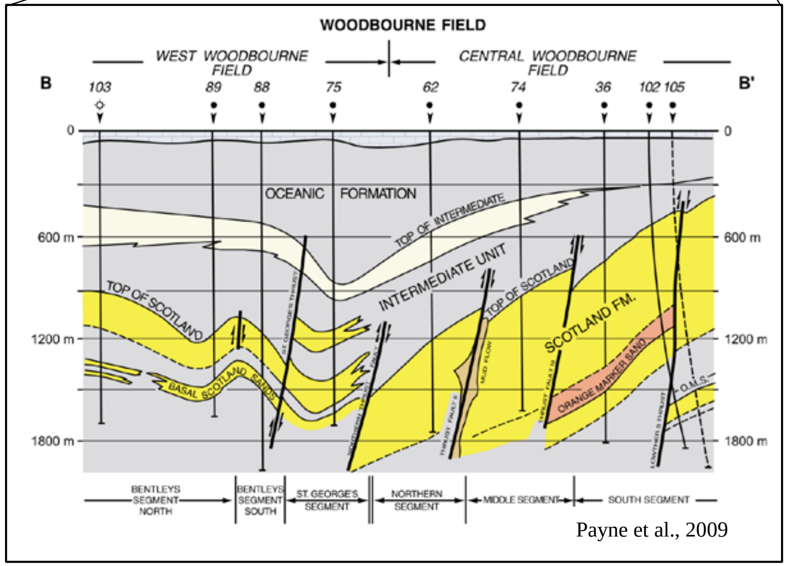


Is there any mixing with compounds older than Cretaceous?

DATA (Barbados Accretionary Prism and easternmost extension of the Tobago basin)



Chaderton, 2009



Payne et al., 2009

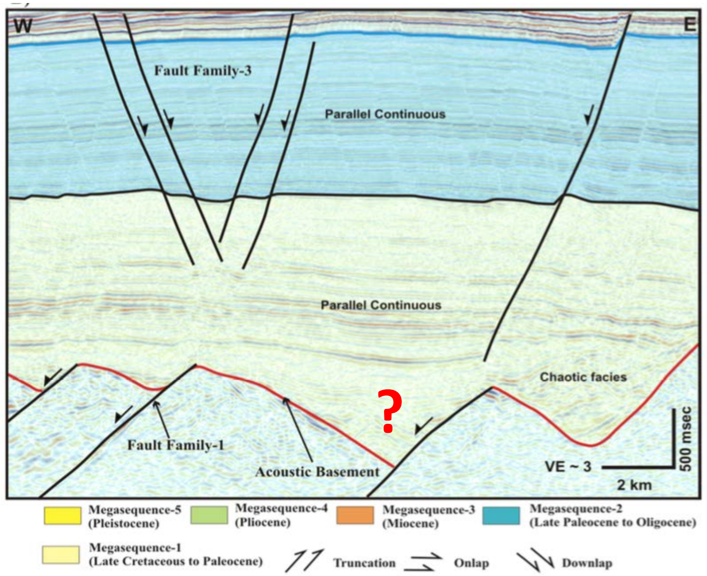
Sampling

- ✓ Outcrops **(Scotland group)**
- ✓ Oil seeps
- ✓ Woodbourne Field oils

Determining potential source rock richness and age

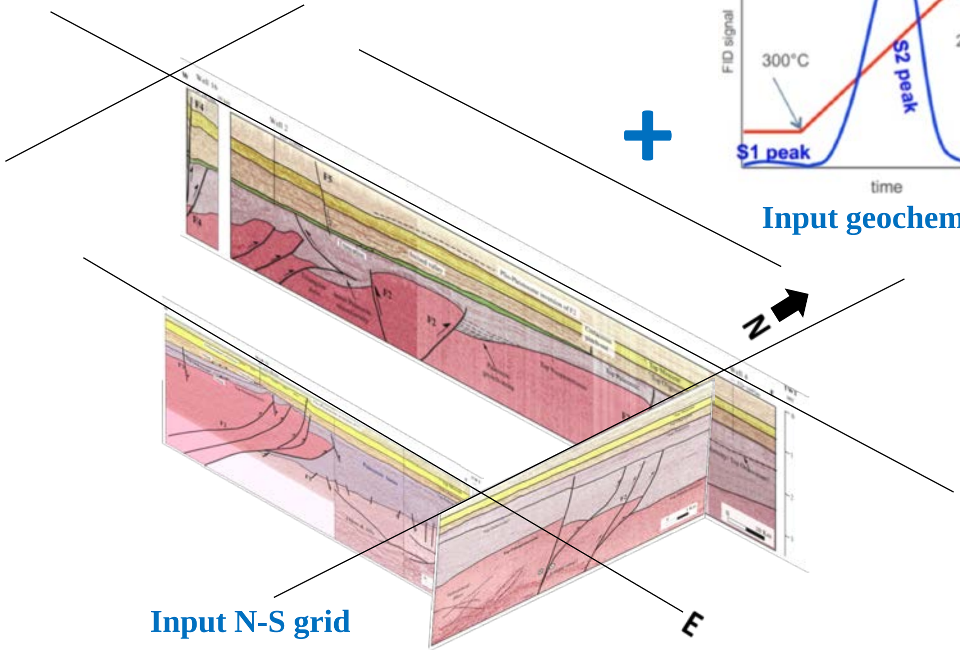
- ✓ TOC (rocks)
- ✓ Rock eval (rocks)
- ✓ GC-GCMS
- ✓ Isotopes

Is there any relation with la Luna fm?



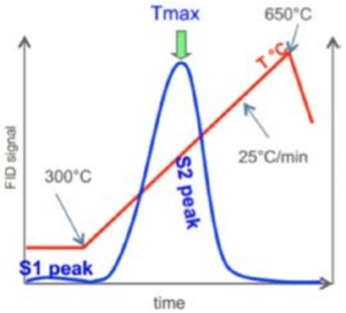
Muddusar 2016

FORWARD MODELING WORKFLOW



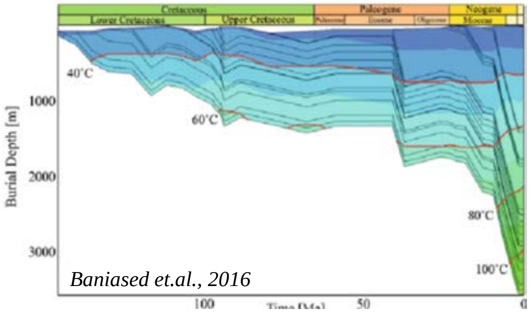
Input N-S grid

+



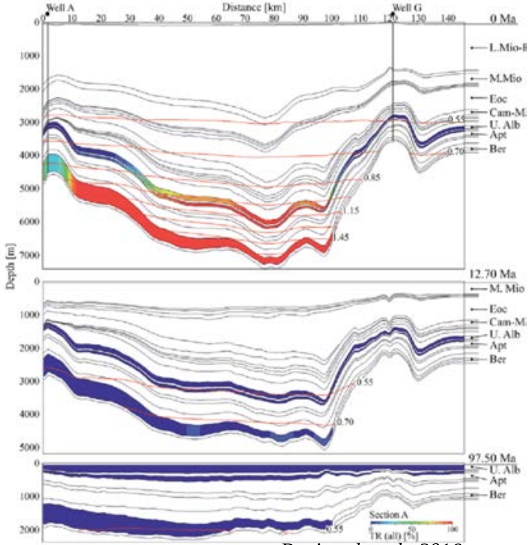
Input geochemical data

Burial and thermal histories and calibration data.



Baniased et.al., 2016

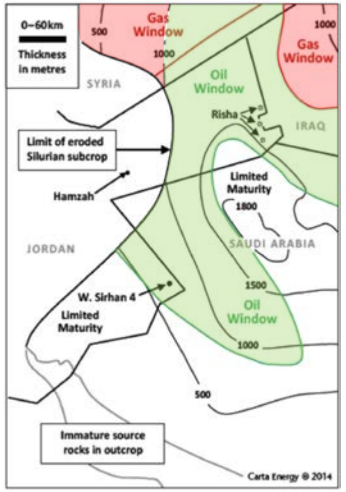
Model burial and thermal maturity pattern

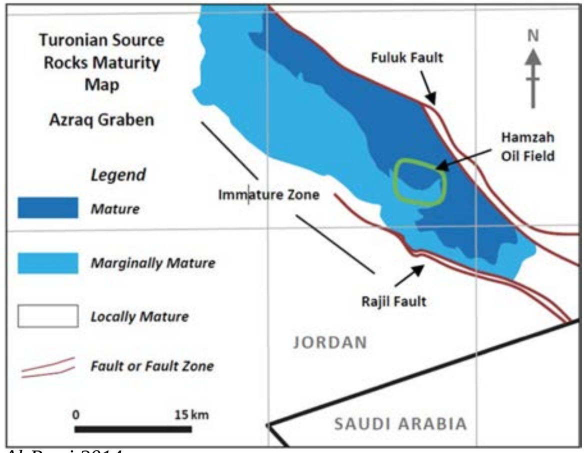


Baniased et.al., 2016

2D BASIN MODELING

Simulate different scenarios inputting diffident parameters





Al-Rawi 2014

Source rock thickness and maturity map

PETROLEUM SYSTEM MODELING

EXPECTED RESULTS

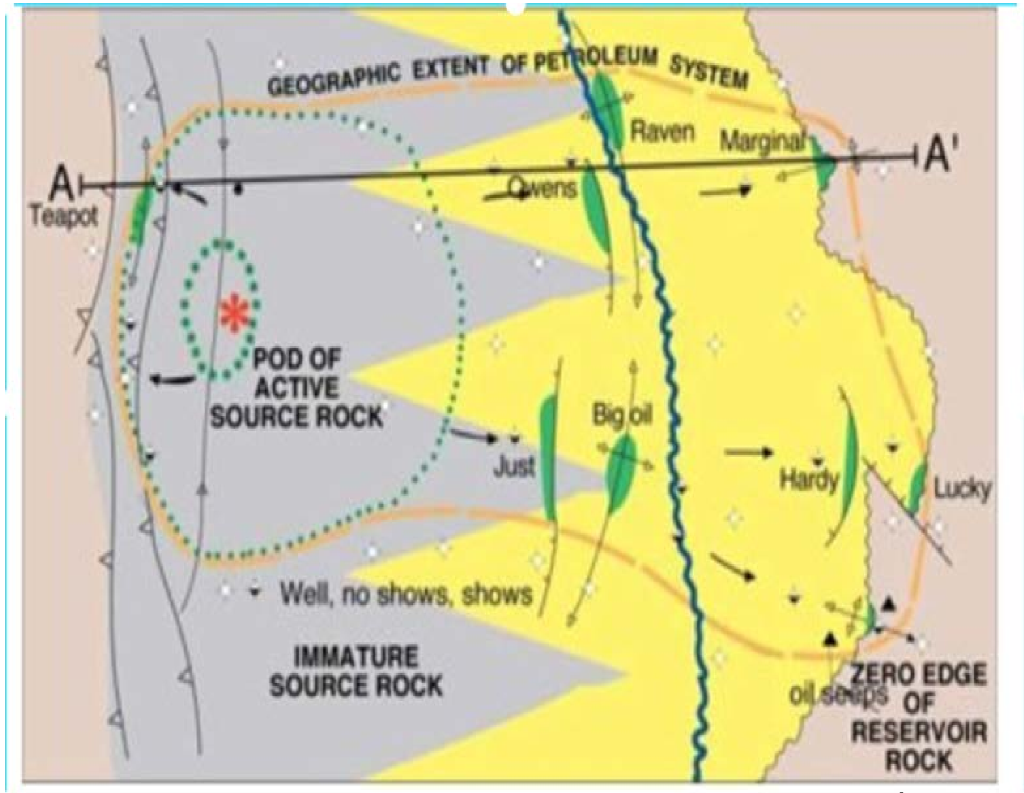
Basin Modeling

- ✓ Source rock richness assessment
- ✓ Maturity
- ✓ Timing

Petroleum system Modeling

- ✓ Likely extension of the existing petroleum systems

Base on the data in hand suggest the most prospective localities within the study areas.



Magoon and Dow 1994

Petroleum system map

THANKS FOR YOUR ATTENTION!

Acknowledgement

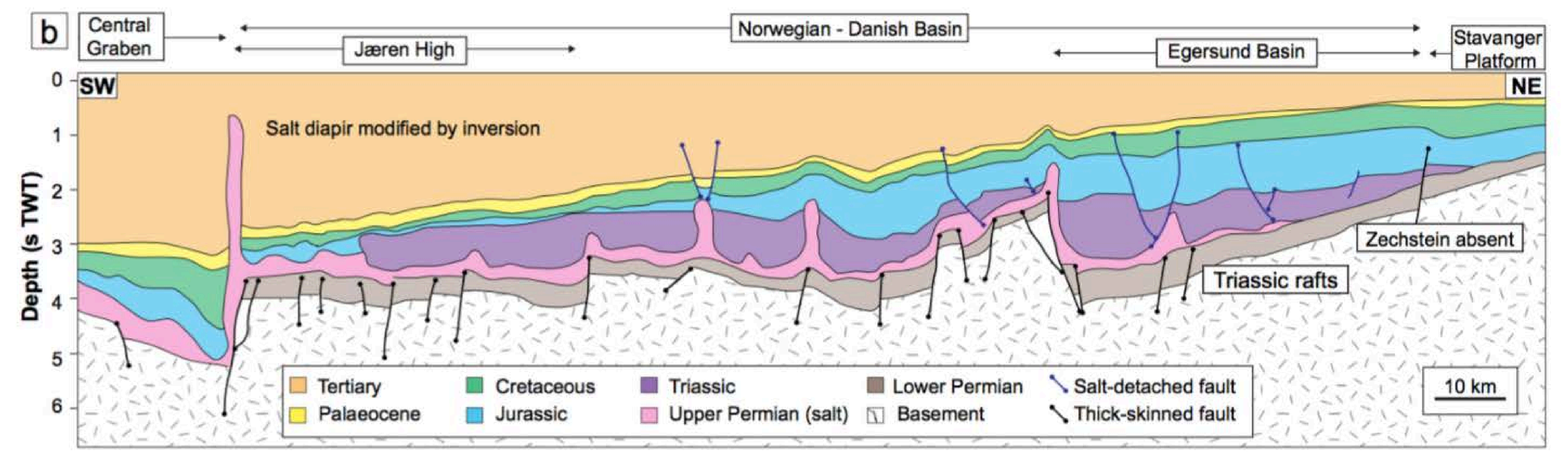
Universitetet i Stavanger

cbth project

ecopetrol

Barbados National Oil Company Limited

EARLY PERMIAN – HOLOCENE TECTONOSTRATIGRAPHIC EVOLUTION OF THE SØRVESTLANDET HIGH AND ÅSTA GRABEN, SOUTHEASTERN NORTH SEA



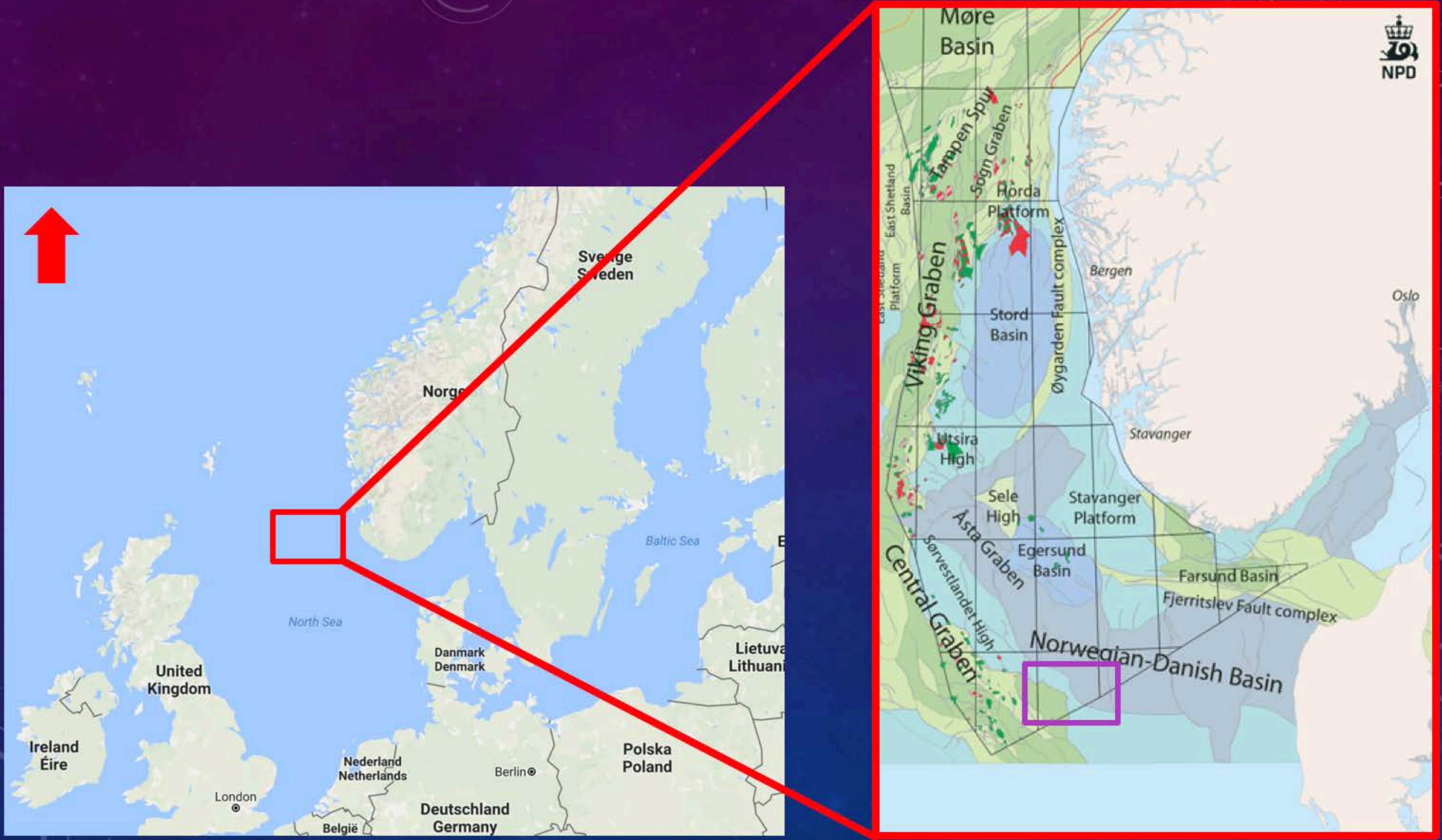
(Tvedt et al., 2016)

MASTER THESIS PROPOSAL BY: LAILA DOUDOUH

SUPERVISOR: ALEJANDRO ESCALONA

OUTLINE

- Objectives
- Introduction
  - ✓ Geological Setting & Tectonostratigraphy
  - ✓ Geological problem & Motivation
- Dataset
- Methodology



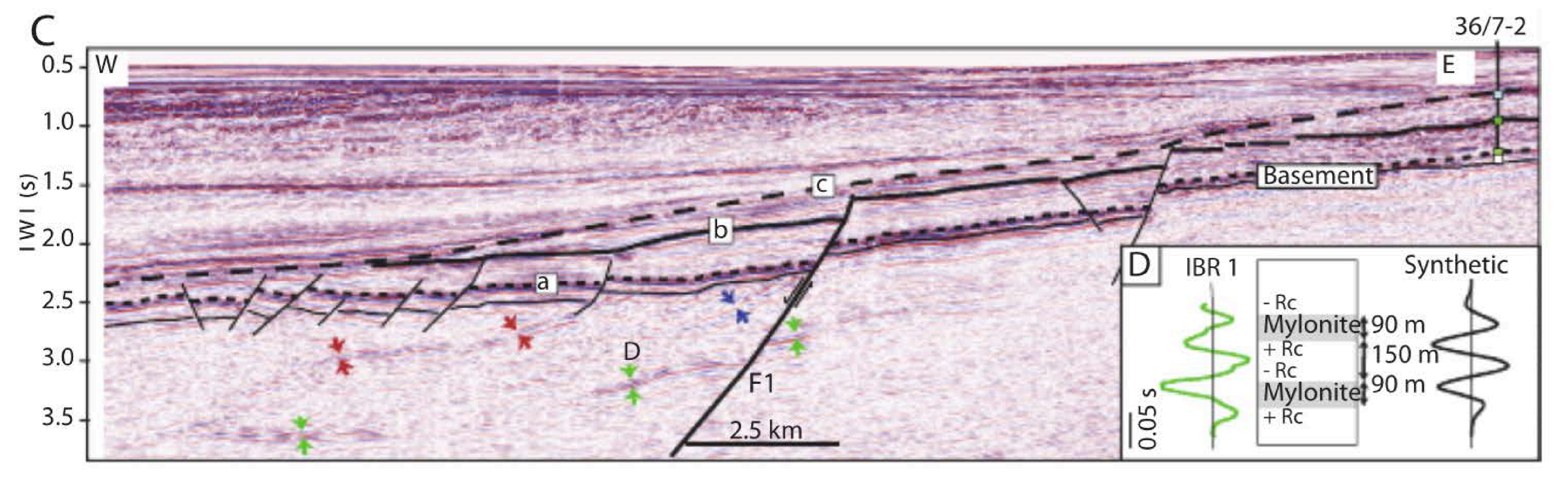
(NPD, 2016)

STUDY AREA

OBJECTIVES

- Create a detailed tectono-stratigraphic framework for rocks from Early Permian to Holocene in age, based on interpretation of the 3D seismic dataset and the wells.
- To understand the structural grain in the basement and how it may correlate to onland geology by analysing the intrabasement seismic reflections.

(Reeve et al., 2013)

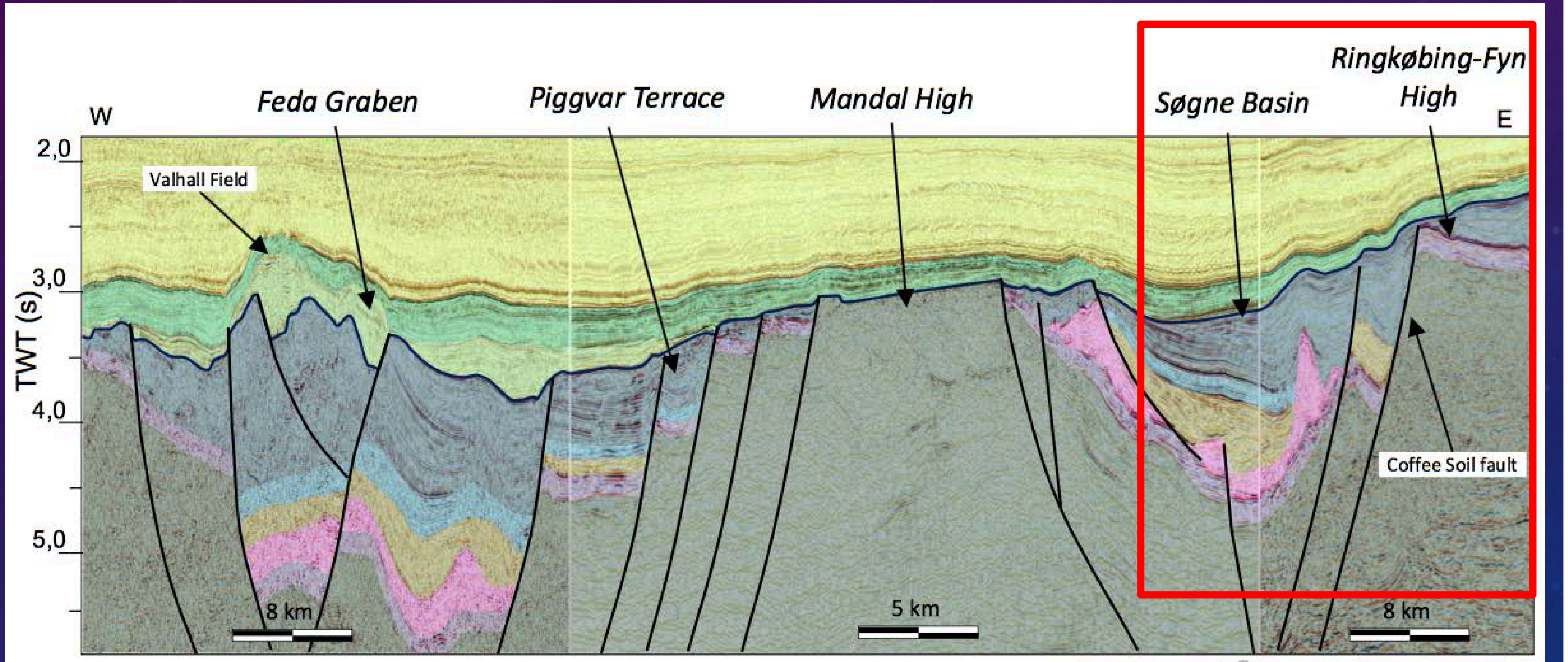


GEOLOGICAL SETTING & TECTONOSTRATIGRAPHY

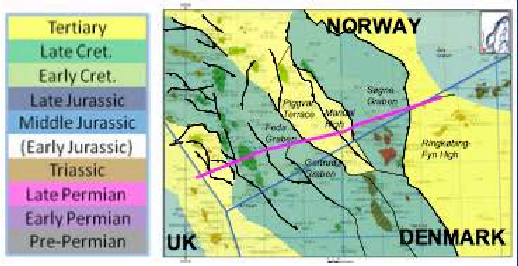
(Tvedt et al., 2016)

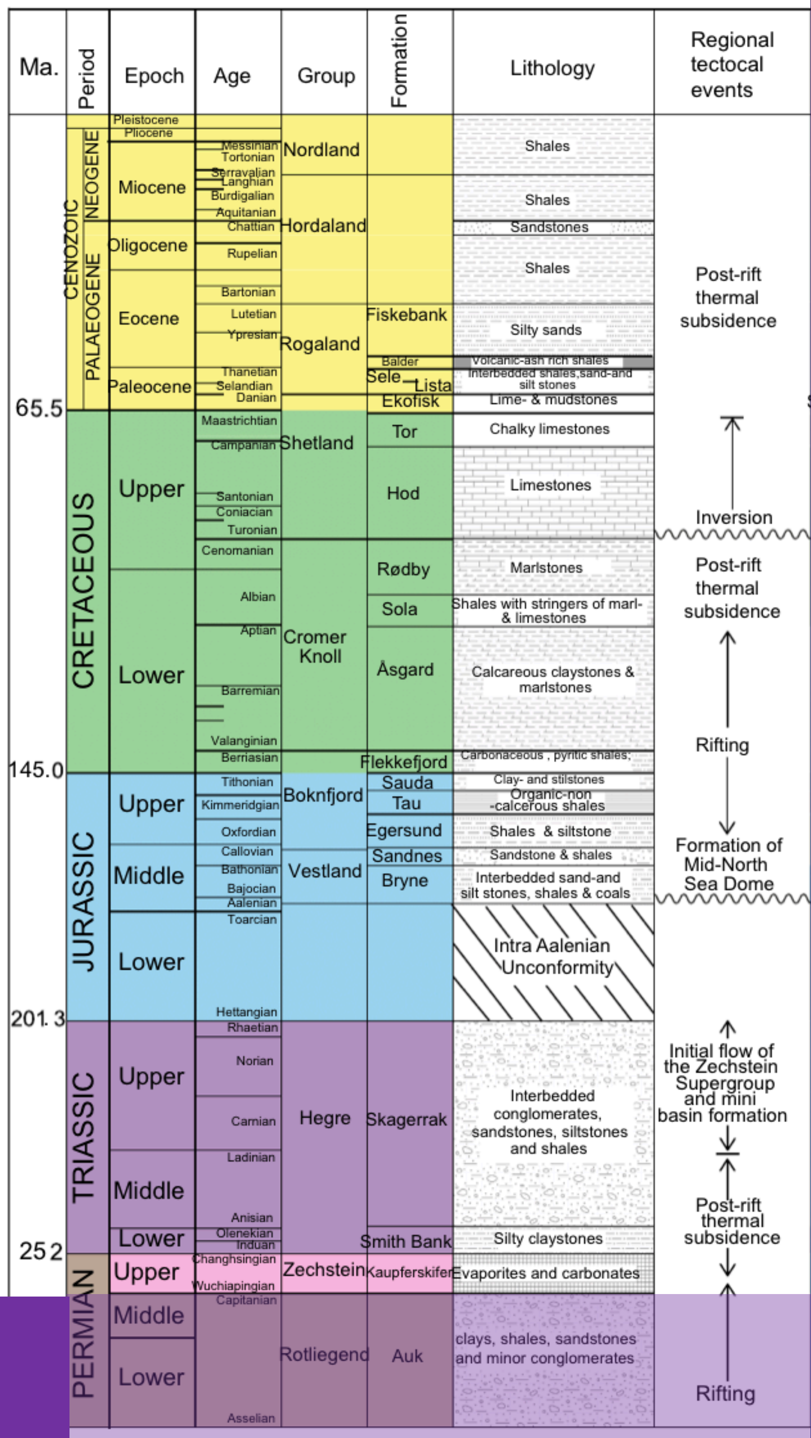
- Early Permian – rifting (Permian basins), volcanism & pre-rift evaporate deposits

(Modified after Rossland et al., 2013)



(Nøttvedt et al., 1995)



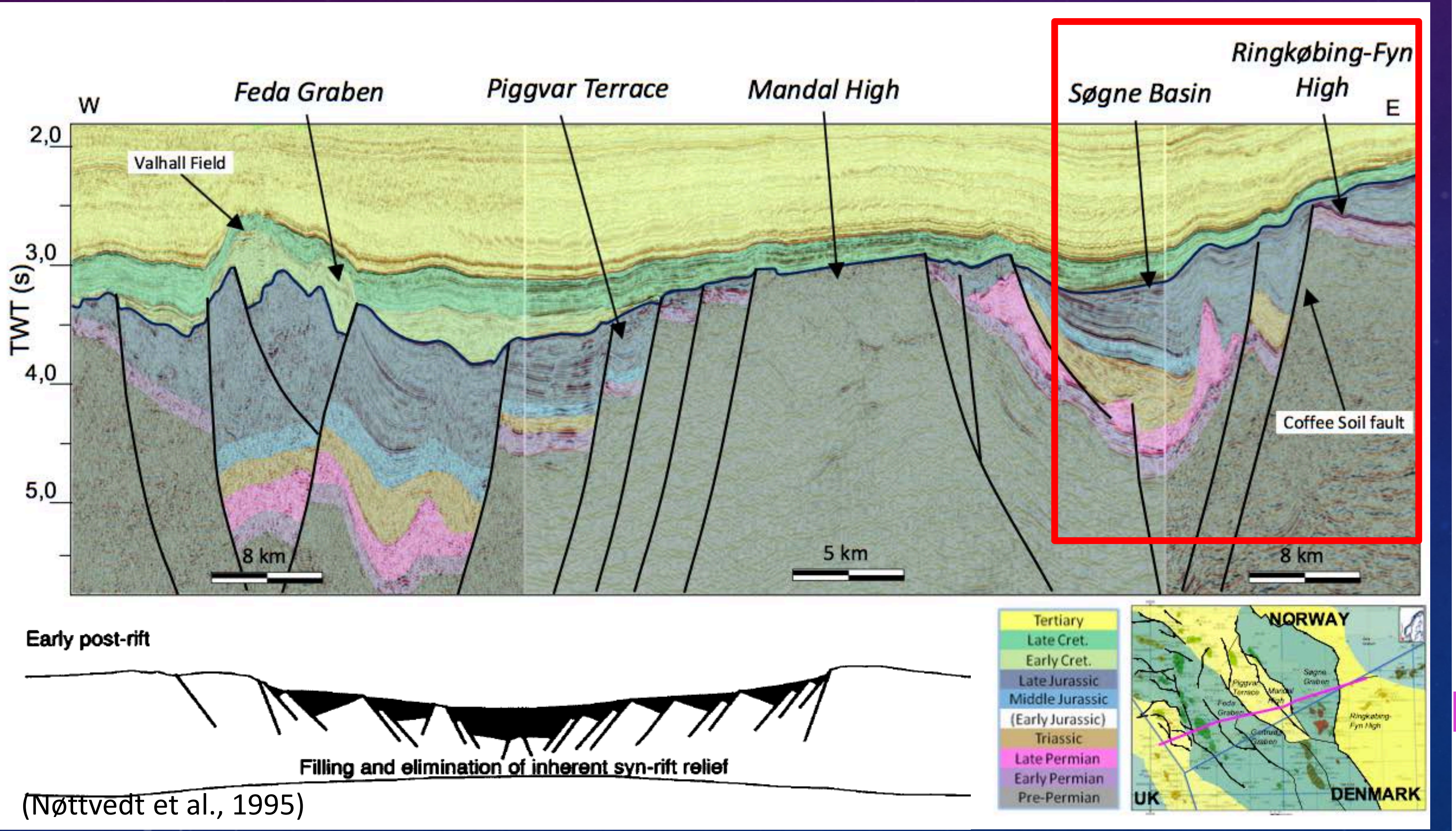


(Tvedt et al., 2016)

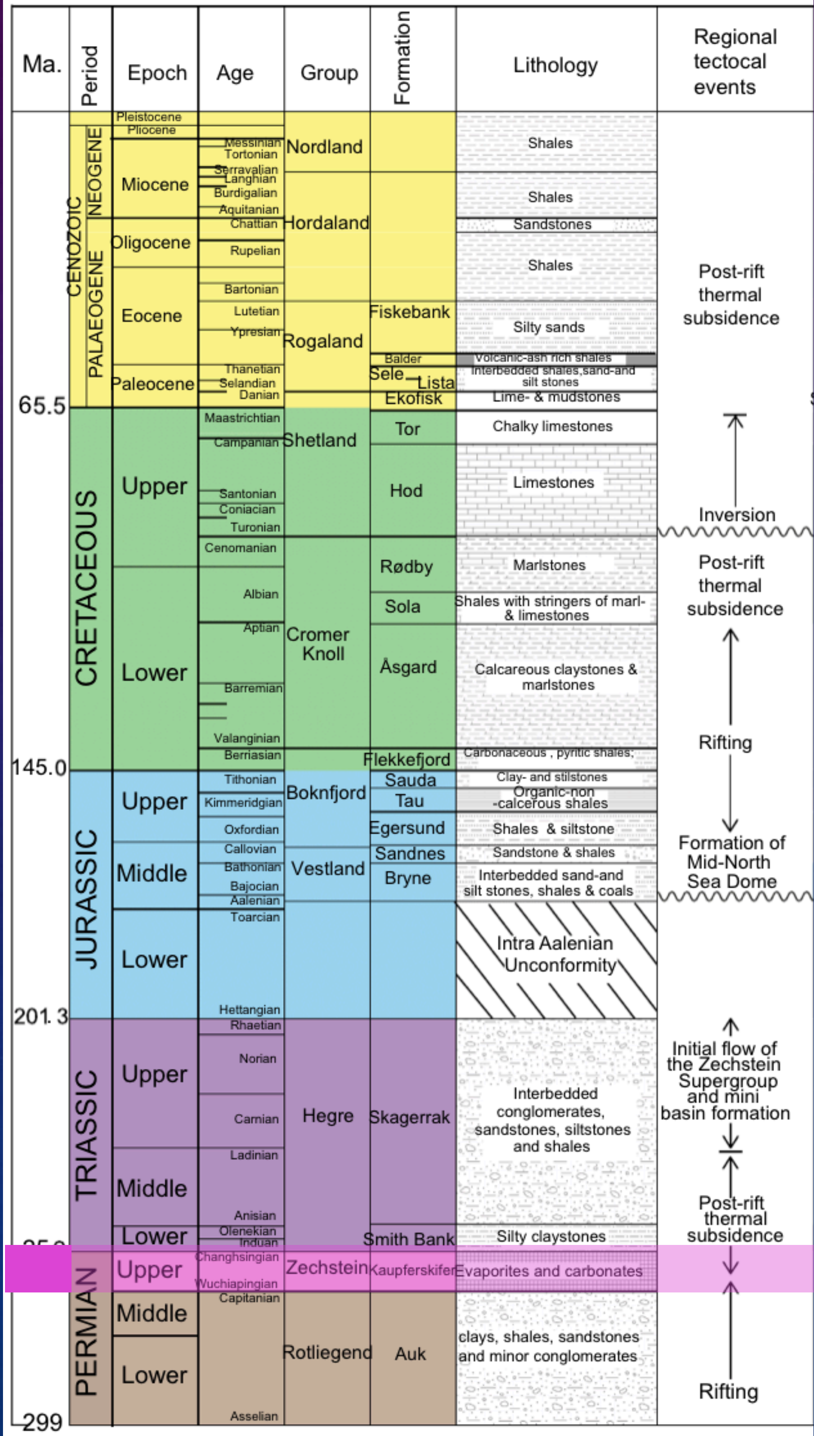
GEOLOGICAL SETTING & TECTONOSTRATIGRAPHY

- Late Permian carbonate, sulphate and halite deposits
- Glacio-eustatic sea level fluctuations

(Modified after Rossland et al., 2013)



(Nøttvedt et al., 1995)

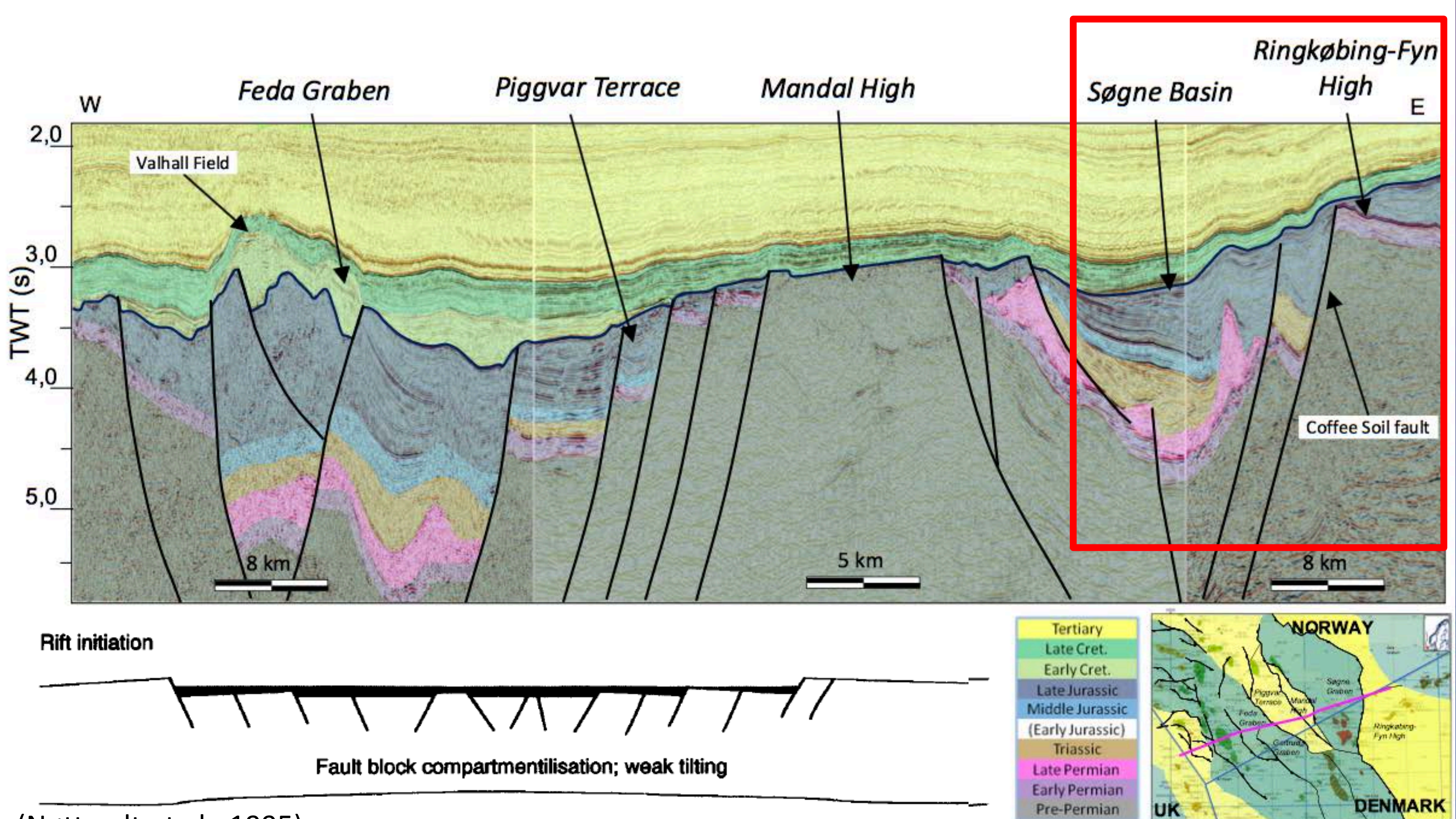


GEOLOGICAL SETTING & TECTONOSTRATIGRAPHY

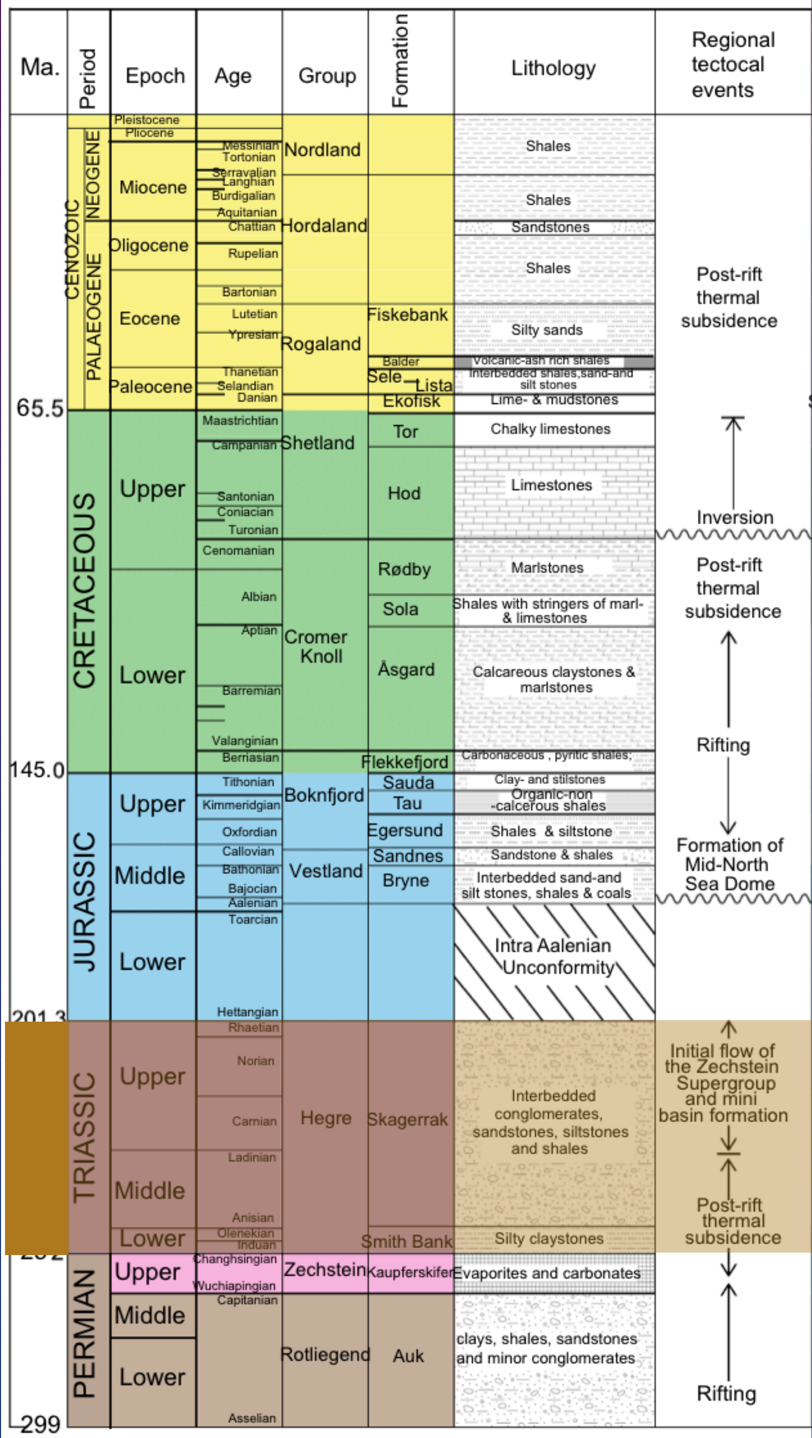
(Tvedt et al., 2016)

- Triassic - Mobilization of evaporates due to faulting

(Modified after Rossland et al., 2013)



(Nøttvedt et al., 1995)

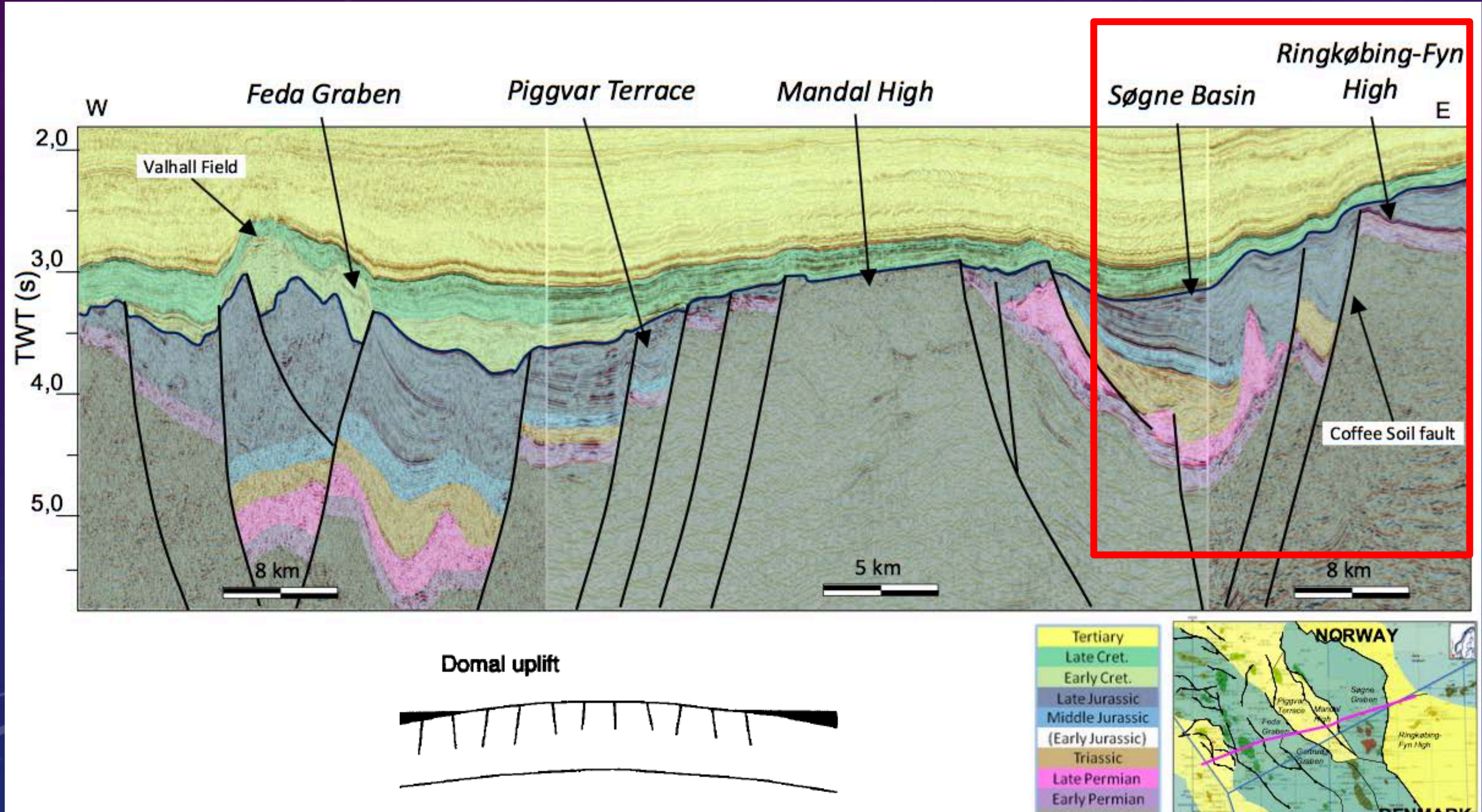


GEOLOGICAL SETTING & TECTONOSTRATIGRAPHY

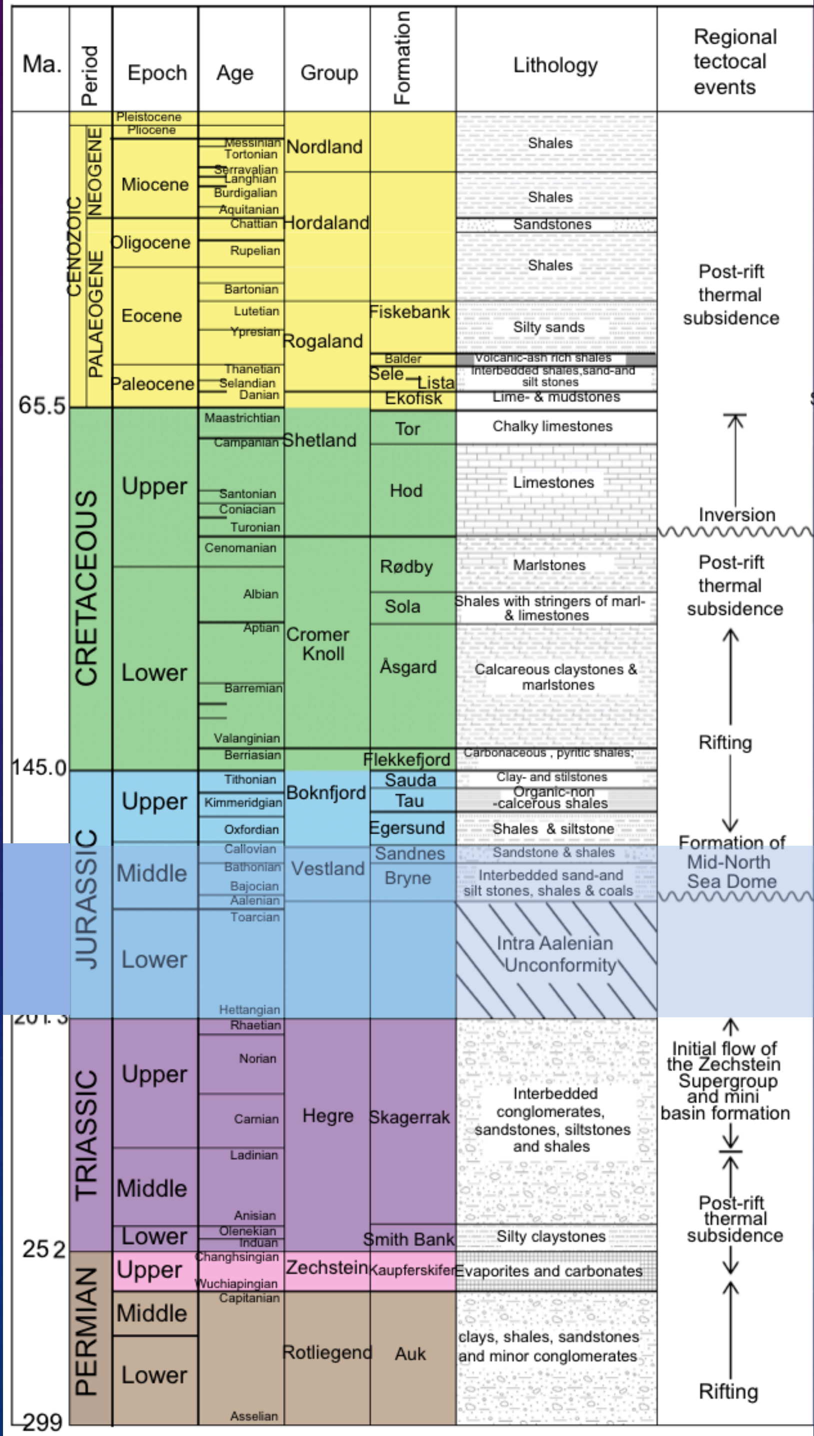
(Tvedt et al., 2016)

- Lower-Middle Jurassic uplift and erosion
- Dome transacted by Central Graben

(Modified after Rossland et al., 2013)



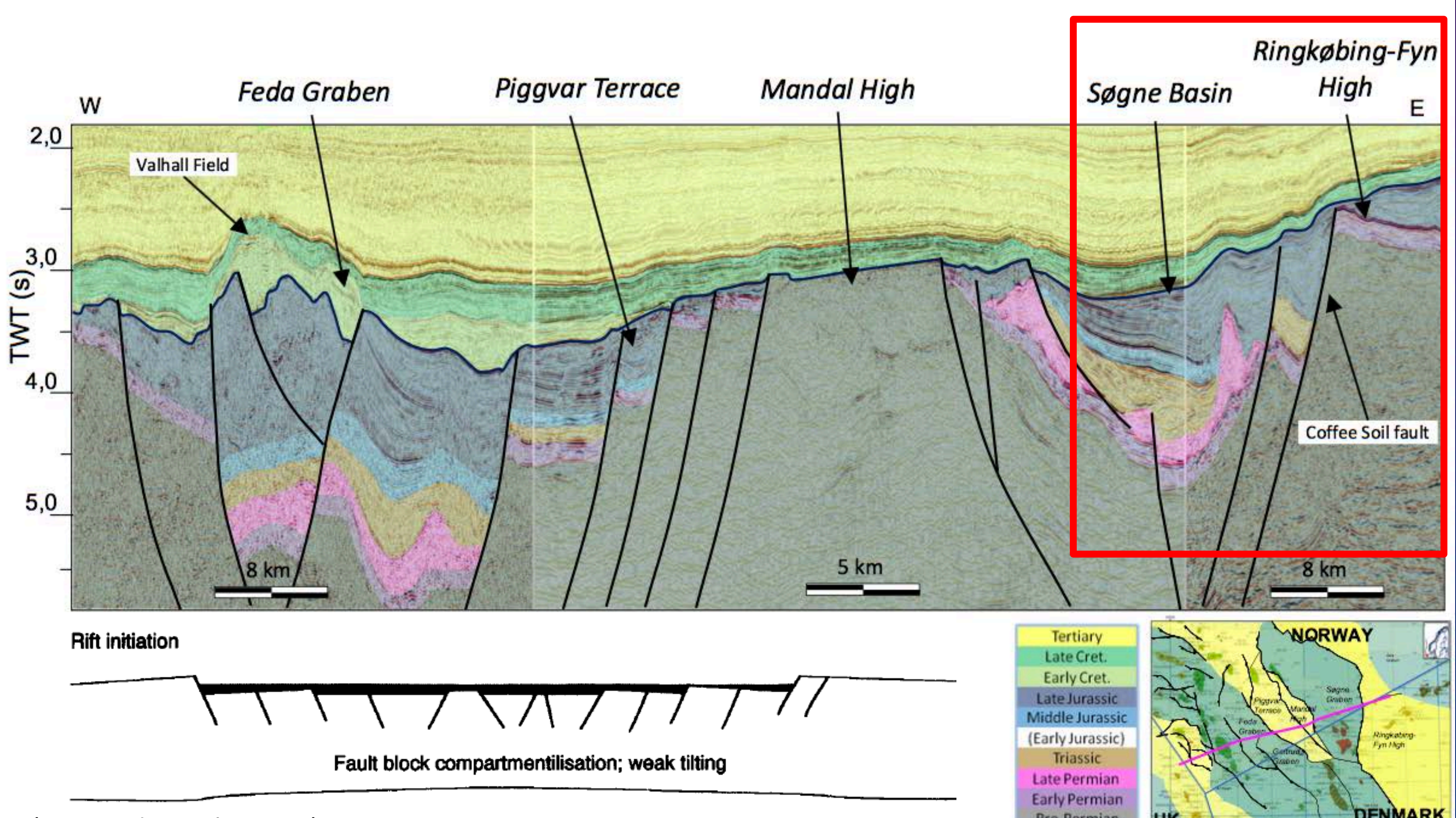
(Nøttvedt et al., 1995)



GEOLOGICAL SETTING & TECTONOSTRATIGRAPHY

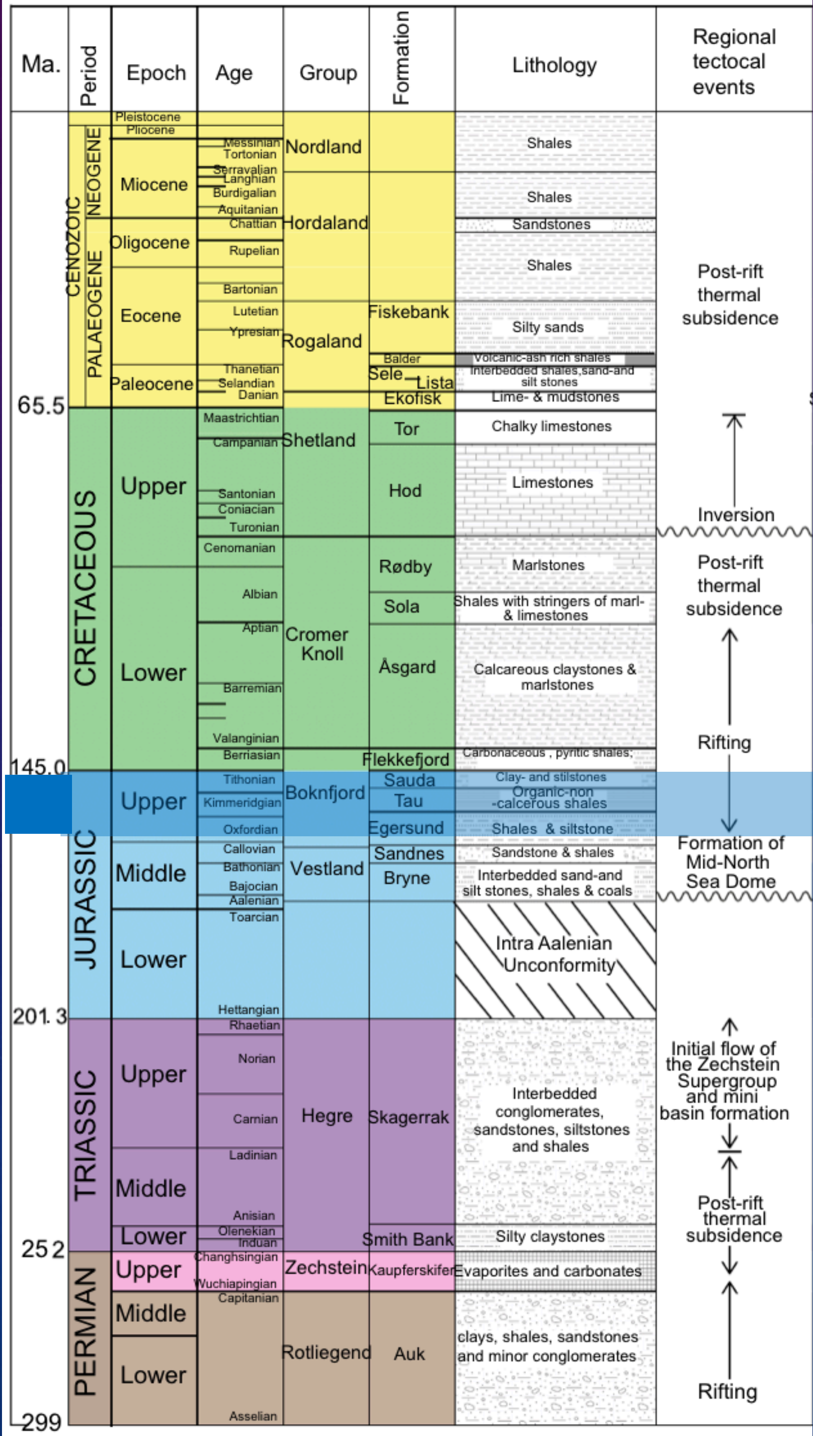
- Upper Jurassic rifting
- NW-SE structures today

(Modified after Rossland et al., 2013)



(Nøttvedt et al., 1995)

(Tvedt et al., 2016)

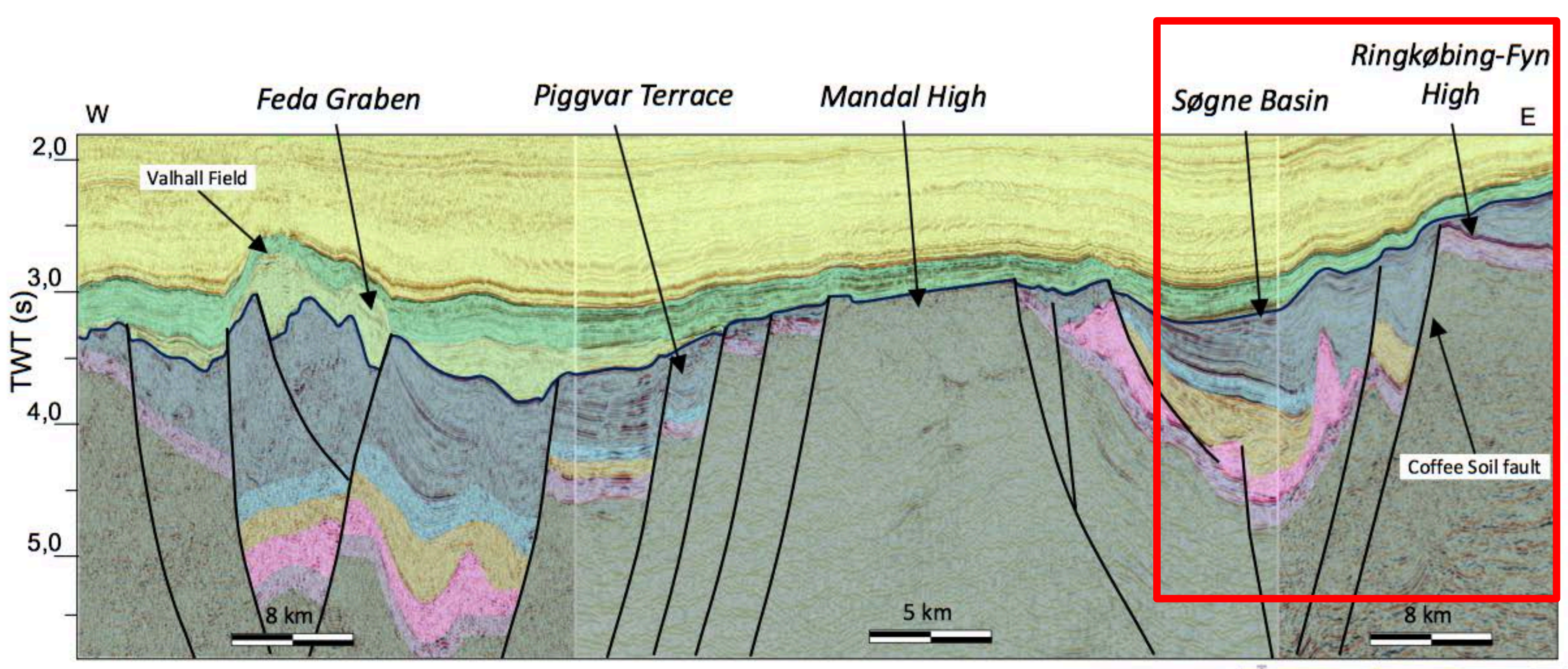


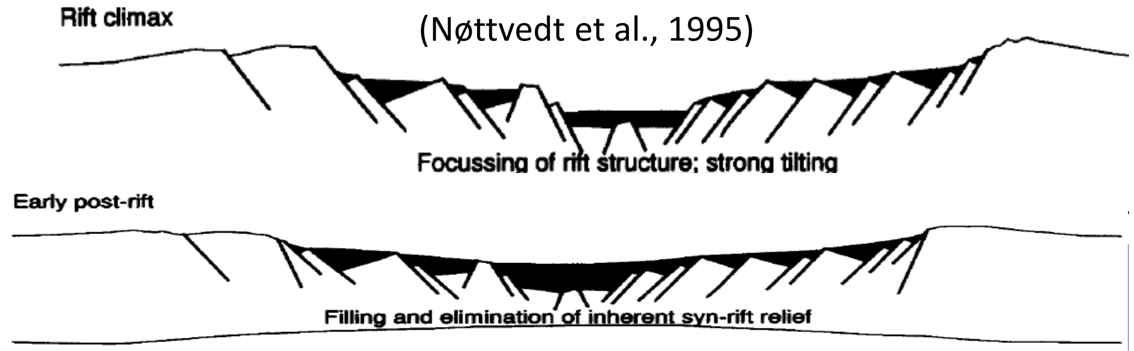
GEOLOGICAL SETTING & TECTONOSTRATIGRAPHY

(Tvedt et al., 2016)

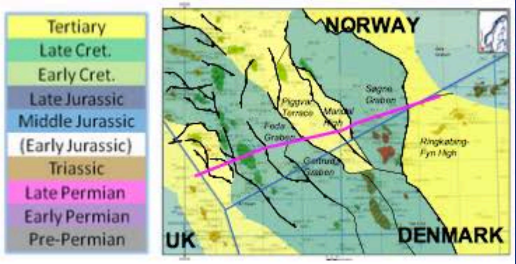
(Modified after Rossland et al., 2013)

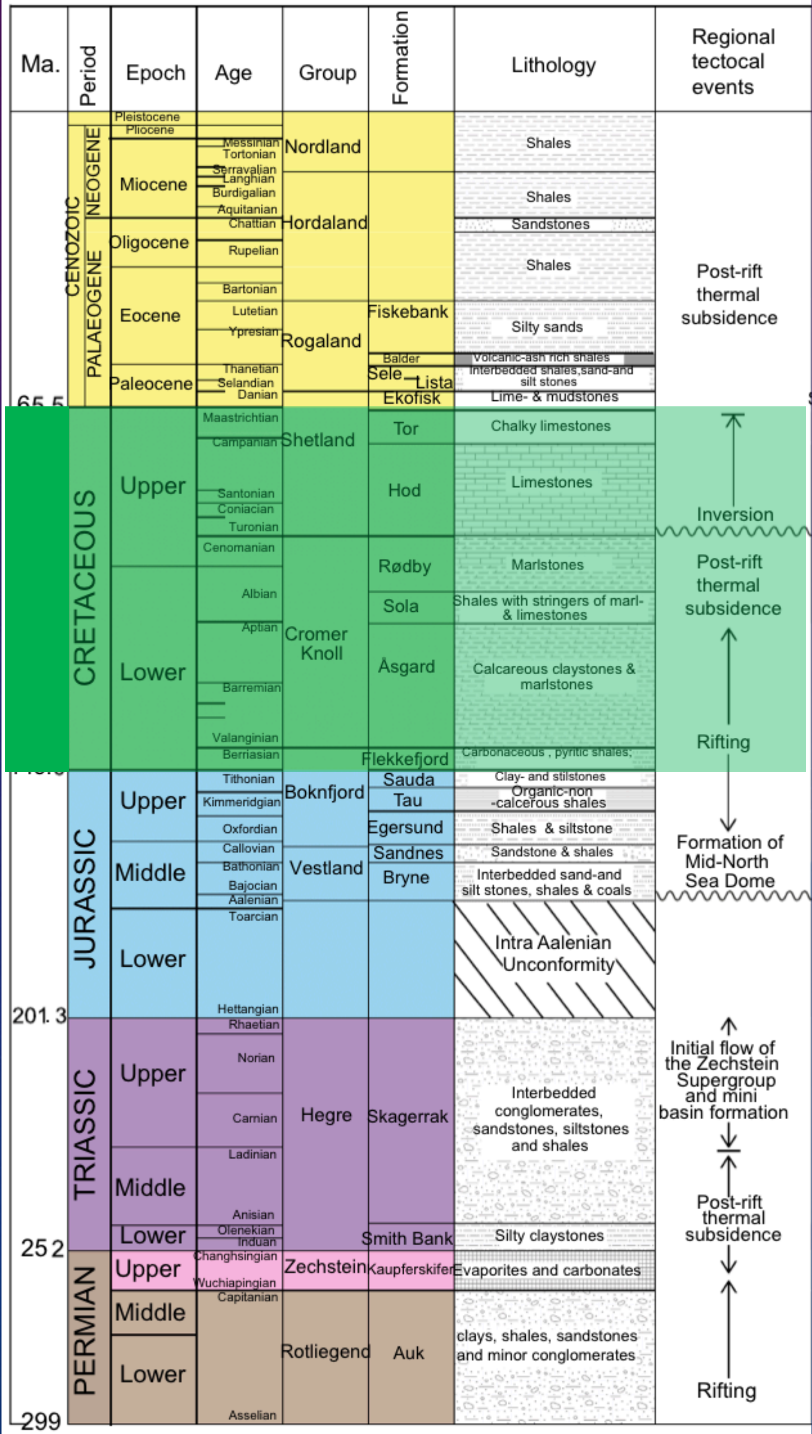
- Cretaceous post rift & inversion, rejuvenation of salt





(Nøttvedt et al., 1995)



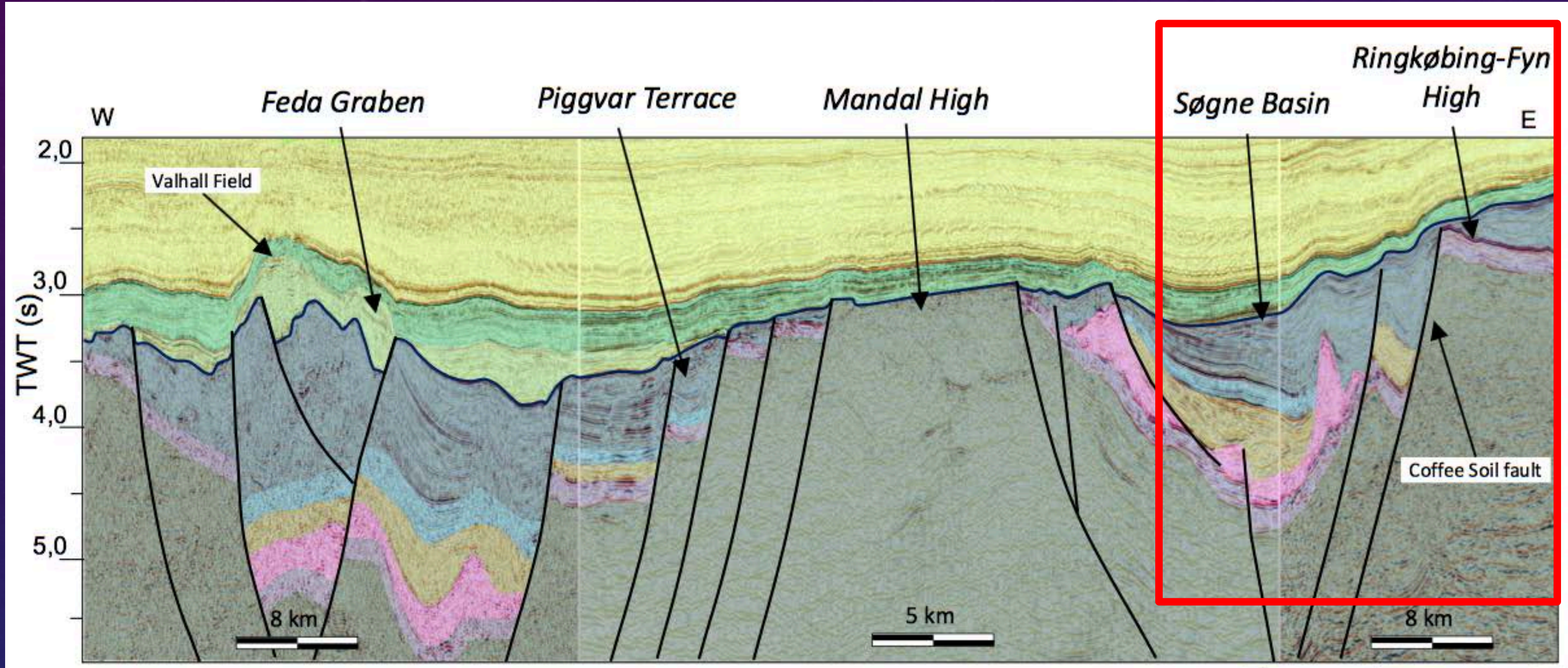


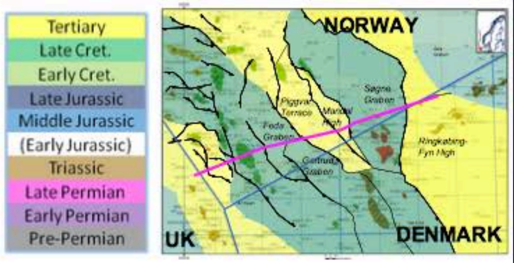
GEOLOGICAL SETTING & TECTONOSTRATIGRAPHY

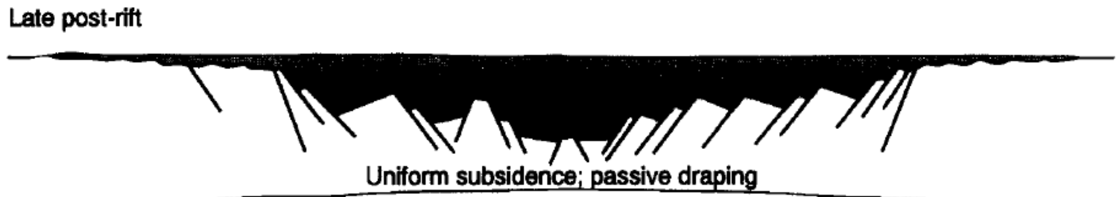
- Cenozoic Basin Subsidence
- Halokinetic activity

(Tvedt et al., 2016)

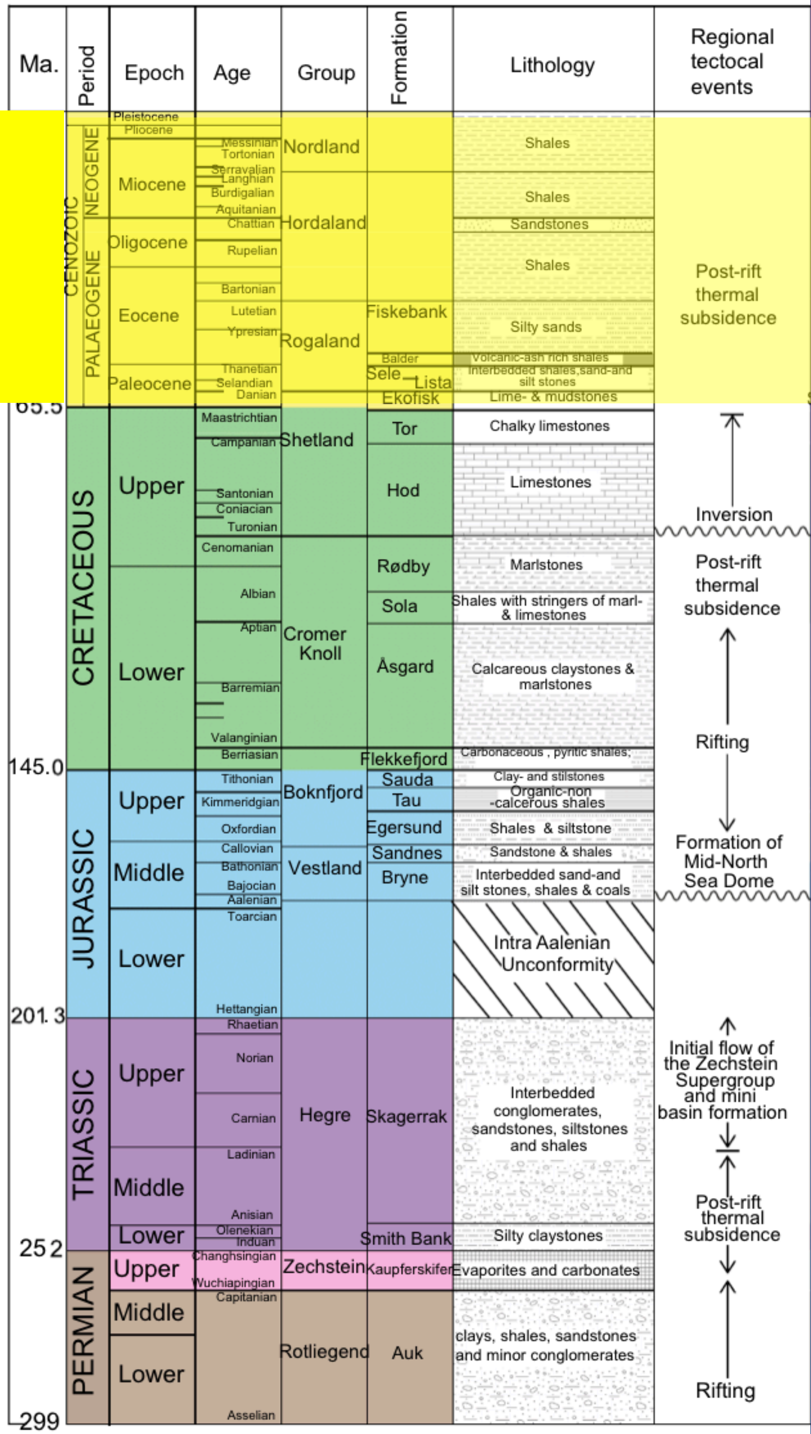
(Modified after Rossland et al., 2013)







(Nøttvedt et al., 1995)



MAIN STRUCTURAL ELEMENTS

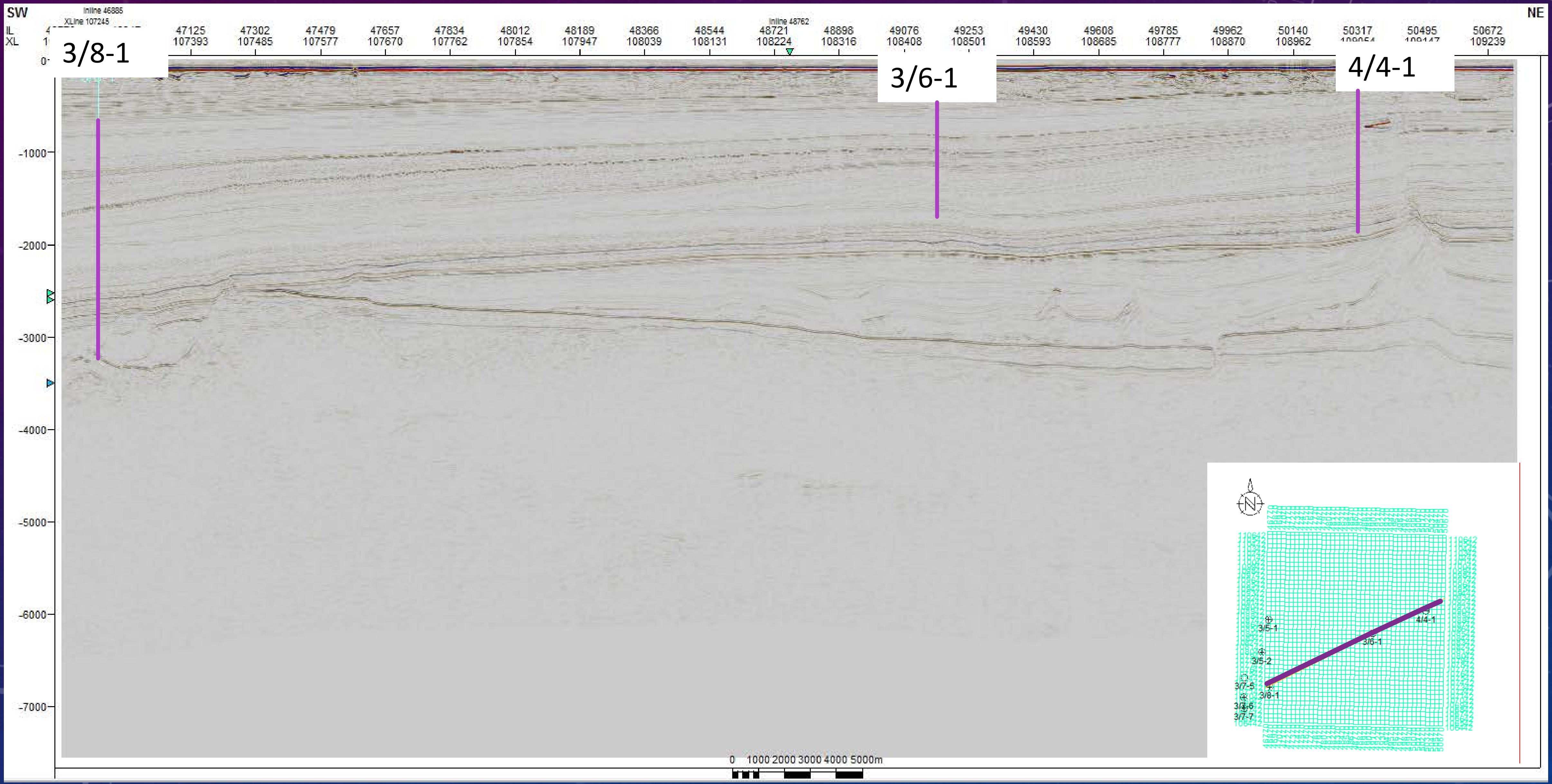
(NPD, 2016)

Søgne Basin
Åsta Graben
(Permian Triassic basin)
Danish Norwegian Basin

Sørvestlandet High
Ringkøbing-Fyn High
(Major intrabasinal high)

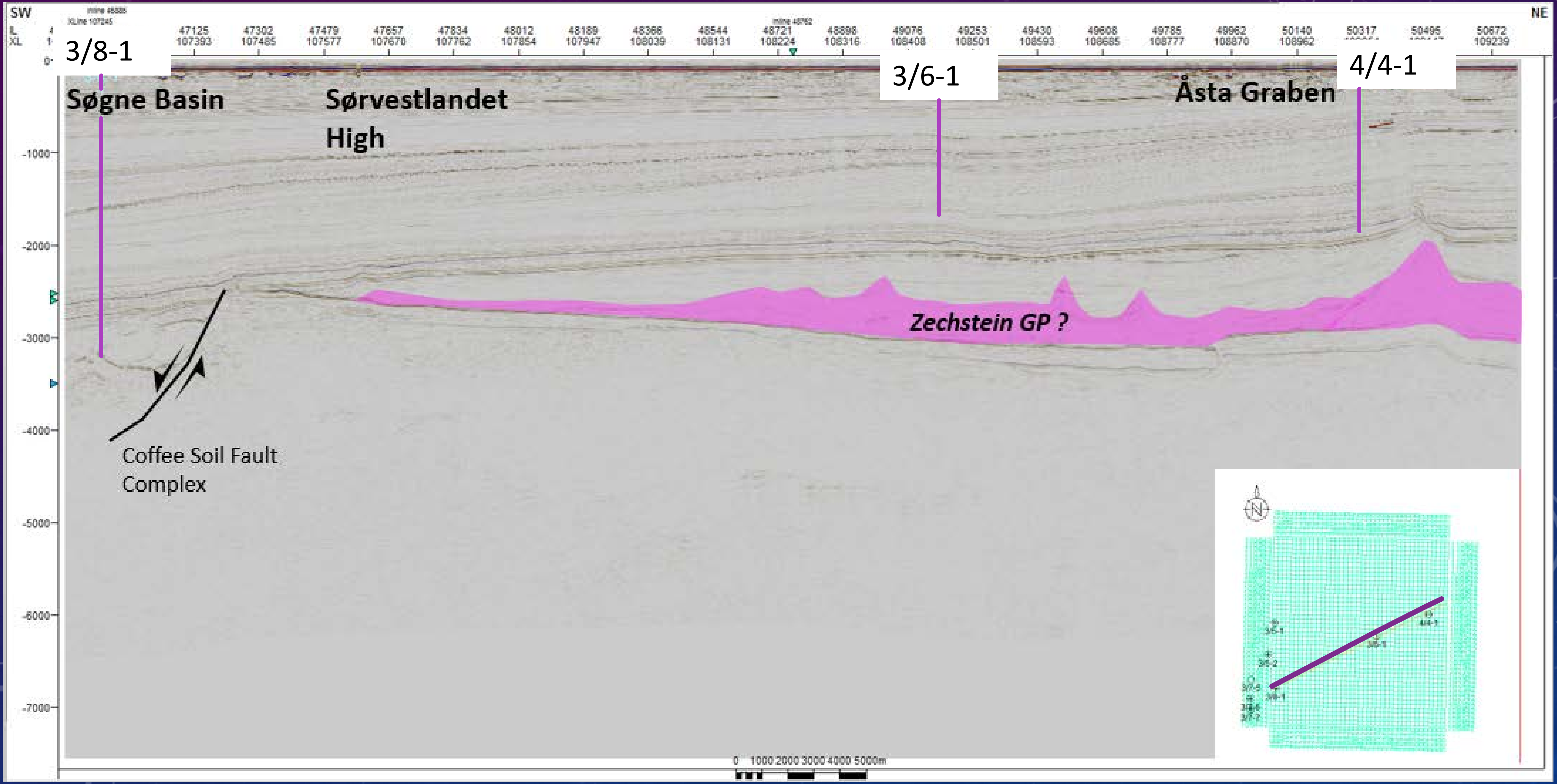
Coffee Soil Fault Complex
Krabbe Fault Zone

Line AA`

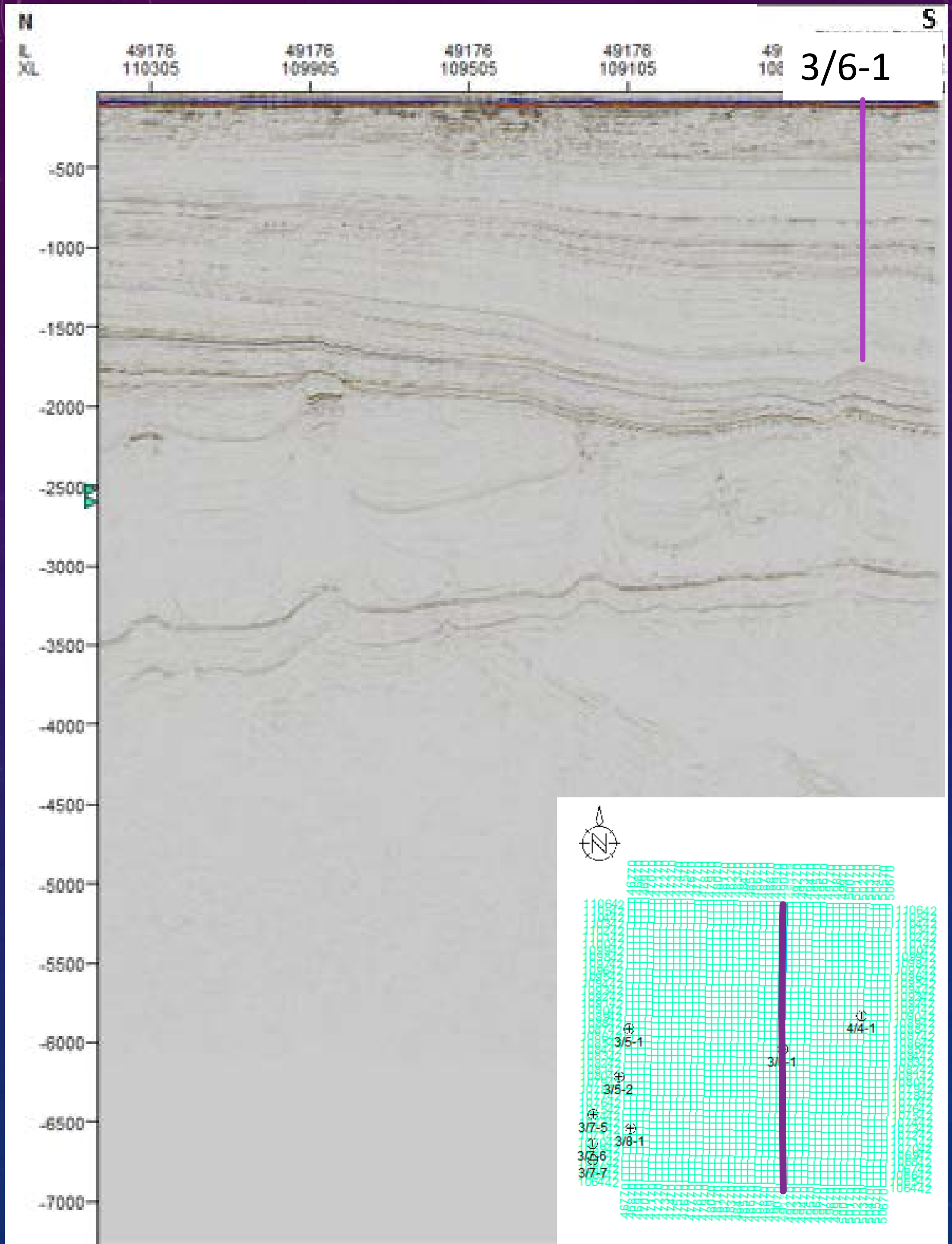


SW
NE
3/8-1
3/6-1
4/4-1
-1000
-2000
-3000
-4000
-5000
-6000
-7000
0 1000 2000 3000 4000 5000m
3/5-1
3/5-2
3/7-5
3/8-1
3/6-1
4/4-1

Line AA`


SW
NE
3/8-1
Søgne Basin
Sørvestlandet
High
3/6-1
Åsta Graben
4/4-1
Zechstein GP ?
Coffee Soil Fault
Complex
-1000
-2000
-3000
-4000
-5000
-6000
-7000
0 1000 2000 3000 4000 5000m

Line BB`



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109905
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109105
3/6-1
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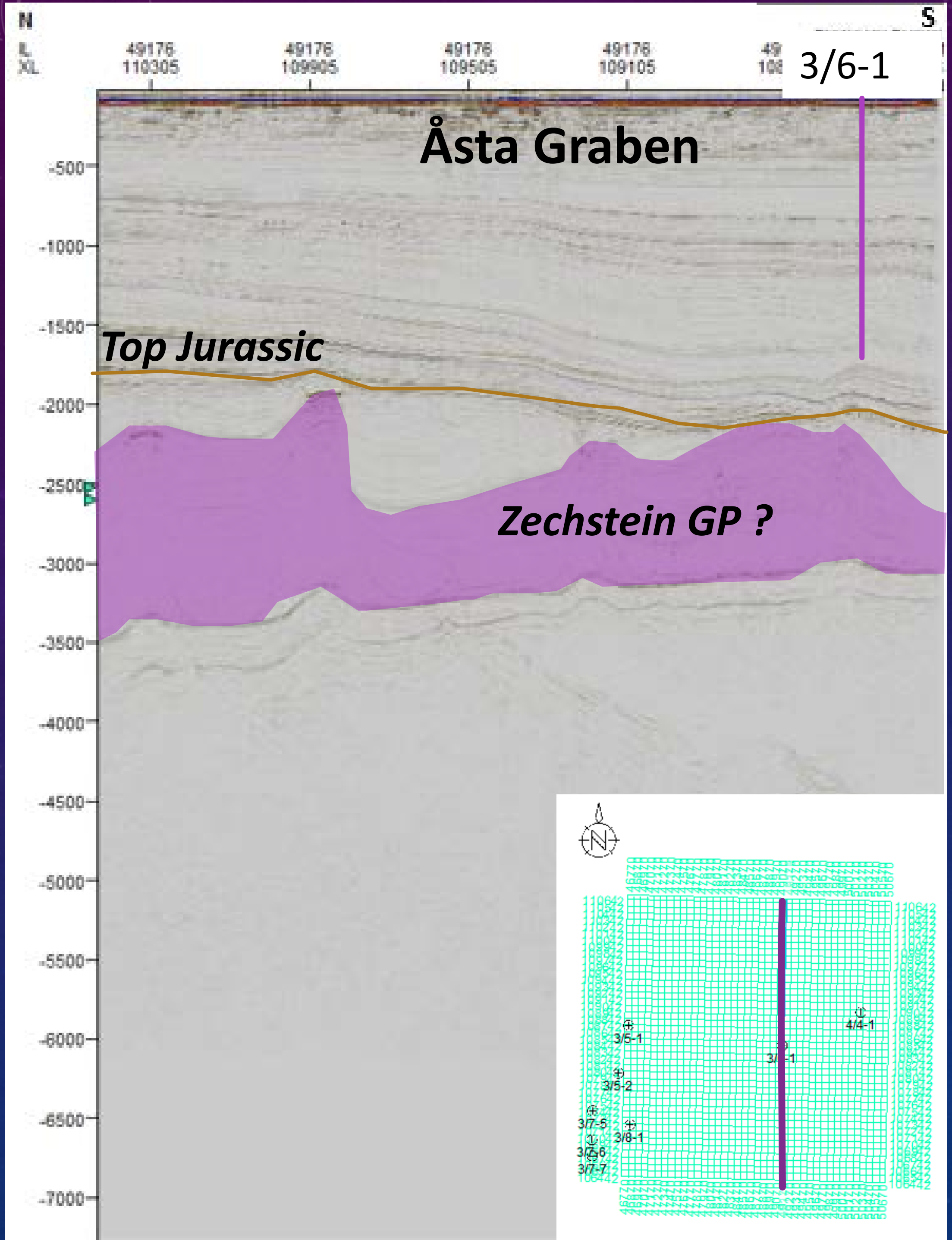
3/7-5
3/8-1
3/7-7
4/4-1

Line BB`



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Åsta Graben
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-2000
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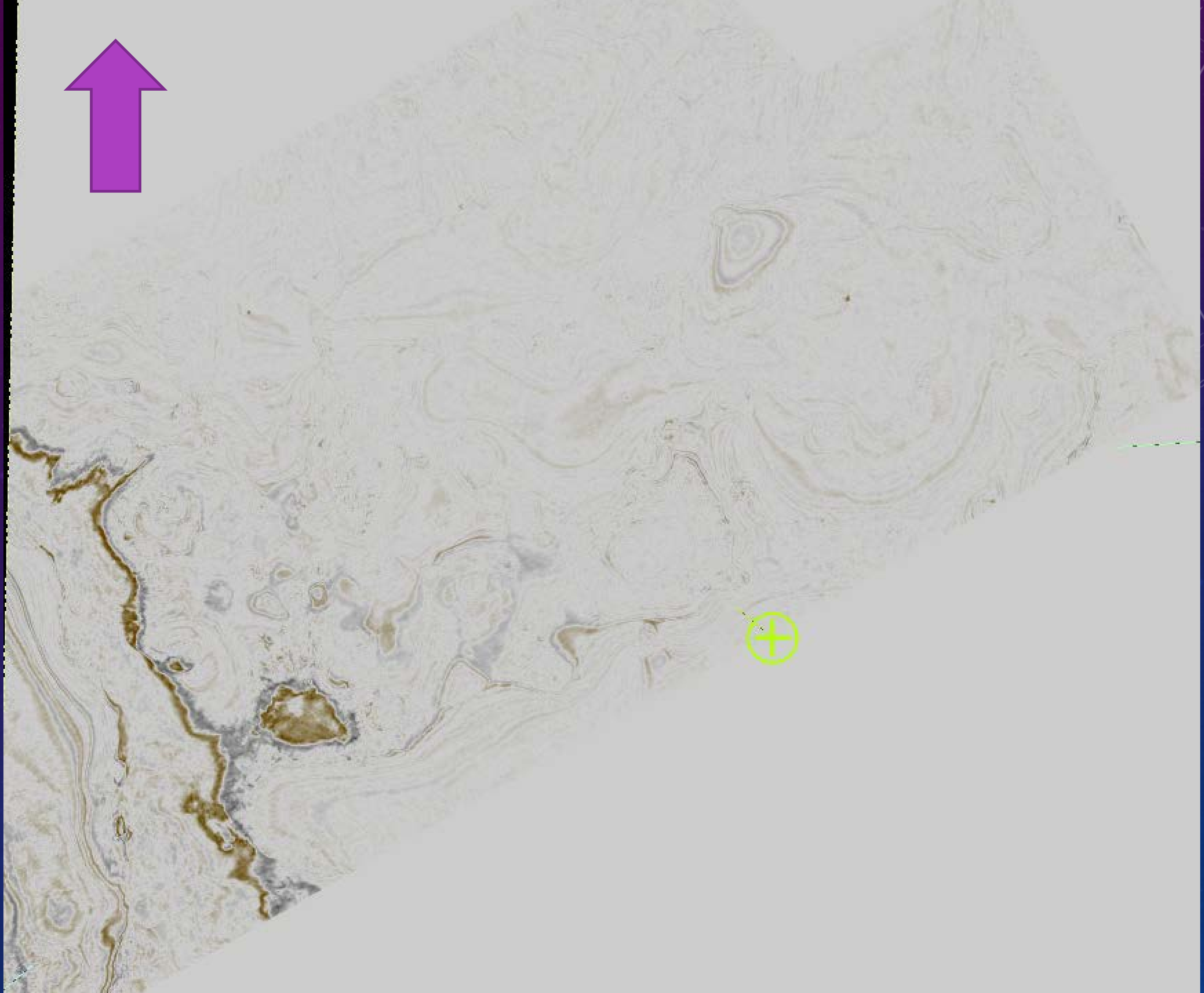
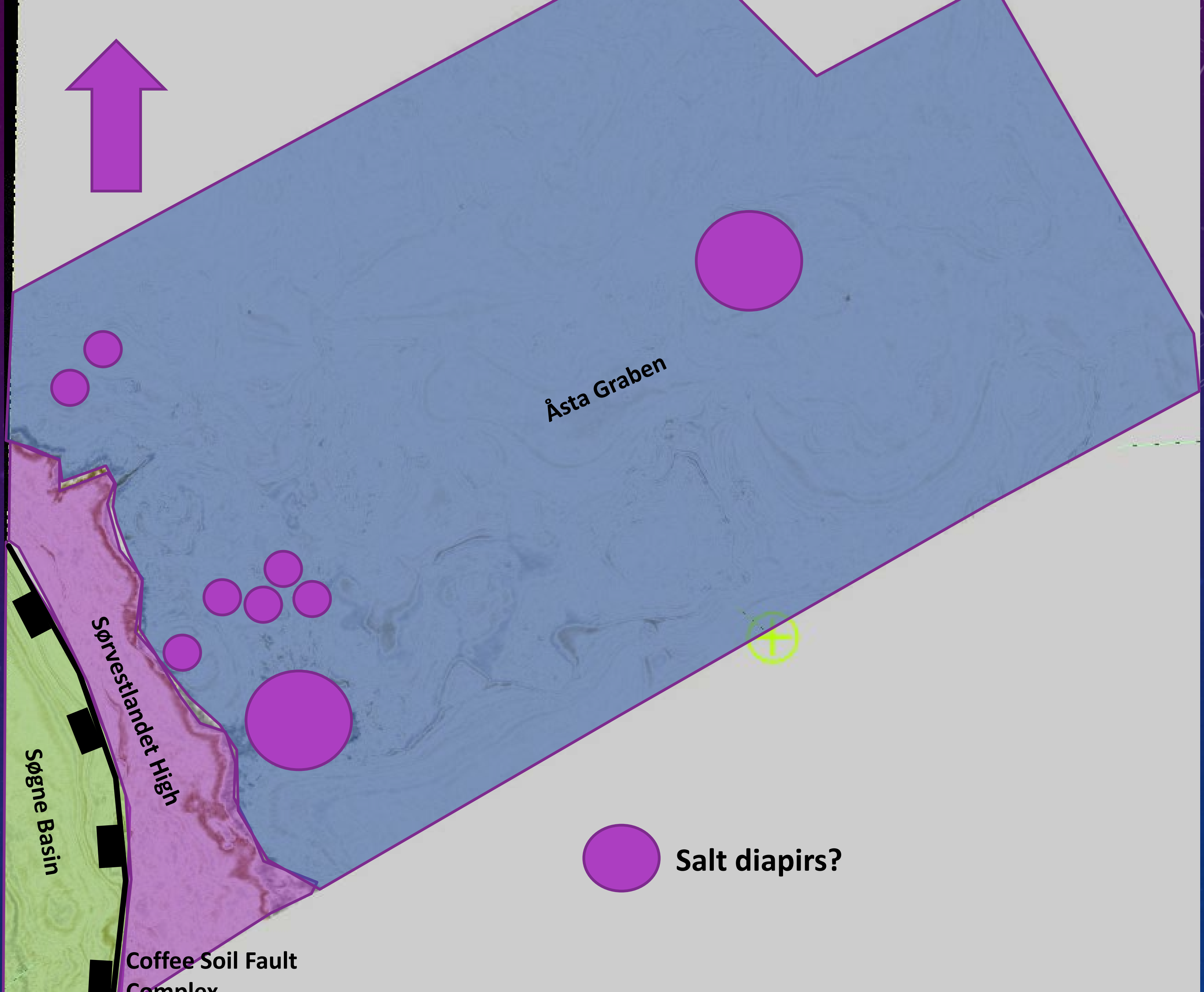
-3000
-3500
-4000
-4500
-5000
-5500
-6000
-6500
-7000
Top Jurassic
Zechstein GP ?
N
3/5-1
3/5-2
3/7-5
3/8-1
3/7-6
3/7-7
4/4-1

Z= -2600 msec



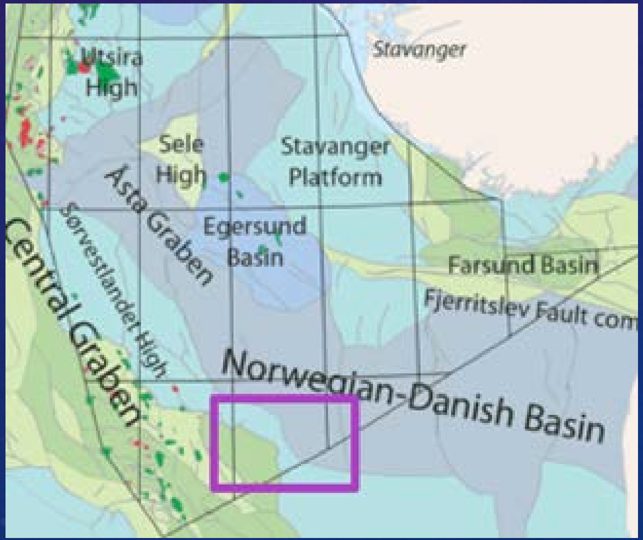
Z= -2600 msec

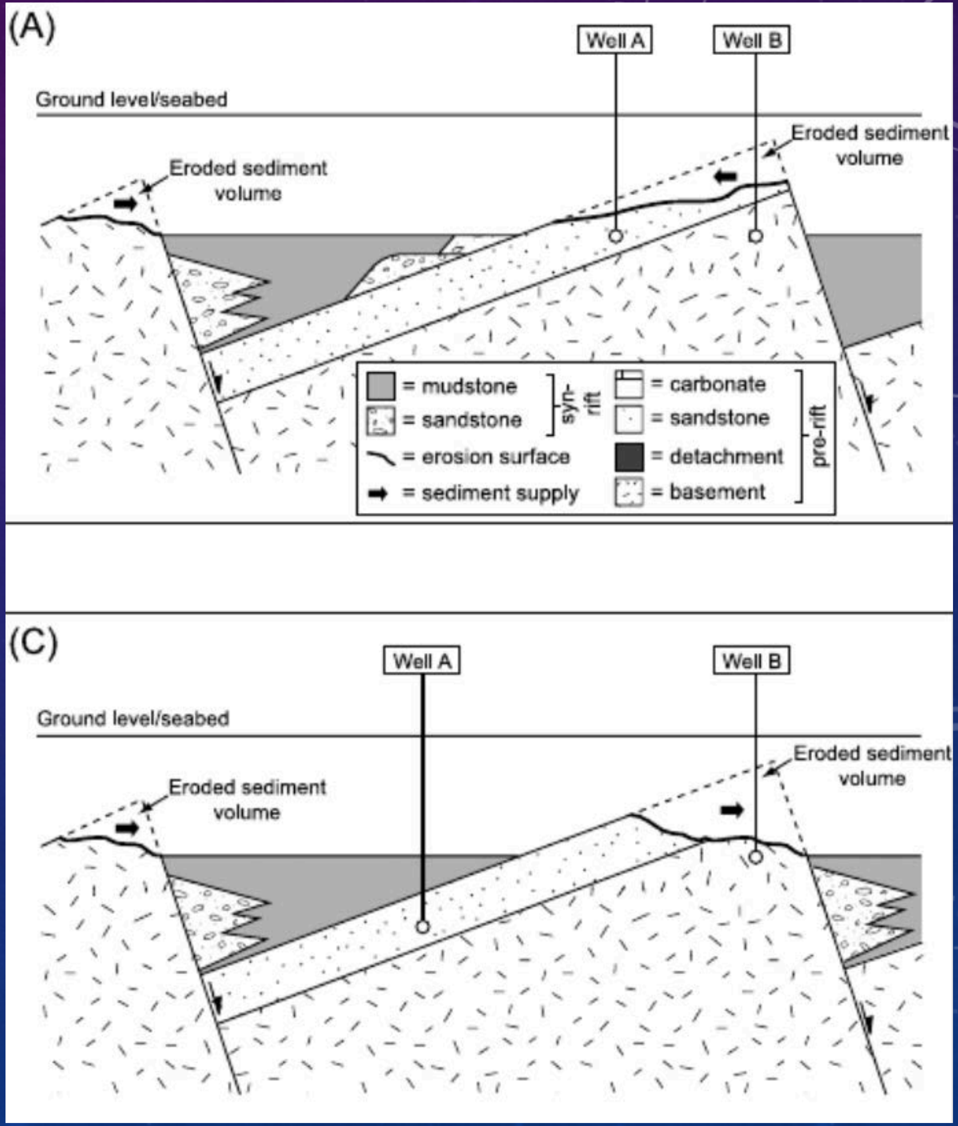


Åsta Graben
Sørvestlandet High
Søgne Basin
Salt diapirs?
Coffee Soil Fault

GEOLOGICAL PROBLEM & MOTIVATION

- Utsira high characterized by weathered, porous and fractured granitic rocks overlaid by Jurassic sandstones of excellent reservoir quality.
- Primary source for these Jurassic sandstones are the eroded material of the crystalline highs.
- However recent exploration in the Mandal High didn't appear to have commercial fields





(Jackson et al., 2011)

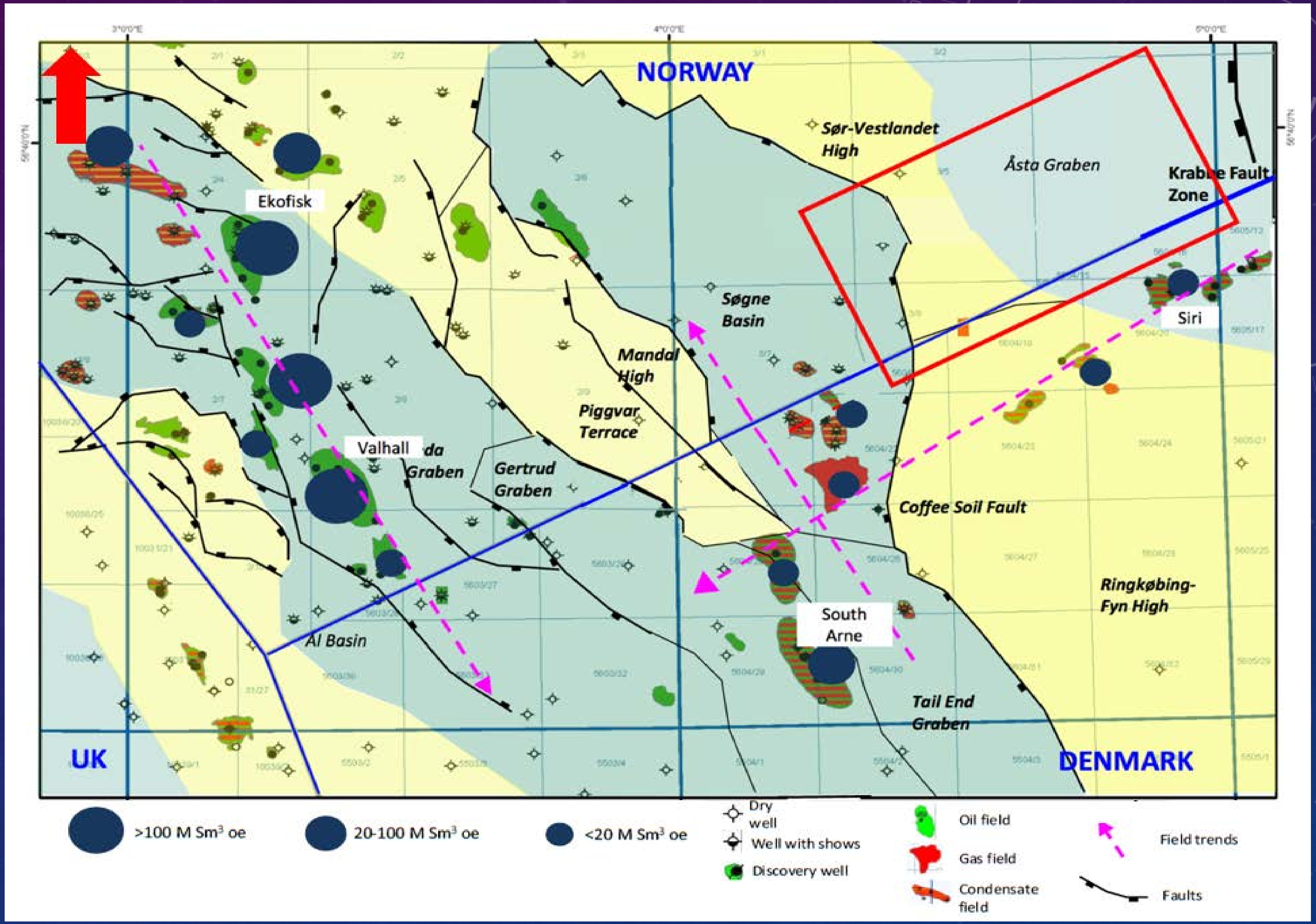
GEOLOGICAL PROBLEM & MOTIVATION

- Targeting the closures around the salt diapirs or the inverted structures in the basins around the highs.

- HC accumulations trend:

  NW-SE trending Mesozoic

  SW-NE trending Paleocene clast (DK)



(Modified after Rossland et al., 2013)

DATASET

The 3D seismic cube MC3D - NDB2013.

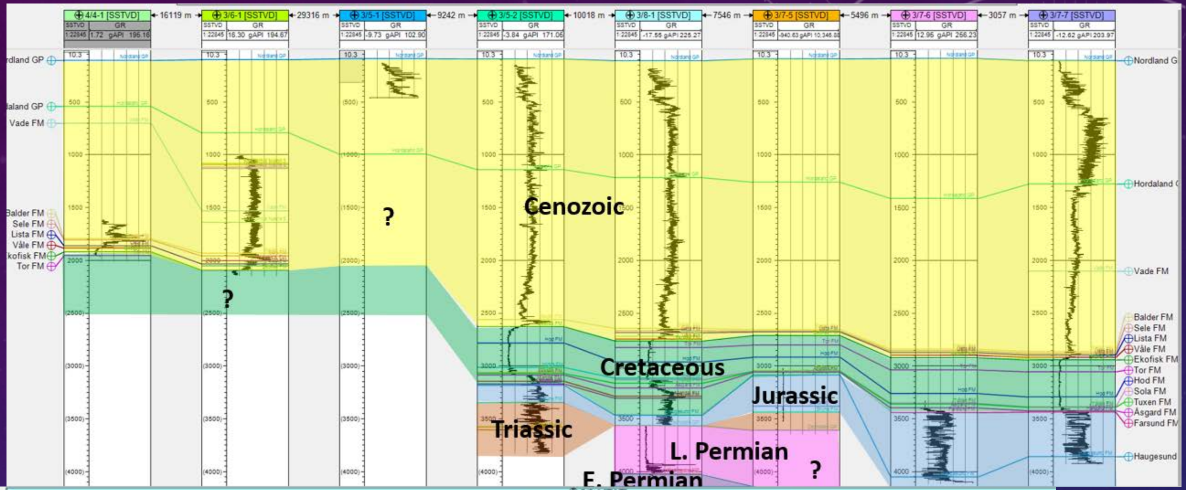
The survey was shot by PGS Geophysical AS and covers a total area of 2601 km^2.

- *Data Details:*
- **Sample Rate:** 4, 0 msec
- **Trace Length:** 7000 ms
- **Data Type:** Final post PSDM full offset stack
- **Polarity:** Zero phase, normal polarity (peak= red hard kick, through= black soft kick)
- **Inlines:** 1319 – 3780, 12,50 m bin size
- **Xlines:** 706 – 3816, 12,50 m bin size

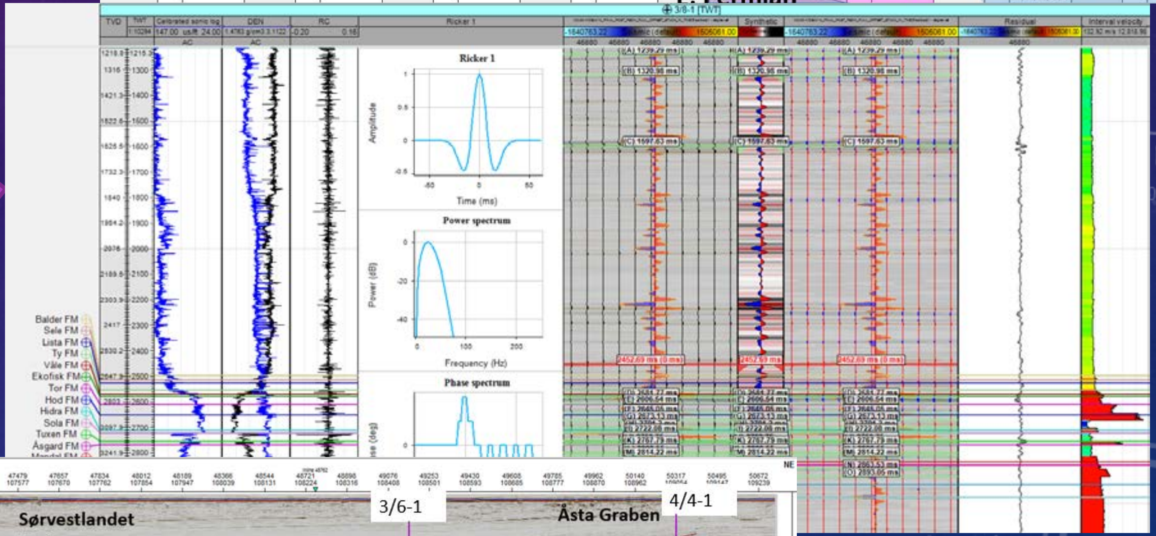
Well	Type	Year	TD (MD) m	Oldest rocks penetrated	Discovery	Reservoir
3/5-1	Wildcat	28.06.1978	3426	Early Permian	No	Dry
3/5-2	Wildcat	20.08.1978	3825	Triassic	No	Dry
3/6-1	Wildcat	10.07.2000	2167	Late Cretaceous	No	Dry
3/7-5	Wildcat	07.02.1992	3666	Late Permian	No	Shows
3/7-6	Wildcat	30.11.1996	4120	Late Jurassic	No	Shows
3/7-7	Wildcat	27.10.2008	3930	Late Jurassic	No	Shows
3/8-1	Wildcat	29.12.2010	4070	Early Permian	No	Dry
4/4-1	Wildcat	13.10.2013	2012	Late Cretaceous	No	Dry

METHODOLOGY

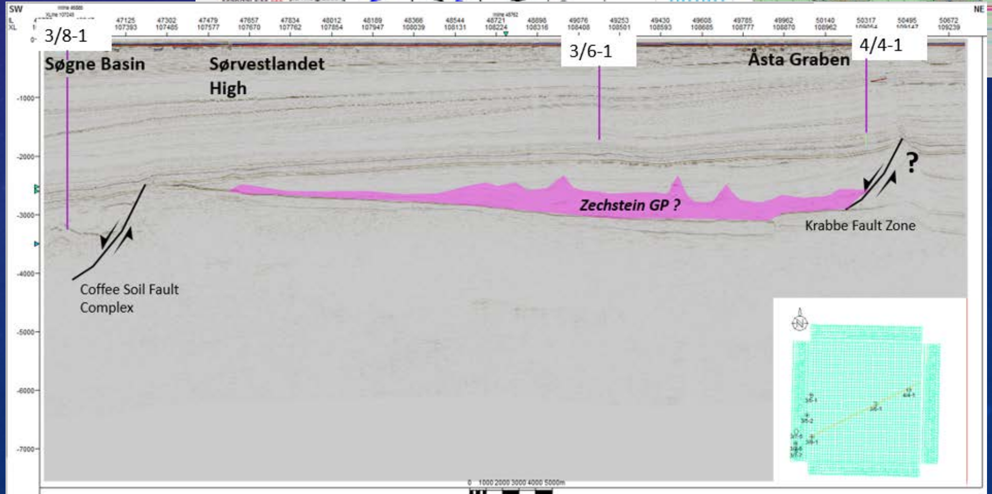
1. Wellcorrelation (Sequencestrat & Lithostrat) and Well Characteristics



2. Seismic to Welltie, seismic attributes

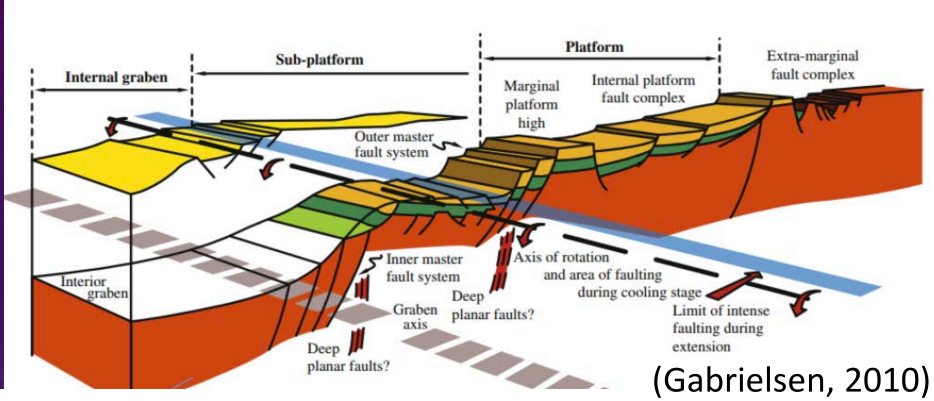


3. Seismic interpretation, Characteristic, sequences



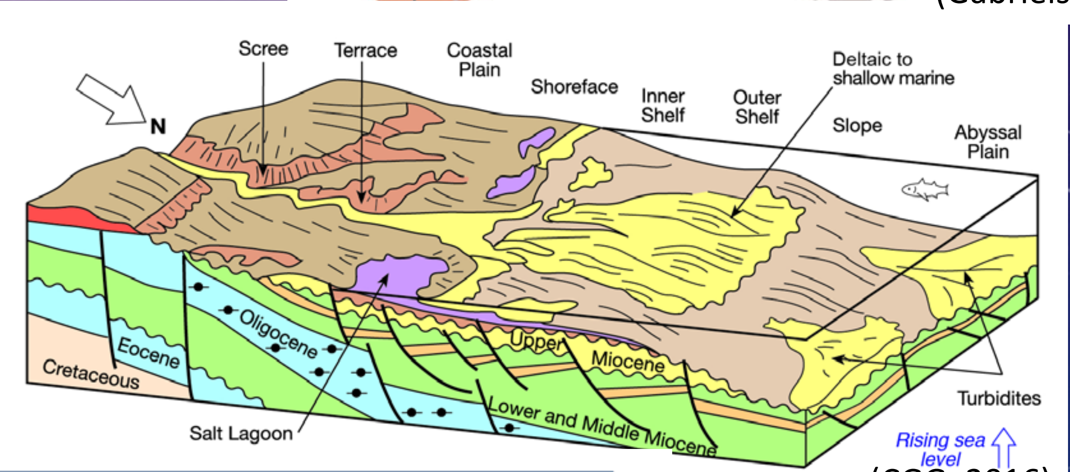
METHODOLOGY

5. Describe fault timings, growth, reactivation, and its effect on sediment steering and deposition and possible restoration



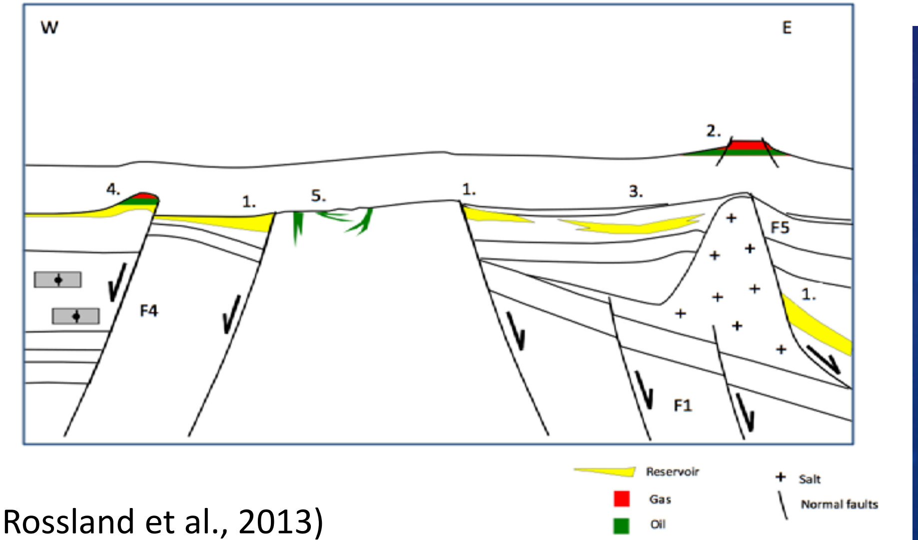
(Gabrielsen, 2010)

6. Interpret basin setting and depositional environment



(CGG, 2016)

7. Investigate possible petroleum plays and prospect



(Rossland et al., 2013)

THANK YOU FOR YOUR ATTENTION!

A rock model for shallow sandstones in the North Sea

Adelya Bilalova

Supervisor: Arild Buland, University of Stavanger, Statoil company

Co-supervisor: Inge H.A. Pettersen, Statoil company

December

2016

Introduction

North Sea

(From http://welt-atlas.de)

- The North Sea is a mature area for the offshore oil and gas exploration.
- There is a numerous amount of data that is available for companies work and various studies.
- It is an area for multidisciplinary interest.
- This project is directed to petrophysical studies, in particular, shear-wave velocity prediction.

North Sea exploration

(From http://www.dn.no/nyheter/energi/2015/)

Introduction

$$Vs = \frac{1}{2}\left\{\left[\sum_{i=1}^{L} Xi \sum_{j=0}^{Vi} aijV_p^i\right] + \left[\sum_{i=1}^{L} Xi \left(\sum_{j=0}^{Ni} aijV_p^i\right)^{-1}\right]^{-1}\right\}$$

$\sum_{i=1}^{L} x_i = 1$,

where L – number of monomineralic lithologic constituent,

x_i – volume fractions of lithological constituents,

aij – empirical regression coefficients,

Ni – order of polynomial for constituent I,

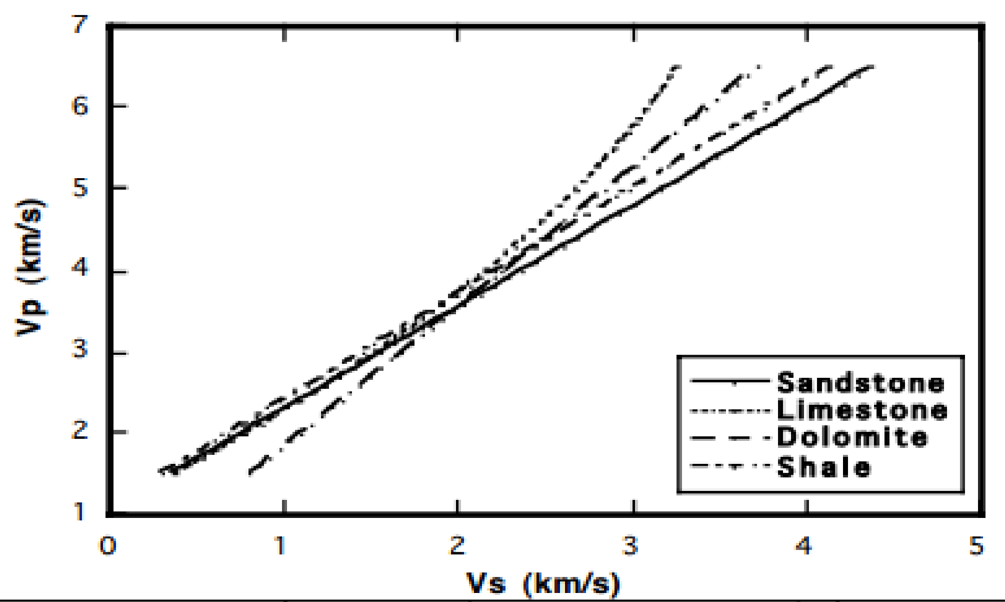
Vp, Vs - P and S wave velocities (km/s) in composite brine-saturated, multimineralic rock.

Greenberg and Castagna empirical model for Vs calculation
(Castagna et al.,1992)

$$Vs = a_{i2} * V_p^2 + a_{i1} * V_p + a_{i0}$$

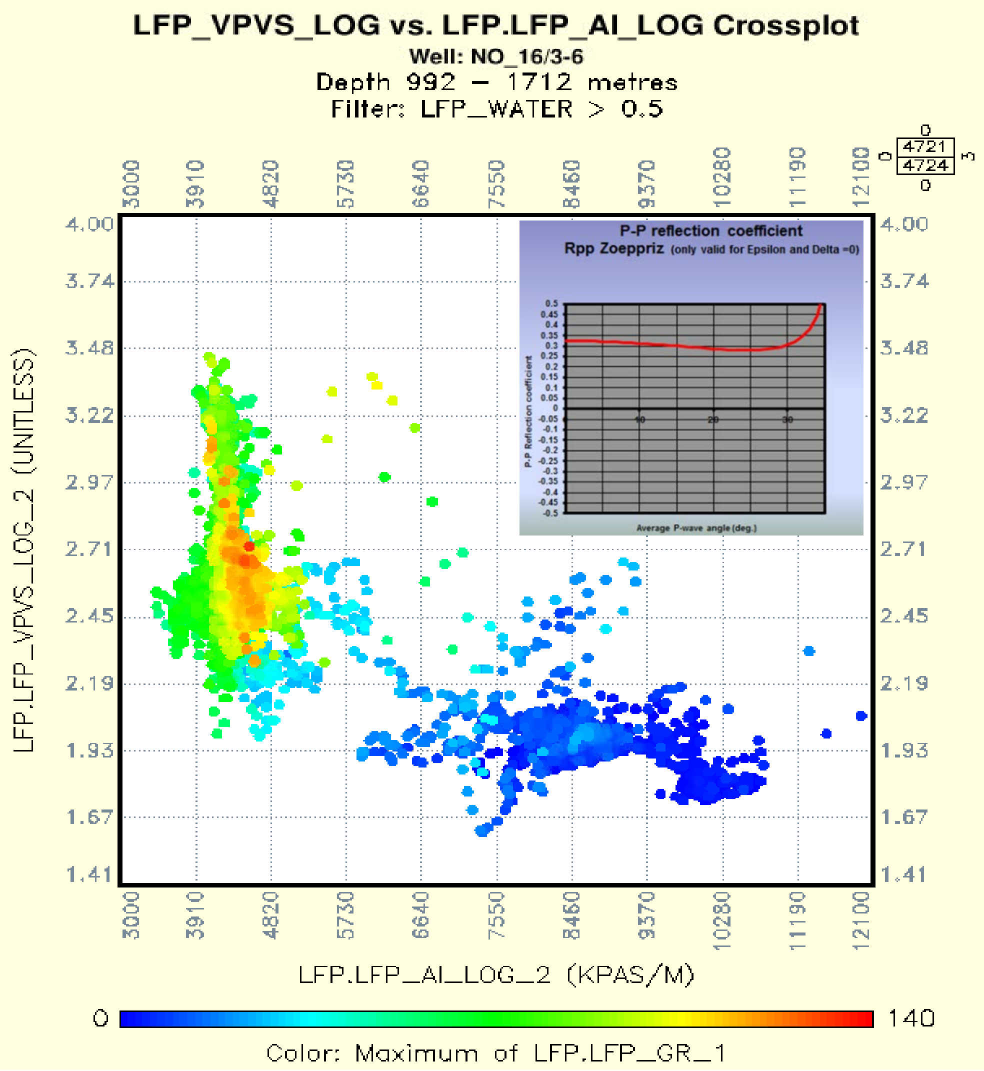
Lithology	a_{i2}	a_{i1}	a_{i0}
Sandstone	0	0.80416	-0.85588
Limestone	-0.05508	1.01677	-1.03049
Dolomite	0	0.58321	-0.07775
Shale	0	0.76969	-0.86735

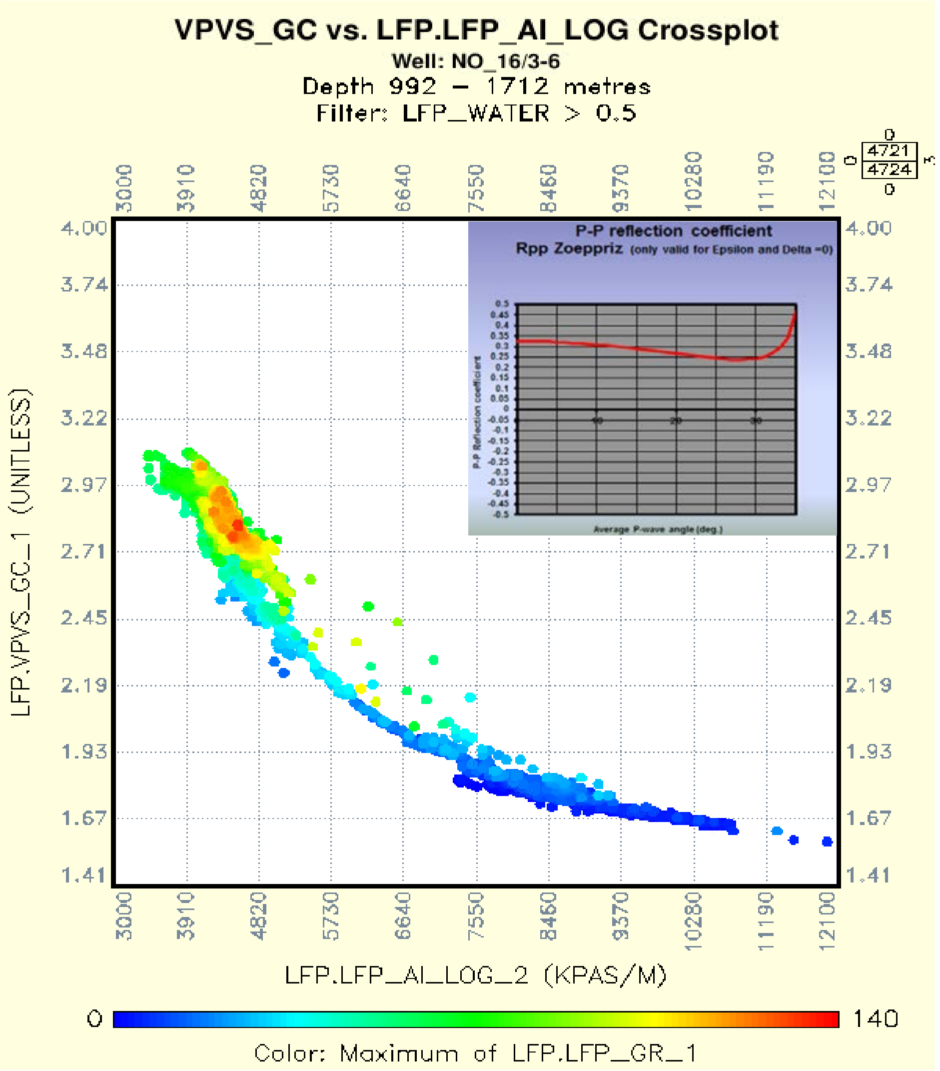
Regression coefficients for pure lithologies with Vp and Vs *(Castagna et al.,1992)*



Greenberg and Castagna model
(Castagna et al.,1992)

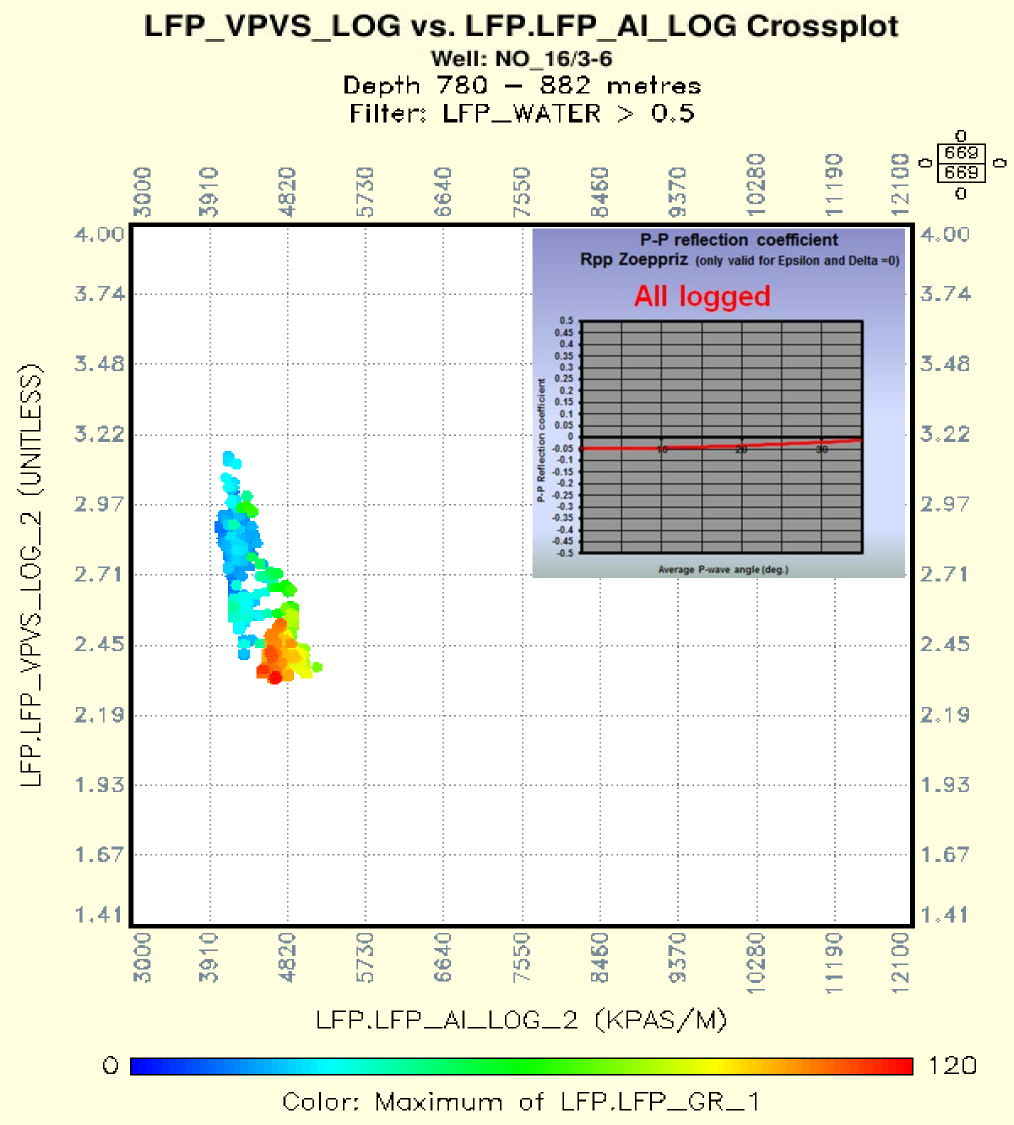
Introduction

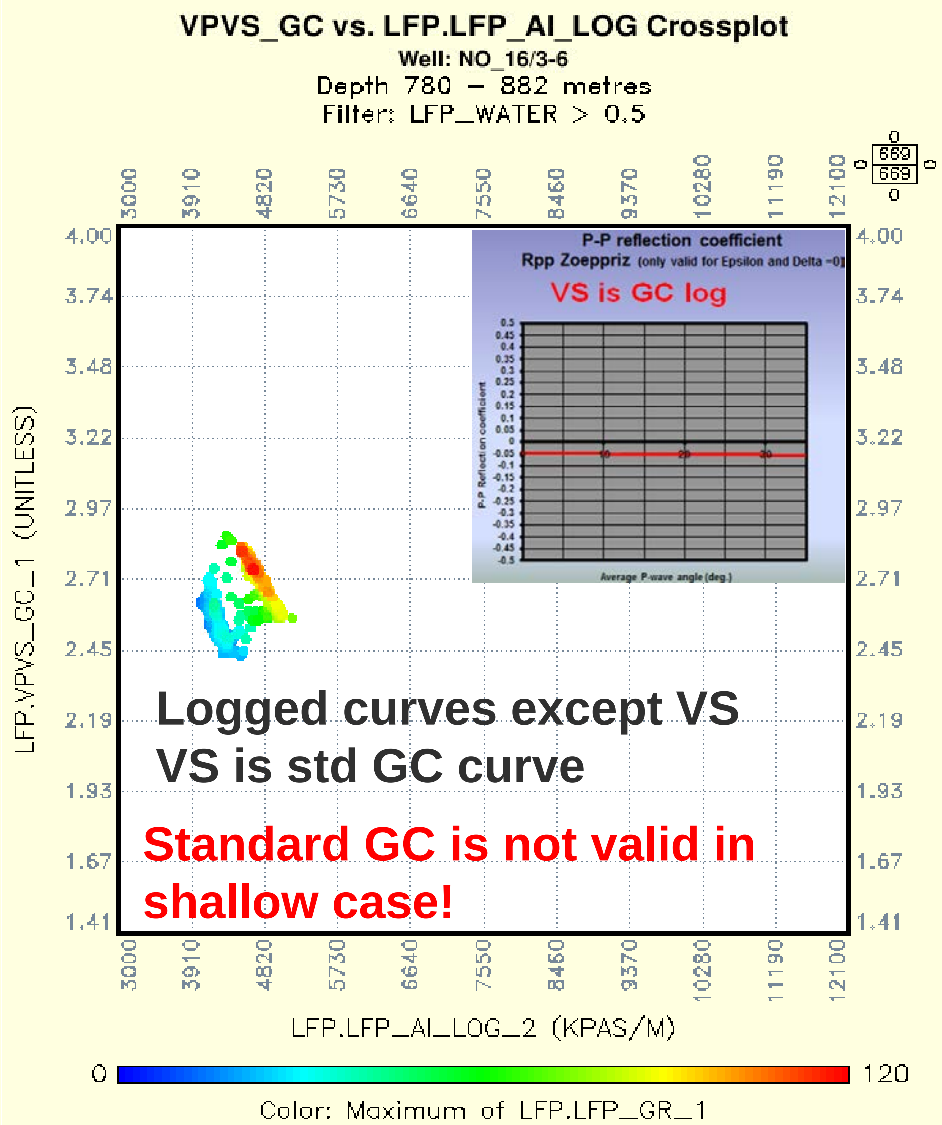




Introduction

Previous observations showed that the Greenberg and Castagna model **is not valid** for the case **of shallow unconsolidated sandstones.**





Objectives

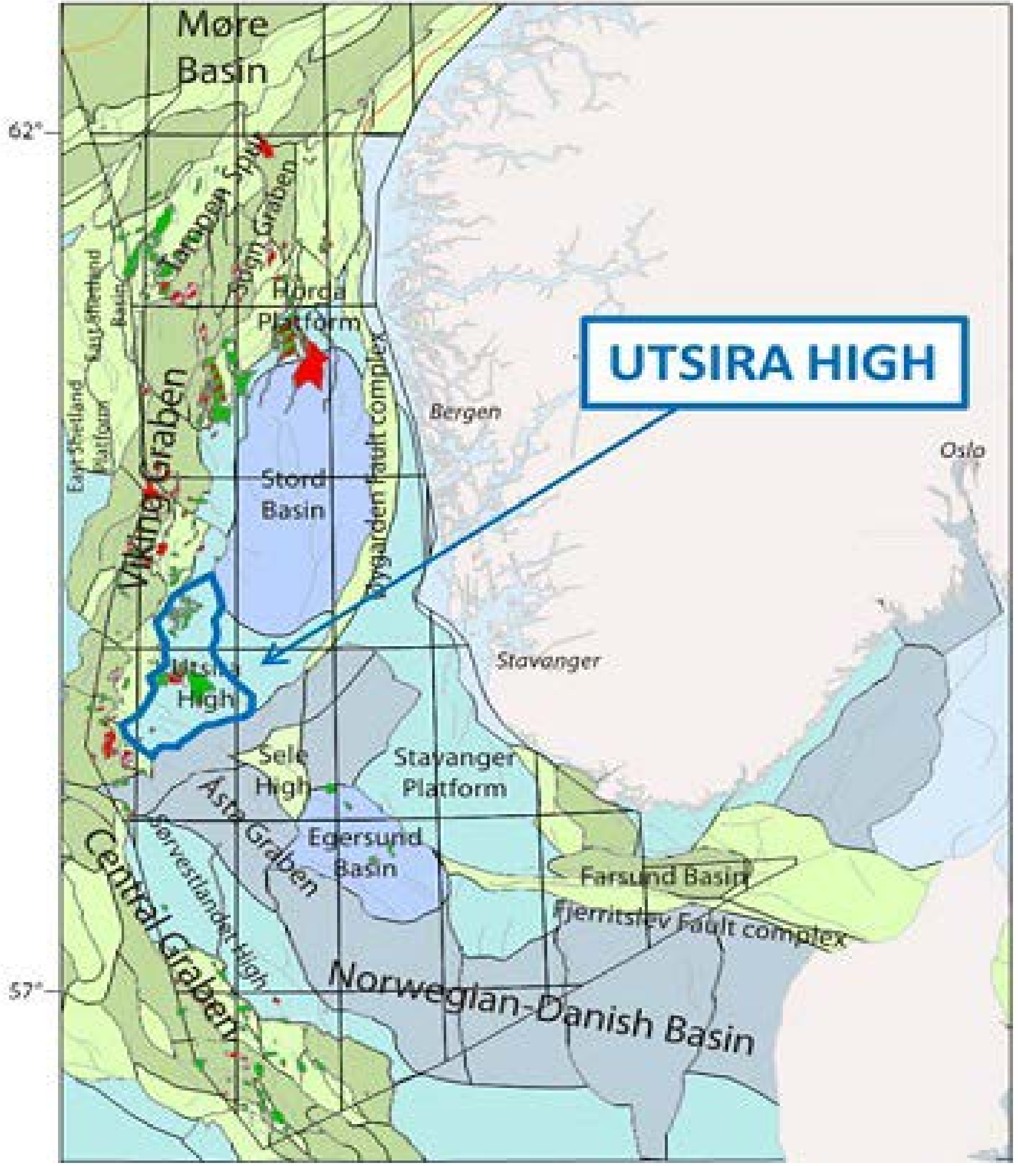
The main objectives of the project are as follows:

- Attempt to define a proper rock physics model for shallow unconsolidated sandstones based on well logging and laboratory data,

- Amplitude Versus Offset (AVO) modeling,

- Analyzing a distribution of the shallow anomaly and its effect to the further exploration and investigation of the area.

Geological setting



Structural elements in the North Sea
(Halland et al., 2011)

- The Utsira High is the area of a studying interest.
- The prospectivity of this area is confirmed by large and predominant oil fields. For example, Johan Sverdrup oil field.
- In the project the object for investigation are shallow sandstones of Utsira Formation.

Methodology

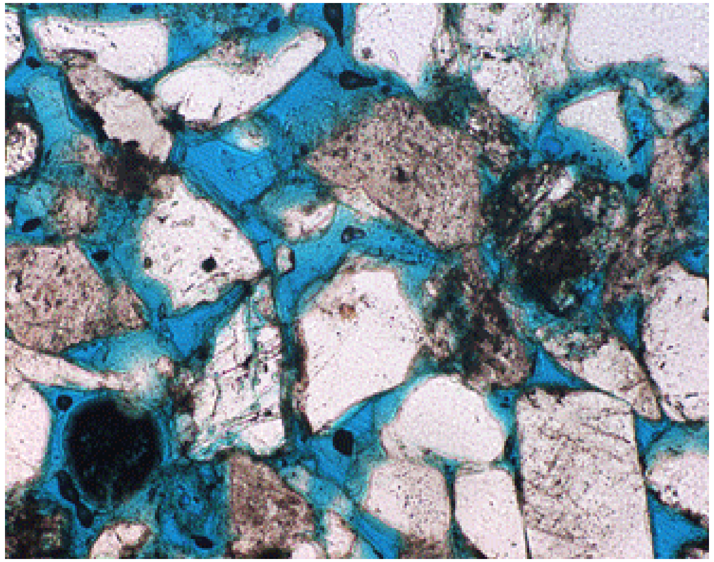
The work flow of the project contains **3 main steps**:

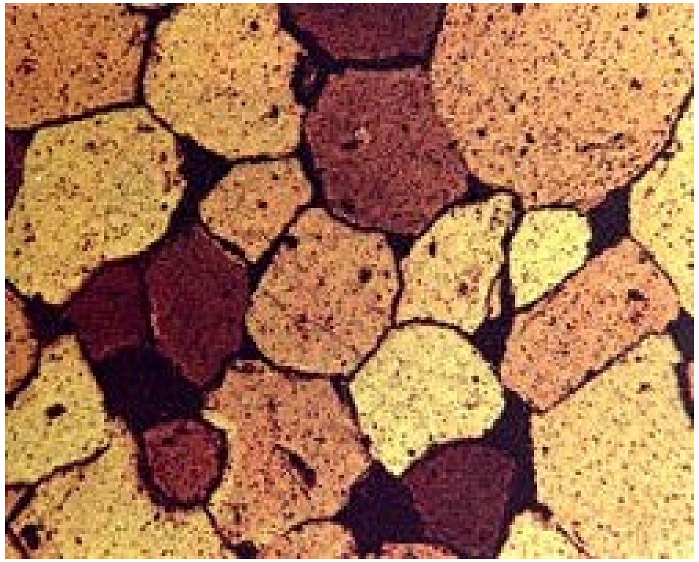
1. Previous laboratory studies of shallow unconsolidated sandstones
2. Petrophysics and building a rock physics model
3. AVO modeling

Methodology

Laboratory studies

- What could be the reason(s) for the shallow anomaly?





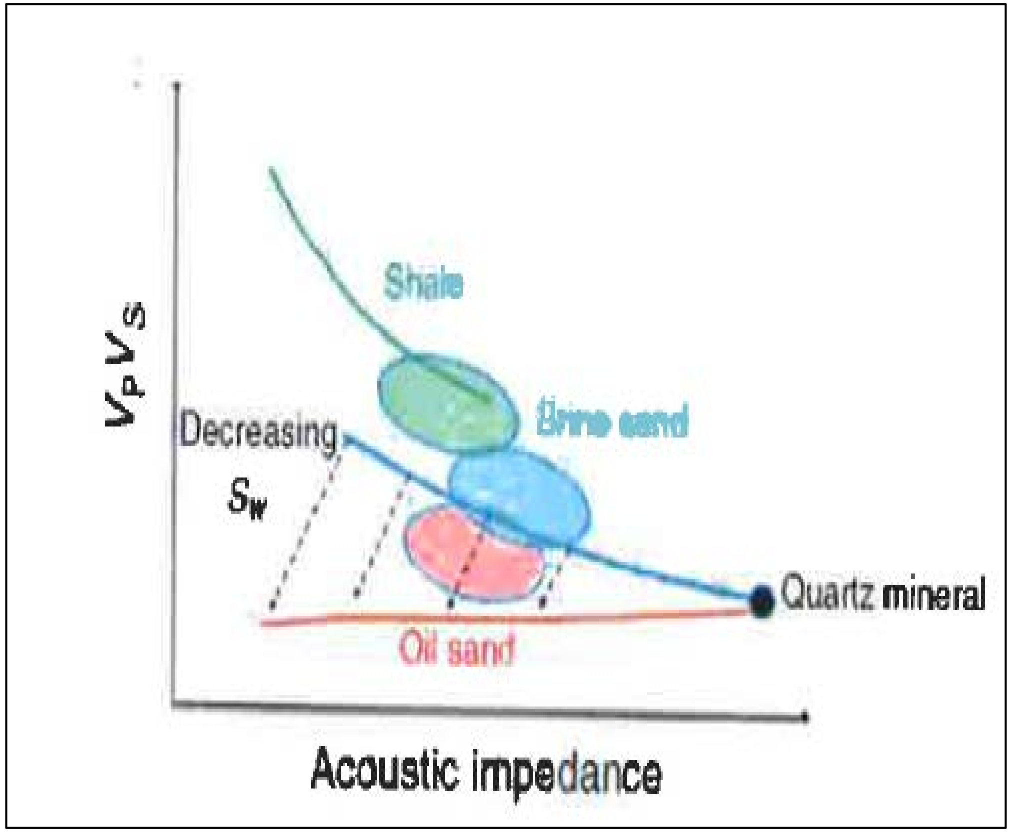
(From http://www.claysandminerals.com)

- ❖ Mineralogy ?
- ❖ Texture?
- ❖ Porosity?
- ❖ Effective pressure?
- ❖ Depth trends?
- ❖ Other?

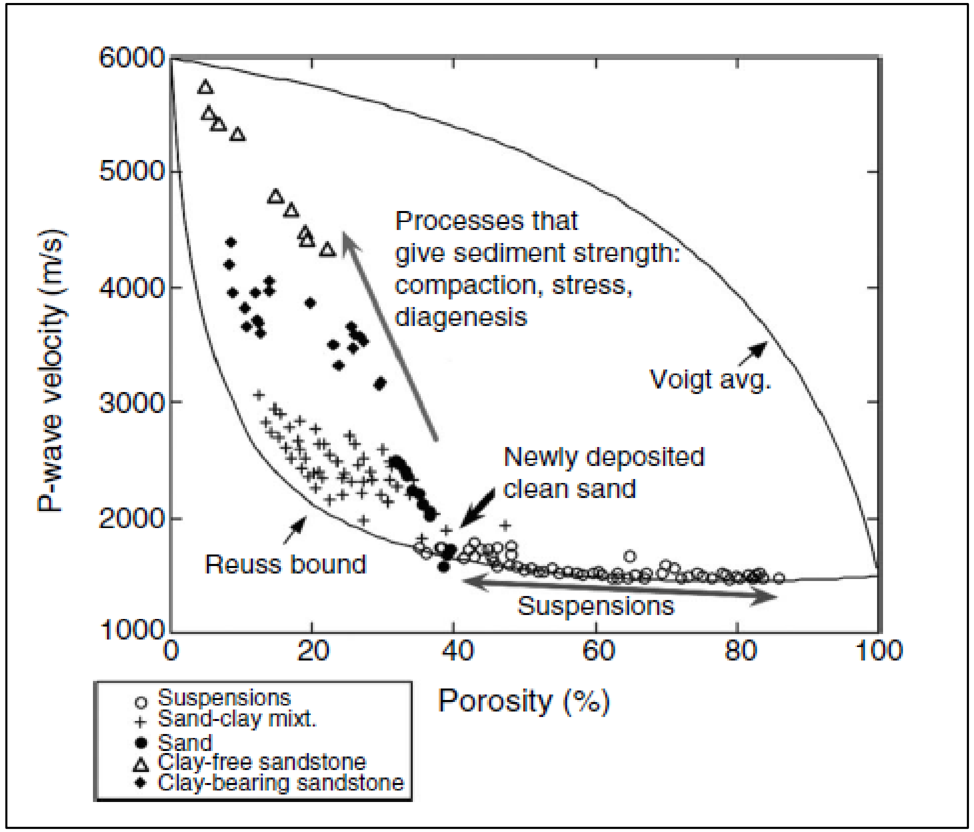
- In order to answer this question it is essential to study previous laboratory works related to geological characteristics of shallow unconsolidated sandstones.

Methodology

Petrophysics and rock physics model



Vp/Vs ratio versus acoustic impedance in unconsolidated sandstones *(From Avseth et al., 2000)*



P-wave velocity versus porosity for a variety of water-saturated sediments *(From Yin et al., 1992)*

- **Rock physics** is a key tool that provides a link between geological reservoir parameters (porosity, clay content, sorting, lithology) and seismic properties (acoustic impedance, P-wave/S-wave velocity ratio Vp/Vs, bulk density and elastic moduli).

Methodology

Petrophysics and rock physics model

- Petrophysical analysis is directed to well logs processing to assess such parameters as porosity, density, saturation, acoustic impedance, P-wave and S-wave velocities.

- The Dvorkin and Nur model ("Vp/Vs-ratio – porosity", "Dry bulk – shear moduli" trends) can be suggested as an initial model for unconsolidated shallow sandstones.

- If this model does not show correct results then other models could be applied in the project with their possible combination or derivation of a new model could be proposed as well.

- Well logs data can not be applied directly to the rock physics model.

- Such parameters as Vp and Vs can be evaluated from sonic logs empirically.

Methodology

AVO modeling

- The attributes for AVO analysis include the basic relative contrast terms $\Delta\alpha/\alpha$, $\Delta\beta/\beta$ and $\Delta\rho/\rho$, where α – Vp, β – Vs.

- This parameters define the equation of reflection coefficient:

$$R(\theta) = \frac{1}{2} * (1 + \tan\theta^2) * \frac{\Delta\alpha}{\alpha} - 4 * k^2 * \sin\theta^2 * \frac{\Delta\beta}{\beta} + \frac{1}{2} * (1 - 4 * k^2 * \sin\theta^2) * \frac{\Delta\rho}{\rho},$$

where $k=\beta/\alpha$, θ – incidence angle.

(From Aki et. al., 1980)

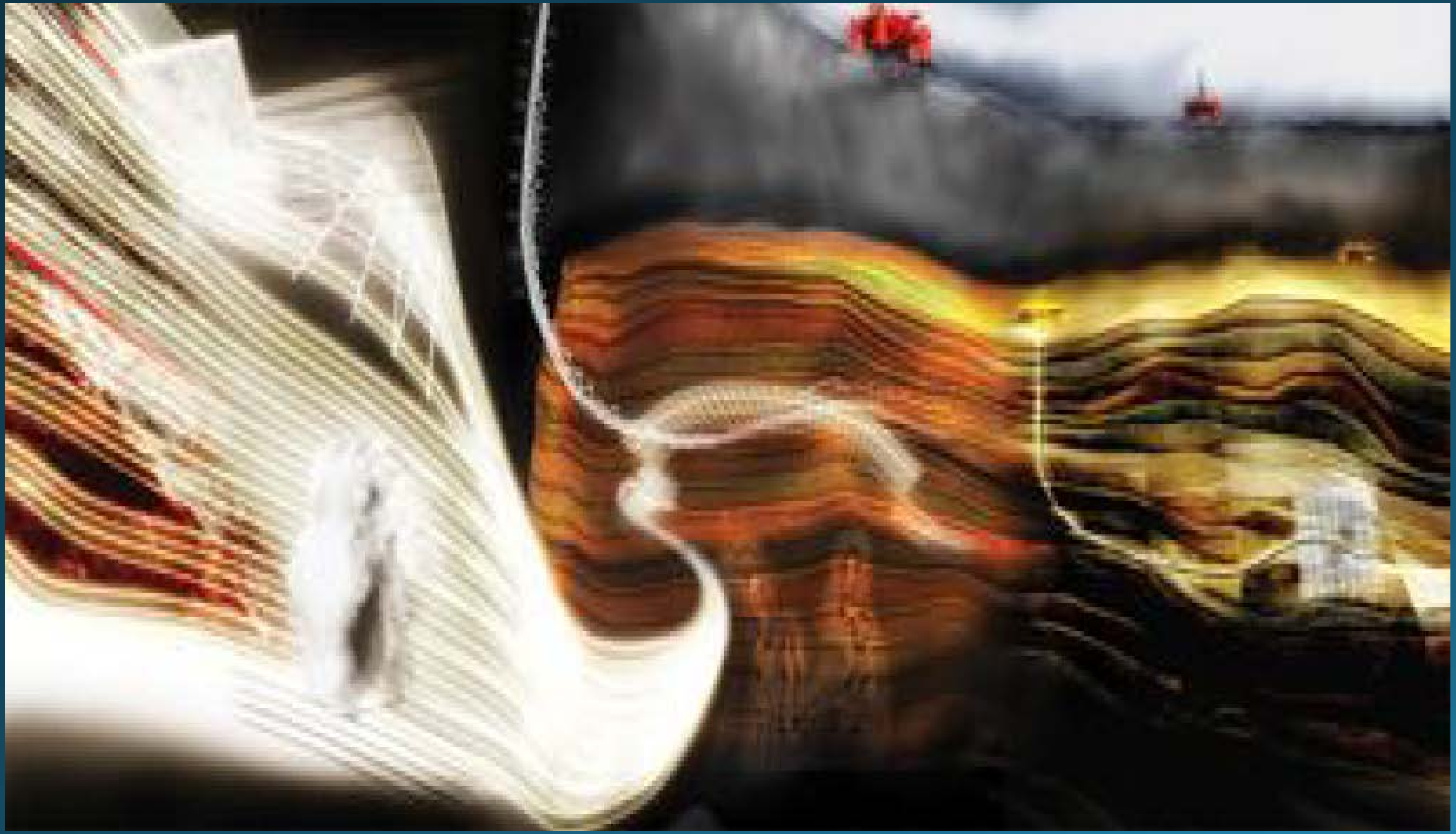
- With reflection coefficient it is possible to create the AVO curve.

Data

- ✓ Well tops;
- ✓ Well logs of 12 wells;
- ✓ Laboratory data;
- ✓ Pre-stack seismic data for AVO modeling.

Master Thesis Proposal

Bayesian Lithology and Fluid Prediction on the Mikkel Field using a geologically constrained prior model



Isaias Castillo
Supervisor: Dr. Arild Buland

Universitetet i Stavanger

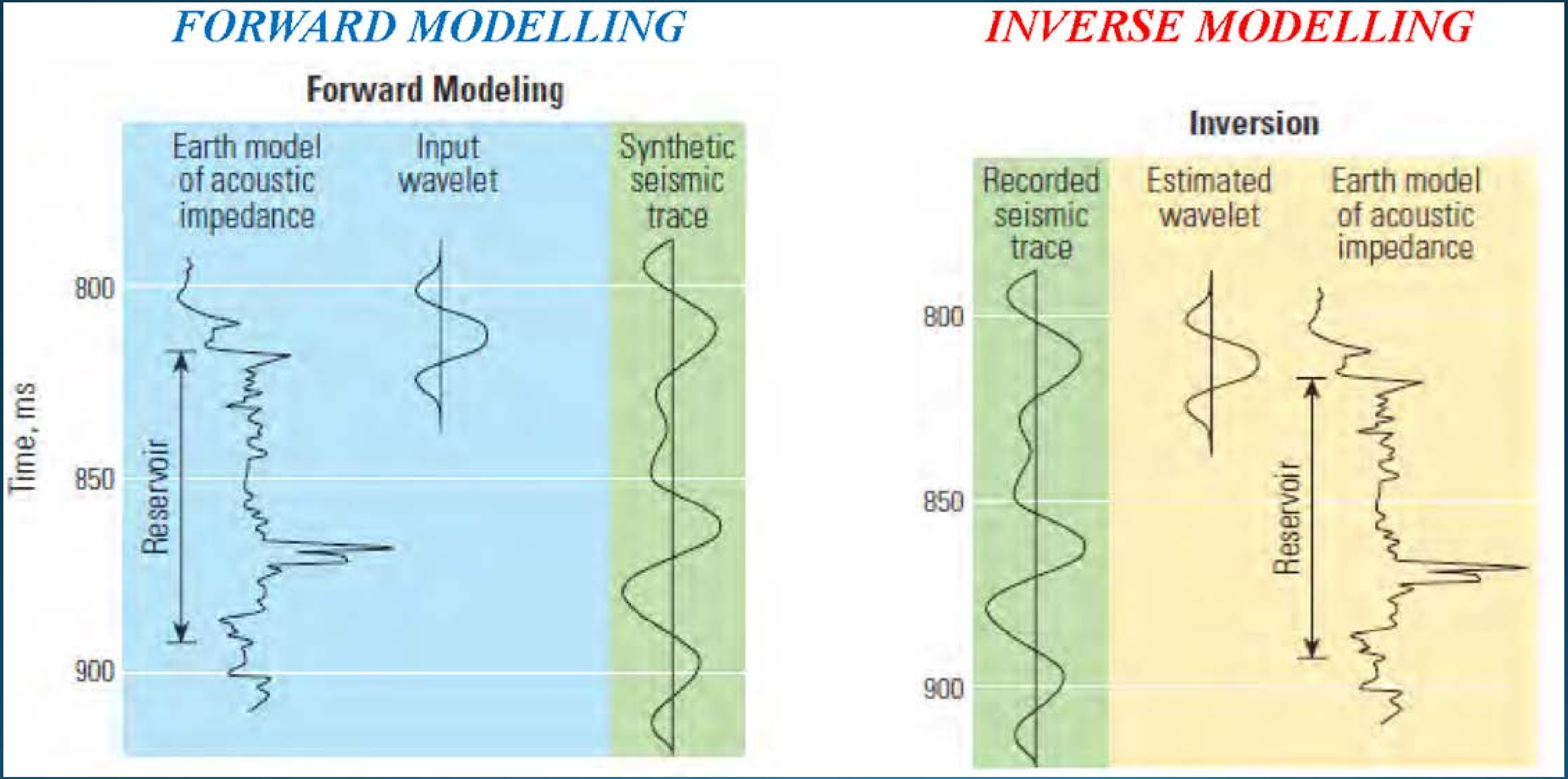
Agenda

Universitetet i Stavanger

1. Introduction
2. Study Area Location
3. Motivation
4. Objectives
5. Dataset
6. Methodology

Introduction

Seismic inversion to acoustic impedance is NON-UNIQUE (uncertainty)



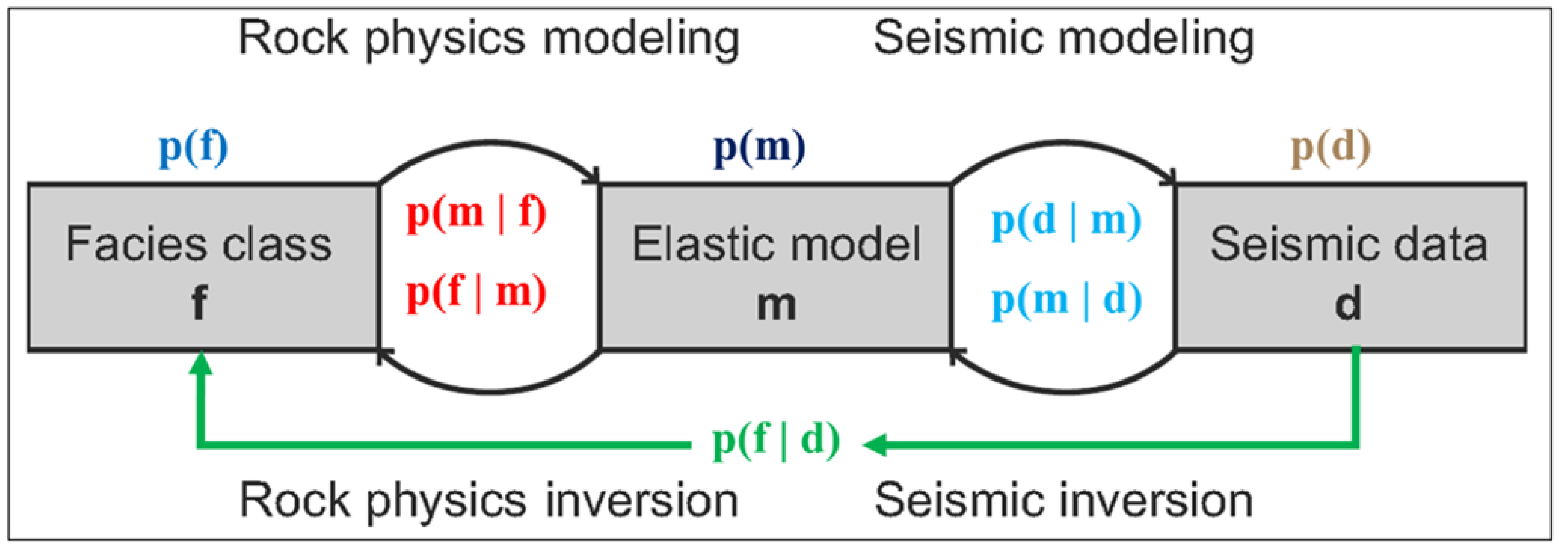
(Oilfield Review, 2008)

Introduction

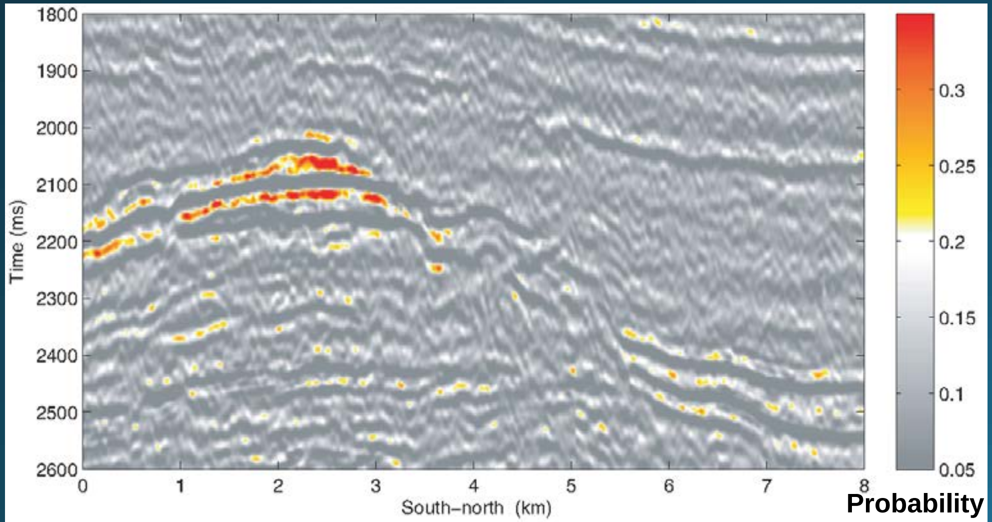
Bayesian pre-stack inversion allows to generate different realizations of the elastic properties with their associated uncertainties.

$$P(B|A) = \frac{P(A|B)P(B)}{P(A)}$$

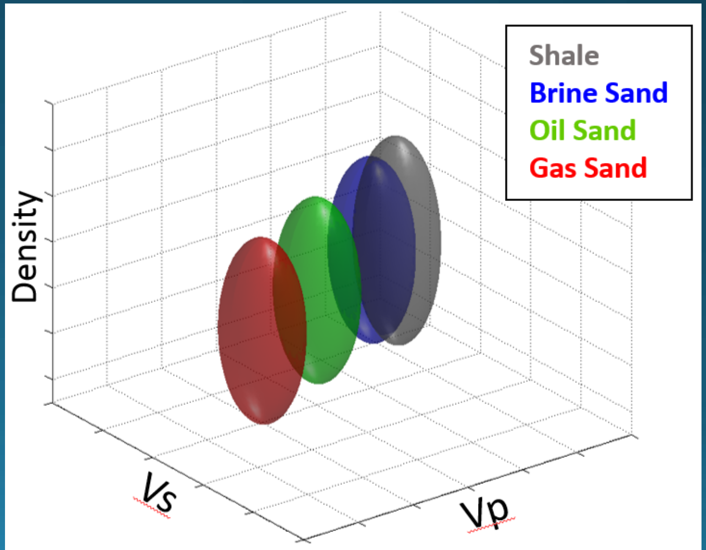
Bayes' Theorem



(Buland et al., 2008)



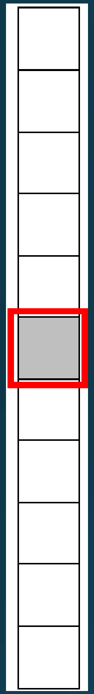
(Buland et al., 2008)

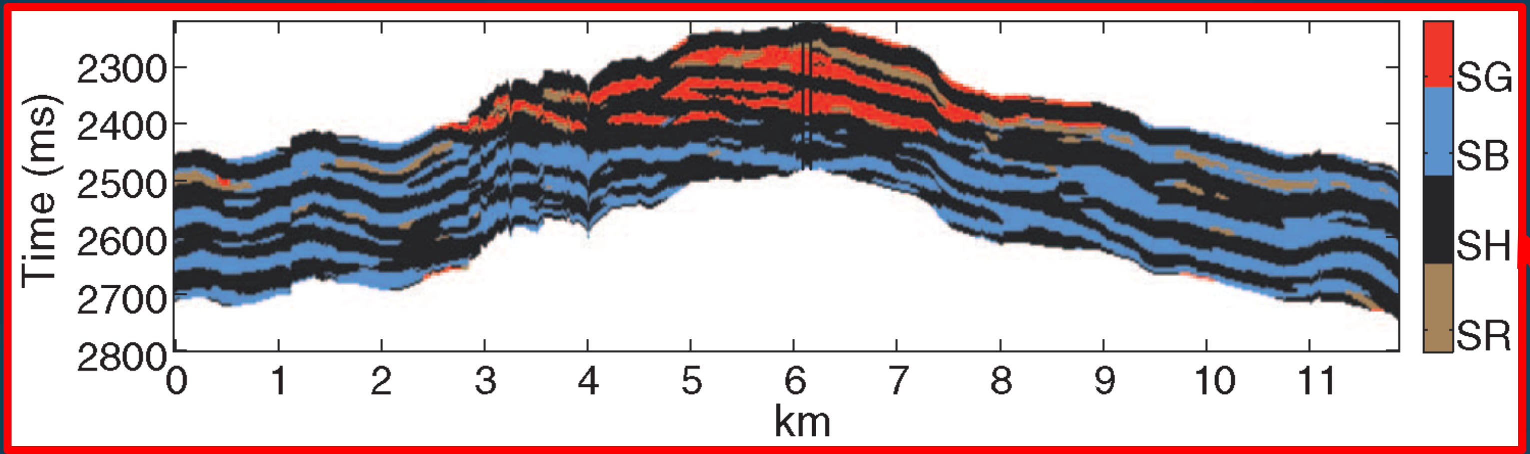


Introduction

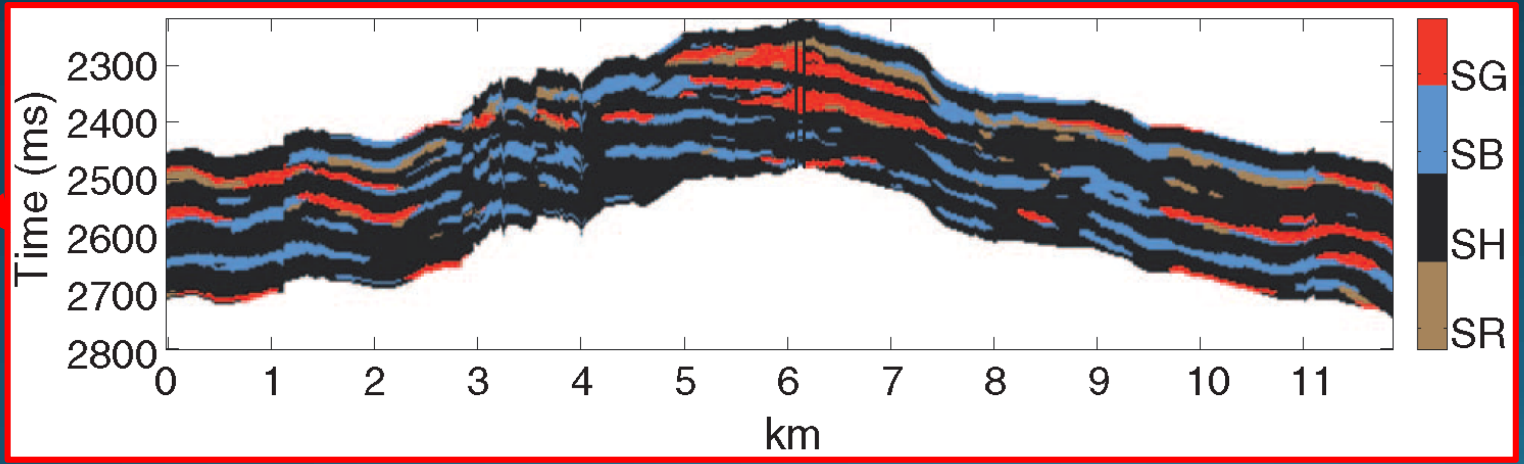
Two main algorithms in the Bayesian pre-stack inversion

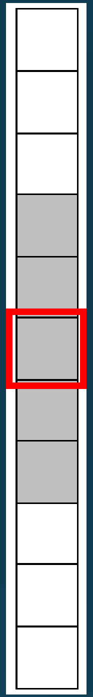
Identify extensive features of the reservoir and vertically enforces fluids configuration.





Most probable lithofluid characteristics prediction





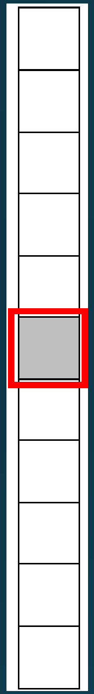
(Ulvmoen et al., 2010)

Pointwise	Neighborhood (Spatial coupling)
Unconstrained geologically	Constrained geologically
Less realistic	More realistic
Fast	Time consuming

Introduction

Two main algorithms in the Bayesian pre-stack inversion

Identify extensive features of the reservoir

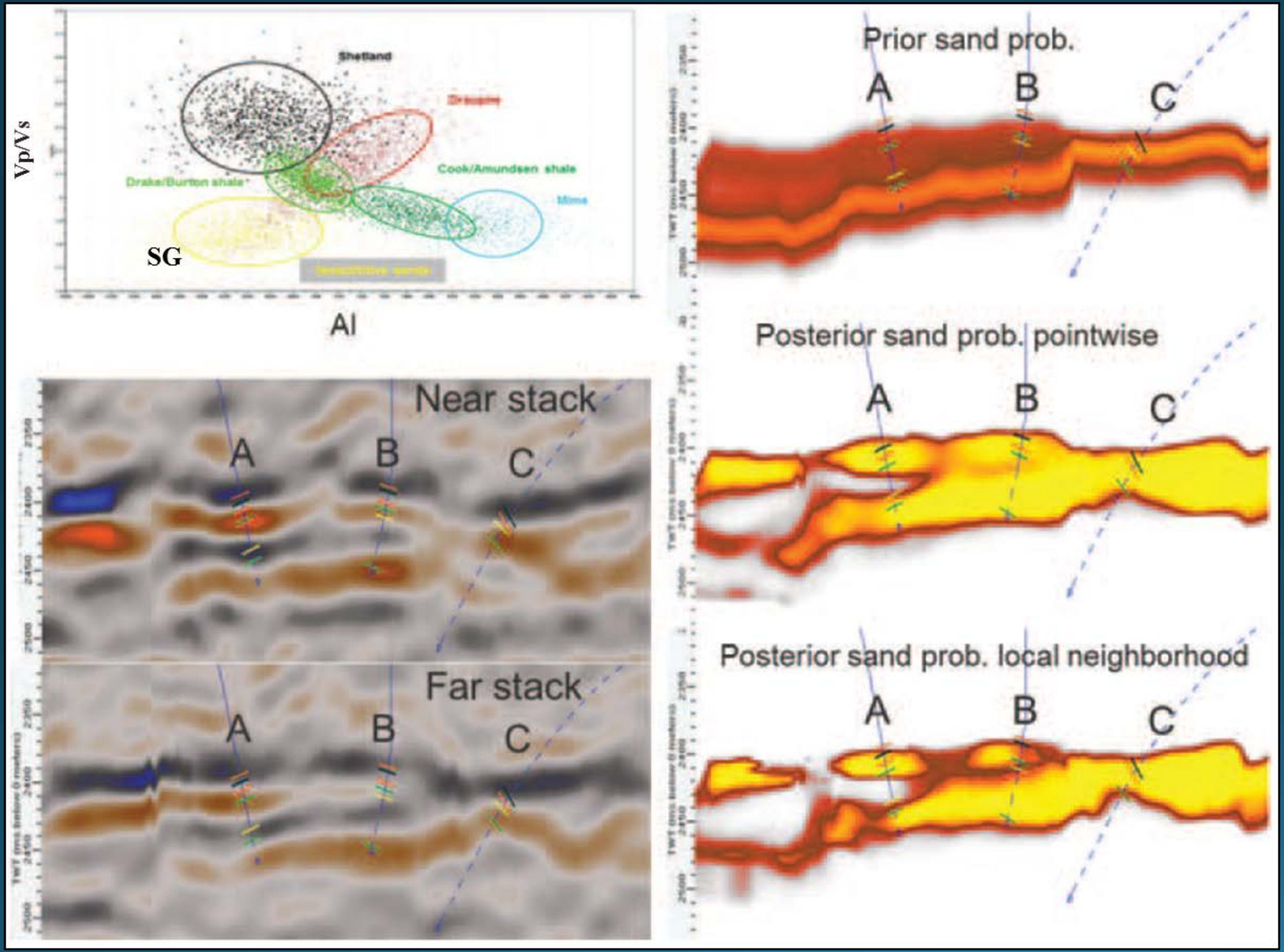


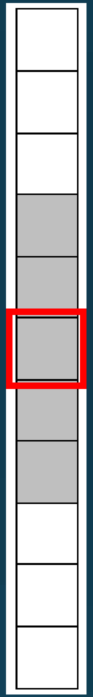
Pointwise

Unconstrained geologically

Less realistic

Fast





Neighborhood (Spatial coupling)

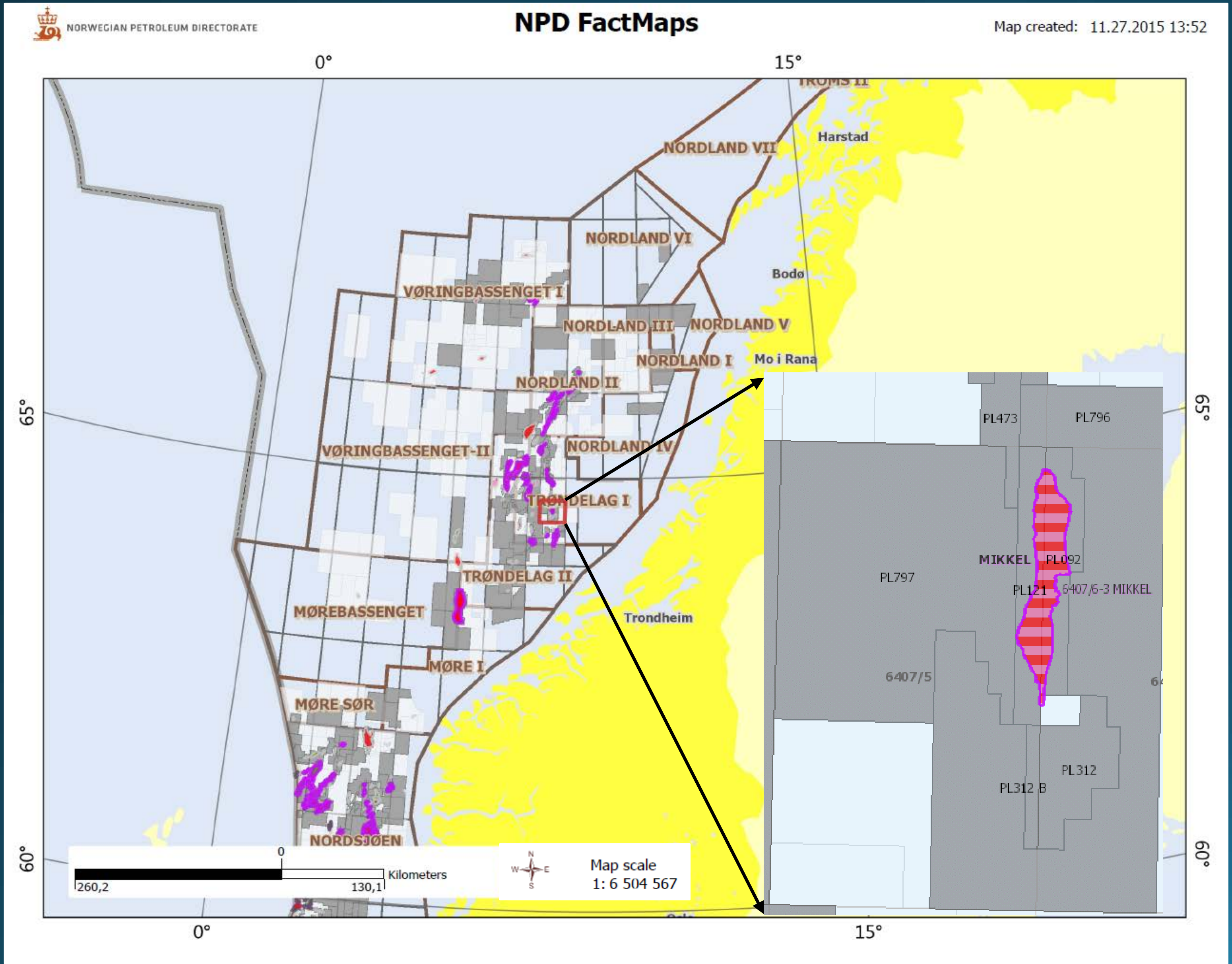
Constrained geologically

More realistic

Time consuming

(Kolbjørnsen et al., 2016)

Study Area Location



Field: Mikkel

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

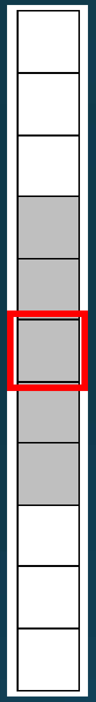
Reservoirs:

300-meter-thick gas and condensate sandstone (Jurassic).

(NPD, 2016)

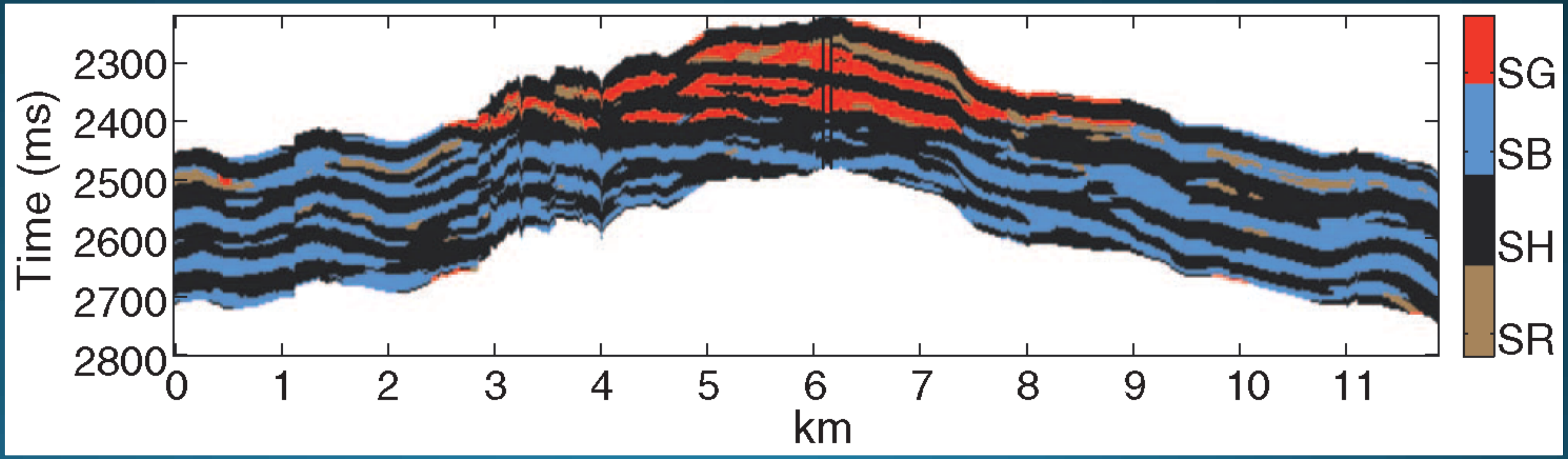
Motivation

- **Generate LFC distribution geologically constrained to predict reservoir quality from seismic data to optimize future development plans**
- **Identify extensive features of the reservoir and vertically enforces fluids configuration**



Neighborhood algorithm (Spatial coupling)

Gas-saturated sandstone
Brine-saturated sandstone
Shale
Source rock



(Ulvmoen et al., 2010)

Objectives

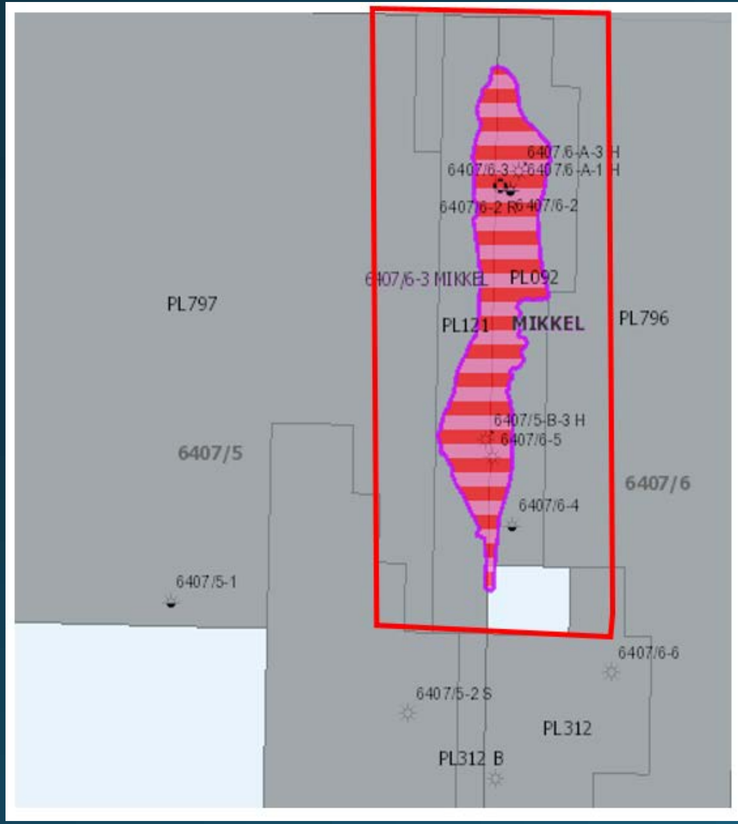
Universitetet i Stavanger

- Generate a 3D volume distribution for each litho-fluid class with their associated uncertainties within the seismic survey using Bayesian inversion with spatial coupling.

- Highlight and quantify the hydrocarbon pay volume versus the non-productive zones.

- Implement structural and stratigraphic information accompanied with inversion result to reduce the uncertainty of the subsurface.

Dataset



(NPD, 2016)

Seismic Survey:

- 186 km² of PSTM, Pre-stack Kirchhoff time migration
- Migration velocity cube

Well data:

- 6 wells with wireline logs

Geological time seismic interpretation:

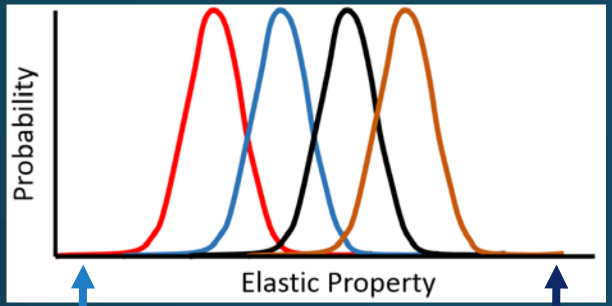
- Horizons and faults

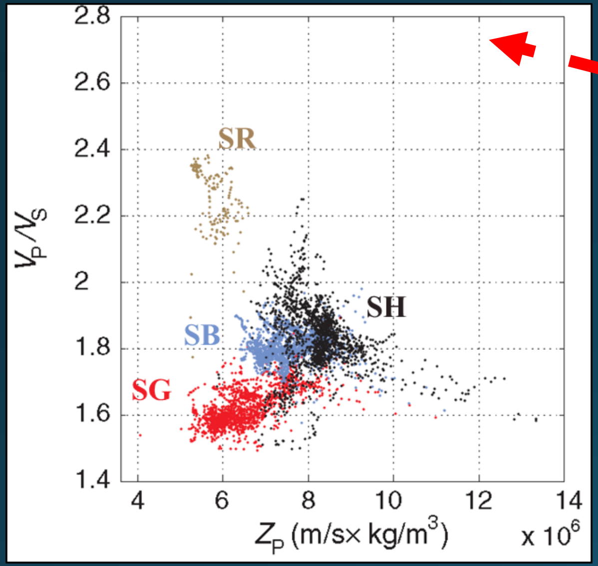
Methodology

P(x | y) ∝ P(y | x) * P(x)

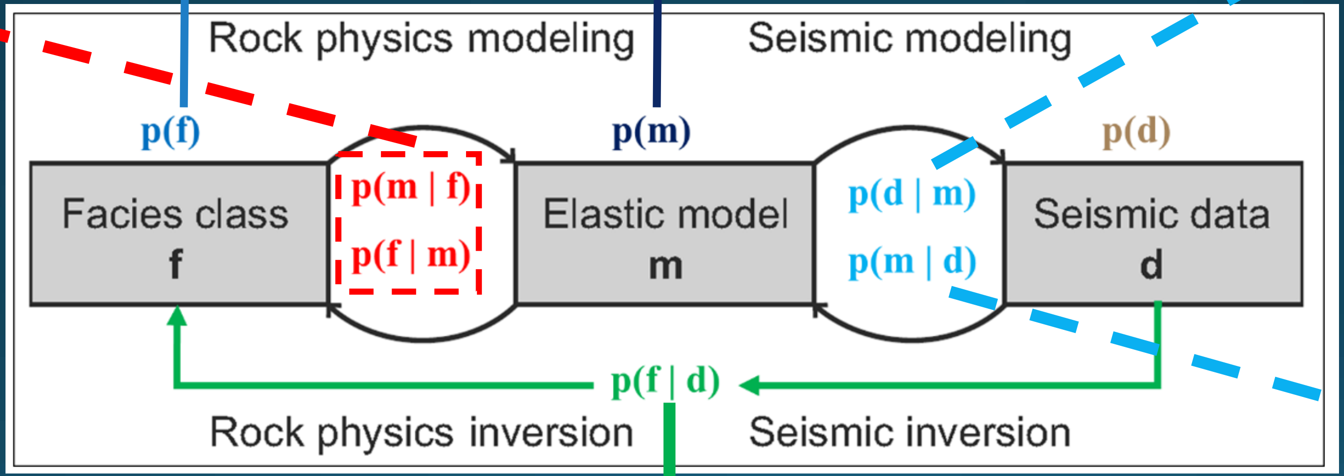
Posterior — Likelihood — Prior

statistics from well data



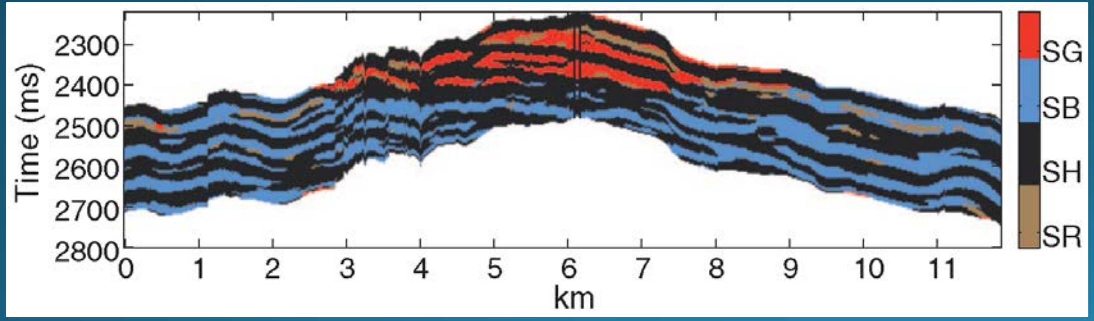


(Ulvmoen et al., 2010)

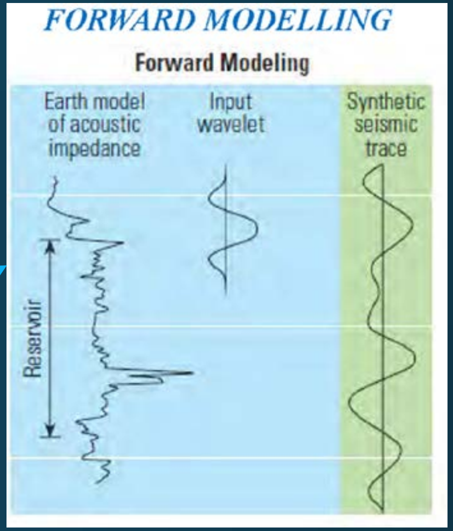


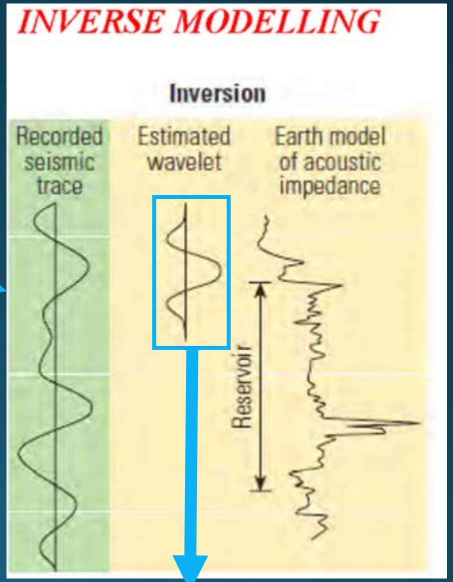
(Buland et al., 2008)

(Ulvmoen et al., 2010)



- SG **Gas-saturated sandstone**
- SB **Brine-saturated sandstone**
- SH **Shale**
- SR **Source rock**





Wavelet estimation and deconvolution

Thank you

Architecture, provenance and reservoir quality of the Late Cretaceous Lange-Lysing Megasequence

Kristina Tegle

Supervisors:
Rodmar Ravnås (UiS & Norske Shell)
Carita Augustsson (UiS)

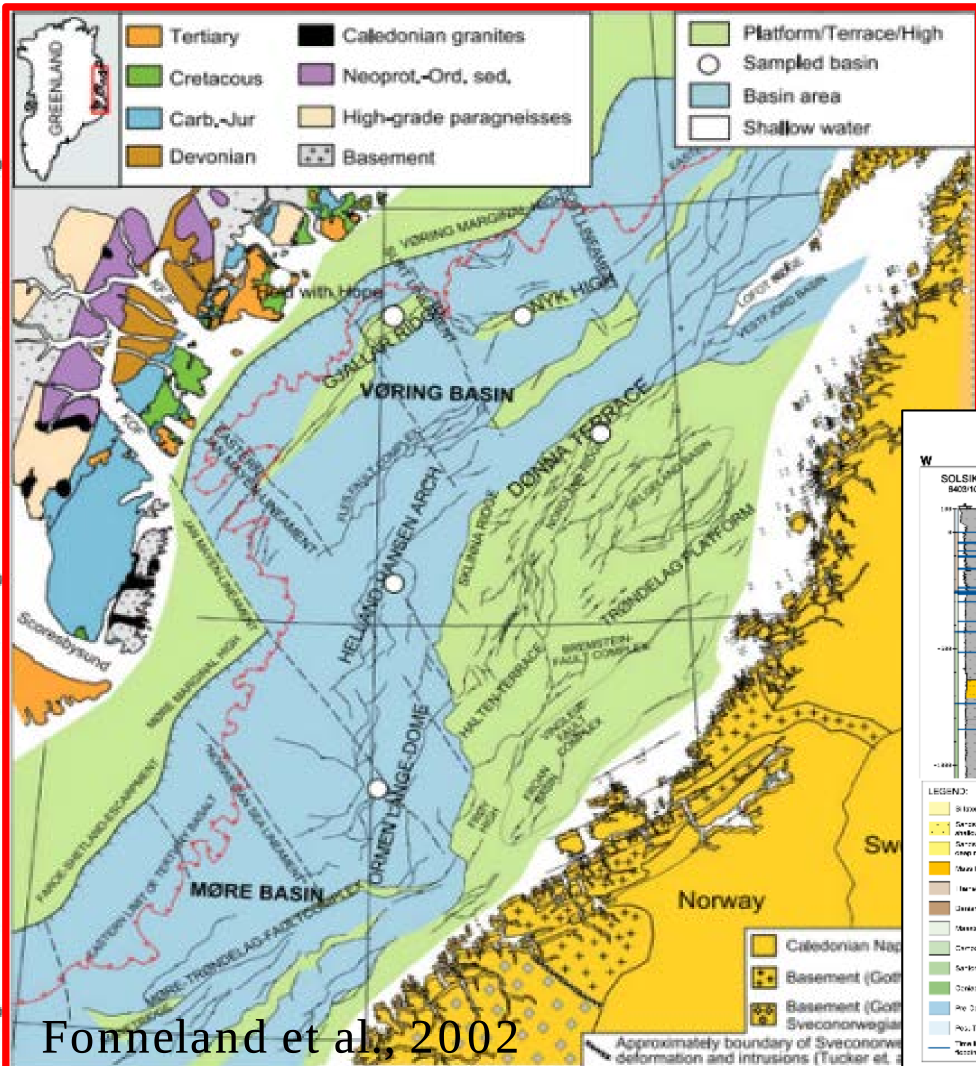
University of Stavanger

Shell

Agenda

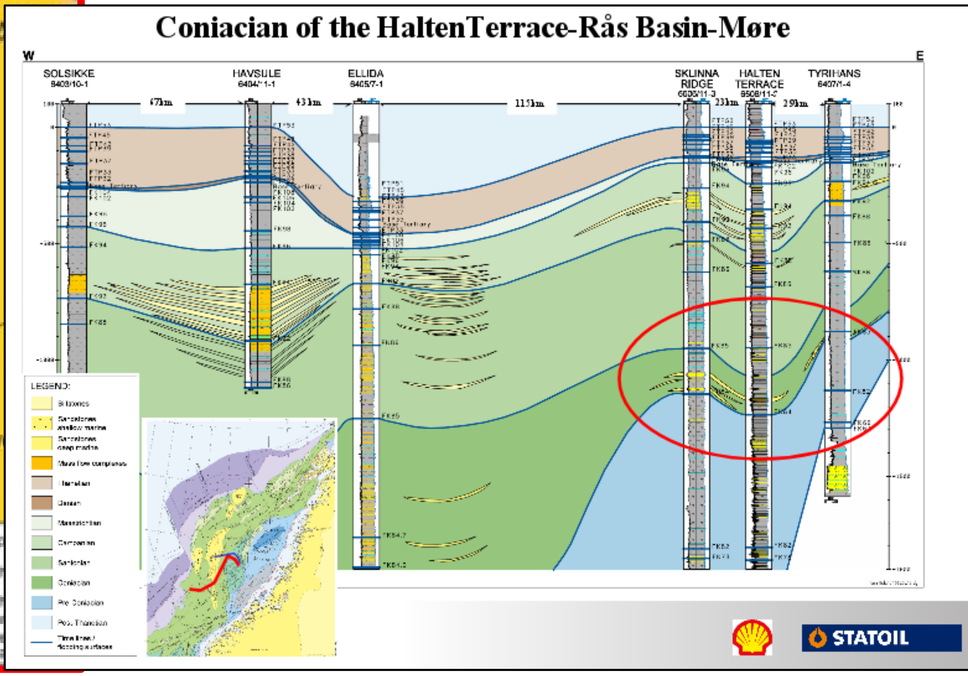
- Introduction of study location & objectives
- Geological setting
- Previous work:
  - Basin infill
  - Depositional model
  - Provenance
- Dataset
- Methodology

Introduction

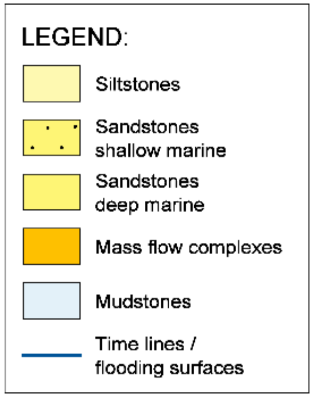


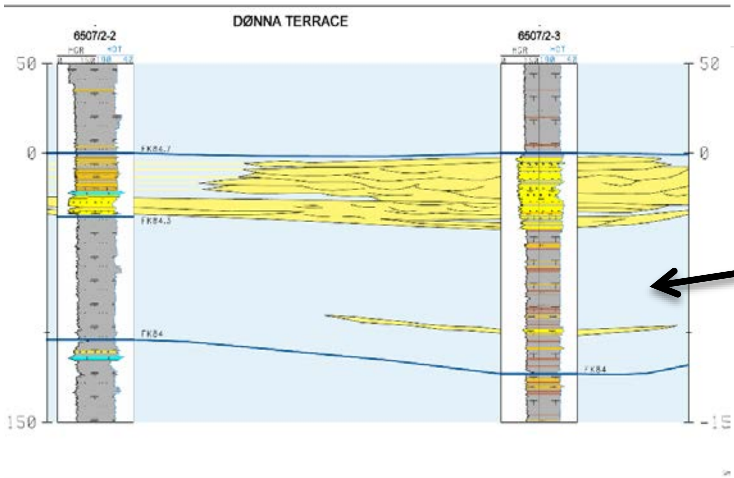
Fonneland et al., 2002

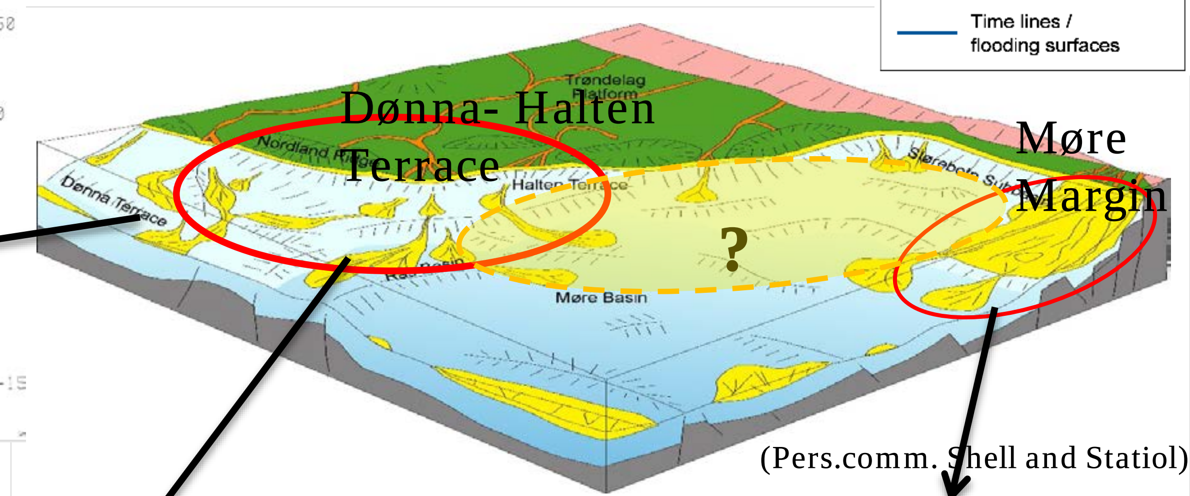

http://www.offshoreenergytoday.com/norway-pgnig-reports-discovery-of-gas-deposits-in-snadd-north-prospect/

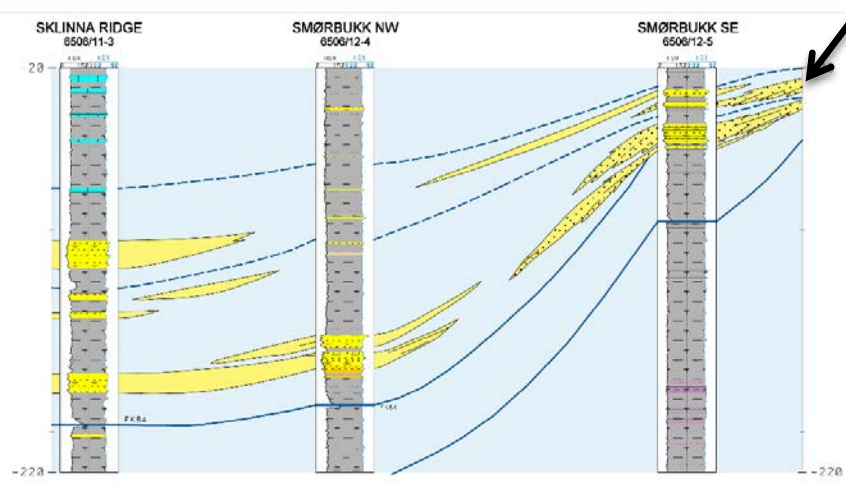


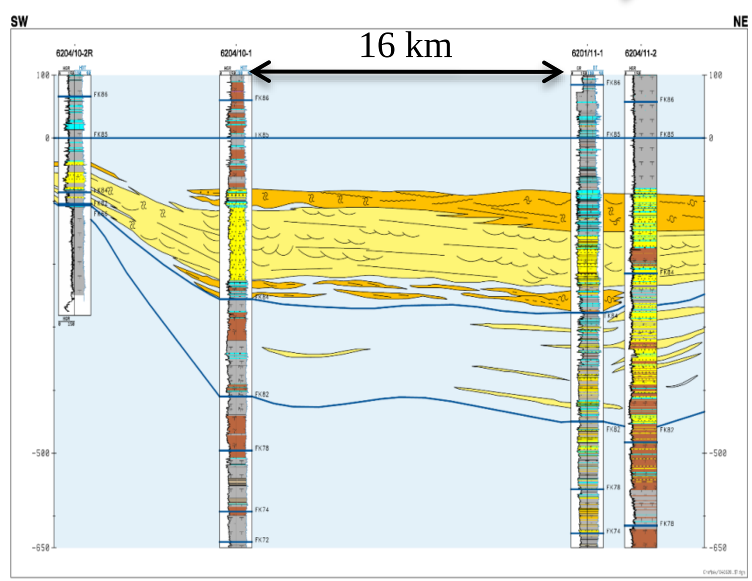
Coniacian Depositional model





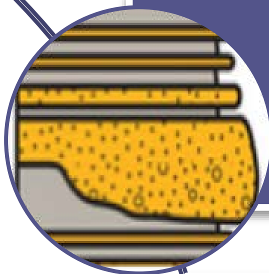






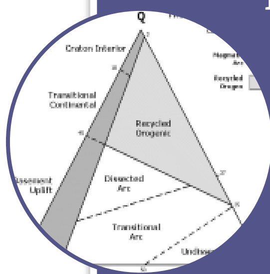
Objetives

Reservoir quality and spatial distribution of reservoir



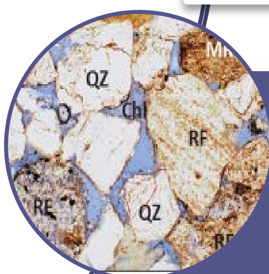
Architecture and facies analysis

- How the architectural elements and facies are partitioned within and possibly vary between the megasequence segments?



Provenance

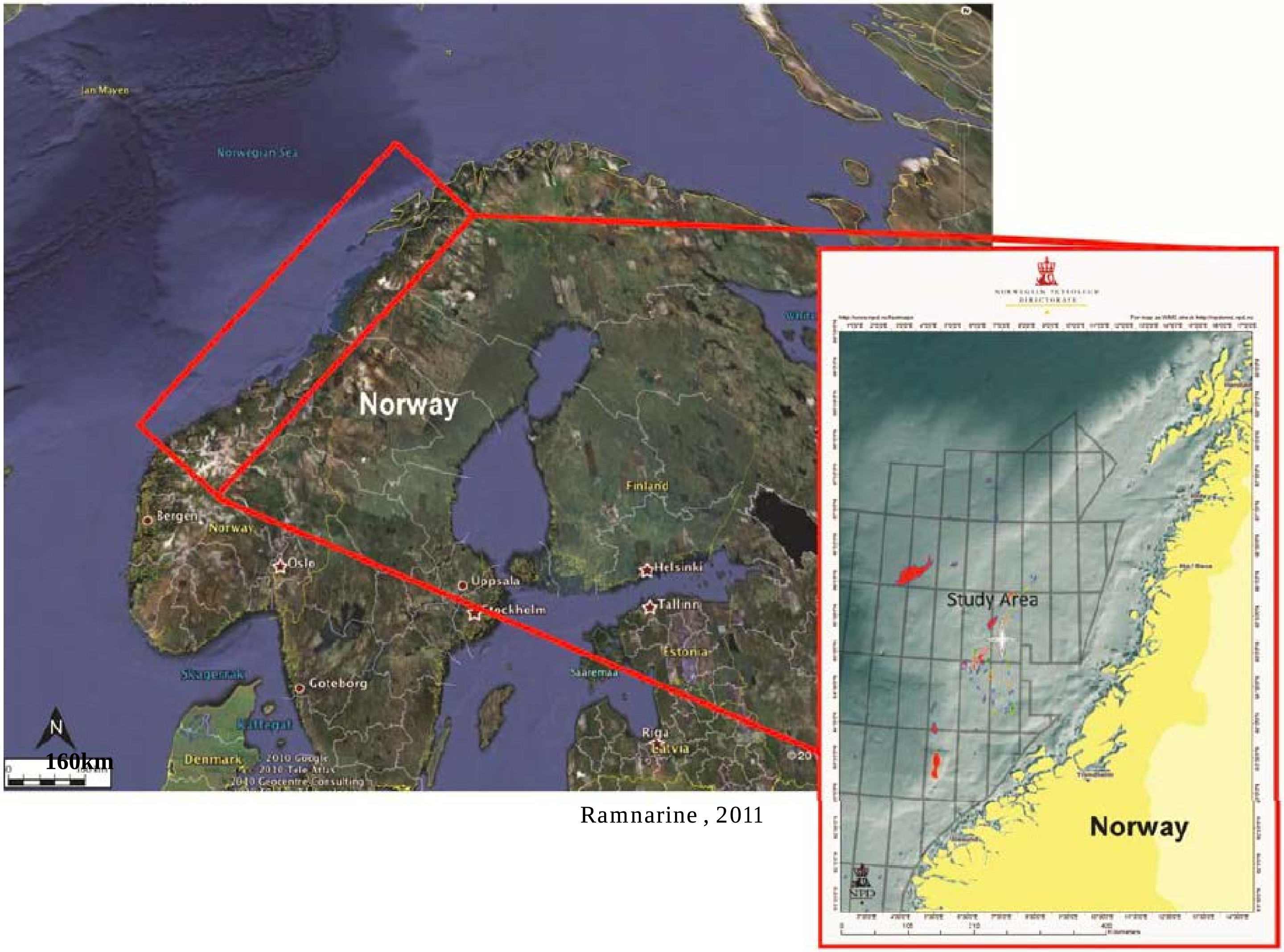
- Investigate the potential to use provenance.
- Correlate stratigraphically and laterally and compare the Lange and Lysing megasequences.
- Where the sand comes from and by what delivery system(s)?



Reservoir characterization

- Examine the variability and spatial distribution of the reservoir quality and diagenetic controls within and between the turbidite system.

Location of interest



Ramnarine , 2011

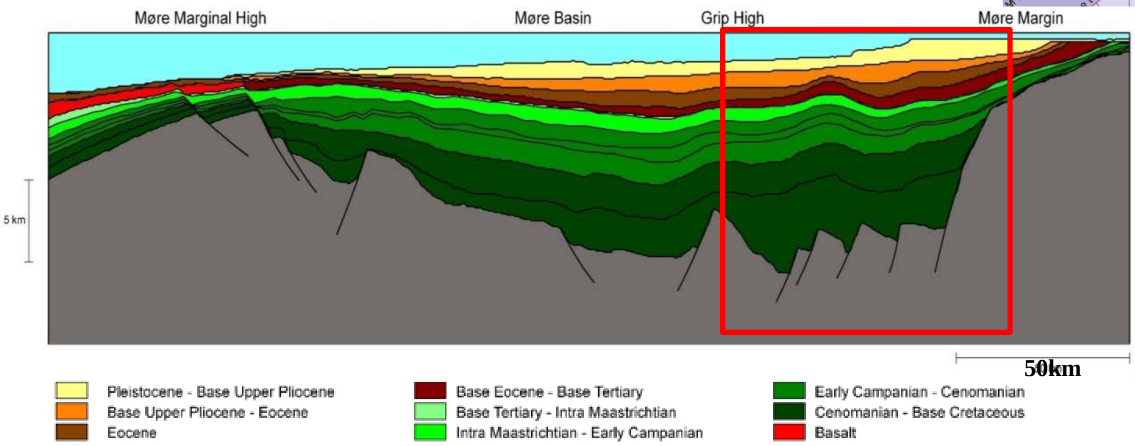
Geological setting

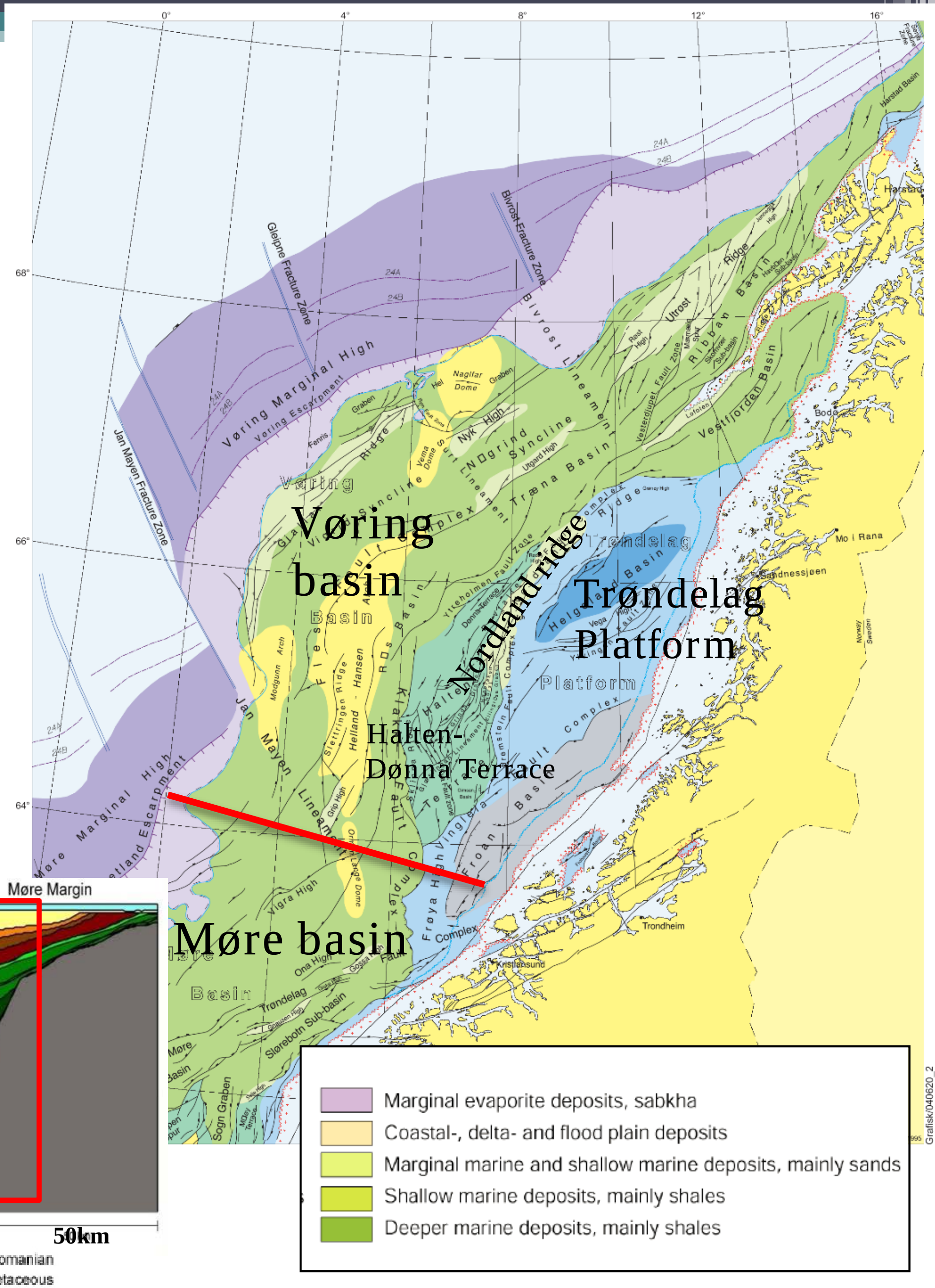
Multi-episodic rifting:

1) Permian to Triassic
2) Middle Jurassic to Early Cretaceous
3) Late Cretaceous to Early Paleocene

Separation from Greenland

Reactivation of Jurassic faults





(Pers.comm. Shell)

Tectonostratigraphy and basin infill

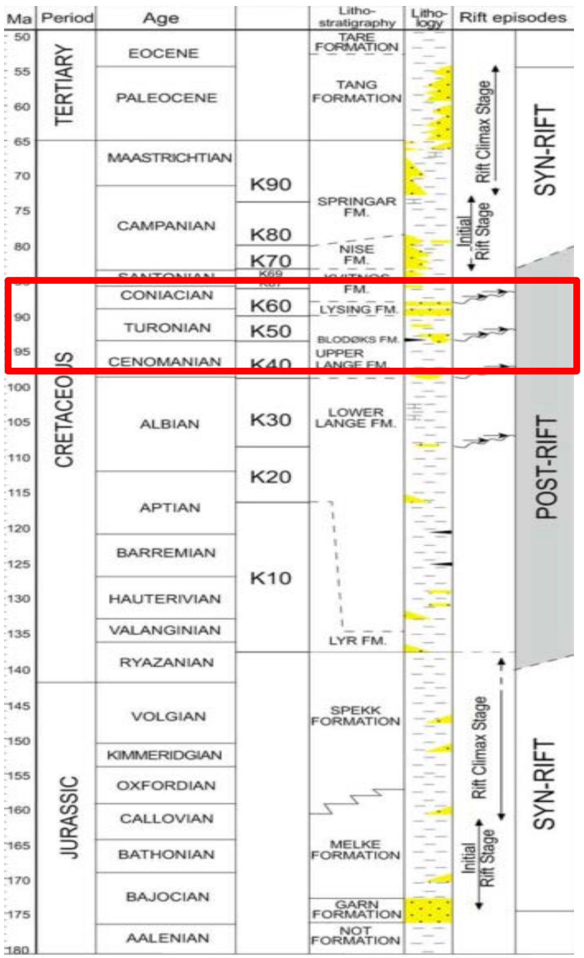
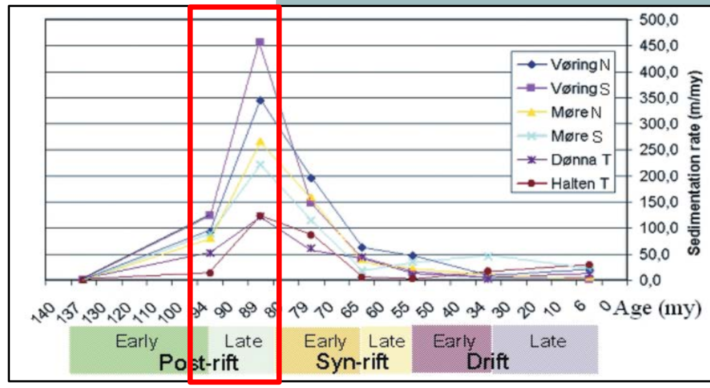


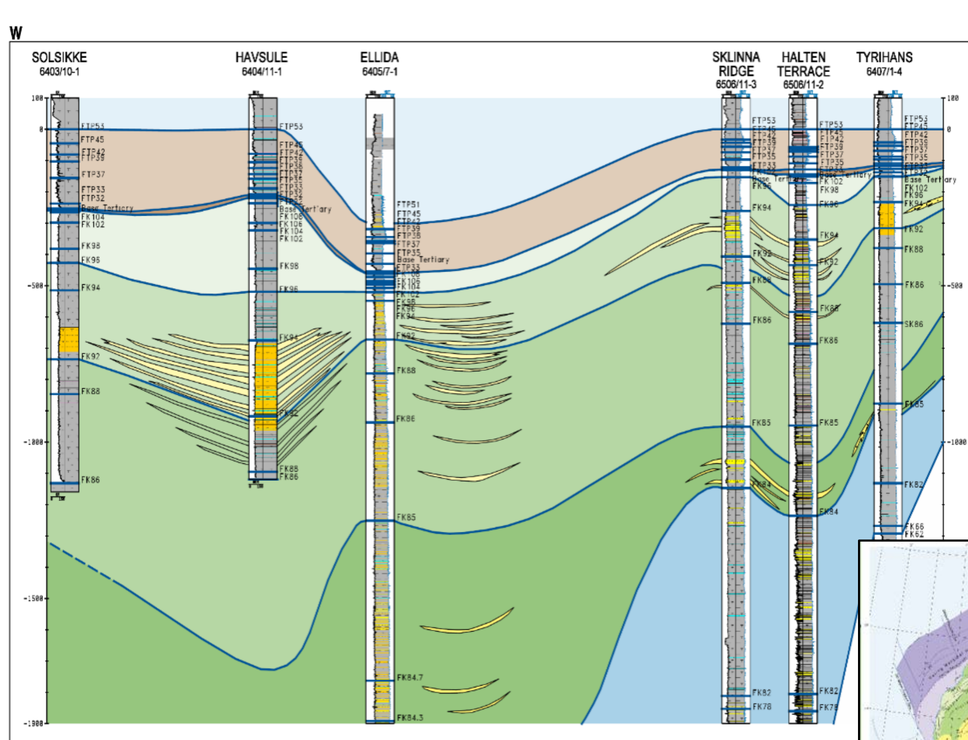
Fig. 2. Tectono-stratigraphic framework for the Norwegian Sea region.

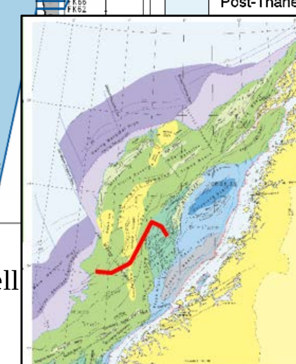
(Lien 2005, Færset and Lien 2002)



Regressive – transgressive megasequences

Fluviodeltaic to marine origin

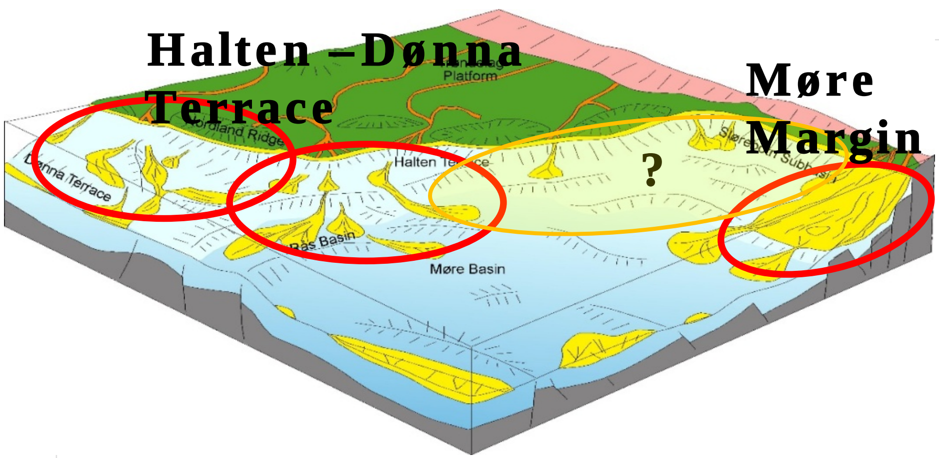




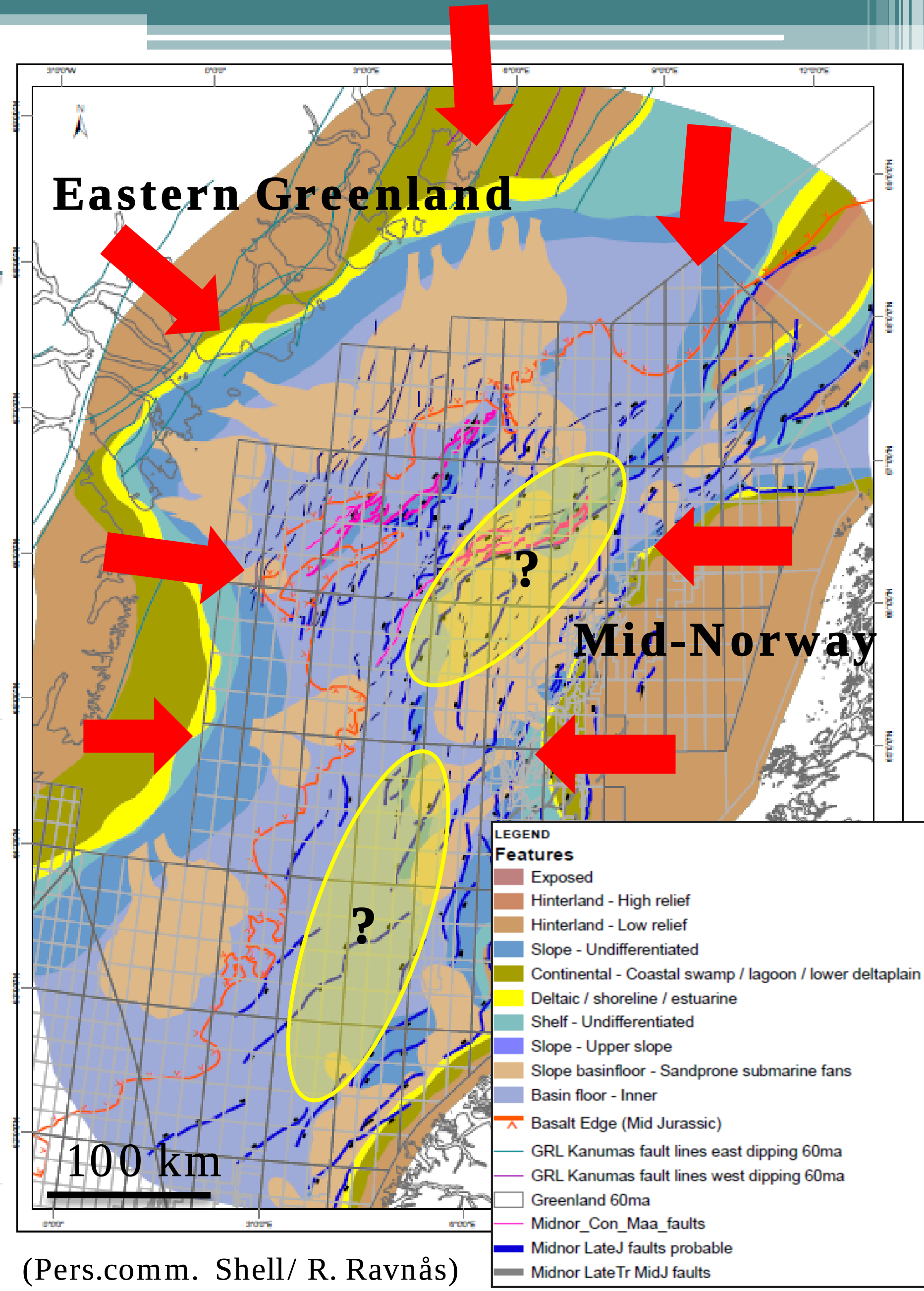
(Pers.comm. Shell and Statoil)

Provenance signatures

Where are the sediments coming from?
What source area(s)?



Coniacian paleogeographic reconstruction



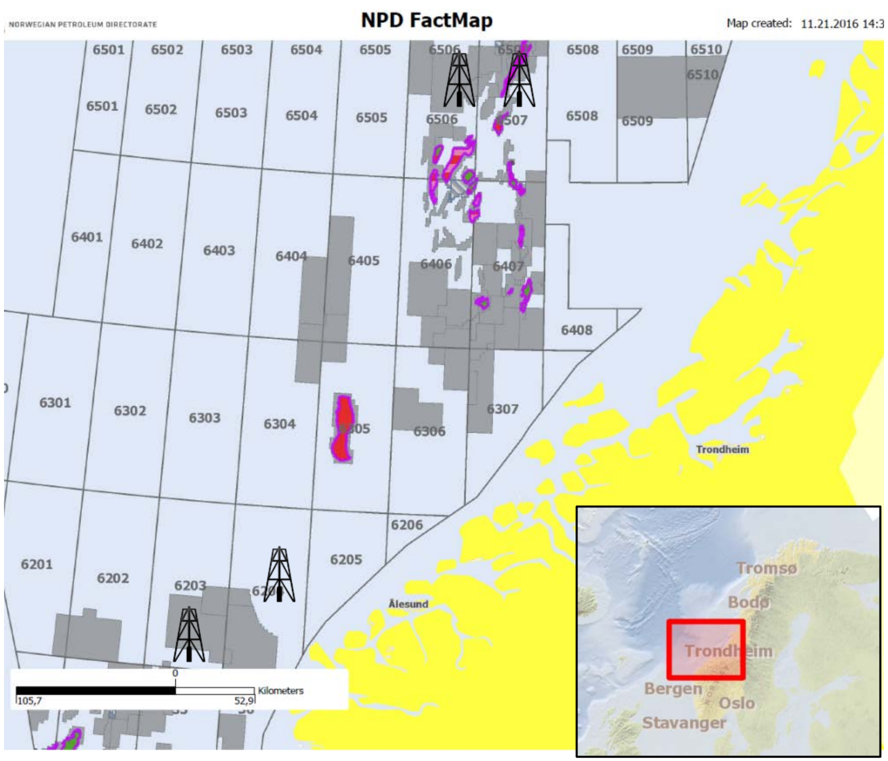
(Pers.comm. Shell/ R. Ravnås)

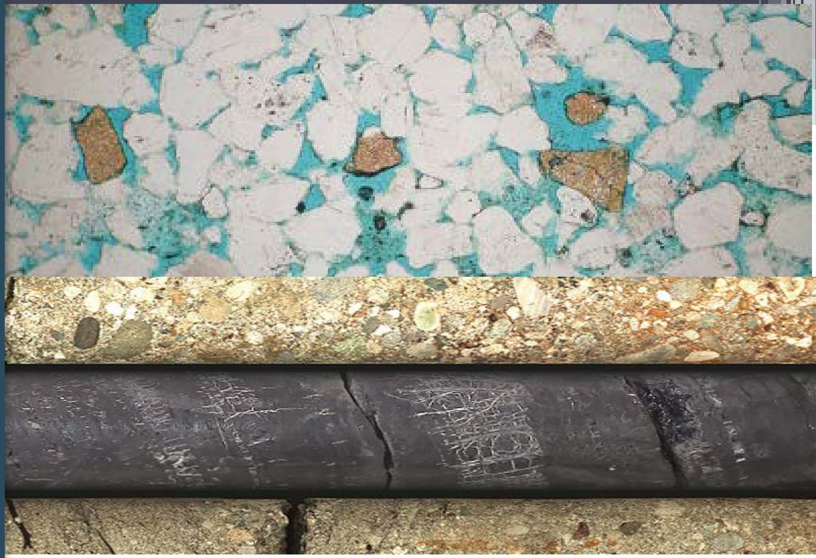
Project description

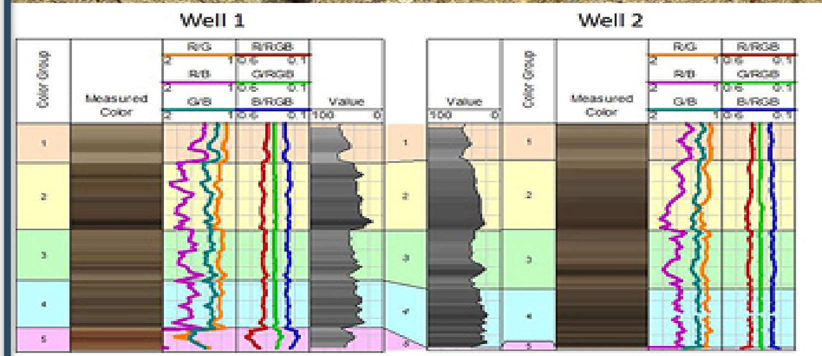
Data set

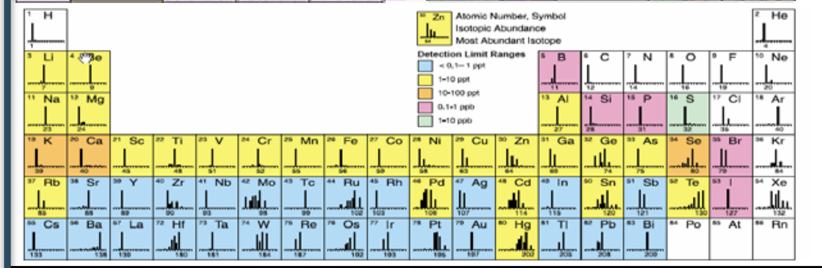
Four study areas have been selected:

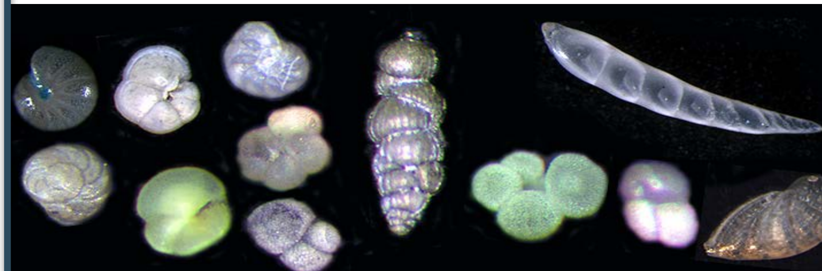
1) SW Møre Margin (5 wells)
2) NE Møre Margin (5 wells)
3) Halten Terrace (7 wells)
4) Dønna Terrace (8 wells)





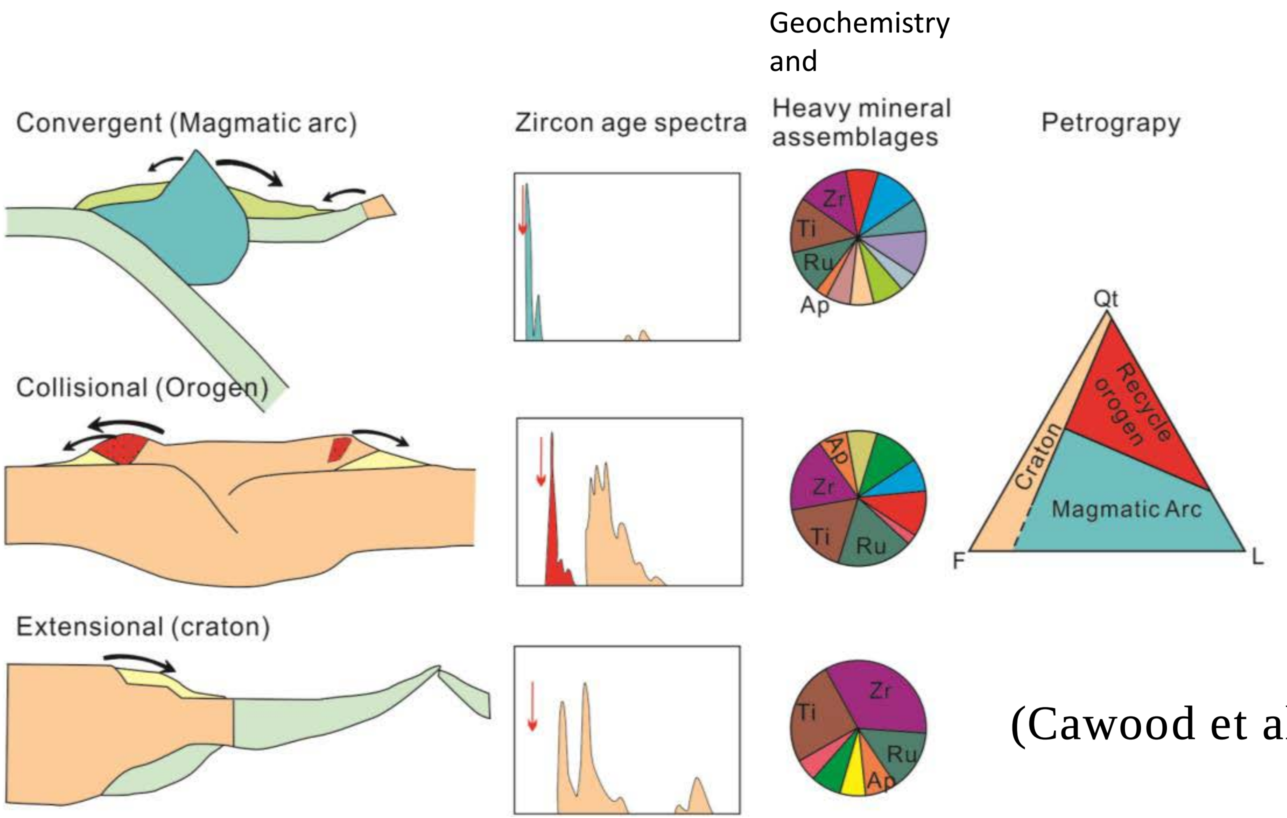






Methodology

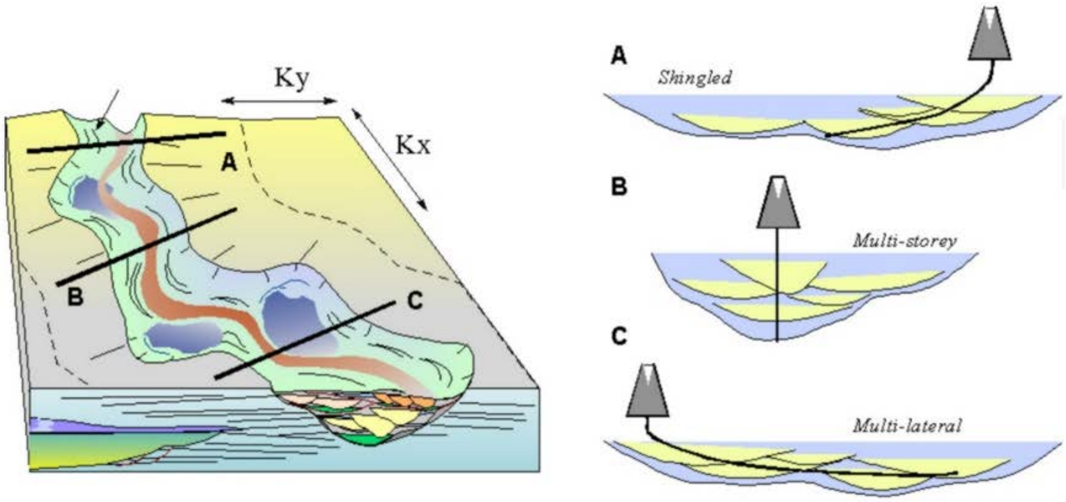
Facies and core interpretation → Petrographic analysis → Geochemical analysis → U-Pb dating → Cathodo-luminescene → Heavy mineral analysis



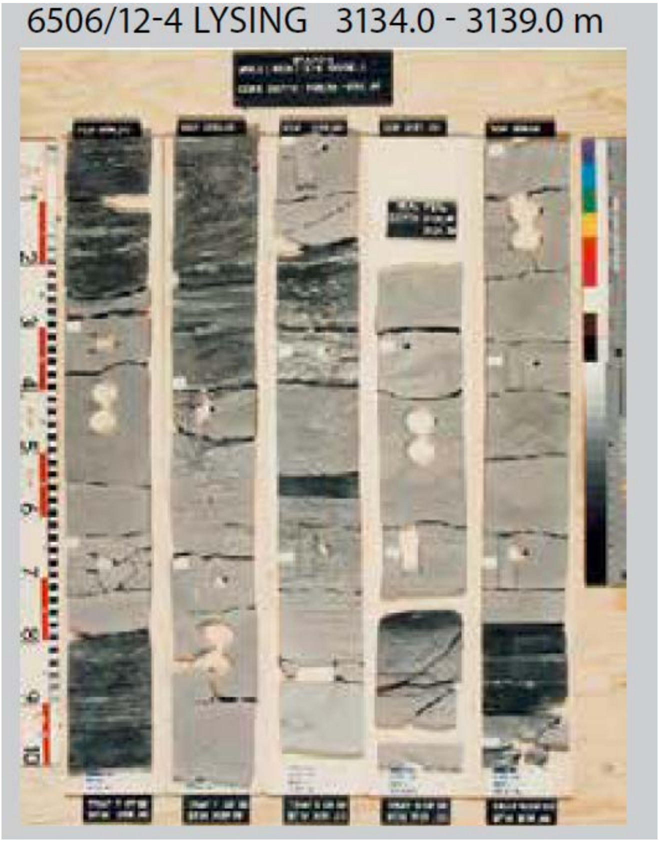
(Cawood et al., 2012)

Facies and core interpretation | Petrography | Geochemical analysis | U-Pb dating

- Location: Stavanger
- Objectives: reservoir distribution and stratigraphy



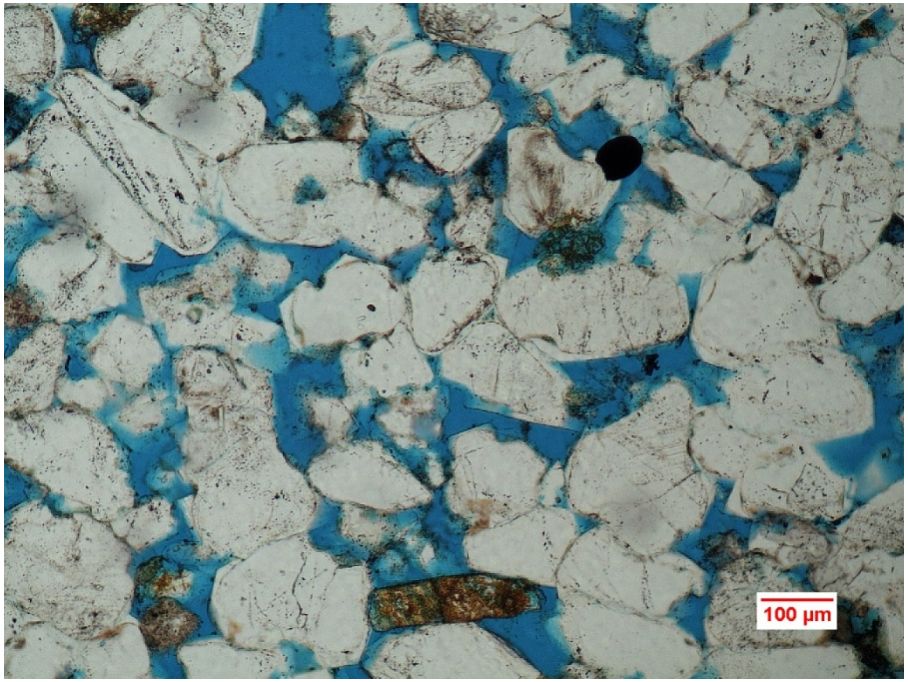
(Mayall et al., 2002)



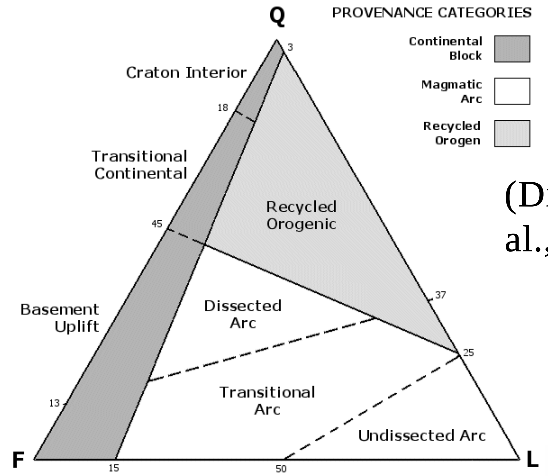
(From npd)

Facies and core interpretation → **Petrography** → Geochemical analysis → U-Pb dating

Optical method: Point counting



http://blogs.cedarville.edu/christian-geology/2015/02/two-new-papers-on-the-coconino-sandstone/



(Dickinson et al., 1983)

- Location: UiS
- Sample: Thin section

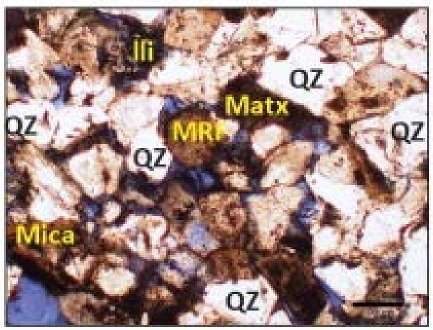
Objectives:

- Provenance and diagenetic aspects
- Permeability/ Porosity

http://www.directindustry.com/prod/carl-zeiss-microscopy/product-20796-704243.html#product-item_1683258,

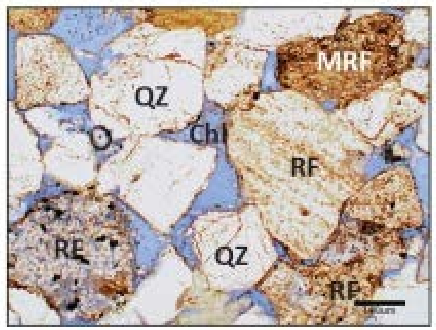
Reservoir quality

POOR RESERVOIR QUALITY
Kobbe Formation



Grain size: Fine - very fine
Sorting: Poor
Primary porosity < 10 %
Matrix content ≈ 15 %

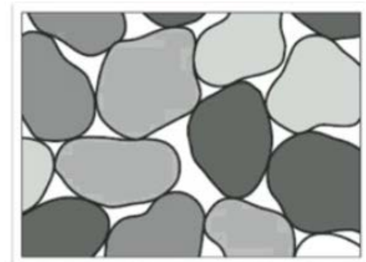
GOOD RESERVOIR QUALITY
Snadd Formation



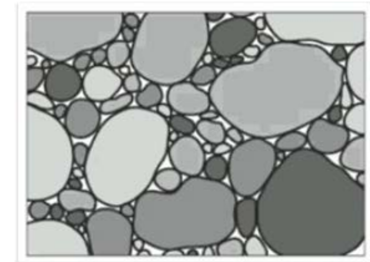
Grain size: Fine - medium
Sorting: Moderately well
Primary porosity ≈ 15 - 30 %
Matrix content < 5 %

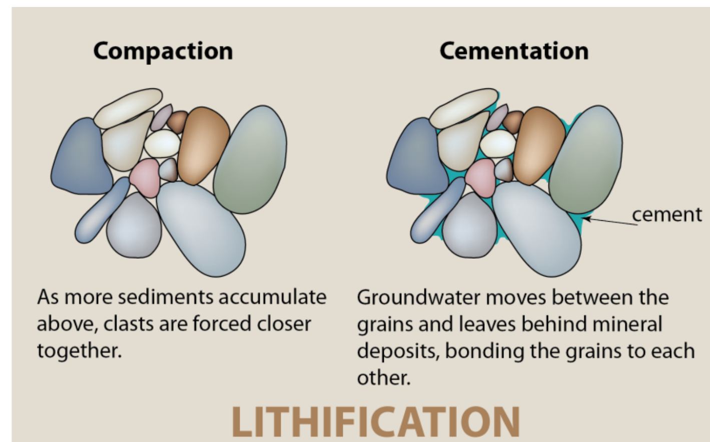
(Line, 2015)

Well sorted



Poorly sorted





(Panchukm, 2016)

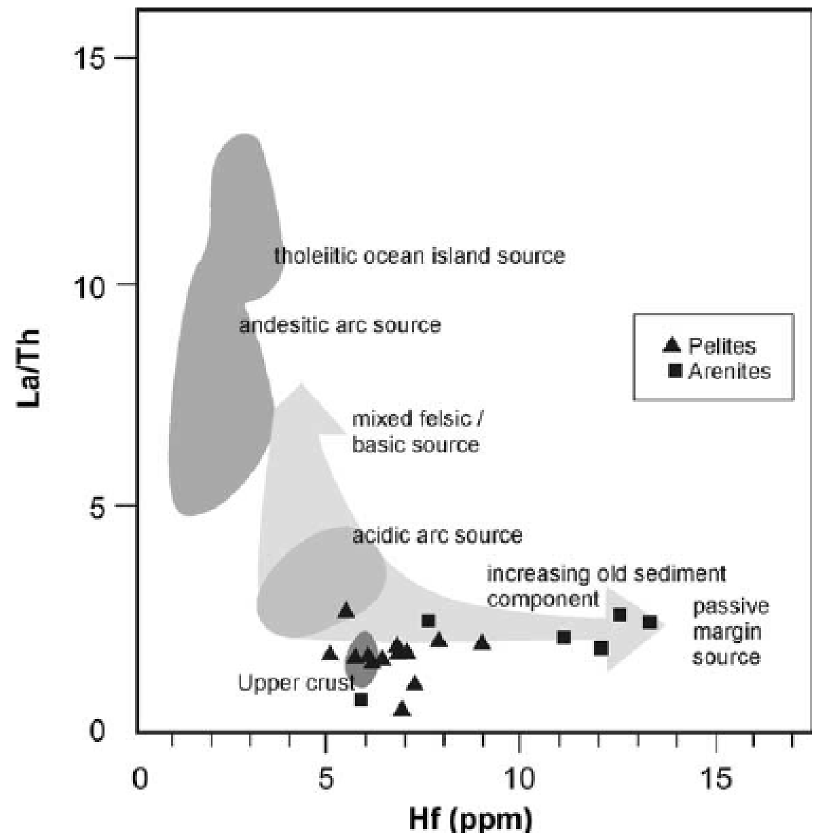
Facies and core interpretation → Petrography → **Geochemical analysis** → U-Pb dating

- Location: outsourced
- Instrument: ICP-MS

Objective:

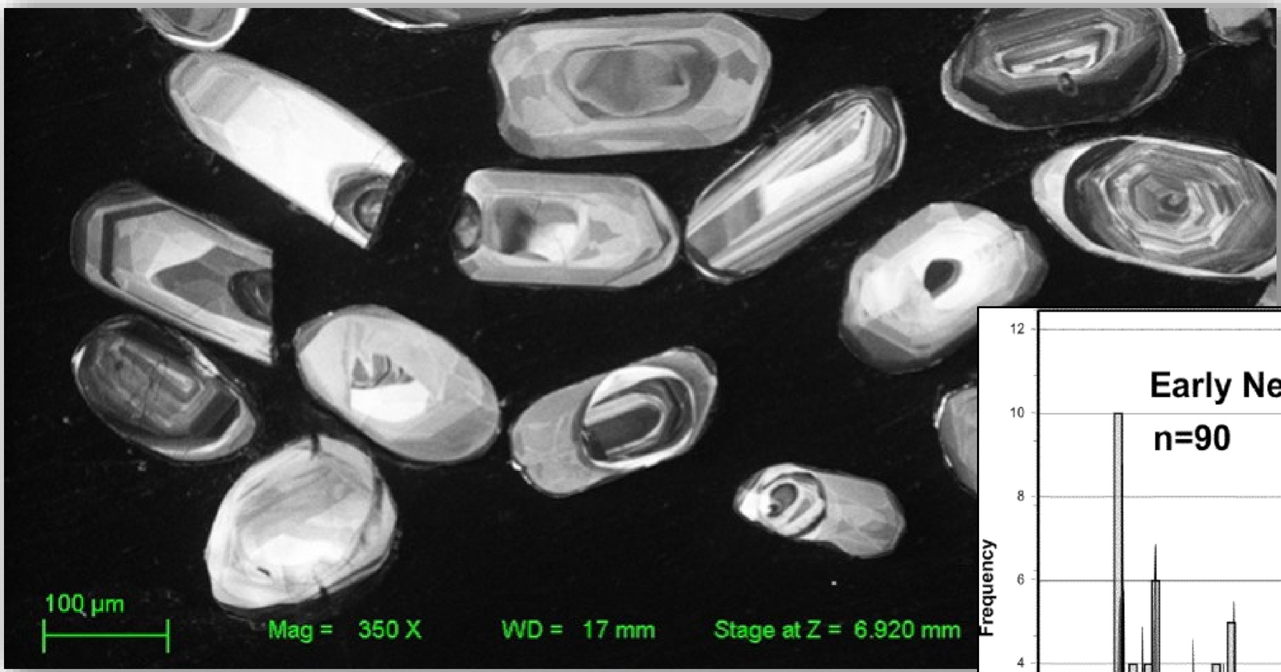
- Chemical composition
- Provenance

https://www.ngu.no/fagomrade/icp-ms

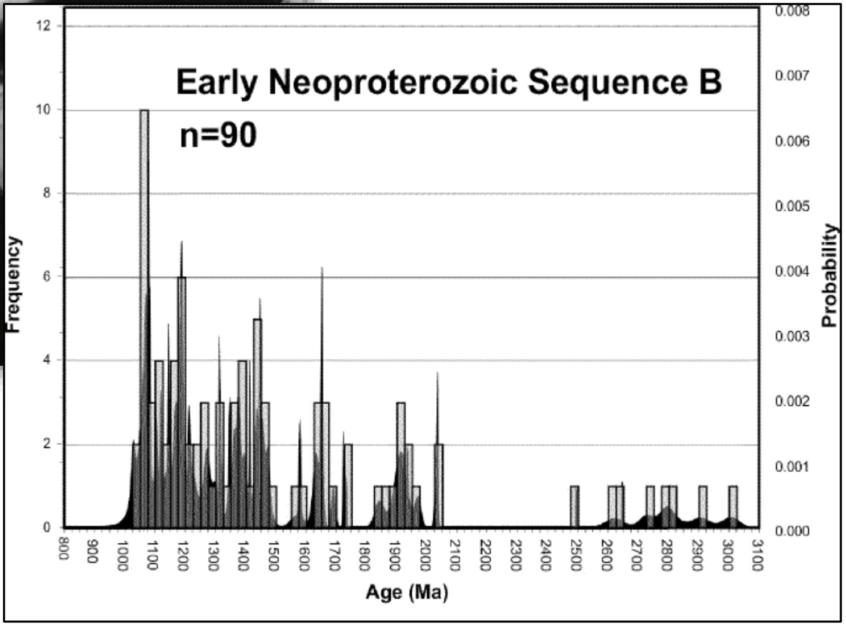


(Floyd and Leveridge ,1987)

Facies and core interpretation → Petrography → Geochemical analysis → **U-Pb dating**



https://www.ngu.no/fagomrade/u-pb-datering

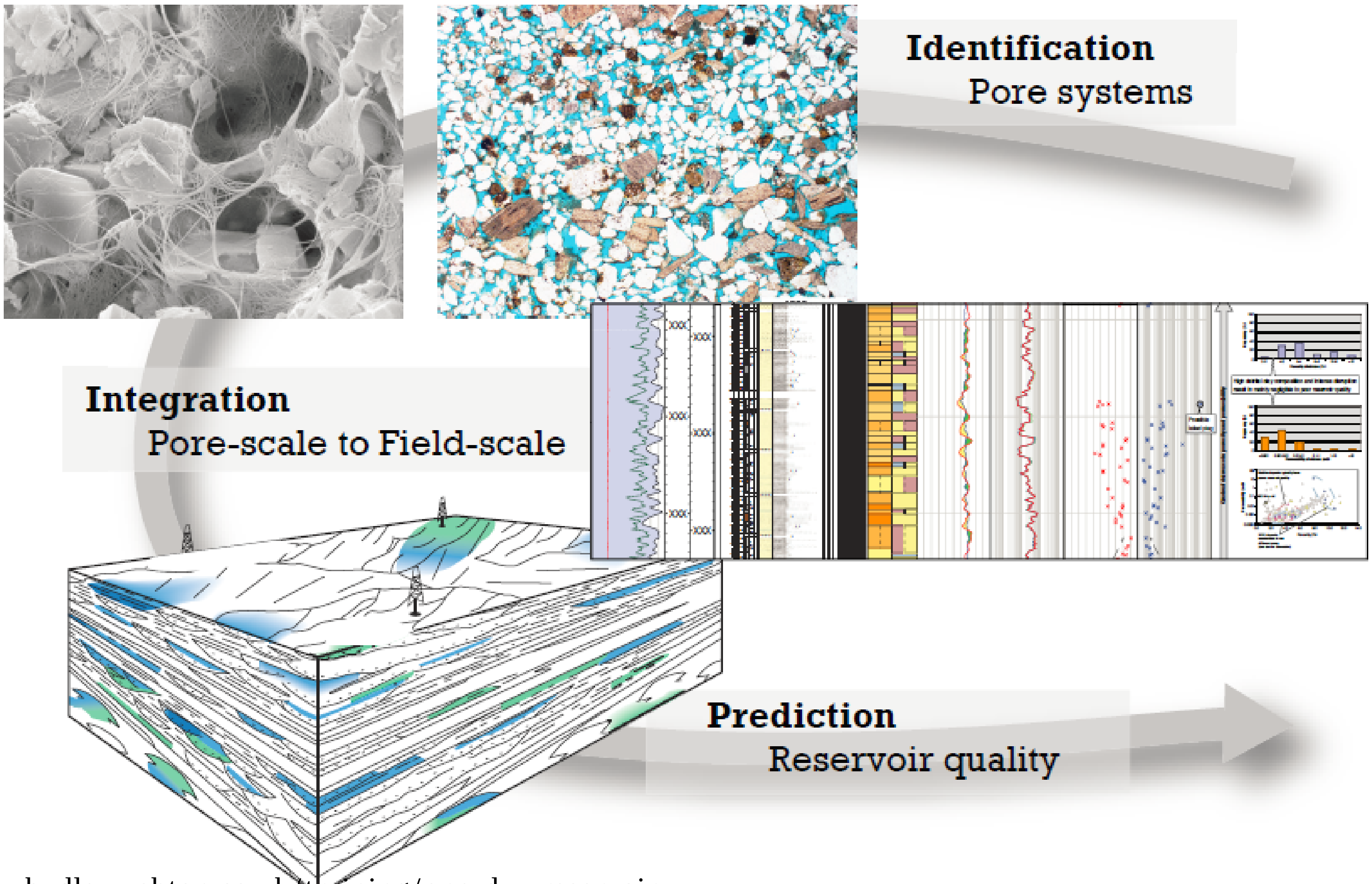


(Fedo et al., 2003)

Location: Oslo
Sample: zircons

Objectives: Determine age of source area(s)

Summary



http://www.badley-ashton.co.uk/training/one-day-reservoir-quality-course

Thank you for listening

- Questions?

High-resolution heavy mineral studies on ’black sands’ from the Nama Group (Fish River Subgroup) in Namibia

Part I: Geology

André Solvang

Supervisor: Udo Zimmermann

University of Stavanger

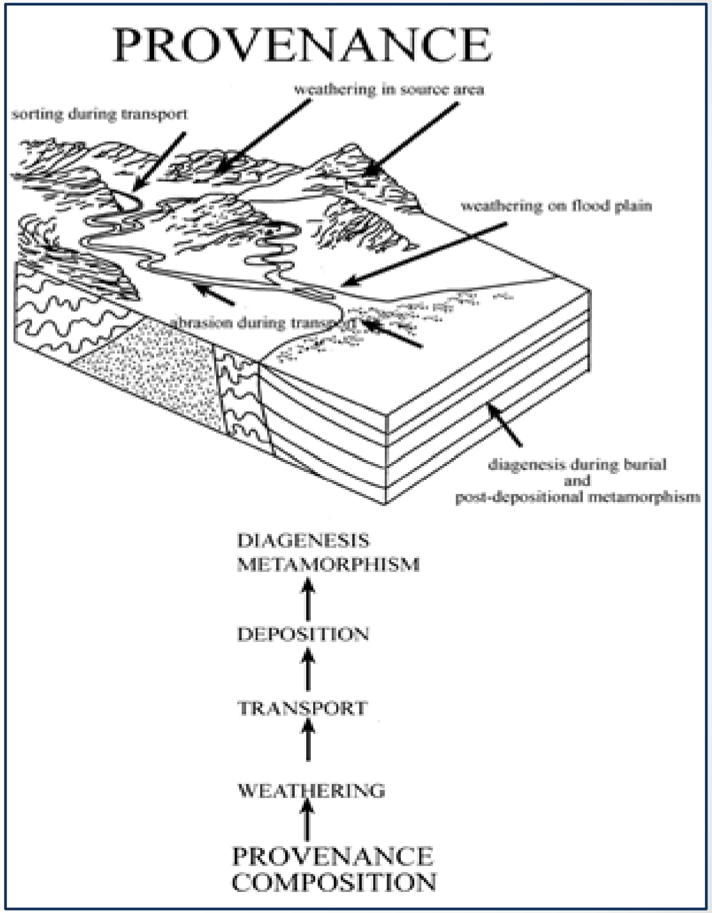
Agenda

- Introduction
- Objectives
- Geological setting
- Stratigraphy
- Facies and placer deposits

University of Stavanger

Introduction

- Provenance
  - Composition
  - Weathering
  - Transportation
  - Deposition
  - Diagenesis
  - Metamorphism



Modified from Rollinson (1993)

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Objectives

- Interpret provenance of ‘black sands’ in the Nama Group, Fish River Subgroup
- Evaluate the effect of sorting caused by grain size fractionation and hydraulic processes
- Compare placer desposits vs normal background sedimentation

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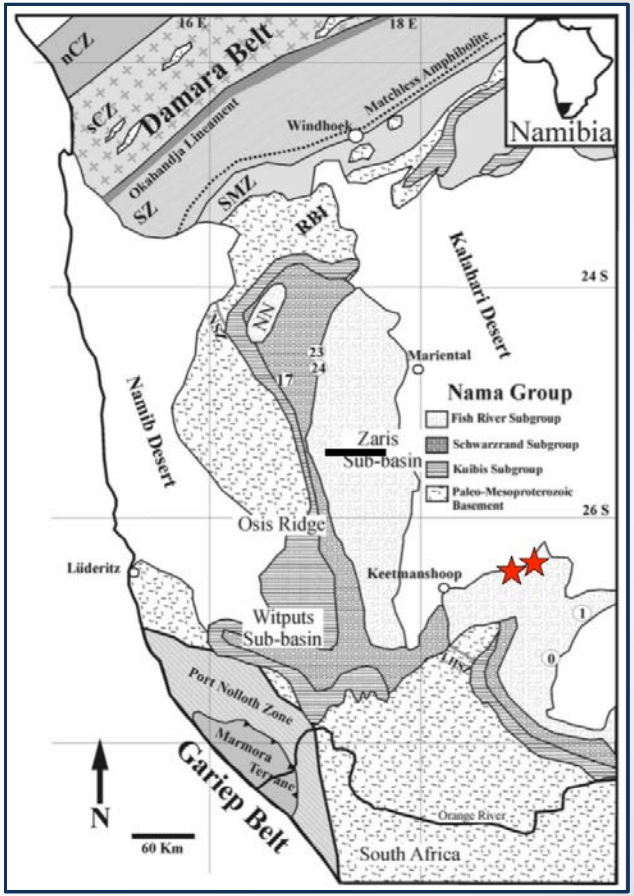
Geological setting

- Rifting of supercontinent
- Subduction and collision
- Kalahari Craton
- Osis Arch
- Kamieskroon Arch
- Damara Belt



Modified after Sailor et. al (1993)

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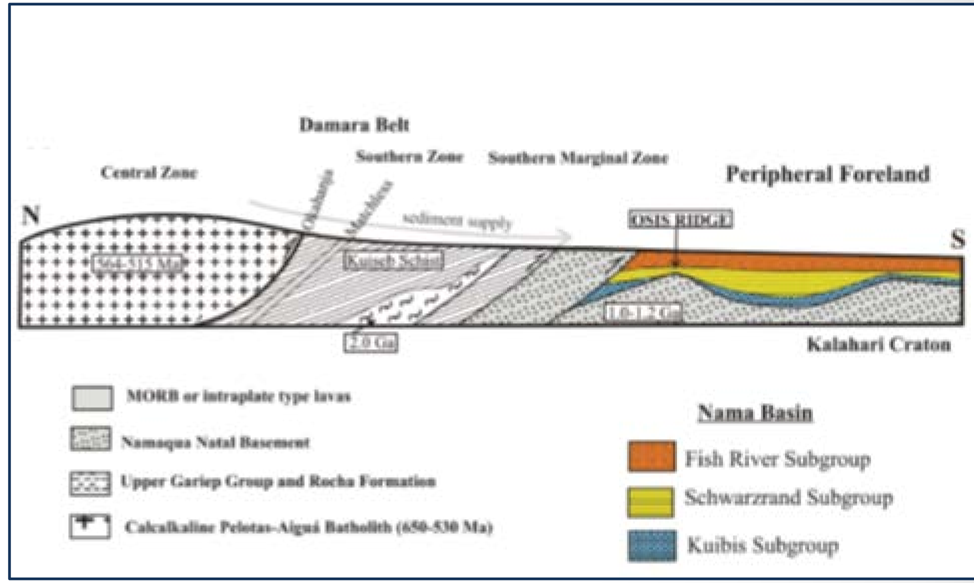
Geological setting

- Rifting of supercontinent
- Subduction and collision
- Kalahari Craton
- Osis Arch
- Kamieskroon Arch
- Damara Belt



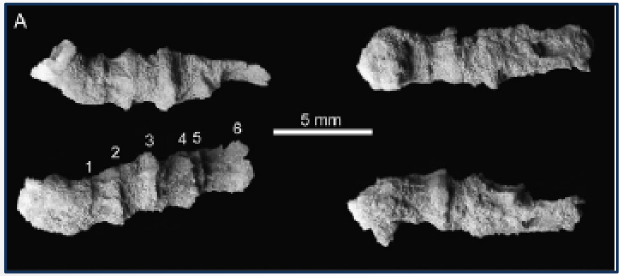
Modified after Blanco et al. (2014)

Stratigraphy

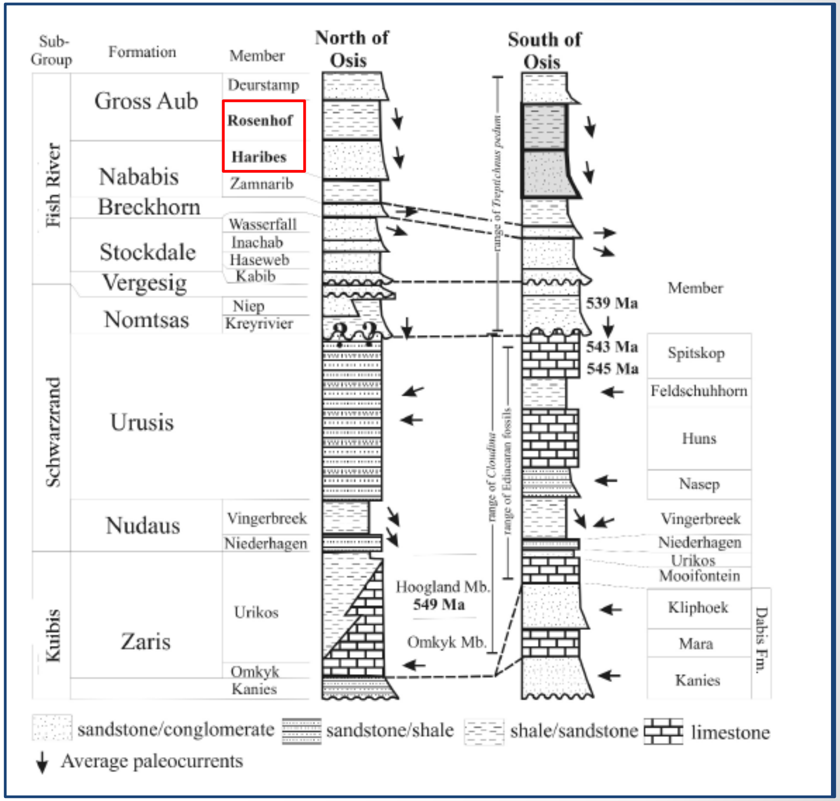
- Nama Subgroups:
  - Kuibis (Ediacaran)
  - Schwarzrand (Ediacaran)
  - Fish River (Cambrian)

    - Nababis Formation
      - Haribes Member

    - Gross Aub Formation
      - Rosenhof Member



After Cortijo et al. (2010)



Modified after Saylor et al. (1995).

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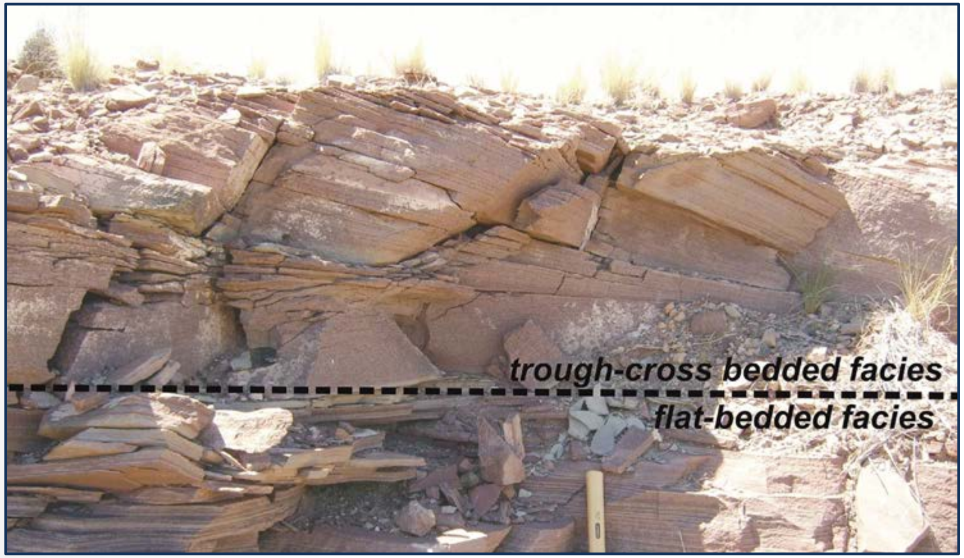
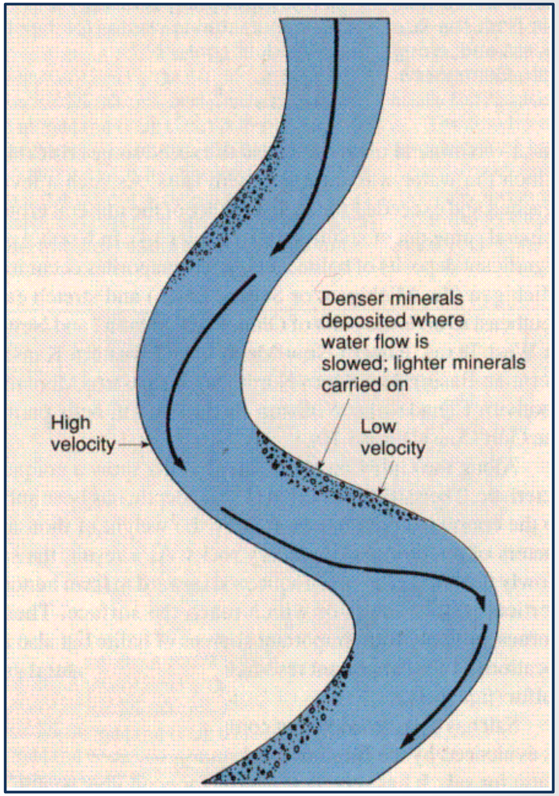
Facies and placer deposits

- Fluvial facies associations
  - Trough cross-bedded
  - Flat-bedded



From Blanco et al. (2014)



Modified from Worthy (1999)

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Thank you for your attention!

To be continued…

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High-resolution heavy mineral studies on ’black sands’ from the Nama Group (Fish River Subgroup) in Namibia

Part II: Dataset and Methodology

Sigrid Øxnevad

Supervisor: Udo Zimmermann

University of Stavanger

Dataset

- Samples collected in 2004-2005
- Heavy mineral content: 20-80 %
- Heavy mineral placers
- Samples separated into fractions:
    1. Magnetic fraction (> 2.7 g/cm³)
    2. Non-magnetic apatite fraction (2.7-3.3 g/cm³)
    3. Non-magnetic zircon fraction (> 3.3 g/cm³)
    4. Zircon concentrate (a fraction nearly only composed of detrital zircons)

Sigrid (samples 1–12)

André (samples 13–28)

#	Sample name	GPS locality	Fraction type	Formation	Member
1	GS12104–19 387	26°36'29.30"S, 19°13'56.40"E	Magnetite Fraction	Gross Aub	Rosenhof
2			Apatite Fraction		
3			Zircon Fraction		
4			Zircon Concentrate		
5	03 - 389	26°36'29.30"S, 19°13'56.40"E	Magnetite Fraction	Gross Aub	Rosenhof
6	GS12104–28 391	26°36'29.30"S, 19°13'56.40"E	Apatite Fraction	Gross Aub	Rosenhof
7			Zircon Fraction		
8			Zircon Concentrate		
9	GS12104–15 BS	26°55'04.20"S, 18°36'15.90"E	Magnetite Fraction	Nababis	Haribes
10			Apatite Fraction		
11			Zircon Fraction		
12			Zircon Concentrate		
13	405	26°55'04.20"S, 18°36'15.90"E	Magnetite Fraction	Nababis	Haribes
14			Apatite Fraction		
15			Zircon Fraction		
16			Zircon Concentrate		
17	408	26°55'04.20"S, 18°36'15.90"E (300 m away)	Magnetite Fraction	Nababis	Haribes
18			Apatite Fraction		
19			Zircon Fraction		
20			Zircon Concentrate		
21	409	26°55'04.20"S, 18°36'15.90"E (300 m away)	Magnetite Fraction	Nababis	Haribes
22			Apatite Fraction		
23			Zircon Fraction		
24			Zircon Concentrate		
25	412	26°55'04.20"S, 18°36'15.90"E (300 m away)	Magnetite Fraction	Nababis	Haribes
26			Apatite Fraction		
27			Zircon Fraction		
28			Zircon Concentrate		

Methodology

Literature research

- Previous work on provenance and heavy mineral studies

Laboratory work

- **Analytical methods:**
  - Optical microscope
  - FE-SEM-BSE-CL-EDS
  - XRD
  - MLA
  - EMPA
  - ICP-MS-LA-MC

Interpretation of results

- Provenance
- Depositional environment and tectonic setting
- Sorting

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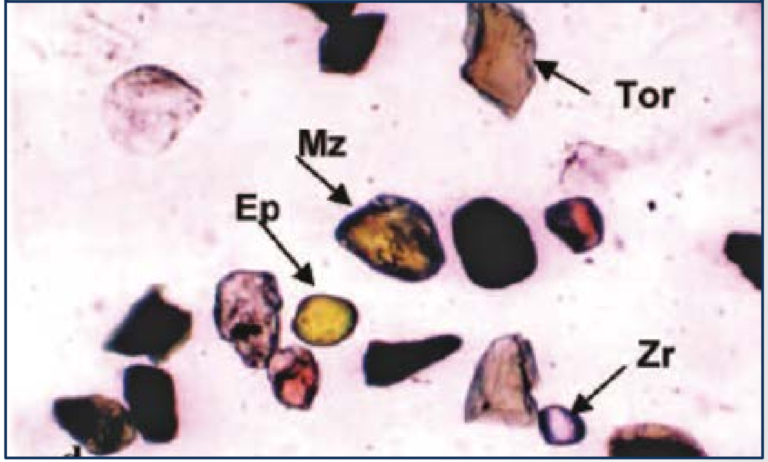
Optical microscope

- Identify minerals
- Take photos

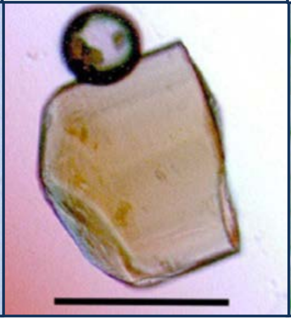
Ep = Epidote, Zr = Zircon, Tor = Tourmaline, Mz = Monazite



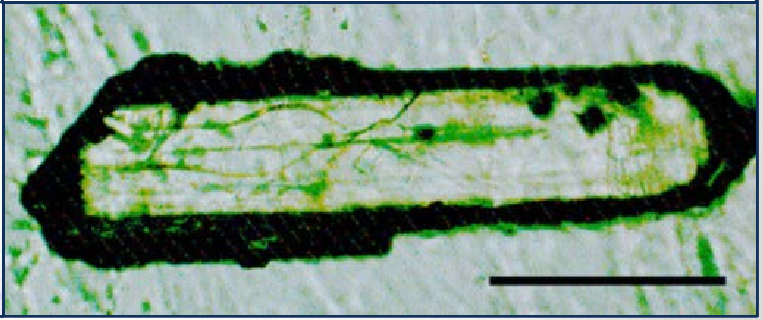
From Hegazy and Emam (2011)

Pyroxene grain (polarized light, scale = 100 µm)

Tourmaline grain (polarized light, scale = 50 µm)



Zircon grain (polarized light, scale = 50 µm)



From Zimmermann and Spalletti (2009)

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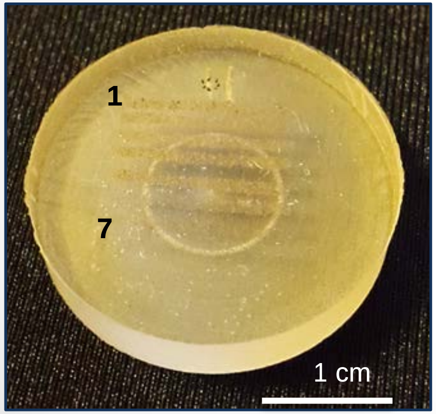
FE-SEM-BSE-CL-EDS

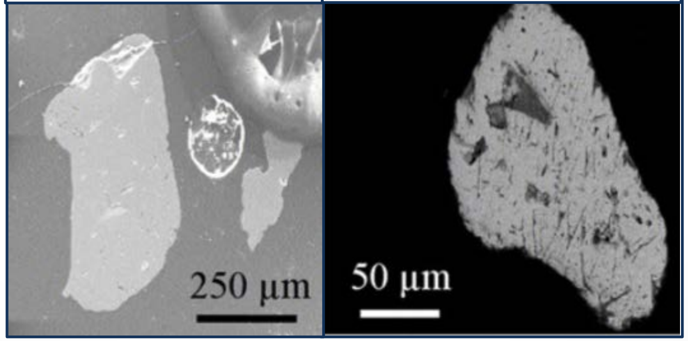
(Field Emission Scanning Electron Microscope with Back-Scattered Electron, Cathodoluminescence and Energy Dispersive Spectroscopy)

- Identification and characterization of heavy minerals
- Identify structures, grain size, grain form and other characteristics
- Detectors:
  - EDS: semi-quantification of heavy minerals
  - BSE: map elements on the surface
  - CL: high-resolution images

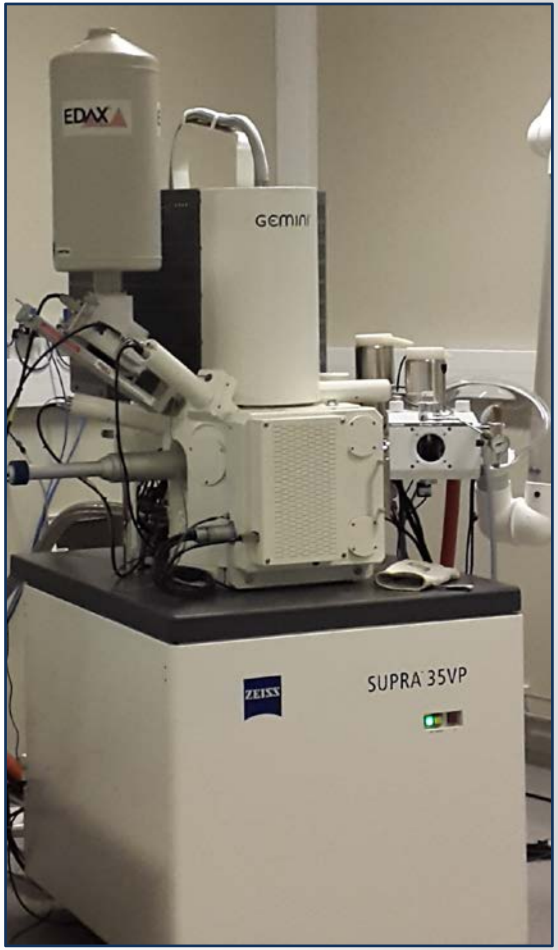


Tourmaline grain, SEM-image, M: 150x

Altered ilmenite grain, BSE-image, M: 500x



From Zimmermann and Spalletti (2009)



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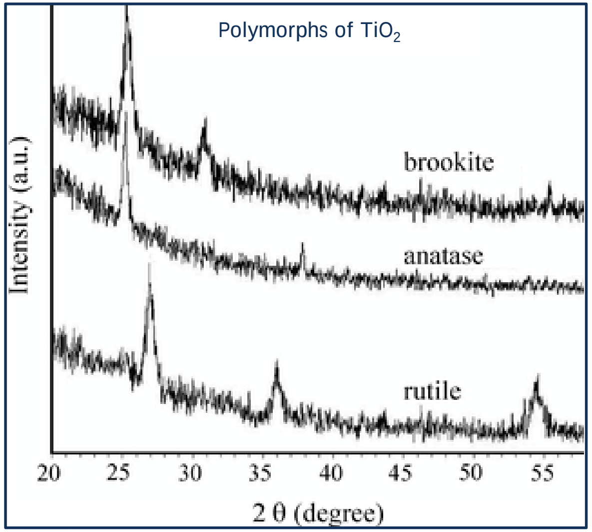
XRD

(X-Ray Diffraction)

- Mineralogical analyses
  - Crystal and crystal structure
- Identify polymorphic minerals
  - E.g. TiO_2



From Addamo et al. (2006)

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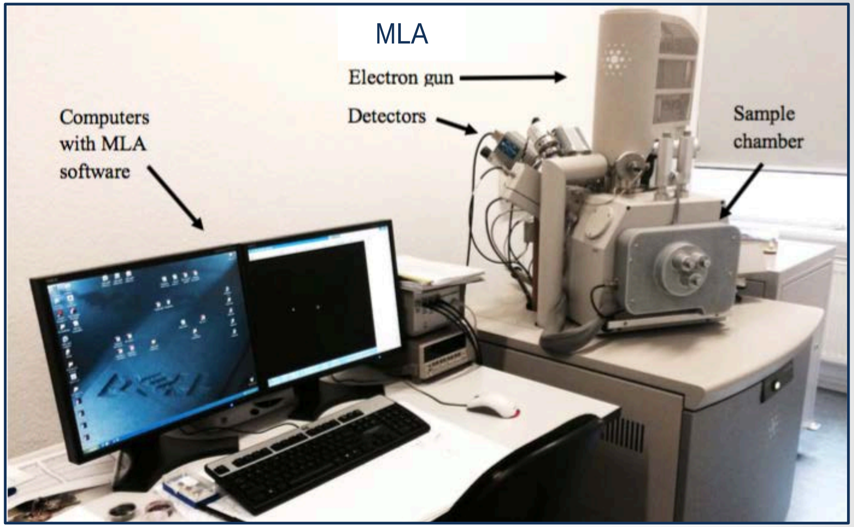
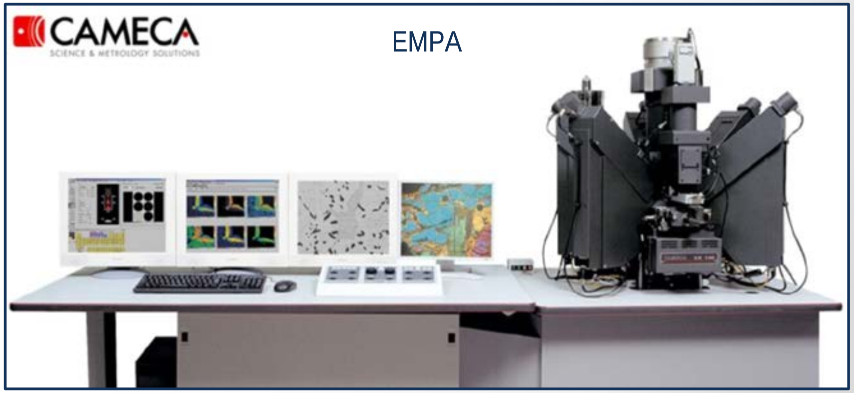
MLA and EMPA

(Mineral Liberation Analyser and Electron Microprobe Analyser)

- Laboratory in Freiburg (Germany)
- MLA
  - Quantify elements of separated heavy minerals on mounds
- EMPA
  - Minerals with potential for provenance
  - E.g. apatite, epidote, garnet, zircon, tourmaline and rutile
  - Determine chemical composition



From Mona Minde (2015)



From CAMECA

ICP-MS-LA-MC

(Inductively Coupled Plasma Mass Spectrometry with Laser Ablation and Multi-Collector)

- Geochemical analyses
- Laboratory in Canada
  - Major and trace element geochemistry
- Laboratory in Brazil
  - U-Pb and Lu-Hf isotope geochemsitry

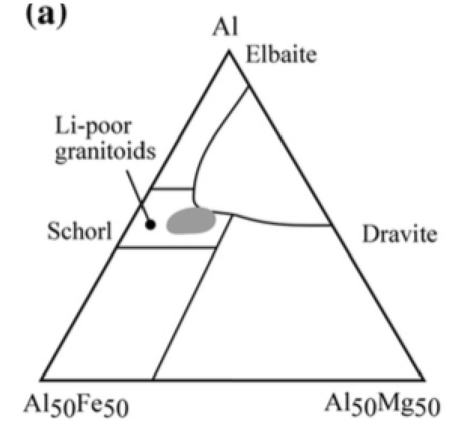
From ThermoFisher

Interpretation of results

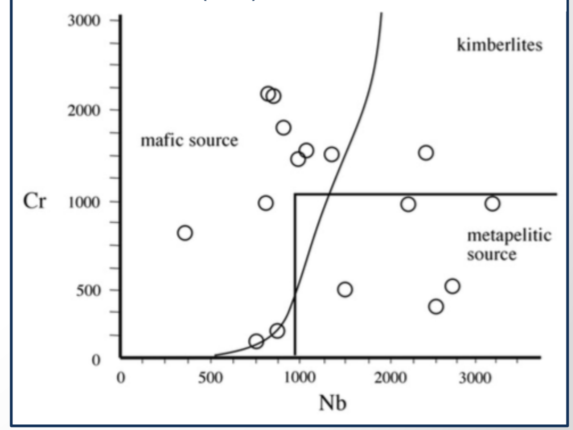
- Interpret provenance
  - Single grain diagrams
- Identify regional and paleotectonic constraints on provenance
- Interpret depositional environment and tectonic setting

- Compare with results from not placers
- Evaluate effect of sorting
- Evaluate approach for the hydrocarbon industry

After Henry and Guidotti (1985): Detrital tourmaline



After Zack et al. (2002): Detrital rutile



From Zimmermann and Spalletti (2009)

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Thank you for your attention!

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An Integrated Study of the Cretaceous Sequence Stratigraphic Development in the Northern Stord Basin, North Sea, using 3D and 2D Seismic Data and Wells

Amrizal

2 December 2016

Supervisor:

Sylvia Nordfjord (Statoil/University of Stavanger)

Universitetet
i Stavanger

Outline

- Introduction
- Objectives
- Geological Setting
- Analogues of Cretaceous Play
- Data
- Methodology

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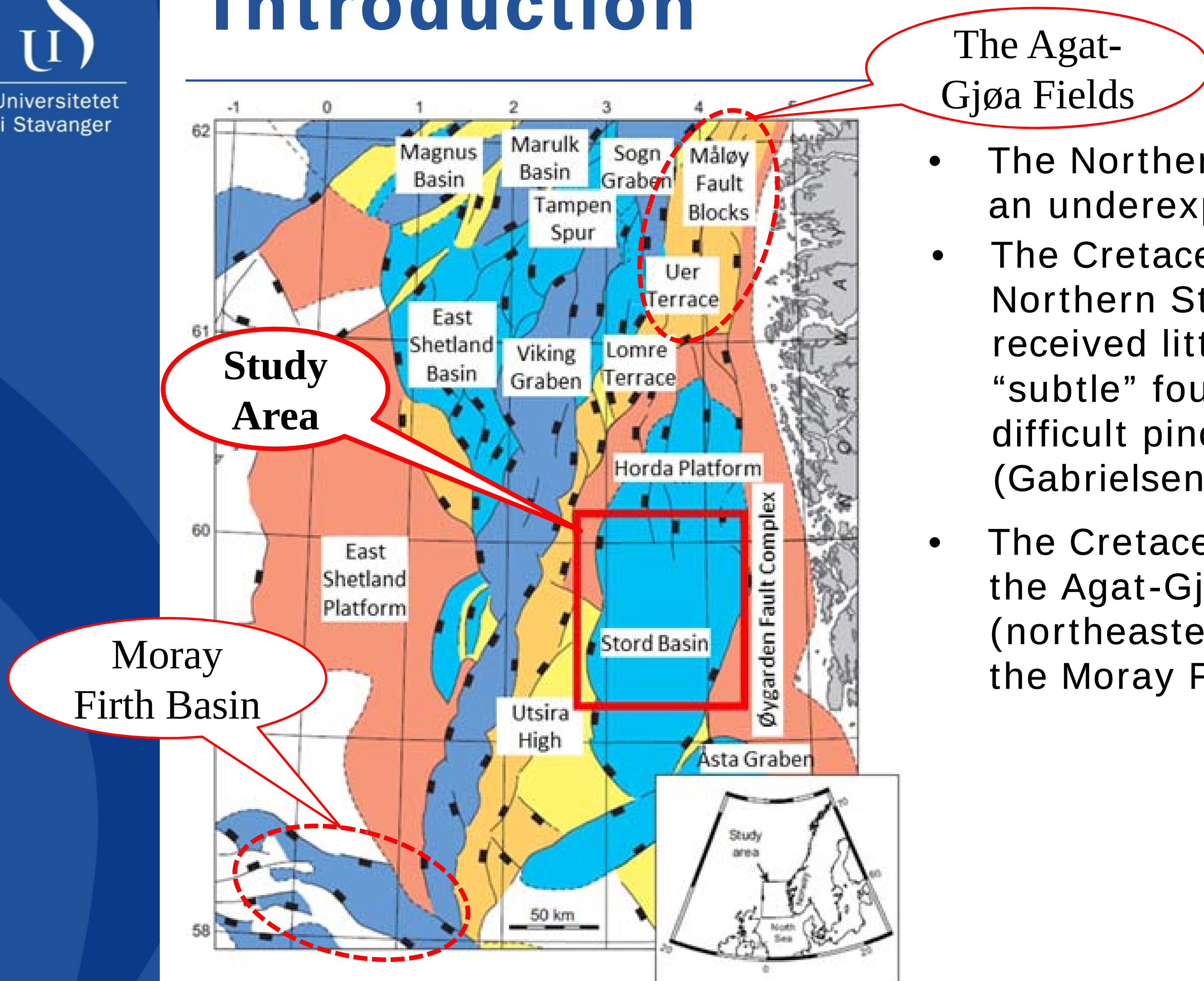
Introduction



The location of Northern Stord Basin (Kyrkjebø *et al.*, 2004)

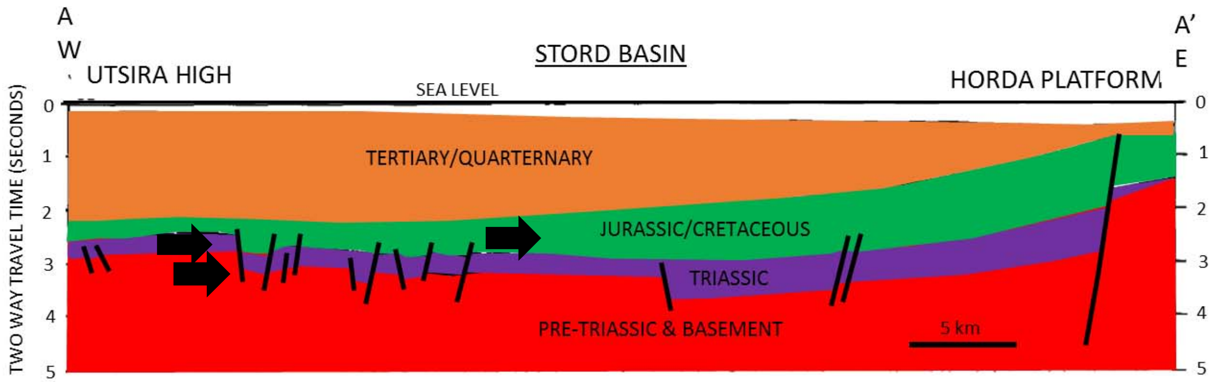
- The Northern Stord Basin is still an underexplored basin
- The Cretaceous play in the Northern Stord Basin has received little attention → "subtle" four-way closures or difficult pinch-out traps (Gabrielsen *et al.*, 1995)
- The Cretaceous play works in the Agat-Gjøa Field (northeastern North Sea) and the Moray Firth Basin

Objectives

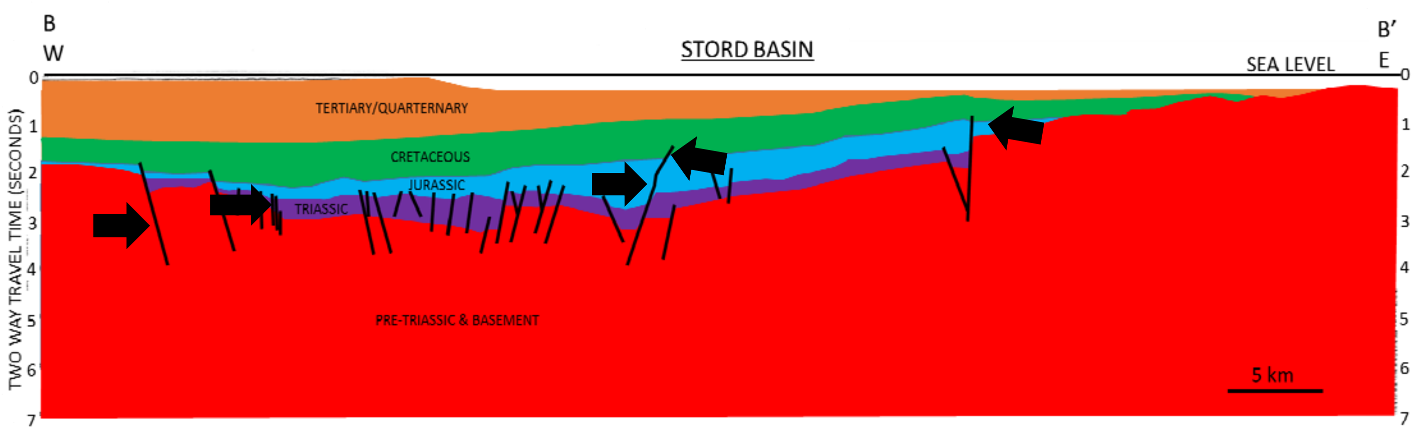
- To identify the tectonostratigraphic evolution of Cretaceous units in the Northern Stord Basin
- To build a sequence stratigraphic framework with identification of regional important surfaces and units

Geological Setting

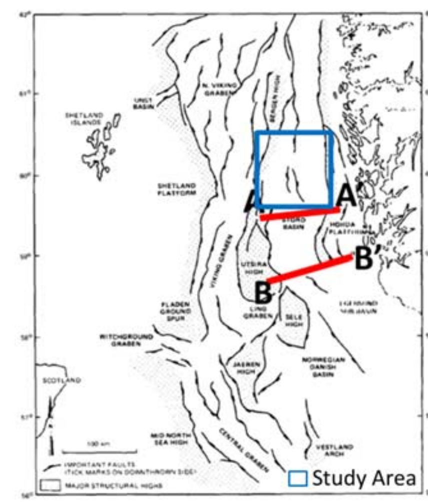
- Pre-Triassic deformation
- Active normal faulting in the Triassic
- Extensional tectonics during the middle Jurassic
- Tertiary to Quarternary uplifting



Schematic cross section in the central part of Stord Basin (Biddle and Rudolph, 1988)



Schematic cross section in the southern part of Stord Basin (Biddle and Rudolph, 1988)



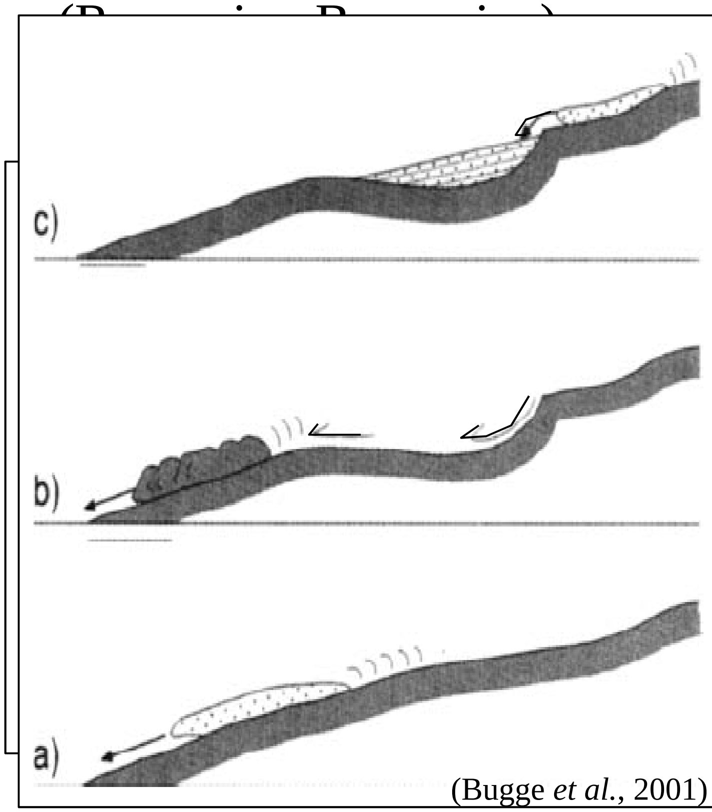
(Biddle and Rudolph, 1988)

Analogues of Cretaceous Play

(Sandstones formations in northeastern part of the North Sea)

1. The Åsgard Sandstone (Ryazanian-Barremian)

2. The Agat Formation (Albian)



(Bugge *et al.*, 2001)

The Agat Formation was deposited in a paleogeographic slope setting from uplifted and eroded areas within the basin and basin flanks

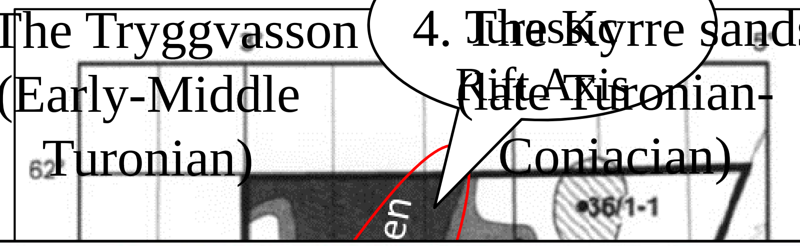
The Åsgard sandstone was sourced from

It was probably sourced from the east.

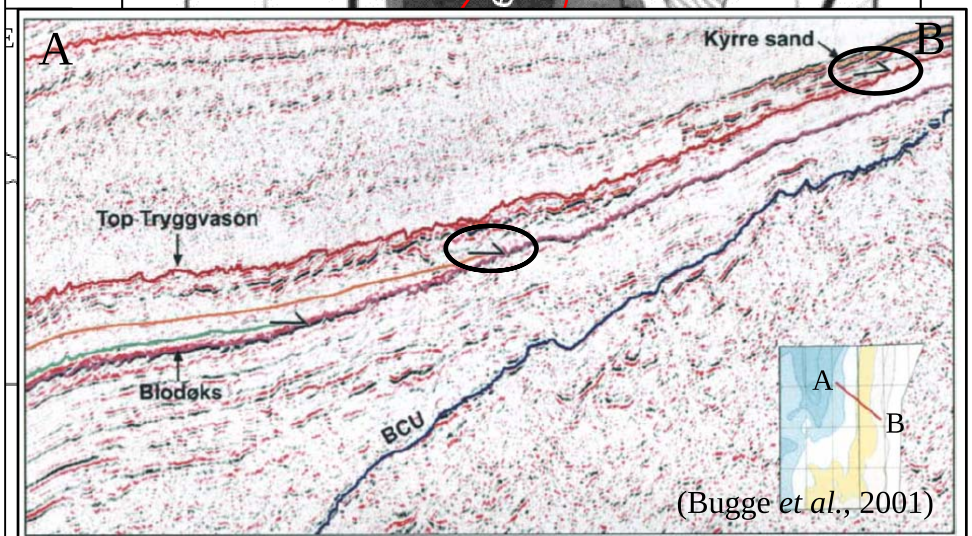
3. The Tryggvasson (Early-Middle Turonian)

4. The Kyrre sands (late Turonian-Coniacian)

Late Jurassic Rift Axis



(Bugge *et al.*, 2001)



(Bugge *et al.*, 2001)

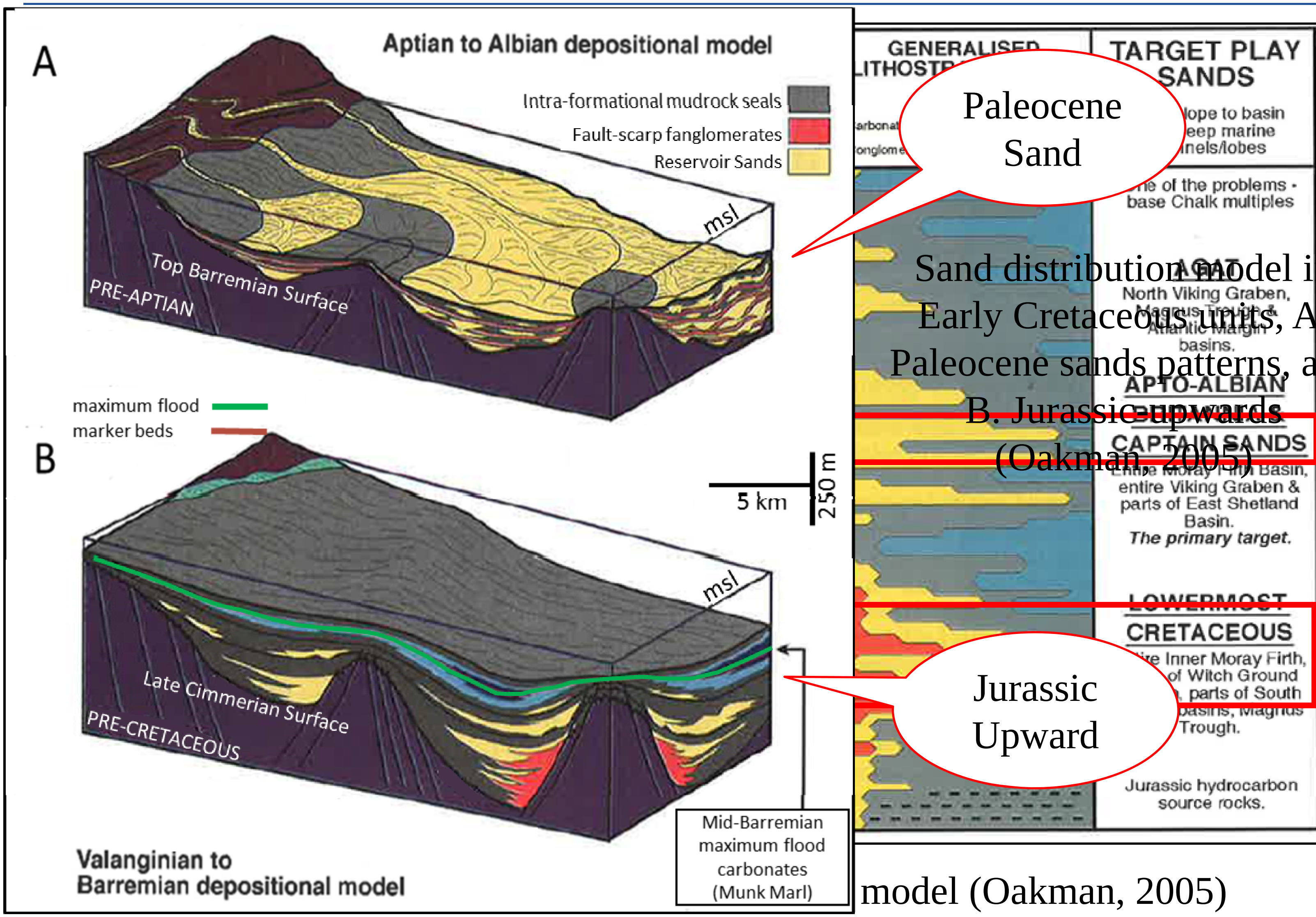
The Tryggvasson and the Kyrre sands were related to tectonic tilting events.

Those sandstones were probably sourced from the east.

Present-day coast of Norway

Analogues of Cretaceous Play

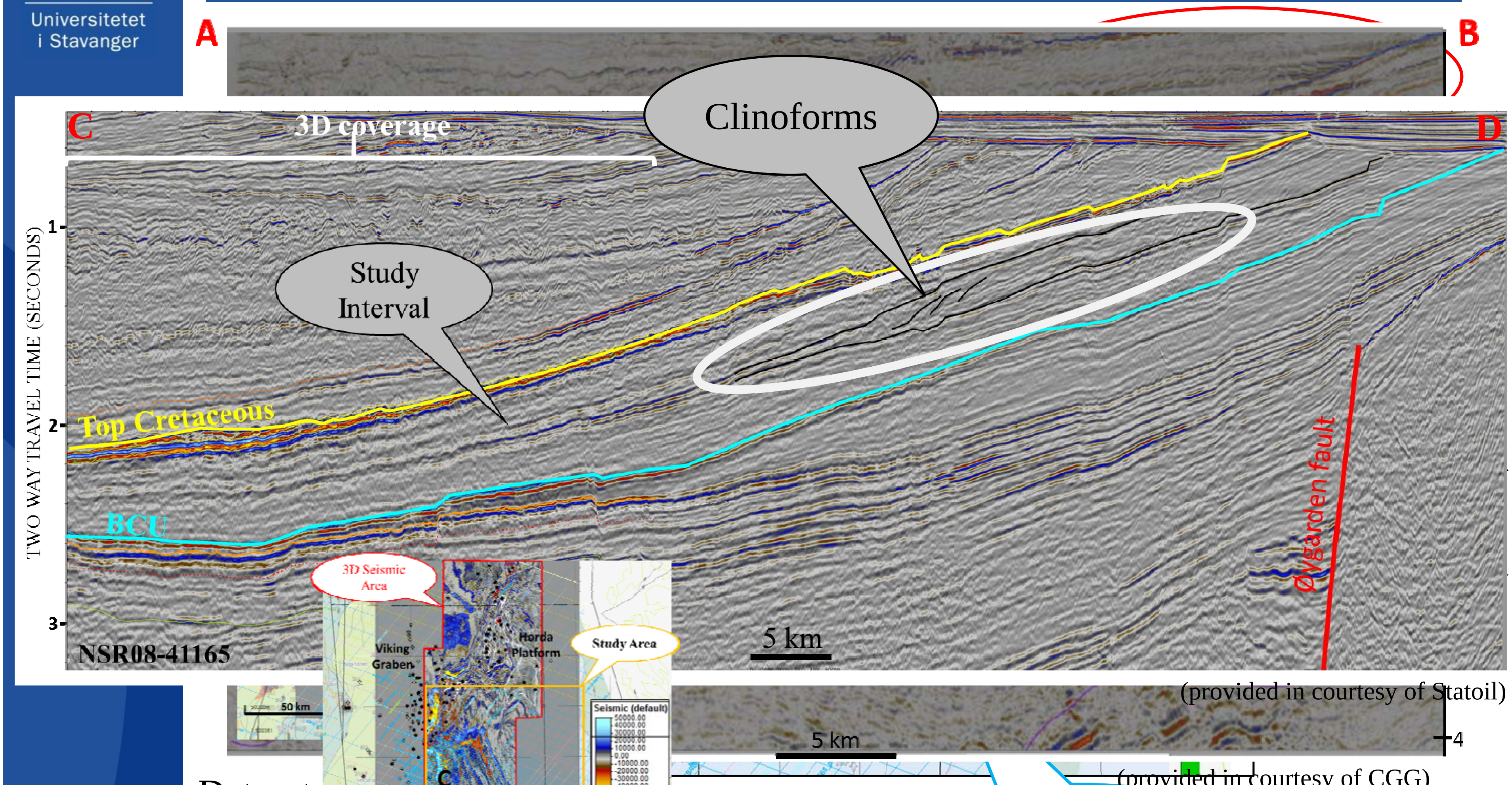
(Sandstones in central and northern part of the North Sea)



Sand distribution model in Early Cretaceous units, A. Paleocene sands patterns, and B. Jurassic upwards (Oakman, 2005)

model (Oakman, 2005)

Data

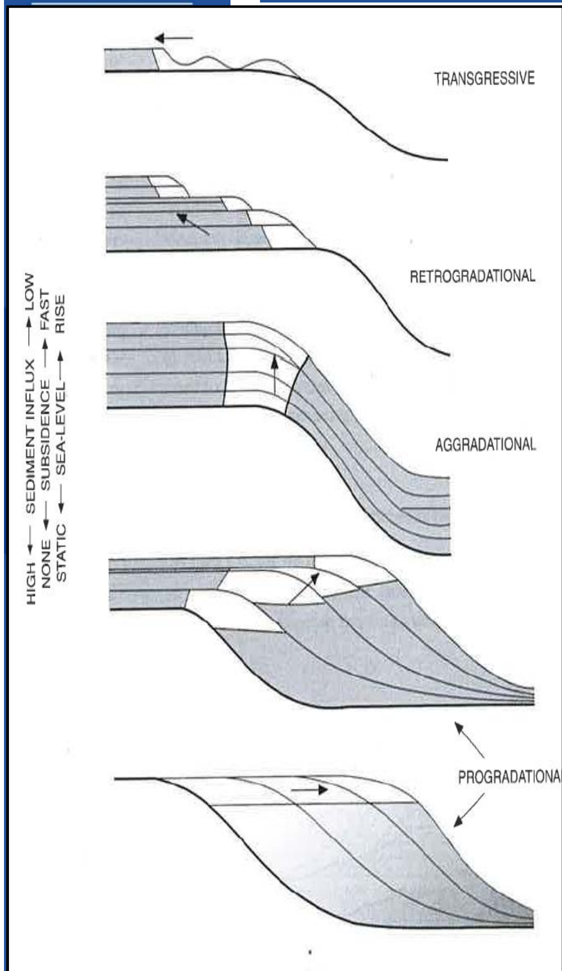


Dataset ... tatoil, CGG and NPD)

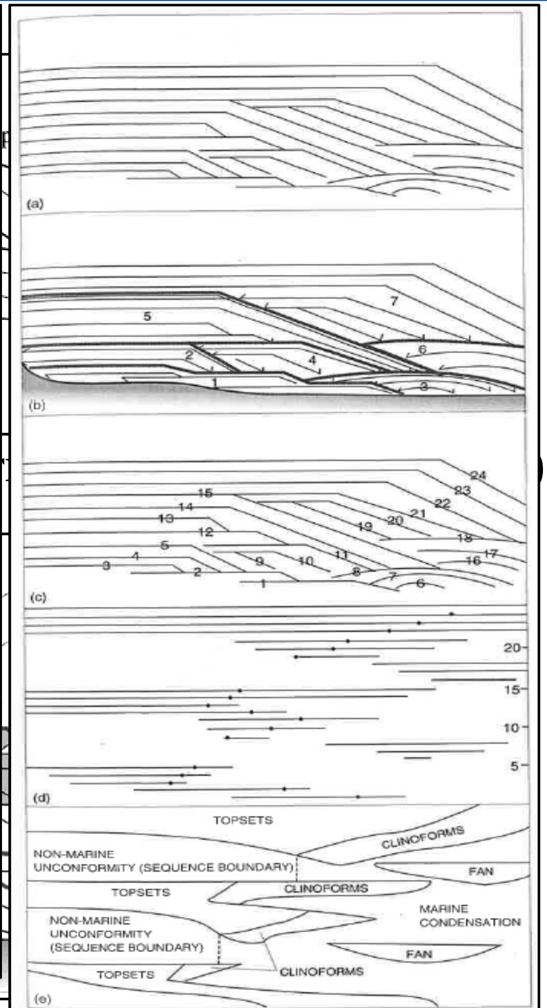
3D ... G

2D seismic dat... s from Statoil

Methodology

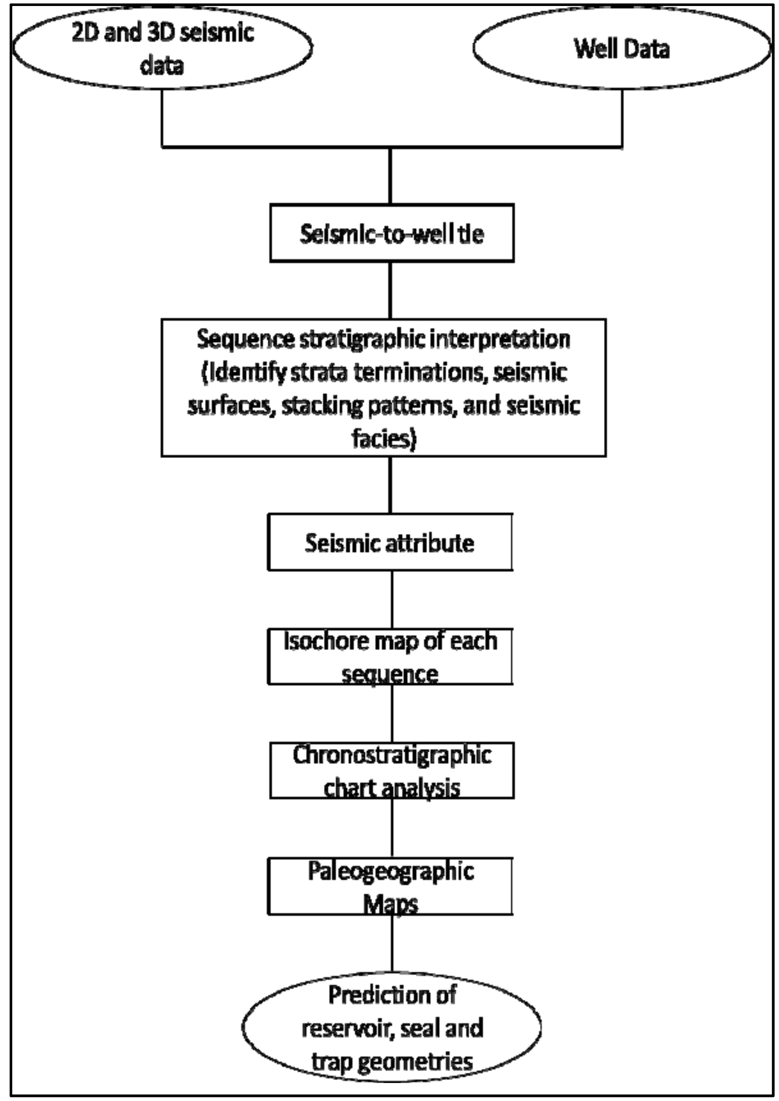


Stacking patterns
(Emery and Myers, 2009)



Seismic surfaces within a sequence
(Emery and Myers, 2009)

Chronostratigraphic Chart
(Emery and Myers, 2009)



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THANK YOU