

# **<sup>AV</sup>Unfolding by Holistic Thinking, Giant and Significant Oil Discoveries in a Mature Area: Discovery of Edvard Grieg, Johan Sverdrup and Luno II in the Norwegian North Sea\***

**Hans Rønnevik<sup>1</sup> and Arild Jørstad<sup>1</sup>**

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<sup>1</sup>Lundin Norway AS, Lysaker, Norway ([Hans.Ronnevik@lundin-norway.no](mailto:Hans.Ronnevik@lundin-norway.no))

## **Effect of Lundin Activities**

- Revitalized exploration on Norwegian Continental Shelf
- Proven 2.5-3 billion bbls in resources
- Proven 500 million bbls in reserves
- 140K bbls/day from Alvheim/Volund
- 90K bbls/day from Edvard Grieg
- 380K+ bbls/day from Johan Sverdrup (Phase1)
- Created substantial activity on land

## **Oil Systems**

The oils in Edvard Grieg and Johan Sverdrup fields are related to migration from Draupne source the last 1.5 mill years

- Undersaturated oils
- “Residual “ fresh oil down to 1960 m related to glacial rebound

Johan Sverdrup: Volgian sand with extremely high quality

1.9-2.9 billion bbls oil recoverable after the delineation by end 2013

Luno 2:

- Discovery (16/4-6) in 2013:
- Resource estimate after 1. well:
  - 25-120 million bbls; saturated oil, derived from Heather Formation
- 280 m homogenous Upper Triassic/Jurassic sand sequence
- Porosity 17 %
- Oil column 45 m; OWC 1950 m msl
- Production test 2000 bbls/day.
- Reservoir pressure 5 bar below hydrostatic.



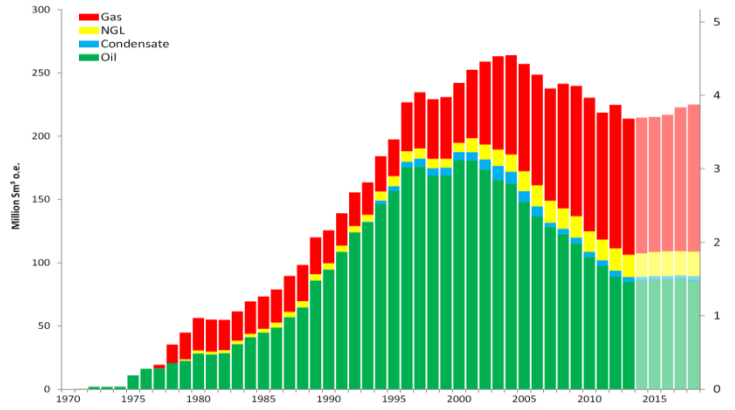
## Hans Rønnevik and Arild Jørstad, Lundin

Unfolding by Holistic Thinking,  
Giant and Significant Oil  
Discoveries in a Mature Area;

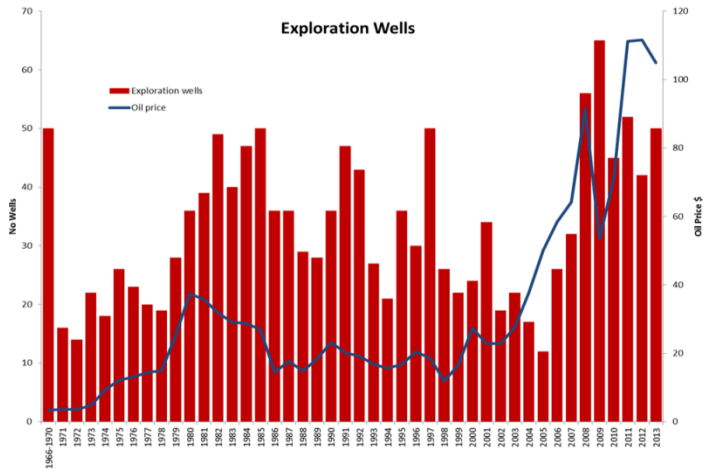
*Discovery of Edvard Grieg, Johan  
Sverdrup and Luno II in the  
Norwegian North Sea*

# Diversity reduces self-fulfilling prophecies

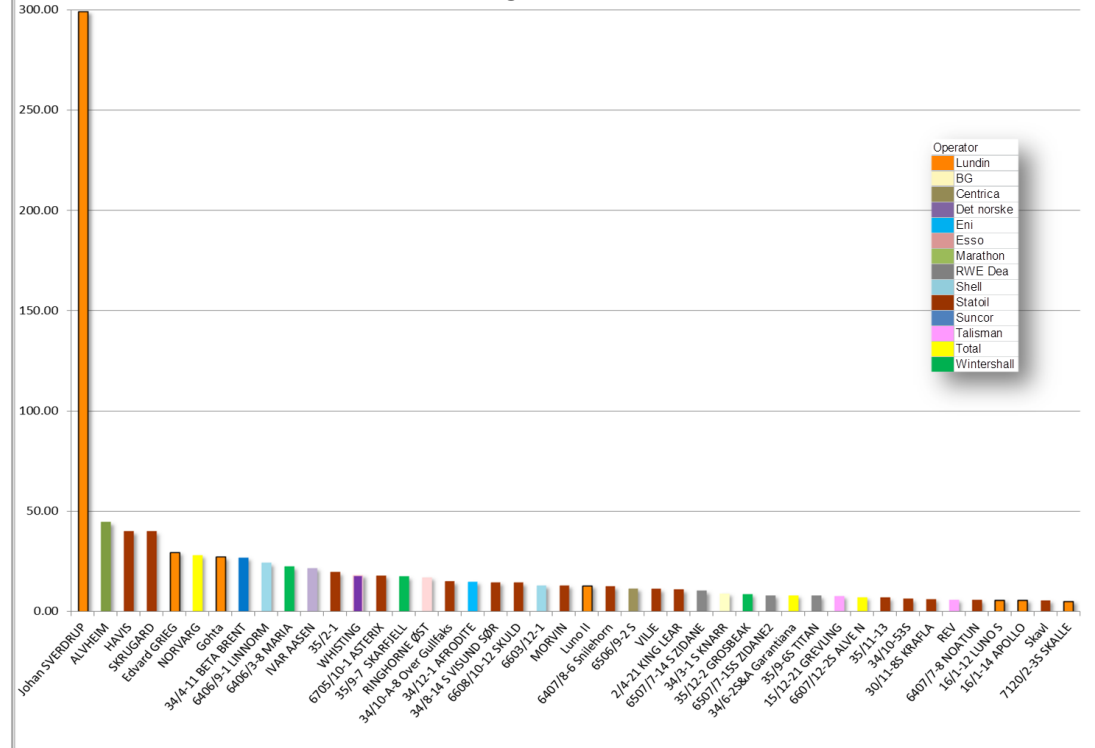
Historical production with 5 year forecast



Exploration Wells

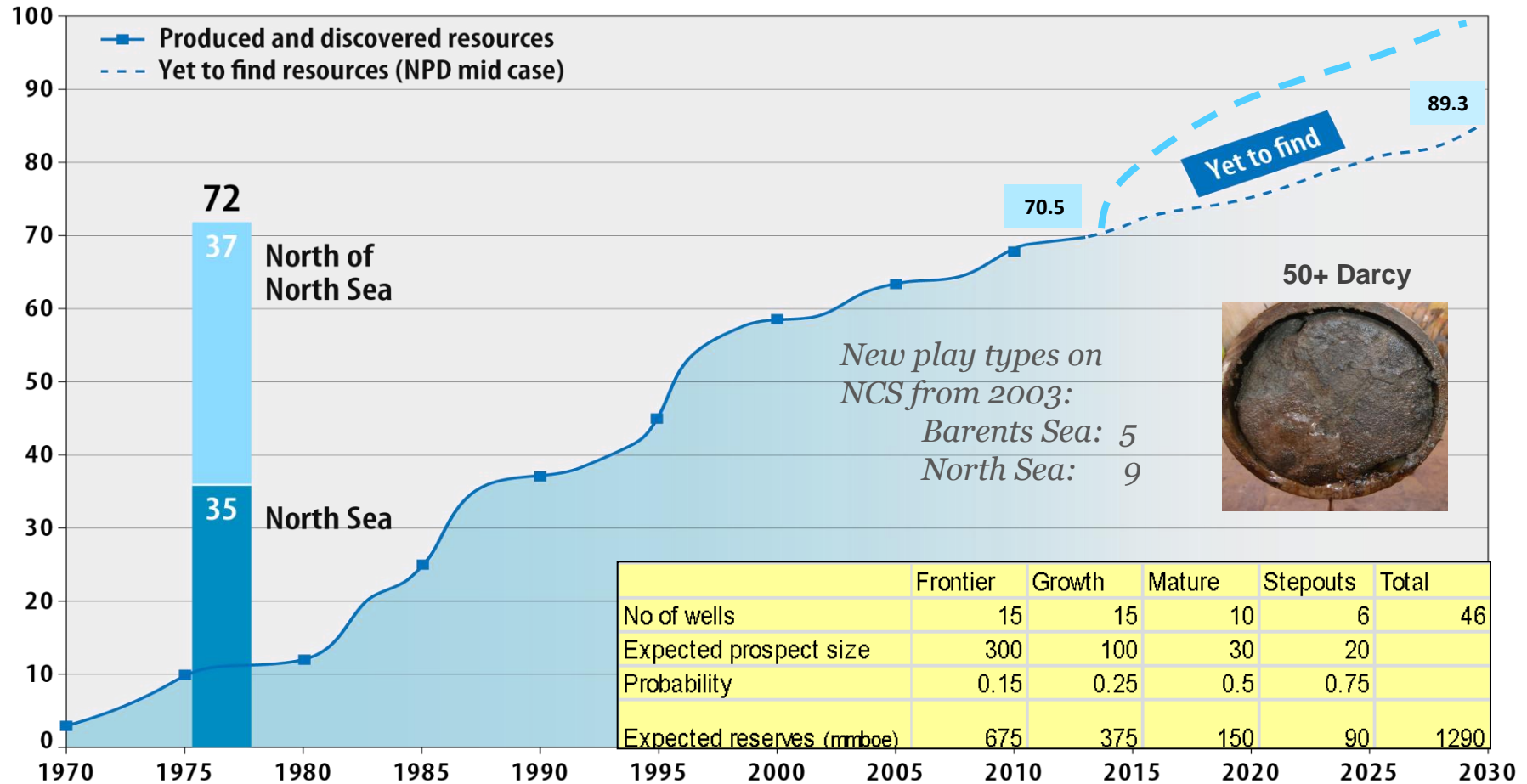


Discoveries on NCS larger than 5million Sm³ since 2000





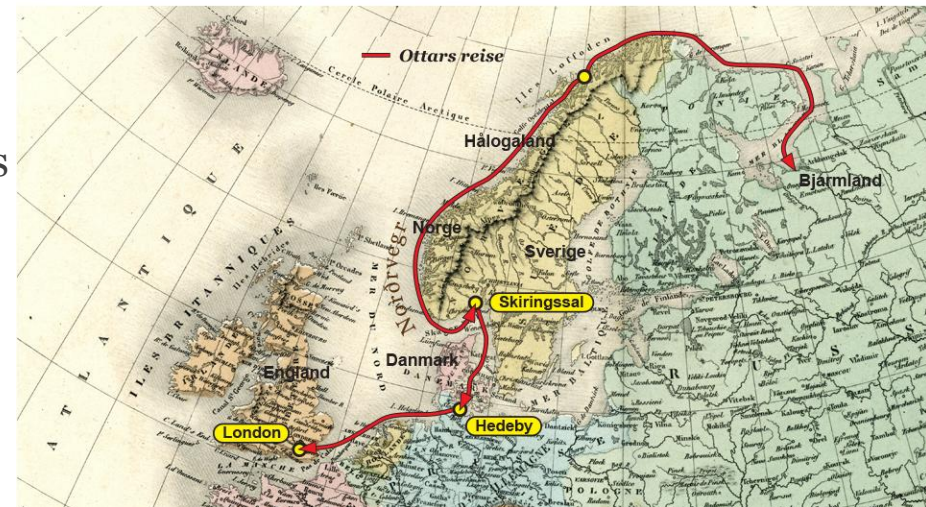
# Balanced exploration is needed for stable growth



# Exploration is continuous unfolding of reality

## How to lead the way?

- Purpose of the journey
- What is known and unknown
- Who needs to join in
- What do we need to bring with us
- Can sail under varying uncontrolled conditions





# Organic growth strategy

## ■ Find new oil

- New and existing play concepts
- Yearly balanced exploration and delineation drilling
- Clustering the portfolio:
  - Efficient exploration
  - Harvest our own breakthroughs
  - Lower economic threshold for commerciality
- Continuous better practice
- Afford to have good ideas

## ■ Develop new oil

- Brynhild
- Edvard Grieg
- Johan Sverdrup
- Luno 2
- Gohta

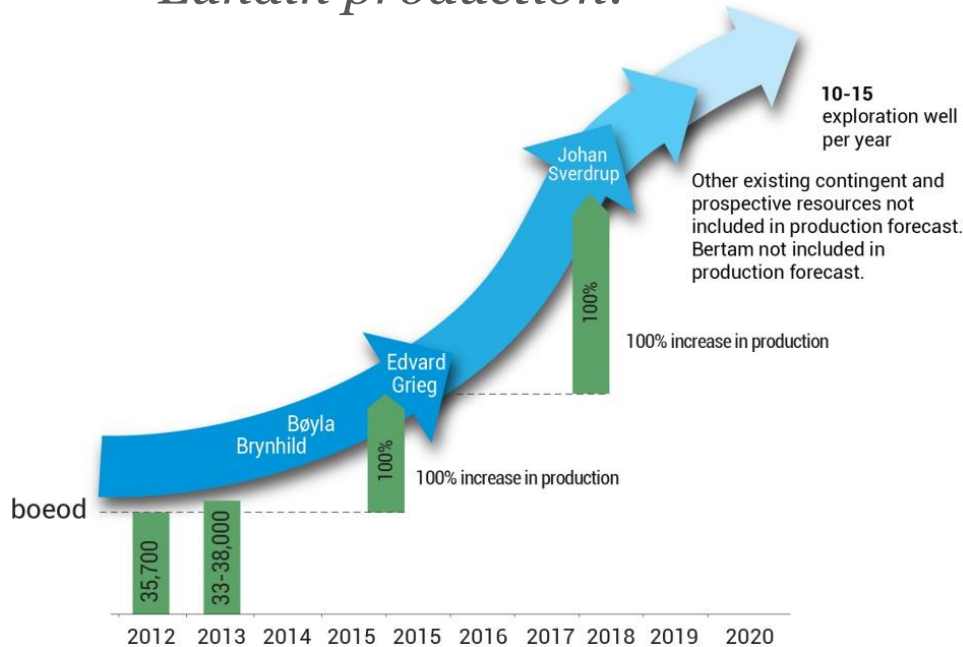
## ■ Produce more from developed fields

- Alvheim and Volund
- Bøyla
- Near field exploration

# Organic growth strategy:

Create values for sharing

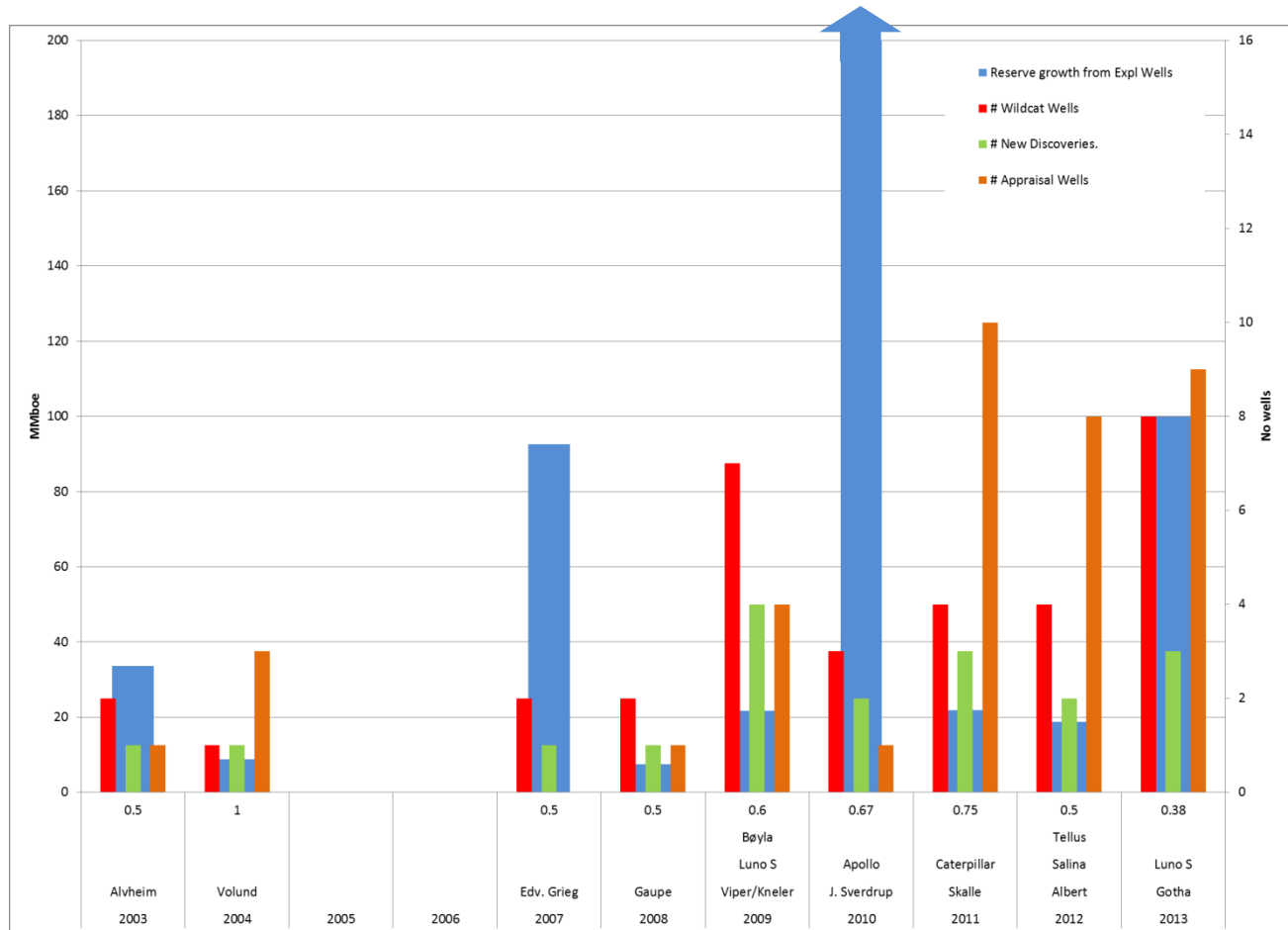
## Lundin production:



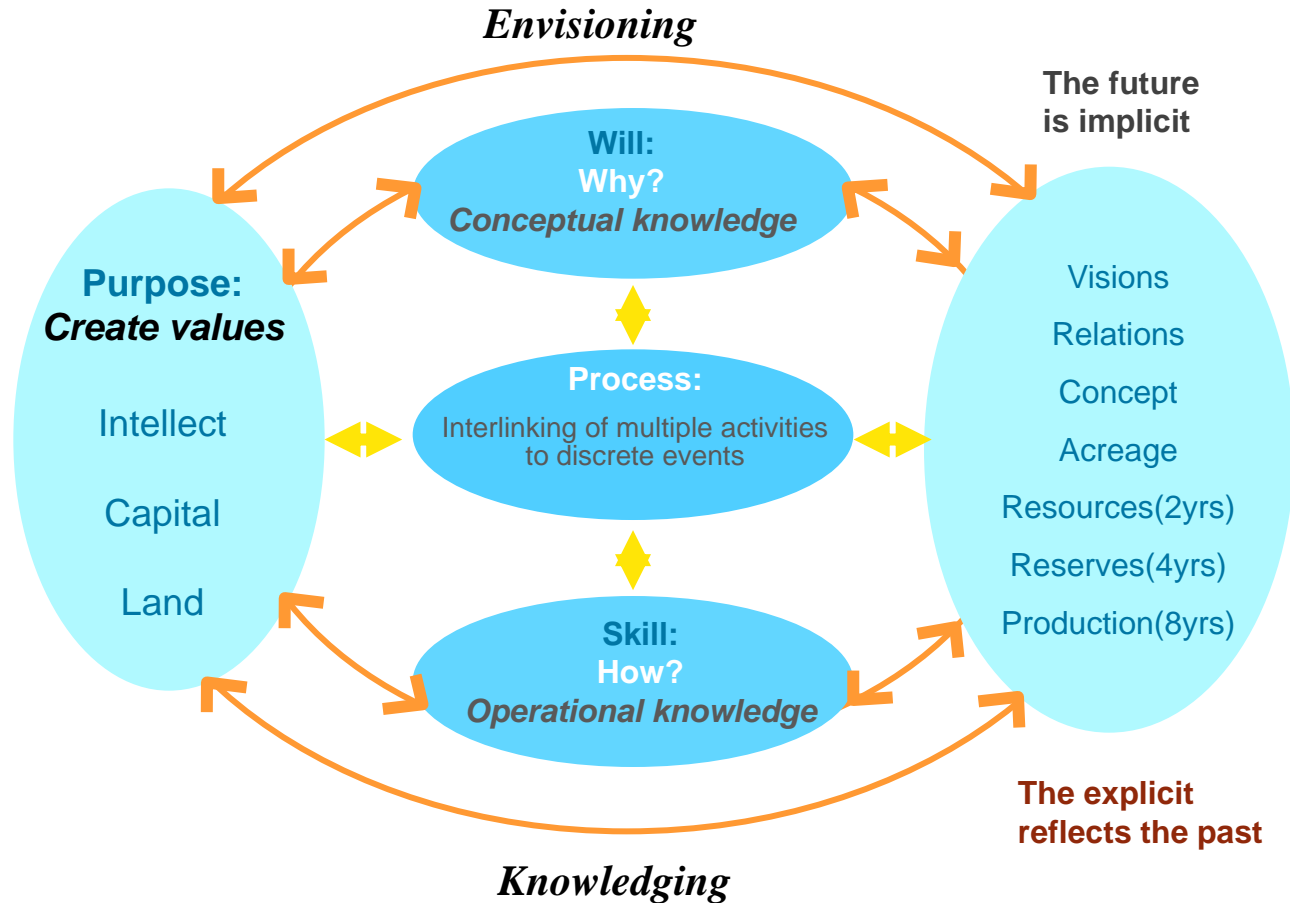
- *Society effect of Lundin activities:*
  - *Revitalized exploration on NCS*
  - *Proven 2.5-3 billion bbls in resources*
  - *Proven 500 million bbls in reserves*
  - *140K bbls/day from Alvheim/Volund*
  - *90K bbls/day from Edvard Grieg*
  - *380K+ bbls/day from Johan Sverdrup (Phase1)*
  - *Created substantial activity on land*



# Lundin Norway discovery curve



# A strategy must include all stakeholders



- Realize and PDO the resource potential
- Walk the talk
- Developed new play concepts in nature and front areas
- Secured acreage for long-term balanced drilling activity
- **Resources: 1.7 - 3 + billion bbls**
- **Reserves: 500 MMbbl+ (gross)**
- **Production: 140.000 bbl/day**



# Organic growth through knowledging

*A multidisciplinary aligned team that covers all phases and are in harmony with other disciplines*

*The Power  
of a  
Shared Vision*

*Internally and externally  
wanted company*



# Organic growth through knowledging

- *He on whom God's light does fall sees the great thing in the small*
- *To know what thou knowest not is in essence omniscience*
- *With technology as master we reach disaster faster*



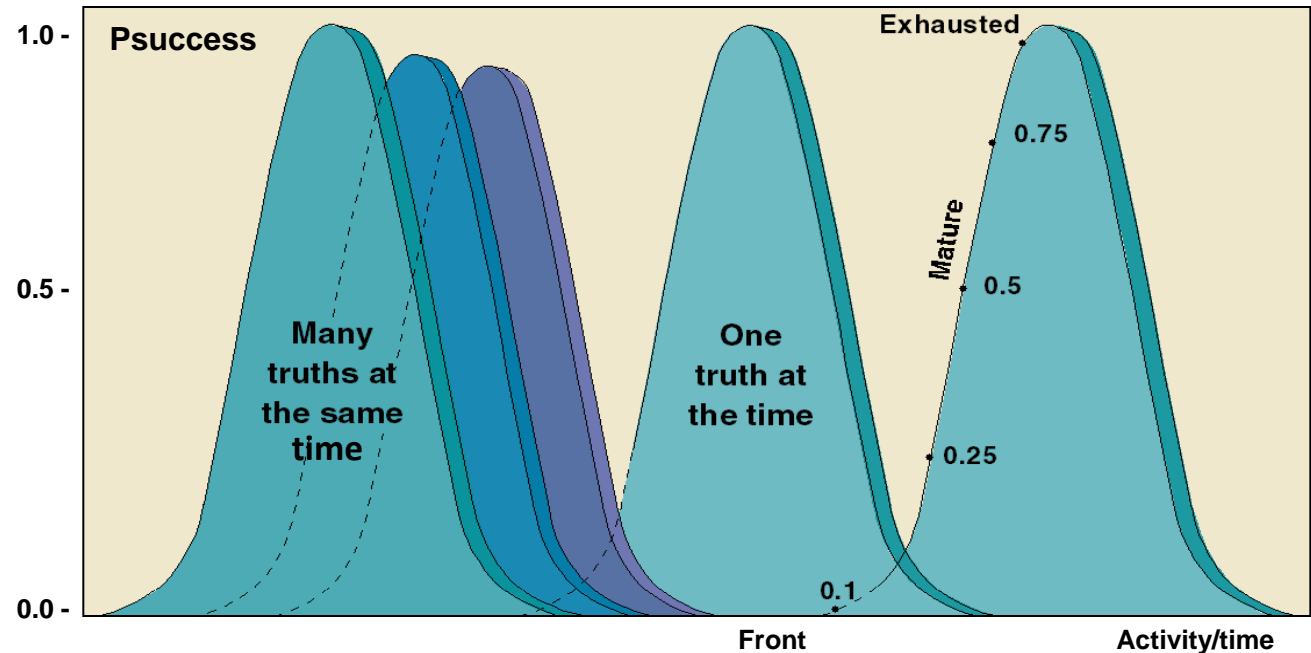
*Internally and externally  
wanted company*

# Stability is based on conceptual changes

## Truths and facts:

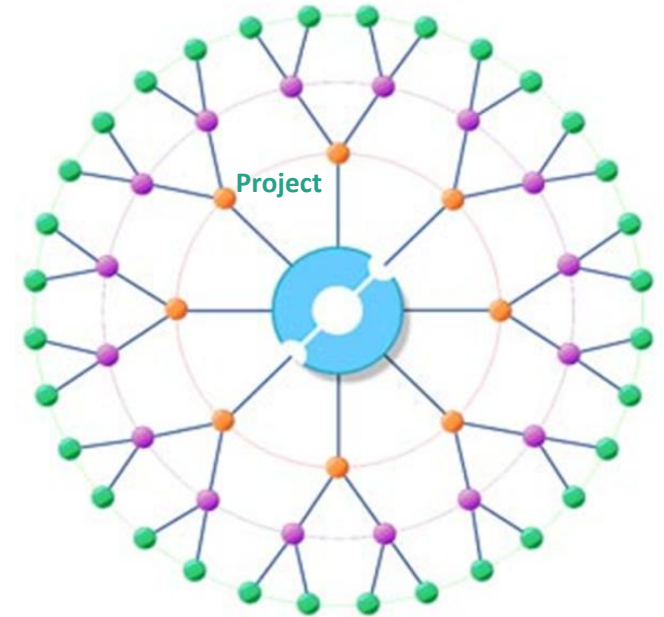
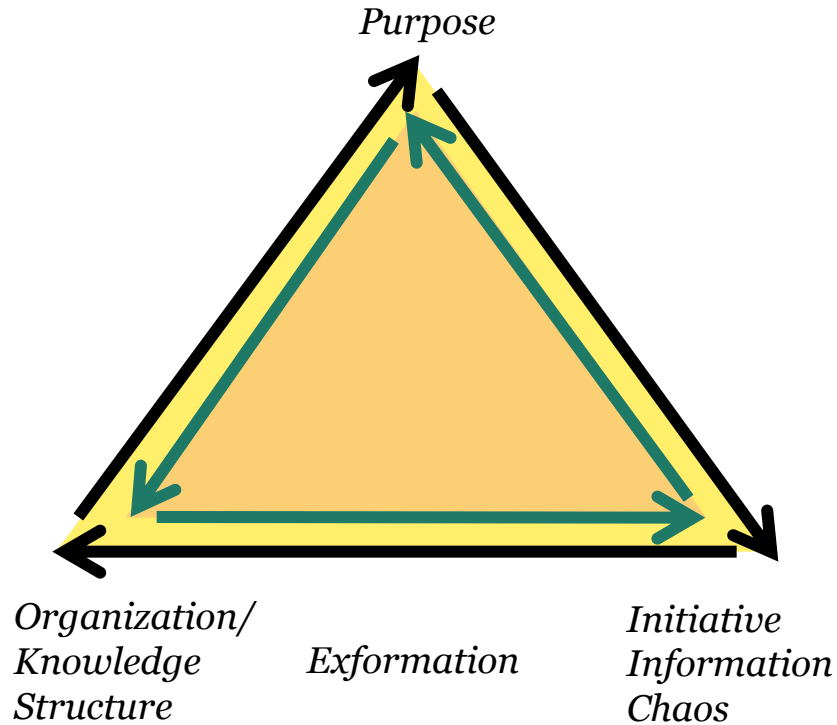
- 1.Thoughts are instant, thinking takes time (self-referencing).*
- 2.Facts are the experienced parts of the truth. The truth must contain, but not be constrained by, facts.*
- 3.What is the likelihood of having experienced the truth based on facts?*
- 4.The truth is so large that everybody can see a part of it but nobody the whole.*
- 5.We should keep on unfolding reality by interacting with it (David Bohm).*

- always
- usually
- general
- by and large
- more often than not
- half the time
- often
- sometimes
- occasionally
- been known to happen
- never
- cannot be true



# Living systems are self-organizing

Knowledge is created and utilized in living networks



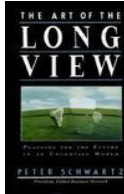
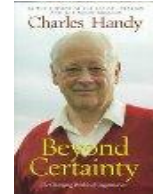
*Purpose oriented (teleological ) organization*  
*Freedom for individuals within the context of the community*

*Multicultural project organization:*  
*Exploration; 15 +pr yr., Development; 3-8 yrs, Production; 10-30 yrs*

# The knowledging culture

1. *Find a unique purpose*
2. *Create an honest culture that walks the talk*
3. *Envisioning and knowledging are the key elements in a road map that stands a rainy day*
4. *Creative learning is a community and individual process based on a maximum diversity and entropy released by diversity and freedom*
5. *Appreciate the learners*
6. *Don't become trapped in best practice and develop continuously better practice by applying developing tools*
7. *Don't be stuck in the explicit or your own propaganda*
8. *Be focused and defocused simultaneously*
9. *Base the concepts on facts and not fictions*
10. *Avoid the empty raincoat syndrome (form without content)*

Applied



*The empty raincoat syndrome*





# Fact and experience-based operational knowledging

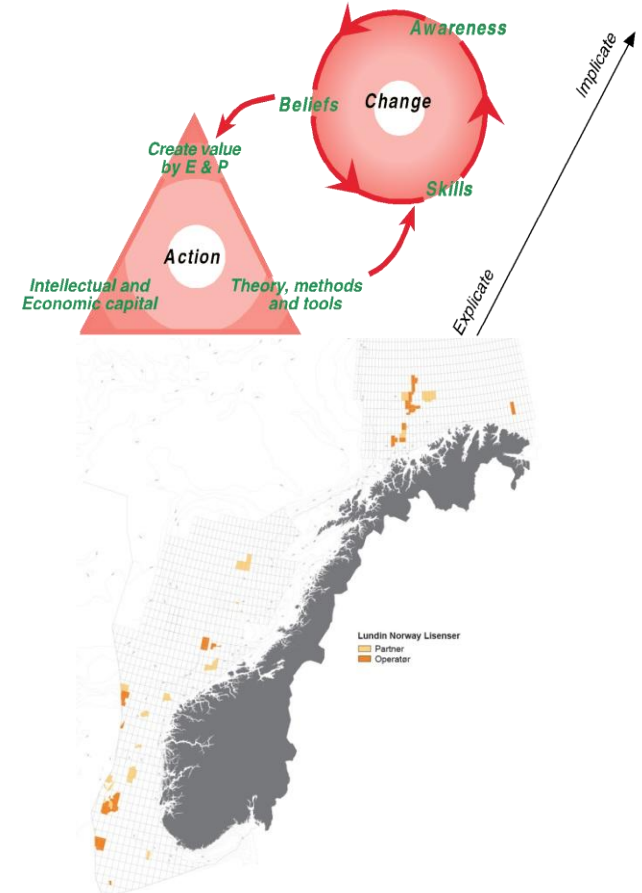
## Generation of consciousness:

- *Possibility analyses are influenced by the time spirit*
- *New knowledge is created:*
  - *beyond 2 standard deviations*
  - *by breakthroughs*
  - *by actions rather than predictions*
- *Concepts must contain, but not be constrained by, the facts*
- *Efficient learning attacks uncertainties, not certainties*
- *New awareness relates to diversity and not more of the same*
- *Modeling is no substitute for thinking*

## Data, tools and methods :

- *Geophysics is being developed towards broadband*
- *Drilling, coring and sidesteps are key to increased knowledge*
- *Coring through hiatuses*
- *Continuous learning on all parameters during operations*
- *Continuous processing and analysis during drilling*
- *DST's to understand continuity*
- *Flexibility to adapt to reality during operations*

*"In times of change, the learners will inherit the earth while the learned will find themselves beautifully equipped to deal with a world that no longer exists."*  
Eric Hoffer



# Clustered license portfolio with balanced activities

2014

Exploration: 285 mill USD

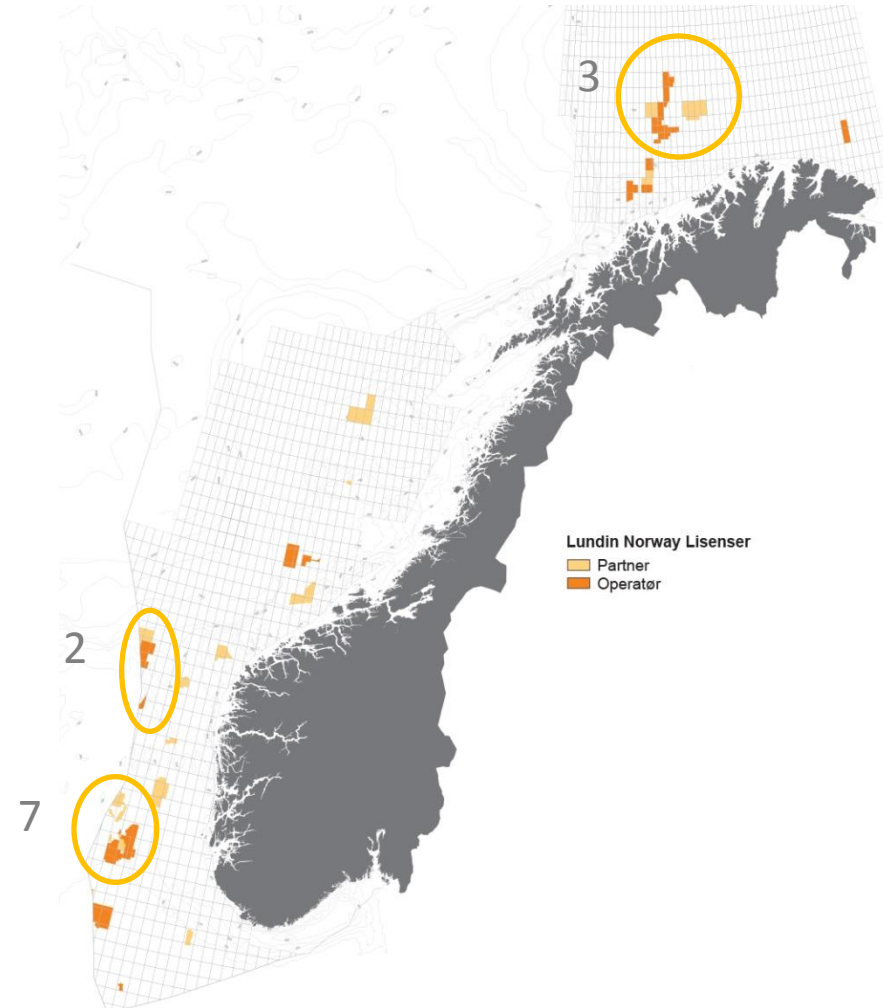
1. *Alta*
2. *Langlitinden; insignificant oil discovery*
3. *Lindardormen*
4. *Storm*
5. *Vollgrav*
6. *Kopervik*
7. *Luno2 North/Fignon (proposed)*

Delineation: 280 mill USD

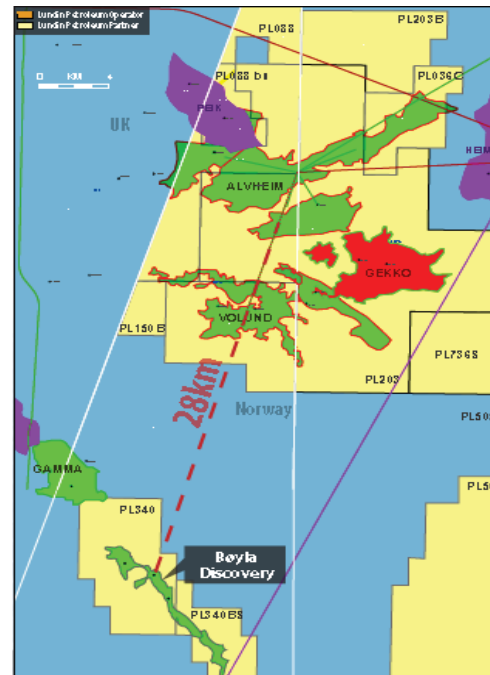
1. *Edvard Grieg : 1 well in the SE*
2. *Luno 2: Central basin south*
3. *Gotha: 1 well*

*Johan Sverdrup:*

4. *Avaldsnes crest finished*
5. *Geitungen*



# Alvheim: The gas satellites that was a major oilfield

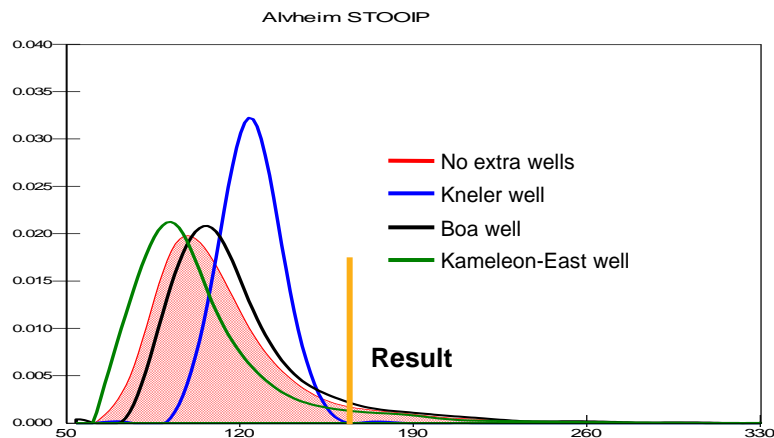


- Alvheim: 196 (PDO)- 276 mill bbls
- Volund: 38 mill bbl+
- Bøyla: 30 mill bbl+

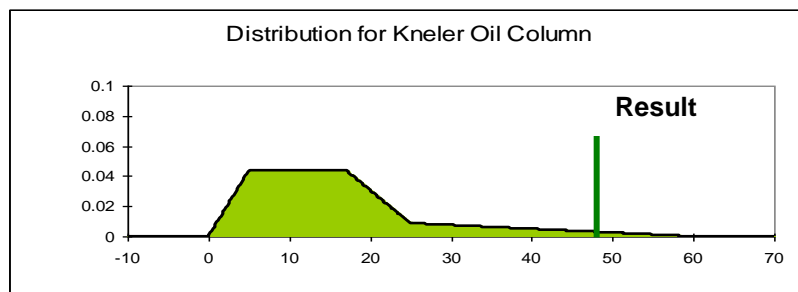
*Sold by NH and bought by  
Marathon as gas prospects.  
Lundin developed the oil play  
strategy*



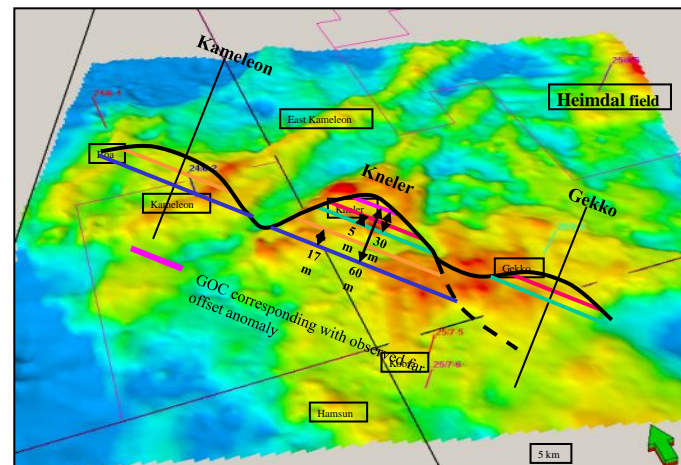
# New knowledge is created outside 2 standard deviations



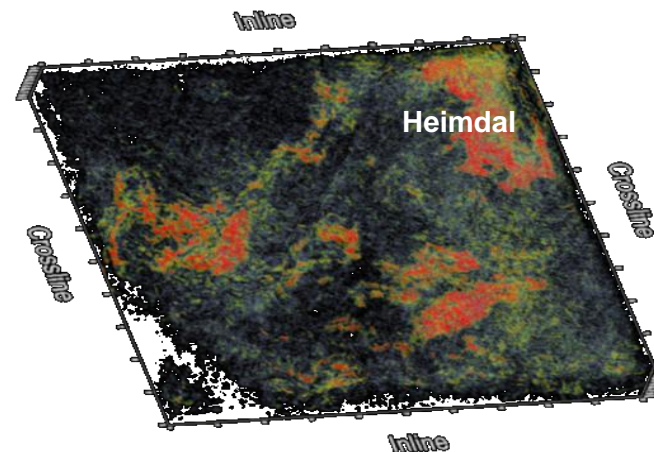
Screening model: Area \* Oil column = Stooip 96 mill Sm<sup>3</sup>



## Oil column sensitivity

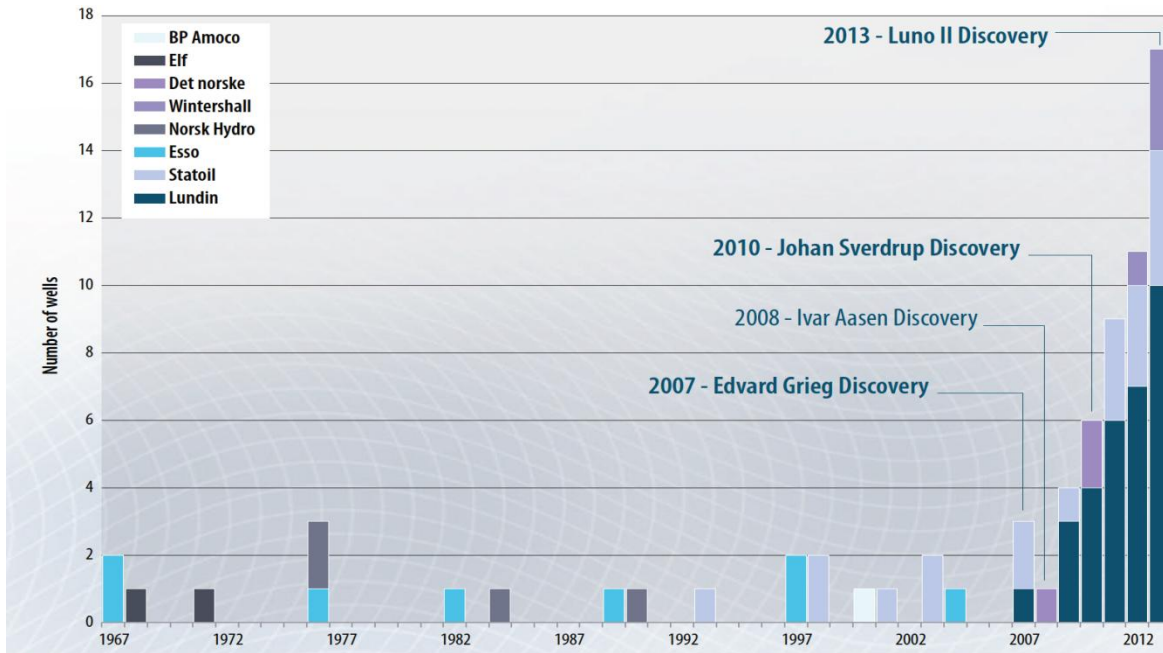


## AVO anomalies

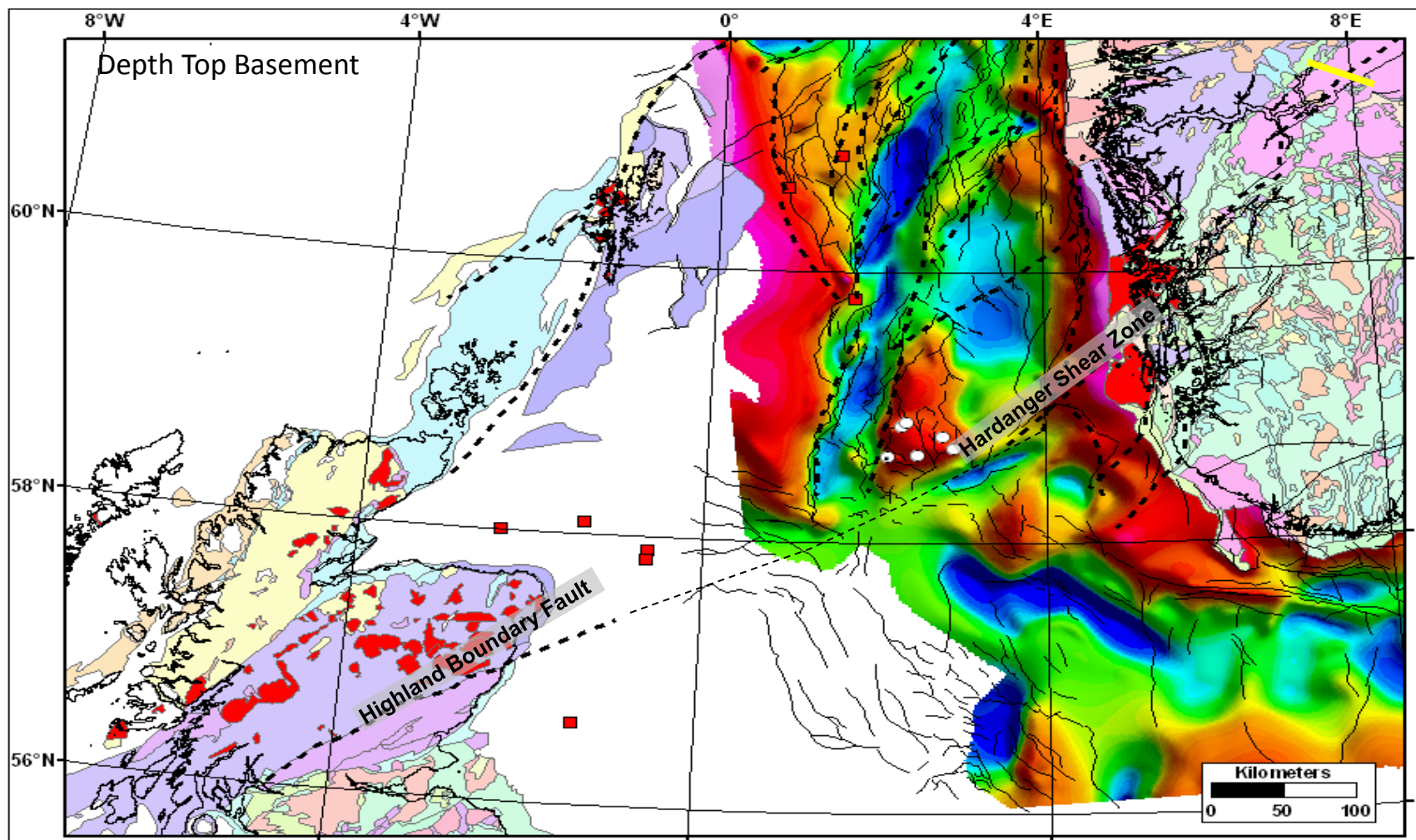


# Southern Utsira High – a new oil production center

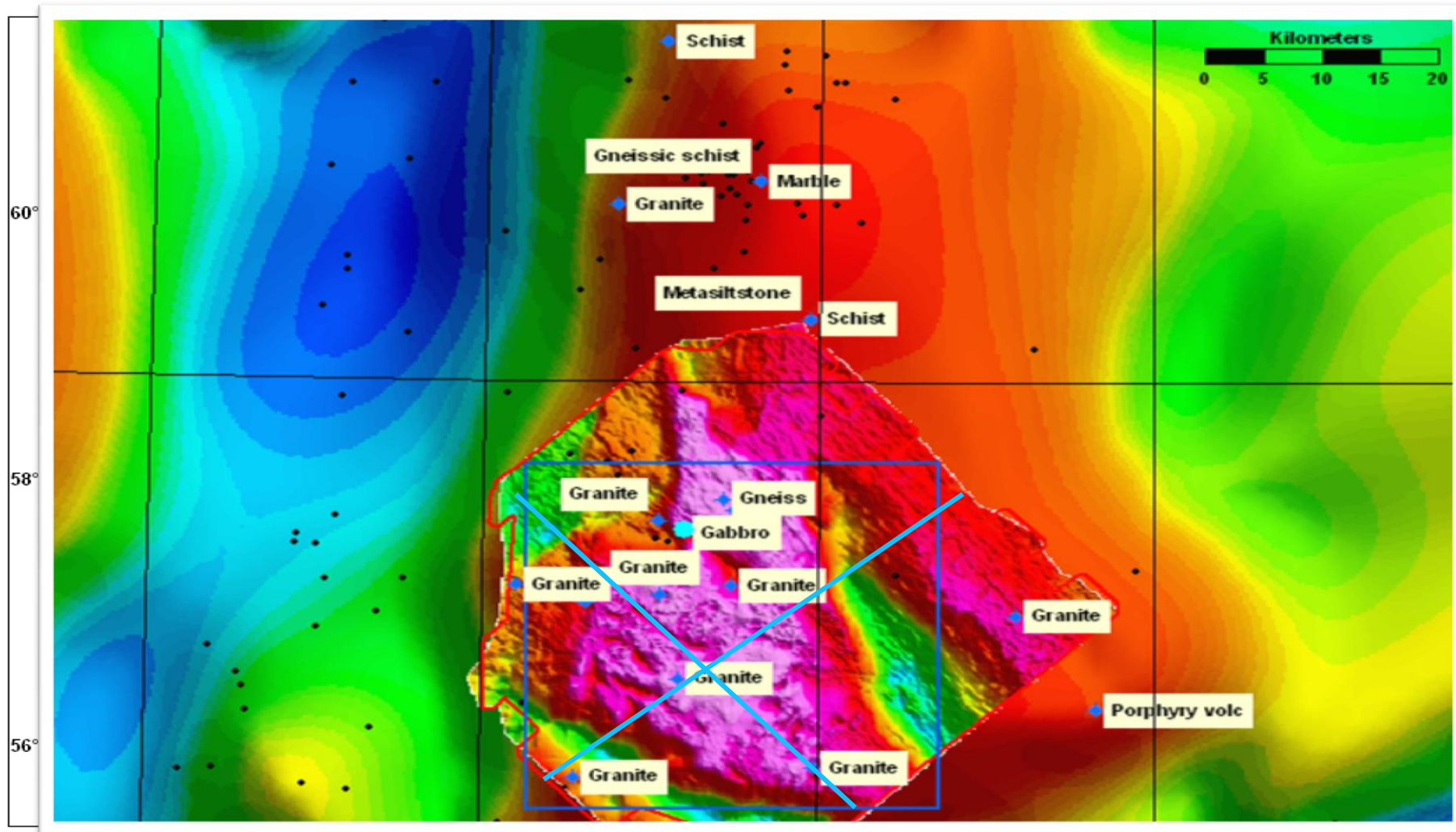
*Breakthrough after 40 years of on/off exploration*

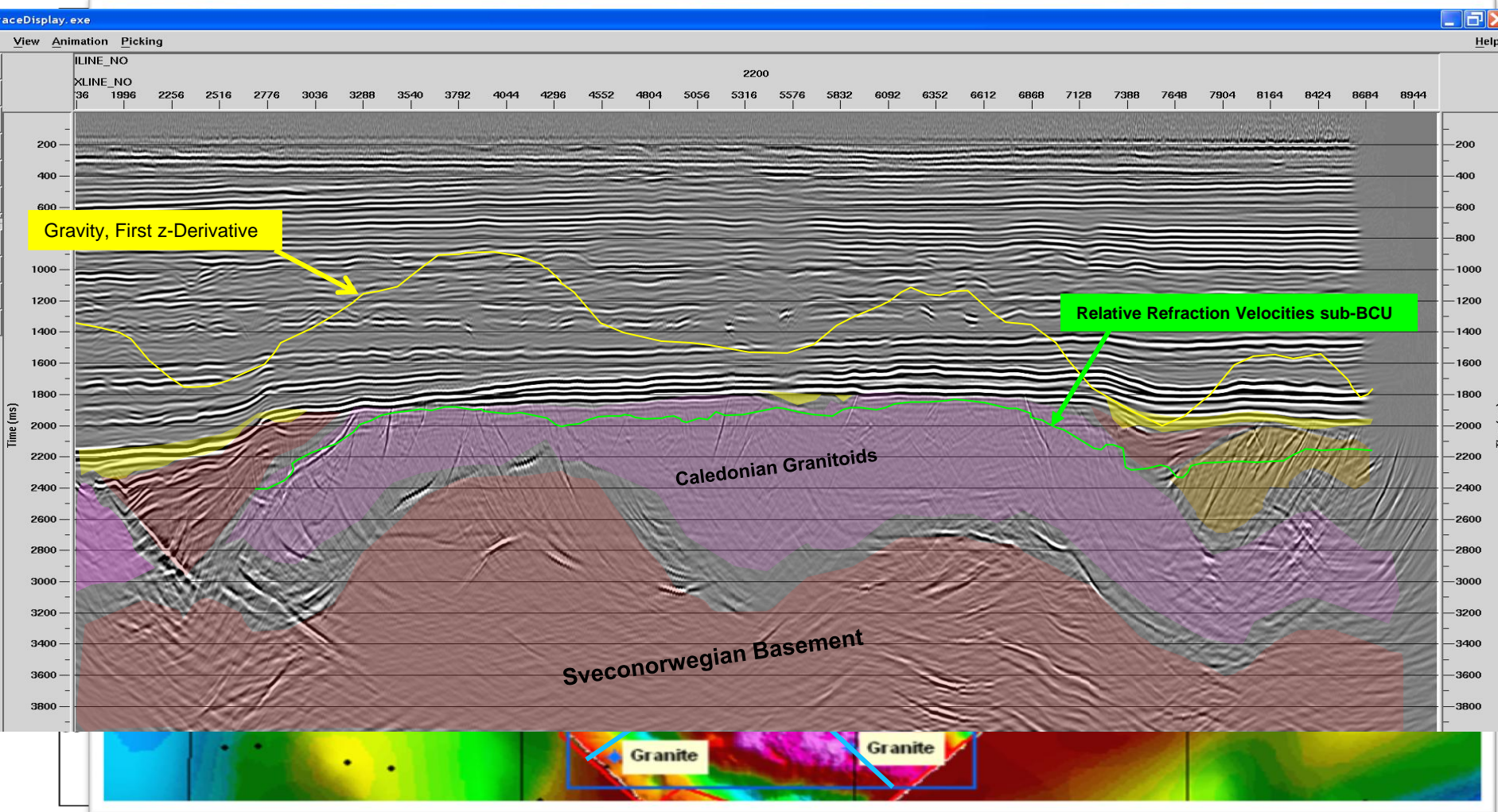


Source: NPD

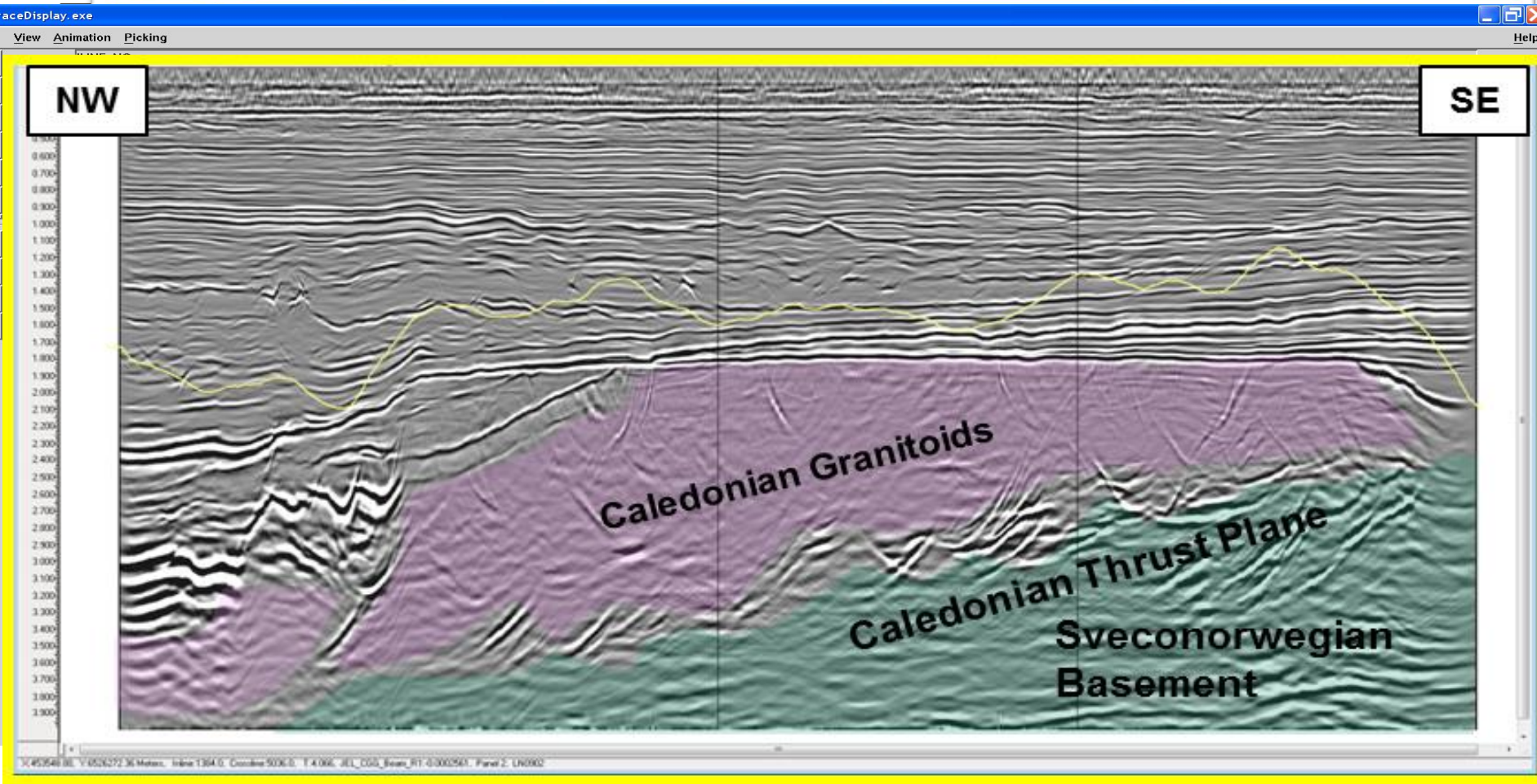


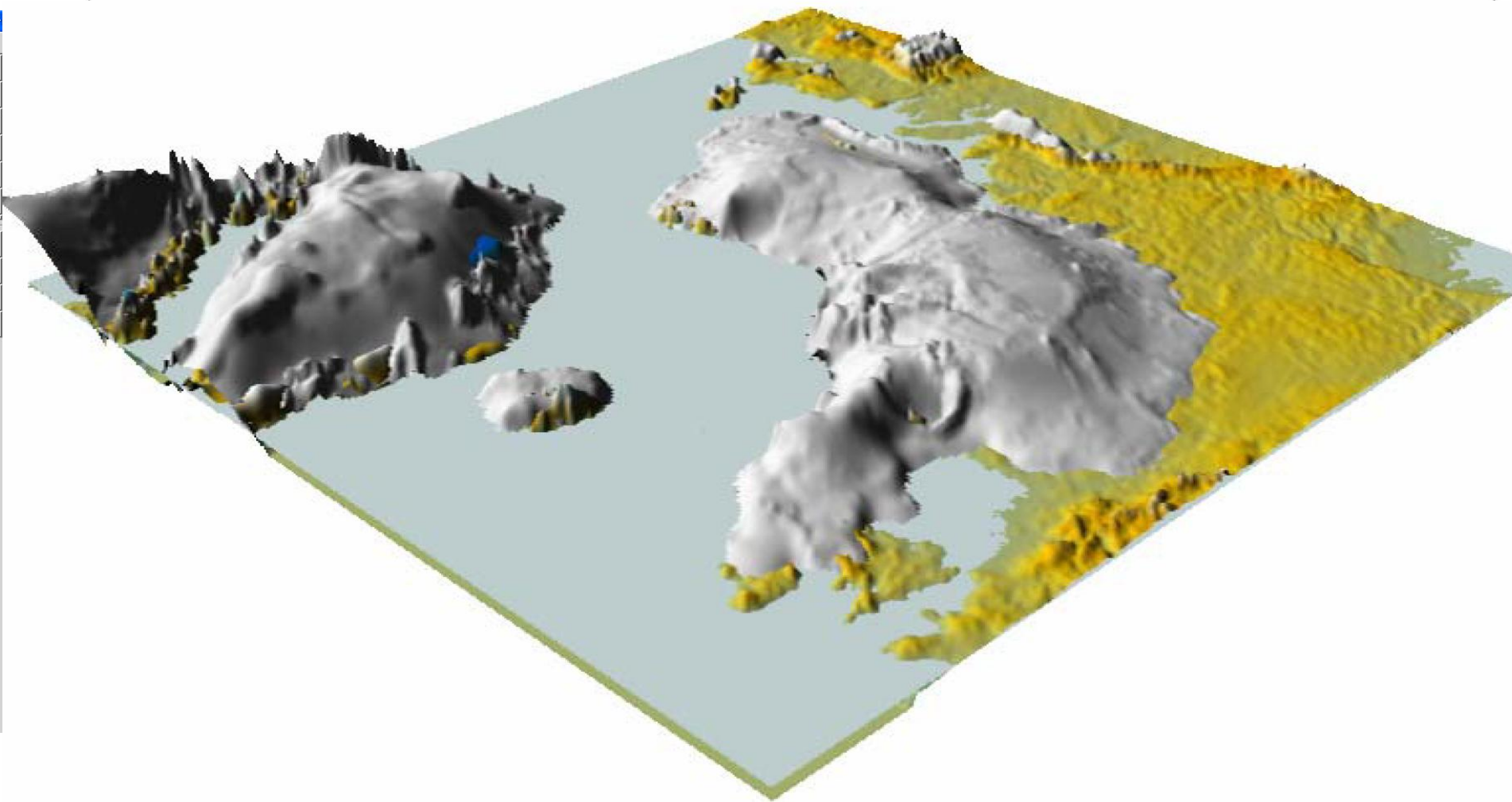










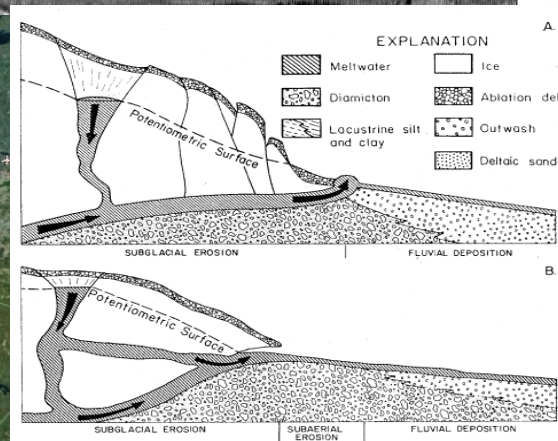
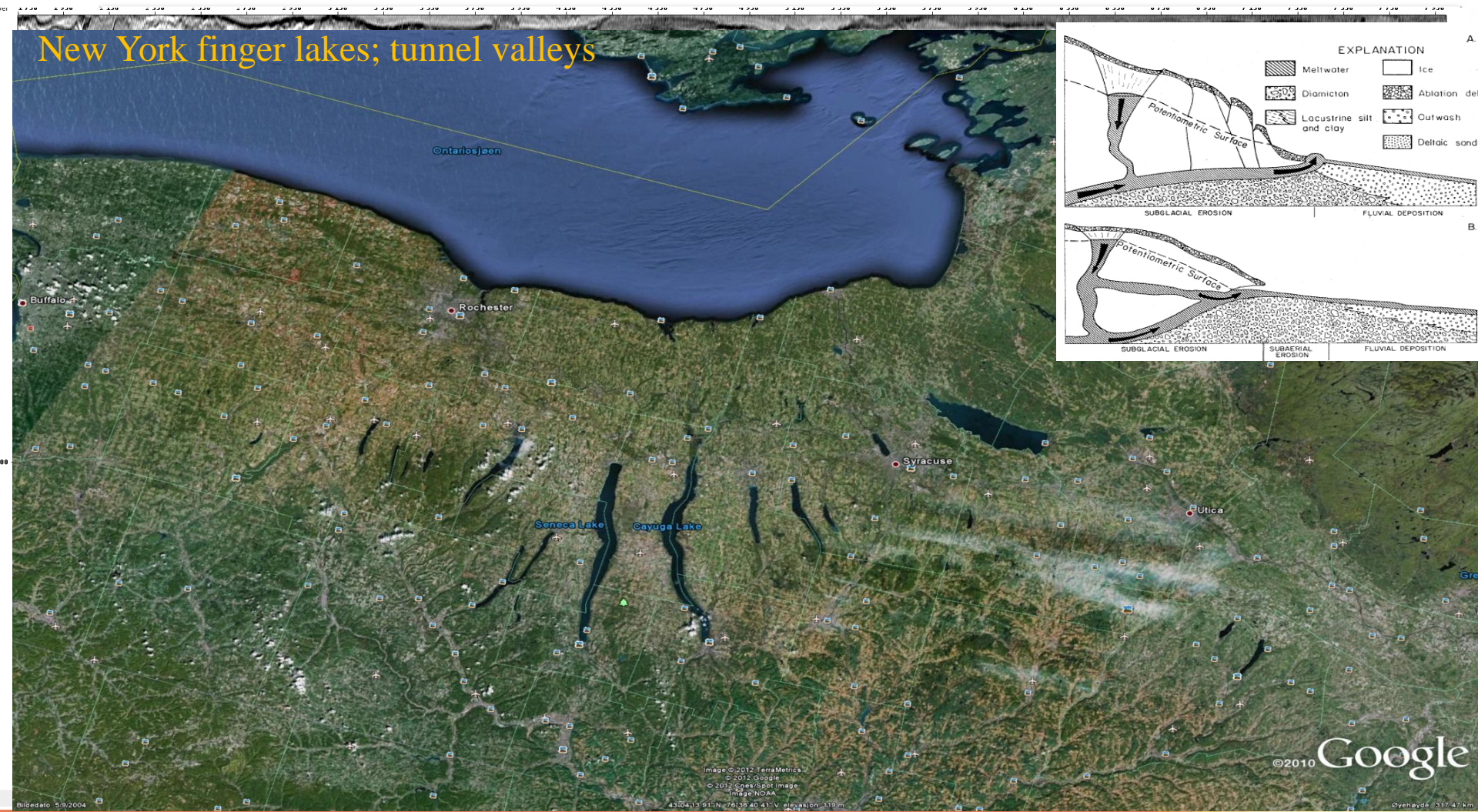




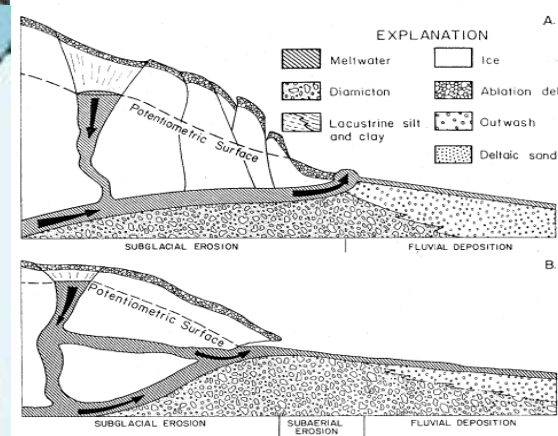
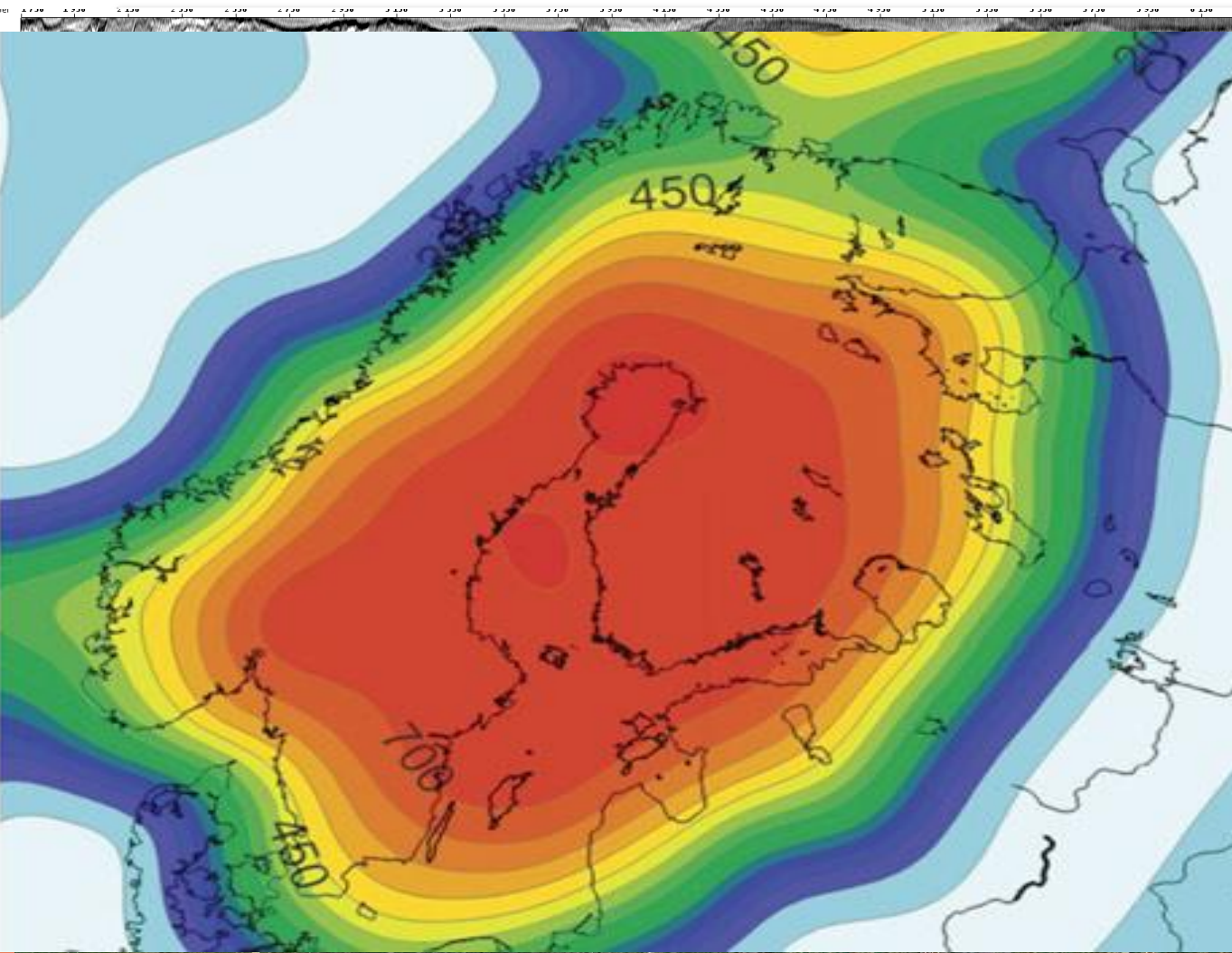




# New York finger lakes; tunnel valleys

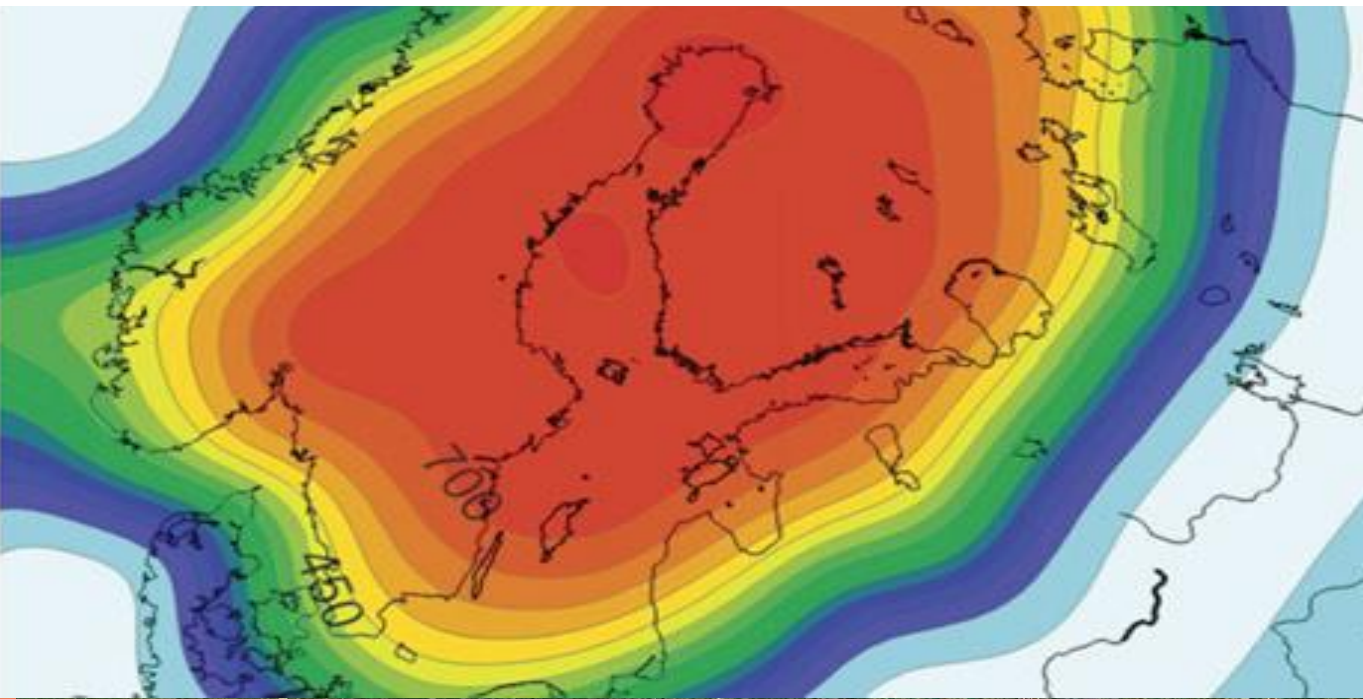






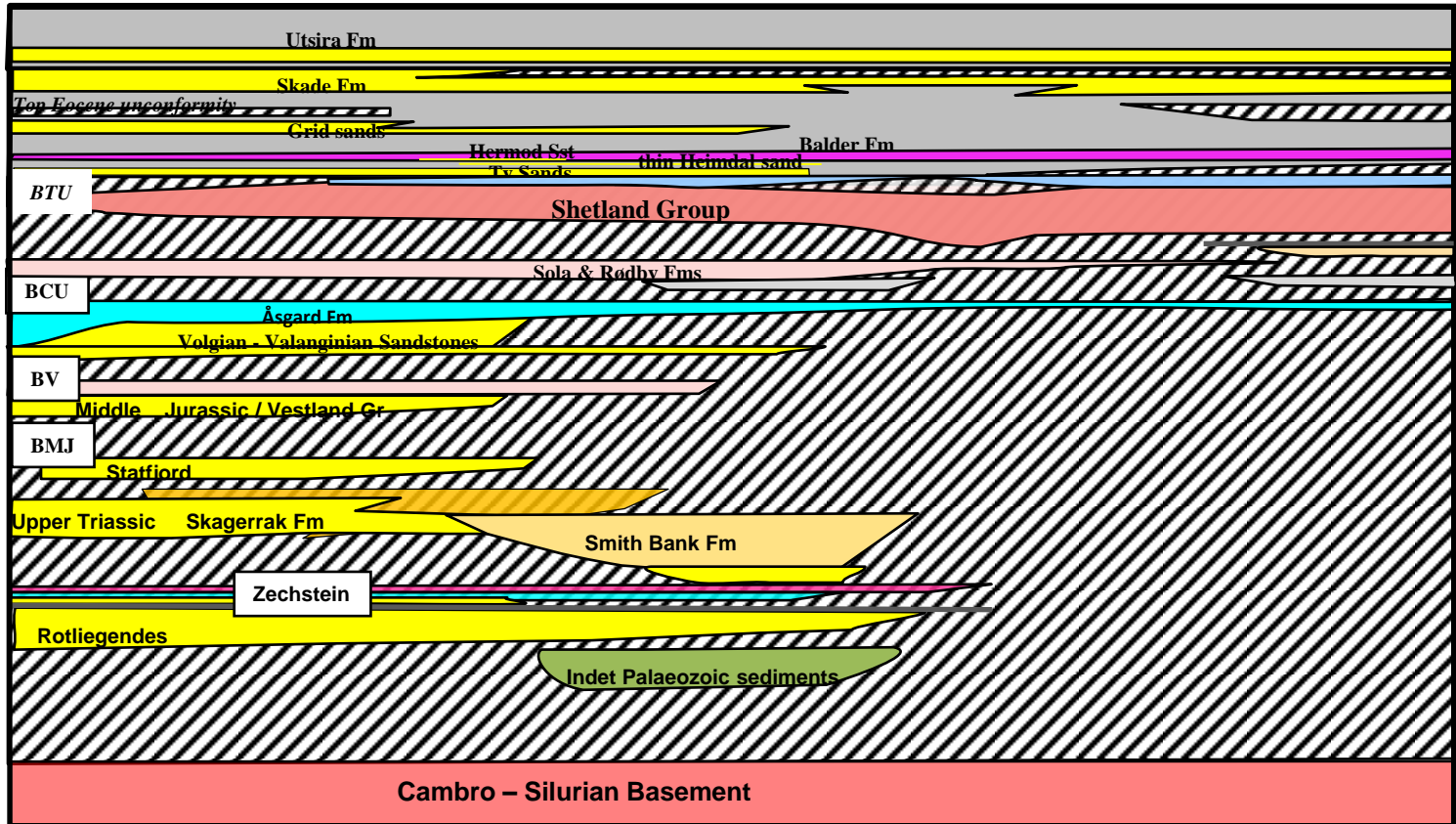
# The whole in the details and details in the whole

*Early focusing reduces the ability to unfold new truths  
New understanding is unfolded by interacting with reality*



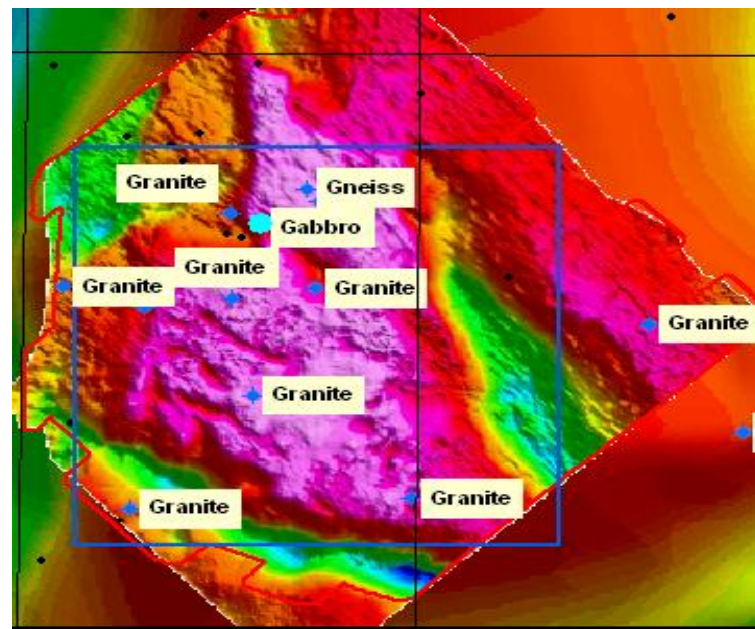
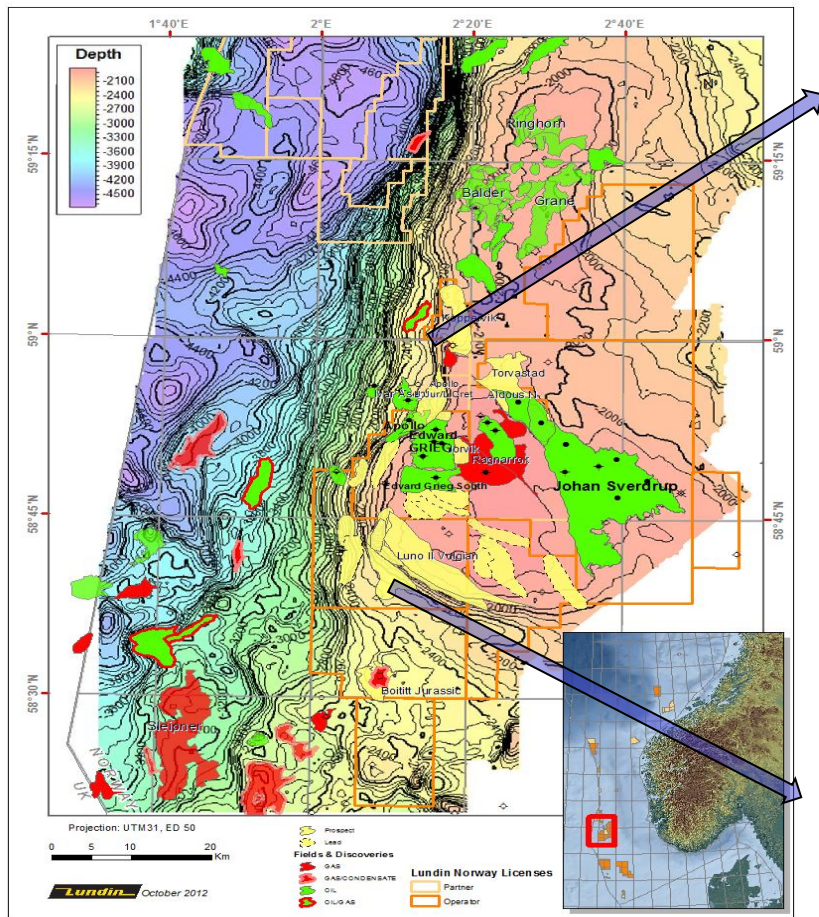
# The usefulness is in the emptiness and changes

Time



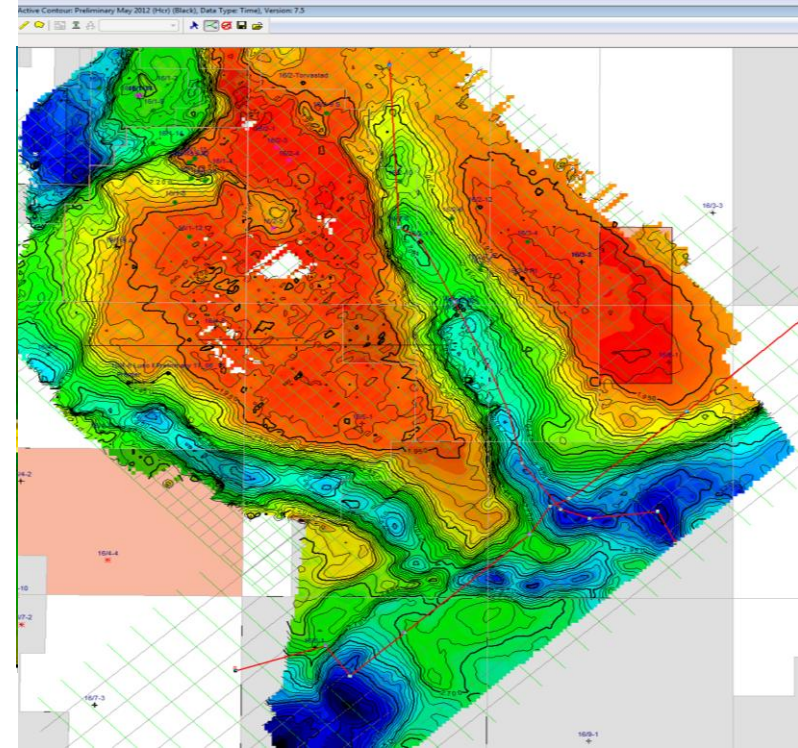
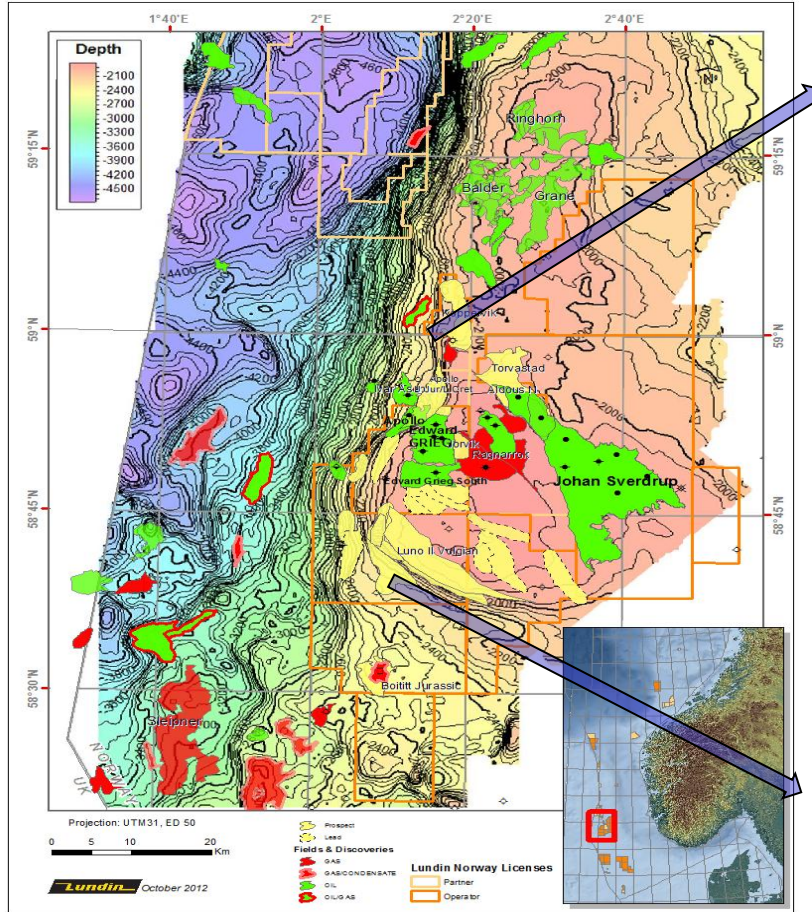


## The Haugaland High; southern part of the Utsira High



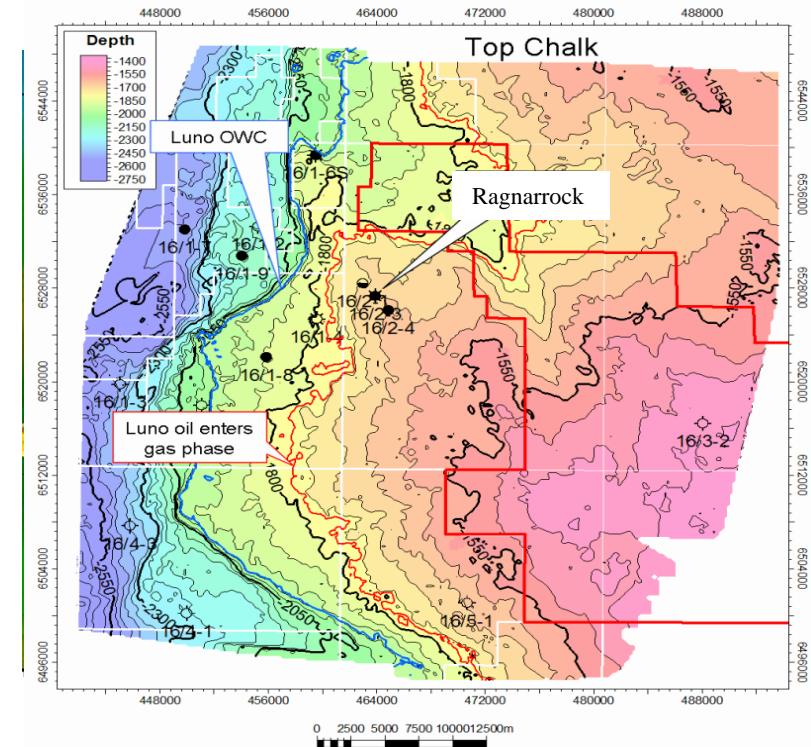
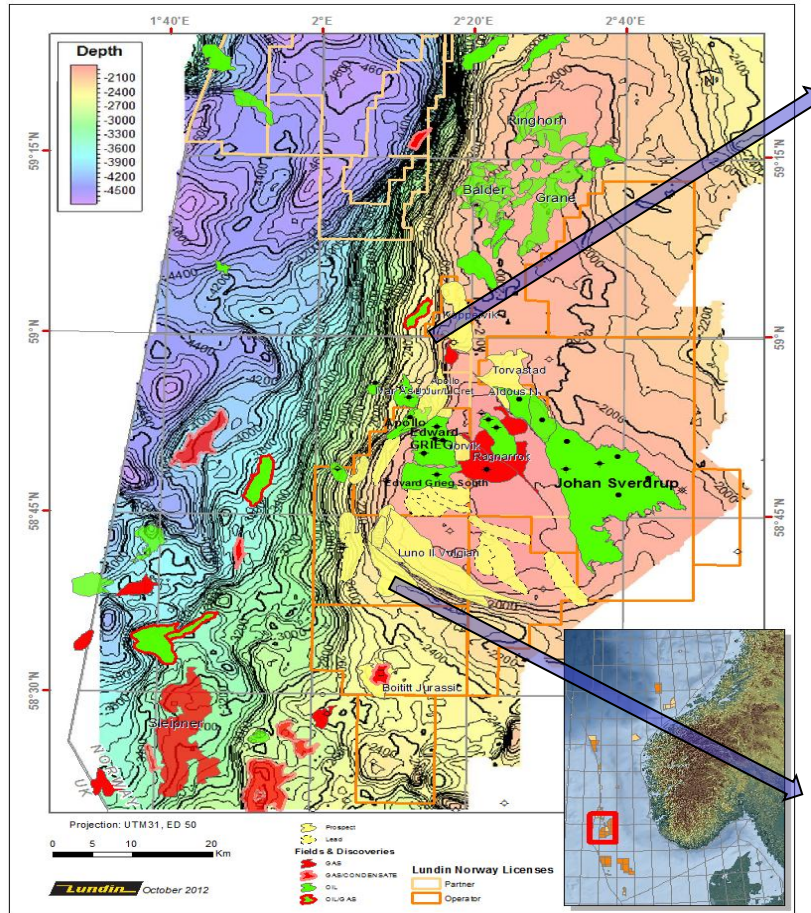


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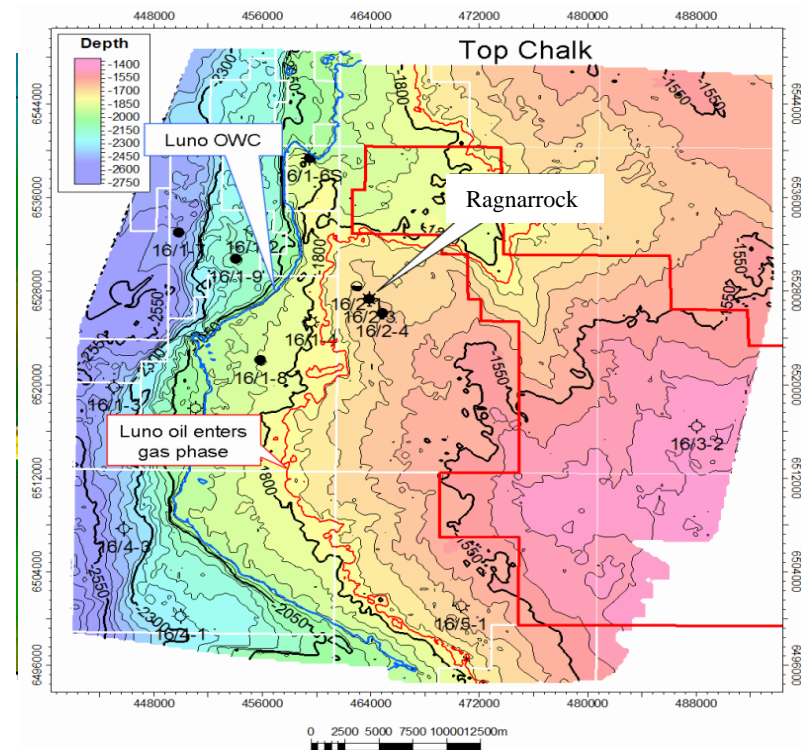
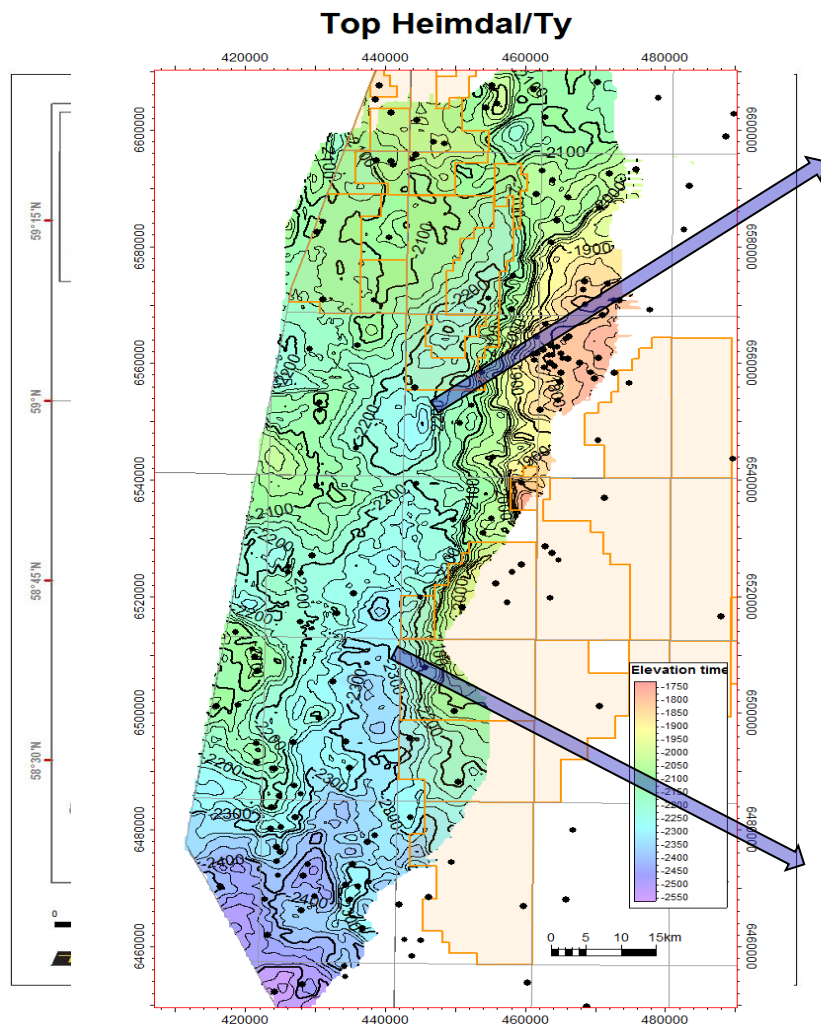




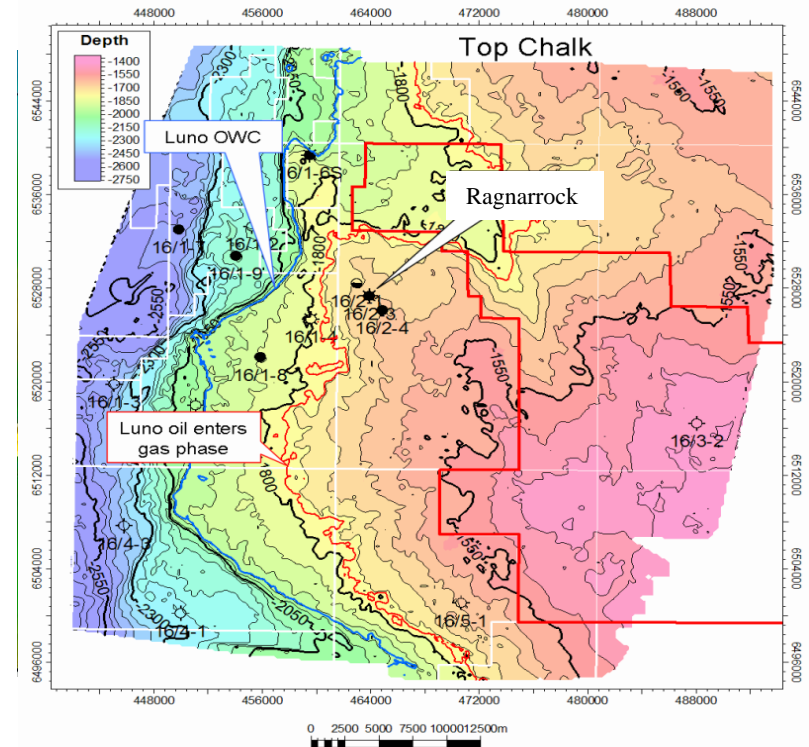
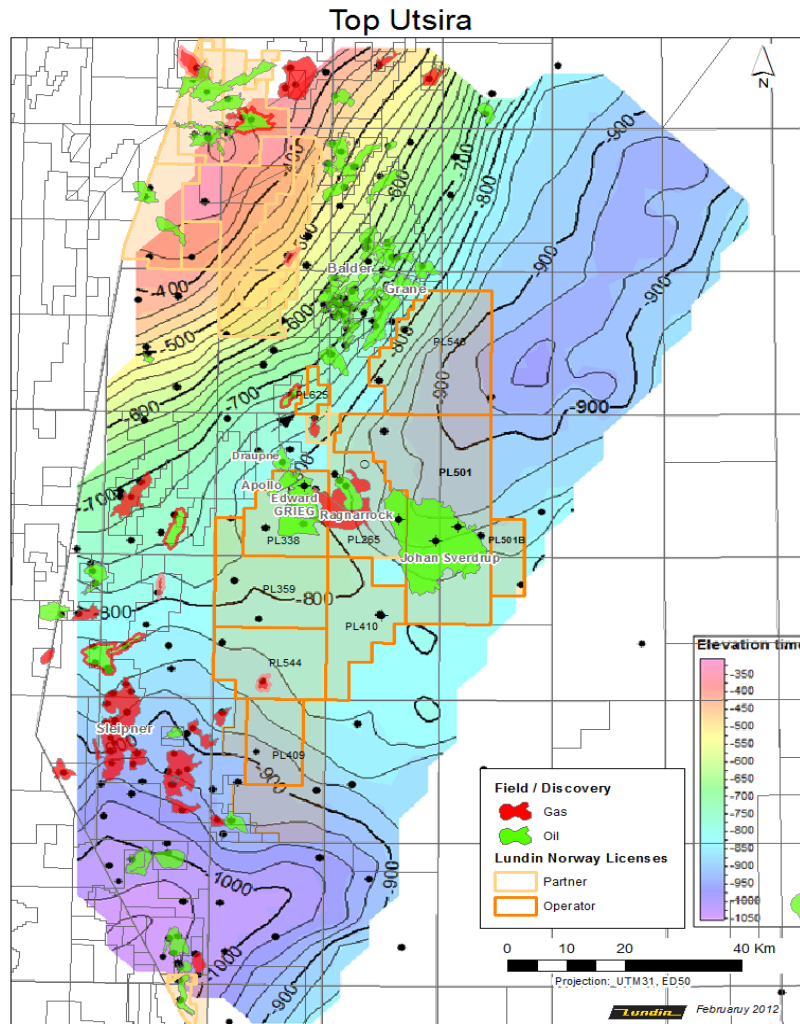
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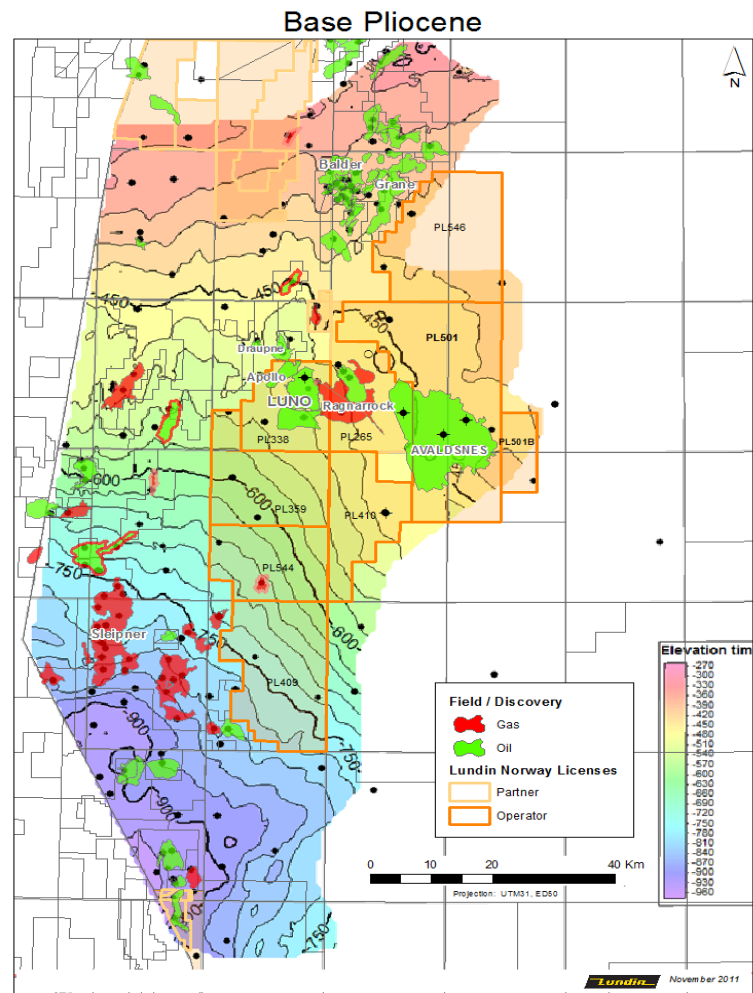
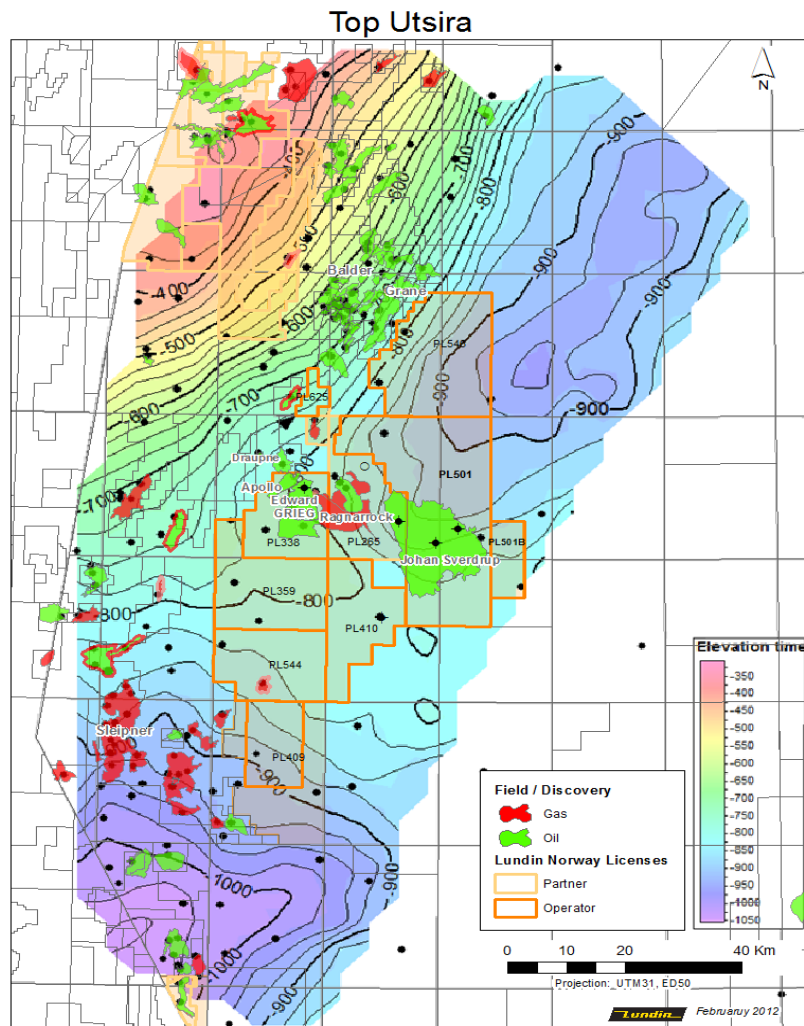


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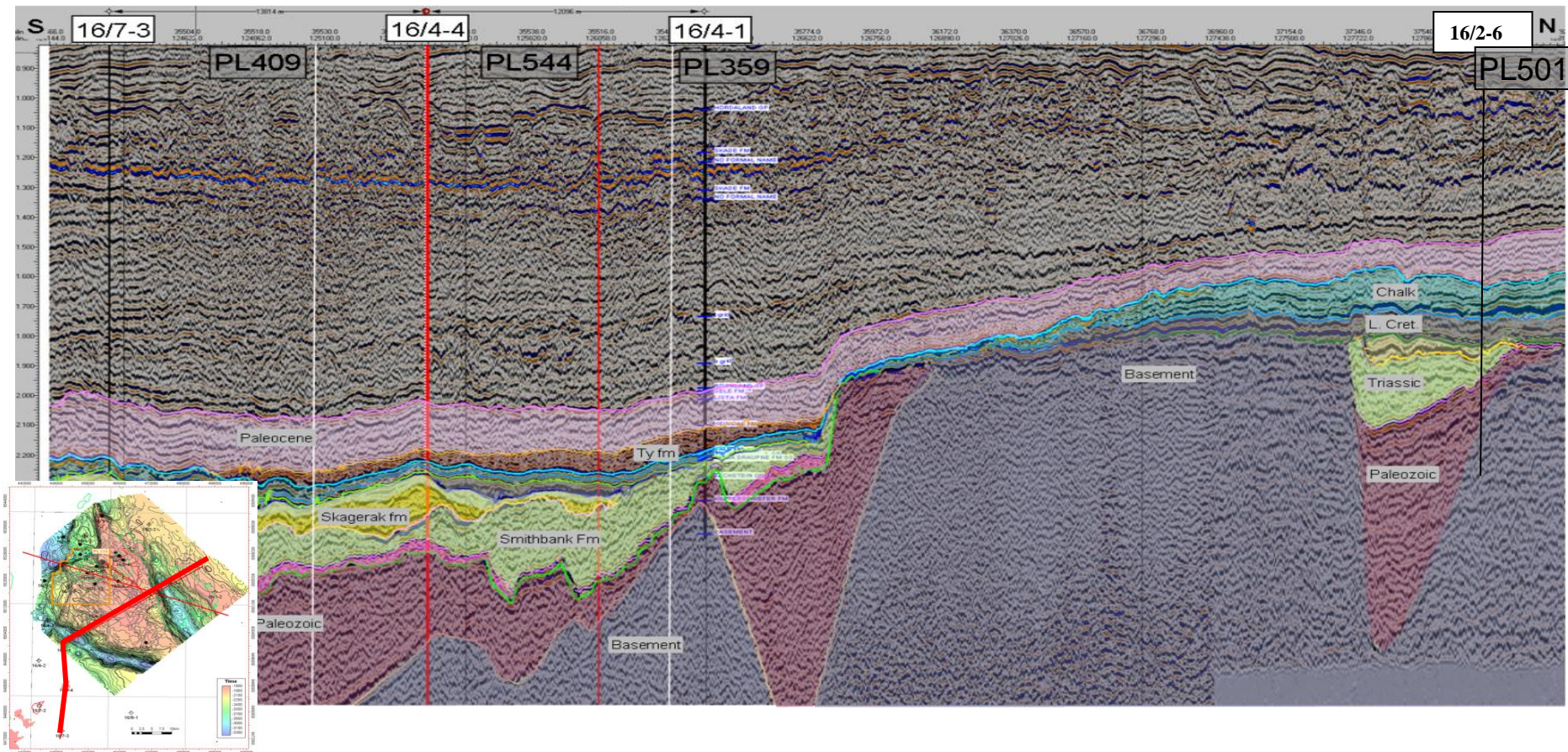


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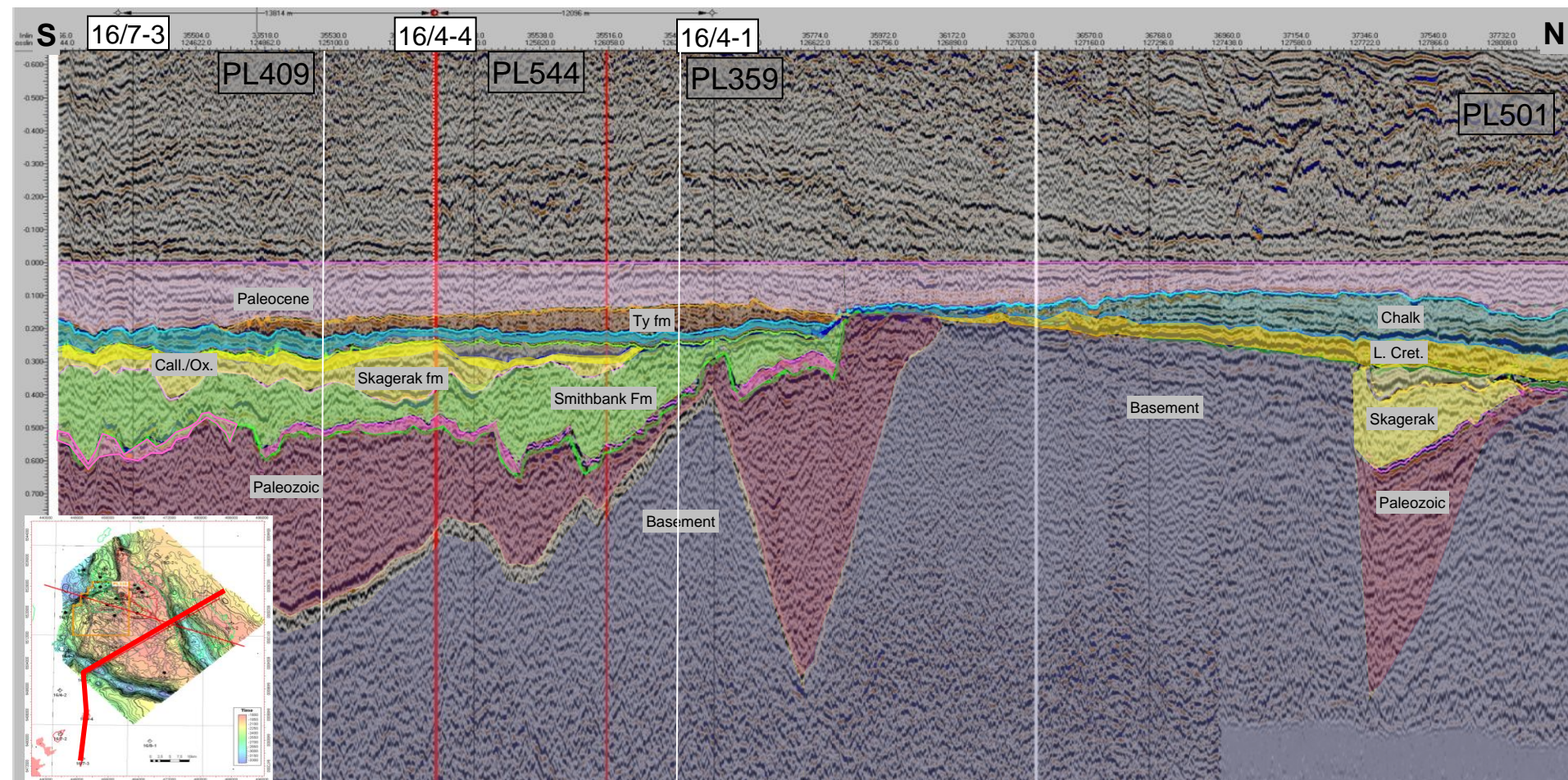


# N-S to SW-NE line from Ling Terrace to Haugaland High



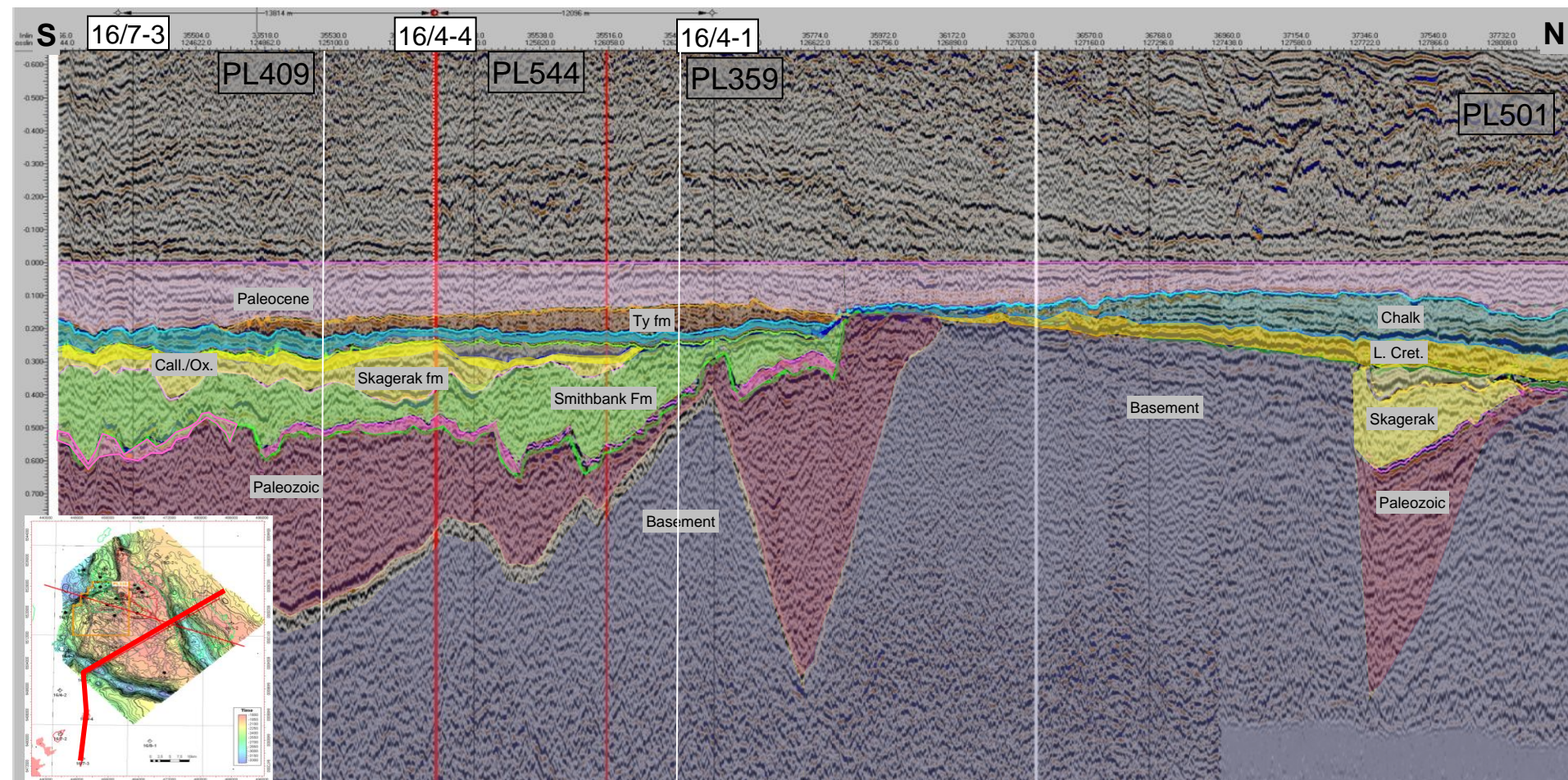


# N-S to SW-NE line from Ling Terrace to Haugaland High



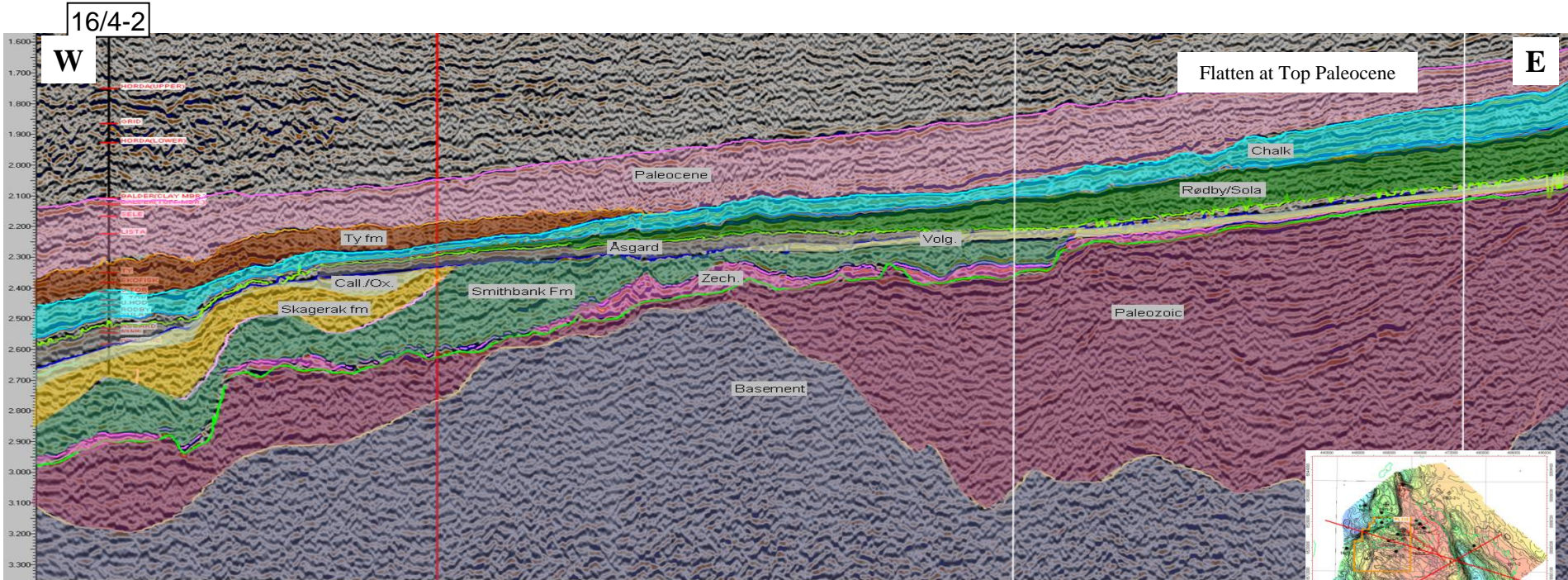


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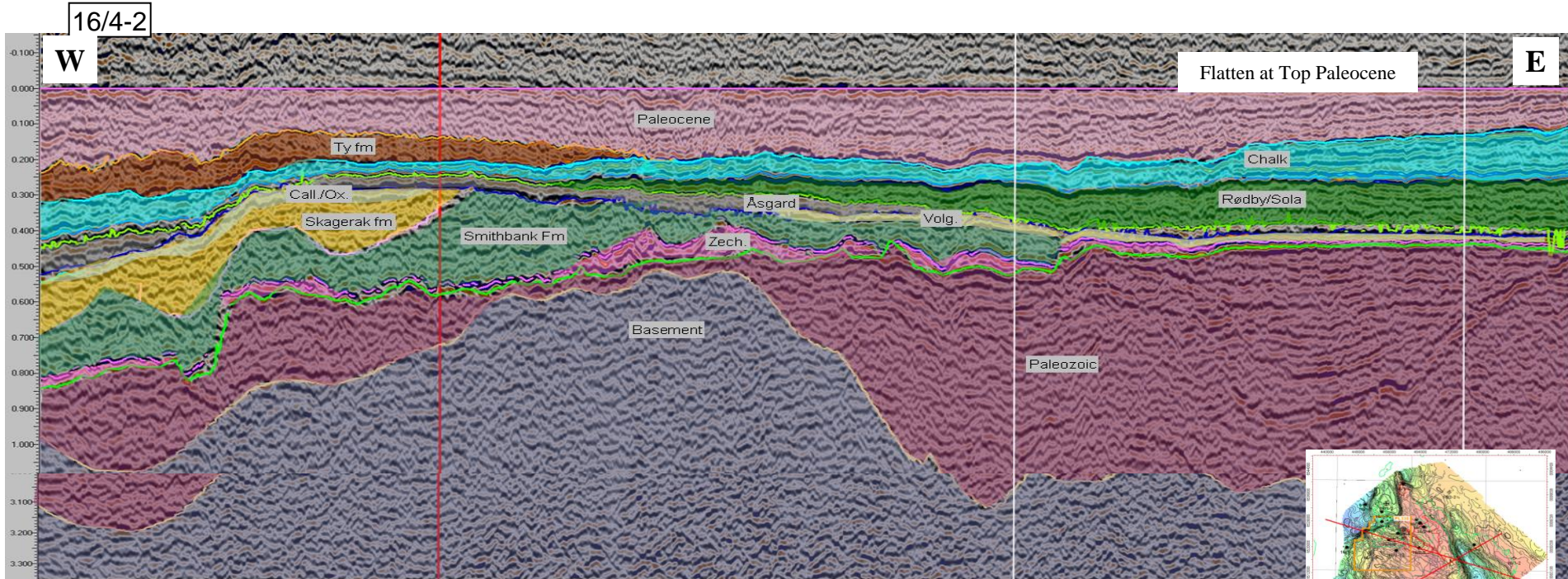


# East- west cross section due south of the Haugaland High





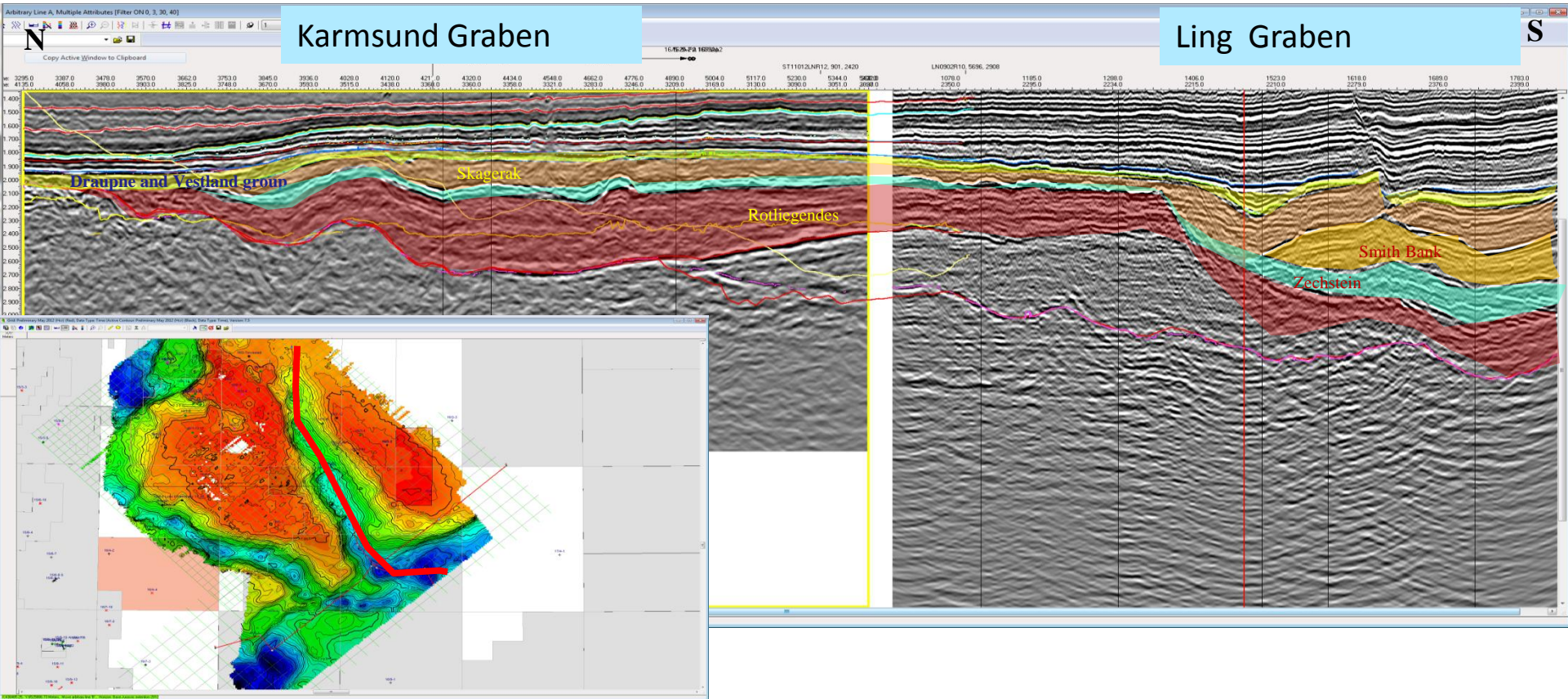
# East- west cross section due south of the Haugaland High



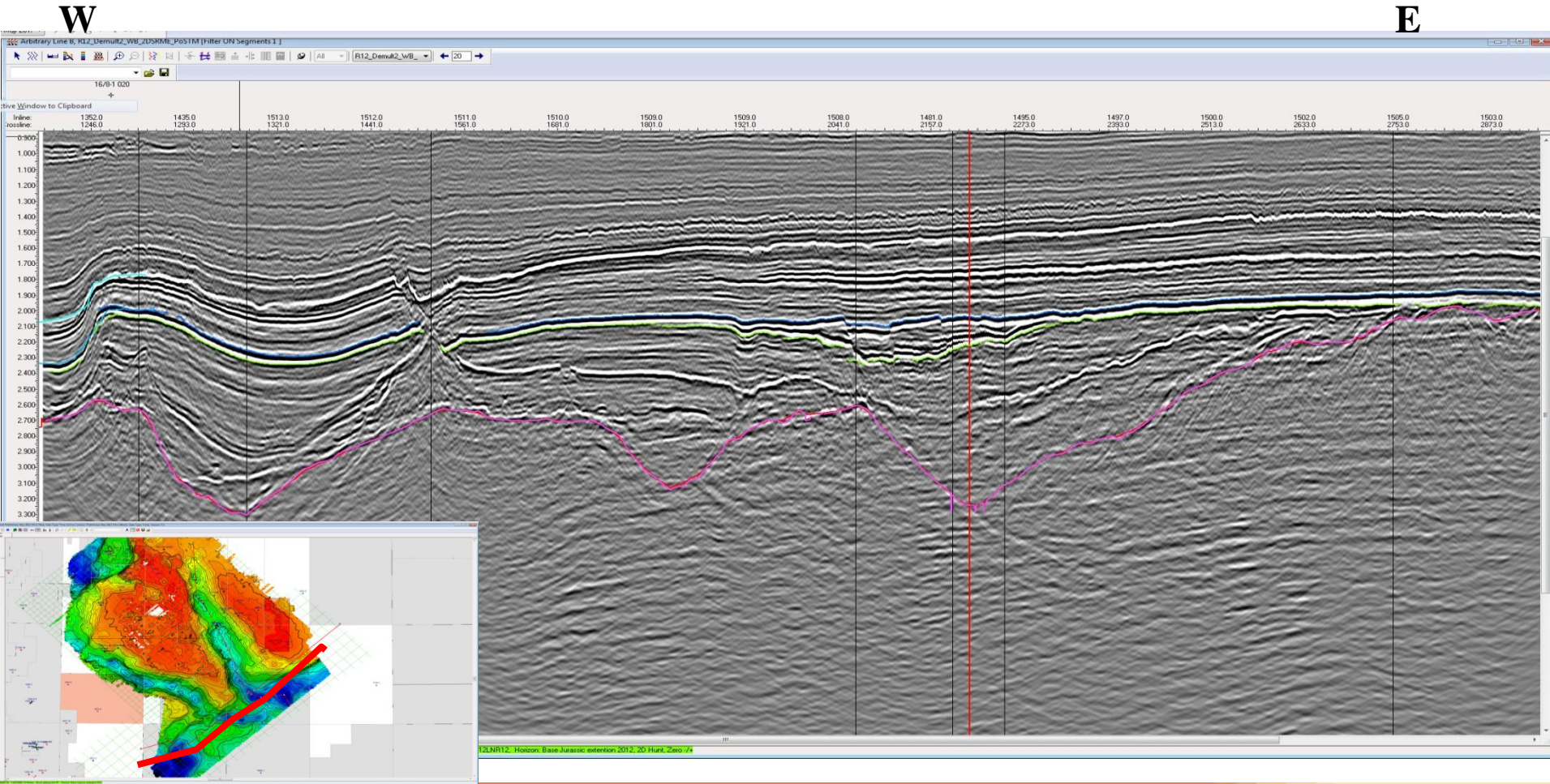


# The transition between Augvald and Ling Graben

16/2-8 16/2-11 16/5-2



# Mid-Jurassic erosion, subsidence and Volgian erosion



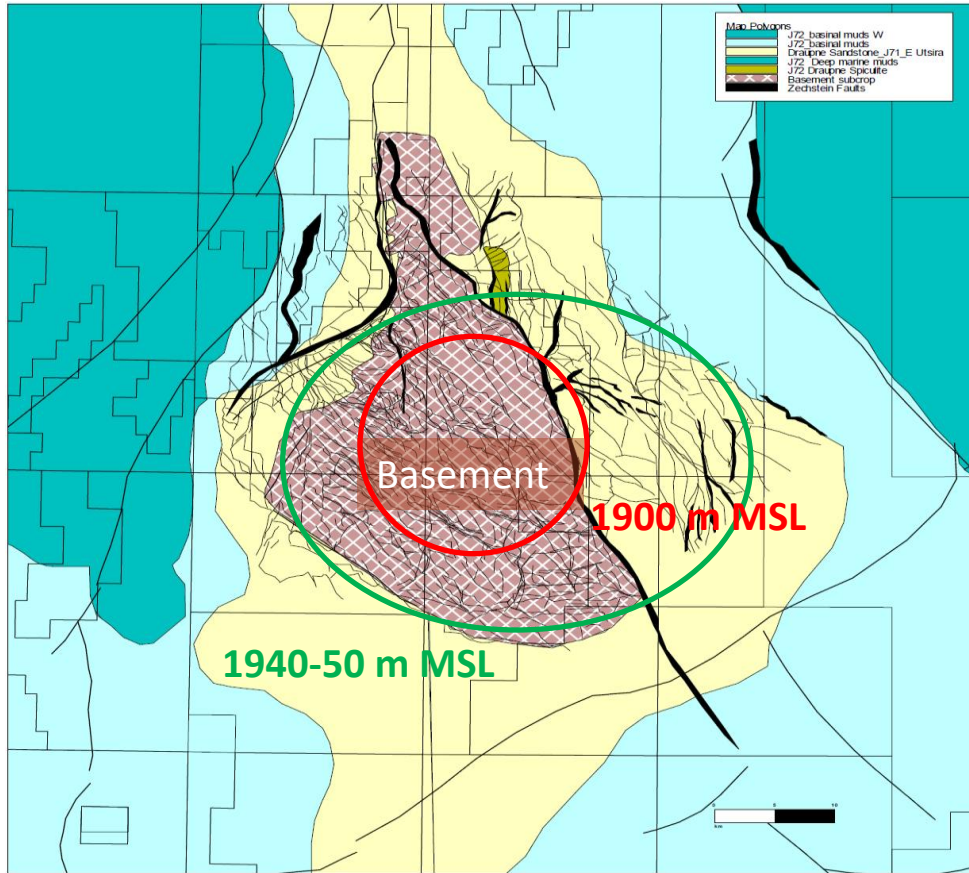


## W

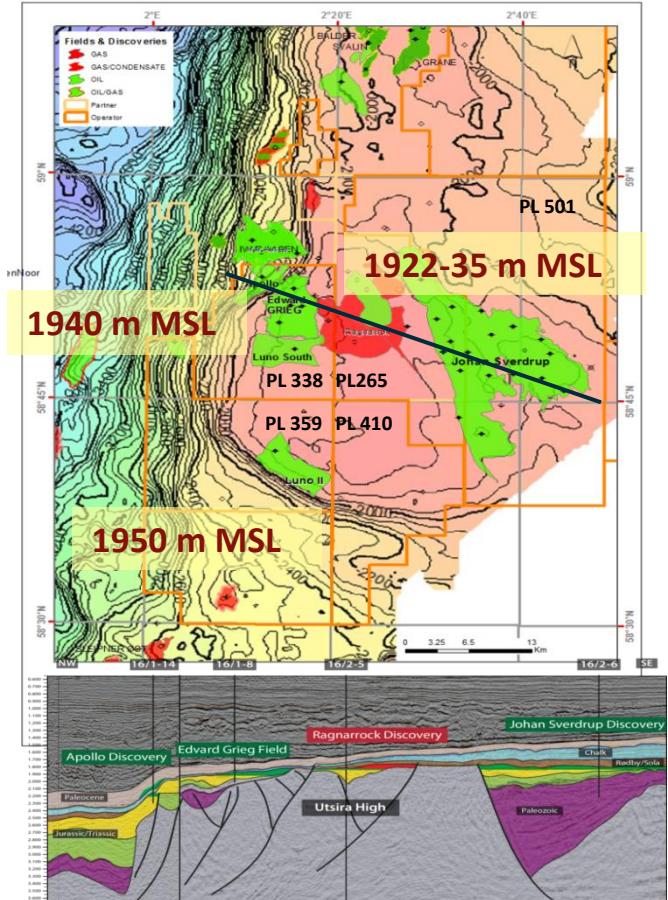




# Reality is more diverse than the models

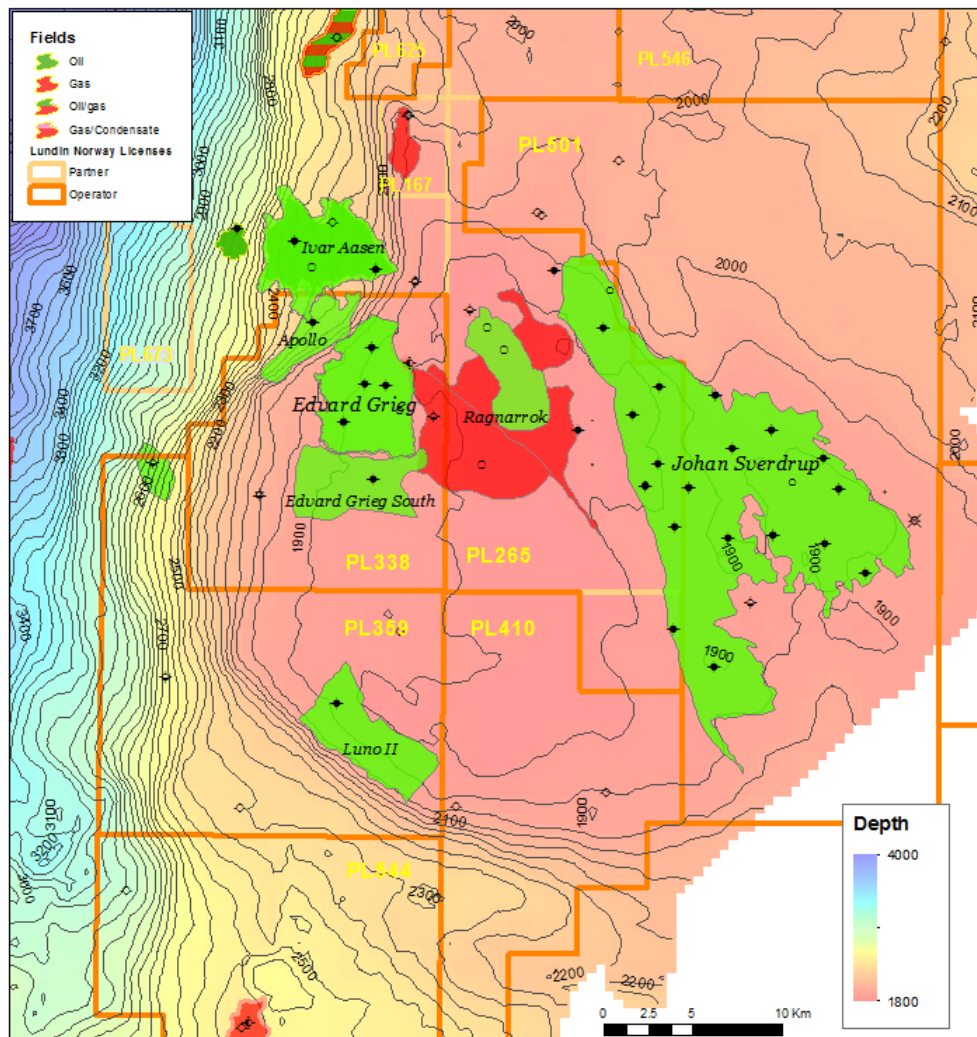


*Hypothesis: Saturated system with 40-50 m oil leg*



*Results: Undersaturated and saturated oil*

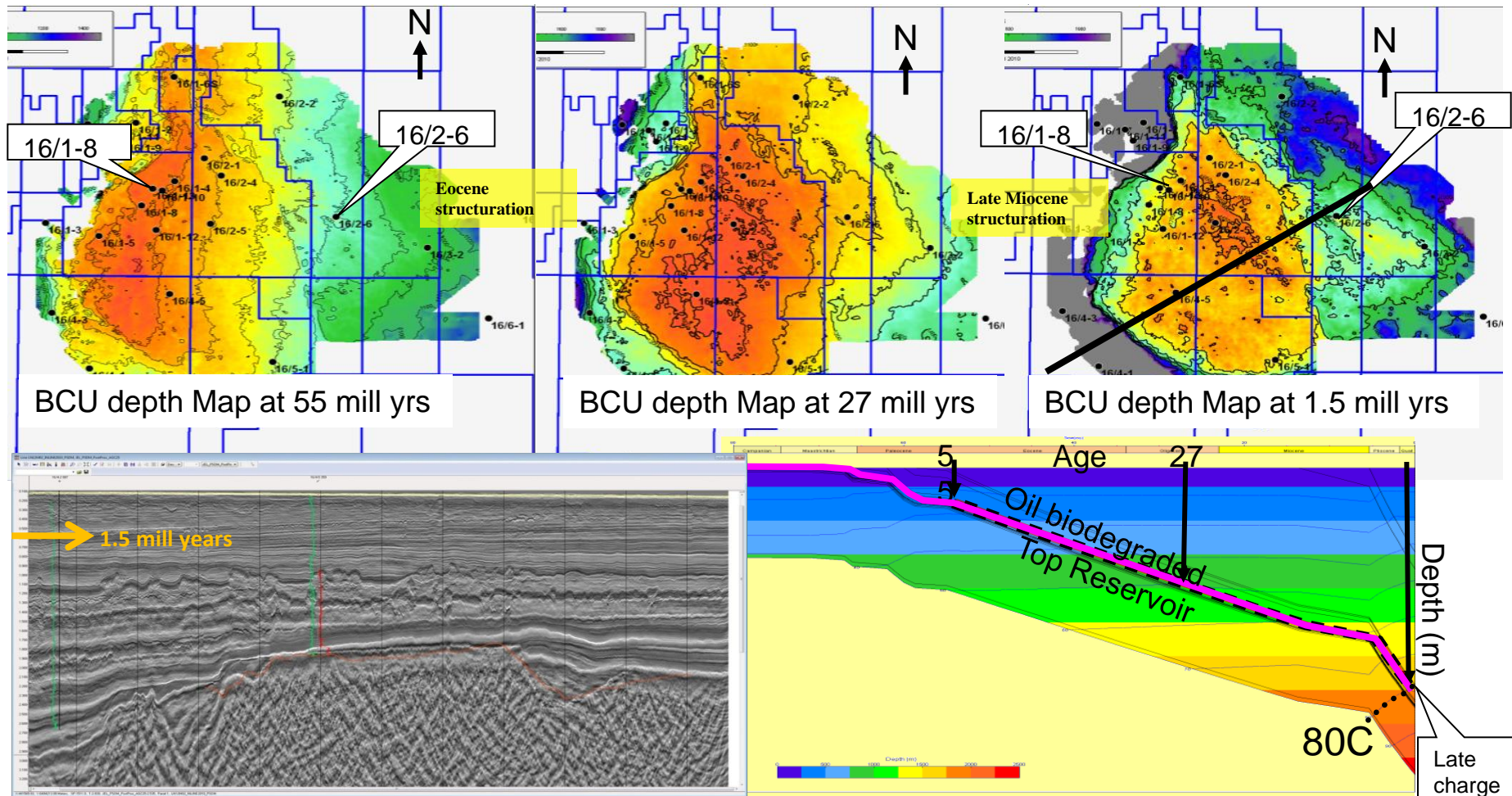
# The reservoirs in E. Grieg, J.Sverdrup and Luno II are new on NCS



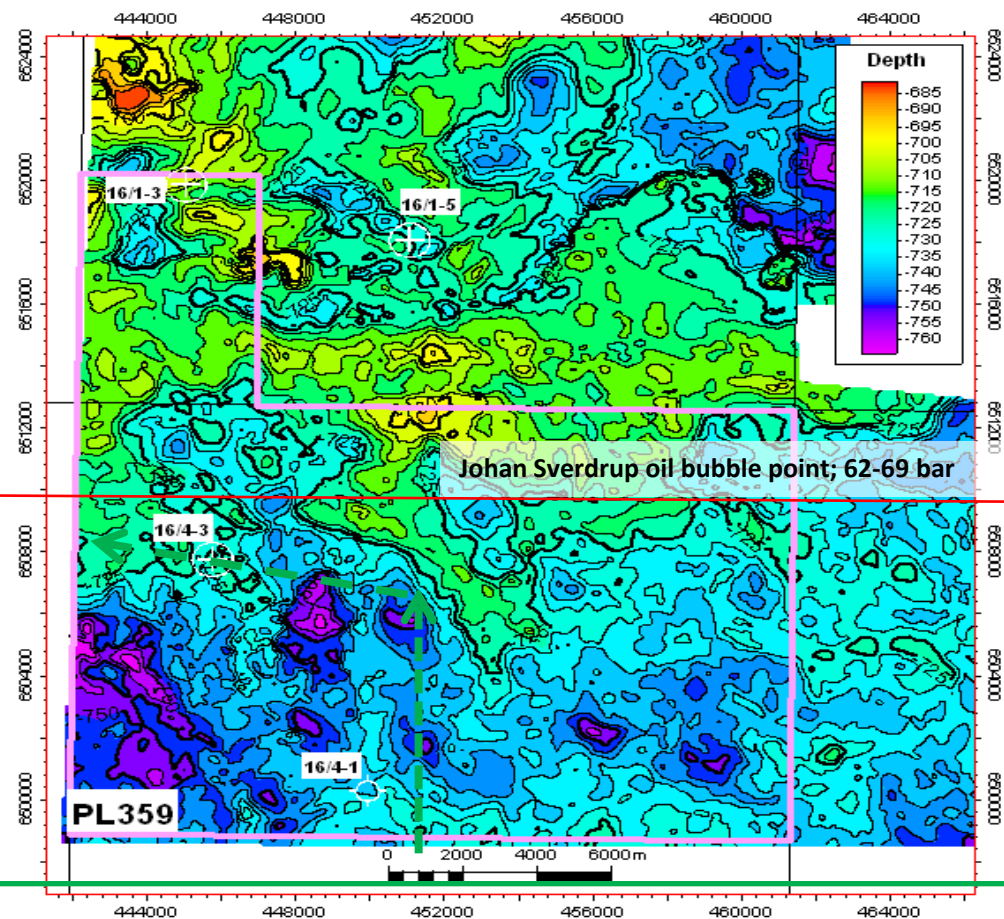
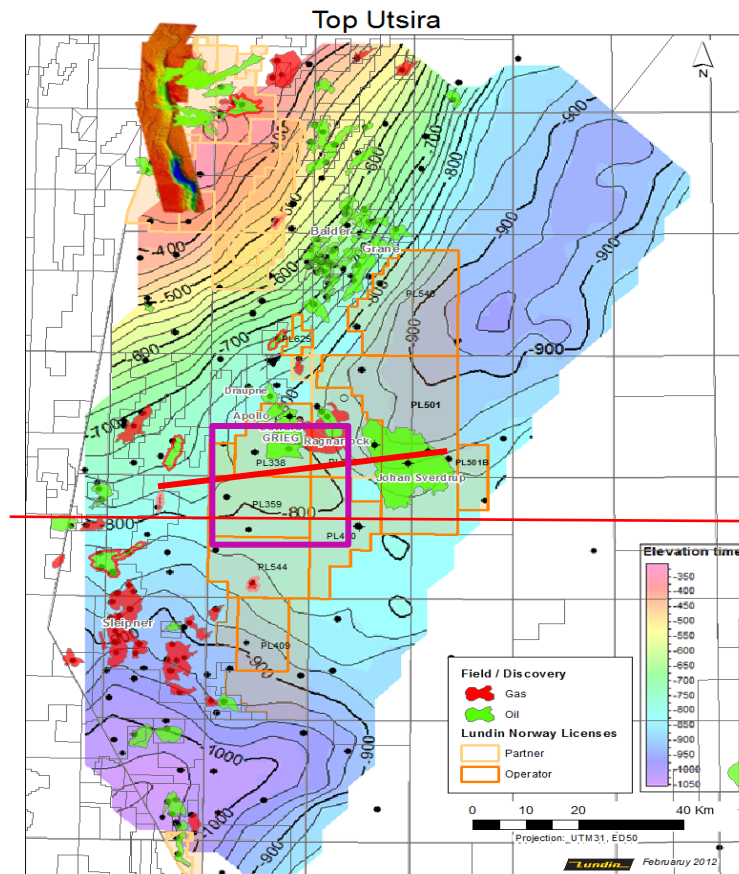
- New breakthroughs become rapidly obvious
- Acreage secured ahead of unfolding by the drill bit.
  - PL 338 in 2004
  - PL 359 in 2006
  - PL 410 in 2007
  - PL 265 and 501 in 2009
- Petroleum migration ongoing the last 1.5 mill yrs



# Final structuring and oil charging the last 1.5 mill years

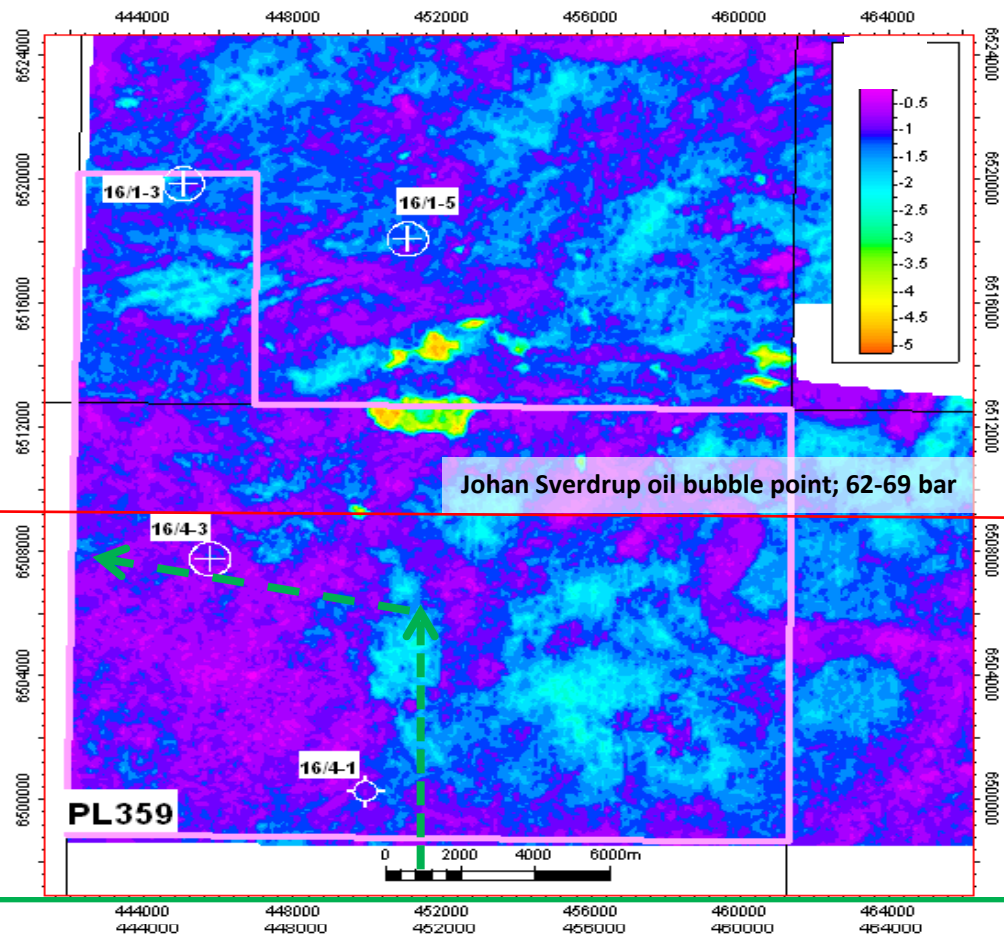
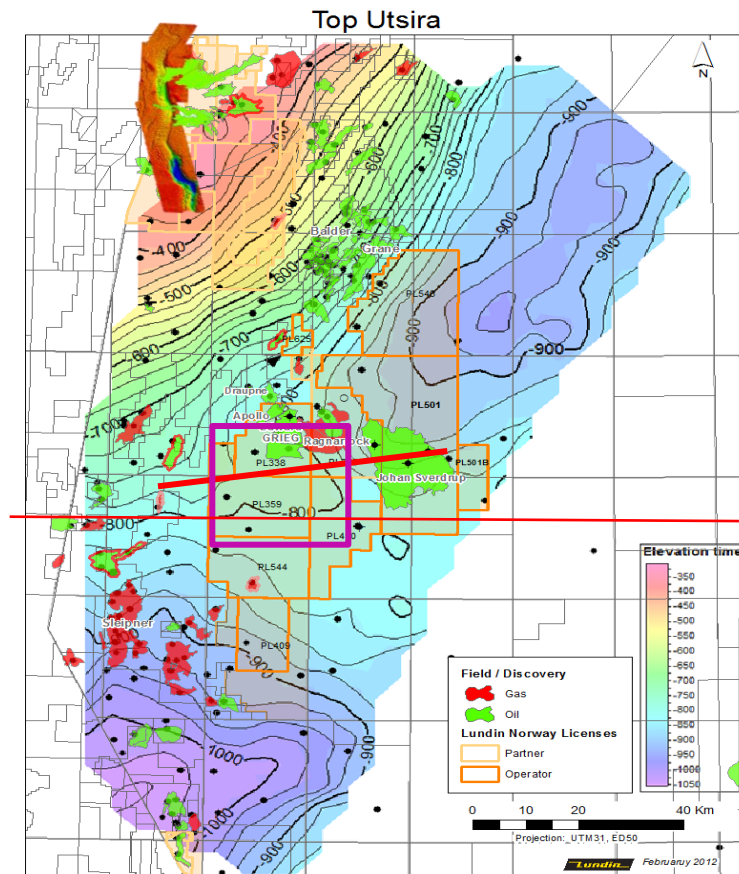


# Recent and ongoing oil migration (2006)

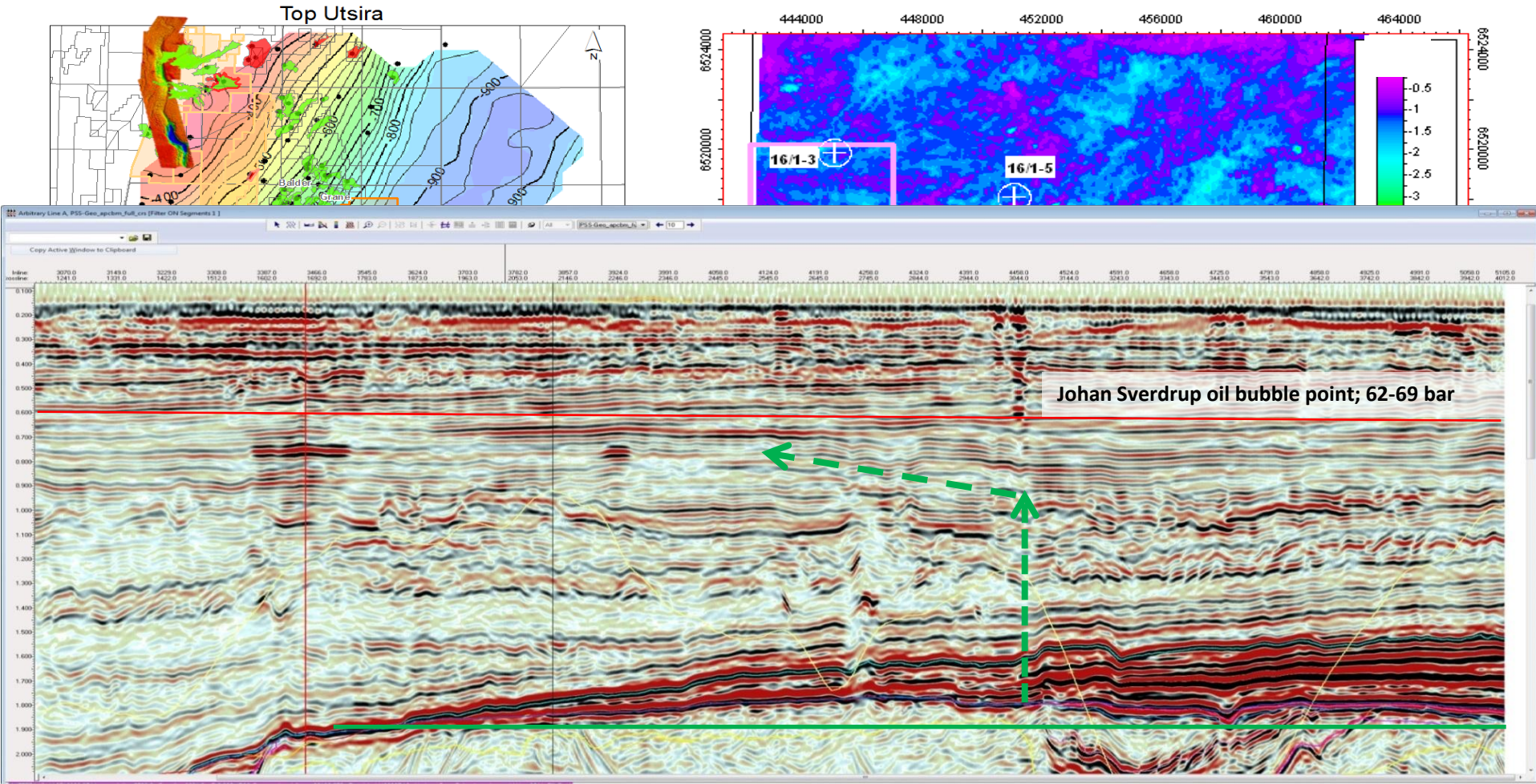




# Recent and ongoing oil migration (2006)

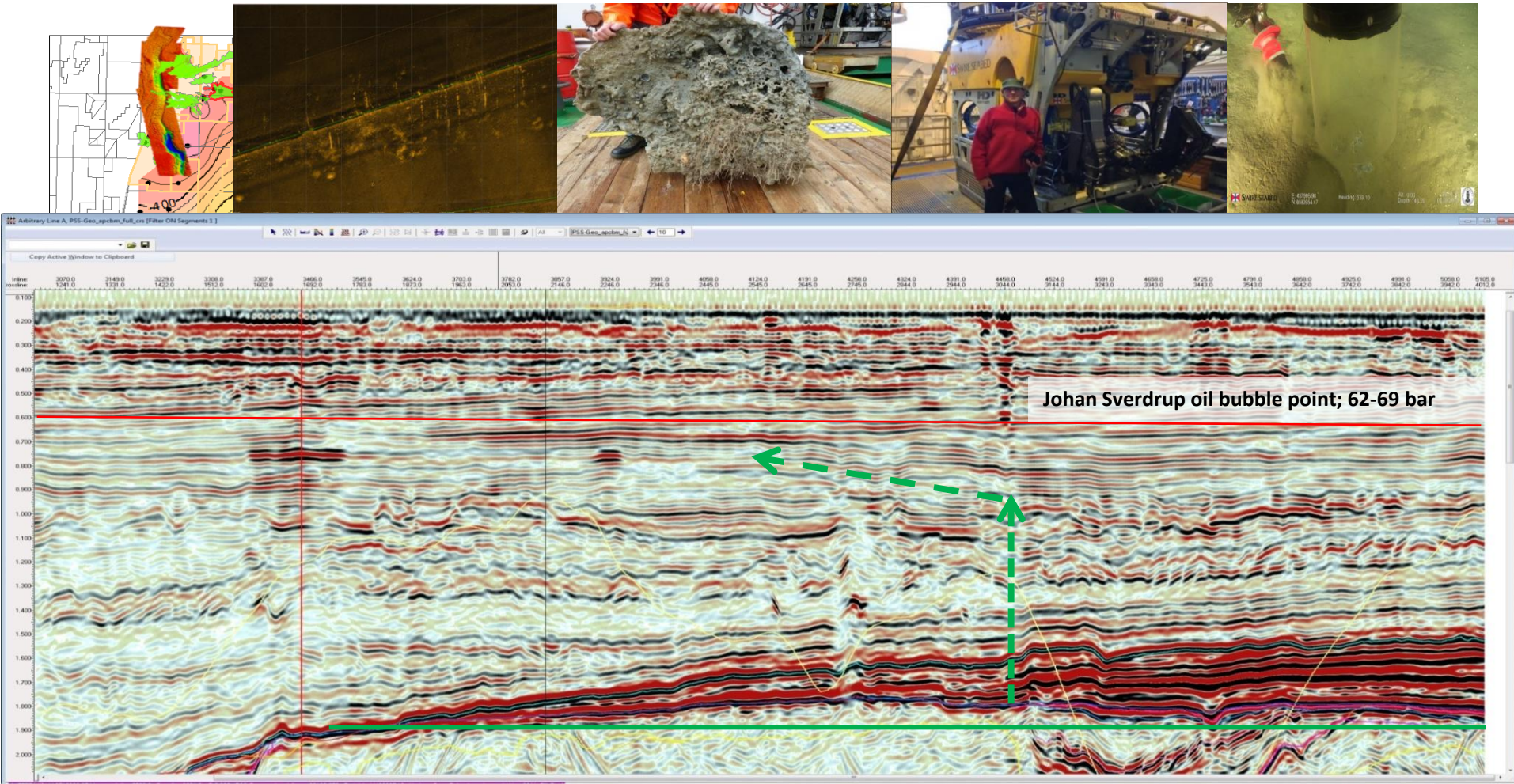


# Recent and ongoing oil migration (2006)





# Recent and ongoing oil migration (2006)



# Diversity in oil populations open for new possibilities

## Upper Jurassic-sourced oil

types

A -	Draupne Fm
B -	Draupne Fm
B/C1 -	Draupne Fm
B/C2 -	Draupne Fm
C -	Draupne Fm
D -	Dr/Hea/MJur
E -	Heather Fm

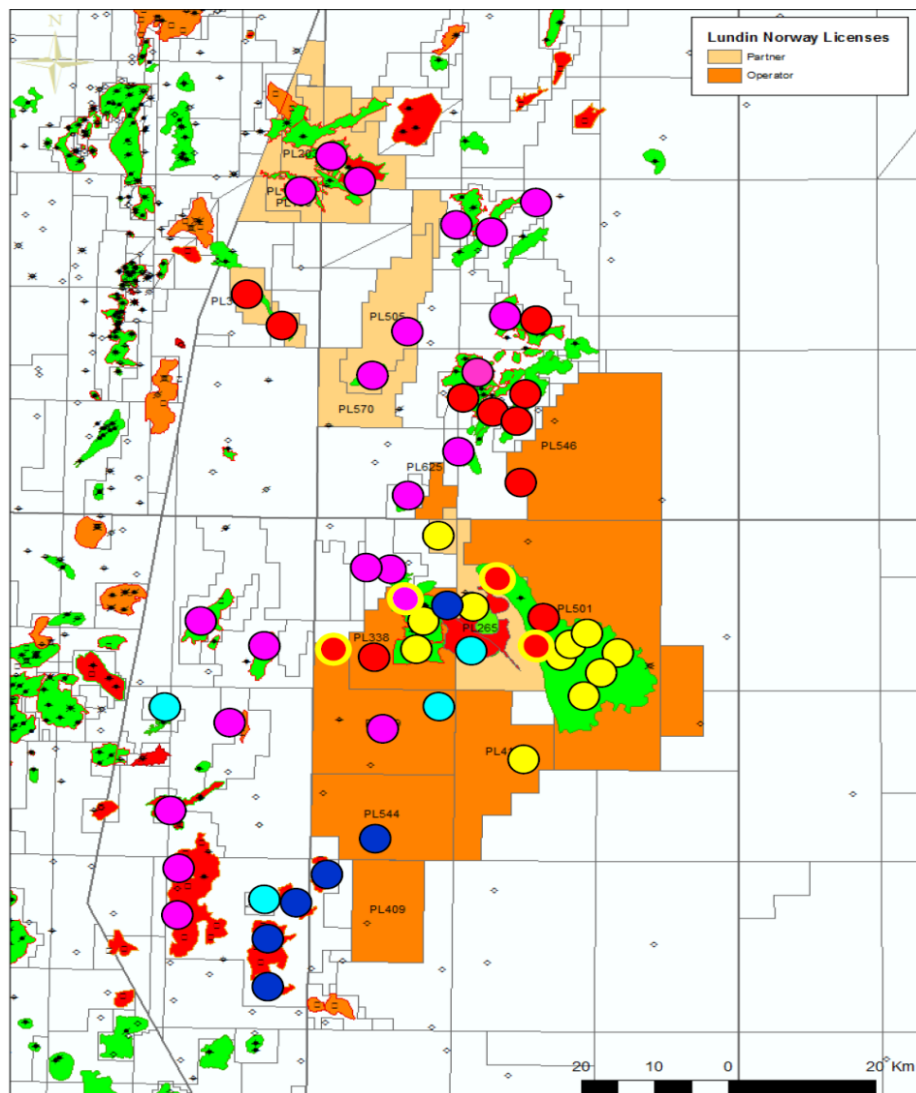
Dysoxic

## Oil systems:

The oils in Edvard Grieg and Johan Sverdrup fields are related to migration from Draupne source the last 1.5 mill years

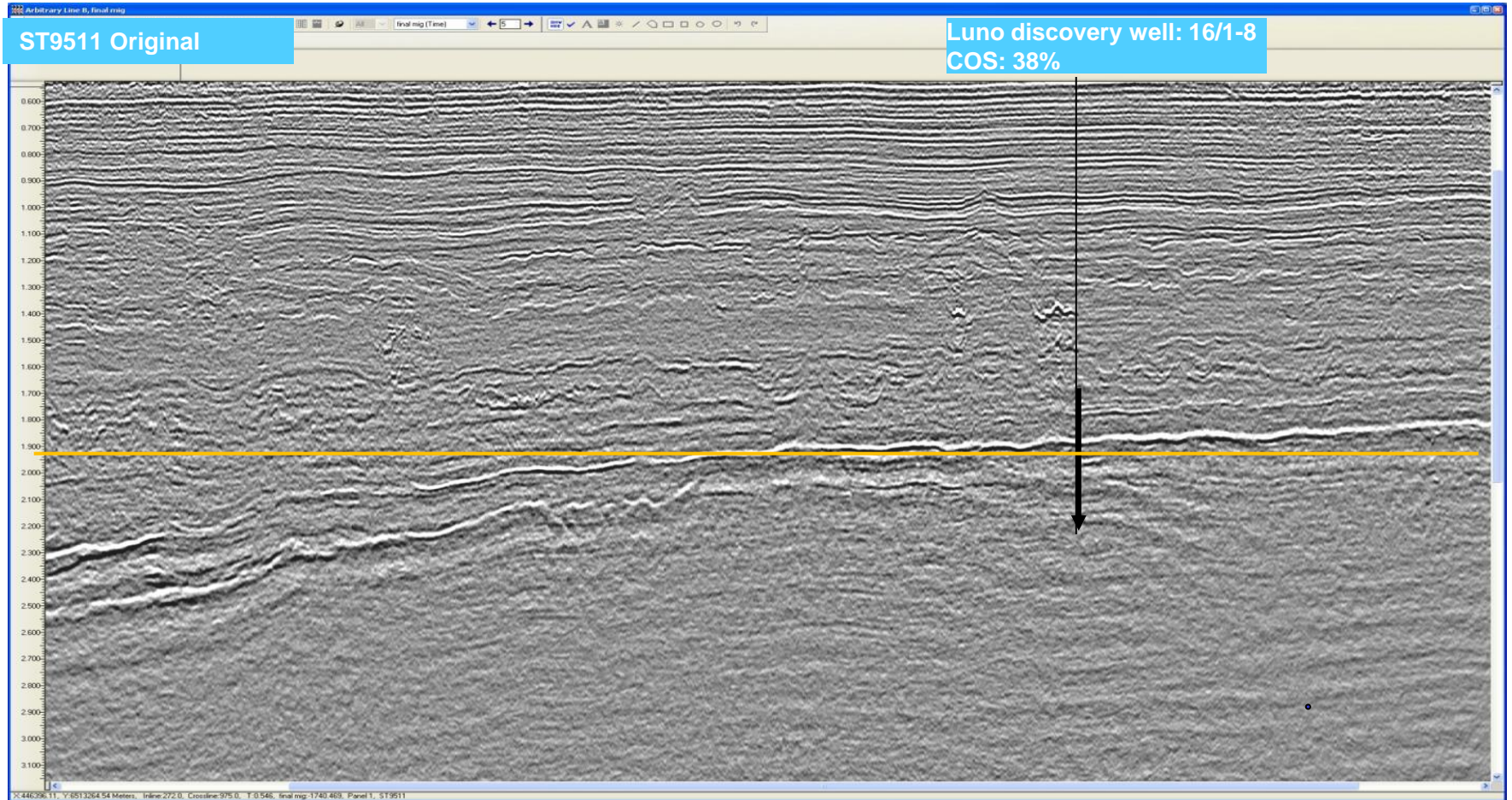
- Undersaturated oils: EG; with 130 and JS; 25-40 Sm<sup>3</sup>/Sm<sup>3</sup> GOR
- “Residual “ fresh oil down to 1960 m related to glacial rebound

The Luno II oil is saturated, derived from Heather Fm



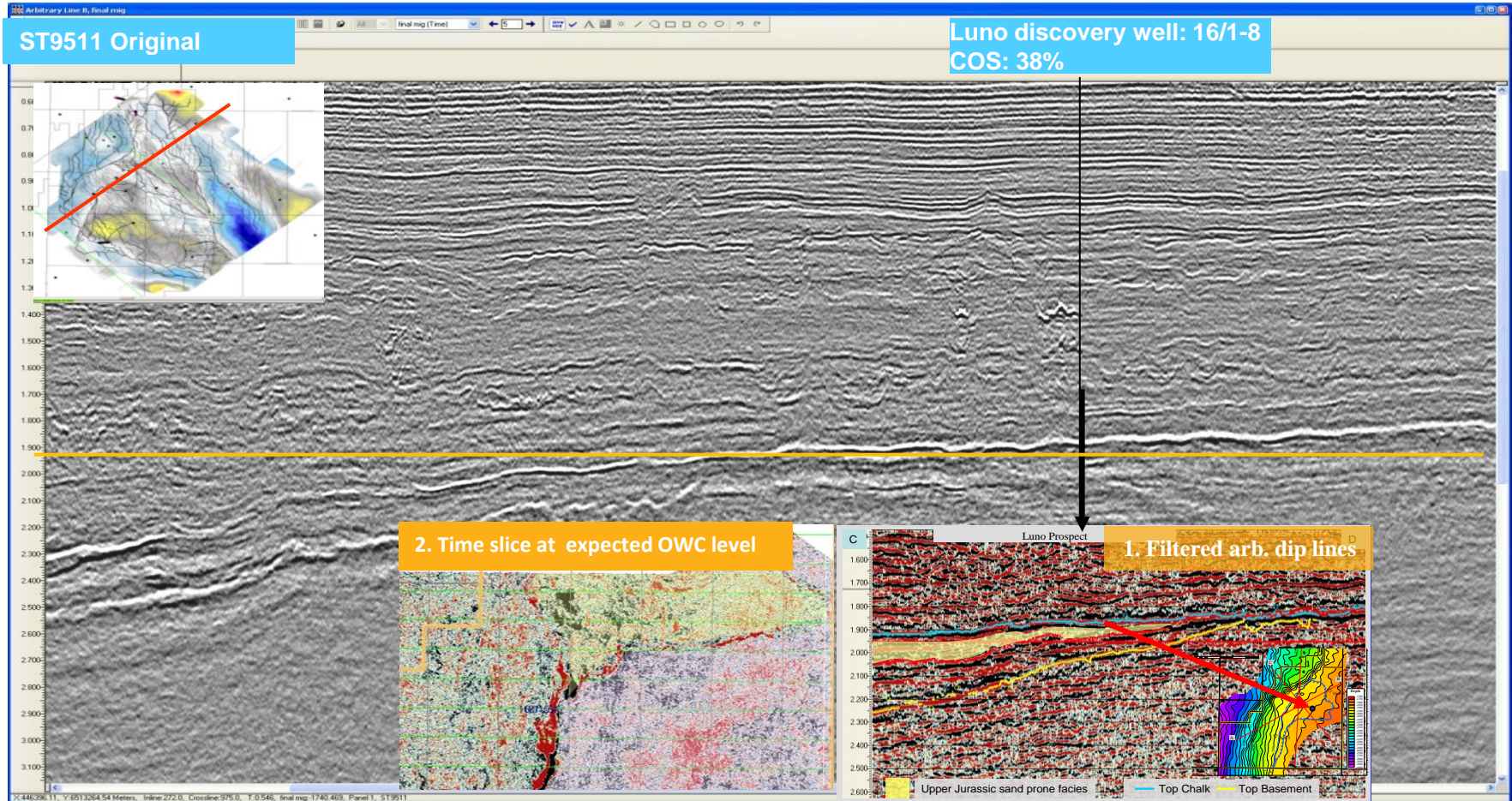


# 3D seismic quality in 2004 was not good, but sufficient



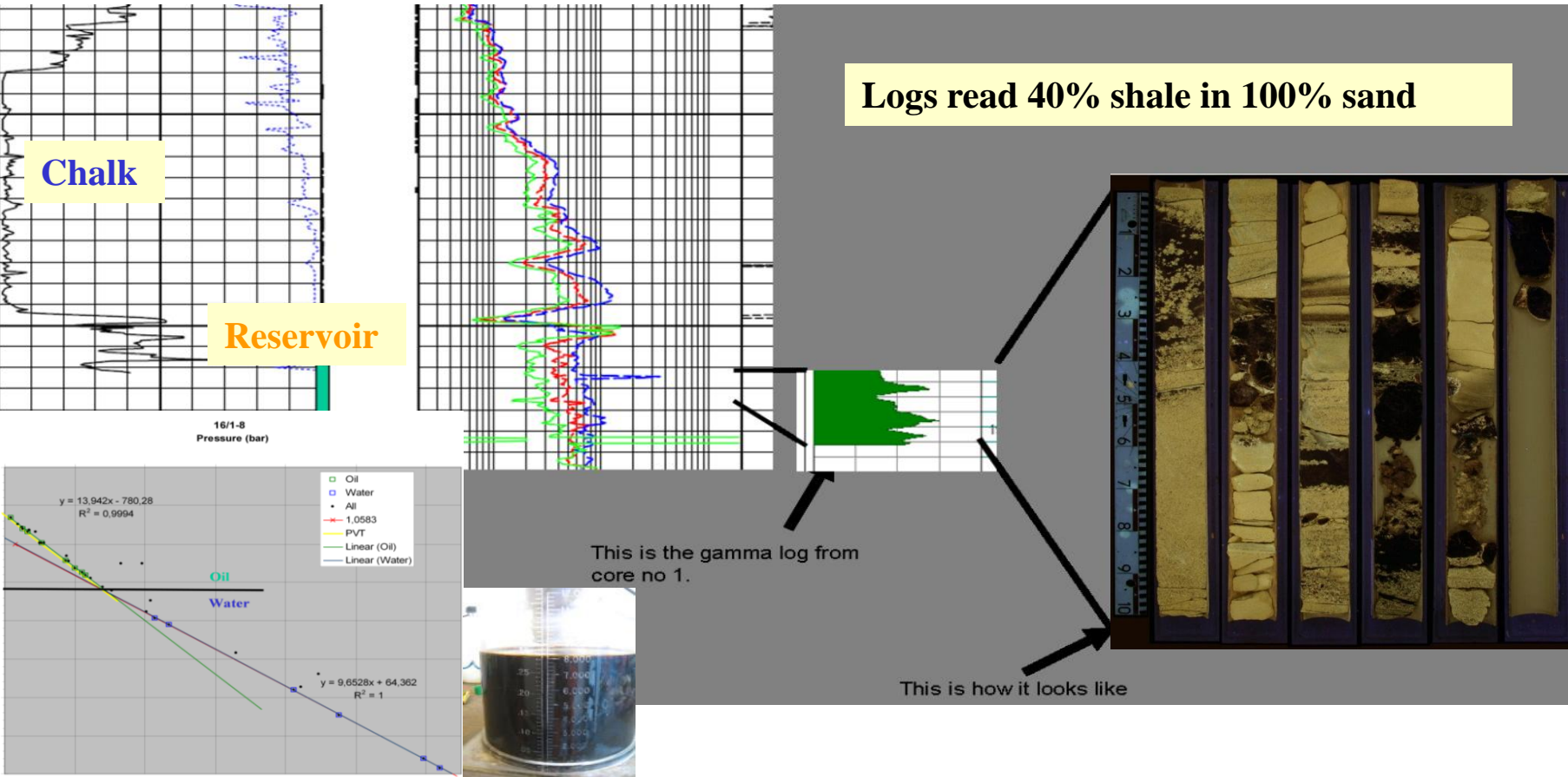


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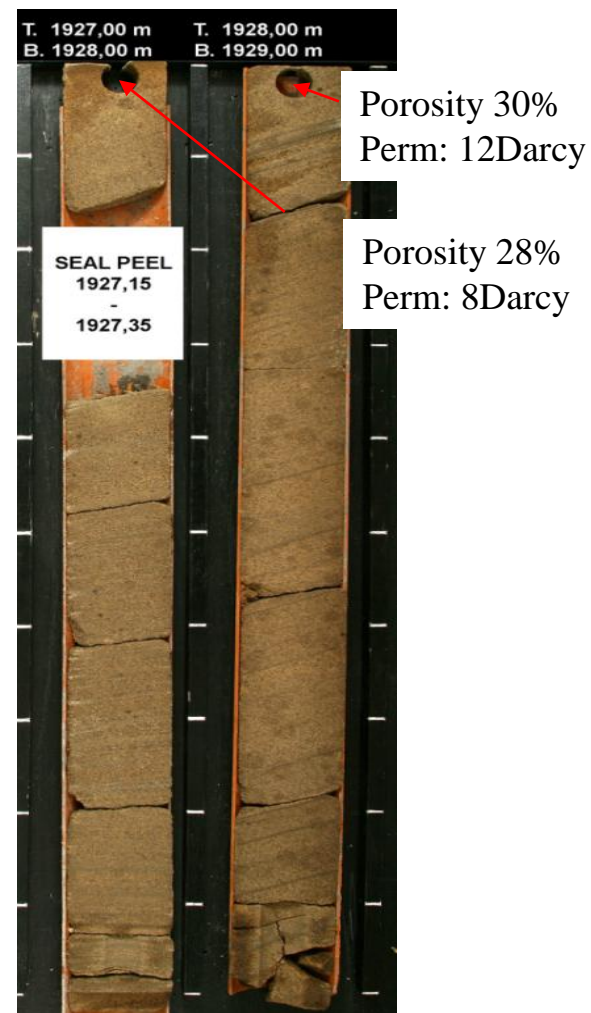
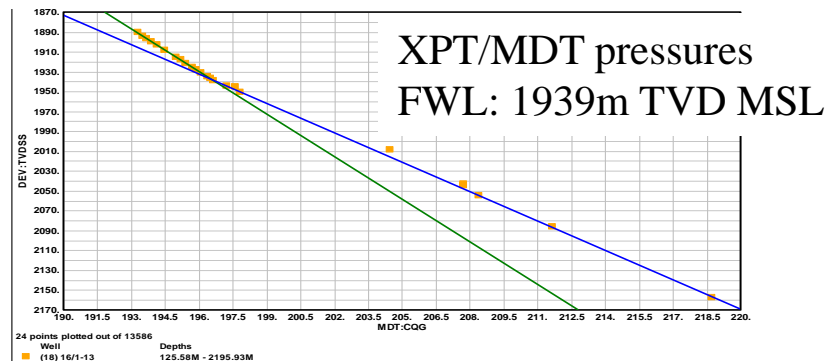
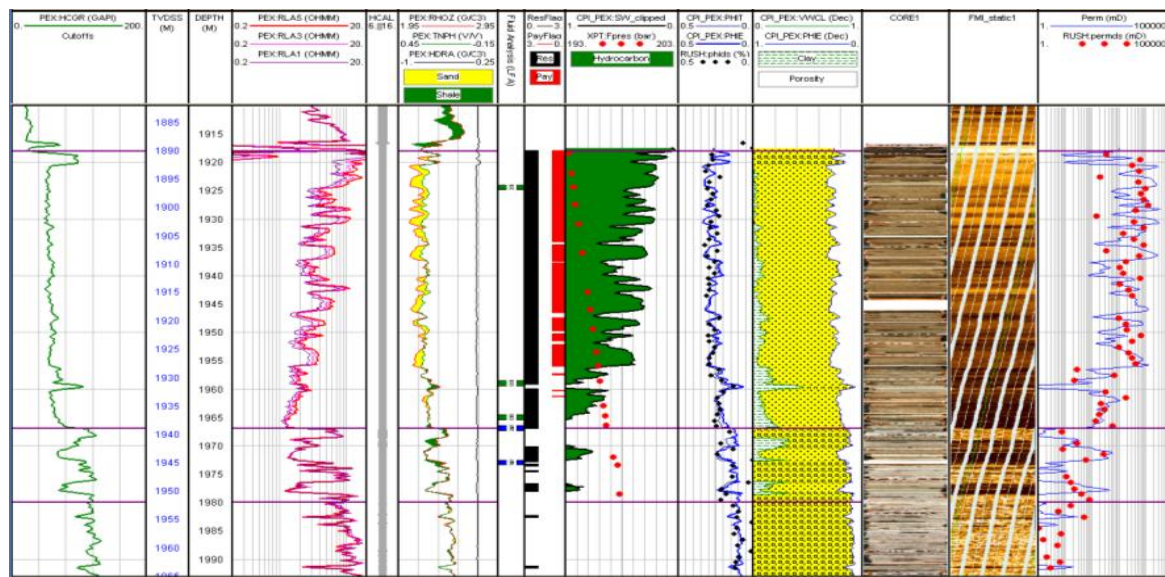




# Without core no discovery of the Edvard Grieg Field

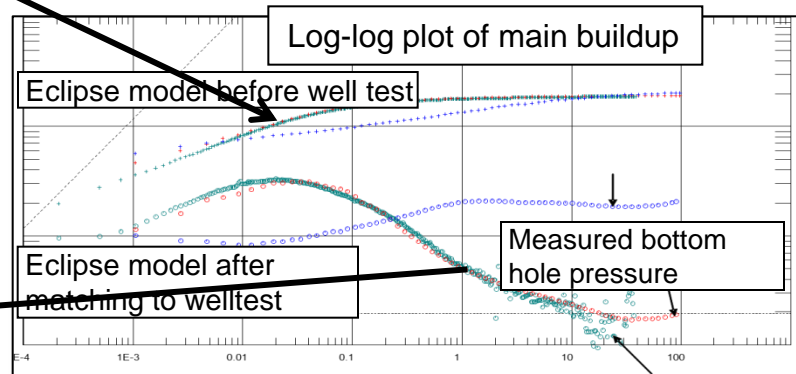
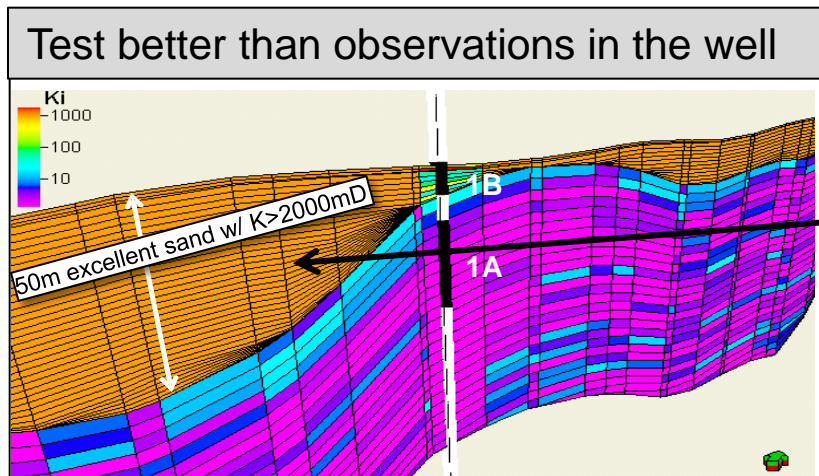
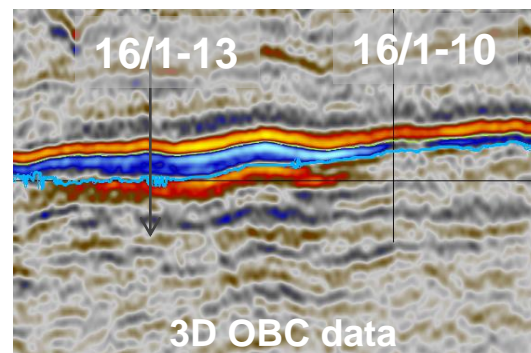
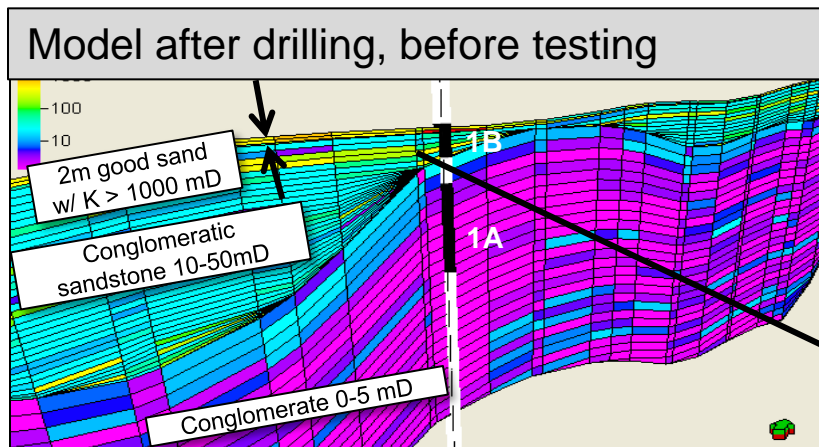


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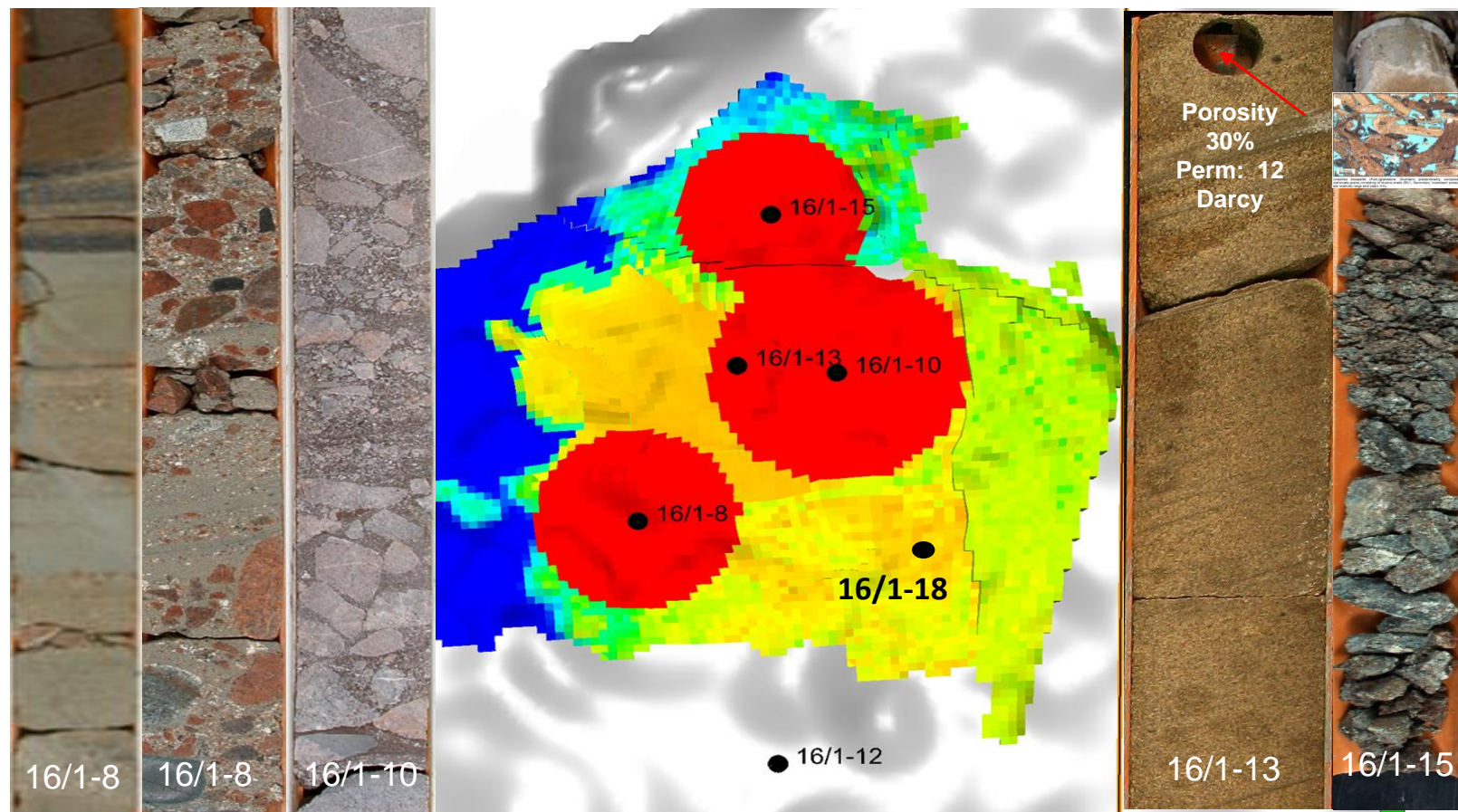


# DST's in exploration as a predictive tool: 16/1-10



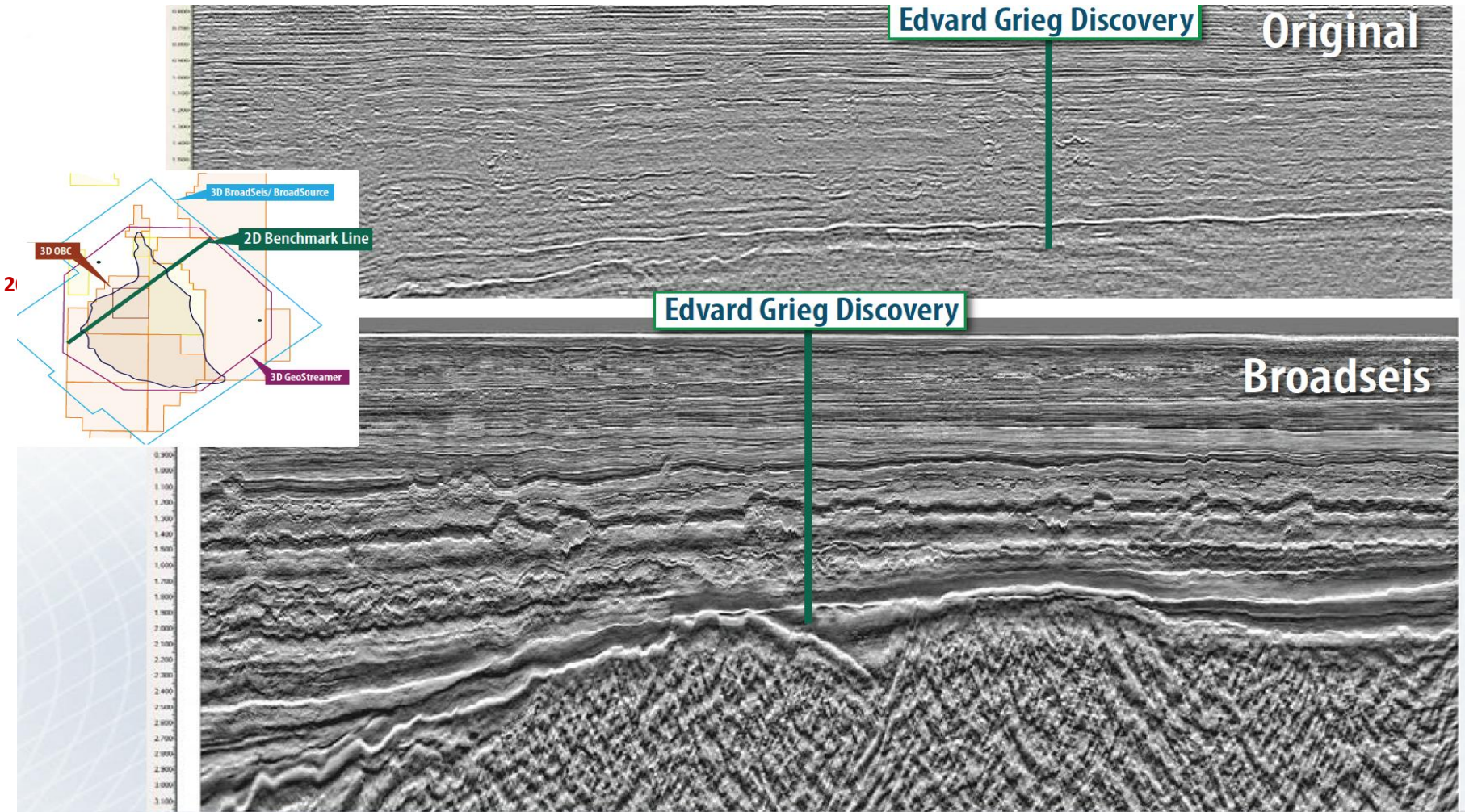
- Test results: Improved  $k \cdot h$  away from well
- OBC seismic in line with predicted in the test
- 50 m 10D reservoir proved by well 16/1-13

# Edvard Grieg reservoir; 6 facies new to NCS



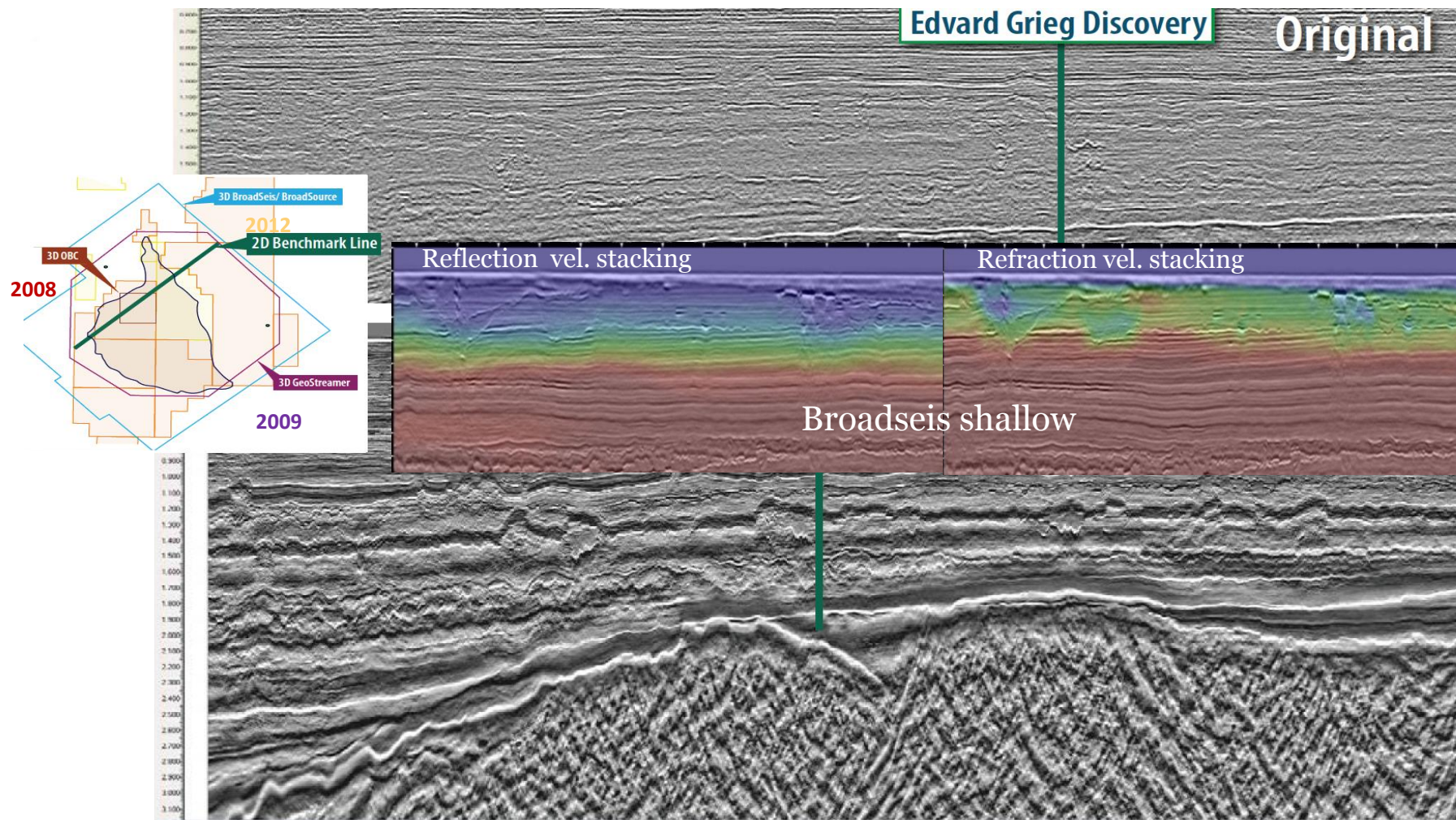


# Broadband gives character from shallow to deep



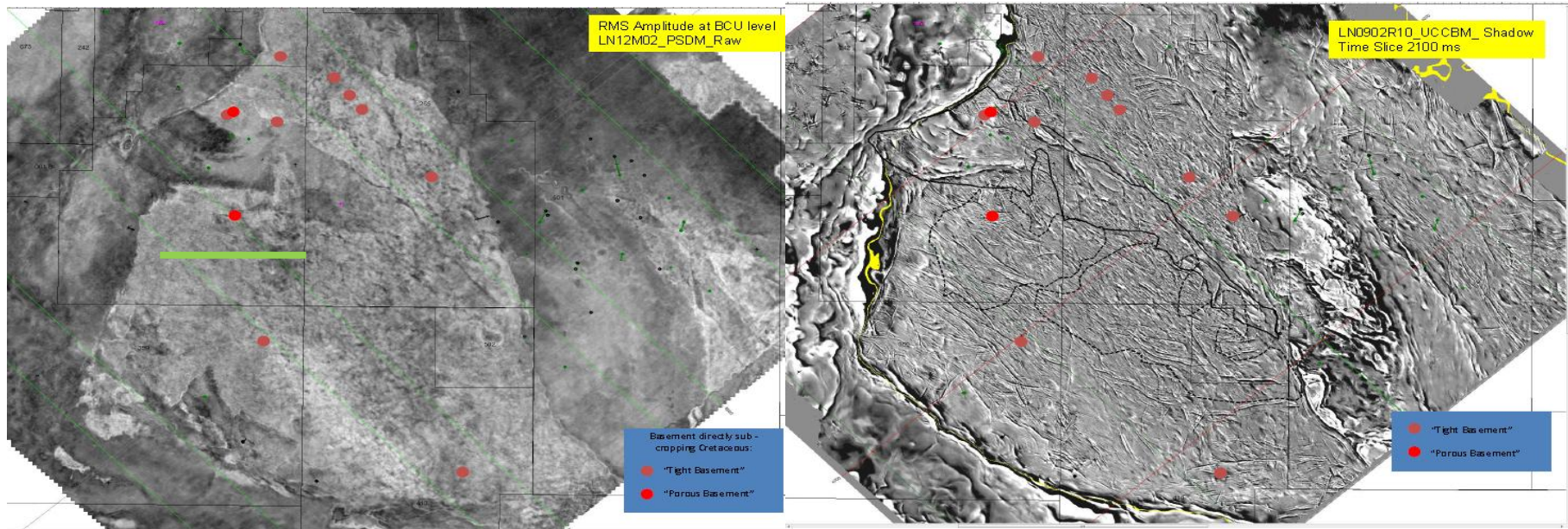


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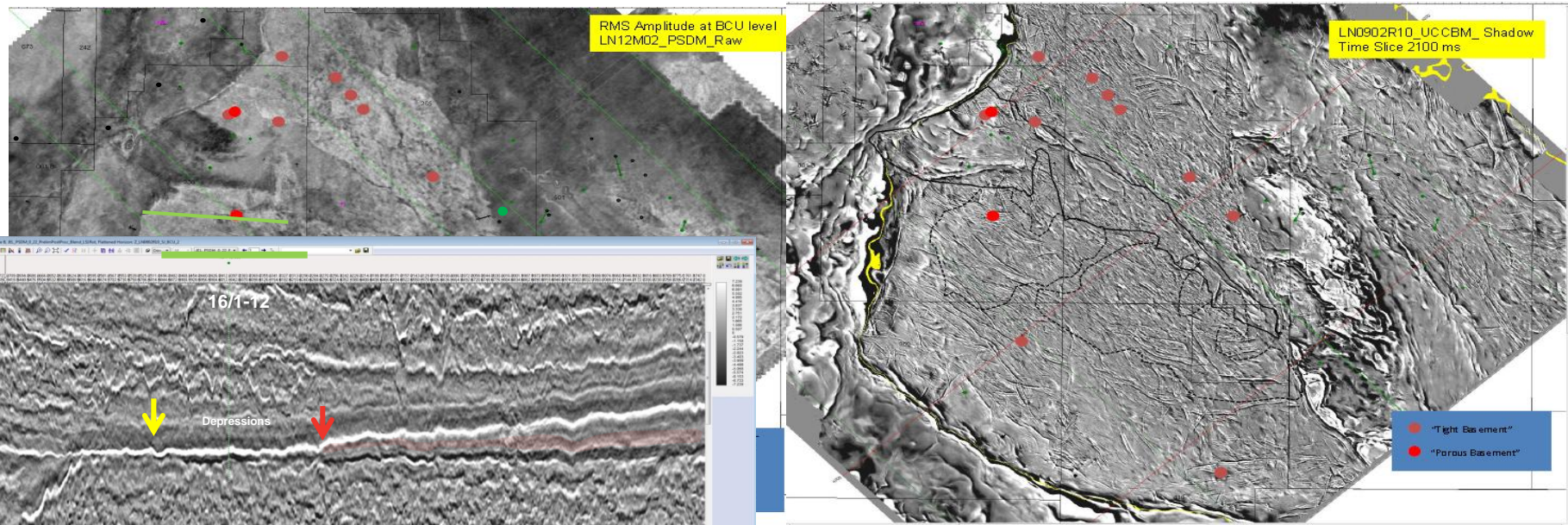


# Evaluations based on maximum 4D entropy (XYZT)



*Information is chaos minus exformation*  
*Knowledge is related to understanding the simplifications*

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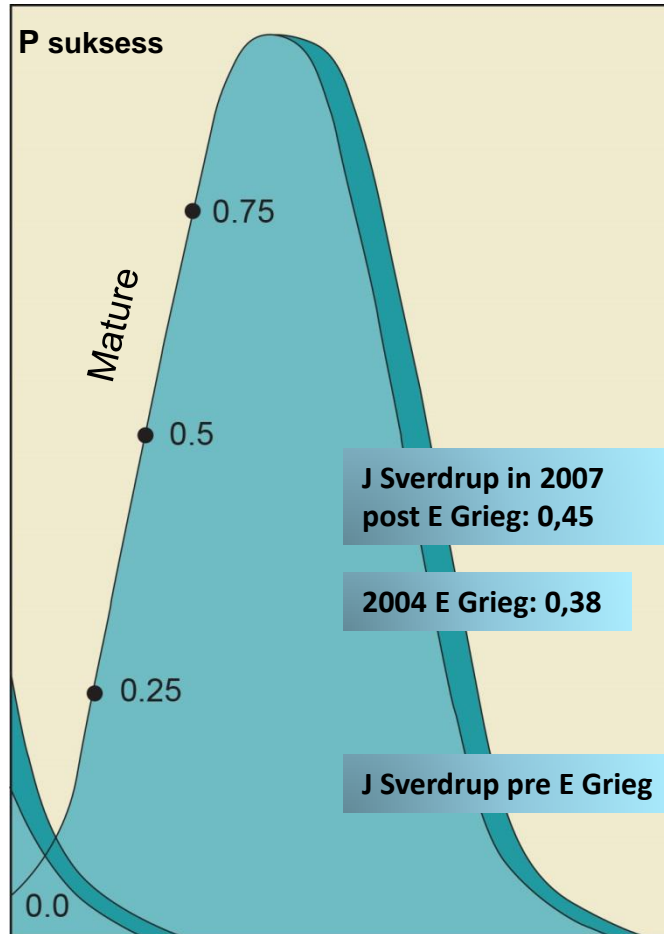


*Information is chaos minus exformation*  
*Knowledgeing is related to understanding the simplifications*



# Probability analyses are generative learning

- always
- usually
- general
- by and large
- more than not
- half the time
- often
- sometimes
- occasionally
- has happened
- never
- impossible

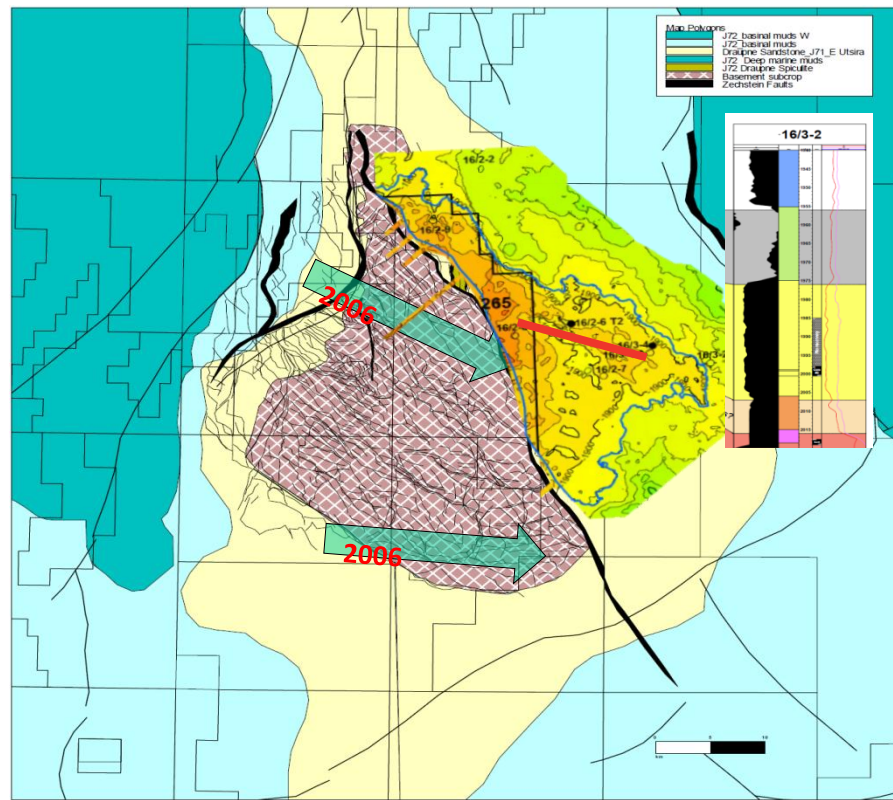
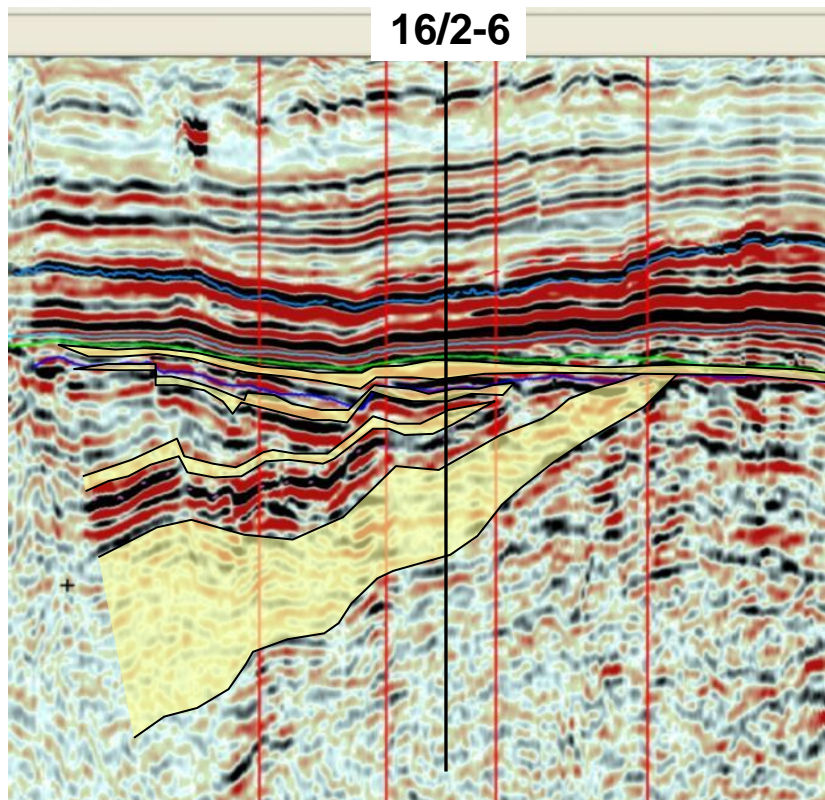


## Probability assessments:

*The simultaneous presence of reservoir, generation, migration and trapping of petroleum*

- The same facts can support alternate possible models or scenarios
- Stochastic modeling based on independent parameters is no substitute for thinking
- Decisions reflect the input that is always insufficient in relation to the truth
- Probability analyses are time contextual

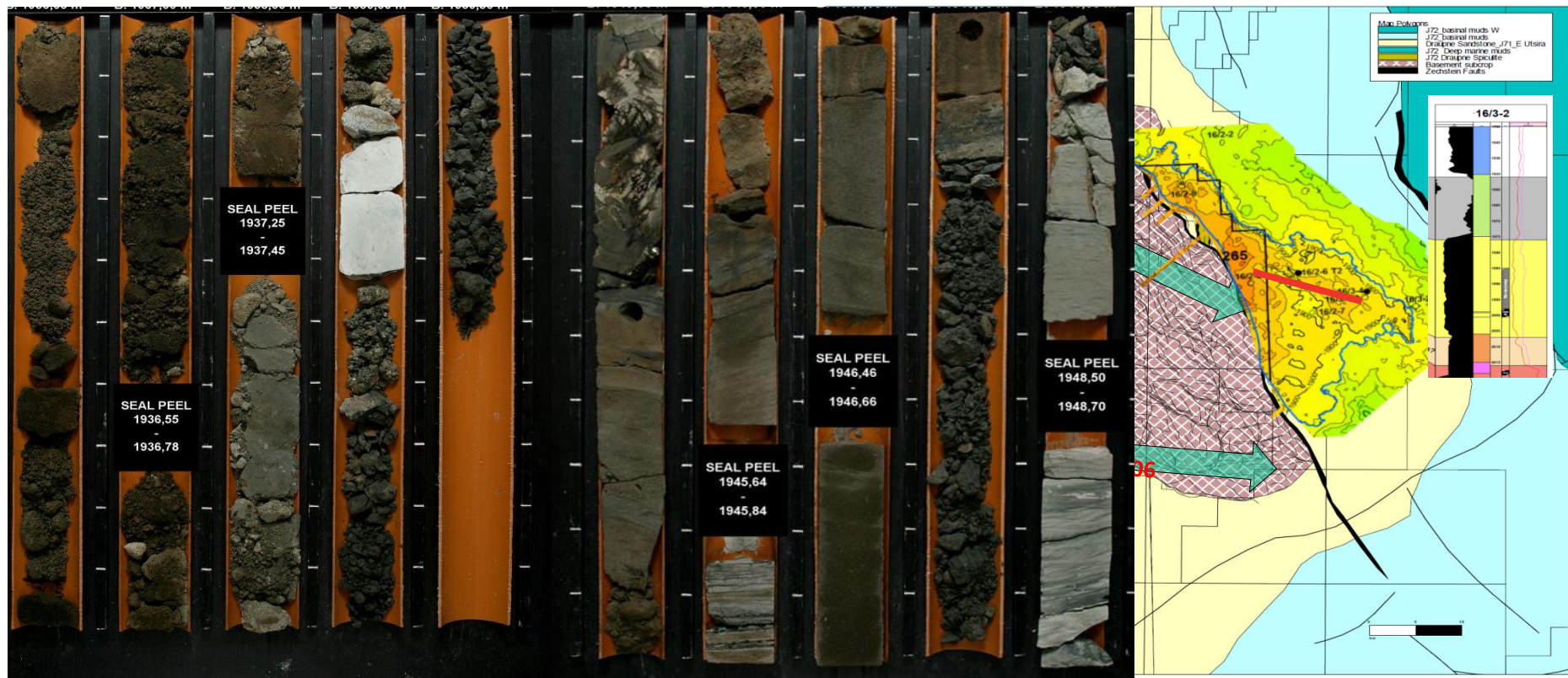
## J. Sverdrup well 16/2-6 in 2010 was located to learn fast



*The first reservoir core defined the uncertainties that have been unfolded by 19 +6 delineation wells in 2011- 14*

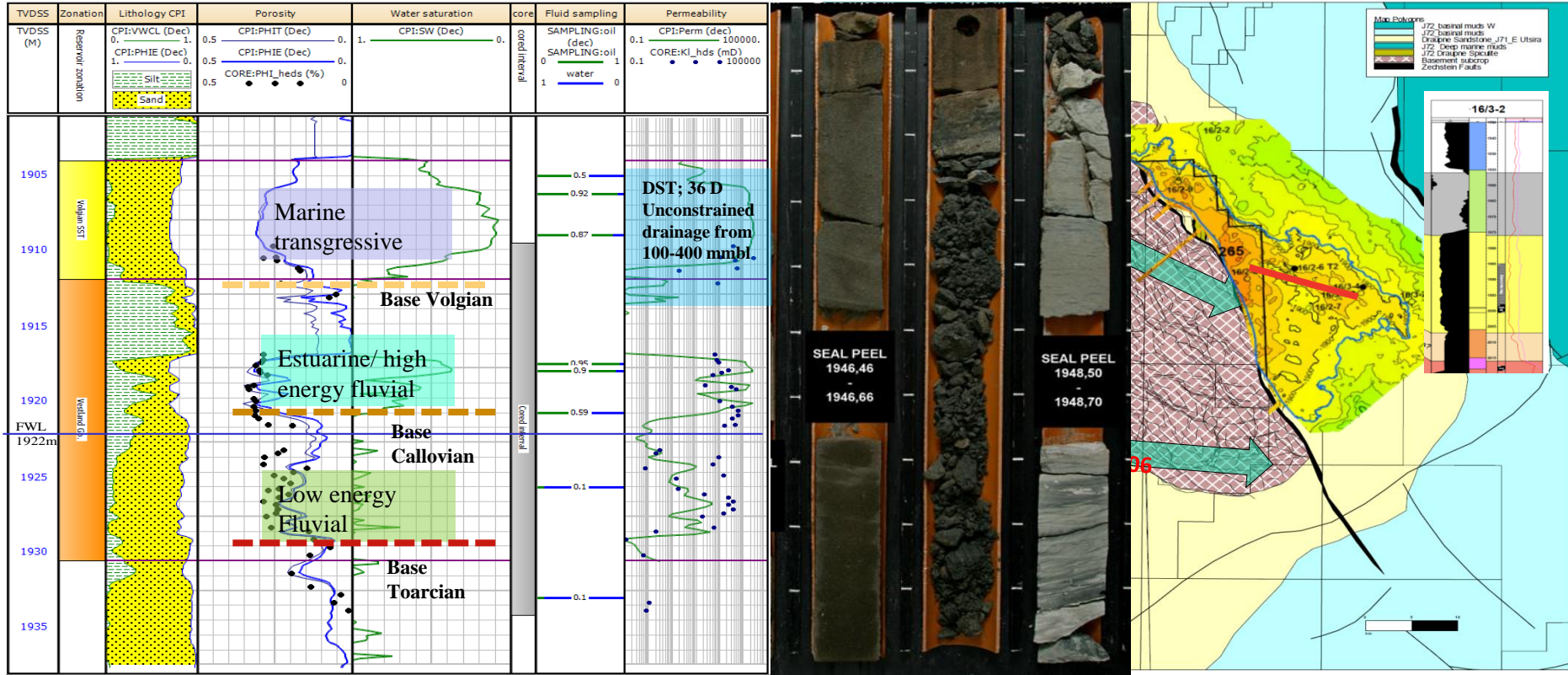


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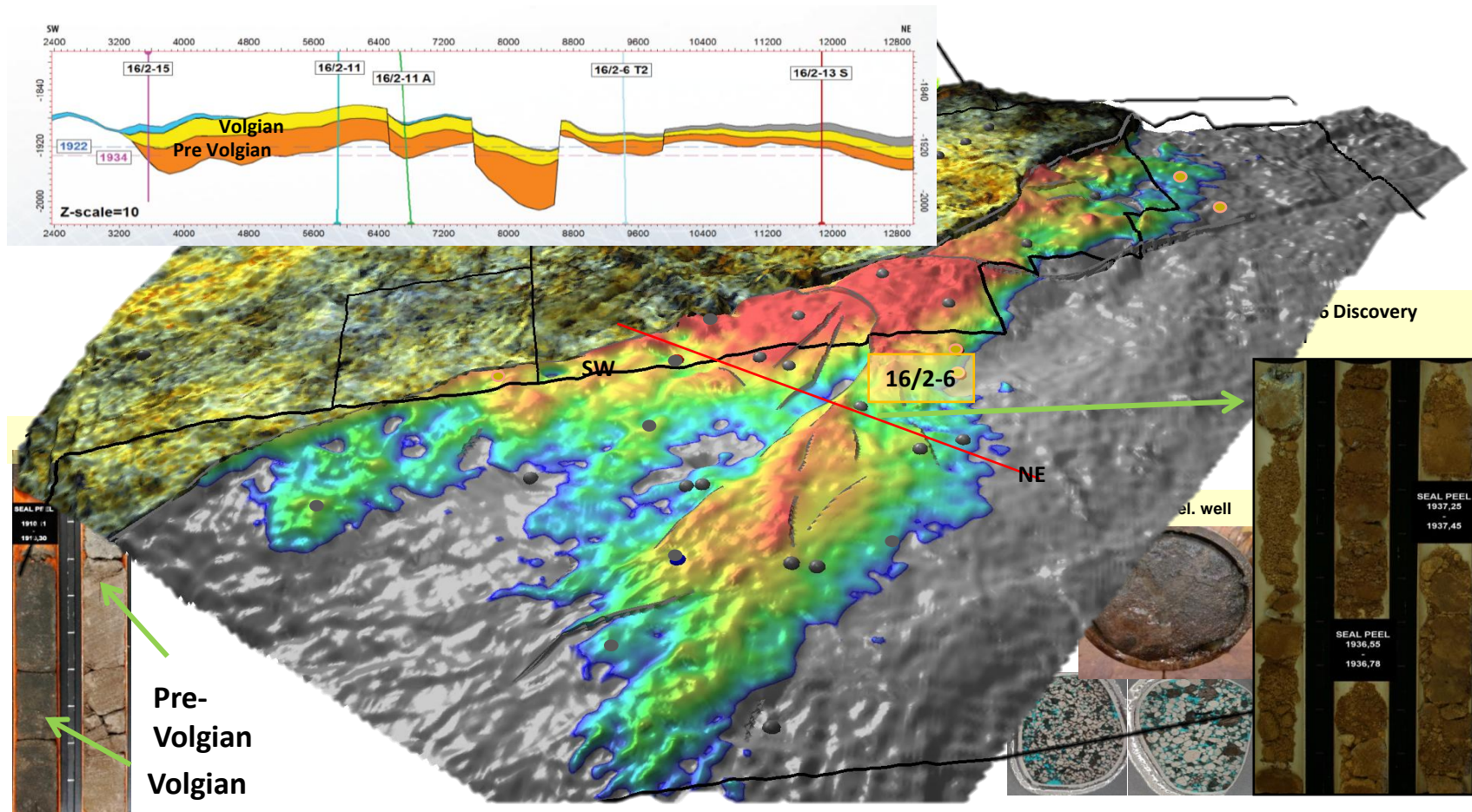
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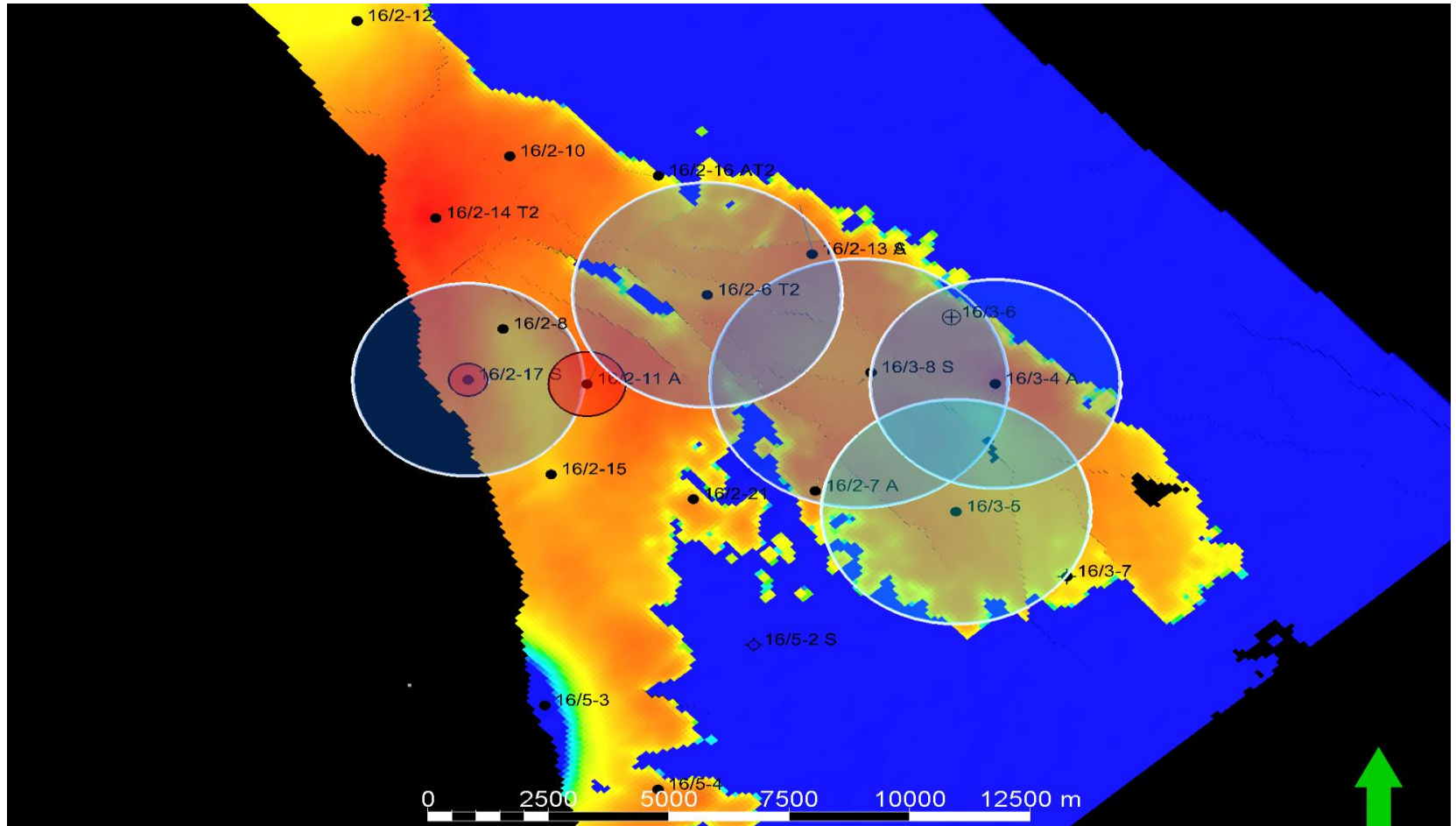


# Johan Sverdrup: Volgian sand with extremely high quality



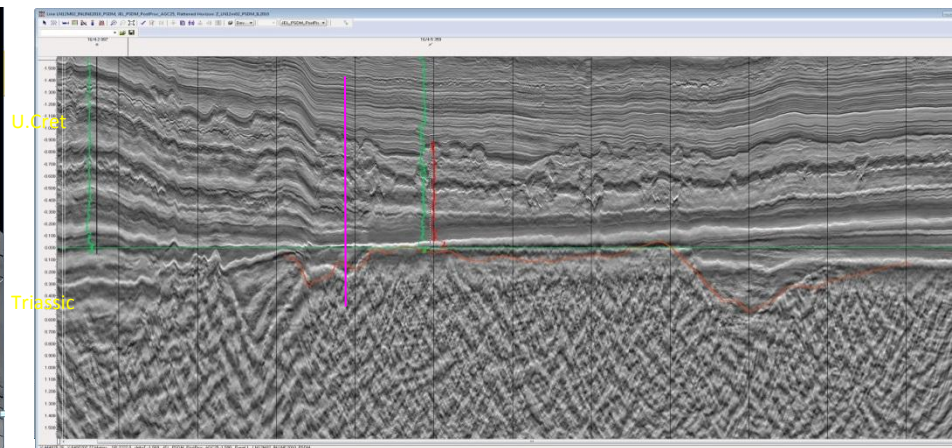
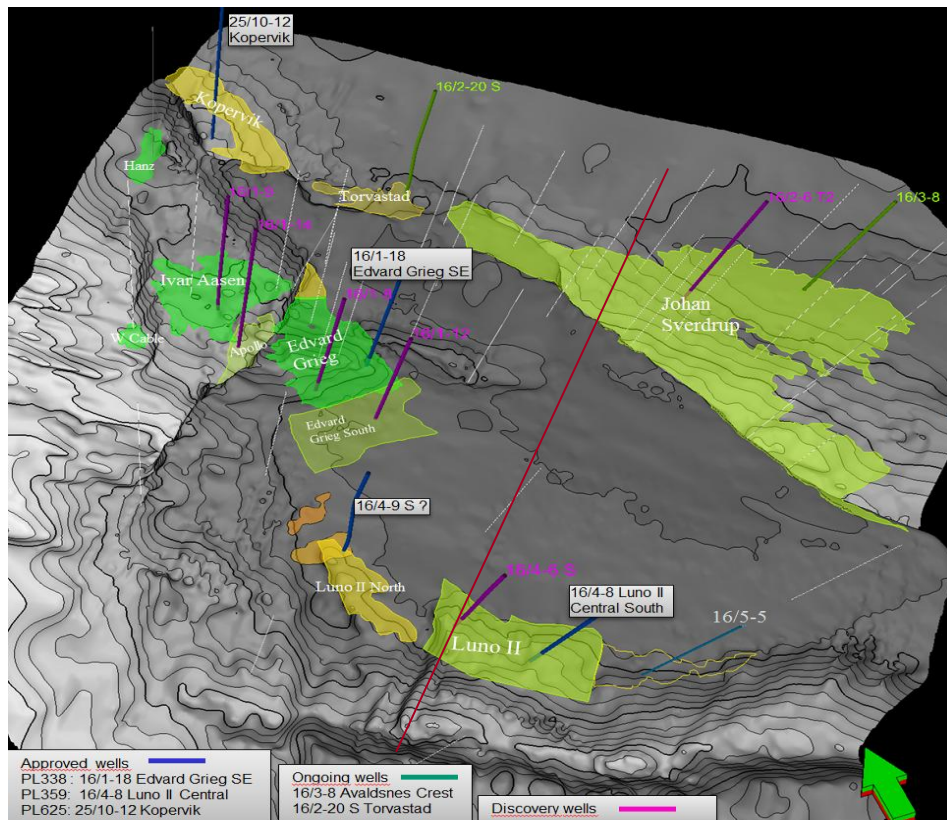
*1.9-2.9 billion bbls oil recoverable after the delineation by end 2013*

# 7 DSTs prove extreme connectivity in high-permeable sand (65D)





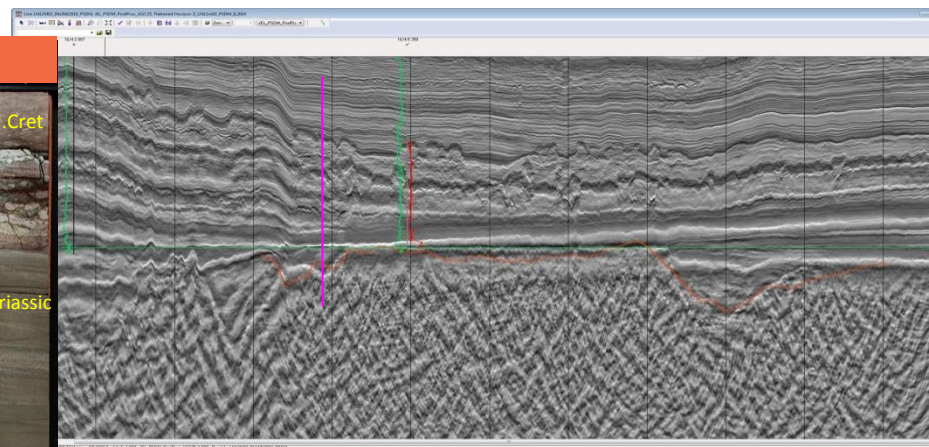
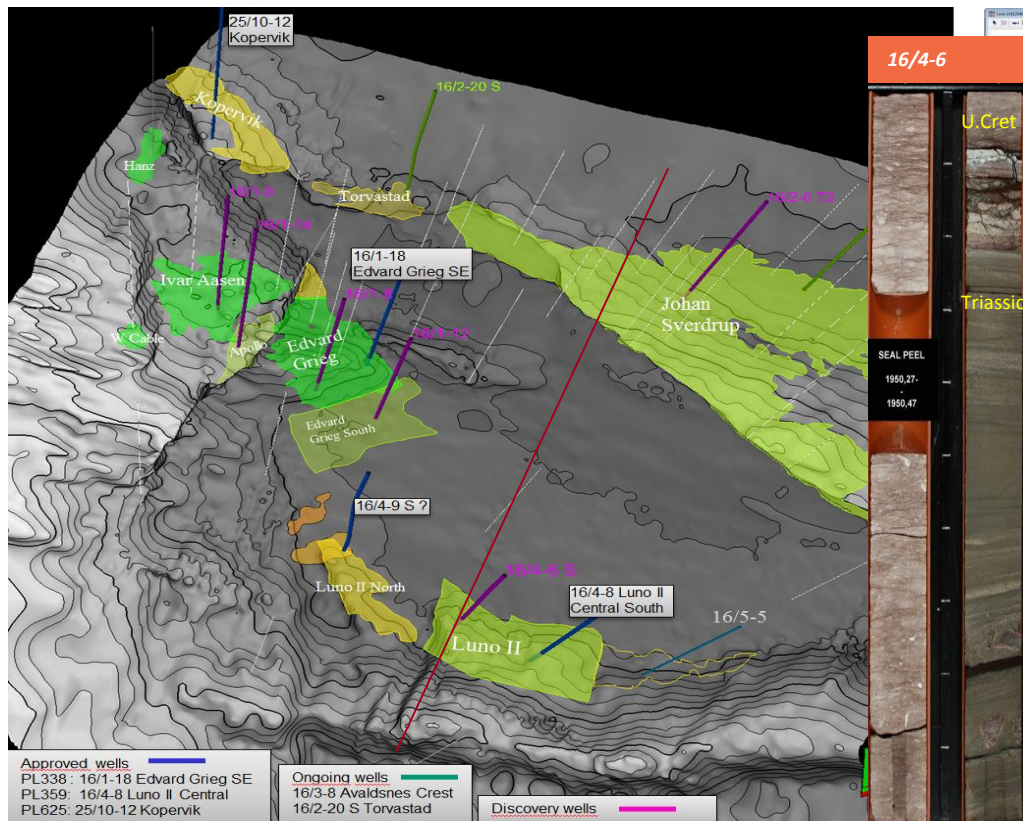
# The Luno 2 discovery: 16/4-6 in 2013



## Luno2:

- Resource estimate after 1. well: 25-120 million bbls. Saturated oil
- 280 m homogenous Upper Triassic / Jurassic sand sequence
- Porosity: 17 %
- Oil column: 45 m; OWC 1950 m msl
- Production test: 2000 bbls/day.
- Reservoir pressure: 5 bar below hydrostatic

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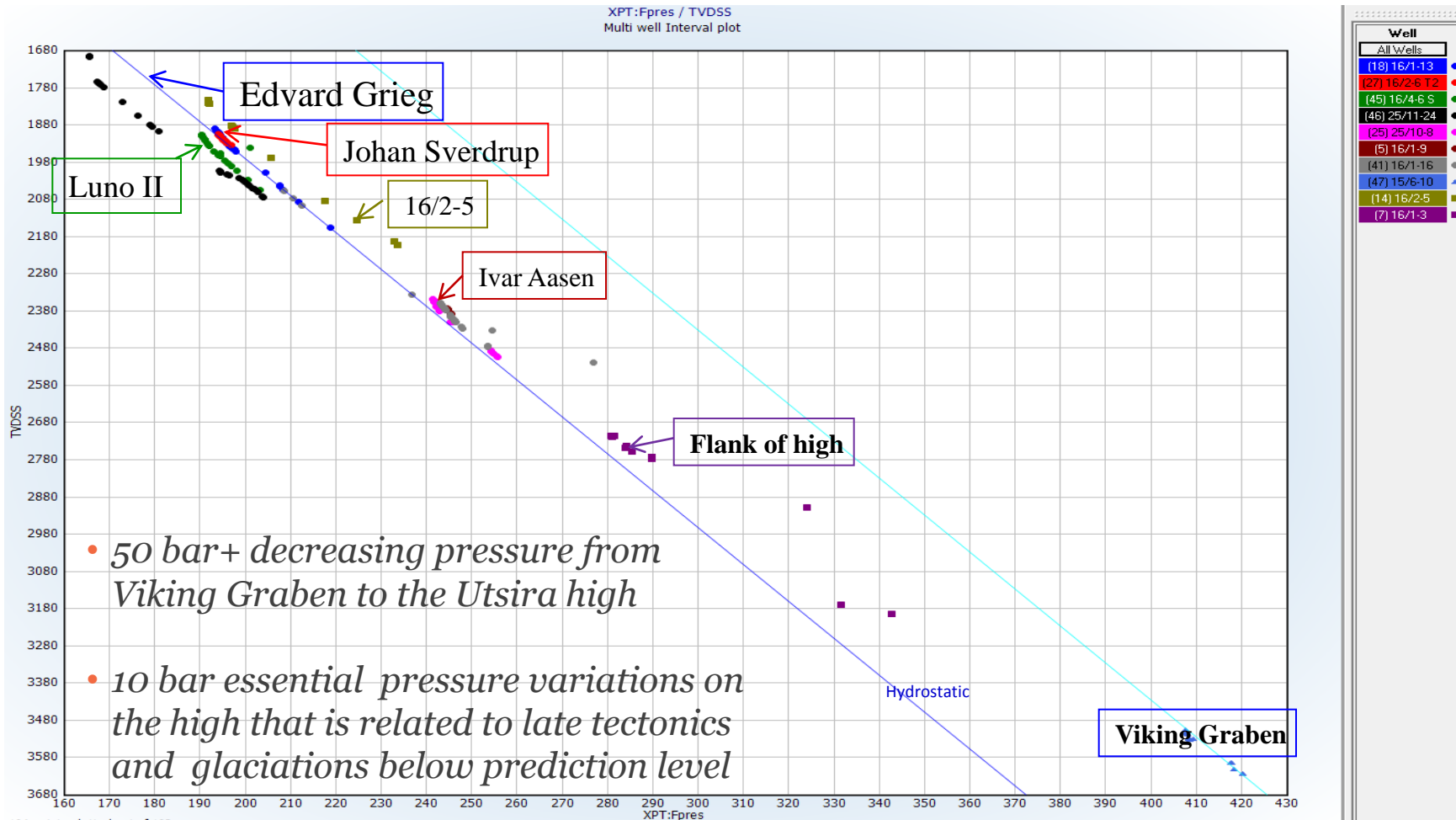


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# Regional pressure on the Utsira High



# Creation of knowledge is the basis for continuity

- Knowledge and wisdom are in the humans and not in the structure
- New knowledge is created by diversity and not more of the same
- Knowledge must be based on facts
- New knowledge is the result of actions (wells) rather than predictions (models)
- Learning is continuous individual and community processes:

## *Adaptive learning :*

- Utilize the existing knowledge
- Master the existing technology by sharing

## *Generative learning:*

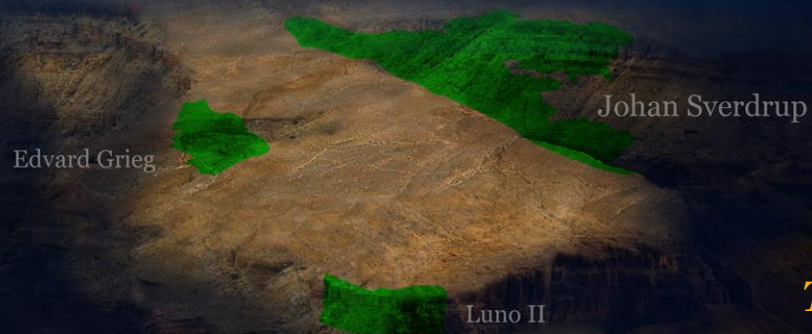
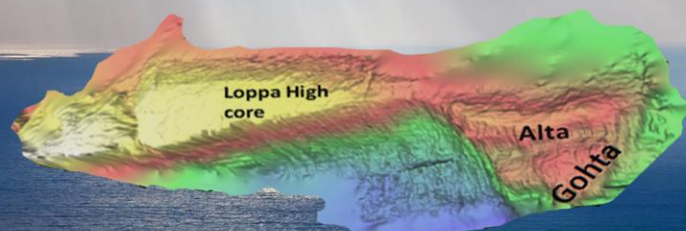
- To know what thou knowest not is in essence omniscience
  - Acknowledge the limitations in the known
  - Do not let the fact shadow for the possibilities
  - Continuous development of better praxis
- Learning speed depends on the conceptual and action relations between humans
  - Generative learning requires open action oriented bottom up culture



*«The will and skill»*

*«Believe what you see  
See what you believe»*





*There are new highs to conquer*