

Johan Sverdrup – Offshore Norway: The Story behind the Giant Sverdrup Discovery*

Arild Jørstad¹

Search and Discovery Article #20177 (2012)**

Posted November 12, 2012

*Adapted from oral presentation at Forum: Discovery Thinking, at AAPG International Conference and Exhibition, Singapore, September 16-19, 2012

**AAPG©2012 Serial rights given by author. For all other rights contact author directly.

¹Lundin Norway AS, Lysaker, Norway (arild.jorstad@lundin-norway.no)

Key Statements

Fewer wells have been drilled on the Norwegian Continental Shelf compared to the United Kingdom Continental Shelf, even though there is the same geological risk. Taxes are lower in the UK; there is an independent sector in the UK. The overall result is lower exploration in Norway.

John Sverdrup Discovery – Fourth Generation Exploration

- In the heart of the Central North Sea
- Located on the southern Utsira High (Haugaland High or Greater Luno Area)
- 40 km south of Grane
- Water depth of 115 m
- Reservoir depth of approximately 1900 m
- Avaldsnes Discovery
 - 100-400 million barrels of recoverable resources
 - Exceptional DST result gained confidence in the discovery
- Upside Potential
 - 200 km² of closure
 - Uncertainty of reservoir continuity and quality

Exploration and delineation drilling

The discovery well 16/2-6 was drilled in 2010; 6 delineation wells were drilled in 2011 unfolded the resource range. Delineation wells in 2012 will narrow the range; yet additional delineation wells will be needed in 2013.

Results to Date:

- Extremely good Volgian (Upper Jurassic) sandstone reservoir - 28% porosity; 10-40 darcy permeability

- Good underlying Upper to Middle Jurassic sandstone reservoir and weathered basement
- OWC varying between 1922 and 1935 m MSL

Main reservoir uncertainties

- Top reservoir depth reflecting velocity variations in overburden
- Thickness variation of extremely good reservoir versus good reservoir sand
- Reservoir wettability
- Variations in oil-water contacts
- Varying aquifer support

Subsurface Learning on the Southern Utsira High

Play concept in 2004 of thin Jurassic sands, with 40-50 m leg, over inlier basins and basement was proved in 2007 by Edvard Grieg; it also lowered the risk of Johan Sverdrup to P45%; Apollo proved the concept in 2010.

The main learning includes: (1) light under-saturated oil flanking saturated oil and gas discovery, (2) late migration of oil into Edvard Grieg and Johan Sverdrup, (3) extreme to very good reservoir quality of the Upper Jurassic sands, and (4) producible oil in weathered basement in Tellus and Luno South.

Seeing is Believing

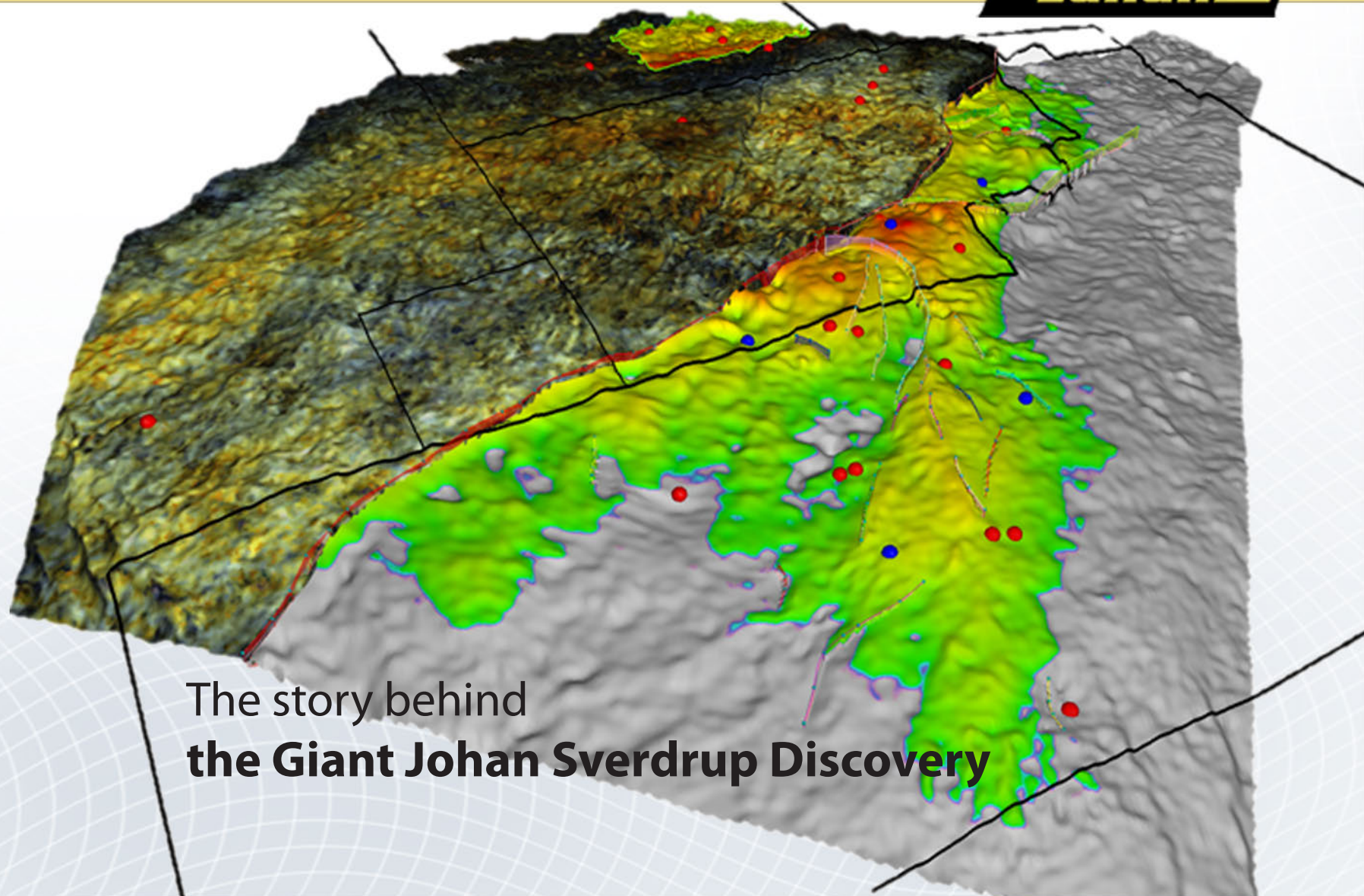
The last years' exploration effort by a diversity of subsurface focused companies demonstrates that the decline in discoveries was not subsurface-based.

To release the exploration potential, companies with a fact-based knowledge creation culture are needed:

Recycling is a Key Word in terms of licences, play models, wells and seismic, and people.

Johan Sverdrup – Offshore Norway

Lundin



The story behind
the Giant Johan Sverdrup Discovery

*Lundin Norway AS
September 2012*

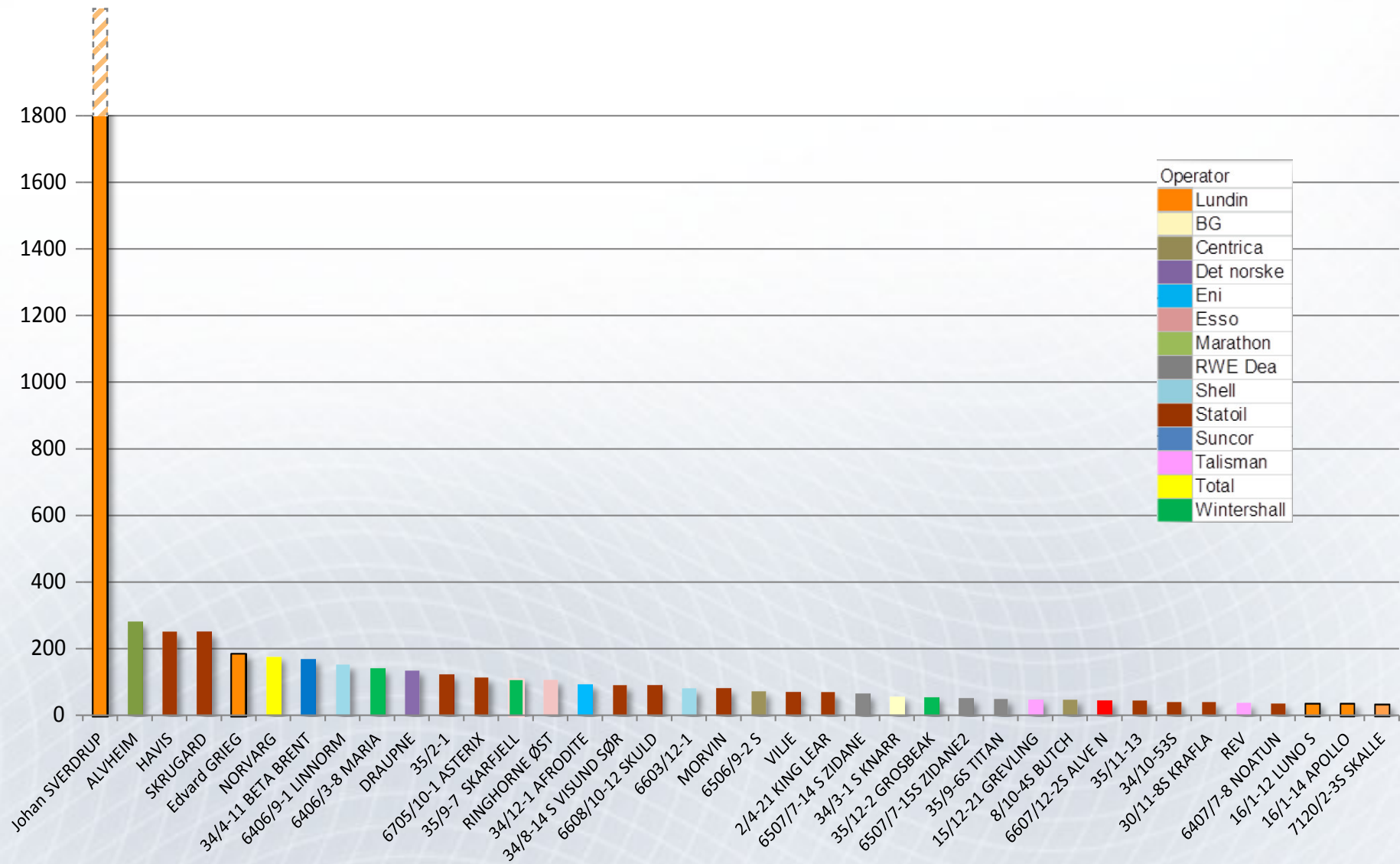
SIDETRACK



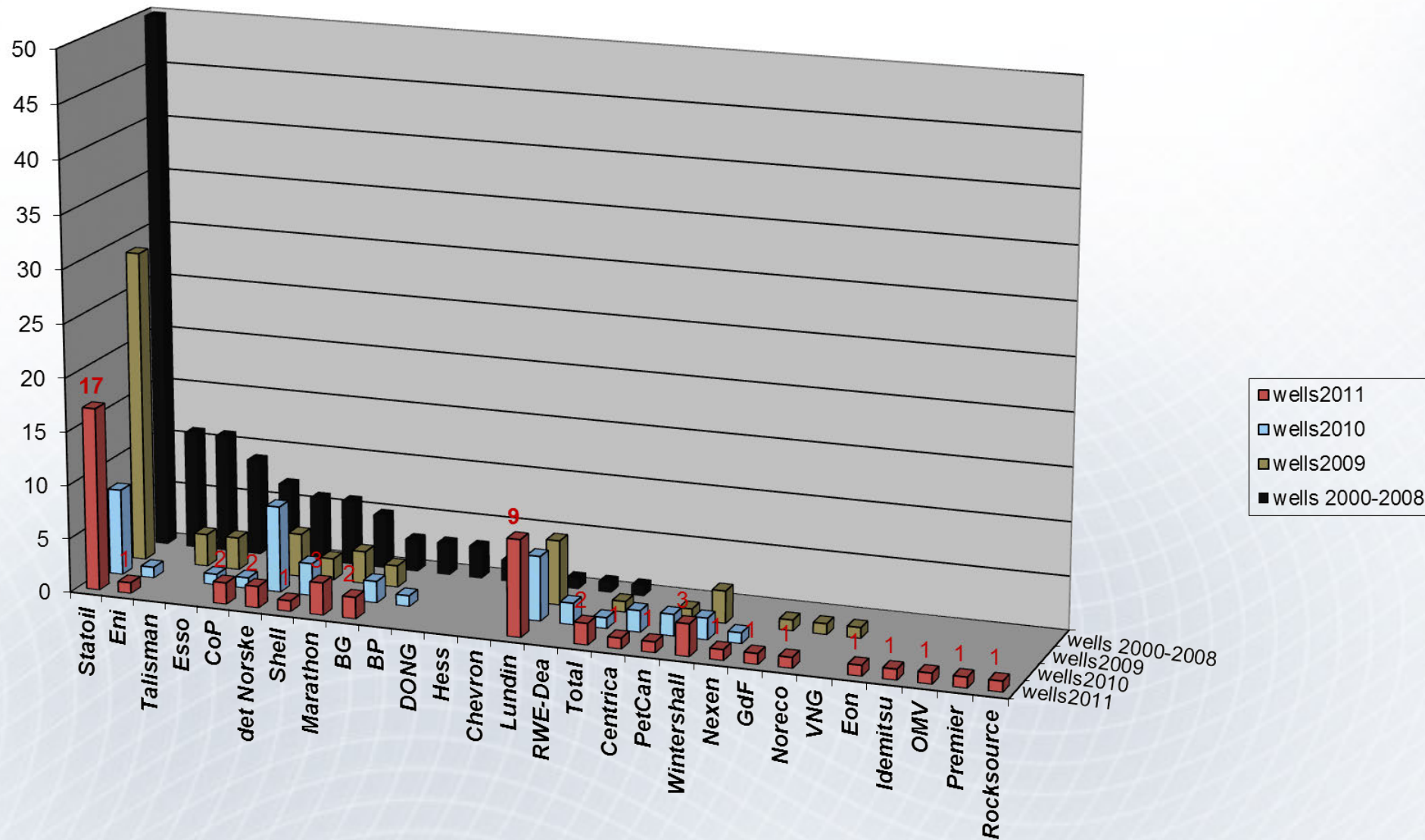
Smooth operator: Swedish junior Lundin has lofty dreams of taking the lead role on the giant Avaldsnes project

RYTIS DAUKANTAS

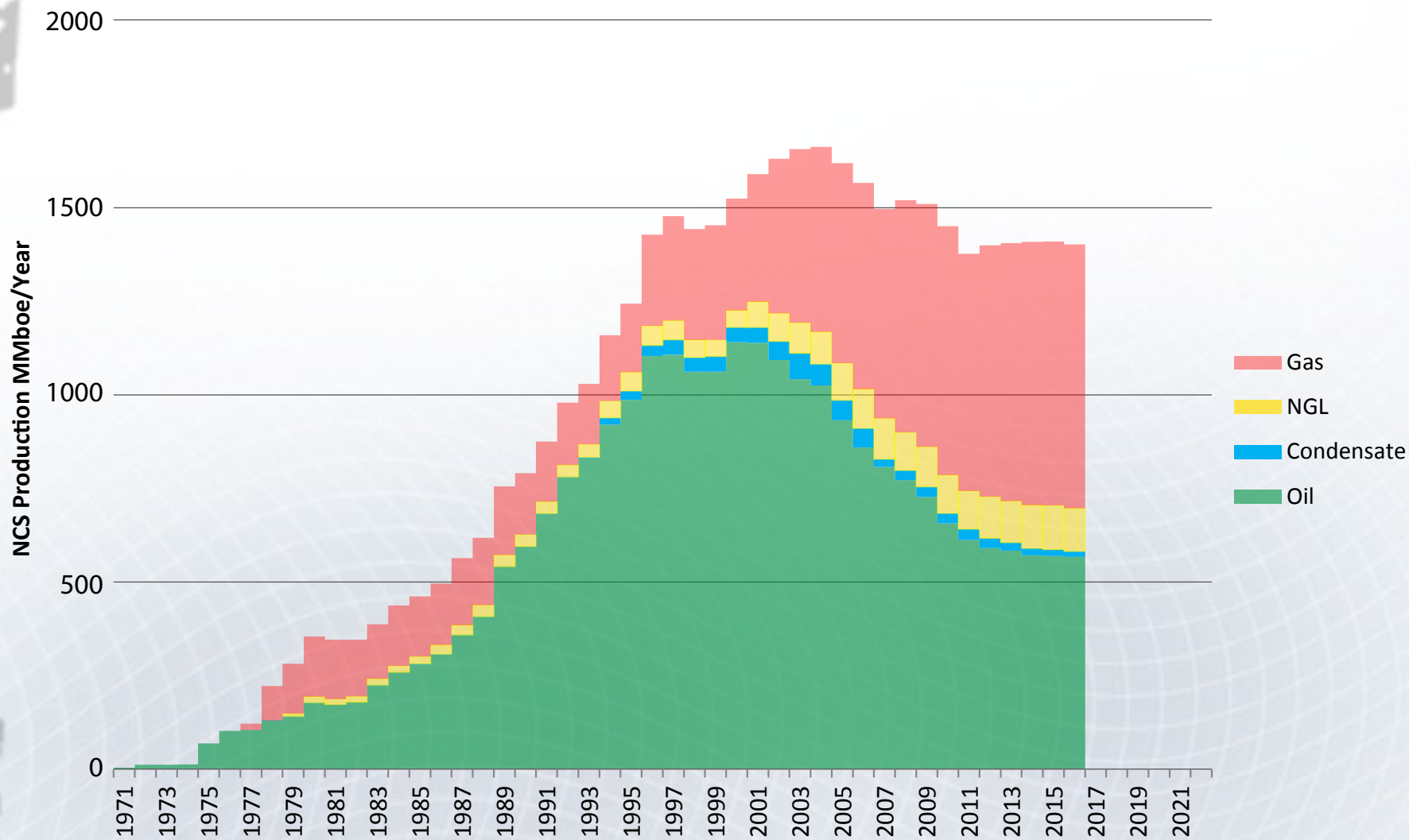
Discovered Resources in Norway 2001-2012



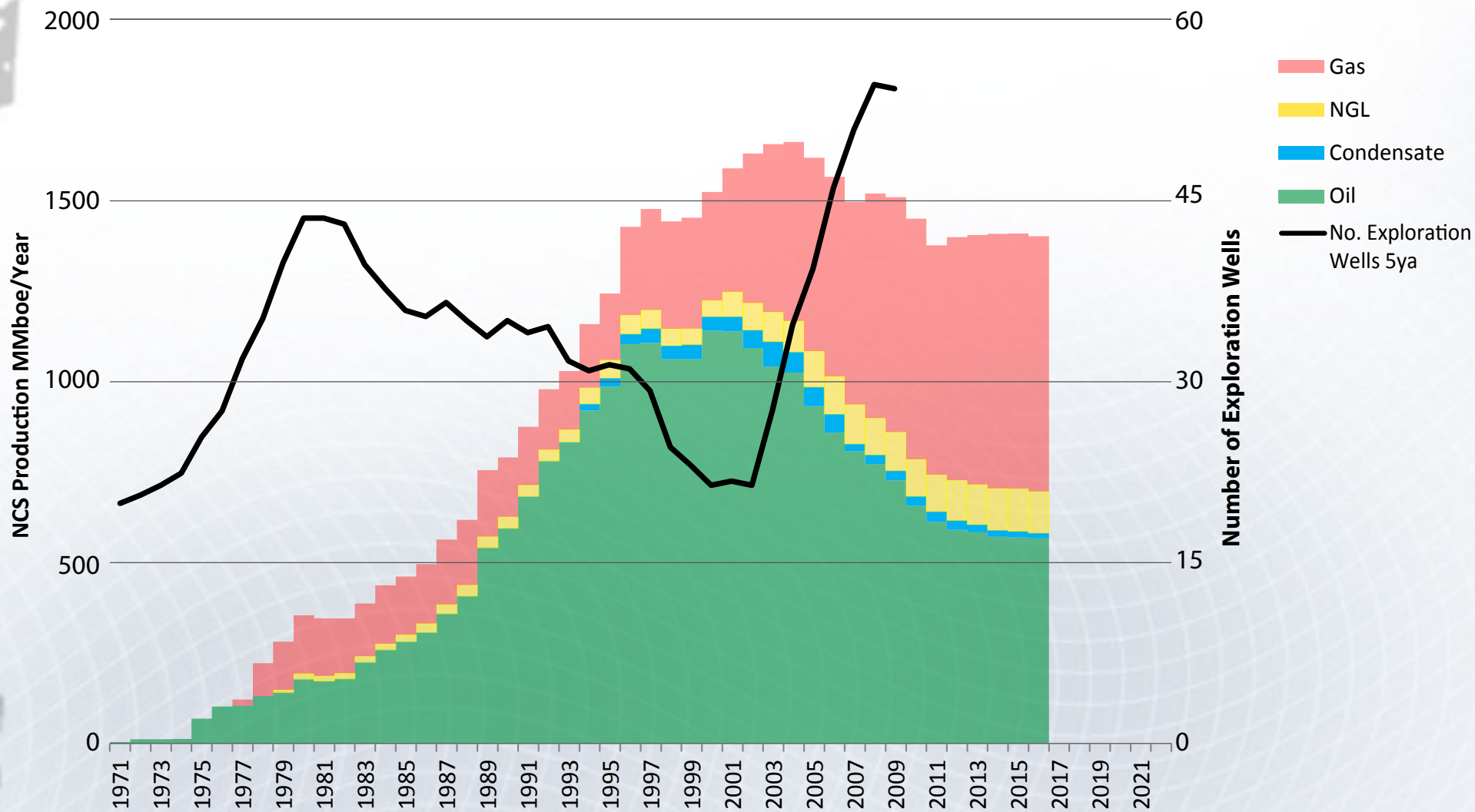
New Companies on the NCS in the Last Decade



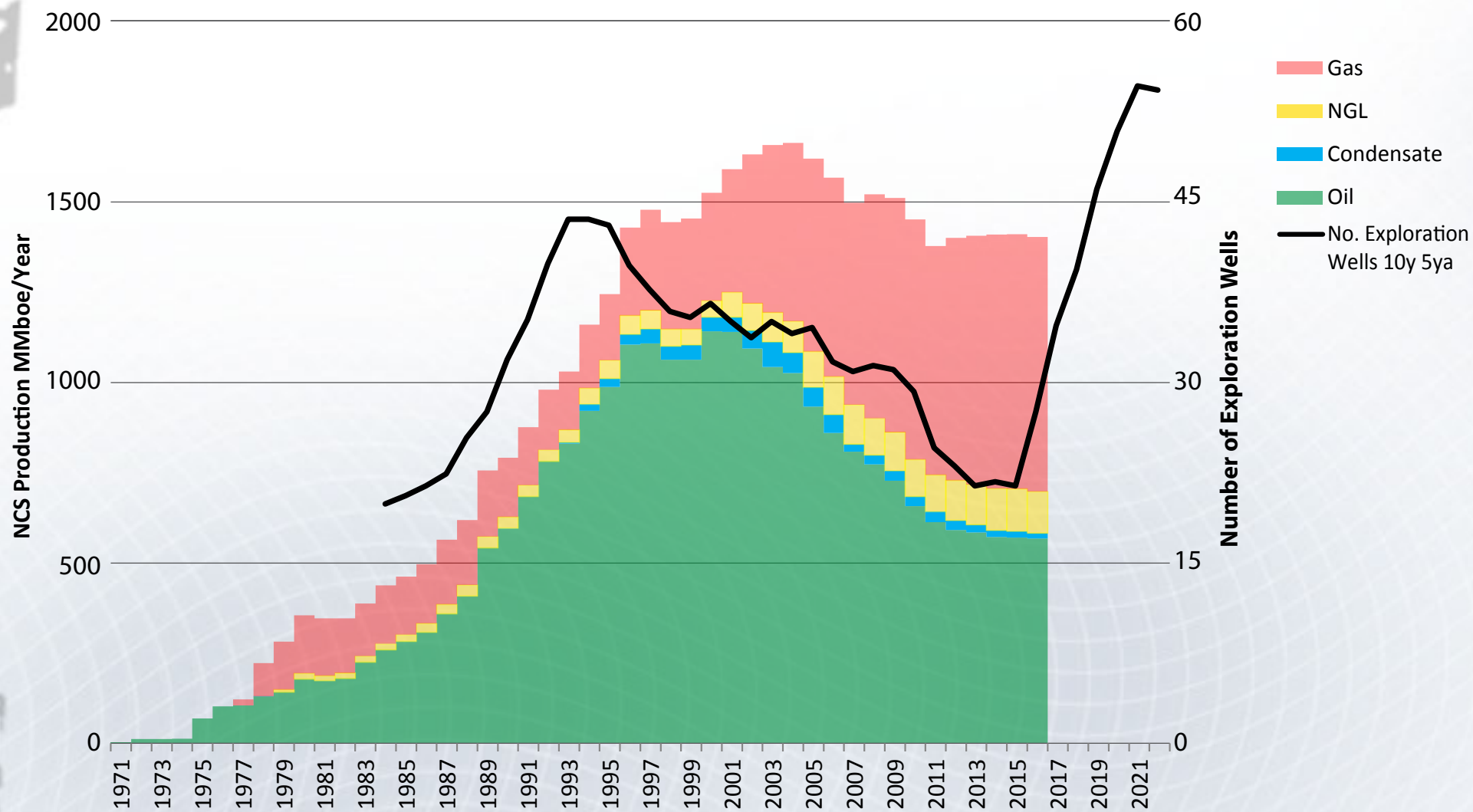
Production NCS 1971-2016



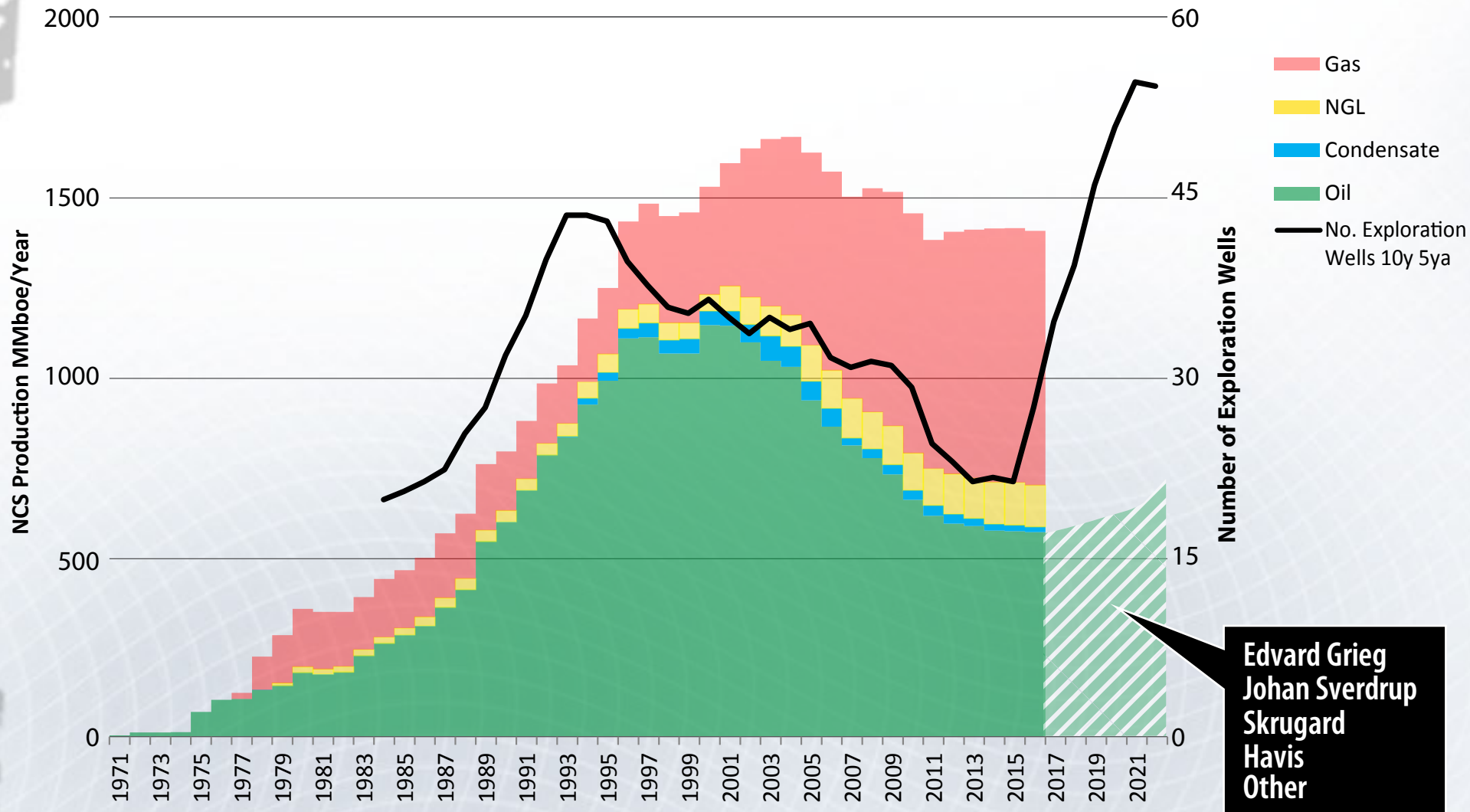
NCS Production / Exploration Wells



NCS Production / Exploration Wells + 10y



NCS Production? / Exploration Wells + 10y



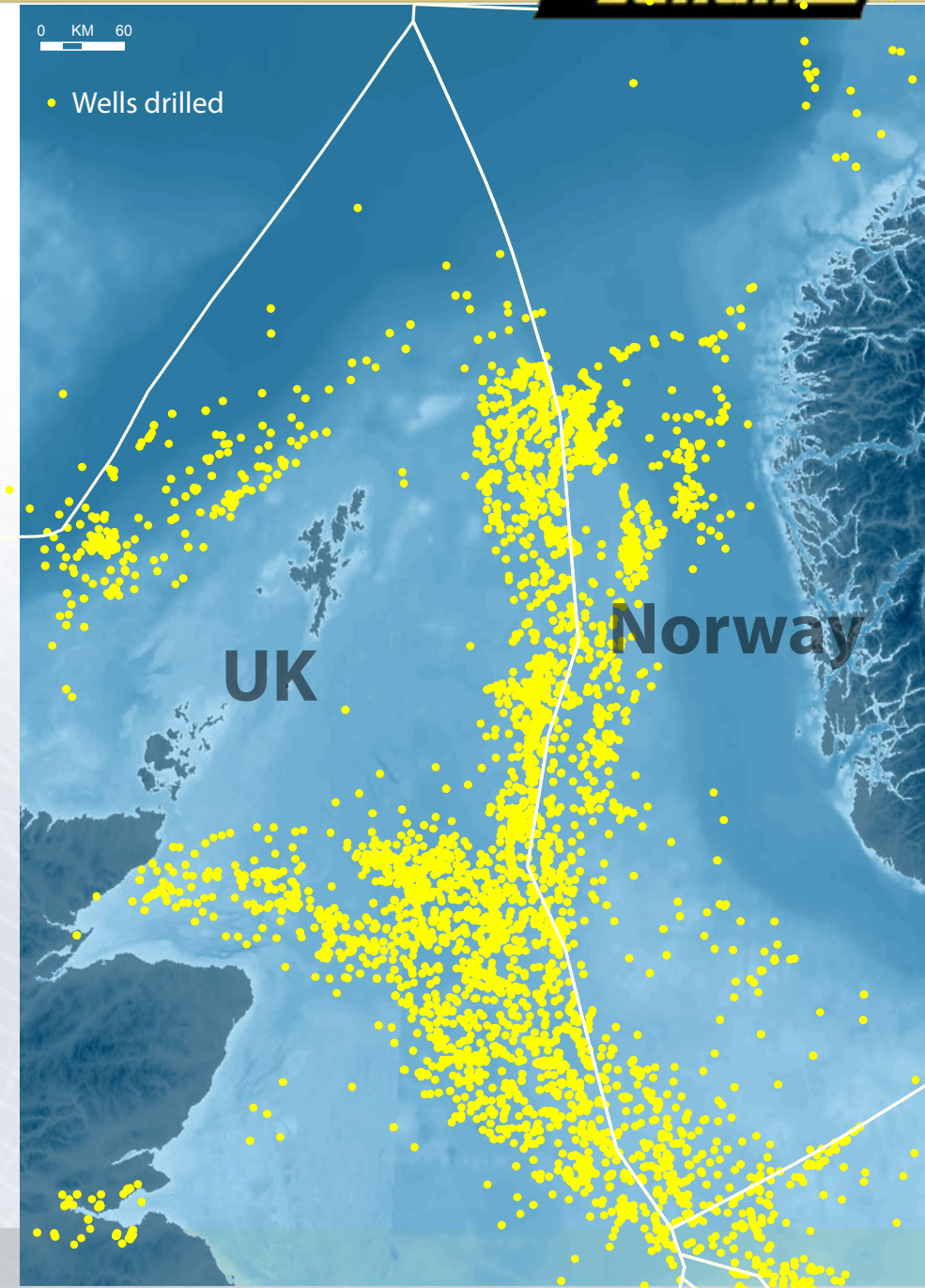
Fewer Wells Drilled on the NCS Compared to UKCS



- Same geological risk
- Lower taxes in United Kingdom
- Independent sector in United Kingdom



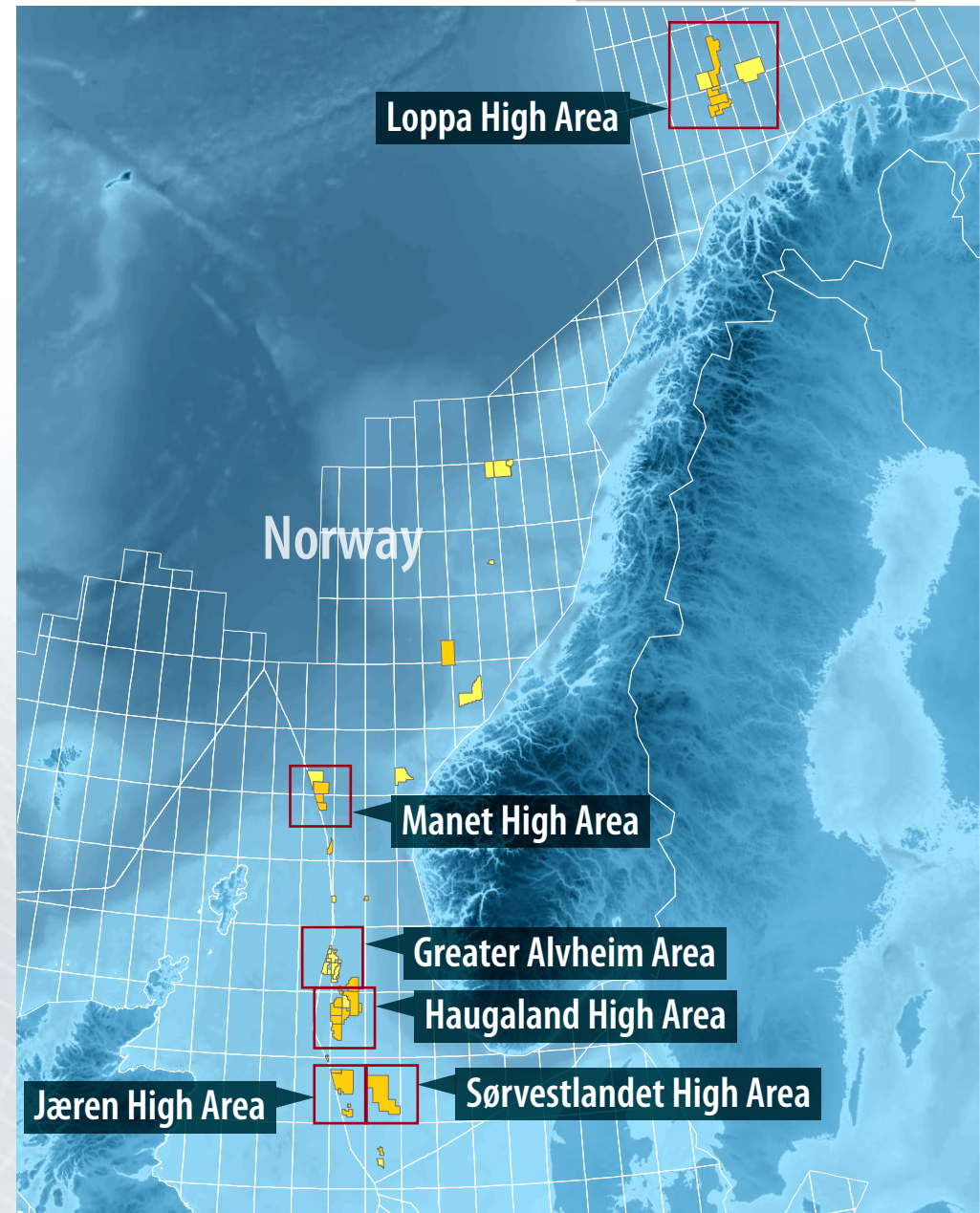
Lower exploration activity in Norway



Organic Growth Strategy

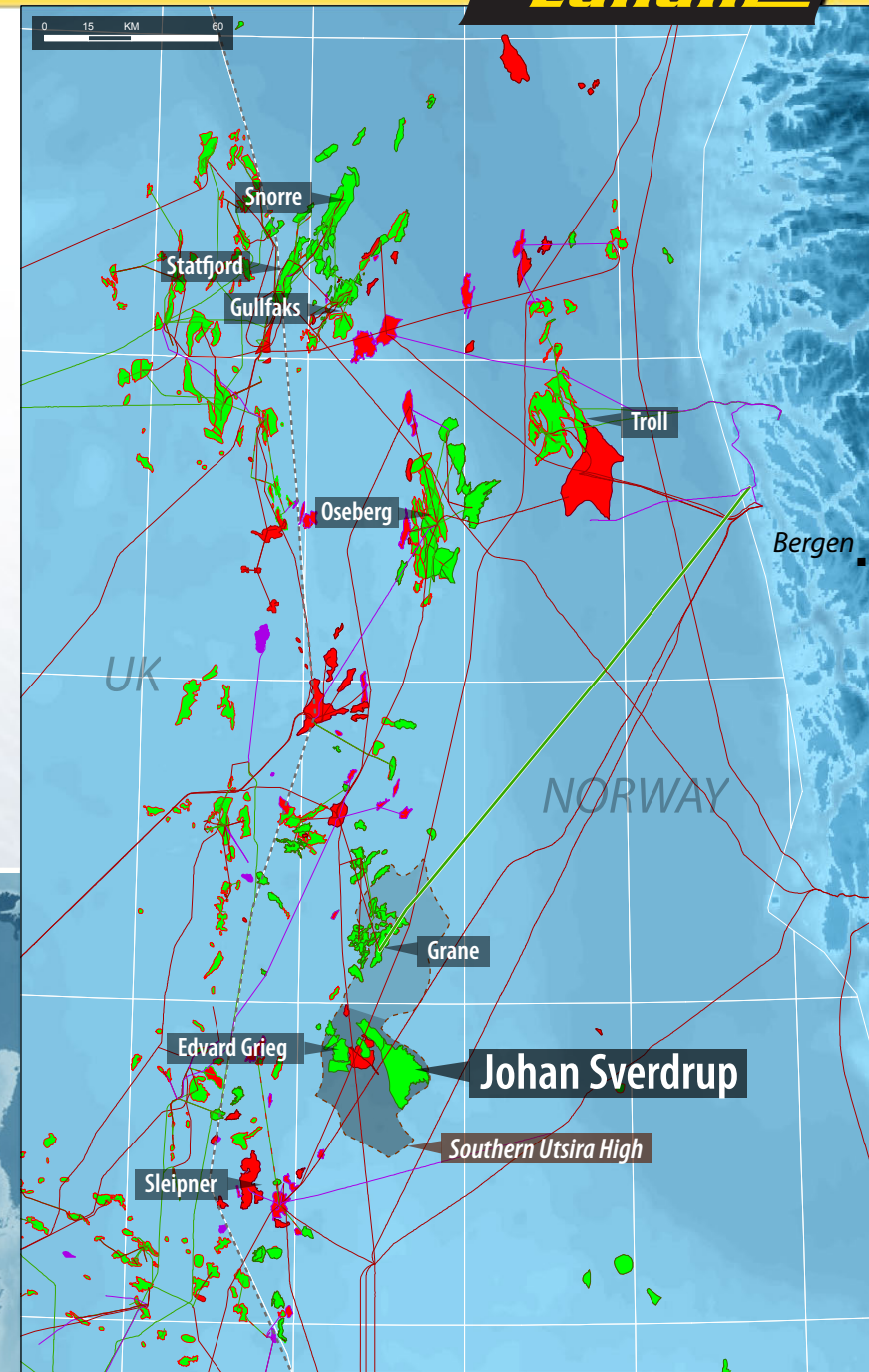


- ➔ Find oil with the drill bit - organic growth
- ➔ Leverage on organisational knowledge
- ➔ Portfolio synergy in relation to improved exploration and development
- ➔ Design yearly balanced exploration drilling portfolios in relation to
 - ➔ Frontier breakthrough
 - ➔ Growth
 - ➔ Mature tie-in
- ➔ Maintain production from existing and emerging developments
- ➔ Applying and developing data and fact-driven subsurface models, based on appreciation of the limitations of data, tools, methods and theories available at any time
- ➔ Applying new emerging technology and methods



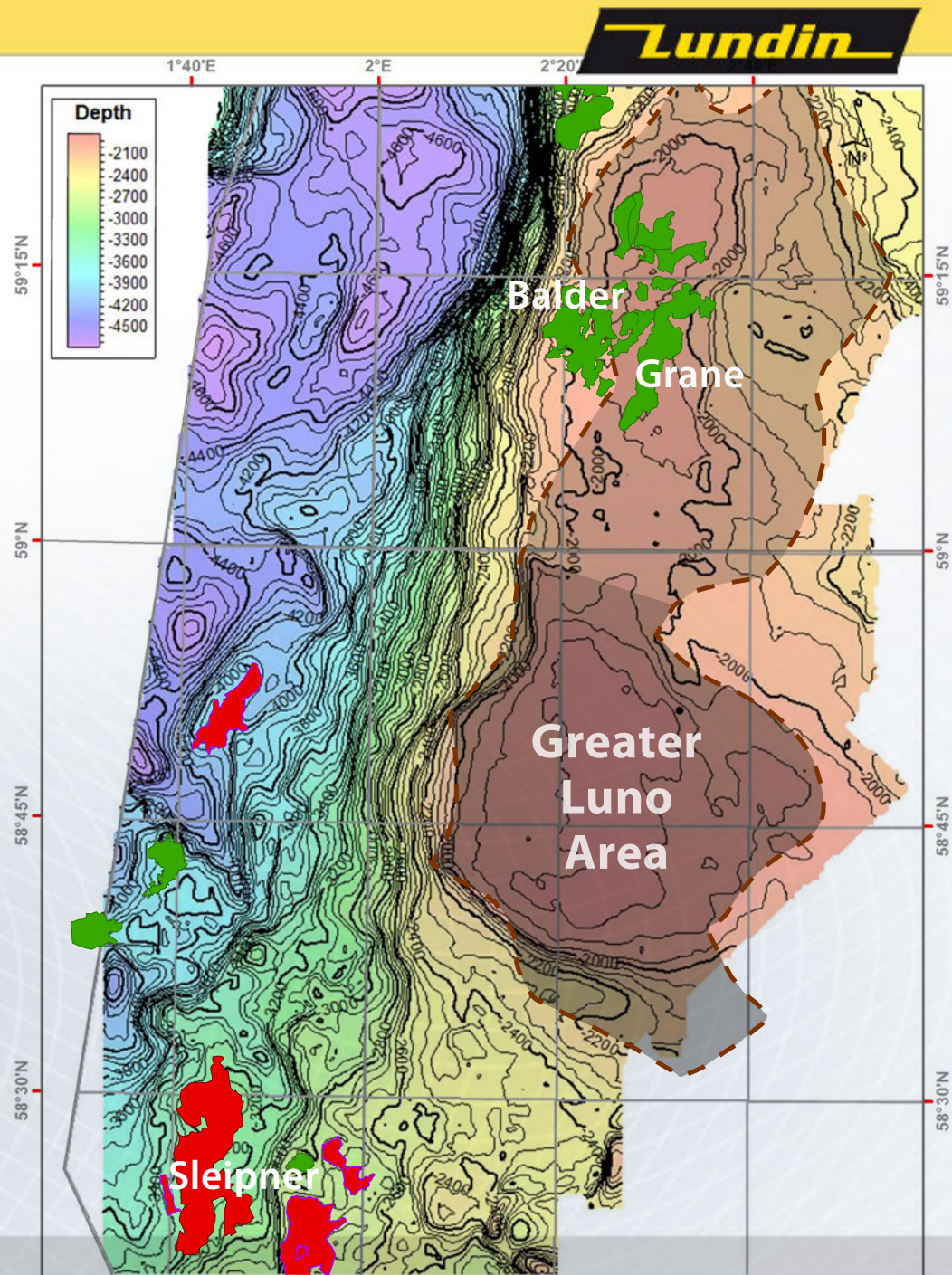
Johan Sverdrup Discovery - Fourth Generation Exploration **Lundin**

- ➔ In the heart of the Central North Sea
- ➔ Located on the southern Utsira High
(Also referred to as Haugaland High or Greater Luno Area)
- ➔ 40 km south of Grane
- ➔ Water depth: 115m
- ➔ Reservoir depth: ~1900m



The Greater Luno Area

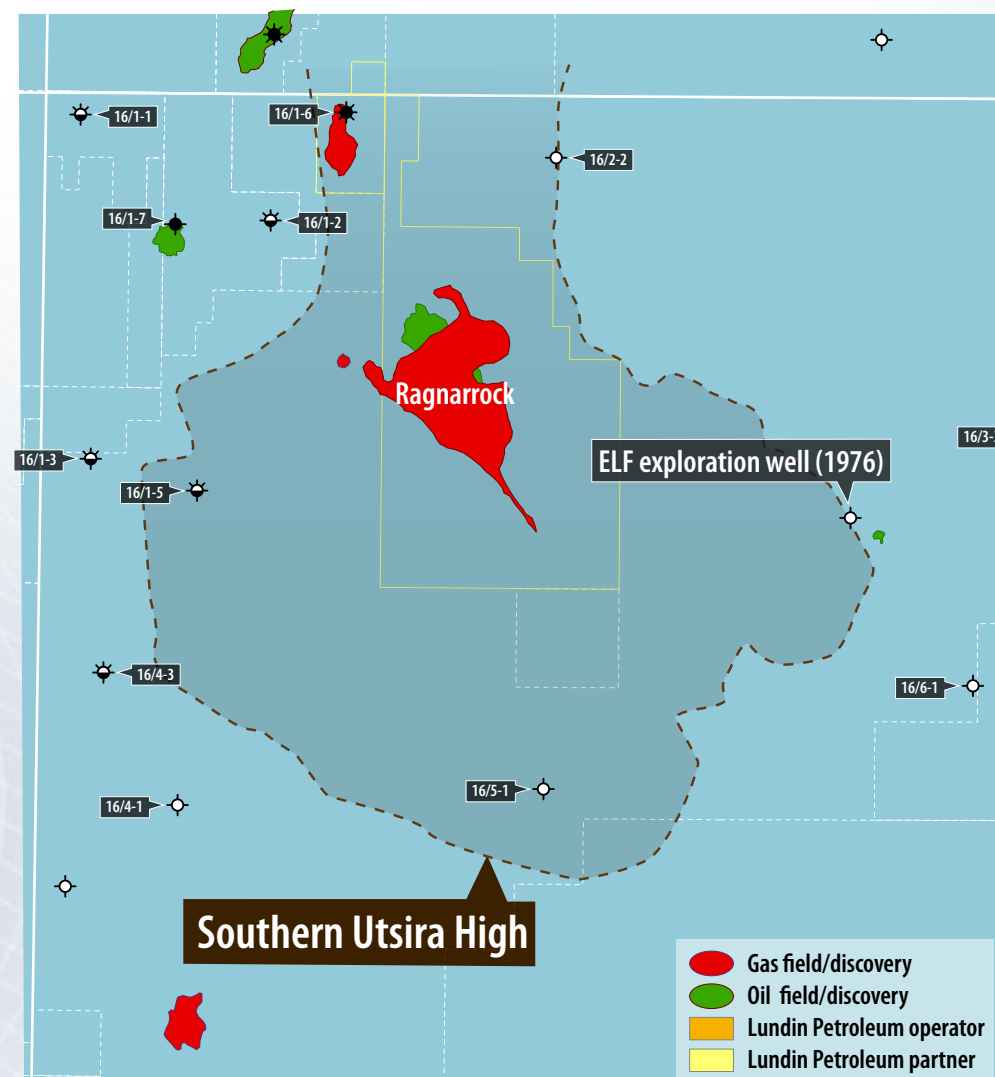
Greater Luno Area
or
Haugaland High
or
South Utsira High



The Greater Luno Area



- ➔ Four operators since 1965
- ➔ Limited exploration success

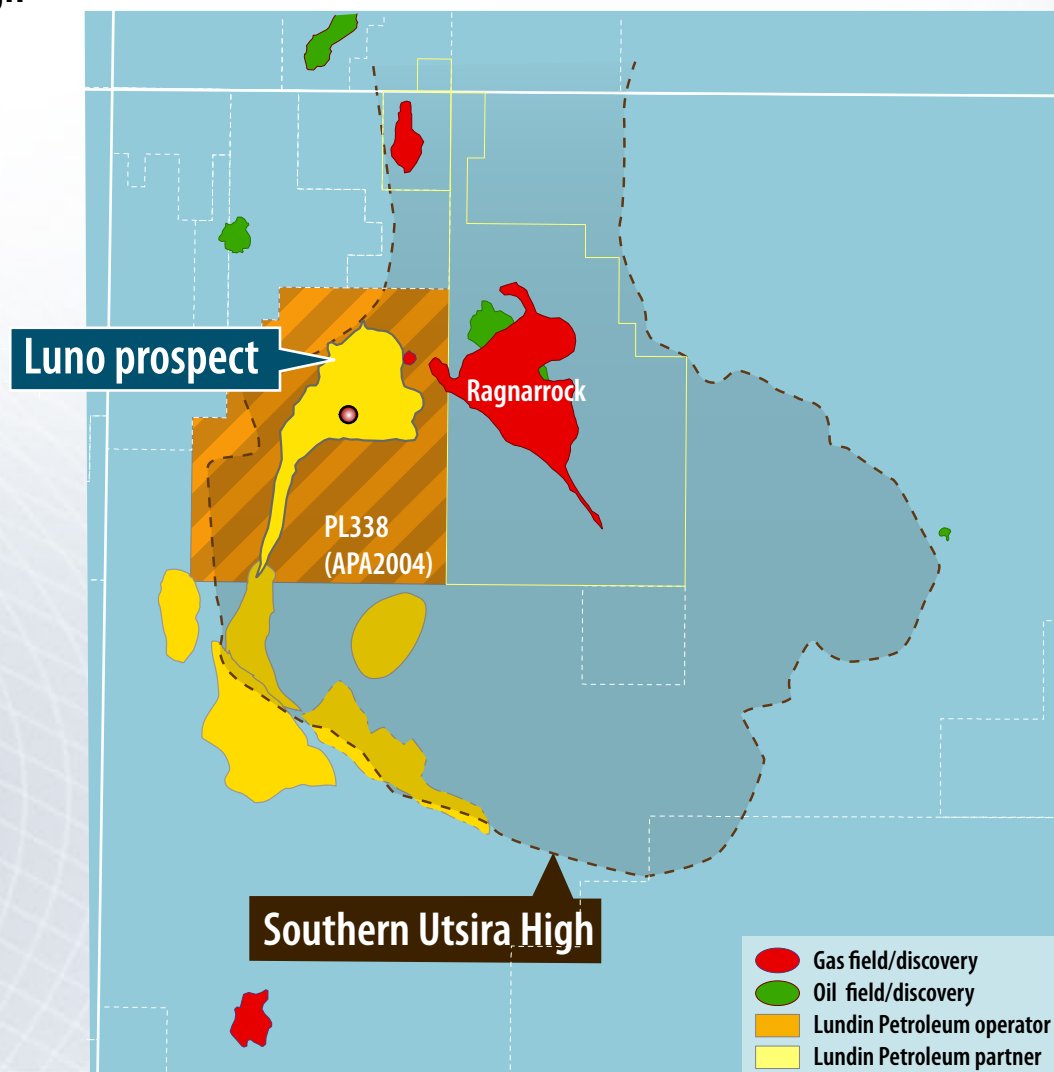
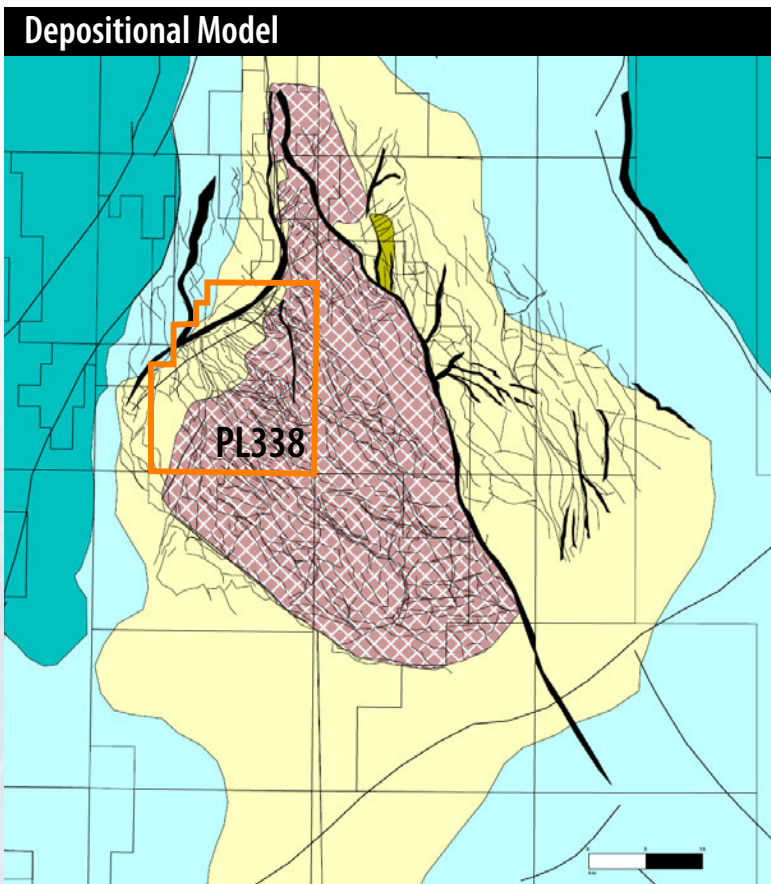


The Greater Luno Area



Greater Luno Area Technical Concept

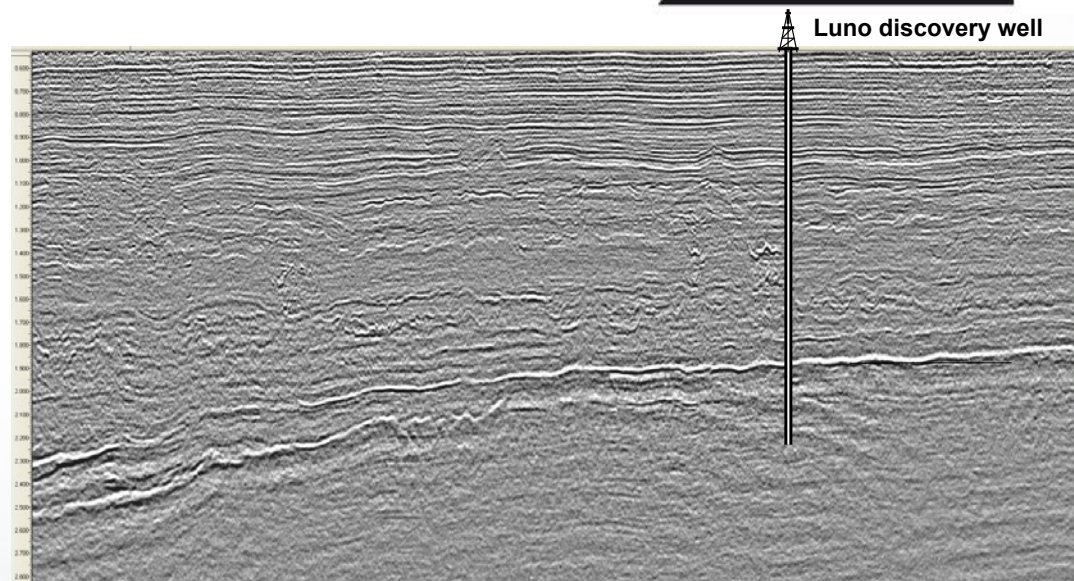
- Jurassic sands deposited around the basement high
- Saturated hydrocarbon system
- Common oil water contact



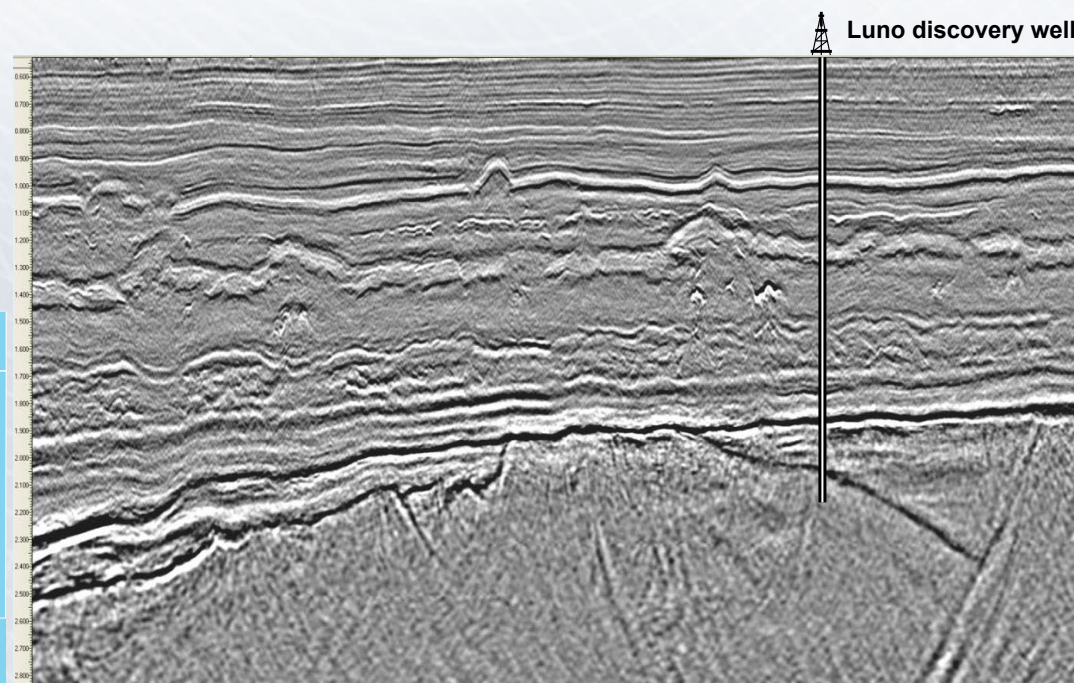
The Greater Luno Area



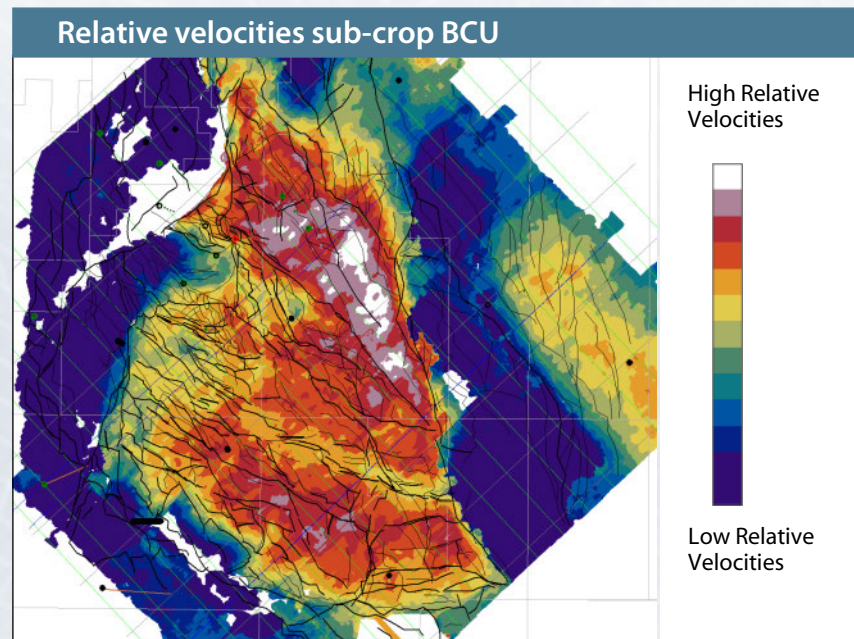
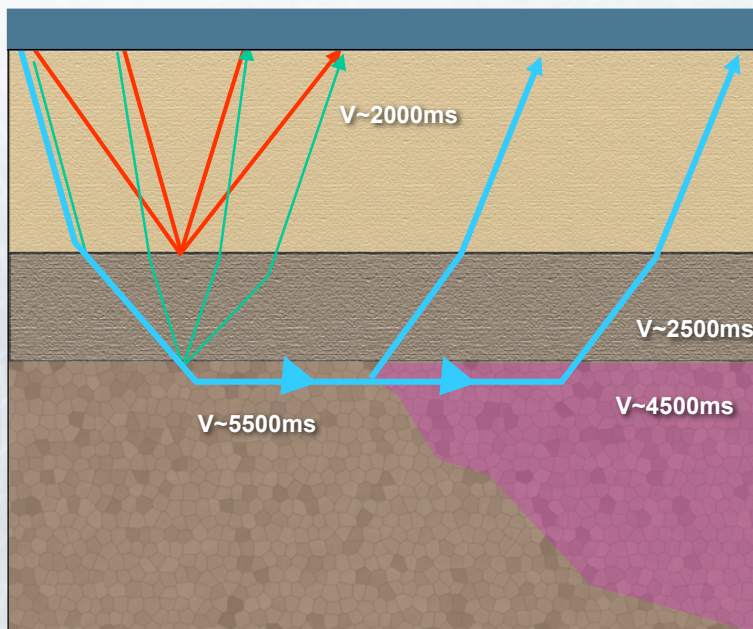
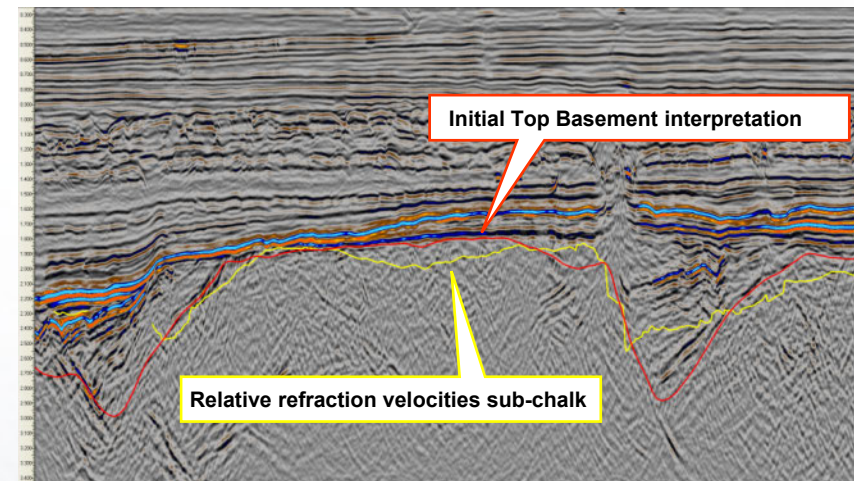
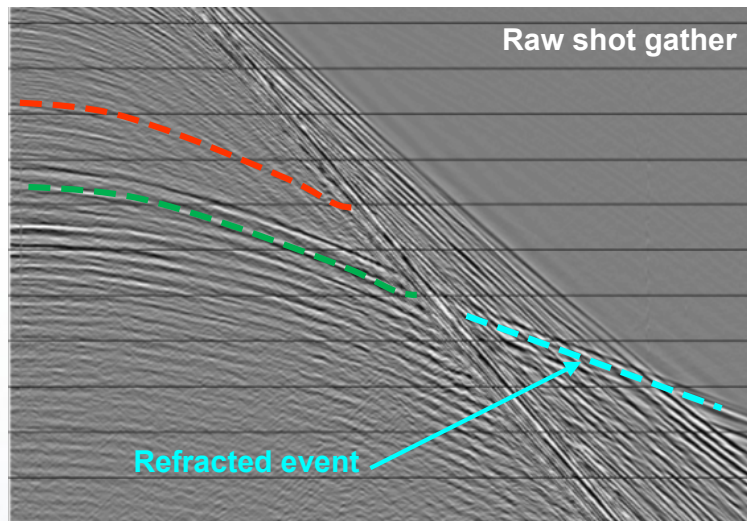
3D Sesimic over Luno Prospect ▶
at time of application



3D Sesimic over Luno Prospect ▶
today



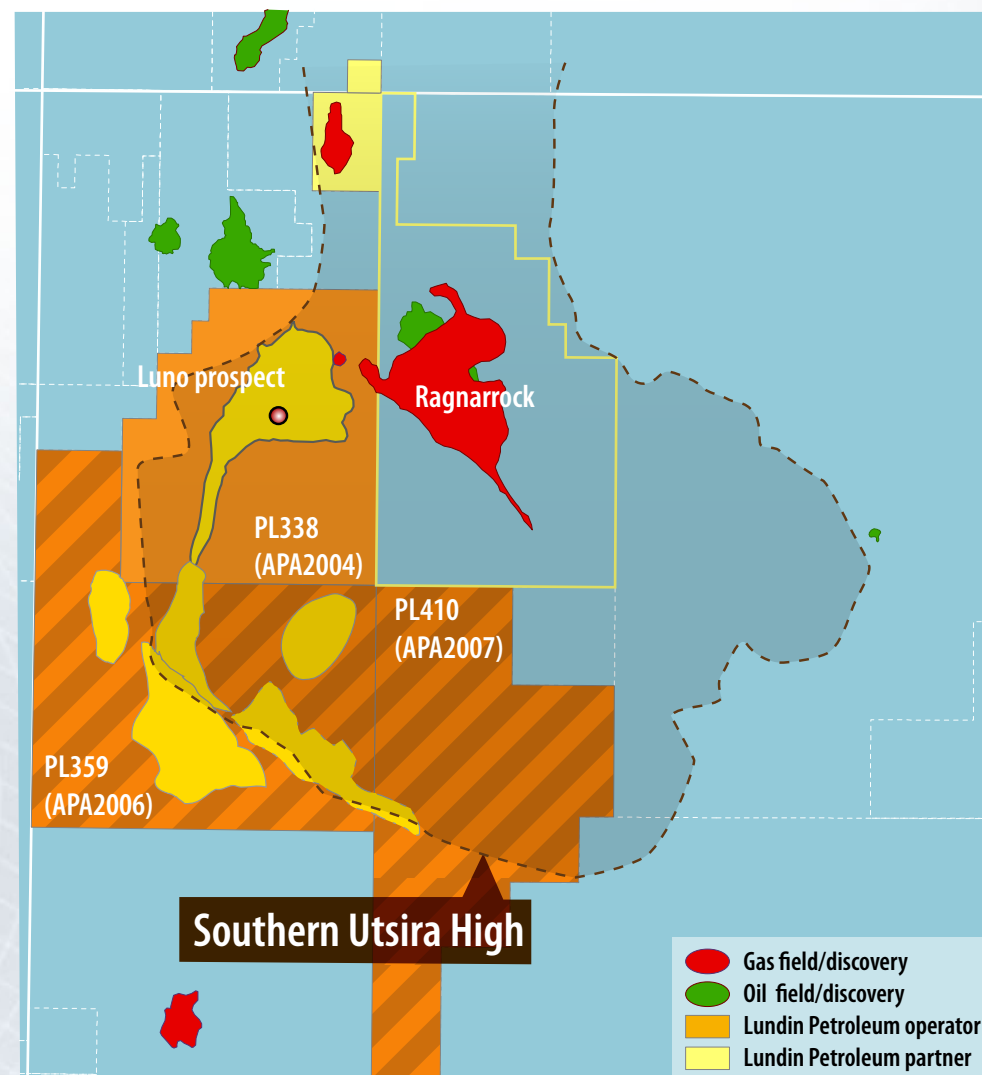
Seismic Velocities Sub-BCU by use of Refraction Events



The Greater Luno Area



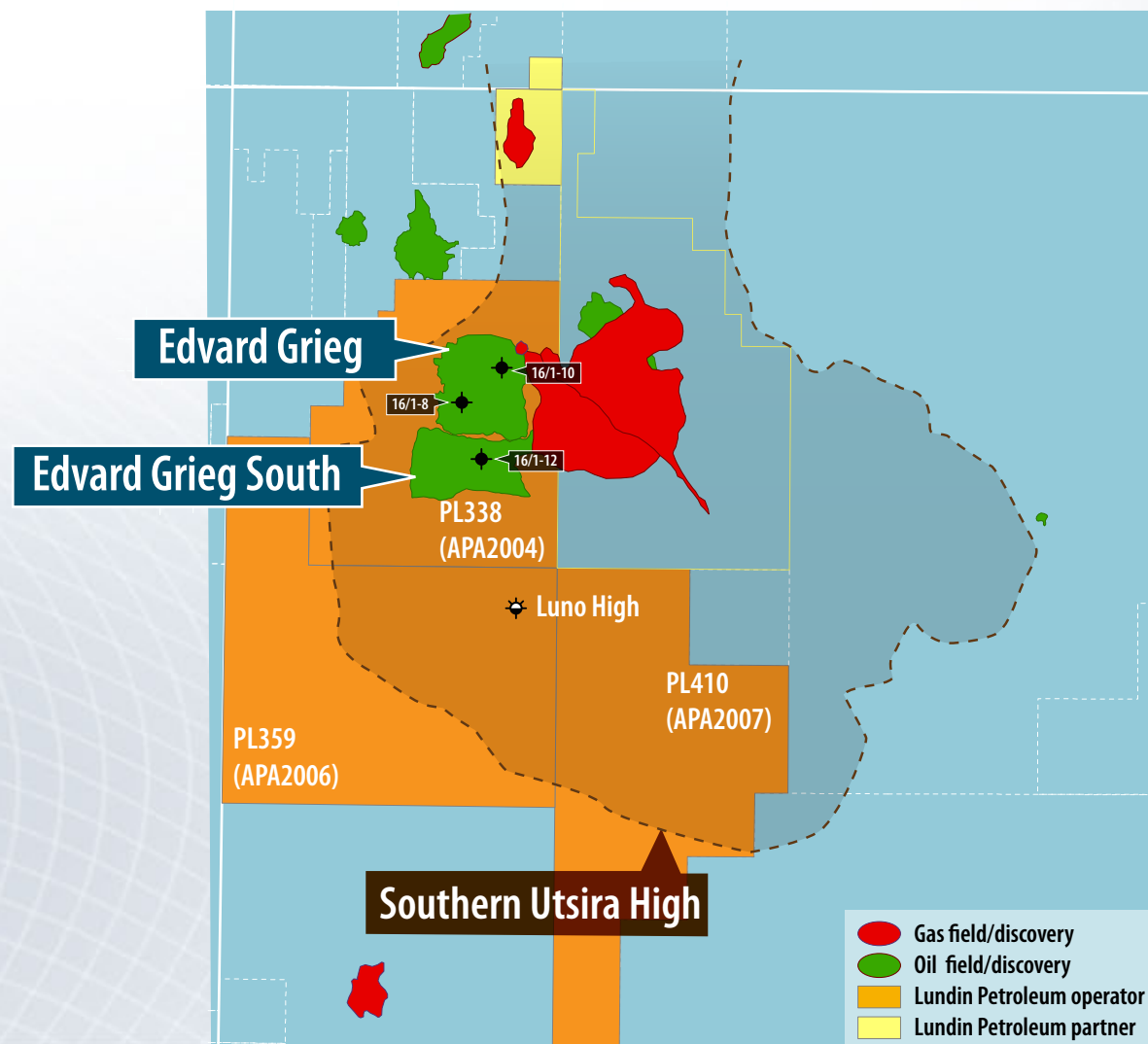
- Securing more acreage prior to drilling Luno exploration well



The Greater Luno Area



- ➔ Two exploration wells fail to find Jurassic reservoir
- ➔ Edvard Grieg South porous basement discovery



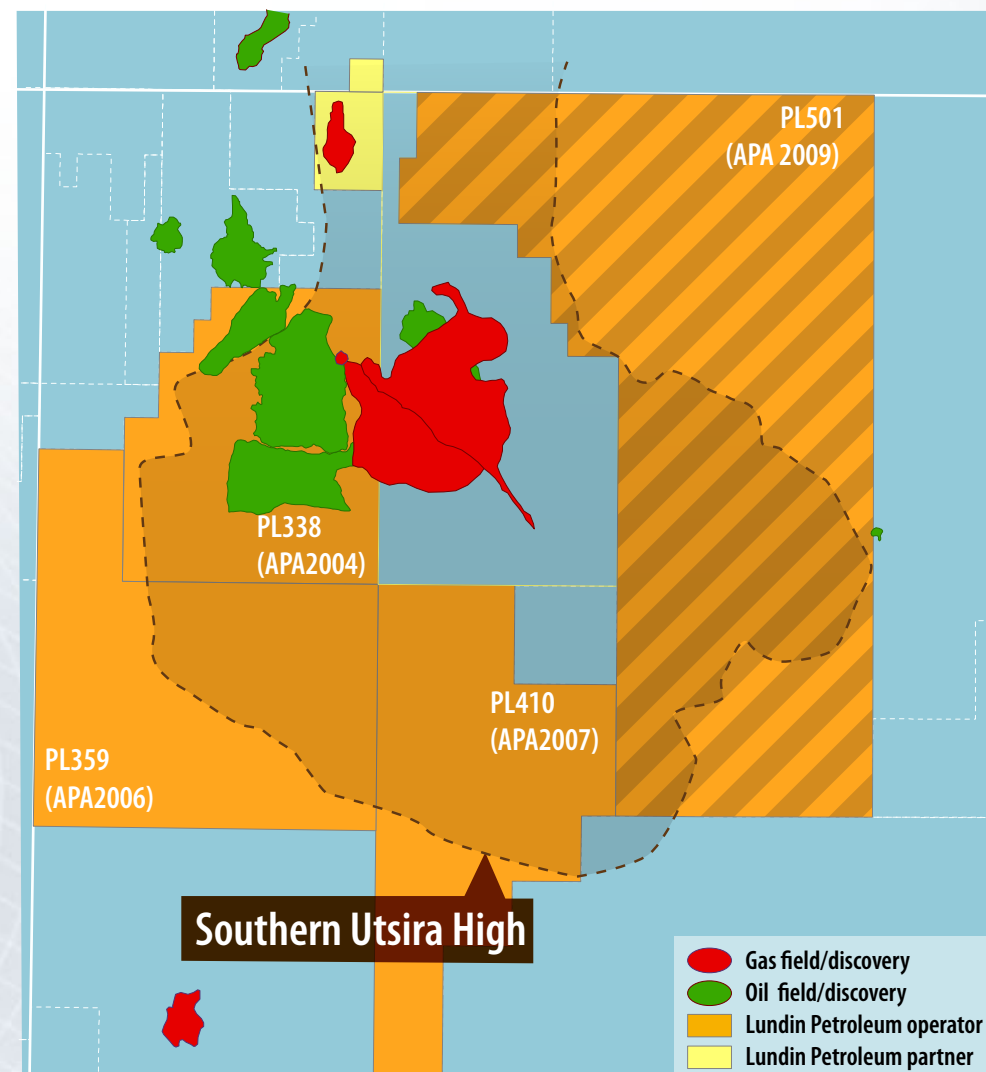
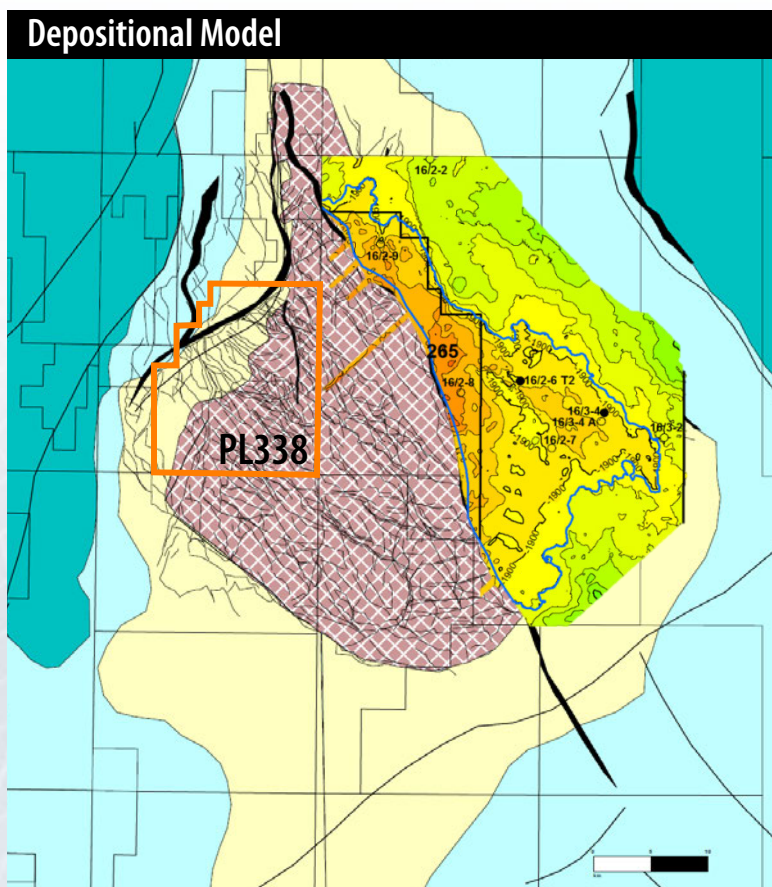
The Greater Luno Area



➔ Edvard Grieg discovery



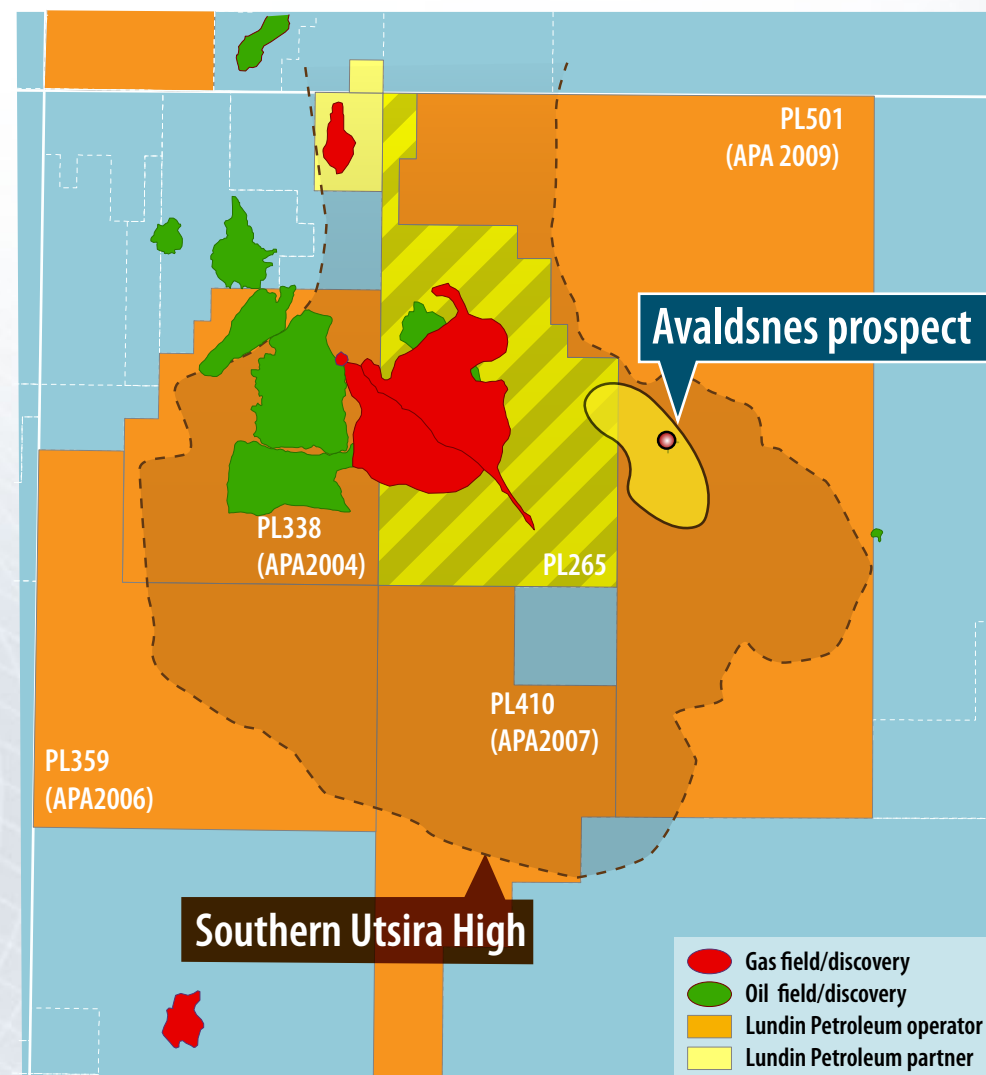
Catalyst to focus on eastern
side of Haugaland High



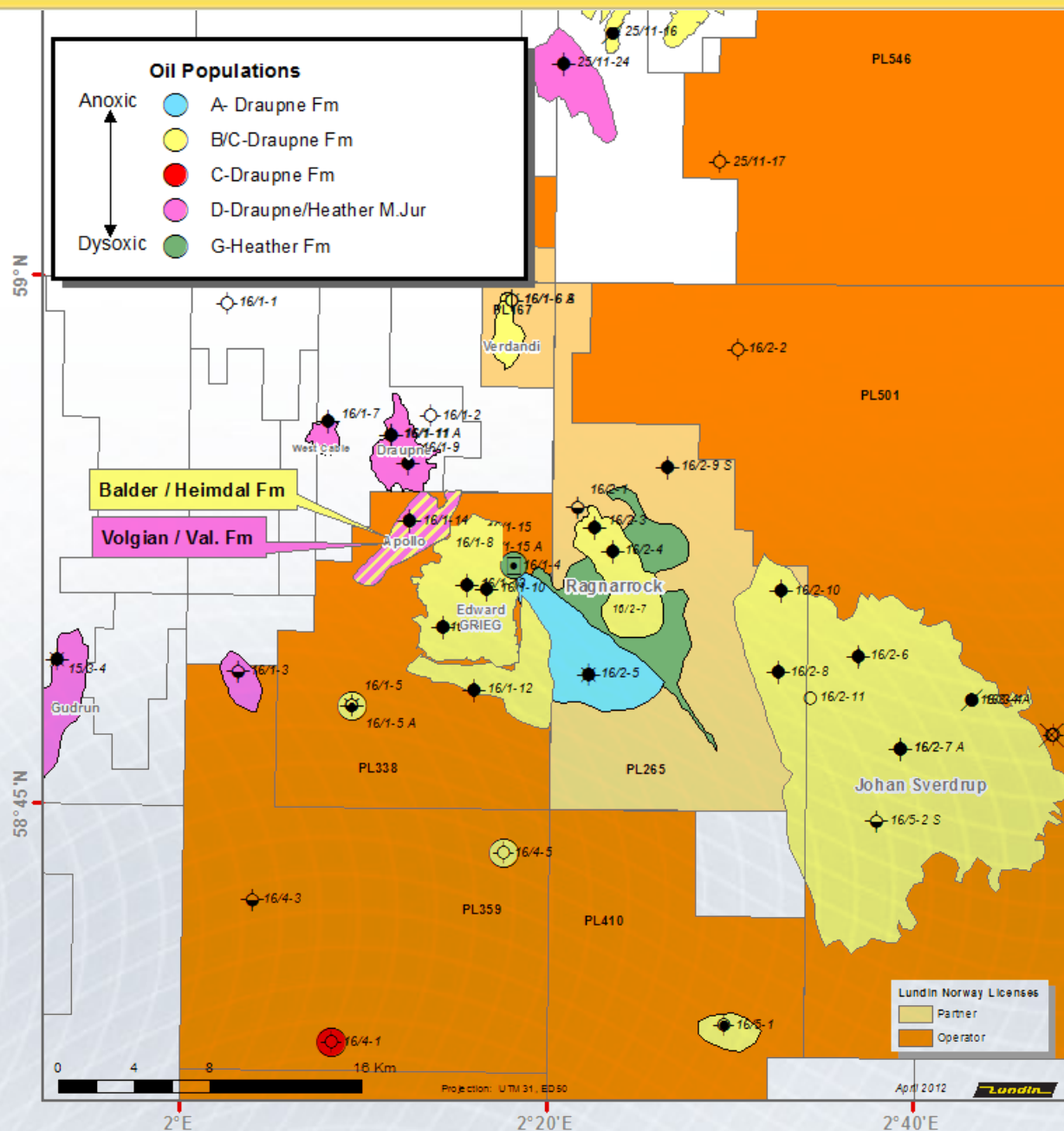
The Greater Luno Area



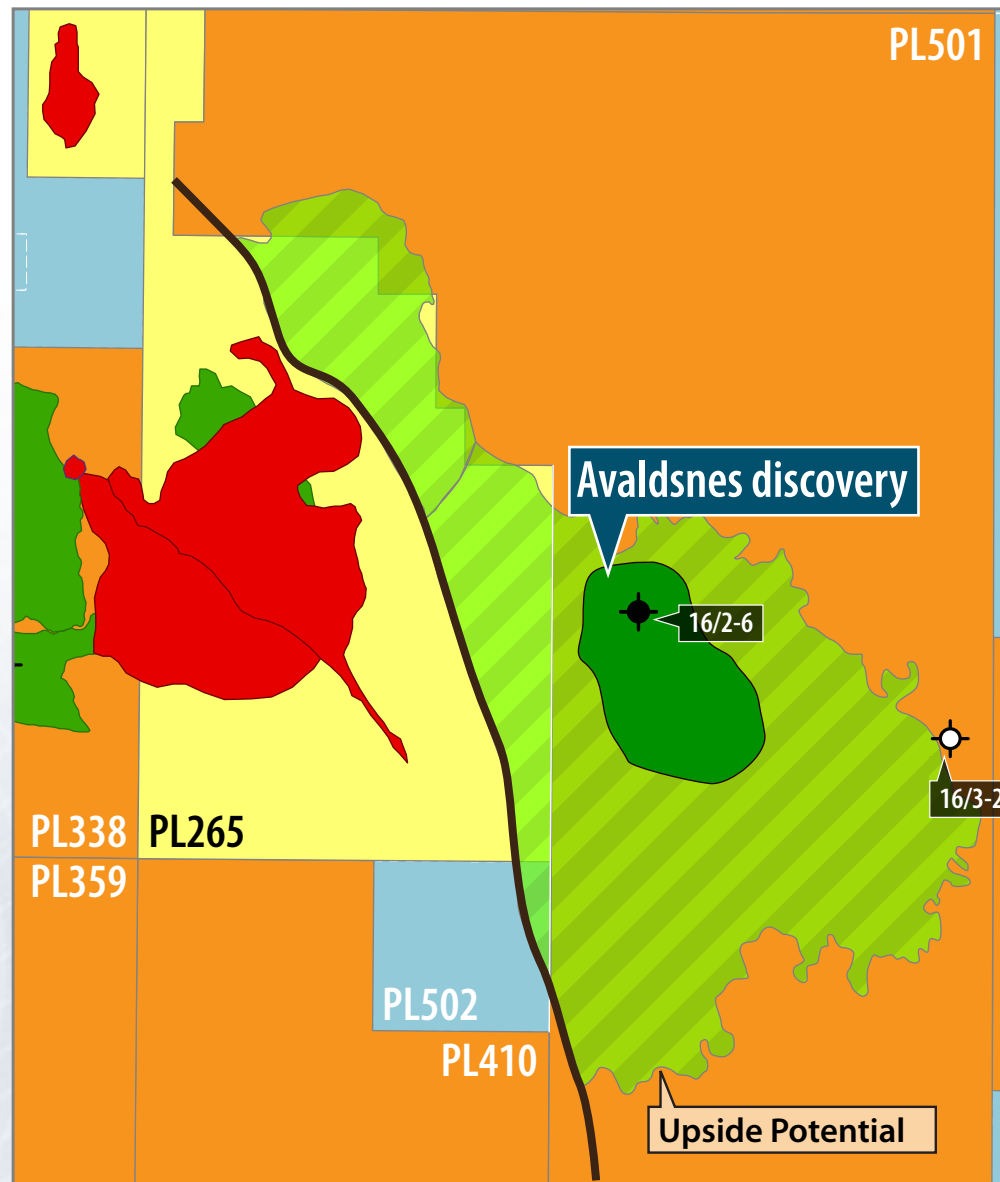
- Identified Avaldsnes prospect extends into PL265
- Acquired a 10 percent interest in PL265



Oil Population Analysis Essential for Charge History



Avaldsnes Discovery



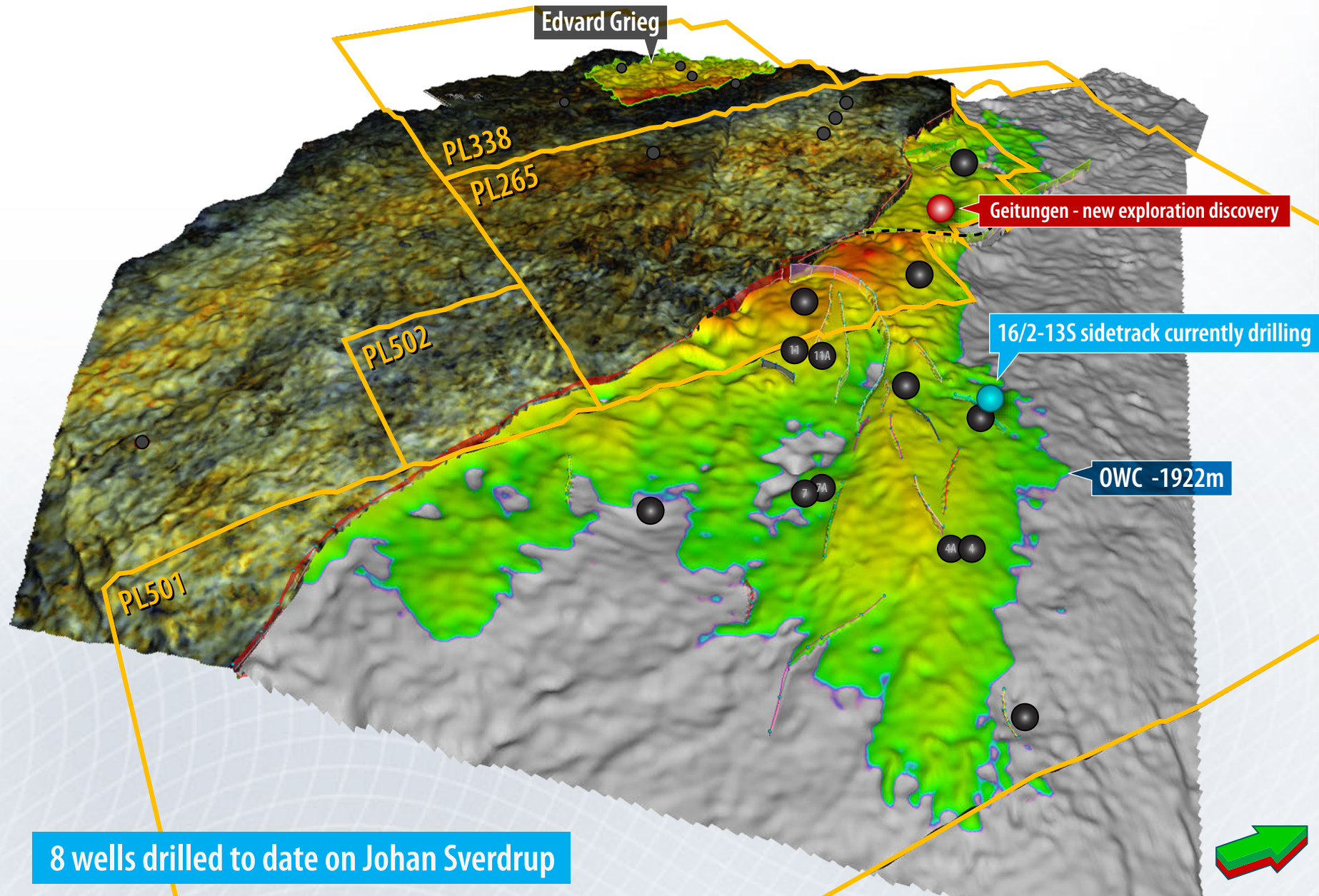
➔ Avaldsnes Discovery

- ➔ 100-400 Million barrels recoverable resources
- ➔ Exceptional DST result gained confidence in the discovery

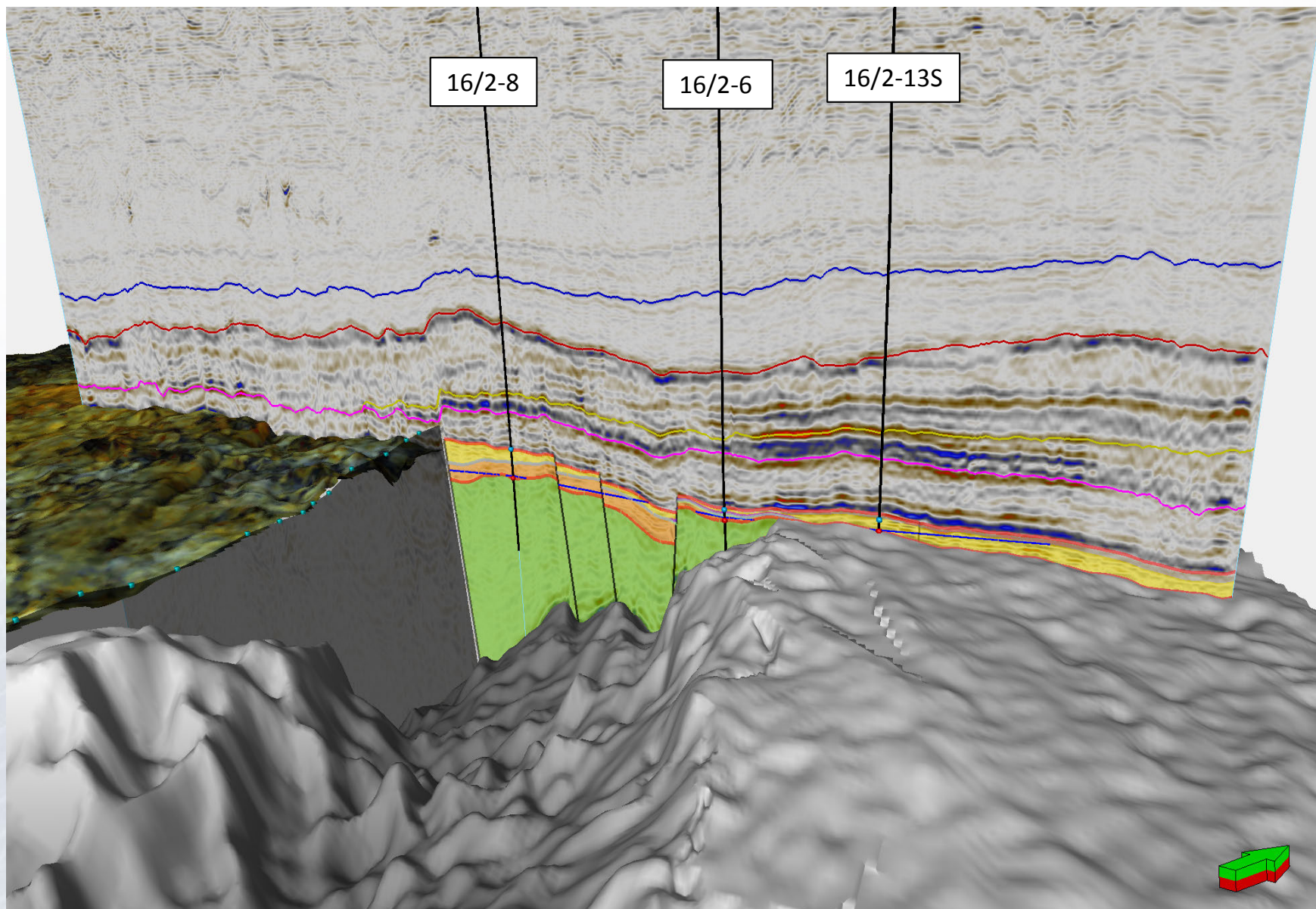
➔ Upside Potential

- ➔ 200 km² of closure
- ➔ Uncertainty of reservoir continuity and quality

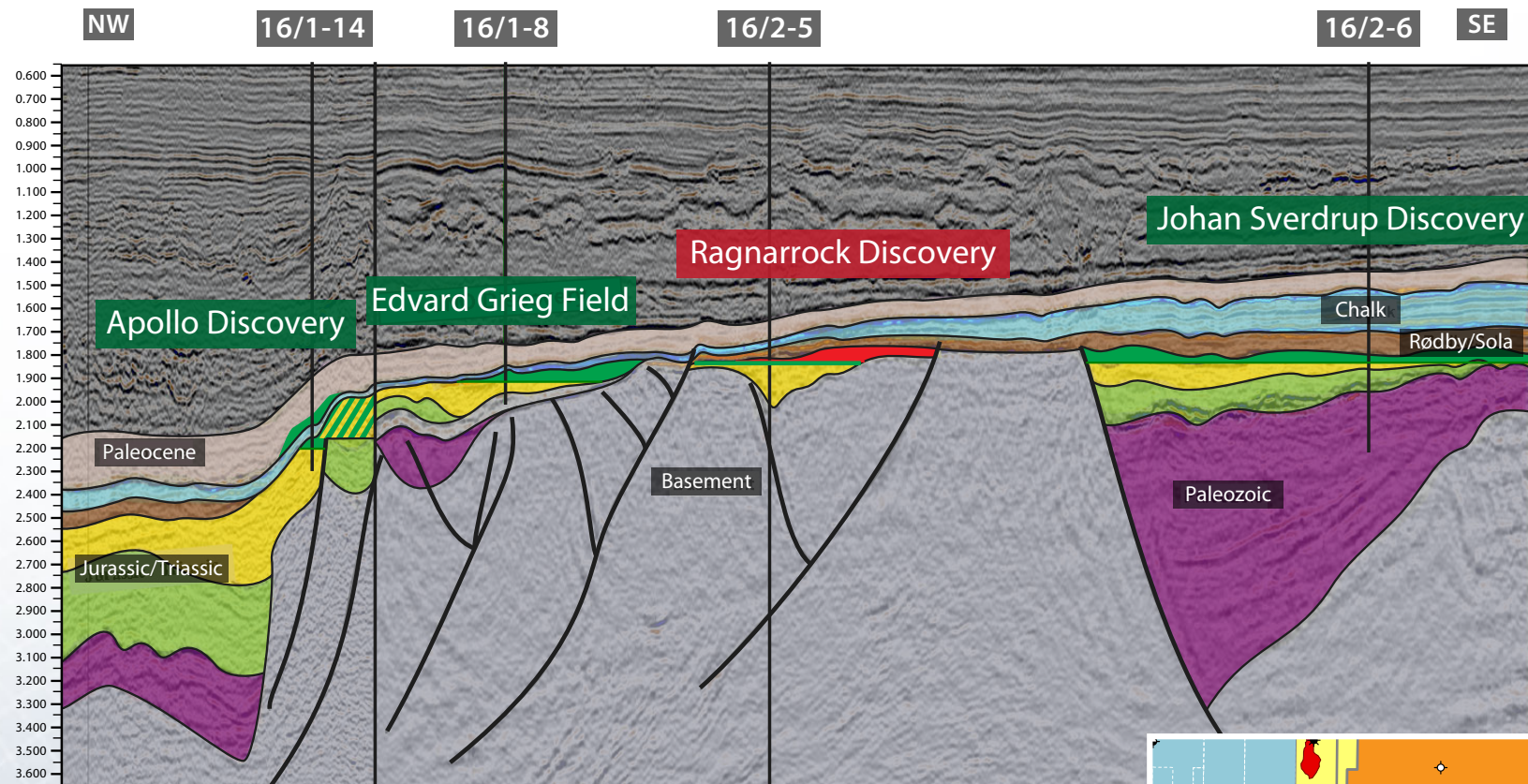
Johan Sverdrup - A New Giant in Norway



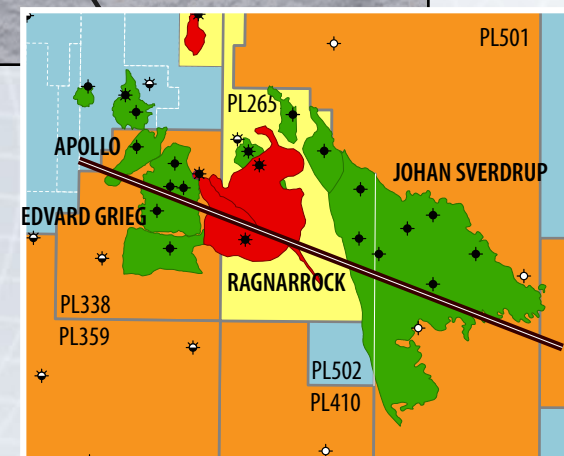
Johan Sverdrup Geological Model



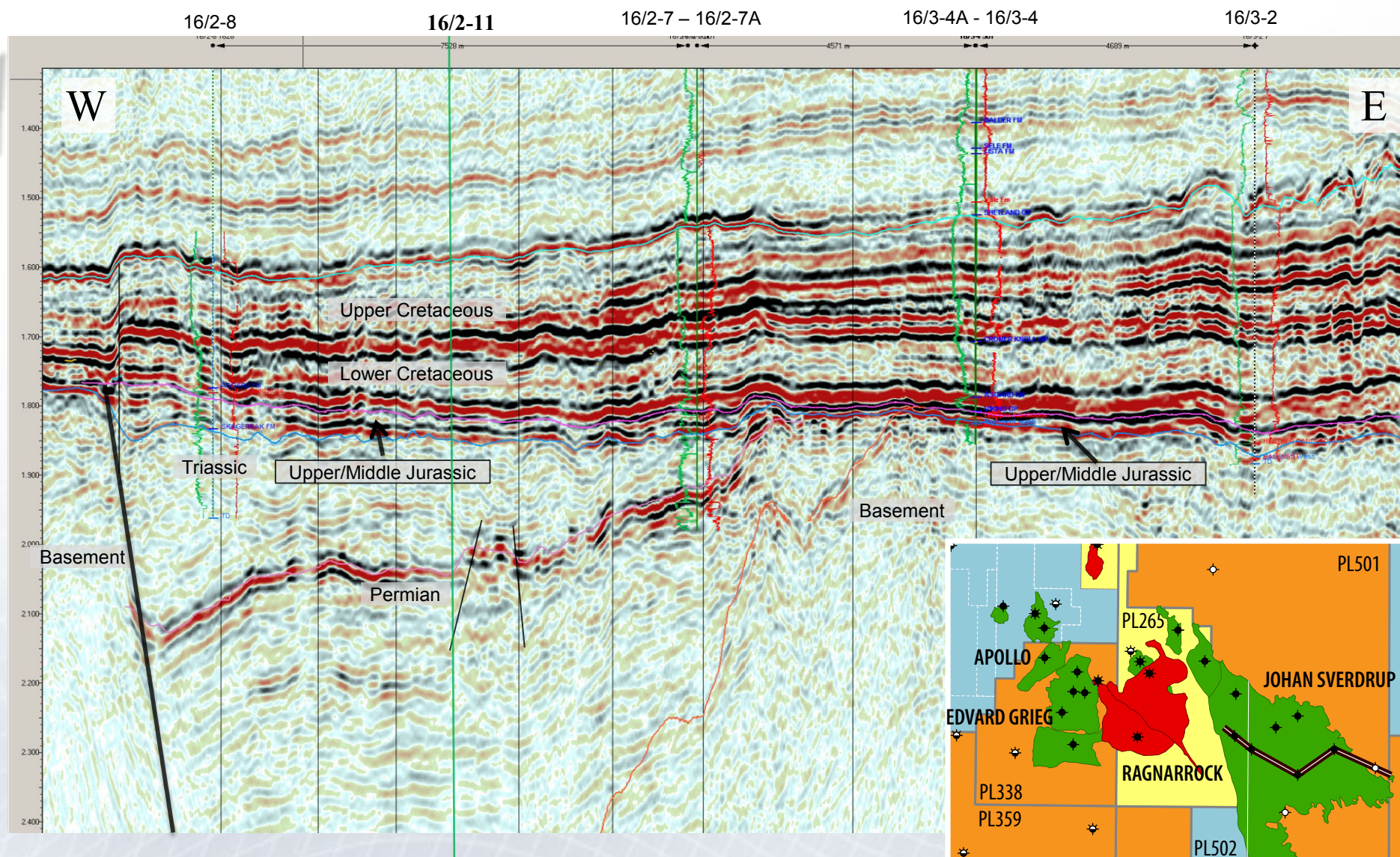
Discoveries on the Southern Utsira High



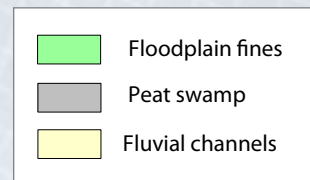
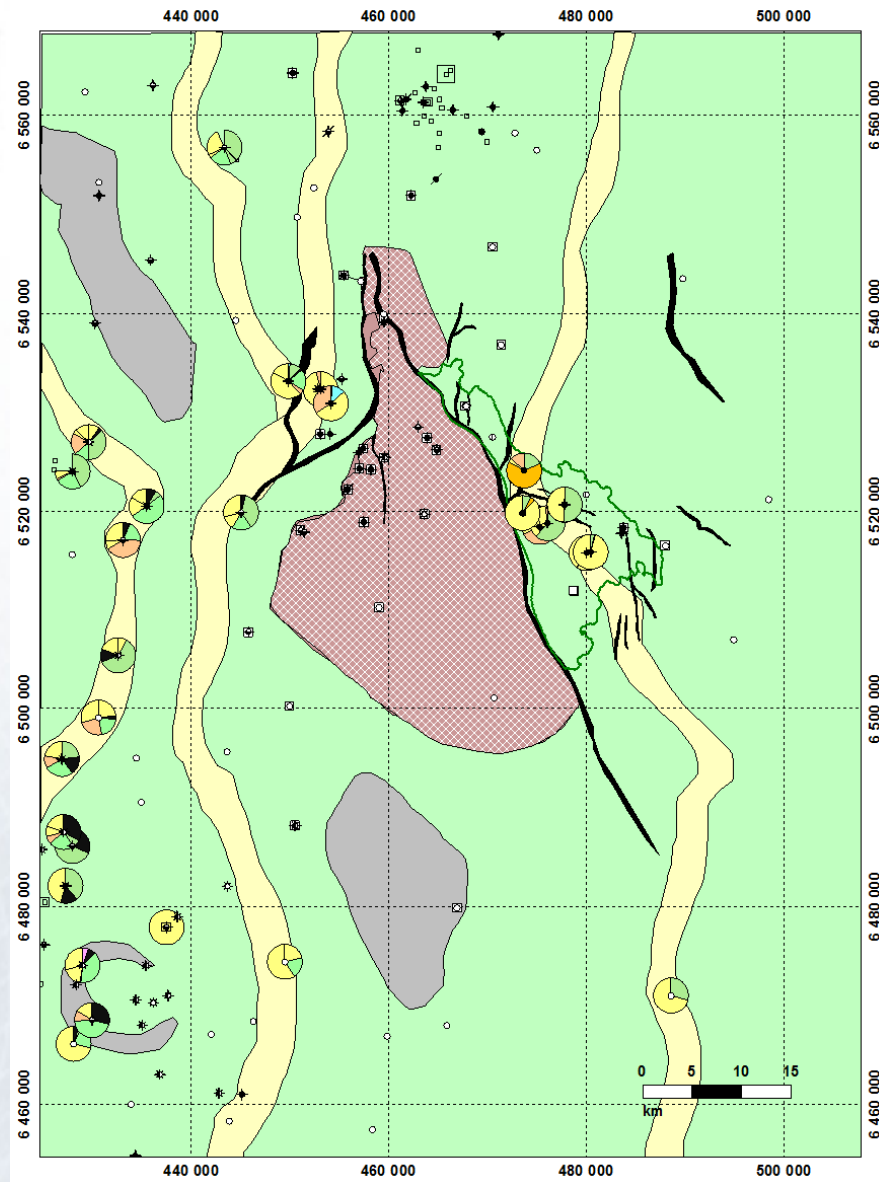
- Edvard Grieg , Johan Sverdrup and Apollo (Cretaceous) contain under-saturated non-biodegraded oil
- Main migration from 1.5 Ma to present day
- Several glacial-induced tilting has redistributed the oil across the high



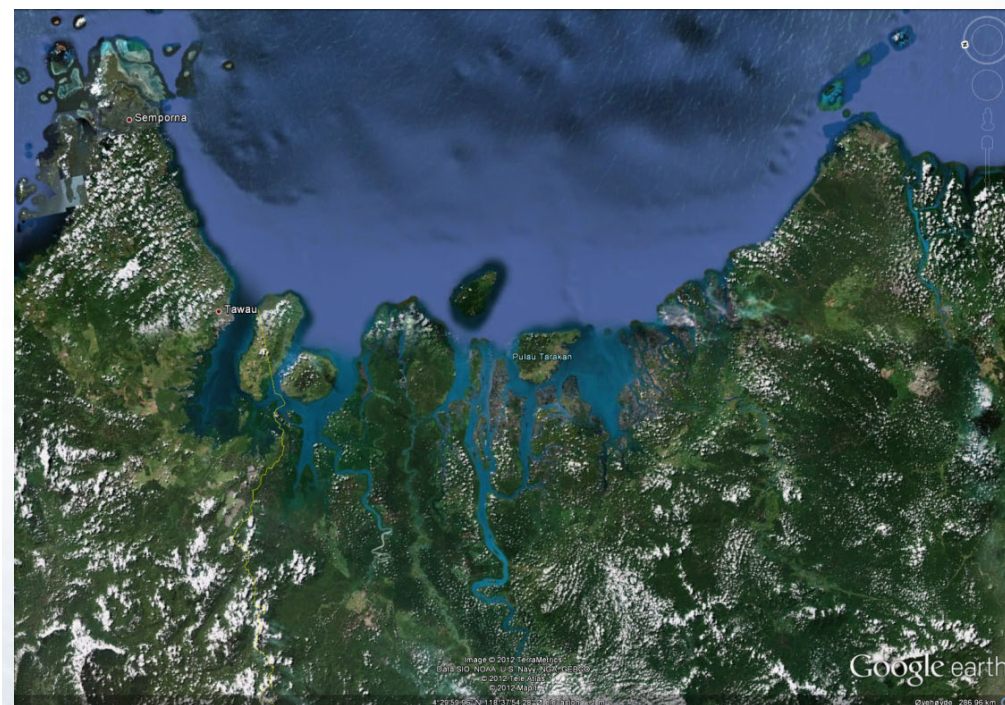
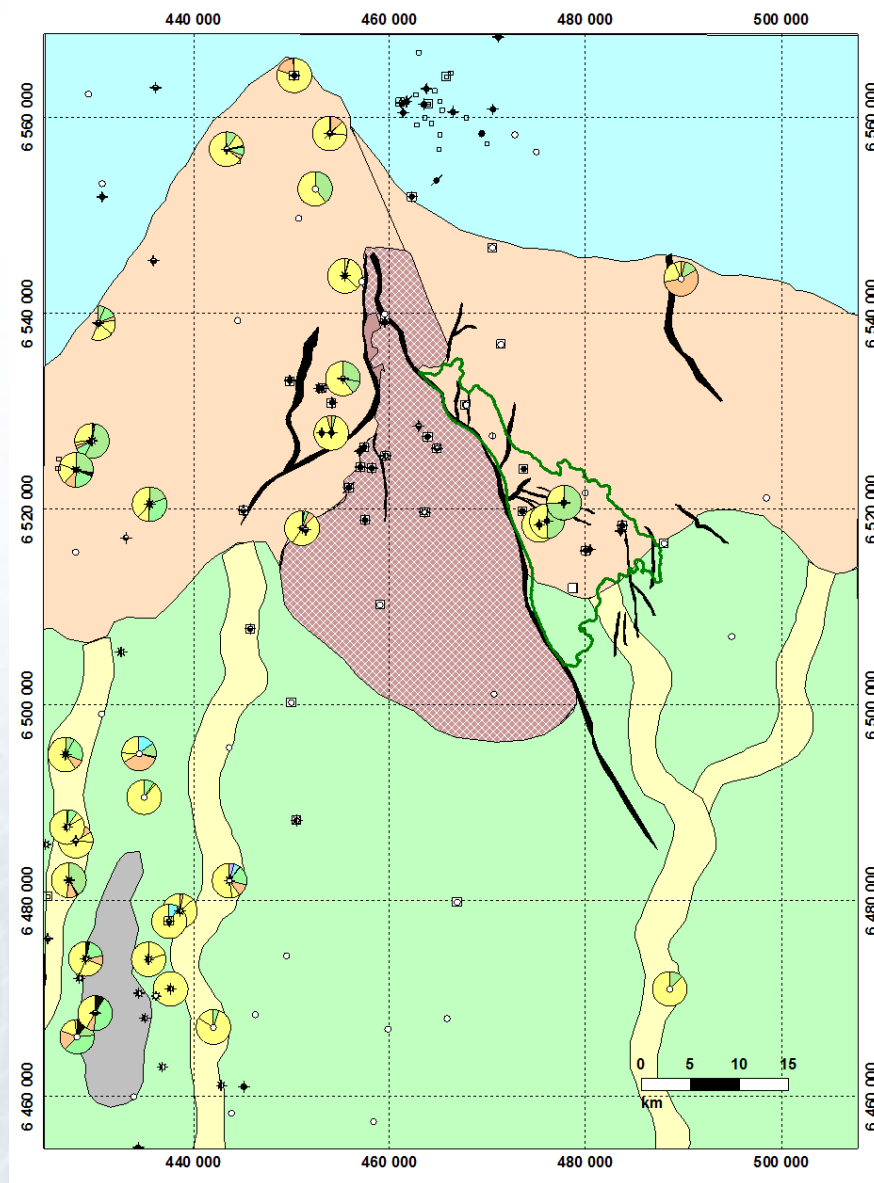
Seismic Cross Section through Johan Sverdrup



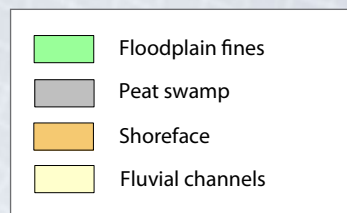
Middle Jurassic Sleipner Formation Palaeogeography



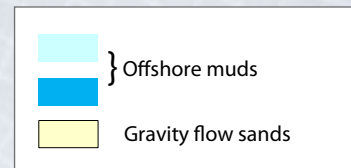
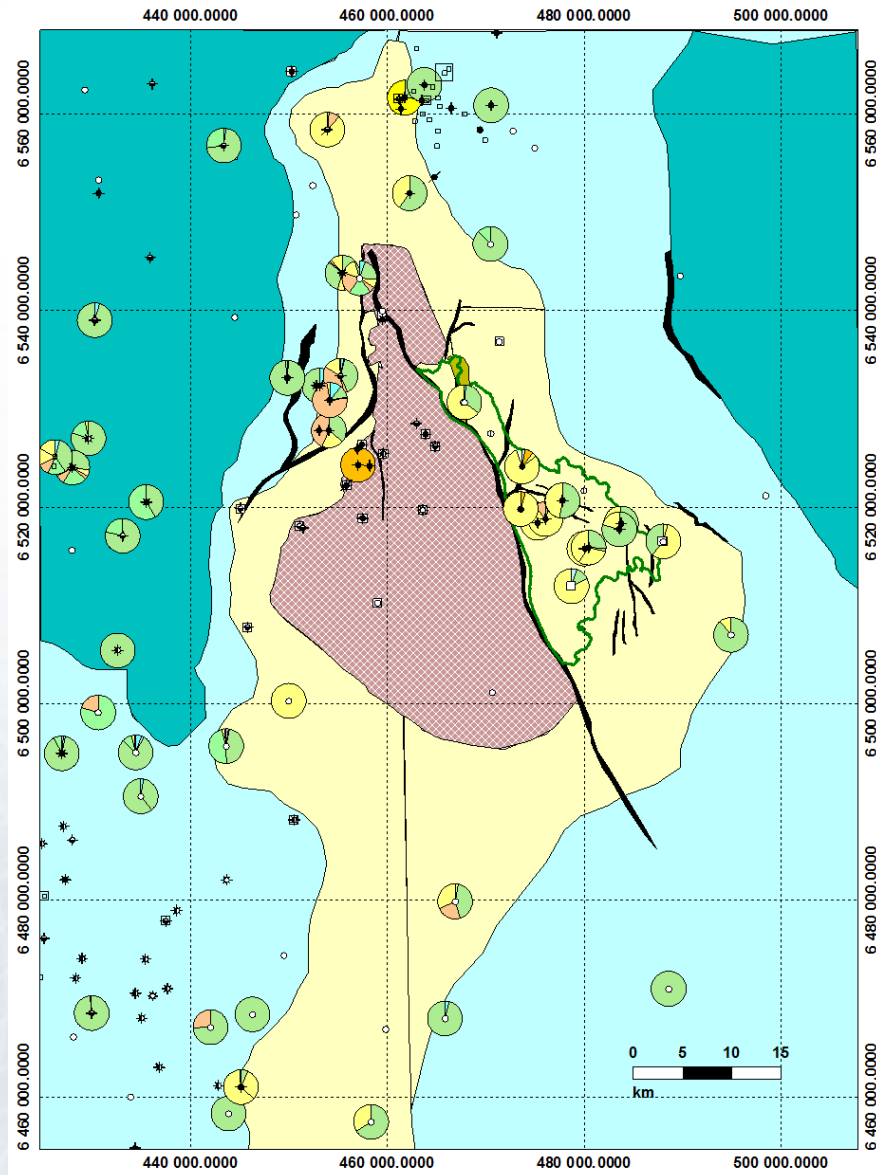
Middle Jurassic Hugin Formation Palaeogeography



Pulau Tarakan delta, eastern Borneo



Upper Jurassic Draupne Formation Palaeogeography



Johan Sverdrup Exploration and Delineation Drilling



➤ Exploration and delineation drilling:

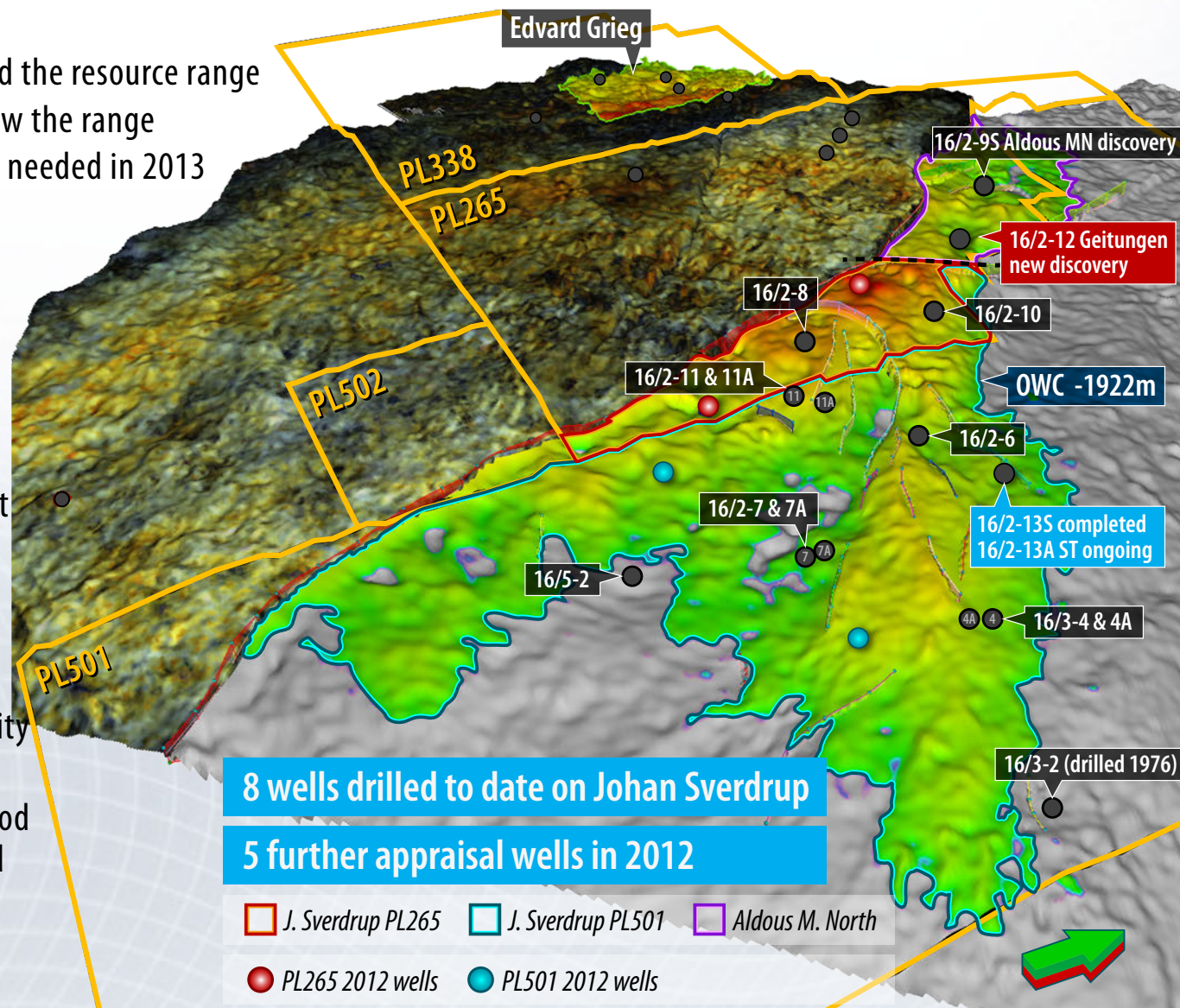
- ➔ Discovered by well 16/2-6 in 2010
- ➔ 6 delineation wells in 2011 unfolded the resource range
- ➔ Delineation wells in 2012 will narrow the range
- ➔ Additional delineation wells will be needed in 2013

➤ Results so far:

- ➔ Extremely good reservoir 28% porosity and 10-40 darcy permeability, Volgian reservoir sandstone overlying older Upper to Middle Jurassic good reservoir sandstone and weathered basement
- ➔ OWC varying between 1922 to 1935 m MSL

➤ Main reservoir uncertainties:

- ➔ Top reservoir depth reflecting velocity variations in overburden
- ➔ Thickness variation of extremely good reservoir versus good reservoir sand
- ➔ Reservoir wettability
- ➔ Variations in oil-water contacts
- ➔ Varying aquifer support



Subsurface Learning on the Southern Utsira High



➤ Play concept in 2004:

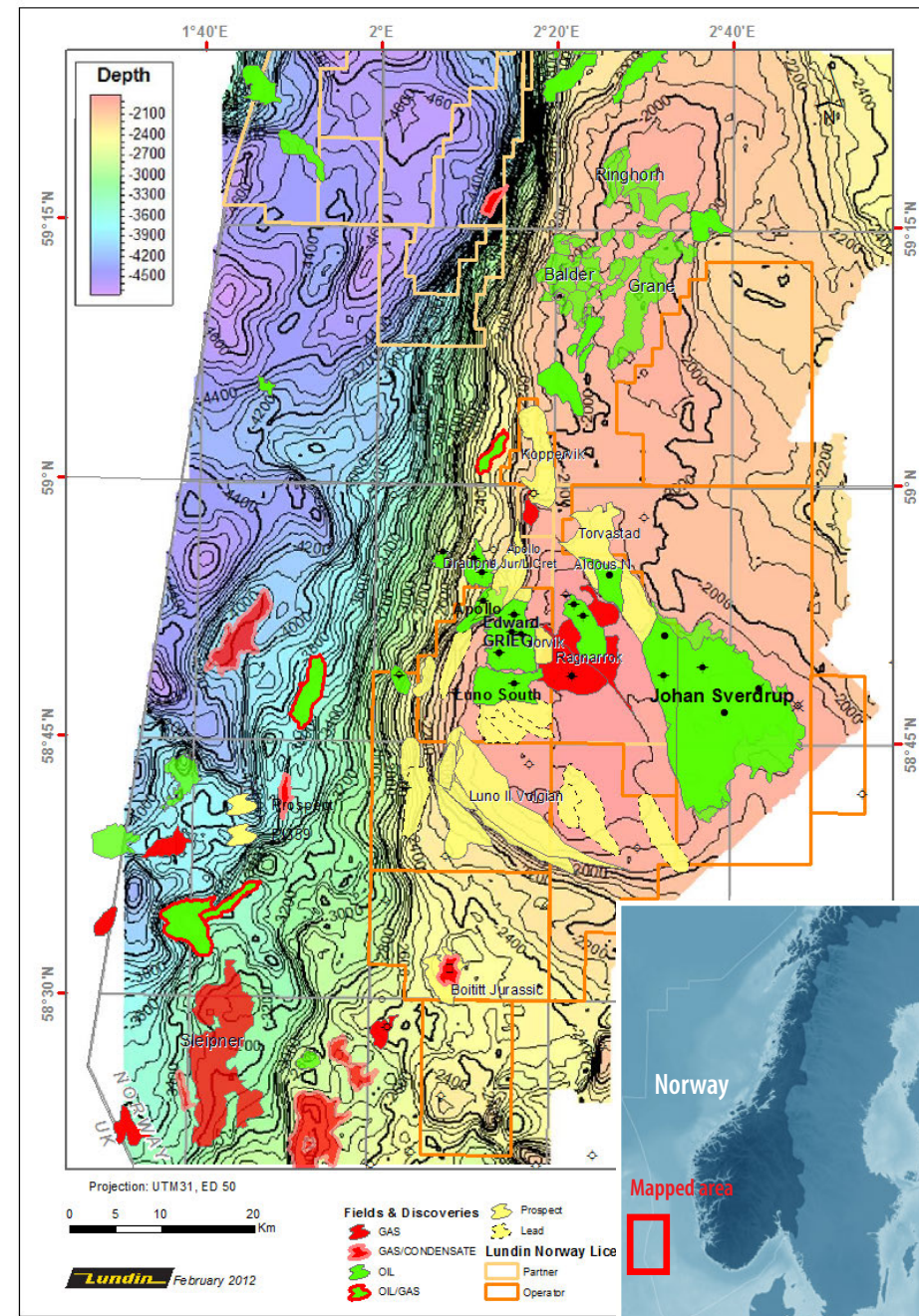
- ➔ Thin Jurassic sands over inlier basins and basement with a saturated system with a 40-50 m oil leg and a common OWC over the whole high
- ➔ Potential stratigraphic traps fringing the high in the west and southwest

➤ Results in 2012:

- ➔ Edvard Grieg proved the concept in 2007 and converted Johan Sverdrup to a low risk prospect (P45%)
- ➔ Apollo proved the concept in 2010

➤ Main learning:

- ➔ Light under-saturated oil flanking saturated oil and gas discovery
- ➔ Late migration of oil into Edvard Grieg and Johan Sverdrup
- ➔ Extreme to very good reservoir quality of the Upper Jurassic sands
- ➔ Producing oil in weathered basement in Tellus and Luno South



Summary - Seeing is Believing



- **The last years exploration effort by a diversity of subsurface-focused companies demonstrates that the decline in discoveries was not subsurface-based**
- **To release the exploration potential, companies with a fact-based knowledge creation culture are needed:**
 - ➔ Several integrated multicultural upstream companies
 - ➔ Cash flow to test the new concepts
 - ➔ Continuous balanced exploration is a must
 - ➔ Play models must include, but not be limited by facts
 - ➔ Investments in new technology
 - ➔ Hard core data sampling is a must (DST has proved very valuable)
 - ➔ Indirect data necessary, but never sufficient (core is core!)
 - ➔ Understand the ambiguity of DTMT
 - ➔ Integrate at highest possible entropy level

Recycling is a Key Word



➤ **Recycling licences**

- ➔ Utsira area licences are 4th generation exploration. Majors have been in the area from 1965

➤ **Recycle play models**

- ➔ Similar licence clusters have been established on NCS prior to drilling at inverted Jurassic high settings

Recycle wells and seismic

- ➔ All relevant exploration wells are internally reinvestigated for biostratigraphic rezonation and hydrocarbon system analysis using newest technology available
- ➔ Seismic is routinely reprocessed internally or externally for improved image. New data acquired where necessary.

Recycling people

- ➔ Industry mergers and acquisitions like Saga/Hydro/Statoil provide recruitment base for opportunistic organisations getting the right people
- ➔ Success is attractive

Summary - Seeing is Believing

Lundin



Disclaimer



This information has been made public in accordance with the Securities Market Act (SFS 2007:528) and/or the Financial Instruments Trading Act (SFS 1991:980).

Forward-Looking Statements

Certain statements made and information contained herein constitute "forward-looking information" (within the meaning of applicable securities legislation). Such statements and information (together, "forward-looking statements") relate to future events, including the Company's future performance, business prospects or opportunities. Forward-looking statements include, but are not limited to, statements with respect to estimates of reserves and/or resources, future production levels, future capital expenditures and their allocation to exploration and development activities, future drilling and other exploration and development activities. Ultimate recovery of reserves or resources are based on forecasts of future results, estimates of amounts not yet determinable and assumptions of management.

All statements other than statements of historical fact may be forward-looking statements. Statements concerning proven and probable reserves and resource estimates may also be deemed to constitute forward-looking statements and reflect conclusions that are based on certain assumptions that the reserves and resources can be economically exploited. Any statements that express or involve discussions with respect to predictions, expectations, beliefs, plans, projections, objectives, assumptions or future events or performance (often, but not always, using words or phrases such as "seek", "anticipate", "plan", "continue", "estimate", "expect", "may", "will", "project", "predict", "potential", "targeting", "intend", "could", "might", "should", "believe" and similar expressions) are not statements of historical fact and may be "forward-looking statements". Forward-looking statements involve known and unknown risks, uncertainties and other factors that may cause actual results or events to differ materially from those anticipated in such forward-looking statements. No assurance can be given that these expectations and assumptions will prove to be correct and such forward-looking statements should not be relied upon. These statements speak only as on the date of the information and the Company does not intend, and does not assume any obligation, to update these forward-looking statements, except as required by applicable laws. These forward-looking statements involve risks and uncertainties relating to, among other things, operational risks (including exploration and development risks), production costs, availability of drilling equipment, reliance on key personnel, reserve estimates, health, safety and environmental issues, legal risks and regulatory changes, competition, geopolitical risk, and financial risks. These risks and uncertainties are described in more detail under the heading "Risks and Risk Management" and elsewhere in the Company's annual report. Readers are cautioned that the foregoing list of risk factors should not be construed as exhaustive. Actual results may differ materially from those expressed or implied by such forward-looking statements. Forward-looking statements are expressly qualified by this cautionary statement.

Reserves and Resources

Unless otherwise stated, Lundin Petroleum's reserve and resource estimates are as at 31 December 2011, and have been prepared and audited in accordance with National Instrument 51-101 Standards of Disclosure for Oil and Gas Activities ("NI 51-101") and the Canadian Oil and Gas Evaluation Handbook ("COGE Handbook"). Unless otherwise stated, all reserves estimates contained herein are the aggregate of "Proved Reserves" and "Probable Reserves", together also known as "2P Reserves". For further information on reserve and resource classifications, see "Reserves and Resources" in the Company's annual report.

Contingent Resources

Contingent Resources are those quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations using established technology or technology under development, but are not currently considered to be commercially recoverable due to one or more contingencies. Contingencies may include factors such as economic, legal, environmental, political and regulatory matters or a lack of markets. There is no certainty that it will be commercially viable for the Company to produce any portion of the Contingent Resources.

Prospective Resources

Prospective Resources are those quantities of petroleum estimated, as of a given date, to be potentially recoverable from undiscovered accumulations by application of future development projects. Prospective Resources have both a chance of discovery and a chance of development. There is no certainty that any portion of the Prospective Resources will be discovered. If discovered, there is no certainty that it will be commercially viable to produce any portion of the Prospective Resources.

BOEs

BOEs may be misleading, particularly if used in isolation. A BOE conversion ratio of 6 Mcf : 1 Bbl is based on an energy equivalency conversion method primarily applicable at the burner tip and does not represent a value equivalency at the wellhead.



Thank You !

*Piet Hein, Danish mathematician
"To know what thou knowest not is in essence omniscience"*