16/1-A-3: a multi-lateral well designed to maximize the drainage of challenging reservoir types (Edvard Grieg Field, PL 338)

Ophélie Durand, Aker BP

On behalf of the Edvard Grieg Reservoir Development Team

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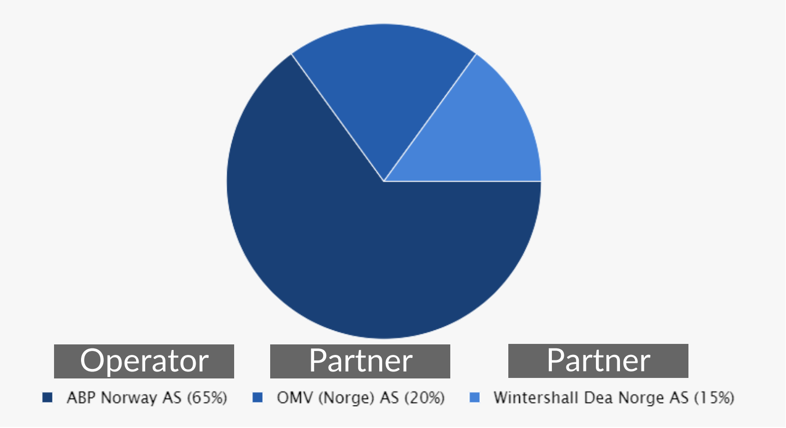
Agenda

- Edvard Grieg Field introduction
- Objectives of 16/1-A-3 and reservoir types
- Results
- Conclusion

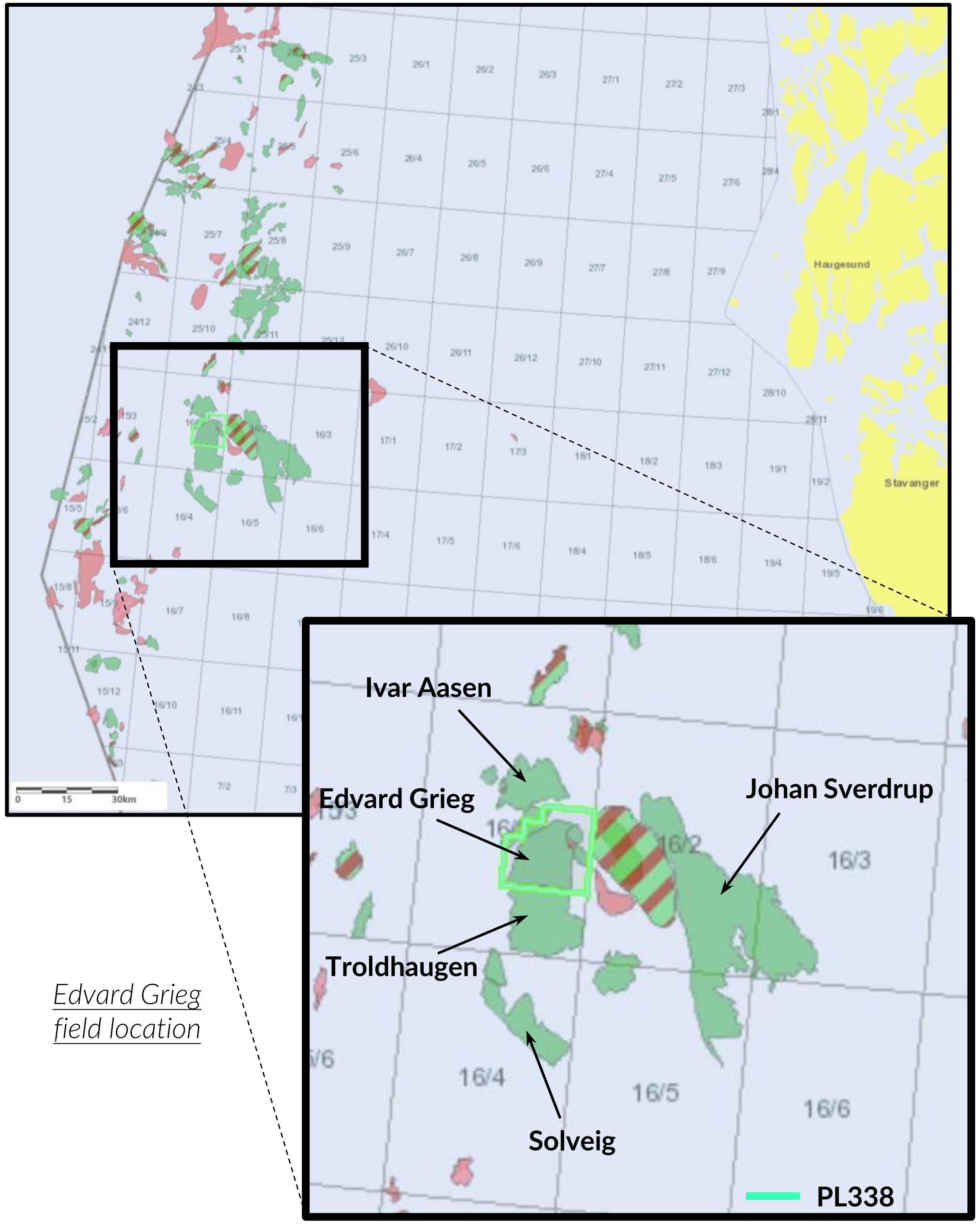
Edvard Grieg Field introduction

General information

- Oil field discovered in 2007 with the well 16/1-8 (PL338)
- Production started in November 2015
- Platform with full processing, 20 well slots and tie-in of the Ivar Aasen platform and the subsea fields Solveig and Troldhaugen



Partnership on PL338



Edvard Grieg field location

(Source: NPD website)

Edvard Grieg Field Status

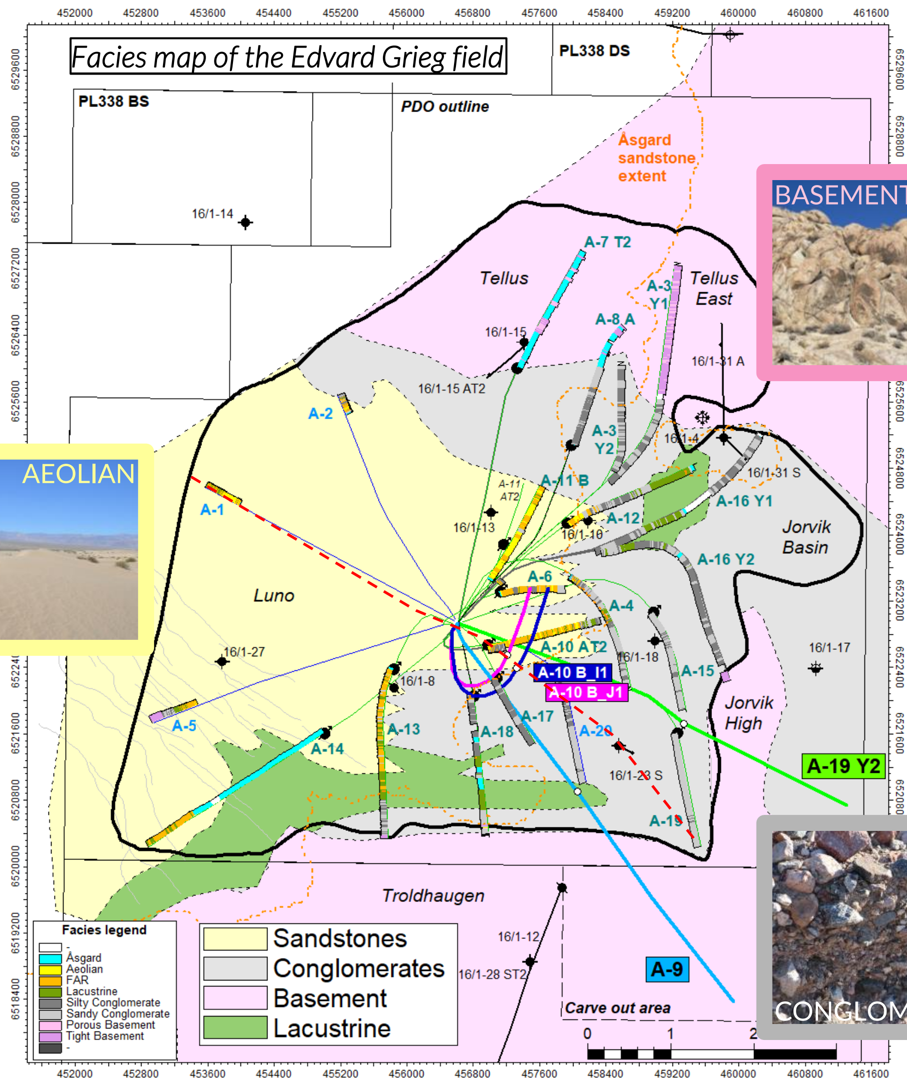
Mature field with various reservoir types

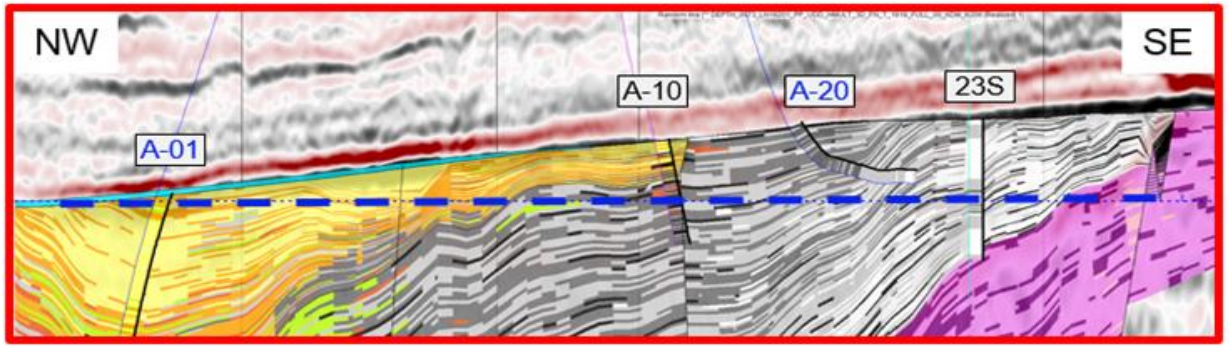
Edvard Grieg is a mature field:

- 17 operational production wells
- 4 injectors

Variations in Geology → large variations in well potential

- Sand PI (Production Index): 200 – 1000 $Sm^3/d/bar$
- Conglomerate PI: 5 - 100 $Sm^3/d/bar$
- Basement PI: 5 - 50 $Sm^3/d/bar$ (high uncertainty)





NW-SE cross section displaying the 2020 model

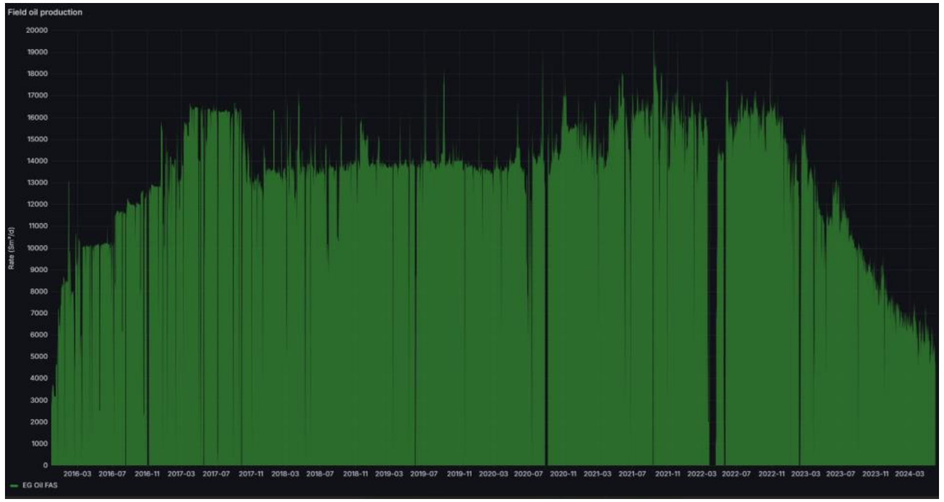
Production decline reduction

Aker BP has been successful in drilling Improved Oil Recovery (IOR) campaigns to increase reserves on the Edvard Grieg field and reduce the production decline.

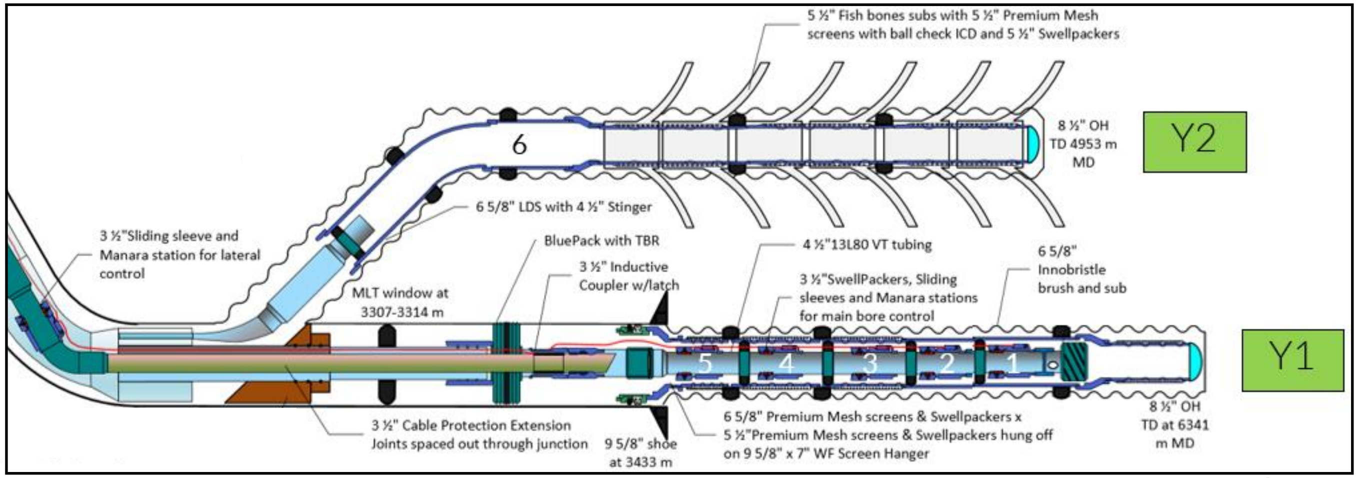
Innovation is key to achieve this objective.

The well 16/1-A-3 is the perfect example of this strategy:

- Long multi-lateral (MLT) well in marginal reservoirs with low reservoir properties, co-producing conglomerates and basement,
- Innovation in implementing the first Manara system in Aker BP on a MLT well to allow for zonal control combined with fishbones completion on the second branch.



Production history of Edvard Grieg



Lower completion of 16/1-A-3

16/1-A-3: Objectives & reservoir types

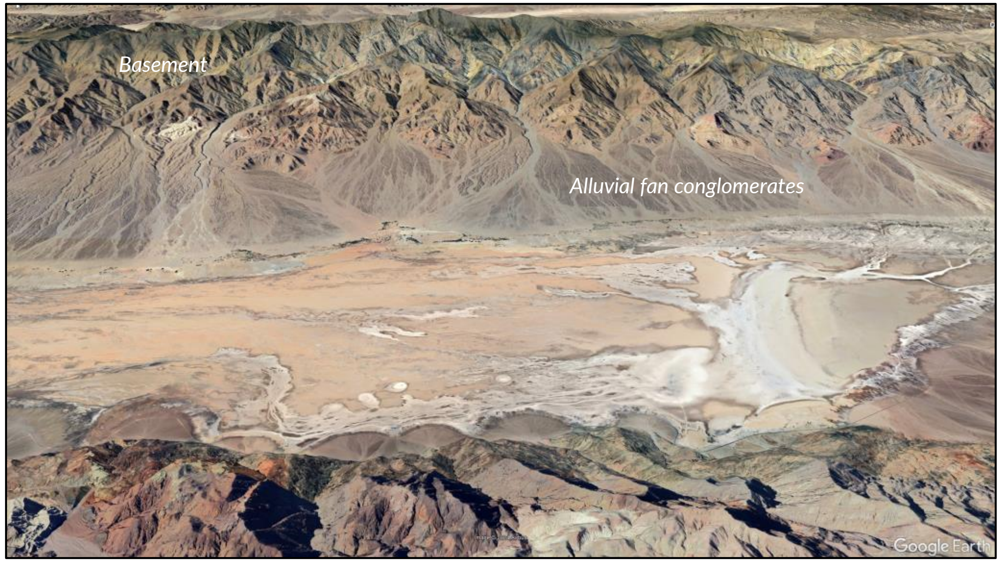
16/1-A-3 Objectives

Objective:

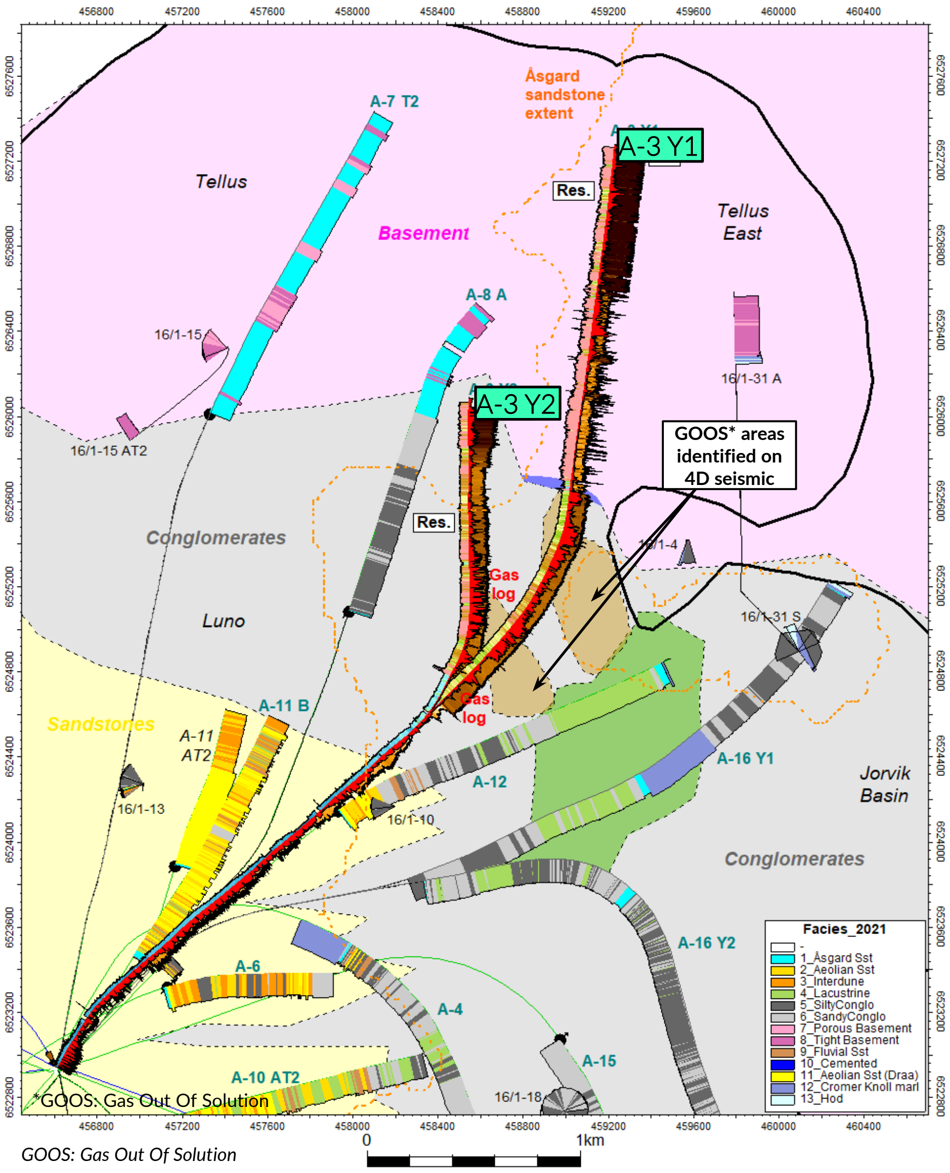
Extend the Edvard Grieg plateau and increase reserves by producing hydrocarbons from:

- Basement in Tellus East (Main objective of Y1)
- Alluvial fan conglomerates in Luno North

Horizontal Multi-Lateral Well



View from Dantes View (Death Valley, USA) over the hanging wall Basement and Alluvial fans conglomerates



Map of the Edvard Grieg field zoomed on the A-3 MLT well

Unconventional reservoirs

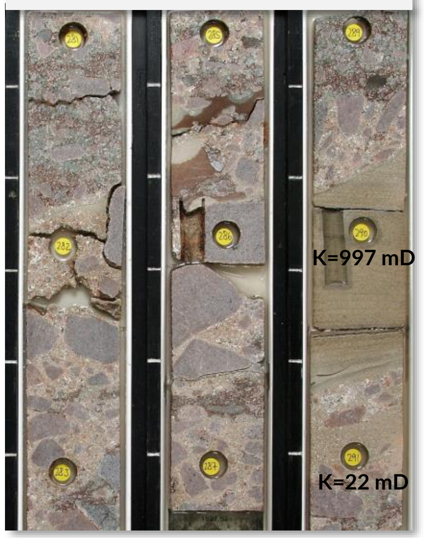
Conglomerates variability & Fishbones solution

2 types of conglomerates

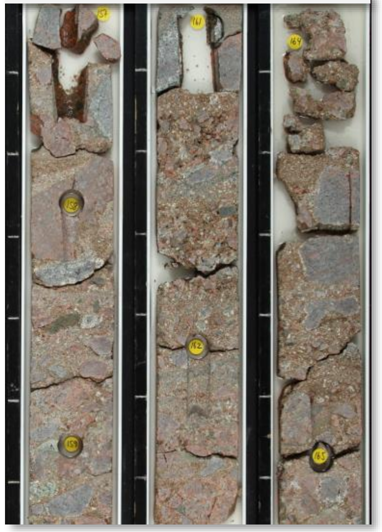
The probability of having more silty-matrix conglomerates in 16/1-A-3 led to planning a fishbone completion in the branch Y2:

- It would increase the effective wellbore radius and the distribution of the production
- Test the technology for further development of low productive conglomerates

16/1-13: Silty conglomerate with sand lenses



16/1-18: Sandy conglomerate

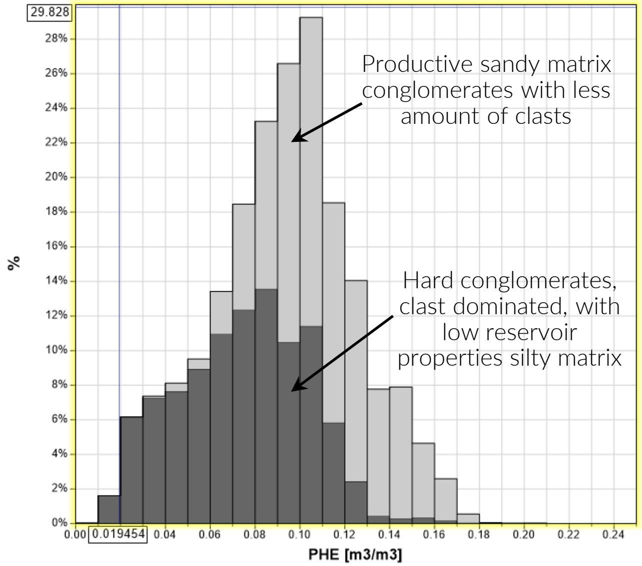


16/1-31 S: porous matrix conglomerate, clast

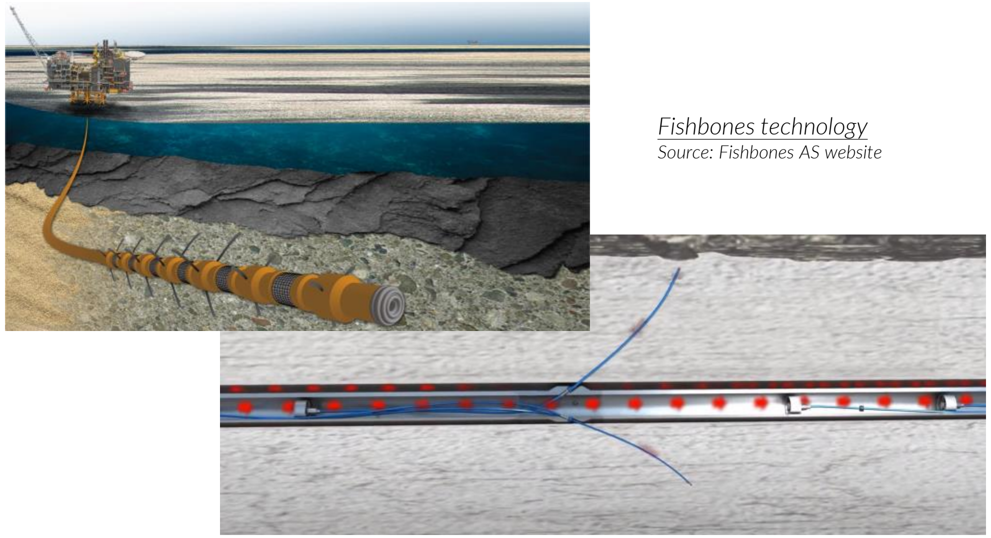
Core pictures of Edvard Grieg conglomerates

Average porosity (NMR-phie)
Sandy conglo: ~11-12 % / Silty conglo: ~7.5 %

NMR measurements are key in such facies



Variability of porosity in silty vs sandy matrix conglomerates over Edvard Grieg



Fishbones technology
Source: Fishbones AS website

Fishbones assembly design

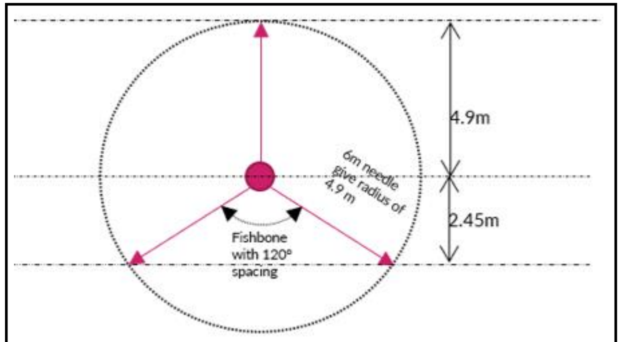
Maximum length of the Fishbone needles inside the screens is 9 meters

- Limited by the distance between ICD check housing and Fishbones sub
- Length of 3 needles: 7.5 – 9 m

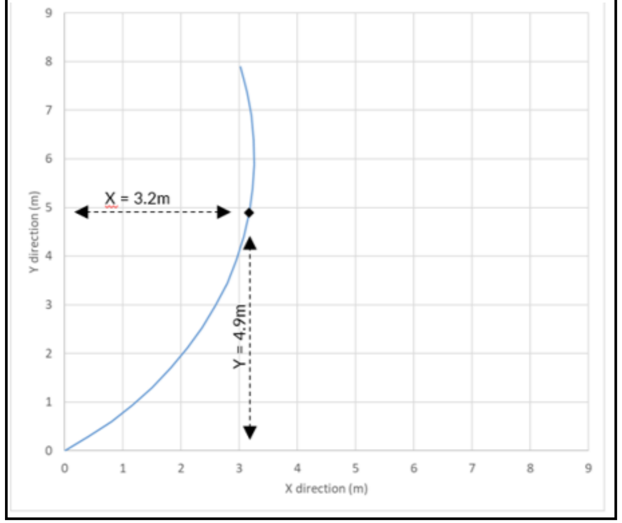
Length of Fishbones in reservoir is 6 m on average

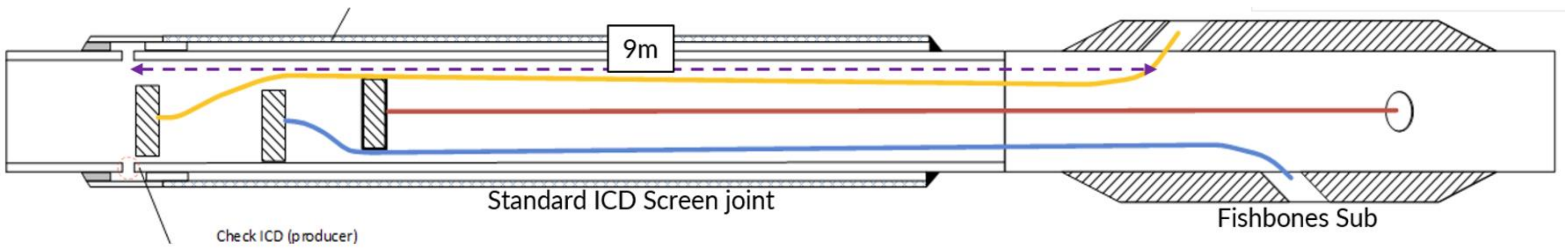
120° spacing of needles

Safe distance to base Åsgard sandstones to be kept in order to drain the low permeability conglomerates only and not the high permeable excellent bioclastic sandstones that could overlay the conglomerates.

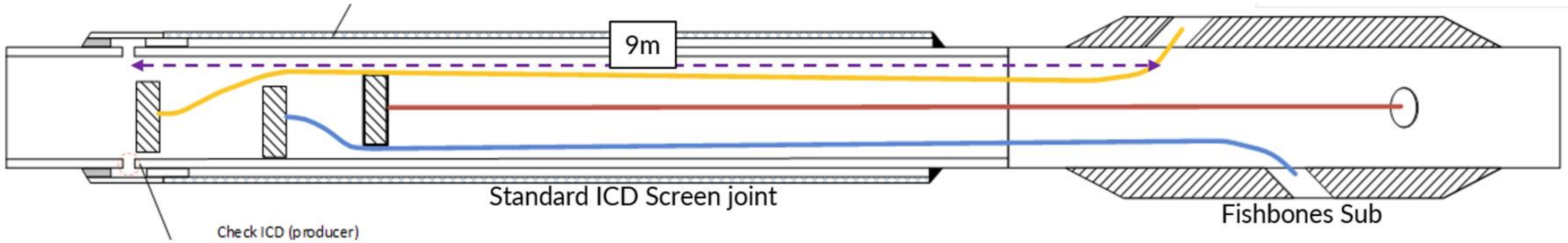


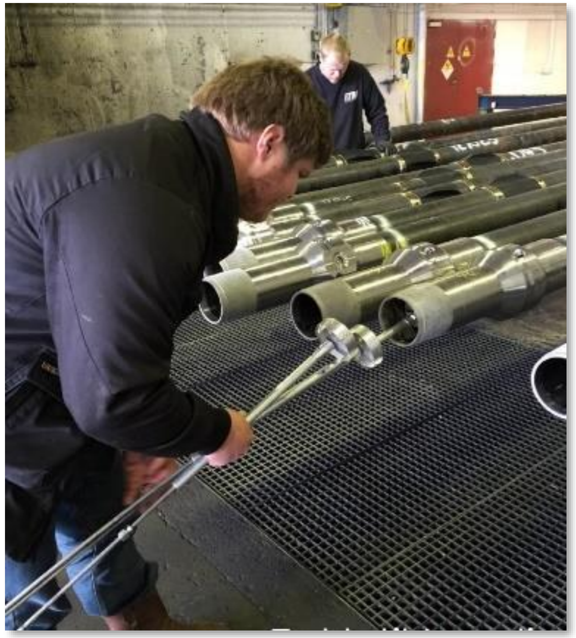
Fishbones needle trajectory





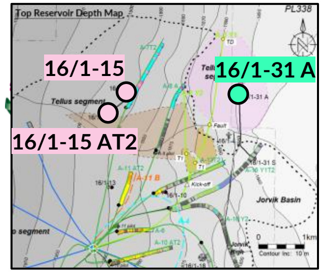
Fishbones drilling





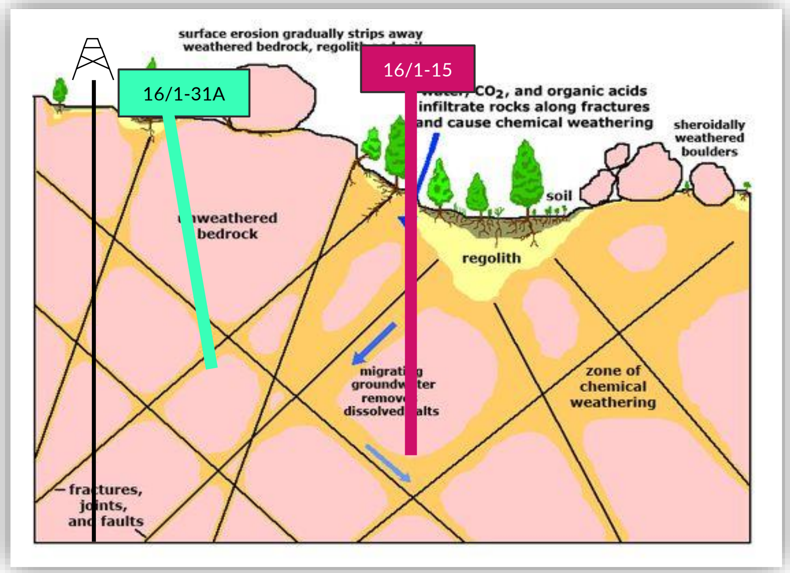
Unconventional reservoirs

Basement variability



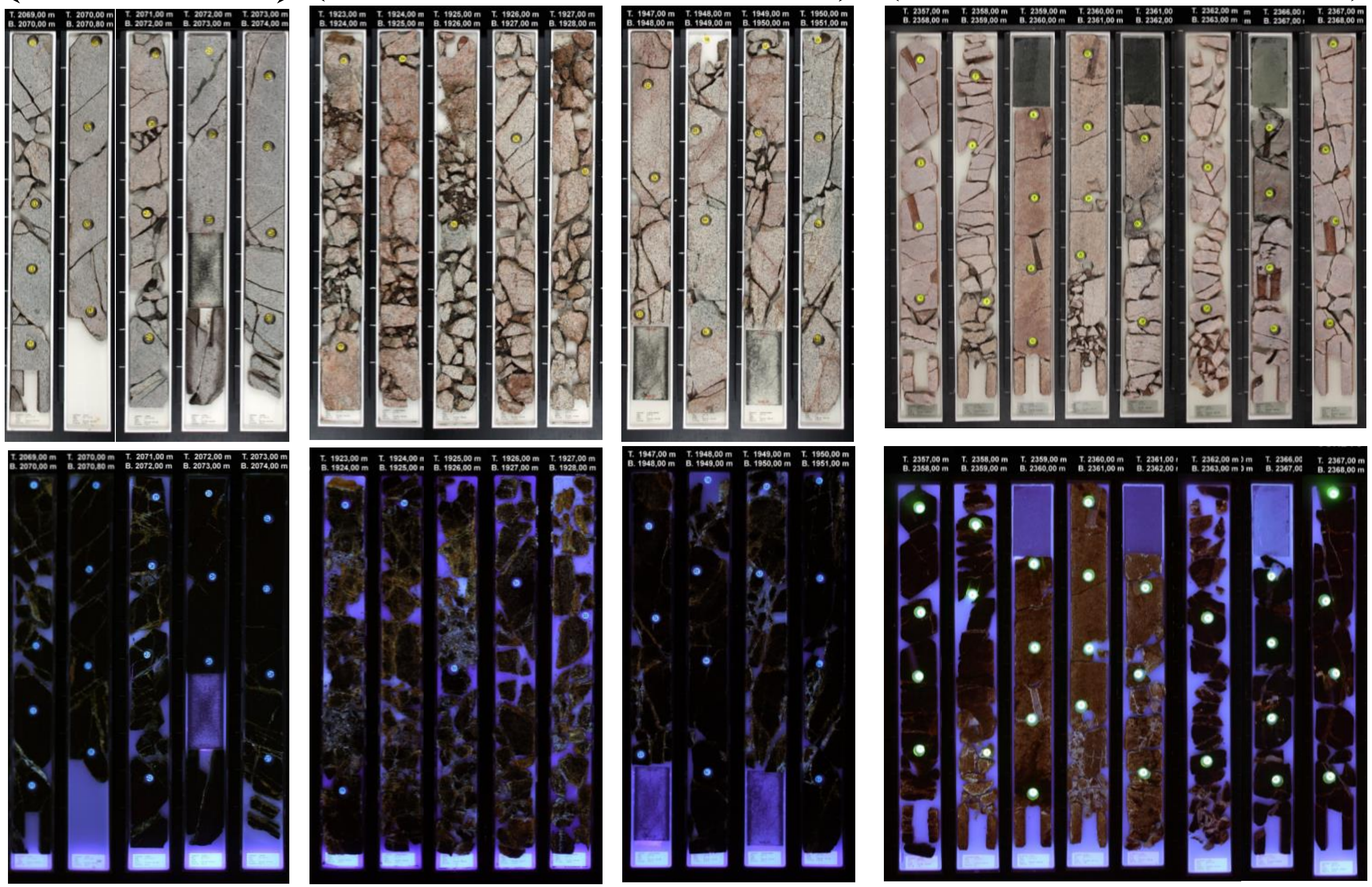
Granitic basement high:

- High degree of variation along a short distance
- Uncertainty related to productivity and reservoir quality
- Long horizontal wells are needed in such facies to get an optimal drainage



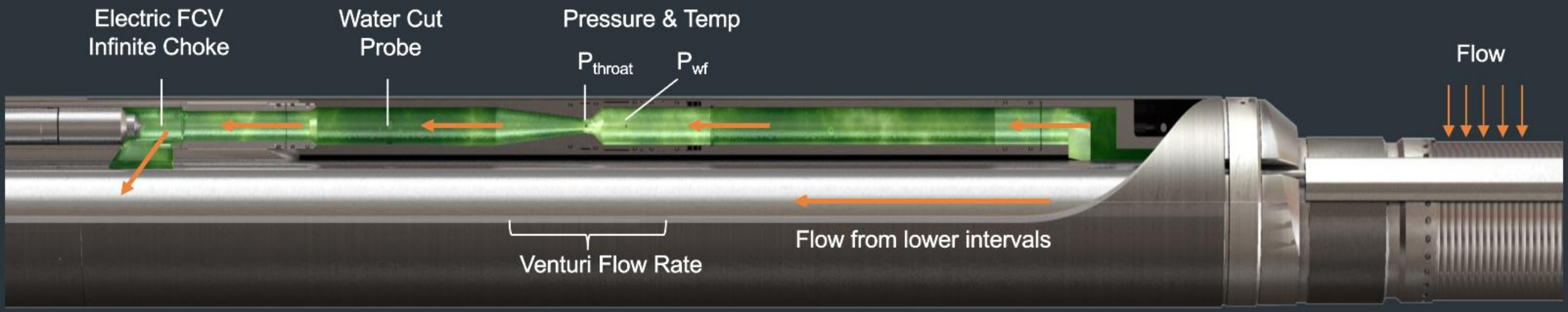
Manara completion to allow for zonal control.

16/1-15 AT2 | 16/1-15 | 16/1-31 A



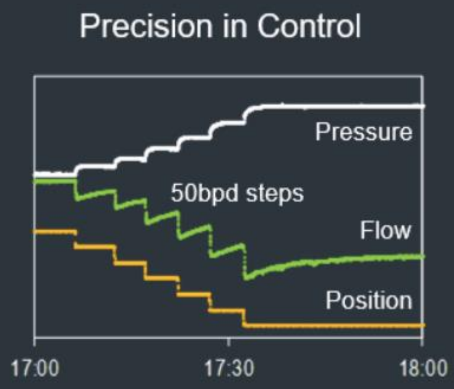
Tight basement with cemented fractures | Weathered basement | Fractured basement | Tight basement with weathered intervals

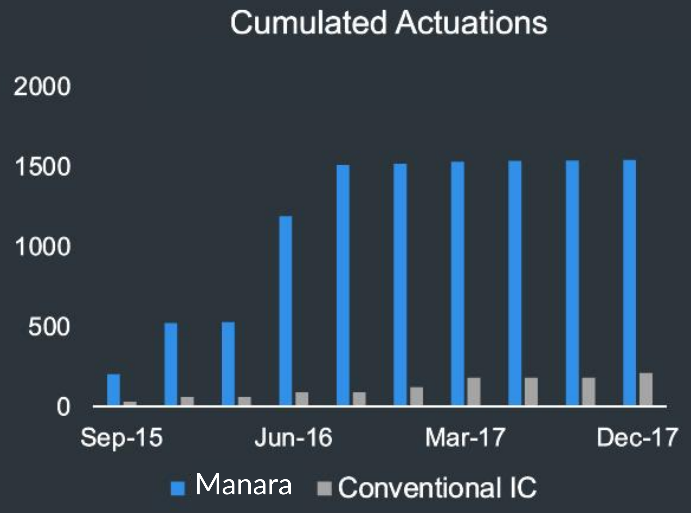
Electric inflow control valve (Electric ICD)



Manara stations allow monitoring and optimization of production along the well in real-time:

- Choke opening
- Pressure
- Temperature
- Liquid rate (oil rate, watercut...)





Results

16/1-A-3

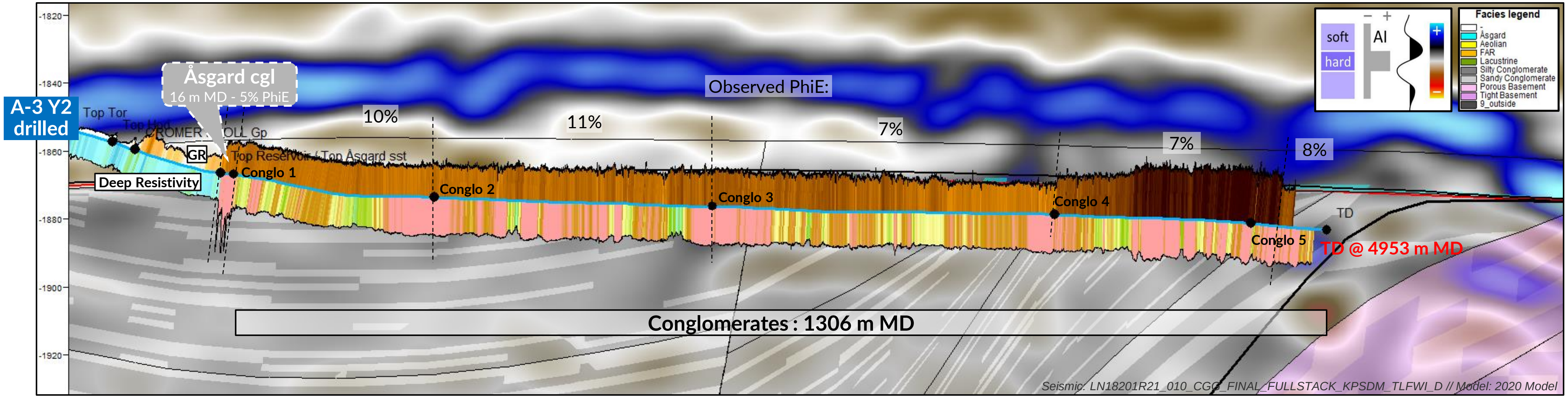
Geology

Successful well placement (geosteering)

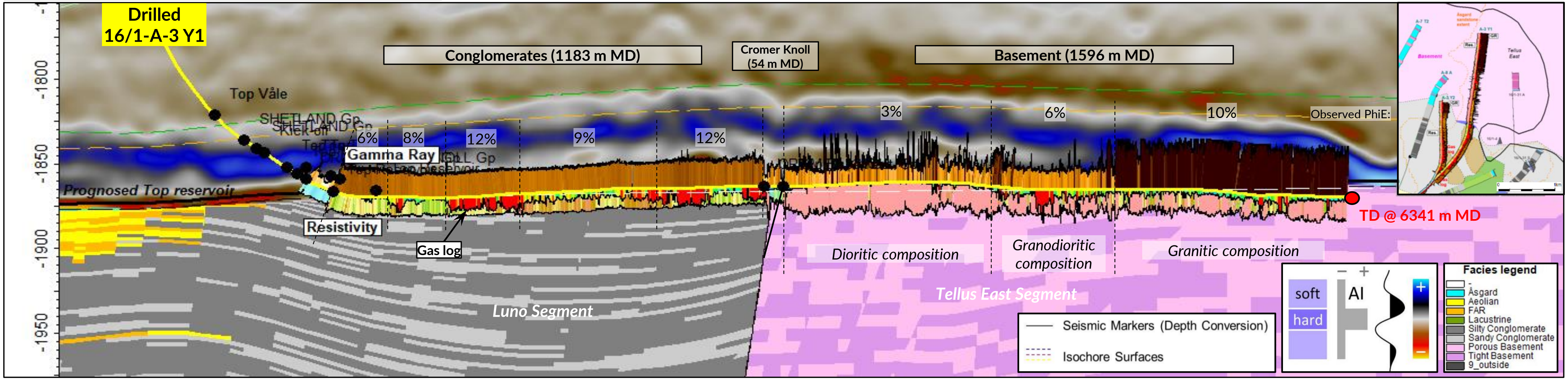
=> Suitable for fishbones completion in branch Y2

Long branches with long reservoir sections

Seismic section along 16/1-A-3 Y2 with the 2020 model facies



Seismic section along 16/1-A-3 Y1 with the 2020 model facies



Manara stations

Successful real-time monitoring

Able to take full advantage of functionality of electric ICVs.

Manara stations allow monitoring and optimization of production along the well in real-time:

- Choke opening
- Pressure
- Temperature
- Inflow rates (oil rate, watercut...)

Water management is key in maintaining production.

Three graph examples of monitoring through the Manara stations in MLT A-3

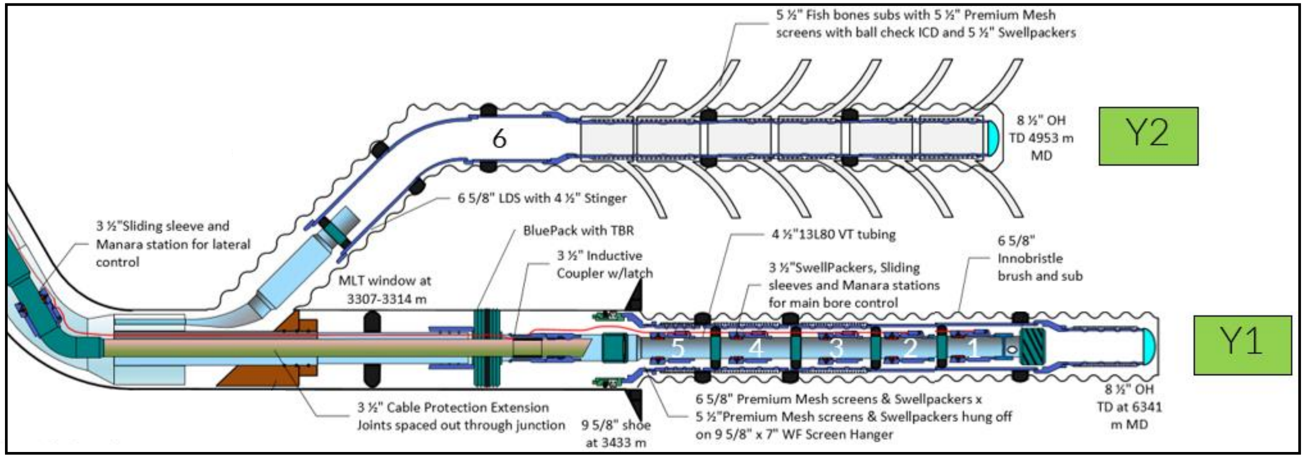
16/1-A-3

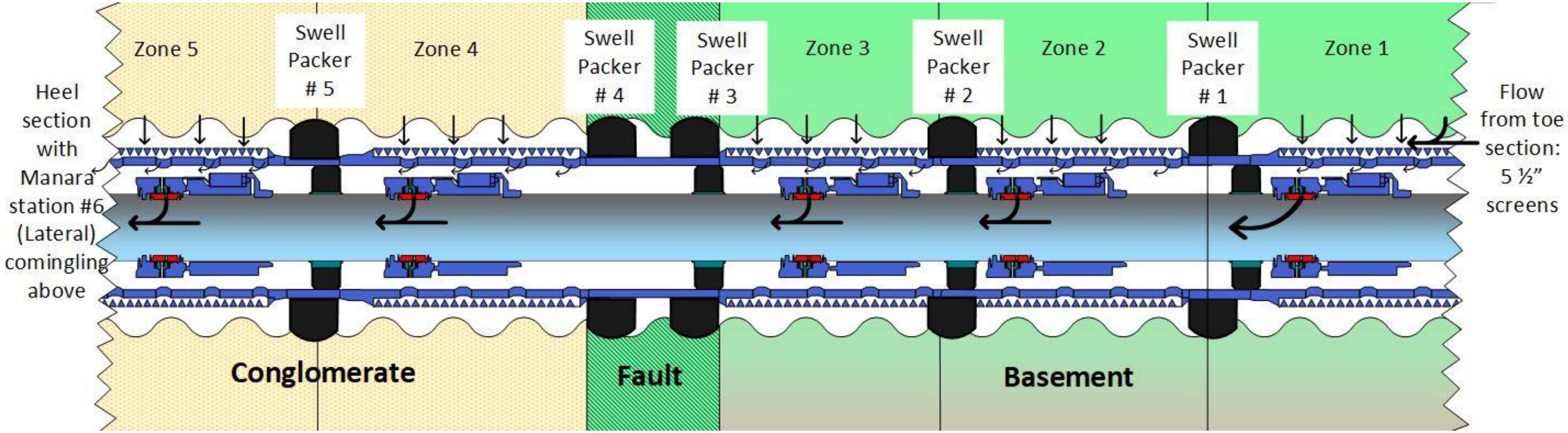
Production Summary

Clean up of the well shows good production rate (1500 Sm^3/day).

However, production has been hold back to allow proper swelling of packers and secure the zonal isolation.

Currently producing at ~250 Sm^3/day at 10-20% watercut (dependent on zones).





Conclusion

Conclusion

- 16/1-A-3 was successfully placed into the reservoir and the completion design optimized in the attempt of maximizing the drainage of the marginal facies:
  - Manara production system to allow for zonal control
  - Fishbones to optimize the production of low reservoir quality conglomerates

- 16/1-A-3 is currently producing from basement zones only for data acquisition and hub optimization
- Successful utilization of electric ICVs
  - Real-time Manara monitoring of Pressure, Temperature, Choke opening, Inflow rates (oil rates and watercut)…
- Ability to monitor and steer production is key to:
  - Total resource optimization on field
  - Data gathering for improved understanding of marginal reservoirs

- Learning phase
  - Evaluate later on the production of conglomerate zones for hub optimization
  - Analyze the benefit of the production with fishbones in conglomerates

- High volume potential in basement areas. Experience from A-3 is important for potential further development of basement reservoirs.

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