

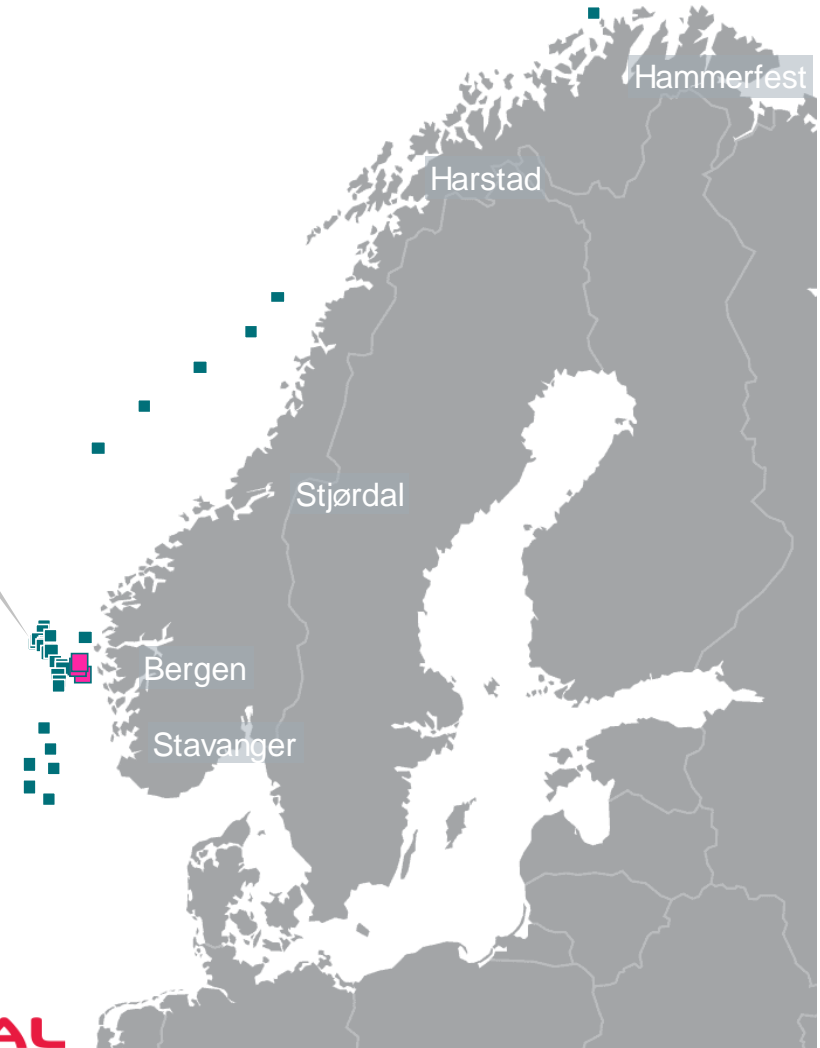
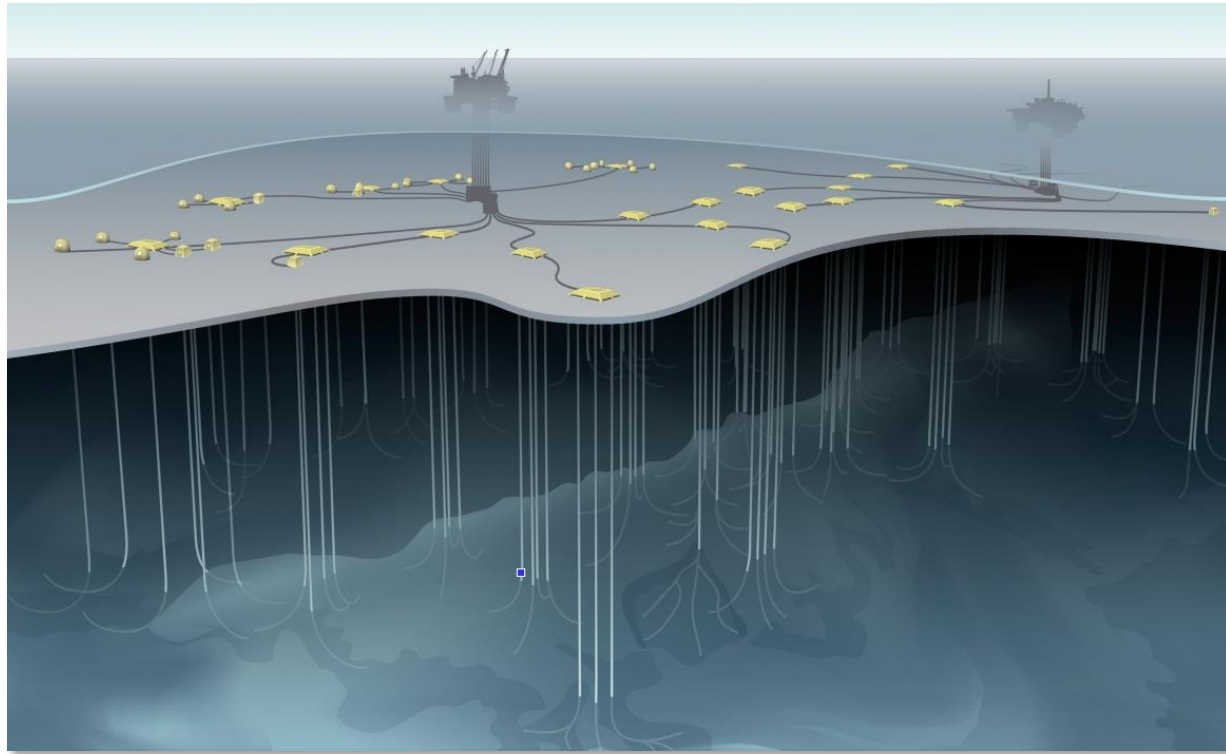


# Well Technology Evolution – Troll Case

Ingvild Lygren

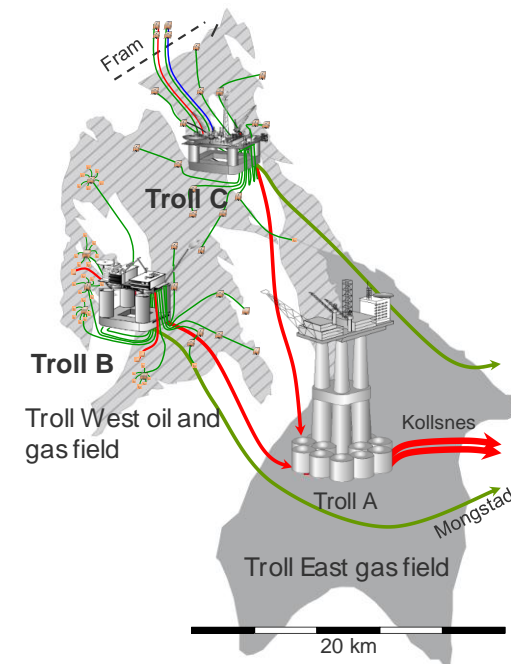
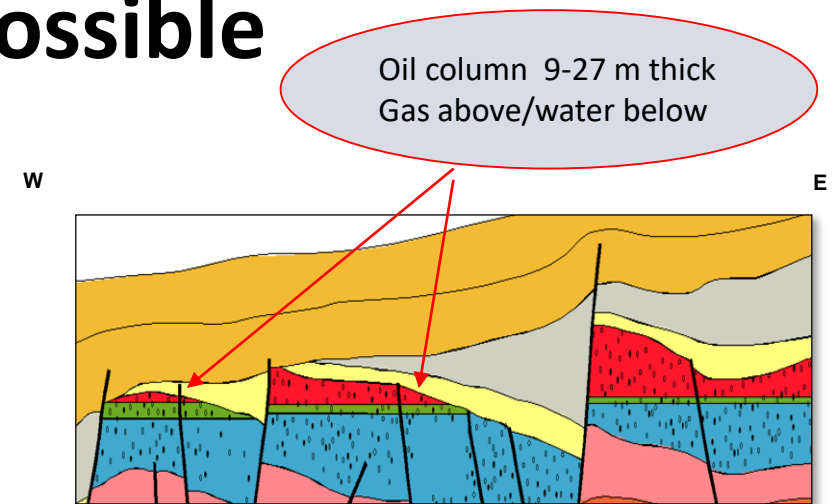


# 40 years of experience in Norway

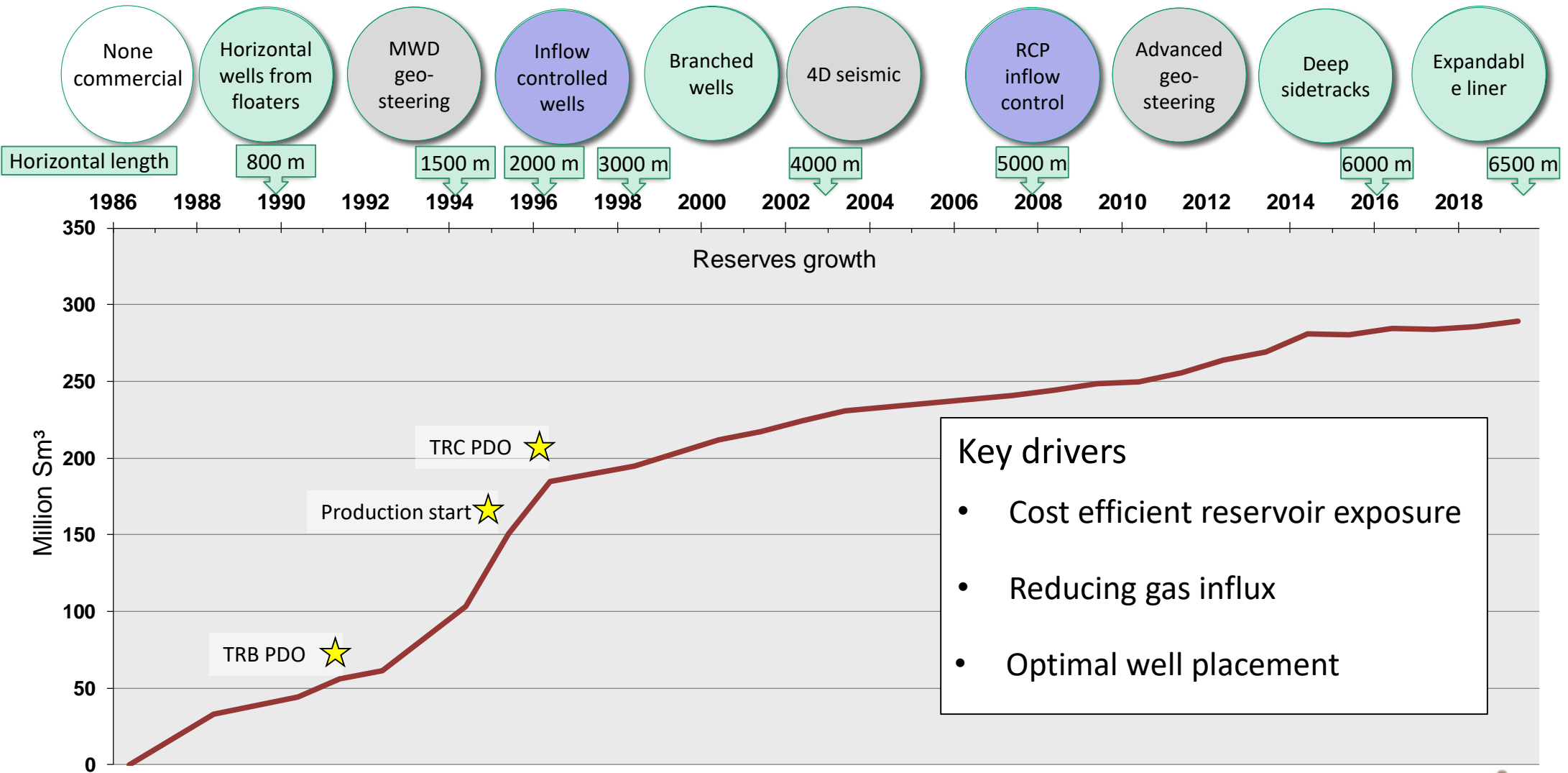


# Troll Oil - Impossible made possible

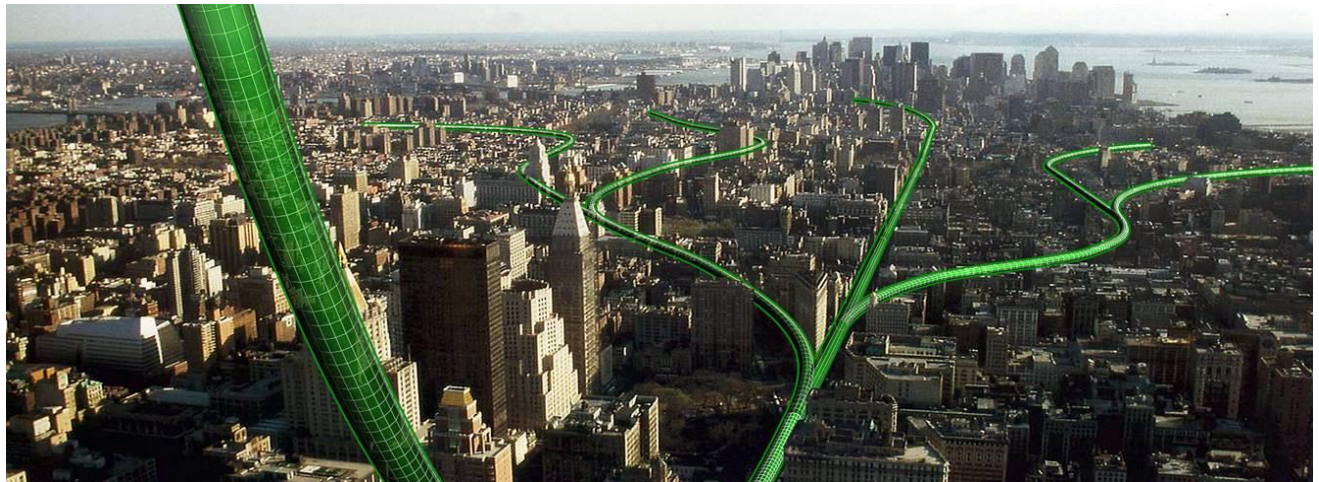
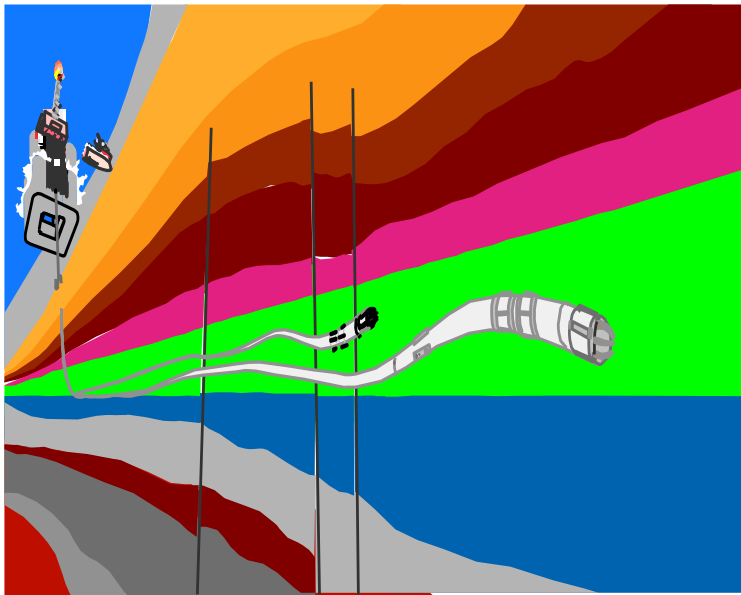
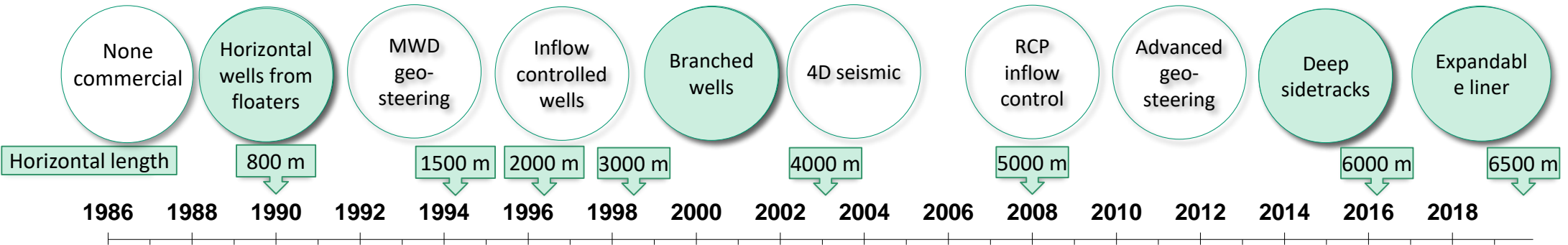
- ◆ None commercial oil field in 1980's
- ◆ The Challenge:
  - ◆ Vertical well technology
  - ◆ Thin oil column (9 - 27 meter) with overlying gas cap
  - ◆ Large area (770 km<sup>2</sup>)
  - ◆ Oil originally in place: 641 mill Sm<sup>3</sup>
- ◆ Status 2019
  - ◆ Largest oil producer on NCS 2013 - 2018
  - ◆ Estimated rec. reserves: 289 mill Sm<sup>3</sup> (RF ~45%)
  - ◆ 120 subsea well slots
  - ◆ 540 horizontal well branches (260 wells)
  - ◆ 1.85 million meter reservoir drilled.



# Technology driven reserves growth

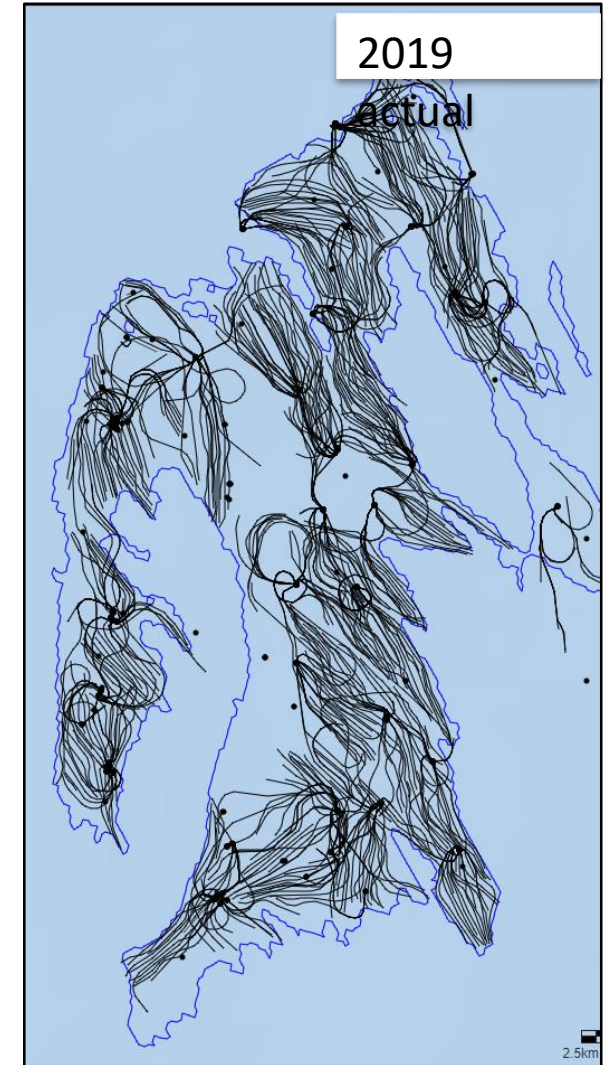
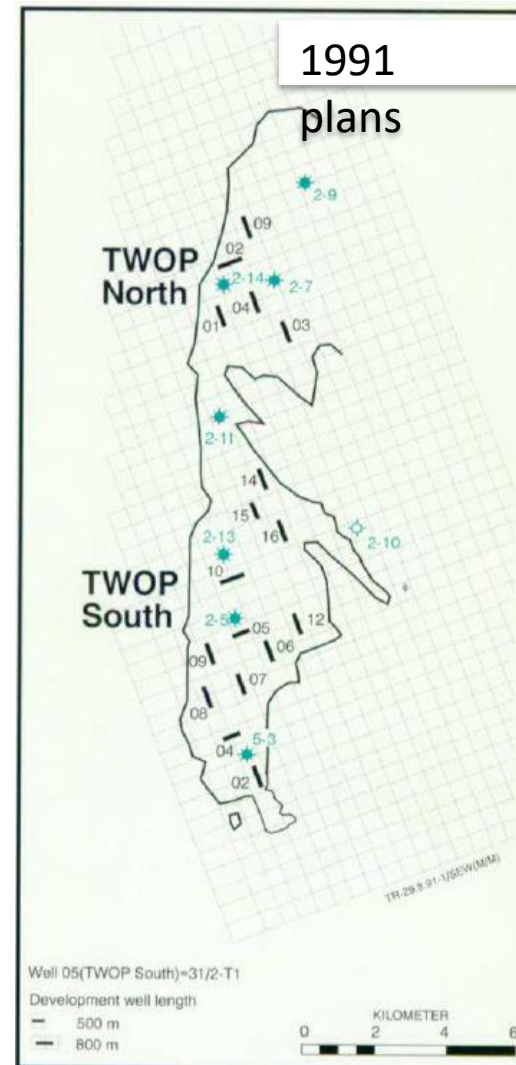


# Cost efficient reservoir exposure



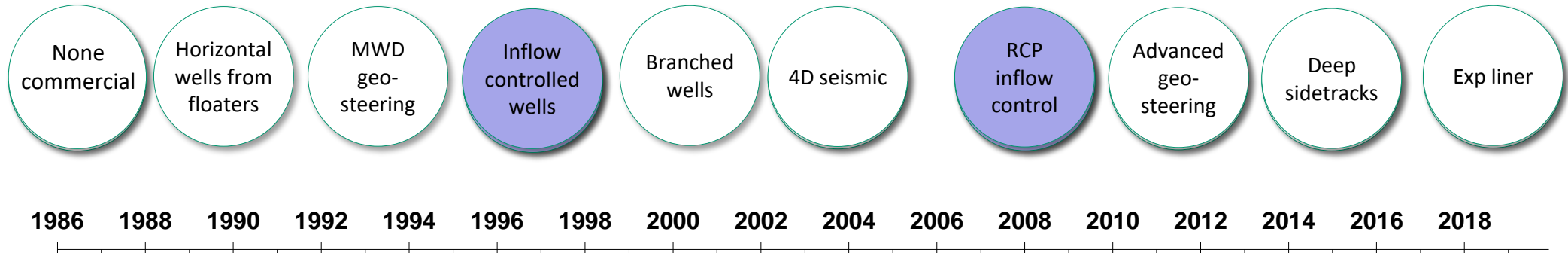
# From 14 to 1 850 km reservoir sections

- ◆ Troll B PDO – 1991
  - ◆ 14 km reservoir drilling planned
  - ◆ 17 horizontal wells in the oil province
  - ◆ 800 m reservoir sections
- ◆ 2019
  - ◆ 1 850 km reservoir drilled
  - ◆ Drilling 140-160 km yearly
  - ◆ 2-4 branched wells
  - ◆ 6500 m reservoir sections
  - ◆ 18 000 m per well.

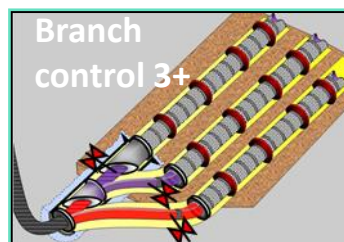
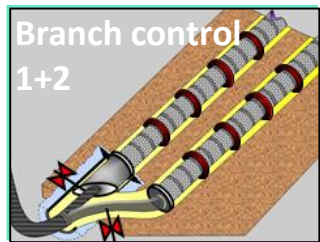
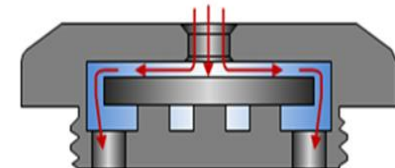




# Reducing gas inflow

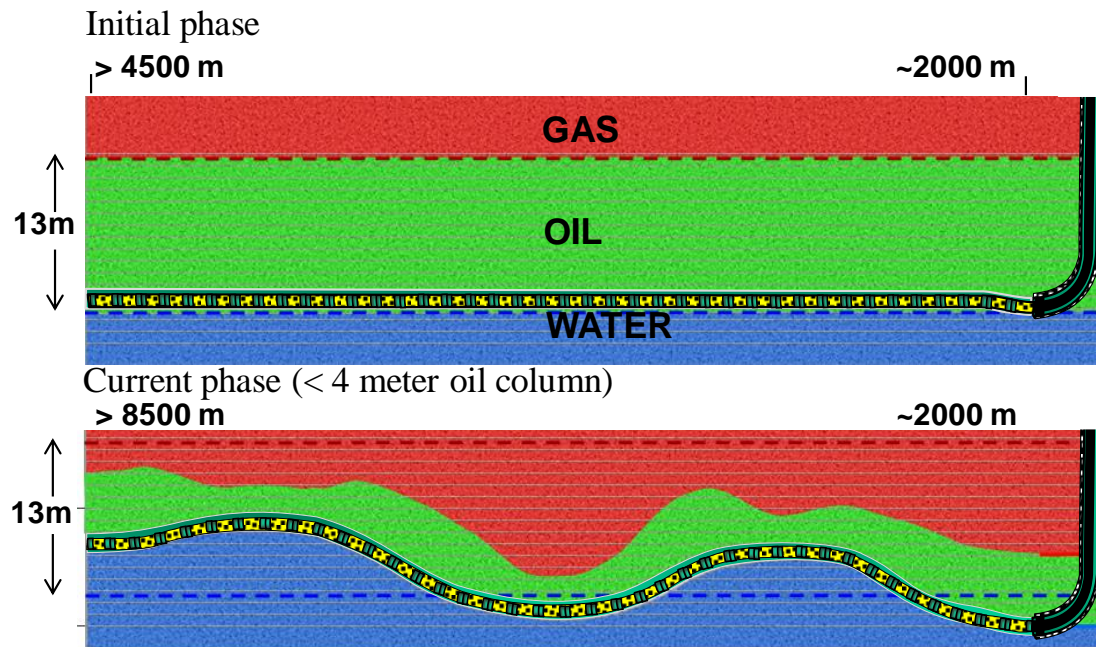
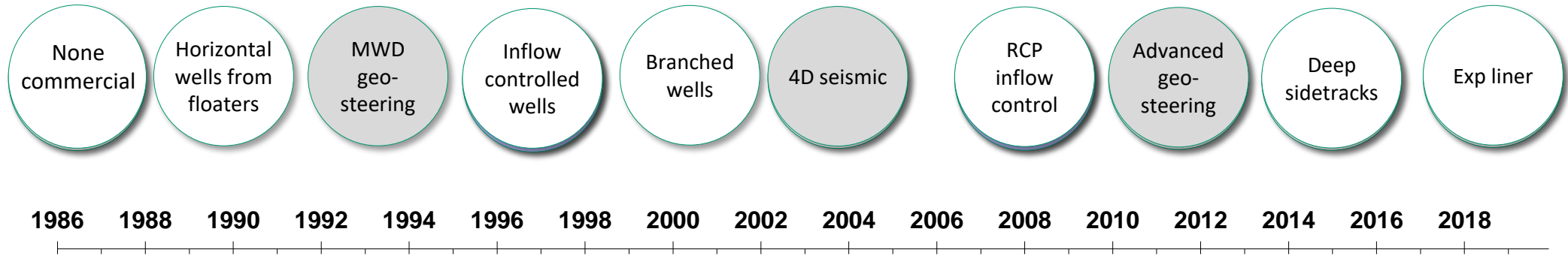


- ◆ Balancing inflow: Inflow control device (ICD)
- ◆ Branch control
- ◆ Autonomous inflow control device (AICD/RCP) and advanced completion planning.

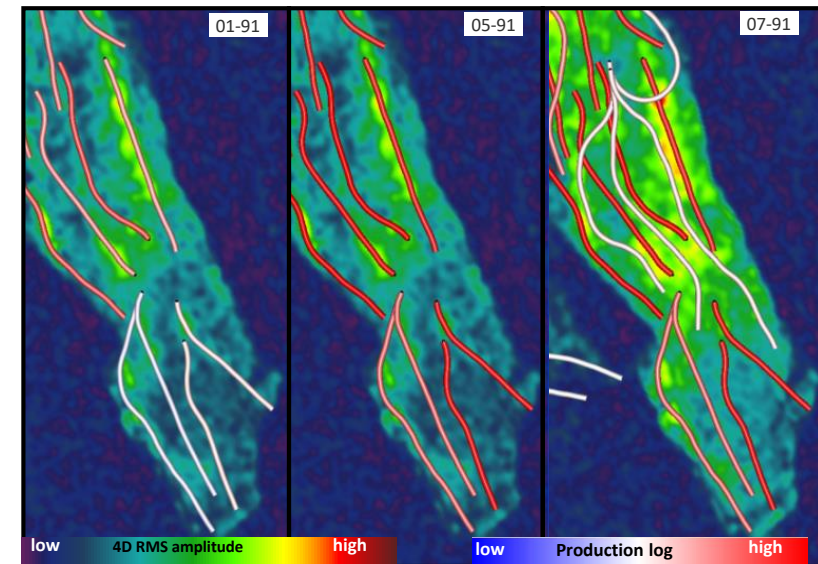




# Optimizing well placement

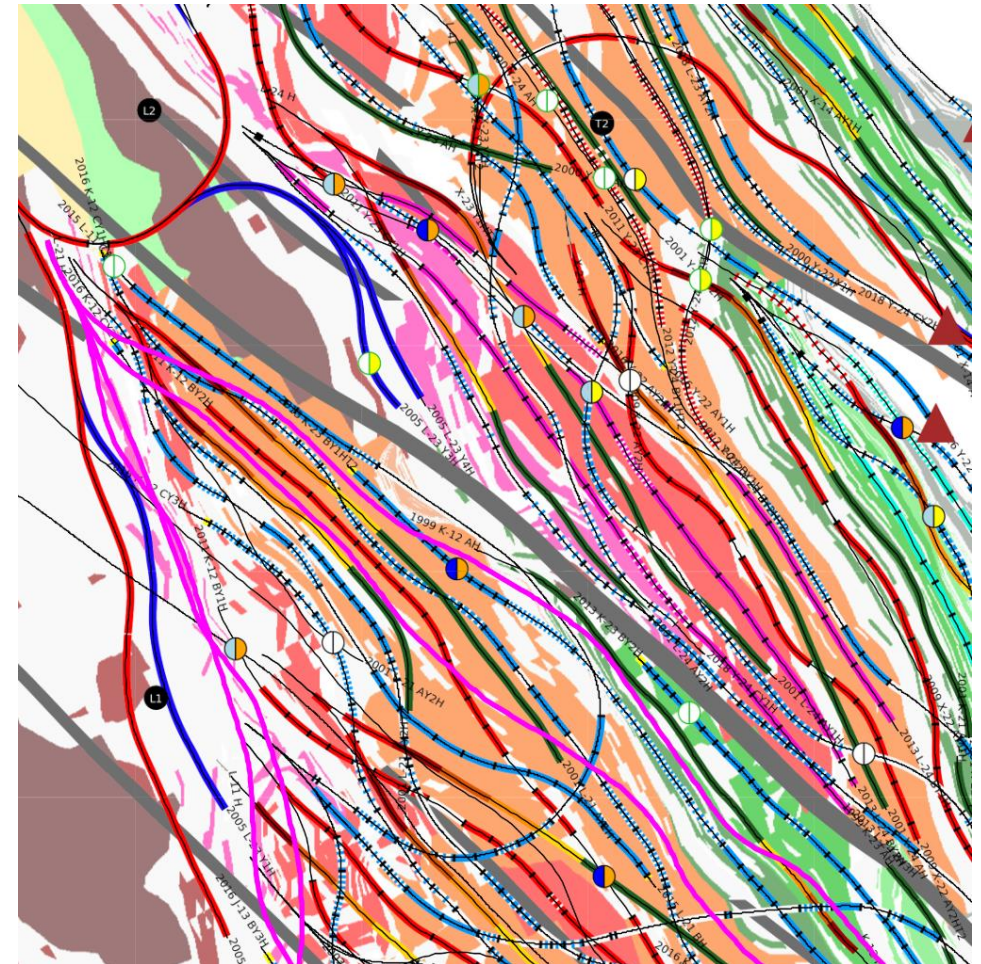
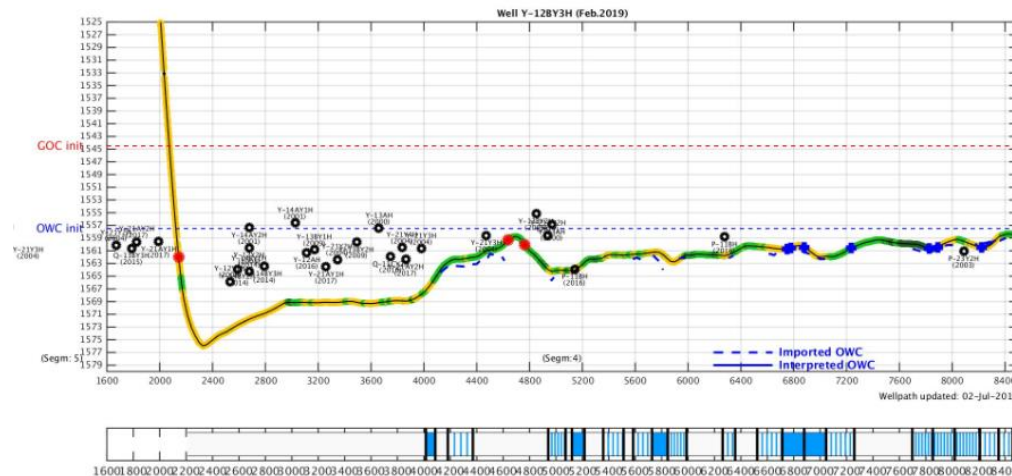


4D EVOLUTION with PRODUCTION



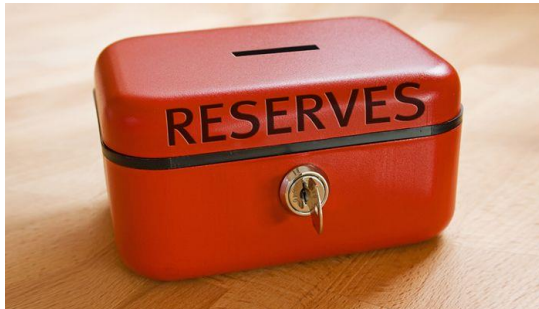
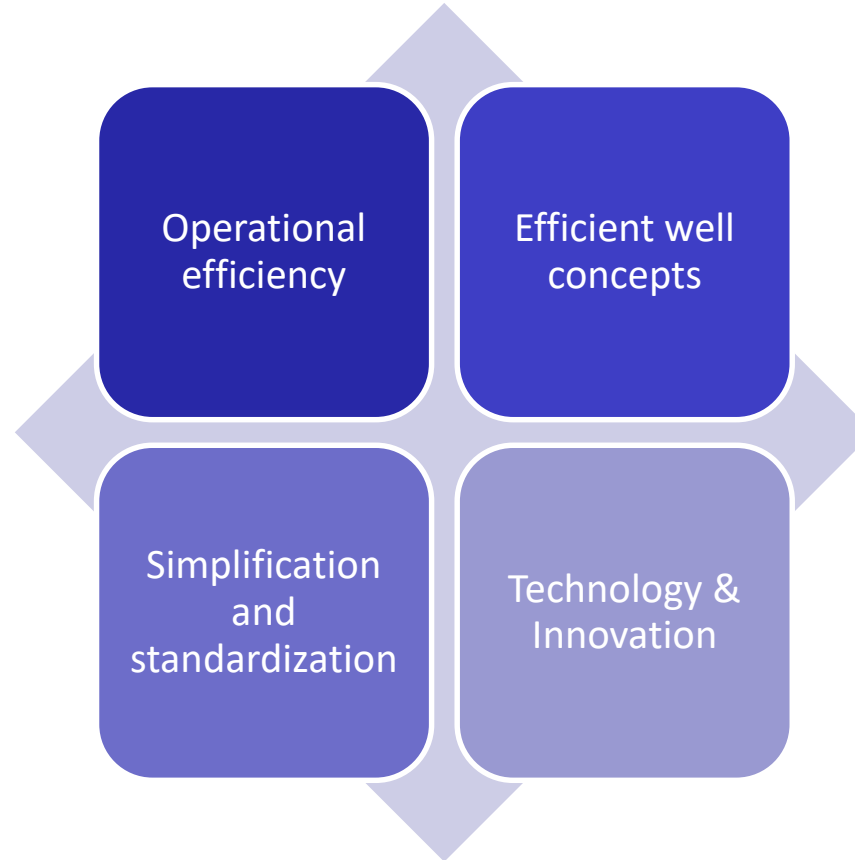
# The Challenge is becoming even harder...

- ◆ Wells located at OWC with thinner oil zone and uneven OWC
- ◆ High well density – challenging to find sufficient space to place new producers
  - ◆ Lateral well spacing 50-100 m
  - ◆ Vertical well spacing 0-5 m
- ◆ Large amount of data!





# Target unchanged from 1990: Reduce cost per reservoir meter



No loss of reserves

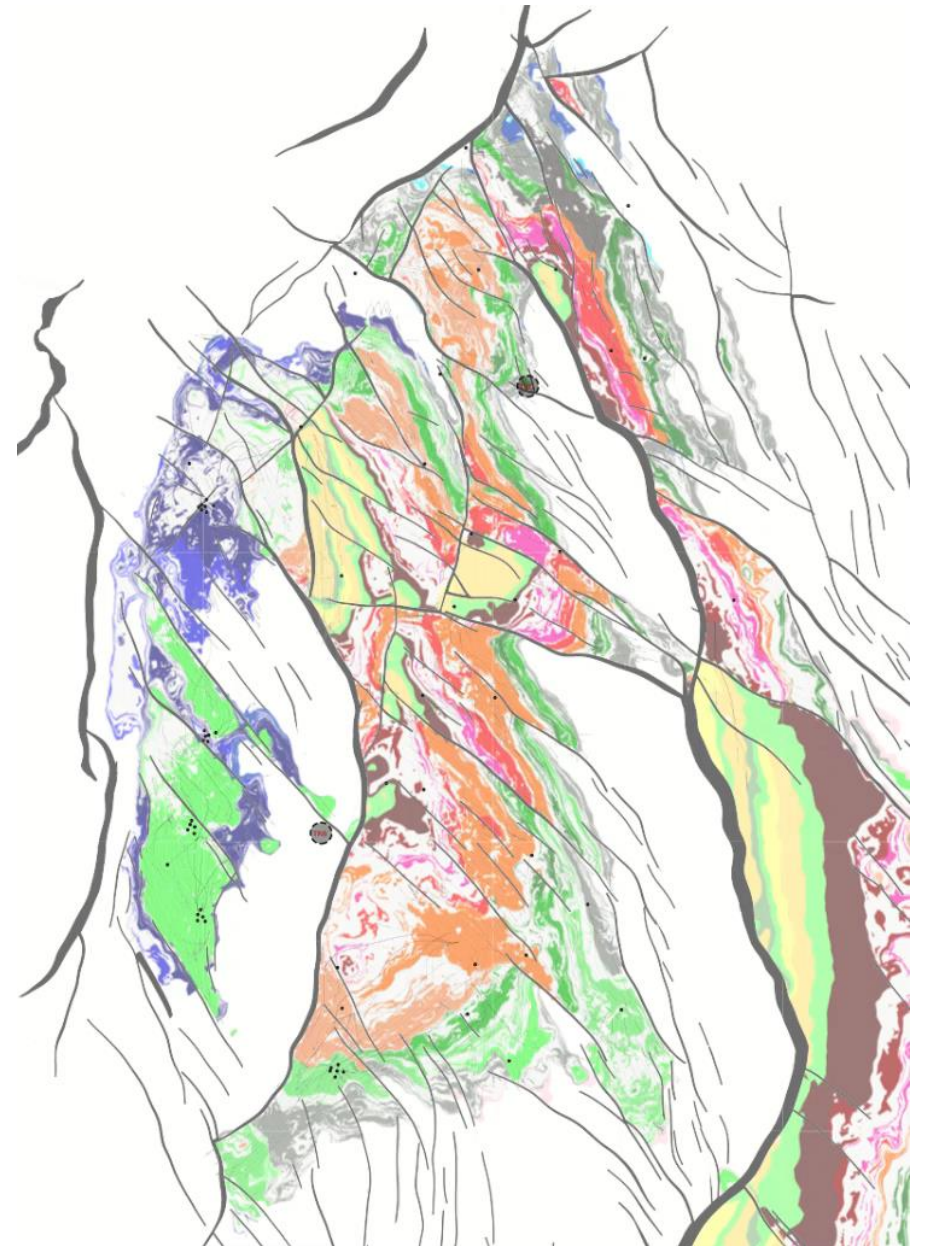


Out of the box



# Looking into the future

- ◆ Troll West – from oil field to gas field
  - ◆ Phase 3 start-up in 2021
- ◆ Development of the oil column still in focus for several years, development dependent on
  - ◆ Reserves development
  - ◆ Oil price and exchange rates
  - ◆ Rig rates
  - ◆ Success in further development of safe and efficient well concepts.



# Troll oil development – key learnings

- ◆ Early understanding of the key challenges
- ◆ Clear expectations from authorities
- ◆ Close collaboration with vendors
- ◆ Dare to fail
- ◆ Be ready to scale
- ◆ Always look for improvements and simplifications.



# Acknowledgements

