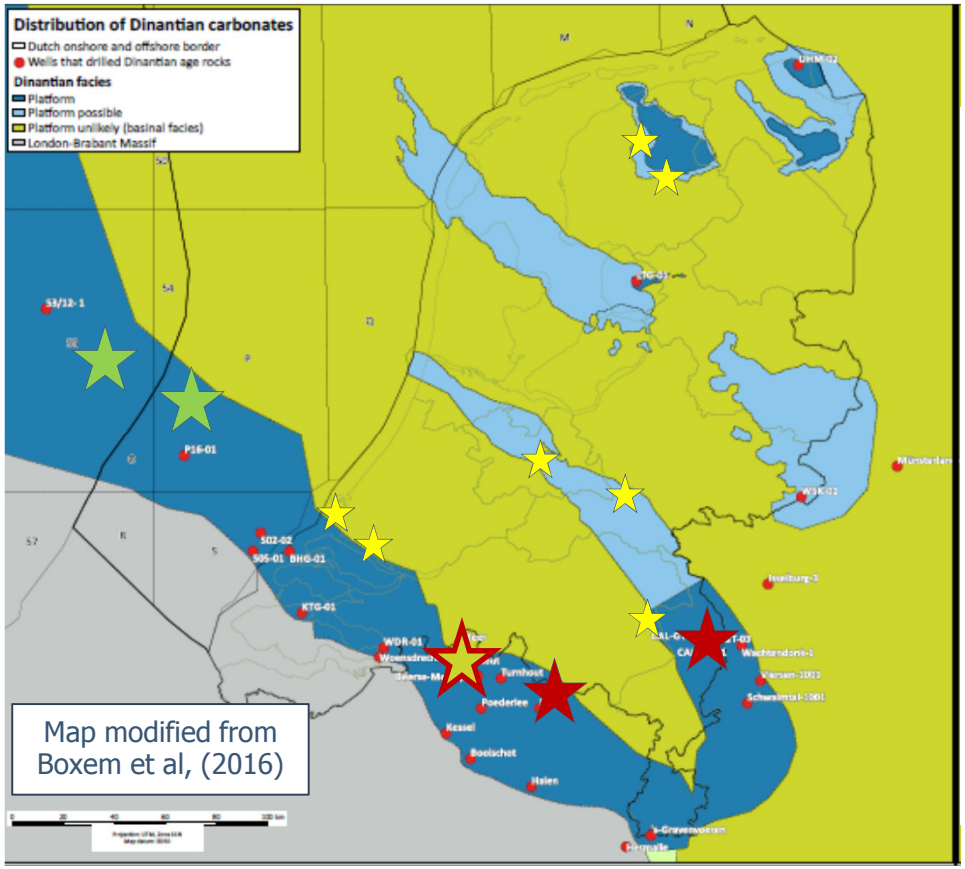
The Dinantian Carbonates are hot!

Assessing reservoir potential of Lower-Carboniferous carbonates in the Dutch subsurface

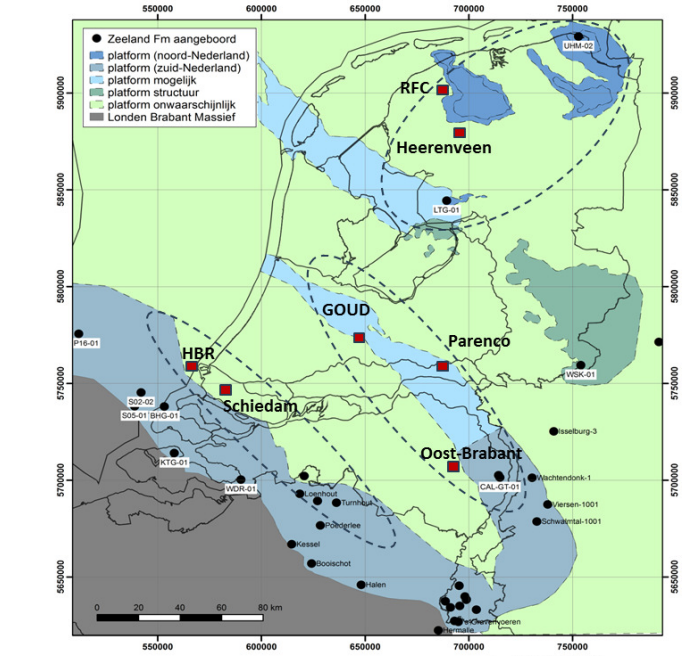
B. Jaarsma*, L.J. Heijnen, E.A. Rosendaal
EBN B.V.

The Dinantian Carbonates are hot!

Potential for hydrocarbons and geothermal being explored at the same time



- Exploration for hydrocarbons in Southern North Sea UK / NL sectors
- Onshore NL / BE geothermal projects
- Green Deal Ultra Deep Geothermal program EBN, TNO and 7 consortia
- Possibly geothermal potential at shallower depths
- UGS project in Belgium




Signing of the Green Deal UDG, 20th June 2017

Green Deal UDG

- Green Deal signed by Ministry of EZ, Ministry of I&M, EBN, TNO and 7 consortia
- Consortia include companies from process industry, oil companies and companies / organizations which will use waste heat, at 7 different locations in the NL
- Ministry of EZK will sponsor 50% of exploration activities, results will be public

Green Deal UDG – KEP and EWP

- UDG Exploration Work Program being set up by EBN, TNO and consortia (95% ready)
- The UDG-EWP is part of the UDG-KEP (Knowledge and Expertise Program) which also comprises business cases, stakeholdermanagement & communication, surface facilities etc.
- Both EWP and KEP are coordinated by EBN

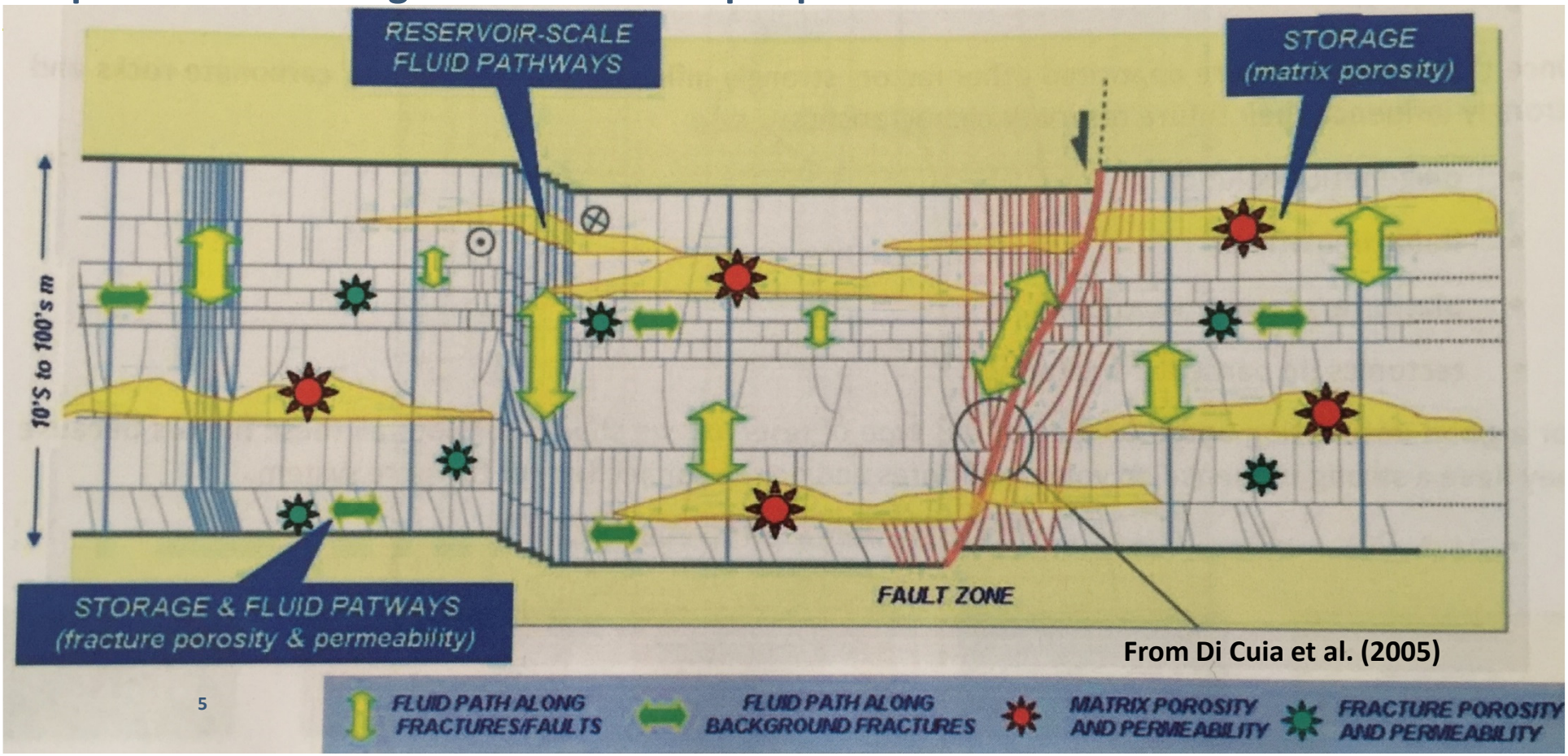
- Aim of the KEP/EWP is to identify 1-3 pilot projects (drilling not included in the program)
- Consortia coorporate as much as possible, at 3 scales; to utilize synergies, lower the risks and increase mutual advantages
- Start early 2018, budget ~28 million €, ~25 FTE, spread over 2-3 years (excl. seismic activities)

- 17 main tasks (partly in parallel, partly sequential)
  - Seismic acquisition and (re-)processing
  - Seismic interpretation / depth conversion, structural restoration / basin modeling,
  - Reservoir distribution and quality prediction, modeling of flow (petrophysics, facies, fractures and diagenesis, analogues / outcrops, effects of operations)
  - Stress models, Risk of seismicity
  - Technical risk assessment, conceptual well and stimulation design

Subject of following slides

The challenge: model reservoir performance projects

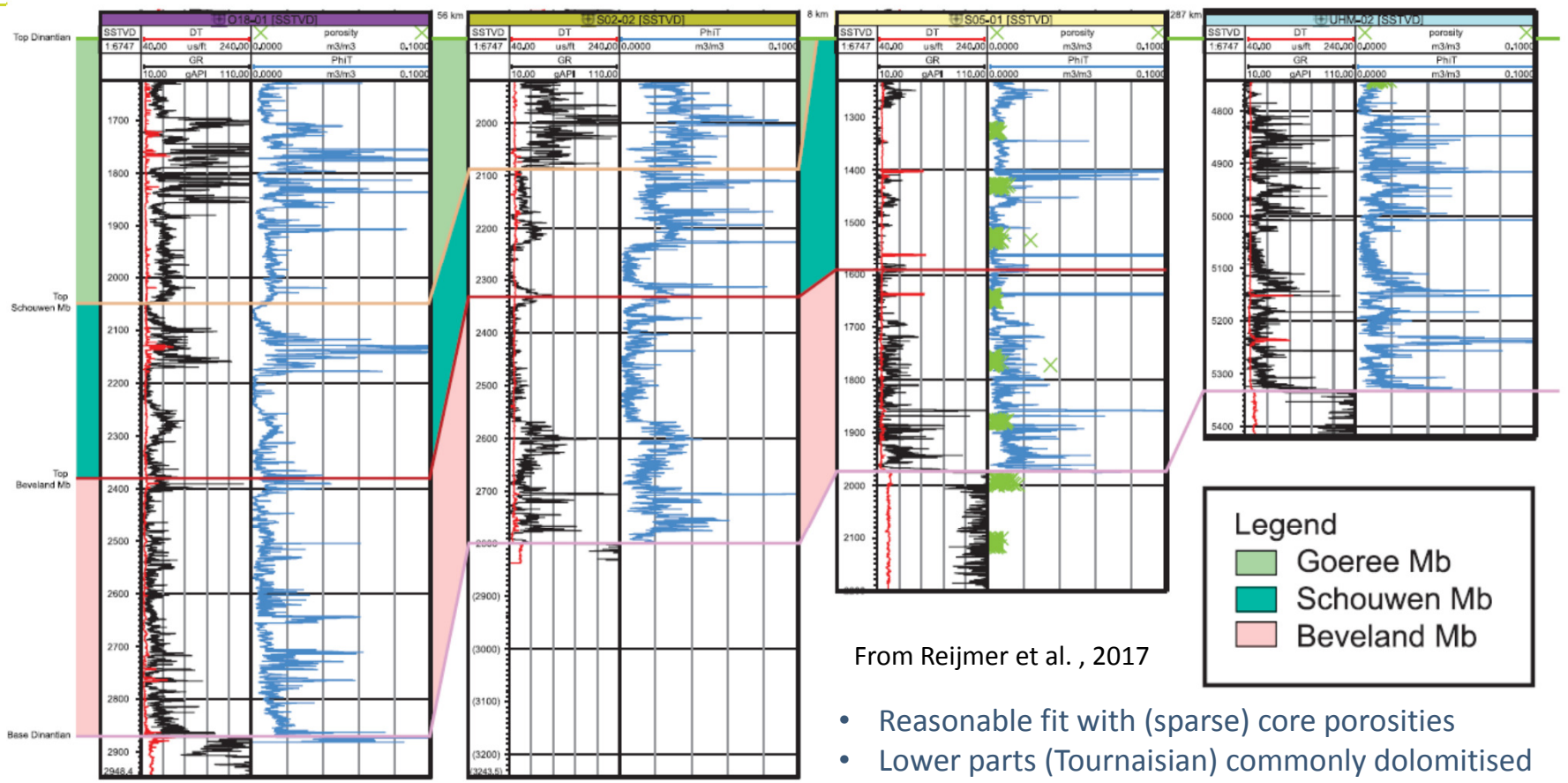
Requires realistic ranges of values for input parameters



From Di Cuia et al. (2005)

Petrophysical evaluation - example 4 wells

Large variations in porosity – no surprise – but just sample points

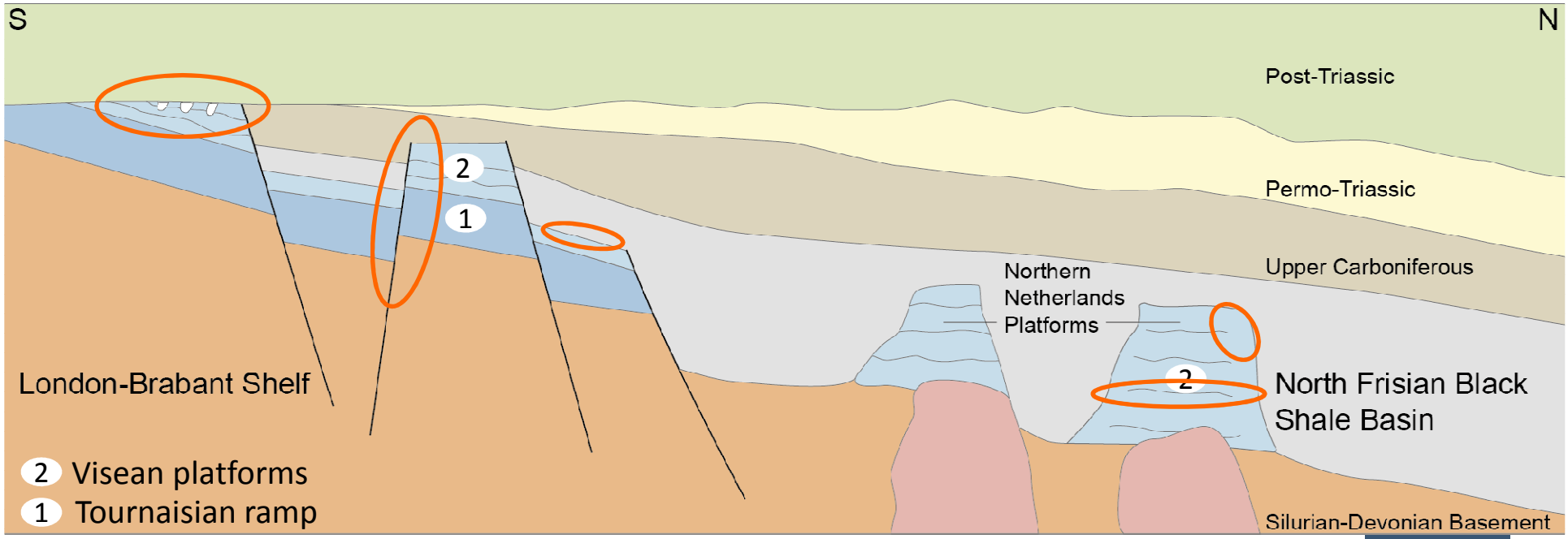


From Reijmer et al. , 2017

- Reasonable fit with (sparse) core porosities
- Lower parts (Tournaisian) commonly dolomitised

NL Dinantian platform carbonates at present

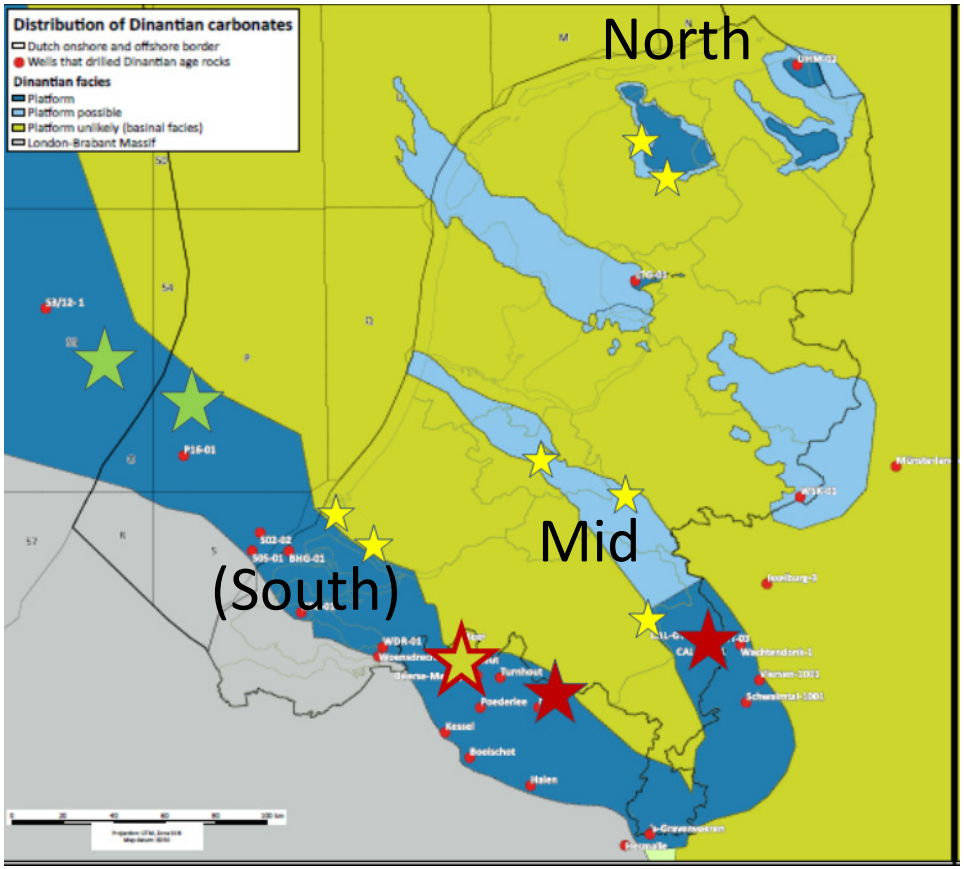
Differences in build-ups; diagenesis, fracturing, Z / T / p, stresses, etc.



Karst and/or fracture scenarios (from well and seismic data and from analogues

Dinantian Carbonate play is hot!

Next 13 slides we will discuss possible input for conceptual reservoir models



- 3 sub-plays with their own characteristics and uncertainties
- Review for each sub-play
  - Seismic
  - Well data
  - Analogs
  - Outcrops

(In view of time, in this presentation we focus on North and Mid and skip area South)

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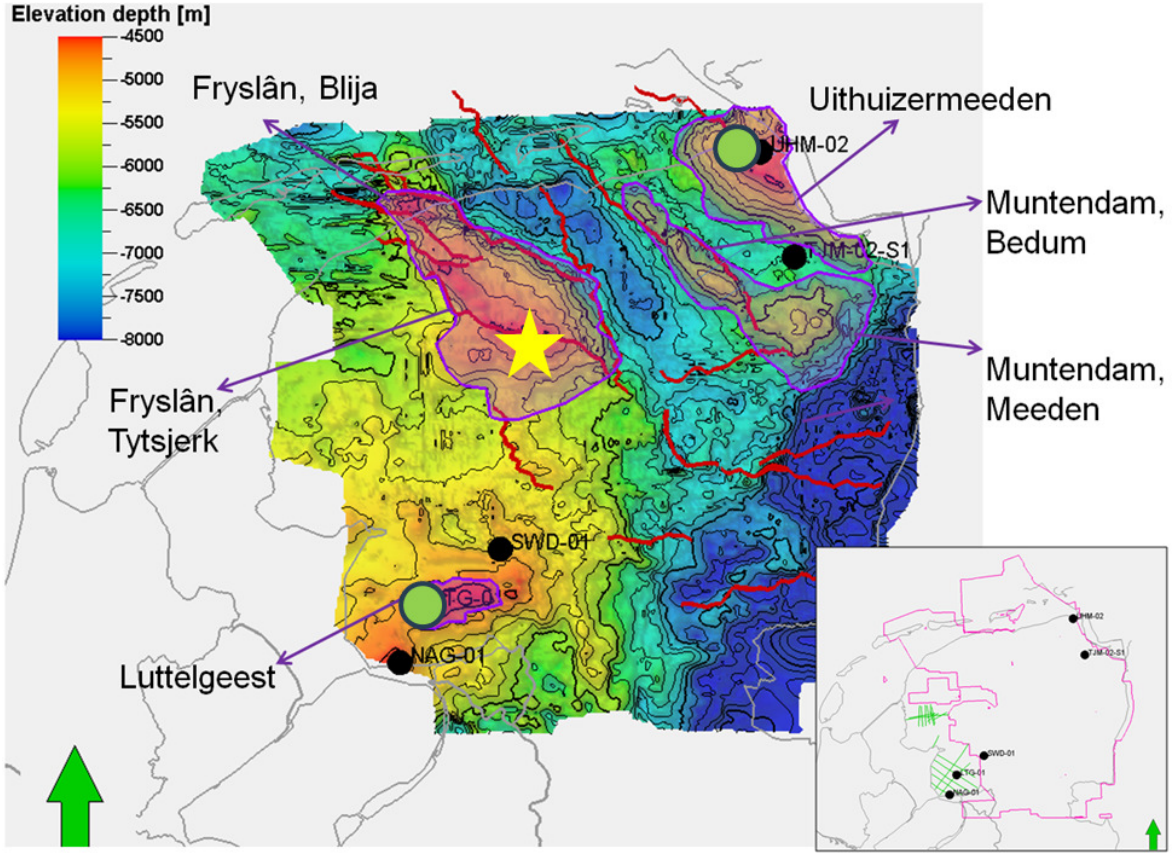
Isolated build-ups in the North

previously target for gas exploration, now target for UDG

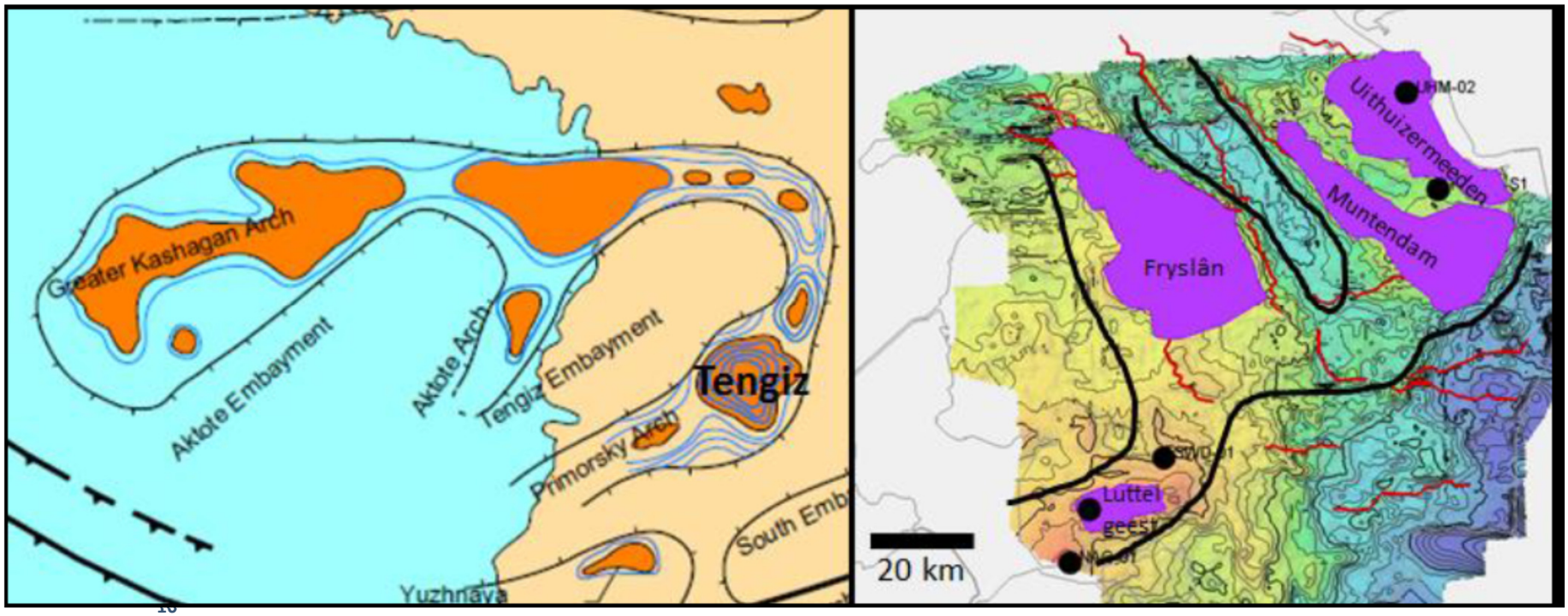
- Only 2 wells – UHM-02 and LTG-01
- Drilled in platform interior
- Tight reservoir, some losses and higher porosity streaks



From Hoornveld, 2013

Isolated build-ups in the North

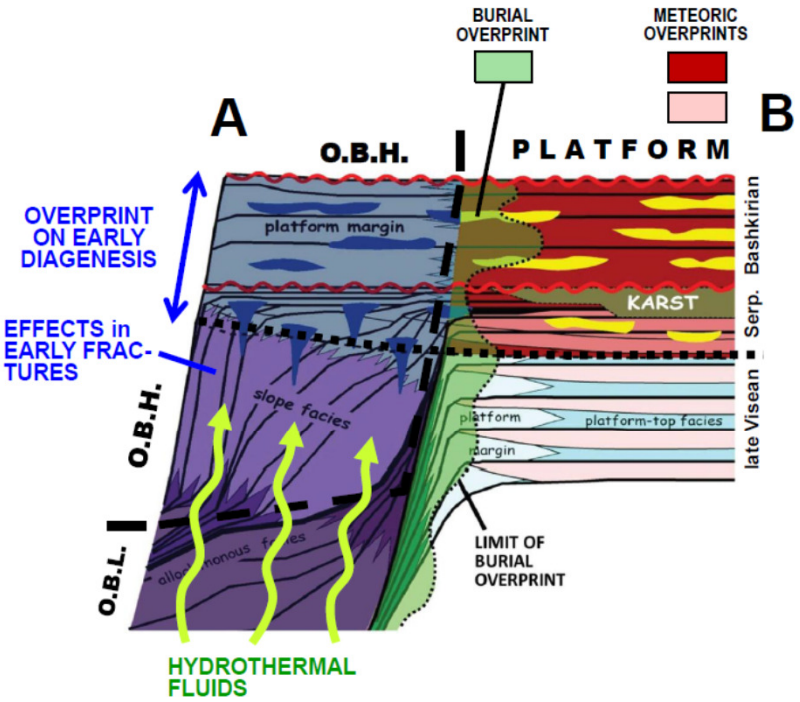
Looking for analogs – giant oil fields Caspian Sea; same age, same depth, similar size

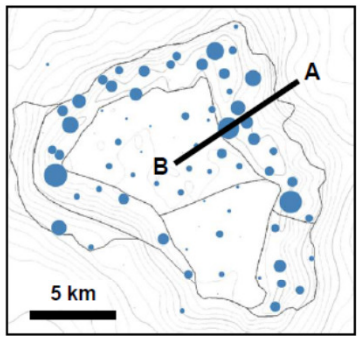


From Hoornveld, 2013

Reservoir quality in the platform interior vs. margin

Tengiz analog – burial diagenetic overprint distribution - Collins et al. (2014)





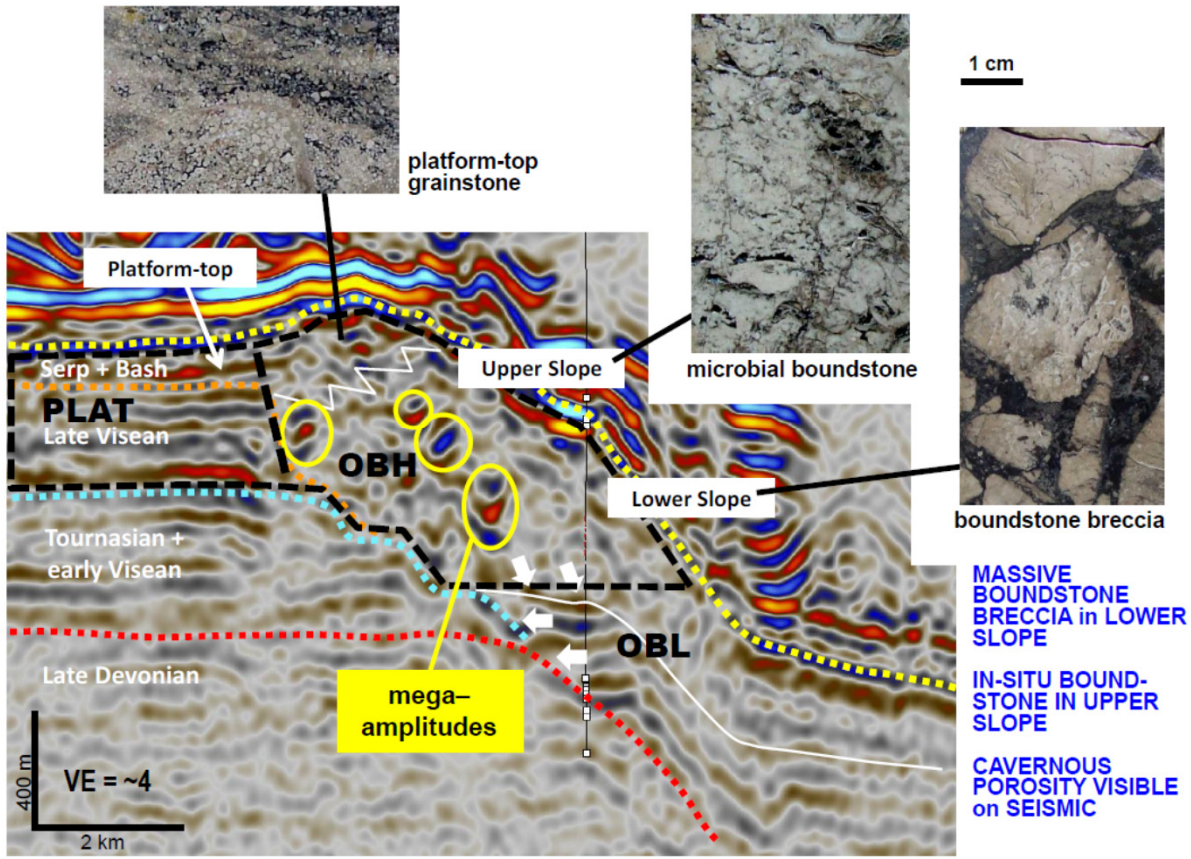
-PROGRADING MARGIN and ADJACENT PLATFORM REGION
-ENLARGED FRACTURES and CAVERNS in SLOPE (MICROBIAL) FACIES
-MATRIX ADJACENT TO ENLARGED FRACTURES

Also relevant:

- Similar concepts for Kashagan in Ronchi et al. (2009)
- Van der Kooij (2009) compares diagenesis in outcrops Spain to Kashagan and Tengiz
- Other analogues in Dnieper-Donets Basin (Ukraine)

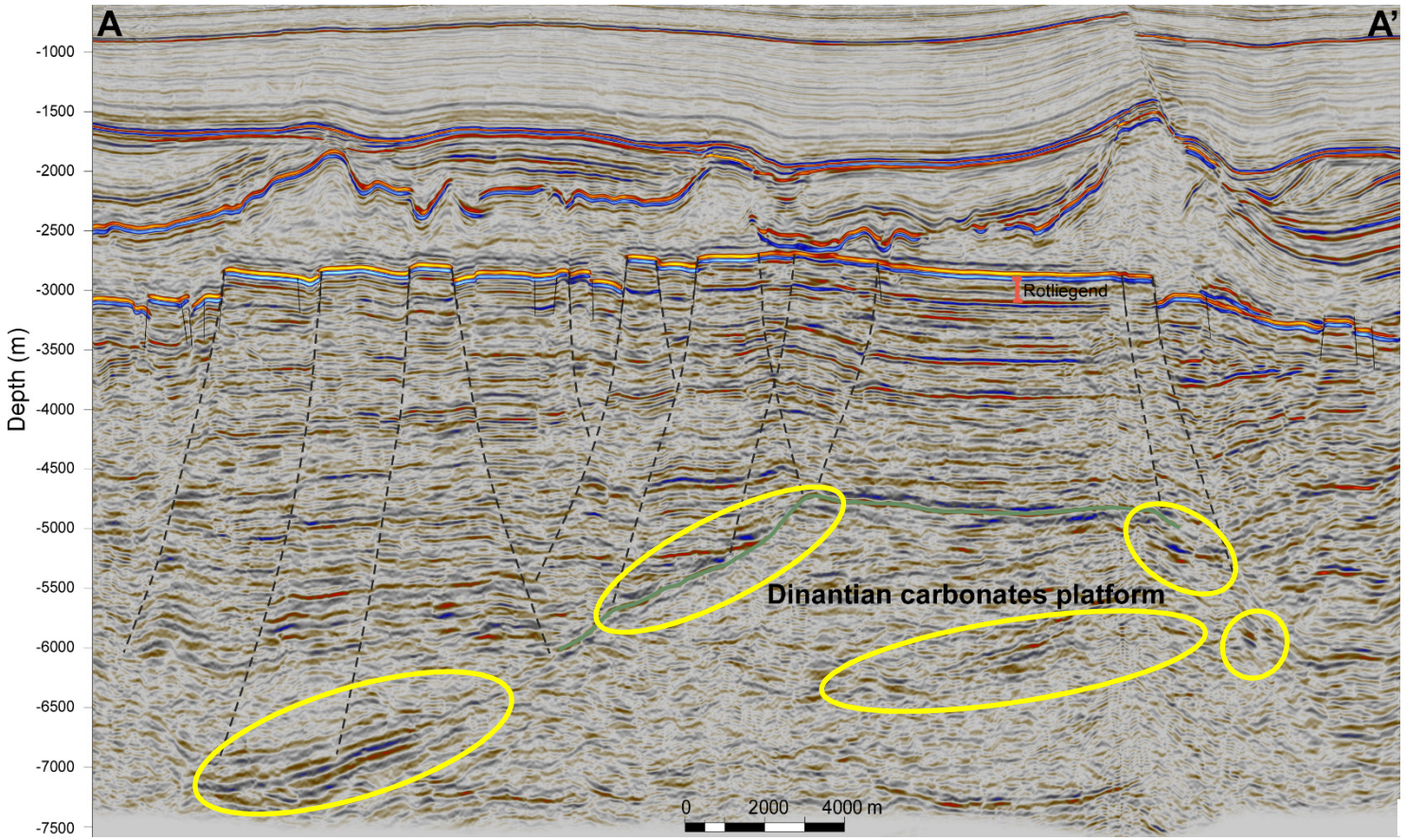
Reservoir quality in the platform interior and margin

Tengiz analog – seismic expression of diagenetic overprint - Collins et al. (2014)



Back to UHM-02 - Reprocessing / PSDM NAM, 2015

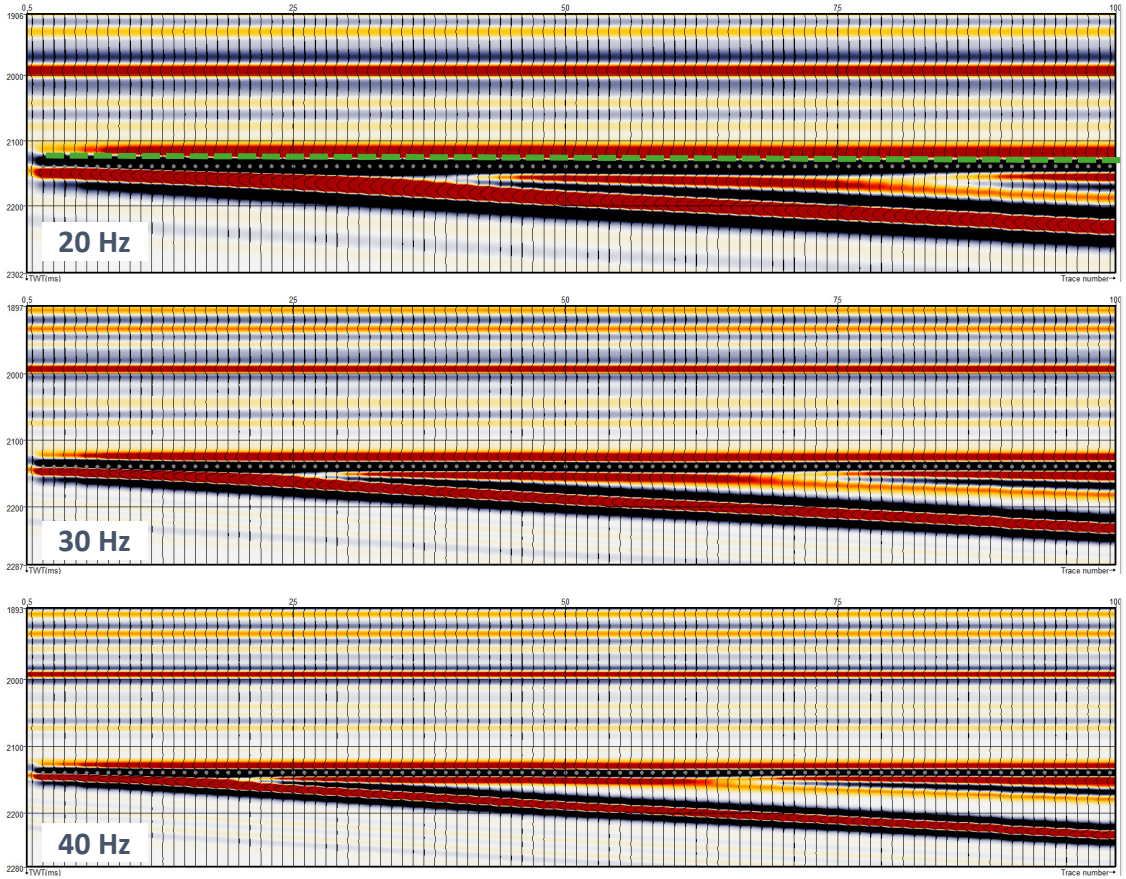
Better definition of the Dinantian and Devonian strata- what do amplitudes mean?

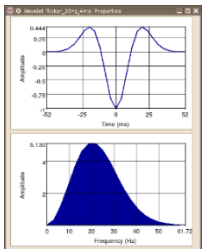


Kortekaas and Jaarsma (2018)

Modeling seismic character Dinantian Carbonates

Modelling seismic character for synthetic wells and cross sections (by dGB, ongoing)





- Results to be used in seismic interpretation, survey design and reprocessing feasibility studies.
- This example - rock properties from well LTG-01, cave thickness varies from 0 – 100m, Ricker waelet 20, 30 and 40 Hz (from top to bottom)

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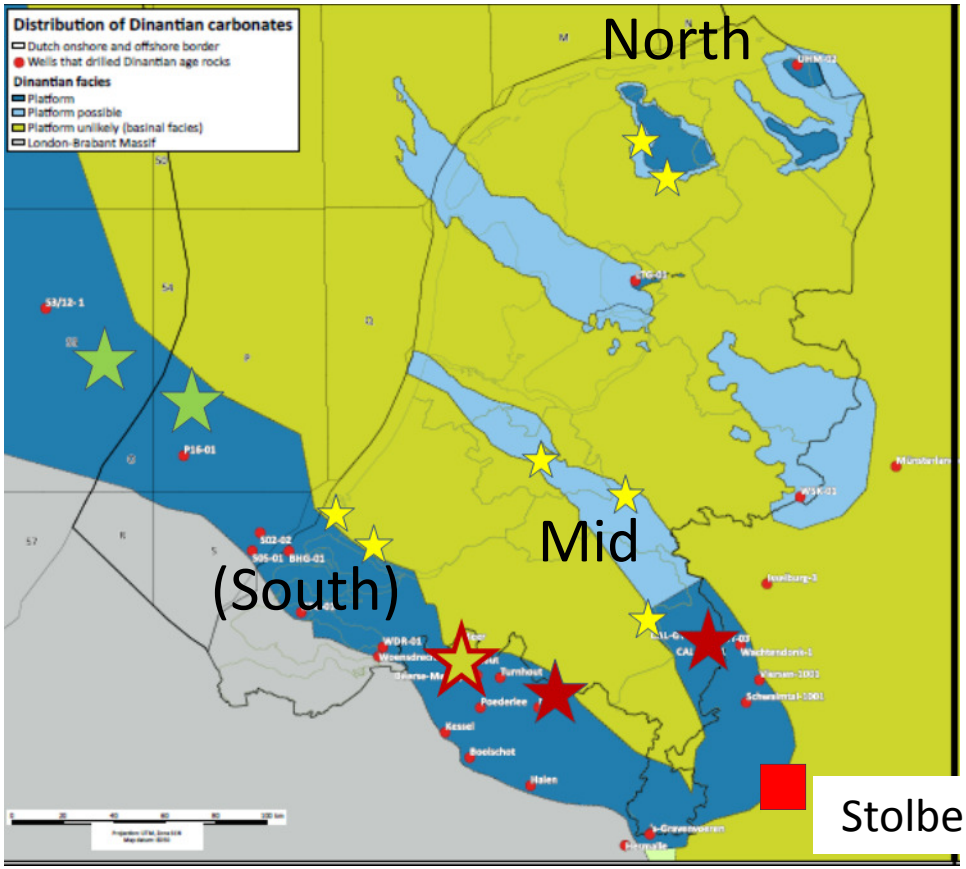

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(In view of time, we skip area South)

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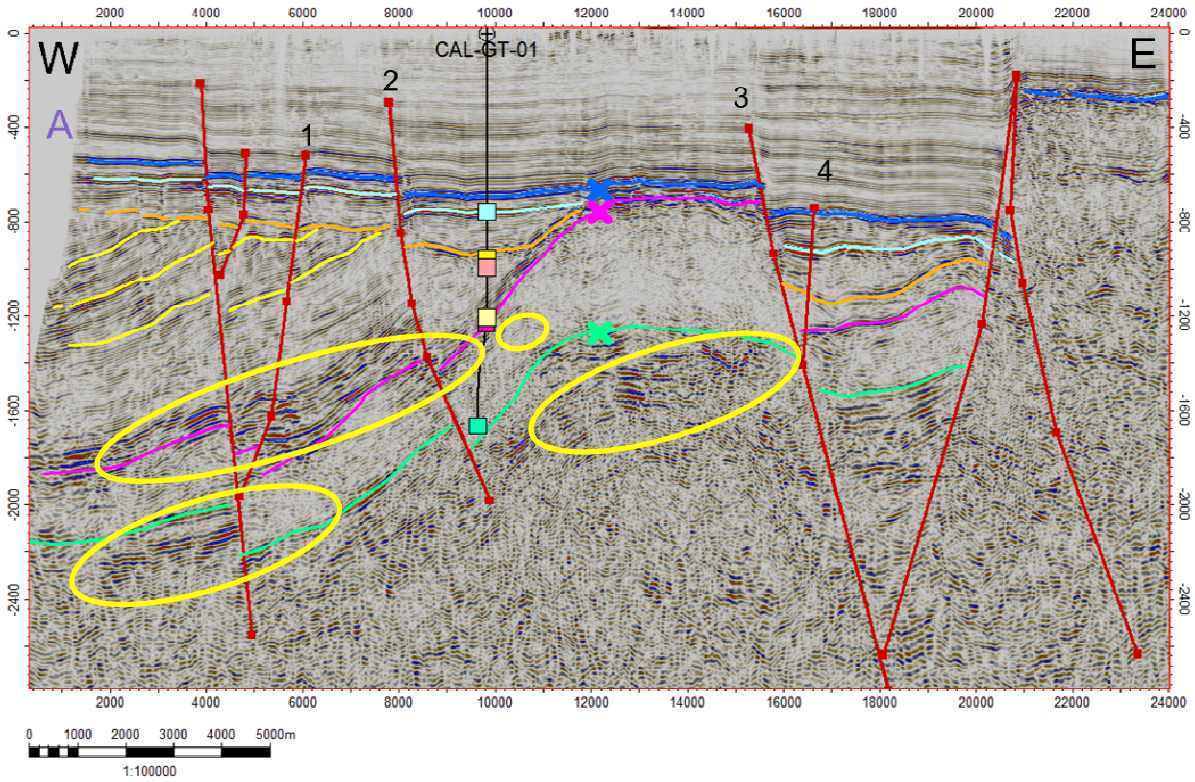
Mid – analogue Californie geothermal project

example of hydrothermal karst and dolomitisation



- Production from fault zone, injectors drilled away from fault zone (productivity ~100's m^3/hr)
- first well encountered karst cavity > 30m

- Result of hydrothermal and/or meteoric karst? One build-up for Mid-South?
- Cuttings shows massive hydrothermal diagenesis and suggest platform setting (Poty, 2014) → key question for region Mid

Quarries in Stolberg area (Germany) (1)

A lot of analogs – input to conceptual model

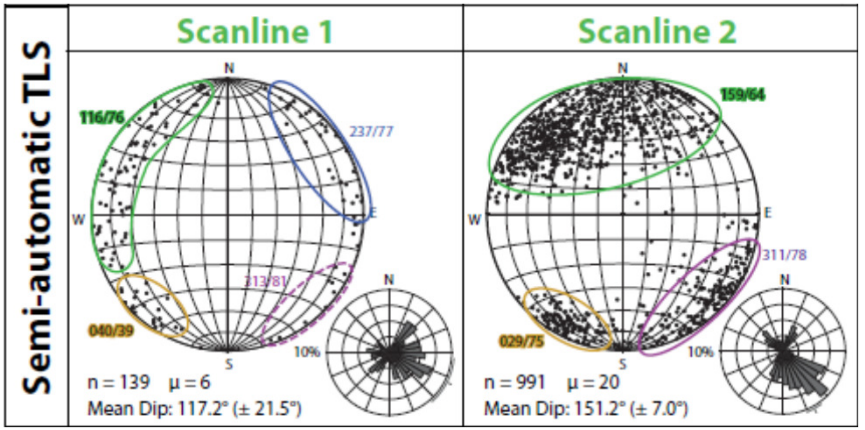
- Stratigraphic, lithological and structural similarities and differences – different location in the basin!
- Large fault zone in Hastenrath quarry; large throw - heavily fractured and (hydrothermal) diagenesis – mineralization and large karst features → CAL-GT!

Picture Harmen Mijnlieff (2002)

Quarries in Stolberg area (Germany) (2)

A lot of analogs – input to conceptual model

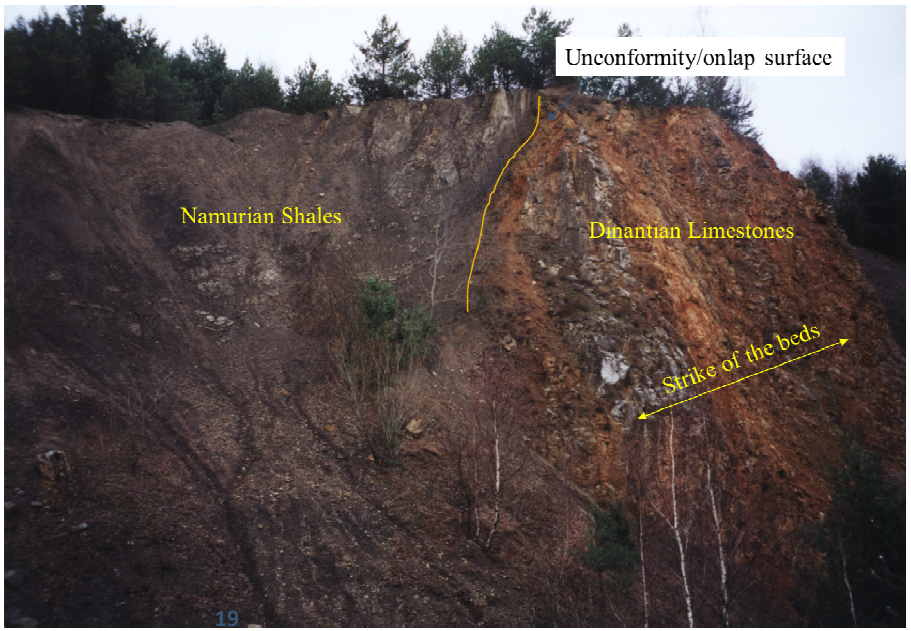
- Fault zone dimensions, fracture density (Becker et al., 2014)



Quarries in Stolberg area (Germany) (3)

A lot of analogs – input to conceptual model

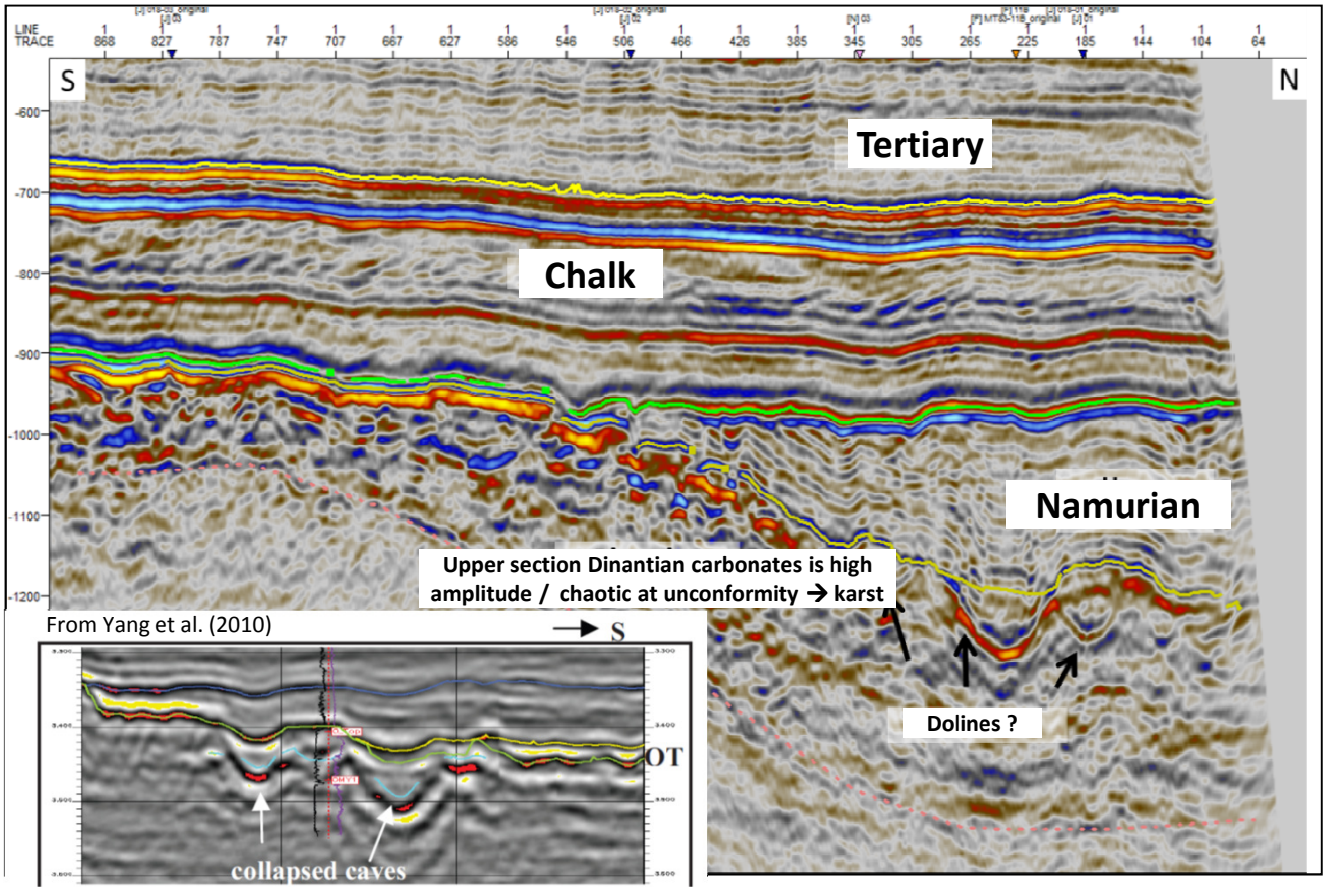
- Dolines and fracture widening from meteoric karstification – Namurian and younger infill



Picture Harmen Mijnlieff (2002)

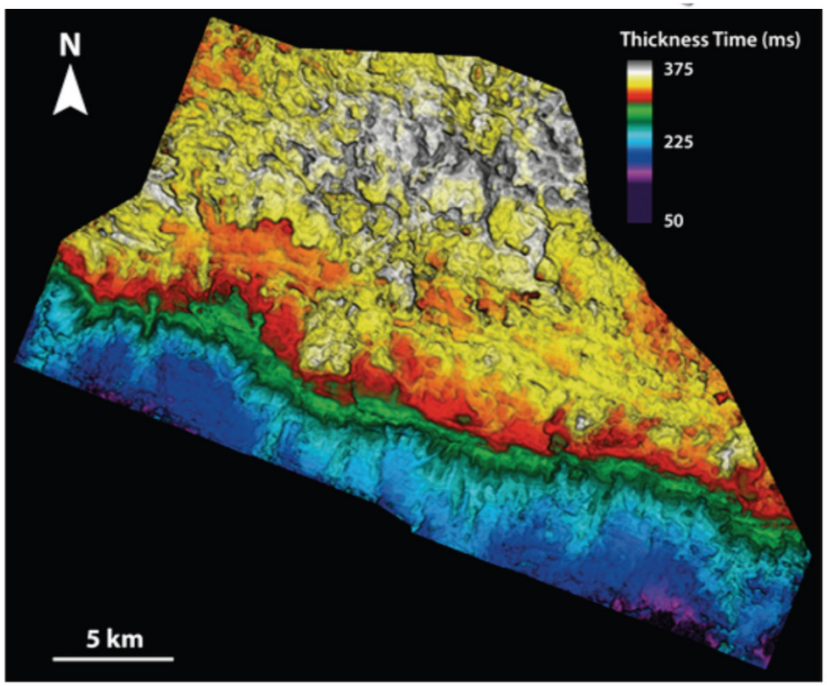
Reservoir quality – meteoric karst in 2D

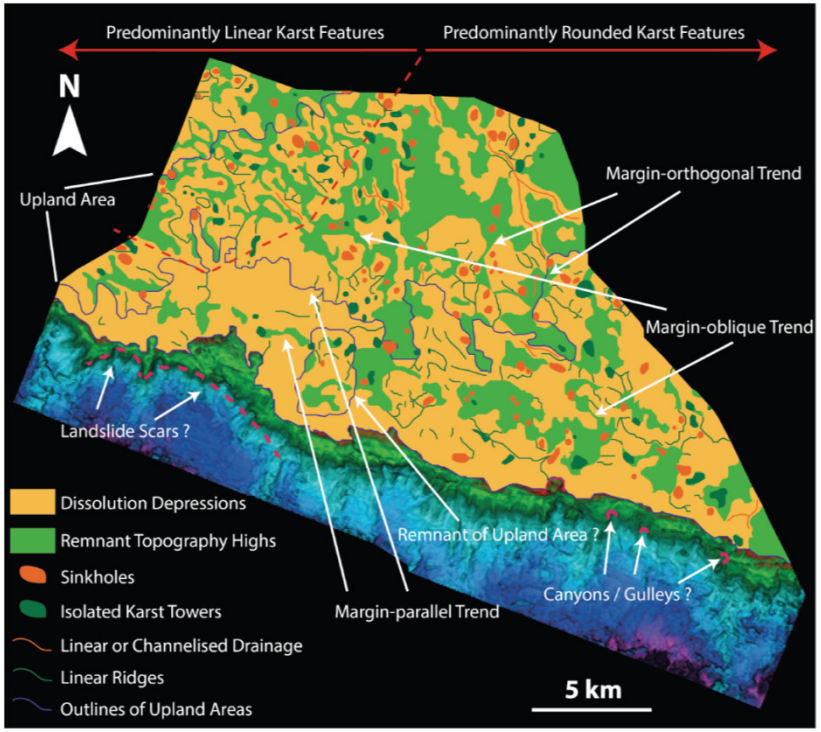
seismic shows clear indications for meteoric karst



Reservoir quality – meteoric karst in 3D

Another example from Caspian, using 3D seismic attributes – Son Tra et al. (2017)





From Son Tran et al. (2017)

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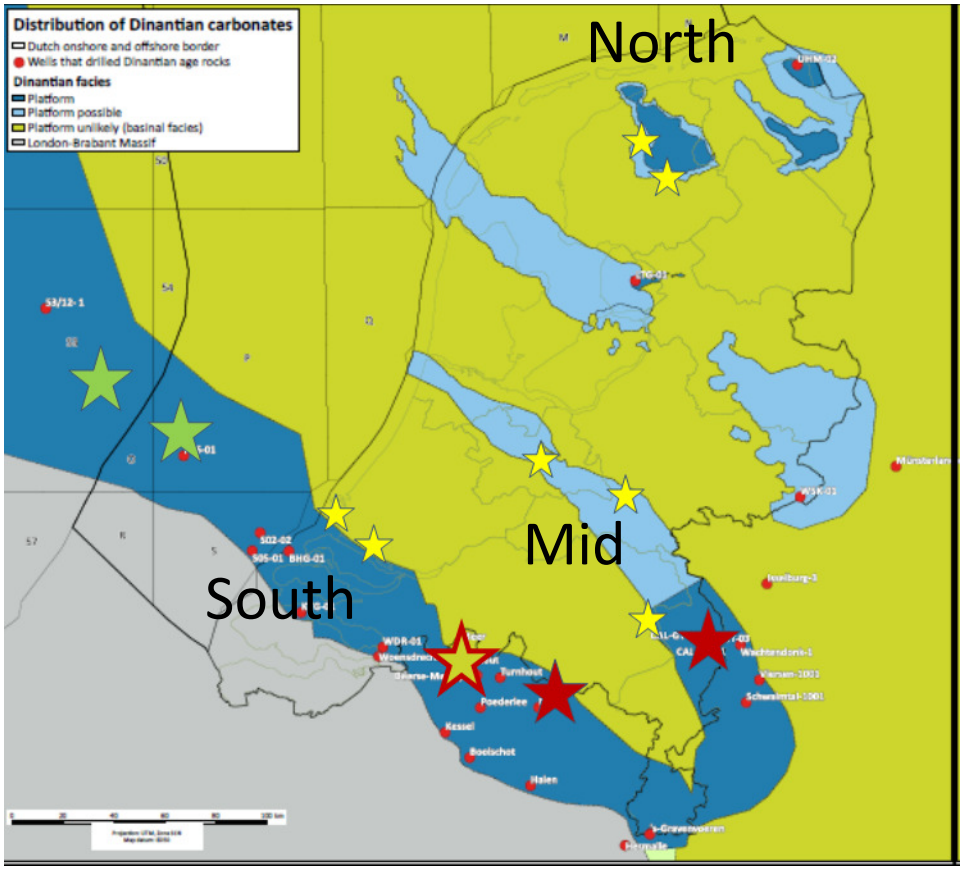
De-risking the Dinantian Carbonate play in UDG program



- Three sub-plays in UDG clearly differ in various ways:
  - geometry, RQ (faults, fractures, diagenesis), Z, T, …
  - Available data and analogues
- Aim of the UDG program is to identify 1-3 pilot projects which can de-risk the play, before 2020
- Start of the UDG-EWP data acquisition and studies early 2018

Thanks for your interest and attention !

Acknowledgements for input

- *Fokko van Hulten, Jan Lutgert, Marten ter Borgh (EBN)*
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