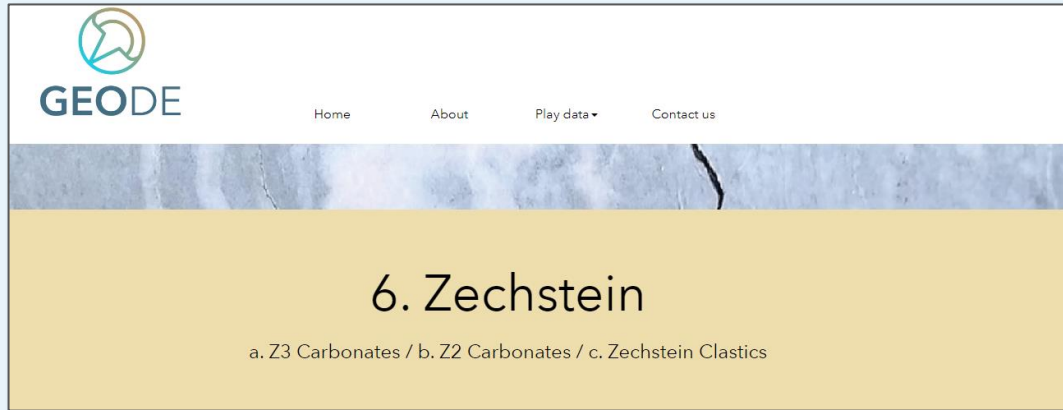
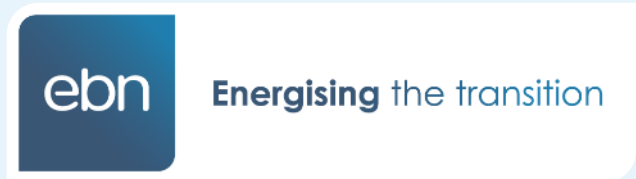


Zechstein carbonate play, N NL offshore: recent developments

Daan den Hartog Jager, 15-03-2023



<https://www.geodeatlas.nl/pages/play-6-zechstein>



ZEZ2C carbonate play, southern flank of the Mid North Sea High



- Introduction: regional setting
- Pensacola discovery (Shell/Deltic, Feb 2023)
- Analogues in N NL offshore: Zephyr study, GEODE platform

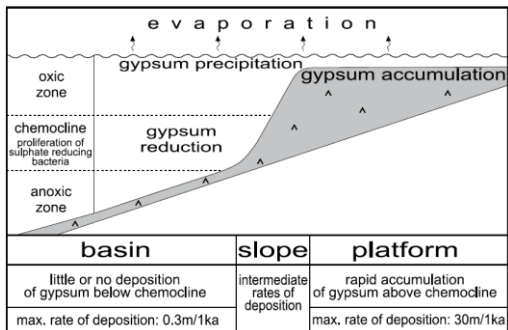
Zechstein stratigraphy incl thickness indication

Grant, Underhill et al, 2019

- Valid for entire Southern Permian Basin!

- Subplays:

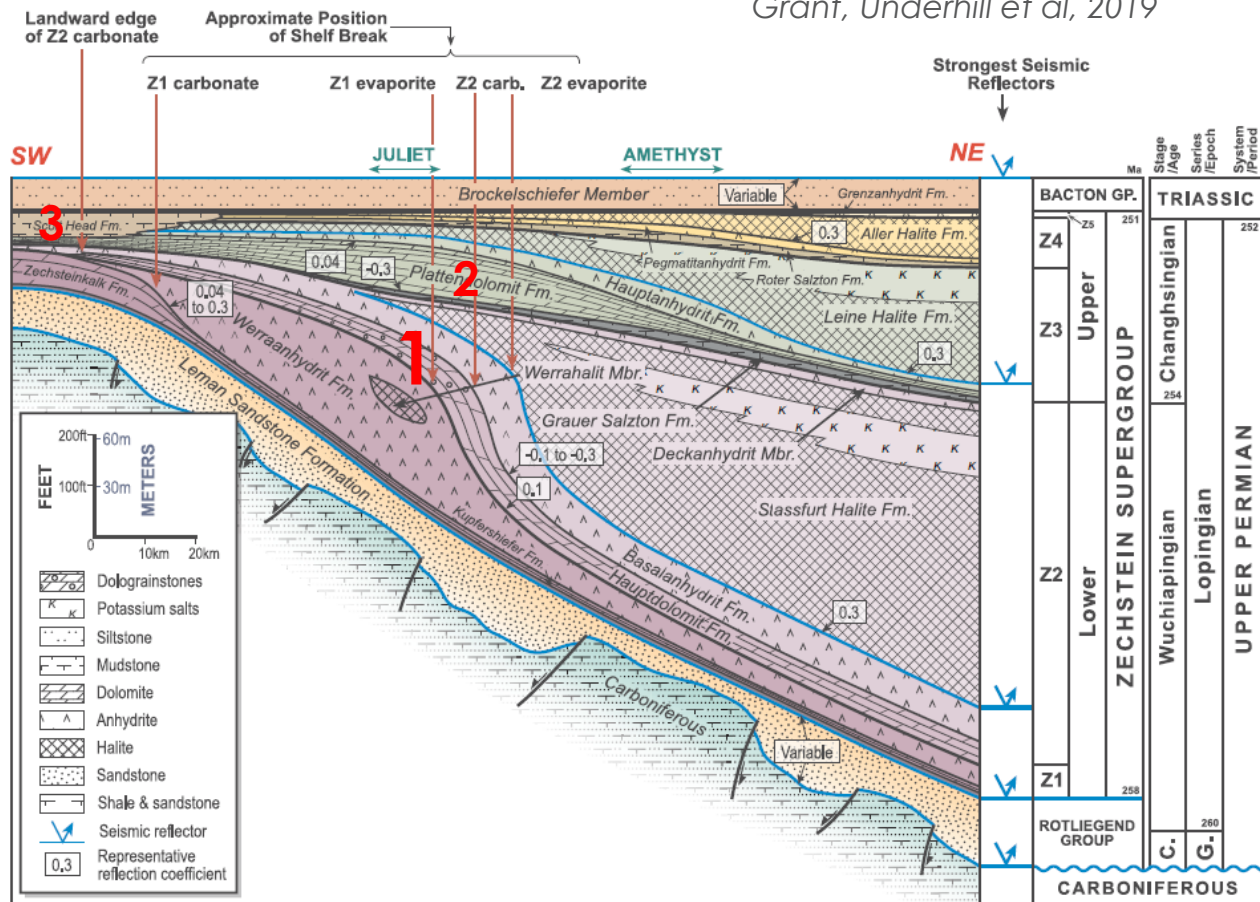
1. ZE2C / Hauptdolomite



Platform carbonate growth on gypsum accumulations: vd Sande et al, 1996

2. ZE3C / Plattendolomite

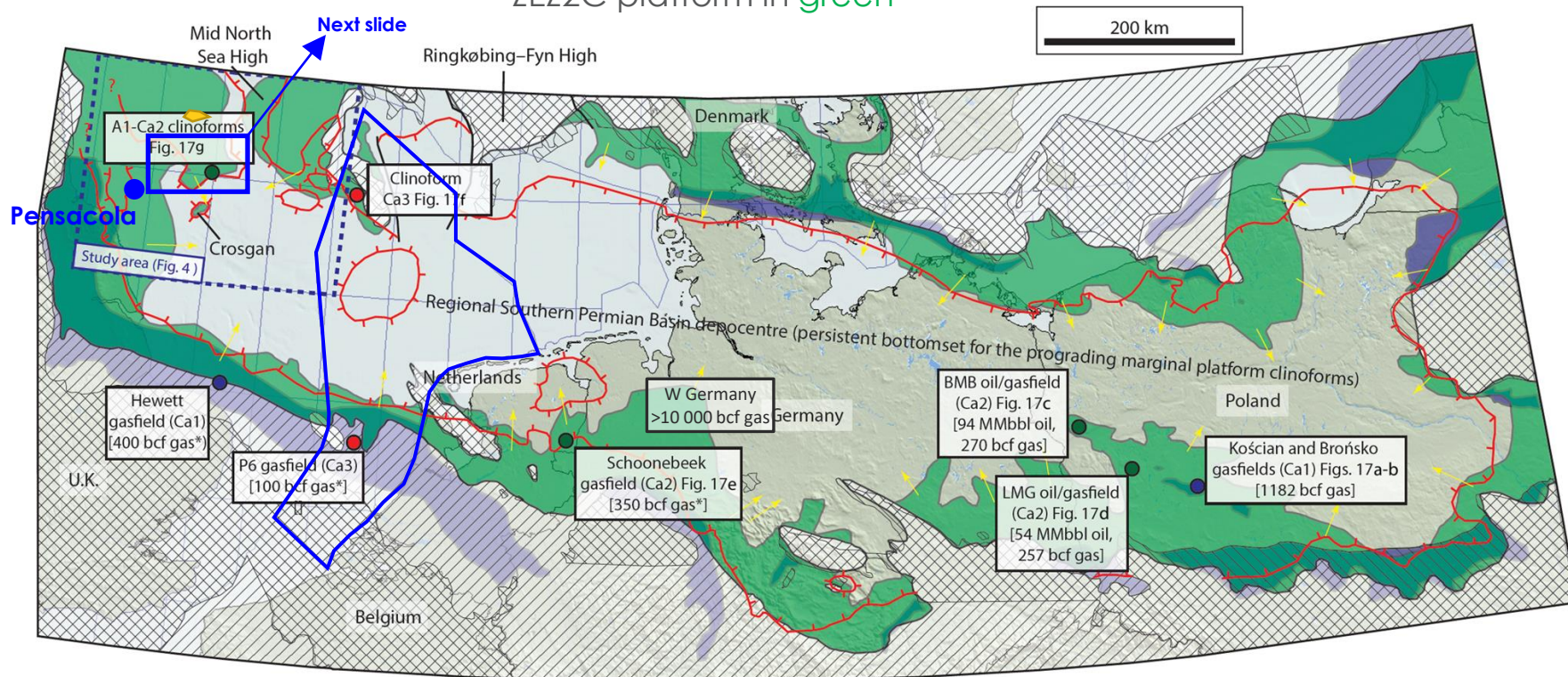
3. ZE2xS / Fringe sandstones



Southern Permian Basin, Zechstein facies

Modified from Patruno et al, 2018

ZEZ2C platform in green



KEY



Z1 Hiatus/ Erosion (modified after Peryt et al., 2010)

Z2 Hiatus/ Erosion (modified after Geluk et al., 2007)



Z2 carbonate platform (modified after Peryt et al., 2010)

Z1 carbonate platform (modified after Geluk et al., 2007)



Major discoveries in Zechsteinkalk (Ca1)



Major discoveries and other data examples in Hauptdolomit (Ca2)



Major discoveries in Plattendolomit (Ca3)

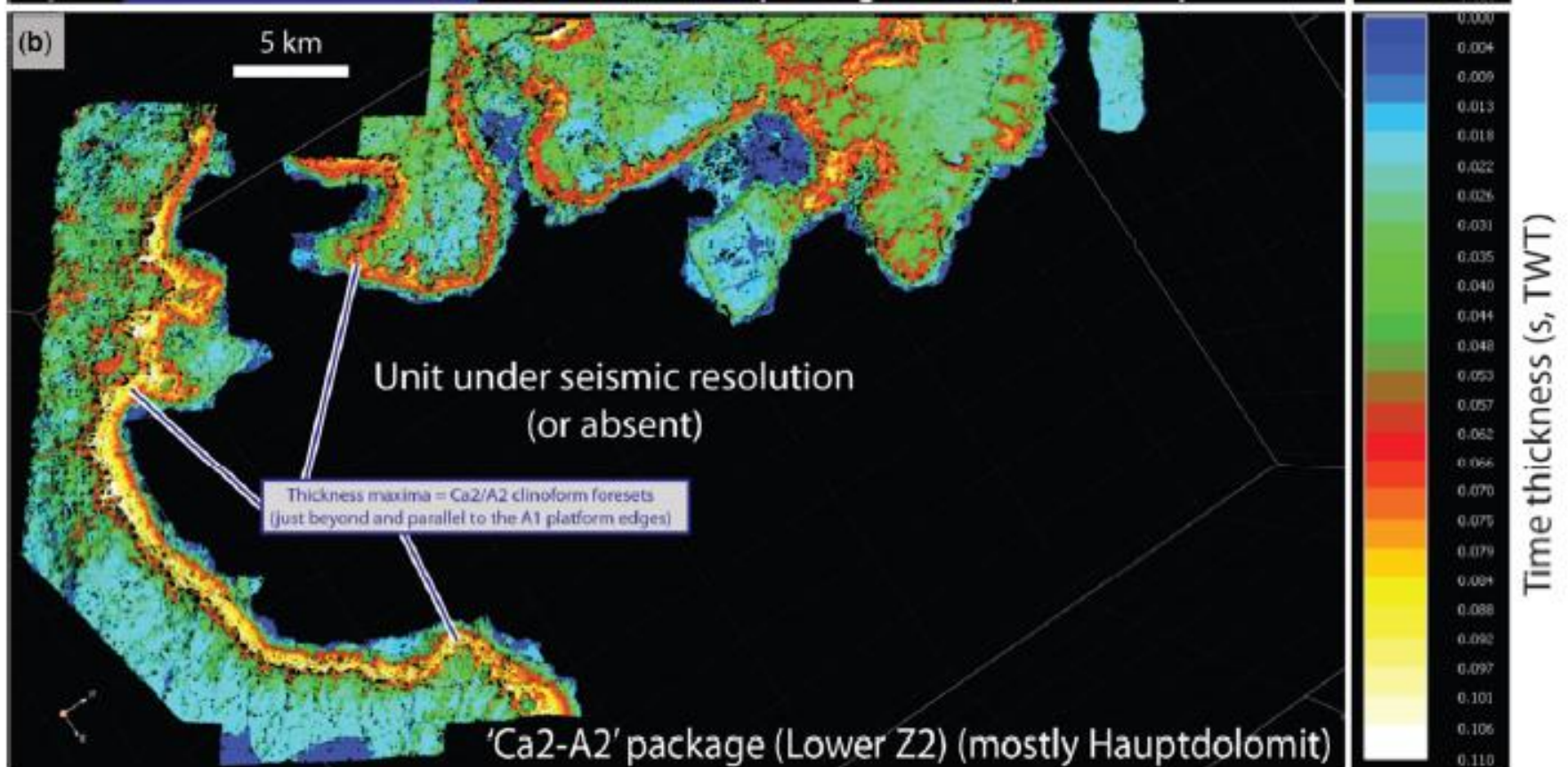
Z3 carbonate shelf edge (modified after Taylor, 1998 and Peryt et al., 2010)

Overall progradation direction

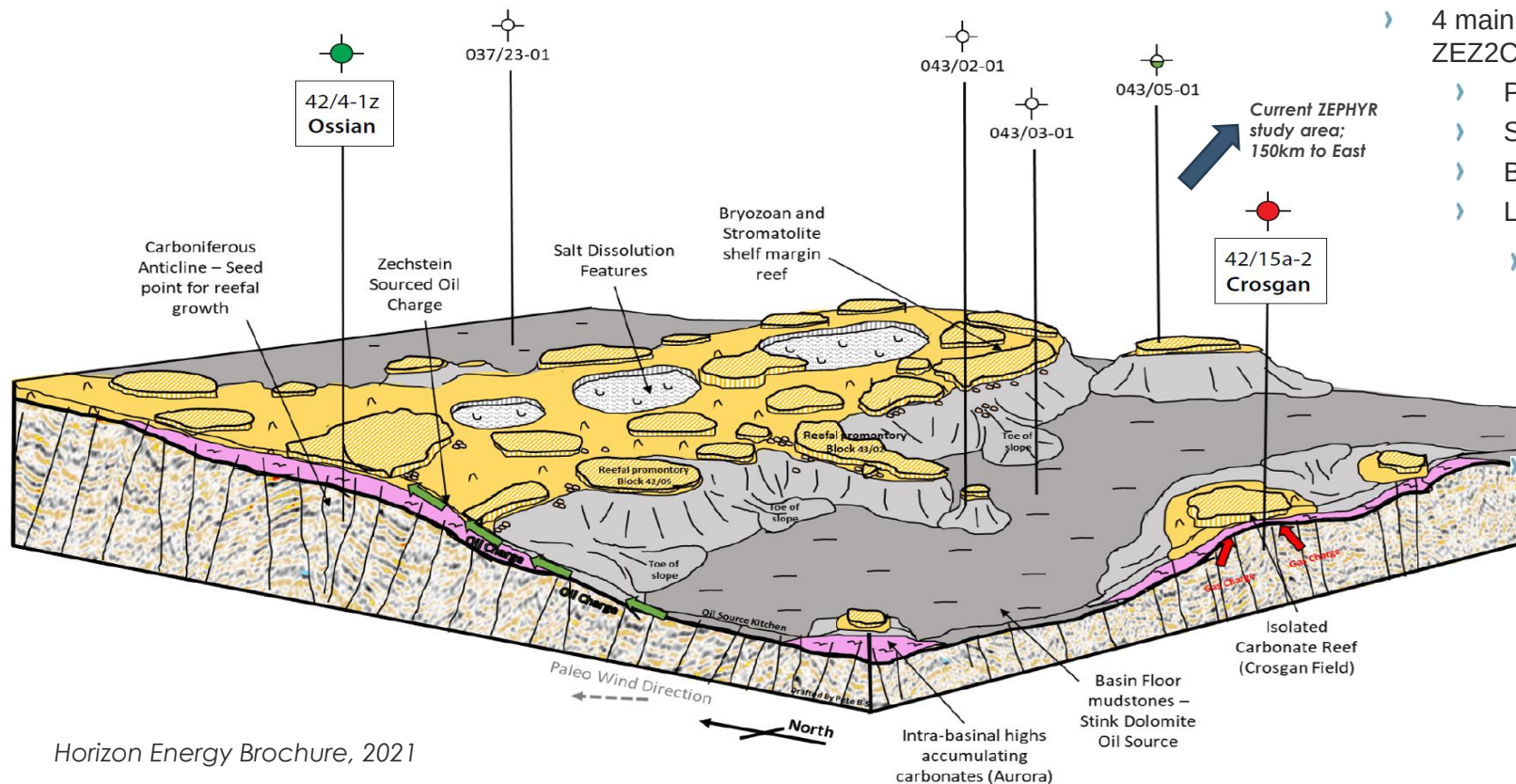
Complexity of ZE2C platform edge

Location: see previous slide

Patruno et al, 2018



Depositional model for the ZEZ2C



› 4 main facies types for ZEZ2C:

- › Platforms
- › Slope
- › Basinal
- › Lagoonal/Back barrier

› Thickest ZEZ2C platforms on top of pre-existing Carboniferous highs and Werra (ZE1W) platforms

The best reservoirs are expected to be found in the platform-, and possibly slope facies.

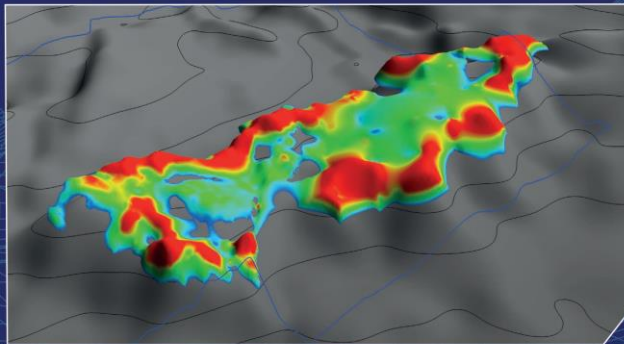
Pensacola prospect summary sheet (Deltic Energy 2018)

Volumes and POS increased after 3D acquisition – POS to 55%

PENSACOLA PROSPECT ZECHSTEIN PATCH REEF

P50 Prospective Resource = 424 BCF

Blocks 41/5, 41/10 and 42/1 – Southern North Sea (CLNR 100% Equity)



1 Figure 1. 3D image of Pensacola Zechstein reef prospect

- Large patch reef structure with clear fringing reef and lagoon architecture
- Covers an area of 15km by 6km and with fringing reef build-up over 200m thick
- **P50 Prospective Resources of 424 BCF (Range 180 - 997 BCF)**
- Many analogous structures mapped on adjacent blocks
- 2018 work programme requires acquisition of new 3D budgeted at £3.5M

PENSACOLA PROSPECT SUMMARY

- Large patch reef structure mapped on mixed 3D and 2D dataset
- Covers an area of 80km² and with a fringing reef build up of over 225m thick
- Potential for high quality reservoir to be associated with the fringing reef
- Play opening opportunity with significant regional running room
- 2018 work programme requires acquisition of new 3D budgeted at £3.5M

Prospect	Type	PRMS Status	Net Prospective Resources (BCF)				GCoS %
			P90	P50	Mean	P10	
Pensacola	Fringing Reef	Prospect	113	270	338	650	20
	Lagoon Fill	Prospect	67	154	186	347	16

INTRODUCTION

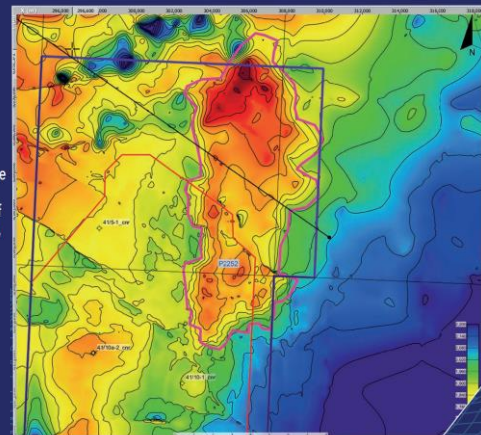
Licence P2252 (Blocks 41/5, 41/10 and 42/1) are located to the NW of the producing Breagh Field in shallow water and close to existing infrastructure. The presence of gas within Zechstein carbonates has been proven in multiple wells within the licence area and a similar reefal build-up located above the Crogan discovery in the Carboniferous. Pensacola is just one of many similar structures mapped on adjacent blocks and is thought to be analogous to producing fields in Poland, Germany, Holland, Canada and the USA.

LICENCE BACKGROUND

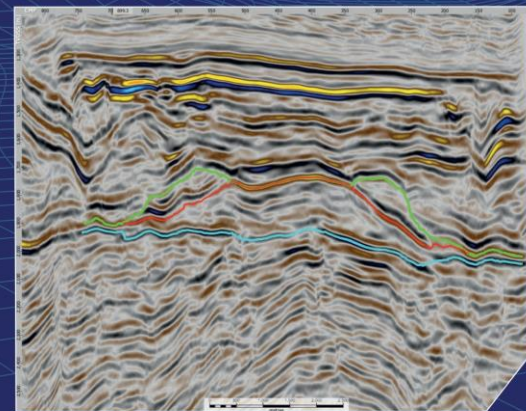
- P2252 is a 28th Round award in which CLNR has a 100% equity interest
- Initial 4-year term expires end November 2018
- The 2018 work programme requires acquisition of new 3D seismic across the Pensacola Reef



2 Figure 2. Location map of CLNR License P2252, Blocks 41/5, & 41/10 and part 42/1



3 Figure 3. Depth Map of Pensacola Zechstein reef prospect



4 Figure 4. East-West line interpretation across the Pensacola Zechstein reef prospect

Pensacola operations and findings: LinkedIn info



- ❑ UK well 41/05a-02, spud 21 Nov 2022, TD 28 Dec 2022, rig release 22 Feb 2023
- ❑ Rig Noble Resilient, water depth 70m, TD 1996mAH, 1936m TVSS
- ❑ Gas discovery announced in ZE2C, reservoir thickness 19m, top 1745mTV, porosity 16%, slope facies. Drilled on the flank, probably long column
- ❑ Post-drill resource estimate P90-P50-P10: 164 – 302 - 519 bcf **(4.6 – 8.6 – 14.7 bcm)**
- ❑ “Largest discovery in the UK Southern North Sea since Tolmount (Rotliegend, 2011)”
- ❑ Test rates Feb 2023: 4.75 mmscf/d gas declining to stable 1.75 mmscf/d after 12 hours (135 000 => 50 000 m3/d; “rates could be higher further updip”). Plus 35°API oil at 18 bbl/d
- ❑ Gas quality: >80% CH₄, ~10% CO₂, <3ppm H₂S (=low)

Sources: [Deltic Energy](#), [Westwood](#), [NSTA](#), [GeoExpro](#), [Trove](#) (13 minute movie)

From Deltic corporate presentation, March 2023 (1)

- Oil ~1750m TVSS, close to spillpoint 1755m TVSS
- Appraisal well mid 2024?



Sample #16 at 1806mAH



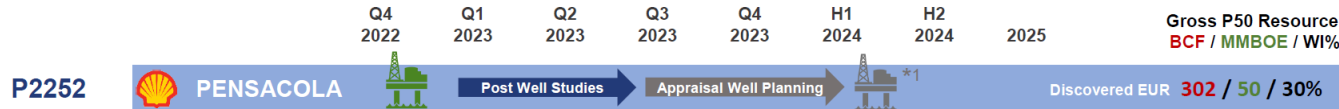
Sample #2 at 1812mAH

Source: [Deltic Energy](#)



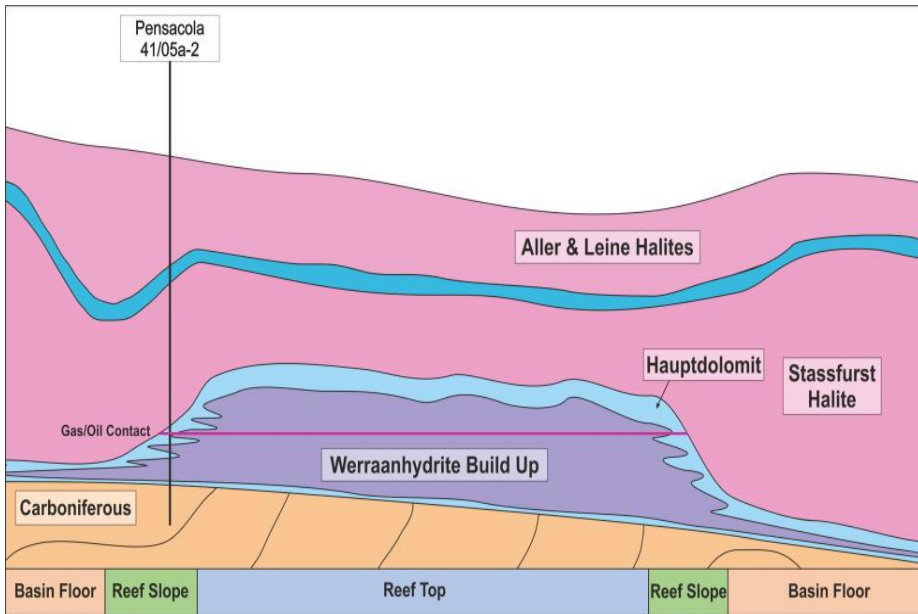
Indicative Operational Timeline

Active schedule with conveyor belt of drilling opportunities

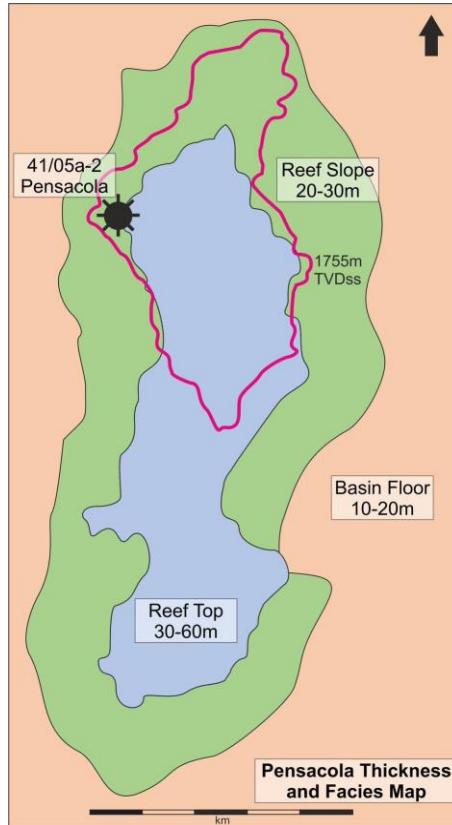


From Deltic corporate presentation, March 2023 (2)

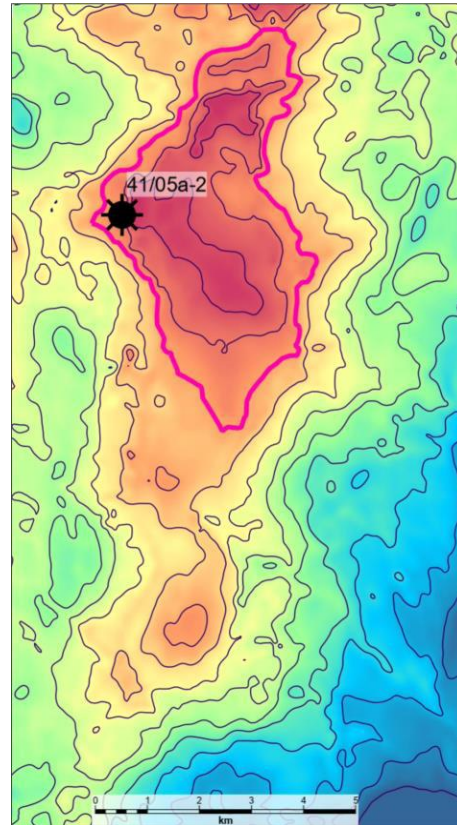
Source: [Deltic Energy](#)



Schematic cross-section:
note downdip position of the well

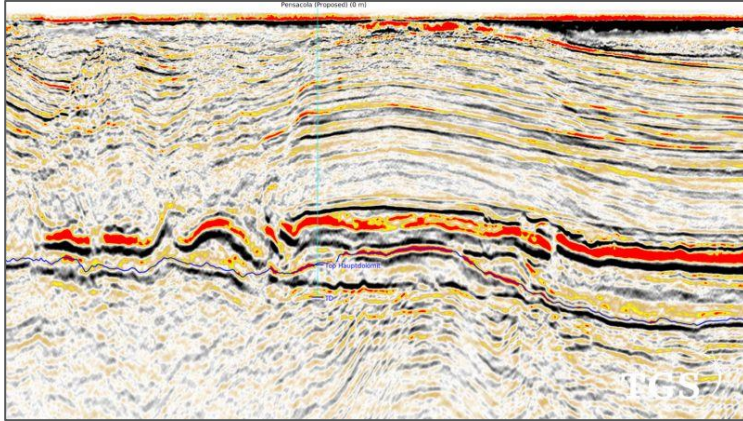


ZEZ2C facies map



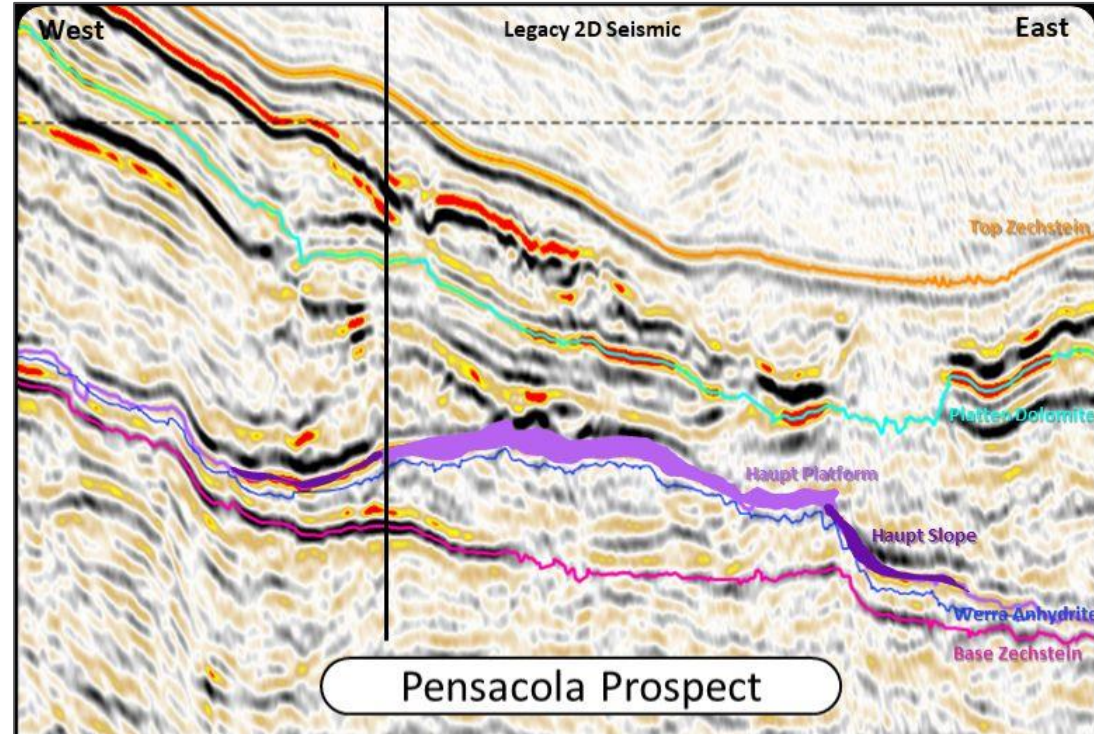
Top ZEZ2C
depth map

Seismic images (LinkedIn)



Uninterpreted: TGS

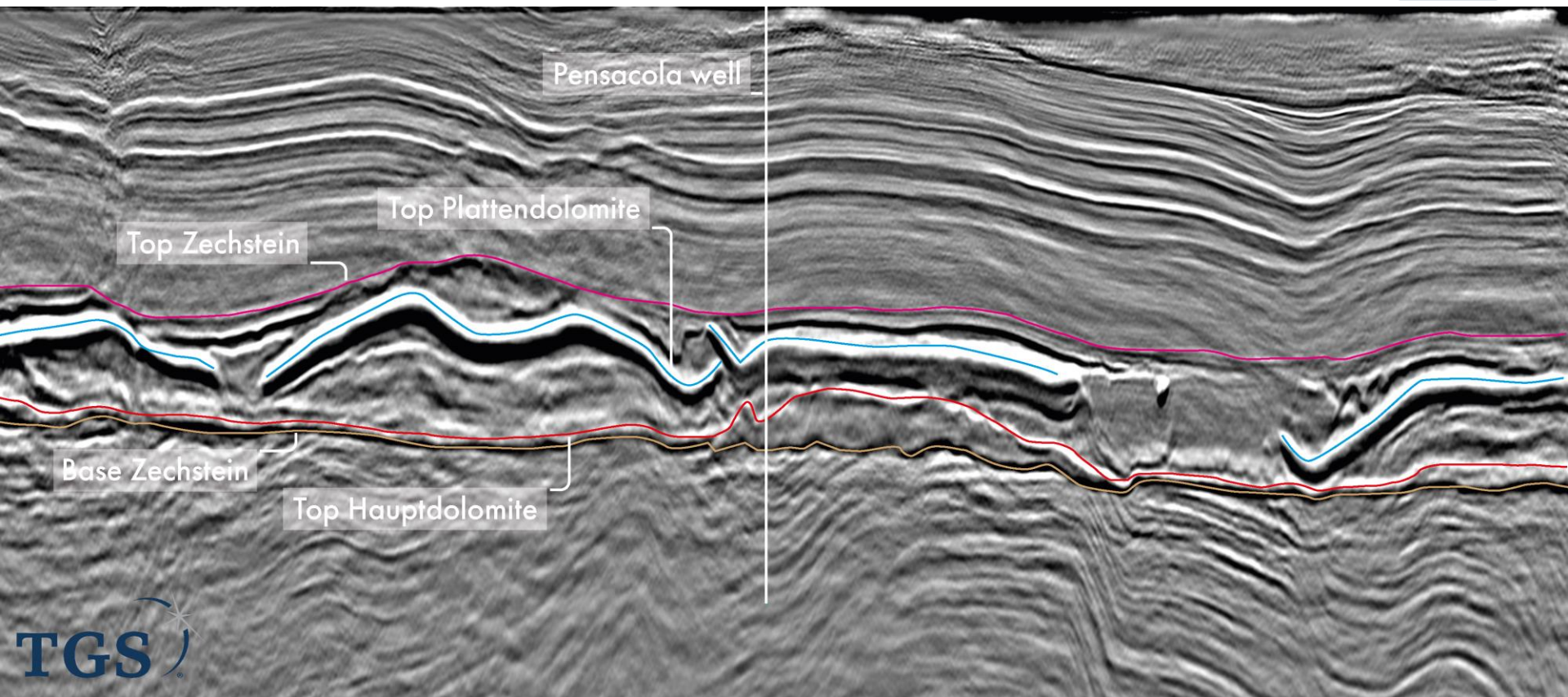
Interpreted by Peter Browning-Stamp,
Horizon Energy Ltd =>



Seismic image 2: TGS via GeoExpro (LinkedIn)

Source: [GeoExpro](#)

ebn



Similar buildups occur in NL Northern Offshore: see Zephyr Study (by TNO for EBN, 2021)

ebn

<https://www.ebn.nl/feiten-en-cijfers/kennisbank/aardgas/zephyr-zechstein-play-project-2021/>



Thema's ▾ Feiten & cijfers

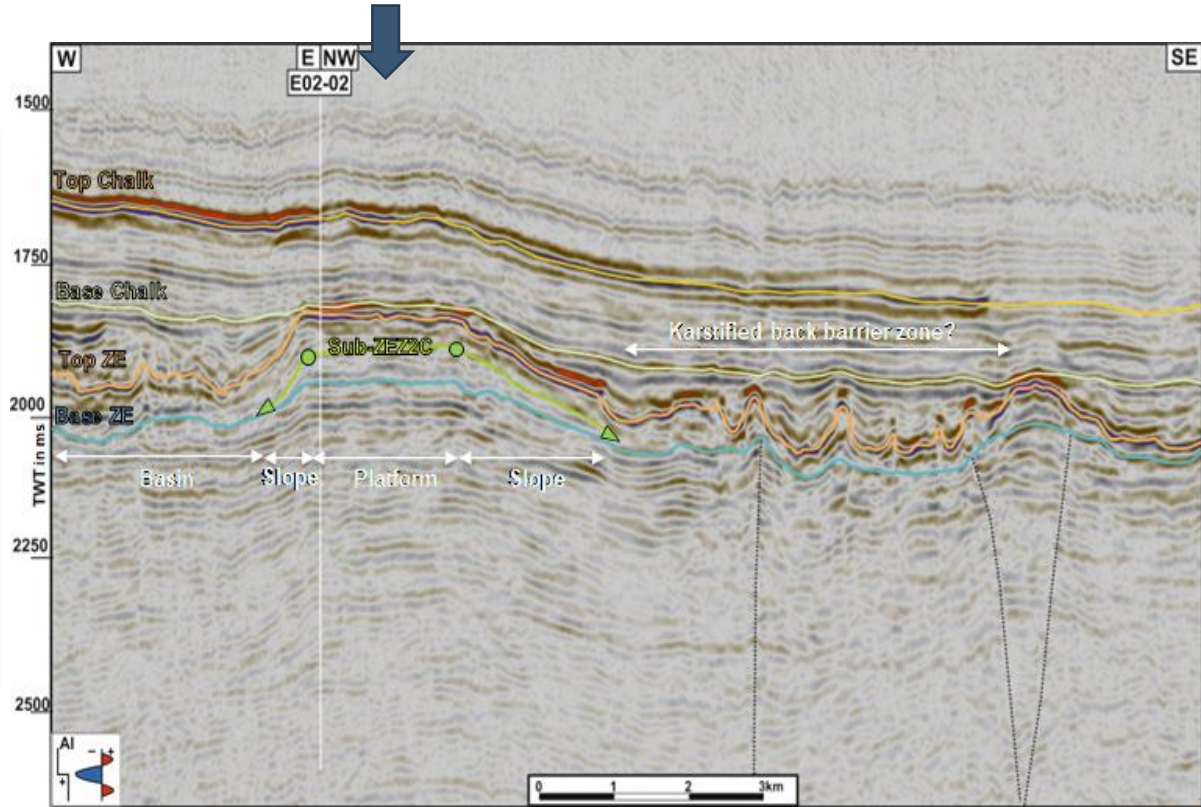
Home > Feiten en cijfers > Kennisbank > Aardgas > ZEPHYR – Zechstein Play Project 2021

ZEPHYR – Zechstein Play Project 2021

Understanding Z2 stratigraphy and paleogeography in the Dutch Northern Offshore.

- 1 ZEPHYR Seismic mapping report beschikbaar via download knop
- 2 Hauptdolomit petrography and diagenesis overview – CambridgeCarbonates beschikbaar [via deze link](#)

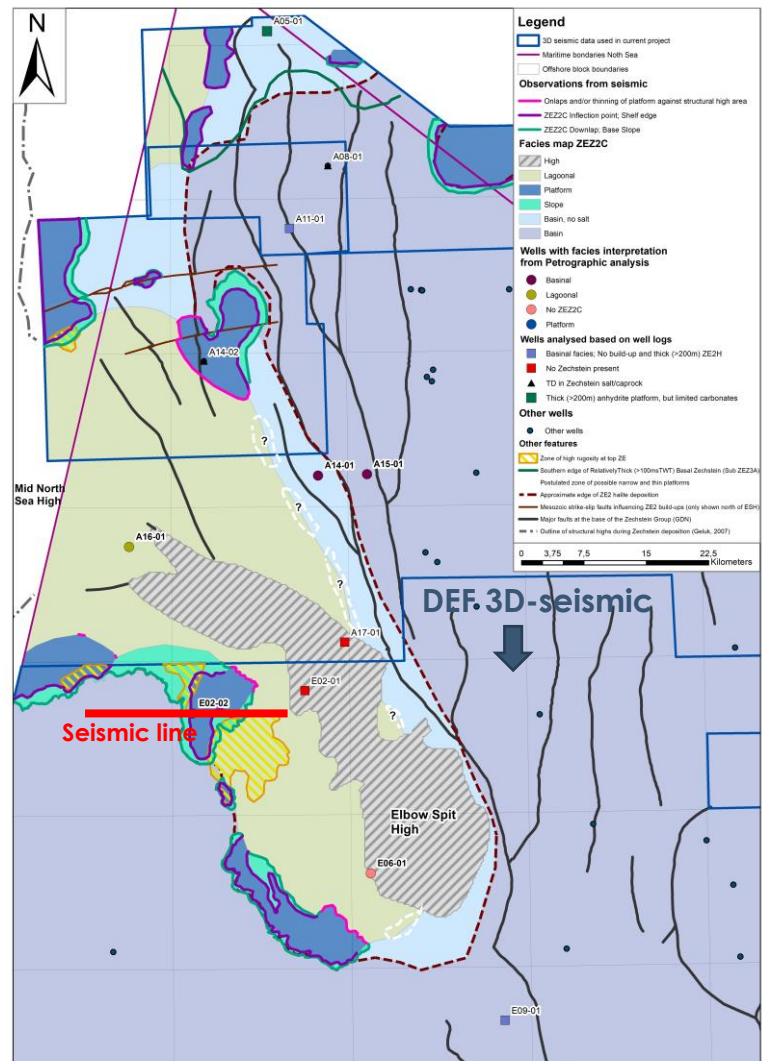
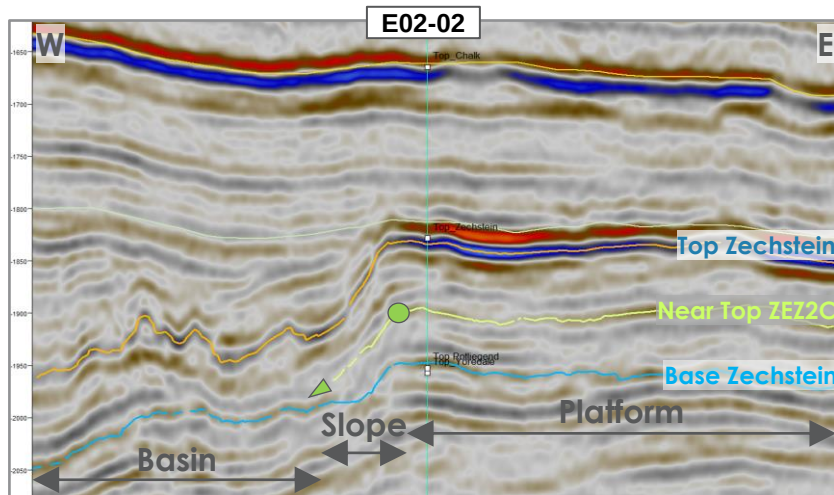
Zephyr study: [Bouroullec and Peeters, 2021](#)



Zephyr study: key conclusions

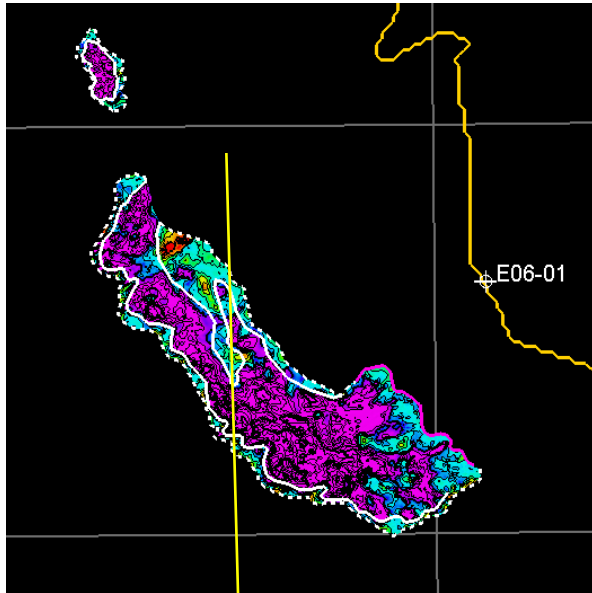
- ❑ ZE2C platform can be mapped, buildups are present
 - Partly on DEF seismic, available via TNO and EBN
- ❑ Well E02-02 (1990): valid test of a ZE2C buildup
 - Dry hole: charge problem? Fits with GEODE results
 - Porosity 16%; porosities >20% in nearby UK wells
- ❑ Buildups further S (block E05) or N (A-blocks):
 - Charge POS may be higher
 - Reservoir sweetspots have not been drilled

Zephyr study
(Bouroullec & Peeters, 2021)

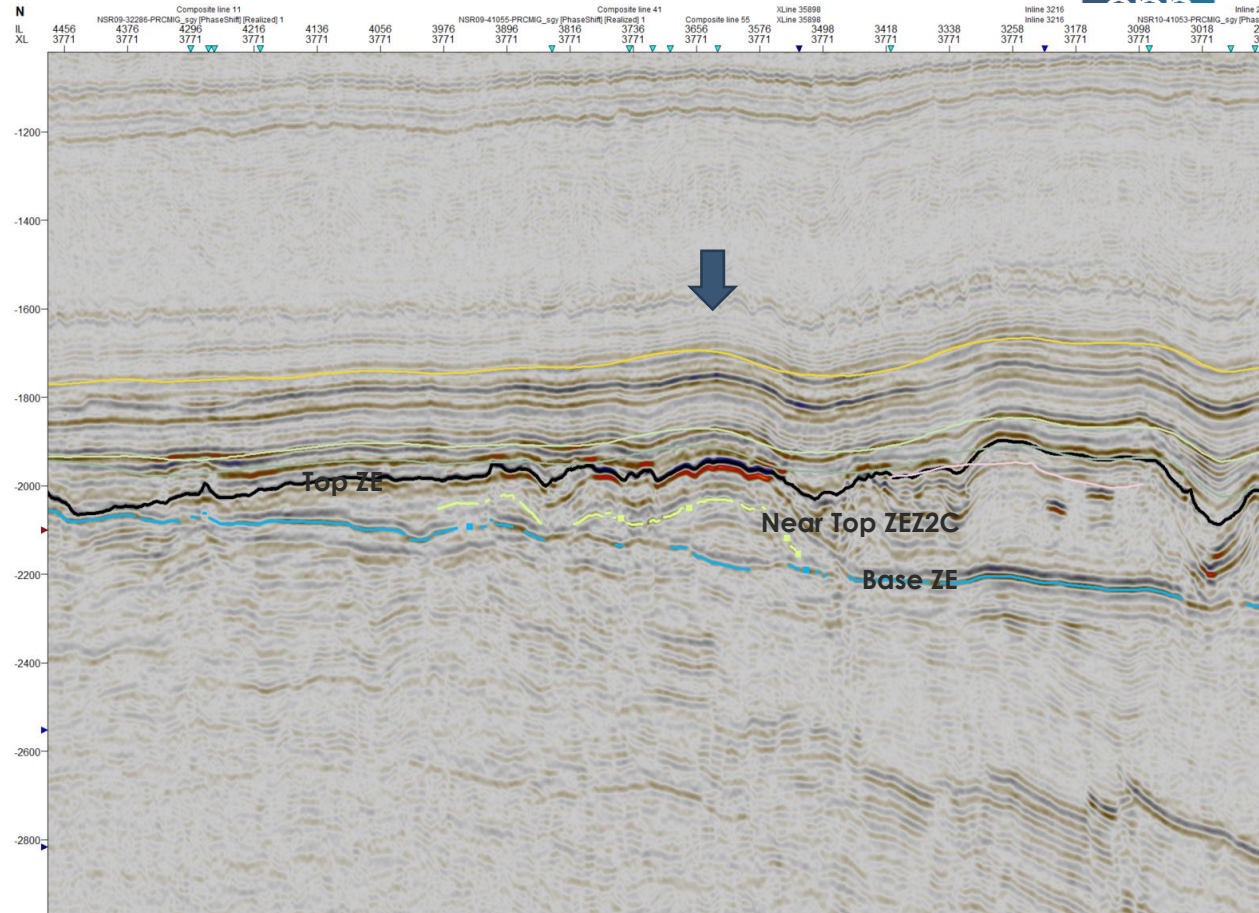


Example 2: E05

- Buildup geometry on DEF seismic

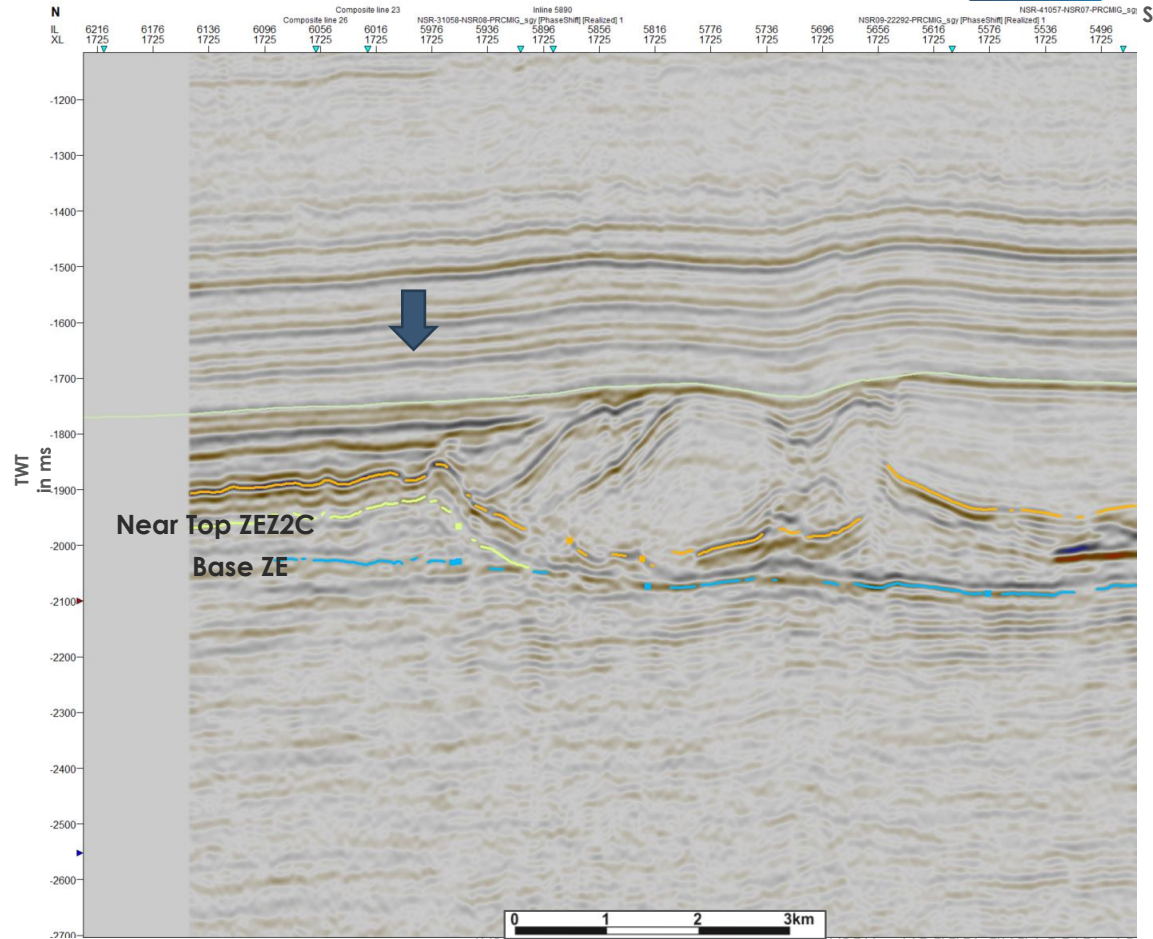
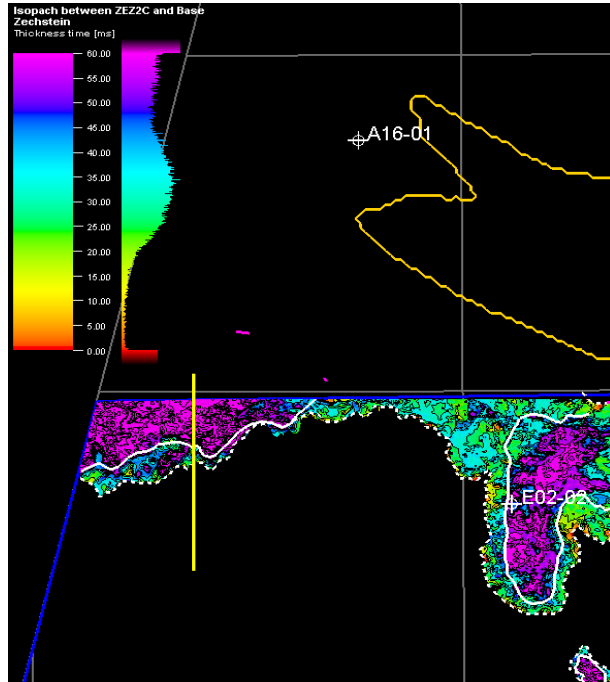


Zephyr study (Bouroullec & Peeters, 2021)

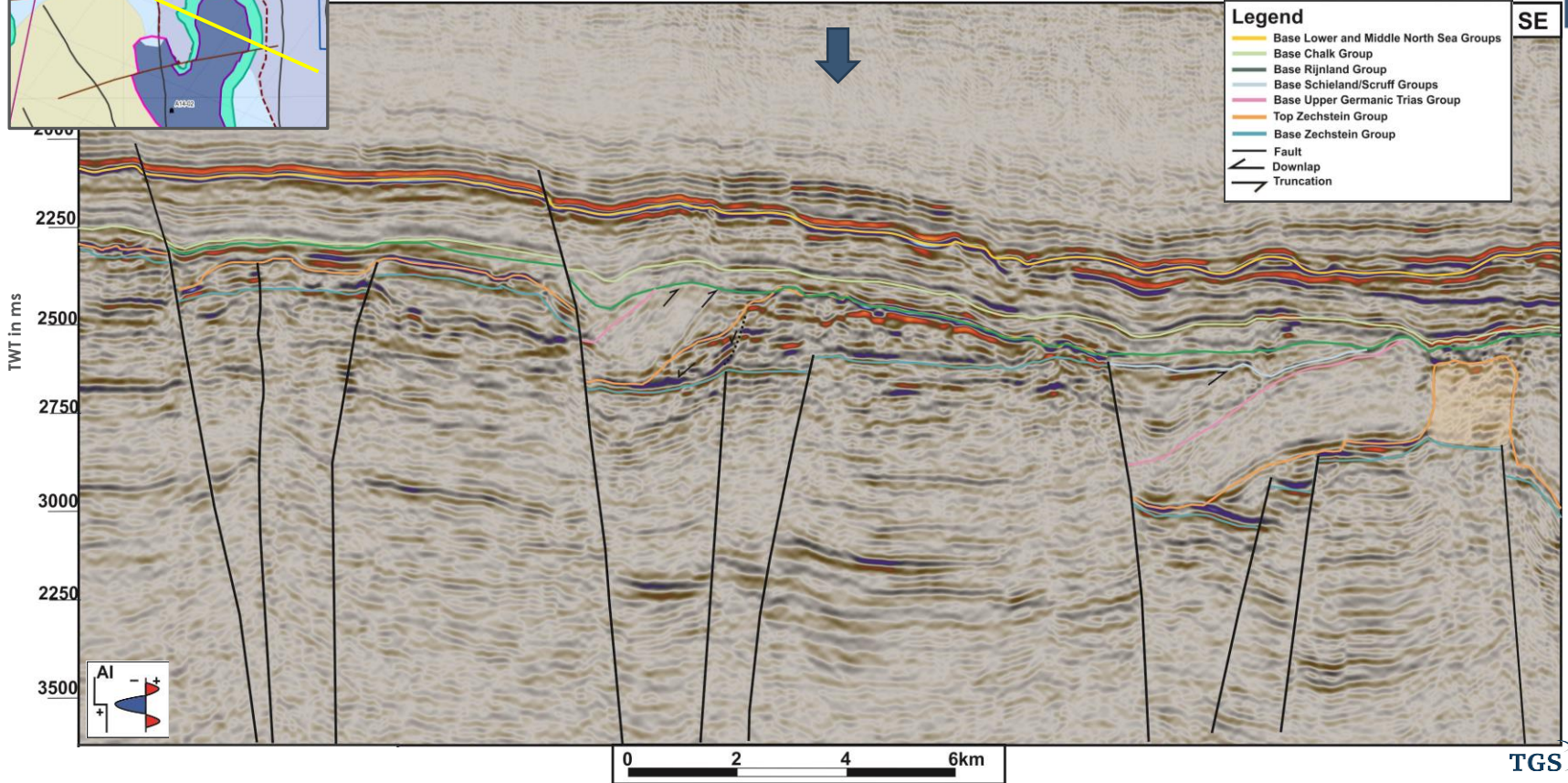


Example 3: E01-A16

□ Buildup geometry, undrilled



Further north: A14 buildup



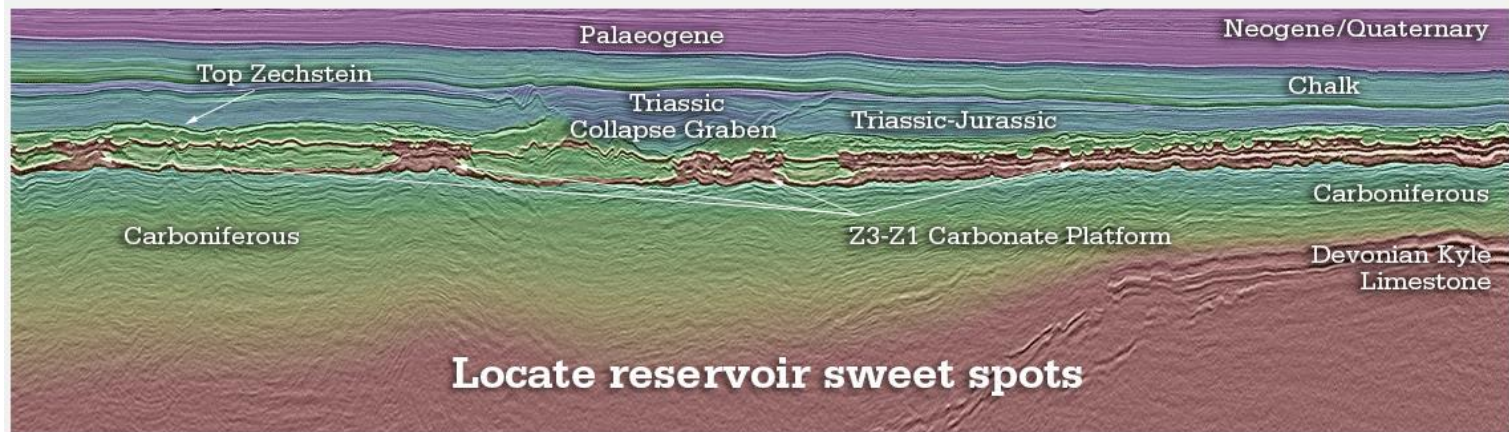
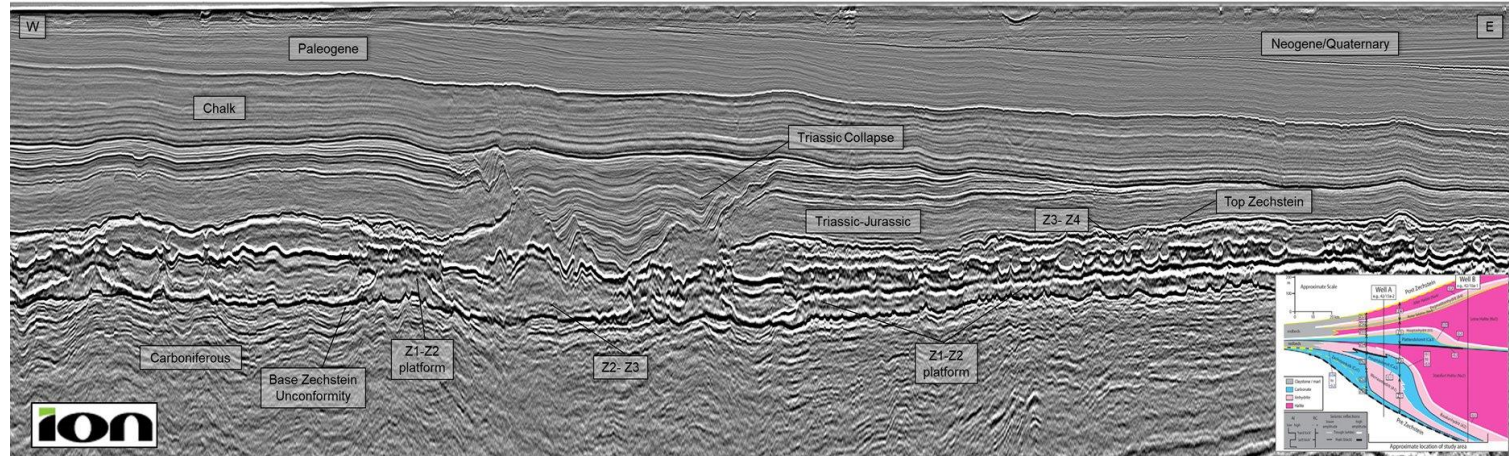
A14-02
build-up
and smaller
build-up
towards NW
on NSR-line.

Salt on
either side
of build-up
causes
Triassic rafts.

Improved imaging is possible: ION 2020, UK

Sources: [ION GEO](#), [GeoExpro](#)

ebn



Conclusions



- ZE2C carbonate is underexplored in NL northern offshore
- Promising discoveries are being made on the UK side
- EBN/TNO studies are available: [GEODE](#), [Zephyr](#)
- Many of the key blocks are currently open: opportunities?

