# Chuditch Gas Field, Offshore Timor-Leste

SundaGas Banda Unipessoal, Lda


## Application of Pre-Stack Depth Migration and Full Wavefield Inversion to unveil a substantial gas discovery


Colin Murray

7 March 2023

*SundaGas Banda UL is a subsidiary of*
BARON OIL Plc

# Acknowledgements

SundaGas Banda Unipessoal, Lda

Timor-Leste government regulator – for permission to show data and presentation

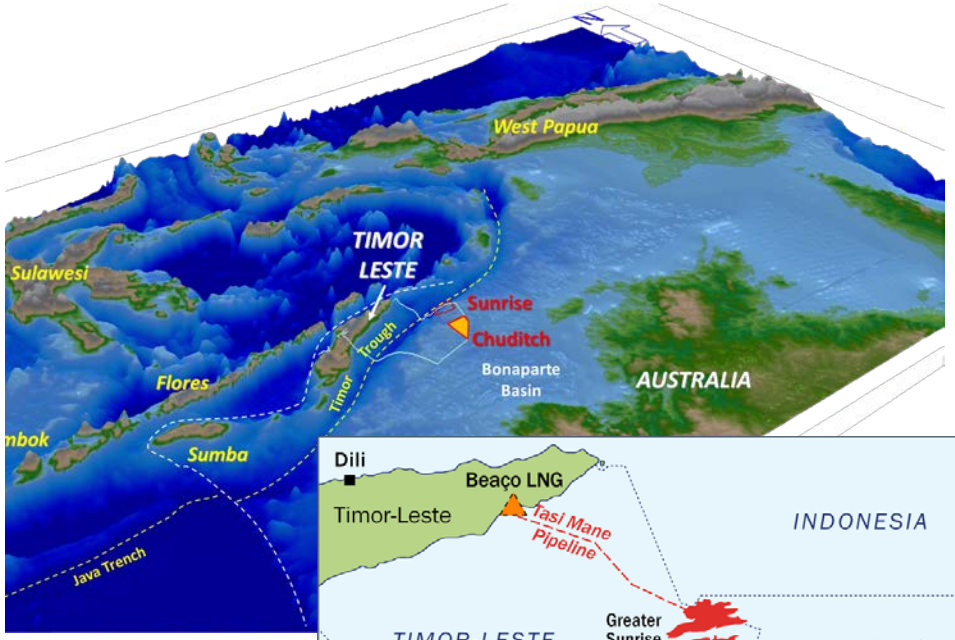
Joint Venture partner

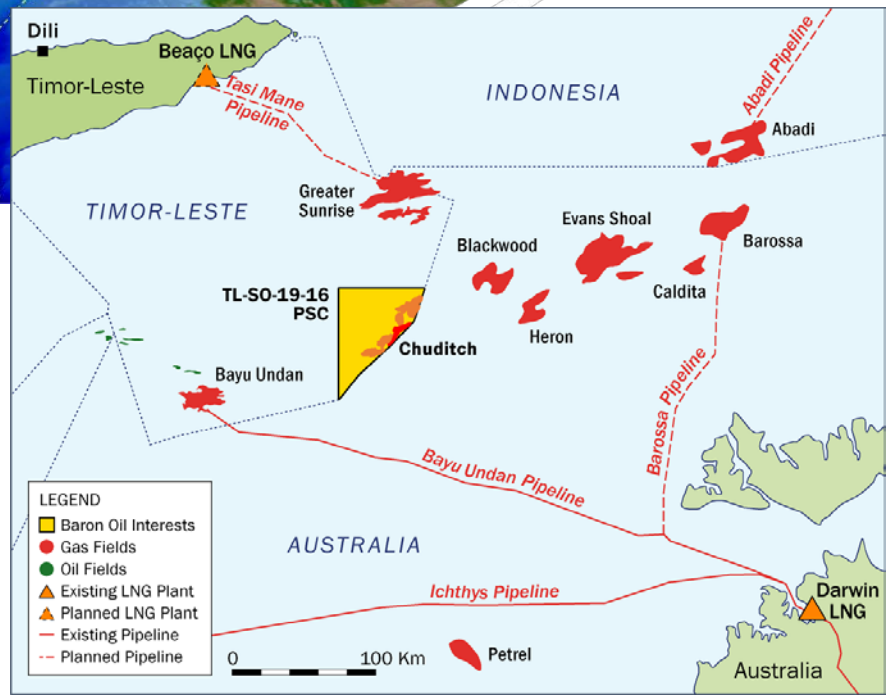
3D seismic PSDM reprocessing and data licensor – for permission to show seismic data and provision of some data images

Post-migration gather conditioning

SundaGas colleagues and co-authors

# Introduction to Timor-Leste and SundaGas




- Timor-Leste is a young, democratic republic, with substantial developmental challenges
- Economy dependent on revenues from Bayu Undan, about to convert to CCS facility
- Keen to see the development of new resources, including Sunrise and Chuditch
- SundaGas Banda UL ("SundaGas")
  - SundaGas shareholder is UK-listed Baron Oil Plc
  - Operator of the TL-SO-19-16 ("Chuditch") PSC
  - 75% WI; JV partner TIMOR GAP
  - 130km east of Bayu Undan, 100km south of Sunrise

# Chuditch PSC: Basin Setting

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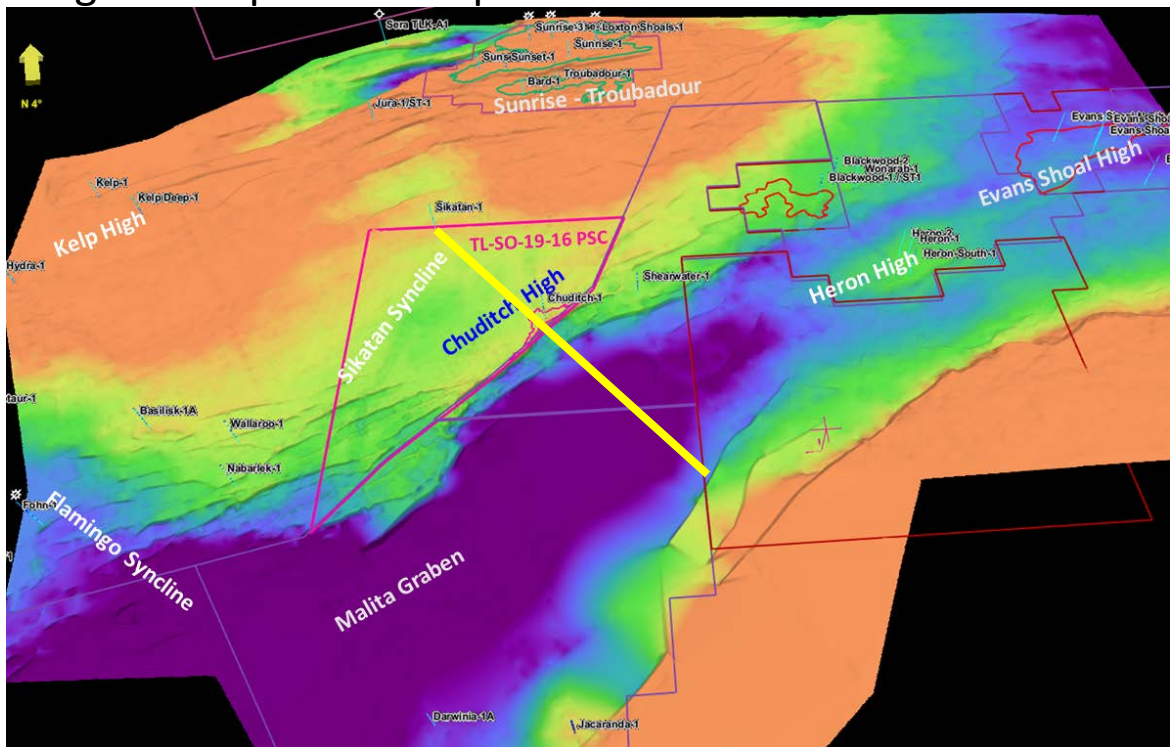
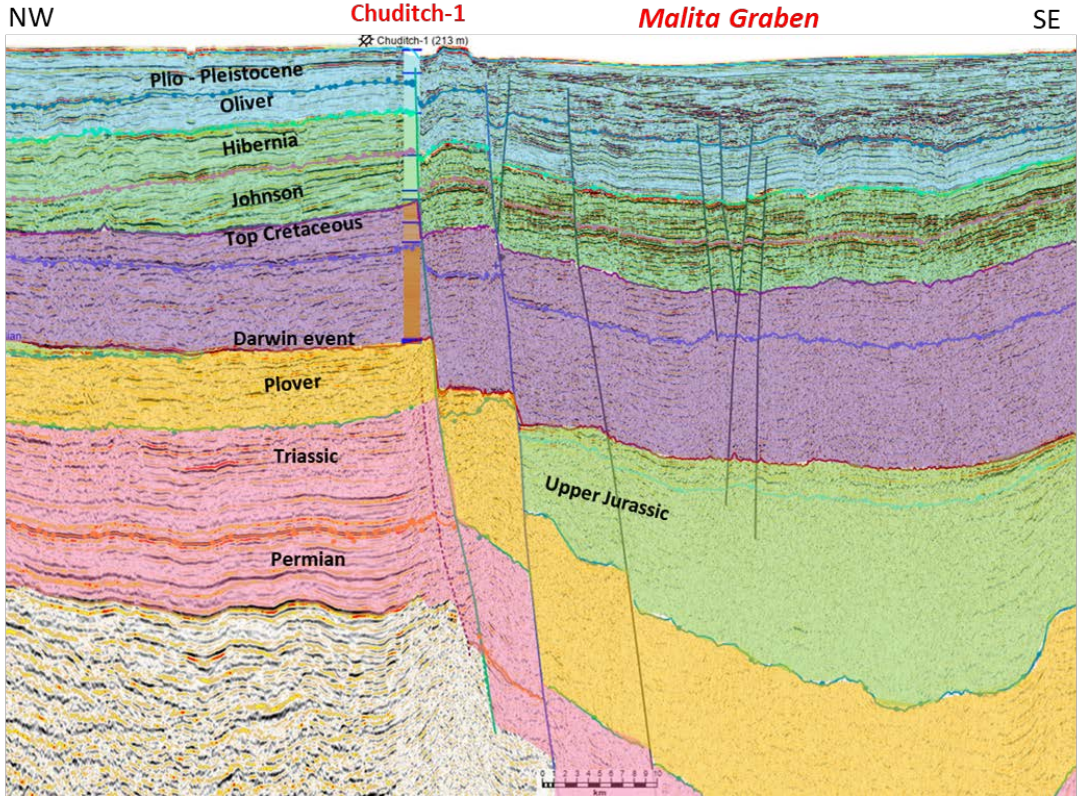
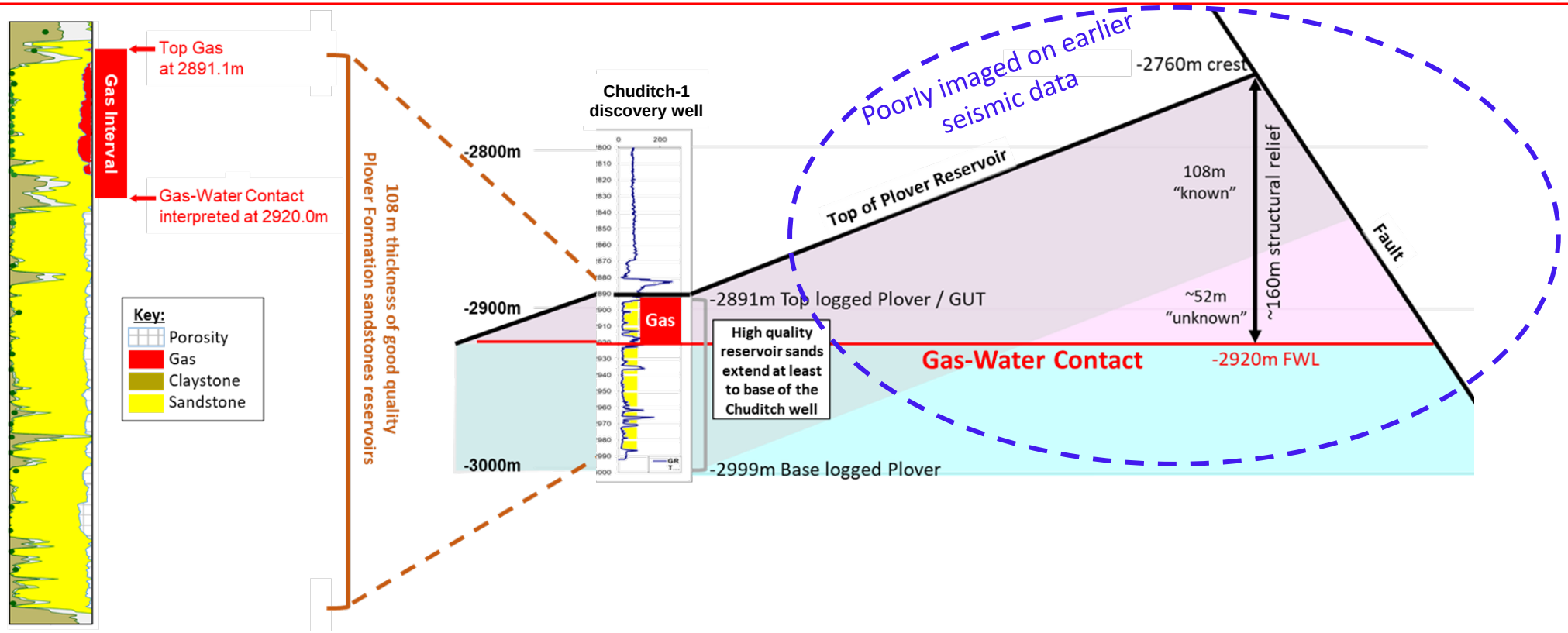
Regional Top Plover Depth




- Middle Jurassic Plover Fm. (Fluvio-deltaic to shallow marine) is the principal reservoir and gas source
- Upper Jurassic rifting along Malita Graben trend, with thick graben fill
- Thick Lower Cretaceous sag sequence shales form regionally extensive seals
- Tertiary interval comprises mixed mudstones and carbonates

# Chuditch-1 unlocked large gas potential

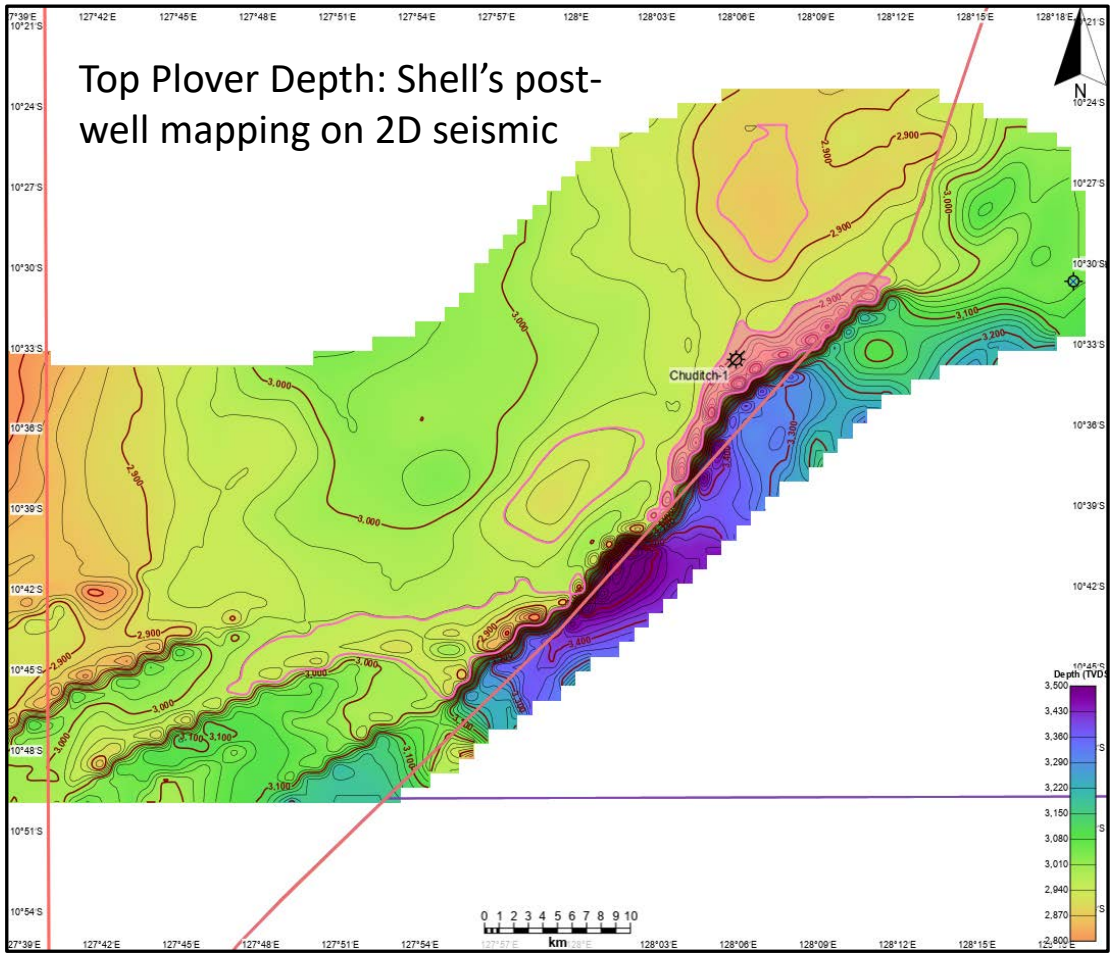



**Good quality reservoir in gas interval**

| | |
|---|---|
| ✓ Net to Gross (= % reservoir) | 89.0% |
| ✓ Ave. Net pay porosity | 12.4% (up to 18%) |
| ✓ Ave .Net pay permeability | 195mD (up to 1 D) |
| ✓ Gas saturation | 85.5% |

- Chuditch-1 drilled by Shell (1998), significant gas discovery
  - Drilled in 64m water to 3,010 m TVDSS
  - 29m gas column in 120m section of good quality Plover Fm reservoir
  - Closely constrained gas-water contact

# Key Challenge: Seismic Imaging

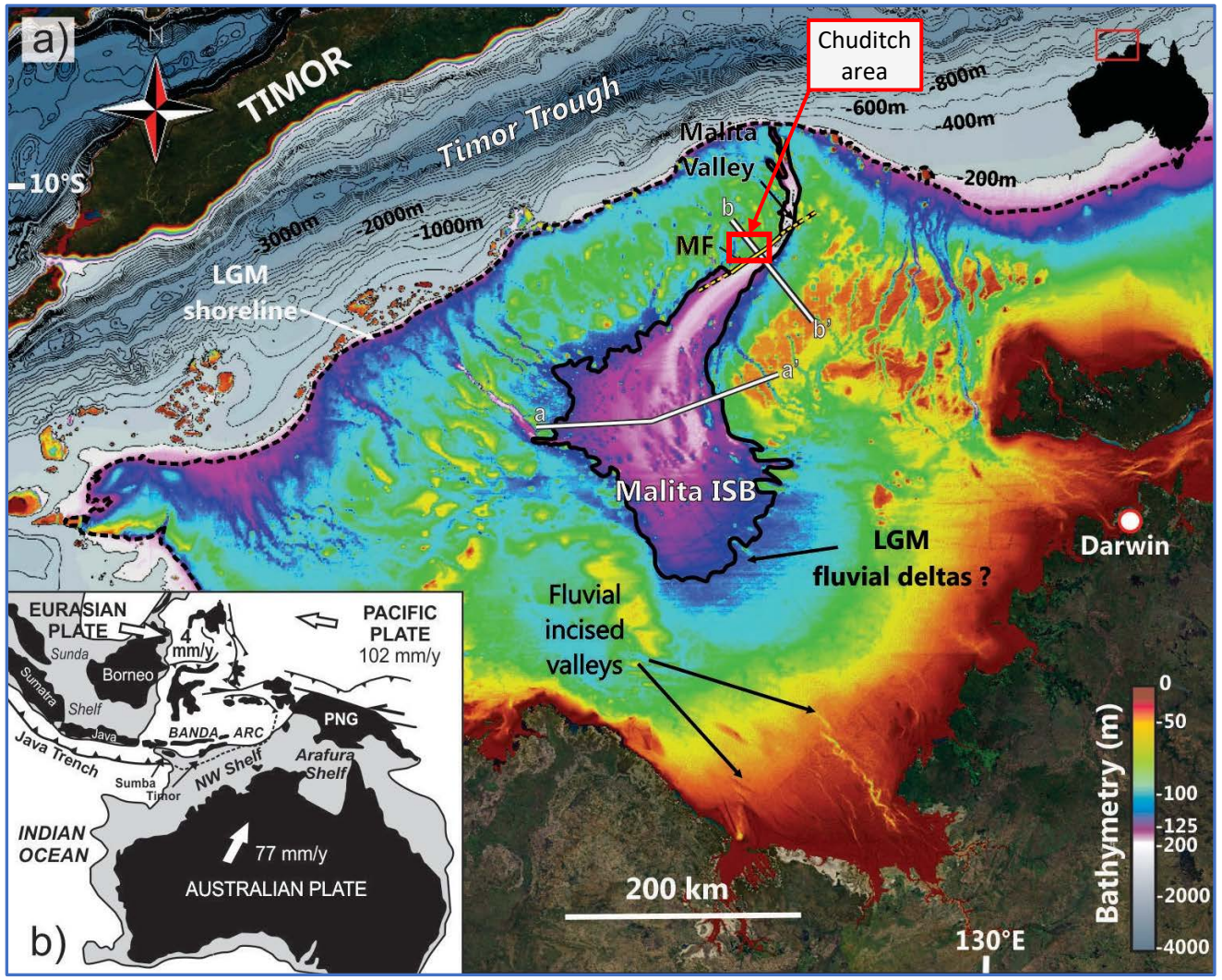



- Chuditch recognised as a Tcf-scale gas resource
  - Relinquished by Shell in 2001, mainly due to lack of commercial gas development solutions at that time
- Drilled at a downdip location on mapped structure
  - Post-well mapping defined a three-way dip and fault trap with offset structures to the north, west and south west
- Significant velocity / depth conversion uncertainties
  - Convoluted seabed (drowned incised terrain)
  - Complex shallow geology (reef and platform carbonates)
  - Large low relief dip and fault bounded structures

together results in…

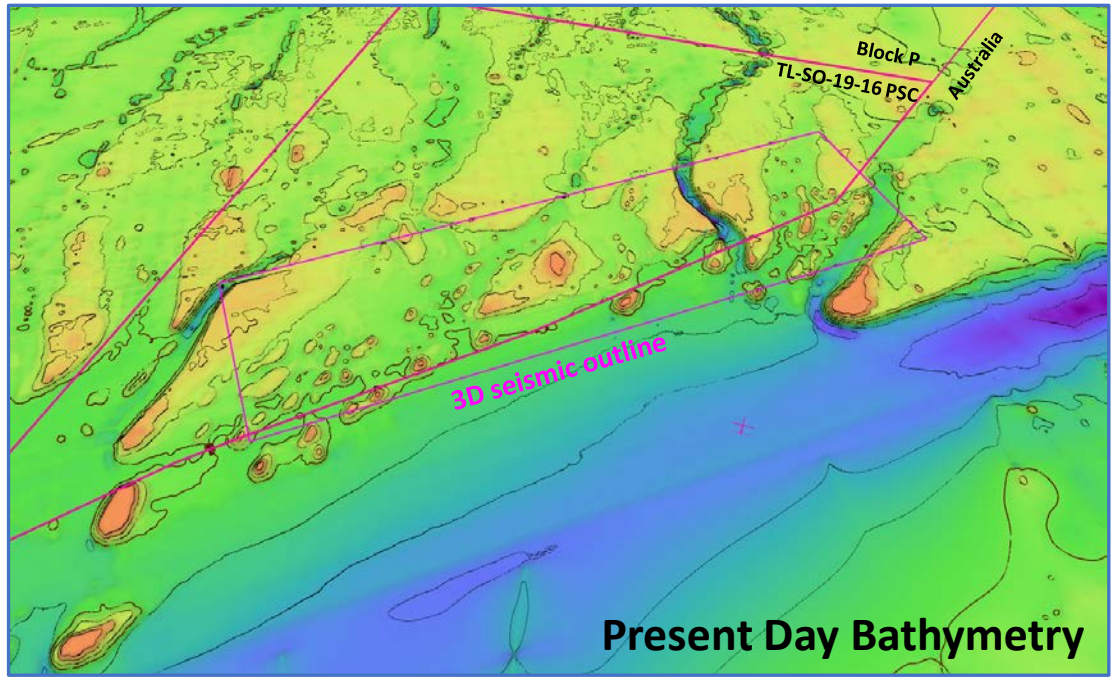
  - Highly complex velocity field
  - Uncertainty in depth imaging of top reservoir surface
  - Poor definition of fault locations

# Changing sea-levels has created seismic complexity




*From Bourget et al., 2013. Seismic Stratigraphy of a Plio-Quaternary Intra-shelf Basin (Bonaparte Shelf, NW Australia)*

- Timor Sea area has historically proved challenging for seismic imaging
  - complex seabed from sub-aerial erosion then flooding during glacial and post-glacial periods
  - seismic ray-paths are highly convoluted



# Seabed features seen on Darwin (near to reservoir) TWT structure

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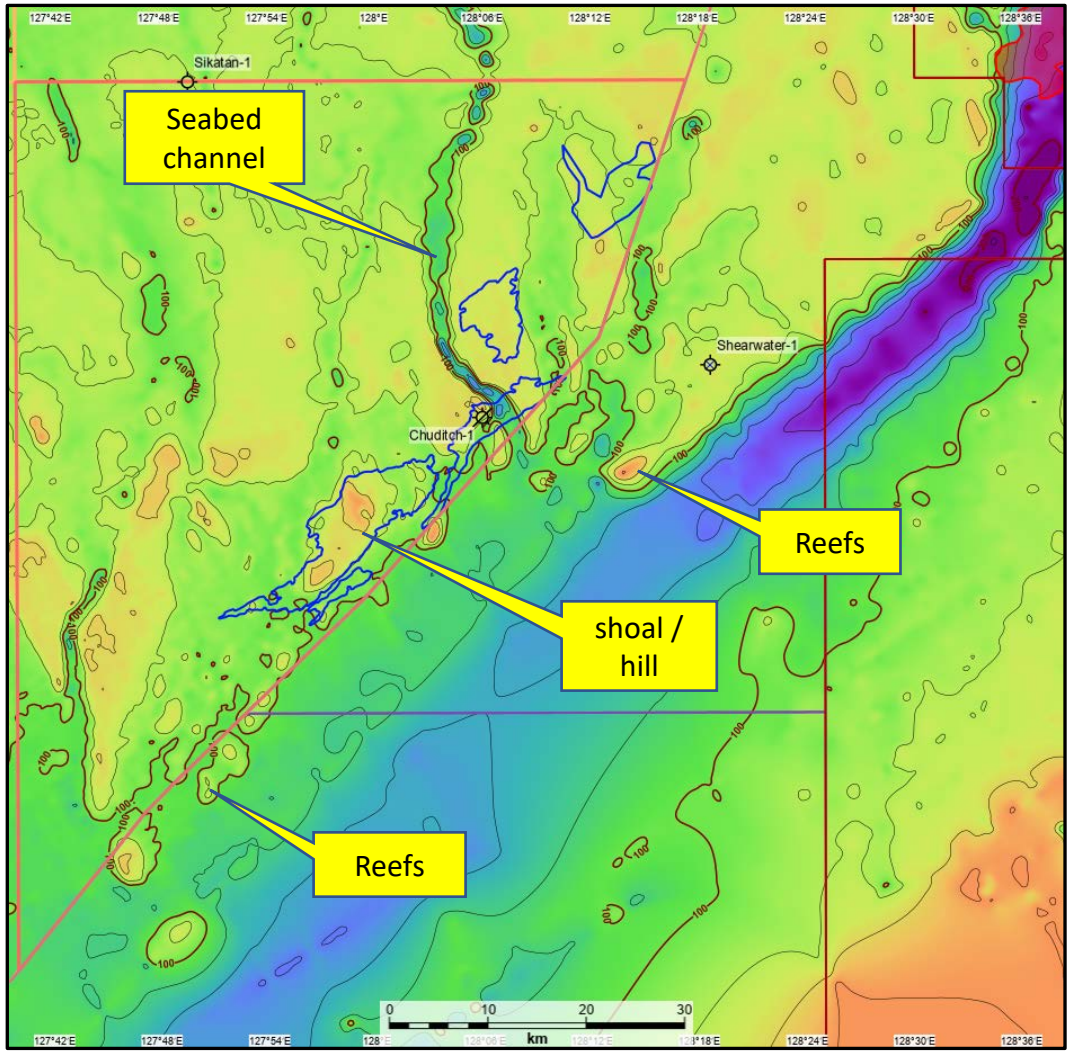
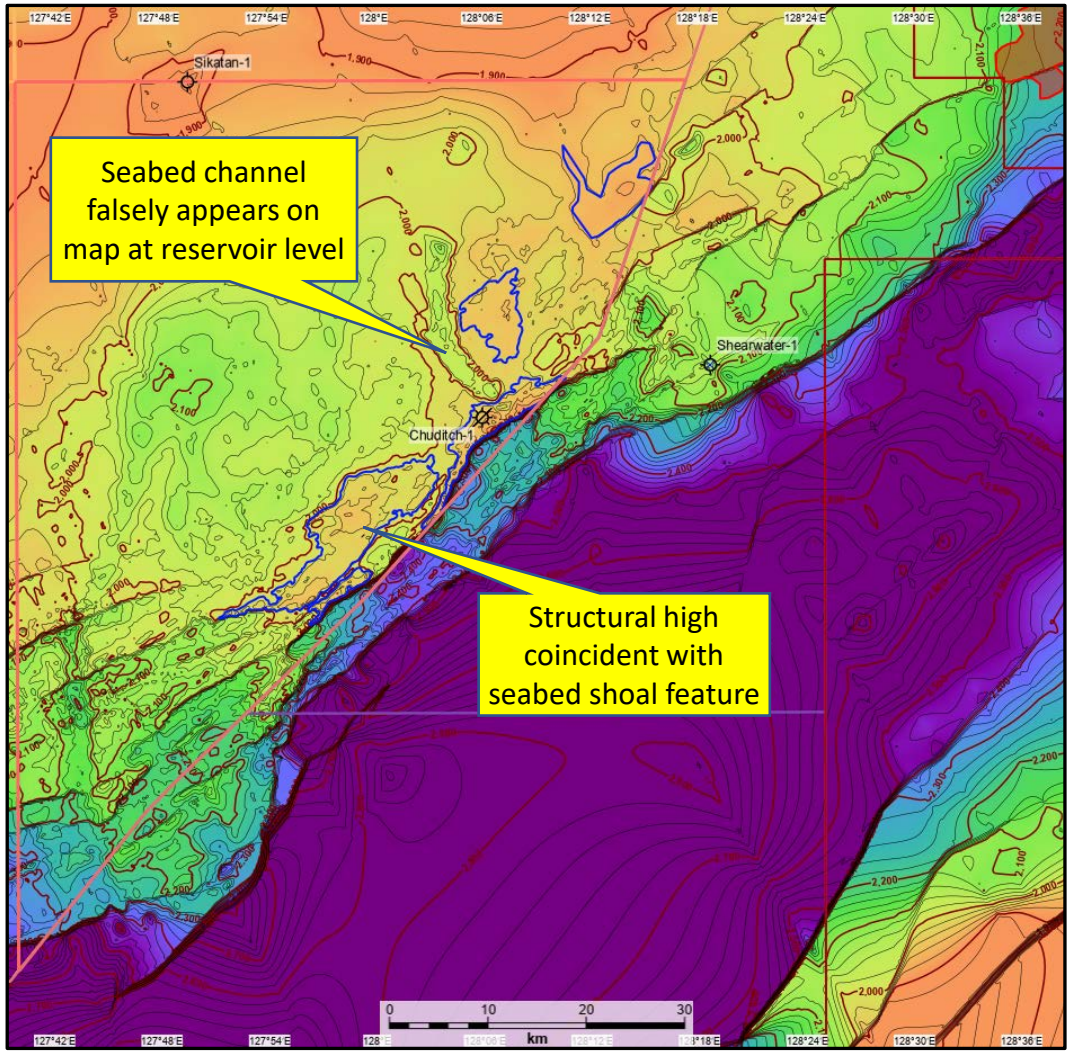



Seabed Bathymetry Map




Darwin TWT Map (SundaGas 2020 mapping on 2D seismic)

# Data Evolution: 2D Seismic, 1993 PSTM

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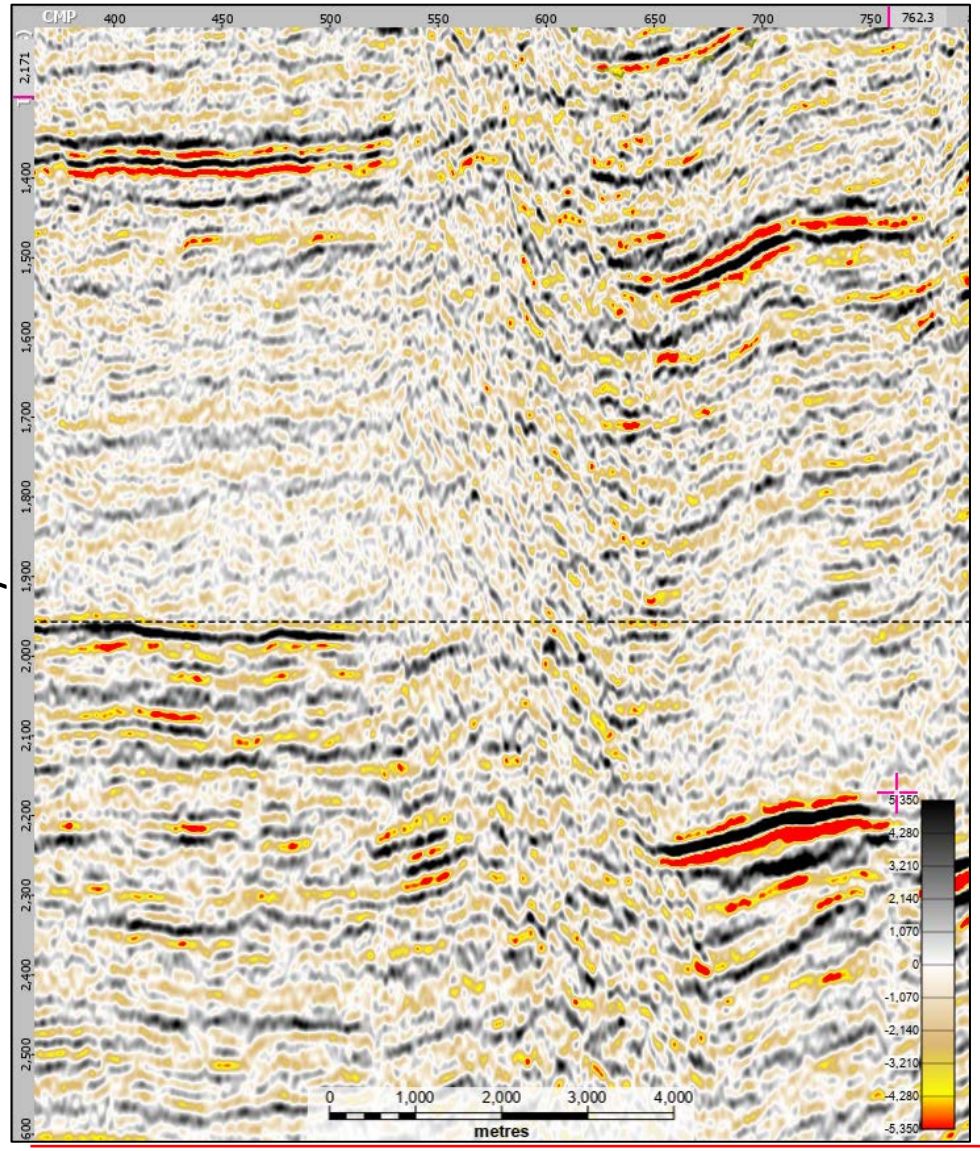
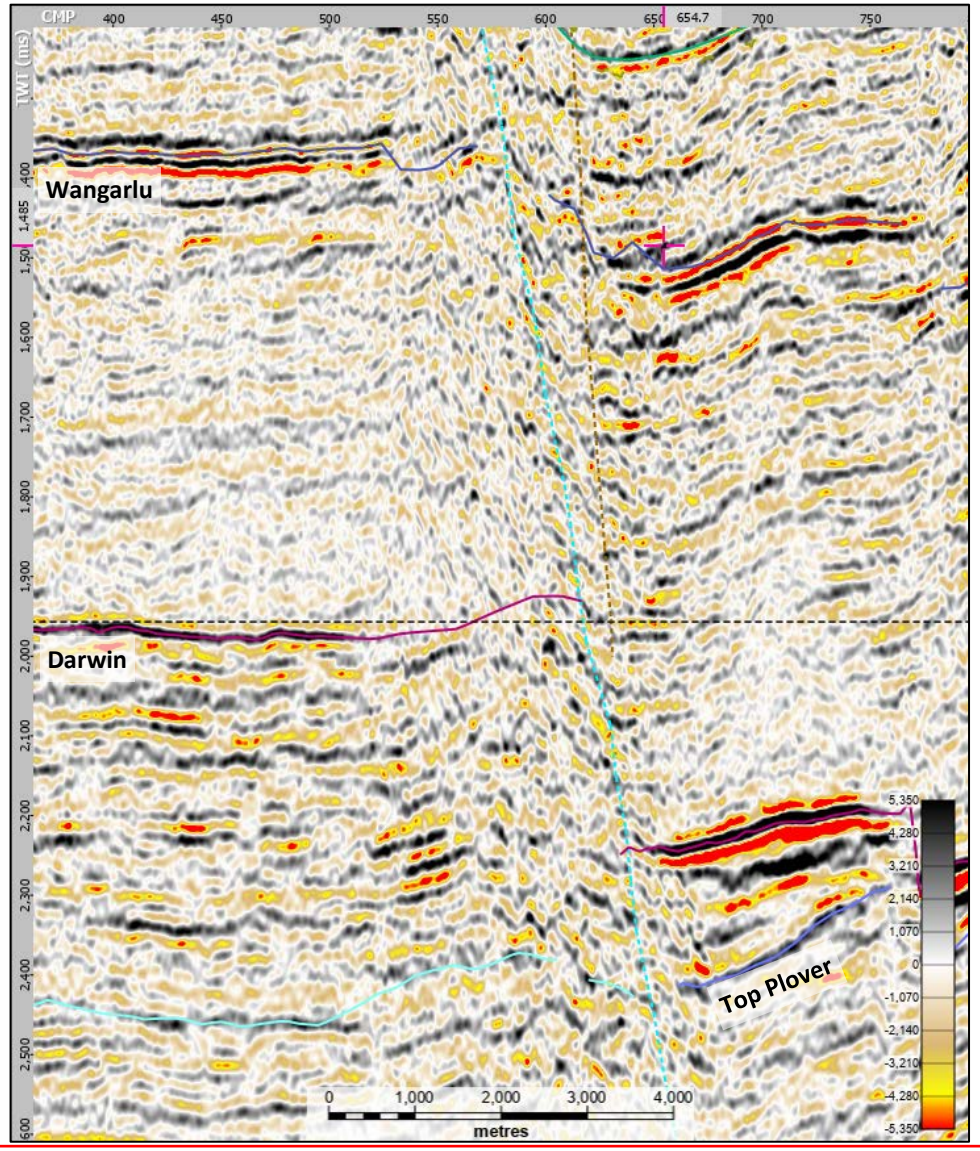
Two-way-time




- Reasonable quality
- Poor imaging of fault and section near fault
- Shell used these data for pre-drill mapping

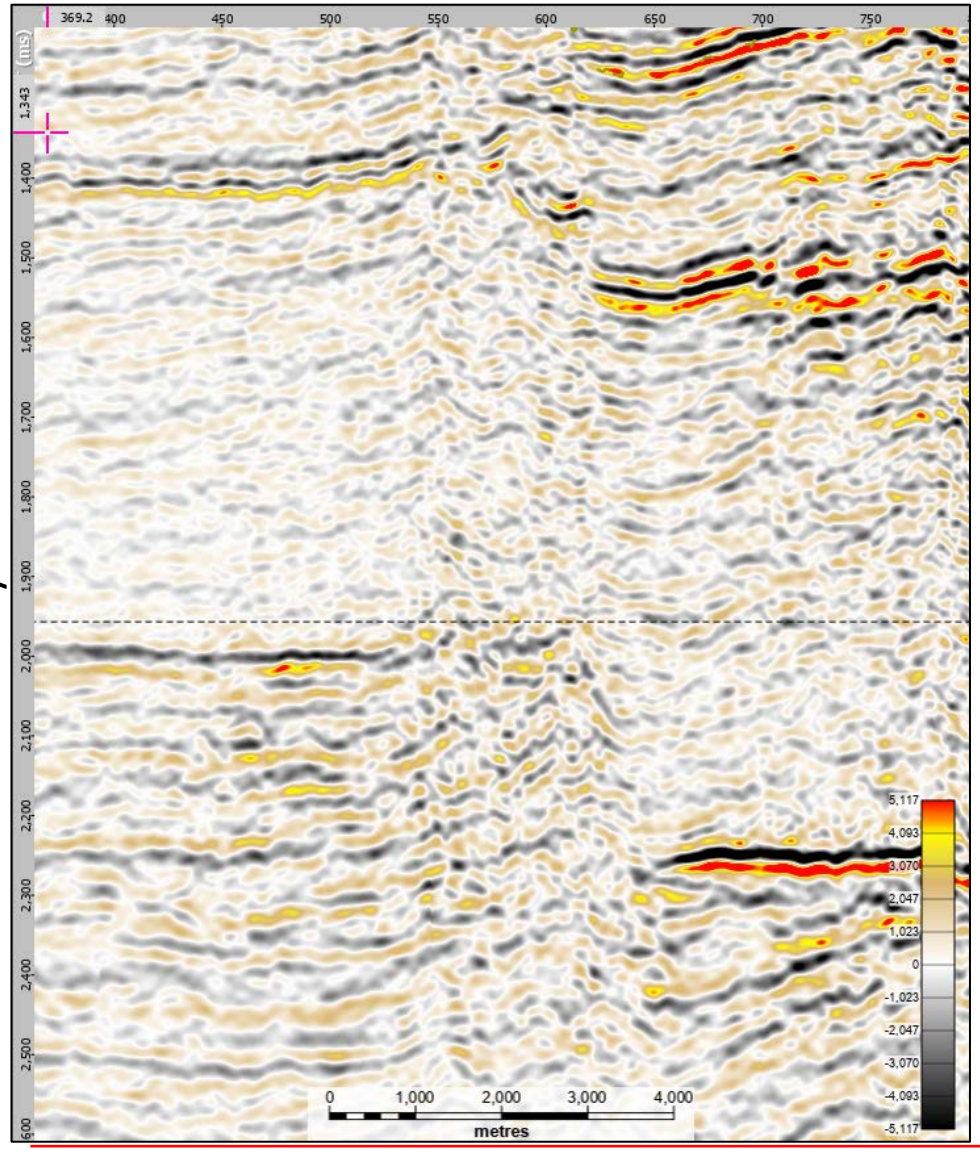
2D Seismic Profile E93TG16-84

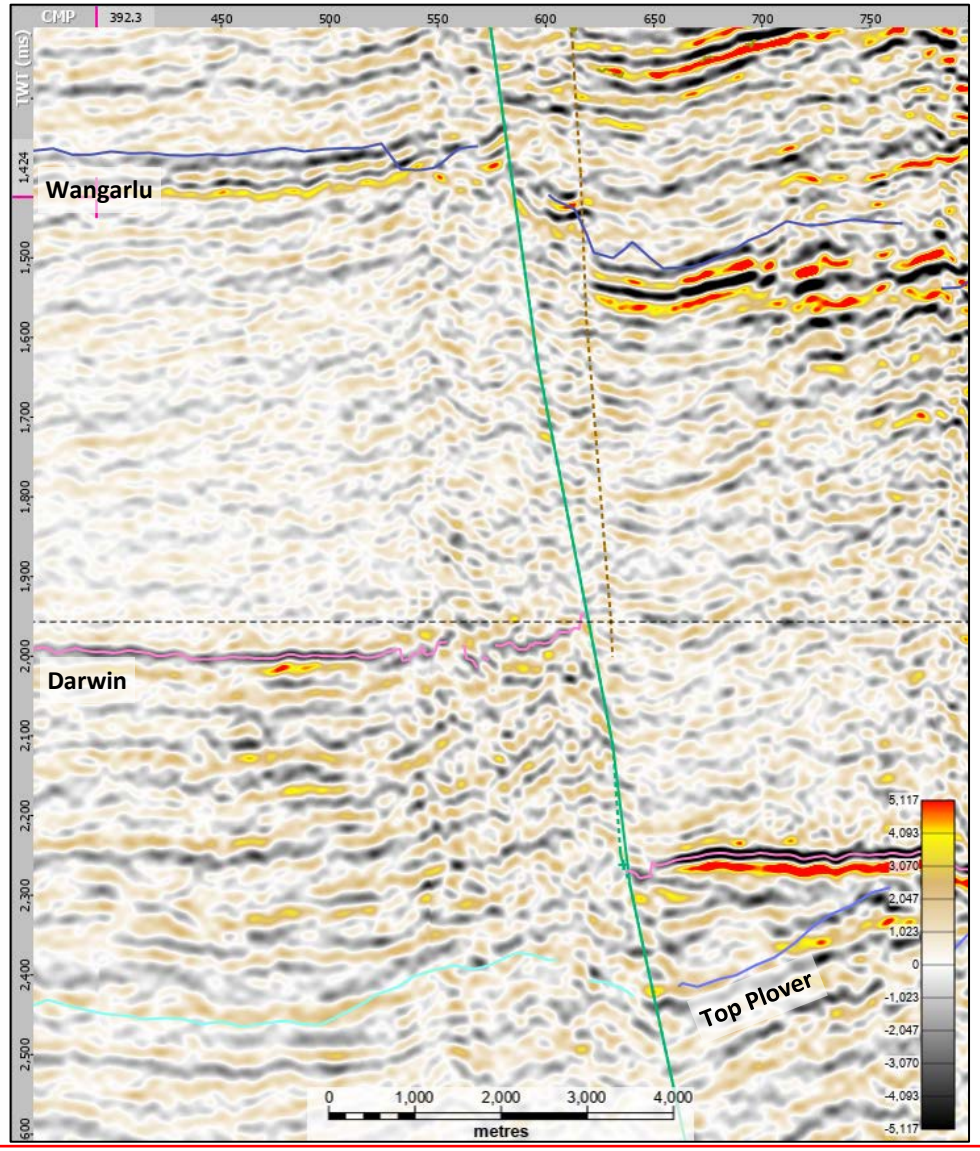
+ve acoustic impedance = negative number – displayed black

# Data Evolution: 3D Seismic: 2013 PSTM (Fugro)

SundaGas Banda Unipessoal, Lda

Two-way-time



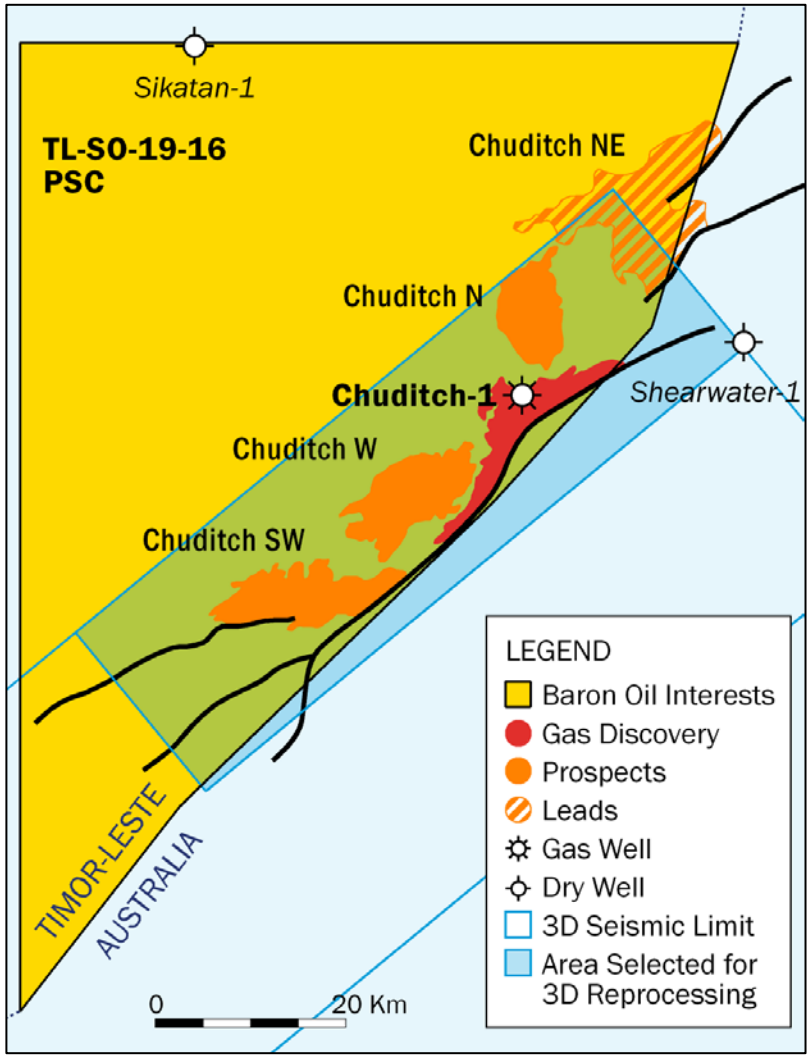

- Appears good quality
- Reasonable fault imaging
- Poor event definition near fault
- Data cosmetically de-noised and enhanced
- SundaGas review revealed data not reliable, owing to arbitrary application of static shifts

Arbitrary line along path of 2D Seismic Profile E93TG16-84

*Data shown courtesy of TGS*

+ve acoustic impedance = negative number – displayed black

# 3D PSDM reprocessing project




- **2012 acquisition**
  - Conventional shallow tow 6m source / 7m cable
  - Wide tow – 10 streamer, 100m separation
  - Acquired in regional strike direction
  - Limited angle range – 6000m streamer length
- **2021-2022 Reprocessing**
  - TGS multi-client project – focus on 1,270 $km^2$ subset over SundaGas area
- **Challenges**
  - Complex seabed and shallow geology – channels, carbonate platforms and reefs producing structural distortions at depth
  - Shallow water depth – seabed not resolved on far cables
  - Multiples
  - Lack of low frequencies below 3-4 Hz – for FWI model building
- **Key Objectives**
  - Resolve velocity complexities to remove distortions in depth image
  - Improve resolution of seismic events and fault definition at reservoir level

# Reprocessing Outline

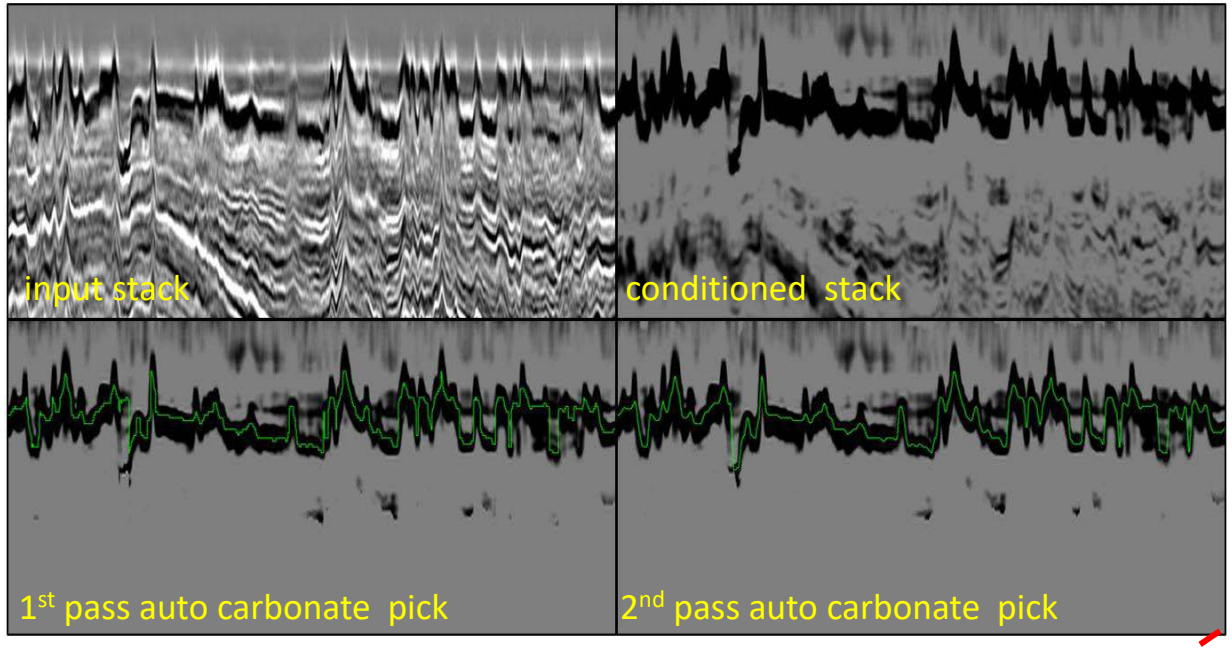
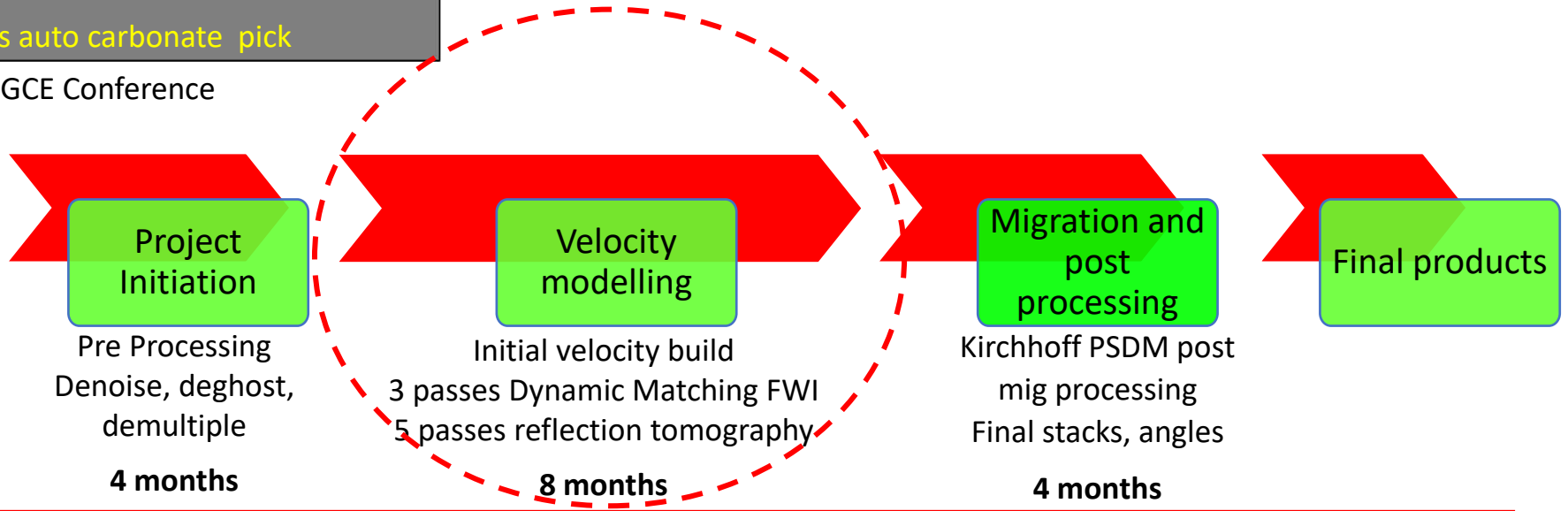



Image courtesy of TGS – Cavalin et al 2022 APGCE Conference

- Depth Velocity Model - multi-pass approach
  - 3 passes of Dynamic Matching FWI at increasing frequencies up to 14 Hz
  - 5 updates of reflection tomography
  - Initial model build for input to FWI required interpretation of the shallow top carbonate surface for velocity flood
  - Required processors and interpreters to work closely



# Initial KPSDM Stack and Velocity Model – 200m depth slice

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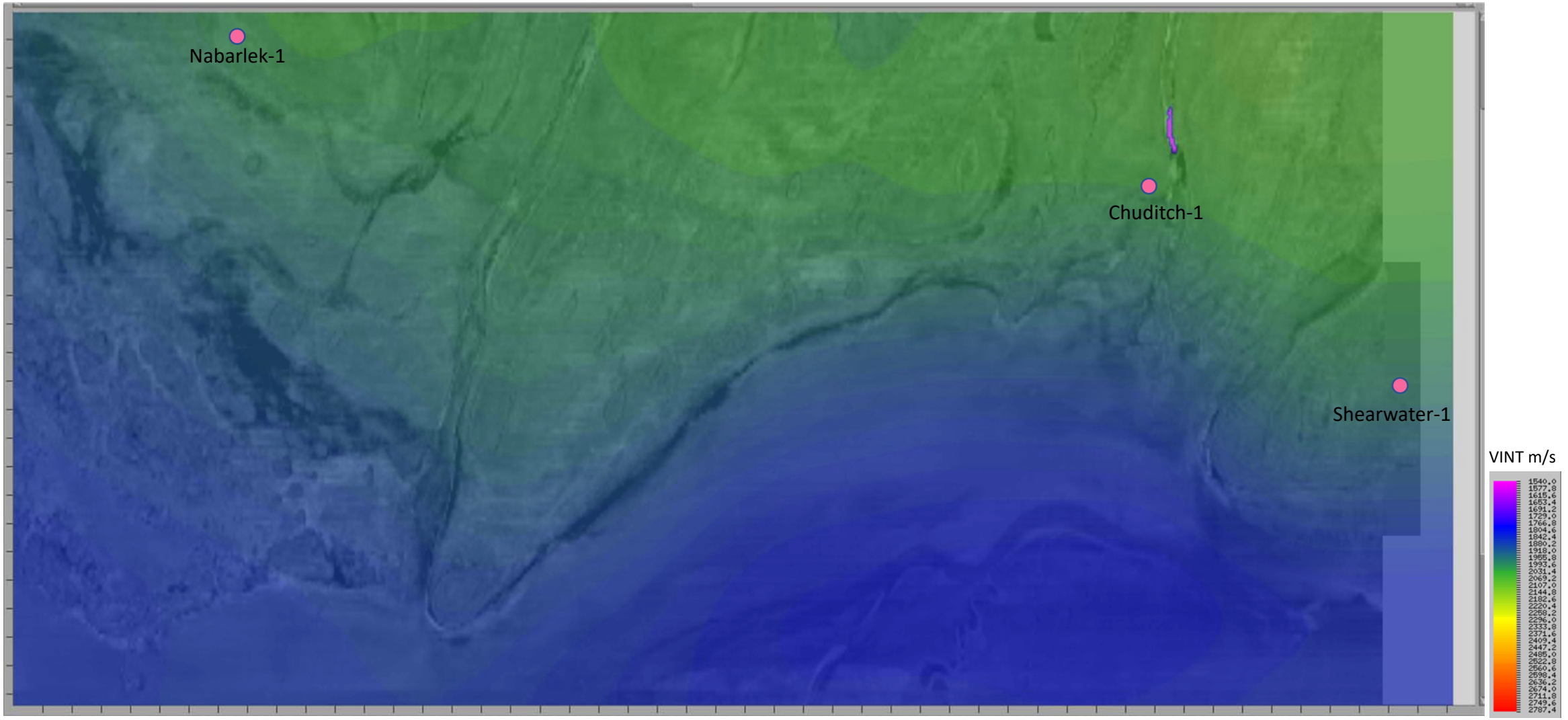


*Data shown courtesy of TGS*

+ve acoustic impedance = negative number – displayed white

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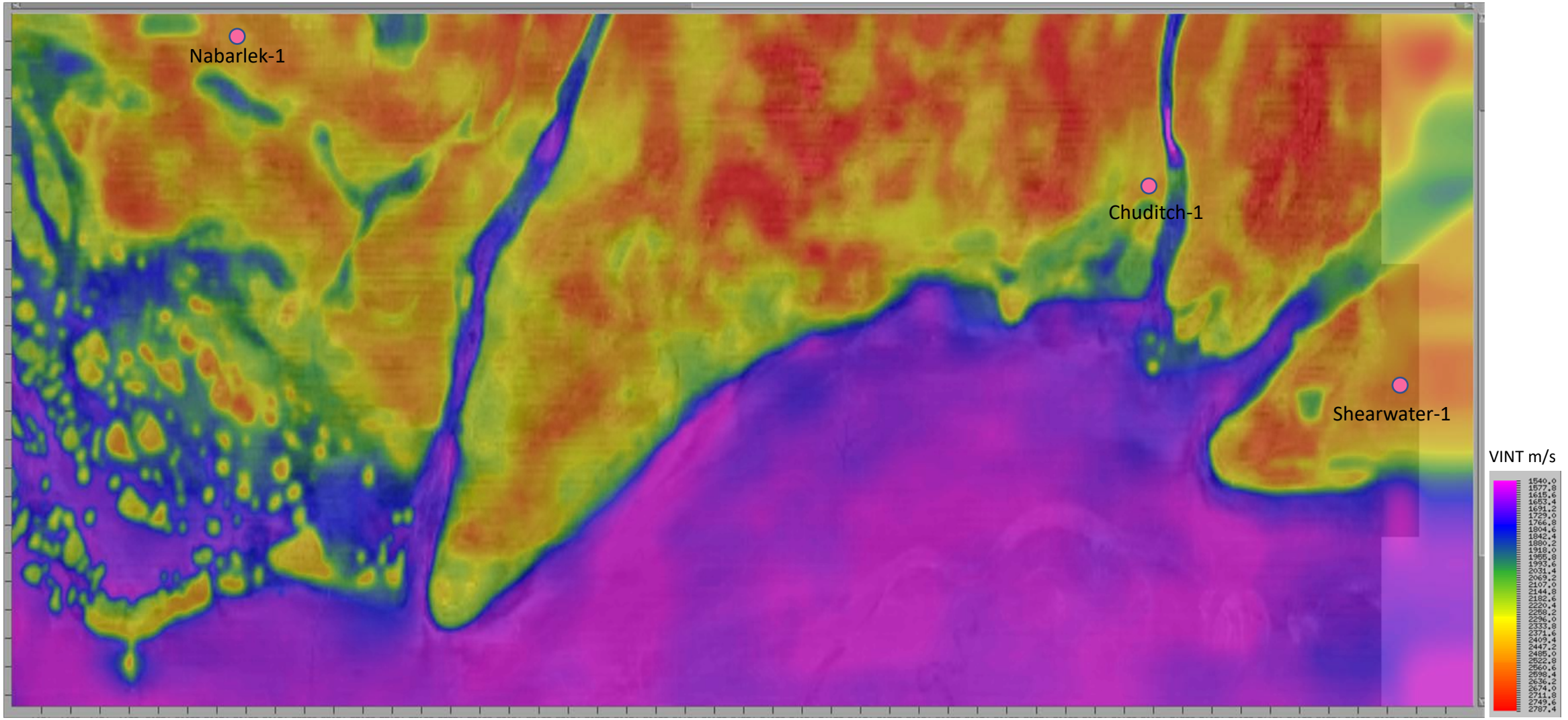


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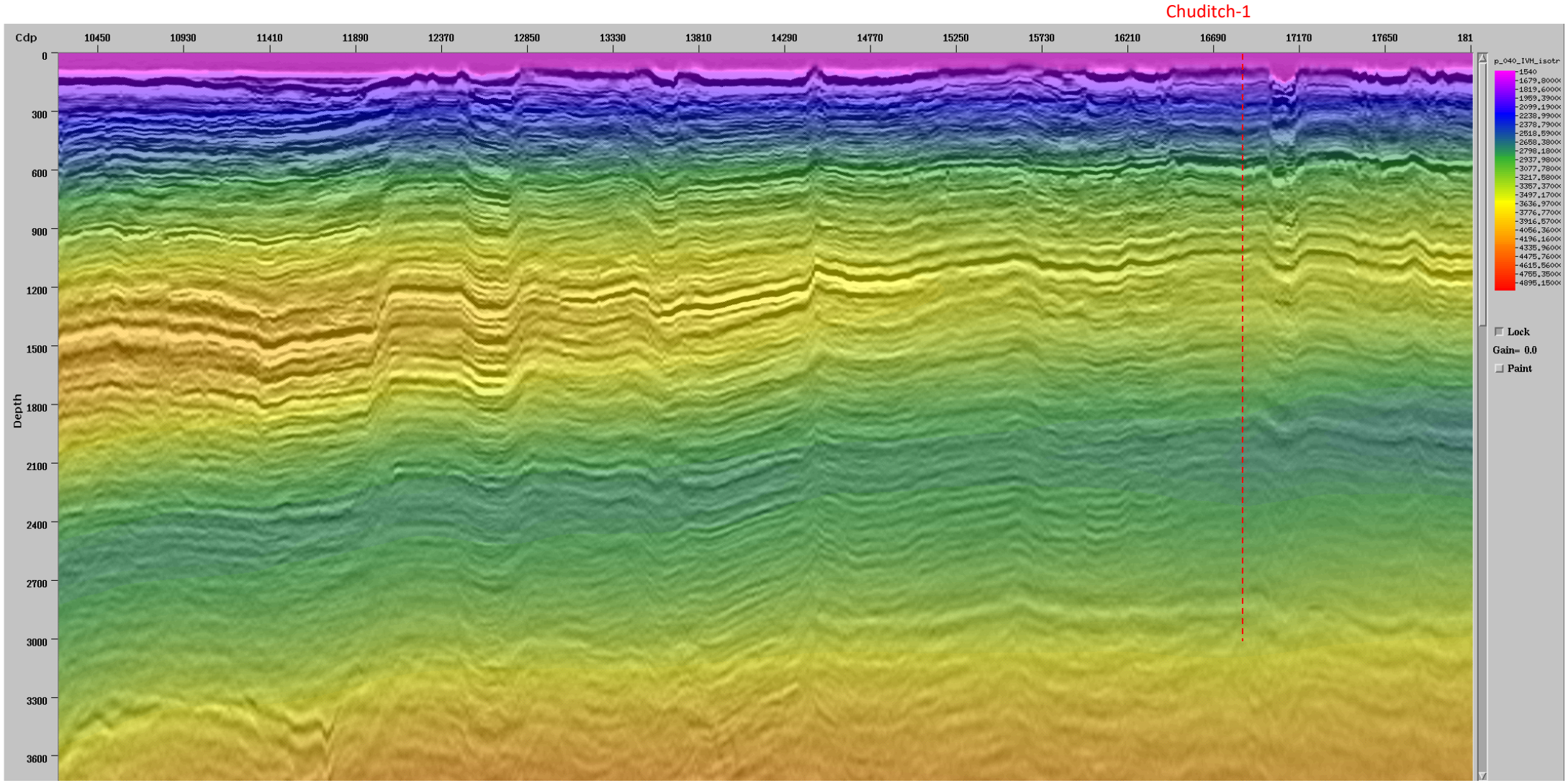
# Initial KPSDM Stack and Velocity Model – Chuditch inline

SundaGas Banda Unipessoal, Lda

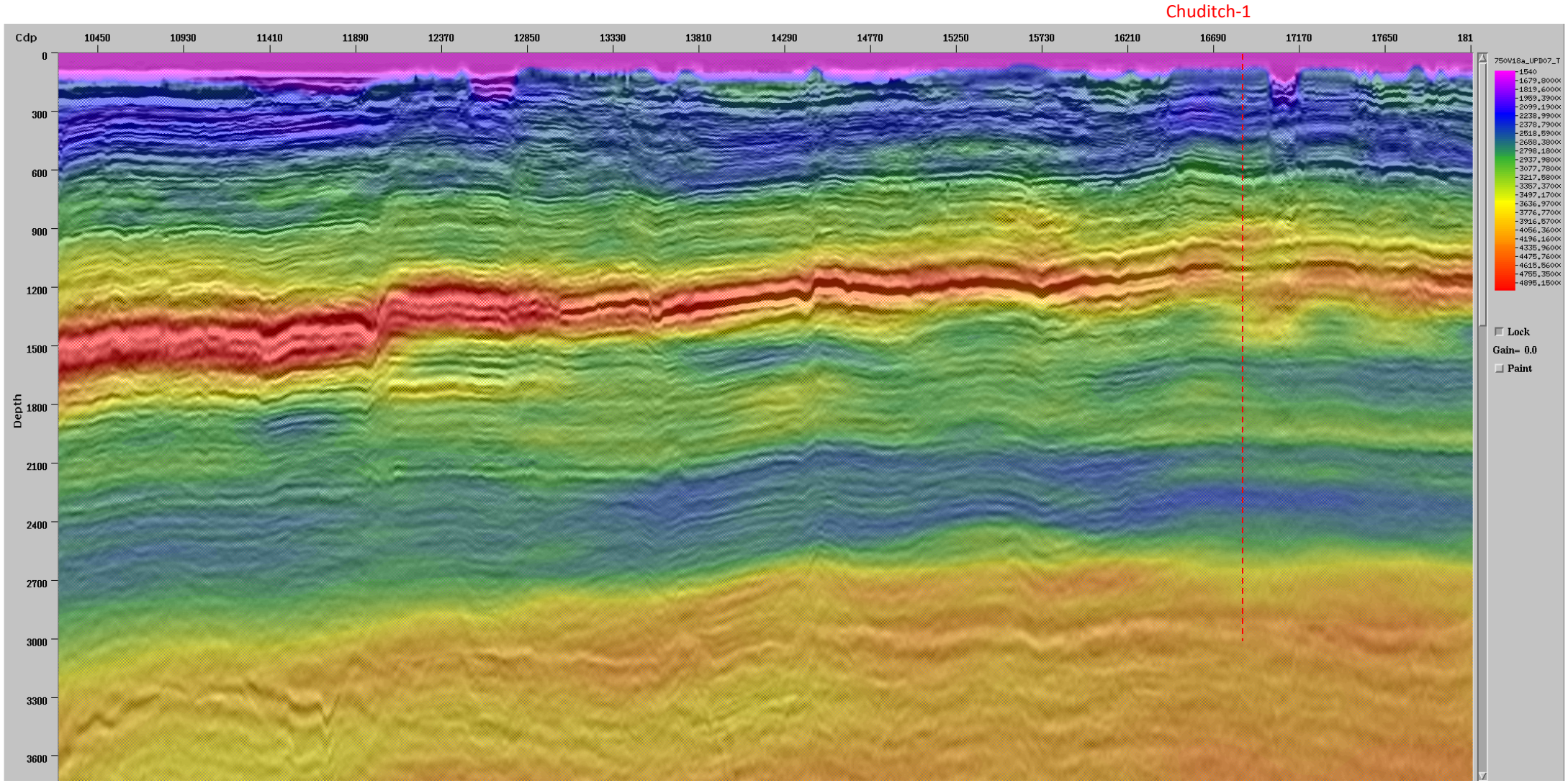



*Data shown courtesy of TGS*

+ve acoustic impedance = negative number – displayed white

# Final KPSDM Stack (raw) and Velocity Model – Chuditch inline

SundaGas Banda Unipessoal, Lda




*Data shown courtesy of TGS*

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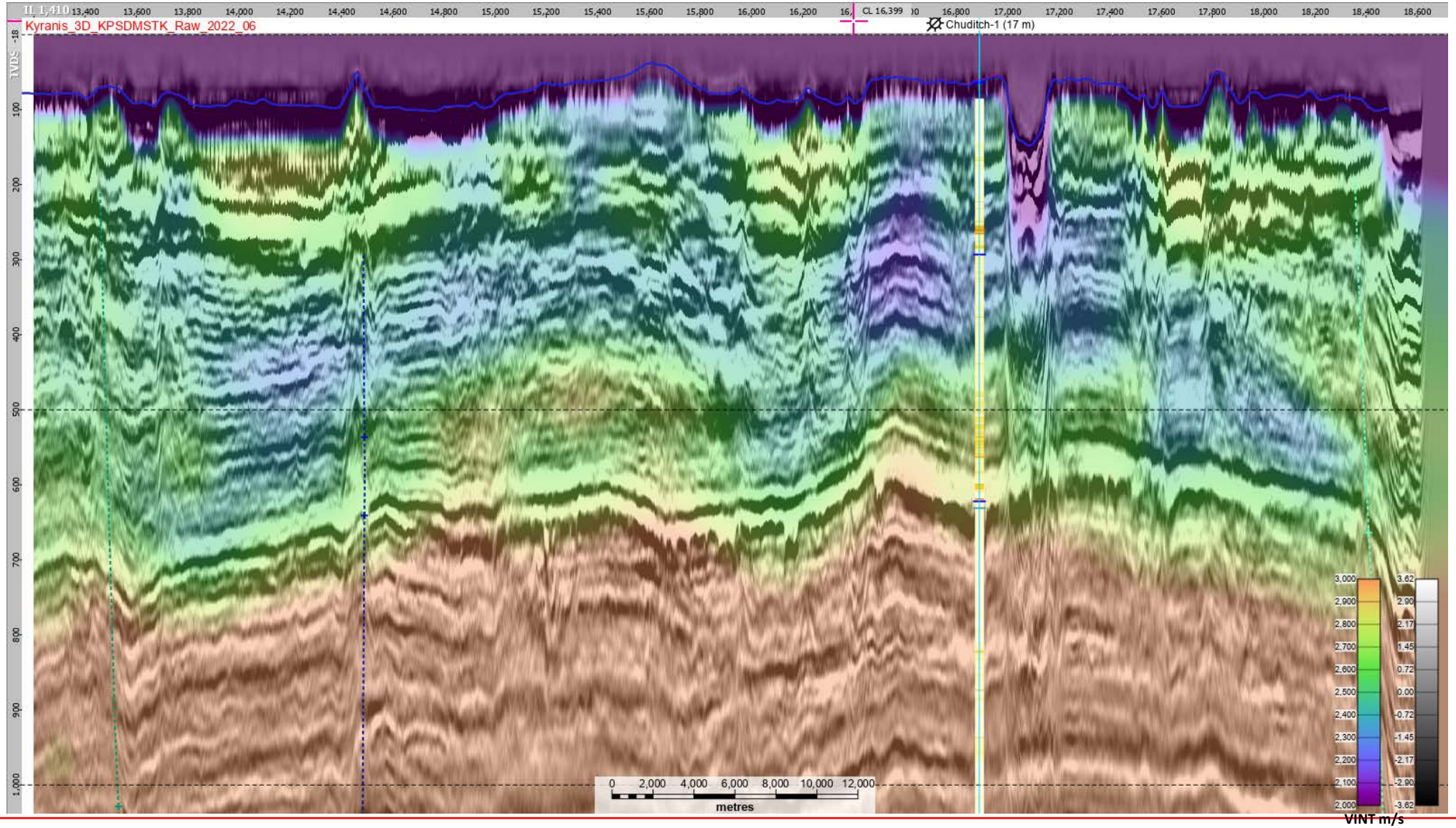
# Final Velocity Model and stack – shallow section zoom

SundaGas Banda Unipessoal, Lda

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# Initial KPSDM Stack – Chuditch inline

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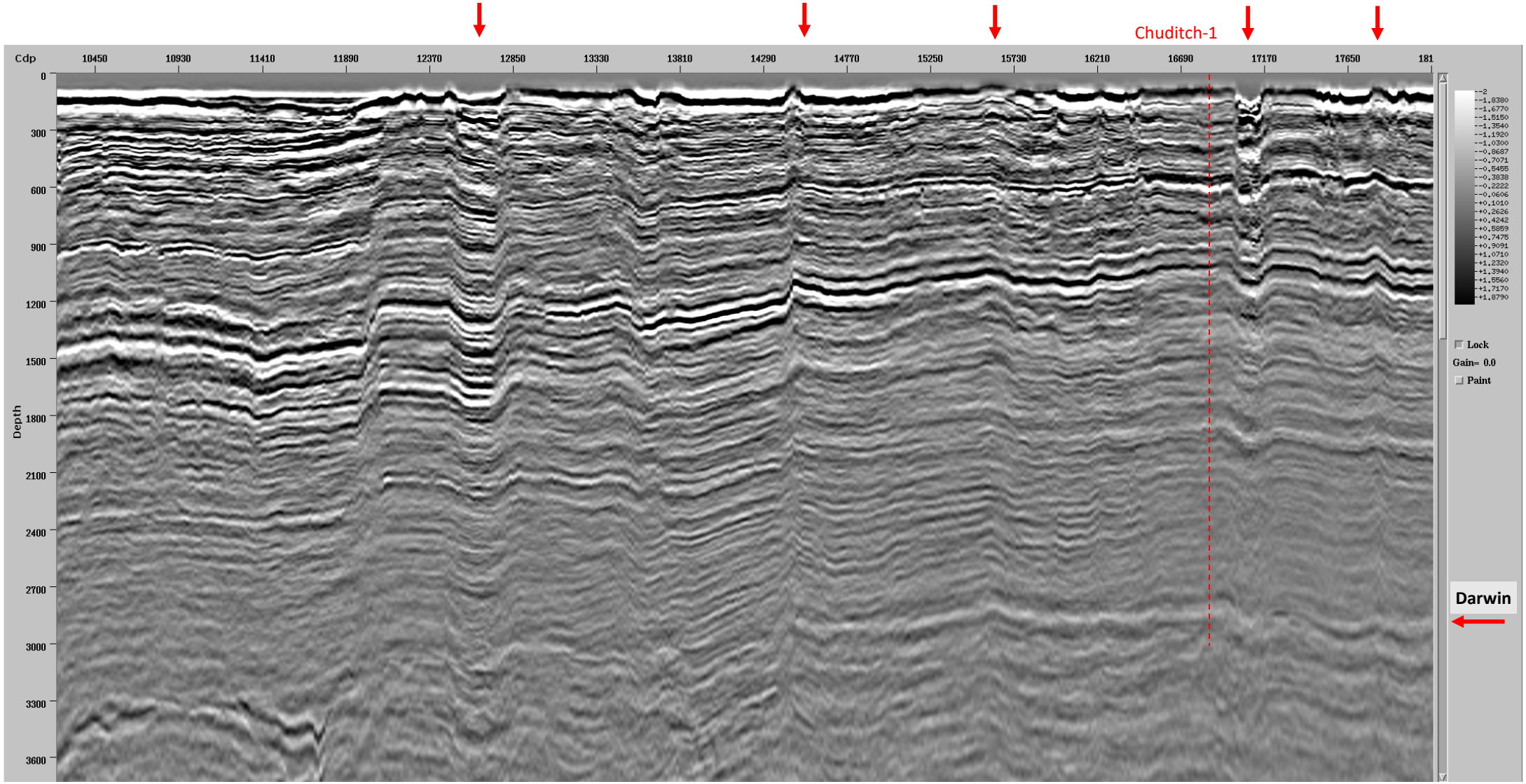


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# Final KPSDM Stack (raw) - – Chuditch inline

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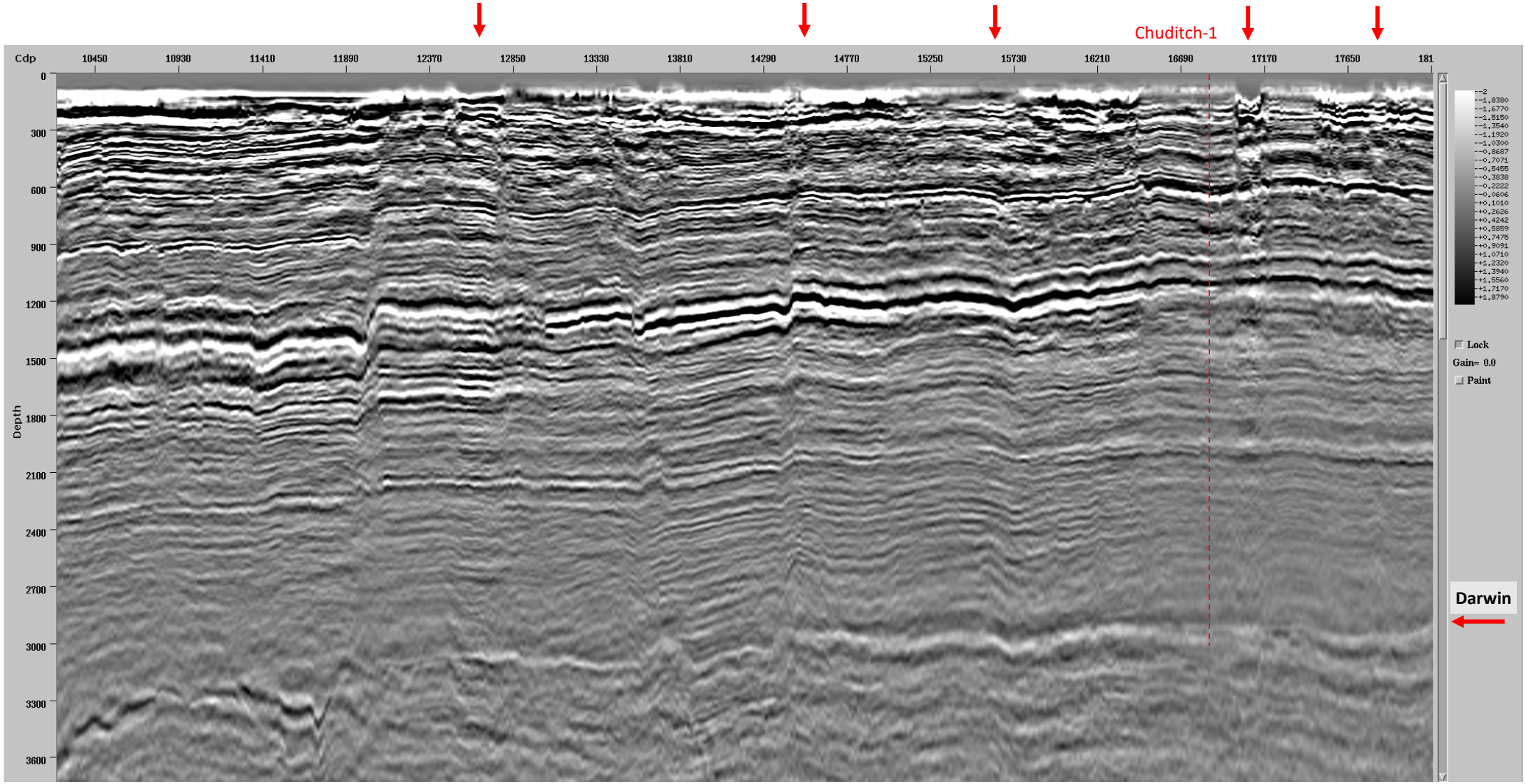


*Data shown courtesy of TGS*

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# Data Evolution: 2022 KPSDM Full Stack

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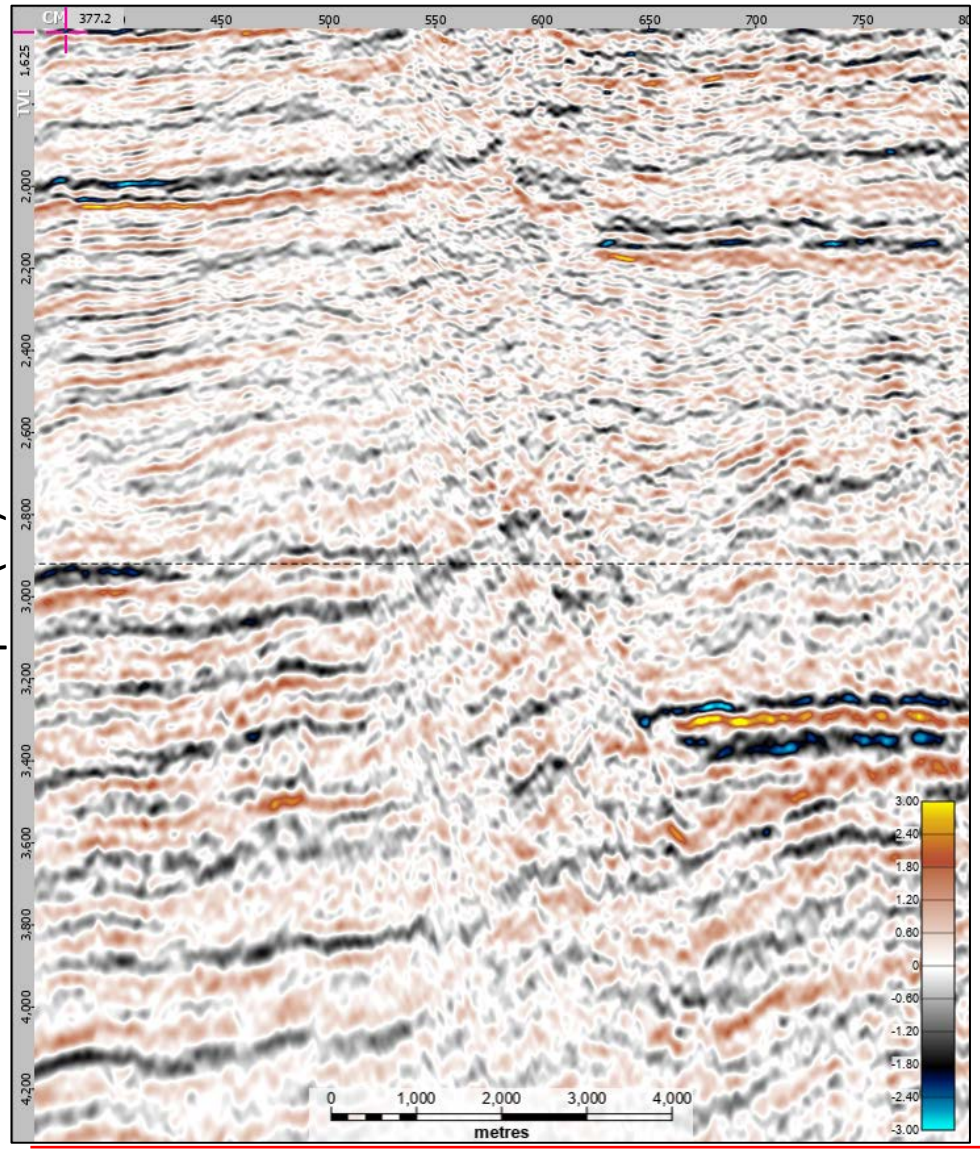


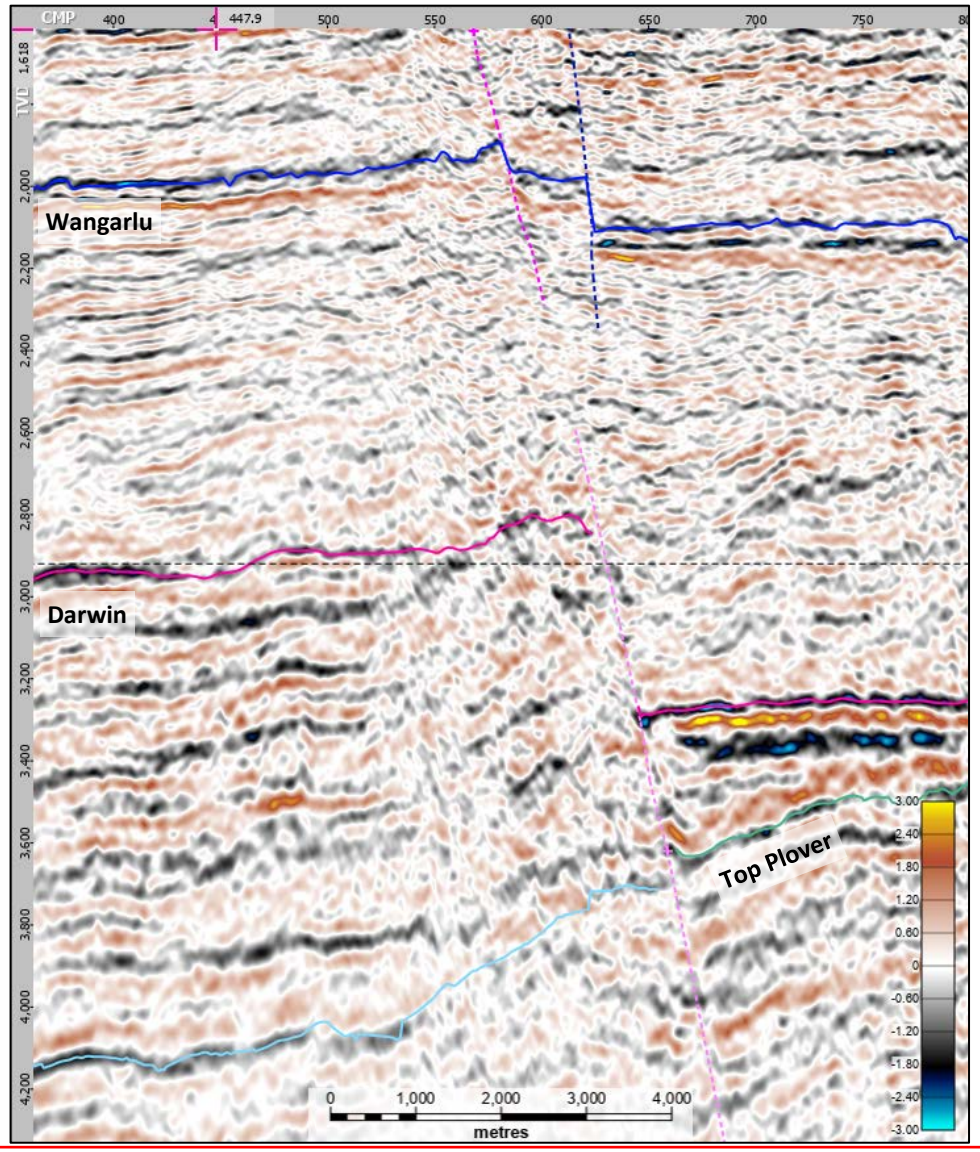


Depth (m)

- Much better structural definition in depth
- Fault imaging more reliable
- Darwin event can be patchy, especially towards Chuditch

Arbitrary line along path of 2D Seismic Profile E93TG16-84

*Data shown courtesy of TGS*

+ve acoustic impedance = negative number – displayed blue/black

# Data Evolution: 2022 PSDM (Sharp Reflections - conditioned)

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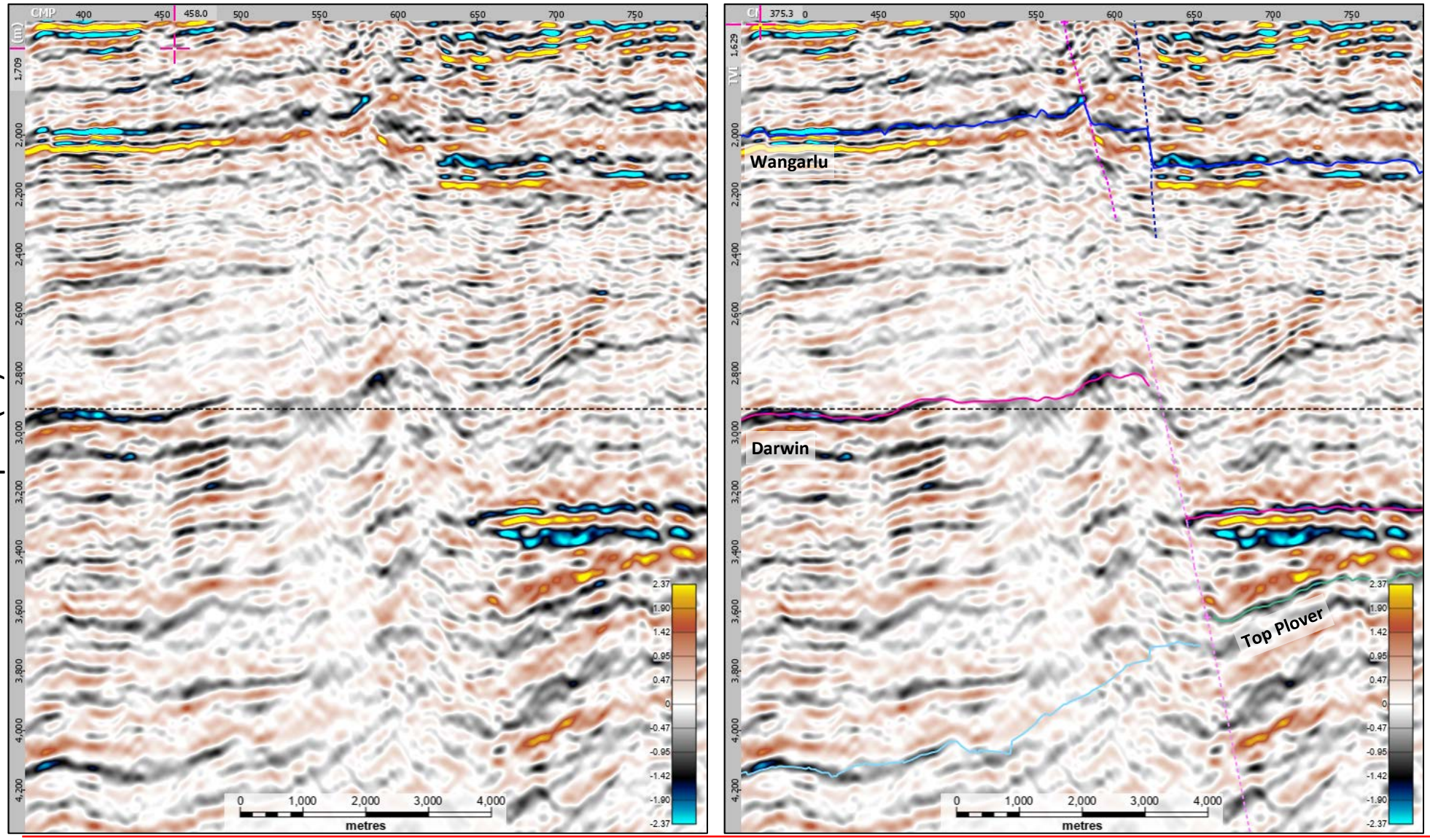


- Focused conditioning of gathers and stack provides much more coherent Darwin pick
- Good structural definition in depth
- Fault imaging reliable
- Volume used for prospect mapping

Arbitrary line along path of 2D Seismic Profile E93TG16-84

*Data shown courtesy of TGS*

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# Xline panels illustrating Darwin event along Chuditch trend

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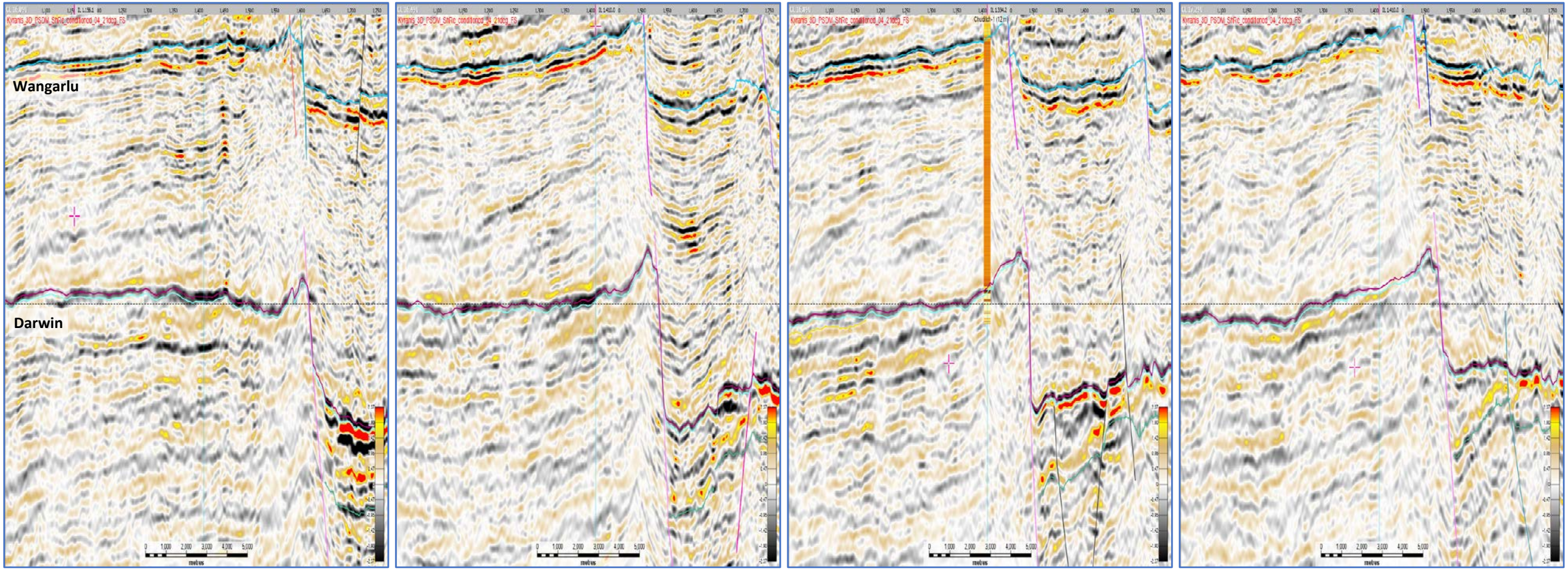
SW → NE




*Data shown courtesy of TGS*

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# Seismic Reprocessing: What has been achieved…?

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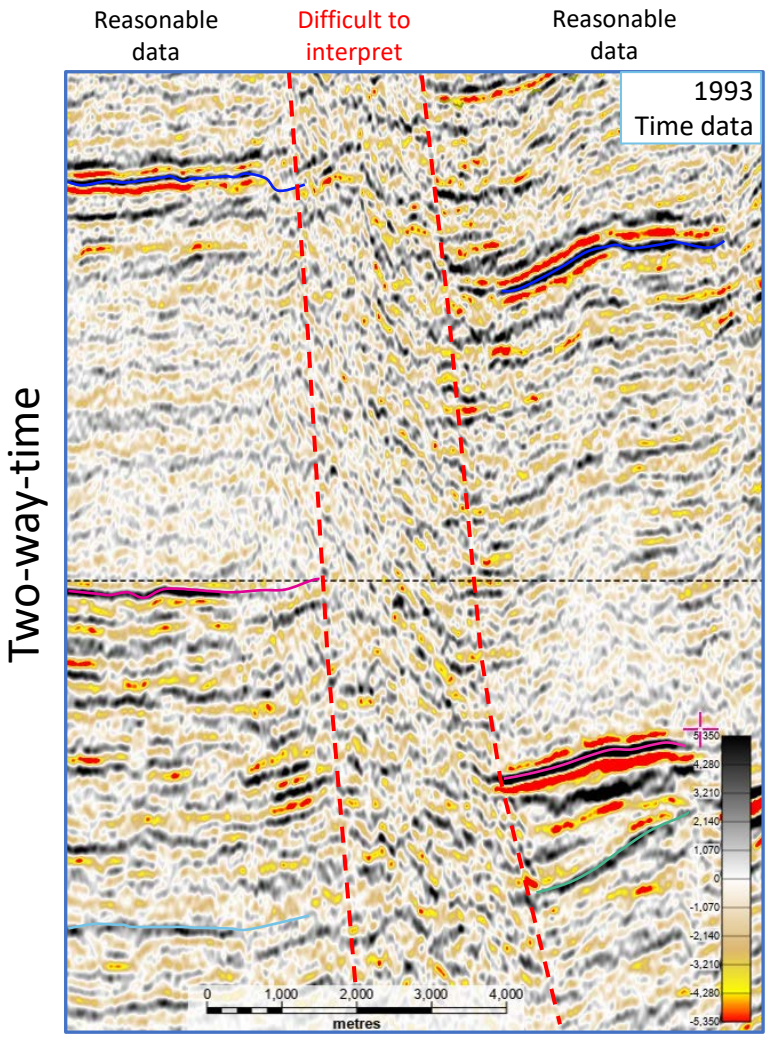
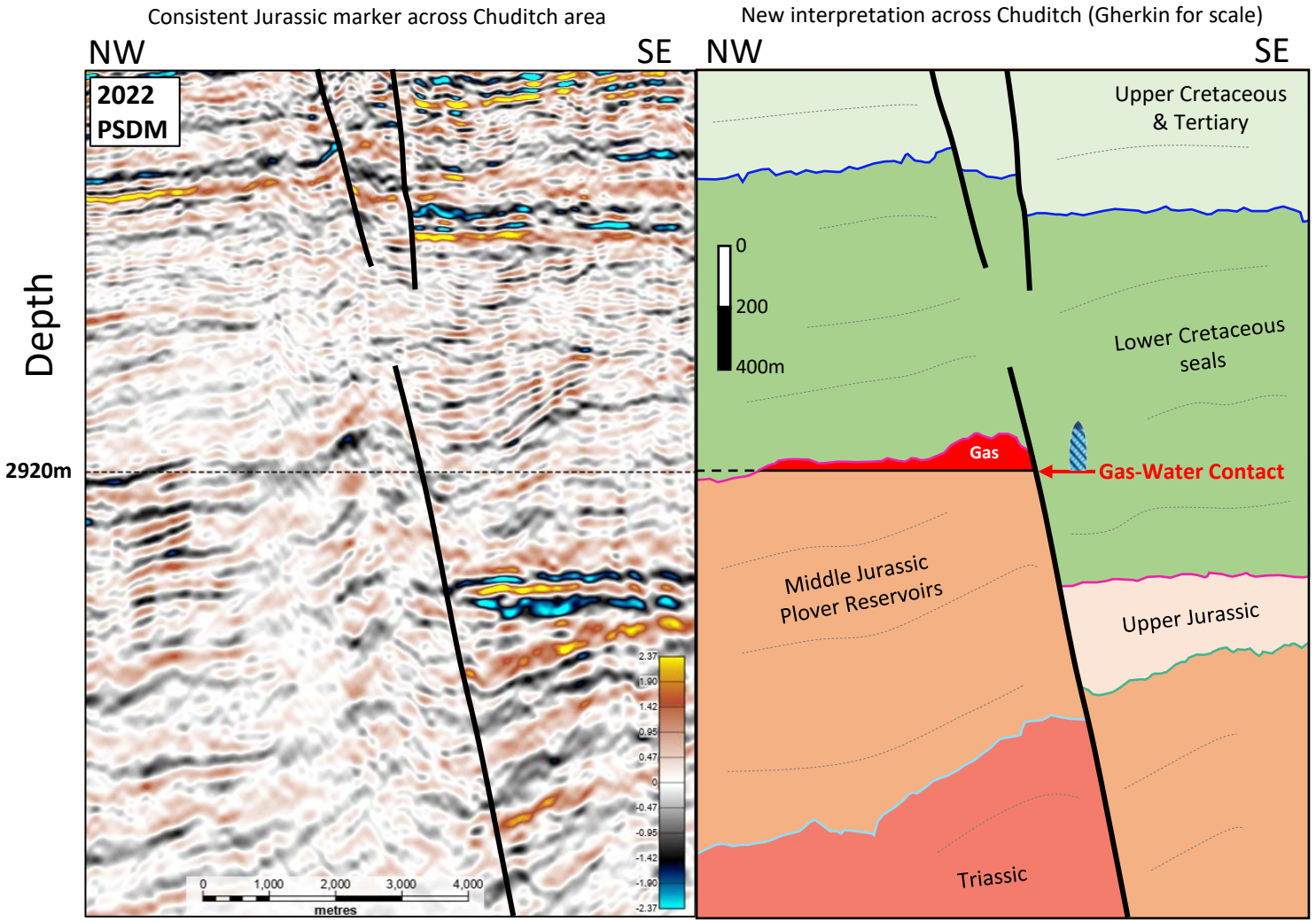
## The data Shell had available…




## The new 3D PSDM data… enables Chuditch to be properly imaged




*Data shown courtesy of TGS*

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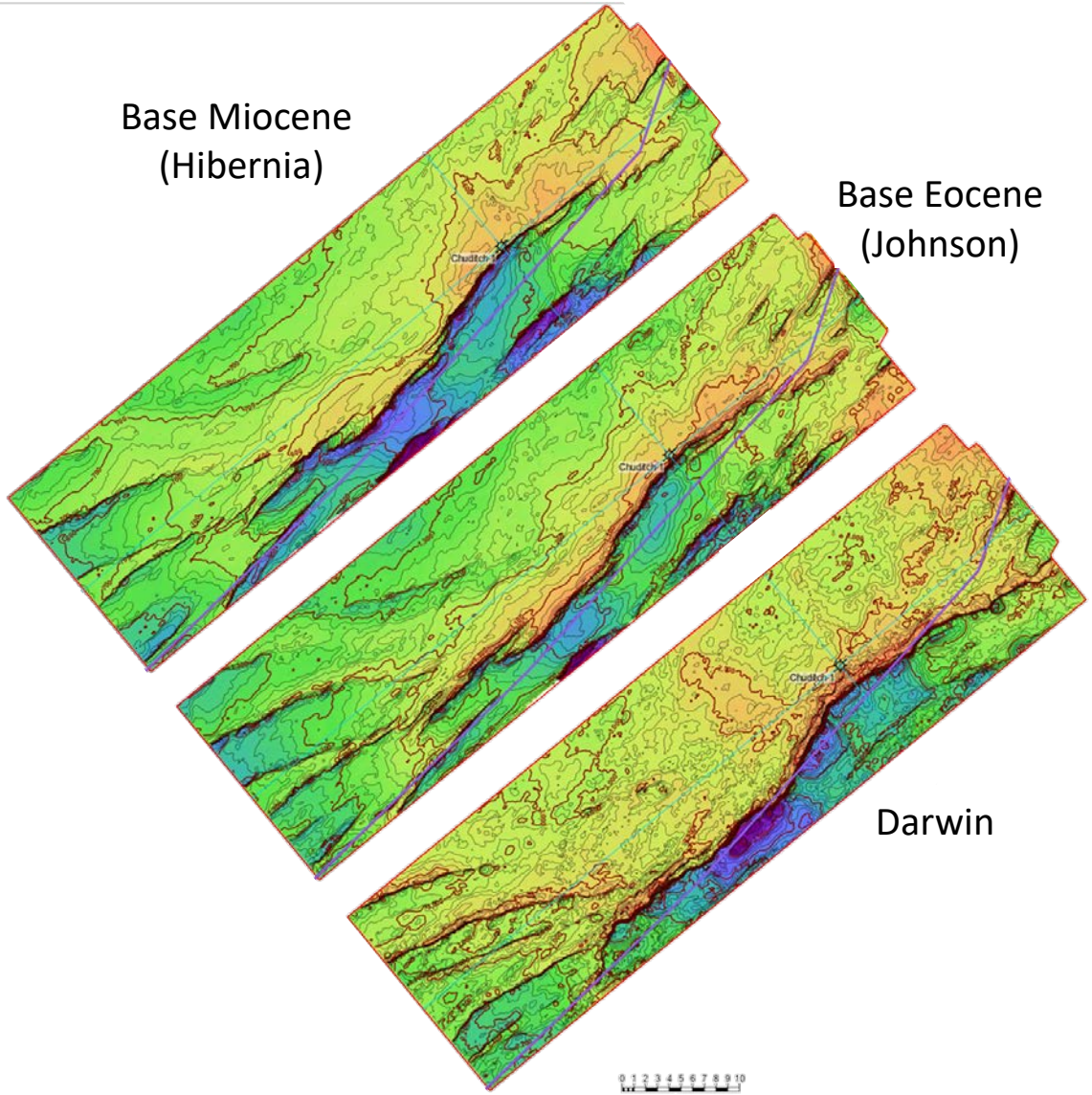
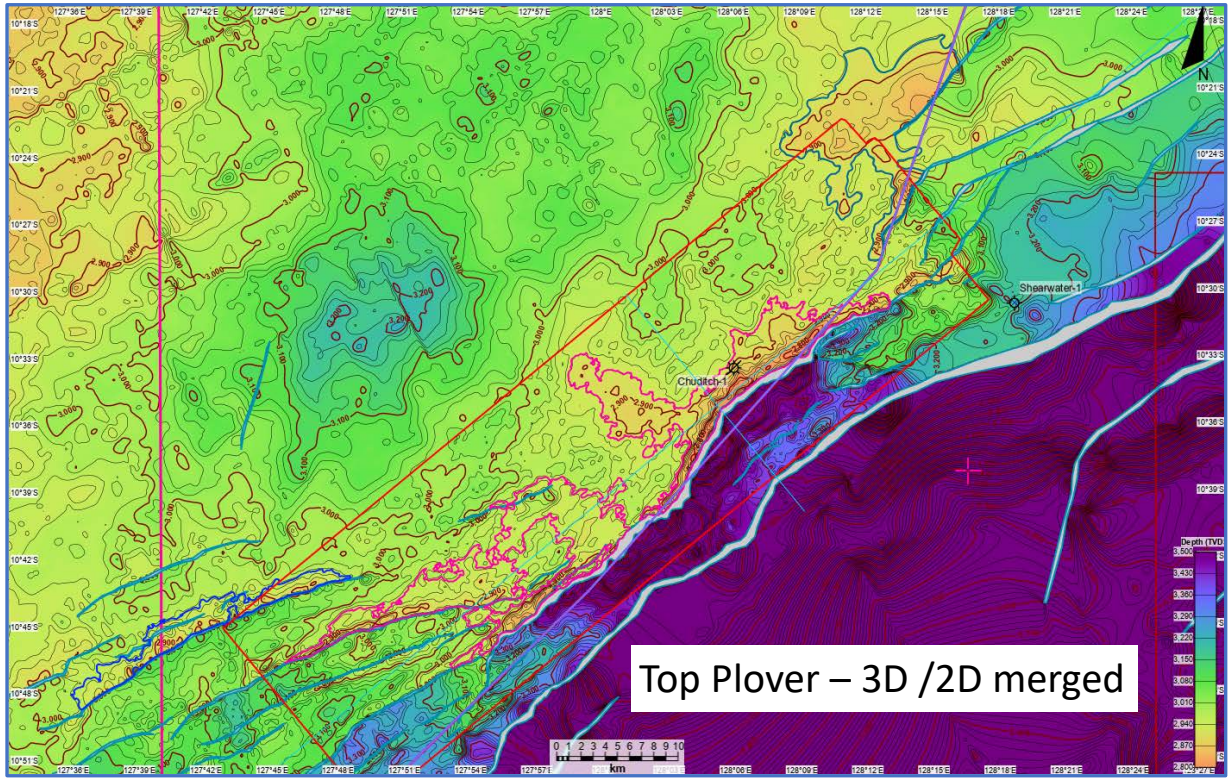
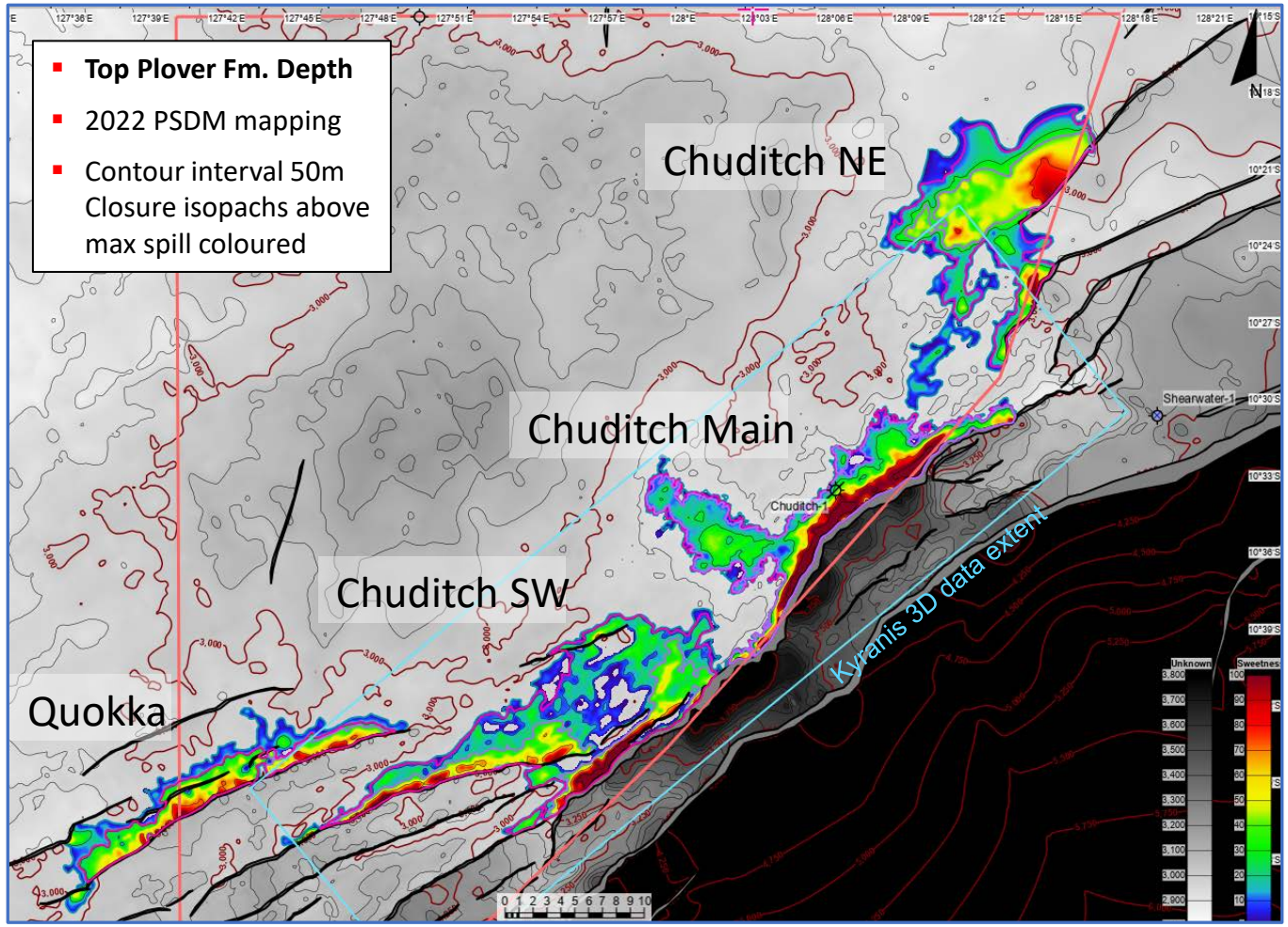
# Horizon Depth Mapping



# Material Contingent and Prospective Gas Resources




## Chuditch-1 Discovery

- Proven gas, >20km structure updip from well

## Chuditch NE Prospect

- …en route to Sunrise, needs further 3D data

## Chuditch SW Prospect

- lower relief structure, several culminations

## Quokka Prospect

- simple structure, extends beyond 3D and off block

| | ERCE CPR Feb 2023 | | | | | SundaGas |
|---|---|---|---|---|---|---|
| Contingent Resource | Gas Resource (Bscf) | | | | Risk | Gas (Bcf) |
| | P90 (1C) | P50 (2C) | P10 (3C) | Mean | POSg | Mean |
| Chuditch Main | 481 | 999 | 2050 | 1165 | 100% | 1161 |

| Prospective Resource | Gas Resource (Bscf) | | | | Risk | Gas (Bcf) |
|---|---|---|---|---|---|---|
| | P90 (1U) | P50 (2U) | P10 (3U) | Pmean | POSg | Pmean |
| Chuditch NE | 167 | 527 | 1587 | 759 | 30% | 863 |
| Chuditch SW - Alpha | 139 | 326 | 729 | 394 | 52% | 855 |
| Chuditch SW - Beta | 107 | 238 | 505 | 281 | 45% | |
| Chuditch SW - total | 246 | 564 | 1234 | 675 | | |
| Quokka | 41 | 142 | 469 | 217 | 26% | 410 |
| Total | | | | 1651 | | 2128 |
| Total CR + PR | | | | 2816 | | 3289 |

*Note: resources are gross, not net attributable to PSC*

# Conclusions and Forward Plans

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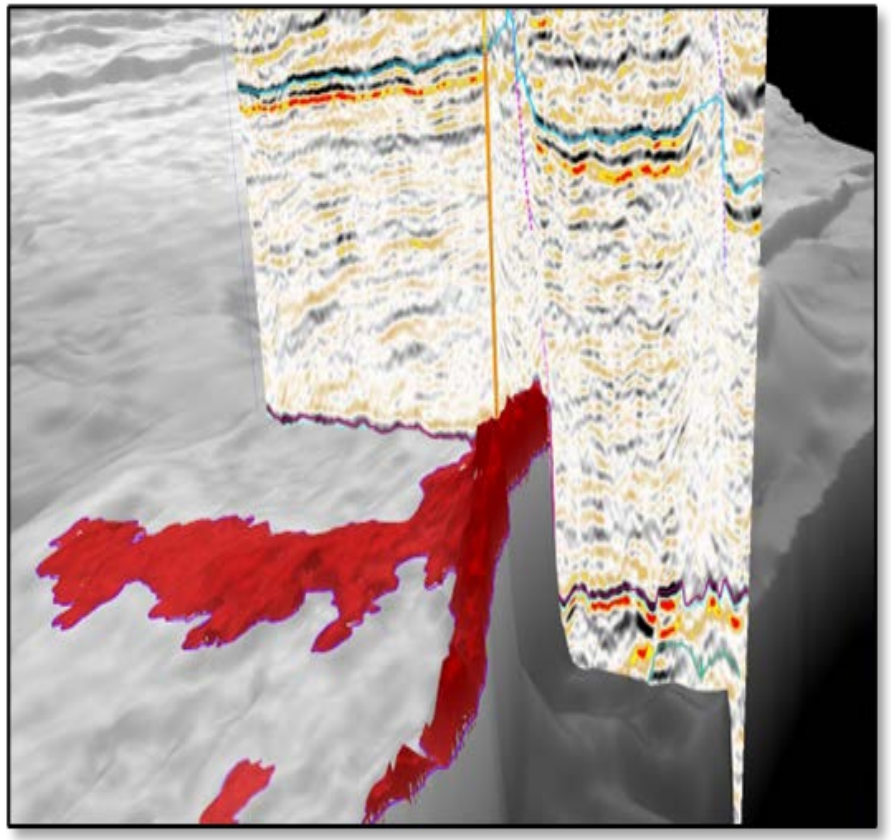
- By utilising modern seismic processing algorithms and techniques, an accurate subsurface image has been enabled
  - Processes are time consuming and require close liaison between processing team and interpreter to produce a valid output
  - Application of FWI has produced a detailed velocity model that conforms to the complex shallow geology
- As a result of the PSDM reprocessing…
  - Fault positioning and definition of key horizons is much improved
  - Chuditch structure has been clearly imaged for the first time
  - Estimated gas volumes have increased
  - 2D seismic based leads have matured into prospects
- Chuditch and its adjacent prospects are finally delineated and confirmed as a significant potential gas resource for Timor-Leste
- Planning for appraisal drilling and DST



- Contact andy.butler@sundagas.com for more info on Chuditch

*Data shown courtesy of TGS*