Petromall Ltd

Transformation!

David Bamford

‘Disruptive’ emerging technologies

1. Several ‘winners’ have appeared:

✓ Sea-bed Nodes (OBN)

✓ Fibre Optics

✓ Non-Seismic Geophysics:

- Full Tensor Gravimetry (FTG)
- Controlled Source Electro-magnetics (CSEM)

2. Critical Questions:

- Which work in which geological setting?
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OBN - Sea-bed Nodes

CRITICAL POINT:

- ✓ Use of sea-bed Cables and/or Nodes has been fraught with difficulties, and drove one or more companies out of business (RXT for example).
- ✓ These operational difficulties now seem to have been solved.

KEY DELIVERABLES:

- ➢ Flexible Patterns=>Full Azimuth=>Better Imaging/Positioning
- ➢ Deployment on the sea-bed allows 4-component recording, opening the way to utilisation of both P and S waves.
- ➢ This improves the chances of successful fluid prediction, *and*
- ➢ Brings in some robust rock physics/geomechanics…..fracture density, fracture orientation, ‘brittleness’, ‘fraccability’ etc

Z3000 Nodal System

Proven Technology

26 deep water Z3000 surveys to date

Average Survey Statistics

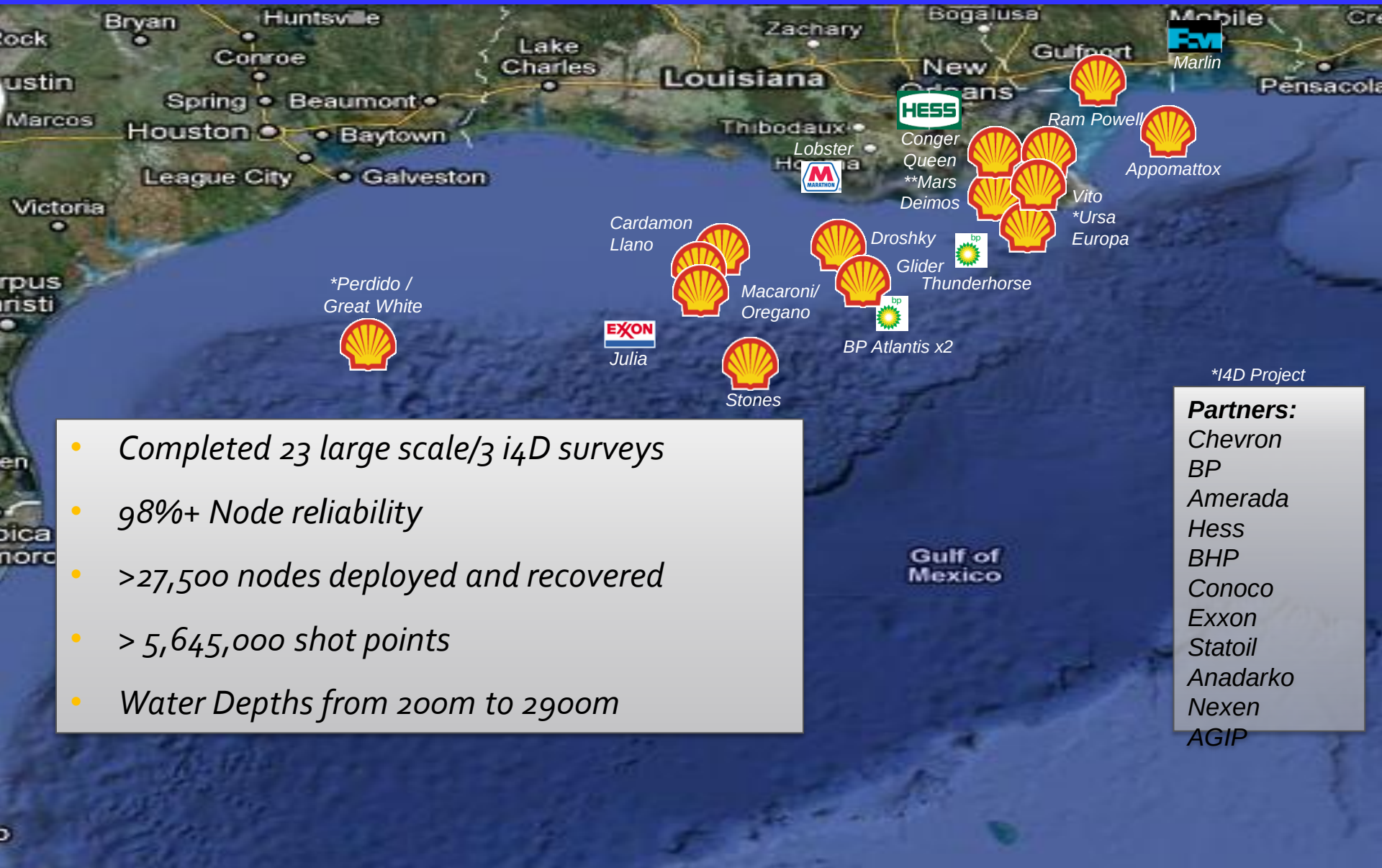
- Survey size: 180km2
- Nodes/survey: 1,178
- SPs / survey: 286,193
- Survey duration: 78 days
- SPs/day (production): 3,676

As of January, 2015

Project	Number of Node	Total Shot Points	Total Number of Days	Water Depths (metres)	Average Water Depth
Atlantis	1,628	458,098	168	2156	2156
Deimos	802	185,180	99	900	900
Shell	20	2,000	14	2D	2D
Micro Queen	454	197,581	76	800	800
Vooring	200	2,500	14	670 km 2D	670 km 2D
Mars	1,097	266,427	78	896	896
Cardamon	924	229,004	56	872	872
Ursa	937	290,117	78	1159	1159
Vito-11	937	314,617	84	1234	1234
Appomatox	1,065	311,208	70	2200	2200
Lobster	899	284,286	60	400	400
Hablano/Cardomom	1,654	433,671	118	1579	1579
Glider	1,089	184,162	71	1050	1050
Europa	1,090	167,862	64	1200	1200
Oregano 12	1,211	221,663	63	1000	1000
*Perdido	103	37,279	41	2400	2400
Brutus / Droshky	1,204	350,613	82	1000	1000
*URSA -1	134	32,030	42	1000	
*URSA-2	132	32,000	45	1160	
Ram Powell	1,210	260,050	70	500-1300	900
Conger	1,207	228,859	68	211-450	436
Perdido	1,500	315,877	101	2200-2400	2300
Marlin Dorado	1,125	183,009	91	750-1500	1125
Julia	1,500	365,724	119	1500	1500
Stones	1,286	291,343	87	2500-2900	2700
Atlantis	1,912	470,696	127	2156	2156

**I4D Project*

The Nodes have it!



- *Completed 23 large scale/3 i4D surveys*
- *98%+ Node reliability*
- *>27,500 nodes deployed and recovered*
- *> 5,645,000 shot points*
- *Water Depths from 200m to 2900m*

**I4D Project*

Partners:
Chevron
BP
Amerada
Hess
BHP
Conoco
Exxon
Statoil
Anadarko
Nexen
AGIP

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Fibre Optics

CRITICAL POINT:

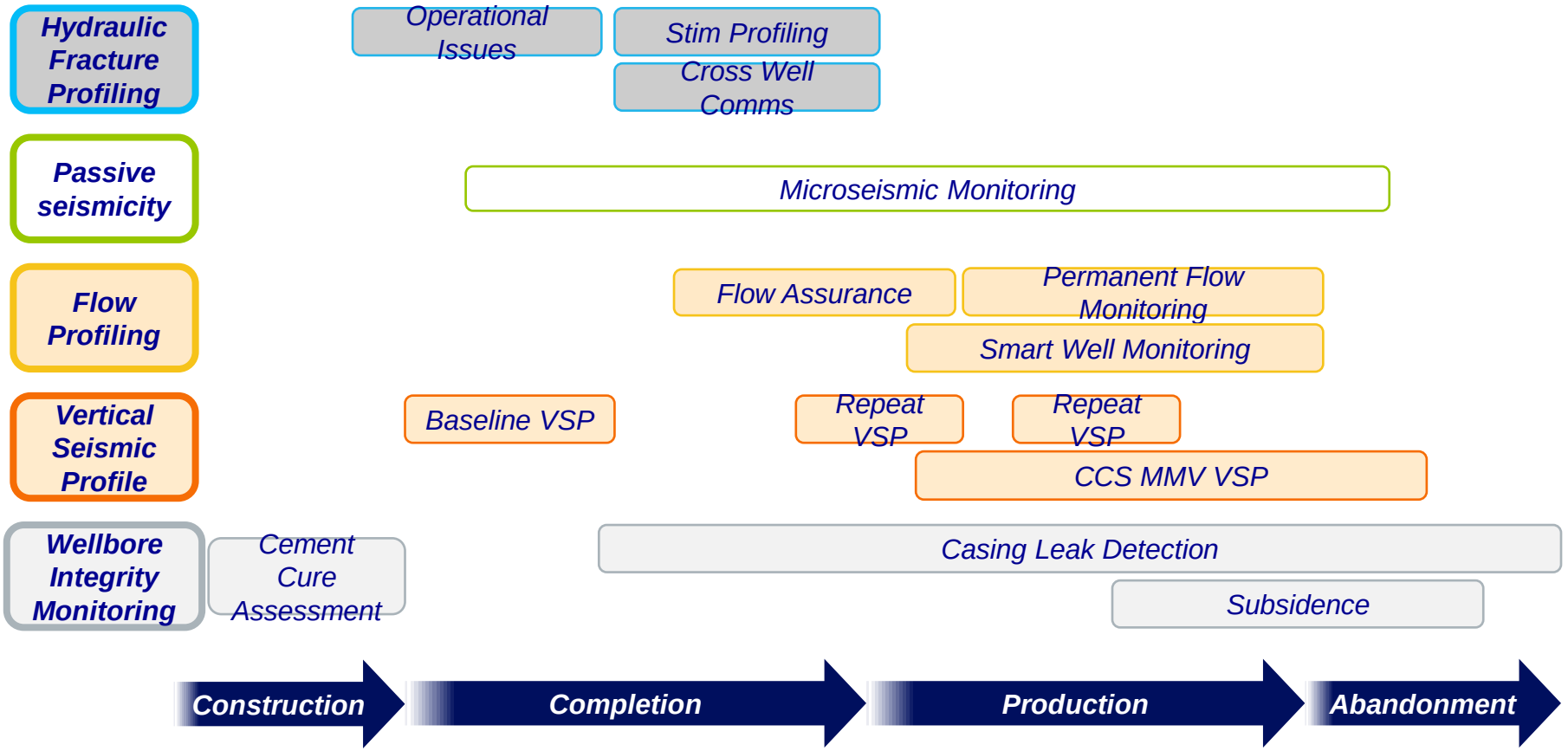
- ✓ Robust cables have now been developed that can be used to achieve 100% deployment in a well or ploughed into the seabed.

KEY DELIVERABLES:

- ➢ 24/7 recording of production acoustics, seismic sources.
- ➢ Pin-pointing of petroleum or water flow into an active well.
- ➢ “Anytime” Vertical Seismic Profiles (VSPs)
- ➢ Permanent Reservoir Monitoring (PRM) – down-hole and sea-bed in combination?

Integrated Well Surveillance Using DAS

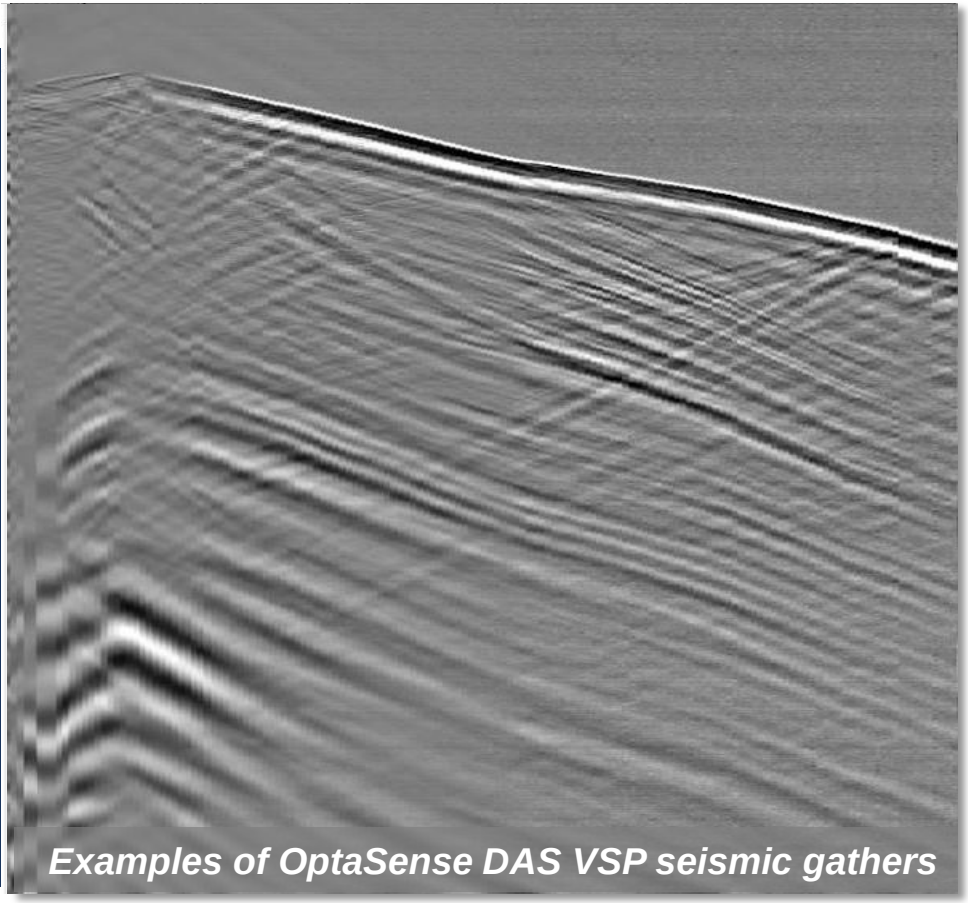
One fibre … multiple applications … applied over the life of the well



DAS-VSP™: Benefits and Examples

Providing unique advantages

- **Non-intrusive**
  - VSP in wells inaccessible to geophones
- **Permanent**
  - Lower cost on-demand monitoring
- **Full vertical coverage**
  - Better imaging
  - Faster acquisition
- **Retrofitable**
  - Deployable on tubing
  - Synergies with in-well monitoring

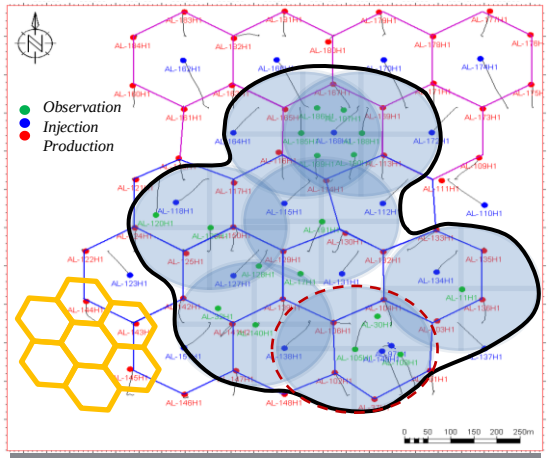


Examples of OptaSense DAS VSP seismic gathers

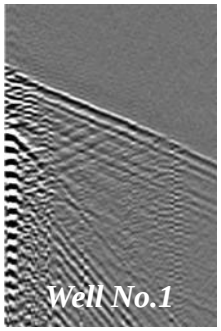
Multi-well 4D DAS-VSP™ acquisition

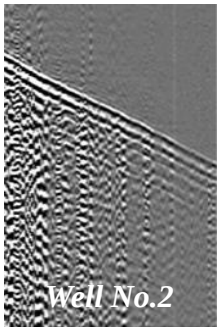
Example from DAS-VSP 3D Baseline Survey

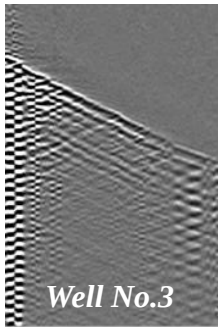
- *Application*
  - *–EOR (steam injection) surveillance*
- *Measurement*

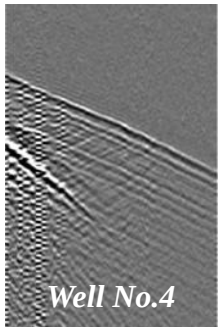


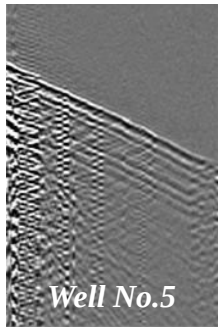
Baseline DAS coverage

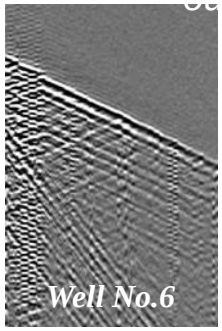


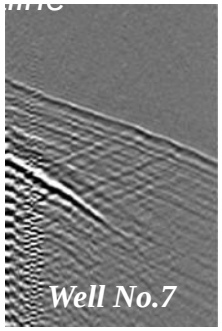


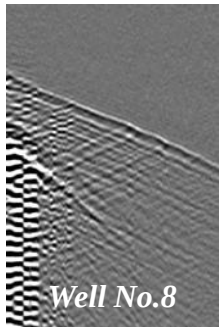












Courtesy of PDO, Oman

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FTG – Full Tensor Gravimetry

CRITICAL POINT:

- ✓ Much higher ‘signal-to-noise’, much higher resolution than conventional gravity technology.

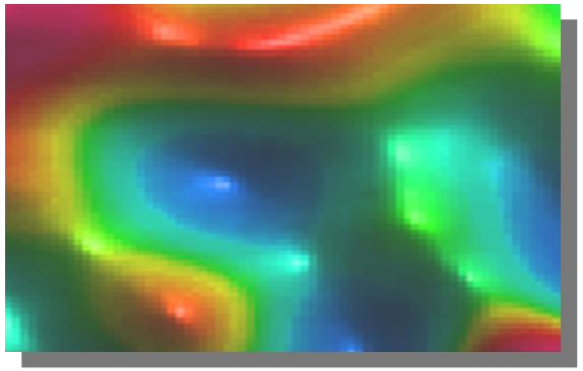
KEY DELIVERABLES:

- ➢ Huge survey areas (10’s of thousands of square kilometres) can be covered quickly at a fraction of the cost of seismic , especially 3D seismic.
- ➢ Extremely useful for demonstrating basin structural architecture, revealing structural patterns from faulting.
- ➢ Extensive demonstrations of its usefulness in helping solve sub-salt problems that are a challenge for seismic.

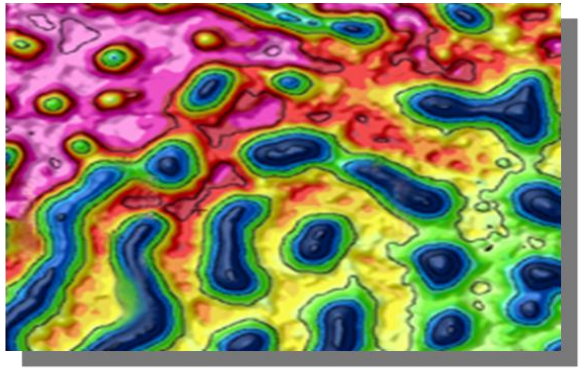
FTG provides increased resolution

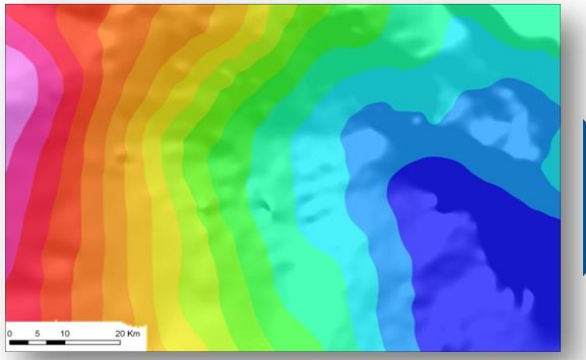
GGI Is Game Changing

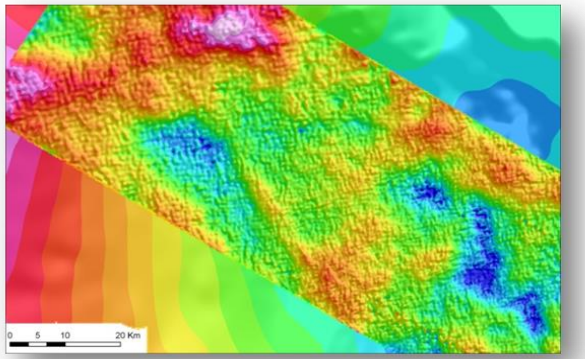
Conventional Gravity



Gravity Gradiometry (GGI)







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CSEM – Controlled Source Electro-magnetics

CRITICAL POINT:

- ✓ Operational difficulties surmounted.
- ✓ Targets conductivity differences between oil, gas and water..

KEY DELIVERABLES:

- ➢ Not a "stand-alone" technique, especially for exploration.
- ➢ Power lies in integration once a 3D seismic-based interpretation is available.
- ➢ *EMGS's summary:*
- *CSEM = significant reduction of the main uncertainties and increase of Pe (chance of economic success)*
- *Needs to be adopted systematically*
- *Workflows must be adapted & Interpreters have to be trained*

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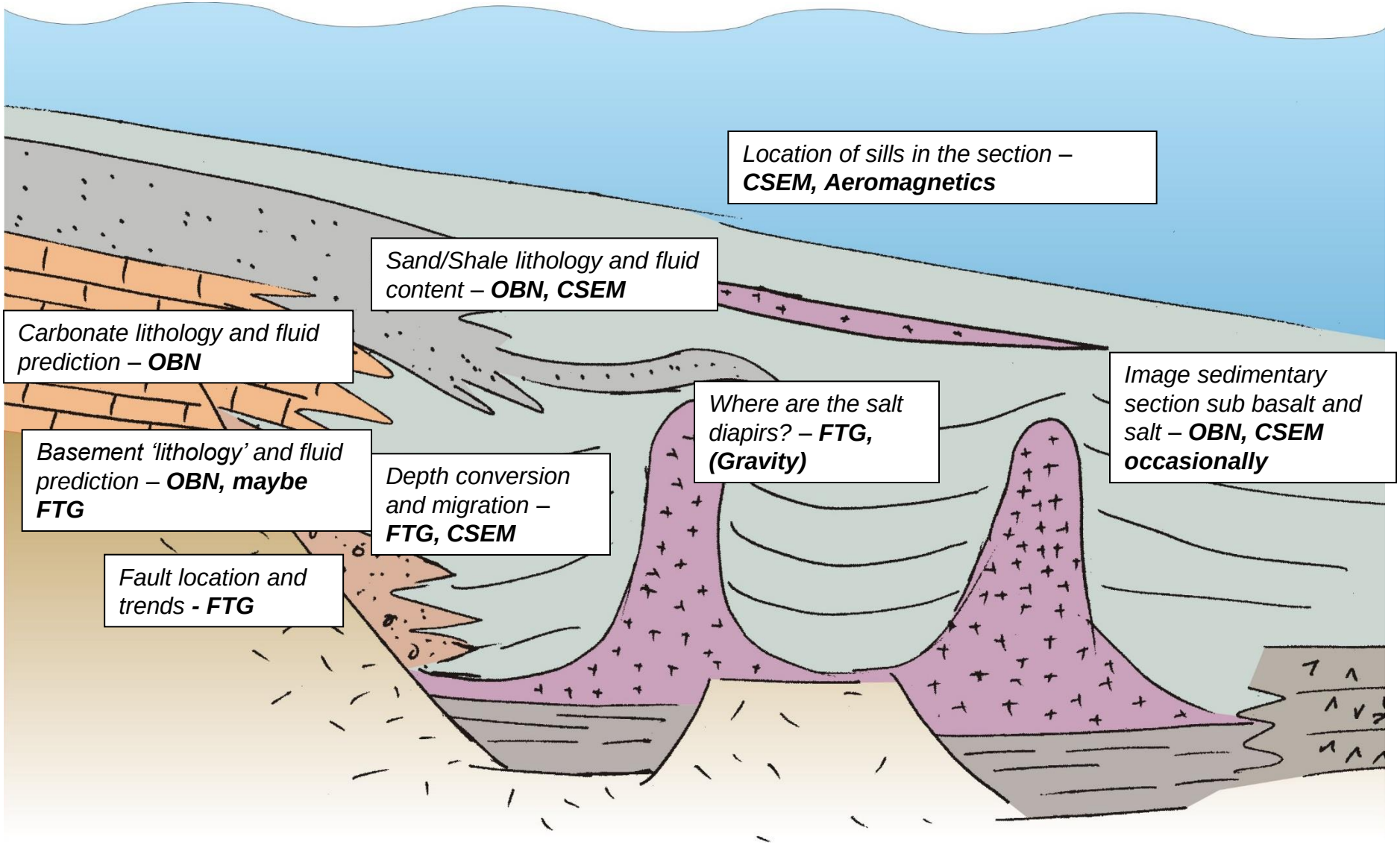
OFFSHORE PASSIVE MARGIN SETTING
(West Africa, Ireland, West of Shetlands, Norwegian Sea, Barents)



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How to Integrate and Interpret "Multi-Measurements?

? Modern workstations are designed for the interpretation of seismic data, increasingly 3D seismic.

? They, and typical work processes built around them, do not allow the easy integration of data say from 3D seismic, OBN, and CSEM, and subsequent interpretation.

➢ If you accept that use of multi-measurements can transform sub-surface interpretations *and*

➢ Therefore increase economic success rates and reduce volumetric uncertainty *then*

➢ It is essential that new systems appear which:

- ✓ Allow a petro-technical professional to deliver a sophisticated interpretation from 3D seismic, *and then*
- ✓ Invert into this 'model' parameters from OBN and/or CSEM and/or FTG etc.

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FAILED RIFT SETTING