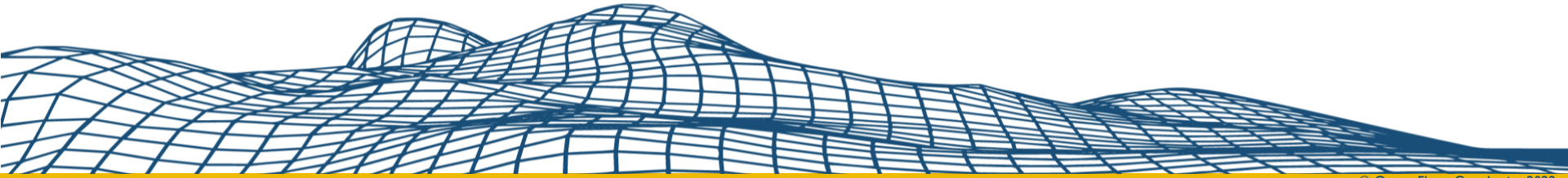
OFG Ocean Floor Geophysics

To 3D or not to 3D ?

That is the question

Richard Cooper (OFG, speaker)
Lucy MacGregor (OFG), Jon Nicholls (OFG), Larry Scott (NCS)

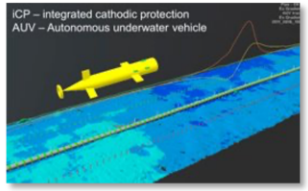
Seismic 2022, Aberdeen, 4th May 2022



Outline

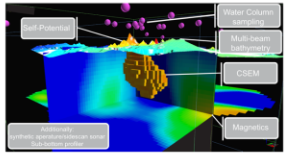
- A few words about OFG
- The role of geophysics in the energy industry
- It's all about time to decision
- Solutions
    1. UHR 3D
    2. Multiphysics
    3. Integrated 3D ground model
    4. Data when you need it
- Summary

A few words about OFG



Formed in 2007 to develop and deploy advanced sensors for use in seafloor mineral exploration

Since then, expanded both technology and market applications.



2007
First commercial mapping of SMS deposit by OFG patented EM system

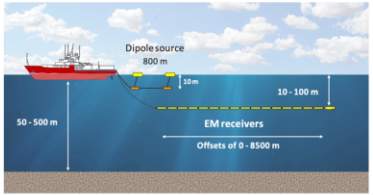
2008
AUV borne gravity surveys, ROV EM Mark II and magnetometers surveys

2009
EM Mark III and magnetometers deployed in SMS survey

2010-present
ROV surveys, operations support, geophysics and hydrography services

2012-present
AUV operations, geophysical, geochemical and hydrography services

2014-present
Vulcan CSEM towed array, 3D vertical Cable Seismic (VCS), Towed Array Marine Induced Polarization System, Improved AUV magnetics



2015-present
AUV technology developed further:
- Synthetic aperture sonar and pipeline technology
- OFG SCM
- CSEM
- iCP (non-contact inspection)
- Self Potential (SP), CSEM

2020-present
Towed streamer CSEM data acquired with the PGS-developed CSEM system

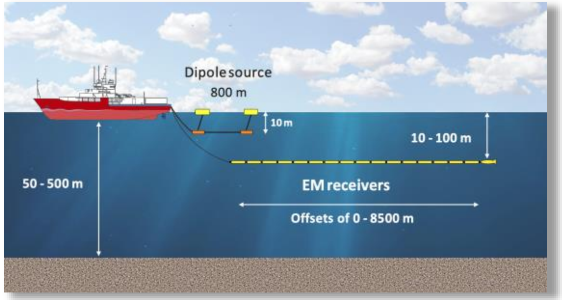
2022 -present
Announced acquisition of NCS Subsea, home of P-Cable UHR-3D seismic system

TODAY

Multiphysics data acquisition from towed and AUV platforms

Delivery actionable knowledge on the subsurface built on integrated interpretation of multiphysics data.

Recent announcements



2021 - Acquires CSEM towed-streamer system from PGS

2022 – OFG, in partnership with PGS, acquires NCS SubSea, provider of P-Cable UHR-3D seismic technology

28-JAN-2021

To whom it may concern

Re: Confirmtion of PGS' commitment to support OFG to acquire marine CSEM data

In 2020, following a six-month due-diligence and knowledge transfer process, PGS and OFG entered into an agreement under which OFG has acquired the exclusive rights to use the hardware, software and intellectual property associated with the PGS towed streamer CSEM system. The PGS towed streamer CSEM system is capable of rapid acquisition of high-quality marine CSEM and is a perfect complement to existing PGS seismic data when added confidence is needed to qualify acquisition, drilling or relinquishment decisions.

PGS entered discussions with several companies before selecting OFG as our partner to operate our towed-streamer CSEM system. An important driver for selecting OFG was because of its long history of providing a variety of geoscience and technical services to a range of offshore industries, with an exemplary safety record. In addition, OFG has considerable experience in operating a variety of marine of CSEM systems, including both nodal and towed receiver types.

As part of the transaction, PGS has entered into a companion Technical Support Agreement, where PGS is committed to supply OFG with technical support in several key areas, including but not limited to:

- Pre-mobilization support and advice on essential 3rd party systems such as navigation, streamer and source rigging, back deck equipment, and depth control systems
- Field engineers, operatives, navigation, and QC specialists for the duration of mobilization and operation of the survey
- Access to PGS survey management systems including crew models, HSE processing workflows and quality control
- Access to equipment and systems for training, testing and familiarization ahead of offshore operations

PGS is both a partner and shareholder in OFG. We confirm we will use best efforts to ensure OFG delivers a high-quality survey.

Best regards,

Rob Adams
Executive Vice President, Operations
PGS

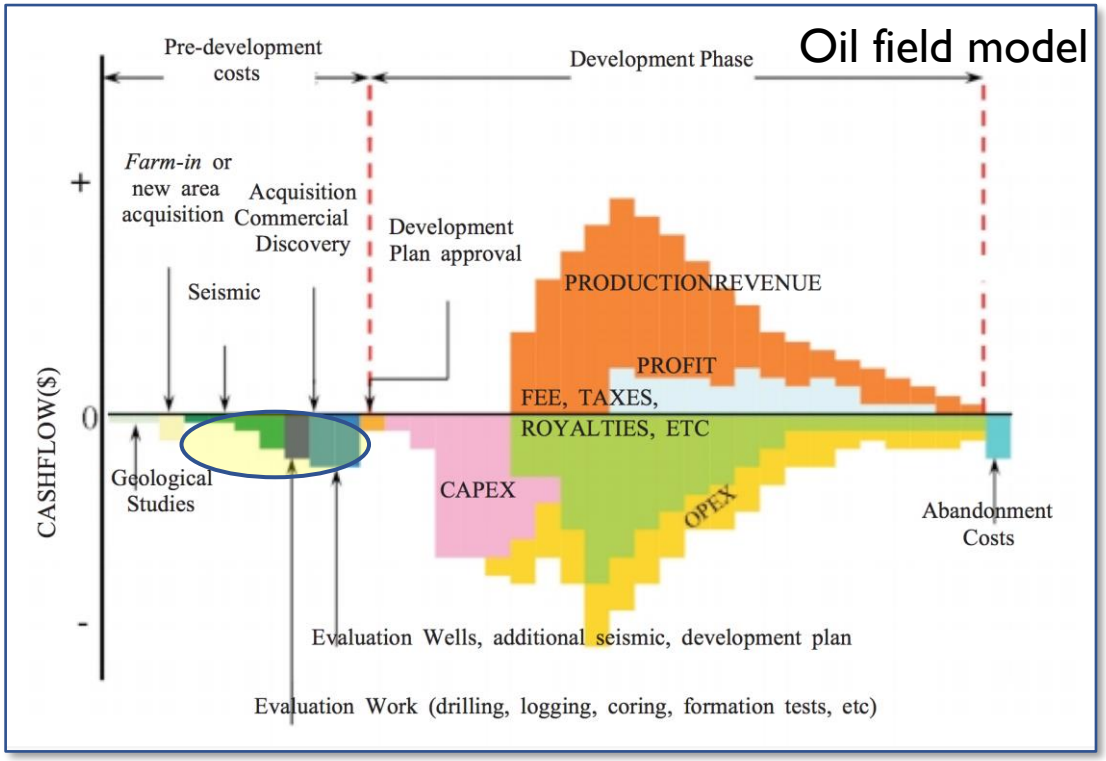
PGS Geophysical AS | Lilleakerveien 4C, P. O. Box 251 Lilleaker, 0216 Oslo, Norway | Tel: +47 6752 6400, Fax: +47 6752 6464 | Foretaksregisteret No. 960563085 MVA, www.pgs.com

2022 - Collaboration agreement with PGS:

- Technology collaboration for New Energy Markets:
  - Wind
  - Minerals
  - CCS
- Operations support
- Technology and knowledge sharing

The role of geophysics in the energy industry

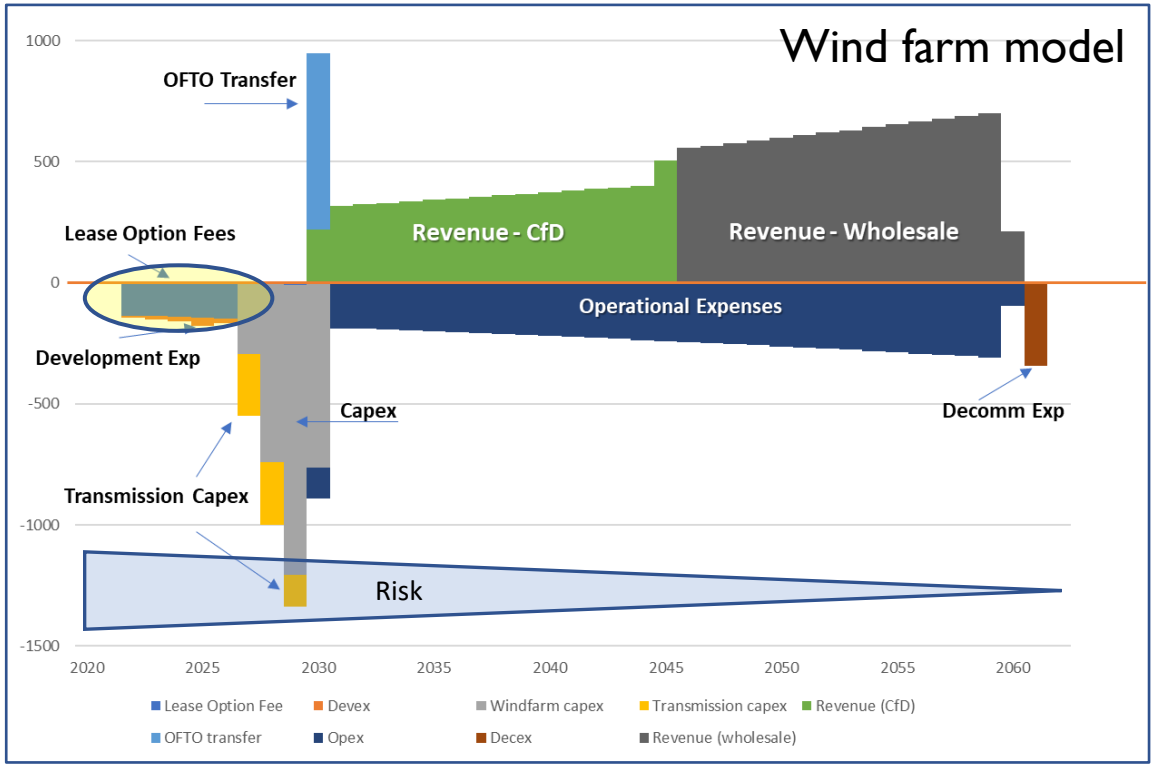
Geology & Geophysics (G&G)
Improve knowledge of subsurface
Accelerate time to market



Typical E&P cash-flow project based upon the Brazil Fiscal System (Suslick, 2005)

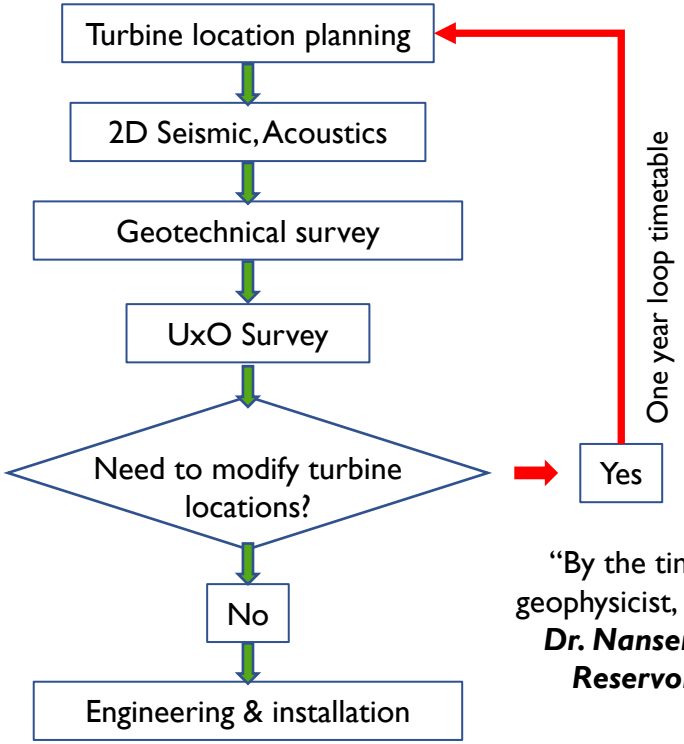
The role of geophysics in the energy industry

Geology & Geophysics (G&G)
Improve knowledge of subsurface
Accelerate time to market



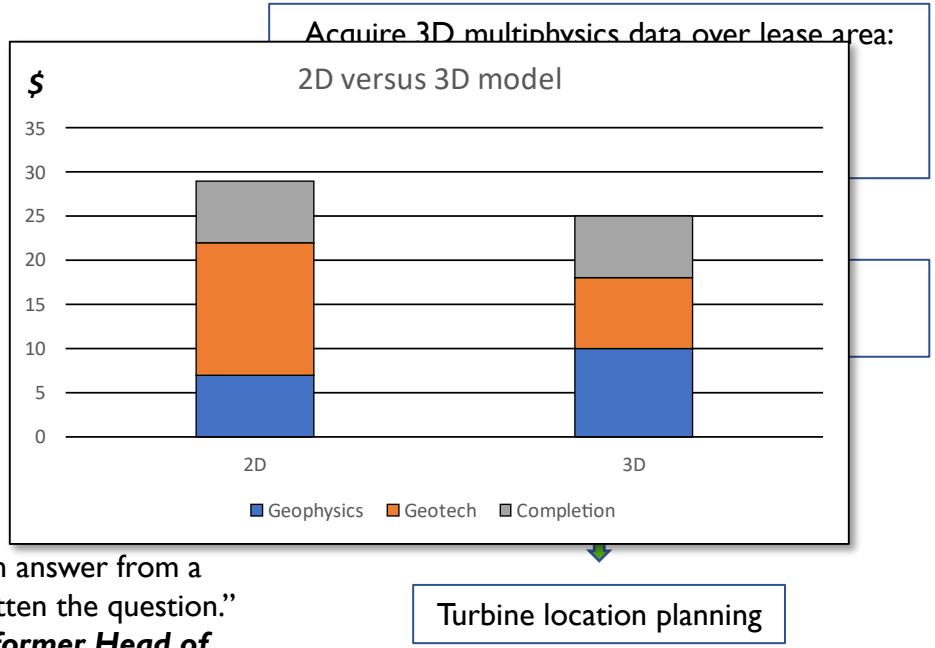
It's all about time to decision

Common Approach



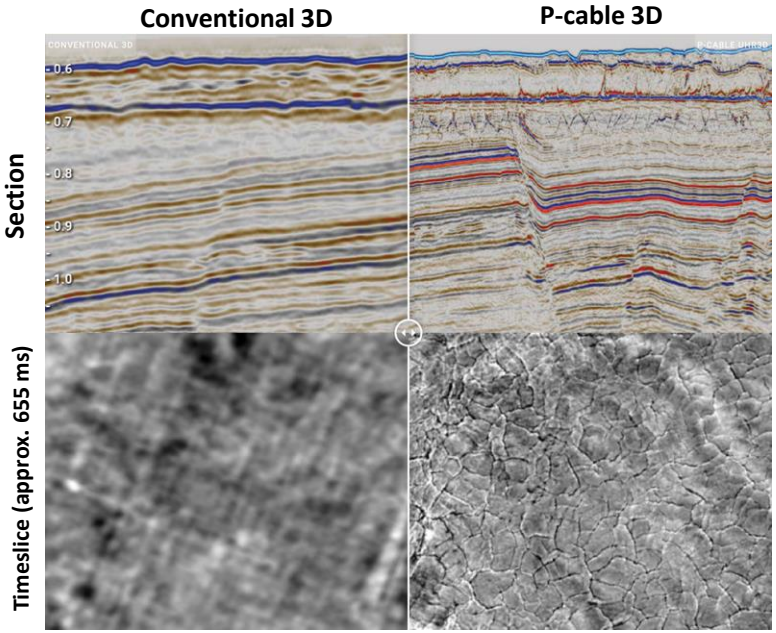
"By the time I get an answer from a geophysicist, I've forgotten the question."
Dr. Nansen Saleri, former Head of Reservoir Management, Saudi ARAMCO

"One Pass" Multiphysics Approach

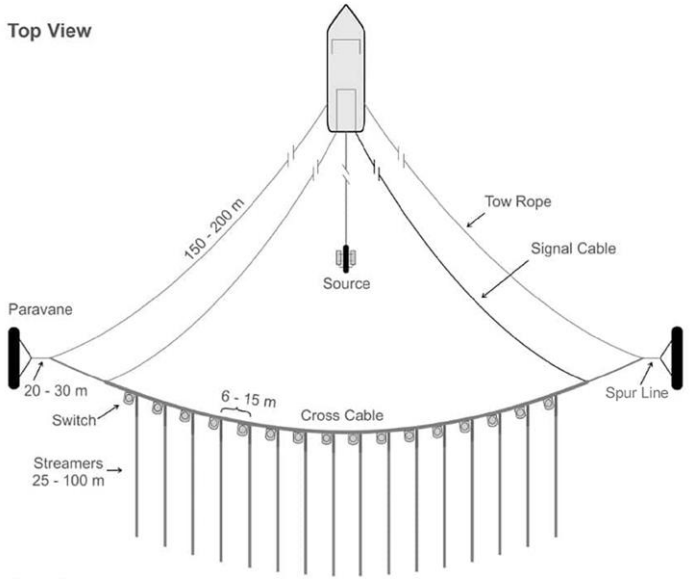


1. Ultra high resolution seismic

Through OFG's partner NCS Subsea, we can provide ultra high resolution seismic, using the P-cable system. This bridges the gap in scale between AUV acoustics, and conventional 3D seismic

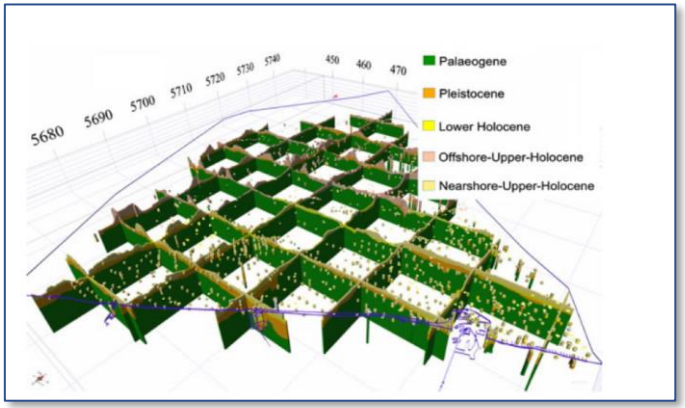


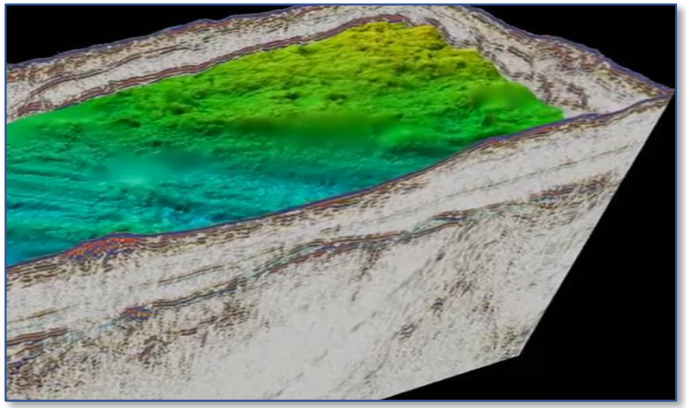
Both datasets have been processed to maximize the bandwidth available within the recorded data, including broadband deghosting. The conventional dataset is 80 fold in 6.25 x 25 meter bins with 6000-meter offsets and the P-Cable UHR dataset is 4 fold in 3.125 x 3.125 meter bins with 100-meter offsets. Images courtesy OMV/NCS subsea (www.ncs-subsea.com)



2D/3D/4D UHR seismic acquisition for oil & gas, CCS, wind farm, site survey and geo-hazard mapping.

2D vs 3D ultra high resolution seismic





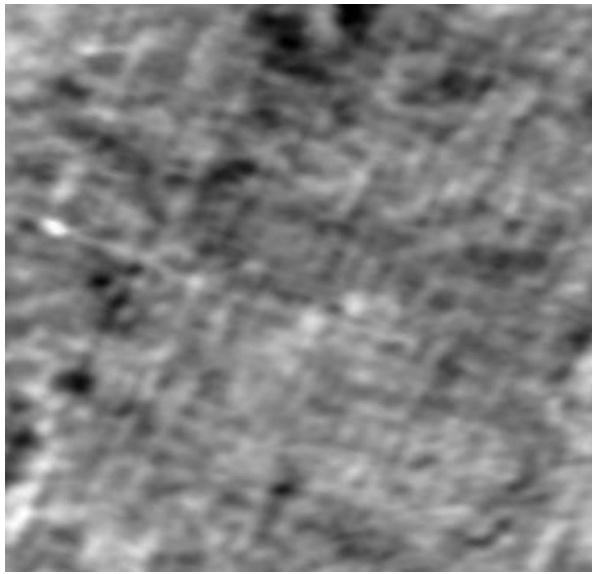
- Minimal geophysical equipment required
- Interpretation uncertainty in is relatively
  morphology and distribution of hazards i
  subsurface cannot be mapped with confi
- Limited spatial coverage of a given area o
- Risk of "false structure" due to reflectior
  geological structure away from the data-profile
- Interpolation may be required to relate geophysical and geotechnical data

	Sail lines	Cross lines	Cost per kms^2
2D	150m	800m	US$ 4K
3D	100m	N/A	US$ 9K

- physical equipment required
- tion uncertainty is low: the morphology
  bution of hazards in the subsurface can be
  with confidence
- l coverage of a given area of interest
- Subsurface features and hazards are imaged properly in space; no "phantom" or missing events
- Geophysical and geotechnical samples are co-incident in space

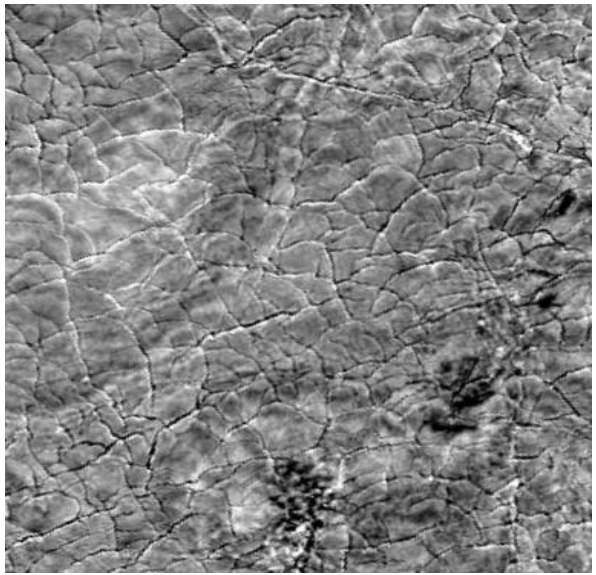
UHR vs conventional 3D

Conventional 3D
(6.25 x 25 meter bin)

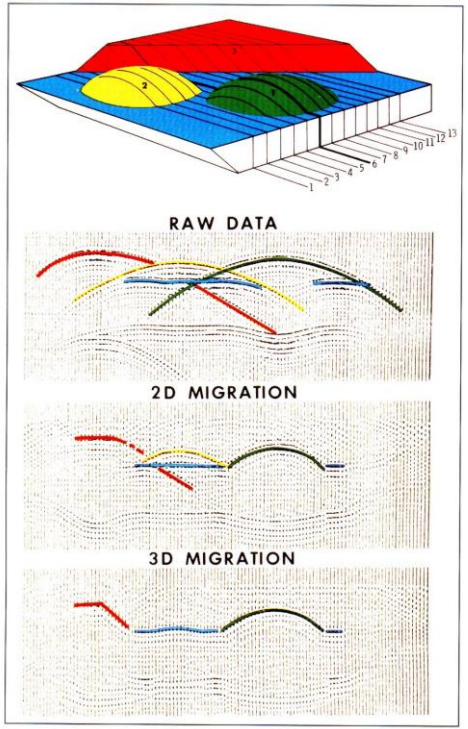


Source: Data courtesy OMV.

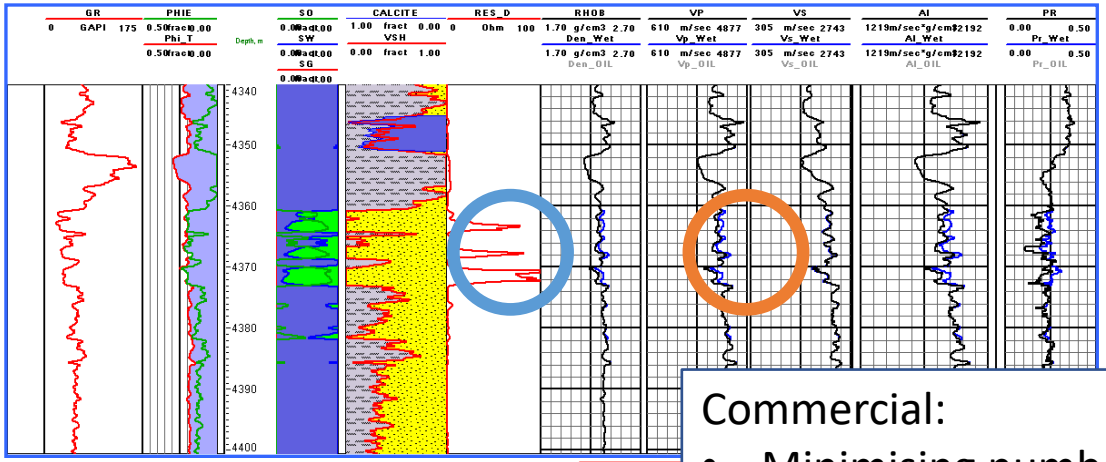
P-Cable UHR3D
(3.25 x 3.25 meter bin)

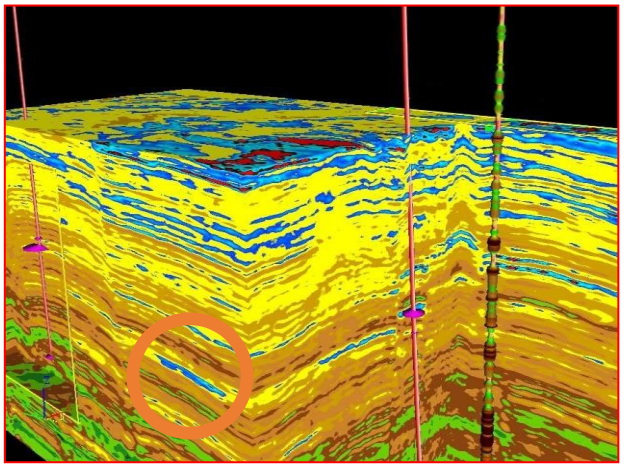


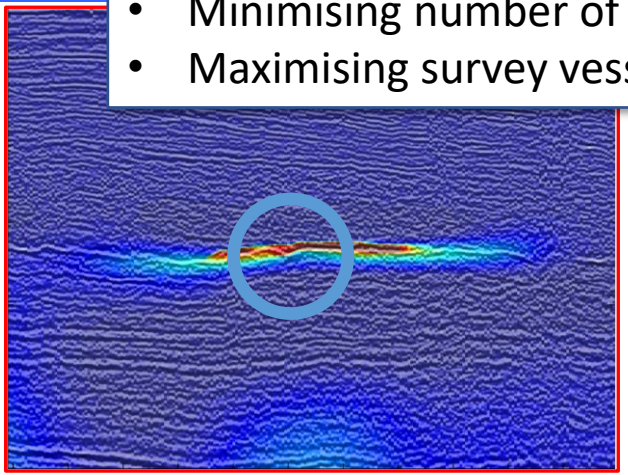
Source: Data courtesy OMV.



2. Multiphysics – why?







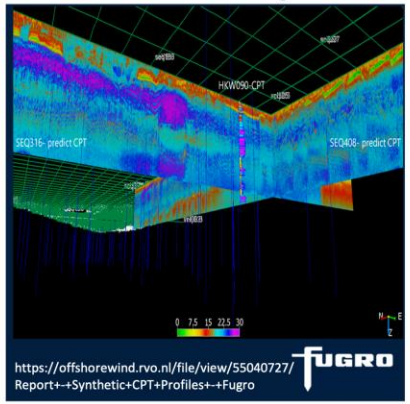
Commercial:

- Minimising number of surveys
- Maximising survey vessel flexibility

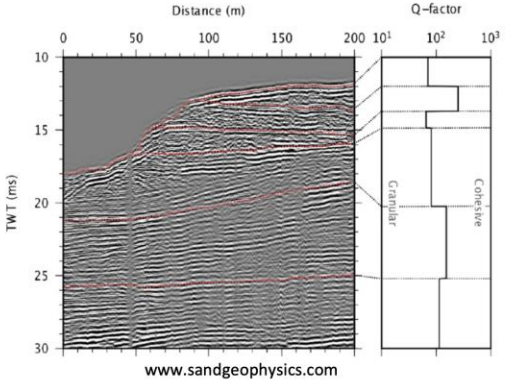
2. Multiphysics

Seismic

Machine learning

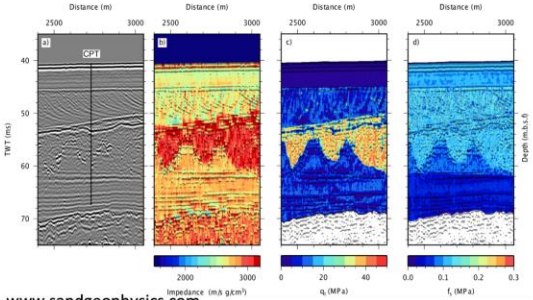


Attenuation quantification



www.sandgeophysics.com

...more machine learning...



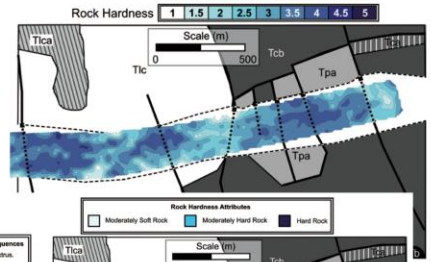
www.sandgeophysics.com

Improved seismic:
e.g. UHR 3D

EM and resistivity

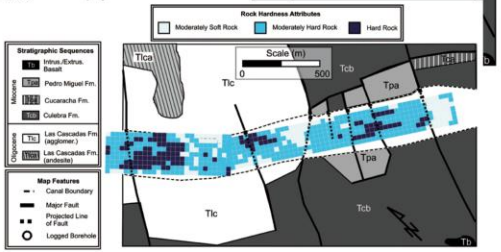
Rock hardness (empirical relationship or clustering)

Rucker et al., 2013,
NSG, 11, 625-637

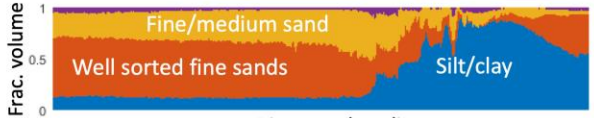


Heterogeneity characterisation

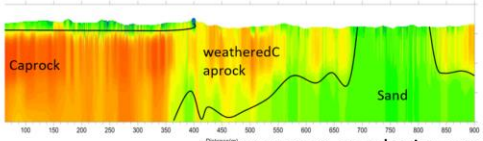
Depth to basement



Quantitative grain size mapping



Baasch et al., 2018, GJI,214,460-473



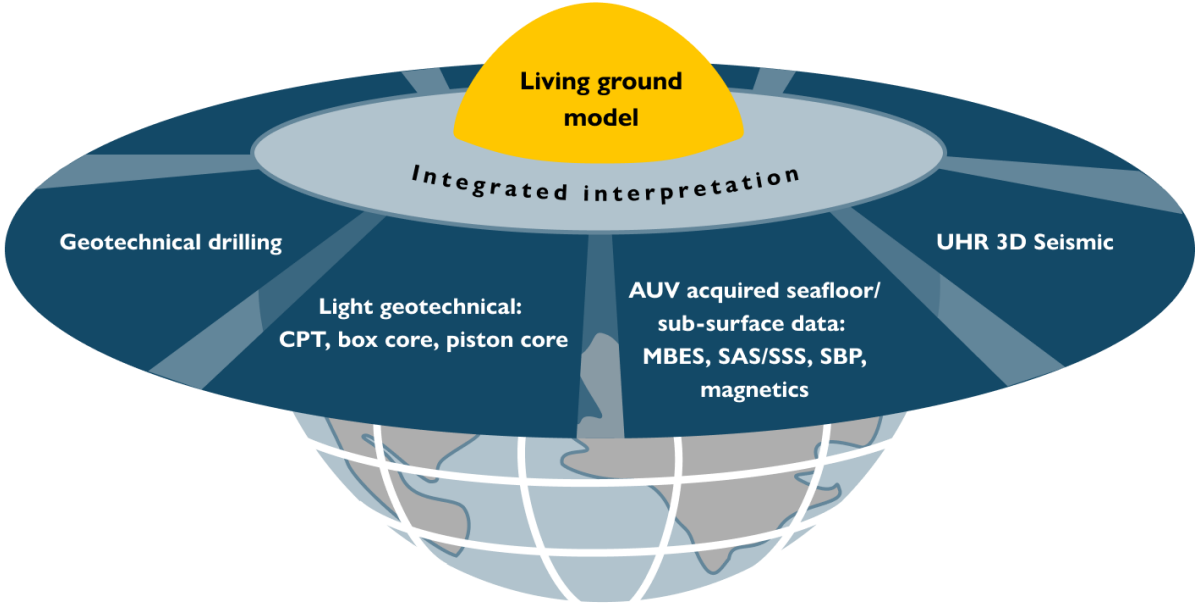
www.mappem-geophysics.com

Karst mapping

Permafrost mapping

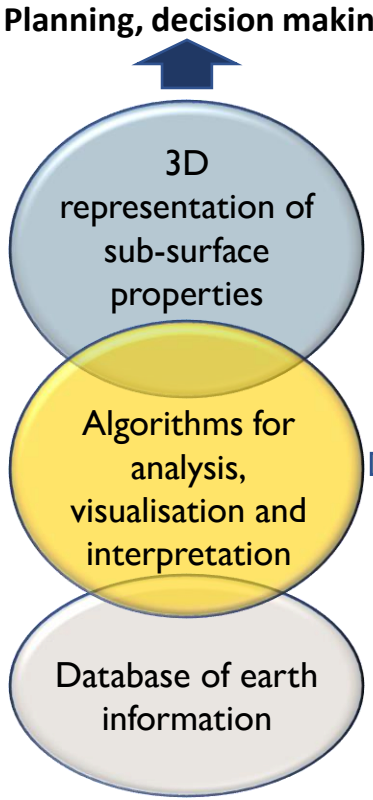
Mapping freshwater aquifers

3. Integrated ground model (digital twin)



"A living ground model delivering actionable knowledge built upon an integrated interpretation of multiphysics and geotechnical data"

What is a digital twin ?

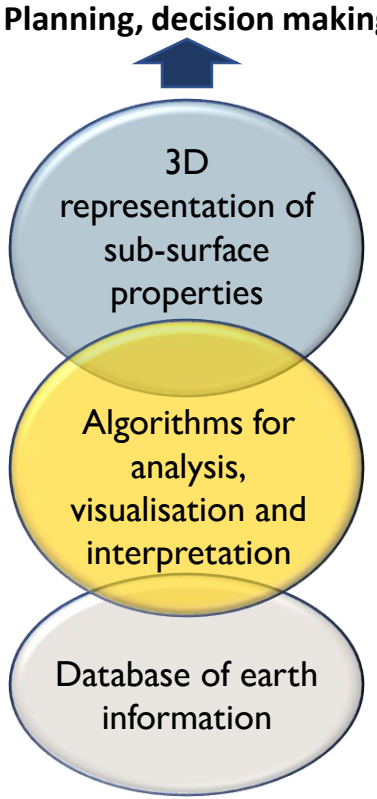


Things our customers want to know: Geology, stratigraphy, rock type, fluid type, rock strength….

Ways of turning measurements into something useful: Inversion, AI, rock physics….

Measurements we make: Seismic data, CSEM data, logs, CPT, cores….

Why is it important ?



Data repository
- Single location to store data
- Version controlled
- Repository for knowledge and experience

Collaboration space
- Between different disciplines
- Between different skill levels

Persistent living model
- Updated as new information is added
- Uncertainty quantified and updated
- Improved efficiency/reduced timescale

Multiphysics environment
- Facilitates data fusion

Most value is derived from controlling DATA
Enables multi-client business models

Integrated platform

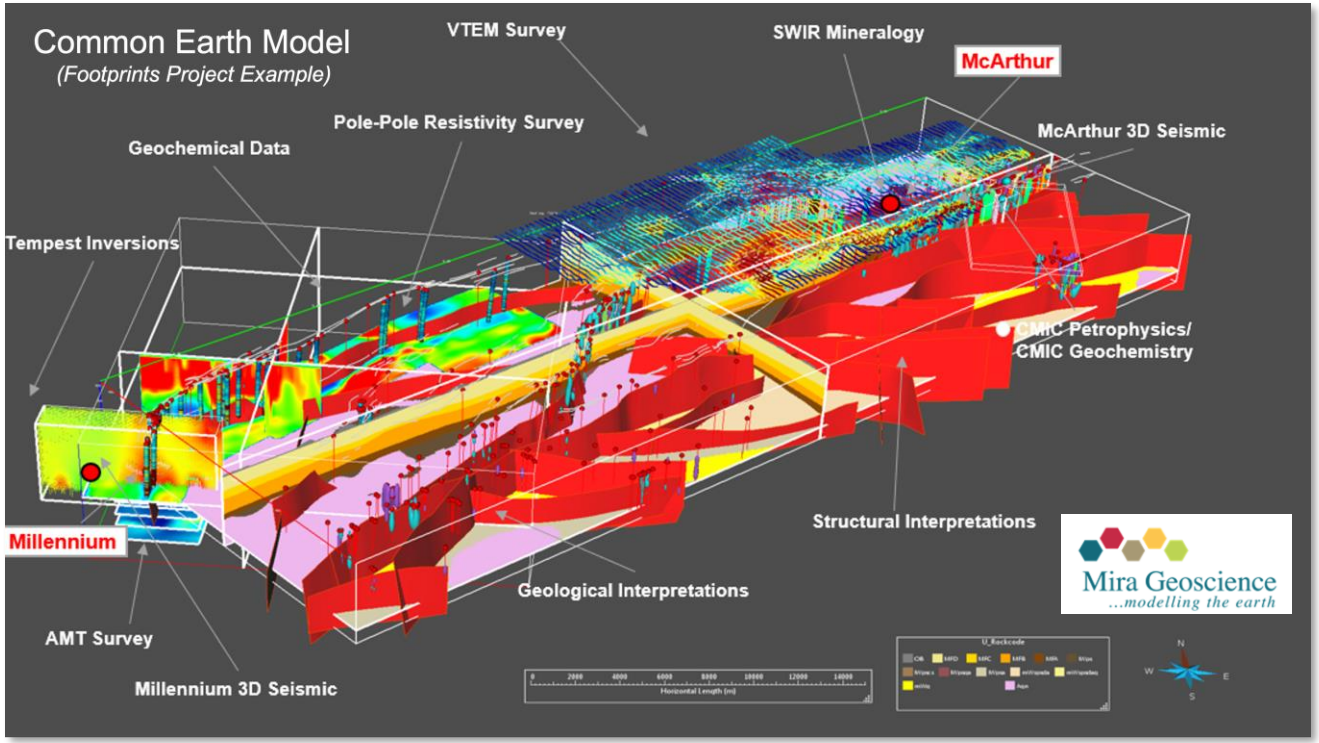
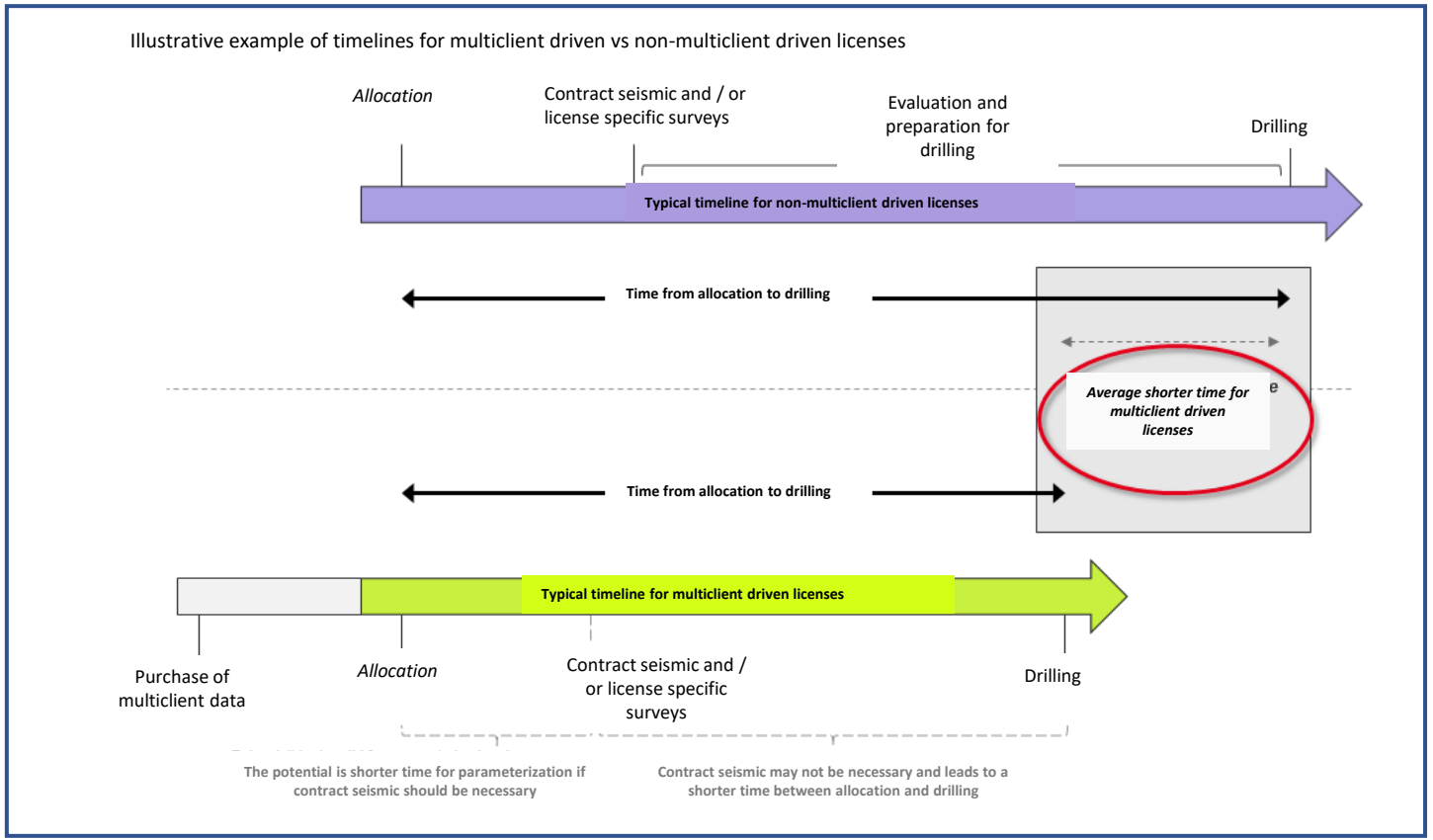


Image courtesy of Mira Geoscience

4. Data when you need it

- Multi-client data deliverables
- Very successful business model in oil & gas
- Applicable to wind-farm markets
- Acquire data in anticipation of licensing rounds, or in partnership with licensing bodies
- Spread risk and cost between operators
- Substantial reduction in decision time

4. Data when you need it – oil & gas example



Source: Rystad Energy Research and Team Analysis

Summary

- 3D seismic introduced into oil & gas exploration in 1980’s
- Quickly became the standard…for a reason:

- Our world is 3D
- Our data should be too.