

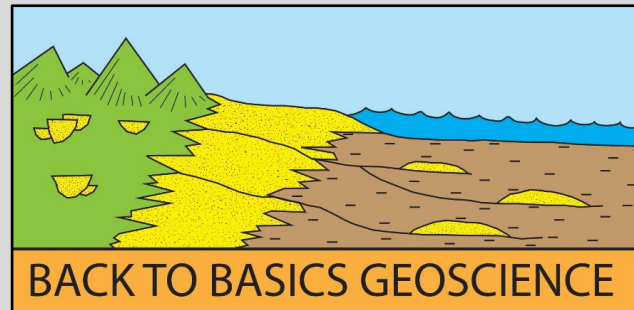
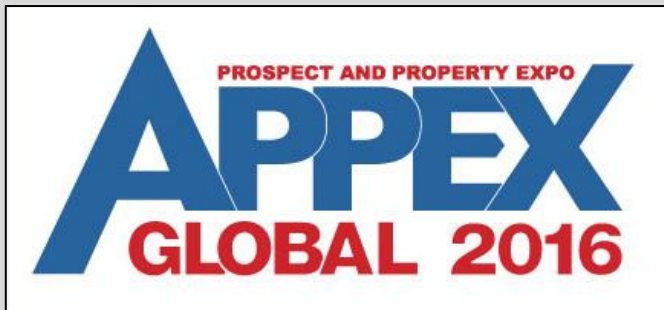
GLOBAL E&P – WHAT NEXT? A GEOSCIENCE PERSPECTIVE

Sue Corrigan

***Back to Basics Geoscience Limited
sue@backtobasicsgeoscience.com***

Mark Attree

***Solaris Exploration Limited
mattree@solarisexploration.com***



“We usually find gas in new places with old ideas. Sometimes, also, we find gas in an old place with a new idea, but we seldom find much gas in an old place with an old idea. Several times in the past we have thought that we were running out of gas, whereas actually we were only running out of ideas”

Parke Dickey, geologist (1909–95) *Encyclopaedia of Petroleum Science and Engineering*

So what ideas do we have for future exploration targets in 2016?

Taking Parke Dickey's quotation we can examine:

- *New places with 'old' ideas*
- *Old places with 'new' ideas*

But the success of these ideas rely heavily on the correct application of:

- *Technological advances*
- *Sound geological principles*
- *Effective planning, leading and organisation of teams, and risk management*

- *Examples of 'new' places with 'old' ideas:*

Unconventionals - any basin with source rock has potential for extraction of hydrocarbons from 'impermeable' shale formations

Fractured Basement - naturally fractured reservoirs comprise 20% of the world's oil and gas reserves ...basement has been exploited around the world for decades

The New Harsh Frontiers - intractable problems for resource exploitation: difficult physical and human geography, difficult geology

UNCONVENTIONALS –

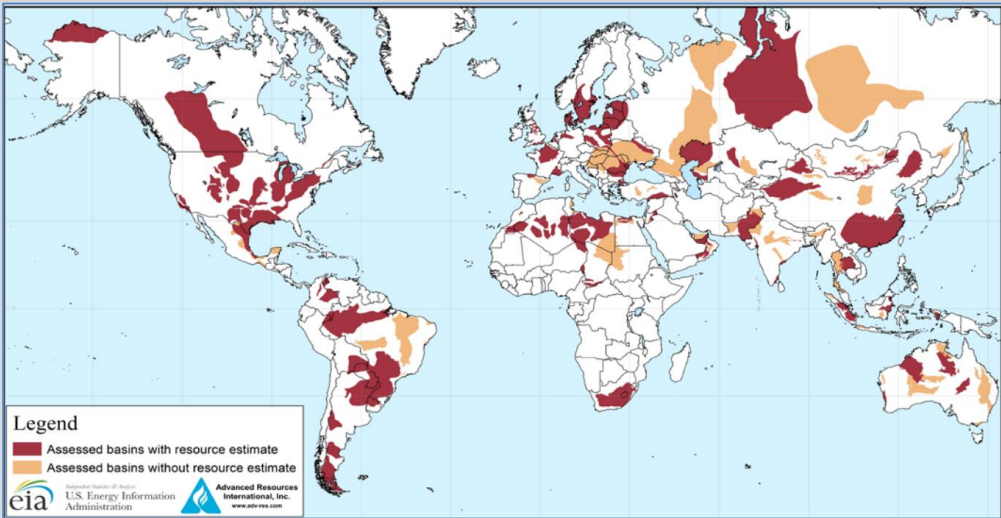
Fuel potential from shale was recognised in the UK in the Middle Ages (‘Kimmeridge Coal’). In the 1850’s in the U.S. oil from shales used as a substitute for whale oil when ports were blocked during the Civil War



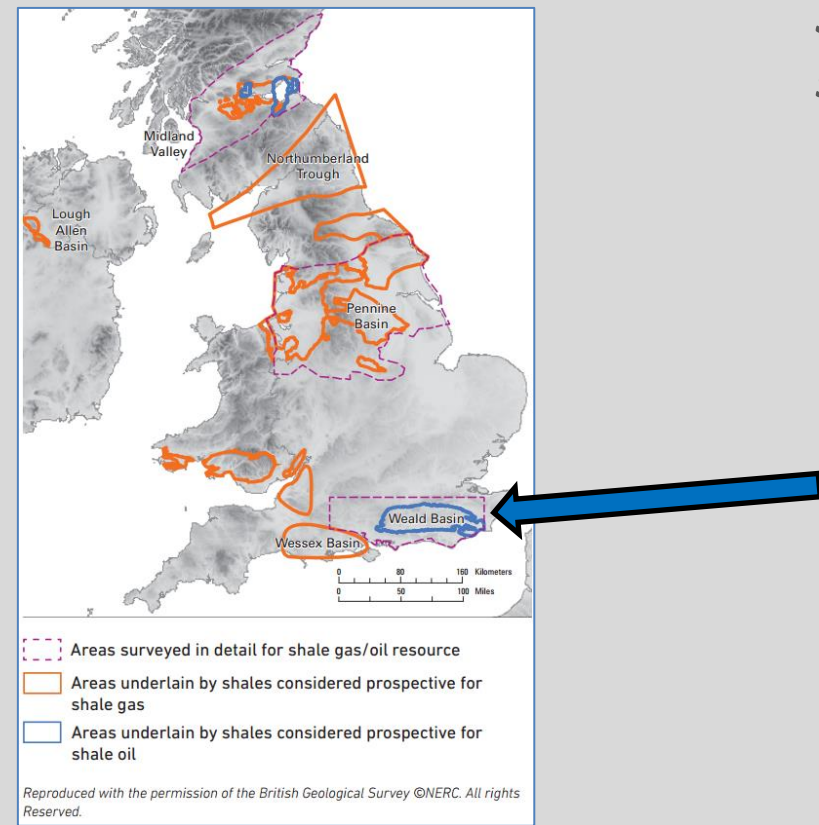
Azerbaijan, Yanar Dag (Baku):

Outcrop of the Maikop (Upper Oligocene source rock) which has caught fire. Prospective for shale hydrocarbons

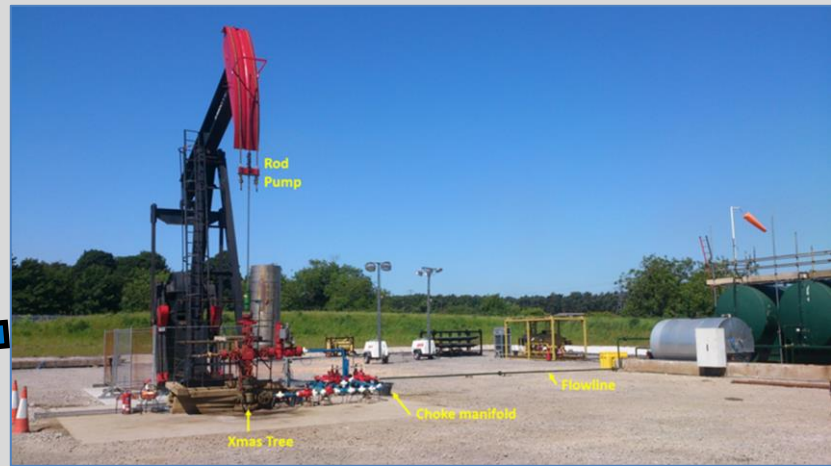
Global distribution of shale hydrocarbon resource estimates (Sanderson, Feb 2016)



UNCONVENTIONALS -



Shale gas and oil in the UK – mainly in the thermally mature Carboniferous shales (gas) in Scotland and Wales, and Jurassic oil shales in SE England



UKOG website



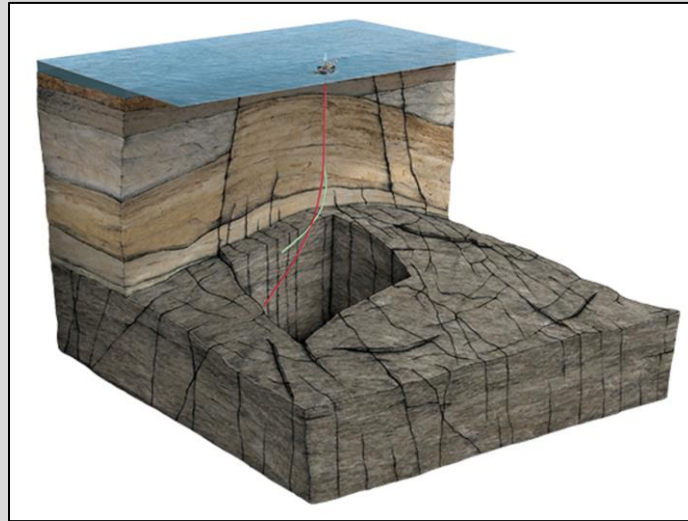
Horse Hill Gatwick Sussex (The ‘Gatwick Gusher’): The first Horse Hill-1 flow test, located within an 83 ft perforated section of the Lower Kimmeridge micrite (BGS definition) at 900 metres depth, recorded stable and sustained natural flow rates in excess of 450 barrels per day over a three-day test period. The light, sweet, 40 degree API gravity oil that was recovered flowed to surface naturally without any artificial lift or pumping.

FRACTURED BASEMENT ROCK -

Oil and gas reservoirs occur in naturally fractured basement rock is not a new concept (e.g. Vietnam, Yemen, Algeria)



Hurricane website, 2015



Fractured basement oil: Lancaster Field, Rona Ridge West of Shetlands

Located in blocks 205/21a, 205/22a and 205/26b, Hurricane discovered Lancaster discovered oil in basement rock in 2009 (S/T 2010) in relatively shallow water depths of 160 metres, and tested light oil (38° API) to surface. Lancaster has proved to be a significant discovery: CPR indicates 207 MMboe of 2C Contingent Resources and individual well flow rates up to 8000 bopd. Source rock is Kimmeridge Clay.

‘The priority is to have the right mindset and the right skills’ (Trice 2015)

THE NEW HARSH FRONTIERS -

Areas with difficult physical geography - difficulty of access, shooting seismic, drilling etc. -

Polar areas with thick ice caps, complex mountainous areas, deep jungles, transition zones, ultra-deep water.

Areas with difficult geology (overburden, complex structure) technology is hampered or inadequate -

Sub-basalt and sub-salt potential, thrust belts. Imaging technology is improving but many areas remain difficult

Areas with difficult human geography –

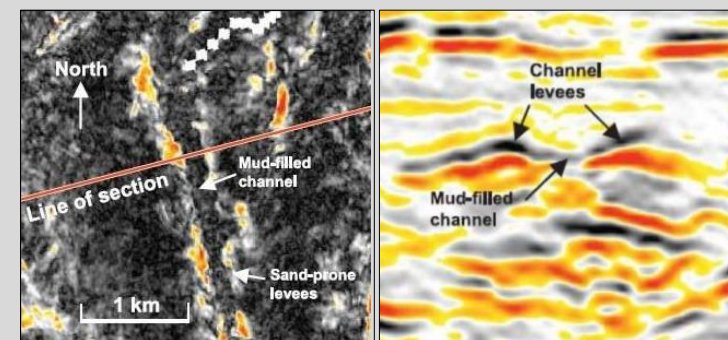
Politically hazardous areas (e.g. Afghanistan), current war zones, densely populated areas, environmental socio-economic constraints

Improving technology is pushing back these frontiers

- *Examples of ‘old’ places with ‘new’ ideas:*

Exploiting potentially ‘high risk’ geological targets –

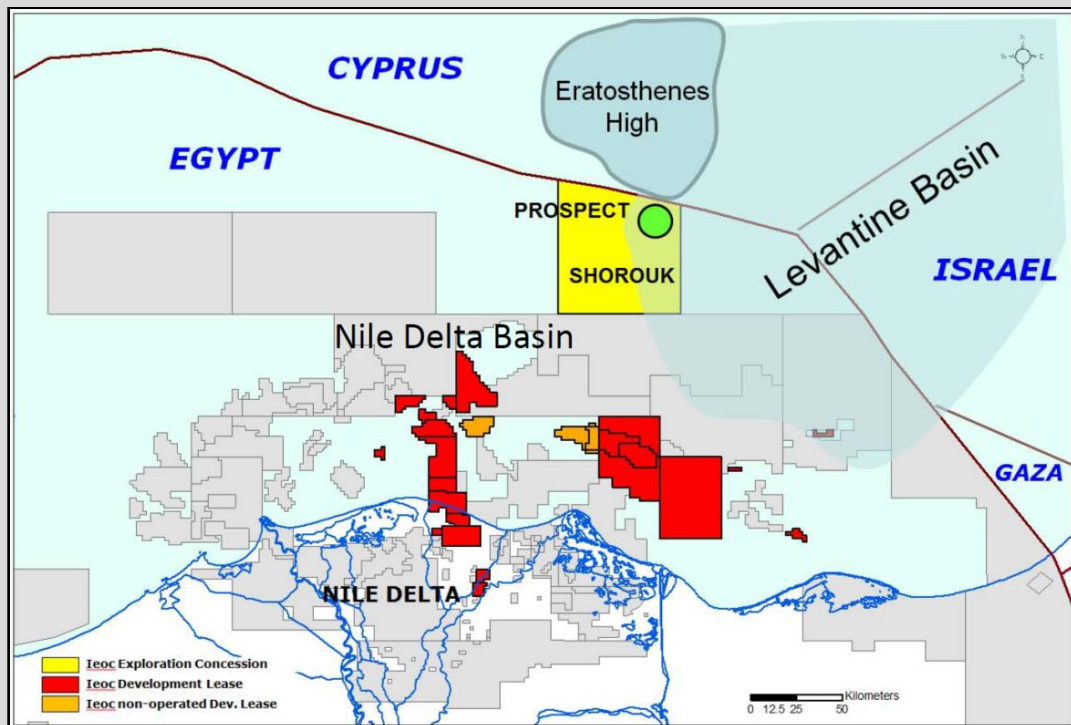
- *avoiding over-simplification of depositional concepts*
- *structurally complex formations (e.g. thrust belts)*
- *stratigraphic traps*
- *diagenetic plays (porosity preservation)*



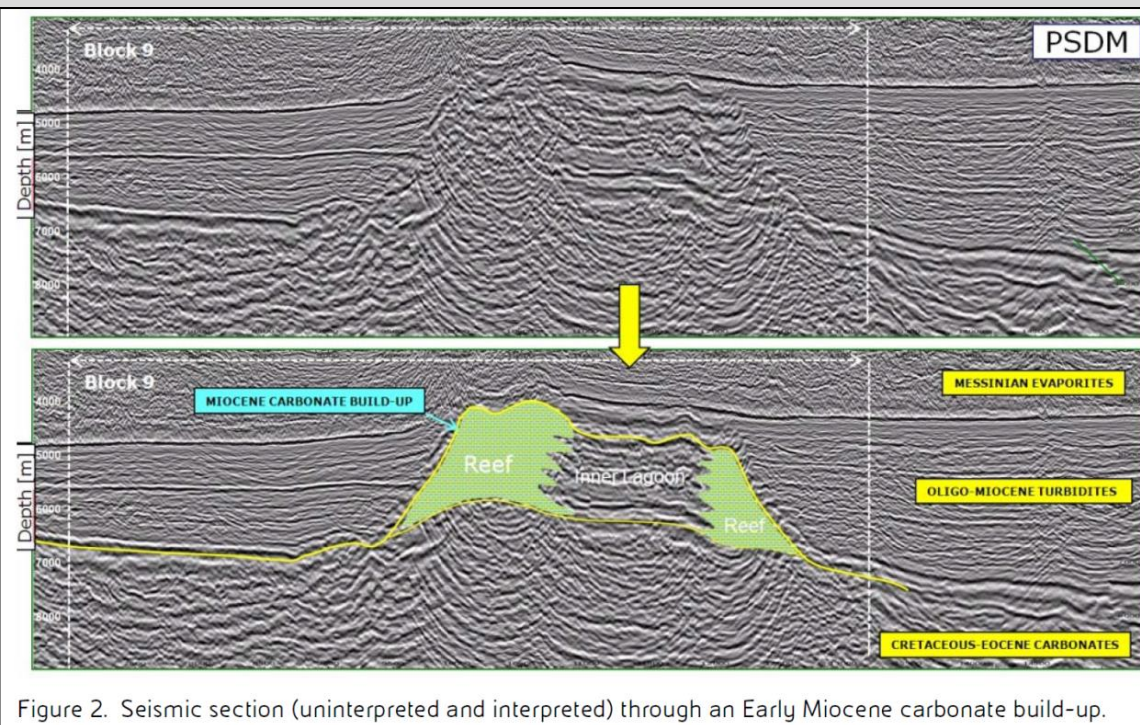
Not all channels are sand-filled!

Can extend to ‘new’ places with ‘new’ ideas!

Exploiting potentially 'high risk' geological targets – avoiding over-simplification of depositional concepts

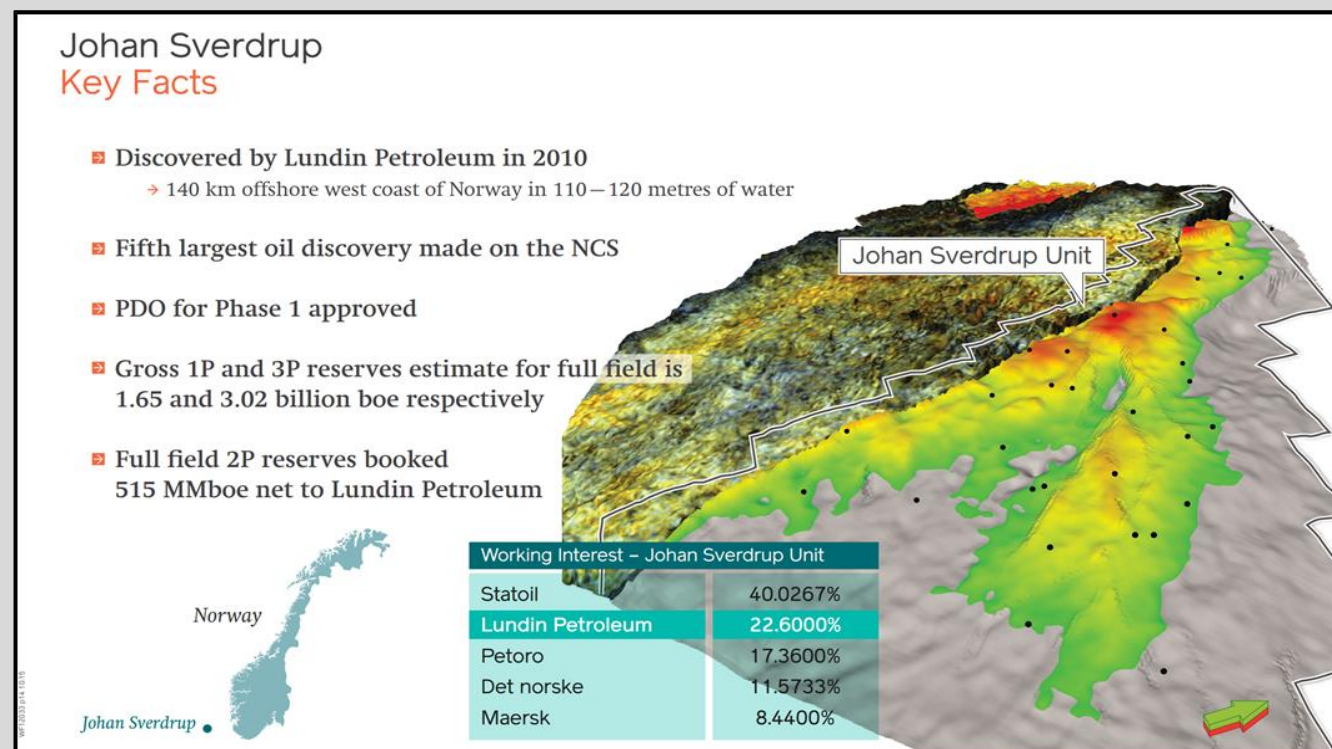


Bertello, Harby and Desouky 2014



e.g ENI's recent gas discovery in an **Early Miocene carbonate build-up off the Nile Delta**
Potentially excellent reservoir, probably charged laterally by the Levantine biogenic gas; reservoir volume estimate 16 Tcf.

Exploiting potentially 'high risk' geological targets – avoiding over-simplification of depositional concepts

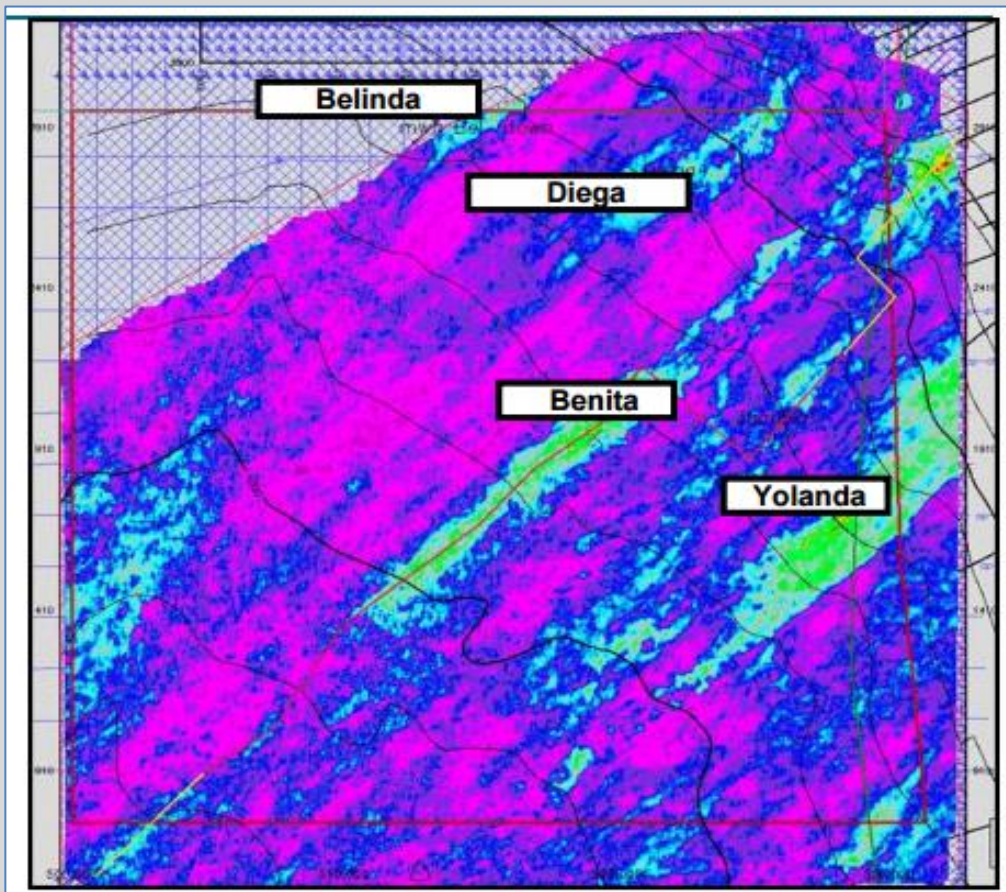


Lundin, February 2016

The recent success of the **Johan Sverdrup oil discovery** in a mature part of the Norwegian North Sea recognised the potential of preserved **shoreface zones around submarine highs**.

A 'geological mystery' (Maersk) – long distance from source and unusually favourable reservoir conditions

*Exploiting potentially 'high risk' geological targets -
stratigraphic traps*



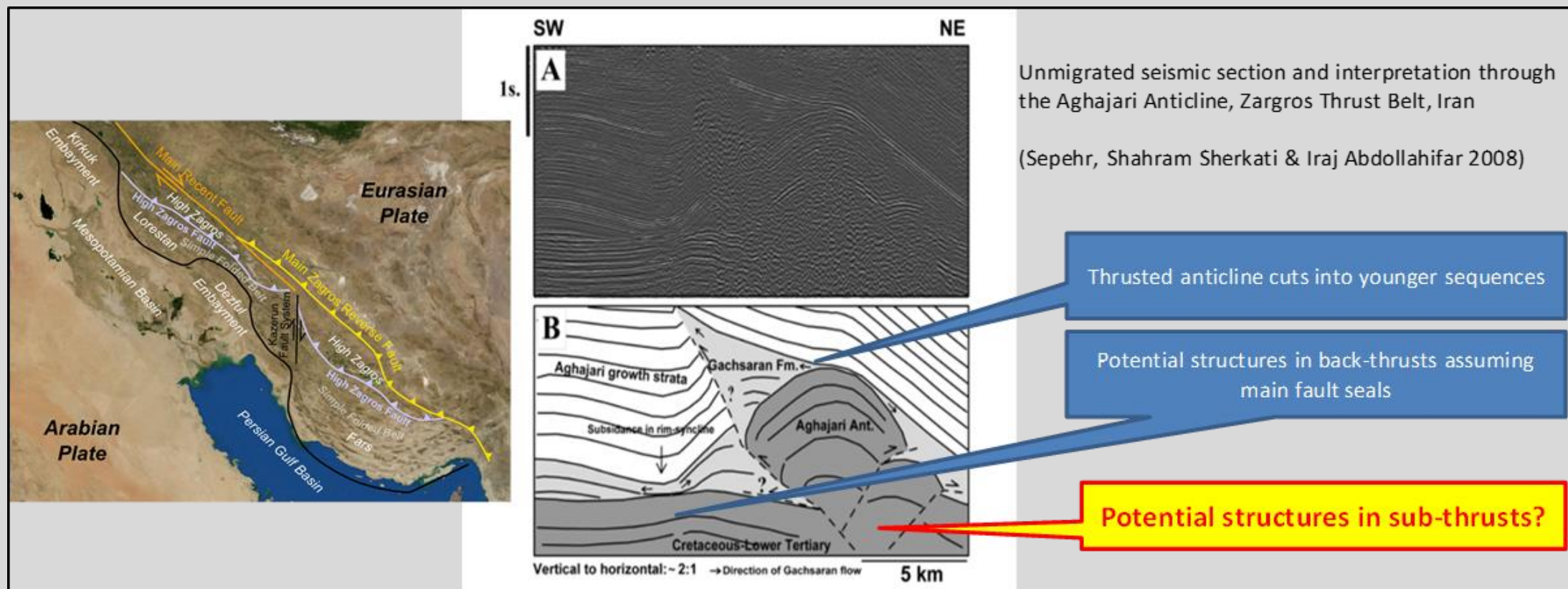
PA Resources website

Floating amplitude anomalies. Block I, Equatorial Guinea

Stratigraphic plays in **poorly confined slope systems**

These amplitude anomalies are all oil and gas discoveries. **There is no obvious amplitude concordance with structure**, even though the amplitude anomalies are a combination of reservoir and fluid parameters and the behaviour is well constrained with a number of well penetrations. Likely that the sands get thin below seismic resolution or pinchout before the OWC is reached.

Exploiting potentially 'high risk' geological targets – structurally complex areas (e.g. thrust belts)



Zagros Thrust Belt, Iran. Major thrust-related anticlines are proven petroleum traps. New targets include stratigraphic traps and **sub-thrust anticlines under sealing faults** (difficult to see on seismic – bad quality)

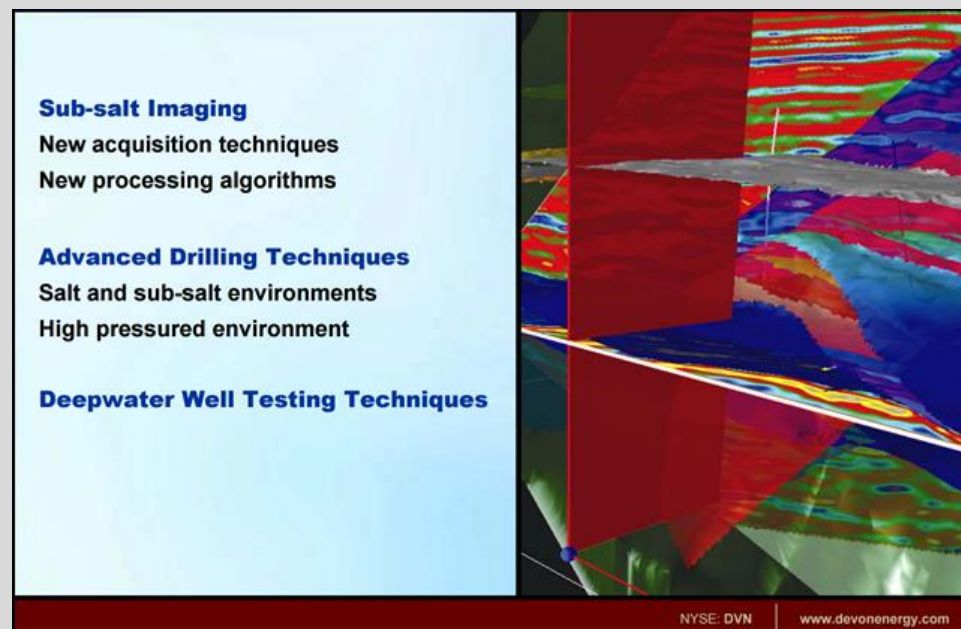
- **Technological Advances -**

Seismic Data quality and interpretability -

In recent years new plays in ‘easy’ areas have been exploited due to vastly improved exploration seismic techniques. In particular, the deepwater submarine fans off the Atlantic margins in Africa and South America, with a combination of structural and stratigraphic trapping, rock physics and seismic amplitude analysis

*Depth migration
Broadband processing
CSEM imaging
Gravity gradiometry
Reservoir modelling*

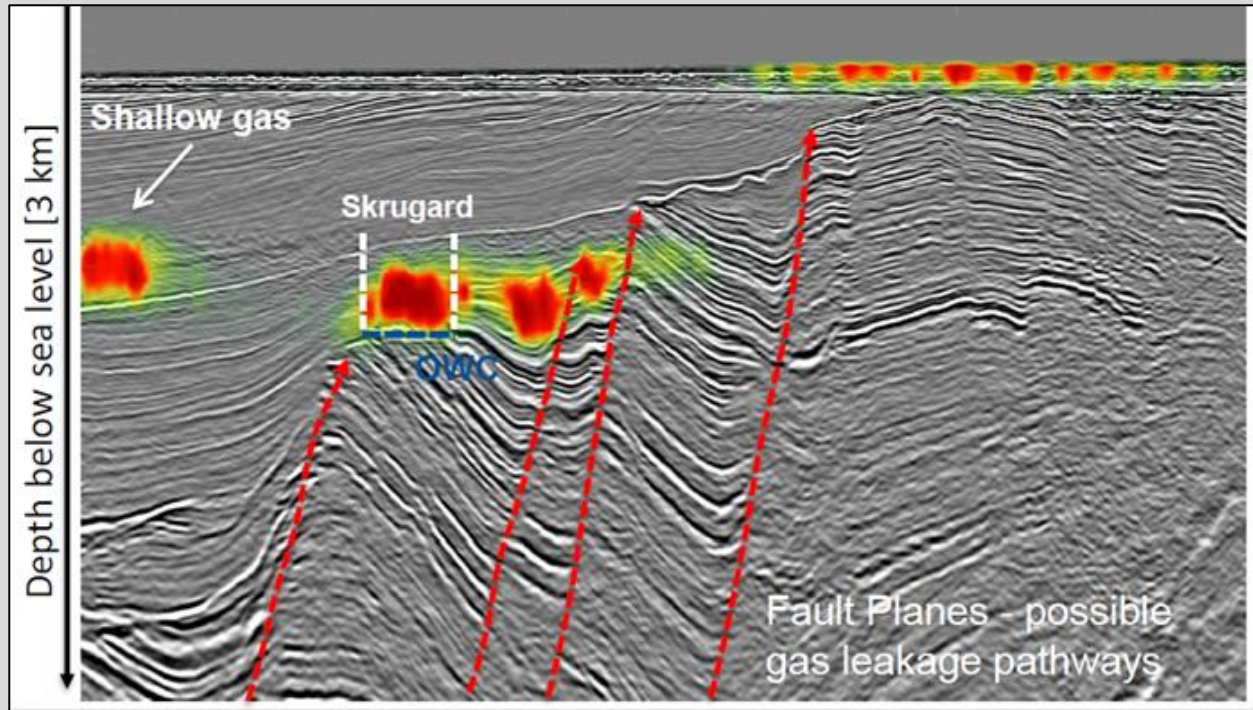
Technology is improving all the time



Montage from GoM (Devon Energy)

e.g. advances in ElectroMagnetic imaging -

Interpretation hinges on a thorough understanding of the geological setting and stratigraphy



Reflects contrasts in
resistivity – fluids by
implication

Skrugaard/ Johan Castberg in Norway (Midgely 2015)

- **Application of sound geological principles -**

Analogue Data

The power of developing suitable **analogues** from robust depositional models – can help identify new plays and drive the perception of **RISK**. e.g. Angola as analogue for mirror image Brazil deep water plays; UDW plays – abyssal plains.

Why did it take so long to recognise giant plays such as Buzzard, East Africa, Eastern Med? Lack of good analogue data

Improving application of correct geology in forward modelling- Avoid the tendency to be over-reliant on advanced technology to generate **precise** numbers at the expense of application of **accurate** geological principles, e.g. the empirical nature of geocellular modelling; the lack of knowledge of past thermal history in basin modelling

Retention of experience – mentoring

Impact of loss of experience in the current climate with fewer ‘thinkers’. Importance of mentoring and training - to ensure that sound geological principles and new thinking are applied.

And last but not least..

Effective planning, leading and organisation of teams, prospect ranking and risk management. Ranking within company’s budgetary constraints

Alternative Wind Power !



Scientists have developed 'fartpacks' that extract 300 litres of methane. Tube from the pack is inserted into cow's digestive tract to collect the gas. The methane is then converted into enough energy to run a car for 24 hours