REVIEW OF NON-SEISMIC EXPLORATION METHODS AND TECHNOLOGIES AND THEIR APPLICATION

Robert Waterhouse, founder and advisor Rosha Resources

The Geological Society
9 March 2017

TEN BARRELS ARE NOW BEING CONSUMED FOR EVERY BARREL BEING FOUND

- **Discovered volumes are at their lowest levels since the 1940s**
- **If solar power, nuclear and renewables are taking over from oil (and if "King Coal" cleans up his act) does it matter?**
- **"The only way to predict the future is to have power to shape the future" - Eric Hoffer**
- **Focus on improving exploration success rates and closing the gap**
- **BUT HOW?**

HOMOGENEOUS TARGETS

- **If targets are homogeneous a single search method should easily find them all**
- **Define the key characteristic of the target**
- **Find a method which identifies that characteristic**
- **Apply that method across the search area**
- **All the targets are identified**

PETROLEUM RESERVOIRS ARE NOT HOMOGENEOUS

Very different in terms of:

- **Ages**
- **Sizes**
- **Depths**
- **Coverings (rock, sand, soil, water)**
- **Source types**
- **Rock types**
- **Porosities**

PETROLEUM RESERVOIRS ARE NOT HOMOGENEOUS

- **Permeabilities**
- **Fracture systems**
- **Trapping mechanisms**
- **Sealing mechanisms**
- **Types of hydrocarbons**
- **Levels of degradation**
- **Levels of natural loss (breach)**

But they all contain hydrocarbons and therefore all have a key common characteristic

SEISMIC IS NOT A FREESTANDING METHOD

- **Explorers do not use pins to decide where to conduct seismic**

SEISMIC IS NOT A FREESTANDING METHOD

- **Seismic is preceded by various "focusing“ methods which vary from case-to-case**
- **Current low success rates on frontier wildcats (8% internationally) cannot be attributed to seismic**
- **Frontier success rates on seismic alone would presumably be much lower than 8%**
- **Success rates in established basins are substantially higher (25% to 33%) where additional non-seismic information is available**
- **There is a varying mix of search methods in use**

THE RIDDLE OF THE NON-SEISMIC SUCCESS RATES

- **A great variety of methods exist**
- **One of these always precedes seismic**
- **The others are variably used**
- **Though some are apparently hardly ever used**

But the success rates claimed for some of these non-seismic methods are individually much higher than those being achieved even in established basins

Question: is seismic, taken on its own, really a hydrocarbon search method at all?

FROM UNLICENCED ACREAGE TO DRILLING RIG

- **Governments draw up licence blocks (how?)**
- **Oil Companies select individual licences (how?)**
- **Geophysicists find leads and prospects (how?)**
- **They are matured into drilling targets (how?)**
- **The targets are drilled**
- **Most of the wells find water**

ANY ADDITIONAL METHODS NEED TO BE INTEGRATED AT THE APPROPRIATE STAGES

SOME THEORETICAL AND PRACTICAL CONSIDERATIONS

HOW TO DISCOVER A CONTAINER'S CONTENT

- **"Have we seen one of these containers before? What was inside it?"**

➢ ***This is a historical method, broadly equating in Exploration and Production to Geology and Geophysics, encompassing Plate Tectonics, Stratigraphy, Sedimentology, Facies Prediction, Rock Physics, Hydrocarbon Phase Prediction***

- **"Is it one of a line of such containers? Or part of a cluster? What do we know about the others?**

➢ ***E&P equivalent: statistical methods (e.g."Dad" Joiner's "Trendology"), databases***

SOME THEORETICAL AND PRACTICAL CONSIDERATIONS

- **"Is the container leaking? Can we analyse such leaks in the laboratory?"**

➢ ***E&P equivalents: Studying of oil seeps, onshore and offshore. Soil sampling***

- **Is the container leaking and affecting microbes in the soil?**

➢ ***E&P equivalent: DNA analysis***

- **"Is the outside of the container stained? Can we study those stains?"**

➢ ***E&P equivalent: hyperspectral analysis, usually from satellite images***

SOME THEORETICAL AND PRACTICAL CONSIDERATIONS

- ***"Is the container making a noise which may indicate its contents?"***
  - ***E&P equivalents: Passive seismic, Acoustic detection of offshore gas bubbles***
- **"What is the density of the container? How uniform is that density?"**
  - ***E&P equivalents: Gravity gradiometry***
- **"Can we image what is inside the container using a sound beam?"**
  - ***E&P equivalent: 2D and 3D seismic***
- **Can we perform additional analysis on those sound beam images?**
  - ***E&P equivalent: Amplitude Conformance and Flat Spot indicators***

SOME THEORETICAL AND PRACTICAL CONSIDERATIONS

- **"Can we detect and analyse electromagnetic waves coming from the container?"**

➢ ***E&P equivalent: EM***

- **"Can we X-ray the container and see what is inside?"**

➢ ***E&P equivalent: X-ray methods***

- **"Is the container radiating or absorbing heat?"**

➢ ***E&P equivalent: Thermal imaging***

- **"Can we make a hole in the container and put a probe inside?"**

➢ ***E&P equivalent: Drilling a well, logging the rocks and flow testing***

SUMMARY OF KNOWN METHODS

Academic

- Geology and Plate Tectonics
- Geophysics
- International databases

Mathematical

- Statistical (trends and clusters, success rates)

SUMMARY OF KNOWN METHODS

Direct Hydrocarbon Indication

- Seeps
- Soil sampling - chemical (onshore)
- Soil sampling - microbial DNA testing (onshore)
- Bubbles (offshore)
- Hyperspectral (onshore)
- EM (partly direct)
- Amplitude Conformance
- Flat Spots
- Thermal (onshore)
- Drilling

SUMMARY OF KNOWN METHODS

Structural Methods

- Gravity gradiometry
- Passive seismic
- 2D Seismic
- 3D Seismic
- Seismic enhancement

That gives 19 methods

This list is not exhaustive (we are in contact with a company applying an additional method)

There is hardly a shortage of methods and half the methods are Direct Hydrocarbon Indicators

SUCCESS RATES OF NON-SEISMIC METHODS

- **This is the $64,000 question**
- **A Consortium of 41 Oil Companies (2001-2012) and also Richmond Energy Partners (February 2017) identified positives from seismic-derived Direct Hydrocarbon Indicators (DHI)**
- **The Consortium study showed that a DHI of 20% plus gave a virtual guarantee of success**
- **For some other DHI methods 70% to 93% correctly-predicted positive results are claimed**
- **A similar range of correctly-predicted negative results are claimed**

SOMETHING REQUIRES EXPLANATION

- **Current exploration success rates are significantly below the claimed success rates for some non-seismic methods**
- **Success rates are not increasing despite extensive use of 3D seismic**
- **Key non-seismic methods are in limited use**
- **Oil companies are not positioned to conduct research into non-seismic success rates**
- **Absence of independent academic research leads to confusion and caution**
- **“Nobody ever got fired for using 3D seismic”**

SEQUENCE IS THE KEY

- **Wide-angle methods initially (academic and mathematical)**
- **Then basin or play methods (satellite, gravity gradiometry, thermal imaging etc)**
- **Then close-up methods (soil sampling, seismic...)**
- **Then carefully chose the target**
- **But a small exploration portfolio will not offer enough raw material for this distillation sequence**

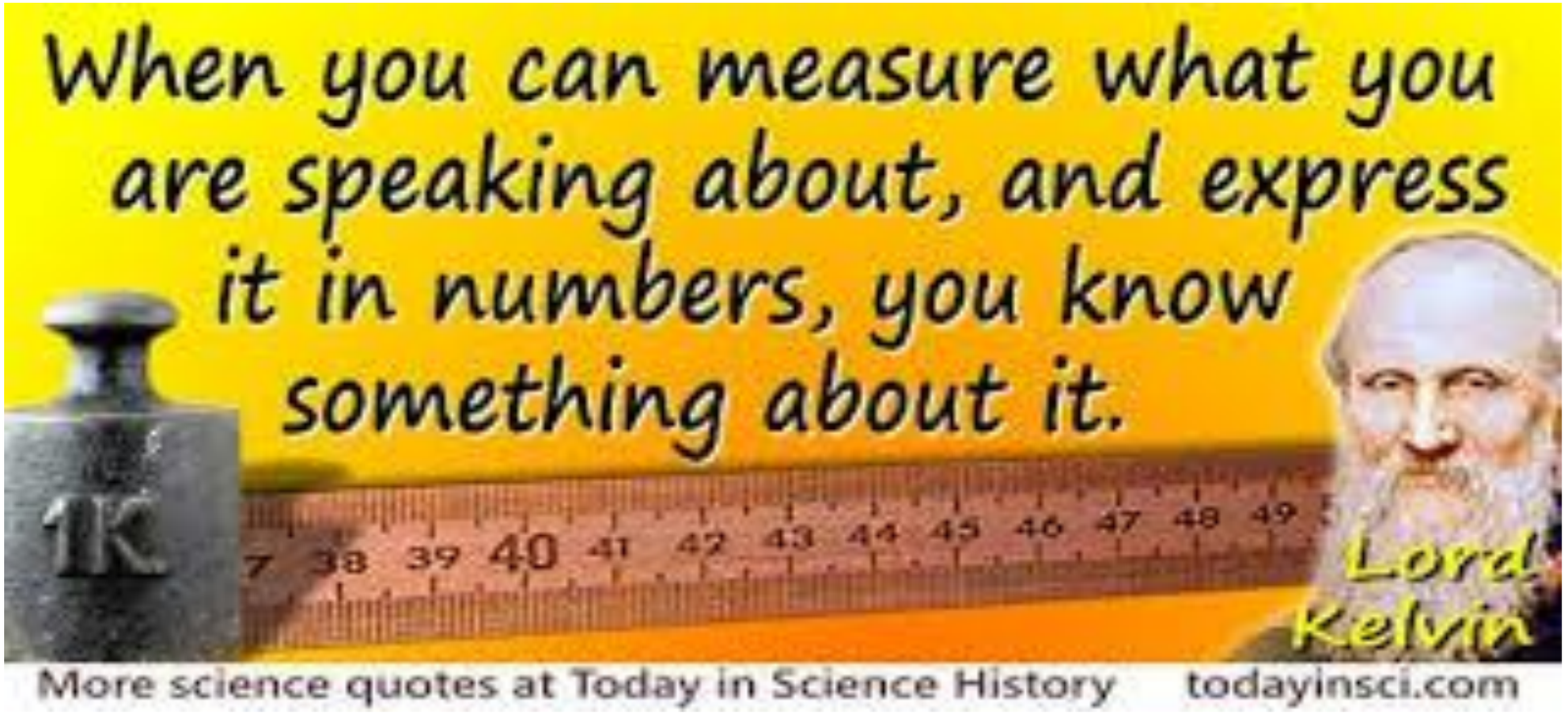
INTRODUCE METHODS AT THE WRONG STAGE AND THEY WON'T BE APPROPRIATE OR WELCOME

POSSIBLE LESSONS OR SUGGESTIONS

- **If there is a problem to address, is it "technical?"**
- **But an extensive range of methods is available**
- **Are "limiting beliefs" conditioning the sector to failure?**
- **Acceptance of poor results as "the norm" is unacceptable elsewhere**
- **Drilling more wells into better targets would greatly increase discovered volumes**
- **Are portfolios big enough to support the wide-angle, basin/play, close-up and target sequence?**
- **The absence of independent assessment of exploration method success rates is an obstacle**

THE MONEY LOST ON JUST ONE MAJOR DRY HOLE COULD FUND SUBSTANTIAL ACADEMIC RESEARCH

Thank you


When you can measure what you are speaking about, and express it in numbers, you know something about it.
1K
Lord Kelvin
More science quotes at Today in Science History
todayinsci.com