Finding Petroleum

New Geophysical Approaches
London, April 2018.

Bob Heath
(not quite retired.)

Seismic & Oilfield Services Ltd

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EAGE asked for article in First Break (January, Land Seismic Issue).

- Agreed on basis I could moan.
- Significant industry input.

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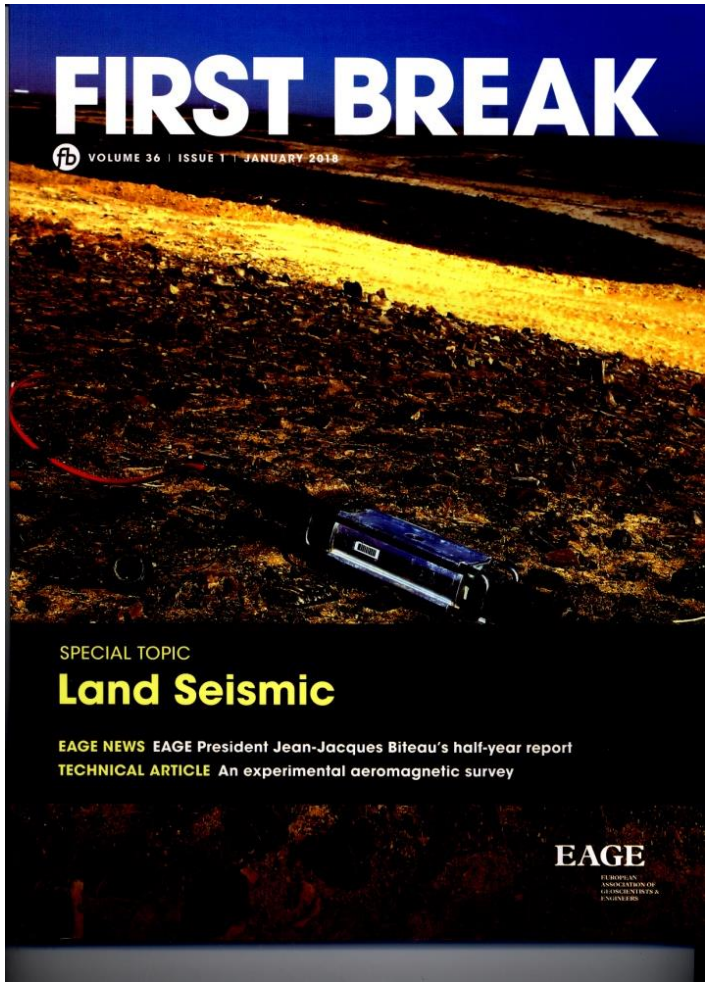

The future of land exploration: brute force and ignorance, or adherence to the science?

Bob Heath[1]* considers the changes that are necessary to revitalize the industry.

Introduction

It is difficult to ignore claims, brought on by the continuing relatively low price of oil, that the business of land seismic surveying is stuck in the doldrums. Those in the know assure us that until oil returns to $100 or more, such operations will be too expensive to undertake routinely while these same 'experts' believe hardware development and manufacture will never be significantly profitable again. As one who has written and spoken extensively on this subject for decades, sadly I have to agree that the bien pensants may for once have a point, or part of one anyway. I do not see that land equipment and exploration can expect a bright future if oil continues to hover around its current price. However, this is only if land seismic carries on in the way it has been doing. If we make some overdue technological changes and adhere better to the science, the future is bright and potentially very profitable. With much of the necessary new technology in or starting to move out of incubators, an investment less than the cost of acquiring a medium sized survey could be all it takes. Therefore, the prospect of low cost oil actually presents significant commercial opportunities to someone.

Most of us in land seismic have known for years that things could not go on the way they were. Consider whether we were even operating in ways which would have made our business sustainable with oil down at $50, a level we all surely knew was coming one day. Where did we go wrong given that this oil price not so long ago would have supported a healthy exploration industry? It seems to some, me included, that for a decade or more we have let ourselves get carried away with the 'brute force and ignorance' approach to land acquisition and processing, while abandoning the need to base all we do on fundamental physics. We did not pay attention to the still small voices within us which were saying things had to change, possibly perhaps they were the whispers from those who did not represent some of the larger commercial interests of the community.

An industry built on the twin towers of high oil prices and low regard for science was never going to thrive when there was not so much cash to throw around. Now, some hardware weaknesses are becoming all too apparent making land exploration even further beyond the reach of most companies who otherwise would willingly use it. The changes necessary to revitalise our industry will not be to everyone's liking but, when the hurlysburly's done, we'll have a business much better suited to the future.

Brute force and ignorance

For some years quite a few manufacturers and contractors have been trying to convince us that simply increasing channel counts along with ever more source effort are the only ways to operate. And equipment was developed to fit this brute force philosophy. The idea is that if Mother Earth won't reveal her secrets willingly, we can beat her into submission with the repeated application of crude hardware and cruder techniques. We forgot Aristotle's suggestion that educated men must look for 'precision in each class of things as far as the nature of the subject admits'. Imprecise approaches, coupled with the increasing cost of applying the brute force, were possibly acceptable when the industry was swimming in money. But that is not now – 'profit' (as well as 'finesse') are words currently absent from much of the industry's vocabulary. It need not be so.

Perhaps the problem is that reflection seismology is seductively simple: create an acoustic wavefield at the surface, pick up its echoes nearby, use a model to dictate how much of the former is needed, use available equipment inventory to deal with the latter. However, at each stage we have been cutting corners and every false assumption degrades data quality, thus unwittingly forcing increases in survey effort to compensate. Yet, what some call the 'minimum acceptable quality' of a seismic survey – the bit that lets us make drilling decisions – is the product we are selling. If the quality falls below this sometimes ill-defined level, or if achieving acceptable quality is currently too expensive, we have to consider whether our recent approaches represent the best way to continue.

If we want lower cost surveys we need to do the job better. And perhaps, given that oil may be many years from being in three figures again, the corollary is that unless we change the way we operate, there will be ever fewer land surveys to do. So it appears we have no choice but listen to Aristotle, and get more precise in hardware design and its operation. The first company to do so may well corner the acquisition market, one that used to be valued in nine figures, for a long while to come.

This article is neither the news some will want to hear nor will it endear me to everyone still full time in the business. However, the great benefit of being half-retired is that one no longer has to worry so much about minority viewpoints. Those who brought to my attention the problems and their fixes, and subsequently helped with this article, will be glad to see this belated promulgation of ideas which have been ignored, in many cases, since the mid-1990s if not before. Their time has arrived.

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The future of land exploration: brute force and ignorance, or adherence to the science.

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Deliberately provocative.

- Excellent response from the "silver seismics".

Surprising because-

I am not a geo-anything.

- Physicist who got into seismic by accident,
  - then into seismic marketing by bigger accident.

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Land exploration – our business model is broken.

- We have lost too much expertise.
- Oil co's used to have on staff physicists.
- The job of applying physics correctly has been subcontracted.
  - Few manufacturers (and fewer oil co's) employ physicists.

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Land exploration – our business model is broken.

- Land exploration can have a bright future, but not by continuance of brute force and ignorance approach.
- Finesse is not in our vocabulary.
  - Aristotle: "Educated men should search for precision in each class of things as far as nature permits".

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Land exploration – our business model is broken.

- Current approach relies on brute force of averaging out the things we do poorly.
  - Rutherford: "If your experiment relies on statistics, you ought to have done a better experiment".
- The search for precision/better "experiments" will result (the only thing that will) in a sustainable land seismic industry.

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Land exploration – our business model is broken.

- System mfrs want to sell equipment. Can be VERY profitable.
- Major mfrs insist that only way is:
  - Ever increasing source effort.
  - Ever increasing receiver effort.
- Of course these are true, but beating Mother Earth into submission is not the only way.
  - At $150 oil, it is NO WAY.

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Reflection seismic is simple:

A: Create wavefield over certain area (use modelling software).

B: Record its echoes (use available equipment inventory).

- **Minimum acceptable SNR in data is our USP.**
  - **The perfect excuse to sell ever more equipment.**

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Vibroseis

- Get bigger vibs
  - Now reached limit of transportability.
- Get more vibs
  - Dozens on some crews.
- Sweep for longer
  - Simultaneous Sweeping.

Vibroseis is maxed out.

- Little work in Impulsive Sources.

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Vibroseis

- Some mfrs more subtle:
  - Stiffer baseplates etc.

But basically still brute force vibroseis.

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Reflection seismic is simple:

Recording Systems:

- Deploy more channels.
  - Employed Delta Sigma over IPF ADCs.
- More channels highlighted problem of telemetry cables.
  - Develop cableless.

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Reflection seismic is simple:

Recording Systems:

- Reduce weight further.
  - Shoot blind.
- Geophones - the next problem.
  - Integrate single geophone/single sensor recording.
  - All options now maxed out.

  Nodal recording!

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Reflection seismic is simple:

- Minimal acceptable data quality is our USP but now no way to check:-
- Source behaviour.
- That we make recordings of highest fidelity over entire survey.
  - Reliance instead on maximum source and receiver effort in the hope of overcoming deficiencies of the approach.

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Reflection seismic is simple:

- (Mostly) the only variable we can monitor or adjust in real time is field effort.
- Look forward to "Peak-Nodal".

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Reflection seismic in simple:

- It is now manufacturers who decide what systems should look like and how they have to be used.
- Mfrs now far too influential.
  - Reliant on ignorance of some end users.
- More competition now in equipment, but little competition in method.
- Race to the bottom.

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Reflection seismic in simple:

- (Some) customers not even sure themselves how to solve their particular problems.
- Some purchases made on the basis purely of wanting what others have.
  - the perfect desert system used in jungles!
- In some cases, even oil co's have no idea of what's available, how best to use equipment to solve problems.

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Advice to new people coming into land seismic:

- If it's not broken, don't fix it.
- But land seismic is broken.
- If it is broken, the say so if you know how to fix it.

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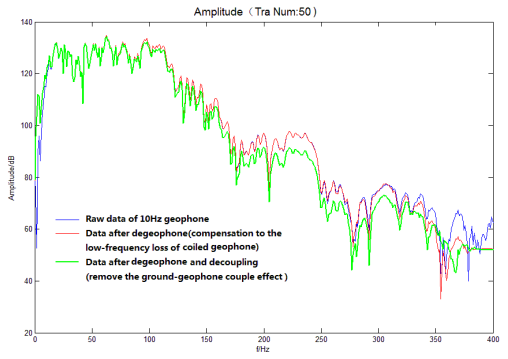
Fixing it:-

- Sensors – the start of data degradation.
  - All coupling eggs in one basket.
- Automatic measurement of geophone coupling.



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Fixing it:-

- Single sensor -high quality, high sensitivity sensors.
- Testing of sensors based on use in arrays.
  - Three parameter testing of step function, variable results.
- More accurate testing now available.

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Fixing it:-
Recording Systems.

- Built around oversampling convertors.
  - (Some now of limited quality).
- Mfrs stress >120 dB IDR but mostly use only 72 dB.

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Fixing it:-

- So we risk recording much noisier data with limited DR.
- And do not realise it (if at all) till processing.
  - If it does not decimate the data.

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Fixing it:-
Vibroseis.

- Why assume WSGF is true representation of down-going signal?
- When we all know it isn't.
- But systems and operations are built around the assumption of its validity.

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Fixing it:-
Vibroseis.

- We do not even make the all the right measurements on the vib to characterise:
  - Vib performance,
  - Earth response.

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Fixing it:-
Impulsive.

- Understanding earth response helps development of impulsive sources.
- Coded impulses:
  - Eventual competition to vibroseis.

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Fixing it:-
Quality Driven Acquisition.

- Not a new idea.
  - AGIP/ENI and Mid East oil co's in 1990s.
- Better quality data than expected reduces field effort-
- On receivers or sources as required.
- Lower quality data increases field effort.
  - QDA development halted (partially) due to lack of dogbox processing power.

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Fixing it:-
Quality Driven Acquisition.

- QDA can now be extended to sensor plants, recording channel quality, source quality etc.
- Unwillingness/inability to restart QDA due to shootblind recorders?
  - Lack of experience of explorationists.

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Fixing it:-
Quality Driven Acquisition.

- QDA can be driven by Artificial Intelligence - "AI Seismic".
- Uses all available inputs from dynamic field situation to enhance quality, reduce cost, improve HSE:
    - Drones, personnel, instrumentation on sources etc etc.

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Fixing it:-
Quality Driven Acquisition.

- If the industry will not train or hire human intelligence, the artificial kind can replace us.
- Other industries do this already – military, NHS.

Fixed it.
None of this is science fiction.

- Each technology offers some improvement.
- Work at various stages by different companies in different countries.
- The real benefit is putting it all together. Value more than the sum of its parts.

Fixed it.
Suitable for all land acquisition.

- Desert, TZ, populated areas.
- 2D & 3D.
- 4D (so far, poor results onshore – but no surprise, 4D currently uses 3D approaches, which cuts too many corners).

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Fixed it.

None of this is science fiction.

- It is inevitable that this will happen.
- Total cost <$20m (far less than cost of average land survey).
- Unlikely that existing mfrs/the west will undertake necessary developments.
- The future of land seismic belongs to China, India, Mid East etc.

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Thanks to David Bamford.

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