New Geophysical Approaches
London, April 2018.

Bob Heath
(not quite retired.)
EAGE asked for article in First Break (January, Land Seismic Issue).

- Agreed on basis I could moan.
- Significant industry input.
The future of land exploration: brute force and ignorance, or adherence to the science?

Bob Heath considers the changes that are necessary to revitalise 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 argue that until oil returns to $100 or more, such ventures will be more expensive to undertake routinely while those 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, oddly, I have to agree that the basis persists for once have hit a point, or part of one anyway. I do not see that land equipment and exploration projects cannot find a 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 necessary technological changes and adhere better to the science, the future is bright and potentially very profitable. With much of the necessary new technology is in starting to move out of incubation, an investment less than the cost of acquiring a modern travel survey could be all it takes. Therefore, the prospect of low cost oil actually presents significant commercial opportunities to someone.

Most of us in the land seismic know for years that things could have gone on the same way they are. Consider whether we were even operating in ways which would have made our business unsustainable with oil at $50 a barrel we would usually have no time for our own work. Where did we go wrong in the past that our oil price is now a long time ago would have supported a healthy exploration industry? It seems to me, if anything, 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 have all we do on fundamental physics. We did not pay attention to the still small voices within us which were saying things had changed, possibly perhaps they were the whisperings from those who did not represent some of the largest 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 no such thing as a threat scenario. Now, some hardware weaknesses are becoming more apparent making land exploration even further beyond the reach of most companies otherwise would have willingly use it. The changes necessary to revitalise our industry will not be to everyone’s liking but, when the halyard’s length, 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 survive in this almost completely outside. For example, equipment was developed in the three linear array philosophy. The idea is that if the Earth was so inclined it would willingly, we can beat the beam submission with the required application of state hardware and create technology. We forget Atlantic’s suggestion that educated man must look for precision in each class of things so as far as the nature of the subject admits. Approximate, coupled with the increasing cost of neglecting the brute force, were possibly acceptable when the industry was swimming in money. That is not now, “profit” (as well as “fitness”) are words currently absent from the mind of the industry’s vocabulary. It need not be so.

Perhaps the problem that field exploration technology is so suspiciously simple, create an economic value, if exploited, a model to deliver how much of the former is needed, our available equipment inventory to deal with the latter,however, at each stage we have been cutting corners and every little cost-cutting, degradation data quality, thus overall costing increase in survey effort to compensate. Yet, what none call the minimum acceptable quality of a seismic survey – the bit that has to make drilling decisions – is the product our selling. If the quality falls below this tolerance (the defined level), at achieving acceptable quality is economically too expensive, we have to consider whether our recent approaches represent the best way to continue.

If we want fewer crew surveys we need to find the ways. And perhaps, that oil may be in many years first being in three figures again, the answer is that unless we change the way we operate, there will be fewer land surveys to do. So we see how few, it does not have to be efficient and, if cost-effective, high enough of processing and operation. The first company to do so may well corner the acquisition market, one that was previously valued at billions of dollars, for a long while to come.

This article is neither the news some want to hear nor will it end here for everyone, but it’s a call to action. However, the great help of being halted is that it no longer has to worry so much about minority viewpoints. Those who brought to my attention the problem and their views, and subsequently helped with this article, will be glad to see this belated recognition of ideas which have been ignored, in many cases, since the mid-1980s if not before. Their time has arrived.

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

Seismic & Oilfield Services Ltd
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.
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.
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.
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.
Vibroseis

- Some mfrs more subtle:
  - Stiffer baseplates etc.

But basically still brute force vibroseis.
Reflection seismic is simple:

Recording Systems:

• Deploy more channels.
  • Employed Delta Sigma over IPF ADCs.
• More channels highlighted problem of telemetry cables.
  • Develop cableless.
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!
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.
Reflection seismic is simple:
- (Mostly) the only variable we can monitor or adjust in real time is field effort.
- Look forward to “Peak-Nodal”.
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.
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.
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.
Fixing it:
- Sensors – the start of data degradation.
  - All coupling eggs in one basket.
- Automatic measurement of geophone coupling.
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.
Fixing it:-
Recording Systems.
• Built around oversampling convertors.
  • (Some now of limited quality).
• Mfrs stress >120 dB IDR but mostly use only 72 dB.
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.
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.
Fixing it:-

Vibroseis.

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

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

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