KN01

KN Presentation - Sensors to Decisions’, Integrating Non-seismic Geophysical Data with Seismic to Impact Exploration Decisions.

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SUMMARY

Shell CEO, Ben van Beurden, has recently summarised the big challenge we all face. “We at Shell have long recognised the importance of the climate challenge along with the ongoing critical role energy plays in enabling a decent quality of life for people across the world. The global energy system is changing, both to meet greater demand and to respond to environmental stresses. The big challenge for society, simply put, is how to provide much more energy with much less carbon dioxide” (1).
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Our exploration industry is supported by a geophysical industry that continues to develop new and improved sensors that exploit a range of deployment vehicles from space (2) to underwater. Interpretation geoscientists integrate data from these new sensors and platforms to improve the performance of exploration, the subject of this session. These skills will also be needed in other stages of our business, such as monitoring production and geological storage of carbon.

Early explorers in the 19th century relied on surface seeps and anticlines to identify drilling locations and found oil with low success rates. Although seismic sensors were initially developed for monitoring earthquakes, the need to identify enemy artillery (sound ranging) and submarines (echo sounding) during the First World War led to the development of the seismic method for prospecting for oil. Gravity measurements also enabled the mapping of subsurface anti-clines and salt-domes and the integration of the two methods led to improved success rates and dominated exploration until digital computers enabled more effective seismic reflection surveys from the 1960’s (3). Since then, although the seismic reflection method has continued to dominate exploration, other non-seismic sensors have also continued to play a role and the subject of integration of non-seismic geophysical data with seismic is as old as the subject of geophysics in our industry.

My personal geophysical integration journey started in the early 1980’s integrating data from five seismometers and a gravity meter to investigate the crust and upper mantle below the Jebel Mara intra-plate volcanic centre in Darfur, Sudan (4). In the early 1990’s, in Oman and Yemen (5), I integrated data from satellites, aeromagnetic, gravity to target more expensive 2D seismic to identify oil prospects. At the time I was particularly influenced by the work of Cordell and Grauch (6) who showed how magnetic data could be processed to image the basement which was particularly useful in onshore terrains where seismic was failing to image the deeper parts of a sedimentary basin.

During 2012-14, I worked with colleagues in Shell to develop an approach we continue to refer to as ‘Sensors to Decisions’. The initial goal was to enhance the impact of new geophysical sensors on exploration performance. The principle idea is that sensors are rigorously matched to key subsurface risk and uncertainty and integrated to enable fast, quantitative, early de-risking, ‘clean-kill’ exit decisions and resulting in high grading the exploration portfolio.

An initial evaluation using legacy data will identify the key risks and volume uncertainties. We then select sensors that might reduce the risk or volume uncertainty and undertake a feasibility study. To assess the potential impact on risk, we may use a Bayesian approach which requires a prior calibration of the method (6). We also need to consider whether the impact on risk or volume uncertainty will have an impact on our decisions by means of a decision tree analysis which can help assess the value of the new information. Post-drill, we review outcomes against pre-drill predictions.

In recent years Shell has used this ‘Sensors to Decisions’ approach in some ventures to select, acquire and integrate data to tackle principle exploration risks. Examples have included;
- integration of airborne full tensor gravity gradiometry to assess structure onshore
- electro-magnetic and multi-beam sonar data to assess charge risk offshore
- integrating gravity, magnetic and seismic data to narrow the range of geological interpretation scenarios related to an offshore mounded structure.

The next generation of interpreters will need to be capable of integrating the data from an increasing range of sensors. For example, Shell is currently exploring in complex fold and thrust geology and rugged terrain onshore Albania where seismic is difficult and expensive. Last December, we
completed a passive source seismic survey involving 390 autonomous seismometers which will be integrated with magneto-telluric and gravity data to build an integrated geological model. This will enable more effective targeting of expensive and difficult seismic reflection data.

Thus, interpretation geoscientists continue to need a variety of interpretation skills, including being able to:

- compile and QC data from relevant non-seismic and seismic sensors and rock property data from well logs, understanding the physics of each method
- build models to check the feasibility and advise decision makers on the potential impact and value of each data type on their decisions
- utilise the data from each method to co-visualize, co-interpret and build models in depth to represent the geology in a way that adds value through reducing risk and uncertainty and impacting decisions

The following papers in this workshop session offer further illustration of the importance of integration of non-seismic geophysical data with seismic for exploration.

References


Bermingham, P.M. 2015,” Sizing up to the energy challenge; seismology and the oil and gas industry. Abstract in “From Hooke to Helioseismology, the UK’s contribution to Seismology past, present and future”. Leicester University, 9-10 April 2015.

