The Role of Seismic in Brownfield

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(This is the first article of a two article series on the Role of Seismic in the Brownfield)

For the past eighteen months or so, it has been difficult to read through any article about the oil and gas industry without the commentary having something prosaic to say about the difficult market environment we are experiencing. Then, there are the endless prognostications about where the market will rebound first – land or offshore – how oil prices will return to $120/b, and when we can all go back to the "way it was." All that aside, I find the most compelling articles are written by those who understand that things have truly changed in our industry, that a "new normal" has already formed, and we are only now just beginning to recognize the full extent of these changes. Specifically, what I want to understand the most is how this great industry is transforming itself. These are truly historic times.

I recently attended a conference primarily for the offshore O&G sector. The who's who of the oil and gas industry CEOs, and other key leaders, were present and provided their expert insight into where the industry was headed. One very clear message delivered by all the majors was that the "E" in E&P is dead … at least for the short to medium term, however long that may be. That admission is the clearest signal yet that the industry has finally recognized that a "new normal" is really here.

That means long term change, perhaps even radical, structural change to the industry, is underway. For an industry that eschews quick change, market forces are already carving away at staid conventional approaches and attitudes about business. Understandably, what I focus on is what these changes mean for our business – marine seismic acquisition, seismic data processing, and data licensing. What I know is that the changes are potentially huge for the seismic industry; and, where there is change, there is opportunity.

Seismic's role in Life of Field

Seismic is a very small share of the enormous economic engine that comprises the global oil and gas industry. But, interestingly enough, nearly every decision made in the oil patch, whether on land or offshore, passes through the seismic stage gate. Frankly, it is "all about the image." The right seismic image can be the difference between a $140M dry hole, or a well that produces a billion dollars in oil profits. Seismic still has a key role to play in the future of our industry – make the industry safer through improved HSE.

Generally speaking, when the oil patch thinks about "seismic" people think front end life of field. Seismic data acquisition is what the operator does in the Exploration (the 'E' in E&P) phase. In the offshore world, the operator hires the conventional towed streamer ship whose massive array of cables, buoys, and geophones blazes a wide swath over the top of virgin seabed recording the seismic data that eventually produces a seismic "image." Then, a group of very smart and talented people, geologists and geophysicists primarily, get together, study the seismic image, and eventually decide if and where to drill a well into the seafloor. Again, it is all about the image! More importantly, it is all about the quality of that seismic image which is critical in making those billion dollar decisions.

If the "E" in E&P is dead, and that is conventionally viewed as where seismic happens, then it might be tempting to suggest that seismic is just as dead. US Oil Producers exploration CAPEX is down on average 29% in 2016, and nearly 20% globally. This follows a larger reduction of approximately 48% in 2015 for US Operators and 29% globally.[1] Expectations are that another flat to down year is possible in 2017 as the industry downturn finally bottoms out. It will be a challenge for Oil Field Service (OFS) companies of all varieties to weather the storm. Seismic companies are

[1] Oil and Gas Financial Journal, "2016 E&P industry and CapEx Outlook: Belt tightening, positioning for recovery." December 10, 2015.

similarly challenged, and for certain types of seismic acquisition, and certain companies operating exclusively at the front end life of field, that may well be true.

Brownfield is the new Greenfield and Seismic is still a key differentiator

So, what about back end life of field? What change is happening in the Production and Maintenance stage of life of field (the 'P' in E&P) where Brownfield gets its name? What is impact of the new normal, and does seismic have any meaningful role to play? Convention says that Seismic is not necessarily viewed as having a big role to play in the brownfield.

While it is a bit of a puzzle to dissect how capital expenditures and operating expenditures flow as it relates to the brownfield, we do know that overall production (P) will grow in 2016, and in the years ahead. The brownfield is very much alive, and will be the only growth area in upstream oil and gas for years to come. The brownfield may be more alive than it ever has been – given what a "new normal" means for the industry.

Despite the fact that producers are attempting to reign in expenditures in every stage in the life of field, it is clear that they will be much more focused on maximizing the productive capacity of existing brownfields. This will be truer for offshore field developments than onshore, simply due to the significant complexities and expense associated with new offshore field developments – a multibillion dollar investment decision in nearly every instance.

The lifting costs and conventional breakeven price per barrel associated with an existing offshore productive field, even mature fields in decline and requiring some form of intervention, is still vastly less expensive than new field, or greenfield, developments. The math is simple: offshore brownfield breakeven prices/barrel range in the $30/b - $50/b spread. Unsanctioned (new) offshore projects, even after the massive supply chain cost compression experienced over the past two years of this downturn, average breakeven costs in the $65/b - $85/b range. Expected average market oil price/barrel in the $40 - $60 range through 2020 makes it clear: oil producers will have to focus on how to best characterize their existing reservoirs, intervene, and exploit oil production from existing fields as its first priority. What's more, those decisions still have to flow through the seismic stage gate. It is still "all about the image."

Seismic's Growing Role in Offshore Brownfield Exploitation

Why is Seismic now ever more critical in maximizing production in the brownfield?

Offshore brownfield exploitation generally involves operations in remote / difficult- to- access areas, environmentally sensitive areas, geologic basins with complex overburden, structure and stratigraphy, and most importantly, with field developments characterized by dense infrastructure. Given these realities, conventional towed streamer "surface" acquisition is challenged in its ability to provide similar high quality, reliable, ocean bottom seismic data acquisition.

Ocean Bottom Seismic (OBS), and specifically Ocean Bottom Node (OBN) seismic acquisition is the technology of choice for the brownfield, and there are a number of valid reasons why. The most important reason is found in the type of seismic acquisition required in the brownfield: generally known as 4D.

4D seismic is critical in the brownfield for establishing the required "time-lapse" characterization of the reservoir. However, most mature brownfield reservoirs, developed using 4D seismic, are surveyed only every 2 or 3 or 5 years apart. This is obviously a function of cost and priority. In the past, it has been mostly about E-seismic. P-seismic has taken a back seat. But this approach creates an unnecessarily high risk scenario; operators can easily miss the opportunity to effectively manage the reservoir and intervene if needed. Ultimately, the 4D, P-seismic game is about creating the highest quality imaging required to accurately characterize the reservoir, and then make the critical, best decision about how to intervene (if at all). Intervention to improve and further exploit the productive capacity

of the well goes beyond additional profit growth. Successful intervention effectively delays decommissioning costs which could run as high as $60 - $70 million in some cases. P-seismic is an effective cost mitigation strategy as well.

The days of $120/b oil and resulting profitability adequate to cover over the significant opportunity costs created by reservoir management mistakes are gone. Effective and affordable reservoir management requires a 4D solution that enables multiple, closely time-separated surveys that measure how the reservoir is responding to production plans and well interventions.

Towed Streamer "Surface" Technology in Brownfield

While towed streamer acquisition is currently the lowest cost alternative in shooting virgin seabed and providing reasonable images for greenfield applications, that is not the case in the brownfield. Towed streamers often conduct 4D seismic in the brownfield for operators. The strategy of surface towed streamer companies has been to develop what are known as Wide Azimuth (WAZ) surveys. WAZ requires a huge commitment of time and expense to conduct, and these surveys have significant limitations imaging brownfields.

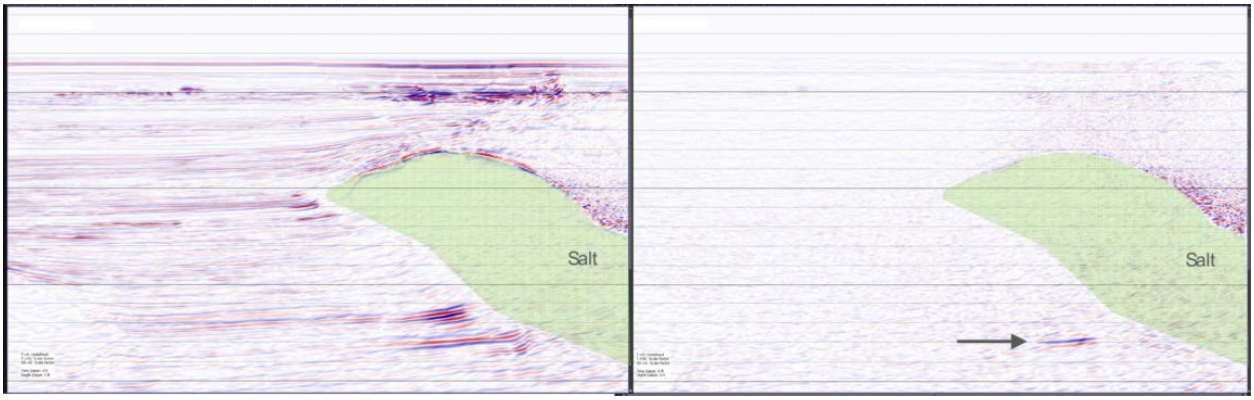
Reservoir image quality is affected by the towed streamer's inability to fill the image gaps created by dense brownfield infrastructure and other constraints. Nothing can change that reality. Additionally, towed streamer image quality suffers due to natural, water column variability (added 4D noise), random surface obstructions, shipping lane restrictions, etc., that make shooting subsequent seismic surveys exactly as the previous survey – known as "repeatability" – virtually impossible. They cannot repeat exactly all the environmental conditions present during the prior survey in order to exactly compare the image generated from the current survey to the image generated from the prior survey. The 4D image quality and comparability is inferior.

OBN: the Seismic Solution of Choice for the Brownfield

OBN seismic technology is superior in the brownfield. The number one reason why is image quality. OBN data for seismic image quality is unsurpassed – and it is all about the image. Consider the graphic, below. This image is a vertical section derived from data captured via a deep water node survey in the Gulf of Mexico. The left hand panel show the image from the initial baseline survey. The right hand panel image shows the reservoir as characterized from the 4D survey two years later. This "4D difference plot" image comparison visibly captures the baseline image reservoir characteristics minus the time-lapsed 4D monitor characterization of the same reservoir two years later. In this case of evaluating the impacts of a water flood intervention, the 4D data clearly images the result of amplitude changes in the reservoir due to water replacing the oil. Even to the untrained eye you can see the virtual absence of any events on the 4D section except at the main reservoir level highlighted by the arrow.

Nodes offer a distinct advantage over streamer surveys in 4D analysis as they are difficult to repeat in the unpredictable currents of the Gulf of Mexico. The geologic and imaging objectives of the survey are met by all azimuth, all offset, high fold and dense subsurface sampling that are now the standard requirements of new imaging and noise reduction technologies. These types of acquisition geometries are easily and efficiently achieved using OBN systems. Additionally, the careful deployment of autonomous nodes amongst crowded field developments balance the competing objectives of subsurface imaging, affordability, acquisition efficiencies and environmental impact.

FIGURE 1: OBN 4D DIFFERENCE PLOT – BASELINE IMAGE (LEFT) VS. 2YR SUBSEQUENT 4D MONITOR IMAGE (RIGHT)



SOURCE: FROM: T.B. BARKER , D.A. CHALENSKI , G.M. WAINRIGHT, W.F. REID, J.G.F. STAMMEIJER , D. KIYASHCHENKO AND P. HATCHELL, [2015], SUBSALT TIME-LAPSE SEISMIC FOR RESERVOIR MONITORING USING I4D IN DEEPWATER, EAGE TECHNICAL PROGRAM ABSTRACTS, MADRID.

Secondly, use of node surveys are very comparable in cost to surface-based, WAZ streamer seismic acquisition, and significantly lower cost than other OBS systems, specifically Ocean Bottom Cable (OBC). Others have tried and failed to deliver an OBC system as the permanent reservoir monitoring solution for repeatable 4D – which have been incredibly expensive and just as unreliable. OBC systems use terminations, connectors, power distribution and data telemetry all subject to significant technical downtime which drives up seismic data acquisition costs and risks, HSE and financial.

Lastly, an ongoing reservoir characterization solution must have the highest system reliability. Reliability allows for repeatability. Repeatability delivers 4D seismic data that provides the highest image quality. Reliability is therefore "critical to quality." The reliability of the nodal systems and the lack of technical downtime allows for more emphasis to be placed on improving the operational performance and lowering expenditures associated with production exploitation. Moreover, new nodal technologies allow for OBN to become the effective, reliable, affordable permanent reservoir monitoring solution for the brownfield, economically deploying a frequent seismic monitoring solution, and delivering repeatable surveys for superior reservoir characterization for production optimization.

Nodes as a Permanent Reservoir Monitoring (PRM) Solution

The value of 4D seismic in reservoir management, increased recovery, and optimizing and extending the life of the field, is just now becoming well established. OBN is today routinely used to acquire full azimuth 3D seismic data for some greenfield development as well as providing effective brownfield initial 4D, or "baseline," surveys. Nodes can be economically deployed and retrieved amongst infrastructure and during simultaneous operations. OBN surveys have proven to be highly repeatable, producing time-lapse 4D data for reservoir monitoring that is the same image quality as data acquired via cable-based PRM systems, but with significantly favorable economics.

New nodal PRM has a deployment life of five years with 300 days of active recording, enough for twelve 25-day surveys. Installation involves little technical risk since it is deployed in the same manner as conventional node deployment which has had over 30,000 successful deployment in the last 10 years.

It Really Is "All About the Image"

With the economic and operational stakes higher than they have ever been for offshore operators to deliver improved profitability and lower risk thresholds for their maturing offshore brownfields, seismic has emerged as a critical part of the production exploitation game. The advantages of production focused OBN extend beyond the seismological benefits, too. The avoidance of the significant potential negative environmental and HSE impacts

should be considered: less “traffic” around the wellhead, fewer vessel-related man days for injury to occur, minimal, if any, seabed disturbance are just a few areas to mention. P-seismic is fast becoming a necessity for the brownfield, and the data (economic, environmental, and safety) indicates OBN technology is the answer. OBN provides both the image quality needed and the permanent monitoring solution required to give operators the best results to manage the most important asset the operator has – the reservoir. It truly is “all about the image.”