Broadband technology is used to increase the frequency bandwidth of seismic data using various acquisition and processing techniques. It should now be standard practice for all new seismic surveys.

For many years most interpreters and processors have worked together to try and boost the high frequency content of their data in a bid to get better resolution of seismic reflections. Broadband technology attempts to boost the low frequency content of the data, which is arguably even more important. In one of the many Joint Venture meetings I attended recently, one of the presenters displayed some new seismic lines and expressed surprise that the sections looked so much better when the low frequency content was only improved by a few Hertz – the low end went from 8 Hz to 4 Hz. This is not really a surprise. Frequency content is calculated in octaves and this new seismic had a full octave improvement. The 4 Hz extra at the low end is equivalent to improving content from 60 Hz to 120 Hz at the high end (4 Hz extra at the high end would hardly be noticed but at the low end its crucial). The old data of 8–64 Hz had a range of 3 octaves while the new data had a 4 octave range.

But why is the low frequency so important?

Actually all frequencies are important but the low frequencies carry critical amplitude information and this is required for quantitative interpretation and characterisation of rocks and fluids associated with seismic reflections. Prior to the rise of broadband considerable effort was applied to creating a low frequency model of the missing 2–8 Hz (say) content for seismic inversion projects. Now we only have to model the 2–4 Hz range.

Figure 1 illustrates the respective benefits of low and high frequency content using a model of a 20 ms thick layer. The centre panel shows the input model with amplitudes shown in colour. On the left the model has a low pass filter applied and as you can see the peak amplitude in the layer (brown) and the amplitude of the background (green) are similar. But while the amplitudes are retained the thickness information is lost. The high pass filtered version of the model on the right retains the location of the top and bottom of the layer but the amplitude information has been lost. There is a trade-off between high and low frequency information – do you want amplitude or thickness information or do you want both?

Well, we have to work with the data we have, but if I had to choose I would opt for the low frequency end so that I could calculate accurate rock properties for reservoir characterisation. But I don’t have to choose – with broadband technology I can have both.

Global drilling activity in the petroleum sector continues to decline

David Denham AM
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Baker Hughes has issued the rotary rig counts as a service to the petroleum industry since 1944, when Hughes Tool Company began weekly counts of U.S. and Canadian drilling activity. In 1975 Hughes initiated the monthly international rig count. These counts are an important indicator, not only for the drilling industry and its suppliers but for the whole petroleum exploration industry.

The most recent results are plotted in Figures 1 and 2. Figure 1 covers the period 1975 through early May 2015 and Figure 2 shows an expanded plot for the period 2000 through early May 2015.

I am still surprised by the domination of the North American industry, in spite of the fact that petroleum exploration has been a global activity for many years. For example, in March 2015 the total global count is given as 2557 of which 196 were in Canada and a staggering 1110 in the United States 2015. In comparison, the Australian count usually varies between 15 and 30 per month. In March this year only 19 rigs were listed as being in operation. So there should be a lot of oil still in the ground ready to be
found and extracted, in both Australia and overseas.

As to be expected the correlation between the oil price and the number of rigs is very strong, but the time difference between the two curves has shortened significantly in recent years. In Figure 1 the price curve leads the rig count curve by about two years, but in the last seven years the time difference has been reduced to only a few months (see Figure 2).

The variability in the number of rigs operating is significant. During the Global Financial Crisis the numbers dropped from over 3500 to 2000 and the recent fall from the drop in oil prices was of a similar size (3700 to 2250). It must be very hard for the service industries to plan ahead for the purchase of new rigs and other exploration facilities in this somewhat chaotic economic environment.

There is clearly going to be an increase later this year, in both the oil price and the number of rigs operating. After the GFC the recovery period was about two years. It will be interesting to see how long it takes this time.

**Figure 1.** Monthly global rig numbers and the oil price from January 1975 to May 2015. These are taken from the Baker Hughes rig count (see: [http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-rigcountoverview]). The oil price is the monthly spot price for West Texas crude ([http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=M](http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RWTC&f=M)) and the price has been adjusted to May 2015 US dollars to correct for the US consumer price index ([http://www.bls.gov/cpi/cpid1503.pdf](http://www.bls.gov/cpi/cpid1503.pdf)).

**Figure 2.** Monthly global rig numbers and the oil price from January 2000 to May 2015. The caption is the same as for Figure 1.

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**Seismic boats stacked**

As a further indication of the downturn in the petroleum industry, PGS and Polarcus have announced they have cold stacked some vessels despite some robust multiclient sales.

Chief executive Officer Rod Starr commented that the current market environment can be best described as uncertain, while releasing the Polarcus first quarter 2015 financial results. In response to continued reduction and deferral of spending by oil companies Polarcus has stayed true to its 2015 agenda announced in February, ‘this focus has included the difficult yet necessary decision to cold stack Polarcus Nadia at the end of the quarter’, he said.

Jon Erik Reinhardsen, President and CEO of PGS said while announcing his company’s first quarter results ‘...in adapting to the weak market we have decided to cold stack Ramform Challenger and Ramform Explorer after they complete this year’s North Sea summer season’.

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**Perth Basin action**

Michael Micenko

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The Perth Basin in Western Australia has been producing hydrocarbons for over 30 years and, despite the recent downtown, two recent announcements suggest that this Basin will continue to be productive. On 6 May, Norwest Energy NL (ASX: NWE) reported their acquisition of the Arrowsmith 3D seismic survey has been successfully on time and within budget. Norwest will now commence processing and interpretation of the data. The survey covered an area of 106 km² within exploration permit EP413 between
Eneabba and Dongara, 250 km north of Perth. The objective of the survey was to assess the extent of the resource surrounding the existing Arrowsmith-2 well location and to assist in defining the optimal location and target formation for Norwest’s first horizontal well, Arrowsmith-3.

Vegetation rehabilitation will now commence and will include annual audits to demonstrate progress. Norwest is confident of meeting all rehabilitation milestones set by the various government agencies. The State offset requirement comprises funding to a value of no less than $200,000, triggered if after 5 years the Environmental Protection Authority determines significant residual environmental impacts remain. The Commonwealth offset requires an upfront unconditional provision of funds to the Department of Parks and Wildlife to purchase no less than 290 Ha of land with similar environmental values to the area cleared.

On 7 May 2015, AWE Limited (ASX: AWE) announced the initial results from the Irwin-1 exploration well, which is also located in the onshore Perth Basin. The well was drilled to a total depth of 4049 m and intersected the primary target Dongara/Wagina sandstones at 3146 m. The Dongara/Wagina sandstone is a tight gas reservoir.

A 32 m gas column is indicated by wireline logs, sidewall cores and gas samples and an interpreted gas-water contact at 3085 m TVDSS. This contact is the same depth as interpreted in the Warradong-1 well located 4.6 km to the south which suggests the wells may have tested a single large gas accumulation. AWE estimates a gross 2C contingent resource of 15 Bcf of gas in the Irwin structure and 134 Bcf of gas in the neighbouring but possibly connected Synaphea structure located in the neighbouring permit L1. The portion of the Synaphea structure updip of Irwin-1 has not been drilled.

Irwin-1 also targeted the Kingia Sandstone which was found to be water bearing. This outcome was not unexpected as the Kingia was penetrated below the interpreted gas-water contact at.

Table 1. Initial gross 2C Contingent Resource estimates for Irwin and Synaphea structures (ASX: AWE)

<table>
<thead>
<tr>
<th>Fields/Permits</th>
<th>Reservoir Interval</th>
<th>Discovered Original Gas in Place (Bcf)</th>
<th>Contingent Resources (Bcf of gas)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P90</td>
<td>P50</td>
</tr>
<tr>
<td>Irwin (EP320, L1)</td>
<td>Dongara/Wagina</td>
<td>34</td>
<td>38</td>
</tr>
<tr>
<td>Synaphea (L1/L2, EP320)</td>
<td>Dongara/Wagina</td>
<td>282</td>
<td>330</td>
</tr>
</tbody>
</table>

Table 2. Initial net 2C Contingent Resource estimates for Irwin and Synaphea structures (ASX: AWE)

<table>
<thead>
<tr>
<th>Fields/Permits</th>
<th>Reservoir Interval</th>
<th>AWE equity</th>
<th>AWE Share (Bcf of gas)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1C</td>
</tr>
<tr>
<td>Irwin (EP320, L1)</td>
<td>Dongara/Wagina</td>
<td>33% – 50%</td>
<td>5</td>
</tr>
<tr>
<td>Synaphea (L1/L2, EP320)</td>
<td>Dongara/Wagina</td>
<td>33% – 50%</td>
<td>50</td>
</tr>
</tbody>
</table>
Waitsia. However, the Kingia reservoir is thicker than, and of similar quality to, that in Waitsia located 8 km to the west. This confirms that the Kingia reservoir system is laterally extensive, as assumed in the assessment of the previously announced gross 2C Contingent Resource estimate of 290 Bcf of gas for the Waitsia field. Aquifer pressure measured at Irwin-1 also supports the interpreted mid-case gas/water contact for the Waitsia field.

The tables were included in the AWE announcement and indicate a significant 2C Contingent Resource in this onshore area only a short distance from Perth.

Table 3. Initial net 2C Contingent Resource estimates announced to date for the north Perth Basin (ASX: AWE)

<table>
<thead>
<tr>
<th>Fields/Permits</th>
<th>Reservoir Interval</th>
<th>AWE equity</th>
<th>AWE Share (Bcf of gas)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1C</td>
<td>2C</td>
</tr>
<tr>
<td>Irwin (EP320, L1)</td>
<td>Dongara/Wagina</td>
<td>33% – 50%</td>
<td>5</td>
</tr>
<tr>
<td>Synaphea (L1/L2, EP320)</td>
<td>Dongara/Wagina</td>
<td>33% – 50%</td>
<td>50</td>
</tr>
<tr>
<td>Senecio (L1/L2)</td>
<td>Dongara/Wagina</td>
<td>50%</td>
<td>20</td>
</tr>
<tr>
<td>Waitsia (L1/L2)</td>
<td>Kingia/High Cliff</td>
<td>50%</td>
<td>33</td>
</tr>
<tr>
<td><strong>TOTAL net to AWE</strong></td>
<td></td>
<td><strong>108</strong></td>
<td><strong>253</strong></td>
</tr>
</tbody>
</table>

SAYING GOODBYE TO A 2D EARTH

INTERNATIONAL 3D MODELLING CONFERENCE AUGUST 2 - 7, 2015
QUALITY INN, MARGARET RIVER, WESTERN AUSTRALIA

CONFIRMED INVITED SPEAKERS

- Clare Bond: University of Aberdeen
- Eric de Kemp: Geological Survey of Canada
- Florian Wellmann: RWTH Aachen, Germany
- Gaby Courrioux: BRGM, France
- Hoshin Gupta: The Uni. of Arizona
- Laurent Ailleres: Monash University
- Roland Martin: CNRS Toulouse, France

Themes include:
- integration of geology and geophysics in 3D
- geophysical inversion
- modelling uncertainty
- model delivery, curation and standards

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