Trials of Seismic Stimulation

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In the last issue of IOR Views Jose Gil Cidoncha presented the principles of a new acoustic stimulation technique which is being extensively trialled in mature onshore fields in the USA. We are indebted to Bill Wooden (wow@zowi.to) of Applied Seismic Research Corporation, Plano, Texas who has provided copious information on current activity using the technique [1, 2, 3, 4]. David Lopez (d.lopez@senergyltd.com) and David Hughes (david.hughes@senergyltd.com), both Principal Reservoir Engineers with Senergy Ltd in Aberdeen have reviewed this material.

Background

There have been a number of examples in high watercut wells where a kick in oil production has been seen following a minor earthquake. The cause-effect connection seemed very strong so this lead to research into whether this "seismic" effect could be reproduced artificially. A detailed review has been produced by Susan Jackson, RMC, Inc. and co-authors for the US DOE National Petroleum Technology Office.

Downhole Generator

Research at Applied Seismic Research Corporation has focused on a down-hole acoustic wave generator. This Hydro-Impact Tool (Figure 1) is installed about 30 ft above the shallowest producing layer. The tool generates shock waves each lasting less than one-hundredth of a second at ten second intervals. The standard size tool fits in a 7 inch or larger casing, but a slim-hole version is also available. Typically each shock wave (six per minute) imparts up to ten million watts of energy to the formation, with the acoustic wave traveling at about 1.5 miles per second. Production is affected at wells up to three-quarters of a mile away from the acoustic source. It is claimed that this process can increase oil recovery over substantially large areas of a reservoir at a lower cost than any other stimulation technology.

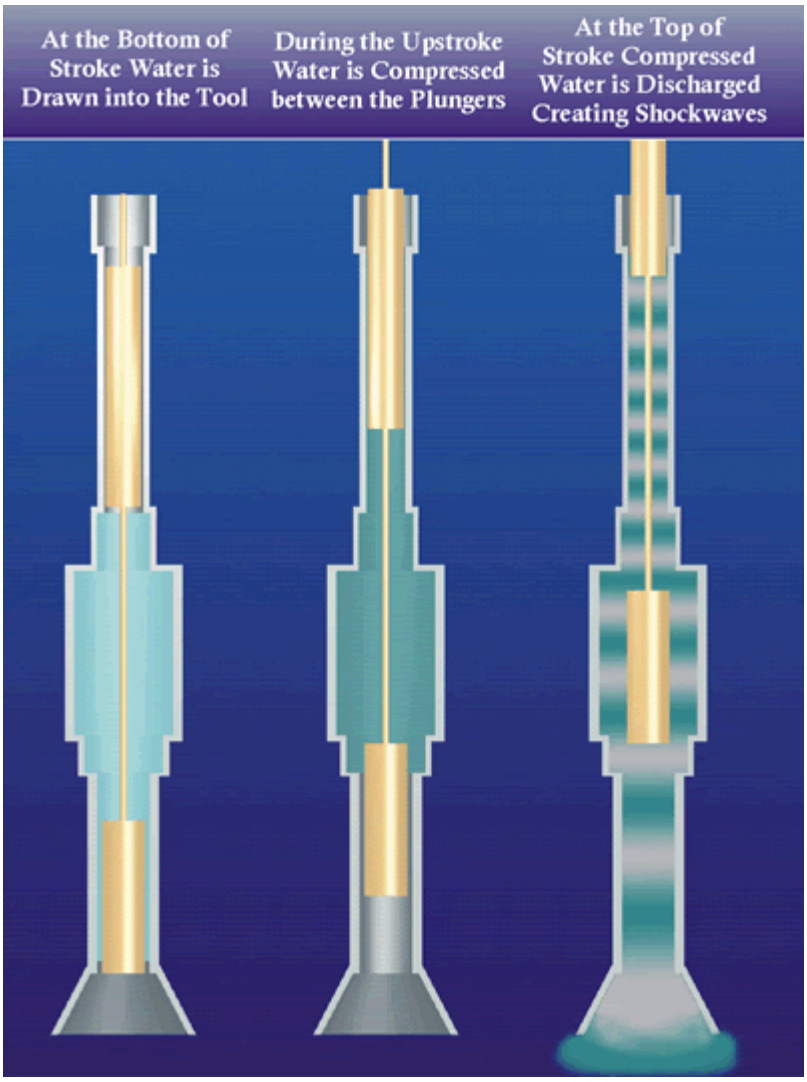

Figure 1: Applied Seismic Research Corporation's Hydro-Impact Tool

Comparison with Earthquake Effect

Figure 2 shows the aggregate oil and water production, and oil cut at 58 producers in ChevronTexaco's Lost Hill Diatomite Reservoir in California [1, 3]. During September and October 1999, there were earthquakes ranging from 5.2 to 7.1 on the Richter scale with epicentres located about 233 miles away at Hector Mine. There is a clear response to the earthquake in terms of a short increase in oil production. Subsequently, a single slim-hole Hydro-Impact Tool was installed and operated for three and a half months from June through November 2000. This gives a clear comparison between the response of the oil field to earthquake events and artificially induced shock waves, both producing about the same effect on oil production (Figure 2). It is clear that the high energy elastic waves generated by the Applied Seismic Research Corporation Hydro-Impact Tool are similar to the seismic waves created by earthquakes. Once the stimulation stopped the response came back on trend.

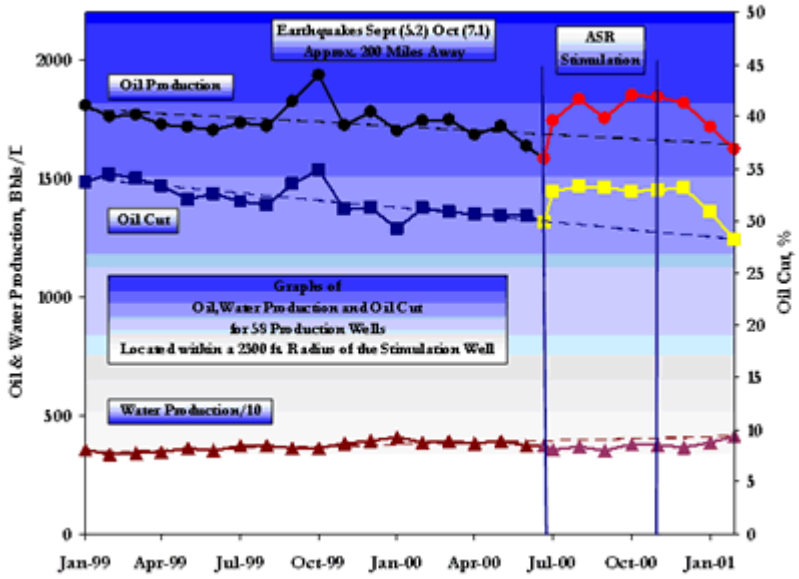

Figure 2: Effect of Earthquakes and Seismic Stimulation at ChevronTexaco's Lost Hills Reservoir

It is postulated that as the elastic waves migrate through the porous media they cause deformation of the grain structure. Once the waves have passed the grains relax back into their normal structure and in so doing cause a vibrational frequency. This high frequency waveform causes oil droplets, otherwise too small to move, to coalesce into larger, mobile droplets. Similarly oil films are transformed into mobile droplets.

Field Application

A significant field trial [3] was undertaken during 2003 in a group of around seventy wells using three Hydro-Impact Tools (Figure 3). There is a significant response to continuous seismic stimulation. From a reservoir engineer's standpoint, in the analysis of the benefit of the stimulation it would perhaps be best to compare with a long term exponential decline in the oil rate - this would be the maximum expected decline for a field with the pressure supported by water injection - by using a liner decline there is the possibility of overestimating the benefit.

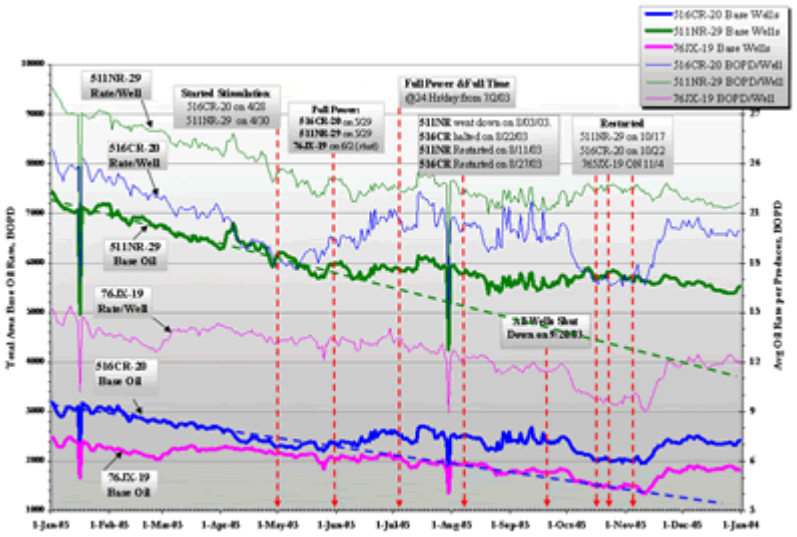

Figure 3: Seismic Stimulation Pilot - Hot Zone Oil Rates Total and Average Per Well

In other tests [3], injectivity has been permanently improved in wells in which the tool was installed, and in other wells as far as one mile away. It is postulated that this changes conformance at the injectors and brings previously non-productive sublayers into play.

Qualifies for EOR Tax Credit

A recent hearing by the Texas Railroad Commission [4] has determined that seismic stimulation qualifies as an enhanced oil recovery technique, so attracts EOR tax credits. Occidental Permian Oil is proposing to use the technique at its South Wasson Clearfork Unit in the Wasson 72 Oil Field in Gains County. Oil production from the Unit is currently 2,400 b/d from 89 active producers. These are supported by 74 active injectors. The initial stimulation is conservatively expected to produce an additional 124,000 barrels of oil over two years.

Application to North Sea

Would seismic stimulation be suitable in the North Sea ? One similarity is that many UKCS fields are operating at high water cuts and the remaining residual oil in the water swept regions exists as disconnected droplets which would flow if stimulated to coalesce. A big difference though is that the closest well to any particular well is likely to be a minimum of half a mile away, rather than having tens of wells within this distance. This means that the mobilised oil has to flow much further to be produced, with a danger that it will again be dissipated into smaller droplets on the way and trapped. Another big difference is that in the USA, wells are often simultaneously producing from a number of relatively thin isolated layers (i.e. the flow from the layers is co-mingled). In the North Sea this is rarely the case, rather production is occurring from massive communicating sands. Also UKCS recovery factors from waterflooding are around 50% of oil initially in

place, or even higher, whereas the recovery factors in USA fields prior to stimulation are more likely around 30% OIIP.

References (supplied by Bill Wooden, Applied Seismic Research Corporation)

- *Lost Hills Diatomite Stimulations*, Memorandum, 6 May 2004, Bill Wooden, Applied Seismic Research Corporation
- *Field Results Showing Shift in Relative Phase Diagram*, Memorandum, 8 October 2004, Bill Wooden, Applied Seismic Research Corporation
- *Hydro-Impact Stimulation Services*, February 2004, PowerPoint Presentation, Dr Sergey Kostrov and Bill Wooden, Applied Seismic Research Corporation
- *Texas Drilling Observer*, Volume 6, Issue 41, October 11-15, 2004

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