EAGE

M06

A Multi-level Source Design Improves Seismic Imaging Below Highly Reflective Layers

G. Cambois* (PGS), B. Osnes (PGS), A. Long (PGS), G. Parkes (PGS), A. Mattsson (PGS) & T. Lundsten (PGS)

SUMMARY

The multi-level source is a new airgun array design that attenuates the effects of ghosting in the low frequency range. This design does not remove the source ghost but shifts energy around to favor low frequencies. It is therefore useful in area with poor seismic penetration due to highly reflective layers such as salt, basalt or carbonates.

The quest for deeper oil and gas targets, or targets covered by a strong reflector (such as basalt or carbonates) requires improved penetration of the seismic waves. In the marine environment the low frequency part of the seismic spectrum, which controls penetration, is limited by ghosting. This interference between up- and down-going waves occurs both on the source and receiver sides. The receiver ghost can be eliminated using dual-sensor technology either at the ocean bottom or within a towed streamer. There is no equivalent technology on the source side. There have been many attempts over the years at improving the low frequency content of airgun arrays. In this paper we present a simple yet extremely effective approach based on a multi-level array design.

A conventional airgun array is made of several sub-arrays each containing a number of guns, or clusters of guns. All guns are at the same depth (typically between 5 and 10 meters) and fire at the same time. This provides constructive down-going energy but also constructive up-going energy. Therefore the ghost has the same energy as the direct wave. The multi-level source concept puts guns, clusters or sub-arrays at different depths and fires them sequentially so that only the down-going waves builds up constructively. The up-going wave does not build constructively and the ghost effects are consequently reduced. With this design the guns can be towed deeper to favor low frequencies and the high frequency limit is guided by the minimum depth interval between the guns.

This technique was first tested in Australia's Browse Basin in 2008. The source was made of 4 sub-arrays, two of which were towed at 12m while the other two were towed at 18m (Figure 1). The deeper sub-arrays were fired after a 4ms delay (which corresponds to the travel time of the depth difference). Figure 2 shows the modeled spectrum compared to the standard source towed at 6m. As expected from the deeper average tow, the multi-level source exhibits more low frequencies. However, it has less energy in the mid-frequency range because it does not benefit from the boost generated by the ghost at these frequencies. The multi-level source does not actually remove the source ghost; it merely shifts energy to favor low frequencies at the expense of other frequencies. In the case of the Browse Basin it provided dramatically improved signal-to-noise ratio at depth below an absorbing carbonate layer (Figure 3).

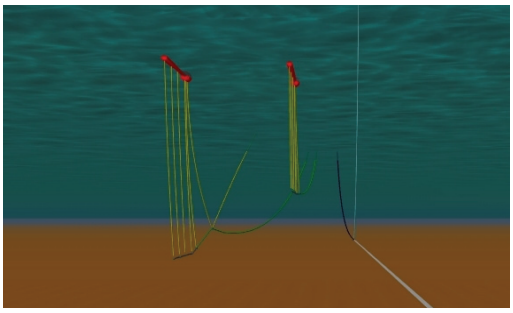

Figure 1: schematic rendition of the multi-level source with 2 sub-arrays at 12 and 18m.

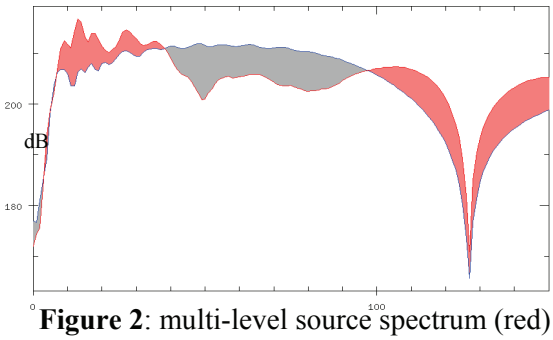

Figure 2: multi-level source spectrum (red) compared to conventional 6m tow (blue).

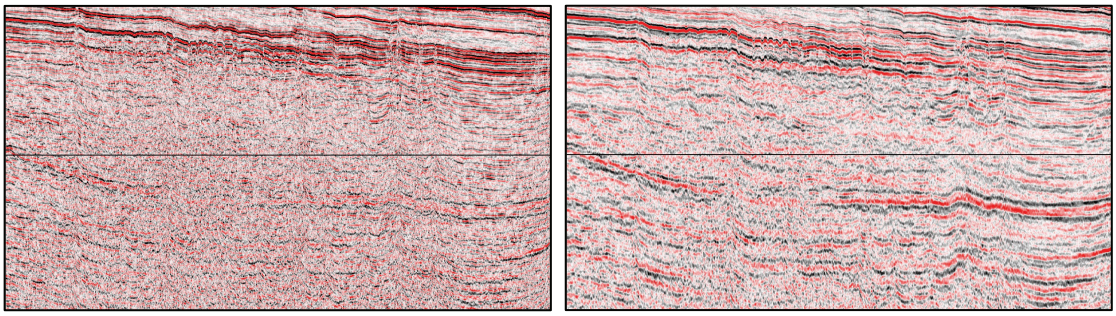

Figure 3: standard source and standard streamer (left) compared with multi-level source and dual-sensor streamer (right). The low frequencies generated by the multi-level source and properly recorded by the dual-sensor streamer provide a much improved image at depth below the carbonate layer.