It is in the phase spectra shown in Figure 11 and Figure 12 that the asymmetry of the linear array can be shown to be the least desirable. The TriCluster™ array diagnostics in Figure 11 again shows virtually no difference with angle from vertical, and both the forward- and rearward-traveling wavelets are identical in terms of phase. Figure 12 shows the dramatic difference between the phase spectra of the non-vertical wavelets which would have the potential to introduce undesirable differences between data acquired on adjacent sail-lines based on array orientation alone. This is in addition to the variation of array output caused by changes in bubble interaction through flexing of the array or variations in separation, etc., that cannot be easily modeled.

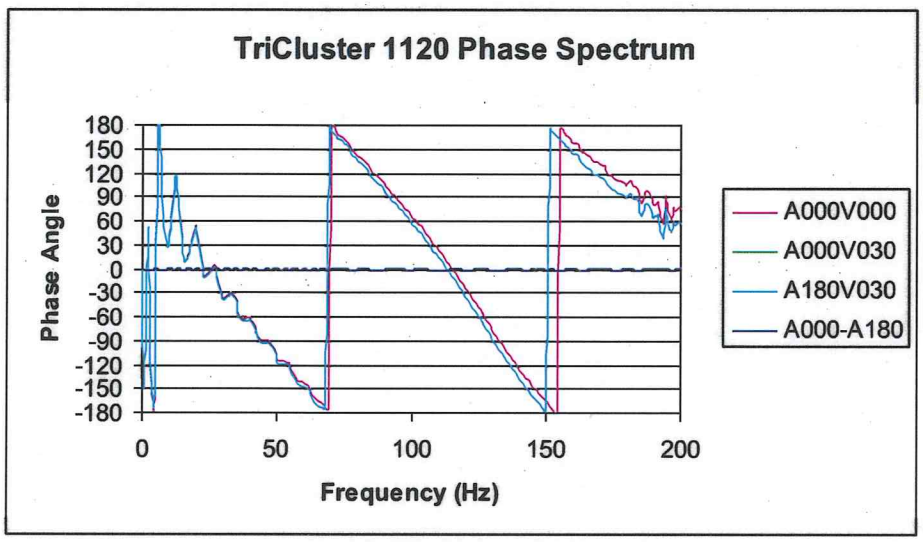

Figure 11 - TriCluster 1120 Phase Spectra

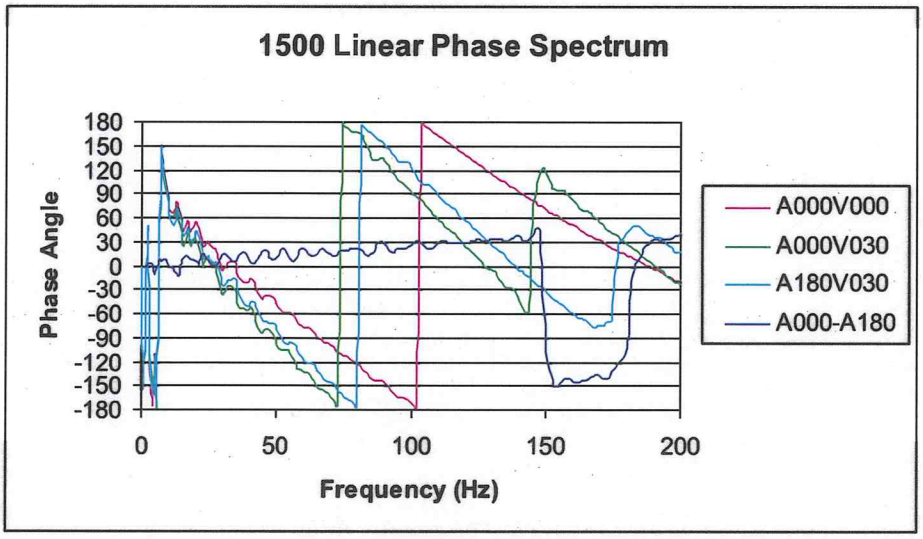

Figure 12 - 1500 Linear Phase Spectra

Additionally the symmetry of the TriCluster source means that there is no difference between the forward propagating wavelet and the backward propagating wavelet. The boat direction is irrelevant to the directionality of the source signature. Boat direction can play a significant part in introducing variations in the effective wavelet from a conventional source array. Figure 13 shows the difference between the source signature at an angle of 30° from vertical, forwards and backwards from the source (but still in a vertical plane parallel to the boat track.

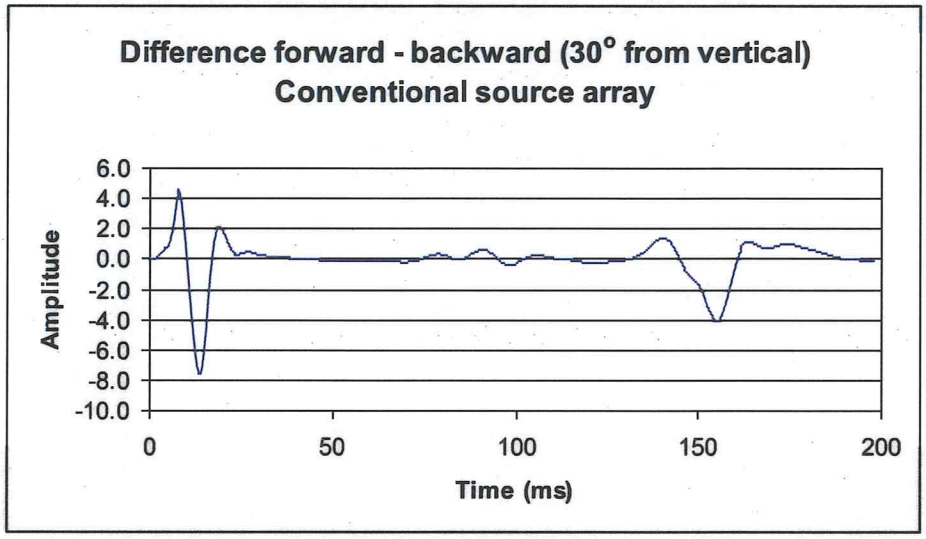

Figure 13 - Directionality of Conventional Source Array

Note that there is significant amplitude in the difference trace shown in Figure 13. This means that for repeated seismic experiments, differences due to source directionality could easily overwhelm the differences that are sought in the reflected energy from the subsurface. Peak difference in the directionality of the array at 30° from vertical is approximately 6 Barm. The peak output of the array (vertically) is only 24 Barm, so the effective change is approximately 25%. At steeper angles from vertical the difference between the forward and backward far field signatures will be even greater.

Typical reflection amplitude changes due to change in fluids in the reservoir are generally estimated to be between 10 and 20%, which means that conventional source array directionality may be bigger than the variations which are sought.

The uniform directionality of the TriCluster array will significantly improve the ability to examine true 4D or reservoir monitoring effects.