Implementation of Individual Polarization Analysis

Technical Note 11 outlines the mathematical and implementation details of Batch Polarization Analysis (BPA), which is appropriate for seismic traces with linearity values exceeding the 0.8 threshold (see Technical Note 15). For traces with lower linearity the polarization analysis has to be done manually one trace at a time, the so-called Individual Polarization Analysis (IPA), which is the topic of this Technical Note.

The implementation of IPA is demonstrated through a simulated Ricker wave as shown in Figure 1. This figure shows the X and Y axis responses for a simulated Ricker source wave with a dominant frequency of 80Hz. The vertical green lines illustrate that the troughs and peak of the X and Y axis responses align very well. This also becomes evident from the hodogram shown in Figure 2. Using a time window between T_1 = 20 ms and T_2 = 40 ms (corresponding to the vertical black lines in Figure 1) the hodogram generates a high linearity (LIN = 0.96) and an incident angle of 215^o.

In Figure 3 the resulting full waveform is depicted, whereby the X and Y axis responses have been rotated onto the full waveform axis (shown as the red trace mapped onto X axis), with the residual shown as a blue line mapped onto the Y axis.

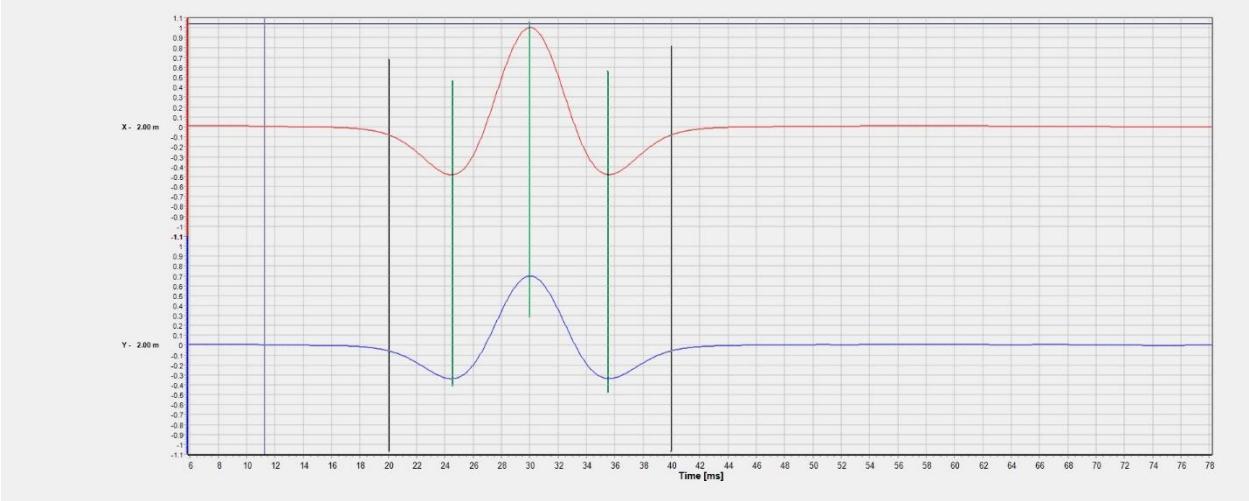

Figure 1. X and Y axis responses for a Ricker source wave – 80 Hz dominant frequency.

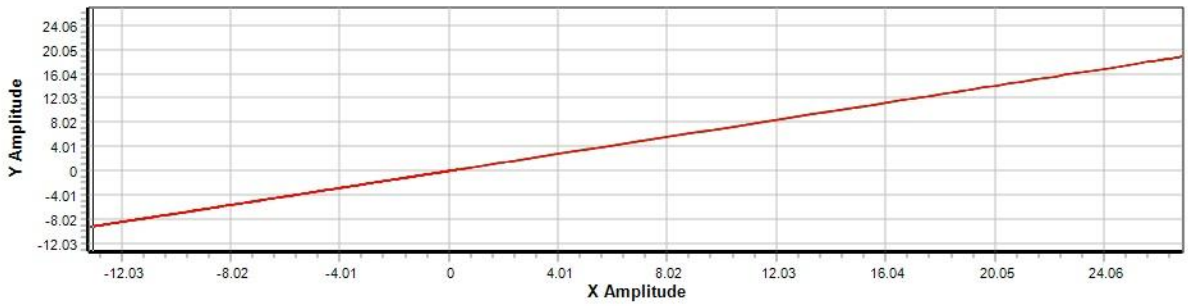

Figure 2. Hodogram of X and Y axis responses illustrated in Fig. 1. Linearity = 0.96 and X-Y plane incident angle = 215°.

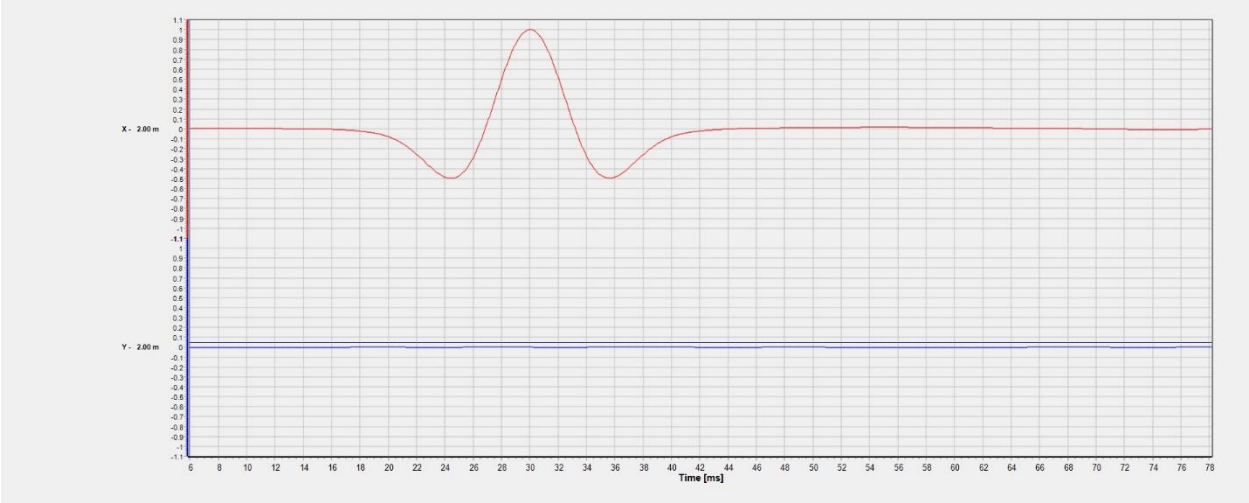

Figure 3. Full waveform (mapped to X axis) after applying PA (Ɵ = 215°) to the traces illustrated in Fig. 1.

Starting in Figure 4 the process is repeated, but now with a simulated Ricker wave where the traces have been significantly distorted starting at 30 ms (simulating possible reflections/refractions or "dirty" source waves). The vertical red lines show that there is still alignment of the first trough and peak responses prior to 30 ms, while the vertical blue lines show that this is no longer the case after 30 ms. The hodogram illustrated in Figure 5 was derived from the X and Y axis responses shown in Figure 4 with a time window between T_1 = 20ms and T_2 = 50ms (represented by the vertical black lines in Figure 4). This time the hodogram generates a lower linearity (LIN = 0.58) and an incident angle of 181^o (or 34° less than the noise free hodogram of Figure 2)

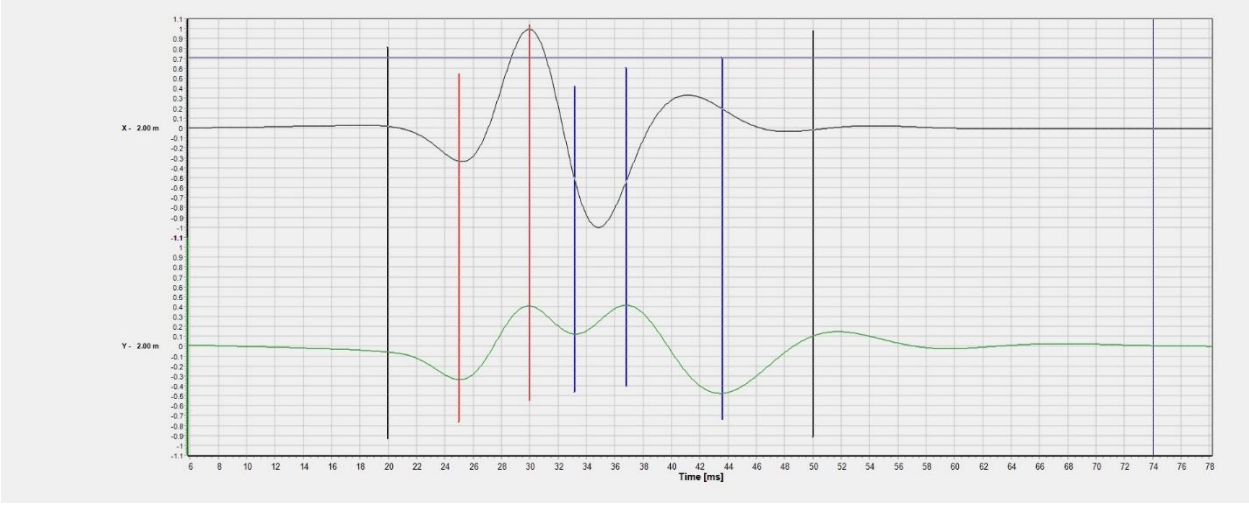

Figure 4. X and Y axis responses for a Ricker source wave – 80 Hz dominant frequency – with distortions starting at 30 ms.

In Figure 6 the resulting full waveform is depicted (in the same manner as in Figure 3), but now there is a clear residual shown as a blue line mapped onto the Y axis, both due to the poor linearity and the inaccurate incident angle, with the latter causing a residual well before the start of the distortions.

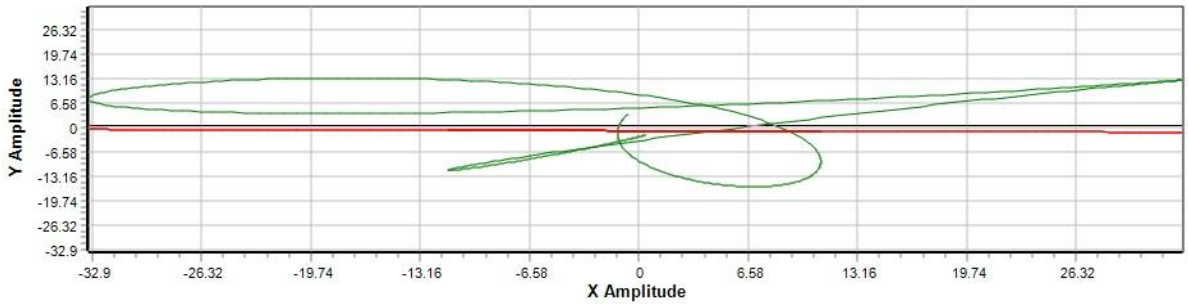

Figure 5. Hodogram of X and Y axis responses illustrated in Fig. 4. Linearity = 0.58 and X-Y plane incident angle = 181°.

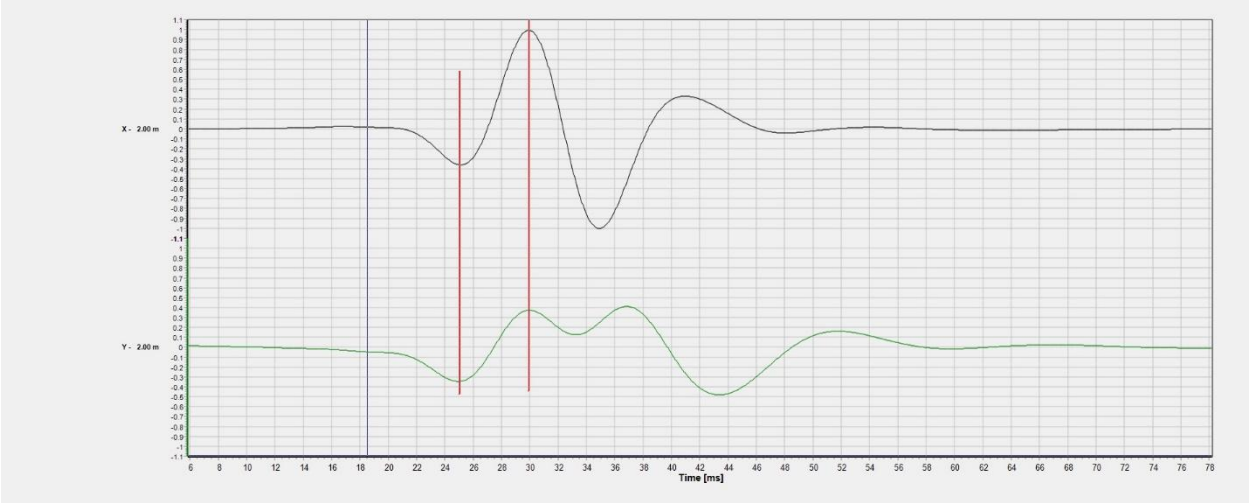

Figure 6. Full waveform (mapped to X axis) after applying PA (Θ = 181°) to the traces illustrated in Fig. 4.

However, if the time window is re-specified such that it only incorporates the X and Y axis responses that are correlated (i.e. between 20 ms and 30 ms) the hodogram shown in Figure 7 is obtained, with again a high linearity (LIN = 0.96) and an incident angle close to that derived for the undistorted traces (Θ = 211° or 4° less than that for the undistorted traces).

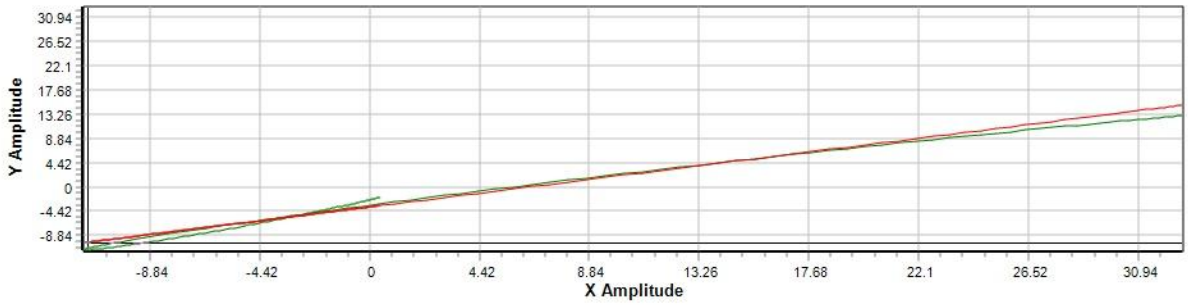

Figure 7. Hodogram of X and Y axis responses illustrated in Fig. 4. Linearity = 0.96 and X-Y plane incident angle = 211°.

Finally Figure 8 shows the generated full waveform (again with the full waveform mapped onto X axis and the residual onto the Y axis), but now there is little residual prior to 30 ms as the correct incident angle was used. Therefore the first trough and the first peak of the full waveform can now be used for the remainder of the analysis.

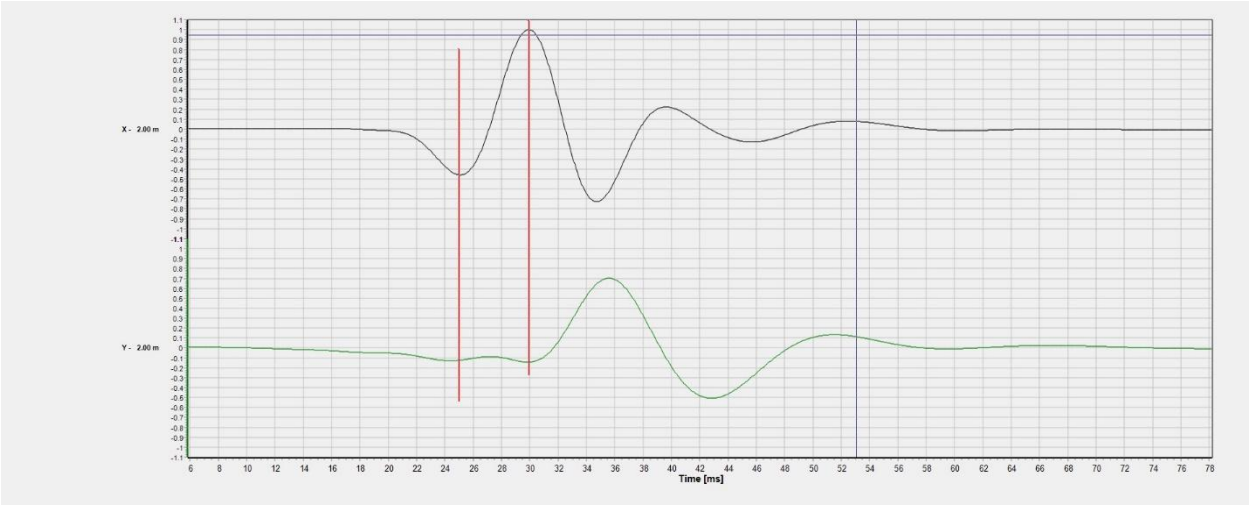

Figure 8. Full waveform (mapped to X axis) after applying PA ((Θ = 211°) to the traces illustrated in Figure 7.

Obviously when applying IPA selecting the correct time window is essential, but at the same time the time window cannot be too short. It is recommended that the user specified window is at least ½ of the source wave period, which in case of an 80Hz dominant frequency equates to approximately 6.25ms.

Erick Baziw
Gerald Verbeek