3D-3C Seismic Data
for Reservoir Characterization

iReservoir has developed a complete workflow to interpret, invert, and analyze multicomponent seismic data and incorporate the results into the rest of the reservoir characterization, geomodeling and flow simulation workflow.

Our workflow starts by conventional structural interpretation of PP data and continues with interpretation of PS data in a way that is consistent with PP data. The interpretation of PS data usually yields geologic features not easily seen in PP data.

The analysis of traveltime and amplitude information of different shear components of a 3C survey yields a wealth of information that in some cases can also be extracted from pre-stack PP data as long as the azimuthal coverage is adequate and pre-stack noises can be successfully removed. If these two conditions cannot be met, 3C post-stack data provides an excellent alternative for the estimation of shear impedance and azimuthal anisotropy of the subsurface. The joint interpretation of acoustic and shear impedances estimated from seismic data can help to understand rock, fluid, and fracture variability in the reservoir. Azimuthal anisotropy can help in the problem of fractured reservoir characterization.

Pseudo-Shear Impedance Formulation

Valenciano and Michelena (2000) show that the result of inverting stacked PS data is a pseudo shear impedance $\overline{Zs}$ that relates to the real shear impedance of the medium Zs through the formula:

$$\overline{Zs} = Zs\rho^{(0.25Vp/Vs-0.5)}$$

where is ρ the density of the medium and Vp/Vs is the ratio of compressional and shear velocities. This equation can be used for two purposes. First, it can be applied to log data to transform shear impedance logs into pseudo shear impedances that can help interpretation of inversion results of stacked PS data. Log scale pseudo shear impedances can be used to compute near offset reflectivities that in turn can be used to compute synthetic stacked PS traces using the convolutional model of the seismic trace. Second, it can be used to estimate real shear impedances from inverted pseudo shear impedances

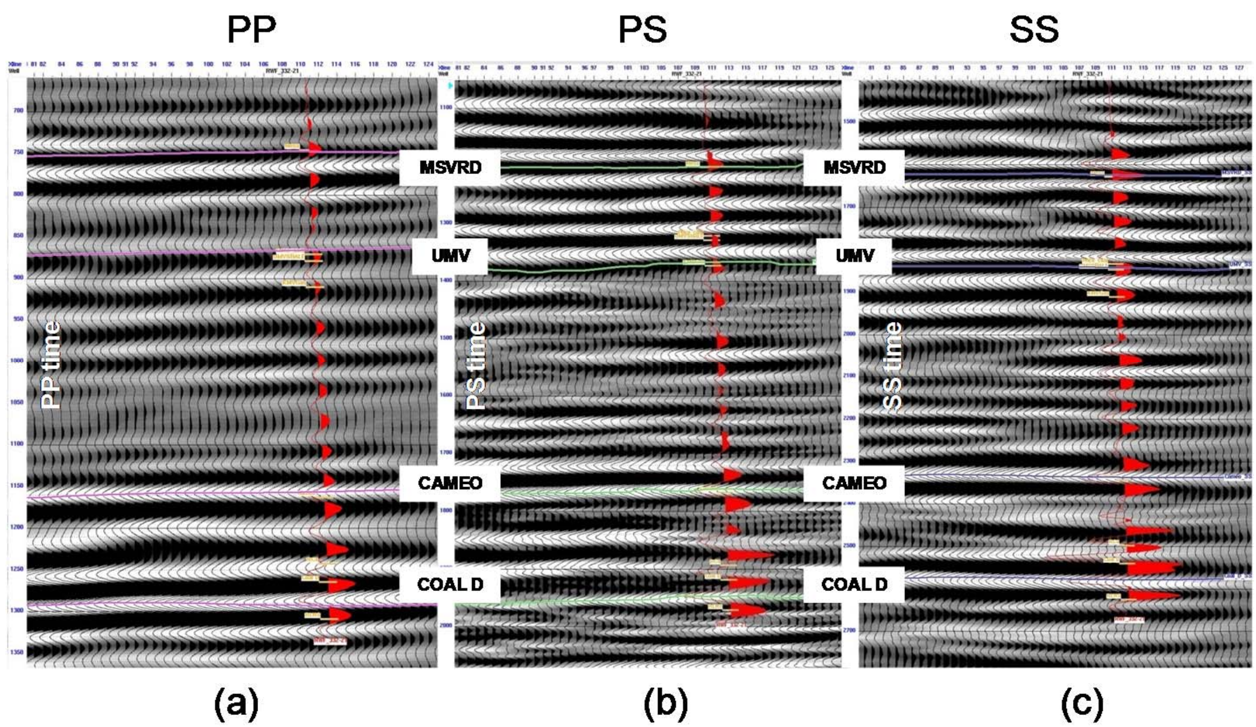

Figure 1. Multicomponent seismic data around reservoir interval. (a) Stacked PP data in PP time. (b) Stacked PS data compressed to PP time for displaying purposes. (c) Stacked SS data compressed to PP time for displaying purposes. No point-to-point registration of the different data sets has been performed. Synthetic seismograms generated at the well location are shown in red. Notice the good agreement between synthetic PP, PS and SS traces with their corresponding field traces. The correlation coefficients between synthetic and field traces are 0.87 for PP data, 0.69 for PS data, and 0.70 for SS data (Guliyev and Michelena, 2009).

3D-3C Seismic Data
for Reservoir Characterization (cont.)

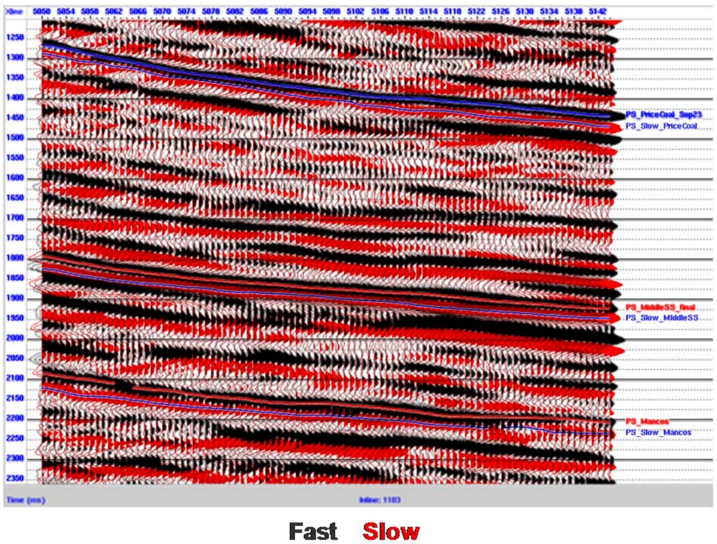

Figure 2. Comparison of fast and slow PS components of a 3C survey. Differences in traveltimes and amplitudes can be used to estimate changes in the anisotropy of the rocks which in turn may be related to variability of natural fractures.

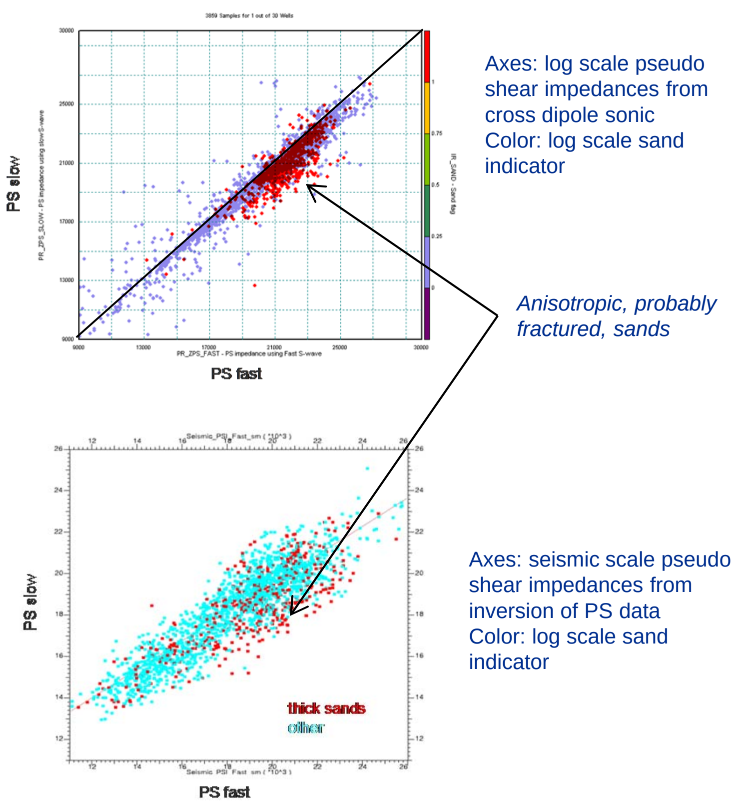

Figure 3. Comparison of crossplots of fast vs slow pseudo PS impedances at log scale and seismic scale. Red colors represent thick sands. Thick anisotropic and probably fractured sands tend to fall in areas of the crossplots away from the average background lines. The crossplot at seismic scale can be used as the basis to generate 3D volumes of fractured sands within the reservoir.

Workflow for interpretation and inversion of 3C stacked data

1) Tie PP seismic data to wells by using synthetic seismograms created from sonic and density logs and a wavelet representative of the field
2) Interpret PP data along markers of interest
3) Transform shear impedance logs into pseudo shear impedances.
4) Create a one way, PS time log (“DTPS”) by averaging compressional (DT) and shear times (DTS) from dipole sonic data.
5) Compute poststack PS reflectivities in PS time from pseudo shear impedances.
6) Tie PS seismic data to wells using synthetic seismograms created from pseudo shear impedance and DTPS logs and a wavelet representative of the field.
7) Interpret PS data along markers of interest (consistent with PP interpretation). Apply the same process to fast and slow components.
8) Generate average Vp/Vs model that honors all marker and horizon information in PP and PS time
9) Convert slow component into fast component using average traveltime anisotropy information
10) Convert PS data to PP time using average Vp/Vs model
11) Invert PS data for pseudo shear impedance in fast and slow directions. Low frequency background model is built by using pseudo shear impedances from different well locations.
12) Compute ratio of amplitudes of fast and slow components. Correlate with ratios of traveltimes
13) Calibrate with lithology, fluid and anisotropy information from well data