

## **Analysis Of Surface Seismic Multi Wave Modes (Pp, P-Sv And Sv-Sv) And Simultaneous 3d 3c Vsp: A Winning Pair**

Michel Denis<sup>1</sup>, Laurence Nicoletis<sup>2</sup>, Philippe Feugere<sup>1</sup>, Eric Suaudeau<sup>1</sup>

<sup>1</sup>Acquisition, CGG, Massy, FRANCE

<sup>2</sup>IFP, Rueil Malmaison, FRANCE

### **ABSTRACT**

Surface seismic acquisition and simultaneous 3D 3C VSP offer a unique way to understand and study the different wave modes generated and recorded with a conventional P acquisition and vertical vibrators. All the modes (PP, P-SV and SV-SV) present in the surface seismic data set have been calibrated using with walk away results acquired simultaneously with the surface seismic. A key conclusion was that even with a targeted PP surface acquisition, the converted mode P-SV has a significant level of energy and is always worth to be investigated. A full azimuth single component surface seismic has been acquired jointly with a 3D 3C VSP over a small surface patch of 4.5km<sup>2</sup>. The main geological targets were around 650m depth.

The surface source and receiver sampling was a carpet grid of 40m by 40m. Equipment used was basic such as 10Hz geophones and Nomads N65 vibrators. The VSP tool was a Slimwave of 12 3C levels and was rigged 3 times on adjacent depth simulating a 34 level.

We will show some results of the P-SV modes and in fact P-SV and SV-P modes as with small dips the 2 modes have the same move-out and may be superposed.

Another result was that the P-SV CCP binning using P signature deconvolution is significantly improved by P residuals and yet we should also correct for SV residuals for the receiver side unless it converts back into P mode in the WZ.

The SV-SV mode is also present on surface seismic and NMO corrected gathers with SV velocity show coherent events corresponding to main target. Stacks after SV wavelet deconvolution were compared to standard deconvolution and no major differences were observed. This suggest we should rather use SV statics from VSP to help reduce shaky determination of SV-SV residuals but keep standard surface consistent deconvolution to flatten the spectrum.

We will show a series of calibration examples for the PP mode and P-SV mode between surface seismic, walk-away and corresponding density logs and shear velocity logs.

The SV-SV mode calibration is more complex as this mode exhibits a polarity change versus angle of incidence. Because the SV-SV walkaway has a poor signal to noise ratio at small incidences we use the SH-SH reflection walkway to calibrate the SV-SV surface mode.

As a conclusion we observe that seismic calibration is quite excellent for all the modes and the difference in seismic bandwidth is striking between borehole and surface data.