[GC]Multicomponent Seismic Augments Seismic Stratigraphy Interpretation*

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General Statement

A fundamental thesis of elastic wavefield seismic stratigraphy (or multicomponent seismic stratigraphy) is that S-wave seismic data have equal value to P-wave data for geological interpretation. Seismic stratigraphy analyses, then, should be based on interpreting P and S data in combination (the full elastic wavefield) rather than restricting interpretation to only single-component P-wave data (traditional seismic stratigraphy).

An example illustrating differences between P-wave and S-wave definitions of reflecting interfaces and the rock physics principles that cause this behavior are discussed here. The particular S-wave mode used in this example is the converted-shear (PSV) mode.

Example

Marked contrasts between compressional-wave (P-P) and P-SV seismic sequences and seismic facies occur across numerous stratigraphic intervals. The example chosen for this discussion is from west Texas (Figure 1). The arrows on the P-P and P-SV images of this figure identify a significant difference between P-P and P-SV reflectivities for a targeted reservoir interval – the Wolfcamp Formation.

Well log data across the Wolfcamp interval local to this seismic profile are displayed on Figure 2. P-P and P-SV reflectivity behaviors are analyzed across the Wolfcamp interface, shown at a depth of approximately 10,300 feet, to demonstrate the geological reason for the difference in P-P and P-SV reflection amplitude strengths exhibited on Figure 1.

Compressional-wave and shear-wave velocities and formation bulk density values were averaged across 300-foot intervals immediately above and below this internal Wolfcamp interface, and these average rock properties were used to calculate the reflectivity curves shown as Figure 3. These curves confirm that for this particular interface, P-SV reflectivity is greater than P-P reflectivity when both reflectivity curves are evaluated over a large range of incidence angles.

For example, P-P reflectivity exceeds 0.04 only for incidence angles between 0 and 15 degrees, but P-SV reflectivity has a magnitude greater than 0.04 for incidence angles between 15 degrees and 45 degrees – an angle range that is twice as large as that of the high-amplitude P-P response.

Because the multicomponent seismic data across this study area were acquired with a full range of incidence angles, the difference in P-P and P-SV amplitude behavior shown on Figure 1 has a valid rock-physics basis. P-P amplitudes should be weaker than P-SV amplitudes, and the data exhibit that behavior.

Conclusion

The principle documented by this example is that an elastic wavefield seismic stratigraphy interpretation based on both P-P and P-SV data can provide a different – and often a more valid – geological model of seismic sequence boundaries and seismic facies than can a single-mode seismic stratigraphy interpretation based on P-P data only. Future applications of seismic stratigraphy probably will rely more and more on full-elastic wavefield seismic data than on only single-component seismic data.

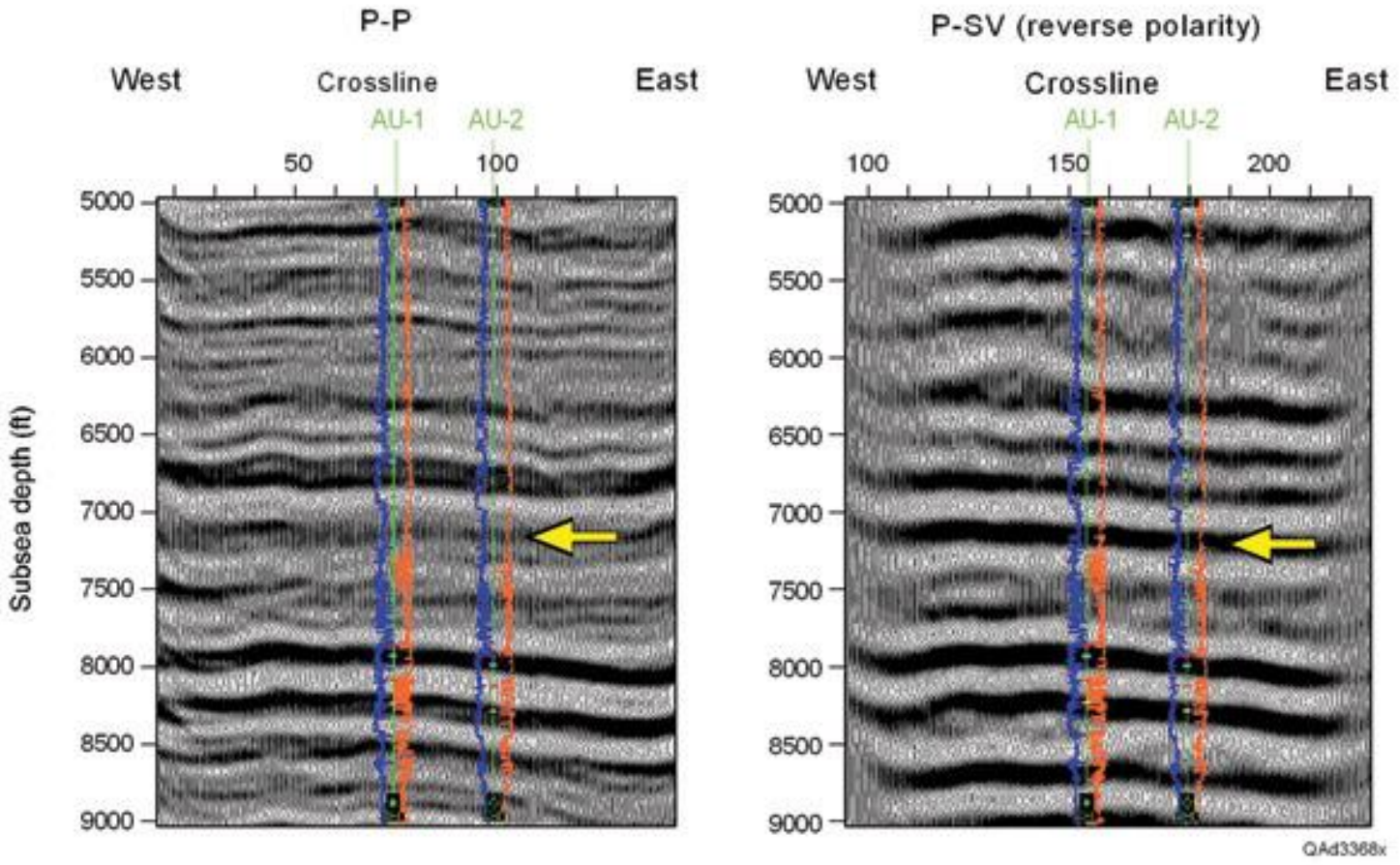

Figure 1. P-P and P-SV images centered on the Wolfcamp (arrows). P-P data exhibit a low-amplitude seismic facies that is difficult to interpret; P-SV data produce a high-amplitude seismic facies. Data provided by Fasken Oil and Ranch.

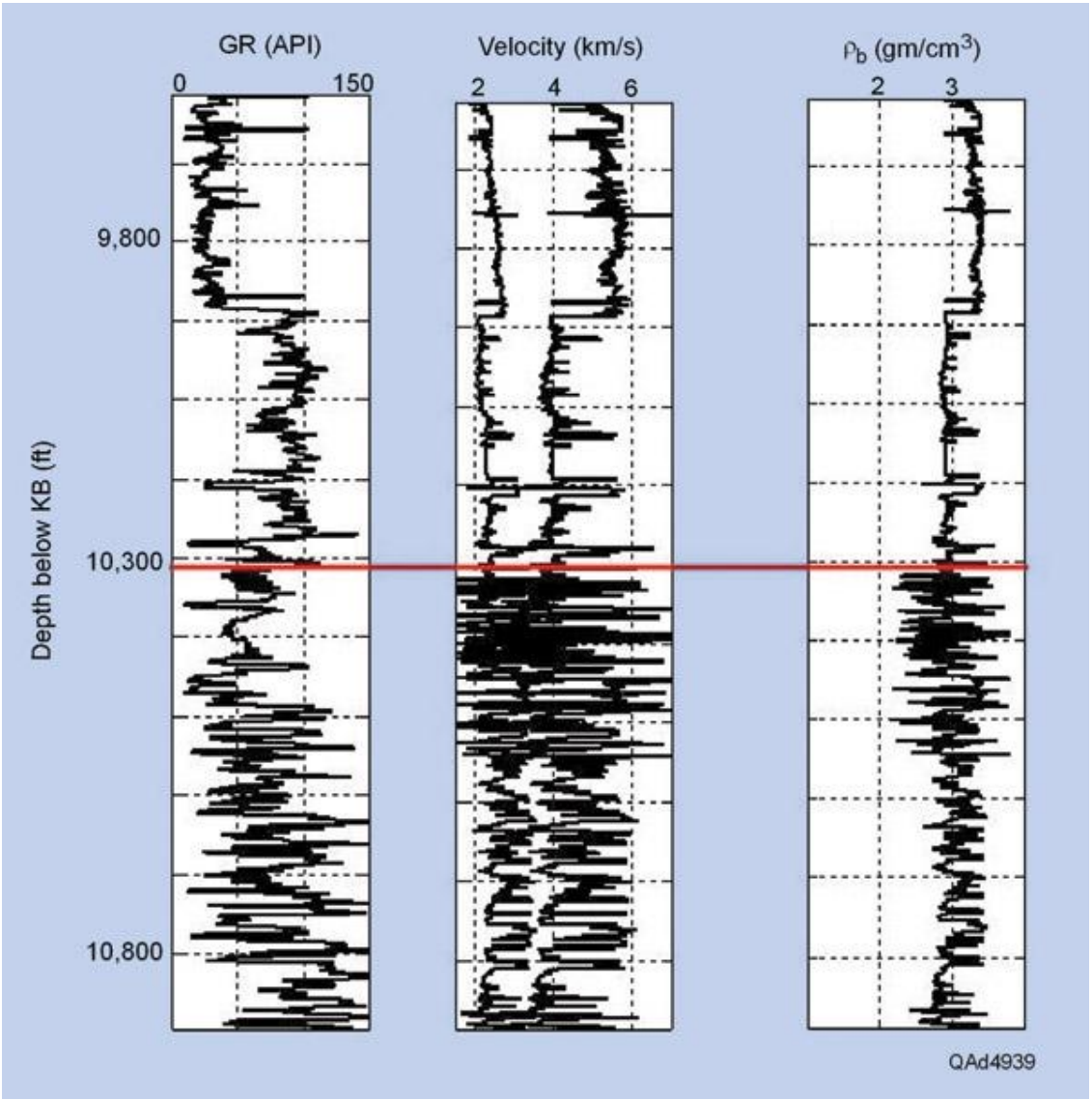

Figure 2. Log data across the Wolfcamp interval (9,714 to 10,902 feet KB). The velocity curve on the left of the center panel is shear velocity, VS. The curve on the right is compressional velocity VP. Wolfcamp reflectivity was evaluated at the interface drawn at approximately 10,300 feet (3,149 meters).

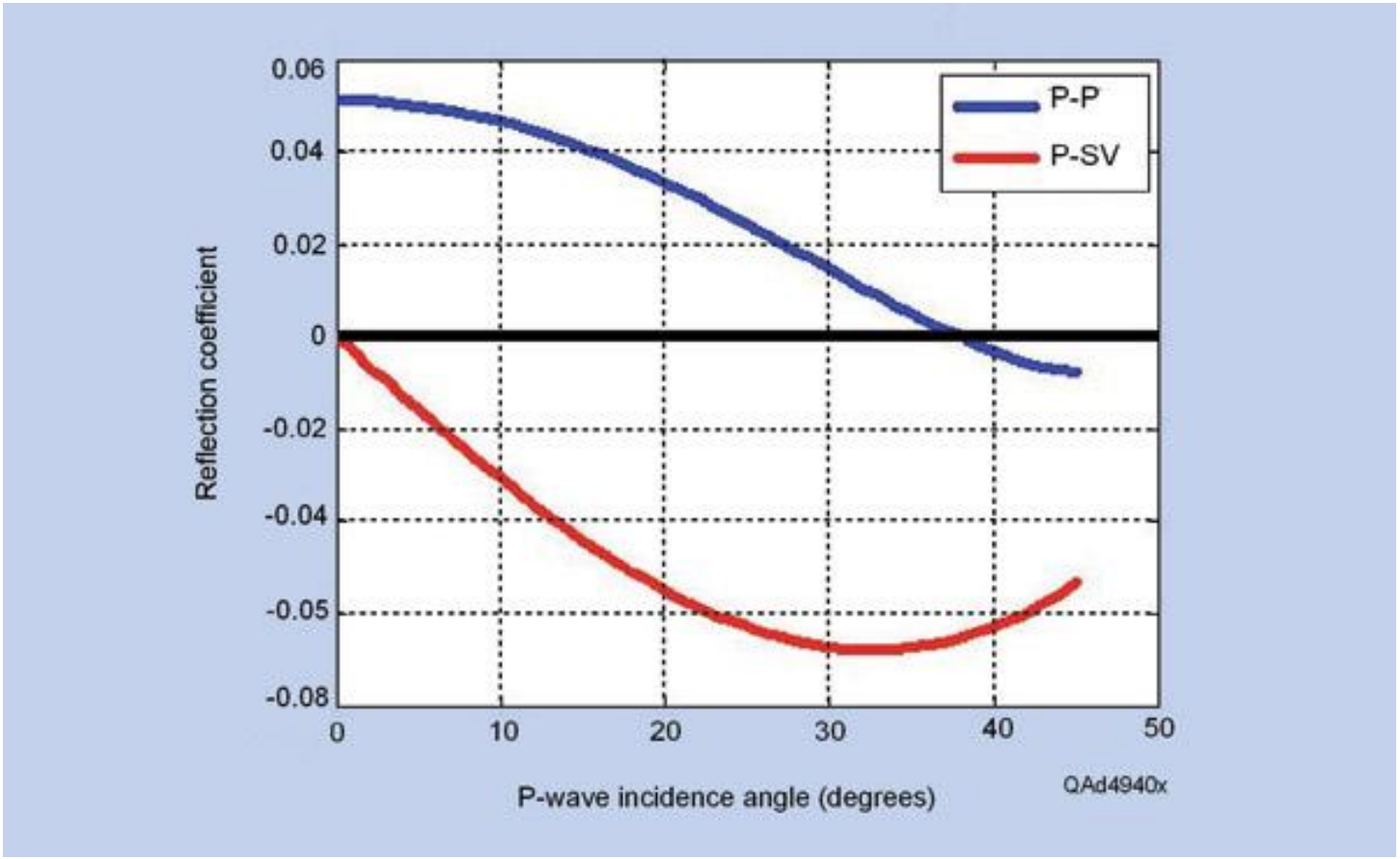

Figure 3. P-P and P-SV reflectivities at the Wolfcamp interface, at approximately 10,300 feet (3,140 meters).