Examples of SV-P Images Made with P Sources

Introduction

Industry reaction to the concept of practicing S-wave reflection seismology with P sources shows that the greatest appeal to end users is to create SV-P images from P-source data recorded by vertical geophones. This option not only allows low-cost S-wave information to be acquired in future P-source seismic programs but allows S-wave images and attributes to be extracted from legacy P-source data. This brochure shows examples of SV-P images. In every example, the data used in imaging are legacy data acquired several years before SV-P imaging was initiated.

P-P, SV-P, P-SV Semblance Stratal Slices Through a “Conventional” Wolfberry Reservoir Interval: Well No. 3

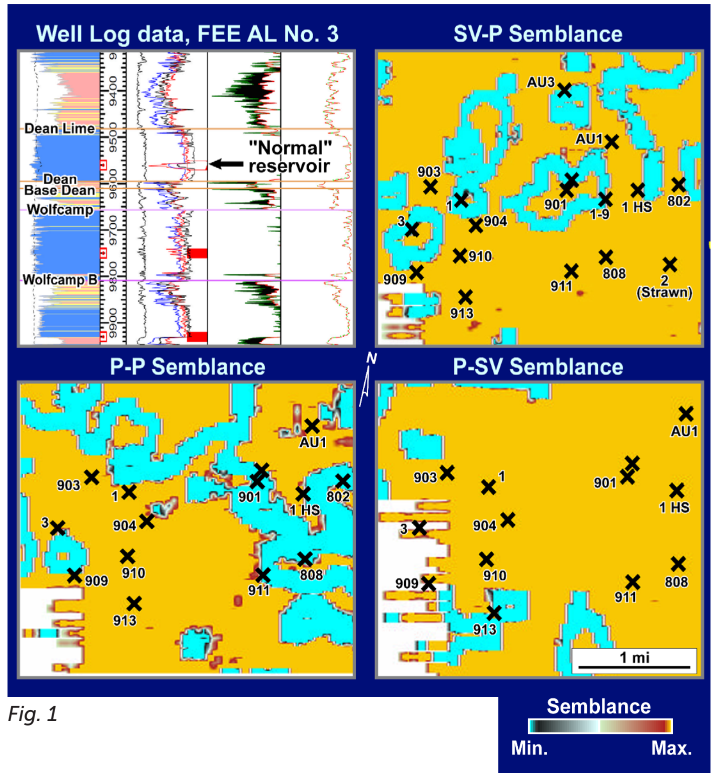

Fig. 1

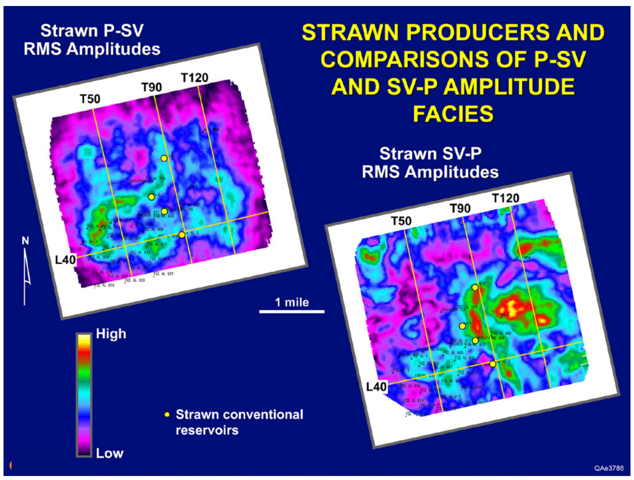

Fig. 2

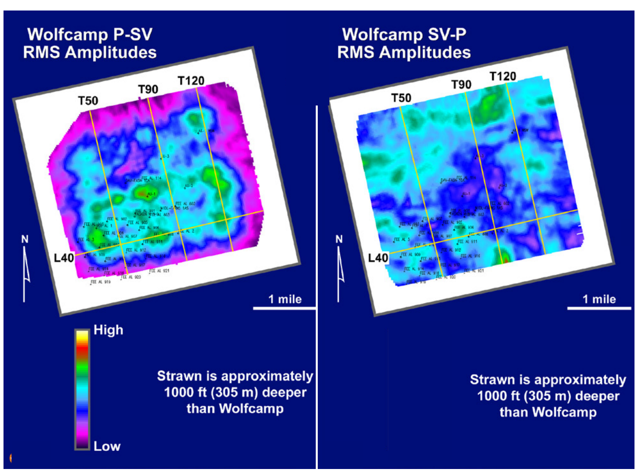

Fig. 3

Defining Reservoir Compartments

Fig. 1 summarizes a study that was done to understand why a producing reservoir could not be found by surrounding wells. This particular reservoir was a normal-porosity unit that is sometimes found when drilling the low-porosity Wolfberry unconventional reservoir system of the Midland Basin. The logs in Fig. 1 were acquired in well 3, shown in the lower left corner of the seismic maps, that penetrated such a high-porosity reservoir. This high-porosity unit was not found in any of the 6 wells that surround well 3. The parameter plotted in the 3 seismic maps is semblance, a quantity that detects significant changes in reflection waveform character. The pattern of SV-P minimum semblance that encircles well 3 implies the targeted high-porosity unit does not extend to any surrounding well. The fact that P-P and P-SV semblance fails to show the same conclusion is due to the fact that well 3 is at the edges of these latter 2 images where their image fold is low. These data were acquired with a (2 mi) X (2 mi) grid of receivers centered inside a (3 mi) X (3 mi) grid of source stations. The SV-P image spans a large area that attempts to extend across all source stations, but P-P and P-SV images cover smaller areas that cause low image fold at well 3. The source was an array of 3 inline vertical vibrators.

Avoiding Acquisition Footprints

Fig. 2 shows P-SV and SV-P images that associate 4 producing wells (yellow dots) with a trend of bold reflection amplitudes. However, the 2 images are quite different, and theory says P-SV and SV-P images should be identical. The amplitude anomalies in the P-SV image are suspicious because they follow linear trends that match the directions of source and receiver lines. To confirm that an acquisition footprint is present, the P-SV and SV-P images were examined at a distance approximately 1000-ft higher in the geological section. These shallower images are shown in Fig. 3. The same acquisition footprint exists in the shallower P-SV data, and again there is no hint of an acquisition footprint in the SV-P data. The reason why an acquisition footprint exists in P-SV data but not in SV-P data in this instance is a puzzle which no one has yet solved. A carry-away message is that it is possible for an acquisition footprint to appear in one converted-mode image but not in its companion converted-mode image. The source in this instance was an array of 3 inline vertical vibrators.

Illuminating Reservoir Targets in Gas-Saturated Sections

This study was done by Chinese colleagues who were confronted with the problem that gas reservoirs at a prospect could not be seen with P-P data. A SV-P imaging effort was done to determine if SV-P imaging would be of value. The P-P and SV-P images extracted from the same vertical-geophone data are shown in Fig. 4 (top half of figure is the P-P image; bottom half is the SV-P image). Not only does the SV-P image show the reservoir, but the increase in resolution is most impressive. This dramatic increase in resolution might cause some to conclude that the SV-P image cannot be showing accurate geology. However, when a basic wavelet is extracted from the SV-P data and used to construct a synthetic seismogram from log data acquired in well A1 on the profile, the synthetic data match the SV-P image quite well (Fig. 5). Horizons H1 and H2 labeled on Fig. 5 are identified in Fig. 4. In this case the source was buried explosives.

Implications

1. SV-P imaging with data generated by a P source and recorded with vertical geophones produces valuable geological information.
2. SV-P images can definitely be made from much, hopefully almost all, legacy P-source data.
3. Software is needed that allows efficient joint interpretation of P and S data (an expansion of Paradise software by Geophysical Insights).

Comparison of P-P and SV-P Images Across Gas Field (Vertical-Geophone Data; Explosive Source)

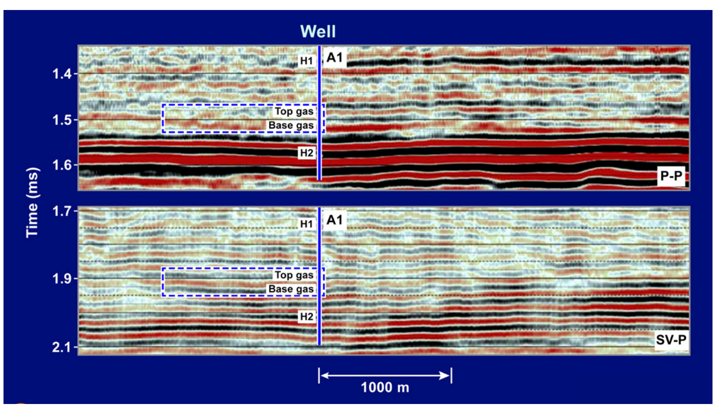

Fig. 4

Comparison of SV-P and P-P Image Traces and Synthetic Seismograms at Well Location (Vertical-Geophone Data; Explosive Source)

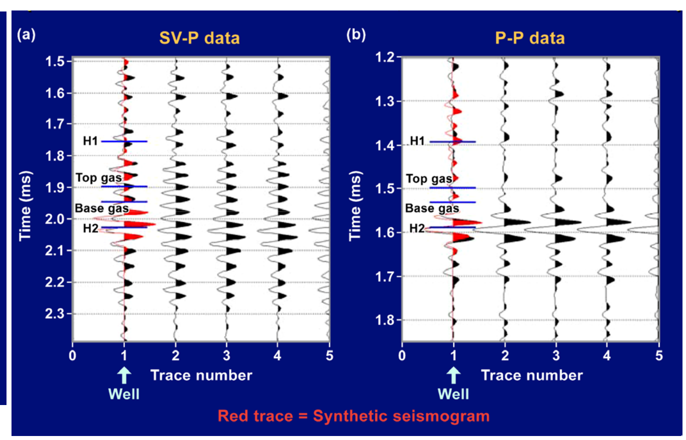

Fig. 5

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