Analyses of P-P Stacking Velocities Also Reveal SV-P Stacking Velocities

Introduction

SV-P images should be created by utilizing common-conversion-point (CCP) binning of vertical-geophone data, which are image coordinates where downgoing direct-SV wavefields convert to upgoing P reflections. However, SV-P images that are approximately correct can also be created using common-midpoint (CMP) binning of vertical-geophone data. Fig. 1 shows both CMP and CCP versions of SV-P images constructed from vertical-geophone data when using a horizontal vibrator, the gold standard S source. The presence of this CMP-based SV-P image means that if a P source also generates illuminating SV wavefields, then SV-P stacking-velocity information will be present in P-source, CMP-based, stacking-velocity analyses of vertical-geophone data. Where then do we look in traditional CMP velocity analyses created to produce P-P stacking velocities and identify SV-P stacking velocities?

Image Quality ≠ Image Accuracy

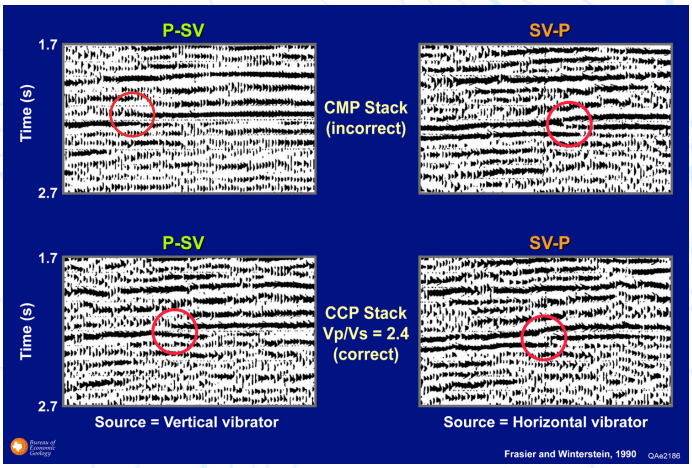


Fig. 1 SV-p images (right side) were made using a horizontal vibrator source, not a P source

CMP Constant-Velocity Analysis of Vertical-Geophone Data Provides Both P-P and SV-P Stacking Velocities

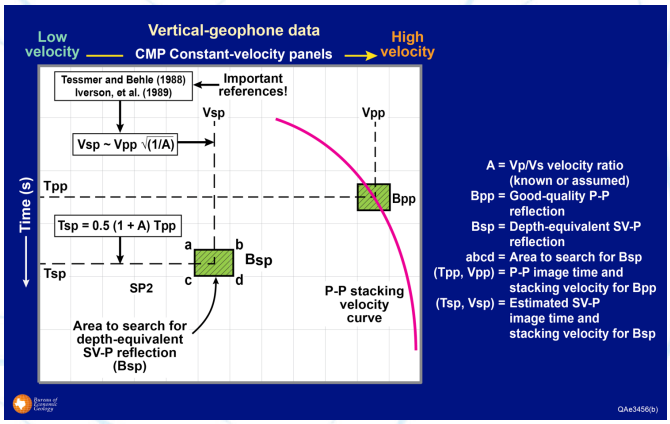


Fig. 2

Procedure That Identifies SV-P Stacking Velocities

The concept of identifying both P-P and SV-P stacking velocities in CMP-based, constant-velocity stacks of P-source, vertical-geophone data is illustrated in Fig. 2. In this drawing, a data processor has created a P-P stacking velocity function (red curve) that identifies a high-quality P-P reflection event **Bpp** that appears at time **Tpp** on stacking-velocity panel **Vpp**. The SV-P reflection **Bsp** that is depth-equivalent to P-P reflection **Bpp** should occur at a later time **Tsp = 0.5(1+y)Tpp**, where **y** is the **Vp/Vs** velocity ratio for this prospect, and on a slower-velocity panel **Vsp** defined by **Vsp = Vpp x (square root of [1/y])**. Developers of this velocity relationship are identified in Fig. 2. If a good-quality reflection exists within a modest-size search area **abcd** centered on coordinates **(Vsp, Tsp)** determined by these two simple equations, a data processor then knows (1) SV-P reflections were generated by the P source that produced the data, and (2) the SV-P stacking velocities that can be used to create a SV-P image to first-order accuracy.

Real Data Example

A panel of CMP, constant-velocity stacks of P-source, vertical-geophone data is exhibited in Fig. 3. The red curve is the P-P stacking velocity function identified at this CDP location. Two P-P reflections **A** and **B** are identified with red circles. Applying the procedure shown in Fig. 2 to these P-P reflections indicates that depth-equivalent SV-P reflections should occur at green circles **A** and **B**. This survey was acquired with 3C geophones, and a companion P-SV image was created from horizontal-geophone data. The P-SV stacking velocity function defined by horizontal-

geophone CCP stacks (not CMP stacks!) at this same CDP is shown as the green curve. This green curve passes through green circles **A** and **B** predicted from CMP stacks of vertical-geophone data when **y** is assigned a value of 1.7 that is appropriate for this prospect. This example illustrates that SV-P stacking velocities estimated from CMP velocity analyses of vertical-geophone data are equivalent to P-SV stacking velocities determined from CCP stacks of horizontal-geophone data.

CMP-Based Constant-Velocity Stacks of Vertical-Geophone Data

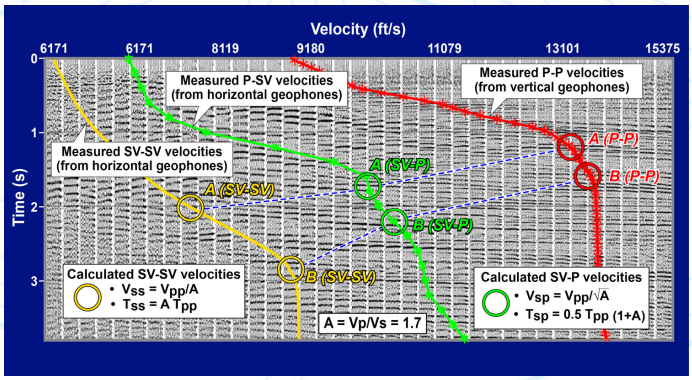


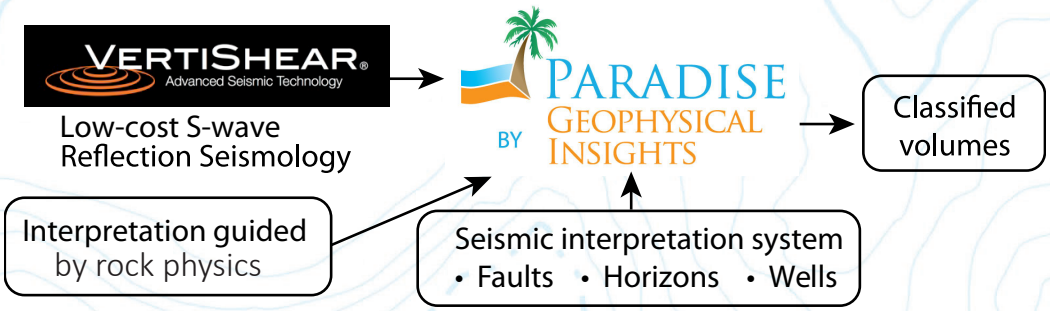
Fig. 3

Possible Evidence of SV-SV Reflections in P-P CMP Velocity Analyses

Also shown in Fig. 3 are yellow circles **A** and **B** that indicate where SV-SV reflections that are depth-equivalent to red P-P reflections **A** and **B** would appear in CMP stacks of P-source, vertical-geophone, data if SV-SV reflections activate vertical geophones to any degree. Searches for SV-SV reflections in vertical-geophone data often are fruitless, but they are quick analyses that should be done. In this example, there is evidence that SV-SV reflection **B** is present. These occasional successes of identifying SV-SV reflections in CMP stacks of vertical-geophone data build stronger confidence that a P source is generating effective illuminating SV wavefields.

Conclusions

1. Examination of P-P stacking-velocity analyses created from legacy P-source data is of great value for determining if SV-P reflections are present in the data.
2. Procedures described in this brochure define SV-P stacking velocities to first-order accuracy.
3. Processing and interpretation of P-source data should be based on the principle that P-P and SV-P modes are always intertwined in responses of vertical sensors, and P-V and SV-SV modes are intertwined in responses of horizontal sensors.



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