3-D P- and S-wave inversion

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ABSTRACT

Procedures to invert P-wave and P-Sv wave reflectivity for underlying P- and S-wave velocity have been developed in the past. P-wave inversion has advanced to the stage of commercial 3-D seismic packages. We propose to extend the 3-D P-wave inversion procedure to that of S waves. The S-wave inversion will use two processes: a post-stack P-Sv trace inversion for S velocity and a pre-stack coupled P and P-Sv inversion for both velocities.

INTRODUCTION

Seismic reflectivity often provides an excellent structural picture of the subsurface. With suitable interpretation, stratigraphic details can also be inferred. However, our main goal in seismic surveying for petroleum is to find lithologic type and the presence of fluids. Seismic inversion is the process by which the seismic reflection amplitude is converted to velocity (Lindseth, 1979; Russell, 1988). This conversion process is, unfortunately, prone to non-uniqueness and is susceptible to error. But, the resultant velocity is a rock property and can be related to rock type, porosity, and pore fill. Thus seismic inversion is a desirable, but somewhat subjective, procedure.

Many algorithms have been developed to turn amplitude into velocity. Some of these use a single seismic trace at a time (e.g., Lindseth, 1979) while others operate on pre-stack data gathers (e.g., Smith and Gidlow, 1987). While most algorithms have attempted to estimate P-wave velocity, a growing number also try to find Poisson's ratio or the S-wave velocity. This proposal addresses two possible methods to find the S-wave velocity.

METHODS

The first method will operate on **post-stack** data and convert the P-SV seismic trace into an S-wave velocity (Figure 1). There are two basic ways to do this: i) use a recursive relationship between P-Sv reflectivity and velocity to define the high-frequency component of the velocity, then from another source add in the low-frequency components (Stewart, 1991) or ii) use general linear inversion (GLI) to perturb a velocity model and, with an estimated wavelet, minimize the mismatch between the calculated trace and the observed seismogram (Hampson and Russell, 1992a).

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The second method will use **pre-stack** P-P and P-SV gathers to attempt to estimate the P and S velocities (Figure 2). Again, there are two main approaches: a coupled, weighted stack of both P and P-Sv gathers to find a least-squares estimate of the velocities (Smith and Gidlow, 1987; Stewart, 1990; Vestrum and Stewart, 1993) and a GLI inverse (Hampson and Russell, 1992b) technique. In the GLI technique, the field data are first modeled by convolutional seismograms generated from an estimated wavelet and a velocity model. These offset-varying traces have amplitudes calculated from the Zoeppritz equations. The velocity model is perturbed until the calculated and observed (field) traces are matched closely enough.

SUMMARY

We have briefly outlined methods to calculate P- and S-wave velocity from P- and P-SV wave reflectivity. P-wave inversion has advanced quite far in the last decade to the stage of commercial 3-D packages. We propose to extend the 3-D P-wave inversion procedures, through the use of pre-stack and post-stack P-Sv data, to include S-wave velocity estimation also.

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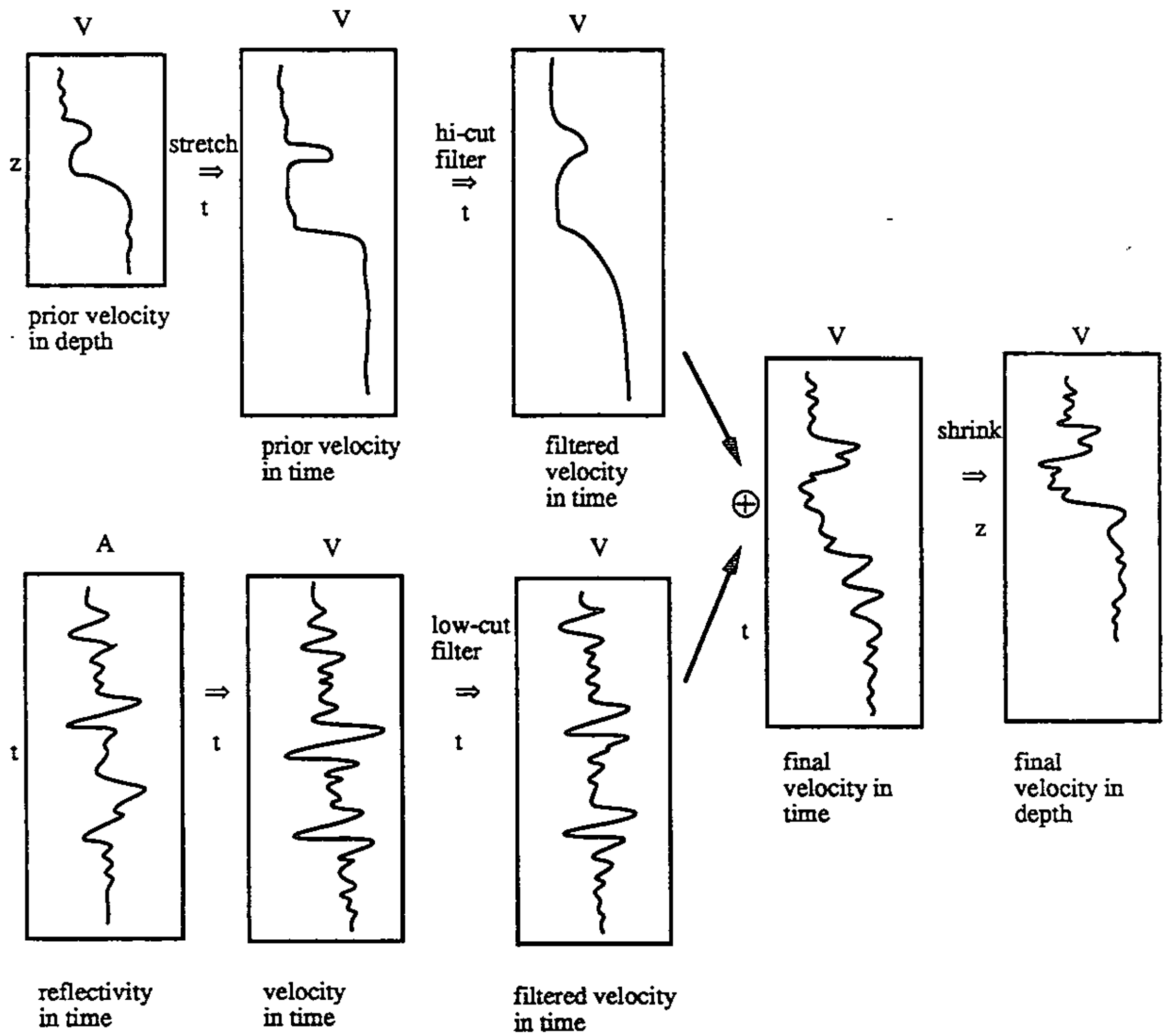

FIG. 1. Block diagram of the post-stack seismic inversion process (Stewart and Foltinek, 1993).

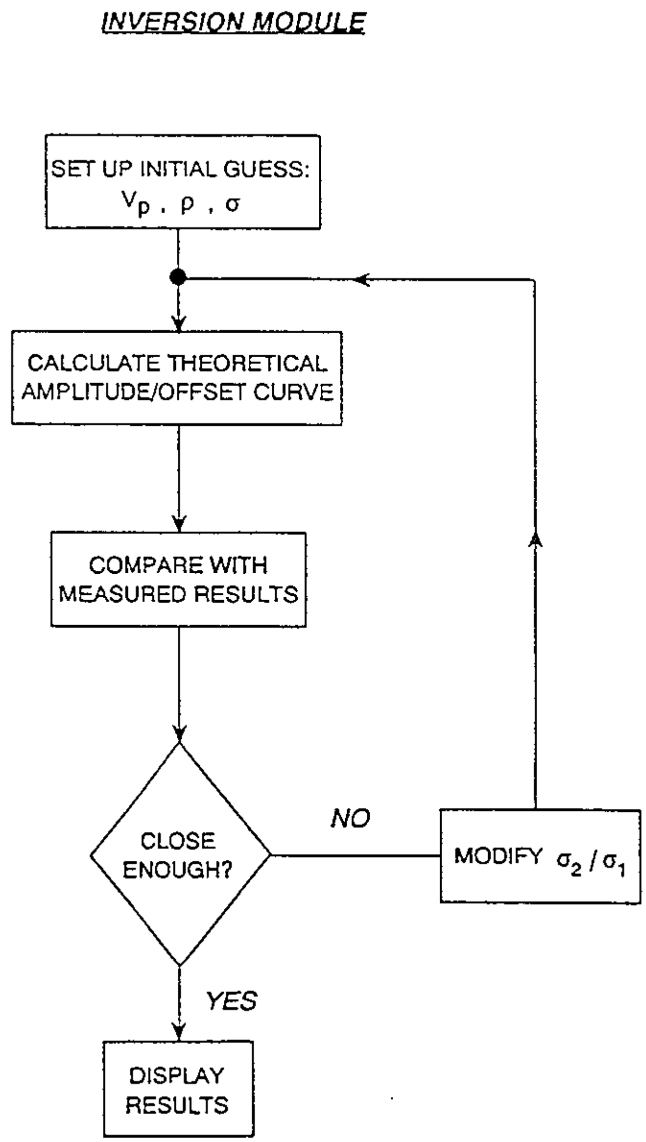

FIG 2. Block diagram of the pre-stack seismic inversion process for offset data at one boundary (Hampson and Russell, 1992b).