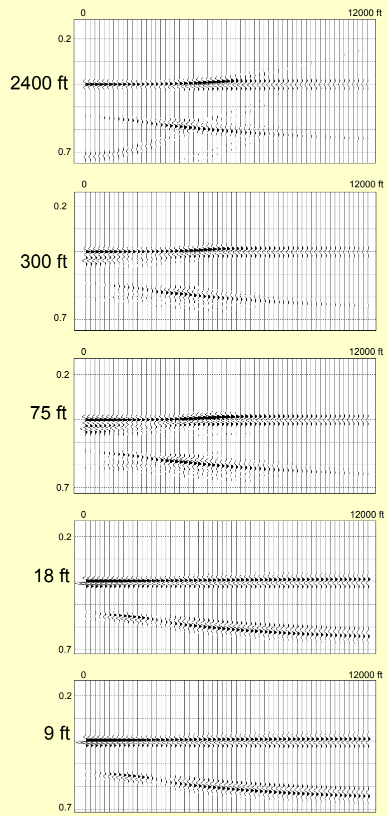
AVO Reflectivity Responses: Pitfalls of High-velocity Layers

Fred Hilterman and Connie J. VanSchuyver
University of Houston

Thickness Variation
High-Velocity Layer

	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25
2000 ft	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25
Variable	Vp = 15000 Vs = 8655 ρ = 2.54 Poisson's ratio = 0.25
	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25



One of our missions is to examine the variation of reflection amplitude with frequency and offset angle. To this end, we have turned to simple reflectivity models for insight. These models reflect some of the earlier work by Simmons and Backus (2001) and Al-Otaibi (2001) who showed unexpected amplitude variations starting at offsets greater than depth. Our current physical modeling data will also be investigated to verify these simple numerical models. Our preliminary evaluation indicates that the physical models with fractures tend to disturb the amplitude of head waves, so we are numerically investigating head waves.

We have known for many years that bed thickness affects amplitude (Widess, 1973). Our investigation of high velocity bed thickness indicates that the head wave is detectable for the very thick bed (2400 ft) but affects the apparent reflection amplitude in less thick beds. The difference between 300 ft and 75 ft thick beds is only seen in the amplitude of the near offsets and those around critical angle. The difference between 18 ft and 9 ft bed thickness is a very subtle amplitude change at the near offsets and the wavelet does not change phase beyond critical angle.

Fractures affect the shear-wave velocity and therefore Poisson's ratio. Our investigation of the effects from changes in Poisson's ratio shows that for low Poisson's ratios the head wave is strong at the top of the bed while its asymptotic partner, the base reflection, has very weak amplitude. Conversely, for a high Poisson's ratio, the base reflection is very strong but there is little or no amplitude associated with the head wave.

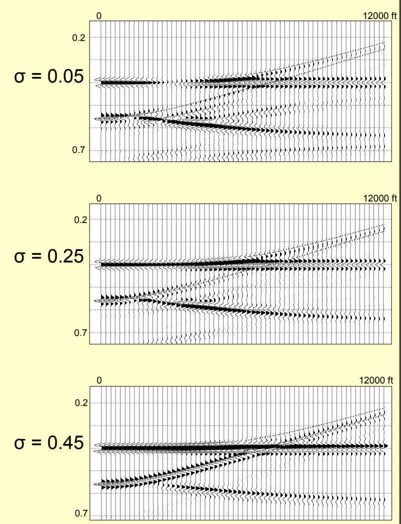
Most beds in the real world do not have sharp contrasts as in the previous models. To investigate the reflection effects of gradational boundaries at large offsets, we have modeled several examples of transitional boundaries, for both higher- and lower-impedance beds. While the top and base reflections are easily detected for the blocky example, only the boundary with strong impedance contrast is apparent for transitional beds. Further, for a bed with transitional boundaries at both top and base, the only reflection is from the point of maximum difference, either high or low.

References:

Al-Otaibi, M., Marfurt, K., Zhou, H., Hilterman, F. and Kabir, N., 2001, Effect of velocity transition zones on the apparent polarization of ocean-bottom cable multicomponent data, 71st Ann. Internat. Mtg: Soc. of Expl. Geophys., 1253-1256.
Simmons, J. and Backus, M., 2001, Shear waves from 3-D-9-C seismic reflection data. Have we been looking for signal in all the wrong places?: The Leading Edge, **20,** no. 6, 604-612.
Widess, M.B., 1973, How Thin is a Thin Bed?, Geophysics, **38**, 1176-1180.

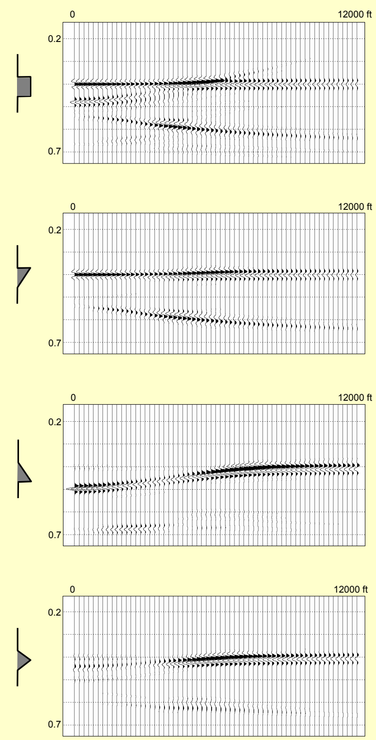
Poisson's Ratio Variation
High-Velocity Layer

	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25
2000 ft	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25
1200 ft	Vp = 15000 Vs = 8655 ρ = 2.54 Poisson's ratio = ?
	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25



Transitional Zone
High-Velocity Layer

	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25	
2000 ft	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25	
600 ft	Vp = 15000 Vs = 8655 ρ = 2.54 Poisson's ratio = 0.25	← Transitional
	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25	



Transitional Zone
Low-Velocity Layer

	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25	
2000 ft	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25	
150 ft	Vp = 6000 Vs = 3462 ρ = 2.02 Poisson's ratio = 0.25	← Transitional
	Vp = 10000 Vs = 5770 ρ = 2.30 Poisson's ratio = 0.25	

All plots reverse polarity