Compensating for the effects of fine-layering on AVA

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Introduction

It is well known that the relation between the angle-dependent reflectivity of an interface in a target zone and the amplitude-versus-offset (AVO) effects observed in the seismic data at the surface is complicated by many factors (Ostrander, 1984, Geophysics **49**, 1637-1648). Some of these factors are "reflection related" (such as thin bed tuning) others "propagation related" (such as transmission losses) or "acquisition related" (such as source directivity). In this paper we address the propagation and reflection related *apparent* amplitude-versus-angle (AVA) effects of finely layered media and we discuss how to compensate for these effects in migration.

The generalized primary response $\tilde{P}^-(p, z_0, \omega)$ reads in the rayparameter-frequency (p, ω) domain,

$$\tilde{P}^-(p, z_0, \omega) = \int_{z_0}^{\infty} \tilde{W}_g^-(p, z_0, z, \omega)\tilde{R}^+(p, z)\tilde{W}_g^+(p, z, z_0, \omega)S(\omega)dz, \tag{1}$$

where S is the source function, $\tilde{W}_g^+$ and $\tilde{W}_g^-$ are the generalized primary propagators and $\tilde{R}^+$ is the reflection function. The generalized primary propagators include internal multiple scattering and thus account for the angle-dependent dispersion effects due to fine-layering (apparent AVA).

Downward extrapolation, based on the generalized primary representation (1), involves

$$\tilde{P}^-(p, z, \omega) = \tilde{F}_g^-(p, z, z_0, \omega)\tilde{P}^-(p, z_0, \omega)\tilde{F}_g^+(p, z_0, z, \omega), \tag{2}$$

where $\tilde{F}_g^{\pm}$ is the inverse of $\tilde{W}_g^{\pm}$. This compensates for the propagation related apparent AVA effects of fine-layering.

Angle-dependent imaging involves

$$\langle\tilde{R}^+(p, z)\rangle = \frac{2\cos\bar{\phi}(p, z)}{\pi\bar{c}(z)}\Re\int_{\omega_1(z)/\cos\bar{\phi}(p,z)}^{\omega_2(z)/\cos\bar{\phi}(p,z)}\left(\frac{\tilde{P}^-(p, z, \omega)}{S(\omega)}\right)d\omega, \tag{3}$$

where $\Re$ denotes that the real part is taken. The p-dependent ω-integration interval compensates for the p-dependent apparent wavelength λ_z (Figure 1) and thus removes the reflection related apparent AVA effects due to interference.

The example in Figures 2 through 4 shows that $\tilde{R}^+(p, z)$ is accurately recovered. A proposal for extensions to more dimensions will be discussed during the presentation.

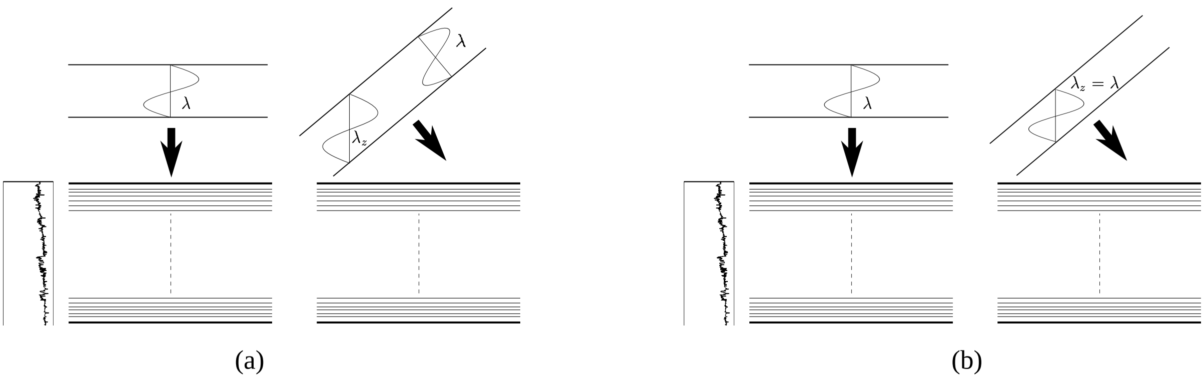


Figure 1: (a) At different angles the medium is observed at different "scales" ($\lambda_z \neq \lambda$), which causes apparent AVA. (b) Imaging according to equation (3) "equalizes" the apparent wavelength λ_z and thus removes the apparent AVA.

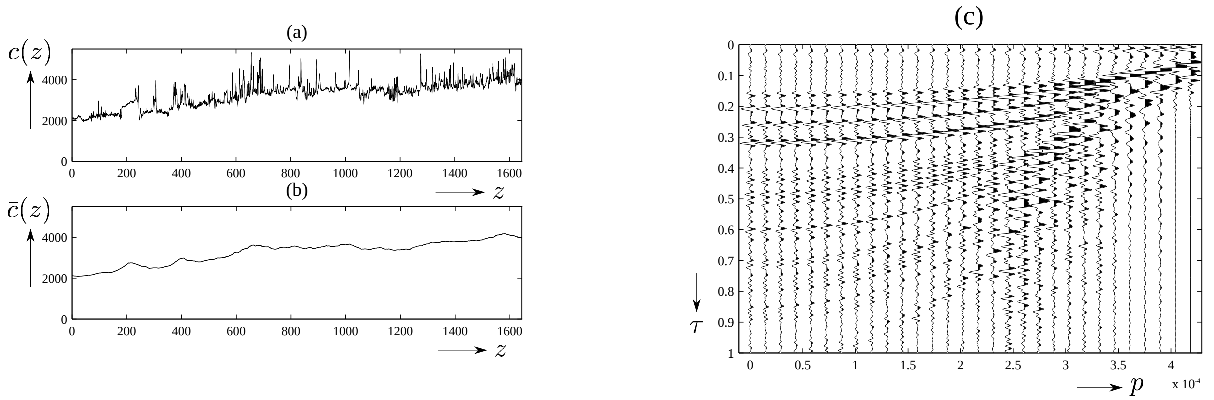
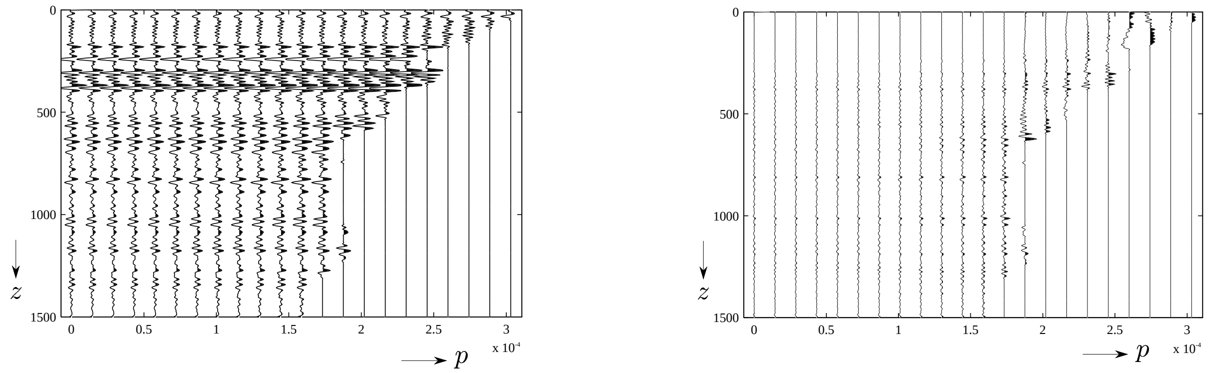


Figure 2: (a) Velocity log. (b) Macro model. (c) Plane wave reflection response, including all internal multiples.



(a) (b)

Figure 3: (a) Result of generalized primary migration (eqs. 2 and 3). (b) Difference with true reflectivity (bandfiltered).

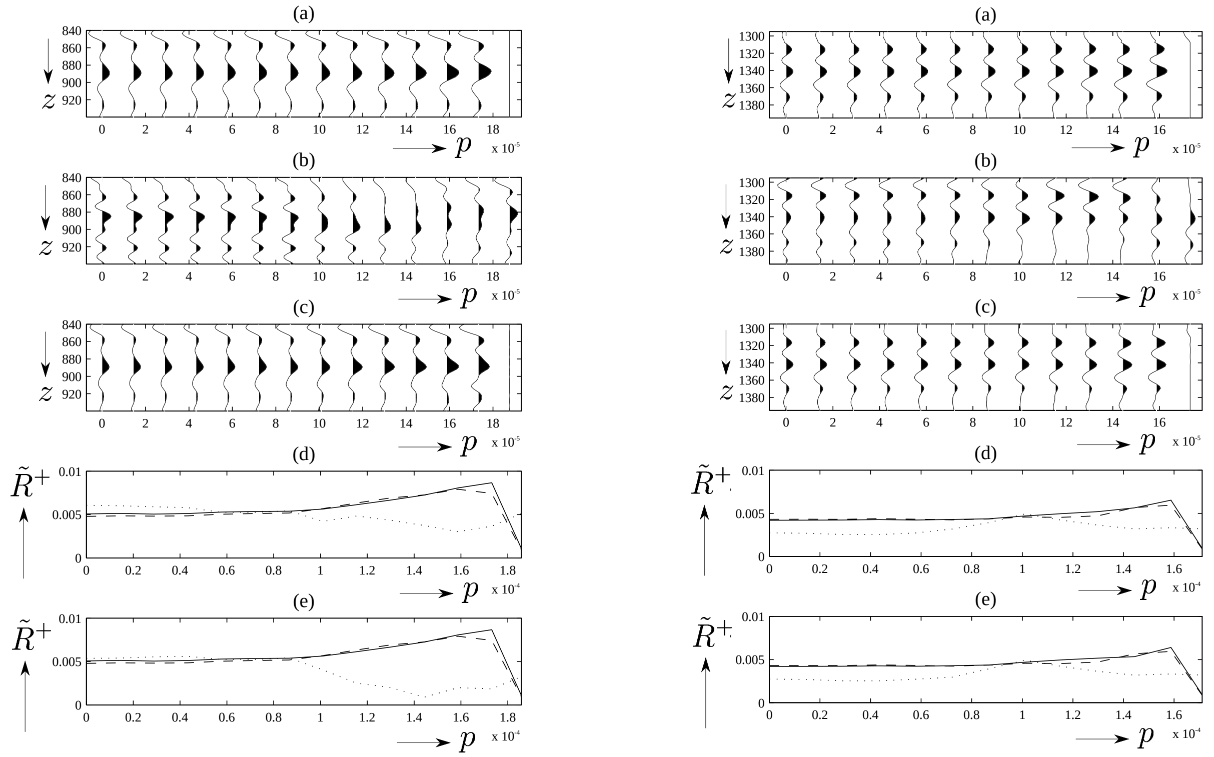


Figure 4: Left column: Reflectivity sections around $z = 890$ m. (a)True reflectivity (bandfiltered). (b) Primary migration result, constant ω-integration interval. (c) Generalized primary migration result, p-dependent ω-integration interval. (d) Picked amplitudes in a small band around $z = 890$ m [solid: (a), dotted: (b), dashed: (c)]. (e) Picked amplitudes exactly at $z = 890$ m. Right column: Reflectivity sections around $z = 1345$ m.