

C041 TRUE AMPLITUDE MIGRATION TAKING FINE LAYERING INTO ACCOUNT

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The underlying assumption of any migration scheme is that a macro model of the subsurface accurately accounts for the propagation effects from the acquisition surface to the target and vice versa. A macro model consists of a number of geologically oriented macro layers, separated by macro boundaries. In general, the velocity and density in each macro layer are chosen to be simple functions of position (for instance linear functions of depth, accounting for the depth dependent compaction properties). Figure 1a shows an example of a homogeneous macro model and the construction of the forward extrapolation operator $\mathbf{W}_p^+(z|z_0)$, where p denotes 'primary'. Recent studies on wave propagation through finely layered media have shown that internal multiple scattering effectively results in an *angle-dependent dispersion* of the wave field (Burrige and Chang, 1989). In the following we refer to this dispersed wave field as the 'generalized primary'. Figure 1b shows a 1-D example of a model with fine layering and the construction of the forward extrapolation operator $\mathbf{W}_g^+(z|z_0)$, where g denotes 'generalized primary'. Current macro models do not account for this dispersion effect. Consequently, this effect is also ignored in migration, which may result in dispersed images and erroneous amplitude versus angle (AVA) effects. In Delft we are investigating how to parametrize the effects of fine layering in an *extended* macro model (Herrmann and Wapenaar, 1992). Now the question arises, what are the implications of the fine layering effects for migration? Generally, the inverse wave field extrapolation operators required for migration are approximated by the matched filter approach:

$$\mathbf{F}_p^+(z_0|z) = \mathbf{W}_p^+(z|z_0)^H, \quad (1)$$

(Berkhout, 1982; H stands for complex conjugate transpose). It can be shown that this approach yields accurate results both for homogeneous as well as inhomogeneous macro models (provided the one-way wave fields are properly scaled). Does this approach also hold for the generalized primary extrapolation operator, defined in an extended macro model? Unfortunately the answer is negative: the dispersion effects in the generalized primary wave are accompanied with an amplitude loss which is not compensated for by the matched filter. Hence, just as is the case with anelastic losses, the matched filter fails to account for losses due to fine layering. There is an important difference, however, between anelastic losses and losses due to fine layering. Whereas anelastic losses represent a conversion of seismic energy into heat, the losses related to fine layering represent a conversion of 'forward propagating seismic energy' into 'back scattered seismic energy', see Figure 1b. By using the power reciprocity theorem for one-way wave fields (Wapenaar, 1993), it will be shown in this paper that the energy loss of the downward propagating generalized primary can be quantified by the multi-dimensional autocorrelation of the 'backscattered wave field', i.e., the reflection measurements at the surface. This leads to a 'modified matched filter', defined as

$$\mathbf{F}_g^+(z_0|z) = \left[\mathbf{I} - \mathbf{X}_0^{(z)}(z_0|z_0)^H \mathbf{X}_0^{(z)}(z_0|z_0) \right]^{-1} \mathbf{W}_g^+(z|z_0)^H, \quad (2)$$

where $\mathbf{X}_0^{(z)}(z_0|z_0)$ contains the (deconvolved) data at the surface, see Figure 1b. In practice, the matrix inversion in (2) is replaced by a Neumann series expansion. Note that this equation holds for 3-D inhomogeneous (anisotropic) acoustic or elastic media. Using reciprocity, the modified matched filter for the upgoing generalized primary follows immediately:

$$\mathbf{F}_g^-(z|z_0) = \mathbf{F}_g^+(z_0|z)^T. \quad (3)$$

The underlying assumption for this approach is that the propagation losses may be entirely ascribed to the fine layering (scattering losses only). It will be indicated how this approach can be generalized when anelastic losses

play a role as well. Using these modified matched filter operators in prestack migration will result in a non-dispersed image with correct AVA behavior.

References

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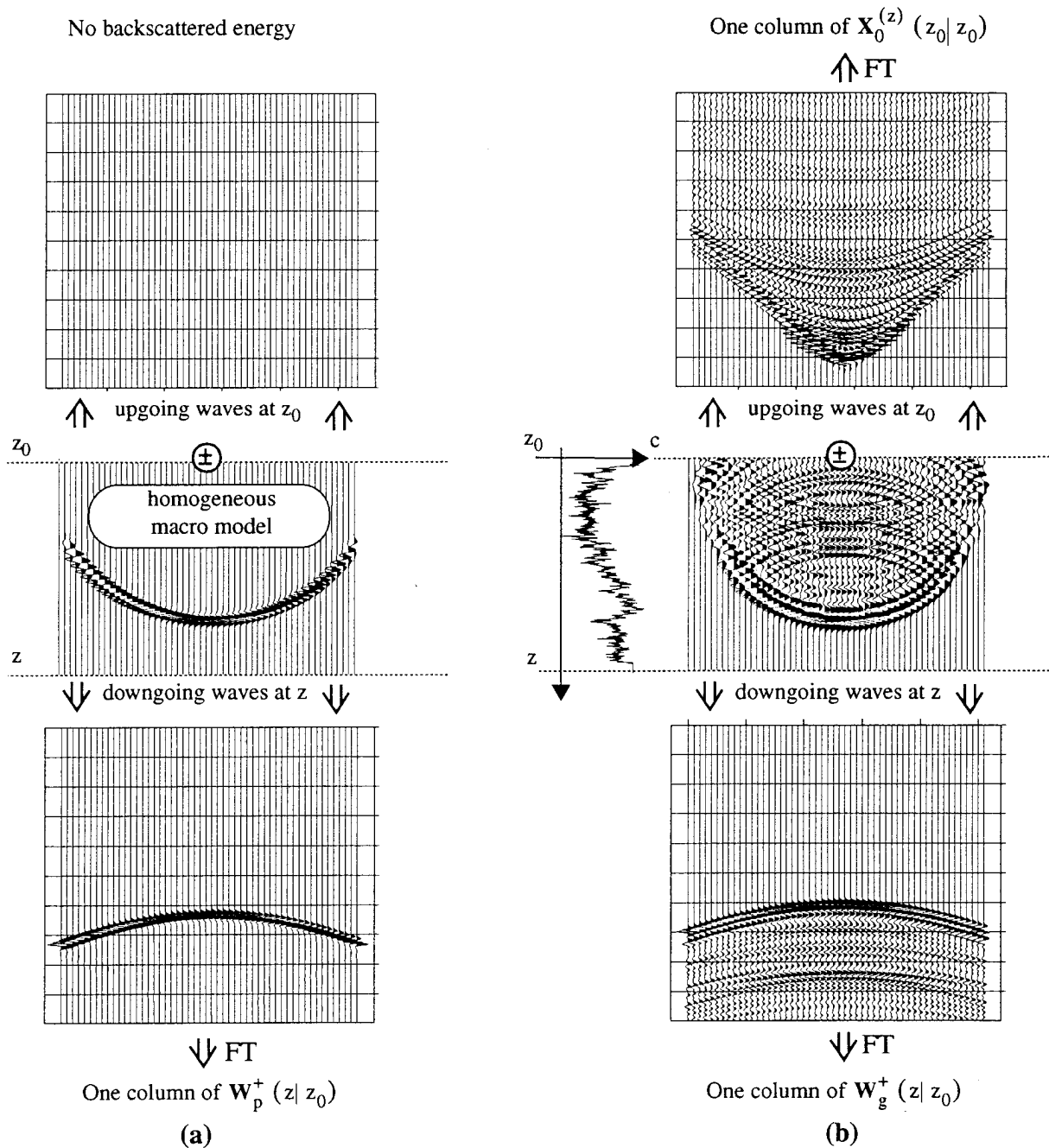


Fig 1. Construction of the forward operators in a homogeneous model (a) and in a model with fine layering (b). The subscripts p and g denote 'primary' and 'generalized primary', respectively. (Courtesy E.J.M. Giling)