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Layer-stripping True-amplitude Common-shot Acoustic RTM

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Introduction

In the exploration of areas with complex salt bodies, such as the Gulf of Mexico, RTM is often run iteratively for testing different scenarios of the base of salt and scanning different sub-salt velocity models. To speed up the iteration of RTM when the upper part of the velocity model is kept invariant. We propose a layer-stripping true-amplitude RTM. The reduction of computation cost and memory requirement is due to a number of factors, including:

- Wavefields above the redatumed depth are propagated only once
- Computation grid size can be greatly increased with increased minimum velocity in depth
- Wavefield propagation time are also reduced when migrating from redatumed depth
- Dip field may be less sensitive in the deeper regions, so that VTI or isotropic RTM may be sufficient, even with a TTI overburden

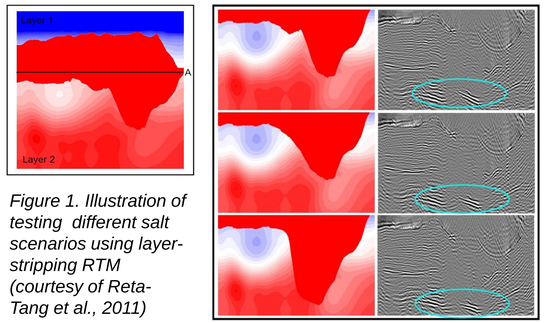

Figure 1. Illustration of testing different salt scenarios using layer-stripping RTM (courtesy of Reta-Tang et al., 2011)

Method

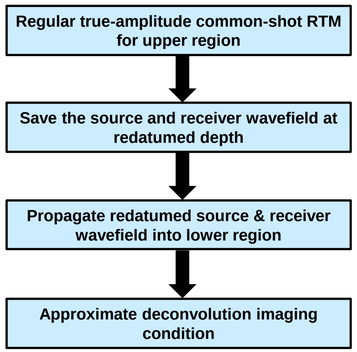

Figure 2. Flowchart of layer-stripping true-amplitude RTM

$$R(\boldsymbol{x}) = \frac{\int P_r(\boldsymbol{x};t)P_s(\boldsymbol{x};t)dt}{\int P_s(\boldsymbol{x};t)P_s(\boldsymbol{x};t)dt + \epsilon}$$

Approximate deconvolution imaging condition to image the structure below redatumed depth

$$P_D(\mathbf{x};\omega) = \int S'(\mathbf{x}_d;\omega)G(\mathbf{x}_d,\mathbf{x};\omega)\frac{\cos(\alpha_d^s)v_d^s}{\Delta x\Delta y\Delta z}d^2\mathbf{x}_d$$

$$P_U(\mathbf{x};\omega) = \int R'(\mathbf{x}_d;\omega)G^*(\mathbf{x}_d,\mathbf{x};\omega)\frac{\cos(\alpha_d^r)v_d^r}{\Delta x\Delta y\Delta z}d^2\mathbf{x}_d$$

Propagation of redatumed source wavefield

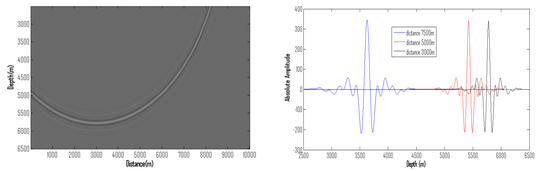

*Figure 3: Left: Source wavefield after injecting the redatumed data **with directional correction** where the redatumed depth is 2500m and velocity is constant. Right: Trace of source wavefield at different location.*

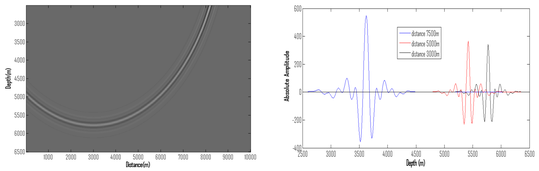

*Figure 4: Left: Source wavefield after injecting the redatumed data **without directional correction** where the redatumed depth is 2500m and velocity is constant. Right: Trace of source wavefield at different location.*

Synthetic Example

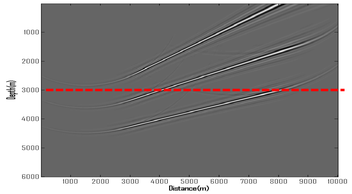

Figure 5. Layer-stripping true-amplitude RTM shot image where the redatumed depth is 2500m. The model has 3 dipping density-contrast reflectors and constant background velocity of v=3000m/s.

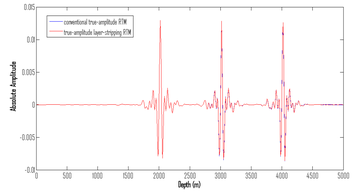

Figure 6. Comparison of the image trace at distance of 4000m between regular true-amplitude RTM and layer-stripping true-amplitude RTM.

Field Example

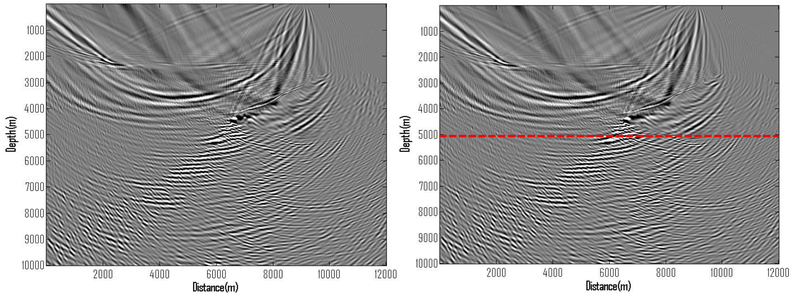

Figure 7. Comparison of regular true-amplitude RTM (left) and layer-stripping true-amplitude RTM (right) where the redatumed depth is at 4500m and cuts across the salt body

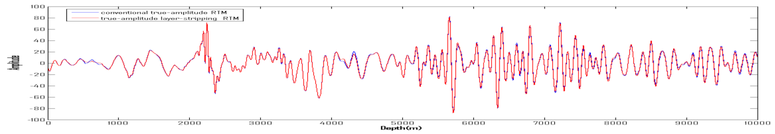

Figure 8. Comparison of the image trace at distance=8000m between regular true-amplitude RTM and layer-stripping true-amplitude RTM for different redatumed depths of 4500m which across the salt body

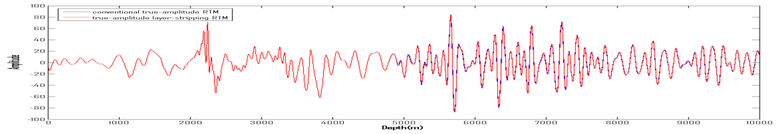

Figure 9. Comparison of the image trace at distance=8000m between regular true-amplitude RTM and layer-stripping true-amplitude RTM for different redatumed depths of 5250m which is below the salt body

Conclusions

- Layer-stripping true-amplitude RTM can accelerate the salt model and sub-salt velocity model building
- Present a new formulation for amplitude-preserved injection of redatumed wavefields
- The layer-stripping true-amplitude common-shot acoustic RTM can give nearly identical results to regular true-amplitude acoustic RTM if the velocity model is properly divided
- Our approach needs only one layer overlap between upper and lower regions

Extension to FWI

Reasons why our approach can be extended into FWI:

- Redatumed receiver wavefield is amplitude preserved
- Injection of redatumed source and receiver wavefield is amplitude-preserved

References

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