The role of source modeling in prestack depth migration for AVO estimation

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INTRODUCTION

- Migration have allowed to obtain useful information especially about the geological structures. Information about with lithology, require true amplitude migration, such as is the case of the AVO (or AVA, Amplitude versus Angle) technology.
- However it is not easy to obtain and it is the subject of many research..
- Wave equation migration, as proposed by Claerbout (1971), requires two steps: downward propagation and imaging condition. This definition assumes the summation of amplitudes for an specific location to obtain the. In this case the downgoing wave corresponds to the source and the upgoing to the recorded data. Pre stack depth migration using the wave equation (WEM) approach is based on a one-way approximation to the wave equation propagation, that requires down-propagation of the recorded wavefield together with forward propagation of a modeled source, which can contribute to enhance or disturb the reflectivity data.
- A study on the source representation is presented in this work. Synthetic seismic data are generated using elastic Finite Difference modeling, and PreStack Depth Migration is carried out on these data using the PSPI approach. Two models were studied, however here only Model 1 is presented.

THEORY

The convolution imaging condition as proposed by Claerbout (1971) reads as follows:

$$I(x,z) = \int_{\omega} \frac{U(x,z,\omega)}{D(x,z;\omega)} d\omega$$

where $I(x,z)$ is the *image* at the location (*x,z*), $U(x,z;\omega)$ corresponds to the Upgoing wave (data recorded), $D(x,z;\omega)$ to the Downgoing wave (source), both for the frequency component ω,

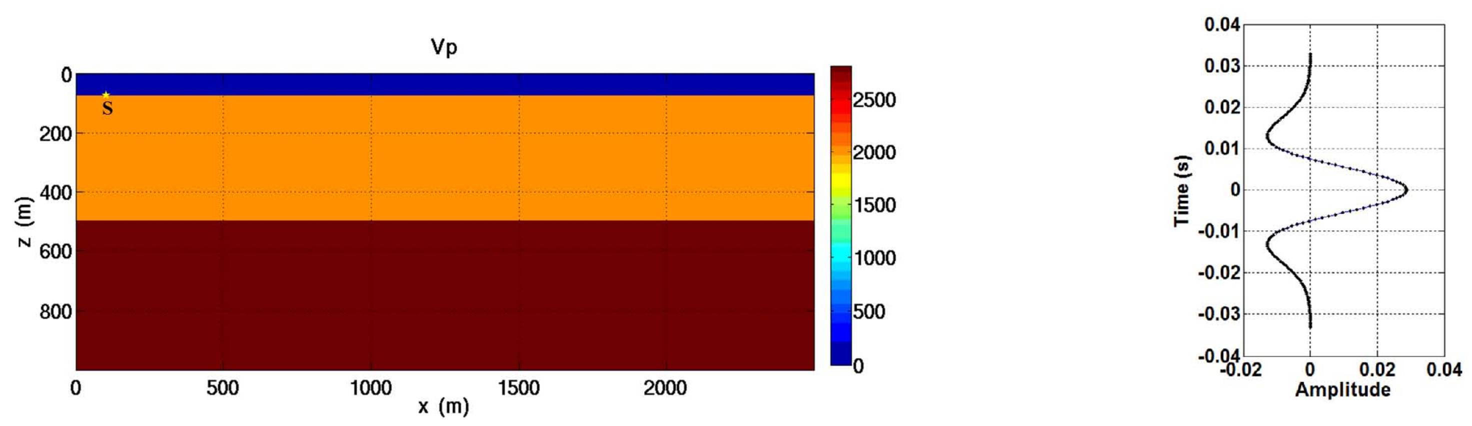
- .This Image can be defined also as the *reflectivity* if amplitudes are taken into account.
- The PSPI approach (a WEM) applied to common source gathers (shot-profile) was used in this work.
- The source implemented is a numerical evaluation of the free-space Green's function at the first depth level below the source, which is a better representation than the extrapolation of an unit pulse, as shown by Al-Saleh et al (2009),
- As for the true amplitude imaging the following analysis, with help of Green's Functions, shows that the source D and the data U wavefields at the reflector, for a specular P-wave reflection, can be represented as

$$D(refl) = \frac{W(\omega)}{4\pi r_s} e^{ikr_s} \text{ and } U(refl) = R_T \frac{W_T(\omega)}{4\pi r_s} e^{ikr_s}$$

where $W(\omega)$ is the estimated wavelet, r_s is the distance to the surface and k is the wavenumber, $W_T(\omega)$ corresponds to the true wavelet and R_T to the reflectivity. Then the amplitude resulting of the deconvolution imaging condition would depend on the wavelet estimation, since:

$$R_D = R_T \frac{W_T(\omega)}{W(\omega)}$$

MODEL



a b

FIG. 1. (a) P-wave velocity of the geological model 1. (b) Wavelet for modeling.

MODELING

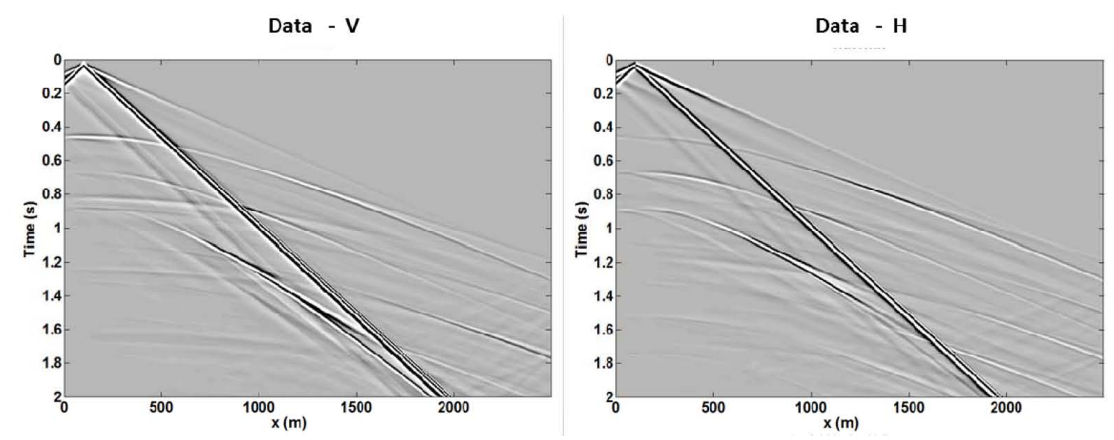


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FIG. 2. Raw data for model 1. (a) Vertical component, (b) Horizontal component.

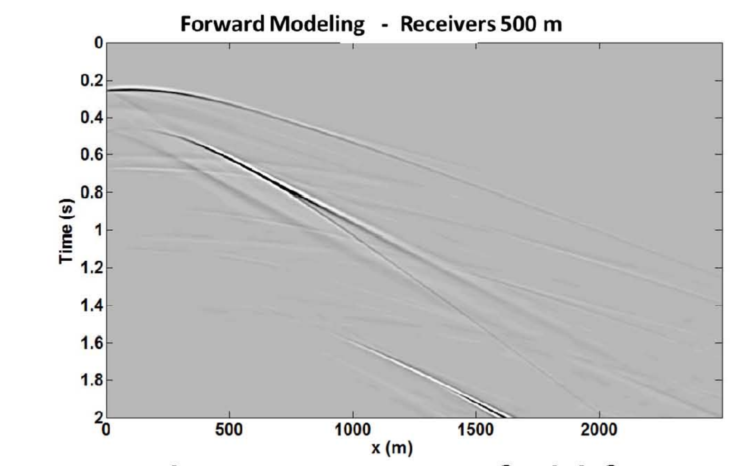
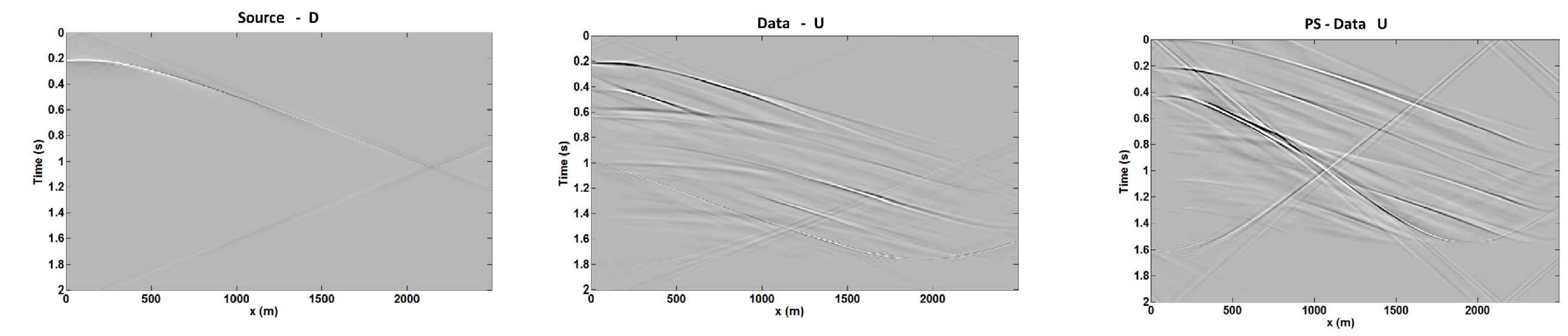


FIG. 3. The source wavefield from modeling:: receivers at the position of the interface.

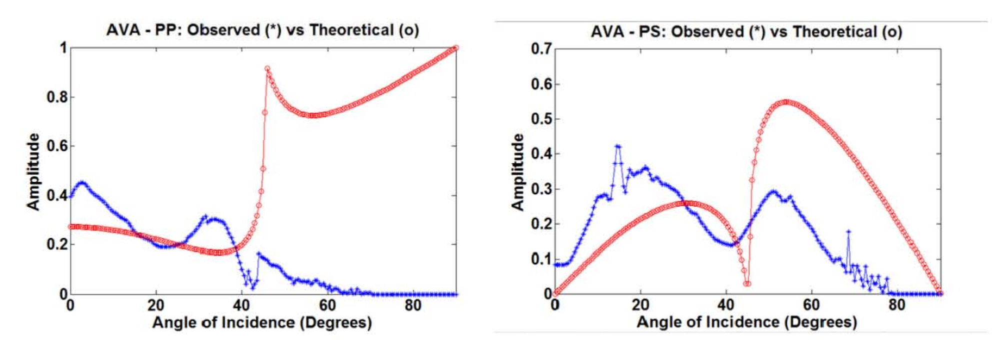
IMAGING CONDITION



a b c

FIG. 4. Downward propagated source (D) and data (U) wave-fields for migrations of the geological Model 1 at the depth corresponding to the reflector.(a) The source wavef-ield, (b) the P-wave data (vertical component) for the PP migration, (c) the S-wave data (Horizontal component) for the PS-migration.

AVA RESPONSE



a b

Fig. 6. Theoretical Amplitude vs Angle, (red) compared with the amplitudes from migration (blue).. (a) PP data, (b) PS data.

CONCLUSIONS

- Modeling and migration methods have a number of assumptions and approximations.
- However there is a reasonable agreement in the amplitudes ratio for angles below the critical angle.
- More experiments and theoretical work will be carried out.

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