True amplitude migration in constant gradient velocity media

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RESUMEN

El algoritmo de Kirchhoff con trazado de rayo se basa en una función de velocidad constante. Esta solución incorpora información de trayectoria de rayos dentro del algoritmo, el cual puede extenderse a un medio de velocidad variable. El modelo de velocidad incluye la localización de reflectores e intervalos de velocidades entre dos reflectores adyacentes, generados a través del análisis de velocidad, pero importante en el procesamiento sísmico tradicional. Este proceso puede alcanzarse al aplicar un operador de función peso de apilado por difracción, cuyo desarrollo teórico se basa en la integral de migración tipo Kirchhoff. Al escoger el propio peso para el peso de apilado de datos, el resultado del proceso de migración es una sección sísmica donde se recupera la amplitud y su valor es proporcional al coeficiente de reflexión, llamado migración con amplitudes verdaderas (recuperación de amplitudes verdaderas).

PALABRAS CLAVE: RECUPERACIÓN DE AMPLITUDES VERDADERES, PSDM, MEDIO CON GRADIENTE DE VELOCIDAD.

ABSTRACT

The kirchhoff conventional algorithm using ray tracing is based on a constant velocity function. This solution, where is incorporated ray path information into conventional algorithm, can be extended to a variable velocity medium. Velocity models include the locations of reflectors and interval of velocities between any two adjacents reflectors that are generally generated through the velocity analyses, process important in traditional seismic processing. This process could be achieved by applying a weighted diffraction stack operator, which theoretical development is based on a Kirchhoff type migration integral. By choosing the proper weight for stacking the data, the result of the migration process is a seismic section where the amplitude are recovered and its value are proportional to the reflection coefficient, the so-called true-amplitude migration (True Ampiltude Recovering). Migration process was applied into different models. the objetive is to reproduce an accurate picture of the subsurface model from the data registered in areas where the velocity changes. The migration process was obtained after trying several testes made with different weigths.

KEY WORDS: TRUE AMPLITUDE RECOVERY, PSDM, GRADIENT VELOCITY MEDIA

INTRODUCTION

By incorporating ray path information into conventional migration algoritm, the solution can be extended to variable velocity medium. The rays are traced from each depth point in the survey of each source-geophone location in order to determine the difraction traveltime surface difraction (Huygens surface). Then, the weighted diffraction stack operator could be used to migrate the seismic data. In this paper we present a fast algorithm that is able to recover true amplitude in depth migration process, by considering a more particular situation when the seismic velocity model is represented by a linear distribution variable with the depth.

This kind of model is important for simulating many situations in the seismic exploration. For instance, variations of the velocity with depth, inversion velocity (negative gradient) and increasing of velocity in a short layer (positive gradient).

MODELLING

Asymptotic ray theory provide useful extrapolating techniques for modelling, migration and inversion, using ray theory of coordinates tracing equations which determine the second derivatives of the traveltime curve. This is desired in order to determine geometrical spreading, and then true amplitude recovery. In order to know

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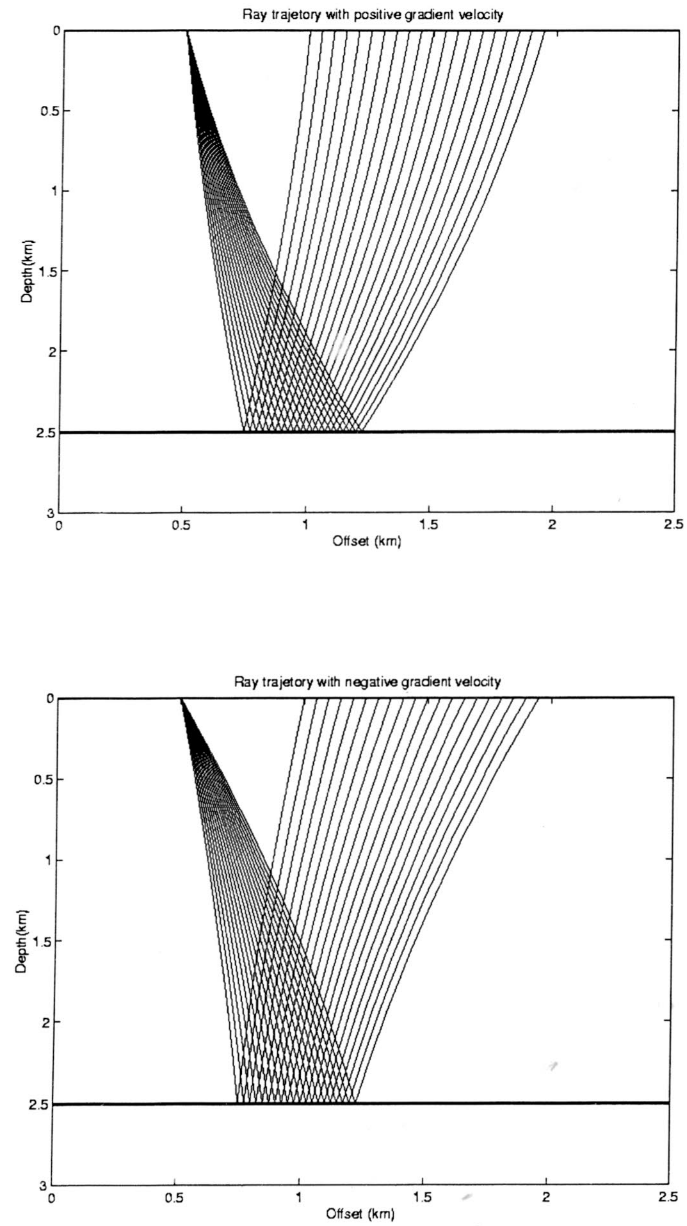

Figure 1. Models for differents gradients in a configuration common shot. Gradient positive (left) and gradient negative (rigth).

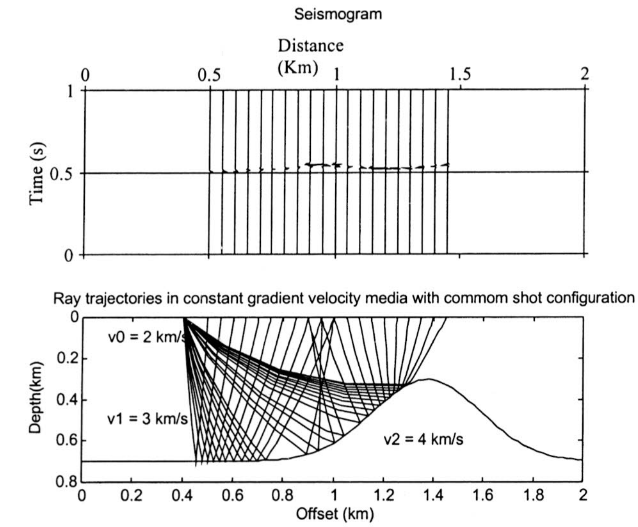

Figure 2. Ray trajectory model(lower) and synthetic seismogram(upper).

the stability of the diffraction stack migration algorithm, we have applied it to a set of seismic data in a common-shot configuration.

DIFFRACTION STACK OPERATOR

After data input, two-dimensional diffraction stack operator can be written following the expression given by Urban (1999), based on Martins *et al.* (1998)

$$v(M,t)=\frac{1}{\sqrt{2\pi}}\int_A d\xi\, w(\xi,M)\,\partial_{t-}^{1/2}U(\xi,t+\tau_D) \qquad (1)$$

with the source and receiver pairs (S,G) described by the vector parameter and the traveltime curve defined by all the points of on the earth surface, and a point M in depth. $\partial_{t-}^{1/2}U(\xi,t+\tau_D)$ is the anti-causal half-time derivative (operator that corresponds in the frequency domain to the filter $\sqrt{-iw}$) of the seismic trace $U(\xi,t+\tau_D)$ registered on the geophone position $G(\xi)$, and it represents the principal component of the seismic primary reflected wavefield. The result of the integral (1) is put at the point M into the model. Providing that we call depth difraction stack migration, with all lines summed along the stacking line and multiplied by the true amplitude (weight function) $w(\xi,t-\tau_D)$ and summed, then the result of migration process is proportional to the reflection coefficient recovered.

DIFFRACTION TRAVELTIME STACK CURVE

Being known the macrovelocity model with a distribution of velocity varying linearly with depth the diffraction traveltime stack curve can be built, for the diffraction stack processing

$$v(z)=v_0+gz \qquad (2)$$

Where v_0 is the velocity near the earth surface, g is the gradient of the velocity function in the direction of the vertical axis z, in depth. This kind of velocity function is the first approximation to be considered when investigating the regional variations of velocity for most sedimentary rocks (Japsen, 1993).

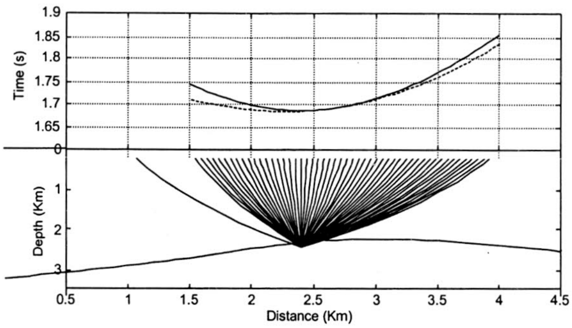

Figure 3. Traveltime difraction and traveltime reflection curve for a depth point.

Inside such model with linear variation of velocity, the ray trajectory is circular and the traveltime is given as solution of the integral (Bleistein, 1986)

$$\tau=\frac{l}{g}\ln\frac{\tan\left(\alpha_M^i\right)}{\tan\left(\alpha_0^i\right)}=\frac{l}{g}\ln(B_s B_G) \tag{3}$$

being $B_i = 1 + (g^2 l^2 + 2g\sigma_i) / 2cc_0$. All the values of this result are known; l_i and σ_i are the circular trajectory and parameter ray, respectively.

COMPUTATIONAL EXAMPLES

The seismic model consists of by a curved reflector bellow an inhomogeneous domo with constant gradient velocity medium, where the near surface velocity is 2.0 *km/s* (varying with the depth), and its gradient is 1.25/*s*. The shot position is 0.4 *km* on the left, with 0.5 *km* and 1.45 *km* for the near and far offset, respectively. The source dominant frequency is about 70 Hz, and the sample interval is of 2.0 *ms*. In the Figure 2 are represented the tracing rays(lower) and the synthetic seismogram(upper) for a asymmetric common shot configuration. The seismic data is noise free. In the figures 3 and 5 we have the image and depth migrated seismic data, after appliying of the diffraction stack operator to the respective set of input seismic data. It is important to note that the proposed algorithm provides a good image of the target reflector, and it is able to be used for migrating seismic data in constant gradient velocity media.

CONCLUSIONS

In this paper, was develop and tested the diffraction stack migration algorithm, applying it to a set of common-shot seismic data, syntheticaly generated by the ray theory for a constant gradient velocity medium. The algorithm was tested providing us a good image of the target reflector. This result is very important in sense that the proposed algorithm is fast, stable and suitable to be used for true amplitude depth migration.

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