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DIFFRACTION STACK MIGRATION IN CONSTANT GRADIENT VELOCITY MEDIA

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ABSTRACT

In order to investigate the reflectivity in the earth subsurface by seismic method, we need to introduce some assumption about the macrovelocity model above the reflector. This is achieved by applying to the input seismic data 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 is proportional to the reflection coefficient, the so-called true-amplitude migration. For considering a more realistic situation, we develope a migration algorithm that works very well with constant gradient velocity media. In order to better understanding the numerical behavior of the proposed algorithm, we consider in this paper only the kinematic aspects of migration process, i.e. when the weight function is the unit.

INTRODUCTION

The weighted diffraction stack operator used to migrate the seismic data, is based on stacking the input data, through a stack trajectory defined by a difraction traveltime surface (Huygens Surface), for a given point in the model and different sources and geophones on earth surface. One of the critical points in this migration method is the computational time increasing, as a consequence of the geometrical complexity of seismic model. In recent years, some alternative methods have been proposed in order to overcome this problem (Vidale, 1988; Schneider et al., 1992; and Zhao et al., 1998). In this paper we present a fast algorithm that is able to do kinematic or true amplitude depth migration, by considering a more general situation when the seismic velocity model is represented by a linear function of the spacial variables. This kind of model is important for simulating many situations in the seismic exploration (Japsen, 1993).

TWO-DIMENSIONAL DIFFRACTION STACK OPERATOR

Following the formalism given by Urban (1999), based on Schleicher et al. (1993), we can write the two-dimensional diffraction stack operator as

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

In the equation (1), the source and receiver pairs (*S,G*) are parameterized by the variable ξ, in such way that the diffraction in-plane traveltime curve τ_D is defined for all points of parameter ξ on the earth surface, and a point *M* within a specified volume of the seismic model. The symbol $\partial_{t-}^{1/2}$ is the anti-causal half-time derivative operator that corresponds in the frequency domain to the filter $\sqrt{-i\omega}$. The weight function *w* may be chosen so that the result of migration process is proportional to the reflection coefficient. The function $U(\xi, t+\tau_D)$ 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 what we call depth difraction stack migration. In the case when the weight function is the unit, considered in this paper, we have only a kinematic image of the seismic reflector.

DIFFRACTION TRAVELTIME STACK CURVE

In the diffraction stack processing, the macrovelocity model is considered a priori known, and a diffraction traveltime stack curve must be built for each point inside a grid into the model. For this paper we consider a situation where the velocity in the overburden is well represented by a linear function

$$v(z) = v_o + gz\ , \tag{2}$$

where v_o 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). 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)

$$\tau = \frac{1}{v_0} \int_0^{z_M} \frac{n^2(z)dz}{\sqrt{n^2(z) - sin^2\beta}} . \qquad (3)$$

In the integral (3) z_M is the depth of the point M in the subsurface, the β is the angle between the vertical axis z, and the direction of the ray trajectory at the point M. The function $n(z) = v_0 / v(z)$ is the refraction index. The referred integral has an analitical solution, which provides us a way to develop a fast and stable algorithm for migrating the seismic data (Figure 1).

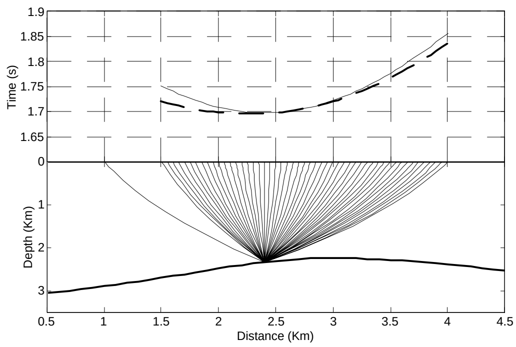

FIGURE 1. Reflection traveltime curve (interrupted line) and Difraction traveltime curve (continous line) . The point in depth coincides with the actual reflection point.

EXAMPLES

For measuring of the stability of the diffraction stack migration algorithm, we have applied it to a set of seismic data in a common-shot configuration. The seismic model (Figures 2 and 4) is constituted by an arbitrary curved reflector bellow an inhomogeneous layer with constant gradient velocity medium, where the near surface velocity is 2.0 *Km/s* and the gradient is 0.9375*/s*. The shot position is 1.0 *Km* on the left, while the first geophone is at 1500 *m*, and the last at 4000 *m*. The source dominant frequency is about 75 Hz, and the sample interval is of 4.0 *ms*. In the Figure 2 the seismic data is noise free, while in the Figure 4 the s/n ratio is 1:0.1. In the Figures 3 and 5 we have the depth migrated seismic data, after application 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 even in noise enviroment, and is able to be used for migrating seismic data in constant gradient media.

CONCLUSIONS

In this paper, we develop and test 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 without and with noise on the data, 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.

REFERENCES

Bleistein, N., 1986, Two-and -one-half dimensional in-plane wave propagation. Geophysical Prospecting, 34, 686-703.

Japsen, P., 1993, Influence of Lithology and Neogene Uplift on Seismic Velocities in Denmark: Implications for Depth Conversion of Maps. The AAPGB, 77, n. 2, 194-211.

Schleicher, J., Tygel, M., and Hubral, P., 1993, 3-D True-Amplitude Finite-Offset Migration. Geophysics, 58(8): 1820-1830.

Schneider, Jr. W. A, Ranzinger, K. A, Balch, H. and Kuse, C., 1992, A dynamic programming approach to first arrival traveltime computation in media with arbitrarily distributed velocities. Geophysics, 57, n. 1, 39-50.

Urban, J., 1999, Two-Dimensional True-Amplitude Migration and Introduction to 2.5-D Case. Master Thesis. Federal University of Pará, Brazil. (In Portuguese).

Vidale, J., 1988, Finite-difference calculation of the travel times. BSSA, 78, n. 6, 2062-2076.

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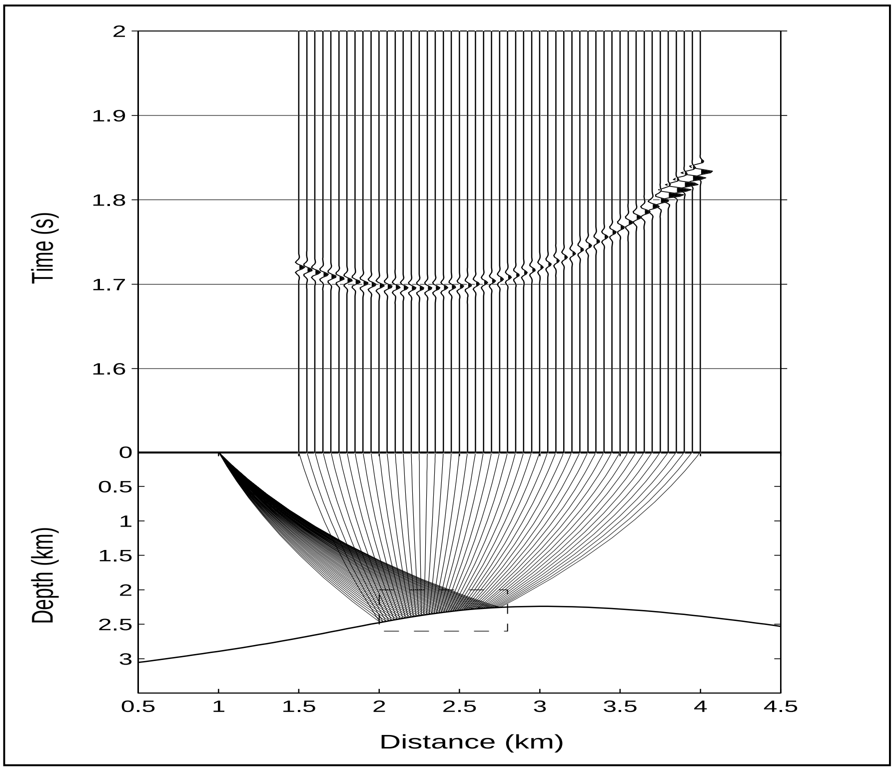

FIGURE 2. Lower part: Model and ray trajectories. Upper part: synthetic sismogram in constant gradient velocity model.(Dashed lines: indicating migration target zone).

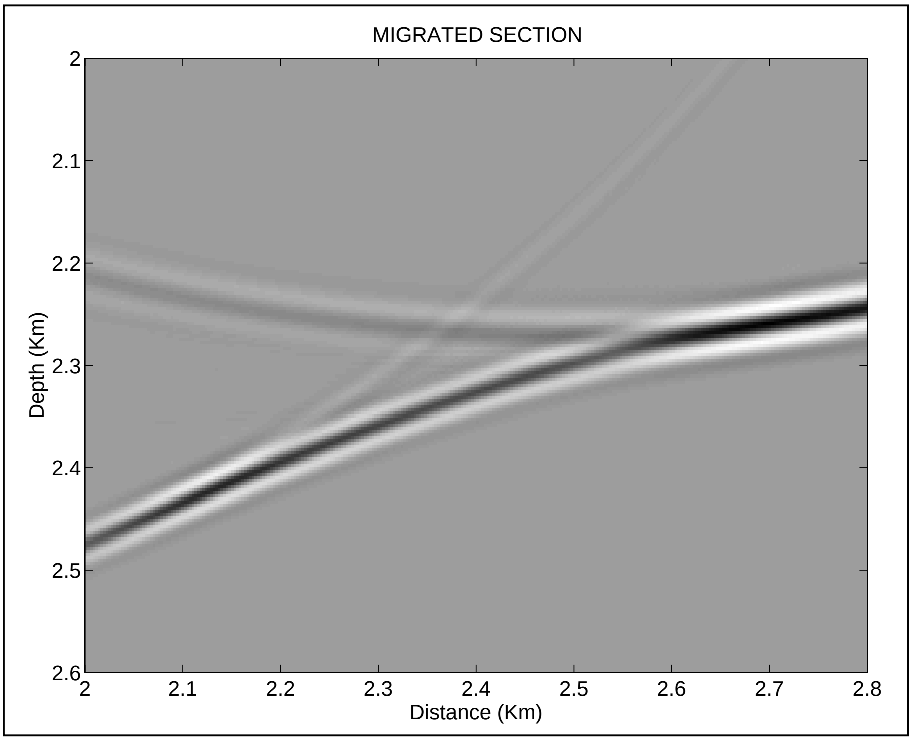

FIGURA 3. Pre-stack depth migration image. Target zone x0=2.0, x1=2.8 and z0=2.0, z1=2.6

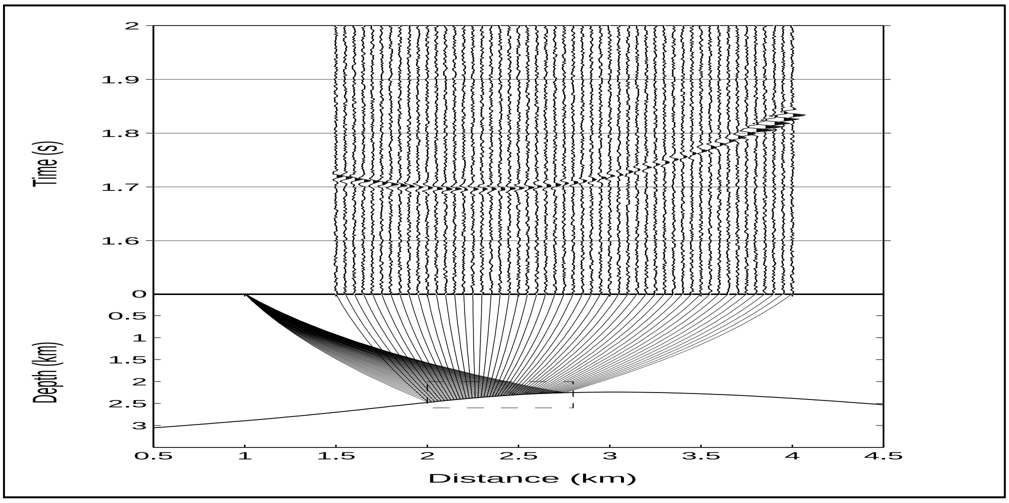

FIGURE 4. Lower part: Model and ray trajectories. Upper part: synthetic sismogram(with noise. S/N ; 1:0.1) in constant gradient velocity model. (Dashed lines: indicating migration target zone).

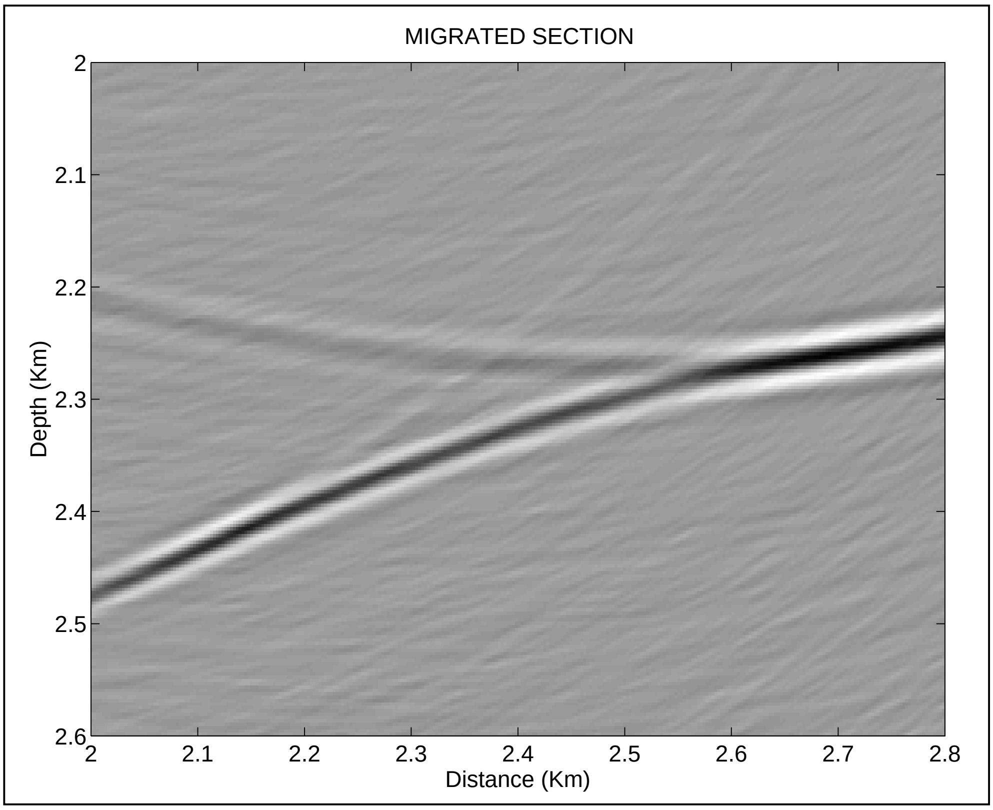

FIGURA 5. Pre-stack depth migration image (with noise). Target zone x0=2, x1=2.8 and z0=2, z1=2.6