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가스 하이드레이트 탄성파 자료에 대한 중합전 심도 구조보정

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Prestack depth migration for gas hydrate seismic data set

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Key words : Gas hydrate(가스 하이드레이트), BSR(해저면 기인 고진폭 반사파), pull up structure(풀업 구조), velocity model(속도 모델), prestack depth migration(중합전 심도 구조보정)

Abstract : Gas hydrate has been attractive topic for two dedicates because it may cause the global warming, ocean hazards associated with the instability of marine slope due to the gas hydrate release as well as high potential of future energy resources. The study on gas hydrate in Ulleung basin has been performed since 1999 to explore the potential and distribution of gas hydrate offshore Korea. The numerous multi channel seismic data have been acquired and processed by Korea Institute of Geosciences and Mineral Resources (KIGAM). The results showed clearly the gas hydrate indicators such as pull up structure, bottom simulating reflector (BSR), seismic blanking zone. The prestack depth migration has been considered as fast and accurate technique to image the subsurface. In this paper, we will present both the conventional seismic data processing and apply Kirchhoff prestack depth migration for gas hydrate data set. The results will be applied for core sample collections and for proposal more detail 2D with long offset or 3D seismic exploration.

1. Introduction

Gas hydrate, consisting of a complex structure of water molecules surrounding methane molecule, are solid-like substance occurring beneath the ocean and in the polar region. It has become of major interest since the last 20 years because i) they may be high potential of future energy resources; ii) they may play a significant role in global climate change and iii) they represent a role in geological hazards. Several estimations of total organic carbon in gas hydrate have been made and although these numbers are highly speculative, natural gas hydrates may represent a large reservoir of hydrocarbon that may dwarf all known carbon fossil deposit combined (Kvenvolden(1), 1993; Collect(2), 2000). In 1999, Korea gas corporation and Korea Institute of Geosciences and Mineral resources started carrying out the research project including regional exploration and technology development of natural gas hydrate. The research program focused on exploring the evidence of natural gas hydrate using seismic survey methods and the development of utilization technology for any potential natural gas hydrate resources. The numerous seismic data had been acquired by vessel TAMHAE II and processed by KIGAM (Lee et al.(3), 2005). The result of seismic processing showed that the gas hydrate evidences such as bottom simulating reflector (BSR), blanking zone or pull up structure were very clearly identified in seismic section indicate the existence of gas hydrate in Ulleung basin.

Kirchhoff depth migration or integral migration have been known as fast and accurate technique to image the

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subsurface with complicated structure such as sand dome or reversed faults. The basic idea of Kirchhoff migration is summing up the different diffraction events as shown in Fig. 1 to the imaging point by taking the partial derivative of wave field. The idea was first proposed by Schneider(4)(1978) then developed more and more by Shin et al.(5) (2003). In general, prestack depth migration requires input velocity model. The more accurate velocity model, the more accurate image will be obtained. However, none of criteria to verify the accuracy of input velocity model. The suitable velocity model will be chose when migration result look close to the stack imaging and reflect all the geological events beneath.

The scopes of this paper are to introduce and to apply the Kirchhoff prestack depth migration to gas hydrate data set with various velocity model such as linear increment velocity, stack velocity and interval velocity in order to locate better BSR and other gas hydrate indicators in the seismic section such as pull up structure or blanking zone as well as geological features. On the other hand, result of conventional seismic data processing will be presented and used it to compare to Kirchhoff prestack depth migration in term of accuracy and time consuming

2. Wave equation and Kirchhoff prestack depth migration

The existence of complex geological structure such as faults, folds or sandome and the lateral velocity change of the subsurface will make the seismic events diffracted. On the other hand, the idea of Kirchhoff migration is to build up the imaging points from diffracted points as insulated in Fig. 1. The result, which is assigned to each diffracted points can be calculated independently. By the way to integrate the diffracted events, the reflectors can be imaged.

Both prestack and post stack Kirchhoff migration is based on the integral solution of wave equation (Dochety(6), 2001). The wave equation in Helmholtz type is expressed as follows:

$$\nabla^2 \Psi - \frac{\omega^2}{v^2} \Psi = - q(x) \qquad (1)$$

Where Ψ is total field due to the source at location x_s. ω, $q(x)$ and v are angular frequency, source density and velocity, respectively.

The solution of Eq. 1 can be found in Morse and Feshbach(7) (1953); Duffy(8) (2001) in term of initial condition, boundary condition and Green 's function. According to Zhu and Lines(9)(1998), by using the WKBJ theory for the Green 's function approximation (Aki and Richard(10), 1980), the solution of wave equation , $\Psi(x,x_s)$, bounded observation surface S_0 and below by reflected surface, $\sum$, is given as follows:

$$\Psi(x,x_s) = \int_{\Sigma} \vec{n} \nabla \tau_r (x_r,x) A(x_r,x,x_s)^* \\ u^m (x_r,\tau_s(x,x_s) \\ + \tau_r(x_r,x),x_s) dx_r \qquad (2)$$

Where τ_s and τ_rτr is traveltime from shot point, x_s, to the subsurface point, x, and from the subsurface point x to the receiver point, x_r, respectively; $\vec{n}$ is outward normal vector of surface $\sum$. Hence, u^m denotes the time derivative of the recorded traces. For a 2-D case, m=1/2. The term $A(x_r,x,x_s)$ is geometrical spreading that functions here as an amplitude modulator recording traces. The Eq. 2 is a basic Kirchhoff migration equation. The other solution of wave equation can be found in Schneider(4)(1978) and it matches with the Eq.2. As seen in Eq.2 the determinations of travel time as well as the amplitude play key roles in the integral calculations. Traditionally, the ray tracing methods will give all the information of τ_x, τ_s. Eq. 2 is basic equation for Kirchhoff prestack migration. The other approach to solve Eq. 1 can be found in Schneider(4) (1978) and the result matches with Eq. 2. As seen in Eq. 2 the determination of traveltime and amplitude term play important roles in the integral calculation. Combination both the inversion procedure and solution of wave equation, the Kirchhoff prestack migration will be conducted as the steps given in Fig.2.

3. Application of Kirchhoff prestack migration for gas hydrate dataset

The data set (line gh00-10) highlighted in Fig. 3 was acquired by KIGAM. The receiver interval and shot interval was 6.25 m and 12.5 m, respectively with 8,464 shot gathers in total and the survey length about 105 km from East to West. Each shot gather consists of 96 channels or traces and the nearest offset is 50 m. The shot gather number 4,784 is shown in Fig. 4. Three events of direct wave occur (Fig. 4) due to the bubble effects which is described in detail by Dobrin and Savit(11) (1988). Thus, it needs to be taken out. This process is called as delay time correction. The slope of direct wave can be used to calculate the velocity of seawater. In this case, the estimation of seawater velocity is about 1,480 m/s. As seen in Fig. 4 the amount for delay time for correcting is about 0.2 ms

The preprocessing steps includes: automatic gain control (AGC), deconvolution, muting and then making shot gathers. The processing steps consist of CDP sorting, velocity analysis and stacking. All the preprocessing and processing steps are performed by GEOBIT developed by Suh(12) (2005). Among of those, the picked velocity values from the velocity spectrum were not unique and depending on the senses of the operators. Consequently, the stacked section will be different. The interactive velocity picking tool based on X-windows developed by Suh[12](2005) gives more accurate and unique picking velocity. So, the stack section will give accurate imaging of the subsurface. For this kind of data set, the stacked section is shown in Fig. 5. As seen in Fig. 5 ,the pull up structure indicating for vertical gas seepage which normally represents for gas hydrate area occur at shot point 5,700 or at the distance of 11km from the beginning of the processed survey line. Additionally, the BSR event which is more common than pull up structure in seismic section indicated by high amplitude, parallel to the sea bottom and reversing phase is clear identified at TWT (two-way traveltime) of 2.86 to 2.9 second in this processed survey line. Moreover, the diffracted events below the BSR may indicate for the free gas stream and minor gas seepage column at shot point # 5184.

Based on the result of stack section, the input velocity model can be built for the prestack migration. As linear increment velocity model is quite good for prestack migration as mentioned by Hien, et al.[13], 2007, thus for this case the linear increment velocity (see Fig. 6) will be firstly adopted as input for amplitude and travel time determination. This model will be divided in to Nx*Nz=2410*610 number of grids with the grid size dx*dz=6m*6m. Fig.7 & 8 show the results of travel time and amplitude calculations of grid point No 1000, respectively. The traveltime and amplitude determination of individual grid points will be used for prestack migration. Fig. 9 shows the result of prestack migration. The pull up structure in migrated section is not as clear as one in the stack section but the position of this event is concise to the stacked section at the distance of 11km. The minor vertical gas flow also can be identified in the migrated section at the position about 4.2km. In the stacked section, the BSR is seen in the time domain; on the other hand, this event is appeared at the depth of 80m to 100m in the migrated section. However, the amplitude of migrated section is isolated. The reason can be referred to the input velocity model. However, it is very hard to verify the accuracy of velocity model for field data set. Several other velocity models such as stacked velocity model, interval velocity model need to be verified.

4. Conclusions and further study

The Kirchhoff prestack migration has been adopted successfully for gas hydrate dataset based on vertical increment velocity model. The result of migrated section looks concisely with the stack section in term of pull up structure and BSR event in the gas hydrate area. However, the amplitude of migrated section is isolated comparing to the one of stacked section. So the velocity input of the prestack migration need to be more carefully studied. Furthermore, the combination of the velocity tomography inversion should be adopted as the input velocity model for prestack migration to expect better image of the subsurface.

Acknowledgement

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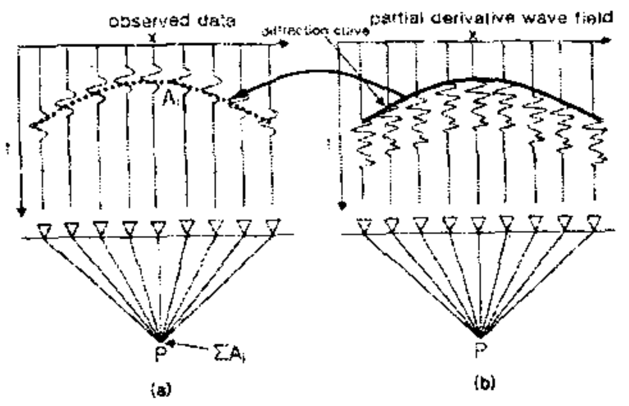

Fig. 1 Schematic diagram for Kirchhoff stack along the difference curve (Ko(14),2001)

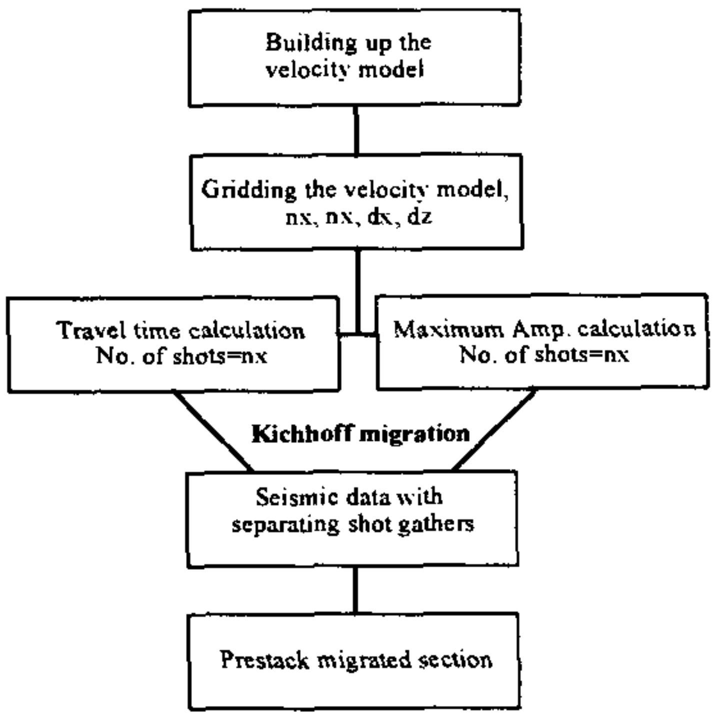

Fig. 2 Procedure of Prestack Kirchhoff migration

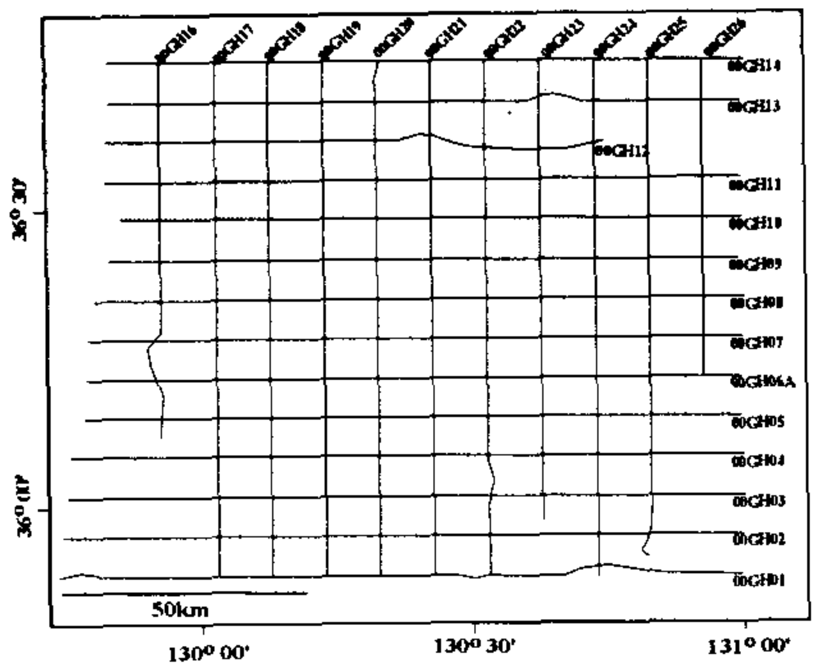

Fig. 3 Location of survey line (After Lee et al.(3), 2005)

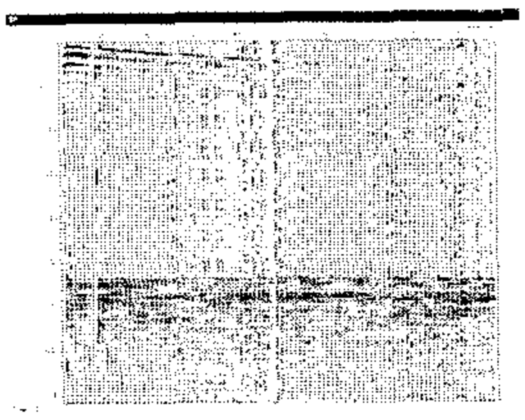

Fig. 4 Shot gather #4874

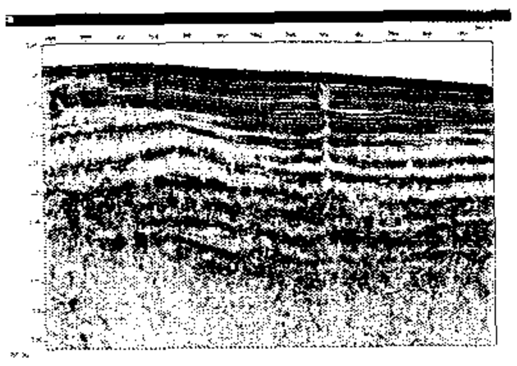

Fig. 5 Stacked section

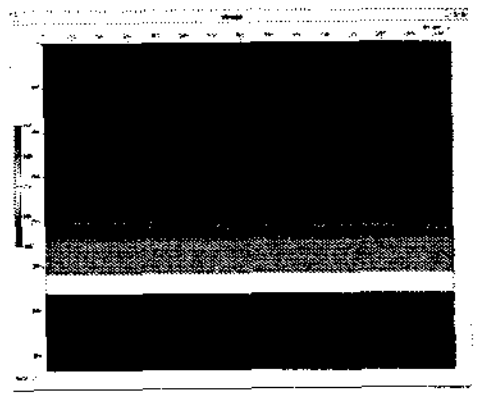

Fig. 6 Linear Increment Velocity model

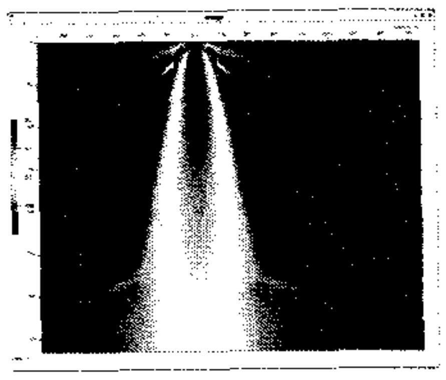

Fig. 7 Amplitude calculation at grid No1000

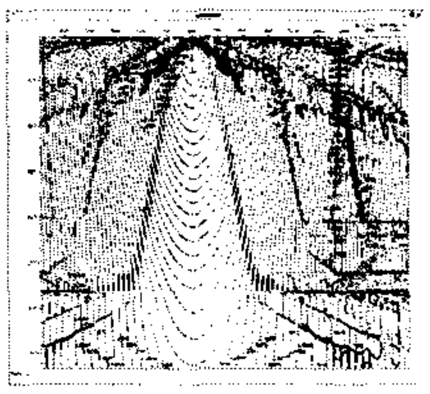

Fig. 8 Travel time calculation base on Vidale[15] (1988) algorithm at grid No1000

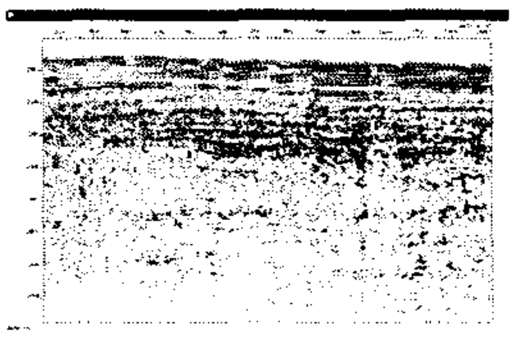

Fig. 9 Kirchhoff prestack depth migration result