Comparing Alternative Seismic Imaging Techniques

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Summary

In this study, we compare different kinds of prestack depth migration methods by using Marmousi model, to demonstrate imaging precision of different migration methods. We also illustrate the importance of depth-domain velocity model building for complicated 3D land field data. Additionally, we compare different common image gathers to conclude that angle-domain common image gather has higher imaging quality and less migration artifacts, which is more beneficial for velocity inversion.

Migration Methods

There are many different types of depth migration methods. Here we tested several of them (results shown in Figure 1), including Kirchhoff, Common Focusing Point (CFP), Split Step Fourier (SSF), amplitude-preserved SSF, Fourier Finite Difference (FFD), amplitude-preserved FFD, and Reverse Time Migration (RTM). Kirchhoff migration is more flexible and effective, but hard to solve multipath problem. Oneway wave equation method could partially overcome it. RTM could adapt to multipath, but it is time-consuming. From Kirchhoff method, to oneway wave equation, then to RTM, the imaging quality is getting better and better, but the requirement of velocity model also becomes higher. From the comparison of migration results (Figure 2) in complicated 3D land field data with ray-based velocity model building method, we can see that there is only slight improvement of RTM compared with Kirchhoff migration. We still need to improve the imaging resolution and velocity model building precision in the areas with complicated structures.

Common Image Gathers

The quality of common image gathers is important for velocity model building. Generally common offset image gathers are used for velocity analysis. However, it would be influenced by multipath problem in complicated areas, and there would migration artifacts to reduce imaging quality. Angle-domain common image gathers could effectively solve this problem and have better imaging quality, which is more beneficial for velocity model building in complicated areas. The comparison is shown in Figure 3.

Discussion

Each migration method has its own adaptability. We should choose proper migration method according to specific geology background and the complexity of structures. Besides velocity model building, we should also improve depth domain migration methods to increase seismic imaging resolution.

Future Work Plan

In the future, we will focus on depth domain prestack least square migration, to improve resolution, imaging quality and amplitude compensation of seismic imaging. We will introduce structure-oriented filtering and other kinds of effective constraints to reduce its iterations. And we will also do numerical tests of model data and field data to verify the effectiveness of our method.

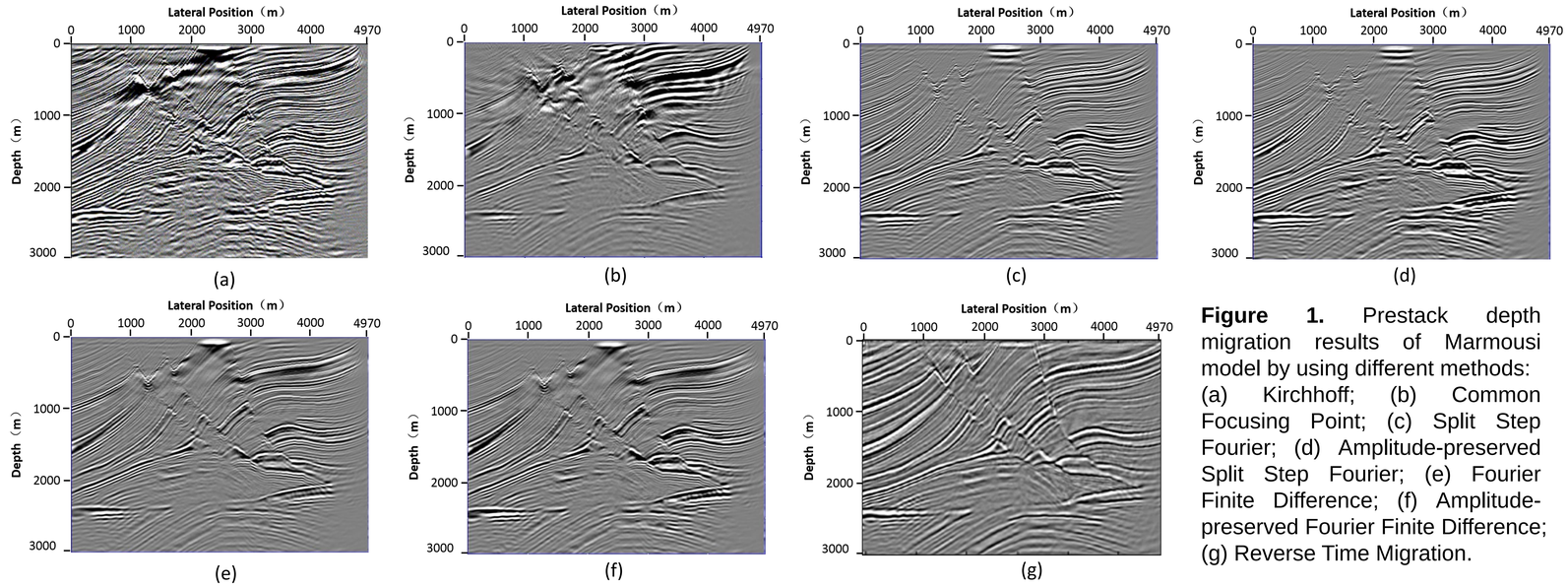

Figure 1. Prestack depth migration results of Marmousi model by using different methods: (a) Kirchhoff; (b) Common Focusing Point; (c) Split Step Fourier; (d) Amplitude-preserved Split Step Fourier; (e) Fourier Finite Difference; (f) Amplitude-preserved Fourier Finite Difference; (g) Reverse Time Migration.

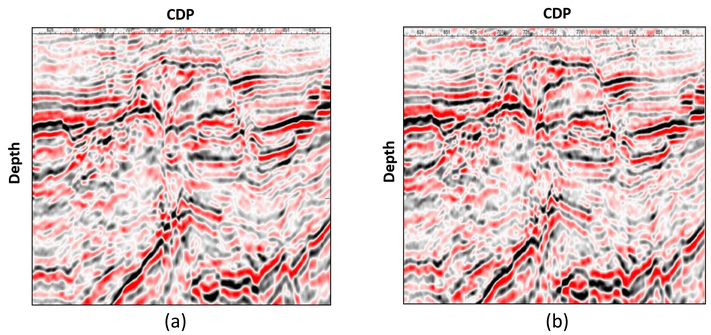

Figure 2. Comparison of depth migration methods of complicated land field data:
(a) Kirchhoff migration; (b) Reverse Time Migration.

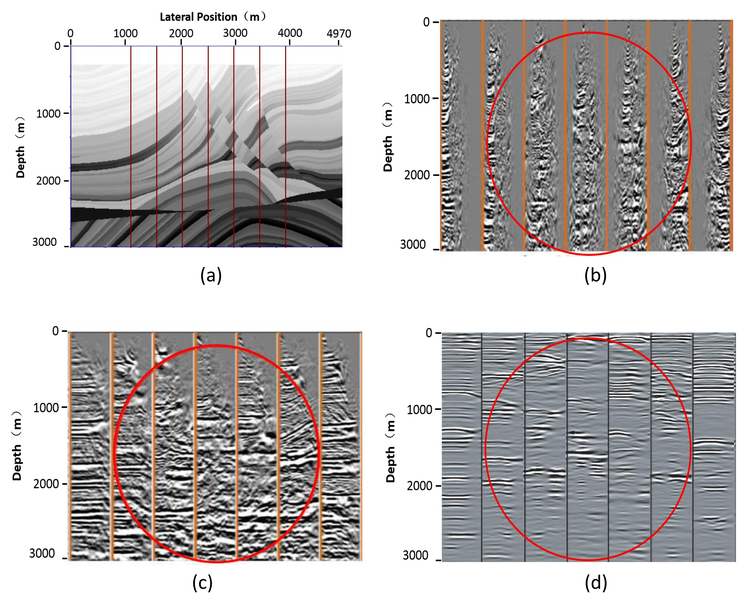

Figure 3. Comparison of different common image gathers:
(a) Marmousi velocity model and image positions;
(b) Migrated common shot gathers (Leading Edge,2010);
(c) Migrated common offset gathers (Leading Edge,2010);
(d) Angle-domain common image gathers.

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