



**OTC 19875**

## **Multi-Step Reverse Time Migration**

Y.C. Kim, J. Ji, K.J. Yoon, B. Wang, Z. Li, and W. Xu, TGS-NOPEC Geophysical Company

Copyright 2009, Offshore Technology Conference

This paper was prepared for presentation at the 2009 Offshore Technology Conference held in Houston, Texas, USA, 4–7 May 2009.

This paper was selected for presentation by an OTC program committee following review of information contained in an abstract submitted by the author(s). Contents of the paper have not been reviewed by the Offshore Technology Conference and are subject to correction by the author(s). The material does not necessarily reflect any position of the Offshore Technology Conference, its officers, or members. Electronic reproduction, distribution, or storage of any part of this paper without the written consent of the Offshore Technology Conference is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of OTC copyright.

---

### **Abstract**

Reverse-time migration (RTM), being based on the two-way wave equation, can generate superior subsurface images in areas where other migration methods based on the Kirchhoff integral or the one-way wave equation cannot correctly image reflectors below complex overburdens such as salt or basalt. In addition, because of its ability to image reflection events that cannot be properly imaged by other imaging techniques (e.g., prism waves), RTM can be used for refining a velocity model. Thus, RTM is a tool of choice when exploring targets below salt canopies or other complexly shaped salt bodies.

Despite considerable advances in computer technology, however, the cost of running RTM is still very high. The amount of computation far exceeds that of conventional one-way wave equation migration (WEM). In addition, it requires a large amount of core memory for computation. Thus, it is critical to speed up the computation and reduce the amount of memory for production usage of RTM.

By dividing a velocity model into a few regions in depth, we are able to substantially reduce the computation time and the memory required to run RTM, thereby making RTM more cost-effective for large-scale production applications. The computation time can be reduced by using a larger grid size for deeper regions. The use of a larger grid size is possible because subsurface velocities usually increase as the depth increases. Since the top region is much smaller than the entire velocity model, the amount of the core memory can also be substantially reduced.

### **Introduction**

The concept of reverse time migration has been described more than two decades ago (e.g., Baysal et. al., 1983 or McMechan, 1983), but only recent advances in computer technology allow for the use of RTM for production data. Fig. 1 illustrates the benefit of RTM over Kirchhoff migration for imaging below salt bodies in the Gulf of Mexico. Fig. 1a shows an east-west line image obtained by Kirchhoff migration, and Fig. 1b shows the corresponding image obtained by RTM. Note that the overall signal-to-noise ratio is significantly higher in the RTM image. It is much easier to interpret the boundary between the salt and sediments on the left hand side of the salt in the middle of the RTM image. In the Kirchhoff image (Fig. 1a), the reflectors terminating against the salt are not well focused and, as a result, the boundary is not clearly discernible. Furthermore, the reflectors below the salt are more clearly defined in the RTM image than in the Kirchhoff image. Kirchhoff-based migration methods cannot properly account for complicated wave propagation patterns caused by complexly shaped salt bodies.

Despite considerable advances in computer technology, however, the cost of running RTM is still very high. The amount of computation far exceeds that of other migration techniques. It also requires a large amount of core memory for computation. Because of the high cost of running RTM with regard to memory requirement and computation time, it is difficult to use RTM routinely for large-volume production projects. As a result, there has been a lot of effort to make RTM more efficient (Karazincir and Gerrad, 2006, and Zhang et. al., 2007)