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基于声波方程的井间地震数据快速WTW反演方法

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摘要 WTW(Wave equation traveltime+Waveform inversion)反演是基于波动方程的走时反演（WT反演）和波形反演的联合反演方法.WT反演利用波动方程计算走时和走时关于速度的导数，和传统以射线为基础的走时反演相比，具有不必射线追踪、不必拾取初至、不必高频假设以及初始模型和实际模型差别较大时也能较好收敛等优点，但WT反演与波形反演相比其结果分辨率低.与之互补的是，波形反演的反演结果分辨率高，但是当所给初始模型和实际模型相差太大时，波形反演迭代算法容易陷入局部极小点.可见结合两种方法的WTW反演是一种比较好的联合反演方法.常规WTW迭代算法是首先以WT反演为主反演得到地质模型的整体特征，然后再以波形反演为主反演模型细节，该算法耗时和占用计算机存储空间接近WT反演或波形反演的两倍.为了节省运算耗时和计算机存储空间，往往采取首先单独利用WT反演然后再单独利用波形反演的算法.这样做的缺点是不能紧密结合两种反演方法，使得它们的优缺点在每一次迭代中无法得到互补，从而影响了最终的反演结果.针对以上事实，本文提出一种新的方法实现WTW，使得WTW运算速度和存储空间在任何情况下等同于WT反演或波形反演.模型计算表明新的算法具有更好的收敛性.

关键词 WTW反演, WT反演, 波形反演,联合反演

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Rapid method for acoustic wave-equation WTW inversion of crosshole seismic data

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Abstract WTW inversion is a hybrid inversion method of wave-equation traveltime inversion (WT) and waveform inversion. Wave function is used to calculate the traveltime and its derivative (perturbation of traveltime with respect to velocity) in WT inversion. Unlike traditional ray-based travetime inversion，WT has many advantages. No ray tracing or traveltime picking and no high frequency assumption are necessary，and a good result can be reached while starting model is far from real model. Comparing with waveform inversion，WT has low resolution. Complementary to WT，waveform inversion has high resolution，but easily sticks in local minima when the starting model is far from real model. So WTW is a good hybrid inversion method. Traditional WTW is to first reconstruct the smooth characters of model with WT inversion being primary and then reconstruct the detailed characters of model with waveform inversion being primary. But the computation time and memory space used for this method are twice that of WT inversion or waveform inversion. So a simplified method is used actually. That is to first use WT singly and then waveform inversion singly. The disadvantage of the simplified method is that there is no link between the WT and the waveform inversions，and the benefit of each method cannot be utilized to compliment the other method during iterations. This paper proposes a new method to implement WTW inversion with a computation time and memory space comparable to those of WT or waveform inversion. The model calculation of the new method shows a better convergence.

Key words WTW inversion WT inversion Waveform inversion Joint inversion

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