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黏弹性VTI介质频率空间域准P波正演模拟

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Quasi-P wave forward modeling in viscoelastic VTI media in frequency-space domain

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摘要 有限差分方法是波场数值模拟的一个重要方法,时间域有限差分计算方法因按时间片递推计算,每个时间片的舍入误差会累积到下一片中,当时间片较多,最终会导致累积误差太大.而频率域计算是按频率片对空间网格进行整体求解方程组,其计算误差分配到了每个网格点上,并且各个频率片之间是独立计算的,因此不存在累计误差,而且在频率-空间域更易于模拟黏弹各向异性介质的衰减,同时采用25点优化差分算子克服了常规差分算子的数值频散.本文首先推导了黏弹性VTI介质的频率-空间域准P波波动方程,在此基础上,利用25点优化差分算子构造了差分格式,实现了频率空间域的正演模拟.并以断层模型为例,模拟并对比分析了利用弹性VTI介质波动方程差分格式和利用黏弹性VTI介质波动方程差分格式模拟的井间地震准P波波场记录,得出黏弹性介质地震记录由于衰减振幅相对较小,主频相对较低的结论.

关键词: 数值模拟 频率-空间域 各向异性 黏弹性 准P波

Abstract: The finite difference is an important method of wavefield numerical simulation. It can calculate recursively by time slice, and the round-off errors of each time slice may accumulate to the next time slice in time domain, eventually, which will lead to too large accumulated error when the time slice is enough. However, solving all equation set in frequency domain is based on the frequency slice on the space grid, whose error is assigned to each grid point, it is without accumulated error and easier to simulate the attenuation of the viscoelastic anisotropic media in frequency-space domain. In order to overcome the numerical dispersion of routine finite-difference operators, 25-point optimized finite-difference operators are applied. This paper derives firstly the formula of quasi-P wave in viscoelastic VTI media in frequency-space domain, and then constructs the difference format using 25-point optimized finite difference operators, so it implements forward modeling. A case study of fault model compares and analyzes the crosswell seismic quasi-P wavefield stimulated with the finite difference method for both elastic VTI media and viscoelastic VTI media. In the end, it comes to the conclusion that the amplitude of seismic wave is relatively smaller and the main frequency is decreased in viscoelastic media.

Keywords: Forward modeling Frequency-space domain Anisotropic Viscoelastic Quasi P-wave

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