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忽略TTI介质对称轴倾角的可行性

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Feasibility to neglect the tilt of the symmetry axis of a TTI medium

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摘要 假设横向各向同性(TI)介质的对称轴是垂直的(VTI)或者水平的(HTI)能给实际资料处理带来便利,然而实际TI介质的对称轴往往是倾斜的(TTI),忽略对称轴倾角可能给各向异性参数提取和成像带来偏差,因此需要研究是否能、以及什么条件下能忽略TTI介质对称轴倾角.本文通过理论研究和数值分析研究了与TTI介质弹性性质最接近的VTI介质(OAVTI)的弹性常数和各向异性参数与原TTI介质的弹性常数和各向异性参数之间的联系与差别.结果表明:OAVTI介质各向异性参数与原TTI介质各向异性参数之间的差别可统一表示成$F(\alpha_0/\beta_0,\varepsilon,\delta,\gamma)\xi^2$的形式,其中$F(\alpha_0/\beta_0,\varepsilon,\delta,\gamma)$是无量纲各向异性参数$(\varepsilon,\ \delta,\ \gamma)$的线性函数,$\xi$是对称轴倾角;$\xi$的大小对各参数的误差起主导作用,一般不建议忽略20°~25°以上的对称轴倾角;当ξ较小时,即使是对强各向异性的TTI介质作VTI近似,引起的P波各向异性参数误差也很小,因此在纵波资料处理中忽略TTI介质对称轴倾角通常是可行的;即使在小ξ条件下,倾斜对称轴对SV波也有显著影响,因此在转换波资料处理中,不建议忽略TTI介质的对称轴倾角.本文的研究为分析忽略TTI介质对称轴倾角的可行性提供了理论依据和简便的判据.

关键词 TTI介质, 各向异性, 横向各向同性, 倾斜对称轴, 弹性张量

Abstract: Most anisotropic processing methods were developed for transversely isotropic (TI) media with vertical (VTI) or horizontal (HTI) symmetry axes. Theoretical formulae and processing methods are much simpler for VTI/HTI media than for TI media with tilted symmetry axes (TTI). However, due to tectonic activity and anomalous local stress, the symmetry axes of real TI materials could be tilted. Thus, it is of great interest if a TTI medium could be treated as a VTI or HTI medium without causing large errors. In this contribution, we derived explicit expressions between elastic constants of a TTI medium and the optimally approximated VTI (OAVTI) medium based on tensor theory. The OAVTI medium is defined as the VTI medium with its elastic tensor closest to the elastic tensor of the TTI medium. Based upon the relations among elastic constants, we also derived the exact and simplified relationships among anisotropic parameters of the OAVTI medium and the TTI medium. The differences between anisotropic parameters could be expressed in the form of $F(\alpha_0/\beta_0,\varepsilon,\delta,\gamma)\xi^2$, where $F(\alpha_0/\beta_0,\varepsilon,\delta,\gamma)$ is a linear combination of the dimensionless anisotropic parameters $(\varepsilon,\ \delta,\ \gamma)$ and ξ is the tilt of the symmetry axis of the TTI medium. The tilt ξ is the most important parameter governing the differences of anisotropic parameters. For ξ beyond 20°~25°, we suggest that the tilt must be taken into account. For small ξ, the differences for anisotropic parameters of P waves are negligible even in the presence of strong anisotropy. For SV waves, the differences are trivial only when the TI medium is nearly elliptical, implying that the SV wave is nearly isotropic. Thus, we conclude that it is feasible to neglect the tilt of the symmetry axis in P-wave data processing if the tilt is not very large, but infeasible to neglect the tilt for PS data.

Keywords TTI medium, Anisotropy, Transverse isotropy, Tilted symmetry axis, Elastic tensor

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