RAYTRACING IN ANISOTROPIC MEDIA

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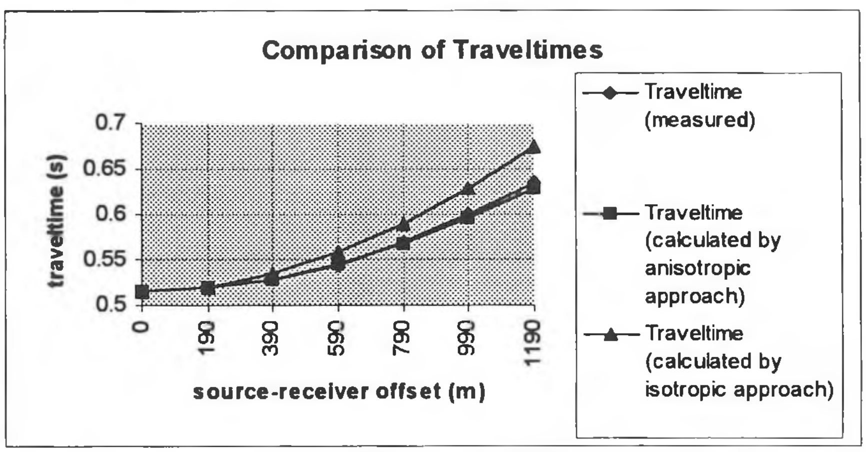
An analytic method relating incidence, reflection and transmission angles at an interface between anisotropic media is elaborated. The method relies on the continuity conditions relating tangential components of phase slowness across the interface, and on the fact that the ray is perpendicular to the phase-slowness surface. The rather familiar concepts of vector calculus are used to create a template for calculating phase and group angles across discontinuities. The angles involved in wave propagation through layered anisotropic media are, at times, significantly different than their isotropic counterparts. Thus the trajectories derived in raytracing by the isotropic versus the anisotropic approach differ considerably if the medium is significantly anisotropic. More importantly, measurable quantities, e.g., traveltimes, differ depending on the approach taken.

This template is used to derive analytic expressions for phase and group angles, and to elaborate a raytracing scheme for acoustic waves in transversely isotropic (TI) media. A relative simplicity and clarity of equations is achieved by using expression for phase velocities as a function of phase angle under the assumption of weak anisotropy.

The weak-anisotropy approach assumes that the difference in speed between the fastest and slowest propagation directions does not exceed 20%. Consequently, the expression for phase velocity is obtained by developing a rather cumbersome expression into a Taylor series and ignoring higher-order terms. The raytracing method can be used to calculate traveltimes for layered, weakly anisotropic media. In the process of raytracing, the bending of rays at discontinuities is taken into account using a derived anisotropic equivalence of Snell's law.

The results of a physical laboratory experiment, which involved propagation in the symmetry plane of an orthorhombic material with known characteristics, have been compared with theoretical calculations. The comparison indicates that the anisotropic approach predicts reasonably well the experimental results and yields a significantly better prediction than an isotropic one. It also suggests that weak-anisotropy assumptions can be useful in practical applications as long as one remains within the intended limits of approximation.



Comparison of measured and calculated traveltimes for a laboratory experiment involving a transmission of acoustic signal across a two-layer anisotropic medium separated by a planar interface. The source-receiver offset corresponds to the separation measured parallel to the interface. The actual dimensions of the physical sample used have been scaled to allow data processing using software developed for seismological studies.