Spherical-wave AVO modelling in VTI media

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Abstract

It is well known that in many situations anisotropy is present either in the form of apparent anisotropy caused by layering of isotropic materials or intrinsic anisotropy caused by, for example, shale. This type of anisotropy is usually called VTI (transversely isotropic with a vertical axis of symmetry). In addition to anisotropy, matters are complicated by ever present anelastic effects, quantified by a frequency independent quality factor, Q. Q-factor dependence of AVO has been observed in isotropic spherical-wave AVO models and also exists in VTI situations.

Previous work by the authors involved using isotropic plane-wave reflection coefficients together with the Weyl integral to compute isotropic spherical-wave potentials. Plane-wave reflection coefficients for VTI-media have been presented by Graebner (1992) and by Rueger (1996). The Weyl integral for anisotropic media is given by Tsvankin (2001). Their "exact" equations are utilized in this investigation. Approximations are introduced by numerical integration.

The appearance of computed AVO-results depends on scaling. Spherical spreading must be compensated for if results are to be compared to plane-wave responses. P-wave examples to be shown give magnitude displays normalized to unity R_{pp} responses. When R_{ps} is set to unity for C-wave examples, the scaled result at small incidence angles is oscillatory. In this region geometrical spreading factors are computed instead.

Because of a velocity increase across the interface, critical angles exist and head waves are generated for Class 1 AVO models. Increasing top layer VTI-type anisotropy decreases this velocity contrast and a shift of the critical point towards larger angles results. For both weak and moderate anisotropy, larger depths "tweak" the AVO response near the critical point to lower angles toward a plane wave comparison. Similarly, VTI AVO responses are also "tweaked" by a change in Q-factors. Decreasing Q-factors shift the spherical-wave response away from plane-wave comparisons. Both C-wave AVO and P-wave AVO are more sensitive to changes in anisotropy than to changes in depth or Q-factors.