Exploration applications of seismic velocity anisotropy

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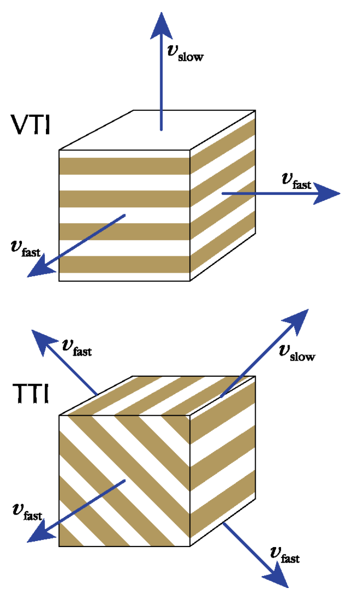
Summary

Much work in geophysical research addresses seismic imaging problems caused by seismic anisotropy. Seismic velocity anisotropy is the dependence of seismic velocities on the direction of wave propagation. A medium that displays this directional dependence is referred to as an anisotropic medium. Despite fifty years of observations in laboratory experiments and over a century of theoretical work, it is only in the past decade that we, the exploration community, routinely correct for anisotropic effects on seismic data. We will focus on these latest developments in seismic velocity anisotropy research–anisotropic corrections on exploration seismic data–and where they apply to exploration problems.

It's all about bedding

Sedimentary basins are the playground of the oil-and-gas exploration seismologist. Anisotropy is directly linked to the bedding planes in sedimentary rocks. In shales, platelet-shaped grains aligned parallel to bedding give the rock a faster P-wave velocity parallel to bedding and a slower velocity perpendicular to bedding. Periodic thin layering (PTL) has the same effect on compressional waves, with slower seismic velocity in the direction normal to bedding. The symmetry class describing this type of anisotropy is called TI or transverse isotropy. Transverse isotropy refers to the velocities being the same, or isotropic, in all directions transverse to the bedding-plane normal.

If our geology is undisturbed by tectonic activity, the bedding-plane normal is typically vertical. We refer to the anisotropy of this particular case as vertical transverse isotropy or VTI. This is the most common symmetry assumption employed in exploration problems. Velocity increasing with incident angle creates the "hockey stick" effect on CDP gathers, which is corrected with nonhyperbolic moveout. I will show data examples of improved stacking and improved far-offset AVO response when using nonhyperbolic moveout to flatten the VTI hockey stick.



Whether the tectonic activity is compressional, extensional, or resulting from salt flows, the resulting dipping layers have a tilted symmetry axis or bedding-plane normal. We call this case tilted transverse isotropy or TTI. Several researchers have observed lateral position errors on structures below TTI media. Nonhyperbolic moveout will flatten CDP gathers on the dipping reflectors, but correcting imaging and positioning errors on events below TTI media requires anisotropic depth migration (ADM). I will show data examples of improved imaging and positioning of structures below TTI media with ADM.

Conclusions

Research into seismic anisotropy has recently found its applicability to practical exploration problems. As we continue to apply anisotropic technologies to exploration problems, we will find more applications for the use of these technologies and we will discover where we can ignore anisotropy with confidence.