Chapter 5

Conclusions

> Han Wavel is a world which consists largely of fabulous ultra-luxury hotels and casinos, all of which have been formed by the natural erosion of wind and rain. The chances of this happening are more or less one to infinity against. Little is known of how this came about because none of the geophysicists who are so keen to research it can afford to stay there. – Douglas Adams (1982)

What lessons have we learned from this long-winded discourse on anisotropy? I will leave the crystallographers to answer that one for themselves. I will try to answer a simpler question: what lessons have we learned that apply to geophysics?

You can't generalize from the simple to the complex. In Chapter 2 we found that transverse isotropy is fundamentally different than isotropy in many ways. Similarly in Chapter 3 we found that general 3-dimensional anisotropy is fundamentally different than transverse isotropy. What sorts of effects can occur if attenuation and piezoelectricity are added? I don't know, but I would be surprised if there were no new surprises. As a corollary it's also worth pointing out that *three-dimensional phenomena need to be studied in three dimensions.*

Even elliptical anisotropy is better than nothing. Simple approximations can be very useful despite their limitations. Fitting elliptical anisotropy to each wavetype independently proved surprisingly useful despite its limitations and ad-hoc nature because it is at least a first step away from isotropy. The sideways-slipping qP waves in Figure 2.13 could be modeled quite well in this way.

For any given anisotropic medium, P waves are more likely to be well-behaved than S waves. The bottom two rows in Figure 2.4 (page 24) tell the story here. As C_{13} increases the qP wave expands out in a stately fashion while the qSV turns itself completely inside out. Similarly, qP waves don't triplicate or have singularities. They can be collapsed into scalar pure modes and removed from the data intact. Since they carry the first news of the source they have sharp first arrivals. Most importantly, they are more likely to approximately fit the isotropic conception of the world underlying basic algorithms such as NMO and stack.

Shear waves are more interesting than P waves. On the other hand, shear waves are more interesting precisely because they have such a wide range of possible behaviors. If we can develop new algorithms that can handle shear waves, we will be able to recover much more information about the interior of the earth.

Singularities are not likely to be directly observable using ordinary techniques. In our examples, singularities only became directly visible on the standard SH into SH or SV into SV sections when there was a very large amount of anisotropy. While it still might happen, I wouldn't count on it.

Record a full set of components if you can. All is not lost, however: in our examples singularities were often quite visible on non-standard SV into SH (Xy) or Vertical into SH (Zx) sections. A full set of nine components also allows the source and receiver to be arbitrarily rotated after the fact to look for such effects in the data.

Don't only record along symmetry axes. The most interesting three-dimensional effects happen off the symmetry planes. Recording at 45° to the symmetry planes is almost as suspect. This suggests we should *record along multiple azimuths when possible.* Things might appear quite different along different azimuths or at different offsets from the source. This is the nature of anisotropy.

Some of the effects associated with singularities might be significant. By using the right source and receiver combinations, we saw that seemingly insignificant esoteric effects such as "connections" could become quite prominent. If observed, they would provide detailed information about the elastic properties of the earth.

Approximations are useful if you know what you're losing. If you aren't ready for the fully elastic world, all is not lost. If you are only interested in kinematics simple methods like finite-difference traveltimes can get you 99% of the way there.

Anisotropy is not hopeless. Anisotropy may be challenging, perhaps, but it is still worth pursuing.