Conclusions The results presented in this thesis establish RWE-based migration as a viable 2D and 3D wave-equation technique that yields images superior to conventional Cartesian migration with modest additional computational cost. Chapter 2 addresses existing issues with Riemannian wavefield extrapolation theory by extending RWE to smoother, but non-orthogonal, coordinate systems. I demonstrate that one can generate an acoustic wave equation in general 3D Riemannian spaces, and that the corresponding extrapolation wavenumber decouples from the other wavenumbers. I incorporate into a one-way extrapolation operator appropriate for propagating wavefields. A method for generating computational meshes that are unconditionally singularity-free is detailed, and used to generate examples that illustrate wavefield propagation on non-orthogonal coordinate meshes using RWE operators. Accordingly, this opens up a range of imaging possibilities including Riemannian plane-wave migration in elliptic and elliptic cylindrical coordinates.

Chapter 3 extends Riemannian wavefield extrapolation to 2D prestack shot-profile migration. I choose an elliptic coordinate system that generally conforms to the wave propagation direction and enables wide-angle extrapolation of both source and receiver wavefields. Post-stack migration results of a turning wave data set validate the approach, while the 2D prestack imaging results show that the RWE migration algorithm generates images more accurate than the corresponding Cartesian results. The cost difference between the elliptic and Cartesian imaging algorithms is only two additional interpolations per migrated shot profile. Finally, I argue that parametric coordinate systems are a good trade-off between the competing constraints of meshes conformal to the wavefield propagation direction and coordinate system simplicity because one can readily develop analytic wavenumbers and more accurate high-order extrapolation implementations.

Chapter 4 extends Cartesian ADCIG theory to 2D generalized coordinate systems. The expressions for ADCIGs contain additional factors describing mesh geometry and wavefield shifts. The geometric expression cancel out for coordinate systems that obey the Cauchy-Riemann conditions, which include tilted Cartesian and elliptic meshes. The method for calculating ADCIGs in elliptic coordinates is very similar to that in Cartesian. This has been confirmed by comparisons of analytically and numerically generated ADCIG domains, and with tests on the BP synthetic data set. Calculated ADCIGs volumes are more robust when computed in elliptic coordinates than in Cartesian coordinate due to improved high-angle propagation and improved sensitivity to steep structural dips.

Chapter 5 introduces the tilted elliptic cylindrical coordinate system to conical-wave migration. I demonstrate that corresponding extrapolation wavenumber is no more complicated than that of elliptically anisotropic media. This allows us to implement an accurate finite-difference extrapolation approach that can handle the effective numerical anisotropy. Tests on 3D wide-azimuth synthetic and 3D narrow-azimuth Gulf of Mexico data sets validate the RWE-based migration approach.