8 Summary and Conclusion

In this thesis, the Nodal Discontinuous Galerkin Method (NDG) is adapted to two and three dimensional seismic wave propagation problems and applied to scenarios from tunnel reconnaissance. The general theory of the method is extended to elastic and anelastic wave propagation. Absorbing boundary conditions relying on the Nearly Perfectly Matched Layer approach are adapted to the NDG as an alternative to the flux based boundary conditions. All features are effectively implemented into software in order to perform parallelized numerical simulations. The accuracy and implementation is successfully validated through different test cases such as Lamb’s problem and compared to simulations based on the Spectral Element Method. The NDG was chosen due to its capabilities for high order approximation of the wave field as well as for the possibility to use triangular and tetrahedral meshes for the model discretization.

Forward simulations for the applications of tunnel reconnaissance are computed and the resulting wave fields are characterized in detail. For two dimensional tunnel simulations, NPML absorbing boundary conditions are successfully used to suppress nonphysically reflections at the outer boundaries and viscoelasticity is applied to the tunnel simulations. Wave field around tunnels exhibit significant complexity making interpretation of tunnel seismic data very challenging. The numerical scheme is also validated in three dimensional tunnel settings and a detailed comparison of a complex tunnel simulation is provided and compared with the SEM. The advantage of the three dimensional NDG is finally shown for a geological model including a curved tunnel, which could be efficiently meshed and successfully simulated. The forward simulation is followed by numerical experiments dealing with the application of the adjoint Full Waveform Inversion to the tunnel reconnaissance process in two dimensions. It is shown in two different numerical tunnel examples that it is possible to reconstruct a valid model from seismic measurements. Nevertheless, for the tunnel setting, it is advantageous to incorporate additional receivers which are installed at the free surface or in boreholes.

Summarizing, it is demonstrated that the NDG perfectly fits the requirements for high order seismic simulation of tunnel reconnaissance problems. In addition, the Full Waveform Inversion represents an appropriate tool to image the domain of a tunnel.