RAY MODELLING FOR INDUCED SEISMICITY IN V0-K MODELS

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Full waveform seismic simulation using 3D finite difference or spectral element algorithms have become computationally feasible in many applications. However, when it comes to our understanding of seismic wave propagation and our ingenuity to design inverse methods we often relate to concepts such as phases, wave fronts, travel times, reflection, refraction, etc., that are well understood in terms of ray theory. Therefore, ray methods will always have at least complementary value, not only due to computational efficiency, but also to add a narrative to the complex picture of full seismic waveforms.

Also for the analysis of induced seismicity due to gas extraction in the Groningen Field we see that ray modelling helps us to interpret features of observed waveforms, such that our understanding of the subsurface processes improves.

We present a ray method that makes use of the rich information on seismic velocities that is often available in an actively exploited reservoir. The velocity model we use is a v0-k layer cake model: a model that is piecewise linear in depth, while both layer interface and velocity intercepts may vary in the horizontal directions. These models are typically used for time-to-depth conversions and are constructed by combining borehole logs and (3D) seismic data. Ray paths are constructed by connecting traversing or diving (refracting) rays within the individual layers. Geometrical spreading, reflection, transmission and phase conversion are taken into account. Graph algorithms are used to determine the most relevant sequences of connections that construct a ray path from the source at depth to the observation points.