Ray modelling

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Content

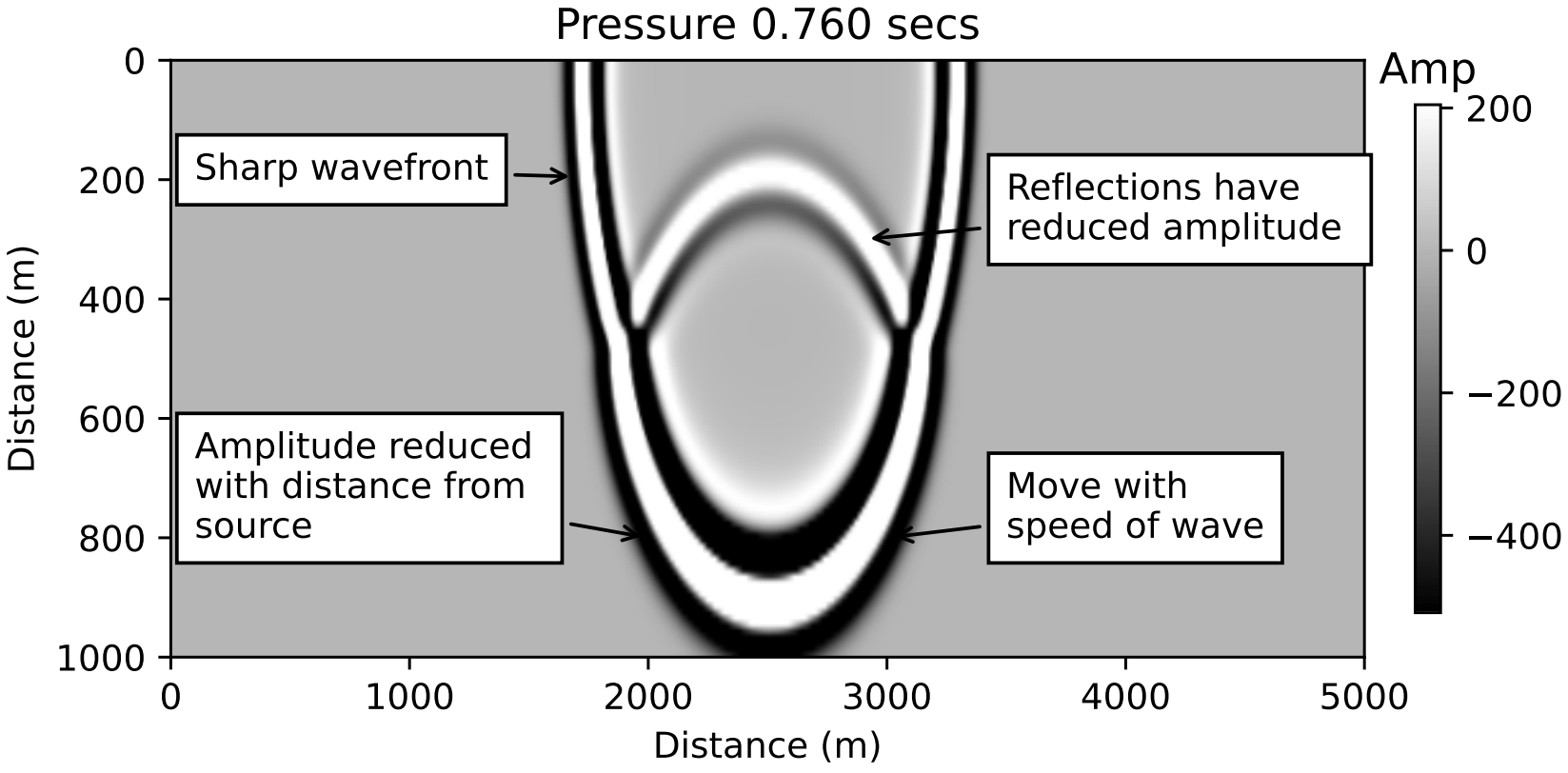
1. Waves, Rays and Wavefronts
2. Ray modeling in simple models
3. Ray modeling for complex structures
4. Seismic imaging using rays

Ray modeling

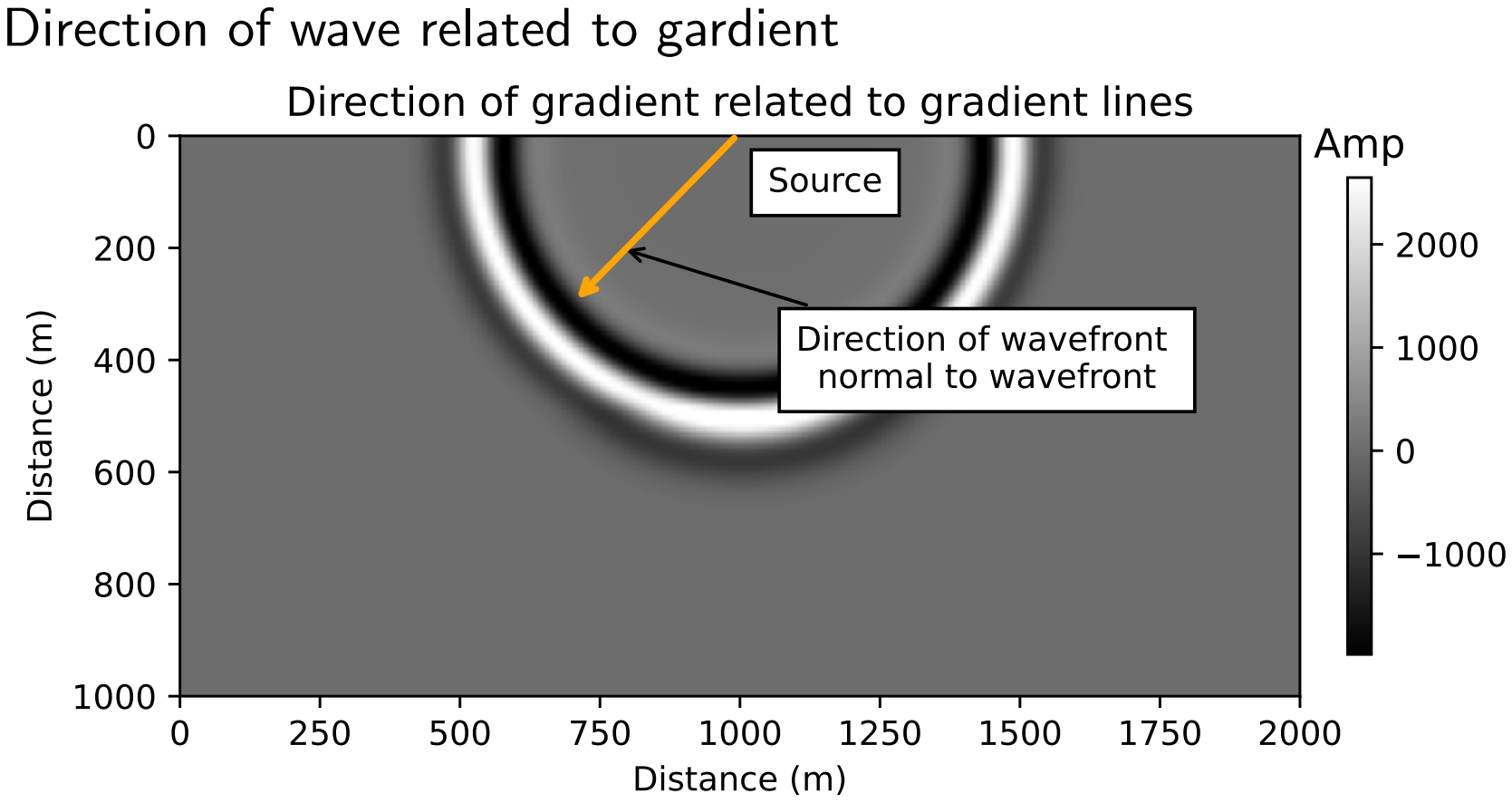
- The objective is to model (simulate) a seismic experiment
- Seismic wave proagation is complex
- Ray modeling is an attempt to simplify

Structure of wavefields

Snapshots reveals the structure of seismic waves

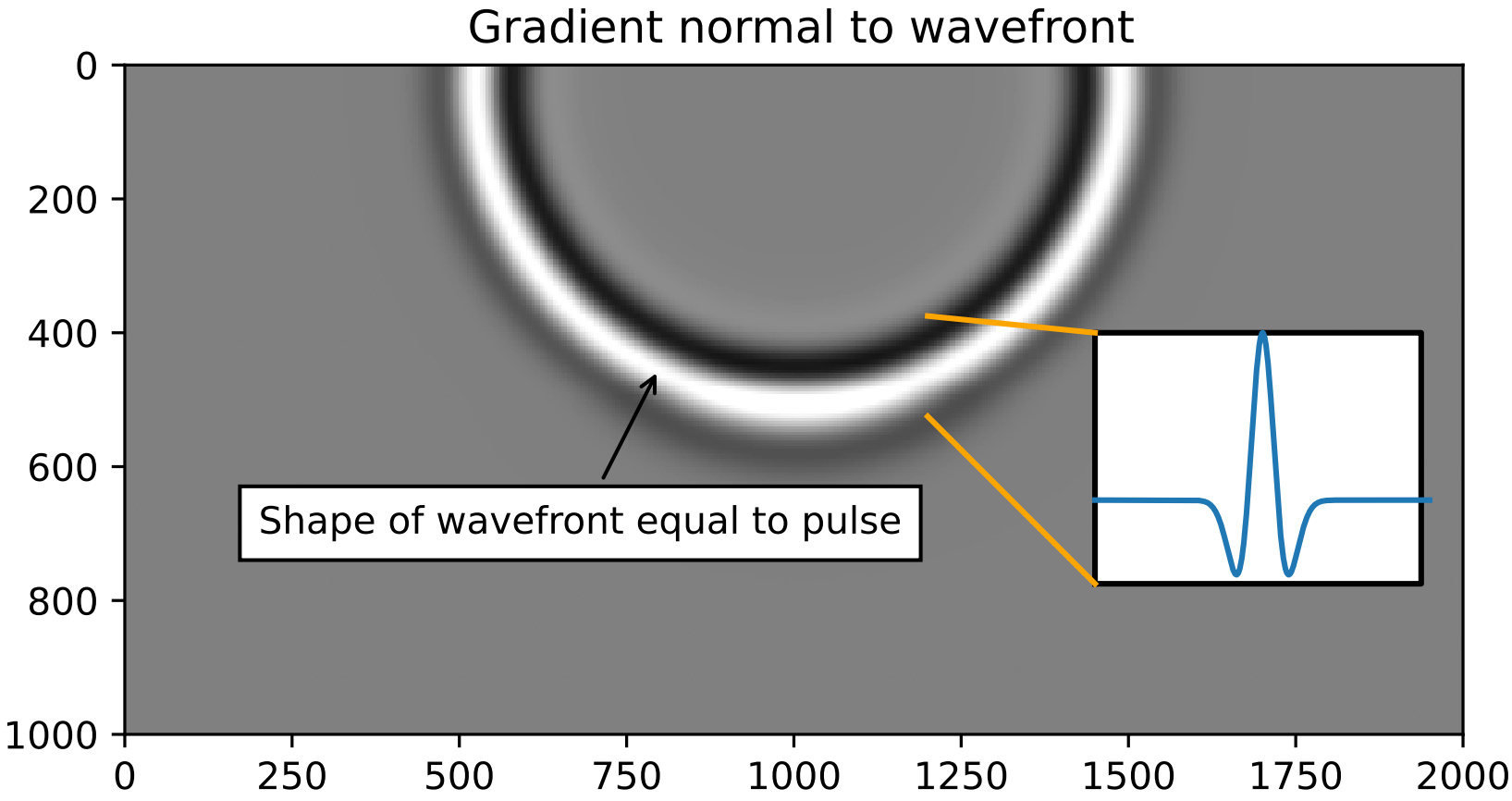


Rays


Direction of wave related to gardient
Direction of gradient related to gradient lines
Source
Direction of wavefront
normal to wavefront
Amp
2000
1000
0
−1000
Distance (m)
0
200
400
600
800
1000
0
250
500
750
1000
1250
1500
1750
2000
Distance (m)

Rays

Wavefron width related to source pulse



Ray modelling

Putting this together we can compute the wavefield generated by a seismic source by

- Draw a line from the source to the wavefront
- The shape of the wavefront is simply the source pulse
- The amplitude of the wavefron decays inversly proportional to distance (Energy conservation)
- All of this can be expressed with an equation

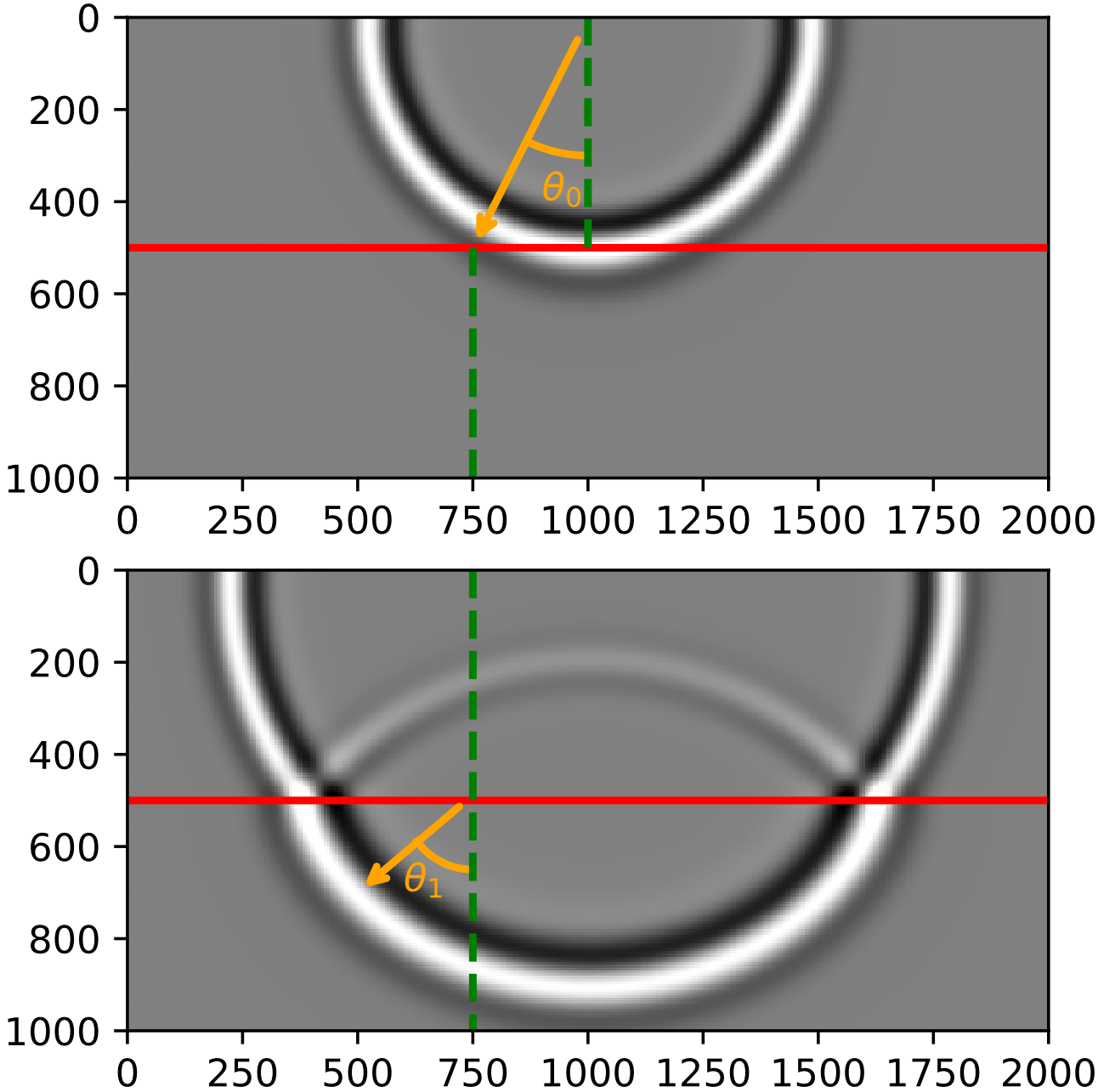
Ray modelling

$$p(r,t) = \frac{s(t-\tau)}{r},$$

where

- t: Time
- r: Distance
- v_p: P-wave velocity
- $p(r,t)$: Pressure
- $s(t)$: Source pulse
- $\tau = r/vp$: Traveltime

Transmission through interface



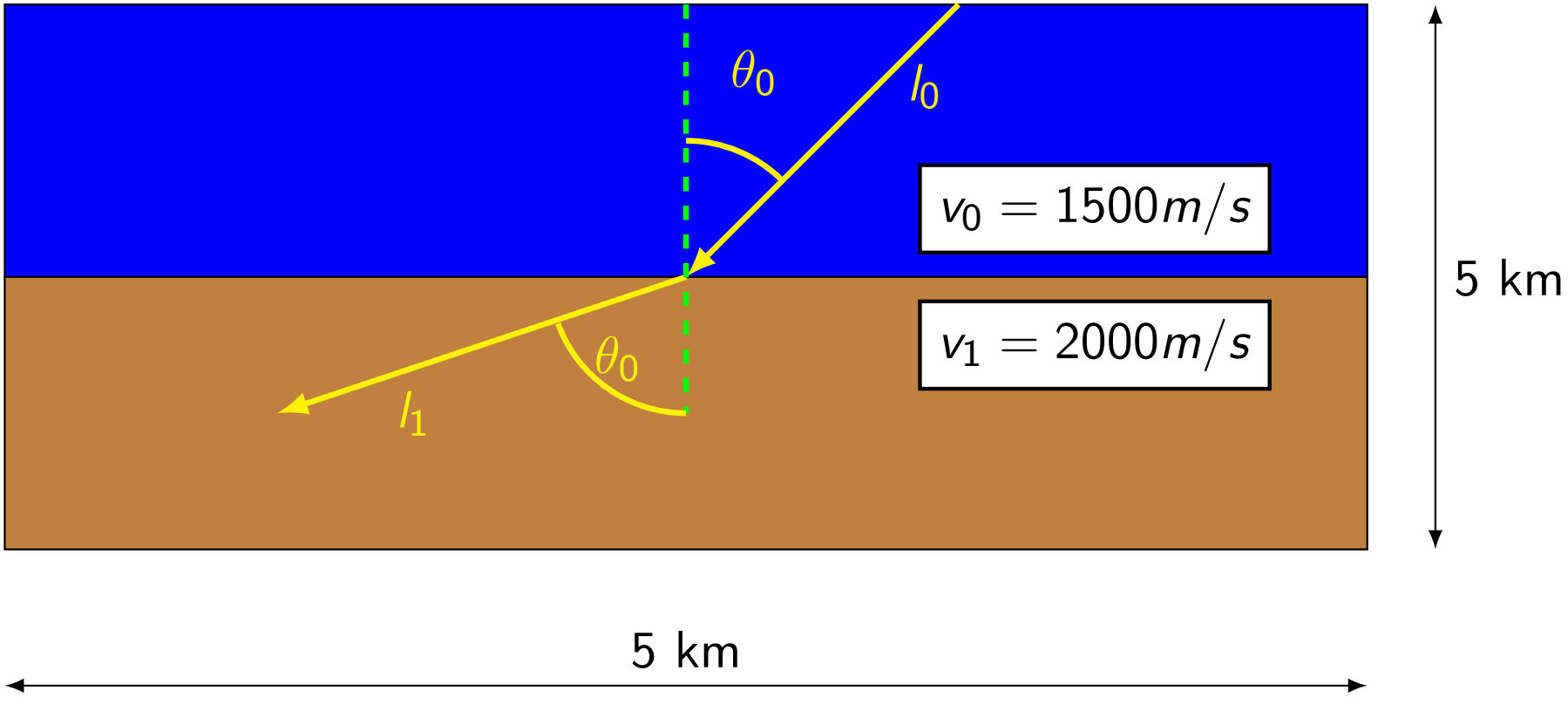
The transmitted ray follows Snell's law

$$\frac{\sin(\theta_0)}{v_0} = \frac{\sin(\theta_1)}{v_1}$$

where

- v_0: P-wave velocity above interface
- v_1: P-wave velocity below interface

Rays

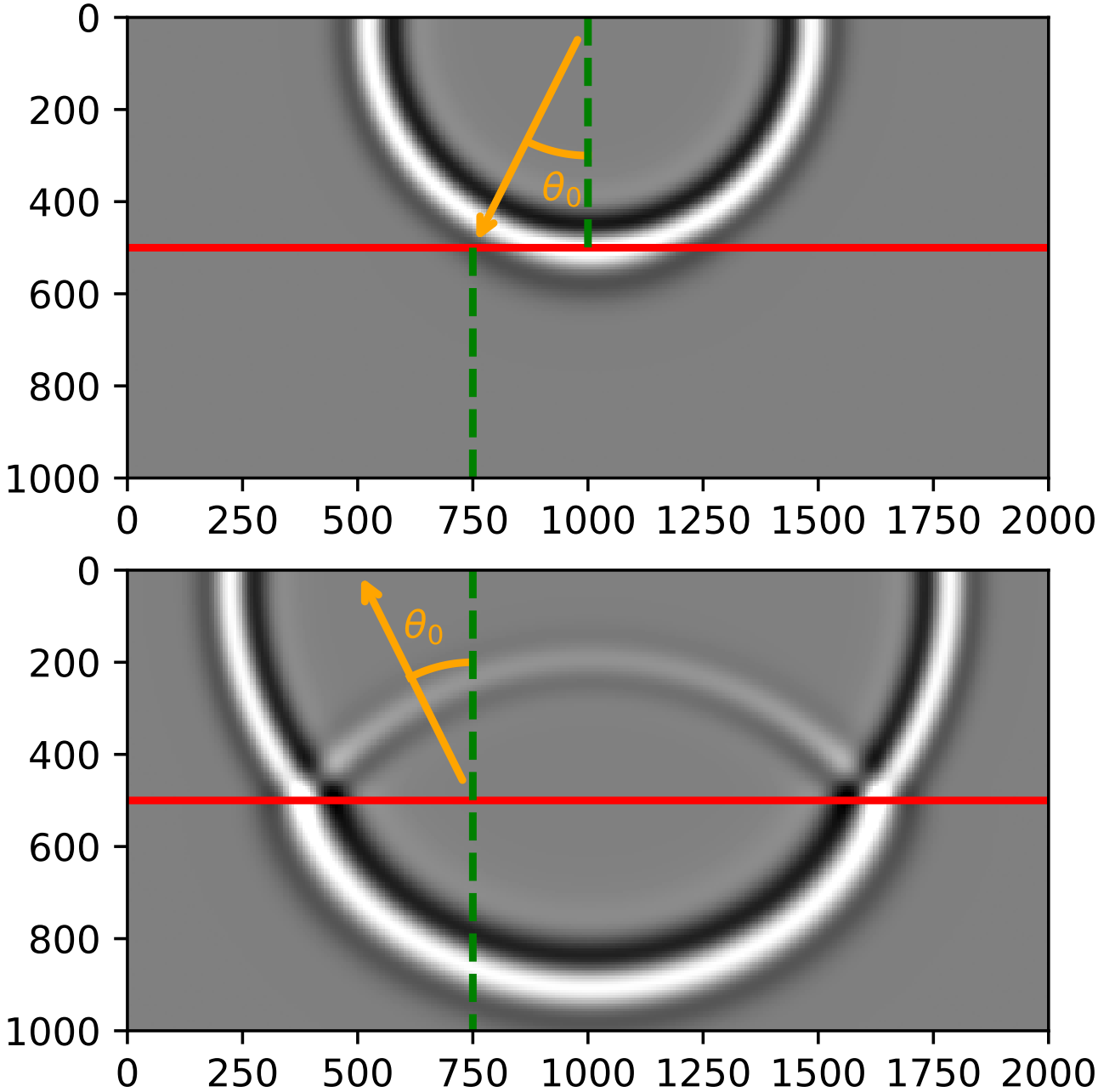


Traveltime

The time to reach the wavefront is called the traveltime and can be calculated as:

$$\tau = \frac{l_0}{v_0} + \frac{l_1}{v_1}$$

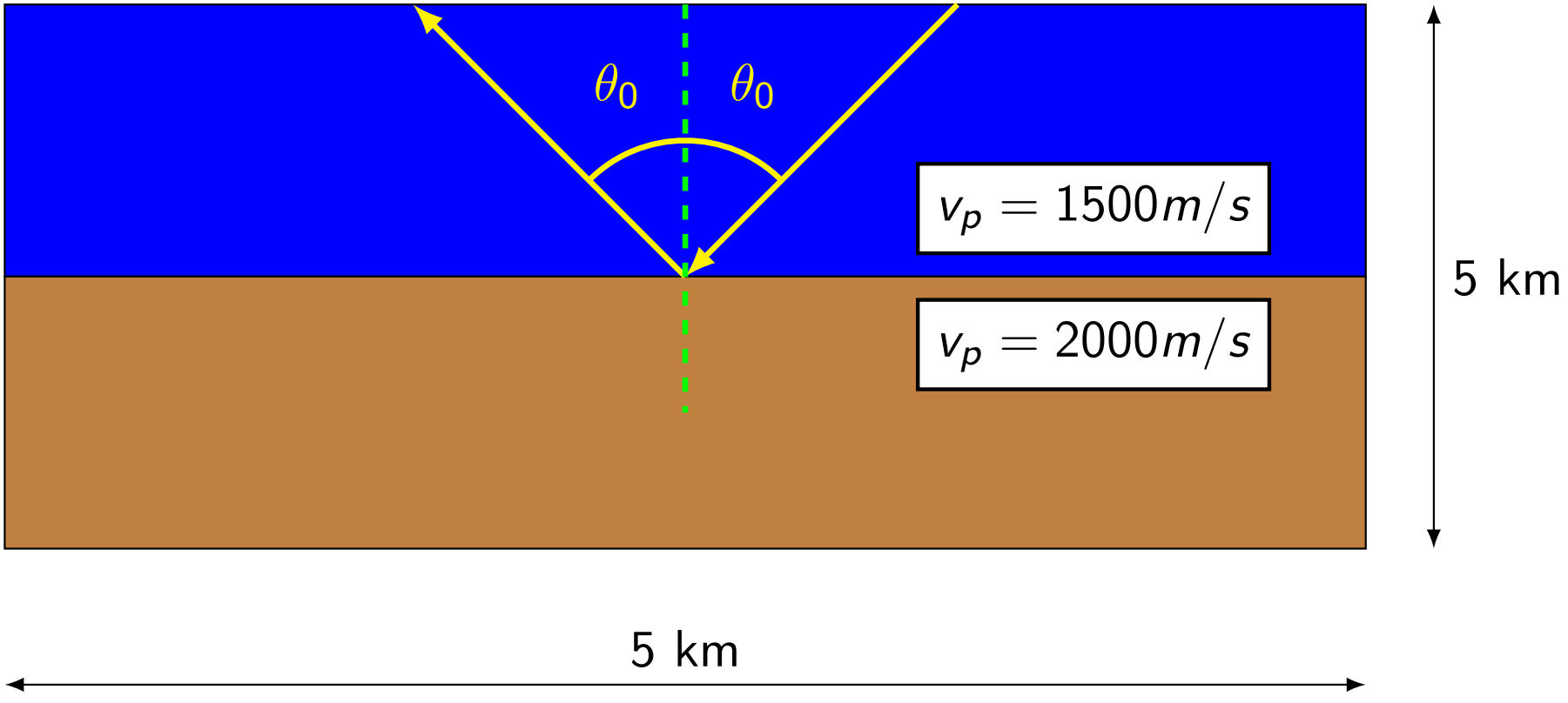
Reflection


0
200
400
600
800
1000
0
250
500
750
1000
1250
1500
1750
2000
θ_0
θ_0

Reflected ray

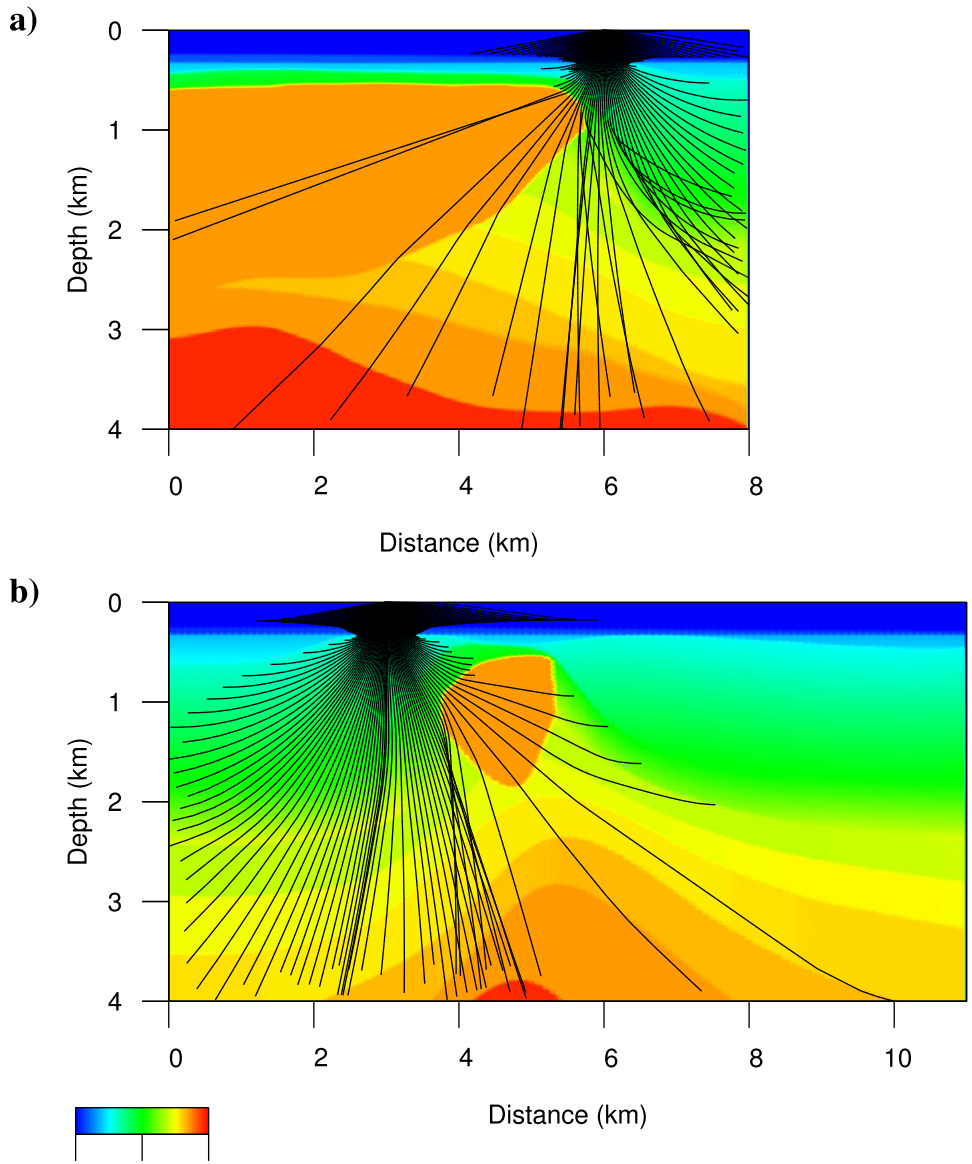
The reflected ray follows Snell's law implying that the angle with the vertical is the same for the reflected as for the incoming ray.

Rays



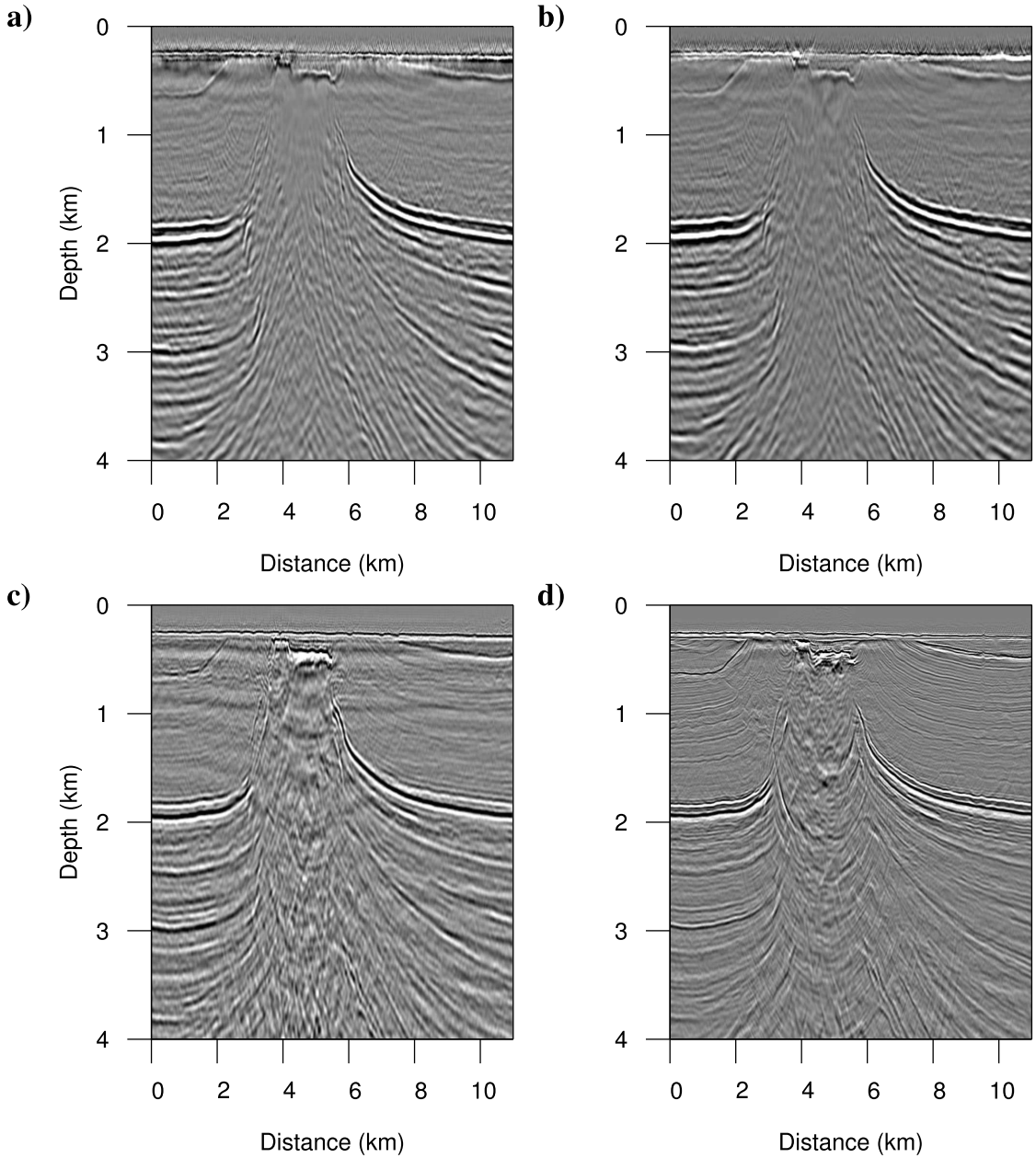
Rays

Ray modeling is very useful to calculate traveltimes and visualize seismic waves in a simple way



Seismic imaging with rays

Ray modeling is also used for seismic imaging



Seismic imaging with rays

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