

# Overview ta3520

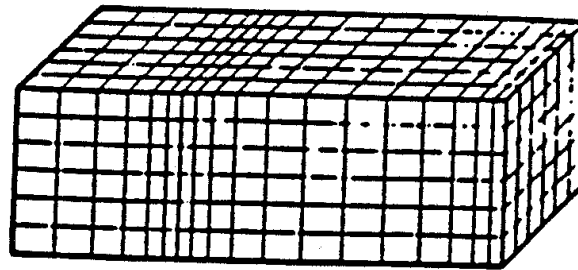
## Introduction to seismics

- Fourier Analysis
- **Basic principles of the Seismic Method**
- Interpretation of Raw Seismic Records
- Seismic Instrumentation
- Processing of Seismic Reflection Data
- Vertical Seismic Profiles

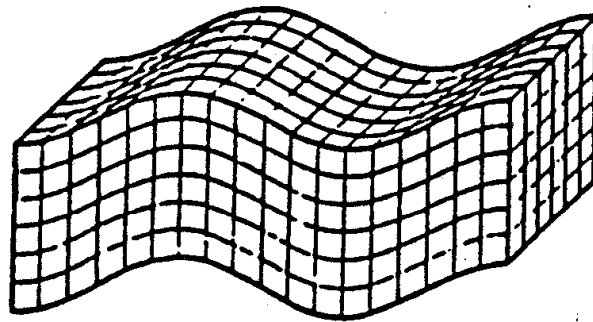
### Practical:

- Processing practical (with MATLAB)

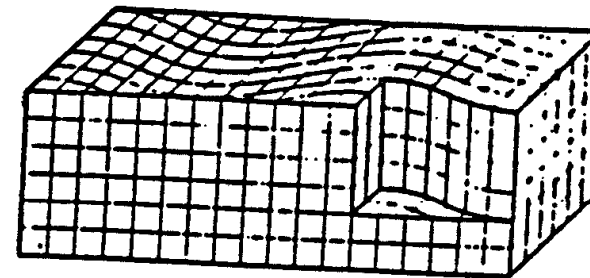
# Types of seismic waves



p-wave



SV-wave



SH-wave

# Types of seismic waves: nomenclature

## P-waves:

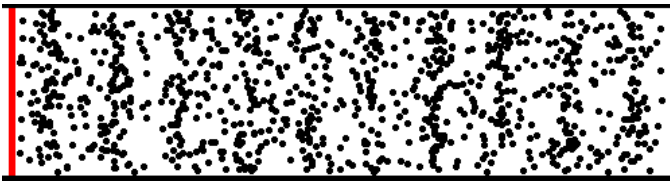
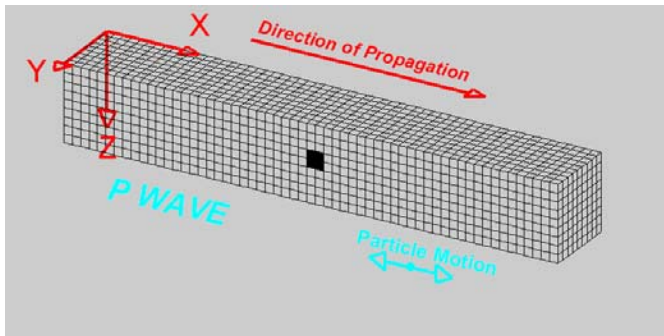
- compressional waves
- longitudinal waves
- Push-waves
- Primary waves

## S-waves:

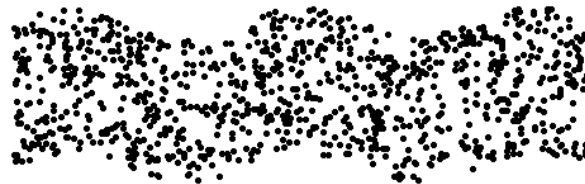
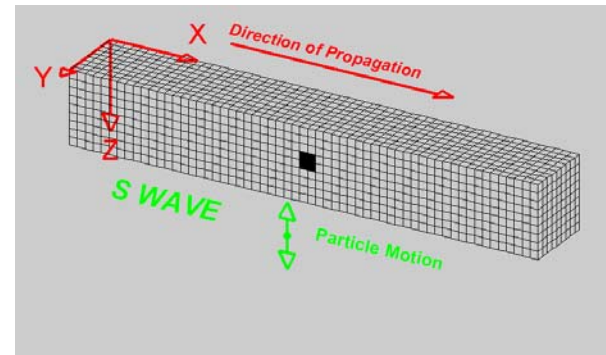
- shear waves (physics)
- transverse waves (mathematics)
- Shake waves
- Secondary waves

# Types of seismic waves: nomenclature

P-waves:



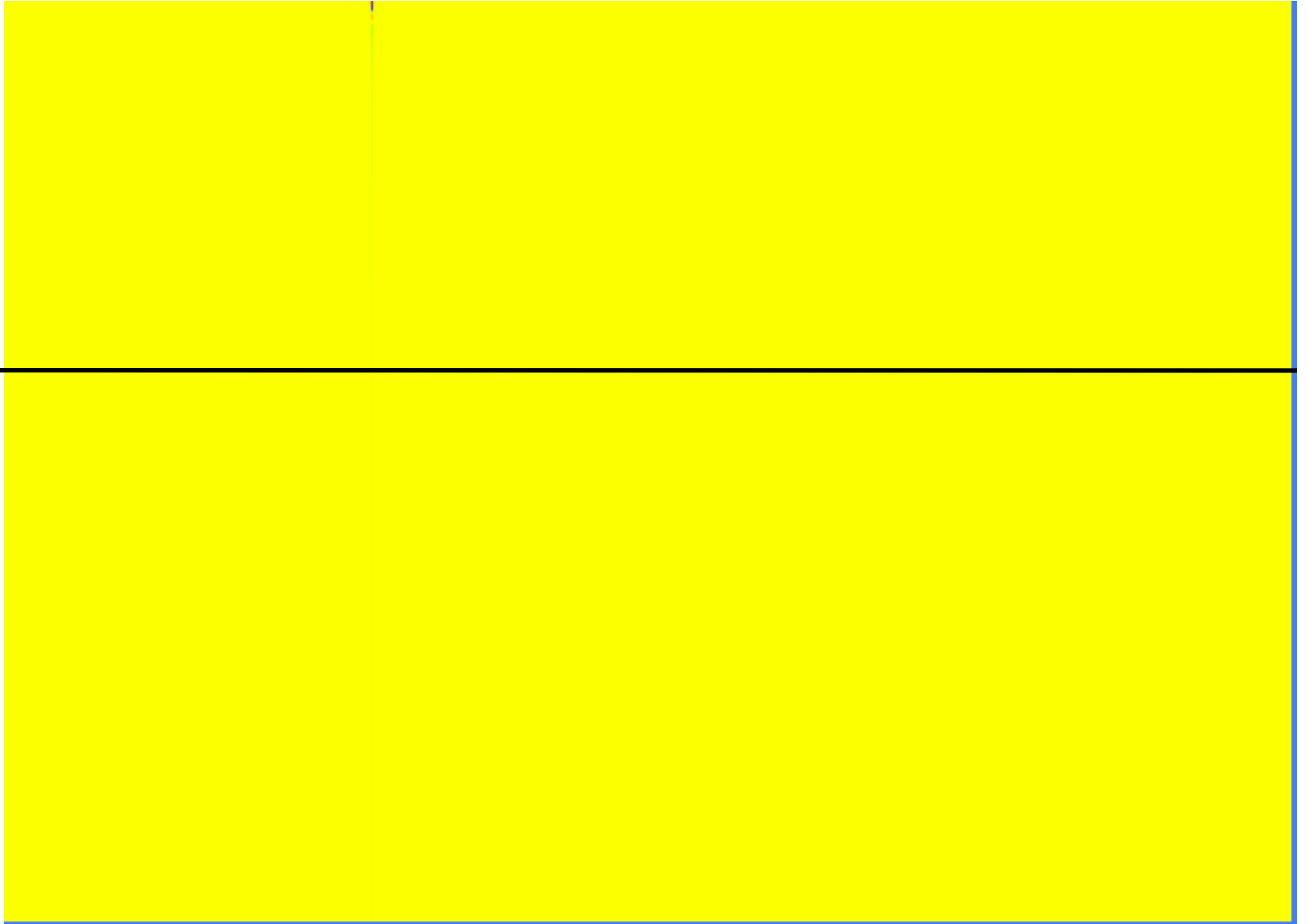
S-waves:



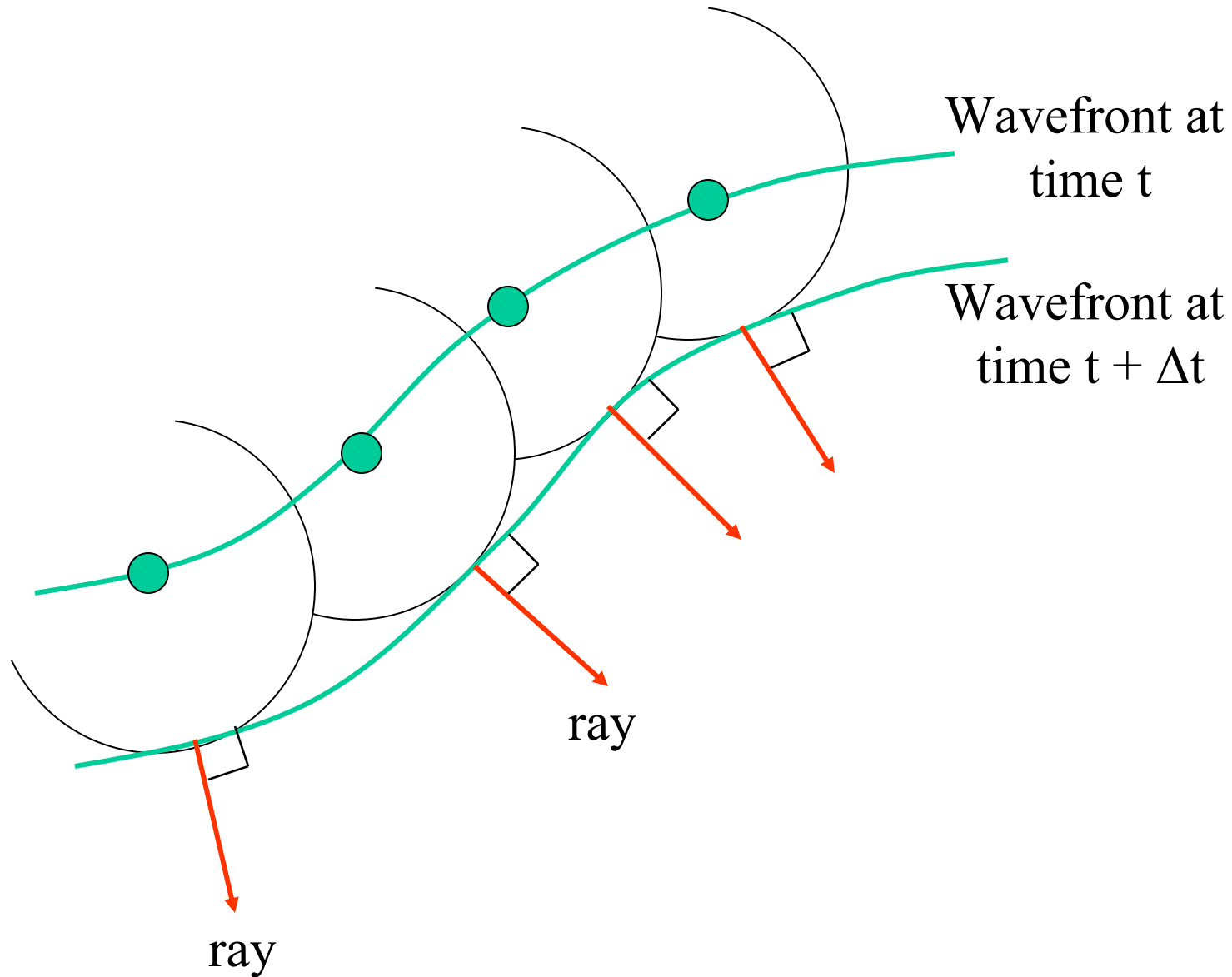
# Seismic Waves

**Medium 1**

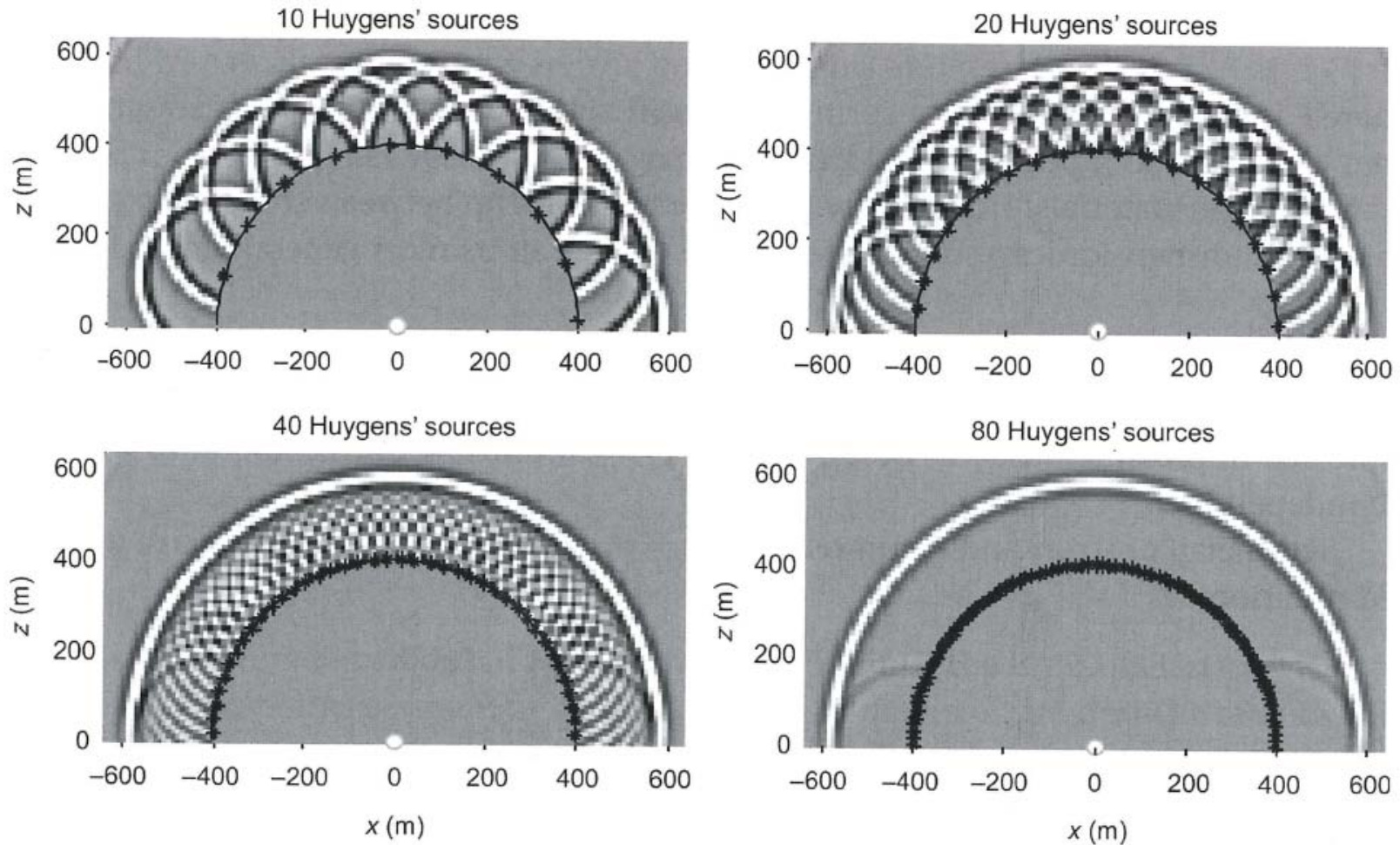
**Medium 2  
(faster)**



# Huygens' principle

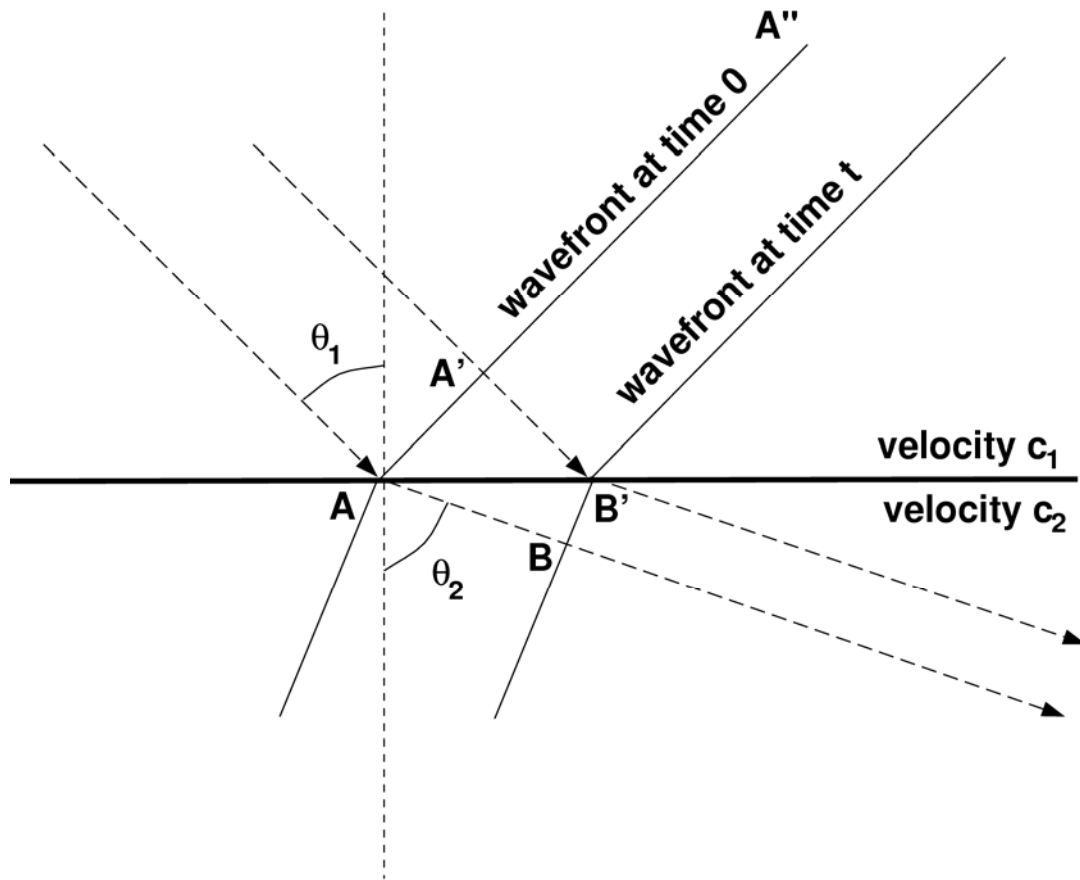


# Huygens' sources



**Figure 8.** Combination of Huygens' secondary sources (black stars) on an original wavefront represented by the black line. If the number of sources is adequate, the envelope of their wavefronts equals the original wavefront at a later time. Courtesy of CGGVeritas. Used by permission.

# Snell's Law (at boundary)



Time  $t$ :

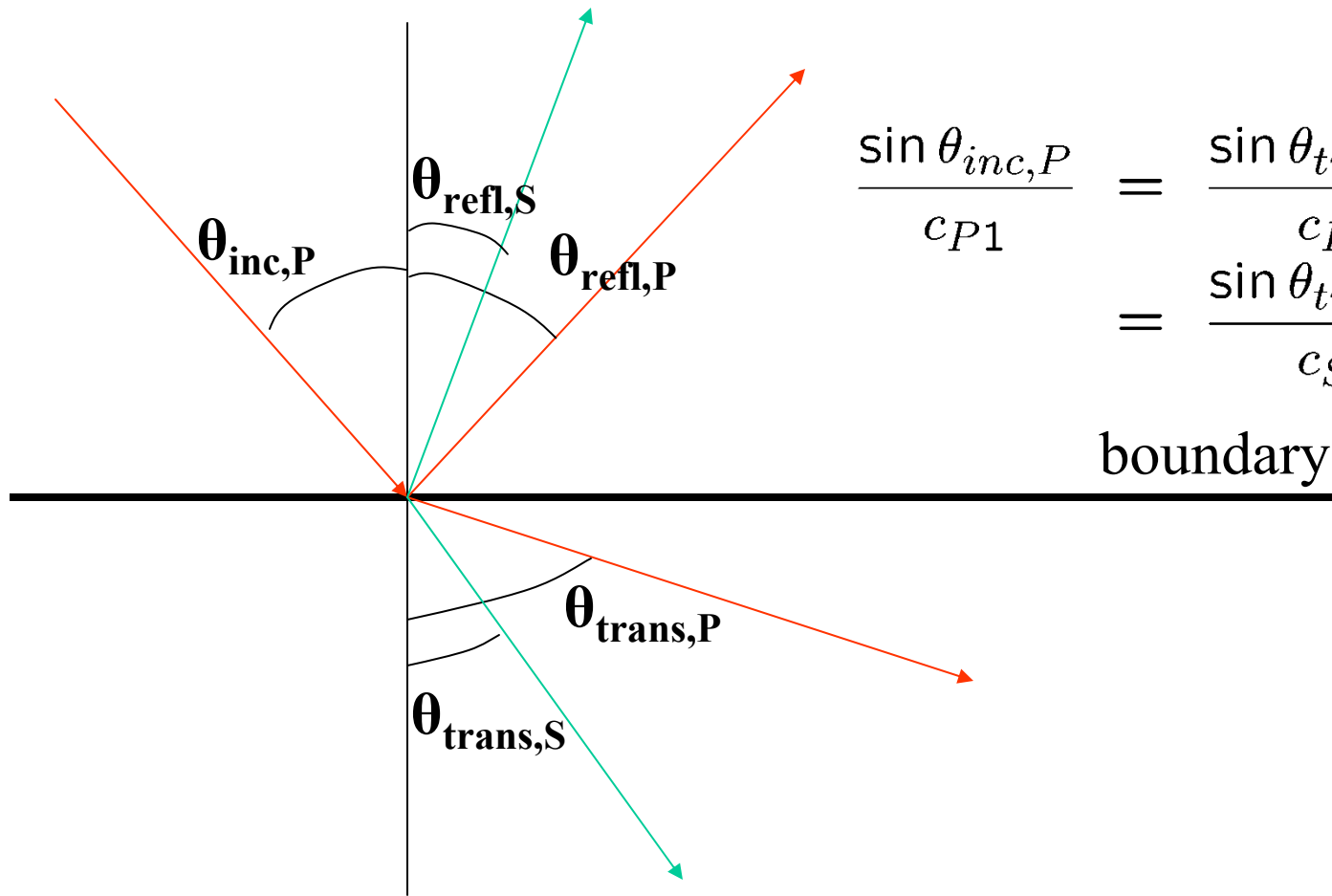
$$\begin{aligned}
 t &= \frac{A'B'}{c_1} = \frac{AB}{c_2} \\
 &= \frac{AB' \sin \theta_1}{c_1} = \frac{AB' \sin \theta_2}{c_2}
 \end{aligned}$$

Hence

$$\frac{\sin \theta_1}{c_1} = \frac{\sin \theta_2}{c_2}$$



# Snell's Law for P- and S-waves

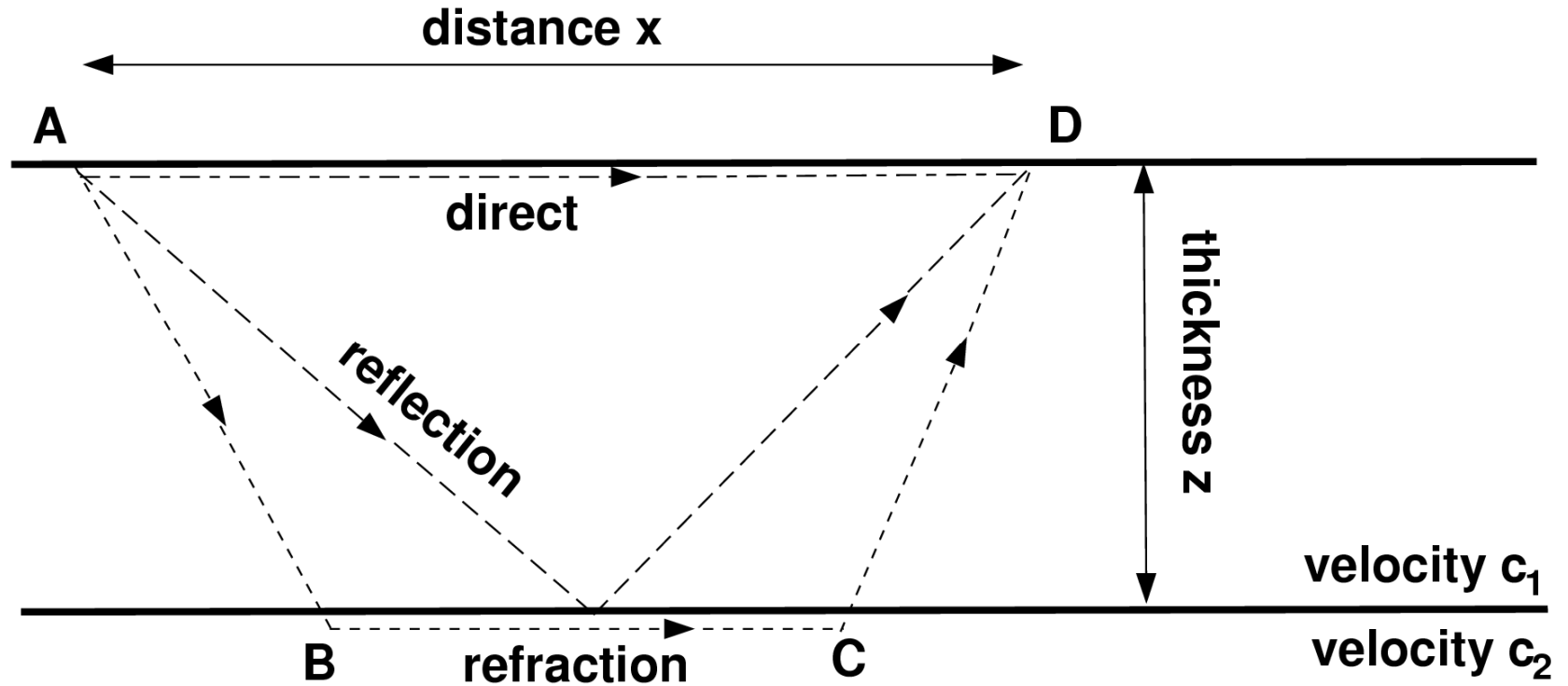


$$\frac{\sin \theta_{inc,P}}{c_{P1}} = \frac{\sin \theta_{trans,P}}{c_{P2}} = \frac{\sin \theta_{refl,P}}{c_{P1}}$$

$$= \frac{\sin \theta_{trans,S}}{c_{S2}} = \frac{\sin \theta_{refl,S}}{c_{S1}}$$

boundary

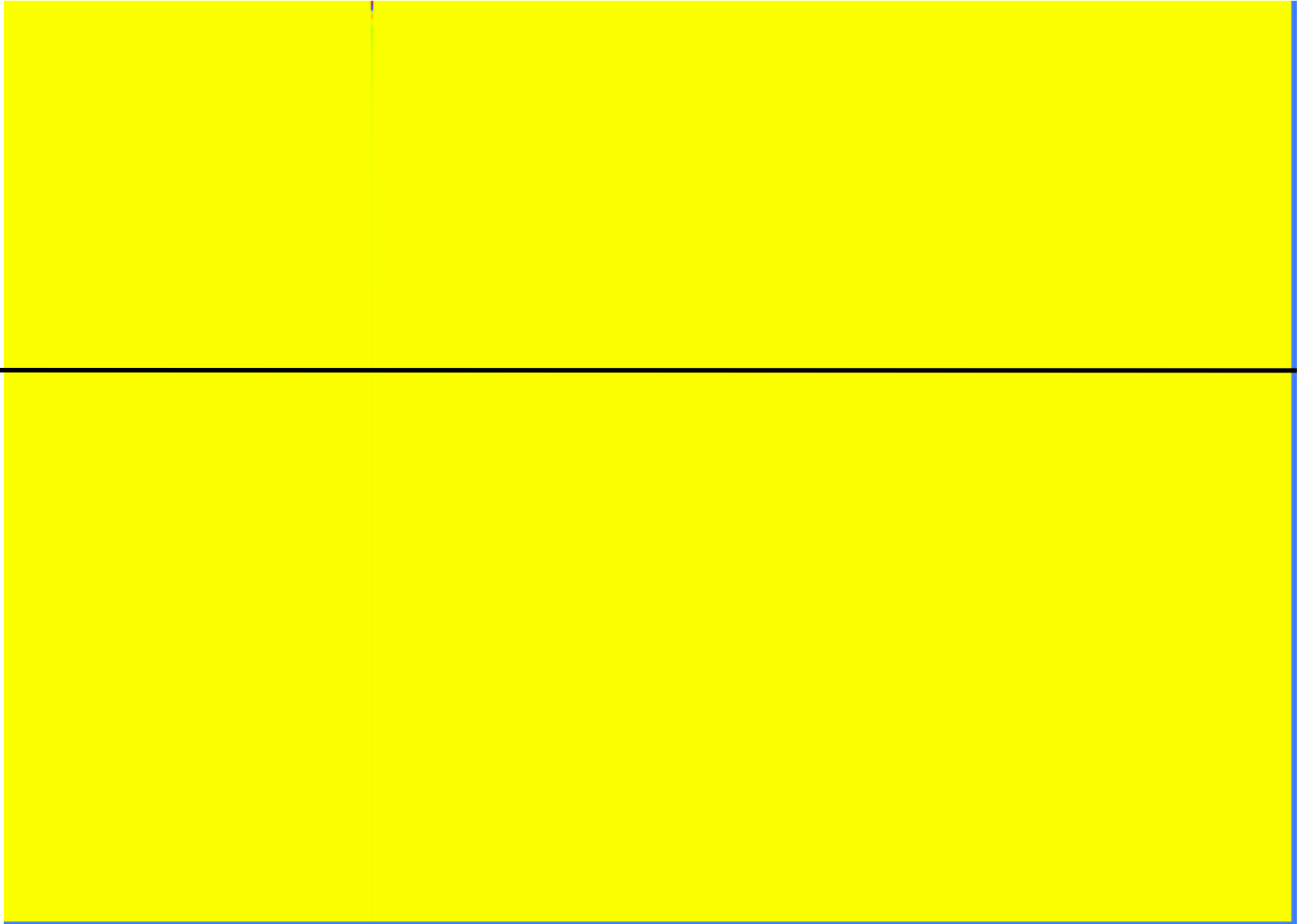
# Different arrivals



# Seismic Waves

**Medium 1**

**Medium 2  
(faster)**



# Seismic Waves

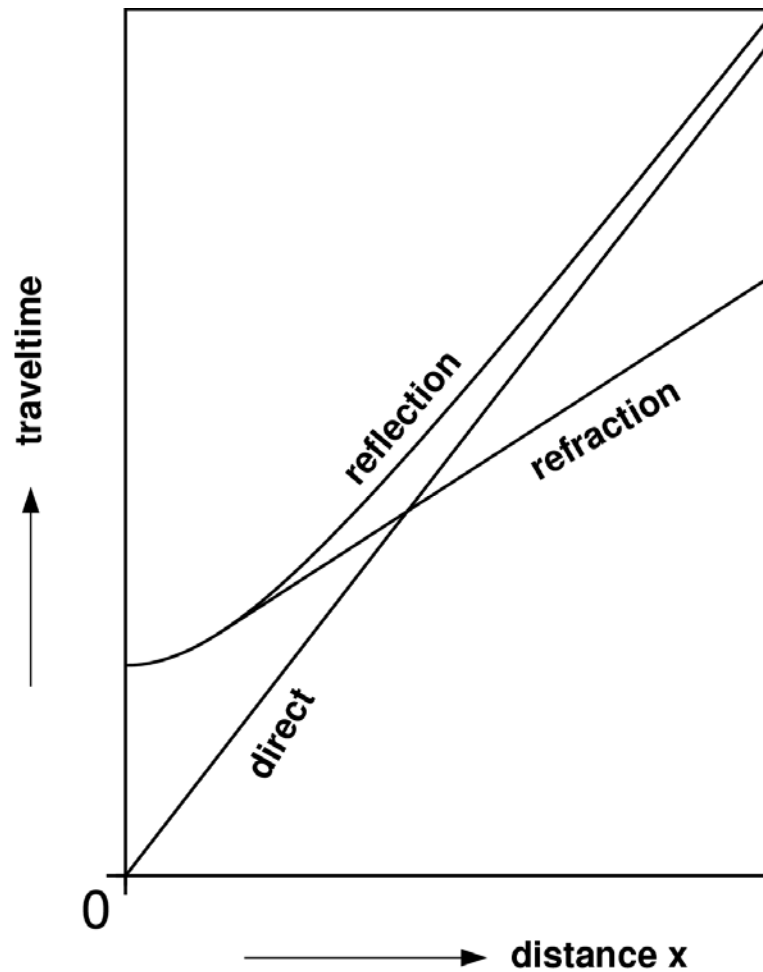


# Different arrivals

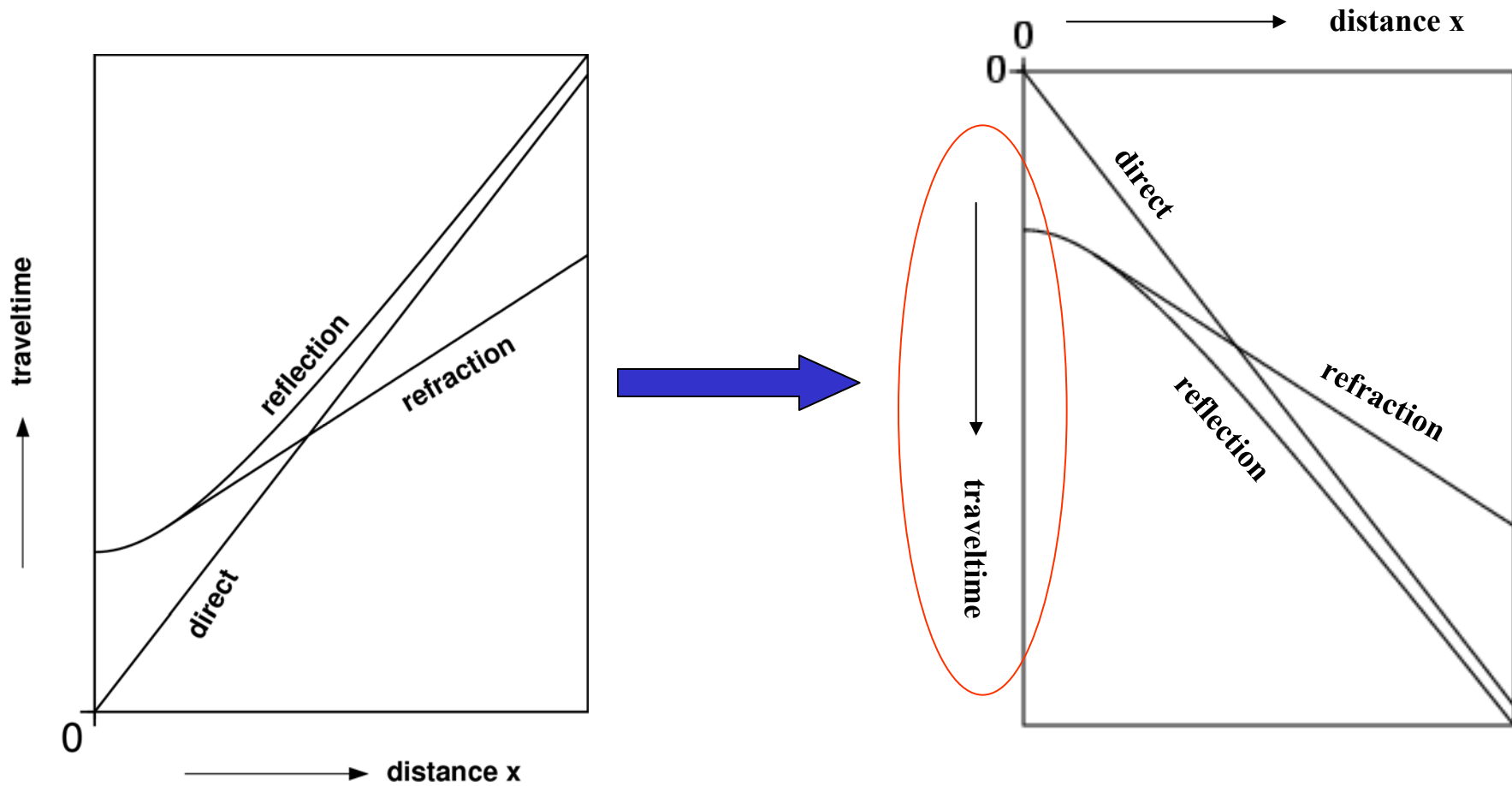
- Direct wave
- Reflected wave
- Refracted wave / Head wave

**Derive each travelttime eq.**

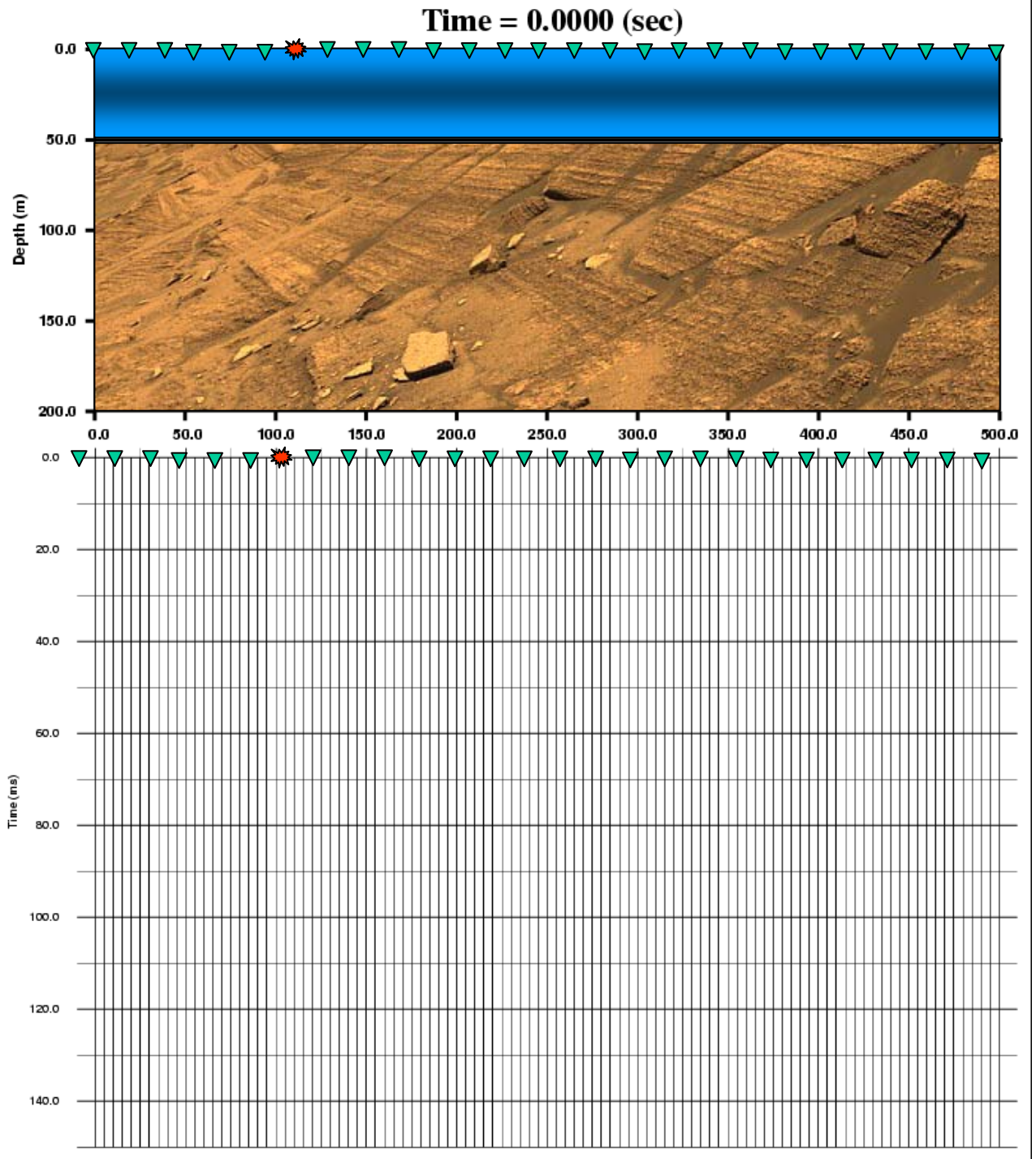
# Different arrivals: arrival times



# Arrival times: time pointing downwards

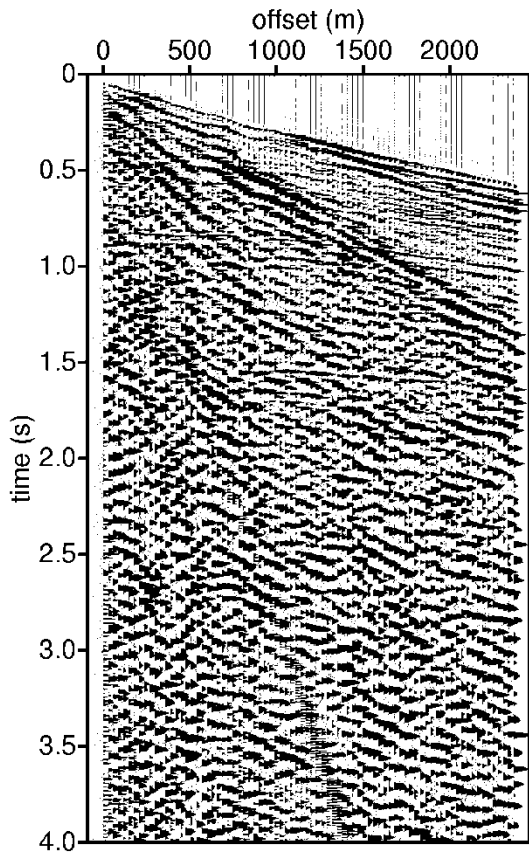


# The seismic record

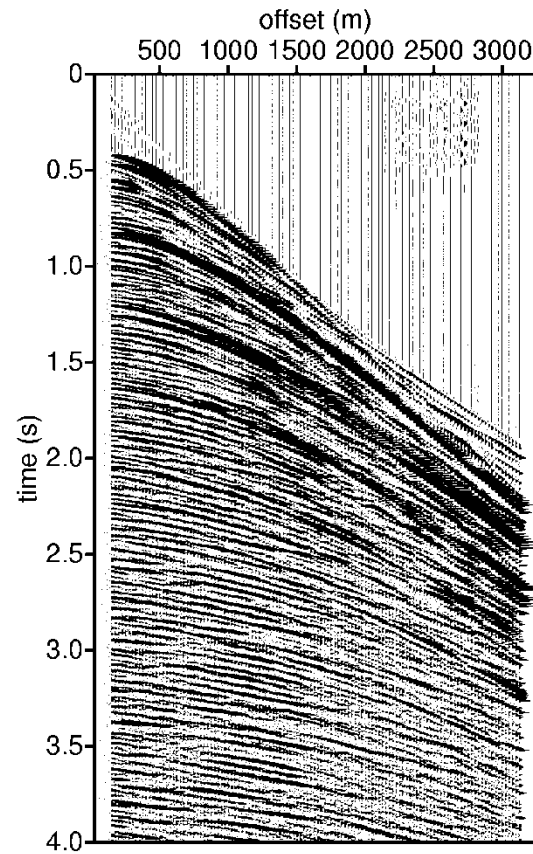




# Examples of records

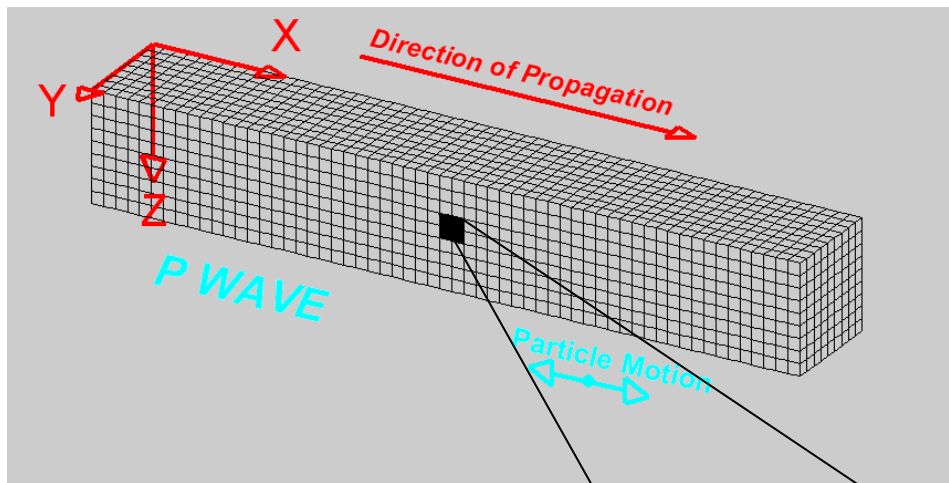


On land

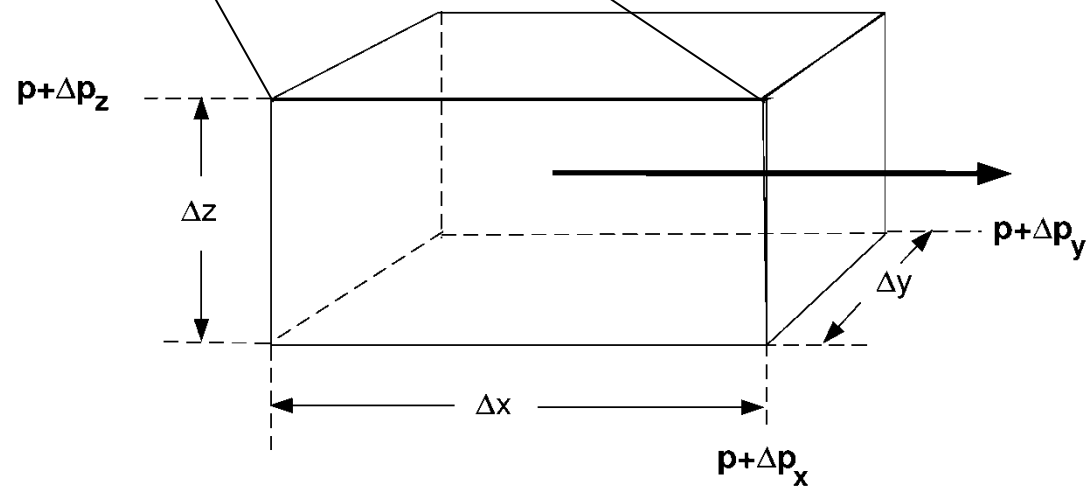


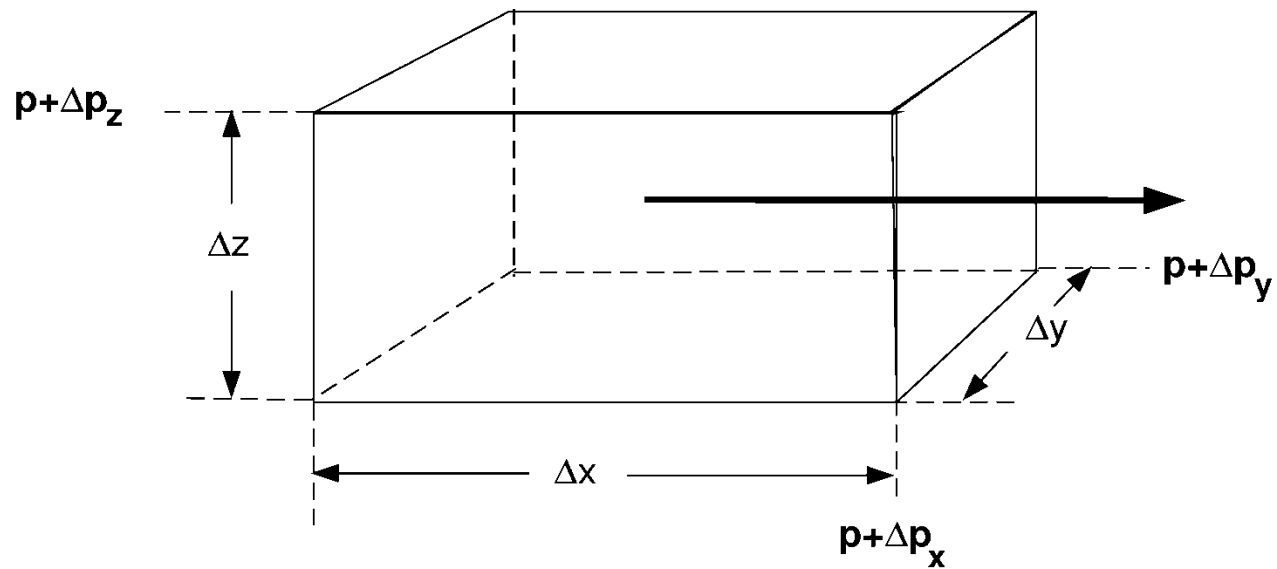
At sea

# The wave equation (for P-waves)



Consider mass with  
volume  $\Delta V$





**Desired:**

**Equations in terms of pressure ( $p$ ) and particle velocity ( $v$ )**

(pdf-file with eqs)

# Different arrivals at surface

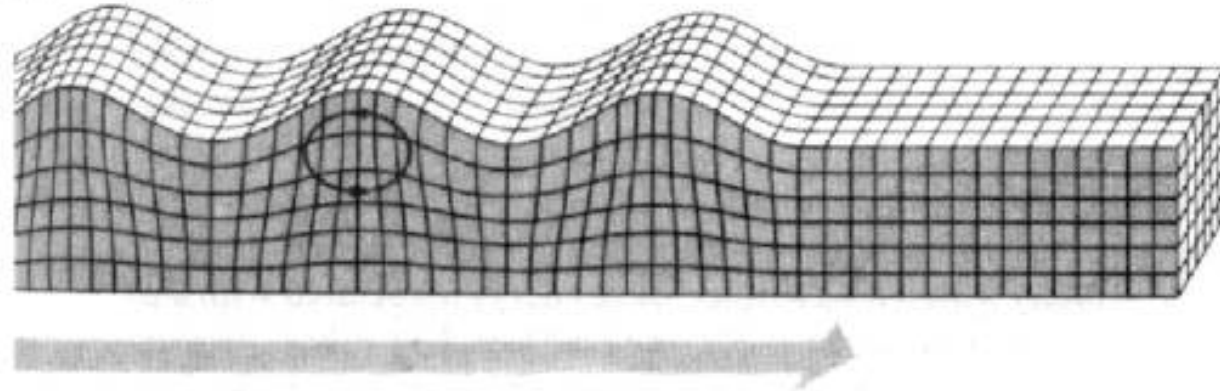
## Direct waves:

- Direct P-wave in solid
- Direct S-wave in solid
- Direct P-wave through air (“air wave”)
- Direct surface wave

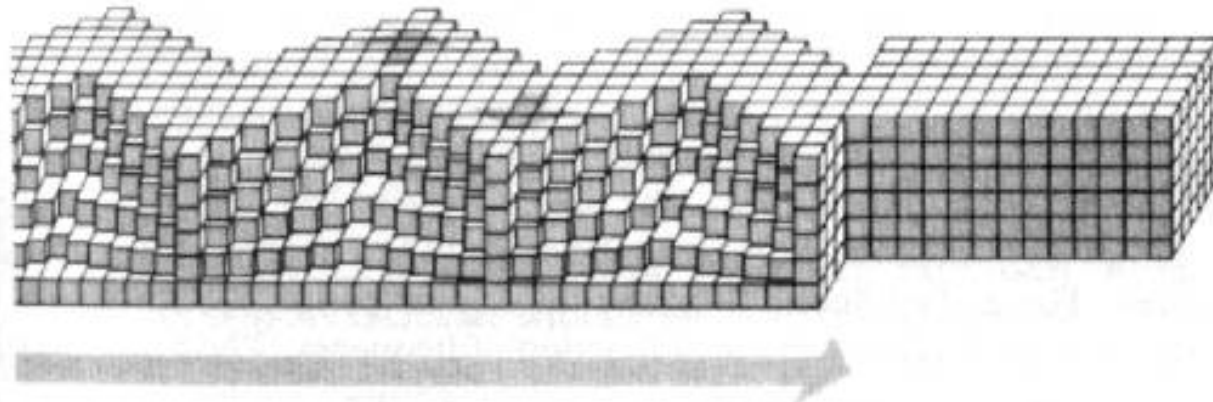
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# Surface wave

(a) Rayleigh wave

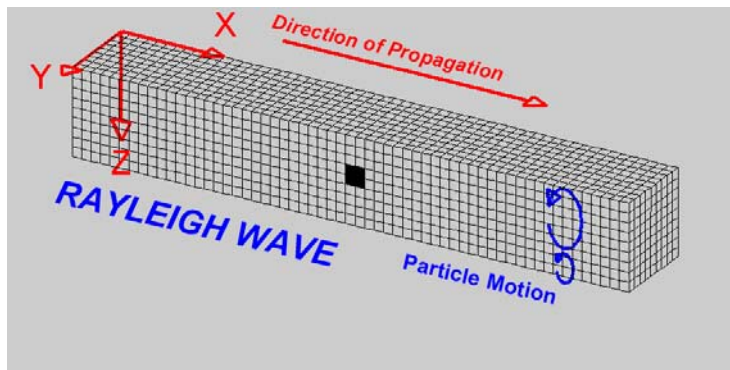


(b) Love wave

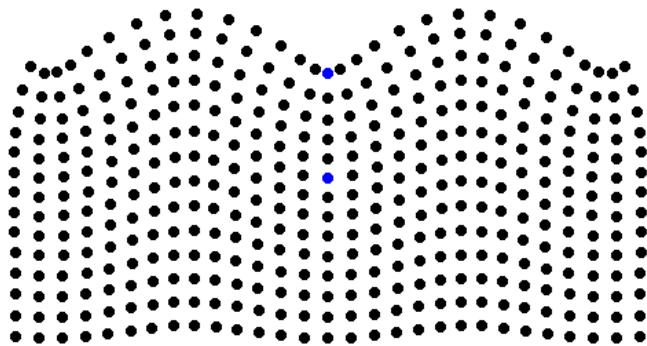
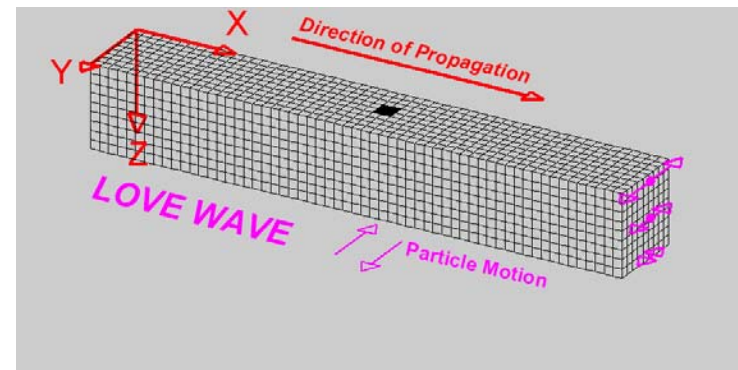


# Surface wave

Rayleigh wave:



Love wave:



# Different arrivals at surface

## Direct waves:

- Direct P-wave in solid
- Direct S-wave in solid
- Direct P-wave through air (“air wave”)
- Direct surface wave

In same medium:

P-wave always faster than S-wave

S-wave always faster than surface wave

So:  $c_P > c_S > c_{\text{Surf}}$

# Different arrivals at surface

## - **Reflected waves:**

- Down-going P-wave and up-going P-wave
- Down-going P-wave and up-going S-wave
- Down-going S-wave and up-going P-wave
- Down-going S-wave and up-going S-wave

## - **Refracted Waves / Head waves**

- Down-going P-, refracted P- and up-going P-wave
- Down-going P-, refracted S- (If  $c_{S2} > c_{P1}$ ) and up-going P-wave
- Down-going P-, refracted S- (If  $c_{S2} > c_{P1}$ ) and up-going S-wave
-