Reflection seismic 1
script

Seismic waves

- Wave propagation
  - Hook's law
  - Newton's law
  - $\Rightarrow$ wave equation
- Wavefronts and Rays
- Interfaces
- Reflection and Transmission coefficients

Seismic Waves

body waves

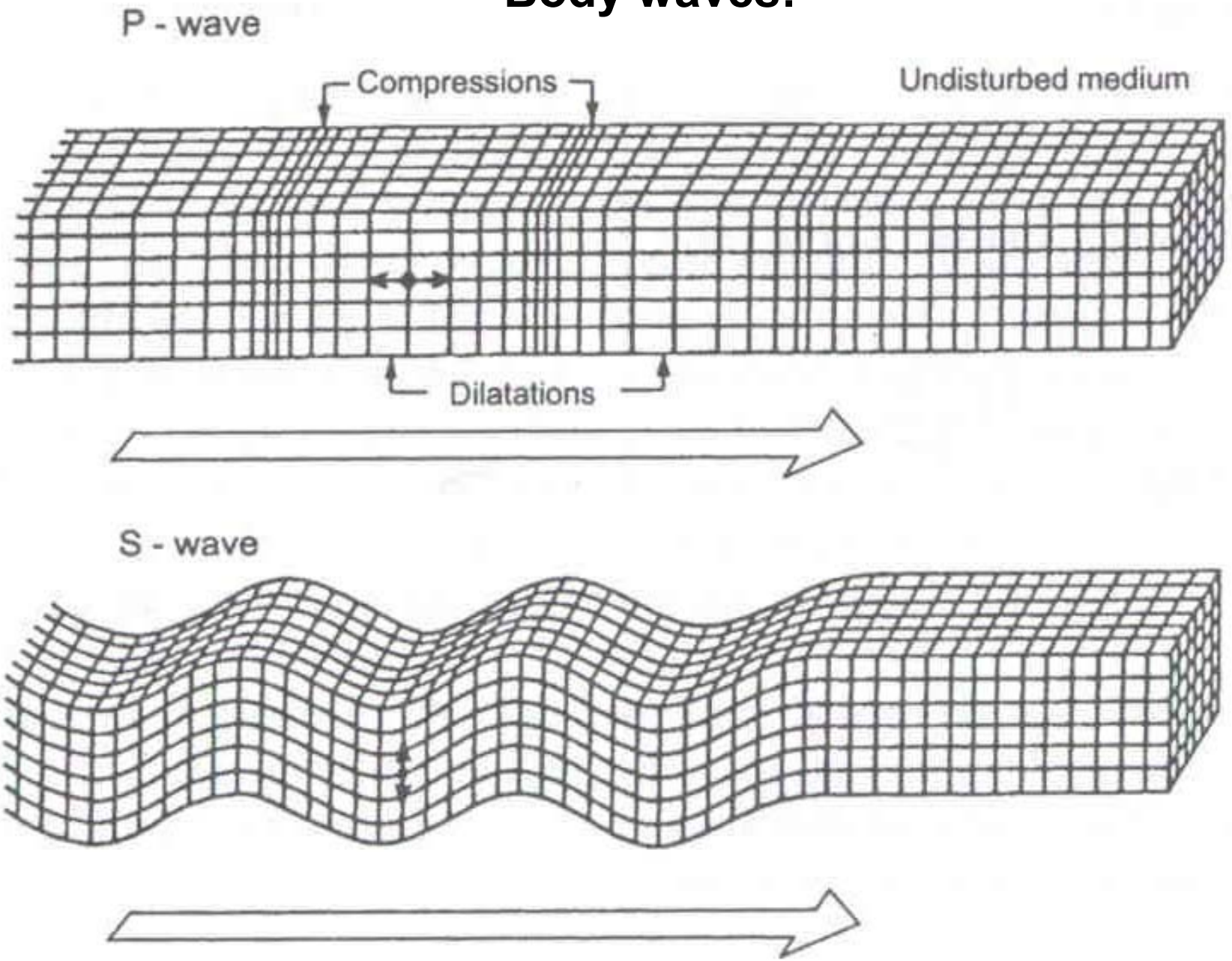
P-waves (longitudinal, compressional)

S-waves (shear, transverse)

S_V-wave

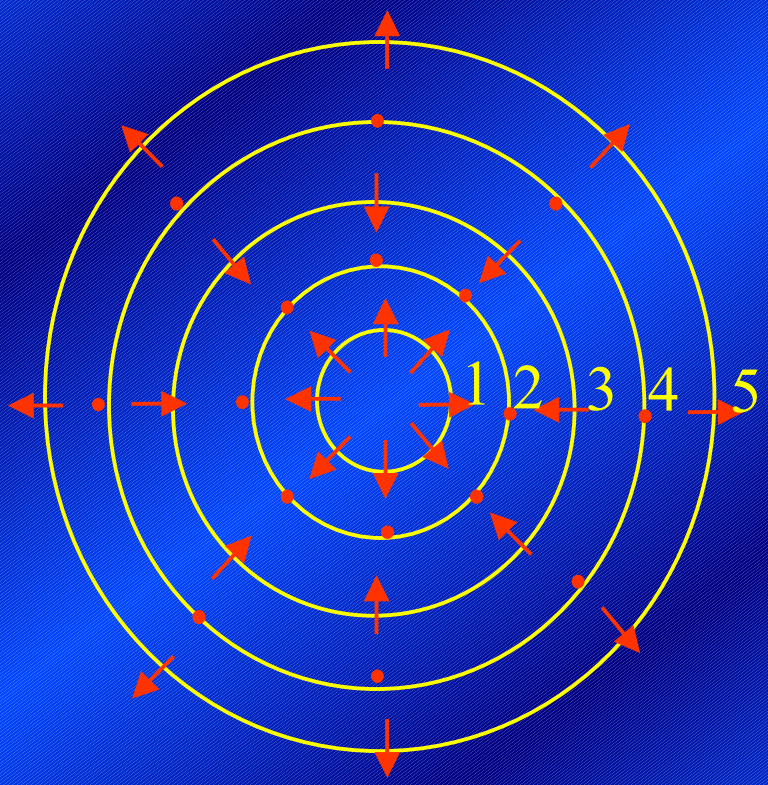
S_H-wave

Body waves:

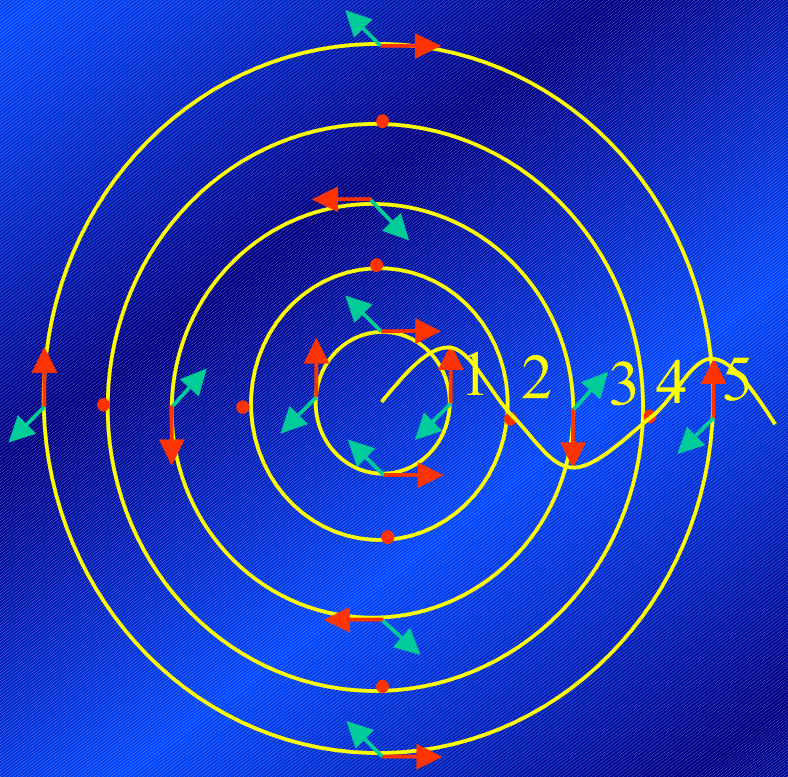

P - wave
Compressions
Undisturbed medium
Dilatations
S - wave

Different kind of waves

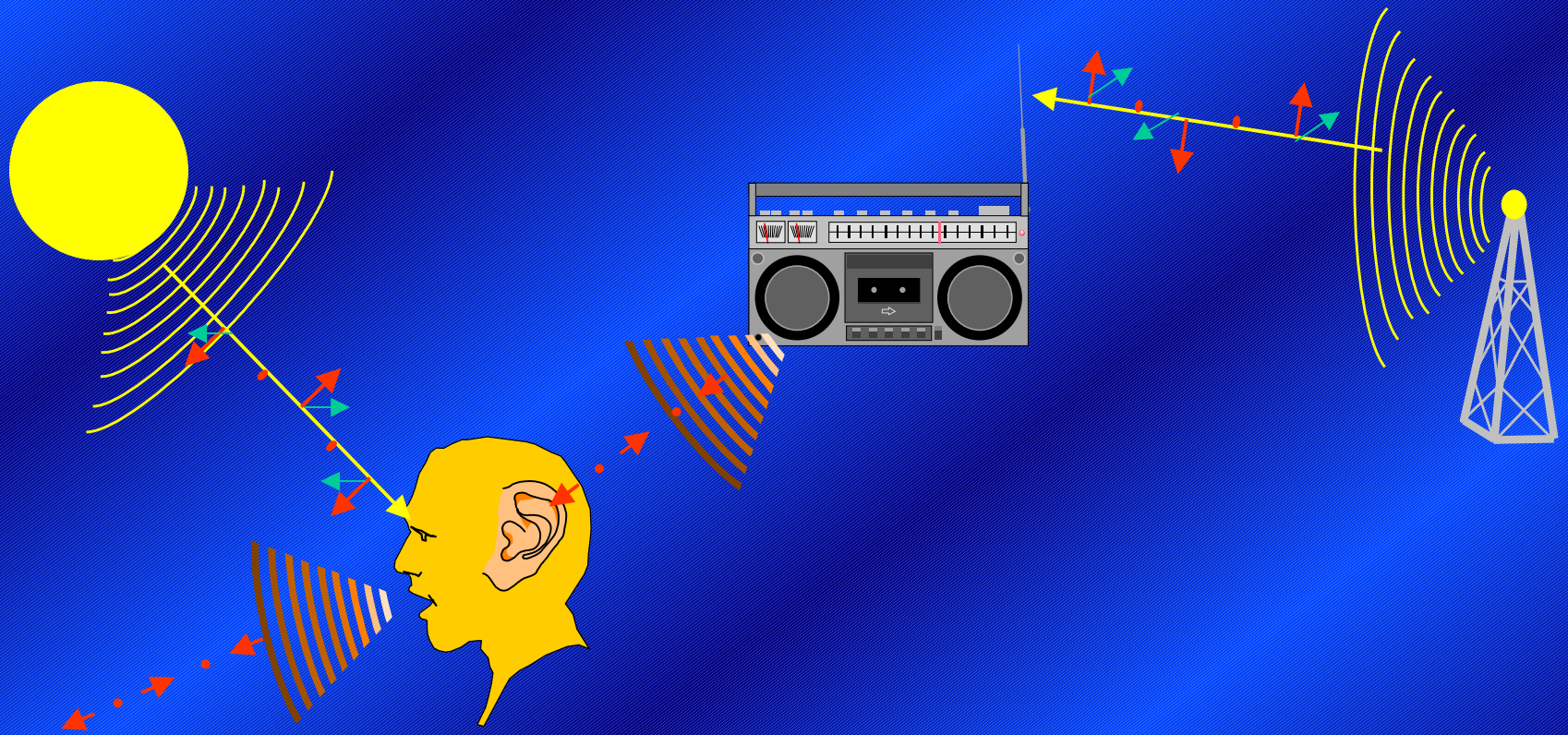
- Longitudinal waves (P-waves)



- Transversal waves (S-waves)



Examples of different waves



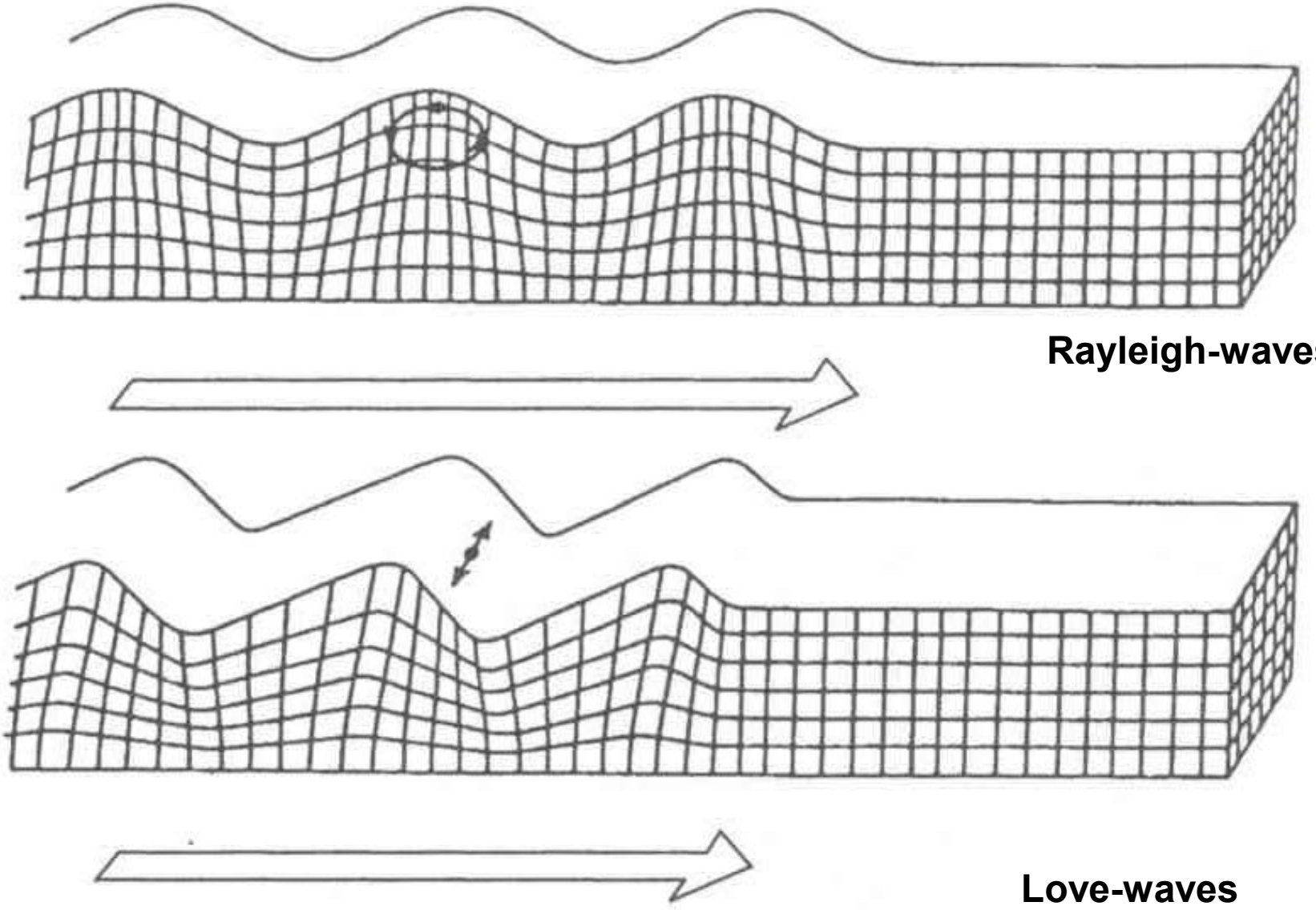
Elektromagnetic spectrum → AM, FM, Georadar, Visible, X-ray

10^0 10^6 10^{19} Hz

Earthquake, audible + seismic ← Acoustic spectrum

Frequency

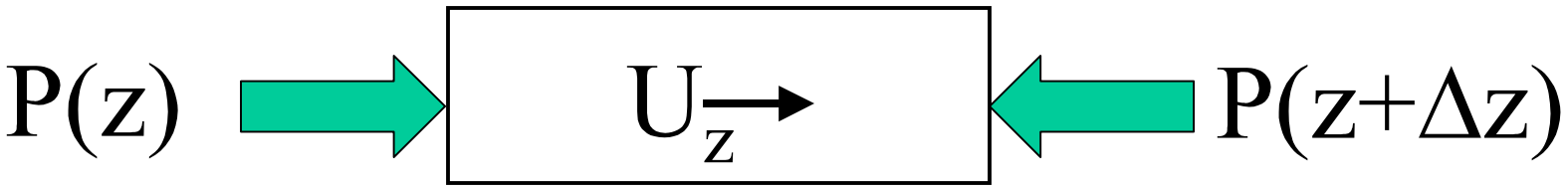
Surface waves



Rayleigh-waves

Love-waves

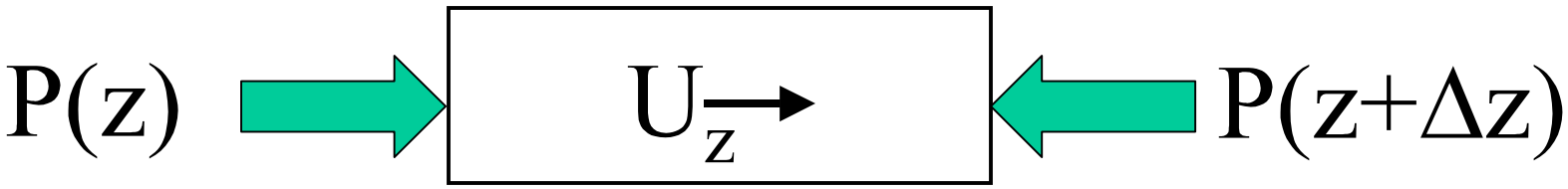
Newton's law



$$P(z+\Delta z) - P(z) = -\rho\, \Delta z\, \frac{d^2}{dt^2} U_z$$

ρ is the massdensity

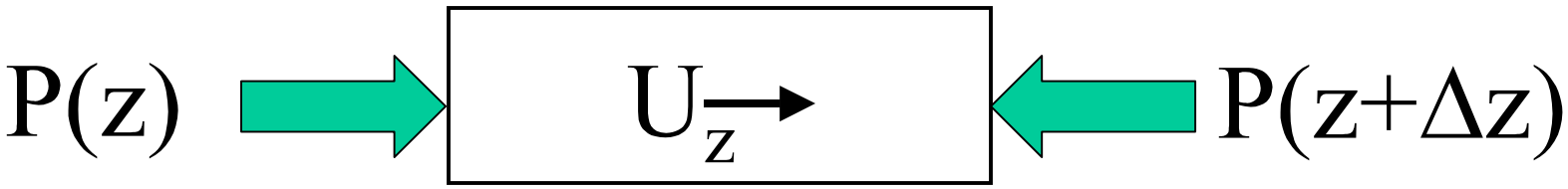
Newton's law



P is the acoustic pressure

U_z is the displacement

Newton's law



$$\frac{\partial}{\partial z}P = -\rho \frac{\partial^2}{\partial t^2}U_z$$

Hook's law

$$U_z(z+\Delta z) - U_z(z) = -\kappa \, \Delta z \, P$$

κ is the compressibility

Hook's law

$$\frac{\partial}{\partial z} U_z = -\kappa P$$

Acoustic Expressions

$$\frac{\partial}{\partial z} P + \rho \frac{\partial^2}{\partial t^2} U_z = 0$$

$$\frac{\partial}{\partial z} U_z + \kappa P = 0$$

Acoustic expressions with source term

$$\frac{\partial}{\partial z} P + \frac{\partial^2}{\partial t^2} \rho U_z = 0$$

$$\frac{\partial}{\partial z} U_z + \kappa P = q\, \delta(z)$$

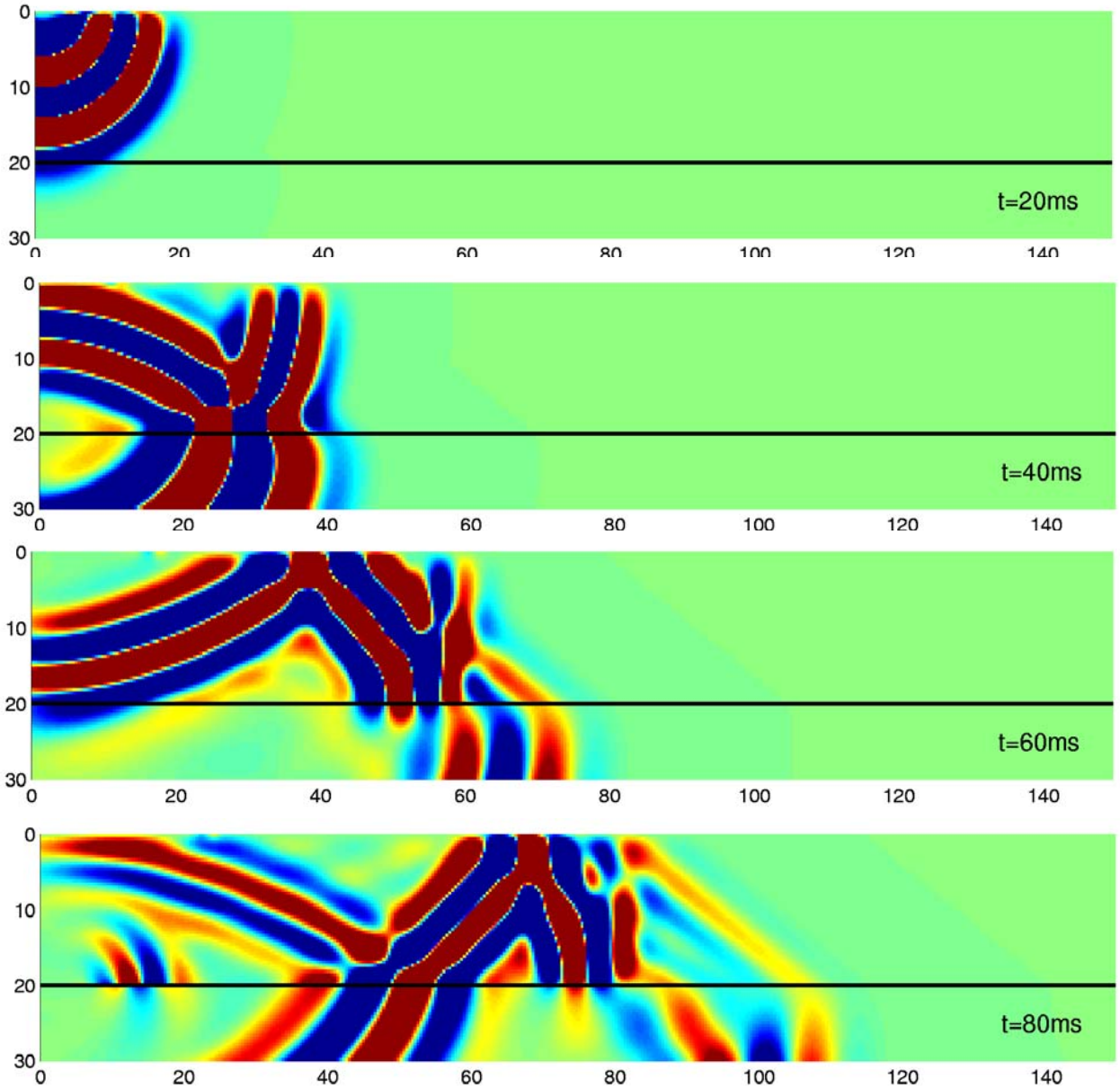
$\delta(z)$ is the Dirac function

Acoustic Wave equation

$$\frac{\partial^2}{\partial z^2} P - \frac{1}{c^2} \frac{\partial^2}{\partial t^2} P = -w(t)\, \delta(z)$$

$$w(t) = \rho \frac{\partial^2}{\partial t^2} q(t) \quad \text{(sourcesignal)}$$

$$c = (\rho\kappa)^{-1/2} \qquad \text{(wavespeed)}$$



(Roth et al., 1998)

Objecten detecteren met behulp van **Golven**

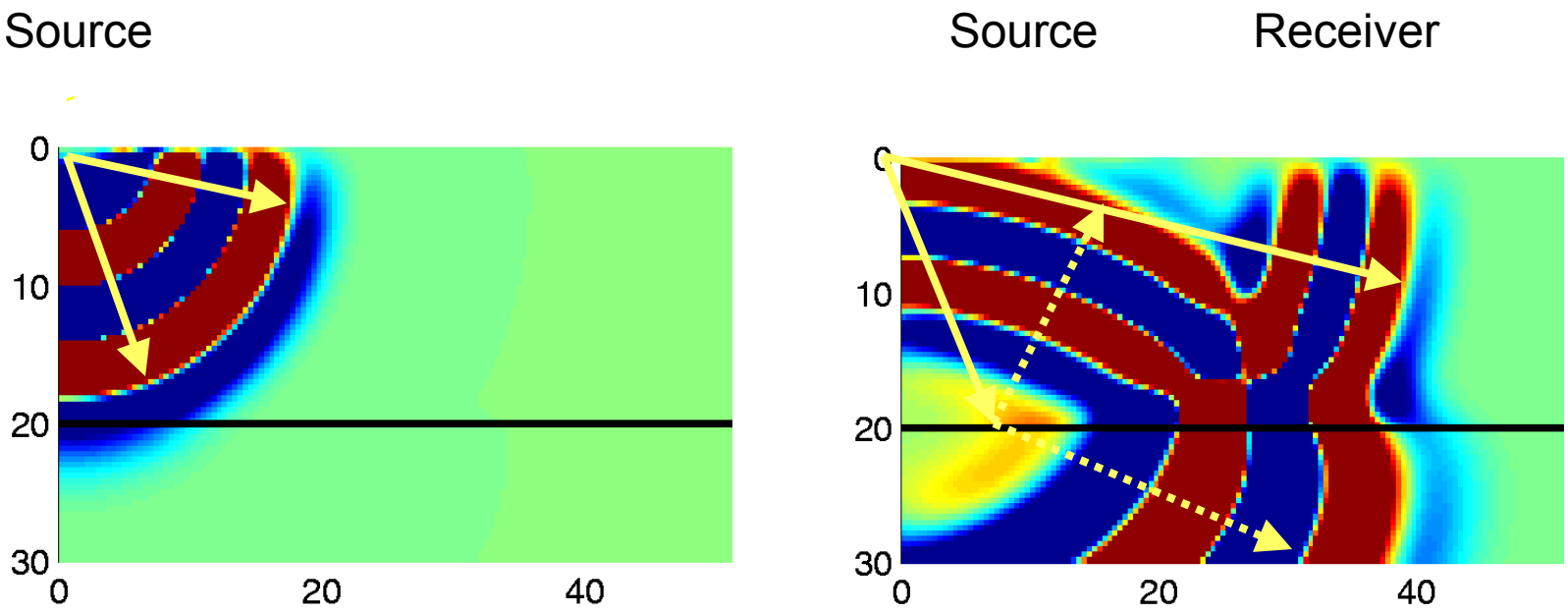
Objecten detecteren met behulp van **Golven**

Wavefronts versus Rays

- Wavefronts indicate the boundary of the material which allready moves and the material which is still undisturbed.

- Rays are plotted perpendicular with respect to the wavefronts and describe the dominant propagation of the seismic energy between two locations

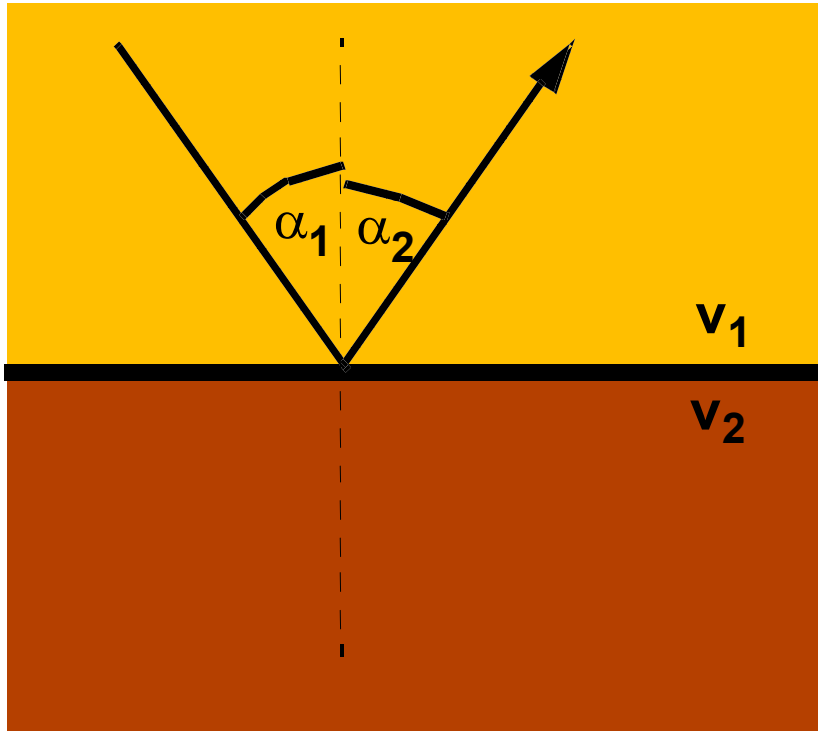
Geometrical Wavepropagation



Consider wavefronts as rays,

perpendicular to the wavefronts

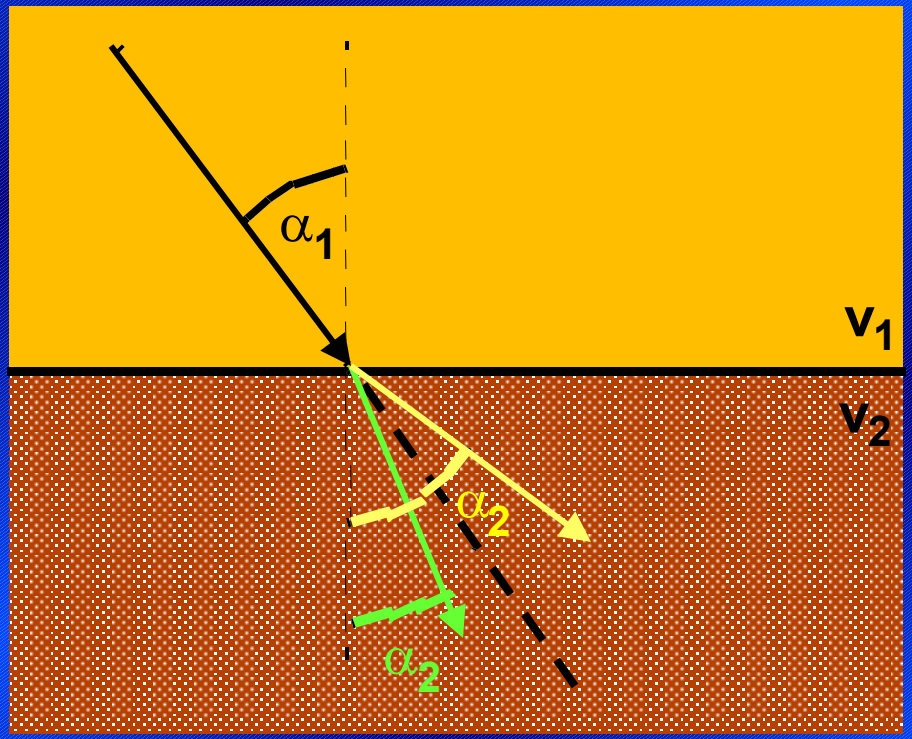
Interface: reflection



Angle of incidence =
angle of reflection

$$\alpha_1 = \alpha_2$$

Interface: Refraction

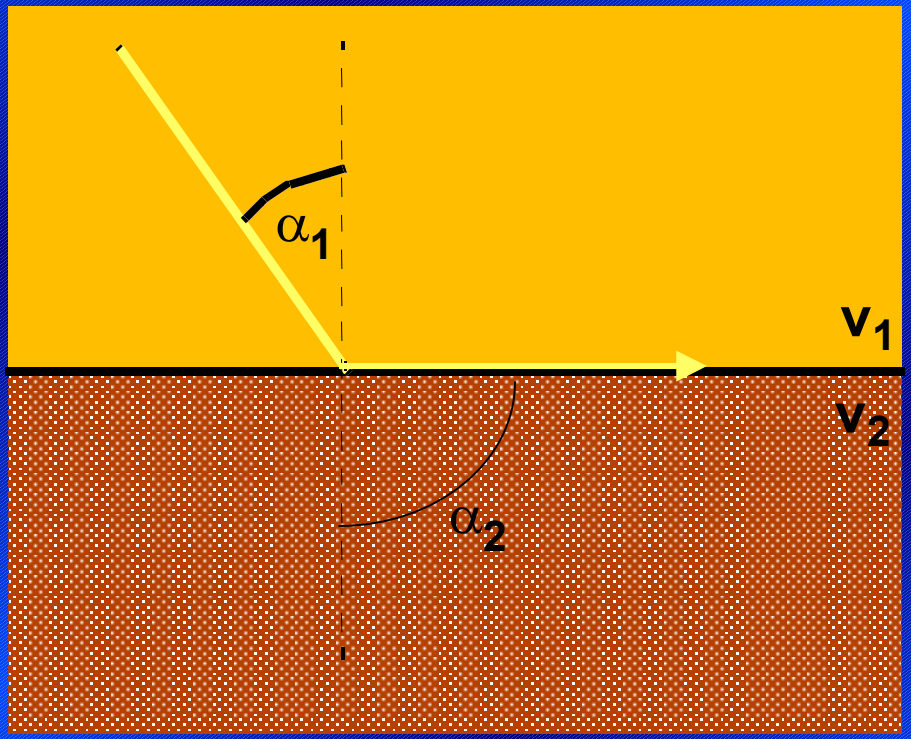


$$\frac{\sin \alpha_1}{\sin \alpha_2} = \frac{v_1}{v_2}$$

$v_2 > v_1$

$v_2 < v_1$

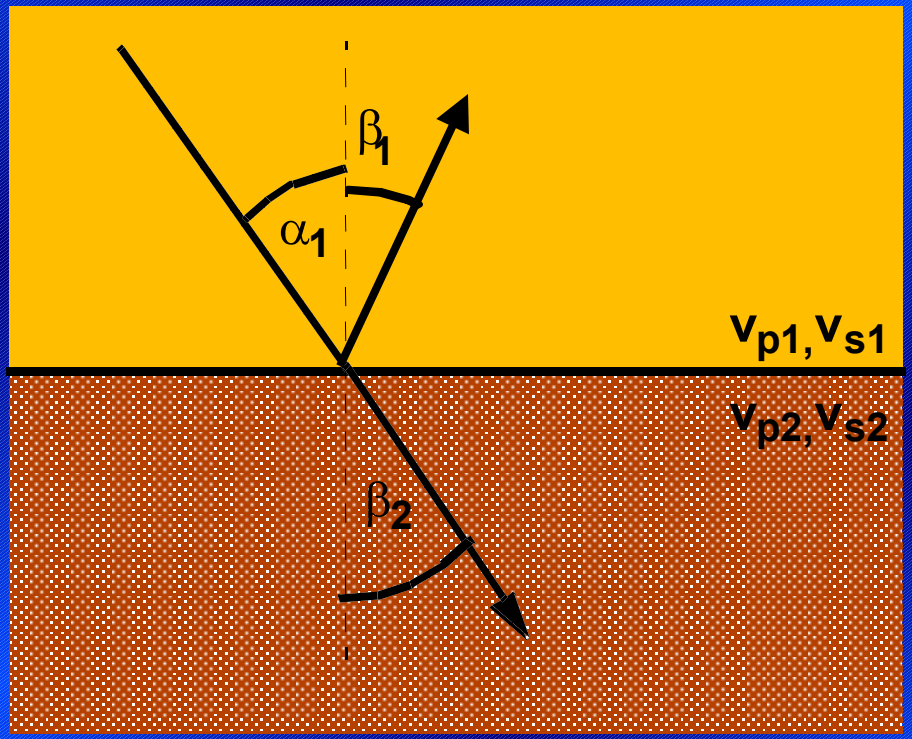
Special case: critical angle



$\alpha_2 = 90°$

$$\frac{\sin \alpha_1}{\sin 90°} = \sin \alpha_1 = \frac{v_1}{v_2}$$

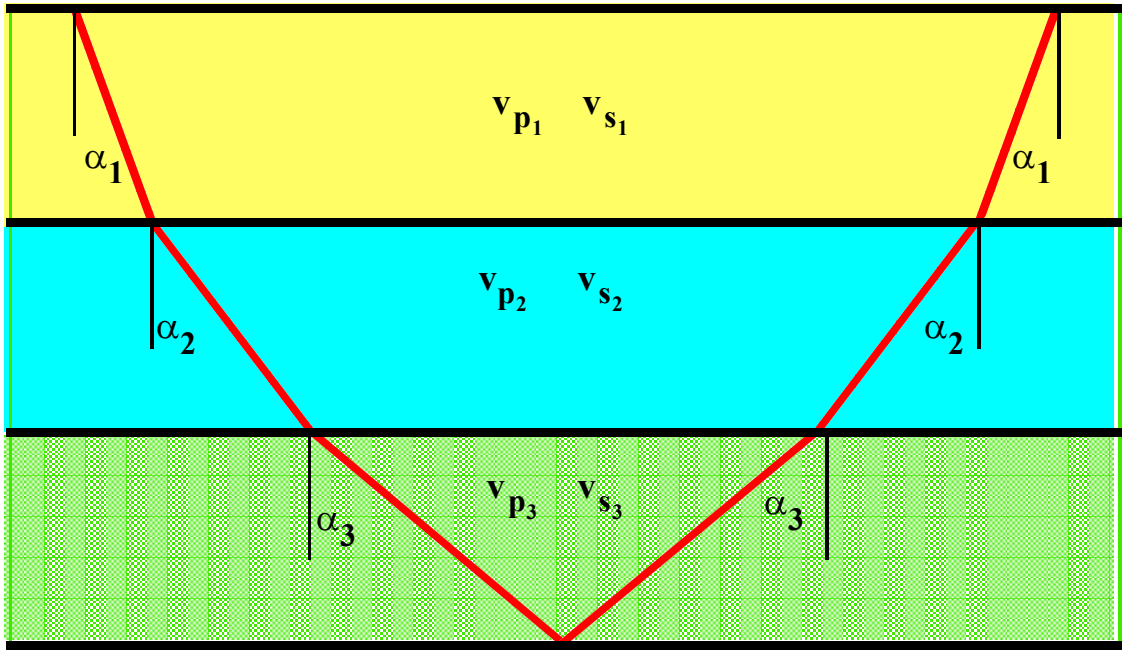
Interface: Conversion from P wave to S wave



$$\frac{\sin\alpha_1}{\sin\beta_1} = \frac{v_{p_1}}{v_{s_1}}$$

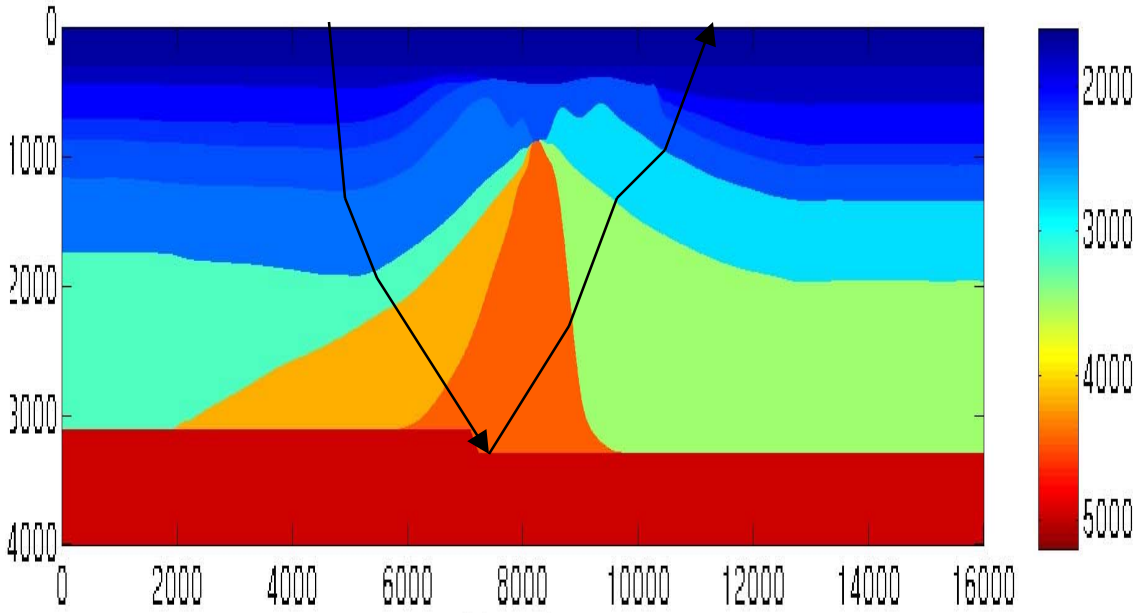
$$\frac{\sin\alpha_1}{\sin\beta_2} = \frac{v_{p_1}}{v_{s_2}}$$

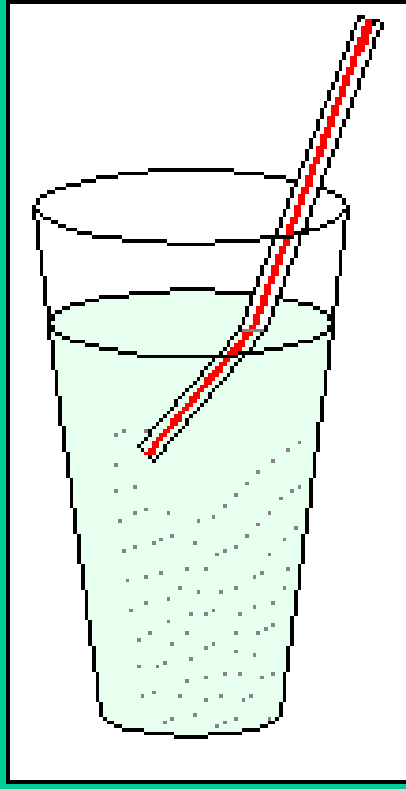
Snell's law



$$\frac{\sin\alpha_1}{v_{p_1}} = \frac{\sin\beta_1}{v_{s_1}} = \frac{\sin\alpha_2}{v_{p_2}} = \frac{\sin\beta_2}{v_{s_2}} = \frac{\sin\beta_n}{v_{s_n}} = p = \text{constant}$$

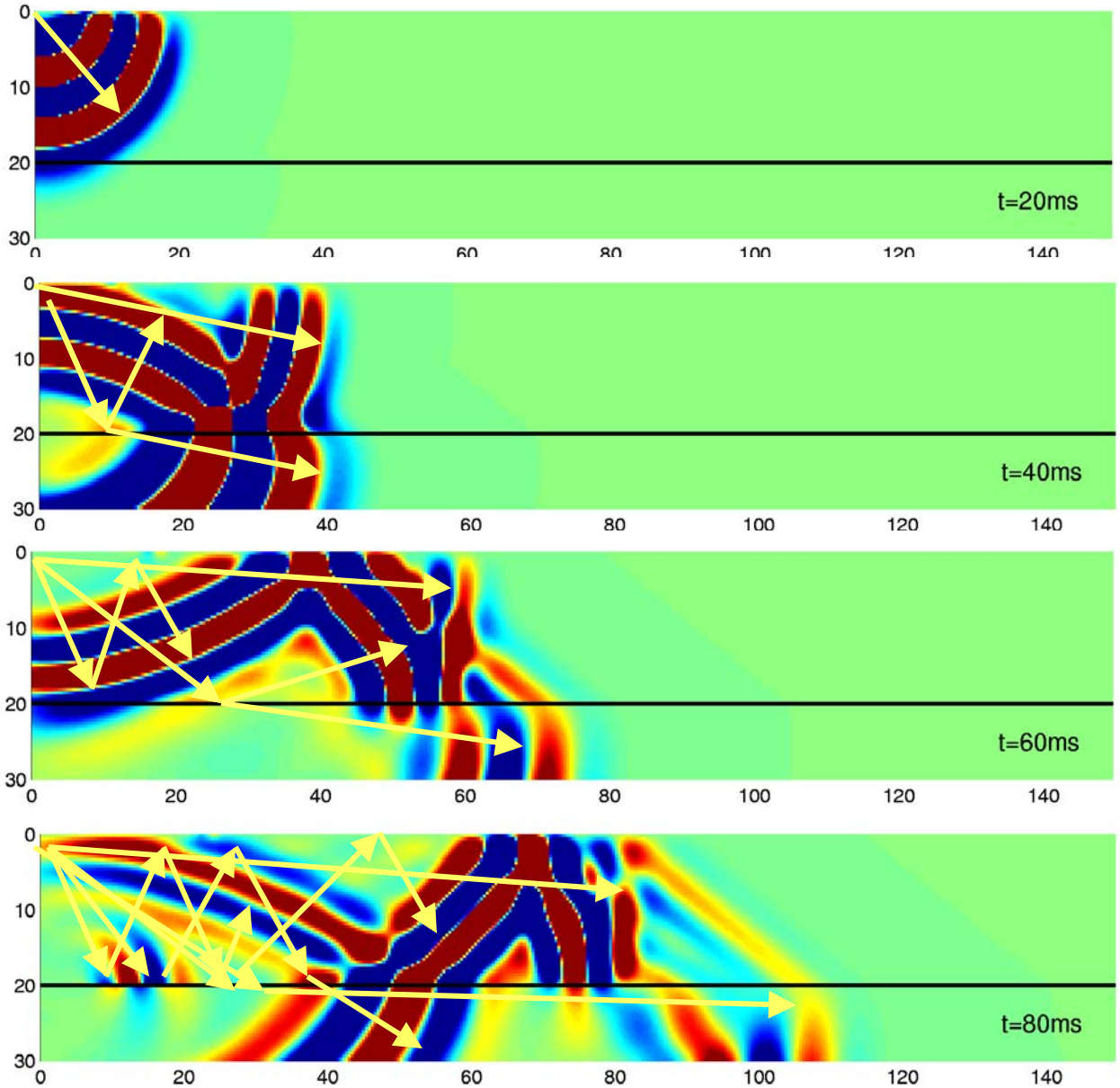
p = Slowness





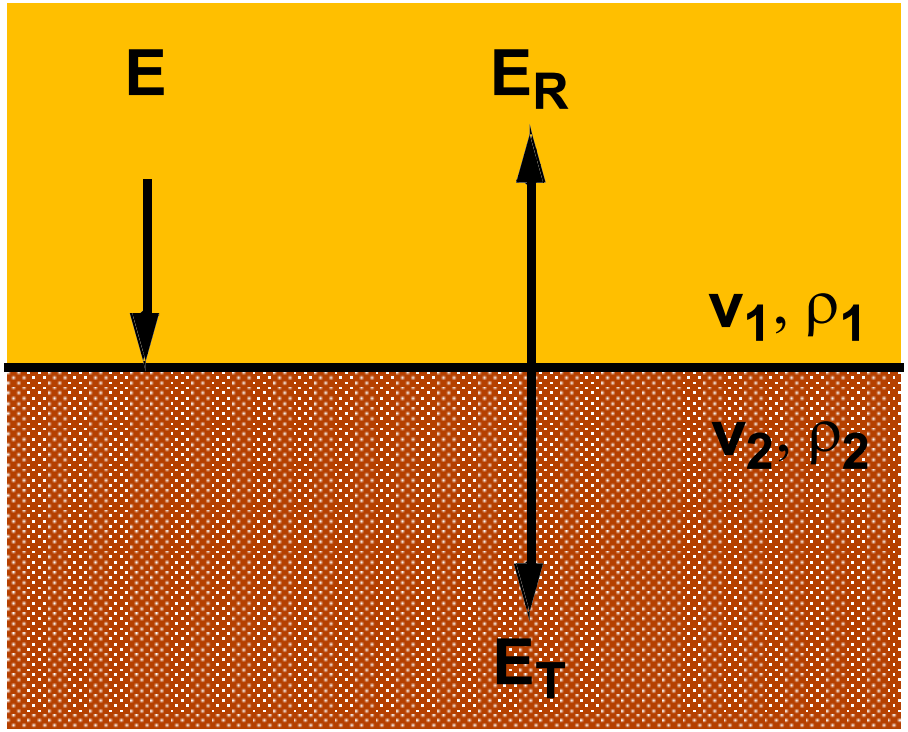
Refraction caused by place dependent propagation velocity

Propagation of seismic waves



(Roth et al., 1998)

Transmission- and Reflection coefficients



$$E = E_R + E_T$$

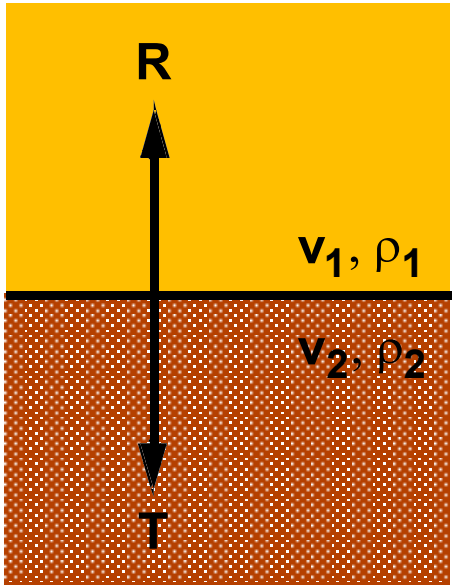
$$R + T = 1$$

E = Energie

R = Reflection coefficient

T = Transmission coefficient

Zoeppritz' equations at normal incidence



Reflection coefficient

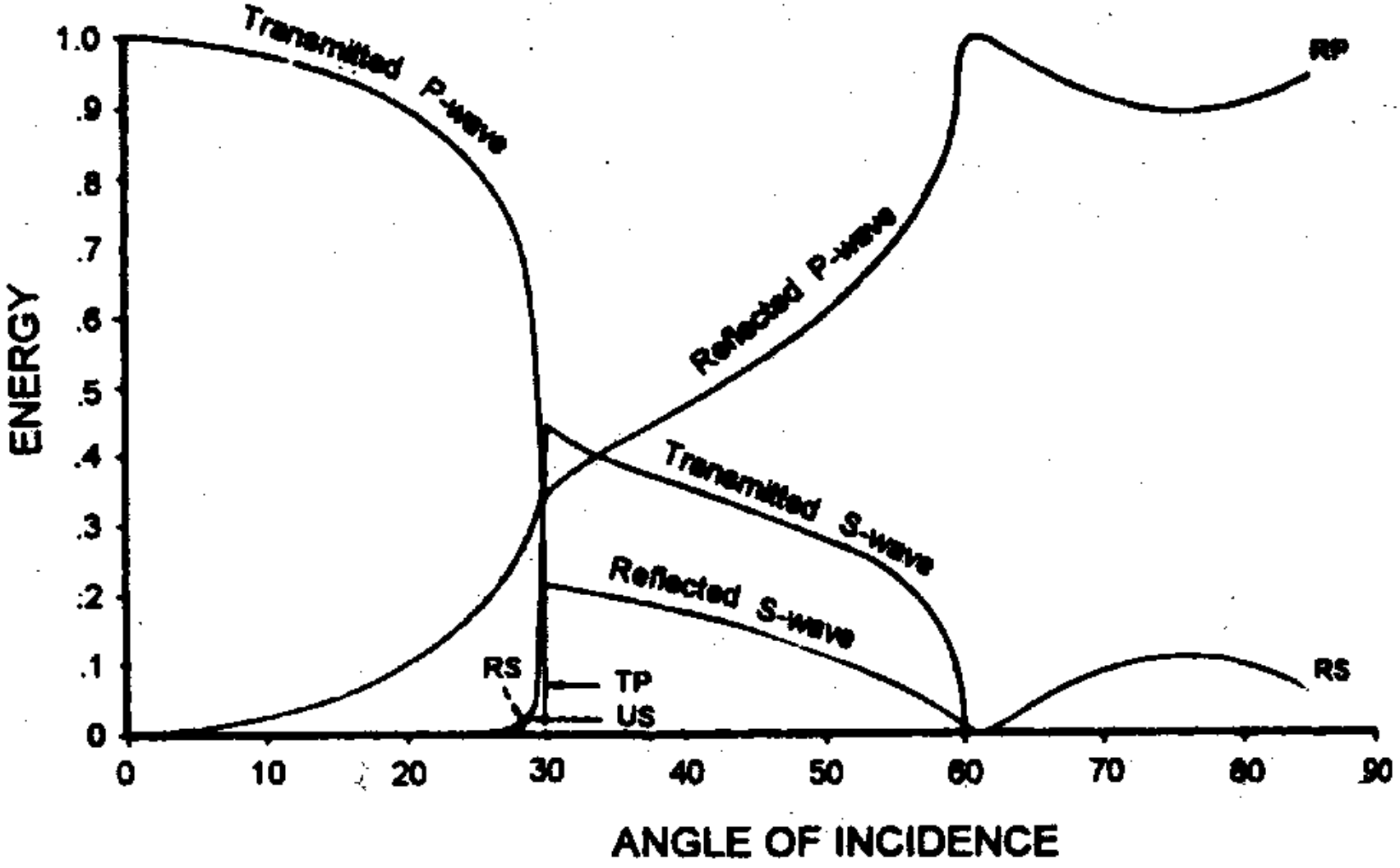
$$R = \frac{v_2\rho_2 - v_1\rho_1}{v_2\rho_2 + v_1\rho_1} = \frac{Z_2 - Z_1}{Z_2 + Z_1}$$

Transmission coefficient

$$T = \frac{2v_1\rho_1}{v_2\rho_2 + v_1\rho_1} = \frac{2Z_1}{Z_2 + Z_1}$$

with $Z = v\rho$ = acoustic Impedance

Angle-dependent reflection- and transmission-coefficients



(Sheriff and Geldart, 1995)