Travel Time (of seismic wave)

Total time required for seismic wave to travel through the rock towards the seismic receiver:

$$T_x = \int_0^{L_x} \frac{dl}{V_p(l)}$$

where

$\{x,\ y,\ z\}$ is cartesian coordinates in 3D space with x-axis aligned between seismic source and seismic sensor, y-axis is traversal to x-axis and z-axis is oriented towards Earth centre,

x is a lateral offset between the seismic source and seismic receiver

$l(x, y, z)$ – trajectory of reflection wave from seismic source @ $(x = 0,\ y = 0,\ z = 0)$ and seismic receiver @ $(x,\ y = 0,\ z = 0)$

$dl = \sqrt{dx^2 + dy^2 + dz^3}$ is differential element of the distance along the reflection travel trajectory,

$V_p(l)$ is p-wave velocity of rocks found at travel point l.

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In relatively simple geological structures the travel time can be approximated by a Dix equation:

(1) $$T_x^2 = T_0^2 + \frac{4x^2}{V_{rms}^2}$$

where T_0^2 is reflection time at zero offset (which means the normal incident wave reflection):

$$T_0 = 2 \cdot \int_0^H \frac{\delta z}{V_p(z)}$$

where H is the depth of the reflecting boundary,

V_{rms} – average p-wave velocity through the reflecting travel distance between the seismic source and seismic receiver:

$$V_{rms}^2 = \frac{\sum_i^N V_p^2(t_i)\,\delta t_i}{\sum_i^N \delta t_i} = \frac{\sum_i^N V_p(t_i)\,\delta h_i}{\sum_i^N \frac{\delta h_i}{V_p(t_i)}}$$

where

$V_p(t_i)$ is p-wave velocity of rocks found at travel time t_i,

δt_i is travel time through the rock element of thickness δh_i in tghe rock element found at travel time t_i.