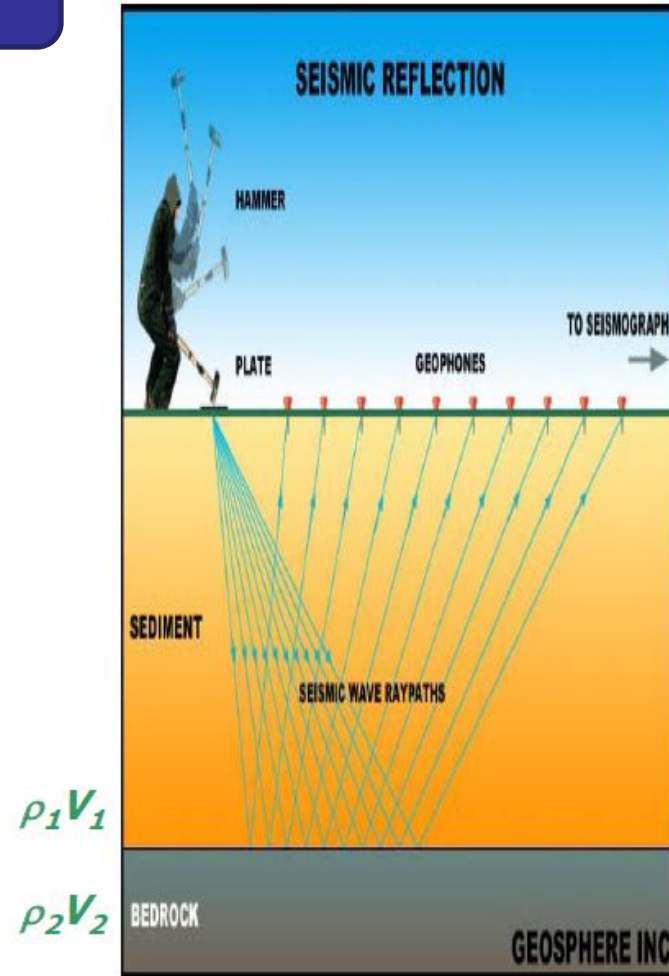


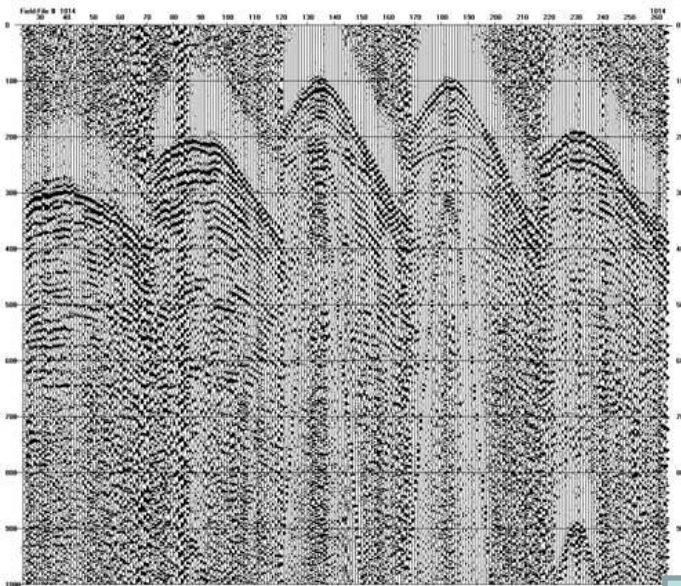
Метод отраженных волн.

- Чувствителен к границам на которых происходит изменение акустического импеданса.
- Используются, в основном, продольные волны.

Масштабы объектов

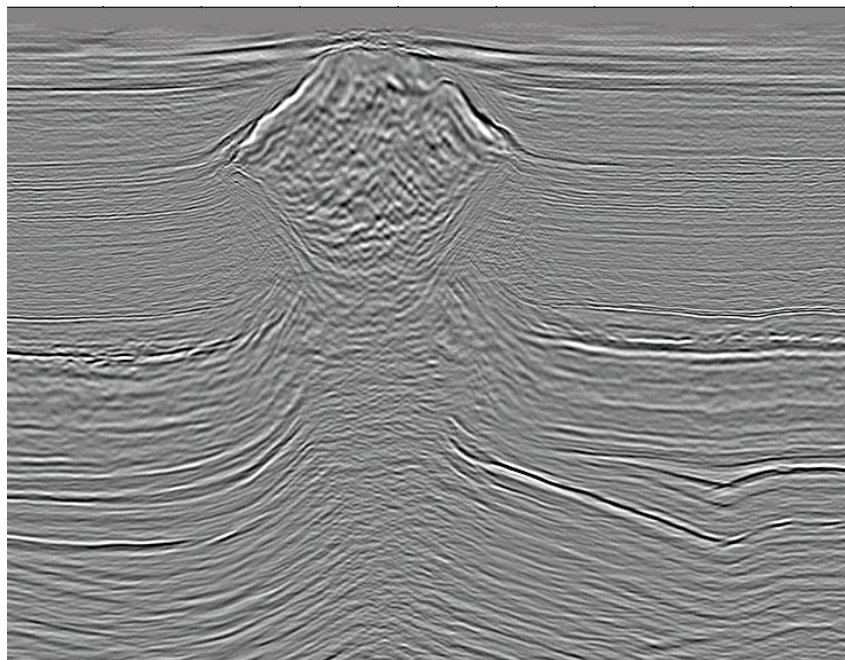
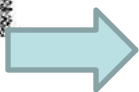
- 10'ки метров - инженерные задачи.
- Первые километры – разведка МПИ.
- 10'ки километров – структура коры.

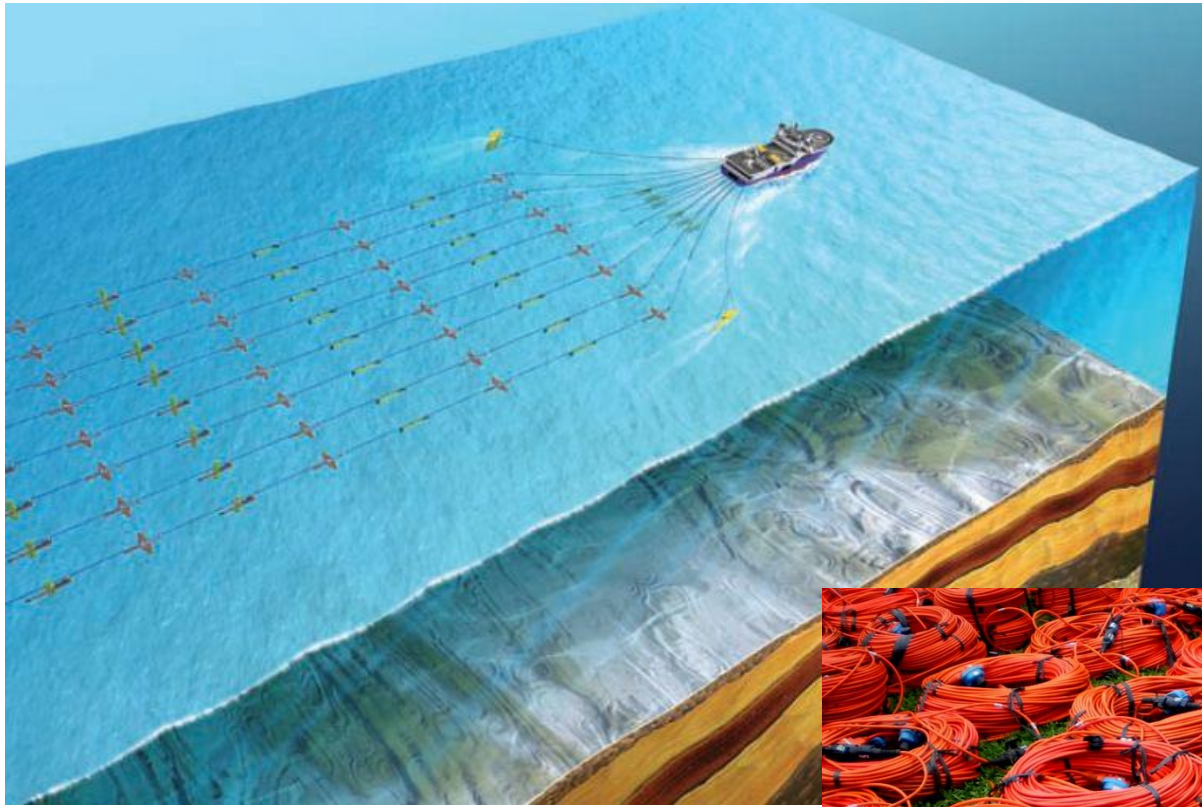


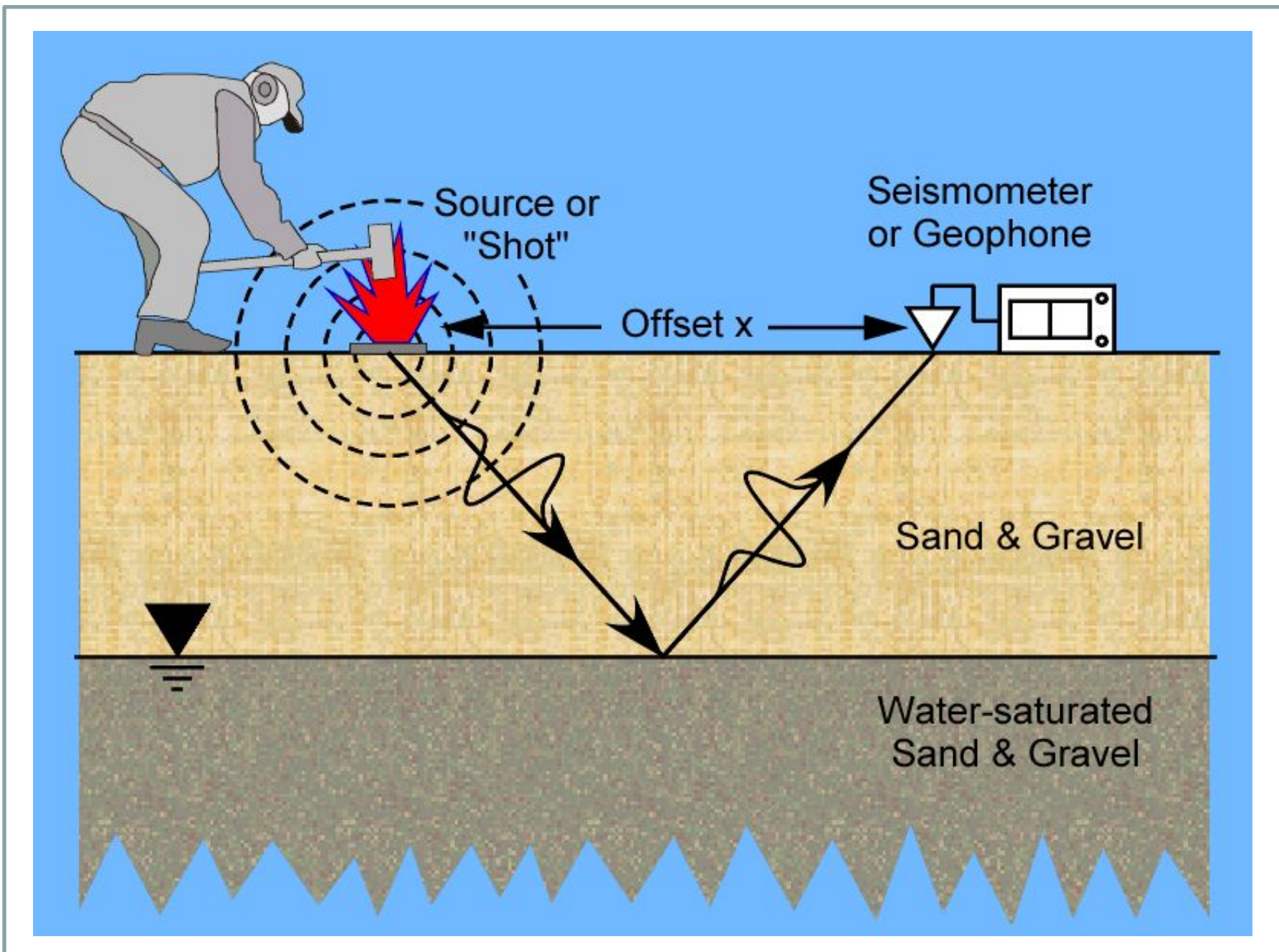


Задача разведочной сейсморазведки.

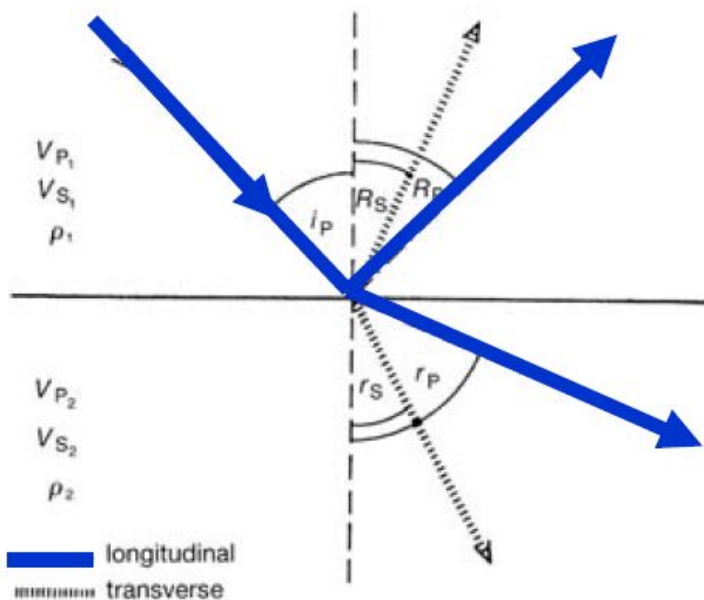
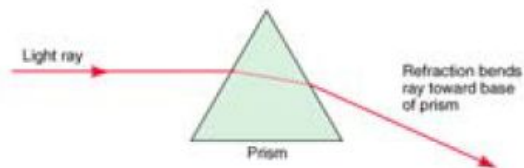
- Спроектировать систему получения данных.
- Получить данные.
- Обработать и получить сейсмический разрез.
- Извлечь и представить максимум информации для данных и соответствующего разреза.







Закон Снеллиуса (отражения) для МОНОТИПНЫХ ВОЛН



Сейсмические лучи
подчиняются закону Снеллиуса
(аналогично с оптикой)

Угол падения равен углу отражения, а
угол прохождения связан с углом
падения через соотношение
скоростей.

$$\frac{\sin i_P}{V_{P1}} = \frac{\sin R_P}{V_{P1}} = \frac{\sin r_P}{V_{P2}}$$

Зависимость коэффициента преломления - отражения от угла падения волны на границу.

Simple case: **Normal incidence**

Reflection coefficient

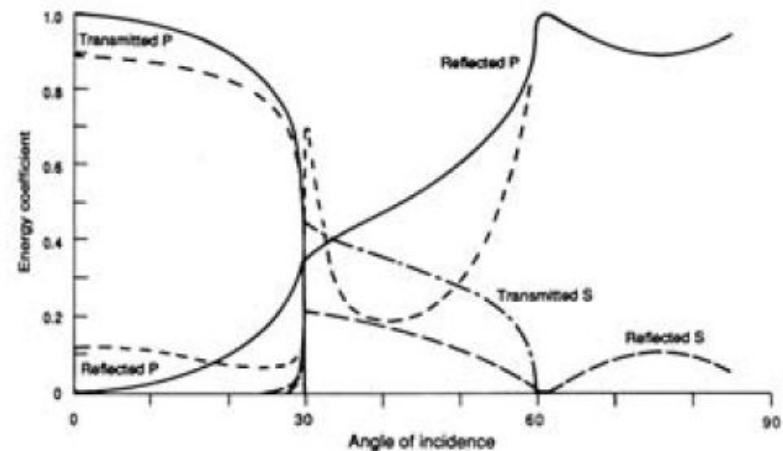
$$R_C = \frac{A_R}{A_i} = \frac{\rho_2 V_2 - \rho_1 V_1}{\rho_2 V_2 + \rho_1 V_1}$$

Transmission coefficient

$$T_C = \frac{A_T}{A_i} = 1 - R_C = \frac{2\rho_1 V_1}{\rho_2 V_2 + \rho_1 V_1}$$

These coefficients are determined by from the product of velocity and density – the **impedance** of the material.

R_C usually small – typically 1% of energy is reflected.



Reflection and transmission coefficients for a specific impedance contrast

Source strength



Spreading loss

$$1/r$$

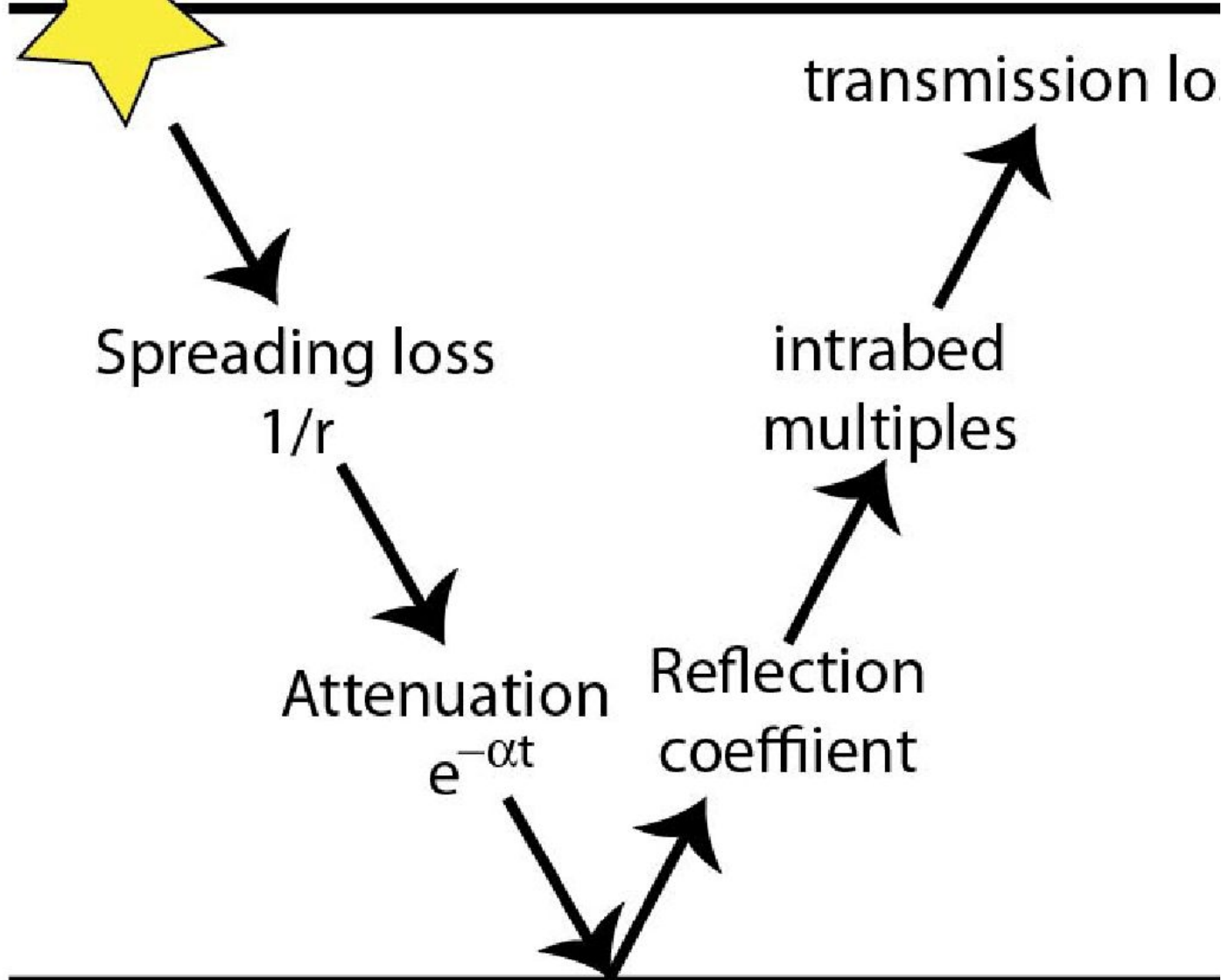
Attenuation

$$e^{-\alpha t}$$

Reflection coefficient

intrabed multiples

transmission I_0

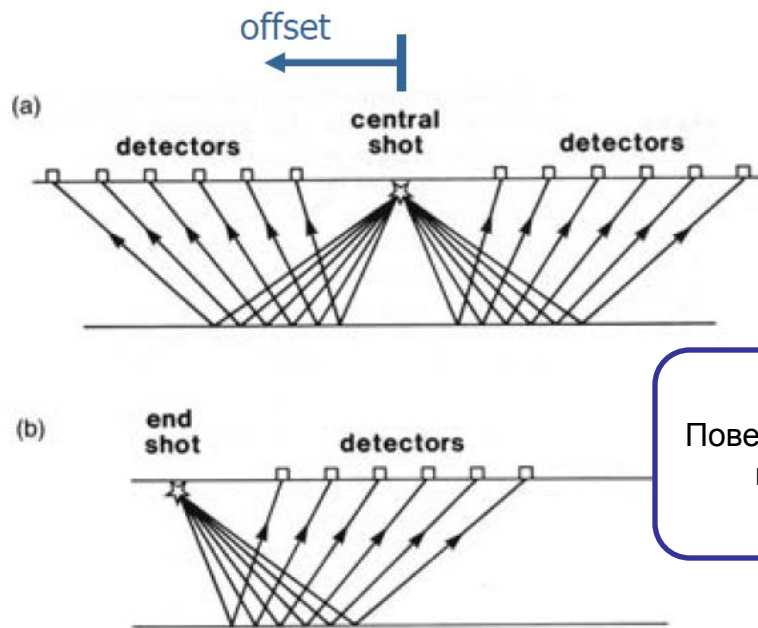


Сейсмическая трасса – запись одного сейсмоприемника $A(x_s, x_s, t)$

Сейсмограмма – совокупность сейсмических трасс

Годограф - график зависимости времени пробега волны от источника до приемника волны от расстояния между ними

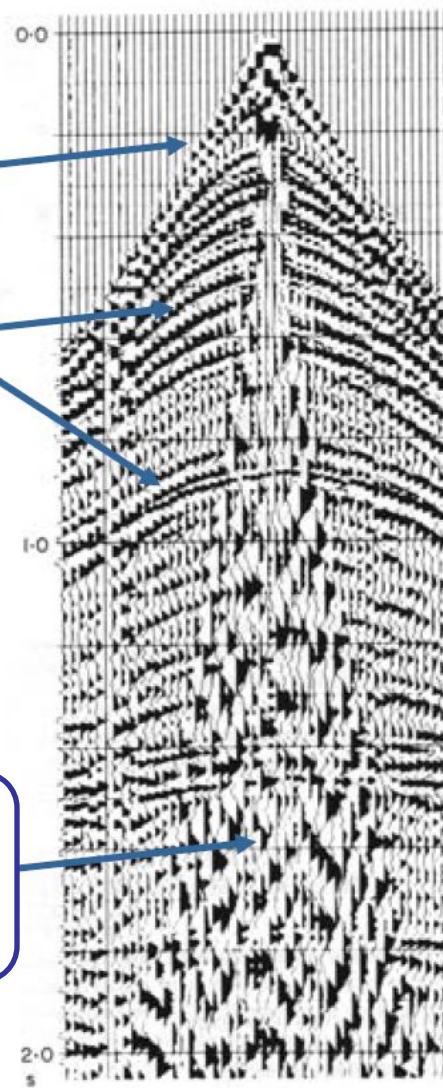
Выборка ОПВ

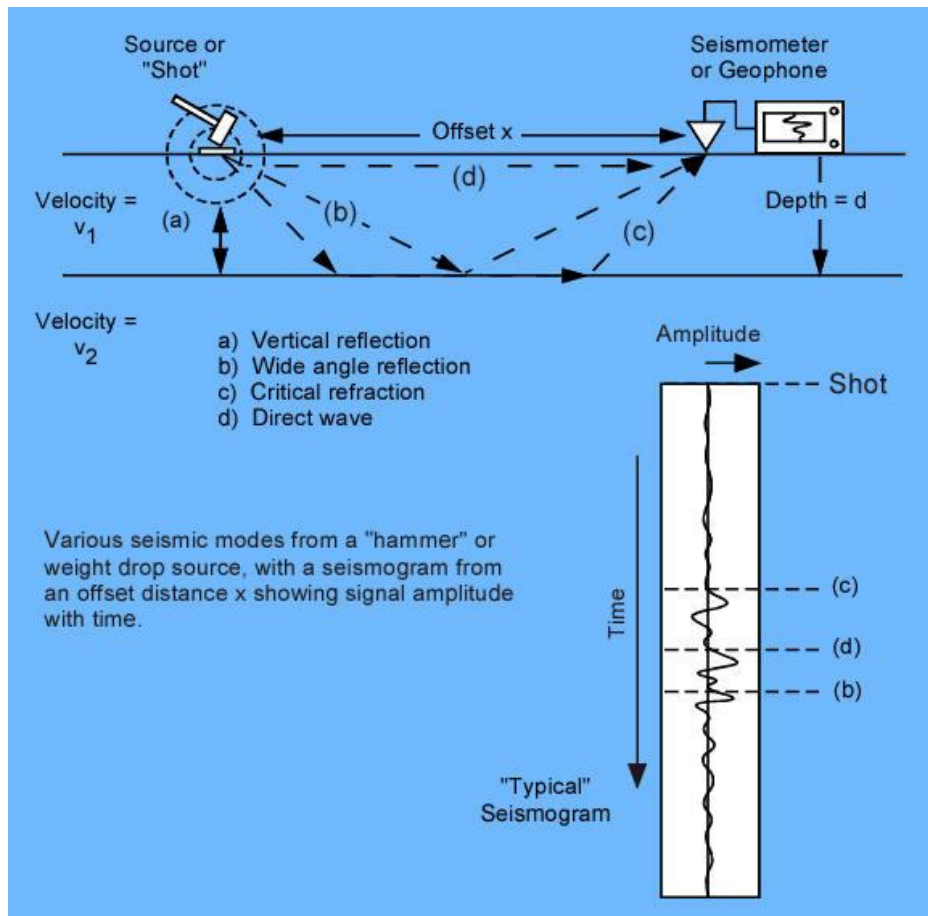


Прямая волна

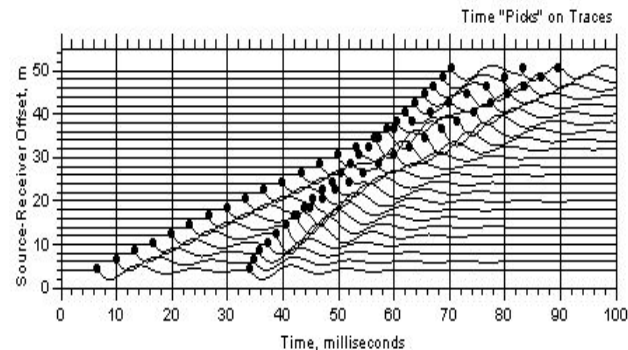
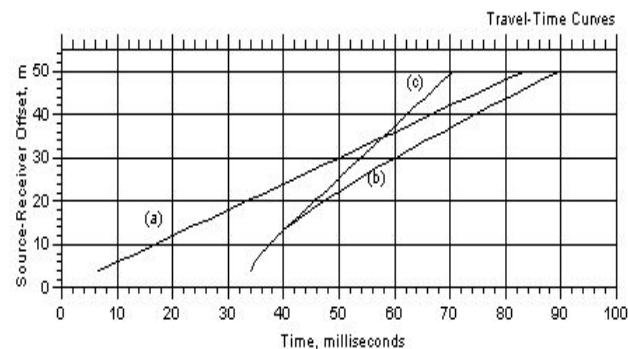
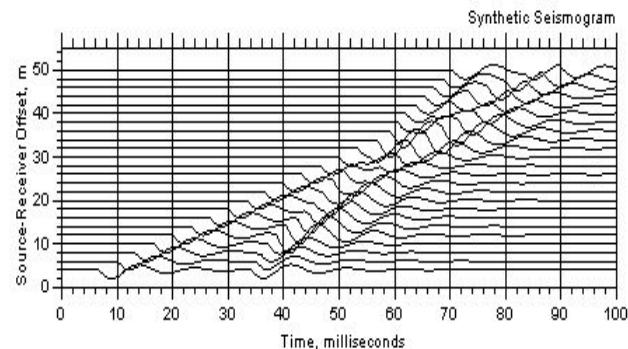
Отраженные волны

Поверхностная волна





Various seismic modes from a "hammer" or weight drop source, with a seismogram from an offset distance x showing signal amplitude with time.



Example of a synthetic seismogram showing (a) the direct wave, (b) the reflected wave, and (c) the critically refracted wave. Parameters of the model are that $V_1 = 600$ m/s; $V_2 = 1200$ m/s; $d = 10$ m.

Годограф отраженной волны. Кинематическая поправка.

В случае одной горизонтальной границы, годограф отраженной волны имеет вид:

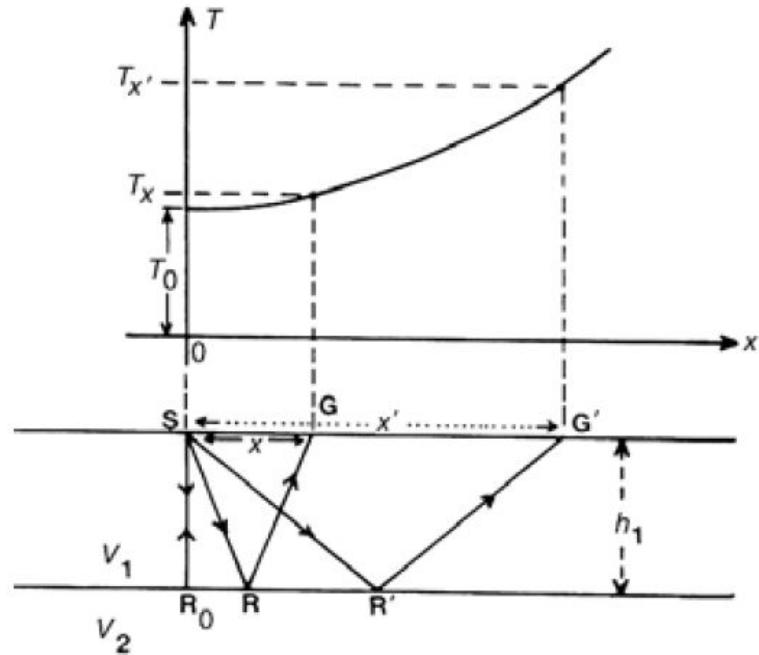
$$T_x = \frac{2SR}{V_1} = \frac{2}{V_1} \sqrt{h_1^2 + \left(\frac{x}{2}\right)^2}$$

или

$$T_x^2 = T_0^2 + \frac{x^2}{V_1^2}$$

The arrival time curve is a hyperbola

Исследование времен прихода волн в чистом виде относится в сейсморазведке к кинематической задаче.

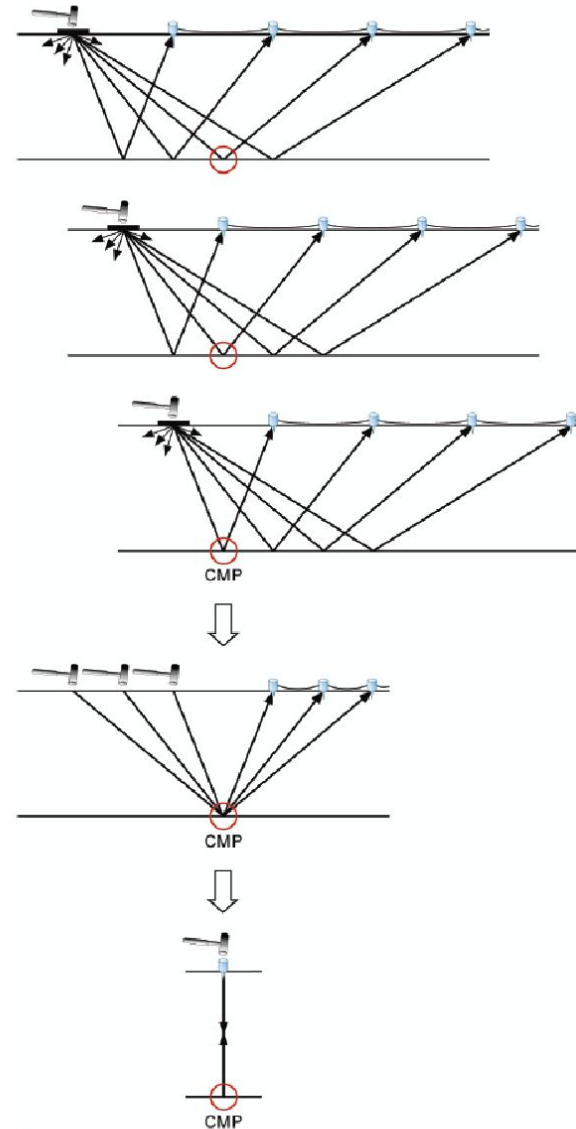


Выборка ОСТ (осуществление)

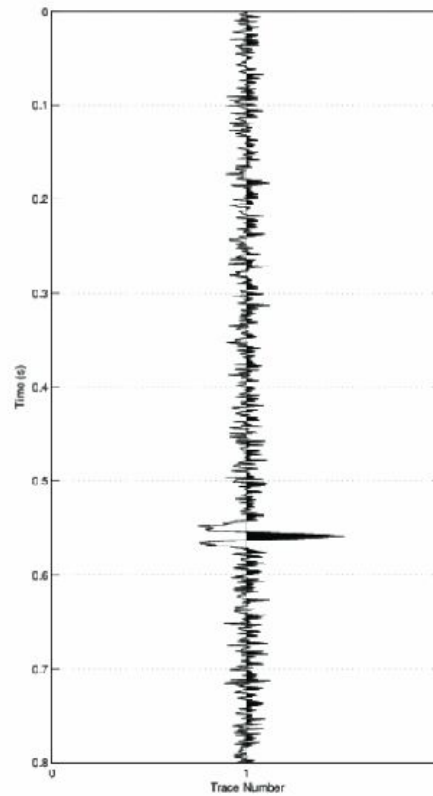
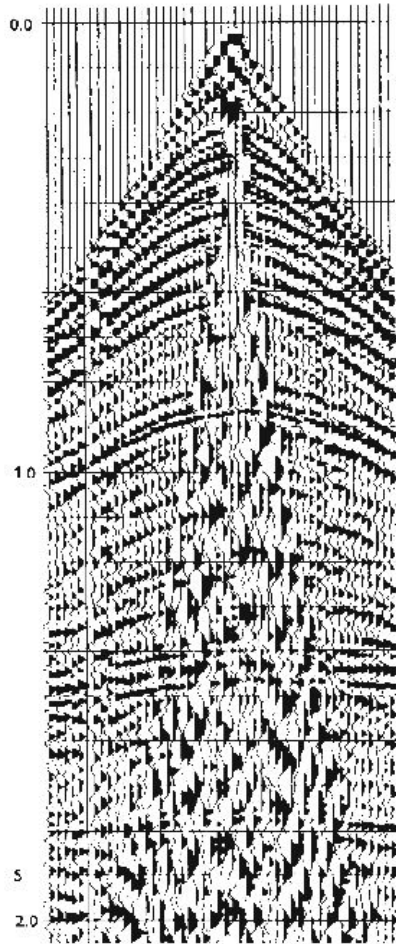
Sequentially move shot and receiver string across the surface

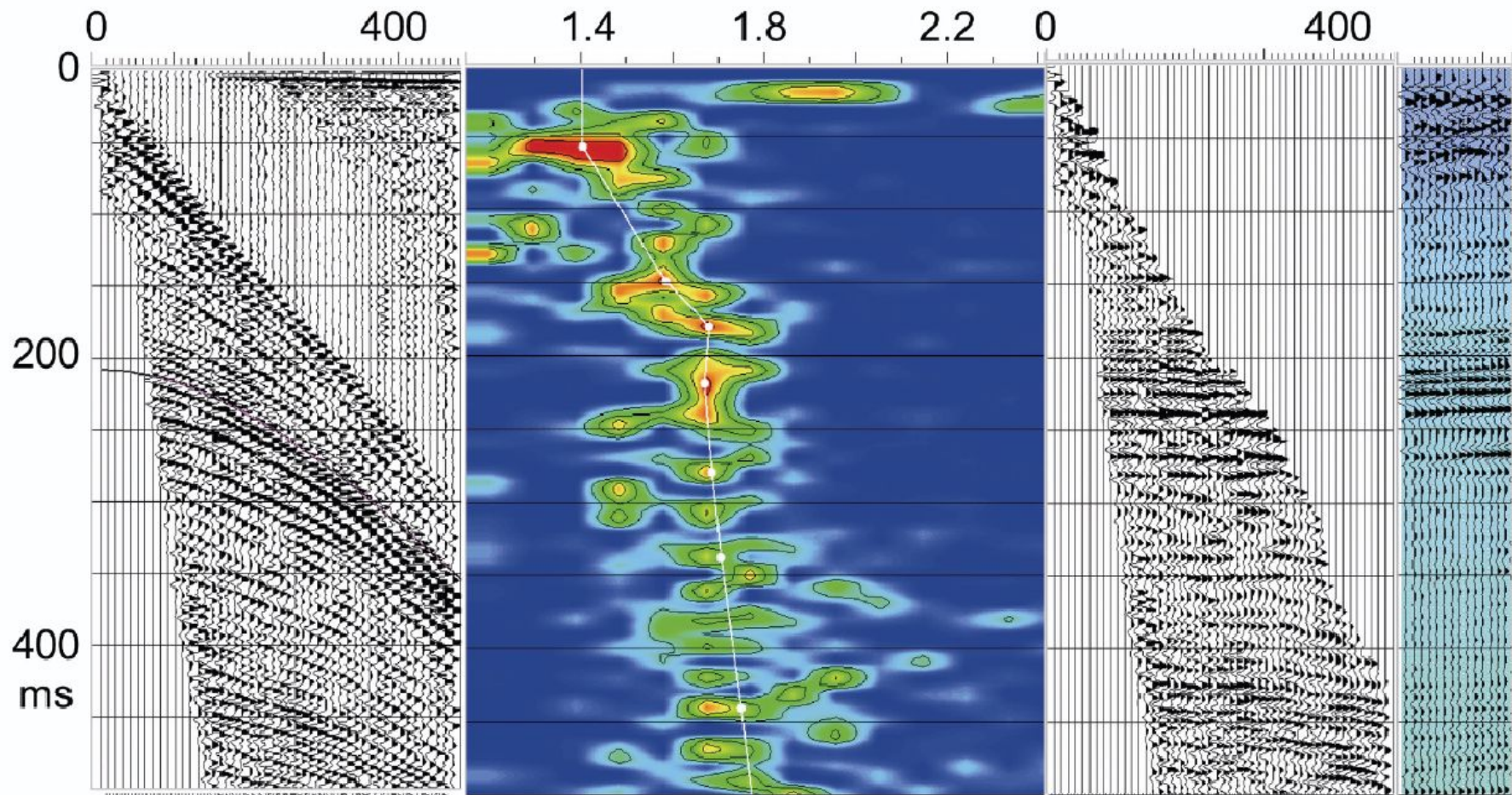
Кратность – Количество трасс в выборке ОСТ.

Типичные значения – около 6 для инженерных работ .
20-50-100 и более для нефгазотеразведочных



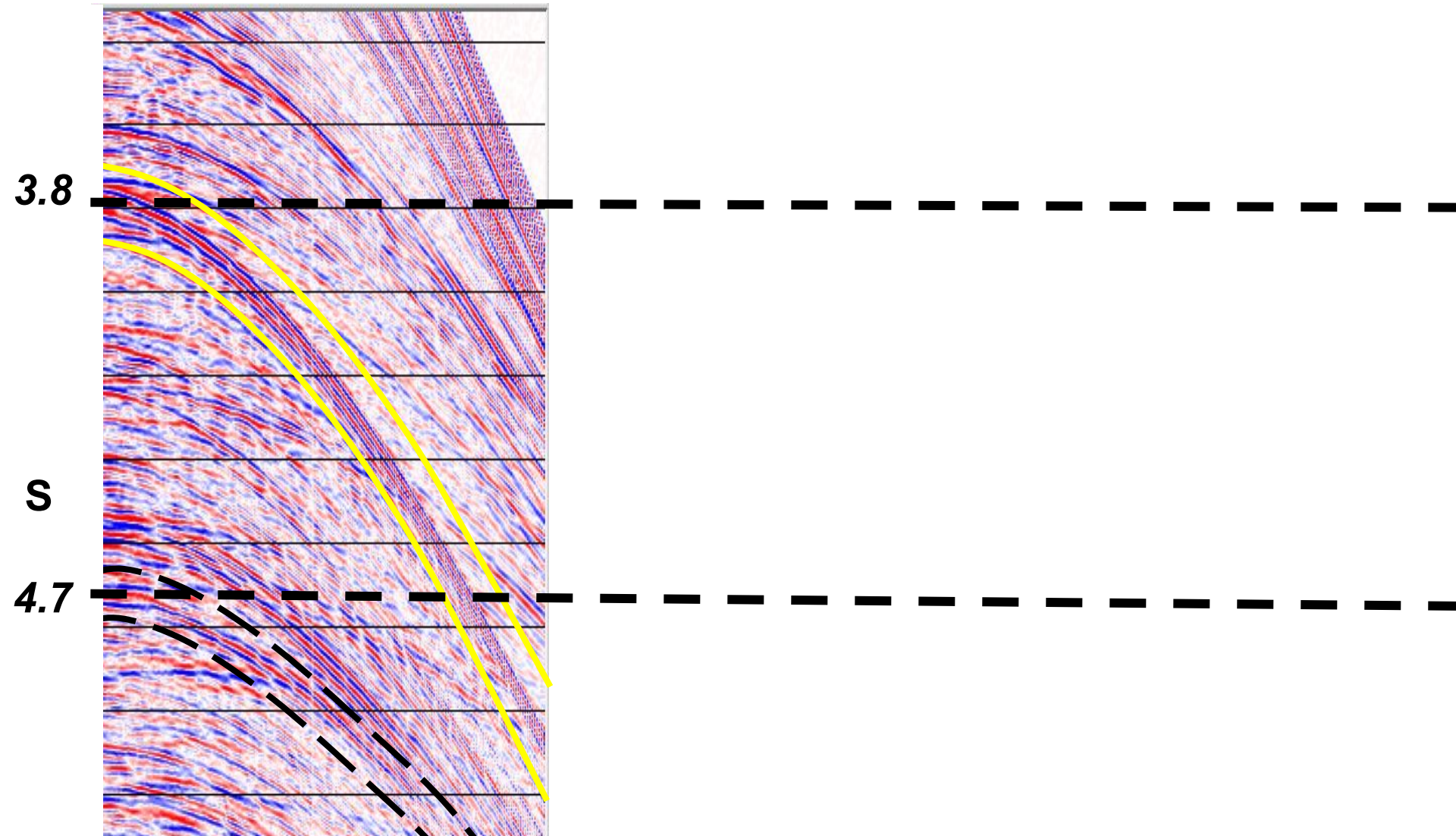
Stacking





Conventional velocity analysis.....

0 Km 5



3.8

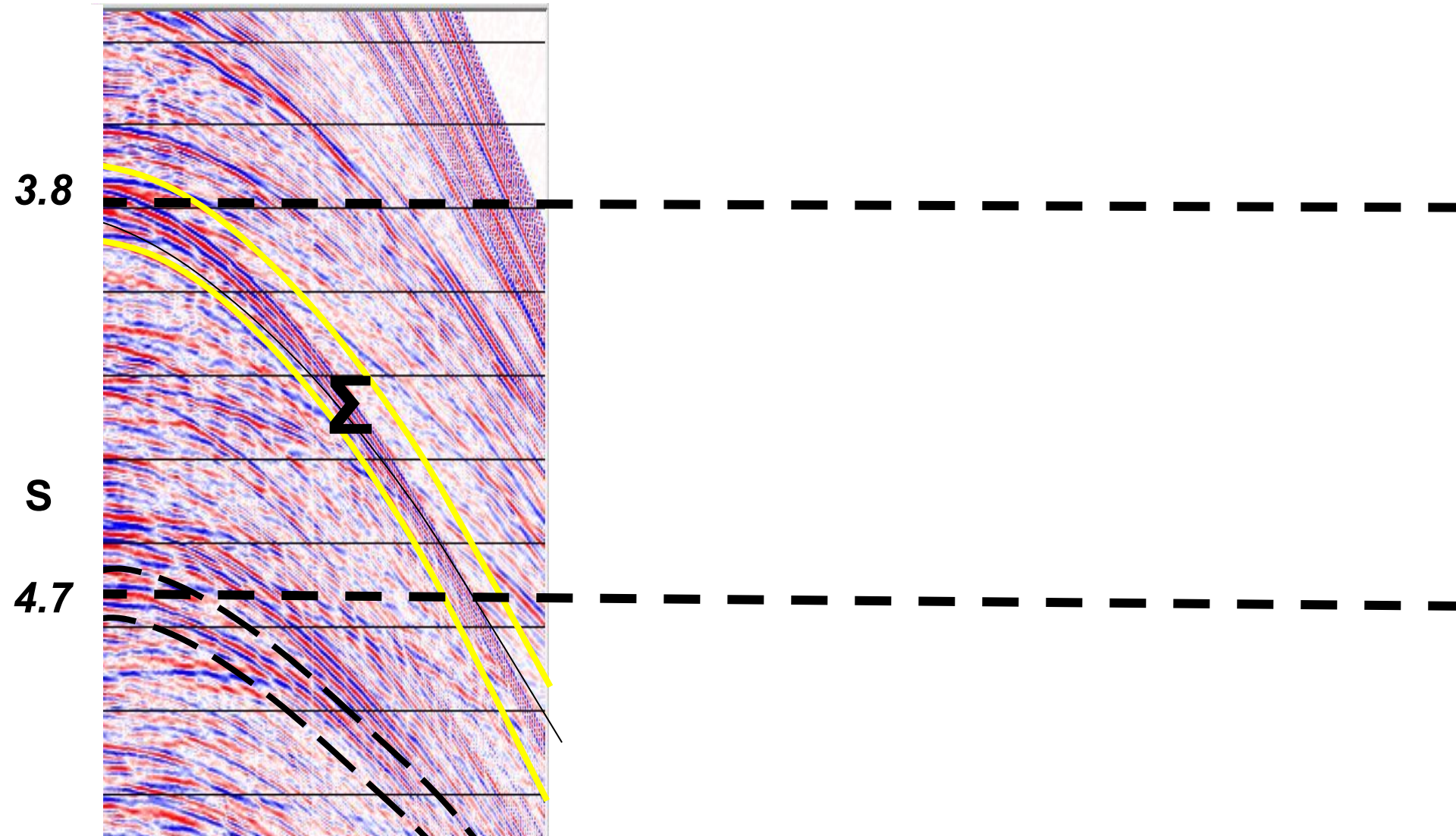
S

4.7

Input CMP data

Conventional velocity analysis.....

0 Km 5



3.8

S

4.7

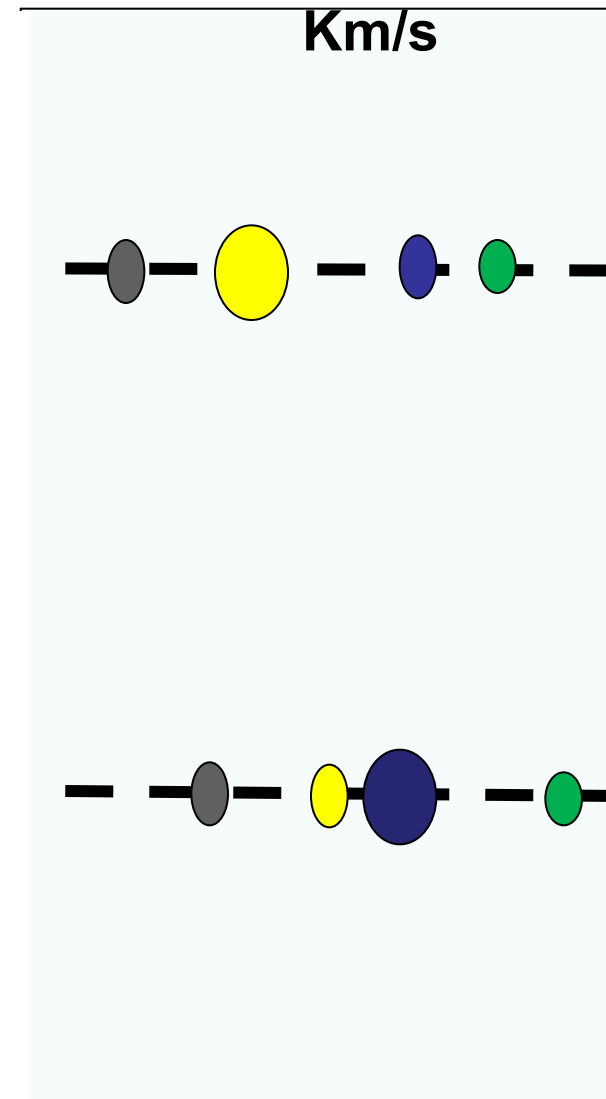
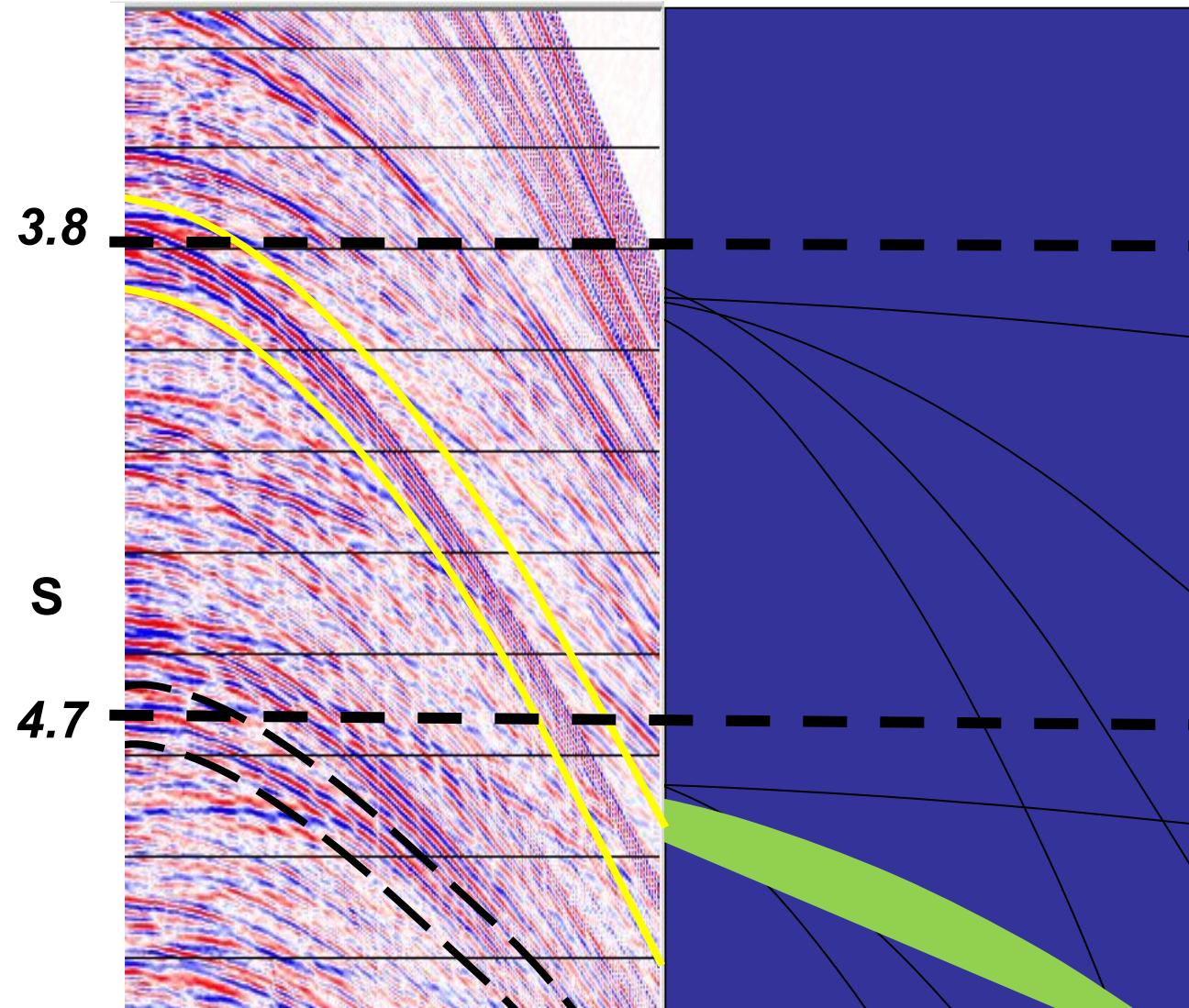
Input CMP data

Conventional velocity analysis.....

0 Km 5 Km

1.5 2.5 3.5

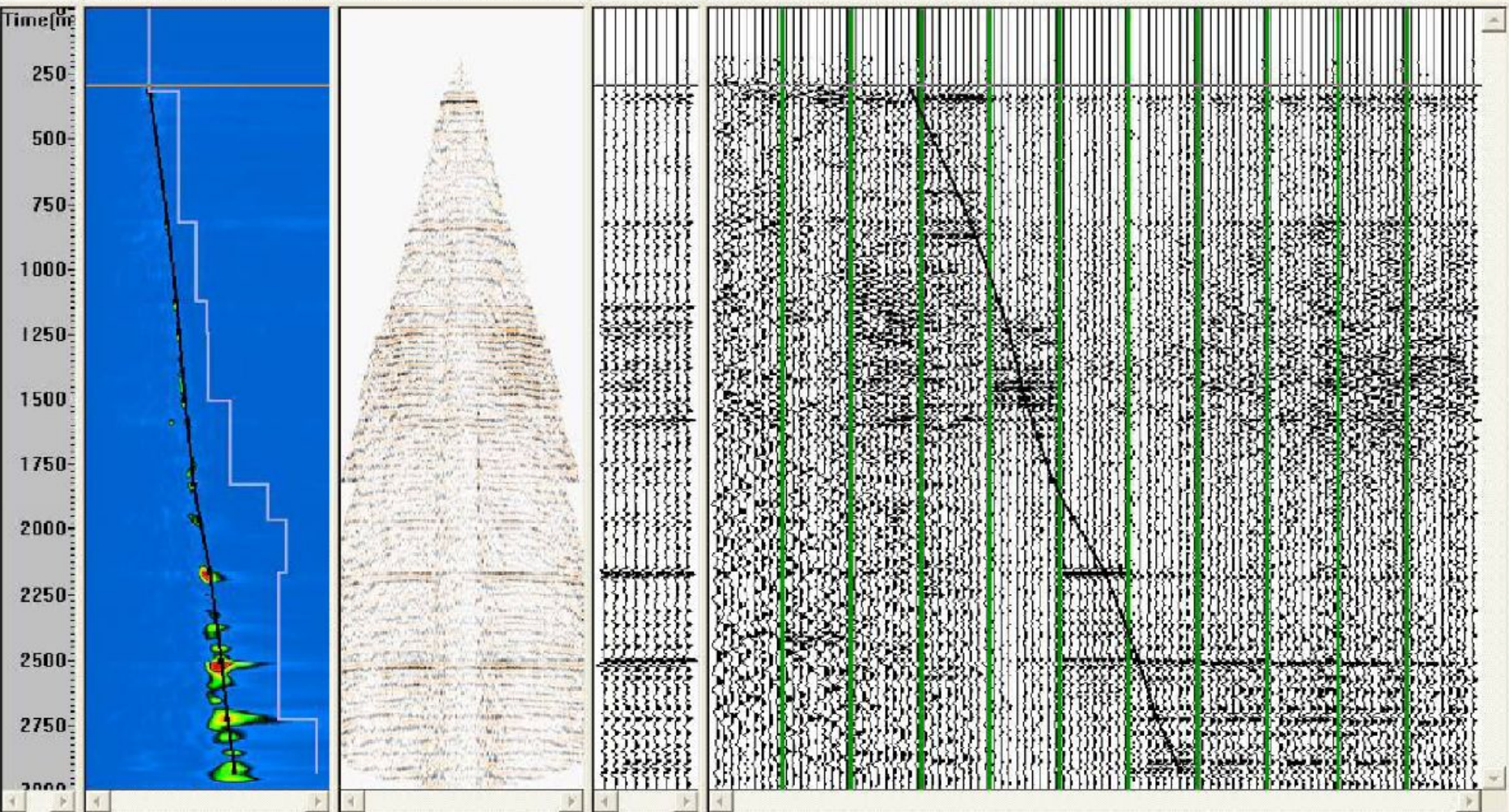
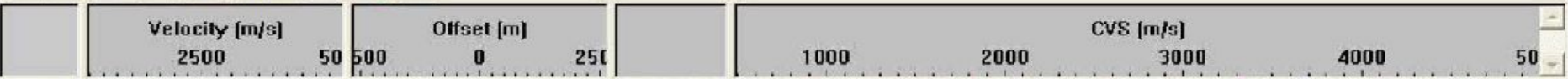
Km/s

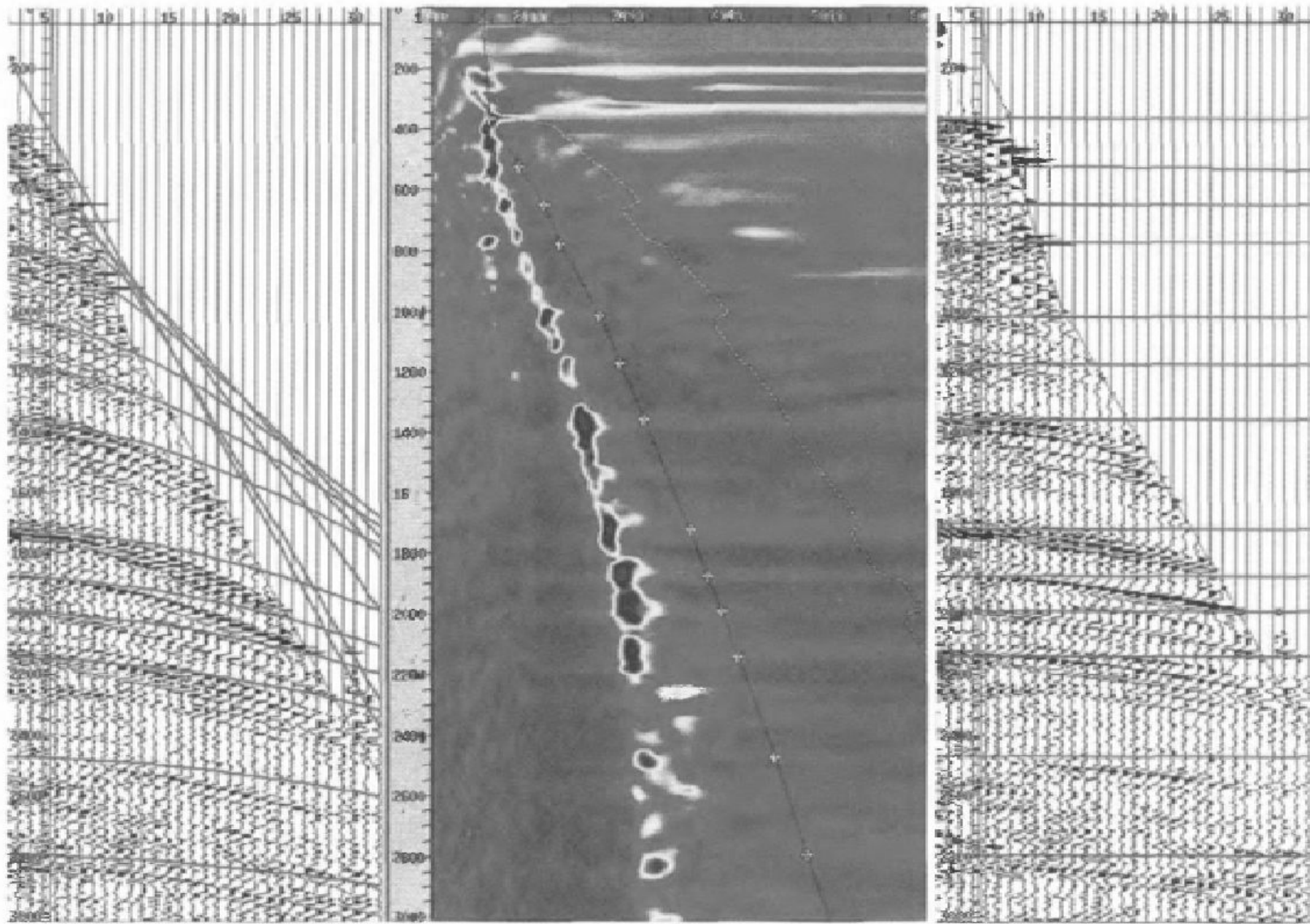


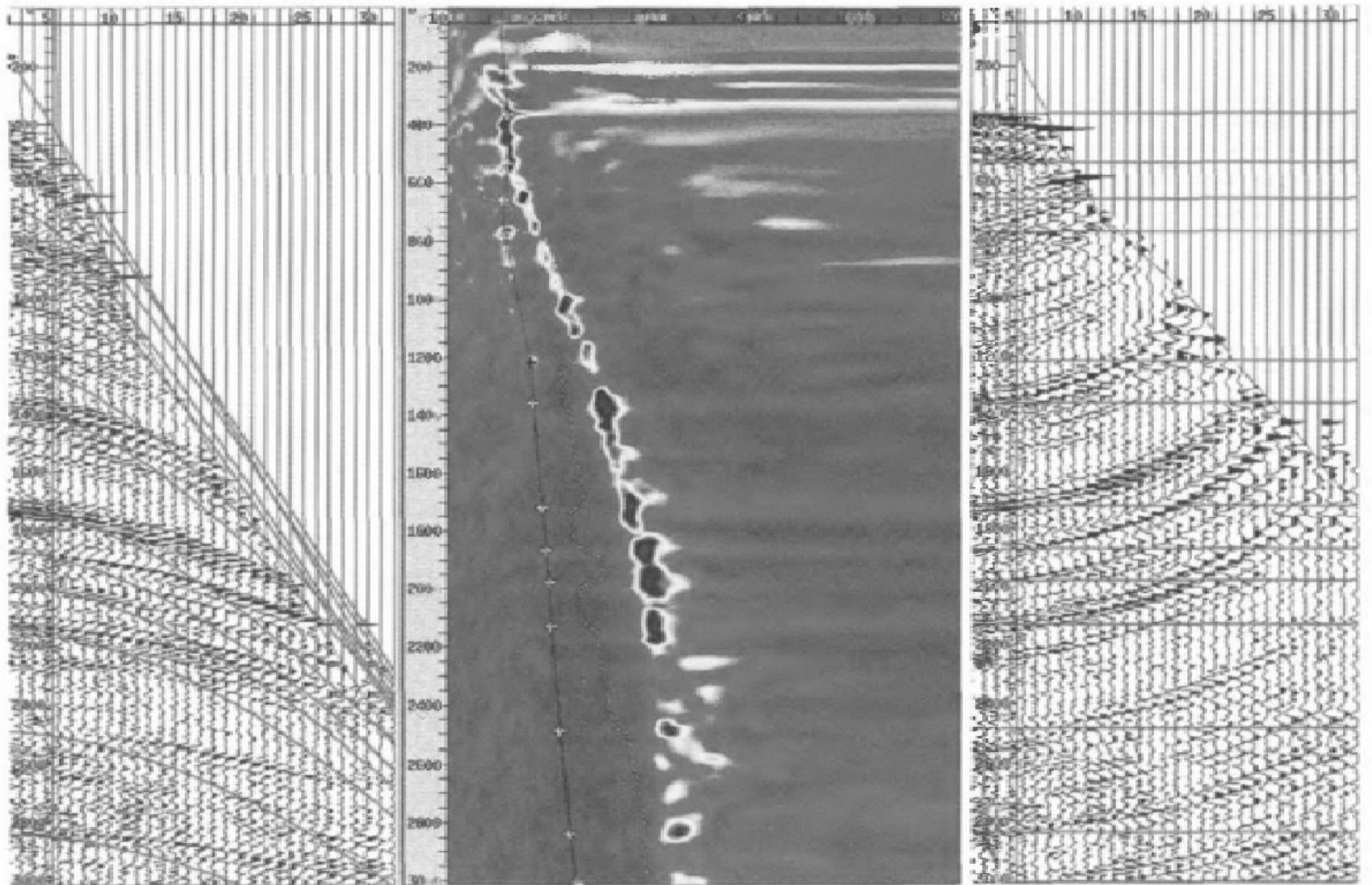
Input CMP data

scan along trajectories

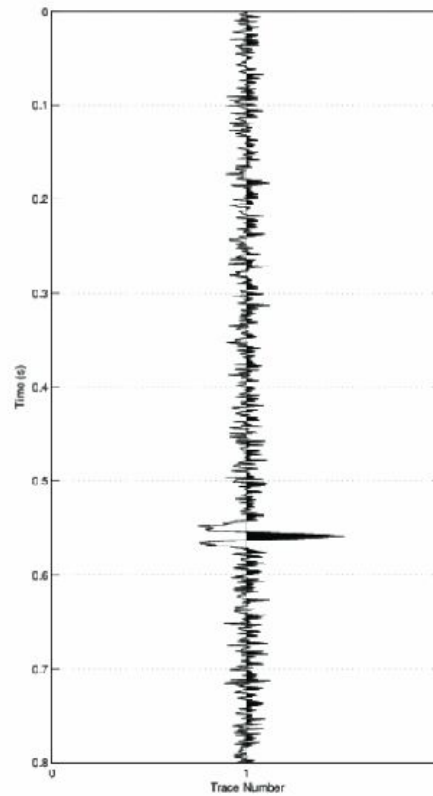
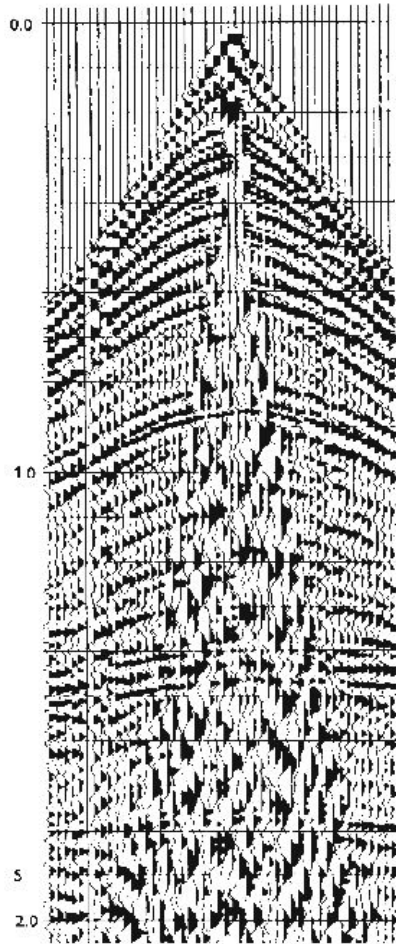
pick corresponding velocity







Stacking



Импульсная характеристика среды, свертка.

Сейсмические волны чувствительны к скачкам импеданса, которые могут быть представлены в виде импульсной характеристики среды (R).

W – сигнал от источника, тогда сейсмограмма S записанная на поверхности может быть представлена как:

$$S = W * R$$

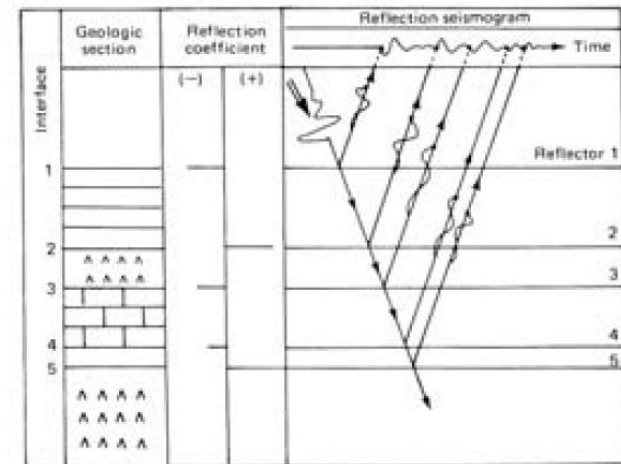
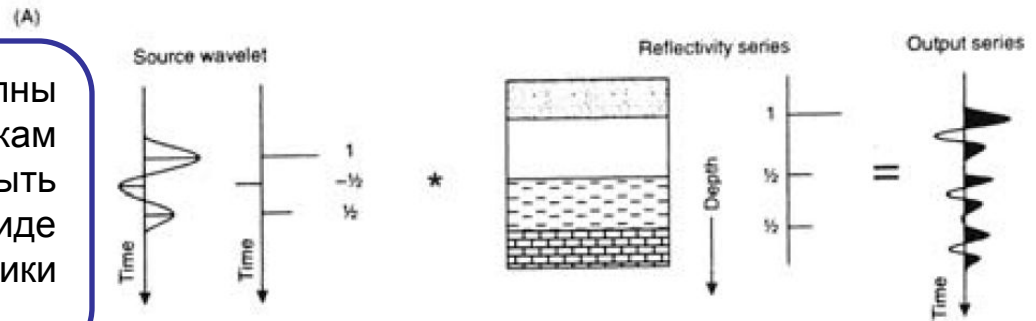
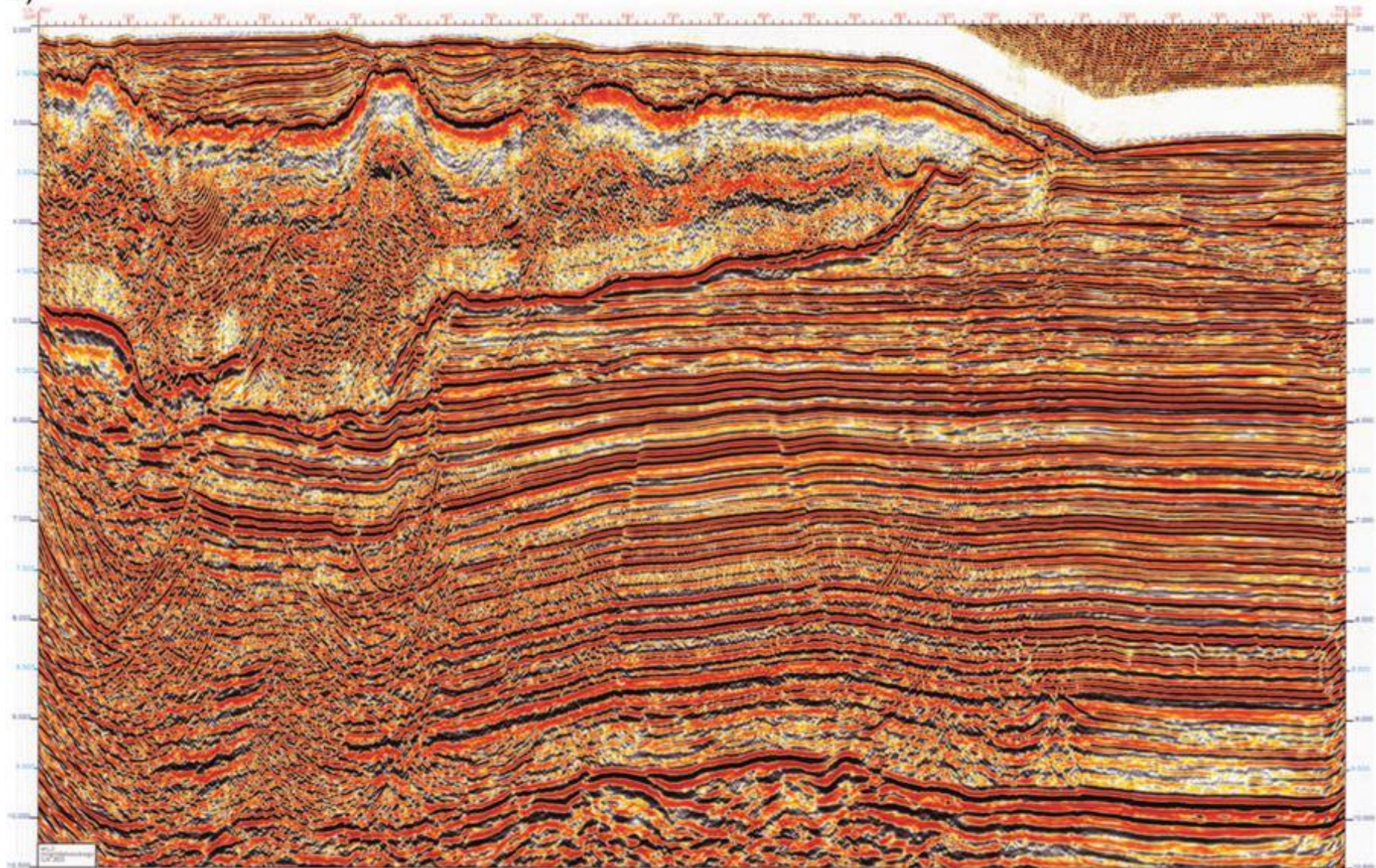
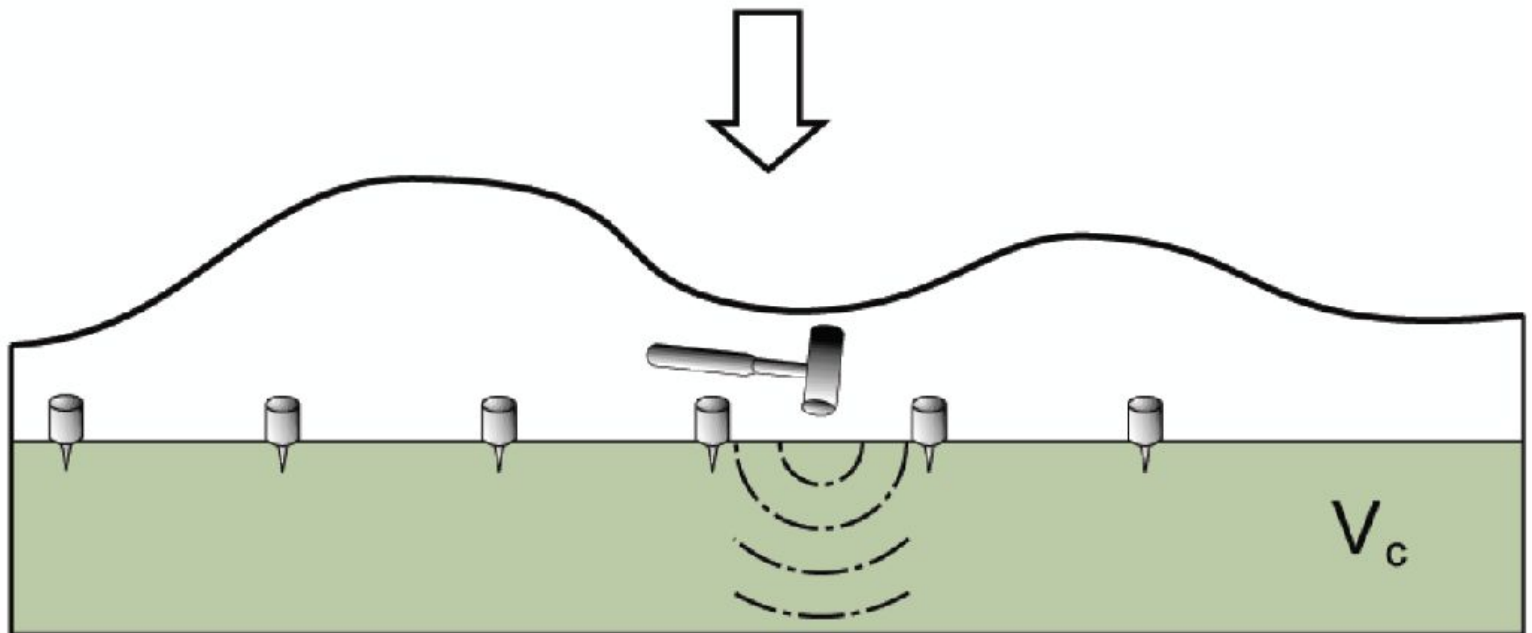
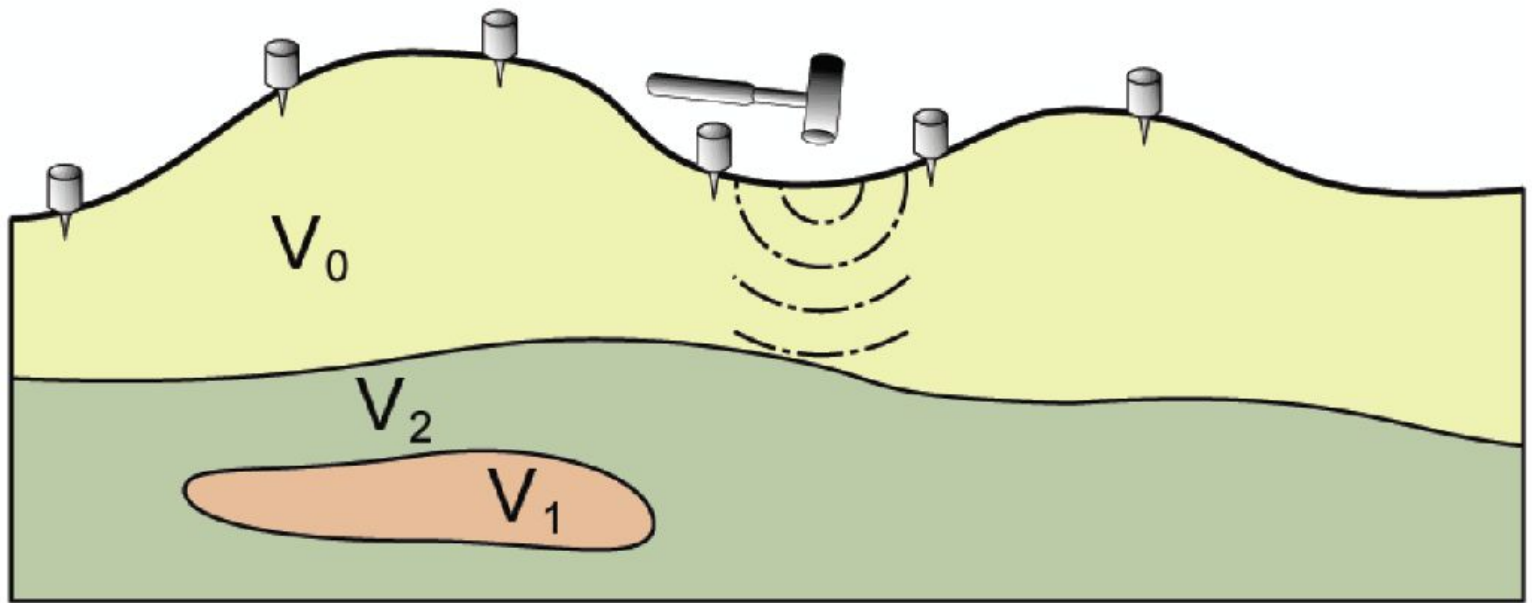


Fig. 4.18 Schematic of a model geological section, a reflectivity log, and a synthetic seismogram. The last is produced by convolving the input wavelet with the reflection effects at each interface derived from the reflectivity log. (Modified from Al-Sadi, 1982.)

b)





Статические поправки.

Correct for surface topography and the weathered surface layer

Surface topography

Time correction to each trace:

$$t_g = (E_g - E_d) / V$$

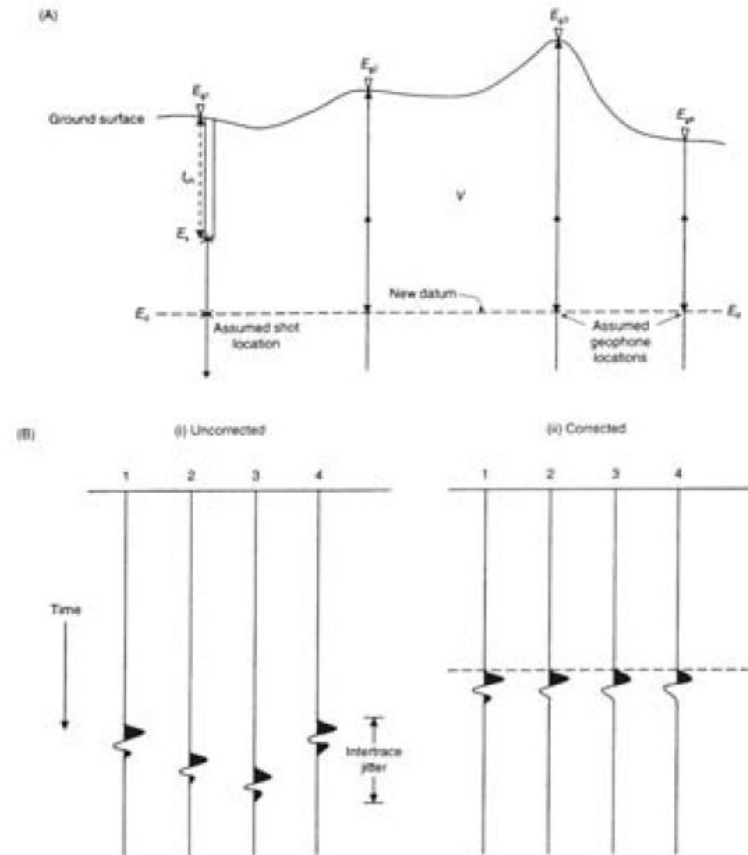
Source depth

$$t_s = (E_s - E_d) / V$$

total correction

$$t_e = t_s + t_g$$

Shift each trace by this amount to line up deeper reflectors

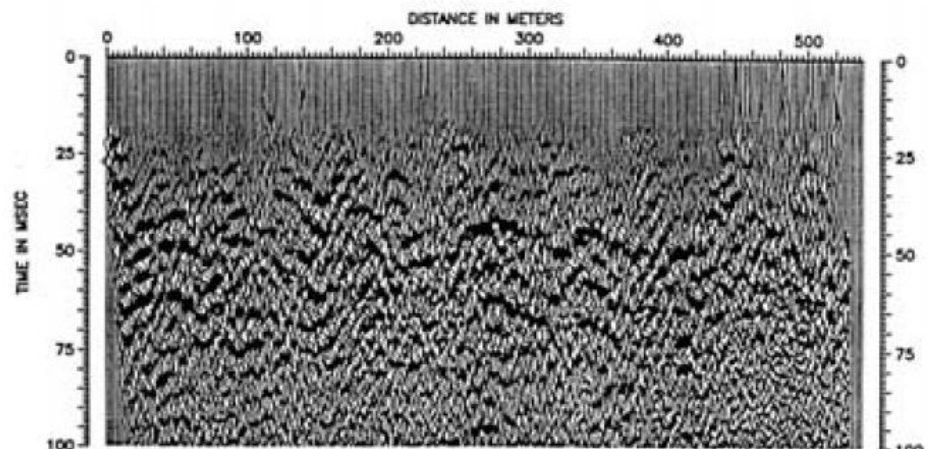


Статические поправки.

An example

Pre-correction

(a)



Post-correction

(b)

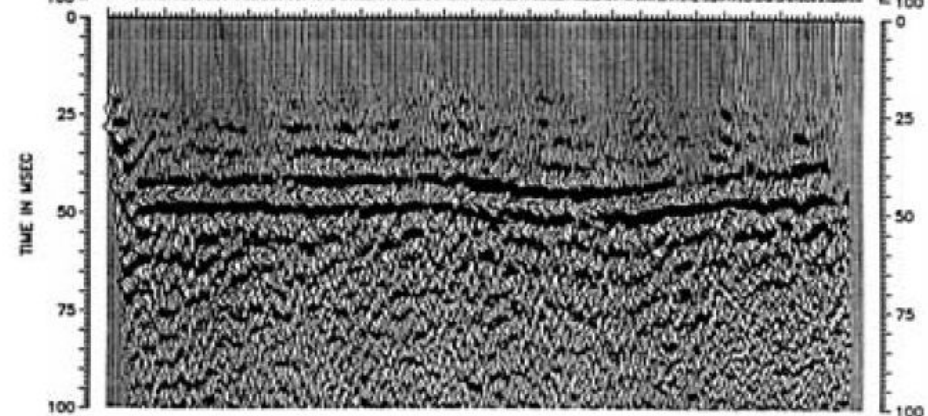


Fig. 4.17 Effect of applying residual static corrections on CDP reflection data recorded at a waste-dump site in Zealand, Denmark. Time section (a) before application of statics and (b) after application of statics. (After Ploug, 1991.)

Fresnel Zone

Tells us about the horizontal resolution on the surface of a reflector

First Fresnel Zone

The area of a reflector that returns energy to the receiver within half a cycle of the first reflection

The width of the first Fresnel zone, w :

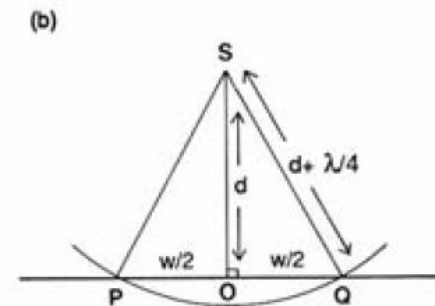
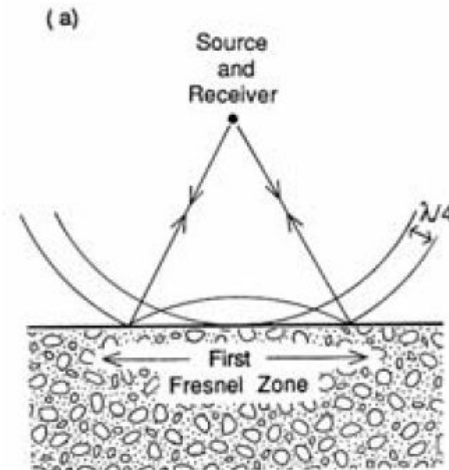
$$\left(d + \frac{\lambda}{4}\right)^2 = d^2 + \left(\frac{w}{2}\right)^2$$

$$w^2 = 2d\lambda + \frac{\lambda^2}{4}$$

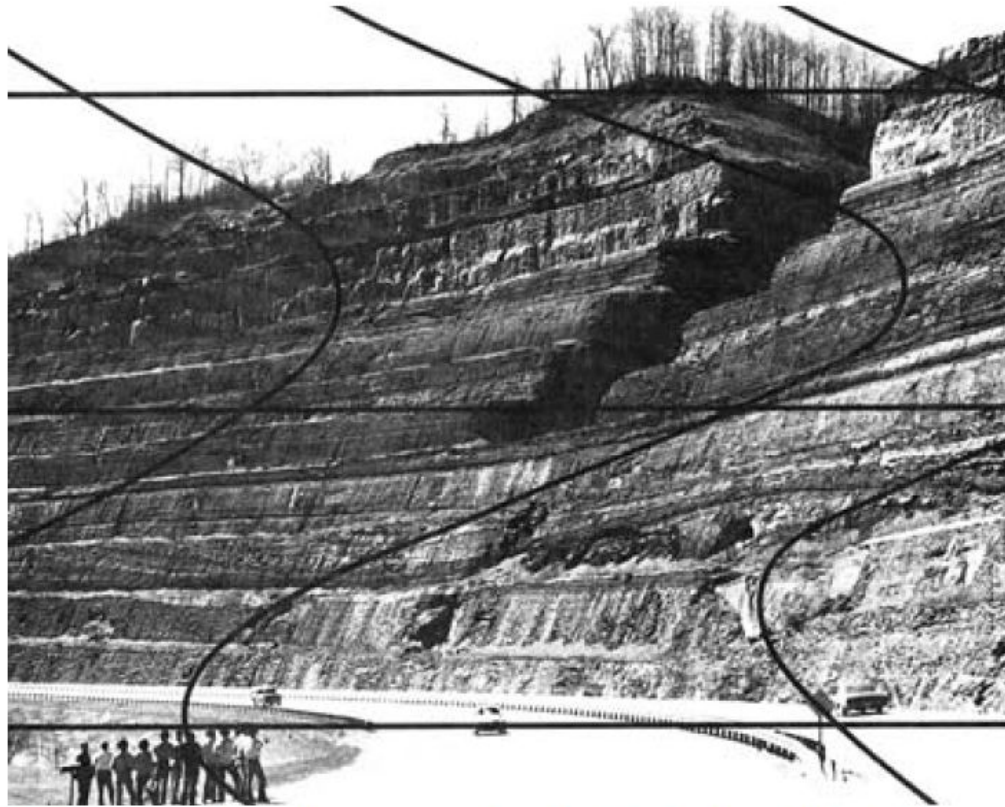
If an interface is smaller than the first Fresnel zone it appears as a point diffractor, if it is larger it appears as an interface

Example:

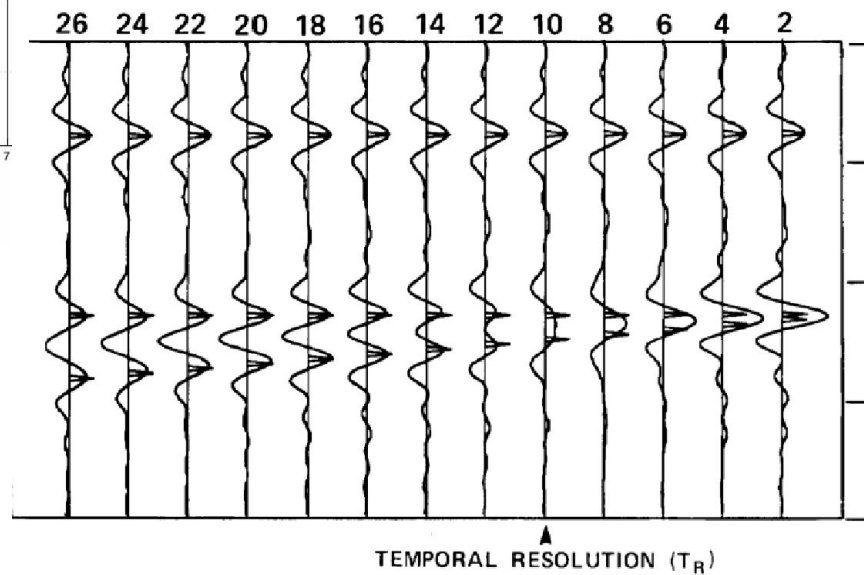
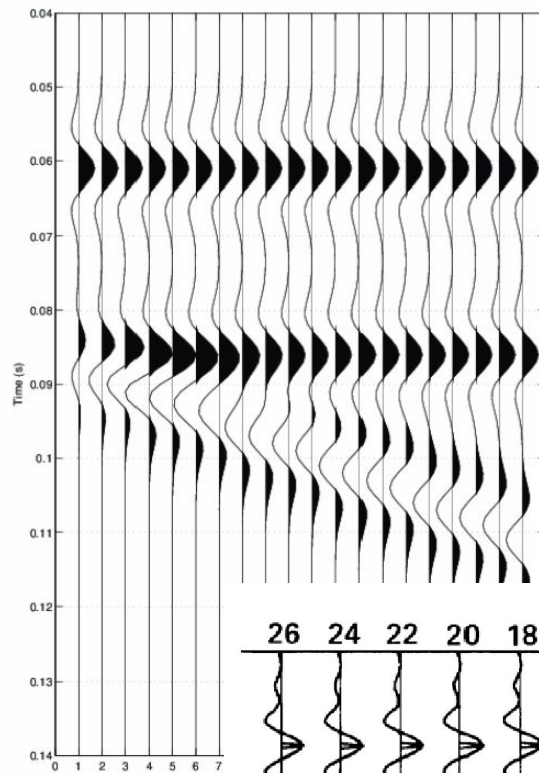
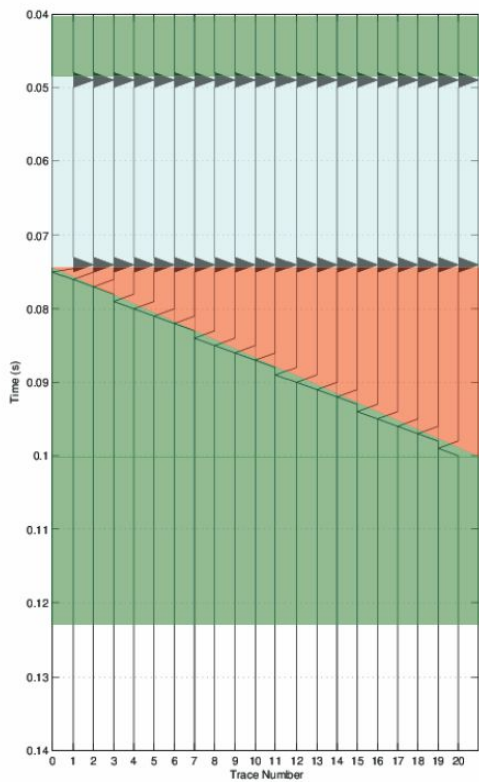
30 Hz signal, 2 km depth where $\alpha = 3$ km/s then $\lambda = 0.1$ km and the width of the first Fresnel zone is 0.63 km



Resolution of structure

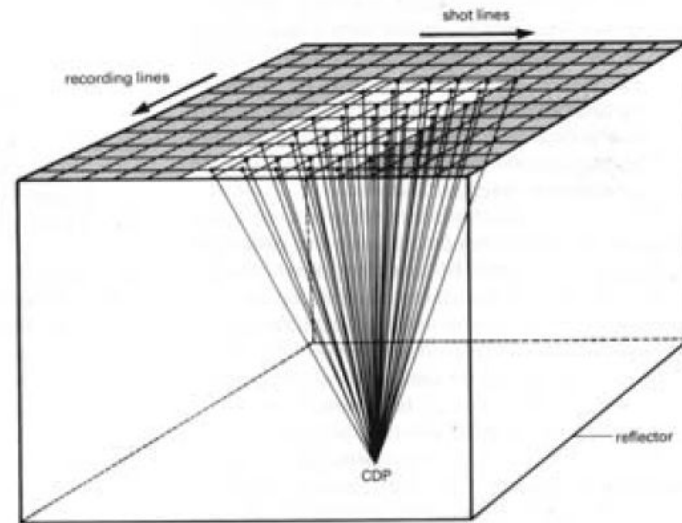
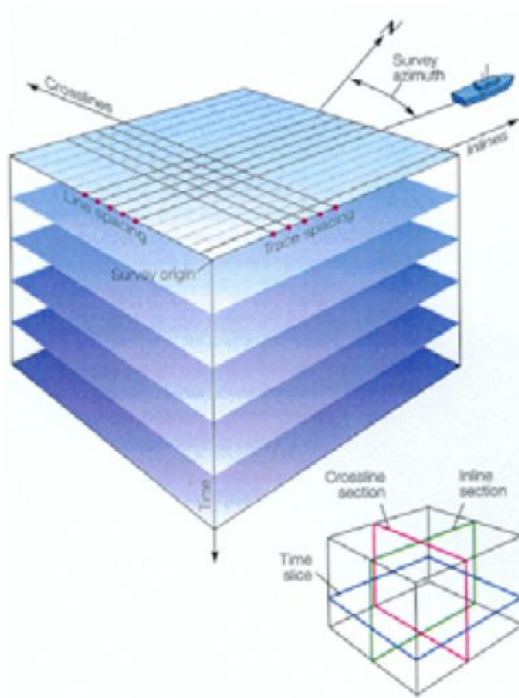


When you have been mapping faults in the field what were the vertical offsets?

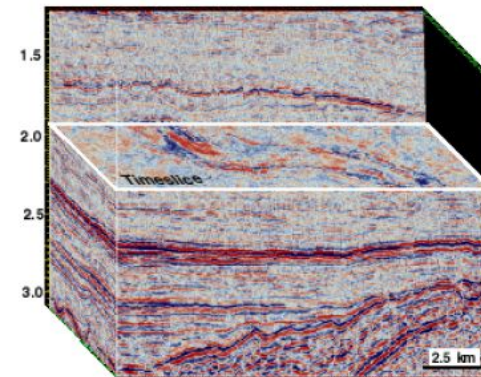


3D surveys

Collect data on a grid rather than along a line



Produces a data cube rather than a line



Кинематические поправки.

The reflection traveltime equation predicts a hyperbolic shape to reflections in a CMP gather. The hyperbolae become fatter/flatter with increasing velocity

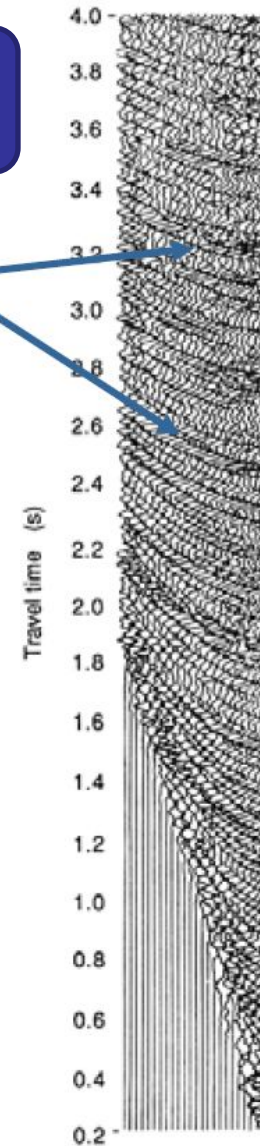
$$T_x^2 = T_0^2 + \frac{x^2}{V_1^2}$$

We want to subtract the NMO correction from the common depth point gather

$$\Delta T_{NMO} \approx \frac{x^2}{2T_0 V_1^2}$$

But for that we need velocity...

reflection hyperbolae become fatter with depth (i.e. velocity)



Годограф отраженной волны для слоистой среды.

Когда расстановка приборов короткая то годограф отраженной волны все еще является гиперболой.

$$T^2 = T_{0,n}^2 + \frac{x^2}{\bar{V}_{rms,n}^2}$$

where

$$T_{0,n} = \sum_{k=1}^n T_{0,k} = \sum_{k=1}^n \frac{2h_k}{V_k}$$

$$\bar{V}_{rms,n}^2 = \frac{\sum_{k=1}^n V_k^2 T_k}{\sum_{k=1}^n T_k}$$

Determine velocity structure one layer at a time

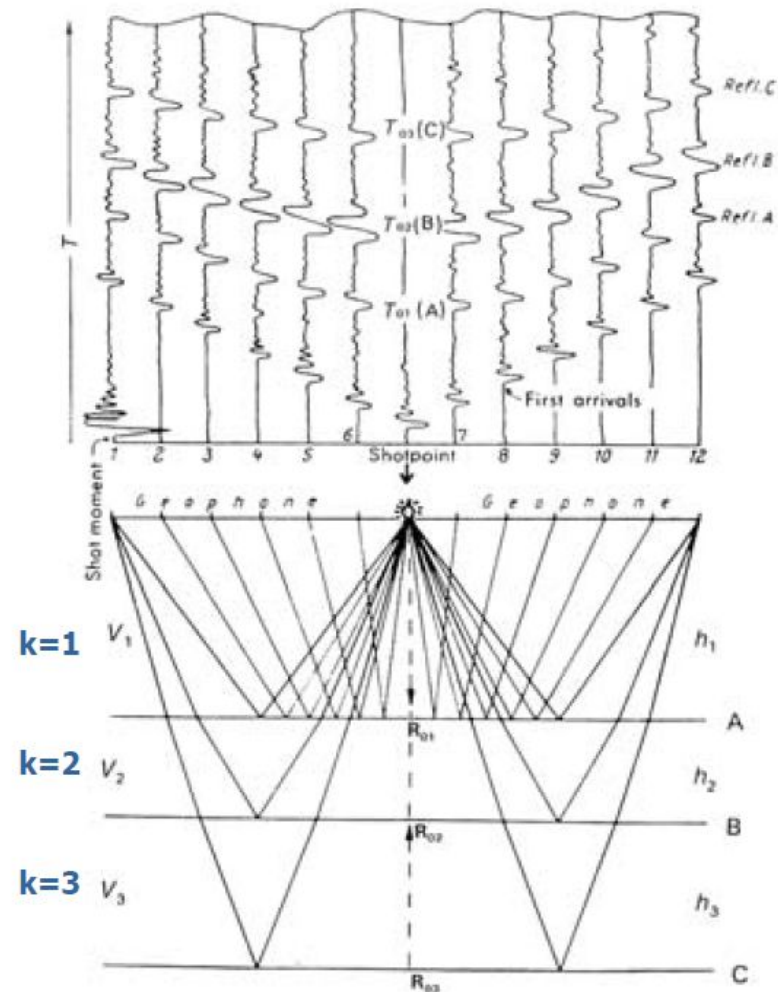


Fig. 4.14 Schematic diagram showing the production of a reflection seismogram. The 12-trace record shows the time sequence of the reflected pulses from reflecting horizons, A, B, and C. T_{01} , T_{02} , and T_{03} are the two-way vertical travel-times from points R_{01} , R_{02} , and R_{03} respectively, below the shotpoint. The significance of first arrivals is discussed in Section 4.4.5.