TPG4190 Seismic data acquisition and processing
Lecture 3: The CMP method

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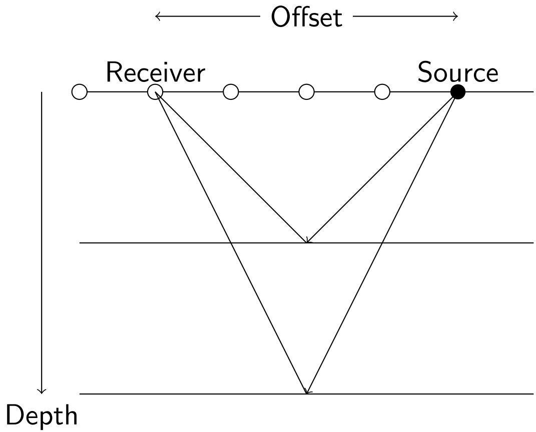
Overview

- Seismic data acquisition
- CMP method 2D
- CMP method 3D
- NMO and stack
- Wide azimuth

Seismic marine data acquisition



Schematic shot record

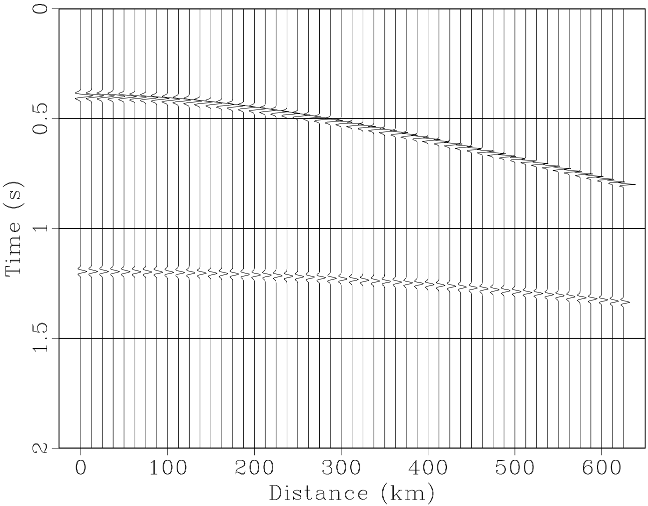


Figure: Schematic shot

Real shot record

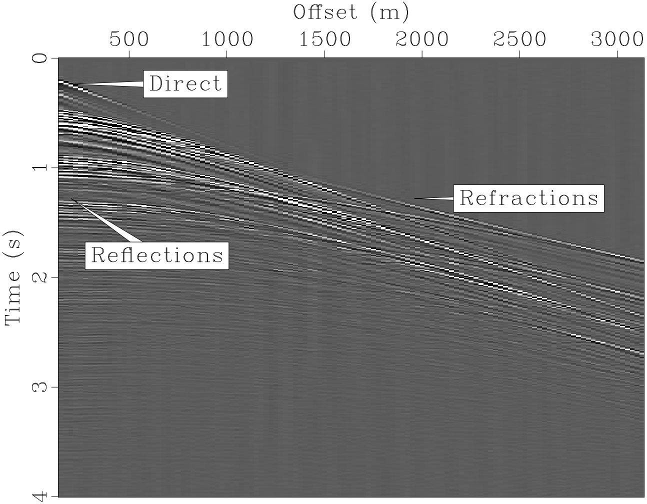
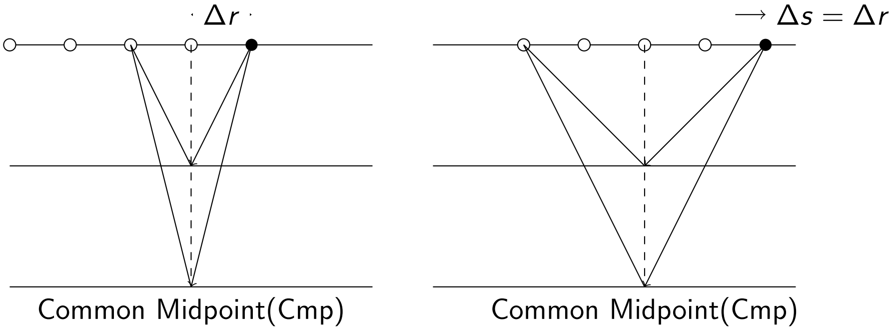
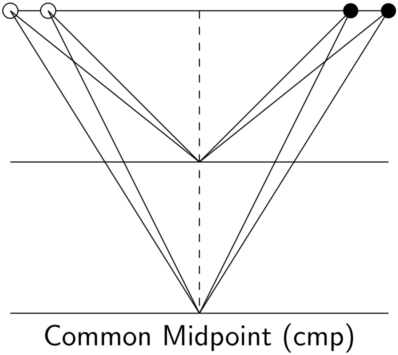


Figure: Real shot

The cmp method



Common midpoint (cmp) gather



Midpoint and Offset Coordinates

$$
\begin{aligned}
x_m &= \frac{s+r}{2}, \qquad (1)\\
h &= \frac{s-r}{2}, \qquad (2)
\end{aligned}
$$

- x_m: Midpoint coordinate
- h: Offset
- s: Source coordinate
- r: Receiver coordinate

Midpoint and Offset Coordinates

Assume that we change the source and receiver coordinates a small amount δs and δr. The corresponding change in x_m and h are:

$$\begin{aligned} \delta x_m &= \frac{1}{2}(\delta s + \delta r), && (3) \\ \delta h &= \frac{1}{2}(\delta s - \delta r). && (4) \end{aligned}$$

If we consider a single cmp then $\delta x_m = 0$

$$\begin{aligned} 0 &= \frac{1}{2}(\delta s + \delta r), && (5) \\ & && (6) \end{aligned}$$

which implies

$$\delta s = -\delta r \qquad (7)$$

Midpoint and Offset Coordinates

Inserting equation (7) into equation (4) I get

$$\delta h = \delta s = \delta r \tag{8}$$

We can now deduce the number of traces in each cmp, or the fold. The largest (half offset) is equal to

$$h_{max} = \frac{N_r}{2} \Delta r \tag{9}$$

where

- Δr : Distance between receiver groups
- N_r : Number of receivers

The fold N_f is then

$$N_f = \frac{h_{max}}{\delta h} = \frac{N_r}{2} \frac{\Delta r}{\delta s} \tag{10}$$

Midpoint and Offset Coordinates

It remains to specify δs. The simplest assumption we can make is that $\delta s = \Delta s$, where Δs is the distance between shots. The final expression for the fold N_f is then

$$N_f = \frac{h_{max}}{\delta h} = \frac{N_r}{2}\frac{\Delta r}{\Delta s} \tag{11}$$

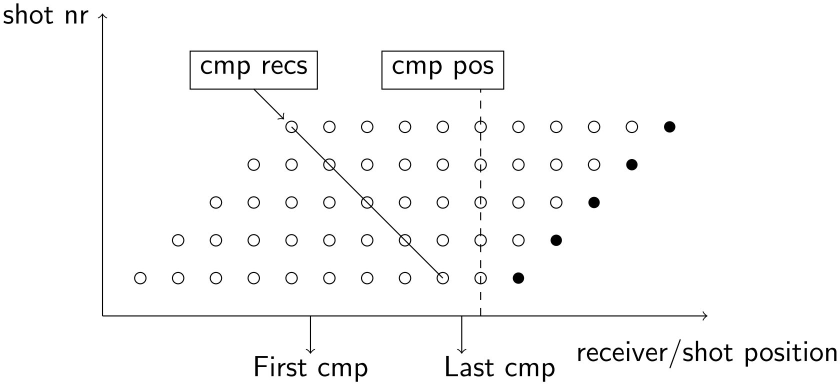
We can also figure out the distance between consecutive cmp's if we assume that the change in δr is equal to the receiver group spacing Δr and that $\Delta r < \Delta s$ and use equation (3)

$$\delta x_m = \frac{1}{2}\Delta r \tag{12}$$

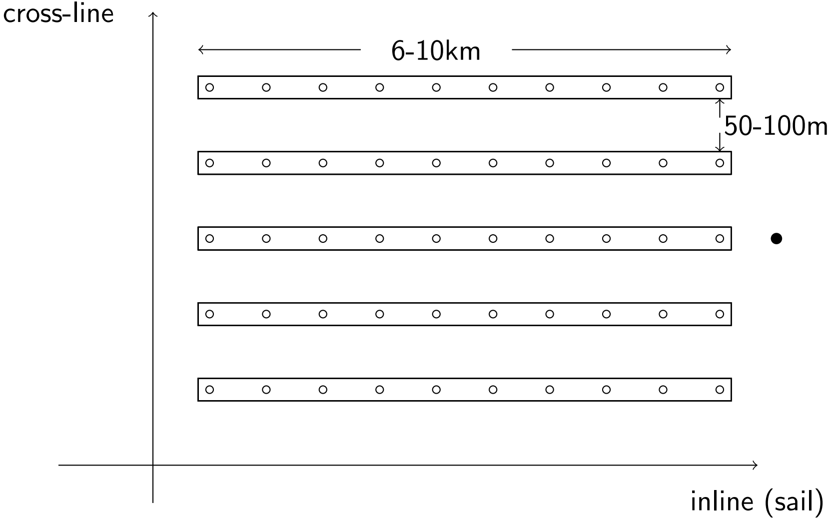
Midpoint and Offset Coordinates

Example:

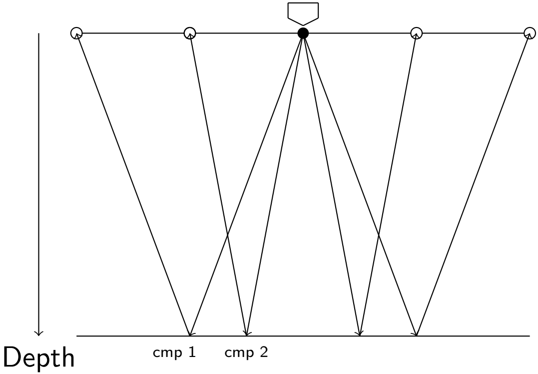
- No of receivers: 10
- No of shots: 5
- $\Delta r = \Delta s = 25.0$m
- Δx_m =12.5m, $N_f = 10/2 = 5$



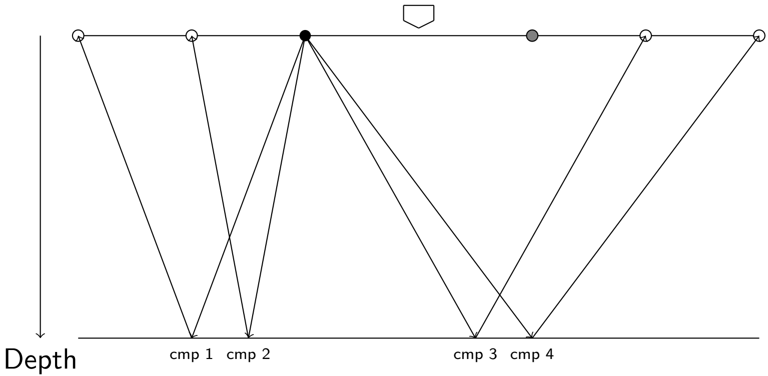
Aqcuisition geometry 3D



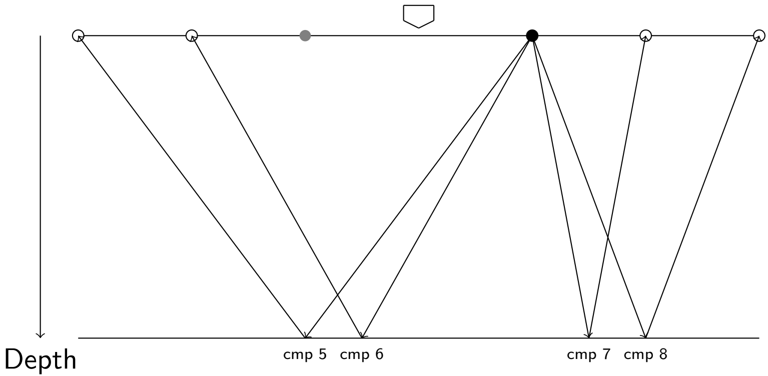
3D Seismic marine data acquisition single source



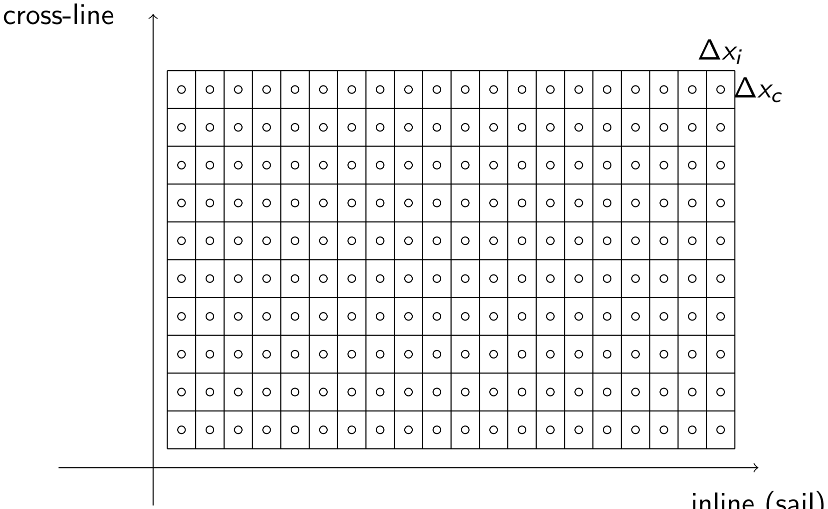
3D Seismic marine data acquisition flip-flop (left)



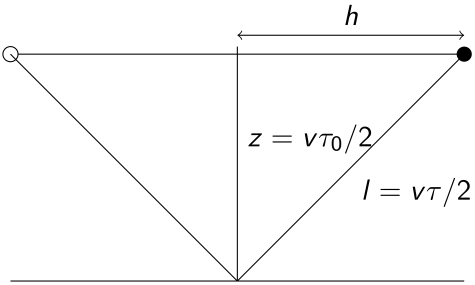
3D Seismic marine data acquisition flip-flop (right)



3D Binning



NMO and Stack



The traveltime $\tau(h)$ is:

$$l^2 = z^2 + h^2 \tag{13}$$

which gives by inserting $v\tau/2$ for l and $v\tau_0/2$ for z

$$\tau(h) = \sqrt{\tau_0^2 + 4h^2/v^2}. \tag{14}$$

NMO and Stack

Nmo-correction:

$$\Delta\tau = \tau(h) - \tau_0, \tag{15}$$

Cmp

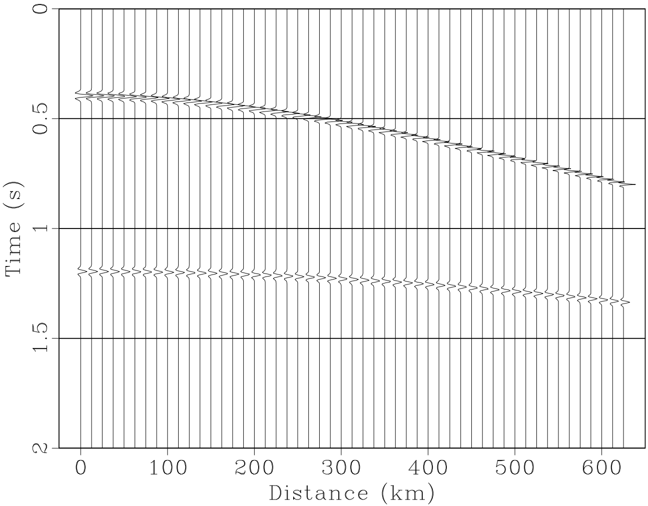


Figure:

Nmo

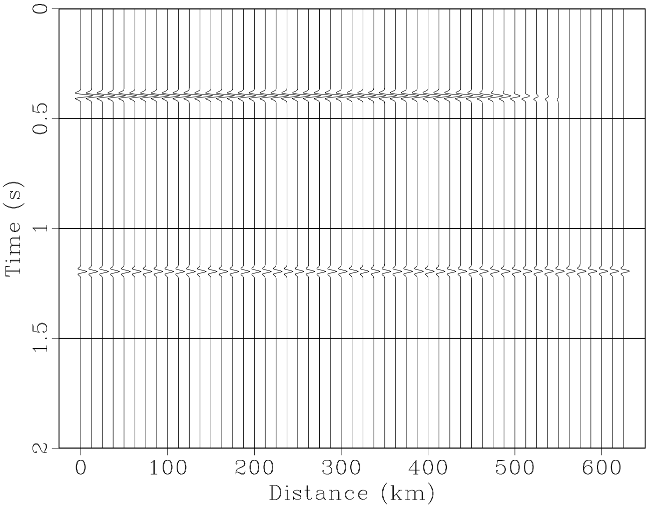
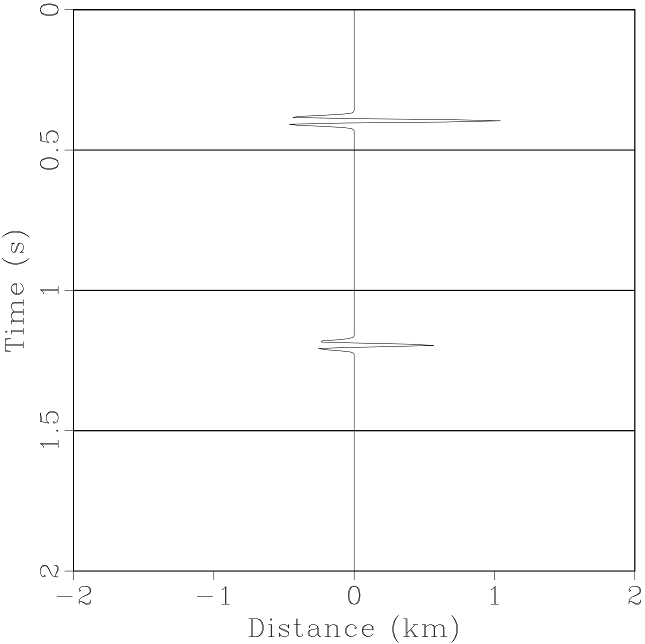


Figure: Synthetic cmp

Stack



NMO and Stack

Average velocity v_{rms} defined by

$$v_{rms}^2(t_0) = \frac{1}{t_0} \int_0^{t_0} v^2(t) dt \tag{16}$$

$v(t)$: Interval velocity. The traveltime equation (14) then becomes

$$\tau(h) = \sqrt{t_0^2 + 4h^2/v_{rms}^2(t_0)}. \tag{17}$$

Real cmp

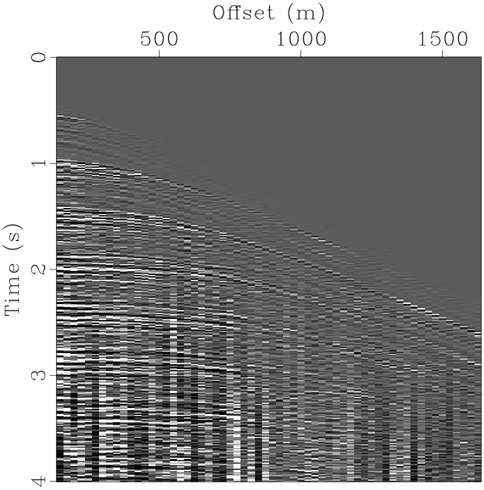


Figure: Real cmp

Real stack

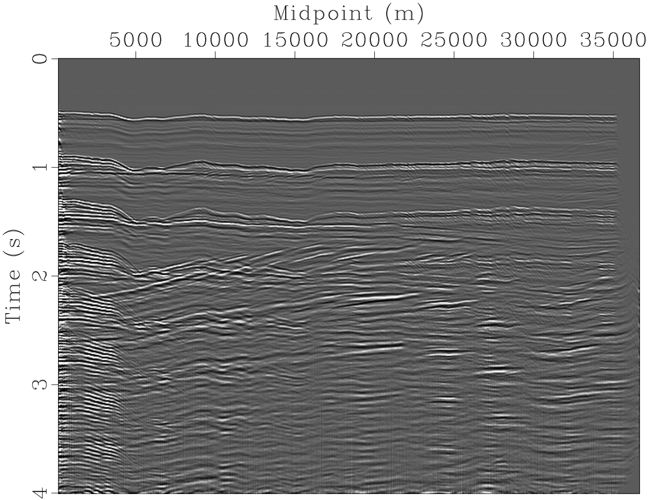


Figure: Real stack

Wide azimuth

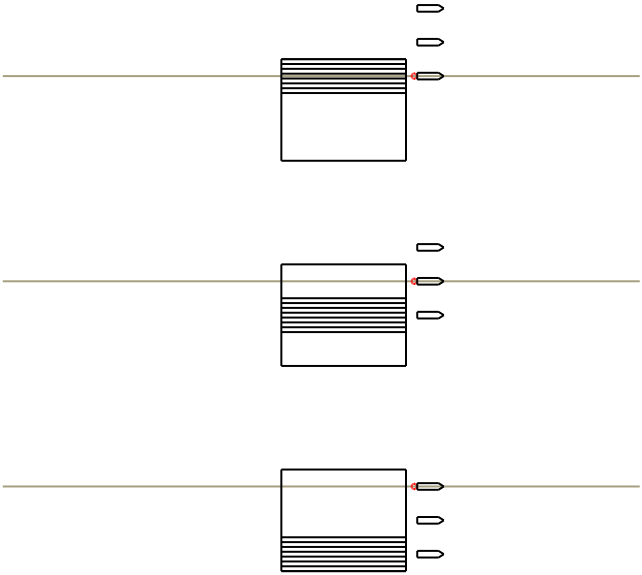


Figure: Real stack

Wide azimuth

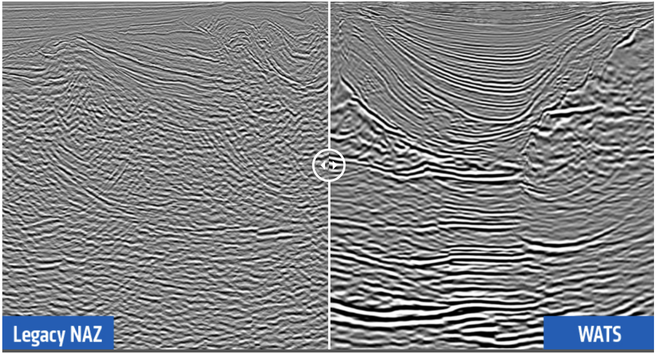


Figure: Real stack

Source: https://www.pgs.com/publications/feature-stories/why-more-azimuths-is-a-good-thing/