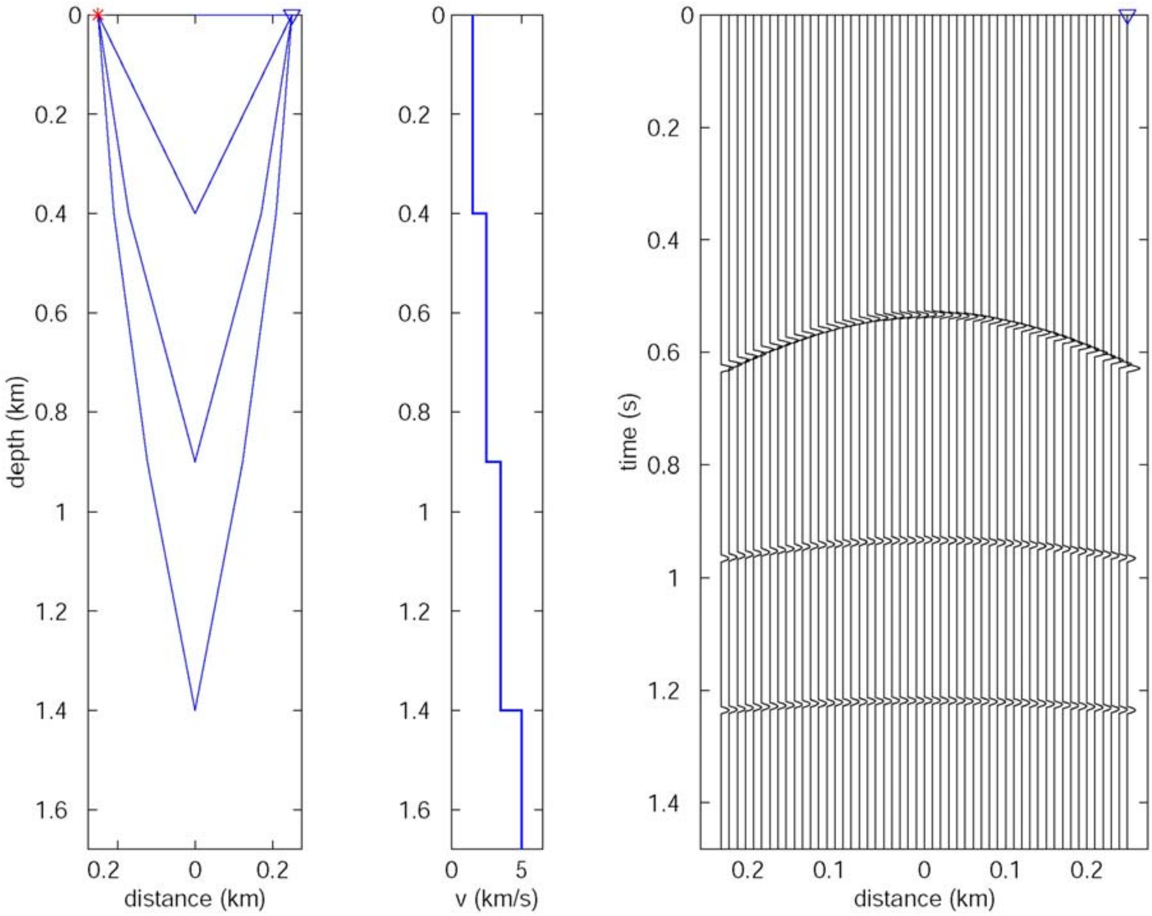
C2.5 Common mid-point profiling

- The shot gather has the disadvantage that each ray has been reflected from a different point on the interface. If there are lateral variations in structure, this will result in errors.

- This can be overcome by using multiple shot points and multiple receivers. From the total dataset, a set of rays are then chosen that have a common reflection point.

- This technique is called both common-mid point (CMP) or common depth point (CDP) profiling. The shot and receiver are located equal distances from the CMP.

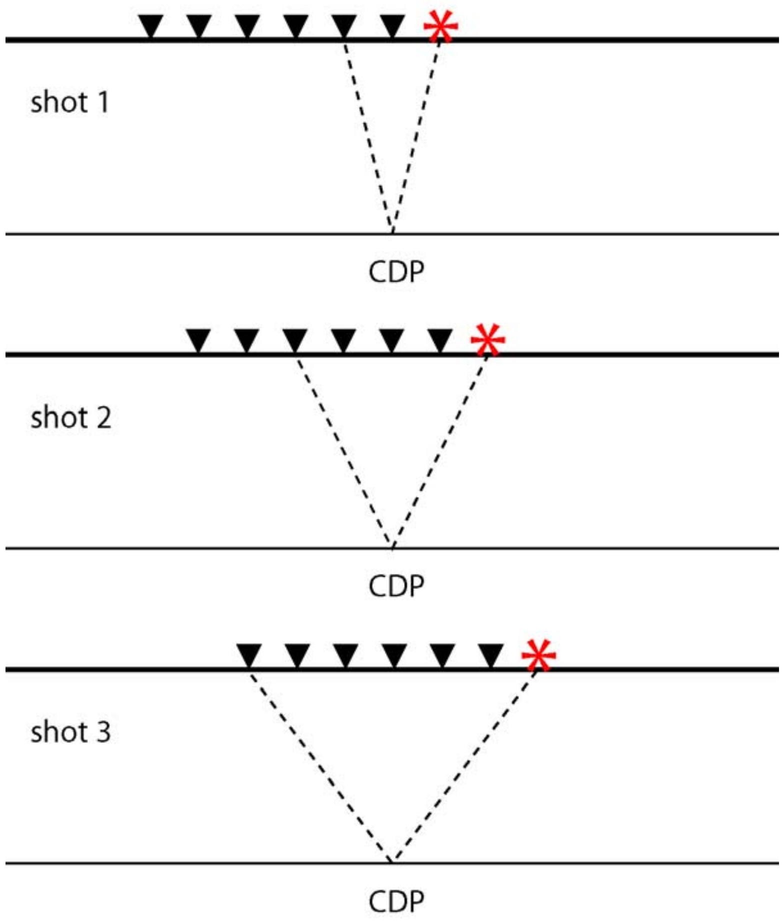
Simple example of a CMP gather



Matlab script **cmp_v1.m** shows the path geometry for a CMP gather.

- Note that the offset is the distance from shot (*) to receiver (v). Thus with geophones from –200 m to + 200 m, the maximum offset between shot and receiver is 400 m.

- The parabolic travel time curve derived for the shot gather can also be used to analyse a CMP gather.



- The technique for collecting CMP data is illustrated above. A seismic source is located at the front of a 6-channel array.
- The spacing of geophones is Δx along the entire array.
- After each shot is fired, the array is moved forward a distance $n\Delta x$.
- In a marine survey this would consist of the whole airgun and hydrophone streamer being towed forward by the survey ship. On land the last geophone would be brought up to the front of the array, a new hole drilled, loaded with explosives and fired.
- If we have N geophones and that array moves a distance $n\ \Delta x$ between shots, then you can show that the number of rays that share the same common mid-points = $N/2n$. This quantity is also called the fold or the coverage (in percent).
- This survey will give 3 rays for each mid-point. This is called **3-fold CMP coverage** or 300% coverage.
- Kearey Figure 4.14 show an example with **6-fold CMP coverage**.

Stacking

- Once we have collected a number of rays that share the same mid-point, we can use **stacking** to improve signal to noise ratio in the data. This is needed because reflections are generally weak. Remember that stacking adds a number of traces. If the signal is the same in each, but the (random) noise is different, then the noise will cancel and the signal be enhanced.

- Prior to stacking, the individual traces must be shifted vertically (i.e. in time) to allow the reflection to occur at the same time.

- Traces at non-zero offset are shifted in time to be equivalent to the zero offset trace.

- This requires that we compute the expected NMO for a given reflection and offset. However we don't know the velocity (this is the goal of the survey!) so a trial and error approach is used.

- This is illustrated in **cmp_v2.m**. If the stacking velocity is too high, then the curve remains a downward parabola. If the stacking velocity is too low, then the curve is an upwards parabola.

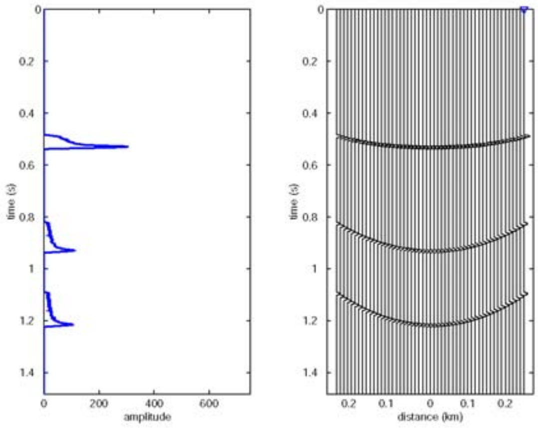
- Each reflection is analysed and the stacking velocity systematically varied. The velocity that gives the best stack (flattest reflection) is then taken to be the r.m.s. velocity from the surface to the reflector. This is equivalent to plotting NMO as a function of x^2.

- A different velocity will be needed for each reflector.

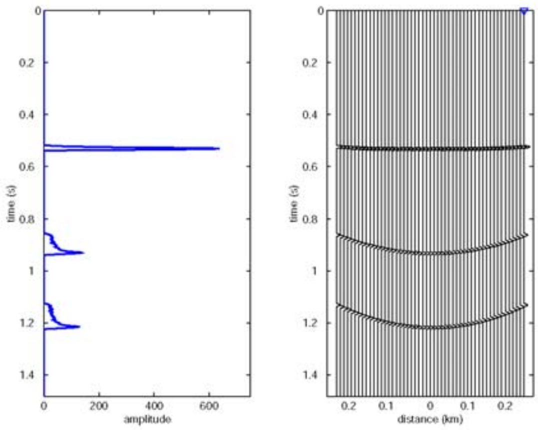
- Note that the direct wave and ground roll do not stack coherently, and this process tends to remove them from the data.

C2.5 Common mid-point gather : stacking to improve signal-to-noise ratio

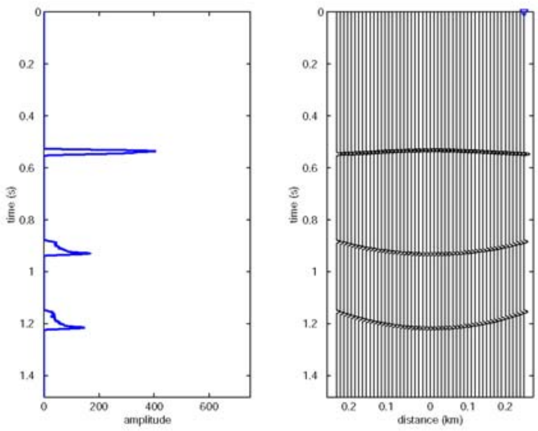
Reflection 1
NMO corrected with v = 1300 m/s



Reflection 1
NMO corrected with v = 1500 m/s



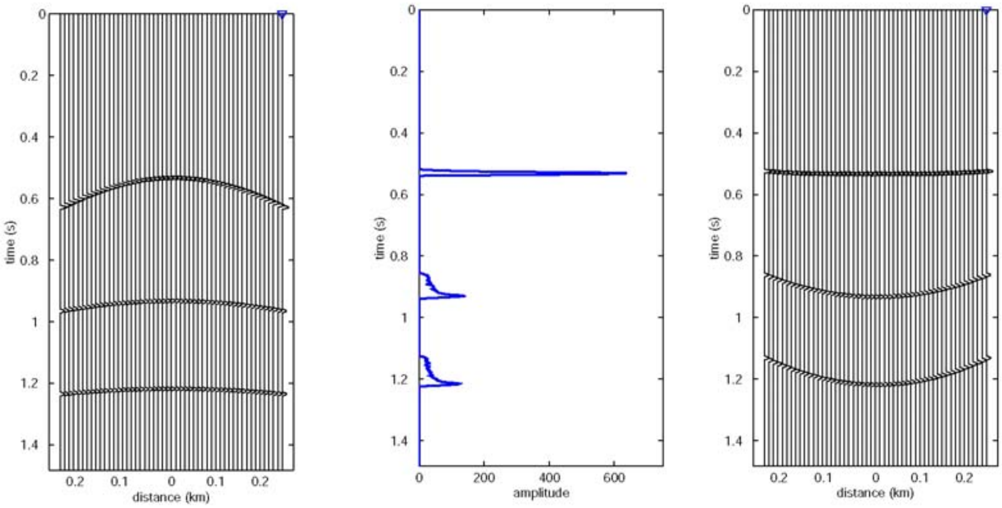
Reflection 1
NMO corrected with v = 1700 m/s



C2.5 Common mid-point gather : stacking to improve signal-to-noise ratio

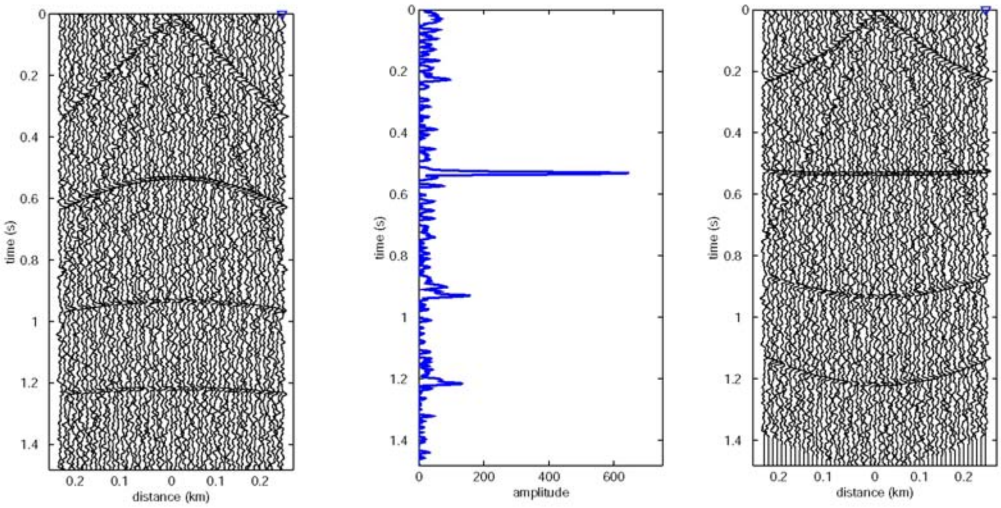
CMP gather
No noise in data

Reflection 1
NMO corrected with v = 1500 m/s



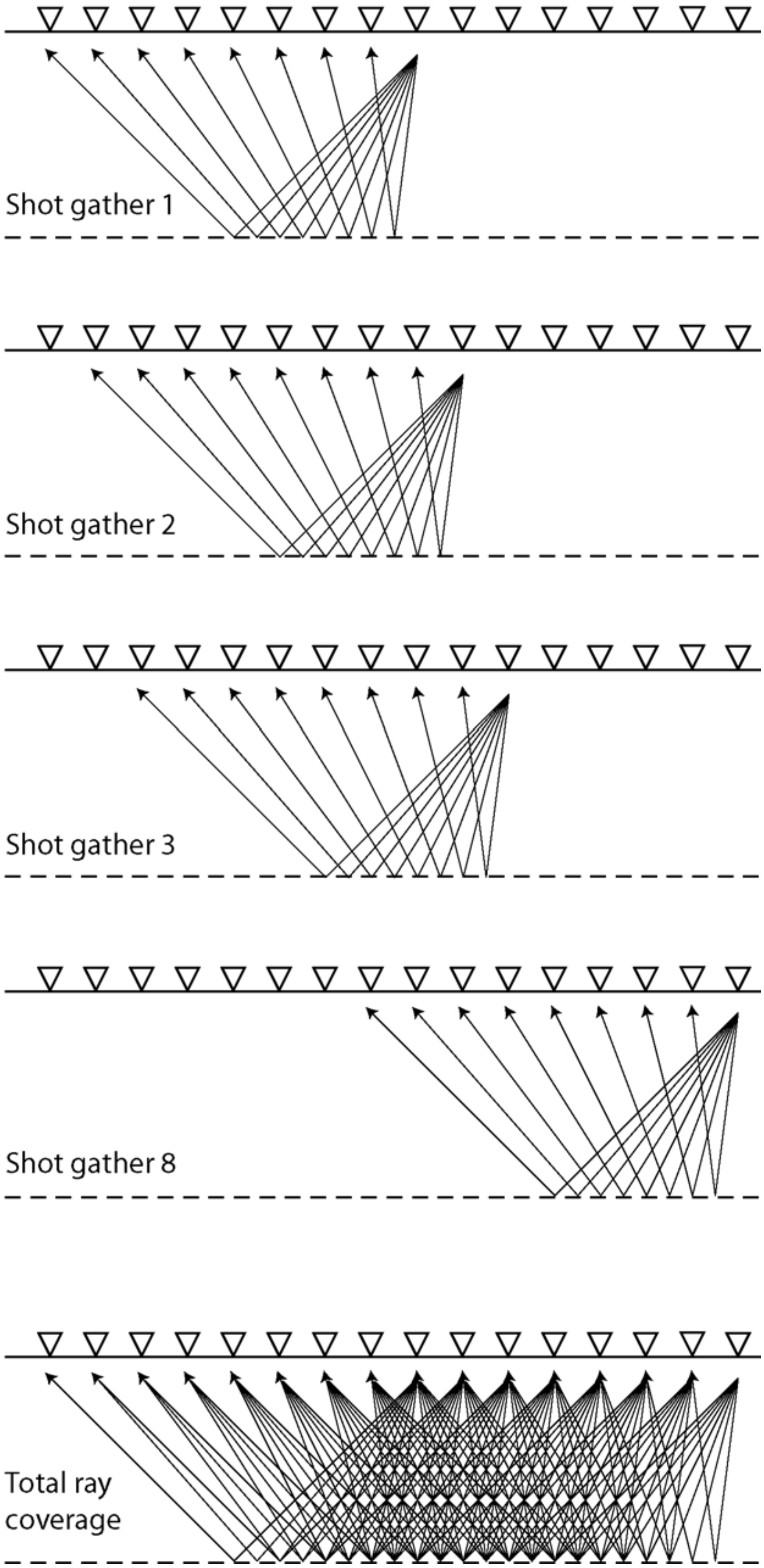
CMP gather
Gaussian noise in data

Reflection 1
NMO corrected with v = 1500 m/s



C2.5 Common mid-point profiling

(a) Data recorded in shot gathers (marine data)



C2.5 Common mid-point profiling

(b) Data sorted into common mid-point gathers
Velocity analysis, apply NMO corrections
Stack to get zero offset trace (4-fold)
Combine into seismic section