# Survey geometry

## Multichannel data collection

First consider the source-receiver geometry. The geometry can be "split spread" in which case there is a central shot with receivers on both sides, or a "single-ended spread" in which the receivers are always on one side of the source. Split spreads are common in land surveys; single-ended spreads are common in marine surveys.

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| ./images/split\_and\_single\_spread.gif |

Shot-detector configurations used in multichannel seismic reflection profiling .(a) Split spread, or straddle spread. (b) Single-ended spread [[1]](#footnote-21)

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| ./images/shot\_gather\_split\_spread.gif |

A split spread seismic record is shown above. The seismic traces all belong to a single source and hence this is referred to as a "Common Source Gather". The first arrivals are direct or critically refracted arrivals. Reflection hyperbolae from numerous boundaries are observed, right. The strong energy in the triangular central portion is ground roll caused by surface waves. It masks the reflection events.

## Common MidPoints (CMP)

Multiple shots and receivers are used in seismic profiling specifically so that some subsurface points are sampled more than once. Ultimately the goal is to identify all the reflections due to that point on the various seismograms and stack these to get an enhanced signal to noise ratio. The idea is illustrated on the upper figure.

The collection of seismic traces that correspond to a particular midpoint is called a Common Midpoint (CMP) gather. In older literature, this collection of traces was referred to as a Common Depth Point (CDP) gather. That is not strictly correct, as the bottom diagram illustrates.

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| ./images/common\_reflection\_pt1.gif |

A series of six shots and associated receivers that would have reflections from a common point. When the layers are plane and horizontal then this common reflection point lies midway between the source and receiver

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| ./images/common\_reflection\_pt2.gif |

Common depth point (CDP) reflection profiling.[[2]](#footnote-23) (a) A set of rays from different shots to detectors are reflected off a common point on a horizontal reflector. (b) The common depth point is not achieved in the case of a dipping reflector.

## Refraction surveys

Seismic refraction is most useful when the velocity of seismic signals in each layer increases with depth. Therefore, where higher velocity (e.g. clay) layers may overlie lower velocity (e.g. sand or gravel) layers, seismic refraction may yield incorrect results. In addition, seismic refraction requires geophone arrays with lengths of approximately 4 to 5 times the depth to the layer of interest (for example the top of bedrock). Therefore seismic refraction is commonly limited to mapping layers to depths less than 30-50 meters. Greater depths are possible, but the required array lengths may exceed site dimensions, and the shot energy required to transmit seismic arrivals for the required distances may necessitate the use of large explosive charges.

## Reflection surveys

By contrast, reflection surveys are not hampered by low velocity layers but they have difficulty imaging the top 50m of the earth because reflections from such shallow depth are difficult to distinguish from direct arrivals and sound waves travelling through the air. In general, identifying a reflection event in a seismic record is more difficult than picking first arrivals for a refraction survey. Much signal processing is typically involved. In order to improve the ability to detect and image a given reflection event geophysicists typically design reflection surveys to detect a reflection from a particular point in the subsurface multiple times.

## Fold

The fold refers to the number of times a particular subsurface point has been sampled. It is equal to the number of traces in the CMP gather and is numerically evaluated by

where is the moveup rate in units of geophone spacing. "Moveup rate" is in fact (shot spacing)/(geophone spacing). For example, if geophones are 2 meters apart and shots are employed every 4 meters, then the moveup rate is n=4/2=2. This can be less than one if there are shots set more often than geophone spacing, a practice that is sometimes done in marine seismology, especially ocean bottom profiling.

The schematic below shows a single ended spread with 8 geophones and moveup rate of n=2.

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| ./images/fold.gif |

We see that each point in the subsurface is sampled only twice. Notice that the distance between the reflection points in the subsurface is half the geophone spacing.

1. From Kearey, Philip and Micheal Brooks, '\*An Introduction to Geophysical Exploration\*'. 2nd ed. Blackwell Science: 1991. [↑](#footnote-ref-21)
2. From Kearey, Philip and Micheal Brooks, '\*An Introduction to Geophysical Exploration\*'. 2nd ed. Blackwell Science: 1991. [↑](#footnote-ref-23)