Lessons in Spatial Sampling
Or . . . "Does Anybody Know the Shape of a Wavefield?"

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Summary
In a homogeneous, isotropic, infinite half space (remember those regimes from Geophysics 101?) a propagating wavefield from a simple impulsive source will be spherical. If we introduce velocity gradients or layers, the wavefield becomes elliptical. Further perturbations of the subsurface create additional complexities in the shape of a wavefield. Our job as exploration geophysicists is to observe those complexities when and where portions of the wavefield return to the earth's surface. From these observations we attempt to infer what subsurface geologic features may exist that caused the irregularities. In a realistic setting, this is a formidable task.

Figure 1 An example of remote sensing (from cover of "PinPressions" toy)*(This stunt performed by an expert - DON"T TRY THIS AT HOME.)*

Imagine a wavefield has propagated to a reflector. As it encounters the structures on that reflector, the shape of the wavefield will adopt the shape of the structures. That shape remains with the wavefield as it returns to the surface where we measure it. The wavefield at the surface is the net result of all distortions introduced to the wavefield during its travels in the subsurface.

The topic of spatial sampling addresses the requirements for discretely sampling a wavefield in order to preserve sufficient information to resolve features of importance to us. This means we must sample our data appropriately, not just in the common source domain, but also in the receiver, offset and CDP domains.

Note in figure 2 that a 2D seismic line recorded with 20-meter group intervals does not necessarily result in CDP's with 20 meter sampling of offset. Noise not properly sampled will not behave the way we might think. If 2D programs present such problems, imagine the complexity due to irregular offset sampling in 3D programs.

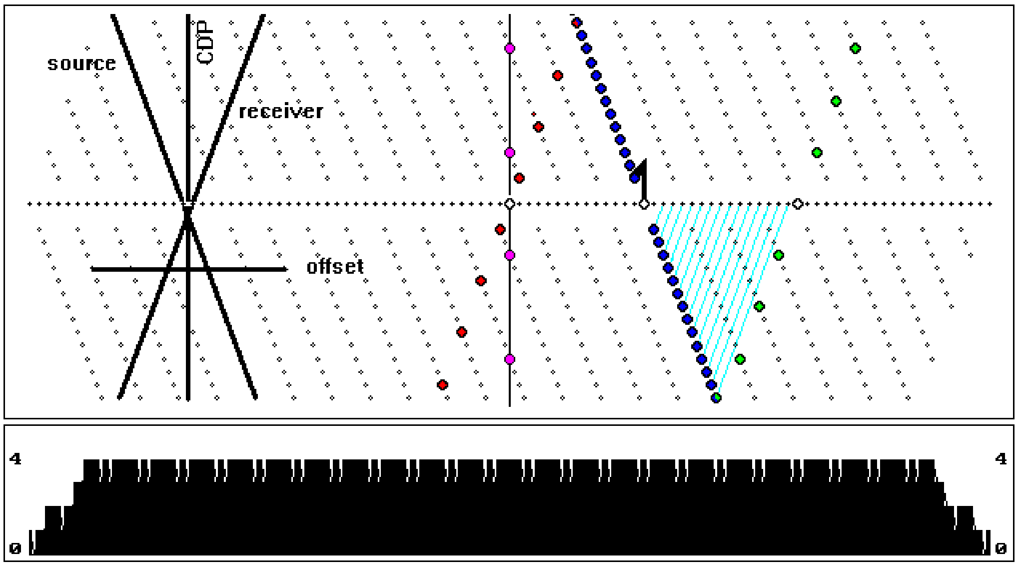

Figure 2 A portion of a 2D stacking chart for a line with a receiver interval of 20 meters and a source interval of 80 meters. The sources were located coincident with receiver points

Note that each shot record will sample receivers every 20 meters. However, each receiver gather will only sample a shot every 80 meters and each CDP only samples recorded traces every 160 meters.

Spatial resolution is integrally tied to temporal (or vertical) resolution. Figure 3 demonstrates this concept. The left column of figures represents data sampled at just 20 Hz for three different spatial sample intervals. Sampling at 10 m and 20 m intervals provides adequate imaging, but the 40 m version is aliased (note the "checkerboard" pattern and the ambiguity as to dip direction). The right column represents data sampled at 40 Hz for the same spatial sample intervals. Note that aliasing now begins at 20 m sampling and the 40 m version is 100 percent aliased (dips now appear flat).

Events that may be appropriately sampled in space for one bandwidth of data may not be sufficiently sampled in space for higher frequencies. Required spatial sampling is determined by wavefield complexity as well as expected imaging bandwidth. Both parameters must be carefully and realistically considered.