[GC]Acquisition Footprint*

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General Statement

Any 3-D seismic survey can have an acquisition footprint. Our problem is to determine whether we have one -- and if so, whether we can recognize it, how severe it is and, most importantly, what we can do about it.

What is an acquisition footprint? It is an expression of the surface geometry (most common on land data) that leaves an imprint on the stack of our 3-D seismic data. Often we recognize it as amplitude and phase variations on time slices, which of course display the amplitudes within our data set at a specified two-way time. More seriously, on horizon slices, footprint can interfere with and confuse stratigraphic patterns.

Many different contributions to the generation of acquisition footprint are possible:

These can be divided into two main categories of geometry effects and non-geometry effects.

Geometry Effects

- Line spacings.
- Fold variations.
- Wide vs. narrow patch geometry.
- Source generated noise.

Non-geometry Effects

- Topography.
- Culture.
- Weather.
- Surface conditions.
- Processing artifacts.

Geometry Effects

Most of the time the acquisition footprint is based on source and receiver line spacings and orientations; the larger the line spacing, the more severe the footprint. In land situations where access is very open and, therefore, the lines are very regularly spaced, we may be able to recognize the footprint very clearly. Because the geometry is regular, the footprint also will have the same periodicity.

Fold variations themselves are the simplest form of an acquisition footprint. Fold changes with offset (or rather mute distance from the source point); each offset range, therefore, has differing fold contributions.

Because each individual bin of a 3-D survey has changing offset distributions, the CMP stack of all traces in a bin will display bin-to-bin amplitude variations. This variation in itself can produce an acquisition footprint (Figure 1).

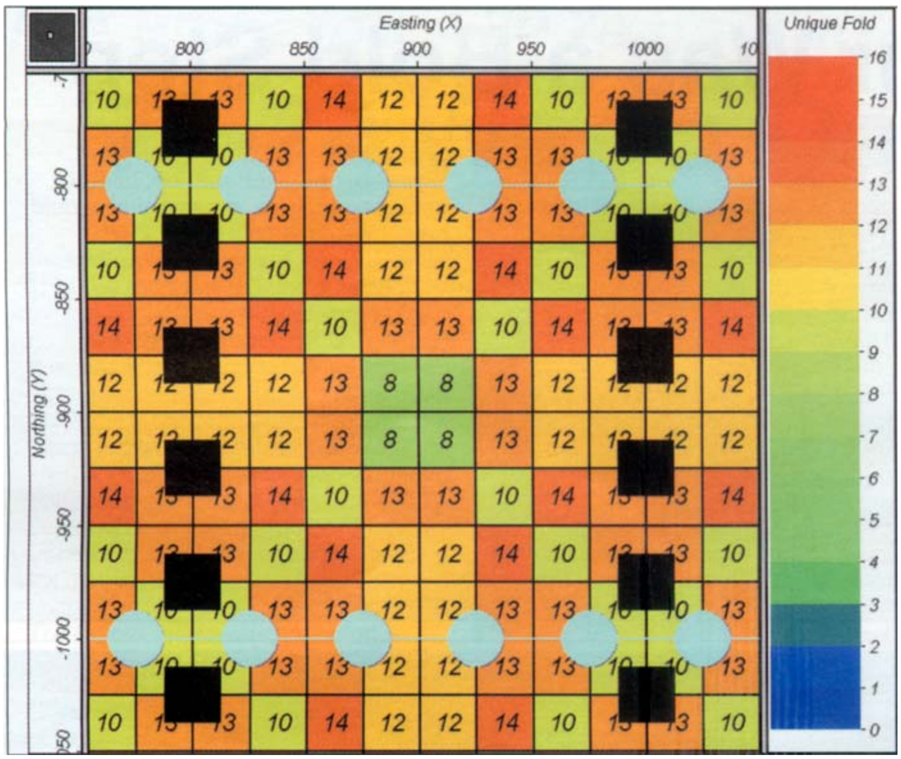

Figure 1. Unique fold variations for a box area bounded by two blue receiver lines and two black source lines.

Some processors compensate for this with simple trace borrowing from surrounding bins to fill in the missing offsets and to provide smooth offset distributions in all bins. Although this may be successful in reducing the footprint, it also may reduce the resolution by degrading the high frequency content.

Generally it has been thought that acquisition footprint is far worse in the shallow part of the seismic -- and therefore, of course, the geological -- section, mainly because the fold is lower, and amplitude variations necessarily are far more dramatic. Offset limited fold variations alone may produce a recognizable footprint. The higher the fold, the better the signal-to-noise ratio; therefore, less footprint is evident.

Wide recording patch geometries are far more accepted these days than narrow patch geometries. The reasons are numerous and range from reduction in acquisition footprint (particularly that due to back-scattered shot noise) to improved statics solutions and the availability of large channel capacities on seismic recording crews (also leading to higher fold).

In addition to the impact of the fold variations, acquisition footprints are made worse by source-generated noise trains that penetrate our data sets (Figure 2). The lower the signal-to-noise ratio is, the worse the footprint will be.

Unfortunately, the noise typically has a low frequency content that is much less affected by attenuation. Therefore, the noise becomes more prominent relative to the signal content deeper in the section. Our experiences have shown that acquisition footprint problems can be just as prevalent in the deep section as they are in the shallower section.

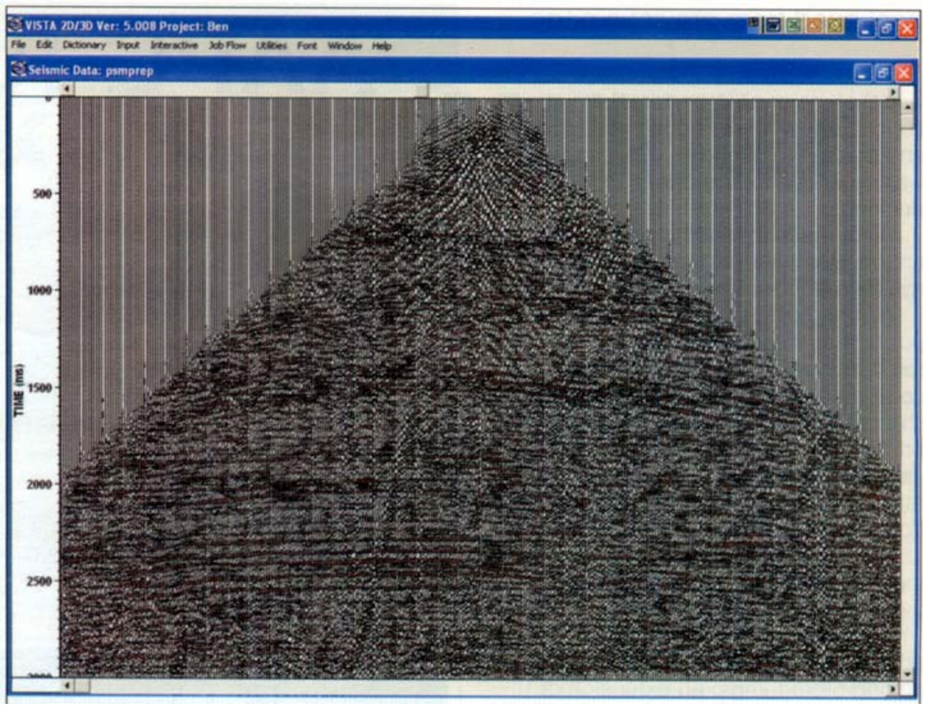

Figure 2. A shot record with NMO Correction. Different shot noise trains can easily be observed.

Non-Geometry Effects

If surface access is poor because of topography variations, tree cover, towns, etc., we irregularize the geometry by moving source points to locations of easier access, and, therefore mask the acquisition footprint. It is still present, however. The footprint is just so much harder to identify.

Weather and surface conditions may also impact the recorded amplitudes. A swamp in the middle of a 3-D survey can have a significant impact on the amplitude of a stack volume. The interpreter reviewing the 3-D volume has to decide what is a geological anomaly and what is acquisition footprint. Not always an easy task!

Modeling

We can model an acquisition footprint by creating a stack response on either synthetic or real data. Starting out with a geological model of the subsurface, any source-generated noise can and should be included if the noise velocities and frequencies are well known.

We stack the data in a 3-D cube (Figure 3) and display the resulting seismic data over a small time window; e.g., 60 ms (Figure 4, depending on the frequency of the data). This process can be repeated using real seismic data as an input. The best input is a single NMO and static-corrected, offset-sorted 2-D (or 3-D) CMP gather. These traces will be applied to each CMP bin in the recording geometry.

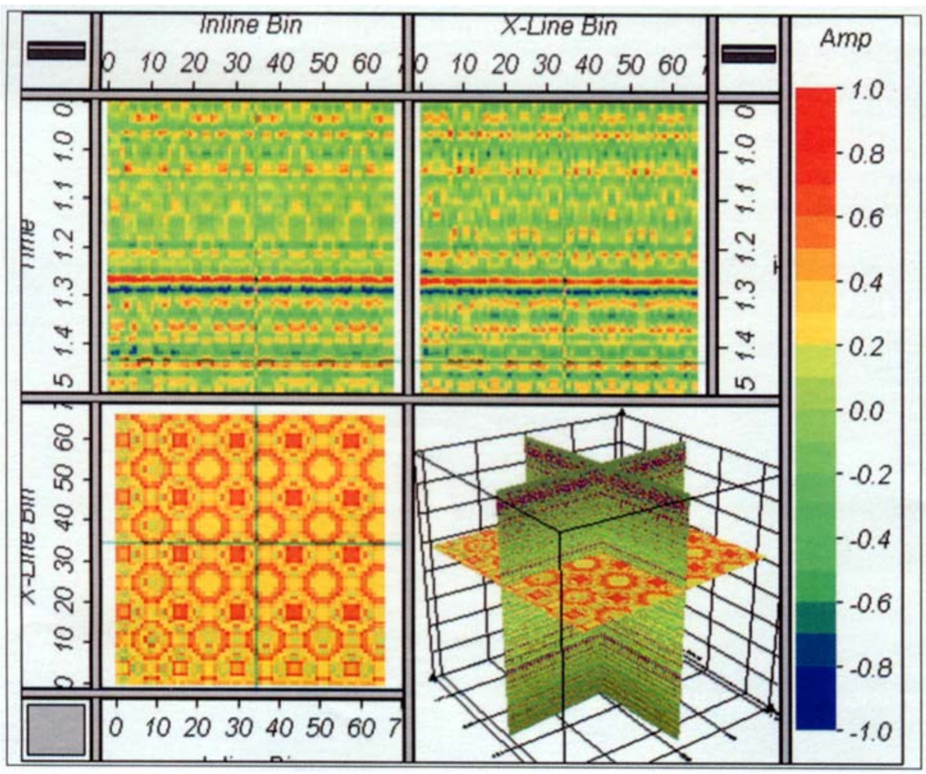

Figure 3. 3-D seismic cube with separate inline, crossline and time slice displays, showing variations in amplitudes caused by acquisition footprint.

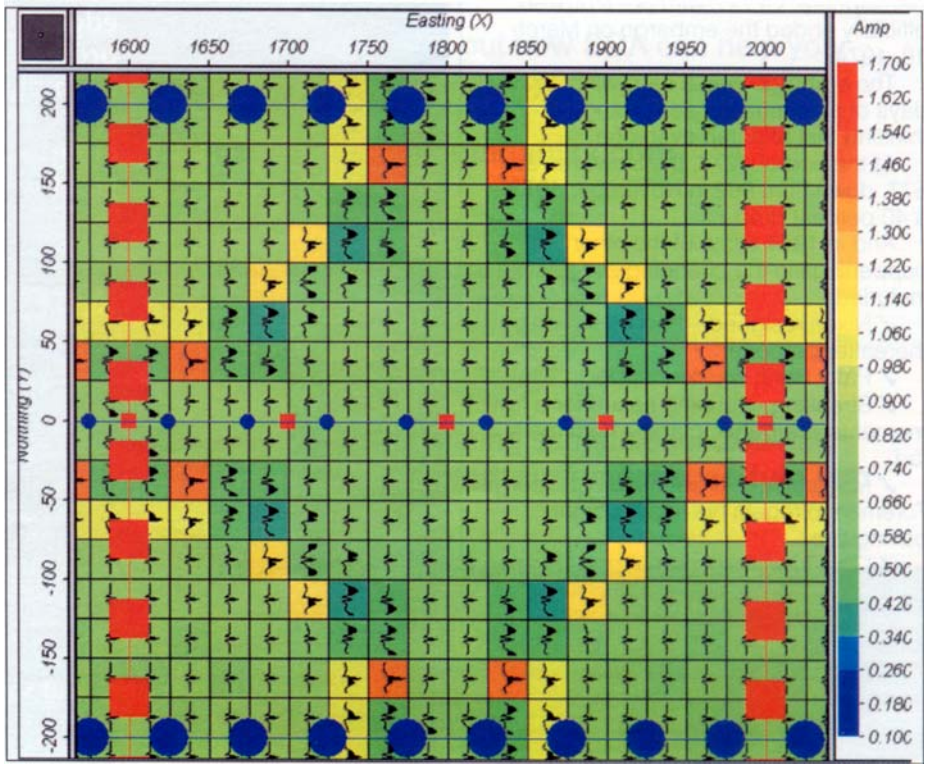

Figure 4. Amplitude at 1100m offset (1.0 sec time slice, 60ms window).

The correct offsets for each bin are then stacked in that bin to create NMO-corrected CMP gathers and the time interval of interest studied. This process is repeated for any acquisition geometry under consideration for the recording of the seismic data. The geometry with the least variation in this modeled stack response (acquisition footprint) should be chosen.

Processing artifacts also can leave an imprint on stacked seismic data, for example, by applying wrong NMO velocities. Choosing incorrect velocities will leave remnant moveout on the horizons that should have been stacked as flat data. This affects the primaries as well as multiples and source-generated noise; now possibly all of them leave undesirable amplitude and phase distortions in our data.

Conclusions

Interpreters have lived with footprint since the advent of 3-D. In order to advance our interpretations further, we need to understand and recognize footprint, and make every effort to distinguish it from geology.

Acquisition footprint has many different sources. It should be minimized as much as possible, preferably at the recording stage. Therefore, one should always model the acquisition footprint for different recording geometries under consideration.

Generally, wider acquisition patches are better. Increasing the fold will help reduce the footprint. Moving source points (and receiver stations) in the field produces an irregular acquisition geometry, and, therefore, the footprint may not be as severe.

Removal of an acquisition footprint is possible to some degree in the sophisticated seismic data processing centers, but is not performed on a routine basis.