

# **GC** Footprints in Seismic Data\*

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## **General Statement**

The term “acquisition footprint” is often used to describe amplitude stripes that appear in time slices or horizon slices produced from 3-D seismic data volumes. Although acquisition design of a 3-D survey has a major influence on the nature and severity of a footprint, improper data processing techniques – such as the use of incorrect normal moveout (NMO) velocities – can also create footprints.

This article discusses the effect of survey design on footprints and illustrates what can be done to mitigate footprint effects at the interpretation stage.

## **Example**

Figure 1a is a time slice extracted from an onshore 3-D seismic volume. The data were acquired with an orthogonal survey design in which source lines were orthogonal to receiver lines, and they show a severe footprint oriented in the east-west direction as alternating weak and strong amplitude stripes. These amplitude stripes are related to acquisition geometry, not to geology.

In this case it is easy to surmise that the footprint tends to mimic the acquisition design. In other cases, a footprint pattern can be unpredictable in real data.

Zig-zag geometry is another common 3-D seismic survey design used across onshore prospects. In this design, receiver lines are oriented parallel to each other, and the source moves in a zig-zag pattern between adjacent pairs of receiver lines. If each source line is a mirror image of the previous source line, a zig-zag pattern is formed.

Figure 1b is a time slice of data acquired with a mirror zig-zag pattern across an area adjacent to the orthogonal survey displayed in Figure 1a. One feature of this latter image is the absence of an obvious footprint. These examples illustrate that survey design influences the presence or absence of acquisition footprints in seismic data.

Any data-acquisition or data-processing technique that causes the stacking fold across a given time slice to vary between bins will produce a footprint.

- In the shallow part of a seismic section, only small-offset traces contribute to a stack. Therefore, the shallow part of seismic image space is more susceptible to footprint problems because the number of small-offset traces almost always differs from bin to bin because of the acquisition geometry.
- In the section's deeper part, the fold-of-stack is equivalent to the maximum bin fold and tends to be reasonably uniform from bin to bin. Although it makes intuitive sense that the footprint will be more pronounced in seismic time slices from a shallower depth than from a deeper depth, the reality is that the footprint is unpredictable.

A comparison of Figure 2 with Figure 1b illustrates this point: For the mirrored zig-zag survey design, the footprint is hardly noticeable in the time slice at 1020 msec (Figure 1b). However, a time slice at 1200 msec (Figure 2a) has a footprint that appears as north-south vertical striping; whereas, a time slice at 1550 msec (Figure 2b) does not show a footprint.

In this data volume, a footprint is absent at a shallower depth (Figure 1b), then appears at a deeper depth (Figure 2a), and then disappears again at yet a deeper depth (Figure 2b).

Other factors can modify an acquisition footprint or create additional footprints. Despite our best efforts to design 3-D surveys to minimize bin-to-bin fold and offset variations, footprints in seismic data cannot be completely eliminated before a final stacked 3-D volume is given to an interpreter.

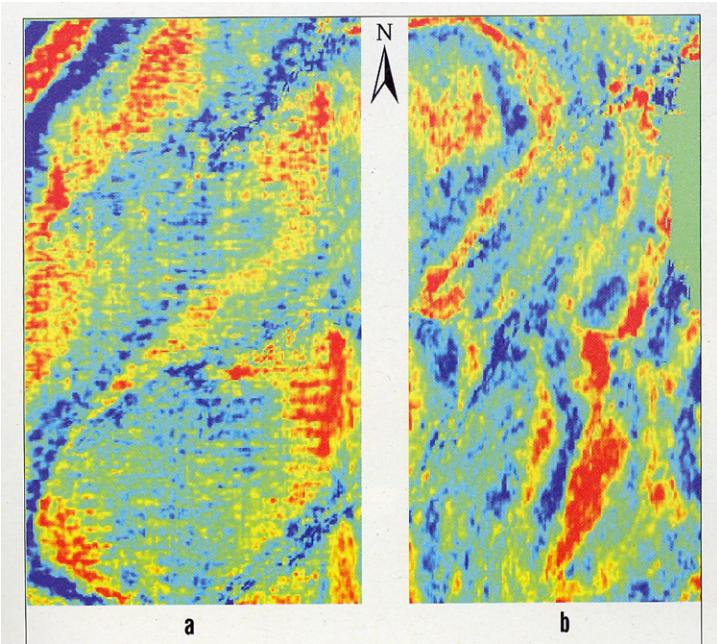
In many cases, such as the example in Figure 2a, an interpreter can look past the footprints and do a good job of inferring the geology. In other instances, the footprint may be so severe that it masks important information about the geology.

In Figure 1a, for example, the presence of a channel in the image's northeast corner is completely masked by the footprint. A properly designed filter applied in the frequency-wave number domain can reduce the vertical and horizontal stripes in the time slice and make it easier to see the channel (Figure 3).

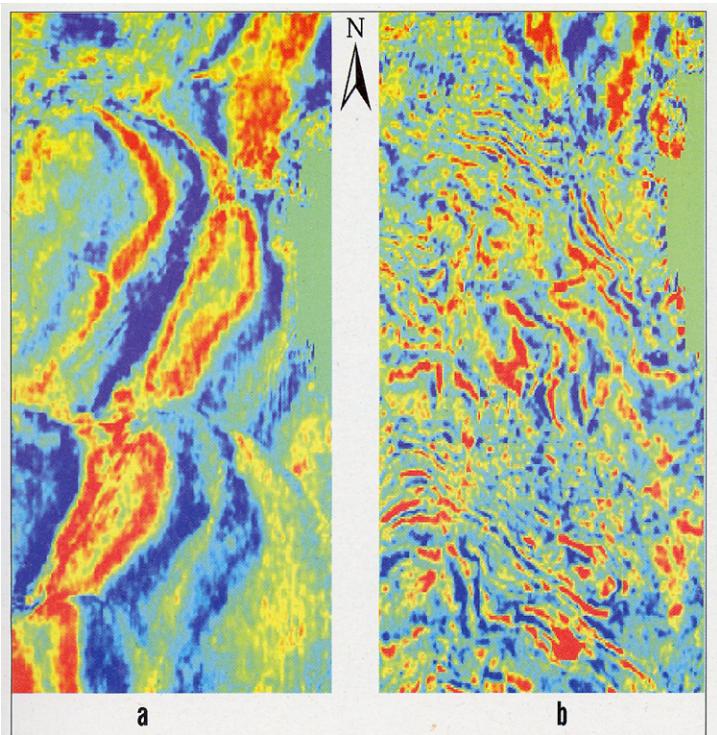
Some interpretation workstations provide the capability to design and apply such filters to data during an interpretation phase.

## Summary

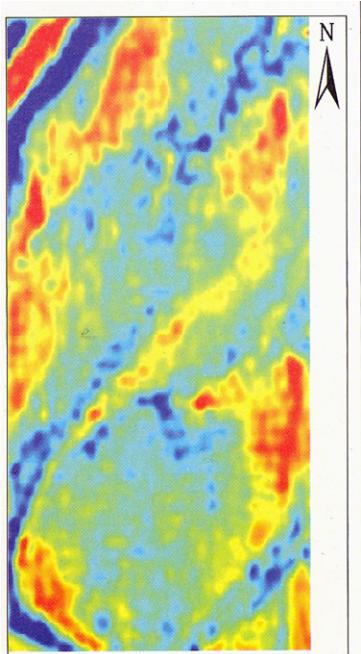
In summary, we should attempt to minimize footprints by employing proper seismic acquisition and processing techniques – but if a footprint persists in the stacked data, there are ways to filter the data and mitigate its effect on geological interpretation.



**Figure 1.** (a) Time slice at 1020 msec extracted from 3-D seismic data acquired with an orthogonal survey design has an acquisition footprint that appears as west-to-east amplitude stripes; (b) time slice at 1020 msec from 3-D data acquired across nearby geology with a mirrored zig-zag survey design does not have a noticeable footprint



**Figure 2.** (a) Time slice at 1200 msec for the mirrored zig-zag survey design has north-south amplitude stripes in the data; (b) time slice at 1550 msec for the mirrored zig-zag design does not show a footprint.



**Figure 3.** Filtered version of time slice at 1020 msec has a much-reduced footprint in comparison to Figure 1a and allows better interpretation of an imaged channel system.