[GC]Equalizing Wavelets Produced by Different Seismic Sources*

Bob Hardage[1]

Search and Discovery Article #40894 (2012)
Posted March 26, 2012

*Adapted from the Geophysical Corner column, prepared by the author, in AAPG Explorer, March, 2012, and entitled "When All Data Are *Not* Created Equally". Editor of Geophysical Corner is Satinder Chopra (schopra@arcis.com). Managing Editor of AAPG Explorer is Vern Stefanic; Larry Nation is Communications Director.

[1]Bureau of Economic Geology, The University of Texas at Austin (bob.hardage@beg.utexas.edu)

General Statement

Tidewater areas can be difficult places to acquire consistent-quality seismic data, because different sources have to be used across exposed land surfaces than what are used across shallow-water areas. Typically, explosives are used in shot holes in the onshore portion of a tidewater prospect, whereas environmental regulations may require that an air-gun source be used in shallow-water areas.

These two seismic sources produce different basic wavelets – and profiles produced with explosives and air guns rarely tie in an optimal manner at common image coordinates without using wavelet-shaping algorithms to create equivalent reflection character across targeted intervals.

Example

An example of using an explosive source and an air-gun source across a Louisiana tidewater area is documented as Figure 1 and Figure 2. This shallow-water test line was recorded twice because, at this location, explosive sources were allowed.

For one profile, the source was a 30-pound (13.6-kilogram) charge positioned at a depth of 135 feet (41 meters) at each source station. For the second data acquisition along the same profile, the source was an array of four air guns with a combined volume of 920 in^3, and eight air-gun pops were summed at each source station.

Considerable processing effort was expended to make the final reflection character identical on each test line. The data illustrated as Figure 1 show the results of the data processing. The frequency content of the two profiles is approximately the same, but wavelet character is not identical at the junction point (station 165). In this instance, the interpreter responsible for this prospect decided that the reflection character expressed by the explosive source was preferred rather than the wavelet response shown by the air-gun source.

The challenge was that in neighboring tideland areas, regulations required that an air-gun source be used in water-covered areas – shot-hole explosives could *not* be used in shallow water as they had been across this initial test site, and a method had to be developed that would allow air-gun-source data to be used in conjunction with explosive-source data acquired across adjacent exposed-land areas.

Said another way, the problem was to create a basic wavelet in air-gun-generated data that was equivalent to the basic wavelet embedded in explosive-source data. This type of problem has to be solved by data-processing procedures, not by data-acquisition techniques.

An approach used by many data processors to ensure that equivalent basic wavelets exist in two seismic profiles acquired with different sources is to calculate numerical cross-equalization operators that convert the phase and frequency spectra of source A to be equivalent to the phase and frequency spectra of source B.

This technique was applied to the tidewater seismic data illustrated on Figure 1 by using data from the image trace at station 153 to calculate cross-equalization operators that converted the phase/frequency spectra of the air-gun data to the spectra of the explosive-source data. The result is exhibited as Figure 2. The wavelet character of the profiles now agrees better at the tie point so that common horizons, sequence boundaries, and facies character can be interpreted on both profiles with greater confidence.

Conclusion

The example discussed here is from a tidewater area where operating and environmental constraints forced different sources to be used on land-based and water-based seismic lines. The concept of numerical equalization of the basic wavelets embedded in any grid of intersecting 2-D (or 3-D) data, however, applies to a variety of onshore and offshore areas where people have access to overlapping legacy seismic data that have been acquired by different companies at different times and with different energy sources.

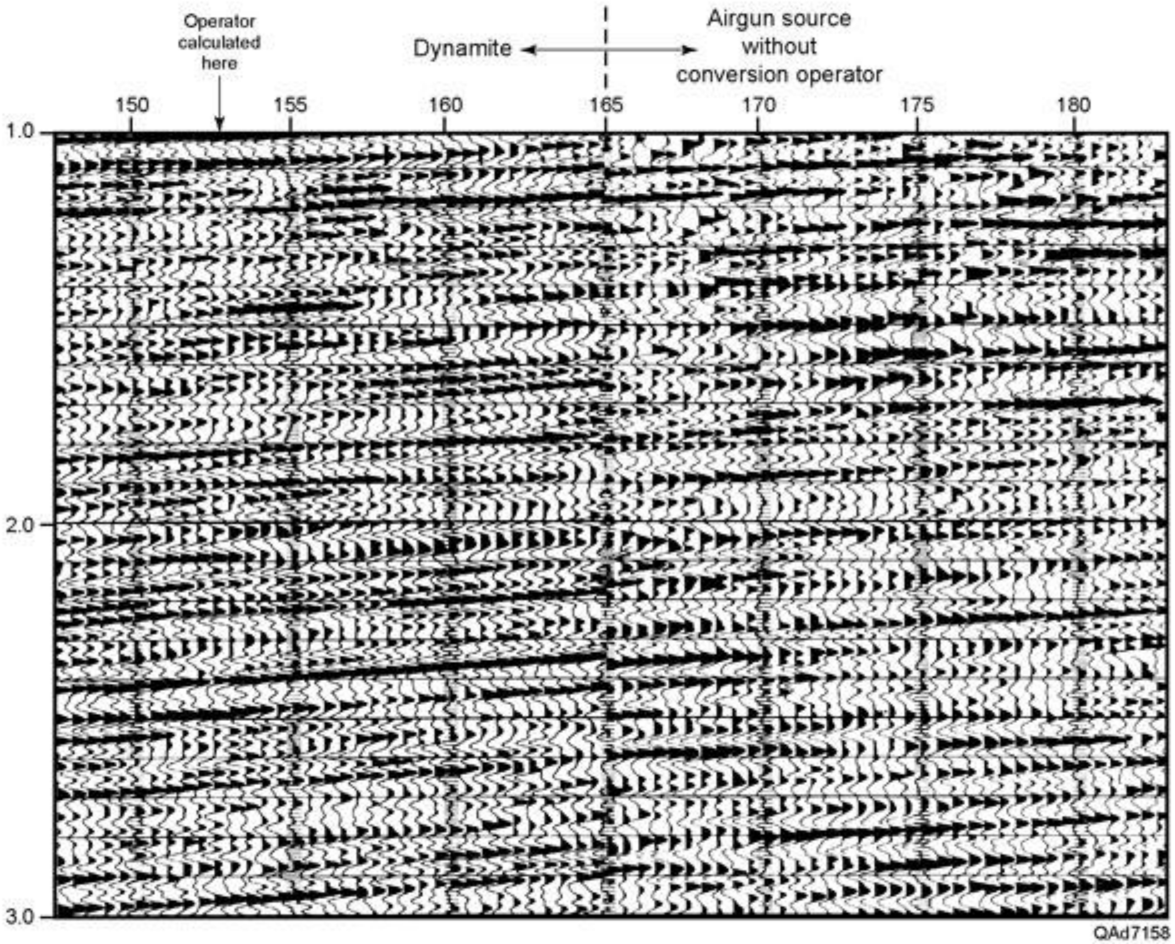

Figure 1. This shallow-water profile was recorded with two different sources – shot-hole explosives and air guns. A portion of the image produced by shot-hole explosives is shown to the left of station 165; a portion of the image produced from the air-gun data is shown to the right. The interpreter preferred the data generated by the shot-hole explosives. Cross-equalization operators that converted the phase and frequency spectra of the air-gun data to the phase and frequency spectra of the shot-hole data were calculated at station 153.

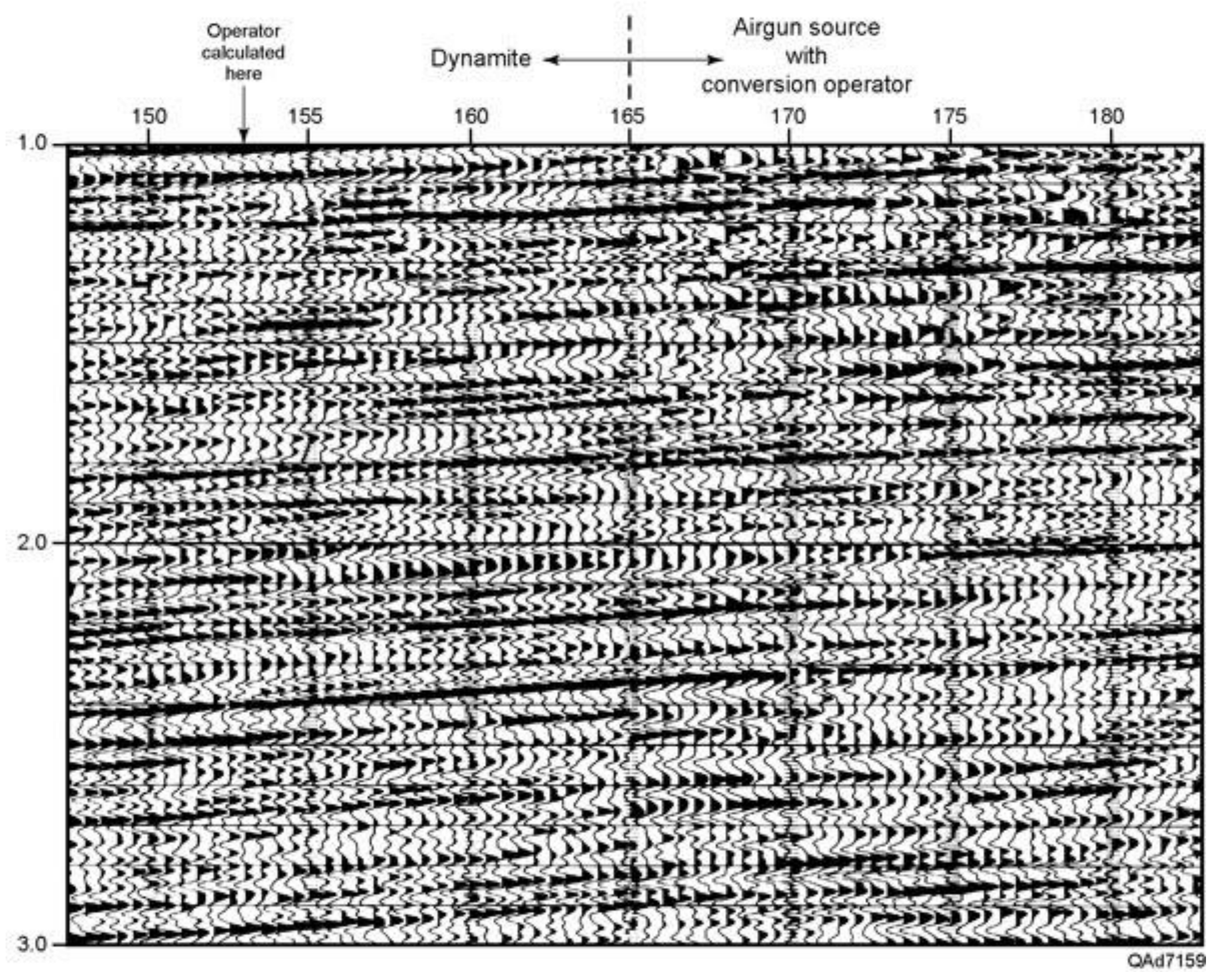

Figure 2. The same data exhibited on Figure 1 after cross-equalization operators determined at station 153 are applied along the complete air-gun source profile to create equivalent basic wavelets in both the air-gun and shot-hole data. The wavelet character at junction point 165 is now almost seamless. When this type of cross-equalization operator is applied to extensive grids of intersecting seismic profiles acquired with different sources, the consistent imaging wavelets produced in the overlapping data allow a better interpretation of subsurface geology to be done across a prospect area.