GC Randomness in 3-D Seismic Survey Design*

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General Statement

Considerable effort can be expended in onshore 3-D seismic data acquisition in surveying the coordinates where source-station and receiver-station flags are placed, because these flags will later instruct field personnel exactly where to plant geophones and vibrator drivers exactly where to position their vehicles. Sometimes there is a long delay (perhaps weeks or months) between the deployment of these station flags and the arrival of the seismic crew. In such instances, a station-surveying crew may visit the prospect a second time and invest additional time and expense to reset station flags that have disappeared for any reason.

The justification for this emphasis on precise, pre-survey station-flag positioning is partly tradition that holds over from days when GPS technology was not available and there was no other way to define the X, Y and Z coordinates of each source and receiver station. But the justification also is partly based on seismic data-processing requirements. Numerous data-processing algorithms require seismic data to be sampled at regularly spaced intervals in X, Y space. To ensure correct data processing, some explorationists exert a serious effort to positioning source-station and receiver-station flags at precise, regularly spaced intervals before any data-acquisition activity is initiated.

Station Flag Positioning

An issue to consider is, "Is it necessary to position station flags accurately before a seismic survey begins, or is it only necessary to know station coordinates accurately after they have been occupied?" Almost every vehicle and every person on a modern seismic crew has a GPS system, and their positions are known at all times. The GPS systems in vibrator trucks define precisely where the source is positioned; GPS units carried by the geophone-deployment crew define precisely where they planted the geophones.

Regarding the issue of regularity of data sampling, powerful algorithms exist to convert irregularly sampled data to regularly sampled data. Thus, if post-survey station coordinates are know with high accuracy, there is less need to expend cost in pre-survey work to position station flags at precisely known coordinates.

If vibrator drivers and geophone-deployment crews are allowed to position their stations according to their best judgment during the course of a seismic survey (rather than following trails of pre-survey positioned flags), the stations will be positioned with some amount of randomness and will not be at precise, regular intervals. This randomness in the positions of source and receiver stations can be beneficial.

Examples

For example, consider the two seismic data-acquisition concepts illustrated as Figures 1 and 2. Great care and expense were taken to make the acquisition geometry in Figure 1 have source/receiver stations at precise, regular intervals. In contrast, the erratic positioning of the stations in Figure 2 suggests one question: “Was the station-surveying crew ill or inebriated?”

Now look at the plots of stacking fold, source-to-receiver offsets and source-to-receiver azimuths that accompany each acquisition geometry. The random-station geometry increases stacking fold in many bins by 10 to 20 percent (panel b in each figure), which is good. Randomness in station positions does introduce minor, erratic, bin-to-bin variations in fold, but these variations are not a serious problem in this example. More importantly, randomness creates more uniform distributions of offset and azimuth than does the regular-station geometry (compare panels c and d in Figure 1 with their equivalents in Figure 2). The offset and azimuth behaviors created by random-station geometry (Figure 2) are preferred for amplitude-vs.-offset and attribute-vs.-azimuth studies.

There are situations where source and receiver station coordinates *must* be known with precision before any seismic data-acquisition commences: In archeologically sensitive areas, regulatory agencies have to inspect each station to determine whether archeological damage will occur if vehicles or people occupy the station coordinates. Some farmers want to know exactly where vehicles will travel across croplands before they will allow a seismic crew to enter their property. Some pipeline companies insist on knowing exactly where each source station is relative to each of their underground lines. The list goes on and on.

Conclusion

We are not advocating that seismic source and receiver stations be positioned willy-nilly across a prospect; we intend only to show that in some seismic surveys, accurate and costly pre-survey positioning of source and receiver stations is not necessary – and that the randomness introduced into an acquisition geometry by casual positioning of source/receiver stations can be advantageous if the amount of randomness is kept within reason.

A good analogy to the introduction of randomness into station positioning is the use of salt on food. A modest amount does considerable good; too much can be a disaster. Perhaps it is time to think about relaxing some of the time demands and expense we invest in precise pre-survey station positioning in those numerous situations where it is really not necessary to do such pre-survey effort.

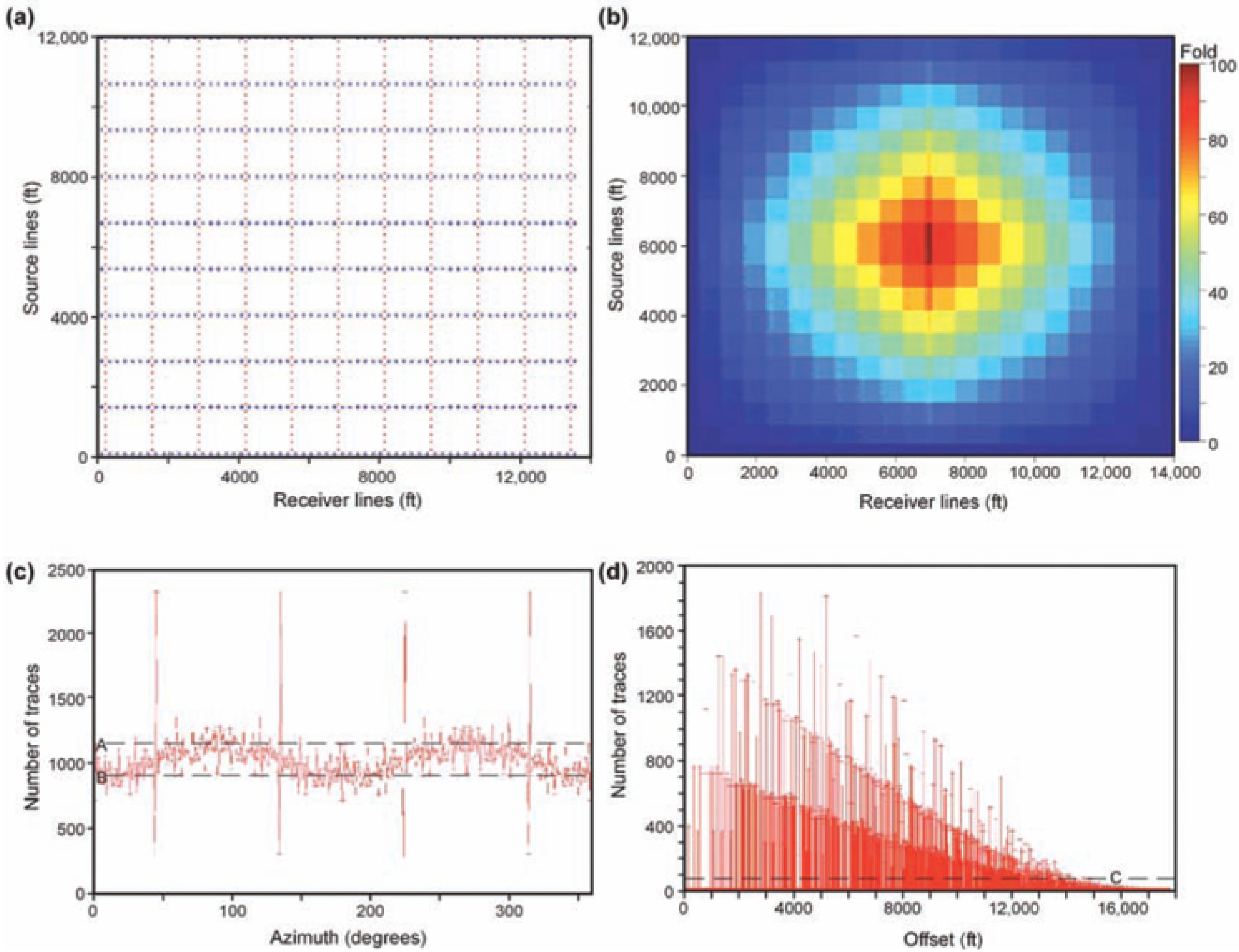

Figure 1. (a) A 3-D seismic data acquisition grid consisting of source and receiver stations positioned at precise regular intervals. (b) Stacking fold across the acquisition template. (c, d) Offset and azimuth distributions have large outliers that create undesirable oscillations of bin statistics. Data constraints A, B and C labeled on panels c and d are discussed in the caption for Figure 2.

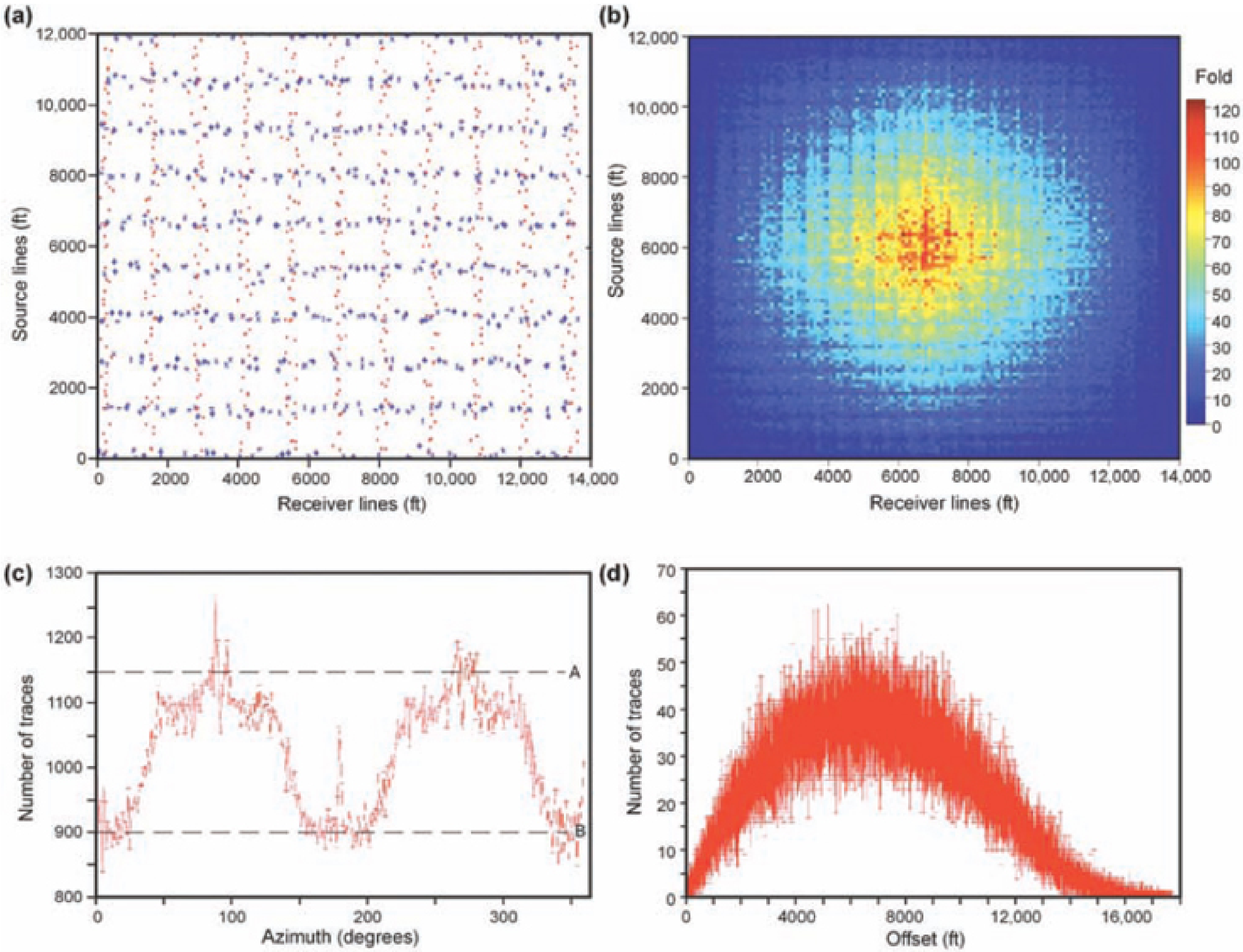

Figure 2. (a) The same data-acquisition grid as in Figure 1, but with source and receiver stations positioned at irregular, random coordinates. (b) Stacking fold. (c, d) Offset and azimuth distributions have minor outliers and are less erratic than the distributions in Figure 1. The data in (c) fit between values A and B in Figure 1c; the data in (d) fit below line C in Figure 1d.