GC What is Seismic Interpretation?*

Alistair Brown[1]

Search and Discovery Article #41125 (2013)
Posted May 17, 2013

*Adapted from the Geophysical Corner column, prepared by the author, in AAPG Explorer, May, 2013. Editor of Geophysical Corner is Satinder Chopra (schopra@arcis.com). Managing Editor of AAPG Explorer is Vern Stefanic.

[1]Consulting Reservoir Geophysicist, Allen, Texas (alistair@airmail.net)

General Statement

Seismic Interpretation is the extraction of subsurface geologic information from seismic data. On that definition we all are agreed.

However, if we seek a more penetrating explanation, we find practitioners get tongue-tied and talk around the subject in a variety of ways. In this article I attempt to give a longer, more descriptive definition that will apply to every interpretation project involving reflection seismic data. The danger in seismic interpretation is in thinking that everything we see is geology!

Reflection seismic data comprise:

- Continuity of reflections indicating geologic structure.

- Variability of reflections indicating stratigraphy, fluids and reservoir fabric.

- The seismic wavelet.

- Noise of various kinds and data defects.

Seismic interpretation is the thoughtful procedure of separating these effects. The seismic wavelet starts as the pulse of seismic energy, which, generated by the energy source, travels down through the Earth, is reflected and travels back up to the surface receivers carrying the geological information with it. This recorded wavelet is a minimum phase of some frequency bandwidth, and during data processing it is converted (we hope) into a zero-phase wavelet, making interpretation easier and more accurate.

The interpreter is not directly interested in the wavelet itself but rather in the geological information that it carries. Thus, understanding the wavelet and distinguishing its characteristics from details of the geology is one of the critical tasks of today's interpreter.

Presence of Noise

Noise is ever-present in seismic data. It may be random noise, it may be multiple reflections, it may be refracted energy, and it may be other energy of unknown source. The data may suffer defects because of:

- Irregular data acquisition showing as footprint.
- Obstacles to the data acquisition crew.
- Equipment difficulties in the field.
- Processing problems.

The interpreter must know enough about the acquisition and processing to recognize these undesirable features, and thus to not confuse them with the geology he/she seeks.

Defining Structure

Seismic energy is reflected from interfaces where the acoustic properties of the rocks change. These interfaces follow sedimentary boundaries created at the time of deposition of the sediments.

Following the continuity of these reflections then defines for us the structure imposed on these boundaries by the tectonic forces of geologic history. Following this continuity and making structure maps is thus the most basic, and most traditional, activity of seismic interpretation. To aid in this endeavor the seismic interpreter can manipulate the data and the display in various ways. The time-honored approach to prepare the data for structural interpretation is to apply AGC (Automatic Gain Control) in the late stages of data processing. This reduces amplitude variability (where most of the stratigraphic information lies), and hence increases visible data continuity.

The interpreter also may compress the display color bar to optically saturate and thus to render invisible more of the amplitude variations. Other techniques include the use of Instantaneous Phase (which completely destroys amplitude information) and Structurally Oriented Filtering. All these are good ideas – provided the interpreter realizes that they are directed at structural interpretation only, and that the requirements of later, more advanced types of seismic interpretation are quite different.

Defining Stratigraphy and Reservoir

Once the structure has been established, the interpreter turns his attention to stratigraphic interpretation and the detection of hydrocarbon fluids. Overwhelmingly important here is seismic amplitude – and the amplitude may be presented to the interpreter or extracted from the data in various ways. The data loaded to the workstation must be True Amplitude and Zero Phase, and the interpreter must satisfy himself that the data used are such. Understanding the wavelet is complicated and very important (part of the fundamental separation of effects) but outside the scope of this article.

In order to increase the visibility of stratigraphic variations the interpreter will remove the structure – and the best way to do this is to make a Horizon Slice. The concept behind the Horizon Slice is the reconstitution of a depositional surface at a key point in geologic history. The structure used for the reconstitution is most commonly defined at the level of the objective. However, it is often better to define the structure at one level (conformable with the objective) and to use this to remove the structure at the objective level. This very effectively separates structure into step one and stratigraphy into step two.

This procedure is illustrated in the accompanying Figure 1. The horizon tracked on the two vertical sections follows a reflection with good structural continuity and little, if any, stratigraphic variability. The horizon track is then displaced downwards by 40 ms (a simple horizon computation on the workstation) to intersect the prominent red blob visible below it, and the amplitude is then extracted along the displaced track. The resulting Horizon Slice, on the right of the Figure 1, shows a very clear channel (the spatial pattern of the red blob) with interesting amplitude variations along it.

When the seismic interpreter extends his analysis even further and enters the field of reservoir evaluation, the data requirements are even more stringent, but the Horizon Slice concept is still effective in removing the effects of structure. Some form of Inversion may be used here, and this process converts interface information (amplitude) into interval information (acoustic Impedance).

The more advanced forms of inversion seek to remove the wavelet, and this is therefore part of the fundamental idea of separating effects. However, the challenge here is to exactly understand the wavelet that has to be removed. This is difficult, and many inversions suffer and projects fail because of this issue.

Conclusion

So seismic interpretation is the thoughtful separation (with workstation assistance) of the various effects that the subsurface and the seismic acquisition process have mixed together!

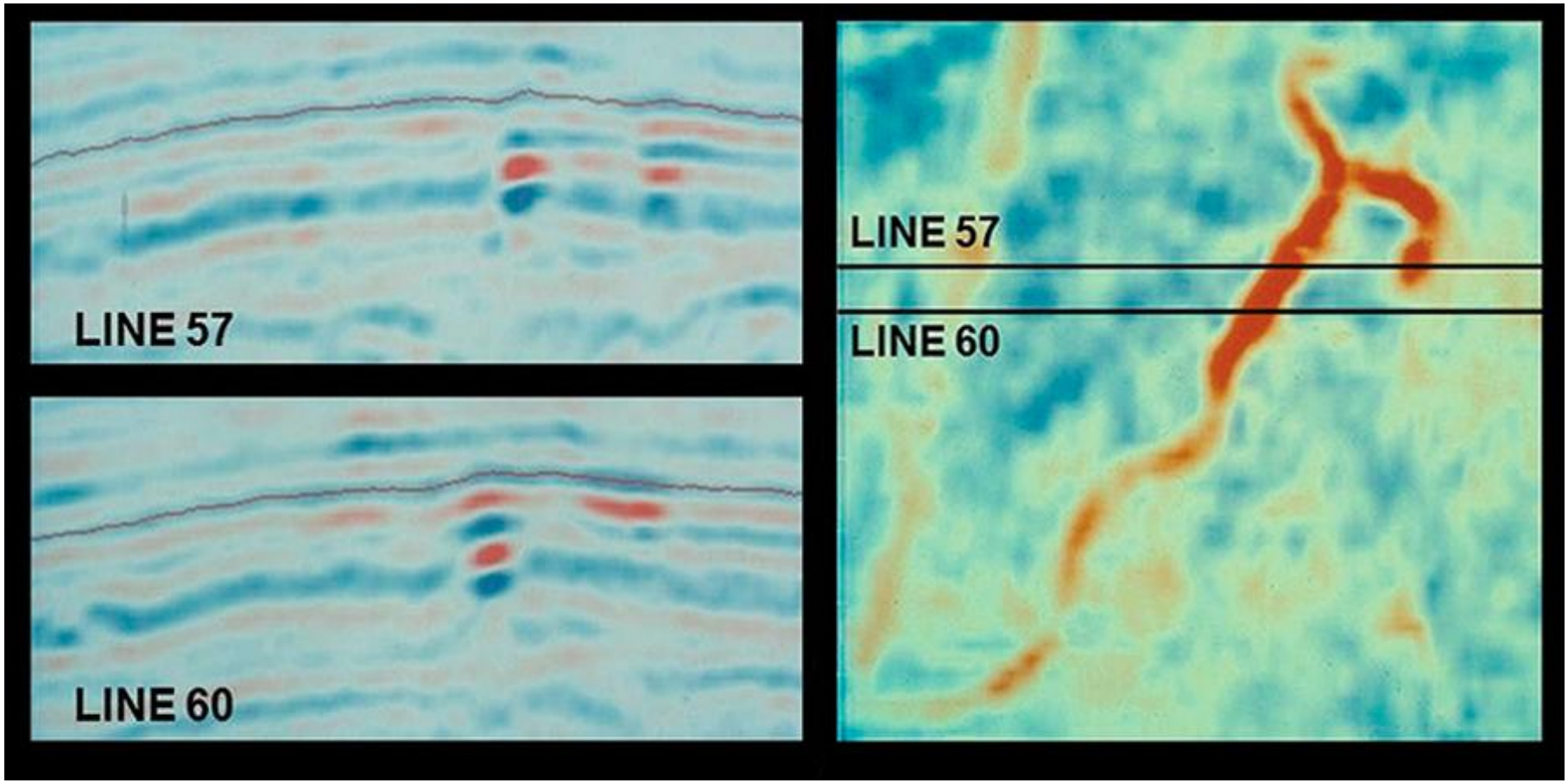

Figure 1. (Left) The horizon track on Lines 57 and 60 defining the structure, and (Right) the Horizon Slice sliced through the data volume 40 ms below. (From Interpretation of Three Dimensional Seismic Data, AAPG Memoir 42, SEG Investigations in Geophysics No. 9, Seventh Edition, 2011.)