GC Frequency in Defining Trend of Productive Thin-bedded Sandstone *

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General Statement

The numerous seismic attributes that can be calculated with various interpretation software packages are based on three fundamental wiggle-trace attributes: amplitude, phase, and frequency. Because these attributes are calculated at every time-sample of a seismic trace, they are referred to as "instantaneous" attributes.

Constructing attributes as instantaneous functions is important because interpreters then have more flexibility in how they use the attributes. For example, a time-based attribute can be analyzed along an interpreted horizon (only one data point thick); within a thin data window (three or four data points thick) that conforms to a reference surface; or averaged throughout an extensive data window (several tens of data points thick) that spans some portion of seismic image space.

Most seismic interpreters, including the author, tend to focus on amplitude-based attributes as they search a 3-D seismic volume for geologic information. However, phase-based and frequency-based attributes are valuable for depicting subtle targets in many instances. This article illustrates an application in which instantaneous frequency was used to define a stratigraphic trend of a productive thin-bedded sandstone.

Example

The net-sand-thickness map in Figure 1 illustrates the distribution of a productive Caddo sandstone in the Bend Conglomerate interval of the Fort Worth Basin. Considerable contour detail is shown on the map because reservoir thickness was defined from logs acquired in about 30 wells across the mapped area. Only a few of these well locations are labeled in Figure 1.

A vertical seismic section along profile AA' is shown in Figure 2. The labeled feature shows the reflection character across the thin-bedded sandstone and illustrates that the sandstone target is stratigraphically trapped and is not a structural feature.

Several seismic attributes were calculated and analyzed in an attempt to follow the trend of this productive Caddo target through 3-D seismic image space. Of all the attributes that responded to the presence of this thin-bedded unit, the attribute that produced the optimal stratigraphic trap image was instantaneous frequency. For example, the instantaneous-frequency map in Figure 3 is a close match to the log-based map in
Figure 1 because:

- The frequency of the reflection signal reacts to the presence of this thin-bedded unit.
- An appropriate color bar is used to display this frequency behavior.

Selection of the color bar used to display a seismic attribute is often the key to attribute interpretation. The correspondence between a seismic attribute value and a targeted geologic condition can be enhanced by the proper choice of color bar that displays the attribute – and, unfortunately, attribute-to-geology relationships can be obliterated by a poor choice of color bar. Some interpreters justifiably take as much time creating an appropriate color bar for attribute maps as they do creating the attribute that is being mapped.

Conclusion

The fundamental message from this example is that frequency-based attributes at times can be ideal indicators of stratigraphic-trap conditions.

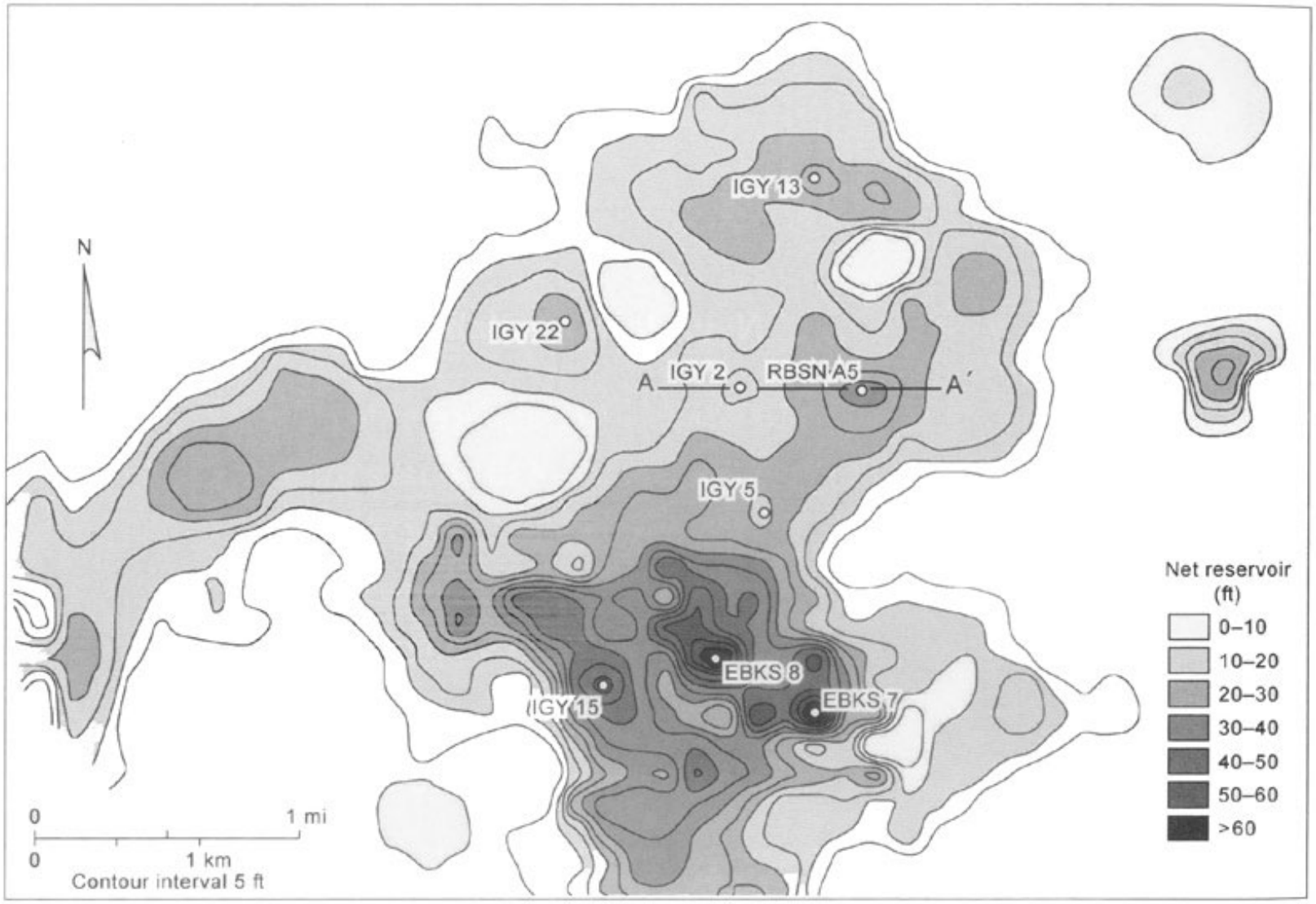

Figure 1. Net thickness of a Caddo sandstone unit defined by well logs from numerous wells across a small area of the Fort Worth Basin. Locations of only a few wells of particular interest in a research study are labeled.

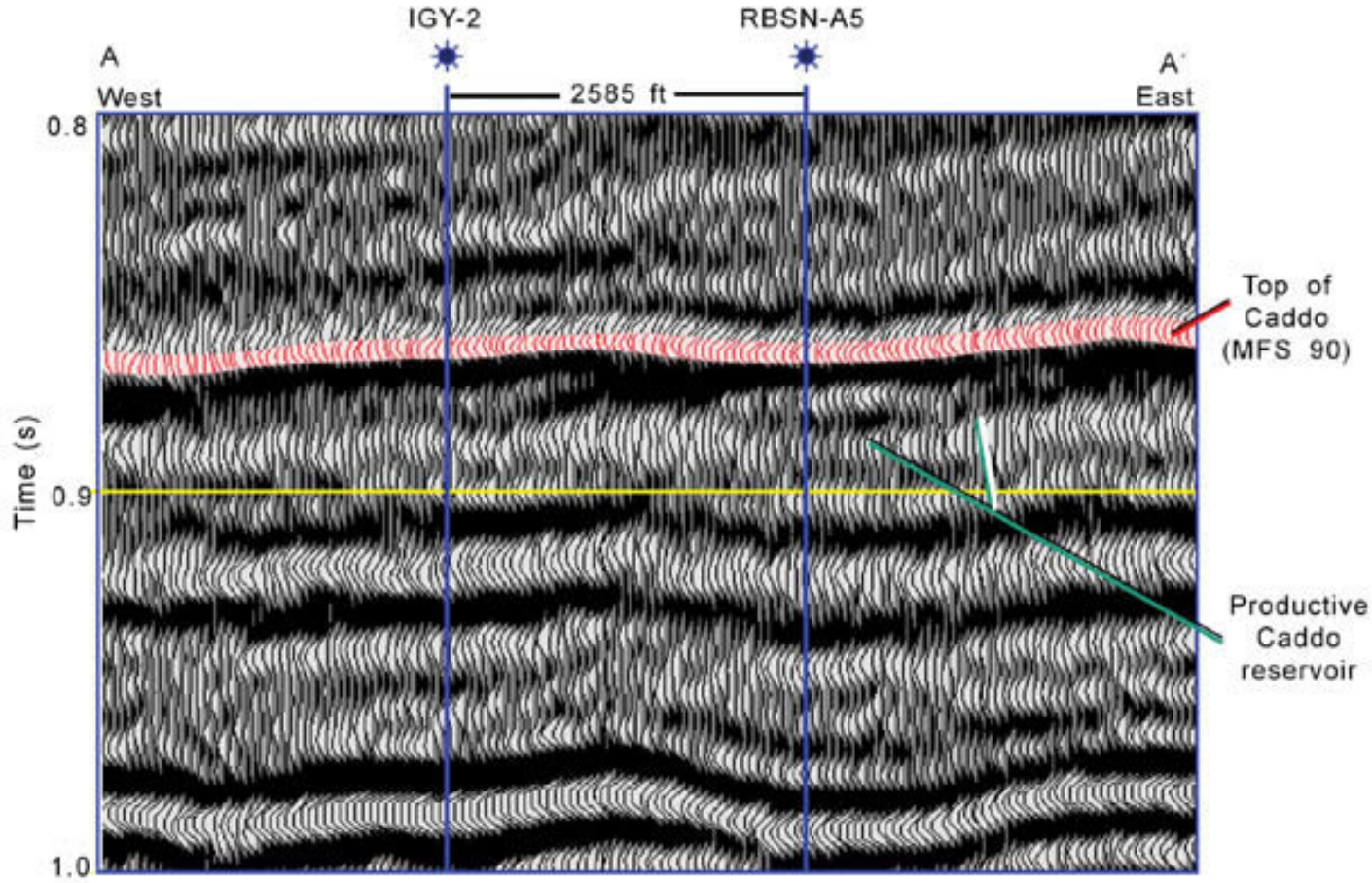

Figure 2. Seismic section along profile AA' labeled in Figure 1 that identifies the unique reflection response of the Caddo sandstone unit.

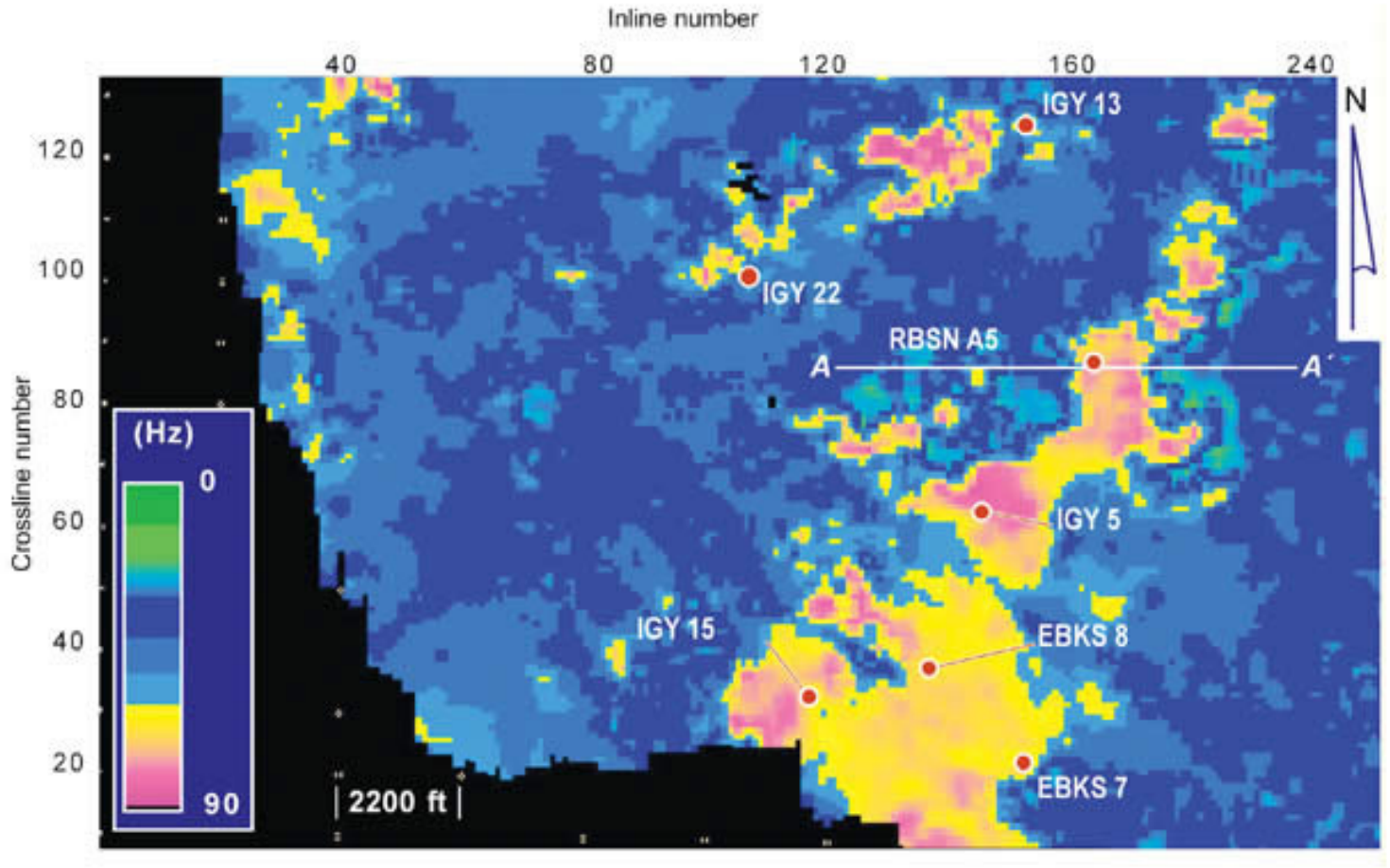

Figure 3. Map of average instantaneous frequency in a 10-ms window positioned 10 to 20 ms below the Caddo horizon. The trend of 60- to 75-Hz average-frequency attributes on this map is a close approximation to the log-based map in Figure 1 and identifies both new drilling locations and locations to avoid.