Salt Related Volume Interpretation: An Example of Utilizing Volume Interpretation Software with Challenging Data Quality

Adam M. Seitchik

Devon Energy, 1200 Smith St., Houston, TX 77002

EXTENDED ABSTRACT

Over the past few years, volume interpretation software has made great usability achievements related in part to a continually advancing hardware sector. These applications showcase abilities to mine large quantities of data, mapping quickly with good accuracy, working with multi-attribute data and displaying all this information clearly. The value of volume interpretation software is clearly demonstrated on good quality data but rarely do we see examples when the quality of the data is less than desirable, such as sub-salt environments in the Gulf of Mexico. Although interpreters are unable to leverage all the benefits of volume interpretation software, this is not a time to shy away from the software, rather it needs to be embraced. When the data quality is low, with limited frequency content, peak frequencies in the 11 to 13 Hz range, low signal to noise due to complex geometries, an interpreter has to use every bit of good data available to interpret salt related features and sediment interactions. By interactively animating through data and changing view angles, interpreters can effectively distinguish good signal from noise, identify residual multiples that were not eliminated in preprocessing, and gain insight into structural evolution of salt and related salt-sediment interactions. In addition, the ability to load multiple data volumes into memory enables interactive use of different types of data that aids the interpretation process, such as near, mid, or far stack data, sediment velocity flood, and velocity model to name a few.

Volume interpretation and visualization is not new to the geoscience community, gaining exposure in the mid to late 1990s. One could argue that rapid growth of usage was inhibited more by the limitations and expense associated with hardware than the applications themselves. With the rollout of a more stable Linux environment and cheaper and more powerful hardware, 3-D volume interpretation and visualization software is becoming integrated into the common interpretation workflow. Working in team environments or at solitary workstations, interpreters use this software to scan large quantities of data, work with multiple data volumes, identify hydrocarbon indicators, study stratigraphic relationships and potential traps, and analyze complex structural environments. Interpreters, limited only by their imagination, have formulated workflows optimizing the interpretation process, coining phrases such as Parallel Interpretation (De La Pena *et al*., 2003) to describe workflows permitting quick and full evaluation of large datasets.

Software venders consistently showcase their software, focusing on ease of use, efficiency, speed, and cycle time reduction. There is no question that with good data quality these applications are efficient and effective interpretation tools, utilizing capabilities such as seeding amplitudes, rapid automated horizon interpretations, and effective fault

interpretations algorithms. What is never showcased is the application's effectiveness when good data quality is not longer available, such as the subsalt environment, where the signal to noise ratio is low, and frequency content is limited to 10 to 15 Hz with complex geometries. In this environment, automated horizon interpretation algorithms break down, and direct hydrocarbon indicators are no longer relevant. An interpreter than asks, "Are 3-D volume interpretation applications effective in such challenging environments, where many of its showcased capabilities are ineffective?" Although rarely discussed, the answer is yes, particularly because there is more to interpretation that automated picking. There is a need to comprehend the data and in order to comprehend the data, we need the most effective tools to see the data. This is where strengths of volume interpretation software come into play and make it a necessary tool for interpretation in data-poor areas. These strengths include data animation and manipulation. Another strength is the ability to quickly and simultaneously work with multiple data sets.

One way volume interpretation software is effective in data challenging areas is its ability to smoothly animate data. Cognitive psychologists have found that dynamic visual stimuli, such as moving objects, attract attention (Pinto, 2006). In addition, the visual system uses mechanisms to integrate patterns along a trajectory for recognition (Nishida, 2004). Objects in motion are easier to identify and recognize. Nature works in the opposite way where animals use camouflage and remain motionless to hide from predators. The way objects move is also important for recognition. For example, dots that may appear random become familiar when organized into a pattern of motion that we recognized.

Extending this practice to data challenging areas such as the subsalt environment in the Gulf of Mexico, and using volume interpretation software to animate the data, interpreters begin to distinguish noise from signal, artifacts from true geologic events, and identifying residual multiples. By analyzing the changing characteristics of the data during animation, geologic events become separated from noise trains and uncollapsed migrations that have different patterns of motion. Such characteristics would not be recognized using traditional interpretation software viewing every 10th or 20th line/ trace, and geologic events hidden by the low signal may not be seen. Some companies have applied this theory to proprietary applications incorporating motion to enhance recognition and interpretation.

Volume manipulation, interactively changing the viewing perspective, is another attribute of volume interpretation. Traditional interpretation software provides one perspective view, that being perpendicular to the screen. Remember the days of paper interpretation? It was not an uncommon sight to see geoscientists with their heads on the table, looking down a seismic section, changing their perspective view of the data to see if any subtle events appear. Monitors, particularly because of their size, make this very difficult to reproduce (have you ever seen a geoscientist looking down the length of a monitor?). Volume interpretation software puts this ability back into the hands of interpreters. Because these application take advantage of three dimensions, the way data are viewed is limited only by the interpreter. Data can be positioned in any orientation that may be advantageous for interpretation. This includes looking down the length of the data, tilting the data up or down, zooming in and out, and any combination of the above in order to capture maximum information.

The prestack depth model building process is a workflow that is aided by volume interpretation software's capabilities, where salt model accuracy is the key to successful depth reprocessing projects. Animation and volume manipulations play a vital role in salt interpretation. Viewing salt morphologies in motion and changing the viewing angles helps interpreters work though more complex geometries, ensuring a more accurate salt model. Base of salt interpretation is the most challenging portion of the pre-stack depth migration workflow and the most pivotal. Even with an accurate top salt interpretation, the base of salt is not always an easily interpretable surface after the salt flood. Automated auto picking may work in isolated areas, but it is the animation and

volume manipulation that aids interpreters. Animating though the data helps separate noise and residual multiples from signal by analyzing their movements. While in motion subtle events become more obvious, making base salt reflections easier to identify. Working with multiple data sets also assists base salt interpretation. Sequencing between different data such as full stack, mid stack and, if available, gathers, helps the interpreter identify potential base salt events, increasing confidence in the overall salt model.

Working good quality data with high peak spectral frequencies is a luxury many interpreters do not have, especially in the deep-water Gulf of Mexico. Contrary to conventional wisdom, this is not a time to dismiss volume interpretation software's interpretation effectiveness. Although automated picking is limited, other characteristics makes the software an instrumental tool. Used in conjunction with traditional interpretation packages, abilities such as animation, volume manipulation, as well as working with multiple data sets enables the interpreter to use the limited data to the fullest extent, gleaning all available information.

REFERENCES CITED

De La Pena, B., M. Morales, H. Bello, J. Hernandez, and G. Kidd, 2003, Early 3-D evaluation using parallel volume interpretation techniques on the eastern Venezuelan Basin: American Association of Petroleum Geologists Annual Meeting Expanded Abstracts, v. 12, p. 38.

Nishida, S., 2004, Motion-based analysis of spatial patterns by the human visual system: Current Biology, v. 14, no. 10, p. 830-839.

Pinto, Y., 2006, When is search for a static target among dynamic destructors efficient?: Journal of Experimental Psychology: Human Perception and Performance, v. 32, no. 1, p. 59-72.

NOTES