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The value of an integrated G&G interpretation system

Collaboration leads to better interpretations.

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In many oil and gas companies, particularly smaller and mid-size organizations, the disciplines of geology and geophysics (G&G) remain surprisingly separate in terms of the daily level of interaction. While business units maintain healthy numbers of geologists, geophysicists, engineers, and supporting geotechnical staff, the geologists and geophysicists remain relatively siloed to their technical domains. Often the primary motivation for geoscience collaboration is preparation for well planning meetings, budget presentations, and technical property reviews.

Outside of such venues, geological and geophysical interpretations are often carried out in relative isolation from one another, with collaborative work being the exception rather than the norm. Seismic interpreters often wait to receive updated well marker picks, and geologists correlate markers from well to well, with little hard data on what is happening structurally or stratigraphically between wells. Many times the only integrated interpretation occurs with a geologist and geophysicist standing around a hardcopy map and annotating features by hand. This may be the final map that is used to plan drilling programs for the next 12 months.

Given the significant overlap in expertise between geology and geophysics, why is the interaction between these disciplines so rare?

Different toolkits

While there may be many reasons why G&G integration is infrequent and less than interactive, a primary cause is the disparate tools and software packages used by geologists and geophysicists. A large number of oil and gas companies have opted not to use a common geoscience interpretation platform. Instead, they have selected tools that meet the technical requirements of each discipline but offer little to no integration at the project or database level.

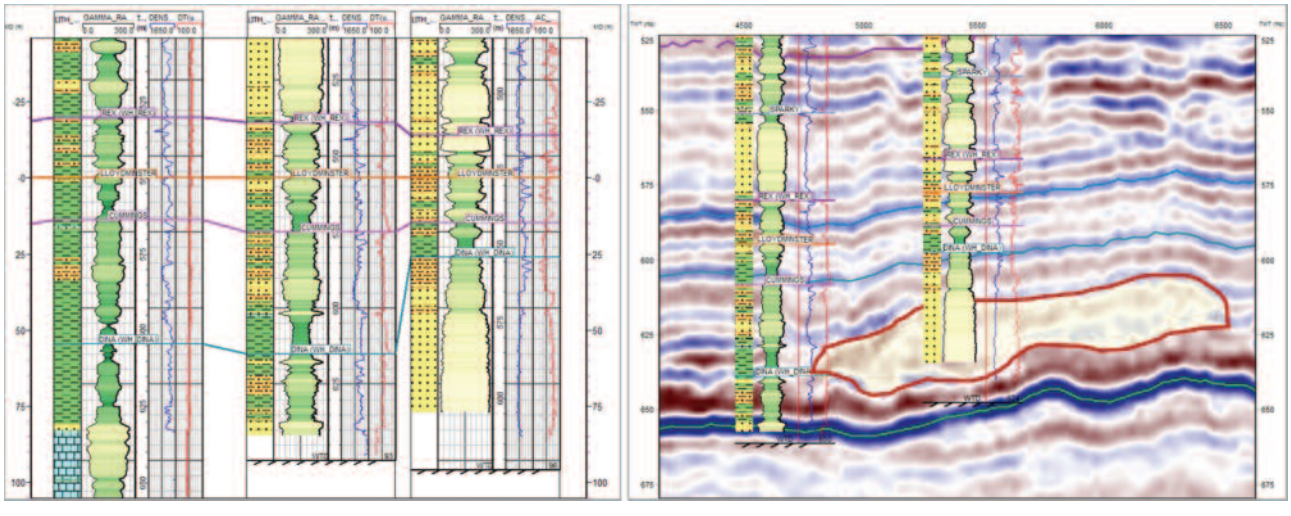

FIGURE 1. Shown left is a well section used for correlating well markers, formation tops, interpretation lithofacies, and a host of other tasks. Notice that the thick sand interval at the base of the third well is missing in the first two. How should this be correlated? By creating a geological cross section and using seismic data as a backdrop (right), it is easy to identify a body corresponding to the sand facies (outlined in red), which pinches out between the wells.

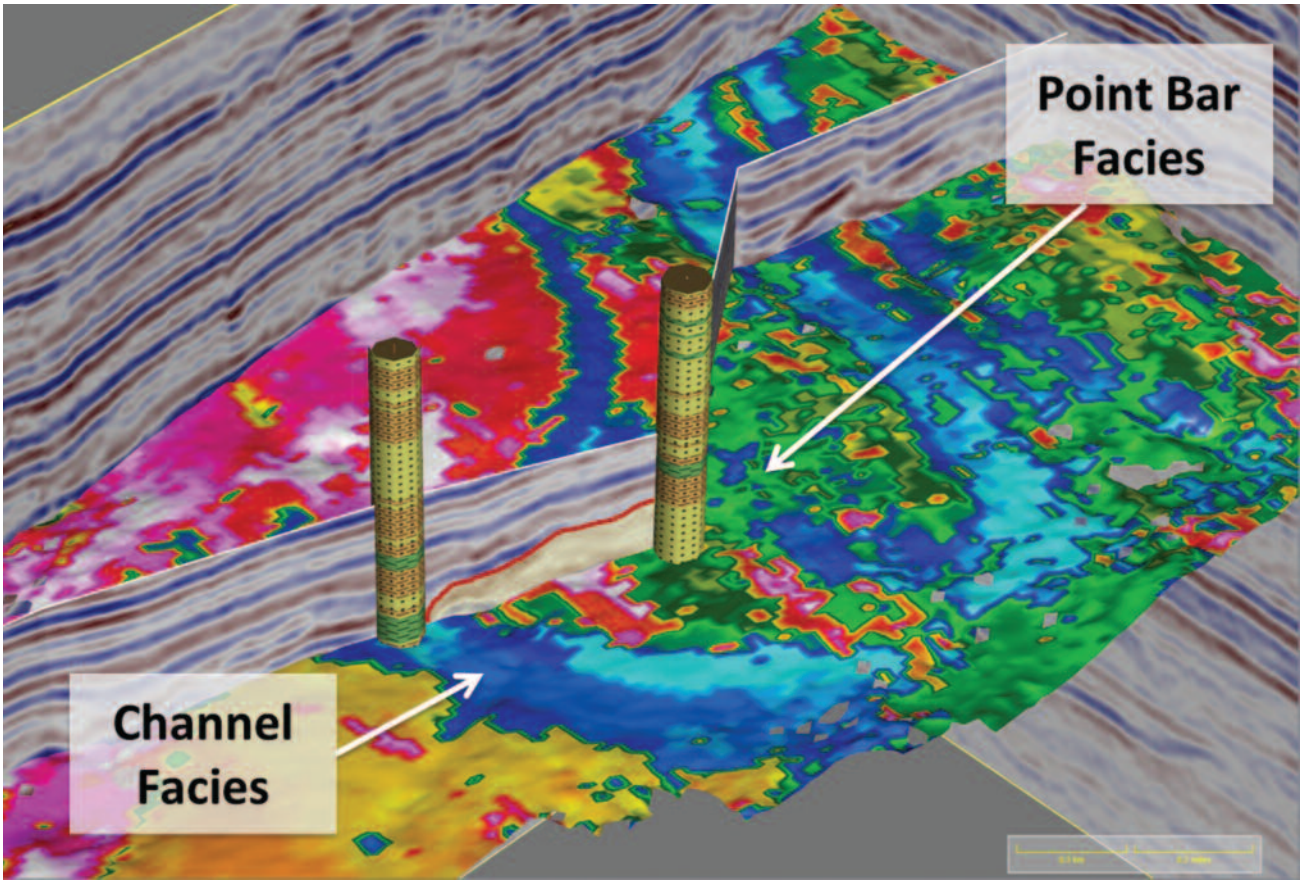

FIGURE 2. This is a view of seismic and well interpretation in a 3D Canvas setting. The horizon slice through the sand body is displaying a map of seismic facies. From the facies geometry it is easy to make out a meandering channel system with what is likely a point bar deposit. Well lithofacies displayed in the 3-D scene indicate the point bar facies correspond with a thick sand interval and the channel facies correspond with a shale channel fill.

A common scenario seen at many mid-size oil and gas companies is the geophysicists working in a stand-alone seismic interpretation system with its own project structure, data repositories, and seismic interpretation functionality. Similarly, geologists will work in their own geological interpretation system with a similar design and data architecture. To share their data, geologists and geophysicists rely on manually exporting and importing data from one system to another. This data transfer can sometimes be performed via dedicated connection modules, but more often than not the default data sharing mechanism is via export and import of ASCII data files.

While data import and export are effective, user-driven manual data transfers provide a critical point of failure where errors can easily be introduced to a project database. The data being loaded are only as good as the data that have been exported. How many technologists will quality-check that each marker has been imported correctly or that all markers have been exported using a common depth reference (i.e. measured depth)? What if there is a slightly different coordinate reference system used in the geologist's and geophysicist's interpretation systems? Would a lateral shift of tens to several hundred meters be noticeable?

These are common errors that occur when manually transferring data between interpretation systems. To ease the data management burden, companies employ geoscience technologists to do much of the project maintenance and data transfer tasks. Even for experienced technologists, however, it can be difficult to catch all data issues. Given the sheer volume of data available for onshore and development fields, performing effective and efficient quality control on these datasets is close to prohibitive.

Beyond data issues

A more significant consequence of separate geological and geophysical interpretation systems is the barrier that these introduce between the two disciplines. If the process of sharing data between asset team members is fast and easy, then collaboration between team members will naturally follow. If sharing data between team members requires manual operations, the pace of collaborative interpretation between geologists and geophysicists will slow drastically. This should be a major concern for interpretive teams.

The process of seismic and geological interpretation is a combination of science, intuition, collaboration, and trial and error. Interpreters attempt to fit structural and depositional models to features and patterns that manifest in geological and geophysical datasets. Comparing these interpretations with modern analogues and vetting with cross-disciplinary team members, geoscientists attempt to unravel the subsurface geology.

Critical to successful interpretation is the interactive ideation process that occurs when geologists and geophysicists collaborate. Each is a specialist in extracting information from specific types of data, the geologist working primarily with wells and the geophysicist with seismic data. If forced to work independently because of software tools, significantly different interpretations of the subsurface can emerge where there should instead be agreement. In such situations, significant time and effort may be required to revise and rework geological and geophysical interpretations until these point to a common model of the subsurface.

For a seismic interpreter to make decisions about plausible geological scenarios, well data always play an important role. Consider the situation where a geophysicist is interpreting a seismic dataset within a zone of complex stratigraphy. If no well data are available, the seismic interpretation could be very poorly constrained and subject to considerable uncertainty. With the addition of well control, the seismic interpreter can have more confidence and a better understanding of what the features observed in the seismic dataset actually are.

Seismic interpreters frequently work with well data through the course of seismic interpretation studies; however, their exposure may be limited to well markers and sonic, density, and gamma ray logs. Geologists, however, generate a vast array of information derived from well data. These may include facies logs, sequence stratigraphic interpretations, reservoir zone attributes, structural cross sections, and net pay maps that can be valuable assets when leveraged for seismic interpretation. Often the choice of seismic interpretation system places constraints on the types of geological data available to seismic interpreters. For example, if a seismic interpretation system does not support facies logs, the geophysicist will not be able to display or interact with these data types.

Geologists often work solely with well data. While this provides a vast amount of information in the vicinity of the wellbore, the lateral resolution of well data is poor compared to seismic data. When correlating markers from well to well in geologically complex areas, geologists should leverage seismic datasets to help understand when formations are thinning, thickening, faulted, eroded, or pinching out. Similarly, when performing facies interpretation based on well log data, seismic amplitude mapping can provide valuable information related to lateral changes in depositional environments.

Case study

Let's look at one example from Western Canada and how a closely integrated geological and geophysical interpretation system can improve the quality of subsurface interpretation.

The left of Figure 1 shows a well section used to correlate formation tops from well to well. Notice that the thick sand interval at the bottom of the third well is missing from the other two wells. What is happening laterally between the wells? The right side of Figure 1 shows a geological cross section through two of the same wells using seismic data as a backdrop. By using seismic data, the geologist can clearly identify a body corresponding to the thick sand facies, which pinches out to the left (outlined in red). The additional information provided by seismic data enables more accurate well-to-well correlations in a stratigraphically complex interval.

Figure 2 shows the same interval and facies logs displayed in a Paradigm 3D Canvas view. A horizon slice through the sand body is colored by seismic facies generated by trace-shape classification. Visually it is easy to identify a meandering channel system and a distinctive point-bar deposit from the facies patterns. By comparing well lithofacies logs with the seismic facies maps, it is clear that the point bar facies corresponds with the thick sand body, while the channel facies is shale-filled.

Through the use of an interpretation system that supports both geological and geophysical interpretation workflows, this field was examined, mapped, and interpreted in a collaborative process between geologists and geophysicists. By removing barriers to integration at both the data and application level, geoscientists are able to dedicate time to high-value interpretation activities. E&P