Can the Workstation Bring Geology Back to Life?
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In 2005, former AAPG Distinguished Lecturer Cindy A. Yeilding began giving a popular talk at local geoscience society meetings entitled, “Is the Workstation ‘Killing’ Geology?” Subsequently, the AAPG Explorer published a lively interview with Yeilding, and she presented her paper again to a much larger audience at the 2006 AAPG Annual Convention.

Is digital technology killing geology? It’s a great question.

Back then, geologic workstation developers lacked a convincing response. But times have changed. Four years later, Landmark Software & Services released its new DecisionSpace® Desktop unified workspace for multi-domain asset teams, which incorporates revolutionary Dynamic Frameworks-to-Fill™ technology designed specifically for geologists. At Landmark, we believe new technologies like this begin to answer a number of Yeilding’s most compelling objections to digital systems for geologists.

No, the workstation isn’t killing geology. We believe, in fact, that it’s bringing geology back to life. Economically, the timing is opportune.

Not long ago, former AAPG President John Lorenz strongly endorsed a remark made by Dr. Kirt Campion of Marathon Oil: “When times get tough, there is less margin for error. Therefore, we should be putting more geoscience into understanding plays, not less.” Good geoscience, added Lorenz, maximizes recovery and minimizes “the amount of money spent unproductively.”

Objections to the geological workstation

Cindy Yeilding—an exploration, operations, development and production geologist with BP in Houston—was one of AAPG’s Distinguished Lecturers in 2002-2003. A well regarded explorationist, Yeilding had led the team that discovered Thunder Horse in the deepwater Gulf of Mexico. Graduating in 1984 with her master’s degree in geology from the University of North Carolina, Yeilding’s career began in the days of paper mapping, and continued through the advent of 3D seismic interpretation on the workstation and the arrival of software intended for geologists. When she presented her talk “Is the Workstation Killing Geology?” in 2005 and 2006 (Fig. 1), she didn’t actually think the answer was “yes.” However, she did have serious questions about the limits of digital technology, and how geologists were applying it. Let’s take a quick look at some of the issues she raised.

Shortcutting first principles.

One of Yeilding’s key questions was: given the amazing speed and visualization capabilities of modern digital workstations, do geoscientists “sometimes lose track of some of the basics,” and shortcut the geology they knew back in the days of colored pencils and paper, light tables, rolls of Mylar and big, shared workrooms? The software and digital working environment, she noted, had failed to “recreate best practices” based on the “first principles of geology” that we all learned in school. As a result, she encouraged geologists to “keep some of those classic texts nearby,” and to challenge the geological workflows foisted on them by then-current software programs, while reexamining their own day-to-day behavior.

Risking inaccurate structural mapping.

One of the problems she cited was that digital mapping packages could generate “aesthetically pleasing” maps more rapidly than ever before. However, they are “not always geologically valid.” For example, she said, sometimes fault patterns and contours do not adhere to the first principles of structural geology—a situation that creates the danger of drilling what she called “dumb” wells. How can we ensure our nice-looking digital maps are accurate?
Lacking robust stratigraphic interpretations. “Some things are missing,” she also noted. One significant gap in conventional software offerings was the ability not just of mapping structures properly, but also of making “robust stratigraphic interpretations.” To pull it off, geologists often had to “fool the software,” or resort to colored pencils and Mylar. “We spend quite a bit of time mapping horizons,” she stated, “but it is much more difficult to capture observations and interpretations of strata between these horizons.” And we forget, she added, that seismic is not geology; it’s an interpretation — “though it reflects some aspects of the geology, it rarely shows the full picture.” We cannot afford to forget about the rocks.

Getting hung up on a single subsurface model. Finally, she observed that when geologists use the computer—especially in today’s cubicles with little collaborative interaction among colleagues—they tend to get hung up on a single interpretation, rather than exploring multiple models that honor all the data.

While Yeilding felt the technology was “not quite there yet” in 2006, she was nevertheless optimistic that one day geoscientists would be able to “create, iterate, collaborate, challenge and capture our projects in a completely digital framework.”

Bringing geology back to the workstation
At Landmark, we think the day Yeilding hoped for has arrived. The 2010 release of Landmark’s integrated DecisionSpace Desktop workspace for multi-domain asset teams includes remarkable new interpretation and mapping technologies (Fig. 2). With new tools, geologists and geophysicists can recreate best practices in the digital environment based solidly on those first principles of both structural geology and stratigraphic interpretation that Yeilding so strongly emphasized. This could, we believe, have a revolutionary effect on the field—and the future—of exploration and operational geology.

As software developers, we agreed with Yeilding’s assessment. We saw how traditional workstation software had failed to leverage critical geologic principles and practices that generations of geoscientists had relied on. With a personal background in exploration geology and expertise in sequence stratigraphy, our development team sought to address the shortcomings we saw in digital geology. New technologies today offer operational geoscientists—not just reservoir modeling specialists—powerful and practical tools to build accurate multi-surface structural and stratigraphic frameworks while they are interpreting. As such, the digital workstation is beginning to answer a number of Yeilding’s main objections.

Returning to first principles. To generate superior 2D maps and 3D geologic frameworks, the new software leverages classic geologic concepts we all learned in school—fundamental principles found in books such as Tearpock and Bischke’s Applied Subsurface Geological Mapping. This is a good example of those “classic texts” worth keeping nearby, as Yeilding advised. A big problem with many geologic software programs has been that they never really incorporated proper geometric techniques, the kinds used in the paper-based methods of the ’70s and ’80s. The flip side is that sophisticated applications capable of accurately modeling faults, structural surfaces, stratigraphic discontinuities, and complex three-dimensional intersections between surfaces have been too arcane and impractical for mainstream geoscientists to use.

Fig. 2. Today, new Dynamic Frameworks-to-Fill™ technology, designed specifically for mainstream geologists, offers compelling answers to Yeilding’s key objections to digital geology.
in routine interpretation. Dynamic framework construction overcomes both of these problems by combining first principles with elegant new tools, automated processes and ease of use.

The concept of “conformance” is an example of a classic geologic principle built directly into the new software to help geologists correlate well logs, pick discontinuities and project surfaces more accurately. While correlating logs and building cross sections, experienced geologists often apply the idea of conformance as a guiding principle. This classic concept acknowledges—based on considerable experience—that chronostratigraphic units comprising sedimentary basin fill tend to be relatively parallel or conformable with one another. Clear exceptions do exist in slope settings and basins with rapidly changing subsidence rates. Nevertheless, conformance is a powerful first approximation geologists routinely assume when they are correlating logs.

It provides, in fact, the basis for identifying faults and unconformities (Fig. 3). For example, geologists can infer missing sections and likely fault locations in wells where correlations from adjacent wells display convergent patterns. Similarly, they can identify stratigraphic discontinuities by noting angular, non-conformable relationships between two “sets” of conformable correlation patterns above and below a particular surface.

Framework building software leverages this powerful concept through a new tool we call “conformance technology.” Just as structural geologists apply the concept of conformance to build cross sections from outcrop data, explorationists can use it to “guide” or shape the geometry of poorly-sampled surfaces using well-sampled reference surfaces, such as seismic horizons (Fig. 4). Conformance technology allows geologists to establish “top-down” or “bottom-up” relationships between reference and target surfaces. This classic approach enables them to map and model multiple surfaces in a more robust and consistent manner than conventional geologic software.

The application of first principles such as conformance, therefore, is bringing classic geology back to the digital workstation. Creating valid structural frameworks and maps. As Yeilding and many other geologists have observed, creating geologically valid structure maps in the vicinity of faults and unconformities can be very difficult. Why? Because mapping algorithms must be instructed to recognize the boundaries of these discontinuities, and then to grid the data independently within each structural or stratigraphic domain. Conventional mapping systems find this difficult for two main reasons. First, it is technically challenging both to recognize faults and unconformities and to properly segregate and grid the data by domain. Second, with sparse data and multiple fault blocks, often insufficient control is available to properly model the shape of surfaces within each block.

Dynamic framework tools solve both of these classic problems by seamlessly integrating conformance technology with an advanced topology engine. The topology engine automatically detects the intersections between fault planes and target surface data, properly segregating data that must be gridded independently within each fault block. And conformance technology overcomes the problem of sparse data within a fault block.

Consider the following example (Fig. 5): a shallow structural surface is well-sampled by seismic, while deeper events are penetrated by only one or two wells per fault block. Conventional gridding of the seismic and well tops by fault block yields geologically unreasonable relationships between surfaces (5a). Applying conformance to the well top surfaces, using the seismic horizon as a reference or guiding surface, generates geologically valid relationships (5b). Finally, advanced topology tools effectively segregate the data by fault block, independently grid the
surfaces, then trim and seal each one properly against the fault planes (5c). Combining conformance with topology technology enables geologists to construct multi-surface 3D structural frameworks with just a few button clicks.

Furthermore, framework building techniques promise to revolutionize existing approaches to structural mapping. Why? Because generating high-quality maps is now a simple byproduct of multi-surface structural framework modeling. Assuming geologists carefully interpret all available subsurface data and set up proper conformance relationships, the technology will produce geologically and topologically accurate maps directly from the 3D framework—in a fraction of the time required by traditional mapping workflows.

Building robust stratigraphic interpretations. The same tools that empower geologists to build consistent structural frameworks can also enable them to build “robust stratigraphic interpretations,” as Yeilding wished—even in the vicinity of unconformities? Here’s how: First, after geologists identify an unconformity surface, they can use “bottom-up” conformance. This involves applying conformance upward to a series of well-top surfaces, from an established reference surface below the unconformity, then projecting those conformable surfaces through the unconformity (Figure 5b). Finally, the topology engine trims projected surfaces and properly seals them against the unconformity, creating a geologically sound stratigraphic framework (5c).

Stratigraphic interpretation requires more than constructing an overall sequence stratigraphic architecture. To this day, many geologists copy cross sections and/or seismic panels into drafting packages to interpret depositional facies between horizons. Dynamic framework building technology offers easier, more integrated methods of interpreting facies and interpolating or extrapolating them between wells. Now geologists can fill the stratigraphic framework with facies modeled using geologic rules derived from classic facies patterns. How? First, by interpreting facies in cores and well logs. Second, by associating those facies interpretations with one of 40 familiar depositional system models (Fig. 6).
seamlessly integrated with the geologic software. Derived from classic facies textbooks such as Walker and James’ Facies Models, these facies templates or palettes are comfortable and intuitive for geologists to apply. Each template includes geologic rules that define horizontal and vertical relationships among facies, which additional modeling tools use to constrain the distribution of facies between wells. As a result, geologists can leverage facies interpretations on a field or regional scale within the context of a robust stratigraphic framework.

**Investigating multiple subsurface models.**
Yeilding also worried about the tendency of geologists to get hung up on one interpretation or model, due to the limitations of traditional workstation software. Conventional tools required users to spend enormous amounts of time integrating and quality-controlling all the surfaces, faults and associated property maps. Making a single adjustment meant redoing a lot of hard work. However, this proved so impractical in most software packages that geoscientists naturally resisted changing their interpretations, as Yeilding observed.

The new interpretation technology is different. Its multi-surface 3D frameworks update instantly and automatically as new wells are drilled, new insights arise and new interpretations are made. Changes visibly ripple through the framework whenever new data are added. It is no longer necessary to individually regrid and contour a half dozen maps every time a new top, horizon or fault is picked. The ease and speed with which 3D structural and stratigraphic frameworks can be created and updated enables geoscientists to investigate multiple subsurface interpretations, if they wish, without feeling forced to settle for a single model based on time or trouble.

**This is just the beginning**
These are just a few examples of how the modern workstation is bringing geology back to life. Other workflows based on dynamic framework construction allow geologists to carry out reservoir characterization with fracture mapping, calculate reliable volumetrics, and feed multi-surface 3D frameworks with real-time drilling data to assist complex geosteering operations.

Sophisticated new technology designed for mainstream operational geoscientists represents the beginning of a genuine breakthrough or “revolution” in digital geoscience workflows. It is no longer necessary to “shortcut the geology” in order to work in a collaborative digital environment. It is no longer necessary to abandon “first principles” just to meet a deadline. It is not even necessary for geologists to let seismic data have the final word! As Cindy Yeilding observed, “seismic does not reflect (no pun intended) all the characteristics of a reservoir and its producibility.”

At Landmark, we are convinced that today’s workstation software makes it possible, for the first time, to “create, iterate, collaborate, challenge and capture our projects in a completely digital framework.”
References


