Hydrocarbons from shale were first produced commercially as long ago as 1821, and from the 1860s through the 1920s gas was produced from shallow, low-pressure, naturally fractured shales in the eastern US. However, today’s shale “revolution” did not really begin until 1985. That is when George Mitchell started developing a model for economically viable exploitation of the Barnett Shale. It took almost 20 years and literally hundreds of wells to find the right formula, based on two transformative technologies: horizontal drilling and multistage hydraulic fracturing.

Shale 1.0: The Quest for Operational Efficiency
Since roughly 2005—the beginning of what I call Shale 1.0—we have successfully revived old shale plays and developed new ones based on Mitchell’s model. Every year, North American companies complete thousands of wells in shale reservoirs. However, even in mature plays like the Barnett where productivity per well has doubled or tripled over the past decade, as many as 30% of all perforation clusters contribute absolutely nothing to production. That is the same as drilling 30 totally nonproductive wells out of every 100. To improve shale economics, operators and oilfield service companies have focused considerable brainpower and technical resources on reducing the unit cost of production through greater operational efficiency.

In many cases, we have brought drilling and completion costs down 50%, largely through application of new technologies, efficient project management, and supply chain negotiations. In some cases, advanced drilling technologies, automation, and real-time data have slashed average time to total depth from 48 days to just eight. Not all new technologies are exotic. For example, installation of rupture disk valves—which replace coiled tubing or drill pipe-conveyed perforations for the first stage in horizontal wells—reduced completion costs in 15 Eagle Ford wells by more than USD 100,000 per well.

The shale revolution has yielded many economic and social benefits, including growth in jobs and local businesses across the US, lower domestic energy costs, reduced CO₂ emissions, and—perhaps most important—access to a new national resource that holds enormous potential for long-term energy security and independence.

According to the Institute for Energy Research, the US has more than 200 years’ capacity of technically recoverable oil reserves and 110 years’ worth of natural gas at current rates of consumption, much of those from unconventional plays. In fact, shale oil is leading the current growth in US crude production. The US Energy Information Administration conservatively predicts global shale oil production will reach more than 4 million BOPD by 2030. Other analysts double that estimate.

The obvious benefits of the shale revolution in the US have sparked the industry’s imagination worldwide. Many nations are scrambling to evaluate their own shale resources. However, development strategies pioneered here in North America—often at great cost—may not translate well overseas. While the industry has made enormous gains in efficiency, we may be reaching our technical limits. Even
highly efficient shale operations today still require large numbers of wells; considerable environmental disturbance during the development phase; extensive services and resources per well; and complex management of water, emissions, and permitting.

Many of these requirements are problematic elsewhere in the world. For one thing, no other country on Earth has the sheer scale of oilfield resources and infrastructure as North America. A single pad operation in the Fayetteville, for example, could assemble more horsepower than entire countries have in other parts of the world. In addition, the tolerance for failure is much lower outside the US. Few national or international operators are willing to drill hundreds of expensive experiments before they achieve economic production. Finally, as characterization work and experience has taught us, every shale is fundamentally different. From a technical perspective, what works in one place may not work elsewhere, even in the same play, much less across the globe.

For unconventional resource development to advance worldwide—indeed, to achieve the next step change even in US shale economics—we must shift from an obsession with well-centric efficiency to a concentration on reservoir-centric effectiveness. It’s time, in other words, for Shale 2.0.

Shale 2.0: The Coming Revolution in Effectiveness

If operational efficiency means doing the same things faster and cheaper, effectiveness entails doing things differently as well. To unlock shale plays worldwide, we need to change the game itself, to eliminate every task and every well that does not contribute directly to production. We must “upgrade” the Shale 1.0 model. How? By understanding the rock first—before we drill 100 or 1,000 wells. That’s what I mean by Shale 2.0. We must take a more scientific, less statistical approach to shale development.

We must understand early on the unique reservoir and completion quality of each shale. Reservoir quality refers to how shale stores and transports hydrocarbons. Completion quality refers to how mechanical properties, local stresses, and regional tectonics impact hydraulic fracturing. Heterogeneity—vertical and lateral variations in reservoir and completion qualities within a given shale—also has considerable impact on productivity. Only with this knowledge will we be able to plan, drill, land, geosteer, stimulate, and produce shale wells more effectively, saving vast amounts of time and money in the process.

The secret lies in better integration of diverse information and tighter collaboration among disciplines that historically focused mainly on their piece of the puzzle. Operators and service companies must begin to access, integrate, and utilize every bit of data available, at every scale from core to seismic, to understand reservoir complexities in sufficient detail to design optimal pilot wells and make effective development decisions. While people are crucial to success, new technology and integrated software platforms will be essential enablers as well.

Consider multistage completion design. Assuming we have successfully remained in the sweet spot along the horizontal lateral, an efficient, well-centric approach to completions would aim to lower per-stage costs, while spacing fracturing stages geometrically—that is, at equal distances along the lateral. In this scenario, some perforation clusters would not fracture sufficiently because rocks of dissimilar quality are staged together, and the better rocks dominate each stage. An effective reservoir-centric strategy, on the other hand, would integrate geological, geophysical, petrophysical, and geomechanical data and simulation models to measure variations in reservoir and completion quality along any proposed lateral. Based on these properties geoscientists and engineers would group perforation clusters into stages that fracture equally and contribute proportionately to production.

Both completion design strategies might use the same number of stages. However, an engineered approach could dramatically increase production and maximize return on investment. In one Eagle Ford field, for example, the average 3-month cumulative production from laterals completed with geometrically spaced fracturing stages was roughly 30,000 BOE per well. Switching to geologically driven completions, optimized based on variations in reservoir and completion quality, boosted average 3-month cumulative production by about 15,000 BOE per well—a whopping 50% improvement in this particular case. Remember that 30% of the completion clusters in many mature shale plays are nonproductive. This is one way to begin rewriting that equation.

The ultimate objective of Shale 2.0 is to unlock the rock as quickly as possible, and then not to forget all that we have learned about operational efficiency to drive down costs and accelerate production. When we become efficient and effective, we will achieve far greater production with fewer wells and fewer total resources.

Unlocking Shale Plays Worldwide

However informative the North American industry’s hard-won experience may be to shale development initiatives abroad, simply exporting the Shale 1.0 model will not be effective. Every shale play, indeed every reservoir, is structurally, compositionally, and geomechanically unique. From a reservoir-centric perspective, each shale requires its own development strategy based on a unique combination of analysis, interpretation, drilling, and completion technologies. Even when an international shale play is lithologically similar to one in the US, other critical properties may differ dramatically.

Consider, for example, a key component of shale productivity: the impact of local and regional stresses on fracture propagation. Most of the unconventional plays in the US occur in relative-
ly relaxed continental basins, although even here stress regimes vary significantly from the mid-continent to the Appalachians. China, which has perhaps the world’s greatest shale potential, is under a completely different stress regime, with the Indian subcontinent driving up the world’s highest mountain range in between.

In Argentina, another nation with promising shale resources, yet another set of tectonic forces is at work, lying as it does between a passive continental margin to the east and a subduction zone to the west. Elsewhere, such as the Middle East and Russia’s Bazhenov shale, conventional development activities are providing vital geomechanical insights into the regional tectonics of source rocks that will help unlock those plays in the near future.

Understanding the rock, therefore, is the first and most critical key to effective shale development worldwide.

In the absence of the “perfect storm” of technical infrastructure, market conditions, regulatory environment, and oilfield services we have in North America, economic success in shales worldwide will depend on new technologies and drilling, perforating, and stimulation strategies tailored to the unique properties of each reservoir.

The good news is that, as an industry, we have proven capable of rising to the challenge, no matter how complex. The next stage in the global shale revolution—Shale 2.0—has just begun.