Introduction to this special section: Resource plays I: Rock physics

Mosab Nasser[1], Lev Vernik[1], and Per Avseth[2]

When we began to soliciti papers for this special section of *The Leading Edge* on "Resource plays I: Rock physics," we debated among ourselves the definition of *resource plays* and what articles we should be looking for. We also searched for how others define the term *resource plays* and have come to realize that it is more of an economic term associated with volume and risk rather than its geologic characteristics.

One definition we found is "a large deposit with low development risk." This definition did not exclude oil sands. However, if development has started, then the deposit is no longer classified as a resource play, according to this definition. Another definition we found is "an estimate of the amounts of oil and gas that are believed to be physically contained in a source rock." The latter differs from the definition of proven reserves: "an estimate of the amount of oil or gas that can technically and economically be expected to be produced from a geological formation." There were many other definitions, including those that related the term *resource plays* to the positive impact it had on the stock prices for companies that used it — the term *play*, in this context, means widespread and low risk.

There is another geologic definition: "Hydrocarbon systems where the source and reservoir are the same rock unit or formation; these source-reservoir units are generally continuous and represent areas of organic matter preservation as reflected in organic richness." According to this definition, which we have chosen for the purposes of this special section, resource plays are essentially shale reservoirs (a generic term frequently applied to many resource plays) in which all of the requisite petroleum system elements (i.e., source rock, reservoir, and seal) are present.

To exploit shale reservoirs effectively, we must characterize each of these basic petroleum system elements separately as well as understand their relative interdependencies. Resource plays are expected to offer the potential for substantial increases in the stock of hydrocarbon resources worldwide, and the successful shale-gas and shale-oil revolution in the United States is evident in the current U. S. energy portfolio. According to recent reports, it has propelled the United States to the position of number-one liquid producer in the world. This is largely because of the growing understanding of self-resourced reservoirs, advancement in hydraulic fracturing, and horizontal-drilling technologies developed for shale reservoir systems.

Moreover, geologists, geophysicists, and engineers are coming to realize that unconventional shale reservoirs are remarkably different from the conventional ones and that those differences have a substantial impact on how hydrocarbons are generated and what technologies to use for mapping and extracting them. For example, conventional seismic-exploration methods used for imaging subsurface structures are rarely important in shale plays because the structures are generally simple. However, the critical issues usually are centered on reservoir characterization such as organic richness, crack density and orientation, rock brittleness, mineralogy, stress states, burial history, and pore-network development, including their effects on elastic properties that are still poorly understood. This means understanding these critical reservoir-characterization issues for increasing economic value requires a deeper dive into the rock physics of resource plays.

The articles in this month's special section on "Resource plays I: Rock physics" reflect the need for a better understanding of these self-contained petroleum systems. Topics range from constraining seismic rock-property logs in organic shale reservoirs to modeling anisotropic elasticity in unconventional reservoirs. One significant overall finding is that the main factors controlling organic shale elasticity vary depending on the specific play/location considered.

Yenugu and Vernik describe the generation of petrophysical parameters, such as total organic carbon (TOC), and quantification of total and organic porosities through a physically consistent petrophysical model. They argue that their modeling results on three shale plays from North America show that compressional-wave velocity is controlled mainly by variations in TOC, mineralogy, and pore shape. They also apply shear-wave velocity prediction in organic shales as a function of compressional-wave velocity and amount of TOC.

Sengupta et al. analyze strongly anisotropic compressional and shear velocities in two formations of interest in an unconventional reservoir. They use rock-physics models to explain the anisotropic elastic response of these rocks. Recognizing that there can be many possible sources of anisotropy, they focus on three sources: mineral orientation, layering, and microcracks. They argue that the preferred orientation of clay minerals is the largest and most significant source of elastic anisotropy in shales with elevated clay content.

Avseth and Carcione investigate the rock-physics trends and properties of clay-rich source rocks in selected wells in the North Sea and Norwegian Sea. They show that the properties can vary significantly because of burial compaction, composition, diagenesis, organic richness, and maturation. However, despite the observed variability, they found that data were still nicely bounded by the linear trends proposed by Vernik and Milovac.

Finally, Bredesen et al. demonstrate a seismic screening method based on inverse rock physics that enables them to better discriminate between hydrocarbon-filled sandstones and organic-rich shales in the Norwegian Sea. TLE

[1]Houston, Texas.
[2]Oslo, Norway.

http://dx.doi.org/10.1190/tle34111324.1.