Trabajos de Geología, Universidad de Oviedo, 29 : 58-59 (2009)

Oviedo (Spain) 1-3 July 2008 International Meeting of Young Researchers in Structural Geology and Tectonics
YORSGET

Future of structural geology research. An Oil Industry perspective

S. NARUK[1], F. DULA[2] AND M. MORA-GLUKSTAD[3*]

[1]*Shell International Exploration & Production, Inc., P.O. Box 481, Houston, TX 77001, U.S.A.*

[2]*Shell Exploration and Production Company, 200 N. Dairy Ashford Street, WCK-7456 Houston, TX 77079, U.S.A.*

[3]*Shell International Exploration & Production, Inc., B.V., Kessler Park 1, 2288 GS Rijswijk, The Netherlands.*

[*]*e-mail: Miguel.Mora-Glukstad@shell.com*

Keywords: structural geology, oil industry, hydrocarbon exploration, seismic data, new technology, research.

For the past two decades, three-dimensional seismic data have dominated the hydrocarbon exploration and production industry, largely supplanting geology, particularly structural geology. The 3D seismic data make it possible to literally see faults and folds in three dimensions, down to the scales of a few tens of meters, and frequently smaller. Stratigraphic features such as valleys, channels and turbidite fans can typically also be seen in many data sets. Minute differences in fluid densities and rock porosities make it possible in many cases to determine the pore-filling fluid types (i.e., oil vs. gas vs. brine), their levels of saturation, and even their fluid pressures. With these capabilities, industry research focused on maximizing their potential.

These capabilities are not unlimited, however, and industry is beginning to come up against those limits. The above, easy, "amplitude supported" plays are largely exploited. The future of the oil and gas industry lies in ever more complex traditional plays, most of which make seismic imaging physically impossible because of difficult terrain, steep bedding dips, velocity inversions, etc. The future also lies in frontier basins, where there simply is little or no data, and geologists must make predictions based on that sparse data, a few 2D seismic lines and surface geologic maps, for example. Further into the future, the industry will become more deeply involved in unconventional plays, tight gas sandstones, shale gas, etc., where the ability to predict fractures, including their orientations, and intensities, is essential.

The current state of the art of structural geology is not adequate to solve these problems. The same 3D seismic data described above show that even simple structures are often far more complex than our current theories can describe. For example, core data commonly exhibit small faults and deformation bands in rocks and sediments that appear to have never experienced the shear stresses required by accepted failure criteria. Deepwater gravitationally driven foldbelts exhibit styles of faulted detachment folds not described by current theories or physical models. Examples of active, critically stressed faults are observed to both leak and seal.

To solve these problems, a renaissance in structural geology research is required, but one which takes maximum advantage of all the new data that are being acquired by modern technologies. Seismic velocity data, wells, logs, core, vertical seismic profiles, and pressure transient analyses, for example, enable deduction of the levels of detail that the seismic does not image -e.g., where the small scale faults and fractures are, and what their effective properties are. Micropaleontology and advances in isotopic geochronology enable us to infer rates of displacement, deformation and uplift/subsidence that were until recently unconstrained. Construction of synthetic seismic models of outcropping analogs, and even physical modeling analogs, enable us to quantify how the subseismic details influence the seismic picture. Discrete element modeling is beginning to enable us to build geologically realistic models of the details of fault zone architecture. Downhole gauges record information that provides a unique knowledge of pressure variations that can provide unique clues of barriers within producing fields. Geomechanics has to be the next forefront in structural geology research, to provide the additional constraints that geometry and kinematics do not. However, fundamentally new failure criteria are required before we can rigorously apply geomechanical constraints. New techniques need to be applied at all scales, from pore throats, micro-fractures and micro-stresses, to plate tectonics dealing with mountain belts, lithosphere isostatic rebound, and plate reconstruction models.

In this challenging business environment, Shell is committed to investing heavily in structural geology research, to stay at the forefront of technology and the global EP business. Shell geologists are on the ground in more than 100 countries, contributing to daily production exceeding 3 BBOE (Billions of Barrels of Oil Equivalents). Technical excellence is consciously perceived and actively pursued as a business competitive advantage. In addition to carrying out their own research, including traditional field work, Shell staff fund and steer research in some of the most prestigious universities in the world. We carry out our own research, and we strongly believe in learning from the field, from the rocks, from the outcrops.

In summary, industry's exquisite 3D seismic data led to the neglect of structural and other geologic research over the past two decades. At the same time, however, that and other related data have yielded many new observations that require fundamental new developments in structural geology. With industry rapidly approaching the inherent physical limitations of that seismic technology, Shell's corporate philosophy is that those new observations must be used to advance our fundamental understanding, to stay on top of the business.