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About Geophysics, Geology, and Regional Hydrocarbon Systems

A Discussion that Contrasts the Gulf of Mexico with Northeastern Venezuela

Comparing and contrasting the Gulf of Mexico with northeastern Venezuela illustrates the importance of regional geology, based on the integration of old-fashioned surface geology with modern subsurface geology and interpretation of regional seismic reflection profiles.

The Gulf of Mexico and northern Venezuela both formed as Mesozoic passive margins connected with the North Atlantic and were initiated by a Late Triassic–Jurassic rifting phase followed by the deposition of widespread evaporites limited to the Gulf of Mexico. By Mid–Cretaceous times, the whole area formed part of the Tethys carbonate passive margin. Important hydrocarbon source bed intervals were formed during the Jurassic and Cretaceous in the Gulf of Mexico. In Venezuela, however, the main source bed is the Upper Cretaceous La Luna formation, which is less prominent in the Gulf of Mexico.

Beginning with the Senonian, the Gulf of Mexico and Venezuela followed widely different plate tectonic evolution, leading to a great variety of hydrocarbon systems and traps. Thus, the northern Gulf of Mexico developed into one of the world's largest petroliferous siliciclastic depocenters, characterized by complex growth faulting and some of the most spectacular salt tectonics ever observed. However, the western Gulf of Mexico was incorporated into the Paleogene and Neogene folded belt of the Sierra Madre in the north, the Neogene folded belt of the Sierra de Chiapas–Campeche in the south, and the uplift of the Mexican plateau. Both fold belts are conjugate to the east-dipping subduction zone that was active on Mexico's west coast.

Northern Venezuela developed in an overall transpressional setting related to relative eastward indentation of the Caribbean plate. This process led to the basement-involved compressional Neogene uplift of the Western Andes and the décollement folded belts of the Cordillera de la Costa and the Serrania del Interior. An eastward migrating Upper Cretaceous–Paleogene–Neogene foredeep was associated with the relative eastward displacement of the Caribbean plate. Toward the Orinoco delta, the foredeep merged with the preserved Atlantic margin. The northern Venezuela offshore is characterized by extensive transtensional faulting related to complex strain partitioning associated with the Bocono-El Pilar strike-slip fault system, and the boundary zone of the Caribbean and South American plates.

A comparison of the Gulf of Mexico with northern Venezuela illustrates that model earth systems of the future will have to link phenomena that occur at widely differing scales; this can be achieved with the help of integrated regional geological studies. In this context, the role of regional 2D and 3D reflection seismic surveys are the cornerstones for an in-depth understanding of hydrocarbon systems.

This brings us to the important role of 3D regional seismic surveys. I believe that the future of regional tectonics be completely recast when regional seismic 3D surveys become available for study to a larger community. Exposure to industry 3D data sets in several areas of the world leads me to conclude that discordantly superposed tectonic levels are ubiquitous. Typically, higher, relatively brittle levels are separated from discordant lower brittle levels by overall more ductile levels. Of course, in some cases, unconformities separate different tectonic domains, but more frequently, the discordant configuration of different levels appears to be due to vertical strain partitioning and/or the influence of paleostructures. In the long run, we are going to have to parlay seismic attributes into relative ductilities that respond to suites of different coeval stress orientations for each layer.

Furthermore, there is also a great need for (1) regional and supraregional time slices (i.e., composited mosaics of adjacent 3D surveys) and (2) regional seismic stratigraphic correlation sections connecting the structurally least-disturbed portions of the sedimentary basins (and if possible, tied to deep wells). All these are necessary to ensure common standards and a common language among, and often between interacting, competitors.⇒

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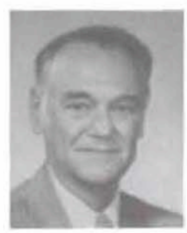
The availability of a practically unlimited number of time slices to great depths, often in excess of four or five kilometers, amounts to the equivalent of an unlimited number of geological maps, which need to be interpreted as maps. Thus, the ability to read geological maps is of critical importance. Unfortunately, I find the map-reading ability of graduate students often deficient, and wish our schools would do a better job in this area. Thus, in the training of students, the understanding of scientific principles must be complemented with renewed training and versatility in geologic map reading if we are ever going to fully exploit 3D seismic data sets.

Also, in the same context, seismic contractors will need to explore more aggressively joint projects with researchers in academia. Many operators in industry, due to their evident inability to forecast oil price fluctuations, are periodically economically overstaffed while remaining technically understaffed. Consequently, they are unable to fully exploit the scientific message—and with it a great part of the new play potential—contained in these huge but under-interpreted 3D seismic data banks. The will to cooperate with academia certainly exists on the industry side, but, unfortunately, a reasonable understanding of the industry's perspective and constraints is often lacking in academic institutions.

There is much talk about teamwork today, as if teamwork did not exist before. There is also much talk about geological systems with dreams that go well beyond the exciting geographic information systems of today. Only teams can further develop these geological systems. Teams do not need dictators, but leaders akin to inspirational orchestra conductors. Above all this, teams need steadily evolving institutions and a modicum of staff stability and continuity. All of these are indispensable for both the development of geological exploration systems and creative teamwork.

Biographical Sketch



Albert W. Bally is Emeritus Professor of Rice University. In 1952, he obtained his Ph.D. degree from the University of Zurich in Switzerland. His thesis project was in the Central Apennines of Italy. After a year of postdoctoral work at the Lamont Geological Observatory of Columbia University, he joined Shell Canada in Calgary. In 1966, he was transferred to Houston to become manager of geological research at the Shell Development Company. He advanced to become chief geologist and senior exploration consultant for the Shell Oil Company. Between 1981 and 1996, Dr. Bally was the Harry Carothers Wiess Professor of Geology in the Department of Geology at Rice University. □

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