ABSTRACTS OF PAPERS

Keynote address 1

Plate tectonics and petroleum habitats

DAVID G. HOWELL
U.S. Geological Survey, Menlo Park, CA 94025

Numerous basin classification and basin formation schemes have been offered in the literature to define the habitat of petroleum occurrences. Many classifications are seemingly tailored to specific settings while others are intended to be global in concept. Classifications based on plate tectonic settings are useful in explaining how basin geometries, kinematic histories and dynamic forces are mutually integrated. Using the U.S. basins as a template, and looking at basins world-wide, one sees how late tectonic processes affect the development of petroleum habitats.

CONVERGENT SETTINGS: The foreland basins of the Rocky Mountains and the various foreland settings cratonward of the Appalachian–Ouachita–Marathon orogen reflect the two most common types of hydrocarbon settings stemming from convergent tectonics. For the first type, convergent stresses are transmitted within the lithosphere a long distance from any plate margin; other examples world-wide include Tarim, Jungar, Ordos, Sichuan, Neuquin, Oriente, Ebro and Aquitaine basins. The second type of convergent basins are those that lie along plate margins and reflect collisional tectonics; examples world-wide include foreland basins regions of Persian Gulf, Ural–Volga, North Slope, and sub-Andean basins.

Source rocks of intermontane basins are generally, but not exclusively, organic-rich lacrustrine debris that accumulated contemporaneously with basin subsidence. Conversely, plate-margin forelands are generally built across an older passive margin containing immature, organic-rich marine strata that accumulated prior to the episode of convergent tectonics. In most foreland basins, expelled oil and gas may migrate into the fold and thrust portion of the orogen, but the largest accumulations of oil occur near the peripheral bulge on the continent side of the foreland basin. Where foreland basins are superposed over preexisting deep basins, major gas plays exist. Examples include preexisting aulocogens, such as at Anadarko, and preexisting rift basins, such as at the Qatar play.

A third, seemingly anomalous, convergent-type basin is the so-called impactogen. These basins lie some distance away from regions of collision, on either the upper or lower lithospheric plates, and are oriented parallel to the direction of maximum stress; i.e. crustal extension is perpendicular to the direction of convergence. Lake Baikal (north of the Himalayan orogeny) and the Rhine graben (north of the Alpine orogen) are examples, albeit, neither are prolific hydrocarbon habitats.

RIFT SETTINGS: The Gulf of Mexico represents a continental rift basin; other examples world-wide include Campos, Niger delta, Sirte, Brunei, Sabah and South China Sea. The numerous basins that lie within the archepelagic setting of the southwest Pacific, bounded by the islands of Palawan, Hainan, Sumatra and Timor, reflect a complex interplay of microplate tectonic processes; nonetheless, the oil-rich basins of eastern Sumatra and Java, Malaya and West Natuna, Tarakan, Brunei and Sabah entail rifting of continental crust.

Source rocks accumulate in anoxic silled troughs during early phases of rifting. Salt, another rock type formed during the early phases in rifting is an important element making up seals and contributing to structural closures as the salt becomes allocthonous. Other trapping mechanisms are associated with rift-related structures and the displacement of gravitationally unstable sediments that accumulate during the drift phase of rifted margins.

Rifting is also responsible for continental sags, such as the Illinois basin or the West Siberian basin. These basins overlie regions of aborted continental rifting during which the lower crust was tectonically thinned and invaded by dense mantle material, both processes effecting regional subsidence within the craton.

TRANSCURRENT MARGINS: The basins along the California margins reflect the formation of basins associated with transform motion between two plates; world-wide other examples include the Bohai and Dajing basins of eastern P.R. China. Crustal thinning attendant with transpressional tectonics result in rapid subsidence. These basins are commonly sealed, promoting the accumulation and reservation of source rock. With minor changes in plate motion or where faults bend the crust may be exposed to transpressional forces which create structural closures as the basins event.

In summary, the formation of basins and associated petroleum habitats can be fully explained in terms of the fundamentals of plate tectonics, and of all the basin types, plate-margin foreland basins are the most prolific hydrocarbon settings. In these basins, the organic-rich source rock are deposited prior to the continental collision. The effects of the younger collision result in both foreland sedimentation, which stimulates petroleum maturation in buried sediments, and the architecture of foreland basins, which provides a safe haven for huge accumulations of both oil and gas. In all of the other basin types, either reflecting intracontinental convergence, continental sags over aborted rifts, continental rifting or tranlational motions, the oil habitat, from source to reservoir, is wholly within the formation cycle of the individual basins.

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