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Tectonic Setting of the World's Giant Oil and Gas Fields

The world's 877 giant oil and gas fields are those with 500 million bbl of ultimately recoverable oil or gas equivalent. Remarkably, almost all of these 877 giant fields, which by some estimates account for 67% of the world's petroleum reserves, cluster in 27 regions, or about 30%, of the earth's land surface (Figure 1). In this talk, I present maps showing the location of all 877 giants located on tectonic and sedimentary basin maps of these 27 key regions. I classify the tectonic setting of the giants in these regions using six simplified classes of the tectonic setting for basins in these regions: (1) continental passive margins fronting major ocean basins (304 giants); (2) continental rifts and overlying sag or "steer's head" basins (271 giants); (3) collisional margins produced by terminal collision between two continents (173 giants); (4) collisional margins produced by continental collision related to terrane accretion, arc collision, and/or shallow subduction (71 giants); (5) strike-slip margins (50 giants); and (6) subduction margins not affected by major arc or continental collisions (8 giants). For giant fields with multiphase histories, I attempt the difficult task of discriminating the single tectonic event/setting I consider to have the most profound effect on hydrocarbon formation, migration, and trapping. My main classification criterion is the basin style dominating at the most typical stratigraphic and structural level of giant accumulations.

Northsiders *continued on page 25*

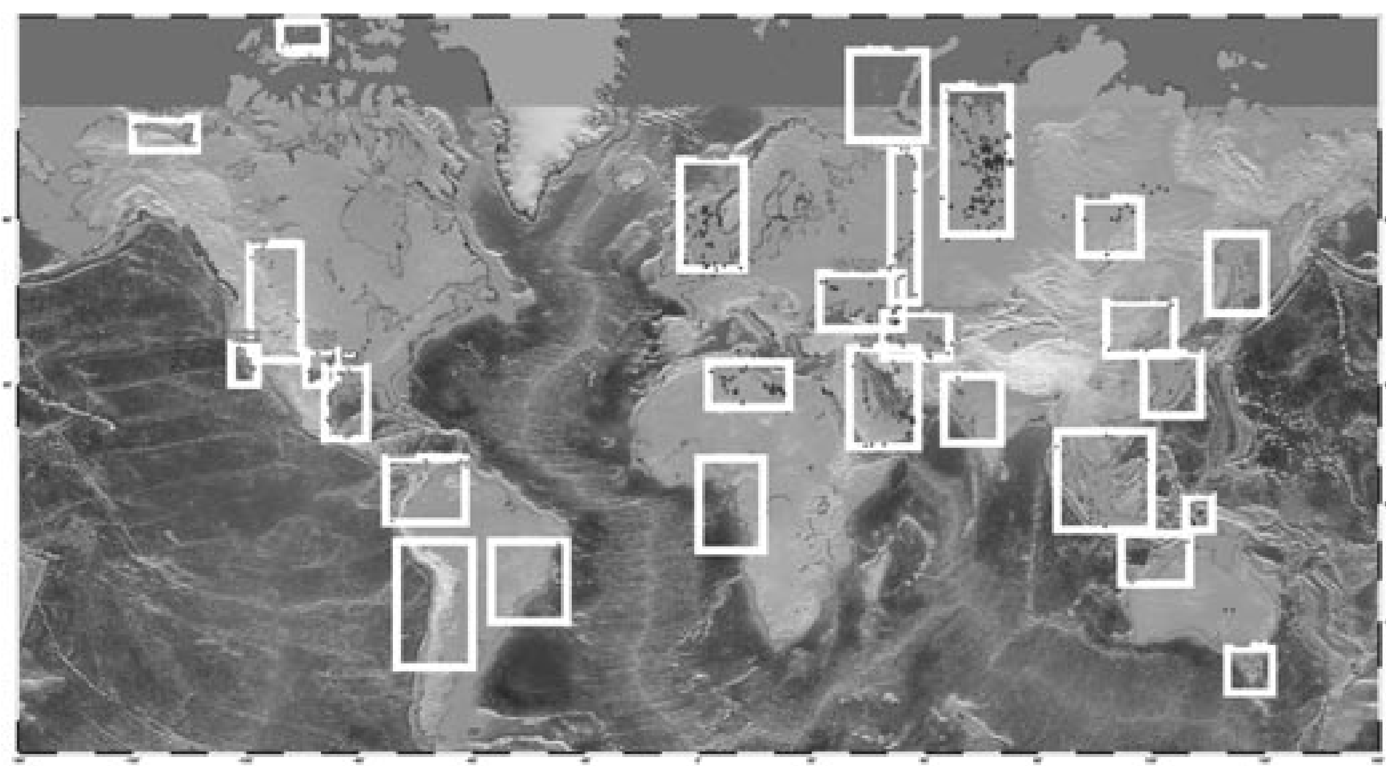

Figure 1. Global distribution of 877 giant oil fields plotted on standard Mercator projection of topographic-bathymetric map of the world generated from satellite gravity data (the satellite's low orbit prevents generation of data in the Arctic region). White boxes indicate regions of concentrated giant oil fields presented in this talk. Six basin types of giant fields on this map are based on our interpretation of the basin type most responsible for the formation of the giant fields in that region.

Continental passive margins fronting major ocean basins form the dominant tectonic setting, which includes 35% of the world's giant fields. Continental rifts and overlying sag basins, especially failed rifts at the edges or interiors of continents, form the second most common tectonic setting, which includes 31% of the world's giant fields. Terminal collision belts between two continents and associated foreland basins form the third setting, with 20% of the world's giant fields. Other setting classes — including foreland basins at collision margins related to terrane accretion, arc collision, and/or shallow subduction; basins in strike-slip margins; and basins in subduction margins — are relatively insignificant, with 14% or less of the total basin population. This tabulation indicates the importance of extensional settings formed during the early and late stages of oceanic opening for giant accumulations: the rift and passive categories combined account for two-thirds, or 66%, of all 877 giants. This result differs significantly from previously published giant classifications in which collisional settings form the dominant tectonic setting for oil giants.

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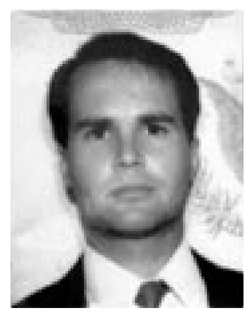
I propose the following possibilities to explain the dominance of extensional rift and passive margin settings over all other tectonic settings: (1) localization of high-quality source rocks in lacustrine and restricted marine settings during the early rift stage, (2) effectiveness of the sag or passive margin section above rifts to either act as reservoirs for hydrocarbons generated in the rift section and/or to seal hydrocarbons generated in the underlying rift section, and (3) tectonic stability following early rifting that allows hydrocarbon sources and reservoirs to remain undisturbed by subsequent tectonic events acting on distant plate boundaries.

Trends in the discovery of giants in the period from 1990 to 2000 that I consider likely to continue into the 21st century include (1) the discovery of fields in deep-water basinal settings along passive margins such as Brazil, west Africa and the Gulf of Mexico associated with nodes of high-quality source-rock areas and stratigraphic traps located using three-dimensional seismic reflection data; (2) continued discoveries of giants in known areas, including expansion of the Persian Gulf hydrocarbon province to the south into Yemen and the Arabian Peninsula and north into Iraq; expansion of the West Siberian Basin in the Arctic offshore area; radial expansion of the Illizi Basin of Algeria; (3) continued discoveries in Southeast Asia, where Cenozoic rift, passive margin and strike-slip environments all coexist around the South China Sea or in the largely submerged Sunda continent; (4) along-strike expansion of elongate foreland trends in the Rocky Mountains, northern South America, the southern Andes, the Ural–Timan-Pechora and Barents Sea, and the North Slope and; (5) expansion of discoveries in the Black Sea–Caspian region associated with closure and burial of northern Tethyal passive margin or arc-related basins.

Despite the association of giant fields with Cenozoic or Mesozoic plate edges (especially failed rifts trending at high angles to continental margins), the possibility always exists for further discovery of "lockbox-type" giants associated with provinces now cratonic interiors, that previously were Paleozoic or Precambrian plate edges, as exemplified by known Paleozoic and Precambrian hydrocarbon giant clusters in the Permian Basin in the United States, the Illizi Basin of Algeria and the Siberian Platform. ■

Biographical Sketch



Paul Mann has worked at the University of Texas Institute for Geophysics for 21 years and is currently a senior research scientist there. He received a BA in geology from Oberlin College in 1978 and a PhD in geology from the State University of New York at Albany in 1983 where his dissertation field areas included Jamaica, Haiti and the Dominican Republic. At the University of Texas, Mann focussed field studies in the circum-Caribbean region, where he was primary supervisor to 14 UT graduate students and two post-doctoral researchers and was co-chief scientist on three marine surveys. He is presently co-leader of an industry-supported synthesis of the tectonics and petroleum geology of the Trinidad area. He has also conducted field work in Kamchatka, the Solomon Islands and Papua New Guinea and was co-chief scientist for two marine surveys of the Solomon Islands. He has edited or co-edited five published volumes on regional geology and tectonics of the circum-Caribbean region and one volume on the marine geology and tectonics of the Solomon Islands. He is currently an associate editor of the *Bulletin of the Geological Society of America* and has held visiting professorships at the University of Canterbury in New Zealand and the University of Nice in France. He invites comments at paulm@ig.utexas.edu.