Regional Structural Styles on Opposite Sides of the Arabian Plate – Their Influence on Petroleum Traps

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ABSTRACT

Most petroleum accumulations associated with the Arabian Plate are an expression of different structural styles. The stable Arabian Plate is surrounded by tectonically highly mobile zones on four sides: While the Red Sea to the W represents an active rift with sea-floor spreading, the Taurus-Zagros-Makran belt to the NE is a SW- to S-vergent contractional belt. Both, the sinistral Dead Sea-Levant system to the NW and the dextral transtensional Gulf of Aden-Masirah system to the SE, are major transform/strike-slip systems. All four boundaries are seismically active due to the NE-ward motion of the Arabian Plate (~20mm/yr). In all four domains the structural grain of the basement and the basement-cover interaction play a key role in the local structural styles and the formation of proven or potential petroleum traps. The objective of this talk is to shed to new light on the structural styles of the Zagros belt and those of the Red Sea shoulders. Orientation analysis of 5200 structural lineaments along the Red Sea, extracted from a proprietary fault database (containing >50,000 faults, based on geological maps, satellite images, digital terrain data), was conducted and is presented here. Five different populations are recognized, dominated by ex- and transtensional kinematic modes (tilted fault blocks in the offshore forming potential petroleum traps). Rift- parallel lineaments are observed up to several hundred kilometers away from the Red Sea coast, revealing how far the present-day stress field acts. On the Saudi Arabian side lineaments of the Najd fault system are confirmed to be slightly oblique to the rift axis and will likely be under dextral transtensional mode, due to the present stress field. These observations have direct implications for prospect mapping in the region. A NE-SW trending 500km long structural transect from the Zagros Suture to the foreland is presented; it was built by integrating digital terrain data, well data, surface geology, published transects and oil seep data; the section was incrementally restored using state-of-the art balancing software. Minimum horizontal shortening was determined to be ~71km for the basement and ~50km for the cover, values that are in line with published data. The restoration confirms the complex basement-cover interaction which is further complicated by the presence of highly ductile infra-Cambrian evaporites (Hormuz Fm.). It is proposed that some of the largest oil accumulations in this region, such as the West Qurna, Majnoon and Azadegan fields, are likely related to thin-skinned, possibly salt-detached anticlines triggered by long distance stress- transfer, about 200km from the present-day mountain front. In summary it can be stated that in both assessed areas the understanding of pre-existent structural grain, its reactivation as well as the basement-cover interaction are of fundamental importance when mapping structural play fairways and migration routes. Petroleum explorers and production/reservoir engineers are encouraged to apply thorough multi-scale and integrative geological workflows to understand the risks at the basin-, field- and wellbore-scale, around the Arabian Plate and elsewhere.