

Control of Intra-plate Tectonic Inversion on the East and North Saudi Arabia Basins; New Exploration Horizon

Dr. Mesbah Khalil¹

¹Exploration, Saudi Aramco

Abstract

New exploration horizon in the eastern and northern Saudi Arabia basins is now guided with the newly interpreted tectonic inversion models. Multi-phases of superimposed tectonics interplayed with sea-level changes to control the sediments influx to generate these highly prolific basins. The main objective of this study is to document the architectures of basin inversion in eastern and northern Saudi Arabia from basin to prospect and field scales. Seismic, potential fields and well data are used to accomplish this study.

Results indicate intra-plate low-strain basement tectonic inversion in the East and north Saudi Arabia basin along with absence of Infracambrian salt. The Arabian Basement Shield remained during Infracambrian as a clastic and freshwater supplier for the two basins. This tectono-stratigraphic setting prevented the hyper-saline environment in the two basins, while hyper-saline environment occurred in limited basins in Oman and Zagros where salt, limestone, and clastics were deposited.

Eastern and northern Arabia basins are interpreted to have been separated with a high ridge referred to as Qiba high in this study. The North Arabia basin was a west-erly verging Paleozoic rift with depo-center in northwestern Saudi Arabia to Eastern Jordan. This basin extends further north to Central Iraq and South Syria. The basin was inverted up from east (uplift of Qiba high) and rotated toward west during Hercynian orogeny (Late Devonian) causing left transpression folds at its western side (west-northwest oriented Kahf fault zone with about 200km width). Carboniferous was deposited with thickening westward (basin-ward). The basin was inverted-up again from west (Jordan side) due to thermal uplift and rotated eastward from Permian to Present in intermittent phases. Inversion and east rotation reached the apex during Late Cretaceous with maximum right transtension stress concentration at the west boundary of the inverted basin (Kahf fault zone). This led to rifting of Sarhan graben that superimposed at the pre-existing Hercynian folds (re-deforming the left transpression Hercynian folds by right transtension faults (negative basin inversion). Strong erosion at the inverted basin created west facing retreat scarp from west Jordan to central part of the Nafud basin in Saudi Arabia. The scarp was transgressed with Late Cretaceous to Tertiary sediments with complex transgression surface.

Tectono-stratigraphy in the East Arabia basin is strongly controlled with multi-basement terranes and local heterogeneous fabric that created several repeated opportunities along major trends. The inherited Hercynian inversion was followed with Early Permian rifting (horsts, grabens and gentle tilted normal fault blocks) and Triassic to Mid-Cretaceous passive margin. Positive basin inversion occurred in East Arabia during Late Cretaceous-Tertiary and was followed with compression and easterly tilt since Tertiary to Present.

The present study introduces key aspects for creating exploration opportunities relying on intra-plate tectono-stratigraphic approaches for predicting subtle structural and stratigraphic traps.