Oman and its Wealth of Seal Diversity

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Abstract

This presentation aims at giving an overview of the hydrocarbon seal architecture in Oman, highlighting its diversity & richness. Oman's seal distribution and types in the subsurface are as prolific as what mother earth has to offer, resulting from some 800 million years of sedimentary & tectonic processes, with environments of deposition ranging from deep marine to terrestrial and lithologies made of carbonates, evaporates and clastics. The stratigraphy is composed of numerous transgressive and regressive cycles, each of them characterized by various facies changes occurring not only vertically but laterally. To date there are some 33 proven plays in Oman, spanning from Neoproterozoic to Cenozoic, out of which some 20 are currently producing.

Hydrocarbon seals, which act as barriers to lateral and vertical migration of hydrocarbons, can be found in the form of evaporites, fine clastics, mudstones or tight carbonates or clastics. The criteria that determine the effectiveness of a seal are its low permeability, thickness and uniformity, ductility and spatial distribution. Based on these criteria, the rocks that classify as seals in Oman are as diverse as the reservoirs themselves and can be organized as either regional, local, or non-conventional/novel seals.

The regional & semi-regional seals are the major seals that are proven to be highly effective and aerally extensive, and include the following:
• Transgressive shales (e.g. Cretaceous Nahr Umr and Shargi, Cambrian Al-Bashair, Cenozoic Shammar)
• Evaporites (i.e. Late Neoproterozoic Ara)
• Paleosols(e.g. Permian Gharif)
• Source Rocks (e.g. Cretaceous Natih B, Neoproterozoic Nafun)

Local seals are minor seals, being generally thinner and areally less extensive. These include:
• Intraformational seals (e.g. Permain Gharif shales)
• Lacustrine shales (e.g.Permian Rahab Shale of the Al Khlata)
• Mudstones/Marls (e.g. Permian Lower Khuff)
• Diamictites (e.g. Permian Al Khlata)

Non-conventional seals are known to be present in various types, with:
• Tight (deep) carbonates and silicilytes
• Reservoirs turning laterally into seals (e.g. Cambrian Mahwis/Miqrat reservoir turning into Miqrat seal; permeable vs tight Cretaceous Natih and Shuaiba)
• Source rocks acting as seal and reservoir (e.g. Cretaceous Natih B)

• Possible ‘capillary’ seals in dynamic traps

All these various seals allow hydrocarbon entrapment, offering multiple trap geometries:
• Conventional four way/ fault dip closures requiring a top & lateral seal juxtaposition
• Stratigraphic traps: e.g. carbonate stringers encased in Ara salt ; pinch out traps such as Barik and Miqrat sandstones
• Truncation traps: e.g. Gharif truncation traps in South Oman; Natih A truncation traps
• Palaeo and diagenetic traps: e.g. Upper Shuaiba in Lekhwair area;, Natih A combination traps with seat seal being a tight reservoir

In many cases, traps are a combination of different elements, having both structural and stratigraphic components. As these can be dependent on multiple seal types, a proper seal risk analysis is essential to assess their trapping potential. Identifying and unlocking additional hydrocarbon potential in Oman is dependent on understanding the reservoir-seal relation in conjunction with charge and structuration. With the conventional structural traps having been largely creamed, exploration is gradually moving towards subtle traps which rely either on multiple seals or on reservoir turning into seals.