Intra-Turonian Stratigraphic Reorganisation on the Arabian Plate: An Important Element of Petroleum Prospectivity

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Abstract

The middle Cretaceous of the Arabian Plate contains some of the most prolific conventional petroleum systems in the world. Cenomanian–Turonian rock units such as the Mishrif, Natih, and Sarvak formations contain high-quality carbonate reservoirs. Undrilled structural closures are now scarce within this mature petroleum province; thus, attention is turning to subtle stratigraphic traps. This includes subcrop trapping beneath a major intra- Turonian unconformity, where variable preservation beneath the hiatus creates prospectivity. However, the timing and drivers of this event require detailed understanding, thus we have undertaken a regional review of this key stratigraphic element.

Shallow-marine carbonate deposition was widespread across the Arabian Plate during the late Permian – Mesozoic but was abruptly ended by a major tectonically-driven stratigraphic reorganisation that took place within the Turonian. Published literature terms this (for example) “the mid-Turonian Unconformity”, “the Wasia- Aruma break” or “the K150 Sequence Boundary (SB)”. In essence this event relates to subduction in a closing Neotethys Ocean and obduction onto the continental margin. As well as a change in facies, a hiatus of locally variable extent is present associated with erosion of the underlying stratigraphy. Thus, at some localities, the hiatus may encompass several million years because of erosion of underlying strata and progressive onlap of overlying strata. At other localities the hiatus may be minor, where erosion is minimal and subsequent transgression begins early.

Despite the event being known for several decades, precision on its timing and minimum duration has been lacking due to the limitations of biostratigraphy and because few other chronostratigraphic proxies have been employed. In order to rectify this, all relevant biostratigraphic data from across the Arabian Plate has been synthesised and evaluated in the context of a review of chronostratigraphic calibration of standard biozones from multiple fossil groups. This shows that the maximum youngest preserved rocks beneath K150 SB belong to the middle Turonian helvetica planktonic foraminifera zone or woollgari ammonite zone. The maximum oldest rocks above K150 SB belong to the same biozones, indicating a very short duration event. Recent ages of 92 Ma for the onset of obduction are substantiated by these observations.

A global review of Turonian relative sea-level change has been carried out to investigate eustatic signals during this time. In multiple sections, a sea-level fall can be detected in the upper part of the woollgari zone of European usage. This coincides with an episode of climate cooling.

However, despite there being correspondence between K150 SB and a significant eustatic event, this seems mostly coincidental as the tectonic drivers across Arabia at this time were much more dramatic.

Exploration potential for subcrop stratigraphic plays occurs where karstified rudist-rich carbonates are juxtaposed against the K150 SB unconformity. An overlying claystone unit (Laffan Formation and equivalents) forms an effective regional seal. Successful exploration for this play requires a detailed understanding of paleogeography, platform morphology, and controls on reservoir quality, all of which can be achieved by applying a sequence stratigraphic model creating a stack of high-resolution gross depositional environment maps to screen for the extent of the likely play fairway.