Sequence Stratigraphy Implications for Reservoir Development in the Lower Triassic Kangan Formation, Northern Part of the Persian Gulf

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Abstract

The Lower Triassic Kangan Formation, one of the most productive petroleum reservoirs of south and southwest Iran, was formed in an extensional basin in the expanded Neotethys Ocean. The Basin was formed as a result of the Late Permian continental drift between Cimeria and Gondwana. The Kangan Formation is over 160 meters thick and consists mainly of carbonates and evaporites. It is unconformably underlain by the Upper Permian Dalan Formation and is conformably overlain by the Upper Triassic Dashtak Formation. Detailed petrographic investigation and well log analysis of the Kangan Formation in (Salman Field) and (Minab Field) led to the recognition of arid tidal-flat, back barrier lagoon and barrier/shoal facies belts related to an inner part of a homoclinal ramp platform.

Vertical facies changes and cycle stacking patterns demonstrate that the Kangan Formation consists of three depositional sequences, each consisting of transgressive and highstand systems tracts and each bounded above by a type 2 unconformity depositional sequences that are related to UAA (Upper Absaroka A) super sequence.. These sequences are correlated with the Lower Triassic global sea level cycles suggesting eustatic control for their development. The Kangan Formation has been affected by several diagenetic processes including dolomitization, which played a significant role in improving reservoir quality. The dominantly ooid grainstone of the highstand systems tracts with intercrystalline, mouldic and Fracture porosity comprise the main reservoir facies of the Kangan Formation.

1. Introduction

The Kangan Formation (Schytian) comprises one the most important carbonate reservoir rocks in southwestern Iran. This formation and its underlying Dalan Formation form the Dehram Group. The type section of the Kangan Formation was reported from the subsurface of southeast of Busher city of Iran.

In this paper, based on facies analysis revealed from cores and cuttings as well as Gamma ray logs of the studied sections, depositional environments and sequence stratigraphy of the Kangan Formation were inferred.

2. Geological Setting

The kangan Formation is the main reservoir in Salman and Minab petroleum fields, located in 140 km. and 40 km south of Lavan Island in Persian Gulf, respectively. correlatable with upper part of Khuff Formation in south of the Persian Gulf [1, 2] . The Formation deposited in extended Neo-Tethys Ocean in the Early Triassic [10].

The Kangan Formation in the study sites is composed of dolomites, evaporites, limestones and shales with an overall thickniss of 156 m. in Salman and 173 m. in Minab feilds,

respectively. The Kangan Formation is unconformably underlain by the Dalan Formation [10] and conformably overlain by the Dashtak Formation [17].
This research is based on petrographic studies of 270 thin sections obtained from a core of the Salman field and 62 ones from cuttings of a borehole in Minab field as well as sedimentological interpretations of Gamma ray log for both sections. Carbonate rocks were classified according to the Schemes of [6] Facies analysis and, vertical and lateral changes carried out based on [11, 4, 8]. The results were compared with recent and paleodepositional environments to determine sedimentary environments of the Kangan Formation [15, 19, 3, 8]. Sequence stratigraphy concepts developed by pervious workers e.g. [20, 18, 7, 12, 13, 5] were extended to the current study.

3. Facies description

According to the study of thin sections and Gamma ray logs, 14 facies in the terms of three facies belts including tidal flat, lagoon and barrier were identified.

3.1. Facies belt A (tidal flat)

This facies belt consists of supratidal and intertidal facies including: A1) layered anhydrites with chicken-wire structure, A2) fenesteral dolomudstone and stramatolite boundstones Dolomudstone with evaporite castes and peloid grainstone with keystone vugs. This Facies belt was deposited in Tidal flat sub environment.

3.2. Facies belt B (lagoon)

The lagoon facies belt contains following facies: B1) peloid grainstone and bioclast peloid packstone-grainstone and B2) bioclast wackestone and bioturbated dolomitized lime mudstone/ mudstone. In this, facies belt some the facies are partly dolomitized or compleatly dolomitized, cemented by the anhydrate in grain-supported facies. This Facies belt is related to semi-restricted, restricted Lagoon.

3.3. Facies belt C (barrier)

The barrier facies belt includes C1) ooid peloid grainstone, dolomitized ooid packstone/ grainstone and dolomitized bioclastic oolitic intraclast packstone/ grainstone and C3) dolomitized intraclastic/ oolitic bioclast grainstone. These facies are deposited in the Barrir/Shoal sub environments.
Regard to the Walter's law in Middleton [14] the carbonate facies in the studied sections were deposited in the inner part of the carbonate ramp platform [15, 8, 9].

4. Sequence stratigraphy

Sequence stratigraphy considers sedimentary rocks of the sedimentary basins in the terms of sequences, genetically related strata bounded by surface of erosion or non-deposition, or their correlative conformities [20]. The study of the vertical facies variations in the Kangan Formation in the Salman ad Minab field sectionss lead to the recognition of three Scythian sedimentary sequences(that are labeled KG1, KG2 and KG3); These sequences are comparable by the Upper Absaroka A super sequence of [16].

4.1. Sequence KG3

The KG3 depositional sequence occurs in the lower part of the Kangan Formation. The sequence is bounded above by a type 2 unconformity. The lower boundary is not clear in the study area.

In the Salman field, the transgressive systems tract (TST) was recognized on gamma-ray logs, which show an increasing-upward profile. The Maximum values of the natural gamma ray indicate the maximum flooding surface (MFS). The highstand systems tract (HST) was identified from core samples and GR logs which show a shallowing and fining-upward parasequence set and consists of leeward shoal, lagoon and upper intertidal facies.

In the Minab field, the TST includes barrier/shoal and lagoon facies as indicated by retrogradational stacking patterns. The MFS was recorded as an ooid peloid grainstone which was deposited as a leeward shoal and which forms the most seaward facies in this systems tract. HST deposition here, which occurred during the latest stages of sea-level rise, still stand, and, the early part of sea-level fall is similar to that at the Salman field. Deposits comprise leeward shoal, lagoon and tidal flat facies in aggradational and progradational stacking patterns.

4.2. Sequence KG2

The second sequence in both sections is bounded by type two unconformities at both base and top. In the Salman field, KG2 includes three shallowing-upward parasequence sets. The TST comprises oolithic shoal and lagoon facies with retrogradational stacking patterns. The MFS comprises dolomitized intraclastic/oolothic bioclast grainstones. The HST is composed of oolithic shoal facies, peloid packstone/grainstones, which show aggradational, and progradational stacking patterns

In the Minab field, three parasequence sets were recognized. Lagoon and lower intertidal facies occur in the TST. The maximum flooding zone consists of bioclast wackestones and bioturbated dolomitized lime mudstones, which show increasing values in the GR log. The HST includes lagoon to the upper intertidal facies.

4.3. Sequence KG1

This sequence at both sections is bounded by type two unconformities at the base and top, and there was no evidence of exposure at these boundaries. At the Salman field, the sequence consists of one parasequence set in the TST, comprising tidal flat and lagoon facies. The MFS consists of bioclast wackestones. The HST contains one parasequence set comprising lagoon to tidal flat facies.

Sequence KG1 at Minab field consists of lagoon facies in the TST. The MFS consists of bioturbated dolomitized lime mudstones indicated by high values of the GR log. The HST consists of tidal flat facies.

5. Diagenetic processes

The Kangan Formation has been affected by several diagenetic processes, such as, Cementation, Microbial micritization, Neomorphism, Compaction (Mechanical and Chemical), Dissolution and Dolomitization. Various types of matrix and non-matrix

porosity types were reported from the Kangan Formation. In the present study, the most important types of porosity identified were interparticle, intercrystalline, fenestral, shelter and mouldic. Fracture porosity was the most frequent type of non-fabric selective porosity.

6. Conclusion and Discussion

The study of lateral and vertical changes of the Kangan facies, absence of deep facies, similarty of the facies Kangan and Khuff formations located with a large distance to each other, in addition to comaparison with recent and ancient sedimentary environments suggest that the Kangan formation deposited in the inner part of a carbonate ramp platform. Sequence stratigraphy studies show that the Kangan Formation comprises three sequences formed due schytian sea level changes.

For the sequences described above, the transgressive systems tract shows low accommodation of the extensive sub tidal facies such as lagoonal and tidal flat facies. The highstand systems tract indicates high accommodation for the oolithic and peloidal facies with higher energy such as C2 and C3 facies. The dominantly ooid grainstone of the highstand systems tracts with intercrystalline, mouldic and Fracture porosity comprise the main reservoir facies of the Kangan Formation.

7. References

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