Evolution of Paleogeomorphology and Sedimentary of the Late Cretaceous on the H Oilfield, Iraq

Introduction

The southeast Iraq (SE) occupies a significant role in the oil and gas industry of the world, which was ramp sedimentary environment in the foreland basin of Mesopotamia during the Late Cretaceous. Massive porous bioclastic limestone reservoirs were developed in the Khasib, Sadi and Hartha Formation of the Upper Cretaceous, while the complex porosity and strong heterogeneity in the study area severely restrict the further development.

The study area, a 30 km NW-SE trending anticline, is located in the south of the Mesopotamia Basin (SE Iraq). Progressive northward drift placed the Arabian Plate in equatorial tropical latitudes (Aqrawi, 2010). During the Early Coniacian period, the unconformity formed on the Mishrif Formation in SE Iraq. And then the transgression of the study area expanded from the edge of the Arabian to the Red Sea. Carbonate was deposited in the shallow open sea of the east Persian Gulf, and the ramp environment maintained to the Late Cretaceous in Mesopotamia basin where the structure was stable, consisting of fine-grained, mixed silicilastic-carbonate middle-shelf to sub-basinal depositional system (Sadooni, 2005).

The mid Turonian-early Campanian succession including Khasib, Tanuma, Sadi, Hartha Formation presents an important exploration and producing interval in SE Iraq. Khasib Formation can be divided into 4 layers: KA1-1, KA1-2, KA2 and KB, and Tanuma Formation into 2 layers. The lower layer is mudstone and the upper one is grainstone in Tanuma Formation. Sadi Formation can be divided into 4 layers which includes Sadi A, Sadi B1, B2, and B3. And Hartha Formation can be divided into 2 layers. Hartha A is dominated by grainstone and packstone. Hartha B is mainly mudstone.

Data base and Methods

There are 328 wells and more than 2,000km² 3D seismic data in the study area. The cored wells with 156 m cores and 133 thin sections were selected to analyse the rock type, sedimentary, reservoir characteristics. The paleogeomorphology was restored based on the analysis of seismic, logging, thin sections and experimental data, and then the control factors of geomorphology on deposition are analyzed.

Paleogeomorphology and Sedimentary Evolution

Base on the classification of Dunham (1962) and petrographic characteristics, the lithology and four microfacies were determined that shown in Figure 2, which shows us that the sedimentary facies of Khasib-Hartha Formation was ramp including inner ramp, middle ramp and outer ramp. The composition and structure of reservoir rock in different sedimentary environments are quite different. Based on thin section observation and analysis, it can be classified into two types: fine-grained and coarse-grained carbonate.

Figure 1 Area of study in the structure map of Iraq, Modified by Aqrawi, 2010.
The fine-grained carbonate mainly distributed in the KA, SadiB3, SadiB2, SadiA and HarthaB Member with widespread matrix material. Medium forams and few bioclastic fragment can be observed (Figure 2c,d,g,h,i). It indicated that the sedimentary environment is deep and quiet where the depth of the water is lower than the base of the storm wave.

**Figure 2** Lithological log of the Khasib, Tanuma, Sadi and Hartha Formation with the sea level change

**Figure 2a** N1, Khasib, 2866.11m, Packstone with rudist fragment(Rud), common bivalve fragments(Biv) and echinoderm fragment. **Figure 2b** N1, Khasib, 2855.14m, Packstone with bivalve fragments and echinoderm. **Figure 2c** M3, Khasib, 2820.23m, Wackstone with bioclast. **Figure 2d** M3, Khasib, 2819.26m, Wackstone with foraminifera(For) and echinoderm fragments. **Figure 2e** Y1, Sadi, 2800.1m, Grainstone with echinoderm fragments and benthic forams. **Figure 2f** N5, Tanuma, 2748.18m, Packstone with green algae(Alg), echinoderms, bivalves and mollusc fragments. **Figure 2g** M3, Sadi, 2690.11m, Wackstone with planktonic forams. **Figure 2h** Y1, Sadi, 2781.1m, Wackstone with planktonic forams, bivalve fragment. **Figure 2i** M3, Hartha, 2673.08m, Wackstone with planktonic forams. **Figure 2j** N5, Hartha, 2577.89m, Grainstone with bivalves, mollusc fragments, benthic forams and echinoderms.

The coarse-grained carbonate is different from fine-grained carbonate due to the different sedimentary environment. Based on the thin section, it mainly distributed in KB, Tanuma, SadiB3 and Hartha A Member with abundant rudist, ooid, echinoderm, bivalve and other biocalstic fragments (Figure 2a,b,e,f,j). It indicated that the sedimentary environment was inner ramp and some middle ramp where had much more water energy. All microfacies have been effected by dissolution(Figure 2a,e,f,j), cementation(Figure 2b,i), neomorphism(Figure 2i), compaction(Figure 2c,d,k,h) and pyrite formation (Figure 2j) in various degrees.
The Khasib Formation is developed in the third-order sequence, with the mudstone at the top of KB1 as the largest flooding surface. The transgressive system tract (TST) is developed down to KB Member, and KA Member is high System domain (HST). The Khasib Formation is composed of obvious transgressive and regressive sequences. The Sadi and Tanuma formations are developed in the third-order sequence, the top mudstone of Sadi B3 is identified as the largest flooding surface, the transgressive system tract (TST) developed from the top of Sadi B3 to the bottom of the Tanuma formation, and from the top of Sadi B3 to Sadi A member developed the high system tract (HST). The sequence of the transgression and regression of Tanuma and Sadi Formation is similar to that of the third-order sequence of the Khasib Formation. The seismic profile shows that between the strong seismic reflection axis of the largest flooding surface and the top and bottom of the formation can determine the sedimentary patterns of different system tracts. The Hartha Formation developed in the third-order sequence which has an incomplete structure and only develops the transgressive system tract. The largest flooding surface developed at the bottom of the Hartha Formation.

The paleogeomorphy evolution had played an important role in the sedimentary of Khasib-Hartha Formation during the Late Cretaceous. According to the well correlation and seismic profiles, there is an unconformity between the Mishrif and the Khasib Formation. And the thickness gradually increases from west to east. The Tanuma Formation can be divided into 2 members. The lower member is mudstone and the upper member is grainstone. The thickness of Khasib gradually increased from west to east. Meanwhile, the thickness of Tanuma decreased. The different of thickness of Khasib and Tanuma Formation is controlled by the evolution of paleogeomorphy. It was a slope during the sedimentary of Khasib. And before the Tanuma start to deposit, the shoal accumulated and regeneration changed the sedimentary environment to sub-basinal inner ramp. According to the seismic profile, the migration of shoal has proven that the paleogeomorphy changed the sedimentary environment. After the deposition of Sadi B3, the paleogeomorphy have changed back to slope environment in the study area. Thus, at the beginning of Hartha, the sedimentary environment was middle ramp and inner ramp. The thickness gradually decreases from west to east.
Conclusions

The paleogeomorphy evolution affected the sedimentary of the Late Cretaceous in South Iraq by controlled the change of sedimentary environment. The Khasib-Hartha Formation in the study area could be divided into two sedimentary cycles. In the first cycle, it was deposited Khasib, Tanuma and lower Sadi Formation including middle ramp and inner ramp. The paleogeomorphy changed from slope to local uplift due to the accumulation of rudist shoal. With the change of the uplift, lower Sadi Formation including Sadi B2 and Sadi B3 Member were sub-basinal sedimentary on the opposite trending. The uplift was vanished after the sedimentary of lower Sadi. In the second cycle, it was deposited upper Sadi and Hartha.

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References


Figure 4 Schematic West-east profile from the B to B' according to Figure 1, illustrating the thickness and evolution of the formation during the late Cretaceous