

Regional Stratigraphic correlation and comparison of the Oligo-Miocene deposits in Dezful (SW Iran) and Kirkuk (N and NE-Iraq) embayments.



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Abstract:

The Oligo-Miocene deposits and their equivalents are one of the most important petroleum systems of the Middle-East, especially Iran and Iraq. In this paper, correlation between these important deposits has been discussed stratigraphically and sedimentologically, with some case studies (in outcrop and subsurface) in SW Iran and N, NE Iraq. Lithologically, the most thickness of the Asmari Formation (Oligo-Miocene) in Iran is deposited in Dezful area. These deposits, consist of shallow carbonate and they are lateral equivalent of Kirkuk group and Euphrates, Dhiban and Jeribe Formations in north and northeastern of Iraq. Microfacies analysis and depositional environments of these deposits are compared in terms of sequence stratigraphy. It appears that there are the relationship between Dezful and Kirkuk embayments in the mentioned period. The study demonstrated that the deposits in SW Iran and N, NE Iraq are almost the same with some minor discrepancies.

Keywords: Oligo-Miocene; Correlation; Dezful embayment, SW Iran; Kirkuk embayment, N, NE Iraq.

I. Introduction

The Oligo-Miocene deposits and their time-equivalents are one of the most important petroleum systems of the Middle-East, especially in Iran and Iraq (Motiei, 1993). A large part of the Middle East's oil and gas reserves have been accumulated in carbonate reservoirs, such as Asmari Formation in many oil-fields such as Gachsaran, Aghajari, Naft safid, in SW Iran, and Euphrates and Jeribe Formations in Kirkuk's oil- fields, e.g., Bai Hassan, in NE Iraq (Jassim and Goff, 2006).

The Oligo-Miocene deposits in Iran have been assigned to the Asmari Formation (a well known fractured carbonate unit) that consists of a thick carbonate sequence of the Oligocene–Miocene in Zagros foreland basin, southwest Iran. It is best developed in the

Dezful Embayment Zone. Figure 1 shows the following lithostratigraphic units in different zones of the Zagros (Van Buchem et al., 2010): (a) the shallow-water carbonates (Jahrum Formation) of the Eocene; (b) the mixed, shallow-water carbonates and sandstones (Asmari Formation) of the Oligo-Miocene; and (c) the deeper water marls (Pabdeh Formation) of the Eocene to Oligocene. The two last formations interfinger with two subaqueous anhydrite beds, namely the Basal and Middle Anhydrites. Furthermore, a sandstone unit (the Ahwaz Sandstone Member) is identified within the Asmari Formation in the SW part of the basin. The Oligo-Miocene rock units in SW Iran and their time equivalents in N, NE Iraq shown in Fig. 2. Sedimentation during Oligo-Miocene was firstly controlled by the palaeotopography of the preceding Eocene

Jahrum platform. This platform included a vast embayment that was open towards the Neo-Tethys and extended into northern Iraq (Fig. 3).

The Asmari Formation at its type section consists of 314 m of limestones, dolomitic limestones, dolomites and marly limestones, with variable thickness (Motiei, 1993). This formation is diachronous as its base toward the coastal Fars area, is mainly Rupelian in age; but in the Dezful Embayment, its age ranges from Rupelian to Chattian (Motiei, 1993).

The top of the Amari Formation is mostly Burdigalian in age, but, toward the coastal and interior Fars, it is Chattian age (Fig. 1). The Oligocene deposits in Iraq are divided as nine formations that attributed to the Kirkuk group. Most of these deposits are reefal facies, as Sheikh Alas, Baba and Azkand Formations belong to reef-fore reef facies but Shurau, Bajawan and Anah Formations are reef-back reef facies while Palani, Tarjil and Ibrahim formations are basinal facies (Bellen et al., 1959). These nine formations range from Early, Middle to Late Oligocene, respectively. The Lower to Middle Miocene deposits in Iraq consists of the Serikagni, Euphrates, Dhiban, Jeribe, and Fat'ha formations (Bellen et al., 1959; Buday, 1980; Jassim and Goff, 2006 and AL-Hietee, 2012).

II. Previous work

Earlier, equivalent of Asmari Formations in Iran is correlated to Early-Middle Oligocene Formations in Iraq (Buday, 1980). Asmari Formation includes shallow marine carbonate deposits and is the lateral equivalent of the Kirkuk Group in northern and northeastern Iraq (Alsharhan, 2003). The equivalent formations of the Asmari formation in Iraq has been studied by Motiei in 1993, too.

In Iraq, Oligocene is less developed than the Eocene; it occupied limited area, and is located mostly within the Mesopotamian basin and low folded zone of unstable shelf, (Al-Hashimi and Amer, 1985). Recently, in Iraq, Khanqa et al. (2009) proved the occurrence of the Oligocene in the High Folded Zone.

The environment of the Oligocene reefal cycle studied by Al-Qayim & Khaiwaka (1980) in Kirkuk oil fields. Main aim of this study is stratigraphic and sedimentologic correlation of the Oligo-Miocene deposits of SW Iran with their equivalents in the north and northeastern of Iraq.

III. Geological setting:

Some adjacent countries such as Iran and Iraq were isolated from the Arabian Plate during the Permian (Berberian and King, 1981). From the Middle Eocene to Early Miocene, the Arabian Plate began to impact the southern Asian Plate border and the Zagros belt orogeny began. The Zagros Basin extends from Turkey, north-eastern Syria and north-eastern Iraq through north-western Iran and continues into south-eastern Iran (Fig. 3). The Zagros Mountains of Iran are divided into three principal tectonic units (Stocklin, 1968; De Jong, 1982) namely the Zagros fold-thrust zone, the imbricated zone and the Urumieh-Dokhtar magmatic zone (Alavi, 2004).

Studied sections of the Asmari Formation in this research are located in the Naft-Safid and Haftkel oilfields in Dezful Embayment (Fig. 3). These two oilfields are placed at 65 km northeast of Ahvaz and 75 km east of Ahvaz, SW Iran, respectively and measured about at 31.54° to 31.44° N, 49.44° to 49.53° E at surface.

IV. Sedimentology:

The Asmari Formation is divided into lower, middle and upper units, based on the presence of foraminiferal assemblages, although these three parts do not exist in anywhere. For example, there is no Lower Asmari in most oil-fields in northern Dezful Embayment, such as Naft-Safid, Haftkel and etc.

Lithologically, the three parts are as follows:

- 1) The Lower Asmari which at the base is composed of marl but at the top is mainly formed of foraminiferal and coralline algal limestone.
- 2) The Middle Asmari which consists of dolomitized, lagoonal limestone,
- 3) The upper Asmari is mainly Evaporitic.

The Oligocene rock units that identified in the NE of Iraq composed of two cycle: Lower cycle which includes Sheikh Alas and Shurau Formations, Upper cycle consists of Baba, Bajawan, Anah and Tarjil Formations. Lithological characteristics of these formations shown in Fig. 4.

The Lower-Middle Miocene deposits in Kirkuk area consist of the Serikagni, Euphrates, Dhiban, Jeribe, and Fat'ha formations (Al-Haiette, 2012). Serikagni Formation composed of globigerinal chalky limestones with some layers of limestones. Euphrates Formation is characterized by recrystallised limestone. Dhiban Formation comprises gypsum, thin beds of marl and recrystallised limestones. Jeribe Formation is identified with the existence of *Borelis melo curdica* as index fossil (Buday, 1980). This index fossil also exists in upper part of the Asmari Formation in studied sections. Fatha Formation or Lower Fars (Middle Miocene) composed of very thick alternation of Gypsum (or anhydrite), marl and limestone. Lithological description of the mentioned formations in NE Iraq

shown in Fig. 5. In the studied section the Dhiban Formation reaches a thickness of about 3 m, which is similar to the Kalhor Member in the studied oil-fields in this study.

V. Microfacies and Depositional environment:

Based on Dunham (1962) and Flugel (2004), 8 Microfacies (7 carbonate microfacies including Dolomitic Mudstone, Echinoid wackestone, Benthic foraminifera wacke to packstone, pelloid pack to grainstone, Boundstone, Algal wacke to packstone, Planktonic wacke to mudstone) and one non-carbonate microfacies (Anhydrite) have been identified, which are classified into five sub-environments: Tidal flat, Lagoon, Barrier (belonging to inner ramp), Middle ramp and Outer ramp. Tidal flat, Lagoonal and Barrier microfacies mostly present in upper and some middle parts of Asmari formation, while middle and outer ramp microfacies largely developed in middle part. The main Microfacies of the Asmari Formation in the studied oil-fields shown in Fig. 6.

Many of these microfacies are similar to the identified microfacies in Kirkuk area, N Iraq by AL-Hietee (2012). For example, in Jambur and Hemrin oil-fields, Serikagni Formation mainly composed of planktonic wacke-mudstone; Euphrates Formation includes Benthic foraminifera wackestone and Pelloid packstone. These two Formations are similar to middle part of the Asmari Formation. Also, the Jeribe Formation consists of Lime/dolomitic mudstone. In addition, there is the index fossil *Boralis melo curdica* in the Jeribe Formation (Above the Dhiban Formation) which appears in upper part of the Asmari Formation, above the Kalhor Member.

Generally, the Oligo-Miocene deposits in SW Iran (Asmari carbonates) show complex lateral and vertical facies

changes. These changes are suggested as an alternation between ramp and rimmed shelf platform geometries for the Oligocene deposits (Ghazban et al., 2009).

Shallow carbonate environments are shown in figure 7. Also, depositional environments of different parts of the Asmari formation has been compared to the lower and upper formations, namely, Pabdeh and Gachsaran formations, respectively.

The lower part of Asmari formation is more or less related to open marine shelf (Fig. 7). The middle and upper parts were deposited in tidal flat (restricted shelf) environment. Generally, the deposition environment wasn't constant in the most parts of the Asmari formation and was changed into shallower and/ or deeper environment, laterally. For example, the middle part of Asmari formation in Middle Dezful embayment shows an intertidal environment while in Lurestan it is related to supratidal or sabkha environment.

These environmental changes from shallow marine (Asmari formation) to shallower lagoonal-supratidal, evaporitic deposits (Gachsaran formation) represent the ideal seal-reservoir sequence.

The Oligocene formations divided into two cycles, by Ditmar and the Soviet team (1971): a lower cycle consists of the Palani, Sheikh Alas, Shurau and Tarjil Formations and an upper cycle including the Anah, Azkand, Baba and Bajawan Formations. These formations are deposited in a different parts of a limited reef environment (Fig. 8.).

Overall, The Oligocene basin in N, NE Iraq shows an isolated platform within a carbonate ramp (Kharajiani, 2008). Lower Miocene reef limestone reservoirs also exist in the Asmari Formation in some oil fields in SW Iran, e.g., Haftkel and Gachsaran (Edgell, 1997). Reef development also exists in the lower and middle part of the Asmari Limestone in

the Gachsaran and Haftkel oil-fields (Thomas, 1950).

Microfacies analyses of the Miocene formations in some wells in Kirkuk area by Al-Hietee (2012) have showed the different subenvironments where the Serikagni Formation was deposited in basinal, deep marine, and shallow open marine environments. The Euphrates Formation represents restricted marine and shallow open marine deposition. He added that the Dhiban Formation shows sabkha, restricted marine, and shallow open marine environments. He further added that the Jeribe Formation reflects deposition in restricted marine, and shallow open marine environments; in addition to shoal and deep marine environments. The Fat'ha Formation deposited mainly in restricted marine, and sabkha environments.

VI. Sequence Stratigraphy

Sequence Stratigraphy of Asmari Formation has been studied in both outcrop and well in different places in SW Iran. For example, Van Buchem et al. (2010) based on Sr isotope stratigraphy, have distinguished three Oligocene sequences (Rupelian, early Chattian and late Chattian in age, respectively) and three Miocene sequences (early Aquitanian, late Aquitanian and early Burdigalian in age), at Tang-e-Gurgudan outcrop section, in the Dezful Embayment and Izeh Zone. Also, three Miocene sequences identified in Well-13 by Van Buchem et al. (2010), in Dezful Embayment (Fig. 9).

From Study of sequence stratigraphy in the studied oil-fields, three Miocene sequences are distinguished: Sequences 4 and 5, related to (Early Miocene/Aquitania), both started with lowstand deposits of subaqueous anhydrites ('Basal Anhydrite' and Middle Anhydrite') that were deposited when the basin became

isolated from the NeoTethys ocean. In Iraq, Basal anhydrite is also informally known as the 'Basal Anhydrite' and can be followed from Khuzestan in Iran to Syria, suggesting the existence of a large basin that became temporarily disconnected from the open ocean (Van Buchem et al., 2010). The Middle Anhydrite (Kalhor Member) is the time-equivalent to Dhiban Formation in N, NE Iraq which was deposited under lagoonal–evaporitic conditions and after the local movement closed the communication of the basin with the open sea. The basin of deposition is of the type "Basin center evaporite" (Abdul-Hameed, 1983).

The base of sequence 4 (SB IV) is placed at the Oligo-Miocene (Chattian–Aquitania) boundary and marked by Basal Anhydrite in the studied oil-fields, the top of this sequence is characterized by the Middle Anhydrite which is also the base of the sequence 5. In the studied oil-fields the Middle Anhydrite reaches a thickness of 3 to 4 m and is known as the Kalhur Member and contains some thin halite unit. In Iraq, this part correlates with the Dhiban Formation, which also contains halite interbeds in the basin centre (Al-Juboury et al. 2007). The Sequence 4 is composed of Middle and Outer ramp microfacies in Transgressive system tract (TST) and Inner ramp microfacies in Highstand system tract (HST). The top of sequence 5 is marked by shallowing upward which shows the existence of the index fossil *Borelis melo curdica* and some echinoids in the early Burdigalian. This shallow open marine facies is also recognized in Kirkuk area by wackestones and wackestones to packstones with abundant millolids (*Borelis melo curdica*), peneroplis, rotalia, echodirm and other shell fragments. TST in this sequence mainly consists of Middle ramp facies and HST is of Inner ramp facies. The Sequence 6, related to (middle Miocene/ Burdigalian), shows the last

stage of the Asmari deposition in the Inner ramp and marks boundary between Asmari and Gachsaran (Lower Fars) formations (Fig. 10).

Facies architecture and Sequence stratigraphy of the Lower and Middle Miocene deposits are investigated by Al-Hietee (2012), at Kirkuk area, Jambur and Hemrin oil-fields, in North Iraq. The studied Miocene deposits is represented by numerous 5th order cycles at the Fat'ha Formation and 4th order cycles at other formations (Alhietee, 2012), which have been correlated with their equivalents in Dezful area (Fig. 11). These cycles have been controlled by variation in the relative sea level resulted from (eustatic and tectonic subsidence).

The Dhiban Formation is marked by cycle D & E at Ja-26 in which cycle D consists of a thick lowstand systems tract (LST) determined by thick anhydrite bounded below by a Type 2 sequence boundary (SB2) while at Hr-41 cycles D & E are divided into two 4th order cycles (D1 & D2) and (E1 & E2) reflecting successive transgression. The Jeribe Formation is showed by 4th order cycles (F, G, H, I) at Ja-26 and Hr-41 in addition to the lower part of cycle (J) bounded below by a Type 2 sequence boundary (SB2) at Hr-41, and Ja-26.

In the Iraq part of the basin, also two anhydrite levels are found: the informally known 'Basal Anhydrite', which lies below the Euphrates and Serikagni Formations dated as Aquitania (Van Bellen et al., 1959; Starkie, 1994), and the anhydritic Dhiban Formation, which is overlain by the Jeribe Formation, assigned to the top of the early Miocene of Burdigalian age (Van Bellen et al., 1959). On the basis of our study, the sequence 4 comprising the lower middle Asmari Formation which correlates likely with Euphrates and Serikagni Formations. The sequence 5 composed of Kalhor Member and upper middle Asmari Formation and

correlates with Dhiban and lower part of Jeribe Formations. Finally, the sequence 6 comprising the upper Asmari Formation and can be correlated with upper Jeribe Formation.

VII. Conclusions

The following conclusions are drawn:

- 1- Generally, Oligocene deposits did not develop in studied oil-fields in North of Dezful Embayment (namely, Naft Safid and Haftkel, etc.). However, Oligocene deposits exist in some outcrops, e.g., Tang-e-Gurgudan outcrop, and many oil-fields such as Ahvaz, Ab-Teymur, Rag-e-Safid in SW Iran and High Folded Zone in NE Iraq (Khanaqa et al., 2009).
- 2- Based on Dunham (1962) and Flugel (2004), 8 Microfacies (7 carbonate microfacies including Dolomitic Mudstone, Echinoid wackestone, Benthic foraminifera wacke to packstone, pelloid pack to grainstone, Boundstone, Algal wacke to packstone, Planktonic wacke to mudstone) and one non-carbonate microfacies (Anhydrite) have been identified. Tidal flat, Lagoonal and Barrier microfacies mostly present in upper and some middle parts of Asmari formation, while middle and outer ramp microfacies largely developed in middle part. Environmental interpretations show that an inner and middle parts of a homoclinal ramp dominated during the deposition of the

Asmari Formation in the studied oil-fields.

- 3- The middle and upper parts of the Asmari Formation (early Aquitanian–Burdigalian) were deposited in semi-to restricted lagoon environments of inner ramp to middle ramp, which are more similar to equivalents Miocene Formations in N, NE Iraq.
- 4- Three Miocene sequences are distinguished: the sequence 4 (early Aquitanian) comprising the lower middle Asmari Formation which correlates likely with Euphrates and Serikagni Formations. The sequence 5 (late Aquitanian) composed of Kalhor Member and upper middle Asmari Formation and correlates with Dhiban and lower part of Jeribe Formations. The sequence 6 comprising the upper Asmari Formation and can be correlated with upper Jeribe Formation. This Sequence 6 (middle Miocene/ Burdigalian), shows the last stage of the Asmari deposition and deposition of evaporate sediments (Gachsaran Formation/ Lower Fars).

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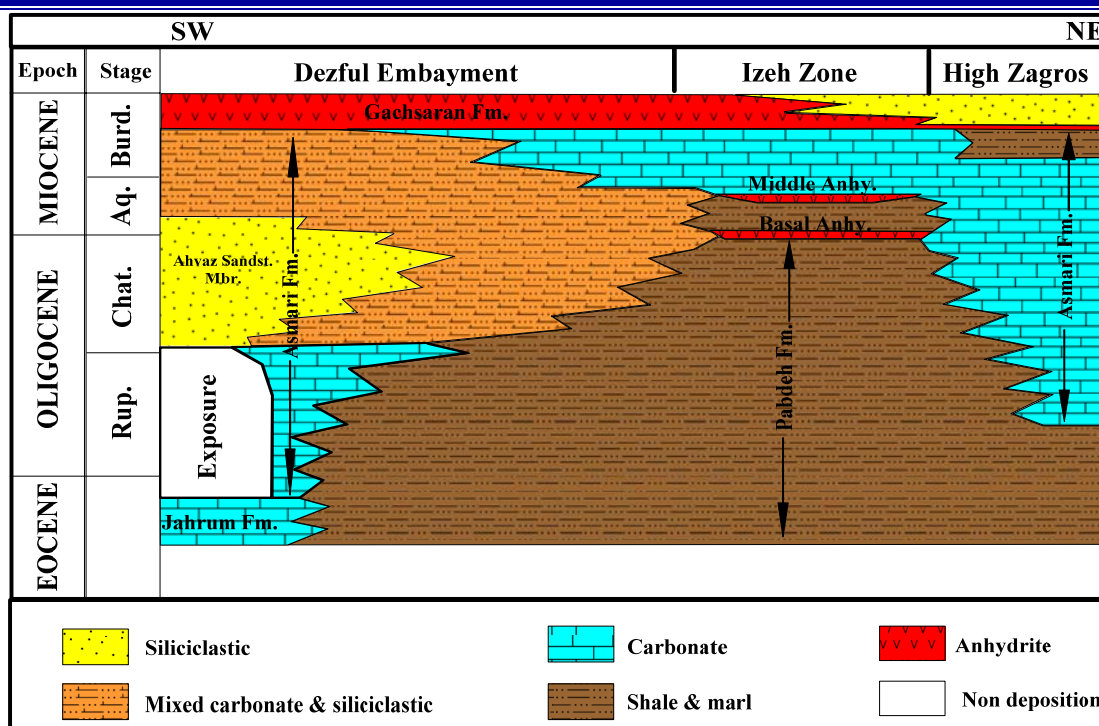


Fig. 1. The Oligo-Miocene wheeler diagram of the Dezful Embayment shows a complex sedimentary system with a large variable lithologies (e.g., sandstones, marls, carbonates and anhydrites) and depositional geometries (James & Wynd, 1965; Adams & Bourgeois, 1967).

Rock Units	Age		Time Equivalent in N, NE Iraq	
Gachsaran	Burdigalian		Lower Fars/ Fatha	
Upper Asmari	Burdigalian		Jeribe	
Upper/ Middle Asmari	Late Aquitanian		Jeribe and Dhiban	
Middle Asmari	Early Aquitanian		Serikagni and Euphrates	
Lower Asmari and Pabdeh	Oligocene	Chattian	Anah, Azkand and Ibrahim	Kirkuk Group
		Rupellian	Baba, Bajwan and Tarjil	
			Shurau, Sheikh Alas and Palani	

Fig. 2. Oligo-Miocene rock units in SW Iran and their time equivalents in N, NE Iraq (Modified from Motiei, 1993).

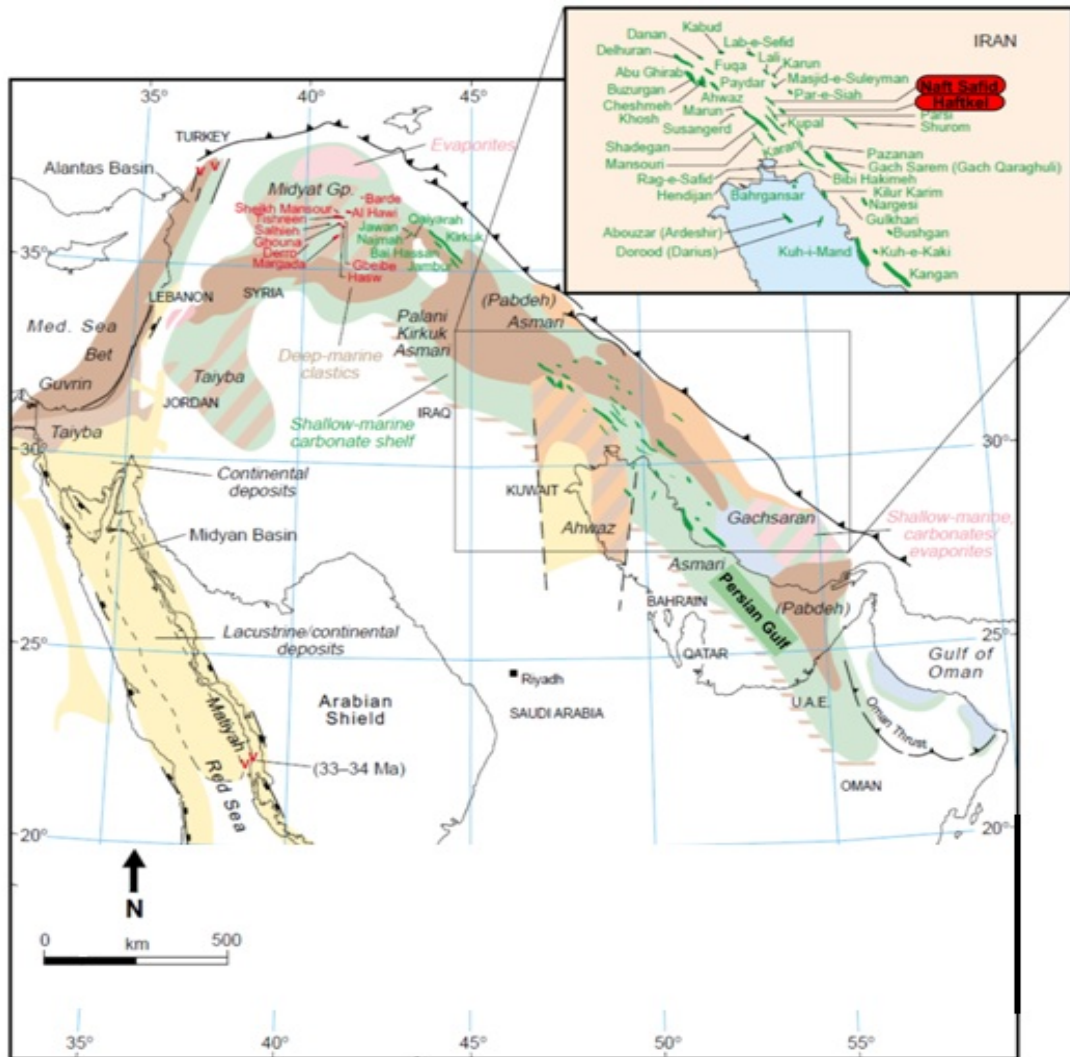


Fig. 3. Location map of studied oil fields and paleofacies map of the Oligocene deposits from Pabdeh-Chilon (Palani) formations and their regional equivalents in SW Iran (Modified from Ziegler, 2001).

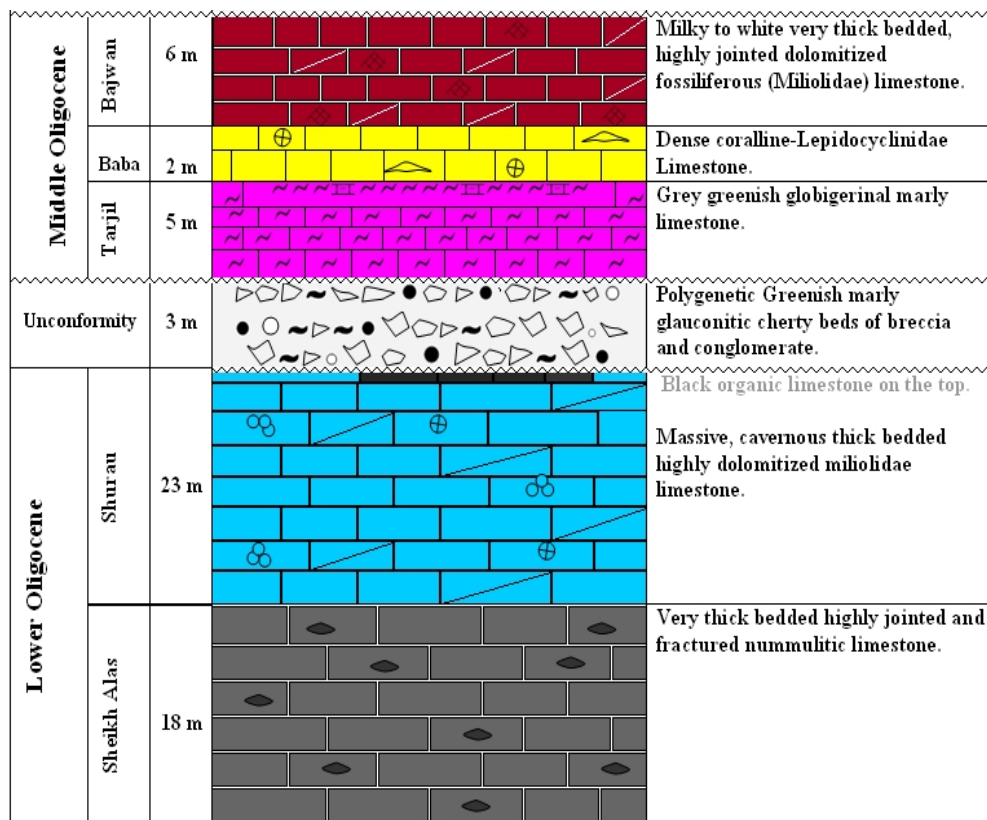


Fig. 4. The Oligocene rock units (Kirkuk group) in Ashdagh Mountain, NE Iraq (From Kharajiani, 2008).


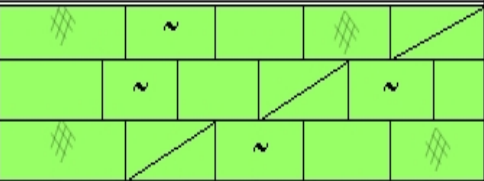
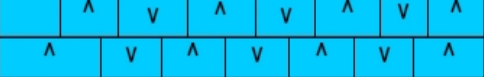


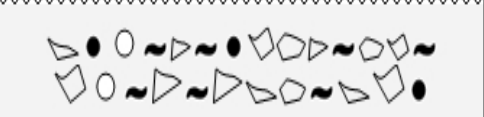
Age	Fn.	Thick.	Lithologic Symbol	Lithologic description
Middle Miocene	Fatha	>50 m		Alternation of red claystone and Gypsum beds.
	Jeribe	2 m		Grey to olive highly jointed and fractured limestone, partially dolomitized and marly
Lower Miocene	Dhiban	1 m		Whitish chalky limestone.
		2 m		Gypsum- Anhydrite beds, sometimes inclusions of sand size grain fill the pores.
	Euphrates	4 m		Thin bed of red Algal Limestone. Pale thick bed highly jointed brecciated recrystallized limestone contains shell fragment.
Unconformity		2 m		Polygenetic Greenish marly glauconitic cherty beds of breccia and conglomerate.

Fig. 5. The Miocene Formations in Ashdagh Mountain, NE Iraq (From Kharajiani, 2008).

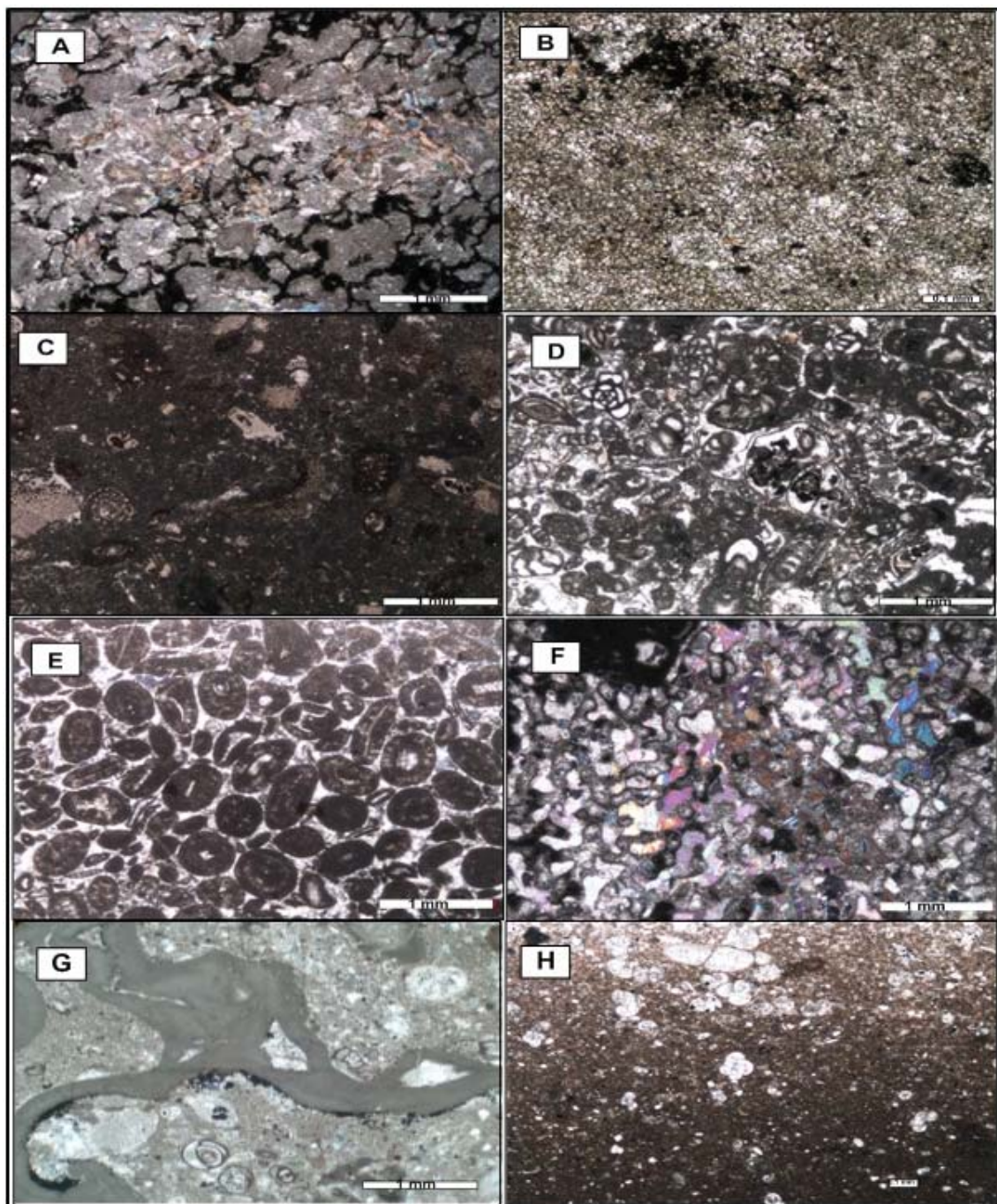


Fig. 6. Identified microfacies of the Asmari Formation in the studied oilfields: A) Anhydrite (Tidal flat), B) Dolomitic mudstone (Lagoon), C) Echinoid wackestone (Lagoon), D) Benthic forminifera wacke-packstone (Lagoon), E) Pelloid pack-grainstone (Barrier), F) Boundstone (Reef), G) Algal wacke-packstone (Middle ramp), H) Planktonic wacke-mudstone (Outer ramp).

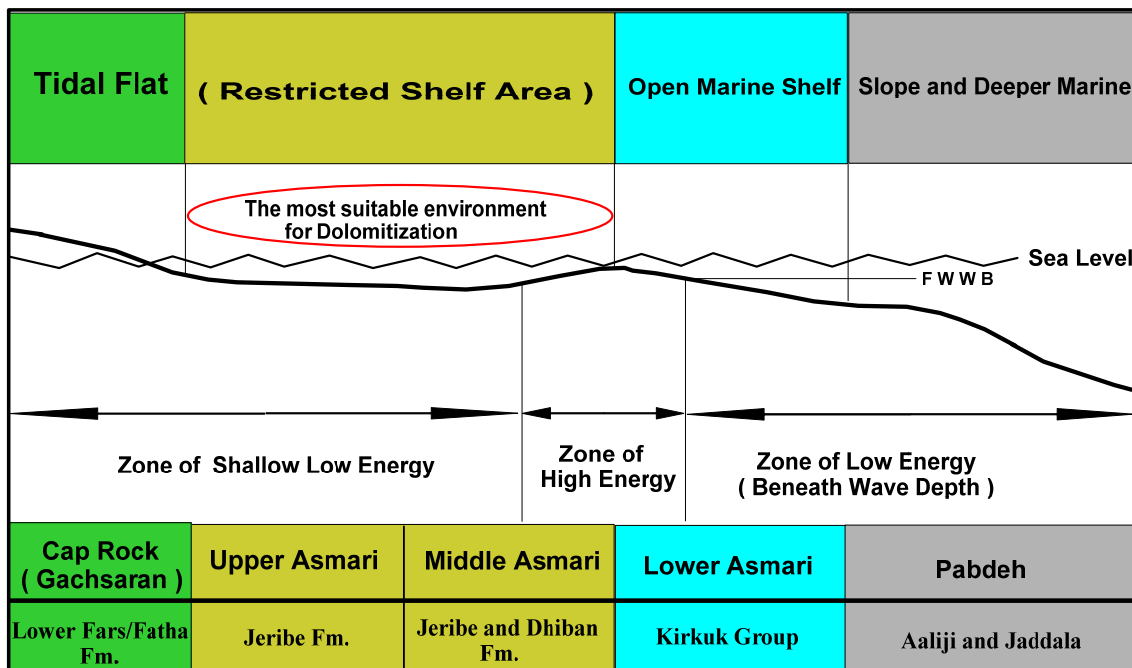


Fig. 7. Sedimentary environment of the three parts of the Asmari formation with its upper and lower formations (Modified from Motiei, 1993) and their equivalents in Iraq.

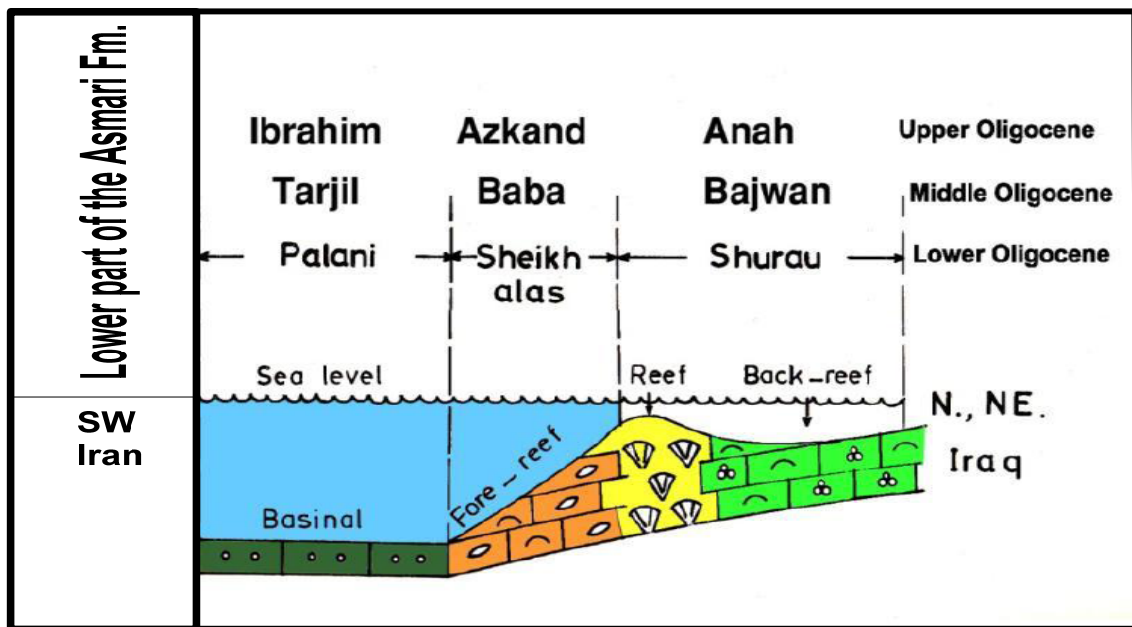


Fig. 8. Oligocene formations (Kirkuk group) and their depositional environments (Al-Hashimi and Amer, 1986).

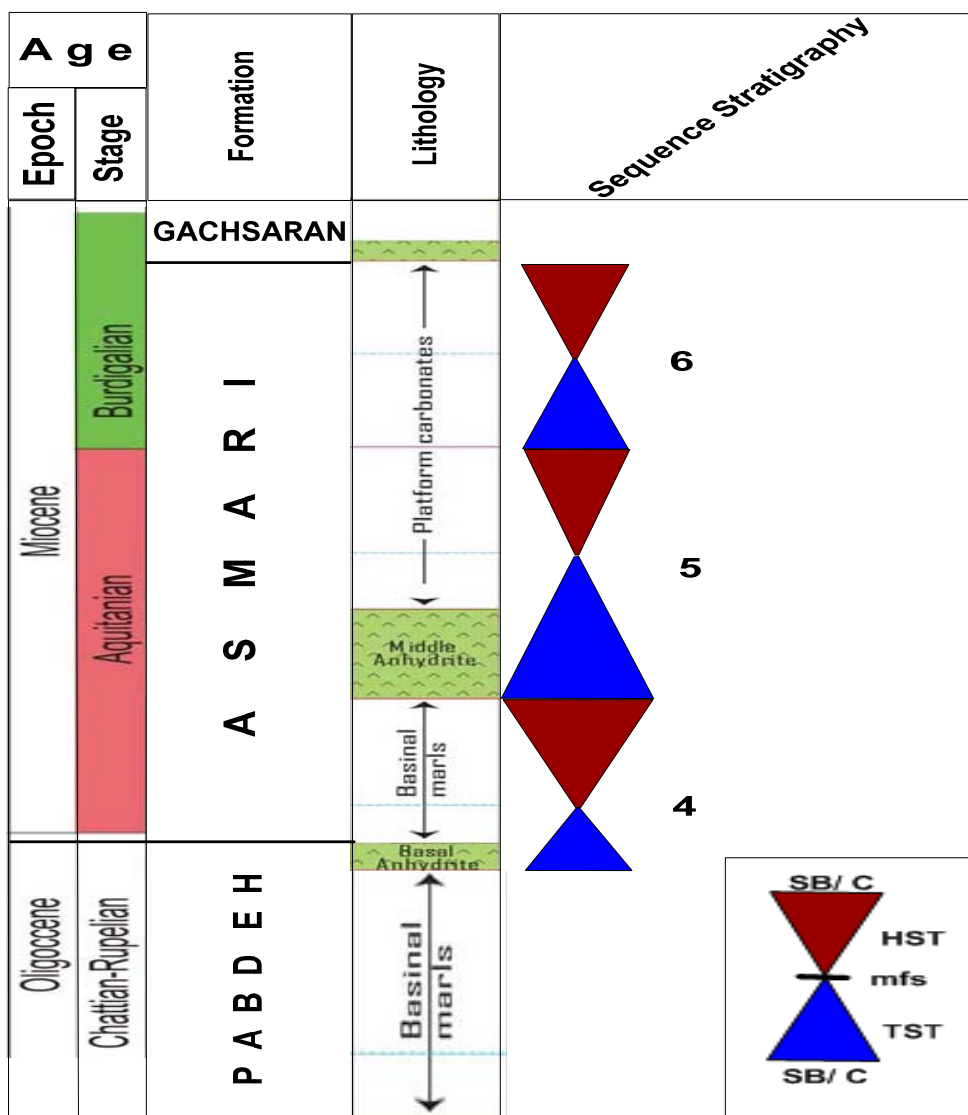


Fig. 9. Sequence Stratigraphy of the Asmari formation in Well-13
(From Van Buchem et al., 2010).

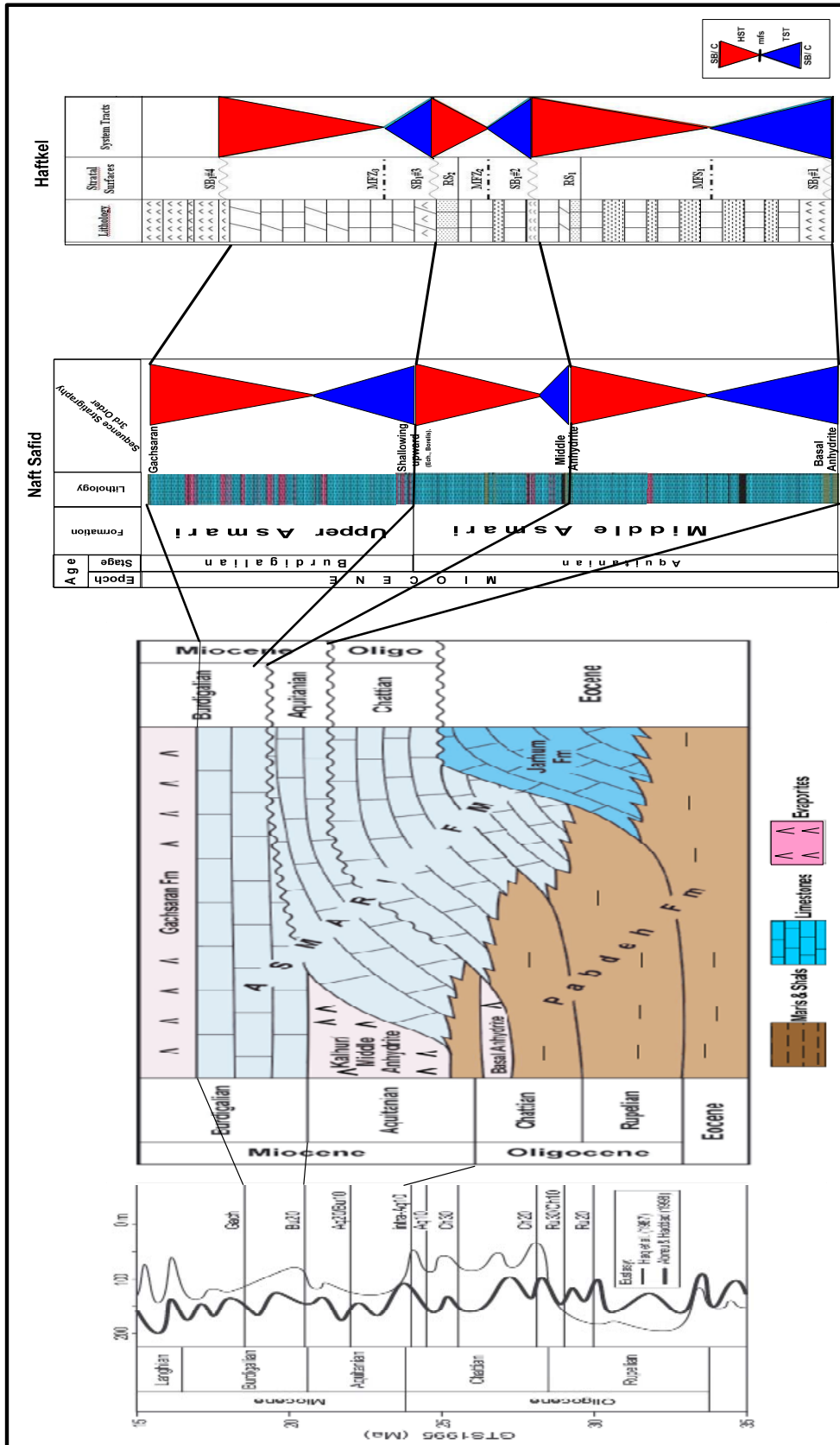


Fig. 10. Sequence stratigraphy of the Asmari formation in two studied oil field compared with global Eustasy curve and with times of global transgressions and regressions (From Gradstein et al., 2004) and stratigraphic relationship between Asmari formation and laterally equivalent formations (Ehrenberg et al., 2007).

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