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### Palynofacies and Paleoenvironment investigation of the Hauterivian – Early Aptian Ratawi and Zubair formations, Balad oilfield, Central Iraq

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#### ABSTRACT

This work depends on a detailed optical observation study of sedimentary organic facies from the Hauterivian – early Aptian Ratawi and Zubair formations from the Ba-1 well, Balad oilfield, Central Iraq. This study has manifested the advantages of palynofacies analysis methods for source rock evaluation of the studied formations, twenty five cutting rock samples organic facies data indicate a wide variation of source richness, quality and thermal maturity, the Ratawi Formation samples has the Type-II> I kerogen indicates marine environment in immature stage, while Zubair Formation has the Type-II>> I kerogen (oil-gas prone) reflect the marine environment with terrigenous influx in early mature to mature stage (early oil window).

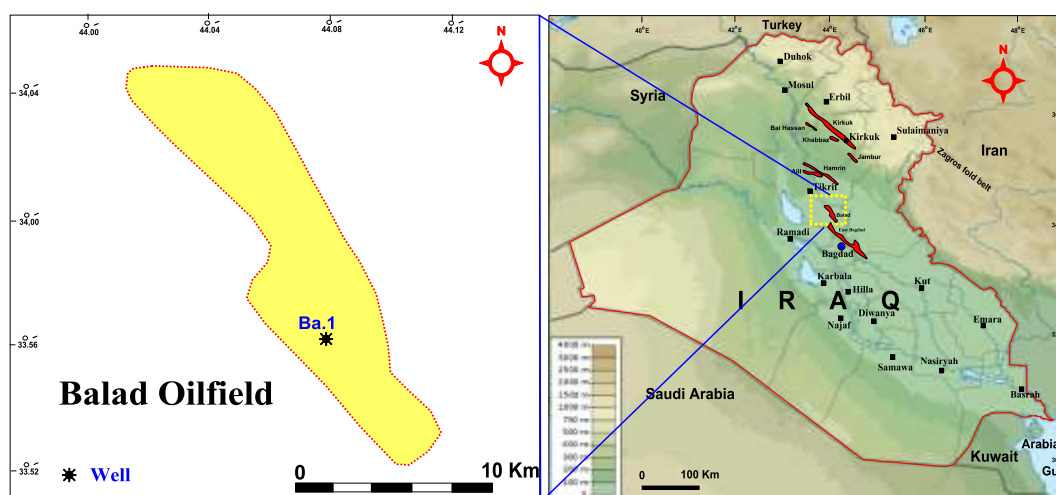
#### 1-Introduction

Iraq is located in the North East corner of the Arabian Plate and has an area of 440,000 km<sup>2</sup>. In the north and North East are the Zagros fold belt whose highest peaks are both a little over 3600 m in elevation, and Near the Centre of the "Fertile Crescent" which is distinctive mostly by central depression area, which extends from the Arabian Gulf to central Syria [1], which led to becoming the one of the world's petroleum-rich countries and a founding member of the cartel of the Organization of Petroleum Exporting Countries (OPEC) with current proven reserves of (133) billion barrels of oil (BBO) and (110) trillion cubic feet (TCF) of gas [2], as soon as it could become one of the main producers in the Middle East because it is endowed with multiple petroleum systems extends from Paleozoic, Mesozoic and Cenozoic rocks [3,4]. The majority of Iraq's oil fields are located in

the Zagros-Mesopotamian Jurassic, Cretaceous-Tertiary petroleum system [3, 4, and 5].

#### 2- Geologic Background

Balad oilfield is one of the important oilfields in Central Iraq along the Tigris River within North Iraq Oil Exploration Company operations in the Salah Al-Din Governorate. It locates approximately 60–70 km to the north of Baghdad (Fig. 1), on the slope of the near platform flank of the Mesopotamian Basin and covered by the Pleistocene and recent sediments represented by alluvial deposits and river terraces these formations consist of silt and clay deposits with presence of sand and gravel [6] and limited by a central faulted zone to the north-east and by the slope of the Afro- Arabian Platform to the south-west [7].



**Fig. 1: Location map of the study area showing the geographic distribution of the studied oil wells, in Balad oilfield, Central Iraq**

Iraq located on the edge between three major tectonic units belonging to the Phanerozoic age; these are the Arabian, the Iranian and the Turkish Plates, which resulted that Iraq has being a part of the Zagros and Arabian sedimentary provinces, [8]. The northern and north east margins of the Arabian Plate are bounded by the collisional Taurus-Zagros suture, while the western plate boundary is stranded in the north west by the left-lateral transtensional Dead Sea fault zone, and in the south west by the Red Sea spreading axis [9].

Balad field is located with the Unfolded Zone (Mesopotamian Basin), in the north-western segment of the Zagros fold-thrust belt of northeastern Iraq. This belt originated and developed between the Arabian and Eurasian plates as a result of multiple stages of convergence. The combination of thick-skinned deformation involving the basement and thin-skinned deformation above a basal detachment near the base of the Lower Paleozoic led to the formation of large-scale Zagros anticlines in Iraq. Long, asymmetric tight anticlines of Balad field probably controlled by thrust faults, are separated by narrow synclines [10, 11].

According to [12], Balad oilfield existing among a series of subsurface structures in west Tigris region represented by Beji, Tikrit, Samarra, Balad and East Baghdad. These structures are sequent to each other in the stage of arrangement. Balad field consider being an extension of east Baghdad field with a diversion to the east and in an

extension of a dextral fault extending from northeast to southwest, reflecting Gotnia Formation [13].

The general stratigraphy of Iraq is summarized in the regional stratigraphic column [14], (Fig.2), shows the presence of a thick Jurassic and Cretaceous succession composed of carbonates, carbonate shales, and anhydrites [15,16]. In this study we will focus on Cretaceous Megasequence (Upper Valanginian – Upper Aptian), comprises Zubair and Ratawi formations which represented the most of the Balad field formations (Fig.3; A).

The Ratawi Formation was first define by [17] and dated as Hauterivian age. The deposit environment indicate a deep inner to middle shelf elastic facies (Fig. 3;B), compresses of a peloidal limestone containing debris of the alga *Lithocodium aggregatum*, overlies Zangura / Yamama Formation and underlies Zubair Formation (Fig. 2). The Formation thickness in the study area is 383 m in the Ba.1 well, Balad oilfield. Zubair Formation was first describe in its type locality in the Zubair field, Basra by [18,19]. Dated as late Hauterivian – early Aptian [20]. The deposit environment of Zubair Formation reflect a fluvio-deltaic to marine setting in humid-tropical climatic conditions (Fig. 3;B), indicate stronger marine influences [21], overlies Ratawi Formation and underlies Shuiba Formation (Fig. 2). Zubair Formation thickness is 468m in the Ba.1 well, Balad oilfield.

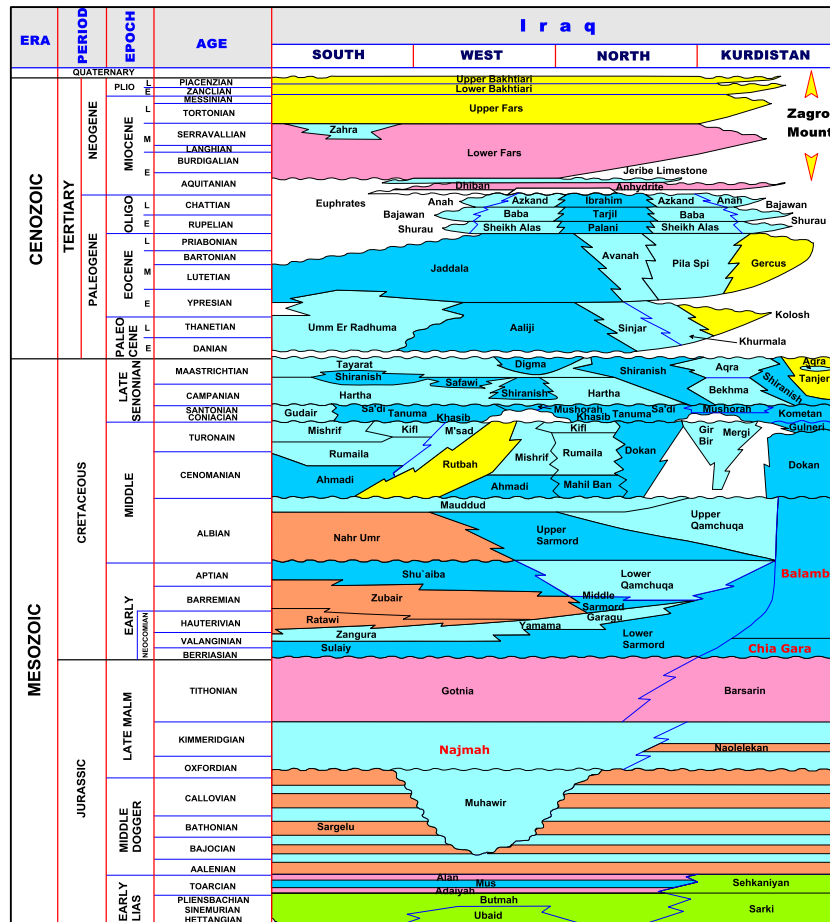


Fig. 2: Stratigraphic correlation chart represent the southern, western, and northern Iraq in the geological column of Iraq [14].

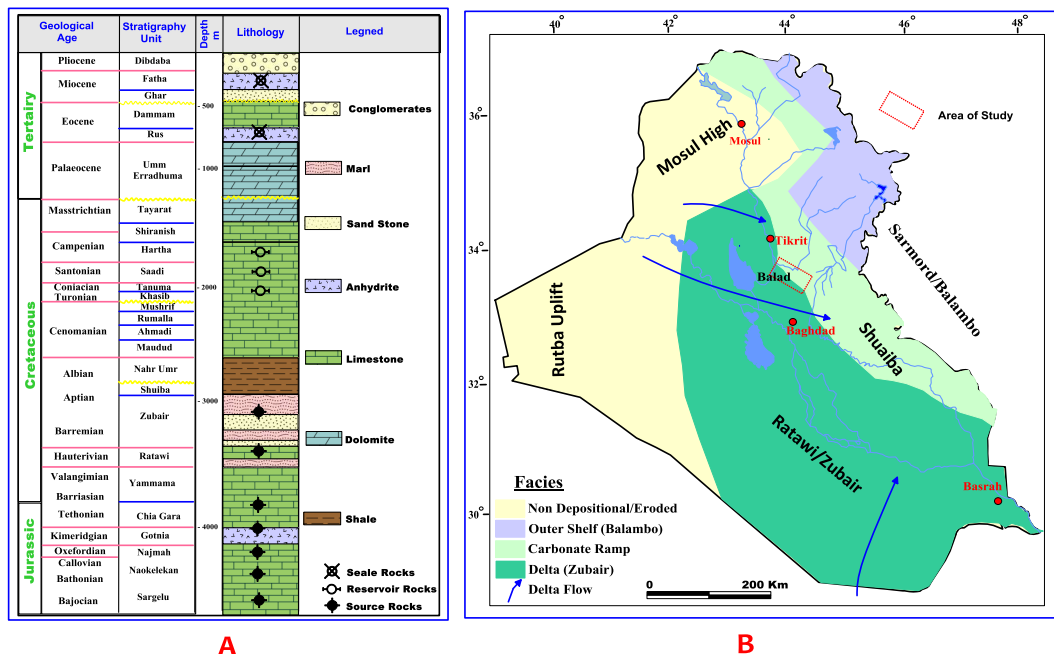


Fig. 3: (A) Stratigraphic correlation chart represent the southern, western, and northern Iraq in the geological column of Iraq [14]; (B) Paleogeography of the Early Cretaceous time (Hauterivian – Aptian) age, Ratawi and Zubair formations [1]

### 3-Samples and analytical procedures

The organic facies work is based on 25 cuttings samples recovered from Ratawi and Zubair formations in well Ba.1, Balad oilfield, within National Oil Company. The samples were prepared palynologically using standard palynological maceration techniques following [22], and modified by [23], and adopted at the Geology Department, Faculty of Science, Sues canal University, Egypt.

### 4-Results and discussion

Based on the microscopic study of organic matter particulate from the analyzed samples of Ratawi and Zubair formations from Ba.1 well, Balad Oilfield, two types of Palynofacies have been designated as PF-1 and PF-2 and established the quantitative and qualitative variations in the kerogen content and the distribution of amorphous organic matter (AOM), phytoclasts and palynomorphs (Table 8). The palynofacies association 1 (PF-1), determined on the basis of high relatively increase and wide distribution in amorphous organic matter (AOM), has been recorded in Ratawi Formation samples from the depth 3618m to 3976m (Table 8) within Ba.1 well, Balad Oilfield. This facies comprises high abundance of AOM reach to 92 wt.% associated with rare phytoclasts, and palynomorphs, the AOM color that recovered from the Ratawi Formation are range from pale yellow to yellowish brown classified as types-A [24] (Plate I, 1 and 2), the phytoclasts represented by pale yellowish brown preserved plant fragments (tracheids, cuticles), as shown (Plate I, 5 and 6), the

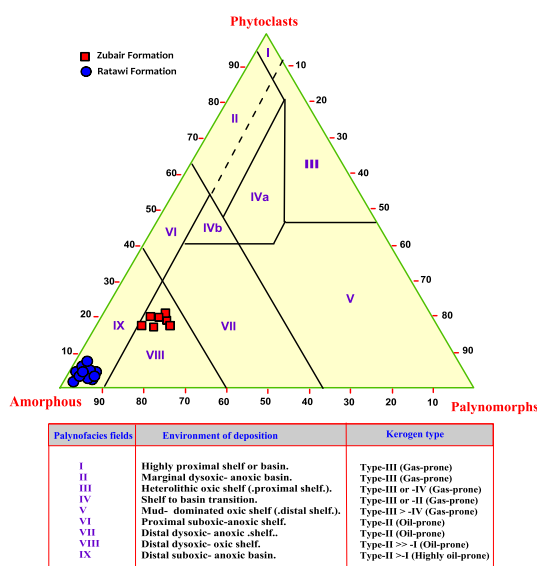
palynomorphs, represented by spores and foraminifera test lining (Plate I, 9 and 10). The palynofacies association 2 (PF-2) has been recorded within the whole samples of the Zubair Formation from the depth 3476m to 3593m (Table 8) characterized by high percentage of AOM associated with relative high abundance of phytoclasts as well as palynomorphs, the AOM that recorded from this formation range from yellowish brown to dark brown (Plate I, 3 and 4) classified as types-A and types-C [24]. The phytoclasts represented by plant fragments tracheids and cuticles as shown (Plate I, 7 and 8). The palynomorphs, represented by dinocysts and pollen (Plate I, 11 and 12). For Interpretation the palynofacies data we use the ternary diagram AOM-phytoclast-palynomorph (APP) of ([25]; Fig. 4) is herein adopted for illustrating our data due to their good potential in showing a clear separation among various groups of samples or assemblages [26]. The palynofacies data plotted on the APP [25], ternary diagram, two main palynofacies types were diagnosed (Fig. 4; Table 8). The PF-1 samples representing the Ratawi Formation within the field IX, which reflects distal-suboxic-anoxic basin, based on the high content of AOM that dilutes all other organic particles, and hence classified as Type-II>-I kerogen ([26]; highly oil-prone). On the other hand, the samples retrieved from the Zubair Formation on which the PF-2 palynofacies is based, are located in the field VIII, representing distal dysoxic-oxic shelf, classified as Type-II>> I ([1]; oil- gas prone).

**Table 1: Distribution of the retrieved palynodebris and percentages of Ba.1 well, Balad Oilfield formations**

Sample no.	Depth (m)	Geological Age	Formation	AOM %	Phytoclasts %	Palynomorphs %
1	3476	Barramian - Aptian	Zubair	65	20	15
2	3497			63	19	18
3	3516			62	21	17
4	3536			68	18	14
5	3557			66	20	14
6	3578			62	19	19
7	3593			71	18	11
8	3618	Cretaceous Hauterivian	Ratawi	88	7	5
9	3634			91	7	2
10	3653			89	8	3
11	3674			92	5	3
12	3694			91	5	4
13	3734			90	4	6
14	3753			89	6	5
15	3774			91	5	4
16	3793			92	7	1
17	3815			92	5	3
18	3835			94	4	2
19	3852			91	6	3
20	3874			92	5	3
21	3895			89	7	4
22	3913			90	6	4
23	3933			90	5	5
24	3954			91	6	3
25	3976			93	4	3



**Plate I. Photomicrographs of amorphous organic matter (AOM), palynomorphs and phytoclasts assemblages of the Zubair and Ratawi formations retrieved from well Ba-1, Balad oilfield central Iraq.**  
 1, 2) pale yellow and yellowish brown marine type A (AOM), Ratawi Formation 3634 m and 3674 m; 3) yellowish brown marine type A (AOM), Zubair Formation 3497 m; 4) Dark brown terrestrial type C (AOM), Zubair Formation 3557 m; 5,6) Pale yellowish brown woody phytoclast and dispersed leaf Cuticle, Ratawi Formation 3793 m and 3933 m; 7,8) Plant fragments tracheids and cuticles Zubair Formation 3536 m and 3593 m; 9,10) Polypodiaceoisporites sp. and foraminifera test lining, Ratawi Formation, 3815 m and 3954 m; 11,12) *Sumatradinium cf. hispidum* and *Tricolpopollenites sp.* Zubair Formation 3516 m and 3578 m.



**Fig. 4: Ternary APP kerogen plot of the investigated samples in the Ba.1 well, Balad Oilfield [25].**

## 5- Conclusions

Twenty five cuttings samples retrieved from the Zubair and Ratawi Formation in Ba.1 well, Balad Oilfield, Central Iraq studied using palynofacies analyses technique. The following key points can be drawn:

1. Ratawi Formation palynofacies analysis indicated a wide variation of source richness and quality, but in immature stage, the kerogen is marine (Type-II) deposits in anoxic marine environment with

negligible terrestrial influx, depending on this Ratawi Formation considered to be possible source that did not have the ability to generated hydrocarbon.

2. Zubair Formation microscopic study indicated of rich in organic matter the kerogen is the mixed (Type-II and Type II/III), deposits in lees reducing marine environment with terrestrial influx and the thermal maturity of the studied rock samples ranges from early to peak oil window.



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## التحري عن السحنات العضوية الباليئولية والبيئة القديمة لتكويني رطاوي و الزبير من عمر الطباشيري (الهاوتروفي الى الأبتى المبكر) من حقل بلد النفطى، شمال غربي العراق

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### الملخص

اعتمد هذا العمل على دراسة مجهرية مفصلة لنماذج صخرية من تكويني رطاوي والزبير من عمر الطباشيري (الهاوتروفي الى الابتي المبكر) مأخوذه من بئر بلد-1 لحقل بلد النفطى، شمال غربي العراق. اظهرت هذه الدراسة افضلية استخدام السحنات العضوية الباليئولية لتقييم صخر المصدر لتكويني رطاوي و الزبير، خمسة وعشرون عينة فتات ضخري جمعت من تكويني الدراسة وتم دراستها باستخدام المجهر الضوئي الخاص بدراسة السحنات العضوية ، بينت الدراسة ان هناك تباين واضح في الاغناء العضوي من المادة العضوية وكذلك درجة نضوجها بين تكويني رطاوي و الزبير ، حيث ان نتائج تحاليل نماذج تكوين رطاوي اعطت درجة واطئة من الاغناء العضوي ، واعطت كيروجين من النوع الثاني الذي ترسب في بيئة بحرية مختزلة، اما تكوين الزبير فأعطى النوع الثاني القريب من النوع المختلط الذي ترسب في بيئة بحرية اقل اختزالا مع وجود تأثيرات قارية واضحة.