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Abstract

cutting rock samples of Late Triassic Baluti Formation from two exploration wells (Atrush and Sheikhan wells), near Duhok city, Iraqi Kurdistan Region were analyzed to determine the Palynofacies, then to evaluate source rock potentiality and the thermal maturity by pyrolysis parameters. Three Palynofacies were identified according to the amount of the each organic matter category. The Palynofacies-1, was deposited in Heterolithic oxic shelf, Palynofacies-2 was deposited in shelf to basin transition and Palynofacies-3 which deposited in Mud-dominated oxic shelf. According to quantitative classification of Total Organic Carbon values, the founded percentage of TOC was higher in well Sheikhan-1B (in Sheikhan Structure), resembling in fair source rock, comparing to well Atrush-1 (in Atrush Structure) which showes poor source rock indications. According to the Tmax values, Baluti Formation in both wells were reached early stage of maturity, but Tmax was higher in well Sheikhan-1B than well Atrush-1. The type of the organic matter were determined from calculation of hydrogen index and oxygen index, thus in well Sheikhan-1B the kerogen is type III to IV while Atrush-1 contains type II to III. Moreover, Sheikhan-1B has ability to generate gas (gas prone), while Atrush-1 is producing mixed oil-gas

Keywords

Upper-Triassic, Baluti Formation, Source Rock, Palynofacies, Pyrolysis

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Palynofacies and Source Rock Evaluation of Late Triassic Baluti Formation, from two selected wells, in the Northwestern Kurdistan Region, Iraq

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ABSTRACT:

cutting rock samples of Late Triassic Baluti Formation from two exploration wells (Atrush and Sheikhan wells), near Duhok city, Iraqi Kurdistan Region were analyzed to determine the Palynofacies, then to evaluate source rock potentiality and the thermal maturity by pyrolysis parameters. Three Palynofacies were identified according to the amount of the each organic matter category. The Palynofacies-1, was deposited in Heterolithic oxic shelf, Palynofacies-2 was deposited in shelf to basin transition and Palynofacies-3 which deposited in Mud-dominated oxic shelf. According to quantitative classification of Total Organic Carbon values, the founded percentage of TOC was higher in well Sheikhan-1B (in Sheikhan Structure), resembling in fair source rock, comparing to well Atrush-1 (in Atrush Structure) which showes poor source rock indications. According to the T_{max} values, Baluti Formation in both wells were reached early stage of maturity, but T_{max} was higher in well Sheikhan-1B than well Atrush-1. The type of the organic matter were determined from calculation of hydrogen index and oxygen index, thus in well Sheikhan-1B the kerogen is type III to IV while Atrush-1 contains type II to III. Moreover, Sheikhan-1B has ability to generate gas (gas prone), while Atrush-1 is producing mixed oil-gas .

Keyword: ***Upper-Triassic, Baluti Formation, Source Rock, Palynofacies, Pyrolysis.***

INTRODUCTION

Petroleum system encompasses a pod of active source rock, enriched with organic matter, and all genetically related to oil and gas generation. It includes all the geologic elements and processes that are essential if there is generation, with respect to suitable time and

sufficient depth. Source rock is one of the essential elements, considered as the core of each petroleum system. Oil or gas plays originates form source rocks, the viability of each play conventional or non-conventional, oil or gas, depends on the source rocks (McCarthy et al., 2011). In the current study, two exploration wells, at Duhok territory, Iraqi Kurdistan Region were chosen to study Palynofacies to evaluate the source rock and thermal maturity of Baluti Formation . ***Well AT-1*** located in (43.450069° E 36.864222° N) with 1210 m RTE, this well in on the Atrush structure located on the High folded zone according to the tectonic subdivisions of Iraq (Jassim and Goff, 2006). Thickness of Baluti Formation in this well is approximately 70 m, which located within range of 2155 m to 2225 m total depth. TAQA Oil Company operates this exploratory well in this block. ***Well SH-1*** located in (43.345914° E 36.776197° N) with 781 m RTE, this well located in the High folded zone, and the thickness of this formation reaches 82 m, this formation appeared in the deeper ranges of 2290 m to 2383 m total depth. Sheikhan block is operated by Gulf keystone Oil Company. Understanding the degree of maturity of Baluti Formation at each well, gives clue about whether, the petroleum found in those wells are generated above or below this formation with respect to the temperature of the borehole or the petroleum (prospective hydrocarbon) came from migration due to structural variations in this area. However, there is no studies that concern about the hydrocarbon generation, rather than stratigraphy and geochemistry studies. Hence the aim of this study mostly outlines the source rock assessment and petroleum potentiality of Baluti Formation from wellbore holes.

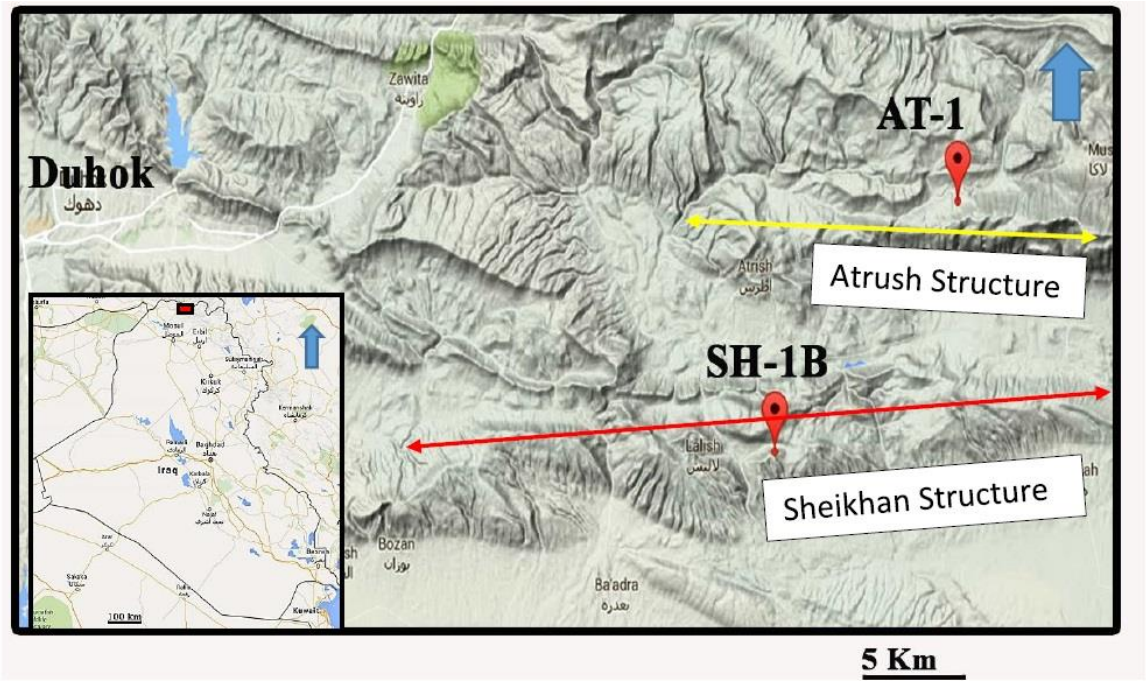


Figure 1: Landsat image, exposing structures and location of the two wells in Northwestern Iraqi, Kurdistan Region

STRATIGRAPHY:

The Baluti Formation was first introduced by Wetzel (1950) and emended by Morton in 1951 (in Bellen et al., 1959). The name of the formation is derived from Baluti village, which is located in the southeastern Amadyia city, Duhok overnorate, Northern part of Iraqi Kurdistan region, near to which the type section is located (Buday, 1980). ***SH-1B:*** The base of the formation begins with alternating shale with anhydrite. Middle part is mostly composed of shale but with very thin layers of anhydrite and dolomite, while the upper part of this column is dominated by shale with dolomitic limestone and dolomite. Thickness of Baluti Formation in this well is 82 m. Generally, the percentage of shale in this well is about 52%, dolomite and limestone is 25%, and anhydrite is 13% (Fig. 2).

AT-1: The lower part of Baluti Formation in this well is mostly dominated by dolomite with thin units of grey to medium dark grey shale. The middle part of this column shows increasing of grey shale with dolomite units and thin anhydritic units, while the upper part is mostly composed of dolomite. The overall thickness of Baluti Formation in this well is 70 m. Generally, the percentage of shale is 43%, dolomite and limestone is about 53%, and anhydrite is 4% (Fig. 3).

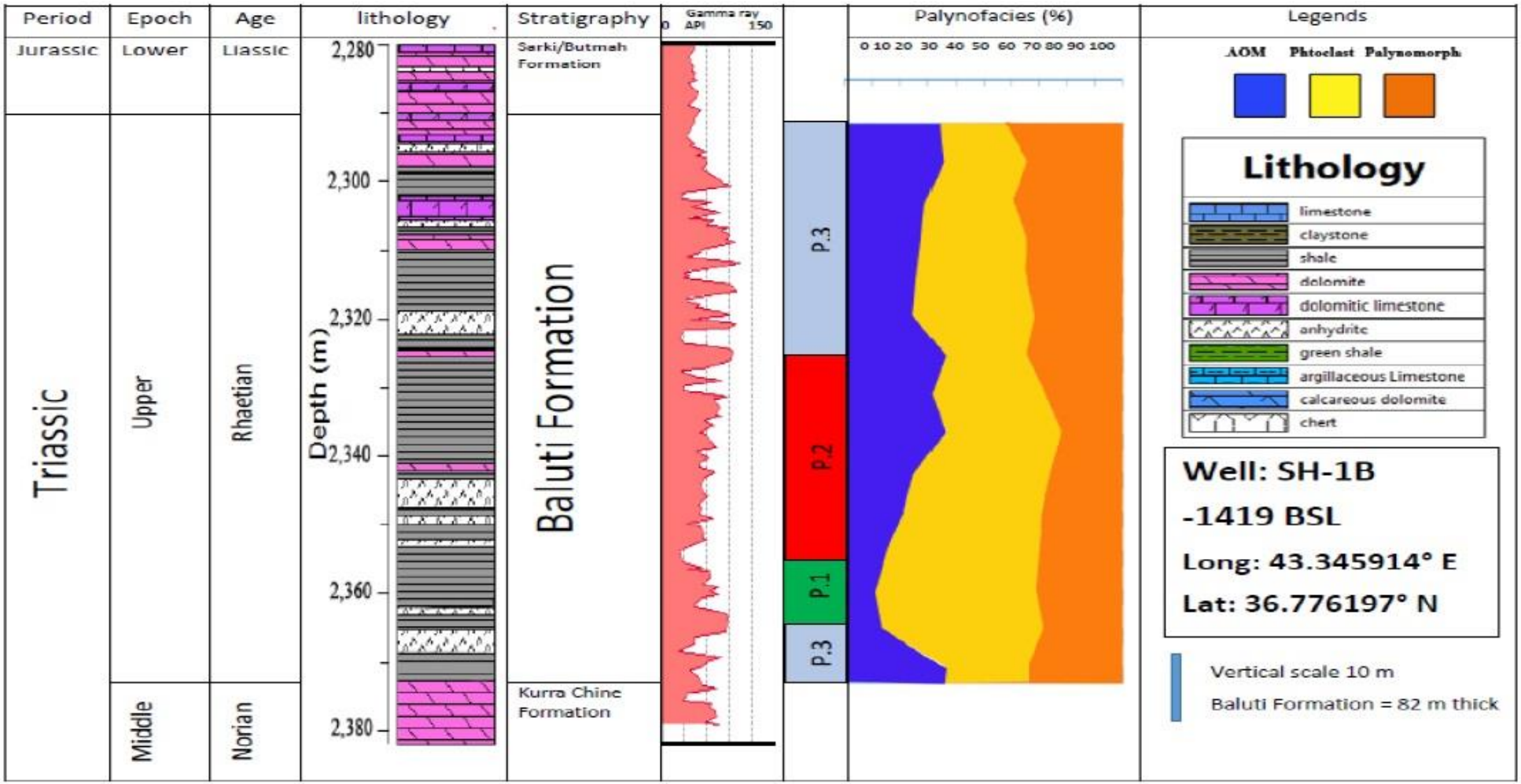


Figure 2: Composite log section correlated to position and percentage of Palynofacies of Baluti Formation in well SH-1B.

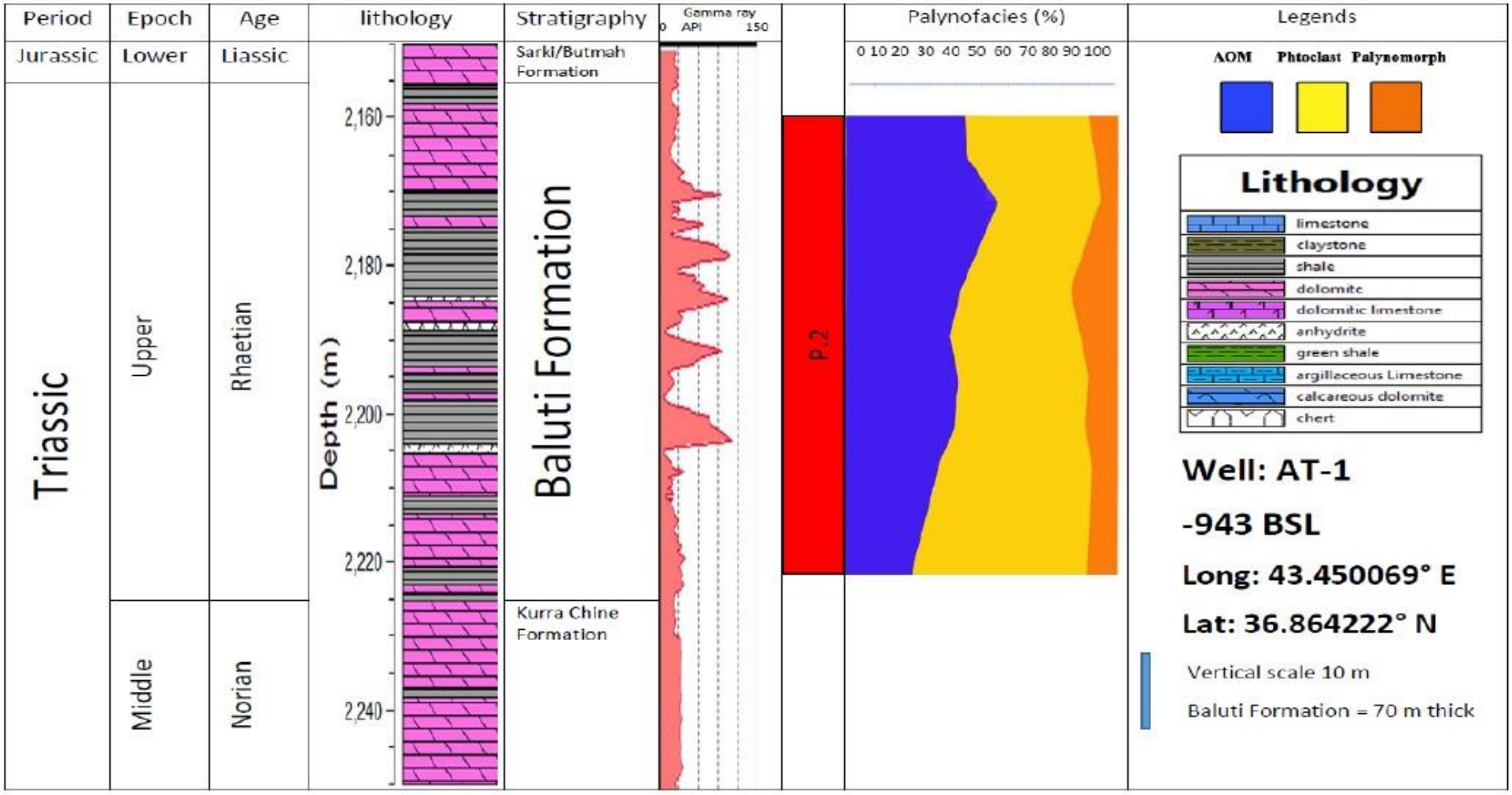


Figure 3: Composite log section correlated to position and percentage of Palynofacies of Baluti Formation in well AT-1.

METHODOLOGY:

Cutting rock samples systematically were taken from the warehouse of the Ministry of Natural Resources, Erbil, Iraq. In order to study Palynofacies, slides were prepared at laboratories of Department of Geology, College of Science, Salahaddin University by using HCL to vanish the carbonate matrix and HF to remove silica. And, some samples were chosen to analyze by Rock-Eval pyrolysis at Research center of Soran University (Table: 1).
A detailed information on the laboratory procedures of Rock-Eval pyrolysis, as well as guidelines for interpreting the results of these analyses were published by Peters (1986), and Peters and Cassa (1994)

Table 1: The values of Rock-Eval (Pyrolysis) analysis for the two wells.

Depth (m)	*Wells*	*TOC (%)*	*S1*	*S2*	*S3*	*T_{max} (°C)*	*HI*	*OI*	*GP*
2170	AT-1	0.68	0.11	1.94	0.49	435	285	72	2.05
2175	AT-1	0.25	0.05	0.49	0.06	439	196	24	0.54
2185	AT-1	0.34	0.06	0.66	0.23	434	194	68	0.82
2190	AT-1	0.34	0.09	0.62	0.23	424	182	68	0.71
2205	AT-1	0.33	0.11	1.13	0.13	434	342	39	1.24
2336	SH-1B	0.68	0.1	0.67	0.81	424	99	119	0.77
2352	SH-1B	0.76	0.07	1.07	1.02	437	141	134	1.14
2364	SH-1B	0.74	0.07	0.91	0.78	436	123	105	0.98
2373	SH-1B	0.3	0.04	0.3	0.57	434	100	190	0.34

RESULTS AND DISCUSSIONS:

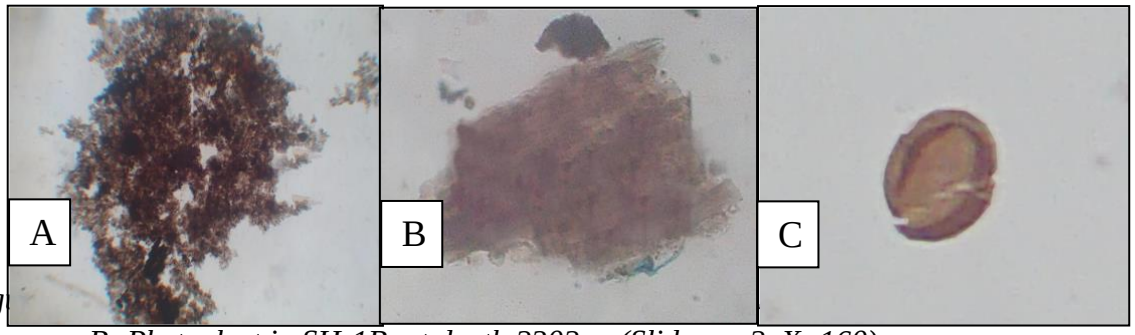
A. Palynofacies:

Palynofacies was defined as assemblages of palynomorphs taxa in a body of sediment, representing local environmental conditions. In this study, the sedimentary organic matter groups was separated from the sediments, each category were counted by using point counter instrument, accordingly their distribution was calculated to find the percentage of each group. Three distinctive Palynofacies were identified based on the estimated percentage amount of each organic matter categories (P-1,P-2 and P-3), and the lithology of the host sediments (Figs. 2 and 3). Then each Palynofacies were plotted on Tyson Ternary (1995) to determine the type of kerogen and their production capability (Fig. 5A and B).

Palynofacies-1 **(P.1)** observed only in well-SH-1B, between 2355 m to 2365 m depth. The lithology of this facies composed of shale, interbedded with anhydrite was characterized by high percentage of Phytoclasts and medium percentages of palynomorphs (includes degraded Spore and Pollen) and low percentage of AOM. This palynofacies is located within field III, deposited at Heterolithic oxic shelf (Proximal shelf), the abundance of the Phytoclast depends on the proximity of the fluvial-deltaic source (Fig. 5 B).

Palynofacies-2 (P.2) located between 2160 to 2220 m depth, in well AT-1, and 2325 to 2355 m in SH-1B well. The lithology of this palynofacies is composed of shale, dolomite, thin layers of anhydrite and dolomitic limestone, This Palynofacies is characterized by domination of Phytoclasts (less than P.1) and medium amount of AOM (higher than P.1), and least amount of Palynomorphs (mainly composed of degraded Spore and Pollen) . The increase of AOM amount is probably due to the change of the basin from shallow marine toward deeper marine, which might be due to a local sea level changes. This palynofacies is mainly seen within field IV, which is suggested to be deposited in shelf to basin transition, this might be due to increase of the accommodation space which was caused by subsidence of the basin or increasing of water depth. (Fig. 5A and B).

Palynofacies-3 **(P.3)** This palynofacies is clearly seen in SH-1B, between 2365 m to 2372 m depth, and repeated at 2290 m to 2325 m. The lithology is mainly consists of shale, dolomite, thin layers of anhydrite, and dolomitic limestone. Characterized by same amounts of the three components (AOM, Phytoclast and Palynomorphs). The stability of AOM amount and the increasing of Palynomorphs, and presence of degraded spore and pollen (continental) indicates the domination of shallow marine to continent environment due to influx of transported continental palynomorphs. This palynofacies plotted within field V, which characterized by Mud-dominated oxic shelf (distal shelf). (Fig. 5 B).



Fig

B: Phytoclast in SH-1B, at depth 2302 m (Slide no. 2, X: 160).
C: Palynomorph in SH-1B, at 2360 m, (Slide no.14, X: 160).

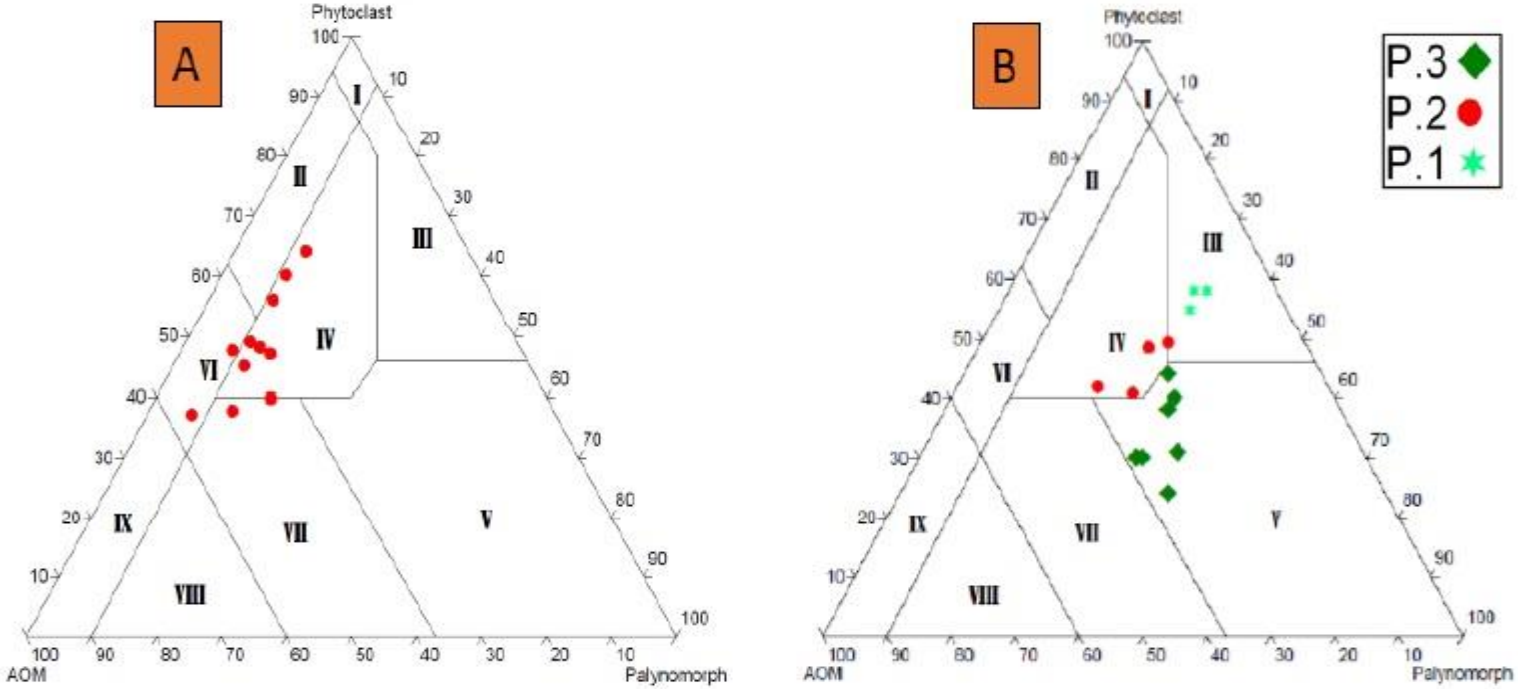


Figure 5: A: APP diagram plotted for well AT-1, which include only Palynofacies.2 (P.2).
B: APP diagram plotted for well SH-1B includes three distinct palynofacies for Baluti Formation in this well.

B. GEOCHEMICAL ANALYSIS

1. **TOC:** the location of well SH-1B, appeared to be richer area of TOC w.t % content. Hence, the maximum TOC w.t (%) detected in well SH-1B, which is 0.76 %. While, minimum TOC value recorded in well AT-1, which is 0.25 %. So according to the source rock classification of Peters (2005), Baluti Formation is assumed to be Fair source rock at SH-1B and poor source rock at AT-1 (Fig. 6).

2. **Rock-Eval Parameters:** as a function of the maturation indicator, T_{max} (C°) values for the two wells were plotted and evaluated according to the Peters (2005) classification. Accordingly, Baluti Formation reached early stage of maturation (Fig. 7). For determining the types of the kerogen and the hydrocarbon generation the values of HI vs OI and T_{max} (C°) were plotted on a standard chart, according to the results, the well SH-1B consist of type III to IV kerogen, while AT-1 consist of type II to III kerogen. Thus, the well SH-1B has ability to generate gas. Meanwhile, AT-1 is capable to generate Oil and Gas (Fig. 8 and 9). The Source rock Evaluation were done according to the amount of the Genetic Potential (GP) (Tissot and Welte, 1984) and its plotted against TOC w.t (%) (Fig. 10).

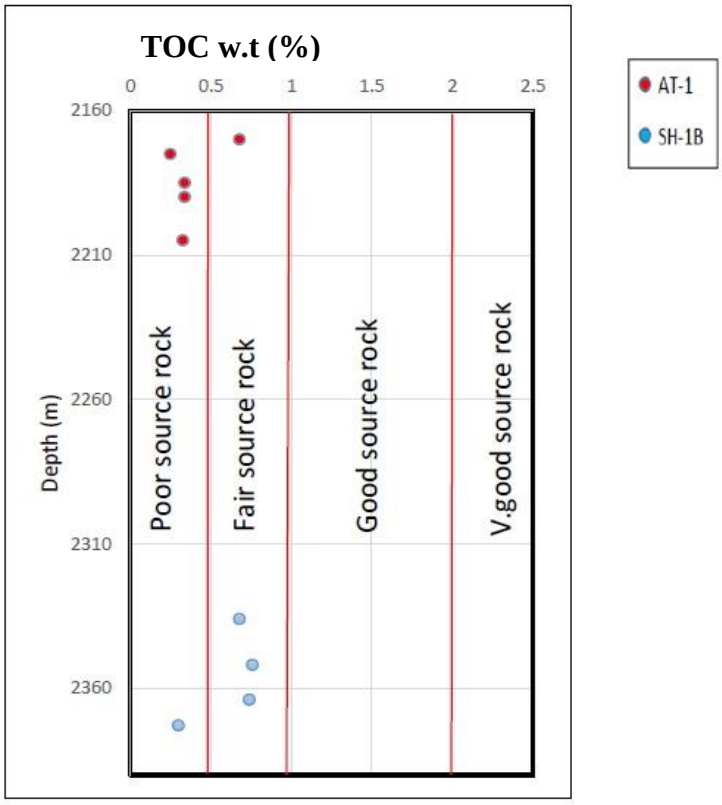


Figure 6: Source rock evaluation by means of TOC w.t (%) vs Depth (m).

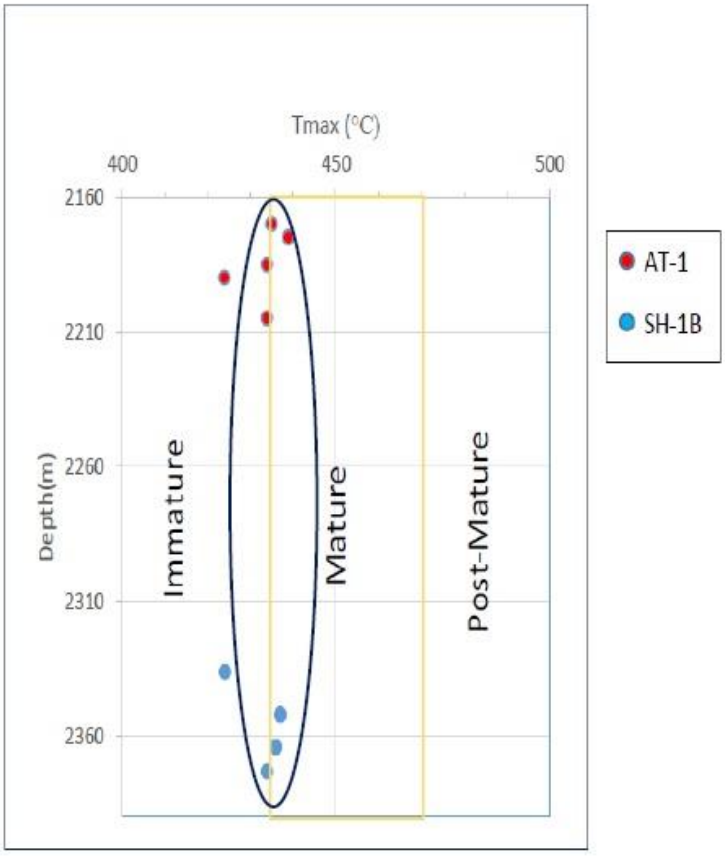


Figure 7: Maturity plot as function of T_{max} (°C) vs depth (m) for the studied samples, for the two wells.

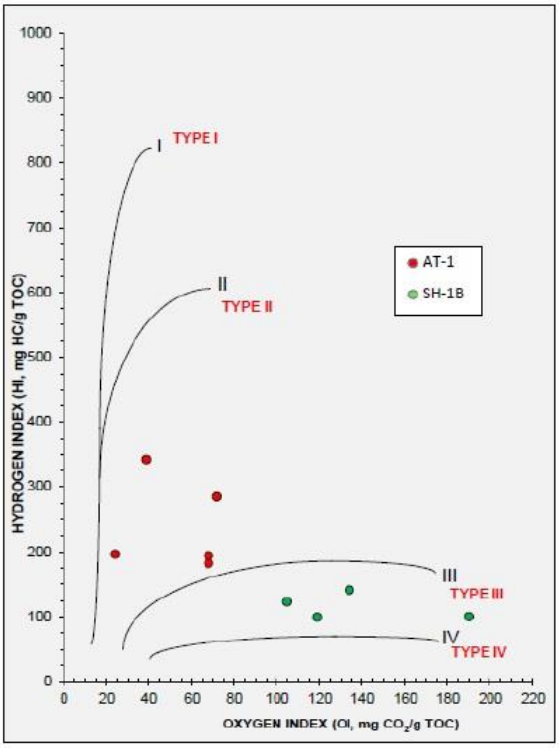


Figure 8: Type of kerogens determined by plotting Hydrogen Index (HI) vs Oxygen Index (OI).

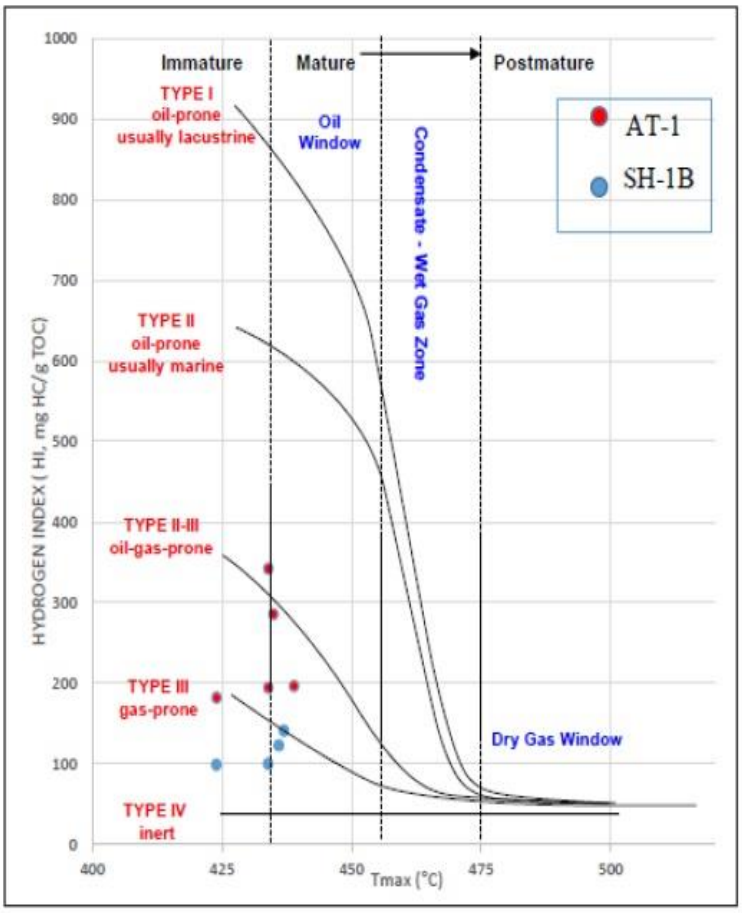


Figure 9: Hydrogen Index (HI) vs T_{max} (°C) to determine type of kerogen and oil window identification to the analyzed samples of the studied wells.

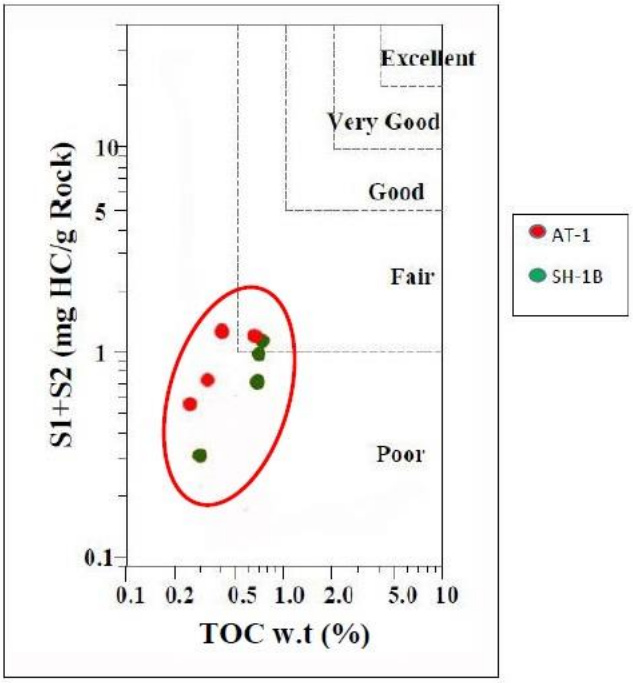


Figure 10: Genetic Potential (GP) vs TOC w.t (%) for the studied samples (diagram from Ghori, 2002).

CONCLUSIONS: according to the obtained results from the Palynofacies, TOC w.t (%) and pyrolysis analysis, the conclusions were shortened into the followings.

1. According to the Palynofacies analysis, Baluti Formation can be divided into three palynofaices, relying on lithology and percentage of the three main components.
2. The P.1, deposited in Heterolithic oxic shelf (proximal shelf, this facies presumed to be kerogen type III or IV, which implied to be gas prone. P.2, deposited in shelf to basin transition, thus assumed to be kerogen type III or II. Finally, the P.3 characterized by mud-dominated oxic shelf, this facies suggested to be kerogen type III<IV.
3. Hence, the location of The well SH-1B is was more affected by local sea level changes and more affected by organic matter influx.
4. According to the amount of the TOC w.t (%), Baluti Formation can be considered as poor source rock. Some of the amounts were negligible at well AT-1.Thus, because they were less than 0.5 w.t (%).
5. According to the values of T_{max} (C°), Baluti Formation reached early stage of maturity, thus, most of the values were reached 435 C°.
6. The amounts of the HI and OI were witnessed type III kerogen for both wells.
7. This formation has ability to generate oil-gas in Atrush Structure and mainly gas in Sheikhan Structure.
8. Baluti Formation can be classified as poor to fair source rock, depending on genetic potential values.

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