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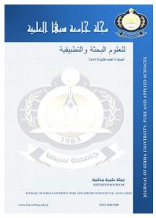

# Geochemical Evaluation for the Hydrocarbon Potential of Source Rocks in Central Sirt Basin, (concession -59), case study, Libya

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**Keywords:**
Geochemical Evaluation
Source rocks.
Organic geochemical analyses.
Organic petrographic analysis
Thermal maturation.
Petroleum Potential
Sirt Basin

**ABSTRACT**

The Sirt Basin important oil producing area in Libya is one of the richest regions in terms of hydrocarbon resources. Exploration studies of this area have shown that the oils are mixtures of several charges and may be from different source rocks particularly in the upper Cretaceous sediments this study based on organic geochemistry and organic petrographic analysis carried out on 179 cutting samples collected from four wells. From Cenomanian to upper Eocene succession within the central Sirt basin, the main aim of this study geochemical evaluation of source rocks, thermal maturation and estimate the other source rock in the area. The recorded geochemical values varied in these wells from one formation to another depending on lithology, paleoenvironment and tectonic events. Our results exposed that, The total organic carbon (TOC) values using Rock-Eval analysis showed that the Sirt Shale is considered the most important regard to hydrocarbon source potential, since it was found to reflect a high total organic carbon content 4.98 %. , (TOC) ranging (average 2.61), type–II kerogen (oil prone) and, with Hydrogen index (HI) mostly below 500. Rachmat average HI = 176 (kerogen types II, III), Organic facies analysis classified Sirt Shale in class B with dominantly amorphous high quality organic matter deposited in anoxic marine environment. Maturity evaluation result of Ro %, SCI, and $T_{max}$ °C, Formations are late immature to early mature stages.

# التقييم الجيوكيميائي للقدرة الهيدروكربونية لصخور المصدر في مركز حوض سرت (امتياز-59) ليبيا

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**الملخص**

تعد منطقة حوض سرت مهمة لإنتاج النفط في ليبيا وواحدة من أغنى المناطق من حيث الموارد الهيدروكربونية. أظهرت الدراسات الاستكشافية في هذه المنطقة أن النفط عبارة عن خليط من عدة شحنات وقد تكون من صخور مصدر مختلفة خاصة في الرواسب الطباشيري العليا ، وتعتمد هذه الدراسة علي التحاليل الجيوكيميائية العضوية والتحليل البتروجرافي العضوي الذي تم إجراؤه على 179عينة قطع صخرية تم جمعها من أربعة آبار من العصر السينوماني إلى الإيوسينية العليا داخل مركز حوض سرت الهدف الرئيسي لهذه الدراسة التقييم الجيوكيميائي والنضوج الحراري وتحديد صخور المصدر في المنطقة.اختلفت القيم الجيوكيميائية المسجلة في

**الكلمات المفتاحية:**
التقييم الجيوكيمائي
صخور المصدر
التحليل الجيوكيميائي العضوي
التحليل البتروجرافي
النضج الحراري
القدرة الهيدروكربونية

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هذه الآبار من تكوين إلى آخر اعتمادًا على الوصف الصخري والبيئات القديمة والاحداث التكتونية. اظهرت نتائجنا قيم الكربون الكلي العضوي (TOC) باستخدام تحاليل Rock-Eval أن صخر سرت الطيني يعتبر أكثر اهمية كمصدر الهيدروكربون، حيث وجد أن المحتوى من الكربون العضوي الكلي يصل 4.98٪. (متوسط 2.61)، النوع الثاني من الكيروجين (منتج للزيت) ومع مؤشر الهيدروجين (HI) في الغالب أقل من 500. (متوسط) ، HI = 176 بالإضافة الي صخر الراشمات الطيني أنواع الكيروجين II، III) ، صنف تحليل السحنات العضوية لصخر سرت الطيني في الفئة B بمواد عضوية عالية الجودة غير متبلورة بشكل سائد تترسب في بيئة بحرية عديمة الأكسجين. نتائج تقييم النضوج باستخدام لـRo٪ وSCI و Tmax oC، تشير إلى مرحلة عدم النضج الي النضج المبكر.

حوض سرت

## Introduction

The Sirt Basin in north central Libya is one of Africa's most productive petroleum basins and the world's 13th largest petroleum province, with reserves estimated at 43 billion barrels of oil equivalent (recoverable) within 16 giant oil fields and 23 relatively large oil fields [1]. In Sirt Basin the Upper Cretaceous with different thicknesses are deep marine shales accumulated in troughs whereas shallow marine carbonates and clastics deposited in platforms represent the hydrocarbon reservoirs. Upper Cretaceous organic-rich shale deposited first, after which continued subsidence led to the gradual on-lap of the platforms during the Late Cretaceous [19].These organic-rich deposits subsequently became the principal source rocks that generated and charged large quantities of high-quality petroleum (Rossi et al., 1991; Hassan and Kendall, 2014).

Aboglila et al. (2010) and Aboglila and Elkhalgi (2013) carried out studies on the Cretaceous source rocks in the eastern Sirt Basin. The geochemical analyses to increase understanding history of petroleum accumulation. This study provides a detailed organic geochemical for organic-rich from Cenomanian to upper Eocene strata throughout central Sirt basin, thereby Permitting a more comprehensive interpretation of the area's petroleum potential. Geochemical methods included Rock-Eval pyrolysis, total organic carbon, thermal maturation and organic petrographic analysis. The aim of this study is to continue the evaluation of hydrocarbon sources in the central Sirt Basin and estimate the other source rock in the area. The study well is located in central part of Sirt Fig 1

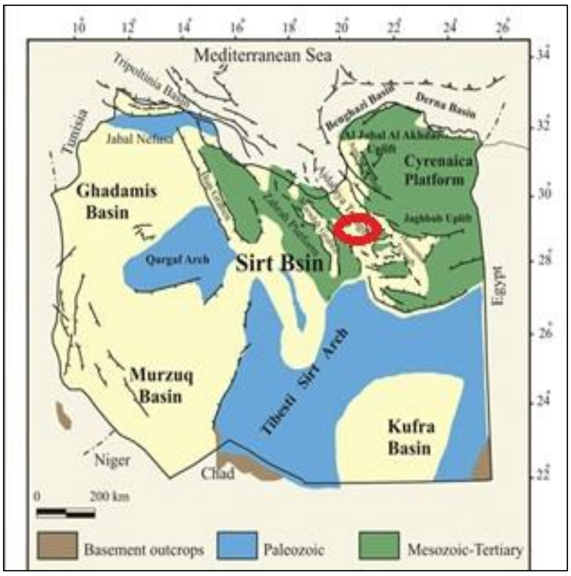


**Fig 1.** Location of study area and wells. (Modified after Rusk 2002)

## STRATIGRAPHY

The stratigraphic nomenclature according [3], used in this study. Basin-fill sequences are preserved within the Sirt Basin, Pre-rift sediments comprise clastic sediments of Cambrian to Ordovician Age The first Mesozoic rift sequence comprises of continental-marine clastics. This cycle followed by deposition of Upper Cretaceous marine clastics and carbonates. The sediment fills of the Upper Cretaceous characterized by extensive lateral and vertical facies changes attributed to the tectonic instability of this period [2]. During this stage, deposition within the troughs characterized by fine siliciclastic whereas, the highs characterized by shallow marine carbonates [2]. The third fill sequences, corresponding to the main Sirt rifting events of Palaeocene to Eocene Age, were carbonates, with minor evaporates. Post rift deposition of shallow marine carbonates occurs from the Middle Eocene to the Oligocene across the Sirt Basin with the exception of the northwest where there are minor units of shale [3]. During the Miocene, the deposition environment in the East Sirt Basin was fluvial along the basin margins, marginal marine towards the north and a marine shelf in the northeast. Fig 2

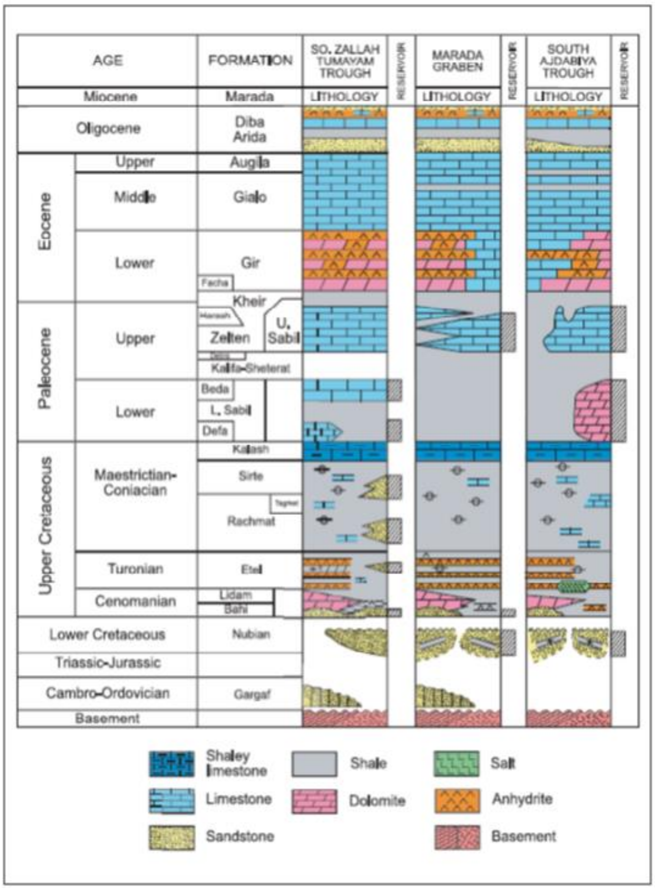


**Fig 2 Stratigraphic** column of the Sirt Basin. [5]

## Materials and Methods.

**Stage I:**The goal of this stage is collect all the available data such geological reports and cutting samples from Al Waha Oil Company for four wells ( XX,YY,ZZ,PP )

Fig 3. The samples washed and cleaned by normal cold water and an appropriate cleaning agent, which used along with 4 mm, 1 mm and 0.125 mm sieves to remove drilling mud and any contaminations, crushed into fine powder, and analyzed using Rock-Eval instrument. It is a useful screening technique for recognizing source rock and kerogen quality. The (Rock-Eval) pyrolysis method consists of programmed temperature heating ( in a pyrolysis oven ) in an inert atmosphere ( helium ) of small sample ( 70 mg ) to quantitatively and selectively determine (1) the free hydrocarbon contained in the sample (2) the hydrocarbon – and oxygen –containing compounds ($co_2$) that are volatilized during the cracking of the un extractable organic matter in the sample (kerogen). With this method, the parameters Measured are TOC, $S_1$, $S_2$, $S_3$ and temperature of maximum pyrolysis yield ($T_{max}$) [18]. The quantity of pyro lysate (mg HC/g rock) generated from the kerogen during gradual heating is normalized to TOC to give the Hydrogen Index (HI, mg HC/g TOC) and kerogen type.

**Stage II**. Thermal maturity levels of the samples carried out using spore coloration and vitrinite reflectances measurements carried out on the 34 selected samples with higher TOC values.

**Stage III**: Organic petrography. Composition of organic matter, palynofacies, paleo-environment and preservation of source rocks were obtained from examination of kerogen slides under transmitted light

**Results and Discussions**

A potential and effective source rocks must satisfy three geochemical requirement these include the quantity, thermal maturity and quality of organic matter. These highlighted by Rock –Eval and optical analysis.

**1- Quantity of organic matter**

According to [16] samples from age Upper Cretaceous to Upper Eocene succession were analyzed for total organic carbon content (TOC %). The average quantity ranges between 0.58 and 2.61, which suggested that the Sirt formation is rich organic matter, therefore considered a very good petroleum source rock within the study area and Rachmat formation second source rock average (1.69) good organic richness, may be related to depositional condition of organic matter (Table 1 , 2 and Fig. 4).

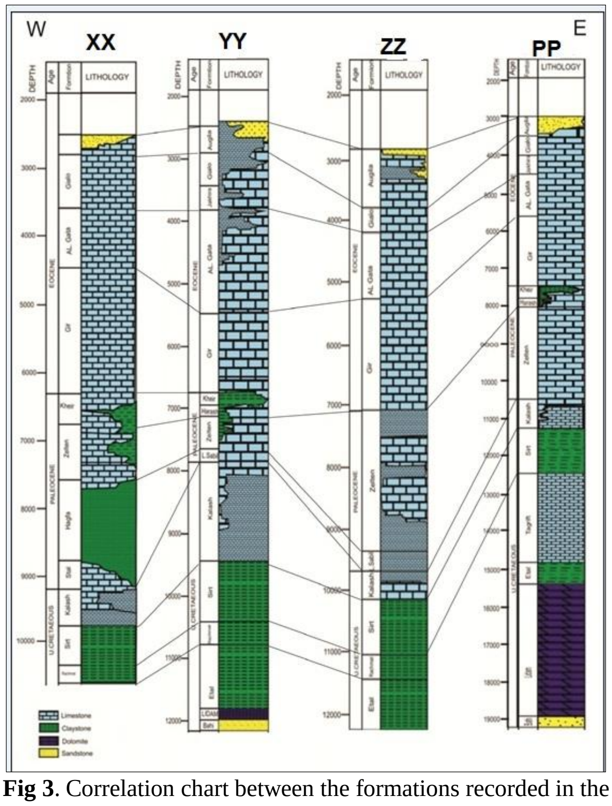


**Fig 3**. Correlation chart between the formations recorded in the study area

**Table1 Standard criteria for ranking source rock richness, [16]**

| Source rock richness | Organic Matter TOC (wt%) Shale | TOC (wt%) Carbonate | Rock-Eval Pyrolysis $S_1$ | $S_2$ |
|---|---|---|---|---|
| Poor | 0.0 - 0.5 | 0.00 - 0.12 | 0 - 0.5 | 0 - 2.5 |
| Fair | 0.5 - 1.0 | 0.12 - 0.25 | 0.5 - 1.0 | 2.5 - 5 |
| Good | 1.0 - 2.0 | 0.25 - 0.50 | 1.0 - 2.0 | 5 - 10 |
| Very Good | 2.0 - 4.0 | 0.5 - 1.00 | 2.0 - 4.0 | 10 - 20 |
| Excellent | >2.0 | >1.00 | >20 | - |

**Table 2. Minimum, Maximum and average TOC % of the analyzed sample collected from the different formations.**

| Age | Formation | Lithology | T.N | TOC % Max | TOC % Min | Average TOC % |
|---|---|---|---|---|---|---|
| EOCENE | AUGILA | SS,SH,LM | 8 | 0.78 | 0.65 | 0.69 |
| | GIALO | LM | 7 | 2.52 | 0.4 | 0.48 |
| | JAKHIRA | LM | 3 | 0.93 | 0.49 | 0.71 |
| | AL GATA | LM , DO | 9 | 0.72 | 0.41 | 0.55 |
| | GIR | LM ,DO, EV | 16 | 1.09 | 0.21 | 0.59 |
| PALEOCENE | KHEIR | SH ,MR | 4 | 0.93 | 0.77 | 0.87 |
| | HARASH | LM | 3 | 1.03 | 0.48 | 0.87 |
| | ZELTEN | LM | 10 | 1.5 | 0.29 | 0.78 |
| | HAGFA | SH | 9 | 0.84 | 0.56 | 0.76 |
| | U . STAL | DO | 3 | 1.33 | 0.98 | 1.17 |
| | L .Stal | DO | 2 | 1.01 | 1.01 | 1.01 |
| | L.SABIL | DO ,LM | 3 | 3.98 | 0.34 | 1.56 |
| CRETACEOUS | KALASH | LM | 9 | 2.08 | 0.28 | 1.25 |
| | SIRT | SH | 44 | 4.98 | 1.16 | 2.61 |
| | TAGRIFT | LM | 3 | 4.11 | 3.16 | 3.5 |
| | Rachmat | SH | 25 | 2.46 | 0.71 | 1.69 |
| | ETAL | DO ,LM, SS | 9 | 1.56 | 0.75 | 1.27 |
| | LIDAM | DO | 9 | 2.36 | 0.86 | 1.58 |
| | BAHI | SS,SH, | 5 | 2.54 | 0.68 | 1.32 |

SS Sandstone, LM: Limestone, DO: Dolomite, SH: Shale, MR: Marl.

T.N = Total numbers of the analyzed samples.

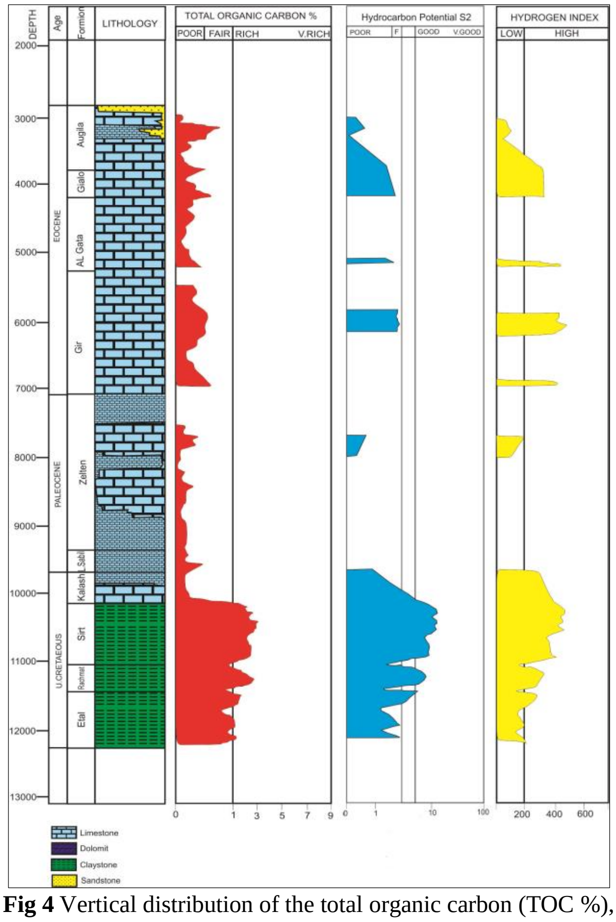


**Fig 4** Vertical distribution of the total organic carbon (TOC %), hydrocarbon potential (S2) and hydrogen index (HI) recorded in the different formations, Well ZZ

Petroleum source potential is measure of the remaining generation ability. This study ability related to type of organic matter and deposition of environment (oxic or anoxic) of petroleum source rock. For estimate the potentiality and maturity of the organic matter for each formation. The important result of the geochemical parameters (S2, HI, and $T_{max}$). Tables 4, 5 Fig 5). screening pyrolysis data show the samples can be classified as fair to good source rock, but the samples from Sirt formation are considerable to be good source rock, which $S_2$ ranging from 2.95 to 16.75 average values 8.47 and HI ranging from 142.5 to 520 average values 325 according to [16] type II kerogen, Table 3:

**Table 3: Hydrogen Index (HI) and Oxygen Index (OI) Values to determine Kerogen types [16]**

| Kerogen | HI (mg HC/g TOC) | OI (mg HC/g TOC) | $S_2/S_3$ | Main Expelled Product at peak maturity |
|---|---|---|---|---|
| Type I | >600 | 15 | >15 | Oil |
| Type II | 300 - 600 | 40 | 1.2 - 1.5 | Oil |
| Type II/III | 200 - 300 | 40 - 115 | 1.0 - 1.2 | Mixed oil and gas |
| Type III | 50 - 200 | 115 | 0.7 - 1.0 | Gas |
| Type IV | <50 | 100 | <0.7 | Gas |

**Table 4: Minimum, Maximum and average values of the hydrocarbon potential (S2) of the analyzed sample Collected from the studied formations.**

| Age | Formations | lithology | T .N | $S_2$ mg HC/gm rock Max | Min | Average $S_2$ |
|---|---|---|---|---|---|---|
| EOCENE | AUGILA | SS,SH,LM | 8 | 13.32 | 0.63 | 1.97 |
| | GIALO | LM | 7 | 4.41 | 0.01 | 1.19 |
| | JAKHIRA | LM | 3 | 1.99 | 1.65 | 1.88 |
| | AL GATA | LM , DO | 9 | 2.96 | 1.59 | 2.03 |
| | GIR | LM ,DO, EV | 16 | 3.87 | 0.45 | 1.99 |
| PALEOCENE | KHEIR | SH ,MARL | 4 | 3.79 | 0.65 | 2.26 |
| | HARASH | LM | 3 | 0.8 | 0.66 | 0.71 |
| | ZELTEN | LM | 10 | 1.47 | 0.81 | 0.79 |
| | HAGFA | SH | 9 | 0.31 | 0.55 | 0.37 |
| | U . STAL | DO | 3 | 0.29 | 0.61 | 0.47 |
| | L.STAL | DO | 2 | 0.53 | 0.59 | 0.56 |
| | L.SABIL | DO ,LM | 3 | 0.71 | 0.88 | 0.79 |
| CRETACEOUS | KALASH | LM | 9 | 4.47 | 0.84 | 2.73 |
| | SIRT | SH | 44 | 16.76 | 2.95 | 8.47 |
| | TAGRIFT | LM | 3 | 9.79 | 1.47 | 4.34 |
| | RACHMAT | SH | 25 | 9.61 | 0.26 | 3.21 |
| | ETAL | DO ,LM, SS | 9 | 3.99 | 0.92 | 2.33 |
| | LIDAM | DO | 9 | 7.68 | 0.91 | 2.69 |
| | BAHI | SS,SH, | 5 | 3.06 | 0.16 | 1.92 |

**Table 5: Minimum, Maximum and average HI of the analyzed sample collected from the different formations**

| Age | Formations | lithology | T .N | HI Max | HI Min | Average HI |
|---|---|---|---|---|---|---|
| EOCENE | AUGILA | SS,SH,LM | 8 | 55.3 | 26.5 | 51 |
| | GIALO | LM | 7 | 173.6 | 50.9 | 152 |
| | JAKHIRA | LM | 3 | 336.7 | 198.6 | 250 |
| | AL GATA | LM , DO | 9 | 531.7 | 237.5 | 377 |
| | GIR | LM ,DO, EV | 16 | 667.2 | 109.8 | 350 |
| PALEOCENE | KHEIR | SH ,MARL | 4 | 425.8 | 84.4 | 248 |
| | HARASH | LM | 3 | 138 | 77.7 | 99 |
| | ZELTEN | LM | 10 | 263.2 | 47.1 | 128 |
| | HAGFA | SH | 9 | 98.2 | 39.3 | 50.6 |
| | U . STAL | DO | 3 | 45.9 | 29.6 | 39.1 |
| | L.STAL | DO | 2 | 58.4 | 58.4 | 58.4 |
| | L.SABIL | DO ,LM | 3 | 232.4 | 22.1 | 147.1 |
| CRETACEOUS | KALASH | LM | 9 | 530 | 100 | 219 |
| | SIRT | SH | 44 | 520.5 | 142.5 | 326 |
| | TAGRIFT | LM | 3 | 238.2 | 46.5 | 112.5 |
| | RACHMAT | SH | 25 | 385.9 | 23.9 | 176 |
| | ETAL | DO ,LM, SS | 9 | 259.1 | 122.7 | 180 |
| | LIDAM | DO | 9 | 325 | 84 | 159 |
| | BAHI | SS,SH, | 5 | 230 | 24 | 139 |

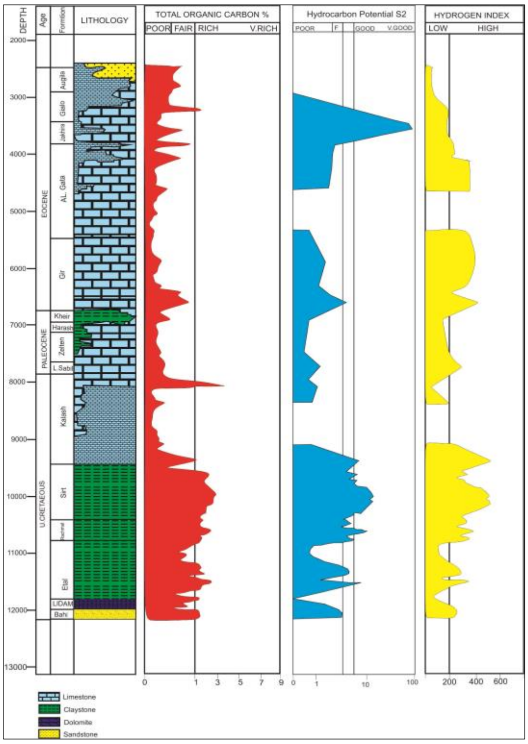


**Fig** 5: Vertical distribution of the total organic carbon (TOC %), hydrocarbon potential (S2) and hydrogen index recorded in the different formations, Well YY.

**Relationship between TOC % and Hydrogen Index**

Katz (1983), and Tyson (1995) consider that the hydrogen index have little meaning where TOC % values are less than 0.3-0.5 %. However, hydrogen index tend to be positively correlated with TOC % values when the TOC% is above 1%. Difference in the slopes of hydrogen indices versus TOC % are partly due to differences in the type of initial organic matter or in the degree of preservation as influenced by bottom water oxygenation. The cross plots of hydrogen index versus TOC % (Fig. 6). The plots in well ZZ shows that the samples from Sirt and Rachmat formations have a higher TOC% and HI compared to samples analyzed from other formations, that means Sirt and Rachmat formations has good preservation of organic matter.

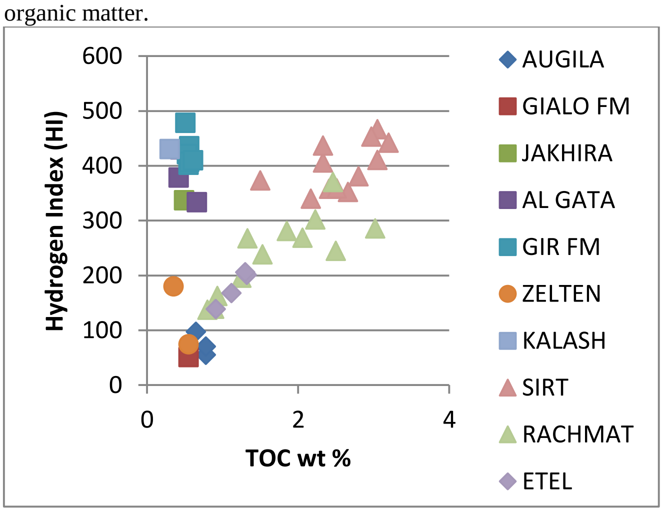


**Fig. 6** cross plot of TOC % versus Hydrogen index HI, (Well ZZ)

**2- Thermal maturation**

Thermal maturity evaluated with spore coloration and Vitrinite Reflectance techniques. Pyrolysis $T_{max}$ are also available but this not preferred maturation parameter.

**2 .1 Vitrinite Reflectance (R0 %)**

Vitrinite reflectance ($R_0$ %) is a key diagnostic tool for assessing maturation. Forty-five samples selected from the studied wells (XX, YY, ZZ, PP), to be measured by vitrinite reflectance. The Vitrinite

($R_0$ %) measurements range from 0.29 to 0.67, we noted that the Ro % values increase gradually with the formations of age Upper Cretaceous. Values of Ro % refer to the organic facies. In the studied formations, organic facies are immature to early mature for oil generation in Sirt formation. The diagenetic level varies from eogenetic to catagenetic stage, (Table 6, Fig 7).

**Table 6 Standard criteria for ranking source rock, [16]**

| Oil Prone Generation | | Gas Prone Generation | |
|---|---|---|---|
| Generation Stage | $R_o$ (%) | Generation Stage | $R_o$ (%) |
| Immature | <0.6 | Immature | <0.8 |
| Early oil | 0.6 - 0.8 | Early gas | 0.8 - 1.2 |
| Peak oil | 0.8 - 1.0 | Peak gas | 1.2 - 2.0 |
| Late oil | 1.0 - 1.35 | Late gas | >2.0 |
| Wet gas | 1.35 - 2.0 | | |
| Dry gas | >2.0 | | |

### 2.2 Spore Coloration Index (SCI)

The color can be related to the maximum temperature that has affected the rock containing the microfossils, Forty four slides collected from the studied wells( XX,YY,ZZ,PP ),were examined under transmitted light for the SCI measurements. Values of SCI varied from formation to the other depending on depth and maturity level of organic matter. SCI measurement range from 2 to 4 indicating to catagenetic, diagenetic level. The Paleocene to Eocene formations are immature whereas the upper cretaceous formations (Sirt and Rachmat formations are early mature, (Fig 7). The color changes in spores and pollens varies from yellow to orange.

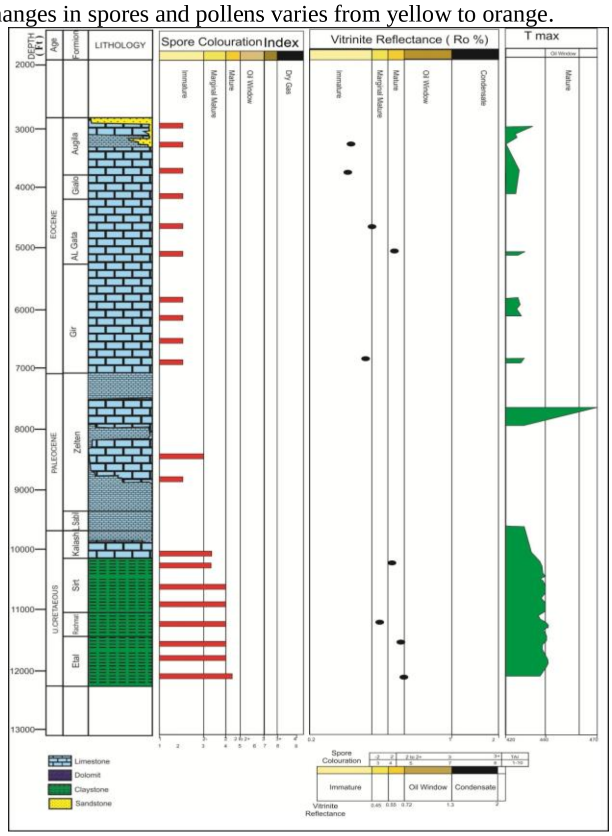


**Fig. 7** Vertical distribution of SCI, Ro and $T_{max}$ values of source rocks recorded

### 2.3- T $_{max}$ °C

The $T_{max}$ measurements range from 355 °C – 444 °C (Table 7). In Sirt Formation $T_{max}$ values range between 429 °C to 443 °C, indicating that organic facies are varying from immature to early mature. The values are good indictors of maturation level of type –II kerogen. In Rachmat Formation, $T_{max}$ values range between 433 °C and 442 °C indicating that organic facies range from immature to early mature (Table 4).

**Table 7 Minimum, Maximum and average $T_{max}$ values of the analyzed sample collected from the different formations.**

| Age | Formation | lithology | T .N | T max °c | | Average T max °c |
|---|---|---|---|---|---|---|
| | | | | max | min | |
| EOCENE | AUGILA | SS,SH,LM | 8 | 436 | 415 | 423.1 |
| | GIALO | LM | 7 | 432 | 403 | 422 |
| | JAKHIRA | LM | 3 | 428 | 402 | 412 |
| | AL GATA | LM , DO | 9 | 430 | 416 | 426 |
| | GIR | LM ,DO, EV | 16 | 434 | 420 | 426.8 |
| PALEOCENE | KHEIR | SH ,MARL | 4 | 425 | 423 | 427.5 |
| | HARASH | LM | 3 | 438 | 425 | 430.3 |
| | ZELTEN | LM | 10 | 435 | 425 | 429.1 |
| | HAGFA | SH | 9 | 437 | 426 | 431.2 |
| | U . STAL | DO | 3 | 435 | 430 | 432 |
| | L.STAL | DO | 2 | 436 | 435 | 435.5 |
| | L.SABIL | DO ,LM | 3 | 434 | 432 | 433 |
| CRETACEOUS | KALASH | LM | 9 | 438 | 424 | 432.8 |
| | SIRT | SH | 44 | 443 | 429 | 436.4 |
| | TAGRIFT | LM | 3 | 443 | 436 | 438.3 |
| | RACHMAT | SH | 25 | 442 | 433 | 438.6 |
| | ETAL | DO ,LM, SS | 9 | 444 | 432 | 438.3 |
| | LIDAM | DO | 9 | 442 | 417 | 427.1 |
| | BAHI | SS,SH, | 5 | 435 | 432 | 417.4 |

#### 2.3.1 HI vs. $T_{max}$

Hydrogen index (HI) can be plotted against $T_{max}$ ( Delvaux et al ; 1991) to classify kerogen types and evaluate the level of thermal maturity of organic matter. The $T_{max}$ effected by the type of organic matter. All samples fall within kerogen type II and II/III. Are ranging from immature stage to early mature stage. The $T_{max}$ is influenced by HI values, where HI is low the $T_{max}$ is low too and high $T_{max}$, the high value of HI. (Fig. 8).

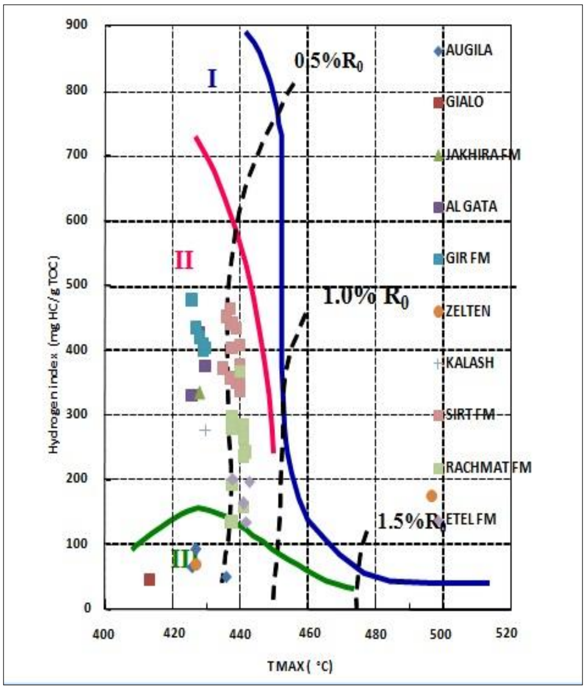


**Fig 8**. Plot of hydrogen index (HI) versus pyrolysis Tmax for the analysed sirt and Rachmat shale samples, showing present-day kerogen quality and thermal maturity stages.

### 3- Quality of organic matter

The quality of organic matter and kind of hydrocarbon generated related to the original types and to depositional environment of sedimentary organic matter (continental, marine or lacustrine), the quality of organic matter done by petrographic and Rock –Eval.

### 3.1 Organic Petrography Counting

Three hundred points counted for each sample under the transmitted light to estimate the Phytoclasts (P), Palaenomorphs (P) and Amorphous (AOM). (Table 8). The data of APP represented in Ternary diagram of Tyson, 1995, to identify the environmental conditions. (Fig.9) show that most samples at Sirt and Rachmat formations fall in distal anoxic environment. This environment offers the appropriate conditions required for preservation of the organic matter and thus, good source rocks

**Table 8 The average counting percentage of Amorphous, phytocasts, and palynomorhps for each formation.**

| Age | Formation | T . N | Phytoclasts % | Amorphous % | Palynomorphes % |
|---|---|---|---|---|---|
| EOCENE | AUGILA | 3 | 69 | 6 | 25 |
| | GIALO | 5 | 14 | 55 | 31 |
| | JAKHIRA | 2 | 51 | 41 | 8 |
| | AL GATA | 7 | 7 | 71 | 22 |
| | GIR | 9 | 5 | 71 | 24 |
| PALEOCENE | KHEIR | 2 | 18 | 74 | 8 |
| | HARASH | 3 | 20 | 57 | 23 |
| | ZELTEN | 7 | 4 | 66 | 30 |
| | HAGFA | 4 | 23 | 62 | 15 |
| | U . STAL | 1 | 20 | 65 | 15 |
| | L.STAL | 1 | 1 | 82 | 7 |
| | L.SABIL | 2 | 6 | 72 | 22 |
| U .CRETACEOUS | KALASH | 3 | 2 | 71 | 26 |
| | SIRT | 15 | 4 | 90 | 6 |
| | TAGRIFT | 3 | 4 | 83 | 3 |
| | RACHMAT | 8 | 2 | 81 | 7 |
| | ETAL | 5 | 13 | 66 | 21 |
| | LIDAM | 4 | 66 | 4 | 30 |

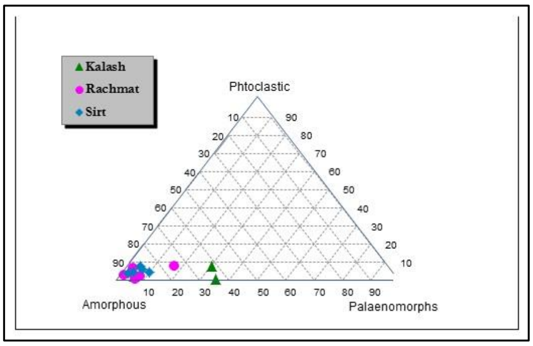


**Fig9 .**organic petrographic composition of source organic matter Sirt and Rachmat formations in the (Well YY)

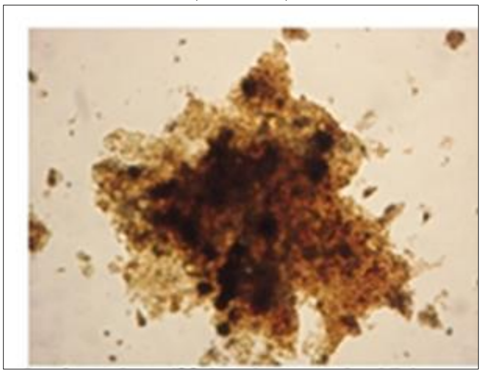

**Fig 10**. Amorphous (20x); under transmitted light (Well YY)

## 4.4 Organic Facies:

The concept of "Organic Facies" introduced during the increase of the integration between microscopy and organic geochemistry methods. The primary objective of organic facies studies is the prediction of the likely occurrence and lateral variability of hydrocarbon source

Potential as a function of depositional environment

The organic facies approach is more realistic than kerogen types, because it emphasizes that the characteristics of kerogen assemblage that are controlled by preservation, as well as organic matter source and thus a diversity of environmental and sedimentological factors [15], Each formation assigned to an organic facies, based on TOC%, hydrogen index, and genetic kerogen type inferred from the palynofacies.

According to [15] the organic facies of the Sirt Shale which is characteristic by high percentage of AOM (90 %), average HI = 326 (kerogen type II), and average TOC % = 2.61 suggesting deposition in a distal environment under an anoxic conditions. This formation reflects the B organic facies (oil prone facies), which is recognized by distal and reducing environment (Table.9).

The organic facies of the Rachmat which is characteristic by high percentage of AOM ( 81 % ), average HI = 176 ( kerogen types II,III ), and average TOC % = 1.69 suggesting deposition in a distal environment under an anoxic -dysoxic conditions, This formation reflects the BC organic facies.

**Table.9Relationship between some selected palynofacies kerogen parameters and organic facies [15].**

| Organic Facies | A | AB | B | BC | C | CD | D |
|---|---|---|---|---|---|---|---|
| Amorphous % of Kerogen | Dominant | | | Mod | Usually low/absent | | |
| Phytoclasts % of kerogen | Low dilution | | | mod | Usually dominant | | |
| Hydrogen index (HI) | >850 | > 650 | > 400 | > 250 | > 125 | 50-125 | <50 |
| Kerogen Type | I | I/II | II | II/III | III | III/IV | IV |
| Total organic carbon TOC % | 5-20 + | 3-10 + | | 3 – 3+ | <3 | <0.5 | |
| **Environmental factors:** | | | | | | | |
| Proximal – distal trend | Distal | | | Proximal | | | Distal |
| Oxygen regime | Anoxic | Anoxic-dysoxic | | | Oxic | | v. oxic |
| Sediment accumulation rate | Low | Varies | | High | | Mod | Low |

## CONCLUSION:

Source rock evaluation analyse, carried-out in the present study provide an interpretation of regional and stratigraphic distribution of source rocks in the study wells within Central Sirt Basin.

1-The Shale of the Upper cretaceous (Sirt, Rachmat) Formations, represent the principle source rock unit in the central sirt basin.

2- Source rock quality in the Sirt Formation is very good quality, the TOC values are generally between 1.16 and 4.98% (average 2.61%). The Rachmat Formation is good quality, the TOC values are generally between 0.71 and 2.46% (average 1.69%), some formations has poor TOC values ranged between 0.55 and 0.87 % (such as, AL Gata member, Gir formation, Hagfa formation).

3- The Sirt Formation contain essentially identical kerogen type, the kerogen are predominantly amorphous and type II kerogen. In Rachmat Formation II/III kerogen.

4- Hydrogen indices (HI) are mostly below 520, from142.5 to 520(average 326 mgHC/gTOC in the Sirt Formation indicating oil-prone. While in the Rachmat Formation average 176 mgHC/gTOC mixed oil and gas prone.

5- The maturity level based on Tmax range from 429 oC to 440 ºC, and TAI, VR %, distributions in the studied wells suggested that the maturity increases from immature to Early mature. This suggests that the Sirt Formation is good petroleum source rock.

6- The organic facies of the Sirt Formation is B organic facies are generally oil prone facies. Rachmat Formation is BC organic facies.

7 -The Sirt shale appears to have been deposited under anoxic environment.

8- Vertical organic facies sequence show gradual change in hydrogen indices from rich in bottom ( organic facies B ) Sirt formation to poor in the top organic (facies CD) of Augila Formation, means rising upward sequence, and indicates change in environment condition from anoxic to oxic

9- Recent geochemical petroleum studies confirmed the domination of the Sirte Shale in Upper Cretaceous as the source of hydrocarbon

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