Libyan Journal of Science & Technology 9:1 (2019) 11–20
The 2nd International Conference on Geosciences of Libya-GeoLibya 2 (2017), 14-16 October 2017, Benghazi-Libya

Faculty of Science - University of Benghazi
Libyan Journal of Science & Technology
journal home page: www.sc.uob.edu.ly/pages/page/77

The hydrocarbon source potential of the Paleozoic rocks of Ghadamis Basin Northwestern Libya.

Moftah Ahmed Dieb

Libyan Petroleum Institute, Tripoli, Libya

E-mail address: dieb63@yahoo.com

Highlights

- **This paper provides comprehensive synthesis of the geochemical analysis of the source rocks and thermal maturity regime for Paleozoic strata in Ghadamis Basin, Northwest of Libya.**
- **This paper also provides a new geochemical knowledge about the characteristics of the main effective source rocks in Ghadamis Basin, Northwest Libya .**
- **A new source rock and thermal maturity maps were constructed based on total organic carbon content and spore color index that can be used to investigate a new petroleum prospective regions in Ghadamis Basin, Northwest Libya .**

ARTICLE INFO

Article history:
Received 01 February 2018
Revised 10 March 2018
Accepted 17 March 2018
Available online 31 March 2019

Keywords:
Source rock, maturity, kerogen type, organic facies, optical; lower 'hot' Tanezzuft Formation, Ghadamis Basin, Libya.

ABSTRACT

Ghadamis Basin is an intracratonic sag basin and is considered as an important hydrocarbon province in the North African continent. In Libya, the Ghadamis Basin is located in the western part of the country and filled by Palaeozoic sediments and overlying thin Mesozoic-Tertiary sequences. The Palaeozoic rocks range from Cambrian to Carboniferous with a maximum thickness of about 12, 000 feet. They consist of alternating transgressive and regressive marine sandstones, shales, siltstones and, locally limestones. The present study, based on the ditch cuttings shale samples, investigate the bulk organic geochemistry, kerogen microscopy and thermal maturity. The geochemical results demonstrated the presence of various organic-rich zones within the Palaeozoic sequences. The Mamuniyat, the lower 'hot' Tanezzuft and the Awaynat Wanin formations are considered to have a good to excellent potential source and are particularly prospective hydrocarbon generation in the study area. The Tanezzuft formation is divided into an upper 'cool' shale and lower 'hot' shale based on the basis of high gamma-ray response in wireline logs and high organic carbon content (TOC). Generally, the Palaeozoic sequence has TOC values ranging from 0.5 to 21.4 wt%. Maturity data indicate that the Devonian shale samples are immature to marginally mature and that the Silurian and the Ordovician shale samples are mostly middle to late mature. Visual Kerogen examination showed that organic matter is comprised mainly of amorphous and palynomorphs components (Type II Kerogen) oil prone with some phytoclasts materials (Type III), gas prone.

1. Introduction

Organic matter-rich sediments in modern and ancient depositional environments are the result of a complex interaction between several factors, such as primary productivity in the water column, supply of nutrients, redox–oxidation processes and sediment accumulation rates (Demaison & Moore 1980). An extraordinary geological test site to unravel the significance of these single factors, which may have controlled organic matter richness, is the marine calstic shale in the Ghadamis Basin (Fig. 3). The Ghadamis Basin of northwestern Libya encompasses an area of about, 200,000 Km². It is situated in the northwestern part of Libya. It is delimited in the north by Nufusa Uplift and to the east Hun Graben, Gargaf Uplift to the south and to the west the basin extends to Tunisia and Algeria (Fig. 1). It is considered one of the largest basins in North Africa, which is filled by Paleozoic sediments, which are overlain by thin Mesozoic–Tertiary sequence (Fig. 2). Cambrian, Ordovician, Silurian, Devonian and Carboniferous rocks represent the Paleozoic sequence. Ghadamis Basin holds approximately the one-third of discovered hydrocarbons in Libya. The Paleozoic sequences consist of thick Cambro-Ordovician sandstone and shale. It is overlain by Silurian section consisting of Tanezzuft and Acacus formations. When new sea invasion started during the early Devonian, the sedimentary sequence was highly deformed by the effect of Caledonian tectonics. The Devonian section is represented by Tadrat sandstone, grading upwards into middle and upper Devonian sandstone and shale Awaynat Wanin Formation. The Carboniferous sections consist of shale and carbonate Mrar and Assedjefar formations. It terminates the Paleozoic sequence. During the late Carboniferous to early Permian, the Hercynian tectonics occurred and changes the tectonic framework causing a general regression of the sea over most Libya (Hamyouni *et al*. 1984).

In this work, we present detailed geochemical investigations of the source rock potential of the Paleozoic sequences in the Ghadamis Basin and the possibility of oil generation from this strata. The purpose of the study is to investigate the aerial extent, thickness, productivity, lateral and vertical variation of potential source rocks and to reconstruct the maturity history of the areas and present the evidence of it's bearing on generation, migration and trapping petroleum. Our investigations focus on selected wells located in the western and central part of the basin.

2-Geological setting

a) Structural framework

Libya, southern Tunisia and Algeria south of Atlas Mountain are part of the stable Saharan platform that was intensively folded in

 ISSN 2663-1407; National Library of Libya, Legal number: 390/2018

the Precambrian. Since then it has been effected only by epeirogenic movements, which produced wide, shallow basins and uplifts. In Ghadamis Basin the sedimentary sequence was affected by the Caledonian orogeny which produced the Edjeleah anticline and Al Gargaf Arch (Fig. 1), respectively. The northern part of the basin was uplifted during Hercynian orogeny (Burollet 1963b) but subsided again during the early Mesozoic. It was uplifted again towards the end of Cretaceous time, the uplift being accompanied by northwest trending faults. The old high, Jifarah to the north and Al Gargaf to the south, were reactivated in Late Cretaceous or Early Paleocene time, (Jordi and Ionfat 1963; Gouderzi, 1991).

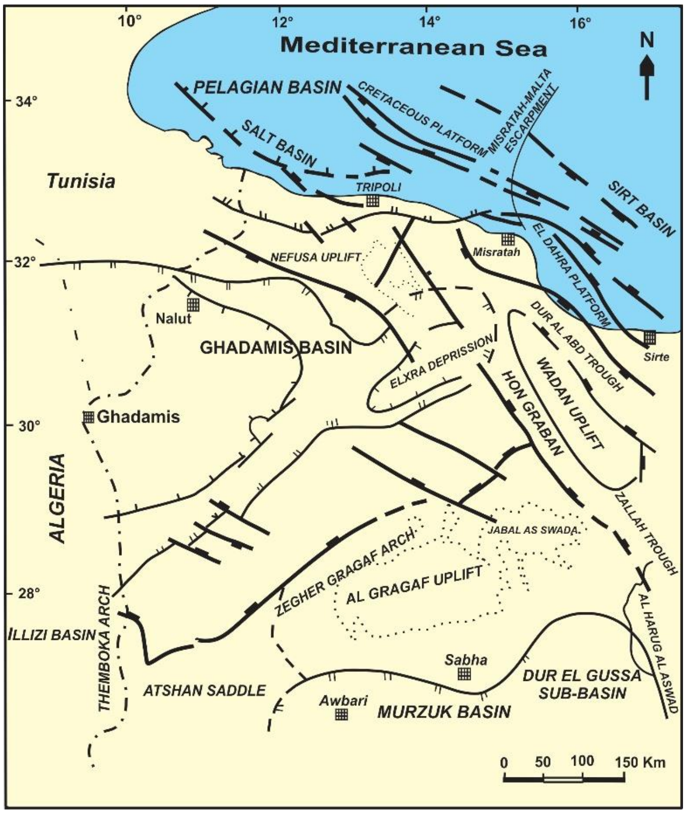

Fig. 1. Tectonic structure map of the Ghadamis Basin Libya.

b) Stratigraphic framework

In Ghadamis Basin, the thickness of the Paleozoic sequence is about 11,000 feet. It is composed of Cambro–Ordovician sandstone and shale. It is overlain by Silurian section consisting Tanezzuft Shale and Acacus Sandstone. The Silurian sections are generally conformable with the Ordovician Memoniate Formation. This sedimentary sequence was highly deformed by the effect of Caledonian tectonics, where a new sea invasion started during the early Devonian (Hamyouni *et al*., 1984). The Devonian section is disconformable with Silurian sediments. The Devonian section represented by Tadrat Sandstone and Ouan Kasa Sandstone with Shale, grading upward into middle and upper Devonian Awaynat Wanin sandstone and shale. The Devonian section is disconformable overlain Carboniferous section. The Carboniferous section is represented by Mrar and Assed Jefar formations and consists of shale and carbonate sediments (Fig. 2) (Hamyouni *et al*., 1984).

The Early Silurian of Lower Tanezzuft Formation is composed of dark gray to black graptolitic shale with rhythmical alterations. It usually shows high gamma-ray response on wireline logs. The true thickness of Lower Tanezzuft Formation that was determined is about 150 to 300 feet. It represents the broad marine transgression of the Silurian Sea over the North African carton.

c) 3-Methods of the study

The main method applied in this study was the analysis of 52 shale samples of well ditch cutting and cores. Samples were analyzed by conventional geochemical and microscopic techniques (Rogers 1979, Demaison *et al*., 1983 and Jones 1984) to evaluate the prospective source rocks and thermal maturation of organic matters in the Paleozoic strata within Ghadamis Basin. Whole samples were washed out, picked, and lithologically described. Rock–Eval II Pyrolysis plus TOC was used for determination of free hydrocarbons (S1), residual potential hydrocarbons (S2), maximum temperature Pyrolysis degradation (T max), Hydrogen index (HI), oxygen index (OI), production index (PI) and total organic carbon content (TOC), Espitalie *et al.* (1977). Selected shale samples were subjected to extract in a Soxhlet apparatus with chloroform and concentrated for determination of soluble organic matter (bitumen). Asphaltene was precipitated from this extract and the remaining filtrate was fractionated on an alumni silica–gel column and separated into the following hydrocarbon fractions. Saturated hydrocarbon, aromatic hydrocarbon and Polar resin (NSOs). Gas chromatography (GC) analysis of the Paraffin–Naphthene were carried out by means of Karlo Erba 4000 instrument equipped with a 25 m * 0.32 mm Cp-sil –5- CB column.

In addition, selected shale samples were subjected to kerogen isolation and visual kerogen assessment for microscopy by treatment with HCl and HF followed by flotation in heavy liquid ($ZnCl_2$ solution, density 2 g/ cm^3). Kerogen composition and spore color index (SCI) scale 1.0 to 10.0 was performed using transmitted and blue fluorescence light on Leica Microscope.

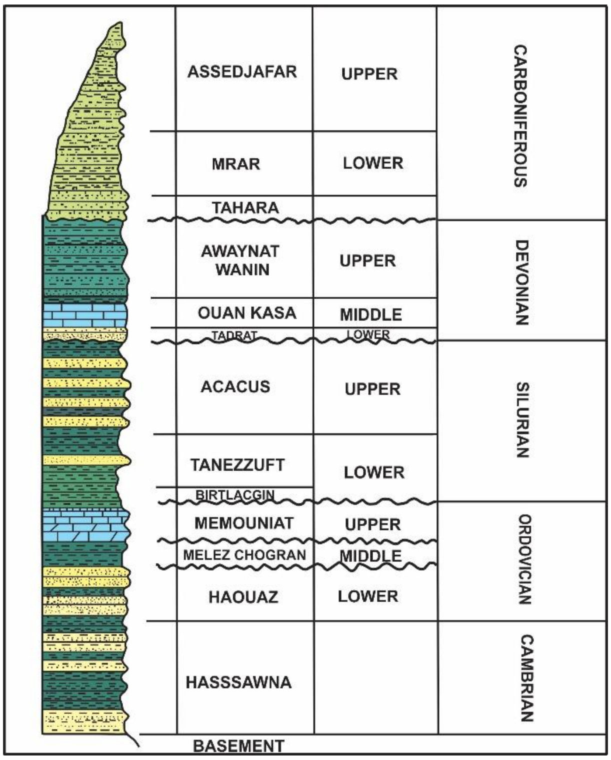

Fig. 2. Stratigraphic column section of the Ghadamis Basin, Libya

4-Results and interpretation

d) Source richness and maturity

The source potential and productivity are related to source rock thickness, maturity and to kerogen facies and therefore to depositional environment and type of organic matter input. Source rock quality is best in the central and west-central part of the basin where a stratified water column and suboxic-anoxic bottom condition, combined with high productivity in the photic zone, favored the preservation of liptinic, oil generative kerogen. The shale generally contains mixed kerogen of marine algal sapropelic (Type II) and land plant (Type III) facies, and proximity to the paleo-shoreline controls source rock quality, with greater amounts of terrestrially derived humic kerogen and consequently poorer oil source rock quality nearer the paleo-shoreline. In the southern flank of the basin close to the Gargaf uplift, the formation contains oxidized organic matter with poor oil source potential; these organic sediments are probably deposited in shallow, to sometimes deep, oceanic water. The marine succession in the studied wells at the southern part of the basin presents evidence for these criteria. In the west-central part of the basin where the Tanezzuft Formation reaches the late maturity stage, they have generated significant volumes of light oil, gas and condensate. The dark shale within the upper Awaynat Wanin Formation of the upper Devonian age is commonly organically rich and contain sapropelic kerogen, with oil and gas source potential. Shales in the Assed Jefar and Mrar Formations of the Carboniferous age are commonly have above average total organic carbon content but contain humic kerogen of mainly vitrinite and inertinite components. Therefore, there are no significant hydrocarbons could be anticipated from these formations.

a) Central and west-central part of the basin

In the central and west-central part of the Ghadamis Basin, the geochemical results of the studied wells showed that the Lower Tanezzuft Formation (Hot shale), has a dark gray to black shale and usually shows high gamma-ray response on wireline logs, and high resistivity with low density and sonic values, is rich in organic matter. It has TOC values range from 1.07% to 19.93 % concentrations with an average value of 8.50% (Fig. 3). These geochemical data confirmed that shale unit has good characteristics to be source rock for generating oil and gas. The genetic potential varied from 1.61 to 58.18 mg HC/g rock, indicating fair to excellent quality source rock (Dow, 1977; Espitalie *et al.*, 1977).

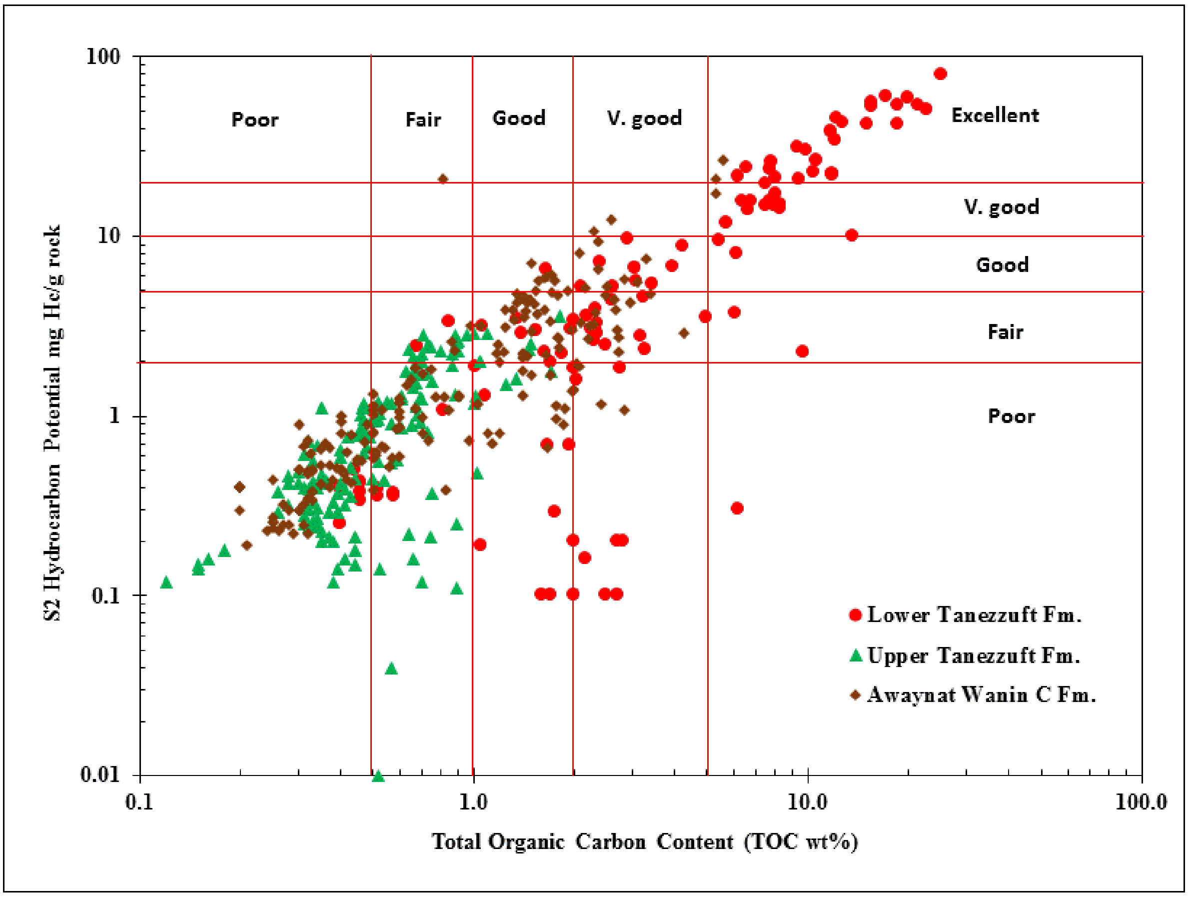

Fig. 3. Total organic carbon content (TOC) versus hydrocarbon potential (S2), showing the hydrocarbon potentiality of the source rocks in the Ghadamis Basin.

The geochemical logs (Fig. 4) show variation in organic matter content and hydrocarbon potential of Paleozoic sequence and its increase with increasing depth of the Tanezzuft Formation. The Lower Tanezzuft Formation in the central and west-central part of the basin has hydrogen index HI ranges from 108 to 393 mg HC/ g TOC. The good total organic carbon (TOC) and a high hydrogen index indicated that the amorphous organic matter probably preserved in an anoxic deep marine condition and good source rock for hydrocarbon generation. The measured T_{max} values indicates that the shale samples from Lower Tanezzuft Formation are immature, and middle to late mature, which are ranged from 423 to 460 °C. This is also in agreement with spore color index SCI, which indicate that the maturity level ranges from middle mature to late mature 6 to 8 SCI, respectively. The gas chromatography C15+ of the Paraffin–Naphtheane hydrocarbon fractions (Fig. 5) indicates that the samples are mature and farther more by the shape of normal Paraffin (envelope) and by the carbon preference index (CPI) values 1 to 1.17. The samples show evidence of a significant contribution from algae amorphous organic matter as suggested by *nC17* and *nC19* dominance. For all analyzed samples, the pristine to phytane ratio indicates that the shale of the Lower Tanezzuft Formation is deposited under reducing marine conditions. The ratio of pristine/phytane ranges from 0.80 to 1, represents the characteristic of normal transgressive anoxic marine shale source rocks (Jones, 1984).

The hydrogen index HI and oxygen index OI cross–plot (Fig. 6) indicates that the organic matter classified as type II kerogen with hydrogen index ranging from 160 to 393 mg HC/ g TOC, these indicated that hydrogen is good to rich and typical for oil-prone (Tissot, 1984). The Pyrolysis maturation index T_{max} gradually increases with depth (Fig. 4). Most of the analysis samples are in the mature petroleum generating range 430 to 451 °C. Fig. 7 shows the hydrogen index HI versus T_{max} of Tanezzuft and Awaynat Wanin formations, most of the samples are in the mature range (430–460 °C) and the rest, including some immature samples, are (less than 430 °C). Kerogen is a mixture between type II and type III, which indicates that source rock will produce oil and gas if its reach enough maturity.

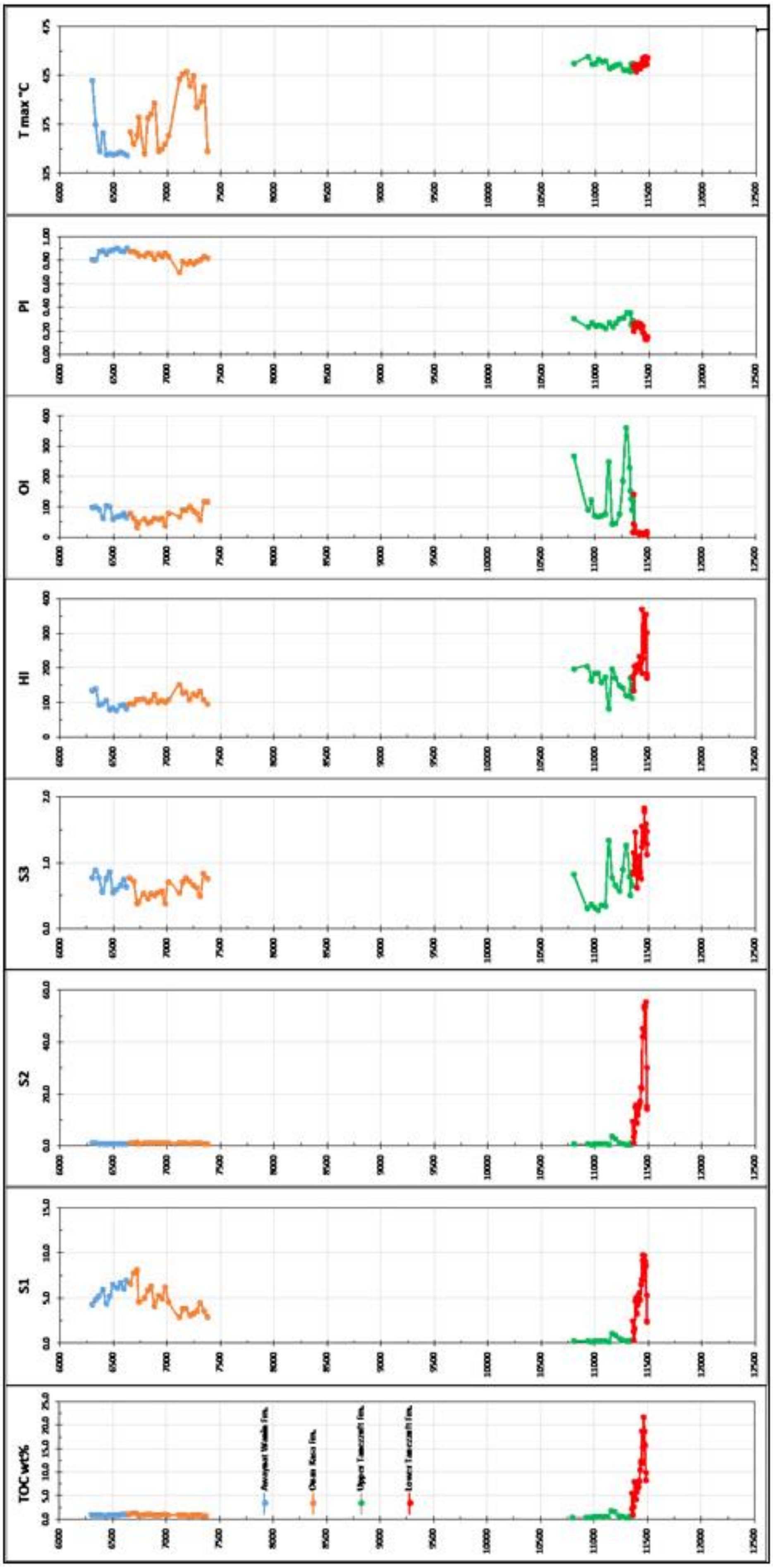

Fig. 4. Geochemical log for the Paleozoic Sequences of the studied well located in the central part of the Ghadamis Basin.

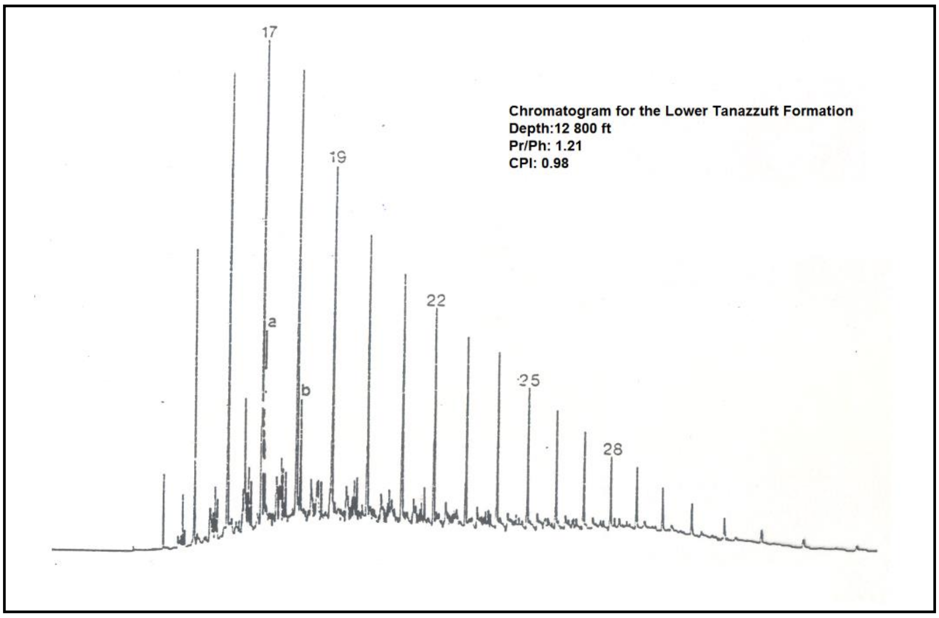

Fig. 5. Gas Chromatogram chart of the hydrocarbon fractions for the Lower Tanezzuft Formation.

Analyzed samples from the Upper Ordovician, Memoniate Formation are consisted mainly of siltstone and shale with some contaminated materials which caved from the overlying formations, their total organic carbon are generally low, and S2 potential hydrocarbon yield are also similarly low, therefore no significant source rock potential can be anticipated from sediments of the Memoniate Formation. The Bir Tlacsin Formation of the Upper Ordovician age consists mainly of limestone, shale and siltstone, the analyzed samples show, a fair to good TOC values that are ranged from 0.7 to 1.7%. Cuttings samples of the Middle Ordovician age, Melaz Shuqran Formation have been analyzed in some wells. The samples consist mainly of shales, black to dark grey, brownish grey with minor siltstone. It has a good TOC values, ranging from 1.2 to 1.85%. Therefore, the Bir Tlacsin shale and Melaz Shuqran formations could be also recognized as additional source rocks potential in Ghadamis Basin.

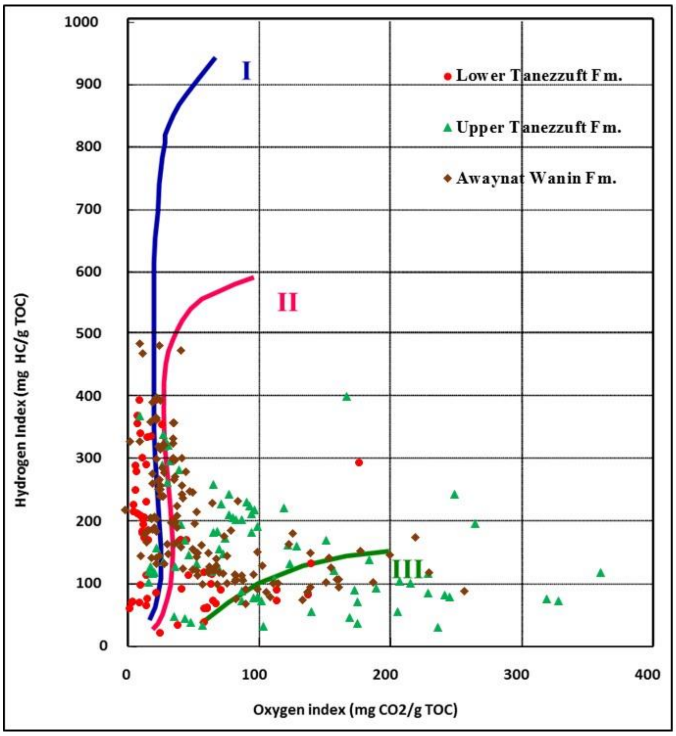

Fig. 6. Hydrogen Index versus Oxygen Index for the Paleozoic Rock, Ghadamis Basin

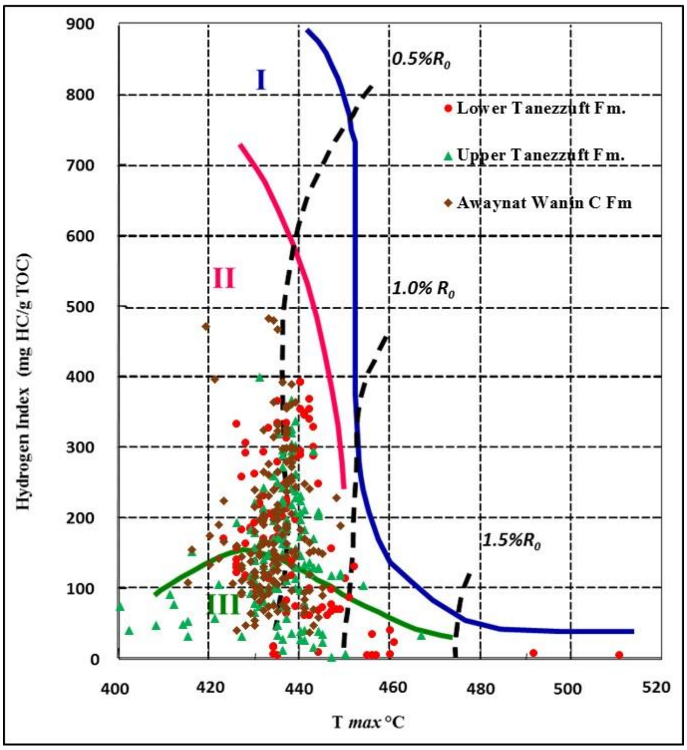

Fig. 7. Hydrogen index versus T max of the Tanezzuft and Awaynat Wanin formations.

Visual examination of kerogen type and maturity

Visual examination of kerogen type and thermal maturity have been assessed by means of spore color analysis supplemented by qualitative fluorescence of planomorphous in UV blue light. Spore color data are presented in terms of spore color index (SCI) assigned values from 1.0 to 10.0 in order to increase color from transparent to orange and finally black. The spore color index data for Lower Tanezzuft Formation in the central and west-central part of the basin are shown in Figure 8. The Lower Tanezzuft Formation is interpreted as mature to late mature for hydrocarbon generation and evidenced by measurement of spore color index SCI 6 to 8, and vitrinite reflectance measurements 0.7 to 1.3 Ro%, respectively.

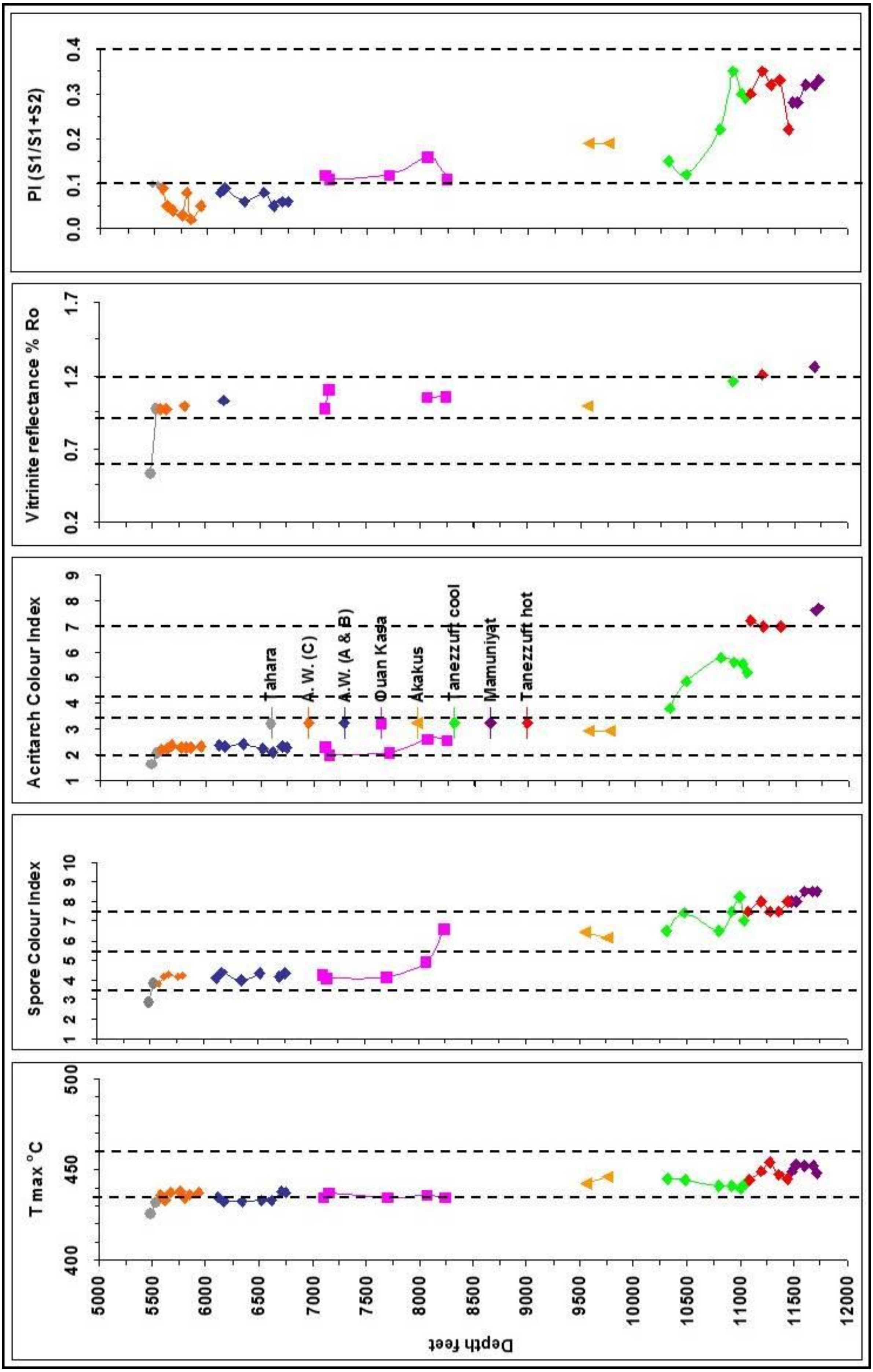

Fig. 8. Geochemical maturity log for the Paleozoic source rocks at the western part of the Ghadamis Basin

The visual kerogen composition analysis was carried out at the same time as spore coloration. Most of the kerogen comprises an amorphous sapropelic material with acritarch, and cuticle and actinozoan with minor inertinite debris Fig. 9. The predominance of the sapropelic amorphous material indicates that the kerogen will generate a significant amount of oil. Most of the samples are organically rich and have significant characteristics to be source potential for hydrocarbon generation.

An isopach map (Fig. 10) of the basal radioactive zone indicates that the Ghadamis Basin has the thickest radioactive zone (Hot Shale) interval in the deepest part of the basin, where thicknesses reach more than 200 feet (Echikh and Sola, 2000). However, the radioactive zone is missing over some palaeohighs area, for instance in the Al Gargaf Uplift, where Ghadamis Basin is separated from Murzuq Basin, suggesting that this area was a positive feature and a site of shallow water depositional environments (Echikh and Sola, 2000). Fig. 11 illustrates the contour map of thermal maturity (SCI) on top of Tanezzuft Formation. The map exhibits that Tanezzuft Formation has enough maturity to be generating hydrocarbon. It also showed that thermal maturity level increase toward the west, the central part of the basin, compared with the southern flank of the basin.

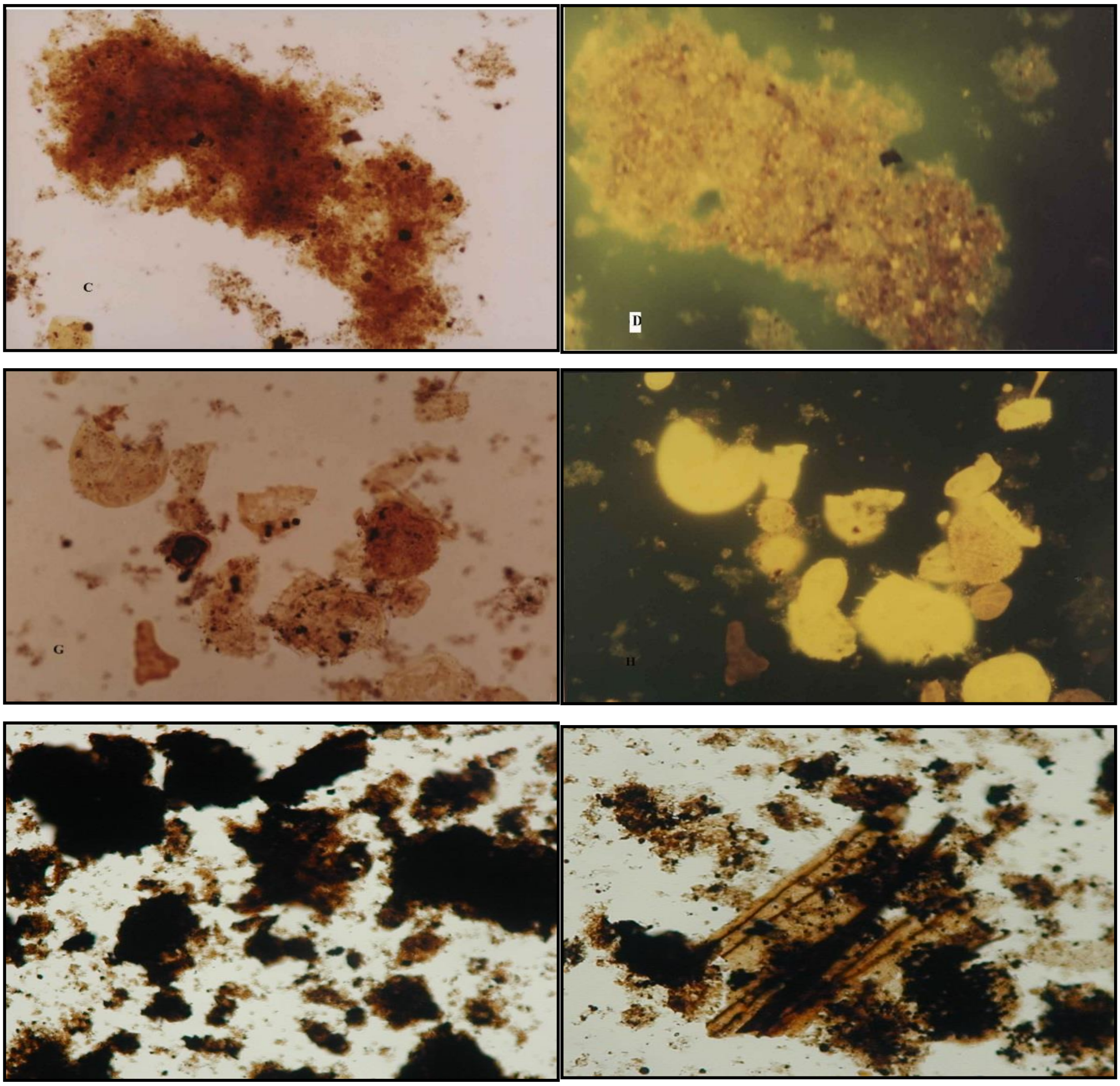

Fig. 9. Amorphous sapropelic material and acritarch, with minor inertinite debris.

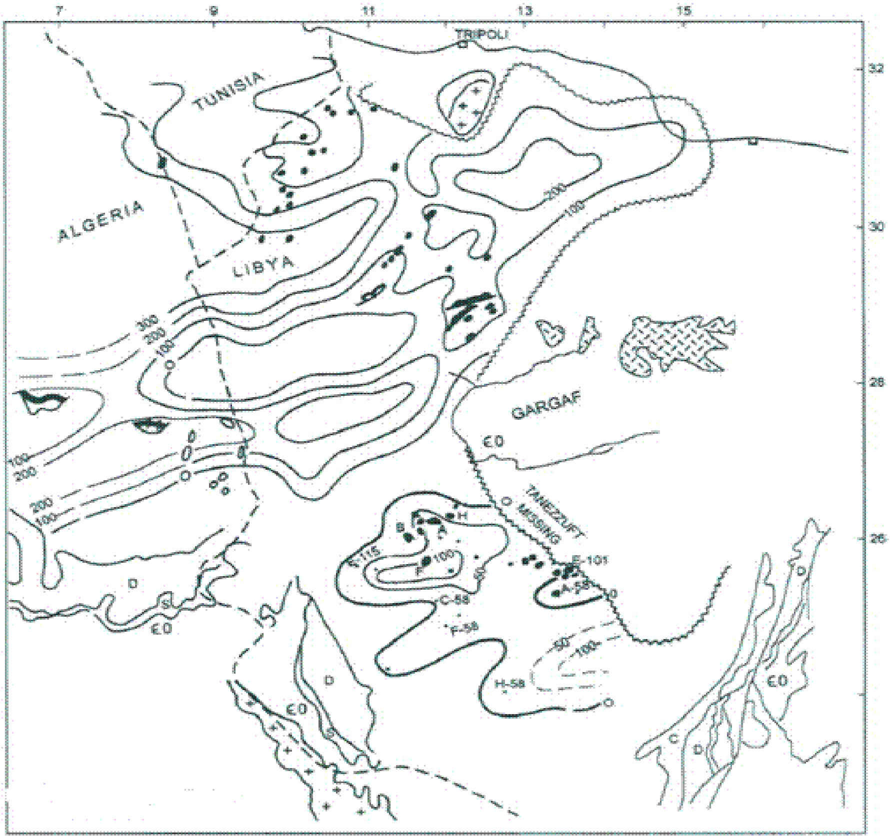

Fig. 10. Tanezzuft Formation "hot shale" radioactive zone map for the Ghadamis Basin and Murzuq Basin Libya, (After, Echikh and Soloa, 2000).

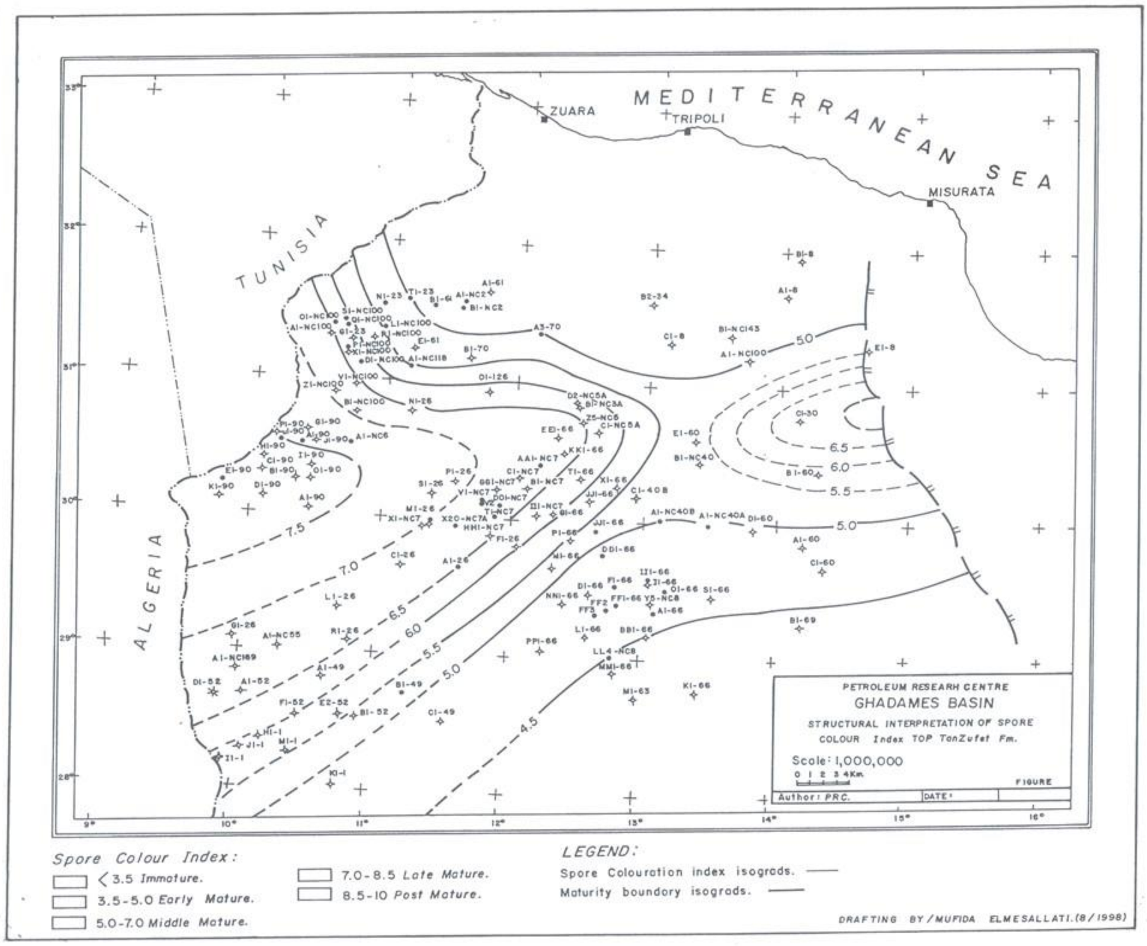

Fig. 11. Maturity map (SCI) for the Tanezzuft Formation, Ghadamis Basin.

b) Southern flank of the basin (close to Gargaf uplift along the paleo-shoreline)

In the southern flank of the Ghadamis Basin close to Gargaf Uplift along the Paleo shoreline, the geochemical data of the selected wells observed that, the lower Tanezzuft Formation consists of gray to dark gray or black shale and has an organic carbon content (TOC) ranges from 0.85% to 3.37% with an average 2.01%. Generally, the low values of pyrolysis potential yield (S2) 0.23 to 4.45 mg HC/ g rock with an average 3.10 mg HC/g rock indicate that the dark gray to black shale of the Lower Tanezzuft Formation at the best will be a gas source potential, which would be generated at higher levels of maturity (Fig. 12).

The pyrolysis maturation index (T_{max}) 439 °C indicates that the shale samples are mature. The low pyrolysis hydrogen index (HI) 6 to 195 mg HC/g TOC with an average of 92 mg HC/g TOC indicated that organic matter is capable to generate gas. The good total organic carbon (TOC) and low hydrogen index (HI) indicates that amorphous organic matter and inertinite probably neither well preserved (on suboxic to oxic condition), or probably post mature source rocks or rocks that probably never had much generation potential. A cross–plot of hydrogen index (HI) and oxygen index (OI) on modified Van Krevelen diagram (Fig. 6) indicates that the organic matter is a mixture of type II and type III organic matter; it is capable to generate oil and gas.

Fig. 7 shows the hydrogen index (HI) versus (T_{max}) of Lower Tanezzuft Formation. The shale samples are mature ranged from 430 to 451 °C and the rest, including some immature samples, (are less than 430 °C). Kerogen is a mixture between type II and type III, which fits with a predominance of oil and gas on the source.

The gas chromatography C15 + of Paraffin–Naphtheane hydrocarbon fractions (Fig. 5) indicates that samples of Lower Tanezzuft Formation are mature, this indicated by the shape of normal Parafins (envelope) and carbon preference index (CPI) values 1.0 – 1.40. All samples show evidence of a significant contribution from amorphous organic matter as suggested by nC17 to nC19 abundance. The pristine to phytane ratio for most samples indicates that the shale of Lower Tanezzuft Formation deposited under marine conditions. Pristine/Phytane ratio between 0.8 and 1 are characteristics of normal transgressive marine shale source rocks.

Visual examination of kerogen type and maturity

The kerogen examined of the Lower Tanezzuft Formation was noted to compose mainly of amorphous with a herbaceous and woody material. The lower part of the formation is interpreted to be mature to post mature for hydrocarbon generation indicated by SCI measurement 6 to 9.5 respectively. The predominance of an amorphous material indicates that the kerogen will generate oil but the higher maturity of that organic matter 9.5 SCI indicates that organic matter will generate gas instead of oil or both.

5-Source rock to reservoirs relationship in Ghadamis Basin

Approximately all of the hydrocarbons accumulations so far discovered in the Ghadamis Basin seem to be generated primarily from Lower Silurian, Tanezzuft hot shale and less degree from Devonian strata, Awaynat Wanin C Formation and was reservoired within the Silurian and Devonian sandstone. According to Echikh (1998), all known commercial oil accumulations are within the porous sandstones of the Upper Silurian, Lower Acacus Formation, and the Lower Devonian Tadrat, and Oan Kasa formations, with only small accumulations in the Upper Tanezzuft, Bir Tlacsin, Awaynat Wanin B and A, Tahara, Marar and Triassic Ras Hamia formations (Echickh, 1998 and 2000). Moreover, communication between these strata (sources and reservoirs) seems to be necessary for any successful hydrocarbons accumulation in the basin. In the Ghadamis Basin, the significant of the direct contact between source and reservoirs rocks is improved with dominate of the reservoirs lithofacies, which has generally a relatively tight clean quartz sandstones that is not inductive to long-distance migration, such as in the Acacus Formation (Echikh and Soloa, 2000).

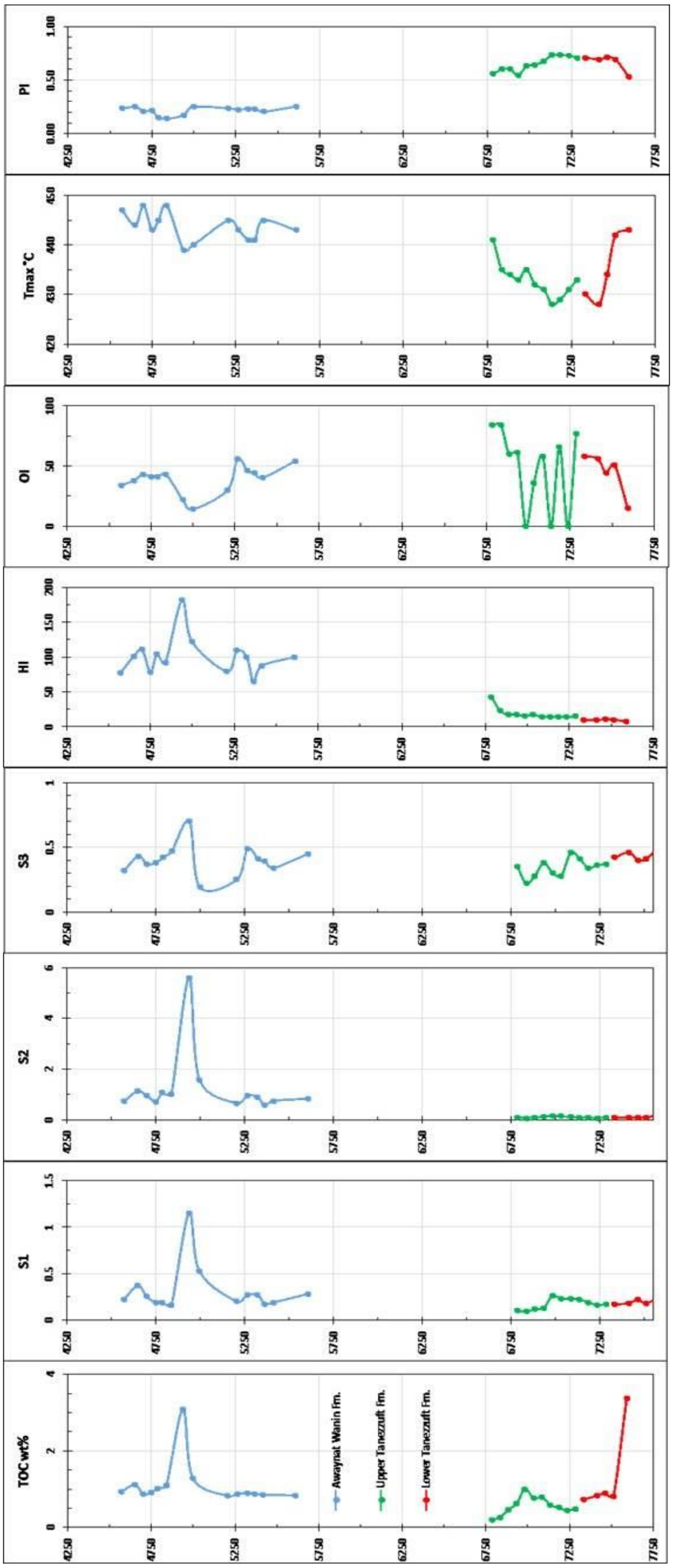

Fig.12. Geochemical log for the Paleozoic Sequences of the studied well located in the southern flank of the Ghadamis Basin.

However, most of the oil fields are gathered in the three discrete areas, which are in the northwest, central and southern parts of the Ghadamis Basin, each has different trap style, charge history and principal reservoir beds (Dardour *et al*,. 2004). Reservoirs occurred in the northwest part characterized by both low-displacement fault and unconformity sub-crop traps such as Acacus Formation. While in the southern part of the basin, three-way dip fault traps characterized the Tadrat reservoir (Dardour *et al*., 2004). In the central part of the basin, traps characterized with more typical of the elongated low-relief anticline structure with reservoirs occurred at several horizons (Dardour *et al*., 2004).

In the Ghadamis Basin, the structural feature is characterized by depocenter migration with a time that was controlling the lateral changes in the depositional environments, in the maturity of the source rocks, and also in migration pathways distributions and directions. However, several factors could be controlled the migration pathways such as source to reservoirs communication, nature of the seal, lateral changes in the reservoir quality and the influences of the folding and faulting.

The migration and accumulation of hydrocarbon are highly depended on the structural morphology of the seal, which is also the surface under which the hydrocarbon generally migrate from the source rocks (kitchen) to the structural highest part in the basin. Echikh and Soloa (2000) illustrated that the distribution areas for any hydrocarbon accumulations are highly affected by the structure of the sealing surface. Therefore, if the highest part of the basin is regional high, folded as anticline in form, hydrocarbon will normally gather on or around this high. Whereas, if the highest part of the basin has a syncline form, the hydrocarbon accumulation may be following a curved distribution trend. The shales of the Upper Tanezzuft and Mrar formations are representing the regional seal for most hydrocarbon accumulations in the Ghadamis Basin.

6-Conclusion

The Lower Tanezzuft Formation consists of gray, dark gray or black shale and usually show high gamma-ray response on wireline logs (radioactive shale). It's age of Early Silurian (Llandovery). The Lower Tanezzuft Formation in the greater part of the Ghadamis Basin appears to have been deposited in deep marine reducing environments. The thickness of Lower Tanezzuft Formation is about 150 – 300 feet and generally considered the main oil source rock unit in the Ghadamis Basin. At the central and west-central parts of the basin, the Lower Tanezzuft Formation is a good source rock unit with high potential for hydrocarbon generation. Toward the southern flank of the basin, close to Gargaf Uplift and along the Paleo shoreline the Lower Tanezzuft Formation is a good source rock unit with low potential for hydrocarbon generation. This is caused either by poor preservation of organic matter or by the high level of thermal maturity. In the central and west-central part of the basin from the analyzed wells, the maturity level rnges from mature to late mature (SCI 6 to 8) and it will generate significant oil. In analyses wells the maturity level range from mature to post mature (SCI 6 to 9.5) and it will generate significant oil and gas in the southern flank of the basin closed to Gargaf Uplift along the Paleo shoreline. The organic facies of the source rock are generally oil prone with type II kerogen and content amorphous, herbaceous with acritarch, cuticle and actinozoan and sometimes algal matter in the central and west-central part of the basin. Southern flanks of the basin closed to Gargaf Uplift along the Paleo shoreline the organic facies of the source rock are generally, oil to gas prone with mixture type II and III kerogen. The marine organic matter contents are amorphous, herbaceous and coaly material. In the northwest part of the basin, oils reservoired within thinly interbedded sandstones of shelf-dominated facies and are characterized by lateral migration with less leakage into an overlain Devonian reservoir. Sub-unconformity traps and low displacement fault represents the main traps in this area. Both traps style influenced by late tilting and fault reactivation with an increased chance of post-charge dispersal. While, in the central part of the basin, most of oils and gases were reservoired within Upper Silurian, Upper Devonian and Carboniferous Strata. Oil fields and gas fields that located in this part of the basin are charged from the west by short distance migration. Structurally, this part of the basin was affected by less late uplift and regional tilting than the west and south. Most of the traps are of low relief structures. The Upper Silurian strata, Acacus Formation and Upper Devonian strata and Tadrart Formation represent the main reservoirs in the south part of the basin, where vertical hydrocarbon short distance migration is dominant in this part. All the hydrocarbon accumulations occurred are structural traps. However, a huge high thick and continuity of the sand intervals that represents Acacus and Tadrat formations make a little chance to form stratigraphic traps in this part.

Acknowledgement

We would like to thank the secretary of the people's committee of Libyan Petroleum Institute Dr. Mansur Imatir and Salam El Akther, and exploration manager Dr. Khalifa Abdulnaser for their support and permission to publish this study. And also thank all member staff of the exploration department for their discussion and helping to conduct this work.

Reference

Burollet, P. F. (1960) 'Lexique Stratigraphic International, 4, Afrique, Pt. 4a, Libya', *Comm. Strat., Cent. Nat. Rech. Sci*., 62p.

Dardour, A. M, Boote, D. R., and Barid, A. W. (2004) 'Stratigraphic controls on Palaeozoic petroleum system, Ghadamis Basin, Libya', *Journal of Petroleum Geology*, 72(20, pp. 141-162.

Demasion, G. J., Holck, A. J. J., Jones, R. W. and Moore, G. T. (1983) Predictive source bed stratigraphy: a guide to regional petroleum occurrence. In: *Proc. 11th Worled Perol. Congr*., London, 2, 17-19.

Dow, W. G. (1977) 'Kerogen studies and geological interpretations', *J. Geochem. Explor*., 7, pp. 79 – 99.

Echikh, K. (1998) Geology and hydrocarbon occurrence in the Ghadamis Basin, Algeria, Tunisia and Libya. In: MACGREGOR, D. S., MOODY, R. J. and CLARK-LOWES, D. D. (Eds), Petroleum geology of North Africa, Geol. Soc. Land, Spec. Publ, 132, pp. 109-129.

Echikh, K. and Sola, M. A. (2000) Geology and hydrocarbon occurrence in the Murzuq Basin, SW Libya. In: SOLA, M. A., and WORSLEY, D. (Eds), Geological Exploration in Murzuq Basin. Elsevier, London, pp. 175-222.

Espitalie, J., Laporte, J. L., Madec, M., Marquis, F., Leplat, P., Paulet, J. and Boutefeu, A. (1977) Methode rapide de characterisation des rocks meres de leur potential petrolier et leur degre d, evolution. Rev. Inst. Fr. Petrole, 32, pp. 23-42.

Gouderize, G. H. 1991. The Geology of Libya, Volume III, Structure of Libya. Elsevire Science Publishers B V. Burgerhartstraat, 25 Amsterdam, the Netherlands, p 883.

Hamyouni, E. A., I. A.Amr, M. A. Riani, A. B. El-Ghull, and S. A. Rahoma (1984) Source and habitat of oil in Libyan basins: Presented at seminar on source and habitat of *Petroleum in the Arab countries*, Kuwait, p. 125–178.

Jones, R. W. (1984) Organic facies. In: Advance in petroleum geochemistry (eds J. Brooks and D. Welet). Academic Press, London, 2, pp. 1-90.

Jordi, H. A. and Lonfat, F. (1963) Stratigraphic subdivision and problems in Upper Cretaceous–Lower Tertiary deposits in north- western Libya. Rev. Inst. Fr. Petrole, 18, pp. 1428–1436.

Rogers, M. A. (1979) Application of organic facies concepts to hydrocarbon source rock evaluation. In: Proc. 10th World petrol. Congr. Bucharest.

Tissot, B. and Wellet, D. H. (1984) Petroleum formation and occurrence, 2nd edition Berlin, springer–verlog, P- 503.