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BIOMARKERS COMPOUNDS AS INDICATORS OF ENVIRONMENTS AND MATURATION OF SOURCE ROCKS OF WELLS, NORTH WESTERN DESERT, EGYPT.

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Abstract:

The reults of biomarker analyses of source rocks of some wells in the North Western Desert, suggest that Lower Cretaceous Alam El Bueib source rock is moderately and has organic matter characteristics of deposition in clay-rich, nearshore or deltaic environment with significant input of terrestrial organic matter as well as marine algae, and bacterial contributions, deposited under reducing conditions. Middel Jurassic Khatatba Formation source rock is marginally mature, has mixed marine and terrestrial organic sources, deposited in a clay-rich marine environment deposited under oxidizing-reducing conditions. Paleozoic Kohla Formation source rock is moderately mature and comprises terrestrial, bacterial and algal precursors, which were deposited under anoxic environment with limited input of marine organic matter.this indicates that the biomarkers analyses have a powerful way to infer source rocks depositional environments and maturation.

Key words: Egypt, Pristane, Phytane, Steranes, Terpanes, Source rocks wells, Western Desert.

INTRODUCTION

Biomarkers of source rock extracts reflect the biological input either from or transported to the site of deposition and the nature of the paleoenvironments. Also biomarkers allow the interpreter to reliably predict source rock characteristics, even when rock samples are not available. The petroleum potentialities the source rocks in the North Western Desert have been evaluated by many investigators and oil companies as: Shahin and Dahi, 1992; Darwish et al., 1994; Khaled, 1999; Sharaf etal., 1999; El Nady and Hammad, 2000; El Nady and Sharaf 2004 among disusses the potentiality of source rocks by aid of pyrolysis analyses. But the evaluation by biological markers is still few where dealt by few authurs as Abdel Gawad et al. (1996) used the biomarker analyses to provide information about the possible source rocks in Faghur-Siwa Basin. They concluded that the Upper Devonian argillaceous limestone and the Upper Jurassic calcareous shales might act as a source rock for oil generation in the northwest of the Western Desert of Egypt. Sharaf and. El Nady 2003; suggested that Khatatba source rock in Umbarka area are mature and deposited under marine environments. El Nady (1999) concluded that the Alam El Bueib Formation is a good source for hydrocarbon accumulations in West-Razzak-Alamein area. El Nady 2009 suggested that the Khatatba and Alam El Bueib formations are mature, derived from source rocks containing marine and terrestrial organic matterin the north Qattara Depression.

The objective of this study is to application of biomarker compounds as indicators environments and maturation characteristics of the Lower Cretaceous Alam El Bueib, the Middle Jurassic Khatatba and the Paleozoic Kohla formations source rocks in some wells in the North Western Desert, Egypt.

ANALYTICAL WORK

Three drilled core rock samples collected from three wells namelly: Yidma-1, Qarun 2-1 and Kahraman-1 (Figure 1). These samples are mainly shale in lithologiy and were extracted by chloroform, using Soxhlet apparatus. The extraction was fractionated using open-column liquid chromatography. A mixture of silica gel and alumina 1:2 wt (%) was used as column packing. A deasphated was dissolved in minimum amount of n-pentane added to the column. Saturates were recovered by eluting with n-pentane, aromatics with a mixture 1:1 of n-pentane and dichloromethane. NSO compounds with methanol

Saturated hydrocarbon fractions were subjected to gas chromatography. The instrument used was Agilent 6890 Series equipped with flame ionization detector (FID) and splitt-aplittless injector. Oven temperature was programmed from 100°C to 300°C at fixed rate of 3°C min-1. HP-1 fused silica capillary column (60 m X 0.53 mm X 0.5 µm) was used for the analysis. Nitrogen (free oxygen) was used as carrier gas at flow rate 2 ml min -1, the injector and detector temperatures are 300 and 325 °C respectively.

2. GC-MS for saturated hydrocarbon using Clarus-500 Perkin Elmer. Samples were injected onto a fused silica capillary column Hp-5 MS (30 m x 0.25 mm i.d. and film thickness 0.25 µm) coated with 5 % diphenyl and 95 % dimethyl poly siloxane. These analyses were done in the laboratories of the Egyptian Petroleum Research Institute (EPRI).

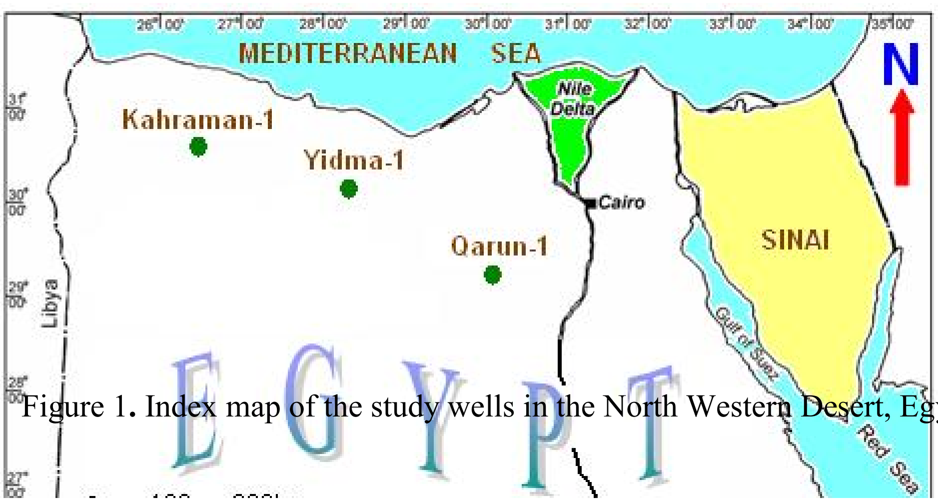

Figure 1. Index map of the study wells in the North Western Desert, Egypt.

Results and Discussion

Yidma-1 Well

The gas chromatogram of Lower Cretaceous Alam El Bueib Formation source rock extract shows slightly odd carbon preference in the n-C_{17}-n-C_{19} and n-C_{21} range and moderate concentration of heavy n-alkanes (Figure 2A). The slight increase in the n-C_{15} and n-C_{25} suggests a primary contribution to the biomass from algae and plankton (Peters and Moldowan, 1993). The carbon preference index (CPI) of 0.49 (Table 1) indicating moderately mature sample (Tissot and Welet, 1984).

Pristane to phytane ratios (pr/ph) have been used as indicator of the nature of the depositional environments. Lijmbach (1975) related intermediate pr/ph ratios (2-4) to fluviomarine and coastal swamp environments. Also, Peters et al., (1999) related the high pr/ph ratio (2.56) of source rock containing mixed terrigenous and marine type II/III organic matter deposited under oxic conditions. Pristane more abundance tha phytane in Alam El Bueib extract (Figure 2A) (pr/ph ratio=1.75) reflects a fluviomarine and coastal swamp environments (Lijmbach,1975). The isoprenoids/n-alkanes ratios (pr/n-C_{17} and ph/n-$C_1$8 are 0.31 and 0.76, respectively, Table 1), revealing marine organic matters, deposited under reducing condtions, Figure 3).

Table 1

Geochemical parameters derived from GC and GC-MS analyses of source rocks of wells in the North Western Desert, Egypt

Geochemical Data	Oilfields		
	Yidma-1	Qarun 2-1	Kahraman-1
Pristane/phytane	1.75	1.25	1.33
Pristane/n-C_{17}	0.31	0. 76	0. 76
Phytane/n-C_{18}	0.47	0.64	0.41
CPI	0.49	0.75	0.57
C27 Steranes (%)	30.0	40.0	30.0
C28 Steranes (%)	26.0	26.0	28.0
C29 Steranes (%)	39.0	33.0	40.0
Diasteranes index[a]	0.78	1.10	0.72
Gammacerane index[b]	0.54	1.70	0.14
C_{29}/C_{30} hopane[c]	0.48	0.57	0.64
Ts/Tm[d]	0.66	0.46	0.46

CPI: ∑odd/∑even carbon numbers, a: Diasteranes index: (C_{27} diasteranes / C_{29} steranes).b: Gammacerane index: gammacerane/(gammacerane + C_{30} hopane). c:C_{29}/C_{30}hopane, d:Ts/Tm:Trisnorhopanes/Trisnorneohopanes ratios.

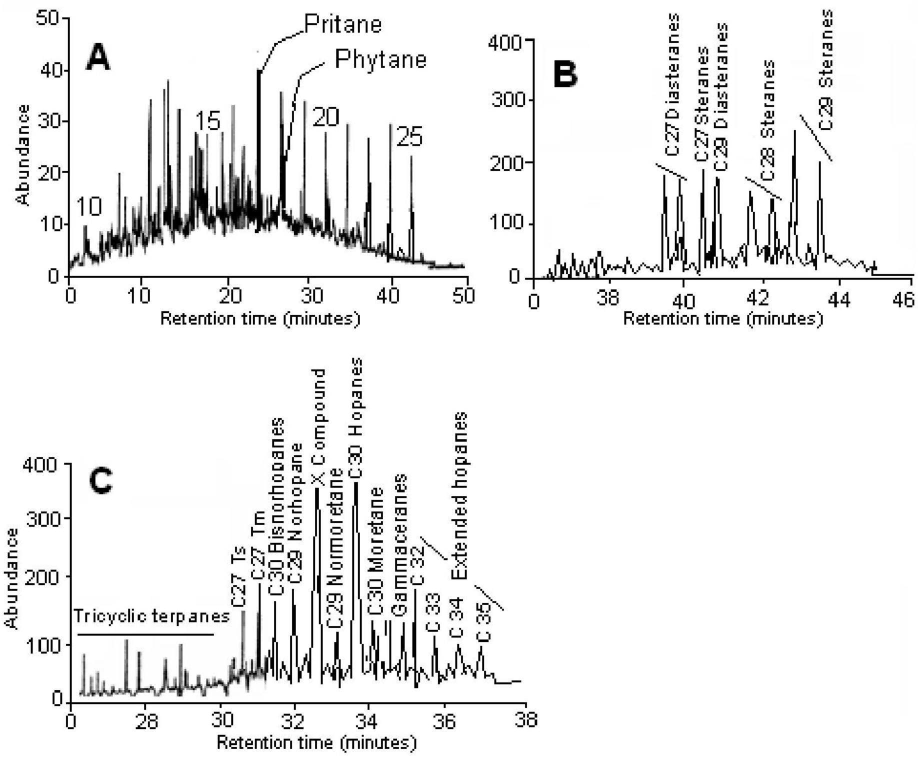

Figure 2. Gas chromatogram (A), ion fragmentograms m/z 217 (B) and m/z191 (C) of Lower Cretaceous source rocks (Alam El Bueib Fm.) in Yidma-1well, North Western Desert, Egypt.

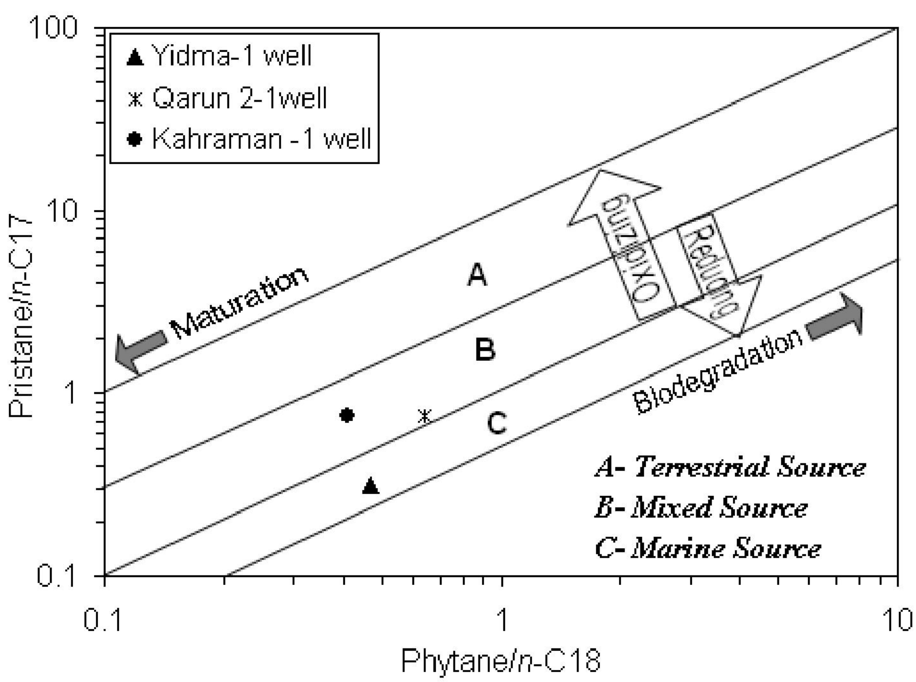

Figure 3. Plot of Pr/n-C_{17} versus Ph/n-C_{18} showing the organic sources and maturation of studied oil samples from some oilfields in the North Western Desert, Egypt.

The sterane distribution is characterized by the dominance of C_{29} over C_{27} and C_{28}steranes (Figure 2B, Table 1), suggesting terrestrial organic matter with input from marine contribution (Czochanska et al., 1988). However, C_{29} sterane could also come from blue-green algae and marine diatoms (Nichols et al.1990). The high diasteranes compared to regular steranes (Figure 3B) suggests a clay-rich source rock; this because clays are required to catalyze the transformation of steroids to diasteranes (Peters and Moldowan, 1993). Also, the relative high concentration of C27 sterane (Figure 2B) and the moderate concentration of C29 hopane (norhopane) (Figure 2C) may also indicate input of marine organic sources. The presence of moretanes (Figure 2C) indicates a source rock comprising organic materials of terrestrial origin. This is in agreement with the high abundance of compound X (an unidentified but common triterpane eluting after the C_{29} norhopane, Figure 2C) which is considered to be strong terrestrial indicator (Waples and Machihara, 1991). Also, the distribution of the extended hopanes with a regular decrease in peak height from the C_{32} to C_{35} (Figure 2C) indicates a clastic facies (Waples and Machihara, 1991). In general, the presence of gammacerane (Figure 2C) may suggest a marine, lacustrine, nearshore or deltaic depositional environments (Waples and Machihara, 1991). Thus, Alam El Bueib source rocks may be deposited in deltaic or nearshore environments, as they are the most favorable environments consistent with all the previous paleoenvironmental parameters. This is also confirmed by the review of the available literature, which reveals that Alam El Bueib source rocks was deposited in a shallow marine environment over a shallow shelf or fluvio-deltaic environment (Schlumberger, 1984). The moderate concentration of C_{30} bisnorhopane (Figure 2C) in extract of Alam El Bueib Fm. may be attributed to algal and bacterial precursors as we mentioned before (Peters et al., 1994). The moderate concentration of tricyclic terpanes (Figure 2C) may also indicate a moderate mature source rock (Huang, 2000). This is evidenced by the increase in the trisnorneohopane Tm peak (Figure 2C) (increase with increasing organic maturity, Abrams et al., 1999).This is confiremed by the Ts/Tm ratio (0.66, Table1).

The amount diasteranes and gammaceranee indeces and C_{29}/C_{30} hopane ratio influences the maturity level. (Petersen et al., 2000) recognized that the maturity level increase with the increase of these parameters. Thus, it is obvious that the Alam El Bueib source rock has diasteranes index is 0.78 and gammcerane index is 0.54 and ratio of C_{29}/C_{30} hopane is 0.48 revealing moderately maturity level.

Qarun 2-1 Well

The representative gas chromatogram of the Middel Jurassic Khatatba Formation source rock is shown in Figure 4A. The analyzed extract is dominated by C_{13}-C_{20} members, usually centered at C_{15} and C_{16} and shows slightly odd carbon preference. The relative high pr/ph ratio (1.25, Table-1) suggests a suboxic depositional environment rich in terrestrial organic matter. The carbon preference index is 0.95 (Table 1) indicating mature sample (Tissot and Welet, 1984). The isoprenoids/n-alkanes ratios (pr/n-C_{17} and ph/n-C_{18}, range from 0.76 and 0.64, respectively,Table 1), suggest that mixed organic matters, deposited under oxidizing –reducing conditions (Figure 3).

M/Z 217 mass fragmentograms of Khatatba extract (Figure 4B) is dominated by C_{27} and C_{29} regular steranes, indicating mixed marine and terrestrial sources. The sterane distributions (C_{27}, $_{28}$ and $C_{29,}$ Table 1) confirms the previous conclusion that the organic matter of Khatatba source rock was deposited in a transitional environment (e.g. shallow marine and/or deltaic) with mixed organic sources. The relative high concentration of rearranged steranes (diasteranes) (Figure 4B) indicates a clay-rich

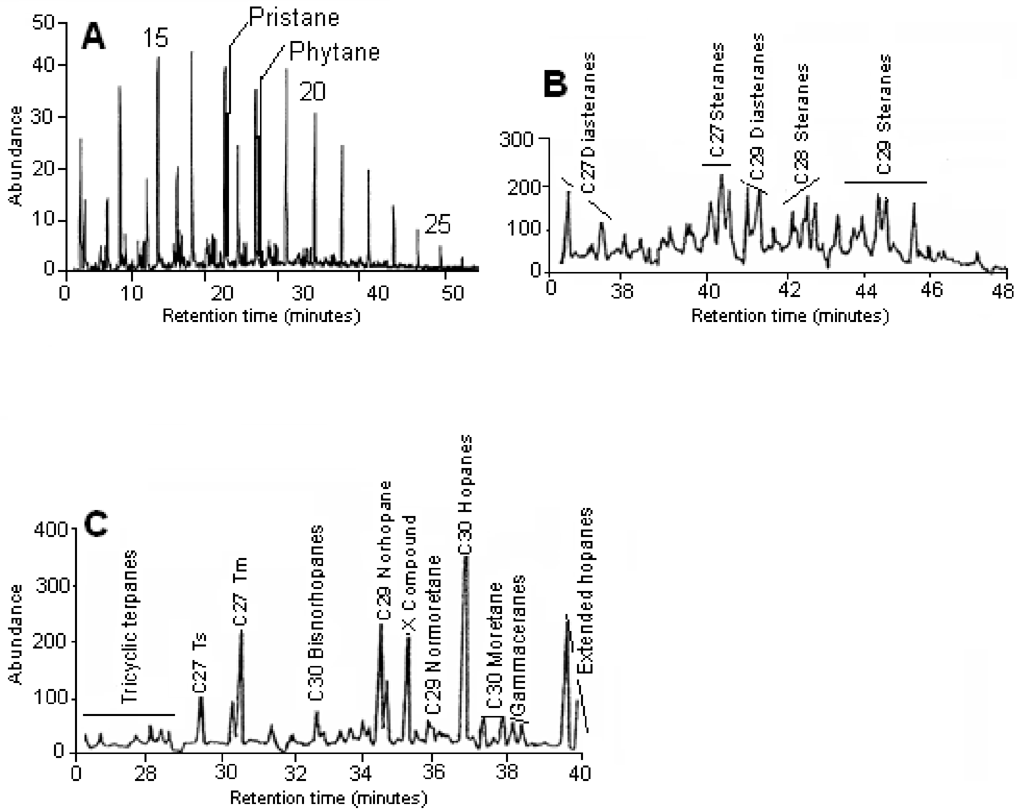

Figure 4. Gas chromatogram (A), ion fragmentograms m/z 217 (B) and m/z191 (C) of Middle Jurassic source rocks (Khatatba Fm.) in Qarun 2-1 Well, North Western Desert, Egypt.

environment (Czochanska et al., 1988). Also, the presence of moretanes (Figure 4C) indicates a contribution of terrestrial sources. The low tricyclic terpanes (Figure 4C) suggest either low maturity of the extracts or low salinity of the depositional environments (Huang, 2000). The predominance of C_{30} hopane and the moderate abundance of compound X and C_{29} norhopane (Figure 4C) suggest a source rock with high concentration of terrestrial organic matter and significant input of marine organic sources. (Peters and Moldowan, 1993).

The amount diasteranes and gammaceranee indeces and C_{29}/C_{30} hopane and Ts/Tm ratios are 1.10, 0.17, 0.57 and 0.46 respectively (Table 1) revealing mature source rock.

Kahramn-1x Well

The saturated hydrocarbons fraction from Paleozoic Kohla source rock (Figure 5A) displays slightly increase in carbon preference in the C_{15}-C_{22} range, indicating a contribution from algae (Petersen et al., 2000; Andrew et al., 2001). The low isoprenoid pr/ph ratio of 1.33 suggest anoxic depositional environment. The carbon preference index (CPI) is 0.97 (Table 1) and show no even or odd carbon preference, indicating mature samples (Tissot and Welet, 1984). The isoprenoids/n-alkanes ratios (pr/n-C_{17} and ph/n-C_{18},are 0.76 and 0.41, Table 1), suggest that mixed organic matters, deposited under oxidizing- reduing conditions.

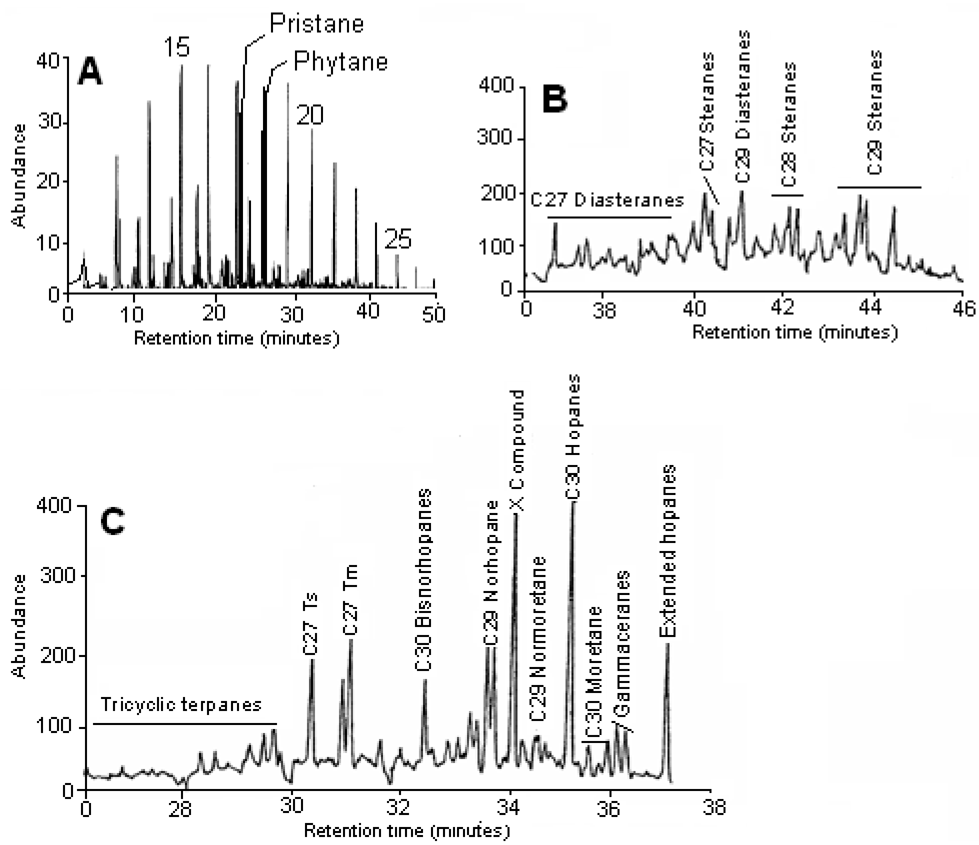

Figure 5. Gas chromatogram (A), ion fragmentograms m/z 217 (B) and m/z191 (C) of Paleozoic source rocks (Kohla Fm.) in Kahraman-1 Well, North Western Desert, Egypt.

The predominance of C29 over C27 steranes (Figure 5B, Table 1) in Kohla extract is held to be diagnostic of nonmarine organic sources (Moldowan et al., 1985). However, source rocks derived from marine carbonate origin older than Early Cretaceous, generally show high relative amounts of C_{29} steranes and are attributed to the algal precursors (Peters and Moldowan, 1993). This is inagreement with the presence of C_{30} bisnorhopane (Figure 5C). Also the high concentration of compound X and presence of moretanes and C30 norhopane (Figure 5C) suggest a terrestrial input. High bacterial contributions and limited input of marine organic matter in anoxic environments are indicated by moderate concentration of C29 hopane, low concentration of tricyclic terpanes, low Ts /Tm ratios (Figure 5C, Table 1) (Mello et al.,1995). All the above biological marker features are characteristics of extracts derived from more contribution from terrestrial organic sources and limited input of marine organic matter. The low Ts /Tm (0.46) indicate that Paleozoic Kohla Formation source rocks is a moderately mature to mature source rock. This is confirmed by the amount diasteranes and gammaceranee indeces and C_{29}/C_{30} hopane ratio (Table 1).

CONCLUSIONS

Biomarker analyses of source rocks of some wells in the North Western Desert, suggest the following:

1. Lower Cretaceous Alam El Bueib Formation source rock is moderately mature and has organic matter has geochemical characteristics of deposition in clay-rich, nearshore or deltaic environment with significant input of marine algae, and bacterial contributions.
2. Middel Jurassic Khatatba Formation mature source rocks has mixed marine and terrestrial organic sources, deposited under oxidizing – reducing conditions.
3. Paleozoic Kohla Formation is moderate mature source rock comprises terrestrial, bacterial and algal precursors, which were deposited under anoxic environment with limited input of marine organic matter.

Therefore, we recomented that the biomarkers anayses of source rocks have a powerful way to infer source rocks depositional environments and maturation.

REFERENCES

1. Abdel Gawad, E. A., Philp, R. P., and Zein El Din, N. Y. 1996. Evaluation of possible source rocks in Faghur-Siwa Basin, Western Desert, Egypt. *EGPC 13th Petrol. Explor. Prod. Conf.,*1: 417-432.
2. Abrams, M. A., Apanel, A. M., Timoshenko, O. M., and Kosenkova, N. N. 1999. Oil families and their potential sources in the northeastern Timan Pechora Basin, Russia. *AAPG Bull.,* 83: 553-577.
3. Andrew, D. H., Bradley, D. R., David, Z. J., Moldowan, M., and Ulderico, B. 2001. Upper Oligocene lacustrine source rocks and petroleum systems of the northern Qaidan Basin , northwest China. *AAPG Bull*., 85: 601-619.
4. Czochanska, Z., Gilbert, T. D., Philip, R. P., Sheppard, C. M., Weston, R. J.,Wood, T. A., and Woolhouse, A. D. 1988 Geochemical application of sterane and triterpane biomarkers to a description of oils from the Taranaki Basin in New Zealand. *J. Organic Geochemistry*, 12: 123-135.
5. Darwish, M., Abu Khadra, A, M., Abdel Hamid, M. L., and Hamid, A., 1994, Sedimentology, environmental conditions and hydrocarbon habitat of the Bahariya Formation, Central Abu Gharadig Basin, Western Desert, Egypt. *EGPC. 12th Petol. Explor. Prod. Conf.*, Cairo, Egypt,1: 429-449.
6. El Nady, M. M. 1999. Contribution to petroleum source rocks and thermal maturation of Cretaceous sequence in the West Razzak-Alamein area, North Western Desert, Egypt. *J. Egyptian Petrol.,* 8: 87-101.
7. El Nady, M. M. 2009. Biomarkers assessment of crude oils and extracts from Jurassic-Cretaceous Rocks, North Qattara Depression, North Western Desert, Egypt. *J. Petroleum Science and Technology*,26 (9): 1063-1080
8. El Nady, M. M. and Hammad, M. 2000. Evaluation of Cretaceous hydrocarbon source rock in Badr El Din Concession, North Western Desert. *J. Environ. Sciences,* 20: 25-51.

9. El Nady, M. M. and Sharaf. L. M. 2004. Contribution to the organo-geochemical characteristics of Paleozoic source rocks in the vicinity of Siwa Oasis, Western Desert, Egypt. *Ann. of Geol. Survey,* 27: 445 – 458.
10. Huang, H. P. 2000. The nature and origin of petroleum in the Chaiwopu Sub-Basin (Junggar Basin), NW China.*J. Petrol. Geol.,* . 23:193-220.
11. Khaled, K. A. 1999. Cretaceous source rocks at the Abu Gharadig oil- and gas field, Northern Western Desert, Egypt. *J. Petrol. Geol.,* .22: 337-395.
12. Lijmbach, G. W., 1975. O n the origin of petroleum. Proceeding of the 9th World Petroleum Congress, Applied Science Publisher, London, 2: 357-369.
13. Mackenzie, A.S., Maxwell, J. R., Coleman, M. L., and Deegan, C. E., 1984, Biological marker and isotope studies of North Sea crude oils and sediments, In, Proceedings of the Eleventh World Petroleum Congress, 2, PDI (4): Chichester, John Wiley, p.1-12.
14. Mello, M. R., Telnaes, N., and Maxwell, J. R., 1995, The hydrocarbon source potential in the Brazilian marginal basins: a geochemical paleoenviromental assessment, In, A. Y., Huc (Ed), Paleogeography, paleoclimate and source rocks: AAPG Studies in Geology 40, p. 233-272.
15. Moldowan, J. M., Seifert, W.K., and Gallegos, E. J., 1985, Relationship between petroleum composition and depositional environment of petroleum source rocks: AAPG Bull., v.69, p. 1255-1268.
16. Nichols, P. D., Palmisano, A. G., Rayner, M. S., Smith, G. A., and White, D. C., 1990, Occurrence of novel C30 sterols in Antarctic sea-ice diatom communities during a spring bloom: Organic Geochemistry, v. 15, p. 503-508.
17. Peters, K. E., and Moldowan, J. M., 1993, The biomarker guide: Englewood Cliff: New Jersey, Prentice Hall, 363p.
18. Peters, K. E., Fraser, T. H., Amris, W., Rustanto, B., and Hermanto, E., 1999, Geochemistry of crude oils from eastern Indonesia: AAPG Bull., v. 83, p.1927-1942.
19. Peters, K. E., Kontorovich, A. Eh., Huizinga, B. J., Moldowan, J. M., and Lee, C. Y., 1994, Multiple oil families in the West Siberian Basin: AAPG Bull., v.78, p. 893-909.
20. Peters, K. E., Suedden, J. W., Sulaeman, A., Sarg, J. E., and Enrico, R. J. (2000). A new geochemical-sequence stratigraphic model from the Mahakam Delta and Makassar Slope, Kalimantan, Indonesia. AAPG Bull. 84, pp.12-44.
21. Petersen, H. I., Andsbjerg, J., Bojesen-Koefoed, J. A., and Nytoft, H. P., 2000, Coal-generated oil: Source rock evaluation and petroleum geochemistry of the Lulita Oilfield, Danish North Sea: J. Petrol. Geol., v. 23, p. 55-99.
22. Sharaf, L. M. and El Nady, M. M. 2003.Geochemical characterization of source rocks and oil-source rocks correlation in some Wells within South Umbarka Area, North Western Desert, Egypt. *J. Egyptian Sedimentology*,11: 61-76.
23. Sharaf, L. M., Ghanem, M. F., Hussein, S.A., and El Nady, M.M. 1999: Contribution to petroleum source rocks and thermal maturation of Jurassic-Cretaceous sequence, South Matruh, Northern Western Desert, Egypt: *J. Sedimentology of Egypt.* 7: 71-83.
24. Shahin, A. N., and Dahi, M., 1992, Paleozoic rocks distribution and hydrocarbon potential in the Western Desert, Egypt. *EGPC 11th Petrol. Explor. Prod. Conf.*, Cairo, 2: 56-78.
25. Schlumberger, 1984. Well evaluation conference, Geology of Egypt, 64p.
26. Tissot, B. P. and Welte, D. H. (1984). Petroleum Formation and Occurrence, 2nd ed., New York springer Verlage, N.Y. 699p.

27. Waples, D. W., and Machihara, T., 1991, Biomarkers for geologists. A practical guide to the application of steranes and triterpanes in petroleum geology. *AAPG Methods in Exploration Series*, No. 9, 91 p.