Biomarker Indicators of Source and Depositional Environment for the Organic Matters within Barsarin Formation (Upper Jurassic) in Kirkuk and Taq Taq Oil Fields, Northern Iraq

Dler H. Baban and Shadan M. Ahmed
College of Science - University of Sulaimani

Abstract

The GC, GC/MS analysis for twelve bitumen extracts from Barsarin Formation in the wells K-109 and Tq-1 (Kirkuk and Taq Taq oil fields respectively) and for two oil samples from K-156 and Tq-1 wells revealed a euxinic, carbonate marine to mix environment for the initial organic matters. Pr / Ph, Pr / nC_{17}, and Ph / nC_{18} ratios indicated also a marine source organic matters deposited under reduced condition with a less effect of biodegradation and mature stage of occurrence. The diasteranes / steranes ratio showed generally low ratios (0.27 – 0.56) as in most marine carbonate sources, while Algal-bacterial organic matter contribution for the extracts and the oil samples suggested depending on the predominance of C_{23} tricyclic terpane relative over the C_{19} tricyclic terpane and the C_{23} tricyclic terpane greater than C_{24} tricyclic terpane. The gammacerane Index indicated a low salinity environment of deposition for the initial organic matters existed in the analyzed samples.

Introduction

The Barsarin Formation was first described by Wetzel (1950), in Bellen, (1959). The type locality and type section of Barsarin Formation located in Barsarin, Rowanduz district, north east Iraq. The formation at the type section comprises of limestones and dolomitic limestone (laminated, some fluffy-textured, locally cherty) and argillaceous, brecciated, and contorted beds. The formation is believed to be-at least partly of lagoonal evaporitic origin, indicated partly by the presence of anhydrites and oolitic in layers in some sections, partly by ubiquitous brecciated and crumbled beds (Buady, 1980). The Formation expected to be a basin floor evaporite facies by Sadooni (1997). A Kimmeridgian-Early Tithonian Age for the Formation is based on its stratigraphic position below the Chia Gara Formation of the Late-Tithonian Age and above the Kimmerdigian-Oxfordian Naokelekan Formation (Jassim & Buday, 2006 in Jassim & Goff, 2006).

The Analyzed Samples

Twelve extracts from Barsarin Formation has been chosen from the two subsurface sections of K-109 well from Kirkuk oil field and Tq-1 well from Taq Taq oil field, in addition to two oil samples from K-156 and Tq-1 wells to be analyzed in Baseline Resolution, Inc. (Analytical Laboratories in Huston, USA) by GC and GC/MS instruments (fig. 1, table 1). The thickness of Barsarin Formation in Kirkuk reached to about 283m and in Taq Taq about 75m. The GC analysis for the extracts from both sections show different degrees of contamination which expected to be caused by oil base mud during drilling. The degree of the contamination varied among the samples and affected the C^{15+} parameters. The three extracts from K-109 (3104, 3164, and 3364m) and one from Tq-1 section (3200m) were the least contaminated and their obtained ratios seem largely to be original or close to original. The biomarker data obtained from the saturate GC/MS analysis of the eight source rock extracts (five from K-109 and three from Tq-1) and the two oil samples show no affect of contamination from the oil base mud (Appendix).
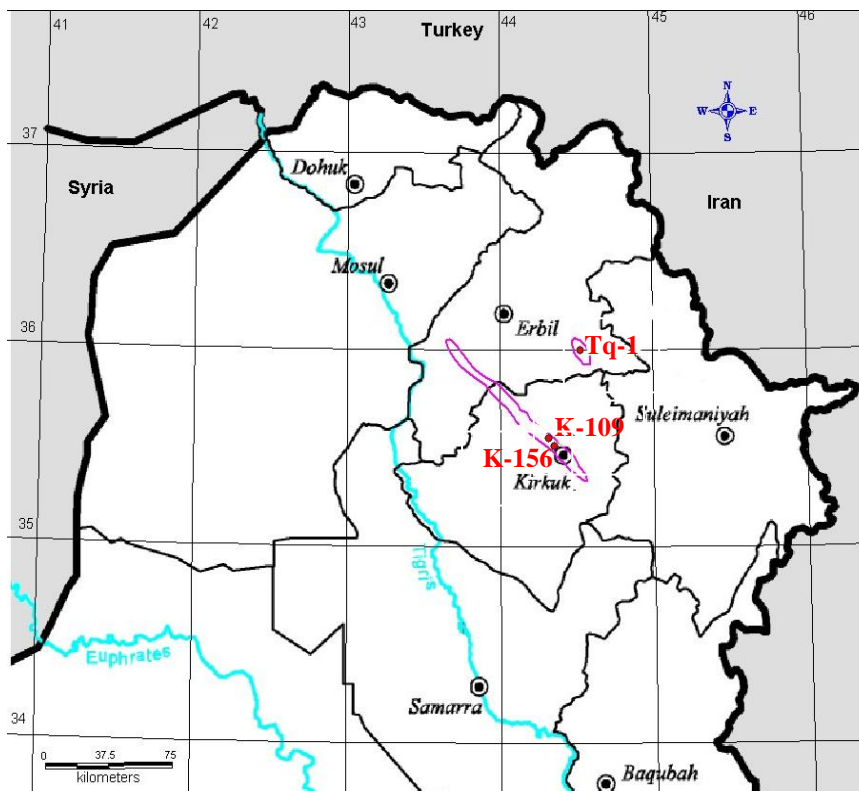

Figure (1): Location map for the studied subsurface sections

Table (1): The analyzed extract samples of Barsarin Formation by GC and GC/MS instrument from both K-109 and Tq-1 wells, in addition to two oil samples from K-156 and Tq-1 wells.

Analyzed Samples	Depth (m)	GC	GC/MS
K-156, oil	64	*	*
Tq-1, oil	1620-1651	*	*
K-109	3104	*	
K-109	3143	*	
K-109	3164	*	
K-109	3188	*	
K-109	3210	*	*
K-109	3289	*	*
K-109	3299.4	*	*
K-109	3316	*	*
K-109	3364	*	*
Tq-1	3143	*	*
Tq-1	3165	*	*
Tq-1	3200	*	*

Depositional Environment and Source Related Biomarkers

Biological markers or biomarkers are molecular fossils, (originated from formerly living organisms), and are complex organic compounds composed of carbon, hydrogen, and other elements. They occur in sediments, rocks, and crude oils and show little or no change in structure from their parent organic molecules in living organisms (Peters et al., 2005) and their carbin skeletons can be traced back to living organisms (Hunt, 1996).

The quality of information provided by the biomarkers or geochemical fossils in terms of depositional environment depends on three factors (as mentioned by Tissot and Welte, 1984):-

1- Their state of conservation, which may or may not allow one to link them to their biochemical precursor molecule.

2- The distribution of the biochemical precursor (parent molecule) in the present animal and /or plant kingdom.

3- The assumption that the distribution was comparable in ancient organisms.

The utility of biomarkers as indicators of depositional environments arises from the fact that certain types of compounds are associated with organisms or plants that grow in specific types of depositional environments (Philp, 2004).

Broocks et al. (1969) in Philp, (2004) noted the presence of the regular isoprenoids pristane (Pr) and phytane (Ph) in crude oils and coal extracts. This led Powell and Mickidy, (1973) in Philp, (2004) to propose a mechanism for the production of relatively high concentrations of pristine in oxic type environments and high concentration of phytane in reducing type environments. Thus, the Pr/Ph ratio evolved as an indicator of the oxicity of the depositional environment.

Because some biomarkers pointed to specific taxa, they can also act as indicators of specific habitats. Fresh water environments are often indicated by the presence of biomarkers of typical fresh water organisms such as *Botryococus braunii*. Lacustrine conditions are often indicated by the predominance of algal steroids (Chen & Summons, 2002 in Brocks & Summons, 2004). Hypersaline lakes and ponds often develop anoxic conditions if saline deep water is covered with water of lower density. Sedimentary rocks that were deposited under these conditions often contain high relative concentrations of gammacerane, which is a biomarker generally associated with water column stratification (Sinninghe Damste et al., 1995 in Brooks & Summons, 2004).

Rearranged steranes (diasteranes) are relatively more abundant in clastic sediments than in carbonates (van Kaam-Peters et al., 1998 in Brooks & Summons, 2004). Hopanoide appear to be similarly affected so that diahopanes and neohopanes are relatively more prominent in bitumen and oils derived from shales as opposed carbonates (Peters & Moldowan, 1993 in Brooks & Summons, 2004). However increase in thermal maturity is also a key factor in the conversion of biomarkers to their rearranged forms.

Carbonate–dominated sediments tend to be deposited in low latitude environments and therefore biomarkers for organisms that preferentially colonize warm water tend to be important signatures in these sediments.

1. Pristane/Phytane:

The abundant source of pristane (C_{19}) and phytane (C_{20}) is the phytal side chain of chlorophyll (a) in phototrophic organisms and bacteriochlorophyll (a) and (b) in purple sulphur bacteria (Mc Kirdy, 1973 in Peters et al., 2005). Reducing or anoxic conditions in sediments promote cleavage of the phytal side chain to yield phytol, which undergoes reduction to dehydrophytal and phytane. Oxic conditions promote the competing conversion of phytol to pristine by oxidation of phytol to phytenic acid, decarboxylation to pristene and then reduction to pristane (Peters et al., 2005).

Didyk et al. (1978) in Peters et al. (2005) interpreted the redox conditions of the source rock depositional environment for crude oil based on a model for the origin of pristane (Pr) and (Ph) phytane. According to many authors, Pr/Ph less than 1 in crude oil indicates anoxic source rock deposition, particularly when accompanied by high porphyrin and sulphur contents, while Pr/Ph more than 1 indicates oxic deposition. Pr/Ph is commonly applied because Pr and Ph are measured easily using gas chromatography.

In summary, the Pr/Ph ratios in the range of 0.8-3.0 are interpreted to indicate specific paleoenvironmental conditions without corroborating data. Pr/Ph more than 3.0 indicates terrigenous plant input deposited under oxic to suboxic conditions, while Pr/Ph less than 0.8 indicates saline to hypersaline conditions associated with evaporate and carbonate deposition (Peters et al., 2005).

The ratio Pr/nC17 is useful for differentiating organic matter from swamp environment (more than ١٠٠) from those formed under marine environment (less than 0.5), but this ratio is affect by maturity, as well as biodegradation (Osuji & Antia, 2005). According to Elvsborg et al., (1985), Cohen and Dunn, (1987) both in Sletten, (2003) Pr/Ph ratios typical for type II marine shales are 0.6-1.6.

An oil accumulation have pristane / phytane ratio more than 3.0, indicative of a predominantly non marine source from terrestrial organic matter. Furthermore, the progressive change from waxy to light oil has been interpreted to indicate an increased contribution of bacterial or algal source inputs to the lighter oil (Powel et al., 1989 in Boreham & Hill, 1998). An alternative interpretation is that the original source input, although dominated from terrestrial organic matter, has been masked by secondary alteration processes.

The ratios of the Pr / Ph for the four uncontaminated extracts mentioned above in this study were generally low and ranged between 0.34 and 0.61 (less than 0.8) (table 2) indicating anoxic, reduced marine carbonate depositional environment.

The ratio of Pr / nC17 for the same four extracts ranged between 0.15 and 0.29 (less than 0.5) indicating marine environment of deposition also.

The cross plot of Pr / nC17 versus Ph / nC18 for the whole analyzed samples (fig. 2) shows clear marine source organic matters deposited under reduced condition with a less effect of biodegradation and mature stage of occurrence.

Table(2):Ratios of Pr/Ph, Pr/(Pr+Ph), Pr/nC17, and Ph/nC18 for the analyzed samples.

Samples	Depth (m)	Pr/Ph	Pr/ (Pr+Ph)	Pr/nC$_{17}$	Ph/nC$_{18}$
K-156, oil	64	0.84	0.46	0.27	0.36
Tq-1, oil	1620-1651	0.87	0.47	0.18	0.25
K-109	3104	0.39	0.28	0.25	0.69
K-109	3143	0.14	0.12	0.24	1.08
K-109	3164	0.39	0.23	0.23	0.45
K-109	3188	0.14	0.12	0.38	3.34
K-109	3210	0.14	0.13	0.29	2.11
K-109	3289	1.88	0.66	0.33	0.19
K-109	3299.4	1.95	0.66	0.32	0.17
K-109	3316	1.51	0.56	0.29	0.21
K-109	3364	0.61	0.38	0.15	0.31
Tq-1	3143	1.34	0.57	0.36	0.34
Tq-1	3165	0.53	0.35	0.28	0.6
Tq-1	3200	0.34	0.25	0.29	1.07

The result of analysis for the two oil samples of K-156 and Tq-1 also seem to be original and no effects of contaminations have been detected. The position of these two oil samples on the cross plot of Pr / nC17 versus Ph / nC18 show a good correlation with the analyzed extracts. The small difference between the Pr / Ph ratio of the two oil samples (0.84 for K-156

and 0.87 for Tq-1 oil) and those of the extracts may be interpreted as those two oils generated from additional marine sources of organic matters (generally of Jurassic age) and not only from Barsarine source rocks.
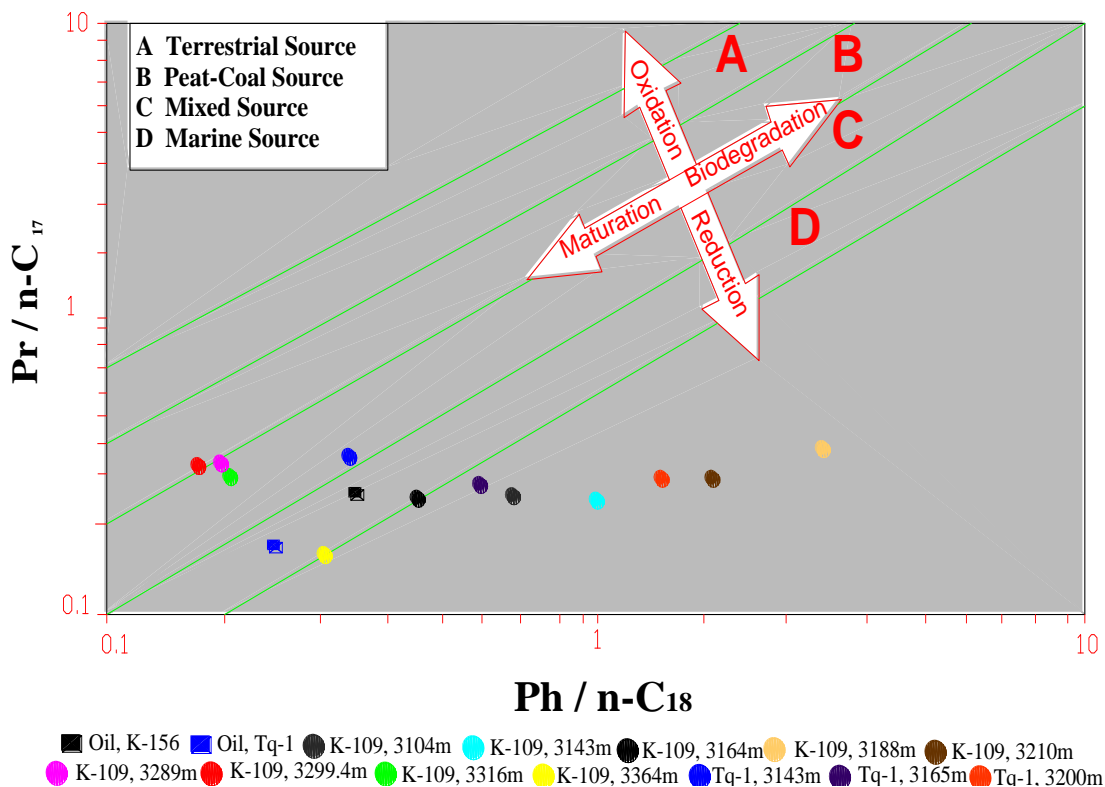

Figure (2): Pr/nC17 versus Ph/nC18 cross plot, from which a mature, marine source organic matter can be detect for the analyzed samples. (The plot after Shanmugam, 1985 in Younes and Philip, 2005).

2. Diasteranes/Steranes:

Diasteranes / steranes ratios are commonly used to distinguish petroleum from carbonate versus clastic source rocks (Mello et at., 1988 in peters et al., 2002). Low diasteranes / steranes ratios (mass/charge 217) in oils indicate anoxic clay-poor or carbonate source rocks. During diagenesis of these carbonate sediments, bacterial activity provides bicarbonate and ammonium ions, resulting in increased water alkalinity. Under these conditions of high pH and low Eh, calcite tends to precipitate and organic matter preservation is improved (Peters et al., 2005). High diasteranes / steranes ratios are typical of petroleum derived from clay-rich source rocks and in some crude oils can result from high thermal maturity (Seifert & Moldowan, 1979 in Peters et al., 2005) and/or heavy biodegradation (Peters et al., 2005).

At high levels of thermal maturity, rearrangement of steroids to diasterane precursors may become possible, even without clays, due to hydrogen-exchange reactions, which are enhanced by the presence of water (Van Kaam-Peters et al., in Peters et al., 2005). Alternatively, diasteranes simply may more stable and survive thermal degradation better than steranes. The diasteranes/steranes ratio is useful for distinguishing source-rock depositional conditions only when samples show comparable levels of thermal maturity (Peters et al., 2005).

Heavy biodegradation can result in selective destruction of steranes relative to diasteranes. However, it's possible that non-biodegraded oil might mix with heavily biodegraded oil showing a much higher diasteranes/steranes ratio. In such cases, only careful quantitative assessment of each biodegradation-sensitive parameter can led to the correct interpretation (Peters et al., 2005).

The diasteranes / steranes ratio for the analyzed extracts and oil samples show generally low ratios (0.27 – 0.56) (table 3) indicating anoxic carbonate source rocks.

There is a positive correlation between Pr / (Pr+Ph) and C_{27} diasteranes/ (diasteranes+steranes) that were controlled by the depositional environments (Moldowan et al. 1994 in Peters et al., 2005). Pr / (Pr+Ph) increases with clay content, as measured by increasing diasteranes, which parallels oxidative strength (Eh) of the water column during deposition. Depending on the relation between Pr / (Pr+Ph) and C_{27} diasteranes/ (diasteranes+steranes) (fig. 3) a slight difference in the source of the organic matters between K-109 and Tq-1 sections appeared as a contribution from anoxic shale source seems to be occurred in the section K-109 while anoxic carbonate source is clear in Tq-1.

The cross plot of C_{27}/C_{29} diasterane versus C_{27}/C_{29} sterane used to identify the source of the analyzed extracts and oil samples in this study (fig. 4).The result of this cross plot indicated a mixed origin of organic matters, and all the extracts and the two oil samples have generally C_{27}/C_{29} diasterane values larger than C_{27}/C_{29} sterane (table 4).

3. C_{27}, C_{28}, and C_{29} Steranes Ternary Plot:
Haung and Meinschein (1979) in Peters et al., (2005) proposed that the distribution of C_{27}, C_{28}, and C_{29} sterol homologs on a ternary diagram might be used to differentiate ecosystems.

The ternary plot of the relative amounts of C_{27}, C_{28}, and C_{29} steranes for the analyzed samples (table 4) definitely indicated hydrocarbons generated in a marine with a carbonate nature source environment (fig. 5).

The locations of the plotted samples are similar with those proposed by Osadetz et al., (2004) for samples of Mesozoic marine source.
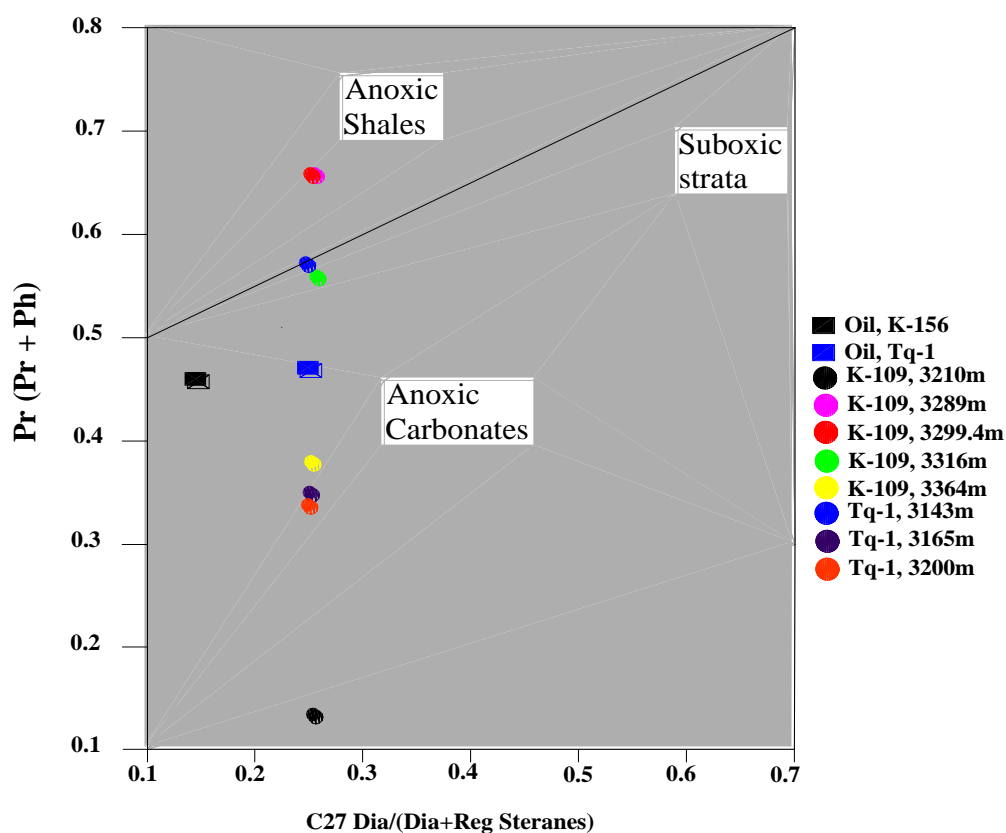

Figure (3): Pr/ (Pr+Ph) versus C_{27} diasteranes/ (diasteranes+steranes) cross plot, from which anoxic carbonate and anoxic shale marine source organic matter can be detect forTq-1 and K-109 samples respectively. (The cross plot is from Peters et al., 2005).

Table (3): C27, C28, and C29 Sterane and Diasterane ratios for the analyzed oil and extract samples.

| Samples	Depth (m)	Sterane (217 m/z)			Diasterane (217 m/z)			Sterane/ Diasterane (217m/z)
		C_{27}	C_{28}	C_{29}	C_{27}	C_{28}	C_{29}	
K-156	64	178.2	195.4	245.7	33.7	76.4	33.6	0.27
Tq-1	1620-1651	37.9	37.2	53.9	13.1	22.8	13.1	0.53
K-109	3210	7204	7652	9372	2567	3890	2035	0.54
K-109	3289	7672	9351	10586	2772	4359	2470	0.55
K-109	3299.4	8650	9895	11356	3068	4932	2741	0.55
K-109	3316	9591	11047	12752	3504	5717	3519	0.56
K-109	3364	3093	3372	4150	1111	1594	1081	0.54
Tq-1	3143	6592	6983	8558	2237	3460	1998	0.51
Tq-1	3165	6365	7134	8942	2250	3503	1933	0.53
Tq-1	3200	10785	12496	14983	3781	5976	3460	0.55
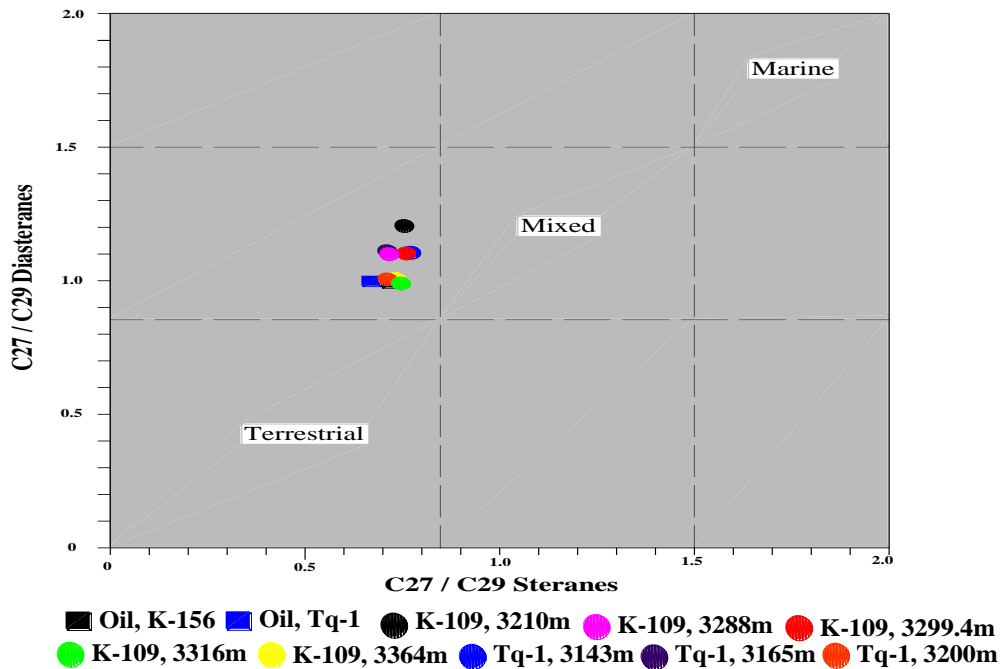
Figure (4): C27/C29 Diasteranes versus C27/C29 Steranes cross plot shows a mixed depositional environment for the analyzed oil and extract samples. Very good oil – source rock correlation also can be recognized. (The cross plot is from Ghori, 2000).

Table (4): The ratios of different biomarkers which have been used in detecting the source and depositional environment for the analyzed oil and extract samples.

| Samples	Depth (m)	C27/C29 Ster. (217m/z)	C27/C29 Dias. (217m/z)	C_{27} Dias./ (Dias.+Ster.) (217 m/z)	Steranes/ Hopanes	Steranes Index (218 m/z)	Olean. Index (191m/z)
K-156	64	0.72	1	0.15	0.34	3.24	0.05
Tq-1	1620-1651	0.7	1	0.25	0.43	3.83	
K-109	3210	0.76	1.2	0.26	0.52	3.72	
K-109	3289	0.72	1.1	0.26	0.63	3.48	
K-109	3299.4	0.76	1.1	0.26	0.6	3.6	
K-109	3316	0.75	0.99	0.267	0.51	3.6	
K-109	3364	0.74	1	0.264	0.48	3.83	
Tq-1	3143	0.77	1.1	0.25	0.58	3.48	
Tq-1	3165	0.71	1.1	0.261	0.55	3.4	0.07
Tq-1	3200	0.71	1	0.259	0.6	3.12	0.04
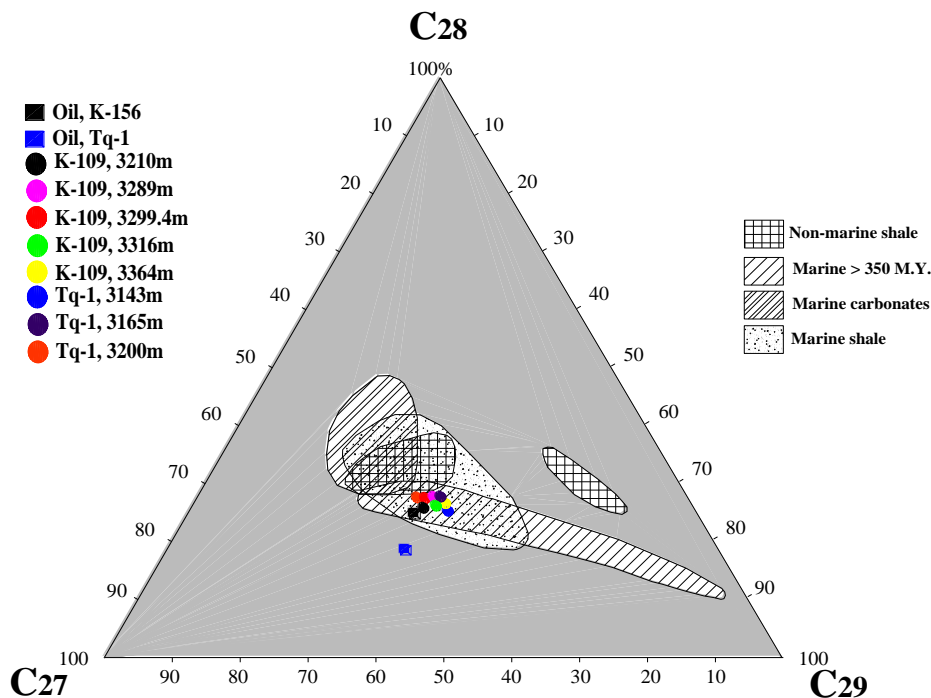
Figure (5): Ternary plot of the relative amounts of C_{27}, C_{28}, and C_{29} steranes for the analyzed oil and extract samples. Marine with a carbonate nature source environment can be recognized. Overlap between the different oil source types limits the use of sterane distribution to describe the source rock

4. C_{30} Sterane Index [C_{30}/ (C_{27}-C_{30}) Steranes]:

The C_{30} sterane ratios generally increase with marine versus terrigenous organic matter input to the source rock (Peters et al., 2005).
The presence of C_{30} 4-desmethysteranes in crude oil is the most powerful means in order to identify input of marine organic matter to the source rock (Peters et al., 1986 in Peters et al., 2005). These C_{30} steranes are identified as 24-n-propylcholestanes, which originate from 24-n-propylcholeseroles (Moldowan et al., 1990 in Peters et al., 2005)

Ratio of C_{30}/ (C_{27}-C_{30}) steranes against oleanane / hopane give a better assessment of marine versus terrigenous input to petroleum than either parameter alone. High oleanane and lower C_{30} steranes, suggesting a deltaic source rock with strong terrigenous input. High C_{30} steranes and lower oleanaes, suggesting a marine source rocks with less terrigenous input.

The generally high ratios of the C30 Sterane Index of the analyzed samples (3.12 – 3.83) (table 4) is an indication for marine source of organic matters. Plotting the obtained values of C_{30}/ (C_{27}-C_{30}) steranes versus oleanane index for the two extract samples from the depths 3165m and 3200m in Tq-1 well and the oil sample of K-156 revealed a marine source organic matters rather than terrigeneous origin figure (6).
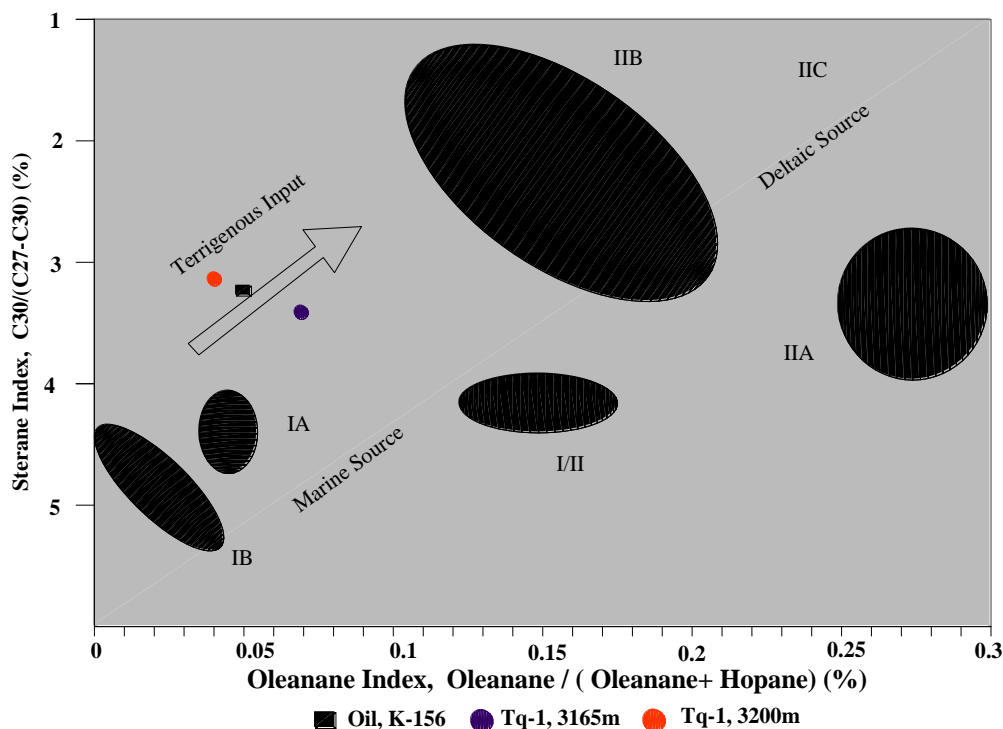
Figure (6): Sterane Index versus Oleanane Index cross plot shows a clear marine influence on the source of the analyzed oil and extract samples. (The cross plot is from Peters et al., 2005).

5. Gammacerane:

A C_{30} pentacyclic triterpane in which each ring contains six carbon atoms. Source rock deposited in stratified anoxic water columns (commonly hypersaline) and related crude oils commonly have high gammacerane indices (gammacerane / hopane). The gammacerane Index (gammacerane / hopane C31) for all analyzed samples (extracts and oil samples) show a low ratio (0.1 – 0.3) (table 5) indicating a low salinity environment of deposition for the initial organic matters.

Higher salinity is typically accompanied by density stratification and reduced oxygen content in bottom waters (i.e. lower Eh), which results in lower Pr / Ph. Figure (7) shows the relationship between the gammacerane index and Pr / Ph ratio for the analyzed oil and extract samples. The cross plot indicates a marine environment of deposition and it is comparable with the results of the diagram of peters et al., (2005).

Table (5): Ratios of different biomarkers within the analyzed oil and extract samples.

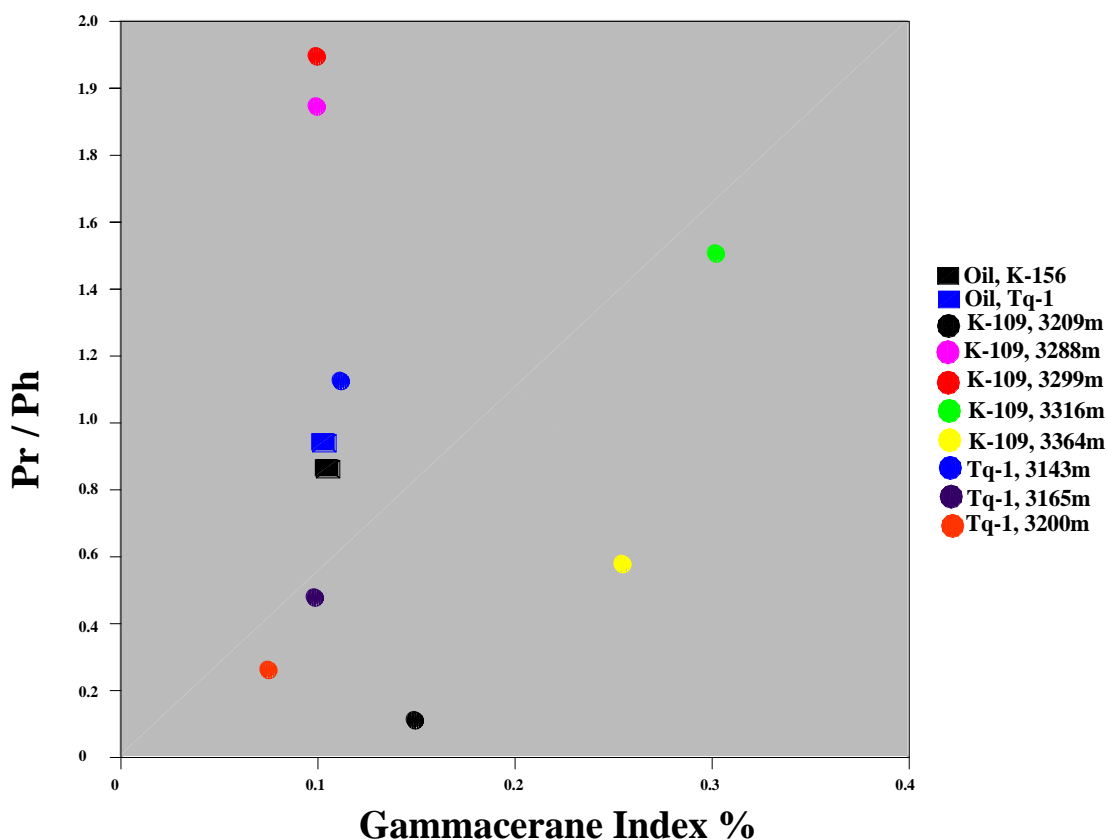| Samples	Depth (m)	Gammacerane Index (191 m/z)	Tricyclic terpanes C_{22}/C_{21} (191 m/z)	Tricyclic terpanes C_{24}/C_{23} (191 m/z)	Tricyclic terpanes $C_{28+}C_{29}$ / Ts (191 m/z)	C29H / C30H (191 m/z)	C35H / C34H (191m/z)
K-156	64	0.1	0.7	0.36	0.84	1.31	1.19
Tq-1	1620-1651	0.1	0.5	0.46	0.50	1.12	1.01
K-109	3210	0.15	0.54	0.56	0.67	1.24	0.96
K-109	3289	0.1	0.63	0.57	0.89	1.17	1.01
K-109	3299.4	0.1	0.52	0.55	0.71	1.21	0.97
K-109	3316	0.3	0.51	0.54	0.40	1.44	0.96
K-109	3364	0.26	0.6	0.6	0.35	1.31	1.04
Tq-1	3143	0.11	0.42	0.58	0.72	1.16	0.98
Tq-1	3165	0.1	0.51	0.56	0.98	1.08	0.88
Tq-1	3200	0.08	0.54	0.62	1.01	1.13	0.97

Figure (7): Gammacerane index versus Pr / Ph ratio for the analyzed oil and extract samples. (The cross plot is from Peters et al., 2005).

6. Terpanes:

The biomarker compounds referred to as terpanes are mainly derived from bacterial (prokaryotic) membrane lipids (Mukhopadhyah, 2004). These ratios help to identify extracts and crude oils derived from carbonate source rocks. Generally, oils from carbonate source rocks can be distinguished by high C_{22}/C_{21} tricyclic terpane and low $C_{24}/_{23}$ tricyclic terpane (Peters et al., 2005). The plot of the analyzed extracts and oil samples (specially the oil sample from K-156) (table 5) (fig.8) shows a great similarity with the analyzed extracts and oil samples of carbonate origin worldwide by Geo Mark Research Inc. (2000) in Peters et al., (2005) and that relating to their included ratios of tricyclic terpanes C_{22}/C_{21} versus tricyclic terpanes C_{24}/C_{23}. In the terpane distribution (m/z 191), the predominantly algal-bacterial organic matter contribution for the extracts and the oil samples can be suggested from the C19 – C25 tricyclic terpanes

distribution by the predominance of C23 tricyclic terpane relative over the C19 tricyclic terpane and the C23 tricyclic terpane greater than C24 tricyclic terpane. The C19 / C23 tricyclic terpane ratio is thus very low (extracts: 0- 0.33; oils: 0.21 and 0.60) and the C23 / C24 tricyclic terpane ratio is greater than 1 (extracts: 1.59- 1.83; oils: 2.16 and 2.71). In the pentacyclic terpanes, the high C24 tetracyclic / C26 tricyclics ratio (extracts: 1.57 – 4.18; oils: 3.94 and 4.04), the high norhopane / hopane ratio (extracts: 1.08 – 1.44; oils: 1.12 and 1.43), and the high C35 / C34 hopane ratio (extracts: 0.88 – 1.04; oils: 1.01 and 1.19) (table 5) indicate marine carbonate facies and anoxic depositional condition for the source rock of the extracts and the oils.

Figure (9) shows the relationship between norhopane / hopane (C29H/C30H) and C35 / C34 hopane ratios for the analyzed extracts and oil samples. From the cross plot a carbonate content and anoxic condition dominant is clear. A high hopane/Sterane ratio can indicate terrestrial input, while low ratios are typical for marine derived petroleum (Sletten, 2003). Based on this, all the analyzed samples as appears in the cross plot between Pr/Ph ratio and hopane/ sterane ratio (fig.10) indicate a marine source of organic matters.
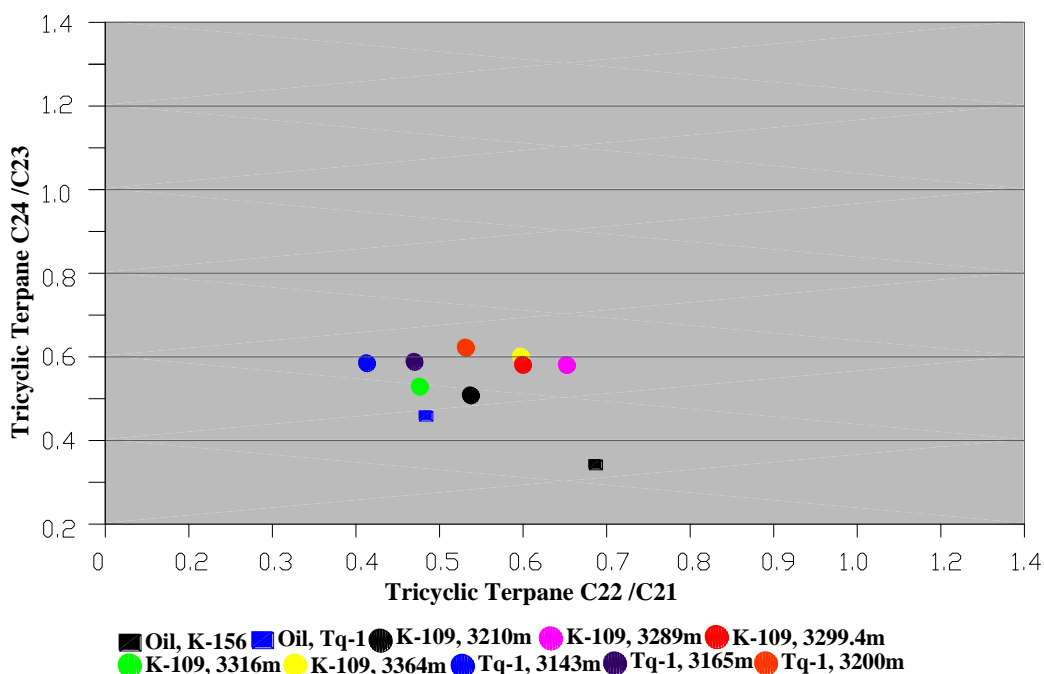
Figure (8): Tricyclic terpanes C_{22}/C_{21} versus Tricyclic terpanes C_{24}/C_{23} ratios for the analyzed oil and extract samples. Such a relationship indicates a marine, carbonate sources. (The cross plot is from Peters et al., 2005).
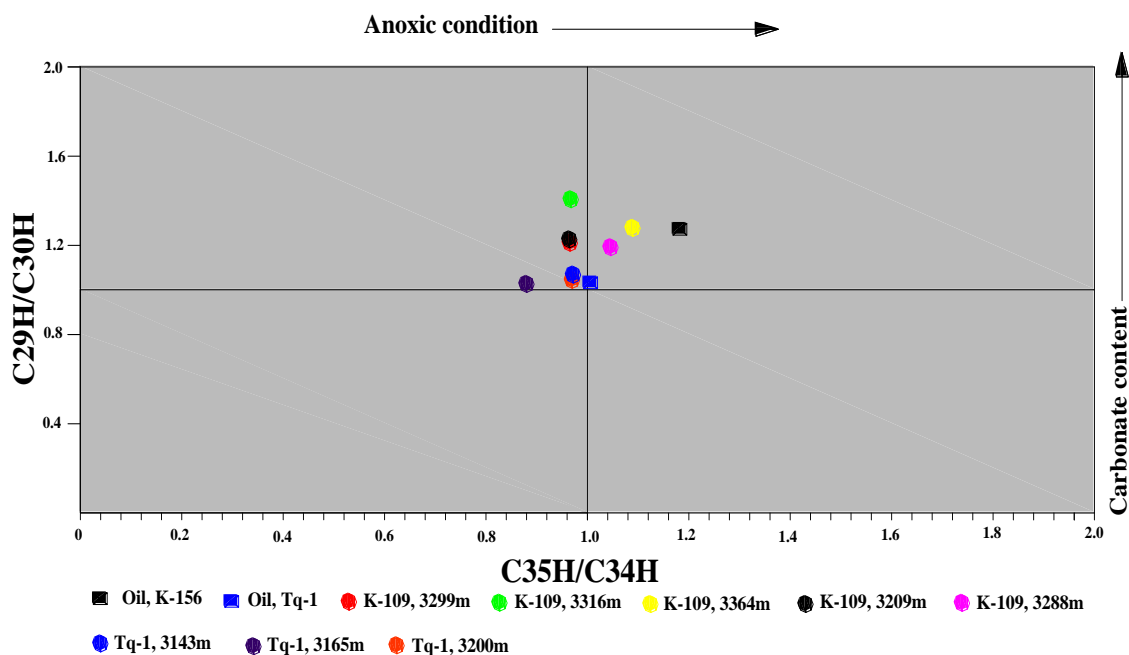
Figure (9): C29H/C30H versus C35H/C34H ratios shows the influence of anoxicity in a carbonate marine environment for the analyzed oil and extracts samples. The diagram also indicates similarity in the source of the extracts and the oil samples.
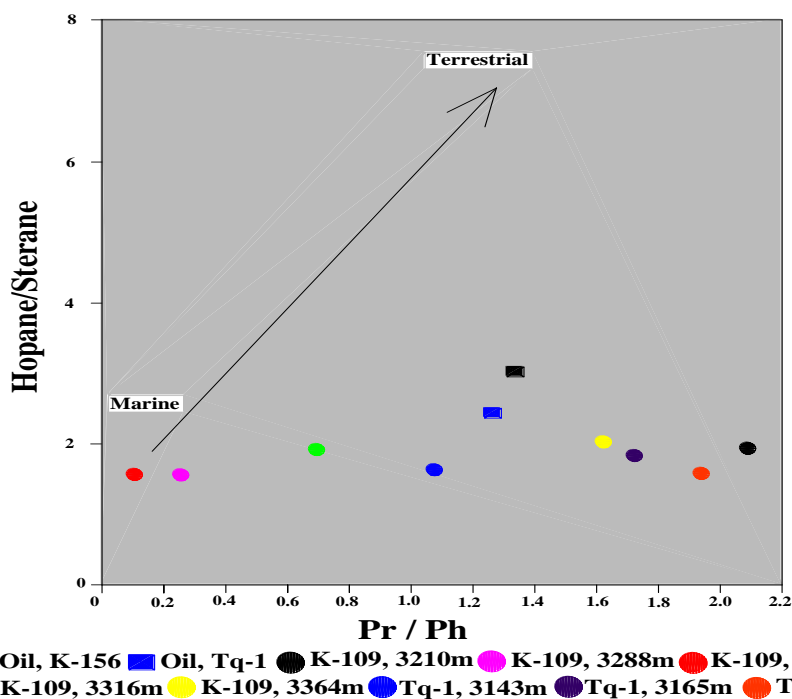
Figure (10): Cross plot between Pr/Ph ratio and hopane/sterane ratio indicating a marine source of the analyzed extracts and oil samples. (The diagram from Sletten, 2003 with modifications)

Conclusions

- The GC/MS analysis for extracts from selected samples from Barsarin Formation in the two sections of K-109 and Tq-1 indicated a euxinic, marine (to mix) carbonate source of deposition. The same source also supposed for the two oil samples taken from K-156 and Tq-1 wells.

- Pr / Ph, Pr / nC17, and Ph / nC18 ratios indicates marine source organic matters deposited under reduced condition with a less effect of biodegradation and mature stage of occurrence.

- The diasteranes / steranes ratio for the analyzed extracts and oil samples show generally low ratios (0.27 – 0.56) indicating anoxic carbonate source rocks.

- Algal-bacterial organic matter contribution for the extracts and the oil samples can be suggested.

- The gammacerane Index indicated a low salinity environment of deposition for the initial organic matters existed in the analyzed samples of both extracts and oil samples.
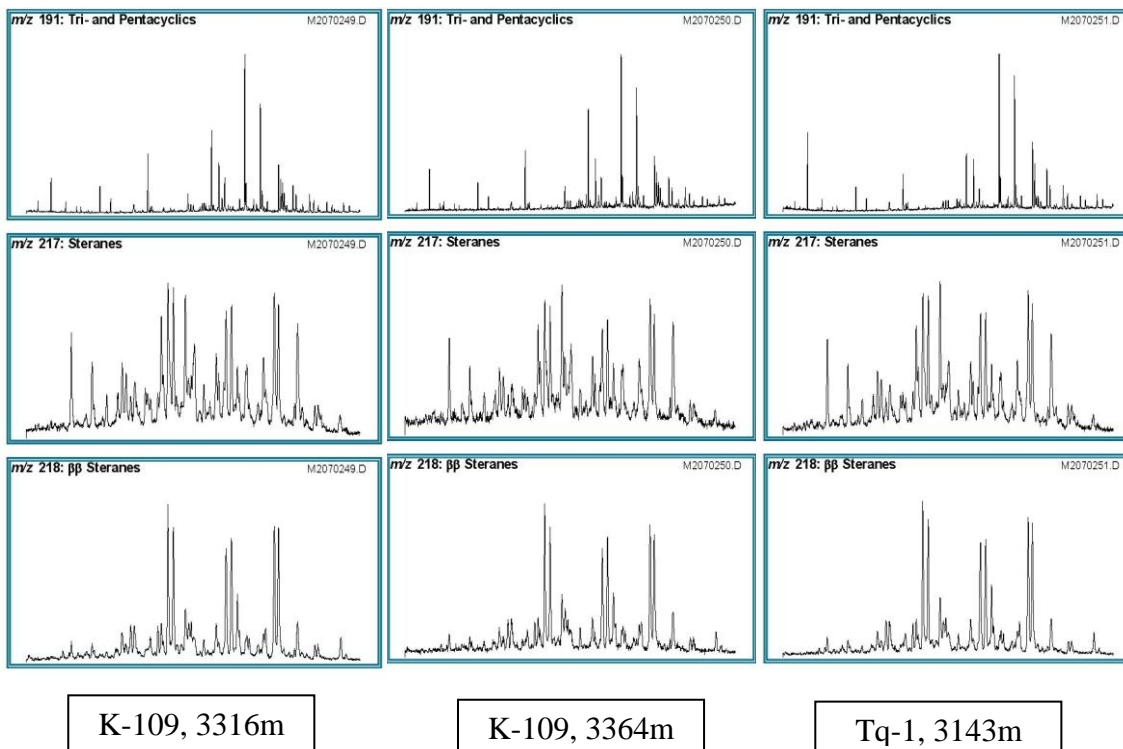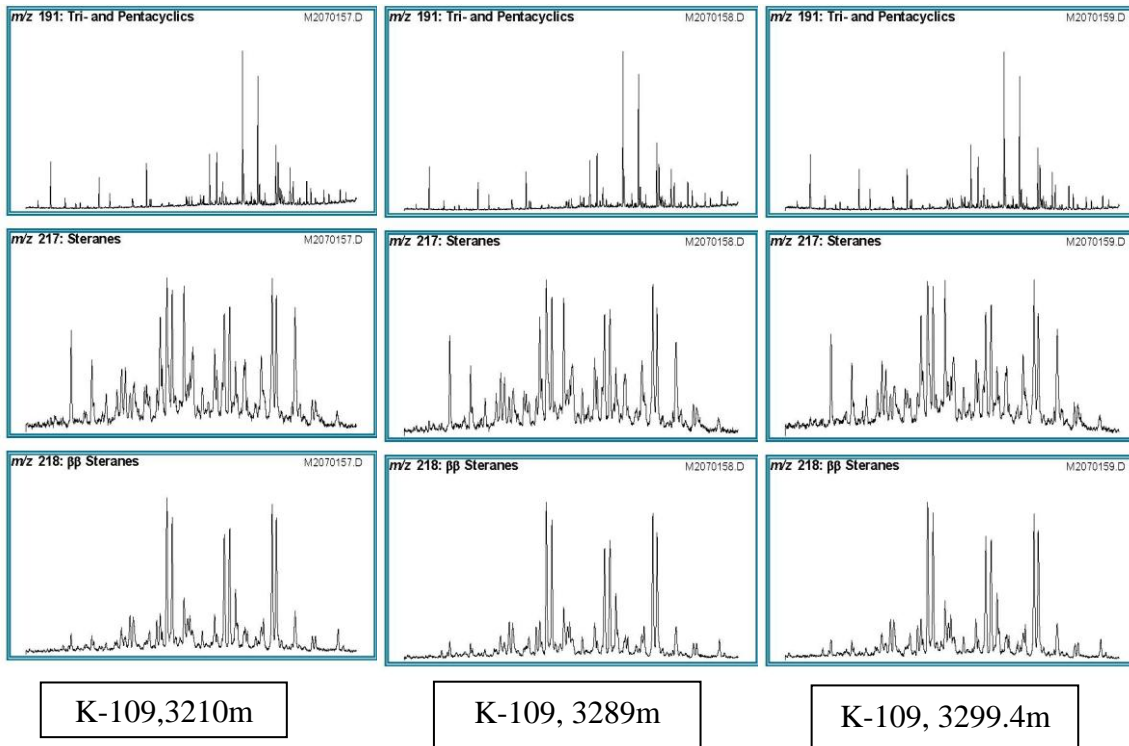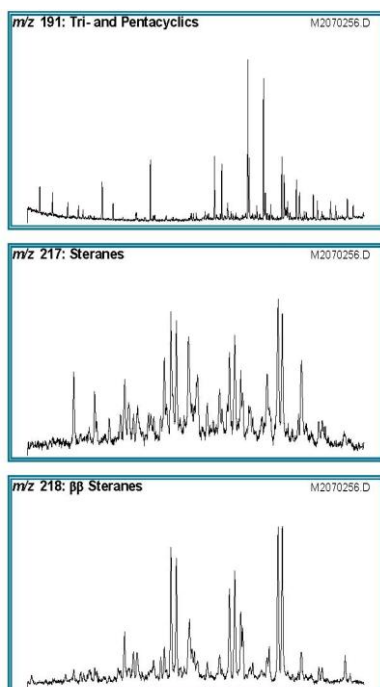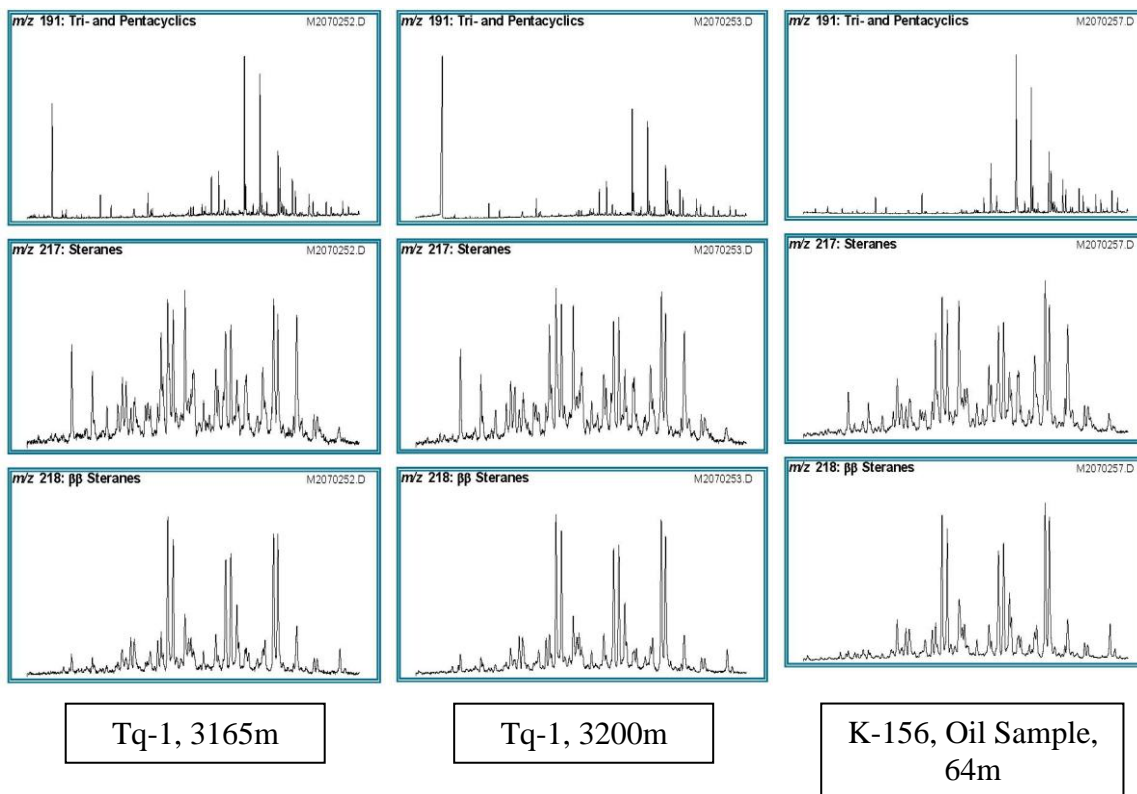
Acknowledgment

References

- Bellen, R.C. van, Dunnington, H.V., Wetzel, R. and Morton, D.M., 1959, Luxique Stratigraphique International, Asie, Fascicule10a, Iraq, Paris, 333 p.

- Boreham, C.J., and Hill, A.J., 1998, Source Rock Distribution and Hydrocarbon Geochemistry, Petroleum Geology of South Australia, Vol. 4, pp. 129-142.

- Broock, J.J., and Summons, R.E., 2004, Sedimentary Hydrocarbons, Biomarkers for Early Life, in Holland, H.D. and Turekian, K.K. (eds.), Treatise on Geochemistry, Vol. 8, Biogeochemistry, Elsevier, Amsterdam, 425 P.

- Buday, T., 1980, The Regional Geology of Iraq, Volume 1, Stratigraphy and Paleogeography, Dar Al-Kutub publishing house, University of Mosul, Iraq, 445 P.

- Jassim S. Z. and Buday T., 2006, Late Toarcian-Early Tithonian (Mid-Late Jurassic) Megasequence AP7, Chapter 10, in Jassim, S.Z., and Goff, J.C. (Eds.), Geology of Iraq, Printed in Czech Republic, 341 P.

- Hunt, J. M., 1996, Petroleum Geochemistry and Geology (Second Edition), Freeman and Company, New York, 743p.

- Mukhopadhyah, P.K., 2004, Evaluation of petroleum potential of the Devonian-Carboniferous rocks from Cape Breton Island, Onshore Nova Scotia, Final Report, Contract Number: 60122058 of March 31, 2004: Global Geoenergy Research Ltd.

- Osadetz, K.G., Jiang, C.A., Evenchick, C.A., Ferri, F., Stasiuk, L.D., Wilson, N.S.F., and Hayas, M., 2004, Sterane Compositional Traits of Bowser and Sustut Basin Cruid Oils: Indication for three effective Petroleum Systems, Resource Development and Geoscience Branch, Summary of Activities, British Columbia Ministry of Energy and Mines, PP. 99-112.

- Osuji, L.C., and Antia, B.C., 2005, Geochemical Implication of some Chemical Fossils as Indicators of Petroleum Source Rocks, AAPL Journal, Sci. Environ. Mgt. Vol. 9, No.1, PP. 45-49.

- Ozcelik, O. and Altunsoy, M., 2005, Organic Geochemical Characteristics of Miocene Bituminous Units in the Beypazari Basin, Central Anatolia, Turkey, The Arabian Journal for Science and Engineering, Vol. 30, No. 2A., PP. 181-194.

- Peters, K.E. and Fowler, M.G., 2002, Applications of petroleum geochemistry to exploration and reservoir management, Organic Geochemistry,vol. 33, pp. 5-36.

- Peters, K.E., Walters, C.C., Moldowan, J.M., 2005, The Biomarker Guide, Second Edition, Volume II, Biomarkers and Isotopes in Petroleum Systems and Earth History, United Kingdom at the Cambridge University Press, 684 P.

- Philp, R.P., 2004, Formation and Geochemistry of Oil and Gas, in Holland, H.D. and Turekian, K.K. (eds.), Treatise on Geochemistry, Vol. 17, Sediments, Diagenesis and Sedimentary Rocks, Volume Editor, F.T. Mackenzie, Elsevier, Amsterdam, 425 P.

- Sadooni, F.N., 1997, Stratigraphy and Petroleum Prospects of Upper Jurassic Carbonates in Iraq, Petroleum Geoscience,Vol. 3, PP. 233-243.

- Sletten, E.B., 2003, A comparison of Petroleum from Reservoirs and Petroleum Inclusions in Authigenic Mineral Cements-Haltenbanken, University of Oslo, Department of Geology, pp. 80-107.

- Tissot, B.P. and Welte, D.H., 1984, Petroleum Formation and occurrence: A new approach to oil and gas exploration, 2nd ed.: Springer – Verlag, Berlin, 699 P.

- Younes, .M.A., and Philp, .R.P., 2005, Source Rock Characterization based on Biological Marker Distribution of Crude Oils in the Southern Gulf of Suez, Egypt, Journal of Petroleum Geology, Vol. 28 No. 3, PP. 301-317.

APPENDIX
The GC/MS chromatograms for the analyzed extracts and oil samples

K-109,3210m

K-109, 3289m

K-109, 3299.4m

K-109, 3316m

K-109, 3364m

Tq-1, 3143m

Tq-1, 3165m

Tq-1, 3200m

K-156, Oil Sample, 64m

Tq-1, Oil sample, 1620-1651m

استخدام الدالات الحياتية لتحديد أصل المواد العضوية الموجودة في تكوين بارسرين (الجوراسي الأعلى) و بيئة ترسيبها و ذلك في حقلي كركوك و طقطق النفطيين / شمال العراق

دلير حسين بابان و شادان محمود أحمد

كلية العلوم ــ جامعة السليمانية

الخلاصة

تحاليل كروماتوكراف الغاز(GC) و كروماتوكراف الغاز/طيف الكتلــي(GC/MS) لأثنــي عشــر مستخلصا بتيومينيا من تكوين بارسرين في بئرى كركوك-١٠٩ و طقطق –١ و نموذجين من النفط مـــأخوذين من بئري كركوك-١٥٦ و طقطق-١ بينت أن المواد العضوية الأولية في التكوين مترسبة في بيئـــة بحريـــة لا هوائية كربوناتية إلى ممتزجة. كما أظهرت نسب البرستين / C17 و الفايتين/ C18 بأن المواد العضوية فـــي التكوين مترسبة في بيئة اختزالية و إنها ناضجة حراريا و غير متأثرة بعمليات التكســـر الحيـــاتي. إن النســبة الواطئة للدايسترين / استيرين (٠,٢٧ ، ٠,٥٦-) أكدت الأصل البحري الكربوناتي للمواد العضـــوية، كمـــا إن شيوع الترايسايكليك تربين (C23) و تجاوز نسبتها نسب كل من الترايسايكليك تربين (C19) و (C24) أكـــدت بأن الطحالب و البكتيريا شاركتا في إنتاج المواد العضوية الممثلة لأصل المستخلصات البتيومينيـــة و نمـــوذجي النفط التي تم دراستها. من ناحية أخرى، أمكن الاستدلال على الملوحة الواطئة لبيئة ترسيب المـــواد العضـــوية الأولية في النماذج المدروسة اعتمادا على عامل الكمسيرين.