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Crude Oil Analyses of the Yamama Formation in the Subbah, Ratawi, Tuba and Luhis Oil Fields, Southern Iraq

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Abstract

It is evident from this study that Yamama Formation is reservoir rocks and source rocks at the same time, based on occurrences of crude oil and source rocks. Bulk properties of Yamama oil in six wells as well as comparing several samples of Yamama oil by using the biological mark have indicated multi source of hydrocarbons with some pay having Jurassic and Lower Cretaceous source affinity that belongs to the Yamama Formation.

Keywords: Crude oil analysis, GC-MS, Source rocks origin, Yamama Formation, S.W of Basrah.

تحاليل النفط لتكوين اليمامة في حقول صبه, رطاوي, طوبة واللحيس, جنوب العراق

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الخلاصة:

لقد تم إعطاء الأدلة من هذه الدراسة على أن تكوين اليمامة هو عبارة عن صخور خازنه ومولدة للنفط بنفس الوقت اعتمادا على تحليلات النفط والصخور المولدة. أكدت التحليلات الكلية لتكوين اليمامة باستخدام الأدلة البيولوجية مصادر متعددة للهيدروكربونات, إذ تكون بعض العطاءات تحتوي نفط يعود إلى نفس التكوين وعطاءات أخرى تكون عاتديتها إلى طبقات أكثر قدما من تكوين اليمامة.

Introduction

The Cretaceous petroleum system is the most important in Iraq [1]. Tithonian (uppermost Jurassic) to lower Cretaceous source rocks charged creations reservoir in structures throughout central and southern Iraq. Underling Triassic source rocks may also have charged Cretaceous reservoir where the upper Jurassic evaporates seal is in effective [2].

Lower Cretaceous reservoir rocks contain about 30% of Iraq's hydrocarbon reservoirs. Yamama is reported to contain hydrocarbons at 26 structures in southern Iraq [3,4] identified three reservoir intervals in the Yamama (Y R- A- B and C).

Porosity is dominated by intergranular macro porosity and some intergranular to chalky matrix microporosity, with local secondary (dissolution) porosity such microporosity often saturated if water – wet, or are bitumen – plugged if oil-wet.

The reservoir potential of the Yamama increases from south to north; probably due to progradation, thickening and stacking of shoal facies in this direction flow rates are very variable. A

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maximum test flow rate of 19,000 b/d was recorded in well Ratawi -3. Only weak flow was recorded in well Jerishan-1 [4].

The study area is located in North West to south west of Basrah governorate. It includes Subbah ,Ratawi ,Luhis , Tuba, Rachi and Jrishan oil fields within 66.9002050 – 74.1235837 latitude 34.09713420 – 33.30957378 longitudes figure 1.

Yamama Formation in this area was deposited in Mesopotamian basin of southern Iraq that constitutes lithostratigraphic sequence with the major total petroleum system of lower Cretaceous and extends stratigraphically between the upper Gotnia Anhydrite as the lower major seal and the AL-Fatha as the upper major seal figure 2.

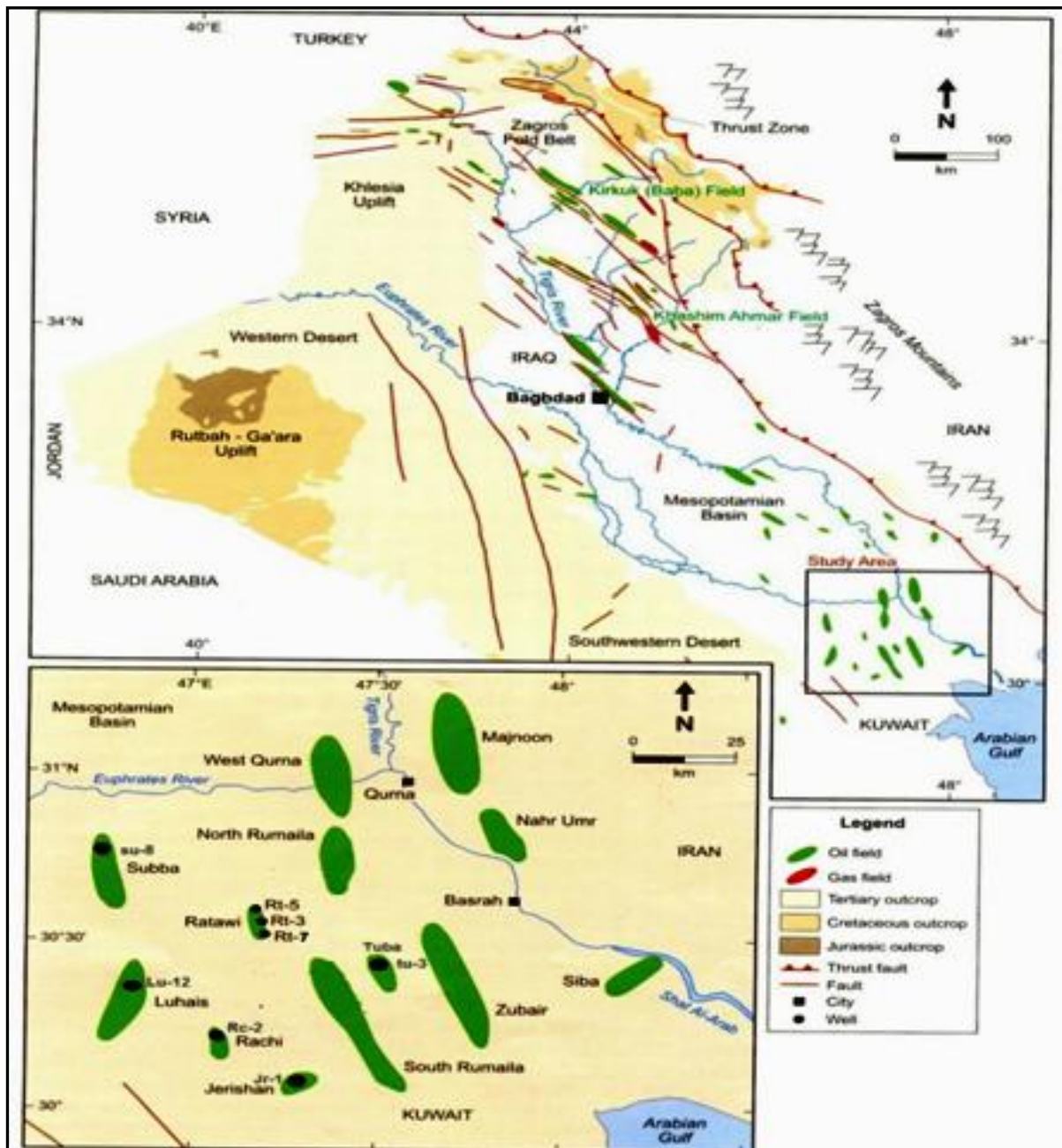


Figure 1-Location map of the studied wells with oil fields.

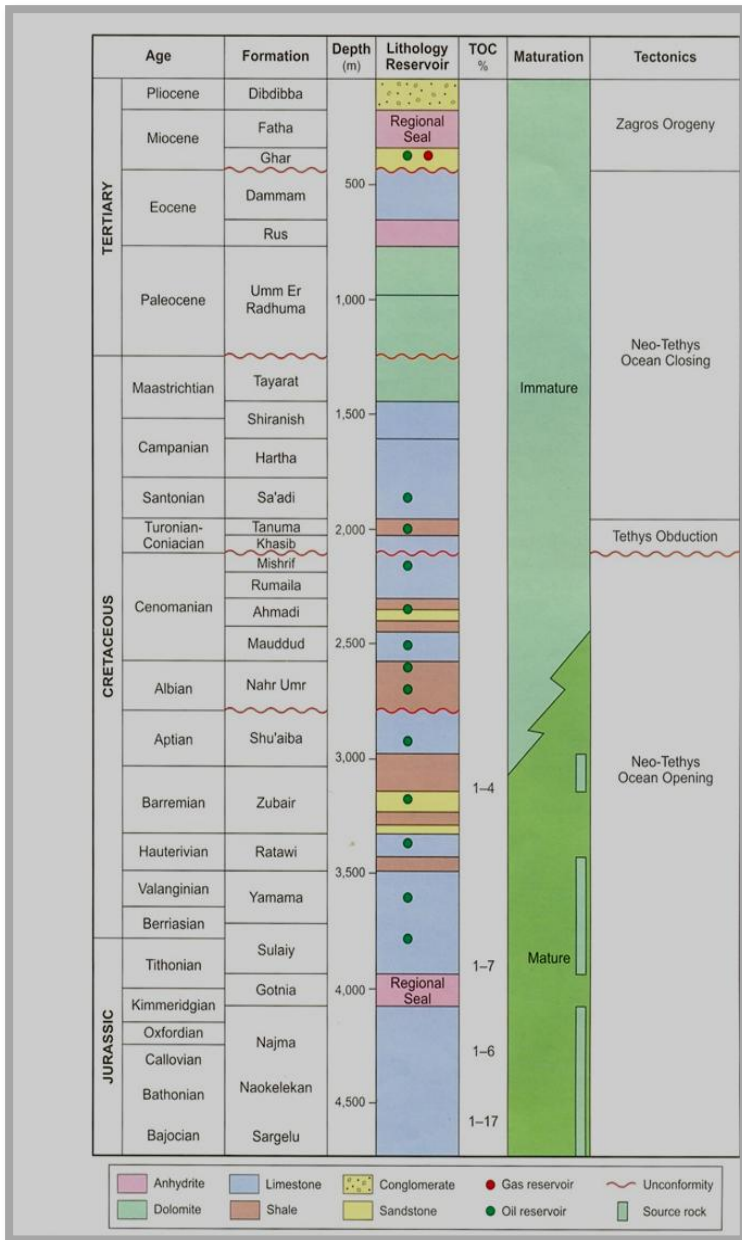


Figure 2-Stratigraphic section and the major phases relevant to Jurassic through Tertiary Total Petroleum System [5].

Geological History

The study area is located at the south part of Iraq within the Mesopotamian basin of the stable shelf on basis of longitudinal tectonic classification of Iraq [3] figure 2. The Yamama Formation was first described by Bramkamp in south of Iraq [6]. Described 257m interval in Ratawi -1 as the Yamama – Sulaiy formation.

The Mesopotamian zone is the easternmost unit of the stable shelf. It is bounded in the NE by the folded ranges of Pesh-i- Kuh in the E, and Hemrin and Makhul in the N. The SW boundary is controlled by faults figure 3. The zone was probably uplifted during the Hercynian deformation but it subsided from late Permian time onwards [3]. Below the Quaternary, cover contains buried faulted structures, separated by broad synclines. The fold structures mainly trend NW- SE in the eastern part of the zone and N-S in the southern part; some NE-SW trending structures occur figure 3.

The Mesopotamian zone is divided into three subzones: The Zubair Subzone in the S with N-S trending structures in the S . The Takhadid – Qurna bound it in the north. Transversal southern boundary of the subzone is either located at the Al Batin fault or along a transversal fault in Kuwait.

The Euphrates subzone lies in the W of the Mesopotamian zone . It is the most extensive and mobile unit of the Mesopotamian zone. It contains synclines and narrow anticlines trending predominantly NW – SE, accompanied by long normal fault. It is bounded by the Foothill Zone in the NE and by a long gravity gradient and line of residual gravity anomalies between Qalat saleh in the SE Falluja in the NE [7].

The Yamama Formation passes into and overlies the Sulaiy Formation [7]. It is 400 m thick in the Zubair area [4,3] .The Formation usually conformably overlies the Ratawi. Toworads the west of the Salman Zone, where the Yamama and Ratawi Formation are absent, The Zubair formation conformably overlies Jurassic rocks [8]. The formation comprises three depositional cycles in southeast of Iraq Cycle tops contain oolitic grainstone . Inner- ramp facies which pass down into finer – graind peloidal facies and middle – ramp bioclastic / coral/ stromotoproid pack – wackestone [4,1].

Twelve to fourteen sub – cycles may occur, bounded by lowstand horizon-containing plant remains [4]. Cycle (YR–A,-B,-C) and bases (YB-1,-2) represent late highstand and trasgressive early highstand system tracts, respectively. They are organized into series of NW – SE oriented depocenters but here it is- interpreted as bank complexes or build -ups. [4,3] .

The uppermost facies are pinkish (intramicrtes) and gray micrites which are locally chalky or contain thin, inter bedded calcarenites .Lower units are dominantly calcarenitic and oolitic. At Nasiria, west Qurna, Majnoon and Ammara fields, the sequence boundaries have been identified within the Yamama Formation at the top of oolite facies.

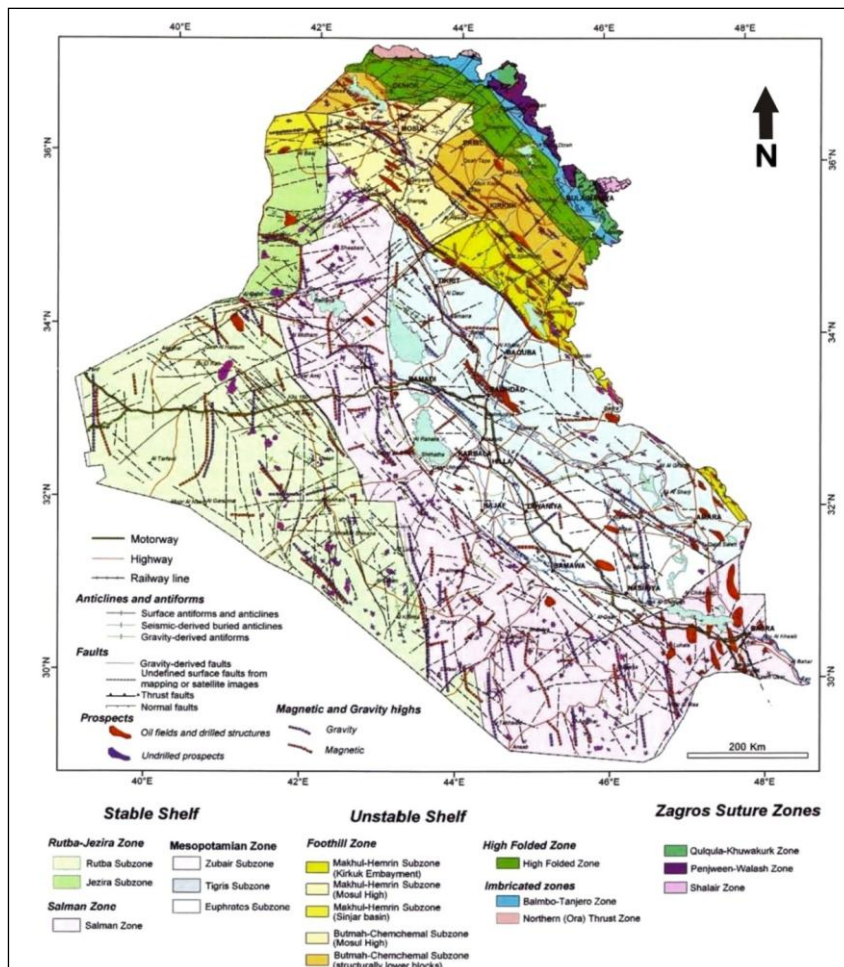


Figure 3-Tectonic map of Iraq [3].

Crude oil analysis

Six (6) crude oil samples of Yamama are analyzed in Gee mark laboratories center-USN to determine whole bulk crude oils in addition to biomarker parameters determination using Gas chromatography (GC) , mass spectrometry (MS) ,and GCMS analytical technique table 1.

Table 1-The analyzed crude oil samples and their depths (Geo mark laboratories).

Sample	well No.	Depth (m)
1	TU-3	3781
2	LU-12	3630
3	SU-8	3698
4	RT3	3693
5	RT7	3663
6	RT5	3809

Sulfur compounds are used as paleo environmental indicators and for maturity and biodegradation evaluation and crude oil correlations. Table 2 shows difference sulfur content (1.58 - 5.38) in study samples. The concentrations of vanadium in cool and crude petroleum oils vary widely (1-1500 mg/Kg). Table 2 shows study sample nickel vanadium content.

Six samples from the Yamama formation in Ratawi, Subbah, Luhais and Tuba oil fields were analyzed at the Houston University using Gas chromatography (GC) and GC – MS, and a short summary of the result is given in table 2. Contrast sulfur content in all samples of Yamama crude oils (1.38 - 5.38%). Table 2, refers to the marine source – rock organic matter and associated with terrestrial [9].

Gravity for the most crude oils, ranges from (25.9- 32.3)API which represents heavy to medium oils, Except (Subbah -8 well 39.9 API), which refers to light oils. Variation in API gravity may be caused by different thermal maturities, where low API means less in thermal maturity [10].

Tricyclic Terpanes are considered diagenetic products of prokaryotic membranes and rarely are found in crude oils derived from terrestrial organic matter origin. Other hopanes such Tm, Ts, C 30 a BCH) C31-C 35- Homohopanes and Terpanes non – hopanoids as oleanen and gammacerane can be identified and quantified [10].

Table 2-Bulk properties, gross compositional parameters, and stable carbon isotope composition of Yamama crude oil fraction for the studied samples.

	Rt- 3	Rt-5	Rt-7	Su-8	Lu-12	Tu-3
Depth	3781	3630	3698	3693	3663	3809
% Sat	40.9	43	43	52.8	13.4	44.8
%Aro	35.9	37.7	38.8	34.2	46	36.5
%NSO	15.2	11.7	10.9	12.4	15.8	11.2
%Asph	8.1	7.6	7.4	0.7	6.8	7.6
Sat/Aro	1.14	1.14	1.11	1.54	0.68	1.23
n-Paraffin/ Naphthene	11	14.5	2.83	3.54	5.53	30
API Gravity	29	30.9	32.2	39.9	25.9	32.3
%S	3.51	3.58	3.35	1.58	5.38	2.27
%<C12	38.9	42.5	44.8	58.3	35.2	4.6
PPMV	64	74	56	0	113	40
PPm Ni	8	23	18	0	35	12
Pr/ph	0.47	0.77	0.77	0.83	0.78	0.72
Pr/n – c17	0.19	0.18	0.17	0.16	0.18	0.19
Ph/ n- C18	0.30	0.28	0.28	0.23	0.29	0.31
n- c27/n – c17	0.16	0.14	0.15	0.16	0.16	0.17
CPI	0.913	0.953	0.944	0.964	0.928	0.923

Table 3 it is shows the result in the studied samples. The (BNH) and (TNH) are not generated from the kerogen but are associated with the original, free bitumen in the rock. Bisnophane / hopane, mostly decreases with thermal maturity, but other factors, such as organic matter input and depositional environment may be important. Thus, mature oil showing BNH/ Hopane of zero is not necessarily unrelated to mature potential source rock sample with a non- zero value for the ratio [10].

Zero values of this ratio for the Yamama crude oil samples in general. Table 3 indicates that these oil samples are mature.

High 30-norhopanes / hopane is typical of anoxic carbonate or marl / source rocks and oils. The C₂₉ 17 α norhopane rivals as the major peak on m/z mass chromatograms saturate fractions of many oils and bitumens. C₂₉/C₃₀ 17 α - hopane (m/z 191) uncorrected peak heights) is greater than 1.0 for many anoxic carbonate or marl source rocks and related oils but generally is less than 1.0 for other samples. Norhopanes is more stable than hopane at high levels of thermal maturity. Thus, within a group of related oils, 30-Norhopanes / hopane can in case with thermal maturity in Yamama crude oils, this ratio equals greater than 1.0, table 3, also these oils high norhopanes / hopane and C₃₅/C₃₄ 225 hopane, table 3 which indicates that these oils are from anoxic carbonate or marl source rocks.

All samples of Yamama crude oils show zero values of ratio table 2 which refer to the non existence of C₃₀ x. thus these oils could be generated under anoxic, non terrigenous source rocks. Crude oil samples of Yamama reservoir show the values of Ts/Tm ratio less than, 1.0, and inverse relationship with CPI value table 3, which indicates anoxic marine depositional environment [11]. Greater oils and their source rock extracts have values located between C₂₇ and C₂₉ sterols table 3. Although this approach is not sufficiently accurate to distinguish upper Cretaceous and Tertiary oils from Paleozoic or older oil [10]. Calculated average C₂₈/C₂₉ sterane ratio of Yamama formation reservoir oils suggesting a source rock of Jurassic age table 3.

Diasteranes (rearranged sterane) are rearrangement product from sterol precursors through diastereomerism. The rearrangement involves migration of C-10 and C-13 methyl groups to C-5 and C-14 and is favored by acidic conditions, clay catalysis and / or high temperature. Diasteranes increase relative to steranes with thermal maturation and they are low in clay – poor carbonate source rocks and related oils [11]. Low values of this ratio in Yamama crude oils indicate that these oils are from anoxic clay – poor or carbonate source rocks table 3.

The ratio of 20S / (20S + 20R) isomers in a sterane, measures the relative abundance of the S and R configuration at the 20 carbon position of sterane hydrocarbons, with 5 α , 14 α , 17 α (H) stereo chemistry. Living organisms process sterols exclusively with the 20R configuration, but during diagenesis and catagenesis, steranes are gradually transformed to a mixture of 20R and 20S isomers, until they reach an equilibrium value of 0.55 for the 20S / (20R + 20S) [10]. All crude oils and most rock extracts, show that the ratio values are within a range referring to mature sample table 3.

Table 3-The results of mass chromatograms of steranes and hopanes (m/z 191) parameters for the studied crude oil samples.

	TU-3	LU-12	SU-8	RT3	RT7	RT5
Depth	3781	3630	3698	3693	3663	3809
C ₁₉ /C ₂₃	0.13	0.11	0.17	0.17	0.17	0.16
C ₂₂ /C ₂₁	0.93	1.08	1.09	0.99	1.03	1.03
C ₂₄ /C ₂₃	0.33	0.26	0.28	0.29	0.3	0.29
C ₂₆ /C ₂₅	0.92	0.72	0.88	0.73	0.76	0.72
Tet/C ₂₃	1.48	1.22	1.71	1.55	1.62	1.57
C ₂₈ /H	0.01	0.01	0.01	0.01	0.01	0.01
C ₂₉ /H	1.38	1.63	1.63	1.48	1.53	1.53
C ₃₀ X/H	0.01	0	0.01	0.01	0.01	0.01
OL/H	0	0	0	0	0	0
C ₃₁ R/H	0.34	0.33	0.36	0.33	0.34	0.35
GA/C ₃₁ R	0.16	0.24	0.16	0.22	0.2	0.2
C ₃₅ S/C ₃₄ S	1.03	0.14	0.87	0.98	1.04	0.98
Ster/Terp	0.25	0.17	0.16	0.2	0.2	0.2
C ₂₇ %	33	34.4	35.5	33.4	33.9	34.4
C ₂₈ %	25.3	24.4	21.6	24.6	23.7	23.8
C ₂₉ %	41.7	41.2	42.9	42	42.4	41.8
C ₂₉ 20S/Tm	0.62	0.6	0.58	0.57	0.67	0.68
C ₂₇ Ts/Tm	0.28	0.17	0.74	0.32	0.32	0.29
C ₂₉ Ts/Tm	0.09	0.07	0.13	0.07	0.09	0.08
TAS3(CR)	0.31	0.34	0.59	0.3	0.36	0.34

Cyclic and acyclic biomarker can be used to provide information on source-rock organic matter input or depositional environment of Yamama crude oils. These oils show high concentrations of nC₁₅, nC₁₇ and nC₁₉ alkanes also low values of pristane/ phytane table 2, which indicate algal biological origin and anoxic marine environment. Many available data can be used to characterize the crude oils of Yamama reservoir in Ratawi ,Tuba ,Subbah, Luhais oil fields, which can be used as an indications of source rocks concerning with its organic matter. These properties in comparison with the Yamama oil compounds table 2 and 3 indicate that the Yamama oils are from marine carbonate source rocks. The very little concentrations compound of oleanane (flowering or higher plants angiosperms) or absent in Yamama crude oils. Table 3, refer that these oils are from a rock older than Early Cretaceous age. The ratio of C₂₈/ C₂₉ steranes for oil samples equal 0.57 in average table 2, which roughly represent as Upper Jurassic to Early Cretaceous oils. Various compounds in source rocks show distributions through geologic time suggesting their use as age- related biomarkers in crude oils figure 10.

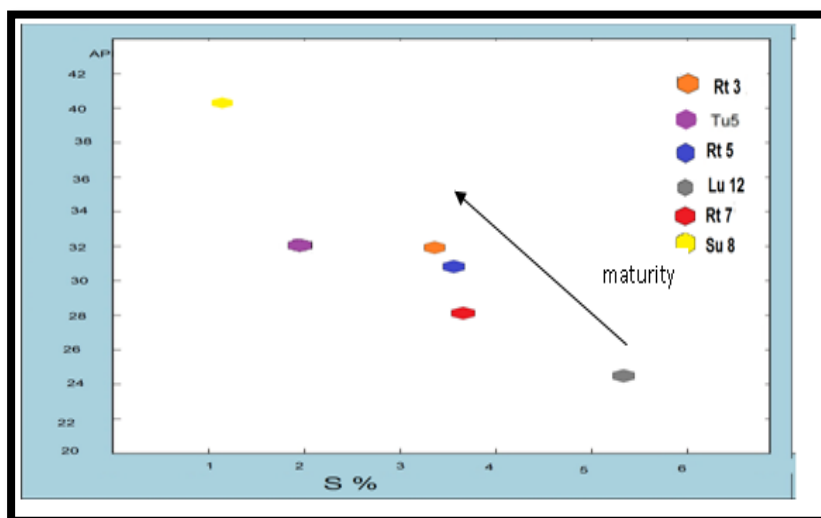


Figure 4-Relation ship between API gravity with sulfur content of Yamama crude oils from (Ratawi, Suba,Luhis and Tuba) oil fields .

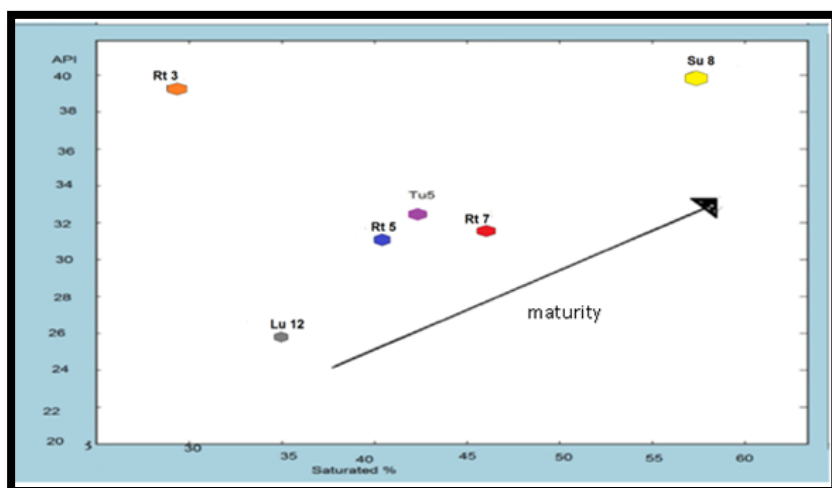


Figure 5-Plot of API gravity versus saturate fraction carbon isotopic composition of Yamama crude oils from (Ratawi , Suba,Luhis and Tuba) oil fields .

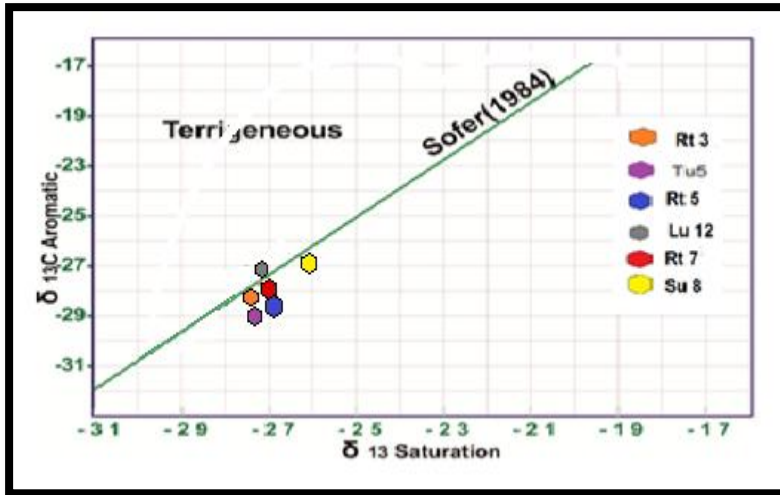


Figure 6-Stable carbon isotop ratios(%relative to PDB)for saturated versus aromatic hydrocarbons differ Yamama oil from Tuba, Ratawi, Suba and Luhais oil fields .

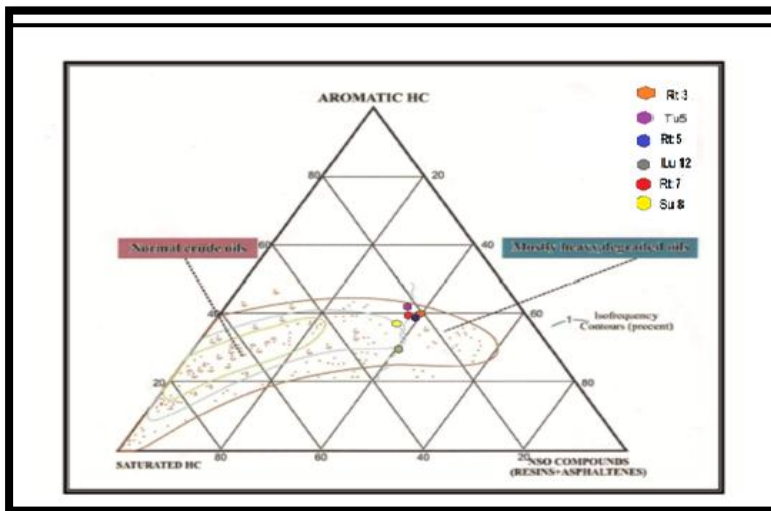


Figure 7-Ternary diagram shows the composition of the Yamama crude oils from west Tuba, Ratawi, Suba and Luhais oil fields.

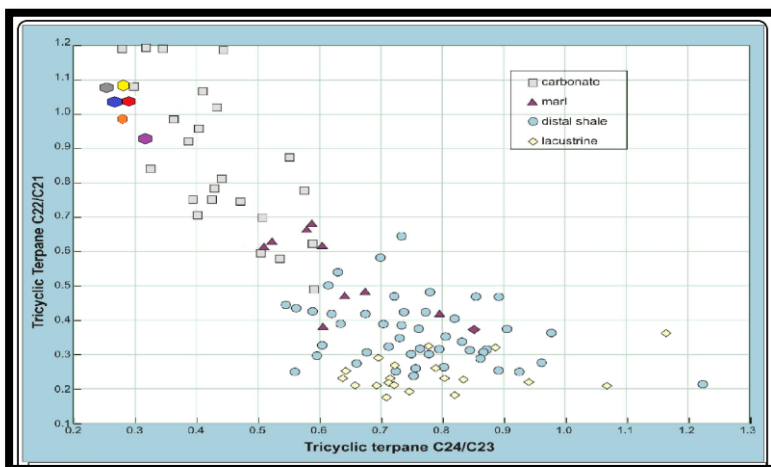


Figure 8-Relationship between Tricyclic terpene C22/C21 and Tricyclic terpene C24/C23 to predicat source – rock depositional environments of the Yamama oil from Tuba , Ratawi, Suba and Luhais oil fields.

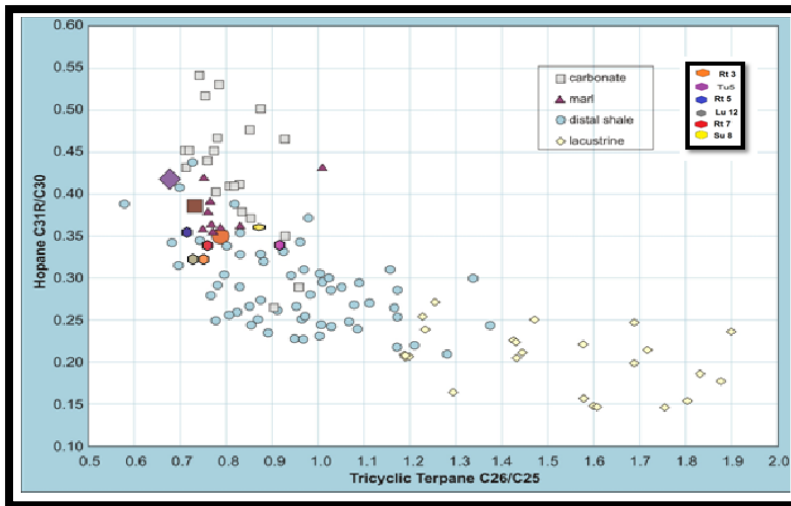


Figure 9-Relationship between C26/C25 Tricyclic terpene and C31 Hopane predicat source –rock deposit environments (a) of the yamama crude from Ratawi,suba,luhais oil fields and (b) for the extract of possible source rocks.

Depositional environments- related biomarkers

The advantage 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 [12]. The relative low concentrations of gammacerane compound presented in Yamama oils samples table 3 actually refer to that these oils are from marine depositional environment, with low salinity according to the decrease of the ratio of the concentration of gammacerane to that of hopane [9]. The pristane to phytane ratio (Pr/ Ph) was used as an indicator of the oxicity of the depositional environment. Oil studied samples show high concentration of phytane rather than pristane (Pr/ Ph less than one) Table 2, which indicate anoxic marine depositional environment oils figure 10. Also the similar isotopic compositions of pristane and phytane of the yamama oils may indicate they are derived from the same source.

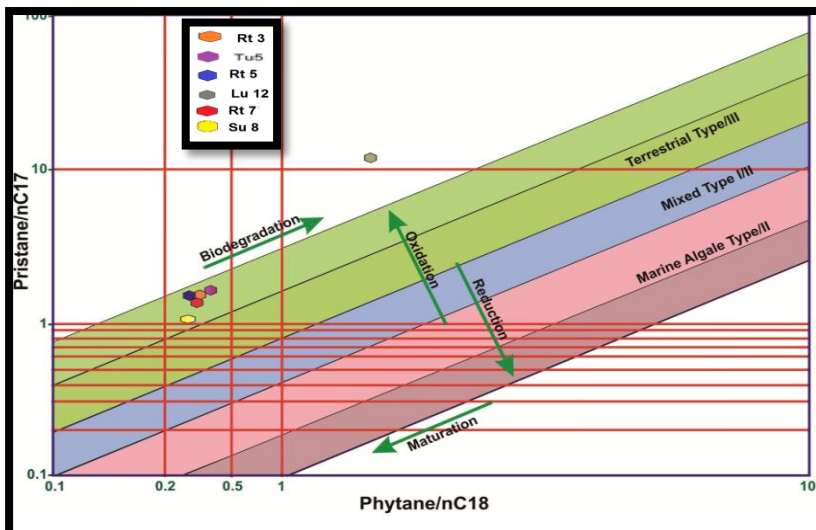


Figure 10-Pristane/ nC17 Versus phytane/nC18 for yamama crude oils from Ratawi , Suba , Luhis and Tuba oil fields to infer oxicity and organic matter type in the source -rock depositional environment.

The carbon preference index (CPI) values table 2 equals approximately one or around one, which exhibit the predominance of marine organic matter during deposition. Low diasteranes/ steranes ratios in Yamama oil samples Table 2 indicate anoxic clay-poor or carbonate source rock depositional conditions. The high C₃₅ homohopane in crude oils of Yamama reservoir Table 3 is interpreted as a general indicator of highly reducing (Low Eh) marine conditions during deposition [13]. Furthermore

the high C_{35} hopane ratios for extracts of potential source rocks can be correlated with the high values of hydrogen indices (HI) for the source rocks table 1,2, which is related to better preservation of oil-prone organic matter). The high ratios of C_{31} 22R homohopane/ 30 hopane ($C_{31} R/ C_{30} > 0.25$) in Yamama crude oil samples. Table 2, 1 refer to marine carbonate depositional environments figure 10. The ratio of C_{29}/ C_{30} 17 hopane is greater than 1.0 for all Yamama oil samples and most extract samples table 3, which are represented as anoxic carbonate or marl source rocks and related oils figure 10.

Maturity-related biomarkers

Ratios of certain saturated and aromatic biomarkers are some of the most commonly applied thermal maturity indicators. These indicators result from two types of reactions: [1] cracking reactions (including aromatizations) and [2] configurational isomerization at certain asymmetric carbon atoms. The homohopane isomerization ratios [$22 S/ (22 S + 22 R)$] (typically using the C_{31} or C_{32} homologs) for all Yamama crude oil samples and rock extracts, located within the range 0.57-0.62, which indicate that these samples have reached the main phase of oil generation, or surpassed [13], table 3. This ratio is only useful in the early stages of oil generation until it reaches its maximum value of approximately 0.64 and does not increase above that with increasing maturity. As the maturity level increases, the concentration of the 22 S epimer increases relative to the 22 R [12].

The low ratio of Ts/ Tm (less than one) for all oil samples and rock extracts table 2 refer that these samples are from carbonate sources, and within the stage of maturity according to the relative amounts of TS and Tm. Also the TS/ hopane ratio table 2 show closed values, which indicate that these oils at the same level of maturation, and related with the samples of the same closed values in rock extracts table 2 [10]. The (BNH+TNH)/ hopanes ratio decreases with thermal maturity. All oil samples showed values equal Zero, which indicate mature oils, and this value is not necessarily unrelated to a less mature potential source rock sample with a non-zero value for the ratio. The steranes isomerization ratios [$20 S/ (20 S + 20 R)$] in all Yamama crude oil samples indicate that these oils have passed the onset of petroleum generation (within oil window and % 20S more than 40%).

The low values of diasteranes/ steranes ratio in all Yamama oil samples table 2 indicate mature oils and do not reach the post mature range. Correlation of crude oils and rock extracts, geochemical correlations involve comparison of the same sorts of data for different samples, looking for compositional similarities that would determine whether genetic relationships exist between different samples. Ideally, the same sample types are used, such as in oil – oil correlation, but oil – source rock correlation is also a very important geochemical approach in petroleum exploration.

Oil - oil correlation

Oil – oil correlations require the use of parameter that distinguish oils from different source and are resistant to secondary processes, such as biodegradation and thermal maturation [10]. Oil - oil correlation uses geochemical characteristics that allow the geochemist to distinguish between different sources whilst being resistant to secondary alteration processes such as maturation, migration, fractionation, water washing and biodegradation. In some cases, simple bulk parameters (Sulphur content, Ni/ V, stable carbon isotope composition) may be sufficient to provide a confident positive or negative correlation. However in most case , molecular parameters from gas chromatograph (GC) or GC – MS are utilized , and these provide more specific source related correlation information [14].

Oil – oil correlation: the source depositional environment of our oil is marine and carbonate rocks with rare marl and terrestrial type III based on stable Carbon isotope ratio

$\delta^{13}C$ Aromatic , $\delta^{13}C$ saturation figure 2 and 3 Relationship between tricyclic terpan C_{22}/C_{21} and tricyclic terpan C_{24} / C_{29} figure 2 and 7 and hopohopene C_{31} / C_{30} and tricyclic terpane C_{26} / C_{25} Figure 9 pristine nC17 versus phytane / nc18 for yamama crude oils.

Discussion and results

Based on the results of biomarker analysis, the migrated hydrocarbons found along the weld in the Yamama formation appear to have a common origin. Comparison of the chromatograms suggests this in a qualitative way, as shown by the similarity of the results in figures 11 and 12. Comparison of the six migrated samples, based on the relative percentages of C_{27} , C_{28} , and C_{29} steranes, shows this in a quantitative way, with the relative abundances of the steranes in the six samples being very similar. Additional biomarker ratios that match well in all samples are the C_{35} hopane / C_{31} – C_{35} homohopane ratio and several of the diasterane/sterane ratios.

Based on the similar biomarker content, it seems that they are likely from a single source and constitute one oil family. The biomarker distributions are consistent with mature oil. All of the samples have biomarker ratios consistent with mature oil. This interpretation is based on several calculated biomarker ratios such as C32 22S/(C32 22S + 22R) hopanes and Ts/(Ts + Tm) ratios. Poor preservation of C34 and C35 hopanes within the samples suggests that the source rock was suboxic; these biomarkers are related to bacterial activity in the depositional environment. A very slight suggestion of carbonate input is observed, shown by the relative height of C24 tetracyclic terpanes, but other biomarker ratios (e.g., diasterane/sterane, Pr/Ph, C35 homohopane) are consistent with derivation from a shale source rock. The Pr/Ph ratios are between 1 and 3, suggesting that the source rock was likely deposited in a suboxic setting.

The large relative amount of C29 steranes compared to C27 and C28 steranes suggests terrestrial organic input. Based on these observations, it appears that a suboxic, mature marine shale was likely the source rock that generated the hydrocarbons found along the weld.

The diasterane/sterane and diahopane/hopane ratios are elevated suggesting a clay-rich source rock (Rubenstein *et.al*, 1975 ; Sieskind *et . al*, 1979), and the homohopanes decrease from C31 to C35 (C33 to C35 are not resolvable in most samples). Suggesting a source Rock deposited in Suboxic conditions (Tkn (Haven *et.al*, 1988). In / Tm (18 a (H) -22, 29, 30 trisnorhopane / 17 a (H)-22, 29, 30 trisnorhopane) ratios, tricyclic 17 α hopane ratios, and n-alkane envelope style are indicative of mature oils [10].

Various ratios were calculated to compare the samples taken along the stays area in Yamama Formation. This ratio is used to limit hydrocarbon generation and migration and are determined by characteristics of the original organic material [10].

The samples are all organic lean, and GC analysis showed that none of the samples yielded a regular n-paraffin envelope. However, GC – msd analysis showed that diasterane/sterane and diahopane/hopane ratios were elevated, and relative homohopane abundances decreased from C31 to C35, similar to what was seen in the migrated samples.

The parameters are mainly used as indicators of maturity but can be used in source rock – migration material correlation as well.

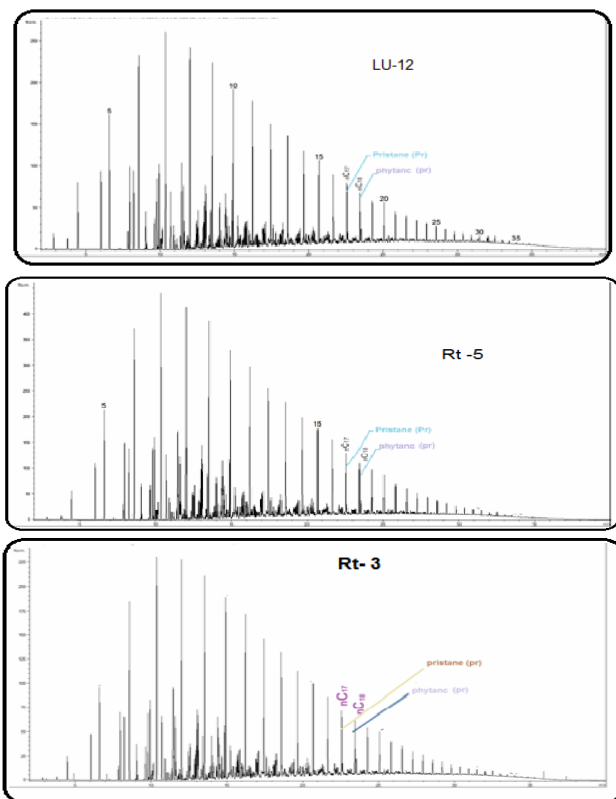


Figure 11-Indicative of comparable of the mass chromatogram (SIM/GCMS mode) for terpane m/z 191 of the possible source rock extracts, sample 1, 7, 11, and 16 of the Yamama Formation respectively.

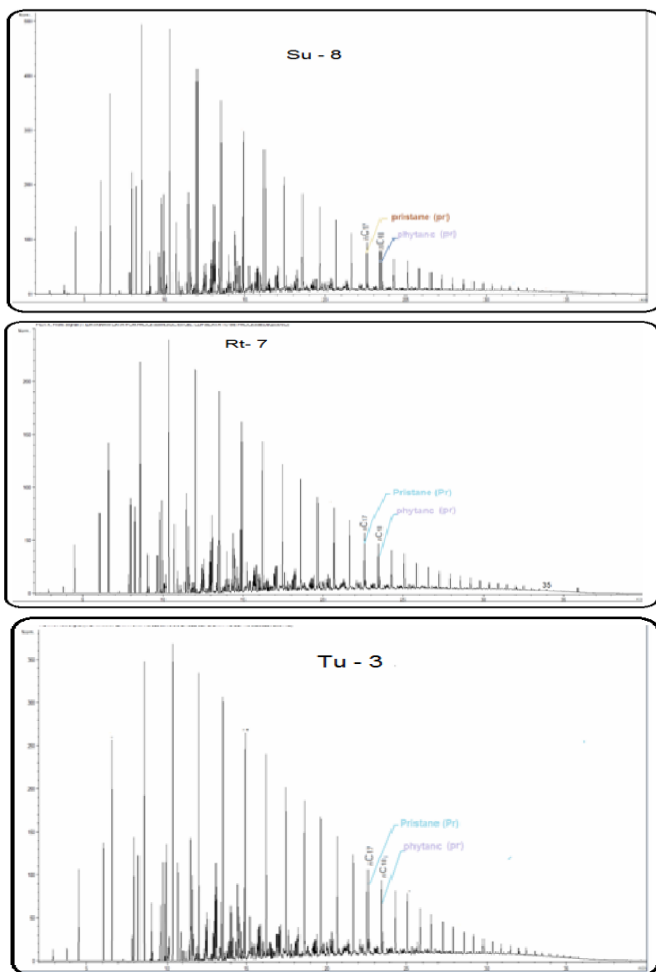


Figure 12-Indicative of comparable of the mass chromatogram (SIM/GCMS mode) for terpane m/z 191 of the possible source rock extracts, sample 1, 7, 11, and 16 of the Yamama Formation.

Reference

1. Sharland, P.R., Archer, R., Casey, D.M., Hall, S.H., Heward, A.P., Horbury, A.D. and Simmons, M.D. **2001** *Arabian plate Sequence Stratigraphy*. GeoArabia special publication 2, Gulf petrolink, Bahrain, 371 P.
2. Pitman, J. K., Steinshouer, D. and Lewan, M.D. **2004** Petroleum generation and migration in the Mesopotamian basin and Zagros fold belt of Iraq : results from basin – modeling study., *GeoArabia*, 9(4), PP:41-71 .
3. Jassim, S. Z., and Goff, J. C. **2005** *Geology of Iraq*. Published by Dolin, Prauge and Moravian Museum, Brno, 341 P.
4. Sadooni, F.N. 1993 *Stratigraphic sequence, microfacies and petroleum prospects of the yamama formation, Lower Cretaceous, Southern Iraq* .AAPG Bull., 77, PP: 1971-1988.
5. Al-Ameri, Thamer K. Al-Khafaji, Amer Jassim and John Zumberge. **2009** Petroleum system analysis of the mishrif reservoir in the Ratawi, Zubair, North and South Rumaila oil fields, southern Iraq. *GeoArabia*, 14(4), pp:91-108.
6. Bellen, R. C. Van, Dunnington, H.V., Wetzel, R. and Morton, D. **1959** *Lexique stratigraphique Internal Asie. Iraq. Intern. Geol. Congr. Comm. Stratigr*, 3, Fasc. 10 a, 333 P .
7. Aqrabi Adnan A.M., Horbury Andrew D., Goff Jeremy c., Sadooni Fadhil N . **2010**. *The Petroleum Geology of Iraq* .State oil, P .424.
8. Buday, T. **1980**. The regional geology of Iraq. Vol. 1: *Stratigraphy and Paleogeography* . Publications of Geosurv, Baghdad, 445 P.
9. Peters K. E. and Moldowan, J. M. **1993** *The biomarker guide, interpreting molecular fossils in petroleum and ancient sediments* .Prentice – Hall ,Englewood Cliffs , N.J.

10. Peters, K.E., Walter, C.C., and Moldowan, J.M. **2005** The biomarker guide. Vol.1: *Biomarkers and isotopes in the environment and human history*. The press syndicate of the university of Cambridge, 471 P. Mello, M.R., Gaglianone, P.C., Brassell.
11. S.C. and axwell, J.R. **1988**. Geochemical and biological marker assessment of depositional environments using Brazilian offshore oils. *Marine and petroleum Geology*, 5, PP:205-23.
12. Philp, R.P. **2004** *Formation and geochemistry of oil and gas*. In *Treatise on geochemistry*, H.D. Holland and K.K. Turekian (Executive eds), Vol. 7, F.T. Makenzie (Vol. ed), Elsevier – Holland, P.223-256.
13. Peters, K. E. and Moldowan, J. M. **1991** Effects of Source, thermal maturity, and biodegradation on the distribution and isomerization of homohopanes in petroleum. *Organic Geochemistry*, 17, PP:47 – 61.
14. Hunt, J. M. **1996** *Petroleum geochemistry and geology*. 2nded. Freeman, New York, 743 P.