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Thermal Maturity History and Petroleum Generation modeling for selected Oil fields Southern Iraq

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Abstract

The thermal maturity , burial history and petroleum generation history of four oil wells selected from four oil fields in Southern Iraq, they are: Nasiriyah(Ns-1 well) , Gharraf (GA-5well) ,Abu Ammood (Ab-1well) and Riffai (Ri-1well) have been studied using 1D basin and petroleum systems modeling. Results showed different period of subsidence, which ranges from high to moderate subsidence, occurred at upper Jurassic to Mid-Cretaceous and slow subsidence in Miocene . The porosity in the studied area represents the highest value in Dammam , Tayarat ,Um-Eradhuma and Khasib Formations. For most of the studied wells, the Paleocene to Miocene has to be regarded as times when the maximum temperature prevailed associated with deep burial could be that the age is the petroleum generation and an additional filling of traps. The organic maturation in Riffai well has entered in the main oil stage, especially Suliay and Yamama Formations whereas only Suliay Formation in GA-5 well entered in the main oil stage Therefore, there are good generated and mature source rocks in this well.

Keywords: Petroleum systems modeling, Vitrinite reflectance, Thermal history, Burial history.

تاريخ النضوج الحراري وموديل التوليد النفطي لأبار منتخبة من حقول نفطية مختلفة في جنوب العراق

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الخلاصة

تضمنت الدراسة تاريخ الدفن و النضوج الحراري وتاريخ توليد النفط لأربعة أبار من أربعة حقول نفطية في جنوب العراق وهي ناصرية (ناصرية -1) ، الغراف (غراف -5) ، ابو عامود (ابو عامود -1) والرفاعي (رفاعي -1) . درست هذه الأبار بأستخدام الموديل النفطي الاحادي .أظهرت النتائج فترات مختلفة من التجلس والتي تراوحت من تجلس عالي الى متوسط في العصر الجوراسي الأعلى الى الطباشيري المتوسط وتجلس بطيء في عصر المايوسين . وسجلت المسامية اعلى قيم لها في تكاوين الدمام ، الطيارات ، ام رضمة والخصيب .وبلغت أعلى الدرجات الحرارية المرتبطة بأزدياد عمق الدفن في عصر الباليوسين الى عصر المايوسين ويعتبر هذا هو عمر توليد النفط . وصل النضوج العضوي مرحلة التوليد الرئيسية للنفط في بئر الرفاعي -1 في تكويني سلي واليمامة بينما تم تسجيل نفس مرحلة النضوج العضوي السابقة في الغراف -5 في تكوين سلي فقط لذلك اعتبرت هذه التكاوين صخور مصدرية جيدة التوليد النفطي في هذه الابار فقط .

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Introduction

1D petromod modelling is utilized to decide burial and thermal history of source rock in addition timing of hydrocarbon generation. 1D basin modelling deals with the single point in a basin for example a drilled well to decide the maturity history of one or several source rocks at the well location. 1D basin modelling can't infer to imply lateral variation in lithology, fluid flow, Petrophysical parameters and calculation of charge volumes in a basinal sense, as no lateral parameter information is available. In any case , assumptions can be made concerning the lateral variations in source rocks. On the other hand, 1-D modelling is easy to calibrate, simple to run and relatively much economical . It enables single-point data to be built from scratch or to be extricated straight forwardly from PetroMod 1D Calibration results such as heat flow histories can then be directly utilized by the 1D simulators, which enables calibration work in all packages to be performed significantly quickly. The steps of 1D modelling could by displaying using Figure-1. It involve deposition, pore pressure calculation and compaction, heat flow analysis and temperature determination, the kinetics of calibration parameters such as vitrinite reflectance or biomarkers, modelling of hydrocarbon generation, adsorption and expulsion processes, fluid analysis, and lastly migration[1]. One-dimensional modelling of burial history and thermal maturity was performed by using PetroMod 1D (version 2016.2).

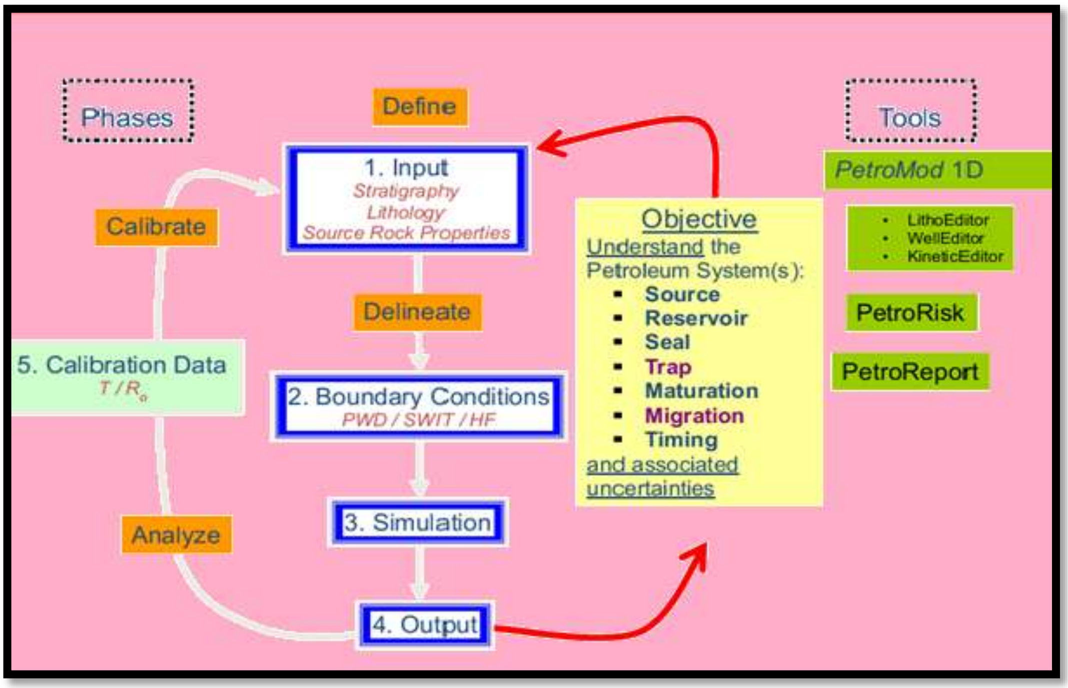

Figure 1- The workflow chart of PetroMode software After[2].

Location of the study area

The study area consists of four oilfields, these are Nsiriyah ,Ghrraf,Abu-Ammood oil fields and Riffai oil fields .One oil well from each field was chosen which are: NS-1, GA-5 ,AAm-1 and Ri-1 Figure-2. The study area is located within the Mesopotamian Zone.

Nasiriyah oil field lies east of the River Euphrates, about 38 Kilometers northwest of the city of Nasiriyah , it is around 34 km length and 13 km width at Mishrif surface reflection, The Nasiriyah field was investigated by the Iraq National Oil Company (INOC) in 1975**.**The field is assembled inside the Gharraf axis, which incorporates the undeveloped Gharraf and Rafidain fields.The Gharraf oil field is around 85 km to the north of Nassriya city , just about (35 km) NW of Al-Riffai city.It was discovered by the seismic review of the national oil company in 1976-1978, where the surveys have demonstrated the presence of convexity of NW-SE trend .The Gharraf oil field is a north west-south east trending anticline with a region of 24 km length and 5 km width.

Abu Amood oil field is located in Dhi Qar Governorate, about 250 km southeast Baghdad and 23km to the southwest Dujaila field, the field covers an area of approximate (120) km2 and is distributed in the northwest-southeast direction[3].

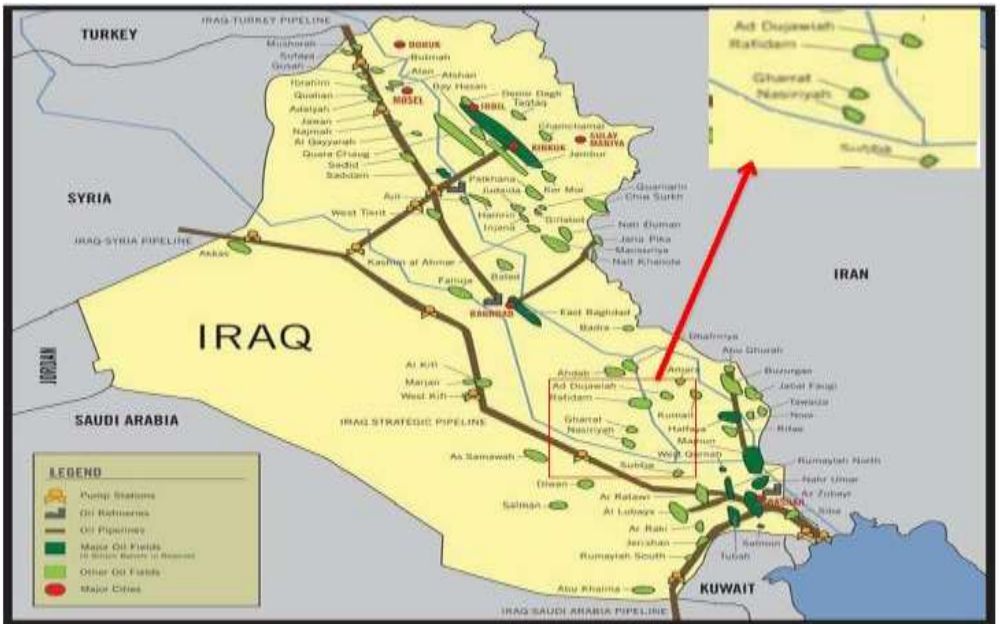

Figure 2-map of the studied area (OEC).

Methodology

The process of model design continues in two stages: a geological model is characterized– a model of rock parameters alteration amid assumed structural evolution of basin, over geological time spans and thermal model is characterized – a thermal evolution of the basin over geological time spans [4]. The software basically needs huge information as an input data, these are:

Deposition

Layers are made on the upper surface or removed during sedimentation or erosion. It is assumed that the geological events of deposition and hiatus are known, therefore, Paleo-time of deposition can be doled out to the layers, the depositional thickness of another layer is computed by means of porosity controlled back-stripping form present day thickness or impetrated form structural restoration programs [1].

Porosity determination:

Porosity can be estimated utilizing open hole well logs for example sonic, neutron, and density logs. These logs are ordinarily used to estimate porosity. The estimated porosity is then plotted against depth to estimate compaction. The connection between these variables (i.e., porosity and depth) mostly display straight relationship in the form [5]

$\Phi p=\phi 0e-cz$

Where Φp= current porosity at depth (z)

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$\phi 0$= Initial porosity (0.49 for sandstone, 0.55fore shale ,0.52 for limestone,0.42 for dolomite) .

c = coefficient (the slope of porosity – depth) curve (0.0003 for sand stone, 0.0005 limestone, 0.0004 for dolomite for shale, 0.0006

Eroded thickness

The eroded thickness can be detected according to beneath equations:

The eroded thickness can be detected utilizing the under beneath equations:

Eroded thickness=To*(age of erosion/age of deposition

Eroded thickness=RF*10*age of erosion

Rf Rate of fill [6]

Sediment decompaction

The initial step in back-stripping is to reproduce the original sediment thickness To of growing sedimentary fill from the basin floor up – to – date stratigraphic boundaries in particular exposure or well logs. The porosity (ϕp) and present thickness (Tp) were utilized to detect initial porosity (ϕo) as in the equation underneath:

$To= [(1- \phi p) / (1-\phi o)]* T6]$

To original thickness

Tp present thickness

ϕp present porosity

(ϕo) initial porosity

Output of 1D

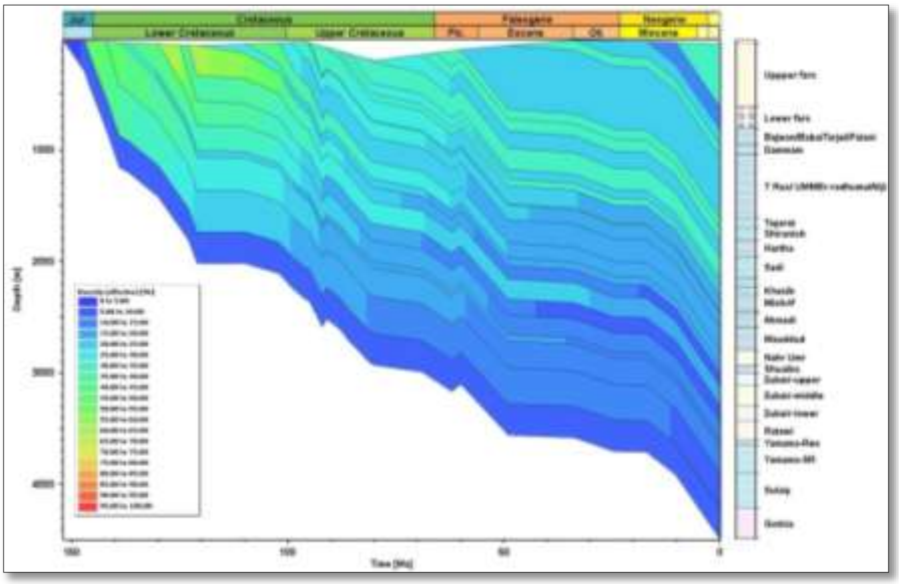
PetroMod Model

After running PetroMod, many outcomes for the assessment of petroleum system were obtained for example vitrinite reflectance, thermal conductivity, porosity, migration properties, permeability, burial history, thermal history...etc.

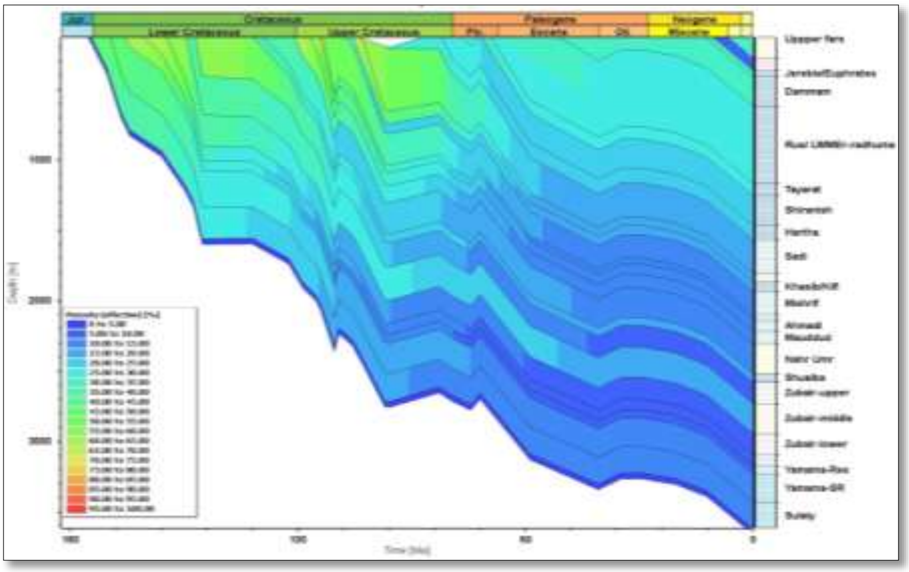
a. Porosity

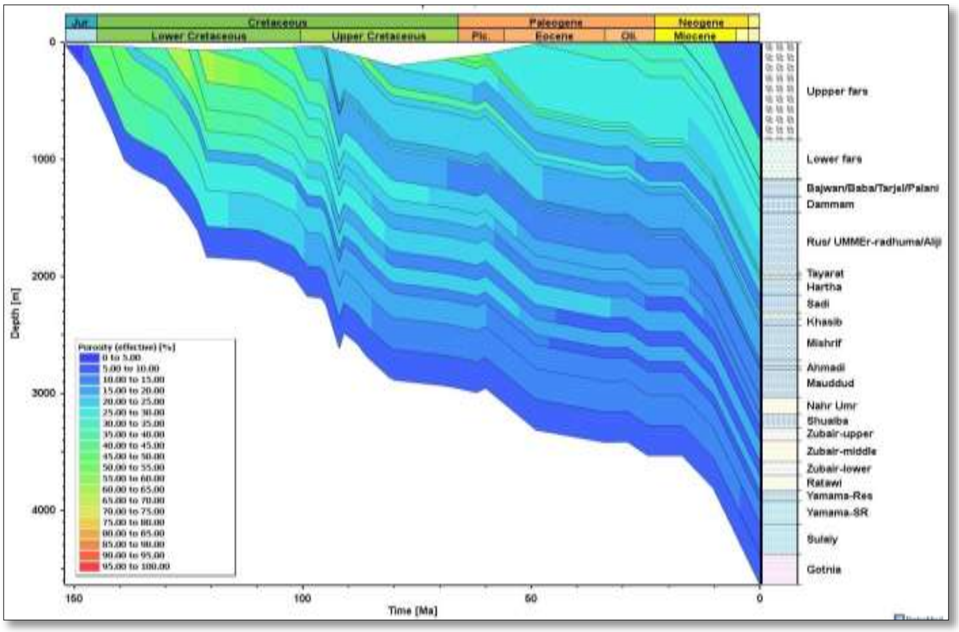
Porosity is a basic property of an oil reservoir that decides the capacity of oil it can contain.it is characterized as the proportion of the volume of bulk volume of a substance[7]. The porosity in the studied area represents less value in Gotnia formation, while it represent the highest value in Dammam , Tayarat ,Um Eraduma and Khasib formations Figure-3.

Ns-1



Ga-5


Cretaceous
Paleogene
Neogene
Lower Cretaceous
Upper Cretaceous
Eocene
Miocene
Dammam
Tayarat
Hartha
Sadi
Mishrif
Nahr Umr
Shuaiba
Zubair-upper
Zubair-middle
Zubair-lower
Yamama-SR
Sulaiy


Jur
Cretaceous
Paleogene
Neogene
Lower Cretaceous
Upper Cretaceous
Plc.
Eocene
Oli.
Miocene
0
1000
2000
3000
4000
Depth [m]
Porosity (effective) [%]
0 to 5.00
5.00 to 10.00
10.00 to 15.00
15.00 to 20.00
20.00 to 25.00
25.00 to 30.00
30.00 to 35.00
35.00 to 40.00
40.00 to 45.00
45.00 to 50.00
50.00 to 55.00
55.00 to 60.00
60.00 to 65.00
65.00 to 70.00
70.00 to 75.00
75.00 to 80.00
80.00 to 85.00
85.00 to 90.00
90.00 to 95.00
95.00 to 100.00
150
100
50
0
Time [Ma]
Uppper fars
Lower fars
Bajwan/Baba/Tarjel/Palani
Dammam
Rus/ UMMEr-radhuma/Aliji
Tayarat
Hartha
Sadi
Khasib
Mishrif
Ahmadi
Mauddud
Nahr Umr
Shuaiba
Zubair-upper
Zubair-middle
Zubair-lower
Ratawi
Yamama-Res
Yamama-SR
Sulaiy
Gotnia

Ab-1

Continue……

Ri-1

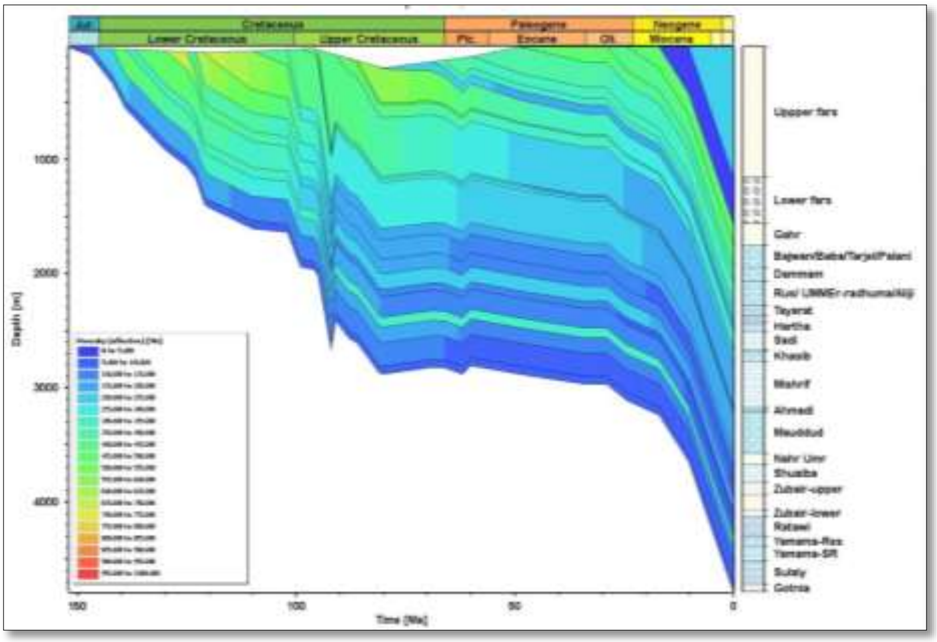


Figure 3- Porosity compare for NS-1,GA-5,Ab-1 and Ri-1 wells .

Thermal history

The thermal history of sedimentary basins can be assessed rely upon the burial history and on the heat-flow evolution [8, 9]. Burial history and thermal history can be utilized to detecte the oil and gas potential of a basin and to determine reservoir porosities. [5].The maximum temperature and maximum burial time has a great importance for the petroleum system in the study area. For most of the studied wells, the Paleocene to Miocene has to be regarded as times when the maximum temperature prevailed associated with deep burial could be that the age is the late petroleum generation and an additional filling of traps Figure-4.

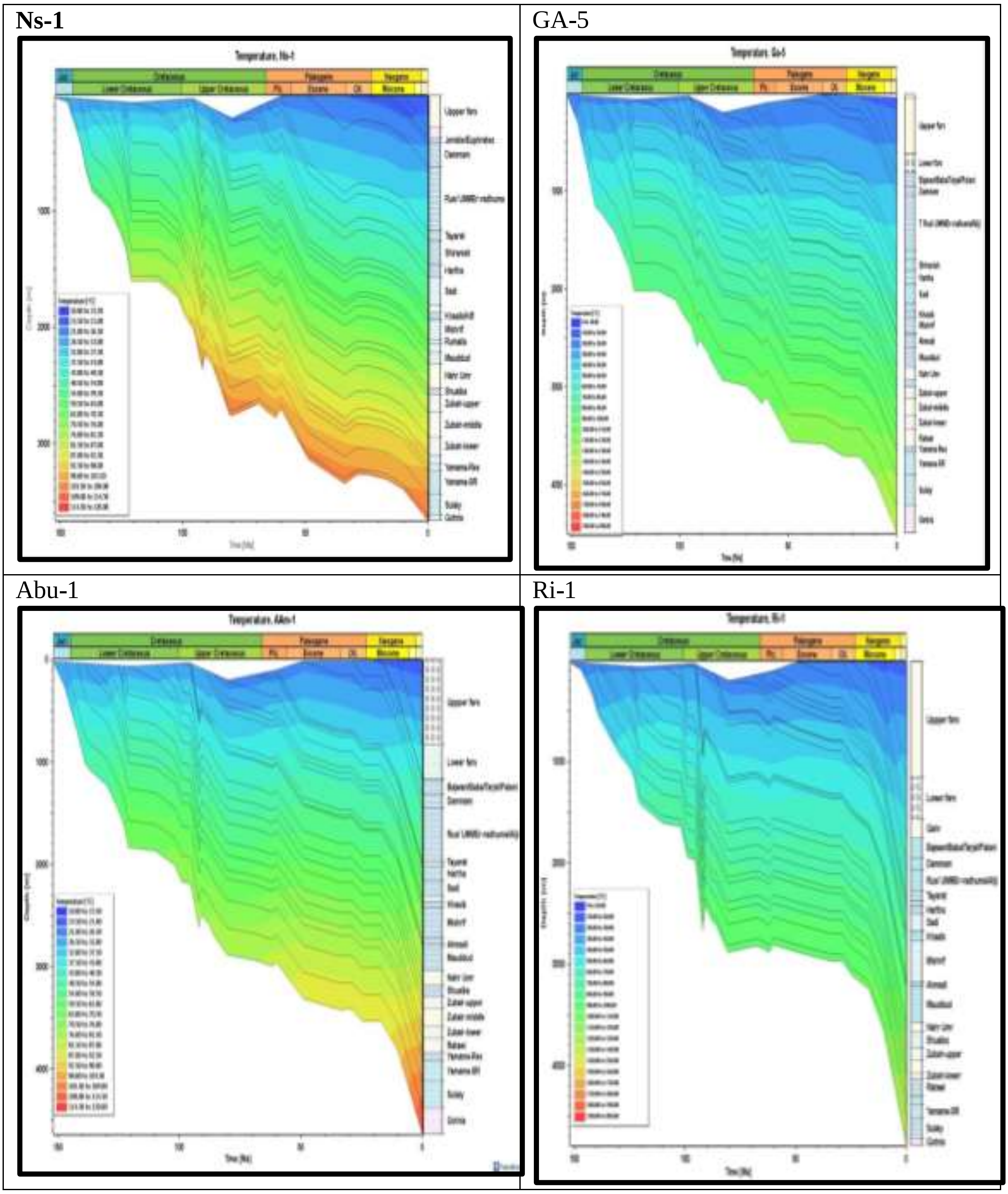


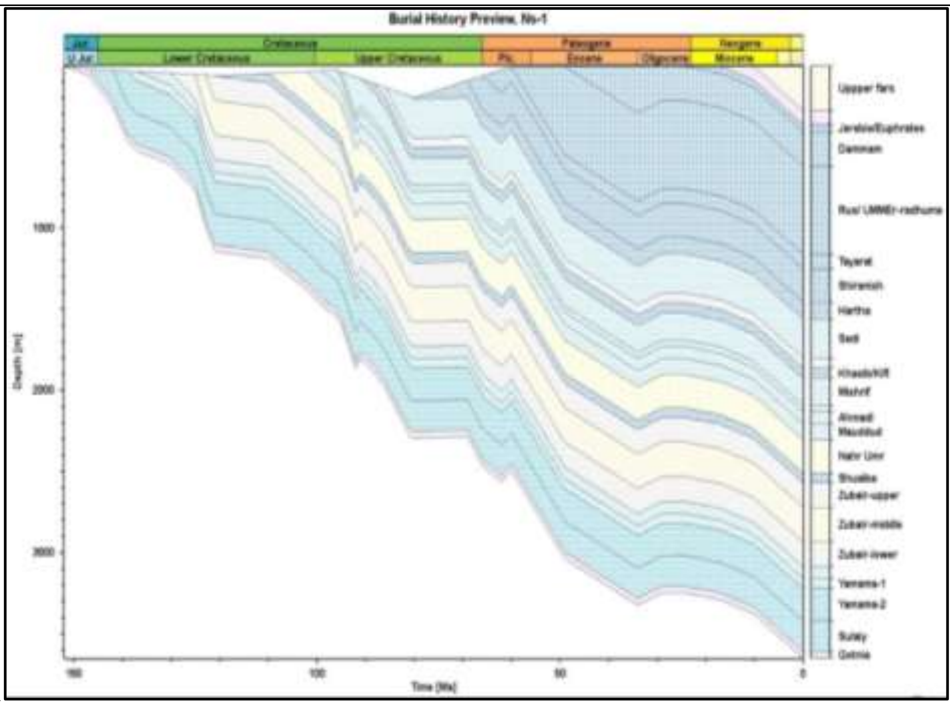
Figure 4- Thermal history for NS-1, GA-5,Ab-1 and Ri-1 wells.

Burial history

The subsidence history of a sedimentary basin through geological time is alluded as the burial history. Subsidence, uplift and erosion are analysed by utilizing burial history graphs, which assume a key part in giving the present day maximum burial depth. The burial history of basin sediments contains data about burial depth and preservation of organic material, which are related to the temperatures and pressures of the sediments were exposed to and the durations of exposure [10]. The histories of water depth, heat flow and surface temperature complement the burial history. Every one of these components goes into the modelling of a sedimentary basin, and they apply at the boundaries of the basin. The development of the basin is Modeled by adding layer on top of layer through the geohistory, eventually with periods of no deposition or periods with erosion [11].

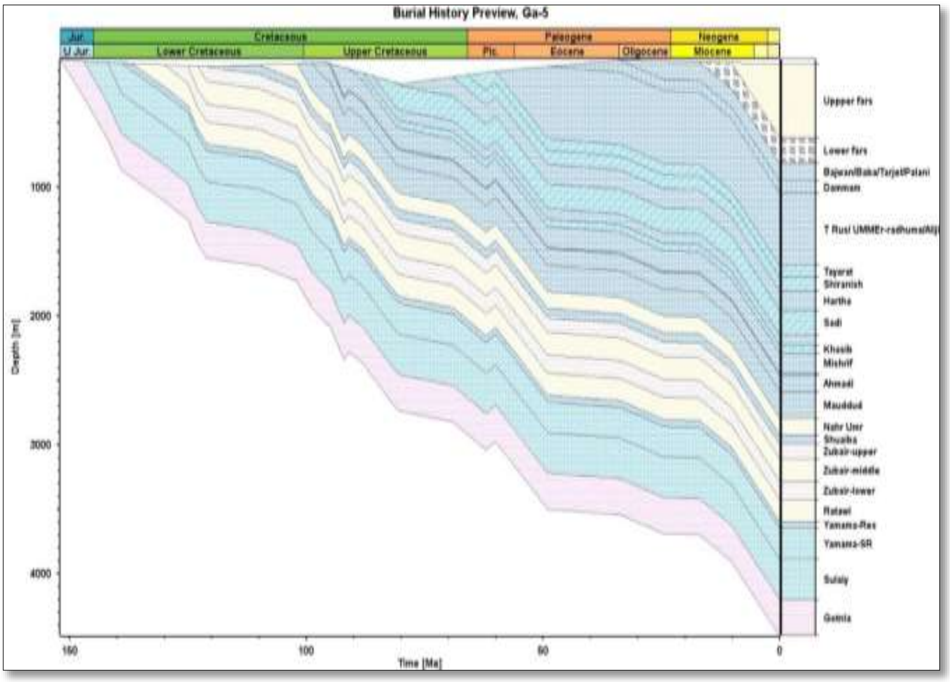
With respect to the study area, the subsidence rates deduced from the mentioned curves Fig.5 are:

1. The output figures to the burial histories reflect the same geological events which happened to the studied area .
2. Four distinctive unconformities occur during the geological history to the Mesopotamian basin.
3. Moderate to rapid subsidence periods during the geological history. It corresponds to the tectonic movement that effected in the Arabian plate motion and typical example to Peripheral foreland basin within overfilled phase.



Ns-1

Ga-5



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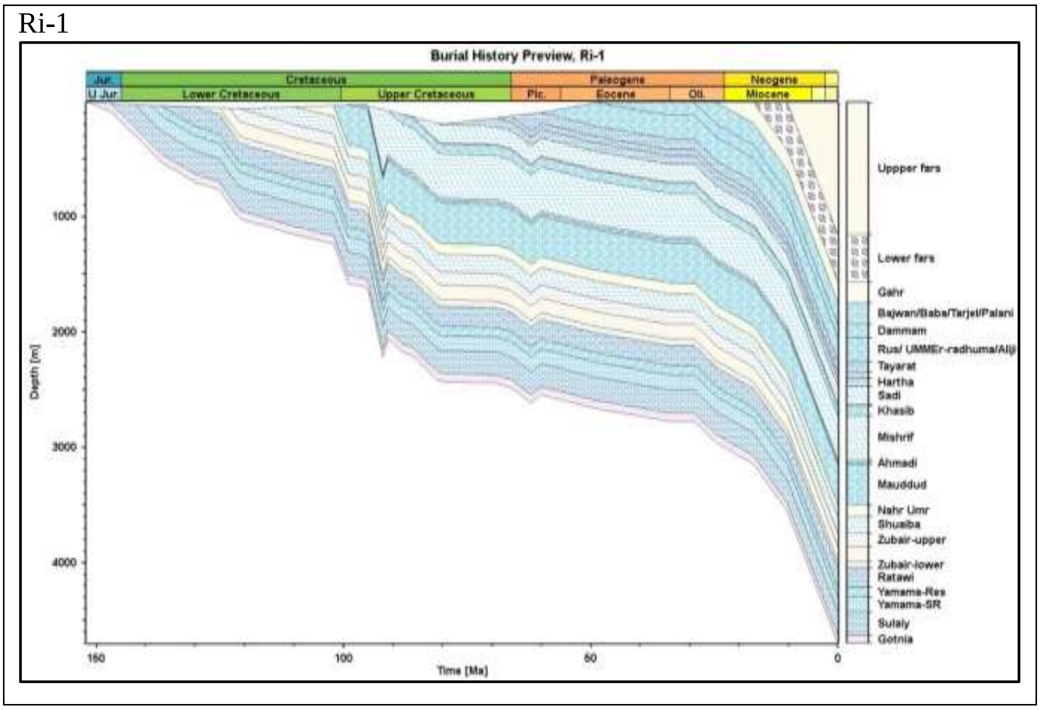

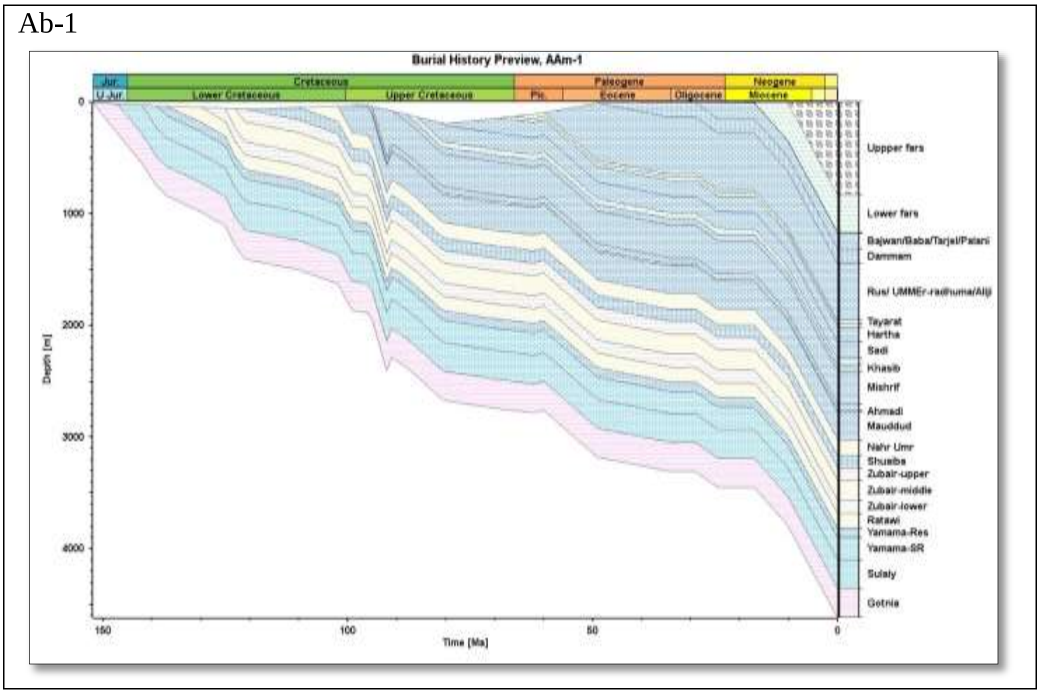

Figure 5- Burial history for NS-1,GA-5,Ab-1 and Ri-1 wells .

Vitrinite reflectance (Ro)

The most broadly utilized thermal maturation pointer is the reflectance of the vitrinite maceral in coal, coaly particles, or dispersed organic matter. It is termed as %Ro. It is optical parameters and is symbolized by VR or Ro (reflectance in oil)[12]. it is utilized to calibrate the burial and thermal history models[5]. It is a percentage measure of the episode light that reflected from the surface of vitrinite particles in a sedimentary rock. The connection amongst %Ro and hydrocarbon generation is rely upon the chemistry of the vitrinite in addition the chemistry of the kerogen [13]. Table -1 clarifies estimations of Easy %Ro relying upon [14].As indicated by the outcomes in Table 2 and Figure- 6 , NS-1 oil field, the Ro values recorded an early oil stages for Sulaiy ,Yammama , and Ratawi formations .The Ro values in GA-5 represented main oil stage for Sulaiy formation, whereas Yammam, and Ratawi formations represented an early oil stages .AAm-1 oil field recorded an early oil stages for Sulaiy ,Yammama , and Ratawi formations similar in these values NS-1 oil field .Ri-1 oil field represented main oil stage for Sulaiy ,Yammama , and Ratawi formations.from the past outcomes we infer that Ri-1 oil field has the better Ro value when compare with the other studied oil fields .

Table 1- Clarifies estimations of Easy vitirinite reflectance after [14] .

0.25 – 0.55	**Immature**
0.55 – 0.70	Early oil
0.70 – 1.00	Main oil
1.00 – 1.30	Late oil
1.30 – 2.00	Wet gas
2.00 – 4.00	Dry gas
> 4.0	Over mature

Table 2- Vitrinite reflectance for study area

Well Name	**Formation**	**Start**		**Stage**	**End**		**Stage**
		Ro %	**Time (Ma)**		**Ro%**	**Time (Ma)**	
NS-1	Sulaiy	0.55	91.17	Early oil	0.67	0	Early oil
	Yammama	0.55	81.67	Early oil	0.63	0	Early oil
	Ratawi	0.55	62	Early oil	0.61	0	Early oil
GA-5	Sulaiy	0.55	85	Early oil	0.71	0	Main oil
	Yammama	0.55	56	Early oil	0.66	0	Early oil
	Ratawi	0.55	43.54	Early oil	0.63	0	Early oil
AAm-1	Sulaiy	0.55	42	Early oil	0.64	0	Early oil
	Yammama	0.55	12.47	Early oil	0.61	0	Early oil
	Ratawi	0.55	4.28	Early oil	0.57	0	Early oil
Ri-1	Sulaiy	0.55	89.49	Early oil	0.78	0	Main oil
	Yammama	0.55	83.9	Early oil	0.75	0	Main oil
	Ratawi	0.55	72.5	Early oil	0.7	0	Main oil

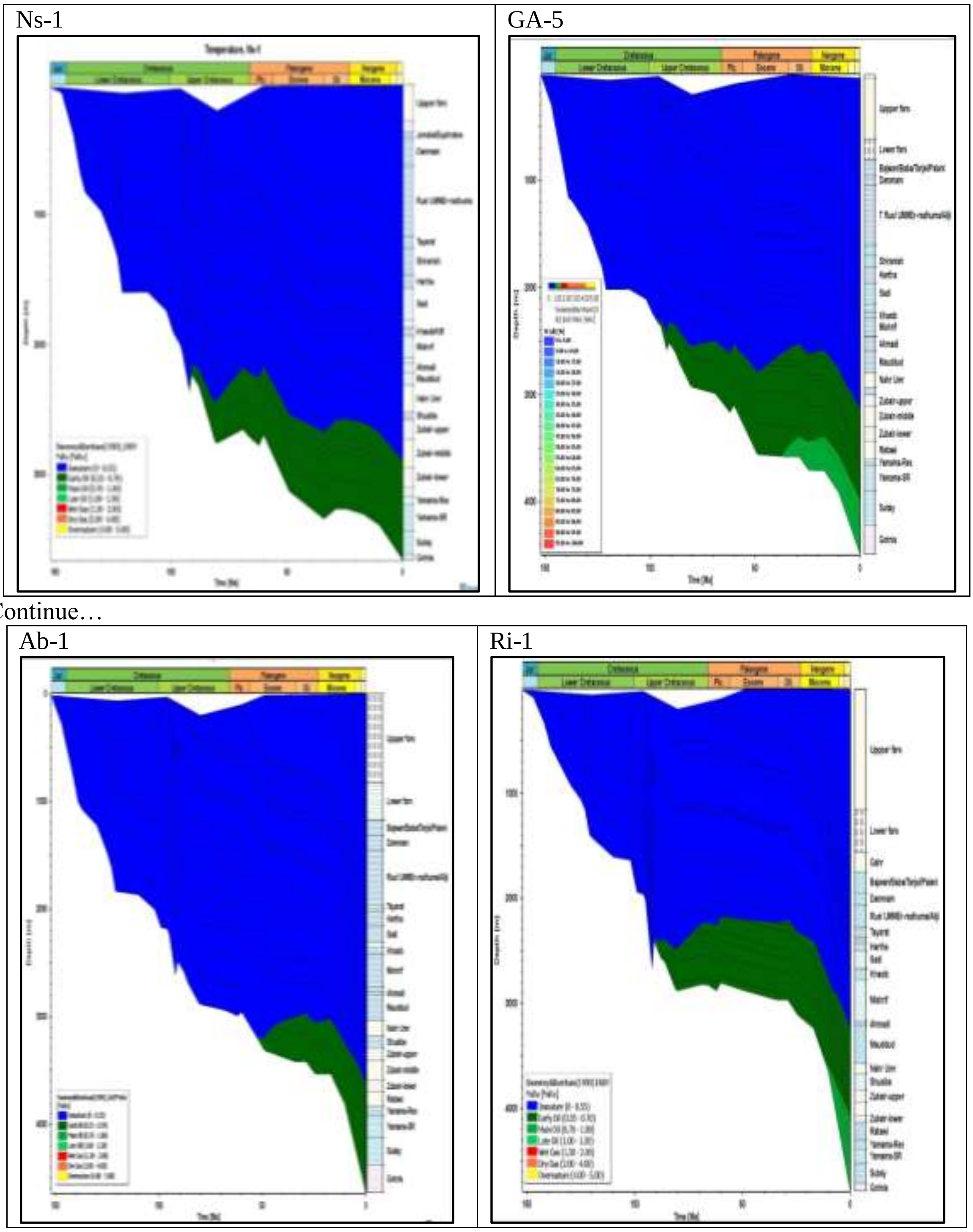

Figure 6- Vitrinite reflectance for NS-1,GA-5,Ab-1 and Ri-1 wells respectively .

Conclusions

1. Geohistory analysis applied on four wells selected from four oil fields. The results showed that the stratigraphic section of the study area contains periods that are different in tectonic and sedimentary subsidence, burial history, sedimentary and erosion rates. It was seen that the burial depth was greater in the Riffai well in compared with other wells in the study area. The subsidence is high to moderate at Upper Jurassic to Lower Cretaceous, which was tectonic subsidence. Slow subsidence with distinctive uplift represented at Miocene.
2. There is similarity in the burial histories of the study area. It indicated that the formations are deposit in the same basin, which was effected by tectonic and sedimentary subsidence.

3. The porosity in the studied area represents less value in Gotnia formation, while it represent the highest value in Dammam , Tayarat ,Um Eraduma and Khasib formations.
4. The organic maturation increasing towards the Riffai well (Ri-1) which have greater maturation than others Oil wells (NS-1, GA-5, AAm-1).
5. The organic maturation in Riffai well has entered in the main oil stage, especially Suliay and Yamama formations whereas only Suliay formation in GA-5 well entered in the main oil stage Therefore, there are good generated and mature source rocks in this well.

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