Recognition of Reservoir Continuity and Reservoir Compartmentalization Using Oil Finger Printing In One of Iranian Oil Region in the Persian Gulf

Idin Shahrezaei[1,*], Mohammad Reza Kamali[2], Amirreza Abadichalaksaraee[1]

1- Department of Geology, Faculty of Sciences, Islamic Azad University, Science and Research Branch, Tehran, Iran.
2- Faculty of Research and Development in Upstream Petroleum Industry-RIPI.

* Corresponding Author: idn_sha@yahoo.com

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Abstract

Salman and Resalat oilfields are such marine oilfields that are in vicinity of each other. There is Resalat oilfield in distance about 80-90 kilometers from Lavan Island in Persian Gulf. This oilfield is located in 25 kilometer southwest in Reshat oilfield. Salman oilfield is located in vicinity of water border line of United Arab Emirate in 140 kilometers of south of Lavan Island. This oilfield is remarkable because of its reservoir value and also it is common between Iran and United Arab Emirate. Surmeh reservoir structure is an oily reservoir that it's common between two oilfields. In order to study of geochemistry features, oil samples of Salman and Resalat's oilfield analyzed by using usual geochemistry techniques such SARA test, gaseous chromatography techniques (GC) and gaseous chromatography – mass spectrograph (GC-MS). According to results, including of distribution of values in formed hydrocarbon cuttings of these oils, study of Biomarkers in Terpans and tabloid steranes group from saturation cutting, we can say that hydrocarbons in Surmeh reservoir in Resalat and Salman oilfield show Paraffinic oil features and kerogen type II that all of these indicate organic material with marine origin. The geochemical study of parent rock in these oilfields shows that the active oil system comes from late Cretaceous and the reservoirs were fed from common hydrocarbon system. The gathering hydrocarbons at mentioned oilfields, also, were produced by carbonate source rock with a little shale in revival conditions. The parameters of mature biomarkers in these oilfields show that in border of two oil-forming windows it gathered the suitable organic material for producing good oil. Thus, according to analyses, there is integration between Surmeh reservoir in Resalat and Salman oilfield and their oil come from one resource.

Keywords: Reservoir Geochemistry, Surmeh structure, Integration, Resalat oilfield, Salman oilfield, Biomarker.

1- Introduction

Determination and evaluation of one area in terms of kind of oil in reservoir, the effect of secondary processes and determination of their probably source stones and vertical and horizontal continuity of oil reservoir together, all of them, are important for exploration targets of experts from the past. Persian Gulf zone is one of the strategic and important zones in Iran and there are more than 3 billion barrels of recoverable oil in this zone. Geochemistry evaluation of the oil of this area can be important from investigation, utilization and development point of view (Fig. 1, Rabbani, 2014).

Therefore, with the study of probably oil resources in available reservoir we can act with

more sure in search and use of hydrocarbon resources and in this regard we can planning for oilfields that have not been discovered by now (Stratigraphic oil trap). The studying reservoir stones in Resalat and Salman oilfield are in Surmeh reservoir structure which they have mainly carbonate lithology (Rabbani, 2013). In this regard, recognition of the oil in producing layers which are in side of them horizontally, study of biological resources and signs by oil fingerprint technique, evaluation of production or reservoir continuity and secondary recovery by oil fingerprint effect, recognition of local and regional probably obstacles of vertically and horizontally of hydrocarbons in reservoir, all of them are next station in this process.

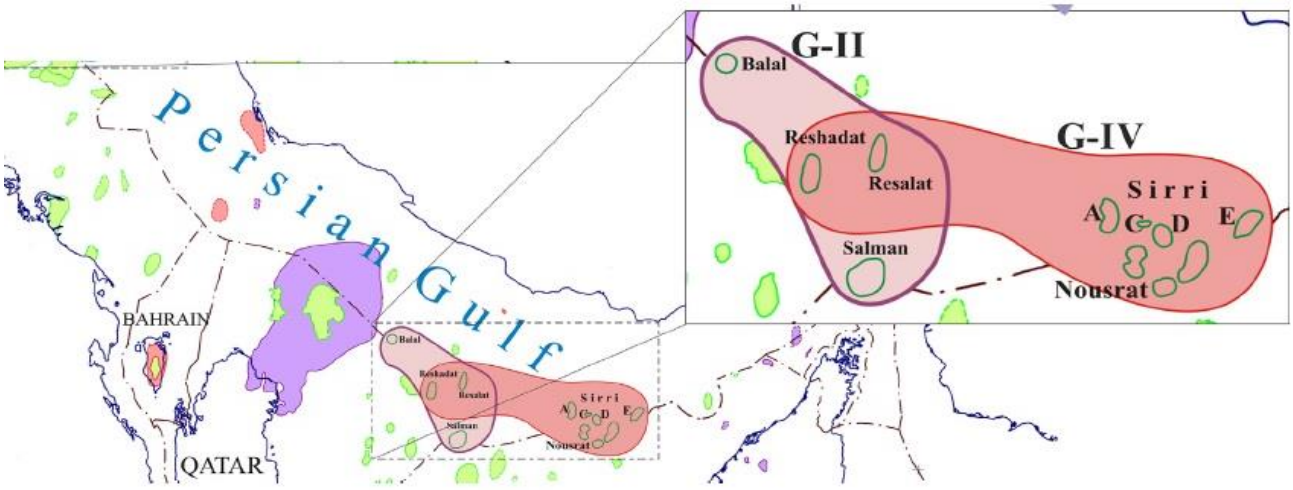

Figure 1) Location of Salman and Resalat Oilfield in Persian Gulf.

2- Research methodology

To determine of Biomarkers and kinds of them (Bordenave, 1993) and find out information about distribution of normal Alkanes and Isopronoids, first, by use of samples of oils and resource stones, have been done experiments such as GC and GC-MS on the samples. Secondly, by using of oil fingerprint find the information about index biological signs of sedimentary environment, the mature degree of organic material and oil, analysis option like leaching or bacterial breakdown, conformity of oil to oil and oil to resource rock (Waples, 1991), and finally by using these information we can achieve our goal and generally manage and use reservoirs optimize. Also, by use of FIS new analysis method or liquid inclusion stratigraphy which do it on samples of teeny of digging and cores, we can draw the history of filling the reservoir and the plan of stratigraphy of fluid chemical. Finally, we can answer many of production and investigations questions.

3- Disscution

To study and diagnosis of differences and similarities of hydrocarbonates in Surmeh reservoir, it has been used columnar chromotography techniques (SARA experiment). The studying oil samples by this method separate from each other. It has been determined different percent of hydrocarbon cuts. Hydrocarbon cuts are included of saturation hydrocarbons, aromatics, resins and asphaltene which this collection called pelar. Thus, the oils which have high saturation hydrocarbons have a very good quality. Increasing Aromatics make Aromatic oils. Heavily oils have more asphaltene and resin which in this kind of oil the quality is low.

Table1) seperated hydrocarbon cuts from Y1 and X5 samples.

Field/Reservoir	Saturate %	Aromatic %	Resin %	Asphaltene %
Resalat Y1	55	32	11	2
Salman X5	62.3	27.5	8.6	1.6

With drawing both oilfields on one chart, we compare two oilfields. As you see on Table 1 the quality of Salman oilfield is better than Resalat in Surmeh layer because oil of Salman oilfield has better saturation hydrocarbons, it's aromatics and non-saturated hydrocarbons are low (Fig. 2).

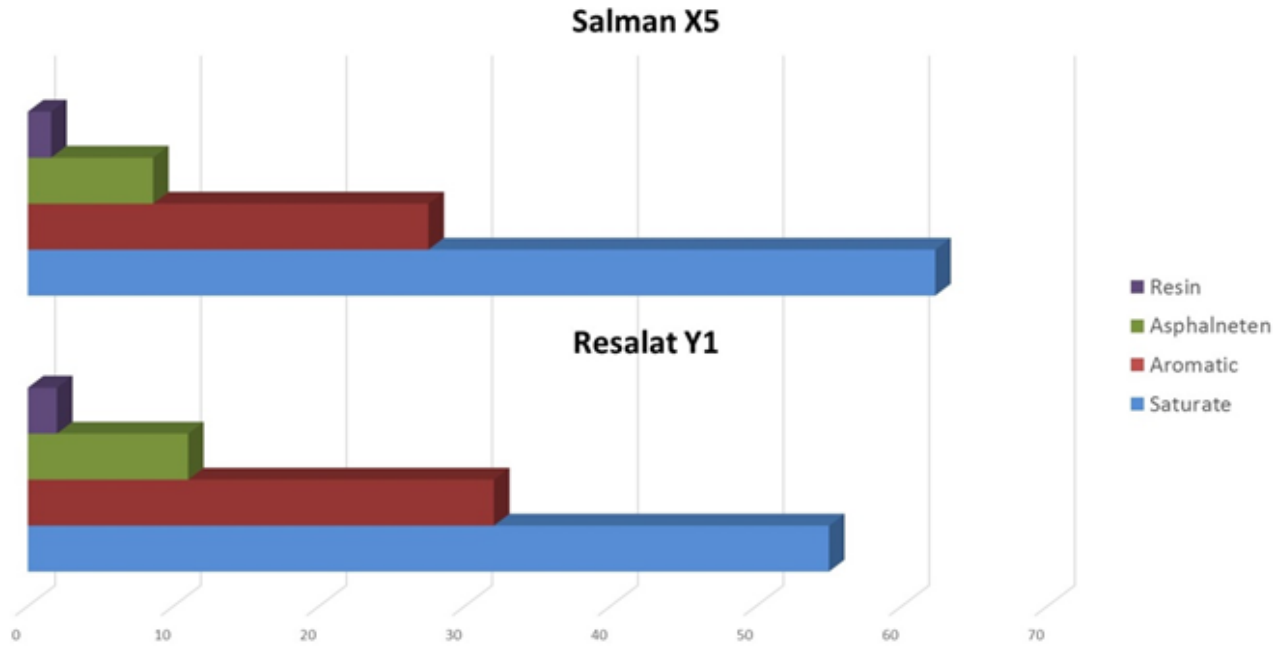

Figure 2) distribution of SARA cuts for X5 and Y1 samples.

Considering to placement of samples in triangle diagram (Fig. 3), Salman oilfields samples are in Paraffin and Paraffin- Naphthenic but Resalat oilfield sample is in Paraffinic area (Tissot and Welte, 1984). So by using the tree plot chart can find that the oil of these oilfields because of be paraffinic with high degree maturity is good in quality.

Table 2) separated hydrocarbon cuts from studying oil samples.

Sample	Saturate (%)	Aromatics (%)	Resin (%)	Asphaltene (%)
Salman X1	45.8	29.6	21.1	3.5
Salman X2	35.1	40.4	21.5	2.9
Salman X3	40	34.7	21.8	3.5
Salman X4	34.8	36.2	26.2	2.8
Salman X5	62.3	27.5	8.6	1.6
Resalat Y1	55	32	11	2

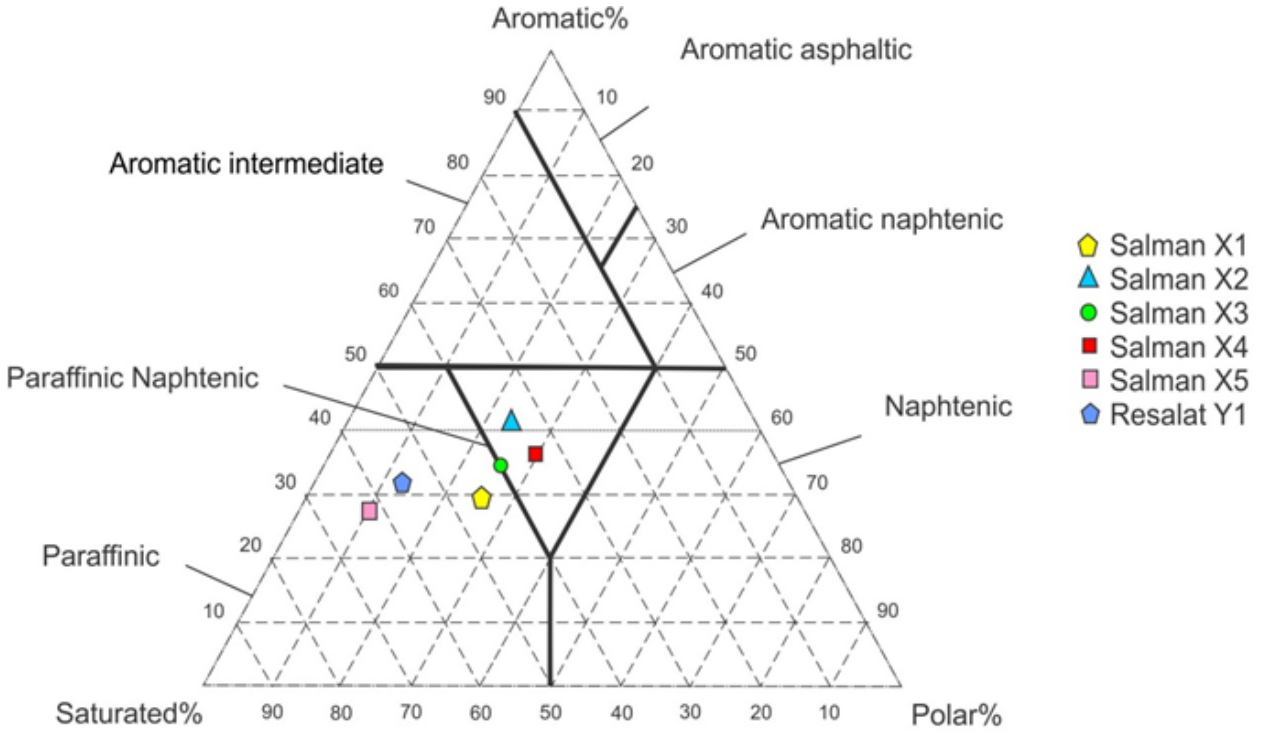

Figure 3) Triangle graph of formation cuts percent in testing samples in Surmeh layers in Salman and Resalat oilfield.

By use of ratio of odd Alkans to even Alkans with the Ph/nC17, Pr/nC18 and Pr/Ph ratios in star shape graph, also comparison of dispersion distribution of these ratios which are gain from analysis of gas choromatography on oil samples of any structure and oilfield, we can recognize sameness or different of hydrocarbones or propebly source ston fitures (Kaufman and Ahmad, 1990).

According to data (Table 3) and drawing all of parameters on a star shape diagram (Fig. 4), we see that same distribution and suitable overlap to odd and even Alkans and non-cyclic isopronoeds show that these reservoirs are fed from same resource.

To diagnosis of type and mature degree in organic matter, to determine of the environment of source stone in oilfield and comparison of oils together and to source stone, could use from different parameters of biomarkers. Biomarkers could be suitable patterns in evaluation of old environments (De Leeuw et al., 1995). Biomarkers use for lithology determination, special sedimentary age and environment source stone, source stone thermal maturity during producing process and also rational amount of producing oil to organic matter of producing gas in source Kerogen. These data have key role in oilfield forecasts model.

Table 3) Parameters and ratios related to impregnating compounds from gas chromatographic analysis on oil samples in studying oilfields.

Well	Resalat	Salman X6	Salman X7
Formation	Arab C (Surmeh)	Arab D (Surmeh)	Arab A (Surmeh)
Pr/ph	0.59	0.54	0.59
Pr/nC17	0.18	0.19	0.2
Ph/nC18	0.34	0.37	0.36
C19/C20	1.06	1.04	1.04
C21/C22	1.12	1.12	1.12
C23/C24	1.06	1.06	1.04
C25/C26	1.08	1.08	1.08
C27/C28	1.13	1.12	1.12
C29/C30	1.12	1.11	1.05
C31/C32	1.17	1.14	1.14

With using of Pri/n-c_{17}, Phy/n-c_{18} parameters, it could evaluate and determine the features of organic materials in this structures from the point of views of kind of Kerogen, process of maturity, probably process of alteration and the conditions of Sedimentation (Hunt, 1996).

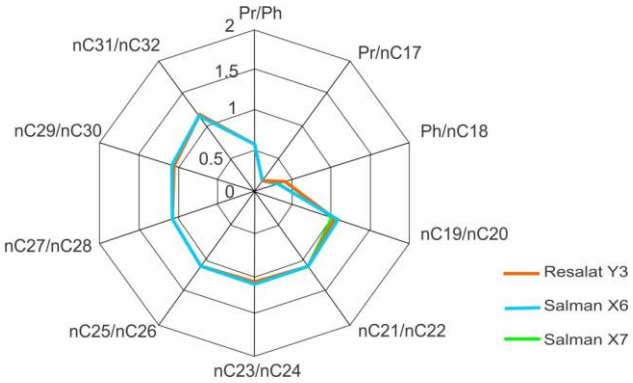

Figure 4) normal alkanes star shape diagram and isonoeds of samples studying

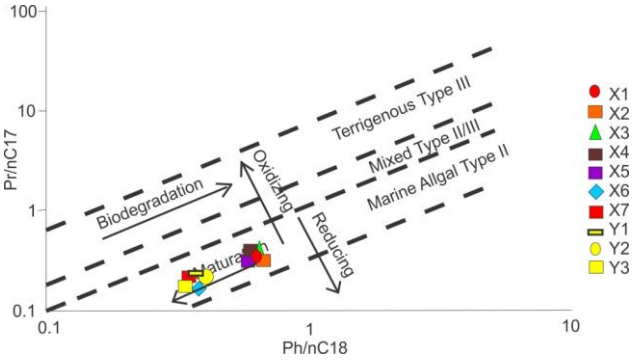

Figure 5) Ph/n C_{18} diagram to Pr/n C_{17} for the samples of Surmeh reservoir in Salman and Resalat oilfield.

In Resalat oilfield our samples show that the condition is suitable for oil. Maturity region and revive conditions show good quality and useful. Three samples of this oilfield are from Kerogen 2 which related to marine environments.

If Pr/Ph<1 shows that sedimentation of source stone happen in revive conditions (Didyk et al., 1978) (if Pr/Ph>1 thus the environment is oxygenic), thus the sedimentation environment is revival absolutely in Sarvak, Daryan and Surmeh Structure. In the meanwhile if Pr/Ph<0/8, the environment is a salty environment to hyper saline or is a carbonate environment and if Pr/Ph<0/3. By the way, more Fitan to Pristan confirm this which high value of Fitan show revival environment and high value of Pristan show oxidic environment (Connan and Cassou, 1980). As we see the because of the samples placement in revival environment have Pr/Ph<1.

Salman oilfield has exactly condition of Resalat oilfield. As you see, these samples in a special compress, when placement in Machur region, means that the samples have high maturity. When the oil is a high qualiy oil, it means that the condition was non oxygen condition. And finally the marin region tell us the kerogens were secon type.

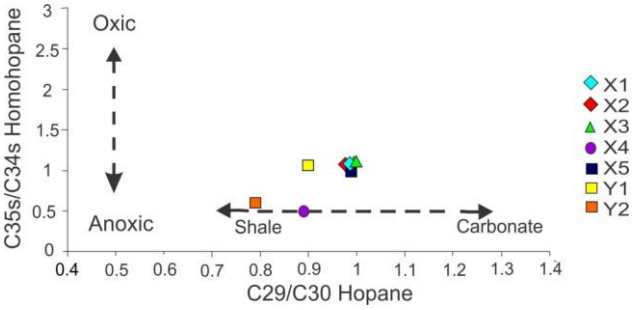

Figure 6) C35/C34 Diagram in front of C29/C3.

The second method of determination of sedementinal environmental and typ of lithology is sue of Hoopan and Homohoopan. The Homohoopan ratio C_{35}/C_{34} shows oxidation ratio of source stone environment. It sugest that as thershold of oxidic and nonoxidic environment, ratio of C_{35} *and* C_{34} homopans becomes one. If this ratio were less than one confirm that the sedimental environment is revival and if were more than one then we find out the sedimental environment is oxidic (Connan and Cassau, 1980).

As we see, our oil has consisted in marny sedimentaly environment which is include of carbonates and sheles. By the way, as it placement in low of diagram, we can find that the condition was a revival and this situation is a marin position exactly. (Fig. 6).

In Resalat oilfield we study Y_1 and Y_2 samples, these samples come from this oilfield and Surmeh layer. This erea shows a sedimentary environment in kind of shele and shele-carbonate, because of a shele layer. The conditions of this oilfield is same as Salman oilfield which is a revival situation.

With use of Ts/(Ts+Tm) and Dia/(Dia+Reg) we can study the condition of sedimentary environmet, by the way we can study if the environment acidic and alkalic PH or environment revival ond oxidic EH or mature thermal also has effect on organic matter. We studied all of these subjects and found out the informations (Moldowan et al., 1994).

Ts is a couple of hoopans which there is in all samples of them.Tm is a biological type that because of diagenesis turn to Ts gradually. Accordingly Ts is a hoopan thermo type. Diasterns which are arrenged strans, are produced in catagensis and diagensis phase also.

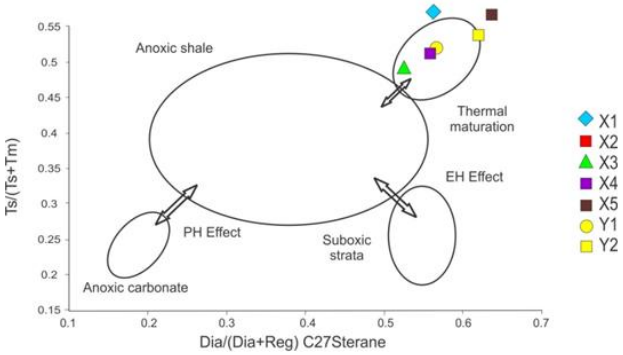

Figure 7) $T_s/(T_s+T_m)$ diagram in Dia / (dia+reg) sterane for all Surmeh reservoir samples.

The samples in Salman oilfield show revival environment in kind of shale sedementry environment. This method is used for tophographic diagnosis of course and is not accurate for litology of resourse stones. Also the samples were in thermo maturity too much which could be burn the samples and it has negetive effect in oil quality.

Because of in marine environment both of Salman and Resalat oilfields are in vicinity of each other, the samples of Resalat oilfield has revival conditions and are affected thermal maturity (Fig. 7).

Sterane diagram in peristan fitan ratio is one of drawing methods of sedimentary environment. According to evaluations, C_{27} Sterane is index of marine environments, C_{28} streranes is index of Lake Environment and C_{29} Steranes are indexes of continental environment (Peters et al., 2005). The resource of C_{29} strerances are usually from land plants which find in kerogens of type III, but the resource of C_{27} strerances are from marine fitoplanktones and C_{28} strerances are from lake algae and find in crogenes of type II and I respectively (Ekweozor et al., 1979).

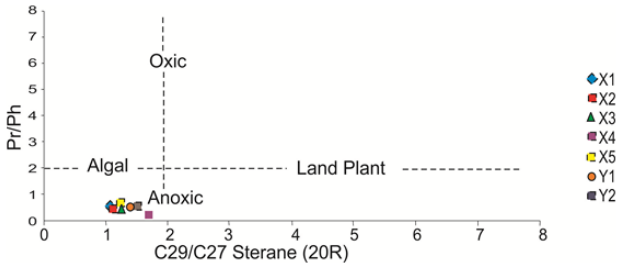

Figure 8) Sterane C_{29}/C_{27} diagram in Pr/Ph for all samples of Surmeh reservoir of Salman and Resalat oilfield.

According to figure 7 in Salman oilfield we can see revival sedimentary environment in surmeh structure while there is in a algea region we find that oil is collecting in marine environment. So, Surmeh reservior has placement in sea and oil marine crogenes are type of II. For samples the ratio of Peristan to fitian is less than one and the ratio of Sterane of C_{29} to C_{27} is between one to two that more Sterane of C_{27} show a marine environment.

The situation in Resalat oilfield is exactly same to Salman oilfield in Surmeh structure. When the oil of these two oilfield placement in revival and marine environment and of course to have algea and more esteran C_{27}, show that oil samples of two Salman and Resalat oilfield have same condition and quality. This fiture could be one the signes that are from one resource. In this case, both oilfields are fed from one resource stone (Fig. 8).

The thermal mature shows the degrees of reactions from heat that sedimentary organic materials turns to oil. In this section, for determination of thermal maturity have been used molecule parameters based on distribution and ratio of specific biological signs. Some of special ratios of saturation and aromatic biological signs are considered as most

important thermal maturity (Peters et al., 2005). In general, organic material are divided to immaturity, maturity and over maturity, based on their relation to oil window. For finding the maturity of crude oil, extracted bitomenes and their collection time the standard diagram of change rates $C_{32} - Hopane\ 22S/(22S + 22R)$ in$C_{29} - sterane 22S/(22S + 22R)$ can be used (Ourisson et al., 1984).

Mostly, the samples are between two oil-forming windows and have good quality.

There are two samples also in Resalat oilfield which are same condition to Salman oilfield samples in Surmeh layer. These features tell us the oil is high quality which gets a thermal maturity well. Finally, we can see thermal maturity in both oilfields.

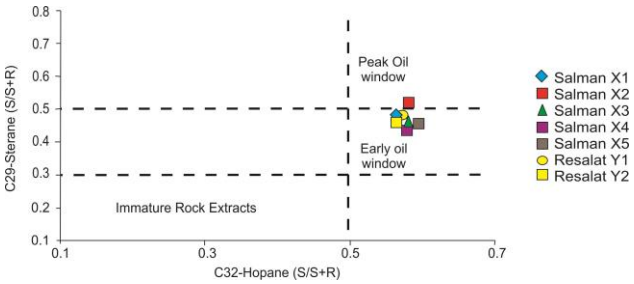

Figure 9) C_{29} Sterane diagram in C_{32} hopane of Surmeh reservoir in Resalat and Salman oilfields.

The most important parameter of mature measurement by use of biomarkers is the rate of two epimerized shapes (20R, 20s) of Sterane $\alpha\alpha$ which their rate is 20s/ (20s+20r) .The 20R figure is Sterane's $\alpha\alpha\alpha$ bio form but when maturity is increasing turn to $\alpha\alpha\alpha - 20s$. When these two forms have their balanced, their ratio don't change, thus after this case, we can't register mature changes. In fact, mature changes have determined by the study of ratio change in 20S/ (20S+20R) in C_{29} Sterane (Justwan et al., 2006).

Regarding to the sample's location in chart maturity of Steranes in Resalat oilfield and Surmeh layer shows good oil. Samples are located in upper part of oil window and near to window of the peak of thermal maturity and the situation implies on a suitable thermal maturity. Such condition illustrates a good thermal maturity in Surmeh layer in Resalat oilfield.

Also, according to the Figure 9 and this chart in Resalat and Salman oilfields in Surmeh layer thermal maturity lies between sub-mature to mature.

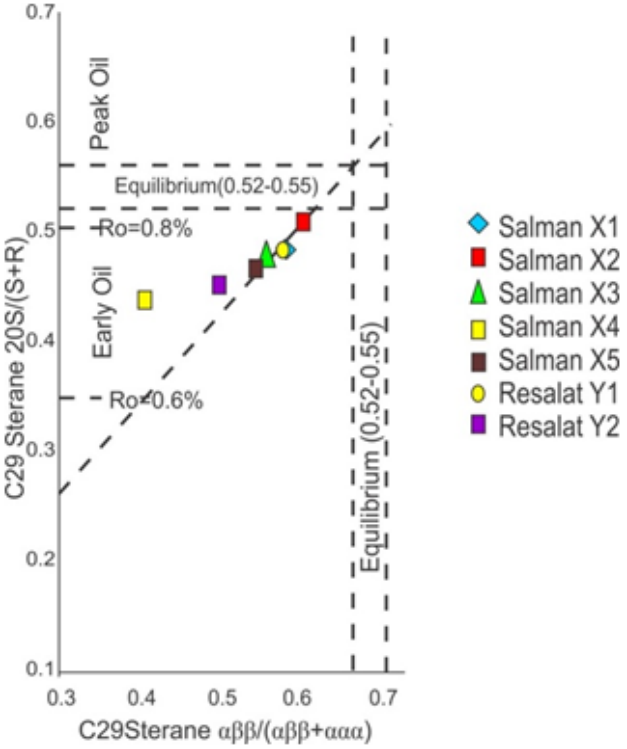

Figure 10) 20S/ (20S+20R) to αββ/ (αββ+ααα) of C29 Sterane isomers in samples from Surmeh source.

While maturity goes up Tm gradually would be disappeared and Ts increases. Unlike, Mortan to Hopane ratio, amount of Tm/Ts decrease. Tm/Ts amount is not a good factor in saline area because the primary Ts is high in samples from saline area (Justwan et al., 2006).

Thermal maturity in Salman and Arab layer is good and samples are in early stages of mature zone making use of Ts, Tm and C29 Sterane. X2 and X5 samples are located in the peak of this zone and have better condition while the others show a little poor quality.

The following describe thermal maturity in Resalat oilfield and Arab layer. Samples from this oilfield like Salman oilfield are located in primary zone and are matured so thermal maturation is good. In comparison with the two

other oilfields thermal maturation in Salman oilfield has better maturity and Arab layer has better maturity either. The reason why Salman oilfield is more mature is the depth which Surmeh layer is burdened in Salman oilfield which is deeper than Surmeh layer in Resalat oilfield.

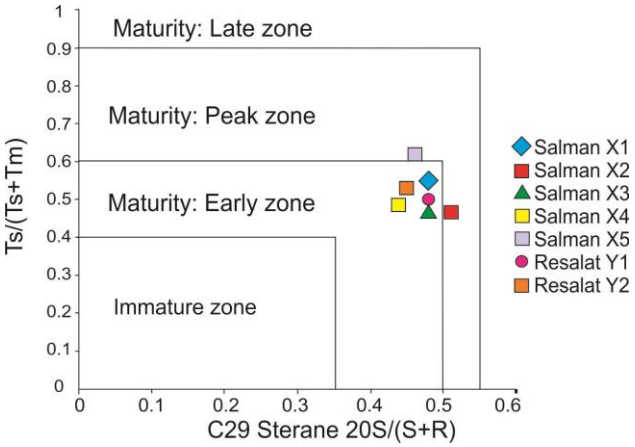

Figure 11) chart of 20S/ (20S+20R) to αββ/ (αββ+ααα) of C29 Sterane isomer ratio, Surmeh source, Resalat and Salman oilfields.

Geological age of source rock has been assessed make use of "$\delta^{13}C$" and C29 Sterane. The isotopes are in two forms, stable and unstable (radioactive). All isomer samples in this case imply on cretaceous and old and mature oil (Seifert and Moldowan, 1986, Table 4).

Table 1) δ13C parameter to sterane C29 ββ/(ββ+αα), Resalat and Salman oilfields.

Sample	δ13C Sat	C29
Salman	-27.31	0.59
Salman	-26.98	0.62
Salman	-27.33	0.57
Salman	-27.19	0.51

Galimov chart could be used for aging the source rock (Galimov, 1973). In this chart, making use of samples analysis and the amount of δ13C for Asphaltine, Resins, whole oil and saturated oil, samples could be plotted on chart and characteristics of whole oil and source rock could be assessed (Fig. 12) .

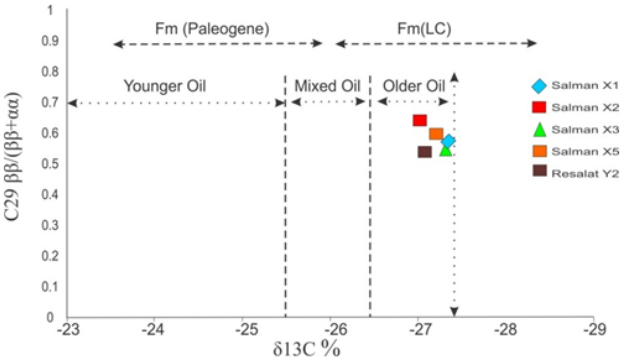

Figure 12) δ13C to C29 / (ββ+αα) sterane, Salman and Resalat oilfields.

Studies has been conducted by Galimov and his chart imply on the isotopic amount of carbon of hydrocarbon is related to age, the amount of isotopic carbon, the less aged the crust is the more weight the isotopes have. Regarding to table above and the line graph related to all samples have same source and they accumulate between -26 to -27 and the probable source rock maturity refers to beginning of oil window and its age is Cretaceous. Also, Y1 sample is better sample and shows better saturated carbon isotope (Table 5).

Table 5) δ13C Asph, Top oil, Resin, Sat, Aro fractions in Salman and Resalat oilfields.

Sample	δ13C Asp %	δ13C Res %	δ13C Oil %	δ13C Sat %	δ13C Aro %
Resalat Y1	-26.0	-26.5	-26.7	-27.2	-26.5
Salman X5	-26.8	-26.3	-26.9	-27.2	-26.3

In this chart regarding to its saturated carbon isotope and top carbon isotope that are respectively -27 and -26.5 the X7 sample has the best condition. Resalat oilfield has the second best sample after Salman oilfield. Sample Y3 from Resalat oilfield and Surmeh layer has top carbon isotope -26.8 is better than X6 sample from Salman oilfield. As we know, the lighter the carbon isotope is the better condition it has and regarding to light hydrocarbon and the amount of them hydrocarbon from Salman and Resalat oilfields are heavy to moderate (Table 6).

Making use of changes in Sterane to Hopane ratio to C27/C29 Sterane the geographic

locations of source rock could be defined. Also lithology of source rocks could be defined by this chart (Andrusevich et al., 2000).

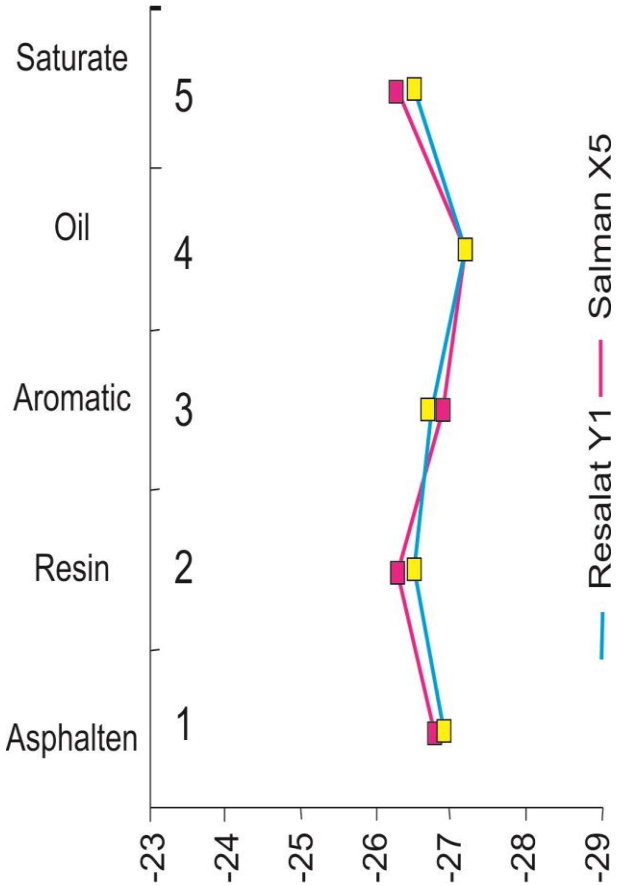

Figure 13) C13δ chart for Asph, Top oil, Resin, Sat and Aro, Samples from Resalat and Salman oilfields.

Table 6) C13δ parameter for Asph, Top oil, Resin, Sat and Aro, Samples from Resalat and Salman oilfields, Surmeh reservoir.

Sample	Asphaltenes	Topped oil	Whole oil	Sat	Aro
Resalat Y3	-26.3	-26.8	-26.9	-26.8	-26
Salman X6	-26.1	-26.7	-26.8	-26.9	-26
Salman X7	-27	-26.7	-26.6	-27	-26

According to the Table 7 the chart for latitude could be illustrated and regarding to samples from upper latitudes have classic and in fact shale lithology while lower latitudes have non-clastic source rock and carbonate lithology.

Table 7) C27/C29 steranes and Steranes/Hopanes ratios in Salman and Resalat oilfields samples.

Sample	C27/C29 Steranes	Steranes/hopanes
Salman X1	0.9	0.21
Salman X2	0.87	0.23
Salman X3	0.77	0.17
Salman X4	0.58	0.17
Resalat Y1	0.69	0.18
Resalat Y2	0.65	0.24

Firstly, the geographic location of Salman oilfield would be assessed. According to all charts and regarding to Sterane to Hopane volume is less than 0.3 and C27 Sterane to C29 is less than 1 it could be resulted that source rocks formed in lower latitude and are non-clastic rocks. Surmeh layer in Salman oilfield is like Arab layer and has carbonate originate (fig 14).

Secondly, Resalat oilfield would be investigated. According to studies Sterane to hopane ration is less than 0.24 and C27 to C29 Sterane below 0.7 is located in lower latitude (Fig. 14).

Regarding to this, Salman and Resalat oilfields are near to each other and both have non-clastic or carbonate source rock.

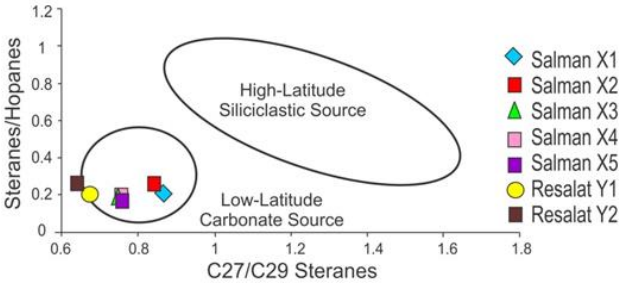

Figure 14) Sterane to Hopane ratio against C27/C29 Sterane chart, Samples from Salman and Resalat oilfield.

4- Conclusions

All geochemistry and biomarker parameters in Surmeh reservoir in Salman and Resalat oilfield like hydrocarbon quality, origin, organic matter and sedentary basin, organic and oil maturity grade in reservoir, hopane and sterane biomarkers, source rock age, latitude of source rock could be assessed making use of GC and GCMS and biomarkers and carbon isotopes. Regarding to all parameters, Surmeh reservoir in both Resalat and Salman oilfield produces same oil and this implies that there is lateral continuity in Surmeh reservoir.

In addition, the samples have same physical and chemical properties and carbon isotopic analysis shows there is a unique source for both reserve. Finally, it is accepted that Resalat and Salman have same source rock there is no oil integration in the studied case.

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