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PVT and Pressure Analysis in Third pay Reservoir of Zubair Oilfield Southern Iraq

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Abstract— In this paper the pressure drop and PVT data that used in the model to describe the behavior of reservoir fluids of 3rd pay reservoir of Zubair field is explained. The wells in Hammar-Shuaiba area show high Gas Oil Ratio, exceeding 1,000 scf/stb. This is bad sign and that mean reservoir pressure is reduce dramatically and gas will produced , finally the energy that use to push the oil from reservoir to the surface will decrease. Eleven samples have been collected and analyzed from all 3rd pay reservoirs over the years, seven samples in Hammar –Shuaiba area. The PVT data resulted to be scattered, being not possible to define any acceptable conclusion about their trend versus depths, taking also into account that they are not referred to the same temperature. The main difference between the old and new PVT is the Bubble Point pressure at reservoir conditions, which increases from 2646 psi to 2760 psi. Historical pressure behavior shows that water Injection is beneficial to maintain stable pressure trend. Pressure analysis shows a strong depletion start from 2013 in various zones of Hammar Shuaiba domes.

Keywords— Pressure analysis, PVT, Bubble point, GOR.

1. Introduction

Zubair Field in the southeast of Iraq is one of the mature fields, 20 km southwest of Basra city. Zubair Field consists of four culminations named from north to south, Hammar, Shuaiba, Rafidiyah, and Safwan Dome. There are two main reservoirs that have been appraised, produced, and are available for further development. These are Mishrif Formation and Zubair Formation (Upper Shale Member, 3rd and 4th Pay) [4]. Upper Sandstone Member (3rd pay) represents the most important target of the Zubair Formation. This reservoir is sandstone units with average thickness more than 115 m and it contain some shale units. It lies above the Middle Shale Member. The average NTG is about 62%, average porosity about 16% with average permeability 150md [3]. The Third pay formation is consist from main sub layers, these layers are AB, H and L.

During production period, the reservoir pressure dropped from an initial value of 5355 psi to less than 3000 psi. Several samples have been collected from eleven wells in undersaturated Third pay reservoir over the years.

PVT measurements are steps of experimental work to know the reservoir fluid properties and phase behavior.

One hypothesis for the increase GOR in third pay reservoir is that the PVT (Pressure-Volume-Temperature) data that used in the model to describe the behavior of reservoir fluids of 3rd pay reservoir is not the best choice. Pressure analysis must be taken into account to recognize which area in the Hammar- Shuaiba Domes in 3rd pay reservoir has sharply pressure drop and compared it with the chosen bubble point pressure from PVT.

2. PVT Analysis

PVT (Pressure-Volume-Temperature) data are fundamental for material balance calculation, development plan, accurate reserve estimation, reservoir simulation studies etc. [7]. This section will provide the evaluation and related comments about the PVT by collecting and reviewing all the available PVT reports in order to select a sample that will use to describe the black oil reservoir simulation model.

To choice, the best reservoir fluids that using in model, sampling process must be accurate. Engineers can use sundry methods to sampling Zubair field fluids, the methods used are [2]:

- subsurface sampling
- surface sampling

After perforation job, the well must be stable in well test at the smallest chock size. The bottom hole tool which provide from Service Company will run in the hole and set at the sampling depth, above the perforation, this process named subsurface sampling. On the other hand, the process of sampling fluid from different parts like separators, wellhead, pipelines, stock-tank, etc. is named surface sampling. Fluid type and status of reservoir are determine the optimal way to take the sample.

In general, several samples have been collected from third pay reservoir over the years. PVT studies were carried out on the fluid samples that collected from eleven wells in third Pay Formation: ZB-6, ZB-9, ZB-11, ZB-58, ZB-59, ZB-109, ZB-139, ZB-106, ZB- 124, ZB-180 and ZB- 205 [1]. In Hammar - Shuaiba domes, the study area, there are 7 samples (ZB-6, ZB-9, ZB-11, ZB-106, ZB-124,ZB-139 and ZB-205), only one sample (ZB-58) is taken from Rafidiyah dome and 3 samples (ZB-59,ZB109 and ZB-180) are from Safwan dome as shown in the **Figure (1)**.

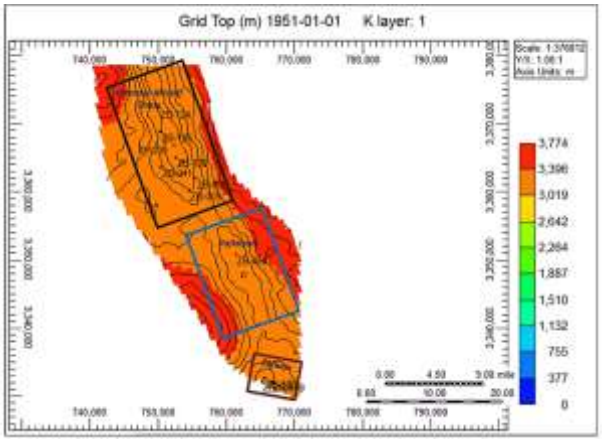

Figure 1: PVT Samples Regions

Figure (2) shows one of PVT parameters, Pb (bubble point) as function of depth. The results of this figure are scattered, it is impossible to define any acceptable conclusion about their trend with depths. Only two wells, ZB-180 that located in Safwan dome and ZB-205 located in Hammar-Shuaiba dome, have the same bubble point.

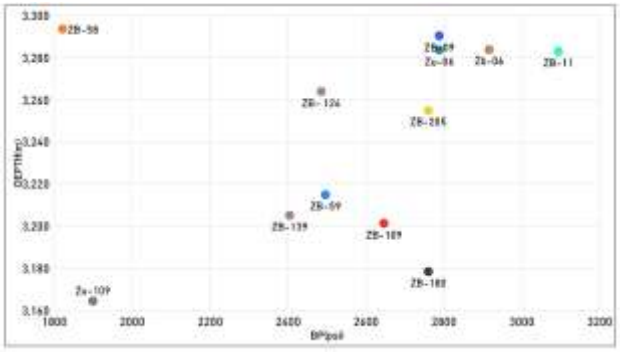

Figure 2: Bubble point as function of depth

2.1 Old PVT reports analysis

At the early stage in the third pay reservoir, the bottom hole sample from Well ZB-6 that collected in 1990 was selected by the company as the most representative for Zubair 3rd Pay Formation. The main reasons were the fluid sample representative most of the third Pay Formation thickness about 61 meters from 125 meters [5]. The analysis for PVT report for this well shows that the chemical composition was determined by distillation technique instead of the chromatographic technique and restricted to C6+ fraction; these compositional data are not accurate to describe reservoir fluid properties, due to the limited range of components.

Fluid sample that collected from well ZB-59 in 1985 could be considered representative when review all the result of properties, but it was produced from (4 m) unit H only of 3rd pay thickness, it was disregarded. Moreover, chemical composition was determined by distillation technique too and restricted to C6+ fraction.

The sample from well ZB- 109 that collected in 1988 is considered as representative in the model and the PVT data for this well is used until now in reservoir evaluations by operating company of Zubair field. Because the fluid sample is taken from H level only and not representative all 3rd pay layers (H+L+AB), as well as it can be noted that the values of saturation pressure, dissolved gas and volumetric factor (Bo) for this sample are less properties values when compared with the new samples from another wells as shown in the **Table(1),** so it is not logical to consider this well as representative for 3rd pay formation.

Table 1: summary of PVT for third pay Samples wells

Properties	*ZB-109*	*ZB-106*	*ZB-124*	*ZB-180*	*ZB-205*
T_{res} (°F)	215	219	206.6	226	216.2
Pressure res psi	4614	3607	3403	3605	3560
Pb @T_{res}	2645.5	2470	2428	2760	2760
Rs (scf/stb)	763	519	755	832	920
Bores (bbl/bblst)	1.5132	1.334	1.489	1.531	1.583
Oil Density (g/cc)	0.699	0.7584	0.6996	0.693	0.691
Oil viscosity (cp)	0.49	1.049	0.552	0.50	0.49

2.2 New PVT reports analysis

The surface samples for wells ZB-106 and ZB-124, only separator gases and liquid companion samples were collected at separator in 2010. These wells have lower values in saturation pressure, Rs and composition of recombined oil are significantly heavier that may be because GOR value that used to recombination or the sampling taken in unstable separator condition.

The new bottom hole samples that taken in 2012 and 2013 from wells ZB-180 and ZB-205 are shown the same value in bubble point pressure and very similar properties as shown in the **Table(1)** and **Figures (2), (3)**.

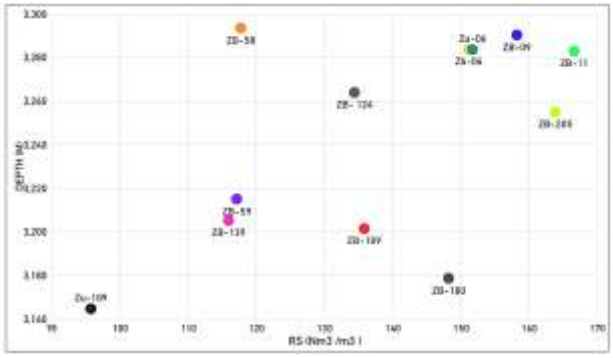

Figure 3: Rs as function of depth

Unlike the sample from well (ZB-06), chemical composition for ZB-180 and ZB-205 are extended to C36. While composition of recombined oil of wells ZB-106 and ZB-124 are significantly heavier, due to the probably underestimated Field GOR value or to an unstable equilibrium conditions existed in the separator unit at the sampling time.

If the saturation pressures of at least two samples are similar to each other, with a reciprocal deviation below 2%, and if these saturation pressures are below reservoir pressure, the samples may be considered as reliable and representative of reservoir fluid [6].
Finally, the sample of the well ZB-205 must be considered as representative and to be use for black oil reservoir simulation model with bubble point value about 2760 psi.

3. Pressure Analysis

During production period, the reservoir pressure dropped from an initial value of 5355 psi to less than 3000 psi and more gas will be produced because most of wells produce oil under bubble point (2760 psi). The GOR will be high, This is bad sign and that mean reservoir pressure is reduce dramatically and gas will produced , finally the energy that use to push the oil from reservoir to the surface will decrease. In this section, static bottom hole pressure data have been analyzed to see the pressure depletion. Based on injection pattern, Hammar –Shuaiba dome is divided into four parts, each part between injection lines as in the **Figure (4)**.

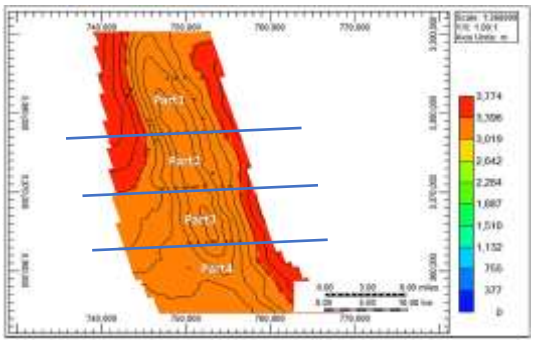

Figure 4: Hammar-Shuaiba map

The pressure data for period before start injection (1951-1998) show higher pressure depletion due to higher production in Hammar- Shuaiba and that data are more scattered. The highest depletion is in part 3, in the central and north –central areas in Hammar-Shuaiba dome as shown in the **Figure (5)**.

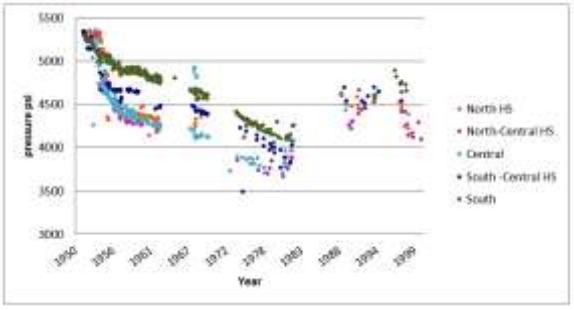

Figure 5: Hammar-Shuaiba pressure trend (1951-1998)

For the period (1999-2003), the first water injection wells start to inject in third pay reservoir. The analysis show that all parts have strong pressure depletion before water injection of about 270 psi /year and still depleted just after water injection to about 140 psi/year and Re-pressurization after increase the injection in 2001 as in **Figure(6)**.

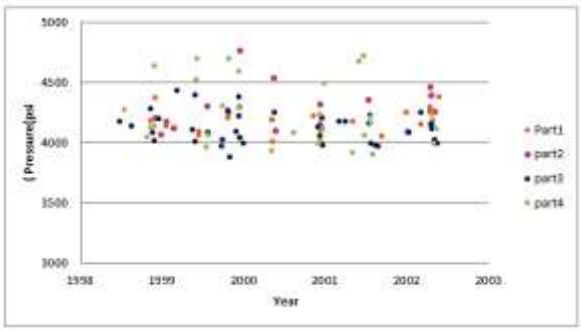

Figure 6: Hammar-Shuaiba pressure trend (1999-2003)

In the period of natural depletion (2003-2011) without water injection, the pressure decline was around 75 psi/year, the wells that located in various zones of Hammar Shuaiba show homogeneous depletion, the wells located in the circumferential area show higher pressure trend as in **Figure (7)**.

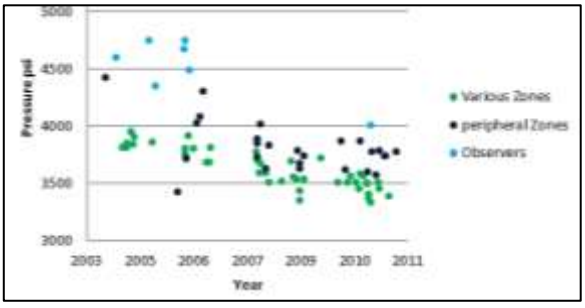

Figure 7: Hammar-Shuaiba pressure trend (2003-2011)

In the period (2011-2018), some points do not show a clear trend, these either originate from injection tests or come from measurements that are considered unreliable. Some wells in the part 3 experienced a high GOR with high-pressure depletion during production from third Pay. Pressure analysis shows a strong depletion started from 2013 especially in the part3 (points below 3000 psi) as shown in **Figure (8)**.

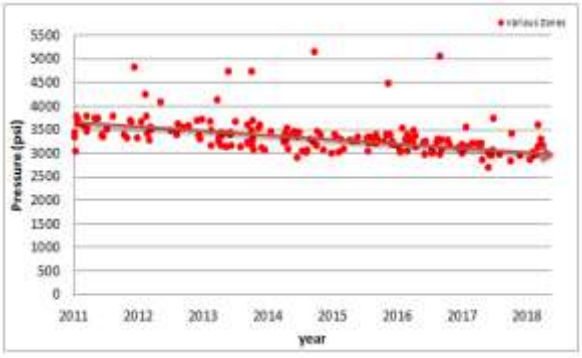

Figure 8: Hammar-Shuaiba pressure trend (2011-2018)

4. Conclusions

The major outcomes of this paper can be listed as follows:

1- The sample of the well ZB-205 must be considered as representative and to be use for black oil reservoir simulation model with bubble point value about 2760 psi.

2- The PVT samples are taken at different layers and locations in the field as well as at different temperatures (the range from 98.9 °C to 105.3 °C). Based on this reuslt, the data are scattered, being not possible to define any acceptable conclusion about their trend versus depths.

3- PVT data for well ZB-109 is used until now in reservoir evaluations and represent as average fluid properties for completely third pay reservoir. This is not logical because the fluid sample is taken from H level only and not representative all 3rd pay layers (H+L+AB) as well as it can be noted that the values of saturation pressure, dissolved gas and volumetric factor (Bo) for this sample are less properties values when compared with the new samples from another wells.

4- Historical pressure behavior shows that water injection is beneficial to maintain stable pressure trend.

5. Recommendations

New PVT samples must be taken for different areas in the field and different Layers to make sure that one PVT will represent all the field or divide the field by regions and develop the model.

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Nomenclature

GOR	Gas Oil Ratio
PVT	Pressure/Volume/Temperature

تحليل سلوك الضغط والفحوصات المختبرية للسوائل المكمنية لمكمن العطاء الثالث لحقل الزبير النفطي في جنوب العراق

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الخلاصة – في هذا البحث تم تحليل سلوك الضغط والفحوصات المختبرية للسوائل المكمنية المستخدمة في الموديل الذي يصف مكمن العطاء الثالث لحقل الزبير النفطي. حيث تظهر الابار الواقعة في منطقة حمار-شعيبة ارتفاعا في نسب الغاز الى النفط تتجاوز 1000 قدم مكعب قياسي/ برميل خزن مكمني. هذه اشارة غير جيدة لان ضغط المكمن ينخفض بشدة ويصاحبه انتاج للغاز وفي النهاية ستنخفض طاقة الدفع في المكمن ولأيمكن انتاج النفط. تم جمع وتحليل 11 نموذج مكمني من كل مناطق مكمن العطاء الثالث على مر السنين، سبعة نماذج منها في منطقة الحمار-شعيبة. ان نتائج الفحوصات المختبرية كانت مبعثرة، حيث لا يمكن تحديد اي استنتاج مقبول بين مستوى القيم والعمق مع الاخذ بنظر الاعتبار ان القيم عند درجات حرارة مختلفة. ان الاختلاف الرئيسي بين الفحوصات المختبرية القديمة والجديدة في ضغط الفقاعة عند الظروف المكمنية الذي ازداد من 2646 *psi* الى 2760 *psi*. سلوك الضغط التاريخي يوضح ان حقن الماء مفيد للحفاظ على مستوى الضغط المستقر. يظهر تحليل الضغط انخفاض كبير في بداية عام 2013 في مناطق مختلفة من قبة حمار-شعيبة في مكمن العطاء الثالث.

الكلمات الرئيسية – " تحليل الضغط ،فحوصات مختبرية ، ضغط الفقاعة ،نسبة الغاز الى النفط ".