A View for Potential apply Enhanced Oil Recovery Projects in Iraqi Oil Fields

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Abstract

The exploration of the large, untapped energy supply is the biggest problem the oil industry has ever faced. In the past decades, the petroleum industry has been engaged in the research and development of various enhanced oil recovery (EOR) processes needed to produce the residual oil in reservoir. Several methods were used in different types of formations all around the world. The EOR method primarily aims to recover the "residual" oil throughout the whole reservoir. This is performed by increased microscopic oil displacement and performance of volumetric sweep. No particular strategy can be known as "to cure everything" for the recovery of additional oil from of reservoir. Each method has its own unique application. Reservoir characteristic and fluid properties and previous development experience should be evaluated before starting an EOR operation. An analysis of the previous secondary recovery stage is important to evaluate the key reasons for retaining the residual oil in this reservoir. This paper would present EOR strategies including method specifications, manufacturing mechanisms, limitations, problems and professional screening guides. It indicates that the method of gas injection arrives in the first rank of applications while the method of Chemical Flooding takes the second spot. The third EOR process utilized for sandstone and carbonate reservoirs is thermal recovery. It also shows that about 40% of the gas injection technologies were used in carbonate reservoirs, while 10% of thermal recovery methods were used in carbonate reservoirs. The present paper focuses on Iraqi oil fields that have been or are being processed. For this Iraq oil field the grade shows zone-based, structure, reservoir, geological age, lithological reservoir, depth, pay thickness net, porosity, permeability, API gravity. The screening criteria for potential EOR ventures in Iraq are assessed in this classification. The article affirms that a significant proportion of Iraqi oilfields are normal or developed, but in future the cautious use of EOR technology in many Iraqi petroleum fields would need to be taken into account so that ultimate recovery can be increased and the lifetime of reservoirs prolonged.

Keywords: oil recovery, enhanced oil recovery, water-flooding, oil reserves, reservoir conditions, Oil reservoir.

1. Introduction

Oil production declined due to oil field problems. However, oil demand continues to rise year after year Because of economic prosperity. Therefore, techniques must be utilized to improve oil production and solve problems in fields.

The renewable generation reservoir energy cannot normally be improved by primary processes to generate more than 40% of the current initial oil. As these energies are exhausted, techniques for chemical flooding or gas injection can be applied during the secondary recovery of the reservoirs Process for the control of the reservoir energy.

In general, waterflood means injecting water into the reservoir through a well (injector). The water is pushed into the pores to pump the oil into the generating wells. The amount of water in the extracted fluids rises slowly until the expense of water collection and disposal reaches oil output revenue. At this point, maintaining the project is not profitable and the waterflood is halted. Some wells remain commercially viable with water cut down to 99%2. Other secondary methods of recovery involve CO2 inundation and injection of hydrocarbon gas involving a close supply of cheap gas in adequate amount. As secondary recovery techniques have entered the stage of non-economic operation, tertiary recovery (EOR) is becoming the next strategic technique for the production of oil and gas reserves.

The operation of the EOR relies on the oil characteristics. EOR refers to the techniques for light oils after primary and secondary recovery which includes surfactant flooding, polymer flooding, miscible push, and even thermal methods. For heavy oils, EOR means techniques that involve injection of steam and in-situ combustion after primary recovery. Using improved oil recovery strategies, the economic benefit of established hydrocarbon areas can be maximized by growing oil recovery and expanding field existence. It may be challenging to classify related ventures in either area because of the vast number of EOR approaches and variations of reservoirs to be addressed.

Because oil production through the EOR process is complicated, dangerous and involves huge costs of capital, it is necessary to choose the EOR system properly for a certain reservoir in order to achieve an effective and viable project. The most challenging question confronting reservoir engineers and specialists is how to pick the right approach for increasing oil output on the basis of technological and economic factors. To accomplish this task, several variables such as depth of reservoir, area of reservoir, temperature of reservoir, porosity, permeability, oil gravity, and oil viscosity must be carefully analyzed as well as how these factors will influence each other.

In the past two decades, different EOR methods have been used. The world's most common gas injection (CO2, N2, and hydrocarbon gas) includes more than 51 % of EOR projects. The second phrase is thermal recovery with more than 41% of the EOR programs. Due to the high expense demanded by this process, chemical flooding is the third technique with more than 8 percent of EOR projects. Figure . (1) .shows the percentage of Enhanced Oil Recovery projects.

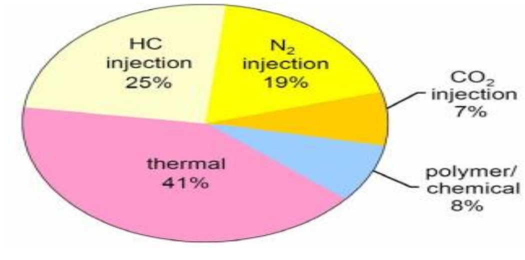

Figure. 1. Enhanced Oil Recovery projects percentages .

2. Enhanced oil recovery methods currently applied in Iraq

2.1. Gas Injection

The gas injection method is used to improve the recovery from light, condensate and volatile reservoirs. Carbon floods require the injection of miscible or immiscible gas into reservoirs. The interface tension between the two fluids (oil and gas) is therefore very low, resulting in a very effective microscopic shifting operation. The hydrocarbon gas can be the displacement fluid Initial contact oil mixes. Miscibility in the case of LPG slug or solvent floods, enriched (condensing) gas and high-pressure (vaporizing) gas drives is reached at different pressures. Oil displacement by propane or LPG is miscible in all proportions at first contact. For high-pressure gas (i.e. CO2 or nitrogen), oil displacement typically happens through multiple contacts. The focus has been moving in recent years to less precious non-hydrocarbon gasses such as CO2, nitrogen and flue gasses. Miscible flooding after thermal recovery adds the most to the various methods of Enhanced Oil Recovery. Screening of recovery parameters for gas injection (hydrocarbon and non- hydrocarbon gas) methods is seen briefly in Table 1. Fig. 1,2 Shows the CO2 injection and hydrocarbon gas injection.

	Oil properties			Reservoir characteristic					
EOR	Gravity (API)	Viscosity (Cp)	composition	Oil saturation	Formation type	Net thickness (Ft)	Perm. (md)	Depth (Ft)	Tem. (°F)
CO_2	>22-36	<10-1.5	High % of c5 to c12	>35-70	Sandstone + carbonate	Wide range	NC	>2500	NC
Nitrogen and flue gas	>23-41	<0.4-0.2	High% of c1 to c7	>40-75	Sandstone + carbonate	Thin unless dipping	NC	>6000	NC
Immiscible gases	>12	<600	NC	>35-70		Good vertical	NC	>1800	NC
hydrocarbon gas	>23-41	<3-0.5	High % of c2 to c7	>30-80	Sandstone + carbonate	Thin unless dipping	NC	>4000	NC

Table.1. proper parameters to apply gas injection project (NIOC)

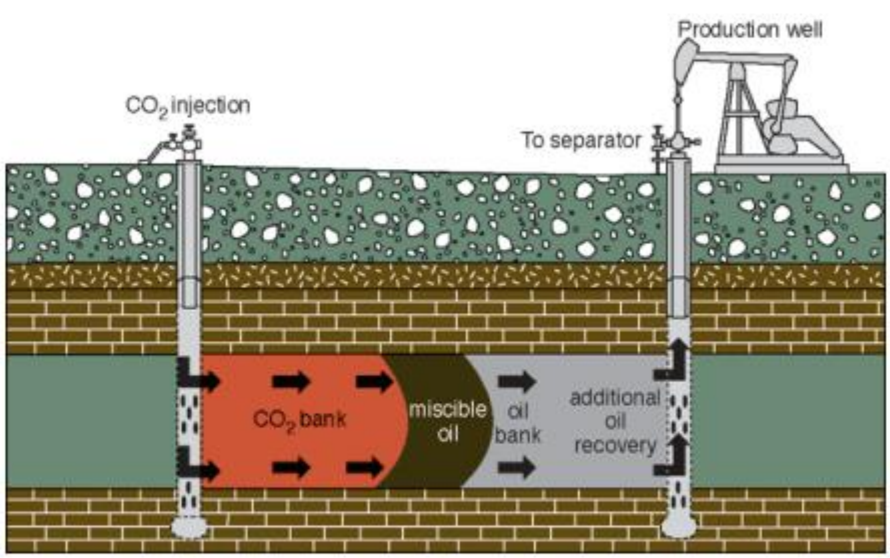

Figure.1. CO2 injection (Advanced CERT Canada Inc)

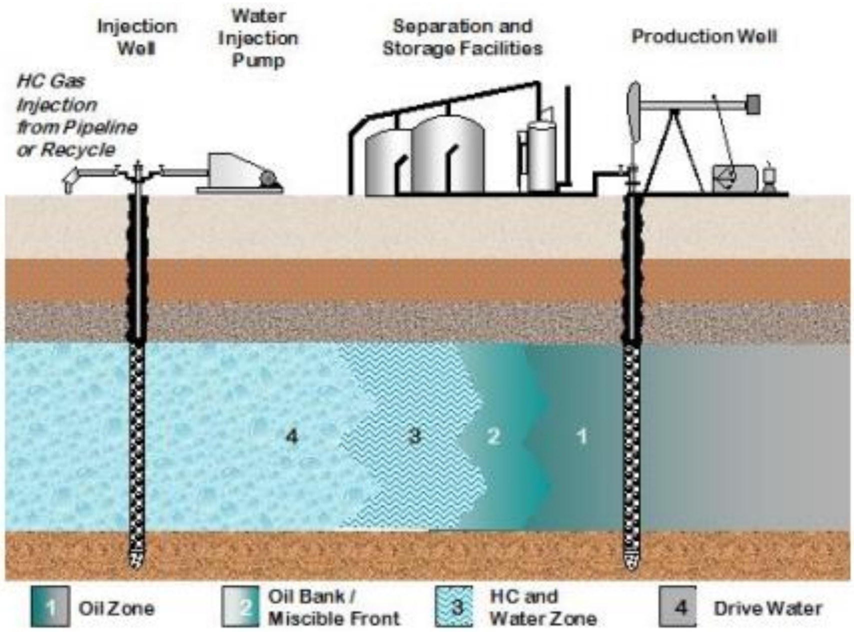

Figure.2.hydrocarbon gas injection *(Advanced CERT Canada Inc.)*

Gas injection studies have been carried out as early to evaluate enhanced oil recovery in Iraq. It is indicated in the table. 2 the oil fields to which it was applied gas injection method for the enhanced oil recovery.

Oil field	Reservoir	Age	Reservoir lithology	Depth (m)	Por. (%)	Perm. (md)	API	S%	EOR
Chia.surkh	Fatha Jeribe	Miocene Miocene	Carbonate carbonate	1010 1720	20 18	--- ---	41 43	0.58 0.67	Gas Injection
Jumber	Jeribe Euph/serik Shiranish	Miocene Miocene Camp-masat.	Carbonate carbonate carbonate	1554 1586 2082	20 30 ---	4 40 ---	40.5 40.6 ---	1.2 1.3 ---	Gas Injection
Jaria pika	Jeribe Dhiban Euphrates serikagni	Miocene Miocene Miocene Miocene	carbonate carbonate carbonate carbonate	1457 1509 1626 1651	--- --- --- ---	--- --- --- ---	48 52 52 52	2.2 0.1 0.1 0.1	Gas Injection
Judaida	jeribe Dhiban Euphrates Kirkuk groub kometan	Miocene Miocene Miocene Oligocene turonian	Carbonate Carbonate Carbonate Carbonate carbonate	2236 2286 2385 2445 3247	17.4 16.9 18.5 17.8 8.9	0.29 21.1 7.8 36.5 0.04	26 25 24.9 25 18	2.9 --- --- 4.18 ---	Gas injection
khabaz	Jeribe Kirkuk groub Mauddud shuaiba	Miocene Oligocene Albian Aptian	Carbonate carbonate carbonate carbonate	2063 2111 2753 3045	20 15 12 8	146 740 25 83	37 37 29 39	2.08 1.5 2.05 2	Gas injection

Table.2.gas injection activities of the Oil fields Iraq

2.2. Chemical Flooding

Chemical flooding is the second most significant of all EOR development projects. It was used for both carbonate and sandstone formations. The 1980s were deemed the best period (peak) for the recovery of oil from chemical floods. These processes involve optimal conditions for water injection, since they are waterflood modifications. Chemical flooding refers to oils that are more viscous than gas-injection appropriate oils, but less viscous than oils that can be extracted through thermal processes. Reservoirs are suitable, with medium permeability. The appearance of a gas cap is not attractive, since the cap is re-saturated with energy. Formations with large clay content are unacceptable, since the clays improve adsorption of the chemicals inserted.

In the chemical flooding three types of chemicals were included. Polymer Group is the most commonly used form for various research sites where the quality of sweeping is significantly enhanced. The group of surfactants is the second class of chemicals used in formulations where the interfacial tension between oil and water is urgently required. Mixed polymer and surfactant (SP) solutions are widely used, also called micellar flooding or micro-emulsion flooding. The third form of chemical flooding is the Caustic solutions community, also known as the alkaline solutions group [5]. A polymer-surfactant-alkaline mixture (PSC) can be used. The technical guides for the screening process of the chemical flooding show in table.3.

	Oil properties			Reservoir characteristic					
EOR	Gravity (API)	Viscosity (Cp)	composition	Oil saturation	Formation type	Net thickness (FT)	Perm. (md)	Depth (Ft)	Tem. (°F)
Polymer Flooding	> 25	<150 (rather between 10-100)	Not critical	> 10 % PV mobile oil	Sandstone preferred but can be used in carbonate	Not critical	>10	< 9000	< 200
Surfactant Flooding	> 25	< 30	Light to intermediates are desirable	> 30 % PV	Sandstone preferred	> 10	> 20	< 8,000	< 175
Caustic Flooding	13° -35°	< 200	Some organic acids required	Above waterflood residual	Sandstones preferred	Not critical	> 20	< 9,000	< 200

Table. 3. Proper parameters to apply Chemical Flooding project (NIOC)

A method has been applied in oil fields according to screening required Oil properties and Reservoir characteristic. It is indicated in the table. 4 the oil fields to which it was applied chemical injection method for the enhanced oil recovery. Fig. 3 Shows the Polymer injection.

Oil field	Reservoir	Age	Reservoir lithology	Depth (m)	Por. (%)	Perm. (md)	API	S%	EOR
Abu-Ghirab N	Kirkuk Group Mishrif Mauddud	Oligocene Cen-Tru Albian	carbonate carbonate carbonate	3014 3797 4258	18 12 13	400 93 5.6	24 24.9 26	3.93 3.6	Polymer flooding
Ain zalah	Shiranish Mushorah Mauddud	Camp-maast Senonian Albian	carbonate carbonate carbonate	1607 2231 3438	3 18 18	Fr.re ---	31.5 31.4 31.4	2.6 2.7 2.7	Polymer flooding
Butmah East	Shiranish Kurra chine	Camp-maast U Triassic	carbonate carbonate	1277 2981	3	Fr.re ---	29.3 36.2	2.6 1.08	Polymer flooding
Butmah west	Kurra chine Geli khana	U Triassic M triassic	carbonate carbonate	2790 3775	--- ---	--- ---	35 34	1.2 0.04	Chemical flooding
khurmala	Kirkuk groub Mauddud shuaiba	Oligocene Albian Aptian	carbonate carbonate carbonate	815 1771 2031		150 --- ---	34 38 29	10. 5 1.95 ---	Chemical flooding
Ahdab North	Tanuma Khasib Mishrif Rumaila Mauddud Nahr Umr Shuaiba	Senonian Turonian Cenomanian Cenomanian Albian Albian Aptian	carbonate carbonate carbonate carbonate carbonate carbonate carbonate	2542 2595 2700 2806 3080 3385 3482	23 22.5 14.8 192 16.7 __ __	_ 80 63 63 0.7 __ __	5 25 25 24 22 22 22	---	Polymer flooding
Buzurgan	Jeribe	Miocene	carbonate	2850	20	15	31	---	Chemical flooding
Buzurgan south	Kirkuk groub mishrif	Oligocene Cenomanian	carbonate carbonate	2864 3733	24 16	20 47	25 23	--- 3.9	Polymer
EB Diyala	khasib Mishrif Nahr umr zubair	Turonian Cenomanian Albian L cretaceous	carbonate carbonate Sandstone Sandstone	2432 2590 3213 3408	30 15 20 20	__ __ --- __	21 19 32 27	3.81 3.76 1.3 1.5	Chemical flooding
Halfaya	Jeribe Euphrates Kirkuk GrouSadi Tanuma Khasib Mishrif Nahar Umr Yamama	Miocene Miocene Oligocene Senonian Senonian Turonian Cenomanian Albian L Cretaceous	carbonate carbonate carbonate carbonate carbonate carbonate carbonate carbonate carbonate	1902 --- 1913 2608 2733 2748 2833 3505 4369	18 20 24 18 16 16 17 18 9	— — --- — — --- --- ---	22 22 22 26 26 21 20 31 27	__ __ __ __ __ 4.7 2.12 __ ---	Chemical flooding

Huwaiza	Hartha Sadi KhasMishrif Nahr UmZubair Yamama __	Camp-maast Senonian Turonian Cenomanian Albian L Cretaceous L Cretaceous	carbonate carbonate carbonate carbonate Sandstone Sandstone carbonate	2912 2966 3078 3145 3721 4095 __	__ __ --- __ __ --- ---	__ __ --- __ __ --- ---	26 26 20 20 20 --- ---	__ --- __ __ --- --- ---	Polymer flooding
Kumait	Mishrif Nahr Umr	Cenomanian Albian	carbonate carbonate	3049 3645	11.3 18.5	--- ---	23 30	3.9 22.9	Chemical flooding
Luhais	Nahr Umr Zubair	Albian L Cretaceous	carbonate Sandstone	2482 2776	--- ---	20 20	32 33	--- ---	Chemical flooding
Noor	Mishrif Nahr Umr	Cenomanian Albian	carbonate Sandstone	3308 3947	14 22	--- 120	23 25	--- ---	Chemical flooding

Table.4. Chemical Flooding activities of the Oil fields Iraq

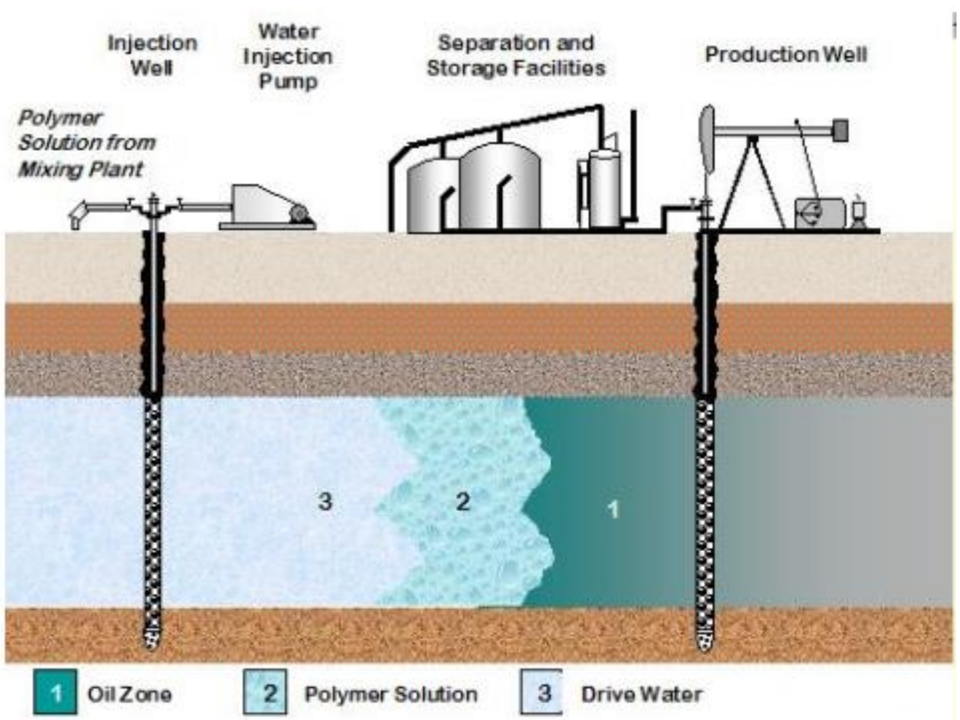

Figure 3.Polymer injection (Advanced CERT Canada Inc.)

2.3. Thermal Recovery

Many reservoirs contain highly viscous crude oil, which we call "heavy oil reservoirs”. Attempts to extract such oil would yield very low recoveries through primary recovery or through waterflooding. This oil is either too viscous to spill, or it takes strong enough pressure to break the reservoir. Even if the oil is movable by waterflooding, low recovery is given by the subsequent fingering induced by the unfavorable viscosity ratio. Applying heat is also the only possible alternative for such reservoirs. Thermal methods are mainly used for heavy viscous oil (10-20 API) and tar sands. Approximately 60% of the overall EOR oil supply was attributed to thermal recovery. There are two types of thermal recovery for the development of heavy oil formations: steam injection and in-situ combustion. Steam injection is a method in which the heat is supplied by steam stream to the formation. This method has three techniques: 1) Steam stimulation 2) Steam flooding, and 3) Steam assisted gravity drainage (SAGD). All three methods are used globally to extract heavy to extra-strong oil from sources of sandstone. Canada and Russia are the two areas where thermal regeneration is centered.

The oldest thermal recovery process is n-situ combustion (ISC). It was used with various achievements and defeats since the 1920s. Although many ventures have been recorded to be economically appealing, this method of recovery is seen as a high-risk operation. Fig. 3 Shows the Steam injection. The technical screening guides for the Thermal Recovery are shown in Table 5.

	Oil properties			**Reservoir characteristic**					
EOR	Gravity (API)	Viscosity (Cp)	composition	Oil saturation	Formation type	Net thickness (ft)	Perm. (md)	Depth (Ft)	Tem. (^{0}F)
Steam Stimulation	8-25	<100000	Not critical but some light ends will help steam distillation	>40	Sand or sandstone with high porosity and permeability preferred	>20	> 200	<5000	Not critical
Steam Flooding	< 25	> 20	Not critical but some light ends will help steam distillation	> 500	Sand or sandstone with high porosity and permeability preferred	> 20	> 200	300-5,000	Not critical
In-Situ Combustion	< 40°	< 1000	Some asphaltic components to aid coke deposition	> 500	Sand or sandstone with high porosity	> 10	> 100	> 500	> 150

Table 5- proper parameters to apply Thermal Recovery project (NIOC)

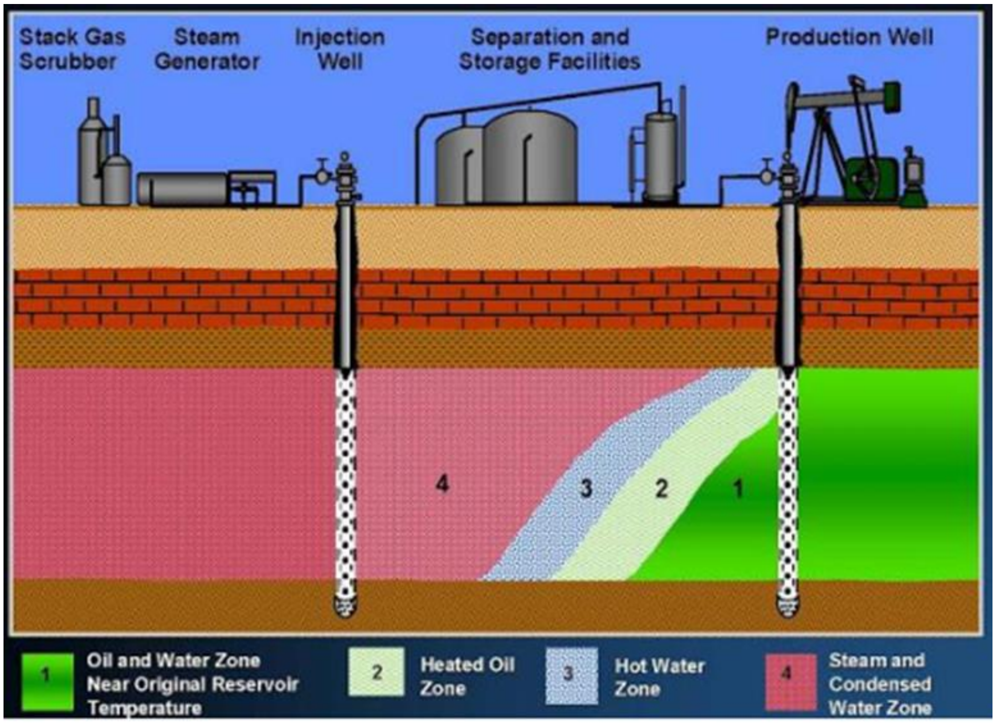

Figure 5- Steam injection (NIOC)

Table 1 shows the thermal recovery activities that have been operated in heavy oil Fields.

Oil field	Reservoir	Age	Reservoir lithology	Depth (m)	Por. (%)	Perm. Md	API	S%	EOR
Demir dagh	Gercus Shiranish Pilsener/Har.	M Eocene Camp-maast Senonian	carbonate carbonate carbonate	1017 1567 ?	--- --- ---	--- --- ---	--- --- ---	14.9 22 14.9	Thermal recovery
Jawan	Jeribe Euphrates Hartha	Miocene Miocene Camp-masat	carbonate carbonate carbonate	175 254 693	--- --- ---	--- --- ---	15 19 20	7 6.8 5.8	Thermal recovery
Ratawi	Mishrif Ahmadi Mauddud Nahr Umr Yamama	Cenomanian Cenomanian Albian Albian L cretaceou	carbonate carbonate carbonate carbonate carbonate	2094 2324 2458 2574 2533	18 23 18 20 13	44 9.2 10.2 152 17.2	26 15 15 25 42	--- ----- ----- ----- 1.24	Chemical Thermal Thermal Chemical Chemical

Table.6. thermal recovery activities of the Oil fields Iraq

3. Future application of EOR in Iraq

In Iraq, there are still significant opportunities for improved recovery, despite various EOR projects under way. With continuing construction stages, the fields mentioned above have substantial potential EOR output and there are several smaller oil fields that currently do not have EOR growth.

It is known that the majority of Iraq's oil fields consist of carbonate rocks. Sandstone formations, however, are also present on several oil fields in Iraq. Iraqi oil is considered as moderate and light oil in which the API gravity covers the range (20-35). A few Iraqi oils are graded as heavy oil (Jeribe reservoir 15.3 API, Euphrates reservoir 15.3 API, and Hartha reservoir 17.3 API) as the oil produced from the Qaiyarah structure. At the same time, very few oils are considered light oil with an API gravity of about 40 such as the Ajeel structure oils (Fatha reservoir 41 API, Gotnia 37 API, and Sargelu 38 API). Figure .1 shows the locations for EOR activities of the fields Iraq.

Depending on the type of rock, both gas injection techniques and chemical injection processes Good candidates for improved processing of oil extraction in Iraqi oil fields. The range of permeability and the viscosity of the oil should be taken into consideration. Most Iraqi oil fields have permeability in the range from many millidarties to nearly one Darcy. The second criterion for the screening requirements of the enhanced oil recovery method in the Iraqi oil fields is naturally fractured carbonate reservoirs. In the tables 1 Shows reservoir characteristic(oil saturation, formation type , permeability ,porosity ,depth) and Oil properties (Gravity, Viscosity, composition) in Iraqi oil fields. These reservoir characteristics can be used in screening criteria for potential EOR projects. Three technical selection criteria must be considered. For the EOR projects, lithology is the first classification criteria where thermal flooding is the dominant technique for sandstone reservoirs whereas gas injection is the best candidate for carbonate reservoirs. The second criterion is the reservoir fluid properties of which the API gravity and the viscosity are the two main parameters that are typically taken into consideration. The third is the formation properties of which the porosity and permeability ranges are the critical factors for the selection of EOR projects. The depth of the reservoir often has some effect on the selection criterion, since the pressure and temperature differential depend on the depth.

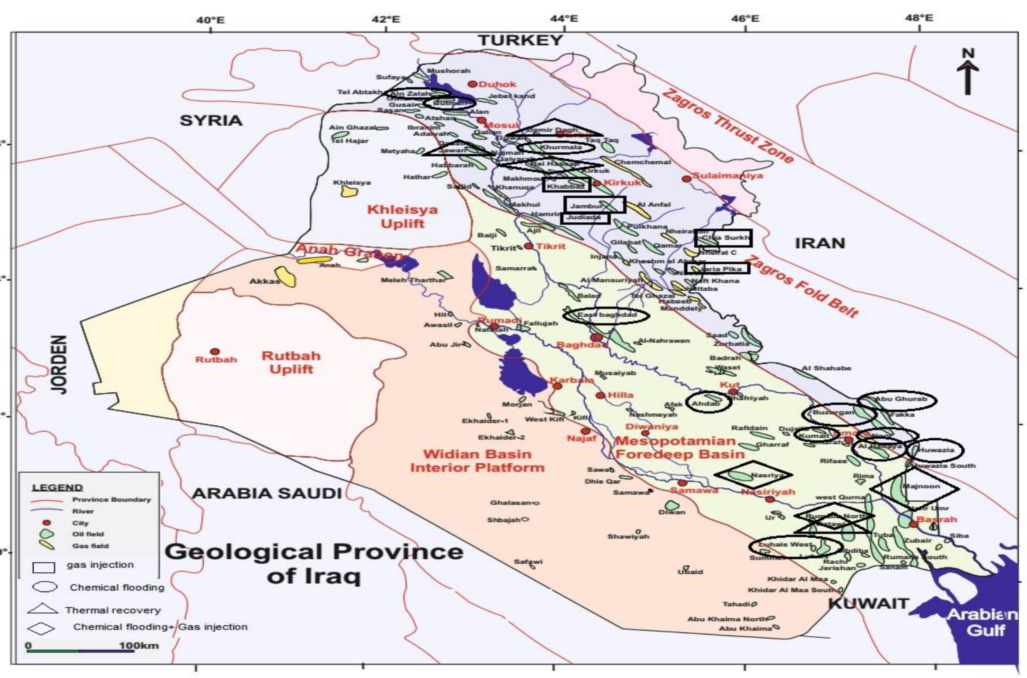

Figure 1. Locations for EOR activities of the fields Iraq.

4. Conclusions

The major phases of production were primary or secondary recovery. In the meantime, exploration activities have not been able to explore new giant fields such as Majnoon and Rumaila Fields. Most fields are then maturing, and the oil reserve and production are rapidly depleting at the same time. The EOR method was the best way to increase oil output in this instance, with tremendous remaining oil in the primary and secondary development phases.

Chemical injection is a potential EOR method to be used in the Iraq oil field. One of major barriers in implementing the method is the chemical cost. Therefore, universities and investigation organizations have been collaborating with oil companies to produce local chemicals such as surfactant and polymer. Gas injection is another method that has shown to be useful in both laboratory tests and field studies. While screening studies have shown that CO2 injection is the most desirable gas injection method to be implemented in the future, there are readily available natural and anthropogenic sources of CO2 gas.

Microbial, seismic vibration and electrical EOR methods were often deemed possible in laboratory at least. These methods were not well developed, however, and therefore are still immature to be applied in the near future.

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