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Petroleum system in Kurdistan (North Iraq)

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1. *Introduction:*

The most important petroleum systems in Iraq are the Jurassic, Cretaceous, and Tertiary Petroleum systems. The Paleozoic petroleum system is important in the Rutba-Jezira zone of west Iraq. The known extent of the Triassic petroleum system is confined to a small area in Kurdistan (north Iraq) (extending into part of north east Syria and south east Turkey).

The petroleum systems are discussed in term of their source rock richness, maturation, time of maturation and migration, reservoirs, cap rocks and the possible traps that might be associated with them.

Middle Jurassic source rocks are very important source rocks throughout S, NE, and N Iraq, due to the high TOC of the Sargelu and Naokelekan formations that where deposited throughout the Jurassic basin, it was concluded that the most of the oil of Iraq was sourced from Jurassic source rocks.

The Sargelu formation is upto 400m thick, with a TOC content of 1.7-7.6% wt%; the lower most 40m of the formation has the highest TOC content. The Sargelu and Naokelekan formations in the Kirkuk embayment entered the oil window at the end of the Eocene (35 MY) and are presently in the condensate and gas generating maturation levels.

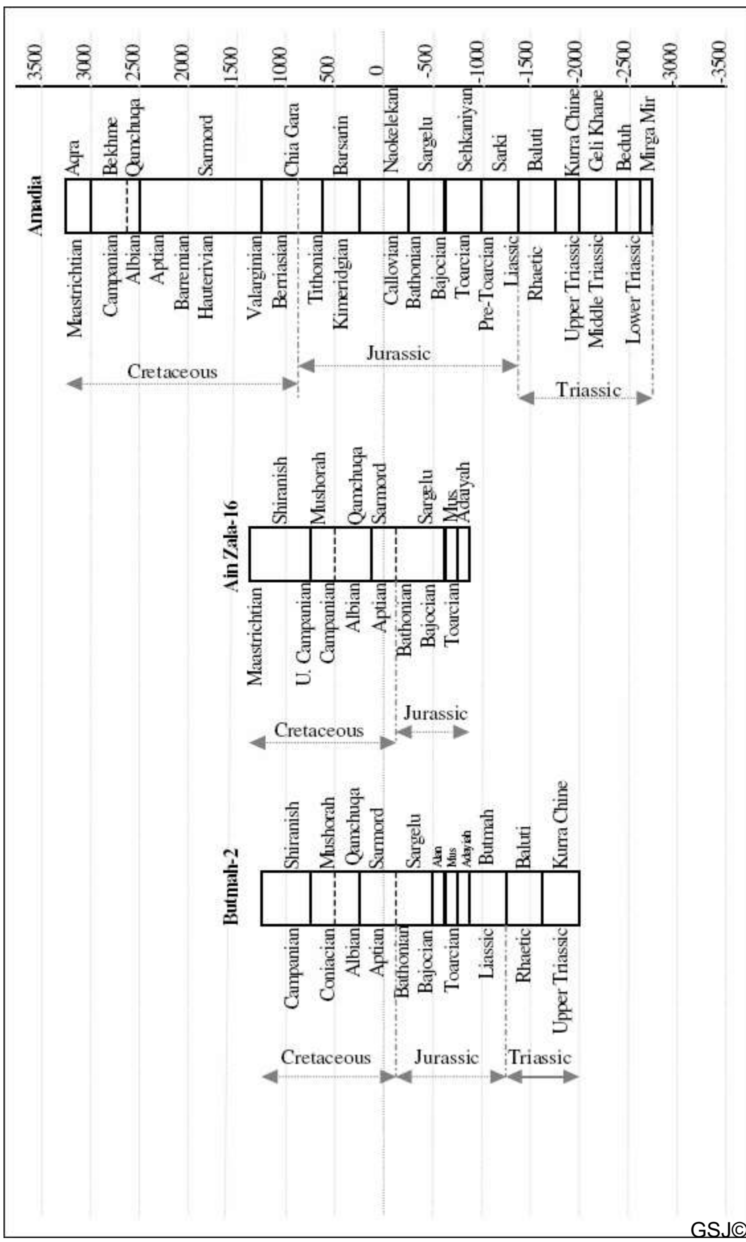
The calculated maturity of the Sargelu sourcerock indicates that it is mostly immature to early mature within the Salman zone and early mature on the Mosul high. The source rocks are mid mature to late mature within the western Mesopotamian zone and within the gas window in the eastern Mesopotamian zone. In the foothill zone, the maturity increases from early mature in the SW to mid-mature in the east. In the high folded zone, the Jurassic source is within the late maturity window. (Jassim and Al-Gailani)

The sargelu formation contains oil in fractures in some structures in N Iraq and in the Salman zone. The oil trapped in the Sargelu formation is often heavy and bituminous, because of the low maturity of this source rock in this area and the lack of a seal where the evaporites of the Gotnia formation are absent, allowing escape of the oil to the shallower Tertiary reservoirs and to the surface. The Sargelu reservoir contains oil with a wide range of oil gravities (13.3-42oAPI) and sulphur contents (1.8-2.5%). (Jassim and Al-Gailani).

2. *Kurdistan Jurassic Formations:*

Five districts in Kurdistan (Northern Iraq) have been chosen to be representing the Jurassic depositional basin, Koi Sanjak, Surdash and Sirwan-Balambo districts consists of same formation as in Amadia. The oil rich formations in Kirkuk oil fields known as Kirkuk group (first pay layers), which is belongs to the Oligocene. Kirkuk group forms sequence of reef controlled sediments, in which three separate cycles can be distinguished, table 2. The second payment layers thought to be from formations belong to the Jurassic. Accordingly, districts north of Kirkuk to Amadia district may contain undiscovered oil-reservoirs.

Figure (1) Shows description of Jurassic Formations in Kurdistan (northern Iraq), (after M.mustafa).



3. Petroleum system elements and processes:

Petroleum system elements:

I. Source rock
II. Reservoir rock
III. Seal rock
IV. Over burden rock

Petroleum system processes:

- Trap formation
- Generation, migration, accumulation of hydrocarbons

Source rock: A rock rich in organic matter which, if heated sufficiently, will generate oil or gas. Typical source rocks, usually shales or limestones, contain about 1% organic matter and at least 0.5% total organic carbon (TOC), although a rich source rock might have as much as 10% organic matter. Rocks of marine origin tend to be oil-prone, whereas terrestrial source rocks (such as coal) tend to be gas-prone. Preservation of organic matter without degradation is critical to creating a good source rock, and necessary for a complete petroleum system.

Reservoir rock: a subsurface body of rock having sufficient porosity and permeability to store and transmit fluids. Sedimentary rocks are the most common reservoir rocks because they have more porosity than most igneous and metamorphic rocks and form under temperature conditions at which hydrocarbons can be preserved. A reservoir is a critical component of a complete petroleum system.

4- Hydrocarbon seepages:

Hydrocarbon seepages and seepage-related features occur in two main belts. One belt is located along the western boundary of the Mesopotamian zone (Euphrates boundary fault), often at intersection with transversal faults; it extends further north along the Abu Jir Fault and along the Tigris river in north Iraq. The location of these seepages is clearly tectonically controlled but it is also apparently related to the western limit of the upper Jurassic Gotnia anhydrite cap rock. The two important areas of seeps are the Tigris in north Iraq and the Abu Jir Fault in west central Iraq.

The other belt of seepages is related to some along anticlinal structures in the foothill zone, for example the Kirkuk, Gilabat, and Hemrin anticlines in the Kirkuk embayment. These anticlines have a detachment level at the base of the Fatha formation. The (eternal fires) of Kirkuk structure and the numerous bitumen seepages and fused rocks produced by gas combustion in Hemrin south structure are prominent seepage phenomena.

Seepage activity along the Tigris in the Mosul area includes bitumen seepages (Mousl and Qaiyarah) and four centers of native sulphur deposits, related to oil seepage in the Fatha formation and the reduction of its Suphate (gypsam and anhydrite) beds. It is estimated that one billion tons of possible sulphur reserves formed in the four mineralization centers in north Iraq requiring a feedstock of about 5-10 billion barrels of oil for their formation.

The Abu Jir seepage zone is situated on the norh-south trending Abu Jir fault, straddling the Abu Jir basement high. It is dominated by large bitumen seepages forming crater lakes more than 2km wide or small conduits; the most famous of which are at Abu Jir, Ain Jabha, Ain Hit and Ata_it. Thick bitumen beds are interbedded with the marls and carbonates of the Fatha formation. Travertine sfinters of Miocene age are common to the south and north of Hit town. Saliferous water springs occur along this fault zone especially near Shithatha. Seepage activity clearly began in the middle Miocene. A substantial volume of oil has probably been lost in this seepage belt. Much of the oil expelled from Jurassic and lower cretaceous source rocks in the area to the east may have been dissipated along this line of seeps.

Sulphur deposits occur locally in some large karsts in the southern desert (Ain Kibritia) and are probably related to the sulphate reduction of the lower Eocene evaporites of the Rus formation possibly in the presence of hydrocarbons which had migrated through faults from deeper (probably Jurassic or older) source rocks.

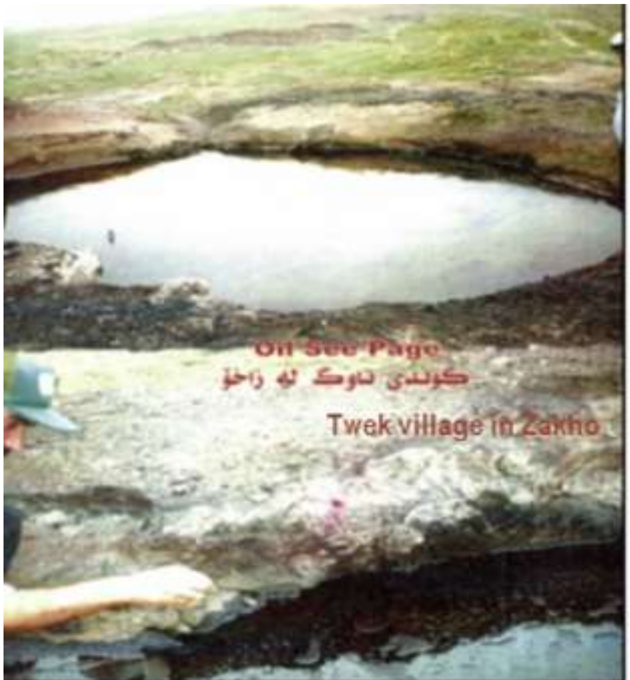


Figure (2) Shows oil springs (seepage) in Twek village, photo Sanist, geological society of Kurdistan.

5- Characterization of the Jurassic Petroleum System of Iraq generally, and Prediction of Petroleum Migration Pathways:

Multiphase-flow modeling of the Jurassic Petroleum System in Iraq provides an integrated analysis of the stratigraphic, thermal maturation, and hydrocarbon migration histories of the Zagros basin and Zagros fold belt. The model incorporates the essential geologic elements and processes required for the accumulation of petroleum in the region. Upper Mesozoic and Cenozoic reservoirs host the majority of oil generated from Jurassic source rocks. The oil generation potential of Jurassic source-rocks was modeled using kinetics for Type II-S kerogen. Fluid-flow and thermal parameters used in the model were calibrated with reservoir pressure and temperature data. Calculated present-day geothermal gradients vary locally averaging 22 C/km in the basin and 25 C/km in the fold belt. These modeled gradients match measured gradients assuming a present day heat flux of 43 and 48 mW/m2, respectively. Calculated vitrinite reflectance profiles are in agreement with measured Ro values, indicating that heat flow has been relatively uniform since the Cretaceous. Peak oil generation and expulsion occurred during Oligocene time in the basin and during the late Miocene in the fold belt. Hydrocarbon flow-path simulations show that structural traps in close proximity to modeled migration pathways that diverged from (local) intra-platform basins were filled earliest. Other structures were charged later as flow pathways focused toward these features. The location of undrilled structures in relation to predicted migration pathways should be considered when evaluating these structures for their hydrocarbon potential. It follows that structures close to modeled migration paths have lower exploration risk than those structures more distant from fluid-flow pathways.(Douglas et, al).

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6- An example on reservoir rocks in Iraq (Kirkuk group -Oligocene epoch):

The Kirkuk group is represented by a complex of backreef/reef/forereef and basinal units. In many fields the whole of the Oligocene Kirkuk group and the overlying Euphrates and Jeribe formations form one reservoir unit sealed by the Fatha evaporite section. The reservoir units of the Kirkuk group are related to reef/forereef facies fringing the shoreline of the Oligocene basin. The NE reservoir belt extends from the Mosul area in the NW to the Iranian border at Naft Khana. The SW reservoir belt extends from the western desert in the NW towards Hit, crossing the Mesopotamian zone towards the Amara area in SE Iraq.

Oligocene	Back-reef	Reef	Fore-reef
Upper	Anah	Azkand	Ibrahim
Middle	Bajawan	Baba	Tarjil
Lower	Shurau	Sheikh Alas	Palani

Table (1) Kirkuk group formation first payment layers (oligocine) of Kirkuk oil fields.

The Kirkuk group is a reservoir unit in the Khurmala, Avanah, and Baba domes of the Kirkuk structure, and in the Judaida, Khabaz, Bai Hassan, Ajeel and Hemrin fields in N iraq. In S Iraq it is a reservoir in the Jabal Fauqi, Halfaia, and Buzurgan fields. The whole complex of the Kirkuk group, Euphrates and Jeribe is refered to as the main Limestone and is equivalent to the prolific Asmari carbonates in the oil fields of the Dezful Embayment of SW Iran.

The porosity and permeability of the carbonates of the Kirkuk group are usually good; some wells within the Baba dome produced 100,000 bbl/day. The porosity ranges from 15% to 25% (averaging about 22%) and the average permeability is about 100md. The API gravity of the oil ranges from 180 to 360 (average 300); the sulphur content is 1.5-4%. The lightest oil with the lowest sulphur content is recorded in the Kirkuk structure. Oils in Oligocene reservoirs in the S Iraq oil fields are relatively heavy (200API) and may have been derived from a mid-mature Cretaceous source rock. (Jassim and Al-Gailani)

Figure (3) Structural sketch map of Kirkuk field, Kurdistan (Northern Iraq) (Gong and Gerken, 2003

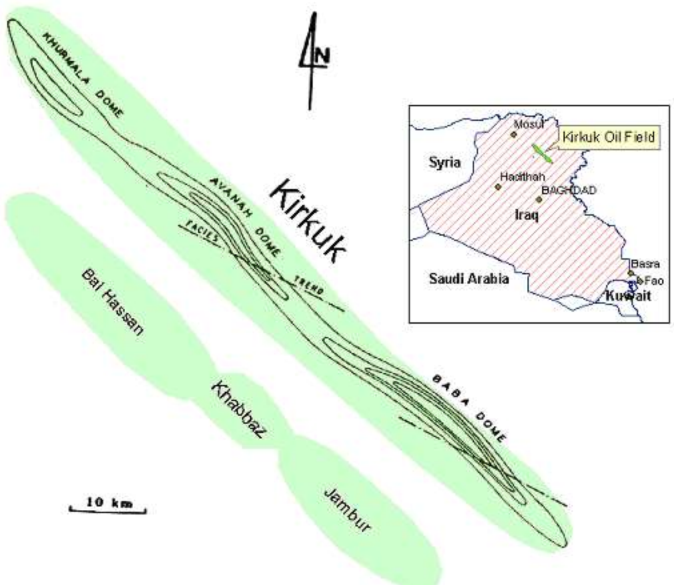
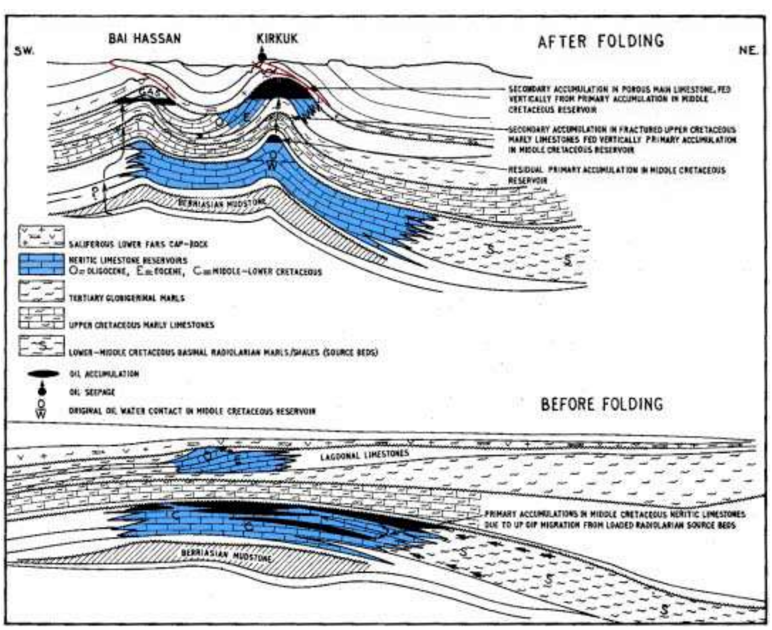


Figure (4) Schematic cross-sections of Kirkuk area, illustrating accumulations in Baba dome and Bai Hassan field. (Gong and Gerken 2003)



7- Conclusion:

Finally, after reader see the fact in these papers, they know that the petroleum system is a dynamic petroleum generating and concentrating physio chemical system, functioning in a geologic space and timescale.

The origin of the petroleum is from organic source, and according to genetic classification of petroleum system its divided in to three categories witch are charge factor, migration drainage style, and entrapment style.

The generation, migration, accumulation of hydrocarbons and entrapment are the most processes witch occur in a system.

The Iraq has an ideal petroleum system which must contain all the elements (source, reservoir, seal, and overburden rocks), and the processes must be took place at exact time (event chart). So the world_s most attractive and super giant oil fields are occur in Iraq. The study of petroleum system is also must name it, so a systematic naming of petroleum system give us a good idea and background just from the name. In addition, the mapping of the petroleum system is the important part of the investigation of petroleum system that leads us to discuss and determine the system easily from the map.

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