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## Salt Eruptions and Their Role in the Shaping of the Oil Trapping for Selected Fields in Eastern Iraq

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### Abstract

This research had been achieved using 2D seismic sections to study the presence of subsurface salty bodies in the Khashim Al-Ahmer, Galabat, Injana fields as a case study. The selected oil fields is located to the northeast of Baquba city within Diyala Governorate.

The study aims to determine the salt accumulations of the selected fields and their role in the formation of oil traps.

The interpretation of seismic data was focused on two reflectors Fatha and Jeribe Formations which belong to the lower and Middle Miocene. Structurally, Two systems of reversal faults are affecting the fields, according to seismic sections, the first represents thrust faults affected on the top part of Fatha (Red Beds & Seepage) and the layers above with large displacements and trending in an NW-SE orientation; The separation surface of these faults is the salt bed in the Fatha Formation. the second represents reversal faults affected on the lower section of Fatha (Transition beds) and the layers beneath with high displacements.

The research concludes Petroleum flow from the source was directed by the faults created by the broad Zagros tectonism to Miocene and younger traps, also seal fracturing exceeds vertical petroleum flow. The differences in fault types are caused by the presence of a salt bed within the Fatha Formation and the high variation in its thickness at the crest and flanks. So, the main recommendation of research is to implement a 3D seismic survey covering these fields to determine salt body areas.

**Keywords:** Salt eruptions, oil trapping, Structure, Hamrin anticline, Diyala

### الاندفاعات الملحية ودورها في تشكيل الاضطرابات النفطية لحقول مختارة شرق العراق

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### الخلاصة

تم انجاز هذا البحث باستخدام المقاطع الزلزالية ثنائية الأبعاد لدراسة وجود أجسام مالحة تحت السطح لحقول خشم الأحمر، جلابات، إنجانة كدراسة حالة. تقع الحقول النفطية المختارة شمال شرق مدينة بعقوبة ضمن محافظة ديالى.

الهدف من الدراسة هو تحديد التراكبات الملحية للحقول المختارة ودورها في تشكيل المصائد النفطية

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تم التركيز في تفسير البيانات الزلزالية على اثنتين من العاكسات لتكويني الفتحة والجريبي التي تنتمي إلى عصر الميوسين الأسفل والوسطى. من الناحية التركيبية ، هناك نظامان من الفوالق العكسية يؤثران على الحقول . وفقاً للأقسام الزلزالية ، يمثل الأول صدوع الدفع المتأثرة في الجزء العلوي من الفتحة (الطبقات الحمراء والتسرب) والطبقات أعلاه مع نزوح كبير واتجاه في اتجاه شمال غرب - جنوب شرق ؛ السطح الفاصل لهذه الفوالق هو طبقة الملح في تكوين الفتحة. والثاني يمثل فوالق عكسية المتأثرة في الجزء السفلي من الفتحة (طبقات انتقالية) والطبقات السفلية ذات الإزاحة العالية.

يخلص البحث إلى أن تدفق البترول من المصدر كان موجهاً من الفوالق التي أحدثتها حركة زاغروس التكتونية العريضة إلى الميوسين والمصائد الأحدث ، كما يتجاوز صخور الغطاء التدفق العمودي للبترول. الاختلافات في أنواع الصدوع الناتجة عن وجود طبقة ملحية في تكوين الفتحة والتباين الكبير في سمكها عند القمة والجوانب. لذلك ، فإن أهم ما يوصى به هو إجراء مسح زلزالي ثلاثي الأبعاد يغطي هذه الحقول لتحديد مناطق الجسم الملحية.

## 1. Introduction

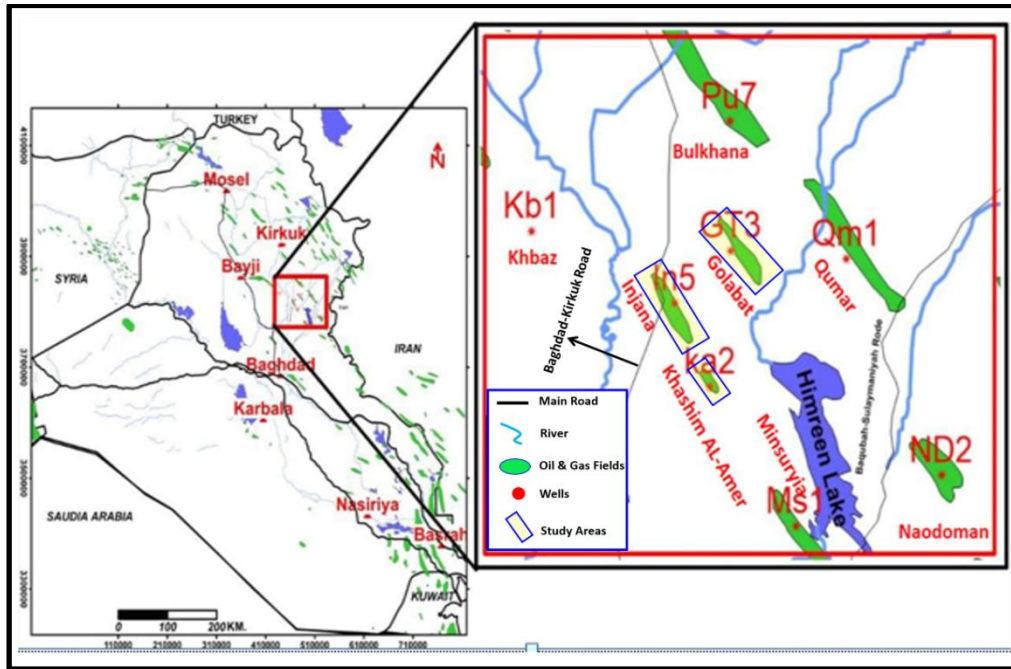
In general, most researchers agreed that salt structures are formed as a result of the rush of layers of halite upwards of salty bodies in different sizes and shapes, the average diameter of the saline structures ranges from (1-10km). Salt structures are either visible on the surface or they are subsurface. These bodies, usually known as cover rocks, are composed of anhydrite, gypsum, and limestone, [1].

One of the basic issues with structural analysis in petroliferous basins and widespread prospecting in petroleum exploration and development is the study of salt tectonics. In seismic reflection, the salt layers can change the underlying horizons for formations, resulting in various structural traps [2].

salt tectonics is categorized according to the variation in gravity potential energy that supports salt flow, [3].

## 2. Location

The area is located in the northeastern part of Iraq, Diyala Governorate within the range of the Zagros mountain series research. The research selected area includes three fields as a study case (Injana, Khashim Al-Ahmer and Galabat), (Figure 1).



**Figure 1:** Location map of the study area [4]

### 3. Stratigraphy

The general stratigraphic column of subsurface sequences of interest area is divided into two sections as below (Figure 2):

#### 3.1 Jeribe Formation:

The stated lithology is primarily 70m thick of massive recrystallized and dolomitized limestone. The Jeribe Formation was likely deposited in a lagoonal (Backreef) and reef environment since the boundaries between the upper and lower Formations are often conformable, according to [5]. The major facies is backreef-reef.

#### 3.2 Fatha Formation:

This Formation is one of the most aerially widespread and economically important Formations in Iraq, it was divided in the early years of exploration into informal units. It comprises anhydrite, gypsum, and salt, interbedded with limestone and marl. The informal units comprise from bottom to top:

1. Transition Beds normally include mudstone, thin limestone, and anhydrite beds. Transition beds usually overlie the so-called "Basal Fars Conglomerate", Which is currently a part of the Jeribe Formation. On the Mosul High, carbonates predominate in this division.
2. Saliferous Beds include deposits of siltstone, mudstone, and less frequently limestone along with anhydrite and halite.
3. Seepage Beds include strata of mudstone, limestone, and siltstone along with anhydrite.
4. Upper Red Beds include strata of anhydrite and limestone that are rather common, as well as siltstone and red mudstones.

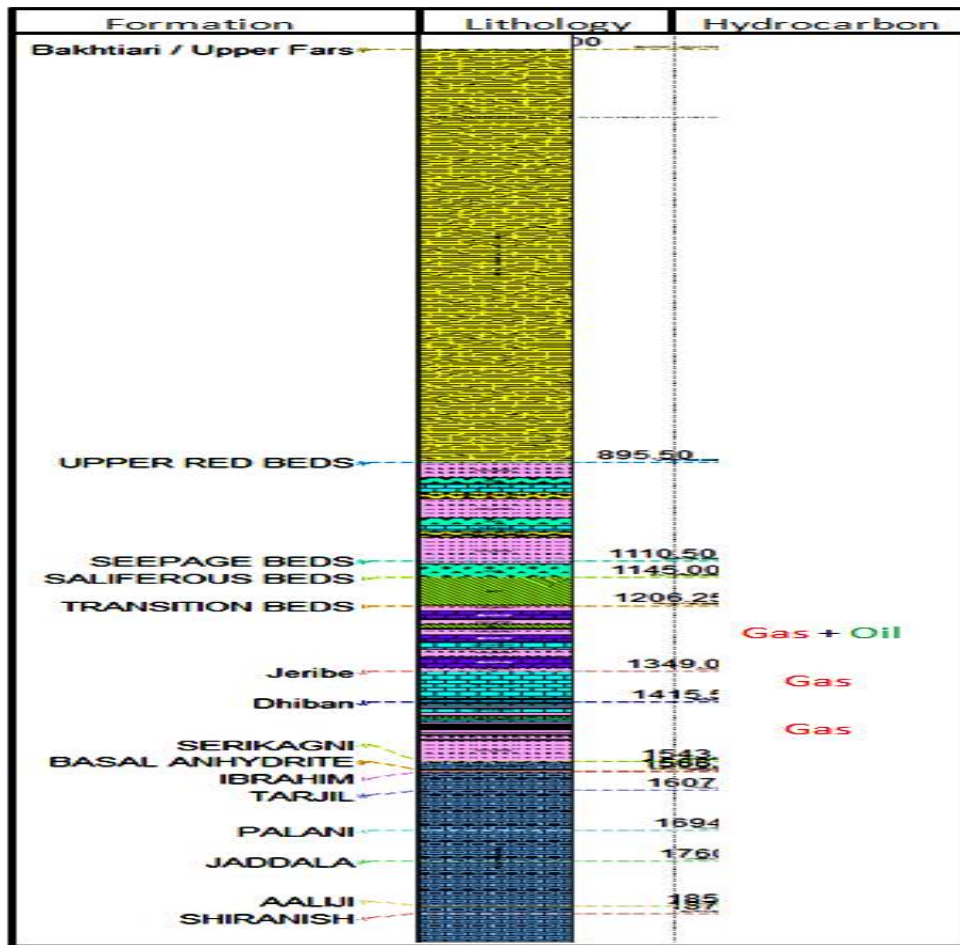
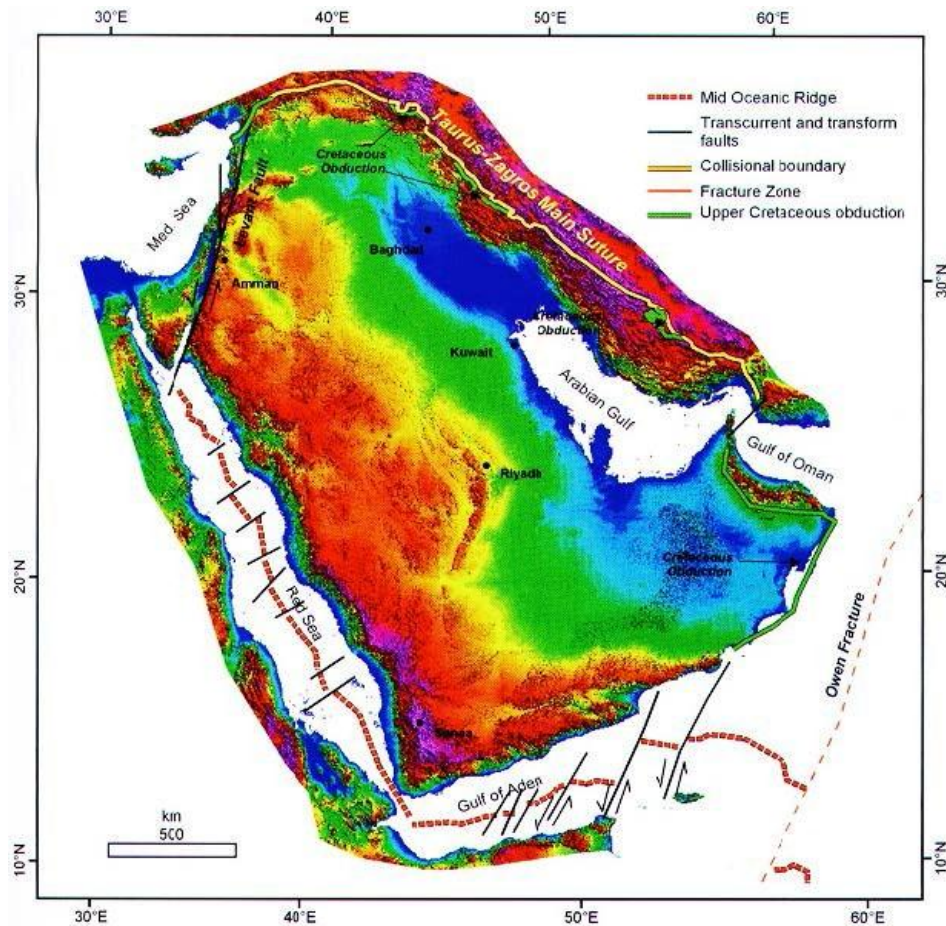


Figure 2: General stratigraphic column, [6]

#### 4. General Tectonics

Iraq is placed in the Arabian Plate's north and northeast, (Figure 3). It is located in the area that separates the Arabian shelf in the west from the severely deformed Taurus and Zagros Suture Zones in the north and northeast. Iraq has been impacted by intracratonic transgressional and trans extensional movements, which are governed by interactions between stress along the plate edge and the structural grain and fabric of the Precambrian bedrock. The collisional Taurus Zagros suture serves as a boundary for the Arabian Plate's northern and northeastern edges [7].



**Figure 3:** Tectonic map illustrates Boundaries of the Arabian plate, [8]

[9], recognized five tectonic-physiographic zones, within Stable and Unstable Shelves, these zones are from NE to SW:

1. Thrust zone, forming a thin strip around Iraq's northern and northeastern borders.
2. Folded zone, including mountainous regions in Iraq's north and northeast.
3. Mesopotamian Basin zone, consisting of the wide, flat plains between the Euphrates and Tigris rivers.
4. Salman zone, a paleo high with a shallow basement in the east of the Stable Shelf.
5. Rutbah-Jezira zone, a Paleozoic Basin in western Iraq.

The Folded zone comprises Hemrin-Makhul and Butmah-Chemchemical Subzones. The selected fields are located within the Hemrin-Makhul subzone. Structurally, It is the deepest portion of the Foothill zone and consists of significant NW-SE trending anticlines coupled with decollement thrust faults that began along surfaces at the base of Saliferous Beds of the Fatha Formation. The anticlines of this subzone are over 100km long, and Additionally, they have divided into doubly plunging Domes at the intersections of transversal faults, where the axes of the anticlines are twisted.

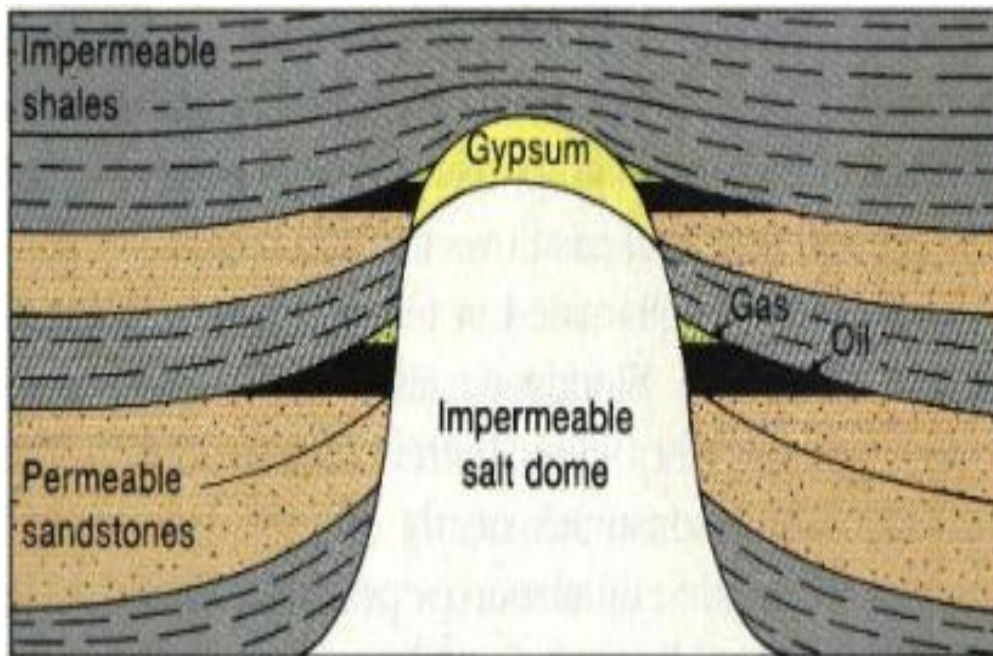
### 5. Mechanical composition of saline structures:

Billings, was the first to try to explain the mechanism of the formation of salt structures, as he pointed out that salt structures arise as a result of the rise of salt to the top, due to the difference in density between the salt and the surrounding rocks, [10].

The most important factor that must be provided for the emergence of salt domes is the presence of salt sediments called the cap rocks layer which is covered with thick sediments. The salt differs from the rest of the weaker sedimentary rocks, therefore it can flow like a viscous flow under the conditions in which the rest of the rocks behave sedimentary brittle material behavior [11].

### 6. Economic Importance of Salt Structures:

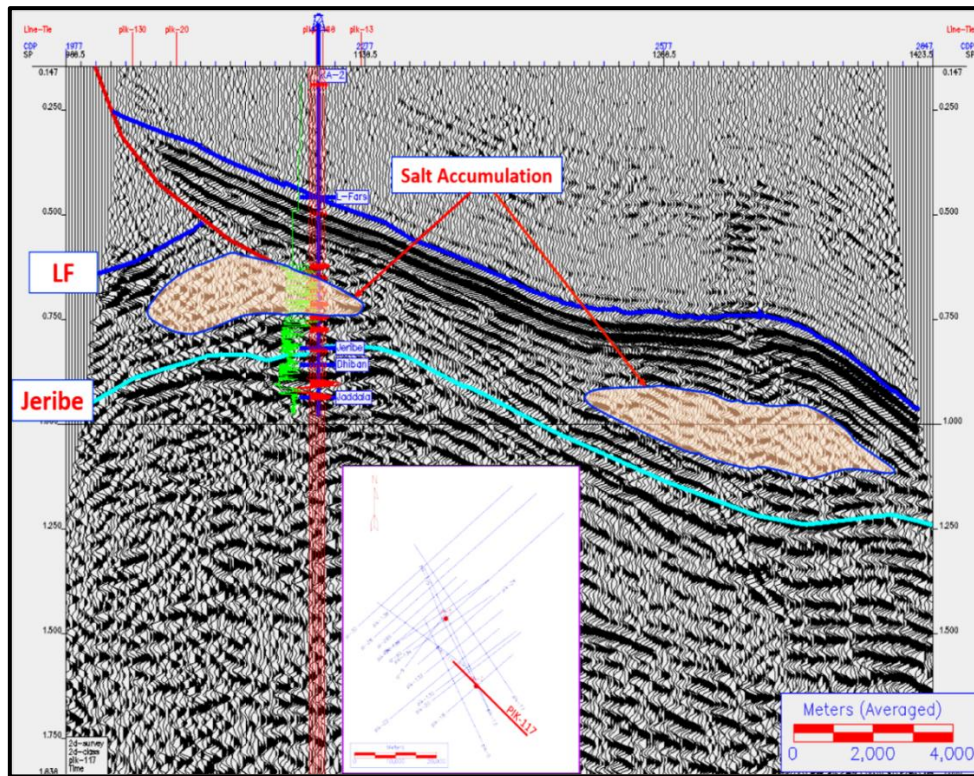
Suitable structures are formed for the gathering of hydrocarbons when porous arc layers, such as sandstone, meet the sides of the impermeable salt structure. Salt structures are important for petroleum trapping (gas and oil assemblies, which may be located on both sides of the salt plugs or above the rocky cover. In many cases, within the cover rocks above the saline structures, the transitional zone and the limestone layer, in particular, contain significant mineral reserves that may be profitably extracted, such as sulfur deposits. In addition, salt (halite rock), which is usually the saline core, is one of the important economic sources [12] (Figure 4).



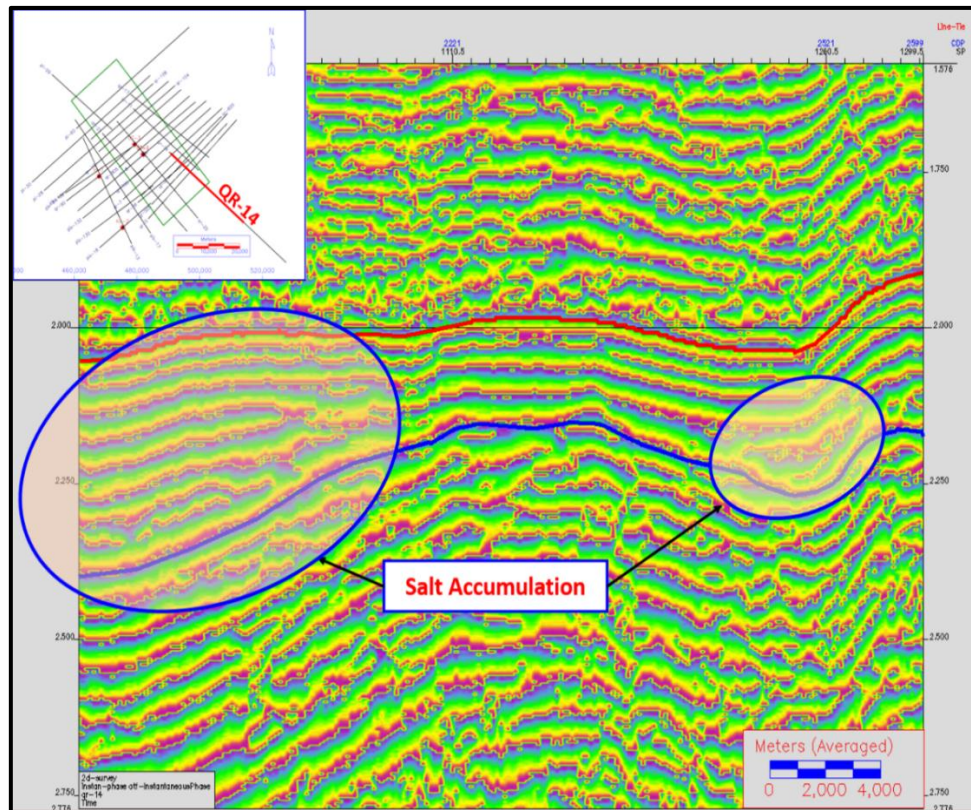
**Figure 4:** illustrates oil traps work by a salt dome [13]

### 7. Salt Recognition and picking

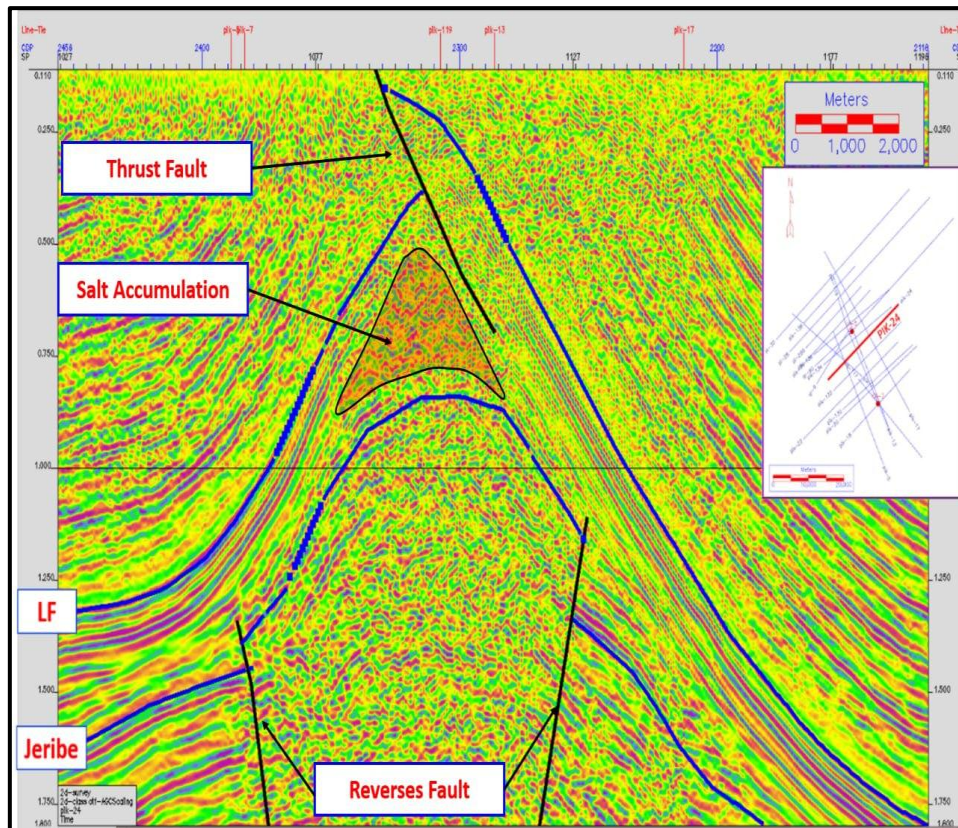
Seismic sections reveal salt bodies within the Fatha reflectors band in the Khashim Al-Ahmer, Galabat, and Injana fields. These bodies were formed as a result of salt layers overlapping under high pressure and temperature during the compressional phase of the Albian Orogeny as a result of the Arabian Plate's separation from the African Continent in the Oligocene, which caused the Arabian Plate to collide with the Eurasian Plate. Also, one can see there are reverse faults affected at Transition beds and layers beneath, these faults are stopped by Fatha salt bodies, (Figures 5, 6, and 7). The presence of the high thickness of salt bodies as a cap rock must be taken into consideration when preparing a program of drilling wells in the oil fields, as drilling failed of the first well in the Khashim Al-Ahmer field, the first two wells in Galabat field, and the first four wells in the Injana field, it is difficult to penetrate these salty bodies that characterized by high hardness and high pressure.



**Figure 5:** PIK-117 seismic section illustrates the presence of salt bodies between Fatha and Jeribe reflectors in the Khashim Al-Ahmer field [14].



**Figure 6:** An instantaneous phase section illustrates the existence of salt accumulation between Fatha and Jeribe reflectors in the Galabat field [15].



**Figure 7:** Instantaneous phase seismic section of PIK- illustrates the presence of salt accumulation between Fatha and Jeribe reflectors in the Injana field [14].

## 8. Conclusion

- 1- The field's area was affected by two types of Reverse fault systems, the first represents thrust faults trending in an NW-SE orientation. These faults have been affected on the top part of Fatha (Red Beds & Seepage) and the layers above. The second consists of two reversal faults that have an impact on the strata below and the bottom portion of the Fatha (Transition beds).
- 2- The salt layer within Fatha Formation is being the detachment surface of the thrust fault, and the salt intrusive through faulted zones led to the presence of salt bodies within the Fatha Formation.
- 3- The faults that originated due to Zagros tectonism which is widespread in the area are a major conduit that channelled petroleum flow from the source to Miocene and younger traps, also seal fracturing exceeds vertical petroleum flow.

## 9. Recommendation

Based on tectonic development and seismic evidence of Fatha and Jeribe Formations, the major recommendation is to implement a 3D seismic survey that provides high folding coverage and get high resolution in both vertical and horizontal directions, to obtain a detailed image of the reverse fault system, salt bodies and targeting of oil traps in these fields to choose the best location for drilling production wells.

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