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Study of the TFT (the Amassak field) Ordovician reservoir by means of geological and petrophysical

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DEDICACE

I dedicate this work to :

*To my Father , to my Mother , my dear grandparents , my brothers , my sisters and all my family **Abidli** and **Guerrida** and **Moussaoui***

To my developer Mr FELLAH LAHCENE who was for me an example, an advisor and a support.

Also to all the teachers at university of ouargla,

To my unforgettable friends: all the Groupe.

All Geology students

ABIDLI BOUBAKEUR

DEDICACE

I dedicate this work to :

To my Father , to my Mother , my dear grandparents , my brothers , my sisters and all my family ***Gerida*** *and* ***Moussaoui*** *and* ***Abidli***

To my developer Mr FELLAH LAHCENE who was for me an example, an advisor and a support.

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OMAR GUERRIDA

DEDICACE

I dedicate this work to :

To my Father , to my Mother , my dear grandparents , my brothers , my sisters and all my family ***Moussaoui*** *and* ***Guerrida*** *and* ***Abidli***

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To my unforgettable friends: all the Groupe.

All Geology students

MOUSSAOUI HADJ BEKKAR

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Introduction

The Illizi Basin is home to the largest recognized oil and gas reserves in the Sahara platform It has been, and continues to be, the most extensively explored basin and remains the focus of intense prospecting, intensively explored. Within the framework of hydrocarbon research and prospecting, almost all and prospecting, almost all work has focused on exploiting the flanks of anticlinal structures, anticlinal structures. This area of the Sahara platform has undergone intense structuring and is characterized by a series of major axes characterized by a series of major axes associated with step folds These structures are of significant petroleum interest, The discovery of the oil ring has stimulated exploration as part of the reassessment of hydrocarbon resources and the and expansion of the oil ring.

Our aim in this work is to attempt to characterize the Ordovician reservoir (Unit IV) Tin Fouyé Tabankort (TFT) reservoir, specifically the Amassak (Tirarimine) deposit. To achieve this objective, we have attempted to carry out a sedimentological and structural study structural study of the Amassak deposit. An analysis of petrophysical parameters to assess their quality and determine their horizontal and vertical distribution. A study of relationship between petrophysical parameters by calculating the correlation coefficient.

Chapter I: This chapter contains a short geographical, geological and morphological morphology of Algeria, A presentation of the Illizi Basin, including the history of its geological architecture, the basin's characteristics, its location, its structural aspect structural aspect.

Chapter II: This chapter is dedicated to the introduction of the Tin Fouyé Tabankort (TFT) Field, It describes its geographical location, its litho-stratigraphic description, the various oil, gas, and the tectonic evolution of the field, and we have also a description of the petroleum system.

Chapter III: This chapter is devoted to the presentation of the various methods and materials used, and to the analyses, which focused on the following elements:

- ✓ Sedimentological study.
- ✓ Study of the distribution of petrophysical parameters.

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General Petroleum Geology of Algeria and Illizi Basin

I.1 Geology of Algeria

Algeria's natural boundaries are the Mediterranean Sea to the north (1200 km), Morocco to the west, Tunisia and Libya to the east, Mauritania and the Western Sahara to the southwest, and Mali and Niger to the south. The prime meridian (Greenwich) passes close to the town of Mostaganem.

In terms of surface area (2,381,741 km2), Algeria is the second-largest country in Africa and the Arab world, after Sudan.

Distances are vast: around 2,000 km from the Mediterranean coast to the Hoggar massif, and 1,800 km from In Amenas in the east to Tindouf in the west. **[1]**

I.1.1 MORPHOLOGICAL DESCRIPTION OF ALGERIA

Algeria is comprised of four main areas, from north to south:

- The Tellian Atlas (or Tell) is comprised of rugged reliefs and coastal plains, with the Mitidja in the center, the Chélif in the west, and the Seybouse in the east representing the most fertile areas.
- The high plateaus serve as a relatively rigid continental base, sometimes the area is sometimes exposed, sometimes covered by littoral deposits or shallow seas. **[2]**
- The Saharan Atlas is a long series of NE-SW oriented reliefs that extend from the Moroccan border to the Tunisian border.
- The Sahara, which contains most of the country's hydrocarbon resources, is a desert made up of large areas of dunes (Erg Oriental and Erg Occidental), stony plains (Regs) and dotted with oases, including urban centers such as El Oued, Ghardaïa and Djanet..

The Eglab massif to the west and the Hoggar massif to the east form the southern border of the Algerian Sahara. **[1]**

The Algerian Sahara, which stretches between the Ahaggar and Atlas mountains, has an extremely simple relief, 11 consists of two peneplains, a Caledonian peneplain and a Hercynian peneplain. **[2]**

I.1.2 TECTONIC DESCRIPTION OF ALGERIA

I.1.2.1 *Structural aspects*

Algeria is divided into two major tectonic units separated by the South Atlantic Fault (Fig. 2) .

- Northern Algeria, characterized by Alpine tectonics.
- the relatively stable Saharan platform, where tectonics is less pronounced. **[1]**

I.1.2.1.(a) The Tellian Atlas

The Tellian Atlas comprises two major groups: the pre-Neogene basement and the Neogene cover.
and the Neogene cover (Fig..1). **[3]**

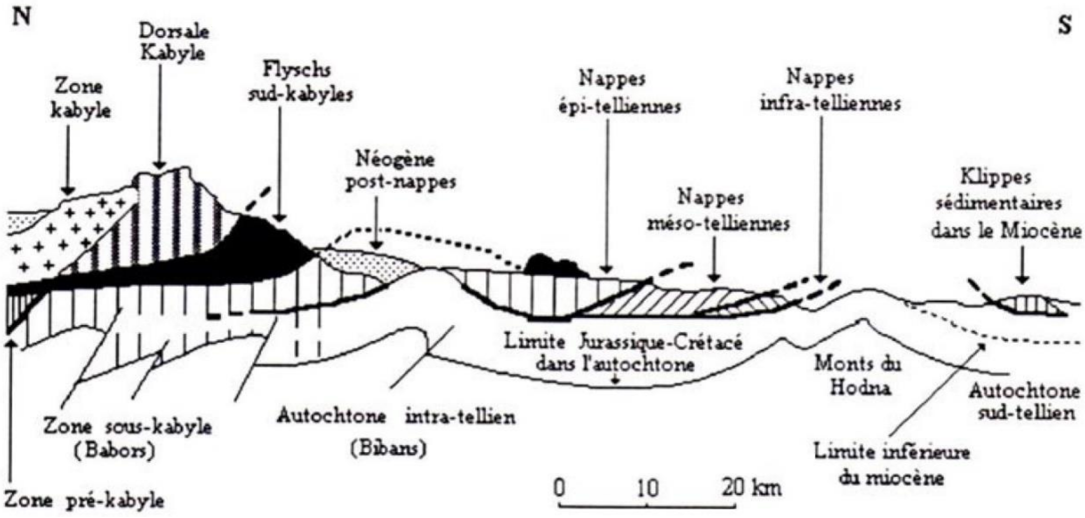

Figure 1 : **Theoretical structural relationships of the Tellian units with each other and with the innermost units (Durand Delga, 1969) and the post-nappe Neogene.** [3]

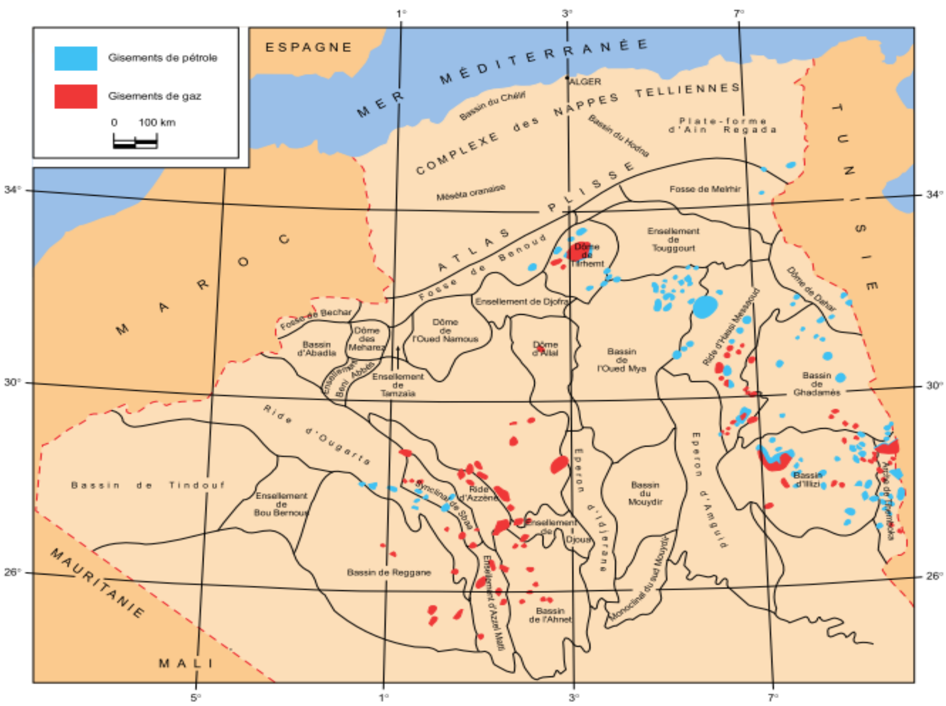

Figure 2 : Algeria's geological units [3]

I.1.2.1.(b) NORTHERN ALGERIA

Northern Algeria is characterized by geological and morphological diversity, alpine domain (Durand-Delga 1969) and consists of Neogene basins bordered mountainranges, mountain ranges, From north to south, there are three main areas: the Tellian Atlas, the High Plateaux and the Saharan Atlas. [3]

I.1.2.1.(c) Northern Algeria is bounded by the following elements:

- to the south, the Saharan Atlas, a mountain range of Alpine origin .
- in the center, platforms such as the Méséta Oranaise to the west and the Ain Regada mole to the east .
- in the northern part, the Tellian Atlas is a complex zone made up of nappes laid down in the Lower Miocene. Late Neogene basins such as the Chélif and Hodna were established on these nappes. [1]

The structure of northern Algeria, more complex than that of the Sahara, is characterized by young relief and active seismicity. In many places, from the Tell to the Saharan border, the Pliocene and Quaternary terrain has been straightened vertically. The orographic system is controlled by two long chains located south and north of the 35th parallel, culminating at about 2000m. One, the Saharan Atlas, runs NE-SW and the other, the Tell, runs E-W. Northern Algeria is part of the North African Alpine Orogen. It lies between the Oligocene oceanic basin of the western Mediterranean and the South Atlasic flexure that separates it from the Saharan platform. [1]

In Algeria, active tectonics is located in the northern region of the country, mainly in the Tell. In this region, the boundary between the African and Eurasian plates, tectonic deformation is the expression of the current convergence of these two plates and is reflected in the gradual closure of the Neogene basins and the continued building of the chain. Along the margin, in the part of the abyssal plain close to the continent, the deformation is expressed by the fading of the plio-quaternary cover. On the slope and on the continental shelf, seismicity is generated by accidents that sometimes extend onshore. This active coastal tectonics is at the origin of coastal uplift, as was the case during the last Boumerdes earthquake on May 21, 2003, when the coseismic uplift was estimated at an average of 0.50 m. On land, seismicity is most pronounced along the margins of the Neogene basins along the coast. These basins are deformed into NE-SW to NNE-SSW folding structures (synclines, anticlines) and sometimes into brittle structures (fold faults, reverse faults, thrust faults). The latter are mostly responsible for the violent earthquakes in Algeria. Further south, seismicity is expressed all along the Tell, along NE-SW trending fold bundles. At present, seismic activity in the High Plateaux and Saharan Atlas regions is low. [4]

In Algeria, as in the rest of the Maghreb, the Cenozoic orogenic domain is divided into two distinct systems: the Tell and the Atlas (Fig. 3). [5]

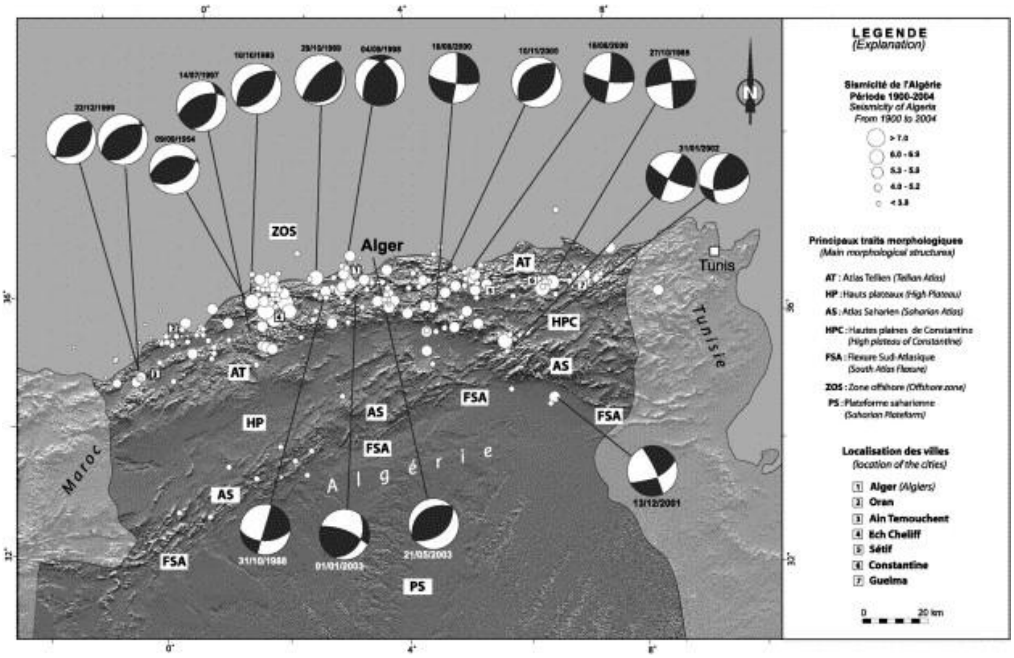

Figure 3 Seismicity and focus mechanisms in northern Algeria. [5]

Quaternary geological formations make up a significant part of Algeria's geological terrain. Quaternary outcrops are mainly found in the sedimentary basins associated with the Tell Atlas and the Eastern Plateau (Hodna). These Quaternary formations in northern Algeria, located mainly in post-Nappe sedimentary basins in continuity with the Neogene, are the terminal deposits of major sedimentary basins such as the Chélif, Mitidja and Hodna. These deposits cover a large area and are particularly continental after the retreat of the Miocene and Pliocene seas and can reach a thickness of 3,000 m in the Chélif basin. However, Quaternary marine levels and terraces have been studied along the Mediterranean coast, Geodynamically; the Quaternary sedimentary basins are part of the evolution of the Maghreb chain associated with the convergence of the African-Nubian plate with the Eurasian plate in the western Mediterranean. [6]

I.1.2.1.(d) ***Saharan platform:***

Geological setting and structural history of the Saharan platform

Since the Paleozoic, the Algerian Saharan platform has been a more stable cratonic domain. In its southern vicinity, we encounter very old Proterozoic terrains (1.8 to 2 Ga), emplaced in the Archean and during the Eburnian orogeny, these formations constitute old, more stable shields such as the Reguibet shield.

The Hoggar Shield, also very old, but less so than the Reguibet, was also affected by the Pan-African Orogeny.

Structurally, the various parts of the Algerian Saharan platform basement are part of Gondwana, which resulted from the breakup of Pangea into a supercontinent formed by the collage of continental blocks from Rodinia during Pan-African orogenic events.

Evidence of this ancient orogenic cycle (625-550 Ma) includes the suture zone of the West Pan-African chain, which corresponds to a collision chain. However, traces of this suture are mainly found in the Ougarta chain. Several subduction zones have been identified in this Algerian-Saharan platform. These led to the development of large Paleozoic intracratonic sedimentary basins, which developed between the shields and are characterized by variable subsidence and deformation, bounded by a series of moles.

Two main sets of basins can be distinguished, located on either side of the Pan-African Suture, marked by the alignment of the mountains of the Ugarta Range.

The main sedimentary basins of the Algerian Saharan platform are those of Illizi-Berkine in the east, where our study area is located; Hassi Messaoud, Hassi R'mel and Oued Mya in the central north; and Tindouf, Béchar, Reggan, Sbaâ, Timimoune and Ahnet in the west. [8]

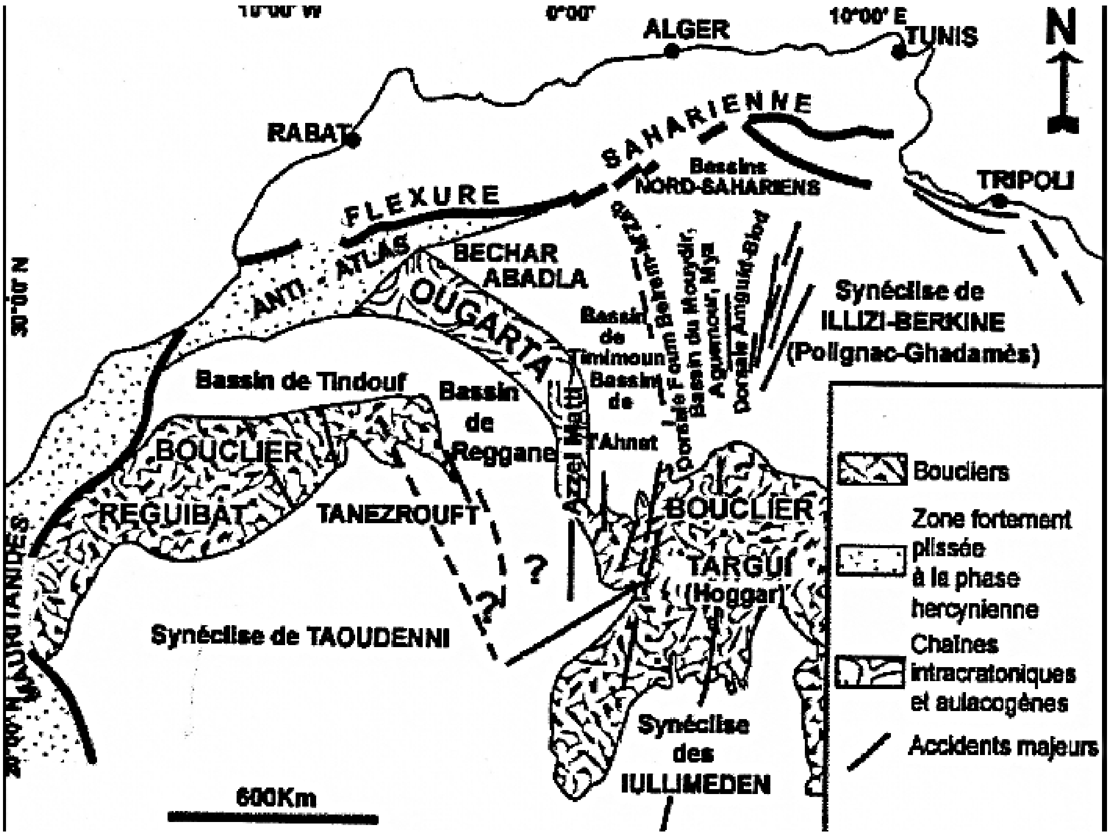

Figure 4 *The major structural units of the Sahara (Beuf, 1971)* [8]

The Sahara platform represents the southern part of Algeria and belongs to the North African craton. It is composed of a Precambrian basement on which rests a thick unconformable sedimentary cover structured into several basins separated by high zones. From west to east:

- Tindouf and Reggane basins
- Béchar basin
- Ahnet-Timimoun basins
- Mouydir and Aguemour-Oued Mya basins
- Illizi and Berkine basins

I.1.2.1.(e) ***Provinces pétrolières:***

From a petroleum point of view, this platform is subdivided into four provinces: Western, Triassic, Eastern and Northern Algeria.. **[1]**

- The Eastern Province encompasses the Illizi, Oued Mya and Amguid-Messaoud basins, as well as the Berkine basin, which is the focus of our study. It is in this province, where the giant Hassi Messaoud, Hassi Berkine (oil) and Hassi R'mel (gas) deposits are located, that the bulk of oil and gas discoveries have been made to date.
- The Western Province encompasses the Ahnet, Timimoun, Béchar-Oued Namous, Reggane, Tindouf, Taoudeni and Sbâa basins. This province is essentially gas-bearing and is attracting a great deal of interest from oil companies.
- The Triassic province.
- Province of northern Algeria - encompasses the basins of the Melrhir, Hodna, Chelif, Offshore and Saharan Atlas. **[7]**

I.2 Geology of the Illizi Basin

I.2.1 INTRODUCTION

The Illizi Basin, with a surface area of 108,424 km², is located in the southeastern part of the Algerian Sahara. It represents the southern part of the East Saharan syncline, also known as the Berkine-Illizi province. **[9]**

I.2.2 GEOGRAPHICAL POSITION OF THE ILLIZI BASIN

The Illizi Basin is located in the south-eastern part of the Algerian Sahara (Figure 1). It represents one of Algeria's largest petro-gasified provinces. It covers an area of around 100,000 km² Figure 5 **[10]**.

Its geographical limits are as follows

- Latitudes: 26° 30' - 29° 45' N.
- longitudes: 05° 00' E - 09° 50' E.

It is represented on the surface by the following major geomorphological complexes:

- In the southern part: the post-Tassilian plateaus between the Tassili.

N'Ajjer and Erg Bourarhat to the east, and the vast dune system of Issaouane N'Iralalen to the west

In the northern part, the vast expanse of the Hamada de Tinhert, bounded to the north by the immense Erg Oriental.**[9]**

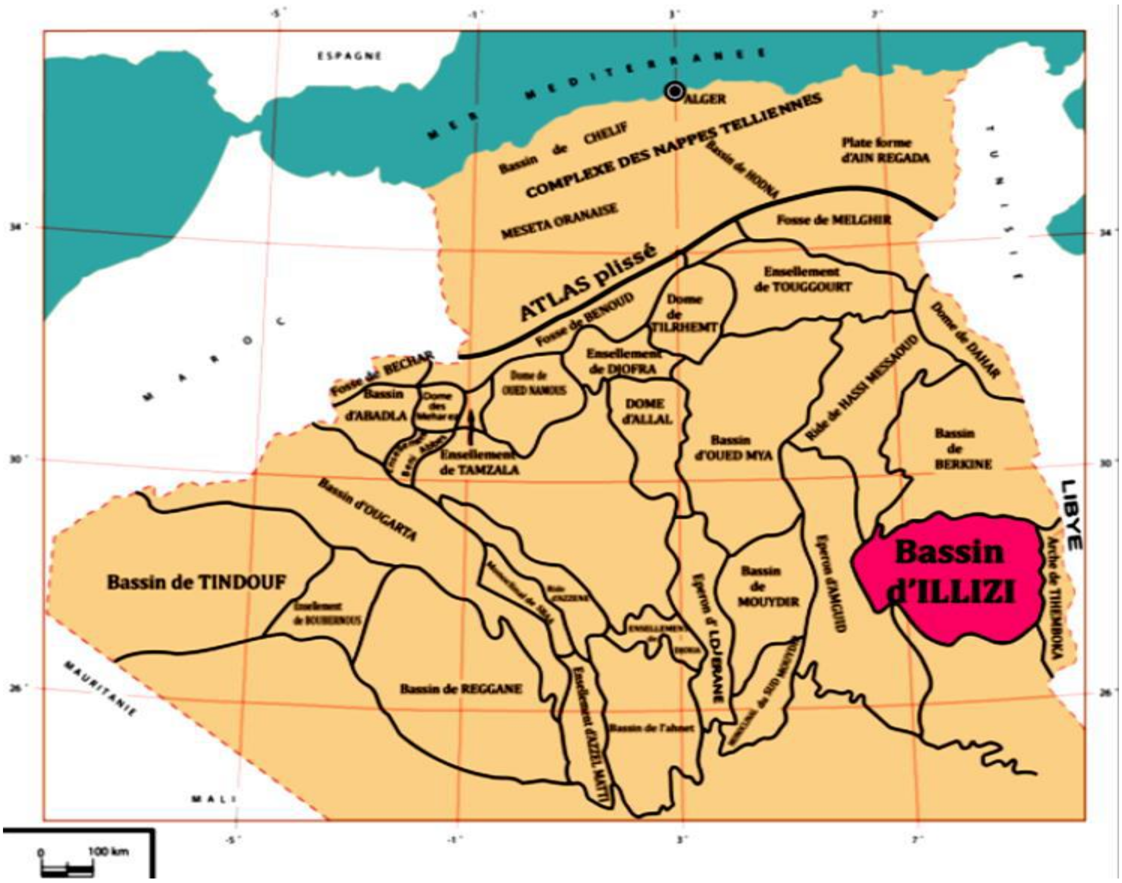

Figure 5 *Geographical location of the Illizi basin (Sonatrach, Production Division)* [8]

I.2.3 GEOLOGICAL DESCRIPTION OF THE ILLIZI BASIN

The Illizi Basin is only one unit of the Saharan platform. It belongs to the category of stable syncline-type intracratonic basins that formed in the northern part of Gondwana and include, from east to west, the Kufra and Murzuk (Libya), Mouydir, Ahnet, Sbaa, Reggane and Tindouf (Algeria) basins. The current structural picture is related to the different tectonic phases that affected the region from the Cambrian to the Quaternary. The individualization of the basin took place at the end of the Silurian and during the Lower Devonian (Figure. 6).**[9]**

The Illizi Basin is bounded to the north by the Berkine Basin, to the east by the Tihemboka Mole, to the south by the Hoggar Massif, and to the west by the Amguid-El Biod Ridge.

To the east, the Tihemboka Gap, located near the Algerian-Libyan border, separates the Illizi basin from the Hamra basin (Libya). To the west, the Amguid-El Biod ridge separates it from the Mouydir basin. To the north, the boundary between the Illizi and Berkine basins corresponds to an elevation in the basement known as the Ahara Mole (Figure 7). **[8]**

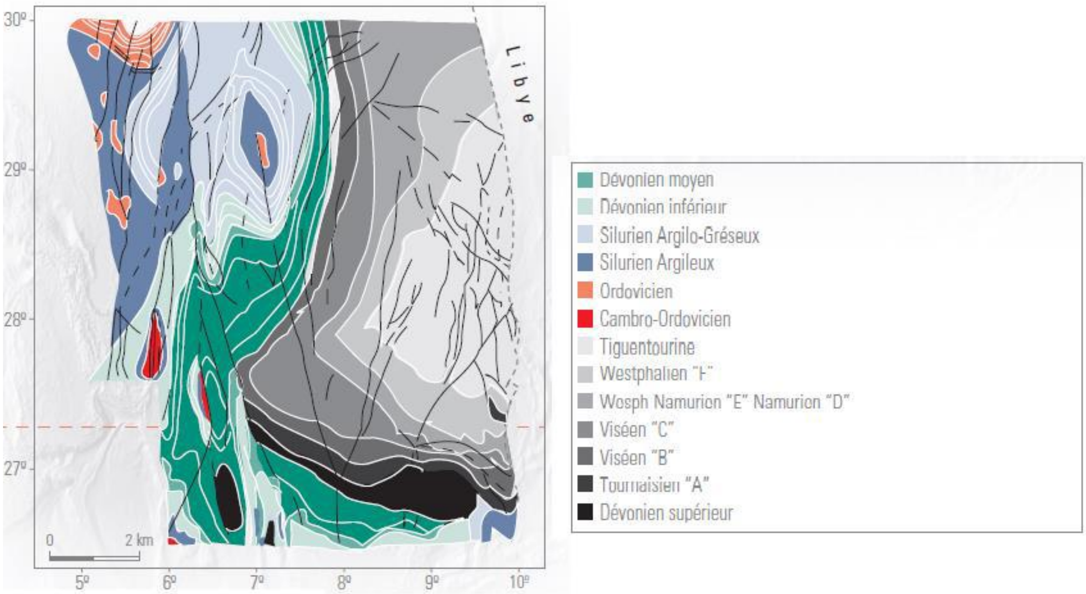

Figure 6 Structural map showing structural directions in the Illizi basin WEC (2007). [9]

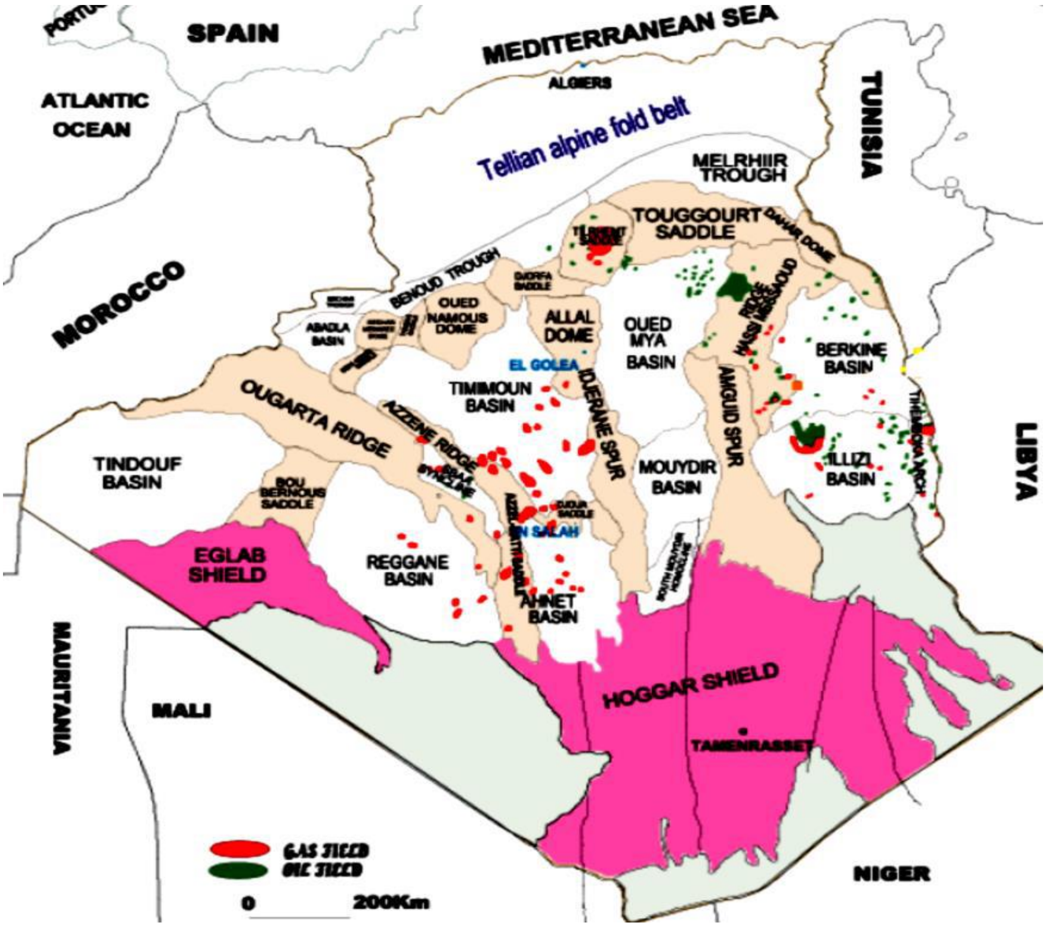

Figure 7 *Geological context of the Illizi basin.* [19]

I.2.4 LITHO-STRATIGRAPHY OF THE ILLIZI BASIN

The sedimentary cover of the Illizi Basin is in major unconformity with the Infra-Tassilian surface on a folded basement of metamorphic, crystalline and volcanic sedimentary rocks (Fig. 8).

The lithostratigraphy of the Illizi Basin consists of a generally detrital sedimentary series ranging from Cambrian to Paleogene, with Paleozoic terrains accounting for two-thirds of the total thickness of the series. The lithostratigraphy of the Tassilian Paleozoic series was established by outcrop studies by Legrand, 1985. The lithostratigraphic division is mainly based on a morphological description of the sedimentary series. **[10]**

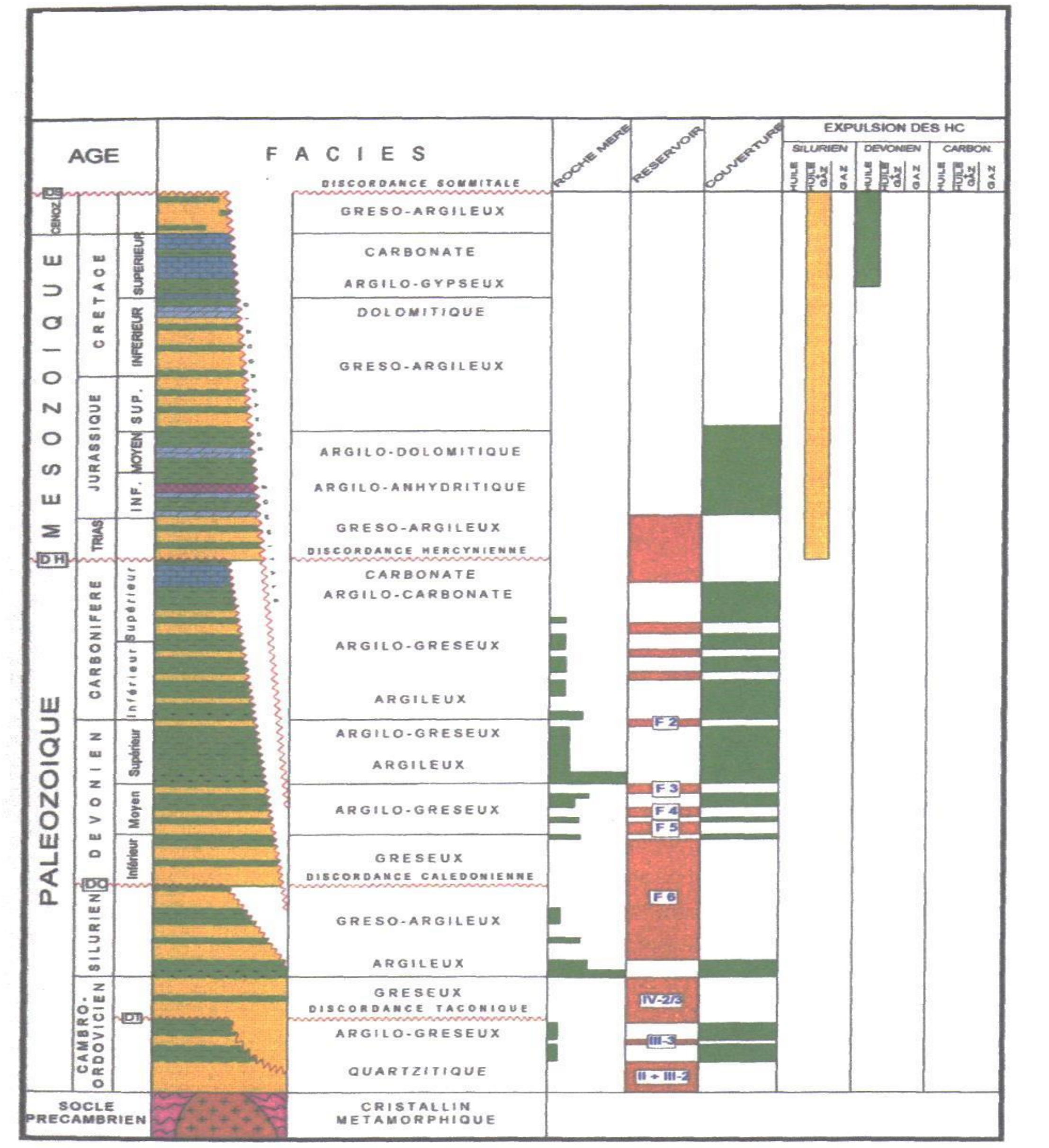

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Figure 8 synthetic stratigraphic and lithological log of the Illizi Basin [15]

The typical stratigraphic series of the Illizi Basin, more than 3,000 m thick, is as follows:

I.2.4.1 The Cambrian

It consists of a succession of detrital formations, mainly sandstone.

I.2.4.1.(a) **Unit I** : (EI-Moungar Conglomerates): 300 m thick and composed mainly of conglomeratic sandstone lenses, this highly localized series represents the last decompositional conditions of the Pan-African chain. These conglomerates rest unconformably on Precambrian crystallophyllous basement.

I.2.4.1.(b) **Unit II:** Corresponds to the Tin-Taradjelli sandstone, about 200 to 300 m thick. The basic deposits are essentially medium to coarse sandstones, obliquely stratified with a few gravels and quartz pebbles. The upper part of this unit is represented by fine sandstones with siliceous cement, and is several meters thick with intercalations of thin silty-clay benches; these benches show traces of bioturbation (Tigillites). The presumed age of this unit is Cambrian.**[8]**

I.2.4.2 ORDOVICIAN

According to Beuf et al, 1971, at the scale of the Illizi basin, the Ordovician is subdivided into four units , From base to summit, we distinguish :

I.2.4.2.(a) UNIT III-1: Variable in thickness, of Tremadoc age, it is represented by alternating fine, obliquely stratified sandstones and clay pebbles with intercalations of silty levels. It contains traces of bioturbation, mainly Tigillites..

I.2.4.2.(b) UNIT III-2 : Mainly composed of fine to coarse sandstones with siliceous cement.Cement development can give rise to true quartzites, with the frequent presence of stylolitic joints and tigillites. This deposition took place in a shallow marine environment. [9]

I.2.4.2.(c) UNIT III-3 Caradoc, with average thicknesses of 40 to 200 meters, consisting of fine micaceous sandstones with clayey or siliceous scolithos cement alternating with rare mudstone beds, towards the top this series changes to coarse to fine scolithos sandstones with oblique beds that become clayey towards the top.

I.2.4.2.(d) UNIT IV : Its average thickness is 100 to 300 metres. It is composed of sandstone and clay of glacial origin , This formation rests unconformably on Unit III-3, and includes :

I.2.4.2.d.(i) **UNIT IV-2** **:** This is a series of deposits that fills in the paleo-topography shaped by the advancing glaciers.

I.2.4.2.d.(ii) **UNIT IV-3:** called terminal slab, is essentially sandstone**.** **[10]**

I.2.4.3 Silurian

From bottom to top, the Silurian is composed of the following formations :

I.2.4.3.(a) Oued Imirhou formation: Graptolite clay with an average thickness of around 300 m, with rare silty intercalations; characterized by a condensed series known as radioactive clay, highly fossiliferous and very rich in organic matter, with a thickness of over 30 m.

I.2.4.3.(b) Passage area (unit M): it forms the basal reservoir of the 100 m-thick F6. This unit consists of alternating sandstones, clays and siltstones, the sandstones being fine to medium-grained and obliquely stratified.

I.2.4.3.(c) F6 Tank Bottom Bar (A unit): Fine to medium-grained, obliquely bedded sandstones with an average thickness of 30 m. **[9]**

I.2.4.3.(d) Tigillite dip (Unit B) in F6 reservoir: Its thickness varies from 40 to 50 m. This unit consists of alternating silty clays and fine clayey sandstones associated with caves.

Graptolite clays extend globally across the Saharan platform and are one of the most important source rocks. **[10]**

I.2.4.4 Devonien

It is the most interesting and important system from the petroleum point of view because of its relative mixed hydrocarbon wealth, and from the scientific point of view because of its richness and variety of fauna.

I.2.4.4.(a) The middle bar (unit C1) of the F6 reservoir : of Gedinian age, 40 to 50m thick, composed of fine to coarse sandstones, with oblique stratifications, discordant on the Tigillite slope.

I.2.4.4.(b) Sidewalks (unit C2) on reservoir F6: of Gedinian to Sigenian age, 20 to 40m thick. It is composed of a complex of ferruginous clays and a few lenses of coarse sand.

I.2.4.4.(c) The top bar (unit C3) : of Sigenian age, 80 to 100m thick, composed of fine to coarse sandstones, rarely conglomeratic, with oblique stratifications. [8]

I.2.4.5 Carboniferous

In the Illizi basin, the Carboniferous is represented by a thick formation Clay-sandstone formation (approx. 100 m thick), which contains carbonate rocks and ends in continental sediments.

This series includes :

I.2.4.5.(a) The Tournaisian clay-sandstone.

I.2.4.5.(b) The clay-sandstone Viséen: characterized by two regional channels B2 B12.

I.2.4.5.(c) The Westphalian: represented at the base by a channel and a clay-limestone series with a gypsum zone, dolomites and oolitic beds.

I.2.4.5.(d) The Tiguentourine series: red clay with gypsum. [9]

I.2.5 EVOLUTION TECTONIQUE

I.2.5.1 Petroleum system in the Illizi Basin region

Petroleum interest in the Illizi Basin is primarily associated with Paleozoic reservoirs. In the early years of exploration, Siluro-Devonian reservoirs were the main targets explored in the study area. Today, exploration efforts are focused on Cambro-Ordovician sandstone-clay formations, in particular the glacial deposit of Unit IV at the top of the Ordovician. [9]

I.2.5.1.(a) Cambro-Ordovician play reservoirs

The main reservoirs in the Bourarhat Sud II area are Cambrian (unit II), Ordovician (unit IV-3 unit III-2), Devonian F2 and F6..[9]

I.2.5.1.A.(I) UNIT II : Unit II is of Cambrian age, with an average thickness of 250 m, and is composed of fluvio-deltaic deposits. This unit is productive in the West Hansaténe, East Tiguentourine, Ouan Taredert and Dôme à collenias deposits.

I.2.5.1.A.(II) UNIT III-2 : This Ordovician unit is composed of fine to coarse quartzite sandstones with a thickness ranging from 0 to 200 m. This reservoir is produced by fracturing at Hassi Tabtab and Assekaifaf.

I.2.5.1.A.(III) UNIT IV : It corresponds to the terminal Ordovician complex, varies in thickness from 10 to 350 m, and consists of fluvio-glacial to periglacial deposits. [11]

I.2.5.1.(b) Upper Devonian (F3-F2) Reservoirs

I.2.5.1.b.(i) Reservoir F3**:**This reservoir consists of tidal bars 0 to 30 m thick. It has a porosity of 10 to 15%. The F3 reservoir is productive at Alrar, Stah and Mereksene, Reservoir F2Intercalcified as sandy lenses in Upper Devonian deposits, this reservoir contains sandstone beds generally less than 5 m thick but locally ranging from 15 to 20 m thick. The F2 is productive at Ouan Diméta and Issaouane. [11]

I.2.5.1.b.(ii) Reservoir F2**:** Clay-sandstone complex composed of fine sandstone, silico-clay, slightly dolomitic, fine grey-black clay, indurated, silty, flaky, finely micaceous.

Clay-sandstone complex composed of fine, white-gray to brown-gray, silicic-clayey, compact, hard sandstone and soft to indurated, silty, laminated, slightly fossiliferous, black-gray clay. Very agitated sedimentation, significant inclusion of Tigillites, overlaid with soft, black-gray clay, Low porosity. [12]

I.2.5.1.(c) Carboniferous set

Reservoirs: The Carboniferous reservoir levels consist of sandstone lenses, productive at Edjeleh, Tiguentourine, Zarzaïtine and Hassi Tabtab. These reservoir levels do not exceed 30m, and their petrophysical properties are weak to average, but can improve locally.

I.2.5.1.(d) Upper Triassic clay-sandstone set

I.2.5.1.d.(i) Reservoirs:

In the Illizi Basin, the only Triassic reservoir present is the Trias Argileux Gréseux Supérieur (TAGS), which corresponds to the Saliferous S4 of the central Berkine area.This formation has a very limited area of extension, located on a narrow margin in the northwestern part of the basin, corresponding to the boundary between the Berkine and Illizi basins. The El Ouar Sud-1 (EOS-1) discovery, with a flow rate of 12 m3/h of oil, demonstrated the oil potential of the TAGS despite its proximity to the limit of its extent. The TAGS has good primary porosity, coarse grain size and relatively low argillosity. These good petrophysical properties are confirmed by the test results: 12 m3/h of oil at EOS-1, 7 m3/h of brine at BTF-1 and 10 m3/h of brine at MDB-1. The best average porosities are recorded at MDB-1, 13%, and EOS-1, 11%, with average permeabilities of 18 mD and 10 Md, respectively. [11]

I.2.5.1.d.(ii) Traps

The discovery of El Ouar Sud-1 (EOS-1) highlighted the interest of the TAGS bevels north of Illizi. The specificity of the Illizi region is the presence of hydrocarbon accumulations affected by active hydrodynamics. Indeed, after the Hercynian orogeny, the surrection of the Hoggar established a gravity-driven hydrodynamic regime over the entire basin. It is in the F6 reservoir that hydrodynamic phenomena play an important role in trapping hydrocarbons. The Tin Fouyé deposit in the Illizi basin is the best example of a deposit affected by hydrodynamic activity.

Another specificity of the region is the presence of dole rites which, although widespread in the basin, have an impact on hydrocarbon trapping. These magmatic rocks are mainly found in the northern part of the basin, and are interbedded in Ordovician, Silurian and Devonian levels. It is as a result of the intrusion of dolerites into the sedimentary series that certain traps, such as those at Stah and Mereksen, were formed. However, in many cases, the emplacement of these dolerites occurred extrusively during the deposition of sediments. **[11]**

They are natural sites for the accumulation of hydrocarbons, preventing them from migrating again. In traps, temperature and pressure are lower than in the source rock. There are six types of trap: structural, stratigraphic, mixed, hydrodynamic, permeability barrier and diapphire. **[10]**

I.3 Results

In the Illizi Basin, it has been established that the structural traps identified but not yet drilled are small. Evaluations show that a significant volume of oil and gas remains to be discovered (217 trillion barrels of oil and 302 TCF of gas). These hydrocarbons are found in hydrodynamic or stratigraphic traps in the Palaeozoic and Triassic reservoirs. Our current state of knowledge enables us to locate stratigraphic traps in the eastern part, which are generally associated with Siluro-Devonian sedimentation, such as the Siluro-Devonian bevels in the Tihemboka sector.

In the north-western part, towards the Môled'Ahara, facies change zones and bevels have been identified in the silico-clastic formations of the Cambro-Ordovician units.

All these new concepts, which are expected to be applied to relaunch exploration in the Illizi Basin, have been confirmed by the recent and first-ever oil discovery in Unit IV-1:-

TAKW-1: 3.67 m3/h of oil and 460m3/h of gas in Ordovician Unit IV-1 and 3.81 m3/h in Unit C (Lower Devonian F6) - TAKE-1: 1,524 m3/h of oil and 460m3/h of gas in Ordovician Unit IV-1 and 3.81 m3/h in Unit C (Lower Devonian F6).

TAKE-1: 1,524 m3/h of gas and 1.04m3/h of condensate in Ordovician Unit IV-1.These two boreholes were drilled in the Gara Tesselit perimeter, prospecting a mixed three-stage trap. **[11]**

II) Lithographic survey of the study area field

II.1 Introduction:

An oil field generally consists of gas, oil and water. These three fluids are not necessarily present at the same time, as there are oil and gas reservoirs and gas reservoirs without oil, but water is a permanent component of the reservoir, with varying levels of salts.

Tin Fouyé Tabankort (TFT) is part of the production division of the Société Nationale of Transport and of Commercialisation of Hydrocarbures (SONATRACH).[13]

-It is responsible for oil and gas production in the various fields located in the TFT region, The principle The TFT regional production department was created in 1976 as part of the reorganization of the former In Aménas sector. [13]

II.2 **Presentation the TFT region:**

The TFT region is part of the production division of the Société Nationale of Transport and Commercialisation of Hydrocarbures (SONATRACH), and in this section we present the most important information about the TFT (geographical location and representation of the region's deposits and the regional management of the TFT region, production history).

II.2.1 GEOGRAPHICAL LOCATION

The Tin Fouyé Tabankort (TFT) region is located in the northwestern part of the Illizi Basin, more precisely 300 km northwest of In-Amenas, 500 km southeast of Hassi Messaoud on National Road N°3, 1300 km from Algiers, and is administratively part of the Wilaya of Illizi. The region lies at an altitude of 432 m and covers an area of 4000 km², according to the following coordinatesThe Tin Fouyé Tabankort (TFT) region is located in the northwestern part of the Illizi Basin, more precisely 300 km northwest of In-Amenas, 500 km southeast of Hassi Messaoud on National Road N°3, 1300 km from Algiers, and is administratively part of the Wilaya of Illizi. The region lies at an altitude of 432 m and covers an area of 4000 km², according to the following coordinates Figure 10 . [13]

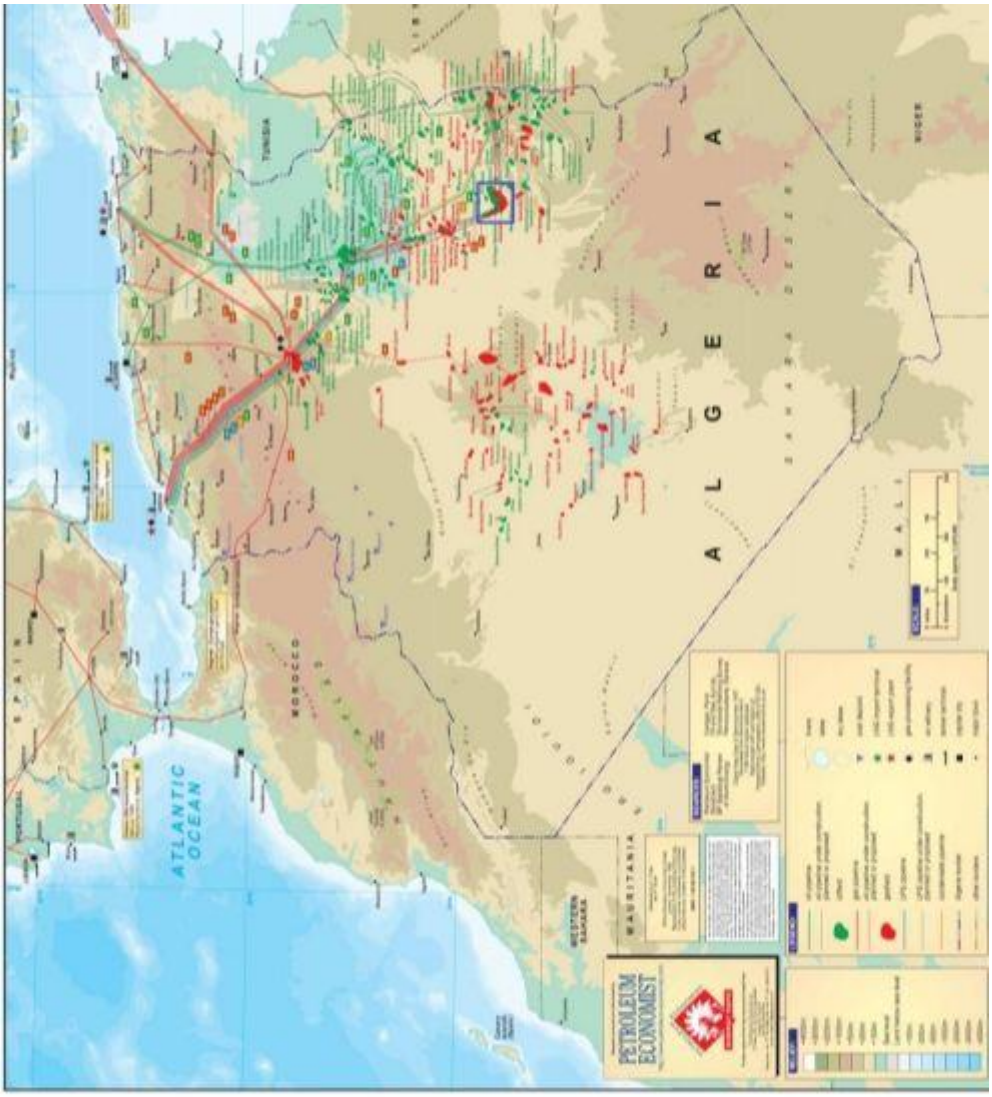


Figure 9 The geographic situation of TFT [17]

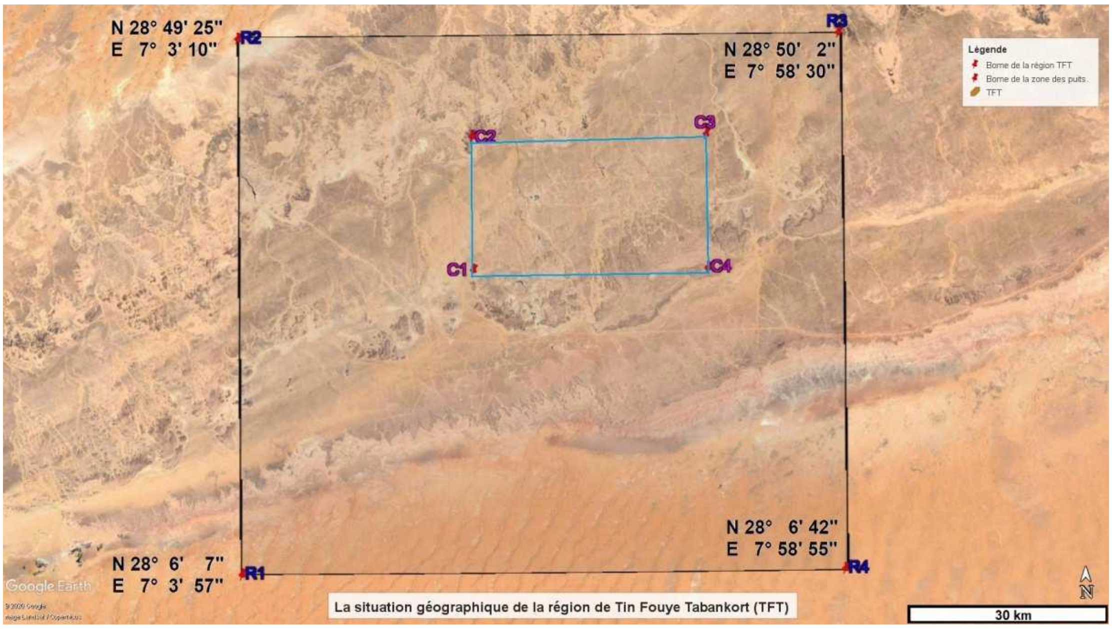


Figure 10 Geographical location of Tin Fouye Tabankort (TFT).

II.2.2 PRESENTATION OF THE (TFT) SITE :

The regional management of (TFT), is part of the production division of the company.
SONATRACH.
It is responsible for the production of oil from the TFT fields and for the management of all its divisions.

The Tin Fouye Tabankort Area is located in the western part of the Illizi Basin, 284 kilometers from In Amenas, between the intersection of two wadis (Tin Fouye) and an artesian well (Tabankort).

The regional division includes nine fields of different sizes and different processing units: oil separation centers, oil collection centers, water production and injection centers (for pressure maintenance), an associated gas processing unit and gas compression units (gas lift), and is interested in the dehydration section and the gas processing section Figure 11. [13]

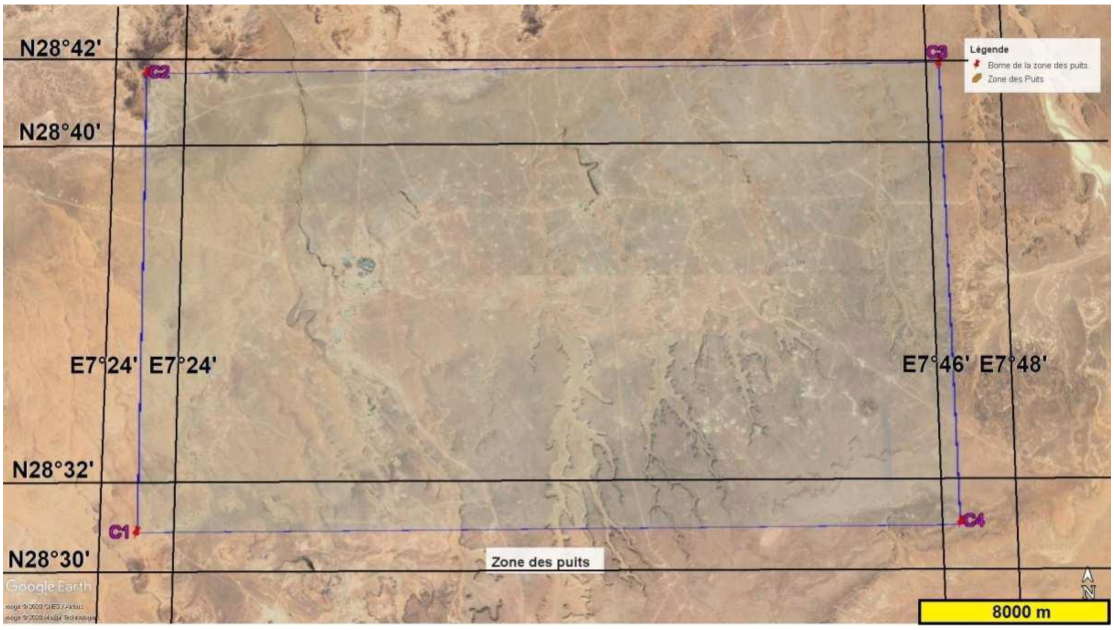


Figure 11 Location of well area (TFT region).

II.3 History of work in the region :

The first discoveries in the region date back to the early 1960s. The TFY field was discovered in 1961, followed by Hassi-Mazoula Sud and Nord in 1963, TFY Nord and Djoua in 1966, TFT Ordovician in 1968, and Tamendjelt and Amassak in 1970.

The TFY deposit is located south of the TFT, with oil in the Devonian F6 unit.
Devonian unit (1300 m) and is exploited by the gas lift technique. The Ordovician TFT reservoir
(2000 m) produces most of the TFT area's production and began production in November 1968. By 1975, 52 wells had been drilled, 49 of which were producing. The area covered by the wells represented only 40% of the TFT area; oil production in 1974 reached 2634,000 tons. [14]

With the goal of increasing the recovery rate to over 25% and recovering flared gas, another
was started in 1987 with the construction of a gas treatment plant.
treatment plant. Currently, 400 oil wells are being drilled in the Ordovician reservoir of the TFT field. The pressure maintenance project was initiated in 1980 due to decreasing reservoir pressure resulting in depletion of reservoir energy.

Results started to show in 1984 with production of 2751,651 tons, 4976886 tons in 1991, 4410176 tons in 1994 and 3504200 tons in 1998.

Several oil recovery techniques have been used in the TFT region, such as primary recovery (eruptive wells), secondary recovery (gas lift, pressure maintenance by water injection, and pumping (electrical and mechanical)) (TAZEBINTE & MESSINI, 2016).
The TFT region is known for its oil production capacity, which ranks second after the Hassi-Messaoud region with an average oil production of 9,000 m3/day. [14]

II.3.1 OVERVIEW OF THE GEOLOGY OF THE AMASSAK FIELD:

The Amassak field is a NE trending monocline cut by numerous submarine faults and bounded by two major faults:

To the west, a large reverse subvertical fault, the strike of which can locally reach 300 m (west of MSK-1). This moderate NNW-trending regional fault is one of the main faults in the Illizi Basin, connecting Tin Tayart to the south and Maouar to the north of Amassak.

To the east, there is a series of N20° reverse and normal faults reflecting a strike-slip system. The maximum dip observed along this series of reverse/normal faults is 120 m. These two tectonic elements meet to the south to form a narrow wedge, giving the Amassak deposit its triangular structural shape, which is strongly uplifted to the south. Between these two major faults , a number of secondary faults can be observed whose vertical dips vary locally from 20 m to about 60 m, dividing the monocline into 3 compartments, north , central and south, which communicate with each other to the south[18]

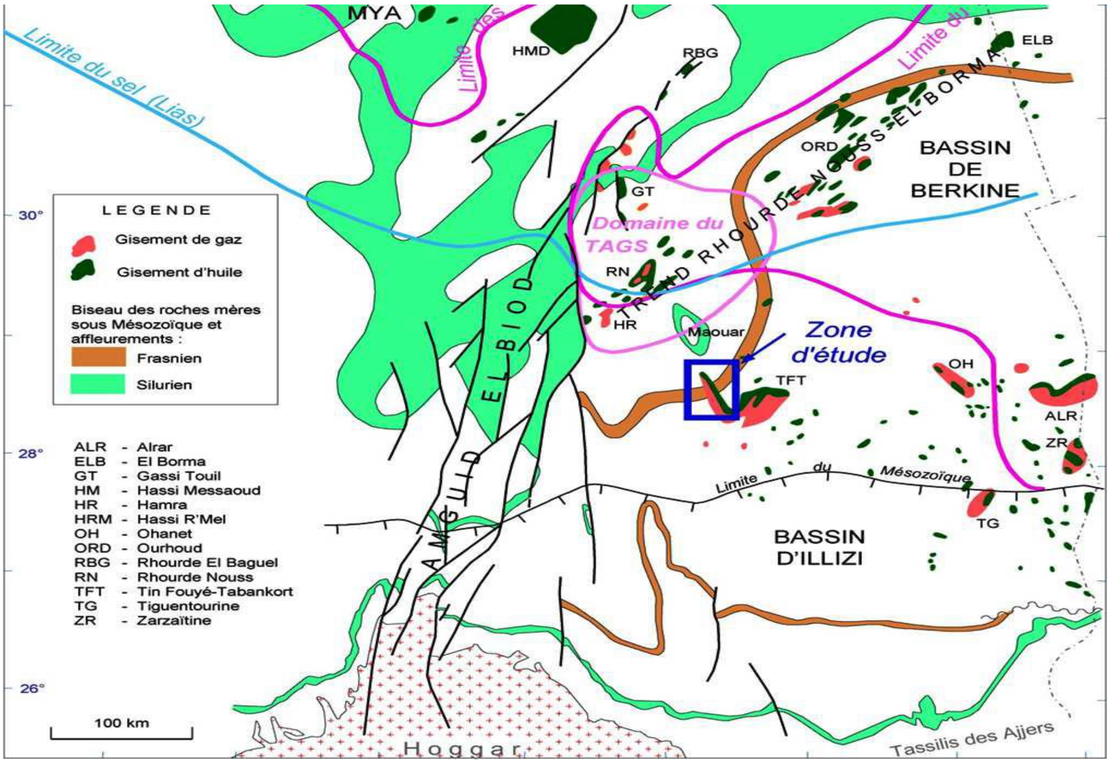


Figure 12 Geographical location of the AMASSAK deposit (WEC, 2007) [18]

II.3.2 LITHO-STRATIGRAPHIC DESCRIPTION:

The typical stratigraphic section of the Amassak field consists of a sedimentary series ranging from Cambro-Ordovician sandstone to Turonian limestone.

Study of the cross-sections of wells drilled in the region shows a certain regularity in the arrangement of layers over the entire extent of the field.

However, the Paleozoic is deeply cut by the Hercynian unconformity in some areas, with only a few metres of the Carboniferous remaining, and the F6 reservoir is completely or partially eroded in places at its summit.[17]

II.3.2.1 Paleozoic

II.3.2.1.(a) ***Cambro-Ordovicien*** : All cores recovered during the drilling of the Ordovician reservoir have been from a facies point of view.

II.3.2.1.a.(i) Unit III-2

It is represented by an intercalation of layers of gray clay, very silty, indurated, and gray-white to gray-beige, silico-clayey, medium to coarse, subrounded sandstones.

II.3.2.1.a.(ii) Unit III-3

Characterized by homogeneous, essentially clayey-sandstone facies.

II.3.2.1.a.(iii) Unit IV-2

Characterized by total clay facies and fine to very fine clay sandstones.

II.3.2.1.a.(iv) Unit IV-3

Characterized by the predominance of generally medium-coarse, clean sandstones, and is locally observed locally by a transition between clean sandstones and clayey sandstones and even argillaceous facies.

II.3.2.1.(b) Gothlandian

II.3.2.1.b.(i) Gothlandian Clay

This ensemble is represented by a dark gray clay, sometimes black, silty and micaceous,A few layers of fine to very fine, siliceous, gray-white sandstone are present at the top , fine , silico-clayey sandstone.

II.3.2.1.b.(ii) Gothlandian Clay-sandstone

II.3.2.1.b.ii.1. Unit M1-X

This is an overlay of fine to very fine grayish-white, silico-clayey, friable sandstone, separated by layers of light gray to black, soft, locally micaceous clay.

II.3.2.1.b.ii.2. Unit M2-IX

It is represented by a light gray, indurated clay; finely micaceous with traces of pyrites, with fine to very fine, silico-clayey, friable white sandstone layers.

II.3.2.1.b.ii.3. Unit A-VIII

II.3.2.1.(c)This is a superposition of metric levels of fine to medium-grained white sandstone, silico-clay, friable, locally pyritic, rich in quartz pebbles. These beds are separated by soft white to gray-green silt beds.

II.3.2.1.b.ii.4. Unit B1-VII

It is represented by a rhythmic succession of layers of light gray to white, fine to very fine, silty sandstone and light gray, slightly silty, soft clay, becoming brick red toward the base , and light gray, slightly silty, soft clay, becoming brick red toward the base,
Soft white to grayish green silt is also present.

II.3.2.1.b.ii.5. Unit B2-VI

It is characterized by a superposition of medium to coarse white sandstone beds subrounded to rounded, moderately consolidated, separated by layers of dark gray clay, finely micaceous silty clay

II.3.2.1.b.ii.6. Unit B2-IV-V

It's a rhythmic succession of light, medium to coarse, silico-clayey sandstone levels and dark gray, indurated, finely micaceous silty clay, dark-gray, finely micaceous, indurated silty clay.

II.3.2.1.(c) Devonian

The Devonian series is characterized by the disappearance of Middle Devonian terms.

II.3.2.3.c.(i) Lower Devonian

II.3.2.3.c.i.1. Unit C1-III

This is a superposition of well-classified, siliceous, medium to coarse white sandstone beds, rich in quartz pebbles, separated by layers of dark gray, silty, finely micaceous, indurated clay ,micaceous .

II.3.2.3.c.i.2. Unit C2-II

his unit is represented by an intercalation of metric levels of fine to very fine, friable, poorly cemented white sandstone , crumbly, poorly cemented white sandstone interbedded with thin beds of dark gray, micaceous clay and soft, white silt,
micaceous clay and soft white silt.

II.3.2.3.c.i.3. Unit C3-I

It is characterized by alternating clay and sandstone. This interval is represented by a dark gray to black silty, finely micaceous clay and white soft silt.
white silt.

II.3.2.3.c.(ii) **Upper Devonian**

II.3.2.3.c.ii.1. Clay series

This interval is represented by a dark gray to black silty, finely micaceous clay and white soft silt ,white silt.

II.3.2.3.c.ii.2. Strunien : Reservoi F2

This is a series of gray-black, silty, micaceous clays interbedded with several metric tons of medium- to coarse-grained of medium- to coarse-grained, silico-clayey, pyritic brown sandstone.

II.3.2.4.(d) Carboniferous

II.3.2.4.d.(i) **Viséen-Tournaisien**

These two formations are represented by an intercalation of metric levels of dark grey to black clay
to black, silty, finely micaceous clay with occasional passages of grey to beige-brown sandstone,
medium to coarse, silico-clayey, moderately hard.

II.3.2.2 **MESOZOIC**

It is characterized by the disappearance of Triassic terrain and an uncertain boundary between the Cretaceous
Cretaceous and Jurassic.

II.3.2.2.(a) Trias

II.3.2.2.a.(i) **Hercynian distortion**

Fine to medium-grained clayey dolomitic sandstone with plastic green clay ,Small patches of massive compact white dolomite are also present.

II.3.2.2.(b) Jurassic

II.3.2.2.b.(i) Lias

It is characterized by alternating levels of translucent white sand, medium, sub-rounded, white sandstone hard, pyritic, siliceous sandstones, becoming micro-conglomerated in places ,in places .

II.3.2.2.b.(ii) Dogger

It is a stack of metric levels of fine to medium-grained, translucent, sometimes pinkish sand pasty, versicolored silt, medium to coarse, sub-rounded, siliceous, pyritic white sandstone and brown to green clay.

Thin lignite seams are also present along the interval.

II.3.2.2.(c) Cretaceous

II.3.2.2.c.(i) Neocomian + Malm

This interval is represented by an intercalation of levels of translucent, sometimes pinkish sand,

medium to coarse, sub-rounded, slightly siliceous brown clay, with traces of lignite at the base. lignite at the base

II.3.2.2.c.(ii) Barremian

This stage is represented at the summit by a rhythmic stacking of levels of translucent, opaque, translucent sand, opaque medium to coarse, sub-rounded, separated by soft, slightly carbonated clay and soft yellow limestone; in its lower part, it is represented by translucent translucent medium to coarse-grained sand, rounded to subrounded, with micro conglomeratic micro conglomeratic layers.

II.3.2.2.c.(iii) Aptian

It is represented by a level of soft to pasty grey-green silty clay interspersed with of fine to medium white, rounded sand.

II.3.2.2.c.(iv) Albian

This term is represented by alternating metric levels of fine to very fine, friable, grey-white sandstone with clay-carbonate cement, fine to medium, rounded and subrounded white to pinkish sand and soft to pasty brown to green clay, soft to pasty, locally indurated.

II.3.2.2.c.(v) Cenomanian

It is represented by a green clay at the top and brownish to brick-red towards the bottom, soft to pasty. pasty, locally carbonated, with intercalations of white, translucent, fibrous gypsum and slightly white, translucent, fibrous gypsum and white, slightly dolomitic microcrystalline limestone, dolomitic.

II.3.2.2.c.(vi) Turonien

It is subdivided into two lithological groups: the first is represented by a white to beige, microcrystalline, hard, slightly dolomitic limestone. beige, microcrystalline, slightly dolomitic limestone, the second by soft to pasty grey marl. pasty marl.

II.3.2.2.c.(vii) Sénonien

It is outcropping and 25m high; it is composed of dolomite in its somital part and clay at its base.

ERE	SYST	ETAGES	NOMENCLATURE A L'AFFLEUREMENT	EPmoy (m)	DESCRIPTION
MESOZOIQUE	CRETACE	SENONIEN	ARGILO-GYPSEUX	120	Alternance de dolomie calcaire, gypse et argile.
		TURONIEN	CALCAIRE / MARNEUX	81	Calcaire, marne et argile.
		CENOMANIEN	DALLE CALCAIRE / IN-AKAMIL	176	Argile avec passées de calcaire et de gypse.
		ALBIEN	TAOURATINE SUPÉRIEUR	71	Grès, argile.
		APTIEN	TAOURATINE MOYEN	28	Argile carbonatée, passées de dolomie
		BARREMIEN	TAOURATINE INFÉRIEUR	296	Grès et sable avec passées d'argile et de calcaire.
	CRETACE / JURASSIQUE	NEOCOMIEN + MALM		188	Intercalations de sable et d'argile. Traces de lignite.
	JURASSIQUE	DOGGER	ZARZAITINE SUPÉRIEUR ET MOYEN	195	Sable, silt, grès, argile. Présence de lignite et pyrite
		LIAS		99	Alternance de sable et de grès. Présence de dolomie et pyrite
	TRIAS	discordance hercynienne	ZARZAITINE INFERIEUR	30	Argile, grès.
PALEOZOIQUE	CARBONIFERE	VISEEN & TOURNAISIEN	SÉRIE DES GRÈS D'ISSENDJEL	47	Argile, grès.
	DEVONIEN	SUP – STRUNIEN RESERVOIR "F2"	SÉRIE DE LA GARA MAS- MELLOUKI	65	Argile, grès.
		SUP – SERIE ARGILEUSE (discordance frasnienne)		154	Argile avec présence de silt,passées de calcaire
		INF – UNITE C3 – I (RESERVOIR "F6")	BARRE SUPÉRIEURE	10	Grès, argile. Pyrite
		INF – UNITE C2 – II (RESERVOIR "F6")	TROTTOIRS	25	Argile, silt, grès.
		INF – UNITE C1 – III (RESERVOIR "F6")	BARRE MOYENNE	15	Grès, argile.
	GOTHLANDIEN	GOTHLANDIEN ARGILO-GRESEUX – UNITE B2 – IV-V (RESERVOIR "F6")	TALUS A TIGILLITES	60	Grès, argile.
		GOTHLANDIEN ARGILO-GRESEUX – UNITE B2 – VI (RESERVOIR "F6")		17	Grès.
		GOTHLANDIEN ARGILO-GRESEUX – UNITE B1 – VII (RESERVOIR "F6")		74	Grès, argile.
		GOTHLANDIEN ARGILO-GRESEUX – UNITE A – VIII (RESERVOIR "F6")	BARRE INFÉRIEURE	100	Grès, silt, argile.
		GOTHLANDIEN ARGILO-GRESEUX – UNITE M2 – IX (RESERVOIR "F6")	FORMATION D'ATAFAITAFA	54	Argile, grès.
		GOTHLANDIEN ARGILO-GRESEUX – UNITE M1 – X (RESERVOIR "F6")		56	Grès, argile.
		GOTHLANDIEN ARGILEUX		195	Argile avec passées de grès au sommet.
	CAMBRO-ORDOVICIEN	UNITÉ IV – 3	"COMPLEXE TERMINAL" OU "FORMATION DE TAMADJERT"	15	Grès.
		UNITÉ IV – 2		24	Argilo-gréseux.
		UNITÉ III – 3	FORMATION D'IR TAHOUITE	17	Grès, argile. Tigillites.
		UNITÉ III – 2	"QUARTZITE D'HAMRA" OU "BANQUETTE"	25	Grès quartzitique. Tigillites.
SOCLE					Roches éruptives (gabbro).

Figure 13 lithostratigraphic table of the TFT region. [15]

II.3.3 STRUCTURAL CHARACTERIZATION:

The Tin Fouyé Tabankort deposit is part of a complex anticlinorium of regional extent with structures aligned along major faults. The deposit is cut by faults of various orientations that define submarine compartments (Fig. 51). Discharges are highly variable and can exceed one hundred meters along major faults. These faults are generally subvertical, normal and sometimes reverse. Formations range from Precambrian to Cretaceous, including the Ordovician reservoir. The Ordovician reservoir is covered by 2,000 m of often clayey sedimentary deposits. **[1]**

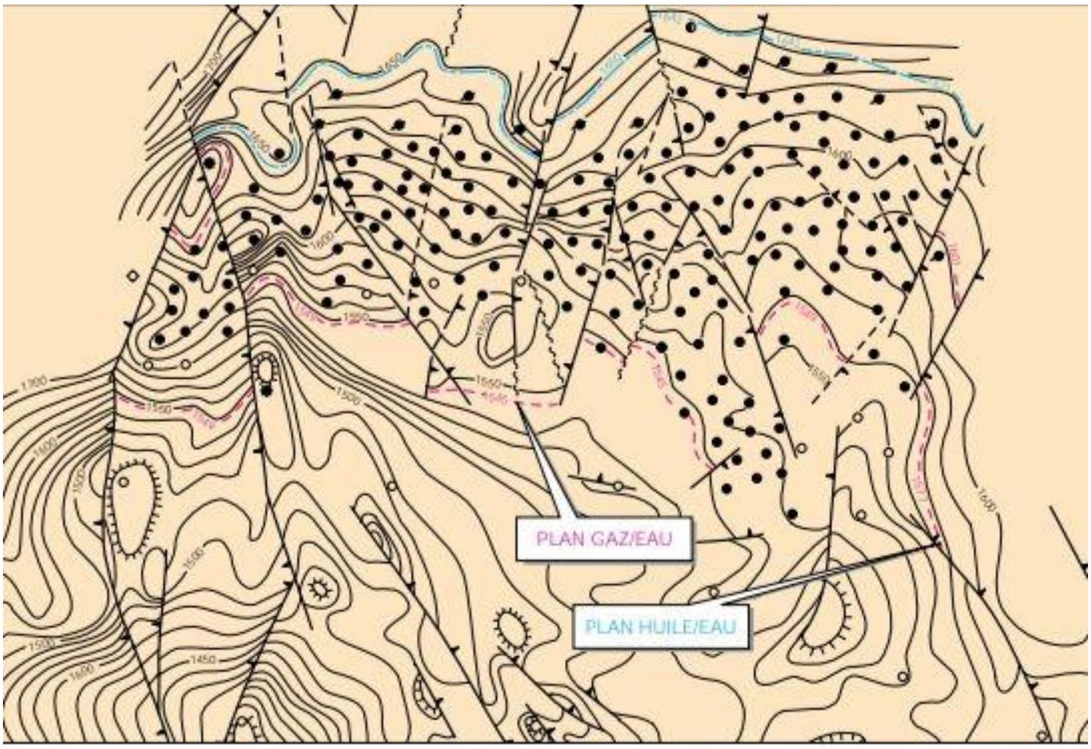


Figure 14 : **Tin Fouyé Tabankort field: isobaths of the roof of unit IV.** [16]

II.4 Existing deposits

II.4.1 TFT DEPOSIT:

The TFT deposit is a ring of oil capped by a large gas cap, The Ordovician reservoir roof forms an east-west, north-dipping monocline , Analysis of the isobath map at the Ordovician roof and at the wall of the layer proves that the deposit has a divided
deposit has a blocky structure.

II.4.2 TIN FOUIYE DEPOSIT:

is an extremely complex high zone consisting of a number of different structures.
structures, the highest of which is Tin Fouyé, the largest in terms of area (306km2) and in thickness (160m at TFY 18), At the TFY deposit, drilling has intersected in the Paleozoic series of undersaturated oil reservoirs,
Devonian F6 reservoir, which contains an active aquifer and gas in the Ordovician, UnitIV, Ordovician, Unit IV,The Devonian reservoir is produced by gas lift.

II.4.3 AMASSAK DEPOSIT

The Amassak deposit is located 25km west-northwest of the TFT deposit,The Ordovician reservoir appears as a monocline sloping to the north-east and cut by several submeridian faults , by several submeridian faults; these faults act as compartment boundaries for the oil accumulation.

Oil and gas have been found in Ordovician Unit IV-3, which is the main reservoir in this zone.

Water injection into this reservoir began in 1995

II.4.4 DJOUA DEPOSIT

The Djoua deposit, located 30km south-east of TFT, is an elongated north-west-south-east anticline, affected by a fault of the same direction. It produces oil mainly from the F6 reservoir (units C1, A-VIII and M1-X) by electric pumping electric pumping.

II.4.5 TAMENDJLET DEPOSIT

The TAMENDJELT reservoir is located around 6 km northwest of TFT. It was discovered in 1970 and commissioned in 1974. The oil from its Devonian F6 reservoir is extracted by gas lift.

II.4.6 HASSI MAZOULA NORD DEPOSIT

The Devonian F6 deposit is a flattened anticline, slightly trending south-southeast to north-northeast. South / East to North - North / East, and is associated with the Mazoula - Belouda Major Fault.

The F6 reservoir is operated by electric pumping.

II.4.7 GISEMENT DE HASSI MAZOULA SUD

The HMZ-B field was discovered in 1963 and put into production in 1966, with a total of 04 wells in operation. Currently, only reservoir F6 produces oil by electric pumping.

II.4 GISEMENT DE HASSI MAZOULA « B »

Discovered in 1966 and commissioned in 1967, it covers an area of 4.4 km2 and has 04 wells in operation. The oil is produced by electric pumping. [16]

II.5 Oil interests and criticism of the region's petroluem system

II.5.1 SOURCE ROCKS

The main source rocks in the Tin Fouyé-Tabankort field are Silurian clays, which vary in thickness from 250 to 300 meters, and Ordovician , Devonian and Carboniferous clays of lesser importance.

II.5.2 RESERVOIR ROCKS

There are numerous reservoir rocks in the Tin Fouyé-Tabankort field. They are characterized by significant variations in thickness, good facies and good petro-physical characteristics.

The main oil accumulations, which have made the region one of Algeria's largest oil deposits, belong to Ordovician Units IV-3 and IV-2, which feature fluvial sandstones with more compact sandstone lobes with good petrophysical characteristics and preserve an original amount of GAS CAP in place amounting to 271.1 mm, and to Units C-3 I, C-2 II, C-1 III, B-2 IV-V and - Units B-2 and VI of the secondary reservoir “F6”..

II.5.3 CAP ROCK

The cover rocks are represented by the Silurian clay, which provides good coverage of the Ordovician reservoir. **[15]**

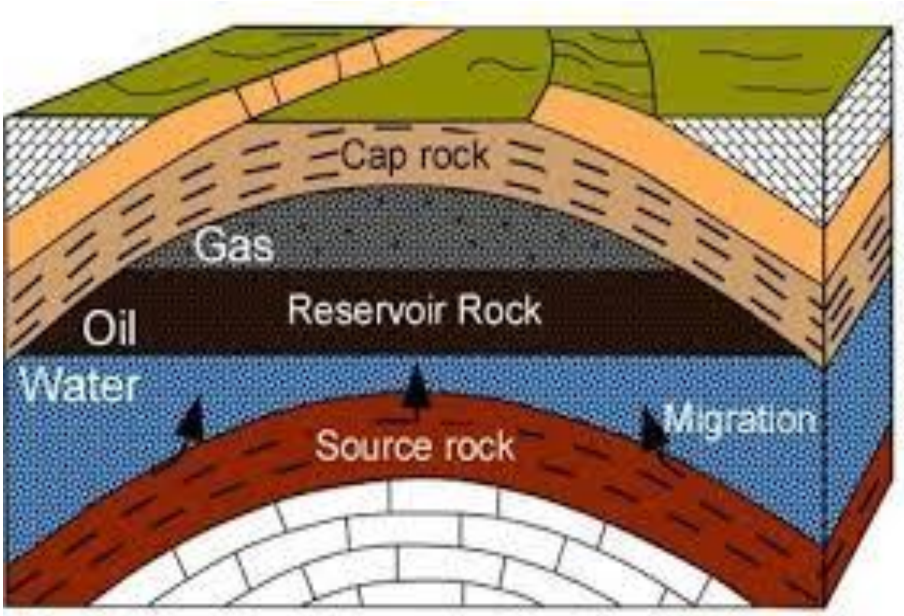


Figure 15 Schematic diagram of system hydrocarbon[18]

II.6 Conclusion

The TFT field, considered the 2nd largest oil production field after Hassi Messaoud, contains several deposits with hundreds of wells across geological formations of different origins, ranging from Turonian at the surface to Ordovician at 2000 m depth.

The reservoirs are of different ages, one Devonian and the other Ordovician (IV-3, IV-2 and III-3).

The lithology of these reservoirs is generally sandstone and sandstone-clay in the TFT monocline.

III) Analysis and interpretation of results

III.1 Introduction

Firstly, we briefly presented the various methods and materials used to achieve the main objective of this work, and then wrote up our analyses, which focused on the following elements:

Study of sedimentology.

Distribution of petrophysical parameters.

Analysis of the relationships between the various parameters.

Interpretation of maps: isobath, isopaque, isoporosity, water isosaturation, isopermeability.

III.2 Petrophysical reminder

In petroleum geology, the main petrophysical parameters must characterize each reservoir layer. These parameters are essentially expressed in terms of porosity, permeability, clay volume, water saturation, etc.

The interpretation of maps of various petrophysical parameters and logs to produce a global petrophysical typology is more precise at the reservoir level in this study.

III.2.1 POROSITY

III.2.1.1 Definition

Porosity is a parameter that depends on grain size, shape and arrangement (grading). It is determined: in the laboratory using a porosimeter, under the microscope, by direct estimation on thin plates, and by logging.

III.2.1.2 Types of porosity

III.2.1.2.(a) Effective porosity

It is defined as the ratio of the volume of interconnected voids to the total volume of the sample. The recovery of a deposit depends on its effective porosity. Only pores that communicate with each other define effective porosity..

III.2.1.2.(b) Residual porosity

It is caused by pores that are not connected to each other.

III.2.1.2.(c) Total porosity

It is the ratio of the total volume of voids (pores) to the total volume of the rock, expressed as a percentage. The sedimentation factor and its evolution characterize two types of porosity:

A3.a. Primary porosity: or intergranular porosity, acquired during sedimentation.

A3.b. Secondary porosity: or intergranular porosity, fissure porosity and dissolution porosity associated with diagenetic phenomena.

III.2.2 PERMEABILITY

III.2.2.1 Definition

This is the rock's ability to allow the fluids contained in its pores to circulate. It is determined in the laboratory using standard constant-load permeametry.

Permeability depends mainly on grain size and configuration, and the nature and volume of diagenetic cements.

It can also be determined from production tests and logs.

MRIL : Magnetic Résonance Imagering Log ; ***Western Atlas*** **CMR :** Combinable Magnetic Resonance ; ***Schlumberger.***

III.2.2.2 Permeability types

III.2.2.2.(a) Specific or absolute permeability

This is the permeability measured with only one fluid present, for example: air permeability, water permeability, oil permeability.

III.2.2.2.(b) effective permeability

When a fluid exists in the rock porosity (at a saturation different from the minimum irreducible saturation), the result of permeability measurement using a second fluid is called the effective permeability for this fluid.

III.2.2.2.(c) Relative permeability

This is the ratio of effective permeability to specific permeability, Permeability relative to a given fluid varies as a direct function of the saturation of that fluid in the rock, and is expressed as a percentage displacement of one fluid relative to the other.

III.3 **Software used :**

III.3.1 SURFER

Surfer software was used to create and visualize various maps such as the well location map, petrophysical parameter mapping and iso maps.

III.3.2 ORIGINLAB PRO

This professional software is specialized in creating various types of curves, diagrams and abacuses. It can perform functional mathematical analysis, data manipulation, integration, differentiation, signal analysis, statistical adjustment and image analysis.

III.3.3 IMAGEJ

ImageJ is a multi-platform, free and open source image processing and analysis software developed by the National Institutes of Health in 1987 [27, 28]. It is written in Java and allows new functionality to be added through plug-ins and macros. ImageJ runs as a downloadable applet on any computer with a Java 5 or later virtual machine.

III.3.4 EXCEL

It is used for entering and managing data files, for certain calculations and is also adopted for all statistical processing.

III.4 Well location

TFT has 281 wells, including approximately 70 in the Amassak area. This work focused on 18 wells where data collection was very difficult. Using the information we were able to obtain, we prepared the sedimentological description. We analyzed the detailed sedimentological study of two wells (MSK-03 and MSK-44), as well as short summaries of the other wells (MSK-02, MSK-03, MSK-04, MSK-08, MSK-27, MSK-30, MSK-31, MSK-38, MSK-39, MSK-40, MSK-42, MSK-43, MSK-44, MSK-45, MSK-46).

We then studied the distribution of petrophysical parameters (porosity, water saturation, permeability) for the 4 wells (MSK-25, MSK-39, MSK-40, MSK-41) and the relationship between porosity and permeability.

Finally, we created the iso-maps: isoporosity map, isopermeability map, water saturation iso-map, isobath map and isopaque map.

The TFT deposit, the Amassak area where the studied wells are located, is shown in (Figure 16).

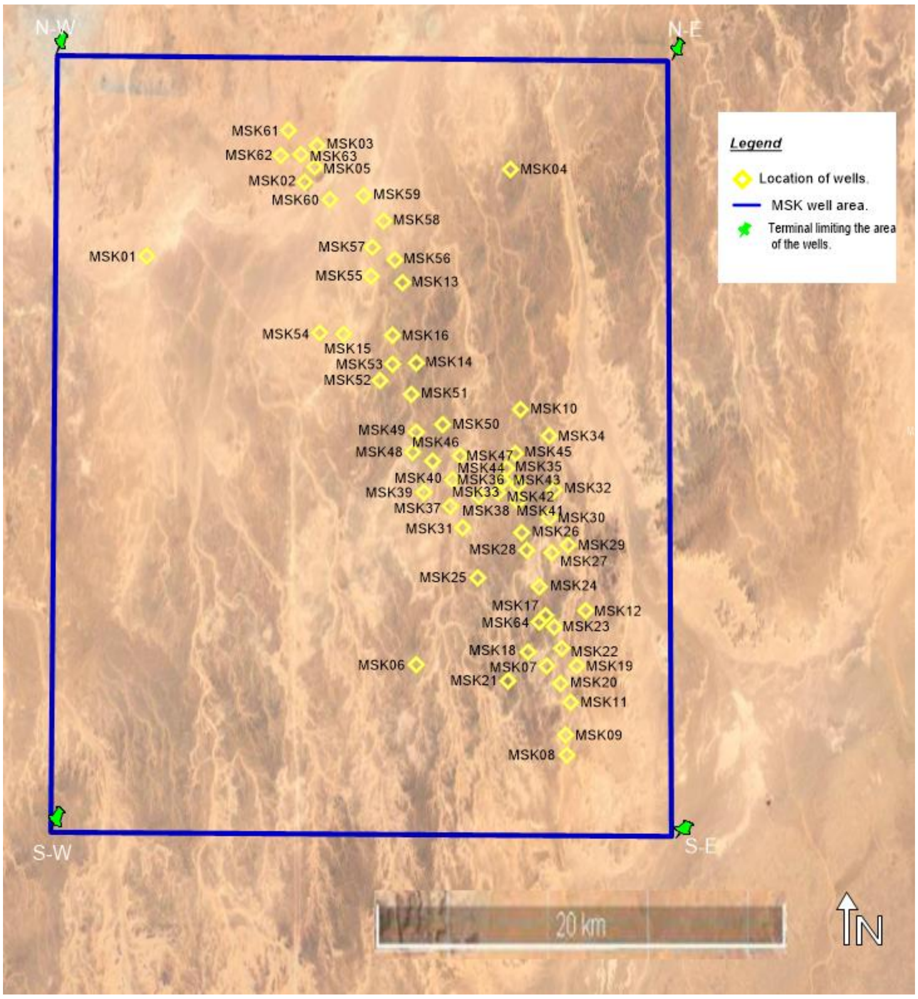


Figure 16. Implementation plan of Ordovician AMASSAK wells.

III.5 3D Geological Model Analysis

The 3D geological model (Figure 17) can be used to analyze certain features of the aquifer, such as variations in unit thickness, and to determine sweetening contrasts in the sedimentary sequence, i.e. the reservoir (MSK) is characterized by

By a large difference in surface thickness petrophysical properties oil and gas accumulations unit IV-3 and IV-2 Ordovician

1: Unit thickness There is some increase in unit thickness along the lines of (southeast and southwest) of the reservoir.

2: Local sedimentary confinement it is possible to construct a 3D geological model to show the to show the extent of local sedimentary contrasts in the reservoir.

To visualize these local conflicts within the sedimentary sequence.

3: It can be used, among other things, to analyze differences in the thickness of geological units and to identify local discrepancies in the sedimentary succession.

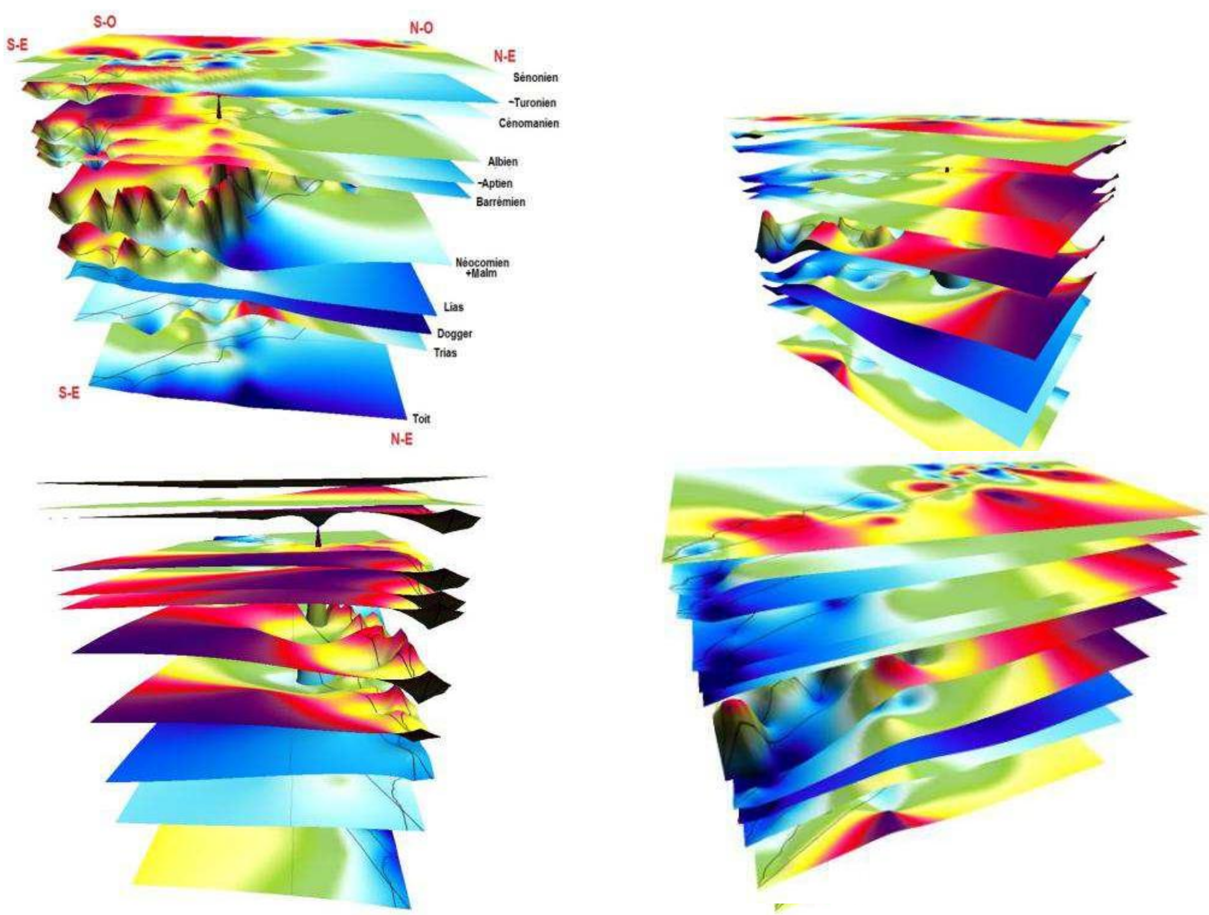


Figure 16 Analysis of the 3D geological model for the reservoir (MSK).

III.5.1 DESCRIPTION: GEOLOGICAL MODEL (3D,STACKINGMAPS)

The 3D geologic model (stacking maps) (Figure 18) also provides an engineering representation of the geologic units at the basin scale. The geological units have been identified and modeled at the basin scale from base to top: 1-Triassic 2-Dogger 3-Bay 4-Neocomian+Malm 5-Barremian 6-Aptian 7-Albian 8-Cenomanian 9-Turonian 10-Senonian.

As shown in Figure 19, the overall stratification of the MSK indicates the completion of the study of wells located at the reservoir level and the arrangement of layers for all existing and non-existing wells(Figure 18).

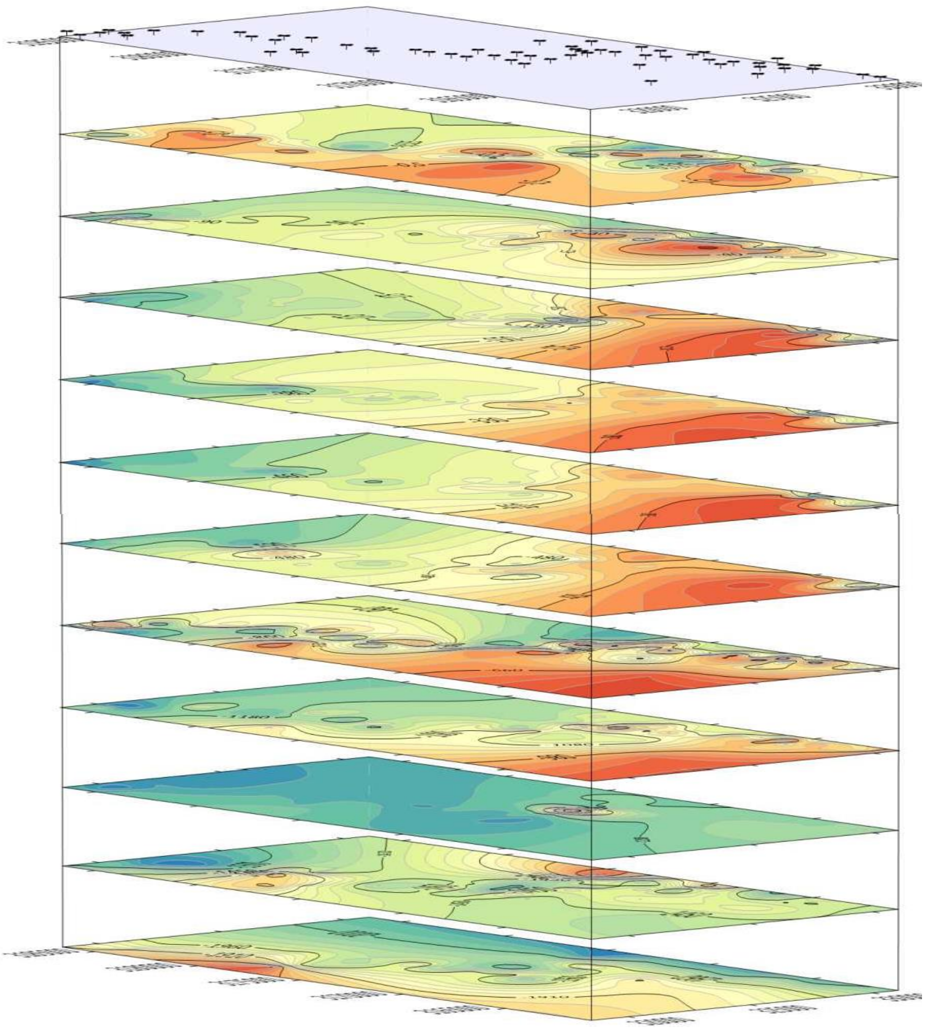


Figure 17 Stratigraphy of the 3D geological model for the reservoir (MSK).

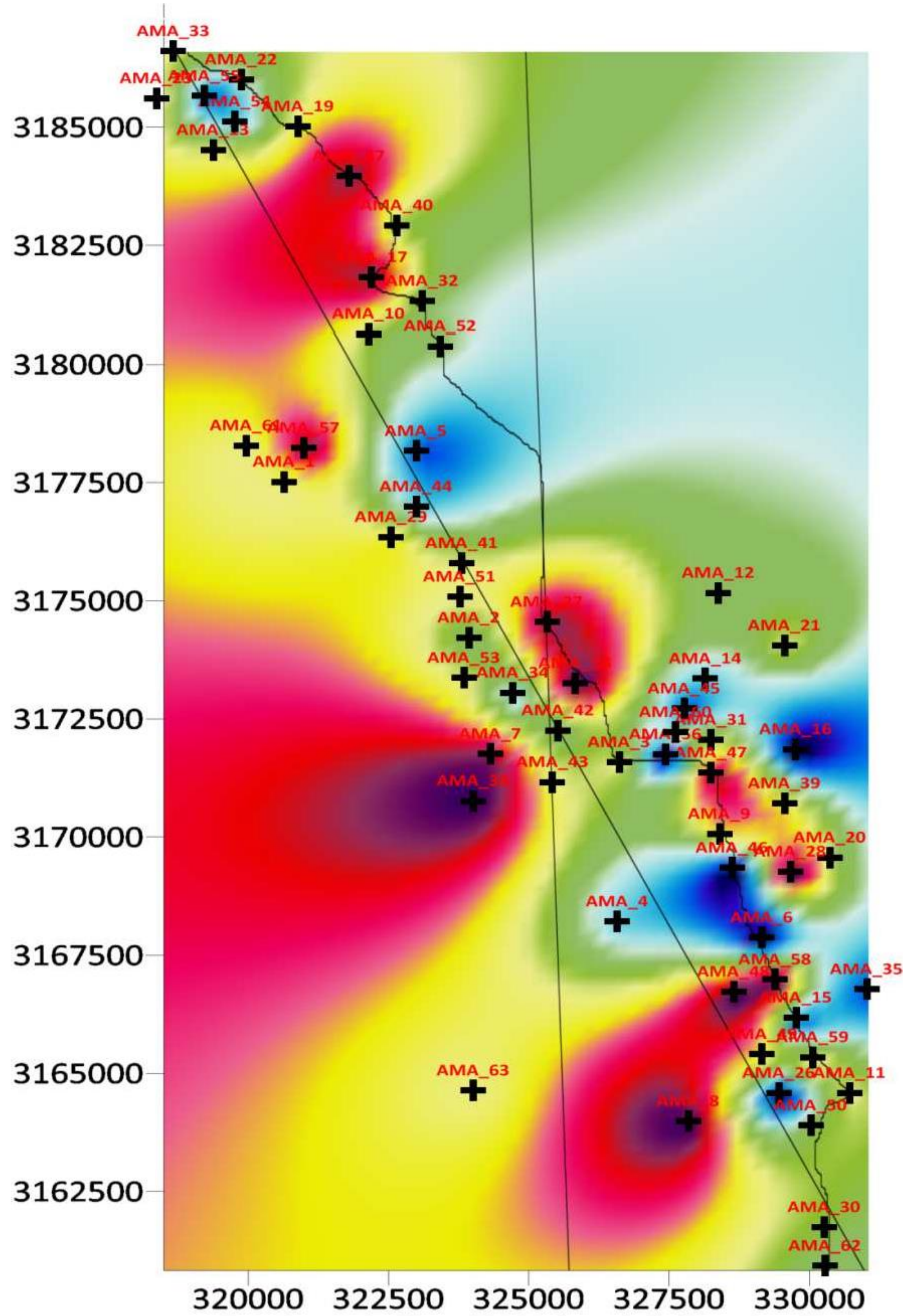


Figure 18 Reservoir roof card (MSK).

III.6 Representation of field profiles

The typical stratigraphic section of the field (MSK) consists of a sedimentary chain from the Senonian to the Trais. A study of the borehole sections drilled in the area shows a certain regularity in the arrangement of the strata throughout the field. There are areas where there are no more than a few meters of residual carbon, and the F6 reservoir, which is located at the top of the field, is completely or partially eroded.

III.6.1 PROFILE INTERPRETATION

III.6.1.1 profiles 1

This profile shows the flat character of the structure as we note the folds at the level of the Neocomian+Malm, i.e. as we can see in wells MSK23 and MSK41 and there is partial erosion of the Albian layer on the west side of well MSK41 and on the east side of well MSK23 and there is total erosion of the Dogger layer which borders it directly on the west side of well MSK41.

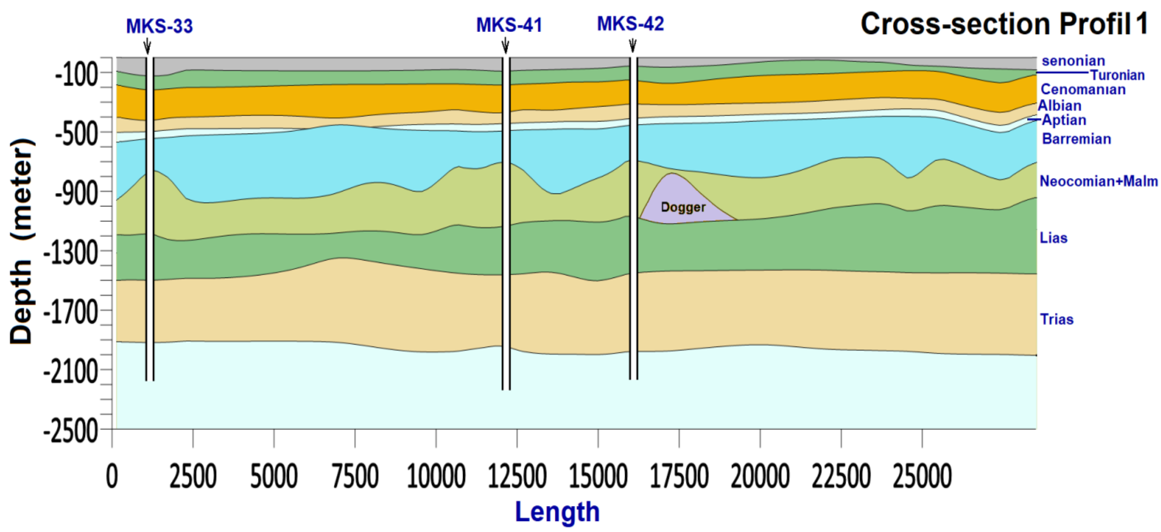
MSK41 well and the east side of the Neocomian+Malm tier.

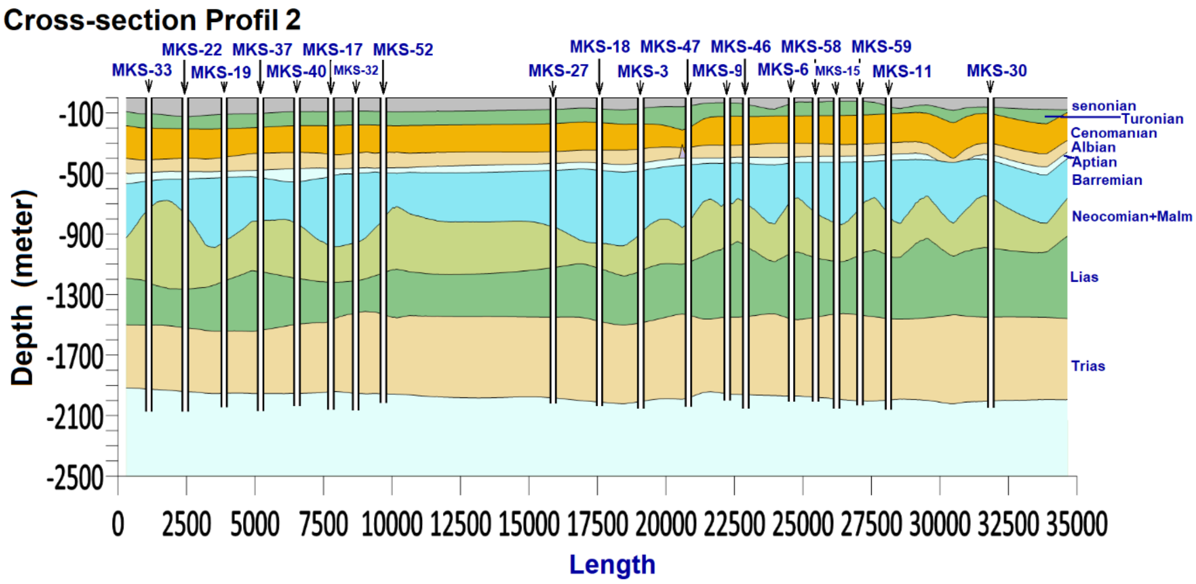
III.6.1.2 Profile 2

It shows the flatness of the structure, with circulating folds in the Neocomian+Malm layer and the Lias layer, and the erosion of the Aptian layer, bounded on the EAST side by the MSK50 shaft and on the WEST side by the MSK11 shaft, as well as other layers of complementary origin and volume preservation.

III.6.1.3 Profile3

This profile demonstrates the flat nature of the structure, as we note on the figure the presence of a large fold at the level of well MSK43 and on the other hand we notice a progressive erosion integrated on the other side of the east, which shows us that wells MSK43 and MSK27 have the same level of layer, which seems to be the integral layers..





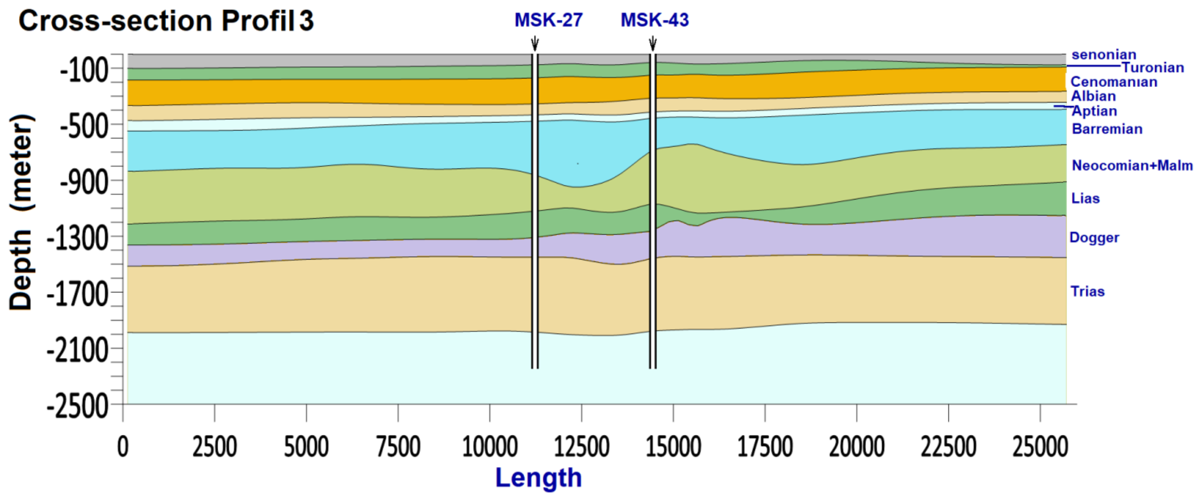


Figure 19 Profiles of the study area (1.2.3).

SEDIMENTOLOGICAL STUDY

From March 11 to 24, 2004, the Sonatrach Hassi Messaoud DOP core library and the Oued S'mar map library in Algiers carried out a geological core analysis to characterize the Ordovician reservoir of the Amassak deposit.

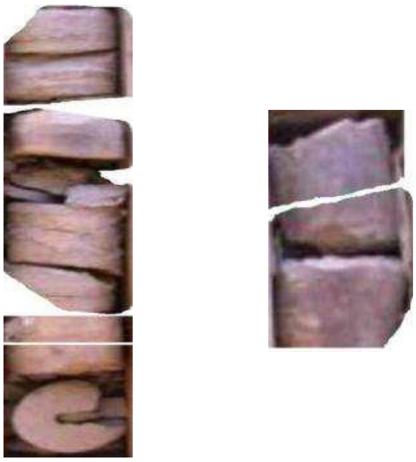
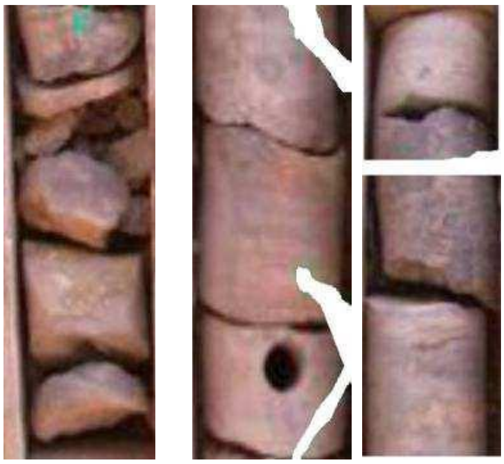
Unit IV corresponds to detailed core descriptions carried out at 1:50 scale on 9 recent wells (post 1991). More general descriptions and observations were carried out on seven wells, enabling part of Unit III-3 to be revised.

III.7.1 ANALYSIS OF SOME TYPICAL WELLS

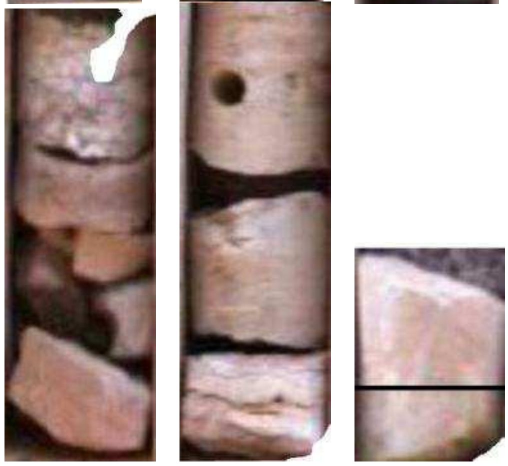
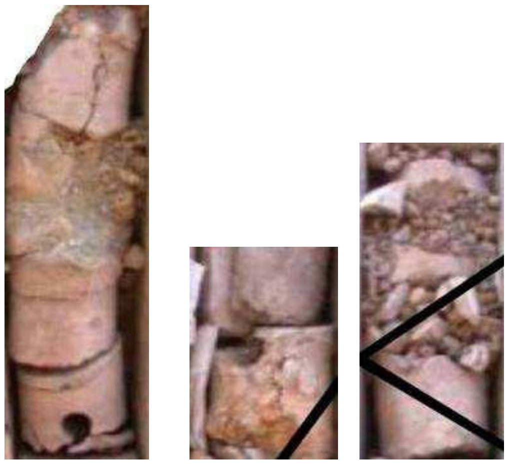
III.7.1.1 Carrot Description

A summary of the various core wells studied is given below. Detailed charters of the 3 cored wells are provided on the following pages.

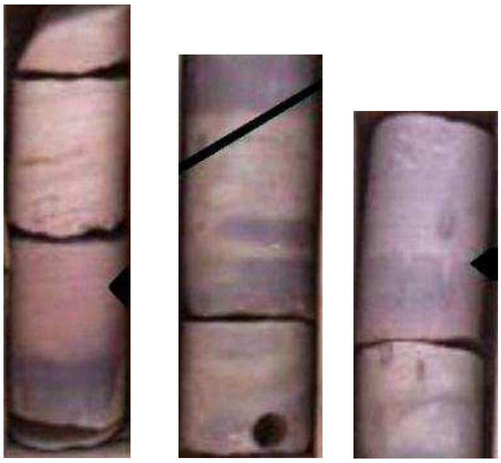
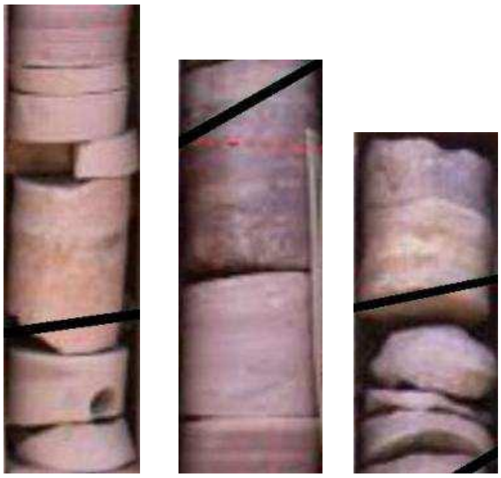
Well MSK3: It crosses lithological units from 2060 to 2062m

Unit	Description	Carrots
2060mm	This level is characterized by the presence of buffers that distinguish level IV-2 from light la-brown to beige-grey. fine to medium grained with open cracks and fractures	
2061.00m	This level has the same characteristics as the previous indications of slight breakage disturbances.	
2062.0mm	This level has the same characteristics as the previous ones, with an increase in thin cracks and partial fractures.	

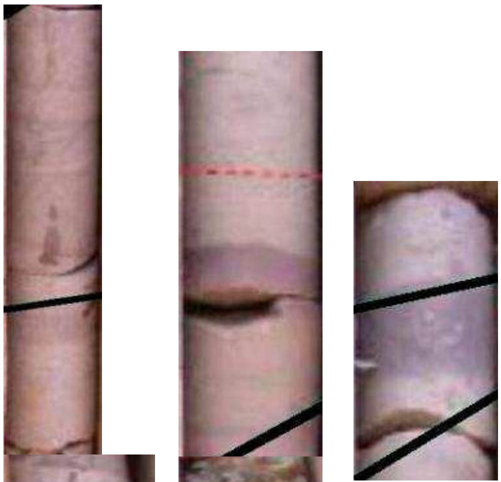
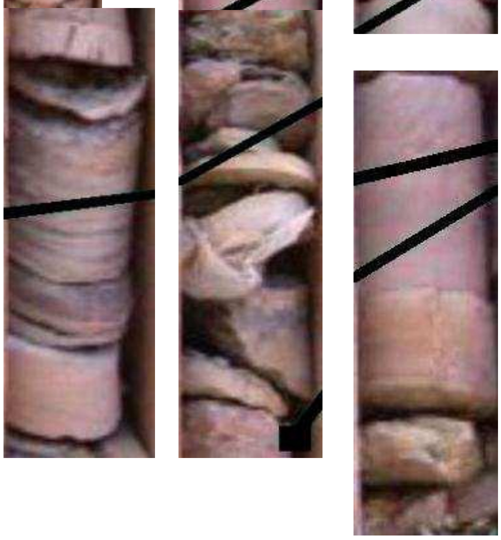
Well MSK3: It crosses lithological units from 2059 to 2062m.

Unit	Description	Carrots
2059–2060m	This level is characterized by the silty clay states that characterize level VI-2.very gray brown color with the presence of patches of black clay, whose fine grain size. There is little bioturbation and few cracks.	
2060-2061m	This level is characterized by the clay contours that characterize level IV-2, its light brown color and with the presence of vital disturbances as well as the presence of cracks.	
2061-2062m	This level is characterized by clay rings with a light-brown color and a crispness Indicating clay availability	

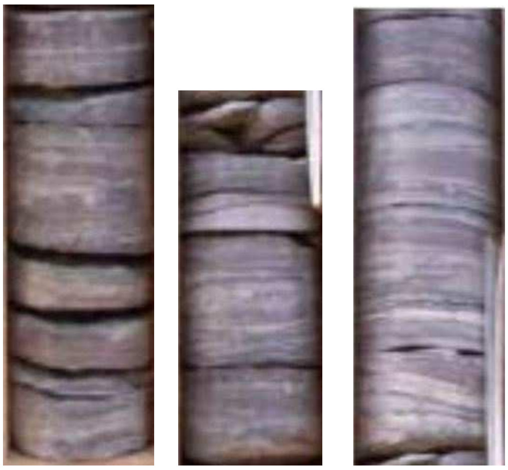
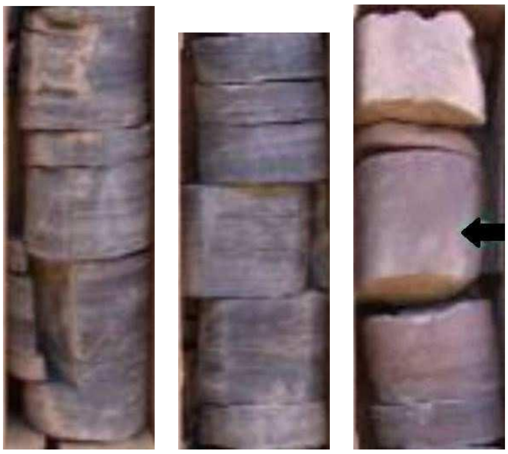
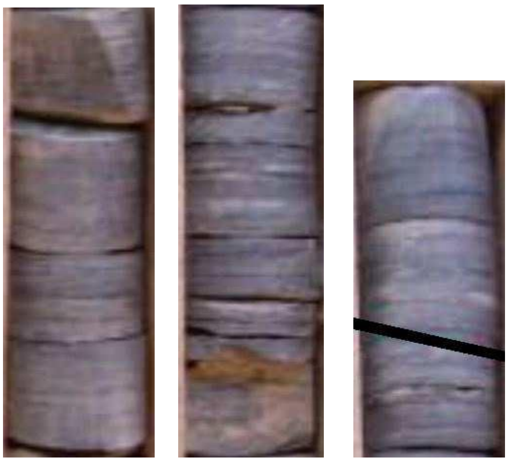
Well MSK3: It crosses lithological units from 2064 to 2067m

Unit	Description	Carrots
2064-2065m	This level is characterized by compact, beige-gray to light-brown-gray clay-limestone surfaces, with the presence of bioturbations. It is characterized by its granulometry and sorting, which indicates the mechanism of deposition. These facies are locally very coarse but well sorted, with intersecting stratifications. This granulometry and sorting can be explained by the action of marine currents (swells or tidal currents).	
2065-2066m	Like the previous level, this level is characterized by compact clay-limestone layers, beige-grey to light brown-grey in color, with the presence of bioturbated reactivation surfaces.	
2066-2067m	Like the previous upper levels, this one is characterized by compact clay-limestone layers, beige-grey to light brown-grey in color, with the presence of bioturbations. Note the presence of low-angle bedding.	

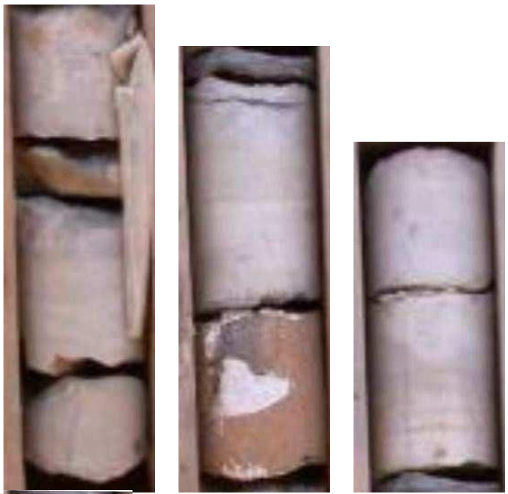
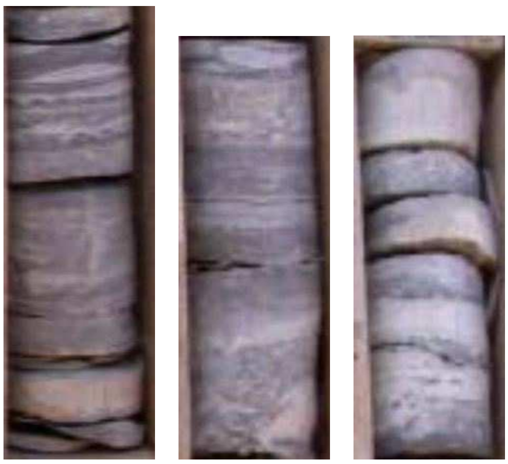
Puits MSK3 : It crosses lithological units from 2068 to 2070m

Unit	Description	Carrots
2068-2069m	This level is characterized by partially compacted calcareous clay surfaces and is characterized by a grey-brown to light color with almost no turbulence, particle precipitation and the presence of a few cracks.	
2069-2070m	It is characterized by the same features as before, with an increase in disturbances and the emergence of almost non-existent violations.	

Puits MSK3 **: It crosses lithological units from** 2100 **to** 2103m

Unit	Description	Carrots
2100-2101m	This level is characterized by compact deposits, level IV-3 limestone, relatively gray in color with slight biotic disturbances and an open horizontal fracture.	
2101-2102m	Also distinguished by the same characteristics as above, i.e. it is distinguished by the measurement and sorting of the granules, which indicates deposition, these faces are locally rough and well arranged.	
2102-2103m	This level has the same characteristics in height, except that it is light grey in color with open fractures, fine cracks and local disturbances.	

Puits MSK3 : **It crosses lithological units from** 2106 **to** 2112m

Unit	Description	Carrots
2106,30-2107,10m	This level is characterized by light beige to beige-gray clay facies, fine to medium grain size, and the presence of cracks and bioturbations.	
2108–2109m	This level is a continuation of the previous one and is characterized by compact, beige to greyish-beige, fine to very fine-grained, siliceous clay facies. The presence of fissures of varying size is noteworthy.	
21011–2112m	This level is characterized by moderately bioturbated sandstone facies (shore face or sand flat). The sandstone is gray in color, with patches of fine-grained black clay. Stratification and cracks are also noticeable.	

Puits MSK44 : **It crosses lithological units from 1881 to 1983m.**

Unit	Description	Carrots
1981.50m	This level is characterized by a dark grey sandstone clay over black clay with weak breccias and open fracture grain sedimentation..	 1981.50m
1982.00m	The level is characterized by the same features as the previous level, indicating the presence of an apparent open fracture that trends color from dark to light downward with relatively increased sedimentation.	 AMA_44: 1982.00m  1982.00m
1982.60m	This level is characterized by limestone sandstones with a characteristic light-brown and light-grey clay with open fractures and fissure disruption.	 AMA_44: 1982.60m  1982.60m

Puits MSK44 **: It crosses lithological units from 1883to 1985m.**

Unit	Description	Carrots
1983.00-1983.50m	1983.00 this level is characterized by a IV-3 level with the presence of calcareous sandstone tending to light gray and the presence of a light brown color with disturbances and sedimentation of particles almost nonexistent. 1983.50 this level has the same general characteristic as another with irregularities and gradation of color from light to dark gray.	 1983.00 m 1983.50 m
1984.00-1984.45m	1984.00level is characterized by the presence of relatively predominant gray sandstones and average grain size over the entire extent of its sedimentation. 1984.45 this level is characterized by the same previous level of light- and medium-grained gray sandstone with increased precipitation.	 1984.00 m 1984.45 m

III.7.1.2 **BRIEF DESCRIPTION OF ALL AMASSAK FIELD WELLS:**

We will now briefly summarize the sedimentological aspects of the wells studied.

❖ **well MSK-2**

Intervals cored from 2006 to 2024.5 m and 2043 to 2051 m (Units IV-3 and IV-2), then interval 2077 to 2138 m (Unit III-3), revealing a very thin Unit IV-3 resting directly on micro-conglomeratic clays with slumps from Unit IV-2. The cored interval in Unit III-3 shows the sandstone and bioturbated clay facies of the top of this unit, as well as the sandstone facies of Reservoir III-3.

❖ **Well MSK-3**

Core interval 1994.5 - 2018 m (Unit IV-3 and top of Unit IV-2), and intervals 2058.5 - 2074 m and 2097.5 - 2115.28 m (Unit III-3). Unit IV-3 is comparable to the adjacent wells, with the upper interval dominated by poorly sorted sandstone deposits (high-density turbidity plain). The top of Unit III-3 is marked by a level of Bryozoan carbonates.

❖ **Well MSK-4**

Core interval from 1999.50 to 2033 m. Unit IV-3 is complete, pyritized towards the top. Unit IV-2 comprises sandstones (gravity deposits) underlain by locally fractured micro-conglomeratic clays.

❖ **Well MSK-8**

Core interval from 1942.65 to 2068.5 m with many intermediate intervals not recovered. Units IV-3, IV-2 and top of Unit III-3. Observation of a gullying conglomeratic level at the base of Unit IV-2, resting directly on Unit III-3 clays.

❖ **Well MSK-27**

Core interval from 2005.5 to 2014.5 m. Very thin level (1m) of conglomeratic sandstone with strong carbonate cement (IV-3) resting directly on the micro conglomeratic clays of Unit IV-2.

❖ **Well MSK-30**

Cored interval from 1999 to 2008 m. Upper part of Unit IV-3, with good reservoir level formed by sandstones representing high-density turbidities.

❖ **Well MSK-31**

Cored interval from 1962 to 1980.50 m. Unit IV-3 appears to be made up of two different genetic units recognized in adjacent wells, and underlain by micro conglomeratic clays from Unit IV-2.

❖ **Well MSK-38**

Cored interval from 1999 to 2011.20 m. Corresponds to Unit IV-3, which appears highly fissured, especially in the upper part.

❖ **Well MSK-39**

Core interval from 2001.5 to 2010.30 m. Only cored in the upper part of Unit IV-3. This interval appears highly cemented and compacted, and is affected by intense fracturing.

❖ **Well MSK-40**

Cored interval from 1962 to 1971.35 m. This well is unusual in that Unit IV-3 is very thin (approx. 2 m). Unit IV-2, visible in core samples, is very clayey and micaceous.

❖ **Well MSK-42**

Core interval from 1987 to 2020.50 m. Unit IV-3 appears to be subdivided into two distinct parts. Unit IV-2 is relatively finer grained and massive. No fractures observed.

❖ **Well MSK-43**

Core interval from 1960 to 1996 m. This well reveals the sandstone facies of Unit IV- 2, underlying a well-developed Unit IV-3 showing the presence of two distinct events: an erosive conglomerate at the base, and a high-density turbiditic plain.

❖ **Well MSK-44**

Core interval from 1981.50 to 2000.50 m. Unit IV-3 is relatively thin, and facies are coarser than in the adjacent shafts. This well reveals bioturbated facies from the top of Unit IV-3, probably belonging to the Silurian transgressive event.

❖ **Well MSK-45**

Cored interval from 1958 to 1972.30 m. Unit IV-3 shows the same subdivision as MSK- 43, with a lower part dominated by conglomeratic sandstone, and a very poorly sorted upper part. The cores are also highly fractured.

- **Well MSK-46**

Core interval from 1971 to 1984 m. The upper part of Unit IV-2 is represented by fine sandstones, and is fractured. The upper part of Unit IV is highly pyritized.

III.7.1.3 Comments

A detailed sedimentological analysis of the reservoirs in the Amassak deposit has allowed us to complete our recognition of the main Fin-Ordovician glaciomarine sedimentary facies and to propose a stratigraphic architecture in relation to the main climatic cycles.

At the scale of the Amassak deposit and at the level of Unit IV, the main facies associations correspond to a regional system of glacial advance and retreat: the phases of advance allow the deposition of fine, often clayey sediments (mainly Unit IV-2), while the phase of glacial retreat allows the deposition of first discontinuous, chenalized sandstone sediments, followed by relatively more homogeneous sediments (turbiditic plain), which constitute the best reservoirs of Unit IV-3.

The Amassak deposit does not show typical paleo-valley development except in the extreme southern part of the study area.

By recognizing the sedimentological and diagenetic characteristics of the studied intervals, this analysis has also made it possible to establish a link between lithofacies and electrofacies with a view to modeling geological and petrophysical properties

III.8 Distribution of petrophysical parameters

n order to better understand the petrophysical parameters characterizing the reservoir under study, we attempted to approximate the relationship between porosity and permeability by constructing "permeability versus porosity" plots. Secondly, histograms were constructed to illustrate the distribution of porosity and permeability values.

III.8.1 INTERPRETATION OF POROSITY AND PERMEABILITY HISTOGRAMS

The Ordovician IV-3 reservoir in the study area is characterized by variable petrophysical parameters, so we will present the results of the statistical analysis of this reservoir on a well-by-well basis.

III.8.1.1 Interpretation of porosity and permeability histograms at the MSK 25 well

Figure (21): The histogram of porosity classes shows a right-asymmetric bimodal distribution, with the first mode corresponding to the [8-10[% class, with a concentration of 42.42% of the population, and the second corresponding to the [10-12[% class, with a concentration of 24.24%.

The histogram of permeability classes shows a uni-modal, left-asymmetric distribution whose mode corresponds to class [0-20[md, with a frequency of 69.7%.

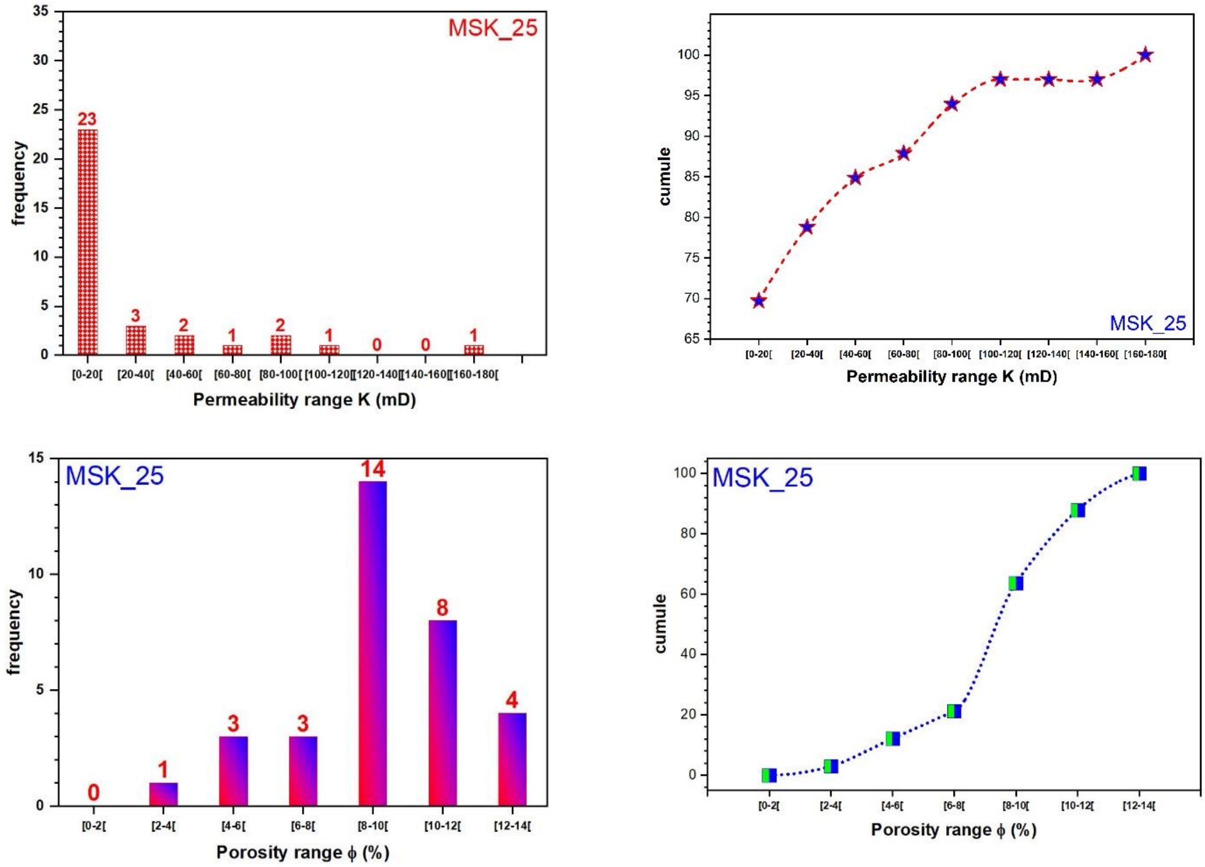


Figure 20 **Permeability and porosity of MSK25.**

III.8.1.2 Interpretation of porosity and permeability histograms for the MSK 39 well

Sur la figure (22): The histogram of porosity classes shows an asymmetrical right-hand bimodal distribution, with the first mode corresponding to the [8-10[%] class, which accounts for 24.63% of the population, and the second mode corresponding to the [10-12[%] class, with a concentration of 21.73%.

The histogram of permeability classes shows a uni-modal, left-asymmetric distribution, the mode of which corresponds to the [0-20[md class with a frequency of 81.15%.

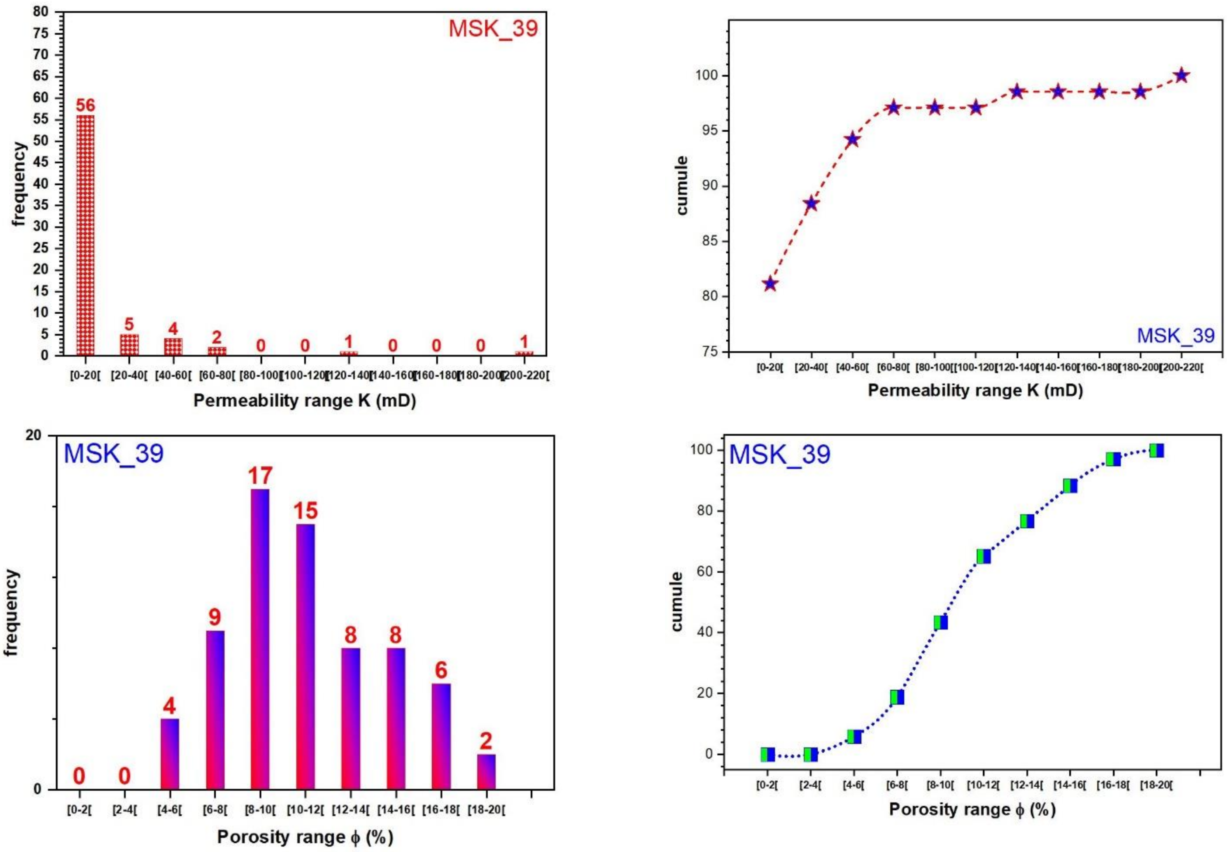


Figure 21 Permeability and porosity of MSK39

III.8.1.3 Interpretation of porosity and permeability histograms for the MSK 40 well

Figure (23): The histogram of porosity classes shows a bimodal, right asymmetric distribution, where the first mode corresponds to the [12-14[% class, which accounts for 41.37% of the population, and the second mode corresponds to the [10-12[% class, with a concentration of 17.24%.

The histogram of permeability classes shows a unimodal, left asymmetric distribution with the mode corresponding to the [0-20[md class with a frequency of 86.2%.

III.8.1.4 Interpretation of porosity and permeability histograms at the MSK 41 well

Figure (23): The histogram of porosity classes shows a bimodal, right asymmetric distribution, with the first mode corresponding to the [8-10[%] class, which accounts for 28.7% of the population, and the second mode corresponding to the [10-12[%] class, with a concentration of 27.82%.

The histogram of the permeability classes shows a unimodal, left asymmetric distribution, with the first mode corresponding to the [0-25[md] class, with a frequency of 76.52

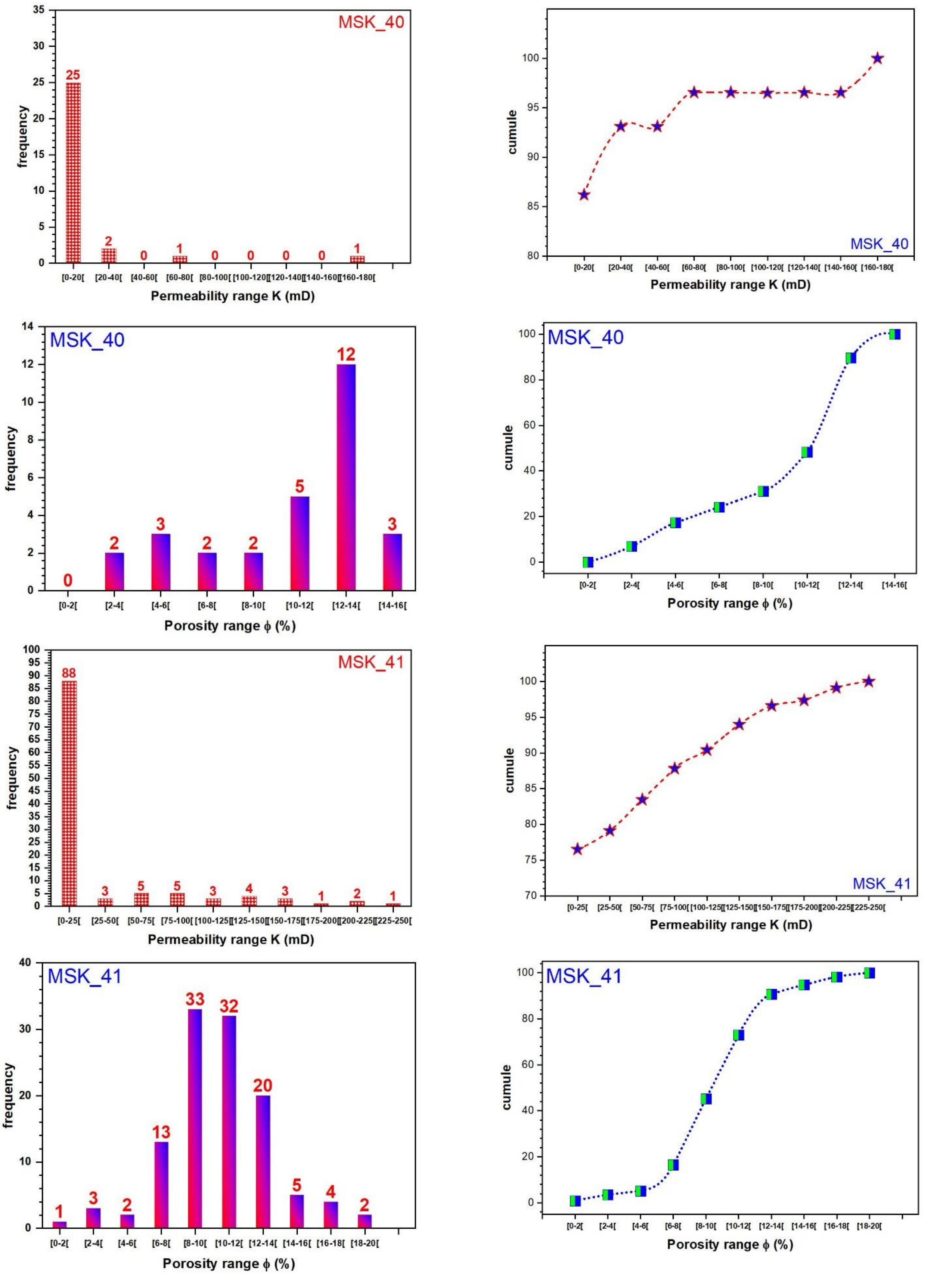


Figure 22 **Permeability porosity of MSK40 and MSK41**

III.8.2 STUDY OF THE CORRELATION “POROSITY VS PERMEABILITY”

Figure (24, MSK_25) shows the correlation graph between porosity and permeability for well MSK-25. The points form two visibly distinct clusters. The first cluster is organized with a Pearson correlation coefficient equal to 0.77086. The points in this cluster form a trend line with a slope equal to a = 0.29222, intercepting the coordinate axis at b = -1.69359. The second cluster is less organized, with a singular point probably caused by the presence of fracturing at this point. Its negative Pearson correlation coefficient is -0.11437. This second cloud has a trend line with a slope equal toa=-4.65843E-4andinterceptingthecoordinateaxisatb= -0.95313.

Finally, from an overall point of view, all the points are weakly correlated, with a Pearson coefficient equal to 0.22103.

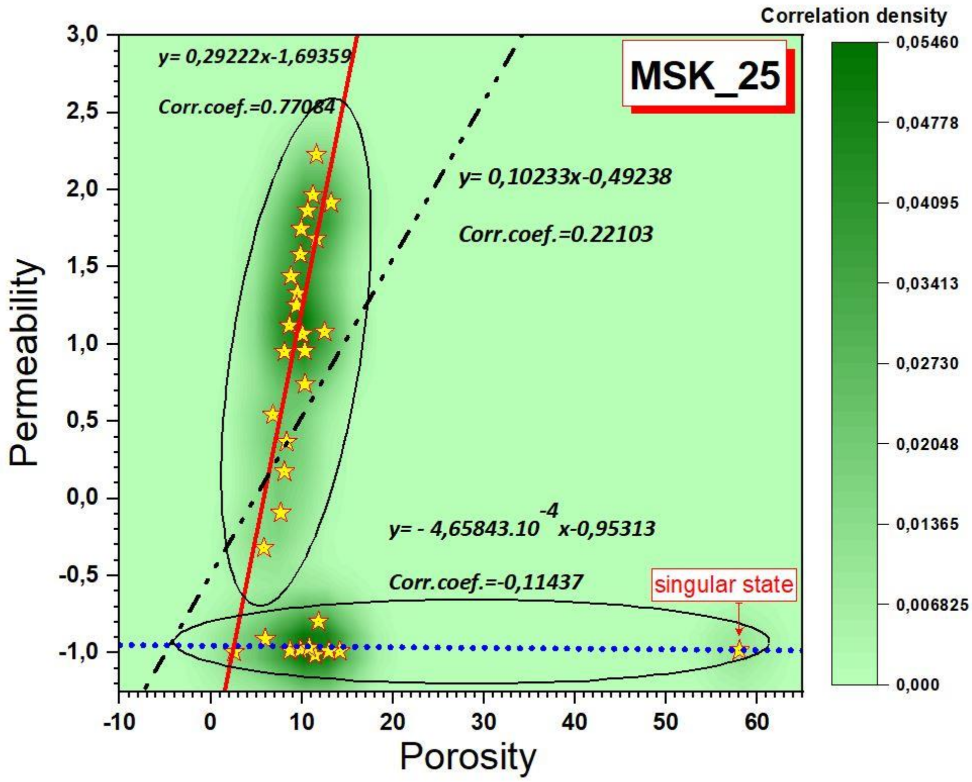


Figure 23 Correlation between permeability and porosity with geostatistics MSK25 well

Figure (25, MSK_39) shows the correlation plot between porosity and permeability for well MSK-39. The correlation plot shows that the points are in the shape of a fairly scattered cloud, with a correlation coefficient equal to 0.13271, which shows that the reservoir is heterogeneous. However, the points form two visibly distinct clouds. The first cluster is organized, with a Pearson correlation coefficient of 0.45607. The points in this cluster form a trend line with a slope of a = 0.1385, intercepting the coordinate axis at b = -4.1152. The second cluster is less organized, showing a singular point probably caused by the presence of fracturing at this point. Its Pearson correlation coefficient is 0.16569. This second cluster has a trend line with a slope equal to a = 0.01051 and intercepting the coordinate axis at b = -0.47668.

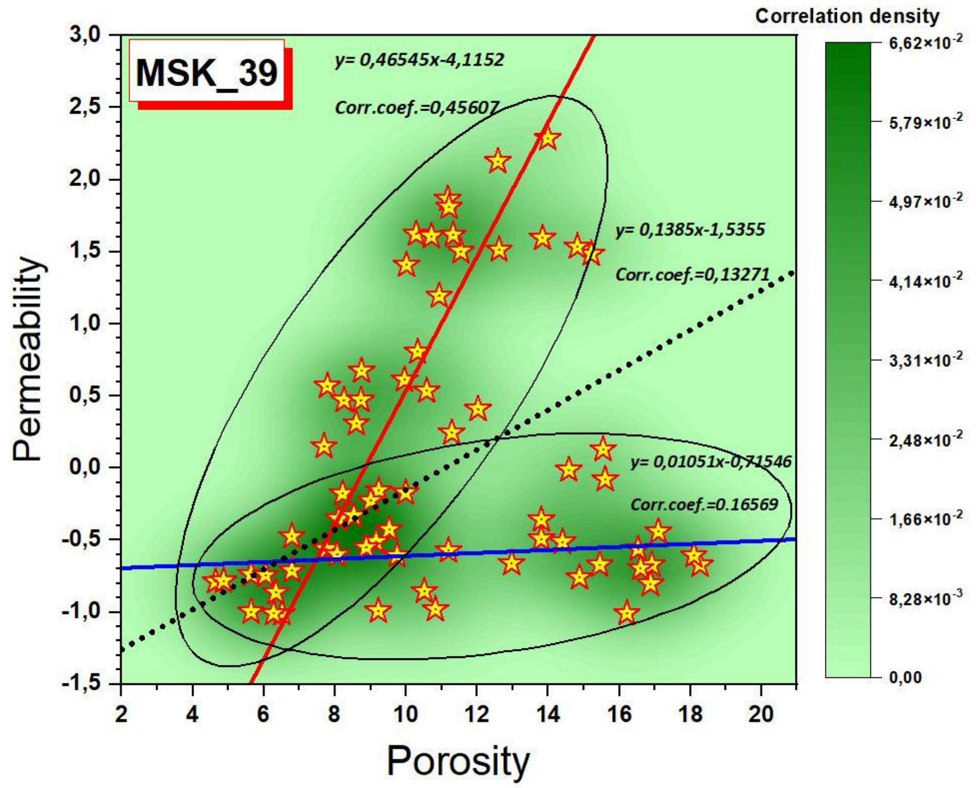


Figure 24 **Correlation between permeability and porosity with geostatistics MSK39 well.**

Figure (26, MSK_40) shows the correlation plot between porosity and permeability for the **MSK-40 well**. The correlation graph shows that the points are in the form of a fairly scattered and very poorly organized cloud, with a correlation coefficient equal to 0.23271, indicating that the reservoir is heterogeneous. However, the points form two visibly distinct clouds. The first cluster is organized, with a Pearson correlation coefficient equal to 0.8829. For the points in this cluster, a trend line with slope a= 0.8250 and intercepting the coordinate axis at b = -9.7542. Its Pearson correlation coefficient is 0.5259. This second cloud has a trend line with slope equal to a = 0.01099 and intercepting the coordinate axis at b = -0.71546.

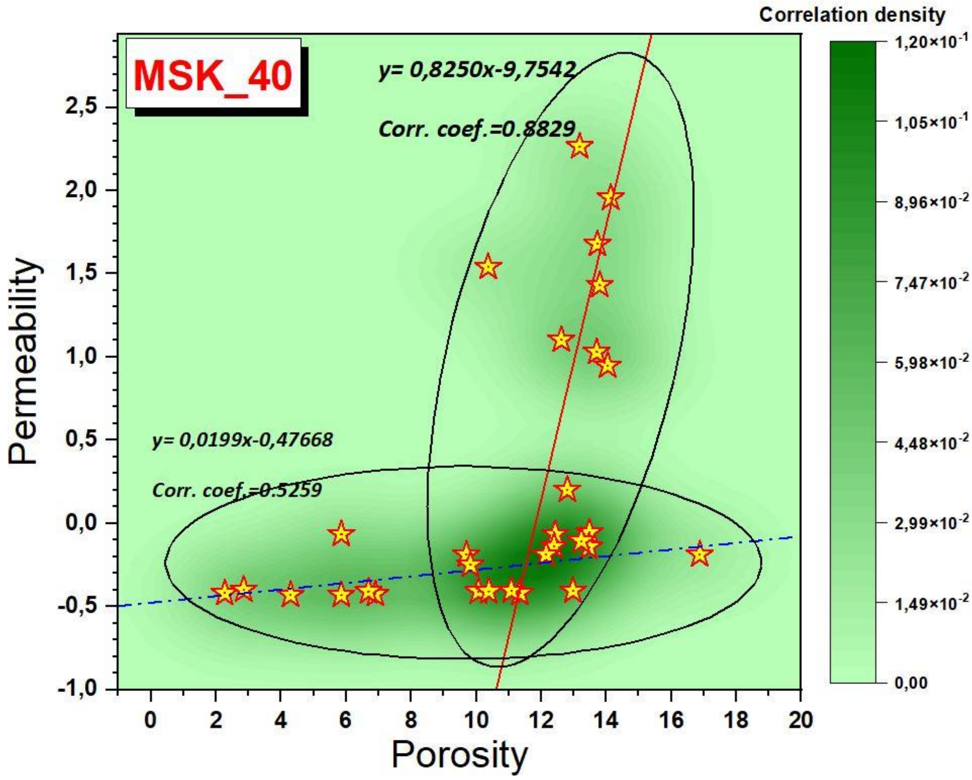


Figure 25 Correlation between permeability and porosity with geostatistics MSK39 well.

Figure (27, MSK_41) shows the correlation plot between porosity and permeability for well MSK-41. Note that the points form a cloud and are slightly organized, with a Pearson correlation coefficient equal to 0.50159. For all the

points, a trend line with slope equal to a = 0.18864 and intercepting the coordinate axis at b = -1.69741. A priori, the reservoir tends more towards homogeneity than heterogeneity.

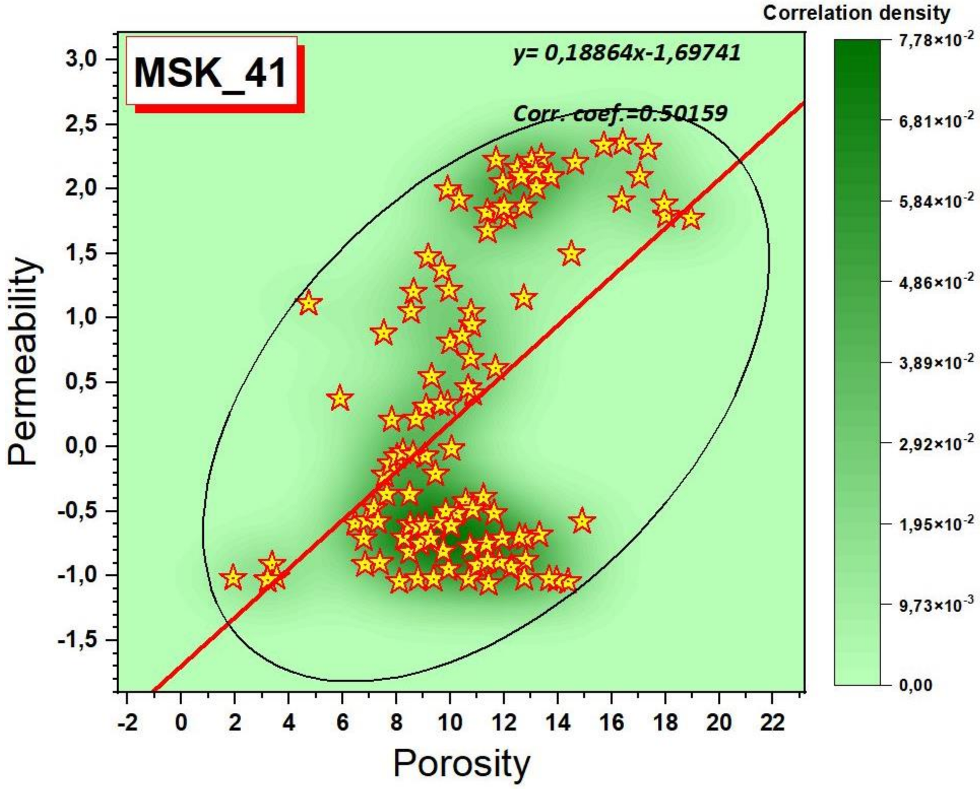


Figure 26 Correlation between permeability and porosity with geostatistics for MSK41

III.9 Interpretation of Ordovician Reservoir petrophysical data

III.9.1 THE ROOF MAP:

Figure (26) shows that depth values vary in this Ordovician Unit reservoir (IV-3). The greatest depth value is -1635m in wells MSK-20 and MSK-21, in the central-eastern and north-western part, while in the western part it decreases to -1470m in wells MSK-1 and MSK-57.

- The Amassak structure takes the form of a monocline affected by a major subvertical reverse fault to the west, which can reach very high rejection locally to the west of MSK-1.

- The North-South fault located to the west of the MSK-4, 45,12 wells, separates the field into two compartments, one in the center and the other to the south.

- The shallowest reservoir roof depths are located in the central and southern parts of the field to the west. The northeastern part of the field is deeper.

- Between the two major north-south trending faults in the center of the field, there is a vast zone inclined steadily to the northeast.

In the south-east and north-west compartments, however, depths vary considerably due to the existing fault network.

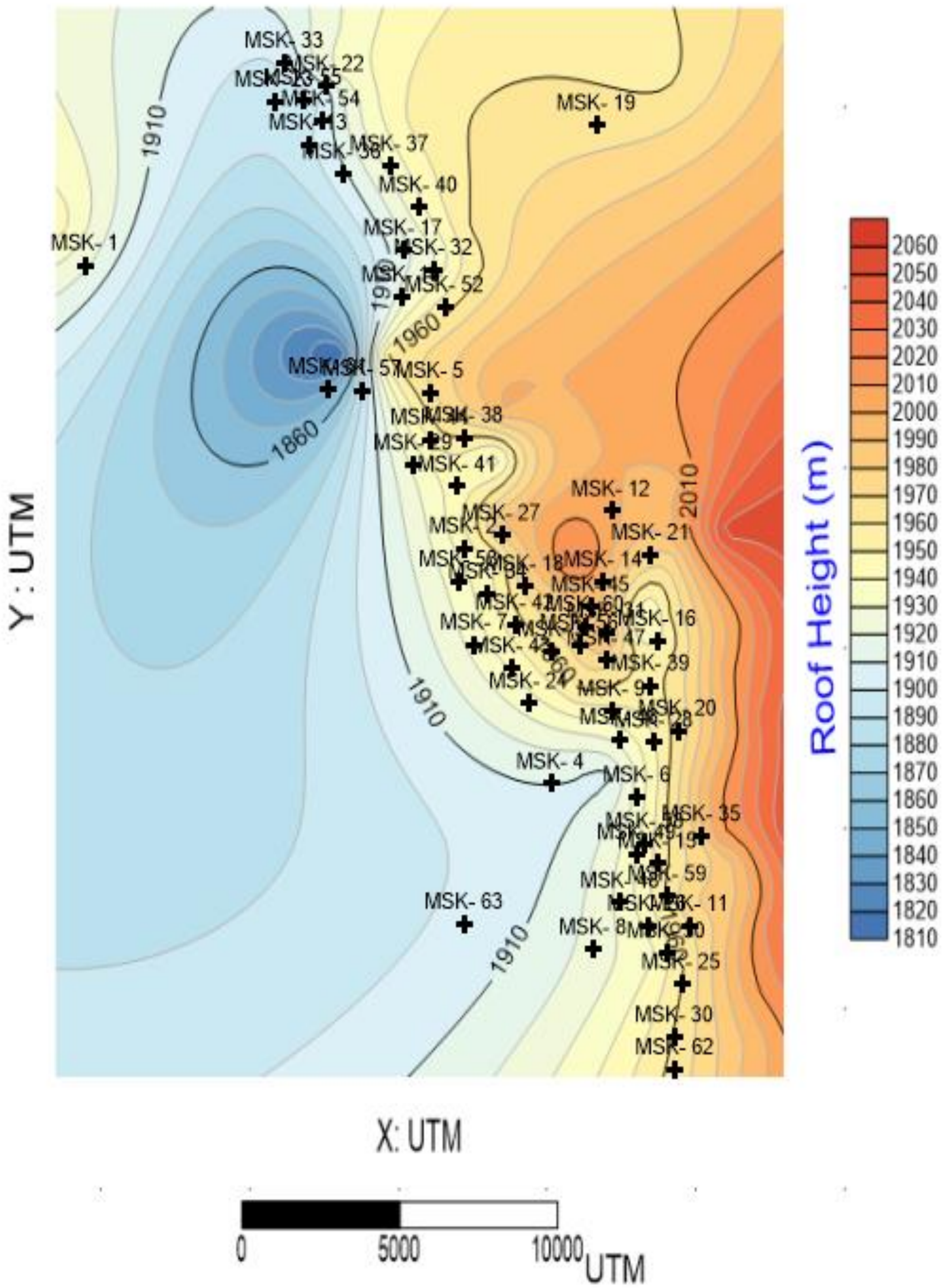


Figure 27 AMASSAK the roof map

III.9.2 ISOPAC MAP

In figure (27), the total thickness distribution of the Ordovician Unit IV-3 reservoir is very irregular.
- The greatest thickness value, 41.5 m, is recorded by well MSK-12 in the eastern part of the deposit.
- The smallest thickness values are found in wells MSK-40 to the north-northwest and MSK-61 to the northwest of the deposit, with only 4m.
- In the northern part, total thickness values are high around shaft 12, but reduced in the north-western part.
- In the central part, total thickness values are relatively higher.

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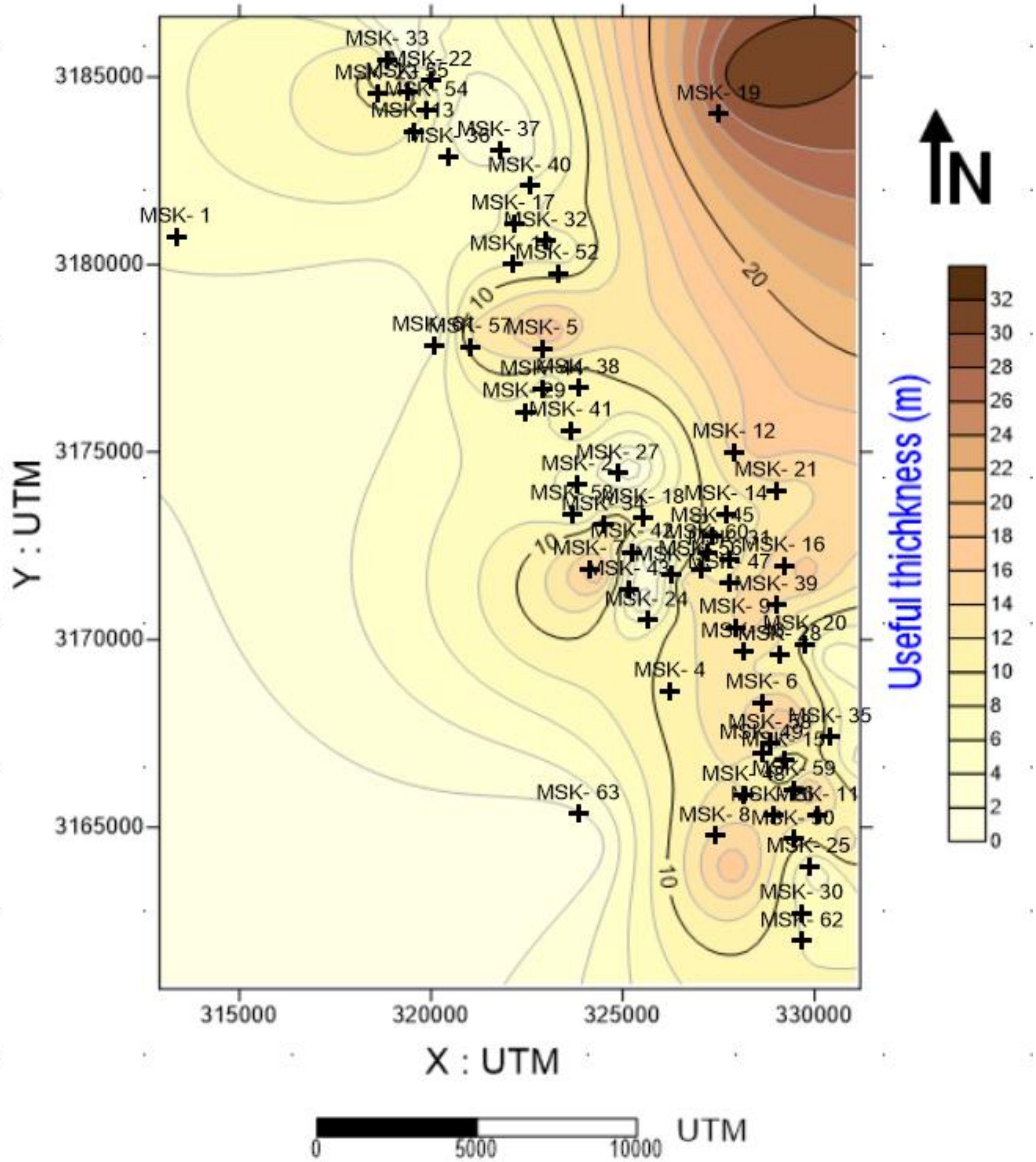


Figure 28 AMASSAK isopac map.

III.9.3 POROSITY MAP

Figure (28) on this card shows that porosity increases towards the northeast of the reservoir and decreases towards the northwest and southwest of the reservoir.

This card shows that there is a wide range of porosity in this reservoir, with the highest value at well MSK38 located towards the southern center of the card at UTM coordinates (X= 324193.33mN; Y= 3177241.52mE) with a value of 13. 30%, while the lowest value was measured for well MSK60 (4.54%) located towards the southern center of the card at UTM coordinates (X= 327768.24mN; Y= 3172410.53mE).

The porosity distribution shows a South-West, North-East gradient of increase.

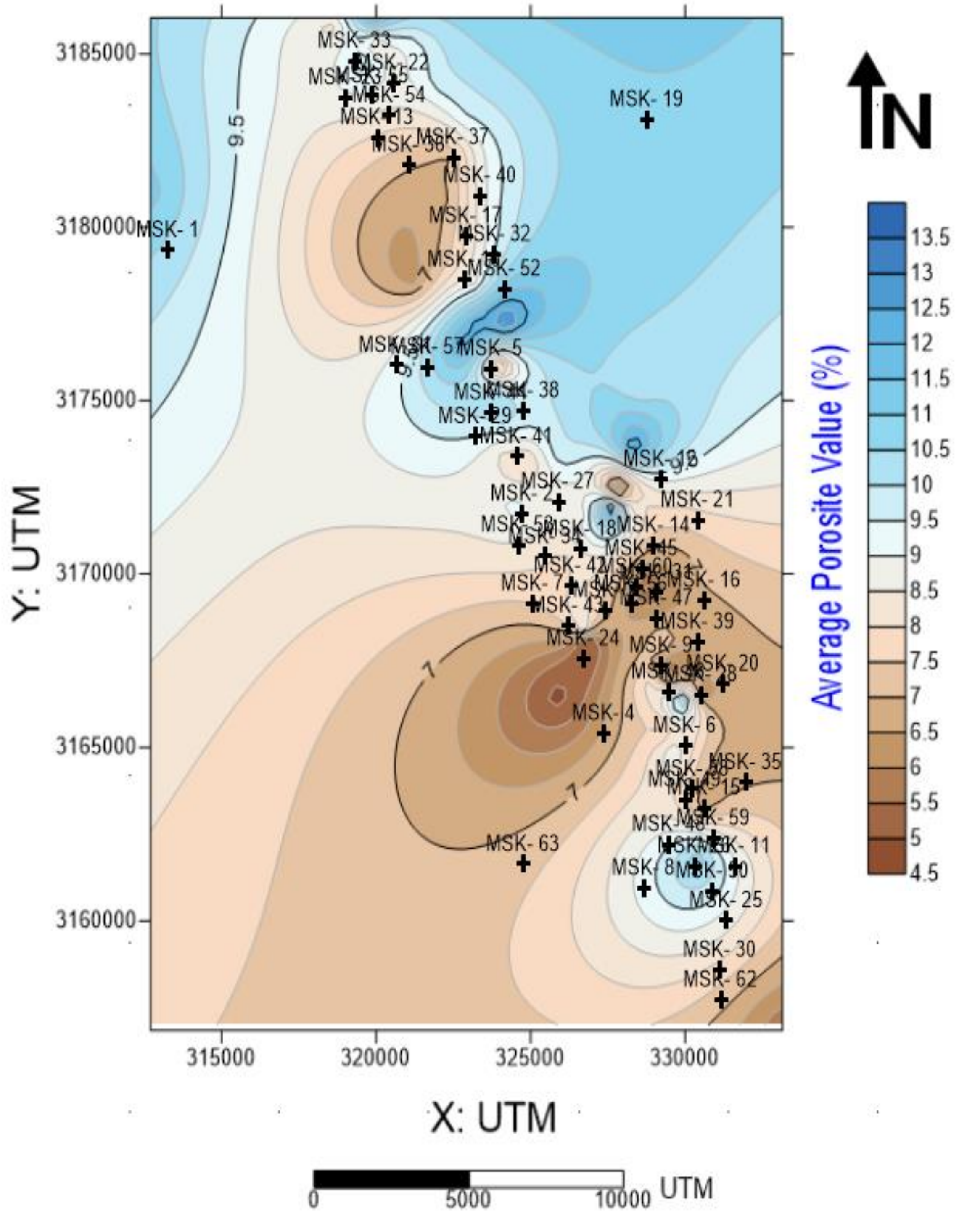
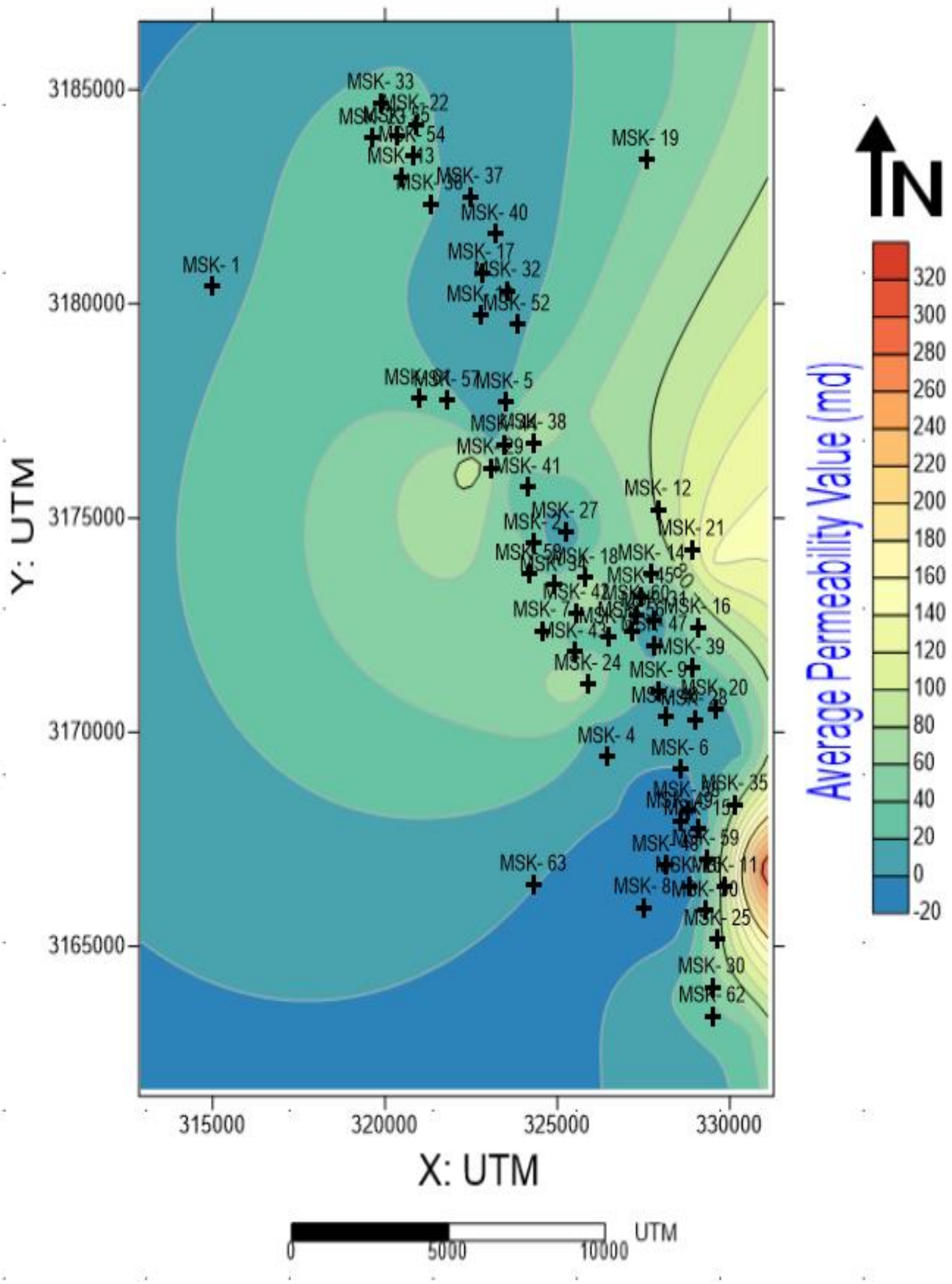


Figure 29 AMASSAK isoporosity map

III.9.4 PERMEABILITY MAP

On figure (29), this card shows a wide range of permeability in this reservoir, with the highest values at wells MSK-21 (144 md) and MSK-35(300 md) in the south-eastern part of the field. On the other hand, lower values are found at wells MSK-27 (0.46 md), 33(0.6md) and 45(0.7md) in the central part. -Zero permeability values are also found in the northeast and southwest parts of the field. The permeability distribution shows the trend of increasing permeability from west to east, with a good value (300md) found in the MSK-35 well located in the south-east corner of the card, confirming the improvement of this parameter in the eastern part of the field



. Figure 29 AMASSAK iso-permeability map.

III.9.5 ISOSATURATION MAP

On figure (30), this map shows that there is a wide range of saturation in this reservoir, where the highest value is found at the MSK63 well located towards the southern center of the card at the UTM coordinate point (X= 325841.66mN; Y= 3166433.98mE) with a value of 87.24%, while the lowest values were measured for the MSK38 (9. 50%), MSK51(11.13%),MSK44(12.49%),andMSK29(13.60%).ThedesaturationdistributionfromWesttoEastis represented by a suitable value which was encountered in well MSK64 located to the South-East of the card at UTM coordinates (X=326782.00mN; Y=3168235.00mE) with a value of 50.45%.

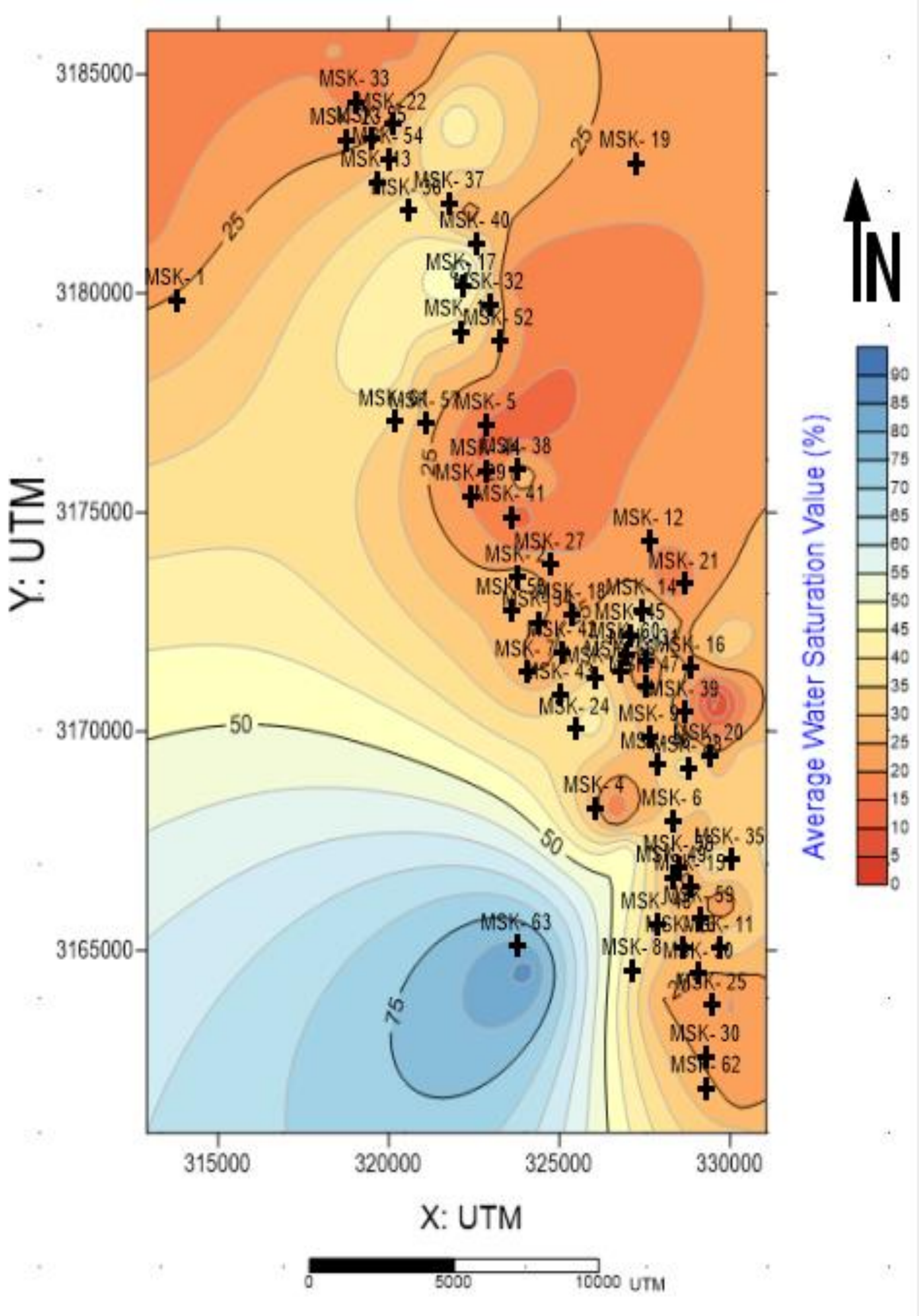


Figure 30 AMASSAK isosaturation map.

Conclusion

This dissertation examines the MSK (Amassak) reservoir, located northwest of In Amenas and northeast of Tamanrasset, Algeria. It focuses on the Ordovician-age MSK (Amassak) reservoir within the Illizi basin, specifically Unit IV-3, which is not affected by a geological unconformity.

The study identifies the optimal reserve as sandstones deposited in the Ordovician period and capped by Silurian clays. Unit IV-3 is the largest unit, boasting a thickness of 13 meters with good porosity (6-13.5%).

Geologically, the reservoir formation reflects a glacial retreat system. Retreating glaciers deposited discontinuous sandstones (Unit IV-3), followed by more homogenous sediments forming the best reservoir zones.

Sedimentologically, the MSK reservoir is a 24-meter thick clay-sandstone formation deposited in glacial to pre-glacial environments. The study also reveals fractures filled with silica and pyrite, alongside horizontal and vertical open cracks. Two main sandstone types are identified: traction current deposits (structured) and gravitational/turbiditic deposits (unstructured) containing fossil tigillites.

Structurally, the area is characterized by a monocline and fractures. The main faults trend NNE-SSW and reach depths of up to 120 meters.

Petrophysical analysis indicates good to average petrophysical parameters. Combining all the data suggests the most significant zones for hydrocarbon production lie in the northeastern region, particularly within Unit IV-3 and the underlying Ordovician sandstones. Units IV-2 and III-3 together form the terminal Ordovician complex deposited in a glacial to pre-glacial environment. Unit III-3 also contains a reservoir within its sandstone levels.

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Abstract:
This dissertation characterizes the Ordovician Amassak (MSK) reservoir in Algeria's Illizi basin. The reservoir consists of Ordovician sands overlaid by Silurian clays, with Unit IV-3 being the most substantial reservoir unit (13 meters thick). Geologically, the reservoir formed in a glacial to preglacial environment. The study identified two main sandstone groups: structured (traction current deposits) and unstructured (gravitational/turbiditic deposits). Structurally, the area is characterized by a monocline and fractures. The largest fault reaches 300 km. Petrophysical analysis indicates good quality reservoir properties. The most significant zones for hydrocarbon production are in the northeastern region, particularly in Unit IV-3 and, to a lesser extent, in underlying sandstones. Units IV-2 and III-3 together form the terminal Ordovician complex, deposited in a glacial to preglacial environment. Unit III-3 also contains a reservoir within its sandstones.
Keywords: Ordovician, reservoir, Illizi basin, Unit IV-3, sandstone.

ملخص:
تصف هذه الأطروحة مكمن أماساك الأوردوفيشي (MSK) في حوض إيليزي في الجزائر. يتألف المكمن من رمال أوردوفيشية يعلوها طين من العصر السيلوري، والوحدة IV-3 هي الأكبر (بسمك 13 مترًا). من وجهة نظر جيولوجية، تشكّل المكمن في بيئة جليدية أو ما قبل الجليدية. وقد حددت الدراسة مجموعتين رئيسيتين من الأحجار الرملية: المهيكلة (رواسب تيار الجر) وغير المهيكلة (رواسب الجاذبية/التوربيدايت). ومن الناحية الهيكلية، تتميز المنطقة بخط أحادي وكسور. يبلغ طول أكبر صدع 300 كم. يشير التحليل البتروفيزيائي إلى خصائص مكمنية جيدة. تقع أهم مناطق إنتاج الهيدروكربون في المنطقة الشمالية الشرقية، وخاصة في الوحدةIV-3 ، وبدرجة أقل في الأحجار الرملية الكامنة تحتها. تشكل الوحدتان IV-2 و III-3 معاً مجمع الأوردوفيشي الطرفي الذي ترسب في بيئة جليدية إلى بيئة ما قبل الجليدية. وتحتوي الوحدة III-3 أيضاً على خزان في أحجارها الرملية.
الكلمات المفتاحية: الأوردوفيشي، الخزانات، حوض إيليزي، الوحدة IV-3، الحجر الرملي.

Résumé :
Ce mémoire caractérise le réservoir ordovicien d'Amassak (MSK) dans le bassin d'Illizi en Algérie. Le réservoir est constitué de sables ordoviciens recouverts d'argiles siluriennes, l'unité IV-3 étant la plus importante (13 mètres d'épaisseur). D'un point de vue géologique, le réservoir s'est formé dans un environnement glaciaire ou préglaciaire. L'étude a identifié deux groupes principaux de grès : structurés (dépôts de courant de traction) et non structurés (dépôts gravitaires/turbiditiques). Sur le plan structurel, la région est caractérisée par un monoclinal et des fractures. La plus grande faille atteint 300 km. L'analyse pétrophysique indique des propriétés de réservoir de bonne qualité. Les zones les plus importantes pour la production d'hydrocarbures se trouvent dans la région nord-est, en particulier dans l'unité IV-3 et, dans une moindre mesure, dans les grès sous-jacents. Les unités IV-2 et III-3 forment ensemble le complexe de l'Ordovicien terminal, déposé dans un environnement glaciaire à préglaciaire. L'unité III-3 contient également un réservoir dans ses grès.
Mots-clés: Ordovicien, réservoir, bassin d'Illizi, unité IV-3, grès