Evaluation of Al Hawaz Reservoir using Core Sample Analysis and Petrophysices Study in (O), Oil Field, Concision NC 115, Morzuq Basin.

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ABSTRACT

The O field which belongs to Akakus Oil Operation which is located in north north west (NNW) of Murzuq basin , NC 115 Concession, It is 30 km west of Awbari. The main objectives of this study were to provide for the reservoir model of the Hawaz Formation:

A detailed sedimentological and fracture description with the identification of significant stratal boundaries, maximum flooding surfaces, discontinuities and other internal structures of the supplied core, The description included determination of the lithology, grain-size, sorting, color, sedimentary structures, bed contacts, abundance of clay, degree of bioturbation and the presence of fossils. To describe and characterise the vertical distribution of sedimentary facies and provide an interpretation of the depositional environments in terms

of sequence analysis. Construct a depositional model, based on regional knowledge and relevant data integration. A petrographic description on selected samples, including SEM and XRD analysis, to characterise detrital and authigenic mineral composition, internal fabric and diagenetic processes of identified facies, in relation to porosity and permeability.

The reservoir is sealed by Tanezzuft shale, which is as a source rock also The porosity of this reservoir sandstone ranges between 11 to 15 % ,The water saturation is from 11 to 15 %.

also based on petrophysices method, I have selected one well study to support the results that obtained from petrography study to get more results such as lithology identification, porosity ,permeability and mineral composition also to calculate the reservoir properties such as volume of shale, water and oil saturation, oil water contact and reservoir reserves, the initial oil in place is 804 MMSTB and the recoverable reserve is 178.5MMSTB.

1.0 Introduction:

The purpose of this study was to describe the physical and petrophysices properties of the Hawaz reservoir in O oil field. In this study the estimation of reservoir quality depends on accurate knowledge of two parts of study include petrographic study and petrophysical study of the reservoir properties from core analysis and borehole logs. The reservoir quality is defined based on combination of all the data that obtained from cores analysis and well logs. this study utilized an integration array of data from core lithology description, borehole logs, and petrography study, Then determining which pore type that conesponeds to highest porosity paired value.

2.0 Available Data and Method of THE study:

2.1 Petrography data analysis :

For petrography Analysis A total of five thin-sections were prepared from well O1-NC115. Full thin-section description includes a detailed description of texture and mineralogy, and for scan electron microscope A total of five samples have been selected to characterise detrital and authigenic mineral composition, internal fabric and diagenetic processes of identified facies, in relation to porosity.the sandstone samples have been petrographically classified following Nagtegaal (1978) on the basis of the relative proportions of quartz, feldspar, lithics and detrital clay.

2.2 Well Logging Data Analysis.

The main objectives of the well logging is to identify the reservoir, estimate the hydrocarbons in place, and estimate the recoverable hydrocarbons, but the data provided from well logs also help so many studies besides their main objectives. In O oil Fields, These logs were used to examine the lithological-mineralogical composition and the petrophysical properties such as porosity and water saturation. Besides the use of raw log data, some cross plots were utilized based on the used log parameters to understand the nature of porosity.

3.0 Core sample and petrography procedures:

Eight cores were recovered (Cores 1- 8) and were included in this study. The entire cored interval is composed predominantly of commonly argillaceous sandstone. Cores 1 to 4 display cleaning and coarsening upward (CU) grain-size trends of variable thickness. Cores 5 to 8 predominantly exhibit fining upward (FU) grain–size trends. The cored sedimentary sequence has been divided up into three large–scale, based on the presence of significant transgressive surfaces and are informally termed Lower, Middle and Upper. The Lower sequence is characterised by thick predominantly bioturbated sands, interpreted as middle shoreface sediments. The Middle and Upper sequence comprise mainly stacked Coursing Up word depositional units of sands, these are interpreted as nearshore bar, tidal flat, The extensive thickness of the shoreface sands present in the Middle and Upper sequence indicate that sediment supply was matching the rate of transgression resulting in periods of aggradation.

3.1 Facies Scheme:

The scheme identifies facies on the basis of lithology, texture, bioturbation and sedimentary structures.

- **Facies1** : Heterolithics, comprising sandy mudstones and silty sandstones. Sedimentary structures include parallel and wavy lamination, rare burrow forms. This interpreted as being deposited in a relatively low energy
- **Facies 2**: Burrowed sandstone, moderately to well sorted fine sands, which are homogenised by extensive bioturbation, the high burrow intensity is consistent with the overall shallow marine to brackish setting, this interpreted that The high burrow intensity is consistent with the overall shallow marine to brackish setting
- **Facies 3**: Vertically burrowed sandstone. moderately well to well sorted fine sands. This interpreted as The sands are clean and massive.

- **Facies 4**: Horizontally laminated sandstone. Typically, moderately well to well sorted fine sands with horizontal to sub-horizontal lamination defined by clays. This interpreted that laminated sands deposited in conditions of high energy, turbulent flow. Those sands where bioturbation is absent.
- **Facies 5**: Wavy laminated sandstone. moderately well to well sorted, fine-grained sands with continuous and locally discontinuous horizontal to sub-horizontal wavy lamination defined by clays. This interpreted it Deposited in lower flow regime conditions.
- **Facies 6**: Massive sandstone. moderately well to well-sorted massive sand, characterised by minor burrow-forms, comprising undifferentiated and vertical (skolithos) burrows.
- **Facies 7**: Rubbled sandstone and argillaceous sandstone.
- **Facies 8**: High-angle cross-stratified sandstone. moderately well to well sorted planar cross-stratified sandstones. This interpreted that These sands record the migration of dune bedforms in unidirectional high energy upper to lower flow regimes. Therefore these sands are inferred as being the product of channel deposition.
- **Facies 9**: Low-angle cross-stratified sandstone. moderately well to well sorted planar cross-stratified sandstones. This interpreted These sands record the migration of dune bedforms in unidirectional high energy upper to lower flow regimes.
- **Facies 10**: Horizontally burrowed argillaceous sandstone. poorly to moderately sorted fine sands. Differentiated burrow forms are dominantly unlined horizontal tubes .

- **Facies 11**: Wavy laminated argillaceous sandstone. Poorly to moderately sorted fine sands with continuous and locally discontinuous horizontal to sub-horizontal wavy lamination defined by clays. This interpreted Deposited in lower flow regime conditions.

3.2 Sedimentological Description:

The cored interval can be subdivided into three large-scale depositional sequences, Lower, Middle and Upper.

✓ **Lower sequences**: 5382.00 – 5544.40 ft.

The Lower sequences is terminated by a significant relative transgressive surface. Bioturbation is the dominant sedimentary structure within the thickly bedded sandstones. This interpreted sandstones are interpreted to represent shallow water, marine influenced sediments. It comprises two main intervals, the first is a series of thick, relatively clean, bioturbated sands. The second, a series of stacked finning upward packages. Bioturbation is the dominant sedimentary structure within the thickly bedded sandstones. The thickly bedded stacked sandstones are interpreted to represent shallow water, marine influenced sediments.

✓ **Middle sequences**: **5265.10 – 5382.00 ft.**

This sequences rests over a sharp contact that represents the transgressive surface, which defines the top of the Lower sequences. The argillacious sands are extensively bioturbated, exhibiting a dominantly vertical burrow assemblage (skolithos) with locally relic primary structures, principally parallel lamination. Locally the argillaceous sands exhibit primary sedimentary structures, sub-horizontal parallel and wavy lamination, with subordinate bioturbation. The sandstones due to the type and extent of bioturbation are interpreted to represent strongly marine influenced shallow water conditions.

- ✓ **Upper sequences (5265.10 ft – 5160.00 ft).**

The Upper sequences is similar to the Middle sequences, except bioturbated argillaceous sands become increasingly dominate. Sandstones are typically abundantly bioturbated exhibiting a dominantly undifferentiated to vertical burrow assemblage (skolithos). The sandstones due to the type and extent of bioturbation are interpreted to represent strongly marine influenced shallow water conditions.

4.0 Petrography Study:

The sandstone samples have been petrographically classified following Nagtegaal (1978), on the basis of the relative proportions of quartz, feldspar, lithics and detrital clay. All the samples are dominated by quartz and are mainly classified as quartz arenites, The detrital mineralogy of the samples is thought likely to have been different at deposition, due to the overall abundance of replacive authigenic phases and secondary dissolution pores occurs at between 0.3% and 12.4% abundance, The main authigenic phases are authigenic clay, principally kaolinite, and quartz overgrowths.

Table (1): Summary of The Detrital Mineralogy In The Study Area

Detrital Mineralogy	**%**	**comments**
Quartz	57-95.3	Quartz predominantly comprises monocrystalline.

Micas	0-4.7	Micas are commonly associated with clay matrix and locally concentrated within stylo-cumulate material.
Lithics	0-1.0	comprise primarily of sedimentary mud rock and clay-rich interaclastic.
Matrix	0-21.3	Concentrations of detrital clay matrix locally define laminae, Plate 1, Plate 2, Plates 3 & Plates 4.
Feldspars	0-0.7	Feldspars are mainly a trace framework-grain constituent occurring as extensively or completely leached K-feldspar grains. Plate 5.

Table (2): Summary of the Authigenic Mineralogy In The Study Area.

Authigenic Mineralogy	**%**	**comments**
Kaolinite	0.3-24.4	The dominant authigenic clay mineral. Plates 7,8,9,10.
Authigenic quartz	0.7-8.0	Present in all samples occurring as discontinuous to near continuous, variably poor to well developed, syntaxial overgrowths plates 11, 12, 13.
Undifferentiated opaque's	0-1.3	Present throughout in minor quantities.
Pyrite	0-1.0	Commonly present, dominantly occurring as very finely crystalline framboids and locally as euhedral to subhedral cubes.

Carbonates	0–0.7	Rare comprising mainly aphanocrystalline to very finely crystalline siderite.plates 14,15.

5.0 Petrophysical study:

In this study the well (O1) have been selected to calculate the reservoir parameters such as porosity , volume of shale , water saturation and hydrocarbon reserves. Wirelines provided for this study comprised calliper, gamma ray, neutron porosity, borehole–corrected resistivity, density, spontaneous potential,and sonic logs.

5.1 Resistivity Logs.

Only the effects of rock mineralogy and texture on resistivity are discussed here. Resistivity suppression resulting from the presence of microporous clays and clay with low cation exchange capacities may be significant in those samples with a high abundance of kaolinite. Other components that suppress resistivity (pyrite and chlorite) are present in insufficient quantities to affect the log response. The formation resistivity factor is likely to be low in the better–sorted and open packed samples, to moderate in the more tightly packed and poorly sorted samples. The high abundance of clay matrix may locally depress the formation factor.

5.2 **Density Logs:** High–density minerals (pyrite, heavy minerals and siderite) are typically present in consistently low abundances, which are not likely to have a significant impact on the log values. Locally mica is a minor component but the abundances are not sufficient to result in an error in the calculated density. Overall the density log is likely to be an accurate record of the formations density content. Clean higher–porosity sands typically exhibit a lower density than the clay-rich sands. Locally there is evidence that zones of stylolitization give a slightly increased density response. It is likely that the scale at which most stylolites are present are below the resolution of the wireline logs.

5.3 **Neutron Logs**: The neutron log records the formations reaction to fast neutron bombardment, which is controlled by the abundance of hydrogen nuclei. The log is therefore principally a measure of water content, whether bound water, water of crystallisation or free pore-water. Kaolinite is the most abundant clay and has a moderate hydrogen index (0.37). It is likely to contain a significant amount of irreducible water associated with inter-plate micropores. Detrital clay matrix is locally common, and comprises illite and kaolinite, its tight packing indicating that pore-water is likely to be low, but absorbed and interlayer water may be present in significant amounts. Mixed-layer clays occur in only minor to rare amounts and therefore will not contain significant bound or absorbed water.Overall the neutron log is likely to be an accurate record of the porosity for the clean sandstone portion of the formation. As expected sands with a significant clays gave anomalously high neutron responses, probably resulting from 'wet clay', and the neutron porosity value cannot be used in this case without correction. Typically these anomalous responses correlate well with elevated gamma ray responses.

5.4 **Sonic Logs**: Sonic response is sensitive to texture, and values are likely to be highest (low interval transit times) in those samples that are cemented. The mudstones and muddy sandstones are likely to exhibit low values (high interval transit times.

6.0 CONCLUSIONS:

- The cored interval studied comprises eight cores, the depth interval 5160.0ft to 5544.4ft .
- The entire cored interval is composed predominantly of sandstone commonly argillaceous. Cores 1 to 4 display cleaning and coarsening upward and the Cores 5 to 8 predominantly exhibit fining upward.
- The cored sedimentary succession has been divided into three large-scale sedimentary successions, based on the presence of significant transgressive surfaces and are informally termed Lower, Middle and Upper within this report. Each succession is further sub-divided into FU or CU cycles. Both the transgressive surfaces represent landward shifts in facies and relative deepening events.
- The Lower Succession is characterised by thick predominantly bioturbated sands, interpreted as middle shoreface sediments, The Middle and Upper Successions comprise mainly stacked CU depositional units of sands, commonly argillaceous, which thicken upward. These are interpreted as nearshore bar, tidal flat, proximal and distal lower shoreface sands.
- An upward increase in marine influence and depth within the sediments indicates an overall transgressive situation.
- The sandstone samples have been petrographically classified following Nagtegaal (1978). All the samples are dominated by quartz and are mainly classified as quartz arenites, Grain-size ranges from vfU to cU sand, but dominantly comprises fine-grained sand. Grains are typically subrounded to subangular and are variably moderate to well sorted.

- Texturally many samples appear massive, with minor samples exhibiting laminae defined by variation in mineralogy.
- Thin–section and SEM analysis reveals that the porosity of the sandstones is dominated by primary intergranular macropores with subordinate dissolution pores associated with the dissolution framework grains.
- Based on petrophysical study The average porosity of the well O1NC 115 ranges between (11 to 15 %) ,The water saturation is ranging from (21 to 24 %), the initial oil in place is 804 MMSTB and the recoverable reserve is 178.5MMSTB.

7.0 REFERENCES:

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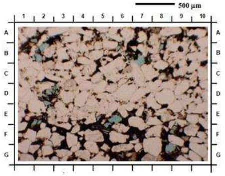
Petrography plates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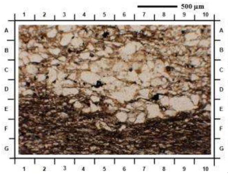
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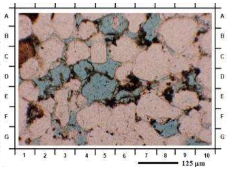
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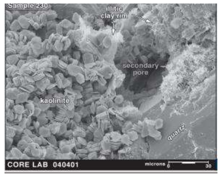
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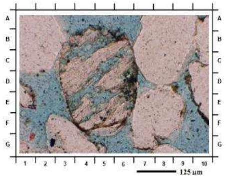
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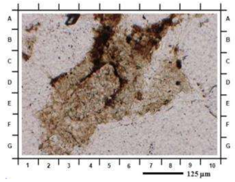
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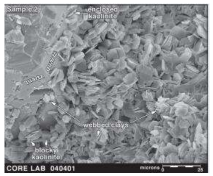
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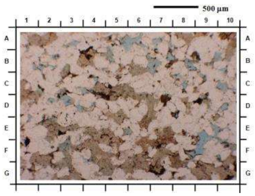
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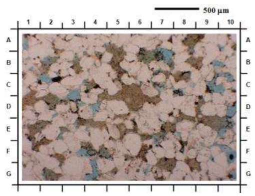
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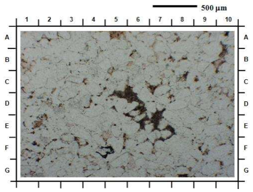

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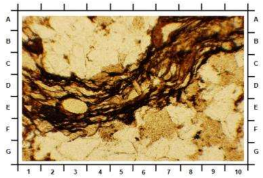

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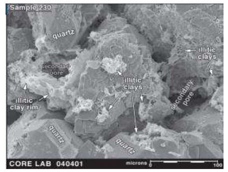

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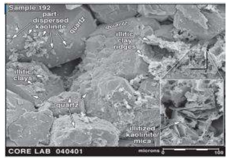
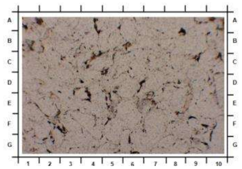


Plate 13

Plate 14



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