CHAPTER (6)

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The present study aims to characterize the reservoir anisotropy of the Bahariya Formation and Abu Roash Members by investigating their geological and the petrophysical characteristics. For this aim, two fields have been studied. The first field is BED-1 field in Badr El Din concession in north Western Desert, which is approximately bounded by long. 26° 29`-28° 35` E and by Lat. 29° 35`-30° 10` N, this field has been represented by BED1-11 well which represents only the lower part of the Bahariya Formation (Lower Cenomanian-Upper Cretaceous). The second field is GPTSW field in Abu Sennan area, north Western Desert which is approximately bounded by Long. 28° 00`-29° 00` E and by Lat. 29° 25`-29° 48` N, this field has been represented by the following wells: TSW-7, TSW-13 and TSW-15 which represent the upper part of the Bahariya Formation (Lower Cenomanian-Upper Cretaceous), TSW-8 well which represents Abu Roash `F` Member (Upper Cenomanian) and TSW-21 well which represents mainly Abu Roash `G` Member (Upper Cenomanian) and to less extent the Upper part of the Bahariya Formation. Fourty seven (47) and sixty three (63) core samples have been collected from BED-1 and GPTSW fields respectively. For BED-1 field all the samples (47) represent the lower part of the Bahariya Formation. For GPTSW field (38) samples represent the upper part of the Bahariya Formation, (11) samples represent Abu Roash `F` Member and (14) samples represent Abu Roash `G` Member. All the samples have been subjected to different laboratory techniques. These techniques comprise petrographical technique to show the characteristics and diagenetic alterations of the studied clastic and carbonate rocks, petrophysical techniques which include porosity, permeability and capillary pressure measurements to investigate the petrophysical properties of the studied samples and finally Scanning Electron Microscope technique (SEM) which has been used for some samples to show the pore geometry which affects the petrophysical parameters. The petrographic study revealed that quartz grains represent the dominant framework grains in the Bahariya Formation (Upper and Lower Members) and Abu Roash `G` Member samples with occurrences of glauconite rock fragments and minor occurrences of allochems as: foraminifera and molluscan shells in Abu Roash `G`, two sandstone facies have been recognized:

A-Quartz arenite which divided into five types: calcareous quartz arenite, glauconitic quartz arenite, laminated sublithic quartz arenite, subfeldspathic quartz arenite and glauconitic subfeldspathic quartz arenite.

B-Quartz wacke which divided into three types: massive quartz wacke, laminated quartz wacke and glauconitic quartz wacke.

These sediments have been suffered from diagenetic processes as: cementation, quartz overgrowth, clay authigenesis, dissolution and fracturing, the depositional environment is shallow marine (upper and lower shore). On the other hand the petrographic analysis of samples Abu Roash `F` Member exhibited one carbonate facies (foramineferal mollusan packstone) with common occurrences of allochems as: foraminifera and molluscan shells, these sediments have been suffered from different diagenetic processes as dissolution and recrystallization, depositional environment is deep marine (offshore) with slow sedimentation. SEM technique has been used for some samples to show the pore geometry which affects the petrophysical properties. This technique displayed a number of the diagenetic processes that have affected the reservoir quality as carbonate cementation, quartz overgrowth, clay authigenesis, framework grain dissolution, recrystallization of calcite inside the foram and fracturing. Concerning the petrophysical studies, (47) and (63) core samples have been drilled into cylinders of 2.54 cm in diameter and about 3 cm long for the petrophysical measurements. These cylinders have been cleaned then dried at temperature of 85 °C. Porosity data have been determined by use of both matrix-cup helium porosimeter for grain volume estimation and DEB-200 instrument which follow Archimedes law for bulk volume determination. Also bulk density has been determined as biproduct of porosity measurements. Permeability measurements have been done by using steady state air permeameter. Porosity-permeability relations have been displayed for each well separately and then the same relation has been displayed for each formation and member. Some relations have higher correlation coefficients, others have no relations as the relation between porosity and permeability in TSW-8 well (Abu Roash Member) and this may be due to the very close values of porosity and permeability of the samples. Also it was found that the studied samples of the lower part of the Bahariya Formation in BED1-11 well are differentiated into three groups (A, B and C). Group (A) has an average porosity 7.3% and average permeability 0.02 md (poor reservoir), group (B) has an average porosity 11.9% and average permeability 1.04 md (fair reservoir) and group (C) has an average porosity 15.4% and average permeability 28.8 md (good-moderate reservoir). The petrographical investigation of the different groups show that all the samples are highly cemented sandstones but there are two factors responsible for the anisotropy between the samples that reflected on the values of porosity and permeability of the different groups. The first factor is the diagenesis (cementation) which is high amount in group (A) which has the lowest values of porosity and permeability then become medium in group (B) which has moderate values of porosity and permeability and reach to lowest quantity in group (C) that has the highest values of porosity and permeability. The second factor is the clay content (lamination) where we found the samples of group (A) are laminated samples. On the other hand the samples of group (B) vary between laminated and non-laminated, but samples of group (C) are non-laminated samples. Kaolinite, chlorite and illite are the clay types that have been recognized in this section. On the other hand, the studied samples of the upper part of the Bahariya Formation obtained from TSW-wells are classified into two groups (A and C). Group (A) has an average porosity 13.6% and average permeability 0.18 md (fair-poor reservoir) where group (C) has an average porosity 21.9% and average permeability 123.9 md (very good-good reservoir). The petrographical description of the studied samples in the two groups exhibit that, samples of group (A) are highly argillaceous, laminated sandstone but samples of group (C) are slightly argillaceous or clean sandstones. The presence of detrital clays in different ratios and lamination are the main factors responsible for the anisotropy between the samples that reflected on the values of the porosity and permeability of the two groups. Also samples of Abu Roash \`G\` Member in TSW-21 well are classified into two groups (A and C). Group (A) has an average porosity 13.5% and average permeability 0.37 md (fair-poor reservoir), on the other hand group (C) has an average porosity 25.7% and average permeability 13.4 md (very good-moderate reservoir). The petrographical investigation of the studied samples in the two groups displayed that, the samples of group (A) are highly argillaceous, laminated sandstone, but samples of group (C) are less argillaceous sandstones. Also the difference in the clay content is the main factor responsible for the anisotropy between the samples as the previous case. Where samples of Abu Roash \`F\` Member in TSW-8 well display one group in porosity-permeability relation has an average porosity 16.9% and average permeability 0.013 md (good-poor reservoir). The petrographical investigation of the studied samples showed all the samples have the same lithology (marl) that affects the permeability values. Also the porosity-bulk density relations have been displayed for each well separately and then the same relation has been displayed for each formation and member. (47) and (63) samples were selected from BED1-11 well and TSW-wells respectively for the capillary pressure measurements by mercury injection to determine the pore size distribution and many derived parameters which affect the reservoir quality. Tracing the different groups that originated from the porosity-permeability relations has been done through the results of the capillary pressure which confirmed that, group (A) in the different studied units always has the lowest, narrow range of the pore size distribution and this reflected in higher values of displacement pressure and unsaturated pore volume (Sw_{irr}) and also lower values of several parameters derived from the pore size distribution as mean hydraulic radius (MHR), median (R50) and (R35). In contrast, group (C) always has the highest, wide range of the pore size distribution and this reflected in lower values of displacement pressure and unsaturated pore volume (Sw_{irr}) and also higher values of mean hydraulic radius (MHR), median (R50) and (R35). Group (B) has moderate properties between (A) and (C). In the present study, a new concept has been introduced which is the effective porosity or (refined porosity) and defined as that part of rock pore spaces above certain pore throat cutoff. It was found out that all porosity-permeability relations have been improved when applying the refined porosity instead of the unrefined one. Finally many correlation charts have been constructed among the petrophysical parameters (porosity, permeability, displacement pressure, water saturation, pore size distribution, MHR, R50, R35 and PVC), they are very useful for the reservoir evaluation in the studied areas where we can predict one of previous parameters by knowing the others.

CONCLUSIONS

1-The presence of the clays, lamination and cementation in different ratios, leads to the facies change (anisotropy) that affect the petrophysical properties of the rocks.

2-The reservoir properties mainly concentrated within group (C) which comprises the clean sandstone samples where group (A) represents a tight group that includes the highly argillaceous laminated samples, on the other hand group (B) has moderate properties.

3-Group (C) of the upper part of the Bahariya Formation obtained from TSW-wells has the highest reservoir potentialities (good reservoir) than the equivalent ones of the lower part of the Bahariya Formation in BED1-11 well and Abu Roash `G` due to its high porosity and permeability values.

4-The majority of the studied samples of Abu Roash `G` Member tend to be a non-reservoir rock due to their weak flow properties.

5- Abu Roash `F` Members considered as a cap rock for the tight flow properties found in it because the type of sediments is mainly marl.

6-The improving of the porosity-permeability relation is an adding value to the refined porosity concept which could be used to enhance that relation and to be used in reservoir production calculations and oil reserve estimation.

7-Separation of the reservoir into different layers based on the petrographical and petrophysical parameters makes the reservoir evaluation more accurate because each rock type has a certain treatment in oil recovery that differs from another one, so we can avoid many problems that originate if we think that all the layers of the reservoir of the same type.

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APPENDICES

Table (3.1): Plug description and thin section of sample (6), BED1-11 well.

Serial	Description	Φ, %	K, md
1	**Depth:** 3514.7 m **Plug:** Sst, whitish grey, very fine, hard, well sorted, highly cemented, pyritic, styolite. **Slide: Subfeldspathic arenite:** Very fine grained, moderately sorted sandstone with abundant pore filling kaolinite. Feldspars and quartz grains display corroded grain margins. Note a meta clast with quartz grains displaying deformed sutured contact.	9.8	0.29

Table (3.2): Plug description and thin section of sample (12), BED1-11 well.

Serial	Description	Φ, %	K, md
2	**Depth:** 3517.1 m **Plug:** Sst, whitish grey, very fine, well sorted, hard, slightly pyritic, ferruginous, massive. **Slide: Subfeldspathic arenite:** Very fine grained, moderately sorted sandstone with partially leached patchy ferroan dolomite and pore filling and pore lining kaolinite. Note the over sized nature of pores resulted from the dissolution of unstable grains and cement.	14.9	1.82

Table (3.3): Plug description and thin section of sample (16), BED1-11 well.

Serial	Description	Φ, %	K, md
3	**Depth:** 3518.2 m **Plug:** Sst, whitish grey, very fine, moderately sorted, well rounded, hard, pyretic, massive. **Slide: Subfeldspathic arenite:** Very fine grained, poorly to moderately sorted sandstone with extensive pore filling kaolinite. Framework grains are dominated by monocrystalline quartz possessing euhedral, syntaxial quartz overgroths and minor feldspar (microcline). Note the concentration of detrital clay and carbonaceous matter along laminlae plane.	15.0	18.3

Table (3.4): Plug description and thin section of sample (21), BED1-11 well.

Serial	Description	Φ, %	K, md
4	**Depth:** 3519.5 m **Plug**: Sst, whitish grey, very fine, well sorted, well rounded, hard, pyretic, massive, styolite and nodules. **Slide: Subfeldspathic arenite:** Very fine grained, moderately sorted sandstone dominantly composed of quartz grains and minor patchy ferroan dolomite. Porosity is predominantly secondary in origin and filled with kaolinite and chlorite. Note the carbonaceous stylolaminlae.	6.3	0.03

Table (3.5): Plug description and thin section of sample (27), BED1-11 well.

Serial	Description	Φ, %	K, md
5	**Depth:** 3521.3 m **Plug:** Sst, whitish grey, very fine, well sorted, well rounded, hard, pyretic, styolite, rippled and fllasser. **Slide: Subfeldspathic arenite:** Very fine grained, moderately to well sorted sandstone with over sized pores developed after grain and cement dissolution. Kaolinite is partly filling pores. Chlorite is dominantly green to reddish brown rim cement around detrital quartz grains. Detrital quartz grains displaying euhedral syntaxial quartz overgrowths partly filling pores.	8.8	0.48

Table (3.6): Plug description and thin section of sample (30), BED1-11 well.

Serial	Description	Φ, %	K, md
6	**Depth:** 3522.5 m **Plug:** Sst, whitish grey, very fine, hard, well sorted, well rounded, opaques. massive. **Slide: Subfeldspathic arenite:** Very fine grained, moderately sorted sandstone with abundant pore filling and pore lining kaolinite and chlorite. Note the carbonaceous matter and altered glauconite concentration along stylolaminlae.	12.6	2.09

Table (3.7): Plug description and thin section of sample (41), BED1-11 well.

Serial	Description	Φ, %	K, md
7	**Depth:** 3526.4 m **Plug:** Sst, whitish grey, very fine, hard, pyretic, carbonaceous, opaques, massive. **Slide: Subfeldspathic arenite:** Fine to very fine grained, well sorted sandstone with patchy pore filling kaolinite and ferroan dolomite. Detrital quartz grains surrounded by authigenic quartz overgrowths. Primary porosity is dominantly enhanced by the dissolution of grains and carbonate cement.	11.5	0.35

Table (3.8): Plug description and thin section of sample (44), BED1-11 well.

Serial	Description	Φ, %	K, md
8	**Depth:** 3528.2 m **Plug:** Sst, whitish grey, very fine, hard, pyretic, carbonaceous, opaques, massive, some nodules. **Slide: Subfeldspathic arenite:** Very fine grained, moderately sorted sandstone with extensive secondary interparticle pores developed following grain and cement leaching. Dolomite is ferroan and patchy. Note the authigenic kaolinite filling secondary interparticle pores.	15.6	21.1

Table (3.9): Plug description and thin section of sample (48), BED1-11 well.

Serial	Description	Φ, %	K, md
9	**Depth:** 3529.1 m **Plug:** Sst, whitish grey, very fine, hard, moderately sorted, well rounded, pyritic, carbonaceous, opaques, massive. **Slide: Subfeldspathic arenite:** Fine to very fine grained, poorly to moderately sorted sandstone predominantly composed of monocrystalline quartz possessing euhedral, syntaxial quartz overgroths. Detrital feldspar and mica are minor components. Pores are partially filled with kaolinite.	14.9	2.86

Table (3.10): Plug description and thin section of sample (51), BED1-11 well.

Serial	Description	Φ, %	K, md
10	**Depth:** 3530.0 m **Plug:** Sst, grey to whitish grey, very fine, hard, well sorted, well rounded, pyretic, opaques, massive. **Slide: Subfeldspathic arenite:** Very fine grained, moderately sorted sandstone with pore lining and pore filling kaolinite and chlorite rim cement. Quartz grains are dominantly corroded and partly displaying syntaxial quartz overgroths. Note the patchy ferroan dolomite partly filling pores.	17.3	61.7

Table (3.11): Plug description and thin section of sample (59), BED1-11 well.

Serial	Description	Φ, %	K, md
11	**Depth:** 3533.0 m **Plug**: Sst, whitish grey, very fine, hard, well sorted, pyretic, opaques, flaser and styolite. **Slide: Subfeldspathic arenite:** Fine to very fine grained, well sorted sandstone with pore lining and pore filling quartz overgrowths possessing euhedral crystal terminations around detrital quartz grains. Note the partly leached mica where the leached part is preferentially filled by kaolinite.	11.0	0.16

Table (3.12): Plug description and thin section of sample (63), BED1-11 well.

Serial	Description	Φ, %	K, md
12	**Depth:** 3534.8 m **Plug:** Sst, whitish grey, very fine, hard, well sorted, well rounded, pyretic, opaques, massive. **Slide: Glauconitic subfeldspathic arenite:** Very fine grained, moderately sorted sandstone composed of quartz, partly altered glauconite grains and minor leached feldspars. Note the greenish brown chlorite lining around detrital grains and pores.	13.9	17.3

Table (3.13): Plug description and thin section of sample (65), BED1-11 well.

Serial	Description	Φ, %	K, md
13	**Depth:** 3536.8 m **Plug:** Sst, whitish grey, very fine, hard, well sorted, well rounded, pyritic, opaques, massive. **Slide: Glauconitic subfeldspathic arenite:** Very fine grained, moderately to well sorted sandstone composed of altered and partly concentrically laminated glauconite, abundant quartz grains and grain and pore lining chlorite. Note the patchy ferroan dolomite partly occluding pores.	13.5	12.5

Table (3.14): Plug description and thin section of sample (73), BED1-11 well.

Serial	Description	Φ, %	K, md
14	**Depth:** 3543.9 m **Plug:** Sst, whitish grey, very fine, hard, argillaceous, glauconitic, pyritic, opaques, slightly calcareous, flaser and close fractures. **Slide: Glauconitic subfeldspathic arenite:** Very fine grained, moderate to well sorted sandstone with abundant pore lining chlorite in association with pore filling kaolinite. Quartz grains are the major framework grains with partly pore filling euhedral quartz overgroths around detrital grains.	8.0	0.11

Table (3.15): Plug description and thin section of sample (32), TSW-7 well

Serial	Description	Φ, %	K, md
1	**Depth:** 2021.5 m **Plug:** Sst, grey, very fine, hard, massive, hi argillaceous ferrigineous. **Slide: Quartz wacke:** Very fine to fine grains, poorly sorted, angular to subrounded, point and long contacts, grains floating in glauconitic clay matrix, cemented by clays and carbonates, some iron oxides, visible porosity mainly secondary porosity, quartz grains are monocrystaline, carbonaceous material are frequent, few fossil fragments.	11.9	0.302

Table (3.16): Plug description and thin section of sample (10), TSW-7 well

Serial	Description	Φ, %	K, md
2	**Depth:** 2023.3 m **Plug:** Sst, grey, very fine, hard, massive, pyritic, opaques. **Slide: Quartz wacke:** Fine grains, angular to subrounded, point and long contacts, well sorted, moderately cemented by clays and carbonates and iron oxides, abundant detrital clays, visible porosity mainly primary intergrauular porosity, quartz grains are monocrystaline, few fossil fragments.	16.7	0.636

Table (3.17): Plug description and thin section of sample (22H), TSW-7 well

Serial	Description	Φ, %	K, md
3	**Depth:** 2024.2 m **Plug:** Sst, as above, slightly calcareous. **Slide: Quartz wacke:** Fine grains, well sorted, subangular to subrounded, point and long contacts, high packed, cemented by clays and iron oxides, abundant detrital clay, some glauconite, calcite pockets, visible porosity mainly intergrauular, quartz grains are monocrystaline.	16.4	4.06

Table (3.18): Plug description and thin section of sample (2H2), TSW-7 well

Serial	Description	Φ, %	K, md
4	**Depth:** 2027.8 m **Plug:** Sst, brownish grey, hard, parallel lamination, pyritic, slightly argillaceous, silty, ripples. **Slide: Quartz arenite:** Very fine grains, well sorted, angular to subrounded, point and long contacts, cemented by clays and iron oxides, visible porosity mainly primary with contribution of secondary porosity, quartz grains are monocrystaline, interlamination of silt and clay sometimes smeared by carbonaceous materials.	14.6	1.02

Table (3.19): Plug description and thin section of sample (31H1), TSW-7 well

Serial	Description	Φ, %	K, md
5	**Depth:** 2028.4 m **Plug:** Sst, grey, hard, silty, slightly argillaceous, pyritic, ripples. **Slide: Quartz wacke:** Very fine to medium grains, moderately sorted, angular to subrounded, point and long contacts, abundant detrital clays, visible porosity mainly intergranular porosity, quartz grains are monocrystaline, cross lamination.	17.0	0.205

Table (3.20): Plug description and thin section of sample (31H2), TSW-7 well

Serial	Description	Φ, %	K, md
6	**Depth:** 2028.9 m **Plug:** as above. **Slide: Feldspathic quartz wacke:** as above, cross lamination.	16.3	0.194

Table (3.21): Plug description and thin section of sample (40), TSW-7 well

Serial	Description	Φ, %	K, md
7	**Depth:** 2035.9 m **Plug:** Sst, grey, hard, calcareous, pyretic, hi argillaceous, ferrigineous, glauconitic. **Slide: Quartz wacke:** Very fine to fine grains, grains floating in carbonate and clay matrix, ferrigineous, glauconitic.	13.3	0.087

Table (3.22): Plug description and thin section of sample (1H1), TSW-7 well

Serial	Description	Φ, %	K, md
8	**Depth:** 2037.3 m **Plug:** Sst, grey, hard, hi argillaceous, ferrigineous. **Slide: Quartz wacke:** Very fine to medium grains, majority is fine grains, moderately sorted, angular to subrounded, point and long contacts, grains floating in clay matrix, highly cemented by clays and iron oxides, some feldspars, visible porosity mainly secondary due to leaching about 3 %, quartz grains are monocrystaline.	10.5	0.049

Table (3.23): Plug description and thin section of sample (1H2), TSW-7 well

Serial	Description	Φ, %	K, md
9	**Depth:** 2037.8 m **Plug:** as above. **Slide: Quartz wacke:** as above, glauconitic, no carbonate present.	9.8	0.149

Table (3.24): Plug description and thin section of sample (58), TSW-8 well

Serial	Description	Φ, %	K, md
1	**Depth:** 1799.9 m **Plug:** Marl, grey, hard, sandy, phosphatic, carbonaceous, pyritic. **Slide: Foraminiferal molluscan Packestone:** The ground mass is composed mainly of micrite and sparry calcite, fossils and shell fragments are disseminated in the ground mass, some quartz grain are disseminated in the ground mass, carbonate present, no visible porosity, quartz grains are monocrystaline.	18.7	0.045

Table (3.25): Plug description and thin section of sample (39), TSW-13 well

Serial	Description	Φ, %	K, md
1	**Depth:** 2049.5 m **Plug:** Sst, brownish grey, very fine, hard, ripples and flasser, carbonaceous, pyritic. **Slide: Quartz wacke:** Very fine to medium grains, moderately sorted, angular to subrounded, point and long contacts, grains floating in clay matrix, cemented by clays, slightly glauconite, some iron oxides, no visible porosity, quartz grains are monocrystaline.	10.7	0.13

Table (3.26): Plug description and thin section of sample (48H1), TSW-13 well

Serial	Description	Φ, %	K, md
2	**Depth:** 2055.25 m **Plug:** Sst, as above. **Slide: Quartz wacke:** Very fine to fine grains, majority is fine grains, well sorted, point and long contacts, grains floating in clay matrix, cemented by clays and carbonates, some iron oxides, no visible porosity, quartz grains are monocrystaline.	14.2	0.16

Table (3.27): Plug description and thin section of sample (48H2), TSW-13 well

Serial	Description	Φ, %	K, md
3	**Depth:** 2055.75 m **Plug:** Sst, brownish grey, very fine, hard, ripples and flasser, carbonaceous, pyritic. **Slide: Quartz wacke:** as above, visible porosity, no carbonate present.	16.1	0.19

Table (3.28): Plug description and thin section of sample (3), TSW-15 well

Serial	Description	Φ, %	K, md
1	**Depth:** 2006.25 m **Plug:** Sst, grey, very fine, hard, massive, argillaceous, pyritic, slightly calcareous. **Slide: Sublithic wacke:** Fine to medium grains, majority is fine grains, well sorted, angular to subrounded, point and long contacts, cemented by clays and iron oxides, detrital clays, glauconite, carbonate present, visible porosity mainly primary intergranular porosity, quartz grains are monocrystaline.	18.2	0.18

Table (3.29): Plug description and thin section of sample (28H1), TSW-15 well

Serial	Description	Φ, %	K, md
2	**Depth:** 2006.75 m **Plug:** Sst, as above, non calcareous. **Slide: Quartz arenite:** Very fine to fine grains, well sorted, sub angular to subrounded, some glauconite, some iron oxides, some feldspars, some detrital clays, visible porosity mainly intergranular, quartz grains are monocrystaline.	24.9	110.6

Table (3.30): Plug description and thin section of sample (28H2), TSW-15 well

Serial	Description	Φ, %	K, md
3	**Depth:** 2007.25 m **Plug:** as above. **Slide: Quartz arenite:** as above.	24.9	100.3

Table (3.31): Plug description and thin section of sample (13H1), TSW-15 well

Serial	Description	Φ, %	K, md
4	**Depth:** 2010.75 m **Plug:** Sst, dark grey, hard, carbonaceous, glauconitic, phosphatic, pyritic, massive. **Slide: Glauconitic quartz wacke:** Fine to medium grains, poorly sorted, angular to rounded, point and long contacts, cemented by clays and iron oxides, some feldspar, no visible porosity, quartz grains are monocrystaline, clay interlamination.	17.1	0.05

Table (3.32): Plug description and thin section of sample (13H2), TSW-15 well

Serial	Description	Φ, %	K, md
5	**Depth:** 2011.25 m **Plug:** as above. **Slide: Glauconitic quartz wacke:** as above, no carbonate present, clay interlamination.	12.8	0.04

Table (3.33): Plug description and thin section of sample (6), TSW-15 well

Serial	Description	Φ, %	K, md
6	**Depth:** 2014.0 m **Plug:** Sst, grey, very fine, hard, glauconitic, pyritic, ripples. **Slide: Glauconitic quartz arenite:** Fine to medium grains, moderately sorted, angular to subrounded, point and long contacts, cemented by clays and iron oxides, visible porosity mainly secondary porosity due to leaching, quartz grains are monocrystaline, clay interlamination.	10.4	0.10

Table (3.34): Plug description and thin section of sample (55), TSW-15 well

Serial	Description	Φ, %	K, md
7	**Depth:** 2015.0 m **Plug:** as above, massive. **Slide: Glauconitic quartz arenite:** Very fine to medium grains, majority is fine grains, well sorted, subangular to subrounded, point and long contacts, cemented, some iron oxides, visible porosity mainly primary intergranular porosity, quartz grains are monocrystaline.	23.5	146.7

Table (3.35): Plug description and thin section of sample (53H1), TSW-15 well

Serial	Description	Φ, %	K, md
8	**Depth:** 2072.25 m **Plug:** as above. **Slide: Quartz arenite:** Medium grains, well sorted, subangular to subrounded, point and long contacts, some iron oxides, some detrial clays, visible porosity mainly primary intergranular porosity, quartz grains are monocrystaline.	24.1	251.9

Table (3.36): Plug description and thin section of sample (53H2), TSW-15 well

Serial	Description	Φ, %	K, md
9	**Depth:** 2072.75 m **Plug:** as above. **Slide: Quartz arenite:** as above.	24.3	184.1

Table (3.37): Plug description and thin section of sample (18H1), TSW-15 well

Serial	Description	Φ, %	K, md
10	**Depth:** 2073.25 m **Plug:** Sst, grey, very fine, hard, massive, pyritic. **Slide: Quartz arenite:** Fine to medium grains, well sorted, subangular to rounded, point and long contacts, cemented by iron oxides, some detrital clays, some feldspars, no carbonate present, visible porosity mainly primary intergranular porosity, quartz grains are monocrystaline.	16.5	9.8

Table (3.38): Plug description and thin section of sample (18H2), TSW-15 well

Serial	Description	Φ, %	K, md
11	**Depth:** 2073.75 m **Plug:** as above. **Slide: Quartz arenite:** as above.	23.3	201.6

Table (3.39): Plug description and thin section of sample (43H1), TSW-15 well

Serial	Description	Φ, %	K, md
12	**Depth:** 2074.25 m **Plug:** Sst, grey, very fine, hard, pyretic, ripples. **Slide: Quartz arenite:** Fine to medium grains, moderately well sorted, angular to subrounded, some iron oxides, some detriral clay, some feldspars, visible porosity mainly primary intergranular porosity, quartz grains are monocrystaline.	25.0	259.9

Table (3.40): Plug description and thin section of sample (43H2), TSW-15 well

Serial	Description	Φ, %	K, md
13	**Depth:** 2074.75 m **Plug:** as above. **Slide: Quartz arenite:** as above.	25.3	237.9

Table (3.41): Plug description and thin section of sample (11H1), TSW-15 well

Serial	Description	Φ, %	K, md
14	**Depth:** 2077.25 m **Plug:** Sst, grey, very fine, hard, pyritic, massive. **Slide: Quartz arenite:** Fine to medium grains, moderately sorted, angular to subrounded, point and long contacts, cemented by clays and iron oxides, glauconite, abundant detrital clays, some feldspars, visible porosity mainly primary intergranular, quartz grains are monocrystaline.	20.2	14.5

Table (3.42): Plug description and thin section of sample (11H2), TSW-15 well

Serial	Description	Φ, %	K, md
15	**Depth:** 2.77.75 m **Plug:** as above. **Slide: Quartz arenite:** as above, some detrital clays.	21.8	207.0

Table (3.43): Plug description and thin section of sample (7H1), TSW-15 well

Serial	Description	Φ, %	K, md
16	**Depth:** 2078.25 m **Plug:** Sst, grey, very fine, hard, pyritic, flasser. **Slide: Quartz arenite:** Fine grains, well sorted, angular to subrounded, point and long contacts, cemented by clays and iron oxides, glauconite, abundant detrital clay, visible porosity mainly primary with contribution of secondary porosity, quartz grains are monocrystaline.	20.3	57.8

Table (3.44): Plug description and thin section of sample (7H2), TSW-15 well

Serial	Description	Φ, %	K, md
17	**Depth:** 2078.75 m **Plug:** as above. **Slide: Quartz arenite:** as above.	18.3	27.9

Table (3.45): Plug description and thin section of sample (17), TSW-21 well

Serial	Description	Φ, %	K, md
1	**Depth:** 1987.0 m **Plug:** Sst, grey, very fine, hard, ripples, pyritic, slightly argillaceous, non calcareous. **Slide: Glauconitic quartz wacke:** Very fine to medium grains, poorly sorted, angular to subrounded, point and long contacts, cemented by clays and iron oxides, some feldspars, no visible porosity, quartz grains are monocrystaline.	21.8	0.17

Table (3.46): Plug description and thin section of sample (25H1), TSW-21 well

Serial	Description	Φ, %	K, md
2	**Depth:** 1987.75 m **Plug:** Sst, as above. **Slide: Quartz arenite:** Fine grains, well sorted, some feldspars, point and long contacts, cemented, some glauconite, abundant detrital clays, some iron oxides and, visible porosity about intergranular porosity, quartz grains are monocrystaline.	24.6	20.2

Table (3.47): Plug description and thin section of sample (25H2), TSW-21 well

Serial	Description	Φ, %	K, md
3	**Depth:** 1988.25 m **Plug:** as above. **Slide: Quartz arenite:** as above.	17.7	3.5

Table (3.48): Plug description and thin section of sample (30H1), TSW-21 well

Serial	Description	Φ, %	K, md
4	**Depth:** 1988.75 m **Plug:** Sst, as above. **Slide: Quartz wacke:** Very fine to fine grains, well sorted, point and long contacts, grains floating in clay matrix, cemented by clays, some iron oxides, some glauconite, visible porosity mainly intergranular porosity, quartz grains are monocrystaline.	15.1	1.2

Table (3.49): Plug description and thin section of sample (30H2), TSW-21 well

Serial	Description	Φ, %	K, md
5	**Depth:** 1989.25 m **Plug:** as above. **Slide: Quartz wacke:** as above, visible porosity mainly primary with contribution of secondary porosity.	14.9	0.45

Table (3.50): Plug description and thin section of sample (9H1), TSW-21 well

Serial	Description	Φ, %	K, md
6	**Depth:** 1990.75 m **Plug:** Sst, grey, very fine, silts, argillaceous, pyritic, massive, ferruginous. **Slide: Quartz arenite:** Very fine grains, well sorted, angular to subrounded, point and long contacts, cemented by clays and iron oxides, abundant detrital clays, glauconite, visible porosity mainly secondary due to leaching, quartz grains are monocrystaline.	11.1	0.13

Table (3.51): Plug description and thin section of sample (9H2), TSW-21 well

Serial	Description	Φ, %	K, md
7	**Depth:** 1991.25 m **Plug:** as above. **Slide: Quartz arenite:** as above.	11.5	0.27

Table (3.52): Plug description and thin section of sample (24H), TSW-21 well

Serial	Description	Φ, %	K, md
8	**Depth:** 1992.0 m **Plug:** Sst, whitish grey, hard, massive, slightly ripples, pyritic. **Slide: Quartz arenite:** Very fine to fine grains, well sorted, angular to subrounded, point and long contacts, cemented by clays and iron oxides, some feldspars, some glauconite, visible porosity mainly intergranular porosity, quartz grains are monocrystaline.	26.9	6.45

Table (3.53): Plug description and thin section of sample (54), TSW-21 well

Serial	Description	Φ, %	K, md
9	**Depth:** 1993.0 m **Plug:** Marl, grey, hard, sandy, pyritic. **Slide: Molluscan-wackstone-packestone:** The ground mass is composed mainly of micrite and sparry calcite, fossils and shell fragments are dissemenated in the ground mass, some iron oxides are present, carbonate present, no visible porosity, quartz grains are monocrystaline, echinoid, shell fragments.	4.1	0.08

Table (3.54): Plug description and thin section of sample (52), TSW-21 well

Serial	Description	Φ, %	K, md
10	**Depth:** 1994.0 m **Plug:** Sst, grey, very fine, hard, pyritic, ripples and flasser. **Slide: Quartz wacke:** Very fine to medium grains, majority is medium grains, angular to subrounded, some iron oxides, point and long contacts, grains floating in clay matrix, cemented by clays slightly glauconite, visible porosity mainly secondary porosity, quartz grains are monocrystaline.	16.0	0.13

Table (3.55): Plug description and thin section of sample (16H1), TSW-21 well

Serial	Description	Φ, %	K, md
11	**Depth:** 1995.75 m **Plug:** as above. **Slide: Laminated quartz wacke:** Fine grains, angular to subrounded, point and long contacts, cemented by clays and iron oxides, some feldspars, visible porosity mainly primary intergrauular porosity, quartz grains are monocrystaline.	13.9	0.16

Table (3.56): Plug description and thin section of sample (16H2), TSW-21 well

Serial	Description	Φ, %	K, md
12	**Depth:** 1996.25 m **Plug:** as above. **Slide: Quartz wacke:** as above.	14.7	0.15

Table (3.57): Plug description and thin section of sample (20H1), TSW-21 well

Serial	Description	Φ, %	K, md
13	**Depth:** 1998.75 m **Plug:** as above. **Slide: Quartz wacke:** Very fine grains, well sorted, angular to subrounded, point and long contacts, ,grains floating in clay matrix, cemented by clays and iron oxides some feldspars, no visible porosity, quartz grains are monocrystaline.	12.2	0.27

Table (3.58): Plug description and thin section of sample (20H2), TSW-21 well

Serial	Description	Φ, %	K, md
14	**Depth:** 1999.25 m **Plug:** as above. **Slide: Quartz wacke:** as above.	12.1	0.55

Table (3.59): Plug description and thin section of sample (45), TSW-21 well

Serial	Description	Φ, %	K, md
15	**Depth:** 2051.50 m **Plug:** Sst, grey, very fine, hard, massive, pyritic. **Slide: Quartz arenite (highly calcareous):** Very fine to medium grains, poorly sorted, point and long contacts, cemented by carbonates, some glauconite, some iron oxides, some detriral clays, carbonate present, visible porosity mainly secondary porosity, quartz grains are monocrystaline.	11.9	0.21

Table (3.60): Plug description and thin section of sample (5), TSW-21 well

Serial	Description	Φ, %	K, md
16	**Depth:** 2052.50 m **Plug:** as above, slightly argillaceous and calcareous. **Slide: Quartz arenite:** as above, visible porosity mainly primary intergranular porosity.	11.8	0.08

Table (3.61): Plug description and thin section of sample (49), TSW-21 well

Serial	Description	Φ, %	K, md
17	**Depth:** 2053.50 m **Plug:** Sst, grey, very fine, hard, carbonaceous, argillaceous, pyritic, flasser, slightly calcareous. **Slide: Quartz wacke:** Very fine to medium grains, majority is fine grains, moderately well sorted, subangular to subrounded, point and long contacts, grains floating in clay matrix, cemented by clays, some iron oxides, glauconite are present, visible porosity mainly secondary porosity, quartz grains are monocrystaline.	14.3	0.04

Table (4.1): Porosity, permeability and bulk density of BED1-11 well.

Formation	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
L. part of Bahariya	3512.9	2	13.5	4.91	2.29
	3513.6	3	13.1	1.47	2.26
	3513.8	4	13.4	1.78	2.30
	3514.6	5	13.1	1.83	2.30
	3514.7	6	9.8	0.29	2.39
	3515.3	7	7.6	0.02	2.43
	3515.4	8	7.6	0.02	2.38
	3515.6	9	10.0	0.02	2.47
	3517.1	12	14.9	1.82	2.27
	3517.2	13	16.2	22.6	2.23
	3517.4	14	13.2	27.9	2.34
	3518.1	15	15.6	24.8	2.24
	3518.2	16	15.0	18.3	2.29
	3519.5	21	6.3	0.03	2.48
	3520.0	24	8.7	0.02	2.38
	3520.9	25	7.3	0.02	2.40
	3521.3	27	8.8	0.48	2.39
	3521.6	28	13.6	0.71	2.29
	3521.9	29	10.2	0.26	2.36
	3522.5	30	12.6	2.09	2.31
	3522.7	31	5.0	0.02	2.51
	3525.5	39	6.5	0.01	2.46
	3526.3	40	6.1	0.03	2.52
	3526.4	41	11.5	0.35	2.34

Table (4.1), cont.: Porosity, permeability and bulk density of BED1-11 well.

Formation	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
L. part of Bahariya	3527.5	43	5.1	0.01	2.52
	3528.2	44	15.6	21.1	2.24
	3528.5	46	15.1	20.4	2.24
	3528.7	47	9.3	0.01	2.50
	3529.1	48	14.9	2.86	2.25
	3529.4	50	17.7	64.0	2.19
	3530.0	51	17.3	61.7	2.20
	3530.1	52	10.0	0.16	2.33
	3530.3	53	9.8	0.02	2.39
	3531.1	54	11.3	0.13	2.32
	3531.6	56	13.8	0.11	2.27
	3533.0	59	11.0	0.16	2.37
	3533.1	60	14.9	0.16	2.17
	3533.7	62	16.7	26.4	2.20
	3534.8	63	13.9	17.3	2.28
	3536.3	64	5.7	0.02	2.50
	3536.8	65	13.5	12.5	2.28
	3543.9	73	8.0	0.11	2.47
	3544.6	74	7.2	0.02	2.58
	3544.7	75	7.8	0.01	2.42
	3545.5	76	8.1	0.10	2.44
	3546.4	78	6.1	0.01	2.48
	3546.6	79	7.6	0.02	2.51

Table (4.2): Porosity, permeability and bulk density of TSW-7 well.

Formation	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
U. part of Bahariya	2021.45	32	11.9	0.30	2.41
	2023.25	10	16.7	0.63	2.23
	2024.20	22H	16.4	4.06	2.23
	2026.85	42	14.4	0.09	2.44
	2027.75	2H2	14.6	1.02	2.29
	2028.43	31H1	17.0	0.20	2.21
	2028.88	31H2	16.3	0.19	2.25
	2030.45	35	8.1	0.04	2.45
	2031.35	19	18.2	4.41	2.17
	2035.85	40	13.3	0.08	2.52
	2037.33	1H1	10.5	0.04	2.45
	2037.78	1H2	9.8	0.14	2.44

Table (4.3): Porosity, permeability and bulk density of TSW-8 well.

Member	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
Abu Roash `F'	1799.70	57	16.4	0.006	2.10
	1799.90	58	18.7	0.045	2.11
	1800.10	59H2	18.7	0.030	2.11
	1801.50	36	18.0	0.013	2.08
	1802.50	38	16.1	0.007	2.10
	1803.50	50H1	16.3	0.003	2.21
	1804.50	33	17.2	0.007	2.05
	1806.25	41H1	15.3	0.006	2.10
	1806.75	44	16.3	0.005	2.06
	1807.50	12H1	17.4	0.016	2.06
	1808.50	51	15.9	0.007	2.01

Table (4.4): Porosity, permeability and bulk density of TSW-13 well.

Formation	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
U. part of Bahariya	2049.50	39	10.7	0.13	2.39
	2052.75	34	12.6	0.27	2.34
	2055.25	48 H1	14.2	0.16	2.30
	2055.75	48 H2	16.1	0.19	2.25

Table (4.5): Porosity, permeability and bulk density of TSW-15 well.

Formation	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
U. part of Bahariya	2006.25	3	18.2	0.17	2.24
	2006.75	28H1	24.9	110.6	2.00
	2007.25	28H2	24.9	100.3	2.00
	2010.75	13H1	17.1	0.051	2.35
	2011.25	13H2	12.8	0.038	2.46
	2014.00	6	10.4	0.10	2.38
	2015.00	55	23.5	146.7	2.03
	2072.25	53H1	24.1	251.9	2.02
	2072.75	53H2	24.3	184.1	2.02
	2073.25	18H1	16.5	9.83	2.21
	2073.75	18H2	23.3	201.6	2.03
	2074.25	43H1	25.0	259.9	2.00
	2074.75	43H2	25.3	237.9	1.98
	2075.50	21	22.5	164.2	2.05
	2077.25	11H1	20.2	14.5	2.12
	2077.75	11H2	21.8	207.0	2.08
	2078.25	7H1	20.3	57.8	2.11
	2078.75	7H2	18.3	27.9	2.19

Table (4.6): Porosity, permeability and bulk density of TSW-21 well.

Formation	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
Abu Roash `G`	1987.00	17	21.8	0.16	2.18
	1987.75	25H1	24.6	20.2	2.01
	1988.25	25H2	17.7	3.54	2.20
	1988.75	30H1	15.1	1.22	2.26
	1989.25	30H2	14.9	0.45	2.26
	1990.75	9H1	11.1	0.13	2.38
	1991.25	9H2	11.5	0.26	2.37
	1992.00	24	26.9	6.45	1.94
	1993.00	54	4.1	0.075	2.62
	1994.00	52	16.0	0.13	2.25
	1995.75	16H1	13.9	0.16	2.31
	1996.25	16H2	14.7	0.15	2.29
	1998.75	20H1	12.2	0.26	2.35
	1999.25	20H2	12.1	0.55	2.35
U. part of Bahariya	2051.50	45	11.9	0.20	2.42
	2052.50	5	11.8	0.079	2.43
	2053.50	49	14.3	0.043	2.32
	2054.50	37	17.0	0.62	2.18

Table (4.7): Porosity, permeability and bulk density of Abu Roash `G`, TSW-21 well.

Member	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
Abu Roash `G`	1987.00	17	21.8	0.16	2.18
	1987.75	25H1	24.6	20.2	2.01
	1988.25	25H2	17.7	3.54	2.20
	1988.75	30H1	15.1	1.22	2.26
	1989.25	30H2	14.9	0.45	2.26
	1990.75	9H1	11.1	0.13	2.38
	1991.25	9H2	11.5	0.26	2.37
	1992.00	24	26.9	6.45	1.94
	1993.00	54	4.1	0.075	2.62
	1994.00	52	16.0	0.13	2.25
	1995.75	16H1	13.9	0.16	2.31
	1996.25	16H2	14.7	0.15	2.29
	1998.75	20H1	12.2	0.26	2.35
	1999.25	20H2	12.1	0.55	2.35

Table (4.8): Porosity, permeability and bulk density of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
TSW-7	2021.45	32	11.9	0.30	2.41
	2023.25	10	16.7	0.63	2.23
	2024.20	22H	16.4	4.06	2.23
	2026.85	42	14.4	0.09	2.44
	2027.75	2H2	14.6	1.02	2.29
	2028.43	31H1	17.0	0.20	2.21
	2028.88	31H2	16.3	0.19	2.25
	2030.45	35	8.1	0.04	2.45
	2031.35	19	18.2	4.41	2.17
	2035.85	40	13.3	0.08	2.52
	2037.33	1H1	10.5	0.04	2.45
	2037.78	1H2	9.8	0.14	2.44
TSW-13	2049.50	39	10.7	0.13	2.39
	2052.75	34	12.6	0.27	2.34
	2055.25	48 H1	14.2	0.16	2.30
	2055.75	48 H2	16.1	0.19	2.25
TSW-15	2006.25	3	18.2	0.17	2.24
	2006.75	28H1	24.9	110.6	2.00
	2007.25	28H2	24.9	100.3	2.00
	2010.75	13H1	17.1	0.051	2.35

Table (4.8), cont.: Porosity, permeability and bulk density of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Depth, m	Sample No.	Porosity, %	Permeability, md	Bulk Density, gm/cc
TSW-15	2011.25	13H2	12.8	0.038	2.46
	2014.00	6	10.4	0.10	2.38
	2015.00	55	23.5	146.7	2.03
	2072.25	53H1	24.1	251.9	2.02
	2072.75	53H2	24.3	184.1	2.02
	2073.25	18H1	16.5	9.83	2.21
	2073.75	18H2	23.3	201.6	2.03
	2074.25	43H1	25.0	259.9	2.00
	2074.75	43H2	25.3	237.9	1.98
	2075.50	21	22.5	164.2	2.05
	2077.25	11H1	20.2	14.5	2.12
	2077.75	11H2	21.8	207.0	2.08
	2078.25	7H1	20.3	57.8	2.11
	2078.75	7H2	18.3	27.9	2.19
TSW-21	2051.50	45	11.9	0.20	2.42
	2052.50	5	11.8	0.079	2.43
	2053.50	49	14.3	0.043	2.32
	2054.50	37	17.0	0.62	2.18

Table (4.9): Frequency distribution of the measured porosity of L. Bahariya, BED1-11 well.

Class interval, %	Frequency	Frequency %
5-10	20	42.6
10-15	19	40.4
15-20	8	17.0
Sum	47	100

Table (4.10): Frequency distribution of the measured permeability of L. Bahariya, BED1-11 well.

Class interval, md	Frequency	Frequency %
0.01-0.1	17	36.2
0.1-1	12	25.5
1-10	7	14.9
10-100	11	23.4
Sum	47	100

Table (4.11): Frequency distribution of the measured porosity, all TSW wells.

Class interval, %	Frequency					Frequency %				
	TSW-7	TSW-8	TSW-13	TSW-15	TSW-21	TSW-7	TSW-8	TSW-13	TSW-15	TSW-21
0-5	0	0	0	0	1	0	0	0	0	5.6
5-10	2	0	0	0	0	16.7	0	0	0	0
10-15	5	0	3	2	10	41.7	0	75	11.1	55.6
15-20	5	11	1	4	4	41.7	100	25	22.2	22.2
20-25	0	0	0	10	2	0	0	0	55.6	11.1
25-30	0	0	0	2	1	0	0	0	11.1	5.6
Sum	12	11	4	18	18	100	100	100	100	100

Table (4.12): Frequency distribution of the measured permeability, all TSW wells.

Class interval, md	Frequency					Frequency %				
	TSW-7	TSW-8	TSW-13	TSW-15	TSW-21	TSW-7	TSW-8	TSW-13	TSW-15	TSW-21
0.001-0.01	0	1	0	0	0	0	9.1	0	0	0
0.01-0.1	4	10	0	2	3	33.3	90.9	0	11.1	16.7
0.1-1	5	0	4	2	11	41.7	0	100	11.1	61.1
1-10	3	0	0	1	3	25.0	0	0	5.6	16.7
10-100	0	0	0	3	1	0	0	0	16.7	5.6
100-1000	0	0	0	10	0	0	0	0	55.6	0
Sum	12	11	4	18	18	100	100	100	100	100

Table (4.13): Frequency distribution of the measured porosity of Abu Roash `G`, TSW-21 well.

Class interval, %	Frequency	Frequency %
0-5	1	7.1
5-10	0	0
10-15	7	50
15-20	3	21.4
20-25	2	14.3
25-30	1	7.1
Sum	14	100

Table (4.14): Frequency distribution of the measured permeability of Abu Roash `G`, TSW-21 well.

Class interval, md	Frequency	Frequency %
0.01-0.1	1	7.1
0.1-1	9	64.3
1-10	3	21.4
10-100	1	7.1
Sum	14	100

Table (4.15): Frequency distribution of the measured porosity of U. Bahariya, all TSW wells.

Class interval, %	Frequency	Frequency %
5-10	2	5.3
10-15	13	34.2
15-20	11	28.9
20-25	10	26.3
25-30	2	5.3
Sum	38	100

Table (4.16): Frequency distribution of the measured permeability of U. Bahariya, all TSW wells.

Class interval, md	Frequency	Frequency %
0.01-0.1	8	21.1
0.1-1	13	34.2
1-10	4	10.5
10-100	3	7.9
100-1000	10	26.3
Sum	38	100

Table (4.17): Comparison of porosity and permeability of the studied units.

Unite	Average Porosity, %	Average Permeability, md
Upper. part of Bahariya Fm. (TSW-field)	17.1	52.3
Lower. part of Bahariya Fm. (BED-1 field)	11.1	7.18
Abu Roash \`G\` Member	15.5	2.41
Abu Roash \`F\` Member	16.9	0.013

Table (4.18): Frequency distribution of the measured bulk density of L. Bahariya, BED1-11 well.

Class interval, gm/cc	Frequency	Frequency %
2.10-2.20	2	4.3
2.20-2.30	15	31.9
2.30-2.40	14	29.8
2.40-2.50	9	19.1
2.50-2.60	7	14.9
Sum	47	100

Table (4.19): Frequency distribution of the measured bulk density, all TSW wells.

Class interval, gm/cc	Frequency					Frequency %				
	TSW-7	TSW-8	TSW-13	TSW-15	TSW-21	TSW-7	TSW-8	TSW-13	TSW-15	TSW-21
1.90-2.00	0	0	0	1	1	0	0	0	5.6	5.6
2.00-2.10	0	5	0	9	1	0	45.4	0	50	5.6
2.10-2.20	1	5	0	3	2	8.3	45.4	0	16.7	11.1
2.20-2.30	5	1	1	2	5	41.7	9.09	25	11.1	27.8
2.30-2.40	0	0	3	2	6	0	0	75	11.1	33.3
2.40-2.50	5	0	0	1	2	41.7	0	0	5.6	11.1
2.50-2.60	1	0	0	0	1	8.3	0	0	0	5.6
Sum	12	11	4	18	18	100	100	100	100	100

Table (4.20): Frequency distribution of the measured bulk density of Abu Roash `G`, TSW-21 well.

Class interval, gm/cc	Frequency	Frequency %
1.90-2.00	1	7.1
2.00-2.10	1	7.1
2.10-2.20	1	7.1
2.20-2.30	5	35.7
2.30-2.40	5	35.7
2.40-2.50	0	0
2.50-2.60	1	7.1
Sum	14	100

Table (4.21): Frequency distribution of the measured bulk density of U. Bahariya, all TSW wells.

Class interval, gm/cc	Frequency	Frequency %
1.90-2.00	1	2.6
2.00-2.10	9	23.7
2.10-2.20	5	13.2
2.20-2.30	8	21.1
2.30-2.40	6	15.8
2.40-2.50	8	21.1
2.50-2.60	1	2.6
Sum	38	100

Table (5.1): Permeability and displacement pressure of BED1-11 well.

Formation	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
L. part of Bahariya	3512.90	2	4.91	40
	3513.60	3	1.47	91
	3513.80	4	1.78	74
	3514.60	5	1.83	91
	3514.70	6	0.29	176
	3515.30	7	0.02	872
	3515.40	8	0.02	529
	3515.60	9	0.02	529
	3517.10	12	1.82	91
	3517.20	13	22.68	24
	3517.40	14	27.93	24
	3518.10	15	24.89	24
	3518.20	16	18.30	24
	3519.50	21	0.03	176
	3520.00	24	0.02	275
	3520.90	25	0.02	275
	3521.30	27	0.48	140
	3521.60	28	0.71	74
	3521.90	29	0.26	60
	3522.50	30	2.09	29
	3522.70	31	0.02	221
	3525.50	39	0.01	872
	3526.30	40	0.03	687
	3526.40	41	0.35	115

Table (5.1), cont.: Permeability and displacement pressure of BED1-11 well.

Formation	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
L. part of Bahariya	3527.50	43	0.01	687
	3528.20	44	21.14	24
	3528.50	46	20.41	24
	3528.70	47	0.01	529
	3529.10	48	2.86	74
	3529.40	50	64.00	19
	3530.00	51	61.73	15
	3530.10	52	0.16	176
	3530.30	53	0.02	447
	3531.10	54	0.13	91
	3531.60	56	0.11	176
	3533.00	59	0.16	140
	3533.10	60	0.16	91
	3533.70	62	26.40	24
	3534.80	63	17.36	24
	3536.30	64	0.02	1290
	3536.80	65	12.50	24
	3543.90	73	0.11	176
	3544.60	74	0.02	529
	3544.70	75	0.01	221
	3545.54	76	0.10	221
	3546.40	78	0.01	687
	3546.60	79	0.02	140

Table (5.2): Permeability and displacement pressure of TSW-7 well.

Formation	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
U. part of Bahariya	2021.45	32	0.30	447
	2023.25	10	0.64	221
	2024.20	22H	4.06	24
	2026.85	42	0.09	872
	2027.75	2H2	1.02	221
	2028.43	31H1	0.20	529
	2028.88	31H2	0.19	529
	2030.45	35	0.05	447
	2031.35	19	4.41	40
	2035.85	40	0.09	1290
	2037.33	1H1	0.05	1985
	2037.78	1H2	0.15	1290

Table (5.3): Permeability and displacement pressure of TSW-8 well.

Member	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
Abu Roash `F'	1799.70	57	0.006	529
	1799.90	58	0.045	447
	1800.10	59H2	0.030	447
	1801.50	36	0.013	687
	1802.50	38	0.007	529
	1803.50	50H1	0.003	872
	1804.50	33	0.007	1032
	1806.25	41H1	0.006	1032
	1806.75	44	0.005	1032
	1807.50	12H1	0.016	872
	1808.50	51	0.007	872

Table (5.4): Permeability and displacement pressure of TSW-13 well.

Formation	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
U. part of Bahariya	2049.50	39	0.13	687
	2052.75	34	0.27	115
	2055.25	48 H1	0.16	1032
	2055.75	48 H2	0.19	1032

Table (5.5): Permeability and displacement pressure of TSW-15 well.

Formation	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
U. part of Bahariya	2006.25	3	0.18	221
	2006.75	28H1	110.62	29
	2007.25	28H2	100.33	29
	2010.75	13H1	0.05	3597
	2011.25	13H2	0.04	4569
	2014.00	6	0.10	1290
	2015.00	55	146.74	19
	2072.25	53H1	251.95	12
	2072.75	53H2	184.11	15
	2073.25	18H1	9.83	29
	2073.75	18H2	201.62	15
	2074.25	43H1	259.91	12
	2074.75	43H2	237.96	15
	2075.50	21	164.20	15
	2077.25	11H1	14.51	24
	2077.75	11H2	207.07	15
	2078.25	7H1	57.83	19
	2078.75	7H2	27.99	19

Table (5.6): Permeability and displacement pressure of TSW-21 well.

Formation	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
Abu Roash `G`	1987.00	17	0.17	687
	1987.75	25H1	20.29	40
	1988.25	25H2	3.55	115
	1988.75	30H1	1.22	140
	1989.25	30H2	0.45	176
	1990.75	9H1	0.13	1290
	1991.25	9H2	0.27	872
	1992.00	24	6.45	50
	1993.00	54	0.08	1985
	1994.00	52	0.13	687
	1995.75	16H1	0.16	687
	1996.25	16H2	0.15	687
	1998.75	20H1	0.27	687
	1999.25	20H2	0.55	275
U. part of Bahariya	2051.50	45	0.21	1032
	2052.50	5	0.08	687
	2053.50	49	0.04	1032
	2054.50	37	0.63	115

Table (5.7): Permeability and displacement pressure of Abu Roash `G`, TSW-21 well.

Member	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
Abu Roash `G`	1987.00	17	0.17	687
	1987.75	25H1	20.29	40
	1988.25	25H2	3.55	115
	1988.75	30H1	1.22	140
	1989.25	30H2	0.45	176
	1990.75	9H1	0.13	1290
	1991.25	9H2	0.27	872
	1992.00	24	6.45	50
	1993.00	54	0.08	1985
	1994.00	52	0.13	687
	1995.75	16H1	0.16	687
	1996.25	16H2	0.15	687
	1998.75	20H1	0.27	687
	1999.25	20H2	0.55	275

Table (5.8): Permeability and displacement pressure of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
TSW-7	2021.45	32	0.30	447
	2023.25	10	0.64	221
	2024.20	22H	4.06	24
	2026.85	42	0.09	872
	2027.75	2H2	1.02	221
	2028.43	31H1	0.20	529
	2028.88	31H2	0.19	529
	2030.45	35	0.05	447
	2031.35	19	4.41	40
	2035.85	40	0.09	1290
	2037.33	1H1	0.05	1985
	2037.78	1H2	0.15	1290
TSW-13	2049.50	39	0.13	687
	2052.75	34	0.27	115
	2055.25	48 H1	0.16	1032
	2055.75	48 H2	0.19	1032
TSW-15	2006.25	3	0.18	221
	2006.75	28H1	110.62	29
	2007.25	28H2	100.33	29
	2010.75	13H1	0.05	3597

Table (5.8), cont.: Permeability and displacement pressure of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Formation	Depth, m	Sample No.	Permeability, md	Displacement pressure, psi
TSW-15	2011.25	13H2	0.04	4569
	2014.00	6	0.10	1290
	2015.00	55	146.74	19
	2072.25	53H1	251.95	12
	2072.75	53H2	184.11	15
	2073.25	18H1	9.83	29
	2073.75	18H2	201.62	15
	2074.25	43H1	259.91	12
	2074.75	43H2	237.96	15
	2075.50	21	164.20	15
	2077.25	11H1	14.51	24
	2077.75	11H2	207.07	15
	2078.25	7H1	57.83	19
	2078.75	7H2	27.99	19
TSW-21	2051.50	45	0.21	1032
	2052.50	5	0.08	687
	2053.50	49	0.04	1032
	2054.50	37	0.63	115

Table (5.9): Grouping of L. part of Bahariya Fm., BED1-11 well based on displacement pressure.

Group name	Displacement pressure average, psi	Permeability average, md
A	527	0.018
B	112	1.04
C	23	28.8

Table (5.10): Displacement pressure properties of TSW-8 well.

Group name	Displacement pressure average, psi	Permeability average, md
A	759	0.013

Table (5.11): Grouping of Abu Roash `G` in TSW-21 well based on displacement pressure.

Group name	Displacement pressure average, psi	Permeability average, md
A	743	0.32
C	45	13.3

Table (5.12): Grouping of U. Bahariya, TSW-7, 13, 15 and 21 wells, based on displacement pressure.

Group name	Displacement pressure average, psi	Permeability average, md
A	1057	0.22
C	21	123.9

Table (5.13): K and Sw_{irr} of BED1-11 well.

Formation	Sample No.	K, md	Sw_{irr} , %
L. part of Bahariya	2	4.91	15.37
	3	1.47	16.22
	4	1.78	14.24
	5	1.83	11.11
	6	0.29	13.10
	7	0.02	20.47
	8	0.02	15.67
	9	0.02	19.53
	12	1.82	10.97
	13	22.68	9.53
	14	27.93	11.18
	15	24.89	10.99
	16	18.30	14.47
	21	0.03	20.52
	24	0.02	14.92
	25	0.02	23.47
	27	0.48	11.42
	28	0.71	18.94
	29	0.26	27.79
	30	2.09	18.78
	31	0.02	9.53
	39	0.01	25.08
	40	0.03	24.41
	41	0.35	12.03

Table (5.13), cont.: K and Sw_{irr} of BED1-11 well.

Formation	Sample No.	K, md	Sw_{irr} , %
L. part of Bahariya	43	0.01	20.60
	44	21.14	12.23
	46	20.41	15.63
	47	0.01	25.95
	48	2.86	14.10
	50	64.00	13.70
	51	61.73	9.28
	52	0.16	13.67
	53	0.02	21.26
	54	0.13	18.03
	56	0.11	25.18
	59	0.16	13.83
	60	0.16	16.53
	62	26.40	13.95
	63	17.36	12.65
	64	0.02	39.63
	65	12.50	14.00
	73	0.11	18.38
	74	0.02	17.36
	75	0.01	26.58
	76	0.10	13.81
	78	0.01	22.49
	79	0.02	20.39

Table (5.14): K and Sw_{irr} of TSW-7 well.

Formation	Sample No.	K, md	Sw_{irr} , %
U. part of Bahariya	32	0.30	19.65
	10	0.64	17.04
	22H	4.06	10.55
	42	0.09	16.38
	2H2	1.02	18.53
	31H1	0.20	21.11
	31H2	0.19	21.74
	35	0.05	20.50
	19	4.41	9.51
	40	0.09	19.78
	1H1	0.05	23.98
	1H2	0.15	18.19

Table (5.15): K and Sw_{irr} of TSW-8 well.

Member	Sample No.	K, md	Sw_{irr} , %
Abu Roash `F`	57	0.006	17.66
	58	0.045	10.47
	59H2	0.030	11.31
	36	0.013	14.45
	38	0.007	19.18
	50H1	0.003	16.71
	33	0.007	19.15
	41H1	0.006	19.63
	44	0.005	15.78
	12H1	0.016	14.11
	51	0.007	18.23

Table (5.16): K and Sw_{irr} of TSW-13 well.

Formation	Sample No.	K, md	Sw_{irr} , %
U. part of Bahariya	39	0.13	23.19
	34	0.27	19.44
	48 H1	0.16	20.93
	48 H2	0.19	15.58

Table (5.17): K and Sw_{irr} of TSW-15 well.

Formation	Sample No.	K, md	Sw_{irr} , %
U. part of Bahariya	3	0.18	21.88
	28H1	110.62	11.86
	28H2	100.33	12.53
	13H1	0.05	22.18
	13H2	0.04	20.51
	6	0.10	24.48
	55	146.74	9.83
	53H1	251.95	10.20
	53H2	184.11	11.08
	18H1	9.83	17.18
	18H2	201.62	12.59
	43H1	259.91	7.50
	43H2	237.96	10.59
	21H	164.20	8.07
	11H1	14.51	14.52
	11H2	207.07	10.31
	7H1	57.83	13.17
	7H2	27.99	14.08

Table (5.18): K and Sw_{irr} of TSW-21 well.

Formation / Member	Sample No.	K, md	Sw_{irr} , %
Abu Roash `G`	17	0.17	21.95
	25H1	20.29	8.75
	25H2	3.55	17.56
	30H1	1.22	16.08
	30H2	0.45	20.10
	9H1	0.13	22.82
	9H2	0.27	19.74
	24	6.45	10.46
	54	0.08	26.89
	52	0.13	18.65
	16H1	0.16	20.68
	16H2	0.15	21.80
	20H1	0.27	21.22
	20H2	0.55	18.35
U. part of Bahariya	45	0.21	20.98
	5	0.08	20.94
	49	0.04	23.99
	37	0.63	14.49

Table (5.19): K and Sw_{irr} of Abu Roash `G`, TSW-21 well.

Member	Sample No.	K, md	Sw_{irr} , %
Abu Roash `G`	17	0.17	21.95
	25H1	20.29	8.75
	25H2	3.55	17.56
	30H1	1.22	16.08
	30H2	0.45	20.10
	9H1	0.13	22.82
	9H2	0.27	19.74
	24	6.45	10.46
	54	0.08	26.89
	52	0.13	18.65
	16H1	0.16	20.68
	16H2	0.15	21.80
	20H1	0.27	21.22
	20H2	0.55	18.35

Table (5.20): K and Sw_{irr} of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Sample No.	K, md	Sw_{irr} , %
TSW-7	32	0.30	19.65
	10	0.64	17.04
	22H	4.06	10.55
	42	0.09	16.38
	2H2	1.02	18.53
	31H1	0.20	21.11
	31H2	0.19	21.74
	35	0.05	20.50
	19	4.41	9.51
	40	0.09	19.78
	1H1	0.05	23.98
	1H2	0.15	18.19
TSW-13	39	0.13	23.19
	34	0.27	19.44
	48 H1	0.16	20.93
	48 H2	0.19	15.58
TSW-15 well	3	0.18	21.88
	28H1	110.62	11.86
	28H2	100.33	12.53
	13H1	0.05	22.18

Table (5.20), cont.: K and Sw_{irr} of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Sample No.	K, md	Sw_{irr} , %
TSW-15	13H2	0.04	20.51
	6	0.10	24.48
	55	146.74	9.83
	53H1	251.95	10.20
	53H2	184.11	11.08
	18H1	9.83	17.18
	18H2	201.62	12.59
	43H1	259.91	7.50
	43H2	237.96	10.59
	21	164.20	8.07
	11H1	14.51	14.52
	11H2	207.07	10.31
	7H1	57.83	13.17
	7H2	27.99	14.08
TSW-21	45	0.21	20.98
	5	0.08	20.94
	49	0.04	23.99
	37	0.63	14.49

Table (5.21): Grouping of L. Bahariya, BED1-11 well based on irreducible water saturation.

Group name	Sw_{irr} average, %	Permeability average, md
A	21.6	0.018
B	14.7	1.14
C	12.5	28.8

Table (5.22): Irreducible water saturation properties of TSW-8 well.

Group name	Sw_{irr} average, %	Permeability average, md
A	16.06	0.013

Table (5.23): Grouping of Abu Roash `G`, TSW-21 well based on irreducible water saturation.

Group name	Sw_{irr} average, %	Permeability average, md
A	20.7	0.23
C	9.6	13.3

Table (5.24): Grouping of U. Bahariya, TSW-7, 13, 15 and 21 wells based on irreducible water saturation.

Group name	Sw_{irr} average, %	Permeability average, md
A	20.2	0.22
C	11.4	123.9

Table (5.25): PVC's percents of BED1-11 well.

Formation	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
L. part of Bahariya	2	2.8	21.9	13.6	16.5	32.4	12.7
	3	4.5	27.6	16.8	21.7	29.4	0.0
	4	2.7	25.3	16.2	20.7	35.1	0.0
	5	2.9	27.1	17.1	26.6	26.3	0.0
	6	6.3	37.1	26.7	29.9	0.0	0.0
	7	13.9	67.7	18.3	0.0	0.0	0.0
	8	13.7	59.5	26.8	0.0	0.0	0.0
	9	10.9	55.3	33.8	0.0	0.0	0.0
	12	3.1	21.3	26.0	21.0	28.6	0.0
	13	2.6	16.9	15.2	11.8	20.0	33.5
	14	3.6	19.2	11.9	9.3	25.7	30.2
	15	3.9	17.8	11.5	9.0	27.6	30.1
	16	3.5	18.0	14.8	10.8	21.5	31.3
	21	16.5	58.9	15.0	9.5	0.0	0.0
	24	5.8	46.9	26.5	20.8	0.0	0.0
	25	5.9	43.0	27.0	24.1	0.0	0.0
	27	5.1	46.2	26.6	20.8	1.3	0.0
	28	2.8	28.7	19.0	16.2	33.4	0.0
	29	5.3	34.4	14.5	12.3	33.6	0.0
	30	4.0	27.2	33.7	18.2	12.8	4.2
	31	14.2	63.5	17.1	5.2	0.0	0.0
	39	17.7	72.6	9.7	0.0	0.0	0.0
	40	22.9	67.5	9.5	0.0	0.0	0.0
	41	3.6	35.8	23.2	29.6	7.9	0.0

Table (5.25), cont.: PVC's percents of BED1-11 well.

Formation	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
L. part of Bahariya	43	12.8	64.2	23.0	0.0	0.0	0.0
	44	2.6	20.3	16.5	10.5	50.2	0.0
	46	2.3	17.3	15.0	8.2	13.6	43.6
	47	22.2	68.8	8.9	0.0	0.0	0.0
	48	5.0	34.0	13.9	18.7	28.4	0.0
	50	1.9	15.2	8.5	6.6	12.9	54.8
	51	2.9	16.8	9.1	6.6	17.2	41.4
	52	4.7	39.2	21.0	34.1	1.0	0.0
	53	5.7	51.2	36.9	6.2	0.0	0.0
	54	2.9	25.9	16.4	22.6	32.2	0.0
	56	5.3	42.2	20.4	30.6	1.5	0.0
	59	3.2	34.7	22.2	32.4	7.6	0.0
	60	3.3	29.0	19.6	20.6	27.6	0.0
	62	2.9	16.6	10.3	8.3	13.4	48.5
	63	2.9	21.0	13.3	11.1	16.8	35.0
	64	21.2	73.9	4.9	0.0	0.0	0.0
	65	2.5	19.8	9.4	9.6	19.6	39.0
	73	6.9	40.2	31.9	20.7	0.3	0.0
	74	6.5	54.5	39.0	0.0	0.0	0.0
	75	6.6	44.7	37.4	11.4	0.0	0.0
	76	6.5	40.4	36.4	16.7	0.0	0.0
	78	12.7	60.9	26.4	0.0	0.0	0.0
	79	13.5	58.9	18.4	7.6	1.6	0.0

Table (5.26): PVC's percents of TSW-7 well.

Formation	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
U. part of Bahariya	32	20.9	61.0	16.4	1.7	0.0	0.0
	10	4.2	37.0	33.5	25.3	0.0	0.0
	22H	5.4	36.0	15.8	14.8	21.5	6.5
	42	15.5	73.6	11.0	0.0	0.0	0.0
	2H2	7.9	52.7	22.9	16.6	0.0	0.0
	31H1	5.1	47.7	47.2	0.0	0.0	0.0
	31H2	6.5	65.6	27.9	0.0	0.0	0.0
	35	16.5	76.2	7.4	0.0	0.0	0.0
	19	1.5	18.1	17.6	13.9	35.1	13.8
	40	18.2	72.0	9.8	0.0	0.0	0.0
	1H1	24.2	75.8	0.0	0.0	0.0	0.0
	1H2	21.5	71.7	6.8	0.0	0.0	0.0

Table (5.27): PVC's percents of TSW-8 well.

Formation	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
Abu Roash 'F'	57	2.2	34.5	63.4	0.0	0.0	0.0
	58	3.8	32.9	60.2	3.1	0.0	0.0
	59H2	4.5	36.9	55.4	3.2	0.0	0.0
	36	2.1	29.7	68.1	0.0	0.0	0.0
	38	2.0	22.4	75.7	0.0	0.0	0.0
	50H1	4.1	39.6	56.4	0.0	0.0	0.0
	33	3.3	46.1	50.6	0.0	0.0	0.0
	41H1	3.5	50.6	45.8	0.0	0.0	0.0
	44	3.0	47.1	49.9	0.0	0.0	0.0
	12H1	2.4	34.2	63.4	0.0	0.0	0.0
	51	2.8	31.6	65.6	0.0	0.0	0.0

Table (5.28): PVC's percents of TSW-13 well.

Formation	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
U. part of Bahariya	39	19.9	66.1	14.0	0.0	0.0	0.0
	34	12.1	65.4	11.3	9.3	1.8	0.0
	48 H1	15.4	78.8	5.8	0.0	0.0	0.0
	48 H2	11.0	82.2	6.8	0.0	0.0	0.0

Table (5.29): PVC's percents of TSW-15 well.

Formation	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
U. part of Bahariya	3	6.0	54.5	25.9	13.7	0.0	0.0
	28H1	3.4	14.4	8.1	6.5	13.8	53.8
	28H2	3.2	13.5	8.8	6.1	12.9	55.6
	13H1	21.2	78.8	0.0	0.0	0.0	0.0
	13H2	26.5	73.5	0.0	0.0	0.0	0.0
	6	22.4	73.9	3.7	0.0	0.0	0.0
	55	3.9	19.8	6.0	2.4	7.6	60.3
	53H1	1.7	8.3	4.6	4.7	5.7	25.1
	53H2	3.1	12.0	7.0	6.1	9.2	44.7
	18H1	5.7	27.0	13.0	14.2	17.2	22.9
	18H2	2.7	8.9	4.6	4.2	5.9	36.0
	43H1	1.8	7.9	3.9	3.2	5.0	24.8
	43H2	2.1	9.2	5.7	4.7	7.4	35.6
	21H	2.4	13.8	8.1	8.5	10.7	36.0
	11H1	4.5	26.0	17.8	17.9	15.3	18.6
	11H2	1.6	8.2	6.1	5.1	7.5	52.6
	7H1	4.0	18.4	11.2	9.3	12.8	44.3
	7H2	6.6	33.3	12.7	9.9	13.7	23.8

Table (5.30): PVC's percents of TSW-21 well.

Formation / Member	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
Abu Roash `G`	17	13.7	73.3	13.0	0.0	0.0	0.0
	25H1	2.8	23.0	12.7	12.1	32.7	16.6
	25H2	5.2	42.0	18.4	21.0	13.5	0.0
	30H1	9.9	54.8	21.6	12.8	0.9	0.0
	30H2	11.1	59.3	22.2	7.2	0.2	0.0
	9H1	17.4	76.3	6.3	0.0	0.0	0.0
	9H2	15.3	70.7	13.9	0.0	0.0	0.0
	24	3.5	30.4	26.8	25.9	12.1	1.2
	54	20.1	79.9	0.0	0.0	0.0	0.0
	52	7.0	69.1	23.9	0.0	0.0	0.0
	16H1	10.8	66.3	22.8	0.0	0.0	0.0
	16H2	9.4	67.3	23.3	0.0	0.0	0.0
	20H1	16.5	70.2	13.3	0.0	0.0	0.0
	20H2	14.4	67.4	16.1	2.2	0.0	0.0
U. part of Bahariya	45	11.4	78.7	9.9	0.0	0.0	0.0
	5	8.3	68.6	23.1	0.0	0.0	0.0
	49	10.9	83.8	5.3	0.0	0.0	0.0
	37	12.8	49.3	16.6	13.3	8.1	0.0

Table (5.31): PVC's percents of Abu Roash `G`, TSW-21 well.

Member	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
Abu Roash `G`	17	13.7	73.3	13.0	0.0	0.0	0.0
	25H1	2.8	23.0	12.7	12.1	32.7	16.6
	25H2	5.2	42.0	18.4	21.0	13.5	0.0
	30H1	9.9	54.8	21.6	12.8	0.9	0.0
	30H2	11.1	59.3	22.2	7.2	0.2	0.0
	9H1	17.4	76.3	6.3	0.0	0.0	0.0
	9H2	15.3	70.7	13.9	0.0	0.0	0.0
	24	3.5	30.4	26.8	25.9	12.1	1.2
	54	20.1	79.9	0.0	0.0	0.0	0.0
	52	7.0	69.1	23.9	0.0	0.0	0.0
	16H1	10.8	66.3	22.8	0.0	0.0	0.0
	16H2	9.4	67.3	23.3	0.0	0.0	0.0
	20H1	16.5	70.2	13.3	0.0	0.0	0.0
	20H2	14.4	67.4	16.1	2.2	0.0	0.0

Table (5.32): PVC's percents of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
TSW-7	32	20.9	61.0	16.4	1.7	0.0	0.0
	10	4.2	37.0	33.5	25.3	0.0	0.0
	22H	5.4	36.0	15.8	14.8	21.5	6.5
	42	15.5	73.6	11.0	0.0	0.0	0.0
	2H2	7.9	52.7	22.9	16.6	0.0	0.0
	31H1	5.1	47.7	47.2	0.0	0.0	0.0
	31H2	6.5	65.6	27.9	0.0	0.0	0.0
	35	16.5	76.2	7.4	0.0	0.0	0.0
	19	1.5	18.1	17.6	13.9	35.1	13.8
	40	18.2	72.0	9.8	0.0	0.0	0.0
	1H1	24.2	75.8	0.0	0.0	0.0	0.0
	1H2	21.5	71.7	6.8	0.0	0.0	0.0
TSW-13	39	19.9	66.1	14.0	0.0	0.0	0.0
	34	12.1	65.4	11.3	9.3	1.8	0.0
	48 H1	15.4	78.8	5.8	0.0	0.0	0.0
	48 H2	11.0	82.2	6.8	0.0	0.0	0.0
TSW-15	3	6.0	54.5	25.9	13.7	0.0	0.0
	28H1	3.4	14.4	8.1	6.5	13.8	53.8
	28H2	3.2	13.5	8.8	6.1	12.9	55.6
	13H1	21.2	78.8	0.0	0.0	0.0	0.0

Table (5.32), cont.: PVC's percents of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Sample No.	PVC1 %	PVC2 %	PVC3 %	PVC4 %	PVC5 %	PVC6 %
TSW-15	13H2	26.5	73.5	0.0	0.0	0.0	0.0
	6	22.4	73.9	3.7	0.0	0.0	0.0
	55	3.9	19.8	6.0	2.4	7.6	60.3
	53H1	1.7	8.3	4.6	4.7	5.7	25.1
	53H2	3.1	12.0	7.0	6.1	9.2	44.7
	18H1	5.7	27.0	13.0	14.2	17.2	22.9
	18H2	2.7	8.9	4.6	4.2	5.9	36.0
	43H1	1.8	7.9	3.9	3.2	5.0	24.8
	43H2	2.1	9.2	5.7	4.7	7.4	35.6
	21	2.4	13.8	8.1	8.5	10.7	36.0
	11H1	4.5	26.0	17.8	17.9	15.3	18.6
	11H2	1.6	8.2	6.1	5.1	7.5	52.6
	7H1	4.0	18.4	11.2	9.3	12.8	44.3
	7H2	6.6	33.3	12.7	9.9	13.7	23.8
TSW-21	45	11.4	78.7	9.9	0.0	0.0	0.0
	5	8.3	68.6	23.1	0.0	0.0	0.0
	49	10.9	83.8	5.3	0.0	0.0	0.0
	37	12.8	49.3	16.6	13.3	8.1	0.0

Table (5.33): Grouping of L. Bahariya, BED1-11 well based on PVC2 values.

Group name	PVC2 average, %	Permeability average, md
A	59.5	0.019
B	32.5	1.04
C	18.1	28.8

Table (5.34): PVC1 properties of TSW-8 well.

Group name	PVC1 average, %	Permeability average, md
A	2.8	0.008

Table (5.35): Grouping of Abu Roash `G`, TSW-21 well based on PVC2 values.

Group name	PVC2 average, %	Permeability average, md
A	67.5	0.35
C	26.7	13.3

Table (5.36): Grouping of U. Bahariya, TSW-7, 15 and 21 wells based on PVC2 values.

Group name	PVC2 average, %	Permeability average, md
A	66.3	0.23
C	17.2	123.9

Table (5.37): K, Mhr, Median and R35 of BED1-11 well.

Formation	Sample No.	K, md	MHR, µm	Median, µm	R35, µm
L. part of Bahariya	2	4.91	1.717	0.215	0.770
	3	1.47	0.789	0.090	0.370
	4	1.78	0.973	0.170	0.530
	5	1.83	0.804	0.160	0.450
	6	0.29	0.310	0.044	0.147
	7	0.02	0.061	0.010	0.019
	8	0.02	0.092	0.013	0.025
	9	0.02	0.105	0.012	0.025
	12	1.82	0.799	0.150	0.370
	13	22.68	2.958	0.430	1.590
	14	27.93	2.835	0.322	1.590
	15	24.89	2.889	0.450	1.550
	16	18.30	2.807	0.217	1.280
	21	0.03	0.174	0.009	0.011
	24	0.02	0.229	0.028	0.072
	25	0.02	0.233	0.024	0.068
	27	0.48	0.296	0.037	0.089
	28	0.71	0.915	0.080	0.310
	29	0.26	0.953	0.021	0.090
	30	2.09	1.066	0.070	0.140
	31	0.02	0.123	0.008	0.017
	39	0.01	0.045	0.007	0.012
	40	0.03	0.043	0.006	0.009
	41	0.35	0.524	0.060	0.180

Table (5.37), cont.: K, Mhr, Median and R35 of BED1-11 well.

Formation	Sample No.	K, md	MHR, μm	Median, μm	R35, μm
L. part of Bahariya	43	0.01	0.075	0.012	0.022
	44	21.14	2.942	0.237	1.320
	46	20.41	3.228	0.321	2.290
	47	0.01	0.051	0.008	0.012
	48	2.86	0.868	0.054	0.290
	50	64.00	4.514	1.510	4.267
	51	61.73	4.542	1.030	2.660
	52	0.16	0.383	0.045	0.140
	53	0.02	0.154	0.021	0.048
	54	0.13	0.812	0.120	0.430
	56	0.11	0.323	0.025	0.072
	59	0.16	0.468	0.070	0.210
	60	0.16	0.764	0.088	0.270
	62	26.40	3.357	0.530	2.650
	63	17.36	2.986	0.250	1.250
	64	0.02	0.030	0.005	0.008
	65	12.50	3.099	0.450	1.950
	73	0.11	0.260	0.021	0.080
	74	0.02	0.113	0.021	0.054
	75	0.01	0.191	0.016	0.052
	76	0.10	0.238	0.028	0.099
	78	0.01	0.079	0.011	0.022
	79	0.02	0.194	0.010	0.018

Table (5.38): K, Mhr, Median and R35 of TSW-7 well.

Formation	Sample No.	K, md	MHR, μm	Median, μm	R35, μm
U. part of Bahariya	32	0.30	0.080	0.008	0.012
	10	0.64	0.281	0.054	0.111
	22H	4.06	1.567	0.053	0.201
	42	0.09	0.051	0.011	0.016
	2H2	1.02	0.220	0.021	0.044
	31H1	0.20	0.127	0.035	0.067
	31H2	0.19	0.097	0.020	0.037
	35	0.05	0.043	0.008	0.013
	19	4.41	2.059	0.375	1.270
	40	0.09	0.040	0.008	0.013
	1H1	0.05	0.025	0.007	0.010
	1H2	0.15	0.036	0.007	0.011

Table (5.39): K, Mhr, Median and R35 of TSW-8 well.

Member	Sample No.	K, md	MHR, μm	Median, μm	R35, μm
Abu Roash `F`	57	0.006	0.158	0.074	0.110
	58	0.045	0.170	0.077	0.109
	59H2	0.030	0.160	0.062	0.098
	36	0.013	0.146	0.084	0.114
	38	0.007	0.175	0.100	0.134
	50H1	0.003	0.110	0.058	0.086
	33	0.007	0.089	0.051	0.080
	41H1	0.006	0.087	0.045	0.072
	44	0.005	0.091	0.055	0.080
	12H1	0.016	0.115	0.076	0.107
	51	0.007	0.113	0.072	0.108

Table (5.40): K, Mhr, Median and R35 of TSW-13 well.

Formation	Sample No.	K, md	MHR, μm	Median, μm	R35, μm
U. part of Bahariya	39	0.13	0.056	0.007	0.012
	34	0.27	0.221	0.011	0.021
	48 H1	0.16	0.039	0.009	0.014
	48 H2	0.19	0.047	0.014	0.022

Table (5.41): K, Mhr, Median and R35 of TSW-15 well.

Formation	Sample No.	K, md	MHR, μm	Median, μm	R35, μm
U. part of Bahariy	3	0.18	0.207	0.025	0.049
	28H1	110.6	2.947	1.360	3.270
	28H2	100.3	2.969	1.410	3.270
	13H1	0.05	0.020	0.008	0.011
	13H2	0.04	0.018	0.007	0.010
	6	0.10	0.032	0.007	0.011
	55	146.7	4.787	1.890	4.170
	53H1	251.9	7.348	2.950	6.180
	53H2	184.1	5.755	1.290	5.080
	18H1	9.83	1.975	0.051	0.333
	18H2	201.6	5.776	2.126	5.540
	43H1	259.9	7.613	3.900	6.400
	43H2	237.9	5.726	2.255	5.565
	21	164.2	5.262	1.155	4.720
	11H1	14.51	2.158	0.099	0.333
	11H2	207.0	6.485	4.420	5.740
	7H1	57.8	3.816	0.299	2.095
	7H2	27.9	2.822	0.038	0.212

Table (5.42): K, Mhr, Median and R35 of TSW-21 well.

Formation	Sample No.	K, md	MHR, µm	Median, µm	R35, µm
Abu Roash 'G'	17	0.17	0.059	0.010	0.017
	25H1	20.2	1.990	0.310	1.170
	25H2	3.55	0.500	0.032	0.103
	30H1	1.22	0.219	0.015	0.030
	30H2	0.45	0.165	0.012	0.022
	9H1	0.13	0.038	0.007	0.013
	9H2	0.27	0.053	0.009	0.015
	24	6.45	0.745	0.101	0.205
	54	0.08	0.024	0.006	0.010
	52	0.13	0.083	0.021	0.035
	16H1	0.16	0.078	0.012	0.022
	16H2	0.15	0.077	0.012	0.024
	20H1	0.27	0.056	0.008	0.014
	20H2	0.55	0.095	0.010	0.018
U. part of Bahariya	45	0.21	0.051	0.011	0.019
	5	0.08	0.079	0.015	0.030
	49	0.04	0.044	0.011	0.020
	37	0.63	0.356	0.012	0.025

Table (5.43): K, Mhr, Median and R35 of Abu Roash `G`, TSW-21 well.

Formation	Sample No.	K, md	MHR, μm	Median, μm	R35, μm
Abu Roash `G`	17	0.17	0.059	0.010	0.017
	25H1	20.2	1.990	0.310	1.170
	25H2	3.55	0.500	0.032	0.103
	30H1	1.22	0.219	0.015	0.030
	30H2	0.45	0.165	0.012	0.022
	9H1	0.13	0.038	0.007	0.013
	9H2	0.27	0.053	0.009	0.015
	24	6.45	0.745	0.101	0.205
	54	0.08	0.024	0.006	0.010
	52	0.13	0.083	0.021	0.035
	16H1	0.16	0.078	0.012	0.022
	16H2	0.15	0.077	0.012	0.024
	20H1	0.27	0.056	0.008	0.014
	20H2	0.55	0.095	0.010	0.018

Table (5.44): K, Mhr, Median and R35 of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Sample No.	K, md	MHR, µm	Median, µm	R35, µm
TSW-7	32	0.30	0.080	0.008	0.012
	10	0.64	0.281	0.054	0.111
	22H	4.06	1.567	0.053	0.201
	42	0.09	0.051	0.011	0.016
	2H2	1.02	0.220	0.021	0.044
	31H1	0.20	0.127	0.035	0.067
	31H2	0.19	0.097	0.020	0.037
	35	0.05	0.043	0.008	0.013
	19	4.41	2.059	0.375	1.270
	40	0.09	0.040	0.008	0.013
	1H1	0.05	0.025	0.007	0.010
	1H2	0.15	0.036	0.007	0.011
TSW-13	39	0.13	0.056	0.007	0.012
	34	0.27	0.221	0.011	0.021
	48 H1	0.16	0.039	0.009	0.014
	48 H2	0.19	0.047	0.014	0.022
TSW-15	3	0.18	0.207	0.025	0.049
	28H1	110.62	2.947	1.360	3.270
	28H2	100.33	2.969	1.410	3.270
	13H1	0.05	0.020	0.008	0.011

Table (5.44), cont.: K, Mhr, Median and R35 of well of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Sample No.	K, md	MHR, µm	Median, µm	R35, µm
TSW-15	13H2	0.04	0.018	0.007	0.010
	6	0.10	0.032	0.007	0.011
	55	146.74	4.787	1.890	4.170
	53H1	251.95	7.348	2.950	6.180
	53H2	184.11	5.755	1.290	5.080
	18H1	9.83	1.975	0.051	0.333
	18H2	201.62	5.776	2.126	5.540
	43H1	259.91	7.613	3.900	6.400
	43H2	237.96	5.726	2.255	5.565
	21	164.20	5.262	1.155	4.720
	11H1	14.51	2.158	0.099	0.333
	11H2	207.07	6.485	4.420	5.740
	7H1	57.83	3.816	0.299	2.095
	7H2	27.99	2.822	0.038	0.212
TSW-21	45	0.21	0.051	0.011	0.019
	5	0.08	0.079	0.015	0.030
	49	0.04	0.044	0.011	0.020
	37	0.63	0.356	0.012	0.025

Table (5.45): Grouping of L. Bahariya, BED1-11 well based on MHR values.

Group name	MHR average, Microns	Permeability average, md
A	0.117	0.02
B	0.698	1.04
C	3.28	28.8

Table (5.46): MHR properties of TSW-8 well.

Group name	MHR average, Microns	Permeability average, md
A	0.129	0.013

Table (5.47): Grouping of Abu Roash `G`, TSW-21 well based on MHR values.

Group name	MHR average, Microns	Permeability average, md
A	0.086	0.32
C	1.36	13.3

Table (5.48): Grouping of U. Bahariya, TSW-7, 13, 15 and 21 wells based on MHR values.

Group name	MHR average, Microns	Permeability average, md
A	0.099	0.221
C	4.31	123.9

Table (5.49): Grouping of L. Bahariya, BED1-11 well based on median values.

Group name	Median average, μm	Permeability average, md
A	0.01	0.018
B	0.08	1.04
C	0.52	28.8

Table (5.50): Median properties of TSW-8 well.

Group name	Median average, μm	Permeability average, md
A	0.069	0.013

Table (5.51): Grouping of Abu Roash `G`, TSW-21 well based on median values.

Group name	Median average, μm	Permeability average, md
A	0.012	0.32
C	0.21	13.3

Table (5.52): Grouping of U. Bahariya, TSW-7, 13, 15 and 21 wells based on median values.

Group name	Median average, μm	Permeability average, md
A	0.015	0.221
C	1.48	123.9

Table (5.53): Porosity, refined porosity, mercury porosity and permeability of BED1-11 well.

Formation	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
L. part of Bahariya	3512.90	2	13.5	11.4	13.4	4.91
	3513.60	3	13.1	11.0	13.1	1.47
	3513.80	4	13.4	11.5	13.3	1.78
	3514.60	5	13.1	11.6	13.0	1.83
	3514.70	6	9.8	8.5	10.4	0.29
	3515.30	7	7.6	6.0	7.6	0.02
	3515.40	8	7.6	6.4	7.6	0.02
	3515.60	9	10.0	8.1	10.0	0.02
	3517.10	12	14.9	13.3	16.5	1.82
	3517.20	13	16.2	14.7	13.2	22.68
	3517.40	14	13.2	11.7	12.5	27.93
	3518.10	15	15.6	13.9	15.9	24.89
	3518.20	16	15.0	12.8	13.4	18.30
	3519.50	21	6.3	5.0	7.7	0.03
	3520.00	24	8.7	7.4	10.9	0.02
	3520.90	25	7.3	5.6	11.1	0.02
	3521.30	27	8.8	7.8	12.0	0.48
	3521.60	28	13.6	11.0	12.0	0.71
	3521.90	29	10.2	7.4	11.4	0.26
	3522.50	30	12.6	10.2	10.9	2.09
	3522.70	31	5.0	4.5	5.5	0.02
	3525.50	39	6.5	4.8	6.5	0.01
	3526.30	40	6.1	4.6	6.1	0.03
	3526.40	41	11.5	10.1	13.1	0.35

Table (5.53), cont.: Porosity, refined porosity, mercury porosity and permeability of BED1-11 well.

Formation	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
L. part of Bahariya	3527.50	43	5.1	4.0	8.8	0.01
	3528.20	44	15.6	13.7	14.9	21.14
	3528.50	46	15.1	12.7	15.1	20.41
	3528.70	47	9.3	6.9	6.3	0.01
	3529.10	48	14.9	12.8	15.7	2.86
	3529.40	50	17.7	15.3	16.2	64.00
	3530.00	51	17.3	15.7	17.5	61.73
	3530.10	52	10.0	8.6	12.8	0.16
	3530.30	53	9.8	7.7	11.6	0.02
	3531.10	54	11.3	9.3	12.9	0.13
	3531.60	56	13.8	10.3	16.7	0.11
	3533.00	59	11.0	9.5	12.2	0.16
	3533.10	60	14.9	12.4	16.9	0.16
	3533.70	62	16.7	14.4	15.4	26.40
	3534.80	63	13.9	12.1	10.8	17.36
	3536.30	64	5.7	3.4	4.8	0.02
	3536.80	65	13.5	11.6	14.4	12.50
	3543.90	73	8.0	6.5	11.2	0.11
	3544.60	74	7.2	6.0	9.5	0.02
	3544.70	75	7.8	5.7	11.8	0.01
	3545.54	76	8.1	7.0	10.9	0.10
	3546.40	78	6.1	4.7	10.9	0.01
	3546.60	79	7.6	6.1	7.6	0.02

Table (5.54): Porosity, refined porosity, mercury porosity and permeability of TSW-7 well.

Formation	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
U. part of Bahariya	2021.45	32	11.9	9.6	12.3	0.30
	2023.25	10	16.7	13.8	16.8	0.64
	2024.20	22H	16.4	14.7	16.2	4.06
	2026.85	42	14.4	12.1	10.2	0.09
	2027.75	2H2	14.6	11.9	13.5	1.02
	2028.43	31H1	17.0	13.4	17.5	0.20
	2028.88	31H2	16.3	12.8	17.7	0.19
	2030.45	35	8.1	6.4	10.5	0.05
	2031.35	19	18.2	16.5	20.2	4.41
	2035.85	40	13.3	10.7	12.0	0.09
	2037.33	1H1	10.5	8.0	10.5	0.05
	2037.78	1H2	9.8	8.0	9.9	0.15

Table (5.55): Porosity, refined porosity, mercury porosity and permeability of TSW-8 well.

Formation	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
Abu Roash `F`	1799.70	57	16.4	13.5	19.8	0.006
	1799.90	58	18.7	16.7	18.5	0.045
	1800.10	59H2	18.7	16.6	18.1	0.030
	1801.50	36	18.0	15.4	20.6	0.013
	1802.50	38	16.1	13.0	20.5	0.007
	1803.50	50H1	16.3	13.6	19.0	0.003
	1804.50	33	17.2	13.9	18.9	0.007
	1806.25	41H1	15.3	12.3	17.0	0.006
	1806.75	44	16.3	13.7	17.7	0.005
	1807.50	12H1	17.4	15.0	18.1	0.016
	1808.50	51	15.9	13.0	19.6	0.007

Table (5.56): Porosity, refined porosity, mercury porosity and permeability of TSW-13 well.

Formation	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
U. part of Bahariya	2049.50	39	10.7	8.2	12.3	0.13
	2052.75	34	12.6	10.2	13.5	0.27
	2055.25	48 H1	14.2	11.2	13.1	0.16
	2055.75	48 H2	16.1	13.6	15.8	0.19

Table (5.57): Porosity, refined porosity, mercury porosity and permeability of TSW-15 well.

Formation	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
U. part of Bahariya	2006.25	3	18.2	14.2	20.6	0.18
	2006.75	28H1	24.9	22.0	22.4	110.62
	2007.25	28H2	24.9	21.8	21.0	100.33
	2010.75	13H1	17.1	13.3	17.2	0.05
	2011.25	13H2	12.8	10.2	16.6	0.04
	2014.00	6	10.4	7.8	14.8	0.10
	2015.00	55	23.5	21.2	21.2	146.74
	2072.25	53H1	24.1	21.6	23.9	251.95
	2072.75	53H2	24.3	21.6	22.7	184.11
	2073.25	18H1	16.5	13.7	18.0	9.83
	2073.75	18H2	23.3	20.4	23.1	201.62
	2074.25	43H1	25.0	23.1	23.0	259.91
	2074.75	43H2	25.3	22.6	23.3	237.96
	2075.50	21	22.5	20.7	23.4	164.20
	2077.25	11H1	20.2	17.3	19.4	14.51
	2077.75	11H2	21.8	19.6	20.5	207.07
	2078.25	7H1	20.3	17.6	19.1	57.83
	2078.75	7H2	18.3	15.8	18.8	27.99

Table (5.58): Porosity, refined porosity, mercury porosity and permeability of TSW-21 well.

Formation	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
Abu Roash `G`	1987.00	17	21.8	17.0	19.6	0.17
	1987.75	25H1	24.6	22.5	21.7	20.29
	1988.25	25H2	17.7	14.6	18.2	3.55
	1988.75	30H1	15.1	12.6	16.0	1.22
	1989.25	30H2	14.9	11.9	15.0	0.45
	1990.75	9H1	11.1	8.6	14.6	0.13
	1991.25	9H2	11.5	9.2	13.4	0.27
	1992.00	24	26.9	24.1	22.5	6.45
	1993.00	54	4.1	3.0	8.2	0.08
	1994.00	52	16.0	13.0	15.6	0.13
	1995.75	16H1	13.9	11.0	14.3	0.16
	1996.25	16H2	14.7	11.5	15.8	0.15
	1998.75	20H1	12.2	9.6	15.1	0.27
	1999.25	20H2	12.1	9.9	14.0	0.55
U. part of Bahariya	2051.50	45	11.9	9.4	13.2	0.21
	2052.50	5	11.8	9.3	15.3	0.08
	2053.50	49	14.3	10.8	10.9	0.04
	2054.50	37	17.0	14.5	19.8	0.63

Table (5.59): Porosity, refined porosity, mercury porosity and permeability of Abu Roash `G`, TSW-21 well.

Formation	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
Abu Roash `G`	1987.00	17	21.8	17.0	19.6	0.17
	1987.75	25H1	24.6	22.5	21.7	20.29
	1988.25	25H2	17.7	14.6	18.2	3.55
	1988.75	30H1	15.1	12.6	16.0	1.22
	1989.25	30H2	14.9	11.9	15.0	0.45
	1990.75	9H1	11.1	8.6	14.6	0.13
	1991.25	9H2	11.5	9.2	13.4	0.27
	1992.00	24	26.9	24.1	22.5	6.45
	1993.00	54	4.1	3.0	8.2	0.08
	1994.00	52	16.0	13.0	15.6	0.13
	1995.75	16H1	13.9	11.0	14.3	0.16
	1996.25	16H2	14.7	11.5	15.8	0.15
	1998.75	20H1	12.2	9.6	15.1	0.27
	1999.25	20H2	12.1	9.9	14.0	0.55

Table (5.60): Porosity, refined porosity, mercury porosity and permeability of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
TSW-7	2021.45	32	11.9	9.6	12.3	0.30
	2023.25	10	16.7	13.8	16.8	0.64
	2024.20	22H	16.4	14.7	16.2	4.06
	2026.85	42	14.4	12.1	10.2	0.09
	2027.75	2H2	14.6	11.9	13.5	1.02
	2028.43	31H1	17.0	13.4	17.5	0.20
	2028.88	31H2	16.3	12.8	17.7	0.19
	2030.45	35	8.1	6.4	10.5	0.05
	2031.35	19	18.2	16.5	20.2	4.41
	2035.85	40	13.3	10.7	12.0	0.09
	2037.33	1H1	10.5	8.0	10.5	0.05
	2037.78	1H2	9.8	8.0	9.9	0.15
TSW-13	2049.50	39	10.7	8.2	12.3	0.13
	2052.75	34	12.6	10.2	13.5	0.27
	2055.25	48 H1	14.2	11.2	13.1	0.16
	2055.75	48 H2	16.1	13.6	15.8	0.19
TSW-15	2006.25	3	18.2	14.2	20.6	0.18
	2006.75	28H1	24.9	22.0	22.4	110.62
	2007.25	28H2	24.9	21.8	21.0	100.33
	2010.75	13H1	17.1	13.3	17.2	0.05

Table (5.60), cont.: Porosity, refined porosity, mercury porosity and permeability of U. Bahariya, TSW-7, 13, 15 and 21 wells.

Well	Depth, m	Sample No.	Porosity, %	Refined porosity, %	Mercury porosity, %	Permeability, md
TSW-15	2011.25	13H2	12.8	10.2	16.6	0.04
	2014.00	6	10.4	7.8	14.8	0.10
	2015.00	55	23.5	21.2	21.2	146.74
	2072.25	53H1	24.1	21.6	23.9	251.95
	2072.75	53H2	24.3	21.6	22.7	184.11
	2073.25	18H1	16.5	13.7	18.0	9.83
	2073.75	18H2	23.3	20.4	23.1	201.62
	2074.25	43H1	25.0	23.1	23.0	259.91
	2074.75	43H2	25.3	22.6	23.3	237.96
	2075.50	21	22.5	20.7	23.4	164.20
	2077.25	11H1	20.2	17.3	19.4	14.51
	2077.75	11H2	21.8	19.6	20.5	207.07
	2078.25	7H1	20.3	17.6	19.1	57.83
	2078.75	7H2	18.3	15.8	18.8	27.99
TSW-21	2051.50	45	11.9	9.4	13.2	0.21
	2052.50	5	11.8	9.3	15.3	0.08
	2053.50	49	14.3	10.8	10.9	0.04
	2054.50	37	17.0	14.5	19.8	0.63

Table (5.61): Correlation coefficients values before and after applying the refined porosity concept in TSW-7, 8, 13, 15 and 21 wells.

Well	Correlation coefficient before applying the refined porosity	Correlation coefficient after applying the refined porosity
TSW-7	0.70	0.79
TSW-8	0.87	0.89
TSW-13	0.27	0.32
TSW-15	0.87	0.91
TSW-21	0.71	0.78

Table (5.62): Comparison of different petrophysical parameters of the different studied units.

Unit	Group	Averages								
		Φ, %	K, md	Pd, psi	Swirr, %	Pvc1 %	Pvc2, %	MHR, µm	Md, µm	R35, µm
U. Bahariya, TSW-field	A	13.6	0.18	1057	20.2	-	66.3	0.099	0.015	0.027
	C	21.9	123.9	21.6	11.4	-	17.2	4.31	1.48	3.40
L. Bahariya, BED-1 field	A	7.3	0.02	527.9	21.6	-	59.5	0.117	0.01	0.029
	B	11.9	1.04	112.5	14.7	-	32.5	0.698	0.08	0.26
	C	15.4	28.8	23.6	12.5	-	18.1	3.28	0.52	2.03
Abu Roash \`G\`	A	13.5	0.37	743.7	20.7	-	67.5	0.086	0.012	0.02
	C	25.7	13.4	45.1	9.6	-	26.7	1.36	0.21	0.69
Abu Roash \`F\`	A	16.9	0.013	759.6	16.06	2.8	-	0.129	0.069	0.10

التطبيق الجيولوجى لبيانات الضغط الشعرى والنفاذية باستخدام مفهوم عدم التجانس للخزان-الصحراء الغربية-مصر.

رسالة مقدمة من

أسامة محمد السيد النجار

ماجستيرفى العلوم فى الجيولوجيا – جامعة عين شمس

٢٠٠٢

باحث مساعد بمعهد بحوث البترول

للحصول على

درجة دكتوراه الفلسفة فى العلوم فى الجيولوجيا

تحت إشراف

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ملخص

التطبيق الجيولوجي لبيانات الضغط الشعرى والنفاذية باستخدام مفهوم عدم التجانس للخزان الصحراء الغربية- مصر.

تهدف هذه الدراسة الى توصيف صخور الخزانات الحاملة للبترول وغير المتجانسة في طبقات البحرية وأبو رواش وذلك بدراسة خواصهم الليثولوجية والبتروفيزيقية. لأجل ذلك تم اختيار حقلين لدراستهما: الحقل الأول هوGPTSW ويوجد فى منطقة أبو سنان فى شمال الصحراء الغربية ويقع بين خطى طول ٢٨°-٢٩° شرقا وخطى عرض ٢٥` ٢٩°-٤٨` ٢٩° شمالا ويمثل هذا الحقل بالأبار (TSW-7, 8, 13, 15 and 21) وتنتمى عينات الدراسة فى هذا الحقل الى الجزء العلوى من مكون البحرية التابع للعصر السينومانى السفلى وعضوى أبو رواش (G & F) التابعين للعصر السينومانى العلوى ضمن العصر الكريتاوى العلوى. أما الحقل الثانى فهو حقل بدر الدين-١(BED-1) فى منطقة امتياز شركة بدر الدين للبترول بشمال الصحراء الغربية ويقع بين خطى طول ٢٩` ٢٦°-٣٥` ٢٨° شرقا وخطى عرض ٣٥` ٢٩°-١٠` ٣٠° شمالا ويمثل هذا الحقل بالبئر(BED1-11) وتنتمى عينات الدراسة لهذا الحقل الى الجزء السفلى من مكون البحرية التابع للعصر السينومانى السفلى. وقد تم تجميع عدد (٦٣) و (٤٧) من العينات الاسطوانية (اللب) من حقلى GPTSW ، BED-1 على التوالى. بالنسبة لحقل GPTSW فان عيناته (٣٨ عينة) تنتمى الى الجزء العلوى من مكون البحرية و(١١ عينة) من أبو رواش (F) و(١٤ عينة) من أبو رواش (G). وبالنسبة للحقل BED-1 فان كل عيناته تنتمى الى الجزء السفلى من مكون البحرية. وقد خضعت كل هذه العينات الى معالجات معملية مختلفة متضمنة أساليب بتروجرافية لمعرفة خواصها الصخرية وكذا عمليات التغيير التى طرأت عليها بعد الترسيب من خلال دراسة القطاعات الميكروسكوبية الرقيقة وأيضا معالجات بتروفيزيقية والتى تشمل قياس المسامية والنفاذية والضغط الشعرى لمعرفة خواصها البتروفيزيقية كما تم استخدام الميكروسكوب الالكترونى المجسم لبعض العينات لدراسة الشكل الهندسى للمسام الموجودة فى الصخور لبيان تأثير ذلك على الخصائص البتروفيزيقية. وقد أظهرت الدراسات البتروجرافية أن عينات مكون البحرية فى الحقلين (GPTSW وBED-1) وعينات أبو رواش (G) فى حقل (GPTSW) تتكون بصورة أساسية من معدن الكوارتز مع تواجد لمعدن الجلوكونيت وكذا بعض الكربونات المتمثلة فى الفورامنيفرا فى بعض عينات أبو رواش (G). وقد أظهرت دراسة القطاعات الميكروسكوبية الرقيقة تعرض تلك الصخور لعمليات تغيير مابعد الترسيب مثل المواد اللاحمة ونمو

بلورات الكوارتز والاذابة والتشققات وقد أمكن تحديد بيئة الترسيب حيث وجد أنها بيئات بحرية ضحلة. وعلى الجانب الأخر أظهرت الدراسات البتروجرافية أن عينات أبو رواش (F) فى حقل (GPTSW) تتكون بصورة أساسية من المارل مع تراجد شائع للفورامنيفرا. وقد أظهرت دراسة القطاعات الميكروسكوبية الرقيقة تعرض تلك الصخور لعمليات تغيير مابعد الترسيب مثل الاذابة واعادة تبلور بلورات الكالسيت. وقد أمكن تحديد بيئة الترسيب حيث وجد أنها بيئة بحرية عميقة نوعا. وقد أظهرت الدراسات البتروفيزيقية (علاقة المسامية بالنفاذية) تقسيم عينات الجزء العلوى لمكون البحرية فى الحقل (GPTSW) الى مجموعتين (أ،ج) نتيجة التواجد المتفاوت لمعادن الطين الفتاتية. حيث تتميز عينات المجموعة (أ) بأحتوائها على كمية كبيرة من معادن الطين فى تركيبها المعدنى بينما تتميز عينات المجموعة (ج) بأنعدام معادن الطين تقريبا فى تركيبها المعدنى وقد انعكس التواجد المتفاوت لمعادن الطين على الصفات البتروفيزيقية للعينات حيث نجد أن صفات الخزان الجيد تظهر بوضوح فى عينات المجموعة (ج) التى تتميز بقيم مرتفعة من المسامية و النفاذية على العكس من ذلك فى عينات المجموعة (أ) التى تتميز بقيم منخفضة من المسامية وبقيم أقل من النفاذية. وبالنسبة لعينات الجزء السفلى لمكون البحرية فى الحقل (BED-1) فقد أظهرت علاقة المسامية بالنفاذية أمكانية تقسيم العينات الى ثلاث مجموعات (أ، ب،ج) نتيجة التواجد المتفاوت للمواد اللاحمة كعامل أساسى ومعادن الطين كعامل ثانوى (الكاولينيت، الكلورايت والأليت) حيث تتميز عينات المجموعة (أ) بأحتوائها على كمية كبيرة من معادن المواد اللاحمة وكذا على معادن الطين بينما تتميز عينات المجموعة (ج) بأحتوائها على كمية أصغر، أما المجموعة (ب) فلها صفات وسطية وقد انعكس هذا التفاوت على الصفات البتروفيزيقية للعينات حيث نجد أن صفات الخزان الجيد تظهر بوضوح فى عينات المجموعة (ج) التى تتميز بقيم عالية من المسامية و النفاذية على العكس من ذلك فى عينات المجموعة (أ) التى تتميز بقيم منخفضة من المسامية وقيم أقل من النفاذية وبالتالى فهى تمثل خزان ردىء أو صخر غطاء وتقع المجموعة (ب) فى صفاتها بين المجموعتين السابقتين. أما عينات أبو رواش (G) فقد قسمت الى مجموعتين (أ ، ج) نتيجة التواجد المتفاوت لمعادن الطين ولكن تنتمى معظم العينات الى المجموعة (أ) ذات النفاذية القليلة جدا والتى تتشابه معها كل عينات أبو رواش (F) نظرا لأن تركيبها الصخرى هو المارل. وقد تمت دراسة العينات من خلال اجراء قياسات الضغط الشعرى باستخدام الضغط الزئبقى واستنتاج العديد من المتغيرات التى تفيد فى دراسة وتقييم الخزان البترولى مثل التوزيع الحجمى للفراغات بين الحبيبات والذى له علاقة قوية بالنفاذية وقد أوضحت الدراسات أن صفات الخزان الجيد لاتتواجد الا فى عينات المجموعة (ج) ذات التوزيع الحجمى الأفضل للفراغات بين الحبيبات وبالتالى انعكس ذلك فى زيادة قيم النفاذية لتلك العينات. وبصورة عامة فان عينات مكون

البحرية فى الحقلين(GPTSW و BED-1) لها قدرات عالية فى تخزين وتمرير الموائع وذلك لقيمها العالية فى المسامية والنفاذية مقارنة بعينات عضوى أبو رواش (G & F). وقد أظهرت الدراسات البتروفيزيقية أيضا أن طبقات الجزء العلوى من مكون البحرية فى حقل (GPTSW) لها قدرات أفضل فى تخزين وتمرير الموائع مقارنة بطبقات الجزء السفلى من مكون البحرية بحقل (BED-1). كما أن أقل الطبقات فى تمرير الموائع كانت طبقات أبو رواش (F) نظرا لأنها تتكون بصورة أساسية من المارل.