

# بسم الله الرحمن الرحيم



-Cardon - Cardon - Ca





شبكة المعلومات الجامعية التوثيق الالكتروني والميكروفيلم





## جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات



يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار







بعض الوثائق

الأصلية تالفة







بالرسالة صفحات

لم ترد بالأصل



### PETROLOGICAL AND PETROPHSICAL STUDIES ON UPPER RUDEIS IN WEST JULY AREA, CENTRAL GULF OF SUEZ, EGYPT

BIYNIN

 $\mathscr{B}_{oldsymbol{y}}$ 

**ALAA HASSAN HEFNAWY** 

(B.Sc., M.S.c)

Submitted for the

**Degree of Doctor of Philosophy** 

Under Supervision

#### PROF. DR. MOHAMED SHARAF EL DIN

Head of Geology Department, Faculty of Science, BenhaUniversity

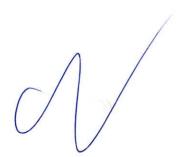
#### DR. HESHAM SHAKIR ZAHRA

Assistant professor of Geophysics, Geology Department faculty of Science, BenhaUniversity

#### DR. AL-MOUTAZ HASSOUBA

Exploration general manager, Gulf of Suez petroleum company (GUPCO)

2005







انا ملذ لا علم الها (هالوا سبحانات لا علم الها علم المكيم )

صدق الله العظيم سورة البقرة الاية ٣٢ "

#### **CONTENTS**

Subject	page
Acknowledgements	X
Abstract	XI
1.Introduction	1
1.1 Statement of problem	
1.2 Selection of the study area	3 5 5 6
1.3 Scope and purpose of the study	5
1.4 Materials and data used in the study	6
1.5 Methods of investigation and interpretation	9
1.6 Computer facilities	12
1.6 Previous work	12
2.Synrift geological setting and stratigraphic history of the study are	ea 14
2.1 Background and current understanding of syn-rift history	14
2.2 Straigraphy of the study area	17
2.2.1 Stratigraphic history background	17
2.2.2 Stratigraphic history and prospectivity of the study area	20
2.2.2.1 Pre-Miocene straigraphy and facies variations	20
2.2.2.2 Miocene straigraphy and facies variations	27
2.2.3 Structural evolution of the study area	47
3. Reservoir characterization, depositional and diagenetic models	52
3.1 Introduction	52
3.2 Reservoir definition	53
3.3 Depositional model	54
3.3.1 Lithofacies description and interpretations	57
3.3.2 Sequence stratigraphy and reservoir quality	59
3.4 Reservoir rock types (RRT's) 3.4.1 Reservoir rock types definition	60
3.4.1.1 Porosity and permeability distributions	60
3.4.2 Flow units and petrologic characteristics	62
3.4.2.1 Rock types and flow units characteristics	66
1)Rock types and flow units of Asl Formation at SG310-5A wel	66
2)Rock types and flow units of Hawara Formation at SG310-5A well	1 66
3)Rock types and flow units of Hawara Formation at J37-37A	109

3.4.2.2 Macroscopic and microscopic petrographic characteristics	
1) Thin sections description and flow units analyses	116
A) Thin sections description and flow units of Asl Formation	116
at SG310-5A well	
. 1) Reservoir flow units	116
2) Non reservoir flow units	120
B) Thin sections description and flow units of Hawaral	120
Formation at SG310-5A well	
1) Reservoir flow units	120
2) Non reservoir flow units	123
C) Thin sections description and flow units of Hawara	123
Formation at J37-37A well	
1) Reservoir flow units	123
2) Non reservoir flow units	125
3.4.3 Capillary presseure curves measure for reservoir quality	125
3.4.4 Fracture analysis and implication to reservoir permeability	129
3.4.5 Megascopic and macroscopic diagenetic model	131
(field and well scales)	
3.4.5.1 Very early diagenetic stages	134
3.4.5.2 Early to middel diagenetic stages	136
3.4.5.3 Middel to late diagenetic stages	138
4.Petrophysical reservoir characterization using petrofacies analysis	140
4.1 Introduction	140
4.2. Petrofacies analysis and flow units	141
4.2.1 Petrofacies analysis results	144
4.2.1.1 Pickett plots	144
1) Applications of the Pickett plots	145
4.2.1.2 Reservoir heterogeneity analysis	168
1) Small scale heterogeneity analysis	169
4.2.2 Intergration of repeat formation tester (RFT/MDT) and	194
combinable magnetic resonance (CMR) for flow units	
identifications	
4.2.2.1 Wire line repeat formation tests (RFT)	195
1) Applications of repeat formation testing tools (RFT/MDT)	196
a) Reservoir fluid pressure measurments	196
b) Permeability anisotropy away from the well bore	199
4.2.2.2 Flow units and fluid properties identification using CMR	201
1) Combinable magnetic resonance (CMR) theory	202
a) Single phase response	202
b) Two phase response	203
2) Combinable magnetic resonance (CMR) applications	204
a) CMR porosity	204
b) CMR permeability	204

c) CMR reservoir fluid properties	206
2) CMR applications on SG310-5A well	208
5. 3D static modeling	213
5.1 Introduction	213
5.2. Geostatistics and reservoir modeling	214
5.2.1 Modeling approach	215
5.2.2 Modeling techniques	217
5.2.3 Modeling process	218
5.2.3.1 3D static modeling work flow	218
1) Review, prepare and input data	220
2) Data analysis	221
3) Construct reservoir framework	221
4) Performed 3D static property modeling	221
5) Validate the model	221
5.2.4 Uncertainty assessment in the 3D reservoir modeling	222
5.2.4.1 3D uncertainty analysis	222
1) Model uncertainty	222
2) Multiple realizations	223
3) Uncertainty of reservoir framework	223
a) Errors in picking	224
b) Depth conversion problems	224
5.3. Simulation of reservoir properites and framework	224
5.3.1 3D structural model	224
5.3.2 Rock properties model	227
5.3.2.1 Grid and data analysis	227
1) Grid type and size	227
2) Blocked wells	228
3) Data analysis and transformation	228
4) Porosity and permeability relationship	230
5) Varigram setting and modeling	234
5.3.3 3D lithological model	234
5.3.3.1 Facies model	236
1) Small scale heterogeneities	236
2) Large scale heterogeneities	236
5.3.4 3D petrophysical property models	237
5.3.4.1 3D porosity models	237
5.3.4.2 3D permeabilty models	246
5.3.4.3 3D water saturation model	250
5.4. Model validation	251
Summary and conclusion	254
Recommendations	268
References	269 277
Appendiecs	211
Arabic summary	

Figures	page
1. Base map exhibits the location of July oil field	2
2. Base map exhibits studied key and cored wells	4
3. Regional tectonic of the Gulf of Suez (based on Garfunkel and Bartov, 1977)	15
4. Biostratigraphic sequences and terraces (Krebs, 1997)	18
5. Base map exhibits drilling history of July oil field (Gupco, 1991)	21
6. North-South stratigraphy of July area (Gupco, 1986)	22
7. Top Asl structure map of west July area (Gupco, 2001)	32
8. Top Hawara structure map of west July area (Gupco, 2001)	33
9. Stratigraphic correlation panel on top Asl and Hawara formations north-south direction, west July area	34
10. Stratigraphic correlation panel on top Asl and Hawara formations northwest-southeast direction, west July area	35
<ol> <li>Stratigraphic correlation panel on top Asl and Hawara formations west-east direction, west July area</li> </ol>	36
12. Hawara H1- sequence gross isopach (Gupco 2001)	38
13. Hawara sandstone gross isopach (Gupco 2001)	39
14. Hawara sandstone net reservoir (Gupco 2001)	40
15. Hawara shale gross isopach (Gupco 2001)	41
16. Upper Rudeis model shows facies progression controlled by rate of fault subsidence in west July area (after Pivnik, 2001)	42
17. Asl formation gross isopach (Gupco 2001)	44
18. Asl sandstone net reservoir isopach (Gupco 2001)	45
19. Structural cross section in July and west July area (Gupco, 2001)	49
20. Basin morphology during Upper Rudeis sediments deposition (Gupco 1990)	55
21. Core, log and thin section porosity versus depth and cement percent plots, SG310-5A well	64
22. Core, log and thin section porosity versus depth and cement percent plots, J37-37A well	65
23-44. Core photos of Asl Formation exhibits reservoir rock types and 6 cycles, SG310-5A well	8-89
	2-108
	-114
66. Capillary pressure curves versus water saturation plots for Hawara formation, J37-37A well	128
67. Pore size distribution and pore throat radii plots for Hawara Formation, J37-37A well	130
68. Generalized diagenetic sequence of Upper Rudeis	135
69. Pickett cross plots exhibit Asl and Hawara formations, EGJ-3 well	146

70	. Pickett cross plots exhibit Asl and Hawara formations, J-3 well	148
71	Pickett cross plots exhibit Asl and Hawara formations, GS301-1 well	150
72.	Pickett cross plots exhibit Asl and Hawara formations, J58-84ST1 well	152
73.	Pickett cross plots exhibit Asl and Hawara formations, J58-52A well	154
74.	Pickett cross plots exhibit Asl and Hawara formations, J15-48 well	156
<i>7</i> 5.	Pickett cross plots exhibit Asl and Hawara formations, J37-43A well	157
76.	Pickett cross plots exhibit Asl and Hawara formations, J10-44 well	159
<i>7</i> 7.	Pickett cross plots exhibit Asl and Hawara formations, SG310-4 well	161
78.	Pickett cross plots exhibit Asl and Hawara formations, SG310-5A well	163
79.	Pickett cross plots exhibit Asl and Hawara formations, J37-37A well	165
<sub>:</sub> 80.	Pickett cross plots exhibit Asl and Hawara formations, SG310-6A well	167
81.	Heterogeneity analysis of Asl and Hawara formations, EGJ-3 well	171
82.	Heterogeneity analysis of Asl and Hawara formations, J-3 well	173
83.	Heterogeneity analysis of Asl and Hawara formations, GS301-1 well	175
84.	Heterogeneity analysis of Asl and Hawara formations, J58-84ST1 well	177
85.	Heterogeneity analysis of Asl and Hawara formations, J58-52A well	179
86.	Heterogeneity analysis of Asl and Hawara formations, J15-48 well	181
. 87.	Heterogeneity analysis of Asl and Hawara formations, J37-43A well	182
88.	Heterogeneity analysis of Asl and Hawara formations, J10-44 well	185
89.	Heterogeneity analysis of Asl and Hawara formations, SG310-4 well	187
90.	Heterogeneity analysis of Asl and Hawara formations, SG310-5A well	189
	Heterogeneity analysis of Asl and Hawara formations, J37-37A well	191
	Heterogeneity analysis of Asl and Hawara formations, SG310-6A well	193
93.	True vertical depth (TVD) versus formation pressure gradient for selected wells	197
	Core permeabilities and mobility relationships versus depth of Asl and Hawara formations, SG310-5A	200
95.	Porosity-permeability relationships of Asl and Hawara formations, SG310-5A and J37-37A wells	205
96.	Core permeability, K CMR and mobility relationships versus depth of Asl and Hawara, SG310-5A	207
97.	Qualitative values and relaxation measurements of T2 for different fluid types and rock pore sizes	209
98.	T2 versus diffusivity plot as indication of fluid expected position and characterization	210
	CMR bin properties (from 0.3 to 3000 mesc) and CMR total porosity, SG310-5A well	211
	3D static geological modeling workflow	219
101.	3D structural model exhibits top Asl formation faults pattern	225

102. 3D structural model exhibits top Hawara formation faults pattern	226
103. SG310-5A an example of blocked wells, Upper Rudeis reservoir	229
104. Effective porosity before transformation below top Asl and above	231
base Hawara formations	
105. Effective porosity after transformation below top Asl and above	232
base Hawara formations	
106. Multiple scenarios of variogram ranges for effective porosity,	235
Upper Rudeis reservoir	
107. Facies sequential gaussian simulation realization -1, Upper	238
Rudeis reservoir	
108-112. 3-D effective porosity sequential gaussian simulation	239-243
realizations (1-5), Upper Rudeis reservoir	
113. 3D effective porosity kriging simulation realization-1, Upper	244
Rudeis reservoir	
114-116. 3-D permeability sequential gaussian simulation	247-249
realizations (1-3), Upper Rudeis reservoir	
117. 3D water saturation sequential gaussian simulation realization-1,	252
Upper Rudeis reservoir	

Plates	Page
Thin sections photos of Asl Formation exhibit reservoir rock types	117
(RRT's 4 and 6), SG310-5A well	
2. Thin sections photos of Asl Formation exhibit reservoir rock types (RRT's 8 and 10), SG310-5A well	119
3. Thin sections photos of Asl Formation exhibit reservoir rock types (RRT's 9 and 11), SG310-5A well	121
4. Thin sections photos of Hawara Formation exhibit reservoir rock types (RRT's 2 and 3), SG310-5A well	122
5. Thin sections photos of Hawara Formation exhibit reservoir rock types (RRT's 11 and 12), SG310-5A well	124
6. Thin sections photos of Hawara Formation exhibit reservoir rock types (RRT's 12 and 13), J37-37A well	126
7. Thin section and scanning electron photos of Hawara Formation exhibit (RRT's 11 and 12), J37-37A well	133
8. Thin sections photos exhibit middle to late diagenetic stages	137

1. Reservoir modeling Nomenclature (modified after Seifert and Jensen,	216
2000)	

2. Transformation sequences to normalize effective porosity (PHIE), core horizontal permeability (CKH) and water saturation (SW) parameters.