

***The Impact of Structures and Tectonics on
Pore Pressure Regime and Gas Reserves
Of the Off–Shore Nile Delta of Egypt***

BY

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M.SC. In Geophysics (2004)

A Thesis

***Submitted for the Doctor of Philosophy
Degree of Science in Applied Geophysics***

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Dedication

To Allah

To My Country (Egypt)

To my father

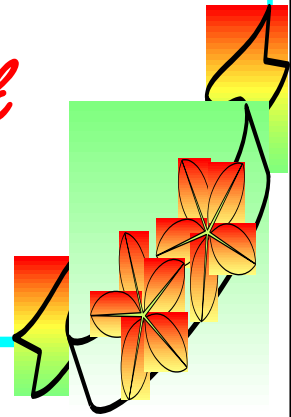
To my mother

To my wonderful wife for her support and encouragement

To my lovely children Mustafa and Noor El Yon

I dedicate this work

Ayman Mustafa Mahmoud Morshedy



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قالوا

سبناك لا علم لنا
إلا ما علمتنا إنك أنت
العليم العظيم

صدق الله العظيم

سورة البقرة الآية: ٣٢



Faculty of Science
Geophysics Department

APPROVAL SHEET

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ABSTRACT

Pressure regime in the untested Nile Delta basin, a major concern of the exploration and drilling communities, is the possibility of encountering overpressure and water-bearing sands in the rising less section of the wells. Formation pressure, is the pressure of pore fluid, can be considered the major factor affecting drilling operations and well planning processes. If the pressure is not properly evaluated, it can lead to many drilling problems, such as loss circulation, blowouts, stuck pipe, borehole instability and excessive costs. In the well planning process, the knowledge of formation pressure is the foundation for many segments of the well design, such as casing programs, mud programs, cementing programs, tubing design and rig selection. Without proper prediction of formation pressure, the well plan may be inadequate. The elements of the work plan are proposed as follows:

- 1- Reviewing the general geologic setting of the Eastern Mediterranean region, with Particular emphasis on the off-Shore Nile Delta Provence
- 2- Nile Delta geopressure well analysis, which documents the results of pore pressure analysis in each well and defines the basic petrophysical trends.
- 3- Nile Delta Overburden Gradient is involved and results obtained from applying the best practices in the Nile Delta.
- 4- Fracture gradient in the Nile Delta and Fracture pressure are estimated.
- 5- Appendix summarizes the best practices for the methods and procedures used in determines the pore pressure and fracture gradient.

The study documents the results of pore pressure analysis performed on 14 wells from the Nile Delta (water depths range from 19 to 2800 m). The study aims at developing best method(s) to estimate pore pressure regime. This study overall the results (geopressure trends, modeling parameterization summary, geological events and their impact on the pore pressure ... etc.) Based on the geopressure analysis performed on the 14 wells, the following conclusions are obtained:

1. The pore pressure and fracture pressure can be computed, according to methodologies derived largely from the Gulf of Mexico basins and have been modified empirically to suite the Nile Delta geological environment.
2. The calibrated sonic and resistivity models are important tools in the real

time geopressure monitoring on the rig site during exploratory drilling.

3. The onset of over pressuring started in the Pliocene, at the beginning of the first major shale interval (Kafr El Sheikh) and increased rapidly just below the Messinian unconformity. Sand and shale ratio plays a dominant role in the position and development of over pressuring in the Pliocene section.
4. The presence of sealing at the top of Miocene provides the proper environment for accelerated the pressuring build-up, immediately below the seal as a result of the increased rate of fluid retention (under compaction) and to a minor contribution from the aqua thermal expansion and illitization.
5. When the structural data are available, it has been postulated that the structure of sand bodies affected the development of the over pressuring in these sands, when the well penetration is at the crest (or above the Centroid point) of these sands.
6. The pore pressure estimation model, based on the acoustic data, is uniquely defined for the Nile Delta, which applies well to the Pleistocene, Pliocene and in some cases to the Miocene/Oligocene sections. This model is based on the equivalent depth method.
7. Parameters for the sonic normal compaction trend are sensitive to the sedimentation rate in the Pliocene or younger sediments. This provides a rational sand for the sonic model calibration based on anticipated geological environment, if required for an exploration well application.
8. The Miocene and older sediments may be unloaded due to the high temperature, illitization, uplifting and erosion. Under these conditions, an unloading model is proposed for the pore pressure estimation. So, recommend Miller's method due to its simplicity. Both Bowers' and Eaton methods can be used with care. It is difficult to set generalized parameters for any model.
9. In the case of unloaded Miocene section, the traditional pore pressure estimation methods (Eaton, Equivalent Depth ... etc.) will under estimate the pressure (for example in Tineh-1, the conventional method pore pressure gradient is 5ppg less than the actual).
10. Excluding of sedimentation loading, the most significant geological events which control the application of a geopressure models are the uplifting and

erosion. Habbar-1, Aida- 1 and Tineh-1 wells are known to have significant erosion. Uplifting is known to be a factor in Tineh-1 but not in the others.

11. Erosion effect on the pore pressure development in the Miocene and older section, is a complex phenomenon, which can be attributed to many factors. The most notable factors are: grain cementation that may occur during sediments exposure to sea water or rain, amount of loading (burial) after the erosion took place and the possible pressure leakage during erosion. Tineh-1 well may be subjected to severe cementation after erosion more than the other wells (Aida-1 and Habbar-1). This may explain the large error in the predicted pore pressure from RFT measurements and mud weight.
12. Seismic velocity data are inherently of poor resolution and cannot be used reliably to predict pore pressure in the Miocene or older sediments. Since the pore pressure prediction study became fundamental in the pre-drill phase of challenging wells, the target is to consider the study as a routine job to be proposed to shareholders, both for the technical concurrence and for costs approval with the help of good velocity data, we can evaluate better the pore and we can calculate well the seal capacity and minimizing the well risk. So, we can use a new technology of broad band frequency to enhance the velocity content or use of AVA velocity or the 3D HDHR velocity picking.
13. Formulating the relation between Pore Pressure of the studied formations and Risk Evaluation, based on the Fore –Warning and Warning Stages of the Pore Pressure Regime and pore pressure affecting on the performance of reservoirs.
14. Utilizing the Pore Pressure Prediction as a future prospective tool in the new areas of exploration and future view for reserves oil and gas on the Off-Shore Nile Delta province of Egypt.

Finally the main effect for accumulation pore pressure is tectonic elements which lead to occupied fluids and overburden sediments so the area which have heavy tectonic means pore pressure prediction is very important before drilling and pore pressure one of evidence of accumulation hydrocarbon.

List of Contents

Acknowledgments	--
Abstract	--
Dedication	--
List of Abbreviations	i
List of Tables	v
List of Figures	vii

CHAPTER 1: GEOLOGIC SETTING OF NILE DELTA OFFSHORE

1.1 Introduction	1
1.2 Structural Setting and Tectonic Framework.....	5
1.2.1 Plate Tectonic Framework.....	5
1.2.2 Structural Setting.....	7
1.2.3 Structural Domain	11
1.3 Stratigraphy and Reservoir Prediction	14
1.3.1 Pliocene Reservoirs	14
1.3.2 Unconfined and Confined Setting	16
1.3.3 Channels in Rotated Fault Blocks	16
1.3.4 Basin Plain Sheets sand.....	17
1.3.5 Upper Miocene Reservoirs.....	17
1.4 Hydrocarbon Play Types	20
1.4.1 Platform-Pliocene Channel Play	20
1.4.2 Platform-Upper Miocene Canyon Play	22
1.4.3 Rotated Fault Block Play.....	23
1.4.4 Diapiric Salt Basin Play	24
1.4.5 Basin Floor Fan Play	25
1.4.6 Pre-Salt Play.....	25
1.5 Source Rocks and Hydrocarbon Prediction.....	27

CHAPTER 2: PORE PRESSURE METHODOLOGY

2.1 Introduction	33
2.2 Centroid Analysis.....	34
2.3 Unloading Analysis	35
2.4 Pore Pressure Trends.....	38
2.5 Acoustic-Based Pore Pressure Prediction	39
2.6 Seismic Data Analysis.....	43
2.7 Resistivity- based pore pressure production	47
2.8 Sedimentation Rate Mapping.....	49
2.9 Effect of Unloading due to Erosion and Sealing Summary	52
2.9.1 Effect of erosion	52
2.9.2 Effect of Seal.....	53
2.9.3 Effect of Erosion, Sealing and Continued Burial	54
2.9.4 Modeling Unloaded Sediments	58

2.10 Results' Analysis and Conclusions	64
2.11 Attachment A: Unloading Theory Review and Diagnostics	66
2.11.1 Theory Review	66
2.11.2 Diagnostics of Unloading.....	72

CHAPTER 3: OVERPRESSURE WELL ANALYSIS

3.1 Introduction	79
3.2 Well Data Analyses.....	80
3.2.1 Habbar-ST 1 Well.....	80
3.2.1.1 Pore Pressure Analysis	81
3.2.1.2 Resistivity-based analysis.....	82
3.2.1.3 Velocity-based analysis	82
3.2.1.4 Sonic analysis	82
3.2.1.5 Seismic velocity/check-shot analysis	82
3.2.1.6 Centroid based analysis	82
3.2.1.7 Unloading Analysis	84
3.2.1.8 Well Data Review.....	86
3.2.2 Libra 1 Well	87
3.2.2.1 Pore Pressure Analysis	87
3.2.2.2 Resistivity-Based Analysis.....	87
3.2.2.3 Velocity-Based Analysis	88
3.2.2.4 Sonic Analysis.....	88
3.2.2.5 Seismic velocity/check-shot	88
3.2.2.6 Centroid Analysis: Shallow Water Flow (SWF)	
Incident	89
3.2.2.7 Unloading Analysis	90
3.2.2.8 Well Data Review.....	91
3.2.3 Taurus HJ-1x Well	92
3.2.3.1 Pore Pressure Analysis	92
3.2.3.2 Resistivity-based analysis.....	94
3.2.3.3 Velocity-based analysis	94
3.2.3.4 Sonic analysis	94
3.2.3.5 Seismic velocity/check-shot	95
3.2.3.6 Centroid analysis	95
3.2.3.7 Unloading Analysis	95
3.2.3.8 Well Data Review	96
3.2.4 Well Tineh-1	99
3.2.4.1 Pore Pressure Analysis	100
3.2.4.2 Resistivity-Based Analysis.....	100
3.2.4.3 Velocity-based analysis	100
3.2.4.4 Sonic analysis	100
3.2.4.5 Seismic velocity/check-shot	101
3.2.4.6 Centroid analysis	101
3.2.4.7 Unloading analysis	102
3.2.4.8 Well Data Review.....	102

3.2.5 BaltimNE-1 Vertical Well.....	108
3.2.5.1 Pore pressure analysis.....	108
3.2.5.2 Resistivity-Based Analysis.....	109
3.2.5.3 Velocity-Based Analysis	109
3.2.5.4 Sonic Analysis.....	109
3.2.5.5 Seismic Velocity/Check-shot	109
3.2.5.6 Centroid Analysis.....	109
3.2.5.7 Unloading Analysis	109
3.2.5.8 Well Data Review.....	111
3.2.6 Barracuda ST1 Well.....	113
3.2.6.1 Pore Pressure Analysis	113
3.2.6.2 Resistivity-Based Analysis.....	113
3.2.6.3 Velocity-Based Analysis	113
3.2.6.4 Sonic Analysis.....	113
3.2.6.5 Seismic Velocity/Check-shot	113
3.2.6.6 Centroid Analysis.....	115
3.2.6.7 Unloading Analysis	115
3.2.6.8 Well Data Review.....	115
3.2.7 EDDM 1 Well	116
3.2.7.1 Pore Pressure Analysis	117
3.2.7.2 Resistivity-Based Analysis.....	117
3.2.7.3 Velocity-Based Analysis	117
3.2.7.4 Sonic Analysis.....	118
3.2.7.5 Seismic Velocity/Check-shot	119
3.2.7.6 Centroid Analysis.....	119
3.2.7.7 Unloading Analysis	119
3.2.7.8 Well Data Review.....	119
3.2.8 Haret-1 Well.....	121
3.2.8.1 Pore Pressure Analysis	121
3.2.8.2. Resistivity-Based Analysis	122
3.2.8.3. Velocity-Based Analysis	122
3.2.8.4. Sonic Analysis.....	122
3.2.8.5. Seismic Velocity/Check-shot	123
3.2.8.6 Centroid Analysis.....	123
3.2.8.7. Unloading Analysis	123
3.2.8.8 Well Data Review.....	123
3.2.9 Segan-1 ST1 Well.	125
3.2.9.1. Pore Pressure Analysis	125
3.2.9.2 Resistivity-Based Analysis.....	126
3.2.9.3 Velocity-Based Analysis	126
3.2.9.4 Sonic Analysis.....	126
3.2.9.5 Seismic Velocity/Check-shot	127
3.2.9.6 Centroid Analysis.....	127
3.2.9.7 Unloading Analysis	127
3.2.9.8 Well Data Review.....	127

3.2.10 Temsah-2 Well:	128
3.2.10.1 Pore Pressure Analysis	128
3.2.10.2 Resistivity-Based Analysis	130
3.2.10.3 Velocity-Based Analysis	130
3.2.10.4 Sonic Analysis	130
3.2.10.5 Seismic Velocity/Check-shot	131
3.2.10.6 Centroid Analysis	131
3.2.10.7 Unloading Analysis	131
3.2.10.8 Well Data Review	134
3.2.11 Aida (Jg 66-1A) Well	136
3.2.11.1 Pore Pressure Analysis	136
3.2.11.2 Resistivity-Based Analysis	136
3.2.11.3 Velocity-Based Analysis	137
3.2.11.4 Sonic Analysis	137
3.2.11.5 Seismic Velocity/Check-shot	137
3.2.11.6 Centroid Analysis	137
3.2.11.7 Unloading Analysis	141
3.2.11.8 Well Data Review	142
3.2.12 Leil-1 Well	145
3.2.12.1 Pore Pressure Analysis	145
3.2.12.2 Resistivity-Based Analysis	146
3.2.12.3 Velocity-Based Analysis	146
3.2.12.4 Sonic Analysis	146
3.2.12.5 Seismic Velocity/Check-shot	147
3.2.12.6 Centroid Analysis	147
3.2.12.7 Unloading Analysis	147
3.2.12.8 Well Data Review	147
3.2.13 Rosetta-7 Well	148
3.2.13.1 Pore Pressure Analysis	149
3.2.13.2 Resistivity-Based Analysis	150
3.2.13.3 Velocity-Based Analysis	150
3.2.13.4 Sonic Analysis	150
3.2.13.5 Seismic Velocity/Check-shot	152
3.2.13.6 Centroid Analysis	152
3.2.13.7 Unloading Analysis	152
3.2.13.8 Well Data Review	152
3.2.14 Rosetta-9 Well	154
3.2.14.1 Pore Pressure Analysis	154
3.2.14.2 Resistivity-Based Analysis	155
3.2.14.3 Velocity-Based Analysis	155
3.2.14.4 Sonic Analysis	155
3.2.14.5 Seismic Velocity/Check-shot	156
3.2.14.6 Centroid Analysis	156
3.2.14.7 Unloading Analysis	156
3.2.14.8 Well Data Review	157

3.2.15 Shorouk-1 Well	159
3.2.15.1 Pore Pressure Analysis	159
3.2.15.2 Resistivity-Based Analysis	160
3.2.15.3 Velocity-Based Analysis	160
3.2.15.4 Sonic Analysis	160
3.2.15.5 Seismic Velocity/Check-shot	162
3.2.15.6 Centroid Analysis	162
3.2.15.7 Unloading Analysis	162
3.2.15.8 Well Data Review.....	162

CHAPTER 4: OVERBURDEN GRADIENT

4.1 Introduction	165
4.2 Description of Approach	165
4.3 Shallow Density Correlation	166
4.4 Effect of Shale Damage.....	167
4.5 Calibration of Gardner's equation	169
4.6 Development of a Composite Density Profile.....	169
4.7 OBG Results.....	171

CHAPTER 5: FRACTURE GRADIENT & FINAL RESULTS

5.1 Introduction	182
5.2 Description of Approach	189
5.3 Basic Theory	191
5.4 Gulf of Mexico Model.....	192
5.5 Results & Conclusions	195
5.6 Recommendation for Future Work.....	196
5.7 integrated Fracture pressure predication & Results.....	197

CHAPTER 6: NILE DELTA OFFSHORE PRESENTS PORE PRESSURE & RESERVES INTERPRETATION

6.1. Introduction	248
6.2 Petroleum Geology	249
6.2.1 Source rocks and Charge.....	249
6.2.2. Reservoir rocks.....	252
6.2.3. Cap rocks.....	253
6.2.4. Traps.....	254
6.2.5. Maturation	255
6.2.5.1 Oil Discoveries	257
6.2.5.2 Condensate Gas Ratio (CGR).....	257
6.2.6. Petroleum occurrence	258
6-2-7. Petroleum system of the Nile Delta	259
6.2.8. Existing Discoveries &Future resources of the Nile Delta Basin .	260
6.2.9 Introduction	263
6.3 General principles on pressure prediction	264
6.3.1 Geo-pressures	267

6.3.2 Origin of Abnormal Pressures:.....	267
6.3.3 Pressures Estimation	267
6.3.4 Overpressures in the Nile Delta.....	268
6.3.5 Seal integrity in the Nile Delta.....	270
6.3.6 Pressure Regime study area and its effecting on the seal Integrity reserves.....	275
6.3.7 Exploration risk – seal capacity	275
6.3.8 Nile Delta-3D petroleum system modeling of the Oligocene And Miocene sequences (hydrodynamic model).....	318
6.3.9 Source Rock Model.....	324
6.3.10 Petroleum System Modeling Calibration	334
6.3.11 Deterministic Simulation.....	335
Summary and Conclusion	350
References	354
Appendices	363
Arabic Summary	--