Chapter (1)

INTRODUCTION

CHAPTER I

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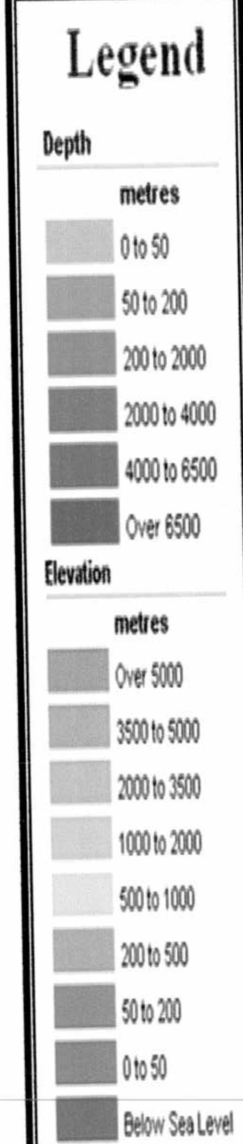
1. Introduction

The July field is the fifth largest oil field in Egypt, located on the west coast of Gulf of Suez 18 kilometer southwest of Ras Gharib Town, figure (1). This field together with el Morgan and Ramadan Oil Fields were account for over 39% of the oil reserves in Egypt. The Upper Rudeis reservoirs, of Lower Miocene age (Asl and Hawara formations) were deposited adjacent to a major structural transfer zone which has controlled sediment input in the rift basin center. The Upper Rudeis sand is the third most important reservoir of the two main producing horizons, Nubia sandstones and Lower Rudeis sand in July field.

Although the Upper Rudeis reservoir is in a mature stage of development, bypassing of zones of high oil saturation is the cause of the effects of heterogeneity in this reservoir and recent water injector wells. Additional prospectivity exists in this reservoir in the northwest of the field is outlined in the recommendations.

It is known that a significant part of the uncertainty in descriptions of reservoir properties can be due to the limited information about the spatial distribution of properties in interwell regions. The major consequence of a new reservoir characterization exercise integrating geological, petrophysical, petrographic characteristics (rock types) and their diagenetic aspects and to relate these to the main syn-Miocene rifting phase is that the resultant model can be used to better predict flow characteristics in Upper Rudeis reservoir.

Because of the tremendous amount of subsurface data available in July field coupled with the fact that two cores were taken in two wells in Upper Rudeis reservoir (J37-37A cored in Hawara Formation and GS310-5A cored in Asl and



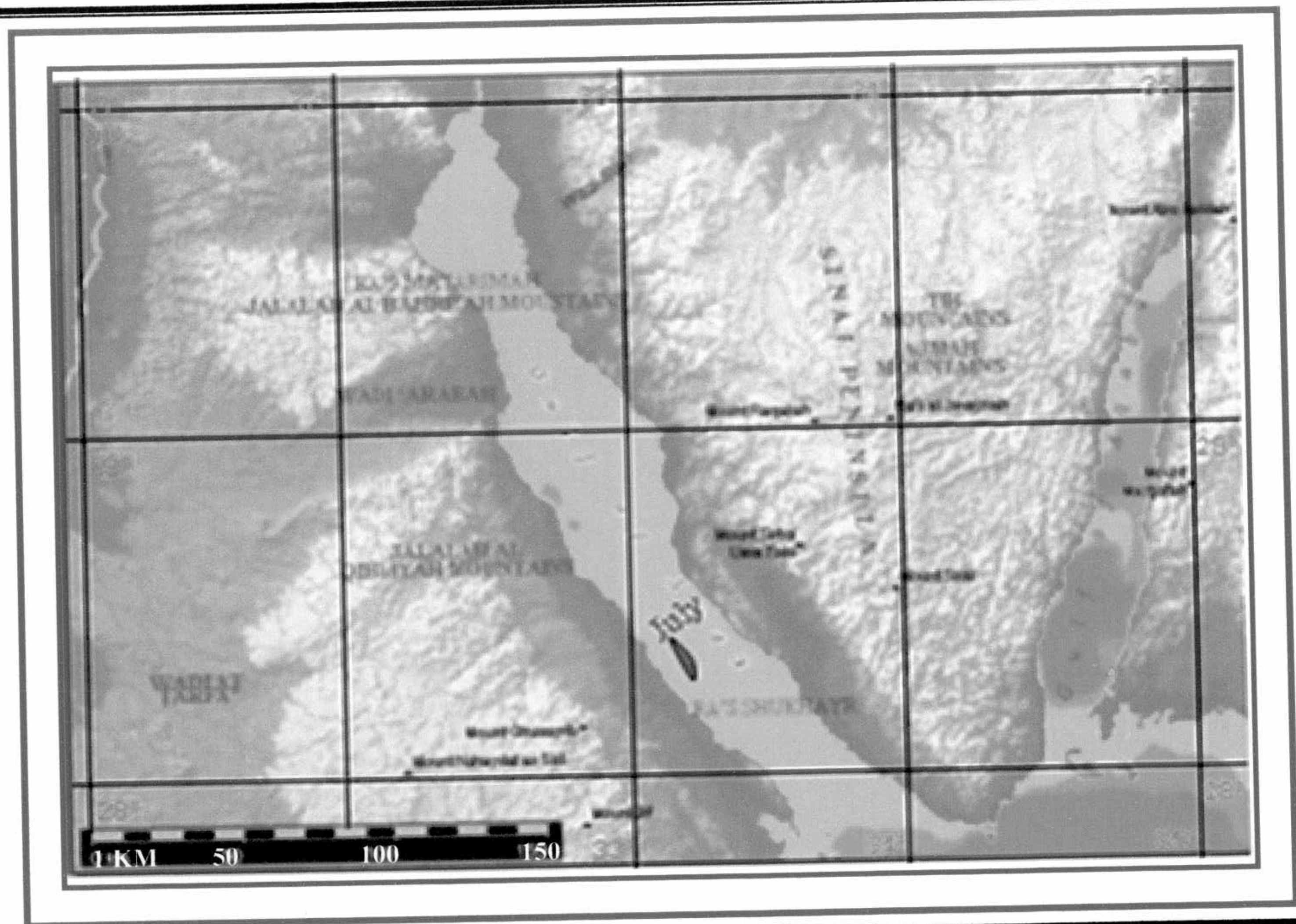


FIG. (1) BASE MAP EXHIBITS THE LOCATION OF JULY OIL FIELD

Hawara formations), a more appropriate description is now possible. The descriptive parameters derived from this study will constitute a subsurface model, which can be used in other oil provinces, provided similar petrographic and petrohysical patterns (heterogeneities) are present.

The petrological, petrofacies, and petrophysical techniques, thus, have been applied for selected twelve wells to the study from key wells that penetrated these Miocene rocks in the study area. They are located in an area restricted between latitudes 28° 24′ 58.1″ and 28° 32′ 35.9″ N and longitudes 33° 21′ 00.0″ and 33° 25′ 46.2″ E, figure (2).

To build a 3D static geological model from the subsurface well information incorporating new data, the following tasks were performed:

- Examination of ditch cutting, cores and thin sections data and review the geological framework using sequence stratigraphic concepts.
- Analyze the raw petrophysical and geological information, within each parasequence and the appropriate scales for modeling.
- Estimate and model spatial relationships for various rock fabrics in the study area using the available well data.

1.1 Statement of problem

The main problem is the significant anomalies marked by the small scale heterogeneity in reservoir permeability. The primary objective of this study is to resolve these anomalies and provide a reservoir characterization that more closely describes the geological heterogeneity through the recognition of facies based reservoir rock types (RRT's), sampled at an appropriate scale of core investigation.

Another limitation of investigation is the inter well prediction of permeability, porosity and microfacies changes from vertical and deviated wells only due to the lack of horizontal wells that can provide the small-scale of reservoir properties to understand more fully three dimensions (3D) distribution of reservoir heterogeneity.

Diagenesis appears to have played only minor, secondary role in the development of the reservoir quality when compared to the dominant role of the primary depositional texture and grain size of Upper Rudeis reservoir rocks.

1.2 Selection of study area

The reasons behind the selection of West July filed area are as follows:

- The field is at a mature stage of development and has large amount of well data from cores, thin sections, logs, data, 3 D seismic and production history.
- The field provides information for three dimensional heterogeneity through a large geological and engineering database.
- The distribution of petrophysical properties within the field is complex and covering different environments from shallow to deep marine conditions.
- Considerable reserves to be produced.

The resultant reservoir characterization established from this research can be used as a predictive tool in similar reservoirs and regional geological trends. In addition to that, a set of reservoir description parameters and models can be used as reservoir management tools to predict fluid flow characteristics and the future reservoir performance.

1.3 Scope and purpose of the study

The main purpose of this research work is to deliver the following:

- Definition and characterization of different reservoir rock types for the Upper Rudeis rocks of Asl and Hawara formations as a new approach and spatial correlation parameters for different facies and their associated petrophysical parameters and model different zones of the reservoirs.
- Focus on small scale heterogeneity, which is the blank area between wells.

The challenges that solved during the course of this research were:

- Integrated interpretative study of the stratigraphy of the Miocene sediments (Asl and Hawara formations), with reference to their geological setting. In order to achieve this, the structural framework and the evaluation of geological and

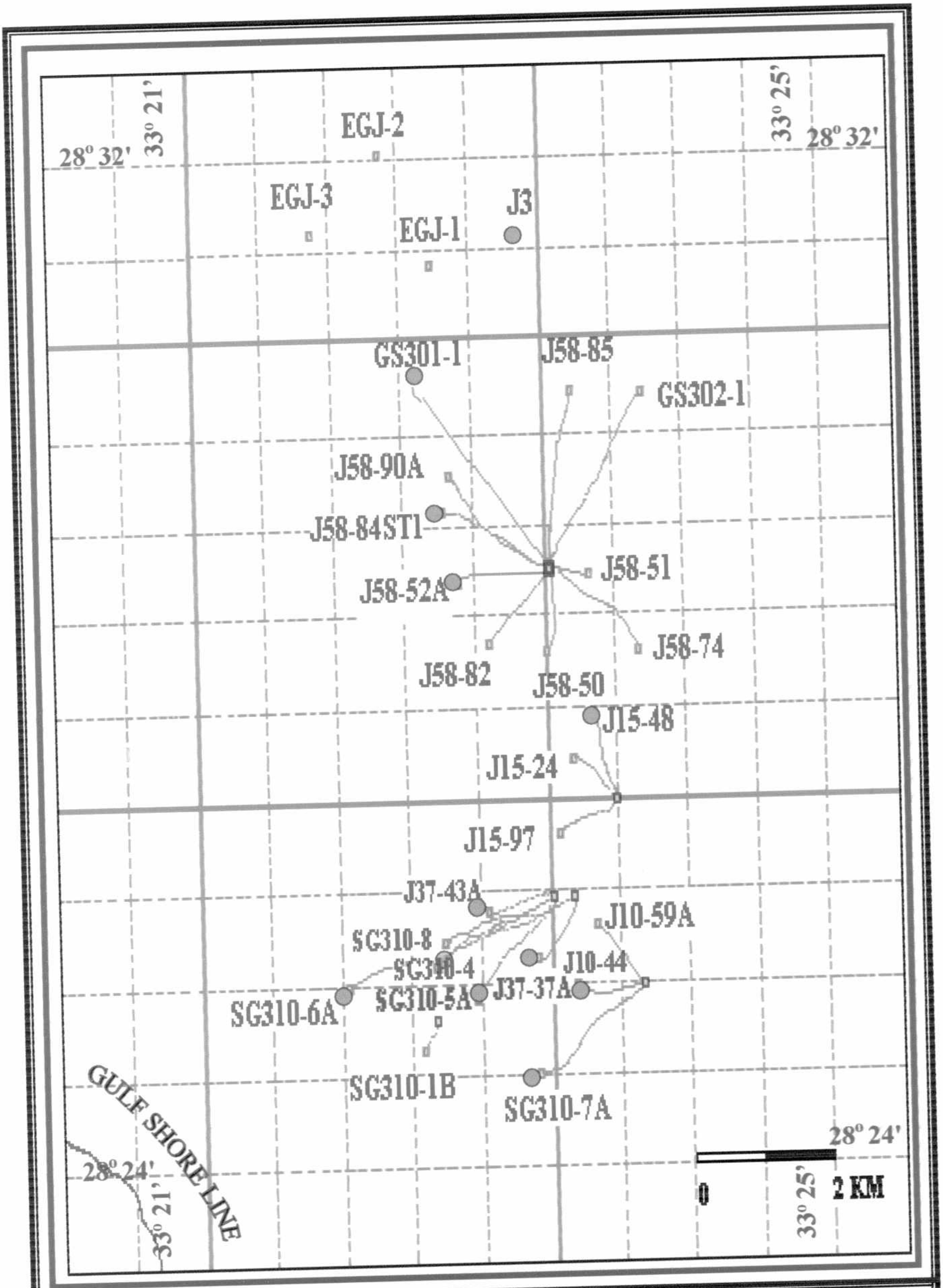


FIG. (2) BASE MAP EXHIBITS STUDIED KEY AND CORED WELLS sedimentation history have been studied in detail.

- Development of a depositional and diagenetic models for prediction of rock types in the inter well region.
- Characterization of the fractures observed from cores and to evaluate their impact in the reservoir performance.

1.4 Materials and data used in the study

All July field wells penetrating Upper Rudeis are available for this study of which selected twelve key wells where, core material and core analysis data is present for two wells and selected ditch cutting samples intervals were from the remaining studied wells. Wire line logs, Gamma ray log (GR), Litho-density log (LDL), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC) and Resistivity log [Deep Induction Laterolog (DIL)], are available for all wells, while Repeat Formation Tester (RFT/MDT) data were used for selected wells. Dipmeter (UBI) and Combinable Magnetic Resonance (CMR) data have been acquired in available wells.

Below is a list of the support material available and used for this study:

- Slabbed core material of each cored well (40 feet from J37-37A well and 265.5 feet from SG315-5A well).
- Ditch cutting samples description (1200 samples) and selected thin sections (132 thin sections) from key and selected wells.
- Available core plugs and SCAL data (special core analysis) of SG310-5A well.
- Available thin sections of each cored well (170 thin sections from horizontal core

- Specialized logs such as computed Dipmeter data (UBI) by GEODIP processing, Combinable Magnetic Resonance (CMR), Repeat Formation Tester (RFT) and Modular Dynamic Tool (MDT).
- Summary charts for each well showing "geological layers-log correlations".
- Conventional core data list including, porosity, permeability, water saturation, oil saturation, grain density data for cored well J37-37A and special core analysis (SCAL) for SG310-5A well.
- Location maps, structural contour maps, and other background materials for the field.

The selected twelve wells, cores and log data used in reservoir characterization and modeling are:

1) <u>EGJ-3:</u> The available logs are:

Gamma ray log (GR), Litho-density log (LDL), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC) and Resistivity log [Deep Induction Laterolog (DIL)].

2) <u>J3</u>: The available logs are:

Gamma ray log (GR), Litho-density log (LDL), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC) and Resistivity log [Deep Induction Laterolog (DIL)].

3) <u>GS301-1</u>: The available logs are:

Gamma ray log (GR), Litho-density log (LDL), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC), Resistivity log [Deep Induction Laterolog (DIL)]

5) **J58-52A**: The available logs are:

Gamma ray log (GR), Litho-density log (LDL), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC) and Resistivity log [Deep Induction Laterolog (DIL)].

6) **J15-48**: The available logs are:

Gamma ray log (GR), Litho-density log (LDL), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC) and Resistivity log [Deep Induction Laterolog (DIL)].

7) **J37-43A**: The available logs are:

Gamma ray log (GR), Litho-density tool (LDT), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC), Resistivity log [Deep Induction Laterolog (DIL)] and Repeat Formation Tester (RFT), Dipmeter (HDT).

8) **J10-44**: The available logs are:

Gamma ray log (GR), Litho-density log (LDL), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC) and Resistivity log [Deep Induction Laterolog (DIL)].

9) **SG310-4**: The available logs are:

Gamma ray log (GR), Litho-density log (LDL), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC) and Resistivity log [Deep Induction Laterolog (DIL)].

10) **SG310-5A**: The available logs are:

Gamma ray log (GR), Litho-density log (LDL), Bore-Hole Compensated Sonic log (BHC), Array Induction Resistivity tool (AIT), Modular Dynamic Tool (MDT), Dipmeter (UBI), Combinable Magnetic Resonance (CMR), Vertical permeability (VK), Horizontal permeability (HK), Core Helium porosity (HOC),

11) J37-37A: The available logs and core data are:

Gamma ray log (GR), Litho-density tool (LDT), Compensated Neutron log (CNL), Bore-Hole Compensated Sonic log (BHC), Resistivity log [Deep Induction Laterolog (DIL)], Repeat Formation Tester (RFT), Dipmeter (HDT), Vertical permeability (VK), Horizontal permeability (HK), Core Helium porosity (HOC), Core fluid porosity (FOC), Core oil Saturation (COSo), Core water Saturation (COSw), and Grain density (GD).

12) SG310-6A: The available logs are:

Gamma ray log (GR), Litho-density log (LDL), Compensated Neutron log (CNL) and Resistivity log [Deep Induction Laterolog (DIL)], Dipmeter (OBDT).

The wells EGJ-1, EGJ-2, SG310-1B, J58-82, GS302-1, J10-59A, J58-50, J58-85, J58-90A, J15-24, J58-74, J15-97A, SG310-8 and SG310-7A are used for correlation with the above mentioned wells.

The stratigarphy and geology of the area have been reviewed in details and various types of subsurface maps have been established. This review useful for highlighting on some stratigraphic (mainly lithostratigraphic) problems related to the studied region, the use of formation evaluation techniques for qualitative estimation of lithology and to solve such problems related to the studied region. Also, the different rock units will be treated by the formation evaluation programs in order to estimate their hydrocarbon potentialities, and to give a reasonably applied picture of the petroleum geology of the studied sequences.

1.5 Methods of investigation and interpretation

The first part of the research consisted on reviewing the basic data available for Upper Rudeis reservoir. A literature search was carried out with the aim of understanding the problem of reservoir description and to build a model based on

The work has involved the following:

1- The syn-rift facies in the Gulf of Suez are highly variable, and thus vary greatly in terms of lithostratigraphic nomenclature. For our purpose, the stratigraphical subdivision of the Gulf of Suez sedimentary section is based on data provided from previous literature and is utilized later in various types of subsurface maps with a correlation panels for the studied wells.

2- Examination of composite and wire line logs, well reports and correlation of these wells across the area. Construction of qualitative interpretation through the processing of well logging data by graphical methods, to achieve complete formation evaluation and to evaluate specific petrophysical parameters.

3- Computer programs were used to achieve the above mentioned performed operations. The software programs used in this study are known as POWERLOG, PETROWORK, PRESSGRAPH, WINLAND and RMS.

4- Lithological examinations have been carried out on core and ditch cuttings samples from key wells and selected intervals with reservoir potentials from remaining wells in the study area, the results were defined the composition of major textural (grain size comparison, cement type, and clay type), depositional and diagenetic, compositional changes with depth and stratigraphic position of the intervals within the cores.

5- Thin section petrography which is defined the composition of framework grains, determined cements composition and their distribution, identified of secondary porosity from dissolution of the framework grains (intergranular) on best fit matching of core character with log character. Gamma ray and sonic were utilized for correlation.

7- Reservoir rock type is the foundation of permeability modeling in the 3D static model approach, where better rock type control help to reduce model uncertainty. So far, rock type has been derived at cored wells only. Techniques to infer rock type from well log data explored but found immature during this study

8- Facies based and diagenetic detailed 3D geological models to appraise remaining reserves and determine strategies for economic redevelopment. Since its discovery, extensive subsurface data, including core, well log, dipmeter, seismic and production data have been used to evaluate these Miocene reservoirs. Previously these data had only been evaluated in 2D map form and had never been subject to a modern 3D geological modeling analysis.

Integration of all relevant information has been used to evaluate lithofacies, Reservoir Rock Types (RRT's) and sequence stratigraphy of Upper Rudeis reservoirs with the aim of assisting the construction of the framework model, sedimentation and how sediment transported into the basin from the rift shoulders and dispersed around actively deforming normal fault blocks. A selection of maps included in the study comprises structural, isopach and facies maps for selected horizons showing reservoir data. The purpose of these maps was to capture the main geological and petrophysical trends and describe spatial distribution of properties, which incorporate observed heterogeneity and variability due to the geologic complexities. The scale of the heterogeneity is sufficiently small (typically less than 1 inch), that significant heterogeneity will be observed at the determining Reservoir Rock Types from standard logs, because the properties distinguishing the Reservoir Rock Types from one another are at a scale below that which the standard logs are sensitive. On the other hand, properties measured by the logs can be expected to reflect the larger scale reservoir properties around the well.

1.6 Computer facilities

Most of the techniques applied in this work were operated through a computer program POWERLOG, PRESGRAPH, WINLAND (AMOCO PROGRAMS), PETROWORK (LANDMARK) and RMS (ARAB ROXAR) which prepared to achieve the above mentioned manually performed operations; including data entry, graphical and computational approaches involved in formation evaluation techniques. The main advantage of the computer in well logging analysis is giving the chance to calculate each petrophysical parameters using large number of methods. This is done to cover the different conditions, which may affect the validity of parameter estimation. Then, the resulted values are weighted to choose the proper value that is the least, affected by any other parameter.

1.7 Previous work

The syn-rift stratigraphy of the Gulf of Suez has been studied by many authors such as Garfunkel and Bartov (1977), Sellwood and Netherwood (1984), Montenat et al., (1998), Richardson and Arthur (1988), Evans (1990), Ouda and Masoud (1993), Patton (1994), Bosworth et al., (1998), and McClay et al., (1998). Many of these studies were based on small numbers of widely spaced wells and outcrops on the uplifted margins of the rift (the areas between the present-day coast and the rift-boundary fault systems); and did not have the benefits of abundant well data, detailed biostratigraphy or extensive, regional 3D seismic data. Models of rift basin stratigraphy have proven to be of great importance in understanding large-scale stratigraphic patterns related to rift evolution and have been previously

Bosence (1998). However, Syn-rift sediment dispersal patterns, and ultimately, rift-basin stratigraphy are dramatically affected by finer-scale features such as spacially and temporally variable point sources, the three dimensional geometry of fault blocks, and the episodic nature of fault motion.

There have also been many excellent outcrop and subsurface studies that focus on the fault-block scale details of sedimentary response to normal faulting in the Suez rift discussed by Evans and Moxon (1986), Gawthorpe et al., (1990), Gawthorpe et al., (1997), Bosworth et al., (1998), Montenat et al., (1998), Purser et al., (1998), Gupta et al, (1999), Sharp et al., (2000), and Young et al., (2000). These mostly relate to locally derived sediment and sedimentary facies and stratal geometries on the immediate hanging walls and footwalls of faults on the rift margins and shoulders (the areas outside of the rift-bounding fault system). What remains under emphasized is the complexity of Syn-rift stratigraphy within the main axis of the rift, and how sediment transported into the basin from the rift shoulders and dispersed around actively deforming normal fault blocks.

On the other hand, unpublished and published detailed studies on July area and central Gulf of Suez were carried out by Heath, C.P.M. (1972), Hagras, M., (1976) and Hagras, M. and S.Slocki (1982),. Also, the study was guided with Routine core analysis for SG310-5A and J37-37A wells which done by AMOCO to evaluate reservoir quality and depositional environment of Asl and Hawara formations (Upper Rudeis).

Despite the fact that the earlier studies were deterministic and were not based on reservoir rock types analyses, their conclusions provided a useful starting point for this research.