FACIES AND FRAMEWORK OF SEDIMENTATION OF THE MIDDLE MIOCENE OIL-BEARING CARBONATE ROCKS IN RAS FANAR OIL FIELD, GULF OF SUEZ, EGYPT

A Thesis Submitted By

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بسم الله الرحمن الرحيم

الحمد لله رب العالمين الرحمن

الرحيم مالك يوم الدين

إياك نعبد وإياك نستعين

اهدنا الصراط المستقيم

صراط الذين أنعمت عليهم

غير المغضوب عليهم ولا الضالين

صدق الله العظيم

بسم الله الرحمن الرحيم

TO MY PARENTS

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NOTE

This thesis is submitted to the Faculty of Science, Ain Shams University, in partial fulfillment of the requirements for the degree of Master of Science in Geology.

Beside the research work materialized in this thesis, the candidate has attended and successfully passed examinations in the following post-graduate courses:

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2- Sedimentary Petrology
3- Igneous Petrology
4- Metamorphic Petrology
5- Ore Mineralogy
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7- Sedimentation
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SUMMARY

The present research project focuses on the petrographic, facies and sedimentological characteristics and reservoir properties of the subsurface oil-bearing Middle Miocene "Nullipore" carbonate sequence in the Ras Fanar Field. This sequence (400'- 980' thick) consists of limestones rich in algal fragments and nodules and rarely intercalated with marl and chert bands. It unconformably overlies the Lower Eocene Thebes Formation and underlies the Middle to Upper Miocene South Gharib Formation.

Wireline log suites (GR, FDC/CNL and BHC) of fifteen wells in the Ras Fanar Field were studied. The composite logs of some other wells were also revised. 54 core samples were examined using the naked eye, binocular microscope and conventional core analyses (helium porosity, horizontal and vertical permeabilities). In addition, about 500 thin sections were prepared from the core samples and microscopically examined. Microchemical tests using HCl (2% and 10%) and Alizarin Red "S" were conducted for the proper identification of carbonate minerals.

Study of the sonic and porosity logs combined with the core description reveal that the ""Nullipore"" sequence consists of 8 electro-lithofacies zones. They are underlain by a carbonate body (Basal Beds) which is not represented by core samples. Isochore maps of the delineated zones show remarkable lateral variations in their thicknesses.

The main facies types recognized in the carbonates are: lime mudstone, mudstone-wackestone, packstone, boundstone and packstone-boundstone. They are distributed among the electro-lithofacies zones as follows:

Zone I	sandy mudstone to wackestone (biomicrite)
Zone II	dolomitic packstone (molluscan biomicrite)
Zone III	fosssiliferous packstone to boundstone (algal biomicrite)
Zone IV	deeply weathered dolomitic wackestone to packstone (biomicrite)
Zone V	fossiliferous dolomitic wackestone to packstone (biomicrite)
Zone VI	anhydritic fossiliferous packstone to boundstone (algal biomicrite)
Zone VII	anhydritic dolomitic wackestone to packstone (algal biomicrite)
Zone VIII	anhydritic dolomitic packstone (biomicrite)

The isochore maps constructed for the delineated zones show remarkable lateral variations in their facies characteristics.

Petrographic studies on the "Nullipore" carbonates reveal that the bioclasts are made up predominantly of algal fragments and oncoides. Besides, molluscan, bryozoan, foraminiferal, ostracod and echinoid remains are present. The matrix is commonly dolomicritic. Porosity is biomoldic, intercrystalline, intracrystalline, vuggy and represented by fractures. Occasionally, the cavities and fractures are partially or completely filled with anhydrite, celestite and dolomite.

The results obtained reveal that the "Nullipore" carbonates represent reefal buildups in which the boundstone and packstone-boundstone facies constitute the reef core accumulated under high-energy conditions. The majority of the wackestones make up the reef flat and/or reef back. The mudstones and some wackestones reflect deposition under subtidal, partly protected, less-energetic conditions. Assessing the depositional history of the carbonates along a NW-SE profile reveals that the "Basal Beds" were accumulated on an irregular pre-Miocene relief. The thickness variations of the overlying Zones IX, VIII and VII indicate that the southeastern part of the field was deeper (trough with continuous subsidence) than the northwestern sector. However, deposition of Zone VI was accompanied by sea regression which resulted in the absence of Zone V in some sites. Zones III and II were accumulated during continuous subsidence and carbonate building. Due to the beginning of a regressive cycle, the reef core sediments represented by Zone III were restricted to the central part of the field. The mudstone facies of Zone I reflects deposition under relatively calm conditions probably in a protected environment with intermittent terrigenous influx. The distribution of the various types of coralline algae and the vertical facies variations indicate that the "Nullipore" succession can be subdivided into lower, middle and upper regressive sequences. Their tops coincide with the tops of Zones VIII, IV and I, respectively. Generally, these sequences represent environmental variations from inner- to mid-ramp.

The diagenetic history of the studied carbonates comprises both pre-uplift and post-uplift changes which are either porosity-constructive or porosity-destructive. Lithification took place both syndepositionally and after accumulation. Compaction followed primary lithification and was occasionally accompanied by pressure-solution effects. Micritization and calcitization of the originally aragonitic shells affected most of the bioclasts. Filling of cavities with anhydrite, celestite and dolomite took place during several phases of diagenesis. Dolomitization affected the whole sequence although with a variable intensity. It was accomplished by Mg-rich porewaters in the mixed meteoric/marine phreatic zone. Dissolution resulted in the frequent development of biomolds, vugs and cavities and the occasional formation of rottenstones. Fracturing is more common in dolostones. It followed mainly the dissolution and cavity-filling processes.

Evaluating the reservoir quality of the Ras Fanar carbonates reveals that highest porosity values are related to dissolution and leaching of skeletal grains (telogenetic porosity). Dissolution resulted also in the formation of vugs which are typically interconnected (eogenetic porosity). Intercrystalline pores are mainly an artifact of dolomitization (eogenetic porosity) and are commonly open and interconnected. Intracrystalline pores, on the other hand, are isolated. Fracture porosity (mesogenetic porosity) often grades into breccia porosity. The ranges of the measured porosity and permeability values for the delineated electro-lithofacies zones are 7-39 % and 0.1-1000 mD.

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