Fractured reservoirs provide over 20% of the world reserves and production. However, few of these reservoirs are optimally developed. It is undeniable that the reservoir characterization modeling and simulation of naturally fractured reservoirs present unique challenges that differentiate them from conventional reservoirs which also means that they require unique solutions and strategies for optimum production.

Zeit Bay Field is considered the first field in the Egyptian Petroleum Sector that explored and produced oil from the fractured basement. This field is located in the southwestern offshore part of the Gulf of Suez. The field was discovered in June 1981 and started to produce commercially in December 1983. Hydrocarbons are produced from all the porous and permeable intervals from Hammam Faraun of the Belayim Formation down to Precambrian basement. These units are in complete hydraulic communication, making it one of the unique reservoirs.

In this study, the authors use all available data and various methods and techniques to construct a reservoir model for the basement reservoir of the Zeit Bay Field aiming to:

1) Identify and model a basement reservoir that predicts content and behavior of the wells.

2) Explain the past basement reservoir performance and predict its future performance.

3) Formulate a reservoir management policy and development plane of the field throughout its life with minimum expenditures.
A Multidisciplinary Approach To Recognize And Predict The Role Of Fractures In Maximizing Economic Recovery From Basement Reservoirs By Integrating Different Disciplines

ZEIT BAY FIELD GULF OF SUEZ, EGYPT

Abstract

Fractured Reservoir Provide Over 20% Of The World Reserves And Production. Few Of These Reservoirs Are Optimally Developed.

It Is Undeniable That The Reservoir Characterization Modeling And Simulation Of Naturally Fractured Reservoirs Present Unique Challenges That Differentiate Them From Conventional One Which Also Mean That They Require Unique Solutions And Strategies For Optimum Production.

Zeit Bay Field Is Considered As The First Field That Explored And Produced Oil From The Fractured Basement In Egypt. So, The Authors Selected That Field To Produce 3D Fractures Modeling For That Type Of Reservoir.

Objectives

1.- Demonstrate How Different Data Sets Can Be Integrated Into The 3D Static & Dynamic Models To Achieve & Obtain Better Reservoir Management To Obtain The Maximum Productivity From The Reservoir Units.

2.- Identify & Construct Model Of Fracture Basement Reservoir To Predicts Content & Behavior Of Wells Using All Available Data & Applying Various Methods And Techniques.

3.- Formulate Reservoir Management Policy & Development Plane Throughout Field Life With Minimum Expenditures.

Field Highlights

Zeit Bay Oil Field Is Located In The South Western Part Of The Gulf Of Suez, Egypt. It Was Discovered In June, 1981.

It Has A Stratigraphic Sequence Similar To The Southern Part Of Gulf Of Suez With Multi Reservoir Units Of Different Ages.

These Units Are In Complete Hydraulic Communication Making It One Unique Reservoir.

Commercial Production From The Field Had Been Started In December 1983 At Average Rate 20,000 Bbl/Day & Reached 80,000 Bbl/Day In 1986.

Nowadays, The Production Became 5,000 Bbl/Day.

Significant Movement Of G.O.C. And O.W.C. Leading To Decreasing In Oil Column And Declination In Reservoir Pressure Has Been Noticed Due To Long Time Of Productivity. Hence, good Reservoir Management Of The Field Becomes Highly Required.

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Surface Basement Analogue Northern & Southern Gebel Zeit

Gebel Zeit Outcrops

- SW Flank of North Gebel Zeit shows 'pink' Prophyritic Granite with Jagged Topographic Expression.
- Rotated Orthogonal Joint Set Amplified By Subaerial Erosion. Prior To Block Faulting The Contraction Cooling Joints Were Vertical Or Sub-vertical And The Stress Relief Joints Were Horizontal Or Sub-horizontal.

Subsurface Basement in ZB Field

Seismic Interpretation & Mapping

Seismic Cross Section

- Gebel Zeit located closely to the North of Zeit Bay Field. It was used as an analogue to simulate Zeit Bay Field structure and stratigraphy.

Types Of Basement

- Open Fracture Through Feldspar Clusters (pp)
- Metasiltstone (pp)
- Meta-Andesite (pp)
- Fractured Granite
- Metasediments
- Metavolcanic

Layering of Basement Reservoir

Fractured Basement Reservoir Can Be Differentiated Into Layers Depending on Petrophysical & Petrographical Discrimination

- HI Porosity Low Density (Pegmatite Granite)
- Low Porosity HI Density
- Moderate Porosity Low Density (Aldi Granite)

Histograms Showing The Variations in Bulk Density for Each Layer Reflecting the Variations in Porosity

Layering Of Fractured Basement Reservoir Based on Neutron - Density Log Response

Alteration Processes & Layering Developed in Granitic Reservoir

Geologic Cross Section Shown Layering Of Basement Reservoir
Fracture Trend Modeling

Fracture Analysis
Fracture Micro Scanner (Image Logs)

Intersecting Sets Of Fractures
Single Set Of Fractures
Fracture Orientation (fracs)
Basement Fracture Orientation Map

Well Deviation Angle With Production Performance

Facies Distribution Map Of Basement Rocks

Relative Productivity And O.W.C Move-up And Fractures Analysis Diagram.

Fracture Types

Sheeting Fractures (Fracture Density Is Set To 5 Fracture / Meter)
Mode I

The Basement Top Has Sheeting Fractures Density Distribution
The Fractures Strike Distribution Which Is Also The Fracture Orientation
The Discrete Fracture Network (DFN) Of Sheeting Fractures

Fault Zone Shear Fractures (Created In Fault Zone)
Mode II

The Fracture Density Distribution Of The Clysmic Fault Zone Fractures
The Fracture Orientation Of The Clysmic Fault Zone Fractures
The (DFN) Model Of The Clysmic Fault Zone Fractures (Gulf Trend)

Fault Related Shear Fractures (Created Under Local Stress)
Mode II

The Fracture Density Distribution Of The Cross Fault Related Shear Fractures
The Fracture Orientation Distribution Of The Cross Fault Related Shear Fractures
The (DFN) Model Of The Cross Fault Related Shear Fractures

DFN Model Of All Fracture Sets

The DFN Model of All Fracture Sets Show Two Main Fracture Orientation Trends, NW - SE Trending (Gulf Trend) & NE - SW Trending Fractures (Aqaba Trend). The Uplifting Events Created The Clysmic Faults and The Lateral Compression Created The Cross Faults.
Basement Reservoir Modelling

Basement Reservoir was selected to illustrate the fracture reservoir modelling workflow in RMS including:

- Structure Modelling (horizons & faults)
- Geological & Simulation grids building static reservoir
- Attributes population (matrix porosity, permeability & water saturation)
- Fracture modelling including (fracture trends, DFN & fracture-related reservoir attributes.)

**Structure Modelling**
- Structure Contour Map (Top F.Basement Zone A)
- Isocore Map (Top F.Basement Zone A)
- Porosity Map (Top Fractured Basement Zone A)

**Petrophysical Modelling**
- Structure Contour Map (Top F.Basement Zone B)
- Isocore Map (Top F.Basement Zone B)
- Porosity Map (Top Fractured Basement Zone B)
- Structure Contour Map (Top F.Basement Zone C)
- Isocore Map (Top F.Basement Zone C)
- Porosity Map (Top Fractured Basement Zone C)

**3D Basement Structure & Stratigraphic Layering**

**Property Distribution Modelling**
- Porosity Distribution
- Permeability Distribution
Results & Conclusion

1. The Authors Built 3D Structure And Fracture Models Of Fracture Basement For Zeit Bay Field Using All The Available Data.

2. To Achieve That, Different Techniques And Methods Had Been Applied And Different Software Had Been Used.

3. The Study Reveals The Following Facts:-
   - Zeit Bay Area Had Been Affected By Two Main Tectonic Events:-
     1) Ancient Uplifting Event (Created An Extensional Environment).
     2) More Recent Compression Event From The Gulf Of Suez (Created A Strike-slip Environment).
   - The Fracture Types Related To The Two Events Are, Sheeting Fractures, Fault Zone Fractures And Fault-Related Shear Fractures.


   - The Fracture Model Should Be Modified For The Simulation Purpose In Order To Get Better History Match.

Recommendations

Many Factors Should Be Taken Into Consideration In Dealing With Fractured Basement Productivity In Zeit Bay (The Productivity Index, Movement Of Oil-Water Contact Upward, Fractures Dip Intensity & Orientation) In Addition To Well Path Deviation.

Based Upon The Above Factors, The Optimal Locations For Infill Wells To Be Drilled Are In The South East & North East Portions Of The Field As They Have High Productivity Index, 60 Degree Fracture Dip In Conjugate Set & Slow Movement Of Oil - Water Contact Upward.

Well Deviation Design Is Recommended To Be At 30 - 40 Degree In Order To Penetrate Maximum Fracture Sets. Hence, Maximum Oil Productivity Can Be Achieved.

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