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FULL LENGTH ARTICLE

Geophysical Evaluation for Wadi Rayan Field, Western Desert, Egypt

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Abstract Wadi Rayan Field is located approximately 115 km from Southwest Cairo. The study area is a platform lying between Abu Gharadig and Beni suef basins.

It was discovered in September, 1996 through drilling well WR-1x which has been drilled to a total depth of 7740 ft. in basement.

Abu Rawash G member is Cenomanian in age and the only producing horizon in this area; it's composed of shale and sandstones intercalations with minor carbonate interbeds.

The main producing interval in this member is ARG-5 which consists of sandstone, silt and shale. The thickness is varying along whole study area. It ranges from 1 to 100 ft.

There are two intervals of producing sandstone which not only vary from one well to another but also not deposited in some wells. For these reasons, it is important to integrate all available geological and geophysical data to come up with a model for ARG reservoir.

1. Introduction

1.1. Stratigraphy

The sedimentary sequence of the Wadi El-Rayan Field ranges in age from Lower Cretaceous to Middle Eocene (Figs. 1 and 2). The sedimentary section in the Wadi El-Rayan province is characterized by the absence of the Paleozoic and Jurassic rocks as a result of non-deposition on the Wadi El-Rayan platform. A thin Lower Cretaceous section was deposited directly over the Precambrian basement rocks [1].

1.2. Structure

The Western Desert of Egypt consists of a series of small rift basins. Some of them dated back to the Permian, but the majority can be considered to have initiated during the Late Jurassic-Early Cretaceous, contemporaneously with the creation of the Mediterranean basins [3].

Despite a relatively complex history, the geological framework of Egypt is highly suited for oil and gas exploration. It comprises eight major tectono-stratigraphic events:

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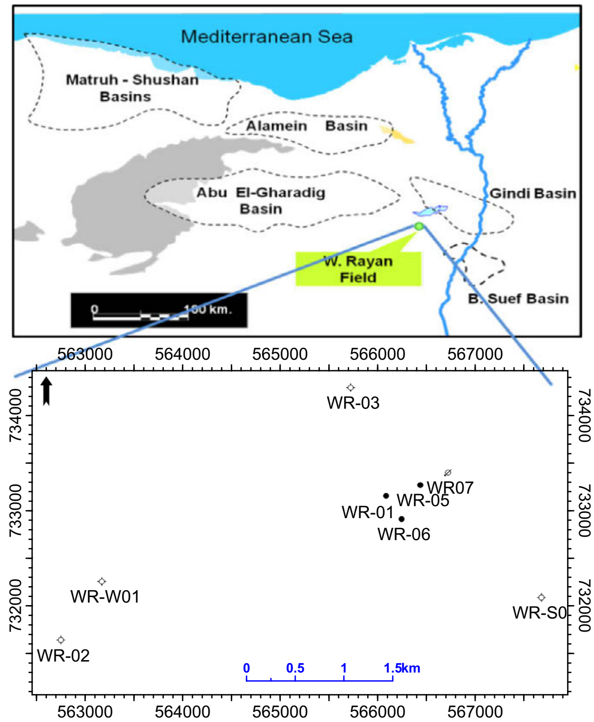

Figure 1 Index map showing the locations of the Wadi Rayan Field lying between Abu Gharadig basin and Gindi basin, Western Desert, Egypt.

1. Paleozoic craton,
2. Jurassic rifting,
3. Cretaceous passive margin,
4. Cretaceous Syrian arc deformation and foreland transgressions,
5. Oligo-Miocene Gulf of Suez rifting,
6. Miocene Red Sea breakup,
7. The Messinian salinity crisis and
8. Plio-Pleistocene delta progradation.

Each of these events has created multiple reservoir and seal combinations. Source rocks occur from the Paleozoic through to the Pliocene and petroleum is produced from Precambrian through Pleistocene age reservoirs [4].

Seismic and borehole data indicate that the Jurassic and Cretaceous (mainly Lower Cretaceous) rocks were deposited in rift basins in the Northern Western Desert. These basins had the form of half-grabens, each bounded by a major fault on its downdip side. Away from this fault, the dip angle of the rocks within the basin decreases and at the extreme updip edge of the basin they have a very gentle dip and are usually referred to as platforms by several investigators, e.g. Sitra and Wadi El Rayan platforms [5].

The area under consideration is located within the northern Egypt fold belt that is part of the Syrian Arc System that extends from Palmera Mountains in Syria to the central Western Desert of Egypt, passing through Northern Sinai [6].

After the deposition of the Cenomanian–Turonian; and Lower Senonian rocks; folding and reverse faulting affected the Abu Roash Formation and older rocks as well as the lower part of the Khoman Formation. The structures of study area include both folds and faults. Folds in Wadi EL-Rayan platform are symmetric and have gentle dipping flanks and have NE-SW orientation [1].

Most folds owe their origin to compressional movements which affected the area during the Late Cretaceous-Early Tertiary tectonic event. These folds have a northeast–southwest trend and a particular geometry.

In addition, there are other folds which owe their origin to normal or horizontally displaced fault blocks. Their axes are parallel, oblique or perpendicular to the fault block trend depending on the magnitude of the strike slip component of the movement [7].

The faults of the study area have three main orientations. They are oriented ENE–WSW, NE–SW and NW–SE. The oriented faults are predominantly normal and were active at least two times. These faults were active in the Early and Late Cretaceous time [1].

In Wadi Rayan Field, the Turonian A/R F member is the most prolific source rock in the stratigraphic succession that contains enormous amounts of oil-prone organic matter (Type-I and Type-II kerogens).

2. Methodology

The methodology used to model ARG reservoir includes:

Well-log editing and pseudo-log generation, tying a synthetic model to surface seismic data.

2.1. Well-log editing and pseudolog generation

Constructing missing or poor-quality well logs, especially compressional and shear sonic and density logs, which is a big challenge in making a synthetic for well-to-seismic tie.

Castagna's equation [8] was used to create a Shear-wave by applying a linear transform to *P*-wave log as an input. See Fig. 3

$$S\text{-wave } (ft/s) = 0.86190 * P\text{-wave } (ft/s) + (-3845.14439) \quad (1)$$

And to create *P*-wave, Gardner's equation [9] was used as an input. Fig. 4.

$$\rho = aV^b \quad (2)$$

where $a = 0.23$, $b = 0.25$.

2.2. Well-to-seismic tie

Logs from the WR-1 and WR-4 wells and 3D seismic lines were used for the synthetic-to-surface seismic tie. A wavelet extracted from the surface data around the target reservoirs and the edited well logs was used to generate the zero-offset synthetic seismogram necessary to tie surface seismic data at the well locations.

The synthetic-to-surface seismic ties at the WR-1 and WR-2 wells are shown in Figs. 5 and 6. The tie is very good and suggested that the ARG and the ARG-5 tops should be picked at about 1105 ms and 1108 ms two-way time in the WR-1 well consequently, and at about 1064 ms and 1081 ms in the WR-4 well.