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Research paper

Petrophysical and microfacies analysis as a tool for reservoir rock typing and modeling: Rudeis Formation, off-shore October Oil Field, Sinai

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ABSTRACT

Petrographically, the Lower Miocene Rudeis reservoir rock samples in October oil field can be summed up into three reservoir rock types RRTs. The RRT1 samples are mostly calcareous to ferruginated sandstones, sometimes are fossiliferous, whereas the RRT2 and RRT3 samples are carbonate rocks of grainstone and packstone microfacies, respectively. Cementation by sparite and compaction are the most important porosity-reducing diagenetic factors, whereas dissolution and leaching out as well as fracturing are the most dominant porosity-enhancing factors.

The petrophysical and reservoir quality studies include measuring density, porosity, permeability measurements as well as reservoir quality index (RQI), flow zone indicator (FZI) and reservoir potential index (RPI) calculations. The permeability-porosity plot is the key-factor for discriminating the petrophysical behaviour into these three rock reservoir types.

Petrophysically, the studied sandstone RRT1 samples have the best storage capacity and reservoir quality (the RQI, FZI and the RPI indicate poor to very good reservoir quality), whereas the RRT3 samples have the least prospective properties (the RQI, FZI and the RPI indicates impervious reservoir quality).

Based on the FZI values, the studied Rudeis Formation was discriminated into a number of hydraulic flow units (6 HFUs). HFU 5–6 are the best reservoir zones; they are assigned in the central parts of the studied area, whereas the least quality (HFU 1–3) was assigned to the south. In addition, the mercury injection capillary pressure tests (MICP) indicates that, the RRT1 samples are ranked as IV (fair) to VI (impervious) ranks, the RRT2 as V (poor) to VI, whereas the RRT3 samples are impervious samples. Wettability of the studied RRT1 samples is mostly neutral.

1. Introduction

The Gulf of Suez is considered as a north-western extension of the Red Sea rift system and now it is a well-established hydrocarbon province, presently ranked seventh in terms of production among the major grabens or rift basins all-over the world (Lashin et al., 2011). A number of significant discoveries have been made in its central province including Belayim, Morgan, July, and October fields.

The off-shore October oil field is the third largest oil field in Egypt. It is located in the offshore central part of the Gulf of Suez, at 135 km to SE of Suez city (Fig. 1). It produces oil from different reservoirs of different geological ages ranging from the Lower Cretaceous Nubia sandstones to the Miocene Rudeis, Nukhul, and Belayim Formations (Schlumberger, 1995).

It is structurally trapped in a complex of rotated fault blocks which is a common trap type in the Gulf of Suez (Lashin et al., 2011).

October Field was discovered in 1977 with drilling of GS 195-1 (Oct-A1) well. From this date and up going, a large number of wells were drilled and the Lower Miocene Rudeis Formation became an important hydrocarbon bearing-reservoir in the Gulf of Suez province (Zahran, 1986; Hilaly and Darwish, 1986; Darwish and El Araby, 1994; Alsharhan and Salah, 1995).

The shallow to deep marine Rudeis Formation has been deposited during the rift-climax stage, where many of the intra block faults became inactive and fault activity is partially progressively localized close to the master fault after initial rifting (Patton et al., 1994; Sharp et al., 2000a).

The aim of this work is to study the storage capacity properties of

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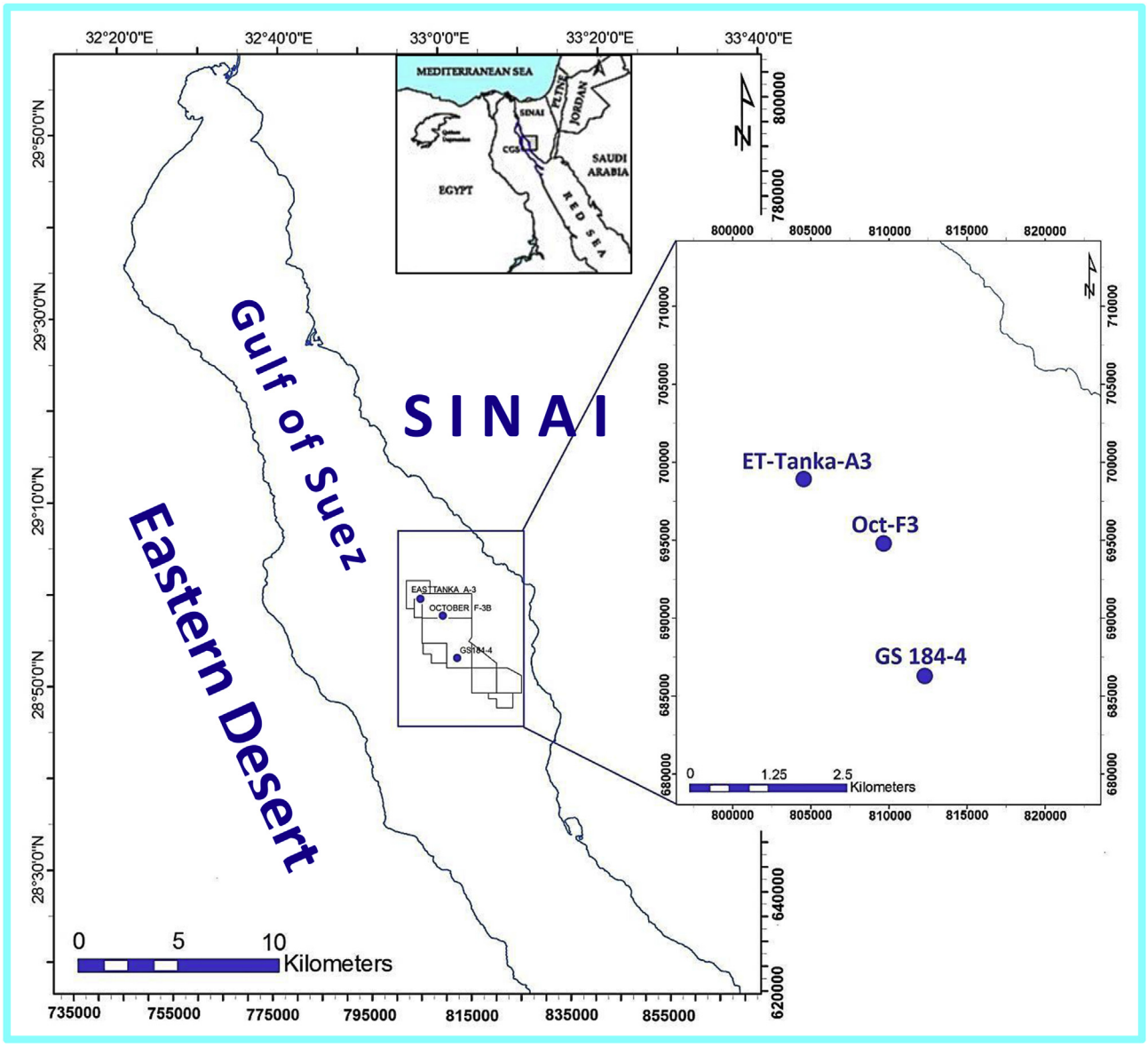

Fig. 1. Location map of the study area showing the location of the studied wells in October Oil Field, Central Gulf of Suez, Egypt.

Rudeis Formation (including porosity, permeability and fluids saturations), to evaluate and rank its reservoir quality, and to determine its conductive and super conductive zones in October field. To achieve these aims, core analysis data (porosity, permeability, oil and water saturation) of the Rudeis Formation in ET-TANKA-A3, GS 184-4, and Oct-F3 wells were used (Fig. 1). The hydraulic unit concept of Amaefule et al. (1993) was applied to slicing the Rudeis reservoir into a number of distinct reservoir rock types (RRT). Each distinct reservoir type has unique reservoir quality index (RQI) and flow zone indicator (FZI) values. In addition, a number of high reliable relationships can be established between both parameters and the flow properties of the studied reservoir and between the different petrophysical properties on the core plug scale (Nabawy and Al-Azazi, 2015).

In addition, studying the mineral composition and the dominated diagenetic factors of Rudeis Formation in October Field is a supplementary target to explain the different petrophysical behaviors of the studied rock types.

2. Geologic and structural settings

The Gulf of Suez as one of the most prolific provinces in Egypt is recognized as a superb example of the interplay between sedimentation and extensional fault development. It is one of the best examples of the integration of outcrop and subsurface data to enhance the hydrocarbon exploration and exploitation (Gawthorpe et al., 1990; Patton et al., 1994; Sharp et al., 2000a; Sharp et al., 2000b).

The stratigraphic sequence of the Gulf of Suez ranges in age from Cambrian to Recent and can be classified into three mega sequences: Pre-rift (pre-Oligocene), Syn-rift (Miocene to Pliocene) and Post-rift (Pliocene-Recent).

The Lower Miocene Rudeis Formation in the Gulf of Suez has been studied in different fields by many authors (e.g. Bobbit and Gallagher, 1978; Shahin and Shehab, 1984; Gadallah et al., 2010; Lashin et al., 2011; Lashin and Mogren, 2012; Zaid, 2012; El-Ghali et al., 2013). The Burdigalian to Early Langhian Rudeis Formation (15.8–20.4 Ma, Smale et al., 1988, Hughes et al., 1992) is considered as one of the most important oil productive formations in the Gulf of Suez. It has a wide distribution in the Gulf of Suez and on its both sides as outcrops or buried in the subsurface, and vary in thickness up to 2000 m in the depocenters of the Gulf of Suez basin. Rudeis Formation is mostly differentiated into two units, Lower and Upper Rudeis. The lithological composition of its lower unit is mostly composed of brownish, fine-