Journal of African Earth Sciences 85 (2013) 31–52

Contents lists available at SciVerse ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

Provenance, diagenesis, tectonic setting and reservoir quality of the sandstones of the Kareem Formation, Gulf of Suez, Egypt

Samir M. Zaid

Geology Department, Faculty of Sciences, Zagazig University, 44511 Zagazig, Egypt

ARTICLE INFO

Article history:
Received 20 November 2011
Received in revised form 6 April 2013
Accepted 26 April 2013
Available online 11 May 2013

Keywords:
Provenance
Diagenesis
Reservoir quality
Kareem sandstones
Gulf of Suez

ABSTRACT

The Middle Miocene Kareem sandstones are important oil reservoirs in the southwestern part of the Gulf of Suez basin, Egypt. However, their diagenesis and provenance and their impact on reservoir quality, are virtually unknown. Samples from the Zeit Bay Oil Field, and the East Zeit Oil Field represent the Lower Kareem (Rahmi Member) and the Upper Kareem (Shagar Member), were studied using a combination of petrographic, mineralogical and geochemical techniques. The Lower Rahmi sandstones have an average framework composition of $Q_{95}F_{3.4}R_{1.6}$, and 90% of the quartz grains are monocrystalline. By contrast, the Upper Shagar sandstones are only slightly less quartzose with an average framework composition of $Q_{76}F_{21}R_3$ and 82% of the quartz grains are monocrystalline. The Kareem sandstones are mostly quartzarenite with subordinate subarkose and arkose. Petrographical and geochemical data of sandstones indicate that they were derived from granitic and metamorphic terrains as the main source rock with a subordinate quartzose recycled sedimentary rocks and deposited in a passive continental margin of a syn rift basin. The sandstones of the Kareem Formation show upward decrease in maturity. Petrographic study revealed that dolomite is the dominant cement and generally occurs as fine to medium rhombs pore occluding phase and locally as a grain replacive phase. Authigenic quartz occurs as small euhedral crystals, locally as large pyramidal crystals in the primary pores. Authigenic anhydrites typically occur as poikilotopic rhombs or elongate laths infilling pores but also as vein filling cement. The kaolinite is a by-product of feldspar leaching in the presence of acidic fluid produced during the maturation of organic matter in the adjacent Miocene rocks.

Diagenetic features include compaction; dolomite, silica and anhydrite cementation with minor iron-oxide, illite, kaolinite and pyrite cements; dissolution of feldspars, rock fragments. Silica dissolution, grain replacement and carbonate dissolution greatly enhance the petrophysical properties of many sandstone samples.

1. Introduction

The Middle Miocene Kareem Formation is an important hydrocarbon bearing-reservoirs in the southwestern part of the Gulf of Suez including Zeit Bay Oil Field and East Zeit Oil Field (Hilaly and Darwish, 1986; Saudi, 1992; Darwish and El-Araby, 1993; Alsharhan and Salah, 1995; Zahran, 2005; Fig. 1). The Middle Miocene Kareem sandstones served as one of the primary source of oil and gas, while the Middle Miocene evaporites (Belayim Formation) represent the excellent capping rocks for these reservoirs. Almost 23% of the oil is produced from the sandstones of the Kareem Formation (Alsharhan and Salah, 1997). In the Gulf of Suez area, the Miocene rocks have wide geographic distribution, either exposed or subsurface.

Provenance studies of clastic sedimentary rocks often aim to reveal the composition and geological evolution of the sediment source areas and to constrain the tectonic setting of the depositional basin. Previous works have revealed that the chemical composition of clastic sediments is a function of a complex interplay of several variables, including the source rock composition, the extent of weathering, transportation and diagenesis (Taylor and McLennan, 1985; Bhatia and Crook, 1986). However, the tectonic setting of the sedimentary basin may play a predominant part over other factors, because different tectonic settings can provide different kinds of source materials with variable chemical signatures (Pettijohn et al., 1987; Bhatia, 1983; Chamley, 1990; Armstrong-Altrin and Verma, 2005). Many attempts have been made to refine provenance models using the framework composition (Suttner et al., 1981; Dickinson et al., 1983; Weltje et al., 1998) and geochemical features (Bhatia, 1983; Suttner and Dutta, 1986; Roser and Korsch, 1986, 1988; Armstrong-Altrin et al., 2004).

Significant contributions have been made by several studies in relation to the regional geology, petroleum prospects, sedimentology and tectonic evolution of the Kareem Formation including the

E-mail address: samir_zaid75@yahoo.com

1464-343X/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jafrearsci.2013.04.010

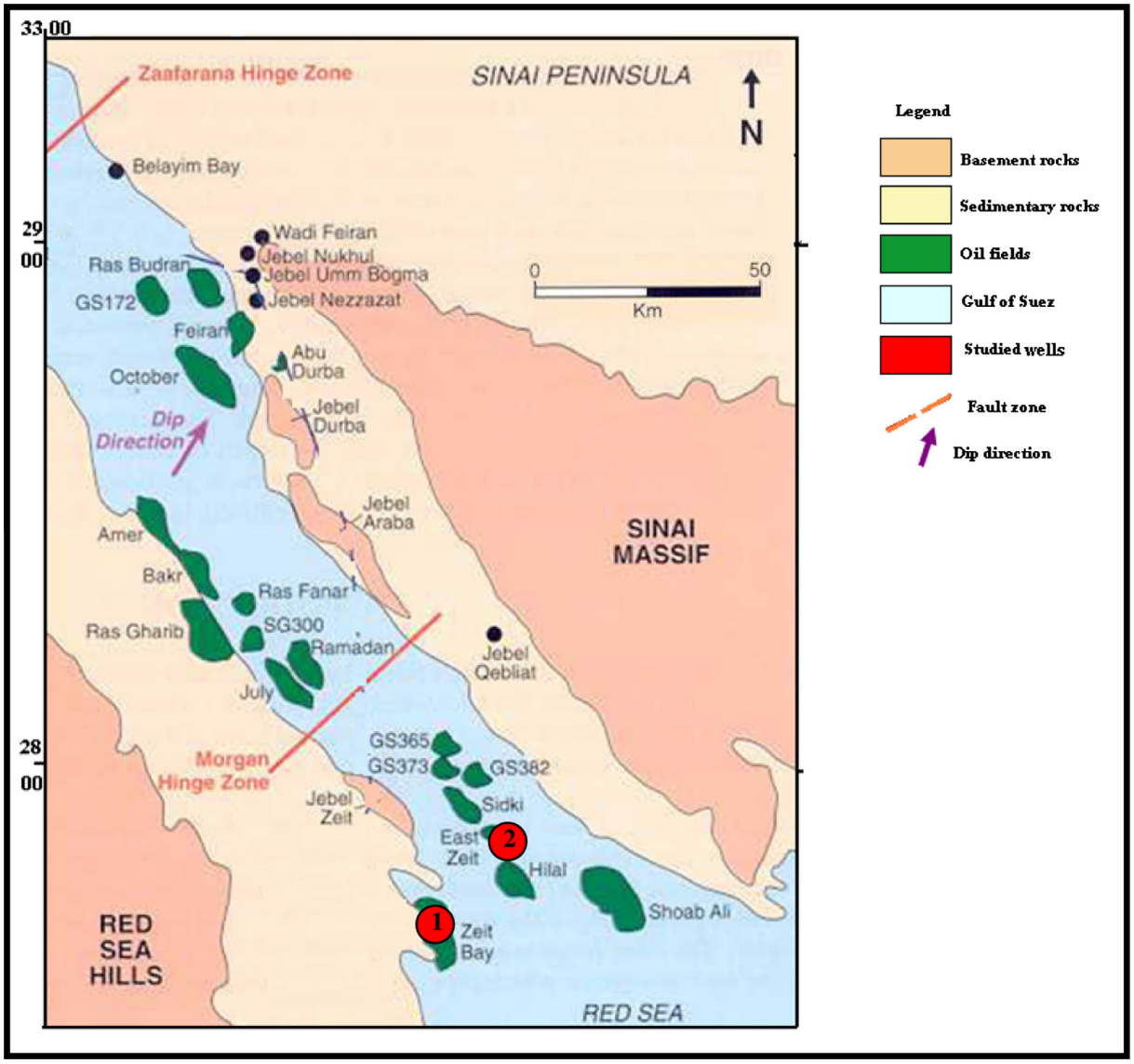

Fig. 1. Location map of studied wells, Gulf of Suez, Egypt.

EGPC Stratigraphic Committee (1964), Hilaly and Darwish (1986), Darwish and El-Araby (1993), Salah (1994), Alsharhan and Salah (1994, 1995) and Salem et al. (2000). However, very few studies have ever been related to reservoir properties, diagenesis and its implications for reservoir quality except Alsharhan and Salah (1997) and Zahran (2005).

In this regard, there still exists a gab between the understanding the reservoir properties and factors controlling the reservoir quality of Kareem sandstones. With the main of helping to close the gab, this paper gives an account of the petrophysical properties of reservoir rock to characterize the reservoir and also describes how the diagenetic aspects, petrophysical parameters and detrital composition influence the reservoir quality.

The stratigraphic columns of Zeit Bay Oil Field and East Zeit Oil Field include the rock units from Paleozoic to Post Miocene normally encountered in the Gulf of Suez (Fig. 2). The Miocene sequences were previously subdivided by the EGPC Stratigraphic Committee and Subcommittee (of 1964 and 1974, respectively) into two main groups, the Gharandal and Ras Malaab. The term "Gharandal" was introduced by Said (1962) to describe the strata that lie beneath the Miocene evaporites on the Sinai side of the Gulf of Suez. The rocks were divided into two formations: the Nukhul and the Rudies. The term "Ras Malaab" was first introduced to describe surface exposures at the entrance to Wadi Gharandal. As the name "Gharandal" was already reserved for the underlying clastic group, the closest geographic name, "Ras Malaab," was chosen for this group (EGPC, 1964). This group was redefined and subdivided by the EGPC (1974) into the Zeit, South Gharib, Belayim, and Kareem formations, in descending order.

The Kareem Formation disconformably overlies the Rudies Formation and unconformably overlies by the Belayim Formation. The average thickness of the Kareem Formation is around 165 m.

The Kareem Formation is composed mainly of interbedded sandstones, shales and carbonates with minor anhydrites in its lower parts. The sandstones of the Kareem Formation is medium to dark greenish grey, brownish grey, argillaceous and fossiliferous. The siliciclastics were deposited in alluvial and submarine fans building out from the rift shoulder, while the carbonates and anhydrites were precipitated in local lagoons as a result of sea level fluctuations. The formation is divided into the Rahmi and overlying Shagar members, and is Langhian to Serravalian in age (Alsharhan and Salah, 1997).