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FULL LENGTH ARTICLE

Evaluation of organic matters, hydrocarbon potential and thermal maturity of source rocks based on geochemical and statistical methods: Case study of source rocks in Ras Gharib oilfield, central Gulf of Suez, Egypt

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Abstract In this study, we apply geochemical and statistical analyses for evaluating source rocks in Ras Gharib oilfield. The geochemical analysis includes pyrolysis data as total organic carbon (TOC%), generating source potential (S2), production index (PI), oxygen and hydrogen indices (OI, HI) and (Tmax). The results show that the Cretaceous source rocks are poor to good source rocks with kerogen of type III and have the capability of generating gas while, the Miocene source rocks are good to excellent source rocks with kerogen of type III–II and type II and have the capability of generating oil and gas. The analyzed data were treated statistically to find some factors, clusters, and relations concerning the evaluation of source rocks. These factors can be classified into organic richness and type of organic matter, hydrocarbon potentiality and thermal maturity. In addition, cluster analysis separated the source rocks in the study area into two major groups. (1) Source rocks characterized by HI >300 (mg/g), TOC from 0.76 to 11.63 wt%, S1 from 0.44 to 9.49 (mg/g) and S2 from 2.59 to 79.61 (mg/g) indicating good to excellent source rocks with kerogen of type III–II and type II and are capable of generating oil and gas. (2) Source rocks characterized by HI <300 (mg/g), TOC from 0.31 to 2.07 wt%, S1 from 0.17 to 1.29 (mg/g) and S2 from 0.31 to 3.34 (mg/g) indicating poor to good source rocks with kerogen of type III and are capable of generating gas. Moreover, Pearson's correlation coefficient shows a strong positive correlation between

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TOC and S1, S2 and HI and no correlation between TOC and Tmax, highly negative correlation between TOC and OI and no correlation between Tmax and HI.

1. Introduction

Petroleum geochemistry is used as the fundamental science for understanding the properties of source rocks, productive and non productive zones, oil migration (all of which result in more efficient exploration), development of oil fields and sustainable production. The term source rock refers to an organic-rich fine-grained sedimentary rock which can produce hydrocarbons due to thermal maturation [1]. Source rock is one of the main elements of a hydrocarbon system. Therefore, to identify a region of hydrocarbon, it is necessary to investigate the source rock and its characteristics first. Thermal maturity is the primary factor that determines whether a source rock can produce oil, gas, or condensate [2]. In order to evaluate the source rocks various laboratory methods are used. Among these techniques, Rock–Eval pyrolysis has been widely used in the industry as a standard method in petroleum exploration [3]. From laboratory methods, the Rock–Eval pyrolysis method has been extensively used, worldwide, for oil and gas exploration in sedimentary basins [4]. This method is used in determining the thermal maturation of kerogen. Behar et al. [4] defined the thermal parameters based on which maximum temperature (Tmax) can be used to determine the dimensions of the oil window. According to that definition, the Tmax value for the beginning of the oil window is usually 445–435 °C, for the peak is 450–445 °C, and for the end is 470–450 °C [5]. Thermal maturity of samples can be determined with plotting Tmax values versus HI. In this study, we used both geochemical and statistical analyses for evaluating the source rocks in Ras Gharib oilfield.

Although organic matter undergoes many types of evolution, thermal maturation is important in assessing hydrocarbon generation. In the present work, three major characteristics need to be studied in order to determine the petroleum potential of source rocks: (1) geochemical properties of organic material, (2) thermal maturation, and (3) the abundance of hydrocarbon. The maturity of organic matter is, however, one of the most important parameters in the evaluation of oil–gas [6]. In this study, both geochemical and statistical analyses were used to discriminate the maturity and hydrocarbon potentialities of Cretaceous and Miocene source rocks in Ras Gharib area that lies between latitudes 28°23′–28°24′N and longitudes 33°03′–33°04′E (Fig. 1). The study area covers a surface area of about 2.4 km^2 in the central part of the coastal strip of the western side of the Gulf of Suez. Fig. 2 shows the lithostratigraphic column of Ras Gharib oilfield, compiled from the drilled wells in the study area.

The purpose of this study is to establish reliable indices for an integrated assessment of organic material for petroleum potential evaluation and focuses on multivariate statistical analysis and cross-plots of TOC, and parameters of Rock–Eval pyrolysis. With experimental and analytical investigation, we expect to reveal that the values of eight parameters (HI, QI, PI, S1, S2 and S1 + S2) increase as the thermal maturity of organic materials increases during the initial stage of thermal maturation. In addition, this study is to characterize the relationships between organic material and thermal maturity. Samples studied include Cretaceous (Nubia''A'', Raha and Wata formations) and Miocene (Basal Miocene Beds, Belayim, South Gharib and Zeit formations) source rocks.

2. Regional geology

The Gulf of Suez in Egypt has a north-northwest–south-south east orientation and lies at the junction of the African and Arabian plates where it separates the northeast African continent from the Sinai Peninsula. It has excellent hydrocarbon potential, with the prospective sedimentary basin area measuring approximately 19,000 km^2, and it is considered as the most prolific oil province rift basin in Africa and the Middle East. This basin contains more than 80 oil fields, with reserves ranging from 1350 to less than 1 million bbl; in reservoirs of Precambrian to Quaternary age [7]. The lithostratigraphic units in the Gulf of Suez can be subdivided into three megasequences: a pre-rift succession (pre-Miocene or Paleozoic-Eocene), a syn-rift succession (Oligocene–Miocene), and a post-rift succession (Pliocene-Holocene). These units vary in lithology, thickness, areal distribution, depositional

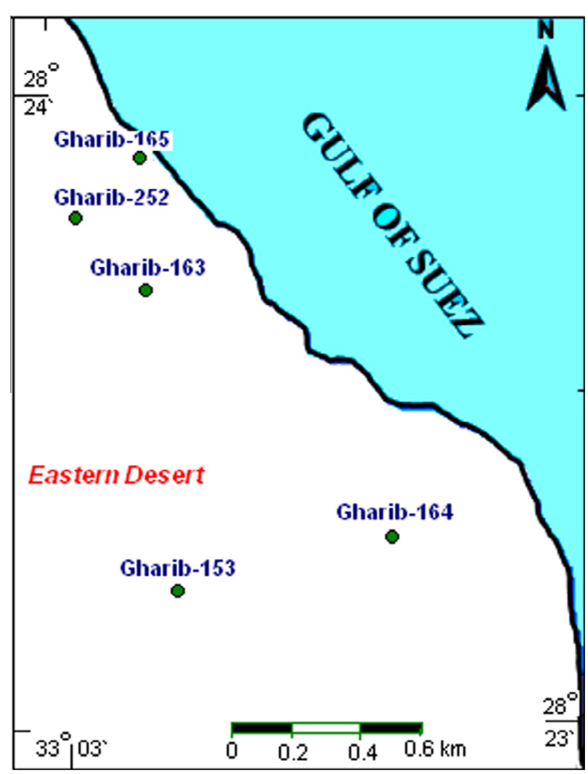

Figure 1 Location map of the studied wells, Ras Gharib, central Gulf of Suez, Egypt.