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Research paper

Petroleum generation characteristics of heterogeneous source rock from Chia Gara formation in the Kurdistan region, northern Iraq as inferred by bulk and quantitative pyrolysis techniques

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ABSTRACT

This study is the first attempt which provides information regarding the bulk and quantitative pyrolysis results of the Chia Gara Formation from the Kurdistan region, northern Iraq. Ten representative early-mature to mature samples from the Chia Gara Formation were investigated for TOC contents, Rock Eval pyrolysis, pyrolysis-GC and bulk kinetic parameters. These analyses were used to characterize the petroleum generated during thermal maturation of the Chia Gara source rock and to clarify the quantity of the organic matter and its effect on the timing of petroleum generation.

Pyrolysis HI data identified two organic facies with different petroleum generation characteristics; Type II–III kerogen with HI values of >250 mg HC/g TOC, and Type III kerogen with HI values < 100 mg HC/g TOC. These types of kerogen can generate liquid HCs and gas. This is supported by the products of pyrolysis–gas chromatography (Py–GC) analysis of the extracted rock samples. Pyrolysis products show a dominance of a marine organic matter with variable contributions from terrestrial organic matter (Types II–III and III kerogen), and produces mainly paraffinic-naphthenic-aromatic low wax oils with condensate and gas.

Bulk kinetic analysis of the Chia Gara source rock indicates a heterogeneous organic matter assemblage, typical of restricted marine environments in general. The activation energy distributions reveal relatively broad and high values, ranging from 40 to 64 kcal/mol with pre-exponential factors varying from 2.2835 E+12/sec to 4.0920 E+13/sec. The predicted petroleum formation temperature of onset (TR 10%) temperatures ranges from 110 to 135 °C, and peak generation temperatures (geological T_{max}) between 137 °C and 152 °C. The peak generation temperatures reach a transformation ratio in the range of 42–50% TR, thus the Chia Gara source rock could have generated and expelled significant quantities of petroleum hydrocarbons in the Kurdistan of Iraq.

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1. Introduction

The Late Jurassic-Early Cretaceous Chia Gara Formation is widespread and well exposed in northern Iraq. In the Kurdistan region, the Chia Gara sediments have thicknesses in the range 110–225 m (Mohialdeen, 2008; Mohialdeen et al., 2013). Organic-rich limestone and calcareous shale sediments in the Chia Gara Formation are important and prolific oil- and gas-prone source rocks in the Kurdistan region, northern Iraq (Al-Ameri and Zumberge, 2012; Mohialdeen et al., 2013, 2015). Most of the oil accumulated in the Kurdistan region is considered to be sourced from the organic-rich limestone and calcareous shale of the Chia Gara Formation (Mohialdeen et al., 2015). The organofacies recognised within the Chia Gara source rock, indicate a marine Type II facies and a mixed marine Type II/III facies (e.g., Mohialdeen et al., 2013). These facies strongly affects the petroleum type and the timing of petroleum generation. However, the kerogen characteristics and its relevance to petroleum generation studies of Chia Gara

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source rock from Kurdistan have not been investigated yet. In this respect, the main objective of this study is to determine the organic matter in the Chia Gara Formation and the petroleum type that is generated from the Chia Gara source rock. These data are then used as input for kinetic modeling to predict temperatures for the onset (TR 10%) and peak (maximum geological temperature) of petroleum generation. The petroleum characteristics of organic matter within the Chia Gara source rock and its relevance to predict HC generation have been approached using bulk kinetic and quantitative pyrolysis techniques.

2. Geological setting

The Kurdistan region is an oil-rich area and has become the largest oil-producing part of northern Iraq (Fig. 1a). Kurdistan oil fields in northern Iraq are located in the Zagros Fold Belt, which extends throughout the region, primarily in the elongated area folded zone between the thrust zone in the triple junction boundary with Iran and Turkey (Fig. 1a). The Zagros Fold Belt in the northeastern Arabian Plate formed close to the Tethys paleo-ocean, which includes a NW-trending Zagros Fault system through a series of composite faults oriented between N35 W and N30 W (Al-Sharhan and Nairn, 1997; Aqrawi et al., 2010).

The main stratigraphic succession of the Kurdistan region is presented in Fig. 2, and is dominated by a thick Mesozoic succession that consists of Jurassic and Cretaceous strata. The sedimentary rocks of the Iraqi Kurdistan region are composed of carbonates, shales and anhydrites (Fig. 2), which were deposited under marine and subordinate lagoonal environments (Buday, 1980). The Chia Gara Formation is one of the formations in the sedimentary sub-cycle, which extended from Jurassic to Early Cretaceous. It is underlain by the Barsarin Formation and overlain by the Lower Sarmord Formation (Fig. 2). The Chia Gara Formation is mainly composed of organic-rich limestone and shale sediments with rich Ammonite faunas and diverse foraminifera, radiolarian, ostracode and tintinnid species (Mohialdeen, 2008). The type section of the Chia Gara Formation is located at the Chia Gara anticline, south of Amadiya town in the strongly folded zone in northern Iraq (Bellen et al., 1959). The Chia Gara Formation has been studied by many authors who have discussed the

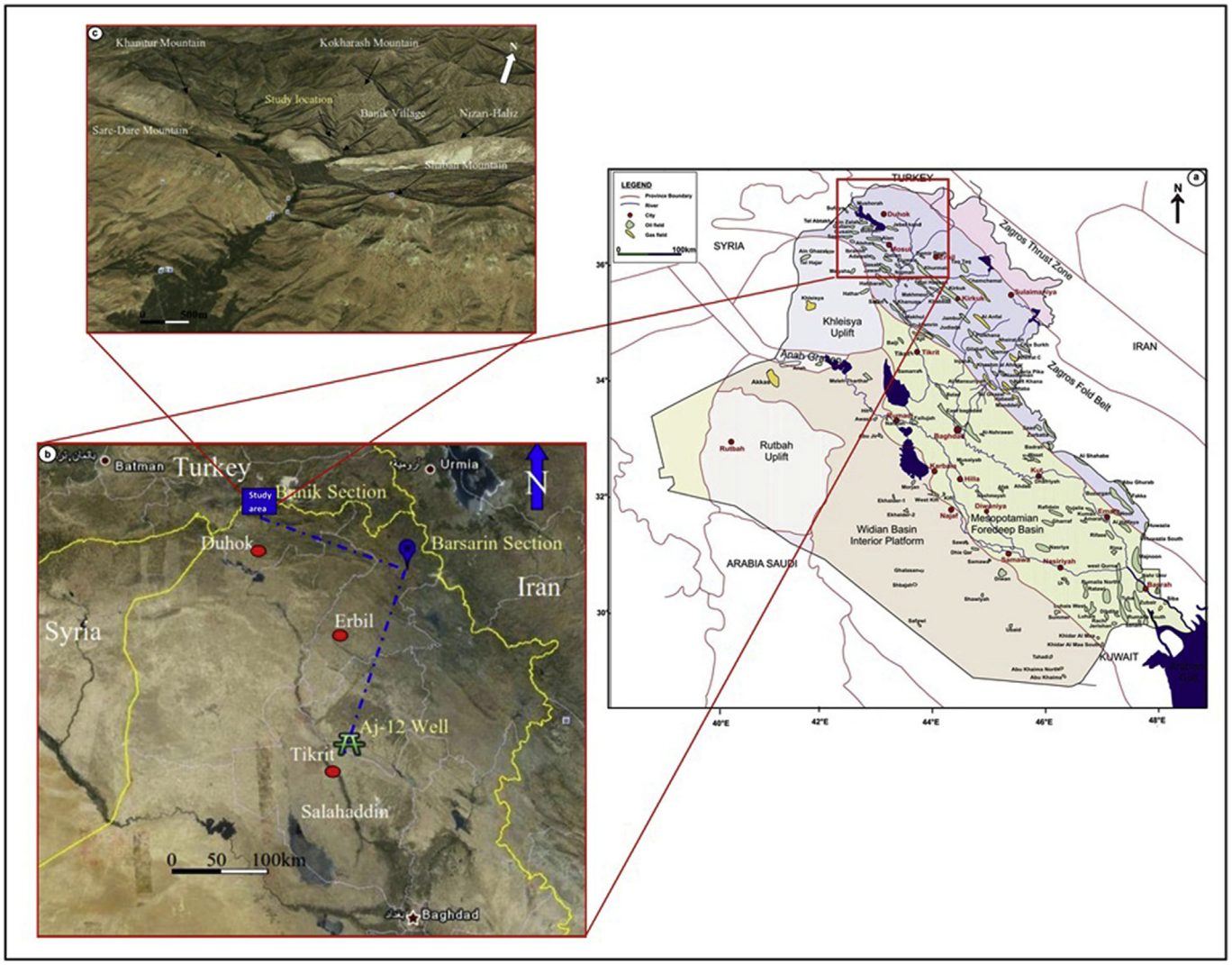

Fig. 1. (a) Location map for the northeast Arabian Peninsula in Iraq, which shows the Zagros Fold Belt with oil and gas field locations in the Iraqi Kurdistan (compiled and modified using the map from Al-Ameri and Zumberge, 2012) (b) Location map of the studied section from Banik Village in the Kurdistan Region (c) Satellite image of area around Banik Village (modified after Edilbi, 2010).

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