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Organic geochemical and petrographic characteristics of the oil shales in the Lajjun area, Central Jordan: Origin of organic matter input and preservation conditions

Mohammed Hail Hakimi [a], Wan Hasiah Abdullah [b], Mohammed Alqudah [c], Yousif M. Makeen [b,*], Khairul Azlan Mustapha [b]

[a] Geology Department, Faculty of Applied Science, Taiz University, 6803 Taiz, Yemen
[b] Department of Geology, University of Malaya, 50603 Kuala Lumpur, Malaysia
[c] Department of Geology, Yarmouk University, 2116 Irbid, Jordan

HIGHLIGHTS

- Jordanian oil shales have high TOC and TS contents, suggesting highly marine reducing conditions.
- The kerogen is characterized by predominantly Types I/II.
- Jordanian oil shales are considered to be generated commercial oil HCs.
- Jordanian oil shales are thermally immature and require artificial heating to generate oil HCs.

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ABSTRACT

Oil shales, located in Lajjun area (Central Jordan), were analyzed based on organic geochemistry, coupled with microscopical study to define the origin, type of organic matter input, and the influencing factors that govern organic matter (OM) enrichment, including the OM preservation conditions. Oil shales are thermally immature petroleum-source rocks for oil that require artificial heating to generate oil of commercial value. The analyzed oil shales have high total sulfur content values in the range of 2.08–4.06 wt%, and the organic carbon contents are also consistently high (>10%). The high total sulfur content and its relation with organic carbon values indicate that the Jordanian oil shales were deposited in a marine environment under reducing conditions. The organic matter input and paleoenvironmental conditions have also been evidenced from their biomarker distributions and microscopic study. The microscopical investigation indicated that the oil shales contain an abundant liptinitic organic matter (i.e., alginite, structureless (amorphous) and planktonic foraminifera). The presence of these liptinitic materials and planktonic foraminifera assemblages in the oil shale samples, further suggests a marine origin. Their biomarkers also provide evidence for a high contribution of marine plankton/algal and microorganisms and persevered under highly hypersalinity reducing conditions. The good preservation under reducing conditions contributes to the high amounts of organic matter enrichment during deposition of these oil shale sediments. Consequently, the Jordanian oil shales have very good oil generative potential, owing to high content of hydrogen rich Type I/II oil-prone kerogen.

1. Introduction

Oil shale is an important form of unconventional resources in the world and it occurs in a number of countries such as USA, Russia, Jordan and China. However, Jordan is ranked the 8th out of 37 countries in the world with oil shale reserves [1]. The oil shales contribute around ~97% of current energy needs, which underlines the importance of finding alternative energy resources and it have a big say in the future prospect of petroleum exploration in Jordan [2]. The oil shale resources have been increased in this country which exceeds 65 billion tons [3]. There are several oil shale occurrences in the Jordan, including the Late Cretaceous

* Corresponding author.
E-mail addresses: ibnalhakimi@yahoo.com (M.H. Hakimi), wanhasia@um.edu.my (W.H. Abdullah), mohammad.alqudah@rub.de (M. Alqudah), makeen77um@yahoo.com (Y.M. Makeen), azlan_0401@um.edu.my (K.A. Mustapha).

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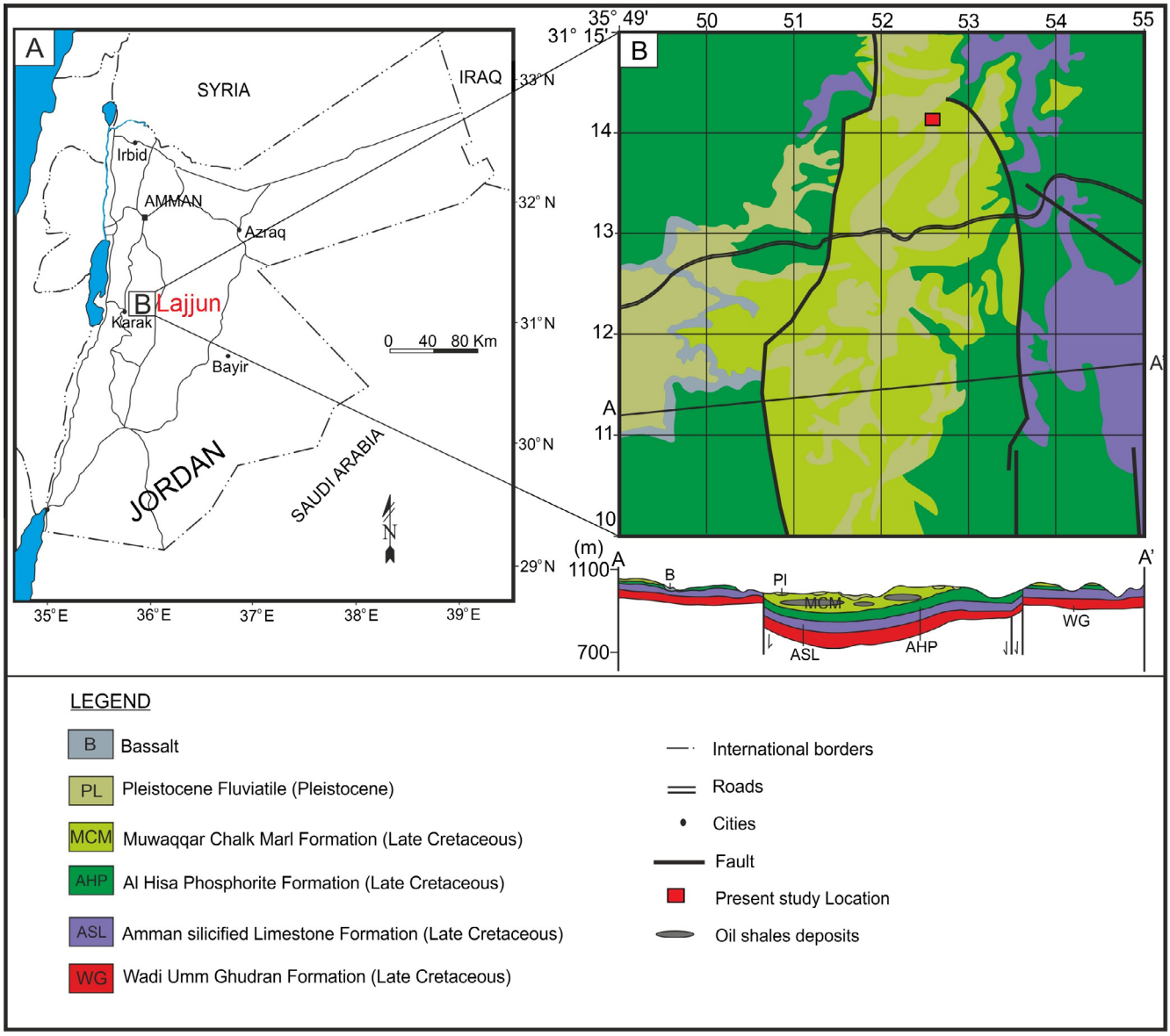

Fig. 1. (A) Location map of Jordan, showing the oil shale location in the study area (Lajjun) of Central Jordan. (B) Geological map of Lajjun are, with vertical scale of the cross section is 1:20,000 and horizontal scale 1:50,000 [10].

and Eocene oil shales whilst most of the oil shale resources are located in the Northern and Central region of Jordan [4,5]. The exploration and development of oil shale have been achieved under the auspices of the Jordanian Natural Resources Authority (NRA) with a focus in commercializing of the resources. At present, several studies have been conducted on the oil shale in Jordan, including inorganic geochemical characteristics [2], examinations of its ichnology accumulations and depositional environment [3], reworked microfossil accumulations and related to depositional environment [4]. However, integrated studies to understand the origin of organic matter and paleoenvironmental conditions of the Jordanian oil shale are limited. This current studies is part of a set of integrated studies, with the aim to investigate the condition of depositional environment of the Jordanian oil shales by using organic geochemistry and organic petrology. Here, we present total organic carbon (TOC) and sulfur contents, pyrolysis data and biomarker distribution on outcrop oil shales collected from Lajjun area in the Central Jordan (Fig. 1A) to provide a more comprehensive understanding of the origin of the organic matter input and paleoenvironmental conditions.

2. Geological setting

Along the African–Arabian Platform, Tethyan Circumglobal Current that flowed from east affects the phosphorite and oil shales deposition in the eastern Mediterranean regions [6–8]. During the Maastrichtian and in a regional and local scale, the plate-tectonic movements played a major role in basin formation [9]. Oil shales accumulated in silled sub-basins in Jordan and ringed by paleohighs that obstructed the Tethyan Circumglobal Current [6]. The Lajjun area comprises of a small graben bounded by two parallel fault systems striking NS [10]. The sedimentary rocks in the Lajjun area are dominated by a thick Mesozoic succession (Late Cretaceous) and Pleistocene as shown in a geological map as illustrated in Fig. 1B. The oldest exposed sedimentary rock is Amman silicified Formation which it is a Campanian in Age. This formation consists of cherts interbedded with limestones. Al Hisa Phosphorite Formation overlies the Amman silicified Formation and contains chert, limestone, phosphatic limestone and marl. A shallow marine sediments were deposited during Maastrichtian include bituminous marls (oil shales), marly limestone and chalk (Fig. 2). These