Journal of African Earth Sciences 129 (2017) 579–595

Contents lists available at ScienceDirect

Journal of African Earth Sciences

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

Geochemical characterization of the Jurassic Amran deposits from Sharab area (SW Yemen): Origin of organic matter, paleoenvironmental and paleoclimate conditions during deposition

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A R T I C L E I N F O

Article history:
Received 11 June 2016
Received in revised form
4 January 2017
Accepted 6 January 2017
Available online 13 January 2017

Keywords:
Jurassic marine
Amran deposits
Organic matter
Paleoenvironmental conditions
Paleoclimate
Sharab area
Taiz Governorate
Yemen

A B S T R A C T

Calcareous shales and black limestones of the Jurassic Amran Group, located in the Sharab area (SW Yemen), were analysed based on organic and inorganic geochemical methods. The results of this study were used to reconstruct the paleoenvironmental and paleoclimatic conditions during Jurassic time and their relevance to organic matter enrichment during deposition of the Amran calcareous shale and black limestone deposits. The analysed Amran samples have present-day TOC and S_{total} content values in the range of 0.25–0.91 wt % and 0.59–4.96 wt %, respectively. The relationship between S_{total} and TOC contents indicates that the Jurassic Amran deposits were deposited in a marine environment as supported by biomarker environmental indicators. Biomarker distributions also reflect that the analysed Amran deposits received high contributions of marine organic matter (e.g., algal and microbial) with minor amount of land plant source inputs. Low oxygen (reducing) conditions during deposition of the Jurassic Amran deposits are indicated from low Pr/Ph values and relatively high elemental ratios of V/Ni and V/(V + Ni). Enrichment in the pyrite grains and very high DOP_T and high Fe/Al ratios further suggest reducing bottom waters. This paleo-redox (i.e., reducing) conditions contributed to preservation of organic matter during deposition of the Jurassic Amran deposits. Semi-arid to warm climatic conditions are also evidenced during deposition of the Amran sediments and consequently increased biological productivity within the photic zone of the water column during deposition. Therefore, the increased bio-productivity in combination with good preservation of organic matter identified as the major mechanisms that gave rise to organic matter enrichment. This contradicts with the low organic matter content of the present-day TOC values of less than 1%. The biomarker maturity data indicate that the analysed Amran samples are of high thermal maturity; therefore, the low present-day TOC is attributed to the thermal effect on the original organic matter. This high thermal maturity level is due to the presence of volcanic rocks, which have invaded the Jurassic rocks during Late Oligocene to Early Miocene.

1. Introduction

The Sharab area is located in the northwestern Taiz city, Southwestern Yemen (Fig. 1a). It is one of the directorates in the Taiz (Fig. 1a). Sharab area is also pristine area and possesses unique geological formations which comprises of complex basement rocks and thick Mesozoic sedimentary rocks (Fig. 1b). Several studies have been conducted in the Sharab area such as an extensive geological mapping which has been achieved under the auspices of the cooperation between Yemeni Geological Survey and Mineral Resources (YGSMRB), Yemen and the Federal Institute for Geosciences and Natural Resources (BGR) of the Hannover, Germany. However, the characteristics of the organic facies and the depositional environment conditions of the sedimentary deposits in the Sharab area and the thermal effect of the Tertiary volcanic rocks on the organic matter of the Mesozoic have not been studied. In this study, the sedimentary rocks under investigation constitute part of the Jurassic Amran Group

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http://dx.doi.org/10.1016/j.jafrearsci.2017.01.009

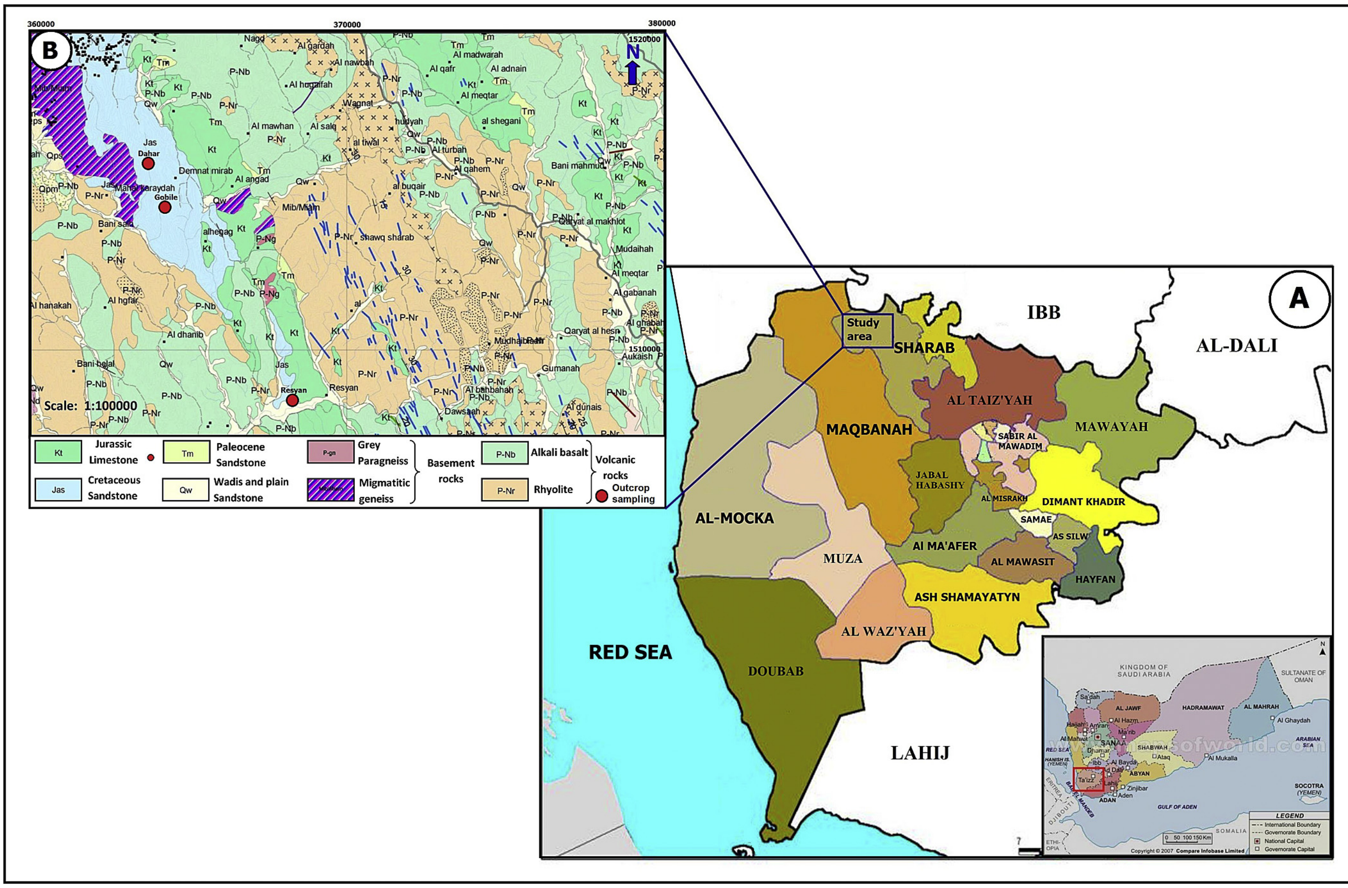

Fig. 1. (a) Location map for the Taiz directorates including Sharab; (b) geological map of study area, showing location of outcrops.

outcrops, which mainly comprise of black limestone with shales and a minor occurrence of gypsum (Fig. 2). This work is an integrated study based on organic geochemical characterization (i.e., biomarkers data) and geochemical investigations of the inorganic elements. The molecular geochemistry of organic matter aims to provide insight into the organic matter in ancient sediments and the paleodepositional environmental conditions (e.g., Peters and Moldowan, 1993; Peters et al., 2005; Hakimi et al., 2012; Mohialdeen et al., 2013; Makeen et al., 2015; Sarki Yandoka et al., 2016). More so, geochemical analysis of inorganic elements provide insight into the depositional environment conditions (e.g., Galarraga et al., 2008; Moosavirad et al., 2011; Mohialdeen and Raza, 2013; Shu et al., 2013; Jia et al., 2013; Mohialdeen and Hakimi et al., 2016; Sarki Yandoka et al., 2015). The primary objectives are to provide information regarding the source of organic matter input, to reconstruct the paleoenvironmental/paleoclimatic conditions during the Jurassic time in the Sharab area and their relevance to organic matter enrichment during deposition of the Jurassic Amran sediments. This study also aimed to investigate the effect of thermal maturity on the original organic matter. The thermal maturity is attributed to the presence of the volcanic rocks that invaded the Jurassic rocks during the Late Oligocene to Early Miocene.

2. Geology and stratigraphy

Sharab area is located in the northwestern part of Taiz city (Fig. 1a) and was surrounded by basement complex rocks, Mesozoic sedimentary rocks, and Tertiary volcanics (Fig. 1b). The study area has stratigraphic succession ranging from Precambrian to Tertiary in age (Fig. 2). The oldest rocks, Precambrian basement complex, consist of granite, gneises, amphibolite, and migmatites and underlie the Mesozoic sedimentary rocks at a sharp unconformity surface (Fig. 2). The Mesozoic sedimentary rocks have two main groups, which lithology comprise of marine limestone and sandstones with minor occurrence of shales. The Mesozoic sedimentary rocks include Amran Group and Tawilah Group, respectively (Fig. 2). The sediments of Amran Group composed of mainly marine limestone and calcareous shale, which unconformably lay on the basement rocks. (Fig. 2). La Davison et al. (1994) have indicated that the limestone of the Amran Group is characterized by dark skeletal of micrite with wackestone and packstone. The Amran deposits has also been dated and assigned from Callovian to Tithonian (Al Thour, 1992; Kruck et al., 1996). The Upper Cretaceous Tawilah Sandstone Group was deposited unconformably on the Jurassic Amran Group (Fig. 2), The Tawilah Sandstone Group consists mainly of medium to coarse-grained sandstones with interbedded shales and conglomerate horizon at the base of the Tawilah sequence (Fig. 2). The shallow volcanic intrusions are also widely recognized in the study area (Fig. 1b), where the magma of rhyolite and basaltic compositions concordantly (sills) and disconcordantly (dykes) intruded along the bedding plane of Jurassic limestone and Cretaceous Tawilah sandstone (Fig. 2). The volcanic rocks intruded the older