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International Journal of Paleobiology & Paleontology
ISSN: 2642-1283

Ichnology of the Middle Jurassic Deposits of NE Iran: Depositional Environment Interpretation

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Research Article
Volume 3 Issue 1
Received Date: October 06, 2020
Published Date: November 04, 2020

Abstract

The Kopet Dagh Basin of northeast Iran formed in the Neotethys Ocean after the closure of Paleotethys in the south of Turan plate. A thick sequence of Jurassic to Miocene sediments has been deposited in this basin without any major break. The siliciclastic Kashafrud Formation (Middle Jurassic), overlying unconformably on Triassic rocks and ultrabasic rocks of turbidite and fluvio-deltaic facies, consists of sandstone, shale and conglomerate. Trace-fossil assemblages are presented in some units with different environments. The most important ichnofossils in this formation are Skolithos, Palaeophycus tubularis, Belorhaphe, Taenidium, Planoloites beverleyensis, Thalassinoides suevicus, Conichnus, Psilonichnus, Lophoctenium, Palaeophycus striatus, Rhizocorallium jenense and Scolicia.. It is interpreted, based on identified ichnofossils, the starat may have been deposited in fluvio-deltaic and deep water (turbidity conditions) environment.

Keywords: Ichnofossil; Kopet-Dagh Basin; Jurassic; Turbidetic Deposition; Iran

Introduction

The Kopet-Dagh Basin of northeast Iran (Figure 1) formed after northeast Iran collided with the Turan Plate early in the Mesozoic [1]. This successor basin accumulated 7 km of post-Triassic strata [2] after which the strata were uplifted and deformed during Cenozoic collisional events along the southern Asian margin [3]. In the eastern part of the basin, the major rock units are the Kashafrud and Mozduran Formations sic) and the Shurijeh Formation (Cretaceous). The Kashafrud Formation of Middle Jurassic age crops out over a large area of the Kopet-Dagh Basin of northeast Iran. Poursoltani and Gibling [4] suggested that the Kashafrud Formation, a Middle Jurassic unit is the source rock for these hydrocarbons. Other formations in the Kopet-Dagh Basin are important hydrocarbon producers. The Khangiran and Gonbadli gasfields near Sarakhs [5] are hosted in the Mozduran and Shurijeh formations of Late Jurassic and Cretaceous age, respectively The Kashafrud Formation (Figure 2), the focus of this study, comprises nearly 2 km of fluvio-deltaic and deep-marine siliciclastic strata. The present paper documents for the first time the paleogeographic setting of the Kashafrud Formation in the eastern Kopet-Dagh Basin based on ichnofossils.

Geological Setting and Stratigraphy

The Mesozoic geotectonic setting of northeastern Iran is poorly constrained, and alternative explanations are possible for some events. In general terms, subduction in northeastern Iran led to Early Cimmerian deformational events during the Late Triassic to Early Jurassic, during which the Turan Plate collided with the Cimmerian continental block and Paleo-Tethys closed [2-4,6-11]. In the Mid Jurassic, sedimentation commenced in the Kopet-Dagh Basin on the southern Turan Plate [1,3,5,12-14], probably reflecting back-arc extension

associated with northward subduction[14,15].

The Middle Jurassic clastic deposits of the Kashafrud Formation (Late Bajocian to Bathonian) in age, may be a consequence of Mid Cimmerian compressional events, evidence from the Turan Plate east of the Caspian Sea suggests that extensional faults influenced deposition during this period [3]. The Kashafrud Formation ranges in thickness from 280 m to 1753 m, rests unconformably on Triassic volcanogenic sedimentary rocks of the Sina Formation or nonconformably on ultrabasic intrusive rocks, and disconformably overlain by marine carbonates of the Mozduran Formation (Oxfordian to Kimmeridgian) [5].

Although most fossils are too fragmented for formal identification, the presence of the gastropod Lepidorrochus, the brachiopod Capillirhynchia, and the ammonites Parkinsonia, Partschiceras, Calliphylloceras, and Lytoceras confirm a Late Bajocian to Bathonian age for the bulk of the formation. Indeterminate shell fragments may have been contemporary or reworked from older bedrock.

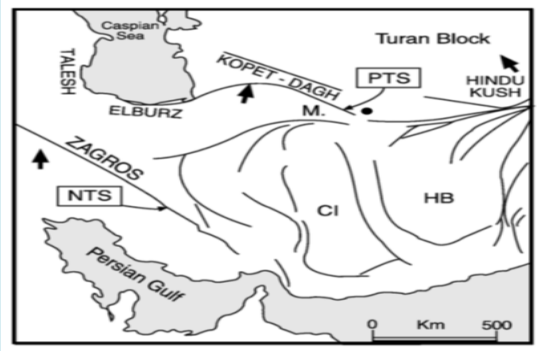

Figure 1: Present location of the Kopet-Dagh Basin relative to plates and major structural lines. CI=Central Iran. HB=Helmand Block. PTS=Paleo-Tethys Suture. NTS=Neo-Tethys Suture. M=Mashhad. Capitalized names indicate major mountain belts. The arrows indicate present-day relative motions. Modified from [10]. Black circle showing study area.

Methods

The Kashafrud Formation was studied in four stratigraphic sections (Agh-Darband, Kole-Malekabad, Sefid-Sang, Ghale-Sangi), where the formation's base and top are observed. The sections were measured bed-by-bed, and facies types were identified. Vegetation is sparse, and outcrops provide good exposure of conglomerate, sandstone, and limestone but only limited exposure of mudstone. Field observations were used to assess the lateral extent and thickness variation of sandstone and mudstone packages. Ammonites were collected and identified, and outcrop samples and photographs of trace fossils were obtained.

Result

Facies Associations

The strata are described in terms of 12 facies of conglomerate, sandstone, mudstone, and carbonate, which were assigned facies codes commencing with G, S, M, and C, respectively. The Basal Conglomerate Facies Association consists largely of fluvio-marine conglomerate with maximum clast size in the boulder range [10]. The overlying Sandstone and Mudstone Facies Association consists largely of interbedded packages of deep-water sandstone and mudstone. The facies are described below with the association in which they predominate. Sandstone and mudstone together form more than 90% of the formation, with sand proportions of 24% to 68.5% in individual sections.

Trace Fossils and Paleogeographic Setting

Trace-fossil assemblages have been identified in some stratigraphic intervals that may have formed under different environmental conditions. The most important ichofossils identified in this formation are Skolithos, Palaeophycus tubularis, Belorhaphe, Taenidium, Planoloites beverleyensis, and Thalassinoides suevicus. Thickbedded sandstones yielded Conichnus, Psilonichnus, Lophoctenium, Palaeophycus striatus, and Rhizocorallium jenense and Scolicia (Figure 2).

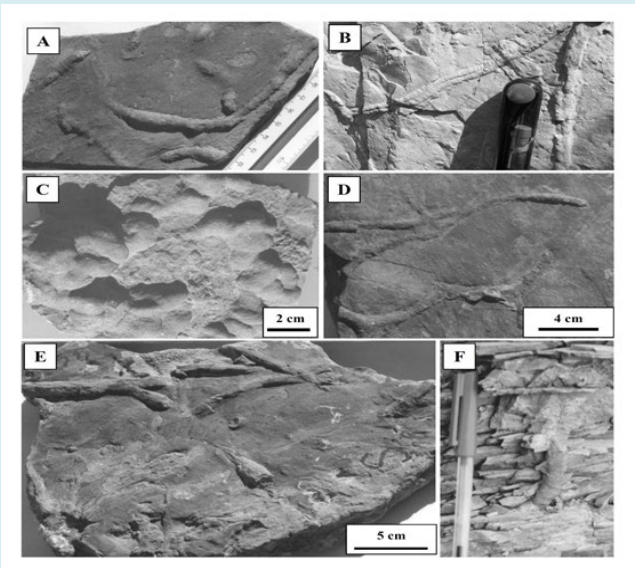

Figure 2: Kashafrud Formation trace fossils: A) Planololites beverlyensis; B) Scolicia; C) Lophoctenium; D) Thalassinoides suevicus; E) Palaeophycus striatus; F) Skolithos.

Based on identified ichnofossils as well as sedimentological evidences, the depositional environment of Kashafrud Formation has been interpreted as fluvio-deltaic and turbidite.Although evidence for bioturbation was observed at many levels, more identifiable occurrences were noted in the upper part of the formation.

Discussion and Conclusion

The Kashafrud ichnotaxa are largely traces made by deposit feeders, with a few formed by suspension feeders. The sandstones were deposited from density flows, including turbidity currents, that traversed submarine channels and laid down sand on levees, lobes and distal overbank areas. Rare boulder beds are attributed to submarine debris flows. Separating the sandstone sheets are mudstone units tens to hundreds of metres thick. They are mainly grey-green with some darker beds, and contain plant fragments, ammonites, belemnites, brachiopods and gastropods. They are interpreted as the deposits of hemipelagic settling and low-concentration turbidity currents [10]. A broadly similar trace fossil suite has been identified in many other deep-water basins [7-9, 15]. Buatois and Lopez Angriman [12] identified a suite of suspension feeders (including Skolithos) in minor channels and sandy plains distant from deep-water channels, with a suite of deposit feeders in muddy substrates. Within slope minibasins, Shultz and Hubbard [16] identified the Skolithos ichnofacies in thick-bedded sandstones, attributed to lobes or channel-termination sheet complexes. Consistent with the observations of Crimes [13] and Shultz and Hubbard [16], many of the Kashafrud ichnofossil assemblages are probably related to sediment gravity flows that brought oxygen and food to deep-water settings. The apparent upward increase in trace fossil occurrences may record a greater frequency of energetic sediment gravity flows with time, possibly linked to shallowing of the basin. According to Kashafrud Formation ichnofossils, it was deposited in a large, rapidly subsiding intracontinental basin, intertidal to shoreface, offshore and deeper water (Figure 3) [17].

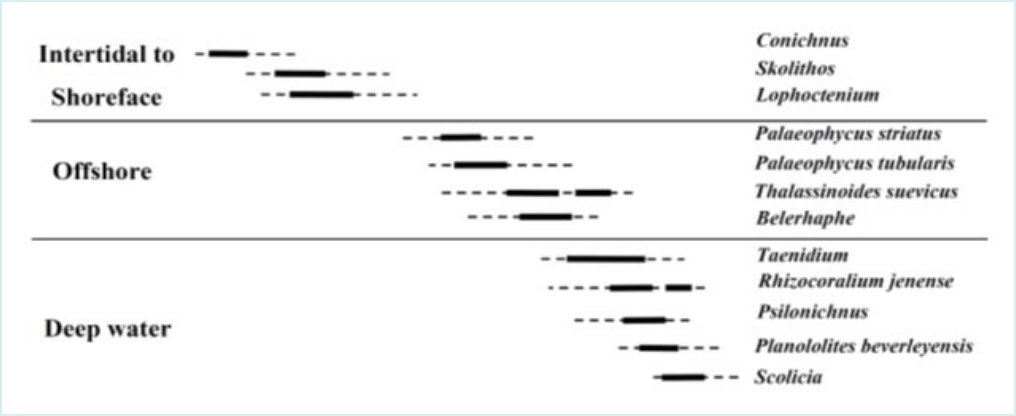

Figure 3: Identified ichnofossil assemblages of Kashafrud Formation, based on depth formation.

Acknowledgment

The author thanks the Islamic Azad University, Mashad branch, for financial support. Field support was also provided by the Geological Survey of Iran. He also grateful of George Pemberton kindly assisted with identification of some ichnofossils.

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