

## DEPOSITIONAL ENVIRONMENT OF THE PABDEH FORMATION (PALEOGENE) ELUCIDATED FROM TRACE FOSSILS, ZAGROS BASIN, W IRAN

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### ABSTRACT

*In the present study the Pabdeh Formation (late Paleocene-early Oligocene) was investigated in the Zagros Basin (W Iran). The main goal of this research was elucidating the depositional environments of this formation. This research was performed based on field observations and measurements, thin section petrography, trace fossil studies and OM (TOC % and kerogen type) measurements, from which seven microfacies assemblages were recognized. The Pabdeh Formation comprises alternation of thin to thick limestones and dark to light gray shale beds, rich in planktonic microfauna.*

*These facies are interpreted as pelagic facies in the Zagros Basin and consist of mudstone (md), wackestone (wk), packstone (pk) and shale beds. Based on systematic study of the ichnofossil content of these facies, five ichnogenera grouped in two separate assemblages were recognized. The first assemblage present a relatively high ichnodiversity (Arenicolites, Chondrites, Planolites and Neonerites) and occurs in md-wk-pk facies. This assemblage represents the Cruziana ichnofacies, formed in relatively moderate-energy conditions. The second assemblage with lower ichnodiversity (Zoophycos and Chondrites) is found in shale, wk, md and pk beds and represents the Zoophycos ichnofacies which were formed in low energy and deeper conditions. Vertical stacking of these facies suggest a shallowing-up ward trend with these facies deposited in a distally steepened carbonate ramp, where the depositional settings evolved from an outer ramp with pelagic and turbidite facies (Microfacies 4B and 4C) and reducing condition to oxygen depleted waters (TOC > 2.5%; kerogens type II, I and less amount III) that gradually changed into a middle ramp where marine currents (e.g. turbidity currents) had an important impact on sediment reworking and resedimentation.*

**Keywords:** *Pabdeh Formation, Zagros Basin, Depositional Environment, Ichnofossil, Carbonate ramp, Turbidite facies.*

### FACIES, ICHNOFACIES AND DEPOSITIONAL ENVIRONMENTS

In this study, two exposed sections of the Pabdeh Formation were selected from the NW of Illam city (Reno Pass and Hajbakhtiar sections) and more than 380 samples collected for petrographic and organic geochemistry analysis (Fig.1). Field observations focused on trace fossils content and sedimentary structures. Ichnofacies were classified based on Seilacher's method (1967; after Bromley 1990) for environmental interpretations. Bioturbation index was calculated according (Taylor & Goldring 1993) based on sharpness of primary sedimentary fabric, burrow abundance and amount of burrow overlap. Depositional environment was inferred based on Pedley's (1998) model. According to trace fossils, ichnofacies and petrographic evidences, this formation was divided into three units (lower, middle and upper)

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that comprising microfacies 1 to 4B, microfacies 4C to lower part of 6C and upper part of microfacies 6C to 7C, respectively. The *zoophycos* ichnofacies was recognized in the lower and middle units whereas the *cruziana* ichnofacies was recognized in the upper unit (Fig.2).

Kerogen type and TOC content of some selected nonbioturbated samples were measured by type III Rock-Eval pyrolyze in the Petroleum Industry Research Institute of Tehran.

### **TRACE FOSSIL ASSEMBLAGES**

Five different ichnogenera grouped into two distinct assemblages were recognized within the Pabdeh Formation. Moreover, *Chondrites* of different size are registered throughout the formation.

#### **ARENICOLITES-CHONDRITES ASSEMBLAGE**

This assemblage included *Arenicolites*, *Chondrites*, few *Planolites* and *Neonerites*? (diversity 2-4). Bioturbation index varies between 2-4 (mainly 4). This assemblage is frequent in the upper unit of the Pabdeh Formation (microfacies 7).

Penetration depth of *Arenicolites* varies between 2 to 10 cm and maximum burrow diameter is 10 mm in this assemblage. Large specimens of *Chondrites* (4-6 mm in diameter) are usually common in this assemblage. The details of cross-cutting relationships of ichnotaxa are as follows: 1- In few cases *Arenicolites* and *Neonerites* are cut by large *Chondrites*. 2- *Planolites* is cut by large *Chondrites* and *Neonerites*.

#### **ZOOPHYCOS-CHONDRITES ASSEMBLAGE**

This assemblage comprises *Zoophycos* and *Chondrites* (diversity 1-2). Bioturbation index varies between 3-5 (mainly 4). This assemblage is restricted to middle and lower units of the Pabdeh Formation (microfacies 3 to 6C). This assemblage begins with umbrella shape *Zoophycos*, sperite bearing *Zoophycos* (4 to 8 mm in diameter), and *Chondrites* (2mm in diameter) and terminated to irregular *Zoophycos* (3 mm in diameter) and small *Chondrites* (1 mm in diameter) (Fig.3). In several cases *Zoophycos* is cut by small *Chondrites*.

### **DISCUSSION**

Evidences such as trace fossils, microfacies and turbidite facies (e.g., calciturbidite of microfacies 4B and 4C) suggest that the depositional environment of the Pabdeh Formation was a distally steepend ramp (Fig.4). Absence of facies attributable to processes common on a rimmed shelf (e.g., breccia and megabreccia, shallow protected rimmed shelf with barrier reef/shoal) support these conclusions. Basinal sediments comprise rhythmic facies rich in OM (Droste 1990) (Microfacies 2 and 4A) or bioturbated sediments (Read 1985; Calvert et al. 1996) (Microfacies 3). These parts of the ramp that are relatively more deep and located at oxygen minimum zone, are suitable for deposition of reducing OM rich facies (microfacies 2 through 7A); these are called intrashelf basins. Bordenave and Huc (1995) interpreted OM rich facies of the Gurpi and Pabdeh Formations as deposited in such intrashelf basins. Al-Sharhan and Nairn (1995) also believe that some parts of the Pabdeh Formation were deposited in intrashelf basins.

There is a pronounced relation between ichnofacies, TOC content, kerogen type and depositional setting throughout the vertical section of the Pabdeh Formation. Obviously the

lower and middle units of this formation (*Zoophycos* ichnofacies, outer ramp) contain kerogens type II, I and less amount III with high TOC content (more than 2.5%) (except the base of the formation that coincide with microfacies 1 which has been interpreted as a deltaic facies with kerogen type III). Upward of the section (upper unit; middle ramp), the dominant kerogen type is III accompanying *Cruziana* ichnofacies with relatively low TOC content (2.8%-0.6%). In comparison with these facies, we concluded that depositional environment of the Pabdeh Formation was a steep ramp that passed basinward to intrashelf basins, wherein shallow facies of middle ramp gradually prograded on the outer ramp facies (middle and lower units of the Pabdeh Formation).

## CONCLUSIONS

- 1- The Pabdeh Formation was divided into three units: a lower unit (composed of microfacies 1 to 4B), a middle unit (microfacies 4C to lower part of 6C) and an upper unit (upper part of microfacies 6C to 7C) based on trace fossils, ichnofacies and petrographic evidences.
- 2- *Arenicolites-Chondrites* assemblage (BI: 2-4) were related to more oxygenated conditions in the upper unit of the Pabdeh Formation, whereas *Zoophycos-Chondrites* assemblage (BI: 3-5) reveals relatively oxygen depleted conditions in the middle and lower units of studied area.
- 3- Depositional environment of the Pabdeh Formation was distally steepened ramp terminated to intrashelf basin wherein OM rich facies was deposited.

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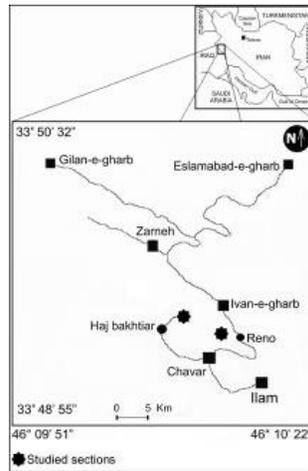


Fig.1- Location map of the study area in W Iran.

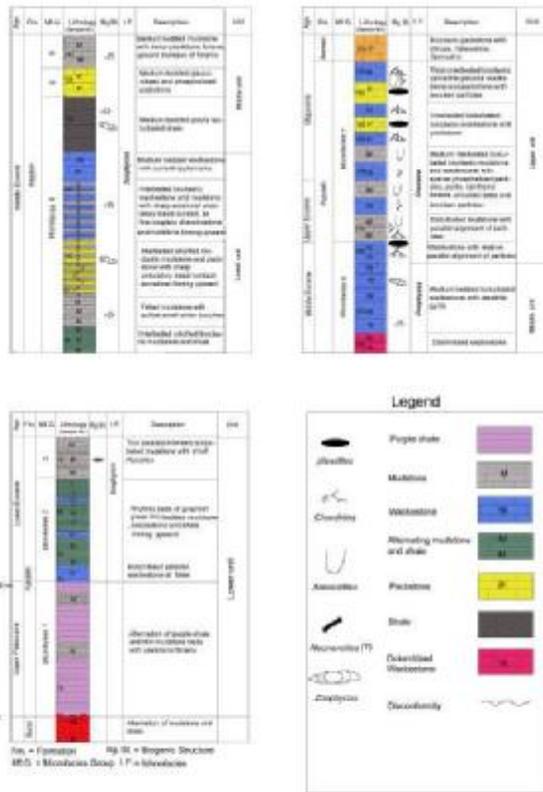


Fig.2- Detailed stratigraphic columns of the Pabdeh Formation at the Reno Pass section.

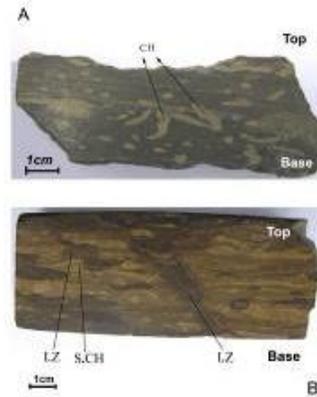


Fig.3- Zoophycos – Chondrites assemblage of Zoophycos ichnofacies at the lower unit of the Pabdeh Formation. I.Z=irregular Zoophycos, S.CH = small Chondrites.

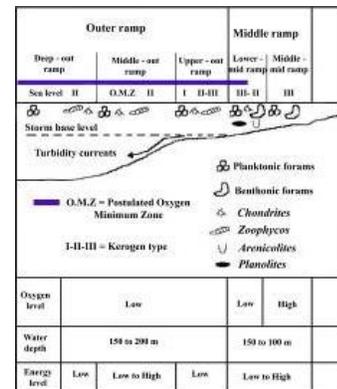


Fig.4-Depositional model proposed for the Pabdeh Formation in NW Ilam.