International Journal of Geography and Geology
2017 Vol. 6, No. 1, pp. 8-17
ISSN(e): 2305-7041
ISSN(p): 2306-9872
DOI: 10.18488/journal.10/2017.6.1/10.1.8.17

PALEOECOLOGY OF PERMO-TRIASSIC BOUNDARY ACCORDING TO PALYNOFLORA IN SHOURJESTAN, IRAN

B Mostafa Yousefi Rad[1]† --- Hamideh Noroozpour[2]
[1]*University of technology,Arak, ,Markazi State, Iran*
[2]*Department of Geology, Faculty of Science, Payame Noor University(PNU) Tehran, Iran*

ABSTRACT

Using palynoflora findings, the present study was conducted to determine paleoecology of Permo-Triassic boundary in Shourjestan Region in north of Fars Province. Permo-Triassic boundary in this region is gradational (transitional) and continuous. Four stratigraphic sections were selected and 7 spore and pollen instances were identified after sampling and performing needed experiments for separation of palynomorph samples. Based on the achieved palynomorphs on pyroclastic deposits in the studied sections, it can be concluded that Coniferophyta, Equisetopsids, Filicopsids, Progymnosperms and Cordaitales had probably higher relative frequency in plant tissue around the basin environment. According to relatively high frequency of land palynomorphs in the studied deposits and on the basis of association of land and marine palynomorphs in the studied palynoflora, it can be concluded that pyroclastic deposits of upper Permian are formed in shallow marine setting. Regarding studies on the identified palynomorphs of Elika Formation equivalent deposits, one might infer that probably in plant tissue around these deposits, Triassic seed ferns and Coniferophyta had higher frequency and distribution and also the aforementioned deposits are settled in shallow marine settings.

Keywords: Permian, Triassic, Paleoecology, Palynoflora, Abadeh, Shourjestan area, Iran.

Received: 8 August 2016/ **Revised:** 27 September 2016/ **Accepted:** 28 October 2016/ **Published:** 3 November 2016

1. INTRODUCTION

As of today, Permo-Triassic deposits have been studied with objectives such as identification of sedimentary environment, organic accumulations and determination of boundary type between Permian and Triassic sediments in different parts of Tethys Basin. The main examples of studies on Permo-Triassic deposits of Iran Basin include:

- Iran-British Petroleum Company experts investigated Abadeh Region and southwestern areas of Iran during 1935-1936. Later, results of this investigation were published by British Petroleum Company (1963) and Permian and Triassic deposits of Hambast Formation and Abadeh regions were also illustrated on 1:250,000 maps of Iran.
- Iranian-Japanese Research Group (1981) analyzed deposits of Permian-Triassic system in central Iran (Abadeh Region) and considered the boundary between these deposits as para-conformity.
- Having investigated Upper Permian-Lower Triassic sequence in Abadeh Region, Bando (1979) studied the Ammonoidea of the region and rendered a detailed report.
- Baghbani (1996) studied Permian deposits of Abadeh Region and Gol-Faraj stratigraphic section near Ali-Bashi stratigraphic section. In his point of view, Permian sequence is complete in these stratigraphic sections and encompasses all the Permian epochs of Tethys Region.

† Corresponding author

- Having studied Late Permian-Early Triassic sequence of Abadeh Region, Heydari *et al.* (2003) and Baud *et al.* (1989) carried out a geochemical investigation (carbon and strontium isotopes) and sedimentological survey on the respective deposits.
- Partoazar (2002) studied conodonts of Permian-Triassic boundary of Abadeh-Jolfa Belt in central Iran and northwestern expanses of the country.
- Noroozpour *et al.* (2013); Richoz *et al.* (2010); Angiolini and Stephenson (2008) and Muttoni *et al.* (2009) are also among the researchers each of whom conducted significant studies on the Permian-Triassic deposits in different basins of Iran.

The area under study is situated in Central Iran sedimentary basin and northern part of Fars province.

Stratigraphic Section A is located 6.6 km south of Esteghlal (2) Incombustible Clay Quarry at geographical coordinates of 52° 32" eastern longitude and 31° 26" northern latitude.

Stratigraphic Section B is located at geographical coordinates of 52° 32" eastern longitude and 31° 26" northern latitude near Shiraz-Isfahan Road (22 km from Izadkhast), 14 km advancing in Ramsheh branched road, and then, 3 kilometer northward along the dirt road.

Stratigraphic Section C is located at geographical coordinates of 52° 32" eastern longitude and 31° 29" northern latitude near Shiraz-Isfahan Road (35 km from Abadeh City), 18 km from Shourjestan village along the unpaved road. The aforementioned stratigraphic section is situated behind the dormitory of staff working in Esteghlal (2) Incombustible Clay Quarry (Fig. 1).

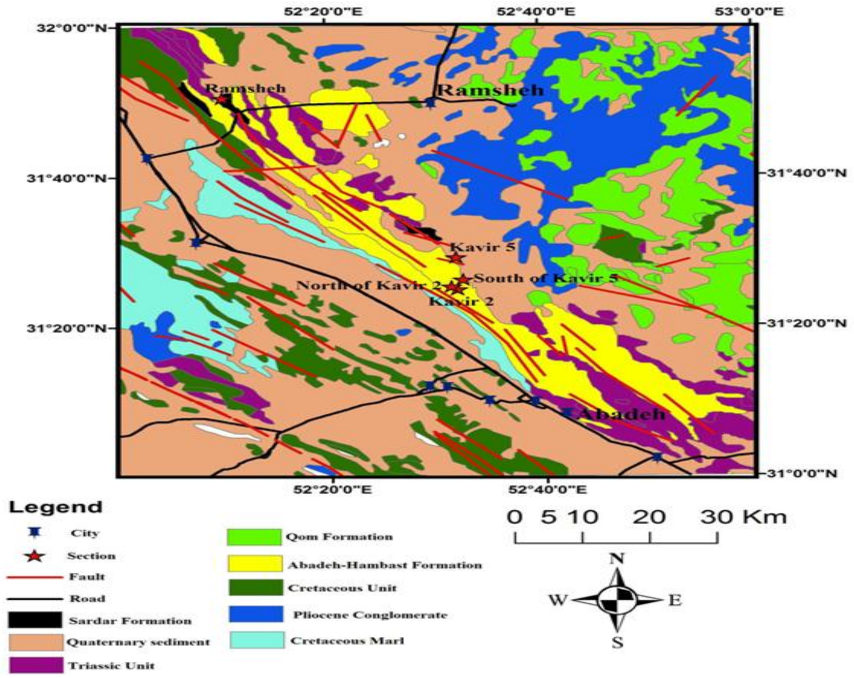

Fig-1. Land use map and approximate location of the studied section, Shourjestan area (This study).

2. DISCUSSION

Samples were taken in order to conduct palynology studies on appropriate horizons of Permian and Triassic deposits in Shourjestan Region. Strew slides were then prepared from the respective samples. The work procedure in the current study comprises the following three stages:

- A- Sampling
- B- Separation of palynomorphs from the host sediments and preparation of strew slides
- C- Studying the palynomorphs using microscopic and imaging tools

Lithological characteristics of Hambast Formation in the studied stratigraphic sections are as follow:

(Figure 2):

- Total thickness of this Formation varies between 23 to 32 meters in the studied stratigraphic sections.
- Lithology of Member 6 of this Formation consists of marly limestones with intercalations of green, red, and grey shales containing palynomorphs.
- Lithology of Member 7 of this Formation consists of red to purple limestones with interbeds of red and grey shales, and occasionally, gypsum intercalations as thick as 3-10 cm are observed. Presence of extremely thin gypsum intercalations indicates gradual and intense shallowing of the basin and extinction occurrence at the Permian-Triassic boundary. Red color of limestones in this unit can be differentiated throughout the region (Figure 3).
- Both upper and lower boundaries of Hambast Formation deposits are continuous and gradational with respect to Abadeh Formation and equivalent deposits of Elika Formation.

Lithological characteristics of equivalent Elika Formation in the studied stratigraphic sections are as below: (Figure 2):

- Early Triassic deposits in the studied stratigraphic sections starts with red to occasionally grey shale layers (suitable for palynology studies) with approximate thickness of 0.5 meter followed by sequence of marly limestones, red, green and grey shale strata and 1-3 meters of igneous rocks (Figure 3).

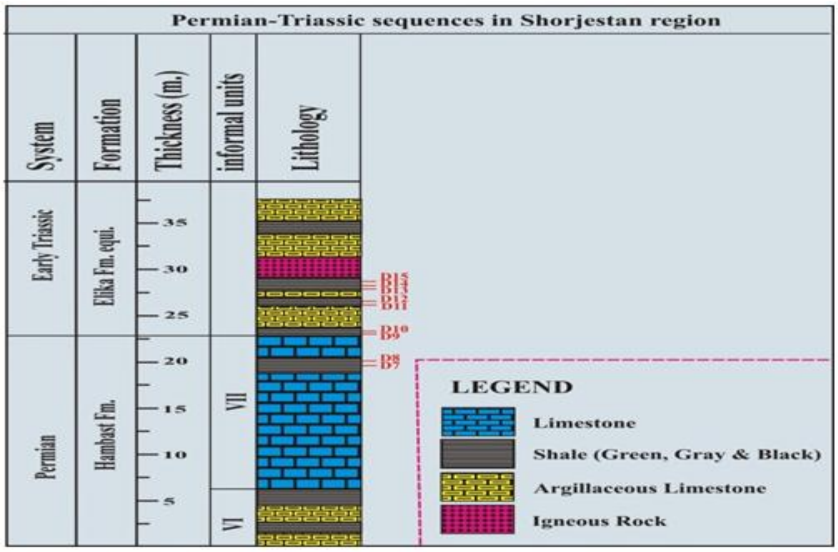

Fig-2. Lithostratigraphic column of the Early Triassic deposits, Shourjestan area, Central Iran (This study).

Fig-3. Hambast and Elika formations deposits, Shorjestan area, Central Iran (This study).

2.1. Palynology

In the Permian-Triassic deposits of Shourjestan region in northern part of Fars Province encompassing Abadeh and Hambast formations and equivalent Elika Formation deposits, there exists relatively well-preserved but poorly diverse marine and land palynomorphs including myospores, internal walls of foraminifera as well as plant tissues. Overall, 6 genus and 7 species were identified in the respective palynomorphs (Fig 4).

The findings include a relatively long time needed for recovery of vegetation (Eshet *et al.*, 1995; Looy *et al.*, 1999; Grauvogel-Stamm and Ash, 2005) and accumulation of large volume of decomposable organic matters and fungal spores, which indicate post-extinction circumstances (Steiner *et al.*, 2003; Vajda and McLoughlin, 2007) as well as bisaccate pollens such as Falcisporites sp. & Alisporites sp. It is noteworthy that Early Triassic palynoflora is by far poorer in terms of diversity and abundance, and mainly contains fungal spores.

The following species were identified in samples from the pyroclastic layers of Hambast Formation: monolete spores such as Laevigatosporites ovatus Wilson & Webster 1946, and monosaccate pollens such as Florinitesbalmei (Stephenson and Filatoff, 2000b); bisaccate pollens such as Alisporitesnuthallensis (Clarke, 1965) and Vittatinalata (Wilson, 1962).

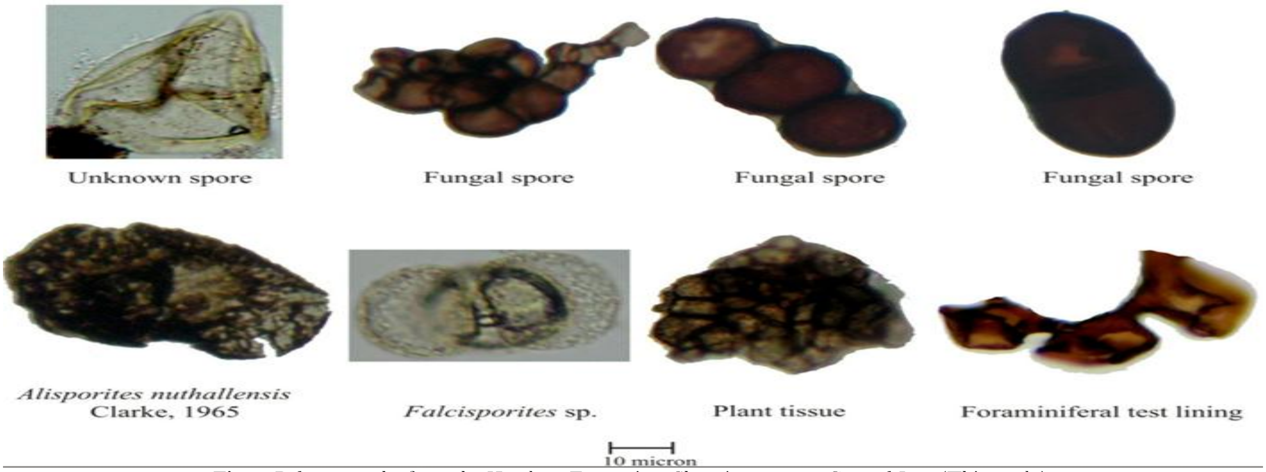

Fig-4. Palynomorphs from the Hambast Formation, Shourjestan area, Central Iran (This study).

2. 1. 1. Systematic Myospores

Anteturma Proximegerminates Potonie, 1970

Turma Triletes Reinsch emend. Dettmann, 1963

Subturma zonotriletes Waltz, 1935

Infraturma Cingulati Potonie & Klaus emend. Dettman, 1963

Unknown spore

Description: The spore features radial symmetry, trilete structure, triangular amb, relatively pointed radial zones, and somewhat convex inter-radial zones. Arms of trilete sign are distinctive and straight, equal to spore radius, with lips of 8-micron wide, undecorated proximal and distal surfaces, and the equatorial part of the sample contains a singulum with thickness of 10 microns. There is folding at the edge of corpus.

Dimensions: total diameter: 60 microns

Stratigraphic distribution: this sample was found in the studied stratigraphic sections from Elika Formation equivalent deposits (Early Triassic).

Turma Monoletes Ibrahim, 1933

Suprasubturma Acavatomonoletes Dettmann, 1963

Subturma Azonomonoletes Luber, 1935

Infraturma Laevigatomonoleti Dybova & Jachowicz, 1957

Genus *Laevigatosporites* Ibrahim emend. Schopf *et al.* (1944)

1933 *Laevigatosporites* Ibrahim, p. 39.

1944 *Laevigatosporites* Ibrahim emend. Schopf, Wilson, & Bentall, p. 36.

Type species: *Laevigatosporites vulgaris* (Ibrahim) Ibrahim, 1933; by original designation.

Laevigatosporites ovatus Wilson & Webster, 1946

1946 *Laevigatosporites ovatus* Wilson & Webster, p. 273, fig. 5.

Description: The spore is characterized by bilateral symmetry, monolete structure, oval to elliptical amb, completely distinctive and simple laesura; length of laesura is 25 micron or ¾ of spore length. The exine is single-layered, undecorated, and has thickness of 1-1.5 microns. The total length-to-width ratio of amb of the samples is 1:1.5.

Dimensions: total size is 22*23 microns

Stratigraphic distribution: This species has broad stratigraphic distribution and has been reported in Lower Carboniferous deposits in Canada (Playford, 1971) Middle Jurassic in Koppeh-Dagh (Sajjadi *et al.*, 2007) and also, Upper Devonian and Early Permian deposits in northern part of Persian Gulf (Hashemi and Nezam, 2015). This species has been also found in stratigraphic sections of the studied area (Shourjestan Region) from deposits of Hambast Formation.

Resemblance: The plants producing this species are classified as Equisetopsida (Order: Bowmanitales), Filicopsida (Order: Marattiales, Family: Polypodiaceae), and Progymnospermopsida (Order: Noeggerathiales) (Balme, 1995).

Anteturma Variegerminantes Potonie, 1970

Turma Saccites Erdtman, 1947

Subturma Monosaccites Chitaley, 1951 emend. Potonie & Kremp, 1954

Infraturma Aletesacciti Leschik, 1955

Genus *Florinites* (Schopf *et al.*, 1944)

1944 *Florinites* Schopf et al., p. 56.

Type species: *Florinites antiques* Schopf in S. W. & B. 1944; by original designation.

? *Florinites balmei* (Stephenson and Filatoff, 2000b)

2000 ? *Florinites balmei* Stephenson & Filatoff, p. 24.

Description: The spore is characterized by monosaccate pollen with bilateral symmetry, lack of laesura sign, elliptical to oval amb where the pollen corpus is nearly circular to elliptical in the polar view. The sac cannot be generally differentiated, and is occasionally identifiable due to presence of a narrow elliptical folding. The longitudinal axis of sac and the corpus are orientated along the same direction. The sac diameter is often half of the diameter of the corpus. Also, the sacs feature infra-reticulate structure and their muri width does not exceed 1 micron. In some samples, thickening is observed in the equatorial margin.

Dimensions: longitudinal axis: 35-45 microns and lateral axis: 25*38 microns

Stratigraphic distribution: This species has been so far widely reported in the southern margin of neo-Tethys. The instance are Late Permian deposits of Saudi Arabia (Stephenson and Filatoff, 2000b; Stephenson *et al.*, 2003) Middle Permian deposits in Pakistan (Jan *et al.*, 2009) pyroclastic deposits of basal Khowf Formation in UAE, Qatar, and Kuwait (Tanoli *et al.*, 2008). Also, the respective species was found in the studied stratigraphic sections in the pyroclastic deposits of Hambast Formation.

Resemblance: This species was produced by primitive conifers such as Ernestiodendron, Lebachia, and Walchiostrobus and also by cordaitalesincluding Cordatanthus (Potonié and Kremp, 1956; Bharadwaj and Venkatachala, 1968; Rothwell, 1982; Trivett and Rothwell, 1985)

Subturma Disaccites Cookson, 1947

Genus *Alisporites* Daugherty, 1941

1941 *Alisporites* Daugherty, p. 98.

Type species: *Alisporites opii* Daugherty, 1941; by original designation.

Alisporites nuthallensis (Clarke, 1965).

1965 *Alisporites nuthallensis* Clarke, p. 325.

Description: Bisaccate pollen, bilateral symmetry, elliptical corpus, lacking longitudinal and lateral thickening lines (non-taeniate), having two generally interconnected sacs (haploxylonoid); the connection of two sacs to corpus is observed thicker and darker. The internal structure of the sacs is poorly preserved.

Dimensions: Length of corpus: 51-62 microns, width of corpus: 25-37 microns, length of sacs: 45-50 microns, width of sacs: 24-35 microns

Stratigraphic distribution: This species has been reported from Late Permian deposits of England (Clarke, 1965) Permian deposits in Australia (Foster, 1975) Early Permian deposits in Turkey (Akyol, 1975) Late Permian sediments in Saudi Arabia (Stephenson and Filatoff, 2000b) Permian deposits of Saudi Arabia and Oman (Stephenson *et al.*, 2003) and Middle Permian sediments of Pakistan (Jan *et al.*, 2009). The respective species has been also observed in Iran's Early Permian deposits in Doroud Formation (Hashemi, 1991) Faraqan Formation (Ghavidel-Syooki, 1996; Nezam-Vafa and Hashemi, 2013) Early Permian sediments of Alborz Region (Muttoni *et al.*, 2009). In addition, it was found in the studied stratigraphic section in different horizons of Hambast Formation.

Alisporites sp.

Description: Bisaccate pollen, bilateral symmetry, circular to elliptical corpus, lacking longitudinal and lateral thickening lines, two interconnected relatively symmetrical sacs; the connection of two sacs to the corpus is observed thicker and darker with a width of 5 microns. The internal structure of sac is not preserved.

Dimensions: length of corpus: 47 microns, width of corpus: 32 microns, length of sacs: 39 microns, and width of sacs: 23 microns

Stratigraphic distribution: This species has been found in the studied stratigraphic sections at different horizons of Elika Formation equivalent deposits (Early Triassic).

Resemblance: This species has been produced by conifers such as Pteruchus, Lelestrobus, Willstostrobus (Townrow, 1962; Grauvogel-Stamm, 1978; Srivastava, 1984).

Infraturma Disacciatrileti (Leschik, 1955) R. Pot, 1958

Genus *Falcisporites* Leschik emend. Klaus, 1963

1955 *Falcisporites* Leschik, p. 47.

1963 *Falcisporites* Klaus, p. 54.

Type species: Pityosporites zapfei Potonie & Klaus, 1954; by original designation.

Falcisporites sp.

Description: bisaccate pollen with overall globular shape, bilateral symmetry, rounded to elliptical corpus, lacking longitudinal and lateral thickening lines (non-taeniate), having two separate sacs (diploxylonoid); connection of two sacs to the corpus is observed thicker and darker. The sacs are convergent on the distal surface and a wide furrow (sulcus) is observed. The internal structure of the sac is poorly preserved.

Stratigraphic distribution: This species was found in the studied stratigraphic sections in Elika Formation equivalent deposits (Early Triassic).

Resemblance: The same as Esignisporites and Vitrisporites, Falcisporites have been generated by Triassic seed ferns such as Harristothechan (Townrow, 1962).

Turma Plicates Naumova emend. Potonie, 1960

Subturma Costates Potonie, 1970

Genus *Vittatina* Luber ex Samoilovich emend (Wilson, 1962).

1940 *Vittatina* Luber, p. 63. (nom nud)

1953 *Vittatina* Luber *ex* Samoilovich, p. 85.

1962 *Vittatina* Luber ex Samoilovich; Wilson, p. 24.

Type species: *Vittatina subsaccata* Smaoilovich, 1953 by subsequent designation; (Wilson, 1962).

Vittatina lata (Wilson, 1962).

1962 *Vittatina lata* Wilson, p. 22.

Description: bisaccate pollen, elliptical corpus, having 8-14 longitudinal thickenings which widens in the central part (4-5 microns) and tapers toward the edges; having two separate tiny sacs much smaller than the corpus; exine thickness of the corpus is 1-1.5 microns.

Dimensions: total length: 45 and 37 microns, total width: 32 and 21 microns

Stratigraphic distribution: This species has been reported in Late Permian deposits of USA (Wilson, 1962) and Permian deposits of India (Venkatachala and Kar, 1968). The respective species have been also recorded in Iran's Lower Permian deposits in Doroud Formation (Hashemi, 1991) and also in Faraghan Formation by Nezam-Vafa and Hashemi (2013). It was found in the studied stratigraphic sections at different horizons of Hambast Formation.

Resemblance: This species has been probably produced by coniferous plants (Potonié, 1967).

3. DISCUSSION

This study is one of few studies which have investigated as analysis the samples taken from Hambast Formation in the stratigraphic sections of Shourjestan Region for palynology is indicative of the fact that palynoflora is characterized by low diversity and relatively good preservation, comprising monosaccate pollens, non-striped bisaccate pollens, striped bisaccate pollens, few monolete spores, inner wall of foraminifera, and plant tissues within the respective deposits.

The identified samples include terrestrial palynomorphs together with few marine palynomorphs. Based on the certain and probable resemblances determined for the palynomorphs (such as the study by Balme (1995)) palynomorphs can be used for determining probable vegetation around the studied sedimentary basin.

- Florinites have been probably generated by cordaitales (Schopf *et al.*, 1944)
- Alisporites have been produced by conifers such as Pteruchus, Lelestrobus, and Willsiostrobus (Townrow, 1962; Grauvogel-Stamm, 1978; Srivastava, 1984).
- Vittatina have been also produced by conifers (Wilson, 1962; Potonié, 1967)
- Laevigotosporites have been generated by equisetopsides, filicopsids, progymnosperms (Balme, 1995).

Based on this study documents and according to above-mentioned discussions, it can be assumed that Coniferophyta, Equisetopisds, Progymnosperms, and Cordaitale shad higher relative abundance in the vegetation surrounding the sedimentary basin of Hambast Formation. Furthermore, various palynomorph groups have been used as of today to analyze the depositional environment and also distance from paleo-shoreline. Due to relative frequency of terrestrial palynomorphs in the studied deposits and also based on coexistence of continental and marine palynomorphs in the studied sample, one might conclude that pyroclastic deposits of Hambast Formation have been formed in highly shallow marine environment of continental margin.

Taking into account occurrence of the massive extinction at the end of Permian, elimination of most of vegetation and lack of sufficient time for their recovery in Lower Triassic deposits of the studied stratigraphic section,

A palynoflora with poor diversity including *Alisporites* sp., *Falcisporites* sp., and fungal spores was found. Remarkable abundance of fungal spores and plant tissues in Lower Triassic deposits most probably results from extinction of vegetation in the Permo-Triassic boundary and accumulation of decomposable organic matters. It is also noteworthy that relative frequency of terrestrial palynomorphs as well as poor presence of marine palynomorphs leads to the inference that the respective sediments settled in a highly shallow marine environment at the edge of continent. Additionally, regarding resemblance of the identified palynomorphs, conifers and Triassic seed ferns had larger frequency and distribution in the vegetation surrounding the depositional environment of the respective sediments (Townrow, 1965; Taylor, 2009).

4. RESULTS AND CONCLUSIONS

Based on the analysis of the pyroclastic deposits of Hambast Formation in the studied stratigraphic sections, it can be concluded that Coniferophyta, Equisetopsids, Filicopsids, Progymnosperms, and Cordaitales probably had the largest relative frequency in the vegetation surrounding the sedimentary basin of respective Formation. Besides, due to relative abundance of terrestrial palynomorphs in the studied deposits and also based on simultaneous presence of terrestrial and marine palynomorphs in the studied samples, it can be inferred that the pyroclastic deposits of Hambast Formation were formed in highly shallow marine environment of continental margin.

According to the study on the palynomorphs identified in the Elika Formation equivalent deposits, another conclusion is that conifers and Triassic seed ferns had the largest relative frequency in the vegetation surrounding the depositional environment of the respective sediments which have been deposited in a highly shallow marine environment at the edge of continent.

Funding: This study received no specific financial support.

Competing Interests: The authors declare that they have no competing interests.

Contributors/Acknowledgement: All authors contributed equally to the conception and design of the study.

REFERENCES

Akyol, E., 1975. Palynologie du Permien inferieur de Sariz (Kayseri) et de Pamucak Yaylasi (Antalya-Turquie) et contamination Jurassique observee due aux ruisseaux"Pamucak et Goynuk". Pollen et Spores, 17(1): 141-179.

Angiolini, L. and M.H. Stephenson, 2008. Lower permian brachiopods and palynomorphs from the Dorud formation (Alborz Mountains, north Iran): New evidence for their palaeobiogeographic affinity. Fossils and Strata, 54: 117–132.

Baghbani, D., 1996. Biostratigraphy of Permian deposits in Abadeh, Shorjestan, Shahreza belt. Ph.D. Thesis, Islamic Azad University, Science and Research Branch, 168.

Balme, B.E., 1995. Fossils in situ spores and pollen grains: An annotated catalogue. Review of Palaeobotany and Palynology, 87(2-4): 85-323.

Bando, Y., 1979. Upper Permian and lower Triassic ammonoids from Abadeh, central Iran. Mem. Fac. Educ. Kagawa Univ, 29(2): 103-138.

Baud, A., M. Magaritz and W.T. Holser, 1989. Permian-triassic of the tethys: Carbon isotopes studies. Geologische Rundschau, 78(2): 649-677.

Bharadwaj, D.C. and B.S. Venkatachala, 1968. Suggestions for a morphological classification of sporae dispersae. Review of Palaeobotany and Palynology, 6(1): 41-59.

British Petroleum Company, 1963. Geological map of Deh-Bid (Iran), 1: 250,000.

Clarke, R.F.A., 1965. British Permian saccate and monosulcate miospores. Palaeontology, 8(2): 322-354.

Eshet, Y., M.R. Rampino and H. Visscher, 1995. Fungal event and palynological record of ecological crisis and recovery across the Permian-Triassic boundary. Geology, 23(11): 967-970.

Foster, C.B., 1975. Permian Plant microfossils from the Blair Athol Coal measures, centeral Queensland, Australia. Palaeontographica Abteilung B, 154: 121-171.

Ghavidel-Syooki, M., 1996. Acritarch biostratigraphy of the Palaeozoic rock units in the Zagros Basin, Southern Iran. ACTA-UNIVERSITATIS CAROLINAE GEOLOGICA: 385-412.

Grauvogel-Stamm, L., 1978. La flore du Grès à Voltzia (Buntsandstein supérieur) des Vosges du Nord (France): Morphologie, anatomie, interprétations phylogénique et paléogéographique. No. 50. Alexander Doweld.

Grauvogel-Stamm, L. and S.R. Ash, 2005. Recovery of the Triassic land flora from the End-Permian life crisis. Comptes Rendus Palevol, 4(6–7): 593-608.

Hashemi, S.H., 1991. Palynology of Dorud formation (Central Alborz) and investigating the Paleogeography relationship between study area and Permian of Gondwana Supercontinent. Master of Science Thesis. University of Tehran. pp: 161.

Hashemi, S.H. and V.N. Nezam, 2015. Palynology and palaeoecology of the Zakeen formation, Kish Gasfield, Northern Persian Gulf. Journal of Stratigraphy and Sedimentology, 3(56): 1-16.

Heydari, E., J. Hassanzadeh, W.J. Wade and A.M. Ghazi, 2003. Permian–Triassic boundary interval in the Abadeh section of Iran with implications for mass extinction: Part 1–Sedimentology. Palaeogeography, Palaeoclimatology, Palaeoecology, 193(3): 405-423.

Jan, I.U., M.H. Stephenson and F.R. Khan, 2009. Palynostratigraphic correlation of the Sardhai formation (Permain) of Pakistan. Review of Palaeobotany and Palynology, 158(1): 72-82.

Leschik, G., 1955. Die Keuperflora von Neuewelt bei Basal 2, Die Iso-und Mikrosporen. Schweizer. Palaoni, 72: 5-70.

Looy, C.V., W.A. Brugman, D.L. Dilcher and H. Visscher, 1999. The delayed resurgence of equatorial forests after the Permian–Triassic ecological crisis. Proceedings of the National Academy of Sciences, 96(24): 13857–13862.

Muttoni, G., M. Gaetani, D.V. Kent, D. Sciunnach, L. Angiolini, F. Berra and A. Zanchi, 2009. Opening of the Neo-Tethys ocean and the Pangea B to Pangea a transformation during the Permian. GeoArabia, 14(4): 17-48.

Nezam-Vafa, N. and S.H. Hashemi, 2013. Early permian palynology of Faraghan formation, Kish Gas field, Northern Persian Gulf. 17th Congress of Geological Society of Iran. pp: 65-73.

Noroozpour, H., Y.M. Rad, M. Arian, A. Solgi and N.N. Vafa, 2013. Permo-Triassic deposits of Shorjestan area, central Iran: The palynological report of the greatest phanerozoic disaster in Iran. Disaster Advances, 6(2): 48-53.

Partoazar, H., 2002. Permian- Triassic boundary conodonts from Jolfa-Abadeh belt along Northwest and central Iran. Permophiles, 41: 34-40.

Playford, G., 1971. Lower carboniferous spores from the Bonaparte Gulf Basin, Western Australia and Northern territory. Bureau of Mineral Resources, Geology and Geophysics, Bulletin, 115: 105.

Potonié, R., 1967. Versuch der Einordnung der fossilen Sporen dispersae in das phylogenetische system der Pflanzenfamilien, Forschungsber, Landes Nordrhein-Westfalen. Nr. 1761.

Potonié, R. and G. Kremp, 1956. Die sporae dispersae des Ruhrkarbons, ihre Morphographie und Stratigraphie mit Ausblicken auf Arten anderer Gebiete und Zeitabschnitte, Teil III. Palaeontographica Abteilung B, 100(4-6): 65-121.

Richoz, S., L. Krystyn, A. Baud, R. Brandner, M. Horacek and P. Mohtat-Aghai, 2010. Permian–Triassic boundary interval in the Middle East (Iran and N. Oman): Progressive environmental change from detailed carbonate carbon isotope marine curve and sedimentary evolution. Journal of Asian Earth Sciences, 39(4): 236–253.

Rothwell, G.W., 1982. New interpretations of the earliest Conifers. Review of Palaeobotany and Palynology, 37(1): 7-28.

Sajjadi, F., H. Hashemi and A. Dehbozorgi, 2007. Middle Jurassic palynomorphs of the Kashafrud formation, Koppeh Dagh Basin, Northeastern Iran. Micropaleontology, 53(6): 391–408.

Schopf, J.M., L.R. Wilson and R. Bentall, 1944. An annotated synopsis of paleozoic fossil spores: And the definition of generic groups. Report of Investigations No. 091.

Srivastava, S.C., 1984. Lelestrobus: A new microsporangiate organ from the Triassic of Nidpur, India. Palaeobot, 32(1): 86-90.

Steiner, M.B., Y. Eshet, M.R. Rampino and D.M. Schwindt, 2003. Fungal abundance spike and the Permian–Triassic boundary in the Karoo Supergroup (South Africa). Palaeogeography, Palaeoclimatology, Palaeoecology, 194(4): 405–414.

Stephenson, M.H. and J. Filatoff, 2000b. Description and correlation of Late Permian palynological assemblages from the Khuff Formation, Saudi Arabia and evidence for the duration of the pre-Khuff hiatus, in Al-Hajri, S., and Owens, B., eds., Stratigraphic Palynology of the Paleozoic of Saudi Arabia: GeoArabia Special Publication 1. Bahrain: Gulf PetroLink. pp: 192-215.

Stephenson, M.H., P.L. Osterloff and J. Filatoff, 2003. Palynological biozonation of the Permian of Oman and Saudi Arabia: progress and challenges. GeoArabia, 8: 467–496.

Tanoli, S.K., R. Husain and A.A. Sajer, 2008. Facies in the Unayzah formation and the Basal Khuff clastics in subsurface, Northern Kuwait. GeoArabia, 13(4): 15–40.

Taylor, T.N., 2009. Paleobotany, the biology and evolution of fossil plants. Acad. Press of Elsev, 1230.

Townrow, J.A., 1962. On some disaccate pollen grains of Permian to middle Jurassic age. Grana Palyn, 3(2): 13-44.

Townrow, J.A., 1965. A new member of the corystospermaceae Thomas. Ann. Bot. N.S, 29: 495-511.

Trivett, M.L. and G.W. Rothwell, 1985. Morphology, systematics, and paleoecology of Paleozoic fossil plants: Mesoxylon priapi, sp. nov. (Cordaitales). Systematic Botany, 10(2): 205–223.

Vajda, V. and S. McLoughlin, 2007. Extinction and recovery patterns of the vegetation across the Cretaceous–Palaeogene boundary—a tool for unravelling the causes of the End-Permian mass-extinction. Review of Palaeobotany and Palynology, 144(1): 99-112.

Venkatachala, B.S. and R.K. Kar, 1968. Palynology of the North Karanpura Basin, Bihar, India- 2. Barakar exposures near Lungatoo, Hazakibagh district. Palaeobotanis, 16(3): 258-269.

Wilson, M.R., 1962. Plant spores and other microfossils from Upper Devonian and Lower Mississippian rocks of Ohio. No. 364. US Govt. Print. Off.

BIBLIOGRAPHY

Barss, M.S. and G.L. Williams, 1973. Palynology and nonofossils processing techniques. Geological Survey of Canada, Paper, 73(26): 1-25.

British Petroleum Company, 1964. Geological maps, columns and sections of the High Zagros of Southwest Iran. London: British Petroleum Co., Ltd.

Kozur, H.W., 2004. Pelagic uppermost Permian and the Permian-Triassic boundary conodonts of Iran, Part I: Taxonomy. Hallesches Jahrb. Geowiss, 18: 39-68.

Kozur, H.W., 2005. Pelagic uppermost Permian and the Permian-Triassic boundary conodonts of Iran. Part II: Investigated sections and evaluation of the conodont faunas: Hallesches Jahrb. Geowiss., Beiheft, 19: 49-86.

Kozur, H.W., 2007. Biostratigraphy and event stratigraphy in Iran around the Permian- Triassic boundary (PTB): implications for the cause of the PTB biotic crisis. Global and Planetary Change, 55(1): 155-176.

Phipps, D. and G. Playford, 1984. Laboratory techniques for extraction of palynomorphs from sediments. Paper, Department of Geology, University of Queensland, 11(1): 1-23.

Stampfli, G.M. and G.D. Borel, 2002. A plate tectonic model for the Palaeozoic and Mesozoic constrained by dynamic plate boundar and restored synthetic oceanic isochrones. Earth and Planetary Science Letters, 196(1): 17-33.

Taraz, H., 1974. Geology of the Surmaq-Deh Bid area, Abadeh region, Central Iran. No. 37. Geological Survey of Iran.

Traverse, A., 2007. Paleopalynology. Dordrecht: Springer. pp: i-xvii, 813.

Wood, G.D., A.M. Gabriel and J.C. Lawson, 1996. Palynological techniques-processing and microscopy. Palynology: Principles and Applications, 1: 29-50.

Yazdi, M. and M. Shirani, 2002. First research on marine and nonmarine sedimentology sequences and micropaleontologic significance across Permian- Triassic boundary in Iran (Isfahan & Abadeh). Journal of China University of Geosciences, 13(2): 172-176.