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Palynostratigraphy, Palaeogeography and Source Rock Evaluation of the Nayband Formation at the Parvadeh area, Central Iran, Iran

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Abstract

The Nayband Formation was measured and sampled in Parvadeh area, southern Tabas city. In this area, this formation has a thickness of 1410 m, dividing into four members, namely Gelkan, Bidestan, Howz-e-sheikh and Howz-e-khan. A total 573 samples were treated for Palynological analysis, and only 120 samples were productive. A total of 57 miospore taxa and 11 plant macrofossil were encountered. Based on stratigraphic distribution of macrofossil and miospore taxa ten assemblage zones were established throughout the Nayband Formation. The encountered miospore taxa and plant macrofossil suggest Upper Triassic (Norian-Rhaetian) for the Nayband Formation.Rock-Eval data shows the presence of organic matter-rich shales with Type III kerogen. The Nayband Formation in the studied section has experienced high temperature which is confirmed by vitrinite reflectance measurements of 0.9-1.2 %VRr. At this thermal maturity stage, organic-rich shales in the formation have generated liquid hydrocarbons as evidenced by the occurrence of solid bitumen in the respective samples.

Keywords: Palynostratigraphy; Palaegeography; Source Rock; Upper Triassic; Nayband Formation.

Introduction

The Lower Triassic sediments in Iran are mainly of shallow marine or continental shelf in nature (e.g., Elika dolomite Formation in Alborz, Sorkh shales and Shotori dolomite Formation in Central Iran) [3]. Likewise, a continuous Permian–Triassic sequence has been reported from several areas in Iran, including Jolfa (northwest of Iran), Abadeh (Southern Central Iran), and Southern Urumiyeh (the continuation of Taurus in Turkey), north of Kandovan and Southern Amol.

The transition from Middle to Upper Triassic coincides with Early Cimmerian orogenic episode, which led to the segmentation of the sedimentary basin

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into three sub-basins: Zagros in south and southwest, Alborz in north, and Central Iran [1].

Nayband Formation

The Nayband Formation is the oldest stratigraphic unit of Shemshak Group of Central Iran. This formation was introduced by [39] in Nayband area and divided into three series, Houz-i-sheikh (lower), Nayband serie (middle) and Houz-i-khan (upper). Later on, Stöcklin, 1961 in [109] revised these series and showed that Houz-i-sheikh serie is younger than Nayband serie. Type section of Nayband Formation was introduced by [17] that they measured it in southern flank of Nayband Mountain and it was approved by National Iranian Stratigraphic Committee (NIRSC) in 1976 [68]. In this area, the type section of Nayband Formation consists of four members which are discussed in ascending stratigraphic order in below:

a) Gelkan Member is 915 m thick and includes intense weathered pencil shales and light gray siltstone and thin sandstone beds in 1/3upper part. Sedimentary structures such as ripple marks and cross-bedding are present in this Member. The Gelkan Member contains Bivalves (*Megalodon*) and plant remains in some horizons.

b) Bidestan Member has a thickness of 450 m which consist of shale, siltstone sandstone and intercalation of brownish, thin-bedded sandy limestone and marl bearing Coelantaria fossil (*Heterastridum* sp.). In general, this Member is marked by pinkish-to cream color which distinguishes it from other members of Nayband Formation. Index fossil of this Member is *Heterastridum*, indicating the Late Triassic age (Norian).

c) Howz-e-Sheikh Member is 365 m thick and consists of pencil shales which change upward to siltstone and brownish sandstone. The most common fossils in this member are Bivalves and Hydrozoans. This Member has been assigned to Late Triassic (Norian) based on stratigraphical position

d) Howz-e-Khan Member has a thickness of 465 m which, consist of cliff forming reefal limestone with intercalations of shale and sandstone. This Member contains Corals, Hydrozoans, Brachiopods, Bivalves, Gastropods and some Echinoderms, indicating Late Triassic (Norian).

These four members of Nayband Formation don’t have uniform lithology and thickness and their characteristics change from place to another place. Therefore, their recognition from each other is sometime difficult. It should be mentioned that the Howz-e-Khan was the uppermost of Nayband Formation since 1978 in Central Iran. In 1983, [71] added three new informal members to the Nayband Formation. At the time being, the Nayband Formation comprises of four formal members (Gelkan, Bidestan, Howz-e-Sheikh and Howz-e-Khan) in the lower part and three informal members (coal shale, sandstone, corally limestone and red sandstone) in upper part of the sequence. However, the geologists of Steel National Company (SNC) combined three informal members and introducing as Qadir member. Therefore, the Nayband Formation consists of five members (Gelkan, Bidestan, Howz-e-sheikh, Howz-e-khan and Qadir) based on the geologists of Steel National Company. Furthermore, there is an ancient karst content of iron oxide and somewhere Barite and Galena between Nayband Formation (in upper) and Shotori Formation (in lower). It should be mentioned that upper contact of Triassic sedimentary succession is not clear with lower Jurassic strata (Ab-e-Haji Formation). Palynological investigation was carried out on the Nayband Formation by [67]. They established nine local biozones in this formation. Based on their study, the Gelkan member has assigned to late Carnian-early Norian, Bidestan to middle Norian, Howz-e-Sheikh member late Norian and Howz-e-khan member late Norian-early Rhaetian age. On the other hand, the marine palynomorph (dinoflagellates) is more abundant than land derived palynomorph (pollen grains and spores), representing a shallow marine environment which variety plants had grown in adjacent area.

Correlation and development geographical

The Nayband Formation is part of coaly sediments in Upper Triassic of Iran with pseudomollas facies which corresponds to early Cimerian Orogeny with high subsidence in shallow environment. In Central Iran, this Formation has been reported from different provinces such as Yazd (Kharanagh, Ardakan), Khorassan (Shotori mountain range, Boshroyeh, Gonabad, Biabanak-Bafgh, Kalmard), Isfahan (Kashan, Golpayegan,), Arak (Tafresh) and Kerman (Lakar-kouh) (Fig. 2). The lithological characteristics of Triassic sediments are quite different in the Zagros Mountains with those of Alborz Mountains (Elika Fm, Mian kuhi Fm and Sina Fm) as well as Central Iran.

Except Zagros Basin, the Upper Triassic deposits from lithostratigraphical and chronostratigraphical points of views are the same. This is due to foreland environment with the shallow depth and warm climate. They compare to rocks units at the same time in Central Asia in Northeastern of Zagros thrust (Iran plate) with Central Asia (Touran plate). Palynological assemblages of Nayband Formation are most similar to Afghanistan, Germany, North of America and North of Europe. [67]

believe that Central Iran was in south side of Eurasia land in Late Triassic.

Material and Methods

Palynological analysis

A total of 574 samples were processed and only 120 samples mainly shale, coaly shale, coal and siltstone were yielded well preserved and abundant miospores. Processing followed standard pa1ynological techniques [101] using HCl and HF in order to remove carbonate and silicates respectively. Heavy liquid separation ($ZnBr_2$ with specific gravity of 1.95). All slides used in this study are housed in palaeontological collection of Tehran University.

Elemental geochemistry

Total organic carbon (TOC) and total inorganic carbon (TIC) were measured using an Elementary Liquid TOC II with a solid phase module. The amount of TOC was determined from the amount of CO_2 released by combusting the sample at 550 °C under oxygen atmosphere. CO_2 yields at 1000 °C were measured to determine the TIC amount of the sample.

Rock-Eval pyrolysis

Rock-Eval pyrolysis measurements were performed using a DELSI INC Rock-Eval 6 instrument. The principle procedures of Rock-Eval pyrolysis are described in [40]. Measurements followed the procedures described in the NIGOGA, 4^{th} Edition. A more detailed description of the temperature program used is described in [76].

Vitrinite reflectance measurements

Vitrinite reflectance (VRr) measurements were performed according to the general procedure described in [100], whereas the microscopic setup and reflectance standards used for this study are described in great detail in [18]. Table 1 shows results of TOC, TIC, TC, S, Rock-Eval data and vitrinite reflectance values from the samples investigated.

Stratigraphy column of Nayband Formation in study area

The best available way to study area is Tabas-Yazd paved road which after going 30 km, a side-road in right direction derived with length of 60 km and it is a special road for coal mines. Likewise, there are the other ways from Parvadeh and Korit villages to reach to

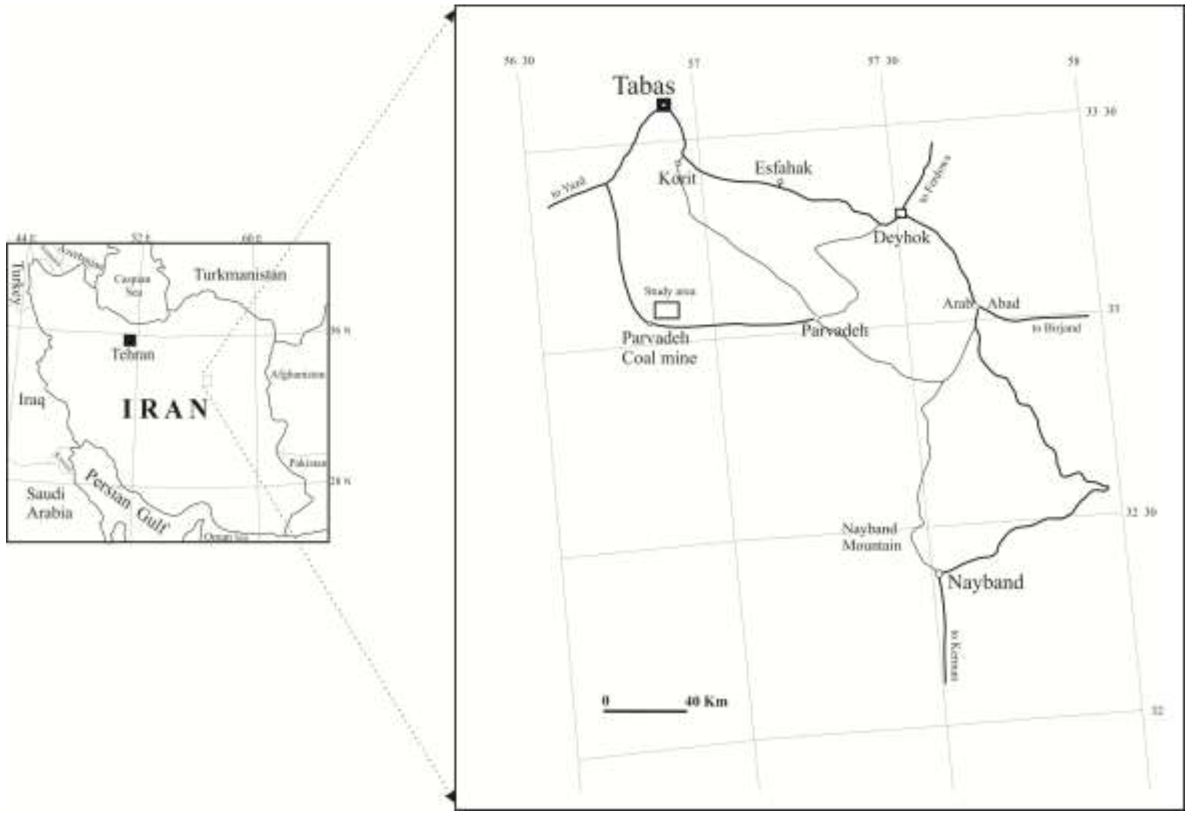

Figure 1. Geographic setting and location of study section

Figure 2. Stratigraphic extension of the Nayband Fm in Central Iran (modified from [95])

the study area. These ways are shorter than Tabas-Yazd paved road, but they are unpaved and unsuitable (Fig. 1). In Parvadeh area, the Nayband Formation has a thickness of 1410 meters (Fig. 3). In this area, the Nayband Formation from lithological point of view is different with its type section and one cannot easily differentiate different members of this formation. On the other hand, the boundary between Shotori and Nayband Formations is complicated because of activities of Rostam fault. This subject resulted in different opinions between NSC experts and Geological Survey of Iran (GSI). For instant, the geologists of Steel Company believe that there is not the Howz-e-khan Member in Parvadeh area whereas the geologists of Survey of Iran (GSI) are opposite to NSC 's statement [1]. In the Parvadeh area, Howz-e-sheikh and Bidestan Members are exist, but both groups have ignored the Gelkan Member [2, 77]. Based on my field trip observations from Parvadeh and Nayband areas, many parts of the Gelkan Member have missed in Parvadeh area due to activity of Rostam fault.

Results and Discussion

Palaeobotany and Palynology

Except for plant microfossils, the Nayband Formation was also investigated for plant macrofossils and only Howz-e-Khan Member of this Formation contains well-preserved plant macrofossil entities, including 11 species (8 genera). Based on stratigraphic potential of the encountered plant macrofossils such as *Pterophyllum bavieri*, *Equisetites arenaceus*, *Pterophyllum schenki*, *Nilssoniopteris musafolia* and *Scytophyllum persicum*, the Howz-e-Khan Member is assigned to the Rhaetian age. On the other hand, the presence of the above-mentioned plant macrofossil assemblage (Zone VII) with their well-preserved structures in host sediments such as clay, silt, fine coaly sandstone, a coastal delta environment with humid climate and warm condition is suggested for Howz-e-Khan Member.

At the Parvadeh area, the Nayband Formation consists of moderately to well-preserved land-derived palynomorphs (spores and pollen grains). In general, a total of 31 spore species (21 genera) and 27 pollen grained species (17 genera) were recognized. Pollen grained species belong to gymnosperm group and includes of bisaccate (*Ovalipollis*), monosaccate (*Guthoerlisporites*) which are associated with trilete, monolete spores. Based on the encountered pollen grained species, consisting of *Limbosporites lundbladii*, *Quadraeculina anellaeformis*, *Kyrtomisporis laevigatus* and *Ovalipollis ovalis*, the Nayband Formation is assigned to Late Triassic (Norian-Rhaetian). Ten

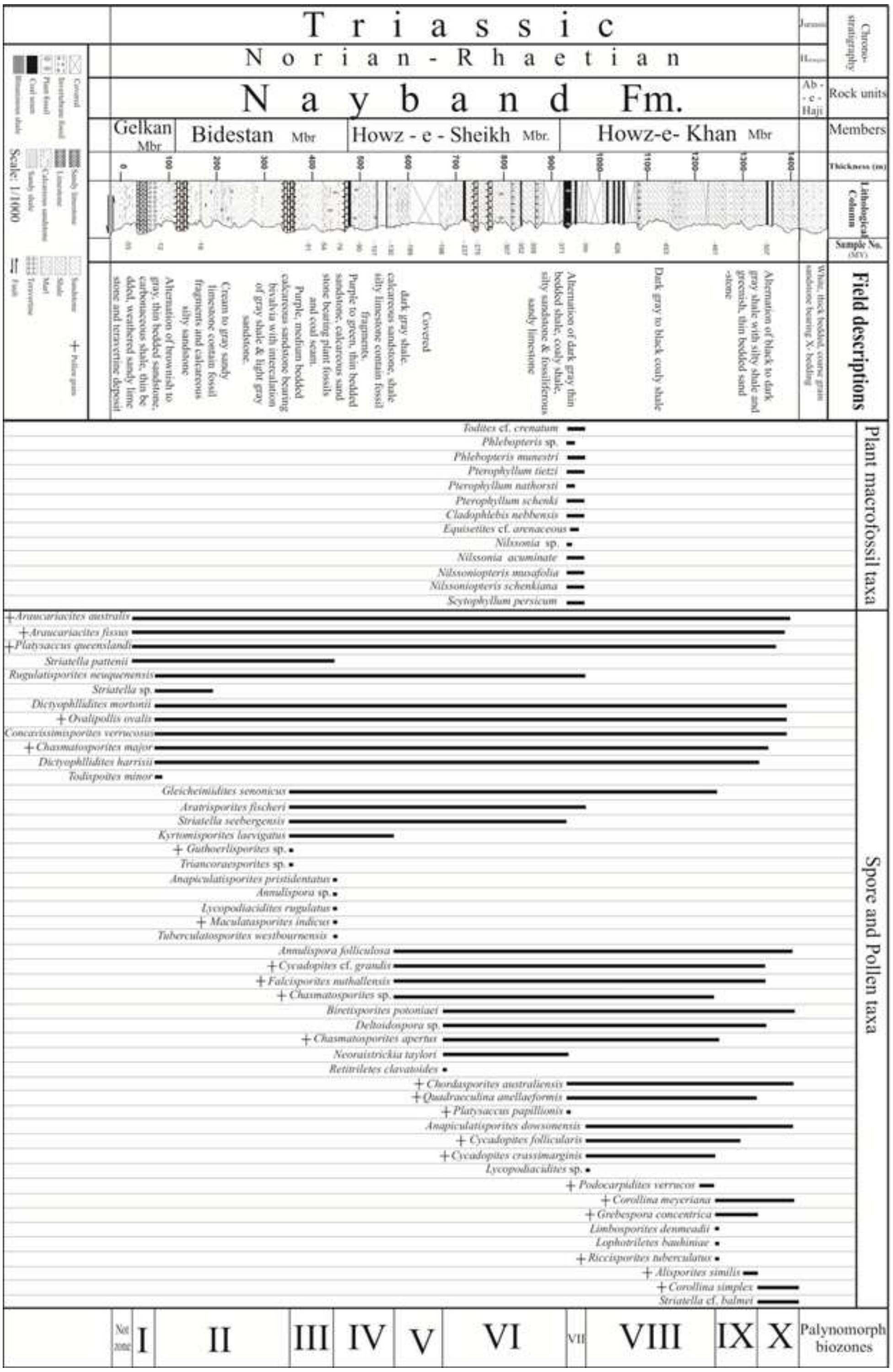

Figure 3. Stratigraphic column of Nayband Formation at the study area

miospore assemblage zones have been recognized in the Upper Triassic sequence of Parvadeh and they are discussed below in ascending stratigraphic order.

(I): assemblage zone I

This biozone is characterized by first occurrence of miospore taxa such as *Araucariaites fissus,*

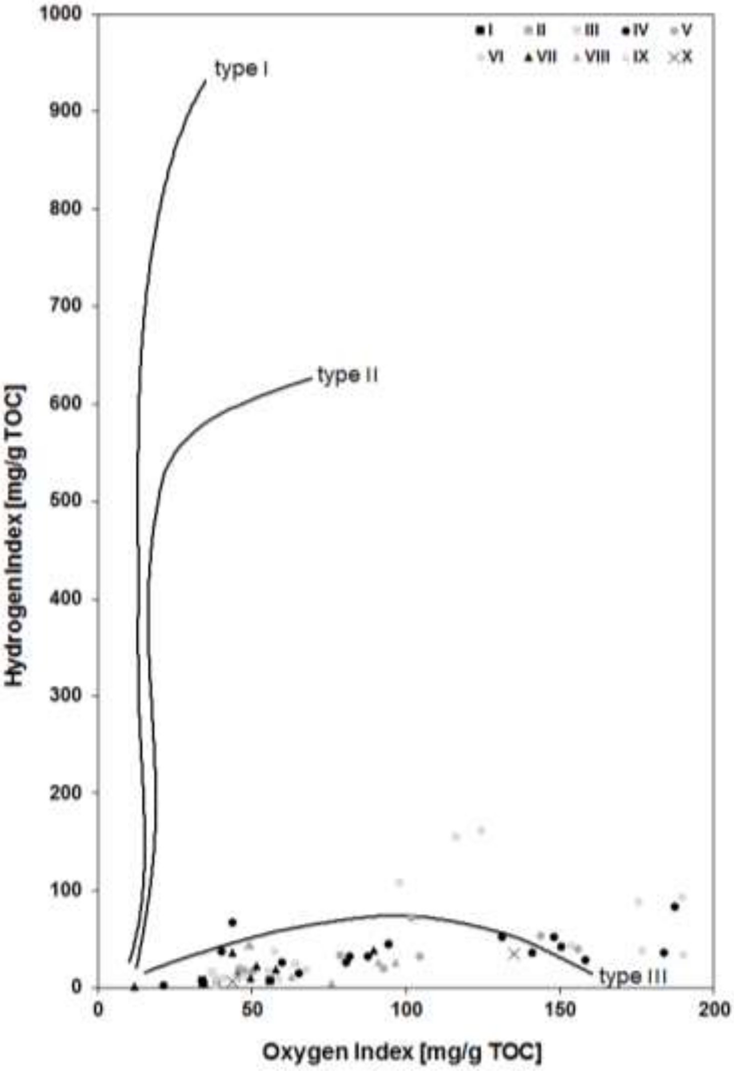

Figure 4. Correlation Pseudo-Van-Krevelen diagram of the samples from different assemblage zones

Araucariaites australis, *Platysaccus queenslandi* and *Striatella patenii* and they extend within samples MY-01 to MY-11 (40 m) in the Gelkan Mbr of Nayband Formation (Fig. 3). The above-mentioned spore and pollen taxa suggest Late Triassic for the lower part of the Nayband Formation.

Araucariaites fissus is present within the samples of MY-03 to MY-507 of the Nayband Formation at the Parvadeh area (Plate. 6, Fig. 6). This species has been reported from the Lower Jurassic the Queensland, Australia [72] and Upper Triassic sediments of Central Iran [15].

Araucariaites australis is present within the samples MY-03 to MY-525 of Nayband Formation (Plate. 6, Figs. 1-4). This specie has so far been recorded from the Lower Jurassic (Lias) of west Australia [44], Lower Cretaceous in the Queensland Australia [81], Lower Cretaceous of Argentina [73], Mesozoic of India [53], Lower Jurassic of Antarctic [75], Upper Jurassic to Lower Cretaceous of southeast Tanzania [86], Lower to Middle Jurassic of Spain [11], Upper Jurassic of Montenegro, boundary of Triassic- Jurassic of northeast China [55], Jurassic of Iran [13, 27, 48, 49, 52, 64, 69, 79, 98] and Upper Triassic strata Central Iran [15].

Platysaccus queenslandi is present within the samples MY-03 to MY-505 of Nayband Formation. This species has been recorded from the Triassic of Pakistan [10], Uppermost Triassic (Rhaetian) and Lower Jurassic (Lias) of South Australia [31, 72], Triassic strata of Australia [28, 33], Late Triassic

(Norian-Rhaetian) of Argentina [106] and Jurassic of Iran [69, 102].

Striatella patenii is present within the samples MY-03 to MY-79 of Nayband Formation (Plate. 4, Figs. 2, 3 & 9). This species has been recorded from the Lower Jurassic of west Australia [45] and Upper Triassic of Central Iran [15].

(II): assemblage zone II

This biozone immediately begins above preceding

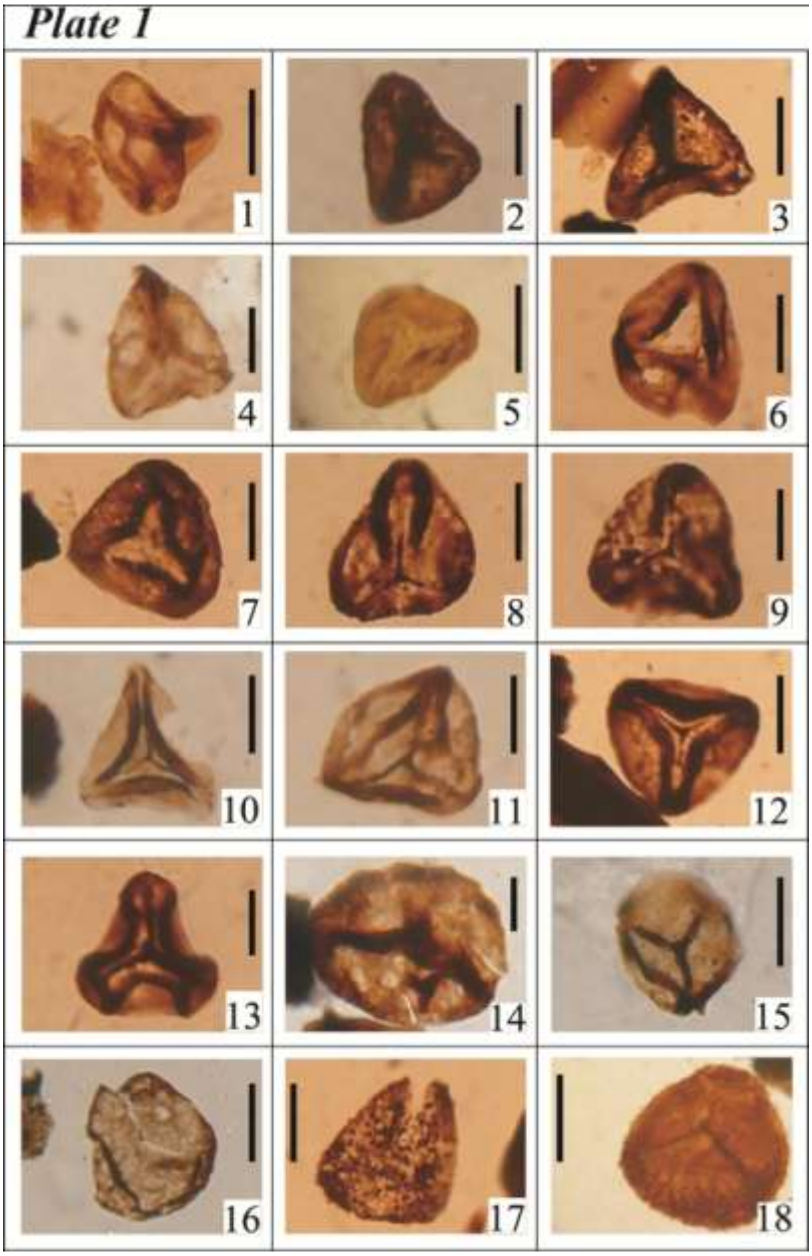

PLATE 1

Scale bars of all plates 30 µm

Figs. 1- 3 *Biretisporites potoniaei* Delcourt & Sprumont, 1955.

Figs. 4- 6 *Deltoidospora* sp.

Figs. 7- 9 *Dictyophyllidites harrisii* Couper, 1958.

Figs. 10- 13 *Dictyophyllidites mortonii* (de Jersey) Playford & Dettman, 1965.

Figs. 14- 16 *Todisporites minor* Couper, 1958.

Figs. 17, 18 *Anapiculatisporites dawsonensis* Reiser & Williams, 1969.

assemblage and it is marked by appearance of spore and pollen grained taxa such as *Rugulatisporites neuquenensis*, *Striatella* sp., *Dictyophyllidites mortonii*, *Ovalipollis ovalis*, *Concavissimisporites verrucosus*, *Chasmatosporites major*, *Dictyophyllidites harrisii* and *Todisporites minor*. These taxa extend through a

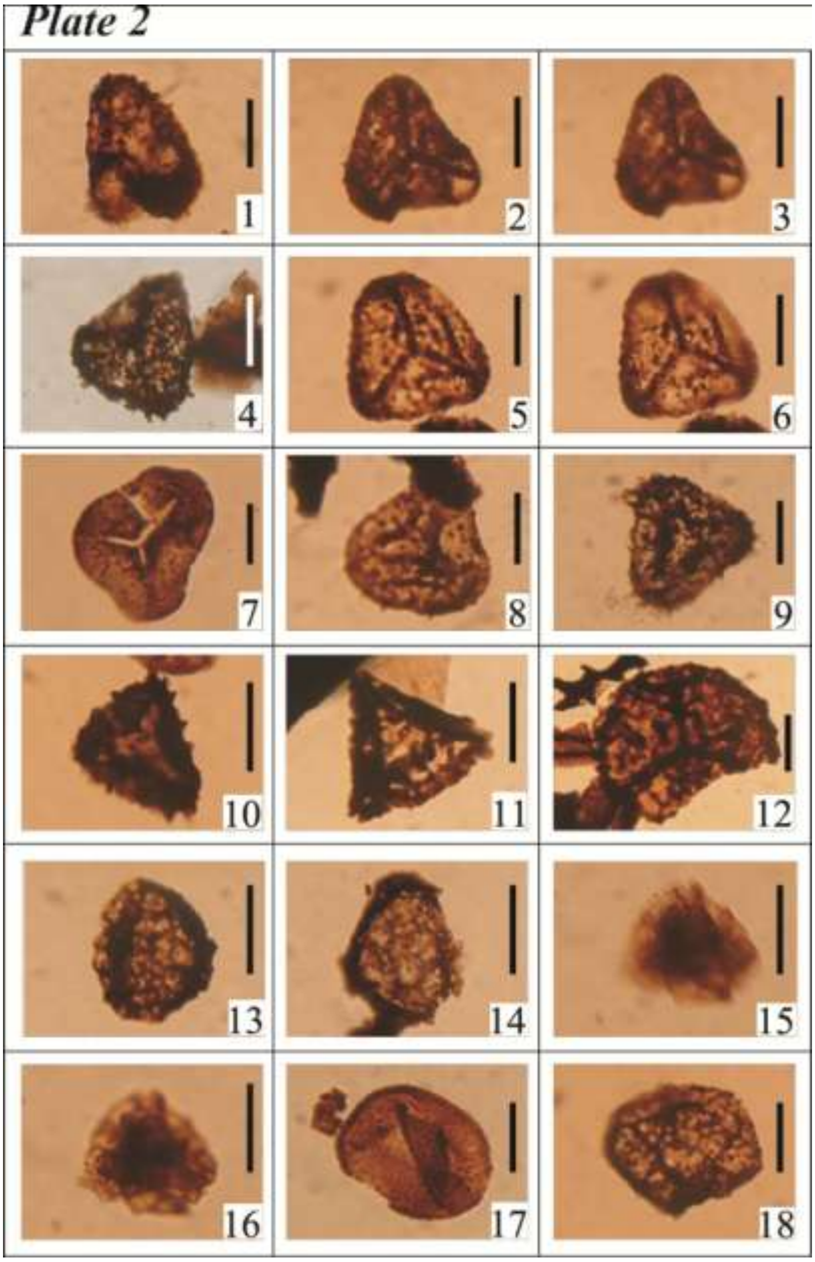

PLATE 2
Fig. 1 *Anapiculatisporites dawsonensis* Reiser & Williams,1969.
Figs. 2- 4 *Anapiculatisporites pristidentatus* Reiser & Williams, 1969.
Figs. 5, 6 *Lophotriletes bauhiniae* de Jersey & Hamilton, 1967.
Figs. 7, 8 *Concavissimisporites verrucosus* Delcourt & Sprumont emend McKellar,1998.
Figs. 9- 11 *Neoraistrickia taylori* Playford & Dettmann, 1965.
Fig. 12 *Lycopodiacidites rugulatus* (Couper) Schulz, 1967.
Figs. 13, 14 *Lycopodiacidites* sp.
Figs. 15, 16 *Retitriletes clavatoides* (Couper) Doring, Krutzsch, Mai & Schulz, 1963.
Figs. 17, 18 *Rugulatisporites neuquenensis* Volkheimer, 1972.

thickness of 275 m in the Bidestan Mbr of Nayband Formation (Fig. 3). Besides of the aforementioned the palynomorph taxa such as *Araucariaites fissus*, *Araucariaites australis*, *Platysaccus queenslandi*, and *Striatella patenii* continuous from preceding biozone in this biozone. Amongst of palynomorph species of this assemblage.

Rugulatisporites neuquenensis is present with rare to uncommon frequencies within the samples of MY-11 to MY-390 of the Nayband Formation at the Parvadeh area

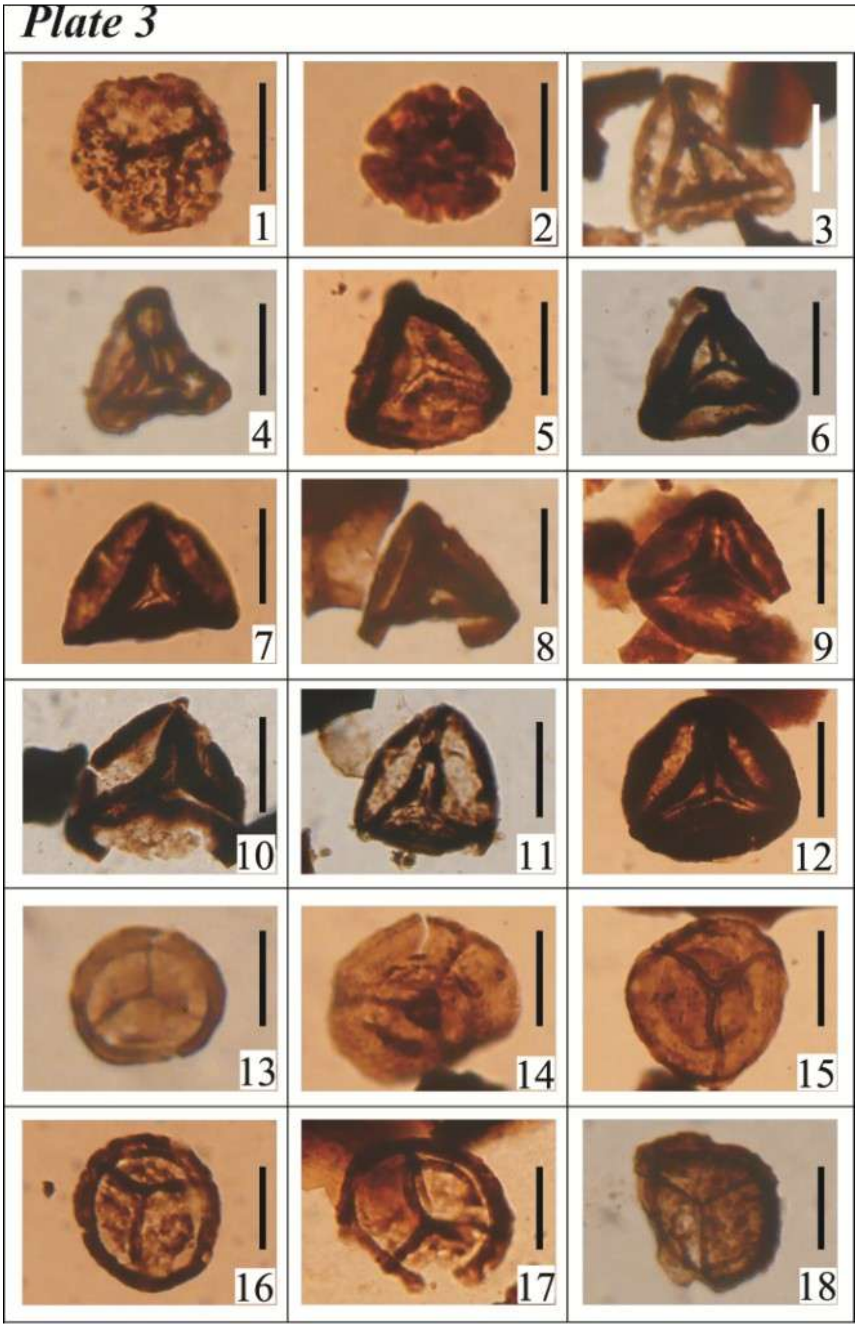

PLATE 3
Fig. 1 *Rugulatisporites neuquenensis* Volkheimer, 1972.
Fig. 2 *Triancoraesporites* sp.
Figs. 3 – 8 *Gleicheiniidites senonicus* Ross emend. Skarby, 1964.
Figs. 9 – 12 *Kyrtomisporis laevigatus* Madler, 1964.
Figs. 13 – 17 *Annulispora folliculosa* (Rogalska 1954) de Jersey, 1959.
Fig. 18 *Annulispora* sp.

(Plate. 2, Figs. 17, 18). This species has been so far reported from the Upper Triassic to Lower Jurassic the Argentina [4, 84, 103, 104, 106]; Upper Jurassic and Lower Cretaceous in the Queensland Australia [80, 82] and Upper Triassic sediments of Central Iran [15].

Dictyophyllidites mortonii is present within the samples MY-11 to MY-537 of Nayband Formation (Plate. 1, Figs. 10-13). This species has so far been recorded from the Lower Triassic of Queensland [34], Uppermost Triassic (Rhaetian) and Lower Jurassic (Lias) of south Australia [72], Triassic strata of Tasmani [71] and Triassic to Middle Jurassic of Iran [12, 52, 83, 97, 98, 102].

Ovalipollis ovalis occurs within MY-11 to MY-537 of the Nayband Formation (Plate. 5, Figs. 13, 14). So far, it has been recorded from the Uppermost Triassic (Rhaetian) and Lower Jurassic (Lias) of Slovakia [76]; Uppermost Triassic (Rhaetian), Lowermost Jurassic (Hettangian) of Germany [16, 105]; Uppermost Triassic (Rhaetian) and Lower Jurassic (Lias) of U.S.A [46] and Upper Triassic of Central Iran [15].

Concavissimisporites verrucosus is present samples MY-11 to MY-537 of Nayband Formation (Plate. 2, Figs. 7, 8). It has previously been recorded from the Middle Jurassic – Lower Cretaceous of Australia [81, 82] and Upper Triassic of Central Iran [15] and Jurassic of north Iran [69, 98].

Chasmatosporites major is present through samples MY-11 to MY-507 of Nayband Formation (Plate. 7, Figs. 1-3). So far, it has been recorded from the Middle to Upper Jurassic strata (Upper Lias and Dogger) of Germany [87]; Upper Triassic of Sweden [61] and Upper Triassic and Lower Jurassic sediments of Iran [48, 49, 69, 79].

Dictyophyllidites harrisii occurs in the Nayband Formation and extend within samples MY-11 to MY-500 (Plate. 1, Figs. 7-9). This species has been recorded from the Upper Triassic of Australia [33, 71] and Upper Triassic to Lower Jurassic of Iran [12, 13, 15, 56, 57, 83, 97, 98].

Todisporites minor is present in the Nayband Formation and extends through samples of MY-11 to MY-13 (Plate. 1, Figs. 14-16). This taxon has been recorded from the Upper Triassic (Rhaetian) to Lower Jurassic (Lias) Slovakia [76]; Jurassic of west Australia [44]; Upper Triassic deposits (Norian-Rhaetian) of Central Iran [25] and Jurassic of Iran [6, 12, 52, 56, 69, 83, 98].

(III): assemblage zone III

This biozone is characterized by appearance of palynomorph taxa, including *Gleicheiniidites senonicus*, *Aratrisporites fischeri*, *Striatella seebergensis*, *Kyrtomisporites laevigatus*, *Guthoerlisporites* sp., and *Triancoraesporites* sp., and they extend through Bidestan Mbr of Nayband Formation (90 m) (Fig. 3). Besides of the aforementioned taxa, the miospore species of the preceding assemblage such as *Araucariaites fissus*, *Araucariaites australis*, *Platysaccus queenslandi*, *Striatella patenii*, *Rugulatisporites neuquenensis*, *Dictyophyllidites mortonii*, *Ovalipollis ovalis*, *Concavissimisporites verrucosus*, *Chasmatosporites major*, *Dictyophyllidites harrisii* and *Todisporites minor* continuous in this assemblage biozone.

Gleicheiniidites senonicus is present within samples MY-46 to MY-462 of Nayband Formation (Plate. 3, Figs. 3-8). This taxon has been recorded from the Lower Jurassic to Tertiary of Australia [7, 9, 38, 51, 44, 74, 80]; Lower Cretaceous of Argentina [73]; Upper Triassic of Argentina [107]; Lower Jurassic of Montenegro [41]; boundary of Jurassic and Cretaceous of Sweden [61]; Upper Triassic of Central Iran [15] and Jurassic of Iran [27, 48, 49, 52, 69, 79, 83, 97, 102].

Aratrisporites fischeri is present within samples MY-46 to MY-390 of Nayband Formation (Plate. 4, Figs. 17, 18). This species has been recorded from the Triassic of Pakistan [10]; Australia [71, 72] and Jurassic of Iran [48].

Striatella seebergensis ocuurs within samples MY-46 to MY-373 of Nayband Formation (Plate. 4, Figs. 5, 7, 8). It has been recorded from the Middle Triassic to Middle Jurassic of Australia [28, 32, 50, 72, 80]; Upper Triassic to Lower Jurassic of Newzealand [29]; Lower Jurassic of Antarctic [75]; Upper Triassic of Argentina [107]; boundary of Triassic-Jurassic of China [55]; Upper Triassic of Central Iran [15] and Jurassic Iran [27, 49, 69, 79].

Kyrtomisporites laevigatus is present within samples MY-46 to MY-135 of Nayband Formation (Plate. 3, Figs. 9-12). This taxon has been recorded from the boundary of Triassic- Jurassic deposits of Austria [14]; Upper Triassic of France [88]; Upper Triassic of Central Iran [5] and Jurassic of Iran [69].

(IV): assemblage zone IV

This biozone is characterized by appearance of miospore taxa consisting of *Anapiculatisporites pristidentatus*, *Annulispora* sp., *Lycopodiacidites rugulatus*, *Maculatasporites indicus*, *Tuberculatosporites westbournensis* and they extend through a thickness of 133 m in the Bidestan and Howz-e-sheikh Mbrs of Nayband Formation (Fig. 3). Besides of the aforementioned the miospore taxa , some taxa from preceding assemblaes such as *Araucariaites fissus*, *Araucariaites australis*, *Platysaccus queenslandi*,

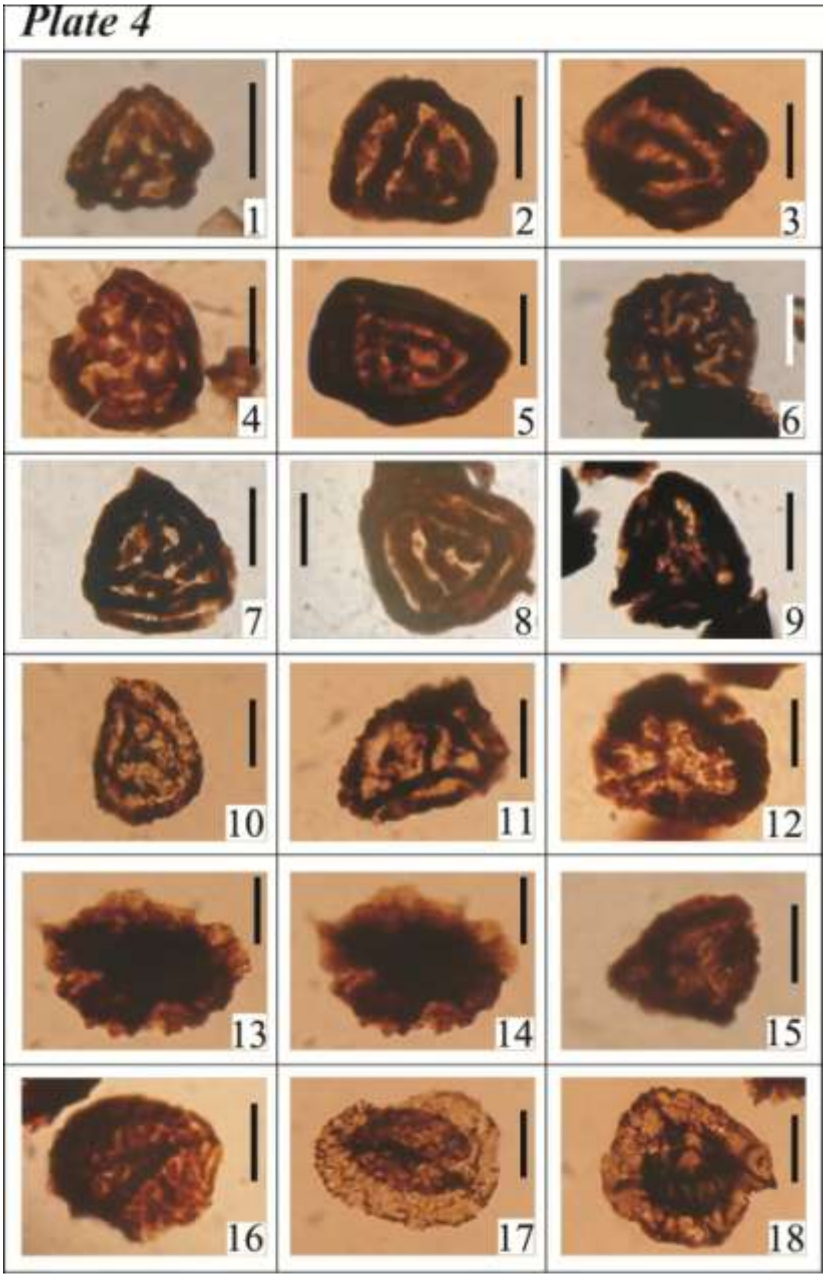

PLATE 4
Fig. 1 *Striatella* sp. cf. *S. balmei* Filatoff & Price, 1988.
Figs. 2, 3, 9 *Striatella patenii* Filatoff & Price, 1988.
Fig. 4 *Striatella scanica* (Nilsson) Filatoff & Price, 1988.
Fig. 6 *Striatella* sp.
Figs. 5, 7, 8 *Striatella seebergensis* Mädler, 1964.
Figs. 10- 12 *Limbosporites denmeadii* (de Jersey, 1962) de Jersey & Raine,1990.
Figs. 13, 14 *Limbosporites lunblandii* Nilsson, 1958.
Figs. 15, 16 *Lycopodiacidites* sp.
Figs. 17 – 18 *Aratrisporites fischeri* (Klaus) Playford & Dettmann, 1965

Rugulatisporites neuquenensis, *Dictyophyllidites mortonii*, *Ovalipollis ovalis*, *Concavissimisporites verrucosus*, *Chasmatosporites major*, *Dictyophyllidites harrisii*, *Gleicheiniidites senonicus*, *Aratrisporites fischeri*, *Striatella seebergensis* and *Kyrtomisporites laevigatus* continuous in this assemblage biozone.

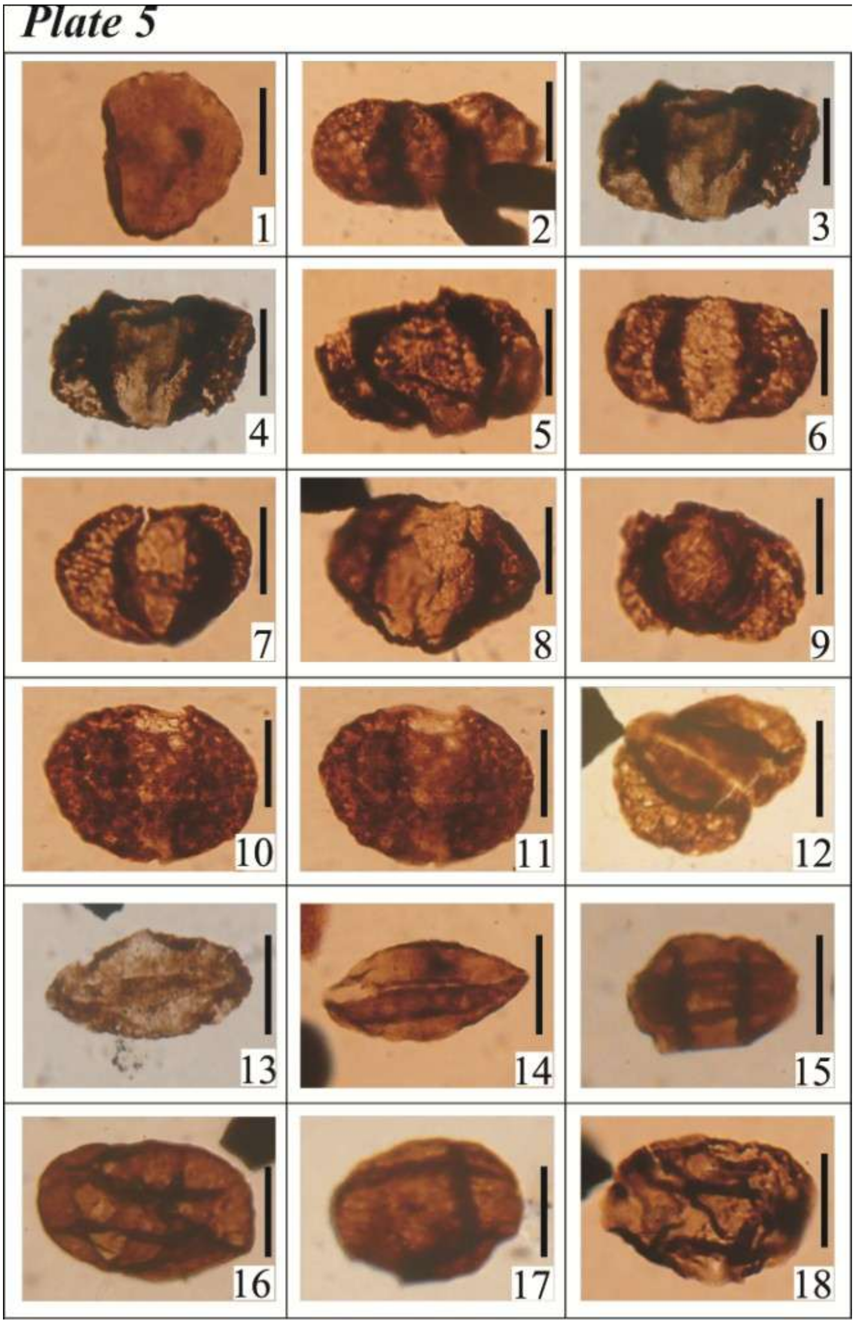

PLATE 5
Fig. 1 *Callialasporites microvelatus* Schulz, 1966.
Figs. 2 – 9 *Chordasporites australiensis* de Jersey, 1962.
Figs. 10 – 11 *Alisporites similis* (Balme) Dettmann, 1963.
Fig. 12 *Falcispories nuthallensis* (Clarke) Balme, 1970.
Figs. 13, 14 *Ovalipollis ovalis* Krutzsch, 1955.
Figs. 15- 18 *Araucariacites australis* Cookson, 1947.

Anapiculatisporites pristidentatus appears in the samples MY-65 to MY-67 of Nayband Formation (Plate. 2, Figs. 2-4). This taxon has been recorded from the Upper Triassic to Lower Cretaceous of Australia [19, 20, 21, 22, 23, 24, 34, 35, 36, 37, 40, 65, 66, 74, 81, 99]; Middle Triassic to Lower Jurassic Newzealand [29]; Norian- Rhaetian Argentina [106] and Jurassic of Iran [27].

Lycopodiacidites rugulatus is present within the samples MY-65 and MY-67 of Nayband Formation

(Plate. 2, Fig. 12). This specie has been recorded from the Middle to Upper Jurassic of Sweden [61]; Norian-Rhaetian of Central Iran [15] and Jurassic of Iran [48, 69, 79].

Tuberculatosporites westbournensis appears in the samples MY-65 to MY-67 of Nayband Formation. This taxon has been recorded from the Middle to Upper Jurassic of Australia [66]; Upper Triassic of Iran [15]

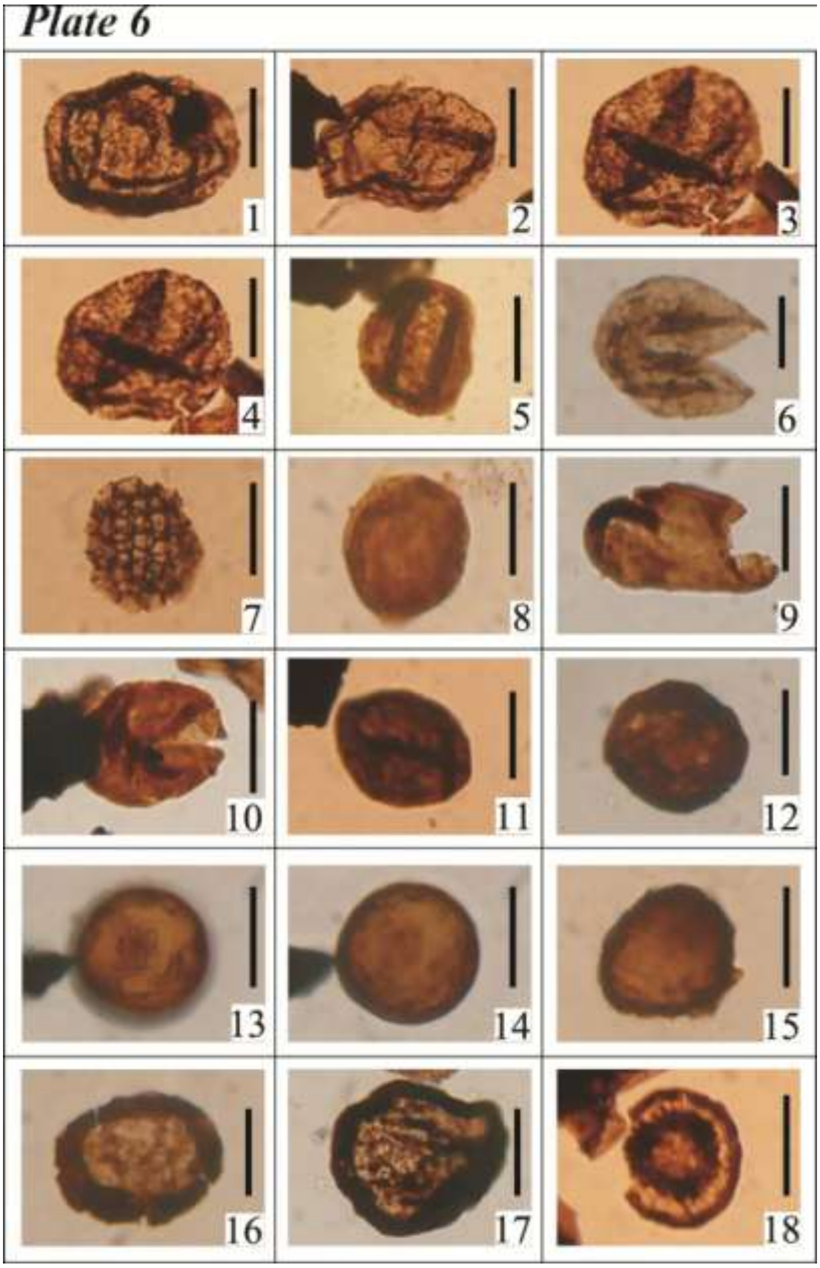

PLATE 6
Figs. 1- 4 *Araucariacites australis* Cookson, 1947.
Fig. 5 *Quadraeculina anellaeformis* Maliavkina, 1949.
Fig. 6 *Araucariacites fissus* Reisser & Williams, 1969.
Fig. 7 *Maculatasporites indicus* Tiwari, 1964.
Figs. 8- 10 *Corollina meyeriana* (Klaus) Venkatachala & Goczan, 1964.
Figs. 11, 12 *Corollina simplex* (Danze- Corsin & Laveine) Cornet & Traverse, 1975.
Figs. 13- 17 *Chasmatosporites* apertus Nilsson, 1958.
Fig. 18 *Grebespora concentrica* Jansonius, 1962.

and Jurassic of Iran [52, 98].

(V): assemblage zone V

This biozone is characterized by appearance of palynomorph taxa, including *Annulispora folliculosa*, *Cycadopites* cf. *grandis*, *Falcispories nuthallensis* and *Chasmatosporites* sp., in the Howz-e-sheikh Mbr of Nayband Formation (100 m) (Fig. 3). Besides of the aforementioned the miospore several taxa from preceding assemblage zones such as *Araucariaites*

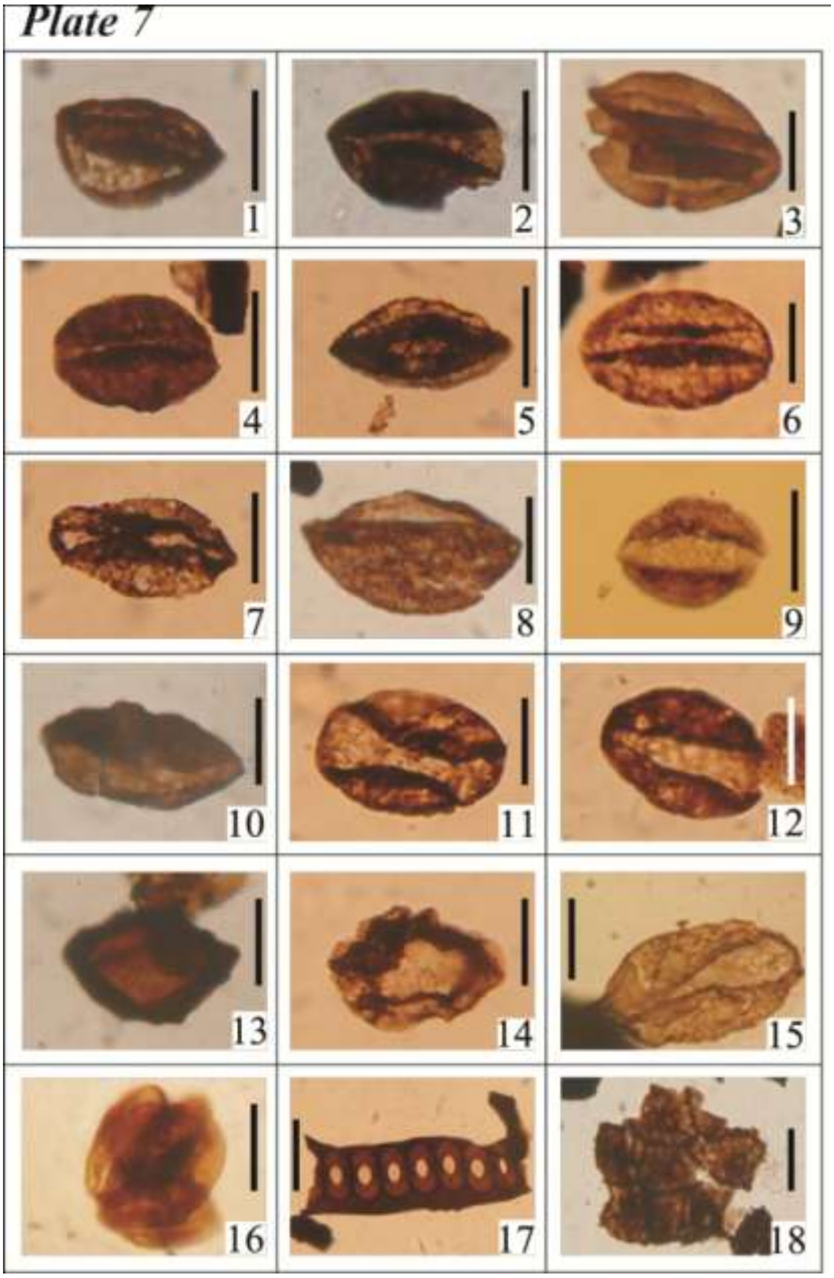

PLATE 7

Figs. 1- 3 *Chasmatosporites major* Nilsson, 1958.
Figs. 4- 9 *Cycadopites crassimarginis* (de Jersey) de Jersey, 1964.
Figs. 10 – 12 *Cycadopites follicularis* Wilson & Webster, 1946.
Figs. 13 – 14 *Cycadopites* sp. Cf. C. grandis de Jersey & Hamilton, 1967.
Fig. 15 *Cycadopites* sp.
Fig. 16 *Ricciisporites tuberculatus* Lundblad, 1954.

fissus, *Araucariaites australis*, *Platysaccus queenslandi*, *Rugulatisporites neuquenensis*, *Dictyophyllidites mortonii*, *Ovalipollis ovalis*, *Concavissimisporites verrucosus*, *Chasmatosporites major*, *Dictyophyllidites harrisii*, *Gleicheiniidites senonicus*, *Aratrisporites fischeri* and *Striatella seebergensis*, continuous in this assemblage biozone.

Annulispora folliculosa appear in the samples MY-135 to MY-568 of Nayband Formation (Plate. 3, Figs. 13-17). This taxon has been recorded from the Upper Jurassic-Lower Cretaceous of Australia [80]; Triassic and Jurassic of Queensland [30, 31, 32] and Upper Triassic of Central Iran [25].

Cycadopites cf. *grandis* appear in the samples MY-135 to MY-506 of Nayband Formation (Plate. 7, Figs. 13-14). This taxon has been recorded from the Middle Jurassic of Australia [28] and Jurassic of Iran [48, 49, 69, 79].

Falcispories nuthallensis appears in the samples MY-135 to MY-506 of Nayband Formation (Plate. 5, Fig. 12). So far, this taxon has been recorded from the Permian and Triassic of Pakistan [10]; Norian- Rhaetian Argentina [106] and Upper Triassic of Iran [15].

(VI): assemblage zone VI

This biozone is characterized by appearance of miospore taxa, including Biretisporites potoniaei, *Deltoidospora* sp., *Chasmatosporites apertus*, *Neoraistrickia taylori* and *Retitriletes clavatoides* and disappearance some taxa from preceding biozone such as *Striatella seebergensis*, *Neoraistrickia taylori*, *Retitriletes clavatoides* and extend through a thickness of 250 m of Nayband Formation (Howz-e-sheikh Mbr, Fig. 3). Besides of the aforementioned the palynomorph taxa such as *Araucariaites fissus*, *Araucariaites australis*, *Platysaccus queenslandi*, *Rugulatisporites neuquenensis*, *Dictyophyllidites mortonii*, *Ovalipollis ovalis*, *Concavissimisporites verrucosus*, *Chasmatosporites major*, *Dictyophyllidites harrisii*, *Gleicheiniidites senonicus*, *Aratrisporites fischeri*, *Annulispora folliculosa*, *Cycadopites* cf. *grandis*, *Falcispories nuthallensis* and *Chasmatosporites* sp. continuous in this assemblage biozone.

Biretisporites potoniaei appears in the samples MY-198 to MY-570 of Nayband Formation (Plate. 1, Figs. 1-3). So far, this taxon has been recorded from the Jurassic of Zirab, Tazareh and Zangroud areas at the Alborz Mountain Ranges, Northern Iran [2] and Upper Triassic of lower part of Shemshak Formation in Glandroud area, Eastern Alborz Range [26].

Chasmatosporites apertus appears in the samples MY-199 to MY-463 of Nayband Formation (Plate. 6, Figs. 13-17). So far, this taxon has been recorded from the Uppermost Triassic (Rhaetian) and Lower Jurassic (Lias) of Germany [87]; Lower and Middle Jurassic of Greenland [59]; Triassic to Jurassic of Northern Austria [60]; Upper Triassic of Sweden [62]; boundary of Jurassic- Cretaceous at the Southern Sweden [61]; boundary of Triassic- Jurassic at the northwestern China [55]; Rhaetian to Middle Jurassic of Iran [48, 79] and Upper Triassic of Central Iran [15, 25].

Neoraistrickia taylori appears in the samples MY-199 to MY-378 of Nayband Formation (Plate. 2, Figs. 9-11). This taxon has been recorded from the Upper Triassic at the Southern Australia [72]; Triassic of Queensland [33]; Jurassic of Australia [44]; Upper Triassic of Antarctic [43]; Upper Triassic (Norian-Rhaetian) of Argentina [106] and Rhaetian to Middle Jurassic of Iran [48, 49, 69, 79].

Retitriletes clavatoides appears in the samples MY-199 to MY-203 of Nayband Formation (Plate. 2, Figs. 15, 16). So far, this taxon has been recorded from the Lower to Middle Jurassic of Germany [87]; Lower to Middle Jurassic of China [63]; Upper Triassic (Norian-Rhaetian) of Central Iran [15]; Rhaetian to Middle Jurassic of Iran [48] and Middle Jurassic of Iran [49, 69].

(VII): assemblage zone VII

This biozone is characterized by appearance of miospore taxa, including *Platysaccus papillionis*, *Quadraeculina anellaeformis* and *Chordasporites australiensis* and disappearance some taxa from preceding biozone such as *Rugulatisporites neuquenensis* and *Aratrisporites fischeri* which they extend through a thickness of 41 m of Howz-e-khan Mbr in the Nayband Formation (Fig. 3). Besides of the aforementioned the miospore taxa such as *Araucariaites fissus*, *Araucariaites australis*, *Platysaccus queenslandi*, *Dictyophyllidites mortonii*, *Ovalipollis ovalis*, *Concavissimisporites verrucosus*, *Chasmatosporites major*, *Dictyophyllidites harrisii*, *Gleicheiniidites senonicus*, *Annulispora folliculosa*, *Cycadopites* cf. *grandis*, *Falcispories nuthallensis*, *Chasmatosporites* sp., *Biretisporites potoniaei*, *Deltoidospora* sp. and *Chasmatosporites apertus*, continuing in this assemblage biozone.

Platysaccus papillionis appears in the samples MY-203 to MY-207 of Nayband Formation. So far, this taxon has been recorded from the Lower Triassic of Australia [34]; Upper Triassic (Norian-Rhaetian) of Argentina [106] and Late Triassic of Iran [15].

Quadraeculina anellaeformis appears in the samples MY-203 to MY-375 of Nayband Formation (Plate. 6, Fig. 5). Likewise, this taxon has been recorded from the Lower to Middle Jurassic of Denmark [59]; Triassic to

Jurassic of Austria [60]; Upper Triassic of Sweden [61]; boundary of Triassic and Jurassic of Austria [14]; boundary of Triassic and Jurassic of China [55]; Late Triassic of Iran [15] and Rhaetian to Jurassic of Iran [48, 69].

Chordasporites australiensis appears in the samples MY-203 to MY-207 of Nayband Formation (Plate. 5, Figs. 2-9). So far, this taxon has been recorded from the Triassic of Queensland [28, 31, 33]; Norian-Rhaetian of Argentina [106]; Upper Triassic of Central Iran [15] and Rhaetian to Jurassic of Iran [69]. One of the most important characteristic this miospore assemblage is appearance and disappearance of plant macrofossils including *Phlebopteris muensteri*, *Cladophlebis nebbensis*, *Nilssonia acuminate*, *Nilssoniopteris* cf. *musafolia*, *Nilssoniopteris schenkiana*, *Pterophyllum schenki*, *Pterophyllum tietzei*, *Todites* cf. *crenatum*, *Phlebopteris munestri*, *Equisetites* cf. *arenaceus* and *Scytophyllum persicum*. Most of the above–mentioned macrofossils suggest Upper Triassic (Rhaetian) age.

(VIII): assemblage zone VIII

This biozone is characterized by appearance of miospore taxa, such as *Anapiculatisporites dawsonensis*, *Cycadopites follicularis*, *Cycadopites crassimarginis* and *Lycopodiacidites* sp. and disappearance some of taxa such as *Podocarpidites verrucosus*, *Cycadopites crassimarginis*, *Chasmatosporites apertus*, *Chasmatosporites* sp. and *Gleicheiniidites senonicus* which they extend through a thickness of 275 m of Howz-e-khan Mbr in the Nayband Formation (Fig. 3). Besides of the aforementioned the miospore taxa such as *Araucariaites fissus*, *Araucariaites australis*, *Platysaccus queenslandi*, *Dictyophyllidites mortonii*, *Ovalipollis ovalis*, *Concavissimisporites verrucosus*, *Chasmatosporites major*, *Dictyophyllidites harrisii*, *Annulispora folliculosa*, *Cycadopites* cf. *grandis*, *Falcispories nuthallensis*, *Quadraeculina anellaeformis* and *Chordasporites australiensis*, continuing from preceding biozone in this biozone.

Anapiculatisporites dawsonensis appears in the samples MY-390 to MY-570 of Nayband Formation (Plate. 1, Figs. 17, 18). So far, this taxon has been recorded from the Lower Jurassic of Australia [74] and Upper Triassic (Norian- Rhaetian) Iran [25].

Cycadopites follicularis appears in the samples MY-390 to MY-482 of Nayband Formation (Plate. 7, Figs. 10-12). So far, this taxon has been recorded from the Permian and Triassic of Pakistan [10]; Jurassic of Western Australia [44]; Upper Triassic (Norian-Rhaetian) of Iran [15] and Rhaetian to Jurassic of Iran [2, 52, 69, 83, 98, 102].

Cycadopites crassimarginis appears in the samples MY-390 to MY-461 of Nayband Formation (Plate. 7, Figs. 4-9). This taxon has been recorded from the Triassic-Jurassic of Australia [65]; Triassic of Australia [28] and Triassic of Iran [15] and Triassic and Jurassic of Iran [5, 52, 69, 83, 98, 102].

(IX): assemblage zone IX

This biozone is characterized by appearance of miospore taxa, including *Limbosporites denmeadii*, *Corollina meyeriana*, *Grebespora concentrica*, *Lophotriletes bauhiniae* and *Riccisporites tuberculatus*; extend through a thickness of 90 m of Howz-e-khan Mbr in the Nayband Formation (Fig. 3). This biozone is marked by disappearance preceding assemblage miospore taxa such as *Alisporites similis*, *Grebespora concentrica*, *Quadraeculina anellaeformis*, and *Dictyophyllidites harrisii*. Besides of original miospore taxa of this biozone, several miospore taxa such as *Araucariaites fissus*, *Araucariaites australis*, *Platysaccus queenslandi*, *Dictyophyllidites mortonii*, *Ovalipollis ovalis*, *Concavissimisporites verrucosus*, *Chasmatosporites major*, *Annulispora folliculosa*, *Cycadopites* cf. *grandis*, *Falcispories nuthallensis*, *Biretisporites potoniaei*, *Deltoidospora* sp., *Chordasporites australiensis*, *Anapiculatisporites dawsonensis* and *Cycadopites follicularis*, are continuous from preceding biozones.

Limbosporites denmeadii appears in the samples MY-461 to MY-463 of Nayband Formation. So far, this taxon has been recorded from the Triassic to Lower Jurassic of Newzealand [29]; Norian-Rhaetian of Iran [25] and Jurassic of Iran [48, 79].

Corollina meyeriana appears in the samples MY-461 to MY-571 of Nayband Formation (Plate. 6, Figs. 8-10). So far, this taxon has been recorded from the Jurassic of Australia [44]; Upper Triassic (Rhaetian)–Lower Jurassic (Lias) of Slovakia [76]; Triassic and Jurassic of Iran [5, 49, 79].

Grebespora concentric appears in the samples MY-461 to MY-500 of Nayband Formation (Plate. 6, Fig. 18). So far, this taxon has been recorded from the Lower Triassic of Canada [54]; Triassic of Queensland [28]; Carnian to Lower Norian of Argentina [106].

Lophotriletes bauhiniae appears in the samples MY-461 to MY-463 of Nayband Formation (Plate. 2, Figs. 5, 6). So far, this taxon has been recorded from the Middle Triassic of Queensland [72]; Triassic of Australia [28]; Norian- Rhaetian of Argentina [106] and Norian-Rhaetian of Central Iran [15].

(X): Assemblage zone X

This biozone is characterized by appearance of palynomorph taxa, including *Corollina simplex*, *Striatella* cf. *balmei* and disappearance some of taxa such as *Alisporites similis*, *Grebespora concentrica*, *Quadraeculina anellaeformis*, and *Dictyophyllidites harrisii*, and extend through a thickness of 76 m of Nayband Formation (Howz-e-khan Mbr, Fig. 3). Besides of the aforementioned the palynomorph taxa such as *Araucariaites fissus*, *Araucariaites australis*, *Platysaccus queenslandi*, *Dictyophyllidites mortonii*, *Ovalipollis ovalis*, *Concavissimisporites verrucosus*, *Chasmatosporites major*, *Annulispora folliculosa*, *Cycadopites* cf. *grandis*, *Falcispories nuthallensis*, *Biretisporites potoniaei*, *Deltoidospora* sp., *Chordasporites australiensis*, *Anapiculatisporites dawsonensis* and *Corollina meyeriana* which continuous from preceding biozones.

Corollina simplex appears in the samples MY-491 to MY-574 of Nayband Formation (Plate. 6, Fig. 11, 12). So far, this taxon has been recorded from the Jurassic of Western Australia [44]; Lower Jurassic of Queensland [74, 32]; Jurassic of Iran [49, 79].

Striatella cf. *balmei* appears in the samples MY-491 to MY-574 of Nayband Formation (Plate. 4, Fig. 1). So far, this taxon has been recorded from the Rhaetian-Jurassic of Australia [45]; Rhaetian to Middle Jurassic of Iran [48, 49].

Elemental geochemistry

The TOC values for the Nayband formation differ strongly across the vertical profile depending on the lithological units which were sampled. Samples from smaller coal seams in assemblage zones IV and VII show TOC amounts of up to 48 %. Silty to sandy strata generally yield very low organic carbon (lower than 0.5% TOC). Organic-rich shales can be found in several assemblage zones, reaching TOC values of up to 10% e.g. in assemblage zones I and V-VII. TIC and therefore carbonate in the whole Nayband succession is generally low (< 0.2% TIC) with the exception of the aforementioned organic-rich shale units where the total inorganic carbon can reach values over 1.2%.

Rock-Eval pyrolysis

Results from Rock-Eval pyrolysis show that the sampled units mainly comprise type III kerogen indicating the terrestrial origin of most strata of the Nayband formation. Fig. 4 shows a Pseudo-Van-Krevelen diagram with the oxygen and hydrogen indices of the sampled material and the kerogen decomposition paths upon maturation. For the organic-rich shales a contribution of type II kerogen is possible due to the findings of solid bitumen and alginites in these samples, although liquid hydrocarbon generation is almost depleted as seen from vitrinite reflectance data and thermal alteration indices. Due to very low S_2 yields, T_{max} values are generally overestimated or not trustworthy with some exceptions listed in Table 1.

Thermal maturity

Vitrinite reflectance measurements are in line with observations from the miospore taxa, showing thermal maturities of 0.9 %VRr to 1.13 %VRr and therefore sediments in the late oil generation maturity stage. A general increase of thermal maturity from the top to the base of the Nayband Formation can be observed in this context.

Conclusion

From palynological and geochemical studies of Nayband Formation, the following points can be derived:

1- Nayband Formation at the Parvadeh section, southern Tabas city has a thickness of 1410 m which mainly consists of shale, siltstone, coal and intercalations of coarse grained sandstone and sandy limestone.

2- A total of 58 miospore species were encountered including 31 spore species (21 genera) and 27 pollen grained species (17 genera). These were arranged to ten miospore assemblage biozones.

3- Based on diagnostic miospore taxa such as *Riccisporites tuberculatus*, *Limbosporites lundbladii*, *Quadraeculina anellaeformis*, *Kyrtomisporis laevigatus*, *Ovalipollis ovalis* and taeniate bisaccate pollen grains, the Nayband Formation assigned to Late Triassic (Norian-Rhaetian) age.

4- The plant macrofossil is confined to Howz-e-khan Mbr of Nayband Formation, encountering *Phlebopteris muensteri*, *Cladophlebis nebbensis*, *Nilssonia acuminate*, *Nilssoniopteris* cf. *musafolia*, *Nilssoniopteris schenkiana*, *Pterophyllum schenki*, *Pterophyllum tietzei*, *Todites* cf. *crenatum*, *Phlebopteris munestri*, *Equisetites* cf. *arenaceus* and *Scytophyllum persicum*. The age of Howz-e-khan Mbr On base of some Late Triassic diagnostic fossils such as *Pterophyllum bavieri*, *Equisetites arenaceus*, *Pterophyllum schenki*, *Nilssoniopteris musafolia* and *Scytophyllum persicum*, suggesting Late Triassic (Rhaetian).

5- A late oil generation stage thermal maturity of the strata is also underlined by vitrinite reflectances of 0.9 – 1.2 %VRr.

6- Solid bitumen occurrences in organic-rich shales hint to hydrocarbon generation in some stratigraphical units of the Nayband Formation.

Table 1. Organic geochemical (Rock-Eval) characteristics of the Nayband Formation at the Parvadeh area, Central Iran

						Rock–Eval pyrolysis									
Sample No.	**Distance from the base (m)**	**Weight (mg)**	**TOC (wt%)**	**TIC (wt%)**	**TC (wt%)**	**S_1**	**S_2**	**S_3**	**T_{max} (°C)**	**HI**	**OI**	**PI**	**VR_r (%)**	**S (wt%)**	**Biozone**
12-MY-02	3	99.5	8.137	0.912	9.049	0.07	0.68	2.74	602	8.30	33.68	0.10	1.023	0.130	I
12-MY-03	6.5	99.9	0.201	5.404	5.604	0.03	0.14	0.90	381	71.11	448.5	0.15			I
12-MY-05	23	100.1	4.318	0.091	4.409	0.03	0.32	2.41	603	7.48	55.84	0.09	1.019	0.088	I
12-MY-06	24	100.2	10.63	1.451	12.10	0.06	0.45	3.63	606	4.23	34.18	0.11	1.032	0.106	I
12-MY-12	55	99.6	6.347	0.068	6.415	0.04	0.37	2.45	606	5.80	38.58	0.09			II
12-MY-18	80	99.8	3.270	1.373	6.643	0.04	0.34	1.47	553	10.34	44.88	0.10			II
12-MY-48	465	100.2	3.315	1.386	4.701	0.03	0.55	1.22	605	16.62	36.79	0.06			III
12-MY-50	466	100.0	1.094	0.021	1.115	0.03	0.51	1.03	605	46.94	94.50	0.05			III
12-MY-51	467	100.2	1.490	0.033	1.522	0.04	0.38	0.95	606	25.65	63.98	0.09			III
12-MY-52	468	100.0	0.221	0.017	0.238	0.03	0.38	0.76	604	171.6	344.8	0.06			III
12-MY-54	469.5	100.1	0.120	0.013	0.133	0.02	0.66	0.72	632	552.4	598.7	0.03			III
12-MY-56	470	100.1	0.037	0.009	0.046	0.03	0.32	0.92	606	883.7	2499	0.08			III
12-MY-68	501	99.9	40.26	1.562	41.82	0.12	1.23	8.57	606	3.05	21.29	0.09	1.067	0.127	IV
12-MY-73	502	100.4	0.838	0.018	0.856	0.02	0.27	0.73	605	32.15	87.59	0.08			IV
12-MY-74	502.5	100.9	0.036	0.058	0.094	0.02	0.13	0.71	606	384.9	1978	0.13			IV
12-MY-79	507	100.0	0.713	0.026	0.739	0.02	0.37	1.05	606	52.10	147.9	0.06			IV
12-MY-83	512	100.0	0.996	0.022	1.018	0.03	0.46	0.94	605	45.70	94.17	0.06			IV
12-MY-84	513	100.4	0.405	0.016	0.421	0.03	0.34	0.76	606	84.00	187.3	0.07			IV
12-MY-87	517	100.3	1.812	0.024	1.835	0.07	0.47	1.08	599	26.04	59.62	0.13			IV
12-MY-90	521	99.7	1.030	0.018	1.048	0.02	0.33	0.84	606	32.10	81.66	0.07			IV
12-MY-93	522	100.3	0.530	0.021	0.546	0.02	0.23	0.80	602	42.68	150.5	0.08			IV
12-MY-95	523	100.2	0.730	0.026	0.750	0.03	0.22	1.15	442	29.52	158.3	0.14			IV
12-MY-98	525	100.2	0.419	0.246	0.664	0.05	0.15	0.77	606	36.36	183.9	0.25			IV
12-MY-101	527	99.9	0.625	0.019	0.643	0.03	0.33	0.82	606	52.44	131.0	0.07			IV
12-MY-106	530	100.5	4.082	0.034	4.116	0.04	0.61	2.67	453	15.00	65.31	0.06			IV
12-MY-107	531	100.2	2.700	0.033	2.733	0.22	1.82	1.18	422	67.31	43.59	0.11			IV
12-MY-109	535	100.0	4.119	0.051	4.169	0.19	1.53	1.65	467	37.14	39.99	0.11	1.126	0.056	IV
12-MY-112	539	100.3	3.805	0.065	3.870	0.09	0.67	1.74	485	17.64	53.79	0.11			IV
12-MY-114	541.5	100.3	1.765	0.036	1.801	0.03	0.46	1.42	450	26.04	80.50	0.07			IV
12-MY-130	548	100.8	0.667	0.040	0.707	0.03	0.24	0.94	606	35.91	140.9	0.10			IV
12-MY-138	552	100.3	7.712	0.024	7.736	0.18	1.53	3.53	487	19.81	45.79	0.11	0.957	0.053	V
12-MY-145	556	99.7	0.797	0.020	0.817	0.03	0.43	1.14	395	53.84	143.6	0.07			V
12-MY-147	557	100.2	0.688	0.689	1.376	0.02	0.14	1.58	605	20.57	229.3	0.15			V
12-MY-152	559.5	100.2	1.679	0.053	1.372	0.03	0.29	0.84	570	17.52	50.33	0.09			V
12-MY-154	560.5	99.7	1.604	0.022	1.626	0.05	0.54	1.26	604	33.49	78.55	0.09			V
12-MY-156	562.3	100.6	1.46	0.019	1.483	0.04	0.13	3.29	422	9.00	224.5	0.22			V
12-MY-158	565.8	100.3	2.876	0.096	2.972	0.09	0.96	3.01	422	33.31	104.6	0.08			V
12-MY-165	572	100.3	0.475	0.021	0.495	0.04	0.67	1.04	425	141.8	218.9	0.05			V
12-MY-172	578	100.1	0.898	0.018	0.916	0.13	0.65	0.91	347	72.16	101.6	0.17			V
12-MY-180	582	100.3	1.106	0.044	1.150	0.04	0.22	1.03	605	20.23	92.83	0.14			V
12-MY-182	583	100.3	0.625	0.028	0.601	0.02	0.23	0.89	605	39.62	155.7	0.07			V
12-MY-184	584	100.2	4.082	0.020	0.573	0.03	0.49	2.08	605	88.27	376.2	0.06			V
12-MY-186	585	99.9	0.427	0.039	0.466	0.02	0.17	0.87	605	39.73	203.6	0.13			V
12-MY-189	596	100.6	0.408	0.020	0.428	0.03	0.61	1.02	605	149.7	250.4	0.05			V

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Table 1. Cntd

12-MY-198	605	99.8	0.750	0.025	0.775	0.02	0.33	1.15	606	43.92	153.3	0.05			VI
12-MY-200	607.2	99.8	0.501	0.044	0.545	0.02	0.20	1.02	604	39.40	203.7	0.08			VI
12-MY-202	608.5	100.4	0.430	0.017	0.447	0.02	0.30	1.17	605	69.44	270.9	0.06			VI
12-MY-208	611	100.0	0.600	0.014	0.675	0.04	0.59	1.16	605	89.07	175.5	0.07			VI
12-MY-209	615	99.5	0.623	0.016	0.639	0.02	0.24	1.10	605	38.50	176.7	0.08			VI
12-MY-237	729	100.6	0.545	0.028	0.573	0.02	0.19	1.04	604	34.20	190.1	0.09			VI
12-MY-275	781.5	100.2	0.570	0.017	0.587	0.17	1.33	1.26	605	232.9	220.6	0.11			VI
12-MY-277	782.2	100.0	0.480	0.017	0.497	0.17	0.57	1.25	388	119.6	259.8	0.23			VI
12-MY-279	783.5	100.5	0.301	0.012	0.312	0.09	0.65	1.29	606	215.8	430.0	0.13			VI
12-MY-286	785	99.8	3.084	0.212	3.296	0.16	1.18	1.76	508	38.27	57.18	0.12			VI
12-MY-287	786	100.2	1.112	0.057	1.169	0.40	1.20	1.09	404	108.0	97.79	0.25			VI
12-MY-296	789.1	100.4	6.199	0.038	6.237	0.05	0.63	2.52	461	10.14	40.64	0.07	1.097	0.103	VI
12-MY-298	791.5	99.9	0.561	0.018	0.579	0.03	0.45	1.59	604	80.14	283.1	0.06			VI
12-MY-307	796.7	100.7	0.861	0.048	0.909	0.31	1.40	1.07	407	162.5	124.3	0.18			VI
12-MY-309	802	100.4	0.839	0.047	0.886	0.34	1.31	0.98	413	155.9	116.4	0.20			VI
12-MY-328	825	100.2	0.847	0.020	0.867	0.06	0.79	1.61	605	93.06	189.5	0.08			VI
12-MY-336	841	100.2	3.652	2.451	6.103	0.06	0.33	2.14	601	9.11	58.68	0.14			VI
12-MY-352	870	100.2	0.259	0.017	0.276	0.03	0.46	0.95	604	176.0	366.2	0.05			VI
12-MY-355	880.5	100.4	3.827	0.169	3.996	0.06	0.75	2.59	486	19.52	67.61	0.08			VI
12-MY-358	885	100.0	0.479	0.018	0.498	0.08	0.84	2.03	605	174.9	423.2	0.09			VI
12-MY-361	887.4	100.7	0.265	0.025	0.291	0.26	1.07	1.62	434	403.3	609.2	0.20			VI
12-MY-363	916.2	99.7	8.904	0.205	9.109	0.17	1.53	4.92	605	17.17	55.22	0.10	0.897	0.075	VI
12-MY-365	917.5	100.2	16.08	0.130	16.211	0.21	2.04	7.58	605	12.70	47.16	0.09			VI
12-MY-368	918.6	99.8	7.237	0.069	7.306	0.19	0.84	2.75	474	11.61	37.98	0.18			VI
12-MY-371	920	100.2	3.864	0.111	3.974	0.28	1.42	1.68	326	36.64	43.49	0.17			VII
12-MY-374	921	99.8	2.481	0.037	2.518	2.17	40.77	65.24	606	1643	2629	0.05			VII
12-MY-376	922	99.5	5.763	0.050	5.813	0.19	1.29	2.95	488	22.46	51.25	0.13	0.978	0.121	VII
12-MY-379	925	100.3	47.99	0.685	48.68	0.21	1.03	5.66	605	2.14	11.79	0.17	1.008	0.103	VII
12-MY-381	927	99.6	45.69	0.000	45.69	0.71	4.77	22.69	396	10.44	49.66	0.13	0.994	0.084	VII
12-MY-384	930.5	100.1	1.148	0.049	1.197	0.05	0.44	1.03	353	38.55	89.49	0.10			VII
12-MY-389	948	100.1	5.705	0.173	5.878	0.06	1.12	3.29	602	19.60	57.65	0.05	0.942	0.118	VII
12-MY-390	950	99.7	7.273	0.175	7.448	0.07	1.43	3.49	604	19.63	47.94	0.05	1.097	0.101	VIII
12-MY-392	955	100.5	28.34	0.257	28.60	0.34	3.22	17.79	490	11.35	62.77	0.10	1.043	0.120	VIII
12-MY-403	1015.4	100.1	1.927	0.082	2.009	0.11	0.86	0.95	454	44.47	49.36	0.11			VIII
12-MY-405	1019	100.3	1.954	0.182	2.135	0.12	0.86	0.95	506	44.13	48.66	0.12			VIII
12-MY-408	1021	100.3	0.397	0.019	0.416	0.04	0.56	2.05	602	141.4	516.0	0.06			VIII
12-MY-426	1036	99.6	1.303	0.048	1.351	0.04	0.35	1.26	535	26.55	96.46	0.11			VIII
12-MY-427	1040	99.8	1.230	0.029	1.259	0.03	0.33	1.12	603	26.83	91.18	0.08			VIII
12-MY-453	1196.2	100.3	27.89	0.005	27.90	0.20	1.43	21.08	603	5.11	75.60	0.12	0.840	0.088	VIII
12-MY-461	1262	99.6	18.50	0.369	18.87	0.07	0.53	7.07	540	2.86	38.23	0.11	0.967	0.101	IX
12-MY-507	1375	99.5	0.721	0.041	0.762	0.03	0.25	0.97	605	34.71	135.0	0.10			X
12-MY-510	1395	100.6	4.720	0.770	5.490	0.06	0.33	2.05	554	6.96	43.47	0.15	0.951	0.098	X

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