



Middle Jurassic biostratigraphy of plant macro and microfossils in Soltanieh Mountains, south of Zanzan, NW Iran

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ABSTRACT

Jurassic deposits a section in south of Zanzan contain various taxa of macro and microfloras. Six plant macrofossil species belonging to five genera of various orders such as Equisetales, Cycadales, Bennettiales, and Pinales (Coniferales) are identified. This section contains seventeen species of palynomorphs in which six spore species allocated to six genera, eight pollen species allocated to five genera, and three dinocyst species allocated to two genera are present. Based on the occurrence of Index fossils such as *Ptilophyllum harrisianum*, *Nilssonina* sp. cf. *N. bozorga*, and *Equisetites* sp. cf. *E. beanii*, an early Middle Jurassic (Aalenian-Bajocian) age suggested for these sediments. Therefore, these deposits considered to belong to the Dansirit Formation. Moreover, based on the stratigraphic distribution of index fossils of plant macrofossils, miospores, and dinocysts, three assemblage biozones recognized. These biozones are *Nilssonina* sp. cf. *N. bozorga*-*Ptilophyllum harrisianum*, *Klukisporites variegatus*-*Cycadopites crassimarginis*, and *Pareodinia ceratophora*-*Nannoceratopsis triceras* Assemblage Zone, respectively. All these biozones are comparable to the other Known Iranian biozones. Therefore, it is concluded that uniform environmental conditions are dominant through North, Central, and East Central of Iran during this interval. Furthermore, because of the occurrence of dinoflagellates, this area was located at the margin of Tethys Ocean.

1- Introduction

Middle Jurassic sediments of Iran have well exposures in the Alborz Mountains, central Iran and eastern parts of central Iran. Assereto (1966) established Jurassic coal bearing Shemshak Formation around the Shemshak village of central Alborz Mountains, which involved four lithostratigraphic Members. Afterwards, Fürsich et al. (2009) revised this rock unit and upgrade it to a group with nine formations: Ekrasar, Laleband, Kalariz, Shahmirzad, Alasht, Javaherdeh, and Shirindasht formations, of Pliensbachian to Aalenian age, and Filzamin and Dansirit formations, Aalenian-Bajocian in age. Paleobotany of Shemshak Group started since 1881 that shows diverse plant fossils of Late Triassic to Middle Jurassic (e.g. Schenk, 1887; Kilpper, 1968; Barnard, 1965 and 1967; Barnard and Miller 1967; Fakhr, 1977; Corsin and Stampfli, 1977; Schweitzer and Kirchner, 1996, 1998

and 2003; Schweitzer et al., 1997, 2000 and 2009; Vaez-Javadi 2006, 2008, 2011, 2012 and 2016; Vaez-Javadi and Abbasi, 2012, Vaez-Javadi and Allameh, 2015, Vaez-Javadi and Namjoo, 2015).

Since there are no data about paleobotany or palynology of Shemshak Group from the Soltanieh Mountains, northwest Iran, and consequently, subunits of this group are not define in the Zanzan area, we study this section. This study reports plant macrofossils and palynomorphs from the Zanzan section for the first time. Most plant fossils of this area are poorly preserved in the sandstone layers at the upper part of the section. We supply, however admissible data for reconstruction of Jurassic vegetation of Soltanieh Mountains in Jurassic period. Moreover, presence of cysts of dinoflagellate indicates a shallow marine environment with transported palynomorphs in this area.

2- Material and methods

Seventeen specimens collected from a section located at south of Zanjan in order to study its plant macrofossils. Specimens photographed and the photos improved in quality by Photoshop CC 2014. The biozonation of the studied Jurassic section was undertaken based on the “first observed occurrence” (FOO) of stratigraphically significant plant macrofossil species, and of the “last observed occurrence” (LOO). The established biozones from this area compared with other biozones from northern, central, and east central Iran and comparative biostratigraphic charts produced (Figs. 3 and 4).

Ten palynological samples selected out of the collected samples which constitute the basis of this investigation. Standard palynological procedures (e.g., Phipps and Playford, 1984) utilized for retrieval and concentration of the palynomorphs. After a mild surface washing the samples crushed and ca. 50g weighed out. This fraction of the material chemically treated as follows: ca. 20 h. of cold 10% HCl, 30 h. 40% HF and 20 min. of 90°C 10% HCl. The samples then washed in water and sieved on a 20µm filter. The organic residues evaluated, attention focused on the palynomorph content, as the purpose was exclusively biostratigraphy/ systematics. In this context, the optimal conditions for microscopically observations are clean preparations with transparent light brown palynomorphs. The palynomorphs, if too dark, bleached with 5% KOH. All the slides microscopically scanned and ten of the richest and most diverse from different levels throughout the section counted to differentiate marine and terrestrial palynomorph components. These slides were abbreviated AJSZ (acronym Abbasi, Javadi, Shemshak, and Zanjan). Afterwards, distribution of miospore species studied and biozonation was recognized. All rock samples, residues, and strew slides used herein are permanently housed in the Palynology Collection at the School of Geology, College of Science, University of Tehran, Tehran, Iran. Finally, integrated biostratigraphy of plant macrofossils, miospores, and dinocysts established (Fig. 3).

3- Geological setting of Zanjan

Soltanieh Mountains in the south of Zanjan-Abhar plain, northwest Iran are famous, because of the type sections of Precambrian-Cambrian rock units, such as Bayandor, Soltanieh and Barut formations surveyed in these mountains (Stöcklin and Setudehnia, 1991). Soltanieh fault strongly deformed rock units of uplifted Soltanieh Mountains, which include over thrusted Precambrian-Paleozoic rocks on the Cenozoic sediments during the Pyrenean orogenesis

(Aghanabati, 1998). It seems that, Soltanieh fault has ruptured Paleozoic rocks as late as Cambrian and put Soltanieh horst on long-aged hiatuses. Main Phanerozoic hiatuses occurred in the Ordovician-Carboniferous, Triassic, Late Cretaceous, and Oligocene-Pleistocene periods. Actually, presence of thick regolith and structural deformations, finding of well exposures and complete profile of the rock units of Shemshak group is limited in the Soltanieh Mountains. For example, most outcrops of Shemshak Group have been covered by soil profiles, where involved mostly shale sediments. Detection of Shemshak Group however is possible by U-shaped geomorphology between cliffs of Ruteh and Dalichai-Lar carbonate formations (Fig. 1).

Studied section is located in 13 km south of Zanjan, around Chavarzagh crossroad (Fig. 2). Here, Shemshak Group covers limestone layers of Ruteh Formation (Late Permian), and overlain unconformably by conglomerate of

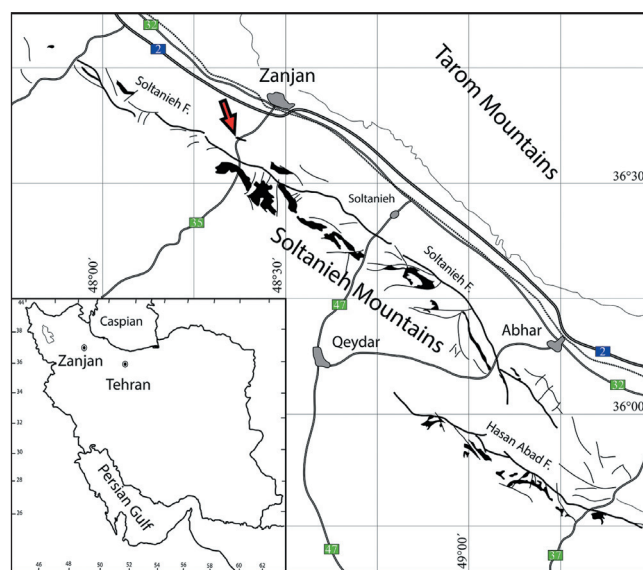


Fig. 1- Shemshak Group outcrops in the Soltanieh Mountains, northwest Iran. Arrow shows studied section, south of Zanjan (modified from Stöcklin and Eftekhari-nezhad, 1969; Alavi et al., 1982; Bolourchi, 1979).

Fajan Formation (Paleocene). Olive to gray sandstone, dark gray shales and coal shale, alternation of shale and thin-bedded sandstone, thick-bedded sandstone with coal seam are main lithologies of Shemshak Group in south of Zanjan, with 81.5 m thickness (Fig. 3).

4- Systematic paleobotany of plant macrofossils

The Jurassic deposits in south Zanjan section contain poorly preserved plant macrofossils. They distributed mainly along

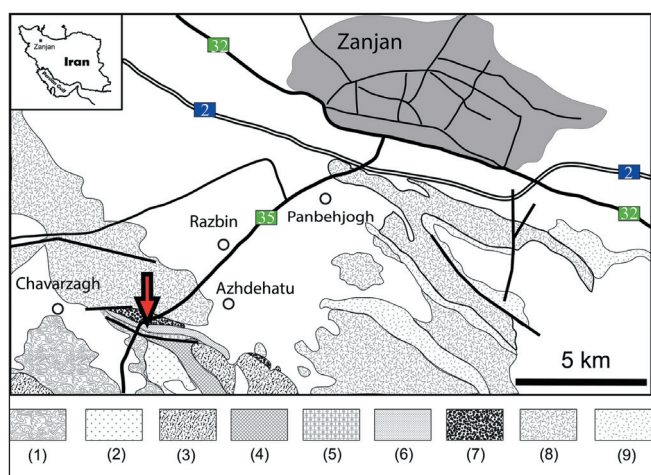


Fig. 2- Outcrops of rock units in south of Zanjan (modified from Babakhani and Sadeghi, 2004). Arrow shows studied section location and rock units include: 1) metamorphic rocks and Kahar Formation, Precambrian; 2) Doran granite; 3) Bayandor Formation, Precambrian; 4) Soltanieh Formation, Precambrian-Cambrian; 5) Ruteh Formation, Permian; 6) Shemshak Group, Jurassic; 7) Fajan Formation, Paleocene; 8) Karaj Formation, Eocene; 9) Andesite porphyrite.

the upper parts of the section. Herein we report these fossils for the first time. The Dansirit Formation contains six species of plant macrofossil remains allocated to five genera of various orders. These species are *Equisetites beanii* Seward 1894, *Ptilophyllum harrisianum* Kilpper 1968, *Nilssoniasp. cf. N. bozorga* Barnard & Miller 1976, *Nilssoniasp.*, *Cyparissidium sp.*, and *Podozamites distans* (Presl 1838) Braun 1843 (Plate 1).

Division: Equisetophyta Scott 1900

Order: Equisetales Candolle ex Berchtold and Presl 1820

Family: Equisetaceae Michaux ex Candolle 1804

Genus: *Equisetites* Sternberg 1833

Type species: *Equisetites muensteri* Sternberg 1833

Equisetites sp. cf. E. beanii (Bunbury 1851) Seward 1894 emend. Harris 1961

Plate 1, Fig. 6

1851 *Calamites beanii* Bunbury; p. 189.

1894 *Equisetites beanii* (Bunbury) Seward; p. 270, text-figs. 60-62.

1961 *Equisetum beanii*: Harris; p. 24; text-fig. 6A, B.

1997 *Equisetites beanii*: Schweitzer et al.; pp. 139-141, pl. 7, figs. 1-5; pl. 8, figs. 1-6; text-figs. 16, 17.

2011 *Equisetites beanii*: Vaez-Javadi; p. 82, figs. 3C; 4B, D; 5A.

2014 *Equisetites beanii*: Vaez-Javadi; pp. 72-73, pl. II, fig. 2; text-fig. 4: 1.

Description: This specimen is a stem, 21 mm long (full length unknown), 47 mm wide, with ribs and furrows along the surface of stem, 21 per cm. Ribs separate ca. 0.8 mm.

Since this specimen is an incomplete stem, we prefer to attribute "sp. cf." to it.

Division: Cycadophyta Bessey 1907

Order: Cycadales Coulter & Chamberlain 1910

Genus: *Nilssoniasp.* Brongniart 1825

Type Species: *Nilssoniasp. brevis* Brongniart 1825

Nilssoniasp. cf. N. bozorga Barnard & Miller 1976

Plate 1, Fig. 1

1976 *Nilssoniasp. bozorga* Barnard & Miller; p. 82, pl. 11, figs. 1-5; text-fig. 19 A-I.

2000 *Nilssoniasp. bozorga*: Schweitzer et al.; p. 26, pl. 6, figs. 1, 2; text-fig. 5 a-c, 6.

2012 *Nilssoniasp. bozorga*: Vaez-Javadi & Abbasi; p. 44; pl. VI, fig. 1; text-fig. 4: 10.

2014 *Nilssoniasp. bozorga*: Vaez-Javadi; pp. 131-132; pl. VII, fig. 1; text-fig. 2: 5.

2015 *Nilssoniasp. cf. N. bozorga*: Vaez-Javadi & Allameh; p. 29, Pl. 3, fig. 1.

Description: Frond is once pinnate, over 5 cm long. Pinnae arise at 75° and cover the rachis. Pinnae with variably width, margins converge. Veins are fine, simple and parallel with a concentration from 24-26 per cm basally. Since the apices are not preserved we prefer to use "cf."

Nilssoniasp.

Plate 1, Fig. 2

Description: This specimen is a part of a leaf, 6 mm wide, and 21 mm long (full length unknown). Veins are simple and parallel.

Division: Uncertain/? Cycadophyta Bessey 1907

Order: Bennettitales Engler 1892

Genus: *Ptilophyllum* Morris 1840

Type species: *Ptilophyllum acutifolium* Morris 1840

Ptilophyllum harrisianum Kilpper 1968

Plate 1, Fig. 3

Description: Frond is once pinnate, over 52 mm long and 26 mm wide, rachis concealed; blade dissected into closely spaced segments, 20 mm long and 2 mm wide, linear, opposite to sub-opposite, arising at angles of 70°. Veins are simple or forked once with a concentration of 25-27 per cm.

Division: Pinophyta Cronquist, Takhtajan and Zimmermann 1966

Order: Pinales Dumortier 1829

Genus: *Podozamites* Braun 1843

Type species: *Podozamites distans* (Presl 1838) Braun 1843

Podozamites distans (Presl 1838) Braun 1843

Plate 1, Fig. 5

Description: Several dissected leaves with contracted bases, 6-5 mm wide. Veins are parallel, fine, simple or forked once near the base of leaf, 19-20 per cm.

Class: Coniferopsida

Genus: *Cyparissidium* Heer 1874

Type species: *Cyparissidium gracile* Heer 1874

Cyparissidium sp.

Plate 1, Fig. 4

Description: This specimen is a stem, 27 mm long, which covered by spirally arranged small leaves, 2.3x0.4 mm in size, almost diamond in shape, obtuse-acute apices.

5- Palynomorphs of the south Zanjan section

Samples from south of Zanjan contain six species of spores (six genera), eight species of pollen (five genera), and three dinocyst species (two genera) (Plate 2). Miospores of the Zanjan section are: *Cyathidites mesozoicus* (Thiergart 1949) Potonié 1955, *Dictyophyllidites mortonii* (de Jersey 1959) Playford & Dettmann 1965, *Concavisporites kermanense* Arjang 1975, *Klukisporites variegatus* Couper 1958, *Limbosporites lundbladii* Nilsson 1958, *Undulatisporites* sp., *Cycadopites crassimarginis* (de Jersey 1959) de Jersey 1964, *Cycadopites* sp., *Araucariacites australis* Cookson 1947 ex Couper 1953, *Chasmatosporites* sp. cf. *C. elegans* Nilsson 1958, *Chasmatosporites apertus* (Rogalska 1954) Nilsson 1958, *Chasmatosporites hians* Nilsson 1958, *Parcisorites* sp. cf. *P. cacheutensis* Jain 1968, and *Alisporites* sp.

Moreover, three dinocysts in this assemblage identified. It comprises the following species: *Nannoceratopsis tricerias* Drugg 1978, *Pareodinia ceratophora* Deflandre 1947, and *Pareodinia* sp. cf. *P. prolongata* (Sarjeant 1962) Downie & Sarjeant 1965.

6- Biostratigraphy of plant macrofossils, miospores, and dinocysts

Based on the occurrence of index fossils (Barnard, 1965; Schweitzer and Kirchner, 1997; Schweitzer et al., 2000, 2009) such as *Equisetites* sp. cf. *E. beanii*, *Nilssonia* sp. cf. *N. bozorga*, and *Ptilophyllum harrisianum* Aalenian-Bajocian is proposed for this assemblage. Based on the FOO and LOO of the plant macrofossils index species one biozone established in the upper part of this stratigraphic section. It is *Nilssonia* sp. cf. *N. bozorga*-*Ptilophyllum harrisianum* Assemblage zone (Fig. 3). Therefore, it is concluded that the upper part assigned to Dansirit Formation. Miospore and dinocysts species distributed along the lower part of section.

Moreover, based on the FOO and LOO of index miospore and cyst of dinoflagellate species two assemblage biozones erected. They are *Klukisporites variegatus*-*Cycadopites crassimarginis*, and *Pareodinia ceratophora*-*Nannoceratopsis tricerias* respectively in the lower part of this stratigraphic section (Fig. 3).

7- Comparative biostratigraphy of the Middle Jurassic of Iran

The biostratigraphy of several localities such as Mazino, North Kouchekali, Calshaneh (Tabas Block), Baladeh, Rudbarak (Central Alborz Mountains), and Bazehowz (South Mashhad) studied during recent years (Vaez-Javadi, 2006, 2011, 2014, 2015; Vaez-Javadi and Abbasi, 2012; Vaez-Javadi and Allameh, 2015; Vaez-Javadi and Namjoo, 2015). Here, we correlate the biozones of the Middle Jurassic of Zanjan with the similar age sediments. Moreover, Vaez-Javadi and Mirzaei-Ataabadi (2006) figured and described 39 species from the Middle Jurassic of Pabdana, Hashooni mine, and Dashte Khak in the Kerman Basin, and these species are closely similar to other Iranian floral localities (Fig. 4).

The erected miospore biozone is comparable with the *Klukisporites variegatus* Assemblage subzone of Arjang (1975), *Klukisporites (Ischyosporites) variegatus*-*Striatella seebergensis (Duplexisporites problematicus)* Zone of Ashraf (1977), Assemblage C- *Klukisporites variegatus* of Bharadwaj and Kumar (1986), and Sajjadi et al. (2007). Moreover, it compared with the *Vitreisporites pallidus*-*Cycadopites follicularis* Assemblage Zone in the Jajarm, East Alborz (Vaez-Javadi and Ghavidel-Syooki, 2005), *Klukisporites* Zone in the Eshkelli, Kerman Basin (Hashemi-Yazdi et al., 2014), *Klukisporites variegatus*-*Monosulcites minimus* Assemblage Zone in the Hojedk, Kerman Basin (Kimyai, 1968), and *Vitreisporites pallidus*-*Klukisporites variegatus* Assemblage Zone in the South Kouchekali, Tabas (Vaez-Javadi, 2017).

Furthermore, this miospore biozone is comparable with the *Contignisporites cooksoniae* Assemblage Zone in the West Bengal, India (Vijaya and Sen, 2005), *Klukisporites variegatus*-*Concavisporites subgranulosus* Zone in the Yorkshire, England (de Jersey, 1970), *Ischyosporites variegatus*-*Duplexisporites problematicus*-*Tsugapollenites dampieri* Zone in the southwest of Germany (Weiss, 1989), *Callialasporites*-*Perinopollenites* Zone in the Bornholm, Denmark (Koppelhus and Nielsen, 1994), and *Tugapollenites (Callialasporites) segmentus*-*Callialasporites dampieri* Assemblage zone in the Eastern Queensland, Australia (Reiser and Williams, 1969) (Fig. 5).

Moreover, the taxonomic identification of the dinoflagellate cysts and their vertical distributions enable recognition of one distinct Middle Jurassic dinoflagellate assemblage- *Nannoceratopsis gracilis*-*Nannoceratopsis deflandrei* Assemblage Zone (Ng-Nd). The assemblage is recognized mainly on the basis of first appearance datums (FADs), last appearance datums (LADs) and relative abundance of particular species. *Nannoceratopsis*

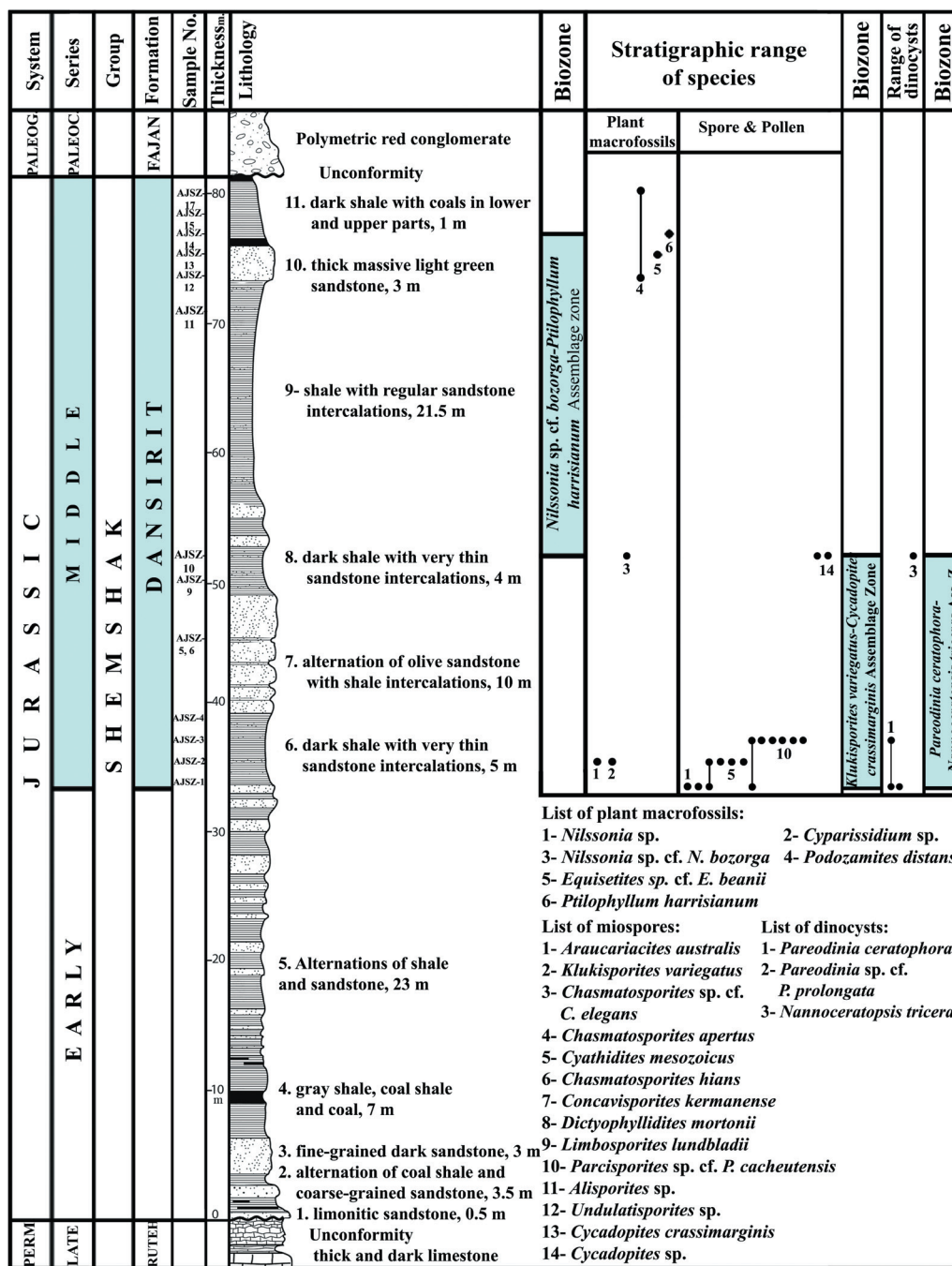


Fig. 3- Distribution of plant macrofossils and palynomorph species through the sampled succession and proposed biostratigraphic units of the Dansirit Formation at the section.

gracilis was a cosmopolitan species during Jurassic (Van Helden, 1977; Davies, 1983). The erected dinocyst biozone compared with the *Nannoceratopsis spiculata* Total Range Zone (Toarcian) and *Valensiella ovulum* Total Range Zone (Bajocian) in the Jajarm, East Alborz (Vaez-Javadi et al., 2003), *Nannoceratopsis triceras-Pareodinia ceratophora* Assemblage Zone in the South Kouchehali, Tabas (Vaez-Javadi, 2018).

Of dinocyst zonal subdivisions of the Jurassic strata in northwest Europe summarized by Riding & Thomas in Powell

(1992), the zones are indicative of short time intervals. They erected *Nannoceratopsis gracilis* (Ngr) Interval Biozone from the early Toarcian-early Bajocian age. This biozone yielded following species: *Nannoceratopsis triceras*, *N. spiculata*, *N. dictyambonis*, *N. plegas*, *Phallocysta eumekes*, *Pareodinia ceratophora*, and *Mancodinium semitabulatum*.

Bucefalo Palliani and Riding (2000) studied Jurassic (Sinemurian-Aalenian) dinocyst biostratigraphy. They considered *Liasidium variable* zone for Sinemurian and *Nannoceratopsis deflandrei-Nannoceratopsis gracilis*

PERIOD	EPOCH	AGE	IRAN								
			KERMAN 1 Pabdana, Dashte-Khak	TABAS 2 Calshanch	TABAS 3 S Kouchehali	TABAS 4 N Kouchehali	TABAS 5 Mazino	BALADEH 6	SEM NAN 7 Rudbarak	BINALUD 8 Baze-Howz	ZANJAN This study
JURASSIC	MIDDLE	BAJOCIAN	<i>Coniopteris hymenophylloides-Klukia exilis</i> Assemblage Zone								
AALENIAN											
			<i>Nilssonia</i> sp. cf. <i>N. bozorga-Klukia exilis</i> Assemblage Zone <i>Ginkgoites</i> cf. <i>paracingularis</i> - <i>Coniopteris hymenophylloides</i> Concurrent Range Zone								
			<i>Coniopteris hymenophylloides-Klukia exilis</i> Assemblage Zone <i>Elatides thomasi</i> - <i>Sphenobaiera longifolia</i> Concurrent Range Zone								
			<i>Ptilophyllum harrisianum</i> Taxon Range Zone <i>Coniopteris hymenophylloides-Klukia exilis</i> Assemblage Zone <i>Ptilophyllum harrisianum</i> - <i>Nilssonia macrophylla-Nilssonia bozorga</i> Conc. Range Z. Taxon Range Z.								
			<i>Klukia exilis-Nilssonia macrophylla</i> Assemblage Zone <i>Sagenopt. nilssoniana</i> - <i>Equisetites beanii</i> - <i>Ptiloph. harrisianum</i> Conc. Range Zone Tax. R. Z. Assemblage Zone								
			<i>Klukia exilis-Coniopteris hymenophylloides</i> Assemblage Zone <i>Coniopteris hymenophylloides-Ptilophyllum harrisianum</i> Assemblage Zone								
			<i>Coniopteris hymenophylloides-Nilssonia sarakhs</i> Assemblage Zone								
			<i>Klukia exilis-Coniopteris hymenophylloides</i> Assemblage Zone								
			<i>Nilssonia</i> sp. cf. <i>N. bozorga-Ptilophyllum harrisianum</i> Assemblage Zone								

Fig. 4- Plant macrofossils biostratigraphy of the Middle Jurassic (Aalenian-Bajocian) sediments of Iran (1- Vaez-Javadi and Mirzaei-Ataabadi, 2006; 2- Vaez-Javadi, 2015; 3- Vaez-Javadi 2016; 4- Vaez-Javadi and Namjoo, 2015; 5- Vaez-Javadi, 2014; 6- Vaez-Javadi and Abbasi, 2012; 7- Vaez-Javadi and Allameh, 2015).

PERIOD	EPOCH	AGE	IRAN													
			E ALBORZ Jajarm ¹	SEM NAN ² Dictash	KERMAN Eskelli 3, 4 Pabdana...	KERMAN Hojejd ⁵	TABAS S Kouchehali ⁶	Karkar & Dahana-i-Tor ⁷	WESTERN Perth Basin ⁸	EASTERN Queensland 9 Surat Basin	Yorkshire Deltaic series ¹⁰	Bornholm Baga Fm. ¹¹	Swabian Alb, SW Germany ¹²	Western Canada ¹³	Eastern Desert ¹⁴	West Bengal ¹⁵
JURASSIC	MIDDLE	BATHONIAN	<i>Vireisporites pallidus-Cycadapites follicularis</i> Assemblage zone <i>Contignisporites-Sriatella</i> Assemblage zone <i>Klukisporites</i> zone <i>Klukisporites variegatus</i> subzone <i>Klukisporites variegatus-Monosulcites minimus</i> Assemblage zone <i>Vireisporites pallidus-Klukisporites variegatus</i> Assemblage zone <i>Contignisporites problematicus</i> Taxon Range zone <i>Ischyosporites variegatus-Duplexisporites problematicus</i> zone <i>Exispollenites tumulus</i> Assemblage zone <i>Dicypophyllites harrisi</i> Assemblage subzone <i>Tsugapollenites (Callitalasporites) segmentus-Callitalasporites dampieri</i> Assemblage zone <i>Klukisporites variegatus-Concavisporites subgranulosus</i> zone <i>Callitalasporites-Perinopollenites</i> zone <i>Ischyosporites variegatus-Duplexisporites problematicus-Tsugapollenites dampieri</i> zone <i>Alisporites thomasi-Vireisporites pallidus-Pflugpollenites (Callitalasporites) dampieri</i> zone <i>Clavosporites/ Circulina-Deltidospora</i> spp. Assemblage zone <i>Verrucosporites spp.-Converrucosporites spp. Trilobosporites</i> spp. Assemblage zone <i>Contignisporites coossoniae</i> Assemblage zone													
AALENIAN	BAJOCIAN	CALLOVIAN														

Fig. 5- Miospores Palynostratigraphy of the Middle Jurassic sediments of Iran and elsewhere (1- Vaez-Javadi and Ghavidel-Syooki, 2005; 2- Navidi-Izad et al., 2015; 3- Arjang, 1975; 4- Hashemi-Yazdi et al., 2014; 5- Kimyai, 1968; 6- Vaez-Javadi, 2017; 7- Ashraf, 1977; 8- Filatoff, 1975; 9- Reiser and Williams, 1969; 10- de Jersey, 1970; 11- Weiss, 1989; 12- Pocock, 1970; 13- Ibrahim et al., 2001; 14- Vijaya and Sen, 2005).

Assemblage Zone for Toarcian to Aalenian. They also stated that *Nannoceratopsis triceris* and *Nannoceratopsis symmetrica* were present in Toarcian strata and *Nannoceratopsis ambonis* in Aalenian strata. This biozone is comparable with the Zanjan dinocyst zone herein.

The erected dinocyst biozone is comparable with *Nannoceratopsis gracilis* zone (late Toarcian-early Aalenian) from Bagå in Bornholm, Denmark (Koppelhus and Nielsen, 1994), *Nannoceratopsis gracilis-Nannoceratopsis senex* Assemblage Zone, and *Sentonusidinium pelionense* Assemblage Zone from the Aalenian-early Bajocian from the Sortehat in East Greenland (Koppelhus and Hanson, 2003), *Dissiliodium caddaense* Zone (Aalenian), and *Nannoceratopsis deflandrei* Zone (Bajocian) from Australia (Helby et al., 2004).

Ibrahim et al. (2003) introduced three biozone from shallow water coastal environment of Qatar. These biozones are *Mancodinium semitabulatum-Pareodinia ceratophora* Assemblage Zone (early Bajocian), *Gonyaulacysta pectinigera-Escharisphaeridia* Assemblage Zone (late Bajocian), and *Ctenidodinium continuum-Dichadogonyaulax sellwoodii* Assemblage Zone (Bathonian). The first biozone is nearly comparable with erected biozone herein. There is no evidence from Paris Basin, Poland, and North Siberia on the Aalenian-Bajocian dinocyst biozonation (Huault, 1999; Gedl, 2007; Riding et al., 1999).

8- Conclusion

Jurassic plant macro and microfossils from the south Zanjan section studied for the first time. Total of twenty-three species identified in which six plant macrofossil species

allocated to five genera of various orders such as Equisetales, Cycadales, Bennettitales, and Pinales recognized. Based on the occurrence of index fossils such as *Equisetites* sp. cf. *E. beanii*, *Ptilophyllum harrisianum*, *Nilssonina* sp. cf. *N. bozorga*, and *Klukisporites variegatus*, Aalenian-Bajocian age is suggested for these assemblages. Therefore, these sediments belong to the Dansirit Formation. Besides, the studied Aalenian-Bajocian strata contain moderately to weak preserved palynomorph species in which six spore (six genera), eight pollen (five genera), and three dinocysts (two genera) identified. Vertical distribution of plant macrofossils and palynomorphs allow erection within the Dansirit Formation of one plant macrofossil biozone-*Nilssonina* sp. cf. *N. bozorga-Ptilophyllum harrisianum* Assemblage zone, one miospore biozone- *Klukisporites variegatus-Cycadopites crassimarginis* Assemblage Zone, and one distinct dinocyst biozone-*Pareodinia ceratophora-Nannoceratopsis triceris* Assemblage zone. These biozones are comparable with biozones from ± the coeval strata in Iran (Baladeh, Rudbarak in Alborz Mountains, Jajarm, Bazehowz in Binalud Mountains, Calshaneh, Mazino, Eshkelli, Pabdana, Dashtekakh in Kerman Basin, North and South Kouchekali in Tabas Block) and elsewhere especially in Northern hemisphere. Therefore, we conclude that uniform condition and climate occurred in Iran during this period. Moreover, the south of Zanjan was located at the coastal boundary of Tethys Ocean.

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PLATE 1

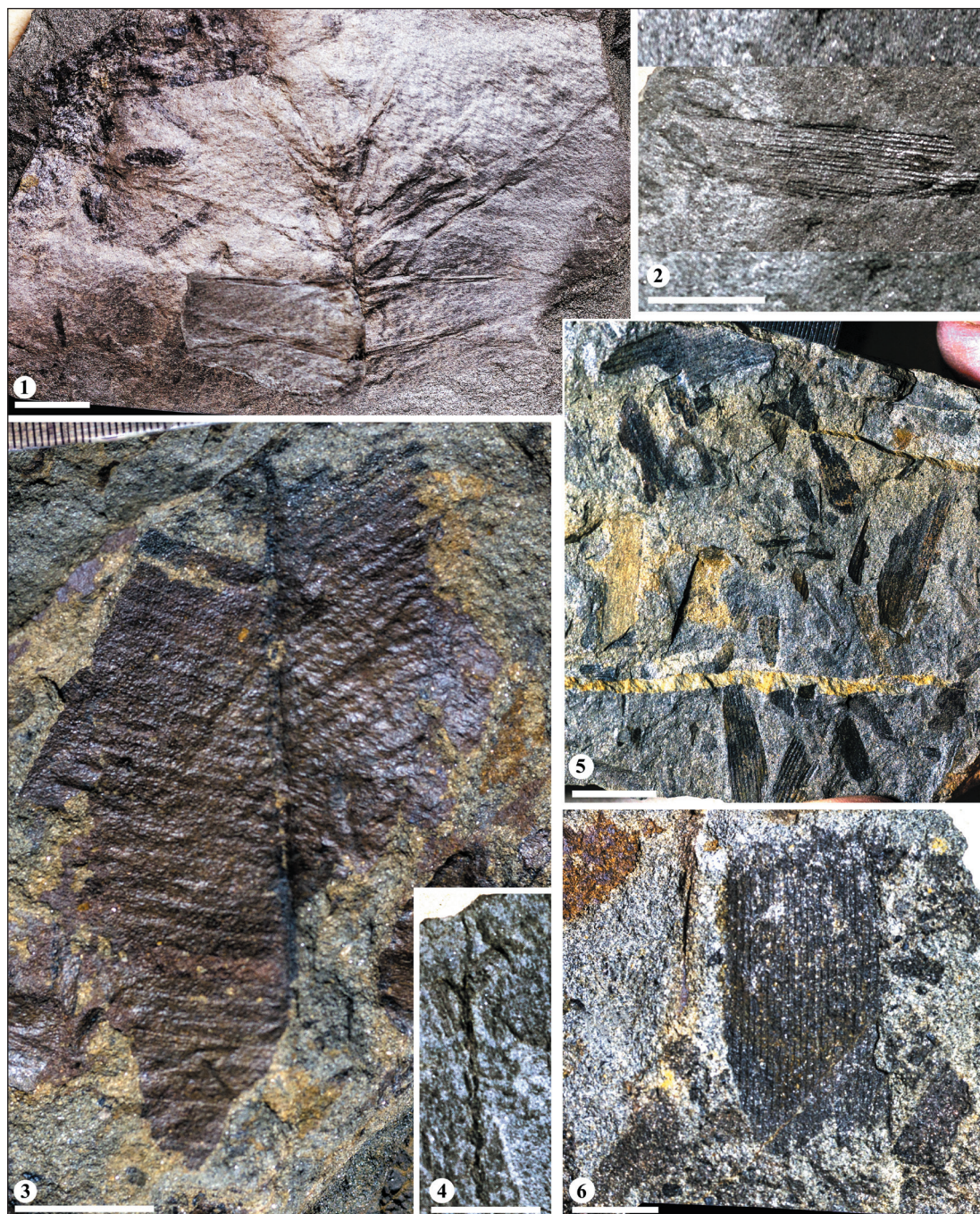


Fig. 1- *Nilssonia* sp. cf. *N. bozorga*, AJSZ-10

Fig. 2- *Nilssonia* sp., AJSZ-2

Fig. 3- *Ptilophyllum harrisianum*, AJSZ-15

Fig. 4- *Cyparissidium* sp., AJSZ-2

Fig. 5- *Podozamites distans*, AJSZ-12

Fig. 6- *Equisetites* sp. cf. *E. beanii*, AJSZ-14. Scale bars are 1 cm.

PLATE 2

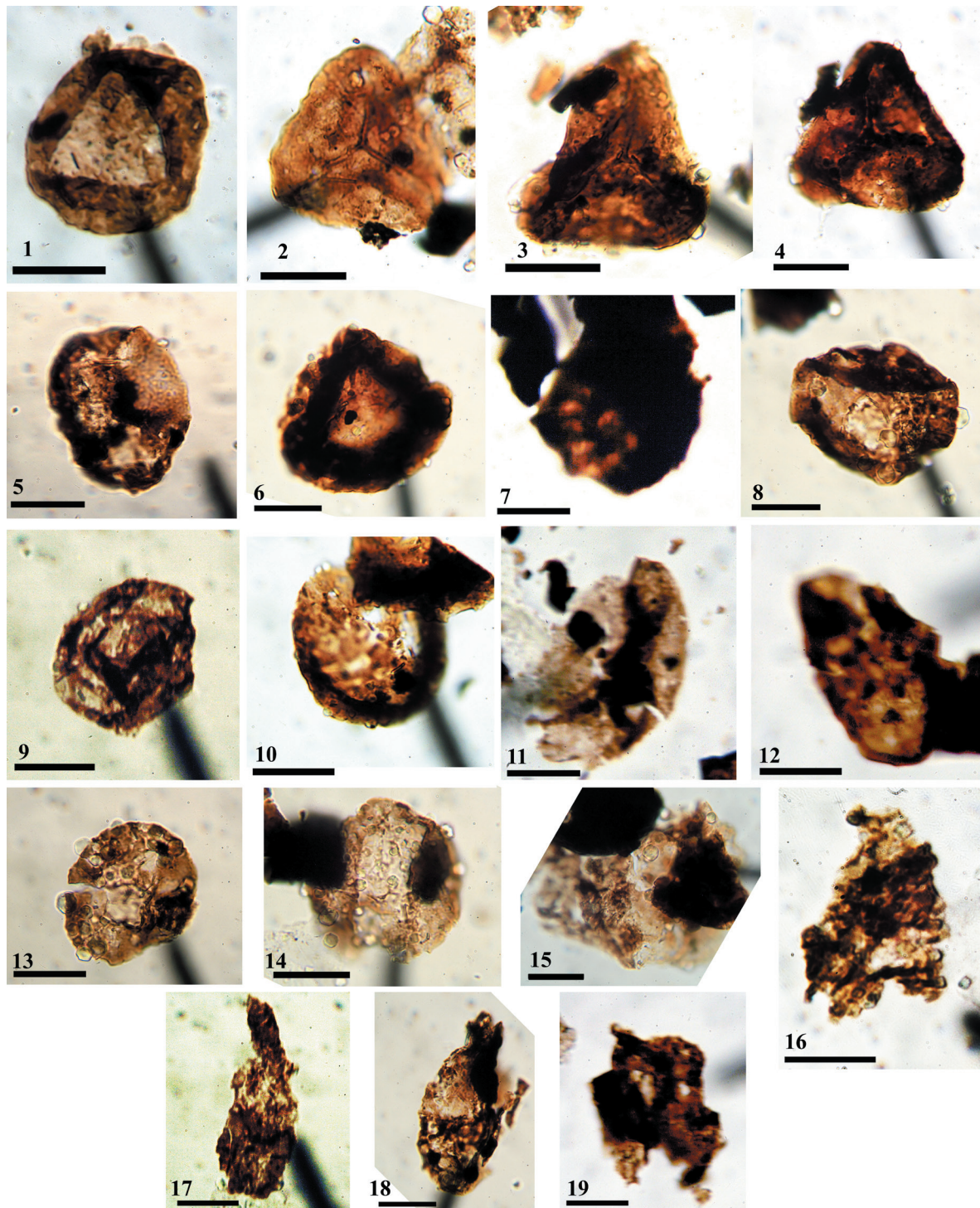


Fig. 1- *Cyathidites mesozoicus* (Thiergart 1949) Potonié 1955, AJSZ-2; **Figs. 2, 3-** *Dictyophyllidites mortonii* (de Jersey 1959) Playford & Dettmann 1965, AJSZ-3; **Fig. 4-** *Concavisporites kermanense* Arjang 1975, AJSZ-3; **Fig. 5-** *Undulatisporites* sp., AJSZ-3; **Fig. 6-** *Limbosporites lundbladii* Nilsson 1958, AJSZ-3; **Fig. 7-** *Klukisporites variegatus* Couper 1958, AJSZ-1; **Fig. 8-** *Chasmatosporites* sp. cf. *C. elegans* Nilsson 1958, AJSZ-2; **Fig. 9-** *Araucariacites australis* Cookson 1947 ex Couper 1953, AJSZ-1; **Fig. 10-** *Chasmatosporites apertus* (Rogalska 1954) Nilsson 1958, AJSZ-2; **Fig. 11-** *Cycadopites crassimarginis* (de Jersey 1959) de Jersey 1964, AJSZ-10; **Fig. 12-** *Cycadopites* sp., AJSZ-10; **Fig. 13-** *Chasmatosporites hians*, AJSZ-2; **Fig. 14-** *Parcisporites* sp. cf. *P. cacheutensis* Jain 1968, AJSZ-3; **Fig. 15-** *Alisporites* sp., AJSZ-3; **Figs. 16, 19-** *Nannoceratopsis triceris* Drugg 1978, AJSZ-10; **Fig. 17-** *Pareodinia* sp. cf. *P. prolongata* (Sarjeant 1962) Downie & Sarjeant 1965, AJSZ-1; **Fig. 18-** *Pareodinia ceratophora* Deflandre 1947, AJSZ-3. Scale bars = 20 μ .

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