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NEW DATA ON PALYNOLOGY OF LOWER PART OF YONG'ANCUN FORMATION (UPPER CRETACEOUS) IN JIAYIN OF HEILONGJIANG, ZEYA-BUREYA BASIN, CHINA*

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Some new palynological fossils were newly found from the lower part of Upper Cretaceous Yong'ancun Formation in Jiayin, China, nearby the Heilongjiang (Amur) River. 43 genera and 54 species of palynomorphs, and three palynological sub-assemblages have been recently identi fied in the lower Yong'ancun Formation. The palynomorphs are dominated by gymnosperms and ferns, angiosperm pollen not abundant. The fern spores are represented mainly by *Cyathidites-Dictyotriletes*, gymnosperms by *Pinuspollenites-Podocarpidites*, and angiosperms by *Retitricolpites-Mancicorpus.* The palynological assemblage is comparable in general to those from the Members 2–3 of Yaojia Formation and the Member 1 of Nenjiang Formation in Songliao Basin, China, indicating the Santonian age. The new palynological material provides supplementary evidence for better understanding of the Santonian palyno flora of the Yong'ancun Formation in Jiayin.

Key words: **Palynology, spores, pollen, assemblages, Upper Cretaceous; Santonian, Yong'ancun Formation; Jiayin of China, Zeya-Bureya Basin.**

INTRODUCTION

The Upper Cretaceous strata of the Zeya-Bureya Basin are well exposed along the right side of the Heilongjiang (Amur) River. This sequence is outcropped nearby Jiayin of Heilongjiang, China. The strata were subdivided into (in ascending order) the Yong'ancun, Taipinglinchang, Yulangzi and Furao Formations, in 1990s [1], and re-studied in detail by the international research team during 2002–2011 [14, 15, 16, 18]. The Upper Cretaceous in Jiayin is very significant for the research on the K-Pg boundary, which is related to the extinction of dinosaurs in the Heilongjiang (Amur) River region. Its biostratigraphic study has been paid much attention by geoscientists in the world [4, 11, 12, 24]. The palynological study of the Yong'ancun Formation was made by V.S. Markevich [5–8].

The stratotype of the Yong'ancun Formation nearby the Yong'ancun village is situated in the right bank of Heilongjiang (Amur) River, about 15 km from the Jiayin Town to east (Fig. 1). The formation is composed of grey, greyish green and yellow siltstone and mudstone intercalated with sandstone, conglomerate, shale, few coal seams, and tuffaceous fine-grained beds, mainly showing a lacustrine-alluvial facies, over 158 m in thickness [1, 15, 18]. This formation yields abundant fossils, including plants, pollen, spores, brackish-water dinoflagellates, ostracods, conchostracans, insects, dinosaur footprints *Jiayinosauropus johnsoni* Dong, Zhou et Wu [2, 8, 13, 17], contacting its overlying Taipinglinchang Formation in conformity, and the underlying Ningyuancun Formation in unconformity [1].

The palynoflora of the Yong'ancun Formation is named by V.S. Markevich as *Kuprianipollis santaloides--Duplosporis borealis* Assemblage and dated as Santonian [7, 8]. The mega-plant fossils of the formation consist of *Equisetum* sp., *Asplenium dicksonianum* Heer, *Arctopteris* sp., *Cladophlebis* sp.; *Ginkgo adiantoides* (Ung.) Heer; *Cupressinocladus sveshnikovae* Ablajev, *Metasequoia disticha* (Heer) Miki, *Parataxodium* sp.; *Trochodendroides arctica* (Heer) Berry; *Celastrinites* sp., *Platanus* sp., *Quereuxia angulata* (Newb.) Krysht. named as *Parataxodium- Quereuxia* Assemblage [17].

However, all the previous research results were received with the material collected from the middle-

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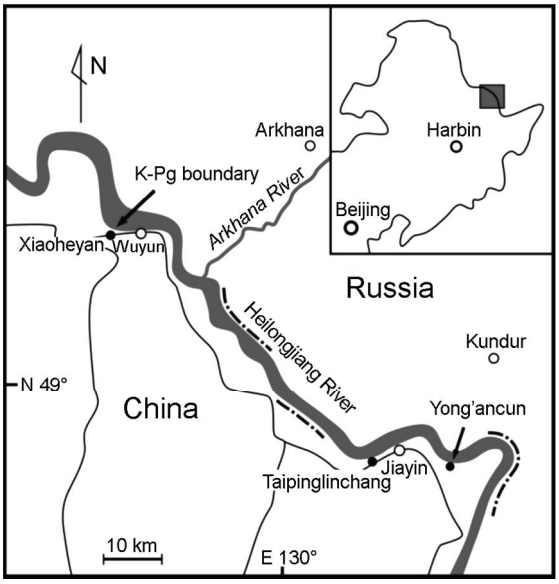

Fig. 1. Sketch geographic map of Jiayin, China (after Sun et al., 2011, revised).

Arrows showing the sites of Late Cretaceous Yong'ancun fossils and the K-Pg boundary in Jiayin.

upper parts of the Yong'ancun Formation. While in 2014, taking the opportunity of a new road construction carried out in East Hill of the Yong'ancun village, the authors have done the new palynological collecting in the lower part of Yong'ancun Formation.

Nearby the Jiayin area to southwest, there is the Songliao Basin, the largest Mesozoic sedimentary basin in Northeast China, consisting mainly of the Upper Cretaceous deposits, yielding abundant fossils and oil-gas resources. The Upper Cretaceous of the Songliao Basin is composed of (in ascending order) the Quantou, Qinshankou, Yaojia, Nenjiang, Sifangtai and Mingshui Formations, which have been studied in high resolution with radiometric dating in recent years [19–23]. Among these formations, the upper Yaojia Formation and lowest Nenjiang Formation could be correlated to the Yong'ancun Formation of Jiayin. Thus, the biostratigraphic study of the Yong'ancun Formation of Jiayin is also very significant for the correlation between the south-eastern part of Zeya-Bureya Basin and the oil-bearing Songliao Basin.

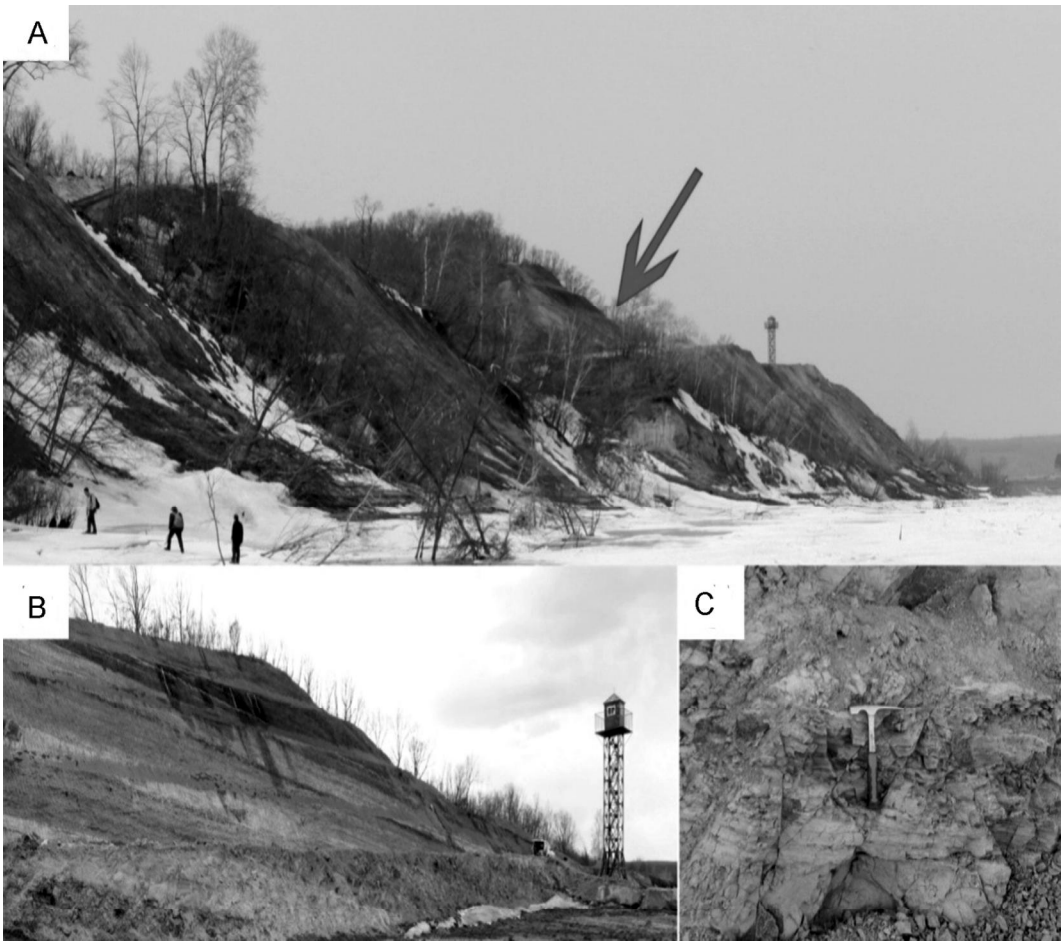

Fig. 2. The outcrop of Yong'ancun Formation in East Hill of Yong'ancun, Jiayin.

A – The arrow indicating the palynological sampling places. B, C – showing the outcrop in detail.

MATERIAL AND METHOD

The new palynological sampling was done in the lower part of Yong'ancun Formation in the East Hill of Yong'ancun of Jiayin (Fig. 2). Coordinates of this locality are N48°50′57″, E130°31′24″. Eleven samples have been collected in total from the outcrop of the strata which is about 29.5 m in thickness (Fig. 3). The strata consist of sandy mudstone, mudstone, siltstone, intercalated by coarse sandstone, in which some mega-plant fossils including horsetails (*Equisetum* sp.), ferns (*Asplenium dicksonianum, Cladophlebis* sp.), ginkgos (*Ginkgo adiantoides*), conifers (*Cupressinocladus sveshnikovae, Metasequoia disticha, Parataxodium* sp.), and angiosperms (*Platanus* sp., *Trochodendroides arctica, Nyssidium* sp., *Quereuxia angulata, Cobbania corrugata* (Lesquereux) Stockey, Rothwell et Johnson) were collected.

Each sample was treated by a standard preparation technique protocol following V. Mosbrugger' method [10]. Pollen and spores were observed and photographed with a light microscope Olympus BX51 housed in the Research Center of Paleontology and Stratigraphy (RCPS), Jilin University, in Changchun, China, and all the samples, slides and stabs are deposited in the Paleontological Museum of Liaoning (PMOL), in Shenyang, China.

RESULTS

Except the samples yn-002, 008 and 010, in which we have not found pollen or spores, all other eight samples were gained good results in palynological study by the authors. 43 genera and 54 species of palynomorphs have been identified (Table). Particularly, the samples yn-001, 004, 006, and 011 show a higher abundance and diversity in palynomorphs, while the angiosperm pollen was found only in the lowest layer, sample yn-001.

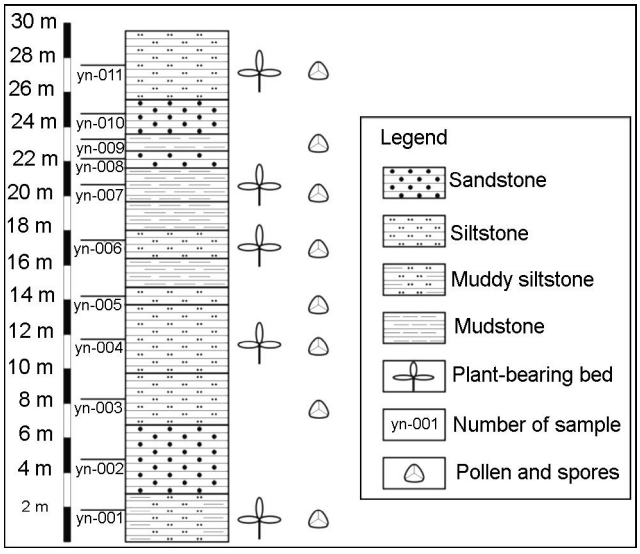

Fig. 3. Stratigraphical column of lower Yong'ancun Formation in Yong'ancun, Jiayin.

In the palynomorphs, fern spores are most abundant, in which *Cyathidites minor* Couper (25.2 %) is predominant, followed by *Dictyotriletes samoilovitchae* Griazeva (11.7 %); while conifer *Pinuspollenites* sp. and *Abietineaepollenites* cf. *pacltovae* (Krutzsch) Zhang are dominant among gymnosperms. Angiosperm pollen is not abundant, represented by *Retitricolpites* sp. (6.5 %), *R. vulgaris* Pierce, *Mancicorpus triangulus* Yu, Gao et Mao. *Dictyotriletes samoilovitchae, Abietineaepollenites* cf. *pacltovae, Phyllocladidites inchoatus* (Pierce) Norris, *Pinuspollenites* sp. and *Podocarpidites* sp. were found in all the palynomorph-bearing samples.

Combined with the palynological horizons, especially well represented in the four samples (yn-001, 004, 006 and 011), three palynological sub-assemblages can be recognized as follows (in ascending order).

(1) Cyathidites-Pinuspollenites-Retitricolpites sub-assemblage

This sub-assemblage (from sample yn-001 of the lowest layer) is characterized by higher abundance and diversity, dominated by fern spores (58.36 %) and gymnosperm pollen (26.77 %). The ferns are represented by *Cyathidites minor* (46.5 %) followed by *Concavissimisporites asper* (Bolkhovitina) Pocock, C. sp. and associated with *Leptolepidites tenuis* Stanley, *Dictyotriletes samoilovitchae, Nevesisporites radiatus* (Chlon.) Sriv., *Triporoletes reticulatus* (Poc.) Playf., *Hymenophyllumsporites* sp., *Gleicheniidites* sp., *Toroisporis* sp., *Interulobites triangulus* (Brenn.) Phillips, *Gabonisporis bacaricumulus* Sriv., *Cibotiidites arlii* Sriv., and *Densoisporites microrugulatus* Pfl. The gymnosperms are represented by *Pinuspollenites* sp., *Abietineaepollenites* cf. *pacltovae, Piceaepollenites* sp., *Podocarpidites* sp. and *Phyllocladidites inchoatus.* The angiosperm pollen include *Retitricolpites* sp. (dominant), *Retitricolpites vulgaris* and *Mancicorpus triangulus*, lower in component.

(2) Dictyotriletes-Cyathidites-Pinuspollenites sub-assemblage

This sub-assemblage (from sample yn-004) is predominated by fern spores (65.74 %) and gymnosperm pollen, with no angiosperm pollen found (Table). The ferns *Dictyotriletes samoilovitchae* and C*yathidites minor* are most abundant, with moderate components of *Laevigatosporites ovatus* Wills. et Webst., and *Osmundacidites* sp. Gymnosperm pollen is predominated by *Pinuspollenites* sp.

Table.Taxonomical composition of spores and pollen from lower part of Yong'ancun Formation.

Spores and pollen	yn-001	yn-003	yn-004	yn-005	yn-006	yn-007	yn-009	yn-011
Pteridophyte spores	**157**	**7**	**71**		**27**	**4**	**1**	**24**
Biretisporites sp.			1					
Cibotiidites arlii	1							
Cicatricosisporites dorogensis								1
Cicatricosisporites pseudoaurifer		1						
Concavissimisporites asper	10	1			1			1
Concavissimisporites sp.	7							
Cyathidites minor	125		25					
Densoisporites microrugulatus	1		1					
Dictyotriletes samoilovitchae	2		28		19	3	1	17
Gabonisporis bacaricumulus	1		1			1		
Gabonisporis labyrinthus					1			
Gleicheniidites sp.	1				1			
Granulatisporites sp.								1
Hymenophyllumsporites sp.	1							
Interulobites triangulus	1							
Klukisporites sp.			1		4			
Laevigatosporites ovatus		3	6		1			
Leptolepidites tenuis	3							1
Multinodisporites sp.			1					
Nevesisporites radiatus	2							
Osmundacidites sp.			4					
Plicifera sp.								1
Punctatisporites sp.		1						
Retitriletes reticulisporites			1					
Toroisporis sp.	1							
Triporoletes reticulatus	1							
Trochicola sp.			2					1
Zlivisporis bireticularis		1						1
Gymnosperm pollen	**72**		**37**	**2**	**82**	**15**	**1**	**56**
Abiespollenites sp.	2		1		1			1
Abietineaepollenites cf. *pacltovae*	12		2		6	5	1	4
Alisporites bilateralis	1		2					
Araucariacites australis	1							
Cedripites densireticulatus			2					
Cedripites dorsatus	1							
Cedripites nolus	2		1					
Cedripites sp.				1		1		
Chasmatosporites sp.			1		2	1		
Ginkgocycadophytus sp.	1		2					1
Laricoidites sp.	1							
Perinopollenites sp.								2
Phyllocladidites inchoatus	7		2		1	1		3
Piceapollenites sp.	7		1		3			3
Piceites sp.					2	1		
Pinuspollenites sp.	27		17		35	2		20
Podocarpidites ellipticus								10
Podocarpidites minisculus	1							8
Podocarpidites nageiaformis	1							
Podocarpidites sp.	7		4	1	32	4		
Pseudopicea magnifica	1							
Psophosphaera minor								1
Psophosphaera sp.			2					3
Angiosperm pollen	**40**							
Mancicorpus triangulus	1							
Retitricolpites sp.	34							
Retitricolpites vulgaris	5							
Total quantities	**269**	**7**	**108**	**2**	**109**	**19**	**2**	**80**

(3) Dictyotriletes-Pinuspollenites-Podocarpidites sub-assemblage

This sub-assemblage (from samples yn-006 and yn-011) is predominated by gymnosperm pollen (70.0–75.7 %), followed by fern spores (24.32–30.0 %) including *Dictyotriletes samoilovitchae* (21.25 %), with no angiosperm pollen found (Table). The gymnosperms bisaccate conifer pollen are represented by *Pinuspollenites* sp. (25 %) and, in less amounts, *Podocarpidites* (including *Podocarpidites ellipticus* Cooks., *P. minisculus* Singh, *P.* sp), and *Abietineaepollenites* cf. *pacltovae.*

In all the three sub-assemblages the genera *Dictyotriletes, Pinuspollenites* and *Podocarpidites* are abundant and widely distributed (Table).

COMPARISON AND DISCUSSION

V.S. Markevich first studied the Late Cretaceous palynoflora of the Yong'ancun Formation of Jiayin in detail (as well as the middle Kundur Formation in Zeya-Bureya Basin, Russia) and named it as *Kuprianipollis santaloides-Duplosporis borealis* Assemblage [8], which is dominated by the gymnosperm pollen (mainly by Pinaceae and Taxodiaceae), followed in abundance of fern spores, and some angiosperm pollen with less than 12 taxa (mainly including Juglandaceae, Fagaceae, Platanaceae, and with a few «unica»-type pollen e.g. *Aquilapollenites*). The main taxa are *Cicatricosisporites dorogensis* Pot. et Gell., *Rouseisporites reticulatus* Chlon., *Cyathidites minor, Classopollis classoides* Pfl. emend Poc. et Jans., *Laevigatosporites ovoideus* Tak., *Taxodiumpollenites hiatus* Pot. et Kremp., *Kuprianipollis elegans* (Zakl.) Kom., *K. santaloides* (Zakl.) Kom., *Cedripites cretaceus* Poc., and the age was considered as Santonian [7, 8, 9]. However, this assemblage was revealed only from the middle-upper parts of the Yong'ancun Formation. Thus, the new palynological material from the lower part of the formation, can be a good supplement for better understanding of palynoflora of the Yong'ancun Formation of Jiayin in whole.

In China side, the lower Yong'ancun Formation of Jiayin, could be compared with its equivalents in the Songliao Basin (Fig. 4). In particular, the Members 2–3 of Yaojia Formation are correlated with Member 1 of Nenjiang Formation. According to the study of Gao et al. [3], the palynological assemblage of the Members 2–3 of the Yaojia Formation is characterized by dominant fern

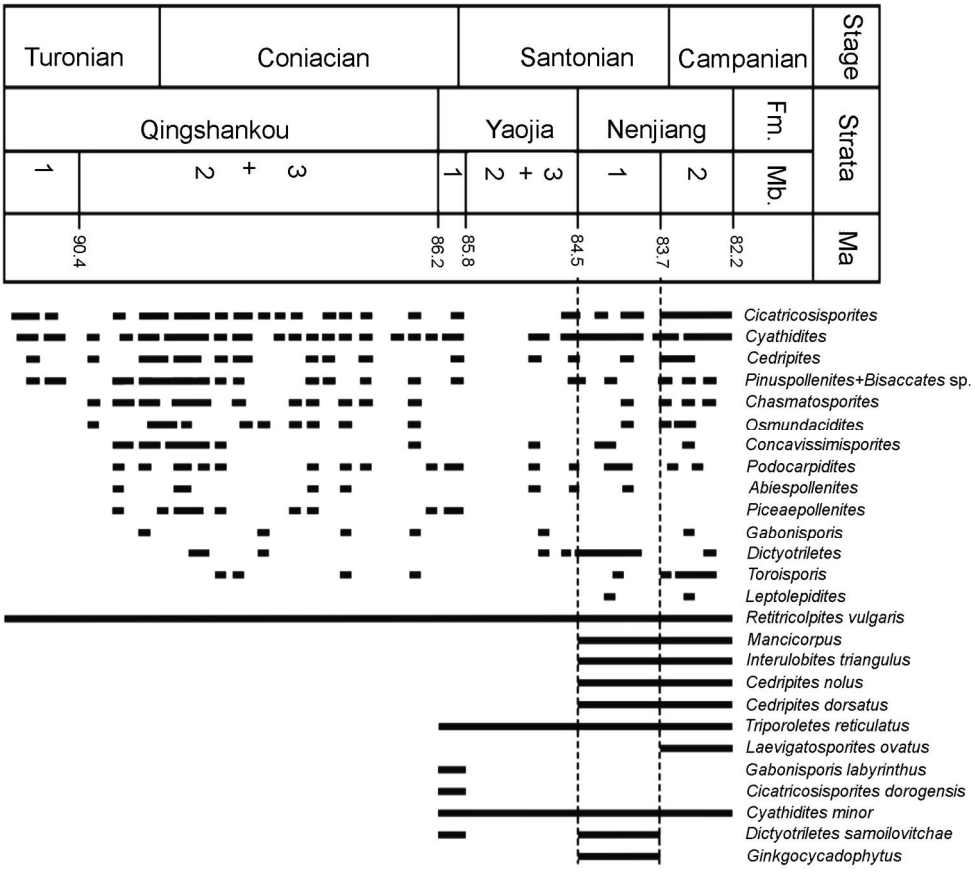

Fig. 4. The geological ranges of the palynological taxa from the lower Yong'ancun Formation and Songliao Basin (Sk1).

Plate I

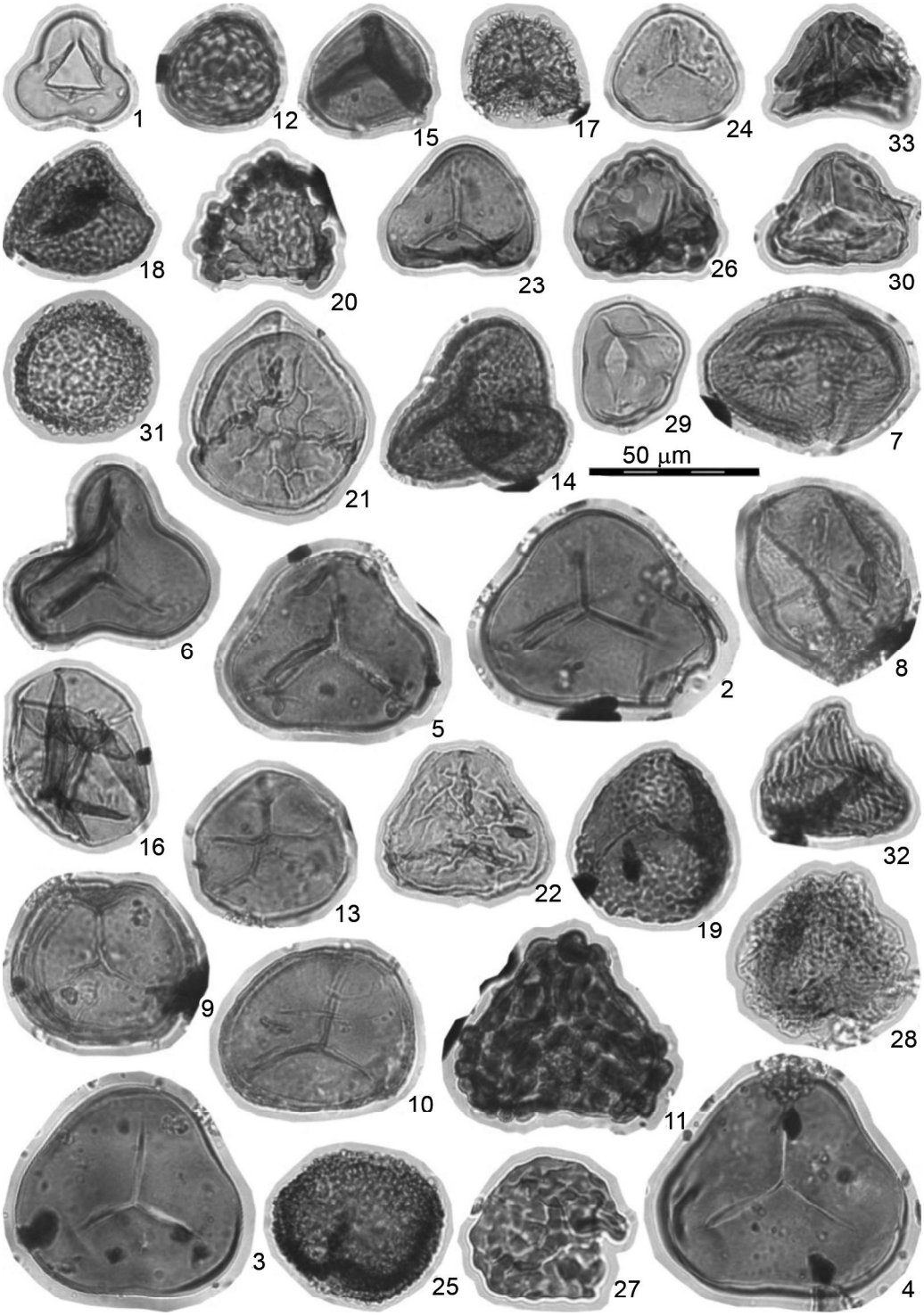

Plate I. 1 – *Cyathidites minor* Coup., 1953, Sample: yn-001; 2–5 – *Concavissimisporites asper* Pocock, 1962, Sample: yn-001; 6 – *Concavissimisporites* sp., Sample: yn-001; 7–8 – *Nevesisporites radiatus* (Chlon.) Sriv., 1972, Sample: yn-001; 9–10 – *Densoisporites microrugulatus* Brenner, 1963, Sample: yn-001; 11 – *Cibotiidites arlii* Sriv., 1975, Sample: yn-001; 12, 14 – *Leptolepidites tenuis* Stanl., Sample: yn-001; 13 – *Triporoletes reticulatus* (Pocock) Ployford, 1971, Sample: yn-001; 15 – *Toroisporis* sp., Sample: yn-001; 16 – *Punctatisporites* sp., Sample: yn-003; 17 – *Retitriletes reticulisporites* (Rouse) Krutzsch, 1963, Sample: yn-004; 18–19 – *Dictyotriletes samoilovitchae* Griazeva, 1965, Sample: yn-004; 20 – *Multinodisporites* sp., Sample: yn-004; 21–22 – *Trochicola* sp., Sample: yn-004; 23 – *Biretisporites* sp., Sample: yn-004; 24 – *Cyathidites minor* Coup., 1953, Sample: yn-004; 25 – *Osmundacidites* sp., Sample: yn-004; 26–27 – *Klukisporites* sp., Sample: yn-006; 28 – *Gabonisporis labyrinthus* Sriv., 1972, Sample: yn-006; 29 – *Laevigatosporites ovatus* Wils. et Webst., Sample: yn-006; 30 – *Gleicheniidites* sp., Sample: yn-006; 31 – *Gabonisporis bacaricumulus* Sriv., 1972, Sample: yn-007; 32 – *Cicatricosisporites dorogensis* Pot. et Gell.,1965, Sample: yn-011; 33 – *Cicatricosisporites pseudoaurifer* (Bolch.)Li, 1979, Sample: yn-003.

Plate II

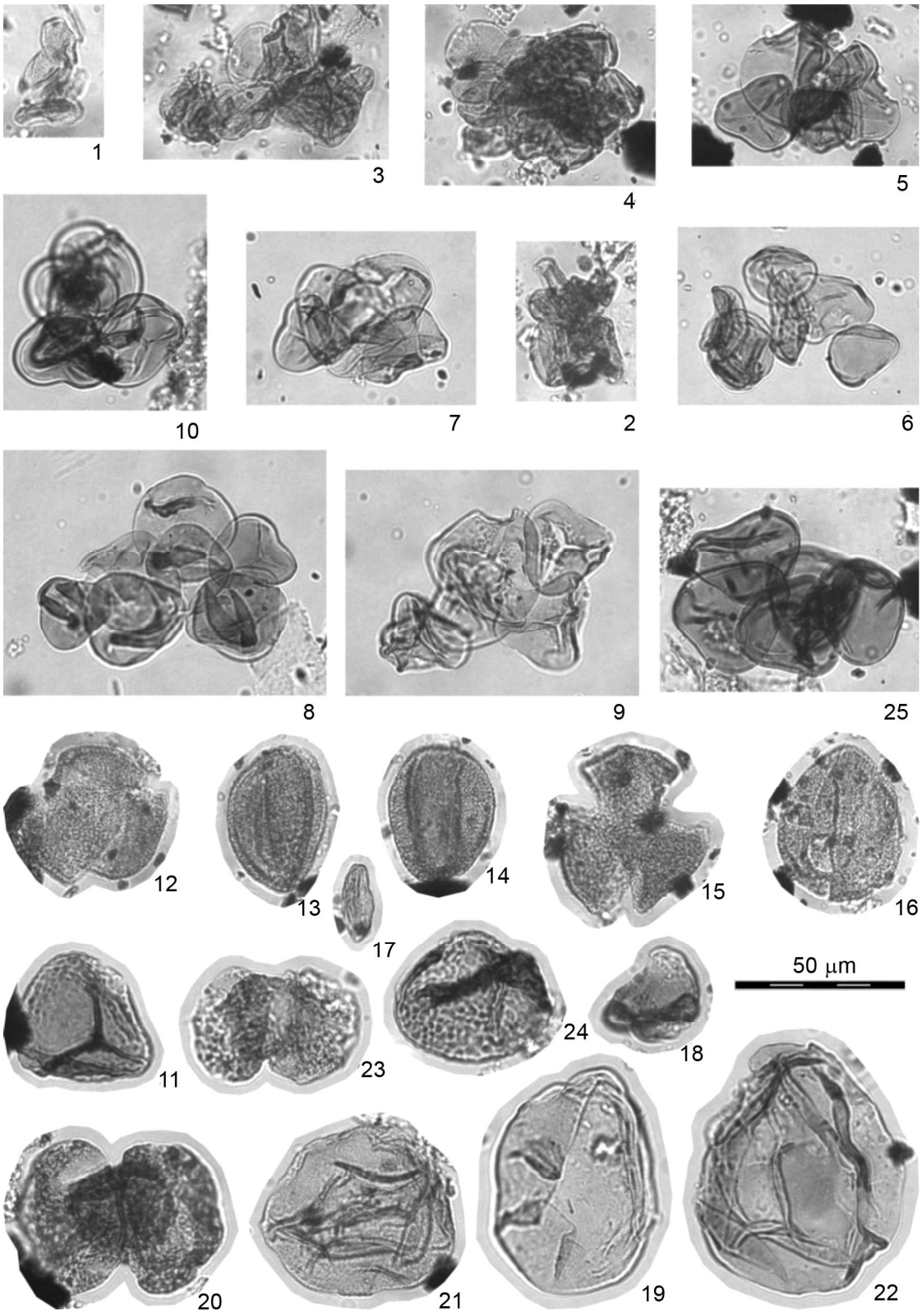

Plate II. 1, 17 – *Retitricolpites vulgaris* Pierce, 1961, Sample: yn-001; 2–4 – *Retitricolpites* sp., Sample: yn-001; 12–16 – *Retitricolpites* sp., Sample: yn-001; 5, 25 – *Cyathidites minor* Coup.,1953, Sample: yn-001; 6 – *Laevigatosporites ovatus*, Sample: yn-004; 7–10 – *Cyathidites minor* Coup., 1953, Sample: yn-004; 11, 24 – *Dictyotriletes samoilovitchae* Griazeva, 1965, Sample: yn-011; 18 – *Mancicorpus triangulus* Yu, Guo et Mao, 1983, Sample: yn-001;19 – *Chasmatosporites* sp., Sample: yn-007; 20 – *Podocarpidites ellipticus* (Cook.) Coup., 1953, Sample: yn-011; 21 – *Psophosphaera minor* (Verb.) Song et Zheng, 1981, Sample: yn-011; 22 – *Psophosphaera* sp., Sample: yn-011; 23 – *Podocarpidites minisculus* Singh, 1964, Sample: yn-011.

Plate III

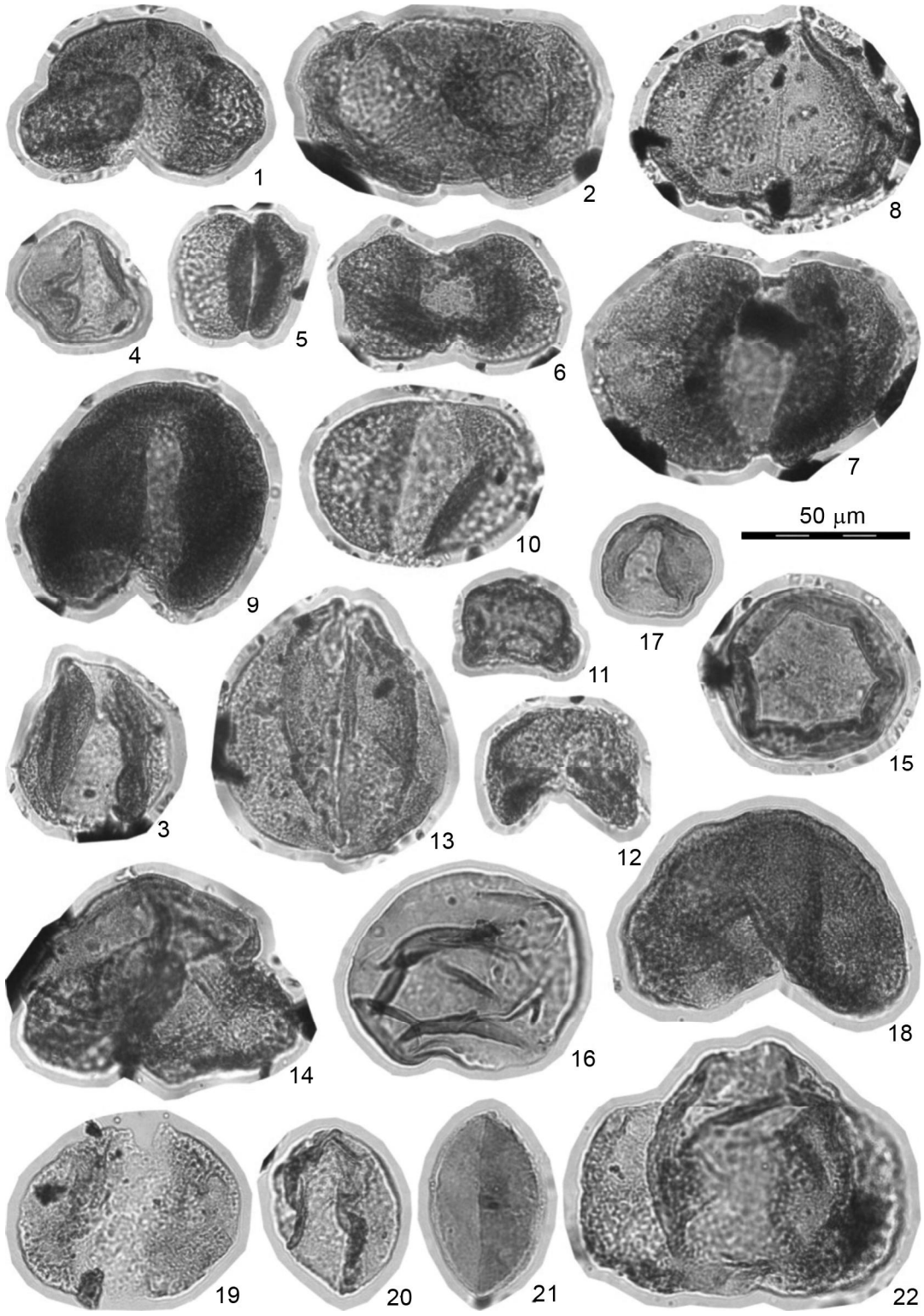

Plate III. 1–2 – *Pinuspollenites* sp., Sample: yn-001; 3 – *Abietineaepollenites pacltovae* (Krutzsch) Zhang comb.nov., Sample: yn-001; 4, 17, 20 – *Phyllocladidites inchoatus* (Pierce) Norris, 1967, Sample: yn-001; 5 – *Podocarpidites minisculus* Singh, 1964, Sample: yn-001; 6 – *Podocarpidites* sp., Sample: yn-001; 7 – *Podocarpidites nageiaformis* (Zakl.) Krutzsch,1971, Sample: yn-001; 8 – *Piceapollenites* sp., Sample: yn-001; 9 – *Cedripites dorsatus* Gao et Zhao, 1976, Sample: yn-001; 10 – *Alisporites bilateralis* Rouse, 1959, Sample: yn-001; 11–12 – *Cedripites nolus* (Gao et Zhao) Sun et He, 1980, Sample: yn-001; 13 – *Pseudopicea magnifica* Bolch., 1956,Sample: yn-001; 14 – *Abiespollenites* sp., Sample: yn-001; 22 – *Abiespollenites* sp., Sample: yn-011; 15 – *Araucariacites australis* Balme, 1957, Sample: yn-001; 16 – *Psophosphaera* sp., Sample: yn-004; 18 – *Cedripites densireticulatus* (Zauer) Krutz., 1971, Sample: yn-004; 19 – *Alisporites bilateralis* Rouse, 1959,, Sample: yn-004; 21 – *Ginkgocycadophytus* sp., Sample: yn-004.

spores (ca. 51.2 %) including *Cyathidites* (ca. 24.1 %), *Schizaeoisporites* (7.5 %), as well as *Cicatricosisporites, Gleicheniidites, Deltoidospora, Laevigatosporites, Balmeisporites, Gabonisporis,* etc.; and secondly abundant gymnosperm pollen (ca. 34.3 %) represented by *Classopollis* (ca. 7.0 %), *Abietineaepollenites* (ca. 4.5 %), *Pinuspollenites* (ca. 4.0 %), *Podocarpidites* (ca. 3.0 %), with commonly occurred taxa such as *Cycadopites*, *Cedripites, Piceapollenites, Taxodiaceaepollenites, Inaperturopollenites, Ginkgocycadophytus, Psophosphaera,* etc. The angiosperm pollen are only about 14.5 %, represented by *Tricolporopollenites* (ca. 3.3 %), *Tricolpites* (ca. 3.0 %) and *Tricolpopollenites* (ca. 3.2 %), with some younger angiosperm pollen e.g. *Talisiipites, Daqingpollis, Beaupreaidites, Callistopollenites, Mancicorpus, Aquilapollenites.* Thus, it seems that the two compared palynological assemblages (the Members 2–3 of Yaojia Formation and the present new material) have the common taxa such as *Cyathidites, Dictyotriletes, Concavissimisporites, Leptolepidites, Nevesisporites, Triporoletes, Toroisporis, Gabonisporis, Klukisporites, Osmundacidites, Laevigatosporites, Pinuspollenites, Abietineaepollenites, Piceapollenites, Podocarpidites, Cedripites, Ginkgocycadophytus,* and *Psophosphaera,* etc. and are both dominated by *Cyathidites minor* among ferns.

The palynological assemblage of the Member 1 of Nenjiang Formation is characterized by the dominance of the gymnosperm pollen (about 47.2 %), followed by fern spores (ca. 28.6 %), while the angiosperm pollen increased in content (up to 24.2 %, even more). The fern spores mainly are represented by *Cyathidites* (ca. 8.5 %), *Schizaeoisporites* (ca. 3.8 %), *Laevigatosporites* and *Dictyotriletes* (both ca. 2.6 %), with other commonly occurred taxa *Triporoletes, Osmundacidites, Cicatricosisporites, Lygodiumsporites, Leiotriletes, Punctatisporites, Verrucosisporites,* etc. The gymnosperm pollen are dominated by Pinaceae including *Cedripites, Pinuspollenites, Piceapollenites* (> 5.0 % for each); *Abietineaepollenites* (ca. 4.5 %), *Taxodiaceaepollenites* (ca. 4.2 %), *Pinuspollenites* (ca. 4.0 %), and *Podocarpidites* (ca. 3.0 %). The angiosperm pollen clearly increased in number and diversity, predominated by tricolpate and tricolporate types, including *Tricolporopollenites* (ca. 5.2%), *Tricolpites* (ca. 4.5 %), and other taxa e.g. *Proteacidites* and *Aquilapollenites* (beginning to occupy some positions), and *Momipites, Rhoipites, Plicapollis, Cranwellia, Dongbeipollis, Songliaopollis, Integricorpus, Orbiculapollis, Accuratipollis, Fibulapollis* etc. The present *Dictyotriletes-Pinuspollenites-Podocarpidites* sub-assemblage (No. 3) has a lot of common taxa with the palynological assemblage of Member 1 of the Nenjiang Formation, such as *Dictyotriletes, Klukisporites, Gleicheniidites, Laevigatosporites, Granulatisporites, Leptolepidites, Cicatricosisporites, Gabonisporis, Pinuspollenites, Abietineaepollenites, Piceapollenites, Podocarpidites, Ginkgocycadophytus, Araucariacites, Psophosphaera, Perinopollenites, Abiespollenites* etc. Particularly, *Dictyotriletes samoilovitchae* and *Pinuspollenites* sp. are dominant in both the comparable palynological assemblages.

According to the recent study in China, the age of Member 1 of Nenjiang Formation is 83.7–84.5 Ma, which corresponds to late Santonian; and the age of Members 2–3 of Yaojia Formation is 84.5-85.8 Ma, corresponding to early Santonian [20].

CONCLUSION

The newly found 43 genera and 54 species of palynomorphs renovate our knowledge on the palynological composition of the Yong'ancun Formation of Jiayin, and provide more evidence for dating this formation as the Santonian. Based on the correlation, the new palynological data on the lower part of Yong'ancun Formation and quite similar to those of the Members 2–3 of Yaojia Formation and the Member 1 of Nenjiang Formation in the Songliao Basin, all indicating the Santonian age. All the fossils including palynomorphs and associated fossil plants, invertebrates (e.g. ostracods, conchostracans etc.), and dinosaurs suggest that their host deposits were accumulated in the lacustrine environments under a warm temperate climate with seasonal changes. During the Santonian (i.e. the Yong'ancun Formation time) the vegetation in Jiayin existed as mixed coniferous and deciduous broad-leaved angiosperm forests, growing in hilled areas.

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REFERENCES

1. BGMRH (Bureau of Geology & Minearal Resources of Heilongjiang). Regional geology of Heilongjiang Province. Beijing: Geological Publishing House. 1993. 734 p.
2. Dong Z.M., Zhou Z.L., Wu S.Y. Note on a Hadrosaur footprint from Heilongjiang River area of China // Vert PalAsiat. 2003. 41(4). P. 324–326.
3. Gao R.Q., Zhao C.B., Qiao X.Y. et al. Cretaceous oil strata palynology from Songliao Basin. Beijing: Geological

Publishing House, 1999. 373 p. (in Chinese)
4. Godefroit P., Lauters P., Van Itterbeeck J., Bolotsky Y. L. et al. Recent advances on the study of hadrosaurid dinosaurs in Heilongjiang (Amur) River area between China and Russia // Global Geology. 2011. 14 (3). P. 160–191.
5. Markevitch V.S. Palynological zonation of the continental Cretaceous and lower Tertiary of eastern Russia // Cretaceous Research. 1994. 15. P. 165–177.
6. Markevich V S. Melovaya palynoflora severa vostochnoi Azii (Cretaceous Palynoflora of Northeastern Asia). Vladivostok: Dalnauka, 1995. 200 p. (in Russian).
7. Markevich V.S., Bugdaeva E.V., Bolotsky Yu.L. et al. New data on K-T interval in Zeya-Bureya Basin // Sun G., Sun Y.W., Akhmetiev M.A. et al. (Eds). Proceedings of the 3rd Symposium on Cretaceous Biota and K/T Boundary in Heilongjiang River Area, Changchun. 2004. P. 39–40.
8. Markevich V.S., Golovneva L.B., Bugdaeva E.V. Floristic characterization of the Santonian-Campanian deposits of the Zeya-Bureya Basin (Amur Region) // Proceedings of the Int'l Conference on the Current Problems in Paleofloristics, Paleophytogeography, and Phytostratigraphy. Moscow. 2005. P. 198-206 (in Russian)
9. Markevich V.S., Bugdaeva E.V., Ashraf A.R. et al.. Boundary of Cretaceous and Paleogene continental deposits in Zeya-Bureya Basin, Amur (Heilongjiang) River region // Global Geology. 2011. 14(3). P. 144–159.
10. Mosbrugger V. The nearest living relative method // Jones T.P. & Rowe N.P (eds.). Fossil Plants and Spores: modern techniques. Geological Society, London. 1999. P. 261–265.
11. Nichols D.J. Biodiversity changes in Cretaceous palynofloras of eastern Asia and western North America // Journal of Asian Earth Sciences. 2003. 21. P. 823–833.
12. Nichols D., Johnson K. Plants and the K-T boundary. Cambridge: Cambridge Univ Press, 2008. 292 p.
13. Riabinin A.N. *Mandschurosaurus amurensis* gen. et sp. nov., a hadrosaurian dinosaur from the Upper Cretaceous of Amur River // Mémoires de la Société paléontologique de Russie, 1930. 2: P. 1–36 (in Russian with English summary).
14. Song Z.C., Shang Y.K. Fossil Spores and Pollen of China (1). The Late Cretaceous and Tertiary spores and pollen. Beijing, Science Press, 1999. P. 1–828.
15. Sun G., Akhmetiev M.A., Dong Z.M. et al. In search of the Cretaceous-Tertiary boundary in the Heilongjiang River Area of China // Journal of Geoscientific Research in Northeast Asia. 2002. 5: P. 105–113.
16. Sun G., Quan C., Sun C.L. et al. Some new knowledge on subdivisions and age of Wuyun Formation in Jiayin of Heilongjiang, China // Journal of Jilin University (Geosci. Edition). 2005. 35(2). P. 137–142.
17. Sun G., Akhmetiev M., Golovneva L., Bugdaeva E., Quan C. et al. Late Cretaceous plants from Jiayin along Heilongjiang River, Northeast China // Courier Forschungsinstitut Senckenberg. 2007. 258: P. 75–83.
18. Sun G., Akhmetiev M., Markevich V., Ashraf A.R., Bugdaeva E. et al. Late Cretaceous biota and the K-Pg boundary in Jiayin of Heilongjiang River area, China // Global Geology. 2011. 14(3). P. 115–143.
19. Wan X.Q., Chen P.J., Wei M.J. The Cretaceous system in China. Acta Geologica Sinica (English Edition). 2007. 81. P. 957–983.
20. Wan X., Zhao J., Scott R.W., Wang P., Feng Z., Huang Q., Xi D. Late Cretaceous stratigraphy, Songliao Basin, NE China: SK1 cores // Palaeogeography, Palaeoclimatology, Palaeoecology. 2013. 385. P. 31–43.
21. Wang C., Feng Z., Zhang L., Huang Y., Cao K., Wang P., Zhao B. Cretaceous paleogeography and paleoclimate and the setting of SKI borehole sites in Songliao Basin, northeast China // Palaeogeography, Palaeoclimatology, Palaeoecology. 2013. 385. P. 17–30.
22. Wang P.J., Xie X.A., Mattern F., Ren Y.G., Zhu D.F., Sun X.M. The Cretaceous Songliao Basin: volcanogenic succession, sedimentary sequence and tectonic evolution, NE China. Acta Geologica Sinica (English Edition). 2007. 81. P. 1002–1011.
23. Wang P.J., Gao Y.F., Liu W.Z., Zhang J.G. 40Ar/ 39Ar age and geochemical features of mugearite from the Qingshankou Formation: significances for basin formation, hydrocarbon generation and petroleum accumulation of the Songliao Basin in Cretaceous // Acta Petrologica Sinica. 2009. 25 (5). P. 1178–1190.
24. Zhang Z.C. The Upper Cretaceous fossil plants from Jiayin Region, Northern Heilongjiang // Professional Papers of Stratigraphy and Palaeontology, 1983. 11. P. 111–132.

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Новые данные по палинологии нижней части формации Юн'аньцунь (верхний мел) Цзяиня провинции Хейлунцзян, Зейско-Буреинский бассейн, Китай

Новые палинологические находки были недавно обнаружены в нижней части верхнемеловой формации Юн'аньцунь, развитой в окрестностях пос. Цзяинь, Китай, недалеко от р. Амур (Хэйлунцзян). В последнее время из нижней части формации Юн'аньцунь были определены 43 рода и 54 вида палиноморф и три палинологических подкомплекса. В палиноморфах доминируют голосеменные и папоротники, пыльца покрытосеменных немногочисленна. Споры папоротников представлены в основном *Cyathidites-Dictyotriletes*, голосеменные – *Pinuspollenites-Podocarpidites*, а покрытосеменные – *Retitricolpites-Mancicorpus*. В целом палинокомплекс сопоставим с комплексами пачек 2 и 3 формации Яоцзя и пачкой 1 формации Нэньцзян бассейна Сунляо, имеющими сантонский возраст. Полученный палинологический материал предоставляет дополнительные свидетельства, способствующие лучшему пониманию палинофлоры сантона формации Юн'аньцунь, Цзяинь.

Ключевые слова: **палинология, споры, пыльца, комплексы, верхний мел, сантон, формация Юн'аньцунь, Цзяинь Китая, Зея-Буреинский бассейн.**