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UPPER TRIASSIC SPORO-POLLEN ASSEMBLAGES FROM MOSUOHE RIVER VALLEY OF BAODING, SICHUAN

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Summary

In 1972, after frequent investigations on lithology, sedimentology and palaeontology (especially on palaeobotany), the Upper Triassic coal series (formerly the “Lalaqing Coal Series”) in the Baoding area, southwestern Sichuan was previously divided by No. 1 Regional Geological Survey Team of Yunnan Province into two formations in ascending order as the Daqiaodi Formation, and the Daqing Formation (consisting of the Lower and Upper Members).

Based on the productive and well-preserved megascopic plants of this coal series Prof. Xu *et al* (1979) published the monograph entitled “The Baoding Flora of Upper Triassic in China”, but no more palynomorphs have been obtained from these two formations ever since. The present paper reports for the first time the spore-pollen assemblage from these two formations along the Mosuohe River valley of the Baoding area, where abundant pollen grains and fern spores together with a few uncertain microfossils have been found, amounting to 57 genera and 102 species in total. Here described are 21 genera and 29 species of them, including one new emended genus, *Semiretisporis* (Reinhardt, 1961), twelve new species, namely, *Knoxisporites mosuohensis* sp. nov., *Polycingulatisporites tenuis* sp. nov., *P. multiannulatus* sp. nov., *Cingulatisporites circularis* sp. nov., *Trizonites venustus* sp. nov. *Semiretisporis flaccida* sp. nov., *Kyrtomispores undulata* sp. nov., *Canalizonospora regularis* sp. nov., *Converrucosisporites delicatus* sp. nov., *Verrumonocolpites minus* sp. nov., *V. magnus* sp. nov., and *Psophosphaera jinshaensis* sp. nov.

The assemblage of the Daqiaodi Formation containing 45 genera and 75 species of microfossils is composed of fern spores and gymnospermous pollen grains, both amounting to 90.10% and 9.79% of the total number respectively, together with some unidentified microfossil types. Among the fern spores, the genera *Concavisporites* and *Dictyophyllidites* play an important role, occupying 39.68%

of the total number, with some other characteristic elements including *Cyathidites australis*, *C. minor*, *Asseretospora gyrata*, *Polycingulatisporites crenulatus*, *P. triangularis*, *P. tenuis*, *Canalizonospora canaliculata*, *C. regularis*, *Crassitudisporites problematicus*, *Apiculatisporis clematisi*, *Osmundacidites wellmanii*, *O. parvus*, *Converrucosisporites delicatus*, *Lycopodiacidites cerebriiformis*, *L. rugulatus*, *Annulispora perforata*, *Cingulatisporites circularis*, and *Semiretisporis reticulatus*; the forms observed only from this formation contain *Knoxisporites mosuohensis*, *Polycingulatisporites densatus*, *Stenozonotriletes* sp., *Densosporites fissus*, *D. velatus*, *Kraeuselisporites punctatus*, *Torispora* sp., *Aratrisporites fischeri*, *Taeniaesporites krauseli*, *Platysaccus papilionis*, *Ovalipollis ovalis*, *Ricciisporites tuberculatus*, etc. Therefore, the Daqiaodi Formation may belong to the early—middle Late Triassic in age (early Noric).

The assemblage from the Lower Member of the Daqing Formation comprises 34 genera and 62 species of microfossils. It is predominantly composed of fern spores and a small quantity of gymnospermous pollen grains, both amounting to 85.57% and 14.21% of the total number respectively. Among the fern spores, the genera *Concavisporites* and *Dictyophyllidites* still occupy the highest percentages. Other important elements are mostly in common with those of the Daqiaodi Formation, with the exceptions of *Todisporites major*, *Siereisporites antiquasporites*, *Brochotriletes ambientis*, *Canalizonospora* cf. *canaliculata*, *C. sp.*, *Trizonites laevigatus*, *Striatopodocarpites* sp., *Platysaccus queenslandi*, *Quadraeculina anellaeformis*, *Verrumonocolpites magnus*, *Classopollis annulatus*, etc., which occur only in this assemblage. All these suggest that the Lower Member of the Daqing Formation may be assigned to late—middle Late Triassic in age (late Noric).

The assemblage of the Upper Member of the Daqing Formation is somewhat different from those of the Daqiaodi Formation and the Lower Member of the Daqing Formation; it consists of 29 genera and 47 species of pollen grains and spores. In this assemblage the gymnospermous pollen grains amount to 52.38% of the total number, whereas the fern spores to 47.44%. This assemblage is characterized by an explosion of *Psophosphaera* which amounts to 43.58% (occasionally to 78.13%). The elements in common with those of the Lower Member of the Daqing Formation are: *Cyathidites australis*, *C. minor*, *Granulatisporites minor*, *Osmundacidites wellmanii*, *O. parvus*, *Annulispora folliculosa*, *A. microannulata*, *Polycingulatisporites crenulatus*, *P. triangularis*, *Crassitudisporites problematicus*, *Kyrtomisporis laevigatus*, *K. coronarius*, *Canalizonospora canaliculata*, *Trizonites venustus*, *Psophosphaera jinshaensis*, *Araucariacites australis*, *Cycadopites dilucidus*, *C. reticulatus*, *C. subgranulosus*, *Verrumonocolpites minus*, *Chasmatisporites apertus*, *Ch. hians*, etc. The genera *Concavisporites* and *Dictyophyllidites* are still rather high in content, though they are lower than those of the Daqiaodi Formation and the Lower Member of the Daqing Formation. Some forms occur only in this assemblage, such as *Calamospora mesozoica*, *Neoraistrickia taylorii*, *Verrucosisporites granatus*, *Taeniaesporites novimundi*, etc. These indicate that the Upper Member of the Daqing Formation may be of the late Late Triassic age (Rhaetic).

Based on the characteristics of gymnospermous pollen grains and fern spores, it can be well inferred that during the middle Upper Triassic Period the climate of the Baoding area was warm and wet, belonging to the tropical type, whereas during the late Late Triassic Period the climate might have changed to a little rather cool and dry, belonging to the tropical—subtropical type.

DESCRIPTION OF NEW SPECIES

Converrucosisporites delicatus sp. nov.

(Pl. III, fig. 9)

Description Equatorial contour triangular, with slightly concave sides and round-blunt

apices, 60—65 μm in diameter; laesurae simple, trilete, about 1/2 radius of spore. Exine 1.5—2 μm thick; surface mainly with small and fine papillar ornaments, occasionally mixed with conic or verrucate ones, 1—1.5 μm in height and 1.5—2 μm in basal diameter, generally disposed rather sparsely, but somewhat densely at the corner.

Comparison The new species characterized by small and fine papillar or conic ornaments can be easily distinguished from all other species of this genus.

Occurrence Daqiaodi Formation; Lower Member of Daqing Formation.

Knoxisporites mosuoheensis sp. nov.

(Pl. I, figs. 16, 17, 20, 21)

Description Equatorial contour nearly circular or rounded-triangular, 65—83 μm in diameter; laesurae trilete, bordered by strong labra 8—9 μm wide, narrow at both ends, reaching to equator. A broad band of exinal thickenings 16—21 μm wide, surrounding a distal polar area 32—45 μm in diameter, with distal band extending to proximal face, forming a triangular zone of exinal thickenings pointed at proximal pole. Equatorial thickenings 3.5—5 μm thick, connected with distal band.

Comparison The new species differs from other species of this genus in having obvious labra around trilete laesurae, and a broad band of thickenings surrounding the distal pole, instead of a distal band of thickenings alternating with laesurae of trilete marks.

Occurrence Daqiaodi Formation.

Polycingulatisporites tenuis sp. nov.

(Pl. II, figs. 1—3)

Description Equatorial contour triangular, with sides convex; 50—68 μm in diameter; laesurae trilete, bordered by labra 5.5—8 μm wide and extending to equator; exine smooth, with a circular area of exinal thickenings around distal pole and a concentric ring parallel and close to equatorial cingulum; diameter of circular area 8—14 μm ; width of concentric ring 6—9 μm ; equatorial cingulum 8—11 μm in width, with thicker inner zone and much thinner outer zone in membrane-like appearance.

Comparison The new species characterized by the large size, wide equatorial cingulum with a thinner outer zone is somewhat similar to *P. fimbriatus* (Verbitskaya) Playford et Dettmann 1965, but the latter differs in the subcircular outline and the absence of labra on both flanks of laesurae.

Occurrence Daqiaodi Formation; Lower Member of Daqing Formation.

Polycingulatisporites multiannulatus sp. nov.

(Pl. II, fig. 6)

Description Equatorial contour triangular, with slightly convex sides, round-blunt apices, about 50 μm in diameter; laesurae trilete, simple, rather curved, extending to equatorial cingulum, 5—7 μm in width. Distal face with a circular area of exinal thickenings around distal pole and two concentric rings more or less surrounding distal polar area. Diameter of circular area 2.5—3 μm ; width of concentric rings 2.5—4 μm ; space about 2 μm apart from each other.

Comparison The new species is distinguished from other species of this genus by the two concentric rings on distal face.

Occurrence Daqiaodi Formation; Upper Member of Daqing Formation.

***Kyrtomisporis undulata* sp. nov.**

(Pl. III, figs. 24, 25)

Description Equatorial contour triangular, about 70 μm in diameter; laesurae simple, trilete, extending to equatorial cingulum. Kyrtome distinct; distal face with striped warts, perpendicular to three sides; warts 4—5.5 μm at bases and with undulate edges connected with each other, showing a reticulate appearance. Equatorial cingulum relatively thin, with gently wavy outer margin, 12—14 μm in width.

Comparison The new species is somewhat similar to *K. speciosus* Mädlar 1964, but differs in the rather large size, striped warts with undulate edges.

Occurrence Daqiaodi Formation; Lower Member of Daqing Formation.

***Canalizonospora regularis* sp. nov.**

(Pl. II, figs. 8, 9; Pl. III, figs. 17, 18)

Description Equatorial contour triangular, with convex sides; 45—76 μm in diameter; laesurae thin, trilete, slightly curved and extending to equatorial cingulum, 6—8 μm wide, consisting of ridges and striped warts. Proximal face of exine with three tangential ridges on interradial area parallel to three sides of spore respectively. Distal face sculptured with sigmoidally coiled ridge lines or striped warts 5—6 μm in width, forming a closed reticulate pattern. Meshes circular in outline, 4—7 μm across, disposed regularly.

Comparison The new species is characterized by the regular reticulate structure consisting of ridges and striped warts. *C. foveolata* Shang et Li also has reticulate structure, but the meshes show a subcircular or irregularly polygonal outline and a rather small diameter.

Occurrence Daqiaodi Formation; Upper Member of Daqing Formation.

***Cingulatisporites circulatus* sp. nov.**

(Pl. II, figs. 11, 12)

Description Equatorial contour rounded-triangular to subcircular, 63—75 μm in diameter; equatorial cingulum distinct, 6—8 μm in width; laesurae thin, trilete, about 2/3 the radius of spore; surface of exine smooth to slightly undulated.

Comparison The new species is somewhat similar to *C. punctatus* Bai 1983, but the latter is obviously smaller with a triangular equatorial contour. The type species of this genus, *C. laevispeciosus* Pflug 1953, is derived from younger strata, 20—60 μm in size.

Occurrence Daqiaodi Formation; Lower Member of Daqing Formation.

***Trizonites venustus* sp. nov.**

(Pl. II, figs. 18—20)

Description Equatorial contour subtriangular or triangular, 42—62 μm in diameter; laesurae trilete, bordered by labra 2—3 μm wide, extending to equatorial cingulum; distal face of central body and equatorial cingulum sculptured with regular microfovea. Meshes subcircular in outline, 1—1.5 μm across; ridges 2—3 μm in width. Equatorial cingulum smaller than semicircle, with the widest part at the middle of three sides, up to 5—7 μm , shrunk or even absent at the corner, gradually thinned to the outer part of cingulum, showing a membrane-like appearance close

to outer margin.

Comparison The new species is characterized by the even fovea sculpture. *T. reticulatus* Li et Shang 1980 bears distinct microreticulate sculpture elongated from central part of spore to equatorial cingulum.

Occurrence Daqiaodi Formation; Upper Member of Daqing Formation.

***Semiretisporis flaccida* sp. nov.**

(Pl. II, fig. 17)

Description Equatorial contour rounded-triangular or subcircular, 52—55 μm in diameter; laesurae trilete, bordered by labra narrow and slightly curved, extending to equatorial cingulum; central body enveloped by thin, perine-like exoexine forming cingulum at equator. Distal face sculptured with weak reticulum as veins; ridges very thin, about 0.5 μm in width, projecting radially and extending onto equatorial cingulum.

Comparison The new species is somewhat similar to *S. reticulatus* Mädlér 1964, but differs in having rather weak reticulate sculpture as veins.

Occurrence Daqiaodi Formation.

***Verrumonocolpites minus* sp. nov.**

(Pl. IV, figs. 10, 11)

Description Equatorial contour elliptical or broadly fusiform, rather small, 41—47 μm in length and 32—38 μm in width. Distal face with monocolpus, 5—6 μm wide; edges of colpus often thickened. Exine 2—3 μm thick except colpus; surface with densely disposed conic warts 4—5.5 μm wide at bases, 2.5—3 μm in height.

Comparison The new species is distinguished from all other species of this genus by the rather small size, conic warts and relatively wide monocolpus.

Occurrence Daqiaodi Formation.

***Verrumonocolpites magnus* sp. nov.**

(Pl. IV, fig. 17)

Description Equatorial contour elliptical or broadly fusiform, 80×118 μm in size; distal face with monocolpus narrow and often thickened along edges. Exine generally 2—3 μm thick; surface sculptured with verrucae and bacula different in size and outline, about 1.5—8 μm wide at base, 2—4 μm in height, irregularly polygonal or semicircular in basal outline, disposed crosswise or very densely.

Comparison The new species characterized by rather large size, crosswise verrucate and baculate ornaments can be easily distinguished from other species of this genus.

Occurrence Lower Member of Daqing Formation.

***Psophosphaera jinshaensis* sp. nov.**

(Pl. IV, figs. 18—21)

1986 *Quadraeculina limbata* Maljavkina, Lei Zhuo-qi, p. 142, Pl. III, fig. 18.

Description Pollen grains with no germinal aperture found; contour elliptical, 32—64×59—80 μm in size. Exine about 1 μm thick, with infrapunctate structure. Two strips of stable folds along the long axis of pollen grains, 5—11 μm in width; some thin folds often across the

main folds in different directions.

Comparison The new species is somewhat similar to *Psophosphaera* (*Podozamites*) *coniferoides* Bolchovitina 1956 (Pl. X, fig. 127), but the latter is rather small and with no stable long folds. The pollen grains identical with the present species were assigned to the genus *Quadraeculina* by Lei, who misunderstood the two long folds for pillow-like sacs.

Occurrence Daqing Formation.

图 版 说 明

所有图影均放大 600 倍,全部标本获自四川宝鼎摩梭河剖面,现保存于中国科学院南京地质古生物研究所。

图 版 I

1. *Cyathidites australis* Couper 玻片号: FP-12(12)。
 2. *Dictyophyllidites* sp. 玻片号: FP-12(12)。
 3. *Auritulinasporites triclavis* Nilsson 玻片号: FP-15(1)。
 - 4,5. *Concavisporites toralis* (Leschik) Nilsson 4,玻片号: FP-12(1); 5.玻片号: FP-12(1)。
 6. *Concavisporites intrastriatus* (Nilsson) Li et Shang 玻片号: FP-15(1)。
 7. *Osmundacidites wellmanii* Couper 玻片号: FP-13(4)。
 8. *Apiculatisporis clematisi* de Jersey 玻片号: FP-13(4)。
 9. *Tigrisporites* cf. *jonkeri* Van Erve 玻片号: FP-15(4)。
 10. *Angiopteridaspora denticulata* Chang 玻片号: FP-17(1)。
 11. *Lycopodiacidites rugulatus* (Couper) Schulz 玻片号: FP-12(6)。
 12. *Polycingulatisporites densatus* (de Jersey) Playford et Dettmann 玻片号: FP-18(12)。
 - 13,15. *Lycopodiacidites cerebriiformis* (Naumova et Jaroshenko) Li et Shang 13.玻片号: FP-12(3); 15. 玻片号: FP-12(2)。
 14. *Stenozonotriletes* sp. 玻片号: FP-12(4)。
 - 16,17,20,21. *Knoxisporites mosuoheensis* sp. nov. 16.正模标本(Holotype),玻片号: FP-12(1); 17.玻片号: FP-12(5); 20.玻片号: FP-12(12); 21.玻片号: FP-15(9)。
 18. *Annulispora folliculosa* (Rogalska) de Jersey 玻片号: FP-12(1)。
 19. *Polycingulatisporites crenulatus* Playford et Dettmann 玻片号: FP-13(8)。
- 层位: 大茅地组。

图 版 II

- 1—3. *Polycingulatisporites tenuis* sp. nov. 1.玻片号: FP-15(9); 2.正模标本 (Holotype), 玻片号: FP-12(7); 3.玻片号: FP-15(2)。
4. *Kyrtomisporis laevigatus* Mädlar 玻片号: FP-18(10)。
5. *Kyrtomisporis coronarius* (Chang) Li et Shang 玻片号: FP-13(6)。
6. *Polycingulatisporites multiannulatus* sp. nov. 正模标本(Holotype), 玻片号: FP-13(8)。
7. *Asserctospora gyrata* (Playford et Dettmann) Schuurman 玻片号: FP-15(7)。
- 8,9. *Canalizonospora regularis* sp. nov. 8.正模标本(Holotype), 玻片号: FP-12(4); 9.玻片号: FP-12(6)。
10. *Kyrtomisporis speciosus* Mädlar 玻片号: FP-12(3)。
- 11,12. *Cingulatisporites circularis* sp. nov. 11.正模标本 (Holotype), 玻片号: FP-12(1); 12.玻片号: FP-22(1)。
13. *Krauselisorites punctatus* Jansonius 玻片号: FP-15(9)。
14. *Densoisporites velatus* Weyland et Krieger 玻片号: FP-13(6)。
15. *Semiretisporis reticulatus* Mädlar 玻片号: FP-15(3)。
16. *Aratrisporites fischeri* (Klaus) Playford et Dettmann 玻片号: FP-18(5)。
17. *Semiretisporis flaccida* sp. nov. 正模标本 (Holotype), 玻片号: FP-18(12)。
- 18—20. *Trizonites venustus* sp. nov. 18.玻片号: FP-12(2); 19. 正模标本(Holotype), 玻片号: FP-15(5); 20.玻片号: FP-13(8)。
21. *Densosporites fissus* (Reinhardt) Schulz 玻片号: FP-15(8)。
22. *Taeniaesporites krauseli* Leschik 玻片号: FP-18(3)。