Chapter 11
Systematic Palaeontology: Part 3 Spore and Pollen Fossils

Jianxin Yu, Hui Li, Jean Broutin, and Xiao Shi

Anteturma **Sporites** Potonié, 1893.

Turma **Triletes** (Reinsch, 1881) Potonié and Kremp, 1954.

Subturma **Azonotriletes** (Luber, 1935) Dettmann 1963.

Infraturma **Laevigati** (Bennie and Kidston 1886) Potonié and Kremp, 1954.

Genus ***Leiotriletes*** (Naumova, 1937) Potonié and Kremp, 1954.

Type species: *Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, 1954, Upper Carboniferous, Germany.

Diagnosis (emended from Smith and Butterworth, 1967, p. 121 (translation from Potonié and Kremp, 1954, p. 120)): Microspores, trilete with smooth outline, triangular amb having straight, distinctly concave, or slightly to rather strongly convex sides. Providing the triangular shape is still obvious or the three proximal pyramidal faces are rather steep. The spores belong to *Leiotriletes*. The apex of the amb is roughly rounded or blunt. Occasionally infrapunctate to infrareticulate. Trilete rays generally greater than one-half of radius but few down to one-third of radius. Sometimes, trilete rays ended with arcuate protuberance and along with torus.

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J. Yu et al. (eds.), *Plants and Palynomorphs around the Permian-Triassic Boundary of South China*, New Records of the Great Dying in South China,
https://doi.org/10.1007/978-981-19-1492-8_11

Discussion: The genus *Leiotriletes* was firstly proposed by Naumova (1937) and then Potonié and Kremp (1954) emened the diagnosis of this genus but in German. After that, Smith and Butterworth (1967) gave the translation for the diagnosis of this genus from Potonié and Kremp (1954). By the way, it was mentioned that Staplin (1960, p. 14) assigned these deltoid, smooth, trilete spores of Mississippian age (Palaeozoic) to the genus *Deltoidospora* Miner, 1935 (often for post-Palaeozoic spores) but others thought the form genus *Leiotriletes* Naumova, 1937 should be conserved especially for the Palaeozoic spores or even some Mesozoic spores. (Potonié, 1960, pp. 26–27; Playford, 1962, p. 573; Smith and Butterworth, 1967, p. 121). In fact, the genus *Deltoidospora* Miner, 1935 was firstly proposed as "small unassigned deltoid or subdeltoid spores of the type that is commonly found associated with many Mesozoic ferns, such as *Gleichenites*, *Gleicheniopsis*, *Laccopteris* and others" (Miner, 1935). So, the genus *Deltoidospora* Miner, 1935 seems to be limited to be applied for simple deltoid spores from those specific mother plants. It seems to be the genus in the half-natural and half-form system. However, the genus *Leiotriletes* is totally and widely form genus that should be more suitable for the most cases in Palaeozoic and even in Mesozoic. As it was also mentioned by Potonié (1960) in the discussion part of the genus *Leiotriletes*'s systematic palaeontology that *Leiotriletes* is more widely various forms than others and sometimes can be assigned to the other genus, e.g. *Deltoidospora*, if you can be sure. Thus, the genus *Leiotriletes* should be conserved as a useful form genus for these simple triangular trilete microspores.

Affinity: Pteridopsida (Remy and Remy, 1957; Potonié, 1960; Palyford, 1962; Smith and Butterworth, 1967; Balme 1995; Hermann et al. 2011). Some in-situ specimens with immature state were also compared as *Leiotriletes* (Balme 1995).

Leiotriletes exiguus Ouyang and Li (1980) (Figs. 11.1-5, 11.1-6, 11.2-1 to 11.2-4).

Holotype: *Leiotriletes exiguus* Ouyang and Li (1980), pl. 1, fig. 4, from the horizon FK-1 (6) of Kayitou Formation, YijintianBu12 core in Qingyun, Fuyuan, Yunnan Province, China. Preserved in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences.

Diagnosis (emended from Ouyang and Li (1980), p. 125): Amb triangular, trilete, side straight to slightly concave or sometimes slightly convex, apex blunt or rounded. Size is 39 (41)-44 μm. Laesurae fine but clear, 1/3–1/2 long of the radius at the equator. Contact area triangular, slightly thickened, dark color. The exine is thin, 1 μm in usual but sometimes up to 2–2.5 μm. Smooth surface and outline. Sometimes, In proximal view, sometimes with relatively slightly thick exine near the equator.

Material examined: Over 6 grains. Some registered specimens of them: ZK4703_ZK5_033, ZK4703_ZK5_073, ZK4703_ZK10_002, ZK4703_ZK10_070, ZK4703_ZK21_017, ZK4703_ZK45_091.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

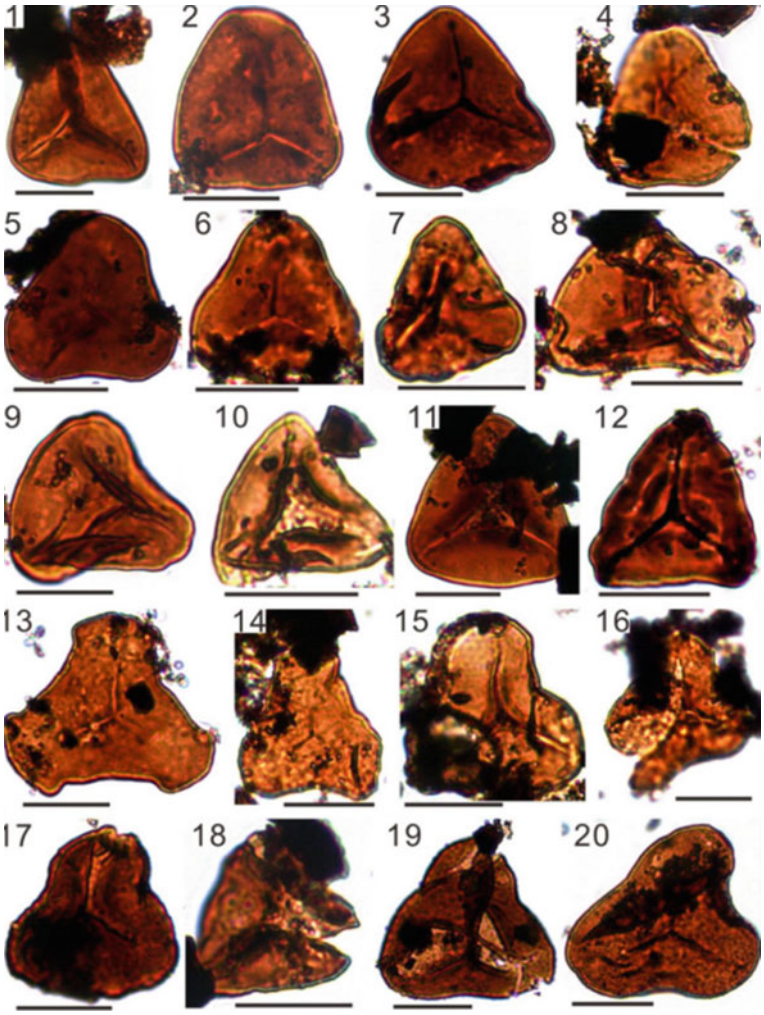

Fig. 11.1 (Scale bar = 20 μm). 1–3 *Leiotriletes directus* Balme and Hennelly. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK31_349, ZK4703_ZK33_039, ZK4703_ZK39_058. 4, 17 *Leiotriletes adnatus* (Kosanke, 1950) Potonié and Kremp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK2_017, ZK4703_ZK10_038. 5–6 *Leiotriletes exiguus* Ouyang and Li. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK5_068&185. 7–10, 12, 15 *Leiotriletes pulvinulus* Ouyang. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK5_068&18. 11 *Leiotriletes inermis* (Waltz) Ishchenko. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK33.5_192. 13–14 *Waltzispora strictura* Ouyang and Li. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK2_006, ZK4703_ZK5_117. 16, 18, 19 *Leiotriletes tenuis* (Peppers, 1964) Ouyang. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK5_088&178, ZK4703_ZK23_213; 20 *Leiotriletes concavus* (Kosanke, 1950) Potonié and Kremp, Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK33.5_062

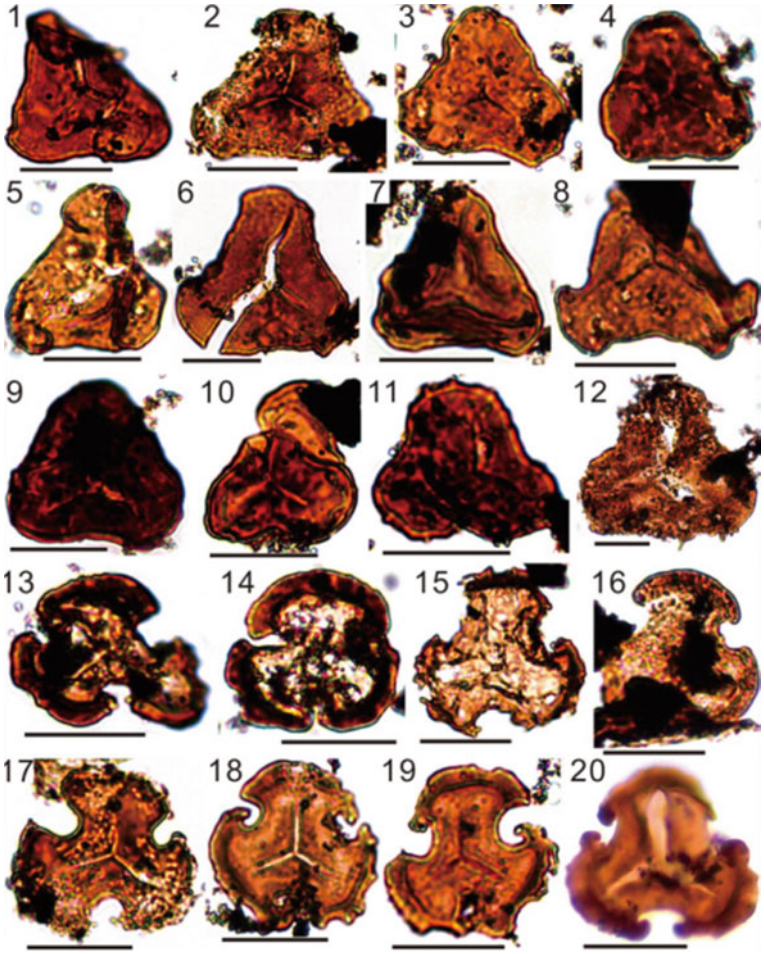

Fig. 11.2 (Scale bar = 20 μm). 1–4 *Leiotriletes exiguus* Ouyang and Li. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK5_187, ZK4703_ZK14_046, ZK4703_ZK29_048&086&194. 5–6, 8 *Waltzispora strictura* Ouyang and Li. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK10_013, ZK4703_ZK12_061, ZK4703_ZK25_035. 7 *Leiotriletes pulvinulus* Ouyang. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK5_187. 9, 10 *Leiotriletes adnatus* (Kosanke, 1950) Potonié and Kremp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK10_062, ZK4703_ZK21_043. 11 *Lophotriletes gibbosus* (Ibrahim) Potonié et Kremp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK10_019. 12 *Neoraistrickia trilobata* Ouyang and Li. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK14_038. 13–20 *Triquitrites proratus* Balme. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK14_023, ZK4703_ZK5_139, ZK4703_ZK16_002, ZK4703_ZK23_002, ZK4703_ZK23_042, ZK4703_ZK25_022, ZK4703_ZK23_181, ZK4703_ZK33_394

Description: Trilete, Amb triangular, side slightly concave, its radius at the equator is about 17–20 μm long. laesurae simple, straight, short but very clear. Three commissures are straight and simple, each commissure is about 8–9 μm long. Dark color in the contact area may be due to the relatively thick exine but sometimes light color in the outline of the contact area. Contact area is triangular with relatively straight sides and blunt apex, the radius of contact area is about 11–14 μm long. And near the equator area it turn to be a little bit thick sometimes. the area ratio of contact area to outline is 0.33–0.39. With smooth surface and outline.

Discussion and Comparison: It is different from *Leiotriletes sphaerotriangulus* (Loose) Potonié and Kremp, 1954 and *Leiotriletes adnatoides* (Kos.) Potonié and Kremp, 1955 on the very short laesurae of this species. It is without torus that can be distinguished from *Leiotriletes pulvinulus* Ouyang (1986).

Leiotriletes pulvinulus Ouyang (1986) (Figs. 11.1-1 to 11.1-10, 11.1-12, 11.1-15 and 11.2-7).

1982, *Leiotriletes* sp. A, Ouyang; pp. 72, pl. 2, fig. 3.

1986, *Leiotriletes pulvinulus* Ouyang; pp. 33, pl. 1, fig. 1, 3, 4.

Holotype: *Leiotriletes pulvinulus* Ouyang (1986), pl. 1, fig. 3, YFH 121 (1), size is about 51 μm, of Xuanwei Formation, ZK-97 core in Housuoyishankou, Fuyuan, Yunnan Province, China. Preserved in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences.

Diagnosis (emended from Ouyang (1986), p. 33): Amb triangular, sides straight or slightly concave or slightly convex, apex blunt or rounded. Laesurae are single ridges, 2/3–3/4 long of the radius at the equator and acuate at the end of laesurae. In the contact area, some torus are common along with laesurae, the width of torus is less than 2 μm, but sometimes they maybe blurry. Exine thin, about 1 μm thick, commonly with small folds or sometimes with irregular distributed micropitted. Smooth outline.

Material examined: Some registered specimens of them: ZK4703_ZK5_068, ZK4703_ZK5_185, ZK4703_ZK5_187, ZK4703_ZK14_046, ZK4703_ZK29_048, ZK4703_ZK29_086, ZK4703_ZK29_194.

Occurrence. Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspore, trilete, radial, triangular outline, sides slightly concave or slightly convex or sometimes straight, apex narrow blunt or rounded. Laesurae well-developed, sometimes open, rays straight to reach the equator and sometimes with arched ridges at the end. Along with rays it bears torus and some folds across the rays. Surface smooth or sometimes few finely punctuates on surface. Outline is smooth.

Discussion and Comparison: This species is different from other species of this genus on its torus along with rays.

Leiotriletes adnatus (Kosanke, 1950) Potonié and Kremp, 1955 (Figs. 11.1-4, 11.1-17, 11.2-9 and 11.2-10).

1950 *Granulatisporites adnatus* Kosanke; p. 20, pl. 3, fig. 9.

1955 *Leiotriletes adnatus* (Kosanke, 1950) Potonié and Kremp;

Holotype: *Granulatisporites adnatus* Kosanke, 1950, pl. 3, fig. 9, with size 35*36 microns, from maceration 573 Slide 8, Coal 20 feet below the Carlinville limestone (No. 8 coal), Macoupin County, Illinois, USA, deposited at the Illinois State Geological Survey.

Diagnosis (emended after Kosanke, 1950, p. 20): Trilete radial microspores, amb roundly triangular, sides slightly concave, apex broadly rounded. The spore coat is levigate distally and proximally except for an area adjacent to the tetrad scar. This area is somewhat thicker and appears slightly granulose under high magnification. Trilete mark is distinct and extends at least three fourths of the radius at the equator. The lips are well developed and there is a definite *area contagionis*. The exine is uniformly slightly less than 2 microns thick except at the contact area.

Material examined: Some registered specimens of them: ZK4703_ZK2_017, ZK4703_ZK10_038, ZK4703_ZK10_062, ZK4703_ZK21_043.

Occurrence: Upper Permian Xuanwei Formation, commonly in eastern Yunnan in South China.

Description: Microspores, trilete radial, with triangular outline, sides slightly concave, apex rounded, Laesurae with obvious lips, the length of rays (12–13 μm) are more than 1/2 of the radius (17–21 μm) at the equator. Smooth but with few small weakly punctuates in the relatively thick contact area.

Discussion and Comparison: It differs from *Leiotriletes exiguus* on its relatively long rays and with small punctuates in contact area. It is without folds along with laesurae that can be distinguished from *Leiotriletes pulvinulus*. It differs from *Leiotriletes concavus* (Kosanke, 1950) Potonié and Kremp, 1955 on its slightly concave sides rather than strongly concave sides.

Leiotriletes directus Balme and Hennelly, 1956 (Figs. 11.1-1, 11.1-2, 11.1-3).

Holotype: *Leiotriletes directus* Balme and Hennelly, 1956, pl. 1, fig. 1–4, from seam at 688 ft, South Wallarah, No. 5 D.D.H. bore, upper part of the Newcastle Stage, N.S.W.

Diagnosis (emended after Balme and Hennelly, 1956, p. 244). Trilete radial microspore, amb triangular, sides straight or slightly convex in polar view, angles rounded. Trilete marks are well defined, rays straight or somewhat sinuous, extending almost to the periphery of the spore. Exine thin, subject to folding during compression, psilate or faintly granulate. Indistinct contact areas sometimes visible.

Material examined: Some registered specimens of them: ZK4703_ZK31_349, ZK4703_ZK33_039, ZK4703_ZK39_058.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspore with trilete marks, radial, triangular outline, sides straight or slightly convex with narrowly or widely rounded apex. Laesurae is well developed with sometime ridge-like shapes, rays straight or sinuous and thin and it can reach near or to the equator. Smooth surface, sometimes with few weakly granulate. The contact area is weak. The length of radius at the equator is 19–24 μm and the length of laesurae is 16–21 μm.

Discussion and Comparison: It is different from *Leiotriletes sphaerotriangulus* and *Leiotriletes exiguus* on its no obvious contact area and long rays and with some foldings and finely granulates. It differs from *Leiotriletes pulvinulus* on without torus along with laesurae.

Leiotriletes concavus (Kosanke, 1950) Potonié and Kremp, 1955 (Fig. 11.1-20).

1950 *Granulatisporites concavus* Kosanke; p. 20, pl. 3, fig. 4.

1955 *Leiotriletes concavus* (Kosanke, 1950) Potonié and Kremp;

Holotype: *Granulatisporites concavus* Kosanke, 1950, pl. 3, fig. 4, with size of 55 * 58.8 microns, from maceration 318 Slide 10, "Ditney" coal bed from New Haven diamond drill core, White County, Illinois, USA, deposited at the Illinois State Geological Survey.

Diagnosis (emended after Kosanke, 1950, p. 20): Trilete radial microspore, amb subtriangular, sides strongly concave, apex rounded. The margin of the spore coat between the radii parallels the radii for a considerable distance. The spore coat is levigate and the tetrad mark extends at least three-fourths of the radius at the equator; the lips and commissure are distinct. Spore coat is less than 2 microns thick.

Material examined: Registered specimen: ZK4703_ZK33.5_062.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspore, trilete, radial, triangular outline, sides strongly concave, apex rounded, laesurae simple but distinct, rays straight and thin, nearly reach to the equator, sides seem to be parallel to the laesurae, the contact area is blurry, some folds during compression, outline is smooth but some finely and weakly punctuates on surface.

Discussion and Comparison: This species is characterized by its strongly concave and simple laesurae.

Leiotriletes tenuis (Peppers, 1964) Ouyang (1986) (Figs. 11.1-16, 11.1-18, 11.1-19).

1964 *Granulatispontes tenuis* Peppers, pp. 20–21, pl. 2, fig. 11–12.

1986 cf. *Leiotriletes tenuis* (Peppers, 1964) Ouyang, pp. 33, pl. 2, fig. 8.

Holotype: *Granulatispontes tenuis* Peppers, 1964, Pl. 2, figure 11; maceration 1170-A, slide 10, coordinates-125.9 * 45.9, negative 6473, Fithian Cyclothem, Late Pennsylvanian, Illinois basin, USA, deposited at the Illinois State Geological Survey.

Diagnosis (after Peppers, 1964, p. 20). Trilete radial microspore, amb triangular, sides straight to slightly convex or concave, apex rounded. The spore coat is thin and usually folded during compression. The commissure is distinct, straight, extends to the spore margin, and generally is open. Lips are absent. A narrow, slightly thickened contact area is present along the aperture and extends almost to the ends of the rays. The surface of the spore coat is discernibly levigate under oil immersion objective. The exine is 1 to 1.5 μm thick.

Material examined: Registered specimens: ZK4703_ZK5_088, ZK4703_ZK5_178, ZK4703_ZK23_213.

Occurrence: Upper Permian Xuanwei Formation, commonly in eastern Yunnan in South China.

Description: Microspores, trilete, radial, triangular outline, sides slightly concave, with rounded apex. Laesurae obvious and open, can reach near the equator, with lips. And the opening of laesurae is more wider at proximal pole region than one at apex region and it is constrained to be narrow or acute at apex region. Thin exine and easy folded during compression. Relatively smooth surface but with few punctuates.

Discussion and Comparison: Its laesurae features are very special one that can be distinguished from other species of *Leiotriletes.*

Leiotriletes inermis (Waltz) Ishchenko 1952 (Fig. 11.1-11).

1938 *Azonotriletes inermis* Waltz in Luber and Waltz, p. 11, pl. 1, fig. 3, pl. 5, fig. 58 and pl. A, fig. 2

1952 *Leiotriletes inermis* (Waltz) Ishchenko, p. 9, pl. 1, fig. 2, 3.

1955 *Asterocalamotriletes inermis* (Waltz); Luber, p. 40, pl. 1, fig. 20, 21.

1955 *Leiotriletes inermis* (Waltz); Potonié and Kremp, p. 37.

1967 *Leiotriletes inermis* (Waltz) Ishchenko; Smith and Butterworth, 1967, p. 121–122, pl. 1, fig. 7, 8.

Holotype: No designated holotype by Waltz, 1938.

Diagnosis (after Smith and Butterworth, 1967): Trilete microspore, amb elongate-triangular, sides straight to slightly convex, apex rounded, laesurae simple with lips of trilete dehiscence mark slightly raised, dark colour in contact area, length of rays a little less than radius at the equator. Surface of exine smooth.

Material examined: One of the registered specimens: ZK4703_ZK33.5_192.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Trilete radial microspore, slightly elongate triangular outline in proximal view, the outline is smooth, sides are slightly convex and each apex is widely rounded with a little bit thickened exine. Laesurae simple and open in the proximal pole with raised lips. And that open turns to be gradually narrow from proximal pole

to the end of rays. Dark color concentrated on the proximal pole region and gradually turn to be light long with laesurae to the surroundings. Radius is about 23 micron in length, ray is about 20 micron in length and same as the radius of contact area, the area ratio of contact area to outline is about 0.45.

Discussion and Comparison: It is different from other species in *Leiotriletes* on its elongate triangular outline and slight convex sides and long open rays and dark regions.

Genus ***Waltzispora*** Staplin, 1960.

Type species: *Waltzispora* (*Azonotriletes*) *lobophora* (*lobophorus*) Waltz, 1938 in (Luber and Walz, 1938), from the Lower Carboniferous of the Moscow Basin and of the Selizharovo, Borovichi and Kizel regions, U.S.S.R.

Diagnosis (emended after Staphlin, 1960, p. 18; Playford, 1962, p. 581; Smith and Butterworth, 1967, p. 159; Ouyang and Li 1980, p. 126; Playford et al., 2010, p. 185)**:** Microspores, trilete, radial, amb subtriangular-triangular and trilobate, and various shapes at each apical extremity: reflexed or expanded, mushroom, saddle, T-shaped, shoe-last-shaped. Trilete mark distinct, with or without lip development, the exine ornament ranging from laevigate to apiculate.

Discussion: genus *Waltzispora* Staplin, 1960 is thought to be defined by Staplin (1960, p. 18). In fact the type species was firstly proposed by Waltz in (Luber and Walz, 1938) as *Azonotriletes lobophorus* Waltz, 1938.

Due to its various sculptures, ranging from smooth to apiculate. Thus, it should be considered if some species with smooth surface should be put in Infraturma Laevigati (like Playford, 1962; Ouyang and Li 1980; Ouyang 1986) while some species with apiculate sculptures should be put in Infraturma Apiculati Subinfraturma Granulati (like Sullivan, 1964; Smith and Butterworth, 1967; Playford et al. 2010) or just put in Infraturma Apiculati Subinfraturma Granulati according to the sculpture of the type species *Waltzispora lobophora.* But here we'd like to put this genus under Infraturma Laevigati because just one levigate-type species is described here.

Affinity: Unknown.

Waltzispora strictura Ouyang and Li (1980) (Figs. 11.1-13, 11.1-14, 11.2-5, 11.2-6 and 11.2-8).

Holotype: *Waltzispora strictura* Ouyang and Li (1980), pl. 1, fig. 9, size is 43 μm, from the horizon FK-1 (7) of Kayitou Formation, YijintianBu12 core in Qingyun, Fuyuan, Yunnan Province, China. Preserved in the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences.

Diagnosis: Amb triangular, sides strongly concave to slightly concave, apex expanded with shoe-last-shaped apical extremity and slightly pointed in the middle of apex, the junction between apex and side is contracted and angular or smooth transition. Trilete marks distinct with narrow lips, the length of ray is 1/2–2/3 of radius at the equator. Rays turn to be weak at the end. Exine is thin and about 1 μm, outline smooth but some fine punctuates on surface.

Material examined: Registered specimens: ZK4703_ZK2_006, ZK4703_ZK5_117, ZK4703_ZK10_013, ZK4703_ZK12_061, ZK4703_ZK25_035.

Occurrence: Upper Permian Xuanwei Formation, commonly in eastern Yunnan in South China.

Description: Microspores, trilete, radial, amb triangular to subtriangular, sides concave, sometime strongly concave, apex expanded with convex shape, the junction between apex and side is angular at angle of over 80 degree and then apex is contracted to sides. Laesurae clear and simple straight with thin lips, without reaching to the equator, sometimes trilete marks are short. The contact area is blurry. The outline is smooth and a few weakly granuloses or punctuates on the surface.

Discussion and Comparison: It is similar to *Waltzispora sagittata* Playford, 1962 but its apex height is short than *Waltzispora sagittate*, the apex part of *Waltzispora sagittate* is strongly pointed and the laesurae of *Waltzispora sagittate* extended almost to the equator. It is different from *Waltzispora polita* (Hoffmeister, Staplin and Malloy) Smith and Butterworth, 1967 on its simple and relatively thin laesurae rather than the broad laesurae of *Waltzispora polita.* It is different from *Waltzispora albertensis* Staplin, 1960 on its convex top part of apex rather than concave top part. It is different from *Waltzispora lobophora* (Waltz) Staplin, 1960 on its smooth outline rather than granulated outline.

Genus ***Calamospora*** Schopf, Wilson and Bentall, 1944.

Type species: *Calamospora hartungiana* Schopf, 1944 in (Schopf, Wilson and Bentall, 1944, pp. 51–52, fig. 1) from slide Y of maceration 90, deposited in the Illinois Geological Survey collections, Urbana, USA.

Diagnosis (emended after Schopf, Wilson and Bentall, 1944, pp. 49–51 and Smith and Butterworth, 1967, pp. 130–131): Microspores or some small megaspores, trilete, amb circular and very smooth, Laesurae distinct with very short, usually less than 1/2 of the radius at equator features, commissure distinct and attenuate, sometimes lips are moderately developed. Contact area distinct with color difference from other regions or unclear. Some arcuate ridges are commonly and sharp taper-point secondary folds with crescentic or narrow lenticular shape on the surface during the compression. A few minutely punctuates or slightly rugose may be seen under oil. Exine thin.

Discussion: It is characterized by its secondary folds on its thin exine. It can be also distinguished from *Leiotriletes* on its circular outline and from *Punctatisporites* on its very smooth surface and darker contact area.

Affinity: Mostly Sphenophytes, some Noeggerathiales and few megaspores of Lycophytes (Smith and Butterworth, 1967; Balme 1995).

Calamospora breviradiata Kosanke, 1950 (Figs. 11.3-1, 11.3-2).

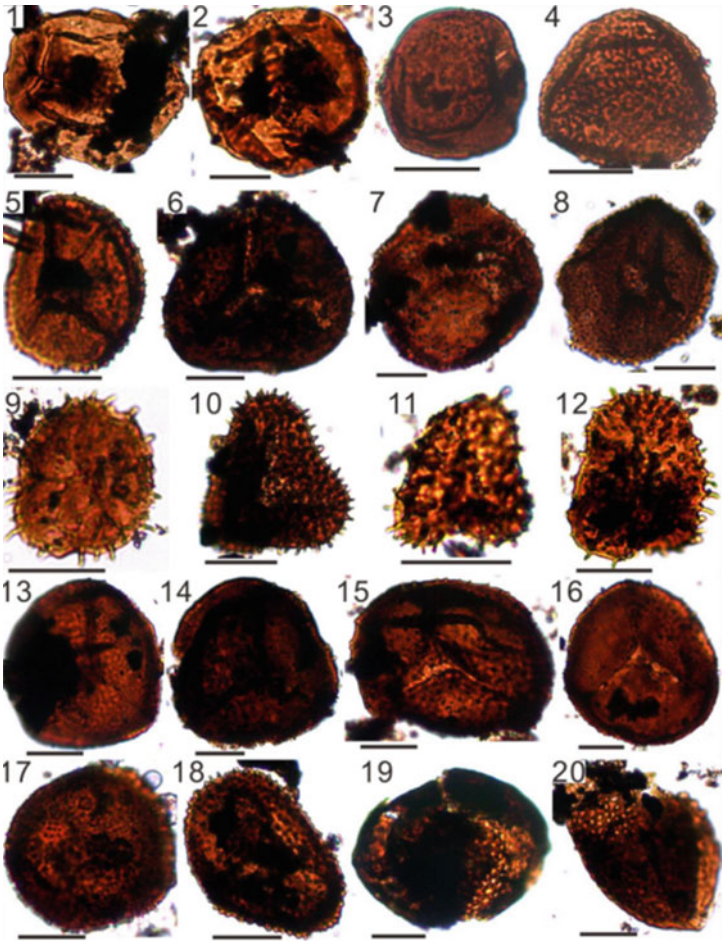

Fig. 11.3 (Scale bar = 20 μm). 1–2 *Calamospora breviradiata* Kosanke. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK5_010, ZK4703_ZK23_057. 3 *Punctatisporites minutus* Kosanke. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK52_152. 4 *Punctatisporites longinquus* Ouyang and Li. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK52_114. 5 *Cyclogranisporites* cf. *micaceus* (Imgrund) Imgrund. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK23_214. 6 *Granulatisporites mirus* Ouyang. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK23_194. 7 *Cyclogranisporites aureus* (Loose) Potonié and Kremp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK14_042. 8 *Punctatisporites contractus* Ouyang and Li. Locality: Chinahe section, Xuanwei City, Yunnan Province. Sample Number: CNH13 + 1.8_031. 9 *Neoraistrickia* cf. *truncates* (Cookson, 1953) Potonié. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK14_067. 10–12 *Neoraistrickia rigida* Ouyang, Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK34_075, ZK4703_ZK05_128, ZK4703_ZK02_049. 13–18 *Crassispora orientalis* Ouyang and Li. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK23_035, ZK4703_ZK7_044, ZK4703_ZK12_034, ZK4703_ZK14_019, ZK4703_ZK23_167, ZK4703_ZK25_016. 19, 20 *Eupunctisporites chinensis* Ouyang and Li. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK25_059, ZK4703_ZK14_067

Holotype: *Calamospora breviradiata* Kosanke, 1950, p. 41, pl. 9, fig. 4, size 57.7 * 65.1 microns from Maceration 579-B Slide 1, No. 2 coal bed, Bureau County, Illinois, deposited in the Illinois Geological Survey collections, Urbana, USA.

Diagnosis (after Kosanke, 1950, p. 41): Spores are radial, trilete, originally spherical, amb circular, laesurae distinct with short trilete rays, less than 1/2 of radius at the equator. The lips are distinct and elevated while the commissure is thin and attenuate. Contact area is distinct with dark color. The spore coat is levigate and is not over two microns thick and have folds generally parallel to the margin of the spore.

Material examined: Registered specimens: ZK4703_ZK5_010, ZK4703_ZK23_057.

Occurrence: Upper Permian Xuanwei Formation, commonly in eastern Yunnan.

Description: Microspores, circular outline, laesurae distinct with short rays, commissure straight with lips, contact area is circular and distinct with dark color. Levigate surface and outline, some secondary folds near the amb during compression. These folds are in narrow lenticular shapes. And few finely granulose can be seen. It radius at the equator is 55–56 microns.

Discussion and Comparison: This species was proposed by Kosanke (1950) with two distinct characters: short rays and dark contact area. But Kosanke (1950) also pointed that dark contact area is not just limited in this species. The type species is also with dark circular contact area (Schopf, Wilson and Bentall, 1944, fig. 1) but the secondary folds of *Calamospora breviradiata* Kosanke, 1950 are always near the equator and parallel to margin of spore. It can be distinguished from *Calamospora microrugosa* by its developed lips and short rays.

Genus ***Punctatisporites*** (Ibrahim, 1933) Potonié and Kremp, 1954.

Type species: *Punctatisporites punctatus* Ibrahim, 1933.

Diagnosis (emended after Kosanke, 1950, p. 18; Smith and Butterworth, 1967, pp. 124–125; Potonié and Kremp, 1954, p. 120): Trilete isospores or microspores having a circular, or near-circular, equatorial outline with a mere suggestion of triangular shape. Margin smooth, as exine devoid of ornamentation. Structure unrecognizable or only discernible owing to the presence of punctation, infrareticulation, or infragranulation (which must not be confused with a granulation causing roughness of the margin). On occasions, punctation is not more than locally visible, as, for instance, along the trilete rays. Rays generally longer than one-half the radius at the equator. Some arcuate folds or markings may be present on surface.

Discussion: This genus was first proposed by Ibrahim (1933, p. 21) as "spore with Y-marked, with finely punctate on the surface of exospore" in translation. And then Potonié and Kremp (1954) modified the diagnosis for this genus as above. But Guennel (1958) thought some species as *Punctatisporites orbicularis*, *Punctatisporites provectus* and *Punctatisporites vagus* had been carelessly transferred to

Cyclogranisporites by Potonié and Kremp (1955) because they possess finely punctate sculptures with rough outlines. In fact, in the emended diagnosis above (Potonié and Kremp, 1954) it stated that "margin or outline is smooth" but "Structure unrecognizable or only discernible owing to the presence of punctation, infrareticulation, or infragranulation (which must not be confused with a granulation causing roughness of the margin). On occasions, punctation is not more than locally visible, as, for instance, along the trilete rays". And Kosanke (1950) suggested to add arcuate markings or folds to Diagnosis: Thus, here following the emended diagnosis above by Potonié and Kremp (1954) and translated by Smith and Butterworth (1967).

Affinity: Pteridophytes (such as some Filicales: *Pecopteris*, *Scolecopteris*, *Danaeopsis*, *Todites* and so on) (Smith and Butterworth, 1967; Balme 1995; Hermann et al. 2011).

Punctatisporites minutus Kosanke, 1950 (Fig. 11.3-3).

Holotype: *Punctatisporites minutus* Kosanke, 1950, pl. 16, fig. 3 from Pennsylvanian Maceration 584 Slide 7, Woodbury (?) coal bed, Jasper County, Illinois, USA.

Diagnosis (after Kosanke, 1950): Microspore, radial, trilete, spherical shape with folded coat. Coat with minutely punctate under oil. Trilete rays distinct and lips slightly developed, commissure thin.

Material examined: Registered specimen: ZK4703_ZK52_152.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: This grain showed the lateral view, with circular outline and a few thin folds on surface, trilete rays on the right upper part, distinct and with thin slightly develpoed lips. Outline is nearly smooth but still some finely punctuates can be seen.

Discussion and Comparison: It can be distinguished from *Punctatisporites contractus* Ouyang and Li (1980) on its finer sculptures and thin laesurae.

Punctatisporites contractus Ouyang and Li (1980) (Fig. 11.3-8).

Holotype: *Punctatisporites contractus* Ouyang and Li, 1980, pl. 1 fig. 31 from FK-4 (8), Kayitou Formation, Fuyuan, Yunan Province, China.

Diagnosis (Ouyang and Li, 1980, p. 128; translation): Amb circular, laesurae distinct with well-developed lips, the width of laesurae is changeable ranging from 1–5 microns. The length of trilete rays is nearly 1/2 of radius at the equator. Exine thin and less than 2 microns, with finely and dense punctuates evenly distributed on it. Some folds may be developed.

Material examined: Registered specimen: CNH13 + 1.8_031.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspore, amb circular, laesurae distinct and short with developed lips. With finely but dense punctuates on surface and some folds appeared on surface. But outline is smooth.

Discussion and Comparison: It is different from *Punctatisporites contractus* Ouyang and Li (1980) on its relatively short rays and the latter with rounded triangular outline.

Punctatisporites longinquus Ouyang and Li (1980) (Fig. 11.3-4).

Holotype: *Punctatisporites longinquus* Ouyang and Li, 1980, pl. 1, fig. 33 from FK-1 (14), Kayitou Formation, Fuyuan, Yunan Province, China.

Diagnosis (after Ouyang and Li, 1980, p. 128; translation): Amb rounded triangular (nearly circular), laesurae distinct with lips, 2–3 microns, slightly sinuous or straight, can reach to the equator sometimes with vertex. Exine thin and folded, finely and densely granuloses or slightly rough, the outline is relatively smooth.

Material examined: Registered specimen: ZK4703_ZK52_114.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: In proximal view, rounded triangular outline with relatively smooth outline, trilete rays distinct but thin, straight, can nearly reach to the equator but the ending of the laesurae is blurry, folds parallel to ambe and some across the rays. With finely granulose on surface.

Discussion and Comparison: It is featured by its rounded triangular outline.

Turma **Zonales** Potonié and Kremp, 1956.

Subturma **Zonotriletes** Waltz, 1935.

Infraturma **Auriculati** (Schopf) Dettmann, 1963.

Genus ***Triquitrites*** (Wilson and Coe, 1940) (Schopf, Wilson, and Bentall, 1944) Potonié and Kremp, 1954.

Type species: *Triquitrites arculatus* Wilson and Coe, 1940, p. 185, fig. 8, from the Slide Nos. 191–200. Pennsylvanian Green County Coal Mine, NW 1/4 SE 1/4s. 1, Franklin Township, Green County, Iow, USA.

Diagnosis (emended from Wilson and Coe, 1940, p. 184; Schopf, Wilson, and Bentall, 1944, pp. 46–47; Potonié and Kremp, 1954, pp. 153–154; Smith and Butterworth, 1967, pp. 201–202): Microspores, trilete, amb approximately triangular, sides slightly convex to strongly concave, apex with thickened exine, appear to be valvae or fairy small projections (some rounded projection being called auriculae), no flange in usual case at equator, but no radially plicated on valvae or auriculae.

Discussion: *Triquitrites* was proposed by Wilson and Coe (1940, p. 184) as "triradial, side concave and equatorial flange at angles". And then its diagnosis was expanded or emended (Schopf, Wilson, and Bentall, 1944, pp. 46–47; Potonié and Kremp, 1954, pp. 153–154). In addition, another similar genus *Tripartites* was proposed by Schemel (1950) as difference of "usually plicated in widest flange at corners". Especially, Sullivan and Neves (1964, p. 1088) compared the genus *Triquitrites* with other similar genus and gave the most important feature of radial plicated at apical region (auriculae) for *Tripartites* to distinguish from *Triquitrites.* And one version of diagnosis was translated from (Potonie and Kremp, 1954, pp. 153–154) in (Smith and Butterworth, 1967, pp. 201–202) but another version of diagnosis was adopted from (Schopf, Wilson, and Bentall, 1944, pp. 46–47) in (Balme, 1970). So, here the diagnosis was combined from two versions.

Affinity: Filicales: *Szea sinensis* Yao and Taylor, 1988 (Schopf, Wilson, and Bentall, 1944; Yao and Taylor, 1988; Balme 1995).

Triquitrites proratus Balme (1970) (Figs. 11.2-13 to 11.2-20).

Holotype: *Triquitrites proratus* Balme (1970), pl. 3, fig. 7, U.W.A. 57,782, Field no. K11-6D, Wargal, Salt Range, Chhidru Formation.

Diagnosis (after Balme 1970, p. 332, 334): Microspore, trilete, auriculate, amb triangular, sides concave. Trilete mark distinct, laesurae extending about three-fourths distance to the inner margin of the auriculae, sometimes bordered by slightly thickened darker exine. Exine 1–2 μm thick on proximal and distal faces, smooth or faintly maculate. Auriculae 2–5 μm wide, outer margins undulate, extremities usually markedly prolonged and incurved.

Material examined: Registered specimens: ZK4703_ZK14_023, ZK4703_ZK5_139, ZK4703_ZK16_002, ZK4703_ZK23_002, ZK4703_ZK23_042, ZK4703_ZK25_022, ZK4703_ZK23_181, ZK4703_ZK33_394.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspore, trilete, amb approximately triangular, trilobate, sides concave, laesurae distinct with thin lips, trilete mark can reach onto apical part, slightly thickened exine on apex forming narrow auriculae or sometimes mixed with rounded projections, some granulose or levigate no plication on auriculae. In the central part, smooth to granulate surface.

Discussion and Comparison: It is different from Triquitrites arculatus Wilson and Coe, 1940 on its equatorial flange just in apical regions. It differs from *Triquitrites tribullatus* Potonié and Kremp, 1956 and *Triquitrites exceptus* Potonié and Kremp, 1956 on its strongly concave sides and relatively wide auriculae. It differs from *Triquitrites microgranifer* Ouyang, 1962 on its no flange connection between auriculate apex. It is different from *Triquitrites sinensis* Ouyang, 1962 on its sculptures without tuberculiforms.

Turma **Triletes** Reinsch 1881.

Subturma **Azonotriletes** Luber 1935.

Infraturma **Apiculati** (Bennie et Kidston 1886) Potonié et Kremp 1954.

Subinfraturma **Nodati** Dybová and Jachowicz, 1957.

Genus ***Lophotriletes*** (Naumova, 1937) Potonié et Kremp, 1954.

Type species: *Lophotriletes gibbosus* (Ibrahim) Potonié et Kremp, 1955, pl. 14, fig. 220 after Ibrahim, B61, e5, from Westphalian B, Agir Seam, Ruhr Coalfield, Germany.

Diagnosis (emended after Smith and Butterworth, 1967, p. 155; Potonié et Kremp, 1954, p. 129; translation)**:** Microspores, trilete, amb distinctly triangular rather than circular, sides generally convex, sometimes concave. Apex rounded. Trilete rays distinct, simple or flexuose, more than 1/2 radius at the equator even can reach the equator. With coni, apex of coni pointed or rounded.

Discussion: *Lophotriletes* was proposed by Naumova (1937) and emended by Potonié et Kremp (1954). The type species was defined as *Lophotriletes gibbosus* (Ibrahim) Potonié et Kremp, 1955, pl. 14, fig. 220 after Ibrahim, B61, e5. And then, Smith and Butterworth (1967) translated the diagnosis of Potonié et Kremp (1954) but some features were not defined clear, such as the trilete rays, apex and coni. Thus, here it was emended to give more details as more formal Diagnosis: It is different from *Apiculatisporis* on its triangular outline rather than circular outline.

Affinity: Filicopsida (Smith and Butterworth, 1967; Balme 1995).

Lophotriletes gibbosus (Ibrahim) Potonié et Kremp, 1955 (Fig. 11.2-11).

Holotype: *Lophotriletes gibbosus* (Ibrahim) Potonié et Kremp, 1955, pl. 14, fig. 220 after Ibrahim, B61, e5, from Westphalian B, Agir Seam, Ruhr Coalfield, Germany.

Diagnosis (after Smith and Butterworth, 1967): Microspore, amb triangular, sides concave, apex rounded, trilete rays more than 2/3 of radius at equator, tecta rather high, vertex sharp, slightly flexuose, ornament of small coni differing slightly in size, apices rounded, seldom flat. Width of coni generally equal to height, but may sometimes be greater. A negative reticulum may be appeared between the coni.

Material examined: Registered specimen: ZK4703_ZK10_019.

Occurrence: Upper Permian Xuanwei Formation, commonly in eastern Yunnan.

Description: Microspores, trilete, triangular outline with rounded apex, sides concave, laesurae distinct, slightly open, its length more than 2/3 of radius at the equator, the widest part of the commissure in the middle part and acute at the ending of the commissure. The coni is relatively evenly distributed in the proximal view and the width of coni is equal to its height. Some folds during the compression.

Discussion and Comparison: It is different from *Lophotriletes paramictus* Ouyang (1986) and *Lophotriletes mictus* Ouyang (1986) on its concave sides and regular

coni. It is similar to *Lophotriletes confertus* Ouyang (1986) but the latter with very dense coni.

Turma **Triletes** (Reinsch, 1881) Potonié and Kremp, 1954.

Subturma **Azonotriletes** Luber 1935.

Infraturma **Apiculati** (Bennie and Kidston 1886) Potonié and Kremp, 1954.

Subinfraturma **Baculati** Dybová and Jachowicz, 1957.

Genus ***Neoraistrickia*** Potonié, 1956.

Type species: *Neoraistrickia truncates* Potonié, 1956, p. 34 (*Trilites turncatus* Cookson, 1953, p. 471, pl. 2, fig. 36 from pre-Tertiary Clays in the Comaum Bore, South Australia).

Diagnosis (emended after Potonié, 1956, p. 34)**:** Microspores, trilete, amb roundly triangular or subtriangular, sides biconvex or slightly concave, apex rounded, trilete rays simple, can reach to the equator, with bacula mostly on distal region and some in proximal region or smooth in proximal region. The bacula strong and straight or slightly curved, with truncated or dilated or rounded or inflated apex.

Discussion: *Neoraistrickia* was defined by Potonié (1956, p. 34) and the *Trilites turncatus* (Cookson, 1953, p. 471, pl. 2, fig. 36) was defined by Potonié (1956) as type species *Neoraistrickia truncates* (Cookson, 1953) Potonié, 1956. Dettmann (1963) thought *Cepulina* Maljavikina, 1949 and *Reticulatisporites*? Ibrahim (in Krutzsch, 1959, p. 162) are synonym of this genus. Bharadwaj and Kumar (1970) emended the diagnosis of this genus as "only distally baculate but proximally smooth". But in fact the type species *Trilites turncatus* (Cookson, 1953, p. 471, pl. 2, fig. 36) showed the proximal view with bacula sculptures. And also Dettmann (1963, p.36, pl. 5, fig. 4–5) described the proximal bacula inconspicuous and sparsely distributed on *Neoraistrickia truncates* (Cookson, 1953) Potonié, 1956. And Playford and Melo (2009) also denied that emended diagnosis of (Bharadwaj and Kumar 1970, pp. 214–215).

Affinity: Lycophytes (Dettmann, 1963).

Neoraistrickia trilobata Ouyang and Li (1980) (Fig. 11.2-12).

Holotype: *Neoraistrickia trilobata* Ouyang and Li (1980), p. 132, pl. 2, fig. 25 from FK-1 (20), Kayitou Formation, Fuyuan, Yunan Province, China.

Diagnosis (after Ouyang and Li 1980; translation): Amb subtriangular, trilobate, sides deeply concave, apex rounded, trilete distinct, sometimes with thin lips, commonly open, ray is more than 2/3 of radius at the equator with acute ending, with bacula and coni, these sculptures strong in the apex and weak in the central proximal part. The width of bacula is 1.5–4 μm, height is 3–7 μm. The apex of bacula is truncated or rounded or sometimes expanded, coni is 1–2.5 μm in height and 1–2 μm in width with pointed ending.

Material examined: Registered specimen: ZK4703_ZK14_038.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspores, trilete, sides concave, apex rounded, trilete rays distinct with lips and open. Rays reach to the equator. In the proximal view, just some coni and few bacula can be seen but in amb more bacula can be seen. And it seems to be more bacula in the distal region. The bacula is thin and height is much larger than width with rounded apex.

Discussion and Comparison: It is different from *Neoraistrickia truncates* Potonié, 1956 on its concave sides.

Neoraistrickia rigida Ouyang (1986) (Figs. 11.3-10, 11.3-11, 11.3-12).

Holotype: *Neoraistrickia rigida* Ouyang (1986), pl. 5, fig. 26, YFH 105 (23), Upper Xuanwei Formation, Fuyuan, Yunan Province, China.

Diagnosis (after Ouyang 1986, p. 55): Amb triangular, sides concave, apex rounded, laesurae distinct and reach to the equator and sometimes with open commissures. Exine solid, with very dense and long bacula and coni, the base width is 1.5–4.0 micron sometimes up to 6.5 microns and height is 2.5–6.0 microns sometimes up to 8.0 microns, with blunt, rounded, trunctate, forked, pointed or slightly expanded apex of bacula or coni.

Material examined: Registered specimens: ZK4703_ZK34_075, ZK4703_ZK05_128, ZK4703_ZK02_049.

Occurrence. Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspores, amb triangular, two slightly concave sides with one slightly convex side, apex rounded. Surface was covered by very dense bacula and coni, coni with pointed apex and bacula with various shaped apex, including rounded, trunctate, pointed, curved and expanded apex. Trilete rays open, covered by bacula and coni.

Discussion and Comparison: It is different from *Neoraistrickia trilobata* Ouyang and Li (1980) on its slightly concave sides and dense bacula and coni.

Neoraistrickia cf. ***truncates*** (Cookson, 1953) Potonié, 1956 (Fig. 11.3-9).

Material examined: Registered specimen: ZK4703_ZK14_067.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Amb rounded triangular, two convex sides and one straight side, rounded apex, laesurae can be seen covered by bacula, the ending of bacula is trunctate or some rounded. In proximal view, bacula loose distributed.

Discussion and Comparison: It has commonly trunctate apex of bacula and laesurae existed but not very clear. But its outline is nearly circular. So, it is very similar to *Neoraistrickia truncates* (Cookson, 1953) Potonié, 1956.

Subinfraturma **Granulati** Dybová and Jachowicz, 1957.

Genus ***Granulatisporites*** (Ibrahim, 1933) Potonié and Kremp, 1954.

Type species: *Granulatisporites granulatus* Ibrahim, 1933, p. 21 from the Aegir coal bed at the top of the Westphalian B.

Diagnosis (after Smith and Butterworth, 1967)**:** Microspore, trilete, amb more or less triangular, a closely granular ornament of the exoexine. The grana are approximately circular, in lateral view, grana are flat or rounded.

Discussion: genus *Granulatisporites* Ibrahim, 1933 was emended by Schopf, Wilson and Bentall (1944), including various surfaces ranging from smooth to punctate and reticulate or apiculate. Potonié and Kremp (1954) emended it again with limitation of sculptures. Thus, here it adopted the translation of Potonié and Kremp (1954)'s diagnosis by Smith and Butterworth (1967).

Affinity: Filicales (Smith and Butterworth, 1967).

Granulatisporites mirus Ouyang (1986) (Fig. 11.3-6).

Holotype: *Granulatisporites mirus* Ouyang (1986), pl. 3, fig. 18, size 85 microns in diameter, from YFH 118 (2), Upper Xuanwei Formation, Fuyuan, Yunan Province, China.

Diagnosis (after Ouyang 1986; translation): Amb triangular, sides slightly convex or straight, laesurae is more than 3/4 of radius at the equator with relatively strong lips and open, rays slightly prominent, single and thin with slightly thickened radial region. With loose distributed grana on surface (especially in distal regions), diameter of grana is about 1 microns and its height is about 1 micron, and with also dense small grana in other regions.

Material examined: Registered specimen: ZK4703_ZK23_194.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspores or miospores, with triangular outline in proximal view, sides slightly convex with rounded apex, laesurae distinct with well-developed lips and open. The commissures straight and can nearly reach the equator. Radial regions thickened. Surface with grana loosely distributed, in outline grana show the loose distributed pattern and the height is equal to the width.

Discussion and Comparison: It is different from *Granulatisporites granulatus* Ibrahim, 1933 on its convex sides. It is similar to *Granulatisporites adnatoides* (Potonié and Kremp, 1954) Smith and Butterworth, 1967 but the latter with more dense grana pattern.

Genus ***Cyclogranisporites*** Potonié and Kremp, 1954.

Type species: *Cyclogranisporites leopoldi* (Kremp, 1952) Potonié and Kremp, 1954, pl. 20, fig. 11.

Diagnosis (after Smith and Butterworth, 1967, p. 142)**:** Microspore, trilete, amb circular, laesurae distinct with lips, the rays can reach to the equator or short. Surface with grana in different distribution pattern.

Discussion: It is different from *Granulatisporites* on its circular shape.

Affinity: Ferns and Noeggerathiales (Smith and Butterworth, 1967).

Cyclogranisporites aureus (Loose) Potonié and Kremp, 1955 (Fig. 11.3-7).

Holotype: *Cyclogranisporites aureus* (Loose) Potonié and Kremp, 1955, pl. 13, fig. 184 from Upper Westphalian B, Bismarck Seam, Ruhr Coalfield, Germany.

Diagnosis (after Smith and Butterworth, 1967, pp. 142–143): Amb circular, laesurae distinct and simple straight, 1/2–2/3 of radius at the equator. Surface with dense grana, evenly distributed, more than 1 micron in diameter. 70–100 projects at the margin. With some narrow folds during compression.

Material examined: Registered specimen: ZK4703_ZK14_042.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: In proximal view, the outline is subcircular to circular, laesurae distinct and rays slightly curved during compression, contact area is not clear, rays are simple and its length is more than 1/2 of radius. Surface with dense evenly distributed grana. Near to margin some folds appeared during compression.

Discussion and Comparison: It is most different from other species on its thin exine with many folds.

Cyclogranisporites cf. ***micaceus*** (Imgrund) Imgrund, 1960 (Fig. 11.3-5).

Material examined: Registered specimen: ZK4703_ZK23_214.

Occurrence: Upper Permian Xuanwei Formation, commonly in eastern Yunnan.

Description: Subcircular outline, laesurae distinct, straight and reach to the equator. Few narrow long folds in irradial region. With dense thin grana on surface.

Discussion and Comparison: It is similar to *Cyclogranisporites* cf. *micaceus* (Imgrund) Imgrund, 1960 on narrow long folds during compression. But the size of grana is larger than the latter.

Infraturma **Murornati** Potonié and Kremp, 1954.

Genus ***Eupunctisporites*** (Bharadwaj, 1962) Ouyang and Li (1980)

Type species: *Eupunctisporites poniatiensis* Bharadwaj, 1962, pl. 1, fig. 4, from Upper Permian, Poniati Seam, Poniati Mine, East Raniganj Coalfield, India.

Diagnosis (after Ouyang and Li 1980, p. 133)**:** Miospores, circular to subcircular, trilete. Laesurae distinct, thin, low vertex and apex, sometimes with curvaturae imperfectae or curvaturae perfectae at the ending of rays, the length of rays equal to 1/2 of radius. Contact area sometimes distinct. Exine thick, distinctly punctate (pitted), mainly distributed on distal regions and equator. Surface of the exine ornamented with pits of various sizes and outline, usually small and fairly evenly spaced. Spore outline broken or smooth accordingly as the margin runs across a pit or the space between the pits respectively.

Discussion: This genus was firstly proposed by Bharadwaj (1962). And then Ouyang and Li (1980) gave some emendation on 'sometimes with curvaturae imperfectae or curvaturae perfectae at the ending of rays' and 'punctate (pitted), mainly distributed on distal regions and equator'.

Affinity: Lycophytes (Ouyang and Li 1980).

Eupunctisporites chinensis Ouyang and Li (1980) (Figs. 11.3-19, 11.3-20).

Holotype: *Eupunctisporites chinensis* Ouyang and Li (1980), pl. 2, fig. 32, size 73 micron, from FK-1(4), Kayitou Formation, Fuyuan, Yunan Province, China.

Diagnosis (after Ouyang and Li 1980, pp. 133–134): Amb subcircular to roundly triangular, subcircular in the lateral view and the distal region convex and the proximal region relatively flat in the lateral view. Laesurae distinct, with lips, the length of rays is equal to the radius, terminated by curvaturae and curvaturae perfectae for connection of laesurae, which also make contact area distinct. Exine with commonly circular punctuate and evenly mainly distributed on distal region to amb. The outline is waved. Sometimes with folds.

Material examined: Registered specimens: ZK4703_ZK25_059, ZK4703_ZK14_067.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: These two grains here with no perfect preservation but still with typical features of this speices. In figure 3.19, it shows the proximal region with relatively smooth surface and laesurae distinct reach to the equator and right down side broken exine show the distal region with punctuates. And In figure 3. 20 show the folded grains with laesurae distinct reach to the amb and distal region with punctuates.

Discussion and Comparison: This species can be distinguished from *Eupunctisporites poniatiensis* Bharadwaj, 1962 on its curvaturae and small punctuates.

Suprasubturma **Laminatitriletes** Smith and Butterworth, 1967.

Subturma **Zonolaminatitriletes** Smith and Butterworth, 1967.

Infraturma **Crassiti** (Bharadwaj and Venkatachala, 1961) Smith and Butterworth, 1967.

Genus ***Crassispora*** (Bharadwaj, 1957) Sullivan, 1964.

Type species: *Crassispora ovalis* Bharadwaj, 1957.

Diagnosis (emended after Sullivan, 1964, pp. 375–376)**:** Radial trilete microspore, amb circular to oval or roundly triangular. Exoexine finely to coarsely infrapunctate; crassitudinous thickening present at the equator. Distal surface ornamented with coni and occasionally spines; proximal surface without ornamentation. Intexine thin and translucent, outline rarely seen; margin conformable to equator of the spore. Apical papillae visible in intertectal areas. These are particularly well seen in over-macerated specimens. Laesurae usually indistinct but sometimes distinct with straight or sinous rays, sometimes with curvaturae imperfectae, sometimes accompanied by folds.

Discussion: This genus was proposed by Bharadwaj (1957, p. 125) and then Sullivan (1964, pp. 375–376) emended this diagnosis above. Main change is about whether the ornaments covering whole exine or just distal regions.

Affinity: Lycophytes (Smith and Butterworth, 1967).

Crassispora orientalis Ouyang and Li (1980) (Figs. 11.3-13 to 11.3-18).

1980 *Crassispora kosankei* (Potonié and Kremp) Bharadwaj, 1957; Ouyang and Li, pl. 3, fig. 5–7.

1980 *Crassispora orientalis* Ouyang and Li (1980), p. 10, pl. 2, fig. 5

Holotype: *Crassispora orientalis* Ouyang and Li (1980), p. 10, pl. 2, fig. 5, size 78 micron, from Kayitou Formation, Fuyuan, Yunan Province, China.

Diagnosis (after Ouyang 1986): Amb circular or roundly triangular, the distal region is more prominent than the proximal region at lateral view. With crassitudinous thickening at the equator but hard to be distinguished with other areas. Laesurae with developed lips and trilete mark projected, usually sinuous, sometimes with open, rays reach to the inner margin of crassitudinous thickening with curvaturae imperfectae at the ending or fused within crassitudinous thickening. Sometimes with big folds on exine, very tiny but dense grana or spongy structure. Some loosely distributed coni on surface.

Material examined: Registered specimens: ZK4703_ZK23_035, ZK4703_ZK7_044, ZK4703_ZK12_034, ZK4703_ZK14_019, ZK4703_ZK23_167, ZK4703_ZK25_016.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspores, trilete, roundly triangular to circular, with crassitudinous thickening at the equator but narrow and hard to be separated from other areas. In proximal regions, laesurae distinct, reach to the crassitudinous thickening, with sinuous or straight rays and sometimes with open commissures. Surface with tiny grana or coni and their small size can be seen at the amb.

Discussion and Comparison: It is different from *Crassispora kosankei* (Potonié and Kremp) Bharadwaj, 1957 on its distinct laesurae.

Turma **Monoletes** Ibrahim 1933.

Subturma **Azonomonoletes** Luber 1935.

Infraturma **Laevigatimonoleti** Dybová and Jachowicz, 1957.

Genus ***Laevigatosporites*** (Ibrahim, 1933) Schopf, Wilson and Bentall, 1944.

Type species: *Laevigatosporites vulgaris* Ibrahim, 1933.

Diagnosis (after Schopf et al., 1944 and Smith and Butterworth, 1967)**:** Spores, monolete, amb oval to elongated oval and smooth, laevigate to infrapunctate, reniform shape in meridian plane. Distal margin convex, polar axis relatively short, without ornaments on exine. Monolete mark straight. Sometimes with folds during compression.

Discussion: It was proposed by Ibrahim (1933, p. 39). And then Schopf, Wilson and Bentall (1944) gave some features to emend this Diagnosis: And Smith and Butterworth (1967) translated the diagnosis given by Potonié and Kremp (1954). Here, we combined these features into diagnosis above.

Affinity: Sphenophytes and Filicales (Smith and Butterworth, 1967).

Laevigatosporites minor (Loose, 1934) Bharadwaj, 1957 (Figs. 11.4-1, 11.4-2, 11.4-3).

1934 *Laevigatosporites vulgaris minor* Loose, p. 158, pl. 7, fig. 12.

1957 Laevigatosporites minor (Loose, 1934), Bharadwaj, p. 109, pl. 29, figs. 8, 9.

Holotype: *Laevigatosporites vulgaris minor* Loose, 1934, p. 158, pl. 7, fig. 12 from Upper Westphalian B, Bismarck seam, Ruhr Coalfield, Germany.

Diagnosis (after Smith and Butterworth, 1967): Amb oval, reniform shape in lateral view. Laesurae simple, greater than 3/4 of spore diameter. Exine laevigate to faintly punctate, its size ranging from 35–64 microns.

Material examined: Registered specimens: ZK4703_ZK23_019, ZK4703_ZK02_046, ZK4703_ZK52_120.

Occurrence: Upper Permian Xuanwei Formation to Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspore, monolete. In polar view, its shape is ellipsoidal. While in equatorial view, its shape is reniform. Laesurae simple and monolete, greater than 3/4 of spore diameter, ray is straight and slightly arching in the middle, with some folds on surface and few tiny punctuates. Their sizes ranging from 40–50 microns.

Discussion and Comparison: It is different from *Laevigatosporites minimus* and *Laevigatosporites vulgaris* on size. The size of *Laevigatosporites minimus* is the smallest one, less than 35 microns, and the size of *Laevigatosporites vulgaris* is the biggest one, more than 64 microns among these three species according to (Smith and Butterworth, 1967).

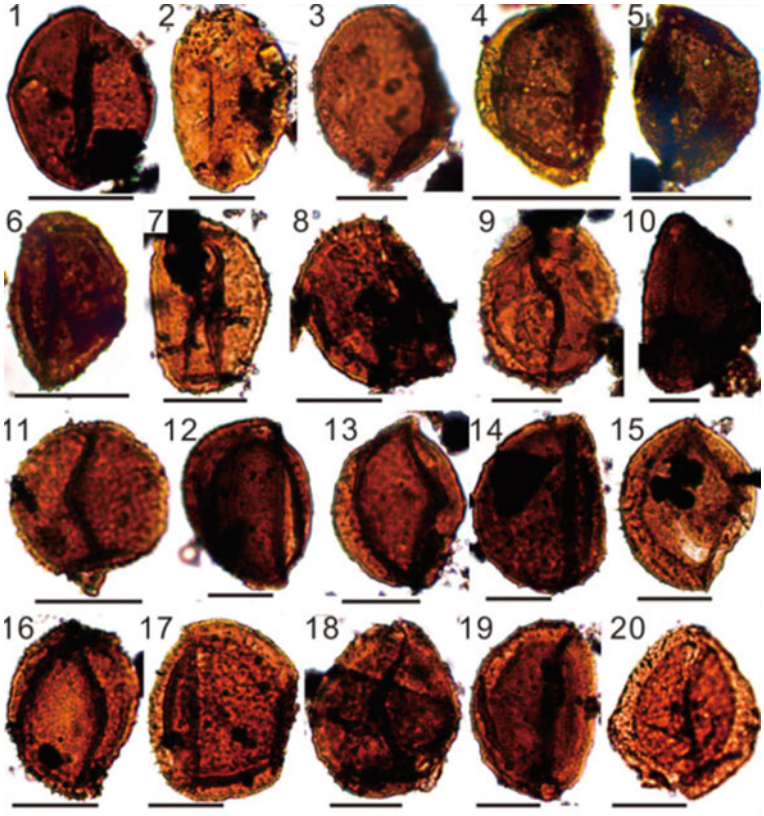

Fig. 11.4 (Scale bar = 20 μm). 1–3 *Laevigatosporites minor* (Loose, 1934) Bharadwaj. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK23_019, ZK4703_ZK02_046, ZK4703_ZK52_120. 4–20 *Aratrisporites yunnanensis* Ouyang and Li. Locality: Chinahe section, Xuanwei City, ZK4703, Fuyuan County, Yunnan Province. Sample Number: CNH13 + 0.3_025, CNH13 + 0.3_038 and 039, ZK4703_ZK14_036, ZK4703_ZK23_006, 015, 016, 067, 166, 182 and 196, ZK4703_ZK25_051, ZK4703_ZK29_012, 047 and 105, ZK4703_ZK33_001 and 006

Subturma **Zonomonoletes** Naumova 1937.

Suprasubturma **Perinomonolites** Erdtman 1947.

Genus ***Aratrisporites*** (Leschik, 1955) Playford and Dettmann 1965.

1955 *Aratrisporites* Leschik, Keuperflora von Neuewelt, p. 38.

1960 *Aratrisporites* Klaus, Sporen der karnischen Stufe, p. 145.

1960 *Saturnisporites* Klaus, Sporen der karnischen Stufe, p. 142.

Type species: *Aratrisporites parvispinosus* (Leschik, 1955) Playford and Dettmann, 1965.

Diagnosis (after Playford and Dettmann, 1965, pp. 151–153)**:** Microspores monolete, bilateral. Spore wall (sclerine) two-layered, cavate; consisting of an outer structured layer (sculptine) loosely enveloping, but proximally attached to, a homogeneous inner layer. Sculptine surface finely patterned (the pattern being formed by an arrangement of structural elements) and with sculptural elevations including grana, coni, spinulae, spinae and saetae. Laesura enclosed within elevated lips which are proximal extensions of sculptine, with curvaturae imperfectae.

Discussion: Leschik (1955) put this genus into alete group but Klaus (1960) found its monolete mark and emended it. And then Playford and Dettamann (1965) included the Saturnisporites Klaus 1960 into this genus.

Affinity: Lycophytes (especially Isoetales and maybe from *Annalepis* or *Tomiostrobus*) (Harris, 1955; Playford and Dettamann, 1965; Grauvogel-Stamm and Duringer 1983; Balme 1995).

Aratrisporites yunnanensis Ouyang and Li (1980) (Figs. 11.4-4 to 11.4-20).

Holotype: *Aratrisporites yunnanensis* Ouyang and Li (1980), Pl. 4, Fig. 5, size 52*40 micron, FK-1 (5), from Kayitou Formation, Fuyuan, Yunan Province, China.

Diagnosis (after Ouyang and Li 1980, pp. 143–144; translation): Microspore, monolete, amb widely ellipsoidal to ellipsoidal. Outline in equatorial view is lenticular and the proximal region convex or flat but the distal region strongly convex. Monolete reach or nearly reach to the equator with lips, sinuous, sometimes with one nearly orthogonal but not distinct ray from the middle part of monolete laesurae, forming "false trilete" structure. Exine with two layers, intexine without ornaments and slightly thicker than exoexine. In the polar regions, two layers are separated. Sexine thin, with grana, spony structure in proximal polar. With evenly distributed coni or small spines and their apex acute or clavate apex. Ornaments mainly distributed on distal regions and equator. Monolete laesurae ended with curvaturae imperfectae.

Material examined: Registered specimens: CNH13 + 0.3_025, CNH13 + 0.3_038, CNH13 + 0.3_039, ZK4703_ZK23_016, ZK4703_ZK23_015, ZK4703_ZK23_006, ZK4703_ZK14_036, ZK4703_ZK23_166, ZK4703_ZK23_182, ZK4703_ZK23_196, ZK4703_ZK23_067, ZK4703_ZK25_051, ZK4703_ZK29_012, ZK4703_ZK33_001, ZK4703_ZK29_047, ZK4703_ZK29_105, ZK4703_ZK33_006.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Microspores, monolete, cavate, widely ellipsoidal to ellipsoidal in proximal view and reniform (fig. 4.4, 4.12, 4.14) to lenticular (fig. 4.5) shape in equatorial view. Laesurae monolete with sinuous shape and always arching in the middle part, sometimes forming "false trilete" structure (fig. 4.4, 4.14, 4.18), with grana or coni on surface. And some folds can be seen on sexine.

Discussion and Comparison: It is different from *Aratrisporites fimbriatus* by the latter with hair-like fimbriae. It is different from *Aratrisporites paenulatus* by its thick exine and sinuous mid-arching laesurae.

Anteturma **Pollenites** Potonié, 1931.

Turma **Saccites** Erdtman, 1947.

Subturma **Disaccites** Cookson, 1947.

Infraturma **Disacciatrileti** Leschik, 1956.

Genus ***Alisporites*** (Daugherty 1941) Jansonius, 1971.

Type species: *Alisporites opii* Daugherty 1941, Upper Triassic, Arizona, National Monument, U.S.A.

Diagnosis (after Hart, 1965)**:** Disaccate Disacciatrileti, haploxylonoid to slightly diploxylonoid in outline and with a transverse distal sulcus running centrally across the central body. The C.B. is circular or oval with an 1-a or t-a elongation and the sacci are equal to or less than the C.B. in size and less than or about semi-circular in shape. The t-a (C.B.) is greater than or equal to the t-a (sacci). The distal zone varies from distinct to obscure.

Discussion: It contains various morphological types with alete bisaccate pollens. It is different from *Vesicaspora* on the latter with lateral bladder. It is different from *Vitreisporites* on the latter with very small size. It is similar to *Falcisporites* but without lemniscatoid transverse sulcus.

Affinity: Conifers (Balme 1995; Bomfleur, 2011).

Alisporites spp. (Fig. 11.5-1 to 11.5-15).

Material examined: Registered specimens: ZK4703_ZK45_038, ZK4703_ZK45_129, ZK4703_ZK39_005, ZK4703_ZK45_097, ZK4703_ZK39_004, ZK4703_ZK39_009, ZK4703_ZK51_048, ZK4703_ZK51_080, ZK4703_ZK34_055, ZK4703_ZK39_078, ZK4703_ZK36_019, ZK4703_ZK52_003, ZK4703_ZK51_025, ZK4703_ZK39_068, ZK4703_ZK45_105.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Bisaccate pollen, alete, haploxylonoid or slightly diploxylonoid, with oval outline in polar view, body is circular to ellipsoid, sacs from semicircle to circular shape. Commonly one transverse sulcus developed in distal region (fig. 5.3). surface on body is finely punctate or few finely grana or smooth and surface on sacs is reticulate or finely punctate or finely grana.

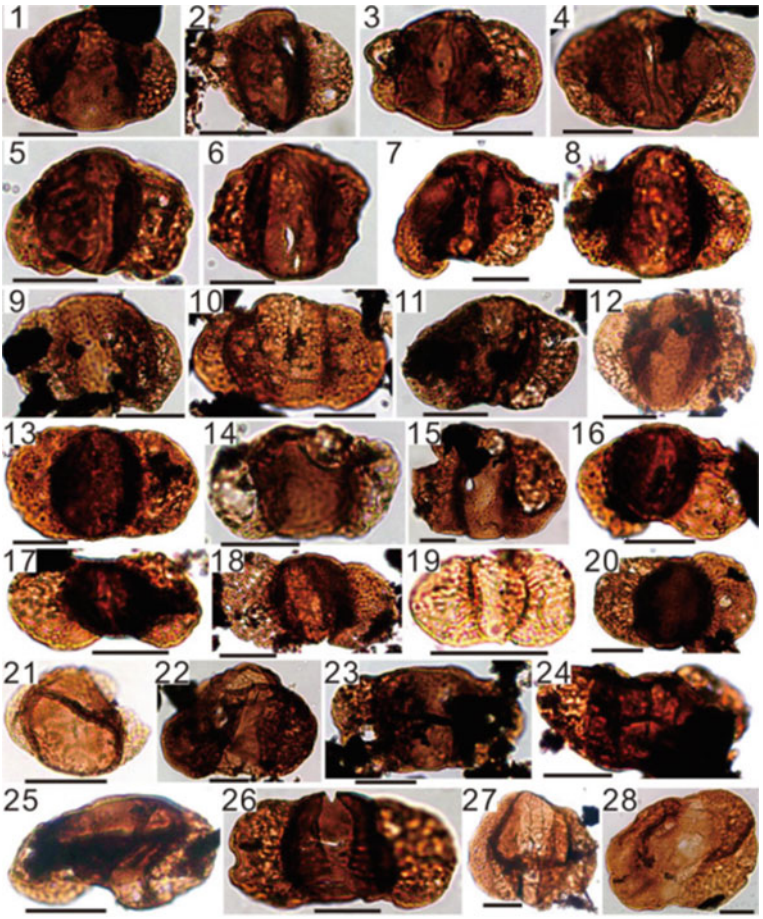

Fig. 11.5 (Scale bar = 20 μm). 1–15 *Alisporites* spp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK34_055, ZK4703_ZK36_019, ZK4703_ZK39_004, 005, 009, 068 and 078, ZK4703_ZK45_038, 097, 105 and 129, ZK4703_ZK51_025, 048 and 080, ZK4703_ZK52_003. 16–18, 20 *Platysaccus* spp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK39_016, ZK4703_ZK51_026, 143 and 146. 19 *Vitreisporites* cf. *pallidus* (Reissinger) Nilsson. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK31_294. 21–23 *Chordasporites* spp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK31_282, ZK4703_ZK45_077, ZK4703_ZK51_045. 24 *Illinites* sp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK45_062. 25 *Lueckisporites* sp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK52_085. 26 *Striatopodocarpites* sp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK45_078. 27 *Protohaploxypinus* sp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK52_090. 28 *Vesicaspora* sp. Locality: ZK4703, Fuyuan County, Yunnan Province. Sample Number: ZK4703_ZK31_350

Discussion: They have various morphological types here.

Genus ***Vitreisporites*** (Leschik, 1955) Jansonius, 1962.

Type species: *Vitreisporites signatus* Leschik, 1956.

Diagnosis: Bisaccate pollen, more or less haploxylonoid, small, sometimes with narrow distal furrow. Body is oval or transverse ellipsoid, sacs usually semicircle. sacs is larger than body.

Discussion: It is different from *Alisporites* and *Falcisporites* on its small size and narrow furrow.

Affinity: Caytoniales (Ouyang and Li 1980).

Vitreisporites cf. ***pallidus*** (Reissinger) Nilsson, 1958 (Fig. 11.5-19).

Material examined: Registered specimen: ZK4703_ZK31_294.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Bisaccate pollen, haploxylonoid to slightly diploxylonoid, very small, outline is ellipsoid at polar view. Body is smaller than sacs with transverse oval shape. Sacs in semicircle. with narrow furrow.

Discussion and Comparison: It is mostly similar to *Vitreisporites pallidus* on its small size and narrow distal furrow.

Genus ***Platysaccus*** (Naumova, 1937) Potonié and Klaus, 1954.

Type species: *Platysaccus papilionis* Potonié and Klaus, 1954, pl. 10, fig. 12, Salzberg Hallstatt, Christina-Horizont, Schwingheim-Querschlag. Kemsalz from the Gray Core Mountains.

Diagnosis (after Potonié and Klaus, 1954)**:** Bisaccate microspores which do not have a Y mark, no proximal laesurae, no sharply marked distal area. The dumbbell-shaped overall outline at the equator. Central body is circular to oval. Sacci usually extremely over hemispherical, significantly larger than the central body. On the longest diameter the ratio of the central body to the total length is about 1: 3 because the outline of the Sacci in the equatorial section is more than semicircular. If their growth stripe is not on the longest diameter of the Sacci, but represents a shorter tendon. Sacci mostly distally approached and provided with pronounced infrared ticulum. Some folds may be seen as radial shape in the roots of sacs.

Discussion: It is different from *Alisporites* and *Falcisporites* on its much bigger sacs than body and without sulcus in distal regions. And it is different from *Vesicaspora* by it without lateral bladder.

Affinity: Seed ferns and conifers (Balme 1995; Rad and Noroozpour, 2017).

Platysaccus spp. (Fig. 11.5-17, 11.5-18, 11.5-20).

Material examined: Registered specimens: ZK4703_ZK51_026, ZK4703_ZK51_143, ZK4703_ZK51_146.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Bisaccate pollen, strongly diploxylonoid, alete, without sulcus both on proximal region and distal region. It is dumbbell shape in polar view. And the body is more or less circular and sacs are more than semicircle. The size of sacs is parentally larger than the size of body. Some radial folds appeared on the roots of sacs.

Discussion: Some grains here show more than two different morphological types.

Genus ***Vesicaspora*** (Schemel 1951) Wilson and Venkatchala 1963.

Type species: *Vesicaspora wilsonii* Schemel, 1951, Mystic Coal Seam, Iowa, U.S.A.

Diagnosis (after Hart, 1965): Disaccate Disacciatrileti haploxylonoid in outline. The central body is usually obscured by the sacci exines but when seen is circular or has a t-a elongation. Running transversely across the central body there is a distal sulcus occupying the whole of the distal zone, i.e. framed by the distal roots. The outline of this sulcus may be fusiform, irregular or appear as a narrow slit. The main characteristic of the genus is the development of lateral bladders so that a completely encircling air chamber with terminal swellings appears in equatorial view.

Discussion and Comparison: This genus was firstly assigned to Monosaccites (Schemel, 1951; Wilson and Venkatchala, 1963). But Potonié (1958) started to assign it to Disaccites and then more and more studies supported this assignation (Bharadwaj, 1962; Hart, 1965).

Affinity: Ginkgophytes (Balme 1995).

Vesicaspora sp.

Material examined: Registered specimen: ZK4703_ZK31_350.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Bisaccate pollen, alete. Haploxylonoid, relatively big size, central body is transverse oval and sacs are roundly crescent-shaped. Sacs are larger than body. The ends of Two sacs are separately connected by lateral bladders from extended margin of body. Some folds appeared on surface of sacs.

Discussion and Comparison: It is marked by its lateral bladders.

Genus ***Illinites*** Kosanke 1950.

Type species: *Illinites unicus* Kosanke 1950, pp. 51–52, pl. 1, fig. 3, Maceration 494 Slide 15, 10-inch coal bed exposed in Coffee Creek, Wabash County, Illinois, U.S.A.

Diagnosis (after Kosanke, 1950, p. 51; Hart, 1965): Disaccate Disaccitrileti, haploxylonoid to diploxylonoid in outline. The central body is circular or oval with a slight l-a or t-a elongation. The proximal surface of the central body has a centrally placed

trilete aperture and is laevigate, punctate or finely granulate. The sutures of the trilete aperture may or may not be of equal length to one another.

Discussion: It is different from *Limitisporites* and *Vesitisporites* on its trilete mark. It is different from *Jugaesporites* on its dilete mark.

Affinity: Voltzian conifers (Grauvogel-Stamm and Grauvogel, 1973; Balme 1995).

Illinites sp.

Material examined: Registered specimen: ZK4703_ZK45_062.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Bisaccate pollen, with trilete mark in proximal region of body. Haploxylonoid to slightly diploxylonoid, body is bigger than sacs. Body is circular shape and sacs are semicircular. Some folds can be seen during compression.

Discussion and Comparison: It is with distinct trilete mark, which should be assigned to *Illinites* but it is hard to classify it into species level due to no good preservation.

Turma **Saccites** Erdtman, 1947.

Subturma **Disaccites** Cookson, 1947.

Infraturma **Striatiti** Pant, 1954.

Genus ***Chordasporites*** Klaus, 1960.

Type species: *Chordasporites singulichorda* Klaus, 1960, pl. 33, fig. 45.

Diagnosis (after Klaus, 1960, pp. 157–158; translation): Bisaccate microspores, the central body of which has a distinct exine cord (chorda) or fold on one side, in the case of saccus convergence on the side facing away from it, in the direction of the longitudinal axis, which is usually directly connected to the sac base lines or runs a piece into them as a fold. Sometimes, however, it is so short that it does not reach the bases of the sacs. The exine strand, often in the form of a bulge that looks like it is twisted, is never divided into itself like a closed back (or crown-back laesur) accompanied by bulges, but more or less homogeneous. As the cord splits and pops open. There is no sharp step between the edge of the saccus base and the cord. Often the Sacci converge on the side opposite the exine strand and leave a less or no ornamented, thinner exine point free between them. The strand side of the central body is usually made thicker and structured approximately up to the equator. The cord is occasionally accompanied by narrow, thinned areas of exine on both sides.

Discussion: It is different from *Lueckisporites* on its one cord-like striate.

Affinity: Peltasperm-type pteridosperms (Aggarwal et al. 2018).

Chordasporites spp. (Fig. 11.5-22).

Material examined: Registered specimens: ZK4703_ZK31_282, ZK4703_ZK45_077, ZK4703_ZK51_045.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Some grains here show bisaccate pollens with one cord-like striate over central body, haploxylonoid, body is in shape of circle to transverse oval, sacs are in shape of semicircle. And the sacs is smaller than body. Some folds can be seen during the compression.

Discussion and Comparison: They are featured by its one cord-like striate over body. But they are different from each other by central body size.

Genus ***Lueckisporites*** Potonié and Klaus, 1954.

Type species: *Lueckisporites virkkiae* Potonié and Klaus 1954, Solvay Werke Borth, Germany.

Diagnosis (after Hart, 1965)**:** Disaccate Striatiti, diploxylonoid in outline. The central body is circular or elongated in the 1-a direction, and has a proximal cap showing two longitudinal ribs in polar view. The sacci are more or less semi-circular in shape and have an infra-reticulate structure. The distal roots are less than t-a (sacci) and leave a distal zone that is usually about one-third or less 1-a (C.B.) in dimension.

Discussion: It is similar to *Gardenasporites* but it has the laesurae in intexine and more darker body.

Affinity: Conifers (Balme 1995).

Lueckisporites sp. (Fig. 11.5-25).

Material examined: Registered specimen: ZK4703_ZK52_085.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Bisaccate pollens, diploxylonoid, with two distinct taeniae on proximal surface and one laesurae inside the proximal surface according to its lighter color than other regions. Central body with circular to slightly elongate oval. Sacs with roundly crescent shape. Some folds can be seen on body surface and a little bit darker color for whole body than sacs.

Discussion and Comparison: It is distinct for assigning to *Lueckisporites* by its two taeniae on body surface.

Genus ***Striatopodocarpites*** (Sedova, 1956) Hart, 1964.

Type species: *Striatopodocarpites tojmensis* Sedova 1956, plate XLI, figure 8, North Dvina basin, River Lower Toima, Lower Kazanian Beds.

Diagnosis (Hart, 1965 emended)**:** Disaccate Striatiti, strongly to moderately diploxylonoid in outline. The length of the distal roots of the sacci are less than the diameter of the central body in transverse direction. The central body is circular to slightly oval in outline and possesses a proximal cap divided into more than four longitudinal ribs. The sacci are distinctly larger than the central body in size and greater

than semi-circular in shape. The terminal sacci may in rare cases be united to form slight lateral bladders.

Discussion and Comparison: It is different from *Protohaploxypinus* and *Lunatisporites* by its diploxylonoid and relatively thin and dense striates.

Affinity: Ginkgophytes or Pteridosperms (Balme 1995).

Striatopodocarpites sp. (Fig. 11.5-26).

Material examined: Registered specimen: ZK4703_ZK45_078.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Bisaccate pollens, moderately diploxylonoid, with numerous thin striates (about 11) on body surface and centrally with possible laesurae. Body with circular shape and sacs with semicircle shape. Body is smaller than sacs. Sacs with reticulate sculptures.

Discussion and Comparison: It is distinct by numerous thin striates and moderately diploxylonoid outline.

Genus ***Protohaploxypinus*** (Samoilovich, 1953) Hart, 1964.

Type species: *Protohaploxypinus latissimus* (Luber and Valts, 1941) Samoilovich, 1953. Solikamsk region, Western Pre-Urals, U.S.S.R.

Diagnosis (Hart, 1965 emended): Disaccatc Striatiti, haploxylonoid or slightly diploxylonoid in outline. The central body is circular, or oval with a slight t-a or slight I-a elongation. The proximal cap is divided into four or more longitudinal ribs. The sacci are semi-circular, less than semi-circular or slightly greater than semi-circular in shape. The sacci structure is infrareticulate. The length of the distal root is equal to or slightly less than the t-a (C.B.). The distal zone is less than or equal to two-thirds 1-a (C.B.).

Discussion: It is different from *Lunatisporites* on its numerous striates (over 5) rather than a few taeniae.

Affinity: Ginkgophytes or Peltaspermales (Balme 1995).

Protohaploxypinus sp. (Fig. 11.5-27).

Material examined: Registered specimen: ZK4703_ZK52_090.

Occurrence: Lower Triassic Kayitou Formation, commonly in eastern Yunnan.

Description: Bisaccate pollen, haploxylonoid, with over 10 striates on body surface with relatively darker color and along with lighter-color grooves. Body shape is transverse oval to lenticular, sacs are in semicircle and body is larger than sac.

Discussion and Comparison: This grain is distinguished by other genus on its numerous striates with haploxylonoid outline.

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