NATURE OF STRIATIONS AND TAENIAE IN GONDWANA SACCATE POLLEN

The presence of striations or taeniae on the cappa of the central body of disaccate pollen is recorded only in fossils, that too mainly of Permian and Triassic age. This span of geological past is very peculiar in this respect because of the occurrence of this global phenomenon, the reason of which is not yet fully understood. The word *stria* (pl. -ae, Latin—a furrow) literally means a furrow ; however, it has been utilised in describing "elongated ridges" by THOMSON AND PFLUG (1953) and as "elongated depressions between the muri of a striate sculpture pattern" by COUPER AND GREBE (1961). Even otherwise those who often used the term striae in the sense of "furrows" differed from each other in their objective meanings, for example—HARRIS (1955) thought them to be a "finger print pattern", FAEGRI AND IVERSON (1950) as "ornamental parallel elements" ; and KOSANKE (1950) as very fine "parallel microridges".

The nature of the so-called "striations" in the disaccate, some monosaccate and polysaccate, e.g. *Striatopodocarpites*, *Lahirites*, *Verticipollenites*, *Striomonosaccites*, pollen genera cannot be encompassed by the above mentioned descriptive usage. These striations are simple, linear, extremely narrow (<0.5 μm wide) grooves running across the body, parallel, subparallel or convergent at ends, polygonal, brick-work pattern or reticuloid, simple or branched with or without vertical partitions. The sexine between these grooves could be unstructured or variously structured (infrapunctate, infrareticulate, etc.). The sexine is completely absent from the groove area. The striations smoothly merge with the saccus-body-line and could be seen as if getting drowned in the saccus structure in various degrees.

A recent SEM study of some material from Raniganj Formation has supplimented the above mentioned light microscopic observations. In a low magnification (Pl. 1, Fig. 1) the grooves appear to be very regular lines shining brightly suggesting thereby the presence of only nexinal part and not covered by sexine. These when seen under high magnification (Pl. 1, Fig. 4) appear to make a plough-furrow pattern. The inter-groove exoexine (sexine) is elevated and its surface is "micro-mouldy" with smooth-contoured subrounded elevations. These grooves (striations) smoothly enter the body-saccus junction (Pl. 1, Fig. 3) beyond which one can see the similar "micro-mouldy" surface-texture on the saccus tectum (also see KLAUS, 1977). In Pl. 1, Fig. 2, a folded body has been photographed to show one branched groove and also the side-contour of several striations at the top depicting the inter-groove elevation of the sexine.

The word *Taenia* (pl. -ae, Gr.— taenia, a band) means a ribbon or fillet-like structure (also the tape-worm genus!). It was first used as a root to derive the name of the genus *Taeniaesporites* by LESCHIK in 1955. Since then, the term "Taeniae' as such has been taken up to describe sexinal strips (ectexinen streifen) on the body of such group of disaccate, e.g. *Lunatisporites*, *Leuckisporites* (a few poly- or mono-saccate) pollen, which ultimately came to bear a name as taeniate pollen (POTONIÉ, 1970 ; KLAUS, 1964 ; SCHEURING, 1970, 1977). Fortunately, there has been a uniformity in the approach towards description of these structures, but still many workers (BALME, 1966 ; WILSON, 1962 ; JANSONIUS, 1962) did not delimit the striate and the taeniate forms separately.

As such, the taeniae are strip-like bands, narrow to wide, mostly not uniform in width, placed sub-parallel to each other on the cappa. They may or may not cover

the cappa in length or some may even be very small in size (rudimentary). The spaces between the taeniae are irregularly wide, exhibiting the unstructured intexine of the body. The taeniae could be variously structured (exoexine) and thickened.

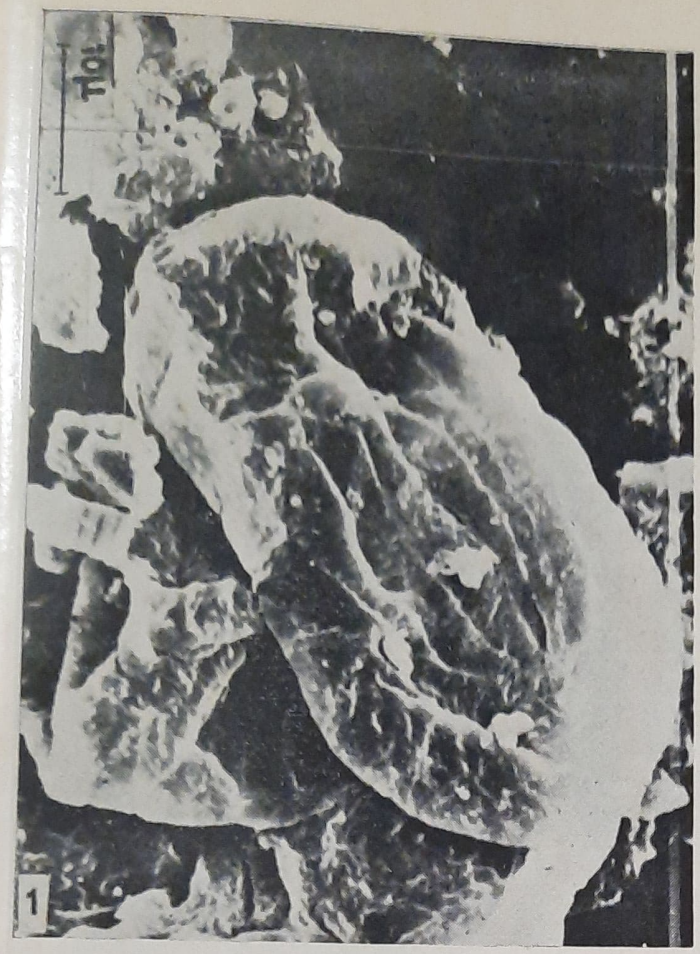
A recent study by SEM of some Lower Triassic (Panchet) material from Raniganj Coalfield has revealed significant characters of taeniae which supplement the above mentioned light microscopic observations.

The 'ribbons' in low magnification appear to be well-organized, raised rounded ridges (Pl. 2, Figs. 5, 7). The surface of the ribbons is similar in texture as that of the saccus, that is—with fine rounded low elevations or moulds, projecting above the exinal surface. The space between the two strips is a path-way or "street" (Strasse ; KLAUS, 1964 ; SCHEURING, 1970) unevenly wide and deep (Pl. 2, Fig. 7). The magnified micrograph of a folded specimen (Pl. 2, Fig. 6) gives a beautiful view of how the "streets" and the ribbons are placed. The smooth nature of the inter ribbon space (inexine) is also clear. The variation in shape and size of taeniae is depicted in Pl. 2, Fig. 8.

It is thus evident that the *striations* and *taeniae* are two different organizations in saccate pollen. The striations are homologous to inter taeniate "pathways". In striations the intexine (nexine) is not exhibited and the exoexine (sexine) is well-developed all over the body except at a linear groove where it is completely reduced ; this observation is evident in light microscopy also. On the contrary, in taeniae the intexine (nexine), the unsculptured layer, is widely and prominently exposed and the sexine is restricted only to the strip regions.

Both these structures are found in the single pollen assemblage of the same age (e. g. early Triassic) but there interrelations is not yet definite. The striate forms appear in early Gondwana and till the end of it normally no typical taeniate pollen (except *Leuckisporites*) is met with. Suddenly at the close of the Lower Gondwana, forms like *Lunatisporites* start appearing in the early Triassic which dominate in the late Lower Triassic and onwards where striate forms decline and ultimately disappear in Jurassic. In the early Triassic one can mark the process of transformation from simple striate form through incipient taeniate pattern to real taeniate arrangement. This occurrence pattern is unique. It is, however, not related with climatic changes because the whole construction, and the nexine-sexine relationship does not explain the possibility of these taeniae and striations being useful to harmomegathy (volume-change accommodation). The nexine in case of both striate and taeniate pollen is not loose or expanded so as to get folded when so needed to accommodate the volume, unlike a case in colpus or a sulcus. Therefore, these organized sexine-free lines and pathways (striations and intertaeniate regions) are tenuitates rather than the shrinking wrinkles. What strikes most is the possibility of the grooves and the path-ways being "emergency tenuitates", the areas where the sexine is completely reduced. These pollen have distal sulcus as well—probably functioning as the main tenuitas.

The change of polarity of germination, from proximal to the distal pole, is related with the occurrence of these tenuitates. Nature seems to had provided immense opportunities of germination during this transformation in organization, i.e. proximal to distal germination. Their disappearance in the younger horizon is related with the perfection attained by the distal sulcus providing security and surity of germ-tube exit. This conclusion is also supported by the primitive structure of the saccus (as protosaccus) in such groups (TIWARI, 1981). Thus in view of the protosaccate condition and the absence of complete and total shifting of the germinal polarity to the distal pole, these

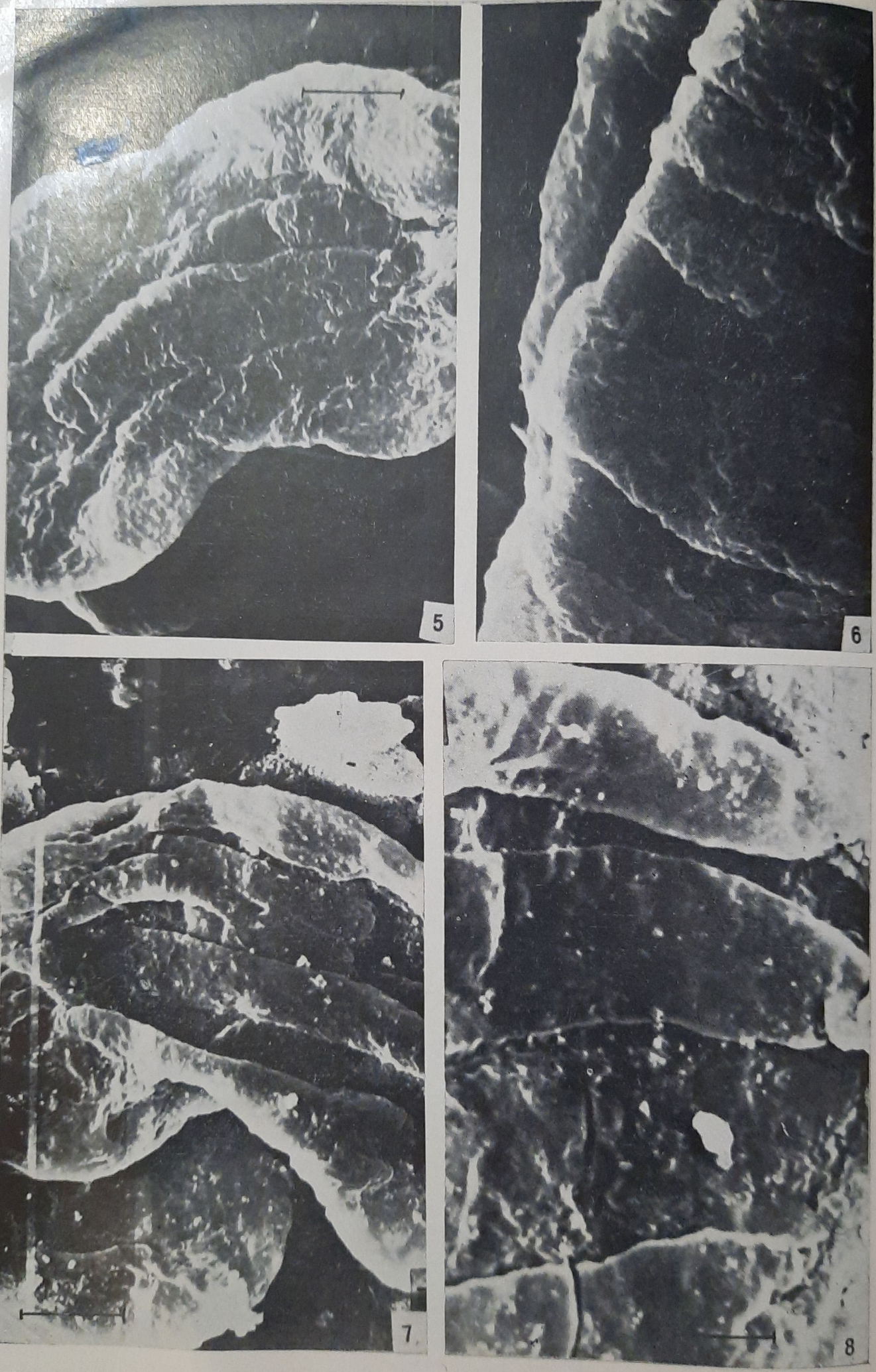


1

2

3

4



Tiwari—Plate 2

groups probably represent an advance level of a pre-pollen condition. The importance of Permo-Triassic periods on the stage of evolution is thus self evident.

The author is thankful to the A. v. Humboldt Foundation, Bonn for the award of a Fellowship (1980) during the tenure of which this work was accomplished at the Senckenberg Museum, Frankfurt a. M.

REFERENCES

BALME, B. E. (1970). Palynology of Permian and Triassic strata in the Salt Range and Surghar Range, West Pakistan. *Strat., Bound. Prob. Perm. Triass., W. Pakistan, Uni. Kansas, Deptt. Geol., Spl. Pub.* **4** : 306-453.

COUPER, R. A. & GREBE, H. (1961). A recommended terminology and descriptive method for spores. *C. R. III Rev. Comm. Internat. Microfl. Palaeoz. Krefeld*, 1961, *Rep. Gr. No.* **16** : 15.

FAEGRI, K. & IVERSON, J. (1950). *Text Book of Modern Pollen Analysis*. Munkgaard, Copenhagen.

HARRIS, W. F. (1955). A manual of the spores of New Zealand Pteridophyta. *New Zealand Dept. Sci. Industr. Res. Bull.* **116** : 186.

JANSONIUS, J. (1962). Palynology of the Permian and Triassic sediments, Peace River area, Western Canada. *Palaeontographica B*, **110** : 35-98.

KLAUS, W. (1963). Sporen aus dem südalpinen Perm. *Jb. Geol.*, **106** : 229-363.

KLAUS, W. (1977). Zur Pollen-diagnose der Röt-Kiefer (*Pinus sylvestris* L.). *Sitzungber Österr. Akad. Wiss. Mathem-Natur. Kl. Abt. I*, **186** : 125-218. Wien.

KOSANKE, R. M. (1950). Pennsylvanian spores of Illinois and their use in correlation. *Illinois State geol. Surv. Bull.*, **74** : 1-128.

POTONIÉ, R. (1970). Synopsis der Gattungen der Sporae Dispersae. V. *Beih. Geol. Jb.*, **87** : 1-222.

THOMSON, P. W. & PFLUG, H. (1963). Pollen und Sporen des mitteleuropaischen Tertiärs. *Palaeontographica, B* **94** : 1-138.

SCHEURING, B. W. (1970). Palynologische und palynostratigraphische Untersuchungen des Keupers in Bolchentunnel.—*Schweiz. Palaeontol. Abh.*, **88** : 1-119.

SCHEURING, B. W. (1978). Mikrofloren aus den Meridekalken des Mte. San Giorgio (Kanton Tessin). *Schweiz. Palaeontol. Abh.*, **100** : 1-100.

TIWARI, R. S. (1981). Protosaccate condition in Gondwana Disaccate pollen. *Geophytology*, **11**(2) : 266-267.

WILSON, L. R. (1962). Permian plant microfossils from the Flowerpot Formation, Greer County, Oklahoma. *Circ. Oklahoma geol. Surv.*, **49** : 50.

R. S. TIWARI

Birbal Sahni Institute of Palaeobotany,
Lucknow-226 007

EXPLANATION OF PLATES

PLATE 1

1. Striate disaccate (*Faunipollenites*) in low magnification showing the general pattern of striations. Scale=10μ (SEM).
2. A folded specimen of striate disaccate depicting the notches at striation ends, Scale=4 μ (SEM).
3. Enlarged portion of the specimen in Fig. 1 at saccus-body junction showing merging of striation in saccus, and the nature of sexine free grooves. Scale=10 μ (SEM).
4. Central portion of the body of the same specimen. Scale=10μ (SEM).

PLATE 2

5. Taeniae, the ridges in *Lunatisporites*—type of pollen showing the sexinal pattern on saccus and the strips. Scale=4μ (SEM).
6. A folded specimen of taeniate pollen showing small and big strip (sexine) and inter-strip area (nexine) smooth in nature. Scale=4 μ (SEM).
7. A taeniate pollen. Scale=10 μ (SEM).
8. Enlarged view of finger-shaped taeniae and the region between them. Scale=4 μ (SEM).