Possible evidence of bacterial degradation in Glossopteris flora of India

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Scanning electron microscopy of cuticles of glossopterid fructification (*Scutum*-type) recovered from the Upper Permian sequence of Jharia Coalfield demonstrates damaged cellular tissue and bacteria-like structures. Occurrence of bacteria over the marred surface of seed cuticle possessing plaque/pit suggests role of micro-organisms in biodegradation of Glossopteris flora.

Key-words—Bacterial degradation, Glossopterid fructification, Jharia Coalfield, Permian (India).

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सारांश

भारत के ग्लॉसॉप्टेरिस वनस्पतिजात में जीवाणविक ह्रास के सम्भाव्य प्रमाण

अश्विनी कुमार श्रीवास्तव एवं रजनी तिवारी

झरिया कोयला-क्षेत्र के उपरि परमी अनुक्रम से उपलब्ध ग्लॉसॉप्टेरिड फलन (**स्क्यूटम**-सदृश) की उपचर्मों के इलेक्ट्रॉन क्रमवीक्षण सूक्ष्मदर्शीय अध्ययन से क्षतिग्रस्त कोशिकीय ऊतक तथा जीवाणु-सदृश संरचनायें उपलब्ध हुई हैं। लवांग/गर्त्त से युक्त बीज उपचर्म की क्षतिग्रस्त सतह पर जीवाणुओं की उपस्थिति से ग्लॉसॉप्टेरिस वनस्पतिजात के जैविक ह्रास में सूक्ष्मजीवों की भूमिका प्रस्तावित होती है।

GLOSSOPTERIS FLORA of India is known by its mega-floral assemblages of different plant groups, however, biological testimony of biodegradation was not known until the discovery of fungal hyphae and spores alongwith degraded plant tissues, signifying the example of biological response in host organisms, i.e., leaves of *Glossopteris* and *Noeggerathiopsis* (Srivastava, 1993). Present finding of bacteria-like structure in association with damaged and degraded plant tissues having pit/plaque found during the cuticular investigation of *Scutum*-type glossopterid fructification demonstrates the role of bacteria in biodegradation of Glossopteris flora.

MATERIAL AND METHOD

Plant fossils were collected from carbonaceous shale bands of the Raniganj Formation (Upper Permian) of Bhatdih Colliery, Jharia Coalfield, Bihar. The specimens are preserved in the form of compression and the cuticular pieces were obtained by using usual Walton's transfer technique. In preparation for scanning electron microscopy (SEM), small pieces of cuticles were coated with gold palladium and viewed with a Phillips 505 Scanning Electron Microscope.

OBSERVATIONS

There are twentyfive complete detached fructification specimens in the collection. They are linear-lanceolate in shape and measure 1.2 to 2.8 cm in length and 0.4 to 1.3 cm in width. The apex is acute to acuminate and the base is flat, rounded and sometimes contracted in shape. In majority of specimens the stalk is absent but in five specimens 2 to 5 mm long and 2 mm wide stalk is present with slightly swollen attachment point. On the basis of presence or absence of border or rim, the specimens are divisible into 3 categories. The first one is represented by the absence of marginal border, the second category shows narrow, 1 mm wide marginal border all around, while the third type possesses 2 mm wide, flap-like margin showing transverse thickenings. The scars are arranged in horizontal rows, one below the other, circular, rounded in shape and measure 0.5 to 1 mm in diameter. Number of scars varies from 14 to 136 depending on the size of fructification and scar. These specimens are devoid of any associated structure, i.e., bract or scale and externally it is difficult to mark out attached seeds or ovules in the fructification. Cuticular pieces show mutilated surface

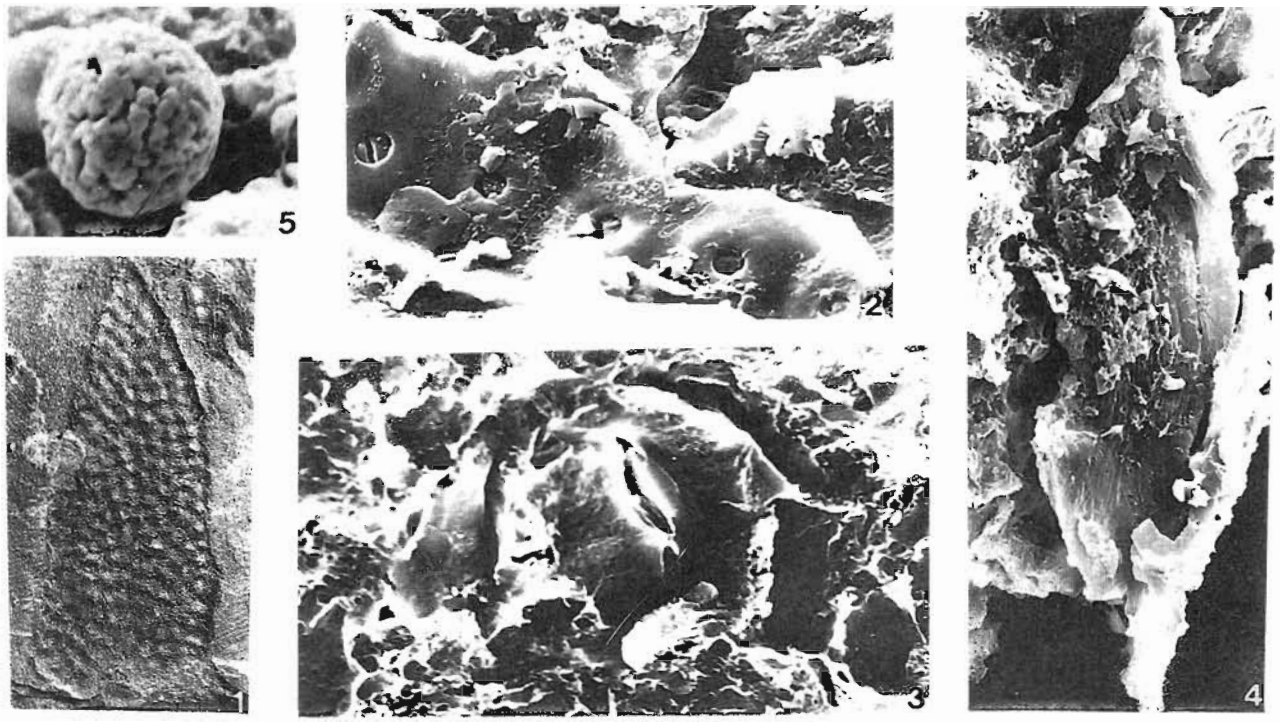

PLATE 1

1. Glossopterid fructification, *Scutum*-type, material utilised for cuticular preparation. × 2.
2. Fructification cuticle showing mutilated surface and obscure cellular tissues with circular perforations. × 2500.
3. Anomocytic stoma showing smooth surfaced subsidiary cell. × 3400.
4. Seed showing injured and impaired surface. × 1500.
5. Framboidal nature of pyrite crystals with damaged cellular tissues. × 5000.

often making difficult to demarcate their cellular details under high power microscope. Therefore, the cuticles have been subjected to scanning electron microscopic study. The study indicates highly damaged and degraded cellular tissues and characteristically distributed, circular, horizontally placed 3 to 3.5 μm in diameter perforations over the surface. Cells bordering the perforations are obscure due to damage. Rest of the cells are irregularly distributed, polygonal in shape and range in size from 21 to 31 × 14 to 27 μm, the anticlinal walls are undulate to sinuous and 1 μm thick. Cell surface is smooth, i.e., without papillae or striations. Only one stoma is observed in one of the cuticular pieces and it appears to be anomocytic (haplocheilic), 20 μm long and 18 μm wide with a pore having a size of 9.3 μm long and 1.3 μm wide. The subsidiary cells apparently lack papillae and damaged surrounding cells pose difficulty in knowing their exact nature.

Cuticular pieces often display seed-like structure (27 μm long and 8 μm wide) with profusely damaged external tissues and number of smooth surfaced, oval to pear-shaped 23 to 30 μm long and 11 to 15 μm wide objectives. These structures are comparable with ovules or represent the seed cuticle, where outer layers and other parts in most likelihood are completely lost. The surface of these ovule-like structures possesses circular to oval and rod-shaped, smooth surfaced micro-organisms. The rod-shaped structures range in size from 6 to 10 μm in length and 3 to 3.5 μm in width, whereas circular bodies are 2-4 μm in diameter. Isolated and groups of circular bodies have also been noticed in other areas of the cuticular surface. The surface of ovule possessing micro-organisms shows plaque/pit-like structures which are 2 to 6 μm in diameter with slightly thickened margins. Group of dispersed and framboidal pyrite crystals ranging in diameter from 1.5 to 8 μm are also commonly present in the samples.

DISCUSSION

Two types of glossopterid fructifications identified by Plumstead (1952, 1958) as *Scutum* with surrounding rim and *Cistella* without any rim or border-like structure are comparable with the present specimens. However, observations of the present specimens suggest that the presence or absence of rim or border is the developmental pattern or maturity stages of single multiovulate form of glossopterid fructification. The cuticular features of the specimens are comparable with the glossopterid fructifications—*Jambadostrobus*

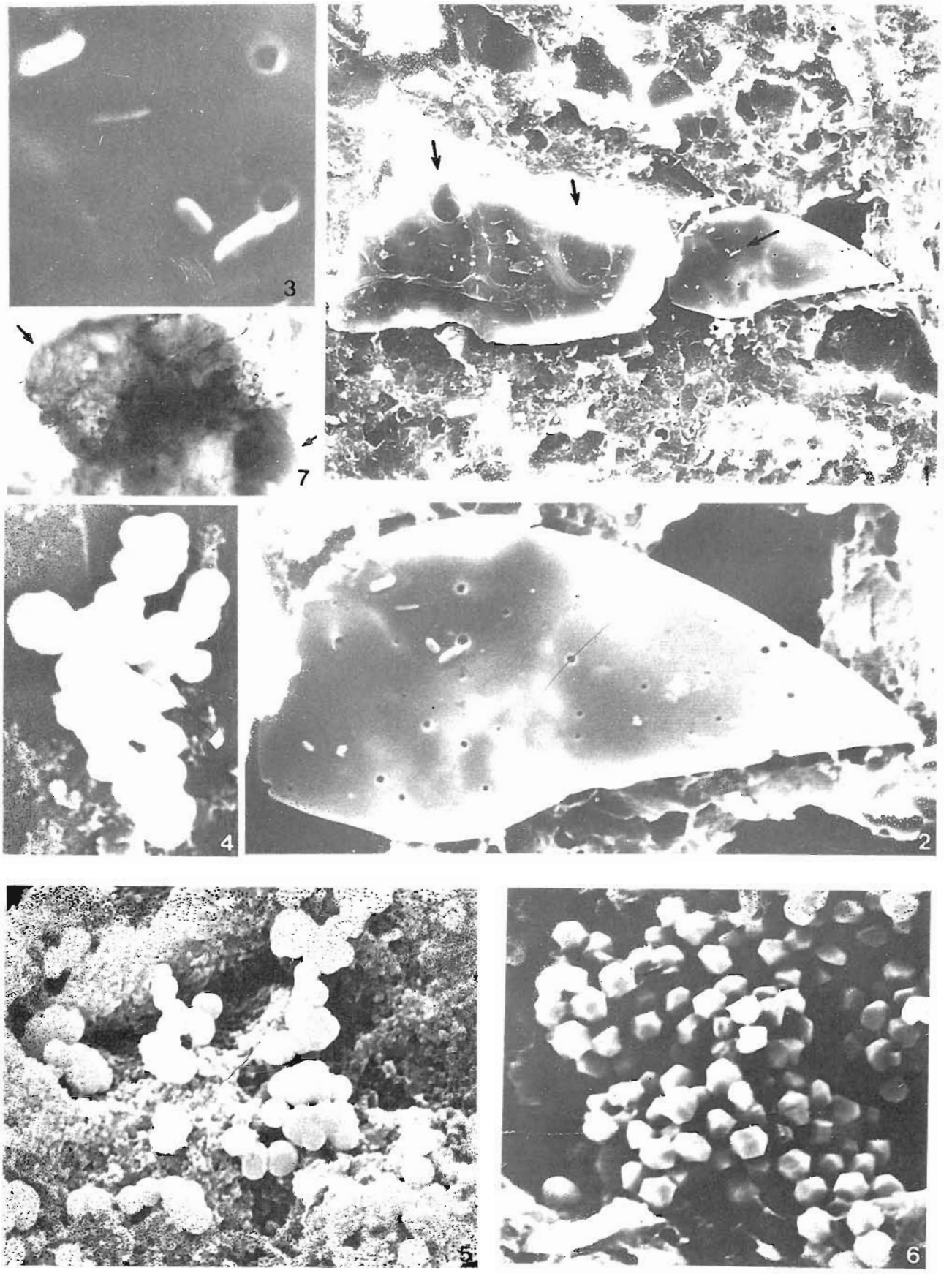

PLATE 2

and *Plumsteadiostrobus* (Chandra & Surange, 1977a,b).

Morphological evidence of bacteria-like forms is shown in micrographs (Pl. 2, figs 1-3). The structures are circular, oval and rod-shaped and show smooth surface ranging in diameter from 2-4 μm (circular) and 6 to 10 μm in length and 3 to 3.5 μm in width (rod-shaped). These structures are comparable with modern bacteria and smaller than the size of pollen, spores of fungi and vascular plants. Most of the microspheres are solitary but few are fused (Pl. 2, figs 4, 5) to form a colony. The surface of ovule/seed bearing bacteria-like structures shows distinct plaque or pit indicating the initial stage of degradation. Similar structures with fossil bacteria are also known (Venkatachala, 1984).

Group of dispersed and framboidal pyrite crystals found in association with bacteria-like bodies (Pl. 1, fig. 5; Pl. 2, fig. 6) favours the presence of anoxic environmental condition convenient for degradation.

Combined evidence of microbiological remains and distorted/damaged surface of cuticles together with pyrite crystals suggests the endemic association of bacteria with plant. Such type of association is expected only if they got preserved at an early stage of degradation, since it is not possible to get distorted or damaged pits/plaque at advance stage of degradation. Such bacterial damage of plant tissues is known in the coalified carboniferous xylem of medullosan seed fern preserved in a Northern Hemispheric coal ball where bacteria-like structures are found scattered around pit on the tracheid (Lyons, 1991).

The evidence of bacteria and fungi recorded earlier in close association with megaspores (Bajpai & Maheshwari, 1983) and glossopterid leaves (Bajpai & Maheshwari, 1988; Bajpai & Tewari, 1990) do suggest the occurrence of biodegrading agents in the Gondwana flora but the present finding of bacteria-like structures with degraded cell tissues and damaged seed/ovule cuticles for the first time demonstrates the role of micro-organisms in biodegradation of Glossopteris flora.

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PLATE 2

1 Damaged, degraded surface of cuticle showing seed/ovule-like structure. Arrows indicate pit/plaque and bacteria-like structure. × 3000.

2. A portion of figure 1, enlarged to show the nature of pit/plaque and attached bacteria-like structure. × 12000.

3. Further enlargement of figure 2 to show the details of pit/plaque and rod-shaped bacteria-like structure. × 30000.

4, 5. Isolated and groups of circular-shaped bacteria-like structure. × 40000.

6. A group of dispersed pyrite crystals. × 9000.

7. Optical photograph under transmitted light showing synsedimentary preservation, arrows point out spheroidal cells of bacteria on article. × 2000.