

Fossil woods resembling *Sonneratia* with fungal infection from Deccan Intertrappean sediments of Seoni District, Madhya Pradesh

Rashmi Srivastava

Birbal Sahni Institute of Palaeobotany, Lucknow-226 007, India

E-mail: rashmi_bsip@yahoo.com

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Fossil woods resembling *Sonneratia* infected with endogenous fungus are described from Deccan Intertrappean sediments of Ghansor, Seoni District, Madhya Pradesh. This forms the first record of dicotyledonous wood as well as fungus from this locality. Prior to this, a few palm remains were reported by Sahni (1943) and Guleria and Mehrotra (1999). Occurrence of fungus infected *Sonneratia* in the Deccan Intertrappean sediments indicates the existence of littoral swamps with warm and humid conditions in the area during Maestrichtian - Danian times.

Key-words— *Sonneratia*, Fossil wood, Fungal infection, Deccan Intertrappean beds, Seoni District, Madhya Pradesh.

INTRODUCTION

ALTHOUGH a large number of dicotyledonous fossil woods are known from various Deccan Intertrappean beds of Central India, but reports of fungal infected fossil woods are relatively infrequent. The material for the present study was collected from Ghansor (22° 40' 40" N: Lat. 80° 1' 30" E) in Binori Reserve Forest, Seoni District, Madhya Pradesh. So far, only palm remains (petrified stems and leaf impressions) were reported, namely, *Palmoxylon sclerodermum* (Sahni, 1943), *P. binoriensis*, *P. canalium*, *P. vaginatum*, *P. lunarianum*, *Phoenicites lakhanpalii* and *Amesoneuron deccanensis* (Guleria & Mehrotra, 1999).

The occurrence of sonneratiaceous wood infected with fungus forms the first report of a dicotyledonous wood from this locality. Fossil records of fungi are meager because palaeobotanists are usually interested in well preserved material rather than decayed or degraded specimens, although fungi are the major decomposers of higher plants in the present day ecosystems and were also important in the geologic past. However, during the last one and half decade, interest in palaeomycology has increased in order to understand interactions between host and parasite in time and space. Evidence of wood decay are known as early as Upper Devonian and the nature of infection in the fossil woods are almost similar to those found today (Stubblefield *et al.*, 1985; Stubblefield & Taylor, 1988).

SYSTEMATIC DESCRIPTION

Family - Sonneratiaceae

Genus - *Sonneratioxylon* Hofmann, 1952

Sonneratioxylon preapetalum Awasthi, 1969

(Pl. 1, Figs 1-10; Pl. 2, Figs 1-11)

Material-The description is based on five small permineralised twigs measuring 2-2.5 cm in diameter and 7-8.5 cm in length. Each specimen has well preserved pith and few strands of primary xylem. Amongst them, three of the specimens were found infected with fungus showing mycelium and decayed patches in infected woods.

Description - Wood diffuse porous. *Cortex* preserved at places, multilayered, cell radially elongated. *Growth rings* present, demarcated by denser fibrous tissue (Pl. 1, Figs 1-4). *Vessels* small to medium (mostly small), medium towards periphery and becoming smaller towards pith; tangential diameter 27.5-110 µm, radial diameter 30-165 µm, solitary and in radial multiples of 2-3 (rarely up to 6), circular to oval when solitary, those in radial multiples are flattened at the place of contact; open or filled with black deposits and a few tylosed (Pl. 1, fig. 4); vessel members 210-375 µm, long with truncate or oblique end walls; perforations simple; intervessel pits alternate, hexagonal, vestured, 6-7.25 µm, in diameter (Pl. 1, Fig. 5). *Parenchyma* absent. *Rays* fine, uniseriate, rarely bicelled due to pairing of cells (Pl. 1, Fig. 8), homocellular to weakly heterocellular, made up of procumbent cells with interspersed upright or square cells; 10-25 cells or 220-700 µm long (Pl. 1, Fig. 9); ray cells crystalliferous, large solitary crystal found in square cells; procumbent cells 50-77 µm in radial height and 27.5-38.5 µm in tangential length; upright or square cells 38-42 µm in tangential height and 27-5-40 µm in radial length. Fungal hyphae traverse along ray cells; vessel-ray pits not observed (Pl. 1, Fig. 9). *Fibres* aligned in radial rows between two consecutive rays; septate, septa rarely seen, 14-20 µm in

diameter (Pl. 1, Figs 4, 8). *Pith* quadrangular (Pl. 1, Figs 1-3), made up of outer 2-4 cells thick sclerenchymatous layer and inner parenchymatous tissue, few cells have some kind of deposits, feebly pitted (Pl. 2, Figs 1-2), collumelate, distinctly lacuner, multilayered, peripheral cell radially elongated, about 25 cells thick, few cells have spiral thickening (Pl. 1, Fig. 10), longitudinal columns can be seen in tangential longitudinal sections which are made up of longitudinally elongated cells, broader towards periphery and gradually tapering towards center forming tubular structures (Pl. 1, Figs 6-7, 10), few sclereids seems to be present intrusively in aerenchyma. The interconnection between neighboring tubes was made by small pores or canals (Pl. 1, Fig. 7). These aerenchymatous spaces are important for plants that grow in flooded and anaerobic habitat like mangrove, because these air spaces provide an internal pathway for oxygen transport. few protoxylem strands towards pith having spiral thickening are also present.

Fungal Infection - Three of the specimens show decayed patches of different shapes and sizes and are irregularly distributed as seen in cross section, often tangentially elongated (Pl. 1, Figs 1-3). Fungal infection mainly occur in the secondary xylem where the hyphae profusely invade wood fibres, vessel segments and ray cells. (Pl. 1, Fig. 9, Pl. 2, Figs 3-8, 10, 11). However, the ray cells seems to be the major area of infection (Pl. 1, Fig. 9, Pl. 2, Figs 3, 5, 10, 11). At some places entire ray cells are occluded by hyphae. The hyphae ranges from 25-35 μm in diameter; septate, and branched (Pl. 2, Figs. 3-8). Both intercalary and single terminal swellings occur (Pl. 2, Figs 5, 7-8, 11). Typically such swellings branch at several points (Pl. 2, Figs 5, 7-8, 11). The pattern of decay is characterized by the progressive thinning and ultimate destruction of primary and secondary walls (Pl. 2, Figs 3-8, 10, 11). The fungal spores seen at places, They are laevigate in nature, round, 40-50 μm in diameter (Pl. 2, Figs 3, 5, 7-9).

Figured Specimens - BSIP Museum Nos. 39323, 39324.

Locality - Binori Reserve Forest, Ghansor, Seoni District, Madhya Pradesh.

Horizon - Deccan Intertrappean sediments.

Age - Maastrichtian-Danian.

Repository - Museum, Birbal Sahni Institute of Palaeobotany.

DISCUSSION

The combination of characters of fossil wood, viz., diffuse porous, small to medium sized vessels, vestured intervessel pits, absence of parenchyma, uniseriate rays and septate fibres are diagnostic of the family Sonneratiaceae (Metcalfe and Chalk, 1950; Pearson and Brown, 1932; Rao *et al.*, 1987a, 1987b). A number of fossil woods comparable to *Sonneratia* are reported from different Deccan Intertrappean exposures (Verma, 1950; Shallom, 1963; Rao & Ramanujam, 1966; Biradar & Mahabale, 1975; Shete & Kulkarni, 1982; Bande & Prakash, 1984; Mehrotra, 1989). Shallom (1963) reported fossil roots of *Sonneratia*. Sonneratious woods are also frequent in other Tertiary exposures of India (Ramanujam, 1957; Awasthi, 1969; Lakhanpal *et al.*, 1984; Guleria, 1991). Besides, the genus is reported from Europe, Africa, South-East Asia and Japan (Hofmann, 1952; Louvet, 1970; Kramer, 1974; Vozenin-Serra *et al.*, 1989; Srivastava & Suzuki, 2001).

Although a number of fossil woods of *Sonneratia* are reported from different Tertiary horizons of the world, but none of the wood is reported with cortex, pith and fungal remains so far. There are many lignicolous fungi of Deuteromycetes which occur on moist woods of various trees and shrubs. Fungal parasitism and saprophytism in fruit, seeds and woods, as well as dispersed fungal spores from Deccan Intertrappean beds have been reported by many workers (Chitaley, 1950a, 1950b, 1957; Chitaley & Patil, 1970; 1972; Chitaley & Sheikh, 1971; Chitaley & Yawale, 1978; Barlinge & Paradkar, 1982; Lakhanpal *et al.*, 1967; Patil & Singh, 1974; Singhai, 1972, 1974, 1978; Kalgutkar *et al.*, 1993).

On the basis of septate, branched mycellium and terminal and intercalary swellings or chlamydospores, it is difficult to identify the fungus up to generic level. However, it may be regarded as a member of either Basidiomycetes or Deuteromycetes. However, in the absence of clamp connections and fruiting bodies (basidiocarps and chlamydospores) it is not possible to differentiate between the two.

Occurrence of *Sonneratia* in other Deccan Intertrappean sediments along with *Cocos*, *Nypa*, *Barringtonia* and *Acrostichum* etc. indicate littoral swamps were present in central India at the time of their deposition. Lately Keller *et al*

PLATE - 1

1. Cross section of a twig showing cortex, secondary xylem, quadrangular pith and decay patches due to fungal infection. x 10. BSIP Museum no. 39323-I.
2. Another Cross section of a twig from basal portion showing emergence of rootlet. x 10. BSIP Museum no. 39324-I.
3. Cross section showing cortex, secondary xylem, quadrangular pith and decay patches. x 10. BSIP Museum no. 39324-I.
4. Cross section magnified showing distribution of vessels and uniseriate xylem rays. x 40. BSIP Museum no. 39323-I.
5. Vestured intervessel pits. x 1000. BSIP Museum no. 39323-III.
6. Fig. 7 magnified showing cellular details of longitudinal columns. x100. BSIP Museum no. 39323-II.
7. Tangential longitudinal section through pith portion showing longitudinal columns and gas spaces. x40.
8. Tangential longitudinal section showing uniseriate rays and septate fibres. x100. BSIP Museum no. 39323-III.
9. Radial longitudinal section showing procumbent and square cells with profuse penetration of fungal hyphae. X100. BSIP Museum no. 39323-II.
10. Enlargement of fig. 7 at peripheral portion showing cellular details. x 400. BSIP Museum no. 39323-II.

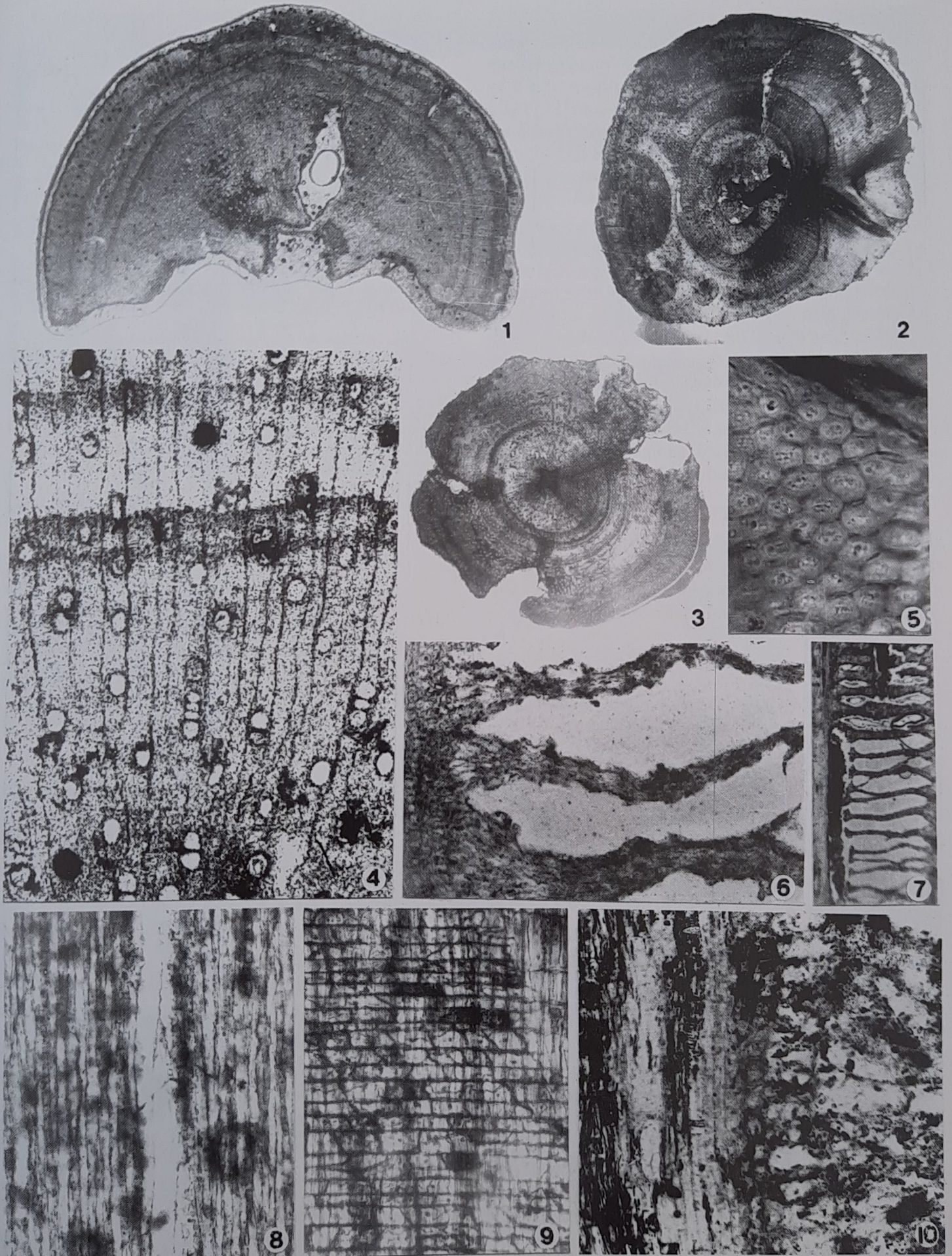


PLATE-1

(2009) have provided evidence about the extension of sea/arm of sea up to central India during Deccan Intertreppan time based on planktonic foraminifera recorded from Chhindwara District of Madhya Pradesh. This was already stated by Lakhanpal (1970), Bande *et al.* (1981); Guleria and Srivastava (2005) based on plants remains. Keller *et al.*, further confirmed that the age of Deccan Intertrappeans ranges up to Danian which has also been stated by Guleria and Srivastava (2001, p. 19; 2005, p. 175).

Distribution-The genus *Sonneratia* Linn. is represented by six species distributed in mangroves of Indian and Pacific Oceans (Mabberley, 1997, p.671) along the coasts of India, East Africa, Madagascar, Hawaiian, Ryukyu Island (Japan), Micronesia, New Hebrides, Solomon Islands and tropical regions of Australia (Willis, 1973, p.1078). Three species, namely, *S. alba* J. Smith, *S. apetala* Buch-Ham. and *S. caseolaris* (Linn.) Engler are found in India in tidal creeks and littoral forests of Sundarbans and along coastal forests of Andhra Pradesh, Karnataka, Maharashtra, Orissa and Andamans extending westwards to Indus delta (Pearson & Brown, 1932 p. 601; Purkayastha, 1982, p. 40-41).

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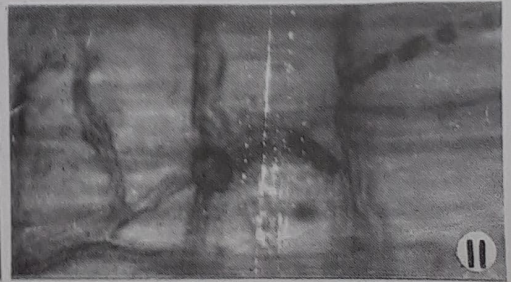
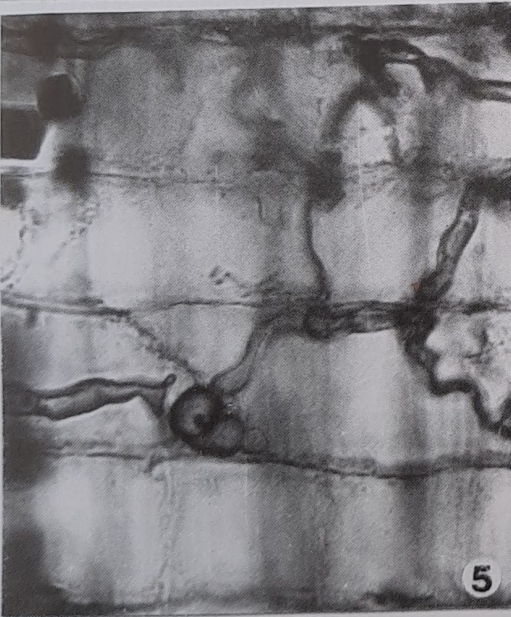
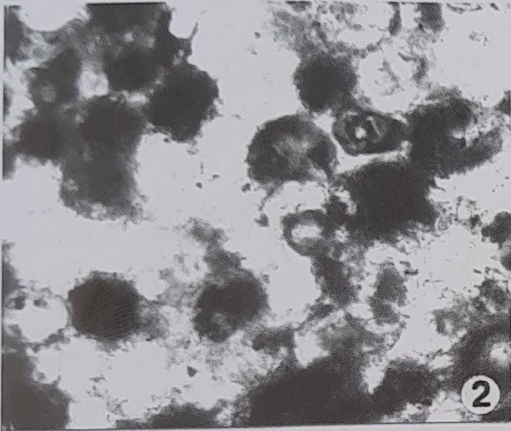
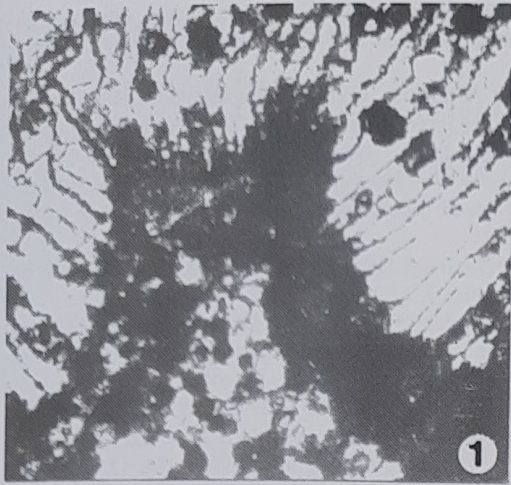
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PLATE-2

1. Cross section showing quadrangular pith with sclerenchymatous 2-4 celled outer layer and parenchymatous central portion. x 40. BSIP Museum no. 39324-I.
2. Enlarged parenchymatous pitted pith cells with some deposits (probably tannin). x 100. BSIP Museum no. 39324-I.
3. Radial longitudinal section showing decomposed ray cells and hyphae. x 400. BSIP Museum no. 39323-II.
4. Tangential longitudinal section showing fungal hyphae penetrating vessel segment. x 200. BSIP Museum no. 39323-IV.
5. Another Radial longitudinal section showing ray cells invaded with hyphae with terminal swellings. x 400. BSIP Museum no. 39324-II.
6. Fig. 4 enlarged showing fungal hyphae penetrating vessel segment through perforation plate. x 400. BSIP Museum no. 39323-IV.
- 7,8. Radial longitudinal sections showing septate hyphae with terminal and intercalary swellings forming spores. x 400. BSIP Museum no. 39323-III.
9. SEM photograph of a spore. x 400. BSIP Museum no. 39323-IV.
10. Radial longitudinal section showing decomposed walls of ray cells. x 400. BSIP Museum no. 39324-I.



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