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A Petrified Pteridophytic Petiole from the Deccan Intertrappean Beds of Wardha, Maharashtra, India

Darshana S. Dhamdar

Abstract

A petrified pteridophytic petiole was collected from the Deccan Intertrappean Beds near Samruddhi Mahamarg, Wardha District, Maharashtra, India. The fossil petiole is circular to oval in outline and shows a single-layered epidermis, three distinct cortical zones, and a protostelic vascular system. The outer cortex is parenchymatous, the middle cortex is sclerenchymatous, and the inner cortex is aerenchymatous with well-developed air chambers separated by septa, indicating hydrophytic adaptation. The stele consists of endodermis, pericycle, protoxylem and metaxylem, while phloem is poorly preserved. Comparative studies with previously reported fossil and living pteridophytes reveal affinities with members of Filicales, particularly Marsileaceae. The anatomical features provide useful information on the structure and palaeoecological significance of pteridophytic vegetation during the Deccan Intertrappean period.

Keywords: *Petrified petiole, Pteridophyte, Deccan Intertrappean Beds, Wardha, Aerenchyma, Protostele, Filicales, Marsileaceae, Hydrophytic adaptation.*

Introduction

The Deccan Intertrappean Beds of India are well known for their rich and diverse fossil flora, including pteridophytes, gymnosperms and angiosperms. Pteridophytic remains such as stems, rhizomes and petioles provide valuable information about the anatomy, diversity and palaeoecology of ancient vegetation.

Petrified pteridophytic petioles are comparatively rare in the Deccan Intertrappean flora. The present study describes a petrified pteridophytic petiole collected from near Samruddhi Mahamarg, Wardha District, Maharashtra. The specimen shows a single-layered epidermis, three distinct cortical zones, well-developed aerenchyma and a protostelic vascular system. Comparative anatomical studies with fossil and living pteridophytes indicate affinities with members of Filicales, particularly Marsileaceae. The present study adds to the knowledge of pteridophytic diversity and palaeoecology of the Deccan Intertrappean flora.

Material and Method

The fossil material was collected from the Deccan Intertrappean Beds near Samruddhi Mahamarg, Wardha District, Maharashtra, India (Lat. 20.834285° N; Long. 78.816127° E). The petrified petiole was preserved in fossiliferous chert and was exposed transversely. Anatomical details were studied from the exposed surface and its counterpart using the peel technique. The chertwas etched with Hydrofluoric acid (HF) following Darrah (1936), and serial peels were prepared to study the internal anatomical features. The peels were examined under a compound microscope, and measurements of the anatomical structures were recorded.

Description:

Petiole Morphology

This section deals with the study of a petiole of pteridophyta. The present fossil was exposed transversely on chert. The petiole is pteridophytic, circular in outline and oval in shape measures in 3.85 mm in length and 2.31 mm in width (Plate Fig. 1, 3 and Text Fig. 1, 2). Epidermis is single layered. The cortex is differentiated into three parts i.c. outer, middle and inner cortex. The outer cortex is parenchymatous in nature, middle is sclerenchymatous and inner cortex is made up of aerenchyma consisting air chamber. The stele consists of endodermis, pericycle and vascular tissues.

Anatomically, the Petiole Shows the Following Structures

Epidermis

A well-preserved epidermis is present. Epidermis is single layered, made up of compactly arranged parenchymatous cells. The cells are elongated and oblong, measuring 3.7 µm in thickness (Plate Fig. 1, 3 and Text Fig. 1-8).

Cortex

The cortex is differentiated into three layers i.e. outer, middle and inner cortex.

Outer cortexis thin walledparenchymatous in nature, measuring about 19.9 µm in size (Plate Fig. 2, 3; Text Fig. 3). Each cell is about 6.9 µm in size.

Next to outer cortex, middle cortex is present. Middle cortex is sclerenchymatous and 3–5 layered in thickness, measuring about 5.9µm in size (Plate Fig. 1 and Text Fig. 1).

Third layer is inner cortex, which is made up of aerenchyma consisting of air chambers. Each air chamber is separated by a single-layered septum. The inner cortex is the broadest zone, measuring about 47.6 µm in thickness (Plate 1 Fig. 3 and Text Fig. 5).

Stele

The stele is protostelic and consists of endodermis, pericycle and vascular tissues, measuring about 58.1 µm in length and 38.3 µm in width.

Endodermis is single layered, well developed and measures about 3.3 µm in thickness. The pericycle is also single layered.

Very few xylem elements are seen. The vascular tissue consists of protoxylem and metaxylemtracheids. Each protoxylem element is about 8.6 µm in thickness, while each metaxylem element is about 10.2 µm in thickness.

Phloem is not well preserved.

Discussion and Identification

The important diagnostic characters of the petiole, based on the study of both the part and counterpart of the specimen, are as follows:

- The petiole is pteridophytic, circular in outline and oval in shape.
- Epidermis is single layered.
- The outer cortex is parenchymatous in nature, middle cortex is sclerenchymatous and inner cortex is made up of aerenchyma showing air chambers.
- The stele is protostelic, consisting of a single-layered endodermis, pericycle and vascular tissues.
- The vascular tissue is composed of protoxylem and metaxylemtracheids, while phloem is poorly preserved.
- The well-developed aerenchymatous cortex indicates hydrophytic adaptation.
- From the above-mentioned anatomical details, the present specimen shows hydrophytic characters of a pteridophytic petiole. Hence, it is compared with earlier reported fossil pteridophytic petioles from the same locality for its identification.

The earlier described fossil pteridophytic petioles from the Deccan Intertrappean Beds of India differ from the present petiole in a few characters.

It is compared with fossil rhizomes, petioles and pteridophytic axes.

Result and Discussion

Comparison with Previously Reported Fossil Pteridophytes

When ***Marsileaintertrappea*** (Upadhye and Patil, 1977), is compared with the present fossil specimen, it shows similarity in the presence of endodermis and pericycle, but differs in having a cortex made up of only outer and inner cortex, and a V-shaped vasculature.

When ***Rodeitespolycarpa*** (Chitaley and Paradkar, 1971), is compared with the present fossil specimen, it shows similarity in having a multilayered outer cortex, but differs in possessing a shallower groove in the petiole and an aerenchymatous middle cortex.

Selaginellachitaleyii (Kapgate, 1998), is compared with the present fossil specimen, it differs in being a heterosporousligulate strobilus, whereas the present fossil specimen represents a petiole.

Comparison with ***Rodeitesdeccanii*** (Bobade, 2005), the present fossil specimen are similar in having a multilayered outer cortex, and the presence of endodermis and pericycle, but differ in not having a middle cortex with aerenchyma, and in possessing a horseshoe-shaped vasculature.

Comparison with ***Pterdoixylonmohgaonii*** (Pundkar, 2014), the present fossil specimen are similar in having a three-layered cortex, but differ in the absence of aerenchyma in the cortex.

Comparison with ***Psilatoxylontrapii*** (Dighe, 2017), shows the presence of a cortex region, vascular cylinder, single-layered endodermis and pericycle, but differs from the present specimen in which the cortex is differentiated into three distinct regions.

Pterostachysmahabalei(Deshmukh, 2019), is compared with the present fossil specimen, it shows similarities in having epidermis, cortex and endodermis, but differs in not possessing a three-layered cortex.

Camparison with ***Fillicophyllitesdeccanensis*** (Thorat 2021), it shows the maximum resemblances but it is different in size and measurement.

Comparison with Living Taxa

The present petiole shows similarities with Class Filicopsida and is therefore compared with the modern families Marsileaceae, Salviniaceae and Azollaceae.

As the present fossil specimen possesses a weakly developed vasculature in the petiole, it is compared only with living genera of Pteridophytes. Anatomically, the specimen shows characters that mainly resemble members of the Order Filicales. Therefore, it is compared with the families Salviniaceae, Azollaceae and Marsileaceae.

Salviniaceae

It resembles the present specimen in having a single-layered epidermis, lacunate cortex and protostelic condition, but differs in lacking a well-developed aerenchymatous cortex with partition walls.

Azollaceae

It resembles the present specimen in possessing a protostelic condition, but differs in having a non-lacunate and compact parenchymatous cortex, whereas the present specimen shows a prominent lacunate cortex.

Marsileaceae

It resembles the present specimen in having a single-layered epidermis, parenchymatous outer cortex and lacunate inner cortex, but differs in not possessing a C-shaped xylem.

From the above features, it is confirmed that the present fossil specimen represents a pteridophytic petiole with an aerenchymatous cortex and a protostelic vascular bundle.

The petiole shows various degrees of resemblance to certain families of the Order Filicales, but does not resemble any particular genus completely. Hence, it is placed under the Family Marsileaceae of Filicales and is named *Fillicophyllites**wardhaii* gen. et sp. nov. The generic name after the order Filicales to which it shows greater affinities and specific name after the locality from where it is collected.

Diagnosis

Fillicophyllitesgen.nov.

Pteridophytic petiole, circular in outline and oval in shape. Epidermis single layered. Cortex differentiated into three parts, i.e. outer, middle and inner cortex. Outer cortex parenchymatous in nature, middle cortex sclerenchymatous and inner cortex made up of aerenchyma consisting of air chambers. Stele protostelic, consisting of endodermis, pericycle and vascular tissues. Endodermis single layered and well developed. Pericycle also single layered. Very few xylem elements present. Vascular tissue consists of protoxylem and metaxylemtracheids, while phloem is not well preserved.

Fillicophyllites**wardhaiigen.et.sp.nov**.**

The petiole is pteridophytic, circular in outline and oval in shape, measuring about 3.85 mm in length and 2.31 mm in width. Epidermis single layered. Cortex differentiated into three parts, i.e. outer, middle and inner cortex. Outer cortex parenchymatous in nature, measuring about 19.9 µm. Middle cortex sclerenchymatous, measuring about 6.9µm. Inner cortex made up of aerenchyma consisting of air chambers, measuring about 53.6 µm. Stele protostelic. Endodermis and pericycle single layered. Very few xylem elements present. Vascular tissue consists of protoxylem measuring about 8.6 µm in thickness and metaxylem measuring about 10.2 µm in thickness. Phloem is not well preserved.

Holotype **:** DSD/Petiole 1 / Deposited in the Department of Botany, RTMNU, Nagpur.
Horizon **:** Deccan Intertrappean series of Central India.
Locality **:** Wardha,M.H ., India.
Age **:** Upper Cretaceous?

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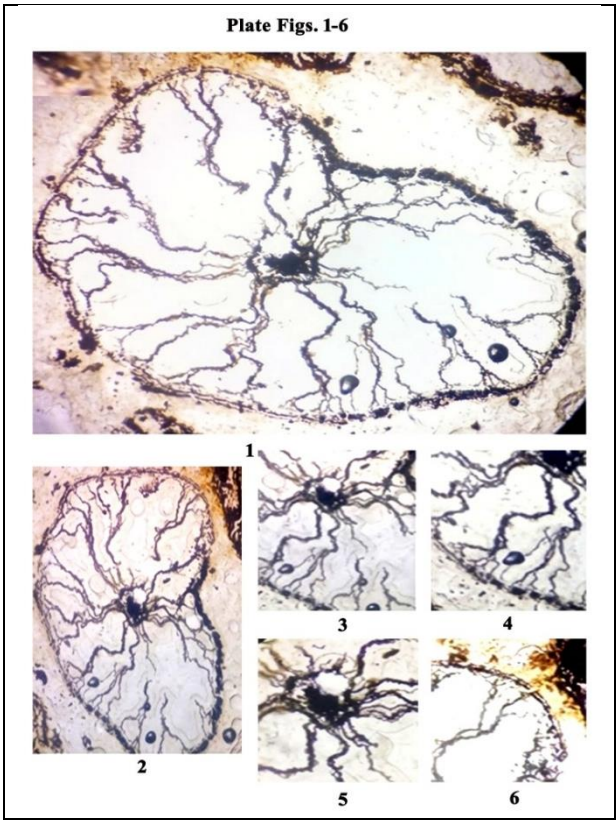
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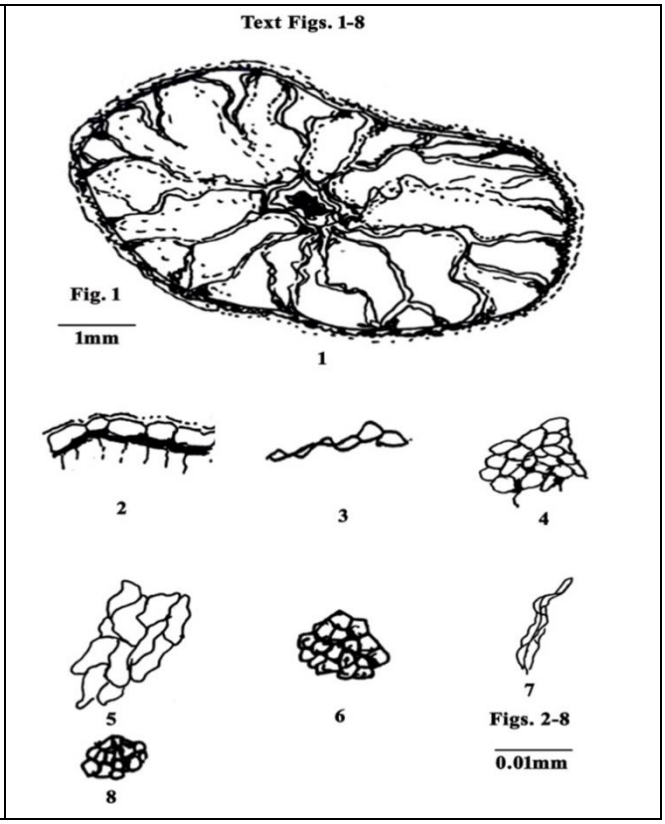
Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of thesis paper.

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Explanation Of Plate 1 Figs. 1-6	**Explanation Of Text Figs 1-8**
Fig. 1: Complete structure of T. S. petiole of pteridophyte oval in shape.(100X); **Fig. 2:**Shows air chamber(100X); **Fig. 3:**Enlarged view of cortex with Stele (450X);**Fig. 4:**Cortex (450X); **Fig. 5:**Stelar region(450X); **Fig. 6:**Air cavity (1000X).	**Figs. 1-8:** Serial section petioleis pteridophytic showing cellular details; **Fig. 1:**Complete Structure of petiole;**Fig. 2:**Epidermis;**Fig. 3:**Parenchymatous cells of epidermis;**Fig. 4:**Parenchymatous cells of cortical region;**Fig. 5:**Loosely arrange parenchymatous cells;**Fig. 6:**Central stellar region cells;**Fig. 7:**Thin layer of hypodermal cells;**Fig. 8:**Compactly arrange sclerenchymatous cells.