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# Reinvestigation of *Dicotylirhizos sahnii* Rao from Deccan Intertrappean beds of Mohgaonkalan, Madhya Pradesh, India

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## ABSTRACT

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The present paper describes anatomical structure in young and advanced secondary growth in matured dicotyledonous roots of 23 fossil specimens. These specimens were collected from black chert of Deccan Intertrappean exposures of Mohgaonkalan, Madhya Pradesh, India. The young roots show unilayered epiblema with root hairs, parenchymatous cortex and pentarch stele with exarch xylem. Some specimens show advanced stelar secondary growth with diffused porous wood. The extrastelar secondary growth remains absent as there is no periderm formation. The present specimens with advanced secondary growth closely resemble *Dicotylirhizos sahnii* Rao (1958) in many anatomical details. However, *Dicotylirhizos sahnii* described by Rao (1958) does not show the primary structure and series of developmental stages leading to advanced secondary growth.

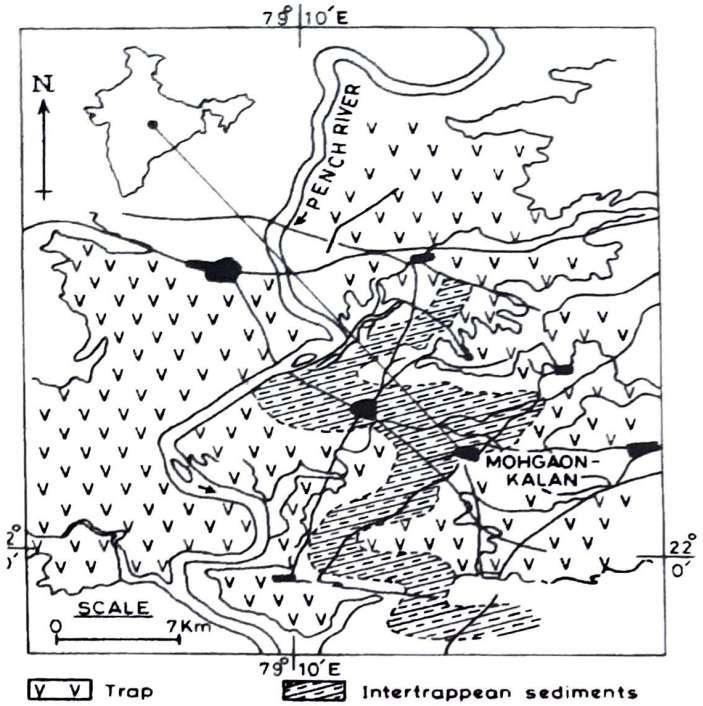
**Key-words:** *Dicotylirhizos sahnii* Rao, dicotyledonous root, anatomy, primary structure, Deccan Intertrappean Beds, Mohgaonkalan, Madhya Pradesh, India.

## INTRODUCTION

Fossil angiosperm stems are commonly found in Deccan Intertrappean beds of Mohgaonkalan. However, so far only two dicotyledonous roots are reported. These are *Dicotylirhizos sahnii* Rao (1958) and *Sonneratiorhizos raoi* Chitaley (1969). The chert from Mohgaonkalan exposed many specimens of *Dicotylirhizos* in various stages of development. These are young roots with root hairs and old roots with secondary growth. Many of them are in organic connection and show exarch xylem. For the first time, such study of various stages of root has been made.

## MATERIAL AND METHODS

All the specimens are exposed in different planes in one and the same chert collected from Deccan Intertrappean beds of Mohgaonkalan, Chhindwara District, Madhya Pradesh (Map 1). Some are seen in organic connection. For the purpose of study, the chert was cut in different planes exposing the young and old specimens. All the stages of root are studied by taking peel sections. The material (MOH/EVU/7) is stored at the Department of Botany, Institute of Science, Nagpur.



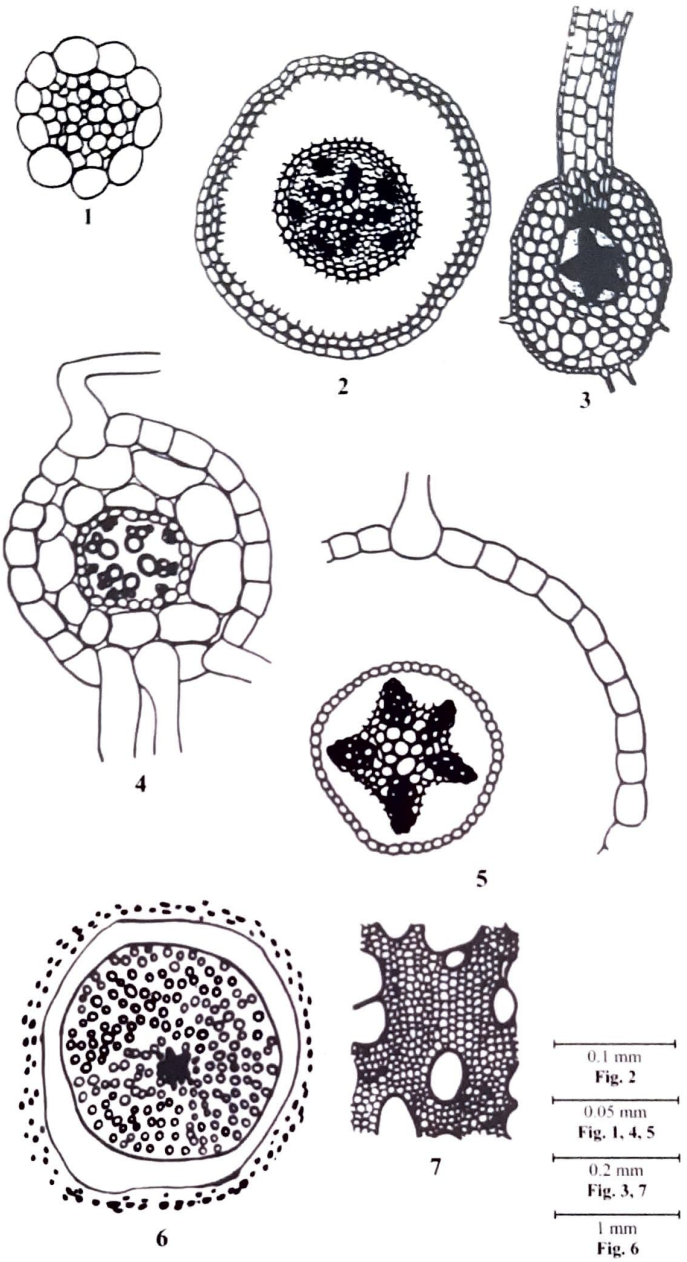

**Map 1.** Map showing location of Mohgaonkalan, Chhindwara District, Madhya Pradesh, from where the material for the present study was collected.

## DESCRIPTION

Twenty-three root specimens belonging to different stages of development are studied. These specimens measure 55-3300 μm in diameter. For the purpose of study, observations were made in four stages. These are: (1) young roots with root hairs, (2) roots in which cambium is differentiated, (3) activity of cambium because of which secondary growth has started, and (4) secondary growth of pronounced nature because of which soft tissue is crushed and five groups of fibres are spread up to form regular ring. Epiblema is detached and became irregular but shows no breaking.

Thirteen specimens are observed which are young and measure 55-260 μm in diameter. The young specimen in cross section shows epiblema, cortex and stele (Plate 1, figure 4, Text-figures 1-4). The epiblema is unilayered and the cells are thin walled parenchymatous, spherical or barrel shaped. Some of the cells, in many specimens, are prolonged into unicellular root hairs (Plate 1, figure 2, Text-figures 4-5). These root hairs are very well preserved. Cortex is parenchymatous. The endodermis is single layered; cells are compactly arranged with thickening on their tangential and radial walls. The stele is pentarch (Plate 1, figure 3, Text-figures 2, 4-5). The outermost layer of stele is pericycle. The pericycle is single layered and the cells in this stage of development are parenchymatous. In young specimens, there is lateral growth of branch from the pericycle (Plate 2, figure 4, Text-figure 3). The internal structure of lateral root in transverse and longitudinal sections shows similar structure to those of specimens of same size (Plate 1, figure 3, Plate 2, figures 1, 4, 6). The vascular bundles of the stele are five in number. Each vascular bundle is radial and with exarch xylem (Text-figures 2, 4). Xylem and phloem of vascular bundles alternate to each other. Xylem consists of protoxylem and metaxylem elements. The protoxylem elements measure 3-6 μm in diameter and metaxylem elements measure 8.5-11 μm in diameter. The protoxylem elements show spiral thickening and metaxylem elements show spiral and pitted thickenings. Associated with xylem and phloem are parenchymatous cells of conjunctive tissue. Phloem preservation is not perfect. Pith in the centre is very small.

The second stage of development includes the differentiation of cambium which started producing secondary vascular tissues (Plate 1, figures 5-6, Plate 2, figures 1-2, 5). Five specimens are studied in which cambium is well developed. These specimens measure 330 μm; 555 μm; 615 μm; 780 μm and 1000 μm in diameter. In the first four specimens, due to the activity of stelar cambium, secondary xylem is formed more as compared to that of secondary phloem. Outside the cambium ring are five groups of sclerenchyma fibres which belong to pericycle. These fibre groups started separating from each other. Associated with these are the cells of phloem which are poorly preserved therefore these fibres may be called hard bast (Plate 2, figure 2). Newly formed secondary xylem shows the primary medullary rays against protoxylem groups and secondary medullary rays remain radially arranged with secondary vessels,




**Text-figures 1-7.** *Dicotylirhizos sahnii* Rao. 1. T.S. of young root. 2. T.S. of root showing stele and outer part of cortex. 3. T.S. of root showing origin of lateral root. 4. T.S. of root with root hairs. 5. T.S. of root showing pentarch stele and root hair. 6. T.S. of old root with secondary xylem and cortex. 7. T.S. of wood showing vessels, parenchyma and fibres (dark).

fibres and parenchyma. Pith is reducing in size gradually. The cortex is well marked but entire region does not show good preservation of tissue. The epiblema is single layered, at places it shows root hairs. The epiblema has become irregular in shape but is not ruptured (Plate 2, figure 2).

The last stage of observation includes specimens which show advanced growth. These specimens are four in number and measure 1.3 mm, 2.4 mm, 2.5 mm and 3.3 mm in diameter. The secondary growth in these specimens is limited to stelar region (Plate 2, figure 3, Plate 3, figure 2, Text-figure 6) and there is no extra-stelar secondary growth. In older specimens, epiblema, cortex with sclerenchymatous fibres, cambium, secondary xylem, primary xylem and pith are seen (Plate 2, figure 3). The secondary xylem or wood is major constituent and consists of xylem vessels,

1

2

3

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6

**Plate 1**

1-6. *Dicotylirhizos sahnii* Rao. 1. Young roots in T.S. x 140. 2. T.S. young root showing root hair, cortex and stele x 320. 3. T.S. young root showing lateral branch x 115. 4. Young root showing epiblema and stele in T.S. x 125. 5. T.S. root showing beginning of stelar secondary growth and pericycle x 135. 6. T.S. root showing stelar secondary growth and pericycle x 100.

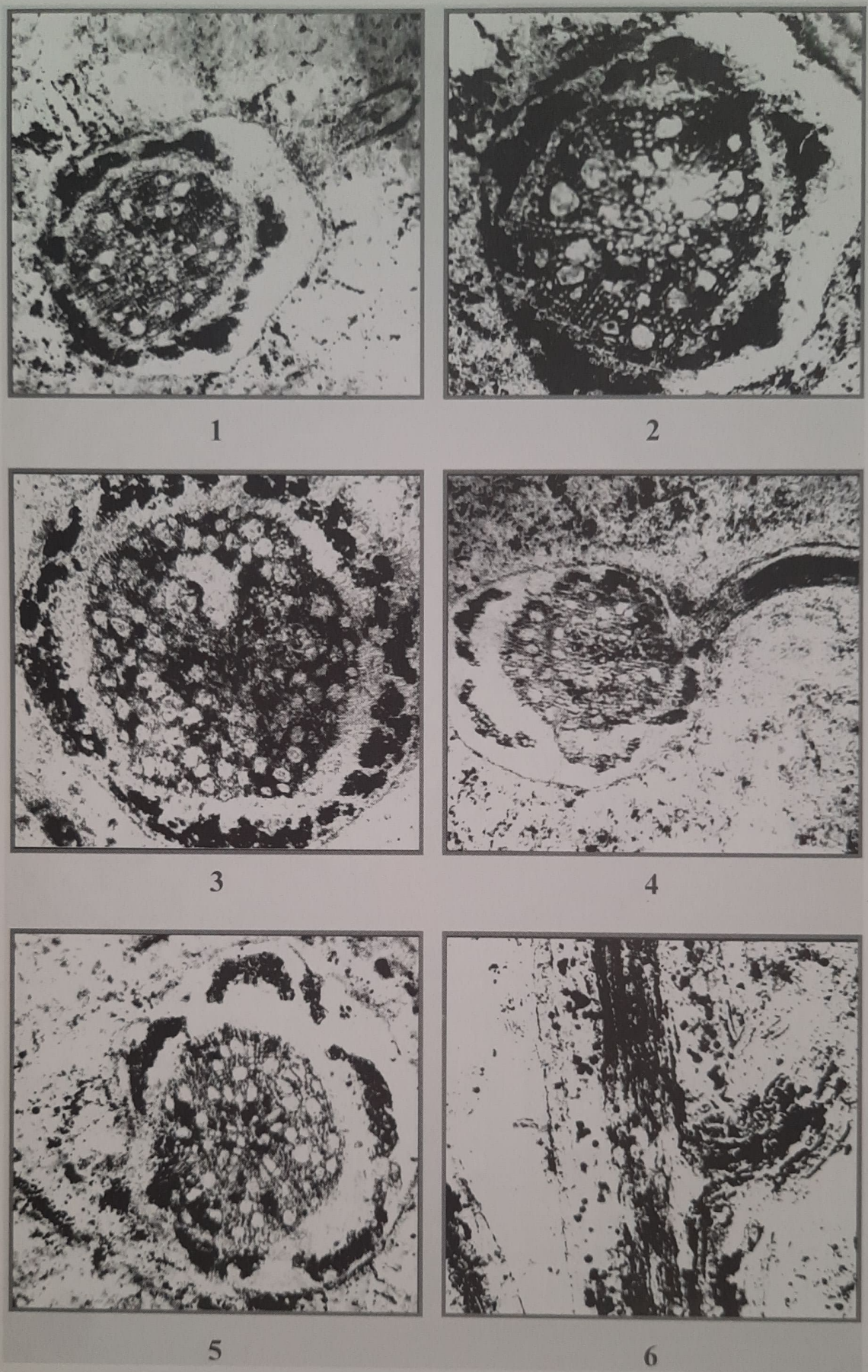
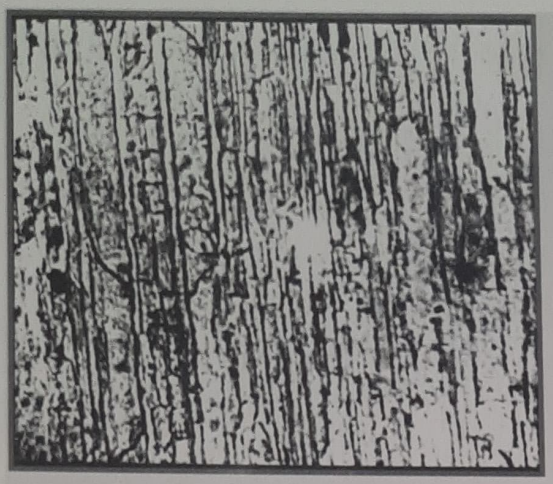



**Plate 2**

1-6. *Dicotylirhizos sahnii* Rao. 1. Stelar secondary growth and lateral roots in T.S., x95. 2. Old root with stelar secondary growth and pericycle in T.S., x120. 3. T.S old root showing secondary xylem and pericycle, cortex epiblema x 38. 4. T.S. root showing lateral root in L.S., x45. 5. T.S. root with secondary xylem and pericycle x 65. 6. L.S. root with branch showing stele, cortex and epiblema x 150



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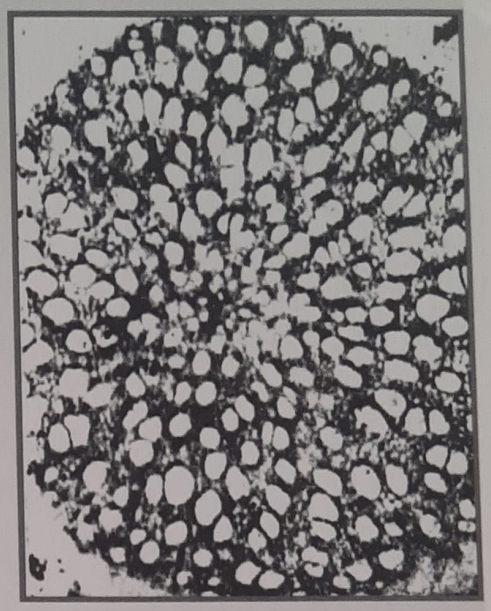

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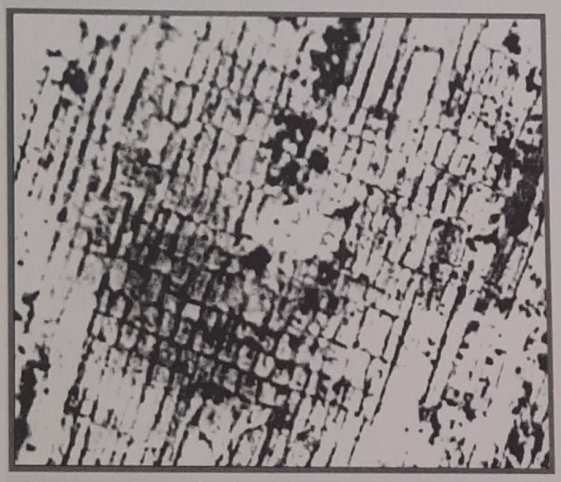

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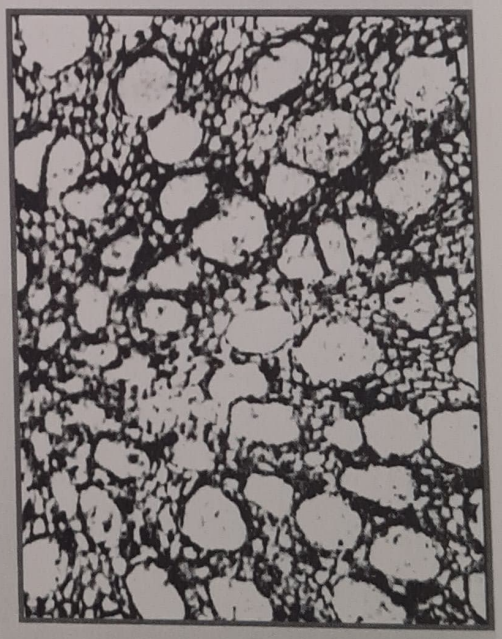

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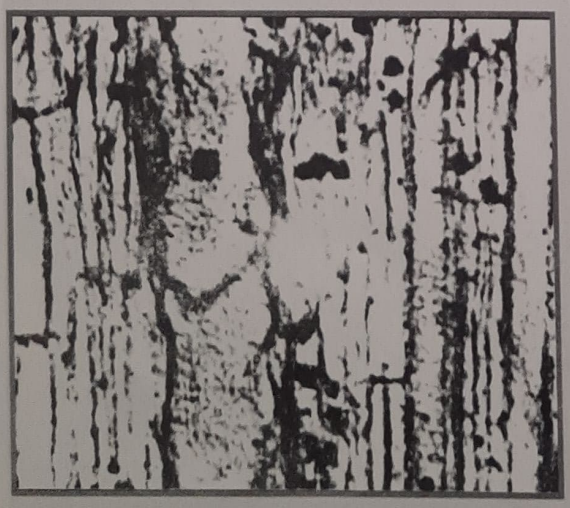

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## Plate 3

1-5. *Dicotylirhizos sahnii* Rao. 1. T.L.S. of root showing vessel with perforation plate, fibres and medullary rays, x180. 2. T.S. root showing secondary xylem and primary xylem in the centre, x45. 3. R.L.S. showing medullary rays, x75. 43. T.S. of wood showing distribution of vessels, parenchyma and fibres, x100. 5. Vessels in L.S. showing bordered pits and perforation plate x 400.

**Table 1. Comparison of present specimens with earlier described *Dicotylirhizos* specimens**

| *Dicotylirhizos sahnii* Rao (1958) | *Dicotylirhizos sahnii* Rao in Chitaley et al. (1970) | Old root specimen, recorded here |
|---|---|---|
| Thin cortex with epiblema | Thin cortex with epiblema | Thin cortex with epiblema |
| Pericycle of parenchyma and sclerenchyma forming ring | Pericycle of parenchyma and sclerenchyma forming ring | Pericycle of parenchyma and sclerenchyma forming ring |
| Cambium differentiation is seen | Cambium differentiation is seen | Cambium differentiation is seen |
| Wood diffuse porous | Wood diffuse porous | Wood diffuse porous, 100 per sq. mm |
| Vessels in radial multiples of 2-4 | Vessels in radial multiple of 2-4 | Vessels in radial multiples of 2-4 |
| Vessels 70-75 μm in tangential diameter | Vessels 40-80 μm in tangential diameter | Vessels 45-80 μm in tangential diameter |
| Intervessel pits not mentioned | Intervessel pits bordered, alternate contiguous; perforation plate simple with oblique pore | Intervessel pits bordered alternate, contiguous; perforation plate with oblique pore. |
| Medullary rays are of primary and secondary types | Medullary rays are of primary and secondary types | Medullary rays are of primary and secondary types |
| Secondary medullary rays | Secondary medullary rays are uniseriate, homocellular of upright cells | Secondary medullary rays are uniseriate and heterogeneous |
| Parenchyma diffuse | Parenchyma paratracheal and metatracheal | Parenchyma paratracheal and metatracheal. |
| Primary medullary rays multi seriate | Primary medullary rays multiseriate | Primary medullary rays multiseriate |
| Fibres sparse | Fibres non-septate | Fibres non-septate |
| Primary xylem in 5 groups forming pentarch stele | Primary xylem in 5 groups forming pentarch stele | Primary xylem in 5 groups forming pentarch stele |
| Nature of xylem exarch | Nature of xylem exarch | Nature of xylem exarch |
| Pith very small, parenchymatous | Pith very small, parenchymatous | Pith very small, parenchymatous |

xylem fibres, xylem parenchyma and medullary rays. The wood is diffused porous. Vessels small to medium, evenly distributed, 100 per $mm^2$, mostly in radial multiples of 2-4 and solitary (Plate 3, figure 4, Text-figure 7). Vessels are oval in shape, 35-120 μm in radial diameter and 45-80 μm in tangential diameter. Growth rings are not seen. Vessel segments are 200-255 μm long. Perforation is simple, oblique or transverse (Plate 3, figures 1, 5). Intervessel pits are bordered, alternate and contiguous (Plate 3, figure 5). Wood parenchyma is paratracheal, vasicentric and metatracheal diffuse. The primary medullary rays are 2-3 seriate broad in the centre and narrow towards the cambium (Plate 3, figures 1, 3, Text-figure 5). Secondary medullary rays are uniseriate. They are heterogeneous (Plate 3, figure 3). The fibres are sparse and nonseptate. In cross section, they appear polyangular. Outside the xylem, stelar cambium is seen. The cells of which are thin walled. Outside the cambium is seen the parenchyma and the sclerenchymatous fibres, which together form complete circular ring. Preservation of phloem is inconspicuous. The cortex is narrow and made up of parenchyma cells. The extrastelar secondary growth remains absent as there is no periderm formation. Epiblema is single layered with root hairs at places. The pith in the centre is parenchymatous. Due to pronounced secondary growth, the cortex and phloem tissues are compressed and the phloem tissue has been crushed. The primary xylem is pushed towards the centre and the pith is reduced in size (Plate 3, figure 2). As there is no extrastelar secondary growth, the epiblema on the outer side remains intact.

## DISCUSSION

An old root was described by Rao (1958) as *Dicotylirhizos sahnii* and reinvestigated by Chitaley et al. (1970). The present root specimens closely resemble *Dicotylirhizos sahnii* described by Rao (1958) and Chitaley et al. (1970) in having diffuse porous wood, vessels in radial multiples of 2-4, 40-80 μm in tangential diameter, intervessel pits bordered, perforation simple and oblique, paratracheal vasicentric and metatracheal diffuse parenchyma and non-septate fibres. Study of younger specimens of present fossils shows certain similarities with *Dicotylirhizos*. The characters

of similarities are five groups of primary xylem with exarch nature and five sclerenchymatous groups in pericycle. The present fossil also shows close similarities with *Dicotylirhizos herbatiales* (Kapgate 2005) but differs in having xylem diffuse, porous and in presence of secondary medullary rays which are not mentioned in *Dicotylirhizos herbatiales* and also in having herbaceous nature.

Both types of specimens of present collection are closely associated to each other and some of them are in organic connection. This suggests that they are different growth stages of same species. The presence of unicellular root hairs, the number and exarch nature of primary xylem and endogenous origin of lateral branch from pericycle confirms root nature of the specimen. From the above discussion, it is clearly seen that the present fossil specimens and *Dicotylirhizos sahnii*, on the basis of resemblance of major characters, are the same, hence the present fossil is placed under *Dicotylirhizos sahnii* Rao.

The present specimens with advanced secondary growth resemble in many anatomical details with *Dicotylirhizos sahnii* (Rao 1958, Chitaley et al. 1970). However, *Dicotylirhizos,* described earlier, does not show primary structure and series of developmental stages leading to advanced secondary growth.

The specimens of *Dicotylirhizos* observed by Rao (1958) and Chitaley et al. (1970) were 1-6 mm in diameter whereas the specimens of *Dicotylirhizos* in young stage of development measure 55-780 μm. The additional characters of *Dicotylirhizos* are unilayered epiblema with unicellular root hairs, intact parenchymatous cortex of few layers, single layered endodermis and pericycle, five radial vascular bundles with exarch xylem, endogenous origin of lateral roots and initiation of stelar cambium besides, the gradual stages of development from very young to old roots where secondary growth of advanced nature occurred.

## EMENDED DIAGNOSIS OF *DICOTYLIRHIZOS SAHNII* RAO 1958

Silicified dicotyledonous root, 55-3300 μm in diameter. Pith very small, made of parenchymatous cells. Xylem and phloem in five radial alternating groups, xylem exarch, protoxylem 3-6 μm in diameter, metaxylem 8.5-11 μm in diameter, xylem elements with spiral and pitted thickenings; phloem contains thin walled parenchymatous cells. Pericycle multilayered, made of parenchymatous and sclerenchymatous cells; origin of lateral branch from pericycle; single layered endodermis with barrel shaped cells, cells have thickenings on radial walls; stelar cambium forming ring of brick shaped cells. Vessels of secondary xylem, parenchyma and fibres; vessels solitary or paired and radial, in multiples of 2-4; vessel segments 35-120 μm in radial dimension, 40-80 μm in tangential dimension, 200-400 μm long, perforation plate simple with oblique pore, intervessel pitting bordered, alternate, contiguous; parenchyma paratracheal, vasicentric and metatracheal diffuse; fibres sparse, nonseptate; primary medullary rays multiseriate and secondary medullary rays uniseriate, heterogeneous; cortex narrow parenchymatous, separate from stele in mature specimens; no periderm and secretary cells seen; epiblema single layered with distinct unicellular root hairs.

**Locality:** Mohgaonkalan, Chhindwara District, Madhya Pradesh, India.

**Horizon and age:** Deccan Intertrappean Series, Eocene.

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